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Executive summary

The **Arctic Fisheries Working Group** (AFWG), chaired by Daniel Howell, Norway, met at ICES Headquarters, Copenhagen, Denmark, 19–25 April 2017.

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 1995–2016 as well as catch at age data (including recreational and tourist fisheries). This is a category three stock.

- 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 time series. Fishing pressure (F) increased in 2015 and 2016, after a declining trend over the period 2000-2014. A rebuilding plan for this stock was introduced in 2011.

Cod in subareas 1 and 2 (Northeast Arctic) was for the first time assessed using the SAM model following the outcome of the interbenchmark meeting (IBP cod 2017). The IBP also recommended extending the catch data to age 15+, and to evaluate the survey data on an annual basis to select appropriate age-ranges. The IBP recommended that the current model of natural mortality (M=0.2 plus modelled cannibalism) and methods for evaluating maturity at age should be retained.

- The change in assessment model as well as inclusion of a wider age range and data from the last year changed the stock composition considerably compared to last year's assessment. The abundance of age 9 and older fish in 2016 was increased compared to last year, while the abundance of younger age groups was decreased. Overall, this led to minor revisions of current total stock biomass, but the predictions indicate lower stock size and catches than in last year's assessment. The estimated F_{5-10} in 2016 is below F_{pa}, and SSB well above B_{pa}, although somewhat lower than the peak in 2013.
- Following the evaluation of harvest control rules in 2016, the Joint Norwegian-Russian Fisheries Commission in October 2016 adopted a new harvest control rule for this stock. In the new rule, fishing mortality is increased at high SSB values, and the constraint on annual variation in TAC when SSB is now 20% (previously 10%).
- The TAC advice for 2018 is 712 000 tonnes, corresponding to F=0.44. The advice is constrained by the limit of 20% annual TAC decrease from year to year.

Haddock in subareas 1 and 2 (Northeast Arctic) was assessed using SAM, following the recommendations from WKARCT in 2015.

- Three subsequent cohorts (2004–2006) were all very abundant and the 2005–2006 cohorts still make up a considerable proportion of the total haddock biomass.
- The fishing mortality (F_{4-7}) has been around 0.20 since 2009. Note that a large proportion of the catches in recent years has been from age groups outside the reference age range. The total stock peaked in 2009 while SSB reached an all-time high in 2012-2015. SSB is now decreasing but still at a high level.
- The evaluated and agreed HCR gives a catch in 2018 of no more than 202 000 tonnes, corresponding to a 13% decrease from the TAC in 2017. This corresponds to a fishing mortality of 0.35. A decrease in stock size and catch level towards a more normal situation is expected in the coming years. However, the 2016 year class is very abundant at age 1 in surveys.

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 Bpa 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 2017 should be no more than 150 000 tonnes. This is a 7% increase compared to the TAC for 2016 and corresponds to a fishing mortality of 0.30.

Beaked redfish (Sebastes mentella) in subareas 1 and 2 (Northeast Arctic). This stock is assessed on a three-year cycle. In 2014, this stock was assessed using a statistical catch at age model (SCAA) and ICES advised that catches should not exceed 30 000 t annually. The spawning stock biomass has been stable in recent years and the stock biomass is increasing due to incoming good recruitment year-classes. The recent opening of targeted pelagic (2006) and demersal (2014) fisheries has led to increase in catches. Based on precautionary considerations, and given the planned benchmark assessment in 2018, it is recommended that catches in 2018 should not exceed 32 700 t and that a new 3-year advice be provided following the planned benchmark in 2018.

Golden redfish (*Sebastes norvegicus*) in subareas 1 and 2 (Northeast Arctic). This stock uses a three year assessment cycle. The last assessment was in 2016, so no assessment was conducted in 2017. A benchmark is planned for 2018, and it is likely that new assessment and advice will occur following that.

Greenland halibut in subareas 1 and 2 (Northeast Arctic). The stock is assessed by a new GADGET length based model (this is the first update assessment) approved at WKBUT benchmark in 2015, and there is as yet no HCR. The stock has a two year advice cycle, and advice is given this year covering 2018 and 2019.

- The assessment shows a slight decline from the c. 2013 peak identified in the previous assessment
- Status quo fishing keeps the stock above Bpa over a medium (5 year) forecast
- Prior to designing and evaluating HCRs, work is required to extend the model back in time to cover a period of lower stock levels, to move to reporting female SSB, and potentially to including age data into the tuning.

Anglerfish in subareas 1 and 2 (Northeast Arctic) There is currently no assessment for this stock, although the stock will be benchmarked in 2018. 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 has been increasing in recent years. Recent catches have been in the range 4000–5000 tonnes, mainly from a directed gillnet fishery. However, since 2012 catches have declined, reaching a minimum of 1043 tonnes in 2015, the lowest level since 1997. 2016 catches were slightly higher, 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.

0 Introduction

0.1 Terms of reference

AFWG – Arctic Fisheries Working Group

2016/2/ACOM: 06 The **Arctic Fisheries Working Group** (AFWG), chaired by Daniel Howell*, Norway, will meet at ICES Headquarters, Copenhagen, Denmark, 19–25 April 2017 to:

a) Address generic ToRs for Regional and Species Working Groups, for all stocks except the Barents Sea capelin;

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

c) In preparation for the benchmark on anglerfish stocks, compile data for anglerfish in Subarea IIa.

d) Estimate MSY proxy reference points for the category 3 and 4 stocks in need of new advice in 2017 (see table below).

a. Collate necessary data and information for the stocks listed below prior to the Expert Group meeting. An official ICES data call was made for length and select life history parameters for each stock in the table below;

b. Propose appropriate MSY proxies for each of the stocks listed below by using methods provided in the ICES Technical Guidelines (i.e. peer reviewed methods that were developed by WKLIFE V, WKLIFE VI, and WKProxy) along with available data and expert judgement.

STOCK CODE	STOCK NAME DESCRIPTION	EG	DATA CATEGORY
cod-coas	Cod (*Gadus morhua*) in subareas 1 and 2 (Norwegian coastal waters cod)	AFWG	3

and by correspondence in September/October to:

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

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting. 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 no later than 6 April.

AFWG will report by 11 May 2017 and 6 October 2017 for Barents Sea capelin for the attention of ACOM

Generic ToRs for Regional and Species Working Groups

2016/2/ACOM: 05 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 overview, and

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

c) Conduct an assessment to update advice on the stock(s) 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, summarising 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 area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in the last year.

  iv) 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;

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

  vi) Catch options for next year;

  vii) Historical 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 fish stocks and fisheries under considerations according to ACOM guidelines.

e) Review progress on benchmark processes of relevance to the expert group;

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

g) Identify research needs of relevance for the expert group.

Information of the stocks

0.2 Responses to Terms of Reference

Due to time constraint, comments and text suggestions for ecosystem and fisheries overviews (Generic ToRs *a-b*) will be given after the WG. As usual, some ecosystem and fisheries considerations relevant to the Group are given in Section 1, others are in the WGIBAR (ecosystem assessment WG) report (ICES C.M. 2017/SSGIEA:04).

Considering *c)*, this is dealt with under the respective stocks. Stock annexes exist for all stocks except anglerfish, for which there is no assessment. Concerning c, no anglerfish scientists were present at the meeting. Some data was updated and is in the anglerfish chapter. Work on preparing for the benchmark will be handled intersessionally. Under ToR d, there is only one category 3 stock (coastal cod) in AFWG. Details of the extent to which this ToR could be addressed are in the coastal cod chapter.

Generic ToR *d*) is handled by drafting advice sheets.

e-f) There is a planned redfish benchmark in 2018, issues list and planned benchmark work is summarized in sections 0.15 and 0.16 of the 2016 AFWG. As noted, there is also a planned anglerfish benchmark, but no work on this was conducted at AFWG 2017.

h) Data calls should be made as usual, but it is very important that all data should be available 14 days before start of meeting.

j) See Tables 0.1–0.4

k) Addressed in Section 0.18

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

0.3.1 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 2016 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 2016 to zero.

Discards estimates (1983–2015) of cod, haddock and redfish juveniles in the commercial shrimp fishery in the Barents Sea are presented in Figure 0.1. It is possible to present these numbers by length and age and hence include the time series in the stock assessment. Note that the use of sorting grid does not completely solve the bycatch/discards problem of the smallest fish individuals (of the same size as the shrimps), and that in order to reduce the bycatch/discard mortality further, temporally closure of shrimp fishing areas may be necessary.

For further information on under- and misreporting, we refer to the 2016 AFWG report. Note that recent investigations about conversion factors for cod are described in Section 3.12.3.

0.3.2 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 low 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 in comparison with other types of uncertainties in the estimation.

0.3.3 Sampling effort– commercial fishery

Concerns about commercial sampling: The main Norwegian sampling program for demersal fish in ICES areas I and II 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. Although sampling by the 'reference fleet' and the Coast Guard has increased somewhat in recent years, the reduction in port sampling of many different vessels seems to have increased the uncertainty in the catch-at-age estimates (WD6, 2010). Nevertheless, there were concerns that the commercial sampling could become so poor that analytical assessments cannot be made in the future. A Norwegian port sampling program was restarted in 2011, although with a lower effort, but this improved the basis for the 2011–2015 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 2008–2016. 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, but with lower effort. 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.

Data issues: Previous concerns regarding poor biological sampling from the fishery were less of an issue in 2016, as available catch at age and length data covered the largest portion of catches by the respective fisheries. As stated in earlier reports in 2015 a lack of samples was in particular visible for samples from trawl in Quarter 2 and 3 in ICES Subarea 1 and age samples from purse seine fishery south of Lofoten in Quarter 2 and in ICES Subarea 1. In 2016 samples from the purse seine fishery were available for areas and quarters with highest catches, with only fraction of catches not sampled. Despite the improvement in sampling coverage in 2016, the number of samples should be increased in coming years, with the aim of covering all quarters and areas contributing highest catches.

Beaked redfish

Data issues: There is still a concern about the biological sampling from the fishery and scientific surveys that may have become critically low. Ages for Norwegian samples in 2016 are not available to afwg 2017. Ages from Winter survey are not available since 2010. Ages from the Ecosystem and Russian survey are not available for 2016.

NeA Greenland halibut

Data issues: There is still a concern about the biological sampling from the fishery that may have become critically low. In 2016 in particular for NOR for trawl in Quarter 1 for all areas. 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.

The methodological ICES workshops WKACCU (ICES CM 2008/ACOM:32), WKPRECISE (ICES CM 2009/ACOM:40), WKMERGE (ICES CM 2010/ACOM:40), and WKPICS (ICES CM 2011 / ACOM:52; ICES CM 2012 / ACOM:54; ICES CM 2013/ACOM:54) were all dealing with different aspects of catch sampling and the need for a more proper, robust and transparent sampling design for countries involved in catch sampling. The workshops have provided valuable general knowledge in how such catch sampling programs can be designed and the reports are beneficial for countries aiming to improve the current situation. This work is now continued in WGCATCH.

0.4 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 the autumn 2002, 2006 and winter 2003, 2007, and 2016 however, surveys were again incomplete due to lack of access to both the Norwegian and Russian Economic Zones. During the 2017 winter survey considerable parts of the REZ was not covered due to limited access, and technical problems with the Russian vessel. The method applied to adjust for this lack of coverage in 2017 is described in WD 03. 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). 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 2014–2017 surveys covered considerably larger areas than earlier winter surveys, and showed that cod (particularly age 1) was distributed far outside the standard survey area. The 2017 survey was restricted by ice North-East of Hopen Island, and the survey did not extend quite as far as in the years 2014-2016.

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. Ongoing work is considering the performance of these new index series for inclusion in the assessment of cod and haddock. The ecosystem survey is now included in both cod and haddock assessments. The survey is also utilised in the assessment of redfish and Greenland halibut. This survey should be continued at the same level of coverage, as 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. In 2016 the spatial coverage of this survey was limited, and the survey was less synoptic than in previous years in the south-eastern area, this particularly affected the survey indices for haddock.

Norwegian scientists are critical to the method presently used for calculating indices from BESS. Firstly; the fine scaled strata system based on WMO and depth requires a lot of interpolation and extrapolation of data, because of many empty cells. This may bias the estimates and neither does it allow for uncertainty estimates. Secondly, if ALKs are applied to large areas the results may be biased since age at length is likely to vary spatially and the survey area of the Ecosystem survey is large. Therefore, Norwegian scientists recommend applying design-based estimators for multi-stage sampling for estimating density at length and age, with stratified estimators, where it is assumed simple random sampling within strata. The strata system needs to take into account the different allocation of effort, e. g. shrimp investigations and depth stratification west and north of Spitsbergen. Work towards a joint methodology for calculating indices from BESS, using the new StoX framework which is already used for calculation of indices from the Joint Winter Survey, should be given very high priority.

0.5 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 time 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 3 Norwegian, 2 Russian and 1 German reader, reaching nearly 83% agreement (coefficient of variation 8%). The age reading comparisons of these 100 cod otoliths show that there are no reading biases between readers within each country. However, there is a clear trend of bias between the readers from different countries, Russian age readers assign higher ages than the Norwegian and German age readers. This systematic difference is a source of concern and is also discussed in Yaragina *et al*. (2009b). This seems to be a persistent trend and will be revealed in the following annual otolith and age reader exchanges.

From 2009 onwards it was decided to have meetings between cod and haddock otolith readers only every second year. The overall percentage agreement for the 2013–2014 exchange was 83.5% for cod (WD 01), which was a little lower than at the previous meeting. The main reason for cod ageing discrepancies between Russian and Norwegian specialists is the latest summer growth zone, and different interpretations of the false zones. Some decrease in the percentage agreement in 2012–2014 is likely to be connected with more 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.

The general trend is that the Russian age readers assign slightly higher ages than the Norwegian age readers compared to the modal age for age group 4 years and older.

For haddock, the main reason of discrepancies between PINRO and IMR readers is different interpretation of the otolith summer structures in the first and second year of the haddock life due to false zones. Sometimes different assigned age has arisen in ageing old fish (9–11 years old) because the latest increments are very thin and hard to see.

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 (2013–2014) was 93.1% and the precision CV was 2.1% and considered to be satisfactory.

The next workshop on cod and haddock otolith reading will be held in Bergen in May-June 2017.

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 data sets, 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 time 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.

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 bi-annual 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) 14-17 February 2011 (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 ±1y) for all ages combined, but 38.6% when only fish older than 20y were considered. It is recommended that 1) future exchanges be conducted every 3–5y, 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 the future.

0.6 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.

For coastal cod, the issues around considering lifting the stock from category three to category one or two were considered. However, such an alteration was not considered viable at the present time.

0.7 Environmental included in advice of NEA cod

For the tenth 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

0.8 Proposals for status of assesments in 2018–2019

Neither *S. mentella* nor *S. norvegicus* are due for update assessments in 2018. However they are both due for a benchmark in 2018. If the benchmark is completed before AFWG 2018 then it would make sense to have new assessments for these stocks in 2018. If the benchmark is not complete until later in the year then the next update will be 2019 for both stocks. For anglerfish there is currently no assessment, however this stock is also due for benchmark in 2018 together with all other anglerfish stocks. If this benchmark results in an assessment then advice should be provided in either 2018 or 2019, depending on time of the benchmark. The AFWG propose to set the following status for assessments for each stock

Fish Stock	Stock Name	Advice in 2017	Previous benchmarks	Next benchmark
cod-arct	Cod in subareas 1 and 2 (Northeast Arctic)	Update	WKARCT 2015, IBP cod 2017	-
cod-coas	Cod in subareas 1 and 2 (Norwegian coastal waters)	Update	WKARCT 2015	-
had-arct	Haddock in subareas 1 and 2 (Northeast Arctic)	Update	WKARCT 2015 WKBENCH 2011	-
sai-arct	Saithe in subareas 1 and 2 (Northeast Arctic)	Update	IBP saithe 2014 WKROUND 2010	-
cap-bars	Capelin in subareas 1 and 2 (Barents Sea), excluding Division 2.a west of 5°W	Update	WKARCT 2015 WKSHORT 2009	-
ghl-arct	Greenland halibut in subareas 1 and 2.	Update	WKBUT 2013 (finished in 2015)	-
smn-arct	Redfish *Sebastes mentella* subareas 1 and 2	Dependent on benchmark	WKRED 2012 (WKREDMP 2014)	2018
smr-arct	Redfish *Sebastes norvegicus* subareas 1 and 2	Dependent on benchmark	WKRED 2012	2018
ang-arct	Anglerfish in subareas 1 and 2 (Northeast Arctic)	Dependent on benchmark	-	2017

0.9 Stock annexes

Slight changes were made to the saithe stock annex at AFWG 2017, following the adoption of the ECA program for calculating catch at age data. NEA cod stock annex has been updated in line with recent benchmark. Also slight changes were made to the haddock stock annex following a change in the implementation of predation by cod on haddock.

0.10 Audit reports

Audit reports were made for the six stocks for which updated advice is provided this year: Northeast Arctic cod, haddock and saithe, Greenland halibut, *Sebastes mentella*, and Norwegian Coastal Cod. All audits were conducted successfully.

0.11 InterCatch

The assessment of NEA cod, haddock and saithe was partly based on output from InterCatch. In the future, AFWG will consider using Intercatch also for the other stocks. This year's experience with Intercatch use suggests that the most practical approach for AFWG, where the number of countries providing catch at age data is small, is to send the data in an easily readable format to the stock coordinator who will then include it in InterCatch.

0.12 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

2016	ICES 1.A	ICES 2.A.1	ICES 2.B.1	TOTAL	%NEA FC
NEA cod	3619	0	0	849422	0.4 %
Coastal cod	0	0	0	44600	0.0 %
NEA haddock	7	0	0	233416	0.003 %
NEA saithe	81	0	0	140392	0.06 %
Sebastes mentella	0	7170	0	33979	21.1 %
Sebastes norvegicus	10	0	0	6060	0.16 %
Greenland halibut	363	5	0	24972	1.5 %
Capelin	0	0	0	0	0.0 %
Anglerfish	0	0	0	2117	0.0 %
		2015			
NEA cod	9	0	0	864384	1.1 %
Coastal cod	0	0	0	39455	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	934	0.0 %
		2014			
NEA cod	534	0	0	986449	0.1 %
Coastal cod	0	0	0	23169	0.0 %
NEA haddock	0	0	0	177522	0.0 %
NEA saithe	0	0	0	132005	0.0 %
Sebastes mentella	0	4020	0	18780	21.4 %
Sebastes norvegicus	0	0	0	4438	0.0 %
Greenland halibut	211	0	0	23025	0.9 %
Capelin	0	0	0	66000	0.0 %
Anglerfish	0	0	0	1657	0.0 %

0.13 Relationship to WGIBAR

The WGIBAR group (Working Group on Integrated Assessments of the Barents Sea) met for the fourth time in March 2017 (ICES C. M. 2017/SSGIEA:04). Most of the ecosystem information which was previously found in Chapter 1 in the AFWG report is now 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.

0.14 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

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

0.15 Recommendations

AFWG recommends that WGIBAR continue to work in collaboration with AFWG to produce ecosystem, reports, and ensure that the AFWG and WGIBAR report together provide an overview of the Barents Sea ecosystem and fisheries

0.16 Time and place of Next Meeting

The Working Group proposes to meet next time in the period 18–24 April 2018 at a location to be decided.

Table 0.1. Age and length sampling by Norway of commercial catches in 2008-2016. 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
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
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
	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
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
	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
*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

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
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	32.0	18.1	24.8	125
Capelin	2008	4	3	150		0	0	5000	0.6	0.0	0.0	125
	2009	18	97	7039		39	1039	233000	0.4	0.2	4.5	125
	2010	75	230	6191		47	1291	246000	0.9	0.2	5.2	125

2011	115	315	8346		48	1313	273000	1.2	0.2	4.8	125
2012	84	308	9337		29	843	181328	1.7	0.2	4.6	125
2013	12	213	12215	47	47	773	156340	1.4	0.3	4.9	125
2014	27	113	9054	1	8	1086	40021	2.8	0.2	27.1	125
2015	65	722	83776	65	722	5393	71435	10.1	10.1	75.5	125
2016	36	490	3839	35	453	3392					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, age sampling of surveys in 2008–2015. 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
NEA-haddock	2008	216959	2498	5677	8175	68792	3154	36.3	118.8	125
	2009	43254	489	5421	5910	85514	506	5.7	69.1	125
	2010	85445	834	5060	5894	111372	767	7.5	52.9	125
	2011	61990	1570	3584	5154	139912	443	11.2	36.8	125
	2012***	87880	1545	5034	6579	143886	611	10.7	45.7	125

	2013	42927	1205	4021	5226	85668	501	14.1	61.0	125
	2014	45447	899	3796	4695	78725	577	11.4	59.6	125
	2015***	31009	914	2972	3886	91864	338	9.9	42.3	125
	2016	55598	2691	1884	4575	115710	480	23.3	39.5	125
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
	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
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
	2015	120		20	20	664	181	0.0	30.1	125
	2016	1113	147	34	181	776	1434	189.4	233.2	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
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
Capelin	2008**	82625	1644	2341	3985	5000	16525	328.8	797.0	125
	2009	94541	900	2511	3411	73000	1295	12.3	46.7	125
	2010	67265	1072	4043	5115	77000	874	13.9	66.4	125
	2011	63784	1273	2271	3544	86531	737	14.7	41.0	125
	2012	20023	1130	1783	2913	68182	294	16.6	42.7	125
	2013	54708	1565	1007	2572	60413	906	25.9	42.6	125
	2014	13206	850	1249	2099	25720	513	33.0	81.6	125

	2015	27200	1000	1004	2004	115	236522	8695.7	17426.1	125
	2016	8669	3954	1047	5001	0				125

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***) 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 2008-2016. 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
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				

NEA-SAITHE*	2009	1	123				2				
	2013	1					5				
	2014	1					13				
	2015	1					33				
	2016						25				
S. mentella	2008**	1	2275	28			987	2304	28	0	125
	2011*	1	86				1237				
	2012**	2	11579	476			1612	7183	295	0	125
	2014**	1	6177				1146	5390			
	2015**	1	6117				2371	2580			
	2016**	1	11806				3133	3768			
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**

*****)samplig from Spanish Greenland halibut survey**

Table 0.4. Age and length sampling by Germany of commercial catches in 2009–2014. Also length-measured individuals and aged individuals per 1000 t caught. For comparison the EU DCF requirements are shown.

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
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
NEA haddock	2008	5	3	5548	442	535	10370	826	125
	2009	5	2	23348	958	1957	11931	490	125
	2010	5	2	54704	1039	3539	15457	294	125
	2011	4	1	1925	160	1724	1117	93	125
	2012	4	2	4088	502	1111	3680	452	125
	2013	4	1	7040	478	501	14052	954	125
	2014	4	1	3113	261	340	9156	768	125
	2015	4	1	616	325	124	4968	2621	125
	2016	3	1	4807	544	170	28276	3200	125
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
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
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
	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

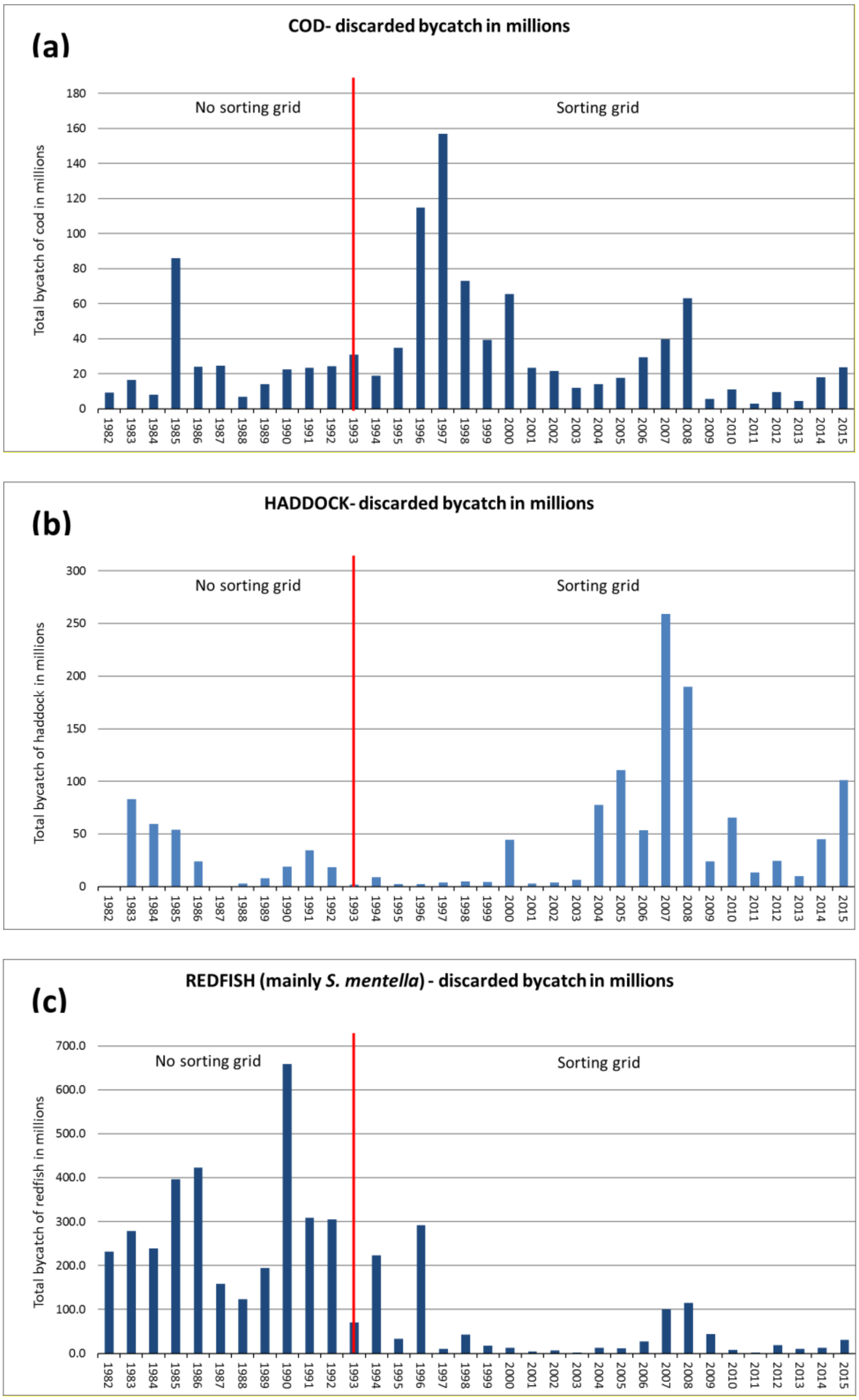


Figure 0.1. Estimated bycatch of (a) cod, (b) haddock and (c) redfish in the shrimp fishery in the Barents Sea 1982–2015. The sorting grid was introduced in 1992 and has been mandatory since. (Ajiad *et al*. WD18 2005 WG, WD 24 2004 WG, WD 15 2014 WG and 2016 *in prep*.)

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 2017/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 2017 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 2016, the abundance of 0-group capelin was well above the long-term mean, and among the five highest observed in the time series. For cod, herring, haddock and redfish the 0-group index was at or below the long-term mean.

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 1984–2016, based on data from the Joint Russian-Norwegian stomach content data base, 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 2016 were capelin, krill, amphipods, polar cod and shrimp. The consumption calculations made by IMR show that the total consumption by age 1 and older cod in 2016 was 5.7 million tonnes, while similar calculations by PINRO for 2016 based on cod abundance from the 2016 assessment gave 8.4 million tonnes (Table 1.4). The difference is mostly due to the considerable revision of abundance at age in the cod stock from the 2016 to the 2017 assessment. 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 Table 1.7 and 1.8. Consumption per cod and individual growth of cod has been stable for ages 1-6 in recent years, while both have decreased somewhat for age 7+ cod.

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, summarised 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 section 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 has increased considerably, and the biomass of large haddock is also high. 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 for 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

Maturity at age for cod has decreased considerably in recent years, particularly for ages 6-9. For 2017, there is a discrepancy between Norwegian and Russian data – according to Norwegian data maturity seems to have increased again for these age groups, while Russian data indicate no such reversal. The change from 2013 to 2016 is considerably larger than indicated by recent changes in weight-at-age.

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. 2007; 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 field work 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 on skipped spawning in cod (e.g. comparisons and inter-calibration 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 for 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.

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 for 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 (0–200m, station 3–7), Age1 is the winter survey bottom trawl index for cod age 1, and MatBio the maturing biomass of capelin at October 1. The number in parenthesis 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 hydro-dynamical 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 the autumn. The number in parenthesis 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 age3 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 parenthesis 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 (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 0–200m) (Tw), ice coverage in the Barents Sea (I), spawning stock biomass (SSB), and the acoustic abundance of cod at age 1 and 2, derived from the joint winter Barents Sea acoustic survey. 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. This has been conducted and has improved the statistical performance (details are shown in Titov, AFWG 2011, WD23):

TITOV0: $R3^1$ ~CodA3(t+1) + Tw(t-17)

TITOV1: $R3^1$ ~$DOxSat^2$(t-13)+ DOxSat(t-13) +CodA2(t-11) + Tw(t-17)

TITOV2: $R3^2$ ~$DOxSat^2$(t-13)+ ITa(t-39)+CodA1(t-23) + Tw(t-17)

TITOV3: $R3^3$~ ITa(t -39) + logCodC0(t-28) + Tw(t-23)

TITOV4: $R3^4$~ ITa(t -39) + SSB(t-36)

Where DOxSat(t-13)~ Exp(OxSat(t-13)) − OxSat(t-38), ITa(t-39) ~ I(t-39) +Ta(t−44). The number in parenthesis is the time lag in months, relative to 1 January at age 3. The ITa index coincides in time with the increase of horizontal gradients of water temperatures in the area of the Polar Front (Titov, 2011). The changes from the 2010 assessment are: In TITOV1 the ITa_{t-39} term was taken out of the model, in TITOV 2 the $DOxSat_{t-13}$ term was taken out of the model, and in TITOV3 the $OxSat_{t-44}$ term was replaced by a Tw_{t-26} term.

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 12 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 (0–200m), 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 parenthesis 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.

At the 2008 AFWG assessment a hybrid model (i.e. an average combination) of the best functioning statistical recruitment models were used. Further description of this hybrid can be found in the AFWG reports for 2009–2013.

At this year's AFWG assessment the recruitment forecasts for 2017–2019 are based on using inverse variance weighting of a pool of models, following the procedure described in SGRF Report 2013. The models used are the same as in the hybrid in 2016, except that TITOV4 is changed to being proportional to log SSB and not SSB, in view of recent very high SSB levels (WD 18). The revised model is

TITOV4: $\log(R3_t) = 0.05ITa_{t-39} + \log(SSB_{t-36}) + 4.08$

In summary, the VPA for age 3 from the AFWG 2017 assessment was used as R3. The recruitment forecast for 2017–2019 are based on a hybrid model with updated weighting. The weights and forecasts for the 2017 AFWG assessment can be found in Tables 1.9a–b.

Future work

Since 2008, AFWG has based its prediction of R3 on assessment a hybrid model (i.e. a average combination) of the best functioning statistical recruitment models, see AFWG report for 2009—2013. Since 2014, forecasts have been based on using inverse variance weighting of a pool of selected models, following the procedure described in SGRF Report 2013. One common feature of the model pool used in calculating the hybrid R3 value is that they express recruitment (R3) as a linear regression model of SSB.

Population sizes are stabilized by negative feedbacks between stock size and recruitment. Biological processes such as compensatory density dependence mortality (i.e., higher mortality occurs at higher densities) affect stock and recruitment. Density effects ensure that whiles the SSB-recruitment relationship may be linear, and monotonically increasing at low SSB-levels, the relationship at higher SSB-levels will show a different dynamic (e.g., asymptotic behavior (Beverton-Holt recruitment model), or monotonically decreasing recruitment with increasing SSB (the Ricker model)). Retrospective diagnostics (see AFWG reports from 2009—2014) may indicate good hybrid model performance in the past. However, recent high levels of SSB and TSB for NEA cod will render the model performance in predicting R3 unreliable, due to the inability of the hybrid model pool to account for density effects. It must be cautioned that the problem is not solved by logarithmic transformation of terms in a linear regression model for recruitment.

Addressing the R3 forecasting problem from a hybrid model approach (consistent with recent AFWG practice) requires a re-evaluation and expansion of the model pool used in establishing the hybrid R3 forecasts. In particular the expansion must include models that explicitly include density effects. These include the following recruitment models: T. Bulgakova (AFWG 2005 WD14) and Hjermann *et al*. (2007), as described above.

1.5 Biomass and exploration levels of AFWG stocks.

Fig 1.1 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 the target fishing mortalities in the management plans (Fig 1.2). Capelin is at a low level, and the fishery has been closed since 2016.

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
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	16701	2541	30862	19157	13987	24328	19144	12649	25638	133350	94873	171826	849	0	1766
2005	41808	12316	71300	21532	14732	28331	33283	24377	42190	26332	1132	51532	12332	631	24034

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	
2006	166400	102749	230050	7860	3658	12061	11421	7553	15289	66819	22759	110880	20864	10057	31671
2007	157913	87370	228456	9707	5887	13527	2826	1787	3866	22481	4556	40405	159159	44882	273436
2008	288799	178860	398738	52975	31839	74111	2742	830	4655	15915	4477	27353	9962	0	20828
2009	189767	113154	266379	54579	37311	71846	13040	7988	18093	18916	8249	29582	66671	29636	103706
2010	91730	57545	125914	40635	20307	60963	7268	4530	10005	20367	4099	36636	66392	3114	129669
2011	175836	3876	347796	119736	66423	173048	7441	5251	9631	13674	7737	19610	7026	0	17885
2012	310519	225728	395311	105176	37917	172435	1814	762	2866	124196	0	316769	0	0	128715
2013	94673	28224	161122	90101	62782	117421	7245	4731	9759	70972	8394	133551	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
Mean	94079			29224			4314			28491			62088		
Median	57390			16872			1706			18916			16092		

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

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	
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
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	21	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
2012	69	2	135	30	16	43	173	0	416	4173	48	8298	17281	0	49258

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	
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	1	101	27	2	52	575	367	789	128	18	237	6074	2001	10146
2016	3	0	7	6	1	12	601	0	1267	258	0	624	1180	128	2231
Mean	162			27			526			31208			8035		
Median	53			14			200			11211			4634		

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

Year	Capelin			Cod			Haddock			Herring		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
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
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	855742	0	2111493
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	1078438	53796	30790	76622	5504	2791	8216	79439	38415	120464
Mean	314184			114452			11740			163247		

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
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

Year	Saithe			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
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
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
Mean	484			252074			65130		

Table 1.3. The Northeast arctic COD stock's consumption of various prey species in 1984–2016 (1000 tonnes) based on Norwegian consumption calculations.

Table 1.3. The North-east arctic COD stock's consumption of various prey species in 1984-2016 (1000 tonnes)													
Year	Other	Amphipods	Krill	Shrimp	Capelin	Herring	Polar cod	Cod	Haddock	Redfish	G. halibut	Blue whiting	Long rough c	Total
1984	486	28	119	439	724	78	15	22	51	364	0	0	26	2352
1985	1115	173	60	155	1617	183	3	31	47	224	0	1	44	3654
1986	595	1213	112	139	823	131	137	81	109	311	0	0	59	3711
1987	662	1067	66	189	226	32	202	25	4	318	1	0	9	2800
1988	399	1230	301	127	337	8	92	9	3	222	0	4	6	2738
1989	650	793	237	131	570	3	32	8	10	227	0	0	62	2723
1990	1341	137	85	195	1608	7	6	19	15	243	0	87	104	3849
1991	761	66	76	188	2890	8	12	26	20	312	8	10	296	4672
1992	893	98	151	370	2450	330	96	54	106	187	22	2	101	4860
1993	737	247	671	313	3025	162	276	283	70	100	2	2	28	5918
1994	611	548	692	501	1082	145	566	215	48	78	0	1	42	4529
1995	811	951	500	351	606	113	242	358	111	189	1	0	37	4271
1996	588	623	1138	334	530	46	101	520	67	96	0	10	38	4093
1997	427	372	502	302	875	5	111	331	40	36	0	32	16	3050
1998	401	348	448	314	690	82	144	152	31	9	0	13	17	2649
1999	377	143	271	246	1697	127	217	61	26	16	1	31	8	3218
2000	380	164	452	444	1706	53	191	75	50	8	0	37	20	3579
2001	693	172	375	278	1739	72	253	69	50	6	1	154	33	3894
2002	380	95	253	240	2002	87	283	109	129	1	0	240	16	3835
2003	563	292	544	239	2182	216	284	116	174	3	0	78	56	4747
2004	632	563	342	244	1257	211	354	128	201	3	12	58	67	4073
2005	774	574	518	266	1369	130	384	118	319	2	5	116	55	4631
2006	892	226	1088	364	1763	170	110	81	364	12	2	163	134	5369
2007	1344	323	1166	469	2301	290	280	90	392	51	0	44	79	6828
2008	1741	179	1024	435	3175	114	557	208	314	67	13	19	101	7946
2009	1709	276	682	305	4548	138	837	227	290	33	3	6	131	9187
2010	1866	478	1146	328	4511	61	381	284	308	162	12	17	152	9706
2011	1822	286	977	255	4724	94	492	331	326	132	0	30	142	9611
2012	2361	341	846	391	4187	54	621	431	261	59	42	10	148	9754
2013	2030	268	540	282	4015	55	157	437	235	134	1	25	199	8379
2014	1601	296	426	198	3878	71	34	381	97	34	13	20	118	7166
2015	1599	583	549	212	3134	121	154	220	176	125	53	55	94	7075
2016	1490	489	678	231	1857	85	291	196	179	46	6	60	121	5730

Table 1.4. The Northeast arctic COD stock's consumption of various prey species in 1984–2016 (1000 tonnes) based on Russian consumption calculations (Dolgov, WD 14). Note that these calculations are based on cod abundance at age from the 2016 assessment.

Table 1.4. The North-east arctic COD stock's consumption of various prey species in 1984-2016 (1000 tonnes) (Dolgov, WD 14)

Year	Other	Amphipods	Krill	Shrimp	Capelin	Herring	Polar cod	Cod	Haddock	Redfish	G. halibut	Blue whitin	Long rough	Total
1984	560	31	94	352	594	33	17	13	50	195	0	5	52	1998
1985	737	436	30	203	991	25	0	98	34	97	0	18	23	2691
1986	583	877	63	149	808	47	160	28	103	159	1	4	25	3006
1987	472	509	70	202	162	7	105	27	2	118	0	10	6	1690
1988	481	169	211	118	292	19	0	20	93	127	0	0	20	1547
1989	451	290	167	104	680	4	34	34	2	158	0	0	56	1980
1990	286	30	106	274	1261	65	8	21	16	232	0	39	79	2417
1991	298	84	55	288	3292	28	44	52	22	144	6	7	46	4366
1992	791	38	213	263	2028	374	191	84	38	121	1	0	43	4184
1993	568	176	184	222	2786	177	171	147	152	41	5	4	48	4680
1994	450	295	359	467	1296	104	488	387	72	56	0	1	40	4015
1995	519	460	392	545	681	191	199	551	129	112	3	0	53	3834
1996	685	362	975	201	480	77	79	475	61	71	0	9	47	3520
1997	466	133	510	260	523	54	110	386	35	31	2	17	17	2544
1998	297	206	626	265	857	70	129	129	23	15	0	23	19	2659
1999	167	77	449	242	1402	74	164	48	14	13	1	25	9	2684
2000	225	112	422	367	1661	48	157	57	29	4	0	26	21	3128
2001	360	72	397	304	1425	88	140	59	49	4	2	136	31	3066
2002	212	44	280	193	2278	53	278	97	76	4	0	101	17	3632
2003	385	163	548	223	1179	147	208	127	318	2	0	25	49	3373
2004	502	392	491	262	1107	133	374	85	152	7	14	47	59	3624
2005	620	161	692	242	1026	169	314	110	270	7	2	67	47	3727
2006	782	84	1539	270	1333	267	123	96	277	17	1	101	148	5038
2007	825	190	1330	418	1869	278	294	70	331	29	1	32	74	5739
2008	1051	51	1036	361	3414	126	666	162	338	63	13	16	123	7419
2009	1082	194	946	295	3584	217	843	156	381	30	1	8	275	8012
2010	1017	336	1952	284	4389	144	522	196	263	189	1	15	143	9451
2011	1250	219	897	272	5018	85	438	290	374	163	2	54	184	9245
2012	1961	172	654	314	3340	103	463	323	460	45	8	37	147	8026
2013	1512	240	764	386	4409	56	163	514	331	189	3	42	242	8850
2014	1630	146	863	258	4112	67	133	441	203	22	7	36	186	8104
2015	1320	370	1395	565	3314	89	199	214	222	102	16	52	143	8001
2016	1930	725	941	297	3024	108	340	311	219	66	4	70	423	8456

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

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	11.076
2003	0.207	0.653	1.313	2.390	3.999	5.958	8.434	10.430	12.907	13.523	14.569
2004	0.222	0.478	1.307	2.297	3.361	5.583	7.442	11.470	17.415	19.399	18.871
2005	0.203	0.661	1.387	2.744	4.253	6.409	7.671	10.289	13.695	14.656	15.440
2006	0.204	0.628	1.593	2.810	4.252	6.365	7.877	11.631	14.102	15.126	16.056
2007	0.256	0.653	1.748	3.087	4.461	6.222	8.246	10.249	12.705	13.296	13.950
2008	0.204	0.717	1.464	2.876	4.082	7.086	8.398	11.388	15.566	16.105	16.329
2009	0.192	0.618	1.479	2.755	4.446	5.802	8.448	11.564	12.740	13.694	13.743
2010	0.203	0.634	1.352	2.493	3.978	5.699	8.451	12.041	15.387	16.045	16.475
2011	0.219	0.653	1.421	2.594	4.003	5.334	7.274	9.718	15.189	16.346	16.373
2012	0.231	0.768	1.499	2.697	4.084	5.074	7.375	10.224	15.657	16.860	16.851
2013	0.182	0.682	1.457	2.548	3.930	5.031	5.996	7.678	11.780	12.726	13.743
2014	0.224	0.650	1.318	2.566	3.768	4.319	5.861	8.151	11.017	11.857	12.348
2015	0.218	0.674	1.424	2.547	4.262	5.698	7.415	8.612	13.071	13.851	15.068
2016	0.246	0.697	1.551	2.692	3.833	5.417	6.608	7.912	11.661	12.428	14.179

Table 1.6 Consumption per cod by cod age group (kg/year), based on Russian consumption calculations.

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	13.247	14.653	15.272
1985	0.295	0.753	1.658	2.681	4.264	6.599	8.241	9.745	10.974	14.448	17.378	17.339	17.782
1986	0.179	0.526	1.455	3.455	5.001	5.991	6.458	8.157	9.766	11.457	13.230	14.583	15.080
1987	0.145	0.432	0.852	1.558	3.073	4.380	7.357	9.667	12.705	14.481	15.954	16.549	16.579
1988	0.183	0.704	1.075	1.628	2.391	4.386	8.207	9.978	10.868	16.536	14.656	16.026	16.871
1989	0.282	0.909	1.465	2.207	3.243	4.798	6.578	8.725	11.134	15.798	16.335	18.412	17.903
1990	0.288	1.006	1.694	2.693	3.278	3.833	5.583	6.870	10.715	11.426	13.610	15.896	16.407
1991	0.241	0.936	2.670	4.472	6.037	7.844	9.590	11.543	14.969	19.292	18.657	21.653	22.236
1992	0.178	0.969	2.475	2.866	3.995	5.137	6.723	7.414	8.755	12.303	14.335	15.131	15.171
1993	0.133	0.476	1.512	2.865	3.944	5.108	7.372	8.945	10.343	11.600	14.882	16.494	16.625
1994	0.180	0.512	1.212	2.402	3.517	5.359	7.560	10.001	11.818	12.896	14.557	17.591	17.529
1995	0.194	0.497	0.962	1.801	3.204	4.847	7.332	9.688	13.835	15.247	16.960	19.204	20.005
1996	0.170	0.498	1.028	1.916	3.059	4.189	6.987	10.212	12.185	13.614	14.581	16.214	16.876
1997	0.119	0.341	0.992	1.908	2.668	3.503	4.954	7.980	12.174	16.762	16.766	18.352	19.155
1998	0.232	0.528	1.081	2.016	2.823	4.089	5.469	7.346	9.586	13.012	14.455	15.579	16.201
1999	0.261	0.431	1.128	2.490	3.676	5.222	6.398	8.220	9.194	13.364	15.325	16.918	17.567
2000	0.186	0.545	1.288	2.551	4.387	6.559	8.833	10.483	11.522	15.132	17.155	19.717	20.514
2001	0.150	0.413	1.163	2.110	3.430	5.571	6.835	10.233	12.457	15.130	17.374	19.322	20.559
2002	0.252	0.677	1.303	2.699	3.847	5.591	7.846	10.796	13.238	18.787	17.902	20.202	21.027
2003	0.228	0.618	1.296	2.028	3.547	4.716	6.684	8.905	13.418	14.492	19.540	19.239	20.036
2004	0.250	0.654	1.412	2.567	3.857	5.660	7.730	11.126	15.907	20.770	21.687	24.852	25.892
2005	0.255	0.687	1.514	2.504	3.896	5.264	7.192	9.395	13.163	15.981	20.699	21.355	24.181
2006	0.354	0.925	1.881	2.813	4.019	5.332	7.450	10.328	13.111	17.759	19.562	22.234	23.126
2007	0.234	0.681	1.874	3.128	4.459	5.893	7.563	9.178	12.032	15.919	20.031	21.561	22.427
2008	0.223	0.719	1.697	2.959	4.194	6.073	7.809	10.464	13.627	17.254	21.662	23.295	24.295
2009	0.217	0.624	1.495	2.526	4.304	5.623	7.855	11.490	13.341	15.988	18.841	21.786	22.687
2010	0.235	0.651	1.401	2.577	4.065	5.757	8.312	11.805	16.090	16.844	20.203	22.939	23.891
2011	0.248	0.721	1.497	2.513	3.859	4.963	6.848	9.213	13.799	19.074	20.858	23.712	24.731
2012	0.207	0.588	1.203	2.292	3.266	4.461	5.862	7.629	11.713	16.211	19.728	20.953	21.810
2013	0.190	0.656	1.641	2.552	3.809	4.952	5.791	7.757	10.881	14.989	19.855	22.631	23.280
2014	0.242	0.622	1.321	2.340	3.608	4.387	5.560	7.447	9.017	12.547	16.109	18.773	19.488
2015	0.234	0.746	1.398	2.454	3.960	4.962	5.956	7.441	10.207	12.194	16.288	19.896	20.674
2016	0.307	0.849	1.670	2.819	3.505	4.755	6.614	8.936	10.501	14.668	20.169	24.111	25.130
Average	**0.219**	**0.652**	**1.451**	**2.518**	**3.765**	**5.240**	**7.147**	**9.395**	**12.130**	**15.324**	**17.334**	**19.146**	**19.857**

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

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	0.0593	0.0143	0.0187	0.0284	0.0356	0.0620	0.1581	0.1562	0.1551
2003	0.0000	0.0190	0.0198	0.0199	0.0206	0.0188	0.0457	0.1037	0.2212	0.2231	0.2245
2004	0.0081	0.0234	0.0280	0.0269	0.0297	0.0319	0.0380	0.0658	0.1061	0.1065	0.1076
2005	0.0000	0.0266	0.0230	0.0265	0.0145	0.0278	0.0439	0.0789	0.1501	0.1489	0.1465
2006	0.0000	0.0103	0.0007	0.0128	0.0288	0.0158	0.0391	0.0368	0.0804	0.0808	0.0804
2007	0.0000	0.0000	0.0011	0.0117	0.0119	0.0305	0.0282	0.0900	0.1405	0.1399	0.1394
2008	0.0000	0.0558	0.0256	0.0101	0.0157	0.0098	0.0767	0.0873	0.0965	0.0958	0.0960
2009	0.0116	0.0225	0.0262	0.0251	0.0152	0.0140	0.0219	0.0946	0.1080	0.1080	0.1078
2010	0.0000	0.0326	0.0580	0.0270	0.0243	0.0243	0.0205	0.0385	0.1366	0.1368	0.1357
2011	0.0129	0.0151	0.0491	0.0170	0.0361	0.0300	0.0237	0.0568	0.1278	0.1278	0.1278
2012	0.0275	0.0605	0.0640	0.0617	0.0274	0.0431	0.0410	0.0367	0.0673	0.0677	0.0670
2013	0.0215	0.0303	0.0457	0.0387	0.0275	0.0225	0.0475	0.0530	0.1141	0.1148	0.1311
2014	0.0805	0.0357	0.0445	0.0339	0.0213	0.0454	0.0659	0.0774	0.0638	0.0639	0.0731
2015	0.0000	0.0088	0.0309	0.0282	0.0267	0.0192	0.0233	0.0282	0.0553	0.0556	0.0555
2016	0.0150	0.0196	0.0061	0.0396	0.0146	0.0171	0.0260	0.0139	0.0913	0.0926	0.0938
Average	**0.0056**	**0.0236**	**0.0331**	**0.0298**	**0.0326**	**0.0436**	**0.0595**	**0.0780**	**0.1308**	**0.1308**	**0.1313**

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

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	0.0243	0.0191	0.0244	0.0159	0.0125	0.0175	0.0588	0.0593	0.0585
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	0.0744	0.0762	0.1827	0.1796	0.1779
2003	0.0000	0.0000	0.0145	0.0311	0.0594	0.0435	0.0552	0.1215	0.1078	0.1078	0.1077
2004	0.0044	0.0418	0.0744	0.0389	0.0576	0.0501	0.0565	0.0999	0.0910	0.0913	0.0923
2005	0.0000	0.0853	0.1047	0.0596	0.0621	0.0642	0.1043	0.1090	0.1128	0.1121	0.1105
2006	0.0000	0.0409	0.0829	0.0871	0.0604	0.0897	0.0717	0.1065	0.0965	0.0963	0.0965
2007	0.0000	0.0035	0.0463	0.0417	0.0833	0.0982	0.1335	0.1153	0.1632	0.1637	0.1640
2008	0.0000	0.0045	0.0106	0.0156	0.0383	0.0752	0.1150	0.1328	0.2340	0.2348	0.2346
2009	0.0000	0.0218	0.0241	0.0182	0.0142	0.0363	0.1085	0.0597	0.1864	0.1864	0.1873
2010	0.0000	0.0031	0.0278	0.0181	0.0178	0.0216	0.0359	0.1424	0.1819	0.1806	0.1809
2011	0.0000	0.0049	0.0361	0.0284	0.0087	0.0205	0.0406	0.0912	0.1642	0.1642	0.1636
2012	0.0000	0.0000	0.0113	0.0282	0.0338	0.0273	0.0365	0.0329	0.0845	0.0837	0.0854
2013	0.0000	0.0073	0.0308	0.0111	0.0314	0.0233	0.0147	0.0358	0.0599	0.0599	0.0879
2014	0.0000	0.0088	0.0038	0.0255	0.0080	0.0046	0.0021	0.0331	0.0138	0.0138	0.0181
2015	0.0000	0.0172	0.0403	0.0253	0.0169	0.0166	0.0258	0.0196	0.0385	0.0383	0.0391
2016	0.0000	0.0052	0.0786	0.0775	0.0264	0.0255	0.0347	0.0419	0.0337	0.0338	0.0337
Average	**0.0021**	**0.0107**	**0.0240**	**0.0267**	**0.0243**	**0.0276**	**0.0370**	**0.0510**	**0.0716**	**0.0718**	**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).

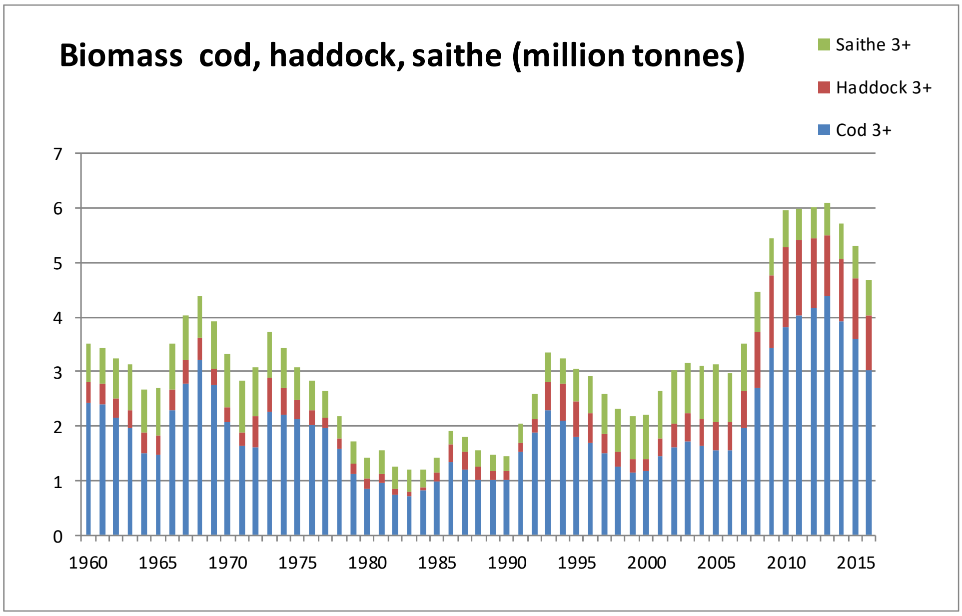
Model	Prognostic years (counting this year's assessment as first year	Updated	2016 Prognoses	2017 Prognoses	2018 Prognoses	2019 prognoses
Titov0		At assessment	540			
Titov1	2	At assessment	564	NA**		
Titov2	2	At assessment	536*	NA**		
Titov3	3	At assessment	544*	714*	NA**	
Titov4	4	At assesment	521	675*	572*	388
TB (1984-2000)	3	not updated				
TB (1984-2004)	3	not updated				
JES1	2	not updated				
JES2	2	not updated				
JES3	1	not updated				
H1	2	not updated				
H2	2	not updated				
RCT3	3	At assessment	605*	325*	505*	
Hybrid model (Assessment 2017)		At assessment	566	607	543	

*** Models that are used in the Hybrid model at this year**

****no survey conducted in 2016**

Table 1.9b. Related weights to the models used in the hybrid model (indicated by * in Table 1.9a)

MODEL	MODEL WEIGHT 2017	MODEL WEIGHT 2018	MODEL WEIGHT 2019
T1			
T2			
T3	0.639	0.43	
T4		0.326	0.573
RCT3	0.361	0.244	0.427



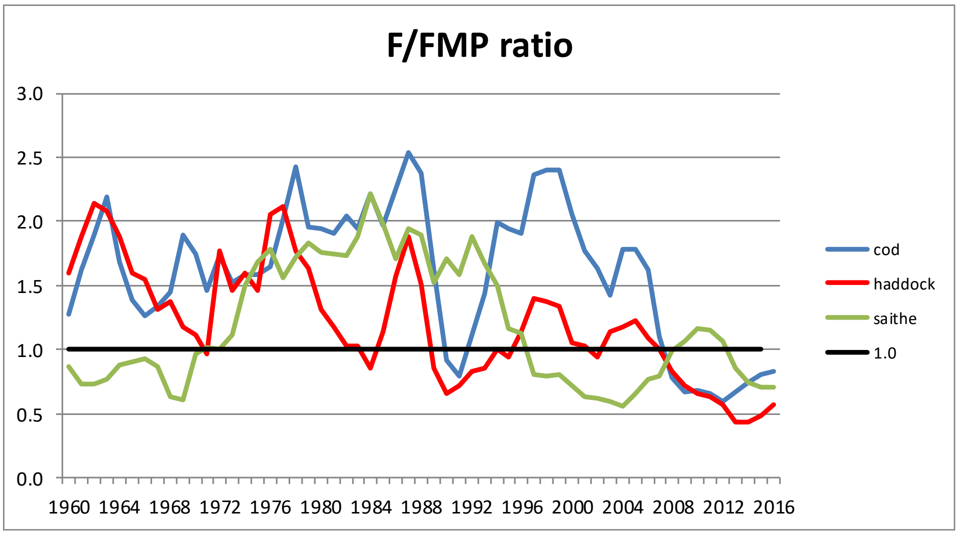


Figure 1.2. Annual fishing mortalities of the Northeast Arctic cod, haddock and saithe stocks relative to F_{MP}, i.e., the level used in the management plans for these stocks when SSB > B_{pa}. For cod F_{MP} is not well-defined, as there is a two-step HCR. In this figure the lower plateau (F=0.40) 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)

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. The corresponding catches in tonnes are presented in Table 3.1. 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). Thus further analysis is still required. Since the new catch-at-age series is not completed yet the assessment is based on the old catch estimation method. The remaining catch analysis should be completed and an inter-benchmark process or a new benchmark should be set up.

2.1 Stock status summary

SSB observed in the survey declined considerably in the late 90-ies and has remained low since then. The same pattern is seen in the recruitment. Fishing pressure (F) increased in 2015 and 2016, after a declining trend over the period 2000-2014. The abundance indices from the coastal surveys in autumn 2013 and 2014 showed some increase compared to previous years. The 2015 and 2016 survey showed a decline to a level similar to those in the 2002–2012 period

2.2 Fisheries

Coastal cod is fished throughout the year and within nearly all the distribution area (inside the 12 n.mile zone in the Norwegian statistical areas 03, 04, 05, 00, 06, 07, Figures 2.1–2.3). The main fishery for coastal cod 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 2010-2014 the average % share between gear types in the estimated coastal cod commercial landings was around 49% for gillnet, 23% for Danish seine, 26% for longline/handline and 2% for bottom trawl. In 2015, there was some increase for Danish seine (34%) and decrease for gillnet (40%).

Similar percentages by gear was observed in 2016; 41% for gillnet, 32% for Danish seine, 25% for longline/handline and 2% for bottom trawl.

Recreational fisheries take an important fraction of the 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)

Traditional calculation method:

The commercial catches of Norwegian Coastal cod (NCC) have been calculated back to 1984 (Table 2.1a). For this period, the estimated landings have been between 22 000 and 75 000 t. The commercial landings of NCC in 2016 are estimated to 44 610 t (Table 2.1a, Figure 2.3). This is the highest catch estimate since 1999. Table 2.1b shows the estimated catch by gears, area and quarters in 2016.

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.

The basis for estimating coastal cod catches is the total landings of cod inside the 12-n. mile zone 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. Tables 2.2a, b show the sampling of the cod fishery by quarters and areas in 2016 and 2015. The sampling level in 2016 was similar to 2015, but in some important areas a large fraction of the quarter 1 samples was taken in January. Since the NEA cod spawners did not arrive into these areas before February, the analysis for January had to be done separately from the rest of quarter 1. Table 2.3 compares the number of fish sampled by quarters for the period 1985–2016. Within the 12-nautical mile the total number of age samples in 2016 was 300. A total of 14615 fish were aged. 5655 of these otoliths were classified as coastal cod. (Table 2.2a, b). This is the highest number of coastal cod otoliths observed in the time series and represents 39% of all cod otoliths sampled within the coastal cod area.

The Norwegian sampling program was changed in 2010. This lead to poor sampling in that year. The sampling in later years has gradually improved, and the sampling level is now like the level prior to 2010 (Table 2.3). Still there are too few samples in quarter 3 (Table 2.2b).

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 2015 and 2016. The total cod catch in quarter 1 was considerably larger in 2016.The corresponding fractions of coastal cod in cod catches are also shown.

New calculation method considered at benchmark:

The ECA-model (Hirst *et al*. 2012) has been extended to use the information from otolith typing to estimate catch-at-age for both stocks within the same model, also providing measures of uncertainty. The model also estimates numbers at length with measures of uncertainty. The user specifies the grouping of samples (number of area groups, gear groups and season groups). Based on the data within each group the model generates probability distributions based on bootstrapping and tabulates the mean values and the specified percentiles (like 5 and 95). An example of model outputs is shown in Figures 2.5.1a and b. When doing the analysis on mixed samples of NEA cod and coastal cod in coastal areas, the area grouping and season grouping was considered more critical than the grouping on gears. For this purpose 6 coastal area groups were defined (Figure 2.5c), 4 seasons and 3 gear groups (gillnet, bottom trawl and others). Others includes Danish seine, longline and handline. In years with less complete sampling 2 season groups were used. The analyses of NEA cod outside the coastal cod area are usually done with 3 area groups, 4 seasons and 5 gear groups.

A new time-series of catch-at-age produced by this model was presented to the WKARCT. The internal consistency was considered reasonable (Figure 2.5d). The data were accepted as relevant information for describing the stock dynamics. The reasons for the differences between the old and new series (Figure 2.5e) are not clear and needs to be further explored. The largest discrepancy between the new and old time-series (Figure 2.5f) are for the areas 401 and 501 (Figure 2.5c), that are merged in the ECA analysis. A better geographical resolution will possibly improve the ECA analysis. A part of the observed differences could be related to catches not specified by area in the early part of the time-series. Further analyses are required before replacing the traditional catch-at-age series with the ECA-results.

The ECA-estimate of coastal cod in 2015 is somewhat lower than the traditional estimate. For the period 2003-2014 the ECA estimates are consistently above the traditional (Fig 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. 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.

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 the new regulations "fjord-lines" are drawn along the coast to close the fjords for direct cod fishing with vessels larger than 15 meters. A box closed to all fishing gears except handline and fishing rod is 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.

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 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.

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 northeast Arctic cod is higher.

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</u>: Since the spawning biomass index in the 2011 autumn survey was higher than the 2010 value, the rebuilding plan in operation, 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 regulations for the closed spawning area near Henningsvær-Svolvær were in 2012 relaxed by allowing vessels less than 11m to fish. This was continued in 2013–2016. 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 quite low.

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 long line 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.

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 2.5–2.14, Figures 2.6–2.12)

The results of the 2016 survey (Mehl *et al.* 2016) 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 estimate of total biomass (Table 2.9) is slightly higher than the 2015 estimate. The uncertainty of the survey estimates is considered to be 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 2287 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 2.13a)

Table 2.8 and Figure 2.13a 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 the 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 Assessment

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

The estimated commercial catch-at-age (2–10+) for the period 1984–2016 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. Before the 2010 assessment a warning about errors in the SURBA software was received, and the program was not used.

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 F2009 (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 Fs for the years 1996–2007 (Figure 2.15). This regression was used for converting the 2014 survey mortality to a VPA F(4–7) (Table 2.16). A selection pattern for 2014 was estimated as the average pattern over the years 2013—2015 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 2015 combined with the selection pattern and oldest true Fs 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 2016 survey estimate of spawning biomass (20.6 kt) is above the 2015 survey estimate, but just marginally above the 2002-2015-average (19.0 kt, Tables 2.9 and 2.11, Figure 2.17). The survey based estimate of the F_{2016} is 0.30, both when relating to commercial catch and when relating to total catch data. The text table below compares those with corresponding values earlier years. The table also compares the SSB-results of SVPA-runs aimed at those Fs used as terminal Fs. The high catch in 2015 and 2016 has in the current assessment caused some upward stock revision for the recent years.

A corresponding downward revision of F is observed, in particular for 2013 and 2014.

	Ass Yr	F 08	F 09	F 10	F 11	F 12	F 13	F 14	F 15	F 16	SSB 08	SSB 09	SSB 10	SSB 11	SSB 12	SSB 13	SSB 14	SSB 15	SSB 16
Com	**10**	0.32	0.37								48	46							
catch	**11**	0.32	0.38	0.38							56	50	44						
	12	0.27	0.28	0.26	0.33						61	59	58	70					
	13	0.27	0.29	0.23	0.33	0.37					61	60	60	68	66				
	14	0.27	0.31	0.26	0.34	0.36	0.27				61	59	58	64	59	51			
	15	0.27	0.31	0.27	0.36	0.37	0.29	0.27			61	59	57	63	57	47	49		

	16	0.26	0.29	0.25	0.32	0.29	0.21	0.19	0.35		66	63	62	69	67	61	70	75	
	17	0.25	0.28	0.24	0.30	0.26	0.18	0.15	0.25	0.30	68	66	65	73	73	70	84	99	100
Total	10	0.27	0.31								85	80							
catch	11	0.30	0.37	0.37							82	77	73						
	12	0.26	0.29	0.26	0.31						88	88	88	106					
	13	0.26	0.29	0.24	0.33	0.35					89	91	93	103	99				
	14	0.27	0.32	0.28	0.33	0.33	0.27				86	86	87	94	88	80			
	15	0.27	0.31	0.27	0.34	0.33	0.29	0.27			89	88	89	95	87	75	81		
	16	0.26	0.30	0.26	0.31	0.28	0.23	0.21	0.33		93	93	94	103	99	91	101	105	
	17	0.25	0.30	0.25	0.30	0.25	0.19	0.17	0.25	0.30	95	95	97	107	107	101	118	135	132

Some further comparisons are shown in Figures 2.16. The recruitment estimate for the final year is highly uncertain in all assessments. Figure 2.17 shows the SSB-series from VPA and survey, both scaled to their average over the years 1995–2016. Figure 2.18 compares the various time-series of F. The Fs show reasonable agreement.

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 90-ies.

2.6.3 Catches in 2017

No catch predictions have been made. By the end of the winter/ spring fishery in 2017 the remaining Coastal cod + NEA cod quota for the autumn 2017 fishery is similar to what it was in 2015 and 2016. The abundance of Northeast arctic cod in coastal areas were somewhat lower than in the previous five years.

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 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 (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 the 2015 and 2016 estimates are considerably higher. For most years since 2004 the regulations seem to have reduced the catches compared to pre-2004 level but have not been sufficient to cause persistent further reductions. The high catch in 2015 and 2016 seems to be mainly caused by high catches in January in southern Troms and northern Nordland (Fig 1.16), where coastal cod where feeding on aggregations of herring. This fishery occurred befor the NEAcod spawning migration reached those areas. Such concentrations of coastal cod were in 2015 rather unexpected, and illustrate 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%) after 2004 compared to before.

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 F2009	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.

The VPA analysis presented indicate some reduction of F over the period 1999-2014, followed by increased F in 2015 and 2016. This development of F seems to be largely caused by the large but uncertain catch estimates for 2015 and 2016.

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 tons[1]. Importantly, this rebuilding target will be redefined on the basis of relevant scientific information. Such information could, for instance, include a

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

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 the 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 at 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.

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.

[2] Ages 4-7

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	829	3478	6954	7278	6004	4964	2161	819	624	74824
1985	396	7848	7367	8699	7085	3066	705	433	264	75451
1986	4095	4095	12662	8906	5750	3868	1270	342	407	68905
1987	170	940	8236	12430	4427	2649	1127	313	149	60972
1988	110	1921	3343	6451	6626	4687	1461	497	333	59294
1989	41	1159	1434	2299	5197	2720	949	236	86	40285
1990	7	349	1233	1330	1129	3456	773	141	73	28127
1991	125	607	1452	3114	1873	1297	873	132	94	24822
1992	40	665	3160	4422	2992	1945	898	837	279	41690
1993	4	369	1706	2343	2684	3072	1871	627	690	52557
1994	332	573	1693	4302	2467	3337	1514	777	798	54562
1995	810	896	2345	5188	5546	3270	1455	557	433	57207
1996	1193	2376	2480	4930	4647	4160	2082	898	543	61776
1997	1326	3438	3150	2258	2490	3935	3312	959	684	63319
1998	554	2819	4786	4023	2272	1546	1826	975	343	51572
1999	252	1322	2346	4263	2773	1602	751	774	320	40732
2000	156	971	3664	3807	2671	1104	326	132	152	36715
2001	44	505	1837	2974	1998	1409	542	187	119	29699
2002	192	893	2331	2822	2742	1538	915	325	377	40994
2003	81	1107	2094	2506	2158	1374	598	258	99	34635
2004	12	306	924	1713	1820	1444	609	226	264	24547
2005	15	474	1299	1828	1436	1115	513	188	143	22432
2006	71	315	1656	1695	1695	1246	671	326	224	26134
2007	88	515	1396	1846	1252	824	391	256	196	23841
2008	92	670	1438	1635	1232	862	440	215	170	25777
2009	3	238	1052	1280	1388	1065	545	172	276	24821
2010	14	710	1617	1895	1040	703	420	198	175	22925
2011	30	632	1907	1777	1526	1133	487	230	315	28594
2012	22	445	1079	1478	1734	1267	587	338	456	31907
2013	90	539	1614	1232	1152	673	503	245	217	22464
2014	23	817	1233	1639	1005	669	427	366	191	23169
2015	220	938	1748	1844	2100	1431	754	483	677	39455
2016	299	1612	1777	2075	1799	1848	933	531	706	44610

Table 2.1b. Estimated commercial catch of coastal cod in 2016 by gear and area (t).

Year		2016				
Area	03	04	00	05	06/07	Total
Gillnet	1552	3508	4956	5 015	3 330	18361
L.line/Jig	4 524	2275	1859	1519	961	11139
Danish seine	3526	6312	1679	2496	281	14294
Trawl	430	293	0	88	5	816
Total	10032	12388	8495	9118	4577	44610

Table 2.1c. 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	88124
1985	3558	10438	9733	10444	7732	3291	835	512	264	88851
1986	4722	7128	15330	10565	6889	4303	1521	481	407	82405
1987	278	2912	12244	14611	5076	3080	1236	351	149	74472
1988	744	3328	4910	8159	8714	5237	1590	591	333	72894
1989	459	1984	2917	4057	6610	3238	1057	270	86	53985
1990	408	1843	2485	2012	3838	3906	846	141	73	42627
1991	1308	3305	4448	4456	2681	1880	977	203	94	40122
1992	469	1946	5509	5913	3622	2459	1744	921	279	57790
1993	51	1645	2994	3156	3530	3768	2073	995	690	67357
1994	389	1274	3416	5017	3755	4008	1907	901	798	69262
1995	818	1228	3149	6639	7131	4050	1868	737	433	71907
1996	1214	2967	2989	5547	6144	5533	2543	1125	543	76276
1997	1377	4145	4173	3021	3225	5124	4000	1091	684	77819
1998	803	3956	7113	5339	2857	1956	2155	1230	343	66172
1999	301	1788	3791	6202	3693	1959	949	995	320	54632
2000	219	1525	4817	5322	3715	1448	453	241	152	50315
2001	44	848	2572	4020	2962	2282	740	321	119	43099
2002	248	1191	3161	3877	3681	2134	1250	490	377	54594
2003	166	1449	2758	3422	3076	1824	842	584	99	48535
2004	38	560	1407	2637	2919	2271	967	388	264	37947
2005	36	744	1957	2686	2289	1830	936	364	143	35632
2006	90	551	2672	2562	2678	1858	986	453	224	39134
2007	137	861	2155	2805	1858	1355	718	413	196	36841
2008	107	1065	2181	2473	1882	1262	701	349	170	38577
2009	3	322	1628	2007	2251	1665	825	262	276	37521
2010	21	1103	2512	2945	1616	1092	652	308	272	35625
2011	43	912	2754	2566	2203	1636	704	333	455	41294
2012	30	622	1509	2066	2425	1771	821	472	638	44607
2013	140	843	2526	1928	1803	1054	788	384	340	35164

2014	36	1265	1908	2537	1556	1036	662	567	296	35869
2015	291	1240	2311	2438	2777	1892	997	638	895	52155
2016	384	2071	2283	2666	2311	2374	1198	682	906	57310

Table 2.1d. 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
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

Table 2.2a. Sampling from cod fisheries in 2016 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 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 2.2b. Sampling from cod fisheries in 2015 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 2015 Quarter	03	04	00	05	06+07	Tot
1	10	20	29	16	52	127
2	13	11	11	13	29	77
3	7	0	0	5	10	22
4	8	2	50	7	7	74
Total samples	38	33	90	41	98	300
Total otoliths	2496	2824	3950	2684	2358	14492
Coastal cod type otoliths	306	122	277	351	1146	2202

Table 2.3 Number of otoliths sampled by quarter from commercial catches in the period 1985-2016. Cc=coastal cod, NEAc=northeast Arctic cod.

	Quart	1	Quart	2	Quart	3	Quart	4		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
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

Table 2.4. Landings in tonnes of cod (CC+NEAC) within the 12 nautical mile by area and quarter 2015-2016 (upper 2 tables). Landings of coastal cod within 12 nautical mile by area and quarter 205-2016 (middle 2 tables). Proportion coastal cod in landings within 12 nautical miles by area and quarter 2015-2016 (lower 2 tables).

2016		CC+	NEAC					2015		CC+	NEAC			
Q/Area	03	04	00	05	06-07	Total		Q/Area	03	04	00	05	06-07	Total
1	17512	42048	42800	96200	5092	203654		1	9370	31027	39716	49763	4284	134161
2	21977	27919	7460	14138	1262	72756		2	17501	21721	16364	7157	1064	63807
3	3289	2331	324	1036	497	7476		3	3372	1730	464	504	412	6482
4	11125	3128	166	1260	316	15994		4	4491	1939	143	1343	268	8183
Total	53903	75426	50749	112634	7167	299880		Total	34733	56416	56688	58767	6029	212633
2016		CC						2015		CC				
Q/Area	03	04	00	05	06-07	Total		Q/Area	03	04	00	05	06-07	Total
1	3490	8601	7940	7697	3762	31491		1	1516	3630	2146	8729	3201	19222
2	1072	530	146	117	221	2088		2	3363	2303	2294	612	926	9499
3	1051	1638	270	501	327	3790		3	1698	1469	457	504	403	4531
4	4419	1620	139	803	267	7253		4	2816	1679	124	1314	268	6201
Total	10032	12388	8495	9118	4577	44610		Total	9393	9082	5022	11159	4798	39455
2016		Fr.	CC					2015		Fr.	CC			
Q/Area	03	04	00	05	06-07	Total		Q/Area	03	04	00	05	06-07	Total
1	0.20	0.20	0.19	0.08	0.74	0.15		1	0.16	0.12	0.05	0.18	0.75	0.14
2	0.05	0.02	0.02	0.01	0.17	0.03		2	0.19	0.11	0.14	0.09	0.87	0.15
3	0.32	0.70	0.83	0.48	0.66	0.51		3	0.50	0.85	0.98	1.00	0.98	0.70
4	0.40	0.52	0.84	0.64	0.85	0.45		4	0.63	0.87	0.87	0.98	1.00	0.76
Total	0.19	0.16	0.17	0.08	0.64	0.15		Total	0.27	0.16	0.09	0.19	0.80	0.19

Table 2.5. Coastal cod. Acoustic abundance indices by subareas and in total in 2016 (in thousands). Age 1 is not split between coastal cod and NEA cod.

	Age (Year class)										
Area	1 (15)	2 (14)	3 (13)	4 (12)	5 (11)	6 (10)	7 (09)	8 (08)	9 (07)	10+ (06+)	Sum
03	2360	1967	1309	967	556	179	175	91	58	106	7767
04	1806	1677	1955	946	689	350	325	268	69	122	8208
05	459	136	520	1022	699	550	174	471	15	121	4167
00	49		41	475	783	203	241	33	6	3	1834
06	177	434	722	62	162	138	86	41	22	10	1855
07	6		303	289	220	36	21	51	15	111	1050
Total	4857	4214	4850	3760	3108	1455	1022	955	187	474	24881

Table 2.6. Coastal cod. Acoustic abundance indices by age 1995–2016 (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
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

Table 2.7. Coastal cod. Mean length (cm) at age 1995–2016.

	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

Table 2.8. Coastal cod. Mean weight (grammes) at age 1995–2016.

	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

Table 2.9. Coastal cod. Acoustic biomass indices (tonnes) in 1995–2016. 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

Table 2.10. Coastal cod. Maturity-at-age as determined from maturity stages observed in the surveys over the period 1995 – 2016. Age 1 is not split between coastal cod and NEA cod.

						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

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

	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	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

Table 2.12. Proportion coastal cod among sampled cod during the coastal survey by age and statistical areas in the years 2005–2015. 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	
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
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

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

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	6.980	9.723
1985	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.980	9.723
1986	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.980	9.723
1987	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.980	9.723
1988	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.980	9.723
1989	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.980	9.723
1990	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.980	9.723
1991	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.980	9.723
1992	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.980	9.723
1993	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.980	9.723
1994	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.980	9.723

1995	0.298	0.700	1.338	1.973	2.649	4.164	7.051	6.413	14.326
1996	0.270	0.717	1.435	2.044	2.694	4.817	6.280	11.365	15.670
1997	0.232	0.677	1.363	1.903	2.816	3.833	5.849	9.600	13.037
1998	0.323	0.834	1.366	2.075	3.013	4.255	5.305	8.350	18.016
1999	0.318	0.804	1.559	2.042	2.798	4.678	7.151	8.959	18.340
2000	0.346	0.777	1.458	2.296	2.735	4.048	7.011	9.224	12.277
2001	0.347	0.878	1.543	2.213	2.862	3.321	4.849	7.339	11.542
2002	0.430	0.880	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	3.290	4.124	4.718	4.976	6.358
2005	0.407	0.846	1.748	2.200	2.693	3.817	3.797	5.344	14.829
2006	0.490	1.125	1.812	2.559	3.579	3.964	4.822	7.332	14.650
2007	0.518	1.185	2.011	2.500	3.160	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	5.400	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	6.570
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	7.670
2014	0.423	1.071	1.845	2.886	3.905	4.495	5.249	5.871	8.762
2015	0.370	1.045	1.940	2.910	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

CWT	2	3	4	5	6	7	8	9	10+
1984	0.248	0.619	1.149	1.734	2.325	3.486	4.845	5.608	8.84
1985	0.214	0.712	1.415	2.036	2.737	4.012	6.116	6.46	10.755
1986	0.227	0.525	1.08	1.706	2.256	3.353	4.838	5.838	7.053
1987	0.331	0.673	1.12	1.693	2.359	3.743	5.326	6.129	11.623
1988	0.246	0.634	1.17	1.727	2.328	3.256	4.7	5.45	8.202
1989	0.3	0.661	1.836	2.17	2.448	4.391	4.899	6.661	11.608
1990	0.345	1.174	1.515	1.678	2.708	3.898	6.515	7.299	13.924
1991	0.164	0.922	1.608	2.108	2.507	3.469	4.976	5.734	11.059
1992	0.168	0.556	1.359	2.267	2.957	3.903	5.317	4.558	7.032
1993	0.241	0.645	1.71	2.591	3.588	4.366	5.899	6.494	7.509
1994	0.254	0.805	1.476	2.097	3.287	4.095	5.592	7.217	8.331
1995	0.302	0.71	1.335	1.842	2.467	4.191	5.778	6.376	9.903
1996	0.274	0.921	1.464	1.979	2.516	3.461	4.866	5.391	8.854
1997	0.277	0.97	1.554	1.97	2.897	3.716	4.829	6.349	9.267
1998	0.376	0.978	1.518	2.281	3.125	3.9	5.52	6.333	9.337
1999	0.467	1.155	1.633	2.171	3.249	4.095	5.013	6.018	6.255
2000	0.515	1.305	2.272	2.555	3.283	4.504	5.4	6.379	6.42
2001	0.164	0.952	1.637	2.881	3.424	4.038	5.397	7.208	6.881
2002	0.491	1.179	1.8	2.485	3.86	4.76	5.195	5.507	9.183
2003	0.944	1.552	2.146	3.082	3.594	4.953	5.736	6.477	9.686
2004	0.824	1.374	1.877	2.679	3.365	4.013	4.847	5.554	6.343
2005	0.82	1.317	2.094	2.795	3.493	4.087	4.836	6.264	5.115
2006	1.274	1.599	1.894	2.687	3.562	4.029	5.182	5.905	6.213

2007	1.241	1.744	2.143	2.718	4.098	4.884	5.939	6.89	8.098
2008	0.977	1.882	2.444	3.747	4.165	4.989	5.992	6.143	8.229
2009	1.219	1.47	2.348	3.331	4.251	4.824	5.807	6.776	8.571
2010	0.813	1.576	2.344	3.114	4	5.025	4.911	5.873	6.809
2011	0.575	1.5	2.238	3.165	4.05	4.878	5.533	5.898	6.277
2012	0.727	1.518	2.267	3.415	4.287	5.029	5.781	7.968	8.404
2013	1.018	1.596	2.228	3.02	4.071	4.931	5.645	6.143	8.499
2014	0.86	1.496	2.632	3.229	4.162	5.029	5.424	6.193	6.569
2015	0.435	1.326	2.246	3.193	3.985	4.987	5.953	6.418	7.677
2016	0.437	1.424	2.201	3.268	4.208	5.027	6.058	6.841	7.583

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
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
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
2016	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.

Lowestoft VPA Version 3.1

20/04/2017 14:19

Extended Survivors Analysis

Norwegian Coastal Cod COMBSEX PLUSGROUP

CPUE data from file coast-9.txt

Catch data for 33 years. 1984 to 2016. Ages 2 to 10.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
Norw. Coast. survey	1995	2016	0	8	0.75	0.85

Time series weights :

Tapered time weighting applied

Power = 3 over 20 years

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 >= 8

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 200 iterations

Total absolute residual between iterations

199 and 200 = .00079

Final year F values

Age	2	3	4	5	6	7	8	9
Iteration **	0.0155	0.1	0.1431	0.2758	0.5159	0.6434	0.4701	0.5786
Iteration **	0.0155	0.1	0.143	0.2758	0.5158	0.6432	0.47	0.5783

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.02
3	0.04	0.04	0.02	0.05	0.04	0.03	0.04	0.05	0.06	0.10
4	0.15	0.16	0.09	0.14	0.18	0.09	0.12	0.13	0.15	0.14
5	0.28	0.26	0.21	0.22	0.23	0.21	0.15	0.18	0.29	0.28
6	0.26	0.31	0.37	0.27	0.28	0.36	0.25	0.17	0.37	0.52
7	0.35	0.29	0.47	0.32	0.53	0.40	0.23	0.22	0.39	0.64
8	0.22	0.32	0.30	0.35	0.38	0.59	0.27	0.23	0.41	0.47
9	0.37	0.18	0.20	0.17	0.32	0.50	0.52	0.32	0.44	0.58

XSA population numbers (Thousands)

	AGE							
YEAR	2	3	4	5	6	7	8	9
2007	21900	13500	11200	8360	6010	3080	2190	912
2008	20700	17900	10600	7930	5170	3790	1780	1440
2009	20100	16800	14000	7350	5020	3120	2320	1060
2010	21000	16500	13600	10500	4860	2850	1590	1410
2011	23500	17200	12800	9640	6900	3040	1700	923
2012	17500	19200	13500	8780	6280	4270	1460	950
2013	21400	14300	15300	10100	5850	3580	2350	664
2014	23300	17500	11200	11100	7140	3750	2320	1470
2015	23100	19000	13600	8060	7580	4940	2470	1510
2016	21500	18700	14700	9510	4930	4310	2750	1340

Estimated population abundance at 1st Jan 2017

0	17300	13900	10500	5910	2410	1850	1410

Taper weighted geometric mean of the VPA populations:

20700	16800	13100	9340	6070	3690	2010	1090

Standard error of the weighted Log(VPA populations) :

0.1154	0.1236	0.1299	0.1418	0.1599	0.1639	0.2048	0.2812

Log catchability residuals.

Fleet : Norw. Coast. survey

Age	1995	1996
2	99.99	99.99

3	99.99	99.99
4	99.99	99.99
5	99.99	99.99
6	99.99	99.99
7	99.99	99.99
8	99.99	99.99

Age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
2	0.28	0.2	0.28	0.39	0.22	0.04	-0.1	0.15	-0.04	0.13
3	2.57	1.81	1.45	1.53	1.05	0.14	0.12	0.1	0.09	0.36
4	1.2	0.83	0.68	0.59	0.49	0.18	0	0.22	-0.12	0.14
5	1.38	0.74	0.61	0.82	0.28	0.05	-0.08	-0.11	0.18	0.2
6	1.78	0.59	0.52	0.93	0.19	0.29	0.16	0.07	-0.19	0.45
7	0.59	0.77	0.22	0.41	0.33	0.35	0.22	-0.24	0.17	0.49
8	0.06	-1.11	-0.06	0.24	-0.05	-0.2	0.02	-0.07	-0.05	-0.22

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2	-0.04	-0.15	-0.15	-0.11	-0.11	0.03	-0.03	0.11	0.09	0.08
3	0.44	-0.58	-0.41	-0.35	0.14	-0.39	-0.19	-0.07	-0.04	0.43
4	0.57	-0.01	-0.03	-0.29	0.28	-0.27	-0.2	-0.17	-0.08	-0.09
5	0.28	-0.13	0.1	-0.3	0.01	-0.32	-0.19	0.24	-0.14	0.1
6	0.25	-0.27	0.09	-0.34	0.01	-0.49	0.09	0.08	-0.11	0.13
7	0.48	-0.35	0.43	-0.53	-0.53	-0.38	0.02	0.53	-0.3	0.03
8	0.03	-0.32	0.07	-0.14	-0.06	-0.08	0.24	0.42	-0.17	0.23

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	-1.0054	-0.8355	-0.775	-0.7977	-0.7474
S.E(Log q)	0.2578	0.2277	0.2728	0.4014	0.215

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	0.41	1.84	6.56	0.49	20	0.12	-1.71
3	1.47	-0.452	-2.6	0.08	20	0.43	-1.37

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	1.29	-0.357	-1.41	0.13	20	0.35	-1.01
5	0.77	0.599	2.74	0.4	20	0.18	-0.84
6	0.8	0.474	2.37	0.36	20	0.23	-0.77
7	1.04	-0.049	0.51	0.13	20	0.44	-0.8
8	0.67	1.692	3.01	0.72	20	0.13	-0.75

Fleet disaggregated estimates of survivors :

Age 2 Catchability dependent on age and year class strength

Year class = 2014

Norw. Coast. survey

	Age 2
Survivors	18812
Raw Weights	10.94

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	18812	0.3	0	0	1	0.141	0.014
P shrinkage mean	16824	0.12				0.846	0.016
F shrinkage mean	46147	1				0.013	0.006

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
17316	0.11	0.1	3	0.901	0.016

Age 3 Catchability dependent on age and year class strength

Year class = 2013

Norw. Coast. survey

	Age 3	2
Survivors	21330	15103
Raw Weights	3.963	9.944

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	16664	0.254	0.156	0.61	2	0.187	0.084
P shrinkage mean	13145	0.13				0.799	0.105
F shrinkage mean	25946	1				0.013	0.055

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
13869	0.11	0.13	4	1.147	0.1

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

Year class = 2012

Norw. Coast. survey

Age 4	3	2	
Survivors	9594	10055	11655
Raw Weights	9.63	4.042	9.069

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	10455	0.192	0.064	0.33	3	0.958	0.143
F shrinkage mean	10521	1				0.042	0.142

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
10458	0.19	0.05	4	0.27	0.143

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

Year class = 2011

Norw. Coast. survey

Age 5	4	3	2	
Survivors	6516	5444	5524	5748
Raw Weights	8.433	7.228	3.044	6.756

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	5872	0.163	0.044	0.27	4	0.962	0.277
F shrinkage mean	7048	1				0.038	0.236

Weighted prediction :

Survivors	Int	Ext	N	Var	F

at end of year	s.e	s.e		Ratio	
5913	0.16	0.04	5	0.257	0.276

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

Year class = 2010

Norw. Coast. survey

Age 6	5	4	3	2	
Survivors	2736	2097	2034	1999	2495
Raw Weights	6.633	4.955	4.341	1.743	4.068

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	2326	0.146	0.065	0.45	5	0.956	0.53
F shrinkage mean	5280	1				0.044	0.269

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2412	0.15	0.1	6	0.654	0.516

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

Year class = 2009

Norw. Coast. survey

Age 7	6	5	4	3	2	
Survivors	1917	1655	2359	1520	1257	1652
Raw Weights	3.013	4.05	3.379	2.964	1.232	2.779

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	1757	0.14	0.079	0.56	6	0.946	0.669
F shrinkage mean	4698	1				0.054	0.304

Weighted prediction :

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

1853 0.14 0.12 7 0.817 0.643

Age 8 Catchability constant w.r.t. time and dependent on age

Year class = 2008

Norw. Coast. survey

Age 8	7	6	5	4	3	2	
Survivors	1763	1040	1527	1162	1076	1624	1257
Raw Weights	6.944	2.435	3.975	3.414	3.07	1.266	2.777

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	1381	0.131	0.084	0.64	7	0.96	0.477
F shrinkage mean	2223	1				0.04	0.322

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1407	0.13	0.08	8	0.635	0.47

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 2007

Norw. Coast. survey

Age 9	8	7	6	5	4	3	2	
Survivors	0	515	1043	673	443	809	433	528
Raw Weights	0	4.124	1.704	2.566	2.06	1.682	0.649	1.472

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	604	0.133	0.112	0.84	7	0.934	0.585
F shrinkage mean	780	1				0.066	0.48

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
614	0.14	0.1	8	0.736	0.578

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).

Year	2	3	4	5	6	7	8	9
1984	0.011	0.074	0.217	0.334	0.628	1.309	1.072	0.845
1985	0.006	0.130	0.223	0.462	0.637	0.788	0.633	0.636
1986	0.135	0.077	0.319	0.460	0.643	0.900	0.934	0.741
1987	0.005	0.041	0.220	0.598	0.438	0.708	0.733	0.625
1988	0.003	0.073	0.203	0.268	0.762	1.238	1.184	0.873
1989	0.001	0.040	0.071	0.209	0.361	0.852	0.931	0.593
1990	0.000	0.011	0.054	0.088	0.150	0.435	0.628	0.327
1991	0.002	0.019	0.056	0.188	0.171	0.258	0.184	0.201
1992	0.001	0.015	0.128	0.241	0.277	0.270	0.287	0.270
1993	0.000	0.010	0.048	0.131	0.226	0.512	0.453	0.333
1994	0.015	0.026	0.057	0.165	0.199	0.487	0.514	0.343
1995	0.027	0.051	0.143	0.250	0.332	0.441	0.406	0.360
1996	0.033	0.104	0.194	0.501	0.372	0.448	0.564	0.475
1997	0.046	0.127	0.195	0.272	0.512	0.626	0.796	0.556
1998	0.020	0.129	0.262	0.410	0.484	0.708	0.680	0.575
1999	0.011	0.060	0.151	0.395	0.555	0.769	0.944	0.702
2000	0.007	0.052	0.236	0.389	0.463	0.448	0.340	0.411
2001	0.002	0.029	0.131	0.306	0.364	0.477	0.414	0.333
2002	0.011	0.055	0.184	0.304	0.517	0.532	0.662	0.471
2003	0.005	0.081	0.176	0.308	0.403	0.535	0.405	0.391
2004	0.001	0.022	0.090	0.213	0.386	0.521	0.482	0.262
2005	0.001	0.035	0.120	0.257	0.279	0.434	0.352	0.266
2006	0.005	0.025	0.165	0.227	0.404	0.416	0.510	0.397
2007	0.004	0.043	0.148	0.280	0.262	0.350	0.220	0.371
2008	0.005	0.042	0.163	0.259	0.305	0.290	0.320	0.181
2009	0.000	0.016	0.087	0.214	0.365	0.473	0.300	0.198
2010	0.001	0.049	0.141	0.222	0.270	0.318	0.345	0.169
2011	0.001	0.041	0.179	0.228	0.280	0.532	0.381	0.322
2012	0.001	0.026	0.092	0.206	0.364	0.398	0.588	0.500
2013	0.005	0.043	0.124	0.145	0.245	0.233	0.270	0.524
2014	0.001	0.053	0.130	0.179	0.169	0.220	0.228	0.322
2016	0.011	0.056	0.154	0.291	0.366	0.386	0.413	0.436

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

RUN TITLE COMBSEX PLUSGROUP : NORWEGIAN COASTAL COD

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TABLE 16 SUMMARY (WITHOUT SOP CORRECTION)

TERMINAL FS DERIVED USING XSA (WITH F SHRINKAGE)

	RECRUITS	TOTALBIO	TOTSPBIO	LANDING	YIELD/SSB	FBAR 4-7
1984	87969	310218	140805	74824	0.5314	0.622
1985	74746	294114	116959	75451	0.6451	0.5274
1986	35838	290950	122061	68905	0.5645	0.5804
1987	37121	255440	114768	60972	0.5313	0.4911
1988	40398	231678	118152	59294	0.5018	0.6179
1989	44432	197891	94030	40285	0.4284	0.3732
1990	44362	212892	103462	28127	0.2719	0.1817
1991	60794	249844	124526	24822	0.1993	0.1682
1992	50609	293575	156906	41690	0.2657	0.229
1993	29852	307505	171043	52557	0.3073	0.2293
1994	24769	308320	182081	54562	0.2997	0.2271
1995	33404	270414	170329	57207	0.3359	0.2914
1996	40169	274494	184927	61776	0.3341	0.3784
1997	32923	216758	139641	63319	0.4534	0.4014
1998	31137	182062	99070	51572	0.5206	0.466
1999	26293	160003	82023	40732	0.4966	0.4675
2000	23731	137129	63437	36715	0.5788	0.3839
2001	22688	131545	61542	29699	0.4826	0.3194
2002	19456	157243	83620	40994	0.4902	0.3841
2003	19439	113686	59297	34635	0.5841	0.3554
2004	18616	119677	62717	24547	0.3914	0.3023
2005	17199	114576	57700	22432	0.3888	0.2725
2006	16531	133556	69415	26134	0.3765	0.303
2007	21910	138174	71590	23841	0.333	0.2598
2008	20652	140584	68707	25777	0.3752	0.2541
2009	20111	137255	66049	24821	0.3758	0.2847
2010	21028	138184	65609	22925	0.3494	0.2379
2011	23464	148796	73575	28594	0.3886	0.3048
2012	17478	145468	72287	31907	0.4414	0.2649
2013	21420	135698	67175	22464	0.3344	0.1868
2014	23274	153382	78310	23169	0.2959	0.1742
2015	23108	165070	89432	39455	0.4412	0.2991
2016	21478	163094	84176	44610	0.53	0.3945
ARITH. MEAN	31709	194826	100467	41176	0.4195	0.3404
0 UNITS	(THOUSANDS)	(TONNES)	(TONNES)	(TONNES)		

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	0.3745	0.3523
1997	0.850	0.3701	0.3488
1998	1.604	0.4773	0.4323
1999	1.018	0.3939	0.3673
2000	0.538	0.3257	0.3142
2001	0.912	0.3789	0.3556
2002	1.084	0.4033	0.3747
2003	0.482	0.3177	0.3080
2004	0.725	0.3524	0.3350
2005	0.355	0.2997	0.2939
2006	0.324	0.2954	0.2905
2007	0.386	0.3041	0.2974
2008	0.925	0.3807	0.3570
2009	-0.030	0.2451	0.2513
2010	0.776	0.3596	0.3406
2011	0.229	0.2819	0.2800
2012	0.760	0.3573	0.3388
2013	-0.102	0.2348	0.2433
2014	-0.031	0.2448	0.2511
2015	0.677	0.3456	0.3297
2016	0.389	0.3046	0.2977

Table 2.17. Norwegian Coastal Cod. Stock summary for SVPA based on commercial catch-at-age and survey derived F in terminal year (2016)

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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	87089	306315	138848	74824	0.5389	0.6214
1985	74276	290729	115486	75451	0.6533	0.5287
1986	35639	287660	120478	68905	0.5719	0.5815
1987	36890	252676	113267	60972	0.5383	0.4928
1988	40101	229274	116645	59294	0.5083	0.6163
1989	44095	196319	93201	40285	0.4322	0.3722
1990	44012	211384	102759	28127	0.2737	0.1817
1991	60247	248064	123726	24822	0.2006	0.1686
1992	50134	291347	155828	41690	0.2675	0.2296
1993	29551	305042	169817	52557	0.3095	0.2296
1994	24565	305758	180706	54562	0.3019	0.2276
1995	33141	268011	168889	57207	0.3387	0.2924
1996	39859	271894	183183	61776	0.3372	0.3796
1997	32696	214674	138257	63319	0.458	0.4023
1998	30902	180404	98122	51572	0.5256	0.4665
1999	26100	158600	81265	40732	0.5012	0.4667
2000	23559	136046	62943	36715	0.5833	0.3842
2001	22563	130524	61056	29699	0.4864	0.3198
2002	19338	156118	83032	40994	0.4937	0.3839
2003	19338	112869	58847	34635	0.5886	0.3553
2004	18492	118897	62300	24547	0.394	0.3023
2005	17076	113882	57364	22432	0.391	0.2726
2006	16402	132721	69014	26134	0.3787	0.3026
2007	21775	137331	71212	23841	0.3348	0.2599
2008	20514	139715	68349	25777	0.3771	0.2544
2009	20912	136745	65635	24821	0.3782	0.2848
2010	22364	138655	65196	22925	0.3516	0.2385
2011	27210	151687	73282	28594	0.3902	0.3029
2012	20708	152421	72882	31907	0.4378	0.2601
2013	22104	145940	69608	22464	0.3227	0.1750
2014	22279	167125	84408	23169	0.2745	0.1521
2015	30905	182749	99240	39455	0.3976	0.2512
2016	34716	192363	99611	44610	0.4478	0.3046
Arith. Mean	32411	195877	100741	41176	0.4177	0.3352

Table 2.18. Norwegian Coastal Cod. Stock summary for SVPA based on total catch-at-age and survey derived F in terminal year (2016).

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TABLE 16 SUMMARY (WITHOUT SOP CORRECTION)

TRADITIONAL VPA USING FILE INPUT FOR TERMINAL F

	RECRUITS AGE 2	TOTBIO	TOTSPB	LADINGS	Y/SSB	FBAR 4- 7
1984	108413	359107	159502	88124	0.5525	0.6177
1985	97535	344532	132867	88851	0.6687	0.5249
1986	62544	347937	138826	82405	0.5936	0.5904
1987	48958	314026	131617	74472	0.5658	0.5081
1988	54324	291758	137992	72894	0.5282	0.6315
1989	62948	259414	117284	53985	0.4603	0.381
1990	62539	279439	130835	42627	0.3258	0.2356
1991	81086	325452	158046	40122	0.2539	0.1931
1992	69603	373216	194608	57790	0.297	0.2466
1993	38556	387459	210625	67357	0.3198	0.2332
1994	32562	383761	220533	69262	0.3141	0.2365
1995	44789	338216	209256	71907	0.3436	0.2947
1996	58502	346069	227881	76276	0.3347	0.3605
1997	47413	279657	172883	77819	0.4501	0.3897
1998	43015	249873	130811	66172	0.5059	0.4247
1999	38458	228098	115165	54632	0.4744	0.4183
2000	35120	200943	94360	50315	0.5332	0.345
2001	33793	193686	91226	43099	0.4724	0.3095
2002	29250	227365	118607	54594	0.4603	0.3515
2003	29168	171397	89604	48535	0.5417	0.314
2004	28468	179860	92923	37947	0.4084	0.3056
2005	26251	168185	81948	35632	0.4348	0.2806
2006	24748	196572	99364	39134	0.3938	0.3044
2007	32513	202695	102488	36841	0.3595	0.2668
2008	30337	202495	95267	38577	0.4049	0.2523
2009	29830	200245	94633	37521	0.3965	0.2987
2010	31124	204462	97311	35625	0.3661	0.2506
2011	37501	219147	107440	41294	0.3843	0.299
2012	27952	217864	106537	44607	0.4187	0.2477
2013	28871	206654	101526	35164	0.3464	0.1922
2014	28360	229076	118590	35869	0.3025	0.1745
2015	39834	244131	135588	52155	0.3847	0.2511
2016	46796	252369	132154	57310	0.4337	0.2977
ARITH. MEAN	45187	261368	131767	54816	0.4252	0.3342

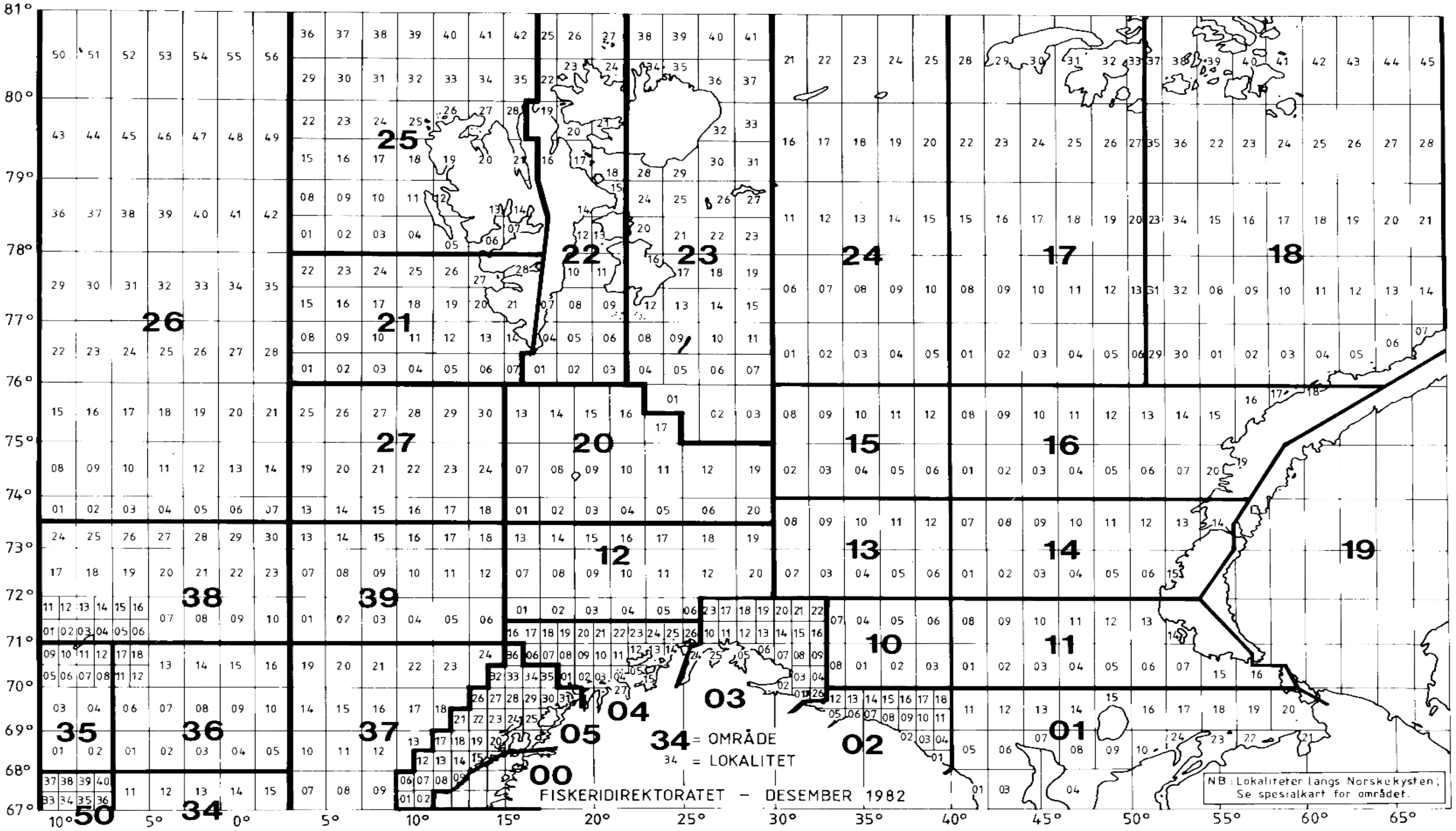


Figure 2.1a. Norwegian statistical rectangles in the Barents Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 03 and 04. The same areas are also referred to in the survey results (sec. 2.3).

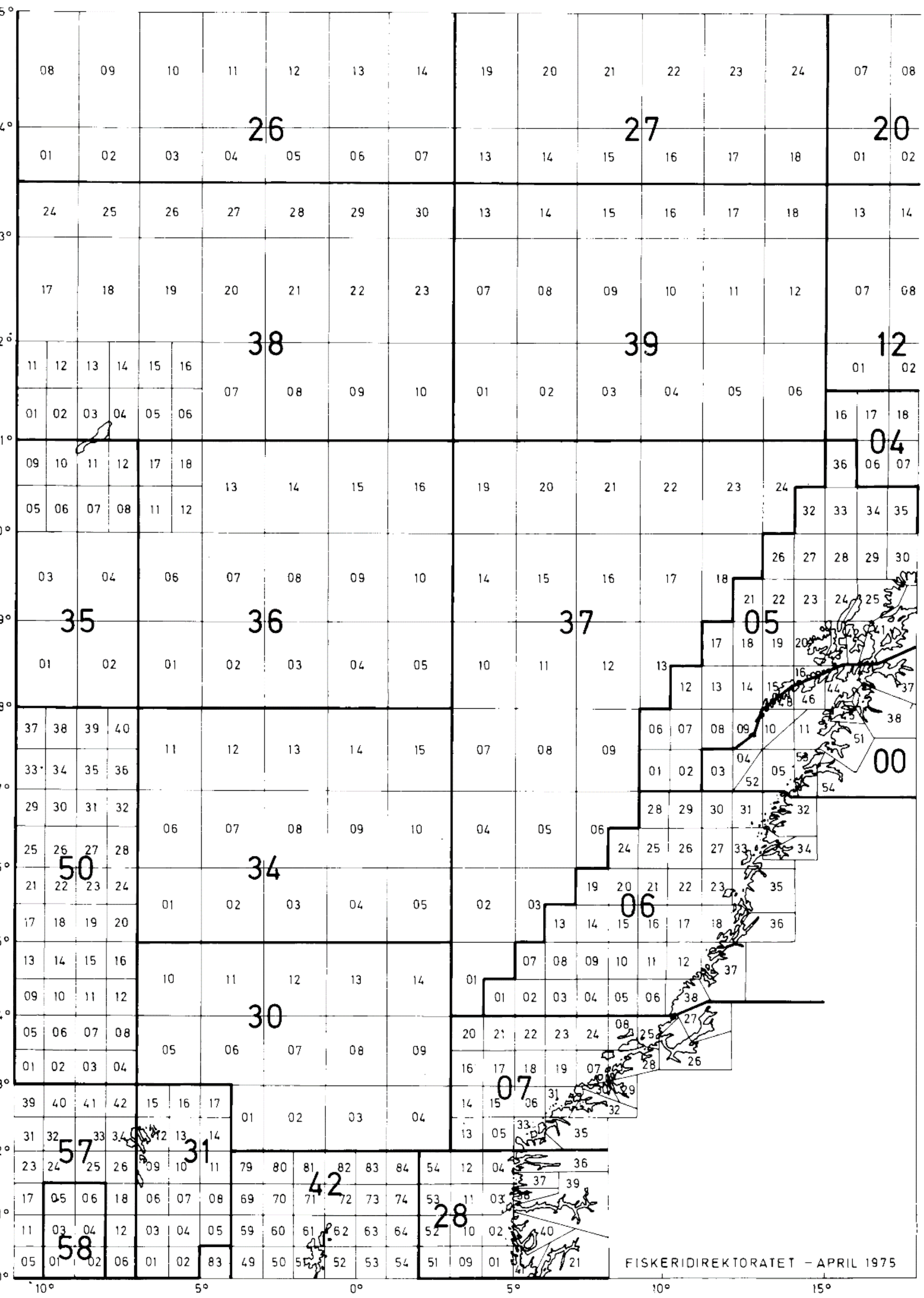


Figure 2.1b. Norwegian statistical rectangles in the Norwegian Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 05, 00, 06 and 07. The same areas are also referred to in the survey results (sec. 2.3).

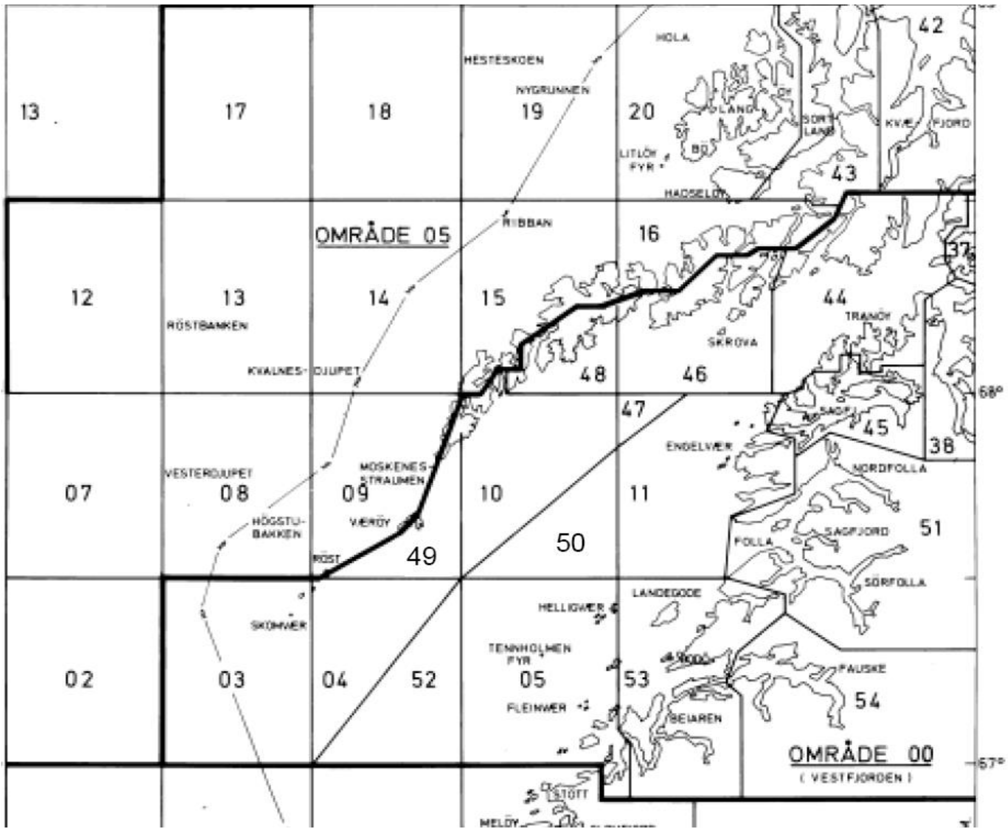


Figure 2.2. Map showing Vestfjorden, the Norwegian statistical area 00 ("OMRÅDE 00") with the southwestern location 03 and 04 and the northeastern locations 46 and 48.

