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Contents

i Executive summary

The Arctic Fisheries Working Group 2020 (AFWG) was chaired by Daniel Howell, Norway, and meetings were conducted online via Webex.

Assessments run at AFWG provide the scientific basis for the management of cod, haddock, saithe, redfish, Greenland halibut and capelin in subareas 1 and 2. Taking the catch values provided by the Norwegian fisheries ministry for Norwegian catches[1] and raising the total landed value to the total catches gives an approximate nominal first-hand landed value for the combined AFWG stocks of ca. 20 billion NOK or ca. 2 billion EUR (2018 estimates).

NEA cod and coastal cod are currently working towards a benchmark planned for 2021, before the next AFWG meeting. For NEA cod this involves refining the existing model, while for coastal cod we need to address the failure of the previous management plan. NEA haddock had a recent benchmark (WKDEM), which resulted in a reduction of the retrospective issue, and better fitting to the catch data in years with large catches. AFWG is currently working towards proposing a benchmark (and subsequent HCR evaluation) for Greenland halibut, ideally in 2022.

Due to COVID-19, the meeting this year was held via Webex. This posed several challenges, and working internationally was more challenging than usual. In general, due to extensive work conducted in advance, the meeting was a success, and the science required for the reduced ICES advice was all produced. However, there were some issues with working in this format: notably, the planned HR_{pa} for Greenland halibut was postponed to next year, and an issue arising with predicting weight-at-age in NEA cod received less discussion than it should have, and so was also postponed to the benchmark. In general, where work progressed smoothly the Webex functioned (although work progressed more slowly than usual), but where more discussion was required, the group found the web-based meetings suboptimal.

Stock by stock summaries

COD IN SUBAREAS 1 AND 2 (NORWEGIAN COASTAL WATERS)

- The cod in subareas 1 and 2, the Norwegian coastal waters, was assessed based on a survey time-series 1995–2019, as well as catch-at-age data (including recreational and tourist fisheries). This is a category three stock. For the years 2012–2019, the advice has been based on the Norwegian rebuilding plan. Although the ADG has felt that this plan has not been successful, advice is currently given on this basis until a revised plan can be devised. The current advice for 2020 and 2021 is based on the recent trend in the survey.
- The stock has varied without a clear trend since 2002. The survey biomass in autumn 2019 is higher than the four previous years, but still low compared to the first years in the survey time-series. Fishing pressure (F) indicates a slowly declining trend since 1999.

COD IN SUBAREAS 1 AND 2 (NORTHEAST ARCTIC)

- The cod in subareas 1 and 2, the Northeast Arctic, was assessed using the SAM model following the outcome of the inter-benchmark meeting (IBP cod 2017). The biomass is declining slowly, but still at a high level, and SSB is well above B_{pa}, although it is considerably lower than the peak in 2013. Weight-at-age in the stock of the younger age groups has declined in recent years, and is now close to a historic low. Ecological effects on cod growth, and how to take these into account in stock projections, was discussed at length during the meeting.

[1] https://fiskeridir.no/Yrkesfiske/Statistikk-yrkesfiske/Statistiske-publikasjoner/Noekkeltall-for-de-norske-fiskeriene

- The TAC advice for 2021 is 885 600 tonnes, corresponding to F=0.47. This is 20% up on the TAC in 2020 and 28% up on the advice for 2020. F is above F_{pa}, because in the harvest control rule adopted in 2016, fishing mortality is increased at high SSB values. The increase from last year's advice is due to upwards adjustment of the abundance of intermediate age groups (5–10).

HADDOCK IN SUBAREAS 1 AND 2 (NORTHEAST ARCTIC) WAS ASSESSED USING SAM

- The spawning-stock biomass (SSB) has been above MSY $B_{trigger}$ since 1989. Due to the strong recruitment-at-age three in 2008–2009 (2005–2006 year-classes) SSB reached an all-time high level in 2013 and afterwards started to decrease, but is currently well above MSY $B_{trigger}$. The 2016 year-class is strong and is entering the fishery.
- Fishing mortality (F) has increased since 2013 and was slightly above F_{MSY} in 2018 – 2019. The higher F was partly due to overestimation of the stock at the start of the intermediate year for the short-term predictions, as seen from the retrospective bias in 2018 and 2019. After the benchmark in 2020, the retrospective bias is much lower.
- Catch predictions for three-year-olds are very uncertain because they depend on the individual growth relative to the minimum fishing size limit. In 2019, a lower proportion of three-year-old haddock (outside the F_{bar} range), and a higher proportion of six-year-old haddock was fished than assumed in the forecast in 2019.
- The 2017 year-class now appear to be weaker than earlier assumed, and the 2016 year-class is currently age four in 2020. Therefore, we expect the uncertainty in the fishing pattern to be less of an issue in the coming years.
- The TAC advice for 2021 is 232 537 tonnes, corresponding to F_{msy}=0.35.

SAITHE IN SUBAREAS 1 AND 2 (NORTHEAST ARCTIC)

- The saithe in subareas 1 and 2, the Northeast Arctic, was assessed using SAM, following the recommendations from the inter-benchmark meeting for this stock held in early 2014.
- The spawning-stock biomass (SSB) has shown wide fluctuations and has been above B_{pa} since 1996 and is currently increasing. The fishing pressure (F) has been close to or below the F management plan (F_{MP}) since 1997. Recruitment (R) has fluctuated with no clear trend.
- Corresponding to the evaluated and implemented HCR, the catch in 2020 should be no more than 197 779 tonnes. This is a 15% increase compared to the TAC for 2019 and corresponds to a fishing mortality of 0.28.

BEAKED REDFISH (*SEBASTES MENTELLA*) IN SUBAREAS 1 AND 2 (NORTHEAST ARCTIC).

- Following the recommendations of the latest benchmark assessment and advice for this stock, it was switched to a two-year cycle in 2018 and was therefore due for advice in 2020. Assessment was done using the same statistical catch-at-age model (SCAA) as in the last assessment, but with updated survey indices using the RstoX software. Adoption of a suggested management plan in 2018 was delayed by the joint Norwegian-Russian fisheries commission until the assessment could be updated with results of the deep pelagic ecosystem survey, which was conducted in August 2019 and served as one of the inputs for the current assessment. Both, total and spawning stock biomasses exhibit an increasing trend, affording an increased quota of 66 158 tonnes and 67 210 tonnes for 2021 and 2022, respectively. However, it must be noted that the, compared to earlier years, the substantially increased quota for 2019 was not fully caught. Per information from the fisheries, this was due to the migratory behaviour of the fish and pricing considerations in a mixed fishery. Partially, this information was confirmed by newly mature fish observed in the deep pelagic ecosystem survey outside the fishing grounds.

GOLDEN REDFISH (*SEBASTES NORVEGICUS*) IN SUBAREAS 1 AND 2 (NORTHEAST ARCTIC).

- This stock is assessed with a GADGET model. The trends identified in recent years have continued. There is a strong signal of incoming recruits, which have not yet entered the

SSB. At the same time catches have continued to rise, resulting in an increased F on the mature fish. As a result, the SSB has continued to decline, while the immature biomass has increased. Provided the fishing can be brought under control, one can expect the immature fish to enter the SSB in the coming years, and this should stabilize the SSB.

GREENLAND HALIBUT IN SUBAREAS 1 AND 2 (NORTHEAST ARCTIC)

- No advice on this stock this year. The stock is assessed on a two-year cycle, using GADGET length-based model approved at WKBUT benchmark in 2015. There is as of yet no HCR. A plan to have an HR_{pa} value in place for 2020 was postponed due to COVID-19, and a rollover advice is being provided for this stock.

ANGLERFISH IN SUBAREAS 1 AND 2 (NORTHEAST ARCTIC)

- This stock is dependent on influx from ICES subareas 4 and 6. There are no survey data, and only length data from the fishery, which is managed by technical regulations. Following a benchmark in 2018, work has progressed on three different data-limited models that suggest the exploitation pattern seems to be sound (the stock is likely around B_{msy}), but that the exploitation rate may well be too high and should be reduced. We recommend work towards defining reference points and an HCR, and that ICES subareas 1, 2, 3, 4 and 6 should be investigated together to get a more complete understanding of migrations and distributions.

BARENTS SEA CAPELIN

- Following ToR b), the data on Barents Sea capelin were updated in this report. No assessment is conducted during the AFWG itself, the assessment occurs in the autumn following the ecosystem survey. There is an ongoing discussion about the possibility of conducting a benchmark over several different capelin stocks, including the Barents Sea stock.

ii Expert group information

Expert group name	Arctic Fisheries Working Group (AFWG)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair	Daniel Howell, Norway
Meeting venue and dates	15-22 April 2020, online correspondence via Webex (18 participants)

1 Ecosystem information

The aim of this Section is to collect important ecosystem information influencing the assessment of fish stocks handled by AFWG. In general, such information is collected and updated by the ICES WGIBAR group (ICES CM 2019/SSGIEA:04), here we only provide information that is directly relevant to the assessment of the AFWG stocks as well as information that is updated after the 2020 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. The most important reasons for this variability are variations in the spawning biomass, hydrographic conditions, changes in circulation pattern, food availability and predator abundance, and distribution. In 2018, 0-group indices could not be calculated due to incomplete area coverage in the southeastern Barents Sea. Preliminary indices for 2019 are available in the survey report (Prozorkevitch and van der Meeren, 2020).

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 1.1–1.2). Cod prefer capelin as a prey, and fluctuations of the capelin stock may have a strong effect on growth, maturation and fecundity of cod, as well as on cod recruitment because of cannibalism. The role of euphausiids for cod feeding increases in the years when capelin stock is at a low level (Ponomarenko and Yaragina, 1990). Also, according to Ponomarenko (1973; 1984), inter-annual changes in euphausiid abundance are important for the survival rate of cod during the first year of life.

The food consumption by NEA cod in 1984–2019, based on data from the Joint Russian-Norwegian stomach content database, is presented in Tables 1.1–1.2. The Norwegian calculations are based on the method described by Bogstad and Mehl (1997). The main prey items in 2019 were capelin, krill, shrimp, haddock, cod, polar cod, amphipods and herring. The consumption calculations made by IMR show that the total consumption by age 1 and older cod in 2019 was 5.6 million tonnes, while PINRO estimates give a corresponding figure of 5.1 million tonnes. The consumption per cod-by-cod age groups is shown in Tables 1.1–1.2 (IMR and PINRO estimates), while the proportion of cod and haddock in the diet by cod age group (IMR and PINRO estimates) is given in Tables 1.3 and 1.4.

Growth of cod and consumption by cod has been relatively stable until 2019. However, some trends were observed in 2019-2020. In the winter survey 2020, weight at age was at or close to the lowest observed in the revised time series going back to 1994 for age groups 2-7. This was mainly due to reduced growth in length, see tables in Chapter 3. Similar trends were observed in the BESS survey 2019 for age groups 2 and 3 only, which is consistent with the reduction in size at age in the winter survey being strongest for age 3 and 4 cod. Other age groups in the BESS 2019 survey did not demonstrate any clear trend in size at age.

However, weight at age in the Lofoten survey was stable from 2019 to 2020, as was weight at age in catch from 2018-2019. The hepatosomatic index (liver weight/body weight ratio) pooled for all size groups shows a decreasing trend in the last couple of years both in the Lofoten survey and in Russian samples (surveys and commercial data combined). No data on hepatosomatic index was available for Norwegian commercial fisheries. Consumption per cod declined somewhat from 2018 to 2019 (Table 1.3-1.4). Altogether this indicates that growth of younger age groups was negatively affected in late 2019 and early 2020 and that the trends were strongest and first seen for younger age groups (age 3-4 in 2020).

How does this then compare to trends in food abundance? This was discussed at the WGIBAR 2020 meeting. To summarize the food situation for young cod, taking also 2020 survey results into account: Abundance of pelagic fish stocks is low, and for the most important pelagic species, capelin, the abundance of immature capelin in 2019 was very low. The 2019-year class of capelin was strong as 0-group, but the relationship between age 0 and age 1 (and older) abundance for this stock is weak. Also, age 1 cod and haddock abundance in 2020 is low. On the positive side, shrimp abundance is high, while the abundance of other prey species is around average. Altogether, there seems to be reasonable consistency between growth, consumption and feeding data. In particular, it makes sense that low abundance of small capelin affects cod ages 2-4 the most, as those age groups have trouble feeding on the larger capelin. For plots of predator size-prey size relationships, see Holt *et al*. (2019). It is also reasonable that we observe a stronger effect in winter than in autumn data, as capelin has been a relatively more important prey in winter in recent years (Johannesen *et al*. 2016).

Looking beyond 2020-2021, it is known from previous capelin collapses in the 1980s, 1990s and 2000s, that capelin may recover quickly, but it should be noted that the cod stock was considerably lower during those collapses than it is at present, which may affect the rate of stock recovery.

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

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

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

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

1.3 Maturation, condition factor, and fisheries–induced evolution

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

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

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

1.4 Recruitment prediction for northeast Arctic cod

Prediction of recruitment in fish stocks is essential to harvest prognosis. Traditionally, prediction methods have been based on spawning-stock biomass and survey indices of juvenile fish and have not included effects of ecosystem drivers. Multiple linear regression models can be used to incorporate both environmental and parental fish stock parameters. For such models to give predictions there need to be a time-lag between the predictor and response variables.

1.4.1 Historic overview

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

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

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

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

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

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

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

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

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

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

TB: R3~ m(-3) exp[-SSB(-3) + N(-3)]

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

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

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

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

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

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

H4: log(R3)~ Temp(-1) + Age3(0)

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

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

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

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

1.4.2 Models used in 2020

The model approach taken in 2020 was the same as in 2018 and 2019. Some changes were made in 2018, they are described below.

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

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

TitovES: $R3^2$ ~ $DOxSat^2$(t-13) + ITw(t-43) + expIce(t-40) + Ice(t-15)

TitovEL: $R3^4$ ~OxSat(t-39)+ ITw(t-43)

Where DOxSat(t-13)~ expOxSat(t-13) + OxSat(t-39), ITw(t-43) ~ I(t-43) +Tw(t−46). The number in parentheses is the time-lag in months, relative to April 2020.

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

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

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

In AFWG 2018, the procedure for estimating weights for various models (TitovES, TitovEL, RCT3) was repeated using the same method as was made on Study Group on Recruitment Forecasting (SGRF) in 2013.

In summary, the SAM estimate for age three from the AFWG 2020 assessment was used as historical R3. The recruitment forecast for 2020–2023 are based on a hybrid model with weighting estimated at AFWG-2018. The weights and forecasts for the 2020 AFWG assessment can be found in Tables 1.7a–b.

1.5 Biomass and exploitation levels of AFWG stocks.

Figure 1.2 shows the biomass development for northeast Arctic cod, haddock, and saithe. The combined biomass of these three stocks peaked in 2013, but is still at a high level. These three stocks have in recent years been harvested below or at the target fishing mortalities in the management plans (Figure 1.3), except for the fishing mortality on haddock in 2018–2019, which was above the target F

Table 1.1. The North-east arctic COD stock's consumption of various prey species in 1984-2019 (1000 tonnes) based on Norwegian consumption calculations

Year	Other	Amphipods	Krill	Shrimp	Capelin	Herring	Polar cod	Cod	Haddock	Redfish	G. halibut	Blue whiting	Long rough c	Snow crab	Total
1984	488	27	119	448	735	81	16	22	52	368	0	0	24	0	2381
1985	1169	180	61	165	1696	197	3	30	48	232	0	1	47	0	3830
1986	631	1350	122	154	891	145	147	69	114	321	0	0	64	0	4007
1987	775	1297	83	225	280	37	212	25	6	321	1	0	10	0	3273
1988	442	1431	352	152	375	7	97	11	2	260	0	5	6	0	3142
1989	725	877	260	134	634	4	38	9	9	237	0	0	70	0	2995
1990	1335	141	84	189	1620	8	6	19	16	232	0	93	100	0	3843
1991	760	66	75	182	2801	8	12	26	19	312	8	10	281	0	4561
1992	877	98	152	367	2420	301	99	51	102	188	22	2	104	0	4784
1993	726	244	669	307	2939	158	276	269	71	96	2	2	28	0	5785
1994	600	541	684	499	1039	144	591	220	48	76	0	1	42	0	4485
1995	817	963	526	355	600	116	242	360	113	190	2	0	35	0	4319
1996	587	611	1156	336	532	46	100	523	66	91	0	10	36	0	4094
1997	443	386	528	325	914	5	113	336	41	33	0	33	15	0	3172
1998	426	384	477	349	771	94	163	157	34	9	0	13	17	0	2894
1999	401	155	290	281	1930	139	237	64	28	17	1	33	8	0	3584
2000	416	182	477	485	1870	59	209	80	56	7	0	40	20	0	3901
2001	723	178	385	292	1831	75	264	69	52	6	1	158	32	0	4066
2002	382	96	256	243	2021	88	286	110	130	1	0	242	16	0	3870
2003	566	294	547	242	2201	217	285	116	174	3	0	78	56	0	4780
2004	634	566	345	247	1266	213	357	129	201	3	12	58	67	1	4099
2005	778	577	523	269	1382	130	385	118	320	2	5	116	54	0	4660
2006	899	228	1101	369	1773	169	111	81	366	12	2	162	135	0	5405
2007	1357	326	1184	476	2327	291	281	88	392	52	0	44	78	0	6895
2008	1759	182	1040	442	3215	115	560	208	311	68	13	19	100	0	8032
2009	1717	280	689	309	4606	138	843	227	288	34	3	6	132	2	9272
2010	1862	482	1157	331	4542	61	382	283	305	164	12	17	152	8	9757
2011	1791	289	989	257	4755	95	489	330	322	133	0	30	140	10	9631
2012	2318	348	877	400	4267	56	618	439	260	59	40	10	147	9	9848
2013	1990	282	582	297	4165	58	160	442	237	133	1	25	198	17	8586
2014	1570	333	485	217	4122	78	35	398	101	35	13	21	122	10	7539
2015	1716	658	651	250	3509	135	163	234	192	147	50	61	95	36	7899
2016	1814	559	768	318	2375	104	381	218	236	61	7	93	136	11	7082
2017	1121	132	602	265	3155	202	96	342	293	48	5	26	152	60	6499
2018	1076	276	655	187	3053	214	270	258	296	37	80	52	57	50	6560
2019	828	232	445	316	2716	196	193	207	229	50	0	3	111	60	5586

Table 1.2. The North-east arctic COD stock's consumption of various prey species in 1984-2019 (1000 tonnes) based on Russian consumption calculations (Dolgov, WD 07)

Year	Other	Amphipods	Krill	Shrimp	Capelin	Herring	Polar cod	Cod	Haddock	Redfish	G. halibut	Blue whitin	Long rough	Snow crab	Total
1984	560	31	94	353	593	34	18	14	50	197	0	5	52		2000
1985	767	441	31	211	1041	26	0	89	36	100	0	18	22		2779
1986	615	949	66	159	855	51	169	26	99	166	1	3	26		3186
1987	541	593	79	233	175	9	118	23	2	119	1	10	5		1908
1988	544	196	239	146	348	21	0	21	76	133	0	0	22		1745
1989	496	324	190	117	767	4	37	35	2	178	0	0	64		2213
1990	278	31	105	266	1264	65	8	24	15	237	0	39	79		2409
1991	289	81	55	277	3204	25	45	52	22	141	5	6	46		4248
1992	788	38	211	258	2021	335	196	82	37	117	1	0	42		4125
1993	563	174	184	220	2743	170	170	144	148	40	5	4	47		4611
1994	447	296	359	458	1276	102	486	383	72	55	0	1	40		3976
1995	502	455	396	533	670	192	191	541	130	110	3	0	52		3775
1996	674	346	957	195	469	74	74	451	57	67	0	9	45		3415
1997	463	134	510	257	511	52	111	383	35	29	2	17	17		2520
1998	311	220	645	286	916	73	134	131	23	15	0	24	20		2797
1999	179	81	458	268	1540	80	177	49	16	14	0	27	9		2898
2000	243	122	437	394	1800	53	167	59	32	4	0	28	21		3360
2001	384	75	411	322	1522	93	148	62	52	4	2	145	31		3250
2002	225	45	286	202	2400	55	302	100	80	4	0	110	17		3825
2003	400	171	547	227	1219	153	221	132	331	2	0	28	51		3481
2004	496	393	478	256	1097	129	369	86	144	7	16	48	62		3583
2005	620	163	688	244	1023	168	320	112	271	7	2	67	47		3731
2006	786	86	1547	274	1341	268	125	95	285	17	1	103	148		5076
2007	831	192	1340	420	1881	275	289	68	329	29	1	32	73		5760
2008	1021	51	1005	345	3278	122	664	156	331	60	13	17	121		7184
2009	1048	189	938	284	3360	229	828	142	347	28	0	8	285		7687
2010	973	330	1843	255	4120	143	512	181	246	163	1	16	136		8918
2011	1251	202	831	226	4473	85	422	259	359	143	2	57	170		8479
2012	1771	164	600	273	2986	97	439	291	415	41	7	33	133		7251
2013	1366	210	648	334	3676	45	146	447	272	178	2	40	216		7581
2014	1391	121	744	208	3340	56	98	390	170	20	7	27	154		6726
2015	1122	301	1160	442	2675	69	159	175	180	87	14	39	117		6539
2016	1542	654	775	216	2221	86	248	239	158	48	3	51	328		6568
2017	1042	85	681	316	2709	99	75	271	315	188	3	26	249		6060
2018	1153	146	1541	178	1624	271	117	352	479	41	41	41	121		6105
2019	751	97	498	189	2103	379	131	415	292	47	0	15	159		5075

Table 1.3		Consumption per cod by cod age group (kg/year), based on Norwegian consumption calculations.									
Year/Age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.247	0.814	1.685	2.521	3.951	5.208	8.009	8.524	9.181	9.912	9.938
1985	0.304	0.761	1.831	3.107	4.675	7.361	11.247	11.971	12.498	13.751	13.905
1986	0.161	0.488	1.348	3.163	5.617	6.834	11.030	11.943	12.749	13.513	13.778
1987	0.219	0.601	1.275	2.055	3.537	5.462	7.044	8.111	8.922	9.344	9.333
1988	0.164	0.703	1.149	2.148	3.744	5.877	10.100	11.222	12.575	13.127	13.366
1989	0.223	0.716	1.609	2.713	3.981	5.612	7.680	8.499	9.599	10.199	10.610
1990	0.363	0.906	1.907	3.043	4.190	5.383	6.439	6.782	6.923	7.362	7.830
1991	0.293	0.972	2.178	3.536	5.318	7.073	9.470	10.238	11.292	12.339	12.005
1992	0.215	0.665	2.100	3.135	4.142	5.093	7.868	9.023	9.402	10.124	10.158
1993	0.112	0.528	1.547	3.045	4.811	6.288	9.422	11.268	11.793	12.284	12.890
1994	0.130	0.408	0.922	2.521	3.508	4.528	6.404	8.889	9.723	10.030	10.215
1995	0.103	0.296	0.921	1.841	3.362	5.263	7.718	10.435	12.383	12.787	13.177
1996	0.108	0.356	0.929	1.847	3.070	4.434	7.412	11.206	14.918	15.097	15.412
1997	0.140	0.319	0.940	1.768	2.710	3.537	5.257	8.185	12.672	13.578	13.174
1998	0.117	0.398	0.984	1.942	2.924	4.188	5.748	8.071	11.471	11.990	12.054
1999	0.163	0.505	1.093	2.718	3.719	5.446	6.968	9.185	11.019	12.023	12.124
2000	0.170	0.499	1.243	2.461	4.253	5.654	7.967	9.401	12.634	13.416	13.475
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	8.433	10.430	12.907	13.523	14.571
2004	0.222	0.478	1.307	2.297	3.361	5.581	7.442	11.470	17.415	19.399	18.873
2005	0.203	0.661	1.387	2.744	4.255	6.414	7.677	10.289	13.935	14.916	15.725
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	13.956
2008	0.204	0.717	1.464	2.876	4.081	7.086	8.398	11.388	15.565	16.104	16.326
2009	0.192	0.618	1.479	2.755	4.446	5.798	8.432	11.563	12.720	13.672	13.718
2010	0.203	0.634	1.352	2.493	3.977	5.694	8.447	12.040	15.385	16.043	16.469
2011	0.219	0.653	1.421	2.594	4.003	5.331	7.230	9.660	15.165	16.320	16.342
2012	0.231	0.768	1.499	2.697	4.084	5.074	7.309	10.047	15.397	16.581	16.568
2013	0.182	0.682	1.457	2.539	3.926	5.019	5.960	7.564	11.499	12.423	13.442
2014	0.224	0.649	1.318	2.565	3.767	4.286	5.815	7.991	10.695	11.510	11.997
2015	0.218	0.674	1.424	2.546	4.262	5.693	7.405	8.575	13.071	13.851	15.057
2016	0.252	0.726	1.576	2.792	3.955	5.546	7.335	8.108	11.939	12.708	14.543
2017	0.248	0.785	1.536	2.651	3.995	5.641	7.050	8.207	11.344	14.194	17.121
2018	0.194	0.775	1.548	2.815	4.406	5.208	6.818	10.592	12.907	17.089	16.143
2019	0.191	0.494	1.330	2.253	3.496	4.414	6.236	9.012	12.150	11.778	13.077
Average	**0.202**	**0.616**	**1.414**	**2.593**	**3.981**	**5.517**	**7.661**	**9.779**	**12.295**	**13.205**	**13.587**

Table 1.4		**Consumption per cod by cod age group (kg/year), based on Russian consumption calculations.**											
Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13+
1984	0.262	0.895	1.611	2.748	3.848	5.486	6.992	8.561	10.572	13.166	13.200	15.547	17.153
1985	0.295	0.753	1.658	2.681	4.264	6.599	8.241	9.745	10.974	14.448	17.327	17.391	19.186
1986	0.179	0.526	1.455	3.455	5.001	5.991	6.458	8.157	9.766	11.457	13.188	14.621	16.134
1987	0.145	0.432	0.852	1.558	3.073	4.380	7.357	9.667	12.705	14.481	15.899	16.616	18.318
1988	0.183	0.704	1.075	1.628	2.391	4.386	8.207	9.978	10.868	16.536	14.639	16.046	17.000
1989	0.282	0.909	1.465	2.207	3.243	4.798	6.578	8.725	11.134	15.798	16.313	18.436	18.041
1990	0.288	1.006	1.694	2.693	3.278	3.833	5.583	6.870	10.715	11.426	13.555	15.964	17.595
1991	0.241	0.936	2.670	4.472	6.037	7.844	9.590	11.543	14.969	19.292	18.590	21.720	23.960
1992	0.178	0.969	2.475	2.866	3.995	5.137	6.723	7.414	8.755	12.303	14.288	15.184	16.745
1993	0.133	0.476	1.512	2.865	3.944	5.108	7.372	8.945	10.343	11.600	14.835	16.536	18.249
1994	0.180	0.512	1.212	2.402	3.517	5.359	7.560	10.001	11.818	12.896	14.499	17.656	19.469
1995	0.194	0.497	0.962	1.801	3.204	4.847	7.332	9.688	13.835	15.247	16.899	19.273	21.254
1996	0.170	0.498	1.028	1.916	3.059	4.189	6.987	10.212	12.185	13.614	14.529	16.275	17.945
1997	0.119	0.341	0.992	1.908	2.668	3.503	4.954	7.980	12.174	16.762	16.710	18.410	20.308
1998	0.232	0.528	1.081	2.016	2.823	4.089	5.469	7.346	9.586	13.012	14.404	15.640	17.243
1999	0.261	0.431	1.128	2.490	3.676	5.222	6.398	8.220	9.194	13.364	15.268	16.990	18.727
2000	0.186	0.545	1.288	2.551	4.387	6.559	8.833	10.483	11.522	15.132	17.090	19.793	21.822
2001	0.150	0.413	1.163	2.110	3.430	5.571	6.835	10.233	12.457	15.130	17.341	19.307	21.345
2002	0.252	0.677	1.303	2.699	3.847	5.591	7.846	10.796	13.238	18.787	17.836	20.278	22.359
2003	0.228	0.618	1.296	2.028	3.547	4.716	6.684	8.905	13.418	14.492	19.480	19.309	21.292
2004	0.250	0.654	1.412	2.567	3.857	5.660	7.730	11.126	15.907	20.770	21.607	24.940	27.503
2005	0.255	0.687	1.514	2.504	3.896	5.264	7.192	9.395	13.163	15.981	20.628	21.448	23.639
2006	0.354	0.925	1.881	2.813	4.019	5.332	7.450	10.328	13.111	17.759	19.488	22.322	24.609
2007	0.234	0.681	1.874	3.128	4.459	5.893	7.563	9.178	12.032	15.919	19.961	21.644	23.863
2008	0.223	0.719	1.697	2.959	4.194	6.073	7.809	10.464	13.627	17.254	21.590	23.373	25.779
2009	0.217	0.624	1.495	2.526	4.304	5.623	7.855	11.490	13.341	15.988	18.770	21.866	24.111
2010	0.235	0.651	1.401	2.577	4.065	5.757	8.312	11.805	16.090	16.844	20.129	23.023	25.387
2011	0.248	0.721	1.497	2.513	3.859	4.963	6.848	9.213	13.799	19.074	20.784	23.791	26.241
2012	0.207	0.588	1.203	2.292	3.266	4.461	5.862	7.629	11.713	16.211	19.345	21.032	23.190
2013	0.190	0.656	1.641	2.552	3.809	4.952	5.791	7.757	10.881	14.989	19.785	22.386	24.691
2014	0.242	0.622	1.321	2.340	3.608	4.387	5.560	7.447	9.017	12.547	16.044	18.854	20.781
2015	0.234	0.745	1.390	2.406	3.915	4.922	5.960	7.505	10.265	12.116	16.245	19.978	22.023
2016	0.307	0.870	1.722	2.813	3.474	4.740	6.754	9.117	10.665	14.810	19.921	24.195	26.683
2017	0.244	0.779	1.582	2.531	3.748	4.943	6.601	9.180	11.302	16.016	20.086	23.464	25.870
2018	0.316	0.867	1.846	2.699	3.736	5.000	6.489	9.170	11.166	14.577	18.672	21.848	24.091
2019	0.269	0.655	1.383	2.204	3.316	4.500	6.415	9.078	13.251	15.509	19.423	22.635	24.958
Average	**0.226**	**0.670**	**1.468**	**2.523**	**3.755**	**5.177**	**7.022**	**9.265**	**11.894**	**15.137**	**17.398**	**19.576**	**21.503**

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

Year/age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.0000	0.0000	0.0032	0.0000	0.0429	0.0264	0.0329	0.0358	0.0378	0.0392	0.0394
1985	0.0015	0.0009	0.0014	0.0017	0.0309	0.0073	0.0821	0.0827	0.0835	0.0837	0.0843
1986	0.0000	0.0022	0.0015	0.0004	0.0129	0.1730	0.1763	0.1761	0.1759	0.1748	0.1745
1987	0.0000	0.0000	0.0007	0.0051	0.0102	0.0248	0.0379	0.0389	0.0401	0.0409	0.0426
1988	0.0000	0.0000	0.0000	0.0002	0.0059	0.0013	0.0037	0.0037	0.0032	0.0036	0.0035
1989	0.0000	0.0006	0.0016	0.0019	0.0027	0.0039	0.0036	0.0036	0.0039	0.0039	0.0039
1990	0.0000	0.0000	0.0000	0.0007	0.0010	0.0010	0.0167	0.0173	0.0184	0.0181	0.0180
1991	0.0000	0.0005	0.0000	0.0003	0.0032	0.0020	0.0224	0.0229	0.0233	0.0234	0.0234
1992	0.0000	0.0021	0.0037	0.0129	0.0248	0.0475	0.0120	0.0161	0.0231	0.0231	0.0230
1993	0.0000	0.0409	0.0369	0.0515	0.0541	0.1141	0.0498	0.0795	0.0796	0.0798	0.0800
1994	0.0000	0.0037	0.0929	0.0349	0.0283	0.0774	0.1248	0.1331	0.2621	0.2644	0.2625
1995	0.0069	0.0813	0.0747	0.0804	0.0922	0.1115	0.1383	0.2523	0.2544	0.2543	0.2545
1996	0.0000	0.1502	0.2570	0.2051	0.1322	0.1262	0.1853	0.2082	0.2438	0.2436	0.2437
1997	0.0000	0.0690	0.0762	0.1138	0.1555	0.1550	0.2314	0.2287	0.2899	0.2878	0.2887
1998	0.0000	0.0135	0.0272	0.0417	0.1047	0.0989	0.1093	0.1494	0.2726	0.2736	0.2723
1999	0.0000	0.0000	0.0048	0.0136	0.0147	0.0340	0.0619	0.1115	0.1901	0.1908	0.1868
2000	0.0000	0.0000	0.0287	0.0148	0.0134	0.0266	0.0500	0.0568	0.2672	0.2675	0.2591
2001	0.0000	0.0159	0.0116	0.0082	0.0131	0.0242	0.0498	0.0375	0.3250	0.3246	0.3271
2002	0.0000	0.0385	0.0593	0.0143	0.0187	0.0284	0.0356	0.0620	0.1582	0.1562	0.1552
2003	0.0000	0.0190	0.0198	0.0199	0.0206	0.0188	0.0457	0.1037	0.2210	0.2229	0.2244
2004	0.0081	0.0235	0.0280	0.0269	0.0297	0.0319	0.0379	0.0658	0.1061	0.1064	0.1076
2005	0.0000	0.0266	0.0230	0.0265	0.0145	0.0278	0.0439	0.0789	0.1480	0.1468	0.1444
2006	0.0000	0.0103	0.0007	0.0128	0.0288	0.0158	0.0389	0.0368	0.0802	0.0805	0.0803
2007	0.0000	0.0000	0.0011	0.0117	0.0119	0.0305	0.0282	0.0900	0.1403	0.1395	0.1392
2008	0.0000	0.0558	0.0257	0.0101	0.0157	0.0098	0.0766	0.0873	0.0966	0.0960	0.0961
2009	0.0116	0.0225	0.0262	0.0251	0.0152	0.0140	0.0219	0.0946	0.1081	0.1081	0.1079
2010	0.0000	0.0327	0.0580	0.0270	0.0243	0.0243	0.0205	0.0385	0.1366	0.1367	0.1355
2011	0.0129	0.0152	0.0492	0.0170	0.0361	0.0300	0.0238	0.0572	0.1280	0.1280	0.1279
2012	0.0274	0.0608	0.0639	0.0617	0.0274	0.0431	0.0413	0.0373	0.0685	0.0689	0.0682
2013	0.0214	0.0303	0.0458	0.0388	0.0276	0.0226	0.0478	0.0539	0.1171	0.1176	0.1341
2014	0.0824	0.0363	0.0448	0.0341	0.0213	0.0458	0.0664	0.0790	0.0658	0.0659	0.0753
2015	0.0000	0.0088	0.0308	0.0283	0.0266	0.0193	0.0234	0.0283	0.0552	0.0554	0.0550
2016	0.0157	0.0192	0.0063	0.0394	0.0146	0.0172	0.0268	0.0138	0.0903	0.0914	0.0925
2017	0.0419	0.0353	0.0383	0.0469	0.0437	0.0402	0.0564	0.0921	0.0687	0.1014	0.1413
2018	0.0000	0.0186	0.0679	0.0480	0.0351	0.0378	0.0569	0.0309	0.0246	0.0076	0.0253
2019	0.0000	0.0000	0.0332	0.0296	0.0340	0.0228	0.0380	0.0752	0.0943	0.0251	0.0810
Average	**0.0064**	**0.0232**	**0.0346**	**0.0307**	**0.0330**	**0.0427**	**0.0588**	**0.0772**	**0.1250**	**0.1237**	**0.1272**

Table 1.6 Proportion of haddock in cod diet, based on Norwegian consumption calculations

Year/age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.0443	0.0175	0.0053	0.0225	0.0454	0.0212	0.0022	0.0020	0.0019	0.0018	0.0017
1985	0.0205	0.0227	0.0052	0.0076	0.0206	0.0108	0.0000	0.0000	0.0000	0.0000	0.0000
1986	0.0000	0.0188	0.0015	0.0864	0.0005	0.0524	0.0242	0.0247	0.0253	0.0291	0.0299
1987	0.0000	0.0052	0.0003	0.0025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	0.0000	0.0000	0.0000	0.0000	0.0003	0.0034	0.0033	0.0034	0.0038	0.0035	0.0035
1989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0338	0.0339	0.0351	0.0350	0.0351
1990	0.0000	0.0000	0.0000	0.0024	0.0021	0.0007	0.0128	0.0123	0.0114	0.0117	0.0118
1991	0.0000	0.0000	0.0098	0.0079	0.0045	0.0051	0.0031	0.0029	0.0027	0.0027	0.0027
1992	0.0000	0.0000	0.0014	0.0684	0.0208	0.0272	0.0279	0.0318	0.0461	0.0460	0.0459
1993	0.0000	0.0000	0.0204	0.0073	0.0149	0.0144	0.0278	0.0261	0.0261	0.0262	0.0262
1994	0.0000	0.0000	0.0065	0.0131	0.0069	0.0142	0.0297	0.0495	0.0467	0.0460	0.0466
1995	0.0000	0.0355	0.0030	0.0428	0.0261	0.0243	0.0383	0.0950	0.1619	0.1618	0.1619
1996	0.0000	0.0000	0.0588	0.0155	0.0098	0.0170	0.0364	0.0480	0.0930	0.0978	0.0983
1997	0.0000	0.0000	0.0242	0.0189	0.0245	0.0159	0.0127	0.0174	0.0571	0.0556	0.0552
1998	0.0000	0.0000	0.0116	0.0119	0.0227	0.0193	0.0106	0.0323	0.0162	0.0164	0.0162
1999	0.0000	0.0000	0.0028	0.0078	0.0158	0.0123	0.0120	0.0139	0.0224	0.0225	0.0220
2000	0.0000	0.0000	0.0233	0.0102	0.0178	0.0116	0.0158	0.0522	0.0286	0.0286	0.0287
2001	0.0000	0.0081	0.0052	0.0163	0.0147	0.0170	0.0194	0.0198	0.0337	0.0336	0.0346
2002	0.0000	0.0000	0.0185	0.0339	0.0353	0.0470	0.0745	0.0762	0.1829	0.1796	0.1780
2003	0.0000	0.0000	0.0145	0.0311	0.0594	0.0436	0.0552	0.1215	0.1078	0.1078	0.1077
2004	0.0044	0.0419	0.0744	0.0389	0.0576	0.0502	0.0565	0.0999	0.0910	0.0913	0.0923
2005	0.0000	0.0853	0.1047	0.0596	0.0620	0.0643	0.1045	0.1090	0.1112	0.1105	0.1089
2006	0.0000	0.0409	0.0829	0.0871	0.0604	0.0898	0.0718	0.1065	0.0966	0.0964	0.0965
2007	0.0000	0.0035	0.0462	0.0417	0.0833	0.0983	0.1335	0.1153	0.1634	0.1639	0.1641
2008	0.0000	0.0045	0.0106	0.0156	0.0383	0.0752	0.1149	0.1328	0.2339	0.2346	0.2344
2009	0.0000	0.0218	0.0241	0.0182	0.0142	0.0363	0.1088	0.0596	0.1869	0.1870	0.1878
2010	0.0000	0.0031	0.0278	0.0181	0.0178	0.0217	0.0359	0.1424	0.1820	0.1806	0.1810
2011	0.0000	0.0049	0.0361	0.0284	0.0087	0.0205	0.0409	0.0919	0.1643	0.1642	0.1635
2012	0.0000	0.0000	0.0113	0.0282	0.0338	0.0273	0.0368	0.0334	0.0861	0.0852	0.0870
2013	0.0000	0.0074	0.0309	0.0112	0.0314	0.0234	0.0148	0.0363	0.0615	0.0615	0.0905
2014	0.0000	0.0090	0.0038	0.0255	0.0080	0.0046	0.0021	0.0338	0.0143	0.0143	0.0189
2015	0.0000	0.0175	0.0408	0.0253	0.0172	0.0166	0.0259	0.0197	0.0385	0.0384	0.0393
2016	0.0000	0.0051	0.0798	0.0772	0.0265	0.0258	0.0324	0.0420	0.0342	0.0343	0.0341
2017	0.0106	0.0430	0.0152	0.0449	0.0462	0.0568	0.0469	0.0529	0.0791	0.0678	0.0844
2018	0.0000	0.0000	0.0434	0.0365	0.0590	0.0661	0.0549	0.0589	0.0823	0.0304	0.1131
2019	0.0000	0.0000	0.0284	0.0563	0.0421	0.0487	0.0523	0.0407	0.0346	0.0654	0.2811
Average	**0.0022**	**0.0110**	**0.0242**	**0.0283**	**0.0263**	**0.0301**	**0.0381**	**0.0511**	**0.0712**	**0.0703**	**0.0801**

Table 1.7a. 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	2020 Prognoses	2021 Prognoses	2022 Prognoses	2023 prognoses
TitovES	2	At assessment	528	585		
TitovEL	4	At assessment	486	588	602	608
RCT3	3	At assessment	828	858	411	
Hybrid model		At assessment	583	635	512	608

Table 1.7b. Related weights to the models used in the hybrid model.

Model	Model weight 2020	Model weight 2021	Model weight 2022
TitovES	0.54	0.59	
TitovEL	0.25	0.23	0.53
RCT3	0.22	0.18	0.47

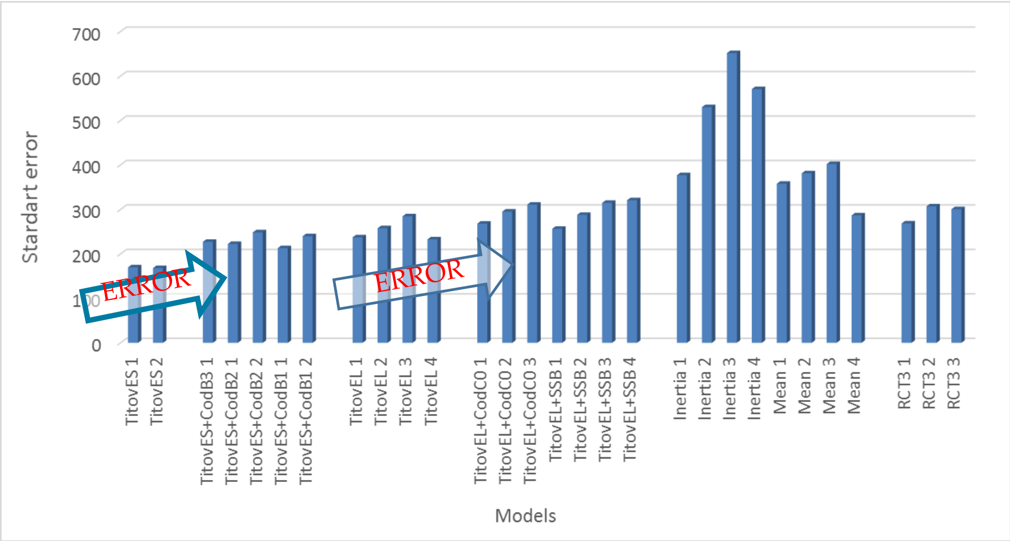

Figure 1.1. Standard errors of the NEA cod recruitment predicted values from the SAM values.

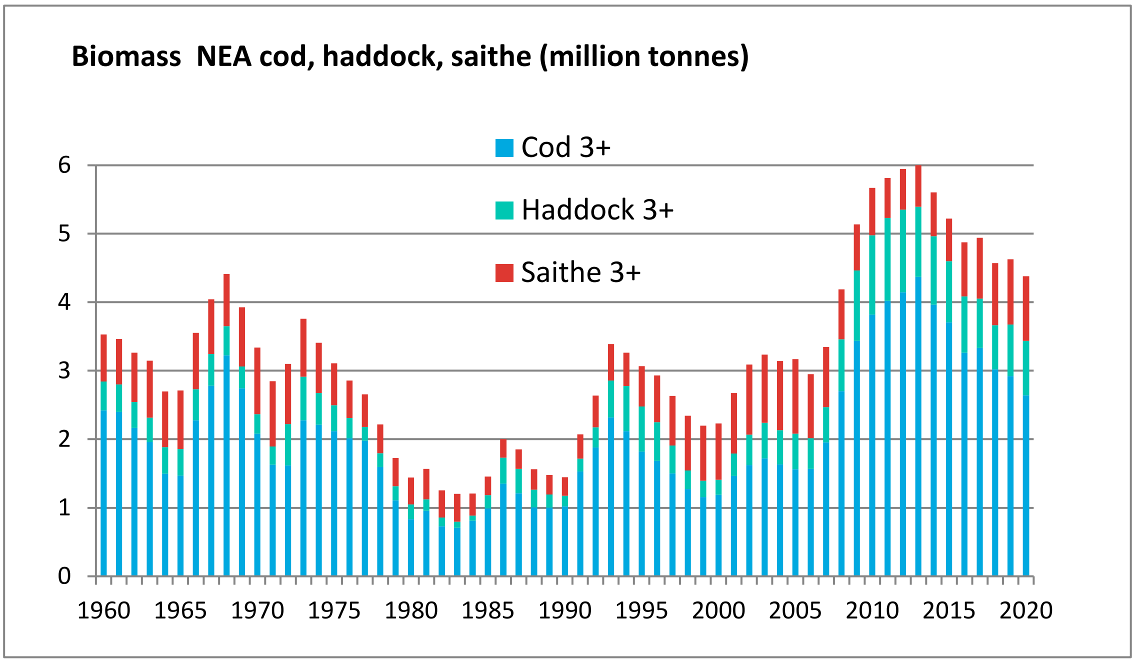

Figure 1.2. Biomass of northeast Arctic cod, haddock and saithe, from 2020 AFWG assessment.

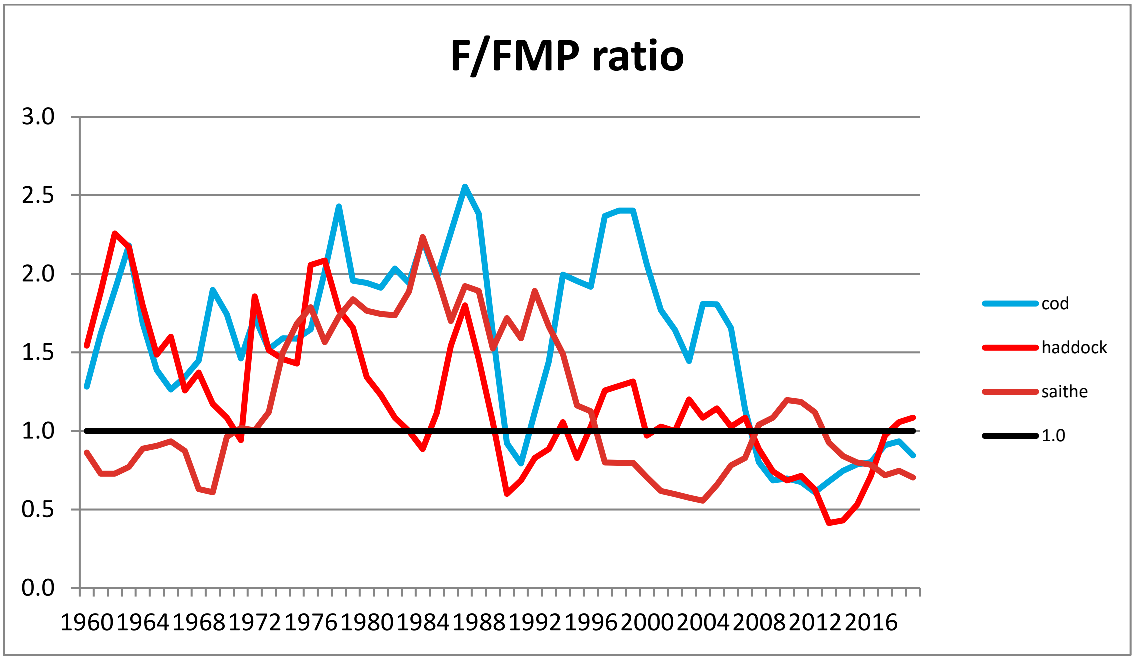

Figure 1.3. Annual fishing mortalities of the northeast Arctic cod, haddock and saithe stocks relative to FMP, i.e. the level used in the management plans for these stocks when SSB>Bpa. For cod FMP is not well-defined, as there is a two-step HCR. In this figure, the lower plateau (F=0.40) is used in 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)

SPALY ASSESSMENT PROCEDURE, (NEW CATCH-AT-AGE TIME-SERIES AT AFWG 2019)
NEED FOR BENCHMARK

The stock was a part of the WKARCT benchmark meeting in January 2015 (ICES 2015/ACOM: 31). There is high uncertainty in the estimation of commercial catch, and useful information about recreational fishing and tourist fishing is largely lacking. A new time-series for commercial catch numbers-at-age with uncertainty estimates was presented to the benchmark by using the ECA-model (Hirst *et al.*, 2012). The corresponding catches in tonnes are presented in Table 2.1a. The benchmark meeting accepted the new catch estimates but noticed that the differences compared to the old method should be further explored. Work after the benchmark has revealed some years with problematic sampling data in some areas (see: section 2.2.1). This has been partly resolved, and results with the new catch-at-age series were introduced at the 2019 AFWG and compared to the results from the old series for the years 1984–2018 (AFWG 2019, section 2.2.1, Figures 2.5b and 2.5.c.)

A new Benchmark is planned for autumn 2020/spring 2021 to deal with:

- Consider a split of the assessment area in two or three regions. There are genetic analysis indicating reasons for splitting the stock in two or more units (Dahle *et al.*, 2018), and more studies are ongoing. Both survey data and catch sampling data have better quality north of 67 than south of 67. About 80% of the annual catches of coastal cod are taken north of 67;
- A new fyke net/gillnet-survey series in shallow areas, during August, has been initiated south of 67, alternating; one year between 67 and 65°N (2013, 2016, 2018, and planned for 2020), and next year between 65 and 62°N (2015, 2017, 2019).
- Ongoing work aims at using the software StoX (Johnsen *et al.*, 2016) for producing a swept-area time-series based on bottom-trawl hauls in the coastal survey (NOcoast-Aco-4Q), as well as re-estimating the acoustic time-series by use of StoX, and an improved strata system;
- Evaluate new information from the recreational fisheries.
- Choice of assessment model.

2.1 Stock status summary

Both the coastal acoustic survey in autumn (Figure 2.14) and the current assessment (Figure 2.17) show a considerable decline in SSB in the late 1990s. The current assessment indicates some increased SSB in the years 2001–2016 and a decline in 2017 and 2018, then some increase in 2019. The highest recruitments occurred in the two first years of the time-series (1984, 1985). Since then there seem to be a long-term declining trend in recruitment. Fishing mortality was very high at the beginning of the time-series (1984–1989) and rather high during 1997–1999. F shows a declining trend over the period 1998–2013 and no clear trend for the latest years. Most recent F appears to be above the target in the rebuilding plan. The abundance indices from the coastal surveys in autumn 2013 and 2014 showed some increase compared to previous years. The surveys in 2015-2018 have showed rather low indices, while the 2019 survey showed some increase.

2.2 Fisheries

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

Except for the open fjords in eastern Finnmark, the quantities fished inside fjords are quite low. In the period 2011–2015 the average percentage share between gear types in the estimated coastal cod commercial landings was around 46% for gillnet, 26% for Danish seine, 26% for longline/handline and 2% for bottom trawl. In 2017, there was some increase for Danish seine (35%) and longline (25%), and a decrease for gillnet (38%). Table 2.1b. shows catches in 2018 by gear groups for <u>coastal cod plus NEA cod</u> in statistical areas 00, 03, 04, 05, and 06+07, and table 2.1c show the ECA-estimated 2018 catches of <u>coastal cod </u>for gillnet, trawl and others. (Due to time constrains, these two tables were not updated with 2019-catches).

Recreational and tourist fisheries take an important fraction of the total catches in some local areas, especially near the coastal cities, and in some fjords where commercial fishing activity is low. However, there are a few reports trying to assess the amount in certain years. In 2010, these reports were used to construct a time-series (ICES CM 2010/ACOM:05) of recreational catches. These catch estimates are quite 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. Historical there has been no reporting system for coastal cod (NCC) taken by recreational or tourist fishers in Norway. In 2019 the Norwegian Directorate for Fisheries established a web-portal for reporting recreational catch (both by the tourist industry and for private fishers). There are several ongoing research projects on recreational fishing. There is a need for synthesising the results from those.

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

Catch numbers-at-age are estimated by the ECA model. The commercial catches of Norwegian Coastal cod (NCC) have been calculated back to 1984 (Table 2.1a). For this period, the estimated annual landings have been between 27 kt and 65 kt. The commercial landings of NCC in 2019 were estimated to 40.1 kt t (Table 2.1a , Figure 2.3). Table 2.1b shows the estimated catch by gears, area and quarters in 2018. Figure 2.5b shows the ECA-estimates (1984-2019) and the results of the “traditional calculation method”(1984-2017).