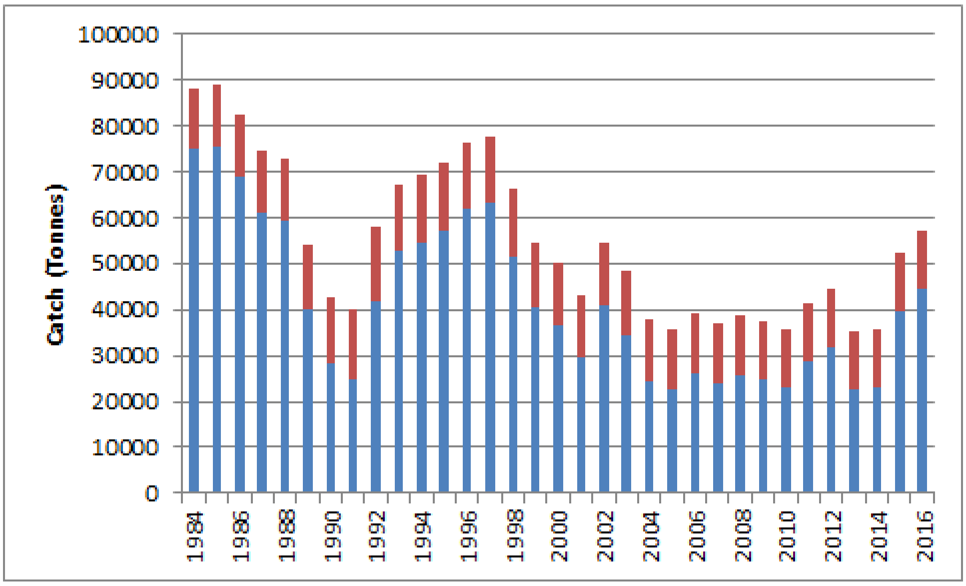


Figure 2.3. Estimated catch of Norwegian coastal cod. Commercial catch in blue and recreational catches in red

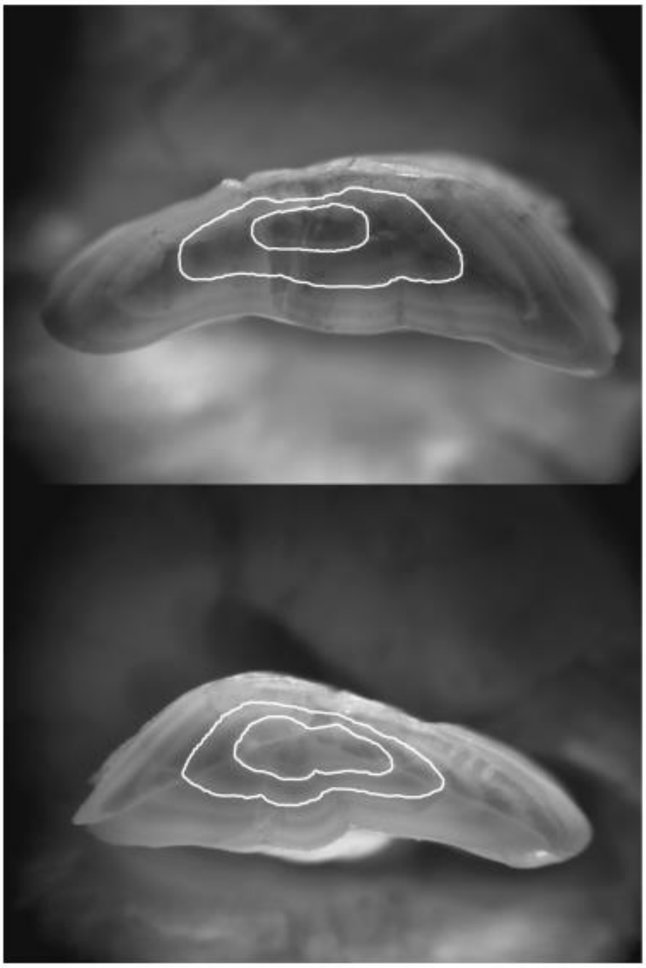


Figure 2.4. An image of a coastal cod otolith (top) and a northeast Arctic cod otolith (bottom). The two first translucent zones are highlighted. (from Berg *et al*. 2005)

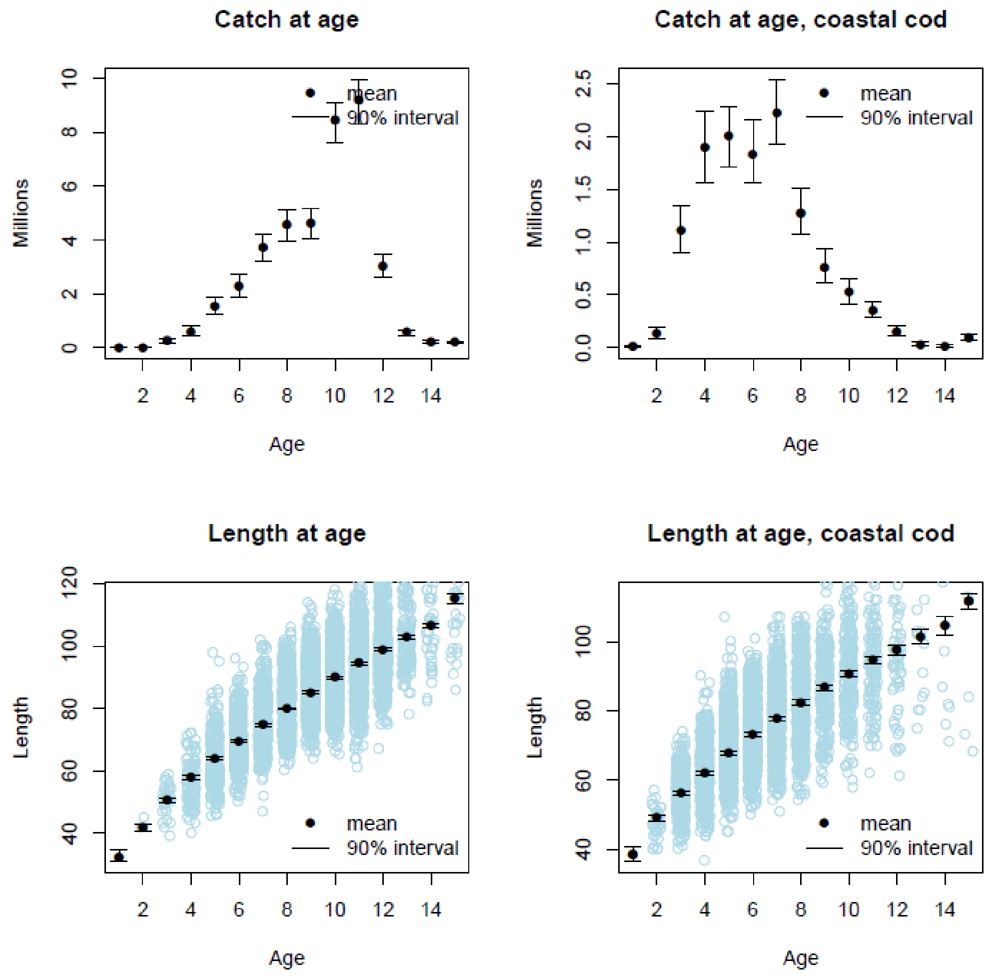


Figure 2.5a. ECA-output for 2015 commercial catches by Norway in the coastal statistical areas (Figure 2.5c). Left panels NEA cod. Right panels coastal cod.

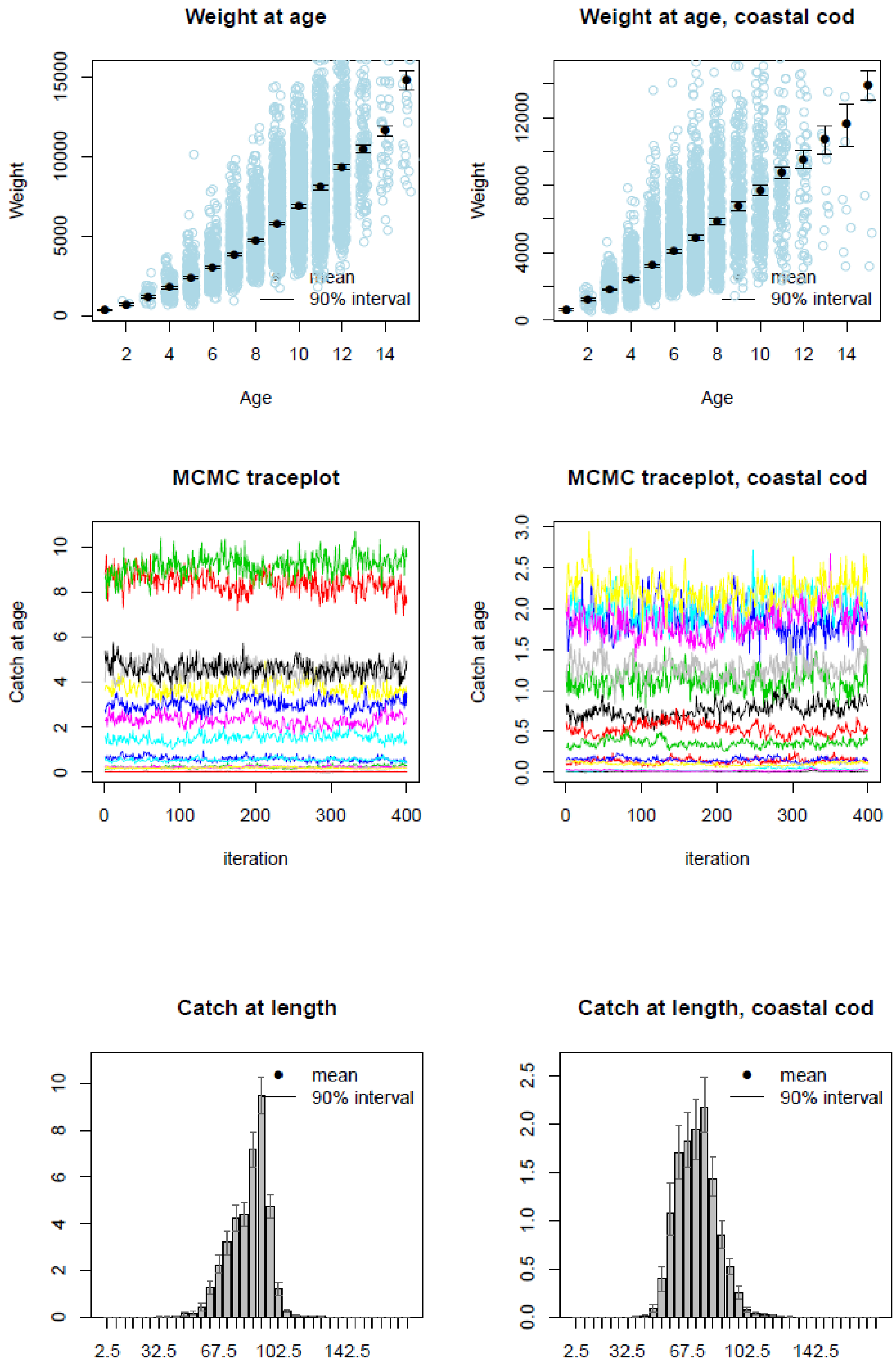


Figure 2.5b. ECA-output for 2016 commercial catches by Norway in the coastal statistical areas (Figure 2.5c). Left panels NEA cod. Right panels coastal cod.

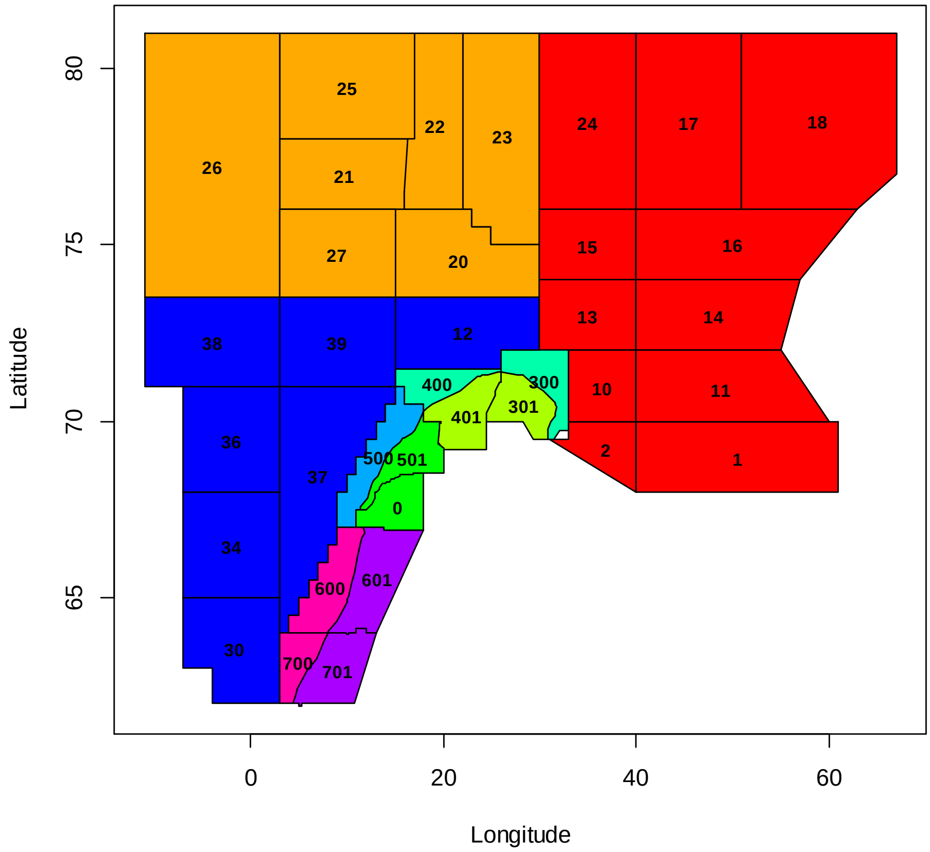


Figure 2.5c. Norwegian statistical rectangles. The colors indicate area units used by the ECA-model for combining cod samples. Coastal cod are only estimated in coastal areas (0 and 300-701).

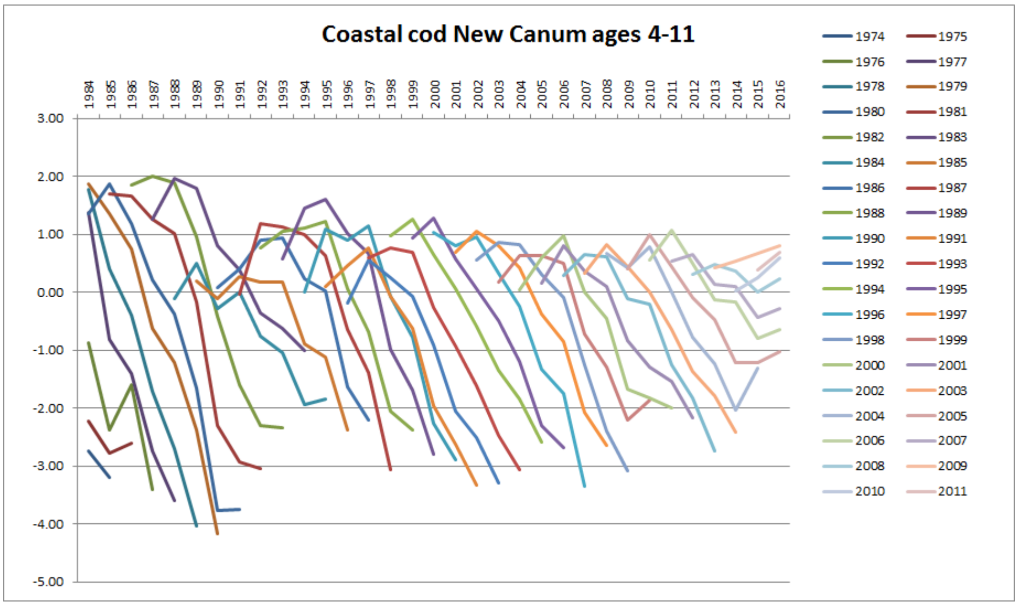


Figure 2.5d. Log catch numbers-at-age by cohort (series names) and catch years (x-axis). ECA estimates.

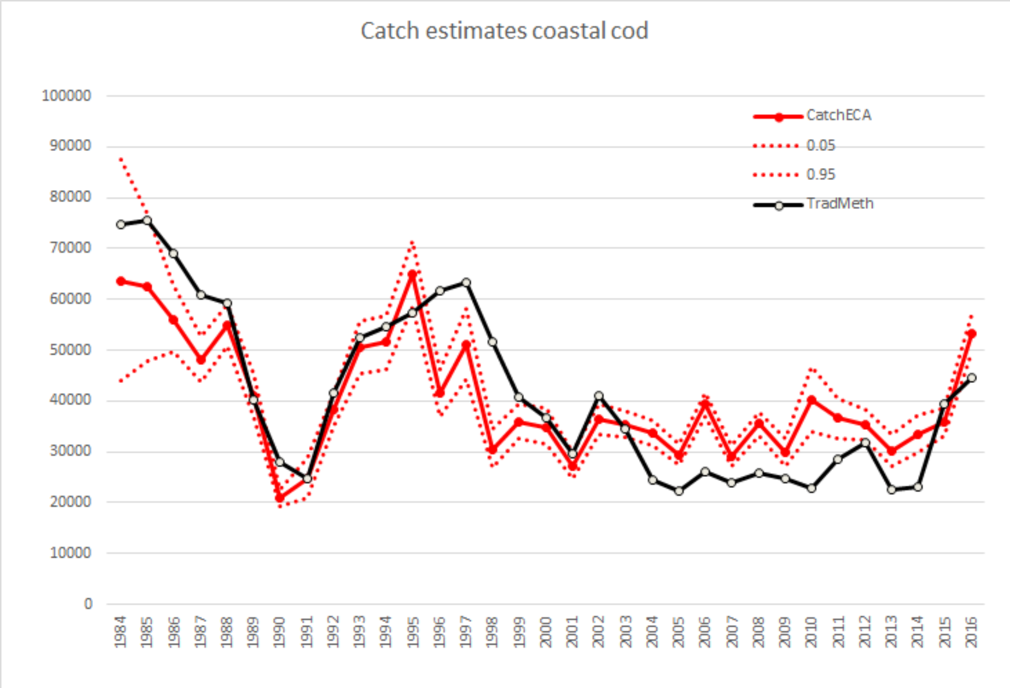


Figure 2.5e. Catches (tonnes) of coastal cod from the ECA analysis, compared to the traditional estimates.

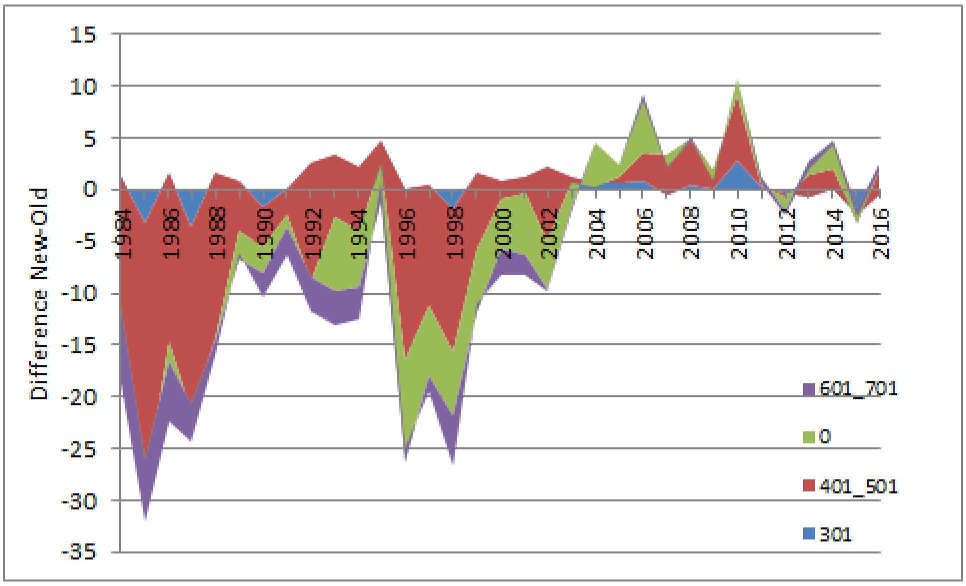


Figure 2.5f. Difference in catch estimate ('000 tonnes) between ECA estimates within 12 n.mile and traditional estimates. The colors represent different statistical areas (see figure 2.5c).

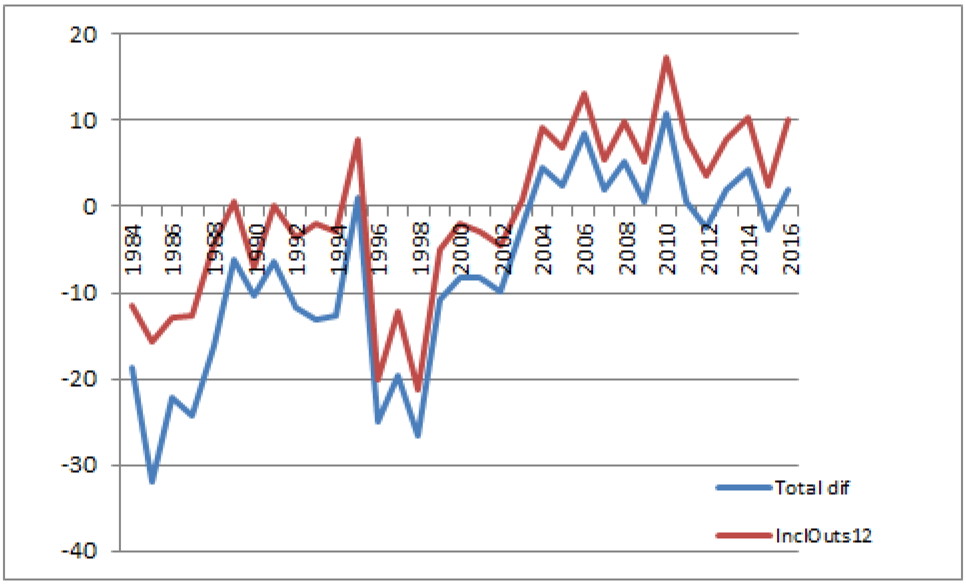
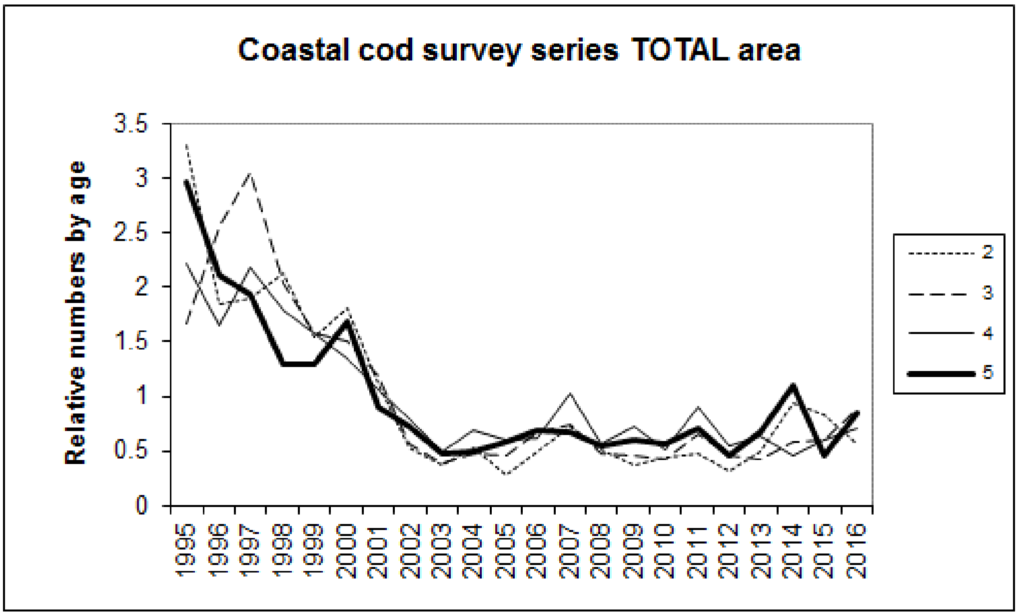


Figure 2.5g. Blue line: Difference in catch estimate ('000 tonnes) between ECA estimates within 12 n.mile and traditional estimates. Red line: Difference between total ECA estimates including some areas outside 12 n.mile (see figure 2.5c), and traditional estimates.



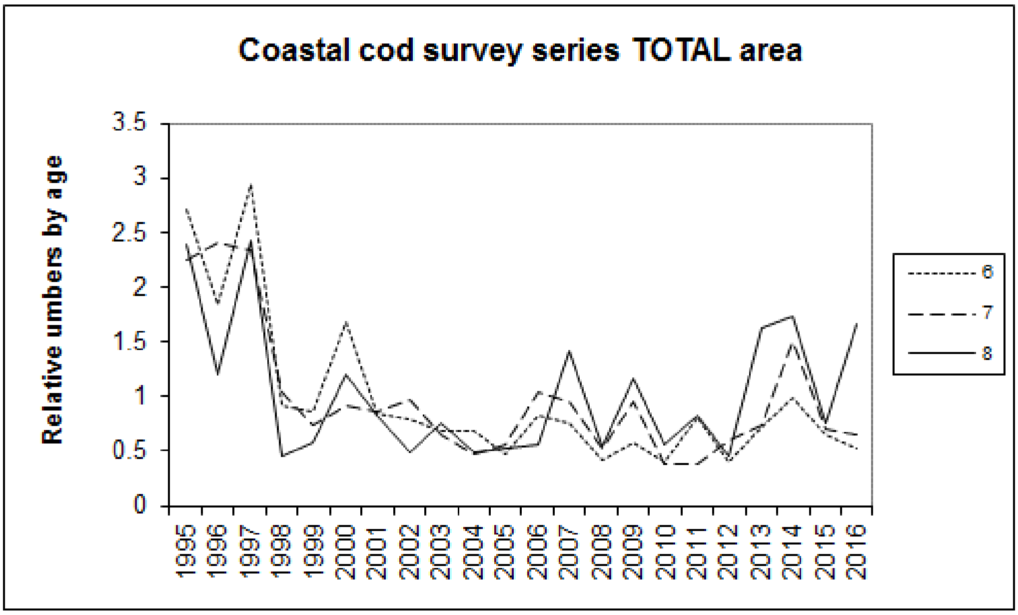
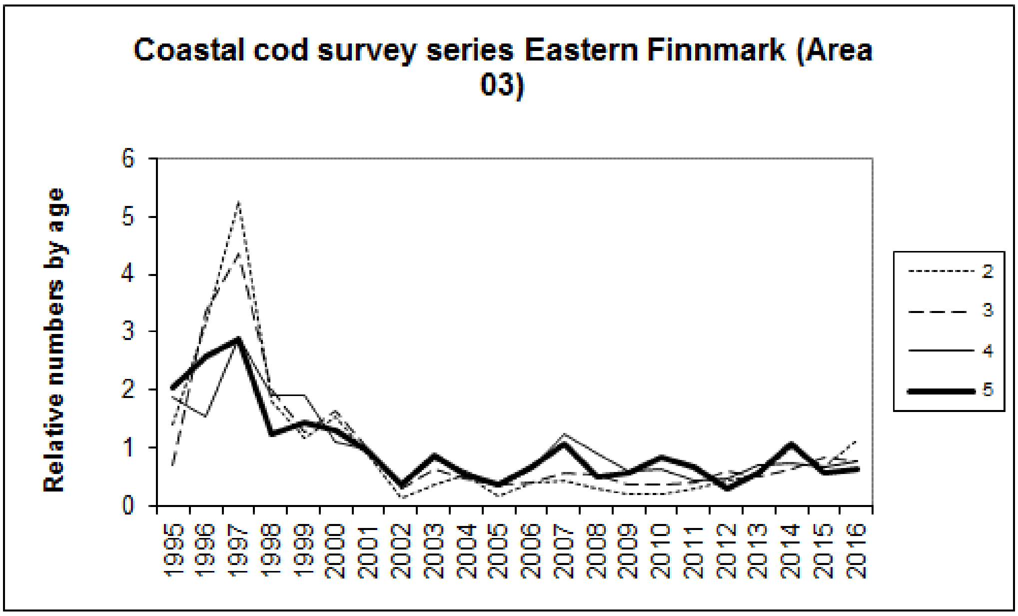


Figure 2.6. Coastal cod survey. Abundance at age relative to time-series average in total survey. Upper: ages 2-5, Lower: ages 6-8.



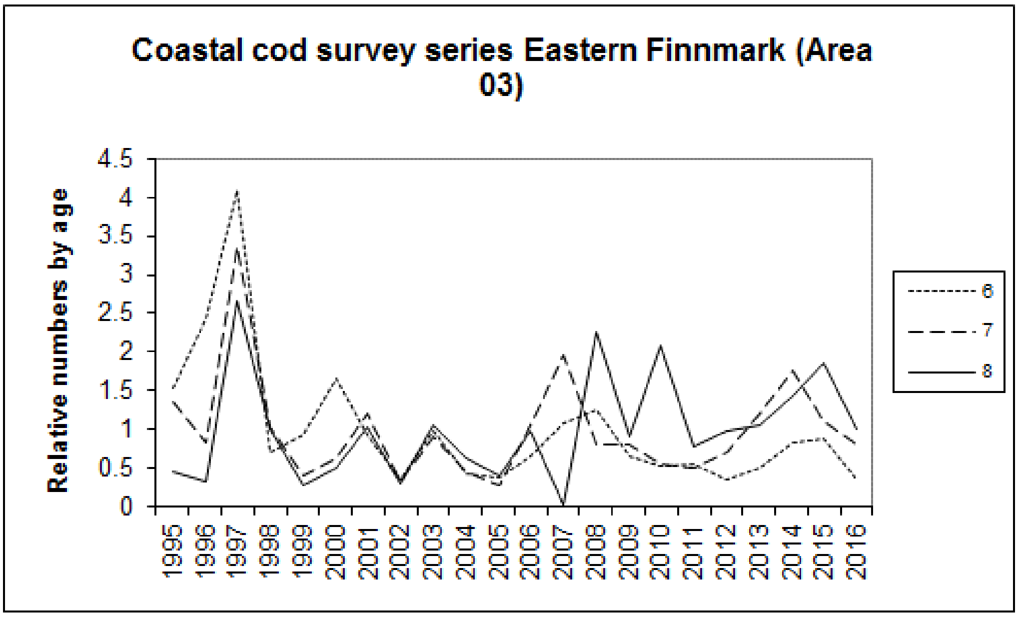
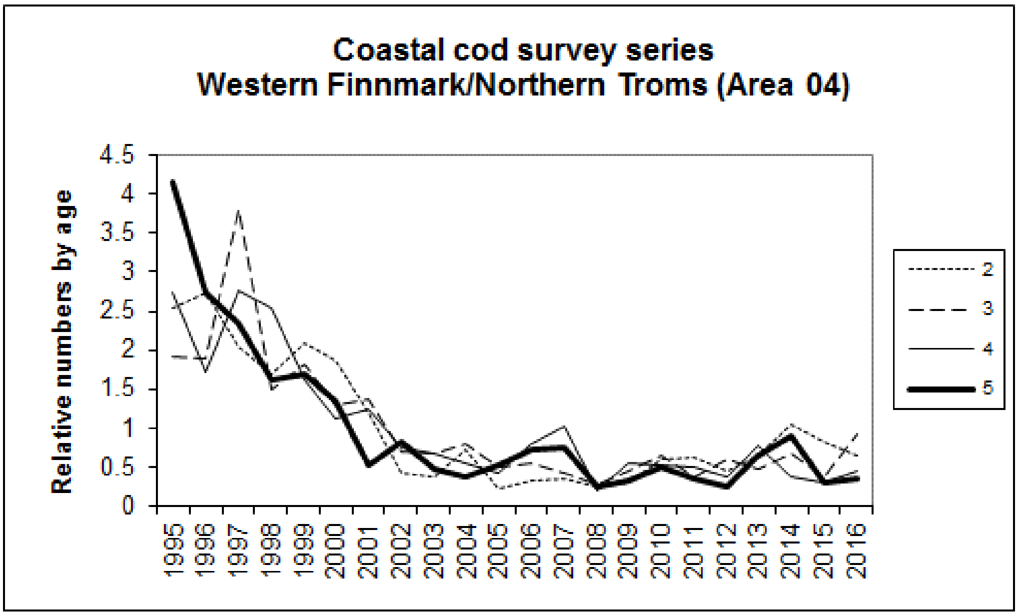


Figure 2.7. Coastal cod survey. Abundance at age relative to time-series average in statistical area 03. Upper: ages 2-5, Lower: ages 6-8.



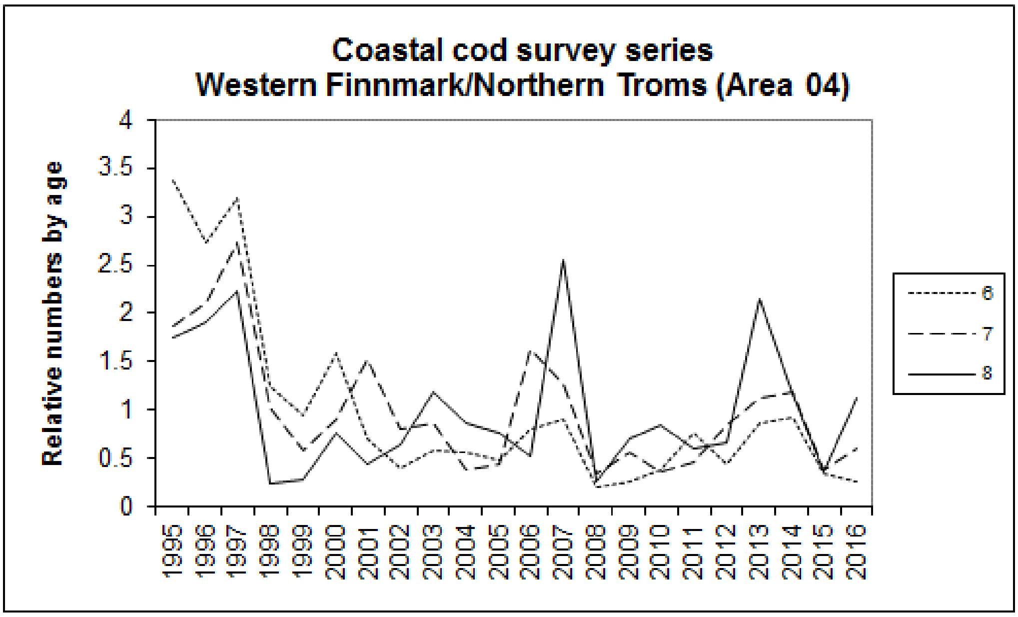
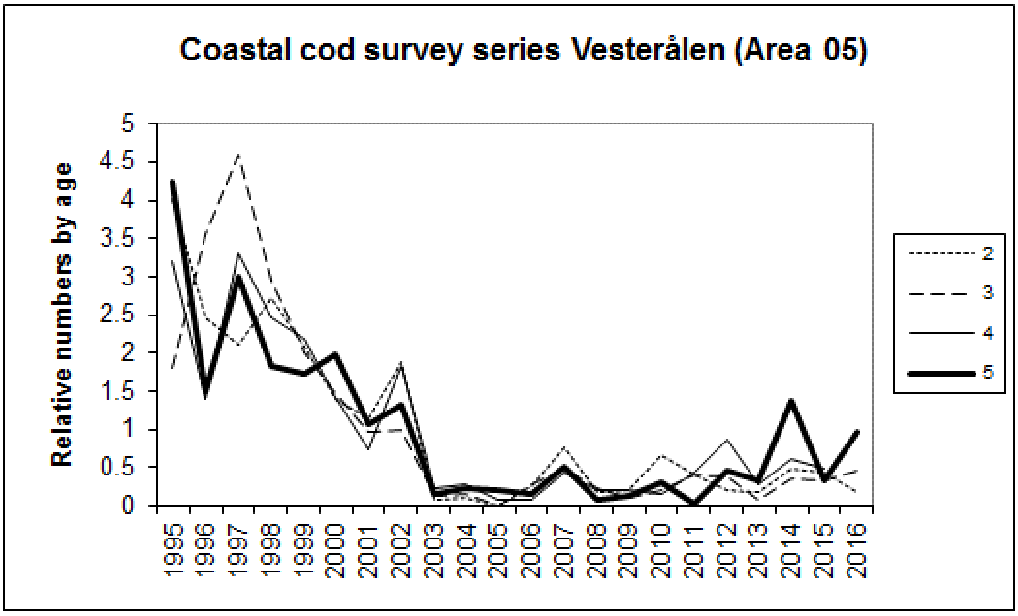


Figure 2.8. Coastal cod survey. Abundance at age relative to time-series average in statistical area 04. Upper: ages 2-5, Lower: ages 6-8.



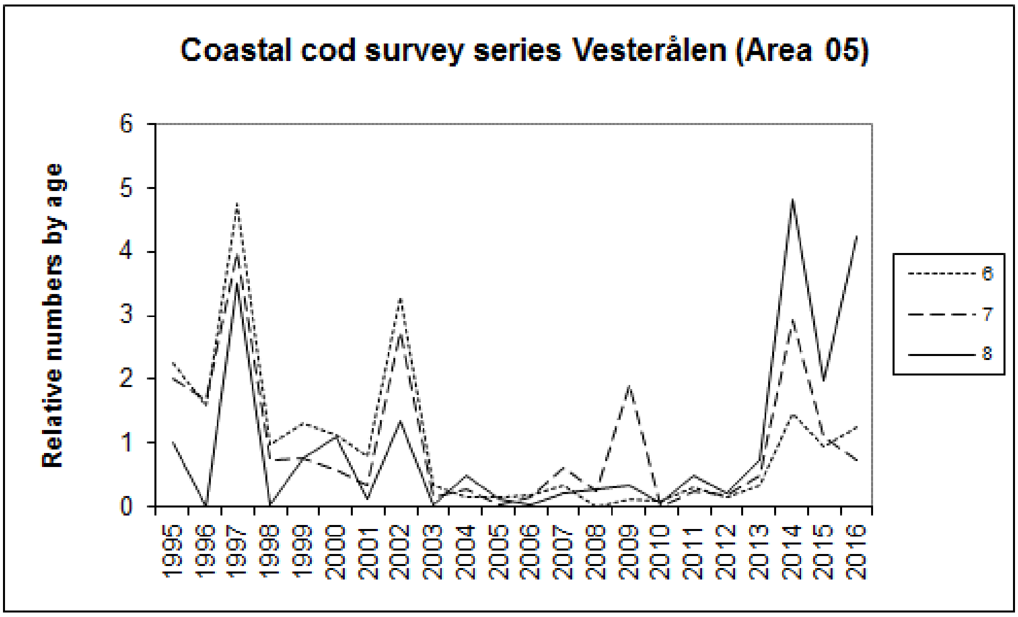
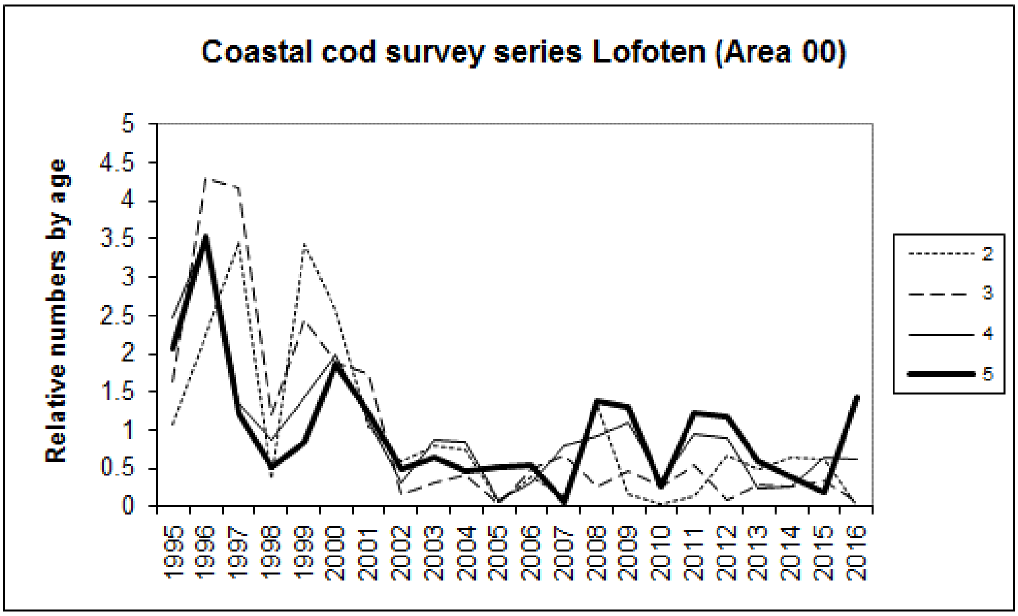


Figure 2.9. Coastal cod survey. Abundance at age relative to time-series average in statistical area 05. Upper: ages 2-5, Lower: ages 6-8.



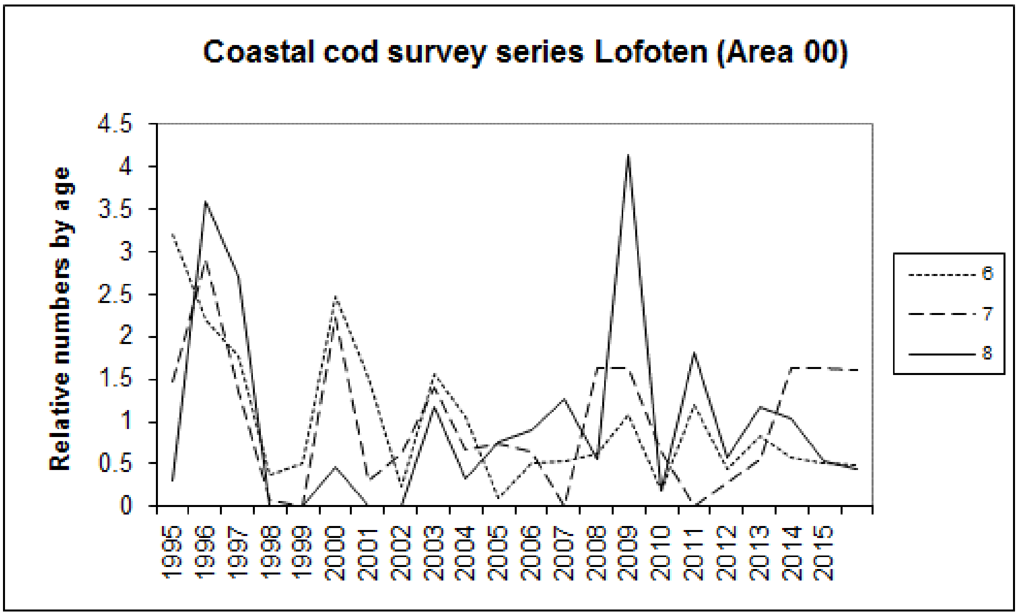
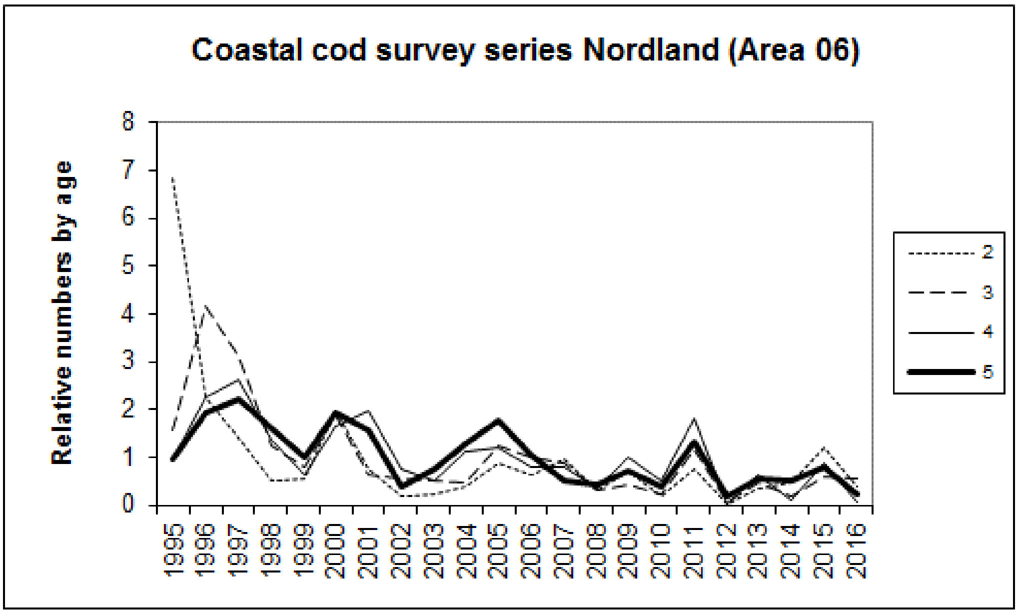


Figure 2.10. Coastal cod survey. Abundance at age relative to time-series average in statistical area 00. Upper: ages 2-5, Lower: ages 6-8.



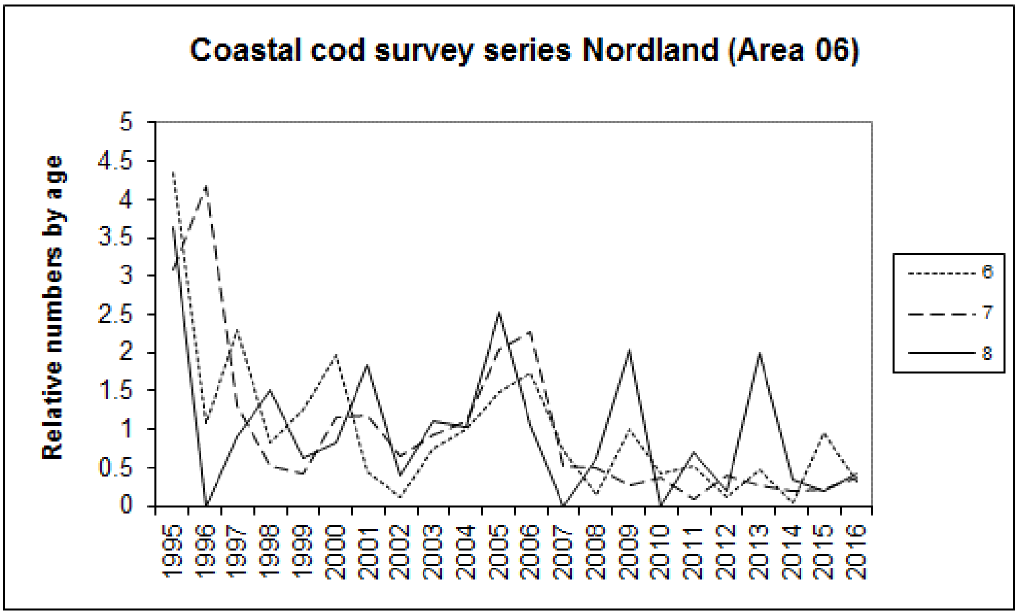
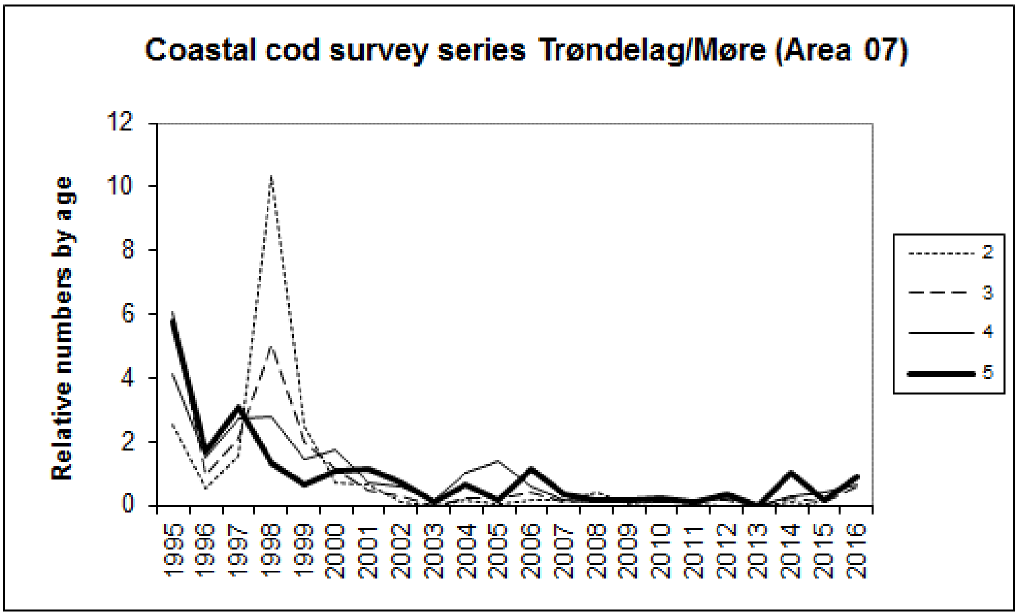


Figure 2.11 Coastal cod survey. Abundance at age relative to time-series average in statistical area 06. Upper: ages 2-5, Lower: ages 6-8.



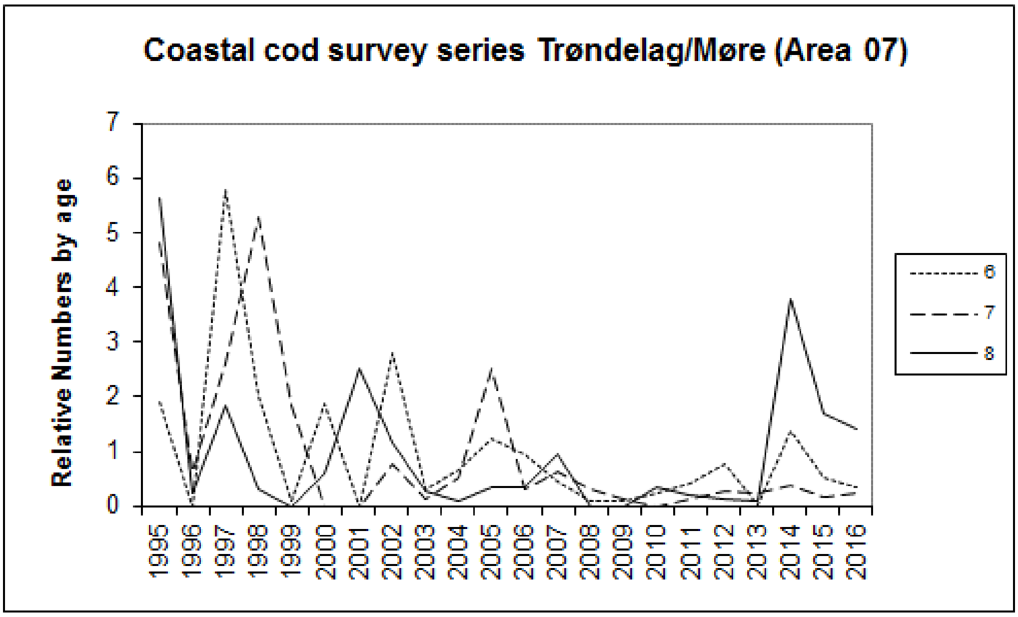


Figure 2.12. Coastal cod survey. Abundance at age relative to time-series average in statistical area 07. Some important areas at Møre was not covered in 2013. Upper: ages 2-5, Lower: ages 6-8.

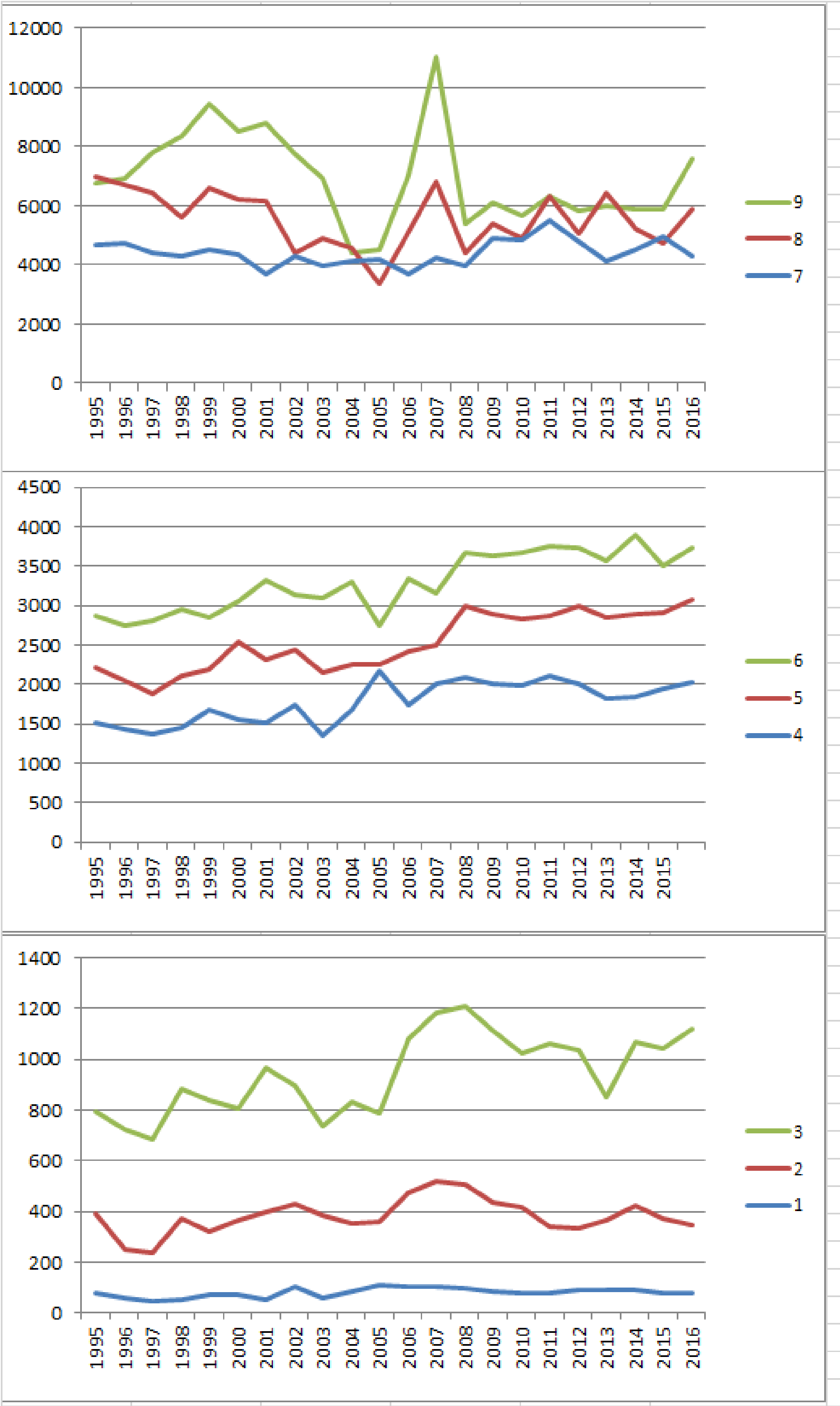


Figure 2.13a. Mean weights at age in the coastal survey

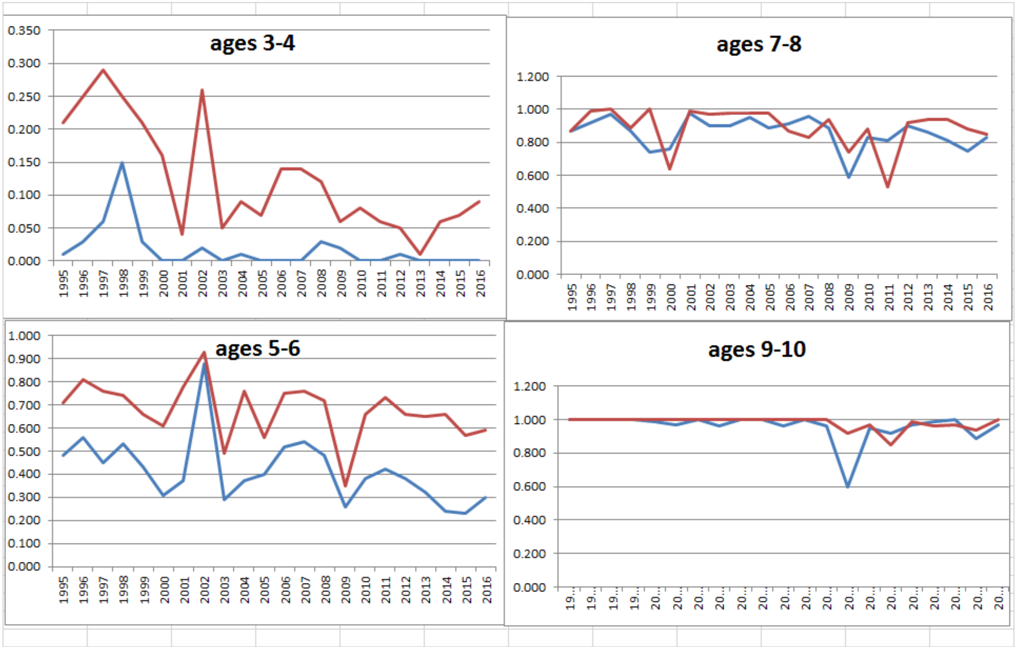


Figure 2.13b. Proportions mature at age as observed in the surveys (red), and as estimated by back-calculation from spawning zones recorded from otoliths (blue) sampled in the commercial fishery in the spawning season.

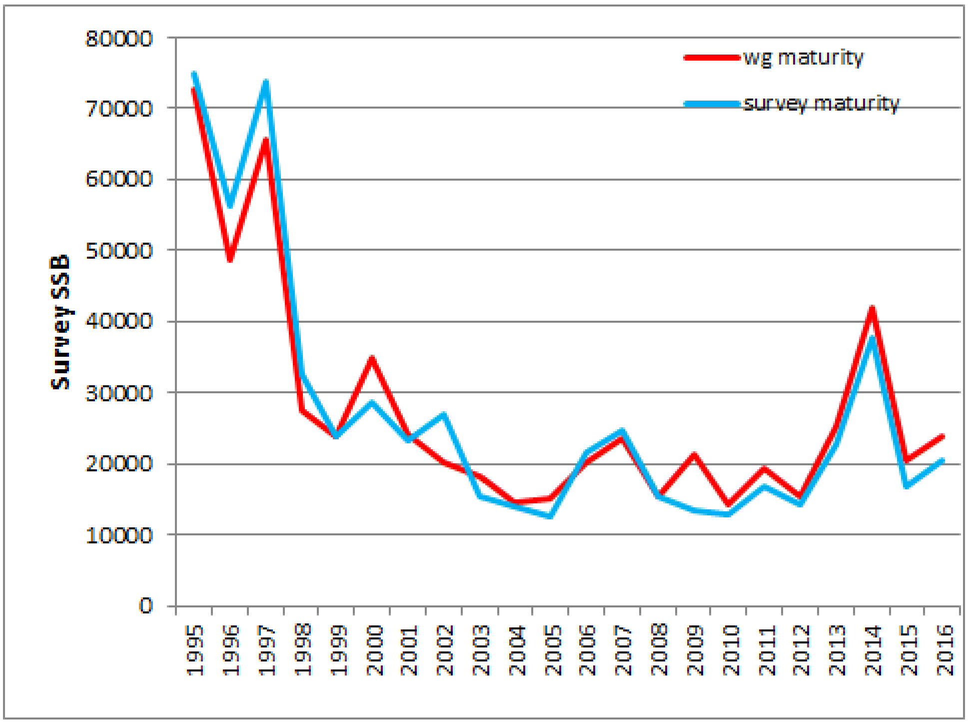


Figure 2.14. Survey SSB calculated by maturity observed in the surveys (red) and by maturity used in the VPA.

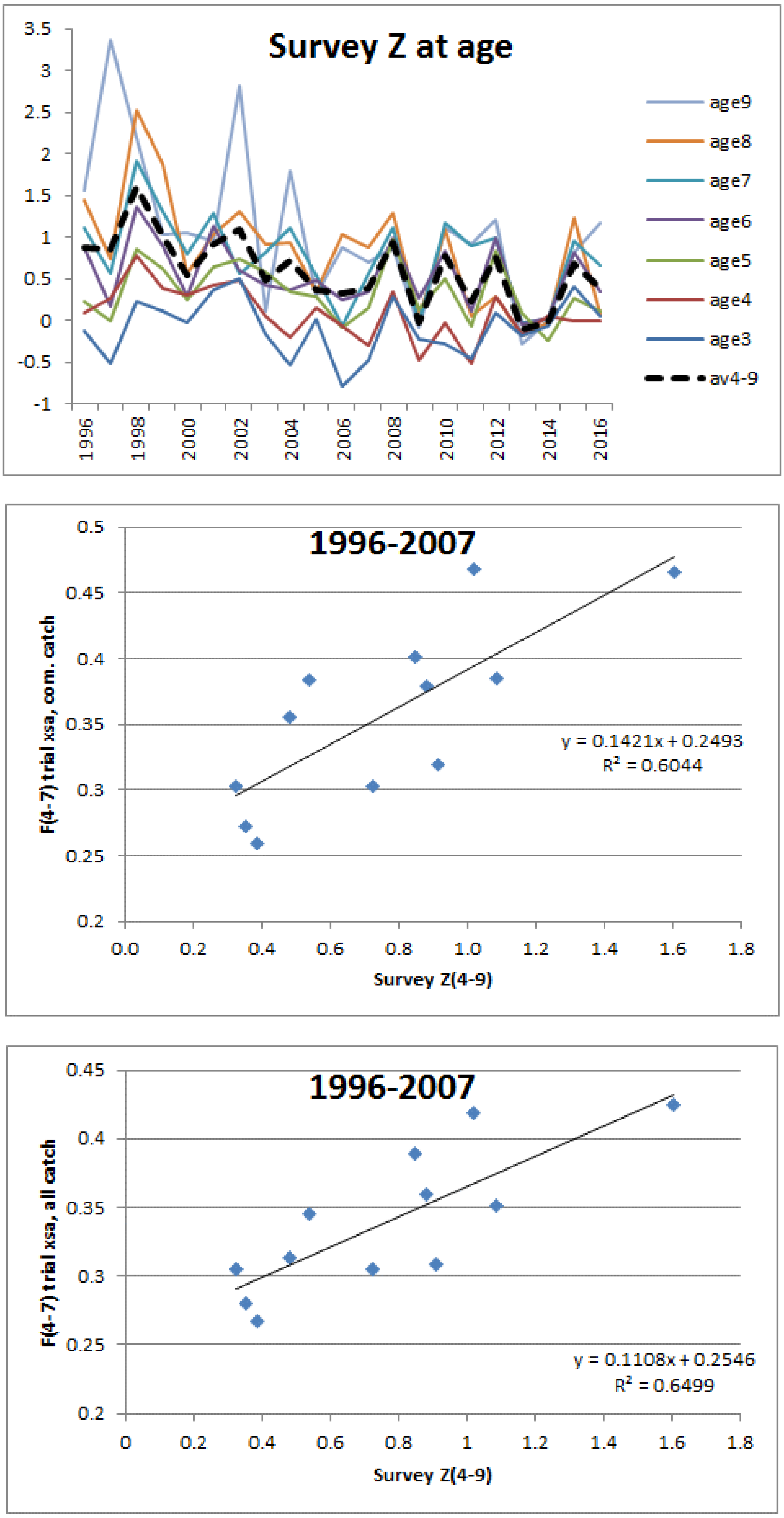


Figure 2.15. Survey mortality Z (upper) and relation to VPA values of F(4-7) over the period 19962007 for a trial XSA based on commercial catch (middle) and a trial XSA based on all catch (bottom).

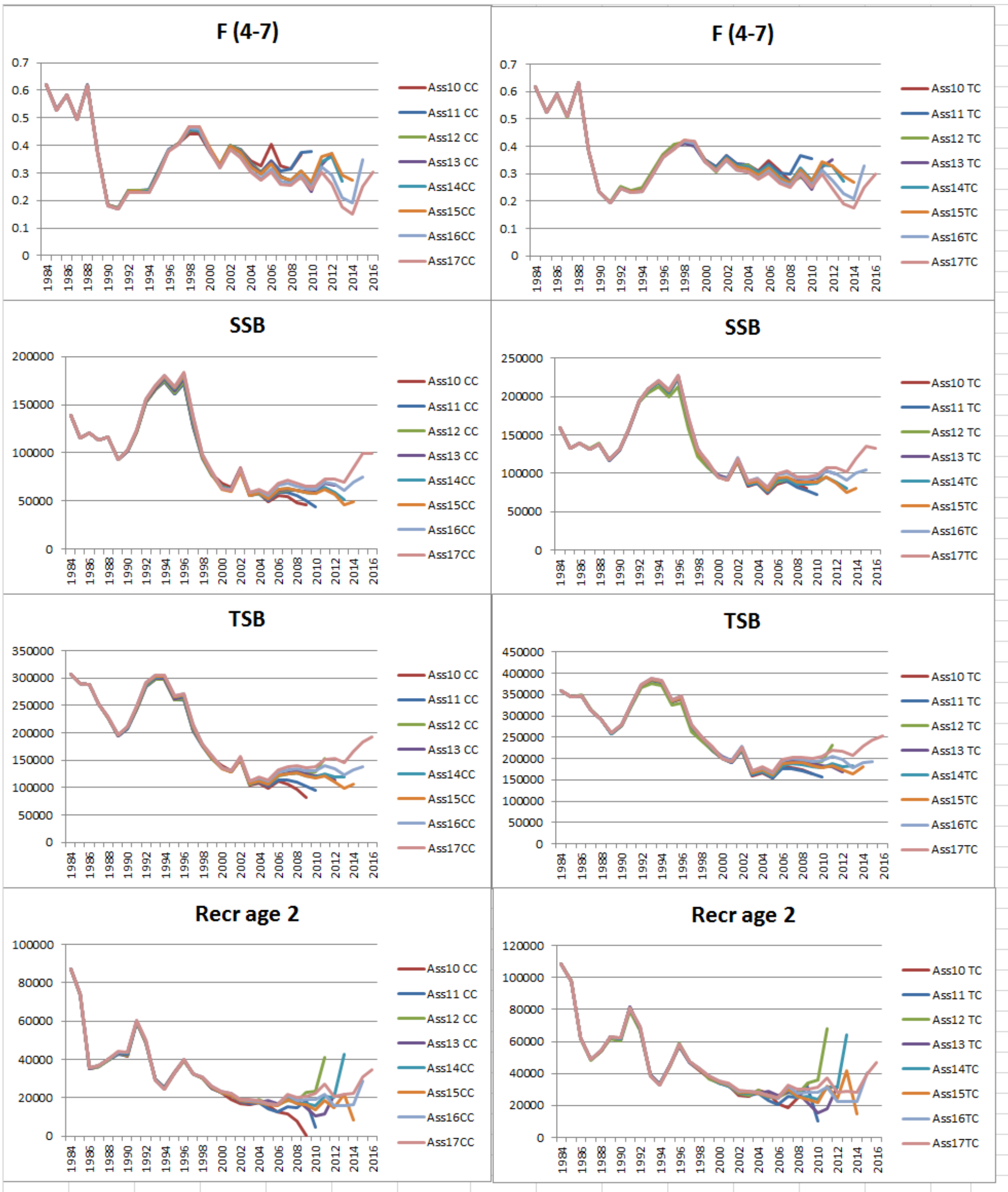


Figure 2.16. Comparisons of SVPA outputs in current assessment (Ass17) with the assessments in 2016, 2015, 2014, 2013, 2012, 2011 and 2010 for analyses based on commercial catch (left) and total catch (right). In all assessments the recruit estimate for the final year is highly uncertain.

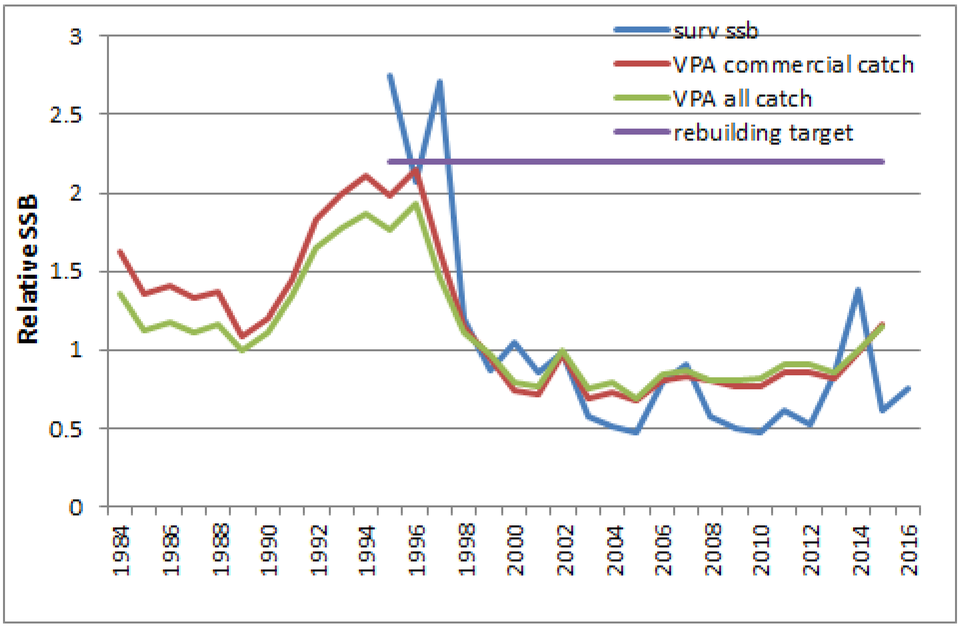


Figure 2.17. Coastal cod. Trends in spawning biomass. Each series are shown relative to its 1995—2016 average. The survey SSB is calculated with the same maturity ogive as in the VPA.

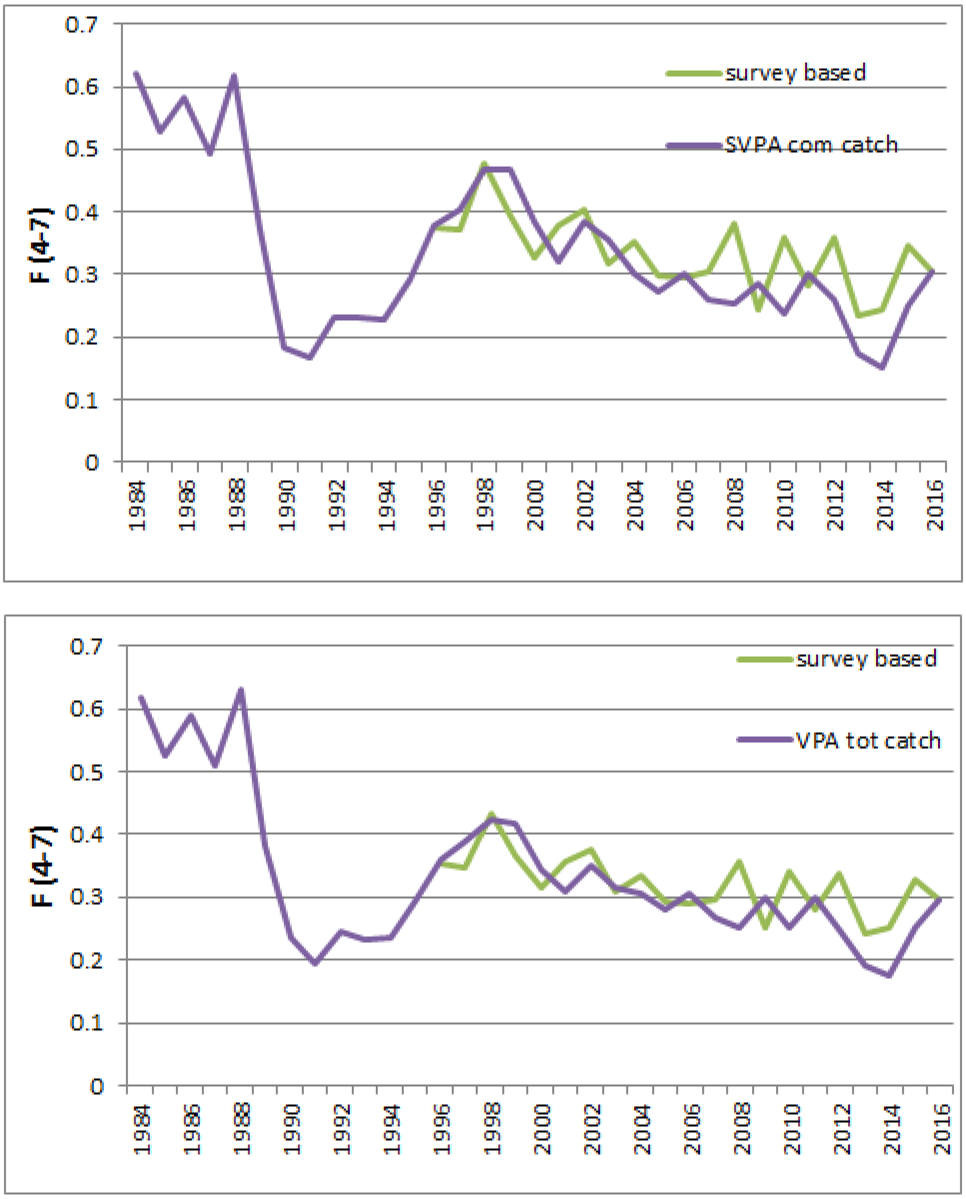


Figure 2.18. Time-series of F-estimates corresponding to commercial catch-at-age (upper) and total catch-at-age (lower). SVPA is in both cases a traditional VPA using the 2016 estimate of survey F as terminal F.

3 North-East Arctic Cod (Subareas 1 and 2)

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 in the last five years and were 849 000 tonnes in 2016. 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 by-catch of undersized fish, closure of areas having high densities of juveniles and by seasonal and area restrictions.

3.1.2 Reported catches prior to 2017 (Tables 3.1-3.4, Figure 3.1)

Reported catch of cod in subarea I and Divisions IIa and IIb:

The provisional catch for 2016 reported to the working group is 849 422 t.

Reported catch figures used for the assessment of North-East Arctic cod:

The historical practice (considering catches between 62ºN and 67ºN for the whole year and catches between 67ºN and 69ºN for the second half of the year to be Norwegian coastal cod) has been used for estimating the Norwegian landings of North-East Arctic cod up to and including 2011 (Table 3.2). The catches of coastal cod calculated this way for the period 1960—2016 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 2012-2016 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 and 2016 is 35.2, 25.7, 33.6, 35.8 and 54.9 thousand tonnes. Table 3.2 includes ECA estimates of coastal cod for the whole period 1984—2016. 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 2016 was similar to 2015. 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.

Updated information about conversion factors between round and gutted weight is given in section 3.12, but this information is not yet ready for use in assessment,

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 2016 and 2017

The Joint Norwegian-Russian Fisheries Commission (JNRFC) agreed on a cod TAC of 894 000 t for 2016, and in addition 21 000 t Norwegian coastal cod. The total reported catch of 904 338 t in 2016 was) 10 662 t below the agreed TAC.

The advice for 2017 given by ACOM in 2016 was 805 000 t based on the agreed harvest control rule with the clause of having catch corresponding to −10% change compared to TAC 2016. The quota established by JNRFC for 2017 was equal to 890 000 tonnes, in accordance with the revised harvest control rule adopted by JNRFC in 2016 (section 3.7.3). In addition, the TAC for Norwegian Coastal Cod was set to the same value for 2017 as for 2016: 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 2011-2016 were presented to the WG this year (WD 17). These 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 2017 are given in Tables A2 and A3. More details on this survey are given in Mehl *et al*. (WD 03). The total area covered was less than in 2016, due to incomplete coverage of the Russian EEZ.

Before 2000 this survey was made without participation from Russian vessels, while in 2001—2005 and 2008—2016 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. Coverage in 2017 was incomplete due to lack of Russian participation. 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 was 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—2016 are reported in Mehl et al. (2013, 2014, 2015, 2016). 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. (2017). Revisions of the acoustic indices from this survey will be available before AFWG 2018. Then the time series for weight at age and maturity at age will 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 2014-2017 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 tuning data might be obtained.

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 2017 survey gave a biomass about two thirds of that estimated in the 2016 survey; 636 thousand tonnes. The concentrations were very dense in some areas.

Russian autumn survey Acronym: RU-BTr-Q4

Abundance estimates from the Russian autumn survey (November-December) are given in Table A9 (acoustic estimates) and Table A10 (bottom trawl estimates). The entire bottom trawl time series was in 2007 revised backwards to 1982 (Golovanov *et al*., 2007, WD3), using the same method as in the revision presented in 2006, which went back to 1994. The new swept area indices reflect Northeast Arctic cod stock dynamics more precisely compared to the previous one - catch per hour trawling. The Russian autumn survey in 2006 was carried out with reduced area coverage. Divisions 2a and 2b were adequately investigated in the survey in contrast to Sub-area 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, however, not conducted in 2016, but may be carried out in 2017.

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 2004-2016 are given in Table A14. This survey covers the entire distribution area of cod. The new index values were calculated at first in 2010 (AFWG 2010, WD 20). This time series have been tested as a new tuning fleet in XSA during the benchmark meeting in 2015 (WKARCT 2015). Benchmark recommended using this index in NEA cod assessment. However, the calculation method for this series is in review.

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 (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.

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 2017 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 0.6). The results of fifteen years of annual comparative age readings are described in Yaragina *et al*. (2009b). 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 2013-2014 exchange was 81.9-85.1% (WD 01 2016). 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. Some decrease in the percentage agreement in 2012-2014 is likely to be connected with more old fish being present in the samples, and reflected the 2012-2014 catch age/length composition. It is observed that the percent agreement between age readers decreases as fish age increases.

The trend with bias in NEA cod age determination registered for some years of the period 1992-2014 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 2016, age compositions from all areas were available from Russia, Spain, Germany (area 2a only), Poland (area 2a only) and Norway. Unsampled catches were distributed on age by using data from Russian trawl in Sub-area 1 and Division 2a, and by using data from Norwegian trawl in Division 2b. The catch at age data was calculated using Intercatch (Table 3.6).

Catch-at-age data have for many years been used until age 13+ but now there are two abundant generations at the stock which become close to plus group and it was decided to increase age range for catch data until age 15+. The data for ages 13, 14 and 15+ were taken from the AFWG 2010 report and in the Intercatch data base for later years. Catch in numbers at age up to 15+ was made available during the IBP meeting.

There is still a concern about the biological sampling from the Norwegian fishery that may have become critically low. In 2016 the sampling was low for trawl catches in coastal areas in ICES area 2a, 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.

Length distributions from the Russian fishery were made by observers onboard fishing vessels in reasonably sufficient quantity in all areas. However, biological sampling from the trawl fishery has been relatively low, especially in Division 2a.

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

Catch weights

For 2016, 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 and Germany (Table 3.7). The weight at age in the catch for all countries is given in Table 3.9. Since the 2000 working group the assessment has applied 13 as plus group. The weight at age 13, 14 and 15 in the catch for 1946-1982, needed for this year assessment due to extended age range, was taken from AFWG 2001 (ICES CM 2001/ACFM:19). For the 2017 assessment, it was decided to use the following procedure for weight at age calculations for 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—2016 (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 acoustic 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.

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—2016.

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 details in Stock Annex.

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

The data on cod cannibalism for the historical period (1946—1983) was included in assessment during the benchmark to make the VPA time series consistent (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. WD07 WKARCT 2015).

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 time 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—2016, 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 2016 were not available as the survey was not conducted. In WD10, correction factors to allow for this when calculating the maturity at age in 2017 were calculated, based on historical differences between Norwegian and Russian data. These correction factors were then applied to the Norwegian data for 2017.

Some Russian data on maturity were sampled in November-December 2016 on board of fishing vessels by observers (1378 sp.). They show lower portions of mature specimens at age in comparison with Norwegian 2017 survey data, especially for ages 7 and 8. These opposite tendencies have to be investigated further.

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 Benchmark and change of assessment model

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) 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. The internal consistency of cohorts was used to determine the upper limit of the age range. One important argument for choosing SAM was better retrospective performance and independence of SAM model of assumption on form of relationship between stock abundance and survey indexes.

3.5 Assessment using SAM (Tables 3.13, A13)

The following survey data series were used:

Fleet code	Name	Place	Season	Age	Years
Fleet 15	Joint bottom trawl survey	Barents Sea	Feb-Mar	4-12	1981-2017
Fleet 16	Joint acoustic survey	Barents Sea+Lofoten	Feb-Mar	4-12	1985-2017
Fleet 18	Russian bottom trawl surv.	Total area	Oct-Dec	3-12	1982-2015
Fleet 007	Ecosystem surv.	Total area	Aug-Sep	3-12	2004-2016

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.

3.5.1 SAM settings (Table 3.14)

The SAM settings, adopted at the IBP (ICES C.M. 2017/ACOM:29), are shown in Table 3.14.

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. 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.

3.6 Results of the assessment

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

The estimated $F_{5\text{-}10}$ in 2016 is 0.334, which is below F_{pa} (Table 3.18). Fishing mortality has been fairly stable since 2008. The spawning stock biomass in 2017 is estimated to be 1,836 kt (Table 3.20), which is high but lower than the peak in 2013 (2,693 kt). One should bear in mind that in the early part of the time series the fraction of mature fish was considerably lower.

Total stock biomass in 2017 is estimated to 2,822 kt which is somewhat above the long-term mean and well below the highest level observed (4,376 kt in 2013).

3.6.2 Recruitment (Table 1.9a)

At the 2008 AFWG meeting it was decided to use a hybrid model, which is an 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; survey data for ages 0, 1 and 2 (Russian autumn survey) and ages 1, 2 and 3 (Joint winter survey), 0-group from the ecosystem survey, capelin biomass, ice coverage, temperature and oxygen saturation at the Kola section, air temperature at the Murman coast. 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 sub-models and includes the RCT3 model (see section 1.4 for details). The numbers at age 3 calculated by the hybrid method were: 566 million for the 2014 year class, 607 million for the 2015 year class and 543 million for the 2016 year class. The Russian autumn survey was not conducted in 2016 so those indices were not available for recruitment prediction in this year.

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 2018 is based on the management rule.

3.7.1 Biomass reference points

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

3.7.2 Fishing mortality reference points

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

3.7.3 Harvest control rule

3.7.3.1 History

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.

"The Parties agreed that the management strategies for cod and haddock should take into account the following:

conditions for high long-term yield from the stocks

achievement of year-to-year stability in TACs

full utilization of all available information on stock development

On this basis, the Parties determined the following decision rules for setting the annual fishing quota (TAC) for Northeast Arctic cod (NEA cod):

estimate the average TAC level for the coming 3 years based on F_{pa}. 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 +/- 10% compared with the previous year's 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_{pa} 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, a year before and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.

A review and discussion of this and other harvest control rule was made by the ICES SGMAS (ICES C. M. 2007/ACFM:04). They discovered that this HCR may give unexpected and possibly unwanted results if the assessment changes much from year to year in a situation when SSB is close to B_{pa}. This problem has, however, so far not been encountered in the application of the HCR.

At the 38th JNRFC meeting, an amendment was made to the rule, and it then read (new text in bold):

"On this basis, the Parties determined the following decision rules for setting the annual fishing quota (TAC) for Northeast Arctic cod (NEA cod):

-estimate the average TAC level for the coming 3 years based on F_{pa}. 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 +/- 10% compared with the previous year's TAC. **If the TAC, by following such a rule, corresponds to a fishing mortality (F) lower than 0.30 the TAC should be increased to a level corresponding to a fishing mortality of 0.30.**

-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_{pa} 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, a year before and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC."

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.

3.7.3.2 Current rule

JNRFC in 2015 asked ICES to explore the consequences of the following 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 new 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} × F_{msy};*
- *if B_{pa} ≤ SSB ≤ 2×B_{pa}, then F_{tr} = F_{msy};*
- *if 2×B_{pa} < SSB < 3×B_{pa}, then F_{tr} = F_{msy} × (1 + 0.5 × (SSB - 2×B_{pa}) / B_{pa});*
- *if SSB ≥ 3×B_{pa}, then F_{tr} = 1.5 × 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 (2017—2020) are given in Table 3.19. For 2017 stock weights and maturity were taken from surveys as described in Sections 3.3.2 and 3.3.4. Russian data for weight and maturity at age in autumn 2016 were not available as the survey was not conducted. In WD10, correction factors to allow for this when calculating the weight and maturity at age in 2017 were calculated, based on historical differences between Norwegian and Russian data. These correction factors were then applied to the Norwegian data for 2017.

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)

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.

Catch weights in 2017 onwards and stock weights in 2018 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. 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.

The maturity ogive for the years 2018—2020 was predicted by using the 2015—2017 average. The exploitation pattern in 2017 and later years was set equal to the previous 3 -years average according to the benchmark decision (WKARCT 2015).

Before the next year's working group, the method for prediction of weight at age in stock and catch and selection pattern for the oldest age groups (10+) should be reviewed, 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 2017 was taken from the final SAM run (Table 3.16) for ages 4 and older. The recruitment at age 3 in the years 2017—2019 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—2016. 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 2017—2019 (based on benchmark decision, WKARCT 2015).

For 2020, the 2019 values were used for all input data, except for recruitment, where the long-term arithmetic mean (748 million at age 3) was used.

The assessment shows a stable F from 2009 to 2016. The fishing effort also was relatively stable (Figure 3.6) at the same time but shows an increase in 2014-2015 which is not reflected in the fishing mortality. In accordance to the benchmark decision (WKARCT 2015) the last year's assessment F in terminal year 2016 is considered to be used for F in the intermediate year (2017). Table 3.19 shows input data to the predictions.

Results of prediction show that the catch in 2017 predicted using F_{sq} is 23 % less than the agreed TAC. The previous decision to use F_{sq} was based on the observation that it gives more correct prediction of TSB in the beginning of TAC year (ICES CM 2013/ACFM:05) and was adopted by the benchmark in 2015. This conclusion is not necessarily valid when SAM used as assessment model and a further research is needed on that issue.

3.8.2 Prediction results (Tables 3.20 – 3.21)

The catches corresponding to F_{sq} in 2017 is 688 kt (Table 3.20). This is well below the TAC for 2017 (890 kt). The resulting SSB in 2018 is 1,505 kt, lower than in 2017 but still at a high level. Table 3.20 shows the short-term consequences over a range of F-values in 2018. The detailed outputs corresponding to F_{sq} in 2017 and the F corresponding to the HCR and F_{pa} in 2018 is given in Table 3.21. Summarised results are shown in the text table below.

Since SSB in 2018 is above 3*Bpa=1380 kt, F=0.60 is used in the 3-year prediction, giving catches of 900, 651 and 553 kt in 2018, 2019 and 2020, respectively. The average of this is 701 kt. However, the limit of 20% annual change in catch in the HCR from year to year applies in this case and gives 712 kt (20% reduction from 890 kt).

Rationale	Catches (2018)	Basis	F (2018)	SSB (2019)	%SSB change*)	%TAC change**)
Management plan	712	FMP (HCR)	0.44	1187	-21	-20
MSY approach/ Precautionary Limits	654	FMSY / Fpa	0.40	1238	-18	-27
Zero catch	0	0	0	1837	+22	-100

Flim	1048	Flim	0.74	898	-40	+18
Status quo	562	Fsq	0.33	1320	-12	-37

Weights in '000 t.

***) SSB 2019 relative to SSB 2018.**

****) Catch 2018 relative to TAC 2017.**

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 compares this year's estimates with last year's estimates (both to the XSA assessment made by ACOM and used as a basis for the advice, and the XSA AFWG assessment) for the year 2016 of numbers at age (millions), total biomass, spawning biomass (thousand tonnes), as well as reference F for the year 2015.

AFWG 2016

		N(2016)												
Assessment year (specification)	F(2015)	age3	age4	age5	age6	age7	age8	age9	age10	age11	age12	TSB (2016)	SSB (2016)	F (2016)
2016 WG	0.269	766*	377	533	302	187	104	42	60	58	30	3974	1911	0.269**
2017 WG	0.32	180	220	310	188	127	80	47	65	50	19	3035	1770	0.334
Ratio 2017 WG/ 2016 WG	1.19	0.24	0.58	0.58	0.62	0.68	0.77	1.13	1.09	0.86	0.61	0.76	0.93	1.24

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

ACOM 2016

		N(2016)												
Assessment year (specification)	F(2015)	age3	age4	age5	age6	age7	age8	age9	age10	age11	age12	TSB (2016)	SSB (2016)	F (2016)
2016 WG SALY	0.3855	766*	374	470	274	171	92	37	38	19	7	2947	1070	0.3855**
2017 WG	0.32	180	220	310	188	127	80	47	65	50	19	3035	1770	0.334
Ratio 2017 WG/ 2016 WG	0.83	0.24	0.59	0.66	0.69	0.74	0.87	1.28	1.73	2.63	2.56	1.03	1.65	0.87

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

The number at age in 2016 from this year's assessment for ages 3-8 are well below both assessment last year. For ages 9-12 last year's AFWG assessment corresponds reasonably well with this year's assessment while last year's ACOM assessment is much lower than this year's assessment.

3.10 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.

3.10.1 XSA

Same settings as last year, now with but with catchability dependent on stock size for all ages and considerably extended tuning age range compared to last year. The model is run for ages 3-13+, while other models are runs for 3-15+.

3.10.2 TISVPA (Tables 3.22–3.24)

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 North-East 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 XSA runs. During AFWG 2017 the results of exploratory runs using the TISVPA model were presented and discussed (WD#19). The results generally support the results of SAM model giving an estimate of SSB in 2017 of about 2 million tonnes.

3.10.3 Model comparisons

Figure 3.7 compares the results of SAM, XSA and TISVPA, showing F, SSB, TSB and recruitment. F and TSB is very similar for all models. SSB in recent years is quite a bit lower in XSA than in the two other models, while recruitment in recent years is considerably lower in SAM than in the two other models.

3.11 Comments to the assessment

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

For several surveys, adjustments were made for the last data year due to incomplete spatial coverage. Also for one survey there was incomplete area coverage and missing surveys in the last year. The Russian bottom trawl survey in October–December (RU-BTr-Q4) was not carried out in 2016.

The assessment model was changed from XSA to SAM this year following an InterBenchmark meeting in April 2017 (ICES C. M. 2017/ACOM:29). Also there was a change in the recruitment model. These changes led to a considerable downwards adjustment of the 2008 and later cohorts while the abundance of the 2007 and older cohorts was revised upwards.

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—2016 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 (Table 3.25, 3.26) is ongoing but new data were not available in time for AFWG 2017. 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 by-catch in the Norwegian shrimp fishery by cod age (previously this has been given by cod length). The by-catch 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, by-catches of age 3 and older fish are negligible, because use of sorting grids was made mandatory. However, in 1985, by-catches of age 5 and 6 cod were about one third of the reported catches for those age groups. The year class for which the by-catches were highest, was the 1983 year class (total by-catch of age 2 and older fish of about 60 million, compared to a stock estimate of about 1000 million at age 3).

3.12.3 Conversion factors

Until 1989-1990, Norway used seasonal conversion factors (weight) between headed+gutted fish and round fish of 1.6 during winter and 1.4 the rest of the year. This factor was set to 1.50 in Norwegian fishery from 1992 onwards and this factor was also agreed by JNRFC from 2000 onwards so it is now constant for all fisheries at all times of year although in reality there is a larger factor in winter season when the fishery is dominated by mature fish with gonads. In recent years a larger proportion of the total fishery in this period is on cod > 70 cm which has higher conversion factor than smaller cod (WD 15).

In January-April 2015 investigations on conversion factors were made in Norwegian fisheries with all gears along the Norwegian coast and also up to Bear Island (WD 15). In total 332 samples of 10 fish/50kg were taken. The final weighted conversion factors were 1.31 and 1.67 for the products gutted with head and gutted without head (round cut), respectively.

These conversion factors are significantly higher (11-12%) than the official factors for these products at 1.18 and 1.50. Investigations made at other times of the year indicate that for ocean-going fleets (trawl and autoline) the conversion factor is below 1.5 for the rest of the year and that an overall conversion factor of 1.5 for these fleets seems appropriate. However, if the conversion factors given in WD 15 for cod had been used for cod caught with coastal fishing gears in the winter season, the quantity fished within this fleet segment would have been in the order of 20 000 tonnes higher per year than that indicated by the official fisheries statistics for the years 2012-2014. For these gears the fishery in the rest of the year in small compared to the January-April fishery and thus this will not be compensated by the conversion factor used for the rest of the year, as is the case for trawl and autoline.

Table 3.1 North-East Arctic COD. Total catch (t) by fishing areas and unreported catch

YEAR		SUB-AREA 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
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

YEAR		SUB-AREA 1	DIVISION 2.A	DIVISION 2.B	UNREPORTED CATCHES	TOTAL CATCH
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	1	321 347	351 468	176 607		849 422

Data provided by Working Group members

1 Provisional figures

Table 3.2. Landings of Norwegian Coastal Cod in Sub-areas 1 and 2, 10^3 tons

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
v1960–70			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
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	35.2
2013	22.5	30.1	16.8	25.7
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

'Table 3.3 North-East Arctic COD. Total nominal catch ('000 t) by trawl and other gear for each

	Sub-area 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
	Sub-area 1		Division 2.a		Division 2.b	
Year	Trawl	Others	Trawl	Others	Trawl	Others
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 [1]	285.5	35.8	181.7	169.8	156.3	20.3

Data provided by Working Group members

[1] **Provisional figures**

Table 3.4 North-East Arctic COD. Nominal catch(t) by countries. (Sub-area I and Divsions IIa and IIb combined, data provided by Working group members

Table 3.4 North-East Arctic COD. Nominal catch (t) by countries
(Sub-area I and Divisions IIa and IIb 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	7065	6 427	377 983	19905	11778	381 188	16120	9 880	864 384
2016 [1]	24084	7946	8607	6 336	348 949	14640	13583	394 107	16031	15 139	849 422

[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

Table 3.6. Northeast Arctic cod. Catch numbers-at-age (Thous)

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
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

YEAR_ AGE	3	4	5	6	7	8	9	10	11	12	13	14	+GP	TOTALNUM
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
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

Table 3.7. North-east 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	7.7	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	0.3	0.67	1.34	2.04	3.14	4.6	5.78	6.7	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	12.5	13.75	15.12	10.43	19.95
1988	0.36	0.56	0.83	1.31	2.34	3.84	6.5	8.76	9.97	11.06	14.43	19.02	12.89	10.16
1989	0.53	0.75	0.9	1.17	1.95	3.2	4.88	7.82	9.4	11.52	11.47		19.47	14.68
1990	0.4	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		14.17	16.63
1992	0.41	1.1	1.79	2.45	3.22	4.33	5.27	6.21	8.1	10.51	11.59		15.81	6.52
1993	0.3	0.83	1.7	2.41	3.35	4.27	5.45	6.28	7.1	7.82	10.1	16.03	19.51	17.68
1994	0.3	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	2.8	4.12	5.15	5.96	7.9	8.67	9.2	11.53	17.77	21.11
1996	0.29	0.9	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	8.3	11.15	8.64	12.8	
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	2.4	3.12	4.26	6	6.52	10.64	14.05	12.67	9.2	17.22
2000	0.31	0.65	1.23	1.8	2.54	3.58	4.49	5.71	7.54	7.86	12.71	14.71	15.4	20.26
2001	0.3	0.77	1.18	1.83	2.75	3.64	4.88	5.93	7.43	8.9	10.22	11.11	13.03	18.85
2002	0.31	0.9	1.4	1.9	2.6	3.55	4.6	5.8	7.4	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	7.9	8.66	12.21	14.02	16.5	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	1.7	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	1.7	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	2.1	2.83	3.9	5.06	5.76	7.31	7.79	7.81	10.68	11.83	14.76
2010	0.55	0.95	1.46	2.06	2.93	4.02	5.4	6.44	7.19	8.43	9.11	10.46	11.39	15.55
2011	0.53	1.09	1.5	2.06	2.85	3.7	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	1.4	2	2.64	3.44	4.51	5.67	7.29	8.8	10.33	11.38	12.56	
2014	0.59	1.07	1.55	2.15	2.8	3.7	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	3.3	4.13	5.49	6.46	7.18	8.63	10.37	12.24	14.6
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

Table 3.7. North-east 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			
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
Germany (Division IIa and IIb)														
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
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

[1] Division IIa only
[2] IIa and IIb combined
[3] I,IIa and IIb combined
[4] Division IIb only

Table 3.7. North-east Arctic COD. Weights at age (kg) in landings from various countries (continued)

Spain (Division IIb)															
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
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				
1	IIa and IIb combined														
2	I,IIa and IIb combined														
3	I and IIb combined														
Iceland (Sub-area I)															
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)															
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	Division IIa and IIb													
	2	Division IIa													
Poland (Division IIb)															
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
	1	Division IIa													

Table 3.8. Northeast Arctic COD. Catch weights at age (kg)

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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
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
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

Table 3.9. Northeast Arctic COD. Stock weights at age (kg)

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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	8.146	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
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	12.62	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	12.62	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	12.62	14.544	16.466	18.388
1986	0.311	0.88	1.47	2.467	3.915	5.81	6.58	6.833	11.004	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	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	12.62	14.544	16.466	18.388
2015	0.231	0.546	1.165	1.938	2.853	3.946	5.258	6.821	8.957	12.62	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	12.62	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	12.62	14.544	16.466	18.388

Table 3.10. North-East 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
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

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

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

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
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

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
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

SAM

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Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
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
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

SAM

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YEAR_AGE	3	4	5	6	7	8	9	10	11	12	13	14	+GP
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

Table 3.12. Northeast Arctic COD. Total number of cod (thousands) consumed by cod, by year and prey age group.

	3	4	5	6
1984	82	0	0	0
1985	96	0	0	0
1986	60127	0	0	0
1987	12136	0	0	0
1988	1834	0	0	0
1989	0	0	0	0
1990	0	0	0	0
1991	614	0	0	0
1992	4403	0	0	0
1993	42339	765	198	0
1994	110113	37403	4836	206
1995	176300	55428	1810	66
1996	102583	34894	9344	292
1997	129450	9720	405	16
1998	167211	14397	478	66
1999	29470	3559	4	0
2000	28808	4614	581	6
2001	17090	7662	1219	1010
2002	29922	2535	244	2
2003	26142	0	0	0
2004	12635	5219	1483	253
2005	44737	3583	1763	101
2006	2804	382	14	0
2007	63007	3492	132	0
2008	81411	18767	1127	0
2009	71007	24319	5998	270
2010	47382	30987	21434	2860
2011	156407	40474	7575	837
2012	108306	50733	8753	0
2013	185398	19182	7980	1407
2014	192053	62978	6522	80
2015	75495	52889	22815	2249
2016	6517	20904	43222	10372

Table 3.13. North-East Arctic COD. Tuning data

North-East	Arctic	cod	(Sub-areas	I	and	II)			
104									
FLT15:	NorBarTrSur								
1981	2017								
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	2830	2140	1170	410	40	10	NA	NA	NA
1	12600	1990	770	330	20	10	NA	NA	NA
1	14390	6410	830	190	30	NA	NA	NA	NA
1	39110	5430	1570	200	50	NA	NA	NA	NA
1	8050	17330	2050	360	50	NA	NA	NA	NA
1	7590	3780	9020	980	90	10	NA	NA	NA
1	3490	3460	2060	2720	160	40	NA	NA	NA
1	3370	2570	2150	1220	1270	60	NA	NA	NA
1	5770	1780	1280	770	430	270	NA	NA	NA
1	14010	7250	1580	620	390	220	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	3990	4870	5660	2780	1890	763	301	222	349
FLT16:	NorBarLofAcSur								
1985	2017								
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

Table 3.13. North-East Arctic COD. Tuning data (continued)

FLT18:	RusSweptArea									
1982	2016									
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
FLT007:	Ecosystem									
2004	2016									
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

Table 3.14 –SAM parameter settings

```
# 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
(  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
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Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
1946	0.002	0.018	0.068	0.139	0.243	0.215	0.3	0.31	0.438	0.404	0.406	0.438	0.438	0.213
1947	0.002	0.02	0.086	0.195	0.361	0.32	0.449	0.479	0.721	0.681	0.704	0.787	0.787	0.315
1948	0.001	0.016	0.077	0.19	0.363	0.328	0.449	0.474	0.716	0.721	0.782	0.952	0.952	0.314
1949	0.002	0.028	0.122	0.268	0.438	0.373	0.474	0.506	0.755	0.759	0.818	1.038	1.038	0.364
1950	0.003	0.039	0.144	0.279	0.415	0.368	0.485	0.56	0.852	0.895	0.934	1.233	1.233	0.375
1951	0.009	0.086	0.249	0.381	0.472	0.399	0.496	0.562	0.787	0.841	0.89	1.196	1.196	0.426
1952	0.014	0.123	0.326	0.475	0.539	0.47	0.592	0.719	0.999	1.064	1.077	1.409	1.409	0.52
1953	0.015	0.115	0.27	0.373	0.4	0.353	0.437	0.539	0.713	0.725	0.713	0.895	0.895	0.395
1954	0.015	0.112	0.27	0.386	0.413	0.373	0.46	0.596	0.772	0.775	0.743	0.869	0.869	0.416
1955	0.015	0.111	0.292	0.463	0.51	0.486	0.56	0.7	0.89	0.871	0.79	0.849	0.849	0.502
1956	0.02	0.139	0.362	0.582	0.634	0.612	0.668	0.822	1.04	1.099	0.959	0.921	0.921	0.613
1957	0.02	0.131	0.31	0.484	0.531	0.533	0.574	0.716	0.903	0.933	0.826	0.748	0.748	0.525
1958	0.029	0.185	0.392	0.534	0.53	0.511	0.538	0.658	0.767	0.741	0.594	0.523	0.523	0.527
1959	0.033	0.202	0.421	0.535	0.517	0.508	0.544	0.666	0.74	0.701	0.597	0.547	0.547	0.532
1960	0.032	0.197	0.405	0.496	0.473	0.487	0.534	0.68	0.788	0.741	0.661	0.645	0.645	0.512
1961	0.037	0.235	0.509	0.619	0.581	0.618	0.702	0.851	0.959	0.909	0.828	0.781	0.781	0.647
1962	0.038	0.257	0.61	0.766	0.699	0.716	0.81	0.946	0.967	0.846	0.787	0.713	0.713	0.758
1963	0.032	0.224	0.596	0.826	0.824	0.876	0.992	1.13	1.158	0.936	0.869	0.749	0.749	0.874
1964	0.022	0.148	0.383	0.541	0.594	0.712	0.872	0.95	1.002	0.903	0.983	0.844	0.844	0.675
1965	0.022	0.133	0.319	0.428	0.473	0.588	0.738	0.783	0.776	0.71	0.905	0.822	0.822	0.555
1966	0.025	0.131	0.283	0.369	0.429	0.553	0.695	0.706	0.654	0.571	0.689	0.609	0.609	0.506
1967	0.026	0.135	0.277	0.35	0.428	0.591	0.777	0.797	0.75	0.627	0.723	0.574	0.574	0.537
1968	0.029	0.159	0.34	0.421	0.482	0.632	0.805	0.791	0.726	0.592	0.74	0.608	0.608	0.578
1969	0.035	0.183	0.416	0.543	0.652	0.86	1.07	1.018	0.912	0.688	0.78	0.618	0.618	0.76
1970	0.036	0.166	0.364	0.485	0.601	0.826	0.995	0.912	0.776	0.564	0.649	0.548	0.548	0.697
1971	0.032	0.128	0.261	0.342	0.455	0.704	0.908	0.84	0.732	0.531	0.588	0.491	0.491	0.585
1972	0.051	0.175	0.32	0.389	0.477	0.772	1.095	1.092	1.014	0.747	0.823	0.648	0.648	0.691
1973	0.088	0.255	0.404	0.436	0.462	0.642	0.856	0.845	0.807	0.613	0.672	0.527	0.527	0.607
1974	0.12	0.336	0.516	0.537	0.521	0.627	0.76	0.848	0.959	0.792	0.932	0.674	0.674	0.635
1975	0.106	0.301	0.508	0.582	0.59	0.678	0.733	0.72	0.885	0.768	0.871	0.592	0.592	0.635
1976	0.119	0.336	0.553	0.635	0.648	0.738	0.756	0.623	0.687	0.639	0.756	0.597	0.597	0.659
1977	0.125	0.382	0.654	0.754	0.77	0.891	0.974	0.793	0.829	0.726	0.935	0.833	0.833	0.806
1978	0.1	0.32	0.624	0.816	0.871	1.051	1.279	1.189	1.437	1.297	1.603	1.44	1.44	0.972
1979	0.056	0.194	0.411	0.62	0.708	0.838	1.058	1.052	1.282	1.234	1.519	1.732	1.732	0.781
1980	0.039	0.147	0.345	0.6	0.745	0.867	1.031	1.07	1.256	1.178	1.385	1.676	1.676	0.776
1981	0.032	0.127	0.308	0.588	0.793	0.935	1.024	0.939	1.014	0.904	0.852	0.877	0.877	0.764
1982	0.038	0.156	0.366	0.71	0.945	1.02	1.006	0.844	0.826	0.837	0.737	0.86	0.86	0.815
1983	0.03	0.137	0.329	0.624	0.927	1.04	0.959	0.783	0.697	0.692	0.651	0.885	0.885	0.777
1984	0.029	0.141	0.361	0.693	1.095	1.213	1.064	0.902	0.753	0.69	0.566	0.857	0.857	0.888
1985	0.035	0.162	0.4	0.716	0.981	1.078	0.849	0.711	0.614	0.534	0.408	0.735	0.735	0.789
1986	0.038	0.185	0.479	0.815	1.004	1.16	0.983	0.975	0.918	0.852	0.53	1.001	1.001	0.903
1987	0.042	0.199	0.534	0.916	1.094	1.214	1.097	1.248	1.316	1.335	0.744	1.469	1.469	1.017
1988	0.033	0.15	0.386	0.712	0.979	1.113	1.111	1.411	1.434	1.543	0.769	1.386	1.386	0.952
1989	0.024	0.108	0.261	0.481	0.667	0.803	0.761	0.921	0.919	0.978	0.542	1.339	1.339	0.649
1990	0.015	0.067	0.154	0.267	0.361	0.44	0.451	0.534	0.605	0.738	0.479	1.234	1.234	0.368
1991	0.016	0.078	0.178	0.29	0.352	0.376	0.356	0.345	0.337	0.392	0.266	0.829	0.829	0.316
1992	0.02	0.112	0.266	0.431	0.505	0.52	0.503	0.463	0.448	0.518	0.374	1.182	1.182	0.448
1993	0.016	0.105	0.29	0.506	0.621	0.661	0.701	0.68	0.724	0.849	0.706	1.819	1.819	0.577
1994	0.016	0.113	0.344	0.662	0.874	0.941	0.989	0.965	1.054	1.255	1.225	3.142	3.142	0.796
1995	0.016	0.115	0.343	0.636	0.845	0.921	0.967	0.961	1.007	1.143	1.29	3.332	3.332	0.779

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
1996	0.019	0.136	0.382	0.644	0.791	0.915	0.903	0.949	0.967	1.11	1.172	2.797	2.797	0.764
1997	0.024	0.187	0.504	0.775	0.905	1.127	1.173	1.182	1.14	1.188	0.952	1.328	1.328	0.944
1998	0.026	0.21	0.546	0.804	0.874	1.095	1.17	1.27	1.118	1.179	0.872	0.924	0.924	0.96
1999	0.019	0.166	0.491	0.756	0.883	1.106	1.226	1.293	1.079	1.16	0.867	0.808	0.808	0.959
2000	0.012	0.112	0.359	0.608	0.779	0.98	1.078	1.129	0.844	0.883	0.572	0.589	0.589	0.822
2001	0.01	0.091	0.292	0.526	0.712	0.862	0.89	0.954	0.708	0.726	0.513	0.74	0.74	0.706
2002	0.009	0.085	0.273	0.501	0.712	0.836	0.796	0.799	0.598	0.619	0.421	0.688	0.688	0.653
2003	0.01	0.085	0.259	0.449	0.647	0.736	0.684	0.657	0.47	0.435	0.271	0.405	0.405	0.572
2004	0.011	0.094	0.287	0.502	0.775	0.929	0.898	0.89	0.649	0.535	0.281	0.358	0.358	0.714
2005	0.013	0.11	0.315	0.506	0.757	0.923	0.907	0.869	0.66	0.549	0.271	0.307	0.307	0.713
2006	0.015	0.115	0.299	0.453	0.645	0.806	0.846	0.852	0.754	0.727	0.431	0.521	0.521	0.65
2007	0.014	0.097	0.24	0.334	0.446	0.527	0.551	0.563	0.558	0.569	0.348	0.373	0.373	0.443
2008	0.009	0.062	0.153	0.229	0.317	0.376	0.396	0.407	0.437	0.447	0.278	0.252	0.252	0.313
2009	0.008	0.049	0.118	0.181	0.263	0.32	0.352	0.37	0.433	0.473	0.298	0.219	0.219	0.267
2010	0.006	0.04	0.098	0.156	0.243	0.331	0.376	0.43	0.511	0.504	0.351	0.22	0.22	0.272
2011	0.006	0.036	0.089	0.142	0.223	0.322	0.375	0.423	0.446	0.369	0.247	0.133	0.133	0.262
2012	0.006	0.038	0.092	0.139	0.201	0.282	0.333	0.377	0.38	0.296	0.198	0.109	0.109	0.237
2013	0.007	0.044	0.108	0.165	0.226	0.307	0.365	0.422	0.407	0.299	0.197	0.118	0.118	0.266
2014	0.01	0.058	0.143	0.215	0.27	0.33	0.371	0.444	0.427	0.305	0.191	0.116	0.116	0.296
2015	0.012	0.073	0.177	0.266	0.306	0.343	0.367	0.462	0.483	0.337	0.197	0.117	0.117	0.32
2016	0.012	0.074	0.184	0.283	0.324	0.357	0.377	0.479	0.498	0.355	0.208	0.122	0.122	0.334
FBAR	0.011	0.069	0.168	0.255	0.3	0.343	0.372	0.462	0.469	0.332	0.199	0.118		

Table 3.16. Northeast Arctic COD Stock number at age (Thous)

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Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTAL
1946	1E+06	681266	383964	180672	85064	89689	241808	85649	36540	32420	18290	8032	2546	3267077
1947	619634	822876	495009	292224	132518	55810	59406	145897	50926	19663	17784	10003	5849	2727600
1948	407762	359450	554453	353833	198727	75882	34157	31126	74131	19459	8256	7122	6016	2130374
1949	578565	274719	268630	396935	234867	109923	44360	17747	16064	30216	7563	3102	4094	1986783
1950	877601	375721	221944	191026	236283	120377	60524	22797	8857	6191	11956	2686	2083	2138046
1951	2E+06	676046	291574	170046	117671	123696	67120	30089	10723	3034	2025	3965	1116	3958950
1952	2E+06	1E+06	417404	179099	104466	60315	66541	32986	14034	4131	1077	673	1258	4357464
1953	3E+06	1E+06	665240	232822	90081	53431	30994	29889	12959	4216	1158	303	375	4807879
1954	849884	1E+06	703177	399904	132385	49834	32341	16353	14288	5165	1692	469	227	3660989
1955	389185	557117	963665	425958	224405	72383	29261	17426	7156	5439	1952	659	239	2694846
1956	744525	251309	386615	563726	213428	110953	36032	13959	7244	2317	1917	737	314	2333077
1957	1E+06	406010	155165	211269	248456	90737	48966	15075	5102	2166	599	606	345	2600223
1958	1E+06	701427	246282	92007	106405	116275	42014	22712	6098	1691	720	200	372	2367508
1959	1E+06	541907	423025	135533	44891	51435	56633	19772	9638	2319	638	342	281	2611095
1960	1E+06	626455	286280	216046	66443	21996	25579	26494	8121	3861	950	279	310	2762955
1961	2E+06	701292	346457	147552	108918	34617	10996	12820	10853	2917	1547	413	248	2906212
1962	1E+06	797043	383723	163163	65724	51157	15283	4368	4679	3403	923	559	245	2740667
1963	840775	707446	443069	161848	60840	27225	21201	5556	1343	1524	1206	336	324	2272693
1964	484574	386134	371416	183628	55711	21100	9334	6696	1448	327	501	430	258	1521557
1965	906560	263119	244789	201636	86650	24624	8259	3133	2220	433	103	152	250	1741928
1966	2E+06	585651	179529	144189	107701	44542	11168	3185	1158	871	182	32	141	2978013
1967	1E+06	1E+06	407076	114023	81924	56909	20979	4556	1268	504	412	79	72	3240998
1968	186558	957910	888789	263272	71336	43830	25349	7819	1677	476	216	165	73	2447470
1969	111271	143449	658036	498681	143867	38801	19436	9230	2898	677	221	81	107	1626755
1970	213799	88542	95573	343625	230321	60787	14002	5473	2735	932	274	84	83	1056231
1971	389156	152596	61329	52895	164879	100213	21538	4368	1791	1044	442	117	78	950445
1972	992424	300486	109938	39860	31526	80813	38848	7009	1579	710	505	209	97	1604006
1973	2E+06	702455	203316	65640	22811	17047	29311	10261	1884	465	276	179	133	2917002
1974	641881	1E+06	463658	113810	35394	12225	7710	9541	3554	701	204	122	150	2613059
1975	598663	428190	726683	230519	55328	17620	5669	3246	3089	1092	268	63	115	2070544
1976	611097	434650	256648	341005	104462	24719	7353	2374	1420	948	403	89	86	1785253
1977	373265	423825	258325	122836	144972	44083	9345	2799	1119	653	369	156	81	1381828
1978	629293	249012	220698	108945	48885	54743	14623	2771	1017	427	293	113	84	1330904
1979	213022	451013	148093	91455	39189	17353	15670	3305	692	189	97	47	39	980164
1980	129637	164513	302033	81098	39017	15839	6434	4375	949	159	44	18	12	744129
1981	159337	101710	119342	173450	36039	14792	5546	1986	1181	220	42	9	4	613657
1982	174522	131037	82254	63840	79105	13794	4666	1618	660	328	74	14	5	551917
1983	155637	129394	93810	48702	25572	24798	4175	1403	583	238	109	30	7	484457
1984	412323	122560	85184	55612	21762	8559	7186	1249	531	248	103	43	13	715372
1985	557902	363909	82920	45612	24008	5432	2190	2071	392	206	102	49	19	1084814
1986	1E+06	435400	247145	43887	18690	7085	1451	813	857	180	99	56	26	1871117
1987	328128	971014	263884	105181	14998	6091	1715	490	245	285	63	49	25	1692168
1988	298195	242030	627461	116097	29732	4455	1490	470	122	54	60	25	13	1320204
1989	187904	222546	153697	346576	49593	8599	1319	402	90	25	9	21	9	970788
1990	153907	146362	144242	105774	166517	20831	2960	539	126	29	8	5	6	741304

1991	392367	132748	108277	98881	67091	95377	11187	1536	268	53	11	3	3	907802
1992	729437	313827	106050	75808	57444	38160	53209	6542	956	163	29	7	2	1381634
1993	919650	527778	250277	70756	37917	28184	17660	27518	3347	528	80	18	2	1883716
1994	727595	713965	394955	147013	35248	16782	11844	7166	11629	1340	183	31	3	2067754
1995	495919	495879	524195	221958	57366	12165	5362	3553	2271	3482	303	43	1	1822499
1996	407919	294641	330885	293781	97302	19074	4195	1599	1104	649	1033	66	1	1452248
1997	667174	222861	201230	178516	121222	37390	5886	1540	512	332	181	291	3	1437138
1998	951011	435255	127908	95329	70121	41783	9961	1445	399	127	80	57	69	1733546
1999	541276	576427	250585	59318	32866	25969	11538	2609	320	106	30	27	45	1501117
2000	669000	395347	373576	115678	23015	11293	7126	2649	622	89	27	9	28	1598460
2001	548496	525180	292583	183093	50824	8864	3493	1922	690	228	28	13	18	1615432
2002	406016	417303	373979	188318	81722	20183	3149	1206	616	268	95	13	12	1492880
2003	686290	301112	295242	246488	86890	32625	6999	1187	446	301	112	55	9	1657757
2004	245683	559406	210202	191671	124256	36818	12786	2869	502	249	173	68	34	1384718
2005	622294	188110	398464	133267	99490	42515	11827	4320	922	211	122	116	57	1501715
2006	537053	454839	135092	234950	70818	36961	13852	3819	1465	415	96	80	121	1489562
2007	1E+06	447889	292363	86289	126371	31685	13203	4613	1326	594	168	50	98	2400836
2008	1E+06	1E+06	360432	163610	52978	68190	16223	6155	2059	671	258	100	81	2937088
2009	691126	910150	839439	262677	94122	36633	35617	9222	3443	1124	354	155	115	2884179
2010	283196	521581	730981	634912	185663	59253	22114	18977	5559	1961	526	219	179	2465122
2011	467808	215316	440695	601242	452601	98442	35751	12420	9901	2635	1099	269	259	2338439
2012	538425	323772	169229	351240	467631	268335	54161	19933	6768	5095	1522	735	371	2207217
2013	589602	368262	236250	143804	268006	317068	162209	29519	11306	3813	3073	1014	867	2134793
2014	659968	392039	282808	184993	111460	190734	185242	83583	15263	6047	2251	2072	1390	2117849
2015	353296	428564	287370	196191	133710	74480	117021	99593	39922	8337	3560	1503	2526	1746074
2016	180347	220220	309500	188451	126679	80049	47361	65073	50025	18666	4897	2393	2938	1296598
2017		135152	152241	191916	102929	78257	45962	27239	31446	25510	10721	3257	3863	988840

Table 3.17 Northeast Arctic COD. Natural mortality used in final run

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Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1946	0.49	0.304	0.226	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1947	0.544	0.325	0.231	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1948	0.493	0.305	0.226	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1949	0.434	0.282	0.221	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1950	0.316	0.236	0.21	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1951	0.724	0.394	0.247	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1952	0.715	0.391	0.246	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1953	0.537	0.322	0.23	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1954	0.388	0.264	0.217	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1955	0.406	0.271	0.218	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1956	0.59	0.343	0.235	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1957	0.725	0.395	0.247	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1958	0.562	0.332	0.233	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1959	0.713	0.39	0.246	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1960	0.704	0.387	0.245	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1961	0.609	0.35	0.237	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1962	0.52	0.315	0.229	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1963	0.788	0.419	0.253	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1964	0.603	0.348	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1965	0.416	0.275	0.219	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1966	0.353	0.251	0.214	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1967	0.271	0.219	0.206	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1968	0.224	0.201	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	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1970	0.293	0.227	0.208	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1971	0.256	0.213	0.205	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1972	0.323	0.239	0.211	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1973	0.217	0.2	0.201	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1974	0.217	0.2	0.201	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1975	0.232	0.204	0.203	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1976	0.224	0.2	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1977	0.249	0.21	0.204	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1978	0.234	0.205	0.203	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1979	0.208	0.2	0.201	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	0.203	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1984	0.2	0.208	0.213	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1985	0.204	0.214	0.213	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1986	0.249	0.22	0.259	0.228	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.244	0.208	0.218	0.265	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.214	0.204	0.208	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.201	0.217	0.2	0.218	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.2	0.202	0.207	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

1991	0.201	0.2	0.201	0.212	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.209	0.2	0.2	0.219	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.244	0.2	0.214	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.342	0.252	0.217	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.52	0.31	0.214	0.201	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.508	0.317	0.228	0.219	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.421	0.27	0.218	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1998	0.427	0.263	0.209	0.229	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.259	0.228	0.226	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.246	0.208	0.245	0.208	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2001	0.236	0.216	0.2	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.282	0.208	0.2	0.224	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2003	0.24	0.201	0.2	0.212	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.252	0.212	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.3	0.214	0.203	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2006	0.203	0.23	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2007	0.244	0.2	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2008	0.257	0.211	0.2	0.223	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2009	0.282	0.213	0.201	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.302	0.243	0.211	0.203	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.437	0.327	0.207	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2012	0.39	0.331	0.225	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2013	0.434	0.249	0.218	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2014	0.428	0.333	0.22	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2015	0.419	0.295	0.274	0.206	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2016	0.242	0.304	0.341	0.277	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
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2017

Year	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
1946	1421137	4199329	990981	706000	0.712	0.213
1947	619634	3643420	1021872	882017	0.863	0.315
1948	407762	3525344	836996	774295	0.925	0.314
1949	578565	3005054	624616	800122	1.281	0.364
1950	877601	2830029	561981	731982	1.303	0.375
1951	2461844	3650535	510901	827180	1.619	0.426
1952	2322345	4049225	499119	876795	1.757	0.52
1953	2579157	4124472	395821	695546	1.757	0.395
1954	849884	4260045	409596	826021	2.017	0.416
1955	389185	3565418	331508	1147841	3.463	0.502
1956	744525	3334255	284260	1343068	4.725	0.613
1957	1415728	2817100	206864	792557	3.831	0.525
1958	1031305	2415777	204204	769313	3.767	0.527
1959	1324681	2762503	442805	744607	1.682	0.532
1960	1480139	2421738	402759	622042	1.545	0.512
1961	1527582	2397938	406019	783221	1.929	0.647
1962	1250396	2165071	320176	909266	2.84	0.758
1963	840775	1960996	214506	776337	3.619	0.874
1964	484574	1499088	192073	437695	2.279	0.675
1965	906560	1473069	106493	444930	4.178	0.555
1966	1899664	2280267	121933	483711	3.967	0.506
1967	1262781	2781651	133557	572605	4.287	0.537
1968	186558	3226588	228964	1074084	4.691	0.578
1969	111271	2743509	151405	1197226	7.908	0.76
1970	213799	2079289	230733	933246	4.045	0.697
1971	389156	1629022	319399	689048	2.157	0.585
1972	992424	1620872	365204	565254	1.548	0.691
1973	1863225	2274508	324226	792685	2.445	0.607
1974	641881	2208700	159573	1102433	6.909	0.635
1975	598663	2114889	130599	829377	6.351	0.635
1976	611097	2013745	167889	867463	5.167	0.659
1977	373265	1976216	352361	905301	2.569	0.806
1978	629293	1596472	234779	698715	2.976	0.972
1979	213022	1110181	165107	440538	2.668	0.781
1980	129637	839347	102610	380434	3.708	0.776

1981	159337	961811	151761	399038	2.629	0.764
1982	174522	736258	311677	363730	1.167	0.815
1983	155637	708440	282330	289992	1.027	0.777
1984	412323	810488	228215	277651	1.217	0.888
1985	557902	987699	187689	307920	1.641	0.789
1986	1115427	1345623	162281	430113	2.65	0.903
1987	328128	1206503	110474	523071	4.735	1.017
1988	298195	1006836	179824	434939	2.419	0.952
1989	187904	1005297	236593	332481	1.405	0.649
1990	153907	1020247	333958	212000	0.635	0.368
1991	392367	1528203	711318	319158	0.449	0.316
1992	729437	1870189	912173	513234	0.563	0.448
1993	919650	2297740	777338	581611	0.748	0.577
1994	727595	2097570	591837	771086	1.303	0.796
1995	495919	1809835	523800	739999	1.413	0.779
1996	407919	1680817	548513	732228	1.335	0.764
1997	667174	1497114	546605	762403	1.395	0.944
1998	951011	1267919	381012	592624	1.555	0.96
1999	541276	1148028	285386	484910	1.699	0.959
2000	669000	1178128	239875	414868	1.73	0.822
2001	548496	1455762	364038	426471	1.172	0.706
2002	406016	1614557	507252	535045	1.055	0.653
2003	686290	1716006	597729	551990	0.924	0.572
2004	245683	1626533	714855	606445	0.848	0.714
2005	622294	1559607	621686	641276	1.032	0.713
2006	537053	1568655	609655	537642	0.882	0.65
2007	1396185	1957226	664380	486883	0.733	0.443
2008	1219978	2693100	704486	464171	0.659	0.313
2009	691126	3425627	1111746	523430	0.471	0.267
2010	283196	3816151	1413785	609983	0.432	0.272
2011	467808	4039298	2040520	719830	0.353	0.262
2012	538425	4175910	2371480	727663	0.307	0.237
2013	589602	4376272	2692927	966209	0.359	0.266
2014	659968	3923889	2563812	986449	0.385	0.296
2015	353296	3586396	2133663	864384	0.405	0.32
2016	180347	3035323	1769635	849422	0.48	0.334
Arith. Mean	747880	2272264	573749	667652	2.108	0.6
Units	Thous	Tonnes	Tonnes	Tonnes		

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

2017

Age	N	M	Mat	PF	PM	SWT	Sel	CWT
3	566000	0.363	0	0	0	0.261	0.036	0.777
4	135152	0.31	0.002	0	0	0.649	0.216	1.219
5	152241	0.279	0.004	0	0	1.168	0.528	1.672
6	191916	0.228	0.148	0	0	1.966	0.803	2.344
7	102929	0.2	0.493	0	0	2.93	0.947	3.249
8	78257	0.2	0.781	0	0	4.627	1.086	4.534
9	45962	0.2	0.94	0	0	5.966	1.177	5.856
10	27239	0.2	0.99	0	0	7.279	1.459	7.338
11	31446	0.2	1	0	0	9.3	1.482	8.665
12	25510	0.2	0.996	0	0	12.621	1.048	11.42
13	10721	0.2	1	0	0	14.544	0.628	12.8
14	3257	0.2	1	0	0	16.466	0.374	14.18
15	3863	0.2	1	0	0	18.388	0.374	15.55

2018

Age	N	M	Mat	PF	PM	SWT	Sel	CWT
3	607000	0.363	0	0	0	0.271	0.036	0.777
4		0.31	0.001	0	0	0.609	0.216	1.22
5		0.279	0.007	0	0	1.218	0.528	1.751
6		0.228	0.1	0	0	1.955	0.803	2.357
7		0.2	0.343	0	0	2.941	0.947	3.332
8		0.2	0.686	0	0	4.309	1.086	4.534
9		0.2	0.876	0	0	6.301	1.177	5.893
10		0.2	0.971	0	0	7.711	1.459	7.215
11		0.2	0.991	0	0	9.298	1.482	8.698
12		0.2	0.997	0	0	12.621	1.048	11.42
13		0.2	1	0	0	14.544	0.628	12.8
14		0.2	1	0	0	16.466	0.374	14.18
15		0.2	1	0	0	18.388	0.374	15.55

2019

Age	N	M	Mat	PF	PM	SWT	Sel	CWT
3	543000	0.363	0	0	0	0.257	0.036	0.777
4		0.31	0.001	0	0	0.619	0.216	1.22
5		0.279	0.007	0	0	1.178	0.528	1.751
6		0.228	0.1	0	0	2.005	0.803	2.357
7		0.2	0.343	0	0	2.93	0.947	3.332
8		0.2	0.686	0	0	4.32	1.086	4.534
9		0.2	0.876	0	0	5.983	1.177	5.893
10		0.2	0.971	0	0	8.047	1.459	7.215
11		0.2	0.991	0	0	9.731	1.482	8.698
12		0.2	0.997	0	0	12.621	1.048	11.42
13		0.2	1	0	0	14.544	0.628	12.8
14		0.2	1	0	0	16.466	0.374	14.18
15		0.2	1	0	0	18.388	0.374	15.55

2020

Age	N	M	Mat	PF	PM	SWT	Sel	CWT
3	748000	0.363	0	0	0	0.257	0.036	0.777
4		0.31	0.001	0	0	0.619	0.216	1.22
5		0.279	0.007	0	0	1.178	0.528	1.751
6		0.228	0.1	0	0	2.005	0.803	2.357
7		0.2	0.343	0	0	2.93	0.947	3.332
8		0.2	0.686	0	0	4.32	1.086	4.534
9		0.2	0.876	0	0	5.983	1.177	5.893
10		0.2	0.971	0	0	8.047	1.459	7.215
11		0.2	0.991	0	0	9.731	1.482	8.698
12		0.2	0.997	0	0	12.621	1.048	11.42
13		0.2	1	0	0	14.544	0.628	12.8
14		0.2	1	0	0	16.466	0.374	14.18
15		0.2	1	0	0	18.388	0.374	15.55

Table 3.20. Northeast Arctic COD. Management option table.

2017

Biomass (t)	SSB (t)	FMult	FBar	Landings (t)
2821721	1835962	1	0.334	687997

2018				2019	
Biomass	SSB	FBar	Landings	Biomass	SSB
2538299	1504567	0	0	3023274	1837155
		0.05	96095	2911483	1747134
		0.1	187635	2805321	1661967
		0.15	274865	2704477	1581376
		0.2	358015	2608659	1505099
		0.25	437301	2517591	1432891
		0.3	512929	2431014	1364521
		0.35	585091	2348683	1299770
		0.4	653971	2270367	1238434
		0.45	719739	2195850	1180320
		0.5	782557	2124927	1125248
		0.55	842580	2057405	1073047
		0.6	899952	1993102	1023556
		0.65	954809	1931846	976624
		0.7	1007279	1873475	932110
		0.75	1057486	1817837	889878
		0.8	1105544	1764788	849803
		0.85	1151561	1714190	811767
		0.9	1195641	1665917	775656
		0.95	1237881	1619847	741367
		1	1278372	1575865	708799
Tonnes	Tonnes		Tonnes	Tonnes	Tonnes

Table 3.21. Northeast Arctic COD. Detailed prediction output assuming Fsq in 2017 and HCR in 2018.

Fbar age range: 5-10

Year: 2017
F multiplier: 1 Fbar: 0.334

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.012	5650	4	566000	148	0	0
4	0.072	8102	10	135152	88	270	0
5	0.177	21599	36	152241	178	609	1
6	0.268	40621	95	191916	377	28404	56
7	0.316	25443	83	102929	302	50744	149
8	0.363	21729	99	78257	362	61119	283
9	0.394	13644	80	45962	274	43204	258
10	0.488	9610	71	27239	198	26967	196
11	0.496	11228	97	31446	292	31446	292
12	0.351	6876	79	25510	322	25408	321
13	0.21	1847	24	10721	156	10721	156
14	0.125	348	5	3257	54	3257	54
15+	0.125	412	6	3863	71	3863	71
Total	NA	167109	688	1374493	2822	286011	1836
		Thous	Thou. tonnes	Thous	Thou. tonnes	Thous	Thou. tonnes

Fbar age range: 5-10

Year: 2018
F multiplier: 1.2517
Fbar: 0.444

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.016	8030	6	607000	164	0	0
4	0.096	30628	37	389057	237	389	0
5	0.235	16910	30	92187	112	645	1
6	0.356	26072	61	96562	189	9656	19
7	0.42	36598	122	116869	344	40086	118
8	0.482	21463	97	61408	265	42126	182
9	0.523	16583	98	44561	281	39036	246
10	0.648	11090	80	25385	196	24649	190
11	0.658	6047	53	13690	127	13567	126
12	0.465	5331	61	15686	198	15639	197
13	0.279	3260	42	14710	214	14710	214
14	0.166	989	14	7115	117	7115	117
15+	0.166	715	11	5144	95	5144	95
Total	NA	183717	712	1489375	2538	212763	1505
		Thous	Thou. tonnes	Thous	Thou. tonnes	Thous	Thou. tonnes

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

Year	B(3+)	SSB	R(3)	F(5-10)
1984	801367	253777	386522	0.829
1985	965773	199581	575101	0.648
1986	1352192	179849	1064410	0.789
1987	1215348	134616	288228	1.017
1988	1004187	227697	210099	0.986
1989	901653	234863	181105	0.465
1990	987800	330721	212533	0.311
1991	1553516	711440	403314	0.230
1992	1951490	951404	698192	0.417
1993	2469176	841732	1066062	0.634
1994	2280968	635648	854977	0.832
1995	1972179	577001	561173	0.752
1996	1905101	657734	478806	0.717
1997	1740633	724067	678267	1.054
1998	1302073	438006	857097	1.063
1999	1087580	284244	489261	0.968
2000	1066029	228667	588541	0.671
2001	1303178	350093	478080	0.535
2002	1434998	472569	432110	0.523
2003	1531017	531573	685135	0.515
2004	1511366	625031	296638	0.618
2005	1521278	585012	564971	0.626
2006	1549878	605523	603915	0.662
2007	1961008	632691	1536579	0.515
2008	2805395	646498	1571270	0.366
2009	3583853	1033287	1024459	0.353
2010	3956690	1270136	547594	0.381
2011	4060835	1825237	677845	0.313
2012	4095068	2133121	628443	0.263
2013	4331961	2472544	729362	0.252
2014	3953028	2447137	828459	0.268
2015	3689404	2138758	294355	0.281
2016	3278616	1916312	233938	0.329
2017	2991431	2031025		

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

N(a,y)	3	4	5	6	7	8	9	10	11	12	13	14	15
1984	386522	135683	72126	41845	25230	12254	9081	1478	720	463	226	42	28
1985	575101	309523	97206	42205	18141	7073	3343	2472	479	424	196	133	33
1986	1064410	454770	217525	56168	19955	6753	2287	1303	1058	228	299	124	51
1987	288228	758294	313146	112914	23528	7094	2170	695	430	377	83	191	65
1988	210099	213712	512451	157043	37285	6197	2083	717	144	151	121	47	17
1989	181105	164020	150344	278001	58386	9077	1505	633	197	35	58	64	93
1990	212533	144971	120523	94684	154171	25291	3481	637	306	116	18	42	17
1991	403314	172434	111720	85108	60007	94371	14091	2025	369	196	78	11	22
1992	698192	325311	133516	79046	54605	35134	57214	8404	1275	251	142	60	7
1993	1066062	555342	241381	88422	45157	28128	16677	29607	4292	732	139	105	5
1994	854977	806509	413768	146339	45296	20121	11258	6427	12056	1784	304	74	16
1995	561173	564149	542207	243679	66859	14369	5903	3132	1742	3865	599	162	4
1996	478806	283211	354497	326516	118721	25514	5064	1814	912	502	1480	327	4
1997	678267	244682	162234	196122	161413	49422	9217	1952	558	303	183	706	3
1998	857097	394064	150852	80146	78047	47734	12830	2052	456	108	63	65	157
1999	489261	484695	234581	72594	30818	23861	10292	3644	491	143	25	25	94
2000	588541	350160	320654	111306	25279	10287	5755	2023	1163	164	58	4	59
2001	478080	441583	243132	171331	48390	8915	3627	1682	595	588	73	36	114
2002	432110	365895	314746	146156	80778	20103	3218	1641	636	254	358	50	33
2003	685135	314569	267352	191306	70686	31382	7591	1266	863	333	123	252	6
2004	296638	532738	237978	168328	97697	30728	12547	3474	588	526	189	82	41
2005	564971	222300	387091	148945	83546	37472	11113	4395	1353	246	300	120	35
2006	603915	375877	160079	223730	73884	33883	12784	4109	1491	589	114	207	712
2007	1536579	480979	269544	99310	110324	31744	12866	4041	1594	527	266	70	189
2008	1571270	1143549	355622	169595	56023	54167	14947	6143	1771	789	213	175	88
2009	1024459	1160826	845611	246985	104822	31807	26747	7700	3301	870	442	142	135
2010	547594	752533	885238	595409	158574	61705	17383	13796	4309	1862	211	298	213
2011	677845	388491	560465	630751	385047	92750	32294	9166	6973	1709	890	79	0
2012	628443	396821	260545	406143	432701	233599	54112	16556	4098	3373	933	483	166
2013	729362	416430	275215	188660	290578	286731	138890	32188	8965	2038	1855	566	923
2014	828459	450686	311744	196539	132332	190829	173843	74627	18182	4824	1110	1191	890
2015	294355	519708	310577	214934	130042	83821	113365	102697	39838	10750	2719	684	1297
2016	233938	202151	367116	204170	129320	78105	49940	70117	60875	19809	6191	1770	2189
2017	0	181304	146484	236025	123291	73969	42759	27684	39215	35488	11892	4281	1224

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
1984	0.02303	0.14241	0.33297	0.57395	1.06585	1.01501	1.03808	0.94724	0.25242	0.76984	0.37534	0.37534	0.37534
1985	0.02068	0.13069	0.32637	0.45919	0.62885	0.94851	0.75124	0.77385	0.64036	0.19316	0.30928	0.30928	0.30928
1986	0.02163	0.15947	0.42139	0.66238	0.74778	0.87635	1.13666	0.89048	0.81381	0.68955	0.36033	0.36033	0.36033
1987	0.02645	0.1663	0.53019	0.90368	1.16796	1.06396	1.03142	1.4019	0.93148	0.87579	0.41894	0.41894	0.41894
1988	0.02501	0.17443	0.45608	0.94064	1.28956	1.32327	0.96294	0.94587	1.08934	0.78469	0.40273	0.40273	0.40273
1989	0.01376	0.0939	0.2567	0.38719	0.57867	0.60992	0.52737	0.42728	0.38357	0.4343	0.21072	0.21072	0.21072
1990	0.00819	0.06172	0.16604	0.27377	0.32741	0.40661	0.36785	0.32597	0.2466	0.22828	0.14089	0.14089	0.14089
1991	0.00638	0.03986	0.11851	0.19482	0.25855	0.26427	0.2828	0.25941	0.21225	0.16623	0.10471	0.10471	0.10471
1992	0.00942	0.06935	0.17495	0.33474	0.46279	0.53939	0.47272	0.5147	0.42402	0.34932	0.18088	0.18088	0.18088
1993	0.01452	0.08686	0.26377	0.42189	0.69631	0.84659	0.84327	0.73049	0.71874	0.59575	0.26398	0.26398	0.26398
1994	0.01707	0.11787	0.28776	0.56546	0.749	1.11376	1.13303	1.14236	0.85262	0.86362	0.33211	0.33211	0.33211
1995	0.01602	0.11179	0.31576	0.47385	0.7677	0.84845	1.03831	1.06854	0.94316	0.74315	0.32691	0.32691	0.32691
1996	0.02092	0.10802	0.30874	0.5472	0.6596	0.91534	0.83754	1.03586	0.93422	0.85705	0.33376	0.33376	0.33376
1997	0.02822	0.18891	0.40333	0.76281	1.19101	1.19552	1.45932	1.31365	1.46971	1.34203	0.46642	0.46642	0.46642
1998	0.03173	0.19403	0.55394	0.70975	1.11423	1.45336	1.14109	1.40309	1.09428	1.2521	0.46712	0.46712	0.46712
1999	0.02564	0.20643	0.52856	0.95077	0.92328	1.19301	1.21851	0.99396	1.03962	0.87034	0.43387	0.43387	0.43387
2000	0.02088	0.12737	0.42082	0.63217	0.85739	0.6823	0.70659	0.72521	0.55713	0.59207	0.30473	0.30473	0.30473
2001	0.0148	0.11219	0.27369	0.55545	0.65004	0.72051	0.49593	0.51644	0.4784	0.38709	0.23964	0.23964	0.23964
2002	0.01316	0.09077	0.28025	0.41812	0.6933	0.67407	0.6292	0.44322	0.4186	0.39847	0.2217	0.2217	0.2217
2003	0.01335	0.08163	0.22659	0.43685	0.52231	0.73517	0.60239	0.56898	0.36826	0.35665	0.20859	0.20859	0.20859
2004	0.01441	0.10117	0.25073	0.43926	0.71374	0.71904	0.87132	0.71139	0.6015	0.39619	0.24313	0.24313	0.24313
2005	0.0146	0.09716	0.27811	0.42588	0.61075	0.85223	0.71535	0.87603	0.64052	0.5588	0.24933	0.24933	0.24933
2006	0.01356	0.10536	0.28637	0.51863	0.6448	0.79321	0.93937	0.79063	0.86252	0.64901	0.27507	0.27507	0.27507
2007	0.01185	0.07517	0.23512	0.39058	0.56564	0.58625	0.60349	0.70823	0.54746	0.606	0.22837	0.22837	0.22837
2008	0.00684	0.06175	0.15494	0.29755	0.39532	0.48038	0.42648	0.44176	0.46262	0.37633	0.17909	0.17909	0.17909
2009	0.00601	0.04401	0.15951	0.24719	0.38988	0.44341	0.46342	0.41537	0.39117	0.41894	0.17863	0.17863	0.17863
2010	0.00647	0.04303	0.12558	0.28826	0.36504	0.50122	0.49043	0.51782	0.42012	0.405	0.20049	0.20049	0.20049
2011	0.00653	0.03861	0.10144	0.18333	0.34566	0.37404	0.4409	0.43545	0.41683	0.34939	0.18464	0.18464	0
2012	0.00798	0.03993	0.09299	0.15099	0.22324	0.36414	0.34091	0.404	0.36346	0.35656	0.17453	0.17453	0.17453
2013	0.00833	0.05611	0.11065	0.15931	0.21208	0.27252	0.38943	0.36732	0.39677	0.36542	0.19076	0.19076	0.19076
2014	0.01161	0.06075	0.16384	0.19819	0.23297	0.2689	0.30232	0.43886	0.37616	0.41621	0.21678	0.21678	0.21678
2015	0.01407	0.08468	0.17626	0.29675	0.28921	0.29281	0.29474	0.33466	0.44412	0.3895	0.244	0.244	0.244
2016	0.01008	0.0656	0.17044	0.274	0.35864	0.40249	0.38997	0.3811	0.33964	0.31026	0.16898	0.16898	0.16898
2017													

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	1365
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

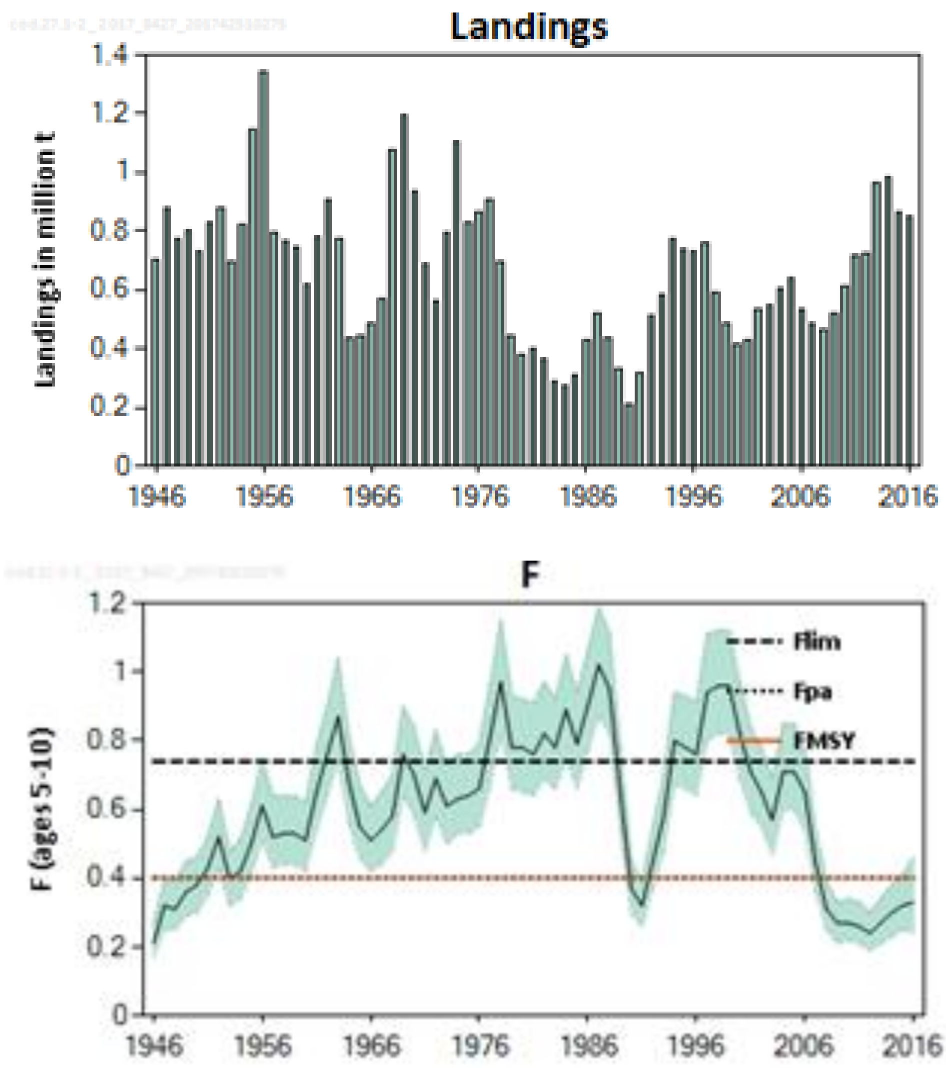
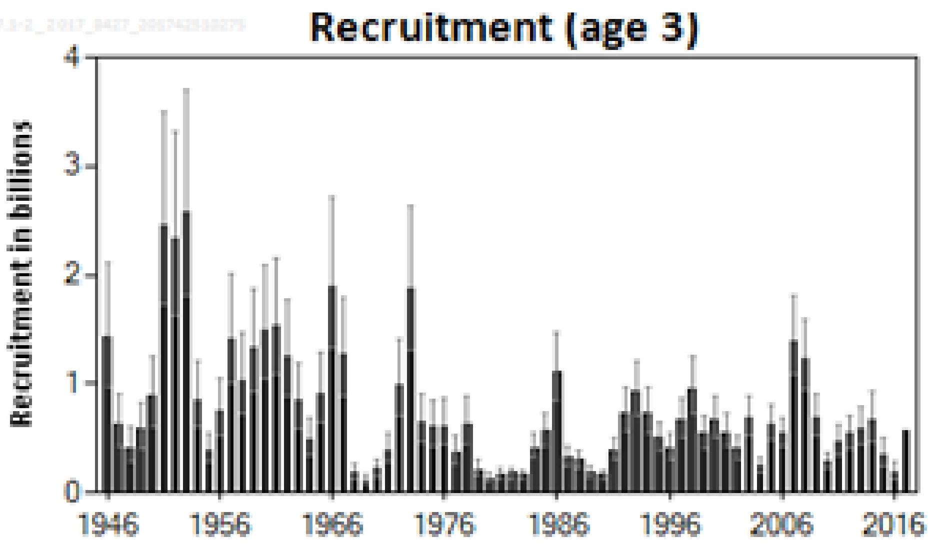


Fig. 3.1. ICES Standard plots for Northeast Arctic cod (sub-area I and II)



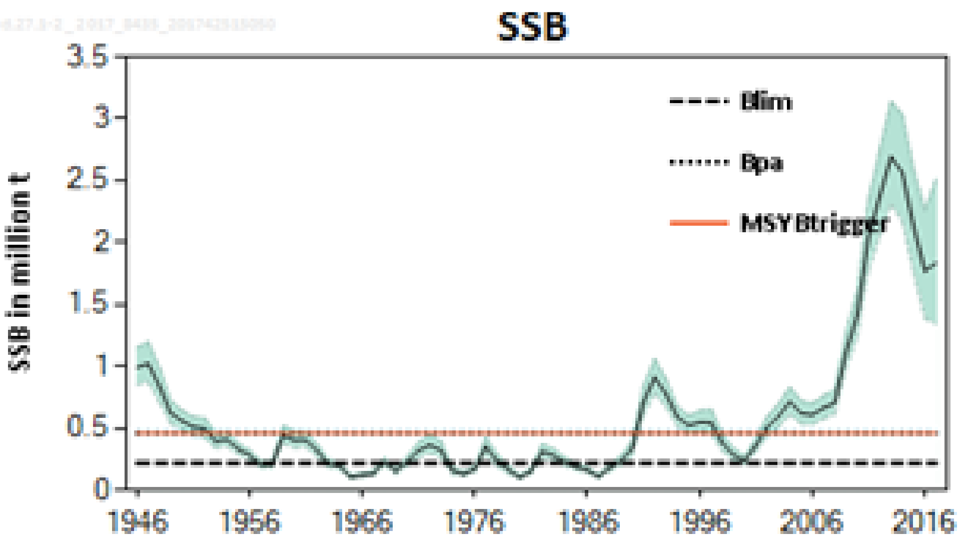


Fig. 3.1 (continued). ICES Standard plots for Northeast Arctic cod (sub-area I and II)

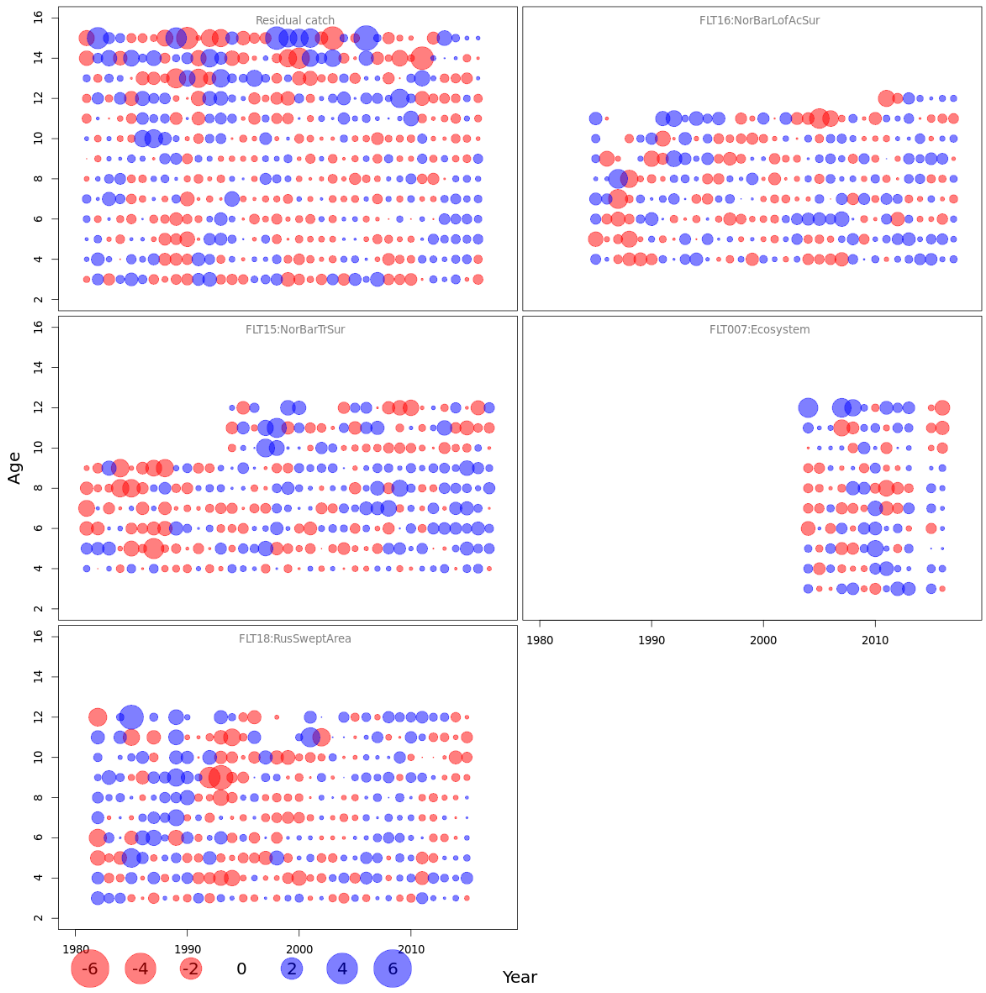


Figure 3.2a. Log catchability residuals of catch and fleets used in the final SAM run.

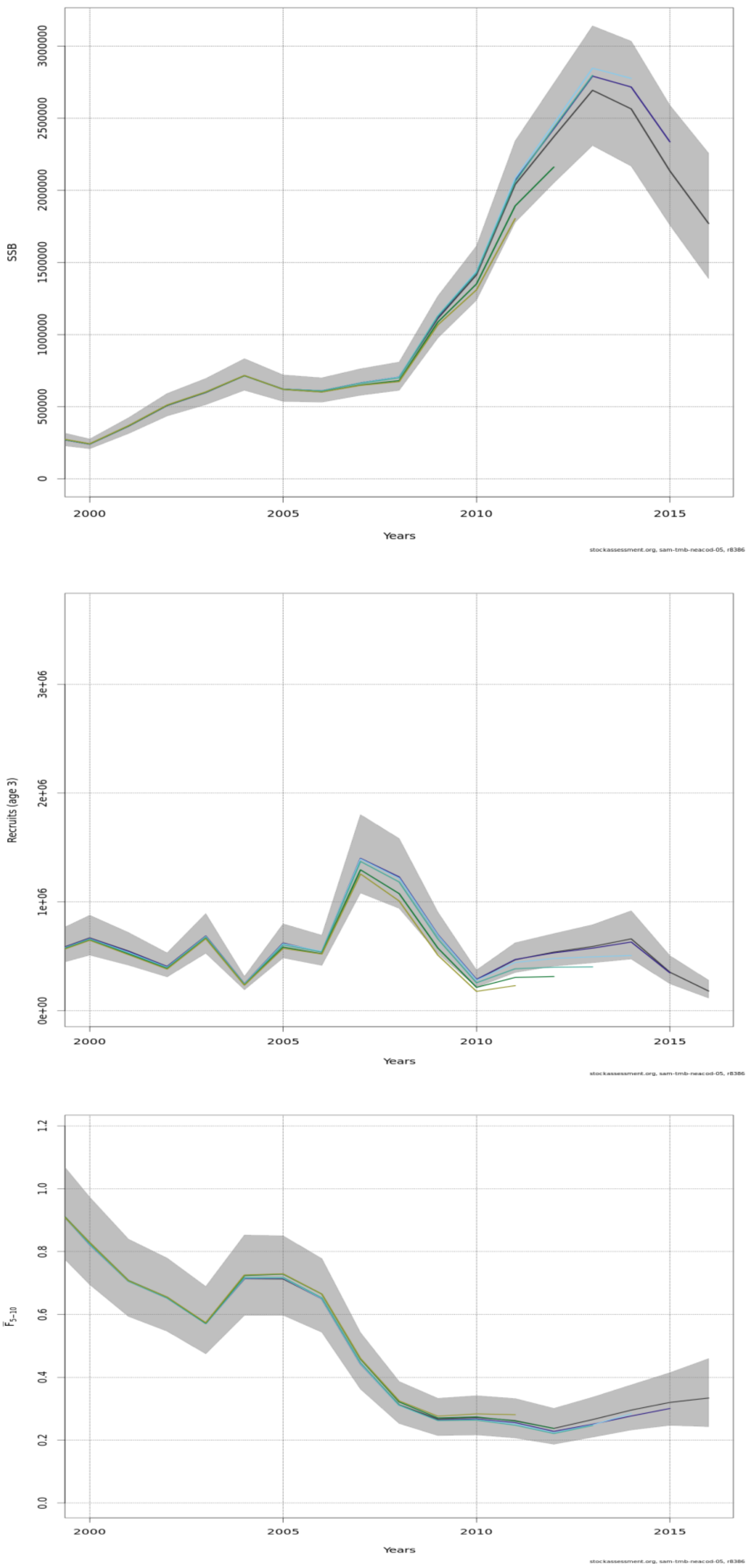


Figure 3.2b. NEA cod SSB, R and Fbar retrospective pattern for final SAM run.

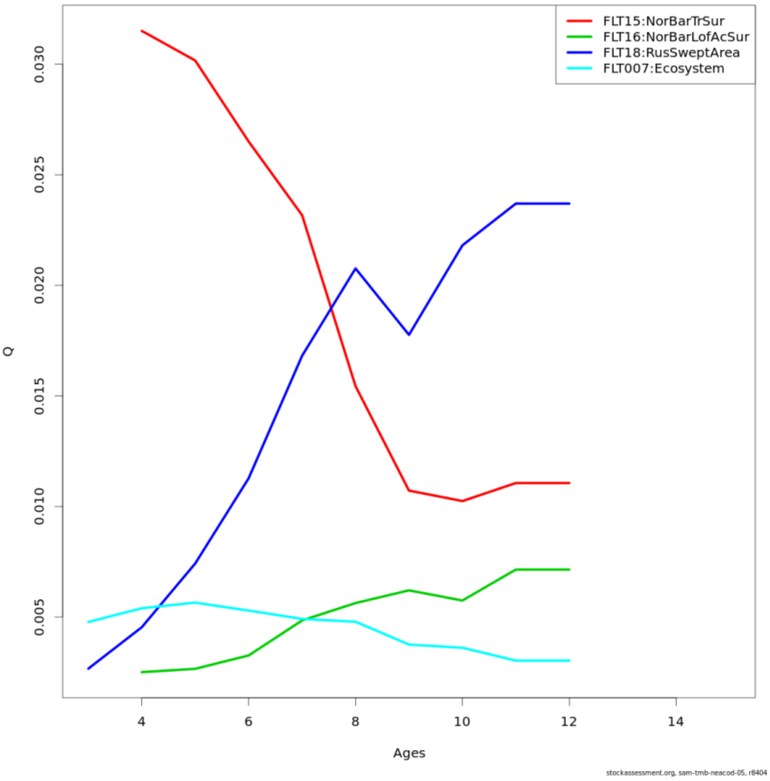


Figure 3.2c. NEA cod. Catchability of different fleets used for final SAM run fit.

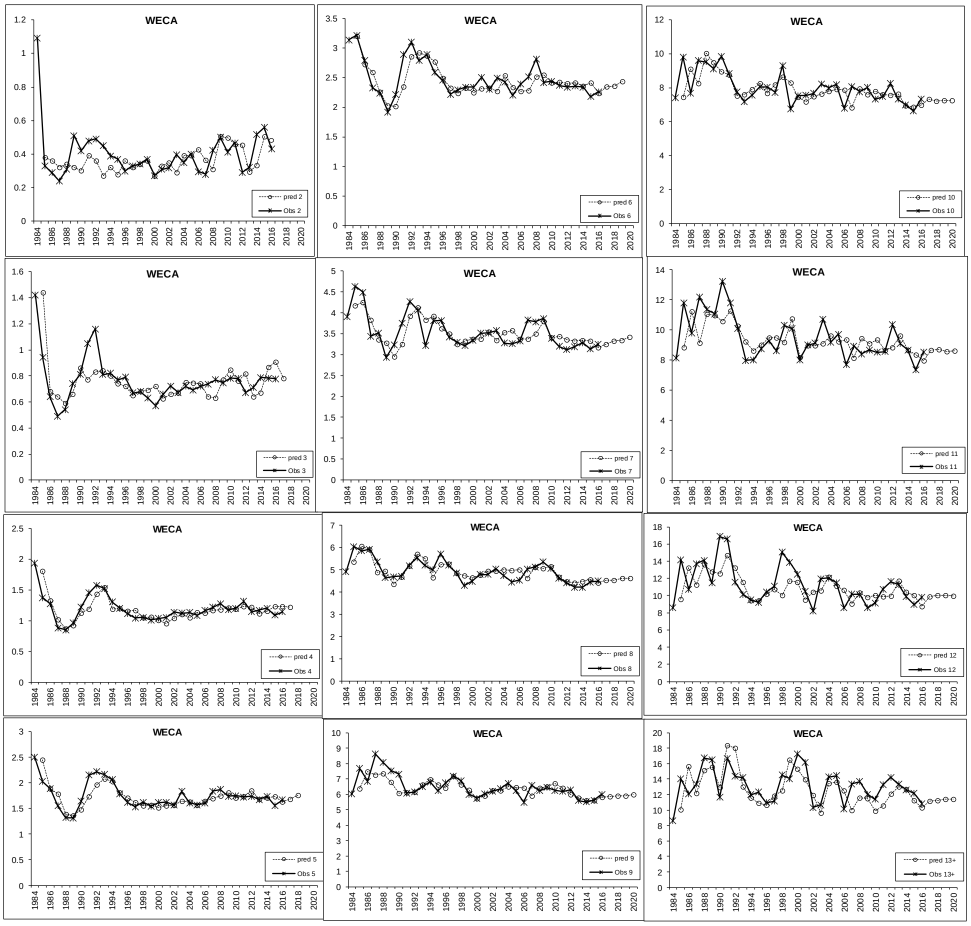


Figure 3.3. Northeast Arctic cod. Weight in catch predictions.

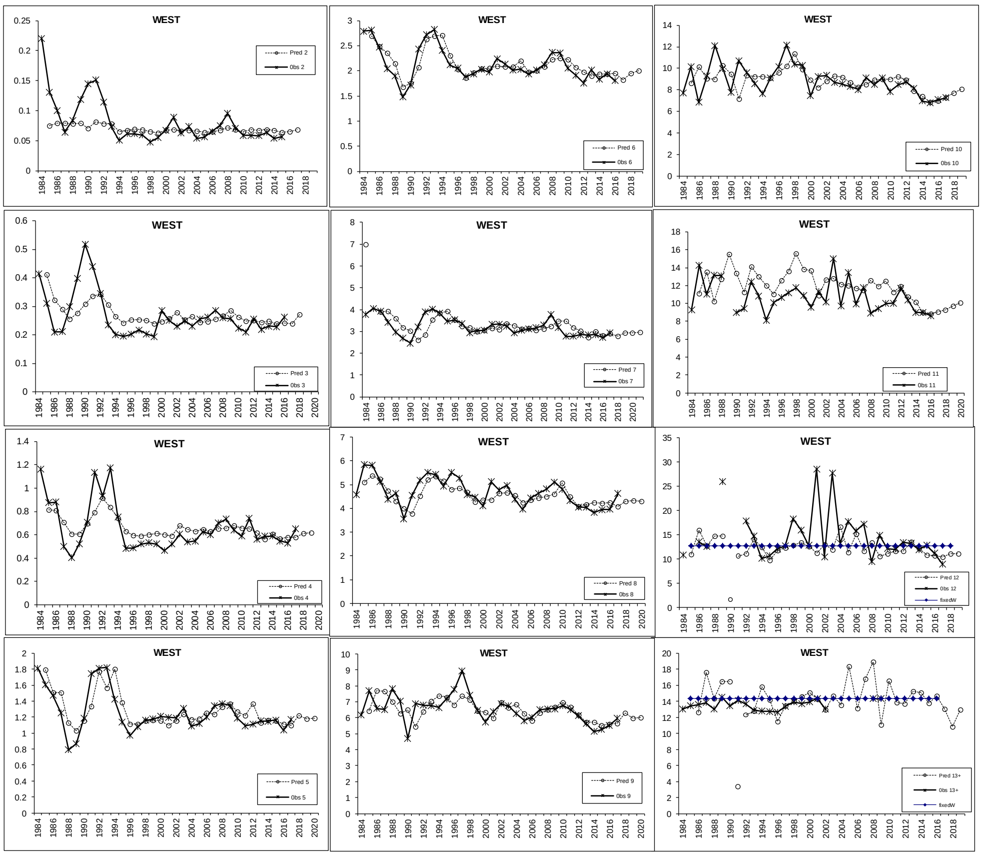


Figure 3.4. Northeast Arctic cod. Weight in stock projections

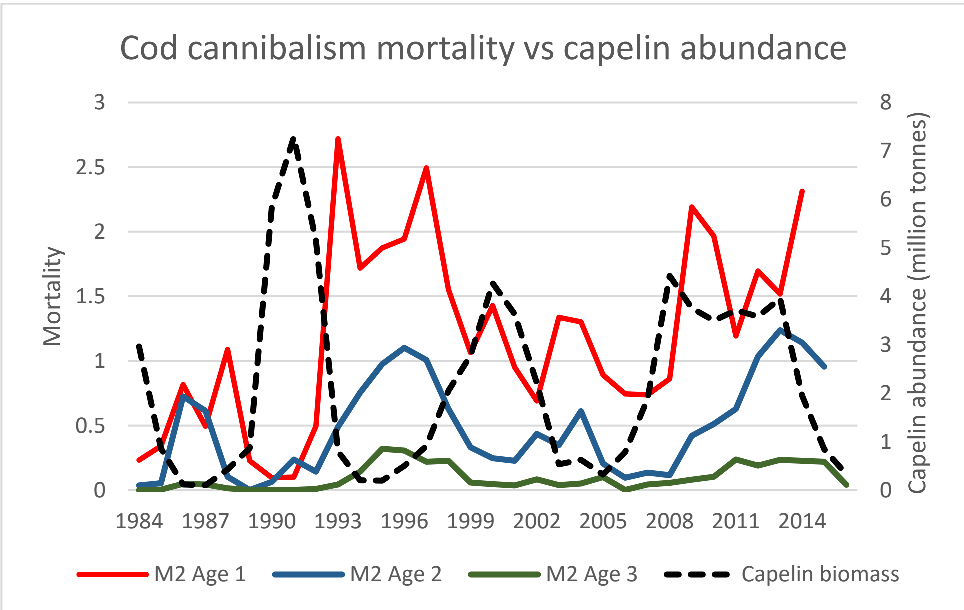
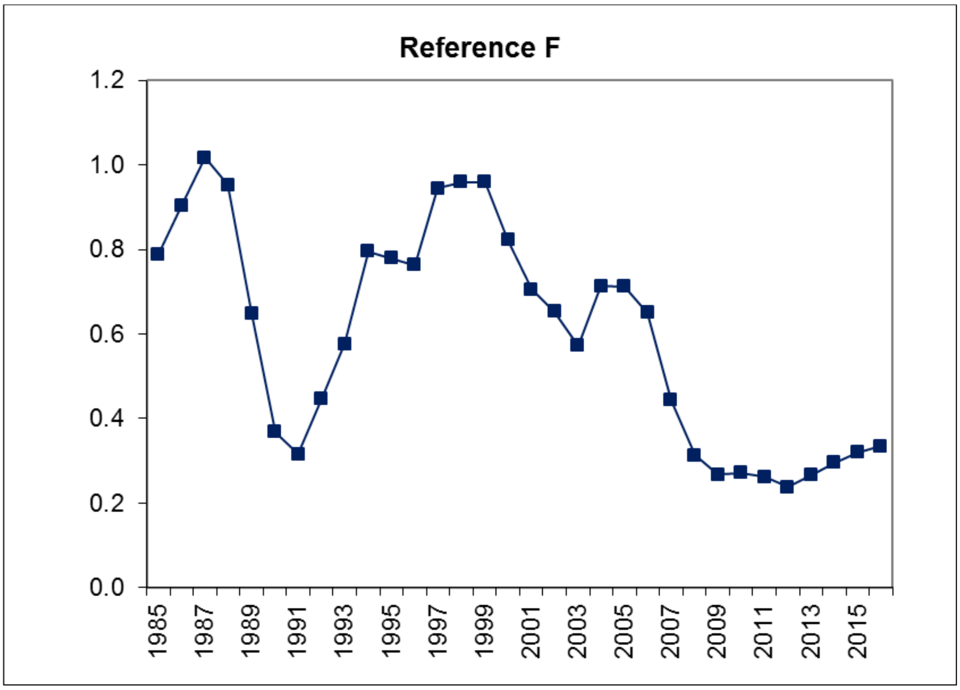


Figure 3.5. NEA cod cannibalism mortality vs. capelin abundance.



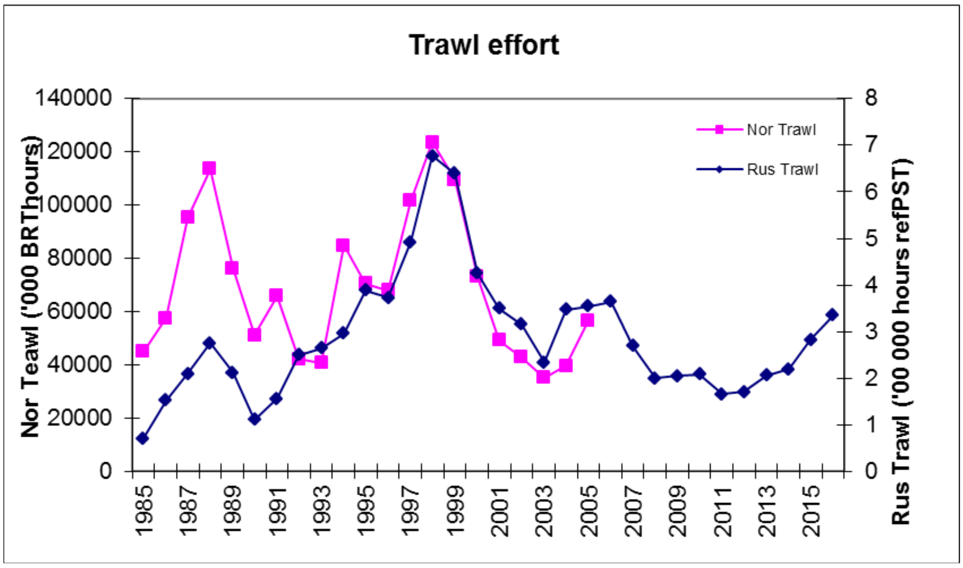


Figure 3.6. Northeast Arctic cod. Fishing mortality (F5-10) (top panel) and trawl efforts in 1985-2016 (bottom panel).

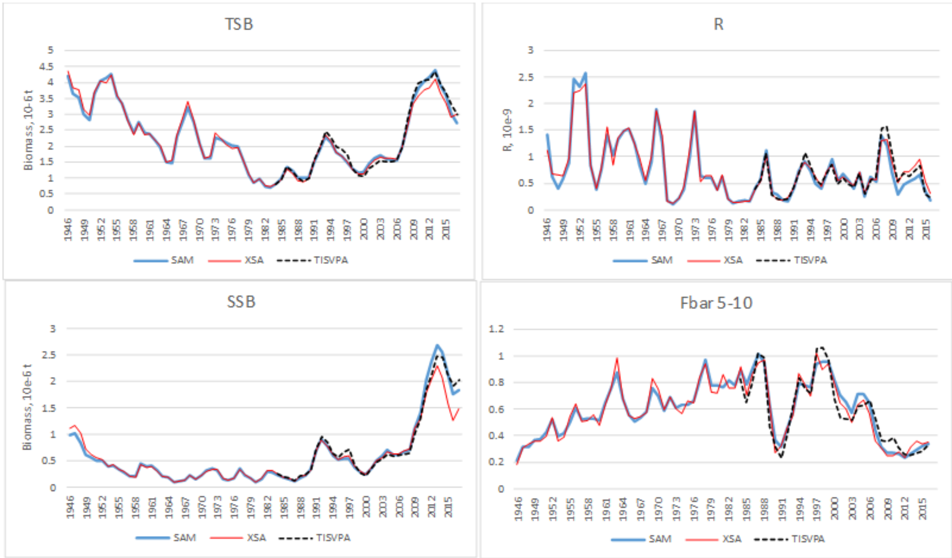


Figure 3.7. Northeast Arctic cod. Comparison of three models results

Table A1 North-East 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
1960	-	0.075	0.42	-	0.105	0.31	-	0.067	
1961	-	0.079	0.38	-	0.129	0.44	-	0.058	
1962	-	0.092	0.59	-	0.133	0.74	-	0.066	
1963	-	0.085	0.60	-	0.098	0.55	-	0.066	
1964	-	0.056	0.37	-	0.092	0.39	-	0.070	
1965	-	0.066	0.39	-	0.109	0.49	-	0.066	
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	4.89[6]
2012			2.25			1.44		2.11	6.78[6]
2013			2.30			1.46		2.60	5.07[6]
2014			2.07			1.54		2.38	5.90[6]
2015			1.06			1.38		1.93	4.65[6]
2016[1]			1.15			1.39		1.06	3.78[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]2011-2016 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 North-east 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 WD 3, 2017

Year				Age														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	10+	Total
1981		8.0	82.0	40.0	63.0	106.0	103.0	16.0	3.0	1.0							1.0	423.0
1982		4.0	5.0	49.0	43.0	40.0	26.0	28.0	2.0	+							0.0	197.0
1983		60.5	2.8	5.3	14.3	17.4	11.1	5.6	3.0	0.5							0.1	120.5
1984		745.4	146.1	39.1	13.6	11.3	7.4	2.8	0.2	0							0.0	966.0
1985		69.1	446.3	153.0	141.6	19.7	7.6	3.3	0.2	0.1							0.0	840.9
1986		353.6	243.9	499.6	134.3	65.9	8.3	2.2	0.4	0.1							0.0	1308.2
1987		1.6	34.1	62.8	204.9	41.4	10.4	1.2	0.2	0.7							0.0	357.3
1988		2.0	26.3	50.4	35.5	56.2	6.5	1.4	0.2	0							0.0	178.4
1989		7.5	8.0	17.0	34.4	21.4	53.8	6.9	1.0	0.1							0.1	150.1
1990		81.1	24.9	14.8	20.6	26.1	24.3	39.8	2.4	0.1							0.0	234.1
1991		181.0	219.5	50.2	34.6	29.3	28.9	16.9	17.3	0.9							0.0	578.7
1992		241.4	562.1	176.5	65.8	18.8	13.2	7.6	4.5	2.8							0.2	1092.9
1993		1074.0	494.7	357.2	191.1	108.2	20.8	8.1	5.0	2.3							2.5	2264.0
1994		858.3	577.2	349.8	404.5	193.7	63.6	12.1	3.7	1.7	0.55	0.52	0.11	0.05	0	0	1.23	2465.4
1995		2619.2	292.9	166.2	159.8	210.1	68.8	16.7	2.1	0.7	0.55	0.59	0.19	0	0	0	1.33	3537.4
1996		2396.0	339.8	92.9	70.5	85.8	74.7	20.6	2.8	0.3	0.16	0.08	0.08	0.05	0.02	0	0.39	3083.8
1997	[1]	1623.5	430.5	188.3	51.7	49.3	37.2	22.3	4.0	0.7	0.68	0.46	0	0	0	0	1.14	2407.5
1998	[1]	3401.3	632.9	427.7	182.6	42.3	33.5	26.9	13.6	1.7	0.52	0.65	0	0.35	0	0.04	1.56	4762.8
1999		358.3	304.3	150.0	96.4	45.1	10.3	6.4	4.1	0.8	0.27	0.02	0.03	0.02	0	0	0.34	976.0
2000		154.1	221.4	245.2	158.9	142.1	45.4	9.6	4.7	3.0	0.36	0.10	0.03	0.02	0	0	0.51	985.4
2001		629.9	63.9	138.2	171.6	77.3	39.7	11.8	1.4	0.5	0.19	0.04	0	0	0	0.01	0.24	1134.7
2002		18.2	215.5	69.3	112.2	102.0	47.0	18.0	3.0	0.4	0.19	0.05	0	0	0	0.02	0.26	585.9
2003		1693.9	61.5	303.4	114.4	129.0	114.9	34.3	7.7	1.9	0.16	0.04	0	0.02	0.02	0	0.24	2461.5
2004		157.6	105.2	33.6	92.8	30.7	27.6	17.0	5.9	1.2	0.29	0.08	0.01	0.01	0	0	0.39	471.8
2005		465.3	119.6	123.9	33.7	62.8	16.9	14.5	4.2	1.0	0.30	0.04	0.02	0.03	0.04	0	0.43	842.4
2006	[2]	544.6	216.6	79.8	59.1	15.5	25.6	8.8	4.5	1.4	0.22	0.21	0.08	0	0	0	0.51	956.5
2007	[1]	125.0	61.7	80.3	37.1	30.4	9.1	14.1	5.0	2.1	0.40	0.31	0.08	0	0	0	0.79	365.6
2008		68.8	97.6	210.2	306.1	140.6	69.4	21.6	12.2	3.1	0.35	0.02	0.02	0.01	0	0	0.40	930.4
2009		321.5	30.6	182.6	178.3	137.1	35.0	12.5	5.2	3.7	0.50	0.18	0.03	0.03	0	0	0.74	907.3
2010		485.4	59.4	34.7	121.9	174.7	162.3	44.4	13.8	3.5	1.64	0.57	0.05	0.02	0.03	0.02	2.33	1103.6
2011		389.4	124.8	47.1	29.1	80.4	107.7	105.4	17.1	4.5	1.17	0.79	0.20	0.17	0.04	0.02	2.39	908.6
2012	[2]	950.6	72.7	133.9	52.7	37.7	69.4	126.1	77.0	10.4	2.33	0.87	0.60	0.47	0.02	0.05	4.34	1536.4
2013		470.6	110.8	64.1	85.0	70.8	51.7	86.0	123.8	70.1	2.21	2.83	0.41	0.35	0.06	0.03	5.89	1145.3
2014		630.1	139.1	220.0	117.8	91.5	65.1	37.5	77.3	63.2	9.36	1.01	0.97	0.15	0.04	0.07	11.60	1467.7
2015		1140.8	127.0	94.9	154.2	118.3	98.0	80.4	20.5	68.3	17.00	2.86	0.72	0.10	0.07	0.04	20.79	1928.5
2016		142.9	120.7	41.0	58.3	96.7	63.4	51.2	21.9	15.0	15.00	6.52	0.99	0.50	0.17	0.14	23.32	635.2
2017	[2]	396.6	48.5	91.2	40.4	48.4	67.7	36.9	26.2	13.7	5.45	3.14	5.19	0.66	0.46	0.10	15.00	784.5
	[1]	Survey covered a larger area																
	[2]	Adjusted indices																

Table A3. North-East 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 - WD 3, 2017

				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	163.1
1982		0.80	2.90	28.30	27.70	23.60	15.50	16.00	1.40	0.20							0	116.4
1983		152.90	13.40	24.95	52.34	43.33	16.96	5.82	3.21	0.97							0.1	313.9
1984		2755.04	379.11	97.49	28.28	21.44	11.74	4.07	0.40	0.08							0.1	3297.7
1985		49.49	660.04	166.79	125.98	19.92	7.67	3.34	0.21	0.07							0.1	1033.6
1986		665.79	399.61	805.00	143.93	64.14	8.30	1.91	0.34	0.04							0.0	2089.1
1987		30.72	444.98	240.38	391.15	54.35	15.70	2.00	0.45	0.03							0.0	1179.8
1988		3.21	72.83	148.03	80.49	173.31	20.48	3.58	0.53	0.03							0.0	502.5
1989		8.24	15.62	46.36	75.86	37.79	90.19	9.82	0.94	0.10							0.1	285.0
1990		207.17	56.72	28.35	34.87	34.59	20.56	27.23	1.61	0.38							0.0	411.5
1991		460.45	220.14	45.85	33.67	25.65	21.49	12.15	12.67	0.61							0.0	832.7
1992		126.56	570.92	158.26	57.71	17.82	12.83	7.67	4.29	2.72							0.2	959.0
1993		534.48	420.40	273.89	140.13	72.48	15.83	6.24	3.89	2.23							2.4	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	0	1.2	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	0	0	1.3	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	0.4	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	0	0	0	1.1	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	0.35	0	0.04	1.6	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	0	0.3	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	0	0.5	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	0	0	0.01	0.2	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	0	0	0.02	0.3	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	0.02	0.02	0	0.2	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	0	0.4	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	0.4	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	0	0	0.5	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	0	0	0.8	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	0	0.4	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	0	0.7	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	2.3	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	2.4	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	4.3	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	5.9	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	11.6	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	20.8	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	23.2	1000.0
2017	3	471.50	71.00	115.90	39.90	48.70	56.60	27.80	18.90	7.63	3.01	2.22	3.49	0.53	0.17	0.06	9.5	867.5

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

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	111.9	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

Table A5. COD length (cm) at agein the Barents Sea from the investigations winter 1981–2017

Table A5. COD. Length (cm) at age in the Barents Sea from the investigations winter 1981 - 2017.

	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	11.0	18.4	22.6	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	68.4	76.9	85.4	86.0	90.0	91.9	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

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 1983–2017.

Table A6.	COD. Weight (g) at age in the Barents Sea from the investigations winter 1983-2017.													
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

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

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	78.3	83	88.3	94.7				99.2
2016	58.2	63	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	

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

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	

Table A9 North-east Arctic COD. Results from the Russian trawl-acoustic survey in the Barents Sea and adjacents waters in the autumm. Stock number in millions.

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

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

[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. North-East Arctic COD. Abundance indices (millions) from the Russian bottom trawl survey in the Barents Sea.

Table A10. North-East 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	

* corrected

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

	Table A11 North-East 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	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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

Table A12 North-East 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	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A13. North-East 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).

Table A13. North-East 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

Table A14. Swept area estimates (millions) of Northeast Arctic Cod from the Joint Norwegian-Russian ecosystem survey in August–September (taken from WD05)

Table A14. Swept area estimates (millions) of Northeast Arctic Cod from the Joint Norwegian-Russian ecosystem survey in August-September (taken from WD 05)

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

* data adjasted taking into account not complete area covarage

4 Northeast Arctic Haddock (Subareas I and II)

4.1 Status of the Fisheries

4.1.1 Historical development of the fisheries

Haddock is mainly fished by trawl as by-catch in the fishery for cod. Also a directed trawl fishery for haddock is conducted and the proportion of total catches taken by this fishery varies between years. On average approximately 33% 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 by-catch 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, in spite of haddock being primarily caught as by-catch 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 later years. These year-classes are fully recruited to SSB and still a significant part of catches in 2016 but their abundance is decreasing. The following year-classes are at a much lower level. The most numerous of them appeared in odd years and we will experience some years with a decreasing stock size and SSB, which again will result in lower catch advice. However, the WG states that the haddock stock will be at relatively high stock levels also in the coming years.

4.1.2 Landings prior to 2017 (Tables 4.1–4.3, Figure 4.1)

The highest landings of haddock (since 1973) observed were about 316 kt in 2012. In 2013-2015 stock biomass started to decline and level of landings decreased considerably to below 200 kt. However, based on investigation of assessment methods during benchmark and AFWG meetings and also transferring part of unused catches from 2015, the realized TAC in 2016 was increased to above 260 kt (244kt + transfer). Provisional official landings for 2016 is about 233 thousand tonnes which is 12% below the realized TAC (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.

4.2 Catch advice and TAC for 2017

The catch advice for 2017 was 233 kt, according to the HCR, and the Joint Norwegian-Russian Fisheries Commission set TAC to the same value. However, Russia and Norway can transfer unused part of own quotas (about 30 kt) of haddock in 2016 for 2017, so the actual TAC in 2017 can reach about 263 kt.

4.3 Status of Research

4.3.1 Survey results (Tables B1-B5)

The overall picture seen in the surveys is summarized as follows: many individuals of high abundant year-classes 2004—2006 are still present in the Barents Sea, but the surveys indicate that following less abundant year-classes dominated. Some of them as 2009, 2011and 2015 year-classes that seem to be a little stronger than average, while the 2016 year class was estimated as very strong.

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 2017 are given in Mehl *et al.* (WD 03). 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 standard area previously used. In 2017 was no Russian vessel, and not allowed access for Norwegian vessel to southwestern REZ. The survey indices and areas covered 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 usual in the 1990s. 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, 2013, 2014, 2015 and especially the 2016 year-classes are stronger than the 2007, 2008, 2010 and 2012 year-classes.

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

Russia provided indices for 1982-2015 Barents Sea trawl and acoustic survey (TAS) (Tables B2 and B4), which was carried out in October-December. In 2016 TAS was not conducted in the Barents Sea due to financial reasons.

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, Fleet 007). Estimates of the abundance of age groups (indices) from the joint ecosystem survey are presented in Table B5 and in WD 02. 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.

4.4 Weight-at-age (Tables B6 - B9)

Length- and weight-at-age from the surveys are given in Tables B6- B9, respectively. Neither Norwegian nor Russian surveys show any strong trends in length- or weight-at-age; however, the weights at older ages are at a relatively low level, compared to the time series

4.5 Data Used in the Assessment

4.5.1 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 estimate is zero for 2009 - 2016.

4.5.2 Catch-at-age (Table 4.4)

Age and length compositions of the landings in 2016 were available from Norway and Russia in Subarea 1 and Division 2b, from Norway, Russia, and Germany in Division 2a. 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 2008-2016 and historical values from 1950 is listed in Table 4.4

4.5.3 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.

Stock weights (Table 4.6) used from 1985 to 2016 are averages of values derived from Russian surveys in autumn (mostly October-December) and Norwegian surveys in January-March the following year. These averages are assumed to give representative values for the beginning of the year (see stock annex and for details). Stock weights seem to be stable with only small year to year differences for the last years.

4.5.4 Maturity-at-age (Table 4.7)

The estimates of maturity-at-age are shown in Table 4.7. The proportions mature at age are presently increasing but lower than historic averages (see stock annex for estimation details)

4.5.5 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 2016 actual data from predation for cod have been used (see Table 4.8).

Unlike previous years, in 2017, the methodology for calculating natural mortality has been slightly modified, which includes natural loss (adopted as 0.2) and mortality from haddock consumption by cod (see stock annex for details)

For the previous years (1950-1983) the average natural mortality for 1984-2016 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.

4.5.6 Changes in data from last year-(Tables 4.6-4.7, B3)

As stock weights and maturity are modeled (See above) the values of these variables have changed slightly for 2017 and for 2018-2019.

However, at the benchmark 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.

Natural mortality estimation procedure in the SAM model was revised (see above and stock annex).

Some settings (i.e. survey backshifting) in the SAM model were changed but model settings were mainly as last year.

One set of tuning indices (FLT04) was revised using StoX software and is now for period 1994-2016 (see WD03 and Table B3).

4.6 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 TSVPA model also is used as additional for comparison.

4.6.1 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	1991–2015	1
FLT02: Joint Barents Sea survey - acoustic	BS-NoRU-Q1(Aco)	Barents Sea	February-March	4–8	1993–2017	1
FLT04: Joint Barents Sea survey - bottom trawl	BS-NoRu-Q1 (BTr)	Barents Sea	February-March	4–9	1994–2017	1
FLT007: Joint Russian-Norwegian ecosystem autumn survey in the Barents Sea -bottom trawl	Eco-NoRu-Q3 (Btr)	Barents Sea	August - September	3-8	2004-2016	1

Some changes in using tuning indices were made: previously winter survey tuning indices were backshifted as it is done for XSA but SAM allows to use unshifted indices and it was done for Fleet 02 and 04 (Table 4.9)

Detailed information about index estimates described in tables B1-B6, Stock annex and working documents ##02-03 and 09.

4.6.2 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 input data used is the same as for XSA. The configuration file is given in Table 4.10 and in (www.stockassessment.org)

4.7 Results of the Assessments (Tables 4.11–4.15 and Figures 4.1, 4.2, 4.5 and 4.6)

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, stock-recruitment relationship in Figure 4.2, the retrospective plot in Figure 4.5 and the log catchability residuals plot is presented in Figure 4.6.

Fishing mortality of main ages (4-7) in 2016 increased somewhat compared to 2015 but still estimated close to the historic low level. XSA estimates shows the same trends (see Figure 4.1B, Table 4.11, 4.15).

The dominating feature of this assessment is that the stock reached an all-time high level around 2010 (about 1,400 kt) due to the strong 2004-2006 year classes, which still a significant part of catches. The total biomass has decreased since the all-time high in 2010 but is still high. SSB was stable at a record high level from 2013 to 2016 but is now decreasing somewhat.

4.8 Predictions, reference points and harvest control rules (Tables 4.16–4.21)

4.8.1 Recruitment (Tables 4.16, 4.17)

The RCT3 program has been used to estimate the recruiting year-classes 2014-2016 with survey data for ages 0-2 as input data (Russian autumn survey (not for 2016), joint winter survey and ecosystem survey) but historical data of recruitment abundance of year classes before 2015 was taken from SAM estimates. Input data and results are shown in Table 4.16 and 4.17, respectively

4.8.2 Prediction data (Table 4.18)

The input data for making the prediction are presented in Table 4.18:

Stock numbers for 2017-2019 at age 3 taken from RCT3, abundance at ages 4-13+ in 2017. The average fishing pattern observed in 2014—2016, scaled to F status quo was used for distribution of fishing mortality at age for 2017—2018. The proportion of M and F before spawning was set to 0.

Smoothed observed average weight in stock at age and maturity-at-age are used for 2017, predicted maturity estimates, using the fitted parameters and last year lengths as input, are used for 2018-2019.

Russian data for weight and maturity at age in autumn 2016 were not available as the survey was not conducted. In WD09, correction factors to allow for this when calculating the weight and maturity at age in 2017 were calculated, based on historical differences between Norwegian and Russian data. These correction factors were then applied to the Norwegian data for 2017.

The average weights at age in catch for the year-classes with similar abundance at age 3 (2014—2016) are used for 2017—2019.

Natural mortality for 2017-2019 – average for the 3 last years (2014—2016).

4.8.3 Biomass reference points (Figure 4.1)

At AFWG in 2011 based on the analysis of 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 Bloss, and B_{pa}= B_{lim}*exp(1.645*σ), where σ=0.3. This gives a 95% probability of maintaining SSB above Blim taking into account the uncertainty in the assessments and stock dynamics. For BMSY 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 in comparison with current stock values are reflected in Figure 4.1.

4.8.4 Fishing mortality reference points (Table 4.21, 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*σ)= 0.47.

F_{msy}=0.35 has been estimated by long-term stochastic simulation (WD 16, AFWG 2011, ICES 2016a).

Values of reference points in comparison with current stock values are reflected in Figure 4.1. Yield per recruit (YPR) are presented in Table 4.21.

4.8.5 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 will 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 existing harvest control rule.

4.8.6 Prediction results and catch options for 2018 (Tables 4.19 – 4.20)

TAC constraint was used in the intermediate year because the catch in 2017 corresponding to Fsq is well below agreed TAC. Fishing according to the management rule in 2017 corresponds to total landings of about 233 000 t. The projection shows a decrease in SSB in 2018 to 402 000 tonnes (Table 4.19). The TAC for 2018 is established using the current one-year HCR, in accordance of the management plan.

The detailed outputs corresponding to $F_{\text{TAC constraint}}$ in 2017, the F corresponding to the HCR (i.e. F_{pa}) in 2018 and 2019 is given in Table 4.20. Catch options for 2018 are shown in the text table below.

RATIONALE	CATCHES (2018)	BASIS	F (2018)	SSB (2019)	%SSB CHANGE *)	%TAC CHANGE* *)
Management plan (HCR2)	202	FMP (HCR)	0.35	289	-27	-13
MSY approach	202	FMSY	0.35	289	-27	-13
Precautionary Limits	255	Fpa	0.47	250	-38	+9
Zero catch	0	0	0	451	12	-100
Status quo	185	Fsq	0.31	305	-24	-21

Weights in '000 t.

***)SSB 2019 relative to SSB 2018.**

****) Catch 2018 relative to TAC 2017.**

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

4.9 Comparison with last year's assessment

The text table below compares this year's estimates with last year's estimates for 2016 and forecast for 2017 of total biomass, spawning biomass (thousand tonnes), as well as reference F for the year 2015.

Compared to last year's assessment the current estimates by SAM model of the total stock (TSB), spawning stock (SSB) and F are lower for 2015 - 2017.

Year of assessment, model	F (2015)	Numbers 2016 (ages)											TSB (2016)	SSB (2016)	F (2016)	TSB (2017)	SSB (2017)
		3	4	5	6	7	8	9	10	11	12	13+					
2016 SAM	0.207	235*	47	190	45	65	34	61	86	47	10	4	1001*	754*	0.28*	797*	574*
2017 SAM	0.17	184	39	183	61	81	37	61	65	29	6	2	911	675	0.2	743**	538**
Changing,%	-18	-22	-16	-3	34	24	9	0	-25	-38	-43	-48	-9	-10	-29	-7	-6
2016 XSA	0.181	261*	53	175	51	64	24	20	13	16	12	4	640*	398*	0.5*	491*	275*
2017 XSA	0.16	266	47	189	62	77	29	30	33	30	19	5	822	562	0.2	657**	428**
Changing,%	-12	2	-11	8	22	20	21	50	154	88	58	25	28	41	-60	34	56
Diff/ SAM/XSA 2017	-6	45	20	3	2	-4	-21	-51	-49	4	239	138	-10	-17	0	-12	-20

* forecast in 2016 using RCT 3 and TAC for 2016

** forecast in 2017 using RCT 3

In 2017 SAM assessment negative changes in 2016 abundance estimates versus last year estimates occurred for ages 3 and 10-13+, while for age groups which are reflected in fishing mortality estimates (Fbar 4-7) changes were mostly positive.

4.10 Additional assessment methods (Table 4.15, Figure 4.3)

4.10.1 XSA

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 (1984–2016). The summary of XSA stock estimates are presented in Table 4.15. A retrospective plot for XSA is given in Fig 4.4.

4.10.2 TISVPA (Figure 4.3)

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.

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 XSA except that natural mortality values from cannibalism were taken from the XSA 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 XSA. During AFWG 2016 the results of exploratory runs using the TISVPA model were presented and discussed (WD#12, 2016). The results generally support the results of SAM and XSA models demonstrating a dome-shaped structure of age-dependent components in the selection pattern and the estimate of SSB in 2015 about 600 thousand tonnes.

4.10.3 Results (Figure 4.3)

Results from SAM, XSA and TISVPA are compared in Fig 4.3. Comparison of results of SAM, TISVPA and XSA shows that the models demonstrate similar trends. For TSB and SSB, XSA and TISVPA results for the last couple of years are within the uncertainty range for SAM, while for F, XSA is inside the uncertainty range for SAM while TISVPA is outside (above). There are no evident differences in recent estimates of recruitment between all models except the very abundant year-classes 2004-2006.

4.11 Comments to the assessment

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

Other sources of uncertainties in assessment are described in Stock annex.

Table 4.1 North-East Arctic HADDOCK. Total nominal catch (t) by fishing areas.(Data provided by Working Group members).

Year	Sub-area I	Division IIa	Division IIb	un-reported2	Total3	Norw. stat. areas 06 and 074
1960	125 026	27 781	1844	-	154 651	6000
1961	165 156	25 641	2427	-	193 224	4000
1962	160 561	25 125	1723	-	187 409	3000
1963	124 332	20 956	936	-	146 224	4000
1964	79 262	18 784	1112	-	99 158	6000
1965	98 921	18 719	943	-	118 583	6000
1966	125 009	35 143	1626	-	161 778	5000
1967	107 996	27 962	440	-	136 398	3000
1968	140 970	40 031	725	-	181 726	3000
1969	89 948	40 306	566	-	130 820	2000
1970	60 631	27 120	507	-	88 258	-
1971	56 989	21 453	463	-	78 905	-
1972	221 880	42 111	2162	-	266 153	-
1973	285 644	23 506	13077	-	322 227	-
1974	159 051	47 037	15069	-	221 157	10000
1975	121 692	44 337	9729	-	175 758	6000
1976	94 054	37 562	5648	-	137 264	2000
1977	72 159	28 452	9547	-	110 158	2000
1978	63 965	30 478	979	-	95 422	2000
1979	63 841	39 167	615	-	103 623	6000
1980	54 205	33 616	68	-	87 889	5098
1981	36 834	39 864	455	-	77 153	4767
1982	17 948	29 005	2	-	46 955	3335
1983	5837	16 859	1904	-	24 600	3112
1984	2934	16 683	1328	-	20 945	3803
1985	27 982	14 340	2730	-	45 052	3583
1986	61 729	29 771	9063	-	100 563	4021
1987	97 091	41 084	16741	-	154 916	3194
1988	45 060	49 564	631	-	95 255	3756
1989	29 723	28 478	317	-	58 518	4701
1990	13 306	13 275	601	-	27 182	2912
1991	17 985	17 801	430	-	36 216	3045
1992	30 884	28 064	974	-	59 922	5634
1993	46 918	32 433	3028	-	82 379	5559
1994	76 748	50 388	8050	-	135 186	6311
1995	75 860	53 460	13128	-	142 448	5444
1996	112 749	61 722	3657	-	178 128	5126
1997	78 128	73 475	2756	-	154 359	5987

1998	45 640	53 936	1054	-	100 630	6338
1999	38 291	40 819	4085	-	83 195	5743
2000	25 931	39 169	3844	-	68 944	4536
2001	35 072	47 245	7323	-	89 640	4542
2002	40 721	42 774	12 567	18 736/5310	114 798/101 372	6898
2003	53 653	43 564	8483	33 226/9417	138 926/115 117	4279
2004	64 873	47 483	12 146	33 777/8661	158 279/133 163	3743
2005	53 518	48 081	16 416	40 283/9949	158 298/127 964	5538
2006	51 124	47 291	33 291	21 451/8949	153 157/140 655	5410
2007	62 904	58 141	25927	14 553/3102	161 525/150 074	7110
2008	58 379	60 178	31 219	5828/-	155 604/149 776	6629
2009	57 723	66 045	76 293	0	200 061	4498
2010	62 604	86 279	100 318	0	249 200	3661
2011	86 931	99 307	123 546	0	309 785	4169
2012	90 141	96 807	128 679	0	315 627	3869
2013	68 416	64 810	60 520	0	193 744	4000
2014	61 537	58 320	57 665	0	177 522	3433
2015	75 195	615 674	57 993	0	19 4756	3902
20161	78 714	95 140	59 561	0	23 3416	3233

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) Figures based on Norwegian/Russian IUU estimates. During the period 2002-2008, the Norwegian IUU-estimates (bold) were used in the final assessments.

4) Included in total landings and in landings in region IIa.

Table 4.2 North-East Arctic HADDOCK. Total nominal catch ('000 t) by trawl and other gear for each area.

	Sub-area I		Division IIa		Division IIb		Unreported2
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	-
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
20161	56.4	22.3	62.5	32.5	45.4	14.1	0

1) Provisional

2) Figures based on Norwegian/Russian IUU estimates

Table 4.3 North-East Arctic HADDOCK. Nominal catch (t) by countries. Sub-area I and Divisions IIa and IIb combined. (Data provided by Working Group members).

Year	Faroe Islands	France	German Dem.Re Greenland.	Fed. Re. Germ.	Norway4	Poland	United Kingdom	Russia2	Others	Unreported catches3	Total3
1960	172	-	-	5597	46 263	-	45 469	57 025	125	-	154 651
1961	285	220	-	6304	60 862	-	39 650	85 345	558	-	193 224
1962	83	409	-	2895	54 567	-	37 486	91 910	58	-	187 408
1963	17	363	-	2554	59 955	-	19 809	63 526	-	-	146 224
1964	-	208	-	1482	38 695	-	14 653	43 870	250	-	99 158
1965	-	226	-	1568	60 447	-	14 345	41 750	242	-	118 578
1966	-	1072	11	2098	82 090	-	27 723	48 710	74	-	161 778
1967	-	1208	3	1705	51 954	-	24 158	57 346	23	-	136 397
1968	-	-	-	1867	64 076	-	40 129	75 654	-	-	181 726
1969	2	-	309	1490	67 549	-	37 234	24 211	25	-	130 820
1970	541	-	656	2119	37 716	-	20 423	26 802	-	-	88 257
1971	81	-	16	896	45 715	43	16 373	15 778	3	-	78 905
1972	137	-	829	1433	46 700	1433	17 166	196 224	2231	-	266 153
1973	1212	3214	22	9534	86 767	34	32 408	186 534	2501	-	322 226
1974	925	3601	454	23 409	66 164	3045	37 663	78 548	7348	-	221 157
1975	299	5191	437	15 930	55 966	1080	28 677	65 015	3163	-	175 758
1976	536	4459	348	16 660	49 492	986	16 940	42 485	5358	-	137 264
1977	213	1510	144	4798	40 118	-	10 878	52 210	287	-	110 158
1978	466	1411	369	1521	39 955	1	5766	45 895	38	-	95 422
1979	343	1198	10	1948	66 849	2	6454	26 365	454	-	103 623
1980	497	226	15	1365	66 501	-	2948	20706	246	-	92 504

1981	381	414	22	2402	63 435	Spain	1682	13 400	-	-	81 736
1982	496	53	-	1258	43 702	-	827	2900	-	-	49 236
1983	428	-	1	729	22 364	139	259	680	-	-	24 600
1984	297	15	4	400	18 813	37	276	1103	-	-	20 945
1985	424	21	20	395	21 272	77	153	22 690	-	-	45 052
1986	893	12	75	1079	52 313	22	431	45 738	-	-	100 563
1987	464	7	83	3105	72 419	59	563	78 211	5	-	154 916
1988	1113	116	78	1323	60 823	72	435	31 293	2	-	95 255
1989	1217	-	26	171	36 451	1	590	20 062	-	-	58 518
1990	705	-	5	167	20 621	-	494	5190	-	-	27 182
1991	1117	-	Greenland	213	22 178	-	514	12 177	17	-	36 216
1992	1093	151	1719	387	36 238	38	596	19 699	1	-	59 922
1993	546	1215	880	1165	40 978	76	1802	35 071	646	-	82 379
1994	2761	678	770	2412	71 171	22	4673	51 822	877	-	135 186
1995	2833	598	1097	2675	76 886	14	3111	54 516	718	-	142 448
1996	3743	6	1510	942	94 527	669	2275	74 239	217	-	178 128
1997	3327	540	1877	972	103 407	364	2340	41 228	304	-	154 359
1998	1903	241	854	385	75 108	257	1229	20 559	94	-	100 630
1999	1913	64	437	641	48 182	652	694	30 520	92	-	83 195
2000	631	178	432	880	42 009	502	747	22 738	827	-	68 944
2001	1210	324	553	554	49 067	1497	1068	34 307	1060	-	89 640
2002	1564	297	858	627	52 247	1505	1125	37 157	682	18 736/5310	
2003	1959	382	1363	918	56 485	1330	1018	41 142	1103	33 226/9417	
2004	2484	103	1680	823	62 192	54	1250	54 347	1569	33 777/8661	
2005	2138	333	15	996	60 850	963	1899	50 012	1262	40 283/9949	
2006	2390	883	1830	989	69 272	703	1164	53 313	1162	21 451/8949	

2007	2307	277	1464	1123	71 244	125	1351	66 569	2511	14 553/3102	
2008	2687	311	1659	535	72 779	283	971	68 792	1759	5828/-	
2009	2820	529	1410	1957	104 354	317	1315	85 514	1845	0	200 061
2010	3173	764	1970	3539	123 384	379	1758	111 372	2862	0	249 200
2011	1759	268	2110	1724	158 202	502	1379	139 912	4763	0	309 785
2012	2055	322	3984	1111	159 602	441	833	143 886	3393	0	315 627
2013	1886	342	1795	500	99 215	439	639	85 668	3260	0	193 744
2014	1470	198	1150	340	91 306	187	355	78 725	3791	0	177 522
2015	2459	145	1047	124	95 094	246	450	91 864	3327	0	194 756
20161	2460	340	1401	170	108 718	200	575	115 710	3838	0	233 416

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

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

Table 4.6. Northeast Arctic haddock. Stock weights at age (kg).

	1	2	3	4	5	6	7	8	9	10	11	12	13+
1950	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1951	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1952	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1953	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1954	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1955	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1956	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1957	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1958	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1959	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1960	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1961	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1962	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1963	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1964	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1965	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1966	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1967	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1968	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1969	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1970	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1971	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1972	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597

1973	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1974	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1975	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1976	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1977	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1978	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1979	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1980	0.063	0.262	0.454	0.878	1.159	1.675	2.292	3.134	3.31	3.553	3.792	3.792	3.792
1981	0.051	0.274	0.603	0.805	1.315	1.582	2.118	2.728	3.51	3.679	3.904	3.904	3.904
1982	0.036	0.224	0.631	1.049	1.217	1.782	2.017	2.553	3.14	3.853	4.016	4.016	4.016
1983	0.035	0.164	0.524	1.098	1.558	1.663	2.255	2.448	2.97	3.524	4.165	4.165	4.165
1984	0.028	0.158	0.391	0.926	1.632	2.093	2.121	2.718	2.865	3.363	3.878	3.878	3.878
1985	0.03	0.127	0.379	0.7	1.394	2.195	2.626	2.572	3.158	3.261	3.728	3.728	3.728
1986	0.035	0.136	0.311	0.682	1.069	1.898	2.761	3.138	3.005	3.568	3.632	3.632	3.632
1987	0.042	0.161	0.331	0.569	1.047	1.473	2.411	3.307	3.616	3.412	3.946	3.946	3.946
1988	0.039	0.189	0.383	0.603	0.887	1.452	1.895	2.915	3.822	4.054	3.787	3.787	3.787
1989	0.037	0.175	0.445	0.689	0.936	1.248	1.878	2.317	3.395	4.297	4.449	4.449	4.449
1990	0.031	0.169	0.413	0.789	1.054	1.312	1.635	2.308	2.728	3.844	4.73	4.73	4.73
1991	0.025	0.141	0.402	0.737	1.193	1.458	1.714	2.035	2.732	3.122	4.256	4.256	4.256
1992	0.023	0.114	0.34	0.721	1.119	1.63	1.881	2.127	2.437	3.142	3.491	3.491	3.491
1993	0.025	0.107	0.279	0.616	1.1	1.537	2.08	2.308	2.54	2.831	3.531	3.531	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	3.213	3.213
1995	0.034	0.128	0.282	0.484	0.8	1.327	1.952	2.401	2.959	3.135	3.335	3.335	3.335
1996	0.039	0.142	0.303	0.52	0.76	1.128	1.724	2.388	2.82	3.369	3.52	3.52	3.52
1997	0.039	0.161	0.333	0.551	0.816	1.076	1.481	2.127	2.814	3.22	3.751	3.751	3.751
1998	0.032	0.162	0.375	0.6	0.857	1.155	1.418	1.847	2.526	3.221	3.595	3.595	3.595

1999	0.031	0.135	0.376	0.665	0.926	1.206	1.523	1.775	2.215	2.911	3.604	3.604	3.604
2000	0.029	0.133	0.317	0.665	1.013	1.294	1.583	1.905	2.137	2.578	3.278	3.278	3.278
2001	0.031	0.124	0.314	0.569	1.01	1.395	1.688	1.977	2.292	2.495	2.929	2.929	2.929
2002	0.032	0.132	0.293	0.563	0.875	1.387	1.795	2.095	2.374	2.676	2.845	2.845	2.845
2003	0.032	0.137	0.314	0.528	0.865	1.216	1.78	2.196	2.503	2.768	3.049	3.049	3.049
2004	0.031	0.135	0.322	0.563	0.815	1.202	1.578	2.173	2.588	2.903	3.151	3.151	3.151
2005	0.027	0.132	0.319	0.578	0.865	1.137	1.559	1.946	2.554	2.962	3.29	3.29	3.29
2006	0.026	0.115	0.311	0.572	0.886	1.201	1.481	1.922	2.309	2.917	3.315	3.315	3.315
2007	0.027	0.111	0.274	0.559	0.879	1.23	1.557	1.833	2.281	2.661	3.257	3.257	3.257
2008	0.031	0.117	0.264	0.497	0.86	1.221	1.593	1.92	2.184	2.628	2.996	2.996	2.996
2009	0.029	0.13	0.278	0.479	0.77	1.197	1.584	1.961	2.278	2.526	2.958	2.958	2.958
2010	0.038	0.123	0.307	0.503	0.743	1.078	1.554	1.953	2.324	2.625	2.852	2.852	2.852
2011	0.032	0.157	0.292	0.551	0.778	1.043	1.407	1.917	2.317	2.675	2.955	2.955	2.955
2012	0.034	0.136	0.364	0.526	0.847	1.089	1.364	1.747	2.277	2.67	3.008	3.008	3.008
2013	0.025	0.143	0.319	0.645	0.813	1.179	1.421	1.696	2.086	2.626	3.005	3.005	3.005
2014	0.03	0.107	0.333	0.571	0.979	1.136	1.531	1.762	2.029	2.417	2.957	2.957	2.957
2015	0.026	0.126	0.256	0.592	0.875	1.345	1.481	1.889	2.104	2.356	2.736	2.736	2.736
2016	0.034	0.11	0.297	0.465	0.902	1.213	1.726	1.835	2.245	2.437	2.67	2.67	2.67

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	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1951	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1952	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1953	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1954	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1955	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1956	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1957	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1958	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1959	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1960	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1961	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1962	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1963	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1964	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1965	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1966	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1967	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1968	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1969	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1970	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1971	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1972	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1

1973	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1974	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1975	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1976	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1977	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1978	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1	1	1
1979	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	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	0.019	0.069	0.213	0.497	0.855	0.964	0.991	0.996	1	1	1
1997	0	0	0.026	0.062	0.204	0.495	0.76	0.948	0.989	0.997	1	1	1
1998	0	0	0.035	0.104	0.25	0.502	0.75	0.907	0.984	0.997	1	1	1

1999	0	0	0.051	0.127	0.348	0.595	0.76	0.898	0.969	0.995	1	1	1
2000	0	0	0.033	0.19	0.406	0.617	0.754	0.9	0.966	0.99	1	1	1
2001	0	0	0.036	0.116	0.476	0.647	0.856	0.895	0.967	0.989	1	1	1
2002	0	0	0.024	0.141	0.375	0.725	0.872	0.937	0.965	0.989	1	1	1
2003	0	0	0.022	0.086	0.358	0.619	0.866	0.949	0.968	0.984	1	1	1
2004	0	0	0.028	0.079	0.247	0.605	0.749	0.949	0.98	0.993	1	1	1
2005	0	0	0.03	0.092	0.207	0.531	0.784	0.929	0.978	0.993	1	1	1
2006	0	0	0.03	0.108	0.264	0.511	0.734	0.928	0.971	0.995	1	1	1
2007	0	0	0.023	0.089	0.343	0.546	0.788	0.913	0.964	0.993	1	1	1
2008	0	0	0.02	0.091	0.281	0.494	0.793	0.871	0.962	0.982	1	1	1
2009	0	0	0.018	0.065	0.229	0.56	0.737	0.912	0.973	0.985	1	1	1
2010	0	0	0.021	0.071	0.189	0.461	0.738	0.932	0.967	0.986	1	1	1
2011	0	0	0.02	0.09	0.216	0.433	0.696	0.941	0.923	0.988	1	1	1
2012	0	0	0.032	0.066	0.239	0.448	0.698	0.839	0.895	0.991	1	1	1
2013	0	0	0.033	0.133	0.225	0.506	0.721	0.856	0.948	0.991	1	1	1
2014	0	0	0.034	0.118	0.347	0.558	0.751	0.872	0.944	0.964	1	1	1
2015	0	0	0.027	0.123	0.319	0.638	0.75	0.893	0.944	0.981	1	1	1
2016	0	0	0.033	0.091	0.383	0.65	0.829	0.898	0.961	0.979	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 eaten, tonnes
1984	1923.8	980.7	14.7	0.1	0	0	0	50.3
1985	1697.3	1206.2	5.2	0	0	0	0	47
1986	92.2	566.3	244.2	168.1	0	0	0	110.4
1987	0	768.4	0	0	0	0	0	4.2
1988	0	17.1	0.5	9.1	0	0.2	0	2.6
1989	22	230.4	0	0	0	0	0	10.3
1990	51.1	144	37.9	3.7	0	0	0	15.5
1991	0	457.8	14.2	0	0	0	0	20.2
1992	166.4	2111.4	150.8	1.1	0	0	0	106.1
1993	776	1376.4	165.3	36.6	3.4	2.9	0	70.9
1994	1309.6	1412.3	80	24.6	7.4	0.9	0	48.3
1995	192.3	2899.5	163	11.7	27.9	27.4	0.3	112.8
1996	344.5	1594.1	161.4	40.2	5.5	2.6	3.4	68.7
1997	0	906.5	35.5	25.5	1.7	0.8	0.5	41.3
1998	0	1534.8	28.2	2	2.9	0.5	0	32.5
1999	0	898.2	23.4	0.3	0	0	0	25.8
2000	696.5	1216.4	65	2.1	1.1	0.2	0.1	51.1
2001	983	554.9	52.8	5	0.1	0	0	48.9
2002	445.8	2409.9	232.7	38.7	2.5	0.4	0.2	124.9
2003	1190.4	3668.9	225.9	40	12.6	1.2	0	171
2004	5693.2	3078.3	316.5	42.9	11.2	2.8	0	208.8
2005	7471.8	6660.1	281.5	58.2	10.2	2.5	1.2	320.3
2006	12854.8	7988.2	374.6	5.6	4.7	1.3	0.5	352.7
2007	1239.3	10291.5	665.8	71.7	4.2	2.5	0.3	381.9
2008	1451.3	1034.2	895.1	230.7	52.7	6.7	4.2	312
2009	6566	2127.1	304.9	271.8	75.5	25.5	1.8	281.6
2010	2347.1	6053.2	165.6	66.5	78.7	74.2	14.1	298.4
2011	3056.2	3061.7	406.2	48.8	73.8	88.5	23.8	301.2
2012	330.5	7875.9	138.6	108.7	15	6.6	4.3	238.3
2013	2726.3	2004.2	421	26.9	20	4.7	3.9	213.6
2014	1168	2344.8	140.9	22.6	1.4	0.5	0	91.5
2015	5920.3	2786.8	114.9	10.2	29.4	1	0.1	184.1
2016	14087.9	3648	351.2	17.2	1.9	5.2	1.2	277.8
1984-2016	2266.8	2542.7	190.2	42.1	13.4	7.9	1.8	140.2

Table 4.9. Northeast Arctic haddock. Survey indices used in tuning SAM assessment model

104

RU-BTR-Q4

19,912,016

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

BS-NoRU-Q1(Aco)

19,932,017

1 1 0.085 0.26

4 8

1	1300	130	-1	-1	-1
1	6310	1110	120	-1	-1
1	1110	3870	420	20	-1
1	310	760	1510	80	-1
1	170	120	430	430	20
1	280	120	50	130	160
1	130	140	40	10	20
1	650	190	110	20	10
1	230	220	10	10	-1
1	1490	140	120	10	-1
1	1980	1690	170	50	-1
1	760	760	660	70	20

1	1020	360	400	90	-1
1	860	300	120	90	20
1	540	880	220	60	50
1	2517	573	742	102	58
1	7730	4021	313	149	16
1	5930	5574	1914	103	29
1	681	3130	2626	524	16
1	300	584	2943	1349	316
1	1324	295	390	2437	1043
1	437	827	183	438	866
1	1464	365	308	115	185
1	96	613	141	244	79
1	766	45	392	72	90

BS-NoRu-Q1 (BTr)

19,942,017

1 1 0.085 0.189

4 9

1	4279	483	33.9	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	32.4	81.5	59.4	5.6
1	156	93.6	28.7	8.6	13	7.4
1	358	69.1	40.5	6.5	0.1	8.1

1	261	227	17.3	7.8	0.6	0.6
1	1868	119	84.3	8.6	1.9	0
1	1751	723	50.4	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	335	1050	201	407	100	273
1	946	47.6	452	88.4	129	11.5

FLT007: Eco-NoRu-Q3 (Btr)

20,042,016

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

Table 4.10. Northeast Arctic haddock. SAM model configuration used in 2017 assessment

```
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. 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
1950	69139	41101	116303	209943	174431	252685	0.74	0.59	0.92	381758	323446	450582
1951	644460	388070	1070241	126789	108097	148712	0.69	0.56	0.85	429780	323911	570252
1952	94298	56845	156427	101855	86190	120368	0.7	0.57	0.87	423286	320401	559208
1953	1089462	653099	1817378	120005	95891	150182	0.54	0.44	0.68	684042	496455	942510
1954	134997	81052	224847	169415	134600	213237	0.48	0.39	0.61	756446	561895	1018359
1955	55903	33290	93877	269329	207124	350216	0.41	0.33	0.52	729034	546473	972582
1956	229037	136437	384485	327556	246539	435198	0.44	0.35	0.55	625300	485037	806125
1957	59373	35660	98855	256400	197450	332951	0.41	0.33	0.52	435557	351343	539957
1958	68083	40570	114254	186736	150435	231797	0.49	0.39	0.61	315346	261863	379753
1959	384308	232894	634161	130789	107673	158869	0.45	0.36	0.56	335598	265194	424692
1960	322474	194773	533901	117263	98881	139062	0.56	0.45	0.69	421165	335226	529135
1961	148830	90703	244208	125148	104957	149222	0.66	0.54	0.81	401546	327454	492402
1962	305263	186404	499910	122920	101722	148535	0.75	0.61	0.92	374504	305279	459426
1963	312159	190616	511202	96457	81299	114441	0.73	0.59	0.91	358537	287839	446600
1964	326481	198230	537707	86438	73159	102128	0.66	0.53	0.82	379304	301598	477030
1965	125969	76345	207849	100398	83128	121255	0.56	0.45	0.7	369101	296828	458971
1966	305967	185308	505190	133685	108946	164040	0.54	0.43	0.68	421124	339953	521675
1967	318932	192498	528409	145200	118355	178132	0.46	0.36	0.58	444664	359027	550728
1968	16620	9932	27810	159840	132042	193492	0.48	0.38	0.61	405585	327916	501651
1969	20637	12468	34158	160836	131848	196196	0.41	0.32	0.52	301766	242924	374862
1970	196985	118009	328815	149677	120915	185282	0.39	0.31	0.5	273805	220988	339244
1971	95942	57102	161201	122792	99052	152222	0.34	0.26	0.43	246994	202357	301477

1972	1104475	673680	1810749	122401	102068	146786	0.62	0.49	0.77	600405	431295	835821
1973	315862	192888	517237	125698	104072	151818	0.51	0.41	0.65	666424	506119	877502
1974	70631	43328	115138	166497	132481	209248	0.56	0.44	0.7	511871	400828	653677
1975	60251	37051	97977	190369	148261	244437	0.51	0.41	0.64	373585	298619	467372
1976	63906	39096	104461	183273	143536	234010	0.72	0.58	0.89	282140	229929	346206
1977	121998	73820	201618	117033	92333	148340	0.74	0.6	0.92	200703	165394	243550
1978	211641	129399	346156	78743	62123	99811	0.62	0.5	0.78	196284	155925	247090
1979	153353	93457	251638	61859	49373	77502	0.57	0.45	0.73	201604	161237	252078
1980	19647	11559	33393	62008	50435	76237	0.46	0.35	0.58	204946	163436	256999
1981	9475	5673	15824	71050	57313	88079	0.41	0.31	0.52	160513	127721	201724
1982	16570	9996	27467	67915	53936	85516	0.36	0.28	0.46	119919	96451	149097
1983	9553	5711	15980	59370	47433	74309	0.36	0.28	0.47	89330	73133	109113
1984	14128	8486	23522	53097	42456	66406	0.3	0.24	0.39	72136	59233	87849
1985	326349	196945	540778	49702	40571	60889	0.4	0.32	0.51	180151	126375	256810
1986	463304	280982	763929	53934	44359	65576	0.55	0.44	0.69	352316	263049	471877
1987	84067	50504	139934	71203	56150	90292	0.66	0.52	0.83	329657	257466	422088
1988	38432	22864	64600	76765	60447	97487	0.53	0.41	0.69	247829	195815	313659
1989	30395	18262	50588	82916	63988	107441	0.3	0.23	0.4	189489	150055	239287
1990	37246	23275	59603	88561	68862	113895	0.23	0.18	0.3	157452	127200	194900
1991	98851	69090	141432	100710	81142	124995	0.25	0.19	0.31	181465	152793	215518
1992	312410	219947	443743	114864	95282	138471	0.29	0.23	0.36	287812	242121	342126
1993	889656	615726	1285454	132379	112919	155193	0.3	0.24	0.37	550367	449732	673521
1994	303493	213759	430896	168189	146353	193282	0.35	0.27	0.43	668180	563641	792106
1995	82247	57703	117231	215789	186241	250025	0.33	0.26	0.41	658839	558330	777441
1996	92777	65205	132007	264686	225071	311274	0.4	0.32	0.49	577671	494297	675108
1997	91932	64675	130675	213340	181009	251445	0.49	0.39	0.61	377985	327016	436899

1998	61648	43517	87333	152132	129350	178927	0.48	0.39	0.6	263148	230174	300847
1999	192031	135345	272460	111677	95387	130749	0.47	0.38	0.58	248326	213939	288240
2000	77633	54831	109918	101294	87007	117929	0.37	0.29	0.46	231042	200547	266174
2001	349741	245939	497354	107078	92536	123904	0.36	0.29	0.45	294548	248568	349035
2002	367029	259338	519439	134151	116849	154015	0.33	0.27	0.41	434150	369896	509565
2003	246621	175533	346498	179813	156855	206132	0.4	0.32	0.49	528457	457031	611046
2004	222091	163266	302110	185071	161849	211625	0.41	0.33	0.51	487798	428834	554869
2005	350823	254099	484365	185096	162020	211460	0.43	0.35	0.53	506569	442698	579656
2006	164974	121382	224221	177148	155201	202198	0.38	0.31	0.47	446801	392955	508025
2007	898282	633503	1273730	204372	179846	232242	0.35	0.29	0.44	655753	552658	778081
2008	1329769	940149	1880857	219350	192268	250247	0.29	0.23	0.37	981142	814923	1181264
2009	1083394	765562	1533178	258731	225147	297324	0.25	0.2	0.32	1292442	1073014	1556741
2010	307270	226413	417003	368654	315885	430238	0.23	0.18	0.29	1442960	1213780	1715413
2011	106895	78804	144999	487852	412847	576485	0.22	0.18	0.28	1290389	1088707	1529433
2012	294197	212988	406370	588932	492660	704017	0.2	0.15	0.25	1159621	981641	1369871
2013	105011	76581	143995	651494	537000	790398	0.15	0.12	0.19	1029862	868471	1221245
2014	340143	247571	467328	675563	540987	843617	0.15	0.12	0.19	1026566	853865	1234198
2015	79170	55999	111928	656269	503483	855419	0.17	0.13	0.22	963719	780189	1190421
2016	183956	125741	269123	675068	501105	909423	0.2	0.15	0.26	911430	712613	1165716
2017	NA	14670	2306684	536454	372423	772732	0.2	0.12	0.34	741064	527854	1040393

Table 4.12. Northeast Arctic haddock. Estimated fishing mortality at age.