Commercial catches of cod are separated to types of cod by the structure of the otoliths in commercial samples. Figure 2.4 illustrates the main difference between the two types: The figure and the following text is from (Berg *et al*., 2005): *Coastal cod has a smaller and more circular first translucent zone than northeast Arctic cod, and the distance between the first and the second translucent zone is larger* (Figure 2.4). *The shape of the first translucent zone in northeast Arctic cod is similar to the outer edge of the broken otolith and to the subsequent established translucent zones. This pattern is established at an age of 2 years, and error in differentiating between the two major types does not increase with age since the established growth zones do not change with age*. The precision and accuracy of the separation method has been investigated by comparison of different otolith readers and results from genetic investigation of cod. The results indicate high accuracy using in the otolith method (Berg *et al*., 2005). Nevertheless, in cases with a low percentage misclassification of large catches of pure NEA cod, the catches of coastal cod could be severely overestimated.

Sampling and landings

The basis for estimating coastal cod catches is the total landings of cod in the Norwegian statistical areas 03, 04, 05, 00, 06, 07 (Figures 2.1a, and 2.1b), combined with the sampling of these fisheries. Since the catches are separated to type of cod by the structure of the otoliths, the numbers of age samples are critical for the estimated catch of coastal cod. Table 2.2 shows the sampling of the cod fishery by quarters and areas in 2018, and similar for the years 2017 and 2016 in Tables 2.3. The sampling level in 2018 was somewhat improved compared to 2016 and 2017. Table 2.4 compares the numbers of fish sampled by quarters for the period 1985–2018. A total of 16 062 fish were aged in 2018. 5196 of these otoliths were classified as coastal cod. This represents 40% of all cod otoliths sampled within the coastal cod area. This percentage is similar to 2016, but well above the time-series average (Table 2.4). Similar tables are not produced for the sampling in 2019. The sampling program in 2019 was similar to previous years, and it is expected that the relative coverage by areas and quarters are similar to 2018.

The Norwegian sampling program was changed in 2010. This led to poor sampling in that year. The sampling in later years has gradually improved, and the number of samples (but not the number of otoliths) is now well above the level prior to 2010.

Tables 2.1b and 2.1.c show the total cod catch by area and quarters within the 12 n-mile and the estimated catches of coastal cod by statistical area and quarter for the years 2017 and 2016. The corresponding fractions of coastal cod in cod catches are also shown. The total cod catch within 12 n-mile was lower in 2017 than 2016, while the coastal cod catch (and fraction costal cod) was higher in 2017. (Due to time constrains, similar tables for 2019 are not produced).

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

2.2.2 Regulations

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

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

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

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

Regulations introduced 2004–2010

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

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

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

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

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

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

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

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

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

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

2.3 Survey data

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

2.3.1 Indices of abundance and biomass (Tables 2.5-2.13, Figures 2.6-2.14)

The results of the 2019 survey (Staby *et al.*, 2020) are presented in Tables 2.5–2.12 for the area inside 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 2019 estimate of spawning biomass is around 30% higher than the 2018 estimate. The uncertainty of the survey estimates is rather large.

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

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

About 2000 cod otoliths were sampled during the 2019 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 quarter 1 and 2, as shown in Table 2.4.

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 autumn. Based on the records of spawning zones in the otoliths a back-calculation of proportion mature at age (Gulland, 1964) was considered at the 2010 AFWG. The analysis was based on samples from the spawning fisheries in March-April. The results are shown in Figure 2.13b. This does not confirm the amount of year-to-year variation seen in the survey observation, and thereby gives some support for rather using a fixed maturation as introduced by the 2010 WG. Since the age at maturation is higher in northern areas compared to southern areas (Berg and Albert, 2003), the back-calculation analysis should be refined by ensuring a reasonable balance in the amount of data from northern and southern areas.

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

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

The estimated commercial catch-at-age (2–10+) for the period 1984–2019 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, 2.15, Figure 2.13b)

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

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

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

In the 2010 WG mortality signals from the survey and from the catch-at-age data were analysed and an SVPA ("user-defined VPA" in the Lowestoft VPA95-menu) were run using the survey based estimate of F_{2009} (details described in Annex 10 in ICES CM 2010/ACOM:05) as terminal F. The same procedure was used this year: By using the survey indices for ages 2 to 8 (Table 2.6) a trial XSA (Tables 2.13–2.15) was run to obtain historic values of $F_{(4\text{–}7)}$. Calculated survey mortalities (Table 2.16 and Figure 2.15) were regressed with XSA F_s for the years 1996–2007 (Figure 2.15). This regression was used for converting the 2019 survey mortality to a VPA $F_{(4\text{–}7)}$ (Table 2.16). A selection pattern for 2019 was estimated as the average pattern over the years 2017–2019 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 $F_{(4\text{–}7)}$ for 2019 combined with the selection pattern and oldest true F_s described above. The same procedure was repeated for catch-at-age data including estimates of recreational catches, but the trial XSA for that dataset is not shown here.

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

2.6 Results of the Assessment

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

The 2019 survey estimate of spawning biomass (34.3 kt) is well above the 2018 (Tables 2.9 and 2.11, Figure 2.17).

The survey-based estimate of the F_{2019} is 0.20 when relating to commercial catch and 0.29 when relating to total catch data. The text table below compares results for commercial catch with corresponding values earlier years (see also Figure 2.16). The table also compares the SSB-results of SVPA-runs aimed at those F_s used as terminal F_s. The high catches in 2015–2017 (containing reasonable amounts of old fish) has in the current (and last year`s) assessment caused some upward stock revision for several years back in time. Corresponding downward revisions of F is observed. The "F on oldest true age" in the SVPA is derived from a trial XSA with a 20-year tuning window with time taper. The effect of the high survey estimates at the beginning of the time-series has thereby been reduced in the later assessments compared to the earlier. This has further contributed to upward revisions of SSB, and downward revisions of F seen in the text table below (also visible in Figure 2.17 for the years 2015–2017). Note that the results of the 2019 and 2020 assessment are based on a revised catch number-at-age series (AFWG 2019).

Ass Yr	F 09	F 10	F 11	F 12	F 13	F 14	F 15	F 16	F 17	F 18	F19
2010	0.37										
2011	0.38	0.38									
2012	0.28	0.26	0.33								
2013	0.29	0.23	0.33	0.37							
2014	0.31	0.26	0.34	0.36	0.27						
2015	0.31	0.27	0.36	0.37	0.29	0.27					
2016	0.29	0.25	0.32	0.29	0.21	0.19	0.35				
2017	0.28	0.24	0.30	0.26	0.18	0.15	0.25	0.30			
2018	0.26	0.22	0.28	0.23	0.16	0.14	0.22	0.25	0.35		
2019	0.22	0.30	0.27	0.19	0.15	0.16	0.17	0.26	0.31	0.27	
2020	0.22	0.29	0.26	0.19	0.15	0.17	0.18	0,28	0.30	0.20	0.20

Ass Yr	SSB 09	SSB 10	SSB 11	SSB 12	SSB 13	SSB 14	SSB 15	SSB 16	SSB 17	SSB 18	SSB 19
2010	46										
2011	50	44									
2012	59	58	70								
2013	60	60	68	66							
2014	59	58	64	59	51						
2015	59	57	63	57	47	49					
2016	63	62	69	67	61	70	75				
2017	66	65	73	73	70	84	99	100			
2018	75	74	83	82	78	95	114	114	109		
2019	88	101	97	101	100	133	129	135	113	95	
2020	89	103	99	102	101	132	126	130	115	100	114

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

2.6.2 Recruitment (Table 2.6, Figure 2.16)

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

2.6.3 Catches in 2020

No catch prediction for 2020 have been made.

2.7 Comments to the Assessment

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

The acoustic survey has a rather large uncertainty. This is because cod contributes to a low fraction of the total observed acoustic values. The cod estimate is thus vulnerable to allocation error. The Norwegian coastal survey is the only survey covering the main distribution area of the stock. The survey is conducted in the period October/November. In this period, the maturity stage can be variable and difficult to define, and a survey index of SSB based on the long-term mean (currently 1995–2009) maturity-at-age is considered to reduce some annual variation caused by staging uncertainty.

2.8 Reference points

No biological reference points are established.

2.9 Management considerations

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

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

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

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

The spawning biomass index in the 2010 survey was below the index in the 2009 survey. This means that the regulation in 2011 was aimed at a 15% reduction of F relative to 2009. The 2011 survey gave a higher spawning biomass index than in 2010. The 2012 survey index for spawning biomass was lower than the previous, and according to the rebuilding plan additional measures for reducing F by 30% (relative to 2009) should apply for 2013. For 2013 and later years no regulations in addition to those in place in 2011 and 2012 have been communicated to ICES. The survey showed an increase both in 2013 and 2014. Therefore, the 30% reduction of F still applied for 2015. The 2015 survey showed a decline, and the regulations in 2016 should aim for 45% reduced F. The 45% also applies for 2017, since the latest survey gave a higher SSB-estimate then the previous. Since the 2017 survey was lower than in 2016, the fourth step (60% reduction) should apply for 2018. Since both the 2018 survey and the 2019 survey showed increasing survey biomass, the 60% also applies for 2020 and 2021.

The VPA analysis presented indicate some reduction of F over the period 1999–2013, followed by increased F in 2014- 2017 and a reduced F (=0.2) in 2018 and 2019.

2.10 Rebuilding plan for coastal cod

The following rebuilding plan was suggested by Norway in 2010:

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

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

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

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

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

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

[2] Ages 4–7.

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

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

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

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

Has the rebuilding plan worked?

According to the catch estimates, the commercial catch of coastal cod was quite high in the years 2015–2017, while the catches in 2018 and 2019 were somewhat lower. The high catches in 2015–2017 are mainly caused by targeting aggregations of cod during the first quarter in southern Troms and northern Nordland, prior to arrival of the spawning NEA cod.

The rebuilding plan has now been in operation for 10 years. The plan implies that the fishing mortality in 2019 should be at least 60% lower than the 2009 value. The 2019 data indicate a fishing mortality 17% below the F in 2009, while the estimated catch in 2019 is 24% above the catch in 2009. The regulations have therefore not been sufficient for constraining the coastal cod catches in the years 2015–2019.

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

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

2.11 Recent ICES advice

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

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

Table 2.1a. Norwegian coastal cod. Estimated commercial landings in numbers ('000) at-age, and total tonnes by year.

	Age								Tonnes
	2	3	4	5	6	7	8	9	10+	Landed
1984	127	1251	3350	5629	5111	3412	359	93	175	63818
1985	72	4302	4794	5660	3377	1319	387	81	750	62954
1986	304	4192	5831	4801	2956	1913	610	223	621	56107
1987	22	177	3294	7016	3314	1153	505	171	281	48274
1988	17	280	836	6686	6222	2573	645	280	252	55065
1989	53	471	1162	1602	5779	2493	813	184	251	41242
1990	50	387	987	805	683	2022	603	91	135	20920
1991	9	273	913	1420	1226	937	1384	190	202	24837
1992	57	401	2156	3296	2477	1201	468	695	346	38195
1993	21	140	1793	2874	3120	2555	1190	355	889	50420
1994	32	117	1015	4266	3011	2709	1276	412	843	51664
1995	31	210	1098	2997	5013	3404	1876	1032	899	64964
1996	50	459	837	1583	2460	2759	1062	524	640	41672
1997	121	594	1804	1752	2152	3164	1970	502	669	51123
1998	105	723	2640	2164	1287	937	924	372	361	30472
1999	55	660	2578	3506	1981	933	539	462	489	35805
2000	20	796	2830	3614	1922	772	401	142	356	34815
2001	20	372	1985	2250	1769	1074	393	128	355	27253
2002	52	405	1763	2880	2610	1070	559	200	250	36405
2003	66	560	1183	2377	2242	1382	618	259	302	35381
2004	24	294	1042	1874	2264	1542	784	303	355	33650
2005	19	266	1179	1807	1904	1369	684	263	318	29255
2006	43	264	1327	2225	2652	1641	908	425	446	39343
2007	48	378	1382	1905	1450	1004	487	287	300	29227
2008	63	553	1955	2284	1857	1106	640	275	273	35552
2009	28	966	1500	1532	1573	902	433	187	288	29987
2010	118	728	1734	2712	2184	1002	815	277	474	40397
2011	74	702	1727	2917	1572	1002	523	287	508	36714

	Age								Tonnes
	2	3	4	5	6	7	8	9	10+	Landed
2012	408	1159	1376	1928	1660	918	458	254	503	35540
2013	131	571	1544	1609	1154	886	627	290	474	30144
2014	110	510	1020	1730	1440	1110	840	300	490	33660
2015	140	680	1470	1290	1950	1010	650	450	820	35843
2016	110	1630	1970	2220	1750	2130	1150	670	1070	54767
2017	190	860	1890	1980	2490	1580	1220	690	850	51053
2018	150	830	1580	1730	1600	1310	800	530	500	36375
2019	70	1020	1600	1950	1870	1470	900	320	540	40107

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

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

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

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

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

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

	AGE									Tonnes
	2	3	4	5	6	7	8	9	10+	landed
2012	30	622	1509	2066	2425	1771	821	472	638	48240
2013	140	843	2526	1928	1803	1054	788	384	340	42844
2014	36	1265	1908	2537	1556	1036	662	567	296	46360
2015	291	1240	2311	2438	2777	1892	997	638	895	48543
2016	384	2071	2283	2666	2311	2374	1198	682	906	67467
2017	338	2233	3090	3181	2938	2117	1572	832	962	63753
2018	202	1120	2132	2334	2159	1767	1079	715	675	49075
2019	92	1343	2107	2568	2462	1936	1185	421	711	52807

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

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

	AGE									Tonnes
	2	3	4	5	6	7	8	9	10+	landed
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
2017	66	432	598	616	569	410	304	161	186	12700
2018	52	290	552	604	559	457	279	185	175	12700
2019	22	323	507	617	592	465	285	101	171	12700

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

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

Table 2.3. Sampling from cod fisheries in 2017and 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 2017 Quarter	03	04	00	05	06+07	Tot
1	30	55	107	86	58	336
2	17	60	30	31	26	164
3	17	5	24	2	21	69
4	25	22	60	8	11	125
Total samples	89	142	221	127	116	694
Total otoliths	3271	4527	2716	3693	1860	16067
Coastal cod type otoliths	915	1133	982	755	1491	5196

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

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

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

	Quart	1	Quart	2	Quart	3	Quart	4	TOTAL	Total	
Year	**Cc**	**NEAc**	**Cc**	**NEAc**	**Cc**	**NEAc**	**Cc**	**NEAc**	**CC**	**NEAc**	**%Cc**
2012	1294	6283	749	1864	379	85	324	185	2746	8417	25
2013	966	5389	832	3155	216	88	1115	385	3129	9017	26
2014	1019	4470	869	3312	338	29	1060	524	3286	8335	28
2015	746	7770	618	3619	327	354	511	547	2202	12290	15
2016	2465	5581	1073	2445	616	207	1501	727	5655	8960	39
2017	2276	4568	879	2742	810	151	1231	475	5196	7936	40
2018	2007	4927	924	1882	498	104	1143	435	4572	7348	40
Av85-18	*1064*	*4018*	*614*	*2102*	*521*	*489*	*796*	*880*	*2996*	*7521*	*28*

Table 2.5. Coastal cod. Acoustic abundance indices by subareas and in total in 2019 (in thousands). Age 1 is not split between coastal cod and NEA cod.

	Age (Year class)										
Area	1 (18)	2 (17)	3 (16)	4 (15)	5 (14)	6 (13)	7 (12)	8 (11)	9 (10)	10+ (pre09)	Sum
03	1726	1253	1965	1303	1120	828	548	244	112	109	9208
04	2665	1065	1425	712	1146	523	227	90	179	172	8204
05	975	308	282	522	398	421	171	82	191	30	3381
00	1025	348	617	401	340	125	243	255	110	110	3573
06	858	497	1960	1177	1193	251	487	139	170	130	6863
07	303	0	114	101	245	372	363	64	39	46	1607
Tot	7552	3470	6363	4216	4442	2520	2037	875	808	552	32836

Table 2.6. Coastal cod. Acoustic abundance indices by age 1995–2019 (in thousands). Age 1 is not split between coastal cod and NEA cod. Fjords in area 07 not covered in 2013.

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

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Sum
2004	3217	3541	3696	4320	2758	1940	783	448	98	110	20914
2005	1443	1843	3525	3198	3217	1700	1120	552	330	78	17006
2006	1929	2525	4049	3783	3472	2509	1811	399	229	13	20719
2007	2202	3300	4080	5518	3259	2447	1444	760	197	34	23241
2008	2128	2181	2475	2863	2101	1219	815	403	319	177	14681
2009	3442	2059	2722	3959	2536	1603	1259	793	443	141	18955
2010	7768	2513	2729	2820	2417	1098	501	426	260	305	20837
2011	9015	3266	3950	4571	3012	2185	448	478	171	339	27435
2012	4887	2292	3003	2993	1990	1125	814	339	144	430	18015
2013	10478	3222	2780	3545	2742	2072	1164	971	449	431	27854
2014	5104	5516	3425	2659	4514	2660	2053	1189	980	676	28776
2015	6939	5084	3695	3441	2053	1984	1029	601	529	404	25759
2016	4857	4214	4850	3760	3108	1455	1022	955	187	474	24881
2017	1712	3950	4402	2910	2220	1412	664	436	248	234	18186
2018	11160	2995	2537	2940	2209	2006	805	444	257	371	25725
2019	7552	3470	6363	4216	4442	2520	2037	875	808	552	32836

Table 2.7. Coastal cod. Mean length (cm) at-age 1995–2019.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
1995	21.5	33.0	43.0	52.0	59.1	64.1	76.0	87.4	89.0	108.3
1996	19.0	30.2	41.7	52.5	59.2	65.2	79.1	84.8	87.0	114.2
1997	16.8	28.7	40.8	51.6	58.1	65.9	73.6	80.8	102.0	110.7
1998	20.3	33.3	43.8	51.4	59.1	66.3	74.1	81.0	93.2	116.9
1999	21.5	32.6	43.8	54.6	59.6	65.8	77.9	90.8	99.4	118.0
2000	21.6	33.3	43.4	53.5	61.0	66.1	75.5	90.8	99.1	105.5
2001	21.1	33.3	44.5	53.6	62.9	64.7	88.7	84.2	85.7	102.1
2002	22.5	34.4	44.6	56.0	61.6	67.7	72.4	66.6	89.0	108.3
2003	18.9	33.8	42.1	51.6	60.0	67.2	72.7	76.9	84.9	94.8
2004	20.7	32.9	43.5	54.5	59.9	68.0	71.9	75.0	74.6	91.8
2005	22.5	32.8	42.2	57.9	60.6	64.0	71.3	69.9	73.5	108.4
2006	22.2	36.1	47.0	55.5	61.4	68.0	69.5	77.8	87.0	100.5
2007	21.6	36.0	48.0	57.9	62.2	66.8	71.8	86.6	100.2	106.3
2008	21.9	36.9	49.2	59.0	66.1	70.9	71.7	74.1	77.6	98.8
2009	20.9	34.5	47.8	57.8	65.8	70.5	77.9	78.4	85.1	73.5
2010	20.3	34.9	46.4	57.5	64.6	71.2	76.9	75.2	78.9	82.7
2011	20.6	32.9	47.2	59.5	66.1	71.5	79.9	82.0	81.1	83.9
2012	21.3	32.4	46.9	58.8	66.1	72.0	77.0	77.5	82.2	87.3
2013	21.5	33.6	44.5	56.7	66.2	71.3	74.2	84.2	84.6	88.1
2014	21.7	35.1	47.7	57.3	66.4	73.5	76.6	80.5	81.7	93.0
2015	19.9	33.5	46.9	58.0	66.5	70.3	77.8	77.7	80.5	85.5
2016	20.5	32.9	47.8	58.7	67.8	72.2	75.1	83.0	89.7	86.9
2017	23.5	35.6	47.2	58.3	66.1	72.6	75.2	82.4	82.6	91.2
2018	19.4	35.4	47.7	58.8	68.1	71.3	79.8	80.3	85.5	84.4
2019	20.3	32.8	48.3	58.5	66.5	73.4	78.3	81.2	85.9	88.7

Table 2.8. Coastal cod. Mean weight (grams) at-age 1995–2019.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
1995	81	390	791	1525	2222	2881	4665	6979	6759	9897
1996	59	252	724	1433	2053	2748	4722	6685	6932	9723
1997	43	240	683	1364	1893	2816	4426	6406	7805	1827
1998	52	372	883	1456	2107	2950	4319	5625	8323	12468
1999	70	323	841	1675	2192	2857	4540	6579	9454	12902
2000	72	365	809	1554	2539	3049	4352	6203	8527	12066
2001	51	396	966	1524	2314	3320	3695	6144	8768	12468
2002	103	428	895	1741	2433	3133	4273	4397	7759	12992
2003	62	385	738	1353	2145	3103	3981	4921	6923	9956
2004	83	352	834	1690	2255	3312	4150	4594	4383	9733
2005	112	359	786	2168	2265	2756	4174	3373	4502	15887
2006	105	474	1080	1746	2430	3336	3684	5125	7028	14650
2007	103	518	1185	2011	2500	3160	4241	6806	11051	14931
2008	96	508	1208	2095	2987	3671	3976	4387	5415	11588
2009	85	434	1116	2003	2894	3632	4875	5400	6125	4719
2010	75	419	1026	1996	2839	3665	4868	4895	5685	6504
2011	77	343	1062	2119	2882	3761	5505	6336	6309	6570
2012	89	336	1038	2006	2998	3727	4783	5071	5851	7446
2013	88	365	851	1815	2856	3561	4122	6435	5974	7670
2014	93	423	1071	1845	2886	3905	4495	5249	5871	8762
2015	75	370	1045	1940	2910	3518	4927	4753	5868	7277
2016	77	344	1121	2033	3081	3734	4286	5895	7556	6980
2017	78	421	1026	1868	2687	3746	4419	6050	6887	7637
2018	69	392	1158	1948	3192	3705	5304	5354	6428	6038
2019	40	354	1222	1991	2806	3843	4975	5457	7415	7123

Table 2.9. Coastal cod. Acoustic biomass indices (tonnes) in 1995–2019. Age 1 is not split between coastal cod and NEA cod. Fjords in area 07 not covered in 2013 and partly covered in 2016.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Sum
1995	2337	7868	10786	23846	36039	27515	14445	8761	4933	7779	144309
1996	145	4386	16521	17739	25687	18731	15562	4376	3130	46	106323
1997	1319	4518	19748	23644	23435	29884	15060	8860	249	8643	135360
1998	752	5078	13247	19274	15627	9255	6675	1646	1329	2083	74966
1999	477	3650	10233	16960	15774	8720	4723	2097	1220	567	64421
2000	688	4321	9824	14464	20482	17067	5936	4359	926	1232	79299
2001	425	2662	7724	11548	10993	8521	5517	3010	1705	1917	54022
2002	137	1279	3672	8600	8801	8124	6282	1794	225	1663	40577
2003	125	876	2569	5328	5788	6995	4201	2754	2674	1136	32446
2004	329	1269	3087	7394	6089	6901	3009	1779	454	1058	31405
2005	109	675	2947	6521	7167	4807	3648	1942	1315	1205	30336
2006	202	1197	4374	6605	8435	8367	6672	2045	1602	190	39689
2007	227	1709	4835	11097	8148	7733	6124	5173	2177	508	47731
2008	206	1212	3120	6085	6593	4203	3437	2014	1492	2066	30506
2009	294	893	3037	7933	7335	5821	6137	4282	2707	665	39107
2010	583	1053	2800	5629	6862	4024	2439	2085	1478	1984	28936
2011	695	1120	4195	9686	8681	8218	2466	3029	1079	2227	41396
2012	295	767	2974	5914	5574	4143	3820	1673	775	3265	29199
2013	519	1192	2767	6890	8067	7252	4756	5937	2797	3178	43355
2014	456	2218	3849	5026	13418	9994	9691	6367	7308	6608	64935
2015	424	1972	3872	6423	5646	6546	4587	2747	3172	2794	38183
2016	250	1364	5792	7746	10236	5409	4165	6091	1322	3657	46023
2017	133	1664	4517	5436	5965	5289	2934	2638	1708	1787	32070
2018	770	1173	2939	5726	7051	7433	4270	2377	1652	2240	35631
2019	291	1228	7773	8392	12466	9685	10135	4775	5991	3932	64669

Table 2.10. Coastal cod. Maturity-at-age as determined from maturity stages observed in the surveys over the period 1995 – 2019. Age 1 is not split between coastal cod and NEA cod.

Year	AGE								
	1	2	3	4	5	6	7	8	9	10+
1995	0.00	0.00	0.01	0.21	0.48	0.71	0.87	0.87	1.00	1.00
1996	0.00	0.00	0.03	0.25	0.56	0.81	0.92	0.99	1.00	1.00
1997	0.00	0.00	0.06	0.29	0.45	0.76	0.97	1.00	1.00	1.00
1998	0.00	0.02	0.15	0.25	0.53	0.74	0.87	0.89	1.00	1.00
1999	0.00	0.02	0.03	0.21	0.43	0.66	0.74	1.00	1.00	1.00
2000	0.00	0.00	0.00	0.16	0.31	0.61	0.76	0.64	0.99	1.00
2001	0.00	0.00	0.00	0.04	0.37	0.78	0.98	0.99	0.97	1.00
2002	0.00	0.02	0.02	0.26	0.88	0.93	0.90	0.97	1.00	1.00
2003	0.00	0.00	0.00	0.05	0.29	0.49	0.90	0.98	0.96	1.00
2004	0.00	0.00	0.01	0.09	0.37	0.76	0.95	0.98	1.00	1.00
2005	0.00	0.00	0.00	0.07	0.40	0.56	0.89	0.98	1.00	1.00
2006	0.00	0.00	0.00	0.14	0.52	0.75	0.91	0.87	0.96	1.00
2007	0.00	0.00	0.00	0.14	0.54	0.76	0.96	0.83	1.00	1.00
2008	0.00	0.00	0.03	0.12	0.48	0.72	0.89	0.94	0.96	1.00
2009	0.00	0.00	0.02	0.06	0.26	0.35	0.59	0.74	0.60	0.92
2010	0.00	0.00	0.00	0.08	0.38	0.66	0.83	0.88	0.95	0.97
2011	0.00	0.01	0.00	0.06	0.42	0.73	0.81	0.53	0.92	0.85
2012	0.00	0.00	0.01	0.05	0.38	0.66	0.90	0.92	0.97	0.99
2013	0.00	0.00	0.00	0.01	0.32	0.65	0.86	0.94	0.99	0.96
2014	0.00	0.00	0.00	0.06	0.24	0.66	0.81	0.94	1.00	0.97
2015	0.00	0.00	0.00	0.07	0.23	0.57	0.75	0.88	0.89	0.94
2016	0.00	0.00	0.00	0.09	0.30	0.59	0.83	0.85	0.97	1.00
2017	0.00	0.00	0.00	0.07	0.30	0.65	0.88	0.94	0.97	0.97
2018	0.00	0.00	0.01	0.15	0.41	0.69	0.83	0.95	1.00	0.92
2019	0.00	0.00	0.00	0.13	0.39	0.62	0.81	0.95	1.00	0.92

Table 2.11. Coastal cod. Acoustic spawning biomass indices (tonnes) 1995–2019, corresponding to maturities in Table 2.10. Age 1 is not split between coastal cod and NEA cod.