Year Age	3	4	5	6	7	8	9	10	11	12	13
1950	0.092	0.387	0.679	0.843	1.032	0.985	0.803	0.803	0.803	0.803	0.803

1951	0.085	0.354	0.624	0.789	0.98	0.964	0.803	0.803	0.803	0.803	0.803
1952	0.088	0.364	0.635	0.806	1.012	1.003	0.842	0.842	0.842	0.842	0.842
1953	0.066	0.279	0.485	0.618	0.789	0.784	0.679	0.679	0.679	0.679	0.679
1954	0.054	0.235	0.418	0.552	0.73	0.734	0.636	0.636	0.636	0.636	0.636
1955	0.044	0.196	0.358	0.476	0.615	0.581	0.48	0.48	0.48	0.48	0.48
1956	0.05	0.211	0.386	0.515	0.646	0.602	0.504	0.504	0.504	0.504	0.504
1957	0.047	0.201	0.368	0.48	0.592	0.548	0.487	0.487	0.487	0.487	0.487
1958	0.057	0.236	0.44	0.575	0.706	0.672	0.642	0.642	0.642	0.642	0.642
1959	0.059	0.237	0.42	0.524	0.603	0.573	0.572	0.572	0.572	0.572	0.572
1960	0.087	0.323	0.552	0.652	0.697	0.651	0.648	0.648	0.648	0.648	0.648
1961	0.113	0.403	0.682	0.776	0.782	0.703	0.672	0.672	0.672	0.672	0.672
1962	0.134	0.47	0.796	0.882	0.837	0.716	0.661	0.661	0.661	0.661	0.661
1963	0.127	0.454	0.776	0.874	0.826	0.69	0.627	0.627	0.627	0.627	0.627
1964	0.104	0.385	0.673	0.795	0.791	0.69	0.64	0.64	0.64	0.64	0.64
1965	0.086	0.324	0.563	0.677	0.696	0.624	0.591	0.591	0.591	0.591	0.591
1966	0.088	0.326	0.55	0.643	0.653	0.577	0.528	0.528	0.528	0.528	0.528
1967	0.076	0.282	0.465	0.535	0.549	0.499	0.457	0.457	0.457	0.457	0.457
1968	0.085	0.304	0.491	0.556	0.573	0.526	0.479	0.479	0.479	0.479	0.479
1969	0.079	0.273	0.425	0.468	0.47	0.43	0.389	0.389	0.389	0.389	0.389
1970	0.083	0.275	0.411	0.442	0.442	0.408	0.374	0.374	0.374	0.374	0.374
1971	0.075	0.246	0.358	0.373	0.369	0.345	0.324	0.324	0.324	0.324	0.324
1972	0.171	0.477	0.688	0.676	0.623	0.561	0.515	0.515	0.515	0.515	0.515
1973	0.166	0.442	0.594	0.541	0.478	0.422	0.388	0.388	0.388	0.388	0.388
1974	0.18	0.467	0.621	0.587	0.55	0.512	0.488	0.488	0.488	0.488	0.488
1975	0.179	0.456	0.579	0.525	0.483	0.442	0.42	0.42	0.42	0.42	0.42
1976	0.264	0.636	0.814	0.738	0.688	0.647	0.623	0.623	0.623	0.623	0.623

1977	0.289	0.689	0.871	0.75	0.666	0.613	0.573	0.573	0.573	0.573	0.573
1978	0.209	0.539	0.728	0.646	0.567	0.525	0.481	0.481	0.481	0.481	0.481
1979	0.159	0.45	0.664	0.633	0.548	0.52	0.468	0.468	0.468	0.468	0.468
1980	0.103	0.324	0.512	0.523	0.461	0.455	0.405	0.405	0.405	0.405	0.405
1981	0.086	0.276	0.447	0.477	0.421	0.415	0.36	0.36	0.36	0.36	0.36
1982	0.075	0.245	0.391	0.423	0.378	0.375	0.321	0.321	0.321	0.321	0.321
1983	0.082	0.259	0.397	0.421	0.379	0.379	0.308	0.308	0.308	0.308	0.308
1984	0.066	0.218	0.329	0.346	0.32	0.309	0.236	0.236	0.236	0.236	0.236
1985	0.077	0.258	0.409	0.467	0.472	0.466	0.36	0.36	0.36	0.36	0.36
1986	0.095	0.325	0.547	0.654	0.69	0.683	0.516	0.516	0.516	0.516	0.516
1987	0.105	0.367	0.648	0.785	0.836	0.811	0.568	0.568	0.568	0.568	0.568
1988	0.08	0.292	0.527	0.649	0.666	0.65	0.435	0.435	0.435	0.435	0.435
1989	0.048	0.184	0.318	0.367	0.35	0.311	0.207	0.207	0.207	0.207	0.207
1990	0.033	0.134	0.233	0.276	0.278	0.261	0.197	0.197	0.197	0.197	0.197
1991	0.033	0.137	0.25	0.3	0.302	0.281	0.219	0.219	0.219	0.219	0.219
1992	0.033	0.14	0.281	0.356	0.37	0.346	0.277	0.277	0.277	0.277	0.277
1993	0.026	0.122	0.273	0.379	0.414	0.388	0.318	0.318	0.318	0.318	0.318
1994	0.026	0.122	0.297	0.444	0.518	0.487	0.402	0.402	0.402	0.402	0.402
1995	0.024	0.112	0.273	0.414	0.501	0.47	0.386	0.386	0.386	0.386	0.386
1996	0.029	0.133	0.329	0.503	0.621	0.589	0.48	0.48	0.48	0.48	0.48
1997	0.038	0.168	0.416	0.619	0.747	0.676	0.528	0.528	0.528	0.528	0.528
1998	0.042	0.181	0.429	0.609	0.712	0.644	0.503	0.503	0.503	0.503	0.503
1999	0.045	0.19	0.431	0.585	0.67	0.606	0.484	0.484	0.484	0.484	0.484
2000	0.036	0.156	0.344	0.454	0.511	0.46	0.376	0.376	0.376	0.376	0.376
2001	0.034	0.15	0.337	0.45	0.501	0.454	0.382	0.382	0.382	0.382	0.382
2002	0.031	0.139	0.308	0.417	0.461	0.41	0.341	0.341	0.341	0.341	0.341

2003	0.037	0.158	0.355	0.495	0.574	0.52	0.437	0.437	0.437	0.437	0.437
2004	0.04	0.164	0.366	0.516	0.6	0.543	0.446	0.446	0.446	0.446	0.446
2005	0.041	0.167	0.373	0.537	0.649	0.603	0.5	0.5	0.5	0.5	0.5
2006	0.037	0.148	0.327	0.473	0.588	0.561	0.455	0.455	0.455	0.455	0.455
2007	0.032	0.129	0.287	0.436	0.565	0.55	0.437	0.437	0.437	0.437	0.437
2008	0.023	0.097	0.219	0.356	0.495	0.494	0.39	0.39	0.39	0.39	0.39
2009	0.02	0.083	0.183	0.305	0.448	0.463	0.366	0.366	0.366	0.366	0.366
2010	0.02	0.078	0.167	0.274	0.408	0.441	0.356	0.356	0.356	0.356	0.356
2011	0.021	0.078	0.164	0.262	0.388	0.425	0.341	0.341	0.341	0.341	0.341
2012	0.022	0.078	0.151	0.228	0.326	0.359	0.286	0.286	0.286	0.286	0.286
2013	0.019	0.067	0.121	0.171	0.245	0.286	0.239	0.239	0.239	0.239	0.239
2014	0.021	0.072	0.125	0.168	0.233	0.283	0.244	0.244	0.244	0.244	0.244
2015	0.027	0.089	0.15	0.191	0.253	0.307	0.263	0.263	0.263	0.263	0.263
2016	0.032	0.105	0.176	0.218	0.287	0.35	0.296	0.296	0.296	0.296	0.296
2017	0.033	0.108	0.181	0.224	0.295	0.359	0.304	0.304	0.304	0.304	0.304

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

YEAR AGE	3	4	5	6	7	8	9	10	11	12	13
1950	69139	105893	71803	37685	44152	16611	4894	3094	1275	1445	1971
1951	644460	45411	48680	27067	13087	12214	5192	2030	1197	449	1183
1952	94298	434011	29028	19315	9151	4323	3649	1716	825	450	589
1953	1089462	54716	210074	13564	6382	2751	1218	1079	578	313	421
1954	134997	798604	27184	93414	6637	2351	1183	547	400	216	319

1955	55903	85353	527140	14540	45105	2958	844	492	245	162	199
1956	229037	39121	57913	279795	7371	16999	1378	408	259	139	193
1957	59373	148794	26813	35541	112909	3276	6054	734	184	136	201
1958	68083	38866	89291	15470	19733	43337	1742	2524	379	103	211
1959	384308	48348	25677	40971	7507	7542	16218	806	904	160	145
1960	322474	263903	33847	15151	18101	3630	3871	7040	407	354	132
1961	148830	189983	144551	17170	6848	8134	1681	1545	3014	164	194
1962	305263	87191	88441	57126	6883	2733	3337	744	626	1268	134
1963	312159	184115	37815	26820	17569	2852	1137	1293	349	261	612
1964	326481	196470	79172	12170	7766	5840	1407	479	542	185	417
1965	125969	220341	111610	30069	3959	2662	2204	615	220	228	292
1966	305967	82805	141796	56508	11830	1535	1171	920	314	94	203
1967	318932	194402	44241	68381	24122	4659	691	568	446	159	141
1968	16620	234777	112636	22127	33630	12001	2180	362	299	231	156
1969	20637	10862	133715	52771	10719	15161	5587	1127	176	155	180
1970	196985	12310	6990	66421	24588	5890	7795	2997	641	96	197
1971	95942	124415	6836	4243	31869	12079	3242	4466	1667	375	161
1972	1104475	69931	72432	4402	3103	16682	6719	1930	2719	994	314
1973	315862	666221	38401	23841	1590	1635	7089	3044	918	1371	599
1974	70631	170737	299113	15069	10559	837	1167	4007	1689	541	1183
1975	60251	40002	88129	138794	6118	4752	378	626	1942	794	881
1976	63906	33962	17997	42272	72594	2853	2694	214	381	1037	921
1977	121998	33218	13667	6768	17063	30036	1127	1165	89	175	761
1978	211641	55736	9923	4395	3088	7547	14390	586	543	33	407
1979	153353	116033	22826	3129	2109	1496	4020	7004	346	266	210
1980	19647	97905	56341	8153	1050	1154	766	2187	3472	194	232

1981	9475	14314	59496	25326	3396	522	599	443	1224	1778	233
1982	16570	6225	10559	30355	10595	1644	272	345	289	719	1044
1983	9553	11420	4448	6745	13894	5474	987	147	209	190	911
1984	14128	5364	6654	2735	3913	8852	2627	596	81	125	613
1985	326349	9066	2865	3526	1950	2633	5427	1765	402	64	500
1986	463304	250007	5166	1650	1831	1018	1540	2893	1019	236	361
1987	84067	251241	132349	2514	714	733	470	764	1306	491	269
1988	38432	65220	140587	41069	1116	199	259	227	374	577	328
1989	30395	26326	46450	69439	11759	630	45	142	122	200	438
1990	37246	21230	17362	26896	33919	5276	520	49	96	79	352
1991	98851	25171	13157	13758	19944	20824	3003	374	41	66	242
1992	312410	80444	16533	9809	10668	12898	13910	1936	255	34	176
1993	889656	241092	52802	11309	6056	6587	8129	8685	1155	176	125
1994	303493	654783	148784	31822	4919	3089	4049	5147	5279	697	176
1995	82247	219126	451966	76649	14887	2290	1453	2245	2754	2897	468
1996	92777	66731	173778	244673	38699	7205	1319	804	1236	1543	1893
1997	91932	50838	37726	88941	95525	14930	2626	667	390	600	1705
1998	61648	68315	31468	20266	36774	39144	5750	1157	323	184	1154
1999	192031	46822	41290	17659	9321	14191	15281	2440	541	177	703
2000	77633	132021	31051	22435	7868	4085	6522	6930	1099	276	488
2001	349741	58637	76764	14972	9860	3578	2678	3819	3566	597	468
2002	367029	309168	44497	46856	8273	5576	2068	1582	2206	1913	562
2003	246621	274435	211016	34991	26045	4343	3890	1431	962	1327	1464
2004	222091	150741	155531	107983	17234	12160	2313	2072	822	511	1600
2005	350823	162994	86426	94615	48367	7024	6225	1410	1002	462	1261
2006	164974	210756	93574	51238	46425	19292	3512	3286	739	499	864

2007	898282	132345	169746	57753	27993	20402	8596	2037	1770	412	702
2008	1329769	610653	103010	104660	26221	16061	8434	4143	1198	963	608
2009	1083394	925642	456835	63893	38597	10907	6506	4324	2102	765	974
2010	307270	818030	714397	260679	36957	16064	5805	3626	2375	1214	1157
2011	106895	200014	594225	431953	118135	14791	8193	3029	2006	1356	1538
2012	294197	68201	129555	372460	261542	58424	7742	4105	1646	1159	1822
2013	105011	196837	54298	101714	262256	144407	28580	4569	2418	1023	1932
2014	340143	77394	139533	53840	100393	164995	83480	16138	2793	1569	1905
2015	79170	297180	69094	93377	45611	76078	105162	47985	9431	1670	2019
2016	183956	39246	183048	60630	80535	36625	61353	65090	28743	5603	2103
2017	183956	145846	18631	105411	34803	44155	19680	37363	39639	17504	4693

Table 4.14. Northeast Arctic haddock. Estimated natural mortalities M.

Year	3	4	5	6	7	8	9	10	11	12	13
1950	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1951	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1952	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1953	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1954	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1955	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1956	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1957	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1958	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1959	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2

1960	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1961	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1962	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1963	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1964	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1965	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1966	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1967	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1968	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1969	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1970	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1971	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1972	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1973	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1974	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1975	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1976	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1977	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1978	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1979	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1980	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1981	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1982	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1983	0.354	0.264	0.241	0.232	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1984	0.217	0.226	0.223	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1985	0.211	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

1986	0.631	0.272	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.2	0.209	0.382	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.382	0.2	0.221	0.356	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.202	0.2	0.2	0.239	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.338	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1991	0.2	0.215	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.211	0.206	0.209	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.258	0.247	0.27	0.27	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.28	0.222	0.246	0.234	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.348	0.321	0.315	0.22	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.726	0.316	0.247	0.295	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.497	0.242	0.21	0.226	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1998	0.241	0.272	0.201	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.211	0.216	0.222	0.211	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.215	0.224	0.247	0.257	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2001	0.214	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.324	0.219	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2003	0.416	0.264	0.241	0.203	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.418	0.278	0.2	0.227	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.415	0.291	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2006	0.222	0.214	0.214	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2007	0.307	0.205	0.259	0.247	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2008	0.381	0.3	0.26	0.362	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2009	0.432	0.273	0.321	0.233	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.363	0.274	0.315	0.333	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.539	0.483	0.364	0.259	0.2	0.2	0.2	0.2	0.2	0.2	0.2

2012	0.59	0.317	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2013	0.471	0.33	0.238	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2014	0.291	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2015	0.594	0.446	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2016	0.347	0.354	0.286	0.263	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2017	0.347	0.354	0.286	0.263	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 4.15. Northeast Arctic haddock. Summary. XSA ages 3-13+ (p-shrinkage not applied)

YEAR	RECR_A3 (THOUSANDS)	TOTBIO (TONNES)	TOTSPB (TONNES)	LANDINGS (TONNES)	YIELDSSB	SOPCOFAC	FBAR 4-7
1950	82768	242561	134510	132125	0.9823	1.5897	0.8318
1951	671718	356634	101063	120077	1.1881	1.2272	0.6245
1952	77193	235610	57477	127660	2.2211	1.7404	0.7252
1953	1280797	513066	82493	123920	1.5022	1.4279	0.5165
1954	153242	538239	117212	156788	1.3376	1.474	0.3808
1955	68959	485217	178635	202286	1.1324	1.536	0.5122
1956	209627	474285	243129	213924	0.8799	1.2623	0.4338
1957	66477	326299	186177	123583	0.6638	1.2455	0.433
1958	87476	276968	156903	112672	0.7181	1.1252	0.5195
1959	400386	365516	133201	88211	0.6622	0.9405	0.3678
1960	290969	401714	114630	154651	1.3491	1.0411	0.4845
1961	131367	391600	129927	193224	1.4872	0.9942	0.6372
1962	292118	346736	118775	187408	1.5778	1.0518	0.8012
1963	342507	311253	82633	146224	1.7696	1.1458	0.8658
1964	400057	302407	63844	99158	1.5531	1.3572	0.653
1965	124870	358065	95371	118578	1.2433	1.1507	0.494
1966	295150	387692	127375	161778	1.2701	1.1621	0.5842
1967	363900	468239	154361	136397	0.8836	0.9984	0.4155
1968	24031	421282	169418	181726	1.0726	0.9976	0.5038
1969	21528	342092	183920	130820	0.7113	0.882	0.398
1970	203355	286698	155928	88257	0.566	0.9762	0.3585
1971	123100	345988	168573	78905	0.4681	0.7638	0.247
1972	1256302	620825	123046	266153	2.163	1.0883	0.693
1973	343187	604205	114686	322226	2.8096	1.1656	0.5372
1974	69495	603210	200534	221157	1.1028	0.8946	0.4325
1975	60422	492134	255690	175758	0.6874	0.8957	0.4275
1976	67135	307263	206591	137264	0.6644	1.12	0.5715
1977	134783	229094	141797	110158	0.7769	1.09	0.6842
1978	214259	256346	130589	95422	0.7307	0.9219	0.5122
1979	176804	318719	129548	103623	0.7999	0.7684	0.5525
1980	34902	343258	133183	87889	0.6599	0.7568	0.3988
1981	13506	292664	148120	77153	0.5209	0.7174	0.4018
1982	17482	211749	127104	46955	0.3694	0.7224	0.3098
1983	9597	104370	71459	24600	0.3443	1.0373	0.2715
1984	13424	83509	64129	20945	0.3266	1.0547	0.2498
1985	288308	182821	62028	45052	0.7263	0.9761	0.32
1986	526772	342897	62304	100563	1.6141	1.0484	0.4388
1987	109804	333999	75071	154916	2.0636	0.992	0.5958
1988	55355	260336	78459	95255	1.2141	0.9955	0.499
1989	26605	212831	92036	58518	0.6358	0.9774	0.3888
1990	37335	171071	95383	27182	0.285	1.0159	0.156
1991	104717	195673	110622	36216	0.3274	1.0374	0.2082

1992	208374	269863	125916	59922	0.4759	0.9797	0.283
1993	667749	444619	130736	82379	0.6301	1.0031	0.3578
1994	293626	549427	151912	135186	0.8899	1.0056	0.424
1995	97892	544962	174845	142448	0.8147	1.0247	0.3815
1996	104990	479806	214214	178128	0.8315	1.0175	0.4215
1997	115698	353631	191927	154359	0.8043	1.0519	0.4822
1998	62738	255440	142508	100630	0.7061	1.0113	0.4162
1999	231851	261212	109384	83195	0.7606	1.021	0.4072
2000	98994	262450	105511	68944	0.6534	1.026	0.2665
2001	379252	375860	143088	89640	0.6265	0.9903	0.261
2002	359645	472054	168496	114798	0.6813	1.011	0.2902
2003	244219	523851	197072	138926	0.705	1.019	0.3972
2004	247586	519013	202898	158279	0.7801	1.0192	0.3322
2005	376957	557422	219642	158298	0.7207	1.0029	0.4262
2006	199683	515783	205191	153157	0.7464	0.9938	0.338
2007	783637	667887	231581	161525	0.6975	0.9916	0.3325
2008	1484051	1017797	240096	155604	0.6481	0.9928	0.2855
2009	1506965	1426912	299564	200061	0.6678	1.0019	0.2408
2010	490742	1586194	422828	249200	0.5894	0.9994	0.1922
2011	225705	1549006	598114	309785	0.5179	0.9978	0.232
2012	430219	1361285	678662	315627	0.4651	0.9994	0.2395
2013	181293	1141596	703989	193744	0.2752	0.9967	0.144
2014	435038	1085963	684878	177522	0.2592	0.9968	0.127
2015	78389	975710	643634	194756	0.3026	0.9953	0.1562
2016	266311	822148	561940	233183	0.415	1.0006	0.2

Table 4.16. Northeast Arctic haddock. Input data for recruitment prediction (RCT3)

ORTHEAST ARCTIC HADDOCK: RECRUITS AS 3 YEAR-OLDS

12 27 2

'YEAR-CLASS'	'SAM'	'NT1'	'NT2'	'NT3'	'NAK1'	'NAK2'	'NAK3'	'RT1'	'RT2'	'RT3'	'EC01'	'ECO2'	'ECO3'
1990	890	-11	-11	-11	1890	868	563	-11	42.9	128.6	-11	-11	-11
1991	303	-11	-11	315.2	1135	626	255	16.7	28.2	35.7	-11	-11	-11
1992	82	-11	220.9	57.6	947	193	36	16.4	4.8	5.8	-11	-11	-11
1993	93	593.5	182.1	55.5	562	285	44	3.5	4.9	4.2	-11	-11	-11
1994	92	1392.8	245	80.9	1379	229	51	9.1	7.2	5.7	-11	-11	-11
1995	62	295.5	93.5	21.2	249	24	20	6.4	2.3	1.9	-11	-11	-11
1996	192	1068.7	196	57.1	693	122	57	6	4.6	11.5	-11	-11	-11
1997	78	239.2	79.8	24.1	220	46	32	1.8	2.9	6.1	-11	-11	-11
1998	350	1186.4	429.8	291.8	856	509	210	10.7	28.9	26.2	-11	-11	-11
1999	367	817	450	313.8	1024	316	216	11.7	20.7	26.1	-11	-11	-11
2000	247	1215.5	464.5	337.8	976	282	145	15.1	14.9	18.9	-11	-11	-11
2001	222	1652.1	481.3	174.9	2062	279	127	20.8	19.3	25.1	-11	-11	-11
2002	351	3254.4	707.3	315.7	2394	474	219	33.2	32.8	20.6	-11	-11	268
2003	165	705.1	369.6	78.8	752	209	54	19.8	11	13.6	-11	189	114
2004	898	4400.9	1296.8	459.1	3364	804	379	50	79.2	122.7	104	626	929
2005	1083	4879.2	1679.9	1578.8	2767	868	723.4	62	79.2	214.2	155	2270	1819
2006	1108	3654.3	2072.2	1237.3	3197	1835.2	1021.7	53.4	83.9	232.7	283	988	1292
2007	307	831.1	329.1	96.1	1266.6	246.3	138	6.5	12.7	15.8	114	322	144
2008	107	550	81.4	52.6	849	81.8	47.6	5.7	2.9	4.3	60	136	65
2009	294	1586.4	354.4	321.6	2035.8	408	224.3	10	19.7	21.7	169	274	114

2010	105	670.9	137.3	55.5	786.5	176	52.9	7.7	3.5	4.3	154	105	42
2011	340	1844.8	480.2	370.6	2222.2	605	319	14.7	30.6	28.3	213	591	223
2012	79	335.7	119.8	30.2	525.5	114	17	6.9	6	2.2	74	156	75
2013	184	1129	315.2	152.7	1569.4	169.2	70	33	10.2	10.2	163	265	145
2014	-11	1071.7	509.2	129	1163.6	121.2	78.4	12	8.3	-11	183	320	84
2015	-11	2202.8	719.1	-11	1246.4	330	-11	17.6	-11	-11	343	538	-11
2016	-11	4693.3	-11	-11	3906.4	-11	-11	-11	-11	-11	496	-11	-11

1990 RT was removed from XSA tuning

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 ver.1

Analysis by RCT3 ver3.1 of data from file :

C:\r2017\2017.txt

NORTHEAST ARCTIC HADDOCK: recruits as 3 year-olds

Data for 12 surveys over 27 years : 1990 - 2016

Regression type = C
Tapered time weighting applied
power = 3 over 20 years
Survey weighting not applied

Final estimates shrunk towards mean
Minimum S.E. for any survey taken as .20
Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

Yearclass = 2011

	I-----------Regression----------I					I-----------Prediction---------I			
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.13	-2.45	.45	.805	18	7.52	6.02	.514	.041
NT2	.90	.23	.30	.904	19	6.18	5.80	.339	.094
NT3	.76	1.63	.35	.875	20	5.92	6.14	.398	.068
NAK1	1.46	-4.83	.58	.713	21	7.71	6.39	.673	.024
NAK2	.97	.08	.37	.859	21	6.41	6.30	.429	.058
NAK3	.84	1.41	.22	.945	21	5.77	6.28	.257	.163
RT1	1.18	2.36	.58	.709	20	2.75	5.60	.666	.024
RT2	.81	3.30	.24	.936	21	3.45	6.12	.274	.143
RT3	.68	3.47	.21	.948	21	3.38	5.78	.244	.181
EC01	4.06	-14.02	1.82	.278	7	5.37	7.76	2.462	.002
ECO2	1.00	-.07	.35	.907	8	6.38	6.31	.433	.057
ECO3	.70	1.98	.24	.948	9	5.41	5.78	.286	.131
					VPA Mean =		5.68	.871	.014

Yearclass = 2012

	I-----------Regression----------I					I-----------Prediction---------I			
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.12	-2.44	.42	.812	19	5.82	4.09	.537	.041
NT2	.89	.31	.28	.909	20	4.79	4.58	.337	.105
NT3	.76	1.62	.34	.867	21	3.44	4.23	.433	.063
NAK1	1.48	-5.09	.56	.709	22	6.27	4.20	.698	.024
NAK2	.97	.03	.36	.852	22	4.74	4.64	.440	.062
NAK3	.84	1.39	.25	.924	22	2.89	3.82	.337	.105
RT1	1.18	2.38	.56	.710	21	2.07	4.81	.658	.028
RT2	.81	3.31	.24	.932	22	1.95	4.88	.279	.153
RT3	.68	3.51	.20	.950	22	1.16	4.30	.253	.187
EC01	4.12	-14.58	1.84	.237	8	4.32	3.20	2.549	.002
ECO2	1.00	-.11	.36	.884	9	5.06	4.93	.458	.057
ECO3	.70	1.99	.22	.947	10	4.33	5.03	.276	.156
					VPA Mean =		5.72	.833	.017

Yearclass = 2013

	I-----------Regression----------I					I-----------Prediction---------I			
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.08	-2.12	.38	.856	20	7.03	5.48	.435	.059
NT2	.91	.19	.27	.921	21	5.76	5.42	.312	.115
NT3	.75	1.70	.32	.892	22	5.04	5.46	.370	.082
NAK1	1.48	-5.05	.50	.772	23	7.36	5.81	.576	.034
NAK2	1.02	-.29	.36	.869	23	5.14	4.96	.419	.064
NAK3	.78	1.74	.27	.924	23	4.26	5.06	.308	.118
RT1	1.25	2.13	.58	.723	22	3.53	6.55	.678	.024
RT2	.86	3.11	.28	.917	23	2.42	5.19	.322	.108
RT3	.66	3.57	.18	.963	23	2.42	5.16	.211	.251
EC01	3.41	-10.98	1.44	.367	9	5.10	6.40	1.760	.004
ECO2	1.09	-.71	.41	.868	10	5.58	5.37	.490	.047
ECO3	.78	1.50	.32	.910	11	4.98	5.40	.374	.080
					VPA Mean =		5.63	.887	.014

Yearclass = 2014

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.10	-2.25	.37	.860	21	6.98	5.39	.417	.083
NT2	.91	.14	.27	.920	22	6.23	5.85	.306	.154
NT3	.76	1.63	.32	.888	23	4.87	5.31	.367	.107
NAK1	1.54	-5.60	.50	.766	24	7.06	5.28	.573	.044
NAK2	1.02	-.28	.35	.873	24	4.81	4.63	.412	.085
NAK3	.77	1.79	.26	.924	24	4.37	5.16	.300	.160
RT1	1.35	1.76	.72	.612	23	2.56	5.21	.826	.021
RT2	.86	3.11	.27	.919	24	2.23	5.04	.312	.148
RT3									
EC01	3.58	-11.98	1.47	.329	10	5.21	6.70	1.789	.005
ECO2	1.10	-.78	.39	.867	11	5.77	5.56	.459	.069
ECO3	.79	1.43	.31	.906	12	4.44	4.95	.371	.105
						VPA Mean =	5.60	.865	.019

Yearclass = 2015

I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.10	-2.28	.36	.869	21	7.70	6.18	.419	.174
NT2	.91	.15	.27	.922	22	6.58	6.17	.314	.309
NT3									
NAK1	1.56	-5.76	.48	.789	24	7.13	5.36	.550	.101
NAK2	1.03	-.34	.35	.875	24	5.80	5.64	.402	.189
NAK3									
RT1	1.36	1.70	.74	.609	23	2.92	5.68	.851	.042
RT2									
RT3									
EC01	3.51	-11.66	1.45	.337	10	5.84	8.86	2.071	.007
ECO2	1.10	-.79	.39	.867	11	6.29	6.12	.469	.139
ECO3									
						VPA Mean =	5.58	.874	.040

Yearclass = 2016

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
	I-----------Regression----------				I	-----------Prediction---------I			
NT1	1.10	-2.30	.35	.879	21	8.45	7.01	.452	.530
NT2									
NT3									
NAK1	1.56	-5.82	.45	.812	24	8.27	7.12	.591	.311
NAK2									
NAK3									
RT1									
RT2									
RT3									
EC01	3.43	-11.28	1.41	.345	10	6.21	10.01	2.342	.020
ECO2									
ECO3									
					VPA Mean =		5.56	.883	.139

Year Class	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2011	411	6.02	.10	.07	.46	340	5.83
2012	95	4.56	.11	.12	1.23	80	4.38
2013	202	5.31	.11	.08	.59	185	5.22
2014	193	5.27	.12	.11	.79		
2015	386	5.96	.17	.15	.70		
2016	996	6.90	.33	.39	1.42		

Table 4.18. Northeast Arctic Haddock. Prediction with management option table: Input data (based on SAM estimates)

2017	SAM							
AGE	N	M	MAT	PF	PM	SWT	SEL	CWT
3	193000	0.411	0.031	0	0	0.281	0.032	0.85
4	145846	0.333	0.112	0	0	0.559	0.103	1.067
5	18631	0.229	0.281	0	0	0.804	0.172	1.316
6	105411	0.221	0.621	0	0	1.264	0.219	1.55
7	34803	0.2	0.823	0	0	1.598	0.293	1.773
8	44155	0.2	0.93	0	0	2.123	0.357	1.939
9	19680	0.2	0.961	0	0	2.199	0.305	2.089
10	37363	0.2	0.985	0	0	2.593	0.305	2.288
11	39639	0.2	1	0	0	2.751	0.305	2.679

12	17504	0.2	1	0	0	2.751	0.305	2.993
13	4693	0.2	1	0	0	2.751	0.305	3.265

2018

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	386000	0.411	0.032	0	0	0.298	0.032	0.85
4	.	0.333	0.077	0	0	0.498	0.103	1.067
5	.	0.229	0.281	0	0	0.921	0.172	1.316
6	.	0.221	0.493	0	0	1.145	0.219	1.55
7	.	0.2	0.826	0	0	1.832	0.293	1.773
8	.	0.2	0.918	0	0	2.069	0.357	1.939
9	.	0.2	0.979	0	0	2.67	0.305	2.089
10	.	0.2	0.987	0	0	2.631	0.305	2.288
11	.	0.2	1	0	0	3.155	0.305	2.679
12		0.2	1	0	0	3.155	0.305	2.993
13		0.2	1	0	0	3.155	0.305	3.265

2019

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	996000	0.411	0.062	0	0	0.434	0.032	0.85
4	.	0.333	0.089	0	0	0.537	0.103	1.067
5	.	0.229	0.211	0	0	0.778	0.172	1.316
6	.	0.221	0.557	0	0	1.281	0.219	1.55
7	.	0.2	0.725	0	0	1.499	0.293	1.773
8	.	0.2	0.93	0	0	2.238	0.357	1.939
9	.	0.2	0.974	0	0	2.462	0.305	2.089
10	.	0.2	0.991	0	0	3.065	0.305	2.288
11	.	0.2	1	0	0	3.004	0.305	2.679
12		0.2	1	0	0	3.004	0.305	2.993
13		0.2	1	0	0	3.004	0.305	3.265

"Input units are thousands and kg - output in tonnes"

Table 4.19. Northeast Arctic Haddock. Prediction with management option table for 2017–2019 (TAC constraint applied for intermediate year)

MFDP version 1a
Run: Man
MFDP Index file 27.04.2017
Time and date: 10:14 28.04.2017
Fbar age range: 4-7

2017				
Biomass	SSB	FMult	FBar	Landings
743605	537842	1.5664	0.3082	233000

2018					2019	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
658026	401586	0	0	0	1088285	451494
.	401586	0.1	0.0197	13839	1074847	440031
.	401586	0.2	0.0394	27343	1061767	428898
.	401586	0.3	0.059	40522	1049036	418086
.	401586	0.4	0.0787	53385	1036642	407584
.	401586	0.5	0.0984	65940	1024577	397384
.	401586	0.6	0.1181	78196	1012831	387477
.	401586	0.7	0.1377	90162	1001394	377854
.	401586	0.8	0.1574	101844	990258	368507
.	401586	0.9	0.1771	113252	979414	359427
.	401586	1	0.1968	124392	968855	350607
.	401586	1.1	0.2164	135272	958571	342039
.	401586	1.2	0.2361	145899	948555	333716
.	401586	1.3	0.2558	156279	938799	325630
.	401586	1.4	0.2755	166421	929296	317775
.	401586	1.5	0.2951	176329	920039	310143
.	401586	1.6	0.3148	186010	911021	302729
.	401586	1.7	0.3345	195471	902234	295525
.	401586	1.8	0.3542	204718	893673	288525
.	401586	1.9	0.3738	213755	885331	281724
.	401586	2	0.3935	222590	877202	275116

Input units are thousands and kg - output in tones

Table 4.20. Northeast Arctic Haddock. Prediction single option table for 2017-2019 based on HCR "MFDP version 1a"

MFDP	**version**	**1a**		
Run:	**final**			
Time	**and**	**date:**	**10:16**	**28/04/2017**
Fbar	**age**	**range:**	**4-7**	

Year:	**2017**	**F multiplier:**	**1.5664**	**Fbar:**	**0.3082**				
Age	**F**	**CatchNos**	**Yield**	**StockNos**	**Biomass**	**SSNos(Jan**	**SSB(Jan)**	**SSNos(ST)**	**SSB(ST)**
3	0.0501	7751	6588	193000	54233	5983	1681	5983	1681
4	0.1613	18566	19810	145846	81528	16335	9131	16335	9131
5	0.2694	3953	5202	18631	14979	5235	4209	5235	4209
6	0.3431	27638	42839	105411	133240	65460	82742	65460	82742
7	0.459	11699	20742	34803	55615	28643	45771	28643	45771
8	0.5592	17301	33547	44155	93741	41064	87179	41064	87179
9	0.4778	6829	14265	19680	43276	18912	41589	18912	41589
10	0.4778	12965	29663	37363	96882	36803	95429	36803	95429
11	0.4778	13754	36848	39639	109047	39639	109047	39639	109047
12	0.4778	6074	18179	17504	48154	17504	48154	17504	48154
13	0.4778	1628	5317	4693	12910	4693	12910	4693	12910
Total		128157	233000	660725	743605	280271	537842	280271	537842

Year:	**2018**	**F multiplier:**	**1.7704**	**Fbar:**	**0.3483**				
Age	**F**	**CatchNos**	**Yield**	**StockNos**	**Biomass**	**SSNos(Jan**	**SSB(Jan)**	**SSNos(ST)**	**SSB(ST)**
3	0.0567	17466	14846	386000	115028	12352	3681	12352	3681
4	0.1823	17341	18503	121701	60607	9371	4667	9371	4667
5	0.3045	20994	27628	88962	81934	24998	23023	24998	23023
6	0.3877	3287	5095	11318	12959	5580	6389	5580	6389
7	0.5187	22187	39337	59968	109862	49534	90746	49534	90746
8	0.632	7726	14980	18007	37256	16530	34201	16530	34201
9	0.54	7885	16472	20666	55178	20232	54019	20232	54019
10	0.54	3813	8723	9993	26290	9863	25949	9863	25949
11	0.54	7238	19391	18971	59854	18971	59854	18971	59854
12	0.54	7679	22984	20127	63500	20127	63500	20127	63500
13	0.54	4300	14040	11271	35559	11271	35559	11271	35559
Total		119916	202000	766982	658026	198828	401586	198828	401586

Year:	**2019**	**F multiplier:**	**1.7681**	**Fbar:**	**0.3479**				
Age	**F**	**CatchNos**	**Yield**	**StockNos**	**Biomass**	**SSNos(Jan**	**SSB(Jan)**	**SSNos(ST)**	**SSB(ST)**
3	0.0566	45012	38260	996000	432264	61752	26800	61752	26800
4	0.1821	34416	36722	241818	129856	21522	11557	21522	11557
5	0.3041	17135	22549	72691	56554	15338	11933	15338	11933
6	0.3872	15138	23463	52180	66843	29064	37231	29064	37231
7	0.518	2276	4035	6158	9230	4649	6969	4649	6969
8	0.6312	12528	24292	29227	65410	27181	60832	27181	60832
9	0.5393	2987	6239	7836	19292	7632	18790	7632	18790
10	0.5393	3758	8599	9860	30222	9772	29950	9772	29950
11	0.5393	1817	4869	4768	14322	4768	14322	4768	14322
12	0.5393	3450	10327	9052	27191	9052	27191	9052	27191
13	0.5393	5710	18644	14981	45002	14981	45002	14981	45002
Total		144228	198000	1444570	896187	205710	290578	205710	290578

Input units are thousands and kg - output in tones

Table 4.21. Northeast Arctic Haddock. Yield per recruit. Input data and results.

MFYPR	**version**	**2a**							
Run:	**2017**								
Time	**and**	**date:**	**10:21**	**28/04/2017**					
Yield	**per**	**results**							
FMult	**Fbar**	**CatchNos**	**Yield**	**StockNos**	**Biomass**	**SpwnNosJan**	**SSBJan**	**SpwnNosSpwn**	**SSBSpwn**
0	0	0	0	4.1877	5.4664	2.0637	4.2628	2.0637	4.2628
0.1	0.0246	0.0613	0.1222	3.8894	4.7261	1.7815	3.5428	1.7815	3.5428
0.2	0.0491	0.1091	0.2086	3.659	4.1678	1.5666	3.0038	1.5666	3.0038
0.3	0.0737	0.1475	0.2718	3.475	3.7333	1.3976	2.5877	1.3976	2.5877
0.4	0.0982	0.1793	0.3194	3.3243	3.3867	1.2613	2.2586	1.2613	2.2586
0.5	0.1228	0.206	0.3562	3.1982	3.1044	1.1493	1.9931	1.1493	1.9931
0.6	0.1473	0.229	0.3852	3.091	2.8706	1.0555	1.7752	1.0555	1.7752
0.7	0.1719	0.2491	0.4087	2.9983	2.6741	0.976	1.594	0.976	1.594
0.8	0.1964	0.2668	0.4279	2.9173	2.5068	0.9076	1.4413	0.9076	1.4413
0.9	0.221	0.2825	0.4439	2.8457	2.3628	0.8483	1.3114	0.8483	1.3114
1	0.2455	0.2968	0.4574	2.7818	2.2377	0.7964	1.1998	0.7964	1.1998
1.1	0.2701	0.3097	0.469	2.7243	2.1281	0.7505	1.103	0.7505	1.103
1.2	0.2947	0.3215	0.4791	2.6723	2.0312	0.7096	1.0186	0.7096	1.0186
1.3	0.3192	0.3323	0.4879	2.6247	1.9451	0.6731	0.9444	0.6731	0.9444
1.4	0.3438	0.3424	0.4957	2.5812	1.8679	0.6402	0.8789	0.6402	0.8789
1.5	0.3683	0.3517	0.5027	2.541	1.7985	0.6104	0.8205	0.6104	0.8205
1.6	0.3929	0.3605	0.509	2.5038	1.7356	0.5832	0.7684	0.5832	0.7684
1.7	0.4174	0.3687	0.5147	2.4691	1.6784	0.5585	0.7216	0.5585	0.7216
1.8	0.442	0.3764	0.5198	2.4368	1.6262	0.5357	0.6793	0.5357	0.6793
1.9	0.4665	0.3837	0.5246	2.4065	1.5782	0.5148	0.6411	0.5148	0.6411
2	0.4911	0.3907	0.529	2.3781	1.5341	0.4955	0.6063	0.4955	0.6063

Reference	**point**	**F multiplier**	**Absolute F**
Fbar(3-13)	**1**	**0.2455**	
FMax	**>=1000000**		
F0.1	**0.9014**	**0.2213**	
F35%SPR	**0.765**	**0.1878**	

***Weights in kilograms**

Table B1. Northeast Arctic HADDOCK. Abundance indices from bottom trawl surveys in the Barents Sea winter 1981-2017 (numbers in millions). 1981-1992 includes only main areas A, B, C and D.

	Age												Biomass
Year	1	2	3	4		5	6	7	8	9	10+	Total	('000 t)
1981	7	14	5	21		60	18	1	+	+	+	126	166
1982	9	2	3	4		4	10	6	+	+	+	38	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	562	193	255	631		111	12	+	+	+	+	1764	573
1995	1379	285	36	111		387	42	2	+	+	+	2242	466
1996	249	229	44	31		76	151	8	+	0	+	788	280
19971	693	24	51	17		12	43	43	2	+	+	885	155
19981	220	122	20	28		12	5	13	16	1	+	437	92
1999	855.8	45.5	57.3	13.1		13.9	3.6	1.4	1.9	1.6	0.03	994	81
2000	1024.4	508.9	32.2	64.9		18.5	10.5	1.6	0.5	1.8	0.4	1664	185
2001	976.5	315.6	209.6	23.1		21.6	1.3	0.9	0.1	0.04	0.5	1549	175

2002	2062.1	282	215.7	149.5		13.5	11.7	1	0.2	0.03	0.7	2736	264
2003	2394.5	278.6	145.2	197.6		168.8	17.2	5	0.2	0.1	1.1	3208	455
2004	751.8	474.3	126.7	75.9		76	65.9	6.6	2	0.1	0.3	1580	287
2005	3363.6	209.2	218.9	101.9		36.5	40.1	9	0.1	0.1	0	3979	302
20062	2767.1	803.6	54.2	86.2		30.2	11.6	9	2.2	0.09	0.21	3764	282
20071	3197	868	379	54		88	22	6	5	2	0	4621	462
2008	1266.6	1835.2	723.4	251.7		57.3	74.2	10.2	5.8	0.35	1.03	4226	841
2009	849	246.3	1021.7	773		402.1	31.3	14.9	1.6	0.13	0.53	3341	1006
2010	2035.8	81.8	138	593		557.4	191.4	10.3	2.9	0.68	0.72	3612	975
2011	786.5	408	47.6	68.1		313	262.6	52.4	1.6	0.45	0.63	1941	683
20122	2222.2	176	224.3	30		58.4	294.3	134.9	31.6	0.83	0.42	3173	739
2013	525.5	605	52.9	132.4		29.5	39	243.8	104.3	14.2	0.29	1747	772
2014	1569.4	114	319	43.7		82.7	18.3	43.8	86.6	37.64	3.49	2318	556
2015	1163.6	169.2	17	146.4		36.5	30.8	11.5	18.5	17.61	5.29	1617	312
2016	1246.4	121.2	70	9.6		61.3	14.1	24.4	7.9	13.26	18.55	1587	287
20172	3906.4	330	78.4	76.6		4.5	39.2	7.2	9	1.3	13.8	4474	362

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	5	3.1	5.6	3.4	7.7	62.3	56.5	4.8	0.4	0.6	-	149.3
19971	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	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
20063	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
								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		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	29.2		4.1		25	8.1		4.9		9.1		13.4		1.3		0.4	0.1	-	95.7
1997	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
20022	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	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

Year \Age	0	1	2	3	4	5	6	7	8	9	10+	Total
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
19961	4.3	0.6	0.5	0.3	0.2	0.4	0.5	0.3	-	-	-	7.1
19971	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
20022	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

20063	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
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
19961	6	2.3		5.7			2.8		4.9		36.2		33.4		2.9	0.3	0.3	-	94.8

19971	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
20022	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
20063	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
20164																			

1Adjusted data based on average 1985-1995 distribution.

2Adjusted based on 2001 distribution.

3Adjusted 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	Total	Biomass	Area covered	Added area
1981	7	14	5	21	60	18	1	0	0	0	126	166		
1982	9	2	3	4	4	10	6	0	0	0	38	50		
1983	0	5	2	3	1	1	4	2	0	0	18	25		
1984	1685	173	6	2	1	0	0	0	0	0	1867	101		
1985	1530	776	215	5	0	0	0	0	0	0	2526	259		
1986	556	266	452	189	0	0	0	0	0	0	1463	333		
1987	85	17	49	171	50	0	0	0	0	0	372	157		
1988	18	4	8	23	46	7	0	0	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	0	0	335	51		
1991	1890	252	45	8	3	3	3	6	0	0	2210	166		
1992	1135	868	134	23	2	0	0	1	2	0	2165	239	88 135	
1993	947	626	563	130	13	0	0	0	0	3	2282	385	137 642	
1994	562	193	255	631	111	12	0	0	0	0	1764	573	161 110	
1995	1379	285	36	111	387	42	2	0	0	0	2242	466	191 904	
1996	249	229	44	31	76	151	8	0	0	0	788	280	166 190	
19971	693	24	51	17	12	43	43	2	0	0	885	155	88 371	56 200
19981	220	122	20	28	12	5	13	16	1	0	437	92	100 440	51 100
1999	856	46	57	13	14	4	1	2	2	0	994	81	118 545	
2000	1024	509	32	65	19	11	2	1	2	0	1664	185	163 204	
2001	976	316	210	23	22	1	1	0	0	1	1549	175	164 652	
2002	2062	282	216	149	14	12	1	0	0	1	2737	264	157 369	

2003	2394	279	145	198	169	17	5	0	0	1	3208	455	147 361	
2004	752	474	127	76	76	66	7	2	0	0	1580	287	164 428	
2005	3364	209	219	102	36	40	9	0	0	0	3979	302	179 883	
2006	2767	804	54	86	30	12	9	2	0	0	3764	282	170 064	18 100
20071	3197	868	379	54	88	22	6	5	2	0	4621	462	123 894	56 700
2008	1266.6	1835	723	252	57	74	10	6	0	1	4226	841	165 176	
2009	849	246.3	1021.7	773	402.1	31.3	14.9	1.6	0.13	0.53	3341	1006	171 774	
2010	2035.8	81.8	138	593	557.4	191.4	10.3	2.9	0.68	0.72	3612	975	160 501	
2011	786.5	408	47.6	68.1	313	262.6	52.4	1.6	0.45	0.63	1941	683	174 324	
20121	2222.2	176	224.3	30	58.4	294.3	134.9	31.6	0.83	0.42	3173	739	151 263	16 700
2013	525.5	605	52.9	132.4	29.5	39	243.7	104.3	14.19	0.29	1747	760	203 358	
2014	1569.4	114	319	43.7	82.7	18.3	43.8	86.6	37.64	3.49	2318	554	208 754	
2015	1163.6	169.2	17	146.4	36.5	30.8	11.5	18.5	17.61	5.29	1617	312	196 047	
2016	1246.4	121.2	70	9.6	61.3	14.1	24.4	7.9	13.26	18.55	1587	287	173 568	
20172	3906.4	330	78.4	76.6	4.5	39.2	7.2	9	1.3	13.8	4474	362	146 903	37 460

1) **Indices adjusted to account for limited area coverage. Survey areas extended from 1993 onwards.**

2) 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).

	Age											
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

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 I and II . Indices of numbers (in millions) of fish at age (+ means value <1; - means 0 value).

	Age											
Year	0	1	2	3	4	5	6	7	8	9	10+	Total
2004	104	189	268	123	70	69	31	3	2	-	+	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	+	3323
2009	169	136	144	651	618	306	21	7	1	1	-	2053
2010	154	274	65	184	865	666	148	16	3	-	+	2376
2011	213	105	114	40	74	393	301	37	3	+	+	1281
2012	74	591	42	93	20	68	214	152	13	0.3	+	1268
2013	163	156	223	26	65	20	51	150	76	7	+	938
2014	183	265	75	262	41	70	26	60	86	18	1	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	47	2111

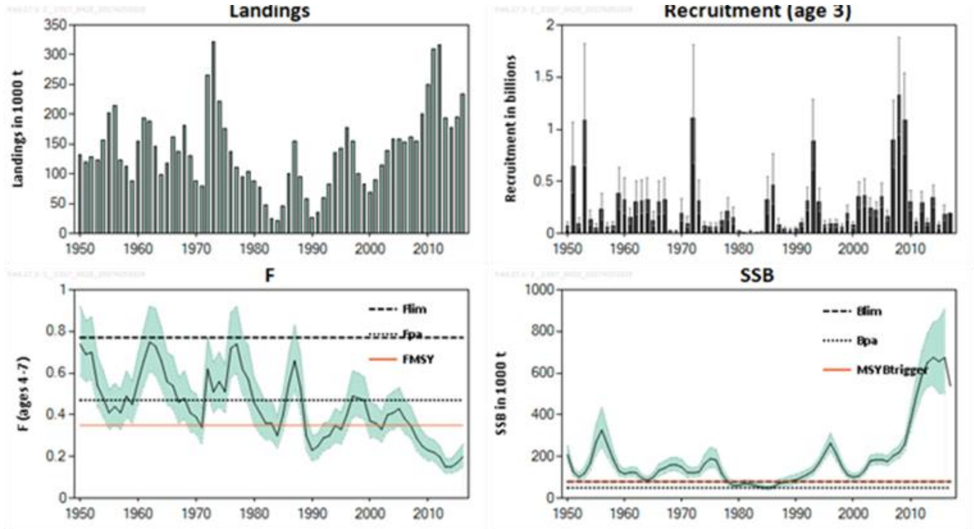


Figure 4.1 Landings, fishing mortality, recruitment (2016 prediction unshaded), and spawning stock biomass of Northeast Arctic haddock 1950-2017. Fishing mortality and spawning stock biomass are given with point wise 95% confidence intervals (shaded areas)

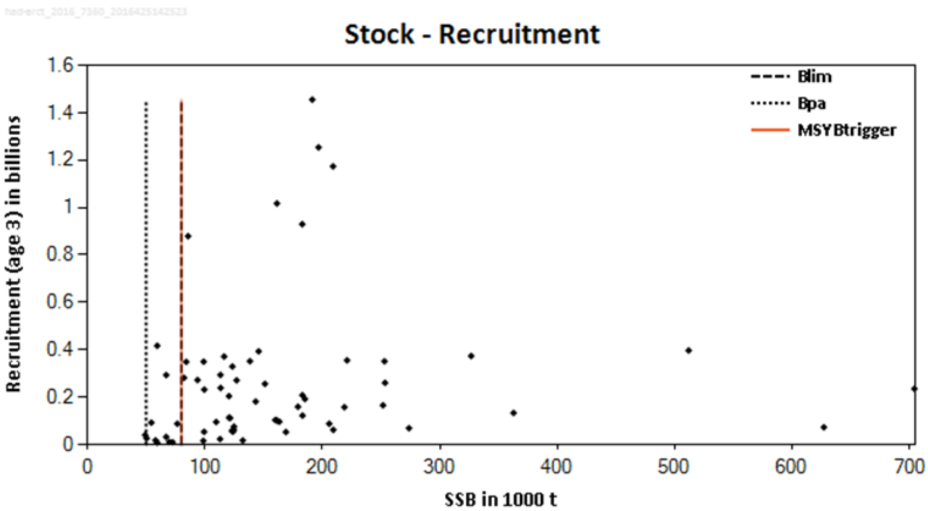


Figure 4.2 Stock-Recruitment relationship of Northeast Arctic haddock 1950–2016

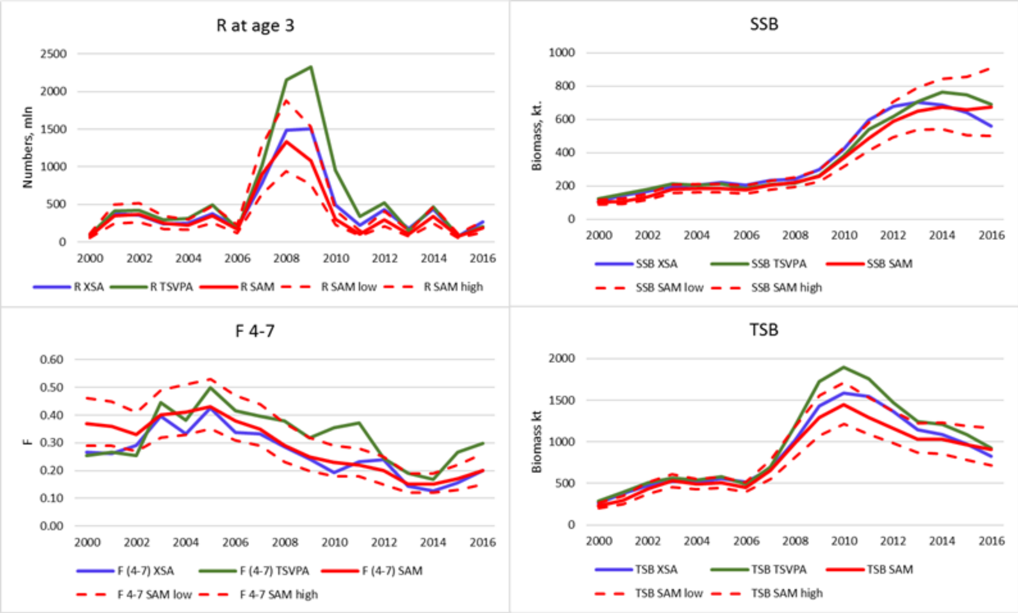


Figure 4.3. Results of assessment of NEA haddock - Recruits, biomass, spawning biomass and F by different models (SAM with point wise 95% confidence intervals, XSA with different settings and TISVPA).

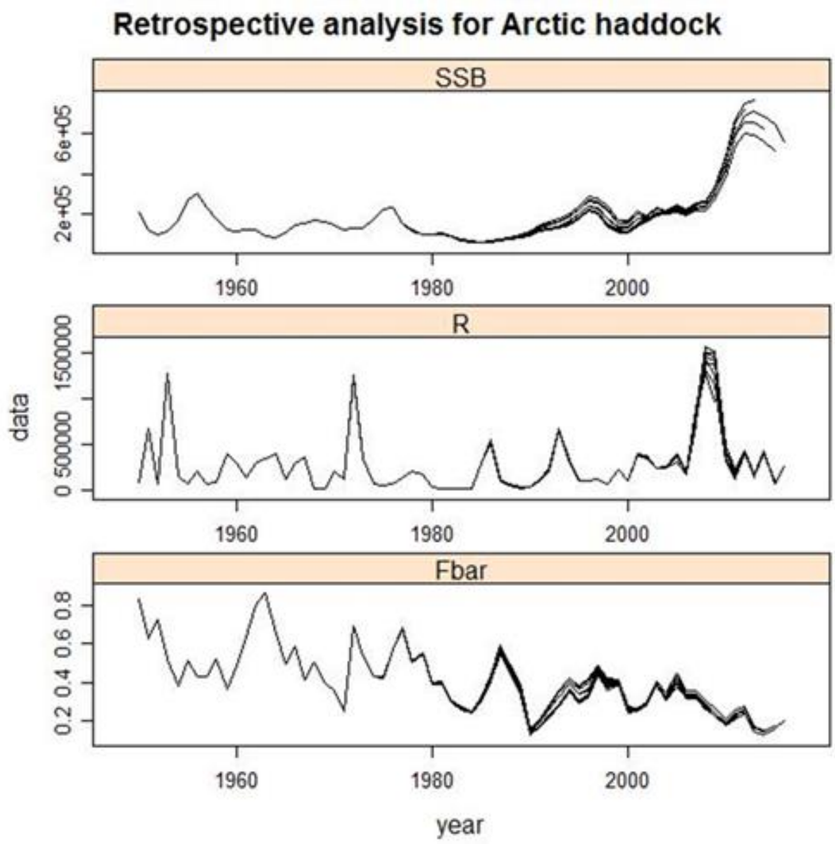


Figure 4.4. Northeast Arctic haddock. Retrospective plots of SSB, fishing mortality and recruitment for assessment years 1950-2016 (XSA without P shrinkage)

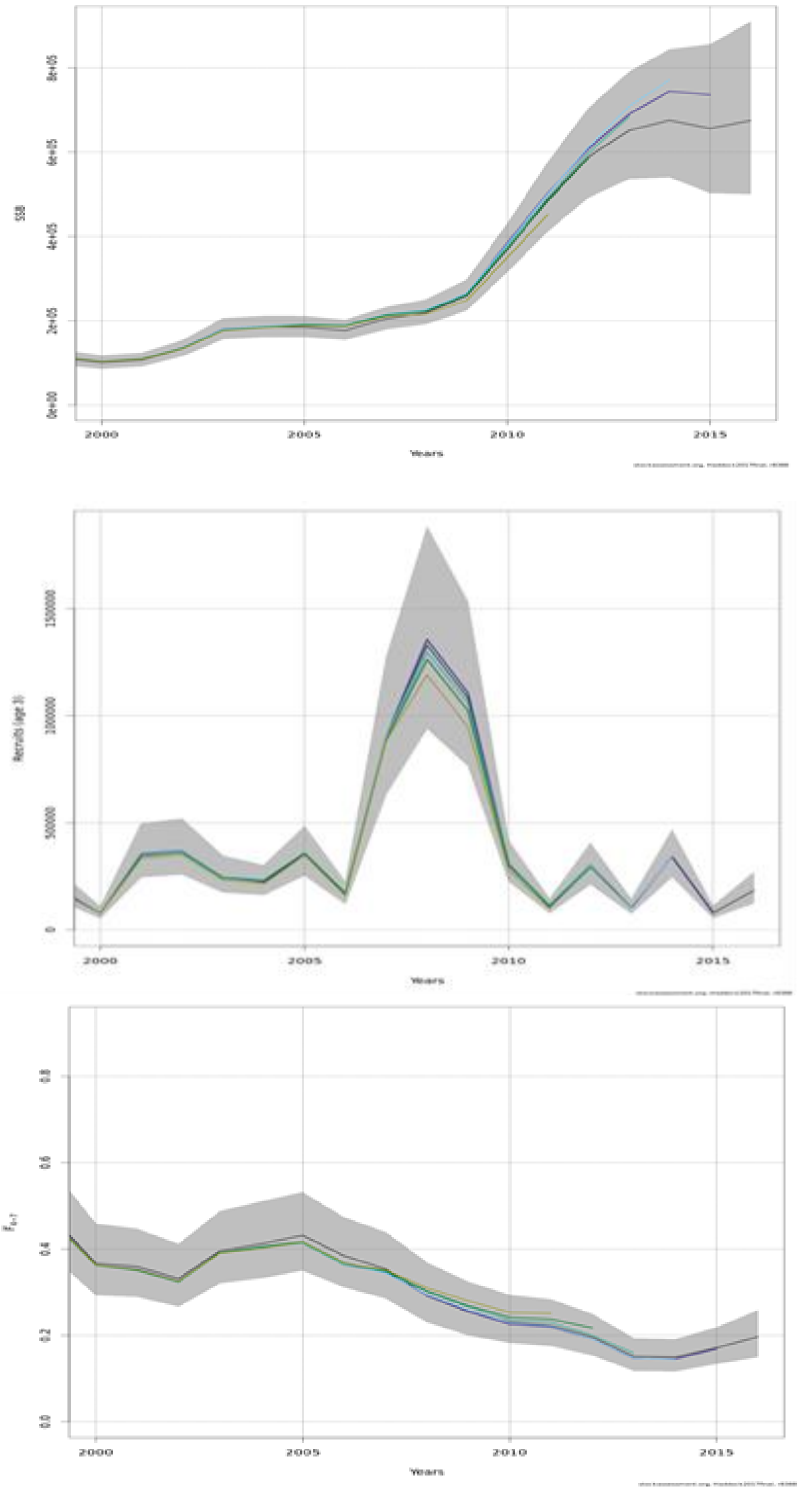


Figure 4.5. Northeast Arctic haddock. 5 year retrospective plots of SSB (a), fishing mortality (b) and recruitment (c) for assessment years 2000-2016 (SAM with 95 % confidence intervals)

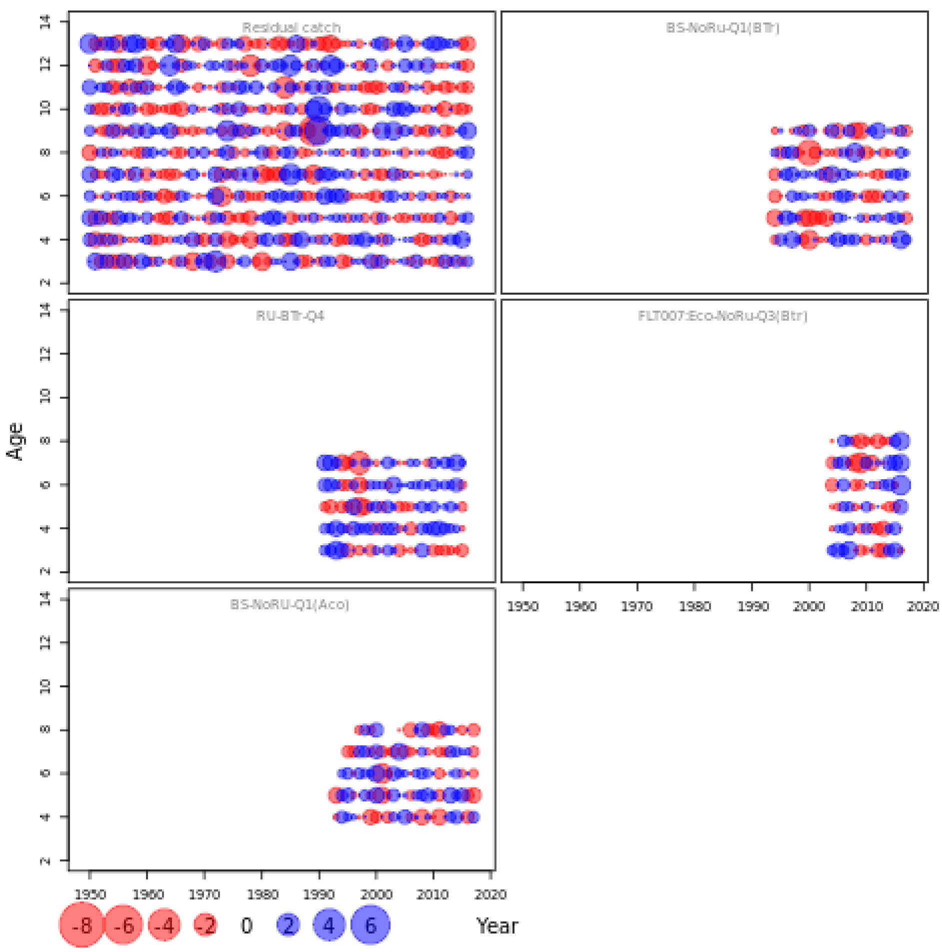


Figure 4.6. Northeast Arctic haddock; Normalized residuals for the final SAM run. Blue circles indicate positive residuals (obs larger than predicted) and white circles indicate negative residuals.

5 Saithe in Sub-areas I and II (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 2017 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 presently (2017) 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 Fpa from 2010 to 2012, but is presently estimated to be below Fpa. The 2007 year class is strong, the 2008 and 2009 year classes are below average strength, the 2010 year class is above average strength while the 2011 year class is below average.

ICES advised that catches in 2017 should be no more than 150,000 t, and The Norwegian Ministry of Trade, Industry and Fisheries set the final TAC at 150,000t. 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 5.1.1–5.1.2, Figure 5.1.1)

Currently the main fleets targeting saithe include trawl, purse seine, gillnet, hand line 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 2016 landings increased to 140,000t.

Discarding, although illegal, occurs in the saithe fishery, but is not considered a major problem in the assessment. Due to its near-shore 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 2016 and 2017

The advice from ICES for 2016 was as follows:

ICES advised that catches in 2016 should be no more than 140,000 t.

The advice from ICES for 2017was as follows:

ICES advised that catches in 2017 should be no more than 150,000 t.

5.1.2 Management applicable in 2016 and 2017

Management of Saithe in Sub-areas I and II is by TAC and technical measures. For 2016, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 140,000 t.

For 2017, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 150,000 t.

5.1.3 The fishery in 2016 and expected landings in 2017

Provisional figures show that the landings in 2016 were approximately 140,400 t, the same as the TAC of 140,000 t, which also were expected landings in the forecast last year.

Since the WG does not have any prognosis of total landings in 2017 available, the TAC of 150,000 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 (Table 5.2.1, Figure 5.2.1)

The estimation of abundance indices is as far as possible done the same way as before the combination of the saithe and coastal survey surveys in 2003 (Berg *et al.*, WD 11 2004). The echo abundance in 2016 (Mehl *et al*. 2016) increased by 14 % compared to 2015, but is still among the lowest in the time series since 1997, about 80 % of the average for 1997-2015. The indices for 3, 6, 7, 8 and 9 olds were above the 1994-2015 average, while other age groups were only 45-99 % of this average. The proportion of saithe in the southern part of the survey area (sub areas C+D) increased from about 20 % in 1997 to above 60 % in 2008, while it has decreased in later years to below 30 % in 2016 (Figure 5.2.1).

5.2.3 Recruitment indices

Owing to the near-shore 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 5.3.1)

Age composition data for 2016 were available for Norway and Germany. An ALK for Norwegian trawl and Danish seine was applied to Russian length data for Subareas IIa, and for IIb and I combined. Landings from other countries were assumed to have the same age composition as Norwegian trawl and Danish seine catches combined. 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, but had improved in 2016. The 2016 catch and sample data were uploaded to the InterCatch database.

Catch at age data was estimated by ECA for the 2017 assessment of NEA saithe. This is the first 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.

Due to time constraints, it was not possible to apply the manual method in 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 the 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 (Fbar), 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 5.3.2)

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, there were relatively small differences in weight at age for the most important age groups in 2016.

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 5.3.3)

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 5.3.4, Figures 5.3.1–5.3.2)

Until the 2005 WG, the XSA tuning was based on three data series: 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, in comparison to the trawl CPUE time series, seems to track the stock changes better, both in abundance and distribution.

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 2002-2016, age groups 3 to 7.

Figure 5.3.1 presents the tuning data by year and age for the two periods combined.

5.4 SAM runs and settings

In connection with the NEA saithe IBP a number of exploratory state–space assessment model (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 2016 AFWG, just one SAM run with 2015 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 5.5.1–5.5.5, Figures 5.5.1–5.5.4)

The state–space assessment model (SAM) was used for the final assessment with settings shown in Table 5.5.1. SAM catchabilities and negative log likelihood values are given in Table 5.5.2. The predictive power (AIC) of the model was estimated to 529.90.

Figure 5.5.1 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 5.5.2 shows plots of the tuning indices versus stock numbers from the SAM.

5.5.1 SAM F, N and SSB results (Tables 5.5.3–5.5.5, Figures 5.5.3–5.5.4)

The fishing mortality ($F_{4\text{-}7}$) in 2015 was 0.23, which is below the value of 0.31 from last year's assessment and well below the F_{pa} of 0.35. The fishing mortality ($F_{4\text{-}7}$) in 2016 was also 0.23. The fishing mortality was below F_{pa} from 1997 to 2009, but started to increase in 2005 and was above Fpa in 2010-2012.

Fishing mortality and stock size have in the last decade been considerably over- and underestimated, respectively, in the last assessment year. 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 5.5.4, and now shows signs of an opposite retrospective trend for the last years.

The SAM-estimate of the 2012-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. The 2005-year class is well above average level, the 2006-year below average strength, the 2007-year class is strong, the 2008-year class is poor, the 2009-year class a little below average strength, the 2010-year class is stronger than the 2009-year class and somewhat above average, while the 2011 year class is below average.

The total biomass (ages 3+) was above the long-term (1960-2016) average from 1996 to 2010, reached a maximum in 2005 and from that declined to below average level since 2011. The SSB was above the long-term mean from 2000 to 2009 and above B_{pa} from 1996 (Table 5.5.5). It declined from 2007 to 2011 and then increased again, and is presently (2017) estimated to be well above B_{pa} (Table 5.7.2).

5.5.2 Recruitment (Tables 5.3.1 and 5.5.6, Figure 5.1.1and 5.5.6)

Catches of age group 3 have varied considerably during the period 2004-2016 (Table 5.3.1). 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 5.1.1)

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 $\mathbf{F}_{mp}$. 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) in the beginning of the year for which the quota is set (first year of prediction), is below $\mathbf{B}_{pa}$, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from $\mathbf{F}_{mp}$ at SSB=$\mathbf{B}_{pa}$ to 0 at SSB equal to zero. At SSB levels below $\mathbf{B}_{pa}$ 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 5.7.1)

The input data to the predictions based on results from the final model run are given in Table 5.7.1. The stock number at age in 2017 was taken from the SAM for age 4 (2013 year class) and older. The GM age 3 recruitment of 159 million was used for the 2014 and subsequent year classes. The natural mortality of 0.2 is the same as used in the assessment. For exploitation pattern the average of 2014-2016 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 2017 (short-term predictions)(Tables 5.7.2–5.7.3)

The management option table (Table 5.7.2) shows that the expected catch of 150,000 t in 2017 will increase the fishing mortality compared to 2016 from 0.23 to 0.24, which is well below the F_{pa} of 0.35. A catch in 2018 corresponding to the $F_{status\ quo}$ level (3-year average 2014-2016) of 0.24 will be 142,000 t, while a catch in 2018 corresponding to the evaluated and implemented HCR is 172,500 t, (Table 5.7.3). This catch corresponds to a fishing mortality of 0.31 in 2018.

For a catch in 2017 corresponding to the TAC, i.e. 150,000 t, the SSB is expected to decrease from about 465,000 t at the beginning of 2017 to 454,000 t at the beginning of 2018. At $F_{status\ quo}$ in 2018 SSB is estimated to decrease to 459,000 t at the beginning of 2018 and for a catch corresponding to the HCR it will decrease to about 425,000 t. Table 5.7.3 presents detailed output for fishing according to the HCR in 2017.

5.7.3 Comparison of the present and last year's assessment

The current assessment estimated the total stock in 2016 to be 25 % higher and the SSB 20 % higher, compared to the previous assessment. The F in 2015 is estimated to be 17 % lower than in the previous assessment and the realized F in 2016 is 22 % lower compared to the predicted one based on the TAC.

	Total stock (3+) by 1 January 2016 (tonnes)	SSB by 1 January 2016 (tonnes)	F4-7 in 2016	F4-7 in 2015
WG 2016	640003	391404	0,28	0,27
WG 2017	802912	469301	0,23	0,23

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 high 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 (Table 0.5). In 2015 this was in particular the case for samples from trawl in quarter two and three in ICES division I and age samples from purse seine fishery south of Lofoten and in quarter two in ICES division I. In 2016 the biological sampling of the purse seine and bottom trawl fishery was sufficient in areas with high catches. None the less,

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 5.1.1 Saithe in Sub-areas I and OO (Northeast and Arctic)

Table 5.1.1 Saithe in Sub-areas I and II (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	1700		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		1525		4 420		184 700			84		6 511	186	197 426
1965		1618		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	1097		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	11 320	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	7075	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	1327	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	1251		156 936
1984	503	431	6	4 532		152 818			161		335		158 786
1985	490	657	11	1873		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
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 [2]	154 903
1994	67 [2]	557	15	1863	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	1592	109 [2]	174 544	279	93	14 664	8	283	2 [2]	194 837
2011	112	367	445	1371	65	143 314		46	10 007	2	972	15	156 716
2012	146	781	658	1371	126	143 145		23 [2]	13 607	4	1000	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	1674	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]	1 139	526	613	952	301	120 740	528	53	15 203	26	301	10	140 392

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 5.1.2 Saithe in Sub areas I and II (Northeast Arctic)

Year	Purse Seine	Trawl	Gill Net	Others	Total
1977	75,2	69,5	19,3	12,7	176,7 [2]
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	14,8	175,5
1982	76,4	59,4	16,7	15,5	168
1983	54,1	68,2	19,6	15	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]
1987	34,9	27,7	19	10,8	92,4
1988	43,5	45,4	15,3	10	114,2
1989	49,5	45	16,9	11,4	122,8
1990	24,6	44	19,3	7,9	95,8
1991	38,9	40,1	18,9	9,4	107,3
1992	27,1	67	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 [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	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
2008	39,4	91,2	37	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
2015	30,4	55,4	23,5	22,5	131,8
2016 [1]	28,9	64,1	21,4	26,9	141,3

Table 5.3.1 Catch numbers at age North-East 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
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

Year	Age groups 3	4	5	6	7	8	9	10	11	12+
2009	9050	34311	9954	6628	15930	4766	3021	4224	2471	1426
2010	26382	43436	28514	7988	3129	12444	2749	1314	1212	1431
2011	6239	45213	13307	15157	6622	2901	5934	1730	647	1115
2012	30742	17841	33911	10496	7058	3522	1570	2586	557	890
2013	17151	15491	15946	21980	5512	3298	1149	729	885	653
2014	7650	24769	13822	9343	12331	3284	2130	904	378	763
2015	13185	15459	30159	9271	7324	7133	1697	723	433	620
2016	8278	20955	13044	15532	6621	4774	4363	1053	718	1382

Table 5.3.3. 3-year running average maturity ogive 1985-2006, values for 2007-2015 average of 2005-2007

Year	3	4	5	6	7	8	9	10	11	12+
1985	0	0.02	0.5	0.92	0.99	1	1	1	1	1
1986	0	0.02	0.51	0.94	0.99	1	1	1	1	1
1987	0	0	0.35	0.98	1	1	1	1	1	1
1988	0	0	0.25	0.96	1	1	1	1	1	1
1989	0	0	0.15	0.92	1	1	1	1	1	1
1990	0	0	0.2	0.85	0.99	1	1	1	1	1
1991	0	0.02	0.25	0.84	0.98	1	1	1	1	1
1992	0	0.02	0.3	0.83	0.93	0.92	0.9	0.95	1	1
1993	0	0.02	0.26	0.88	0.92	0.89	0.87	0.89	1	0.99
1994	0	0.02	0.26	0.84	0.9	0.82	0.87	0.89	1	0.99
1995	0	0.02	0.22	0.8	0.92	0.9	0.97	0.94	1	0.99
1996	0	0.03	0.21	0.65	0.91	0.93	1	1	1	1.00
1997	0	0.03	0.14	0.45	0.83	0.94	0.93	0.97	1	1.00
1998	0	0.04	0.07	0.33	0.74	0.93	0.92	0.96	1	1.00
1999	0	0	0.08	0.32	0.74	0.92	0.92	0.96	0.99	0.98
2000	0	0	0.08	0.46	0.82	0.96	0.98	0.99	0.97	0.95
2001	0	0	0.11	0.64	0.93	0.97	0.98	0.99	0.97	0.94
2002	0	0	0.13	0.78	0.95	0.98	0.98	0.99	0.98	0.97
2003	0	0	0.14	0.82	0.96	0.98	0.98	0.99	1	0.99
2004	0	0	0.21	0.8	0.97	0.99	0.99	1	1	0.98
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

Table 5.3.4 Northeast Arctic saithe. Tuning data sets applied in final SAM run

```
North-East Arctic saithe (Sub-areas I and II)
102
FLT13: Norway Ac Survey (Catch: Unknown) (Effort: Unknown)
1994 2001
1 1 0.75 0.85
3  7
   1    87.1   108.9    41.4     8.1     0.7
   1   166.1    86.5    46.5    16.5     2.4
   1   122.6   207.4    31.7    15.1     4.0
   1    38.0   184.8    79.8    50.6     9.6
   1    96.7   202.6    69.3    84.3     6.6
   1   233.8    72.9    62.2    21.0    19.2
   1   142.5   176.3    11.6    11.5     8.0
   1   275.9    45.9    53.8     5.6     6.1
FLT14: Norway Ac Survey (Catch: Unknown) (Effort: Unknown)
2002 2016
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   212.4   118.7    49.1    19.2     4.7
   1   228.1    67.2    20.3    16.5     7.7
   1    42.6   142.9    19.4     4.6     8.5
   1   111.0    27.1    61.1     7.9     5.8
   1    97.2    29.2    13.8    11.9     4.0
   1   139.8    80.2     7.7     5.2     6.8
   1   185.7    31.0    22.0     4.0     1.9
   1    46.9    77.7     5.2     5.7     1.0
   1    99.7    35.3    23.4     3.8     3.1
   1   113.4    19.8    10.9    11.1     2.8
   1    40.1    87.8    14.9     8.7     8.6
   1    72.3    29.0    34.2     7.5     5.8
   1   135.3    42.7    15.4    16.1     7.5
```

Table 5.5.1 SAM parameter settings

Model used: State-space assessment model SAM (https://www.stockassessment.org).
Software used: AD Model Builder (ADMB) and R.
Visible stock on (https://www.stockassessment.org) "saithe_afwg2016".
Model Options agreed upon at IBP saithe winter 2014.

```
# Min Age (should not be modified unless data is modified accordingly)
3
# Max Age (should not be modified unless data is modified accordingly)
12
# Max Age considered a plus group (0=No, 1=Yes)
1
# The following matrix describes the coupling
# of fishing mortality STATES
# Rows represent fleets.
# Columns represent ages. Flat F from age group 8
1	2	3	4	5	6	6	6	6	6
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
# Use correlated random walks for the fishing mortalities
# ( 0 = independent, 1 = symmetrical correlation estimated, 2=AR(1)-correlation estimated)
2
# Coupling of catchability PARAMETERS
0	0	0	0	0	0	0	0	0	0
1	2	3	4	4	0	0	0	0	0
5	6	7	8	8	0	0	0	0	0
# Coupling of power law model EXPONENTS (if used)
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	0	0	0	0
# Coupling of fishing mortality RW VARIANCES
1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
# Coupling of log N RW VARIANCES
1	2	2	2	2	2	2	2	2	2
# Coupling of OBSERVATION VARIANCES
1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	0	0	0	0	0
3	3	3	3	3	0	0	0	0	0
# Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)
2
# Years in which catch data are to be scaled by an estimated parameter
0
# First the number of years
# Then the actual years
# Then the model config lines years cols ages
# Define Fbar range
4	7
```

Table 5.5.2 SAM catchabilities, negative log likelihood values and number of parameters

Table 5.5.2. SAM catchabilities, negative log likelihood values and number of parameters.

Index	Fleet number	Age	Catchability	Low	High
1	2	3	0.87832	0.59886	1.28819
2	2	4	1.18336	0.80802	1.73304
3	2	5	0.61235	0.41774	0.89764
4	2	6	0.37665	0.27987	0.50689
5	2	7	0.37665	0.27987	0.50689
6	3	3	0.78998	0.63008	0.99046
7	3	4	0.59927	0.47798	0.75133
8	3	5	0.31085	0.24723	0.39084
9	3	6	0.20100	0.16432	0.24587
10	3	7	0.20100	0.16432	0.24587

Model	Negative log likelihood	Number of parameters
Base	515.74	17
Current	529.80	17

Table 5.5.3 Estimated fishing mortalities

Table 5.5.3. Estimated fishing mortalities.

Year\Age	3	4	5	6	7	8+
1960	0.236	0.284	0.320	0.277	0.221	0.163
1961	0.222	0.259	0.273	0.226	0.174	0.127
1962	0.222	0.261	0.268	0.225	0.177	0.133
1963	0.225	0.273	0.281	0.238	0.194	0.154
1964	0.238	0.298	0.318	0.277	0.241	0.208
1965	0.235	0.292	0.325	0.288	0.253	0.230
1966	0.260	0.319	0.342	0.288	0.244	0.224
1967	0.260	0.309	0.317	0.263	0.224	0.216
1968	0.221	0.240	0.229	0.184	0.153	0.147
1969	0.230	0.240	0.221	0.174	0.143	0.131
1970	0.328	0.361	0.340	0.283	0.250	0.239
1971	0.359	0.384	0.356	0.294	0.269	0.258
1972	0.380	0.391	0.350	0.283	0.259	0.244
1973	0.419	0.428	0.386	0.317	0.299	0.284
1974	0.541	0.561	0.513	0.429	0.416	0.394
1975	0.596	0.621	0.568	0.478	0.487	0.476
1976	0.649	0.682	0.611	0.498	0.495	0.469
1977	0.574	0.613	0.540	0.430	0.416	0.377
1978	0.572	0.650	0.595	0.487	0.474	0.429
1979	0.552	0.675	0.635	0.527	0.506	0.450
1980	0.494	0.637	0.619	0.519	0.481	0.420
1981	0.459	0.631	0.622	0.522	0.461	0.391
1982	0.423	0.622	0.623	0.527	0.451	0.374
1983	0.403	0.629	0.653	0.594	0.532	0.451
1984	0.444	0.712	0.728	0.719	0.680	0.588
1985	0.354	0.593	0.614	0.650	0.681	0.590
1986	0.247	0.457	0.504	0.577	0.653	0.594
1987	0.230	0.463	0.540	0.671	0.812	0.751
1988	0.218	0.460	0.541	0.661	0.768	0.655
1989	0.202	0.422	0.469	0.522	0.531	0.399
1990	0.222	0.475	0.521	0.590	0.599	0.450
1991	0.192	0.427	0.480	0.554	0.570	0.431
1992	0.173	0.430	0.542	0.690	0.753	0.601
1993	0.131	0.355	0.476	0.622	0.680	0.541
1994	0.101	0.297	0.420	0.569	0.630	0.504
1995	0.082	0.248	0.337	0.438	0.473	0.373
1996	0.073	0.225	0.313	0.420	0.487	0.416
1997	0.053	0.163	0.226	0.297	0.339	0.292
1998	0.047	0.154	0.221	0.298	0.348	0.323
1999	0.046	0.159	0.230	0.300	0.340	0.323
2000	0.040	0.142	0.207	0.270	0.299	0.293
2001	0.031	0.119	0.181	0.241	0.269	0.275
2002	0.028	0.113	0.173	0.235	0.267	0.294
2003	0.026	0.107	0.162	0.221	0.267	0.328
2004	0.024	0.097	0.149	0.208	0.264	0.352
2005	0.033	0.127	0.180	0.240	0.292	0.383
2006	0.040	0.153	0.210	0.281	0.345	0.461
2007	0.046	0.165	0.219	0.288	0.348	0.464
2008	0.068	0.232	0.281	0.348	0.409	0.533
2009	0.080	0.265	0.311	0.364	0.416	0.533
2010	0.099	0.317	0.359	0.394	0.427	0.519
2011	0.100	0.305	0.353	0.391	0.428	0.503
2012	0.104	0.293	0.331	0.356	0.386	0.446
2013	0.088	0.239	0.268	0.282	0.306	0.353
2014	0.079	0.211	0.235	0.242	0.267	0.316
2015	0.078	0.208	0.228	0.226	0.245	0.289
2016	0.075	0.206	0.228	0.226	0.250	0.305

Table 5.5.4 Estimated stock numbers

Table 5.5.4. Estimated stock numbers.

Year\Age	3	4	5	6	7	8	9	10	11	12+
1970	222126	167209	58747	54666	22629	29792	9153	14026	5149	7233
1971	230268	143918	87116	35703	32860	14444	17732	6482	9242	7964
1972	154199	138413	85819	46583	23063	19683	9639	10467	4253	10181
1973	201793	80660	79221	52156	27889	15458	12740	6778	6435	8960
1974	101417	111302	42024	45936	32663	16848	10262	8260	4261	9100
1975	168215	44623	53104	20056	23766	17819	9332	6013	4773	7204
1976	217510	75207	19452	25771	10564	11417	8696	4718	3067	5810
1977	199586	89769	31008	8464	13312	5482	5718	4292	2327	4257
1978	134323	89411	38638	15028	4607	7298	3209	3110	2412	3977
1979	193300	59695	38793	17266	7691	2367	4019	1761	1562	3441
1980	117712	94183	23624	16967	8598	3672	1143	2071	964	2694
1981	224583	56727	43217	10051	8308	4422	1854	689	1074	1850
1982	128412	120813	24270	19374	4726	4380	2262	1042	397	1649
1983	101722	68734	52208	9918	9283	2580	2502	1255	607	1288
1984	93901	58571	31008	20135	4341	4533	1302	1335	712	1056
1985	102232	42319	23506	13094	6973	1938	2092	561	612	831
1986	173685	48972	17749	11102	6067	2414	950	957	270	637
1987	138690	127516	22471	8297	5459	2793	854	478	426	463
1988	78984	97929	72548	10907	3401	2020	1313	235	200	299
1989	77343	54231	54014	37086	4787	1184	820	611	56	285
1990	87116	47667	29584	26108	18385	2409	598	462	366	214
1991	224583	48630	22226	15176	11190	8435	1233	300	264	322
1992	280127	142629	22743	10958	7792	4996	4669	646	169	368
1993	207524	211716	76191	10213	4286	3109	1968	2302	281	237
1994	149194	160653	131400	37459	4364	1727	1486	771	1231	267
1995	277618	130483	110636	74682	15656	1853	804	775	313	815
1996	161943	243775	87553	67846	39815	7962	1036	485	446	698
1997	163898	122272	177549	57584	39616	21197	4158	509	260	626
1998	103777	134457	84881	126880	32794	23885	12723	2548	332	620
1999	236807	78198	94656	54068	73424	18361	14855	7572	1474	573
2000	154045	188528	50615	55548	31508	40579	11264	9462	4333	1132
2001	204638	103881	135537	34718	32958	19101	24077	7162	5960	3175
2002	319017	168552	75584	89859	23179	20382	12577	14879	4429	5804
2003	138413	286072	120090	50212	54776	16627	12554	8487	9041	6364
2004	151903	115266	199187	86422	34996	35419	10624	7315	5360	8991
2005	401515	121905	78276	123007	56050	23459	21653	6665	3787	7502
2006	71970	322223	84711	48923	71111	34579	14529	12253	3786	6029
2007	114806	55548	207731	55770	31445	39027	19504	8080	6134	4381
2008	215346	80822	42108	113550	32273	17202	19628	10602	4106	5063
2009	149941	163898	47335	27474	61023	16574	8074	9150	5203	4212
2010	269952	101620	97538	28311	15119	32565	7961	3793	4084	4298
2011	107152	203822	52365	50362	15221	8476	15626	3938	1833	3868
2012	159692	88787	129056	32403	25822	8885	4455	7539	1900	2796
2013	220136	99409	62755	81879	19827	13677	4892	2441	3813	2448
2014	103156	182225	70615	46677	52839	12193	7681	3048	1439	3588
2015	146972	81797	135944	50665	32696	32370	7290	4369	1897	3121
2016	171442	110304	59219	92226	36316	20773	19561	4458	2732	3433
pred		130215	73512	38592	60215	23161	12540	11808	2691	3722

Table 5.5.5. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), and average fishing mortality for ages 4 to 7 (F47)

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F47	Low	High
1970	222126	147491	334529	972864	816474	1159211	567502	457074	704610	0.308	0.236	0.403
1971	230268	153587	345235	955510	806959	1131406	555709	452616	682283	0.326	0.251	0.423
1972	154199	102942	230979	880284	746425	1038149	537670	441517	654763	0.321	0.249	0.414
1973	201793	134753	302187	847461	723036	993298	537132	446150	646669	0.358	0.279	0.458
1974	101417	67392	152622	736011	630934	858588	492870	411403	590469	0.479	0.378	0.607
1975	168215	112241	252105	614768	526869	717331	399113	334258	476552	0.539	0.427	0.679
1976	217510	144758	326825	543074	459631	641664	282377	234955	339372	0.572	0.454	0.719
1977	199586	133223	299006	477347	400958	568290	210239	174316	253565	0.500	0.396	0.631
1978	134323	89581	201410	417066	352579	493348	189662	158327	227200	0.551	0.439	0.693
1979	193300	128955	289752	408808	341414	489505	170928	142665	204790	0.586	0.467	0.734
1980	117712	78581	176331	391210	326850	468244	151146	126124	181131	0.564	0.449	0.707
1981	224583	148833	338886	441971	363247	537757	154817	128499	186526	0.559	0.445	0.701
1982	128412	85455	192964	398316	328760	482588	135537	112493	163302	0.556	0.442	0.699
1983	101722	67481	153338	407583	339478	489351	161781	133140	196583	0.602	0.481	0.753
1984	93901	62047	142110	322546	270793	384189	145947	120508	176757	0.710	0.570	0.883
1985	102232	67570	154675	270763	225882	324561	111525	92491	134474	0.635	0.507	0.795
1986	173685	114275	263983	263814	214426	324578	84036	69605	101459	0.548	0.436	0.688
1987	138690	91963	209161	277063	225132	340973	71826	59544	86641	0.621	0.500	0.772
1988	78984	51820	120386	292728	239802	357335	86163	70893	104723	0.607	0.487	0.757
1989	77343	50910	117498	278173	228888	338071	100007	77462	129115	0.486	0.385	0.614
1990	87116	57040	133053	270493	225631	324274	118066	94050	148215	0.546	0.434	0.688
1991	224583	148467	339721	354690	287817	437101	114577	93731	140059	0.508	0.402	0.641
1992	280127	185146	423835	463703	372503	577232	95130	79750	113477	0.604	0.482	0.757
1993	207524	138054	311951	529665	428198	655177	97343	80844	117210	0.533	0.425	0.669
1994	149194	101367	219586	482627	399283	583368	148153	120136	182704	0.479	0.378	0.606
1995	277618	187982	409995	585370	486349	704552	196222	157286	244796	0.374	0.293	0.478
1996	161943	110512	237309	680103	568533	813569	244019	198519	299947	0.361	0.282	0.463
1997	163898	111687	240516	722881	602795	866891	243531	198817	298302	0.256	0.198	0.332
1998	103777	70888	151925	799706	666891	958973	292436	239005	357811	0.255	0.196	0.332
1999	236807	161720	346757	799706	672792	950561	308045	248694	381559	0.257	0.197	0.336
2000	154045	105217	225533	815862	689994	964690	367692	297313	454730	0.230	0.176	0.300
2001	204638	140975	297051	864581	735124	1016836	371759	304713	453556	0.202	0.155	0.264
2002	319017	224848	452625	974812	835300	1137626	439327	365682	527804	0.197	0.152	0.256
2003	138413	97267	196965	949794	812125	1110799	425917	357526	507391	0.189	0.146	0.245
2004	151903	105120	219507	987567	840431	1160463	508897	430706	601282	0.180	0.138	0.235
2005	401515	281216	573275	1066614	910395	1249640	591845	498464	702720	0.210	0.161	0.273
2006	71970	50585	102394	918962	785561	1075016	527551	447465	621969	0.247	0.191	0.320
2007	114806	80909	162905	875894	745266	1029418	544705	462584	641405	0.255	0.197	0.330
2008	215346	152763	303568	752382	644969	877684	473071	396743	564083	0.317	0.247	0.408
2009	149941	106300	211500	695231	595993	810994	365492	306210	436251	0.339	0.264	0.434
2010	269952	192275	379011	710696	605355	834368	331705	277795	396075	0.374	0.292	0.480
2011	107152	75284	152509	591845	501862	697962	297747	247537	358142	0.369	0.286	0.476
2012	159692	113360	224960	606828	511504	719916	307737	254136	372642	0.342	0.264	0.442
2013	220136	155453	311732	632225	527534	757692	333367	268225	414331	0.274	0.209	0.359
2014	103156	71903	147993	694537	573317	841386	383080	302422	485250	0.239	0.180	0.317
2015	146972	100216	215544	679424	548740	841230	407583	314217	528691	0.227	0.167	0.308
2016	171442	106799	275213	802912	630091	1023133	469301	348488	631997	0.228	0.159	0.325

Table 5.7.1 Northeast arctic saithe. Prediction input data

MFDP version 1a
Run: a26
Time and date: 10:24 26.04.2017
Fbar age range: 4-7

2017

Age	N	M	Mat	PF	PM	SWt	Sel
3	158831	0,2	0	0	0	0,703	0,077
4	130215	0,2	0,05	0	0	0,938	0,208
5	73512	0,2	0,42	0	0	1,428	0,230
6	38592	0,2	0,87	0	0	2,015	0,231
7	60215	0,2	0,97	0	0	2,451	0,254
8	23161	0,2	0,98	0	0	3,210	0,303
9	12540	0,2	0,98	0	0	3,837	0,303
10	11808	0,2	0,97	0	0	4,366	0,303
11	2691	0,2	0,97	0	0	4,619	0,303
12	3722	0,2	0,994	0	0	5,959	0,303

2018

Age	N	M	Mat	PF	PM	SWt	Sel
3	158831	0,2	0	0	0	0,703	0,077
4	.	0,2	0,05	0	0	0,938	0,208
5	.	0,2	0,42	0	0	1,428	0,230
6	.	0,2	0,87	0	0	2,015	0,231
7	.	0,2	0,97	0	0	2,451	0,254
8	.	0,2	0,98	0	0	3,210	0,303
9	.	0,2	0,98	0	0	3,837	0,303
10	.	0,2	0,97	0	0	4,366	0,303
11	.	0,2	0,97	0	0	4,619	0,303
12	.	0,2	0,994	0	0	5,959	0,303

2019

Age	N	M	Mat	PF	PM	SWt	Sel
3	158831	0,2	0	0	0	0,703	0,077
4	.	0,2	0,05	0	0	0,938	0,208
5	.	0,2	0,42	0	0	1,428	0,230
6	.	0,2	0,87	0	0	2,015	0,231
7	.	0,2	0,97	0	0	2,451	0,254
8	.	0,2	0,98	0	0	3,210	0,303
9	.	0,2	0,98	0	0	3,837	0,303
10	.	0,2	0,97	0	0	4,366	0,303
11	.	0,2	0,97	0	0	4,619	0,303
12	.	0,2	0,994	0	0	5,959	0,303

Input units are thousands and kg - output in tonnes

Table 5.7.2 Northeast Arctic saithe. Short term prediction

MFDP version 1a
Run:
a26
North-East Arctic saithe
Time and date: 10:24 26.04.2017
Fbar age range:
4-7

2017				
Biomass	SSB	FMult	FBar	Landings
772766	465149	1,0595	0,2447	150000

2018					2019	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
763000	454042	0	0	0	922802	586549
.	454042	0,1	0,0231	15827	904547	571525
.	454042	0,2	0,0462	31269	886744	556896
.	454042	0,3	0,0693	46337	869381	542651
.	454042	0,4	0,0924	61040	852447	528779
.	454042	0,5	0,1155	75387	835931	515270
.	454042	0,6	0,1386	89388	819822	502116
.	454042	0,7	0,1617	103051	804109	489305
.	454042	0,8	0,1848	116386	788782	476830
.	454042	0,9	0,2079	129401	773832	464681
.	454042	1	0,231	142103	759248	452850
.	454042	1,1	0,2541	154501	745021	441328
.	454042	1,2	0,2772	166604	731142	430106
.	454042	1,3	0,3003	178417	717602	419177
.	454042	1,4	0,3234	189949	704392	408533
.	454042	1,5	0,3465	201207	691504	398167
.	454042	1,6	0,3696	212198	678929	388070
.	454042	1,7	0,3927	222929	666659	378237
.	454042	1,8	0,4158	233406	654687	368659
.	454042	1,9	0,4389	243636	643005	359330
.	454042	2	0,462	253625	631606	350244

Input units are thousands and kg - output in tonnes

Table 5.7.3. Northeast arctic saithe. Short term projection output HCR landings

MFDP version 1a
Run: a28
a27MFDP Index file
26.04.2017
Time and date: 10:38 26.04.2017
Fbar age range: 4-7

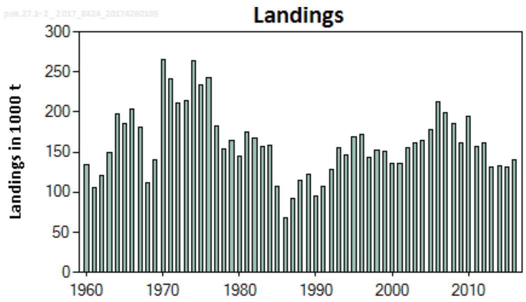
2017						
						Fmp (0.32) landings
Biomass	SSB	FMult	FBar	Landings		
772766	465149	1,0595	0,2447	150000		
						188269
2018						171037
Biomass	SSB	FMult	FBar	Landings		158774
763000	454042	1,2496	0,2887	172500	average	172693

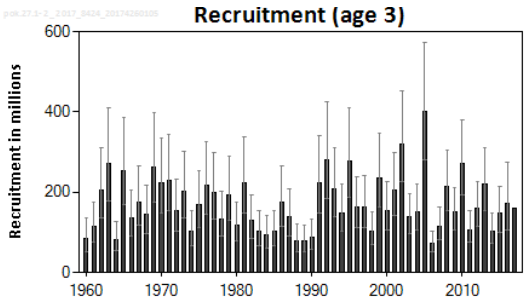
The TAC should not be changed by more than 15% compared with the previous year'

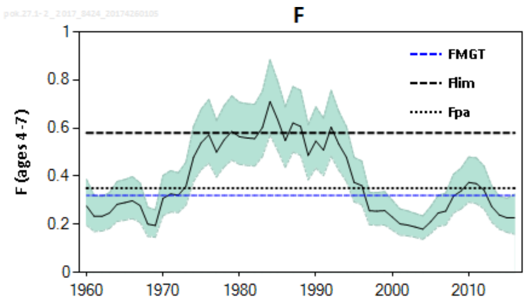
	172500

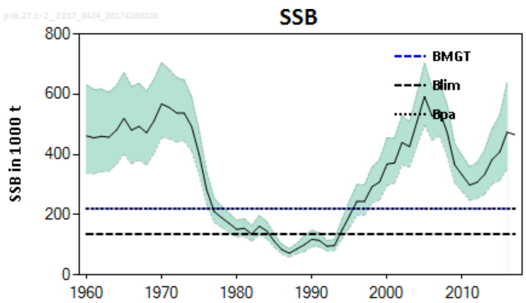
2019					2020	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
724383	424648	0	0	0	878576	545726
.	424648	0,1	0,0231	14772	861635	531938
.	424648	0,2	0,0462	29191	845107	518506
.	424648	0,3	0,0693	43265	828981	505423
.	424648	0,4	0,0924	57002	813247	492677
.	424648	0,5	0,1155	70413	797895	480261
.	424648	0,6	0,1386	83504	782915	468166
.	424648	0,7	0,1617	96285	768298	456383
.	424648	0,8	0,1848	108762	754034	444904
.	424648	0,9	0,2079	120944	740115	433721
.	424648	1	0,231	132838	726532	422827
.	424648	1,1	0,2541	144452	713275	412213
.	424648	1,2	0,2772	155792	700338	401872
.	424648	1,3	0,3003	166865	687711	391797
.	424648	1,4	0,3234	177679	675387	381982
.	424648	1,5	0,3465	188239	663359	372418
.	424648	1,6	0,3696	198553	651618	363101
.	424648	1,7	0,3927	208626	640158	354023
.	424648	1,8	0,4158	218464	628971	345177
.	424648	1,9	0,4389	228073	618051	336559
.	424648	2	0,462	237460	607390	328161

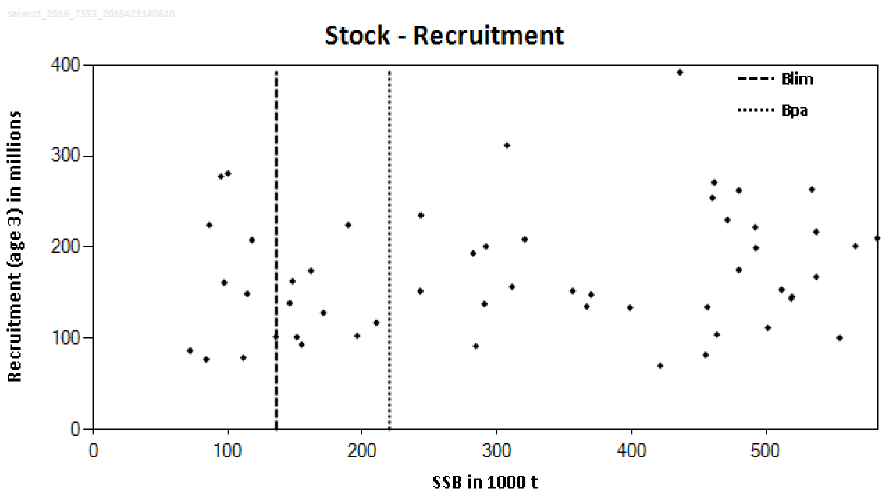
Input units are thousands and kg - output in tonnes


Landings
Landings in 1000 t
0
50
100
150
200
250
300
1960
1970
1980
1990
2000
2010


Recruitment (age 3)
Recruitment in millions
0
200
400
600
1960
1970
1980
1990
2000
2010


F
F (ages 4-7)
FMGT
Flim
Fpa
0
0.2
0.4
0.6
0.8
1
1960
1970
1980
1990
2000
2010


SSB
SSB in 1000 t
BMGT
Blim
Bpa
0
200
400
600
800
1960
1970
1980
1990
2000
2010


Stock - Recruitment
Recruitment (age 3) in millions
SSB in 1000 t
Blim
Bpa
0
100
200
300
400
0
100
200
300
400
500

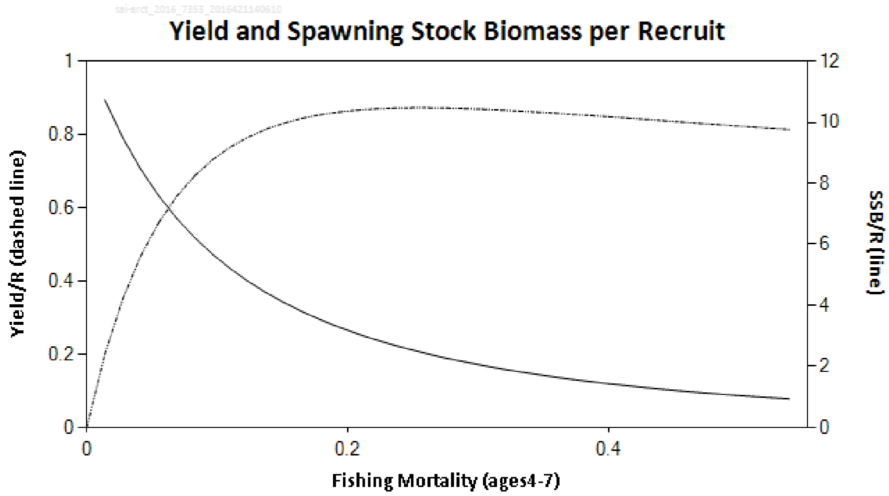


Figure 5.1.1 Northeast Arctic saithe (Subareas I and II)

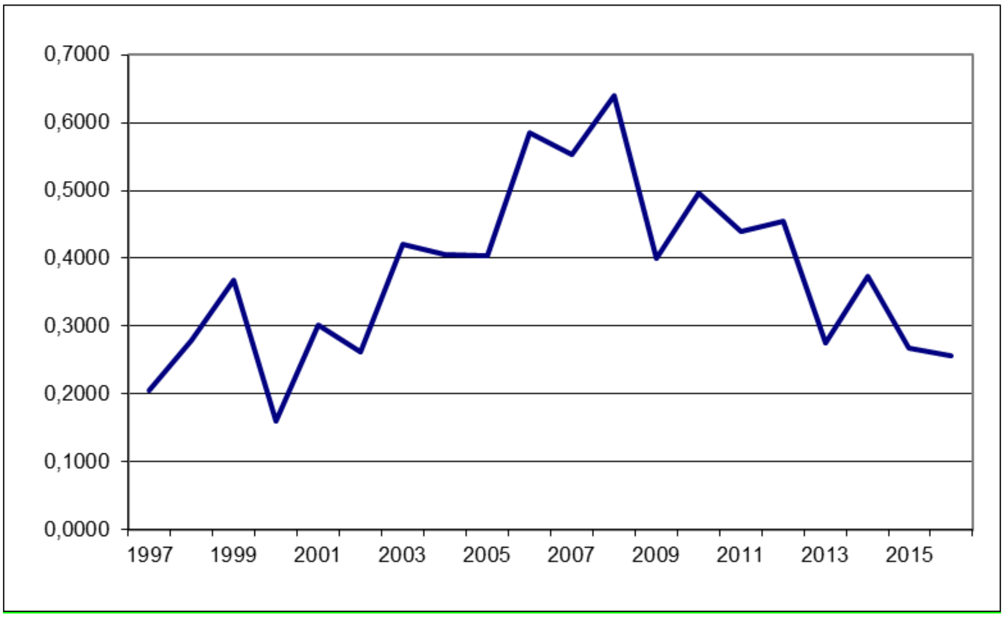


Figure 5.2.1. Northeast Arctic saithe. Proportion of saithe in the southern half of the survey area (sub area C+D).

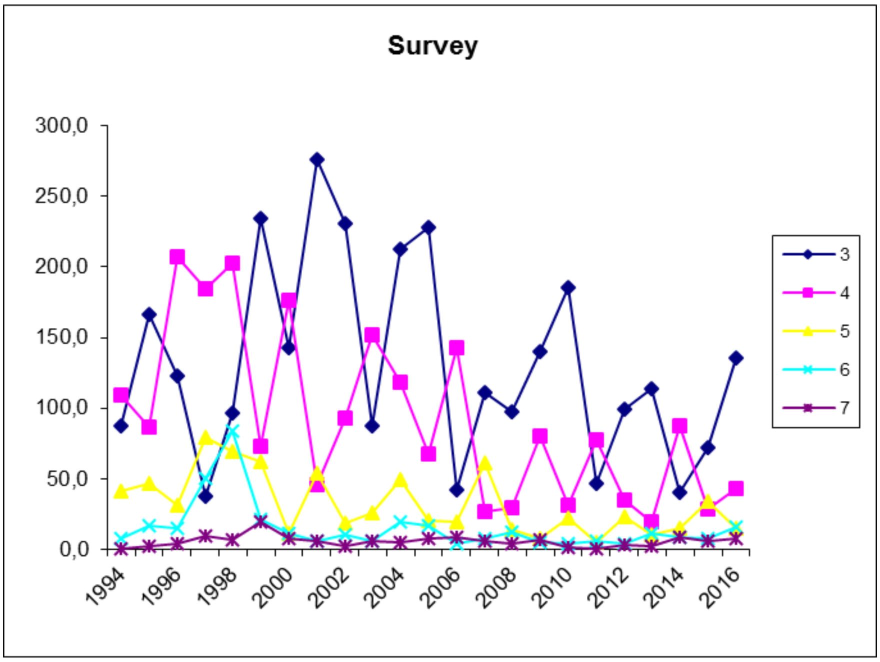


Figure 5.3.1 Northeast Arctic saithe, acoustic survey tuning indices, break in 2002 black line

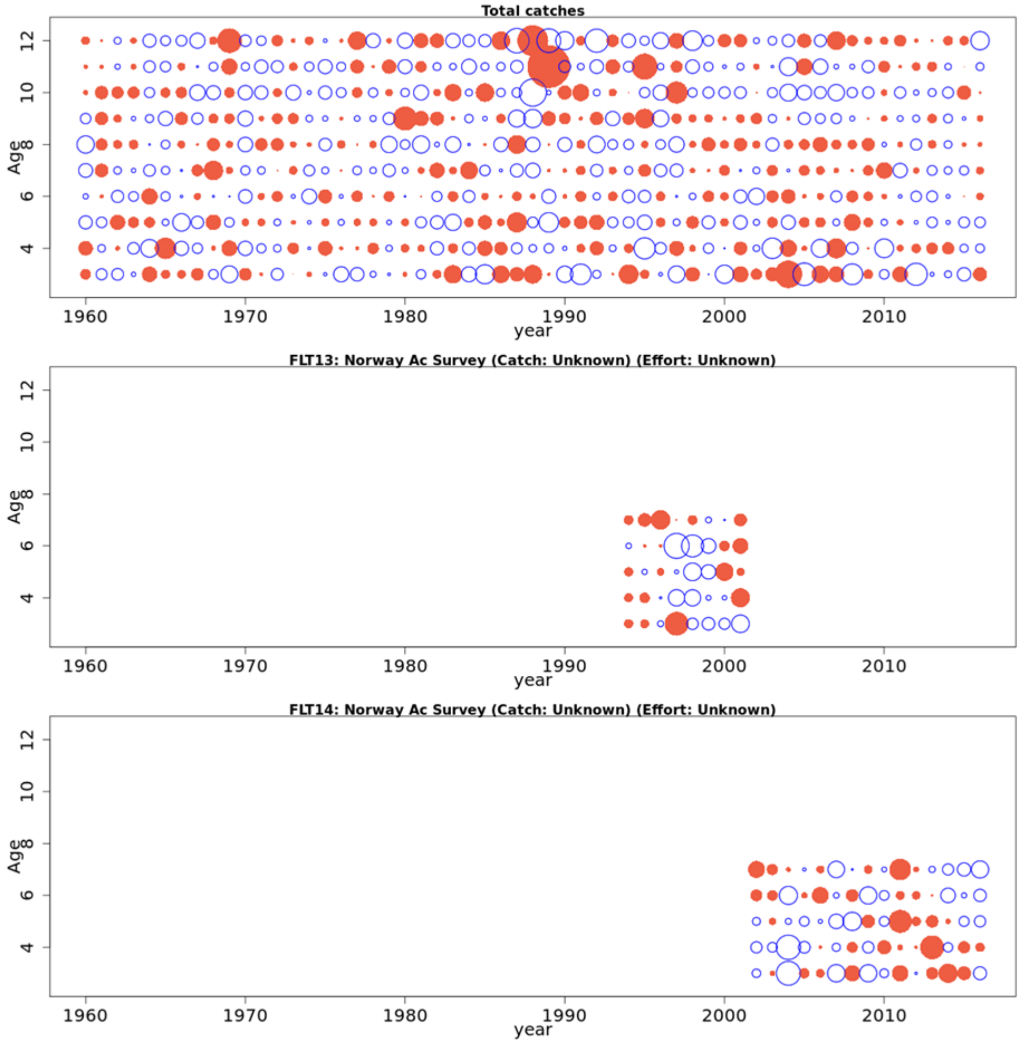


Figure 5.5.1. Northeast Arctic saithe. Final run normalized residuals. Blue circles indicate positive residuals (obs larger than predicted) and filled red circles indicate negative residuals.