Year	Age										
	1	2	3	4	5	6	7	8	9	10+	Sum
1995	0	0	96	4925	17424	19614	12573	7648	4933	7779	74992
1996	0	0	468	4467	14320	15130	14365	4311	3130	46	56237
1997	0	0	1185	6857	10546	22712	14608	8860	249	8643	73660
1998	0	92	2026	4870	8252	6804	5774	1461	1329	2083	32691
1999	0	56	315	3544	6778	5716	3478	2097	1220	567	23771
2000	0	0	0	2366	6354	10426	4486	2798	916	1232	28579
2001	0	0	15	508	4102	6662	5398	2978	1650	1917	23230
2002	0	20	87	2240	7702	7551	5650	1747	225	1663	26885
2003	0	0	0	269	1670	3428	3778	2686	2554	1136	15521
2004	0	0	28	679	2252	5253	2853	1736	434	722	13959
2005	0	0	0	447	2844	2670	3247	1898	1315	288	12709
2006	0	0	0	925	4386	6275	6072	1779	1538	571	21546
2007	0	0	0	1554	4400	5877	5879	4294	2177	508	24689
2008	0	0	107	734	3189	3012	3049	1902	1434	2066	15493
2009	0	0	61	476	1907	2037	3621	3169	1624	612	13508
2010	0	0	0	450	2608	2656	2024	1835	1404	1924	12901
2011	0	11	0	581	3646	5999	1997	1605	993	1893	16725
2012	0	0	22	278	2126	2748	3457	1539	755	3219	14143
2013	0	0	0	56	2580	4713	4112	5576	2773	3046	22856
2014	0	0	0	314	3222	6593	7831	5958	7307	6433	37659
2015	0	0	0	457	1301	3719	3436	2414	2811	2627	16763
2016	0	0	0	725	3084	3196	3464	5190	1278	3657	20597
2017	0	0	0	734	1779	3464	2582	2489	1662	1729	14078
2018	0	0	29	859	2891	5129	3544	2258	1652	2061	18423
2019	0	0	0	1091	4862	6005	8209	4356	5991	3617	34311

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

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

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

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

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

SWT	2	3	4	5	6	7	8	9	10
1984	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1985	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1986	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1987	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1988	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1989	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1990	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1991	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1992	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1993	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1994	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1995	0.298	0.7	1.338	1.973	2.649	4.164	7.051	6.41	14.326
1996	0.27	0.717	1.435	2.044	2.694	4.817	6.28	11.37	15.67
1997	0.232	0.677	1.363	1.903	2.816	3.833	5.849	9.60	13.037
1998	0.323	0.834	1.366	2.075	3.013	4.255	5.305	8.35	18.016
1999	0.318	0.804	1.559	2.042	2.798	4.678	7.151	8.96	18.340
2000	0.346	0.777	1.458	2.296	2.735	4.048	7.011	9.22	12.277
2001	0.347	0.878	1.543	2.213	2.862	3.321	4.849	7.339	11.542
2002	0.43	0.88	1.698	2.452	3.538	4.397	4.191	7.046	15.619
2003	0.308	0.686	1.299	2.149	3.135	4.048	5.008	5.789	10.069
2004	0.339	0.834	1.614	2.269	3.29	4.124	4.718	4.976	6.358
2005	0.407	0.846	1.748	2.2	2.693	3.817	3.797	5.344	14.829
2006	0.49	1.125	1.812	2.559	3.579	3.964	4.822	7.332	14.65
2007	0.518	1.185	2.011	2.5	3.16	4.241	6.806	11.051	14.931
2008	0.508	1.208	2.095	2.987	3.671	3.976	4.387	5.415	11.558
2009	0.434	1.116	2.003	2.894	3.632	4.875	5.4	6.125	4.719
2010	0.419	1.026	1.996	2.839	3.665	4.868	4.895	5.685	6.504
2011	0.343	1.062	2.119	2.882	3.761	5.505	6.336	6.309	6.57

SWT	2	3	4	5	6	7	8	9	10
2012	0.336	1.038	2.006	2.998	3.727	4.783	5.071	5.851	7.446
2013	0.365	0.851	1.815	2.856	3.561	4.122	6.435	5.974	7.67
2014	0.423	1.071	1.845	2.886	3.905	4.495	5.249	5.871	8.762
2015	0.37	1.045	1.94	2.91	3.518	4.927	4.753	5.864	7.277
2016	0.344	1.121	2.033	3.081	3.734	4.286	5.895	7.556	6.984
2017	0.421	1.026	1.868	2.687	3.746	4.419	6.05	6.887	7.637
2018	0.392	1.158	1.948	3.192	3.705	5.305	5.354	6.428	6.038
2019	0.354	1.222	1.991	2.806	3.843	4.975	5.457	7.415	7.123

Table 2.14 Norwegian Coastal Cod. Catch weights (CWT). Input data to all the VPA-analysis.

CWT	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1984	0.832	1.262	1.873	2.608	3.52	5.202	6.23	7.186	14.435
1985	0.893	1.288	1.929	2.63	3.819	5.023	6.432	8.053	14.074
1986	0.225	0.539	1.531	2.393	3.354	4.72	6.13	7.309	14.555
1987	0.423	0.842	1.386	2.266	3.602	4.861	6.287	8.098	19.751
1988	0.349	0.741	1.299	1.878	3.074	4.493	5.898	7.219	18.64
1989	0.647	1.127	1.429	2.136	2.958	4.164	5.155	5.897	11.31
1990	0.779	1.294	1.796	2.5	3.354	4.326	5.326	6.379	13.051
1991	1.069	1.602	2.17	2.811	3.52	4.302	5.043	5.736	9.886
1992	1.009	1.481	2.081	2.748	3.466	4.397	5.16	5.972	10.286
1993	1.028	1.64	2.2	2.903	3.616	4.344	5.204	5.764	8.154
1994	0.882	1.396	1.912	2.567	3.412	4.239	5.017	6.175	9.328
1995	0.732	1.239	1.744	2.302	3.137	4.299	5.424	6.273	9.847
1996	0.845	1.432	2.122	2.93	3.454	4.176	5.135	6.016	9.25
1997	1.053	1.694	2.126	2.959	3.529	4.313	5.427	6.424	8.668
1998	0.789	1.335	1.779	2.556	3.55	4.24	5.066	5.761	10.589
1999	1	1.603	2.045	2.607	3.492	4.317	4.956	5.742	8.169
2000	1.075	1.551	2.205	2.75	3.587	4.483	5.607	6.187	10.939
2001	0.913	1.496	2.055	2.631	3.381	4.143	5.065	5.719	9.9
2002	0.973	1.733	2.352	2.972	3.98	4.877	5.646	6.883	11.221

CWT	2	3	4	5	6	7	8	9	10
2003	1.136	1.861	2.391	3.226	3.956	4.983	5.697	6.056	9.653
2004	1.063	1.857	2.308	2.883	3.79	4.769	5.644	6.239	8.494
2005	1.105	1.811	2.468	2.992	3.574	4.354	5.082	5.848	8.342
2006	1.326	1.737	2.244	3.094	3.794	4.522	5.375	6.296	8.802
2007	1.206	1.82	2.518	3.154	4.334	5.028	5.764	7.044	9.432
2008	1.27	1.76	2.693	3.239	4.137	5.264	5.97	6.69	9.77
2009	1.459	1.92	2.719	3.513	4.355	5.411	6.492	7.43	9.345
2010	1.232	1.903	2.703	3.441	4.31	5.127	5.503	6.654	8.374
2011	1.142	1.767	2.464	3.279	4.293	5.177	6.19	6.733	8.77
2012	1.091	1.736	2.549	3.493	4.571	5.635	6.724	7.532	10.09
2013	1.133	1.706	2.422	3.176	4.142	4.984	5.968	6.869	11.008
2014	1.214	1.915	2.609	3.385	4.302	5.336	6.048	6.725	9.785
2015	1.095	1.633	2.272	3.195	3.977	4.952	5.881	6.722	9.119
2016	1.312	1.867	2.537	3.319	4.165	5.005	5.99	6.964	9.069
2017	1.14	1.801	2.487	3.213	3.919	5.022	6	7.036	9.827
2018	1.132	1.698	2.319	3.14	3.932	4.888	5.836	6.675	9.498
2019	1.440	1.942	2.634	3.318	4.131	4.979	5.891	6.759	8.978

Table 2.15 Norwegian Coastal Cod. Maturity proportions by age (MAT). Input data to all the VPA-analysis.

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

MAT	2	3	4	5	6	7	8	9	10
2013	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2014	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2015	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2016-20	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1

Table 2.16. 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

18/04/2020 13:01

Extended Survivors Analysis

Norwegian Coastal Cod COMBSEX PLUSGROUP

CPUE data from file coast-9.txt

Catch data for 36 years. 1984 to 2019. Ages 2 to 10.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
Norw. Coast. survey	1995	2019	0	8	0.75	0.85

Time series weights :

Tapered time weighting applied

Power = 3 over 20 years

Catchability analysis :

Catchability dependent on stock size for ages < 4

Regression type = C

Minimum of 5 points used for regression

Survivor estimates shrunk to the population mean for ages < 4

Catchability independent of age for ages >= 7

Terminal population estimation :

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

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

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 120 iterations

Total absolute residual between iterations
119 and 120 = .00098

Final year F values

Age	2	3	4	5	6	7	8	9
Iteration **	0.0029	0.0516	0.0986	0.1559	0.2611	0.2918	0.4711	0.435
Iteration **	0.0029	0.0516	0.0984	0.1559	0.2613	0.2917	0.471	0.434

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Regression weights

	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997

Fishing mortalities

Age	2010	2011	2012	2013	2014	2015	2016	2017
2	0.005	0.003	0.021	0.005	0.004	0.005	0.004	0.007
3	0.039	0.036	0.055	0.037	0.026	0.032	0.079	0.038
4	0.11	0.123	0.092	0.097	0.086	0.099	0.12	0.125
5	0.26	0.272	0.196	0.149	0.15	0.15	0.213	0.171
6	0.47	0.236	0.245	0.172	0.193	0.252	0.312	0.393
7	0.338	0.409	0.211	0.2	0.249	0.201	0.483	0.518
8	0.411	0.296	0.332	0.218	0.296	0.226	0.371	0.57
9	0.152	0.247	0.228	0.363	0.154	0.255	0.385	0.399
av4-7	0.2945	0.26	0.186	0.1545	0.1695	0.1755	0.282	0.301

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XSA population numbers (Thousands)

	AGE							
YEAR	2	3	4	5	6	7	8	9
2010	2.68E+04	2.10E+04	1.84E+04	1.31E+04	6.44E+03	3.86E+03	2.67E+03	2.17E
2011	2.92E+04	2.18E+04	1.65E+04	1.35E+04	8.25E+03	3.30E+03	2.26E+03	1.45E
2012	2.16E+04	2.38E+04	1.72E+04	1.20E+04	8.44E+03	5.33E+03	1.79E+03	1.38E
2013	2.66E+04	1.73E+04	1.85E+04	1.29E+04	8.07E+03	5.41E+03	3.54E+03	1.05E
2014	2.97E+04	2.16E+04	1.36E+04	1.37E+04	9.07E+03	5.56E+03	3.63E+03	2.33E
2015	2.90E+04	2.42E+04	1.73E+04	1.02E+04	9.66E+03	6.12E+03	3.55E+03	2.21E
2016	3.11E+04	2.36E+04	1.92E+04	1.28E+04	7.21E+03	6.15E+03	4.10E+03	2.32E
2017	2.95E+04	2.54E+04	1.78E+04	1.39E+04	8.47E+03	4.32E+03	3.10E+03	2.32E
2018	2.75E+04	2.40E+04	2.00E+04	1.29E+04	9.61E+03	4.68E+03	2.11E+03	1.44E
2019	2.67E+04	2.24E+04	1.89E+04	1.49E+04	8.99E+03	6.42E+03	2.65E+03	1.00E

Estimated population abundance at 1st Jan 2020

0.00E+00	2.18E+04	1.74E+04	1.40E+04	1.05E+04	5.66E+03	3.93E+03	1.35E

Taper weighted geometric mean of the VPA populations:

2.71E+04	2.19E+04	1.72E+04	1.25E+04	8.22E+03	4.99E+03	2.85E+03	1.65E

Standard error of the weighted Log(VPA populations) :

	0.1122	0.1216	0.1208	0.127	0.1288	0.1956	0.2447	0.321
1								

Log catchability residuals.

Fleet : Norw. Coast. survey

Age	1995	1996	1997	1998	1999
2	99.99	99.99	99.99	99.99	99.99
3	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99
8	99.99	99.99	99.99	99.99	99.99

Age	2000	2001	2002	2003	2004	2005	2006	2007
2	0.69	0.41	0.05	-0.11	0.22	-0.09	0.1	0
3	3.37	2.32	0.38	0.06	0.15	0.08	0.53	0.59
4	0.93	0.71	0.34	0.08	0.28	-0.02	0.23	0.66
5	1.21	0.53	0.24	0.01	-0.07	0.18	0.3	0.31
6	1.44	0.56	0.45	0.29	0.12	-0.17	0.46	0.32
7	1.04	0.8	0.58	0.29	-0.17	0.19	0.5	0.48
8	1	0.59	0.09	0.2	-0.01	0.03	-0.19	0.06

Age	2010	2011	2012	2013	2014	2015	2016	2017
2	-0.13	-0.08	0.04	0.01	0.19	0.17	0	0.02
3	-0.75	0.3	-0.55	-0.5	-0.14	-0.01	0.92	0.47
4	-0.27	0.33	-0.16	-0.05	-0.05	-0.02	-0.02	-0.19
5	-0.13	0.06	-0.29	-0.08	0.36	-0.14	0.1	-0.35

6	-0.1	0.15	-0.53	0.07	0.22	-0.09	-0.06	-0.19
7	-0.43	-0.33	-0.37	-0.04	0.54	-0.28	-0.07	-0.12
8	-0.17	0.02	-0.06	0.22	0.46	-0.25	0.18	-0.17

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	-1.3583	-1.1897	-1.1323	-1.1795	-1.1795
S.E(Log q)	0.2332	0.241	0.2425	0.3441	0.2131

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Inter-cept	RSquare	No Pts	Reg s.e	Mean Log q
2	0.54	1.273	5.76	0.43	20	0.14	-1.95
3	2.94	-0.89	-14.59	0.02	20	0.88	-1.62

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

Age	Slope	t-value	Inter-cept	RSquare	No Pts	Reg s.e	Mean Q
4	13.39	-1.734	******	0	20	2.87	-1.36
5	0.92	0.138	1.82	0.25	20	0.23	-1.19
6	1.03	-0.043	0.93	0.21	20	0.26	-1.13
7	0.66	0.995	3.71	0.45	20	0.23	-1.18
8	0.8	0.936	2.49	0.69	20	0.17	-1.15

1

Terminal year survivor and F summaries :

Age 2 Catchability dependent on age and year class strength

Year class = 2017

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	22815	0.3	0	0	1	0.139	0.003
P shrinkage mean	21938	0.12				0.849	0.003
F shrinkage mean	9559	1				0.013	0.007

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
21830	0.11	0.07	3	0.656	0.003

Age 3 Catchability dependent on age and year class strength

Year class = 2016

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	18654	0.289	0.464	1.61	2	0.14	0.048
P shrinkage mean	17150	0.12				0.848	0.052
F shrinkage mean	23387	1				0.012	0.039

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
17420	0.11	0.11	4	0.999	0.052

1

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

Year class = 2015

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	14104	0.207	0.171	0.83	3	0.954	0.098
F shrinkage mean	12647	1				0.046	0.108

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
14033	0.2	0.14	4	0.675	0.098

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

Year class = 2014

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	10483	0.171	0.147	0.86	4	0.965	0.156
F shrinkage mean	9745	1				0.035	0.166

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
10456	0.17	0.12	5	0.741	0.156

1

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

Year class = 2013

Fleet	Esti-mated Survi-vors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	5695	0.15	0.13	0.87	5	0.966	0.26
F shrinkage mean	4840	1				0.034	0.3

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
5664	0.15	0.12	6	0.774	0.261

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

Year class = 2012

Fleet	Esti-mated Survi-vors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	4001	0.14	0.118	0.84	6	0.966	0.287
F shrinkage mean	2360	1				0.034	0.447

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3930	0.14	0.11	7	0.811	0.292

1

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

Year class = 2011

Fleet	Esti-mated Survi-vors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	1369	0.139	0.053	0.38	7	0.954	0.467
F shrinkage mean	1082	1				0.046	0.561

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1354	0.14	0.05	8	0.366	0.471

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

Year class = 2010

Fleet	Esti-mated Survi-vors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	512	0.14	0.035	0.25	7	0.923	0.448
F shrinkage mean	838	1				0.077	0.297

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
532	0.15	0.06	8	0.4	0.435

Table 2.17. Norwegian Coastal Cod. Fishing mortalities from trial XSA run based on commercial catch-at-age and survey index at age (ages 2–8 in Table 2.6). (Proportions of F and M before time of spawning was set to 0 for all ages and years).

YR\AGE	2	3	4	5	6	7	8	9
1984	0.002	0.043	0.191	0.481	0.937	1.378	0.968	0.952
1985	0.001	0.104	0.231	0.568	0.602	0.673	0.530	0.598
1986	0.020	0.093	0.201	0.382	0.669	0.847	0.781	0.676
1987	0.001	0.015	0.098	0.396	0.498	0.605	0.562	0.519
1988	0.001	0.018	0.090	0.295	0.747	0.949	0.839	0.714
1989	0.002	0.019	0.097	0.248	0.449	0.785	0.943	0.612
1990	0.002	0.014	0.049	0.090	0.158	0.278	0.434	0.241
1991	0.000	0.010	0.041	0.093	0.192	0.339	0.311	0.235
1992	0.002	0.012	0.105	0.203	0.233	0.293	0.282	0.254
1993	0.001	0.006	0.070	0.200	0.301	0.400	0.529	0.360
1994	0.002	0.009	0.054	0.235	0.333	0.466	0.357	0.350
1995	0.002	0.020	0.113	0.227	0.479	0.788	0.697	0.552
1996	0.002	0.032	0.101	0.238	0.295	0.533	0.610	0.422
1997	0.005	0.031	0.169	0.316	0.590	0.773	0.952	0.664
1998	0.004	0.035	0.185	0.315	0.406	0.557	0.537	0.457
1999	0.002	0.031	0.171	0.400	0.533	0.587	0.742	0.570
2000	0.001	0.038	0.183	0.384	0.399	0.408	0.495	0.407
2001	0.001	0.019	0.124	0.217	0.329	0.408	0.376	0.331
2002	0.002	0.021	0.117	0.266	0.420	0.339	0.385	0.334
2003	0.003	0.032	0.078	0.229	0.342	0.412	0.335	0309
2004	0.001	0.017	0.076	0.172	0.357	0.420	0.435	0.272
2005	0.001	0.016	0.086	0.182	0.265	0.380	0.332	0.253
2006	0.002	0.017	0.104	0.230	0.442	0.384	0.470	0.355
2007	0.002	0.024	0.113	0.213	0.231	0.297	0.186	0.264
2008	0.002	0.028	0.170	0.278	0.333	0.277	0.313	0.152
2009	0.001	0.046	0.100	0.195	0.314	0.267	0.166	0.141
2010	0.005	0.039	0.110	0.260	0.470	0.338	0.411	0.152
2011	0.003	0.036	0.123	0.272	0.236	0.409	0.296	0.247

YR\AGE	2	3	4	5	6	7	8	9
2012	0.021	0.055	0.092	0.196	0.245	0.211	0.332	0.228
2013	0.006	0.037	0.097	0.149	0.172	0.200	0.218	0.363
2014	0.004	0.026	0.086	0.150	0.193	0.249	0.296	0.154
2015	0.005	0.032	0.099	0.150	0.252	0.201	0.226	0.255
2016	0.004	0.080	0.120	0.213	0.312	0.483	0.371	0.385
2017	0.007	0.038	0.125	0.171	0.393	0.518	0.570	0.399
2018	0.006	0.039	0.092	0.161	0.203	0.370	0.543	0.523
2019	0.003	0.052	0.098	0.156	0.261	0.290	0.471	0.435

Table 2.17 cont. Summary output from trial XSA run based on commercial catch

Run title	COMBSEX	PLUSGROUP : Norwegian Coastal Cod
At 18/04/2020 13:14		
Table 16 Summary (without SOP correction)		

Year	R_age2	TotBiom	SSB	Landings	Y / SSB	F(4-7)
1984	58760	168474	68331	63818	0.934	0.7467
1985	63890	189058	74607	62954	0.8438	0.5184
1986	16653	194538	78127	56107	0.7181	0.5249
1987	21181	184071	80787	48274	0.5975	0.3994
1988	34491	178503	92617	55065	0.5945	0.5202
1989	38244	163824	84462	41242	0.4883	0.3948
1990	35933	171550	85246	20920	0.2454	0.1438
1991	44488	205968	105416	24837	0.2356	0.1662
1992	31671	231646	125020	38195	0.3055	0.2084
1993	17063	245645	145008	50420	0.3477	0.2428
1994	14705	238121	152474	51664	0.3388	0.2722
1995	19778	208474	145233	64964	0.4473	0.4017
1996	26637	180981	125940	41672	0.3309	0.2915
1997	28169	143605	90414	51123	0.5654	0.4619

1998	28927	135425	70695	30472	0.431	0.3657
1999	29242	147458	75691	35805	0.473	0.4227
2000	26784	136847	63303	34815	0.55	0.3436
2001	26441	143861	67687	27253	0.4026	0.2692
2002	24437	169382	84541	36405	0.4306	0.2855
2003	24190	147137	80446	35381	0.4398	0.2654
2004	22553	156398	82561	33650	0.4076	0.2558
2005	21630	161584	88738	29255	0.3297	0.228
2006	21203	188161	105473	39343	0.373	0.29
2007	27099	191481	105918	29227	0.2759	0.2136
2008	28893	196098	101686	35552	0.3496	0.2643
2009	25694	182638	89195	29987	0.3362	0.2185
2010	26775	198676	103920	40397	0.3887	0.2943
2011	29178	196626	99770	36714	0.368	0.26
2012	21554	196725	102618	35540	0.3463	0.1861
2013	26580	187805	101626	30144	0.2966	0.1544
2014	29666	226741	132494	33660	0.254	0.1697
2015	28956	222361	126172	35843	0.2841	0.1756
2016	31085	236144	130831	54767	0.4186	0.2821
2017	29487	216334	115593	51053	0.4417	0.3015
2018	27535	207699	99143	36375	0.3669	0.2063
2019	26734	216627	109687	40107	0.3656	0.2018

Table 2.18. 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 ages 4–9	com. Catch Predict F(4–7)	all catch Predict F(4–7)
1996	0.881	0.3198	0.3404
1997	0.850	0.3166	0.3365
1998	1.604	0.3935	0.4301
1999	1.018	0.3337	0.3573
2000	0.538	0.2847	0.2977
2001	0.912	0.3229	0.3442
2002	1.084	0.3404	0.3655
2003	0.482	0.2790	0.2907
2004	0.725	0.2630	0.3210
2005	0.355	0.2693	0.2750
2006	0.324	0.2628	0.2711
2007	0.386	0.2684	0.2788
2008	0.925	0.3171	0.3457
2009	-0.030	0.2308	0.2272
2010	0.776	0.3037	0.3273
2011	0.229	0.2542	0.2594
2012	0.760	0.3022	0.3253
2013	-0.102	0.2243	0.2183
2014	-0.031	0.2307	0.2270
2015	0.677	0.2947	0.3150
2016	0.389	0.2687	0.2792
2017	0.802	0.3060	0.2903
2018	0.379	0.2678	0.2309
2019	-0.292	0.2002	0.2862

Table 2.19. Norwegian Coastal Cod. Stock summary for SVPA based on commercial catch-at-age and survey derived F in terminal year (2019)

	REC	TOTALBI	TOTSPBI	LANDIN(	YIELD/SS	FBAR 4- 7
1984	79507	199527	79743	77118	0.9671	0.7139
1985	87853	221408	83710	76354	0.9121	0.5085
1986	42837	238127	90335	69607	0.7705	0.5459
1987	32962	229589	92757	61774	0.666	0.4404
1988	47702	229473	108933	68665	0.6303	0.5553
1989	56812	224070	107789	54942	0.5097	0.3994
1990	53470	219323	104704	35420	0.3383	0.2138
1991	64187	240506	119446	40137	0.336	0.1923
1992	49926	286678	150850	54295	0.3599	0.239
1993	25560	312390	176713	65220	0.3691	0.249
1994	22541	302831	184226	66364	0.3602	0.2771
1995	31325	265412	176593	79664	0.4511	0.3863
1996	46955	233634	155350	56172	0.3616	0.303
1997	43020	192773	113257	65623	0.5794	0.4395
1998	42077	194554	95169	45072	0.4736	0.3562
1999	41295	206766	101885	49705	0.4879	0.3767
2000	39318	200874	93685	48415	0.5168	0.3044
2001	39004	211435	100349	40653	0.4051	0.2604
2002	35326	237243	117975	50005	0.4239	0.2776
2003	34517	210807	114983	49281	0.4286	0.247
2004	32693	214913	112361	47050	0.4187	0.2655
2005	31751	219826	116925	42455	0.3631	0.2328
2006	30008	251764	136119	52343	0.3845	0.2802
2007	41115	263780	142577	42227	0.2962	0.2219
2008	38660	270592	135025	48352	0.3581	0.2521
2009	34312	249797	120454	42687	0.3544	0.2364
2010	34960	266679	138814	53097	0.3825	0.2705
2011	38841	265928	138018	49414	0.358	0.2546
2012	29454	265071	142458	48240	0.3386	0.1862
2013	35154	250838	137677	42844	0.3112	0.1754
2014	36413	290983	169950	46360	0.2728	0.1878
2015	39835	283956	160483	48543	0.3025	0.1917
2016	45555	298056	161638	67467	0.4174	0.2741
2017	42589	281831	145584	63753	0.4379	0.2837
2018	50960	290153	132360	49075	0.3708	0.2084
2019	22606	308411	149598	52807	0.353	0.2002