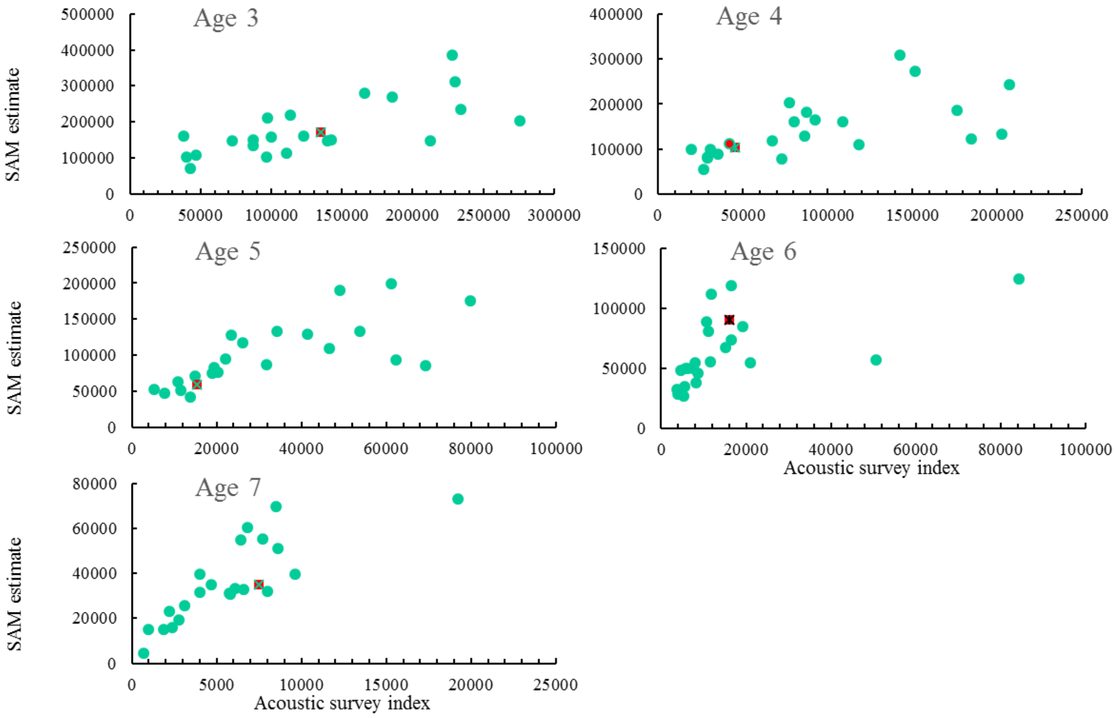
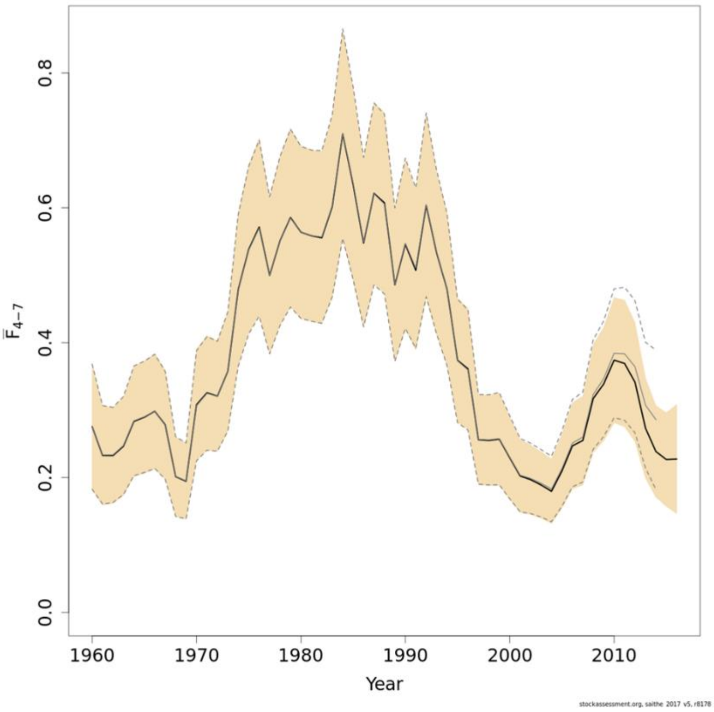


Figure 5.5.2. NEA Saithe - Acoustic survey vs. SAM, red circle shows last data year

.



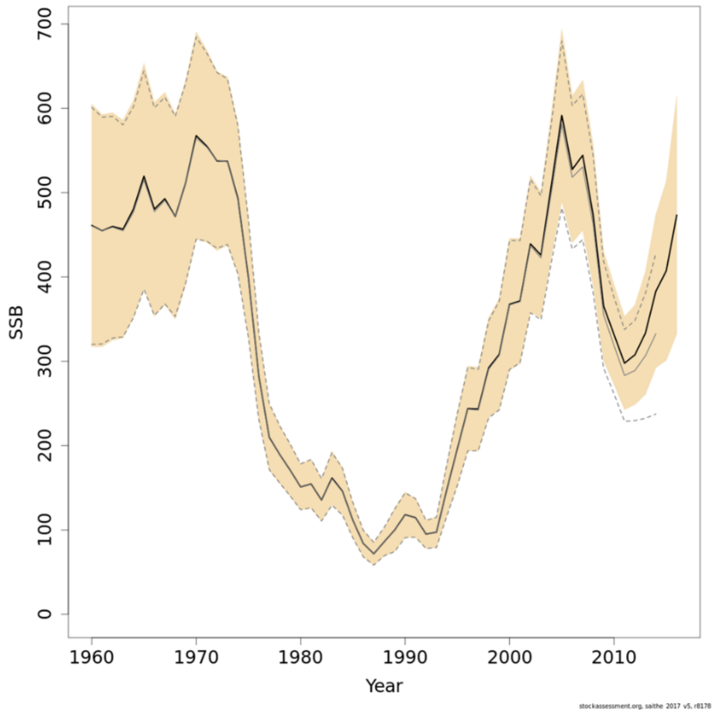


Figure 5.5.3 F4-7 and SSB. Estimates from the current run and point wise 95% confidence intervals are shown by black line and shaded area.

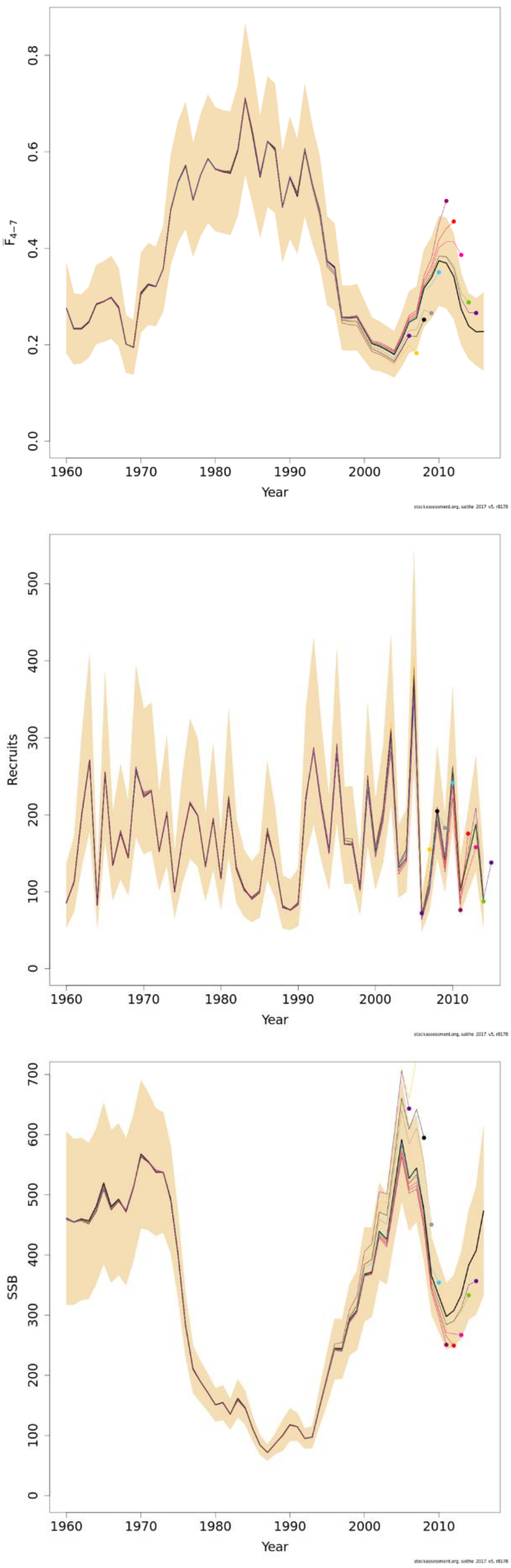


Figure 5.5.4 Saithe in Sub-areas I and II (Northeast Arctic) RETROSPECTIVE SAM $F_{4\text{-}7}$, recruits and SSB.

6 Beaked redfish *(Sebastes mentella)* in Subareas 1 and 2

Following the recommendation from the benchmark assessment for redfish stocks in February 2012 (WKRED, ICES 2012) the analytical assessment is conducted using a statistical catch-at-age model (SCAA, for the period 1992-2016). The additional Schaefer biomass model which was previously used as 'sanity check' for the SCAA output is no longer in use. Advice on beaked redfish in subareas 1 and 2 is provided every third year. A benchmark assessment is scheduled for 2018. The present report therefore updates the advice for 2018 only.

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 Figure 6.22. In 2016, 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 show the location of *S. mentella* catches in the Norwegian EEZ in 2016. Sixteen vessels took part in the pelagic Olympic fishery in 2014, compared with 25 in 2013, 32 vessels in 2012, and 58 in 2011. NEAFC could not provide logbook and/or effort information from this fishery in 2015 and 2016, but 4 752 t of *S. mentella* were officially caught (i.e. reported to NEAFC and/or ICES) in this pelagic fishery in 2015 and 7 170 t in 2016. 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 %).

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.

6.1.3 Landings prior to 2017 (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 year 2015 and new figures presented for 2016. Total international landings in 1952-2016 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.

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 and to 33 979 t in 2016. Of this, 7 170 t were reported from the pelagic fishery in international waters of the Norwegian Sea. The total landings in 2016 are 3 979 t above the TAC advised by ICES. Norway caught the major share of the demersal catches (17 631 t), but Russian demersal catches increased substantially, particularly in ICES Division 2b.

The redfish population in Subarea IV (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 IV have up to 2003 been 1 000—3 000 t per year. Since 2005 the annual landings from this area have varied between 102 and 335 t (Table 6.13).

6.1.4 Expected landings in 2017

ICES has advised on the basis of precautionary considerations that an annual catch in 2015, 2016, and 2017 should be set at no more than 30 000 t, and the 46th Session of the Joint Norwegian-Russian Fisheries Commission decided to follow this advice and set the total TAC in 2017 at 30 000 t.

In 2017 Norwegian fishing vessels can catch and land up to 17 600 t of redfish in the Norwegian economic zone (NEZ) in a limited area north of 65 20′ N (see map in Figure 6.22), in international waters and the fisheries zone around Jan Mayen. Of this quantity 100 t are allocated to cover bycatch in other fisheries and 23 t for research/surveillance and education purposes, while the remaining 17 477 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 vessel quota of 460 t, and a reallocation of vessel quotas will be done after 1 September. 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 1st March until 10th May. Investigations were conducted in 2015 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 6.22) can be opened for directed fishing, either with or without sorting grid. The brief and preliminary conclusion is that males dominated the catches (about 80%) 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 of 5 400 t (18%) and 2 000 t transferred from Norway to Russia of *S. mentella* in the directed fishery. 1 000 t is allocated to bycatch by Russian fishery in addition to the combined Russian-Norwegian quota of 25 000 t, adding up to 26 000 t. It is expected that most of this redfish catch will be *S. mentella*. The remaining 4 000 t are divided between third countries in the NEZ and Svalbard Zone (2 230 t) and the NEAFC areas (1 770 t). It is not unlikely that over 7 000 t will be caught in the NEAFC areas (as in 2016) and therefore that the total catch in 2017 will be above the TAC advised by ICES by about 5 000t.

6.2 Data used in the Assessment

Analytical assessment was conducted for this stock following recommendation from the benchmark assessment working group (WKRED, ICES CM 2012/ACOM:48). 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—2015. 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 11—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 (Figure 6.5)

Winter survey numbers-at-age 2—15 (Table 6.16b)

Ecosystem survey numbers-at-age 2—15 (Table 6.17)

Russian autumn survey numbers-at-age 2—11 (Table 6.14)

There was no direct observation of catch numbers-at-age for the pelagic fishery operating in 2012 – 2016. 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, observation from the scientific survey in the Norwegian Sea was used to derive numbers-at-age in the pelagic fishery. Similar observations were made in 2016, but age readings were not available at the time of the working group meeting.

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 2016, data were available from the Russian, Norwegian, Spanish and Portuguese fleets.

6.2.2 Catch-at-age (Tables 6.6 and 6.8, Figure 6.4)

Catch-at-age in the Norwegian fishery were estimated using ECA for 2014. It was not possible to run ECA on the 2015 data and no age readings were available for 2016. For the pelagic and demersal fisheries in 2015 and 2016 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 and 2016 are expected from Norway at the next assessment in 2018.

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). The model results are illustrated in Figure 6.5. This method resulted in higher weigth-at-age in the +group in recent years (Figure 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 and 2015 when the fixed effects only were considered. There were no age readings available for 2016 and the fixed effect model was therefore used for that year.

6.2.5 Scientific surveys

The results from the following research vessel survey series were evaluated by the Working Group:

6.2.5.1 Surveys in the Barents Sea and Svalbard area (Tables 1.1, 1.3–1.4, 6.14–6.16, Figures 6.8–6.9)

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 6.15b). *ICES acronym: since 2003 part of Eco-NoRu-Q3 (BTr)*

Winter Barents Seabed-trawl survey (February) from 1986—2014 (joint 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)*

6.2.5.2 Additional surveys (Figures 6.11—6.15)

The international 0-group survey in the Svalbard and Barents Sea areas in August-September 1980-2016, now part of the Ecosystem survey (Figure 6.11). *ICES acronym: Eco-NoRu-Q3*

A slope survey "Egga-sør survey" was carried out by IMR from 12th March to 8th April 2016, following similar surveys ran in 2009, 2012 and 2014. The Deep Pelagic Ecosystem Survey (WGIDEEPS, ICES 2016) was conducted in the Open Norwegian Sea from 11th August to 1st September 2016, following similar surveys in 2008, 2009 and 2013. The spatial coverage of the two surveys and the distribution of beaked redfish registered by acoustic are presented in Figures 6.12—6.13). Egga-Sør, Egga-Nor and WGIDEEPS surveys have been repeated several time on a multiannual 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 (Figure 6.14). These surveys are considered as candidates for data input to the analytical assessment of *S. mentella* (see also Planque 2016).

Figure 6.15 shows cod's predation on juvenile (5-14 cm) redfish during 1984—2016. 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.

6.3 Assessment

The group updated the analytical assessment using a statistical catch-at-age (SCAA) model. In earlier years, the SCAA was run in ADMB. In 2016, the model was implemented in TMB (template model builder) and tests based on the 2014 assessment showed that the two implementations gave identical results. The TMB version of the model allows for modelling recruitment as a random walk, using mixed effects. This option gives very similar results to the original approach in which recruitment was estimated independently for each year. Given that there were no available data to inform recruitment (at age 2y) in 2016, the random effect option was used in the current assessment.

6.3.1 Results of the Assessment (Tables 6.20—6.21, Figures 6.16—6.21)

6.3.1.1 Stock trends

The temporal patterns in recruitment-at-age 2 (Figures 6.16, 6.18) 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 steadily increased from 1992 to 2005 (Table 6.21). In recent years, the total-stock biomass (TSB) consists of a larger proportion of mature fish than in the 1990s and is fluctuating around one million tonnes (Table 6.21 and Figures 6.16, 6.18). The decline in SSB in recent years can be attributed to the weak year-classes (1996—2003) entering the mature stock. This trend is expected to reverse in the coming years.

6.3.1.2 Fishing mortality (Figure 6.16, Table 6.21)

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 6.11). This is consistent with the known geographical distribution of different life stages of *S. mentella*. The opening of the demersal fishery in the Norwegian EZ in 2014 has led to a significant increase in the demersal fishing mortality. The steep selectivity patterns combined with the gradual ageing of the adult population of *S. mentella* lead to fishing mortality for ages 12-18 that do not adequately reflect the mortality suffered by the bulk of the adult stock, mostly composed of 19+ individuals. In 2016 $F_{12\text{-}18}$ is estimated to 0.030 while F_{19+} is 0.043 (Table 6.21).

6.3.1.3 Survey selectivity patterns (Figure 6.17)

Winter and ecosystem surveys selectivity at age are very similar and show reduced selectivity for age 8 y 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 y and younger. This is believed to result from gear selectivity.

6.3.1.4 Residual patterns (Figure 6.21)

Residual patterns in catch and survey indices are presented in Figure 6.21-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 potentially resolve the issue.

6.3.1.5 Retrospective patterns (Figure 6.19)

The historical retrospective patterns for the years 2007 to 2016 are presented in Figure 6.19. All model parameters were estimated in each individual run. The most recent model run (last year of data 2016) is consistent with previous runs although indicating higher SSBs in the most recent years of the assessment time-period. This is mainly due to shift from using reported catch weight-at-age to estimated populations weight-at-age, which resulted in higher values for the 19+ group which constitute the bulk of SSB (see section 6.2.3).

6.3.1.6 Projections

Estimated $F_{MSY} = F_{0.1}$ is 0.039 (section 6.5 of AFWG report 2014)

The estimated fishing mortality in 2016 is: $F_{12\text{-}18} = 0.030$ ($F_{19+} = 0.043$).

If catch is maintained at the current TAC (30,000 t), this would correspond to $F_{12\text{-}18} = 0.027$ ($F_{19+} = 0.039$) and would lead to an increase in SSB of 2.5% by 2019.

If $F_{12\text{-}18}$ is maintained as status quo, this would lead to catches of 32,658 t in 2018 and to an increase in SSB of 1.8% by 2019.

Raising $F_{12\text{-}18}$ to F_{MSY} ($F_{19+} = 0.057$) in 2018—2020 would lead to catches of 42,358 t during that period and to a reduction in SSB of 0.35% by 2019.

6.3.1.7 Additional considerations

Historical fluctuations in the recruitment-at-age 2 (Figures 6.16 and 6.18) 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 6.20) is consistent with the age structure reported from the slopes and pelagic surveys (Figure 6.14), although these are not used as input to the model.

Recent recruitment levels estimated with SCAA are highly uncertain since they rely on only few years of observations and since are readings from winter survey were not available for years 2012-2015 and no survey data was 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 6.18)

The history of the stock as described by the SCAA model for the period 1992—2016 is summarized in Table 6.21 and Figure 6.18. The key elements are as follows:

- upward trend in Total-stock biomass from 1992 to 2005 followed by stabilization until 2011 and new upward trend until 2016,
- upward trend in Spawning-stock biomass from 1992 to 2009 followed by stabilization (or slight decline) until 2016,
- recruitment failure for year classes 1996—2003 (2y old fish in 1998—2005),
- good (although uncertain) recruitment for year-classes born after 2005,
- fishing mortality for the 19+ is below natural mortality except in the first years of the assessment period (1992-1994).

6.4 Comments to the assessment

As in previous runs, the trends in numbers and biomass estimated using the SCAA are believed to be robust but the absolute biomass levels are not. These absolute estimates are heavily dependent upon the choice of an appropriate scaling coefficient for the Norwegian-Russian ecosystem survey. The current scaling coefficient used is 3.5 (as in previous assessments) but likely values spans a range of 3 to 6 potentially leading to **uncertainty in SSB from -25% to +75%.**

Estimated fishing mortalities are lower than the assumed natural mortality of M = 0.05 but these estimates depend upon the true absolute stock level, which remains uncertain. In addition, the cod predation estimates suggest greater mortality rates on young juveniles an issue that requires further investigations.

Currently, the survey series used in the SCAA do not appropriately cover the geographical distribution of the adult population. Priority should be given to including data from the slope and pelagic surveys, that include older age groups, in the analytical assessment in the future (WD 5 in 2015).

The new implementation of the SCAA model in TMB has been tested and gives identical results so the earlier implementation with ADMB.

6.5 Biological reference points

No revision. $F_{0.1}$ = 0.039.

Progress towards the development of other reference points for this stock was described in section (6.6) of the AFWG report in 2014.

6.6 Management advice

Moving to F_{MSY} in 2018 would mean a 25% increase in TAC. This seems dangerous for a long-lived, slow-growth, late-maturing redfish stock. Result from the recent pelagic survey in the Norwegian Sea indicate low abundance and the previous ICES Advisory Drafting Group agreed not to move rapidly to the F_{MSY} based purely on model outputs. We therefore recommend that F should be kept at *status quo* for 2018 (=32.7 kt), which represents a gradual increase towards F_{MSY} compared with previous year's quotas. We recommended that this be a single year advice, to be evaluated at the benchmark assessment scheduled prior to AFWG 2018.

6.7 Implementing the ICES F_{MSY} approach

There is no revision since the 2014 AFWG report.

6.8 Possible future model developments

These were outlined in Chapter 0.16 of the Arctic Fisheries Working Group report in 2016 and proposed for the forthcoming benchmark 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		Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia	Spain	UK (Engl. & Wal.)	UK (Scotl.)[2]	Total
1993	**Canada** – 8	4	13	50	35	1	-	-	-	-	5 182	-	963	6 260	5	293	-	12 814
1994		28	4	74	18	1	-	3	-	-	6 511	-	895	5 021	30	124	12	12 721
1995		-	3	16	176	2	-	4	-	-	2 646	-	927	6 346	67	93	4	10 284
1996		-	4	75	119	3	-	2	-	-	6 053	-	467	925	328	76	23	8 075
1997		-	4	37	81	16	-	6	-	-	4 657	1	474	2 972	272	71	7	8 598
1998		-	20	73	100	14	-	9	-	-	9 733	13	125	3 646	177	93	41	14 045
1999		-	73	26	202	50	-	3	-	-	7 884	6	65	2 731	29	112	28	11 209
2000		-	50	12	62	29	48	1	-	-	6 020	2	115	3 519	87	-	130	10 075
2001		**Estonia**	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	**Netherl.**	76	5 493
2005		5	1 147	46	33	39	4	4	-	-	1 760	-	140	5 023	163	7	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	2 220	8	713	7 117	463	13	83	13 096
2009	**EU** - 889	-	1 343	15	42	-	33	-	-	-	2 677	338	806	3 843	177	3	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	13 503	103	505	1 704	1 162	3	-	18 780
2015		-	657	49	242	48	3	-	537	192	19 720	5	678	1 142	2 529	3	52	25 856
2016[1]		-	482	92	434	102	**8**	-	1 243	1 064	17 631	206	1 066	8 419	3 138	-	94	33 979

[1] Provisional figures. **[2] Includes UK (E&W) since 2000.**

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	UK	Total
1993	2	-	-	-	16	-	588	-	606
1994	2	2	-	-	36	-	308	-	348
1995	2	-	-	-	20	-	203	-	225
1996	-	-	-	-	5	-	101	-	106
1997	-	-	3	-	12	-	174	12	190
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[1]	-	-	15	-	176	1	229	-	421

[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	Germany	Greenland	Iceland	Ireland	Lithuania	Latvia	Norway	Portugal	Poland	Russia	Spain	UK	Total
1993		11	15	35	1	-	-	-	-	5 029	648	-	5 328	-	2	11 069
1994		2	33	16	1	-	2	-	-	6 119	687	-	4 692	8	4	11 564
1995		1	16	176	2	-	2	-	-	2 251	715	-	5 916	65	43	9 187
1996		-	75	119	3	-	-	-	-	5 895	429	-	677	5	61	7 264
1997		-	37	77	12	-	2	-	-	4 422	410	-	2 341	9	55	7 365
1998		-	73	58	14	-	6	-	-	9 186	118	-	2 626	55	106	12 242
1999		-	16	160	50	-	3	-	-	7 358	56	-	1 340	14	120	9 117
2000		50	11	35	29	-	-	-	-	5 892	98	-	2 167	18	103	8 403
2001		63	12	161	17	-	4	-	-	13 636	105	-	2 716	18	95	16 827
2002		37	54	59	18	41	4	-	-	1 937	124	-	2 615	8	157	5 054
2003		58	18	17	8	5	5	-	-	1 014	17	-	448	8	102	1 700
2004	**Sweden** - 1	555	8	4	4	10	3	-	-	987	86	-	2 081	7	18	3 764
2005		1 101	36	17	38	2	4	-	-	1 083	71	-	3 307	20	15	5 694
2006	**Estonia** - 396 **Canada** – 433	3 793	199	2 475	52	2 513	3	845	-	4 010	1 731	2 467	10 110	589	958	30 574
2007	**Estonia** - 684	2 157	226	519	29	1 579	16	785	349	3 043	1 395	1 079	5 061	2 159	120	19 201
2008	**Netherland** - 13	1 821	179	9	24	9	9	117	267	1 952	666	1	6 442	430	62	12 001
2009	**EU** – 889	1 316	7	23	-	25	-	-	-	2 208	764	338	3 305	137	62	9 074
2010		961	175	13	12	2	-	457	243	1 705	246	-	5 903	1 183	55	10 955
2011		932	175	697	-	2	-	561	536	1 682	599	-	4 326	1 656	19	11 185
2012		259	-	469	-	32	-	449	447	1 500	1 038	311	3 478	1 770	-	9 753
2013		675	-	24	21	1	-	262	280	921	1 055	68	3 293	1 435	-	8 035
2014	**Netherland** - 2	728	209	411	15	-	-	167	215	4 367	505	100	1 334	1 159	-	9 212
2015	**Netherland** - 3	657	49	236	25	3	-	192	537	11 214	678	3	480	2 508	47	16 632
2016[1]		474	65	434	74	8	-	1 064	1 243	9 641	1 052	182	3 949	3102	43	21 331

[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
1993	**Canada** - 8	-	-	35	-	-	-	137	-	315	344	57	4	291	1 191
1994		-	-	41	-	-	1	356	-	208	21	22	28	132	809
1995		-	-	-	-	-	2	375	-	212	227	2	-	54	872
1996		-	4	-	-	-	2	153	-	38	147	323	-	38	705
1997		-	4	-	3	1	4	223	1	64	457	263	-	22	1 042
1998		-	-	-	42	-	3	521	13	7	642	122	-	29	1 379
1999		-	4	10	42	-	-	457	6	9	902	15	-	20	1 465
2000		-	-	1	27	-	1	82	2	17	946	69	-	27	1 172
2001		-	11	4	37	-	-	293	5	74	763	72	**Estonia**	25	1 284
2002		-	38	4	40	-	-	210	8	118	702	182	15	31	1 348
2003		-	6	4	15	-	-	190	7	27	212	39	-	22	522
2004		-	33	5	6	-	-	386	42	149	443	250	-	58	1 372
2005	**Iceland** - 2	7	46	10	17	1	-	673	-	69	1 389	143	5	80	2 442
2006		-	13	16	8	11	1	688	29	73	843	121	-	67	1 870
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	1 082
2010		-	18	-	8	-	-	339	-	47	501	1	-	24	938
2011	**Lithuania** - 4	-	52	-	139	-	-	741	11	14	698	23	-	36	1 717
2012	**Iceland** - 4	-	-	-	48	-	-	581	7	-	606	10	-	-	1 256
2013		-	22	-	56	-	-	854	16	23	357	23	-	-	1 351
2014		1	15	6	34	-	-	9 099	3	-	307	3	-	-	9 468
2015		-	-	-	6	5	-	8 429	1	-	536	21	-	5	9 003
2016[1]		-	7	27	-	14	-	7 814	23	14	4 241	36	-	50	12 226

[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	-	-	-	-	-	-	1 510	-	-	2 012
2005		-	1 083	-	20	-	-	-	-	-	-	3 299	-	-	4 402
2006	**Canada** - 433	396	3 766	192	2 475	2 510	341	845	2 862	2 447	1 697	9 390	575	841	28 770
2007		684	1 968	226	497	1 579	349	785	1 813	1 079	1 377	3 645	2 155	-	16 157
2008		-	1 797	-	-	-	267	117	330	-	641	4 901	390	-	8 443
2009	**EU** - 889	-	1 253	-	-	-	-	-	-	337	701	1 975	135	-	5 290
2010		-	912	-	-	-	243	457	450	-	244	5 103	820	-	8 229
2011		-	740	175	693	-	536	561	342	-	595	3 621	1 648	-	8 911
2012		-	259	-	469	31	447	449	-	311	1 038	2 714	1 768	-	7 486
2013		8	675	-	-	-	280	262	1	68	1 078	2 720	1 435	-	6 527
2014		-	697	-	409	-	215	167	-	100	505	795	1 146	-	4 034
2015		-	606	-	231	-	537	192	-	-	678	-	2 508	-	4 752
2016[1]		-	393	-	272	-	1064	1243	3	-	821	512	2 862	-	7 170

[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 is missing from the pelagic fishery. For the period 2015-2016, age data is 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	33946	15590
1993	159	159	174	512	2094	3139	2631	2308	2987	1875	1514	1053	527	6022	25154	12814
1994	738	730	722	992	2561	2734	3060	1535	2253	2182	3336	1284	734	3257	26118	12721
1995	662	941	1279	719	740	1230	2013	4297	3300	2162	1454	757	794	2404	22752	10284
1996	223	634	1699	1554	1236	1078	1146	1413	1865	880	621	498	700	2247	15794	8075
1997	125	533	1287	1247	1297	1244	876	1416	1784	1217	537	1177	342	3568	16650	8598
1998	37	882	2904	4236	3995	2741	1877	1373	1277	1595	1117	784	786	6241	29845	14045
1999	9	83	441	1511	2250	3262	1867	1454	1447	1557	1418	1317	658	3919	21193	11209
2000	1	24	390	1235	2460	2149	1816	1205	1001	993	932	505	596	5705	19012	10075
2001	117	372	542	976	925	1712	2651	2660	1911	1773	1220	714	814	16234	32621	18418
2002	2	40	252	572	709	532	1382	1893	1617	855	629	163	237	4082	12965	6993
2003	6	37	103	93	132	220	384	391	434	466	513	199	231	1193	4402	2520
2004	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	15723	8465
2006	0	10	8	89	153	256	877	1980	2774	4580	5154	4823	4261	35350	60315	33261
2007	0	1	3	22	33	86	235	631	2194	2825	3657	4359	3540	15824	33410	20219
2008	0	0	1	10	44	128	186	492	541	1444	1423	923	1730	16389	23311	13095
2009	0	1	16	22	42	48	1507	520	983	1136	1623	1292	2347	7389	16926	10246
2010	10	4	6	19	34	55	61	237	540	532	848	828	792	14659	18625	11924
2011	4	4	4	25	55	114	234	186	177	482	415	445	394	17315	19854	12962
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[1]	14	27	350	220	129	474	226	179	179	181	341	384	266	22670	25640	18780
2015[2]	0	46	90	1077	499	257	847	378	275	261	245	460	524	31551	36510	25836
2016[2]	0	0	129	237	2538	1097	535	1757	620	460	370	355	620	40420	49138	33979

Table 6.7. *S.mentella* in Subareas 1 and 2. Weights at age (kg).

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1992	0.08	0.11	0.15	0.18	0.22	0.27	0.31	0.35	0.39	0.43	0.47	0.51	0.55	0.72
1993	0.07	0.10	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.54	0.73
1994	0.12	0.17	0.21	0.27	0.32	0.37	0.42	0.47	0.51	0.56	0.60	0.64	0.68	0.83
1995	0.12	0.16	0.21	0.25	0.30	0.35	0.39	0.44	0.48	0.52	0.55	0.59	0.62	0.74
1996	0.12	0.17	0.22	0.27	0.32	0.38	0.43	0.48	0.53	0.58	0.63	0.67	0.71	0.89
1997	0.11	0.16	0.20	0.25	0.30	0.36	0.41	0.46	0.50	0.55	0.59	0.63	0.67	0.84
1998	0.12	0.16	0.21	0.26	0.31	0.36	0.40	0.45	0.49	0.53	0.57	0.61	0.64	0.77
1999	0.14	0.19	0.24	0.29	0.33	0.38	0.43	0.47	0.51	0.54	0.58	0.61	0.63	0.74
2000	0.11	0.15	0.19	0.24	0.29	0.33	0.38	0.43	0.48	0.52	0.56	0.60	0.64	0.80
2001	0.10	0.14	0.18	0.22	0.27	0.31	0.36	0.40	0.44	0.48	0.52	0.56	0.59	0.73
2002	0.10	0.14	0.18	0.22	0.27	0.31	0.36	0.40	0.45	0.49	0.53	0.57	0.60	0.76
2003	0.11	0.15	0.19	0.24	0.28	0.33	0.37	0.42	0.46	0.50	0.54	0.58	0.61	0.75
2004	0.11	0.15	0.20	0.25	0.29	0.34	0.39	0.43	0.48	0.52	0.56	0.60	0.63	0.78
2005	0.11	0.15	0.20	0.25	0.29	0.34	0.38	0.43	0.47	0.51	0.55	0.58	0.61	0.74
2006	0.11	0.15	0.20	0.24	0.29	0.34	0.38	0.43	0.47	0.51	0.54	0.58	0.61	0.74
2007	0.12	0.16	0.20	0.25	0.30	0.34	0.38	0.42	0.46	0.50	0.53	0.56	0.59	0.70
2008	0.11	0.15	0.19	0.24	0.28	0.33	0.37	0.41	0.45	0.49	0.53	0.56	0.59	0.72
2009	0.12	0.16	0.21	0.25	0.30	0.34	0.39	0.43	0.47	0.51	0.55	0.58	0.61	0.73
2010	0.13	0.18	0.23	0.27	0.32	0.36	0.40	0.44	0.48	0.51	0.54	0.57	0.59	0.68
2011	0.14	0.18	0.23	0.28	0.33	0.38	0.42	0.46	0.50	0.54	0.57	0.60	0.63	0.74
2012	0.13	0.17	0.22	0.27	0.32	0.37	0.42	0.46	0.50	0.54	0.58	0.61	0.64	0.76
2013[1]	0.13	0.18	0.22	0.27	0.32	0.36	0.40	0.44	0.47	0.51	0.53	0.56	0.59	0.67
2014	0.12	0.16	0.20	0.25	0.30	0.35	0.40	0.44	0.48	0.53	0.56	0.60	0.63	0.77
2015	0.14	0.19	0.23	0.28	0.33	0.38	0.43	0.47	0.51	0.55	0.58	0.61	0.64	0.74
2016	0.14	0.19	0.23	0.28	0.33	0.38	0.43	0.47	0.51	0.55	0.58	0.61	0.64	0.74

[1] preliminary figures

Table 6.8 Pelagic *Sebastes mentella* in the Norwegian Sea (outside the EEZ). Catch numbers-at-age.

NUMBERS10-3				AGE					
YEAR	11	12	13	14	15	16	17	18	19+
2006	23	93	1083	323	1563	3628	2514	3756	29704
2007	75	440	1331	2909	3347	4138	3692	3437	9114
2008	28	146	115	143	214	594	752	753	13258
2009	9	1314	294	471	889	999	869	1150	2981
2010	0	0	130	336	254	466	467	508	11510
2011	0	223	83	83	168	136	166	136	13182
2012[1]	29	19	294	146	132	217	288	126	8939
2013[2]	123	158	96	169	246	196	238	598	7968
2014[3]	406	103	125	70	113	151	112	130	4398
2015[3]	161	714	170	190	98	145	182	129	4859
2016[3]	570	376	1565	345	352	166	231	277	7101

[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 are.

[3]no age data in 2014 – 2016, 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).

				AGE					
YEAR	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	-	-	-	-	-	-	-	-

[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 20112016.**

	LENGTH GROUP																
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
Year	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	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																

Table 6.11. ***S. mentella*** **in Subareas 1 and 2. Catch numbers at length, in thousands, in the pelagic fishery for 2011-2016.**

	LENGTH GROUP																
	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
Year	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	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																

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	Faroe Islands	France	Germany[4]	Greenland	Iceland	Ireland	Netherlands	Norway	Poland	Portugal	Russia[5]	Spain	UK (E&W)	UK (Scot.)	Total
1984	-	-	-	2 970	7 457	-	-	-	-	18 650	-	1 806	69 689	25	716	-	101 313
1985	-	-	-	3 326	6 566	-	-	-	-	20 456	-	2 056	59 943	38	167	-	92 552
1986	-	-	29	2 719	4 884	-	-	-	-	23 255	-	1 591	20 694	-	129	14	53 315
1987	-	+	450[3]	1 611	5 829	-	-	-	-	18 051	-	1 175	7 215	25	230	9	34 595
1988	-	-	973	3 349	2 355	-	-	-	-	24 662	-	500	9 139	26	468	2	41 494
1989	-	-	338	1 849	4 245	-	-	-	-	25 295	-	340	14 344	5[2]	271	1	46 688
1990	-	37[3]	386	1 821	6 741	-	-	-	-	34 090	-	830	18 918	-	333	-	63 156
1991	-	23	639	791	981	-	-	-	-	49 463	-	166	15 354	1	336	13	67 768
1992	-	9	58	1 301	530	614	-	-	-	23 451	-	977	4 335	16	479	3	31 773
1993	8[3]	4	152	921	685	15	-	-	-	18 319	-	1 040	7 573	65	734	1	29 517
1994	-	28	26	771	1026	6	4	3	-	21 466	-	985	6 220	34	259	13	30 841
1995	-	-	30	748	692	7	1	5	1	16 162	-	936	6 985	67	252	13	25 899
1996	-	-	42[3]	746	618	37	-	2	-	21 675	-	523	1 641	408	305	121	26 118
1997	-	-	7	1 011	538	39[2]	-	11	-	18 839	1	535	4 556	308	235	29	26 109
1998	-	-	98	567	231	47[3]	-	28	-	26 273	13	131	5 278	228	211	94	33 199
1999	-	-	108	61[3]	430	97	14	10	-	24 634	6	68	4 422	36	247	62	30 195
2000	-	-	67[3]	25	222	51	65	1	-	19 052	2	131	4 631	87		203[6]	24 537
2001	-	-	111[3]	46	436	34	3	5	-	23 071	5	186	4 738	91	**Est**	239[6]	28 965
2002	-	-	135[3]	89	141	49	44	4	-	10 713	8[3]	276	4 736	193[2]	15	234[6]	16 637
2003	**Swe**	-	173[3]	31	154	44[3]	9	5[3]	89	8 063	7	50	1 431	47[2]	-	258[6]	10 361
2004	1	-	607	17[3]	78	24[3]	40	3	33	7 608[1 2]	42	240	3 601[2]	260[2]	-	146[6]	12 699
2005	**Can**	**Lith**	1 194	56	106	75[3]	12[2]	4[3]	55[2]	7 844[1 2]	-	196	5 637	171[3]	5	147[6]	15 501
2006	433	845	3 919	223	2 518	107[3]	2 544[3]	12[3]	21	11 015	2 496[2]	1 873	12 126	719[2]	396	1 066[6]	40 313
2007	**Latv**	785	2 343	249	587	84[3]	1 647[2]	7[3]	20	8 993[2]	1 081[2]	1 708	6 550	2 186[2]	684	257[6]	27 181
2008	267	117	2 123[3]	250	46	96[3]	36[3]	15[3]	15	7 436[1]	8	785	7 866	467[2]	**EU[7]**	168[6]	19 694
2009	-	-	1 413	16	100	81	99	-	4	8 128	338	836	4 541	177	889	110	16 732
2010	243[3]	457[3]	1 150	226	52	84[3]	24[3]	-	-	8 059	1[3]	321	6 979	1 187	-	123	18 906
2011	536	565	1 008[2]	228	844	51	24	-	1	7 152	59	638	5 956	1 684[2]	-	68	18 814
2012	447	449	346	182	588	58	59	12	5	6 362	352	1 055	4 782	1 780[2]	-	100	16 577
2013	280	262	780	353	81	66	9	1	-	5 606	103	1 114	4 474	1 459	-	493	15 082
2014	215	167	810	433	451	35	29	-	4	16 556	124	510	2 510	1 162	-	211	23 217
2015	537	192	732	102	266	259	39	-	3	22 208	22	678	1 806	2 530	**Denm**	108	29 484
2016[1]	1 243	1 064	672	165	497	161	79			22 237	228	1 066	9 283	3 140	7	197	40 039

[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 IV (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	Sweden	UK (E&W)	UK (Scot.)	Total
1986	-	24	-	578	183	-	-	1,048	-	35	1	1,869
1987	-	16	3	833	70	-	-	411	-	16	55	1,404
1988	-	32	90	915	188	-	-	696	-	125	9	2,055
1989	1	23	13	554	111	-	-	500[2]	-	134	6	1,342
1990	+	41	25	554	47	-	-	483[2]	-	369	6	1,525
1991	5	29	144	914	213	-	2	415[2]	-	43	38	1,803
1992	4	22	23	1,960	170	-	1	416	-	65	122	2,783
1993	28	14	4	1,211	33	-	1	373	-	138	71	1,873
1994	4	13	1	863	324	-	8	371	-	38	66	1,688
1995	16	12	65	1,120	80	-	16	297	-	46	241	1,893
1996	20	20	1	932	74	-	41	363	-	37	146	1,634
1997	16	23	-	1,049	45	-	53	595	-	21	528	2,330
1998	2	27	12	570	370	4	21	1,113	-	68	681	2,868
1999	3	52	1	-	58	39	16	862	-	67	465	1,563
2000	5	41	-	224	19	28	19	443	-	132	486	1,397
2001	4	96	-	272	13	19	+	421	-	80	458	1,363
2002	2	40	2	98	11	7	+	241	-		524[3]	925
2003	1	71	2	26	2	-	-	474	-	**Portugal**	463[3]	1,071
2004	+	42	3	26	1	-	-	287	-	-	214[3]	578
2005	2	34	-	10	1	-	-	84	-	-	28[3]	159
2006	1	49	1	12	3	-	-	155	-	33	79[3]	333
2007[1]	+	27	-	8	1	-	-	107	+	-	78[3]	221
2008[1]	+	3	-	8	1	-	-	77	1	-	54[3]	144
2009	-	4	1	38	-	-	-	119	+	-	86[3]	248
2010	-	5	-	3	-	-	-	62	-	-	150[3]	220
2011	-	10	-	90	1	-	-	66	+	-	71[3]	238
2012	-	10	-	19	-	-	-	71	+	-	87[3]	187
2013	-	7	-	40	+	-	-	54	+	-	176[3]	277
2014	-	-	-	32	1	-	-	160	-	-	933	286
2015[1]	-	1	-	14	1	-	-	157	+	-	61	235
2016[1]	-	3	-	10	+	-	-	180	+	-	21	215

[1] Provisional figures.

[2] Working Group figure.

[3] UK(E/W)+UK(Scotl)

+ less than 0.5 ton.

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").

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
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 onl

[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 1986-2016 (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	1,287
1991	1,533	1,426	563	55	138	38	30	7	1	3,791
1992	149	446	268	43	22	15	4	7	4	958
1993	9	320	272	89	16	13	3	1	+	722
1994	4	284	613	242	10	9	2	2	1	1,165
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
2014[3]	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

[1] - Includes some unidentified *Sebastes* specimens, mostly less than 15 cm.

[2] - Old trawl equipment (bobbins gear and 80 meter 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 1992-2016 (numbers in millions).

	Age													
Year	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	1 462
1993	2	527	117	202	142	8	23	6	13	1	7	1	1	+	1 050
1994	7	280	290	202	235	42	94	1	1	3	4	1	1	+	1 161
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														

[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 surveys in the Barents Sea in the winter 1986-2017 (numbers in millions). The area coverage was extended from 1993 onwards.

	Length group (cm)									
Year	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	>45.0	Total
1986	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	7	259	289	284	51	70	20	1	0.1	982
1995	264	71	638	506	91	69	31	4	0.5	1674
1996	213	100	191	338	134	42	17	1	0.3	1037
1997[2]	63	121	25	278	274	72	41	5	0.2	879
1998[2]	1	91	63	101	203	41	13	2	0.2	514
1999	2	7	68	37	167	72	21	3	0.1	377
2000	9	13	39	77	142	97	27	7	1.5	412
2001	9	22	7	55	77	73	9	1	0.1	254
2002	16	7	19	42	104	114	23	1	+	326
2003	4	4	10	13	71	200	47	6	0.3	354
2004	2	3	7	19	33	87	32	2	0.1	184
2005	+	6	7	11	28	153	87	4	0.2	297
2006	99	2	10	15	23	103	82	3	0.7	336
2007	446	125	3	6	12	119	120	7	0.2	838
2008	846	354	26	5	12	114	180	5	0.1	1542
2009	94	322	134	5	9	66	160	6	0	797
2010	647	273	213	64	7	73	190	6	0	1474
2011	496	228	211	148	14	46	157	5	0	1304
2012	127	275	84	123	46	14	151	17	0.2	838
2013	248	224	243	158	143	35	192	27	0.3	1271
2014	89	173	249	113	123	51	117	14	0.2	929
2015	175	111	218	303	291	214	172	18	0.1	1501
2016	612	105	146	326	209	159	120	14	0.6	1692
2017	593	210	72	201	289	312	233	11	0.1	1918

[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 1992-2017 (numbers in millions). The area coverage was extended from 1993 onwards.

	Age													
Year	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	1,136
1994	7	85	332	189	370	228	73	42	3	30	8	14	25	7	1,413
1995	308	45	146	264	364	211	69	23	7	17	23	9	11	10	1,507
1996	173	119	109	114	128	122	106	64	24	19	12	7	8	4	1,009
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														

[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	1,01 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 1996-2016 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.**

	Age															
Year	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	
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 1269 508	
2016	No age reading																

[1] - Poor survey coverage in 2014

Table 6.19: Proportion of maturity-at-age 5 - 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	AGE6	AGE7	AGE8	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14	AGE15	AGE16	AGE17	AGE18	AGE19+
1992	0.00	0.00	0.01	0.02	0.05	0.09	0.18	0.33	0.51	0.57	0.64	0.70	0.75	1.00
1993	0.01	0.02	0.04	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	0.44	0.59	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	0.05	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	0.28	0.46	0.55	0.60	0.66	0.71	0.76	0.80	0.83	1.00
1998	0.02	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	0.33	0.51	0.57	0.64	0.69	0.75	0.79	0.83	0.87	1.00
2000	0.02	0.05	0.10	0.20	0.35	0.52	0.63	0.73	0.81	0.87	0.91	0.94	0.96	1.00
2001	0.01	0.02	0.04	0.09	0.18	0.32	0.50	0.57	0.63	0.69	0.74	0.79	0.83	1.00
2002	0.02	0.05	0.09	0.19	0.33	0.50	0.55	0.59	0.63	0.67	0.70	0.74	0.77	1.00
2003	0.02	0.05	0.11	0.21	0.36	0.52	0.57	0.63	0.68	0.73	0.77	0.81	0.84	1.00
2004	0.03	0.06	0.11	0.22	0.38	0.51	0.55	0.59	0.63	0.66	0.69	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
2007	0.02	0.04	0.08	0.16	0.29	0.47	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	0.55	0.65	0.73	0.79	0.85	0.89	0.92	1.00
2009	0.02	0.04	0.08	0.16	0.29	0.47	0.60	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	0.45	0.55	0.60	0.66	0.71	0.75	0.80	0.83	1.00
2011	0.01	0.03	0.05	0.11	0.21	0.37	0.52	0.59	0.66	0.72	0.77	0.81	0.85	1.00
2012	0.02	0.04	0.09	0.17	0.31	0.49	0.59	0.67	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	0.45	0.63	0.79	0.89	0.94	0.97	1.00
2015	0.01	0.03	0.05	0.11	0.21	0.37	0.52	0.59	0.66	0.72	0.77	0.81	0.85	1.00
2016	0.01	0.03	0.05	0.11	0.21	0.37	0.52	0.59	0.66	0.72	0.77	0.81	0.85	1.00

[1] **Model parameter estimates were unrealistic and replaced by average parameter values.**

Table 6.20: *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 age (Sa). Numbers are estimated from the statistical catch-at-age model.

		SA (DEMERSAL)	0.000	0.000	0.000	0.000	0.015	0.035	0.079	0.170	0.327	0.536	0.733
		SA (PELAGIC)	0.000	0.000	0.000	0.000	0.000	0.007	0.013	0.026	0.052	0.101	0.185
Fy (demersal)	Fy (pelagic)	Year\age	2	3	4	5	6	7	8	9	10	11	12
0.094	0	1992	550 651	564 816	481 046	253 362	145 151	91 141	82 132	80 643	96 927	62 472	62 023
0.074	0	1993	335 911	523 907	537 384	457 682	241 057	137 907	86 430	77 564	75 513	89 430	56 521
0.054	0	1994	233 692	319 596	498 462	511 284	435 453	229 094	130 870	81 752	72 876	70 128	81 780
0.043	0	1995	223 980	222 342	304 074	474 252	486 452	413 968	217 556	123 981	77 069	68 119	64 813
0.027	0	1996	196 171	213 101	211 543	289 306	451 219	462 525	393 266	206 279	117 094	72 294	63 322
0.026	0	1997	164 783	186 643	202 751	201 269	275 255	429 133	439 653	373 379	195 378	110 443	67 810
0.037	0	1998	76 235	156 780	177 578	192 904	191 493	261 785	407 924	417 448	353 697	184 332	103 641
0.024	0	1999	61 109	72 532	149 165	168 954	183 535	182 092	248 750	386 981	394 698	332 491	171 952
0.018	0	2000	46 662	58 141	69 009	141 921	160 748	174 559	173 105	236 226	366 711	372 636	312 359
0.031	0	2001	29 154	44 396	55 318	65 658	135 028	152 899	165 976	164 461	224 060	346 831	351 098
0.01	0	2002	30 911	27 738	42 239	52 631	62 469	128 411	145 317	157 531	155 660	211 050	324 605
0.003	0	2003	34 199	29 410	26 391	40 188	50 075	59 426	122 131	138 149	149 625	147 614	199 720
0.006	0	2004	42 323	32 538	27 981	25 109	38 236	47 640	56 533	116 170	131 368	142 209	140 204
0.009	0	2005	79 255	40 267	30 958	26 622	23 890	36 376	45 317	53 761	110 411	124 734	134 851
0.009	0.031	2006	180 624	75 406	38 312	29 454	25 329	22 726	34 598	43 084	51 070	104 731	118 087
0.003	0.022	2007	330 396	171 851	71 744	36 451	28 024	24 096	21 611	32 879	40 892	48 361	98 832
0.004	0.011	2008	329 491	314 349	163 505	68 259	34 681	26 661	22 920	20 551	31 250	38 828	45 846
0.004	0.007	2009	312 609	313 488	299 082	155 564	64 944	32 994	25 362	21 797	19 535	29 680	36 830
0.004	0.01	2010	417 305	297 427	298 263	284 556	148 008	61 786	31 386	24 119	20 720	18 554	28 155
0.003	0.011	2011	484 009	397 037	282 981	283 777	270 736	140 812	58 773	29 849	22 927	19 679	17 599
0.003	0.009	2012	334 959	460 502	377 754	269 237	269 994	257 574	133 949	55 897	28 376	21 779	18 671
0.002	0.01	2013	235 885	318 691	438 136	359 407	256 161	256 868	245 021	127 394	53 139	26 955	20 665
0.005	0.016	2014	137 924	224 428	303 213	416 857	341 951	243 713	244 361	233 057	121 137	50 502	25 595
0.008	0.023	2015	187 689	131 226	213 528	288 486	396 611	325 318	231 810	232 347	221 446	114 960	47 837
0.01	0.033	2016	177 777	178 573	124 852	203 158	274 475	377 300	309 380	220 337	220 612	209 859	108 632

Table 6.20…continues

		SA (DEMERSAL)	0.867	0.939	0.974	0.989	0.995	0.998	1.000
		SA (PELAGIC)	0.315	0.483	0.655	0.794	0.886	0.941	1.000
Fy (demersal)	Fy (pelagic)	Year\age	13	14	15	16	17	18	19+
0.094	0	1992	43 244	38 616	32 594	21 090	12 505	8 006	114 782
0.074	0	1993	55 086	37 927	33 639	28 302	18 287	10 836	106 356
0.054	0	1994	50 938	49 155	33 663	29 781	25 028	16 164	103 552
0.043	0	1995	74 780	46 241	44 448	30 383	26 857	22 563	107 899
0.027	0	1996	59 736	68 522	42 239	40 540	27 694	24 474	118 859
0.026	0	1997	59 085	55 541	63 587	39 161	37 572	25 662	132 798
0.037	0	1998	63 312	54 975	51 582	59 003	36 324	34 844	146 937
0.024	0	1999	95 982	58 344	50 527	47 349	54 131	33 316	166 703
0.018	0	2000	160 790	89 467	54 291	46 979	44 008	50 304	185 859
0.031	0	2001	293 252	150 587	83 679	50 748	43 901	41 119	220 644
0.010	0	2002	326 619	271 686	139 203	77 273	46 841	40 513	241 529
0.003	0	2003	306 572	308 058	256 060	131 152	72 792	44 122	265 660
0.006	0	2004	189 575	290 874	292 216	242 865	124 388	69 037	293 794
0.009	0	2005	132 787	179 397	275 133	276 344	229 652	117 616	343 068
0.009	0.031	2006	127 433	125 326	169 203	259 418	260 522	216 491	434 265
0.003	0.022	2007	110 939	119 085	116 430	156 308	238 584	238 897	594 983
0.004	0.011	2008	93 468	104 576	111 813	108 891	145 726	221 965	774 107
0.004	0.007	2009	43 414	88 338	98 623	105 231	102 315	136 779	933 846
0.004	0.010	2010	34 888	41 064	83 433	93 022	99 153	96 340	1 007 344
0.003	0.011	2011	26 664	32 980	38 743	78 572	87 477	93 153	1 035 758
0.003	0.009	2012	16 672	25 212	31 120	36 486	73 878	82 165	1 059 082
0.002	0.010	2013	17 691	15 772	23 811	29 344	34 359	69 515	1 072 817
0.005	0.016	2014	19 599	16 752	14 907	22 464	27 643	32 336	1 073 847
0.008	0.023	2015	24 187	18 469	15 738	13 963	20 993	25 794	1 030 323
0.010	0.033	2016	45 042	22 680	17 241	14 630	12 937	19 408	973 843

Table 6.21. Stock summary for *S. mentella* in subareas 1 and 2 as estimated by the statistical catch-at-age model.

Year	Rec (age 2) in millions	Rec (age 6) in millions	Stock Biomass (tons)	SSB (tons)	F (12–18)	F(19+)
1992	551	145	288685	124220	0.087	0.094
1993	336	241	304632	145116	0.069	0.074
1994	234	435	481345	228190	0.05	0.054
1995	224	486	526851	251943	0.04	0.043
1996	196	451	652211	229135	0.025	0.027
1997	165	275	697966	296910	0.024	0.026
1998	76	191	770636	343876	0.034	0.037
1999	61	184	887812	439069	0.022	0.024
2000	47	161	868440	531670	0.017	0.018
2001	29	135	861483	472034	0.028	0.031
2002	31	62	908738	569041	0.009	0.01
2003	34	50	980190	677674	0.003	0.003
2004	42	38	1051599	722831	0.006	0.006
2005	79	24	1052229	784763	0.009	0.009
2006	181	25	1068341	785615	0.028	0.04
2007	330	28	1026437	939035	0.016	0.025
2008	329	35	1040522	922934	0.01	0.015
2009	313	65	1069911	977252	0.008	0.011
2010	417	148	1036337	881684	0.01	0.014
2011	484	271	1118897	936905	0.01	0.014
2012	335	270	1147477	956327	0.008	0.012
2013	236	256	1078153	819267	0.008	0.012
2014	138	342	1198110	917511	0.015	0.021
2015	188	397	1240661	870576	0.022	0.031
2016	178	274	1262583	856873	0.03	0.043

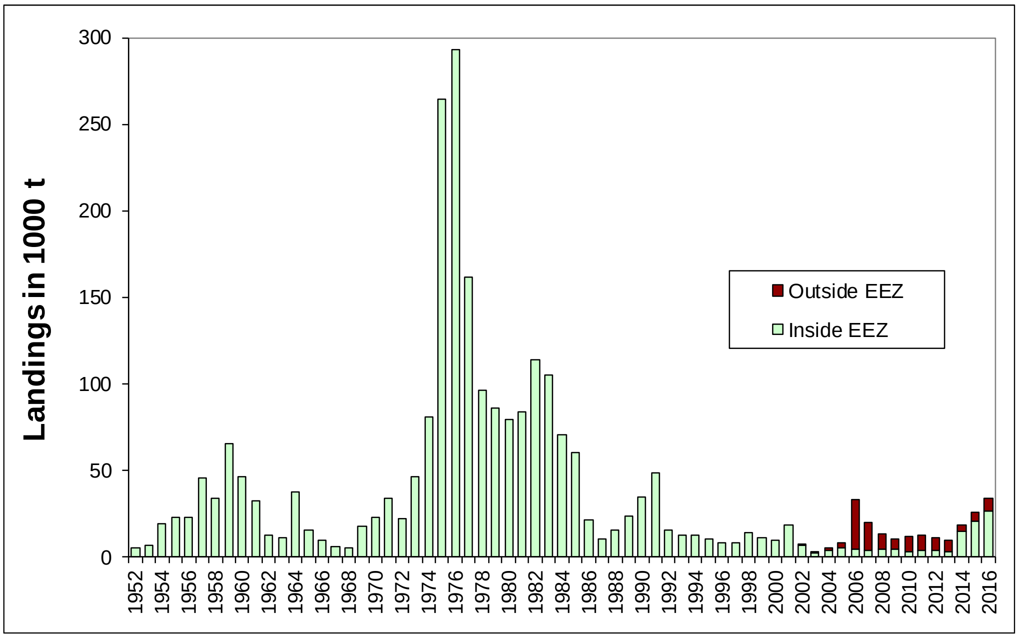


Figure 6.1. ***Sebastes mentella*** **in Subareas 1 and 2. Total international landings 1952-2016 (thousand tonnes).**

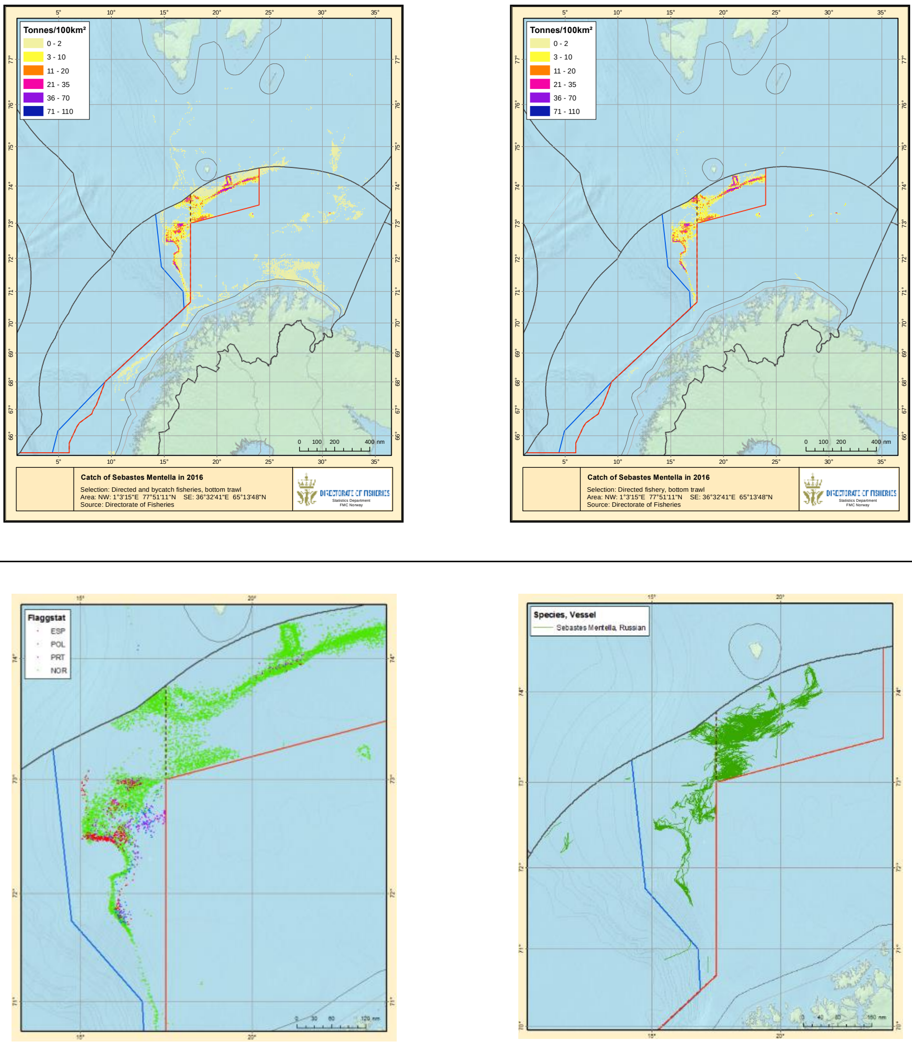


Figure 6.2. ***Sebastes mentella*** **in Subareas 1 and 2. Geographical location, within the Norwegian Exclusive Economic Zone of directed Catches by Norwegian vessesls (top left), directed and by-catches by Norwegian vessels (top right), catches by Spain, Poland, Portugal and Norway (bottom left) and commercial trawl tracks from Russian vessels (bottom right). 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.**

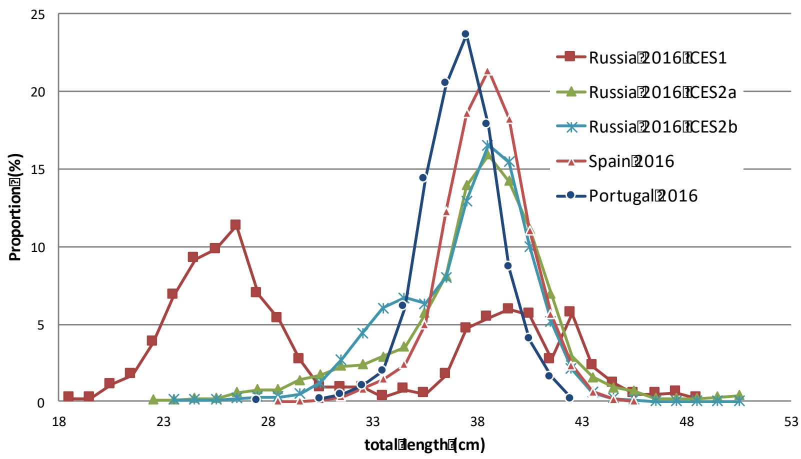


Figure 6.3. ***Sebastes mentella*** **in Subareas 1 and 2. Length-distributions of the commercial pelagic catches by Russia, Spain and Portugal in 2016.**

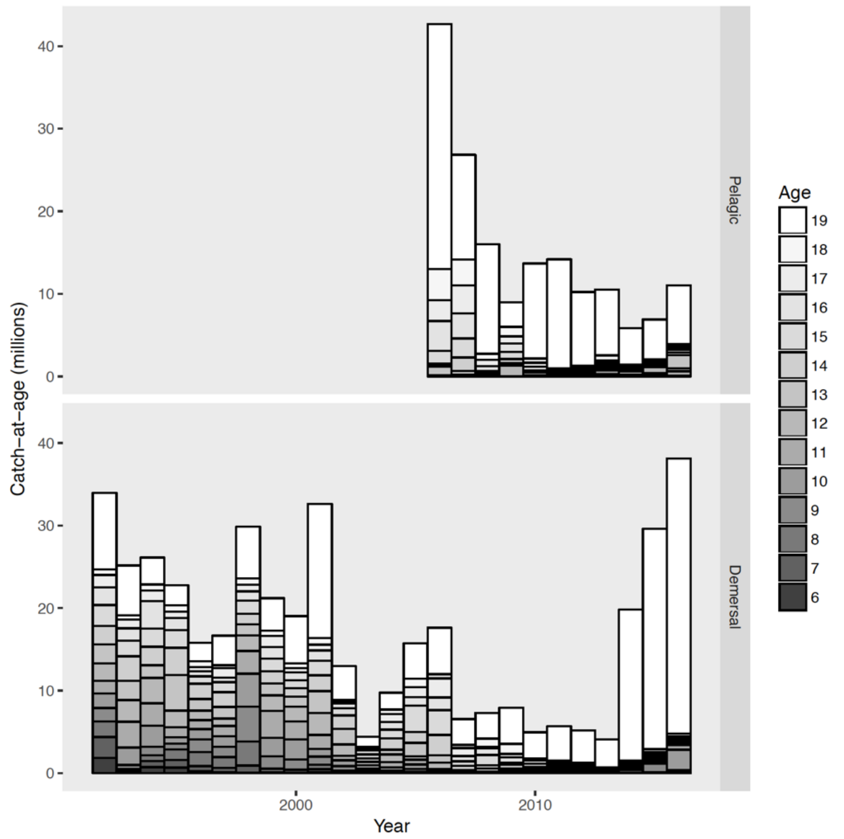


Figure 6.4. ***Sebastes mentella*** **in Subareas 1 and 2. Catch numbers-at-age for the pelagic and demersal fleets 1992-2016.**

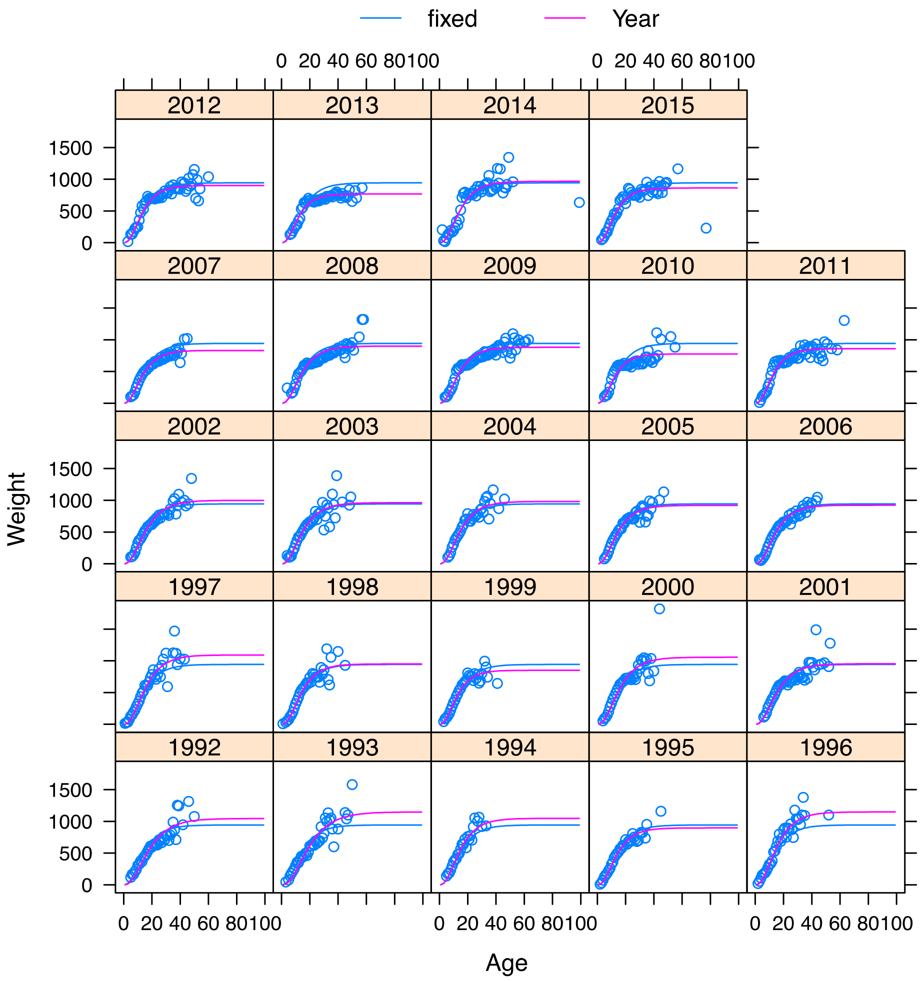


Figure 6.5. Weight-at-age of *S. mentella* in subareas 1 and 2 derived from Norwegian commercial and survey data (Table DXXX). The weights were derived from samples with at least five individuals. The blue and purple lines show the fitted mixed-effect models. Data for 2016 was not available at the time of the meeting.

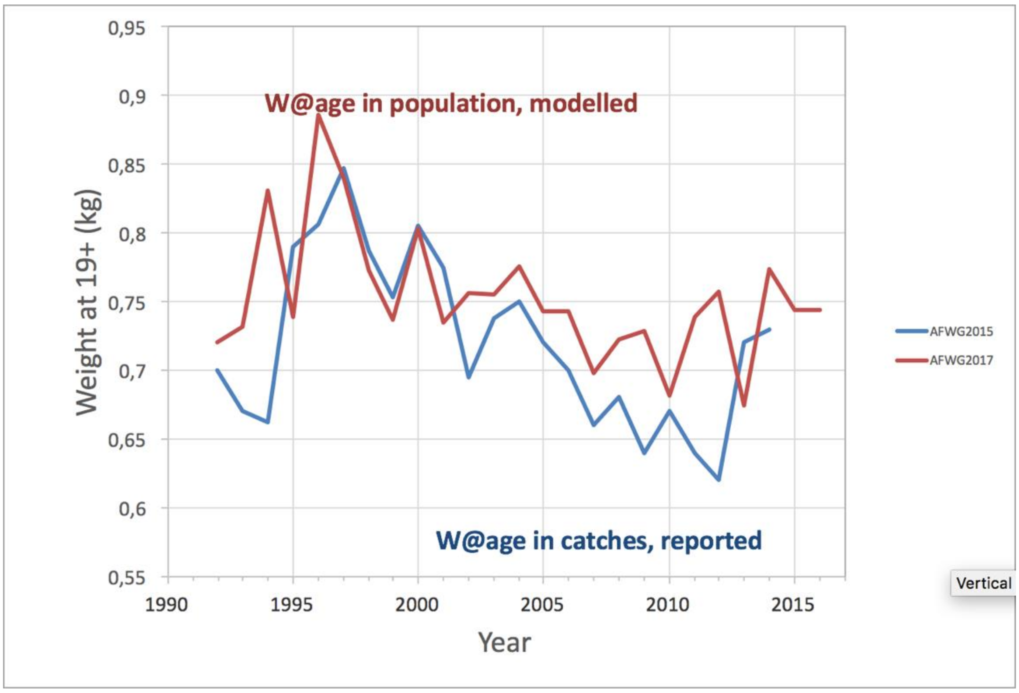


Figure 6.6. *S. mentella* in subareas 1 and 2. Weight-at-age 19+ as reported from catches (blue) or modelled from catches and survey observations (red) using a mixed effect model (Figure 6.X). Data for 2016 was not available at the time of the meeting and modelled weight-at-age for 2015 is used instead.

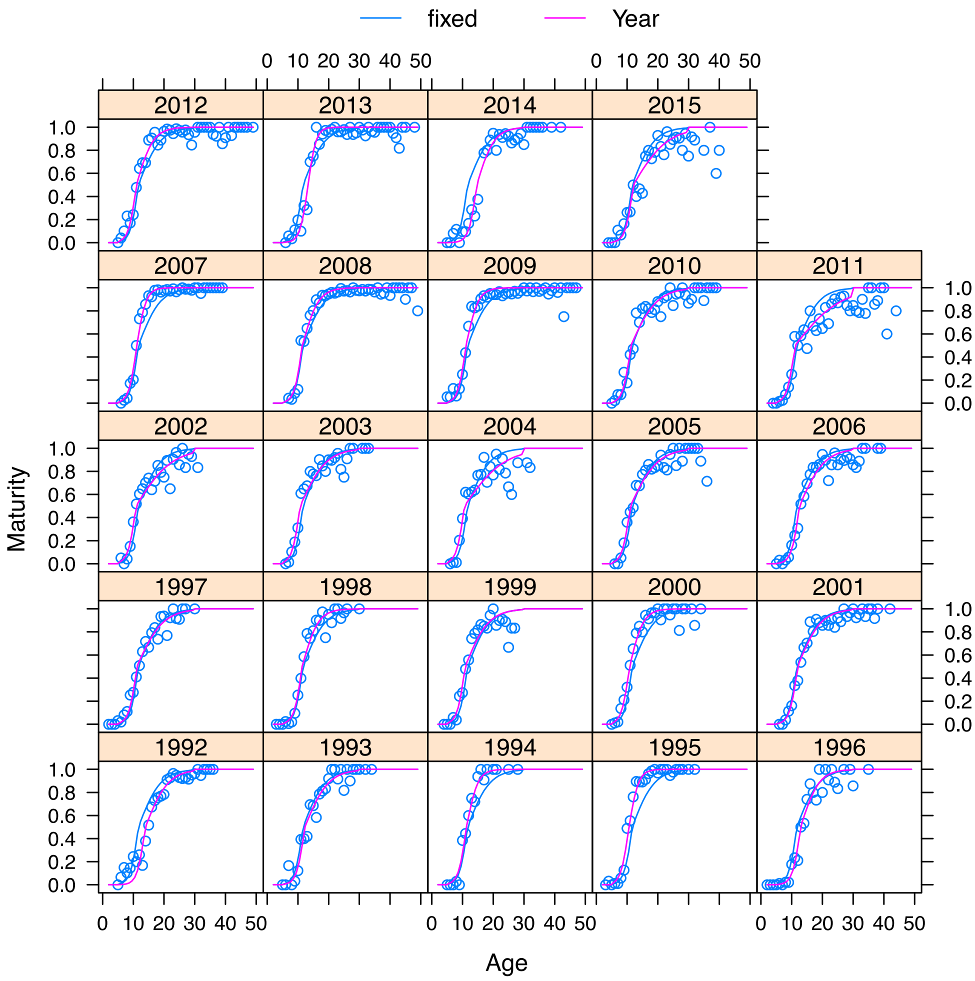


Figure 6.7. Proportion maturity-at-age of *S. mentella* in subareas 1 and 2 derived from Norwegian commercial and survey data (Table D7). The proportions were derived from samples with at least five individuals. The blue and purple lines show the fitted mixed-effect models. For 2011, 2014 and 2015 the common model (fixed effects, blue) was used, for other years the annual models (random effects, purple) were used. Data for 2016 was not available at the time of the meeting and the fixed effect model was used.

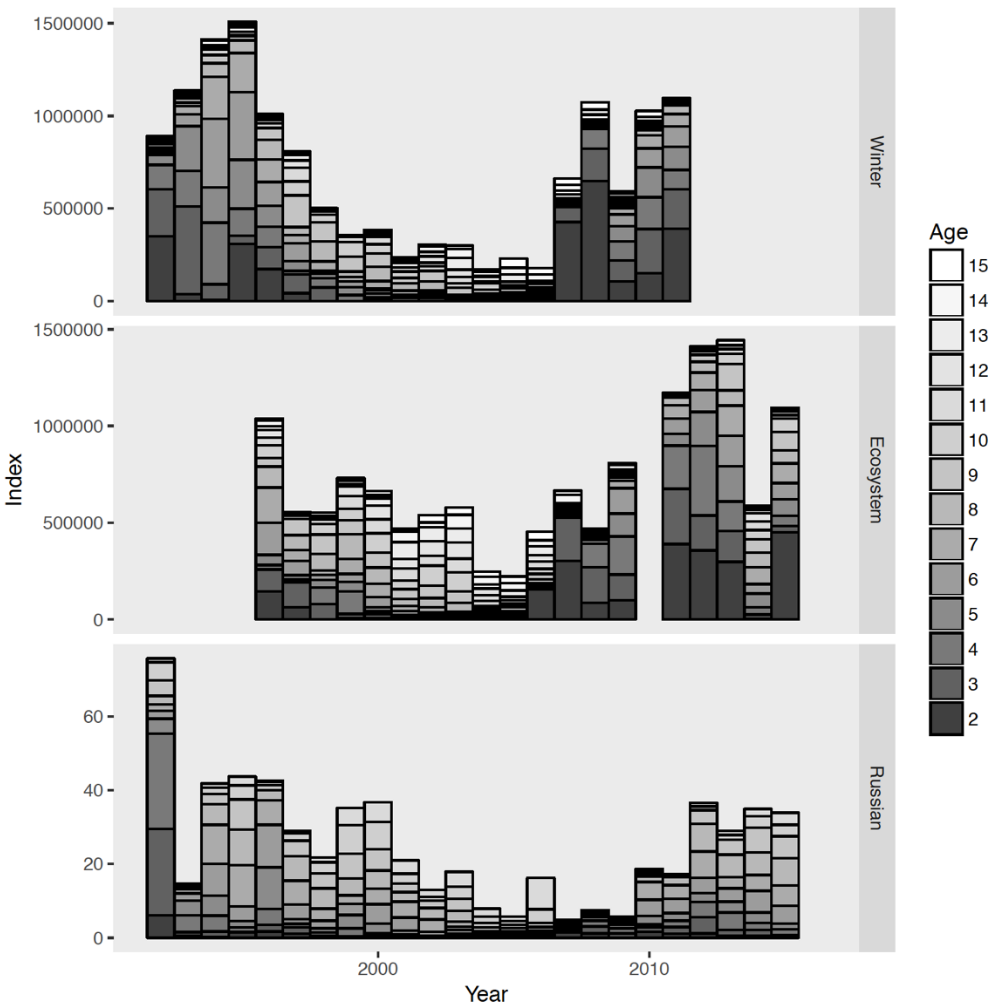
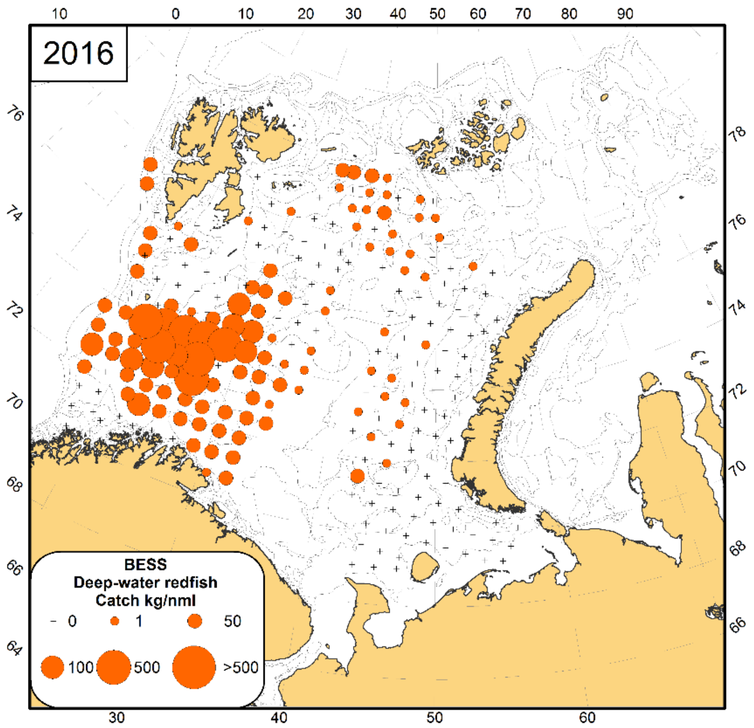


Figure 6.8. ***Sebastes mentella*** **in Subareas 1 and 2. Age disaggregated abundance indices for bottom-trawl surveys 1992-2016 in the Barents Sea in winter (winter survey, top), in summer (Ecosystem survey, middle) and in autumn (Russian groundfish survey, bottom).**



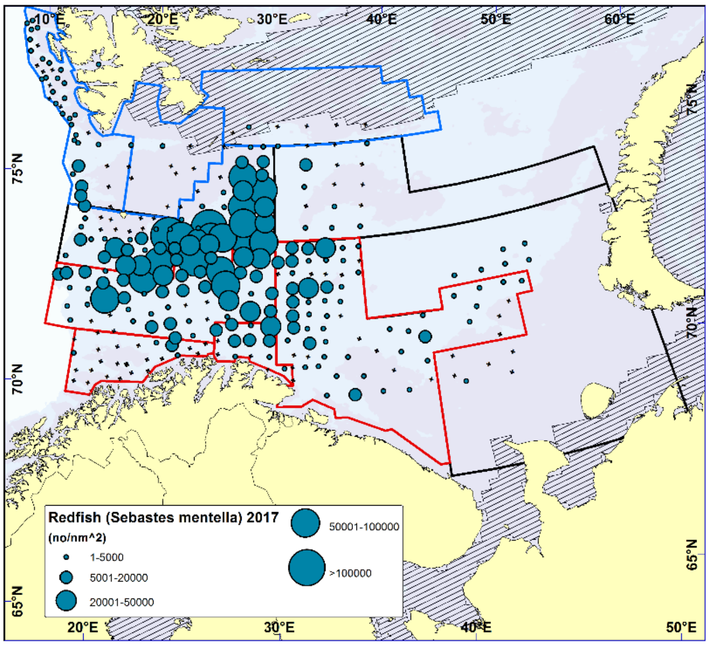
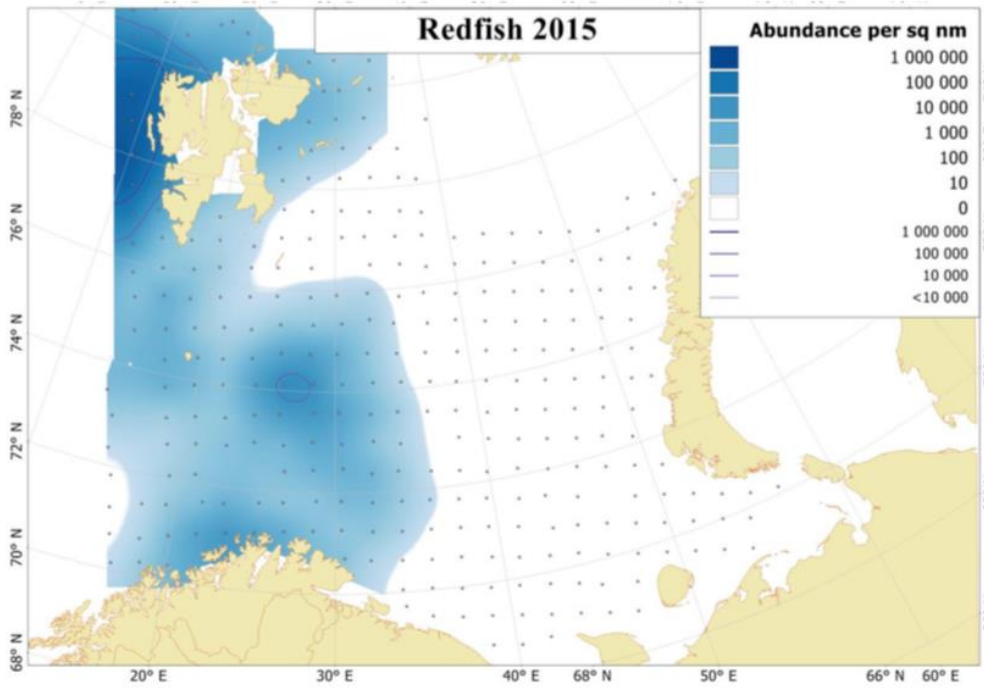


Figure 6.9. ***Sebastes mentella*** **in Subareas 1 and 2. Abundance indices for individual trawl stations during the ecosystem survey in autumn 2016 (top) and winter survey 2017 (bottom).**



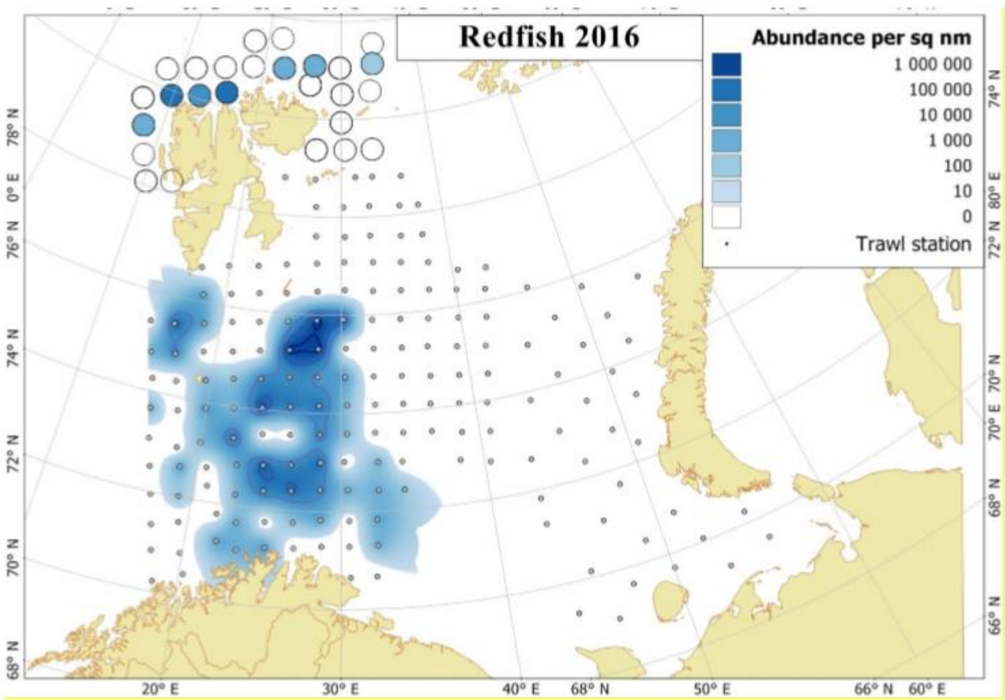


Figure 6.10. Map showing the specific pelagic 0-group trawl stations and the abundance of 0-group *Sebastes mentella* during the joint Norwegian-Russian Ecosystem survey in the Barents Sea and Svalbard in 2015 (upper panel) and 2016 (lower panel).

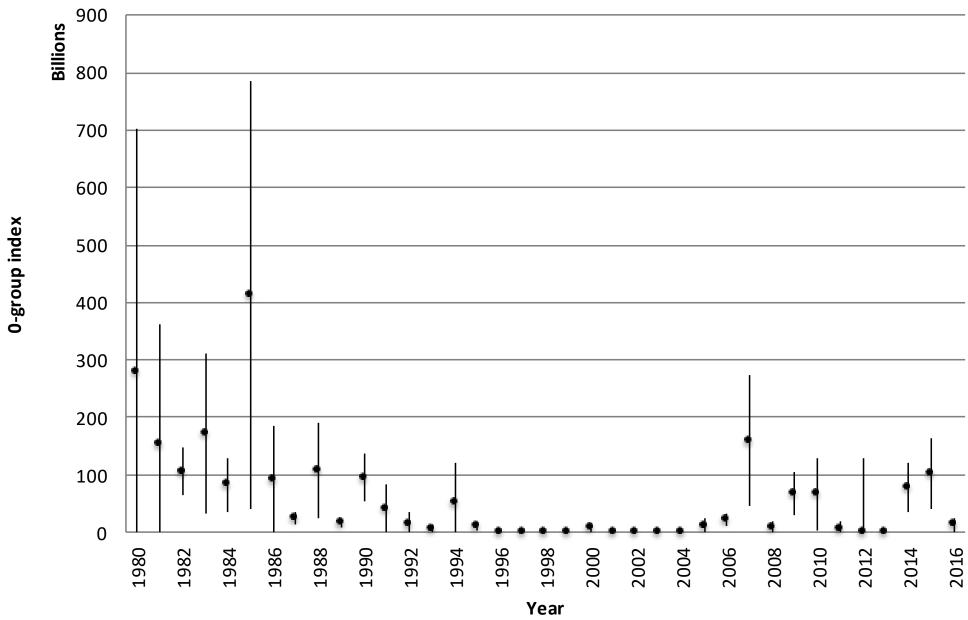


Figure 6.11. ***Sebastes mentella*** **in Subareas 1 and 2. Abundance indices (in millions) with 95% confidence limits of 0-group redfish (believed to be mostly** ***S. mentella*****) in the international 0-group survey in the Barents Sea and Svalbard areas in August-September 1980-2016. Numbers are given in Table 1.1.**

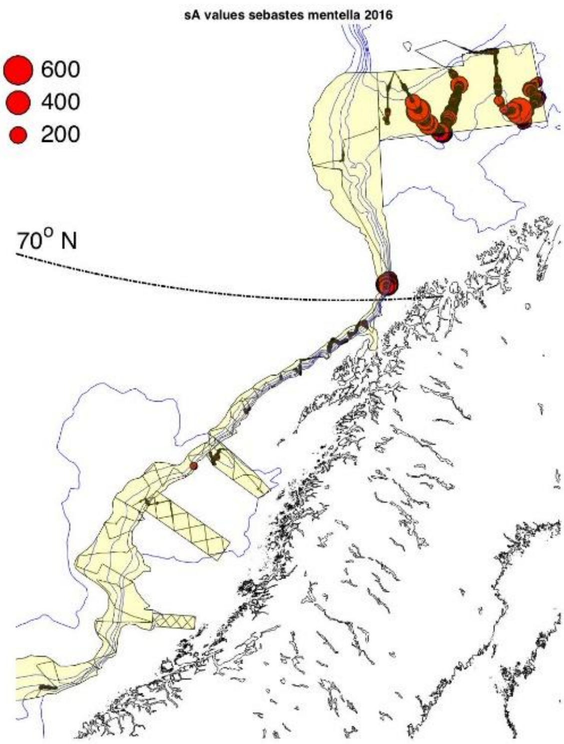


Figure 6.12. ***Sebastes mentella*** **in Subareas 1 and 2. Horizontal distribution of** ***S.mentella*** **hydroacoustic backscattering (sA) during the Norwegian slope survey in spring 2016. The circles are proportional to the sA assigned to redfish along the vessel track.**

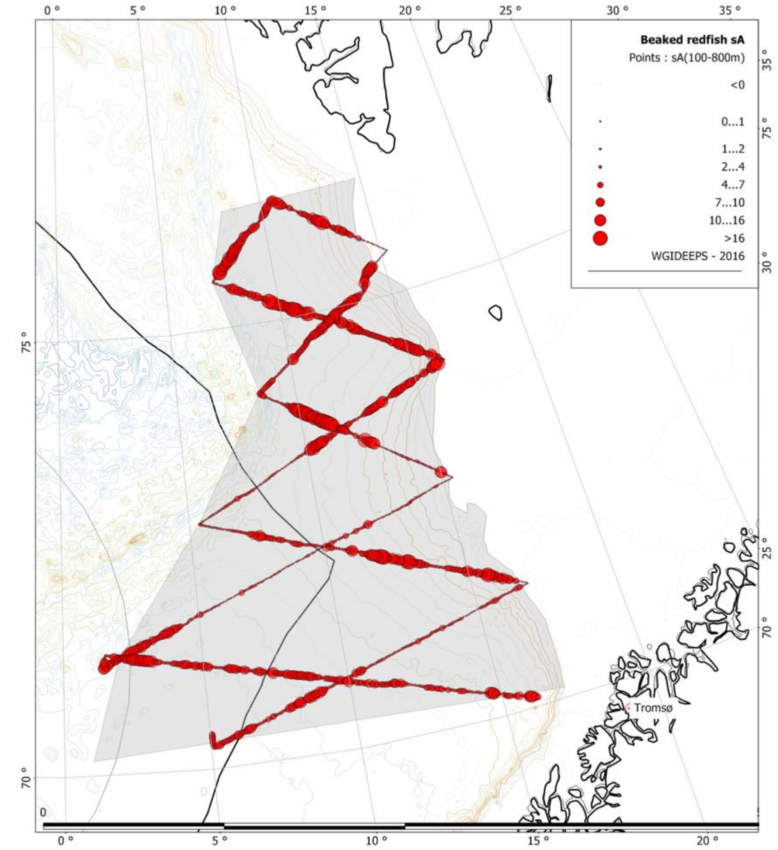


Figure 6.13. ***Sebastes mentella*** **in Subareas 1 and 2. Horizontal distribution of** ***S.mentella*** **hydroacoustic backscattering (s_A) during the Norwegian Deep Pelagic Ecosystem survey in summer 2016. The circles are proportional to the s_A assigned to redfish along the vessel track.**

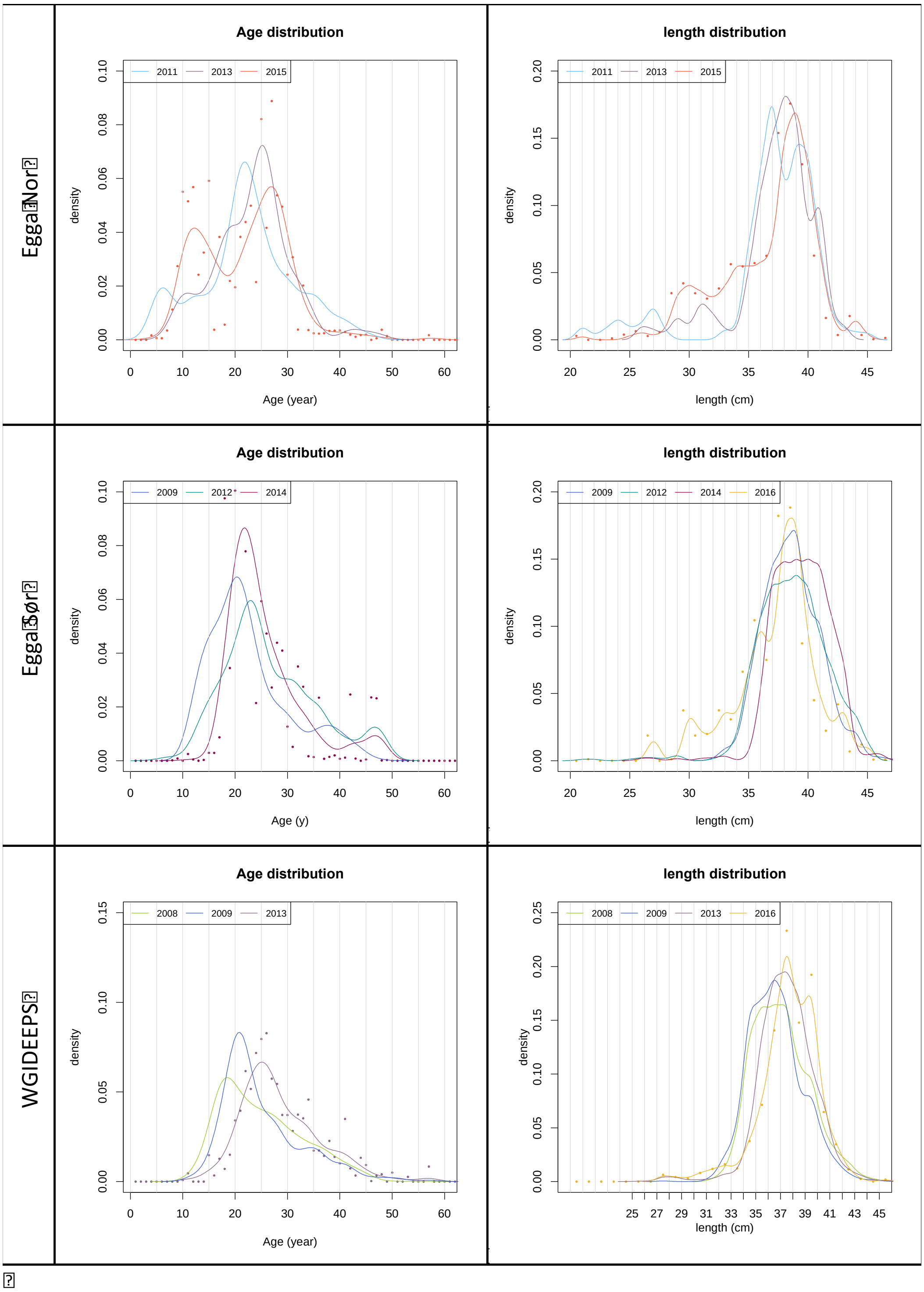


Figure 6.14. ***Sebastes mentella*** **in Subareas 1 and 2. Age (left) and length (right) distribution during the Egga-Nor (top), Egga-Sør (middle) and WGIDEEPS (bottom) surveys between 2008 and 2015. Not all surveys are conducted every year. Most surveys show an increase in age and length of the population over time and the entry of young/small individuals in recent years.**

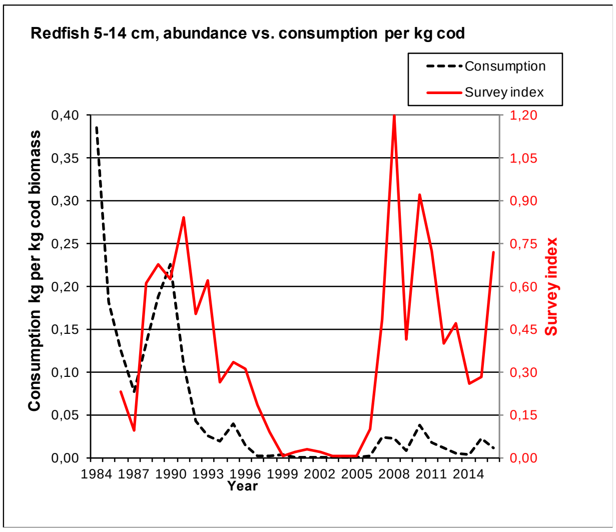
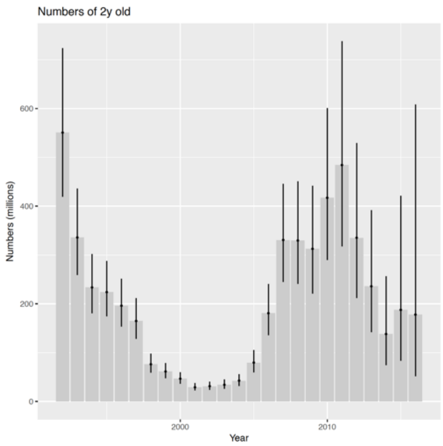
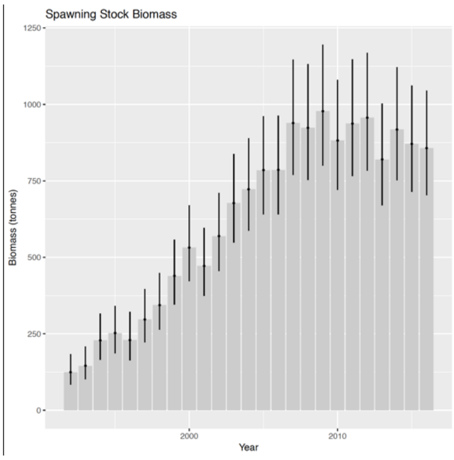


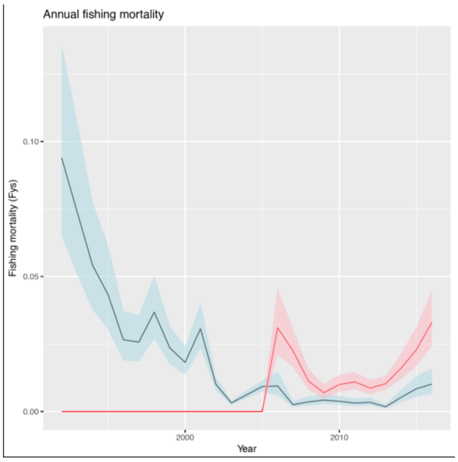
Figure 6.15. Abundance of *S. mentella* (5-14 cm) during the winter survey (February) in the Barents Sea compared with the consumption of redfish (mainly *S. mentella*) by cod (See Chapter 1, Table 1.3).

Recruitment-at-age 2	Spawning-stock biomass





Fishing mortality – year component	Fishing mortality – age component



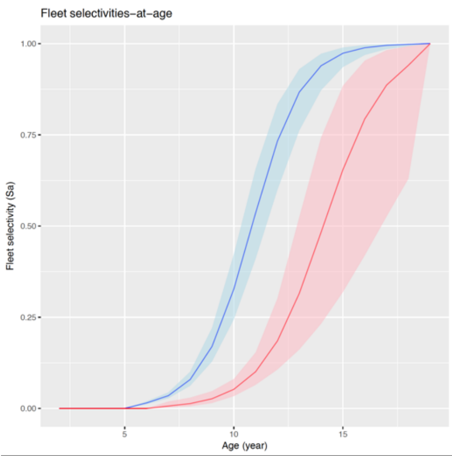


Figure 6.16. *Sebastes mentella* in Subareas 1 and 2. Results from the statistical catch-at-age assessment run showing the estimated recruitment-at-age 2 and spawning-stock biomass from 1992 to 2016 and annual fishing mortality coefficients by year (Fy) and age (Fa) from the demersal (blue) and pelagic (red) fleets. Error bars (top) and coloured envelopes (bottom) indicate 95% confidence limits.

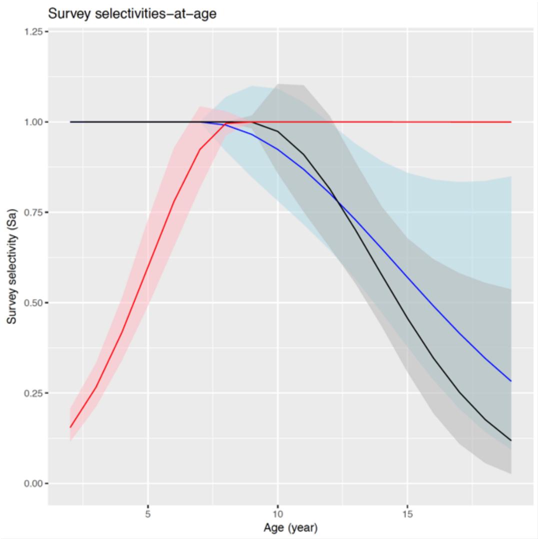


Figure 6.17. ***Sebastes mentella*** **in Subareas 1 and 2. Results from the statistical catch-at-age assessment run showing the selectivity-at-age of winter (blue), ecosystem (grey) and Russian groundfish (red) surveys.**

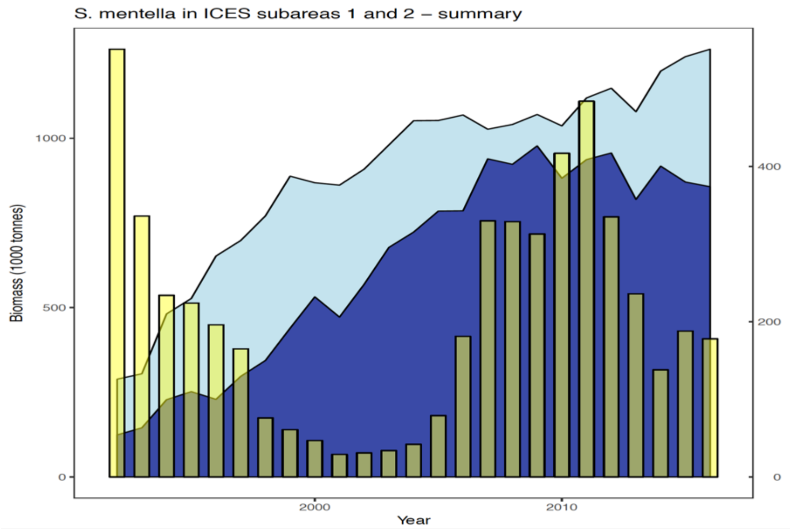


Figure 6.18. ***Sebastes mentella*** **in Subareas 1 and 2. Results from the statistical catch-at-age model showing the evolution of total biomass (in tonnes, light blue, left axis), spawning-stock biomass (in tonnes, dark blue, left axis) and recruitment-at-age 2 (in numbers, yellow, right axis) for the period 1992-2016, for** ***S. mentella*** **in subareas 1 and 2.**

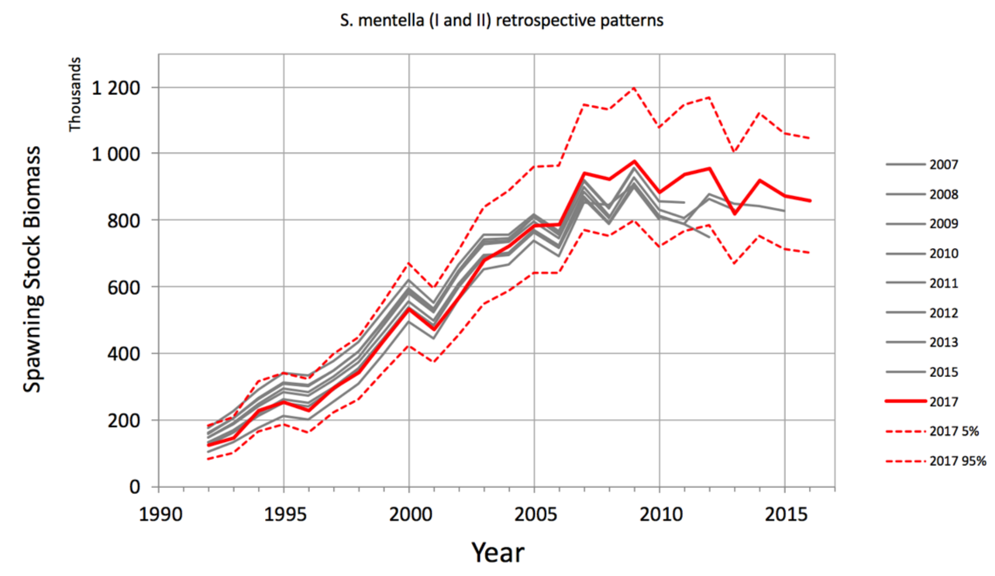


Figure 6.19. Retrospective patterns of the spawning-stock biomass of *S. mentella* estimated by the SCAA model for runs up to years 2007-2016. The higher the SSB estimates in recent years for the 2016 run mainly result from differences in the weight-at-age data for the 19+ group.

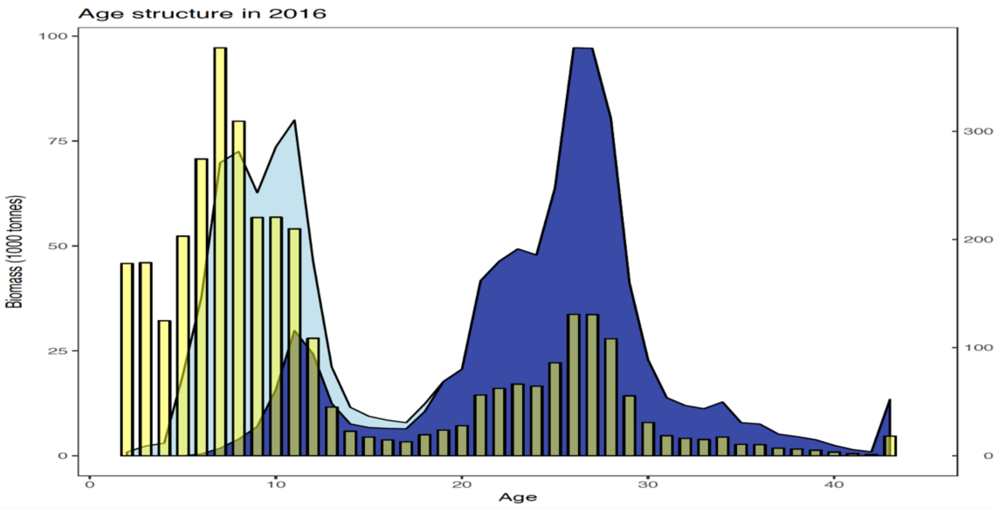


Figure 6.20. *Sebastes mentella* in Subareas 1 and 2. Modelled distribution of numbers (yellow bars), biomass (light blue) and spawning-stock biomass (dark blue) at age 2-43+ in 2016.

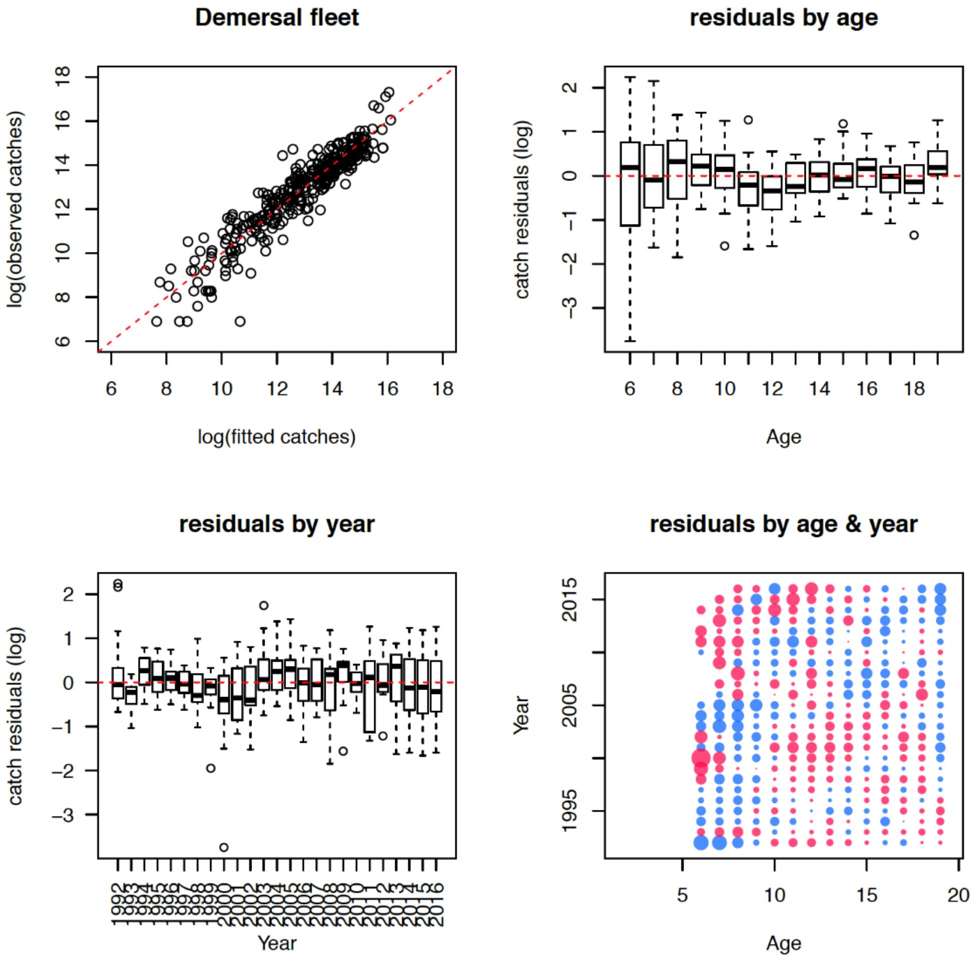


Figure 6.21a. Diagnostic plots for the demersal fleet catch-at-age data. Top-left: scatterplot of observed vs. fitted indices, the dotted red line indicates 1:1 relationship. Top right: boxplot of residuals (observed-fitted) for each age. Bottom left: boxplot of residuals for each year. Bottom right: bubble plot of residuals for each age/year combination, bubble size is proportional to mean residuals, blue are positive and red are negative residuals.

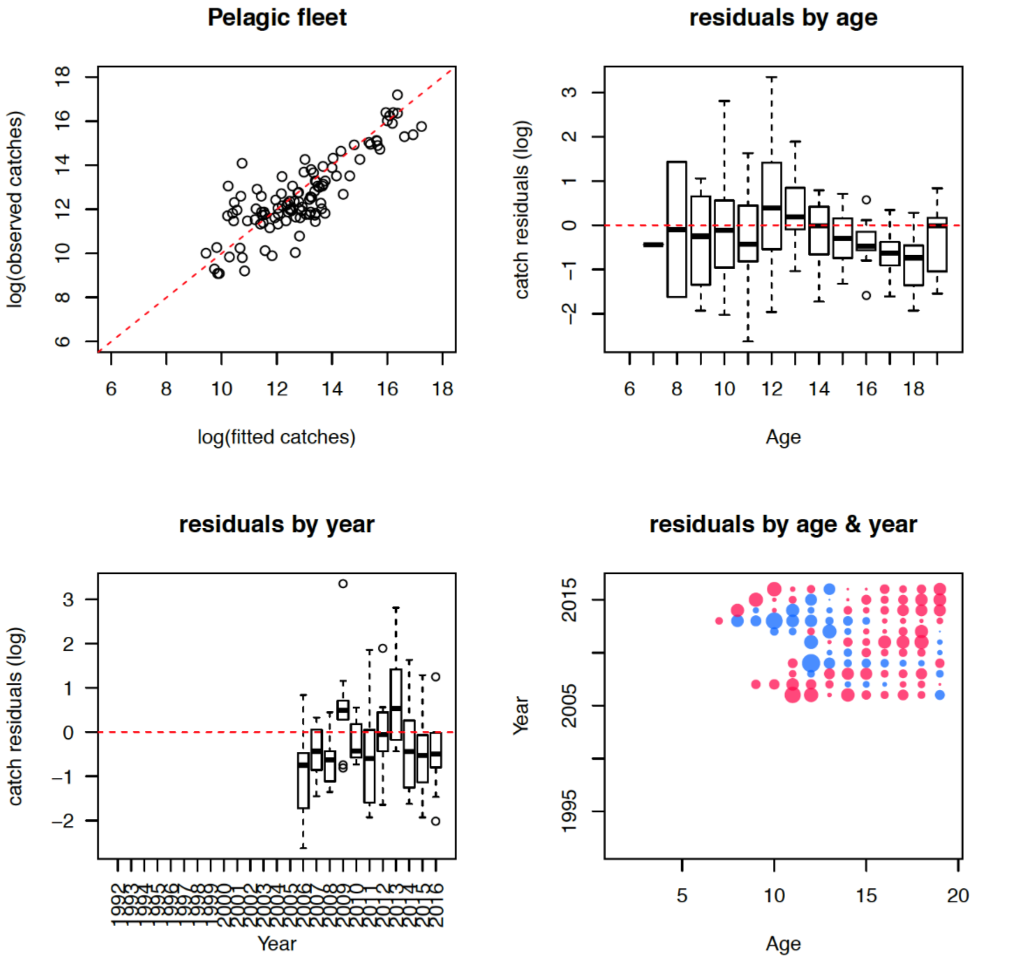


Figure 6.21b. Diagnostic plots for the pelagic fleet catch-at-age data. See legend from Figure 6.21a.

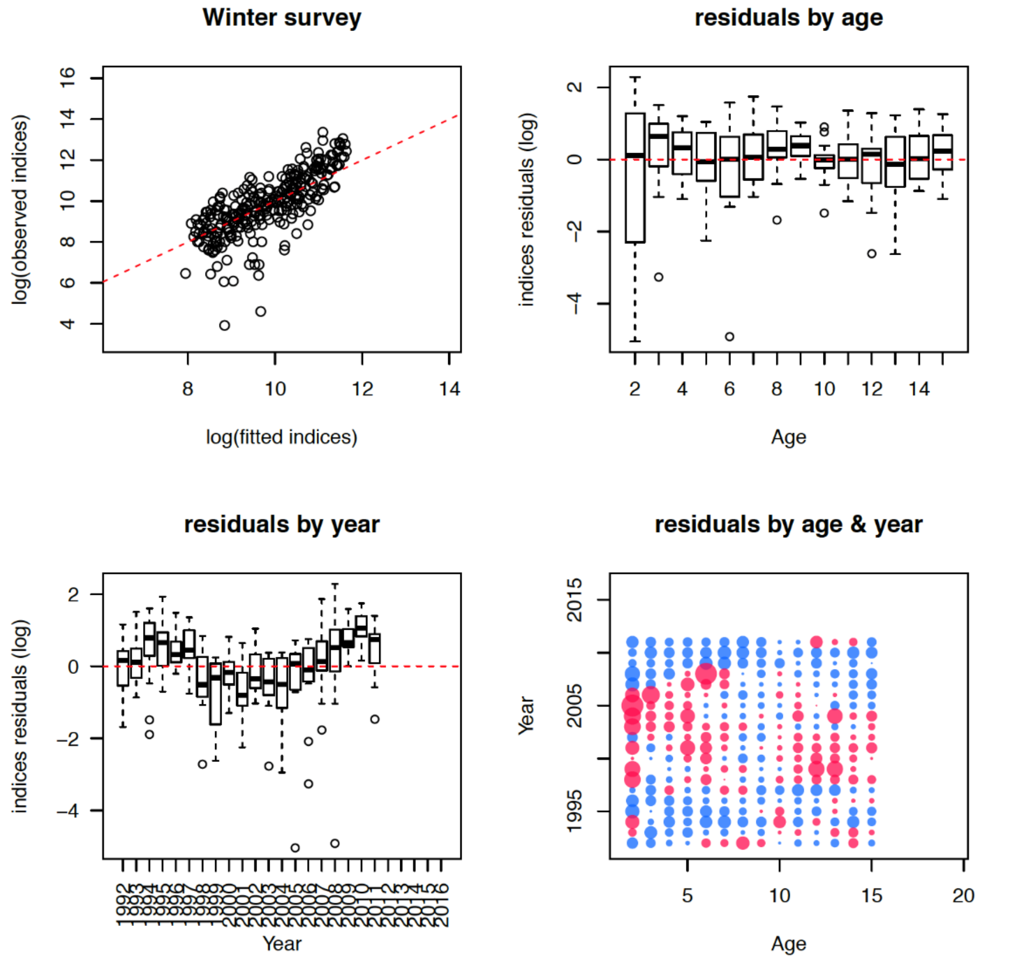


Figure 6.21c. Diagnostic plots for the Winter survey data. See legend from Figure 6.21a

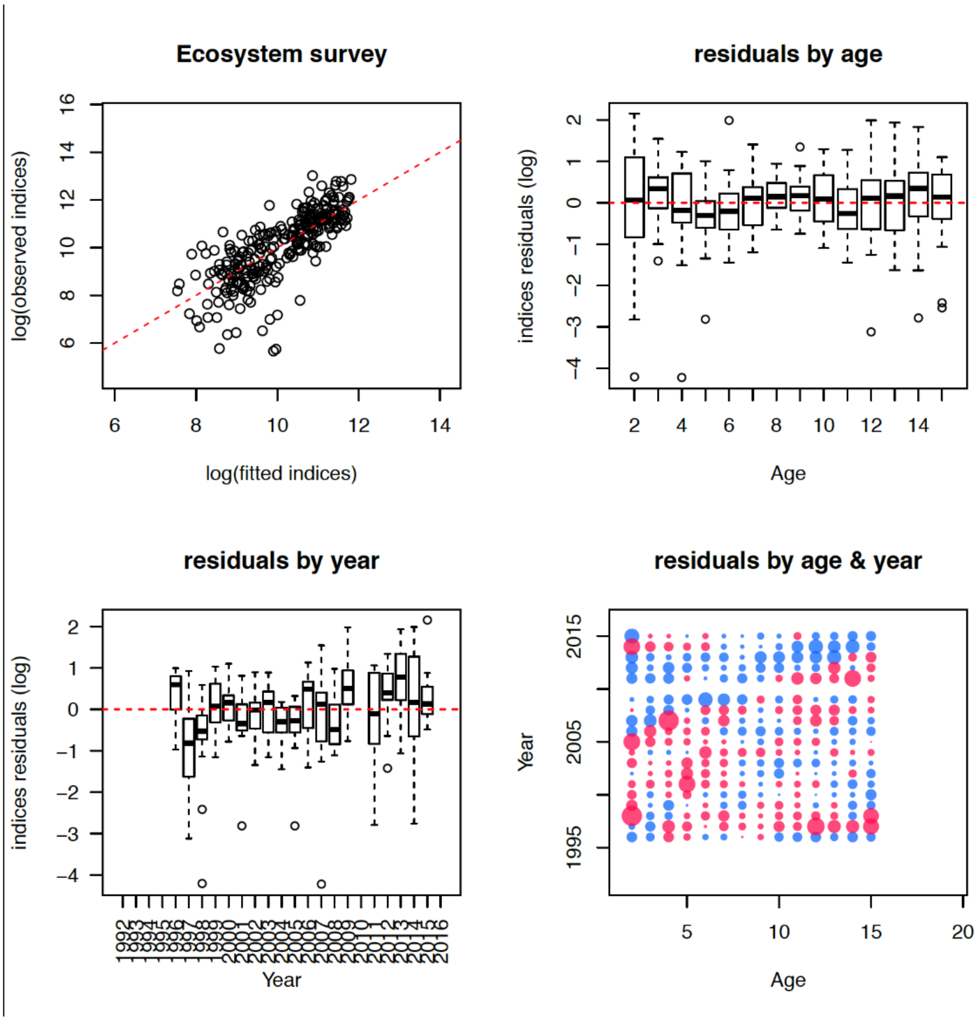


Figure 6.21d. Diagnostic plots for Ecosystem survey data. See legend from Figure 6.21a.

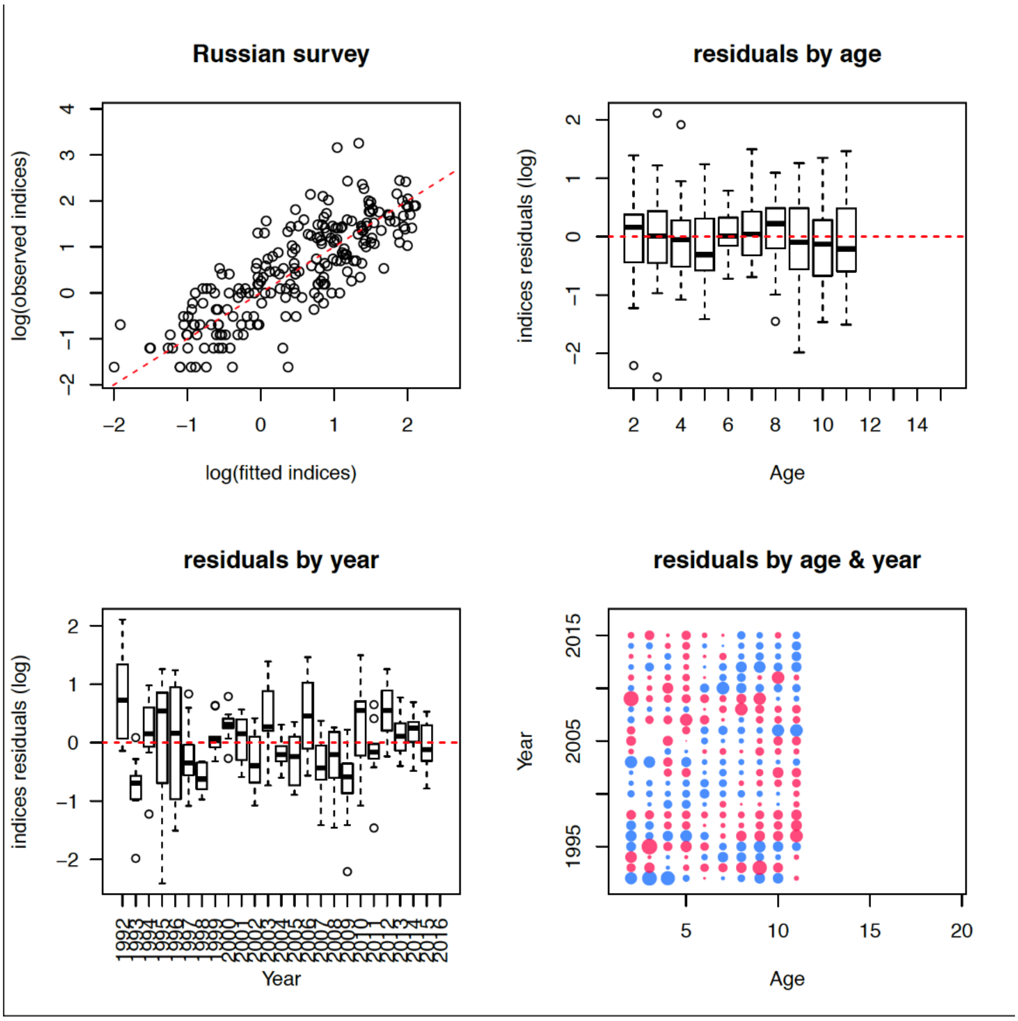


Figure 6.21e. Diagnostic plots for the Russian groundfish survey data. See legend from Figure 6.21a.

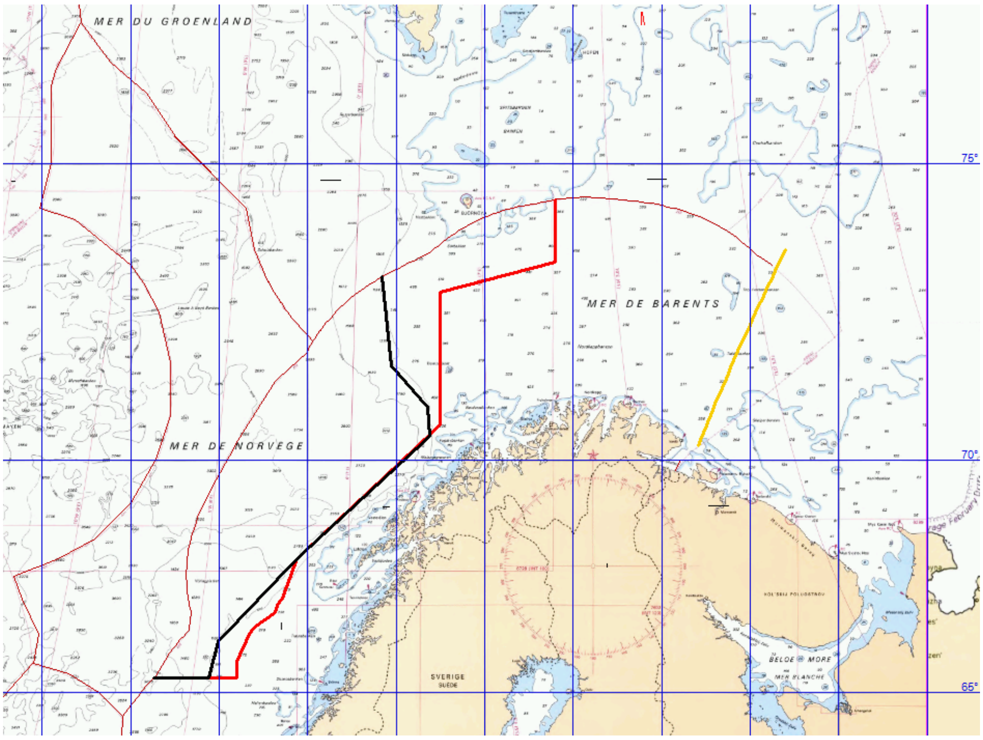


Figure 6.22. Delineation of the geographical limits for directed fishing in the Norwegian Economic Zone in 2014-2015. Directed pelagic trawling is only allowed west of the black line. Directed demersal trawling is only allowed between the black and the red line. The marked area south of Bear Island is currently closed for direct fishing on redfish, but may be reopened later in the year.

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. There is no updated assessment in 2017. This report presents new data available and reproduce the latest assessment (2016) for information. It is anticipated that there will be a new assessment and advice after the next benchmark, planned for 2018.

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 2012.

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 meters. Since 2015 all directed fisheries with conventional gears have been forbidden (except for the smaller handline vessels), and from 2016 trawling outside 12 nm is allowed to 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. It is generally prohibited to fish for redfish with conventional gears north of 62° N. The ban does not, however, apply to vessels less than 15 meters fishing with handline during1 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 meters 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 2016 (Tables 7.1–7.4, D1 & D2, Figures 7.1–7.2)

Nominal catches of *S. norvegicus* by country for Sub-areas 1 and 2 combined, and for each Sub-area 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 4 436 t, followed by a further decrease in 2015 with landings of 3 633 t, mainly due to stronger regulations. This trend has reversed in 2016 with provisional figures indicating catches of 6 060 t. The time-series of *S. norvegicus* landings is given in Figure 7.1.

The Norwegian landings are presented by gear and month/year in Figures 7.2a,b. Reported landings continued to decrease in 2015 and were then at the lowest level since the 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 June31 August.

The reported Russian catches of *S. norvegicus* have been around 600 - 900 t since 2001, while ten other countries together usually report catches of about or less than 300 - 500 t per year (Table 7.1). The bycatch of redfish (*Sebastes* spp.) in the Norwegian Barents Sea shrimp fisheries during 1983 - 2015 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 2017

New regulations have been 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. No further reduction in the catches is hence expected. The total landings in 2017 are expected to be about the same as in 2016, i.e. about 6 000 t.

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 2015 were only provided by Norway, accounting for 70% of the total landings. 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 available from Norway in 2015 (Figure 7.3).

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 2015, and revised for 2014. 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 7.7a-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 7.7a. The maturity ogive modelled by Gadget is presented (Figure 7.7b). 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 7.4a,b-7.5a,b)

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 2016 (joint with Russia some of the years since 2000) in fishing depths of 100—500 m. Length compositions for the years 1986—2016 are shown in Table E1a and Figure 7.4a. Age compositions for the years 1992—2015 are shown in Table E1b and Figure 7.4b. This survey covers important nursery areas for the stock.

Norwegian Svalbard (Division 2.b) bottom-trawl survey (August-September) from 19852015 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—2015 and age compositions for the years 1992—2008 and 2012 and 2013 are shown in Table E2a and E2b, respectively. 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.

Data on length and age from both these surveys have been combined and are shown in Figures 7.5a,b.

Age disaggregated catch rates (numbers/nm^2 averaged for all stations within subareas and finally averaged, weighted by subarea, for the total surveyed area) of Sebastes norvegicus from the Norwegian Coastal and Fjord survey in 1995—2010 from Finnmark to Møre (NOcoast-Aco-Q4) (Table E3). The estimated catch rates in 2008 and 2009 were particularly high due to one trawl station with an exceptional high catch. Updating of table E3 is discontinued. The data are no longer used as input to the Gadget analytical assessment as described in the stock annex.

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 (<25cm) has steadily decreased since 1991 and has dropped to very low levels after 2000 (Figure 7.4a). 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 stock has a three-year advice cycle, and advice was updated in 2016. We therefore do not present updated assessment for 2017, however the results and comments from the 2016 are presented here in full, both for reference and in order to ensure that all data and model results are available in a single document as a basis for the planned benchmark in 2018. Note that the natural mortality estimate (M) was changed from 0.1 to 0.05 in 2012, and results are thus not directly comparable with earlier years. The advice given in 2016 nominally applies for 2017-2019. However, it is likely that a new assessment and advice will be presented following a benchmark planned for 2018.

The GADGET model used for the assessment of *S. norvegicus* in areas 1 and 2 is closely related to the GADGET model that currently is used by the ICES North-Western 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 two commercial fleets (a gillnet fleet and a combined trawl and other gears fleet), and one survey used in the model. Growth and fishing selectivity are assumed constant over time, 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

- Quarterly catch in tonnes from two commercial fishing fleets, i.e. Norwegian gillnet and 'all others', to 2015.
- Quarterly length distribution of total international commercial landings from two commercial fishing fleets, i.e. Norwegian gillnet and 'all others' to 2015. Due to late data submissions, there is one year time-lag in the inclusion of length distributions from other countries than Norway.

Quarterly age–length keys from the same fishing fleets, up to 2015

Length disaggregated survey indices from the Barents Sea (Division 2.a) bottom-trawl survey (February) from 1990—2015 (Table E1a)

Age–length keys and aggregated survey indices from the same survey up to 2015 (Table E1b)

7.3.3 Assessment results using the Gadget model

The text table below compares the results from this year's Gadget model with previous years for two reference years 1990 and 2003. Note that the natural mortality in the model was changed in 2012, meaning that results from the 2012—2015 assessments are not directly comparable with earlier years.

	Total stock (3+) by 1 January 1990 (tons)	Mean weight in stock 1990 (kg)	SSB (15+) by 1 January 1990 (tons)	Total stock (3+) by 1 January 2003 (tons)	Mean weight in stock 2003 (kg)	SSB (15+) by 1 January 2003[1] (tons)
WG 2006	179 313	0.39	64 019	71 013	0.71	38 927
WG 2007	163 536	0.35	66 712	64 240	0.64	43 096
WG 2008	158 851	0.35	64 838	74 717	0.78	47 693
WG 2009	149 763	0.34	66 153	73 673	0.77	51 683
WG 2010	152 419	0.34	58 774	80 073	0.79	55 995
WG 2011	148 727	0.33	56 271	80 808	0.78	55 810
WG 2 2012	109 021	0.43	48 308	55 229	0.80	40 030
WG 2 2013	111 216	0.37	47 620	50 151	0.79	33 400
WG 2 2014	111 850	0.37	48 861	56 090	0.93	39 050
WG 2 2015	113 840	0.37	49 800	59 510	0.91	41 960

Since WG2007 based on modelled maturation and not 15+, dataseries used for estimation of maturity modified in 2010

The natural mortality in the model was reduced from 0.1 to 0.05 in 2012. This reduced overall numbers and biomass, and increased mean weight. Results are therefore not directly comparable with earlier years.

The general patterns in the stock dynamics of *S. norvegicus* are similar to those modelled for the past several years (Figure 7.10). The overall stock numbers and biomass continue to show a decline, with possible good year classes recruited in recent years. Mature biomass and numbers are in steady decline, while modelled immature numbers and biomass show signs of beginning to improve – although this is not yet reflected in the catch data on the older fish,

As in previous reports it should be noted that it is possible that the improved recruitment signal from the 2003 yearclass may be 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 estimate of this recruitment, although not to zero. The largest of these fish are now in the 35-40 cm length category, and have been tracked through multiple survey years. However they are not yet showing up in the catch data, although the model prediction is that they are large enough to begin to enter the fishery. It is therefore still unclear to what extent this recruitment signal is genuine. Assuming the recruitment to be genuine, albeit smaller than originally estimated initially gives the possibility for stabilizing or even starting to recover the stock with improved management. A second, larger, recruitment peak exists from the 2009 yearclass (showing up as age 3 in 2012). This should be considered highly uncertain, as species identification on these smallest fish is difficult. It should therefore be stressed that the exact size of the recruitment events, and the extent to which they will impact on the SSB, remains uncertain.

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 7.9)

There has been somewhat better estimated recruitment in recent years, although still below the long-term average. The exact level is still somewhat uncertain. There may also be a second pulse of good recruitment, however this is still highly uncertain, and will need to be tracked for some years to reduce this uncertainty.

The estimated fishing mortality (F12-19) declined between 1990 and 2005 and steadily increased since 2005, briefly stabilized between 2010 and 2011, and increased again in 2012 and 2013. The current mortality is estimated to 0.27 (Figure 7.8), well above a sustainable level for a redfish species. This estimate is based on the 2003 yearclass 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 to around 20 000 tonnes in 2015 (Figure 7.10, Table 7.8). Due to the improved recent recruitment the total biomass is beginning to stabilize, although the SSB is continuing to decline.

The spawning-stock biomass of *S. norvegicus* has decreased from a maximum of about 55 thousand tonnes in 1996 to barely 10 thousand tonnes in 2015 (Figure 7.10, Table 7.8). This reduction is primarily the result of prolonged low recruitment, combined with excessively high fishing pressure. Although this continues to decline, the rate of that decline is starting to slow, based on the estimated strong 2003 year class.

It should be noted that there is a strong retrospective pattern in the assessment model, with mature biomass consistently revised upwards and F downwards between years (figure 7.11). This may relate to the partial coverage of the stock by the survey (and especially the lack of coverage of mature fish in the survey), or due to errors in species identification. The 7 years Mohn's rho index on F is -0.88, indicating a strong tendency to revise downwards. The revision between years does not change the picture of a declining SSB at a low level, and not does it result in the terminal year estimate being higher than the previous terminal year. There is no strong retrospective pattern in the juvenile biomass, suggesting that it may be fisheries data that is driving the pattern in SSB. An experimental retrospective run excluding the survey offers support for this, showing similar trends in mature SSB stock, and similar retrospective patterns. Note that not all years in this experimental run converged, so this does not represent an alternative assessment. This lack of retrospective in the juvenile biomass also indicates that the estimates of a period of poor recruitment are robust to the identified retrospective trend in the SSB. Consequently, we conclude that this is something which should be considered further in the next benchmark. Ideally one would want survey coverage of the mature individuals in order to get level information on this fraction of the stock. However, given the strong downward trend which is not changed by the revisions, the similar pattern seen in the "no survey" model, and the confirmation of these trends from the WKRED production model, the retrospective patterns should not affect the current advice of "zero directed catch, minimize bycatch".

7.4 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 increasing concentrated on the oldest (18 years and older) individuals, reducing the reproductive capacity of the stock.

There are indications that new recruits 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 it will be several years before these will fully recruit to the fishery and the spawning stock. Rebuilding of this stock is therefore dependent on protecting both the existing SSB and any fish recruiting to the SSB. Note that this is a category 2 stock, 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.

Simulations were performed on the Sebastes *norvegicus* stock using the Gadget model at WKRED. An assumption was made that the recruitment observed over the last 10 years would apply in the future, with recruitment independent of the spawning biomass. This indicated that, at stability, the population could sustain an annual catch of around 1,500 tonnes, a finding which was in line with the Schaefer model estimates conducted during WKRED. Separate simulations done by WKPOOR2 indicate that a constant catch above about 6500 tonnes will lead to a progressive reduction of the stock, and a collapse within 10—15 years if recruitment remains low. However, small changes in recruitment and other parameters that enter the assessment will alter these limits. It should be noted that the fish currently in and entering the fishery are from a period of poor recruitment, and that the stock would need to be stabilized before a catch as large as 1500 tonnes could be safely taken.

7.4.1 Biological reference points

The ability to set biological reference points was examined at WKRED (2012). It was not possible to accurately define a SSB-recruitment relationship, or the productivity level of the stock. In addition, there was considerable uncertainty over recent levels of recruitment (due to possible species misidentification and inconsistent signals in the winter survey). As a result, it was not considered possible to set target reference points for this stock at that time. There is now greater confidence in the recruitment event in 2003. One could therefore consider the associated SSB the previous year (2002) as a lower reference point (B_{loss} that led to good recruitment), which would give a value of just over 40,000 tonnes. This year-class is seen in multiple years of the winter survey, and now shows up as a bimodal length distribution, with low values visible in the mid length ranges representing the extended period of poor recruitment prior to 2003. However, the model predicts that this year-class should have begun to enter the fishery, while the available fisheries biological sampling data does not show any upturn in the youngest ages caught. This may be due to poor sampling of the smallest fraction of the catch or a change in selectivity since there were last abundant fish of this size. However, it may also be that the signal in the survey is misidentified *S. mentella*. Consequently, we do not present a calculation for B_{lim}/B_{pa} here. Rather, we recommend that this be considered at the planned 2018 benchmark, by which time the 2003 year-class will have entered the fishery more strongly. The benchmark is also recommended to take a broader look at available survey data, which should also help confirm (or refute) this good year-class. B_{lim} and B_{pa} are thus currently *undefined* for this stock. We note that the SSB is currently at the lowest observed value in the time period of the model, and the stock should thus be considered below any potential reference level. Therefore this lack of a formal B_{lim}/B_{pa} does not affect the perception of the stock as below safe limits, nor impact on the advice or management of the stock in the short term.

A maximum exploitation rate of 5% has been suggested sustainable for long lived species like *Sebastes* spp. when the stocks show no sign of reduced reproductive potential (corresponding to keeping SPR at 60% of the level when no fishing occurs; see chapter 7.8 and Dorn 2002). If we take this to imply a preliminary F_{lim} of 0.05, then this gives a F_{pa} of 0.036 (0.05/1.4). However, this should be considered further at the next benchmark. Based on the selection curves for the fleets, a reasonable approximation of the fishable biomass would be the mature biomass. The modelling at WKRED, using both Gadget and a Schaefer model, suggested around 1500 t as the sustainable yield at average recent recruitment levels, once the stock has recovered from its current low level. At present a recovery strategy is required rather than MSY fishing.

7.4.2 Management advice

AFWG considers that the current catch level is several times higher than can be sustained by the stock, given the ongoing downwards trend in mature biomass. 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 2015 except for a small-scale fishery with handline that is expected to catch less than 100 tonnes in 2015. The current bycatch regulations are, however, in general too liberal to further constrain the catch as would be required for the stock to recover.

7.4.3 Implementing the ICES F_{MSY} framework

As a long lived species, *S. norvegicus* has many year classes contributing to the population, and consequently a relatively stable stock level from year-to-year. This makes it relatively simple to manage to some proxy of MSY (e.g. F0.1) provided adequate measures can be implemented to reduce fishing pressure to an appropriate level. It should be noted that the current fishery (F(12-19) = 0.27) is well above the suggested F_{pa} of 5% of the stock (Section 7.6). The main focus should therefore be on reducing total F to no higher than F_{pa}. The current priority is to stabilize the stock and prevent further decline, 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.

During the ICES Workshop on Implementing the ICES F_{MSY} framework (WKFRAME, ICES CM2010/ACOM:54), the closely related beaked redfish *Sebastes mentella* stock in Sub-areas 1 and 2 was used as a case study for a data limited situation. The results of this Workshop refer also to Sebastes *norvegicus* in the Barents Sea, where the AFWG is faced with a data limited situation. WKFRAME recommends that the bounds for F_{MSY} proxies should be evaluated in function of the YPR and SPR curves, and that the reproductive capacity of the *S. mentella* (in this case *S. norvegicus*) stock be at least above 30% of the SPR at F=0. The YPR curve left of the plateau can be used as lower bound (F0.1 proxy) and a prescribed per-cent SPR as upper bound. The WKFRAME also illustrates by examples why it is informative and important to carry out sensitivity analyses, particularly assumptions regarding natural mortality, selection pattern, growth (density-dependence) and maturity. The WG did some preliminary analyses of the sensitivity of F0.1 for different natural mortalities. Compared with *S. mentella*, $F_{0.1}$ for *S. norvegicus* is much less sensitive towards changes in natural mortality

During WKRED 2012, the yield-per-recruit (YPR) was calculated by adding recruitment in a single year. Repeat runs were made using a range of values for F, with the results shown in Figure E1. It should be noted that there is no spawning stock–recruitment relationship in the model, rather these calculations assume a constant annual recruitment. Consequently, the model may over-predict yield at higher fishing levels, because these levels will lead to a larger reduction in SSB than in overall stock. The yields presented here should therefore be considered an upper bound (especially at higher fishing levels). The highest yield obtained is at F_{max} = 0.15, but from a rather flat topped curve. $F_{0.1}$ (the point at which the slope is 10% of the slope at the origin, a typical precautionary proxy for F_{MSY}) is around $F_{0.1}$ = 0.08. Other proxy values are certainly possible. Using a constant annual recruitment of 2.6 million individuals with the above fishing mortalities gives the corresponding sustainable yields.

For F_{max} = 0.15 the sustainable yield at (then) current recruitment is 1500 tonnes per year

For $F_{0.1}$ = 0.08 the sustainable yield at (then) current recruitment is 1400 tonnes per year

However, it should be stressed that these are average values for F_{MSY} and yield at the currently estimated recruitment level and for healthy stock. The stock is currently depleted, and recruitment has for a long period prior to the late 2000s been lower than the recent average. Consequently, the stock cannot currently sustain these levels of catches and recover at the same time, and a recovery strategy is required first.

Table 7.1 ***Sebastes norvegicus*** **in Sub-areas 1 and 2. Nominal catch (t) by countries in Sub-area 1 and Divisions 2.a and 2.b combined.**

Year	Faroe Islands	France	Germany[2]	Greenland	Iceland	Ireland	Netherlands	Norway	Portugal	Russia[3]	Spain	UK(Eng. & Wales)	UK (Scot)[4]	Poland	Total
1989	3	796	412	-	-	-	-	20 662	-	1 264	-	97	-	-	23 234
1990	278	1 679	387	1	-	-	-	23 917	-	1 549	-	261	-	-	28 072
1991	152	706	981	-	-	-	-	15 872	-	1.052	-	268	10	-	19 041
1992	35	1 289	530	623	-	-	-	12 700	5	758	2	241	2	-	16 185
1993	139	871	650	14	-	-	-	13 137	77	1 313	8	441	1	-	16 651
1994	22	697	1 008	5	4	-	-	14 955	90	1 199	4	135	1	-	18 120
1995	27	732	517	5	1	1	1	13 516	9	639	-	159	9	-	15 616
1996	38	671	499	34	-	-	-	15 622	55	716	81	229	98	-	18 043
1997	3	974	457	23	-	5	-	14 182	61	1 584	36	164	22	-	17 511
1998	78	494	131	33	-	19	-	16 540	6	1 632	51	118	53	-	19 155
1999	35	35	228	47	14	7	-	16 750	3	1 691	7	135	34	-	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	28	565	3		44	1	6 981
2011	24	53	9	51	22	-	1	4 681	25	919	6		13	48	5 852
2012	87	182	71	58	23	12	5	4 247	17	681	-		100	34	5 517

2013	83	353	1	45	8	1	-	3 771	36	797	-		493	19	5 609
2014	67	219	6	20	29	-	1	3 053	5	806	-	**Denmark**	211	21	4 436
2015	76	53	24	211	35	-	-	2 488	-	664	2	1	57	17	3 629
2016[1]	190	72	62	59	71	-	-	4 606	-	864	2	7	104	22	6 060

[1] **Provisional figures.**

[2] **Includes former GDR prior to 1991.**

[3] **USSR prior to 1991.**

[4] **Includes UK (E&W) since 2000.**

Table 7.2 *Sebastes norvegicus* in Sub-areas 1 and 2. Nominal catch (t) by countries in Sub-area 1.

Year	Faroe Islands	France	Germany[2]	Greenland	Iceland	Norway	Portugal	Russia[3]	Spain	UK(Eng. & Wales)	UK (Scotl)[5]	Total
1989	-	-	-	-	-	1 763	-	110	-	4	-	1 877
1990	5	-	-	-	-	1 263	-	14	-	-	-	1 282
1991	-	-	-	-	-	1 993	-	92	-	-	-	2 085
1992	-	-	-	-	-	2 162	-	174	-	-	-	2 336
1993	24	-	-	-	-	1 178	-	330	-	-	-	1 532
1994	12	-	72	-	4	1 607	-	109	-		-	1 804
1995	19	-	1	-	1	1 947	-	201	-	1	-	2 170
1996	7	-	-	-	-	2 245	-	131	-	3	-	2 386
1997	3	-	-	5	-	2 431	-	160	-	2	-	2 601
1998	78	-	5	-	-	2 109	-	308	-	30	-	2 530
1999	35	-	18	9	14	2 114	-	360	-	11	-	2 561
2000	-	-	1	-	16	1 983	-	146	-		12	2 159
2001	4	-	11	-	-	1 053	-	128	-		16	1 212
2002	15	1	5	-	-	693	-	220	-		9	943
2003	15	-	-	1	-	815	-	140	-		4	975
2004	7	-	-	-	-	1 237	-	213	-		12	1 469
2005	10	1	-	-	-	1 002	-	61	-		4	1 078
2006	46	-	-	-	-	690	-	136	-		-	872
2007	15	-	12	15	-	1 034	-	49	2		20	1 147
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	546	-	27	-		18	623
2013	28	2	1	-	+	574	-	41	-	**Poland**	4	651
2014	59	10	6	17	4	403	-	26	-	2	17	543
2015	57	4	9	211	13	514	-	51	2	2	10	872
2016[1]	161	7	4	59	51	781	-	136	2	2	60	1 264

[1] Provisional figures.

[2] Includes former GDR prior to 1991.

[3] USSR prior to 1991.

[4] Includes UK (E&W) since 2000.

+ Less than 1 t

Table 7.3 Sebastes norvegicus in Sub-areas 1 and 2. Nominal catch (t) by countries in Division 2.a.

Year	Faroe Islands	France	Germany[2]	Greenland	Iceland	Ireland	Netherland	Norway	Portugal	Russia[3]	Spain	UK(Eng. & Wales)	UK(Scotl)[4]	Poland	Total
1989	3	784	412	-		-	-	18,833	-	912	-	93[2]	-	-	21,037
1990	273	1,684	387	-		-	-	22,444	-	392	-	261	-	-	25,441
1991	152	706	678	-		-	-	13,835	-	534	-	268	10	-	16,183
1992	35	1,294	211	614		-	-	10,536	-	404	-	206	2	-	13,302
1993	115	871	473	14		-	-	11,959	77	940	-	431	1	-	14,881
1994	10	697	654	5		-	-	13,330	90	1,030	-	129	-	-	15,945
1995	8	732	328	5		1	1	11,466	2	405	-	158	9	-	13,115
1996	27	671	448	34		-	-	13,329	51	449	5	223	98	-	15,335
1997	-	974	438	18		5	-	11,708	61	1,199	36	162	22	-	14,623
1998	-	494	116	33		19	-	14,326	6	1,078	51	85	52	-	16,260
1999	-	35	210	38		7	-	14,598	3	976	7	122	34	-	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	26	287	2		38	1	6,056

2011	-	51	9	49	20	-	1	3,942	-	695	2		13	-	4,782
2012	49	182	33	57	13	2	2	3,599	1	427	-	**Denmark**	33	-	4,398
2013	55	343	-	45	8	-	-	3,076	9	475	-	1	466	-	4,478
2014	8	209	-	3	25	-	1	2,465	2	559	-	-	178	-	3,449
2015	18	49	15	-	22	-	-	1,946	-	439	-	-	47	12	2,549
2016[1]	29	65	58	-	20	-	-	2,280	-	545	-	-	43	8	3,050

[1] Provisional figures.

[2] Includes former GDR prior to 1991.

[3] USSR prior to 1991.

[4] Includes UK (E&W) since 2000

Table 7.4 *Sebastes norvegicus* in Sub-areas 1 and 2. Nominal catch (t) by countries in Division 2.b.

Year	Faroe Islands	France	Germany[2]	Greenland	Iceland	Ireland	Netherlands	Norway	Portugal	Russia[3]	Spain	UK(Eng. & Wales)	UK(Scotl)[4]	Poland	Total
1989	-	-	-	-				66	-	242	-	-	-	-	308
1990	-	-	-	1				210	-	1157	-	-	-	-	1 368
1991	-	-	303	-				44	-	426	-	-	-	-	773
1992	-	-	319	9				2	5	180	2	35	-	-	552
1993	-	-	177	-				-	-	43	8	10	-	-	238
1994	-	-	282	-				18	-	60	4	6	1	-	371
1995	-	-	187	-				103	7	33	-	-	-	-	330
1996	4	-	51	-				27	5	136	76	3	-	-	302
1997	-	-	20	-				43	-	225	-	-	-	-	288
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	-	-	-				1 211	10	284	-		-	-	1 510
2007	12	-	-	-				649	155	242	-		-	-	1 057
2008	-	-	-	-				126	1	250	-		-	-	377
2009	-	-	-	-				207	-	179	-		-	-	386
2010	-	-	-	-				83	22	257	-		-	-	342
2011	-	2	-	-	1	-	-	65	25	217	4		-	48	362
2012	21	-	35	-	1	8	3	102	16	227	-		49	34	496
2013	-	9	-	-	-	1	-	120	27	281	-		23	19	480
2014	-	-	-	-	-	-	-	185	3	221	-	Denmark	16	19	444
2015	-	-	-	-	-	-	-	28	-	175	-	1	-	3	207
2016 [1]	-	-	-	-	-	-	-	1 544	-	183	-	7	-	7	1 746

[1] **Provisional figures.**

[2] **Includes former GDR prior to 1991.**

[3] **USSR prior to 1991.**

[4] **Includes UK (E&W) since 2000.**

Table 7.5. *Sebastes norvegicus* in Sub-areas 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.	Tons 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
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	0	1	3	9	31	144	245	272	270	416	391	536	431	332	332	266	954	4633	6261
2010	0	0	0	9	8	36	92	336	437	489	420	336	610	537	498	319	317	884	5328	7744
2011	0	0	0	0	2	5	64	305	469	269	317	228	382	295	252	234	257	1010	4089	5852
2012	1	0	3	12	1	3	39	227	285	296	205	174	226	308	268	293	306	1226	3871	5517
2013	0	8	23	34	9	20	51	241	362	429	228	168	151	273	350	236	184	1117	3884	5609
2014	1	2	7	8	8	15	27	50	67	205	198	148	169	186	165	159	215	1228	2858	4436
2015[1]	0	0	6	17	27	44	29	97	113	129	171	148	160	117	99	96	222	1173	2649	3633

[1] **Provisional figures.**

Table 7.6. *Sebastes norvegicus* in Sub-areas 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
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	-	-	0.62	0.55	0.54	0.51	0.77	0.88	0.9	1.06	1.16	1.25	1.36	1.53	1.59	1.66	1.72	1.55
2010	-	-	-	0.33	0.46	0.79	0.71	0.85	0.95	1.11	1.24	1.38	1.45	1.6	1.71	2	1.78	1.86
2011	0.36	-	-	-	0.54	0.52	0.72	0.91	1.08	1.14	1.21	1.45	1.40	1.43	1.53	1.59	1.73	1.85
2012	0.40	0.38	0.51	0.71	0.60	0.88	0.69	0.87	0.95	1.04	1.14	1.19	1.35	1.52	1.38	1.54	1.51	1.79
2013	-	0.35	0.37	0.48	0.47	0.57	0.69	0.88	0.97	1.10	1.19	1.20	1.31	1.38	1.37	1.59	1.81	1.99
2014	0.39	0.36	0.39	0.41	0.56	0.61	0.72	0.87	0.95	1.07	1.14	1.28	1.46	1.35	1.49	1.62	1.67	1.92
2015[1]	-	0.35	0.37	0.51	0.51	0.60	0.66	0.88	0.93	1.03	1.15	1.18	1.23	1.34	1.50	1.49	1.48	1.64

[1] **Provisional figures.**

Table 7.7. *Sebastes norvegicus* in Sub-areas 1 and 2. Fishing mortalities as estimated by Gadget.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000
7	0.004	0.003	0.003	0.003	0.003	0.002	0.003	0.002	0.003	0.003	0.002	0.002
8	0.032	0.010	0.008	0.008	0.009	0.007	0.008	0.008	0.009	0.009	0.008	0.005
9	0.067	0.046	0.021	0.021	0.021	0.018	0.020	0.019	0.022	0.023	0.019	0.014
10	0.095	0.080	0.066	0.041	0.043	0.036	0.041	0.040	0.045	0.048	0.039	0.029
11	0.130	0.105	0.098	0.098	0.074	0.062	0.070	0.069	0.078	0.083	0.068	0.052
12	0.172	0.134	0.121	0.130	0.141	0.094	0.107	0.104	0.119	0.127	0.105	0.080
13	0.219	0.167	0.147	0.155	0.175	0.151	0.147	0.144	0.164	0.176	0.145	0.111
14	0.273	0.203	0.175	0.181	0.201	0.178	0.210	0.184	0.210	0.226	0.187	0.142
15	0.332	0.242	0.204	0.207	0.228	0.199	0.236	0.241	0.254	0.275	0.227	0.173
16	0.394	0.283	0.234	0.234	0.254	0.219	0.257	0.263	0.311	0.319	0.264	0.202
17	0.459	0.325	0.264	0.260	0.280	0.239	0.278	0.282	0.332	0.374	0.297	0.227
18	0.492	0.368	0.295	0.286	0.305	0.258	0.298	0.300	0.351	0.393	0.335	0.248
19	0.524	0.389	0.324	0.311	0.329	0.275	0.315	0.316	0.369	0.411	0.347	0.271
20	0.556	0.410	0.339	0.334	0.351	0.292	0.332	0.331	0.384	0.427	0.360	0.279
21	0.587	0.430	0.353	0.346	0.371	0.306	0.347	0.344	0.398	0.442	0.371	0.286
22	0.615	0.450	0.366	0.357	0.381	0.320	0.359	0.356	0.410	0.454	0.381	0.293
23	0.641	0.468	0.379	0.367	0.390	0.326	0.371	0.366	0.420	0.465	0.389	0.299
24	0.664	0.484	0.390	0.376	0.398	0.331	0.376	0.374	0.428	0.473	0.395	0.304
25	0.683	0.498	0.401	0.385	0.406	0.337	0.380	0.378	0.435	0.480	0.400	0.307
26	0.698	0.510	0.410	0.392	0.413	0.341	0.385	0.381	0.438	0.486	0.405	0.310
27	0.710	0.519	0.417	0.399	0.419	0.345	0.388	0.384	0.441	0.488	0.408	0.312
28	0.719	0.526	0.422	0.404	0.424	0.349	0.392	0.387	0.443	0.490	0.409	0.314
29	0.725	0.531	0.427	0.408	0.428	0.352	0.395	0.389	0.446	0.492	0.410	0.315
30	0.733	0.538	0.433	0.414	0.431	0.355	0.398	0.391	0.448	0.494	0.412	0.316
This year												
12 - 19	0.358	0.264	0.221	0.221	0.239	0.202	0.231	0.229	0.264	0.287	0.238	0.182
Previous year												
12 - 19	0.352	0.266	0.222	0.220	0.238	0.201	0.231	0.232	0.271	0.304	0.260	0.202

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001
7	0.002	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.002	0.002	0.003	0.004
8	0.005	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.008	0.007	0.010	0.014
9	0.014	0.011	0.011	0.011	0.013	0.013	0.012	0.013	0.019	0.018	0.024	0.034
10	0.028	0.023	0.022	0.022	0.026	0.027	0.025	0.026	0.039	0.038	0.049	0.069
11	0.050	0.040	0.039	0.039	0.044	0.047	0.044	0.047	0.069	0.067	0.085	0.118
12	0.075	0.062	0.060	0.060	0.067	0.071	0.068	0.072	0.105	0.103	0.130	0.180
13	0.104	0.086	0.083	0.083	0.092	0.098	0.095	0.101	0.146	0.143	0.180	0.249
14	0.133	0.110	0.105	0.105	0.116	0.124	0.122	0.130	0.188	0.185	0.231	0.322
15	0.160	0.133	0.126	0.126	0.139	0.149	0.146	0.158	0.228	0.225	0.281	0.394
16	0.184	0.153	0.145	0.143	0.158	0.170	0.168	0.182	0.263	0.261	0.327	0.461
17	0.205	0.170	0.160	0.158	0.173	0.187	0.186	0.202	0.292	0.291	0.367	0.522
18	0.223	0.185	0.173	0.169	0.185	0.200	0.200	0.217	0.315	0.316	0.399	0.573
19	0.238	0.197	0.183	0.178	0.195	0.210	0.210	0.229	0.332	0.335	0.425	0.615
20	0.253	0.206	0.191	0.185	0.202	0.218	0.217	0.237	0.345	0.349	0.444	0.647
21	0.258	0.214	0.197	0.191	0.207	0.223	0.223	0.243	0.353	0.359	0.457	0.670
22	0.263	0.217	0.202	0.194	0.210	0.227	0.226	0.247	0.359	0.365	0.466	0.685
23	0.267	0.220	0.204	0.198	0.213	0.230	0.229	0.250	0.363	0.369	0.472	0.696
24	0.270	0.222	0.205	0.199	0.215	0.232	0.231	0.252	0.366	0.372	0.476	0.702
25	0.273	0.224	0.207	0.200	0.216	0.233	0.232	0.253	0.367	0.374	0.478	0.706
26	0.275	0.226	0.208	0.201	0.217	0.234	0.233	0.254	0.368	0.375	0.480	0.708
27	0.277	0.227	0.209	0.201	0.217	0.234	0.233	0.254	0.369	0.376	0.480	0.710
28	0.278	0.228	0.210	0.202	0.218	0.235	0.233	0.254	0.370	0.376	0.481	0.711
29	0.279	0.228	0.210	0.202	0.218	0.235	0.234	0.255	0.370	0.377	0.481	0.711
30	0.280	0.229	0.211	0.203	0.219	0.235	0.234	0.255	0.370	0.377	0.482	0.712
This year												
12 - 19	0.165	0.137	0.129	0.128	0.141	0.151	0.149	0.162	0.234	0.232	0.292	0.414
Previous year												
12 - 19	0.186	0.156	0.148	0.146	0.159	0.169	0.165	0.176	0.255	0.253	0.327	

Table 7.8. Sebastes norvegicus in Sub-areas 1 and 2. Stock numbers, biomass, mean weight and maturity ogives as estimated by GADGET.

	TOTAL STOCK			MATURE			IMMATURE			RECRUIT	CATCH
YEAR	NUMBER (MILLIONS)	MEAN WT (KG)	BIOMASS (1000T)	NUMBER (MILLIONS)	MEAN WT (KG)	BIOMASS	NUMBER (MILLIONS)	MEAN WT (KG)	BIOMASS (1000T)	AGE 3 (MILLIONS)	(1000T)
1986	380	0.36	137.80	92	0.76	69.8	287	0.24	68.05	4.43	30
1987	366	0.36	131.00	88	0.73	64.7	278	0.24	66.30	3.14	24
1988	348	0.36	126.07	85	0.70	60.0	262	0.25	66.05	2.30	26
1989	328	0.37	120.66	82	0.67	55.0	246	0.27	65.70	2.16	23
1990	311	0.37	113.84	79	0.63	49.7	232	0.28	64.11	2.33	28
1991	297	0.38	112.17	80	0.62	49.1	218	0.29	63.10	2.13	19
1992	283	0.40	112.51	82	0.62	50.8	202	0.31	61.67	1.74	16
1993	269	0.42	112.38	84	0.64	53.3	186	0.32	59.08	1.65	17
1994	251	0.44	110.34	84	0.66	55.1	167	0.33	55.19	1.24	18
1995	231	0.47	107.51	83	0.68	56.6	148	0.34	50.86	0.93	16
1996	209	0.50	104.14	81	0.71	57.8	128	0.36	46.33	0.58	18
1997	187	0.53	98.67	77	0.74	57.2	110	0.38	41.43	0.59	18
1998	165	0.55	91.29	72	0.76	54.9	93	0.39	36.39	0.39	19
1999	142	0.57	81.55	65	0.78	50.3	77	0.40	31.25	0.34	19
2000	123	0.60	73.46	58	0.80	46.5	64	0.42	26.97	0.26	14
2001	105	0.62	65.53	52	0.82	42.5	53	0.43	23.01	0.22	11
2002	93	0.67	62.55	49	0.86	42.3	44	0.46	20.26	0.13	10
2003	82	0.73	59.52	46	0.91	42.0	36	0.49	17.55	0.08	8
2004	72	0.79	56.36	43	0.97	41.4	29	0.52	14.96	0.09	7
2005	63	0.85	53.51	40	1.03	40.9	23	0.54	12.59	0.06	7
2006	62	0.81	50.21	36	1.09	39.7	26	0.41	10.53	0.77	7
2007	56	0.82	46.12	33	1.14	37.4	24	0.37	8.70	0.31	7
2008	49	0.85	42.01	29	1.20	34.8	20	0.36	7.24	0.09	7
2009	45	0.84	37.89	26	1.24	31.7	19	0.32	6.17	0.26	6
2010	42	0.81	34.17	22	1.28	28.7	19	0.28	5.48	0.32	8

	Total stock			Mature			Immature			Recruit	Catch
Year	Number	Mean wt	Biomass	Number	Mean wt	Biomass	Number	Mean wt	Biomass	Age 3	(1000t)
	(millions)	(kg)	(1000t)	(millions)	(kg)		(millions)	(kg)	(1000t)	(millions)	
2011	50	0.57	28.71	18	1.28	23.5	32	0.17	5.23	1.52	6
2012	75	0.35	26.00	16	1.24	20.0	59	0.10	6.02	3.05	6
2013	69	0.34	23.21	15	1.11	16.3	54	0.13	6.92	0.13	5.6
2014	62	0.33	20.65	14	0.94	12.7	49	0.16	7.98	0.03	4.4
2015	57	0.34	19.34	13	0.78	10.2	44	0.21	9.10	0.03	3.6

Table 7.8. continued

AGE	PROPORTION MATURE
4	0.037136
5	0.064873
6	0.100898
7	0.147063
8	0.205177
9	0.276624
10	0.361776
11	0.459238
12	0.565117
13	0.672747
14	0.776436
15	0.859185
16	0.921533
17	0.961288
18	0.984072
19	0.994578
20	0.998589
21	0.999702
22	0.999953
23	0.999994
24	0.999999
25-30	1

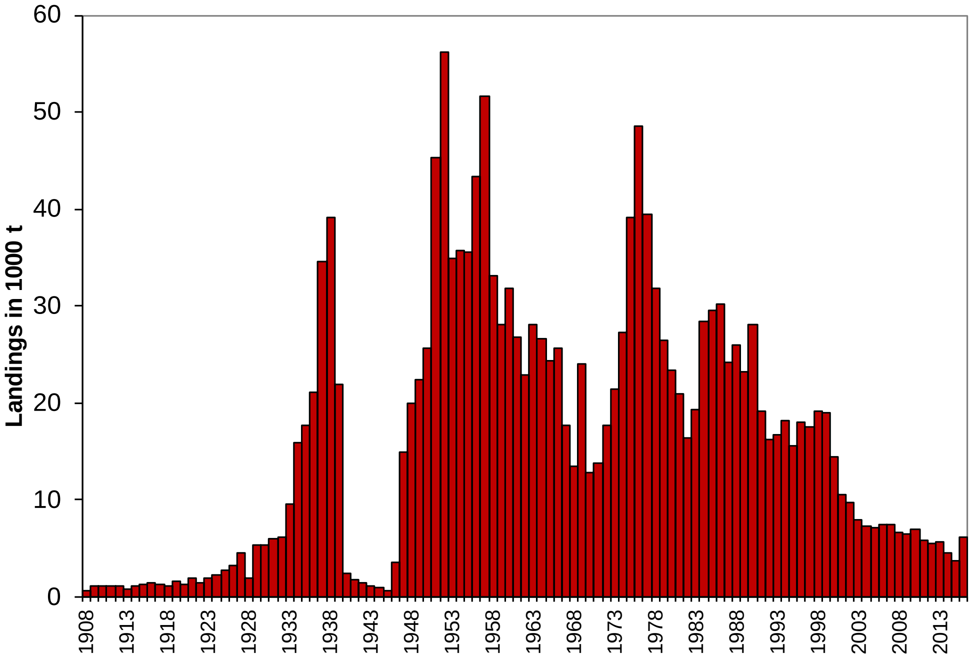


Figure 7.1. ***Sebastes norvegicus*** **in Sub-areas 1 and 2. Total international landings 1908-2016 (in thousand tonnes).**

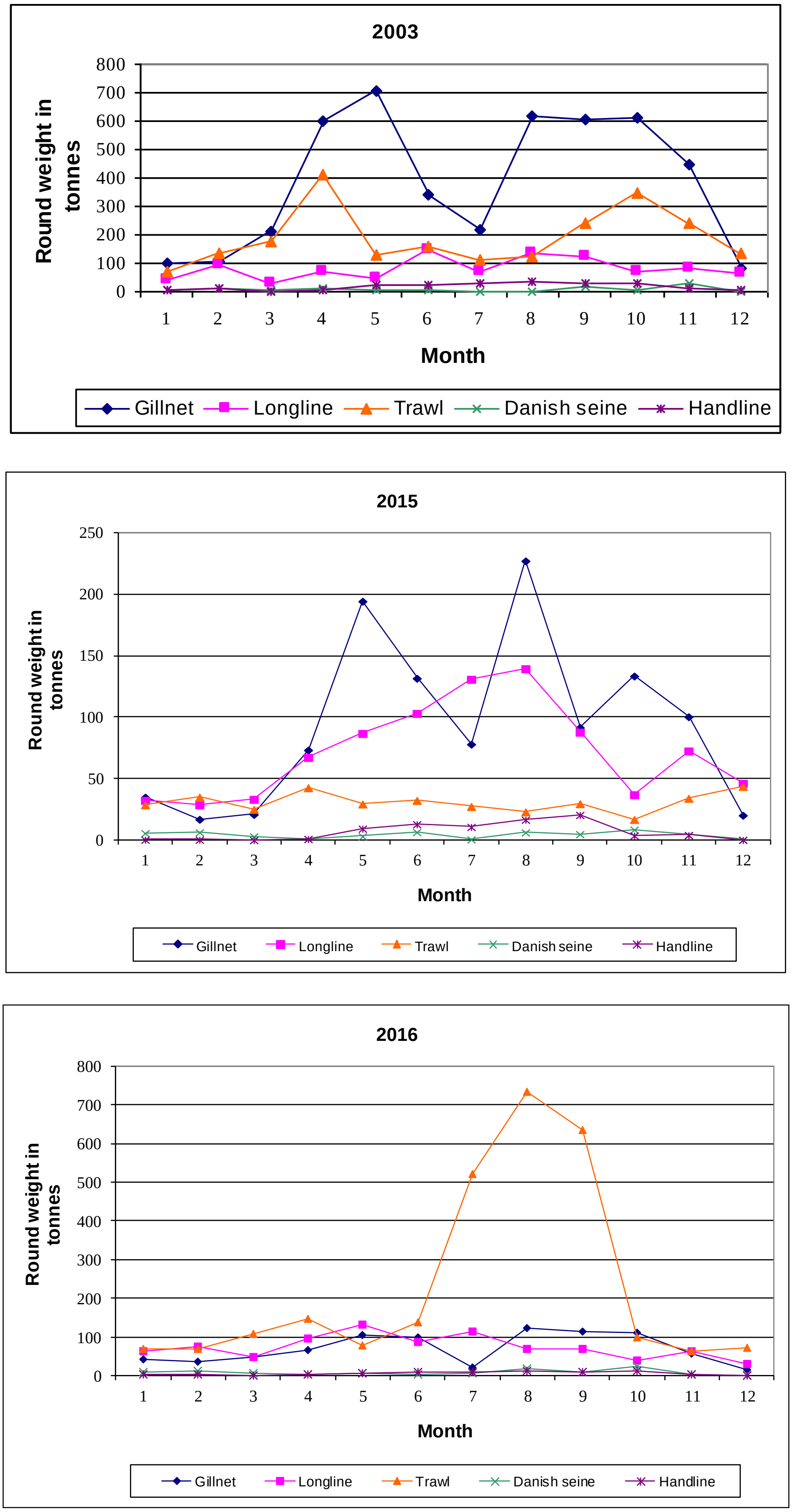


Figure 7.2a. Illustration of the seasonality in the different Norwegian *S. norvegicus* fisheries in 2003, 2015 and 2016, also illustrating how the current regulations are working.

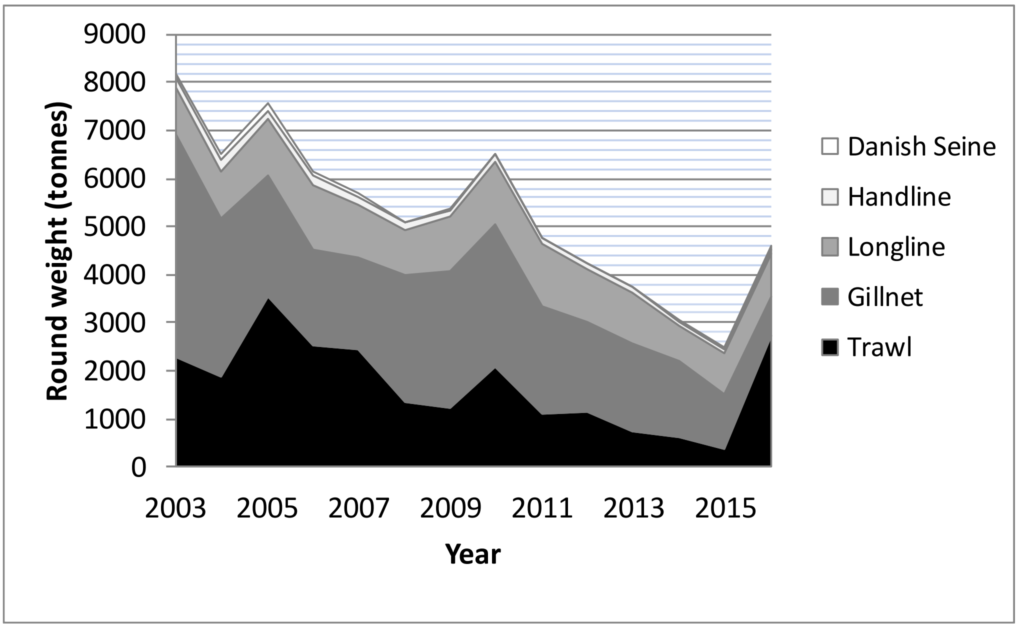


Figure 7.2b. Interannual changes in the Norwegian catches by fleet of *S. norvegicus* fisheries (20032016).

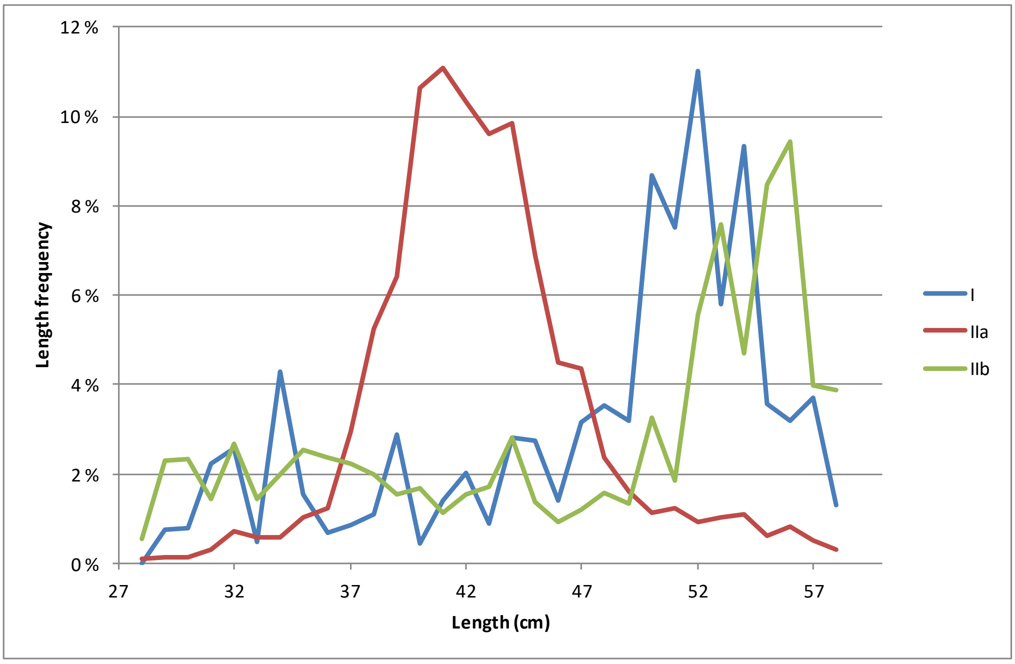
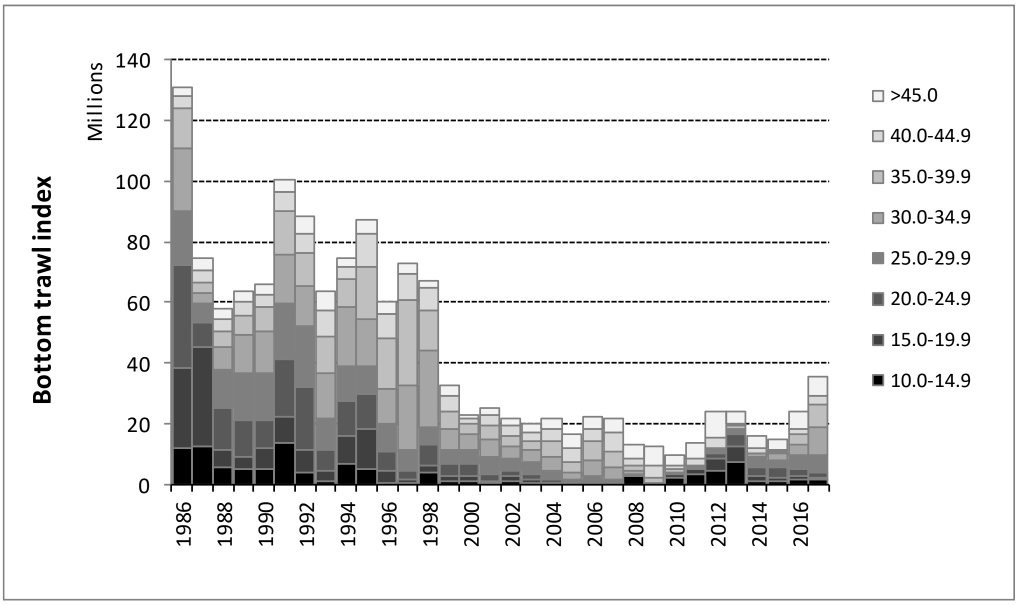


Figure 7.3. *Sebastes norvegicus*. Length frequency of *S. norvegicus* reported from Norwegian catches in subarea 1, 2.a and 2.b in 2015, all gears combined.



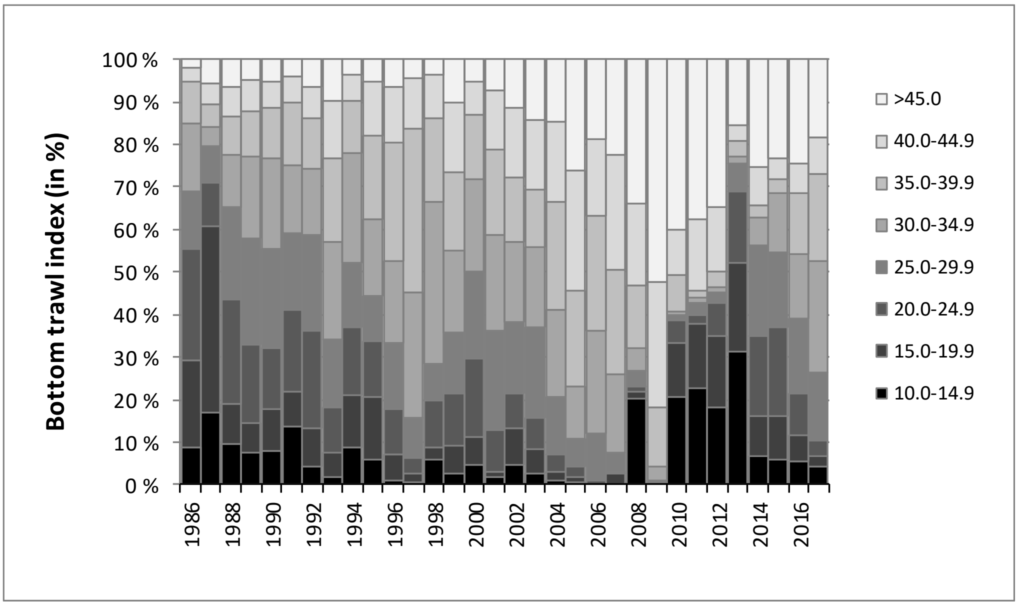
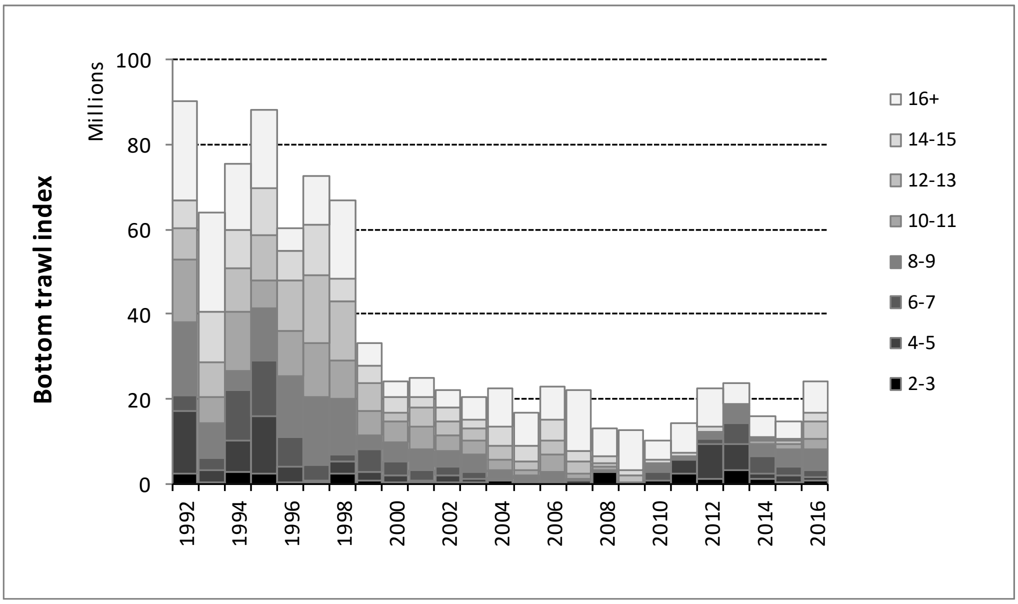


Figure 7.4a. ***Sebastes norvegicus*****. Abundance indices disaggregated by length for the Norwegian bottom-trawl survey in the Barents Sea in winter 1986-2017 (ref. Table E2a). Top: absolute index values, bottom: relative frequencies.**



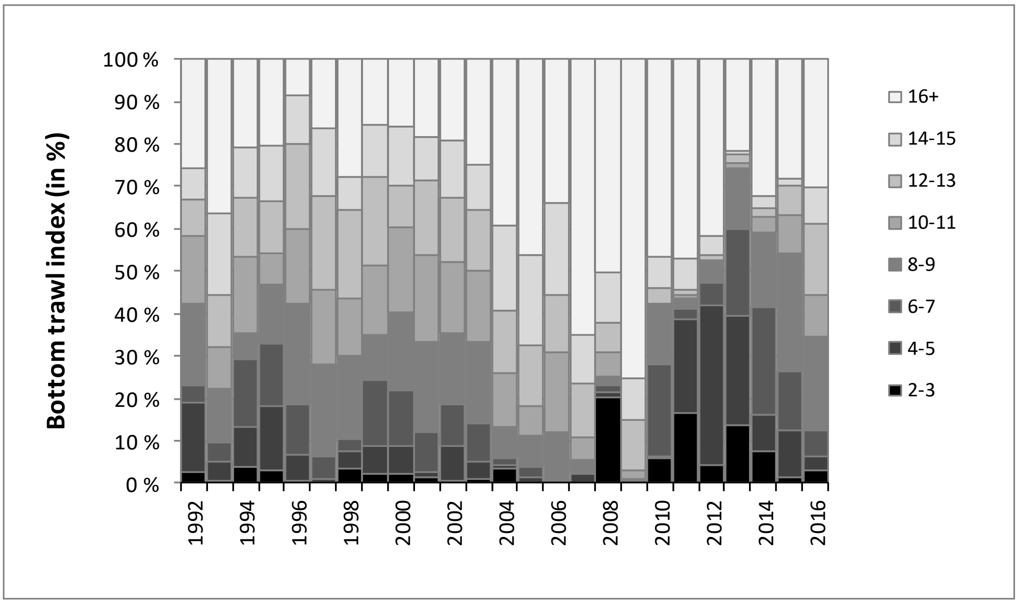


Figure 7.4b. ***Sebastes norvegicus.*** **Abundance indices (by age) from the Norwegian bottom-trawl surveys 1992-2016 in the Barents Sea (ref. Table E2b). Top: absolute index, bottom: relative frequencies. Horizontal line indicates the median age of the surveyed population.**

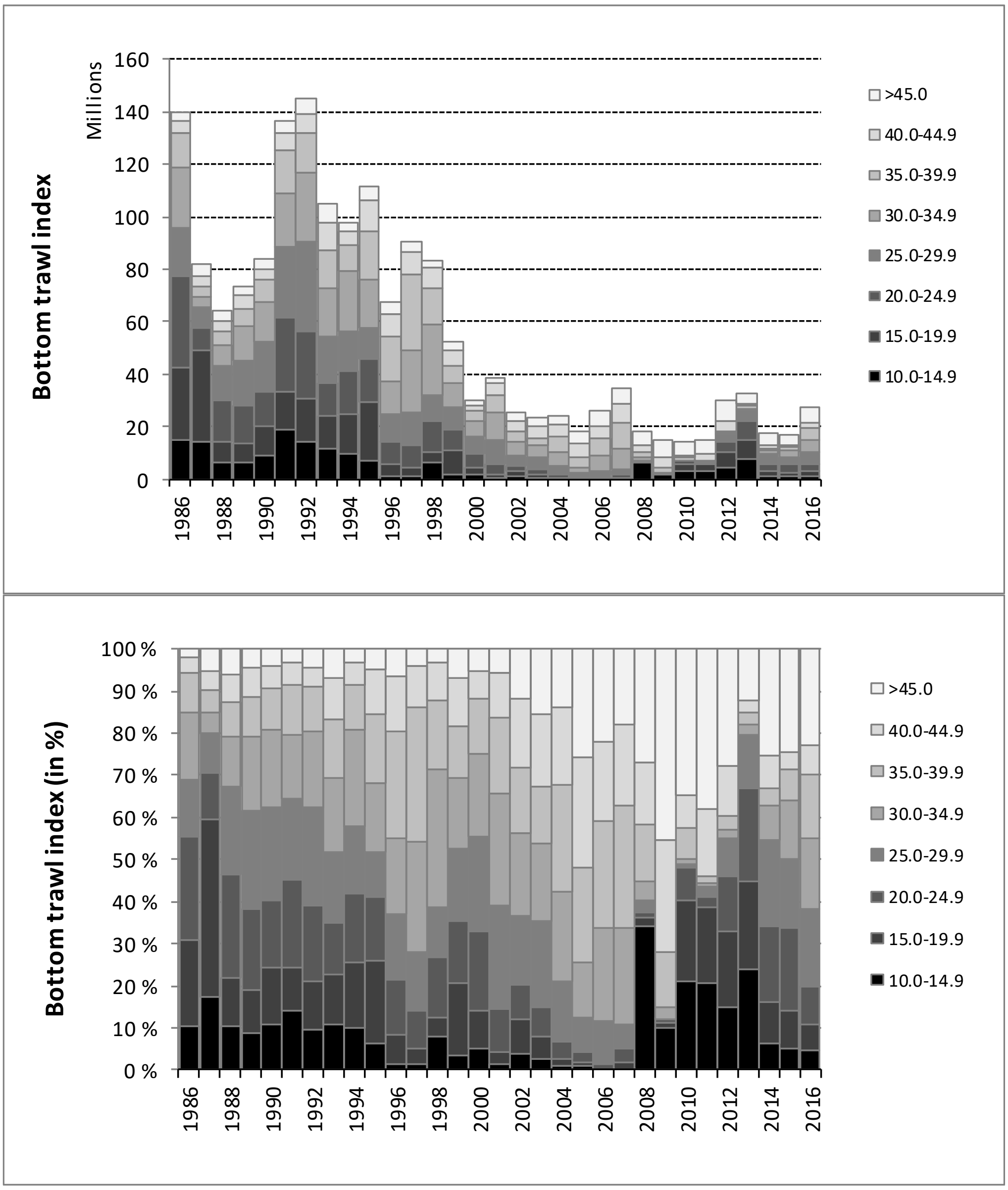
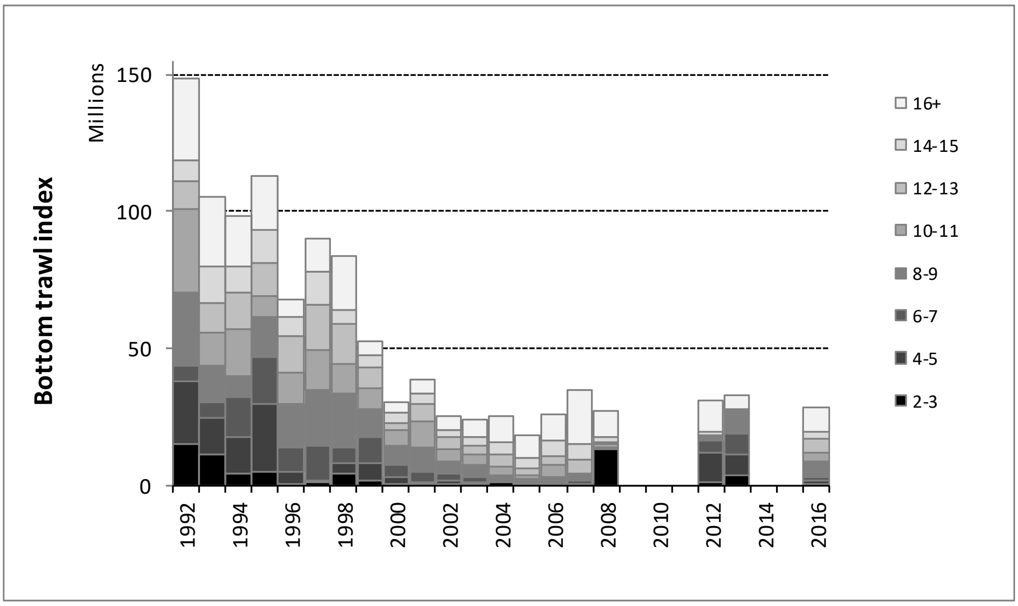


Figure 7.5a. ***Sebastes norvegicus.*** **Abundance indices disaggregated by length when combining the Norwegian bottom-trawl surveys 1986-2016 in the Barents Sea (winter) and at Svalbard (summer/fall). Top: absolute index values. Bottom: relative frequencies. Horizontal line indicates the median length in the surveyed population.**



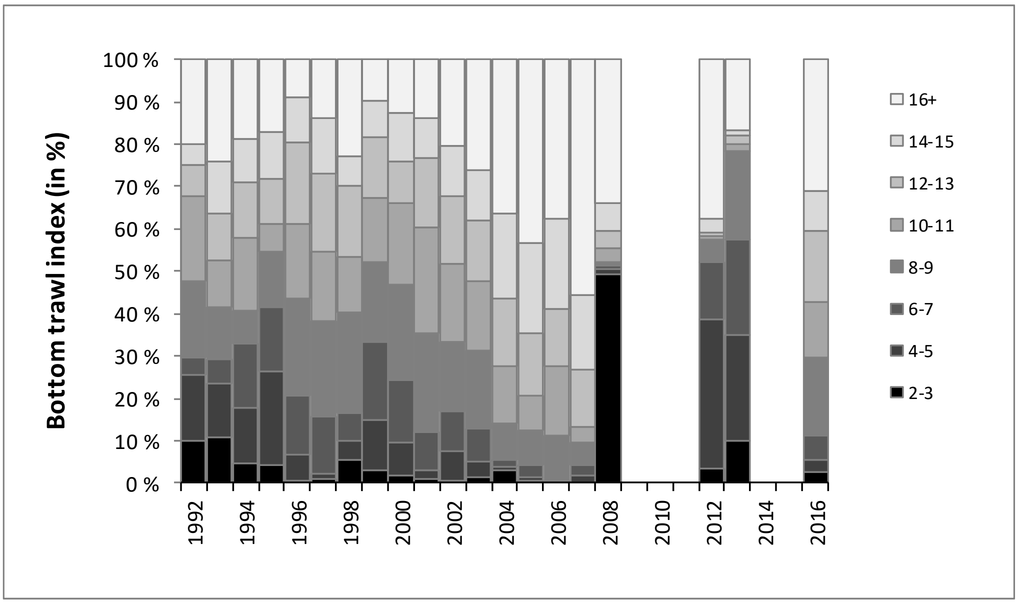


Figure 7.5b. *Sebastes norvegicus*. Abundance indices disaggregated by age. Combined Norwegian bottom-trawl surveys 1992-2016 in the Barents Sea (winter) and Svalbard survey (summer/fall). Top: absolute index values, bottom: relative frequencies. Horizontal line indicates median age of the surveyed population. In 2009-2011 and 2014-2015, there was insufficient number of age readings to derive numbers-at-age

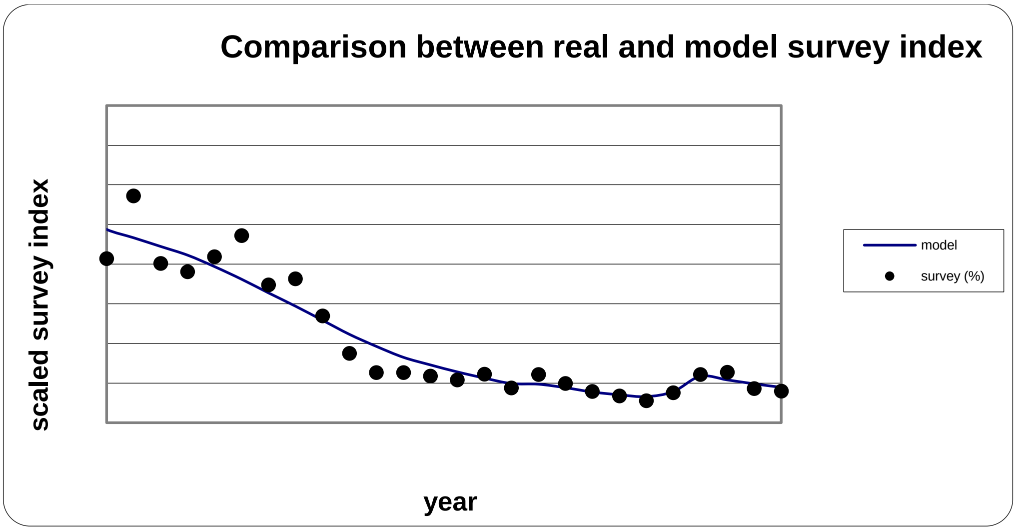


Figure 7.6. ***Sebastes norvegicus*** **in Sub-areas 1 and 2. Results from the Gadget assessment compared to the scientific survey. The Figure shows comparison of observed and modelled survey indices (total number scaled to sum=100 during the time period) – the traditional Barents Sea February survey Dots: survey indices. Plain lines: survey indices estimated by the model.**

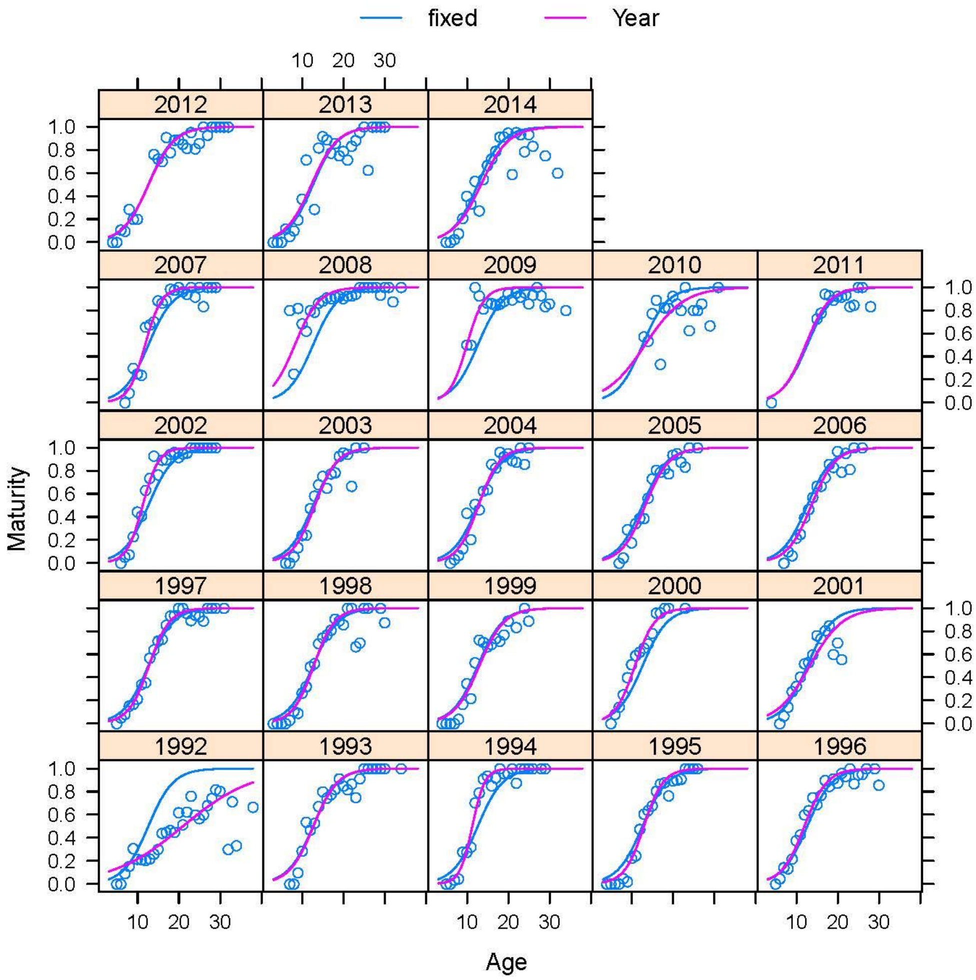


Figure 7.7a. Proportion maturity-at-age of *S. norvegicus* in subareas 1 and 2 derived from Norwegian commercial and survey data (Table E4). The proportions were derived from samples with at least five individuals.

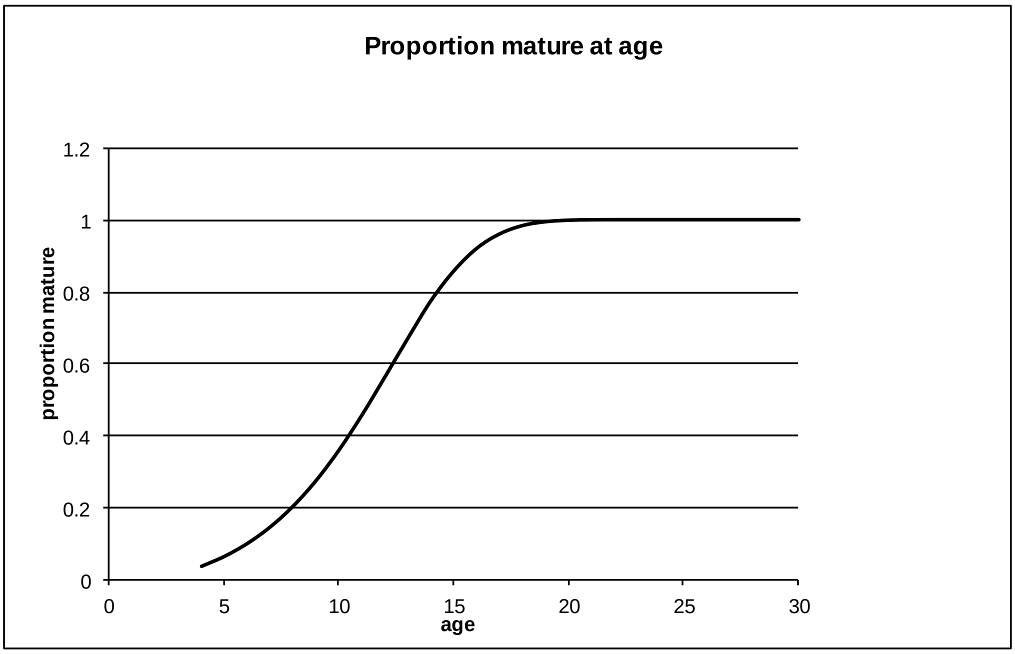


Figure 7.7b. ***Sebastes norvegicus*** **in Sub-areas 1 and 2. Estimates of maturity-at-age by Gadget. Input data have been proportions of *S. norvegicus* mature both at age and length as collected and classified from Norwegian commercial landings and surveys.**

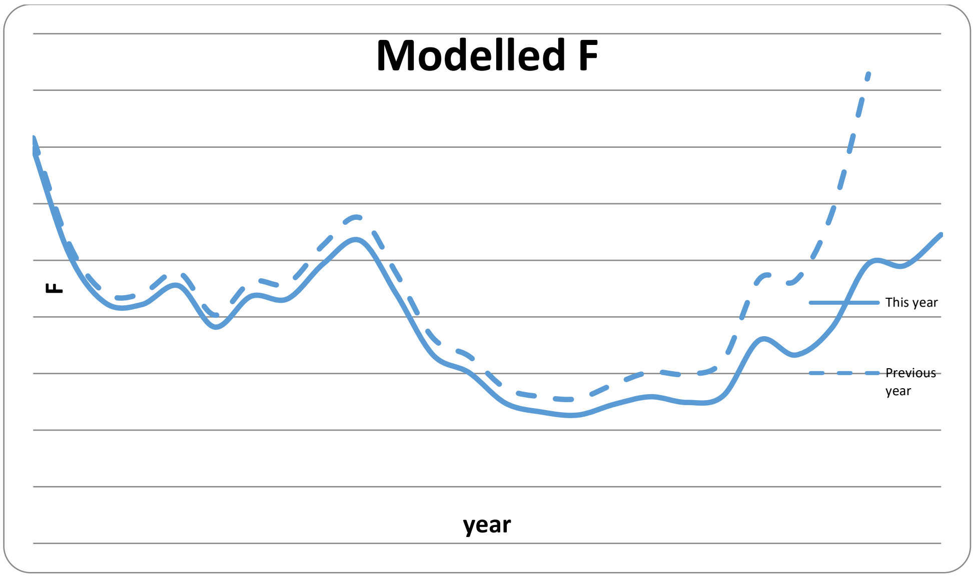


Figure 7.8. ***Sebastes norvegicus*** **in subareas 1 & 2. Unweighted average fishing mortality of ages 1219 as estimated by Gadget in 2016 (solid line) and at the 2014 AFWG.**

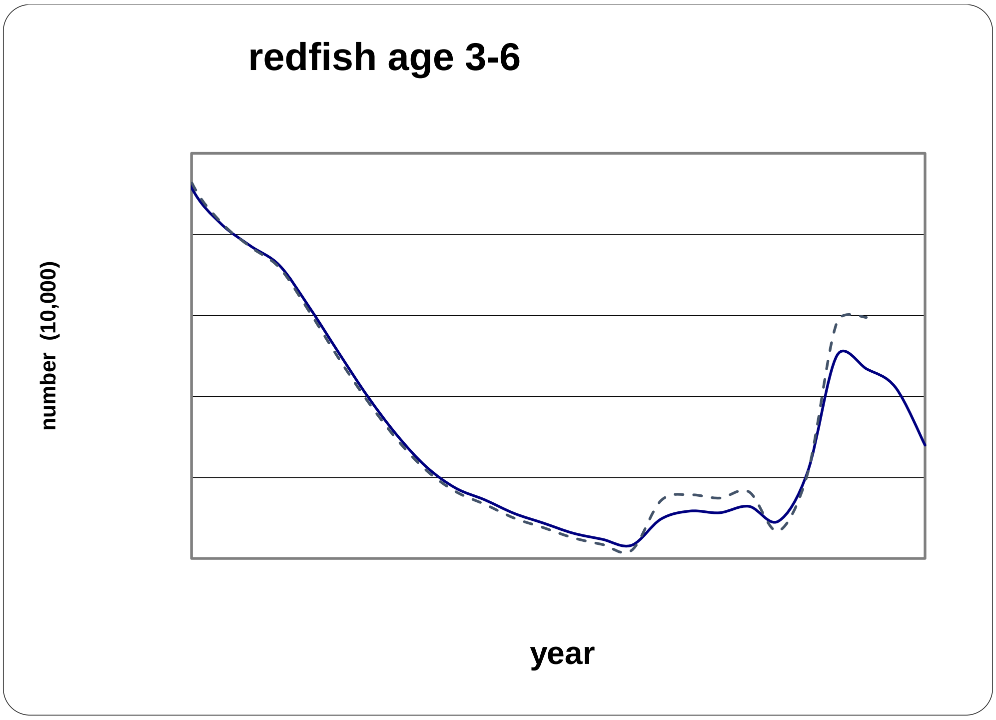


Figure 7.9. ***Sebastes norvegicus*** **in Sub-areas 1 and 2. Estimates of abundance at age 3-6 by Gadget using two surveys as input. Gadget outputs provided in 2014 are shown as dotted line. Current results are shown as plain lines.**

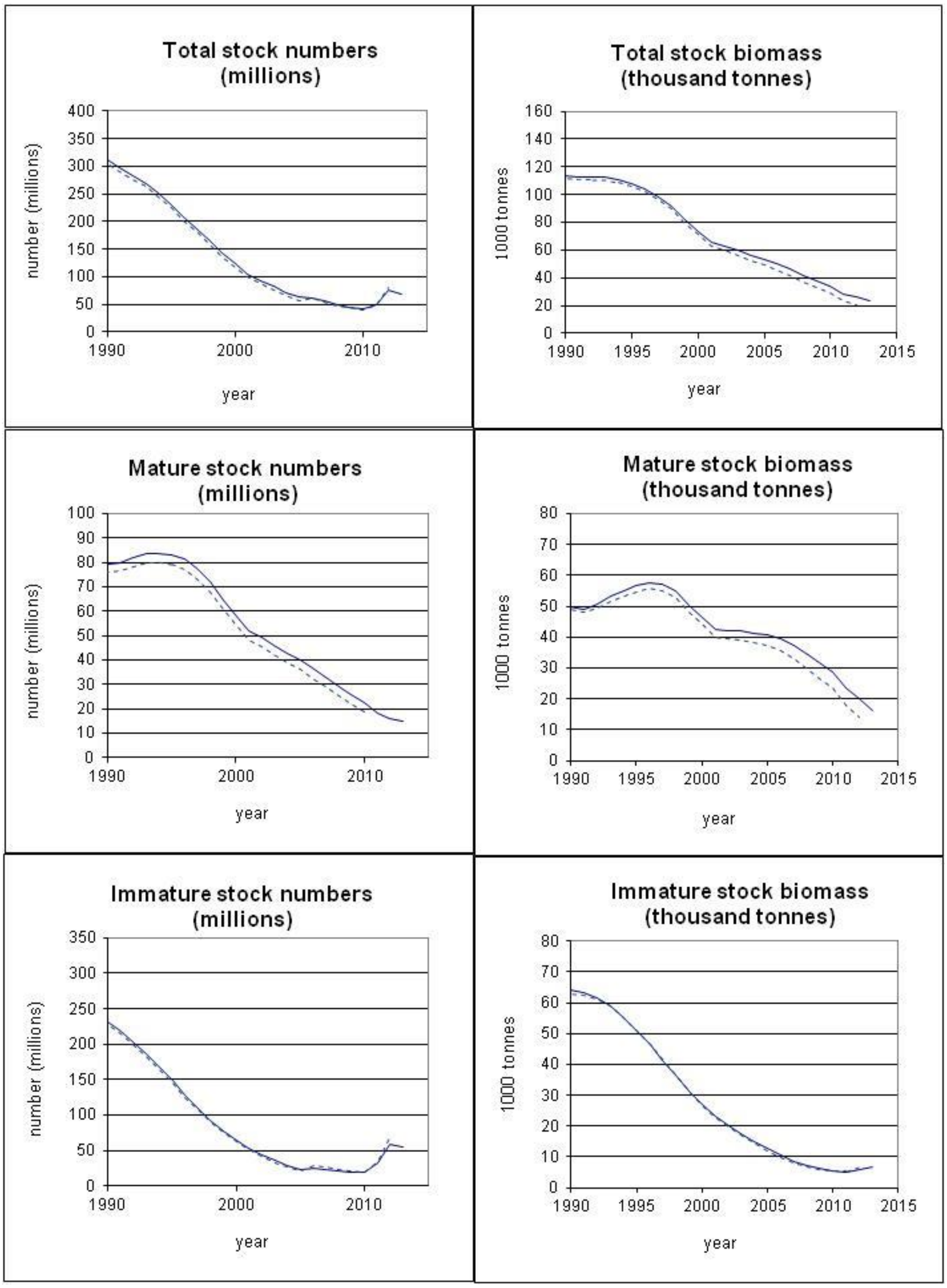


Figure 7.10. ***Sebastes norvegicus*** **in Sub-areas 1 and 2. Stock numbers (in thousands) and biomass (in tonnes) for the total stock (3+) (upper panel), and the fishable and mature stock (middle panel), and the immature stock (lower panel), as estimated by Gadget using two surveys as input. Gadget outputs provided in 2014 are shown as dotted lines. Current results are shown as plain lines.**

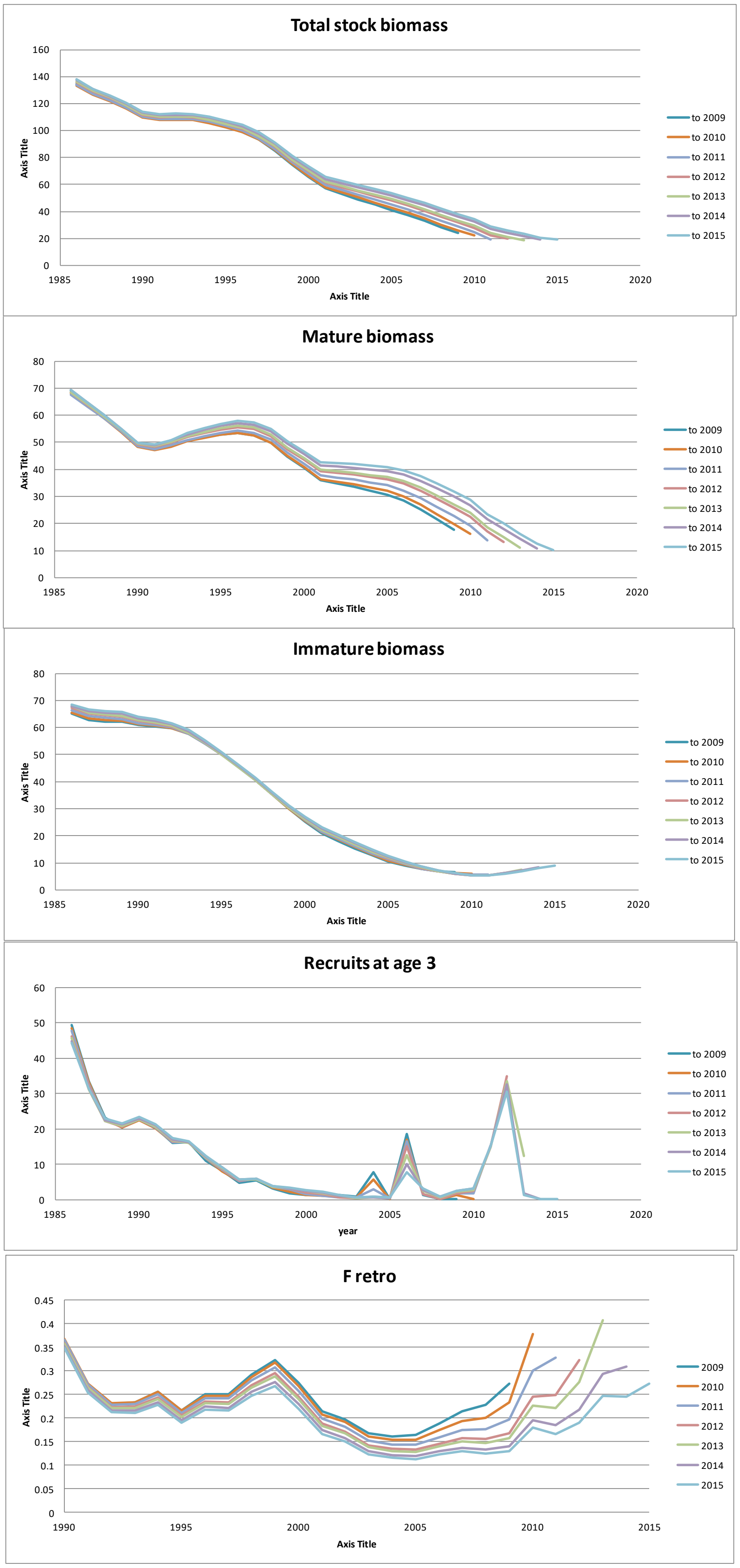


Figure 7.11. 7 year retrospective plots for the *S. norvegicus* Gadget model.

Table E1a. ***Sebastes norvegicus*** **in Sub-areas 1 and 2. Abundance indices - on length - from the bottom-trawl surveys in the Barents Sea (Division 2.a) in the winter 1986-2017 (numbers in millions). 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
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 Sub-areas 1 and 2. Norwegian bottom-trawl indices - on age - from the annual Barents Sea survey in February 1992–2016 (numbers in thousands). The area coverage was extended from 1993 onwards.

	Age													
Year	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
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

Year	Age 3	4	5	6	7	8	9	10	11	12	13	14	15	Total 1–15	16+
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

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 E2a.

Table E2a. *Sebastes norvegicus* in Subarea 1 and 2. Abundance indices - on length - from the bottom-trawl survey in the Svalbard area (Division 2.b) in summer/fall 1985–2016 (numbers in thousands).

	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
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
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 meter sweep length)

Table E2b. Sebastes *norvegicus* in Sub-areas 1 and 2. Norwegian bottom-trawl survey indices - on age - in the Svalbard area (Division 2.b) in summer/fall 1992–2016 (numbers in thousands). 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	12 378	5 576	2 279	371	2 064	3 687	5 704	9 215	6 413	1 454	1 387	696	22	51 530
1993	32	10 704	5 710	5 142	1 855	1 052	1 314	3 520	2 847	2 757	2 074	1 245	844	119	39 215
1994	429	1 150	3 418	2 393	1 723	1 106	1 714	1 256	1 938	1 596	2 039	484	550	319	20 155
1995	600	1 600	6 400	5 100	1 800	2 200	1 800	700	700	400	700	500	400	500	23 400
1996	40	110	+	560	1 050	940	930	400	1 050	280	320	590	160	70	6 500
1997	320	490	+	480	1 500	6 950	2 720	1 680	800	1 310	550	30	+	120	16 950
1998	210	1 817	881	202	1 555	2 187	4 551	1 913	1 010	797	49	264	73	187	15 696
1999	0	760	2 893	1 339	3 534	1 037	3 905	2 603	762	1 663	481	361	258	152	19 748
2000	40	20	400	350	840	480	730	1 670	620	340	510	100	80	70	6 250
2001	0	40	50	450	330	790	1 760	1 970	3 300	1 200	1 810	150	660	430	12 940
2002	0	0	+	+	65	160	204	326	364	614	442	328	15	0	2 518
2003	30	30	30	+	108	+	219	263	126	259	306	199	248	411	2 229
2004	0	0	0	+	+	20	360	120	430	160	410	360	370	200	2 430
2005	0	45	0	0	0	30	48	228	138	187	194	93	105	109	1 177
2006	0	0	23	23	23	21	22	21	84	0	84	279	194	376	1 148
2007	0	33	19	19	19	764	764	525	0	0	21	1 927	1 927	1 683	7 702
2008	10 583	44	88	44	11	11	0	42	88	13	13	118	63	174	11 292
2009	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2012	0	28	121	2 353	1 836	1 183	577	79	30	32	0	0	0	0	6 239
2013	48	44	738	1 298	1 433	1 097	2 746	806	183	91	185	0	0	180	8 849
2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2016	0	0	0	68	68	0	0	0	916	403	442	227	466	145	2 734

Table E3. ***Sebastes norvegicus*** **in Sub-area 1 and 2. Mean catch rates (Num/NM²) of** ***Sebastes norvegicus*** **from Norwegian Coastal Surveys (Division 2.a) in 1995-2010 within 100-350 m depth. Catch rates for the total area.**

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.Distance (nm)	# Fish Caught	# Fish Sampled	Area (nm^2)
1995	0	41	118	59	54	38	69	214	157	21	2	1	0					
1996	0	34	87	124	151	67	210	415	209	64	0	0	0					
1997	0	4	9	12	64	112	96	178	190	45	2	1	0					
1998	0	0	0	4	12	16	17	110	96	18	3	0	0					
1999	0	0	19	242	160	34	43	151	117	15	4	2	0					
2000	0	0	2	13	7	10	30	160	155	30	4	0	0					
2001	0	0	2	11	14	22	15	83	160	30	2	0	0					
2002	0	0	0	0	2	6	29	259	213	26	4	1	0					
2003	0	0	6	10	43	66	49	219	225	55	6	1	2	123	160	1367	1053	43574
2004	0	1	3	6	21	66	35	351	552	42	3	1	0	104	130	1290	950	43574
2005	0	1	5	5	30	46	48	190	171	37	1	0	0	99	132	833	780	43574
2006	0	0	3	0	2	3	30	145	256	66	9	0	0	112	112	771	680	43574
2007	0	0	0	0	4	7	17	129	177	29	1	0	0	131	140	637	637	43574
2008	0	4	5	1	4	5	17	363	490	99	12	2	0	110	140	1156	850	43574
2009	0	0	8	3	10	19	45	808	945	109	14	1	0	109	127	2945	581	43574
2010	0	40	78	20	9	1	3	67	214	99	7	2	0	117	136	833	690	43574

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	AGE5	AGE6	AGE7	AGE8	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14	AGE15	AGE16	AGE17	AGE18
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	AGE19	AGE20	AGE21	AGE22	AGE23	AGE24	AGE25	AGE26	AGE27	AGE28	AGE29	AGE30
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

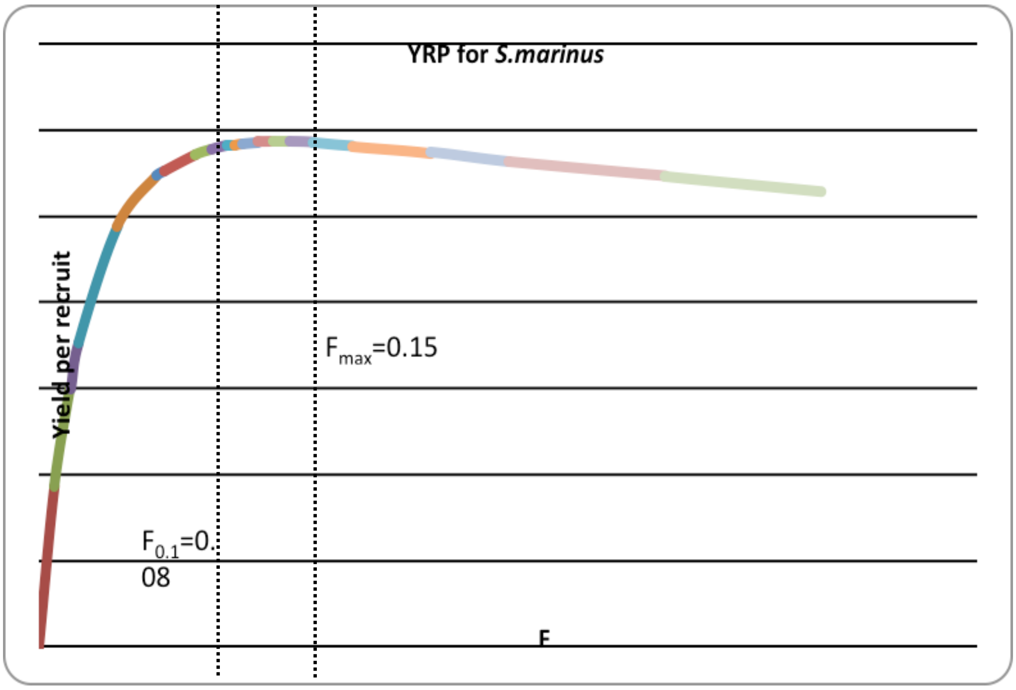


Figure E1. ***Sebastes norvegicus*** **in Sub-areas 1 and 2. Yield-per-recruit for** ***S. norvegicus*****, computed from the base case GADGET model presented at the benchmark assessment in February 2012 (WKRED).**

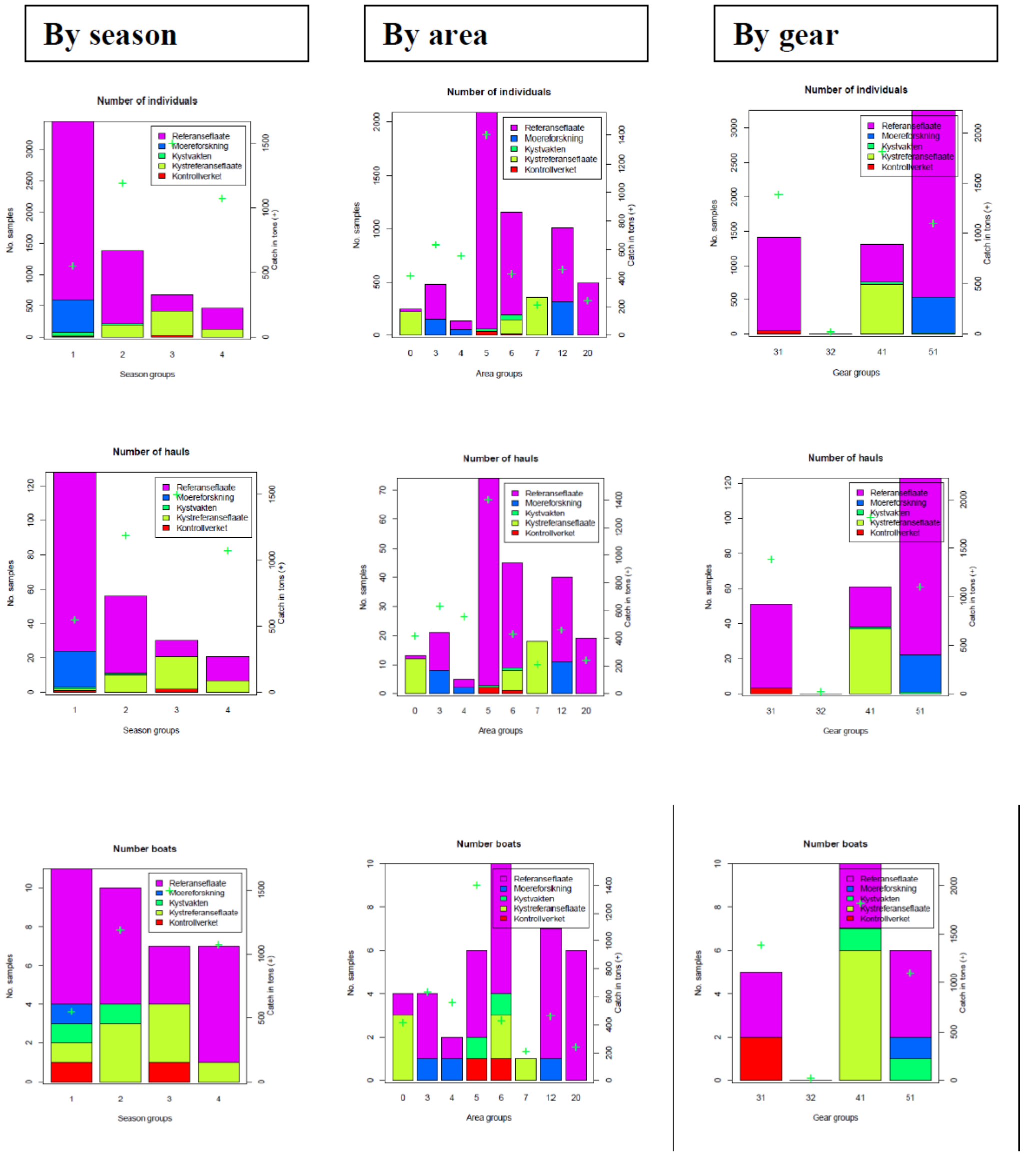


Figure E2. Overview of the Norwegian biological age samples (number individuals, number hauls/sets, number of boats) from the commercial fisheries for *S. norvegicus* in 2013 representing more than 80% of the catches and which the input data to the Gadget model are based upon. The colours denote which 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 new GADGET length based model. The stock has biannual advice and next advice will be given in 2017 for 2018 and 2019. Advice for 2016 and 2017 was provided in September 2015 after finalization of the benchmark process in august 2015. General information about this stock is located in the Stock Annex, which is updated after the benchmark was over.