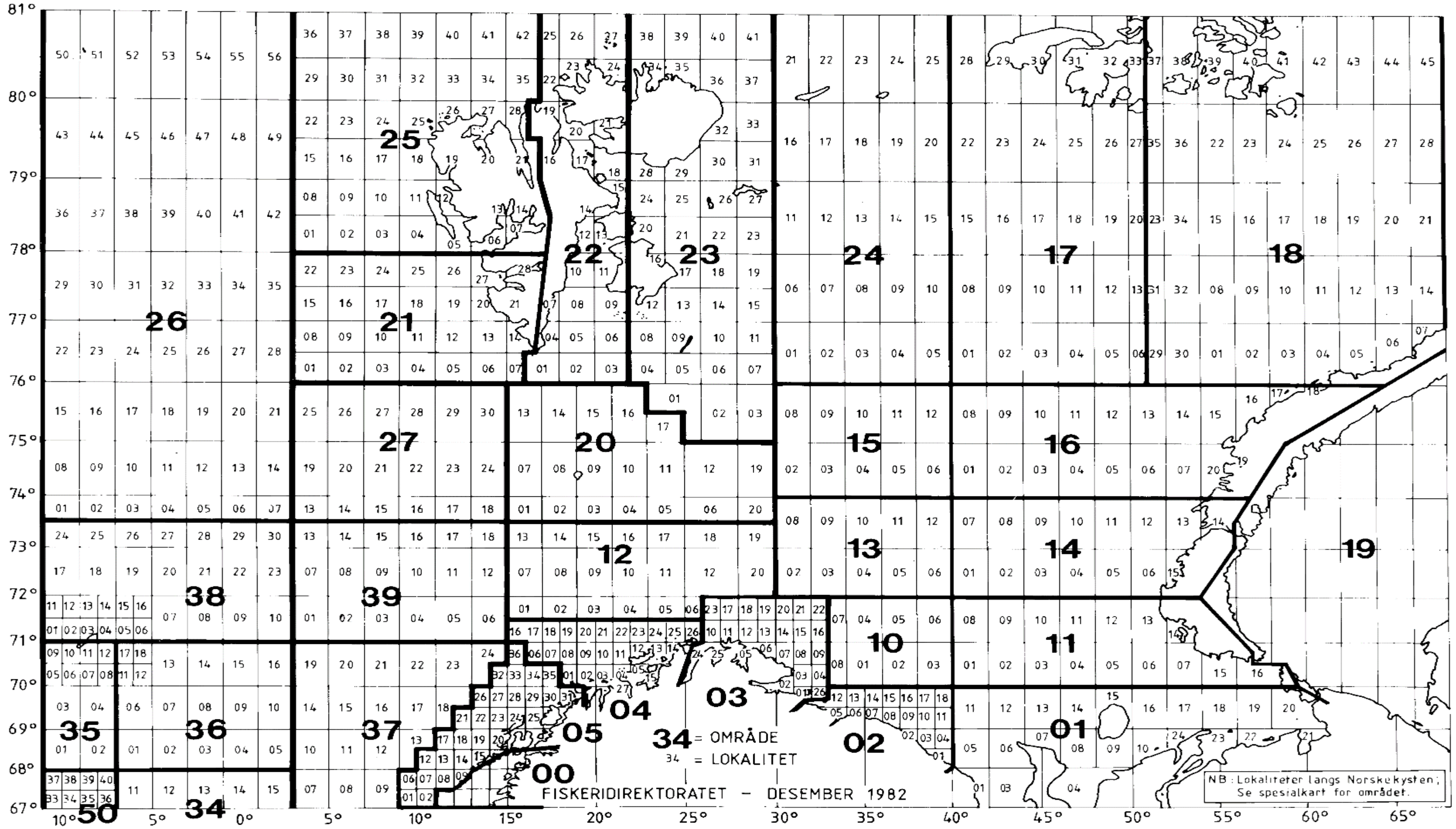


Figure 2.1a. Norwegian statistical rectangles in the Barents Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 03 and 04. The same areas are also referred to in the survey results (sec. 2.3).

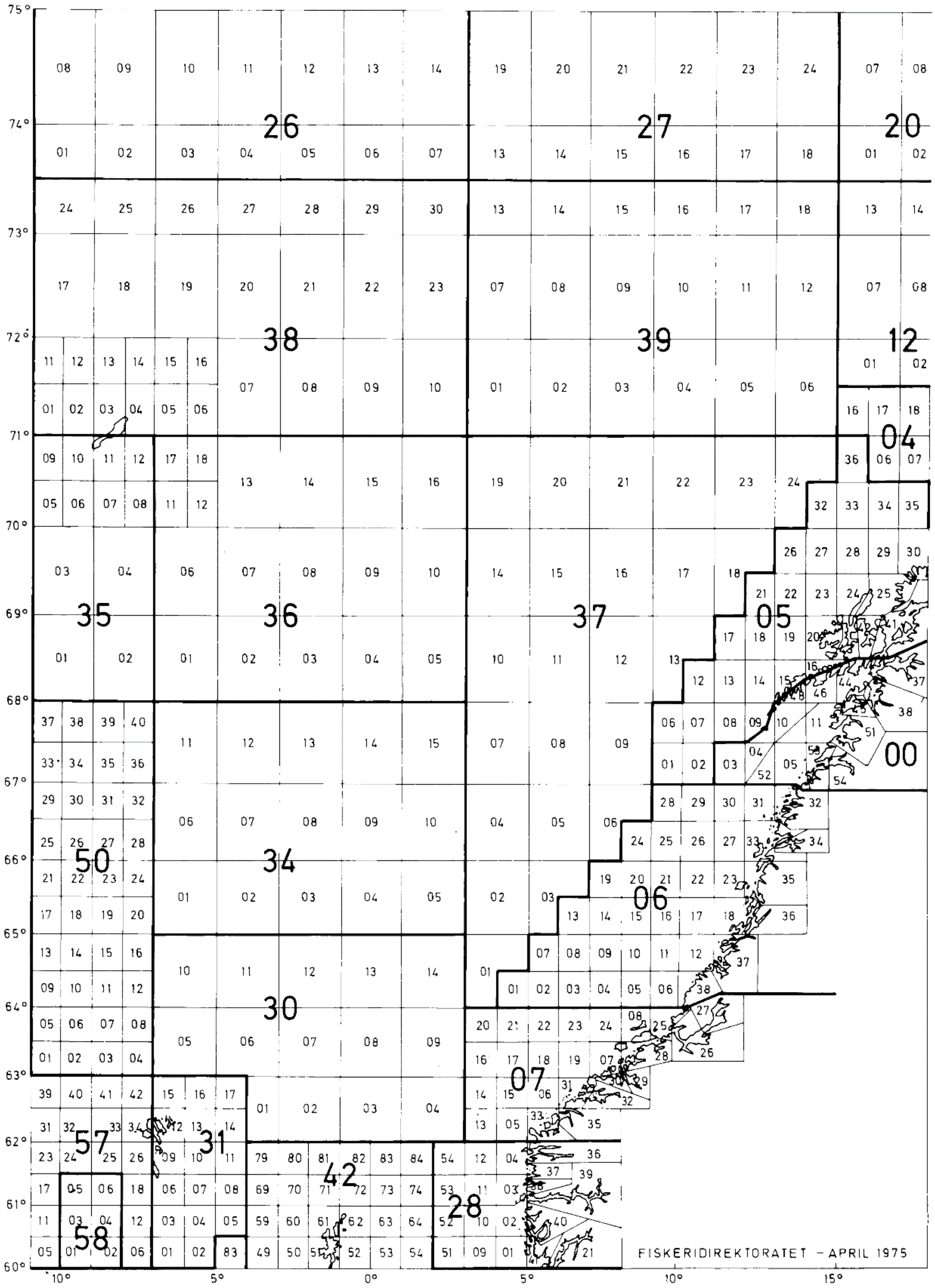


Figure 2.1b. Norwegian statistical rectangles in the Norwegian Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 05, 00, 06 and 07. The same areas are also referred to in the survey results (sec. 2.3).

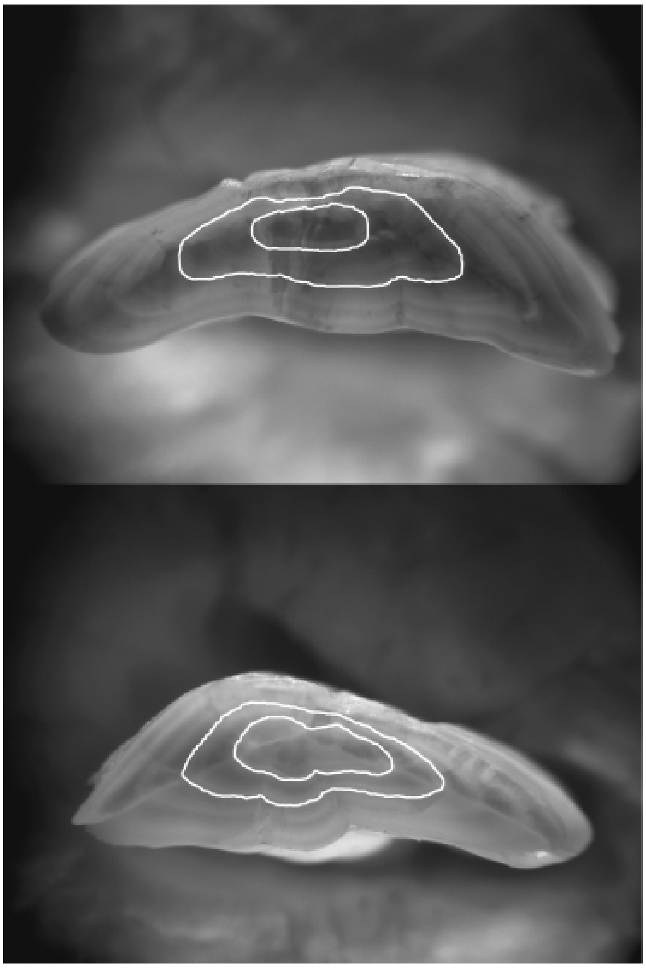


Figure 2.2. An image of a coastal cod otolith (top) and a northeast Arctic cod otolith (bottom). The two first translucent zones are highlighted. (from Berg *et al.*, 2005).

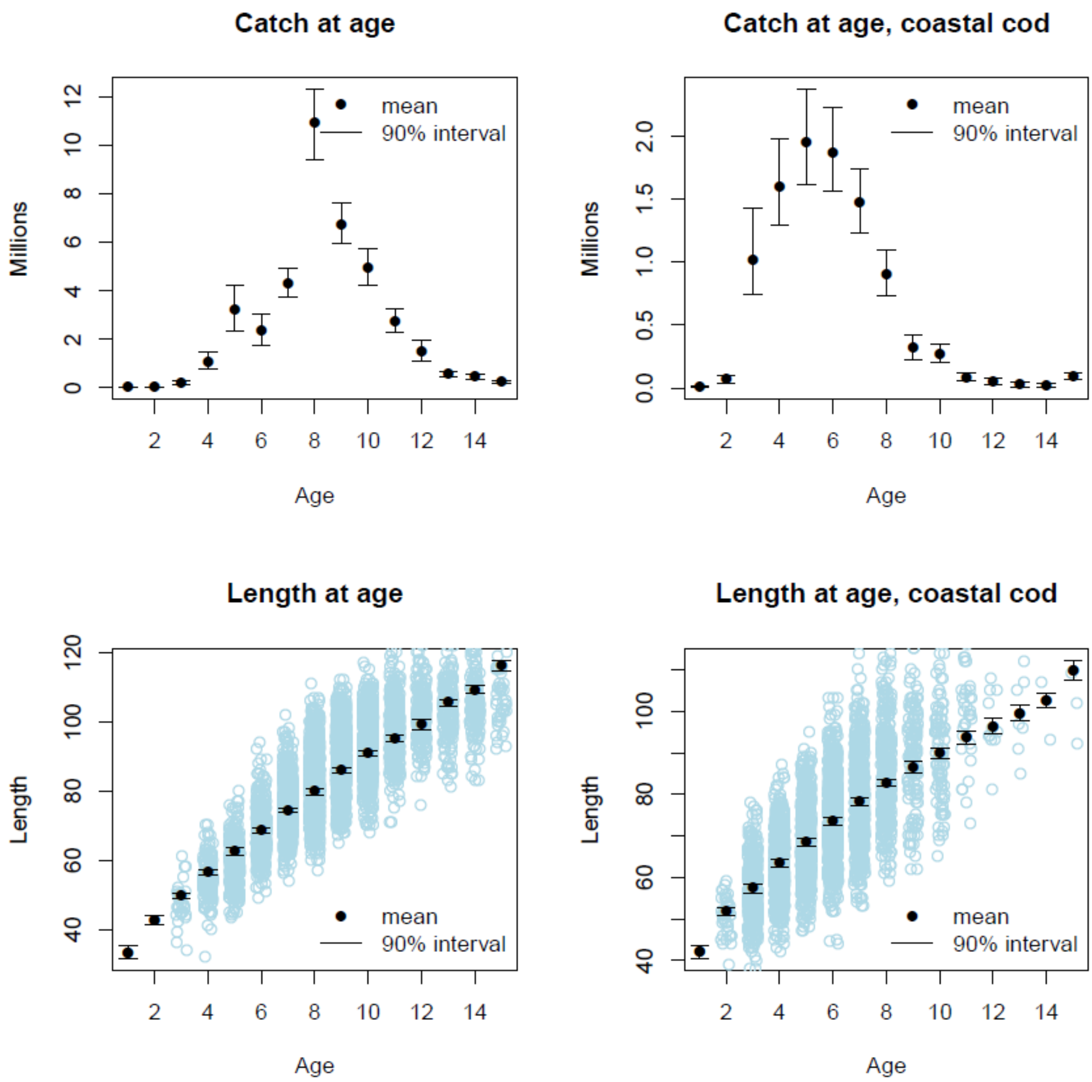


Figure 2.3a. ECA-output for 2019 commercial catches by Norway in the coastal statistical areas (Figure 2.5c). Left panels NEA cod. Right panels coastal cod.

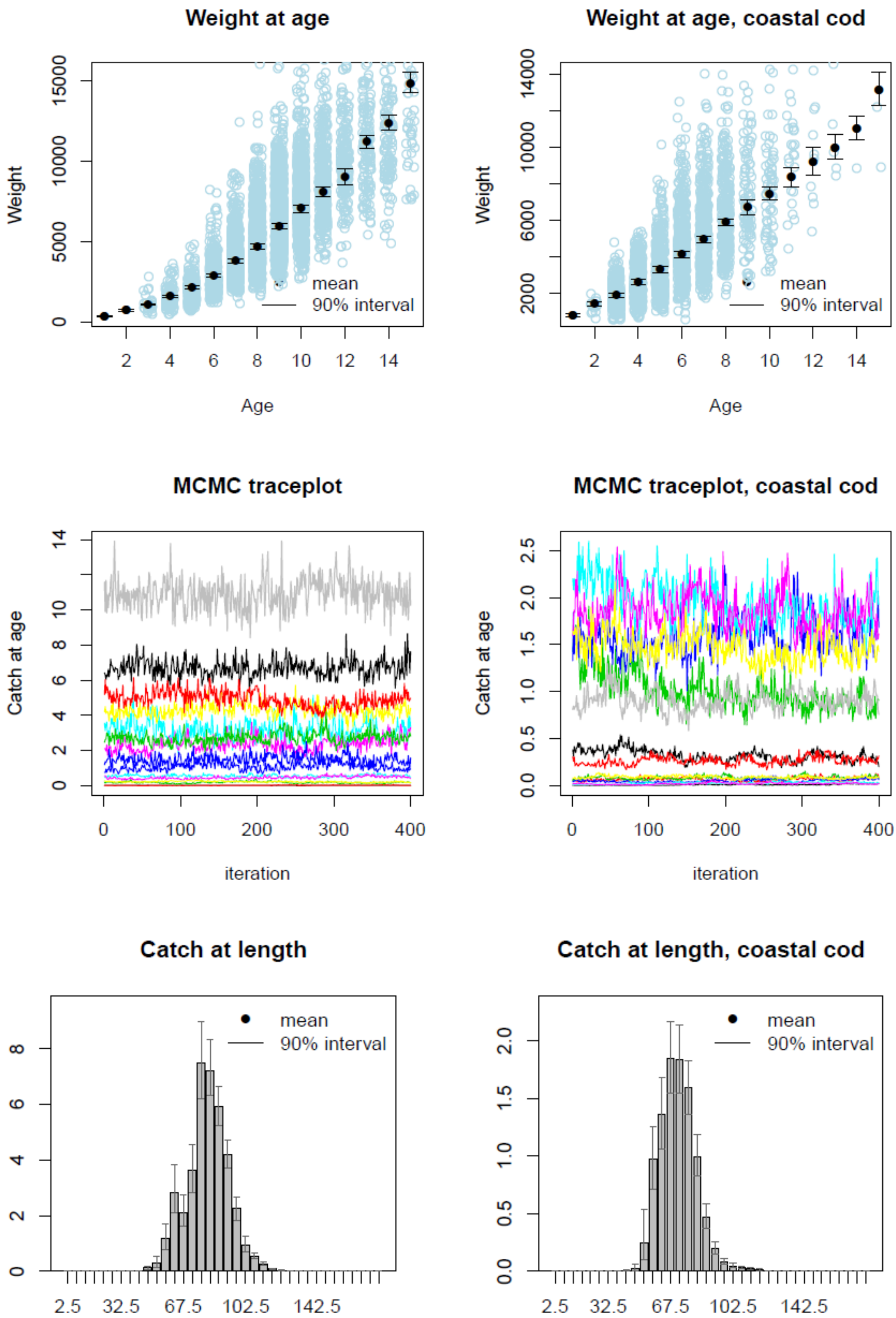


Figure 2.3b. ECA-output for 2019 commercial catches by Norway in the coastal statistical areas (Figure 2.5c). Left panels NEA cod. Right panels coastal cod.

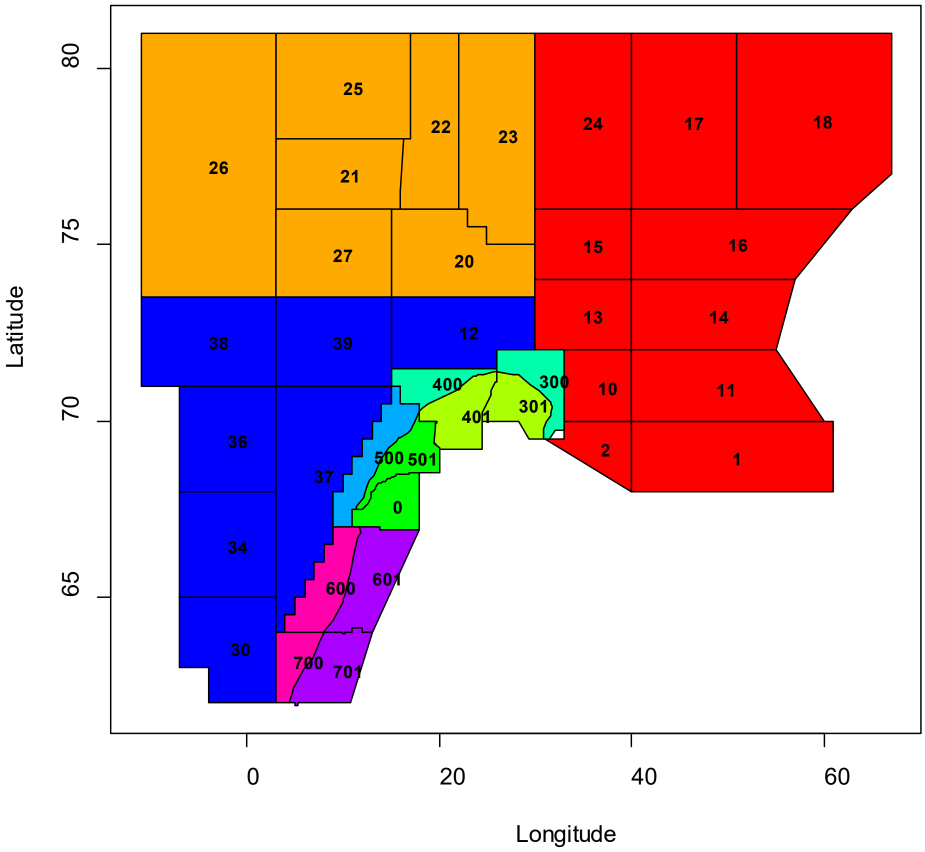


Figure 2.4. Norwegian statistical rectangles. The colors indicate area units used by the ECA-model for combining cod samples. Coastal cod are only estimated in coastal areas (0 and 300–701).

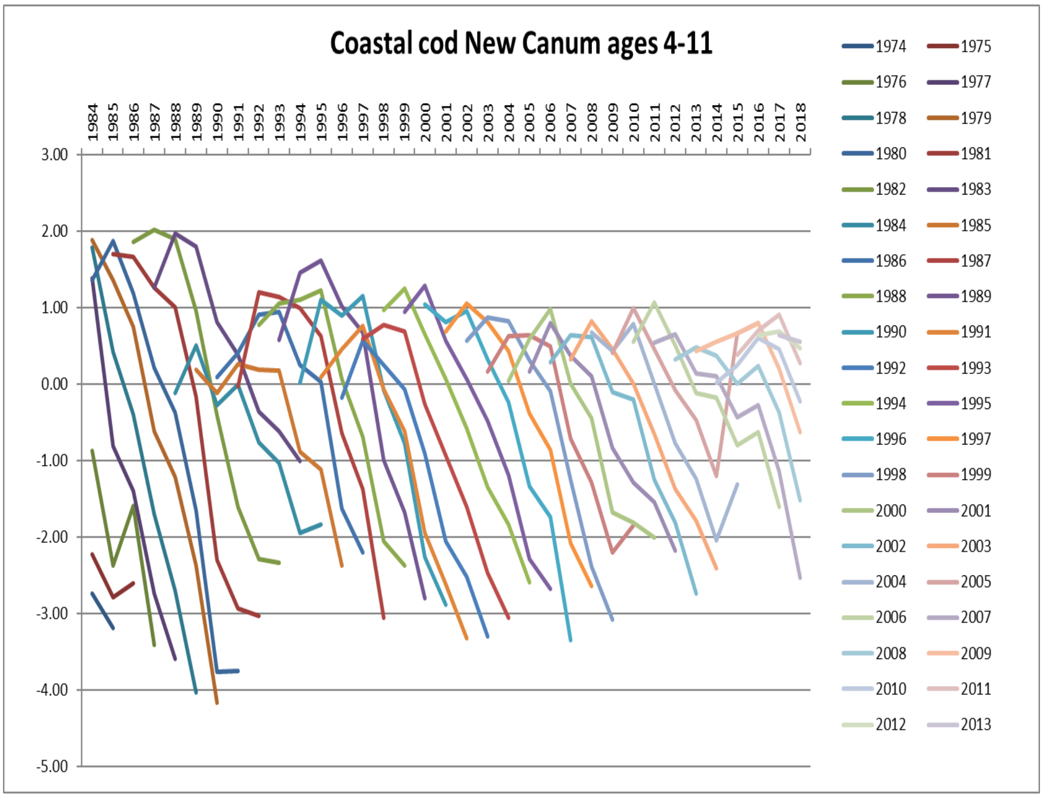


Figure 2.5a. Log catch numbers-at-age by cohort (series names) and catch years (x-axis). ECA estimates.

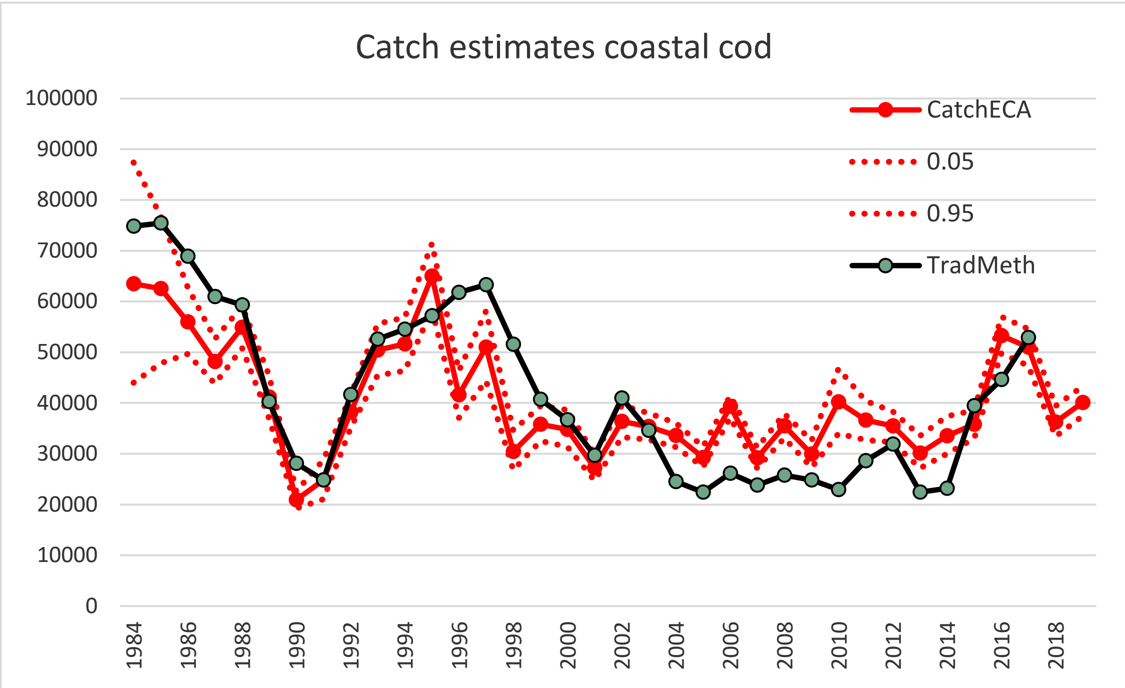


Figure 2.5b. Catches (tonnes) of coastal cod from the ECA analysis (with 5 and 95-percentiles), compared to the traditional estimates.