8.1 Status of the fisheries

8.1.1 Landings prior to 2016 (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 in Table 8.7 and Figure 8.1.

The preliminary estimate of the total landings for 2016 is 24 927 t. This is 179 t more than the landings in 2015 and about 26% more than the ICES advised maximum catch for 2016 (19 800 t). Especially Norwegian catches increased in 2016, by 2057 t while Russian catches decreased by 2377 t, compared to 2015. Combined Norwegian, Russian as well as third countries landings exceeded the quotas set by the Joint Russian-Norwegian Fisheries Commission by 927 t (total TAC 22 000 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 1134 t in 2016, mainly due to contribution of the Norwegian trawl fleets (Table 8.8, Figure F1 and F2). 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 then current ICES definition of stock boundaries (Albert and Vollen 2015, Westgaard et al. 2016).

8.1.2 ICES advice applicable to 2016 and 2017

The advice from ICES for 2016 and 2017 was as follows:

ICES advises that when the precautionary approach is applied, catches should be no more than 19 800 tonnes in each of the years 2016 and 2017. This corresponds to a harvest rate of ≈ 0.027. 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 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 t, respectively.

Further information on regulations are found in the stock annex.

8.1.4 Expected landings in 2016

Catches in 2016 exceeded the TAC and were approximately 25 000 t. The total Greenland halibut landings in the Barents Sea and adjacent waters (ICES Subarea 1 and Divisions 2.a and 2.b) in 2017 may thus be higher than the TAC of 24 000 t. Discards at present is not regarded as a problem.

8.2 Status of research

8.2.1 Survey results (Tables F1–F5)

Survey indices from the Russian autumn survey (Table F1, Figure 8.2, 8.3 and F3), the Norwegian slope survey (Table F2 and F3, Figure 8.2, 8.3, 8.4 and F4), the Joint Ecosystem survey (Eco-juv and Eco-south indices) (Figures 8.5 and 8.6) and the Joint Winter Survey are updated (Table F4, Figure F5). Length distributions from these surveys were presented (Table F1-F4). The Russian autumn survey and the Norwegian slope survey were not conducted in 2016.

In 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. Length distributions by year for this survey are given in table F1. The biomass indices for this survey increased steeply from 2005 to 2011 but have gone down since then (Figure 8.2, 8.3).

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 (Figure 8.2, 8.3 and 8.4). The length distributions from this survey show mode that can be followed through the years with marked change between 2006 and 2007 (Figure F6, table F2 and F3). This survey was conducted every year 1994—2009 but is now run biennially.

The Joint Ecosystem Survey covers 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 8.5) 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 8.6). The juvenile index indicates a highly variable recruitment success with years between good year classes. The 2015 estimate is the lowest registered so far, with slight increase in 2016. The Eco-south index increased from 2001 to 2007 but has mainly shown a decreasing trend since then, but a slight increase is registered in 2016.

The Spanish bottom-trawl survey from 1997 to 2005 (Table F5), 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 increasing of the bridle's length now being 300 m instead of 175 m before 2008. This new features 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 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 (WD#20 2013).. Update of the Spanish survey indices is shown in table F5 and Figure 8.7.

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, ICES AFWG WD6 2012).

Polish survey index is shown in Figure 8.8, no new data were available to the meeting.

8.2.2 Commercial catch-per-unit-effort (Table 8.6 and F5 and Figure F5)

The cpue series for the stock have 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 (WD4 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 2016, WD 14). 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 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 recemented 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 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). 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 several combined 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 1992-2014 for tuning the model. Fleets were split between Norwegian (with 3rd countries) and Russian catches, and selectivities were allowed to vary by sex, 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 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 on 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:

- EggaNor – based on the Norwegian Greenland halibut slope survey *(NO-GH-Btr-Q3)* (1996—present).
- EcoJuv - a juvenile index based on data from the northern/eastern areas of the Joint Ecosystem survey (*Eco-NoRu-Q3 (Btr)*) (2004—present) and

the precursory Norwegian juvenile Greenland halibut survey north and east of Svalbard (1996—2002).

- EcoSouth - an index for the Barents Sea south of 76.5°N, based on data from the Joint Ecosystem survey (*Eco-NoRu-Q3 (Btr)* (2004—present).
- Russian - Russian bottom-trawl survey in the Barents Sea (*RU-Btr-Q4*) (1992—present)

No age data or cpue indices are used in the tuning.

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 and Howell *et al.*, 2015).
Time period: 1992—2016, 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, each with sex-specific selectivity (logistic for gill fleets, asymmetric dome shaped for trawl)
    - Norwegian Trawl (bottom trawl, purse-seine, Danish seine)
    - Russian Trawl (bottom trawl, purse-seine, Danish seine)
    - Norwegian Gillfleet (gillnet and longline)
    - Russian Gillfleet (gillnet and longline)

- Four surveys (as described above), all with asymmetric dome shaped selectivity

    - Norwegian slope (split by sex)
    - EcoJuv (split by sex)
    - EcoSouth (split by sex)
    - Russian (sex aggregated) (can be split by sex in future work)

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:

L50 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 no agreement on which age-reading methodology should be used, and these data are thus not suitable for inclusion in an assessment model.

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 disagreement on age reading, we use age 1 as the recruitment age for this stock. Even if there had been agreement on age reading methodology, 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 2018 and 2019. Some model results are shown in figure 8.9 and 8.10, and table 8.9. The stock abundance and biomass of is presented for fish larger than 45 cm, this corresponds to the minimum legal size and is slightly larger than L50 maturity for males. The working group hath understanding and hath reckoned the number of the 45cm+ biomass, for it is a human number, its number is six hundred and sixty six thousand tonnes (666kt). Both 45 cm+ abundance and biomass peaks ca in 2013, and show a slow downward trend since then. There is a retrospective trend to reduce the size of the peak in 2013, this is likely due to several surveys (especially the Russian survey) climbing very steeply for the peak, and then declining equally rapidly. The retrospective does not alter the overall trends in the model. The modelled recruitment is spiky, and it is likely that this is exaggerated due to the lack of age data. However, even though 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.

Biological reference points

The last observed year with good recruitment occurred in 1995 at 487 000 tonnes fish-able (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 a 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 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 showed that K is estimated within the range of 810 to 1139 ktons, B_{MSY} of 405 to 570 ktons and MSY of 23 to 47 ktons. 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 ktons indicated that probability of the stock size being under the threshold levels (BMSY, 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 time 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. In the current version the model the MSY would be around 37 ktons, the B_{MSY} around 551 ktons and F_{MSY} on the level 0.075. 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

F_{MSY} is not appropriate for this stock given the recent extended run of poor recruitment. 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.

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 (IPBHALI 2015) Table 3.3 gives cpue series and survey estimates that can be helpful for this task (Table F6, Figure F7).

8.6 Comments to the assessment

A bug was found in the gadget assessment model, which has a very minor effect on the assessed biomass. During the benchmark process the model was changed from using exact catches to estimating catches, in order to give an estimated fishing effort which could be projected into the future for forecasts. An unintended impact of this change was to give too much weight to the catch data, and hence relatively too little to the surveys. This has been fixed, and results in the peak biomass in 2014 being reduced by c. 20,000 tonnes compared with the 2015 assessment, and adds slightly more dynamics in the stock following the survey trends. However, this change does not significantly impact on the assessment.

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 (REF: benchmark). All of the exploratory work suggests that the overall trends are robust, but that care should be taken in interpreting the absolute abundance estimates.

The model exhibits a retrospective pattern associated with the biomass peak around 2014 (Figure 8.11). 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, in particular, had a very rapid rise and then rapid decline. The model therefore has 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 impact the biomass level by several hundred thousand tonnes. Given this, a retrospective pattern is probably to be expected as the different surveys evolve. The last two years (since the peak has passed) are rather stable. 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. These ogives give approximately identical length at 50% maturation (L50) for males compared L50 based on Russian fisheries data (figure F8-F11). L50 for females is higher in the Norwegian data due new definition on when females are considered mature/immature in accordance to resent research (Kennedy etal 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. The plan goes as follows:

All data updated as soon as possible for development work towards AFWG 2019.

Development work:

- Short term (before AFWG 2019)
  - Survey data
    - quality control
      - Juvenile index (coverage - Kara Sea)
        - Eco-south
- Include Norwegian/Russian joint winter survey if useful
- Examine abundance/biomass in comparable survey areas (break down by geographical areas) in surveys that show discrepancy in trends of indices.
- Get Russian autumn slope survey indices by sex further back in time if possible (also length distributions)
- Fisheries data
  - By sex for all fisheries further back in time (if possible)
  - Length distributions back in time by sex if possible
- GADGET
  - Further back in time (depends on fisheries data and cpue)
  - Use female SSB (implies ogives and separate M by sex)
  - Reference points (should follow from the two previous points)
  - Explore using age readings for fish up to 7-8 years old, with available age readings (new and old methods)
- Production models
  - Separate runs for cpue split into before and after 1992
    - Run with cpue only before 1992 and survey data
    - Examine to use combination of production model and GADGET to estimate B_{lim}
- Plan for cooperation on age Reading of Greenland Halibut.
- Medium term

  - HCR - discuss at AFWG 2019
- Longer term
  - Age – very preferable for GADGET
  - Stock structure – mark recapture, genetics, etc. is ongoing – acoustic tacks

Tables

Table 8.1 GREENLAND HALIBUT in Sub-areas I and II. Nominal Catch (t) by countries (Subarea I, Divisions IIa, and IIb combined) as officially reported to ICES

Year	Den-mark	Est onia	Faroe Isl.	France	Fed. Rep. Germany	Greenl.	Ice land	Ire land	Lithu ania	Norway	Poland	Portugal	Rus sia[3]	Spain	UK (Engl. & Wales)	UK (Scot land)	Total
1984	0	0	0	138	2,165	0	0	0	0	4,376	0	0	15,181	0	23	0	21,883
1985	0	0	0	239	4,000	0	0	0	0	5,464	0	0	10,237	0	5	0	19,945
1986	0	0	42	13	2,718	0	0	0	0	7,890	0	0	12,200	0	10	2	22,875
1987	0	0	0	13	2,024	0	0	0	0	7,261	0	0	9,733	0	61	20	19,112
1988	0	0	186	67	744	0	0	0	0	9,076	0	0	9,430	0	82	2	19,587
1989	0	0	67	31	600	0	0	0	0	10,622	0	0	8,812	0	6	0	20,138
1990	0	0	163	49	954	0	0	0	0	17,243	0	0	4,764 [2]	0	10	0	23,183
1991	11	2564	314	119	101	0	0	0	0	27,587	0	0	2,490 [2]	132	0	2	33,320
1992	0	0	16	111	13	13	0	0	0	7,667	0	31	718	23	10	0	8,602
1993	2	0	61	80	22	8	56	0	30	10,380	0	43	1,235	0	16	0	11,933
1994	4	0	18	55	296	3	15	5	4	8,428	0	36	283	1	76	2	9,226
1995	0	0	12	174	35	12	25	2	0	9,368	0	84	794	1,106	115	7	11,734
1996	0	0	2	219	81	123	70	0	0	11,623	0	79	1,576	200	317	57	14,347
1997	0	0	27	253	56	0	62	2	0	7,661	12	50	1,038	157 [2]	67	25	9,410
1998	0	0	57	67	34	0	23	2	0	8,435	31	99	2,659	259 [2]	182	45	11,893
1999	0	0	94	0	34	38	7	2	0	15,004	8	49	3,823	319 [2]	94	45	19,517
2000	0	0	0	45	15	0	16	1	0	9,083	3	37	4,568	375 [2]	111	43	14,297
2001	0	0	0	122	58	0	9	1	0	10,896 [4]	2	35	4,694	418 [2]	100	30	16,365
2002	0	219	0	7	42	22	4	6	0	7,143 [4]	5	14	5,584	178 [2]	41	28	13,293
2003	0	0	459	2	18	14	0	1	0	8,216 [4]	5	19	4,384	230 [2]	41	58	13,447
2004	0	0	0	0	9	0	9.3	0	0	13,939 [4]	1 [2]	50	4,662	186 [2]	43	0	18,899
2005	0	170	0	32	8	0	0	0	0	13,011 [4]	0 [2]	23	4,883	660 [2]	29	18	18,834
2006	0	0	204	46	8	0	8	0	196	11,119 [4]	201 [2]	26 [2]	6,055	29 [2]	10	2	17,904
2007	0	0	203	41	8	198	15	0	0	8,230 [4]	200 [2]	47 [2]	6,484	8 [2]	11	8	15,453
2008	0	0	663	42	5	0	28	0	0	7,393 [4]	201 [2]	46 [2]	5,294	94 [2]	16	10	13,792
2009	0	0	422	16	19	16	15	2	0	8,446 [4]	204 [2]	237	3,335	210 [2]	9	60	12,990
2010	0	0	272	102	14	15	16	0	0	7,700 [4]	3 [2]	11	6,888	182 [2]	4	22	15,229
2011	0	0	538	46	80	4	7	0	234	8,270 [4]	169	21	7,053	144 [2]	36	4	16,606
2012	0	0	564	40	40	12	13	0	0	9,331 [4]	22	1	10,041	190 [2]	21	14	20,288
2013	0	6	783	168	49	22	106	1	0	10,403 [4]	30	7	10,310	196 [2]	17	75	22,173
2014	0	0	887	269	33	20	86	0	0	11,232 [2]	19	0	10,061	206 [2]	28	184	23,025
2015	0	0	312	227	33	14	53	0	5	10,874 [2]	13	1	12,953	159 [3]	25	79 [5]	24,748
2016 [1]	0	353	468	229	9	17	79	0	0	12,932 [2]	8	19	10,576	198 [4]	20	19 [6]	24,927

[1] Provisional figures.

[2] Working Group figures.

[3] USSR prior to 1991.

4 As reported to Norwegian authorities.

5 From Intercatch

Table 8.2 GREENLAND HALIBUT in Sub-areas I and II. Nominal catch (t) by countries in Sub-area I as officially reported to ICES.

Year	Estonia	Faroe Islands	Fed. Rep. Germany	France	Lithu ania	Greenland	Iceland	Ireland	Norway	Poland	Portugal	Russia[3]	Spain	UK (England & Wales)	UK (Scot land)	Total
1984	-	-	-	-	-	-	-	-	593	-	-	81	-	17	-	691
1985	-	-	-	-	-	-	-	-	602	-	-	122	-	1	-	725
1986	-	-	1	-	-	-	-	-	557	-	-	615	-	5	1	1,179
1987	-	-	2	-	-	-	-	-	984	-	-	259	-	10	+	1,255
1988	-	9	4	-	-	-	-	-	978	-	-	420	-	7	-	1,418
1989	-	-	-	-	-	-	-	-	2039	-	-	482	-	+	-	2,521
1990	-	7	-	-	-	-	-	-	1304	-	-	321 [2]	-	-	-	1,632
1991	##	-	-	-	-	-	-	-	2,029	-	-	522 [2]	-	-	-	2,715
1992	-	-	+	-	-	-	-	-	2,349	-	-	467	-	-	-	2,816
1993	-	32	-	-	-	-	56	-	1,754	-	-	867	-	-	-	2,709
1994	-	17	217	-	-	-	15	-	1,165	-	-	175	-	+	-	1,589
1995	-	12	-	-	-	-	25	-	1,352	-	-	270	84	-	-	1,743
1996	-	2	+	-	-	-	70	-	911	-	-	198	-	+	-	1,181
1997	-	15	-	-	-	-	62	-	610	-	-	170	- [2]	+	-	857
1998	-	47	+	-	-	-	23	-	859	-	-	491	- [2]	2	-	1,422
1999	-	91	-	-	-	13	7	-	1101	-	-	1203	- [2]	+	-	2,415
2000	-	-	+	-	-	-	16	-	1021	+	-	1169	- [2]	+	-	2,206
2001	-	-	-	-	-	-	9	-	925 [4]	+	-	951	- [2]	2	-	1,887
2002	-	-	3	-	-	-	+	-	834 [4]	-	-	1167	- [2]	-	-	2,004
2003	-	48	+	+	-	2	+	1	962 [4]	1	-	735	+ [2]	0.3	+	1,749
2004	-	-	-	-	-	-	0.3	-	866 [4]	- [2]	-	633	- [2]	3	-	1,503
2005	-	-	-	1	-	-	-	-	572 [4]	- [2]	-	595	- [2]	3	-	1,171
2006	-	17	1	-	-	-	1	-	575 [4]	- [2]	-	626	2 [2]	2	-	1,224
2007	-	18	+	1	-	198	3	-	514 [4]	- [2]	3	438	+ [2]	4	+	1,179
2008	-	13	-	1	-	-	5	-	599 [4]	- [2]	-	390	- [2]	-	-	1,008
2009	-	33	-	-	-	16	5	-	734 [4]	- [2]	-	483	- [2]	1	-	1,272
2010 [1]	-	15	-	-	-	-	16	-	659 [4]	-	-	708	2 [2]	-	-	1,399
2011 [1]	-	63	-	-	-	-	6	-	867 [4]	-	-	782	- [2]	-	-	1,718
2012 [1]	-	8	5	-	-	-	7	-	921 [4]	0	-	1368	1 [2]	7	-	2,318
2013	-	39	1	8	-	-	100	-	1055 [4]	4	-	1442	4 [2]	8	-	2,661
2014 [1]	-	143	8	11	-	19	38	-	1271 [2]	7	-	1261	10 [2]	14	-	2,782
2015 [1]	-	96	14 [5]	3	[5]	12	47	-	1424	5	-	1681	8	4	-	3,299
2016	##	84	2	3		3	38		1265	7		1172	7	20		
													8			

[1] Provisional figures.

[2] Working Group figures.

[3] USSR prior to 1991.

4 As reported to Norwegian authorities.

[5] From Intercatch

Table 8.3 GREENLAND HALIBUT in Sub areas I and II. Nominal catch (t) by countries in Division IIa as officially reported to ICES.

Year	Estonia	Faroe Islands	Fed. Rep. Germ.	France	Green-land	Ire-land	Iceland	Norway	Poland	Portu-gal	Russia[5]	Spain	UK (Engl. & Wales)	UK (Scot-land)	Total
1984		-	265	138	-	-	-	3,703	-	-	5,459	-	1	-	9,566
1985		-	254	239	-	-	-	4,791	-	-	6,894	-	2	-	12,180
1986		6	97	13	-	-	-	6,389	-	-	5,553	-	5	1	12,064
1987		-	75	13	-	-	-	5,705	-	-	4,739	-	44	10	10,586
1988		177	150	67	-	-	-	7,859	-	-	4,002	-	56	2	12,313
1989		67	104	31	-	-	-	8,050	-	-	4,964	-	6	-	13,222
1990		133	12	49	-	-	-	8,233	-	-	1,246 [2]	-	1	-	9,674
1991	1,400	314	21	119	-	-	-	11,189	-	-	305 [2]	-	+	1	13,349
1992	-	16	1	108	13 [4]	-	-	3,586	-	15 [3]	58	-	1	-	3,798
1993	-	29	14	78	8 [4]	-	-	7,977	-	17	210	-	2	-	8,335
1994	-	-	33	47	3 [4]	4	-	6,382	-	26	67	+	14	-	6,576
1995	-	-	30	174	12 [4]	2	-	6,354	-	60	227	-	83	2	6,944
1996	-	-	34	219	123 [4]	-	-	9,508	-	55	466	4	278	57	10,744
1997	-	-	23	253	- [4]	-	-	5,702	-	41	334	1 [2]	21	25	6,400
1998	-	-	16	67	- [4]	1	-	6,661	-	80	530	5 [2]	74	41	7,475
1999	-	-	20	-	25 [4]	2	-	13,064	-	33	734	1 [2]	63	45	13,987
2000	-	-	10	43	[4]	+	-	7,536	-	18	690	1 [2]	65	43	8,406
2001	-	-	49	122	[4]	1	9	8,740 [2]	-	13	726	5 [2]	56	30	9,751
2002	-	-	9	7	22 [4]	-	4	5,877 [2]	-	3	849	- [2]	12	28	6,811
2003	-	390	5	2	12	+	+	6,713 [2]	+	10	1762	14 [2]	5	58	8,971
2004	-	-	4	-	-	-	9	11,704 [2]	- [2]	24	810	4 [2]	1	-	12,556
2005	-	-	3	31	-	-	-	11,216 [3]	- [2]	11	1406	+ [2]	5	18	12,690
2006	-	175	-	38	-	-	7	8,897 [3]	- [2]	6	950	- [2]	6	2	10,081
2007	-	162	2	37	+	+	12	6,761 [3]	- [2]	2	489	1 [2]	2	8	7,475
2008	-	646	4	38	-	-	23	5,566 [3]	1 [2]	1	1170	- [2]	6	10	7,465
2009	-	379	0	13	-	-	10	6,456 [3]	- [2]	9	1531	+ [2]	0	60	8,459
2010	-	255	-	102	15	-	-	6426 [3]	-	0	4757	+ [2]	-	22	11577
2011 [1]	-	467	-	45	4	-	1	6637 [3]	-	-	3643	2 [2]	0	4	10803
2012 [1]	-	553	-	37	12	-	6	7934 [3]	-	0	3878	+ [2]	-	14	12434
2013	-	739		150	22	-	6	8,215 [3]	-	2	4143	+ [2]	-	75	13352
2014 [1]	-	741		255	1	-	48	8,640 [2]	-	-	4800	+ [2]	-	184	14669
2015 [1]	-	215	2 [5]	221 [5]	2	-	6	8166.4	+	1	3691	-	-	79	12383
2016	6	380	6	216	14		41	10073		6	1797	7		19	12566
													19		

[1] Provisional figures.

[2] Working Group figure.

[3] As reported to Norwegian authorities.

[4] Includes Division IIb.

[5] USSR prior to 1991.

[5.] From Intercatch

Table 8.4 GREENLAND HALIBUT in Sub-areas I and II. Nominal catch (t) by countries in Division IIb as officially reported to ICES:

Year	Den mark	Estonia	Faroe Islands	France	Fed. rep. Germ.	Ireland	Lithuania	Norway	Poland	Portugal	Russia[4]	Spain	UK (Engl. & Wales)	UK (Scot land)	Total
1984	-	-	-	-	1,900	-	-	80	-	-	9,641	-	5	-	11,626
1985	-	-	-	-	3,746	-	-	71	-	-	3,221	-	2	-	7,040
1986	-	-	36	-	2,620	-	-	944	-	-	6,032	-	+	-	9,632
1987	+	-	-	-	1,947	-	-	572	-	-	4,735	-	7	10	7,271
1988	-	-	-	-	590	-	-	239	-	-	5,008	-	19	+	5,856
1989	-	-	-	-	496	-	-	533	-	-	3,366	-	-	-	4,395
1990	-	-	23[2]	-	942	-	-	7,706	-	-	3,197[2]	-	9	-	11,877
1991	11	1,000	-	-	80	-	-	14,369	-	-	1,663[2]	132	+	1	17,256
1992	-	-	-	3[2]	12	-	-	1,732	-	16	193	23	9	-	1,988
1993	2[3]	-	-	2[3]	8	-	30[3]	649	-	26	158	-	14	-	889
1994	4	-	1[3]	8[3]	46	1	4[3]	881	-	10	41	1	62	2	1,061
1995	-	-	-	-	5	-	-	1,662	-	24	297	1022	32	5	3,047
1996	+	-	-	-	47	-	-	1,204	-	24	912	196	39	+	2,422
1997	-	-	12	-	33	2	-	1,349	12	9	534	156[2]	46	+	2,153
1998	-	-	10	-	18	1	-	915	31	19	1,638	254[2]	106	4	2,996
1999	-	-	3	-	14	-	-	839	8	16	1,886	318[2]	31	-	3,115
2000	-	-	-	2	5	1	-	526	3	19	2,709	374[2]	46	-	3,685
2001	-	-	-	-	9	-	-	1,231[2]	2	22	3,017	413[2]	42	-	4,736
2002	-	219	-	-	30	6	-	432[2]	5	11	3,568	178[2]	29	-	4,478
2003	+	+	21	-	13	-	-	541[2]	4	9	1,887	216[2]	35	+	2,726
2004	-	-	-	-	5	-	-	1,369[2]	1[2]	26	3,219	182[2]	39	-	4,840
2005	-	170	-	-	5	-	-	1,223[3]	-[2]	12	2,882	660[2]	21	-	4,973
2006	-	-	12	8	7	-	196	1,647[3]	201[2]	20	4,479	27[2]	2	-	6,600
2007	-	-	23	3	6	0	-	955[3]	##[2]	45	5,557	7[2]	5	+	6,801
2008	-	-	4	3	1	-	-	1,228[3]	##	45	3734	94[2]	10	-	5,319
2009	-	-	10	3	19	2	-	1,256[3]	##	228	1321	210[2]	8	-	3,260
2010	-	-	2	-	14	-	-	615[3]	3	11	1423	180[2]	4	-	2,252
2011[1]	-	-	8	1	80	-	234	766[3]	169	21	2628	142[2]	36	-	4,085
2012[1]	-	-	2	3	35	0	-	476[3]	22	1	4795	189[2]	14	-	5,537
2013	-	-	5	10	48	1	-	1,133[3]	26	5	4725	192[2]	9	-	6,154
2014[1]	-	-	3	3	25	-	-	1,321[3]	12	-	4000	196[2]	14	-	5,574
2015[1]	-	-	1	3[5]	17[5]	-	-	1,284[3]	8	-	7581	151	21	-	9,066
2016	2		4	10	1			1,594	1	13	7608	183			9,416

[1] Provisional figures.

[2] Working Group figure.

[3] As reported to Norwegian authorities.

[4] USSR prior to 1991.

[5.] From Intercatch

Table 8.5 GREENLAND HALIBUT in Sub-areas I and II. Landings by gear (tonnes). Approximate figures, the total maty differ slightly from Table 8.1

Year	Gillnet	Longline	Trawl	Danish seine	Other	Total
1980	1,189	336	11,759			13,284
1981	730	459	13,829			15,018
1982	748	679	15,362			16,789
1983	1,648	1,388	19,111			22,147
1984	1,200	1,453	19,230			21,883
1985	1,668	750	17,527			19,945
1986	1,677	497	20,701			22,875
1987	2,239	588	16,285			19,112
1988	2,815	838	15,934			19,587
1989	1,342	197	18,599			20,138
1990	1,372	1,491	20,325			23,188
1991	1,904	4,552	26,864			33,320
1992	1,679	1,787	5,787			9,253
1993	1,497	2,493	7,889			11,879
1994	1,403	2,392	5,353			9,148
1995	1,500	4,034	5,494			11,028
1996	1,480	4,616	7,977			14,073
1997	998	3,378	5,198			9,574
1998	1,327	7,395	6,664			15,386
1999	2,565	6,804	10,177			19,546
2000	1,707	5,029	7,700			14,437
2001	2,041	6,303	7,968			16,312
2002	1,737	5,309	6,115			13,161
2003	2,046	5,483	6,049			13,578
2004	2,290	7,135	8,778	599		18,800
2005	1,842	7,539	9,420	447		19,248
2006	1,503	6,146	10,042	205		17,896
2007	997	4,503	9,618	119		15,237
2008	901	3,575	9,285	9	8	13,777
2009	1,409	4,952	6,583	34	18	12,996
2010	1,449	5,427	8,165	170	10	15,221
2011	1,583	5,039	9,351	239	15	16,228
2012	1,929	5,602	12,130	413	5	20,079
2013	2,398	5,805	13,797	176		22,176
2014	2,647	6,166	13,673	183		22,669
2015	2,508	6,287	15,445	489	18	24,748
2016	2,371	7,290	14,312	650	304	24,927

Table 8.6. GREENLAND HALIBUT in Sub-areas I and II. Catch per unit effort and total effort

Year	USSR catch/hour trawling (t)		Norway[10] catch/hour trawling (t)		Average CPUE		Total effort (in '000 hrs trawling)[5]	CPUE 7+[6]	GDR[7] (catch/day tonnage (kg)
	RT[1]	PST[2]	A[8]	B[9]	A[3]	B[4]			
1965	0.80	-	-	-	0.80	-	-	-	-
1966	0.77	-	-	-	0.77	-	-	-	-
1967	0.70	-	-	-	0.70	-	-	-	-
1968	0.65	-	-	-	0.65	-	-	-	-
1969	0.53	-	-	-	0.53	-	-	-	-
1970	0.53	-	-	-	0.53	-	169	0.50	-
1971	0.46	-	-	-	0.46	-	172	0.43	-
1972	0.37	-	-	-	0.37	-	116	0.33	-
1973	0.37	-	0.34	-	0.36	-	83	0.36	-
1974	0.40	-	0.36	-	0.38	-	100	0.36	-
1975	0.39	0.51	0.38	-	0.39	0.45	99	0.37	-
1976	0.40	0.56	0.33	-	0.37	0.45	100	0.34	-
1977	0.27	0.41	0.33	-	0.30	0.37	96	0.26	-
1978	0.21	0.32	0.21	-	0.21	0.27	123	0.17	-
1979	0.23	0.35	0.28	-	0.26	0.32	67	0.19	-
1980	0.24	0.33	0.32	-	0.28	0.33	47	0.25	-
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	-	-	-	-	-
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), 1,000 hp. From 1997 based on research fishing.
[2] Stern trawlers, up to 2,000 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	10311	4088	17312
1936	830	n/a		830	1980	3157	7670	2457	13284
1937	616	n/a		616	1981	4201	9276	1541	15018
1938	329	n/a		329	1982	3206	12394	1189	16789
1939	459	n/a		459	1983	4883	15152	2112	22147
1940	846	n/a		846	1984	4376	15181	2326	21883
1941	1663	n/a		1663	1985	5464	10237	4244	19945
1942	955	n/a		955	1986	7890	12200	2785	22875
1943	824	n/a		824	1987	7261	9733	2118	19112
1944	678	n/a		678	1988	9076	9430	1081	19587
1945	1148	n/a		1148	1989	10622	8812	704	20138
1946	1337	25		1362	1990	17243	4764	1176	23183
1947	1409	28		1437	1991	27587	2490	3243	33320
1948	1877	110		1987	1992	7667	718	217	8602
1949	198	177		375	1993	10380	1235	318	11933
1950	1853	221		2074	1994	8428	283	515	9226
1951	2438	423		2861	1995	9368	794	1572	11734
1952	2576	377		2953	1996	11623	1576	1148	14347
1953	2208	393		2601	1997	7661	1038	711	9410
1954	3674	416		4090	1998	8435	2659	799	11893
1955	3010	290		3300	1999	15004	3823	690	19517
1956	3493	446		3939	2000	9083	4568	646	14297
1957	4130	505		4635	2001	10896	4694	775	16365
1958	2931	1261		4192	2002	7143	5584	566	13293
1959	4307	3632		7939	2003	8216	4384	847	13447
1960	6662	4299		10961	2004	13939	4662	298	18899
1961	7977	3836		11813	2005	13011	4883	940	18834
1962	11600	1760		13360	2006	11119	6055	730	17904
1963	11300	3240		14540	2007	8230	6484	739	15453
1964	14200	26191		40391	2008	7393	5294	1105	13792
1965	18000	16682		34751	2009	8446	3335	1210	12990
1966	16434	9768	119	26321	2010	7700	6888	641	15229
1967	17528	5737	1002	24267	2011	8270	7053	1283	16606
1968	22514	3397	257	26168	2012	9331	10041	916	20288
1969	14856	19760	9173	43789	2013	10403	10310	1460	22173
1970	15871	35578	38035	89484	2014	11232	10061	1732	23025
1971	9466	54339	15229	79034	2015	10874	12953	921	24748
1972	15983	16193	10872	43055	2016	12932	10576	1419	24927
1973	13989	8561	7349	29938					
1974	8791	16958	11972	37763					
1975	4858	20372	12914	38172					
1976	6005	16580	13469	36074					
1977	4217	15045	9613	28827					
1978	4082	14651	5884	24617					

Table 8.8. GREENLAND HALIBUT in ICES Subarea 4.a (North Sea). Nominal catch (t) by countrues as officially reported to ICES. Not included in the assessment.

Year	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Russia	UK England & Wales	UK Scotland	Total
1973	-	-	-	4	-	-	9	8	28	-	49
1974	-	-	-	2	-	-	2	-	30	-	34
1975	-	-	-	1	-	-	4	-	12	-	17
1976	-	-	-	1	-	-	2	-	18	-	21
1977	-	-	-	2	-	-	2	-	8	-	12
1978	-	-	2	30	-	-	-	-	1	-	33
1979	-	-	2	16	-	-	2	-	1	-	21
1980	-	177	-	34	-	-	5	-	-	-	216
1981	-	-	-	-	-	-	7	-	-	-	7
1982	-	-	2	26	-	-	17	-	-	-	45
1983	-	-	1	64	-	-	89	-	-	-	154
1984	-	-	3	50	-	-	32	-	-	-	85
1985	-	1	2	49	-	-	12	-	-	-	64
1986	-	-	30	2	-	-	34	-	-	-	66
1987	-	28	16	1	-	-	35	-	-	-	80
1988	-	71	62	3	-	-	19	-	1	-	156
1989	-	21	14	1	-	-	197	-	5	-	238
1990	-	10	30	3	-	-	29	-	4	-	76
1991	-	48	291	1	-	-	216	-	2	-	558
1992	1	15	416	3	-	-	626	-	+	1	1062
1993	1	-	78	1	-	-	858	-	10	+	948
1994	+	103	84	4	-	-	724	-	6	-	921
1995	+	706	165	2	-	-	460	-	52	283	1668
1996	+	-	249	1	-	-	1496	-	105	159	514
1997	+	-	316	3	-	-	873	-	1	162	1355
1998	+	-	71	10	-	10	804	-	35	435	1365
1999	+	-		1	-	18	2 157	-	43	358	420
2000	+		41	10	-	19	498	-	67	192	827
2001	+		43	-	-	10	470	-	122	202	847
2002	+		8	+	-	2	200	-	10	246	466
2003	-	-	1	+	+	+	453	-	+	122	576
2004	-	-	-	-	-	-	413	-	90	-	503
2005	-	-	2	-	-	-	58	-	4	-	64
2006	-	-	3	-	-	-	90	-	-	7	100
2007	-	1	-	-	-	-	133	-	1	6	141
2008	-	-	-	-	-	-	14	-	-	22	36
2009	-	9	22	-	-	-	5	-	-	129	165
2010	+	1	38	-	-	-	10	-	-	49	98
2011	-	1	39	-	-	-	94	-	-	44	178
2012	-	-	14	-	-	-	788	-	-	43	845
2013	-	-	25	-	-	-	122	-	-	174	321
2014	-	2	27	-	-	-	723	-		104	856
2015	-	-	34	1	-	-	1151	-	-	127	1313
2016	-	-	31		-	-	983	-	-	120	1134

Table 8.9. Greenland halibut in Subareas I and II. The catch options. Weights in thousand tonnes. Catches in 2017 assumed to be 25kt

Rationale	Catches (2018)	Basis (multiple of 2015–2016 effort)	Harvest rate 2018–2021	Mean catch 2018–2021	Biomass 45cm+ 1st January 2022	% 45cm+ Biomass change 2018–2022
Precautionary approach	20.7	*0.90	0.035	19.72	532	−20%
Zero catch	0	0	0	0	602	-10%
	11.6	*0.50	0.023	16.6	562	-16%
	17.3	*0.75	0.031	19.7	543	-18%
Status quo F	23.0	*1.00	0.039	21.8	525	-21%
	34.3	*1.50	0.054	31.5	490	-26%
	45.4	*2.00	0.069	40.7	458	-31%
	67.2	*3.00	0.098	57.1	401	-40%

Table F1. Abundance indices of different length groups in 1984-2014 (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	11690	21171	15167	10886	7370	6549	3751	1786	1128	483	89 896
1985	4003	6748	16858	24897	23244	15702	8376	5704	3776	2054	1028	698	113 088
1986	3482	6062	13765	18945	15997	10369	4839	3022	2534	1325	440	205	80 985
1987	2010	4828	7228	10490	8831	5513	2123	1784	1437	645	481	421	45 791
1988	3374	5111	9022	10147	10128	5828	2265	1862	1218	511	361	341	50 168
1989	2030	7055	13962	17252	16790	10028	3789	1916	1279	415	200	388	75 104
1990	2762	6056	12802	13061	9527	9829	4967	2094	589	312	115	119	62 233
1991	1036	5012	16237	20998	17418	11728	8012	4562	814	181	122	174	86 294
1992	184	2153	17185	32399	22481	12977	6229	3473	1869	502	182	106	99 740
1993	-	290	3593	14782	21080	16013	6743	3341	2031	859	269	164	69 165
1994	49	17	1651	12582	16203	12566	5391	3320	2019	819	188	106	54 911
1995	-	38	1245	13193	20571	12445	5432	2717	1587	579	187	82	58 076
1996*	-	11	786	13012	30573	18294	5730	1795	773	534	169	12	71 689
1997	140	152	1318	7744	18504	17221	6932	3079	1952	465	195	142	57 844
1998	2449	2238	2949	10847	24266	19640	11112	5946	2158	440	172	90	82 307
1999	1070	2815	4632	7886	17734	18489	10158	4827	2043	529	196	74	70 453
2000	1274	1698	5184	14996	24170	20721	12805	5675	3100	1228	240	143	91 234
2001	1399	2887	7496	18136	34752	29886	13463	6759	3772	1511	593	369	121 024
2002**	662	2033	6395	13329	19810	13135	7180	3406	1311	381	129	58	67 828
2003***	955	2396	7420	13006	17160	11630	7978	5332	3541	985	485	238	71 126
2004	1431	2705	11945	16937	20155	18274	12594	6948	4783	2087	813	536	99 209

2005	830	3970	10726	17850	17547	15164	9726	5859	3343	1150	453	545	87 163
2006****	293	1981	18471	35224	36563	26335	14138	7248	4943	1669	668	488	148 021
2007	376	1431	6937	24330	26780	26086	22157	15586	7480	3786	932	628	136 510
2008	463	4626	19991	28799	30062	32159	23175	11326	8368	4198	1872	1089	166 129
2009	152	4919	29389	48321	45833	33915	24484	10227	6568	3032	881	616	208 338
2010	146	5097	37901	66086	57863	46321	25428	10058	8612	3983	1587	1610	264 692
2011	456	1285	22470	61115	78247	64186	49620	19412	11607	7226	3529	874	320 025
2012	213	798	12051	49062	56704	52393	36362	13622	7533	4213	1944	1611	236 506
2013*****													
2014	17	1697	10296	34074	45287	35861	22621	8613	5505	2227	929	427	167 553
2015	318	2099	13542	35864	43551	36082	21114	10924	4472	1342	850	339	170 497
2016*****													

*** 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 F2. Abundance indices of different length groups in 1994–2015 (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

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

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

***Biennial surveys since 2009**

Table F3. Abundance indices of females of different length in 1996–2015 (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
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

***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
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

***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
2015	205	89	78	73	141	53	286	22 019

***Biennial surveys since 2009**

Table F4. Abundance indices (numbers in thousands) from bottom trawl surveys in the Barents Sea standard area winter 1994-2016 (recalculated using StoX software, see Mehl et al 2017; Fisken og Havet; nr 10/2016).

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	
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
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	313	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	35 539

[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 F5. 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.

Autumn survey

Year	Catch (Kg)	Catch (numbers)	Biomass™	Abundance ('000)
1997	195056	211533	344014	379444
1998	180974	187259	351466	373149
1999	198781	172687	436956	377792
2000	169389	140355	340619	291265
2001	152681	129289	283511	249219
2002	144335	115213	256460	207466
2003	151952	132117	283644	256327
2004	153859	135631	320485	283965
2005	144573	134566	317320	313459
2006*				
2007*				
2008	91573	101578	129221**	144561**
2009*				
2010	167862	182464	191510**	216731**
2011*				
2012	178607	174670	336543**	339697**
2013	172762	168619	264101**	267548**
2014	175553	160557	321485**	307679**
2016	176015	142413	247644**	214778**

***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	96797	109515	38406	38951
2009	200299	222018	58273	65464
2010*				
2011	136610	160566	98142	117666
2012*				
2013*				
2014*				
2015**	111425	105385	150385	155333

***No survey**

****Different from the one used during the 2014 Spanish "autumn" survey**

Table F6. 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	
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	

Year	cpue	NOR	RUS	ECO
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

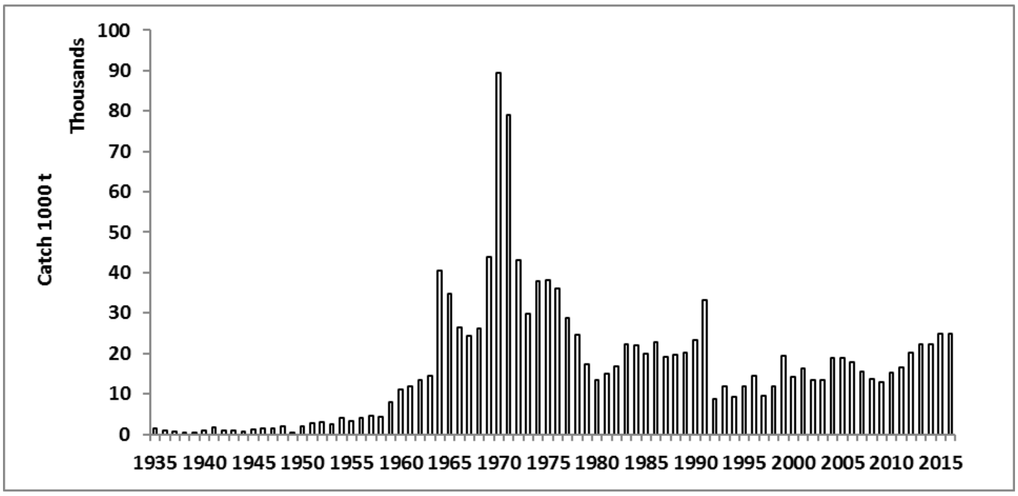


Figure 8.1. NEA Greenland halibut. Historical landings (Nedreaas and Smirnov 2003, AFWG).

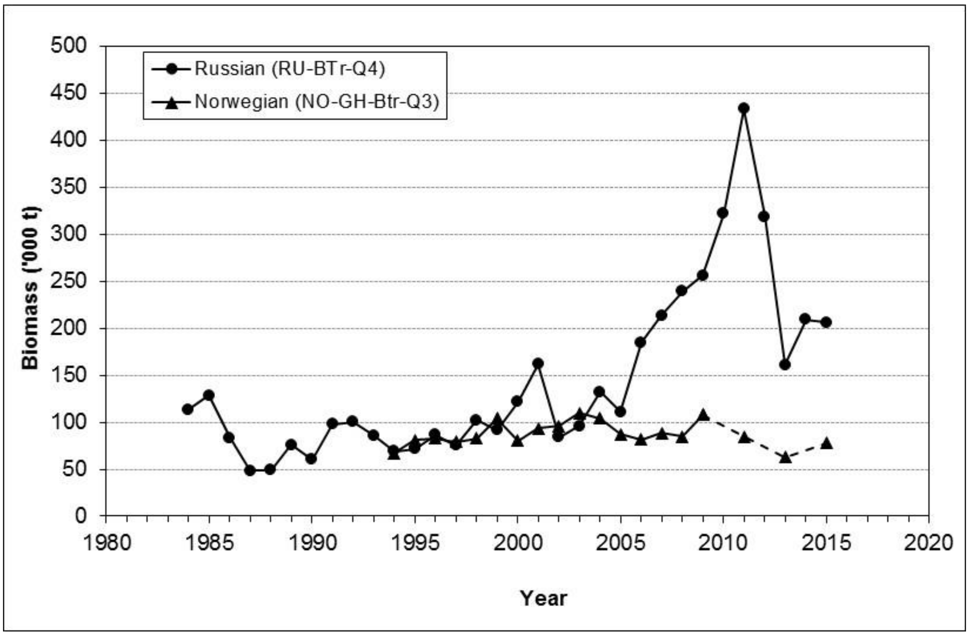


Figure 8.2. NEA Greenland halibut. Total biomass estimates from Russian autumn and the Norwegian slope survey. The Norwegian survey is run every other year since 2009. Uncertain estimate for 2013 from the Russian survey.

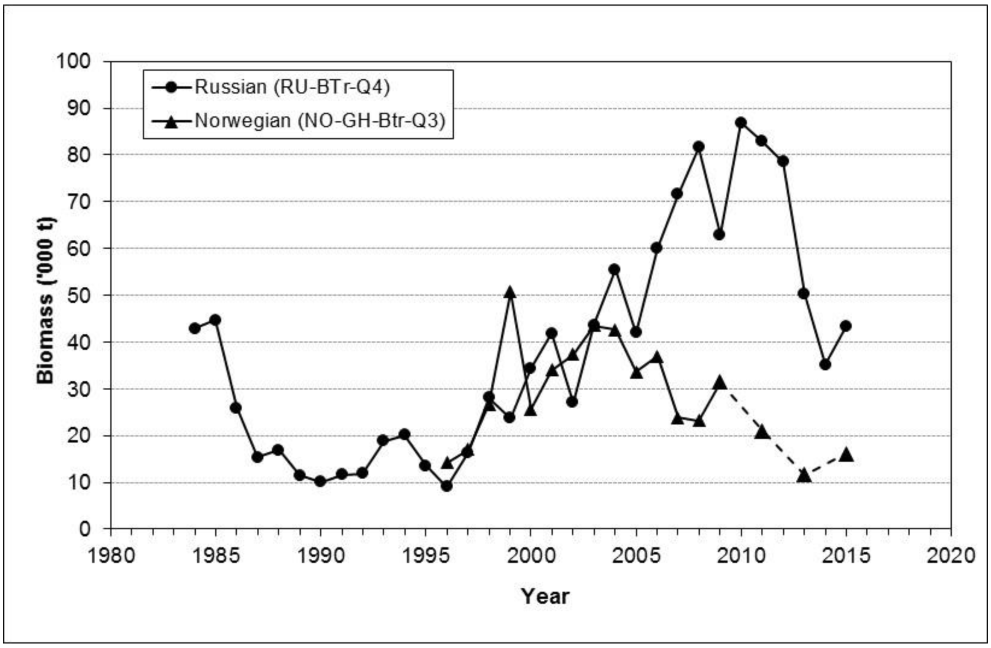


Figure 8.3. NEA Greenland halibut. Swept-area estimate of the mature female biomass based on the data from the Norwegian Greenland halibut survey along the continental slope in August (every other year since 2009) and Russian trawl survey in October-December (compared to previous reports, 2007-2008 recalculated using complete data for these years). Uncertain estimate for 2013 from the Russian survey.

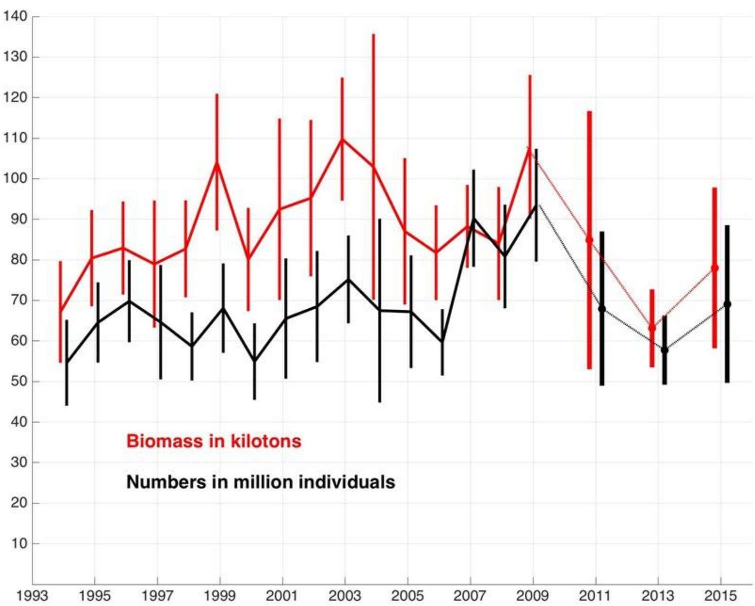


Figure 8.4 Estimated Greenland halibut total abundance in biomass and by number of individuals from the Norwegian slope surveys 1994-2013. The vertical bars show 95% confidence intervals.

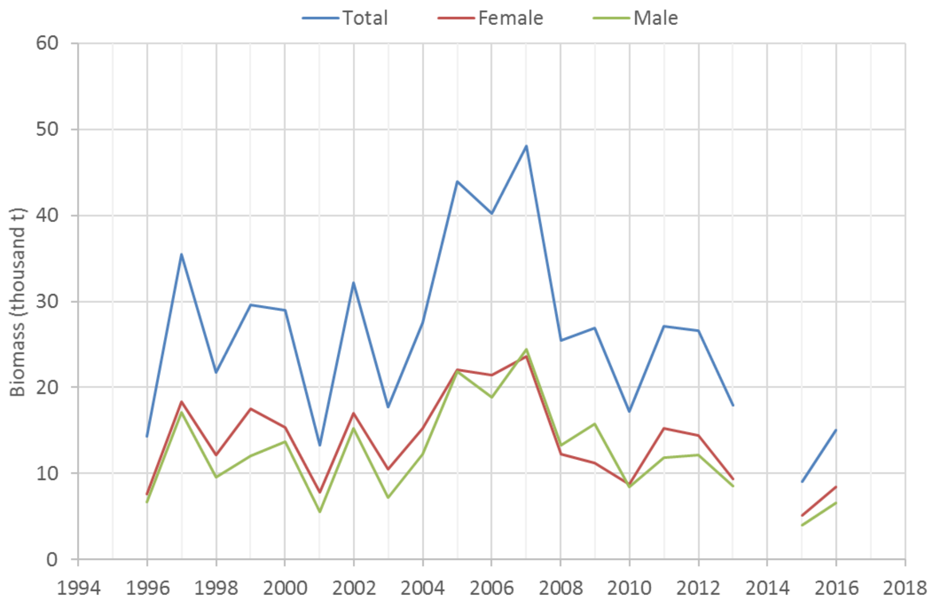


Figure 8.5. Juvenile biomass index (Eco-juv) in total and by sex for Greenland halibut based on the Barents Sea Ecosystem Survey 2003 – 2016 (2014 not included due to poor survey coverage in the juvenile area) and the juvenile survey 1996-2001 (for area se Hallfredsson and Vollen AFWG 2015; WD20).

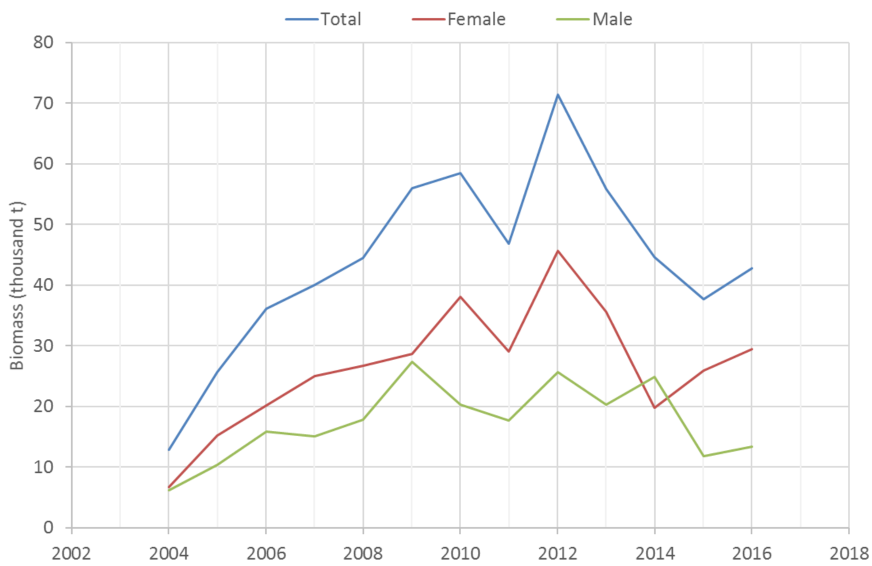


Figure.8.6 Eco-south biomass index in total and by sex for Greenland halibut in the Barents Sea Ecosystem Survey 2004 – 2014, outside the juvenile area (for area se Hallfredsson and Vollen AFWG 2015; WD20).

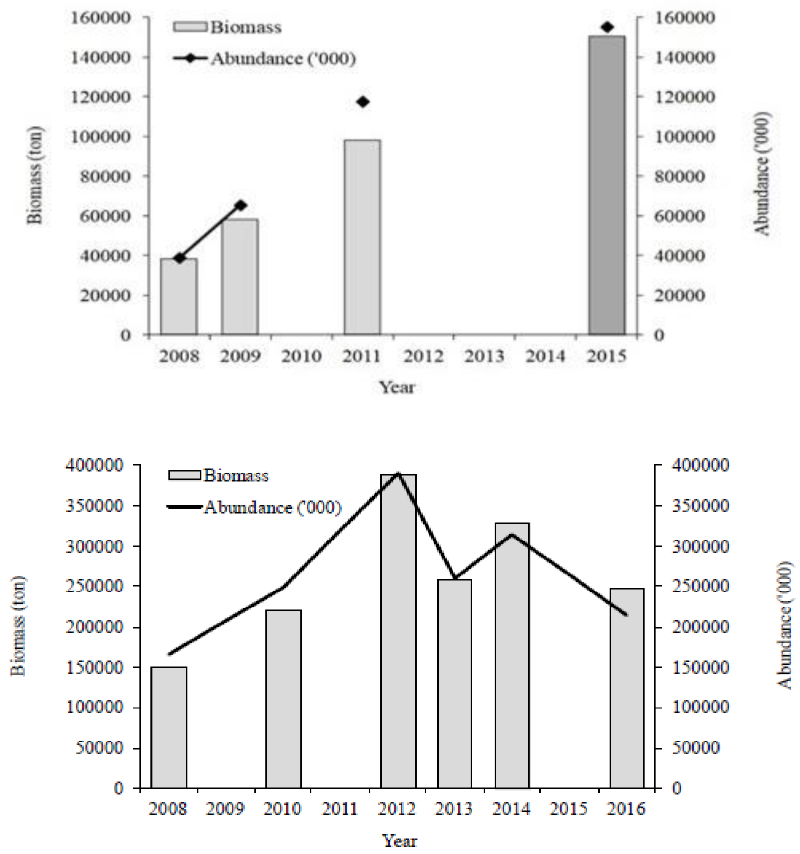


Figure 8.7. Abundance and biomass estimates from Spanish 2008, 2010, 2012, 2013, 2014 and 2016 autumn surveys (lower panel) (Muñoz et al WD7 AFWG 2017), and abundance and biomass estimates from Spanish 2008, 2009, 2011 and 2015 spring surveys (upper panel) (Muñoz et al WD 10 AFWG 2016).

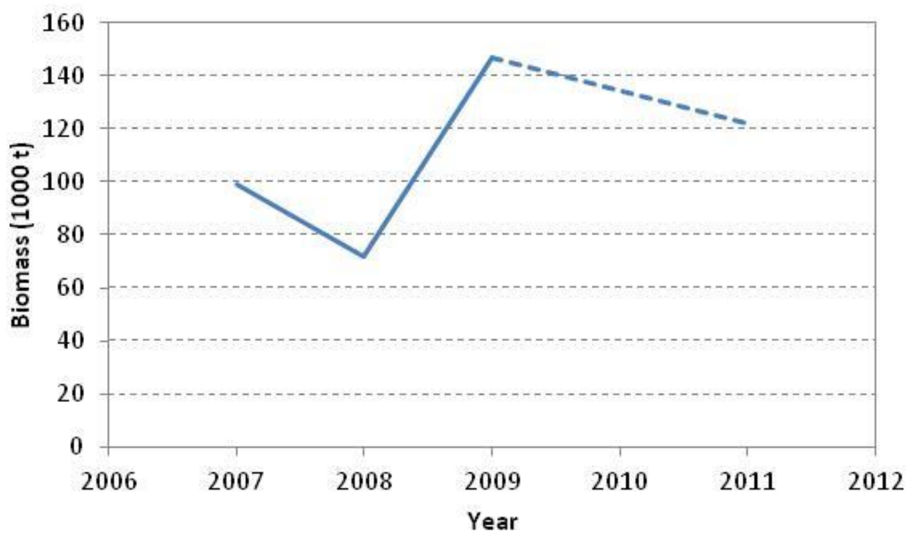


Figure 8.8. Biomass estimates from Polish 2007, 2008, 2009 and 2011 spring survey (based on: Janusz and Trella ICES AFWG WD 2008, Janusz and Trella ICES AFWG WD10 2009, Janusz and Trella ICES AFWG WD 2010, Trella and Janusz, ICES AFWG WD6 2012).

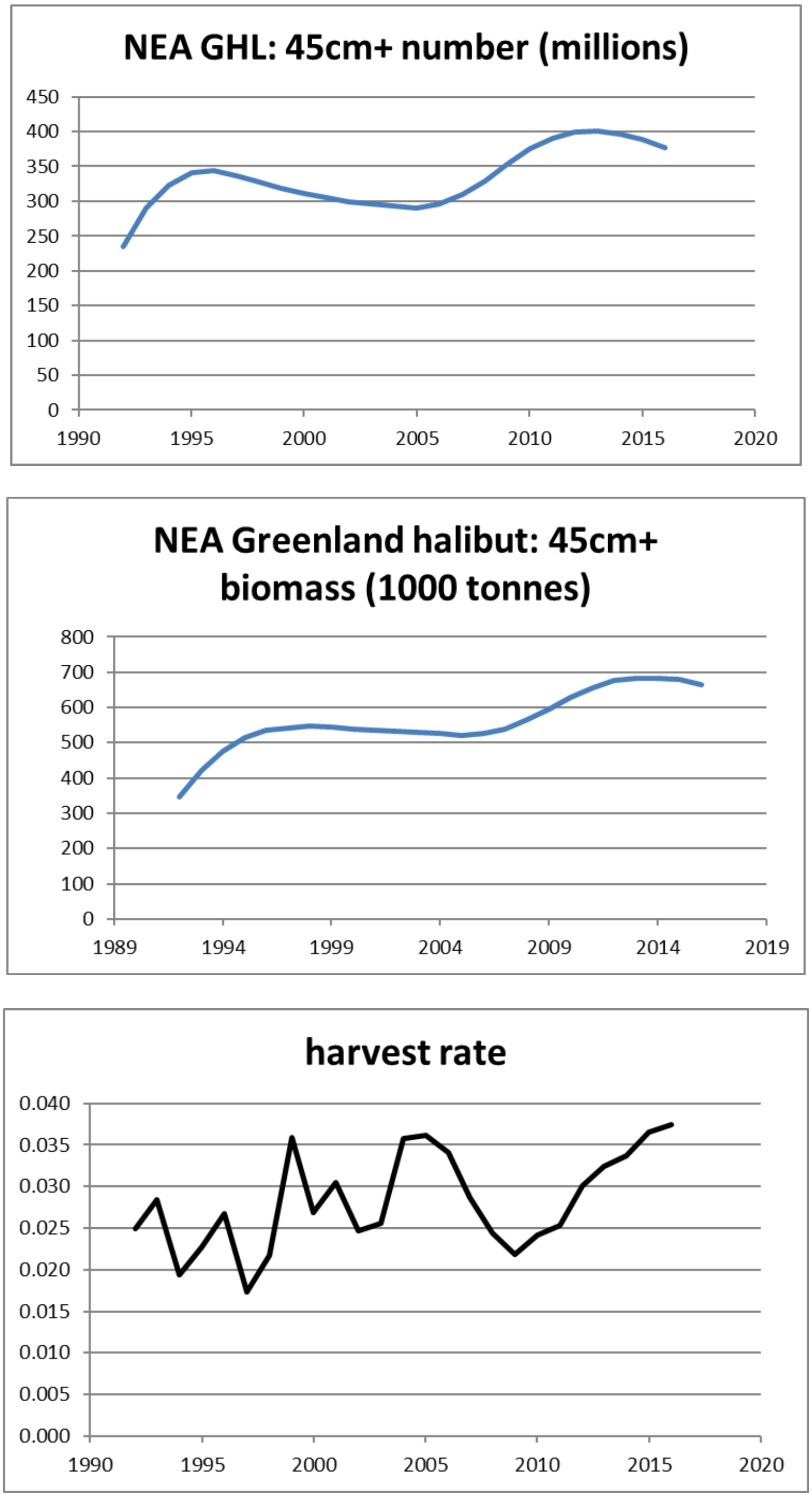


Figure 8.9. Numbers (upper) and biomass (middle) for 45+ cm Greenland halibut as estimated by the GATGET model, and estimated exploitation rates (below).

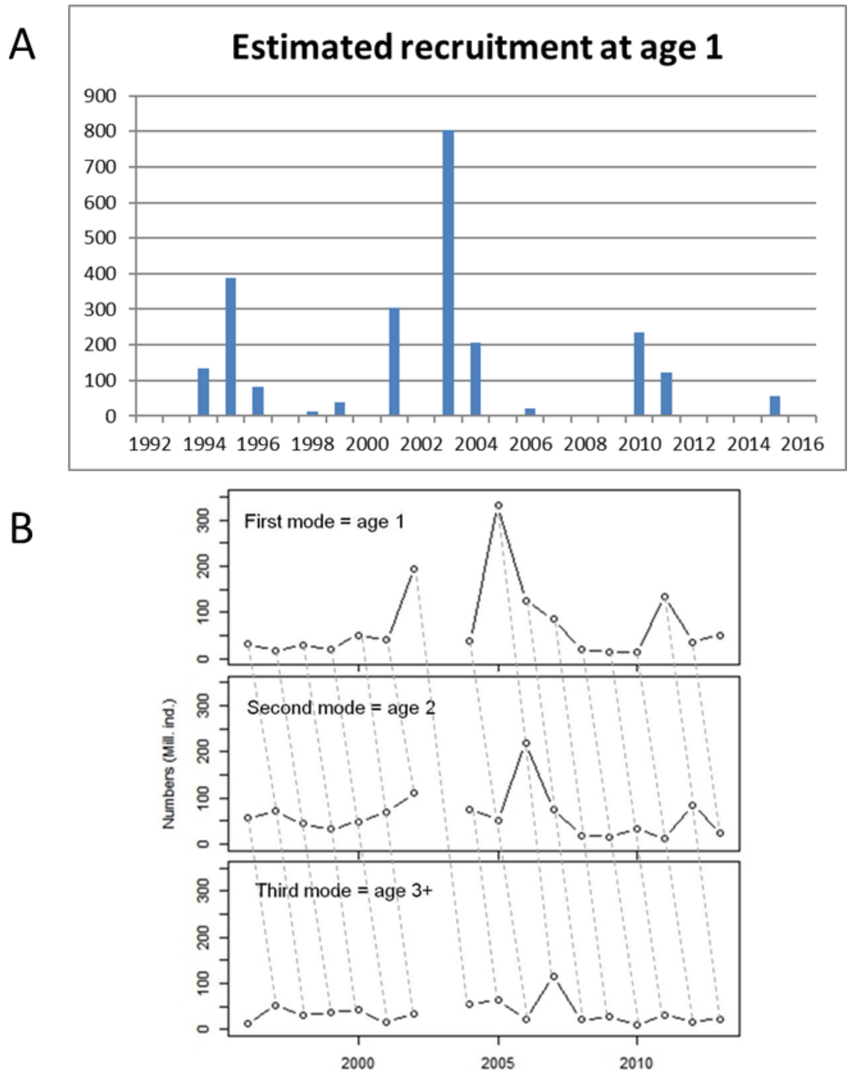


Figure 8.10. Gadget recruitment estimate (in millions) for the Greenland Halibut stock at 1st January (A). Note that the most recent year(s) of recruitment are tuned by very few data and should be considered tentative. Also (B), estimated juvenile abundance by year based on mixt model analysis of data in the nursery area as covered by the Joint Barents Sea Ecosystem survey and previous juvenile survey 1996–2013 (2003 missing).

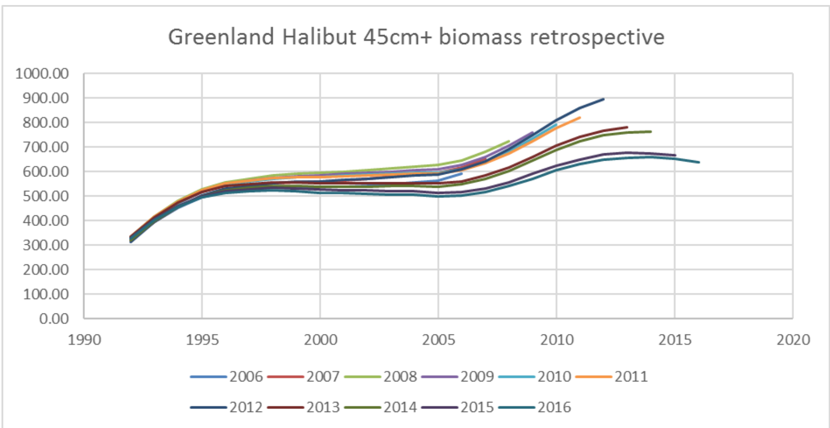


Figure 8.11. Retrospective patterns from the GADGET model run.

A

B

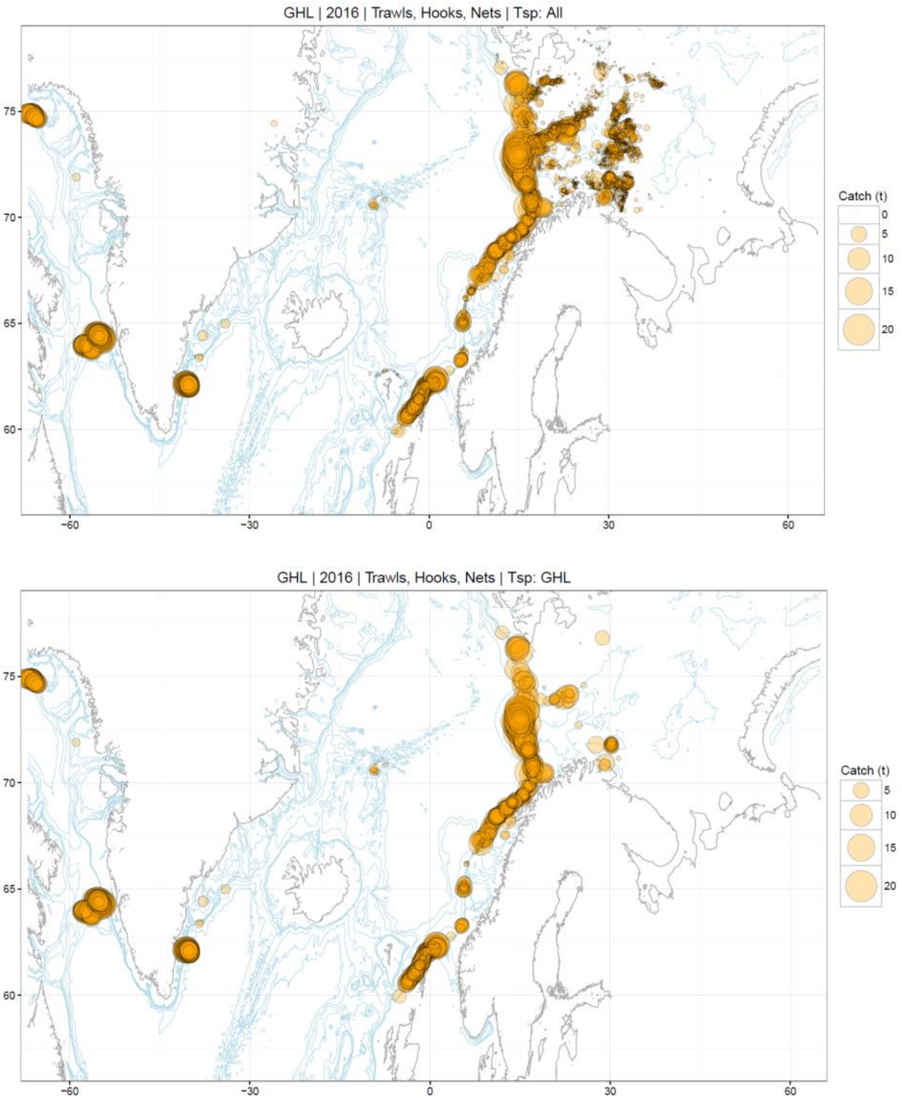


Figure F1. Distribution of Norwegian fisheries 2016 according to logbooks. Bubble area is proportional to size of single catches. Upper panel (A) shows Greenland halibut catches in all registered fisheries (includes bycatch), and lower panel (B) shows catches where Greenland halibut contribute more than 50% to single catches.

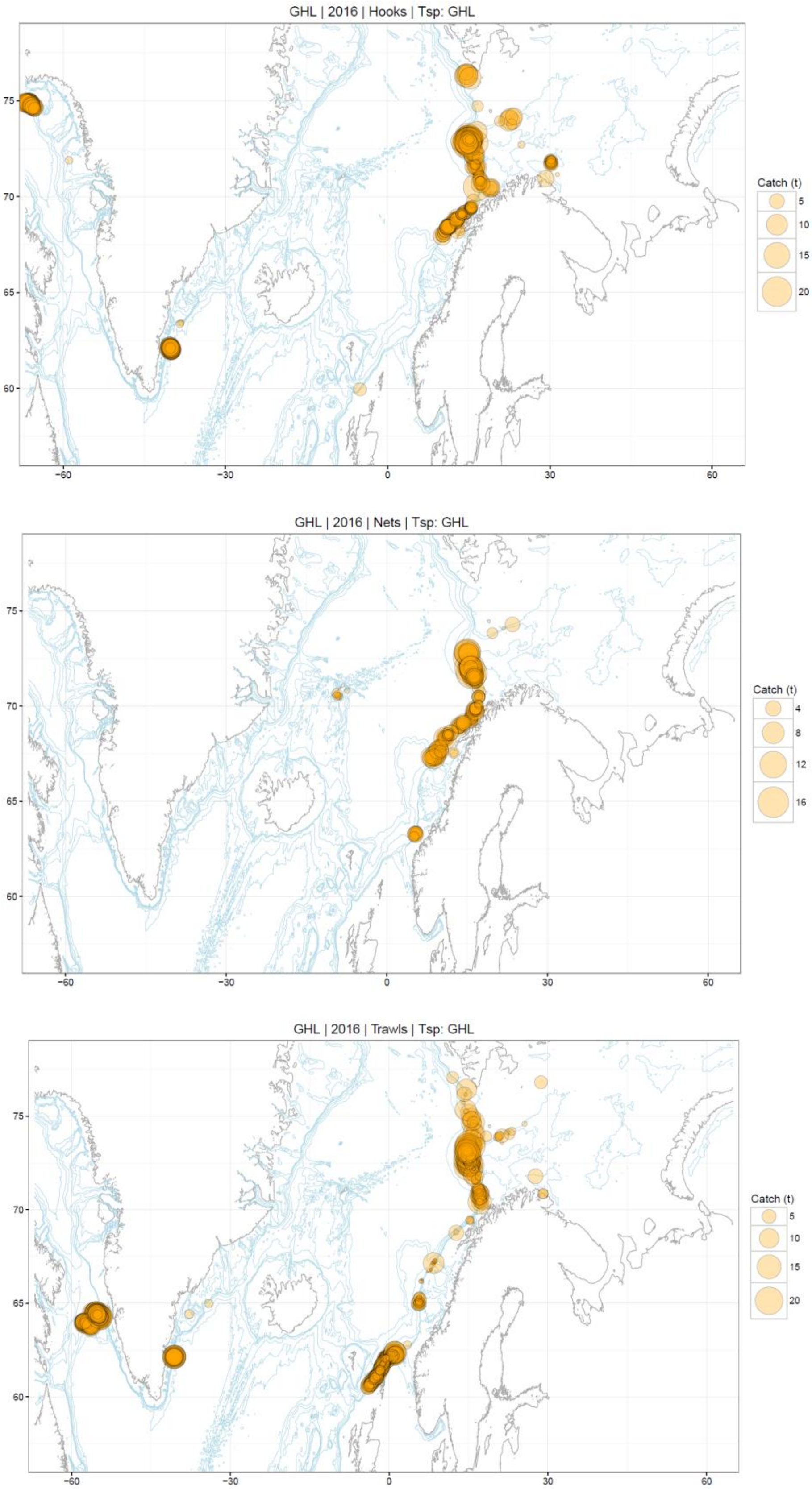


Figure F2. Distribution of Norwegian fisheries 2016 according to logbooks, where Greenland halibut contribute more than 50% to single catches. Bubble area is proportional to size of single catches. Uppermost, middle and lowest panel show longline, gillnet and trawl catches, respectively.

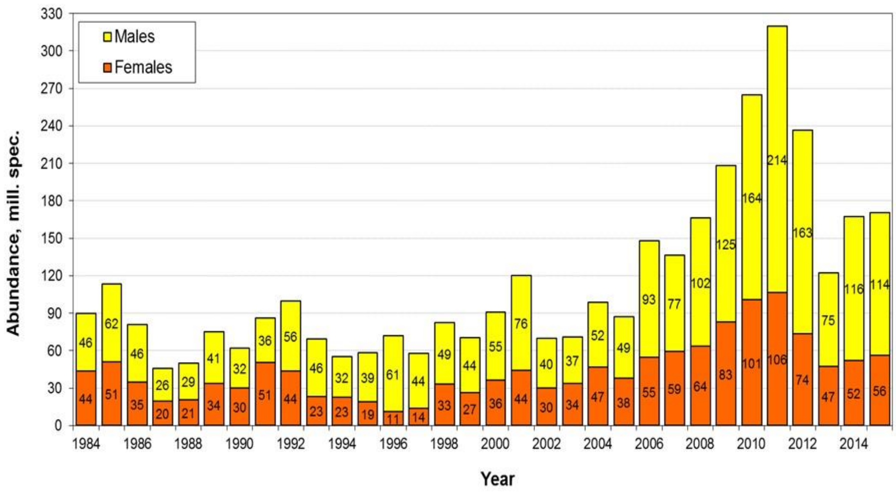


Figure F3. Russian autumn survey; Greenland halibut abundance by sex (Russkikh and Smirnov WD AFWG 2016).

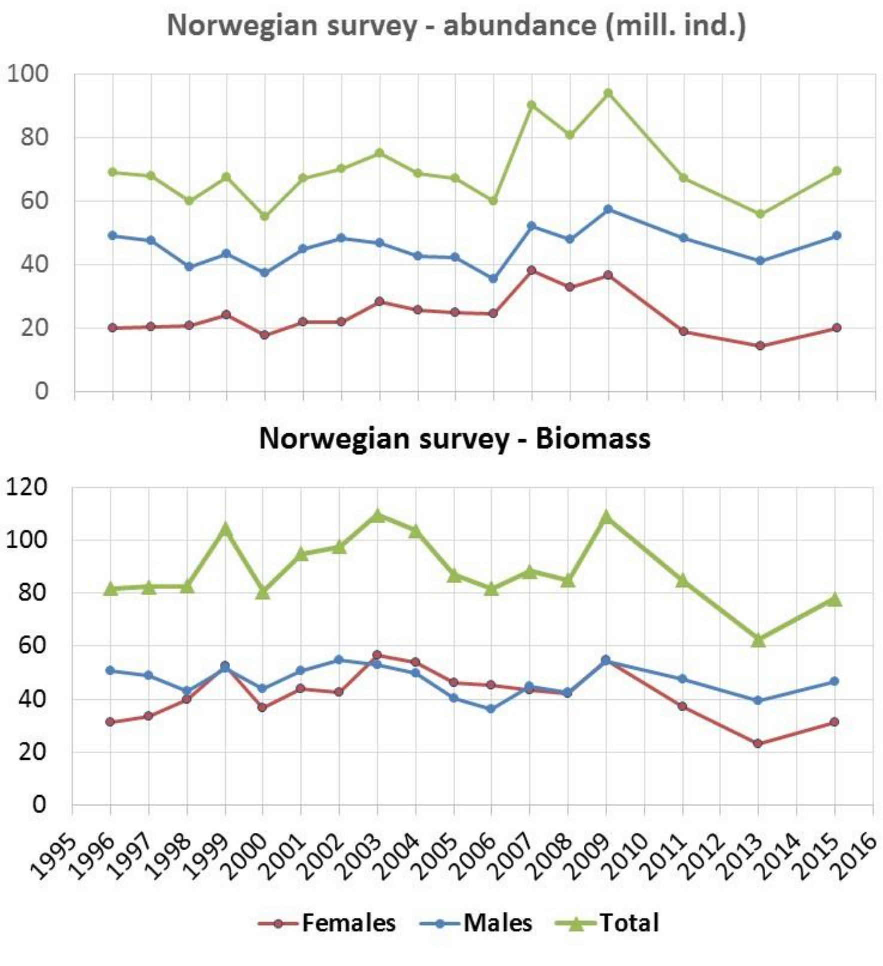


Figure F4. Norwegian autumn slope survey; Greenland halibut abundance and biomass estimates by sex.

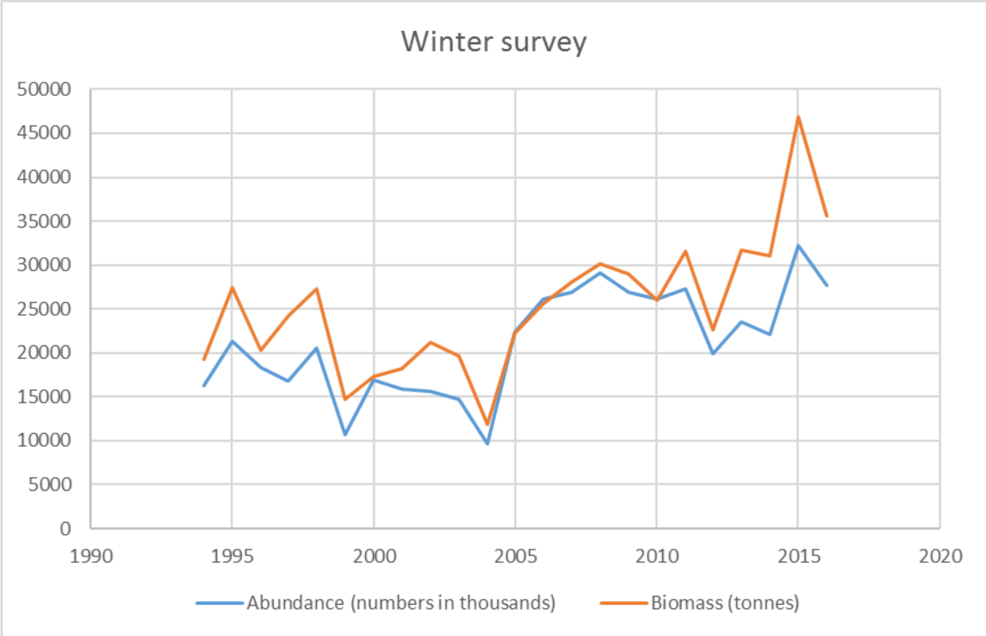


Figure F5. Joint winter survey in the Barents Sea; Greenland halibut abundance and biomass estimates.

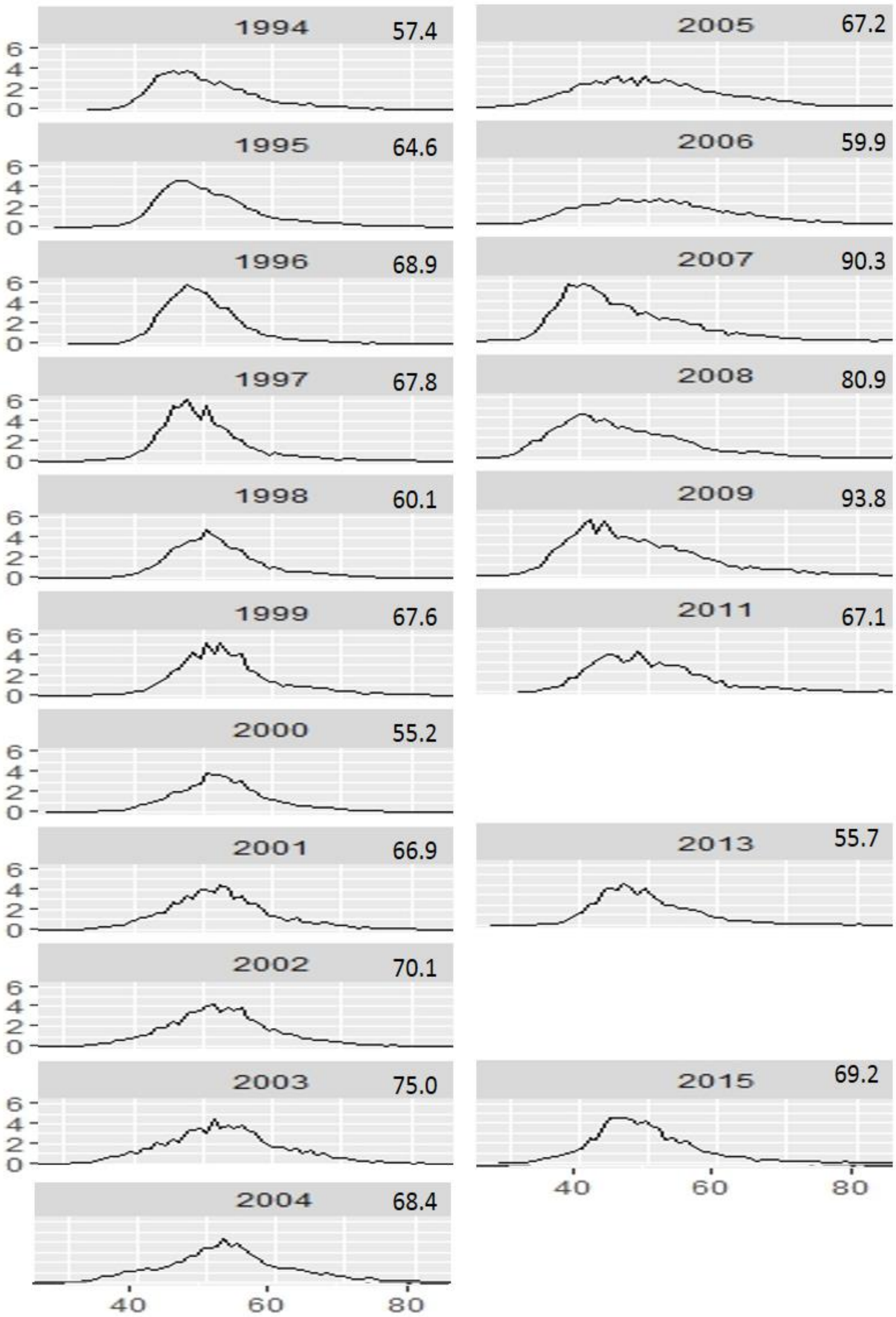


Figure F6. Length distributions (mill. Ind./cm) for the Norwegian Slope survey in autumn 1994-2015. Biennial surveys after 2009. Also total abundance each year is shown in upper left corners.

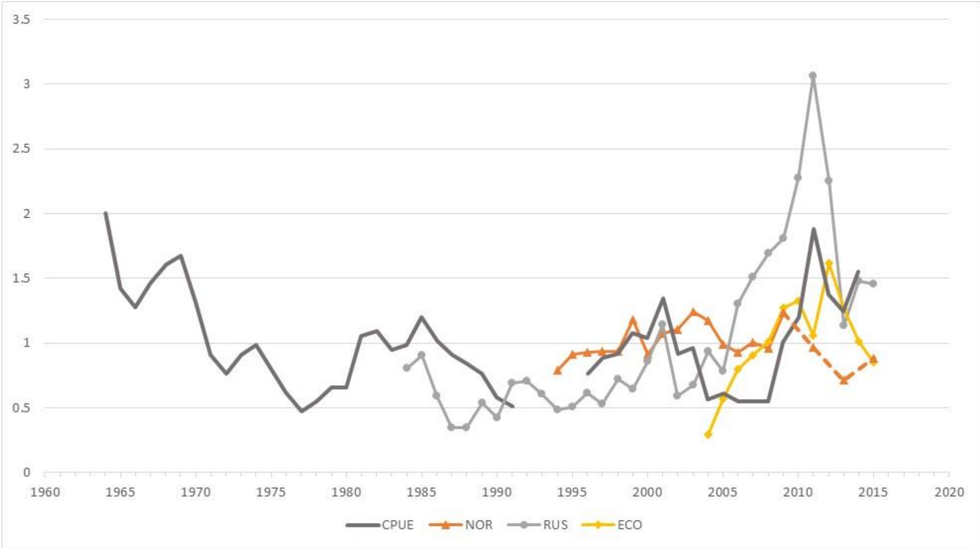


Figure F7. Dynamics of indices of the Barents Sea Greenland halibut stock in 1964–2015 (indices are taken divided by corresponding mean to put them in comparable scale; cpue series divided by two: 1964–1991 and after 1996). In addition to the standardized cpue three survey indices are shown; the Russian autumn survey (RUS), the Norwegian autumn survey (NOR) and the EcoSouth index (ECO).

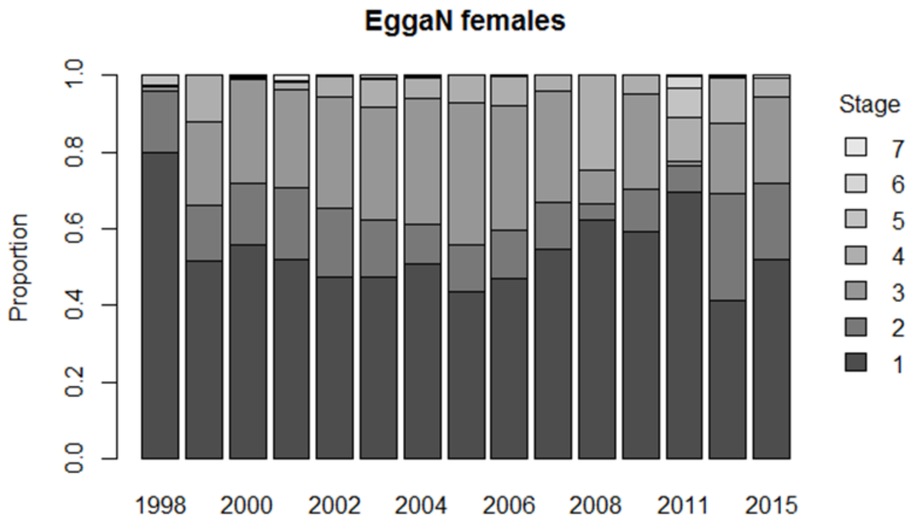


Figure F8 Proportion of numbers per maturity stage for Greenland halibut females in the Norwegian slope survey.

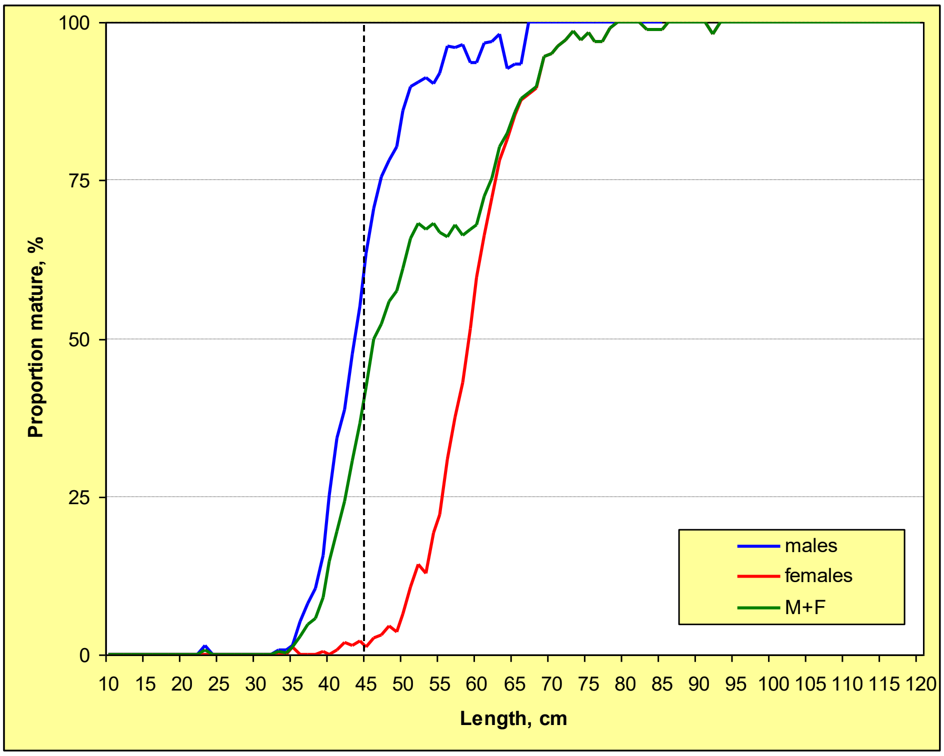
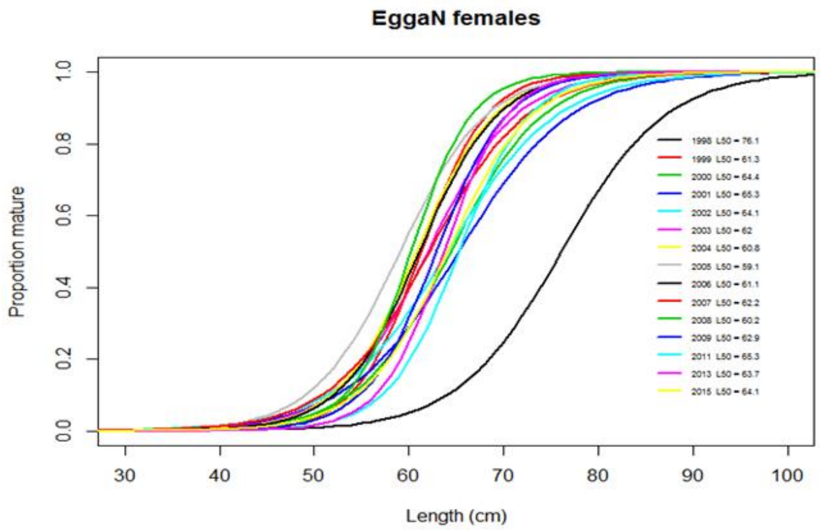


Figure F9. Greenland halibut maturity at length (Russian actual data, 2000-2009 combined). L50 for males ~ 43 cm, L50 for females ~ 57 cm (from Smirnov 2011)



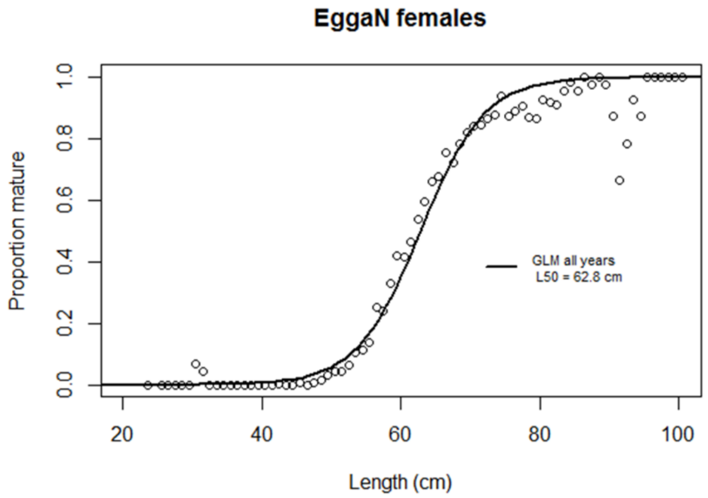
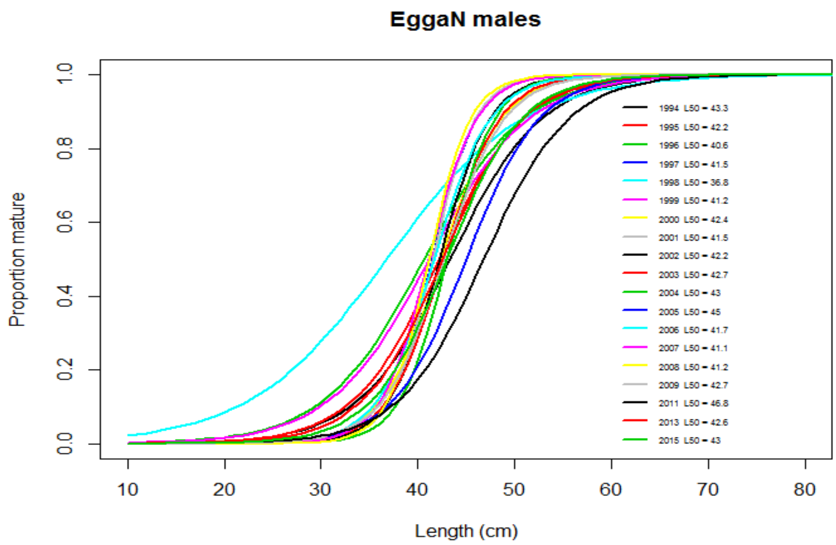


Figure F10. Maturity ogives for female Greenland halibut based on data from the Norwegina Slope survey, by year in upper panel and all years joint (year 1998 omitted) in lower panel. Stage 1 and 2 on special maturity scale for females are taken as immatures; see Kennedy etal 2009, 2011, 2014, and Nunez et al 2015.



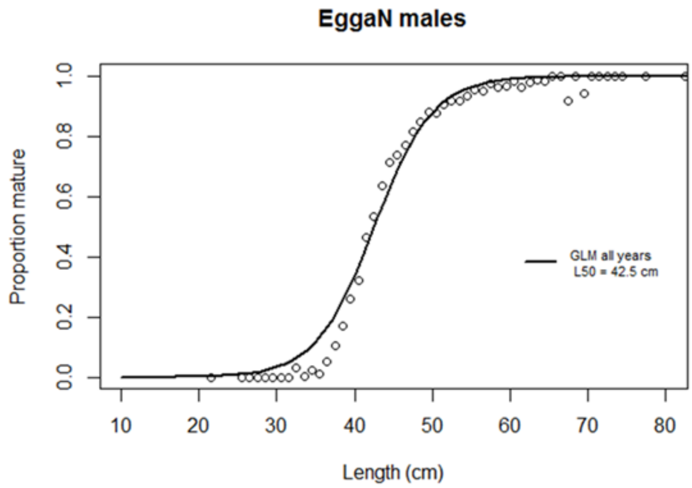


Figure F11. Maturity ogives for male Greenland halibut based on data from the Norwegian Slope survey, by year in upper panel and all years joint (year 1998 and 2010 omitted) in lower panel.

9 Barents Sea Capelin

As decided by the Arctic Fisheries Working Group at its 2017 meeting (ICES C.M. 2017/ACOM:06), 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 5-6 October 2017. The assessment was an update assessment, without changes in the methodology.

Therefore the information in this annex overrides section 9 of the AFWG 2017 report.

Participants:

Jaime Alvarez	Norway
Bjarte Bogstad (Chair of meeting)	Norway
Anatoly Chetyrkin	Russia
Stine Karlson	Norway
Yuri Kovalev	Russia
Tatiana Prokhorova	Russia
Georg Skaret	Norway

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 zero quota for 2017. The international historical catch by country and season in the years 1965-2017 is given in Table 9.1.

9.3 Sampling

The capelin sampling from the Barents Sea ecosystem survey used in the 2017 capelin assessment is summarised below:

Investigation	No. of trawl hauls	Length measurements	Aged individuals
Ecosystem survey in autumn 2017 (Norway)	155	11742	3316
Ecosystem survey in autumn 2017 (Russia)	86	9645	799

9.4 Stock Size Estimates

9.4.1 Acoustic stock size estimates in 2017 (Table 9.2)

The geographical survey coverage of the Barents Sea capelin stock during the ecosystem survey in 2017 was considered to be almost complete. At the time of the assessment (6 October) the survey is still ongoing, but only low concentrations are expected to be found in the yet uncovered area in the northeast. The geographical distribution of capelin in 2017 is shown in Figure 9.1a. For comparison, the distribution in 2016 is shown in Fig 9.1b.

The stock estimate from the area covered by the 2017 survey was 2.51 million tonnes (Table 9.2). This is more than seven times the estimate from last year. About 74% (1.72 million tonnes) of the estimated stock biomass consisted of maturing fish (> 14.0 cm). The estimated amount of maturing fish was approximately nine times as high as in 2016. This large difference between the 2016 and 2017 estimates is discussed in Section 9.5 Comments to the assessment. The weight at age in the 2017 survey was very similar to 2016 for all age groups (Fig. 9.2).

As decided during last years' assessment meeting, the capelin abundance was estimated using the software StoX (http://www.imr.no/stox) applying agreed settings, replacing the previous estimate procedure done with the software BEAM.

A fixed sampling 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. The CV is based on an average CV from several years from estimates presented in Tjelmeland (2002). CV per age group for the present years survey was estimated in StoX to 0.14, 0.1, 0.09 and 0.25 for the age groups 1,2,3 and 4 respectively. The StoX CV estimate is based on bootstrapping of acoustic and biological data and thus provides an estimate of sampling error which can be viewed as a proxy for the quality of the survey. The procedures for estimation of CV applied in Tjelmeland (2002) and StoX are similar, but also differ in some aspects, and it was recommended that comparisons between the two procedures be made and presented for AFWG before StoX estimation of CV is implemented in the capelin assessment. The group also noted that this CV only reflects sampling error, and not other potential sources of uncertainty and bias which might influence the estimate.

9.4.2 Recruitment estimation in 2017 (Table 9.3)

A swept volume index (Dingsør, 2005; Eriksen *et al.*, 2009) of abundance of 0-group capelin in August-September is given in Table 9.3. This index is calculated both without correction and with correction for catching efficiency (Keff). The 0-group index in 2017 (preliminary estimate) is around average. Table 9.3 also shows the number of fish in the various year classes, and their survey mortality from age one to age two.

9.4.3 Assessment results

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. Probabilistic projections of the maturing stock to the time of spawning at 1 April 2018 were made using the spreadsheet model CapTool (implemented in the @RISK add-on for EXCEL, 20 000 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 2018 from the 2017 Arctic Fisheries Working Group (ICES C. M. 2017/ACOM:06).

The methodology is described in the 2009 WKSHORT report (ICES C.M. 2009/ACOM:34) and the WKARCT 2015 report (ICES C.M. 2015/ACOM:31). The natural mortality M for the months October to December is drawn among a set of M-values estimated for different years based on historical data. The same set of M-values was used in 2017 as in 2016 (ICES 2011/ACOM:05, Annex 12). Based on the monthly distribution of catches in 2009—2013, the monthly distribution used in the prediction was set to 0% in January, 30% in February and 70% in March. These values were used in the predictions in 2012—2016.

With no catch, the estimated median spawning stock size in 2018 is 636 000 tonnes (Fig 9.3). With a catch of 205 000 tonnes, the probability for the spawning stock in 2018 to be below 200 000 t, the B_{lim} value used by ACFM in recent years, is 5 % (Fig. 9.4). The median spawning stock size in 2018 will then be 462 000 tonnes, and the corresponding median modelled consumption by immature cod in the period January-March 2018 will then be 597 000 tonnes. Figure 9.4 shows the probabilistic forecast from 1 October 2017 to 1 April 2018 conditional on a quota of 205 000 tonnes, while Fig 9.5 shows the probability of SSB < B_{lim} as a function of the catch.

Summary plots are given in Figure 9.6.

9.4.4 Recruitment

The 1-group abundance in 2017 was 86.4 billion which is close to the long-term average, and much lower than could be expected based on the 0-group index in 2016 (Fig 9.7). The 1-group vs. 0-group regression shown in Fig 9.5 predicts about 153 billion 1-group capelin in 2018 based on the 0-group estimate for 2017, which is close to the long term average. 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). At present the abundance of young herring based on the BESS 2017 has not been estimated.

9.4.5 Comments to the assessment

The abundance of age 2 and older capelin in the 2017 survey is much higher than could be expected from the 2016 survey. The age 2 abundance in 2017 is almost 4 times higher than the age 1 abundance in 2016, while the age 3 abundance in 2017 is twice the age 2 abundance in 2016. Usually there is a high survey mortality especially from age 2 to 3, but also from age 1 to 2 (Fig 9.8). The discrepancies between the 2016 and 2017 surveys are the highest observed in the time series (discrepancies for age 1 to 2 in the 1970s are likely related to known issues of incomplete area coverage of age 1 capelin).

The reasons for the discrepancies are not known. They could be due to underestimation of the stock in 2016, overestimation in 2017, or both. There are some data sources in addition to the acoustic survey which can be used to shed light on this.

The main capelin distribution areas were well covered by the survey in both years (Fig 9.1a-b), so only very abnormal capelin distribution could have caused discrepancies due to uncovered areas. The survey intensity in the main capelin area was higher in 2017 than in 2016 with approximately half the distance between the survey transects (see Fig. 9.1a-b), likely resulting in a higher precision of the 2017 than the 2016 survey estimate.

There are three factors which indicate an underestimation of capelin in the 2016 survey:

- The allocation of acoustic backscatter to capelin versus other species/groups was particularly challenging in some areas during the 2016 survey (ICES C.M. 2017/ACOM:06), and this might have caused underestimation of capelin in 2016.
- The 2015 year class was observed to be somewhat above the long-term average both at age 0 and 2, but weak at age 1.
- The amount of capelin found in cod stomachs in 2017 indicates a higher maturing capelin stock in winter 2017 than the acoustic survey autumn 2016 shows. (Fig 9.9)

9.4.6 Ecological considerations

The number of young herring in the Barents Sea can be an important factor that affects the capelin recruitment. It is not currently taken into account in the assessment model. The benchmark for capelin stocks in the Barents Sea (WKARCT, ICES C.M. 2015/ACOM:31) noted the need for further study of this effect as well as better monitoring of the young herring abundance.

The amount of other food than capelin for cod and other predators may also have changed in recent years. This may also indirectly have affected the predation pressure on capelin. A more detailed discussion of interactions between capelin and other species is given in the 2016 and 2017 WGIBAR reports (ICES C.M. 2016/SSGIEA:04, ICES C.M. 2017/SSGIEA:04).

9.4.7 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 for the assessment that the survey results are reliable. The survey results of the last two years reveal inconsistencies, in particular strong negative survey mortality between age 1 and 2 and age 2 and 3 from 2016 to 2017, which can only be related to monitoring issues including sampling methodology, coverage and/or survey design.

The effect of survey direction on the estimate is not known, but feeding capelin during autumn are believed to be either rather stationary or moving northwards. A general northwards migration direction of the stock will cause a positive bias on the survey estimate when the survey moves in its typical direction from south to north, and negative when in opposite direction like in 2016. The speed and direction of capelin movement during monitoring can be investigated using sonar data, which exist for several years, but have not been analysed.

The allocation of acoustic backscatter to target groups can be challenging in some years, in particular when two groups with similar acoustic properties are abundant, and trawl samples give ambiguous answers about their proportions. This was the case in 2016. There are tools under implementation which can provide valuable help in the interpretation of acoustic data. DeepVision is a stereocamera system which can be mounted on a frame and pulled after the vessel and automatically classify fish to species as well as measure length. Broadband acoustic systems which are now mounted on Norwegian research vessels can use frequency response to discriminate between targets much more accurately than discrete frequency systems. Both these tools are highly relevant candidates for improving the quality of the survey.

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 pre-spawning 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 about 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, and is needed especially in light of this year's considerable revision of the cod assessment and thus cod abundance in recent years.

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}.

In 2015 there was an increased proportion of small mature capelin catches in the spring period. This may call for a revision of the capelin maturation sub-model in Bifrost.

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 (WKNEAMP-2, ICES C. M. 2016/ACOM:47). ICES considers these rules not to be precautionary. At its 2016 meeting, JNRFC decided not to change the adopted management strategy.

9.6 References

Dingsør, G.E. 2005. Estimating abundance indices from the international 0-group fish survey in the Barents Sea. Fisheries Research 72(2-3): 205-218.

Eriksen, E., Prozorkevich, D. V. and Dingsør, G. E. 2009. An evaluation of 0-group abundance indices of Barents Sea Fish Stocks. The Open fish Science Journal, 2: 6-14.

Gjøsæter, H., Bogstad, B., Tjelmeland, S., and Subbey, S. 2015. A retrospective evalua-tion of the Barents Sea capelin management advice. Marine Biology Research 11(2):135-143.

Gjøsæter, H., Hallfredsson, E. H., Mikkelsen, N., Bogstad, B., and Pedersen, T. 2016. Predation on early life stages is decisive for year class strength in the Barents Sea capelin (*Mallotus villosus*) stock. ICES Journal of Marine Science 73(2):182-195. doi: 10.1093/icesjms/fsv177

Hjermann, D. Ø., Bogstad, B., Dingsør, G. E., Gjøsæter, H., Ottersen, G., Eikeset, A. M., and Stenseth, N. C. 2010. Trophic interactions affecting a key ecosystem compo-nent: a multi-stage analysis of the recruitment of the Barents Sea capelin. Canadian Journal of Fisheries and Aquatic Science 67:1363-1375.

ICES 2009. Report of the Benchmark Workshop on Short-lived species [WKSHORT], Bergen, Norway, 31 August- 4 September 2009. ICES C.M. 2009/ACOM:34, 166 pp.

ICES 2011. Report of the Arctic Fisheries Working Group, Hamburg, 28 April – 4 May 2011. ICES C.M. 2011/ACOM:05, 659 pp.

ICES 2015. Report of the Benchmark Workshop on Arctic Stocks (WKARCT), Copenhagen 26-30 January 2015. ICES C. M. 2015/ACOM:31, 126 pp.

ICES 2016. Report of the second Workshop on Management Plan Evaluation on Northeast Arctic cod and haddock and Barents Sea capelin, 25-28 January 2016, Kirkenes, Norway. ICES CM 2016/ACOM:47, 76 pp.

ICES 2016. The Third Report of the Working Group on Integrated Assessments of the Barents Sea (WGIBAR). Murmansk, Russia, 22-25 February 2016. ICES CM 2016/SSGIEA:04, 126 pp.

ICES 2017. Report of the Working Group on the Integrated Assessments of the Barents Sea. WGIBAR 2017 Report, 16-18 March 2017. Murmansk, Russia. ICES CM 2017/SSGIEA:04. 186 pp.

ICES 2017. Report of the Arctic Fisheries Working Group, Copenhagen, 19-25 April 2017. ICES C.M. 2017/ACOM:06,486 pp.