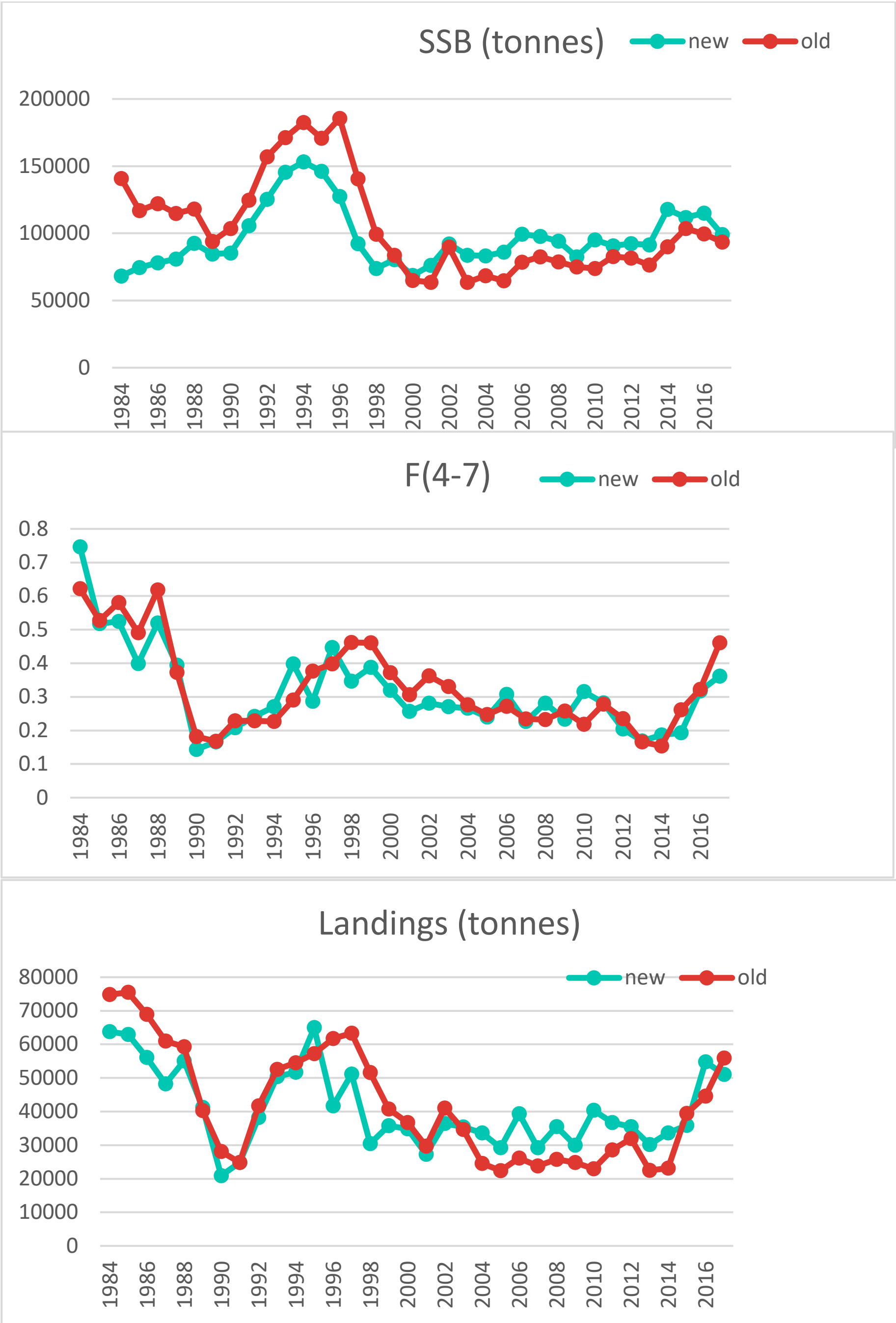
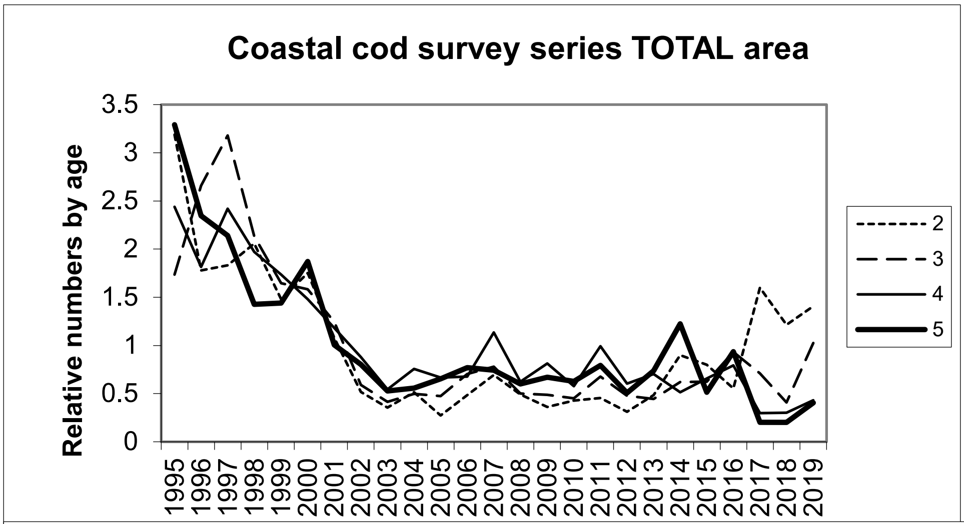


Figure 2.5c. AFWG 2019-XSA run (1984-2017) with Traditional estimates of catch-at-age as input (old), as used in 2018 AFWG, and run with ECA-estimates of catch-at-age as input (new2019), both runs tuned by the coastal survey data 1995-2017, ages 2-10+ (NOcoast-Aco-4Q).



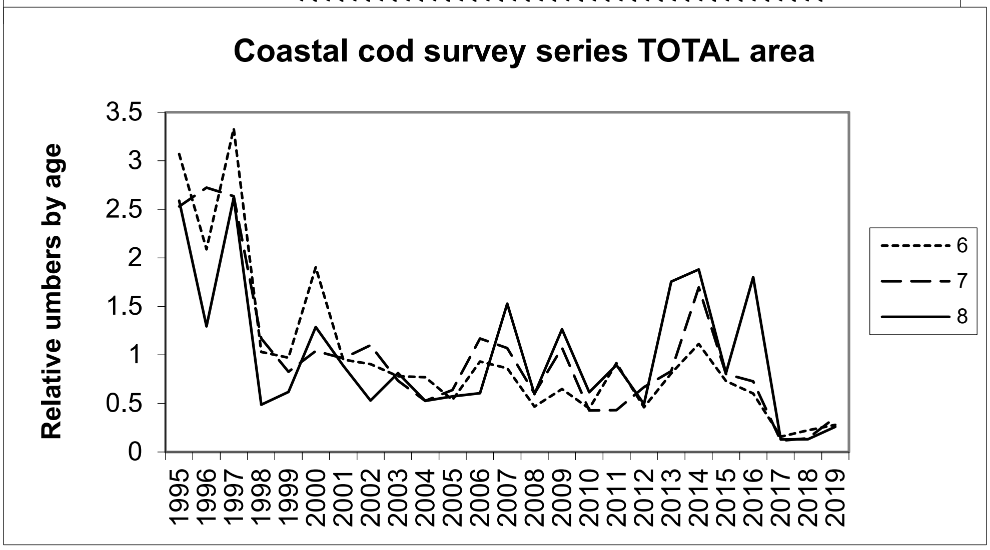
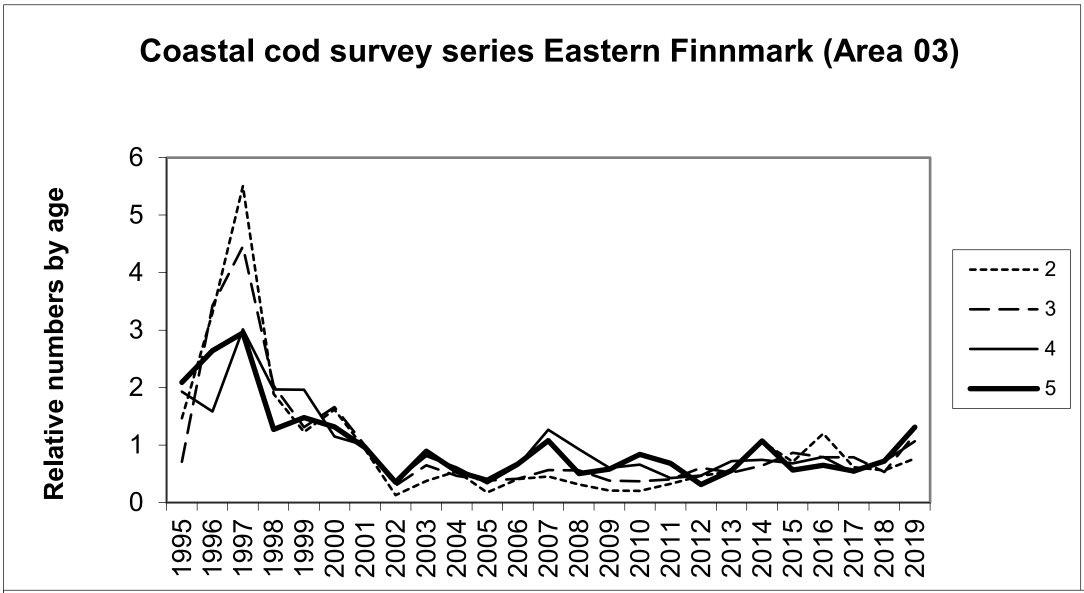


Figure 2.6. Coastal cod survey. Abundance at age relative to time-series average in total survey. Upper: ages 2–5, Lower: ages 6–8.



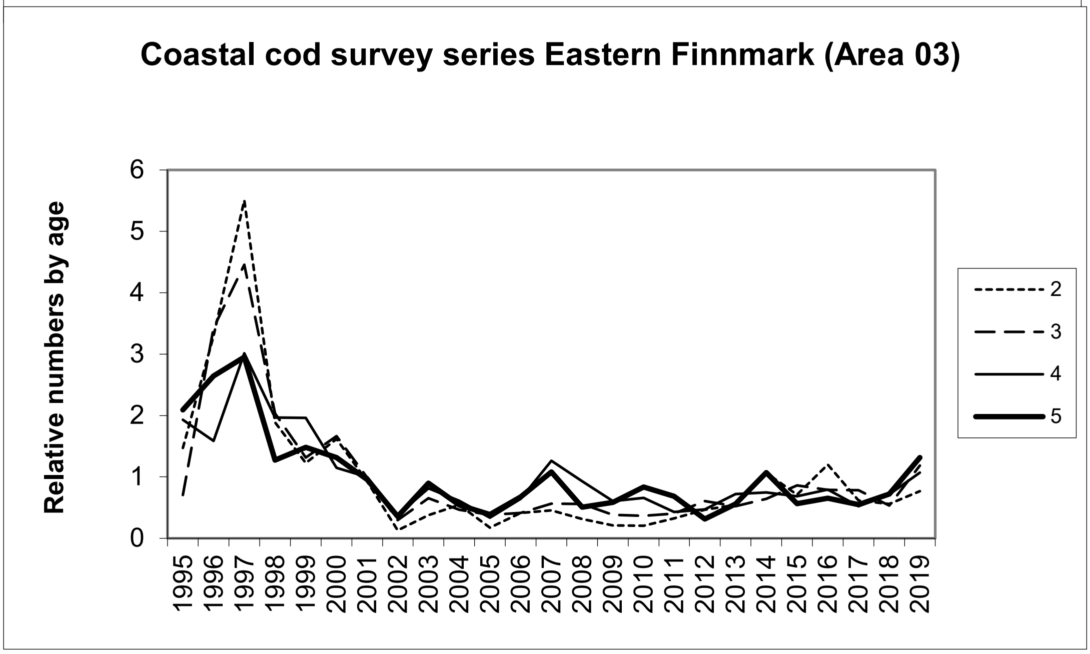


Figure 2.7. Coastal cod survey. Abundance at age relative to time-series average in statistical area 03. Upper: ages 2–5, Lower: ages 6–8.

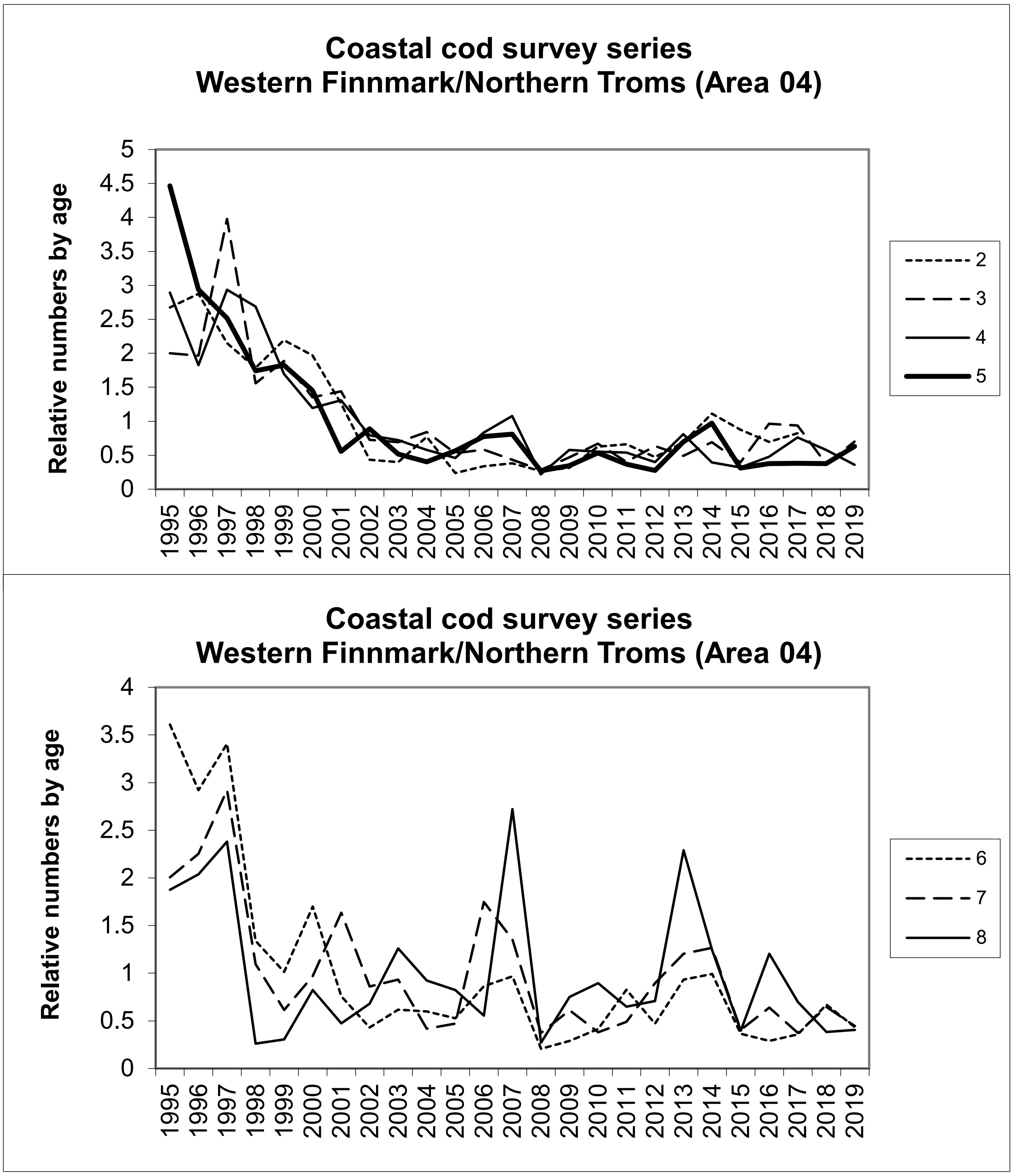
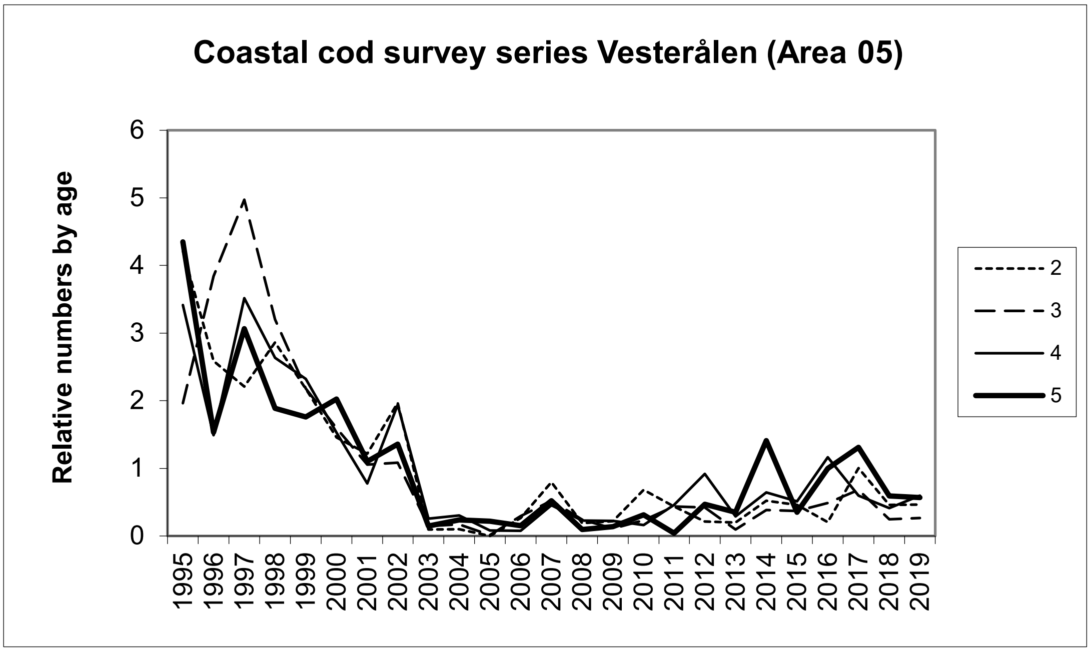


Figure 2.8. Coastal cod survey. Abundance at age relative to time-series average in statistical area 04. Upper: ages 2–5, Lower: ages 6–8



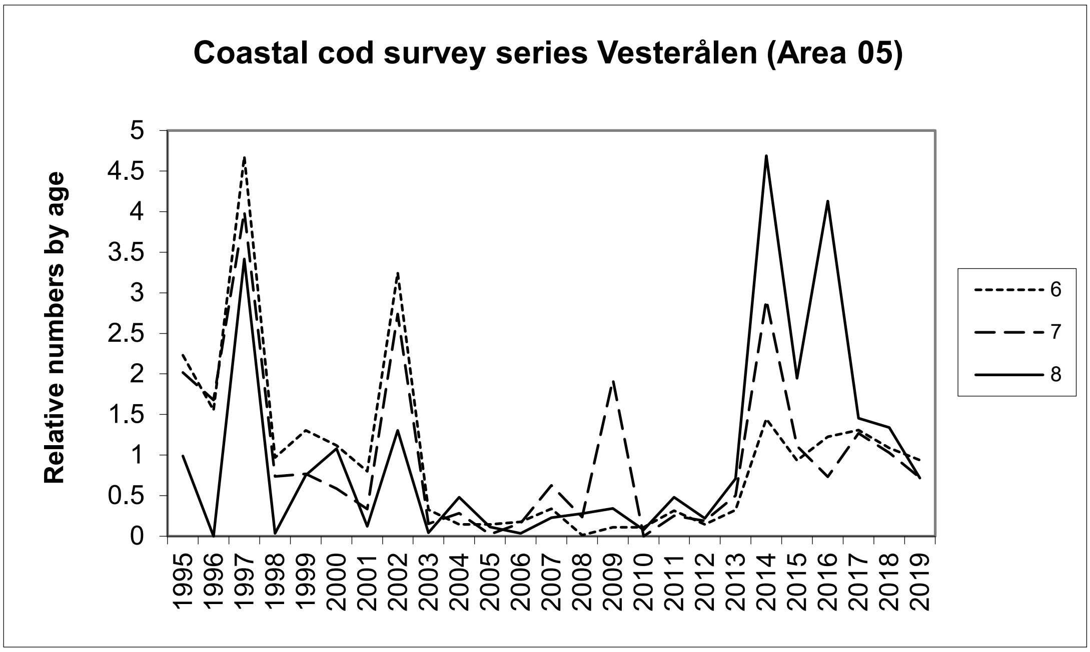
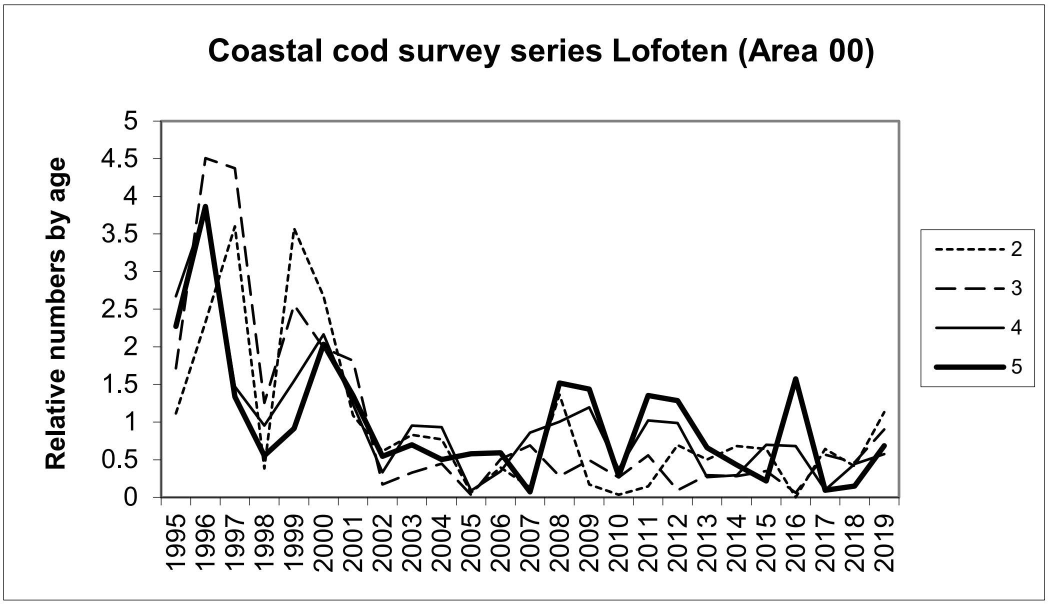


Figure 2.9. Coastal cod survey. Abundance at age relative to time-series average in statistical area 05. Upper: ages 2–5, Lower: ages 6–8.



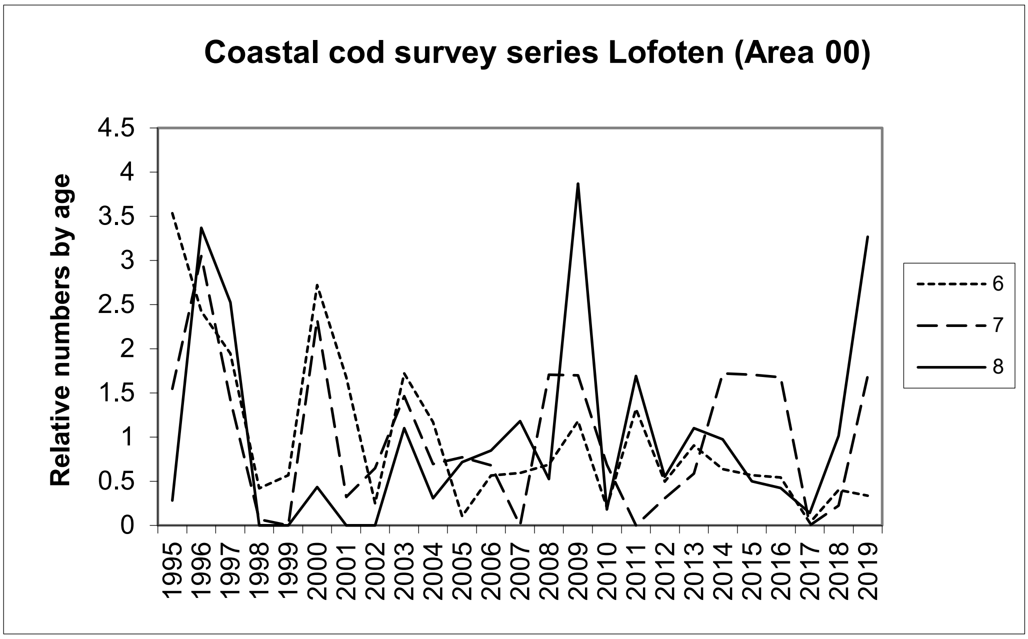


Figure 2.10. Coastal cod survey. Abundance at age relative to time-series average in statistical area 00. Upper: ages 2–5, Lower: ages 6–8.