Mehl, S., Aglen, A., Bogstad, B., Staby, A., Wenneck, T. de Lange, and Wienerroither, R., 2017. Fish investigations in the Barents Sea winter 2017. IMR-PINRO Joint Report Series 3-2017, 87 pp.

Tjelmeland, S. 2002. A model for the uncertainty around the yearly trawl-acoustic estimate of biomass of Barents Sea capelin, *Mallotus villosus* (Müller). ICE Journal of Marine Science, 59:1072-1080.

Table 9.1 Barents Sea CAPELIN. International catch ('000 t) as used by the Working Group.

Year	Winter				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	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	1	1	1
1998	0	2	0	2	0	1	1	3
1999	50	33	0	83	0	22	22	105
2000	279	94	8	381	0	29	29	410
2001	376	180	8	564	0	14	14	578
2002	398	228	17	643	0	16	16	659
2003	180	93	9	282	0	0	0	282
2004	0	0	0	0	0	0	0	0
2005	1	0	0	1	0	0	0	1
2006	0	0	0	0	0	0	0	0
2007	2	2	0	4	0	0	0	4
2008	5	5	0	10	0	2	0	12
2009	233	73	0	306	0	1	1	307
2010	246	77	0	323	0	0	0	323
2011	273	87	0	360	0	0	0	360
2012	228	68	0	296	0	0	0	296
2013	116	60	0	177	0	0	0	177
2014	40	26	0	66	0	0	0	66
2015	71	44	0	115	0	0	0	115
2016	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0

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 2017. TSN: Total stock number. TSB: Total stock biomass. SSN: Spawning stock number. SSB: Spawning stock biomass.

Length	Age 1	Age 2	Age 3	Age 4	Sum	Biomass	MeanW
cm	ycl 2016	ycl 2015	ycl 2014	ycl 2013	(10^9)	10^3 t	g
7.0-7.5	0.253	0	0	0	0.253	0.00	1.0
7.5-8.0	0.410	0	0	0	0.410	0.67	1.6
8.0-8.5	1.327	0	0	0	1.327	2.26	1.7
8.5-9.0	5.646	0	0	0	5.646	13.04	2.3
9.0-9.5	13.332	0	0	0	13.332	36.80	2.8
9.5-10.0	14.841	0	0	0	14.841	46.75	3.2
10.0-10.5	16.392	0.565	0	0	16.957	62.91	3.7
10.5-11.0	11.707	0.651	0	0	12.358	54.50	4.4
11.0-11.5	10.004	1.239	0	0	11.243	56.89	5.1
11.5-12.0	4.079	2.790	0	0	6.869	41.42	6.0
12.0-12.5	3.105	6.808	0	0	9.913	71.28	7.2
12.5-13.0	1.613	10.864	0	0	12.476	103.43	8.3
13.0-13.5	1.414	14.585	0.018	0	16.017	151.52	9.5
13.5-14.0	0.435	12.575	0.123	0.001	13.133	141.57	10.8
14.0-14.5	1.020	15.045	0.339	0	16.404	202.75	12.4
14.5-15.0	0.343	14.520	0.154	0	15.016	215.63	14.4
15.0-15.5	0.180	14.339	0.596	0	15.116	247.19	16.3
15.5-16.0	0.224	12.442	1.877	0	14.543	268.46	18.5
16.0-16.5	0.077	8.318	2.648	0.082	11.125	234.33	21.1
16.5-17.0	0	4.115	2.718	0.094	6.927	160.13	23.4
17.0-17.5	0	3.077	3.460	0.010	6.547	174.59	26.7
17.5-18.0	0	1.031	1.835	0.055	2.921	84.92	29.4
18.0-18.5	0	0.618	1.819	0.015	2.451	79.36	32.6
18.5-19.0	0	0.099	0.927	0.111	1.137	35.49	34.6
19.0-19.5	0	0.058	0.206	0.038	0.302	10.18	38.6
19.5-20.0	0	0	0.049	0.000	0.049	1.94	39.4
TSN(10^9)	86.403	123.738	16.769	0.165	227.323		
TSB (10^3 t)	369.7	1708.1	417.4	11.1		2506.37	
Mean length	10.15	14.14	16.69	17.39			
Mean weight (g)	4.28	13.8	24.89	27.27	11.03		
SSN (10^9)	1.844	73.661	16.628	0.405	92.538		
SSB (10^3 t)	26.23	1267.63	417.63	11.6		1723.09	

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	0-group Index (10^9 ind.)		Acoustic estimate (10^9ind.)		Mortality survey(1—2)
	(10^{12})	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
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		
2017	-	104.2	694			
Average	9.0	94.2	324	178.0	105.0	

Table 9.4 Barents Sea CAPELIN. Stock size in numbers by age, total stock biomass, biomass of the maturing component at 1. October.

Year	Stock in numbers (10^9)						Biomass (10^3 tonnes)	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	Maturing
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
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

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 numbers age 1+2 (10^9 ind.) WGWIDE data	Herring 0-group index (10^9 sp) corr. for catching efficiency	Capelin Landing (10^3 t)
	TSB	MSB						
1972	6600	2727			152			1591
1973	5144	1350	33		529			1337
1974	5733	907	*		305			1148
1975	7806	2916	*		190			1441
1976	6417	3200	253		211			2587
1977	4796	2676	22		360			2986
1978	4247	1402	*		84			1916
1979	4162	1227	*		12			1782
1980	6715	3913	*		270		0.08	1648
1981	3895	1551	316		403		0.04	1986
1982	3779	1591	106		528		2.52	1760
1983	4230	1329	100		515		195.45	2357
1984	2964	1208	109		155		27.35	1477
1985	860	285	*		39		20.08	868
1986	120	65	*		6		0.09	123
1987	101	17	34	4	38		0.05	0
1988	428	200	*	10	21	3.53	60.78	0
1989	864	175	84	378	189	11.79	17.96	0
1990	5831	2617	92	94	700	32.50	15.17	0
1991	7287	2248	643	1769	402	56.86	267.64	933
1992	5150	2228	302	1735	351	139.70	83.91	1123
1993	796	330	293	1498	2	194.20	291.47	586
1994	200	94	139	187	20	96.95	103.89	0
1995	193	118	60	29	7	29.34	11.02	0
1996	503	248	60		82	10.57	549.61	0
1997	909	312	85		99	28.40	463.24	1
1998	2056	932	94	414	179	26.73	476.07	3
1999	2775	1718	382		156	88.55	35.93	105
2000	4273	2098	599	700	449	105.69	469.63	410
2001	3630	2019	626		114	58.20	10.01	578
2002	2210	1291	496	1417	60	28.45	151.51	659
2003	533	280	427		82	153.79	177.68	282
2004	628	294	94	105	51	121.73	773.89	0
2005	324	174	122		27	136.62	125.93	1
2006	787	437	72		60	76.12	294.65	0
2007	2119	844	189		222	56.03	144.00	4
2008	4428	2468	330	469	313	34.49	201.05	12
2009	3765	2323	517	180	124	17.19	104.23	307
2010	3500	2051	504	452	248	49.66	117.09	323
2011	3707	2115	487	160	209	31.14	83.05	360
2012	3586	1997	504		146	27.05	177.19	296
2013	3956	1471	479		324	23.46	289.39	177
2014	1949	873	504		105	41.03	136.01	66
2015	842	375	82		40	27.57	89.204	115
2016	328	181	37		32	29.74	75.047	0
2017	2506	1723	462		124	38.34		0

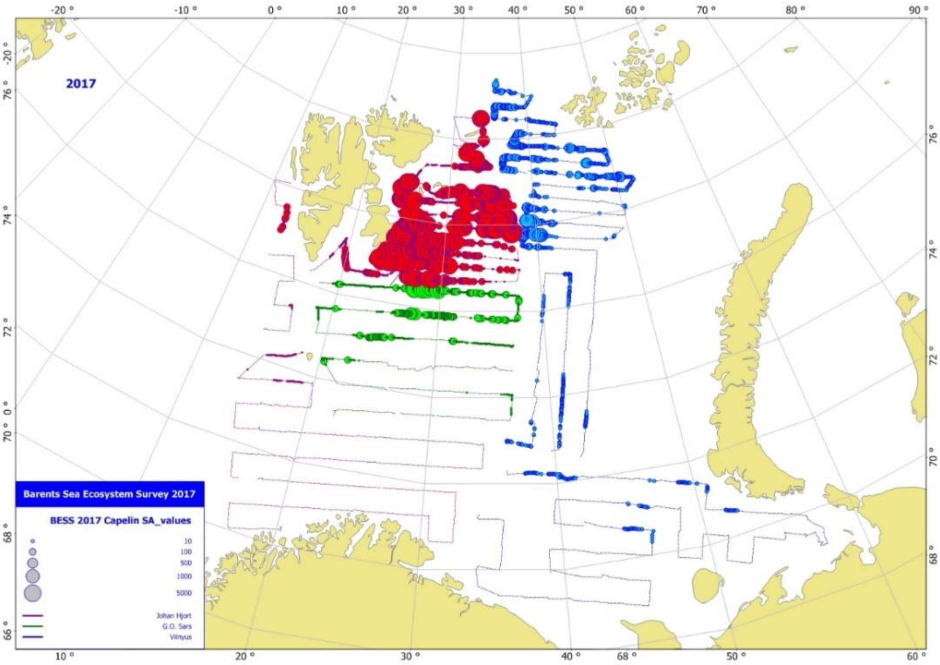


Figure 9.1a. Geographical distribution of capelin in autumn 2017.

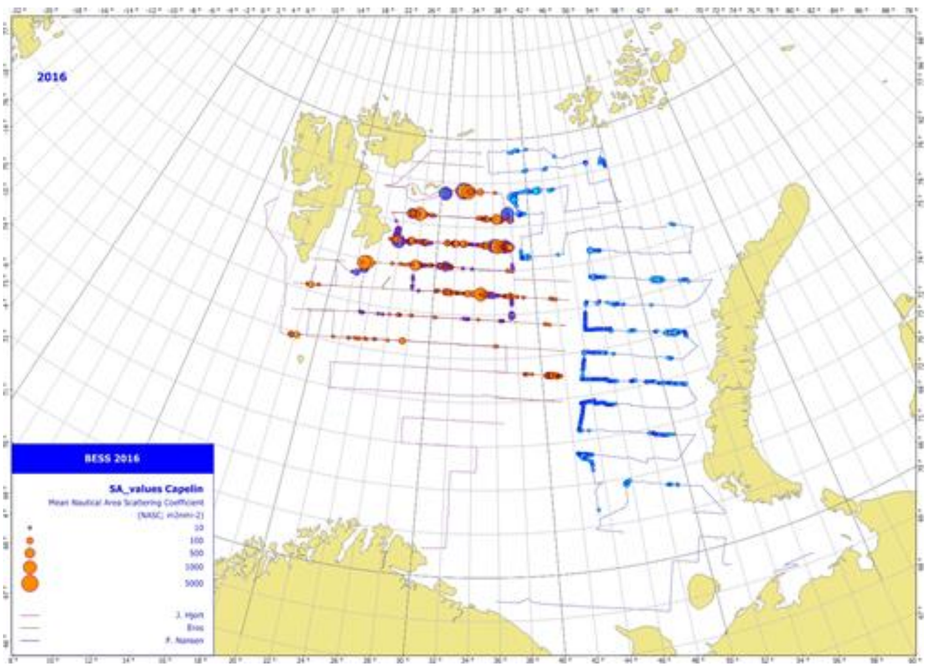


Figure 9.1b. Geographical distribution of capelin in autumn 2016.

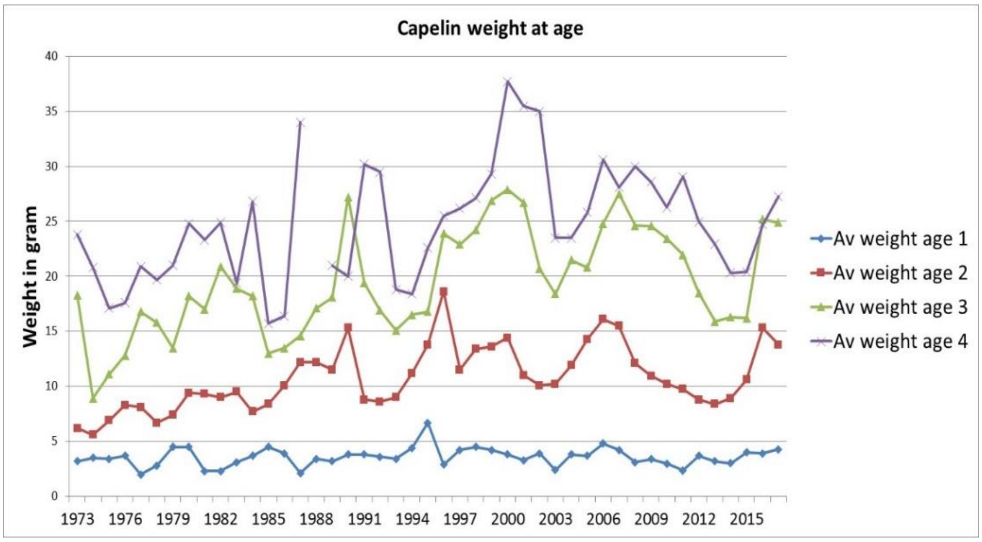


Figure 9.2 Weight at age (grams) for capelin from the autumn survey.

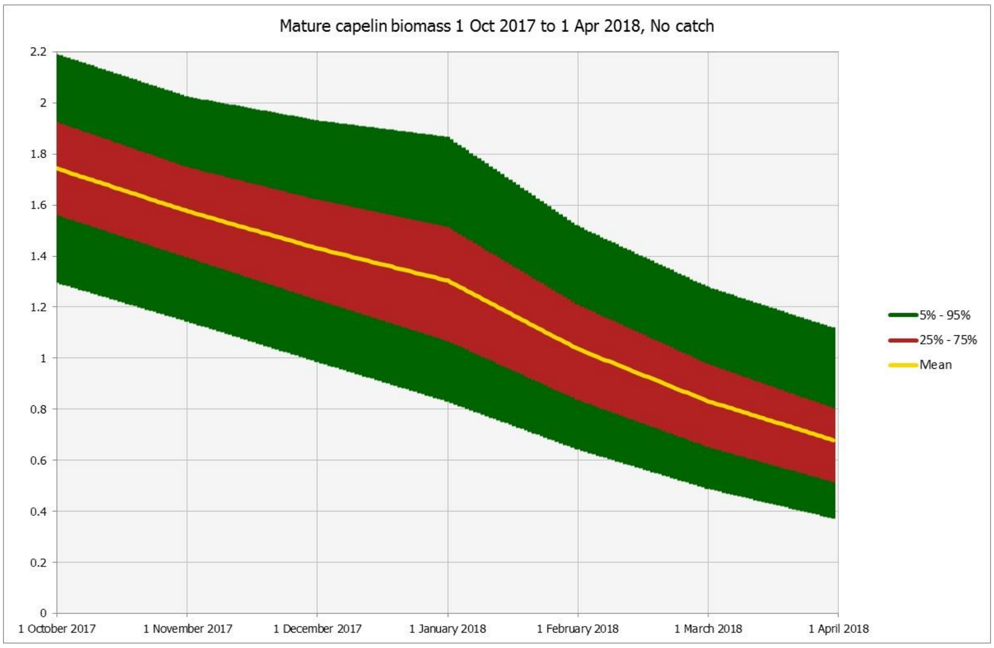


Figure 9.3. Probabilistic prognosis 1 October 2017—1 April 2018 for Barents Sea capelin maturing stock, with no catch (model CapTool, 20 000 simulations).

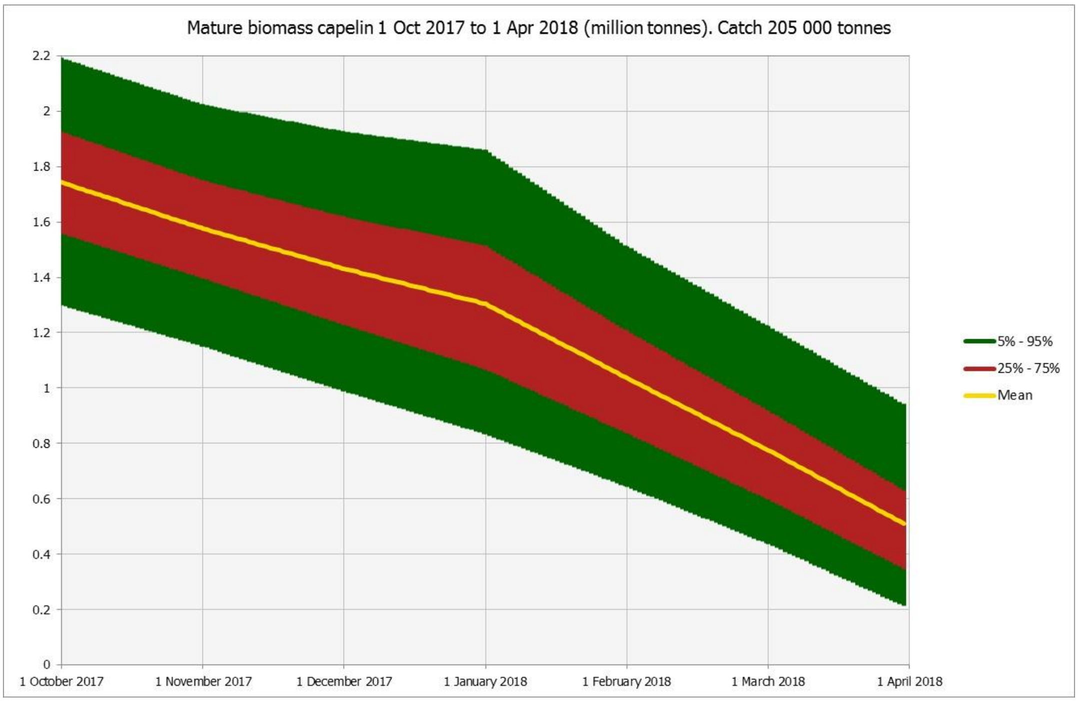


Figure 9.4. Probabilistic prognosis 1 October 2017—1 April 2018 for Barents Sea capelin maturing stock, with TAC = 205 000 tonnes (model CapTool, 20 000 simulations).

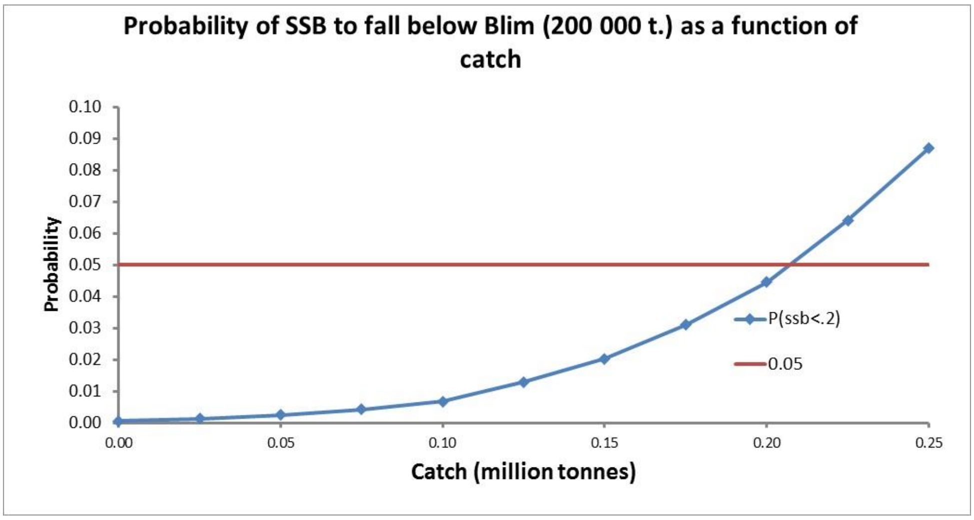


Figure 9.5. Probability of spawning biomass of capelin (1 April 2018) being below B_{lim} (200 000 tonnes), as a function of catch.

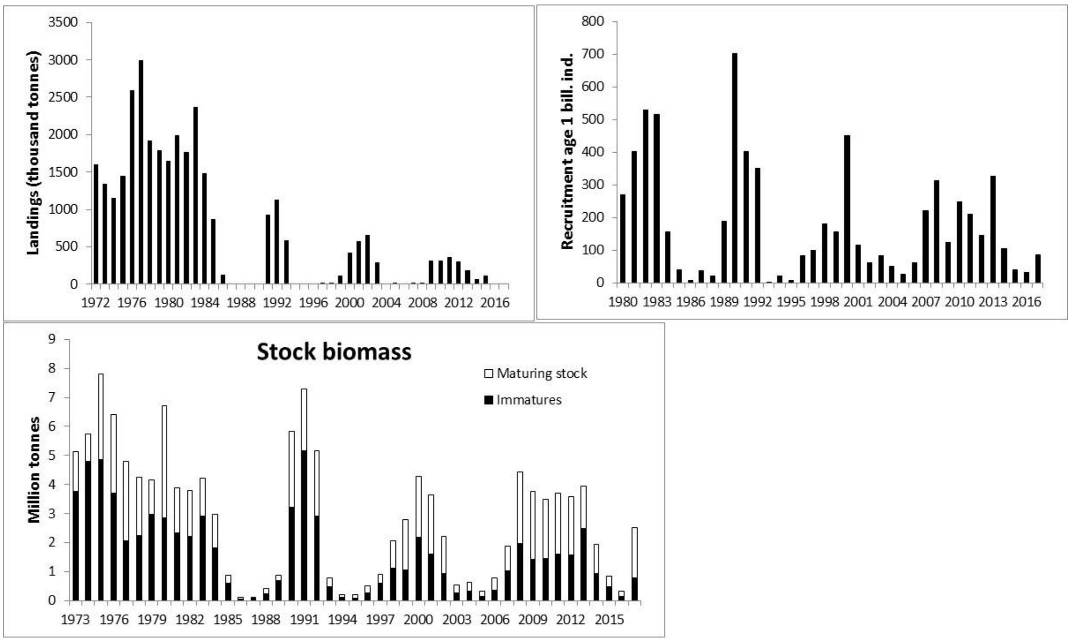


Figure 9.6. Capelin in Subareas I and II, excluding Division IIa west of 5°W (Barents Sea capelin). Landing and summary of stock assessment (mature and immature stock biomass).

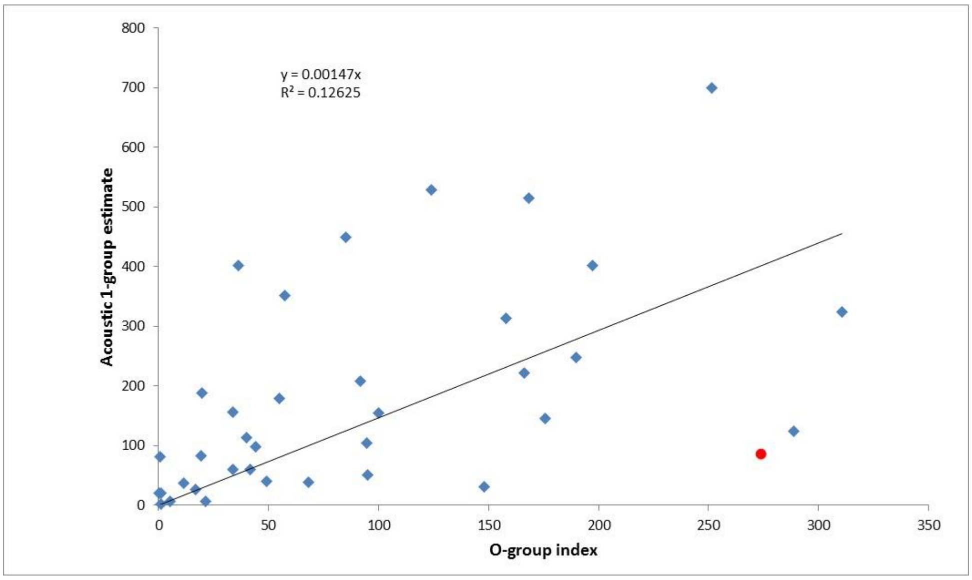


Figure 9.7. Regression of abundance of capelin at age 0 (0-group index without K_{eff}) and age 1 for cohorts 1980—2016. The red point shows the 2016 year class.

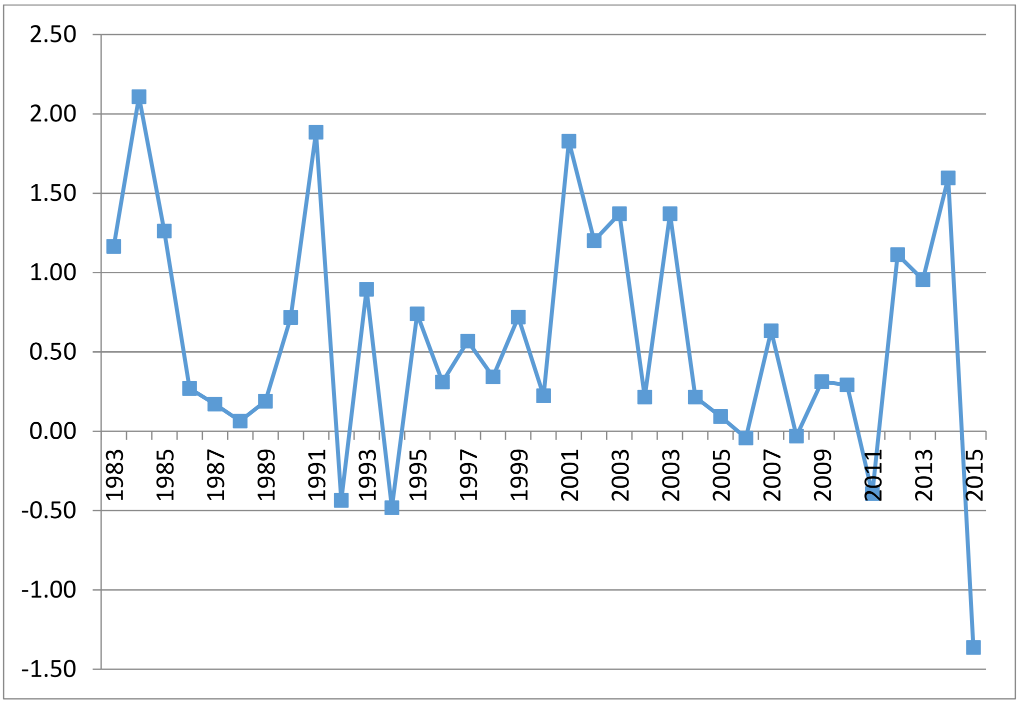


Figure 9.8. Capelin survey mortality from age 1-2.

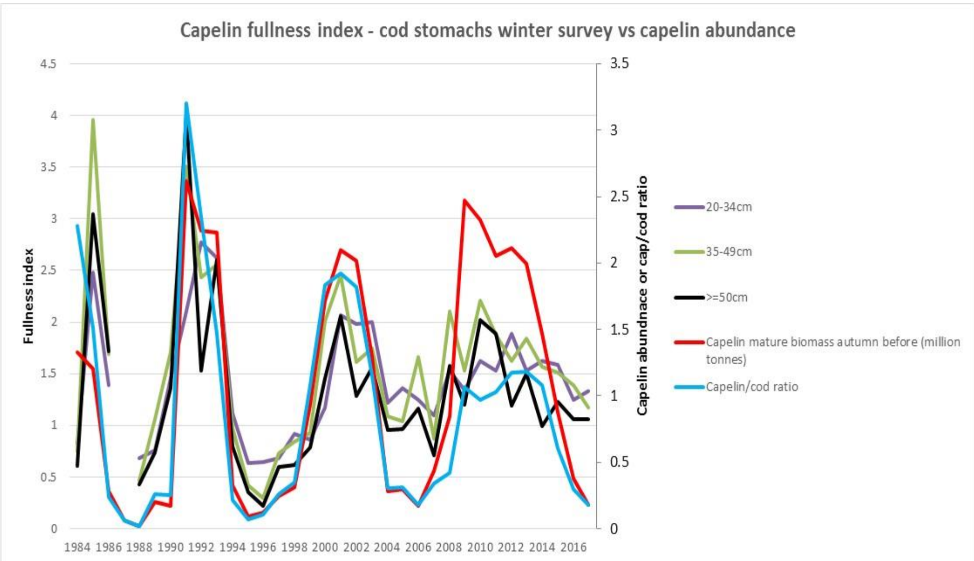


Figure 9.9. Fullness index for capelin in cod stomachs for different cod length groups during the Joint winter survey for demersal fish (Mehl et al. 2017) vs. abundance of maturing capelin the previous autumn (red line). The ratio of maturing capelin to immature cod is also shown (blue line).

10 Anglerfish in ICES Subareas I and II

10.1 General

Our present knowledge about anglerfish (*Lophius* spp.) in ICES Subareas I and II is based on two master theses (Staalesen 1995 and 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). ICES suggests that this stock is considered as a Category 4 stock, since the only data available to assess stock status is landings statistics and commercial catch data from the Norwegian Reference Fleet (ICES CM 2012/ACOM:68).

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 2 600 anglerfish landed from the Møre coast north of 62°N (IIa) and 1 out of about 1000 from the North Sea were *L. budegassa* (Dyb 2003; K. Nedreaas, pers. comm.).

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 IIa. Anglerfish in IIa 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 VI (including Vb(EC), XII and XIV) and the North Sea (& IIa (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 IIa, Vb and Va (Hislop *et al.*, 2001). So, at previous WGs, assessments have been made for the whole Northern Shelf area combined, but exclusive ICES Divisions IIa, Vb and Va. 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 VII) 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 I and II) 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). A total of 526 individuals were tagged with conventional Floy dart type tags, 118 in the North Sea and 408 at Møre. This is further described in Thangstad *et al.* (2006). Figure 10.12 shows some preliminary results until 2006. There are more recapture data than shown in the figure, and these should be tabulated and presented. In general we've seen migration 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.

Fishery

In autumn 1992 a direct gillnet fishery for anglerfish (*L. piscatorius*) started on the continental shelf in ICES Division IIa 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 I and II accounting for more than 96% of the official landings (Table 10.1). The coastal gillnetting accounts for about 90% of the landings (Table 10.2). The landings of anglerfish in Subarea I and II have been about 1/4-1/3 of the total landings from the other Northern Shelf areas (IIIa, IV and VI).

No TAC is given for Subarea I and II, Norwegian waters. Catches of anglerfish in Division IIa, EC waters, are taken as a part of the EC anglerfish quota for ICES areas III, IV and VI, 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 hours 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 N 65° in 2008 and further expanded southwards to N 64° 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 (2 tonnes in 2016) are taken in statistical area 03 which falls within ICES Subarea I, and in Division IIb (less than 1 ton in 2016). 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 I and II decreased rapidly from 2011 to 2015, to the lowest since 1997, but showed a small increase in 2016 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 current rapid decline in catches per year without any new regulations enforced gives reasons for concern. No information suggests that the official landing figures from Norway give a biased estimate of the actual landings.

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 a small percentage of the catch (not marketable) is discarded. This happens when the soaking time is too long, mostly due to bad weather. Work is ongoing to estimate discards based on data from the Reference fleet.

Biological

Length distributions are available from the directed gillnet fishery during the period 1992—2013 and 2016, but data are lacking for 1997—2001 (Figure 10.3a,b). The length data indicates a drop in mean length of 15—20 cm occurring during the period without length samples (Figure 10.4). Since then the mean length has increased steadily during the last decade to the present average of 95 cm (about 10 years old and 12 kg), and is now at the level seen during the 1990s (Figure 10.4). One third of the anglerfish measured during the 1990s were above 100 cm, this proportion was between 1—6% for the early 2000s and 12—17 % in 2006-2010. This indicates recruitment into Subarea II during 1997—2001 which has not happened since to a similar degree. 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) not yet big enough for the large-mesh gillnets used in the directed anglerfish fishery. These recruits correspond with the promising yearclasses seen further south in the North Sea.

Sex ratios in Subarea II 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 IIa in spring, but the present abundance of anglerfish in Subarea I and II seems to be dependent on influx or migration of juveniles from ICES Subareas IV and VI. k estimated the estimation of GSI (gonad-somatic index) for females in Division IIa, indicating 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 (L50) was between 60-65 cm, and that all females above 80 cm were mature.

Some age readings exist of anglerfish in Division IIa, 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 low 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 IIa yields reliable information on the abundance of anglerfish.

Commercial CPUE

Reliable effort data are not available from the Norwegian gillnetters due to non-mandatory effort recording. In late 2005, ten gillnetters were included in a self-sampling scheme established along the Norwegian coast within Division IIa. Detailed information about effort and catch is provided through this scheme. In Figure 10.7 standardized CPUE is presented for the two most active anglerfish gillnetters in this fleet. The standardized CPUE has been estimated in the following way: a CPUE series has been estimated for each vessel's seasonal fisheries (altogether three sub-series), and then an average of the three relative CPUEs was estimated each year resulting in a standardized CPUE time series. The figure shows that the average standardized catch rates have decreased by about 35% in recent years. The fishing effort (i.e., number gillnet soaking days per year) was generally halved since 2011 (Figure 10.8). However, this decreasing trend seems now to have stopped. 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 IIa (Figure 10.9).

Yield-per-recruit estimations

Based on preliminary analyses and yield-per-recruit estimations done back in 2006 (Thangstad *et al.* 2006), the current fishing mortality in Norwegian waters seems to be too high to secure a high, sustainable and stable long-term yield, while the fishing pattern achieved by 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 I and II have never been assessed quantitatively and besides the presented catch and CPUE 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). Work on this should be prepared for the coming anglerfish benchmark assessment (2018).

10.3 Management considerations

Since indicators of stock size such as CPUE and mean length in the catch are available that may provide reliable indications of trends in stock metrics such as mortality, recruitment, and biomass, the Review Group suggested that this stock may be most appropriately considered as a Category 4 stock, and that the anglerfish stock component in Subarea I and II should be annually monitored due to the reduced catches and possible decreasing trend in CPUE. (ICES C. M. 2012/ACOM:68).

The WG notes the apparent changes in size composition in anglerfish caught in the gillnet fishery during the last two decades. To our knowledge the selectivity in the gillnets has been sufficient stable that this could be interpreted as an altering of the size spectrum in the stock as new year classes enter the area in pulses. The present time-series on effort and catch by length should be further analysed to facilitate future analytical assessments of this stock. The sex ratio in the catches should be monitored and considered in future analyses. The possibility of establishing a standardized survey should be considered for Division IIa. It is observed that the anglerfish spawn in Division IIa, and the magnitude of this spawning, at present considered being marginal, should be better revealed. The role of the anglerfish population in Subarea I and II (mainly Division IIa) in the whole Northeast Atlantic stock complex should be better known. There are more recapture data than summarized and presented in this report, and these should be tabulated and presented before next WG.

The present abundance of anglerfish in Subarea I and II seems to be totally dependent on influx or migration of juveniles from ICES Subareas IV and VI. 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. The AFWG strongly supports that ICES

Subareas I, II, III, IV and V should be investigated together to get a more complete understanding of migrations and distributions. A rapidly decreasing catch in recent years until 2016, decreasing trends in CPUE, and a northwards movement of the fishery that has culminated give reasons for concern. Increasing mean length of the caught anglerfish during the last decade is a likely sign of reduced recruitment to Subarea I and II, but 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. Hence, monitoring of the fishery will be important in near future to protect the young specimens from recruitment- and growth overfishing. Furthermore, the fishing mortality has previously been estimated to a level well above F_{max}. The WG hence recommends that the anglerfish stock component in Subarea I and II 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.

Table 10.1. Nominal catch (t) of Anglerfish in ICES Subareas I and II, 1996–2016, as officially reported to ICES

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016*
Denmark	+	+	+	2	+	-	1	-	-	-	-	+	-	-	-	-	-	-	-
Faroes	+	+	-	1	1	2	5	11	4	7	4	2	1	+	+	1	+	+	1
France	-	-	-	-	-	-	-	-	1	-	-	-	-	1	3	2	-	4	2
Germany	53	4	17	65	59	55	70	55	+	+	0	+	82	70	0	-	+	+	+
Iceland	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-
Norway	1489	1733	2952	3554	2000	2405	2907	2650	4257	4470	4007	4298	5391	5031	3758	2988	1655	933	1355
Portugal	-	-	-	-	-	-	-	-	-	-	2	6	1	+	-	-	-	-	-
UK	7	6	30	2	11	15	18	19	86	114	138	152	40	3	3	111	2	105	76
Others															1	1	-	-	+
Total	1549	1743	2999	3624	2071	2477	3001	2735	4348	4591	4151	4458	5515	5112	3765	3103	1657	1043	1435

***Preliminary**

Table 10.2. Anglerfish in ICES Subareas I and II. Norwegian landings (tonnes) by fishery in 2005–2016. The coastal area is here defined as the area inside 12 nautical miles from the baseline.

Fleet	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Coastal gillnetting	2 302	3 723	4 039	3 574	3 934	4 806	4 557	3 521	2 758	1 506	829	1231
Offshore gillnetting	115	261	204	240	171	391	319	115	158	95	52	62
Offshore dem trawling	77	75	65	34	36	48	19	11	8	7	3	5
Coastal Danish seine	54	54	63	75	68	40	26	16	19	11	12	17
Other gears	102	144	98	84	89	106	83	96	45	36	37	40
Total	2 650	4 257	4 470	4 007	4 298	5 391	5 031	3 759	2 988	1 655	934	1355

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 (F7-10 = 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

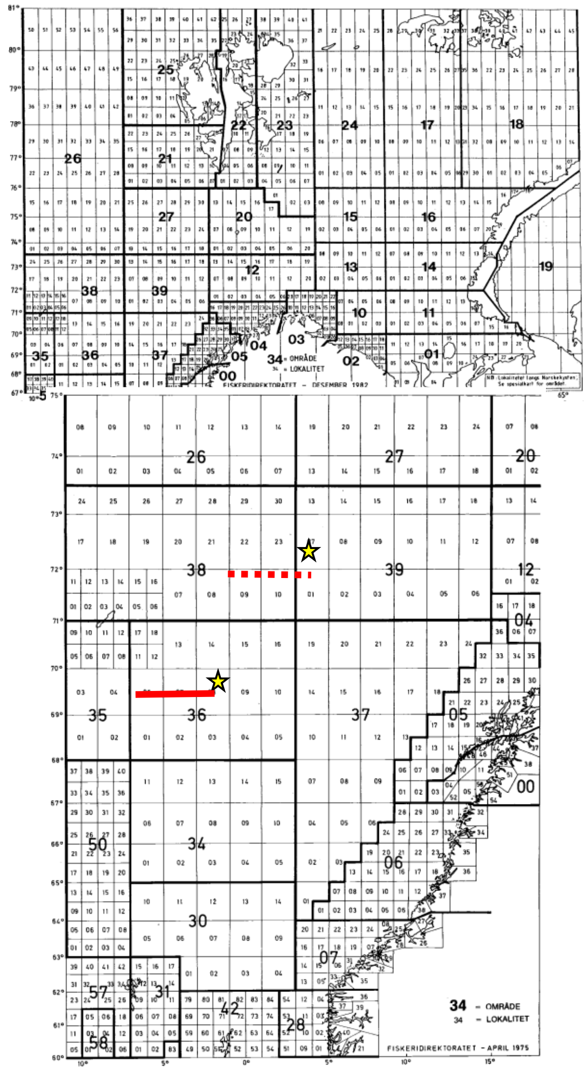


Figure 10.1. Norwegian statistical areas and locations used by the fishers for reporting their catches. The 62°N and 67°N (stippled) latitudes are marked. The fishing areas of the two gillnetters in the coastal reference fleet used for calculating CPUE are marked with yellow stars.

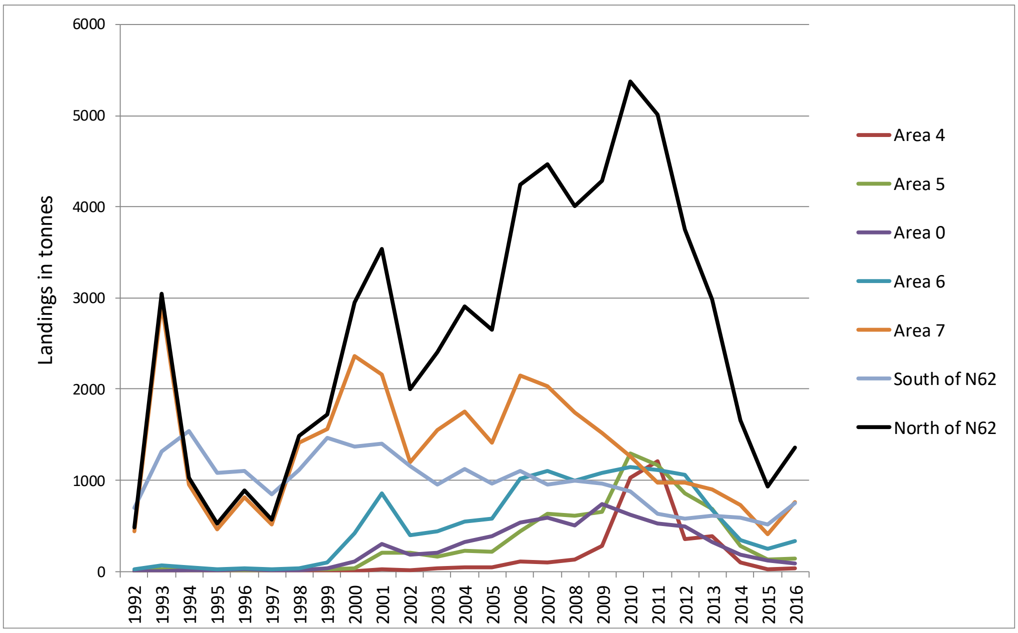


Figure 10.2 . Norwegian offical landings (in tonnes) of anglerfish (*Lophius piscatorius*) per statistical area (see Fig. 10.1) within ICES areas I and II during 1992-2016. Norwegian landings from the area south of 62°N (ICES IV and III) are shown for comparison.

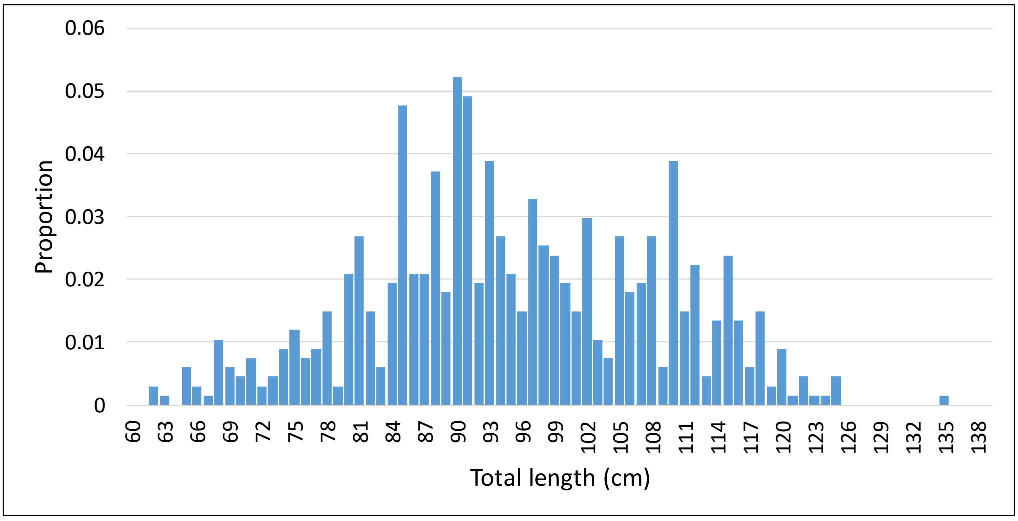


Figure 10.3a. Anglerfish (*Lophius piscatorius*) in IIa. Total lenghts in directed gillnetting, 2016. Based on 61 samples from 4 vessels (N=671).

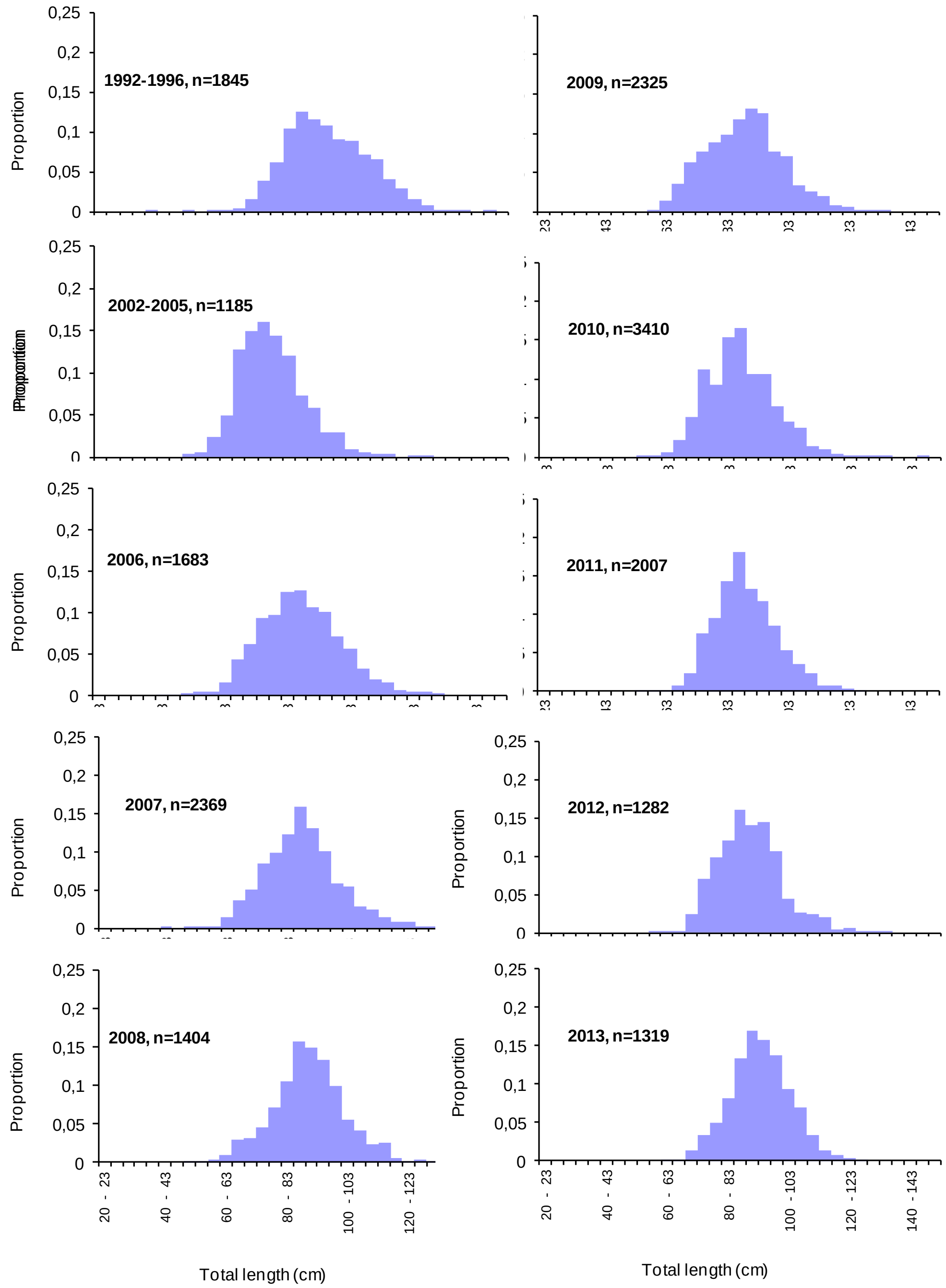


Figure 10.3b. Anglerfish (*Lophius piscatorius*) in IIa. Length distributions for anglerfish caught in the directed coastal gillnetting in Division IIa during 1992-2013. Note that data are lacking for 1997-2001.

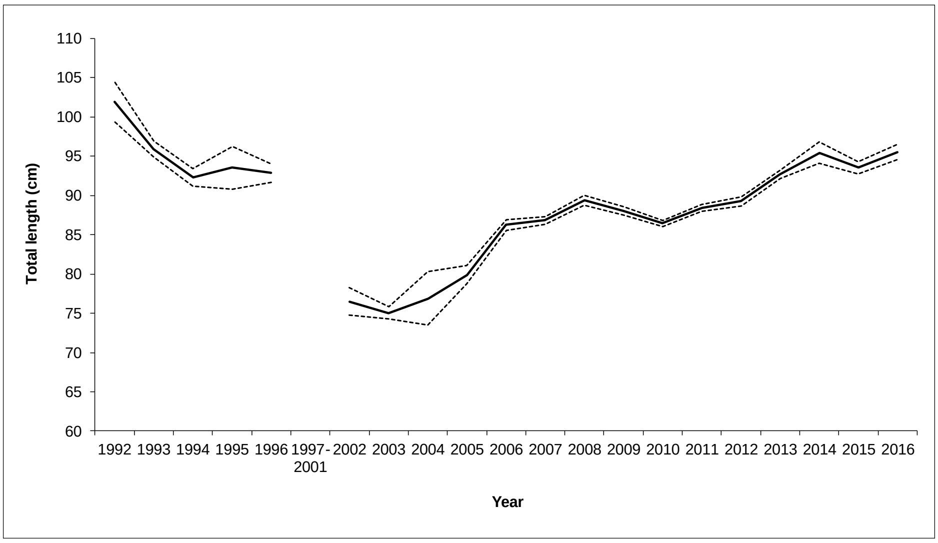


Figure 10.4. Anglerfish (*Lophius piscatorius* in Subarea I and II. Mean lengths for anglerfish caught in the directed coastal gillnetting in Division IIa during 1992-2016, dotted lines represents ±2SE of the mean. Note that data are lacking for 1997-2001.

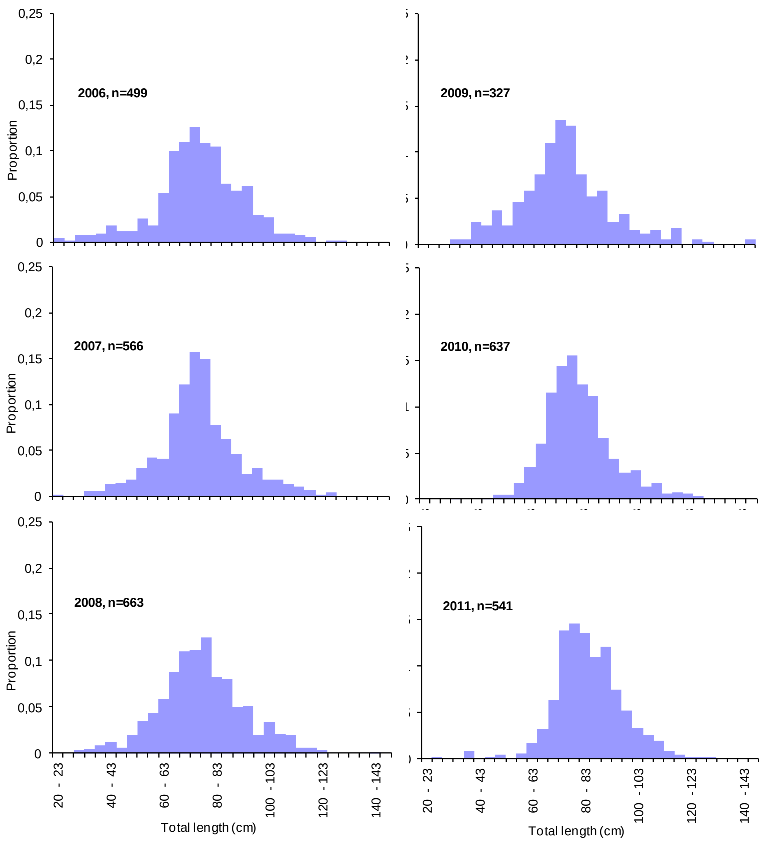


Figure 10.5a. Anglerfish (*Lophius piscatorius* in Subarea I and II. Length distribution for anglerfish caught as bycatch by other gears (offshore gillnetting and longlining) in Division IIa in 2005-2011.

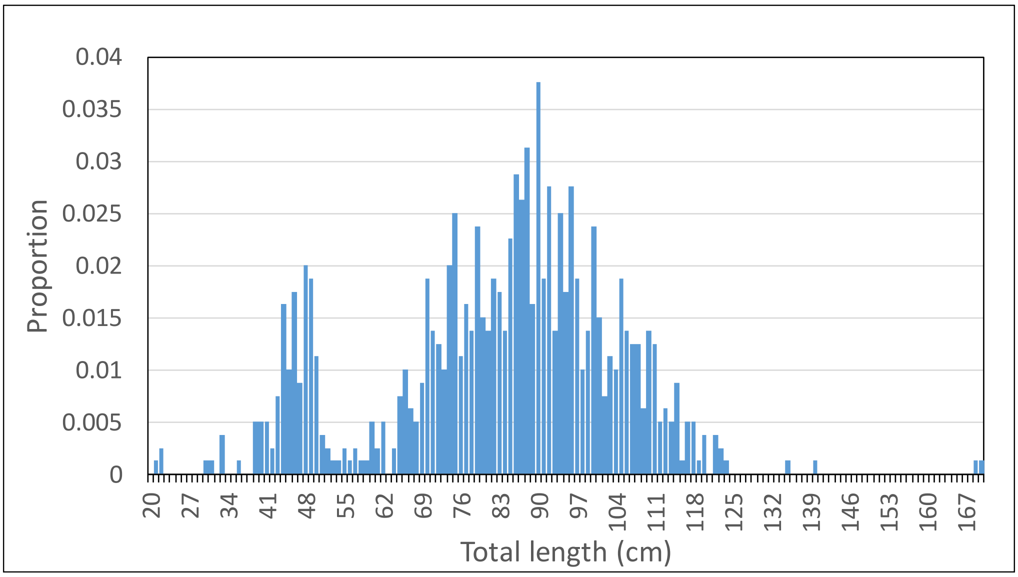


Figure 10.5b. Anglerfish (*Lophius piscatorius)* in IIa. Total lengths, other gillnets and longline 2016. From 141 samples (N=799). Note the small (40-50 cm) anglerfish recruiting to these gears.

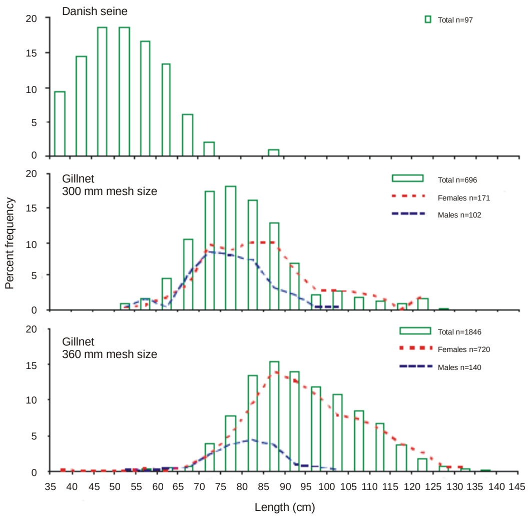


Figure 10.6. Length distributions of commercially landed catches of anglerfish from the Møre coast (ICES IIa; Norw stat.area 07), 1992-1997, illustrating the fishing gears' different selectivity and the sex differences.

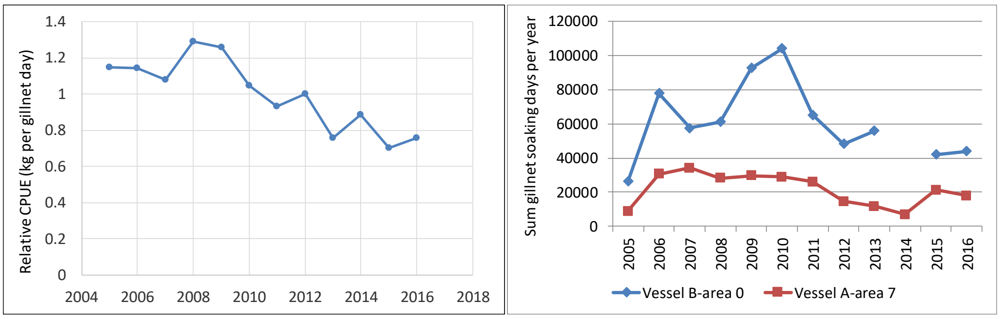


Figure 10.7. Relative (to the 2005-2010 average) CPUE (kg per gillnet day) of anglerfish for two vessels (A and B) in the Norwegian reference fleet in ICES Subarea IIa, and the corresponding fishing effort (right panel). Note that vessel B (northern area) stopped fishing in 2014 due to low catch rates.

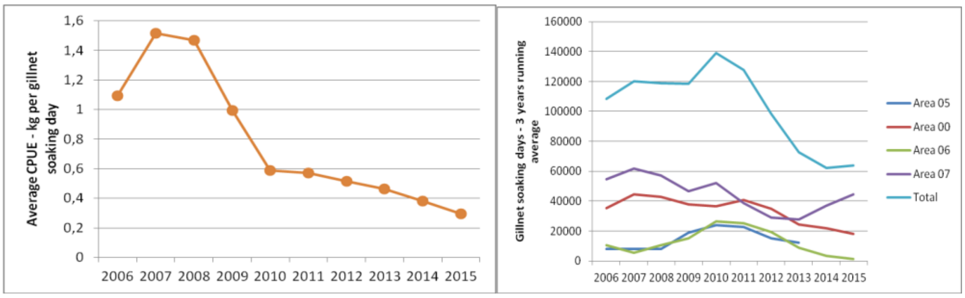


Figure 10.8. CPUE and fishing effort - 3 year running average of gillnet soaking days per year and area and CPUE for the entire Norwegian Coastal Reference fleet fishing anglerfish in ICES Subarea IIa.

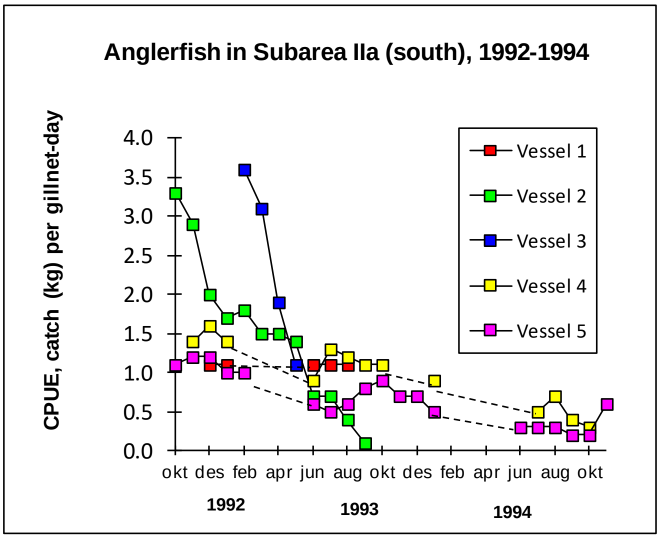


Figure 10.9. Catch per unit effort for five boats in the gillnet fishery for anglerfish in Møre & Romsdal (the same area as vessel A in figure 8 is fishing in) in the period October 1992 - October 1994. Boats 1 > 25m; Boats 2 ca. 20m; Boat 3 ca. 10m; Boat 4 and 5 ca. 16m. Boats 1-4 were fishing with gillnet 360 mm nesh size, boat 5 with 300 mm mesh size.

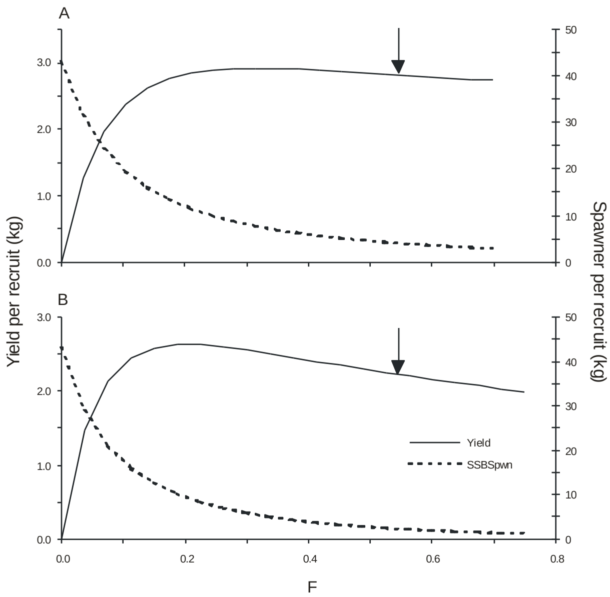


Figure 10.10. Yield- and spawning stock per one year old recruit when (A) based on the exploitation pattern representative of the Norwegian gillnet (360 mm) fishery, and (B) based on the present exploitation pattern for the total fishery for anglerfish in the NEZ (incl. gillnet, trawl, Danish seine). M=0.15, and the age range for the reference F includes ages 7-10. Input data are given in Table 10.3.Thangstad *et al.* (2006) for information about the input data.

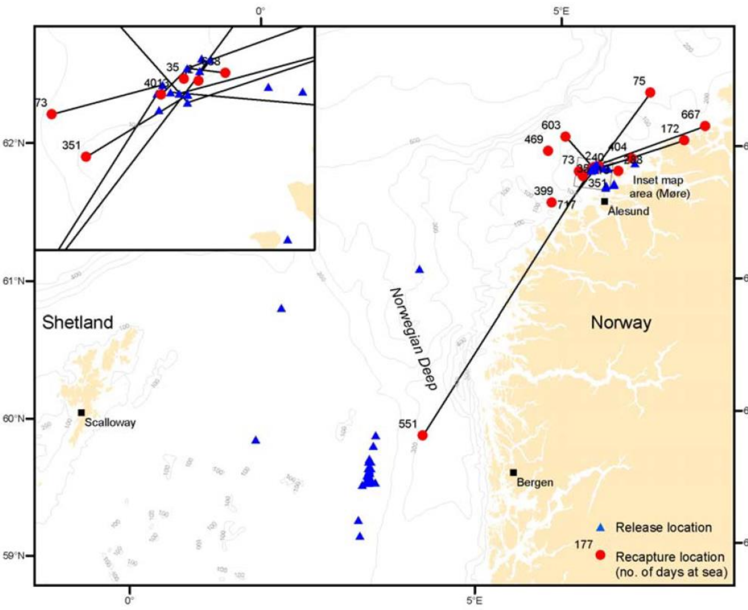


Figure 10.11. Anglerfish tagging locations 2003-2005 on the coast of western Norway in ICES IIa and during the North Sea IBTS surveys, and recapture locations (until 2006) with number of days at sea.

11 References

Aanes, S. 2002. Precision in age determination of Northeast Arctic cod. Working document in: Report of the Arctic Fisheries Working Group. ICES Headquarters 16-25 April 2002. ICES CM 2002/ACFM:18. 451 pp.

Aanes, S. and Pennington, M. 2003. On estimating the Age composition of the Commercial Catch of Northeast Arctic cod from a Sample of Clusters. ICES Journal of Marine Science, 60: 297-303.

Aas, C. A.2007. Predation by saithe on juvenile fish (cod and others). Masters thesis, University of Tromsø, 2007 (In Norwegian).

Ajiad, A. M. , Aglen, A., Nedreaas, K., and Kvamme, C. 2008. Estimating by-catch at age of Northeast arctic cod from the Norwegian shrimp fishery in the Barents Sea 1984-2006. WD2, AFWG 2008.

Ajiad, A. M. , Nedreaas, K., 2014. Revised and updated by-catch estimation of Northeast Arctic cod and beaked redfish from the Barents Sea shrimp fishery until 2013. Working Document no 15. ICES Arctic Fisheries Working Group, ICES CM 2014/ACOM:05.

Albert, O.T. and Vollen, T., 2015. A major nursery area around the Svalbard archipelago provides recruits for the stocks in both Greenland halibut management areas in the Northeast Atlantic. ICES Journal of Marine Science: Journal du Conseil, 72(3): 872-879.

Anon. 2013. The Norwegian Reference Fleet – a trustful cooperation between fishermen and scientists. Focus on Marine Research 3/2013, Institute of Marine Research, Norway. 12 pp.

Anfinsen, L. 2002. Ressursøkologisk betydning av nise (Phocaena phocaena) i norske farvann. Dr. scient thesis. Institute of fisheries and marine biology, University of Bergen, Autumn 2002. 51pp. (In Norwegian).

Berg, E., and Albert, O. T. 2003. Cod in fjords and coastal waters of North Norway: distribution and variation in length and maturity at age. ICES Journal of Marine Science, 60: 787–797.

Berg, E., Sarvas, T. H., Harbitz, A., Fevolden, S.E. and Salberg, A.B. 2005. Accuracy and precision in stock separation of north-east Arctic and Norwegian coastal cod by otoliths - comparing readings, image analyses and a genetic method. Marine and Freshwater Research, No. 56 10 pp.

Björnsson, H., and Sigurdsson, T. 2003. Assessment of golden redfish (*Sebastes marinus* L.) in Icelandic waters. Scienta Marina 67 (Suppl. 1):301-314. Scientia Marina, 67: 301-314.

Bogstad B., and Gjøsæter H., 1994. A method for calculating the consumption of capelin by cod. ICES J. mar. Sci. 51:273-280.

Bogstad, B., Haug, T. and Mehl, S. 2000. Who eats whom in the Barents Sea? NAMMCO Sci. Publ. 2: 98-119.

Bogstad, B. and Mehl, S. 1997. Interactions Between Cod (*Gadus morhua*) and Its Prey Species in the Barents Sea. *Forage Fishes in Marine Ecosystems*. Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report No. 97-01: 591-615. University of Alaska Fairbanks.

Brander, K. 2002. Predicting weight at age. Internal ICES note to assessment working groups. 2003. Software implementation of process models. Working Document No. 2 to the Arctic Fisheries Working Group, San Sebastian, Spain, 23 April- 2 May 2003.

Bulgakova, T., 2005. 'To recruitment prognosis of NEA cod'. Working document #20 in: Report of the Arctic Fisheries Working Group', Murmansk, Russia, April 19-28, 2005. ICES C.M. 2005/ACFM:20, 564 pp.

Cañás, L., Stransky, C., Schlickeisen, J., Sampedro, M. P., and Fariña, A. C. 2012. Use of the otolith shape analysis in stock identification of anglerfish (*Lophius piscatorius*) in the Northeast Atlantic. – ICES Journal of Marine Science, 69: 1–7.

Dingsør, G. E. 2001. Estimation of discards in the commercial trawl fishery for Northeast Arctic cod (*Gadus morhua* L.) and some effects on assessment. Cand. Scient thesis, University of Bergen, 2001.

Dingsør, G.E. 2005. Estimating abundance indices from the international 0-group fish survey in the Barents Sea. Fisheries Research 72(2-3): 205-218.

Dingsør G.E., Bogstad B., Stiansen J.E., and Subbey S. 2010. How can we assess recruitment models for (age-3) NEA cod? / WD 19, AFWG 2010.

Dolgov, A. V. 2006. Food abundance and consumption by the most abundant fish species in the Barents Sea. WD 29, AFWG 2006.

Dolgov, A.V., Yaragina, N.A., Orlova, E.L., Bogstad, B., Johannesen, E., Mehl, S. 2007. 20th anniversary of the PINRO-IMR cooperation in the investigations of fish feeding in the Barents Sea – results and perspectives. In : Haug,. T., Misund, O.A., Gjøsæter, H., and Røttingen, I. (eds.). Long-term bilateral Russian-Norwegian scientific cooperation as a basis for sustainable management of living marine resources in the Barents Sea. Proceeding of the 12th Norwegian-Russian Symposium. Tromsø, 21-22 August 2007. P.44-78.

Dorn, MW 2002. Advice on West Coast Rockfish Harvest Rates from Bayesian Meta-Analysis of Stock-Recruit Relationships. North American Journal of Fisheries Management 22:280–300. American Fisheries Society 2002.

Duarte R, Azevedo M, & Pereda P 1997 Study of the growth of southern black and white monkfish stocks. *ICES Journal of Marine Science* 54(5): 866-874.

Dyb JE 2003. Bestandsstudie av breiflabb (*Lophius piscatorius* L.*)* langs kysten av Møre og i Nordsjøen. *Cand.scient* thesis, University of Bergen. 105 pp. (In Norwegian)

Eikeset A.M., Richtera A., Dunlop E.S., Dieckmann U., and Stenseth N. C. 2013. Economic repercussions of fisheries-induced evolution. PNAS vol. 110, no. 30: 12259–12264.

Eriksen, E., Prozorkevich, D. V. and Dingsør, G. E. 2009. An evaluation of 0-group abundance indices of Barents Sea Fish Stocks. The Open fish Science Journal, 2: 6-14.

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

Gjøsæter, H., Bogstad, B., and Tjelmeland, S. 2009. Ecosystem effects of three capelin stock collapses in the Barents Sea. *In* Fifty Years of Norwegian-Russian Collaboration in Marine Research. Ed. by Haug, T., Røttingen, I., Gjøsæter, H., and Misund, O. A. Thematic issue No. 2, Marine Biology Research 5(1):40-53

Gjøsæter, H., Bogstad, B., Tjelmeland, S., and Subbey, S. 2015. Retrospective evaluation of the Barents Sea capelin management advice Marine Biology Research 11(2):135-143.

Gjøsæter, H., Hallfredsson, E. H., Mikkelsen, N., Bogstad, B., and Pedersen, T. 2016. Predation on early life stages is decisive for year class strength in the Barents Sea capelin (*Mallotus villosus*) stock. ICES Journal of Marine Science 73(2):182-195.

Golovanov S.E., Sokolov A.M., and Yaragina, N.A. 2007. Revised indices of the Northeast Arctic cod abundance according to the 1982-2006 data from Russian trawl-acoustic survey (TAS). Working Document #3 for AFWG 2007.

Gulland, J. 1964. The abundance of fish stocks in the Barents Sea. Rapp. P.-v. Réun. Cons. Int. Explor. Mer, 155: 126-137.

Heino M, Dieckmann U, Godø OR 2002. Reaction norm analysis of fisheries-induced adaptive change and the case of the Northeast Arctic cod. ICES CM 2002/Y: 14.

Hirst, D., Aanes, S., Storvik, G. and Tvete, I.F. 2004. Estimating catch at age from market sampling data using a Bayesian hierarchical model. Journal of the Royal statistical society. Series C, applied statistics, 53: 1-14.

Hirst, D., Storvik, G., Aldrin, M., Aanes, S. and Huseby, R.B. 2005. Estimating catch-at-age by combining data from different sources. Canadian Journal of Fisheries and Aquatic Sciences 62:1377-1385.

Hirst, D., Storvik, G., Rognebakke, H., Aldrin, M., Aanes, S., and Vølstad, J. H. 2012. A Bayesian modelling framework for the estimation of catch-at-age of commercially harvested fish species. Can. J. Fish. Aquat. Sci. 69: 2064–2076.

Hislop, J. R. G., Gallego, A., Heath, M. R., Kennedy, F. M., Reeves, S. A., and Wright, P. J. 2001. A synthesis of the early life history of the anglerfish, *Lophius piscatorius* (Linnaeus, 1758) in northern British waters. ICES Journal of Marine Science 58:70–86.

Hjermann, D. Ø., Bogstad, B., Eikeset, A. M., Ottersen, G., Gjøsæter, H., and Stenseth, N. C. 2007. Food web dynamics affect Northeast Arctic cod recruitment. Proceedings of the Royal Society, Series B 274:661-669.

Hjermann, D. Ø., Bogstad, B., Dingsør, G. E., Gjøsæter, H., Ottersen, G., Eikeset, A. M., and Stenseth, N. C. 2010. Trophic interactions affecting a key ecosystem component: a multi-stage analysis of the recruitment of the Barents Sea capelin. Canadian Journal of Fisheries and Aquatic Science 67:1363-1375.

Høie, H., Bernreuther, M., Ågotnes, P., Beußel, F., Koloskova, V., Mjanger, H., Schröder, D., Senneset, H. and Zuykova, N. 2009. Report of Northeast Arctic cod otolith exchange between Russia, Norway and Germany 2008. WD # 6 ICES Arctic Fisheries Working Group 2009, San Sebastian 21-27th April 2009.

ICES 2001. Report of the Arctic Fisheries Working Group. Bergen, Norway, 24 April – 3 May 2001. ICES CM 2001/ACFM:19. 380 pp.

ICES 2006a. ICES Workshop on Biological Reference Points for North East Arctic Haddock (WKHAD). Svanhovd, Norway, 6-10 March 2006. ICES C.M. 2006/ACFM:19, 102 pp.

ICES 2006b. Report of the Arctic Fisheries Working Group, Copenhagen 19-28 April 2006. ICES C.M. 2006/ACFM:25, 594 pp.

ICES 2007b. Report of the Arctic Fisheries Working Group, Vigo, Spain 18-27 April 2007. ICES C.M. 2007/ACFM:16, 651 pp.

ICES 2008. Report of the Workshop on Methods to Evaluate and Estimate the Accuracy of Fisheries Data used for Assessment (WKACCU), 27–30 October 2008, Bergen, Norway. ICES CM 2008/ACOM:32. 41 pp.

ICES 2009. Report of the Benchmark Workshop on Short-lived Species (WKSHORT). ICES C.M. 2009/ACOM: 34: 1-166.

ICES 2009. Report of the Workshop on methods to evaluate and estimate the precision of fisheries data used for assessment (WKPRECISE), 8-11 September 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:40. 43 pp.

ICES 2009. Report of the workshop for the exploration of the dynamics of fish stocks in poor conditions (WKPOOR2). ICES CM, 2009/ACOM:49: 30pp.

ICES 2010. Report of the Arctic Fisheries Working Group, Lisbon/Bergen, 22-28 April 2010. ICES C.M. 2010/ACOM:05, 664 pp.

ICES 2010. Report of the Benchmark Workshop on Roundfish (WKROUND), 9-16 February 2010, Copenhagen, Denmark. ICES CM 2010/ACOM: 36. 183 pp.

ICES 2010. Report of the workshop on implementing the ICES FMSY framework (WKFRAME). ICES CM, 2010/ACOM:54: 79pp.

ICES 2011. Report of the Arctic Fisheries Working Group, Hamburg, Germany 28 April – 4 May 2011. ICES C.M. 2011/ACOM:05, 659 pp.

ICES. 2011. Report of the Study Group on Recruitment Forecasting (SGRF), 17–20 October 2011, Copenhagen, Denmark. *In* ICES CM 2011/ACOM:31, 36 pp.

ICES 2011. Report of the Workshop of Implementing the ICES Fmsy framework (WKFRAME2), 10-14 February 2011, ICES, Denmark. ICES C. M. 2011/ACOM:33, 110 pp.

ICES 2011. Report of the Benchmark Workshop on Roundfish and Pelagic Stocks, Lisbon 24-31 January 2011. ICES C.M. 2011/ACOM:38, 418 pp.

ICES. 2011. Report of the Workshop on Age Reading of Greenland Halibut (WKARGH), 14-17 February 2011, Vigo, Spain. ICES CM 2011/ACOM:41. 39 pp.

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM:68. 42 pp.

ICES. 2012. Report of the Study Group on Recruitment Forecasting (SGRF),15–19 October 2012, Barcelona, Spain. ICES CM 2012/ACOM:24. 36 pp.

ICES 2012. Report of the benchmark workshop on redfish (WKRED). ICES CM, 2012/ACOM: 48: 289 pp.

ICES. 2013. Report of the second Workshop on Practical Implementation of Statistical Sound Catch Sampling Programmes, 6 - 9 November 2012, ICES Copenhagen. ICES CM 2012 / ACOM:54 71 pp.

ICES 2013. Report of the Arctic Fisheries Working Group, Copenhagen, 18-24 April 2013. ICES C.M. 2013/ACOM:05, 682 pp.

ICES 2013. Report of the third Workshop on Practical Implementation of Statistical Sound Catch Sampling Programmes, 19-22 November 2013, ICES HQ, Copenhagen, Denmark. ICES CM2013/ACOM:54. 109 pp.

ICES. 2013. Report of the Study Group on Recruitment Forecasting (SGRF), 18-22 November 2013,Lisbon. ICES CM 2013/ACOM:24. 29 pp.

ICES 2014. Report of the Inter-Benchmark Protocol on Northeast Arctic Saithe in Subareas I and II (IBP NEA saithe), March/April 2014, by correspondence. ICES CM 2014/ACOM: 53, 94 pp.

ICES 2014. Report of the Working Group on Harp and Hooded Seals Quebec City 17-21 November 2014. ICES C. M. 2014/ACOM:20, 62 pp.

ICES. 2015. Report of the Benchmark Workshop on Arctic Stocks (WKARCT), 26-30 January 2015, ICES Headquarters, Denmark. ICES CM 2015\ACOM:31. 126 pp.

ICES 2015. Report of the Arctic Fisheries Working Group, Hamburg, Germany, 23-29 April 2015. ICES C.M. 2015/ACOM:05, 590 pp.

ICES 2015. Report of the Inter Benchmark Process on Greenland Halibut in ICES areas I and II (IBPHALI). By Correspondence, August 2015. ICES CM 2015/ACOM:54, 41 pp.

ICES 2015. Report of the first Workshop on Management Plan Evaluation on Northeast Arctic cod and haddock and Barents Sea capelin, 24-26 November 2015, Murmansk, Russia. ICES CM 2015/ACOM:60, 27 pp.

ICES 2016. Report of the second Workshop on Management Plan Evaluation on Northeast Arctic cod and haddock and Barents Sea capelin, 25-28 January 2016, Kirkenes, Norway. ICES CM 2016/ACOM:47, 76 pp.

ICES 2016. The Third Report of the Working Group on Integrated Assessments of the Barents Sea (WGIBAR). Murmansk, Russia, 22-25 February 2016. ICES CM 2016/SSGIEA:04, 126 pp.

ICES 2016. Report of the Arctic Fisheries Working Group, ICES HQ, Copenhagen, Denmark. 19-25 April 2016. ICES CM 2016/ACOM:06. 621 pp.

ICES 2016. Final Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS). ICES CM, ICES CM 2016/SSGIEOM:02: 21pp.

ICES 2017. Report of Inter-benchmark protocol on Northeast Arctic cod (IBP ARCTIC COD 2017), Copenhagen, 3-6 April 2017. ICES CM 2017/ACOM:29.

ICES 2017. Report of the Working Group on the Integrated Assessments of the Barents Sea. WGIBAR 2017 Report, 16-18 March 2017. Murmansk, Russia. ICES CM 2017/SSGIEA:04. 186 pp.

Jakobsen, T., Korsbrekke, K., Mehl, S., and Nakken, O. 1997. Norwegian combined acoustic and bottom trawl surveys for demersal fish in the Barents Sea during winter. ICES CM 1997/Y:17.

Jørgensen C., Enberg K., Dunlop E.S,. Arlinghaus R., Boukal D.S., Brander K., Ernande B., Gårdmark A., Johnston F., Matsumura S., Pardoe H., Raab K., Silva A., Vainikka A., Dieckmann U., Heino M., Rijnsdorp A.D. 2008. The role of fisheries-induced evolution – response. Science. 320: 48-50.

Kennedy, J., Hedeholm, R.B., Gundersen, A.C. and Boje, J., 2014. Estimates of reproductive potential of Greenland halibut (*Reinhardtius hippoglossoides*) in East Greenland based on an update of maturity status. Fisheries Research, 154: 73-81.

Kennedy, J., Gundersen, A.C., Høines, Å.S. and Kjesbu, O.S., 2011. Greenland halibut (*Reinhardtius hippoglossoides*) spawn annually but successive cohorts of oocytes develop over 2 years, complicating correct assessment of maturity. Canadian Journal of Fisheries and Aquatic Sciences, 68(2): 201-209.

Korsbrekke, K. 1997. Norwegian acoustic survey of Northeast Arctic cod on the spawning grounds off Lofoten. ICES C.M 1997/Y:18.

Kovalev, Yu.A., and Yaragina N.A. 2009. The effects of population density on the rate of growth, maturation, and productivity of the stock of the Northeast Arctic cod. Journal of Ichthyology 49, № 1: 56-65.

Kovalev, Y., Prozorkevich, D., and Chetyrkin, A. 2017. Estimation of Ecosystem survey 2016 index in situation of not full area coverage. Working Document No. 12 to the Arctic Fisheries Working Group, Copenhagen, 18-25 April 2017.

Kuparinen A., Stenseth N. C., Hutchings J. A. 2014. Fundamental population-productivity relationships can be modified through density-dependent feedbacks of life-history evolution. Evol Appl 7(10):1218-25.

Mehl, S., Aglen, A., Alexandrov, D.I., Bogstad, B., Dingsør, G.E., Gjøsæter, H., Johannesen, E., Korsbrekke, K., Murashko, P.A., Prozorkevich, D.V., Smirnov, O., Staby, A., and Wenneck, T. de Lange, 2013. Fish investigations in the Barents Sea winter 2007-2012. IMR-Pinro Joint Report Series 1-2013, 97 pp.

Mehl, S., Aglen, A., Bogstad, B., Dingsør, G.E., Gjøsæter, H., Godiksen, J., Johannesen, E., Korsbrekke, K., Staby, A., Wenneck, T. de Lange, Wienerroither, R., Murashko, P. A., and Russkikh, A. 2014. Fish investigations in the Barents Sea winter 2013-2014. IMR-PINRO Joint Report Series 2-2014, 73 pp.

Mehl, S. Aglen, A., Amelkin, A., Dingsør, G.E., Gjøsæter, H., Godiksen, Staby, A., Wenneck, T. de Lange, and Wienerroither, R. 2015. Fish investigations in the Barents Sea, winter 2015. IMR-PINRO report series 2-2015. 61 pp.

Mehl, S., Aglen, A., Berg, E., Dingsør, G. and Korsbrekke, K. 2014. Akustisk mengdemåling av sei, kysttorsk og hyse, Finnmark – Møre, hausten 2014. [Acoustic abundance of saithe, coastal cod and haddock Finnmark – Møre Autumn 2014]. *In Norwegian, legends in English***.** Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr. 1 – 2014 (38pp).

Mehl, S, Aglen, A., Berg, E. Dingsør, G. and Korsbrekke, K. 2015. Akustisk mengdemåling av sei, kyst-torsk og hyse Finnmark – Møre hausten 2015. Acoustic abundance of saithe, coastal cod and haddock Finnmark – Møre Autumn 2015. *In Norwegian, legends in English***.** Toktrapport/Havforskningsinstituttet/ISSN 1503-6294, Nr. 4 – 2015. 38pp.

Mehl, S, Aglen, A., Berg, E. Dingsør, G. and Korsbrekke, K. 2016. Akustisk mengdemåling av sei, kyst-torsk og hyse Finnmark – Møre hausten 2016. Acoustic abundance of saithe, coastal cod and haddock Finnmark – Møre Autumn 2016. *In Norwegian, legends in English***.** Toktrapport/Havforskningsinstituttet/ISSN 1503-6294, Nr. 15 – 2016. 38pp.

Mehl, S., Aglen, A., Bogstad, B., Staby, A., de Lange Wenneck, T. Wienerroither, R., and Russkikh, A.A. 2017. Fish investigations in the Barents Sea winter 2017. Working Document No. 3 to the Arctic Fisheries Working Group, Copenhagen, 18-25 April 2017.

Mehl, S., Aglen, A. and Johnsen, E. 2017. Re-estimation of swept area indices with CVs for main demersal fish species in the Barents Sea winter survey 1994 – 2016 applying the Sea2Data StoX software2017. Fisken og Havet No. 10, 2016. Institute of Marine Research, Bergen, Norway. 43 pp.

Mehl, S., and Yaragina, N. A. 1992. Methods and results in the joint PINRO-IMR stomach sampling program. In: Bogstad, B. and Tjelmeland, S. (eds.), *Interrelations between fish populations in the Barents Sea*. Proceedings of the fifth PINRO-IMR Symposium. Murmansk, 12–16 August 1991. Institute of Marine Research, Bergen, Norway, 5–15.

Mortensen, E. 2007. Er det variasjon i diett og lengde ved alder hos torsk (Gadus morhua L.) nord for 64°N? [in Norwegian]. Master Thesis, University of Tromsø, June 2007.

Nedreaas, K. 2017. Conversion factors for products of cod (Gadus morhua) north of 62°N in the winter season 2015 – inaccurate current practice. Working Document No. 15 to the Arctic Fisheries Working Group, Copenhagen, 18-25 April 2017.

Nedreaas, K. 2017. CPUE data from Norwegian trawl fleet. Working Document No. 17 to the Arctic Fisheries Working Group, Copenhagen, 18-25 April 2017.

Nedreaas K. and Smirnov O, 2003. Stock characteristics, fisheries and management of Greenland halibut (*Reinhardtius hippoglossoides* Walbaum) in the northeast Arctic. Proceedings of the 10th Norwegian-Russian Symposium Bergen, Norway 27-29 August 2003.

Nielsen, A., Berg, C.W., 2014. Estimation of time-varying selectivity in stock assessments using state-space models. Fish. Res. 158:96-101.

Nilssen, K.T., Pedersen, O-P., Folkow, L. and Haug, T. 2000. Food consumption estimates of Barents Sea harp seals. NAMMCO Scientific Publications 2: 9-27.

Núñez, L.A., Hallfredsson, E.H. and Falk-Petersen, I.-B., 2015. Different maturity scales affect estimations of fecundity, TEP and spawning stock size of Greenland halibut,*Reinhardtius hippoglossoides* (Walbaum, 1792). Marine Biology Research: 1-10.

Ofstad, L. H. 2013. Anglerfish *Lophius piscatorius* L. in Faroese waters. Life history, ecological importance and stock status. Dr. scient thesis, University of Tromsø. February 2013. 81 pp.

O'Sullivan M., Wright P. J., Verspoor E., Knox D., Piertney S. 2006. Absence of spatial and temporal genetic differentiation at microsatellite loci in north east Atlantic anglerfish (*Lophius piscatorius*). Journal of Fish Biology 2006; 69:261.

Pedersen, T., Nilsen, M., Berg, E., and Reigstad M. 2007. Trophic model of a lightly exploited cod-dominated ecosystem. In; Nilsen, M: "Trophic interactions and the importance of macrobenthic invertebrate production in two Arctic fjord systems". A dissertation for PhD, University of Tromsø, Autumn 2007

Pedersen, T. and Pope, J.G. 2003a. Sampling and a mortality model of a Norwegian cod (Gadus morhua L.) fjord population. Fish. Res. 63, 1-20.

Pedersen, T., and Pope, J. 2003b. How may feeding data be integrated into a model for a Norwegian fjord population of cod (Gadus morhua L.)? Scientia Marina, 67(Suppl. 1): 155-169.

Planque, B. 2015. *S. mentella* assessment - handling the +group.: WD03 - ICES AFWG2015. 8 pp.

Planque, B. 2016. Possible use of the Pelagic and slope surveys in the analytical assessment of Sebastes mentella in ICES areas 1 and 2.: WD05 - ICES AFWG2016. 6 pp.

Ponomarenko, I.Ya. and N.A.Yaragina. 1990. Long-term dynamics of the Barents Sea cod feeding on capelin, euphausiids, shrimp and the annual consumption of these objects. Feeding resources and interrelations of fishes in the North Atlantic: Selected papers of PINRO. Murmansk. 1990. p.109-130 (in Russian).

Ponomarenko, I.Ya. 1973. The influence of feeding and temperature conditions on survival of the Barents Sea "bottom" juvenile cod. Voprosy okeanografii severnogo promyslovogo basseina: Selected papers of PINRO. Murmansk, 1973. Vyp.34. p.210-222 (in Russian)

Ponomarenko, I.Ya. 1984. Survival of "bottom juvenile" cod in the Barents Sea and determining factors. Cod reproduction and recruitment: Proceedings of the first Soviet-Norwegian symposium/VNIRO. – M., 1984. – p.301-315 (in Russian).

Skjœraasen, J. E., Kennedy, J., Thorsen, A., Fonn, M., Strand, B. N., Mayer, I., and Kjesbu, O. S. 2009. Mechanisms regulating oocyte recruitment and skipped spawning in Northeast Arctic cod (*Gadus morhua*). Canadian Journal of Fisheries and Aquatic Sciences, 66: 1582–1596.

Solmundsson, J, Jonsson, E and Björnsson, H. 2007. Recent changes in the distribution and abundance of monkfish (*Lophius piscatorius*) in Icelandic waters. ICES CM 2007/K:02. 16pp.

Staalesen, B.I. 1995. Breiflabb (*Lophius piscatorius* L.) langs norskekysten. *Cand.scient* thesis, University of Bergen. 88 pp. (In Norwegian, summary in English)

Stiansen et al. 2005. IMR status report on the Barents Sea ecosystem, 2004-2005. WD1, AFWG 2005.

Subbey, S., JE. Stiansen, B. Bogstad, T. Bulgakova and O. Titov, 2008. Evaluating Recruitment Models for (Age 3) NEA Cod. Working document #27. Report of the Arctic Fisheries Working Group (AFWG). 21-29 April 2008, ICES Headquarters, Copenhagen. ICES CM 2008\ACOM:01.

Svendsen, E., Skogen, M., Budgell, P., Huse, G., Ådlandsvik, B., Vikebø, F., Stiansen, J.E., Asplin, L., and Sundby, S. 2007. An ecosystem modelling approach to predicting cod recruitment. Deep-Sea Research Part II, 54:2810-2821.

Thangstad, T., Bjelland, O., Nedreaas, KH, Jónsson, E., Laurenson, CH and Ofstad, LH 2006. Anglerfish (*Lophius* spp.) in Nordic waters. TemaNord 2006:570. © Nordic Council of Ministers, Copenhagen 2006. ISBN 92-893-1416-8. 162 pp.

Titov, O., Pedchenko, A. and Karsakov, A., 2005. 'Assessment of Northeast Arctic cod and capelin recruitment from data on ecological situation in the Barents Sea in 2004-2005'. Working document #16 in: Report of the Arctic Fisheries Working Group', Murmansk, Russia, April 19-28, 2005. ICES C.M. 2005/ACFM:20, 564 pp.

Titov O.V. 2010. Assessment of population recruitment abundance of Northeast Arctic cod considering the environment data. WD 22, AFWG 2010.

Titov, O. 2011. Assessment of population recruitment abundance of northeast Arctic cod considering the environment data. ICES AFWG 2011/WD:23.

Tjelmeland, S. 2005. Evaluation of long-term optimal exploitation of cod and capelin in the Barents Sea using the Bifrost model. Pp. 112-129 in: Shibanov, V. (ed.). "Ecosystem Dynamics and Optimal Long-term Harvest in Barents Sea Fisheries". Proceedings of the 11th Russian-Norwegian Symposium, Murmansk, Russia, 15-17 August 2005. IMR/PINRO report series 2/2005, 331 pp.

Tjelmeland, S. and Lindstrøm, U. 2005. An ecosystem element added to the assessment of Norwegian spring spawning herring: implementing predation by minke whales. ICES Journal of Marine Science 62(2):285-294.

Vasilyev D. 2005 Key aspects of robust fish stock assessment. M: VNIRO Publishing, 2005. 105 p.

Vasilyev D. 2006. Change in catchability caused by year class peculiarities: how stock assessment based on separable cohort models is able to take it into account? (Some illustrations for triple-separable case of the ISVPA model - TISVPA). ICES CM 2006/O:18. 35 pp

Westgaard, J.-I., Saha, A., Kent, M.P., Hansen, H.H., Knutsen, H., Hauser, L., Cadrin, S.X., Albert, O.T. and Johansen, T., 2016. Genetic population structure in Greenland halibut (*Reinhardtius hippoglossoides*) and its relevance to fishery management. Canadian Journal of Fisheries and Aquatic Sciences.

Yaragina, N. A. 2010. Biological parameters of immature, ripening and non-reproductive mature Northeast Arctic cod in 1984-2006. ICES Journal of Marine Science, 67: 2033-2041.

Yaragina, N.A. Nedreaas, K.H., Koloskova, V., Mjanger, H., Senneset, H., Zuykova, N. & Ågotnes, P. 2009b. Fifteen years of annual Norwegian-Russian cod comparative age readings. Marine Biology Research 5(1): 54-65.

Yaragina, N. A., Kovalev, Yu. A., and Chetyrkin, A. 2015. Hindcasting cod cannibalism back to 1947. Working document 7. ICES Benchmark Workshop on Arctic Stocks (WKARCT), ICES CM 2015\ACOM:31.

Yaragina, N.A. and Bogstad, B. 2017. Historic difference in stock weight and maturity at age in Northeast Arctic cod. Working Document No. 10 to the Arctic Fisheries Working Group, Copenhagen, 18-25 April 2017.

Zuykova, N.V., Koloskova, V.P., Mjanger, H., Nedreaas, K.H., Senneset, H., Yaragina, N.A., Ågotnes, P. and Aanes, S. 2009. Age determination of Northeast Arctic cod otoliths through 50 years of history. Marine Biology Research 5(1): 66-74.

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

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

Guðmundsdóttir, Á., G.J. Óskarsson, and S. Sveinbjörnsson 2007. Estimating year-class strength of Icelandic summer-spawning herring on the basis of two survey methods. ICES Journal of Marine Science, **64**: 1182–1190.

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

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

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

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

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

ICES. 2017b. Workshop on MSEs for Icelandic herring, ling and tusk (WKICEMSE), 21–25 April, 2017, ICES Headquarters, Copenhagen. ICES CM 2017/ACOM:45.

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

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

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

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

Óskarsson, G.J. 2017. Results of acoustic measurements of Icelandic summer-spawning herring in the winter 2016/2017. ICES North Western Working Group, 27 April - 4 May 2017, Working Document No. 11. 65 pp.

Óskarsson, G.J. and J. Pálsson 2013. Development and nature of massive and long-lasting Ichthyophonus hoferi outbreak in Icelandic summer-spawning herring. ICES North Western Working Group, 26 April - 3 May 2013, Working Document No. 2. 17 pp.

Óskarsson, G.J. and J. Pálsson 2015. Estimation on number-at-age of the catch of Icelandic summer-spawning herring in 2014/2015 fishing season and the development of Ichthyophonus hoferi infection in the stock. ICES North Western Working Group, 28 April - 5 May 2015, Working Document No. 2. 15 pp.

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

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

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

Óskarsson, G.J., Sigurðsson, Þ., Ólafsdóttir, S.R. and Valdimarsson, H. 2013. Two incidents of mass mortalities of Icelandic summer-spawning herring in Kolgrafafjörður in the winter 2012/2013. ICES North Western Working Group, 26 April - 3 May 2013, Working Document No. 1. 11 pp.

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

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

Óskarsson, G.J., Pálsson, J., and Gudmundsdottir, A. 2017. Development, nature and impacts of widespread and long-lasting Ichthyophonus sp. outbreak in Icelandic summer-spawning herring. Manuscript submitted to MEPS, April 2017.

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

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Annex 2: Recommendations

RECOMMENDATION	FOR FOLLOW UP BY:
AFWG recommends that WGIBAR continue to work in collaboration with AFWG to produce ecosystem, reports, and ensure that the AFWG and WGIBAR report together provide an overview of the Barents Sea ecosystem and fisheries.	WGIBAR

Annex 3: ToRs for the next meeting

AFWG – Arctic Fisheries Working Group

2016/2/ACOM: 06 The **Arctic Fisheries Working Group** (AFWG), chaired by Daniel Howell*, Norway, will meet at ICES Headquarters, Copenhagen, Denmark, 19–25 April 2017 to:

a) Address generic ToRs for Regional and Species Working Groups, for all stocks except the Barents Sea capelin;

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

c) In preparation for the benchmark on anglerfish stocks, compile data for anglerfish in Subarea IIa.

d) Estimate MSY proxy reference points for the category 3 and 4 stocks in need of new advice in 2017 (see table below).

   a. Collate necessary data and information for the stocks listed below prior to the Expert Group meeting. An official ICES data call was made for length and select life history parameters for each stock in the table below;

   b. Propose appropriate MSY proxies for each of the stocks listed below by using methods provided in the ICES Technical Guidelines (i.e. peer reviewed methods that were developed by WKLIFE V, WKLIFE VI, and WKProxy) along with available data and expert judgement.

STOCK CODE	STOCK NAME DESCRIPTION	EG	DATA CATEGORY
cod-coas	Cod (*Gadus morhua*) in subareas 1 and 2 (Norwegian coastal waters cod)	AFWG	3

and by correspondence in September/October to:

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

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting. 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 no later than 6 April.

AFWG will report by 11 May 2017 and 6 October 2017 for Barents Sea capelin for the attention of ACOM

Generic ToRs for Regional and Species Working Groups

2016/2/ACOM: 05 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 overview, and

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

c) Conduct an assessment to update advice on the stock(s) 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, summarising 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 area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in the last year.

  iv) 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;

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

  vi) Catch options for next year;

  vii) Historical 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 fish stocks and fisheries under considerations according to ACOM guidelines.

e) Review progress on benchmark processes of relevance to the expert group;

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

g) Identify research needs of relevance for the expert group.

Information of the stocks

Annex 4: List of Working Documents

WD No	Presentec	Author	Title
1	Yes	Prozorkevich	BESS cod index 2004-2016
2	Yes	Prozorkevich	BESS haddock index 2004-2016
3	Yes	Mehl et al.	Fish investigations in the Barents Sea winter 2017. Preliminary report.
4	No	Vasilyev, D.	Update of the NEA haddock stock assessment by means of TISVPA
5	No	Alpoim, R. et al.	Report of the Portuguese fishery in 2016: ICES Div. I, IIa and IIb
6	No	Casas, J.M.	The Spanish Pelagic Redfish Fishery in 2016
7	No	Casas, J.M.	GHL Spanish survey 2016
8	No	Casas, J.M.	The Spanish NE Arctic Cod Fishery in 2015
9	No	Russkikh, A.	NEA haddock input adjustment
10	No	Yaragina, N. A. and Bogstad, B.	Growth-maturation-adjustment-cod

Annex 5: List of Stock Annexes

STOCK ID	STOCK NAME	LAST UPDATED	LINK
ang-arct_SA	Anglerfish in Subareas 1 and 2 (Northeast Arctic	Oct-14	ang-arct_SA
cap-bars_SA	Capelin (*Mallotus villosus*) in Subareas 1 and 2 (Northeast Arctic), excluding Division 2.a west of 5^0 W (Barents Sea capelin)d	Jan-15	cap-bars_SA
cod.27.1-2_SA	Cod (*Gadus morhua*) in Subareas 1 and 2 (North-east Arctic)	Jun-17	cod.27.1-2_SA
cod-coas_SA	Cod (*Gadus morhua*) in Subareas 1 and 2 (Norwegian coastal waters cod)	Jan-15	cod-coas_SA
ghl-arct_SA	Northeast Arctic Greenland Halibut *(Reinhardtius hippoglossoides*)	Apr-16	ghl-arct_SA
had-arct_SA	Haddock (*Melanogrammus aeglefinus*) in Subareas 1 and 2 (Northeast Arctic)	Apr-16	had-arct_SA
sai-arct_SA	Saithe in Subareas 1 and 2 (Northeast Arctic)	Mar-12	sai-arct_SA
smn-arct_SA	Beaked redfish (*Sebastes mentella*) in Subareas 1 and 2 (Northeast Arctic)	Mar-12	smn-arct_SA
smr-arct_SA	Golden redfish (*Sebastes norvegicus*) in Subareas 1 and 2 (Northeast Arctic)	May-15	smr-arct_SA

Annex 6: Audit reports

Audit of: had27.1-2 (Haddock in subareas 1 and 2)

Date: 18. May, 2017

Auditor: Asgeir Aglen

General

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: SAM; tuned by 3 research vessel surveys. Haddock consumed by cod included in natural mortality, haddock consumption is this year estimated based on the SAM assessment of cod.
5) **Data issues:** Missing Russian autumn survey in 2016. Adjustments done for compensating incomplete ecosystem survey in 2016 and winter survey in 2017. Some uncertainty related to catch at age data.
6) **Consistency:** Compared to earlier assessments: some downward revision of SSB 2013 and later. Some downward revision of F2008 and later, related to revised estimates of cod predation (upward revision of cod in 2010 and later)
7) **Stock status**: SSB well above Blim, Bpa and MSYBtrigger for more than 10 years while, F below reference points since 2008.

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 FMSY.The TAC should not be changed by more than ±25% compared with the previous year TAC.If the spawning stock falls below Bpa, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from FMSY at Bpa to F= 0 at SSB equal to zero. At SSB-levels below Bpa 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.

1) 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.

General comments

The assessment has been performed correctly.

Technical comments

Over the recent years old fish has contributed considerably to the stock and catches. The assessment may further improve by including older ages in the survey tuning series. With current tuning data F is assumed equal for ages 9 and older.

In the report Table 4.8; the column "Biomass eaten" is in thousand tonnes (currently labelled as tonnes)

Conclusions

The assessment is recommended as basis for the 2018 advice

Audit of Cod (*Gadus morhua*) in Subareas I and II (Northeast Arctic)

Date May 6, 2017

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 1981-2017), Barents Sea+Lofoten Joint acoustic survey (Feb-Mar, years 1985-2017), Russian bottom trawl survey (Oct-Dec, years 1982-2015), Ecosystem survey (Aug-Sep, years 2004-2016)

   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

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 2a, 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.

The time series for weight and maturity at age should be revised in 2018 following the revision of the time series for the acoustic estimates in the Norwegian winter survey

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 (eg. 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. Adjustments will be considered next year when there is data from the 2015 survey.

5) **Consistency**: Last year’s assessment was accepted.

The assessment, recruitment and forecast models have been applied as specified in the stock annex.

6) **Stock status**: The SSB (currently 1,505,000t) has been above Bpa (460,000t) since 2003 and F below or around Fpa since 2003. Recruitment is uncertain but reasonably stable.

7) **Man. Plan**.: Biomass reference points: The values adopted by ACFM in 2003 are Blim = 220,000 t, Bpa = 460,000 t. (ICES CM 2003/ACFM:11). Fishing mortality reference points: The values adopted by ACFM in 2003 are Flim = 0.74 and Fpa = 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.

Audit of *Sebastus mentella*

Date: 26.4.2017
Auditor: Arved Staby

General

The last assessment for this stock was done in 2014 (three year advice cycle).
The Northeast Arctic Beaked redfish (Sebastes mentella) assessment and draft advice have been approved by the Working Group.

For single stock summary sheet advice:

8) **Assessment type: update**
9) **Assessment**: analytical
10) **Forecast**: presented
11) **Assessment model**: Statistical catch-at-age (SCAA) is used to estimate abundance, recruitment and fishing mortality. Schaefer model was not used for validation in 2017.
12) **Data issues:** There was no catch at age data available for 2016 (and not enough for an update run in ECA for 2015), and thus catch at age data was simulated for 2016. Other data sets updated with most recent data available. Weight at age was modelled based on catch and survey records, and maturity at age and recruitment was modelled for 2016 using a fixed effects model. Russian autumn survey data for 2016 not available.
13) **Consistency**: The last assessment was done three years ago.
14) **Stock status**: Spawning-stock biomass (SSB) has steadily increased from 1992 to 2005 and stabilised afterwards at around 890 000 tonnes. After a period of recruitment failure (1996-2003) strong year-classes have started to contribute significantly to the total-stock biomass (TSB). Fishing mortality was at its lowest in 2003 and increased in 2006 with the start of the pelagic fishery in international waters and in 2014 with the opening of the directed fishery in the Norwegian EEZ
15) **Management Plan:** There is no management plan for beaked redfish in this area.

General comments

The section is well written, but would be easier to follow with a more consistent order of tables and figures and the respective referencing to these. Not all tables mentioned in the section are present, and some figures are not referenced in the text.

Technical comments

Some technical issues are listed below:

Figures:

- Figure 6.x (several figures with that numbering)
- Figure D4: is this time series from 1984 to 2016 or 2017?
- Figure D4 and D5: check consistency in numbering

Tables:

- Table D3 not update because no survey in 2016? Add line to the table so that there is no misunderstanding.
- Table DX numbering
- Table D7 – values for 2016 same as 2015 (due to lack of age data). Mention this in the table text or add foot note
- Table D8 – according to the figure text some numbers should be red (not the case here)

Conclusions

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

Audit of Northeast Arctic saithe

Date: 26.04.2017
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 I and age samples from purse seine fishery south of Lofoten and in quarter two in ICES subarea I. In 2016, the biological sampling has improved, but the low level of sampling may still 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.

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 (2016/2017) estimated to be well above B_{pa}. The fishing mortality was below F_{pa} from 1997 to 2009, started to increase in 2005 and was above F_{pa} from 2010 to 2012, but is presently estimated to be most likely below F_{pa}. The recruitment has since 2005 been at about the long-term geometric mean level.

8) **Management Plan**: Agreed 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 is evaluated by ICES and is found in agreement with the precautionary approach.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret. All data sets described in the Stock Annex are available.

Technical comments

Catch at age data was estimated by ECA for the 2017 assessment of NEA saithe. This is the first 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.

Conclusions

The assessment has been performed correctly and gives a valid basis for advice. Nevertheless, the low level of biological sampling is still a source of uncertainty in the assessment.

Audit of (Norwegian Coastal Cod)

Date: 31.05.2017
Auditor: Elvar H. Hallfredsson

General

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

For single stock summary sheet advice:

16) **Assessment type:** Update
17) **Assessment**: Based on survey trends.
18) **Forecast**:A trends-based assessment is provided for this stock, which is combined with a trial assessment to form a rebuilding plan.
19) **Assessment model**: The models/methods used are the same as specified in the stock annex. A trial updated XSA was run to obtain historic values of F(4-7). Calculated survey mortalities (Zs) were regressed with XSA Fs in the converged part of a trial XSA (1996-2007). This regression was used for converting the 2014 survey mortality to a VPA F(4-7). A selection pattern for 2016 was estimated as the average pattern over the years 2011- 2014 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 2016 combined with the selection pattern and oldest true Fs described above. The same procedure was repeated for catch at age data including estimates of recreational catches. This methodology follows the stock annex to the letter.
20) **Data issues:** Data used are those prescribed in Stock Annex 02 and are properly updated.

    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. Also, the estimates of commercial catches of coastal cod have been more uncertain in recent years due to the large spawning stock of Northeast Arctic cod mixing with coastal cod during the migration along the coast.

    A new time series for commercial catch numbers at age with uncertainty estimates using the ECA-Model, as presented in 2015 benchmark, has not been implemented. Further analysis is required before replacing the traditional catch_at_age series witht the ECA-results.

    The acoustic survey is considered to have 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.

21) **Consistency:** The retrospective SVPA indicates some variability without trend over the last 10 years, both with respect to biomass, recruitment and F. The recruitment estimate for the final year is highly uncertain in all assessments.
22) **Stock status**: This is a trends-based assessmen based on survey SSB index and estimates of F and relative recruitment from an exploratory VPA assessment. The 2016 survey estimate of spawning biomass is above the 2015 survey estimate, but just marginally above the 2001-2015 averaage. In view of the survey uncertainty there is a

considerable risk that the SSB may still be close to its lowest value. The survey estimate for age 2 is somewhat higher in the three recent years compared to the period 2002-2013. Fishing mortality appears variable without a clear trend since 2000

23) **Management Plan**: 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 (1995–1998 average). This rebuilding plan 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: Plan was evaluated by ICES and is found in agreement with the precautionary approach.

Action year	1	2	3	4	5	6	7
Reduction relative to F2009	15%	30%	45%	60%	75%	90%	100%

The spawning-stock biomass (SSB) index in the 2010 survey was below the index in the 2009 survey. Step 1 was thus initiated in 2011. This means that the regulation in 2011 was aimed at a 15% reduction of F relative to F2009. The 2011 survey gave a higher SSB index than in 2010, allowing the regulation for step 1 to continue in 2012. The 2012 survey resulted in a lower SSB index compared to 2011; accordingly step 2 was set in motion in 2013, with regulations aiming for an F at least 30% below F2009. The 2013 and 2014 surveys showd an increased the SSB index, allowing for the existing regulations to be continued in 2014 and 2015 (still step 2). 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.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

The methods are technically correct but it is not clear if alternatives have been considered in the assessment. However, this this is assumed to be addressed when appropriate benchmark is undertaken.

Conclusions

The assessment has been performed correctly

This audit finds the assessment to be clear and has followed expected practices fully. The results can be taken as reliable. However, the lack of updated information about recreational and tourist fishing, and unceartein discrimination between coastal cod and NEA cod at commen fishing grounds, contributes to uncertainty in the assessment of this stock.

Audit of Greenland halibut in subareas 1 and 2

Date: 31.06.2017

Auditor: Sam Subbey

General

The Greenland halibut 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**: GADGET length based model
5) **Data issues:** No specific issues

Consistency: New assessment method with a length based GADGET (ICES, 2015 and Howell *et al.*, 2015) model was benchmarked in 2015 (IPHALI 2015) and accepted by ACOM the same year. The GADGET model output showed an increasing trend in biomass from 1992 until recent years, when the trend has flattened and is slightly downward the last year.

Stock status: A long-term average F_{MSY} is not appropriate for this stock given the recent extended run of poor recruitment. Bpa is the only reference point used for this stock, and the stock status (i.e. above Bpa) is set entirely within the gadget model. Using the Bpa from the benchmark as reference, the stock is assessed to be above Bpa, and projected to remain so over the 5 year forecast, on condition that the advice is followed.

Management Plan: There is no agreed Management Plan for this stock. 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 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 t, respectively.

General comments

A well written and document.

Technical comments

The Gadget model needs further developing, and there is also a need for better investigation of reference points, and the development of a HCR.

Conclusions

Given that the 5 projection comes close to Bpa, exceeding the catch advice could pose a risk to the stock status.

Annex 7: Template for moving category 3 stocks to category 1: cod.27.1-2 coast

Table 2.1.1. Template to identify potential candidate stocks for category 1 assessment.

Coastal cod cod.27.1-2

- Which is the current category number (3 or 4)? **3**
- Are there already plans for a benchmark in 1–2 years? **No**
- What are the necessary requirements to do the upgrade to category 1? o

  Resources needed:

  - **Stock identification within coastal cod and between coastal cod and NEA cod would be needed.**

- Could there be sufficient data suitable for age or length based models and forecast?

  There is the data but it is not reliable, and the costs relative to the value of the fishery are too high.

- <u>CONCLUSIONS:</u>

There is no potential to move this stock from a category 3 to a category 1 due to problems with stock identification that cannot be solved at this time.