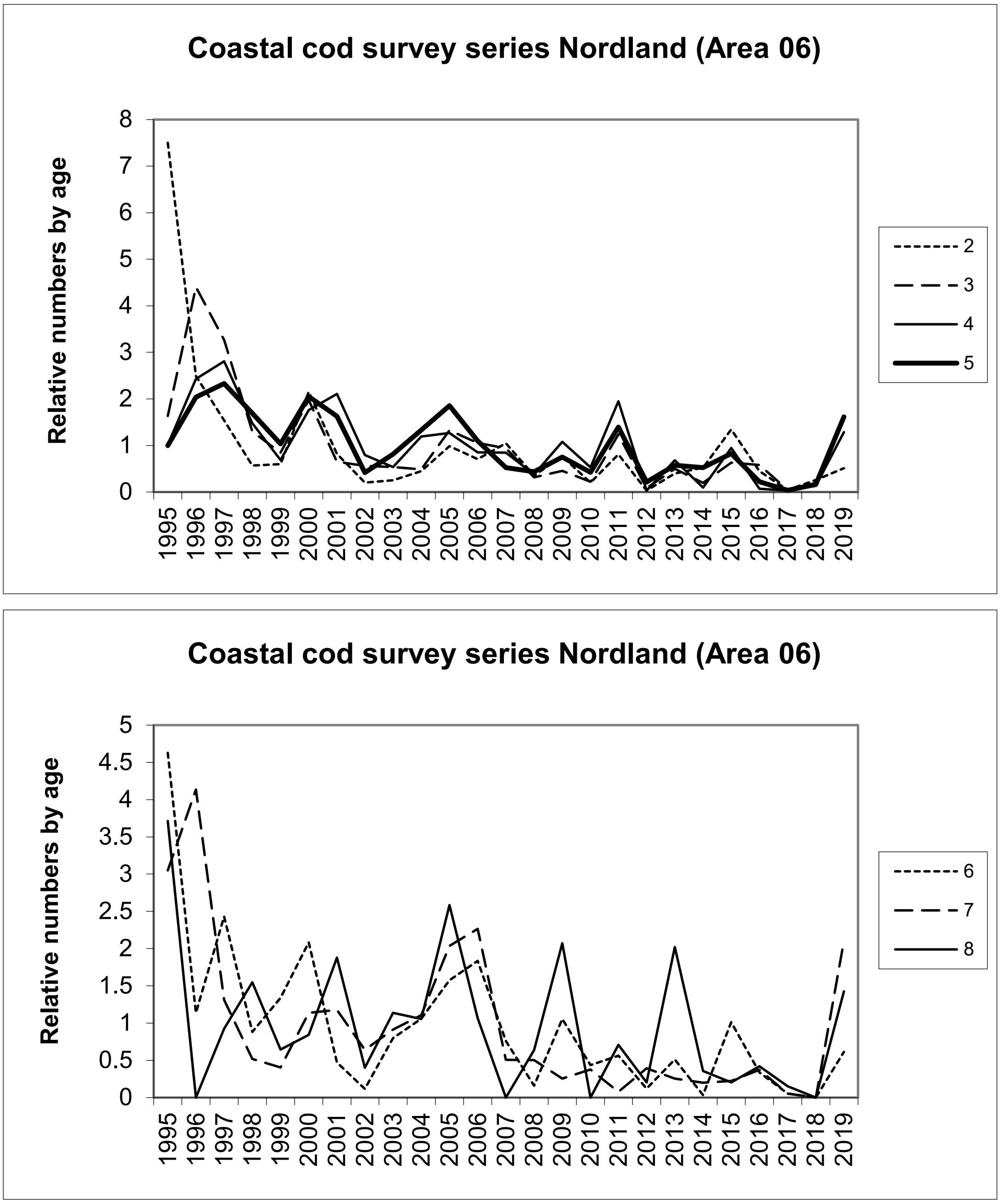
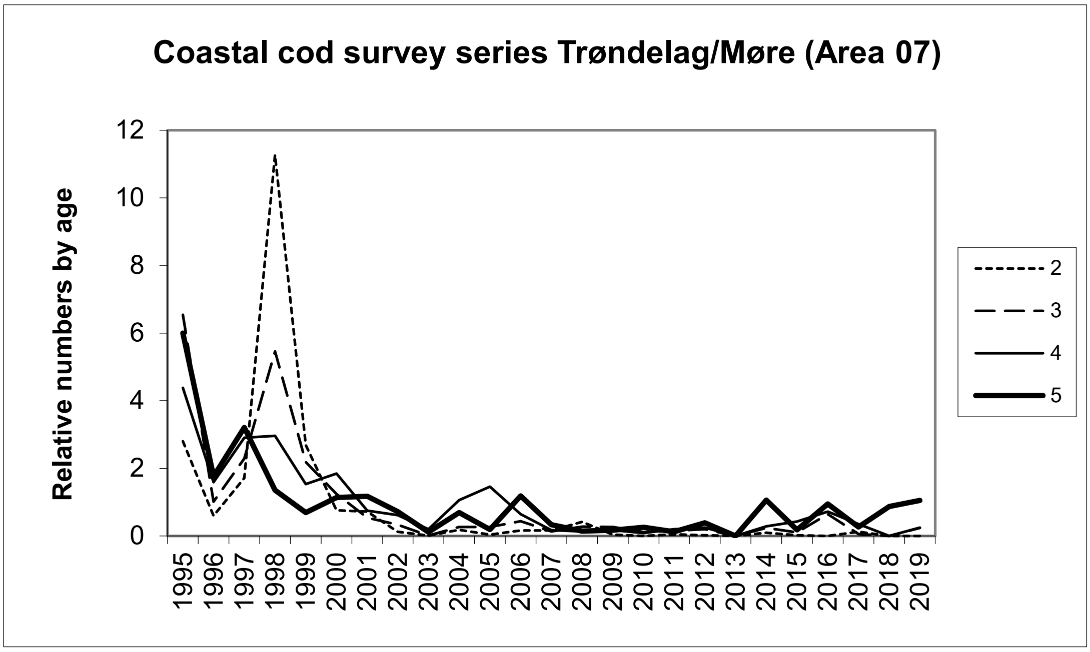


Figure 2.11 Coastal cod survey. Abundance at age relative to time-series average in statistical area 06. Upper: ages 2–5, Lower: ages 6–8.



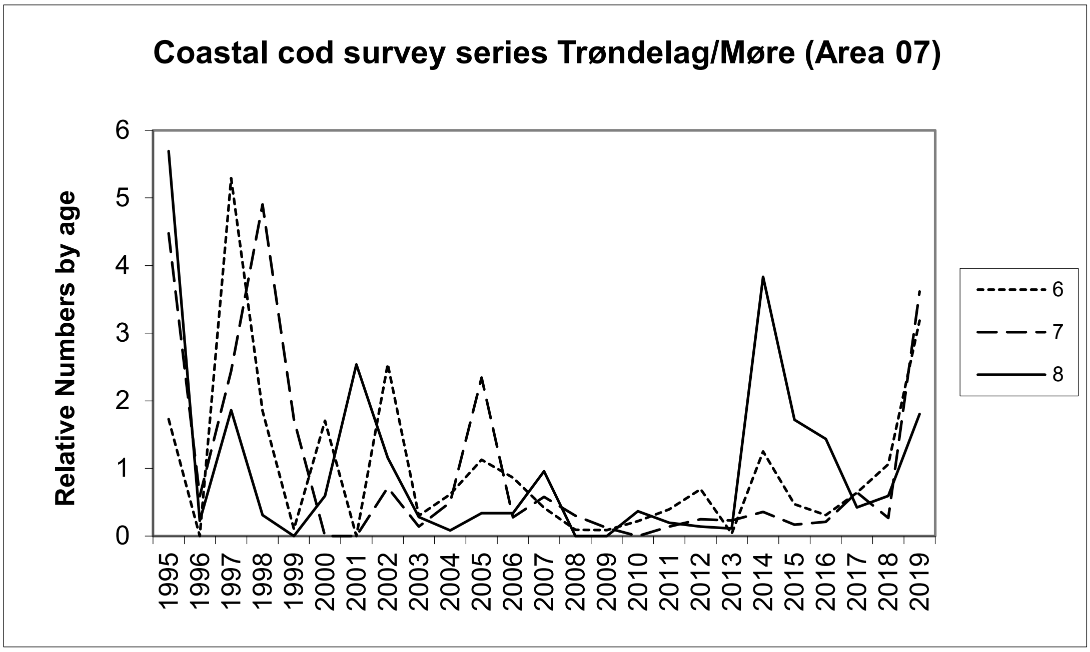


Figure 2.12. Coastal cod survey. Abundance-at-age relative to time-series average in statistical area 07. Some important areas at Møre was not covered in 2013. Upper: ages 2–5, Lower: ages 6–8.

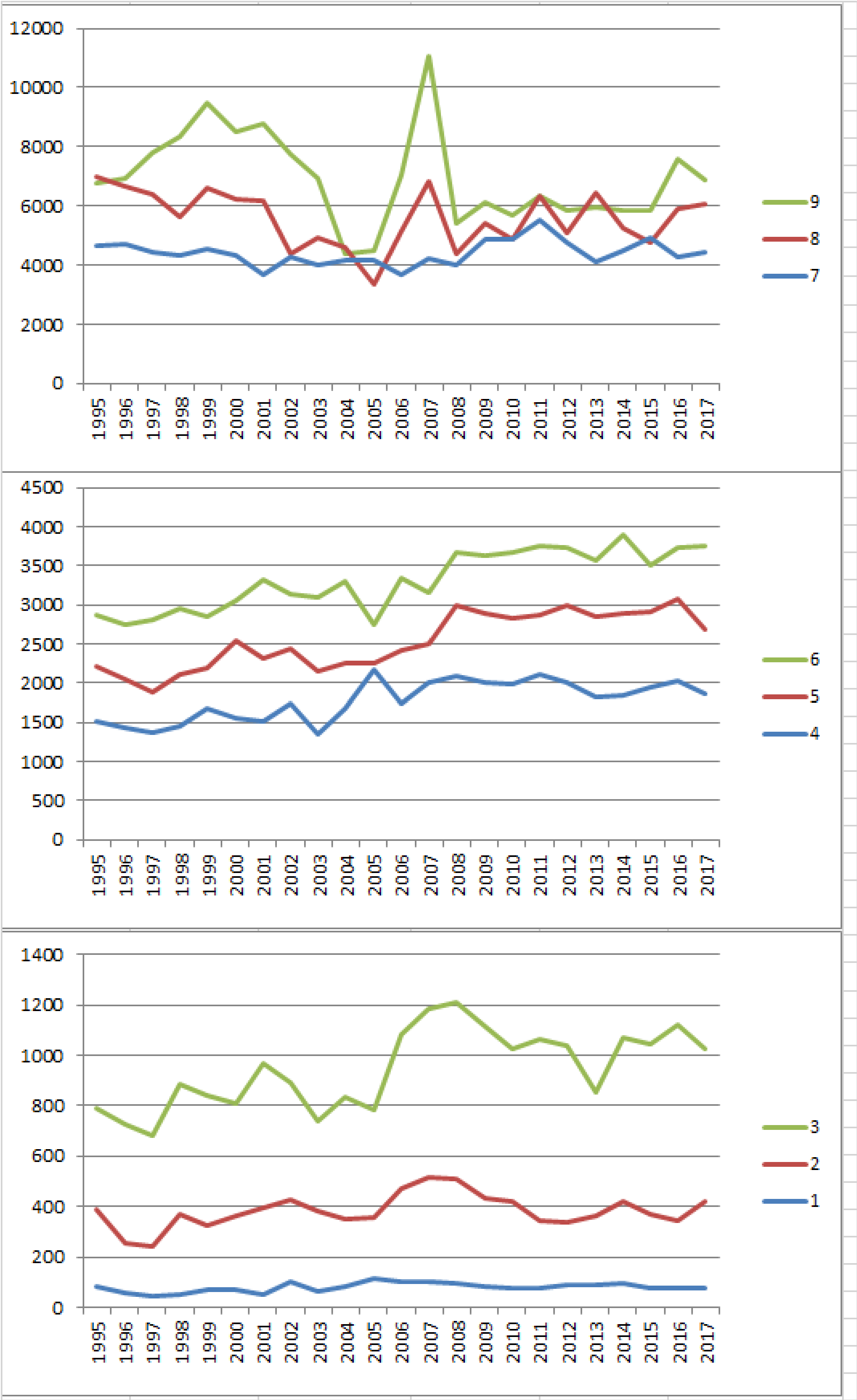


Figure 2.13a. Mean weights at age in the coastal survey, not updated for 2018 and 2019

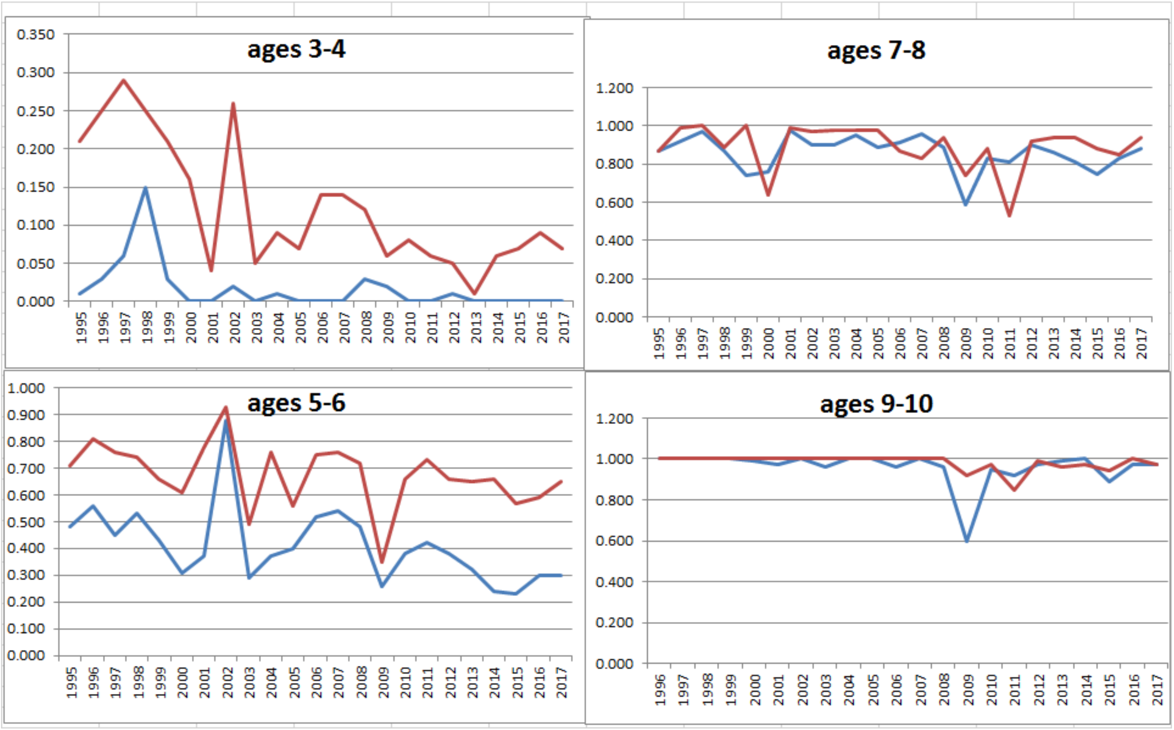


Figure 2.13b. Proportions mature-at-age as observed in the surveys. Ages 3, 5, 7 and 9 in blue, ages 4, 6, 8, and 10 in red. , not updated for 2018 and 2019

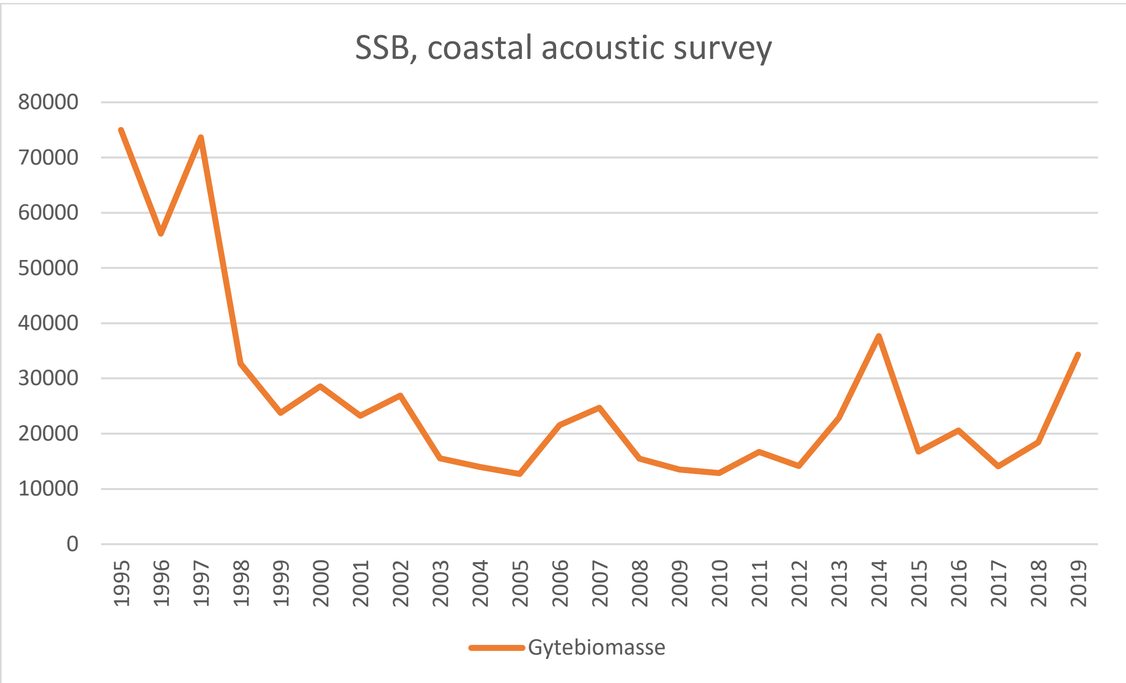
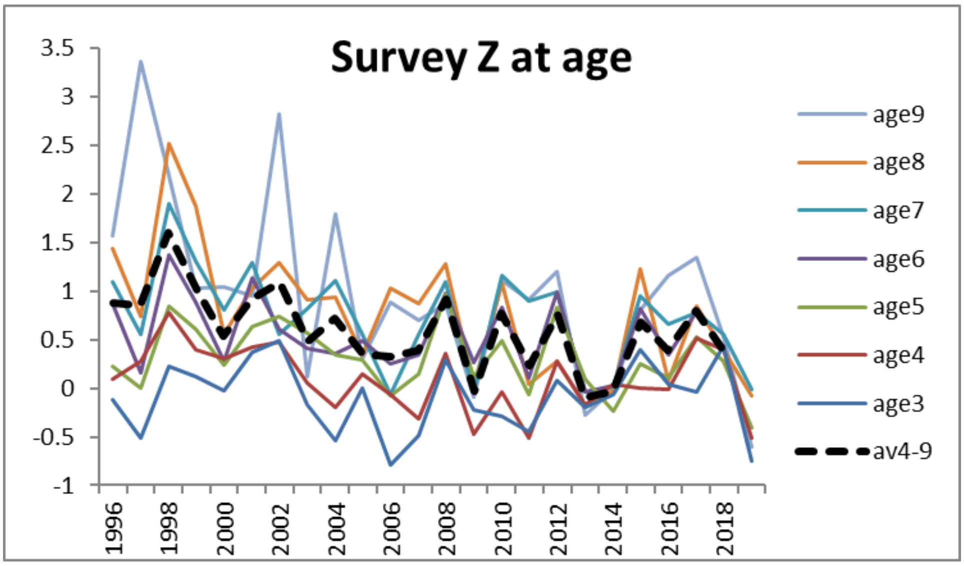
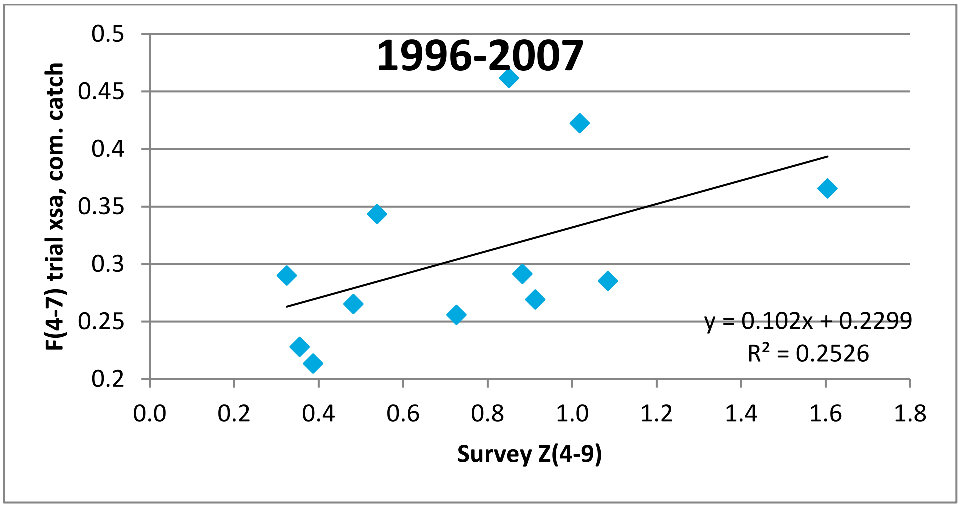


Figure 2.14. Survey SSB calculated by maturity observed in the surveys .





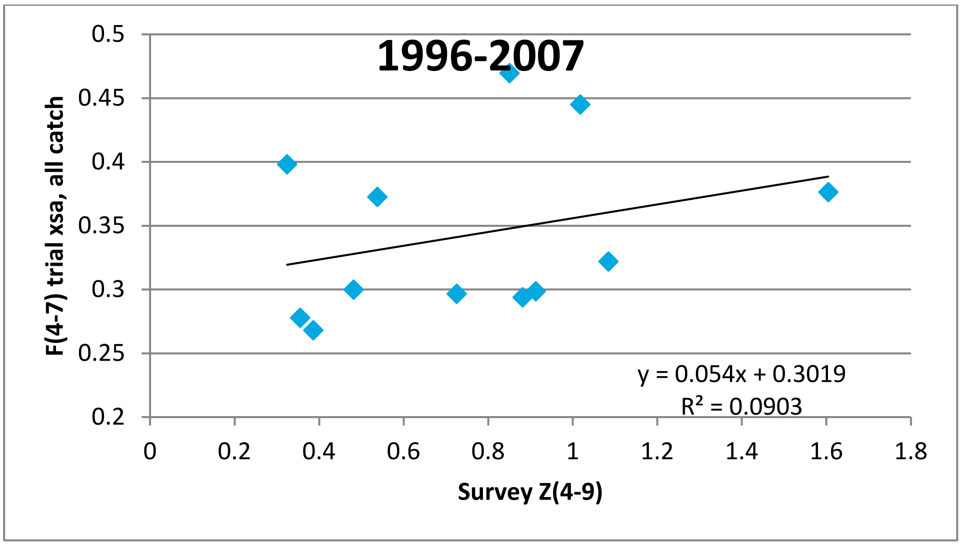


Figure 2.15. Survey mortality Z (upper) and relation to VPA values of $F_{(4\text{–}7)}$ over the period 1996–2007 for a trial XSA based on commercial catch (middle) and a trial XSA based on all catch (bottom).

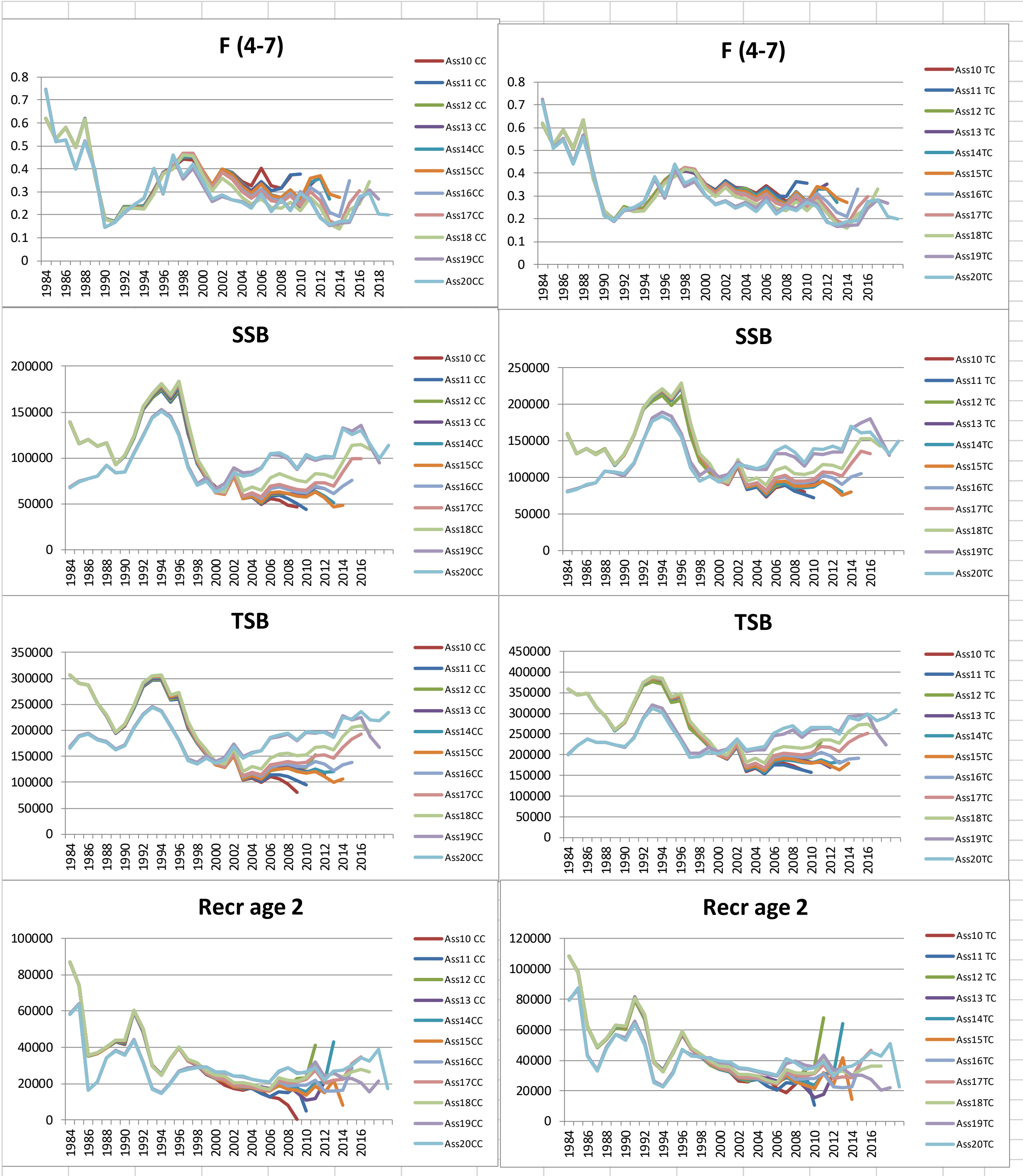


Figure 2.16. Comparisons of SVPA outputs in current assessment (Ass20) with the assessments in the years 2010-2019, for analyses based on commercial catch (left) and total catch (right). In all assessments the recruit estimate for the final year is highly uncertain.

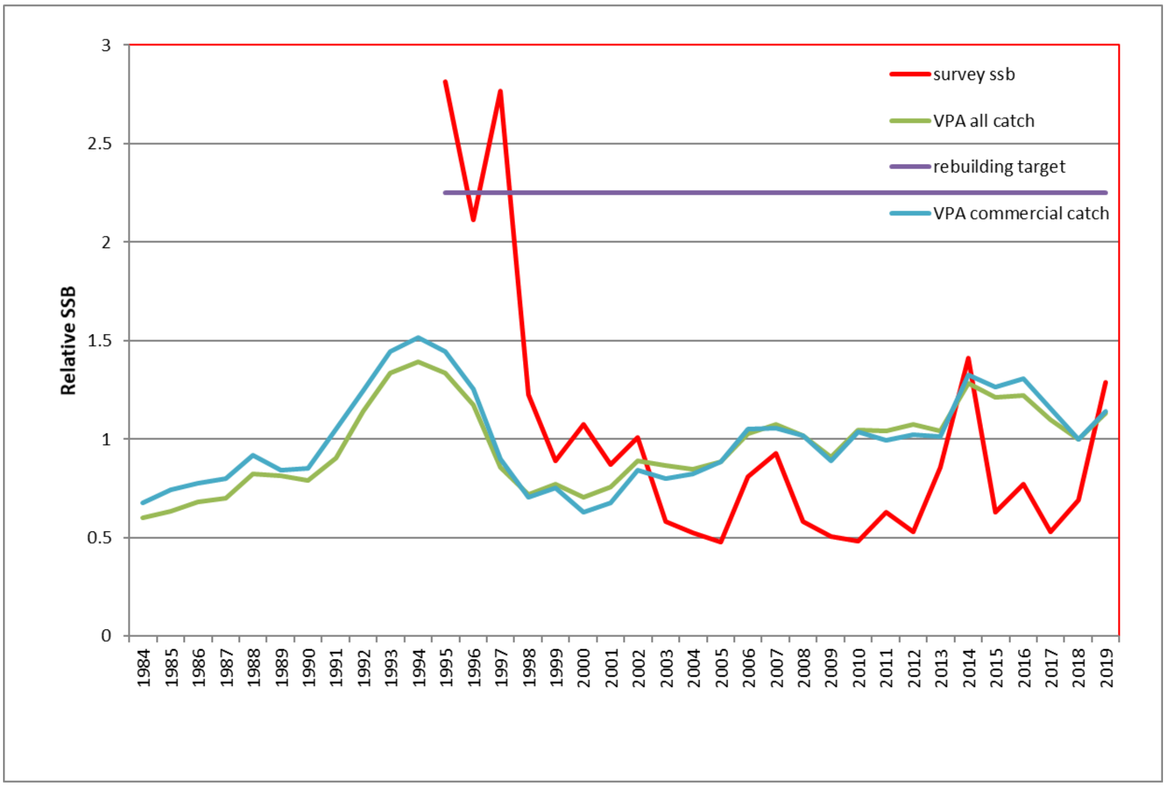
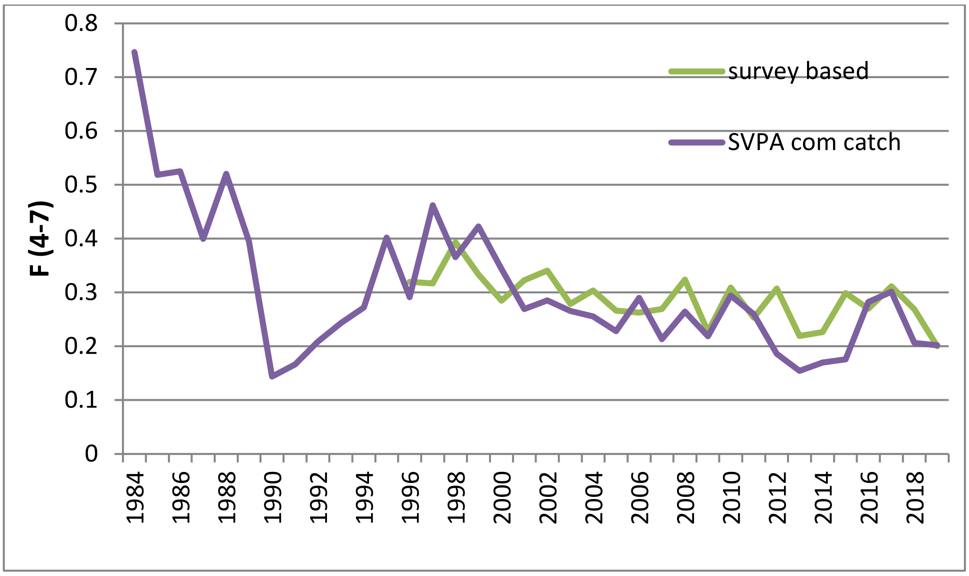


Figure 2.17. Coastal cod. Trends in spawning biomass. Each series are shown relative to its 1995–2017 average. The red line is survey SSB calculated with the same maturity ogive as in the VPA.



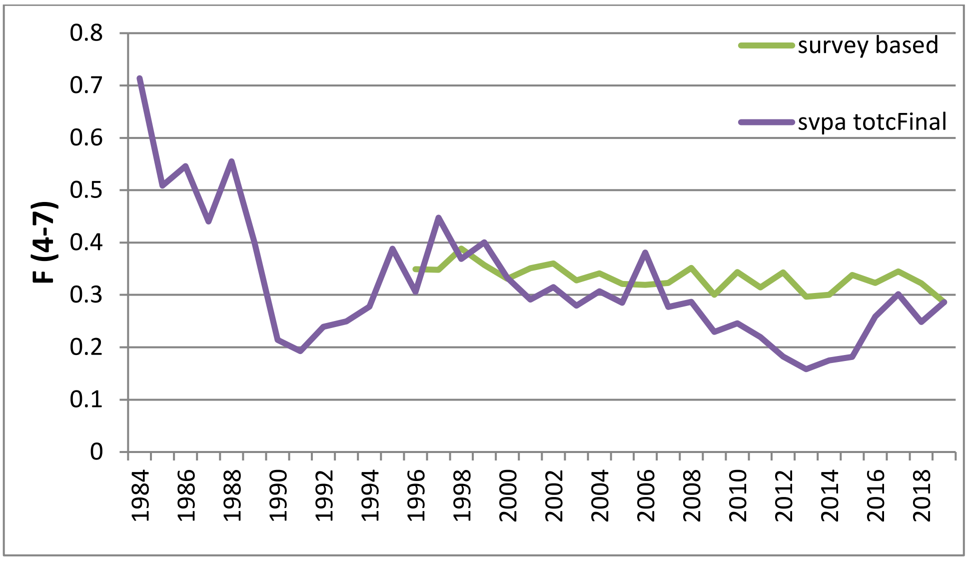


Figure 2.18. Time-series of F-estimates corresponding to commercial catch-at-age (upper) and total catch-at-age (lower). SVPA is in both cases a traditional VPA using the 2019 estimate of survey F as terminal F.

3 Northeast Artic cod in 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 since 2011 and have decreased from a peak of 986 449 tonnes in 2014 to 692 609 tonnes in 2019. The fishery is conducted both with an international trawler fleet and with coastal vessels using traditional fishing gears. Quotas were introduced in 1978 for the trawler fleets and in 1989 for the coastal fleets. In addition to quotas, the fishery is regulated by a minimum catch size, a minimum mesh size in trawls and Danish seines, a maximum bycatch of undersized fish, closure of areas having high densities of juveniles and by seasonal and area restrictions.

3.1.2 Reported catches prior to 2020 (Tables 3.1-3.4, Figure 3.1)

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

The provisional catch for 2019 reported to the working group is 692 609 t.

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

The historical practice (considering catches between 62°N and 67°N for the whole year and catches between 67°N and 69°N for the second half of the year to be Norwegian coastal cod) has been used for estimating the Norwegian landings of Northeast Arctic cod up to and including 2011 (Table 3.2). The catches of coastal cod calculated this way for the period 1960—2019 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 2012–2019 the Norwegian catches have been analysed by an ECA-version designed for simultaneously providing estimates of catch numbers-at-age for each of the two stocks. By this procedure the amount of Norwegian catches calculated to be coastal cod in 2012, 2013, 2014, 2015, 2016, 2017, 2018 and 2019 is 35.2, 25.7, 33.6, 35.8, 54.9, 51.0, 36.3 and 40.1 thousand tonnes. Table 3.2 includes ECA estimates of coastal cod for the whole period 1984—2019. 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 2019 was similar to 2018. The nominal landings by country are given in Table 3.4.

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

In summer/autumn 2018, a Norwegian vessel caught 450 t of cod in the Jan Mayen EEZ, which is a part of ICES area 2a, mostly by long-line. Cod is known to occasionally occur in this area, but rarely in densities which are suitable for commercial fisheries. The cod caught in this area in 2018 was large (65–110 cm), and otolith readings and genetics both showed this cod to be a mix of Northeast Arctic and Icelandic cod. Norway did in 2019 carry out an experimental fishery during four different periods in order to investigate further the occurrence of cod in this area in space and time as well as stock identity. The size distribution and genetic composition of the cod caught in this area in 2019 was similar to that in 2018. Most of the cod caught in April-May 2019 was spawning or spent. Cod spawning in this area has not been observed previously. Total catches in 2019 amounted to 638 t. An experimental fishery will also be carried out in this area in 2020 in a similar way as in 2019, the quota set aside for this fishery in 2020 is 800 t. The 2018 catches in this area were counted against the Norwegian TAC for cod north of 62°N, while the 2019 and 2020 TAC for this area comes in addition to the Norwegian TAC for cod as agreed by JNRFC. These catches have not been included in the assessment.

3.1.3 Unreported catches of Northeast Arctic cod (Table 3.1)

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

There are no reliable data on 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 2019 and 2020

The Joint Norwegian-Russian Fisheries Commission (JNRFC) agreed on a cod TAC of 725 000 t for 2019, and in addition 21 000 t Norwegian coastal cod. The total reported catch of 732 716 t in 2019 was 13 284 t below the agreed TAC. Since 2015 JNRFC has decided that Norway and Russia can transfer to next year or borrow from last year 10% of the cod country’s quota. That may lead to some deviation between agreed TAC and reported catch. Ignoring quota transfers, Norwegian catches in 2019 were about 6 000 t below the TAC, while third country catches were about 7 000 t below the TAC and Russian catches were very close to the TAC.

The advice for 2020 given by ACOM in 2019 was 689 672 t based on the agreed harvest control rule. The quota established by JNRFC for 2020 was equal to 738 000 tonnes. Thus, the TAC was not set according to the agreed HCR. In addition, the TAC for Norwegian Coastal Cod was set to the same value for 2020 as for 2019: 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 2011–2019 are not necessarily compatible with data for 2007 and previous years. CPUE has been relatively stable since 2016. More details on Norwegian CPUE are given in WD 2.

3.2.2 Survey results - abundance and size at age (Tables 3.5, A2-A14, Figure 3.7)

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 2020 are given in Tables A2 and A3. More details on this survey are given in WD 10. The total area covered was smaller than in 2019 as the coverage was limited by ice particularly in the area east and north of Bear Island and by time and weather constraints in parts of the Russian zone.

Before 2000 this survey was made without participation from Russian vessels, while in 2001—2005, 2008—2016 and 2018-2020 Russian vessels have covered important parts of the Russian zone. In 2006—2007 the survey was carried out only by Norwegian vessels. In 2007 and 2016 the Norwegian vessels were not allowed to cover the Russian EEZ. The method for adjustment for incomplete area coverage in 2007 is described in the 2007 report. Table 3.5 shows areas covered in the time-series and the additional areas implied in the method used to adjust for missing coverage in the Russian Economic Zone. In 5 of the 6 adjusted years (including 2017) the adjustments were not based on area ratios, but the “index ratio by age” was used. This means that the index by age for the covered area was scaled by the observed ratio between total index and the index for the same area observed in the years prior to the survey. The adjustments for 2017 were based on average index rations by age for 2014–2016. Adjustments were also made in 2020 using the average index ratios by age for 2018-2019.

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

The new method for calculating bottom trawl indices is described in Mehl *et al*. (2017b) and revised acoustic indices are given in Mehl *et al*. (2018a).

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 2014–2020 surveys covered considerably larger areas than earlier winter surveys, and showed that most age groups of cod (particularly ages 1 and 2) were distributed far outside the standard survey area. The survey estimates within the standard area were used for the tuning data. If a wider coverage is continued in coming years, improved data for tuning and recruitment predictions might be obtained. Fig. 3.7 shows the proportion by age of the swept area index which was found in the new northern area (see also Section 0.4). In 2020 coverage of the northern area was only possible west of Spitsbergen, due to ice.

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 2020 survey results in biomass terms was 556 thousand tonnes, this is 16% below the 2019 level. The survey was carried out from south to north, i.e. in the opposite direction to all previous years. This was due to covid-19 restrictions on where personnel could be exchanged.

This change of direction for the coverage was not considered to have any noticeable effect on the results.

Russian autumn survey Acronym: RU-BTr-Q4

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

This survey was not conducted in 2016, but was carried out in 2017, when 79% of the standard survey area was covered (Sokolov *et al* 2018, WD 11). The index shows a reliable internal consistence and it was decided to use it in the assessment. This survey was not carried out in 2018-2019 and will likely be discontinued.

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

Swept area bottom trawl estimates from the joint Norwegian-Russian ecosystem survey in August-September for the period 2004–2019 are given in Table A14. This survey normally covers the entire distribution area of cod at that time of the year.

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

The survey indices have been revised using the StoX calculation method (WD 01), but the tuning series have not been updated as this was considered a benchmark issue.

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 2020 showed a noticeable decrease in size at age values for most ages (Table A6). For ages 2-6 and 8 the observed values were the lowest observed in the revised time series going back to 1994. For ages 2,3 and 8 the values were also below the minimum in the period prior to 1994. Most of the decrease is due to slower growth in length, changes in condition factor were minor. In the BESS 2019 survey decrease in size at age is not expressed as distinctly but low lengths and weights were observed for ages 2 and 3. Length and weight at age in the

Lofoten survey is stable. The decrease in size at age for younger age groups is discussed in an ecological context in section 1.2.

3.2.3 Age reading

The joint Norwegian-Russian work on cod otolith reading has continued, with regular exchanges of otoliths and age readers (see chapter 0.5). The results of fifteen years of annual comparative age readings are described in Yaragina *et al*. (2009). Zuykova *et al*. (2009) re-read old otoliths and found no significant difference in contemporary and historical age determination and subsequent length at age. However, age at first maturation in the historical material as determined by contemporary readers is younger than that determined by historical readers. Taking this difference into account would thus have effect on the spawning stock-recruitment relationship and thus on the biological reference points. The overall percentage agreement for the 2017–2018 exchange was 87.7%(WD 8). The main reason for cod ageing discrepancies between Russian and Norwegian specialists remains the same, representing the latest summer growth zone, and different interpretations of the false zones. The general trend is that the Russian readers assign slightly lower ages than the Norwegian readers compared to the modal age for all age groups. This is opposite of what we have seen in previous readings, where the Russian readers has tended to be slightly overestimating the age compared to the Norwegian readers. More details can be found in section 0.7.

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

3.3 Data used in the assessment

3.3.1 Catch-at-age (Table 3.6)

For 2019, age compositions from all areas were available from Russia, Norway, Spain (all areas) and Germany and Poland (Division 2a only). Unsampled catches were distributed on age by using data from Russian trawl in Subarea 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).

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

Length distributions from the Russian fishery were made by observers on board fishing vessels in reasonably sufficient quantity in all areas. Also, length samples of cod taken by Norwegian Coast Guard on board Russian fishing vessels in Norwegian economic zone (NEZ) in the second quarter and in Division 2.b in the fourth quarter of 2019 were used in calculations of length/age distributions. These data were combined with Russian observers' data. An advantage of adding the Norwegian Coast Guard data is that they were taken regularly over the whole NEZ area and Division 2.b. However, biological sampling from the trawl fishery has been relatively low, especially in Division 2a.

It should be noted that for ages 15+, the catch at age in 2019 is the highest since the early 1950s (Table 3.6).

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

Catch weights

For 2019, the mean weight-at-age in the catch (Table 3.8) was obtained from InterCatch as a weighted average of the weight-at-age in the catch for Norway, Russia, Spain, Poland and Germany (Table 3.7). The weight-at-age in the catch for all countries is given in Table 3.9. From 2000 to 2016, AFWG working group applied 13 as plus group. The weight-at-age 13, 14 and 15 in the catch for 1946–1982, needed due to extended age range, was as last year taken from AFWG 2001 (ICES CM 2001/ACFM:19). For the 2020 assessment, it was decided to use the same, as in the last year, procedure for weight-at-age calculations for the recent period (1983-onwards): Observations were used for ages up to 11. However, because of very noisy values observed for older fish, weight-at-age 12–15 was set to constant values in this period. Weight-at-age 12 was equal to the mean for 1983–2015; the mean increment for ages 12–13, 13–14 and 14–15+ groups in the 1983–2015 period were used to calculate weight-at-age 13, 14, and 15.

Stock weights

For ages 1—11 stock weights-at-age at the start of year y ($W_{a,y}$) for 1983—2019 (Table 3.9) were calculated as follows:

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

where

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

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

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

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

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

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

This year, the same procedure was used for weight-at-age in stock calculations for retro period (1946—1982) assuming that weight-at-age in stock was equal to weight-at-age in catch. Weight-at-age 12—15 was fixed for recent period (1983-onwards). Average values of Fleet 15 (BS-NoRu-Q1 (BTr)) data available at the moment for older age groups (12—15) were used for calculations of average weight-at-age in stock in this period. The weight at age from the winter survey for 2019 used in the calculations has been revised.

Russian data for weight and maturity-at-age in autumn 2018 were not available as the survey was not conducted. In WD 15 to AFWG 2019, correction factors to allow for this when calculating the weight and maturity-at-age in 2019 were updated, based on historical differences between Norwegian and Russian data in the same way as in the 2017 (Yaragina and Bogstad, 2017, WD 10). These correction factors were then applied to the Norwegian data for 2019 and 2020.

At the moment, the weight-at-age data from the BESS survey are not used in assessment and prediction but during the next benchmark the possibility of including them should be investigated.

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—2019.

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

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

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

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

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

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—2020, Norwegian maturity-at-age ogives have been obtained by combining the Barents Sea winter survey and the Lofoten survey. Russian maturity ogives from the autumn survey as well as from commercial fishery for November-February are available from 1984 until present. The Norwegian maturity ogives tend to give a higher percent mature-at-age compared to the Russian ogives, which is consistent with the generally higher growth rates observed in cod sampled by the Norwegian surveys. The approach used is consistent with the approach used to estimate the weight-at-age in the stock (described in Section 3.3.2). The percent mature-at-age for the Russian and Norwegian surveys have been arithmetically averaged for all years, except 1982—1983 when only Norwegian observations were used and 1984 when only Russian observations were used.

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

Maturity-at-age for cod has been variable the last five years, particularly for ages 6–9. According to the combined data, maturation at age decreased in 2015–2016, then increased, but decreased again from 2019 to 2020.

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

3.4 Changes of assessment model and data at the latest benchmark

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

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

3.5 Assessment using SAM (Tables 3.13, A13)

The following survey data series were used:

Fleet code	Name	Place	Season	Age	Years
Fleet 15	Joint bottom trawl survey	Barents Sea	Feb-Mar	4–12	1981–2020
Fleet 16	Joint acoustic survey	Barents Sea+Lofoten	Feb-Mar	4–12	1985–2020
Fleet 18	Russian bottom trawl surv.	Total area	Oct-Dec	3–12	1982–2017
Fleet 007	Ecosystem surv.	Total area	Aug-Sep	3–12	2004–2019

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

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

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

3.5.1 Model adjustment and settings (Table 3.14, Figures 3.2a-3.2c)

At AFWG 2019 an assessment was carried out using a different variance structure compared to that decided at the 2017 IBP, giving improved model diagnostics. This approach was rejected by ACOM, and the advice given in 2019 was based on the settings decided upon at the 2017 IBP. With a benchmark coming up in 2021, it was decided not to investigate alternative settings in this year's assessment.

Residuals for the 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. Current SAM settings are shown in Table 3.14.

3.5.2 Results (Tables 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 2019 is 0.34, which is below F_{pa} (Table 3.18). Fishing mortality has been stable in recent years. The spawning stock biomass in 2020 is estimated to be 1,368 kt (Table 3.20), which is high but lower than the peak in 2013 (2,639 kt). One should bear in mind that in the early part of the time-series the fraction at age of mature fish was considerably lower. It is noted that the highest fishing mortality at age (age 11) in 2019 is about 7 times higher than the 14+ fishing mortality, i. e. a very strong dome-shaped exploitation pattern.

Total stock biomass in 2020 is estimated to 2,652 kt which is somewhat above the long-term mean and well below the highest level observed (4,360 kt in 2013).

3.6.2 Recruitment (Table 1.7a)

At the 2008 AFWG meeting it was decided to use a hybrid model, which is a weighted arithmetic mean of different recruitment models (Section 1.4). It was agreed to use the same approach this year. The input data for those models are the following time-series; ice coverage, intensity of interaction between the arctic and boreal oceanic systems on the shelf of the Barents Sea, temperature and oxygen saturation at the Kola section. Prognosis from all the models, including the hybrid is presented in Table 1.9a. Since 2014 the hybrid model is based on objective weighting of different sub-models and includes the RCT3 model (see section 1.4 for details). The numbers-at-age 3 calculated by the hybrid method were: 583 million for the 2017 year class, 635 million for the 2018 year class, 512 million for the 2019 year class and 608 million for the 2020 year class.

3.7 Reference points and harvest control rules

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

At the 46th session of JRNFC a new version of the management rule was adopted (see section 3.7.3). The TAC advice for 2021 is based on the agreed harvest control rule.

3.7.1 Biomass reference points

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

3.7.2 Fishing mortality reference points

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

3.7.3 Harvest control rule

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

The current rule reads as follows:

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

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

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

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

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

3.8 Prediction

3.8.1 Prediction input (Tables 3.16, 3.19, A1, Figures 3.3-3.6)

The input data to the short-term prediction with management option table (2020—2023) are given in Table 3.19. For 2020 stock weights and maturity were taken from surveys as described in Sections 3.3.2 and 3.3.4.

Catch weights in 2020 onwards and stock weights in 2021 and onwards for age 3–11 are predicted by the method described by Brander (2002), where the latest observation of weights by cohort are used together with average annual increments to predict the weight of the cohort the following year. The method is given by the equation

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

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

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

The predictions for weight at age in stock indicate that the weights for the younger (mainly immature) age groups will stay approximately at the low level observed in 2020. Growth predictions in an ecological context is discussed in Section 1.2. It was noted that the present method for predicting stock and catch weight at age gave a ratio between catch and stock weights for ages 3-7 in the prediction years which was at or above the maximum ratio observed, and this could be considered as inconsistent. Thus, an alternative set of weights at age in catch was calculated, assuming the catch weight/stock weight at age ratio for all ages not to be higher than the 2010-2019 average. The results of such predictions are given in Section 3.11.1.

The maturity ogive for the years 2021—2023 was predicted by using the 2018-2020 average. The exploitation pattern in 2020 and later years was set equal to the previous 5 years according to the benchmark decision and described at Stock Annex (WKARCT 2015). It was observed that last AFWG the 3 -years average used by mistake. It should not have any noticeable effect because the fishing pattern is very stable in most recent years.

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

The stock number-at-age in 2020 was taken from the "final" SAM run (Table 3.16) for ages 4 and older. The recruitment at age 3 in the years 2020—2023 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—2019. 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 2020—2023 (based on benchmark decision, WKARCT 2015).

The assessment shows a stable F from 2015 to 2019. The fishing effort also increased, and CPUE decreased, but stabilised in 2016-2019 at a lower level than in previous years (Figure 3.6a,b, Table A1). In accordance with the benchmark decision (WKARCT 2015) and with support from AFWG-2019 WD 11 (Kovalev and Chetyrkin. 2019), the last year's assessment F in terminal year 2019 (*status quo*) is used for F in the intermediate year (2020). Table 3.19 shows input data to the predictions. The results of prediction show that the catch in 2020 predicted using F_{sq} is 9 % less than the agreed TAC. As the coastal cod catch in recent years has been almost 20 kt higher than the TAC, this means that the if the total Tac for Northeast arctic cod and Coastal cod will be taken, the difference between predicted catch using F_{sq} and the TAC will be less than 9%.

3.8.2 Prediction results (Tables 3.20-3.21)

The catches corresponding to F_{sq} in 2020 is 674.2 kt (Table 3.20). The resulting SSB in 2021 is 1,373 kt, which is close to SSB in 2020. Table 3.20 shows the short-term consequences over a range of F-values in 2021. The detailed outputs corresponding to F_{sq} in 2020 and the F corresponding to the HCR and F_{pa} in 2021 is given in Table 3.21. Summarised results are shown in the text table below.

Since SSB in 2021 is between 2 × Bpa = 920 000 t and 3 × B_{pa} = 1 380 000 t, F = 0.597 is used in the 3-year prediction, giving catches of 1 059 716, 866 192 and 745 559 tonnes in 2021, 2022, and 2023, respectively. The average of this is 890 489 tonnes. According to HCR the maximum increase in TAC is limited by 20 % which corresponds to 885 600 tonnes.

Basis	Total catch (2021)	Ftotal (2021)	SSB(2022)	% SSB change **	% TAC change ***	% Advice change ****
ICES advice basis						
Management plan*	885 600	0.47	1 171 141	-15	20	28
Other options						
MSY approach: FMSY	774 860	0.40	1 257 564	-8	5	12
F = 0	0	0	1 898 191	38	-100	-100
F = F2019	673 954	0.3381	1 337 566	-3	-9	-2
Fpa	774 860	0.40	1 257 564	-8	5	12
Flim	1 236 791	0.74	907 720	-34	68	79

Weights in tonnes.

*** 20 % increase from TAC 2020**

**** SSB 2022 relative to SSB 2021.**

***** Catch 2021 relative to TAC 2020**

****** Advice for 2021 relative to advice for 2020**

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 and prediction

3.9.1 Comparison to assessment (Figure 3.2b)

As it was said at sec. 3.5.1 at AFWG 2019 two alternative SAM assessments were carried out. One called "SPALY run" with standard SAM settings were used by ACOM as a basis for advice. The text tables below compare this year's estimates with last year's estimates (from SPALY run) for the year 2019 of numbers at age (millions), total biomass, spawning biomass (thousand tonnes), as well as reference F for the year 2018.

					N2019												
Assessment Year	F(2018)	age 3	age 4	age 5	age 6	age 7	age 8	age 9	age 10	age 11	age 12	age 13	age 14	age 15+	TSB 2019	SSB 2019	F 2019
2019	0.42	660*	293.3	346.7	123.58	78.84	95.026	44.249	22.628	9.836	4.259	6.093	7.348	7.504	2613	1496	0.421**
2020	0.37	675	384.4	420.3	160.19	102.9	119.28	54.211	24.015	10.536	4.795	5.329	6.827	6.315	2925	1678	0.338
Ratio 2020/2019	0.89	1.02	1.31	1.21	1.30	1.31	1.26	1.23	1.06	1.07	1.13	0.87	0.93	0.84	1.12	1.12	0.80

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

The number-at-ages 4-9 in 2019 from this year's assessment is considerably (21-31%) above last year's assessment, while the difference is less for other age groups. For ages 13 and older the number at age is lower than in last year's assessment.

The retrospective pattern became worse than observed previously (Figure 3.2b). Adding the last year of data increased SSB and R and decreased F in the recent years. R was underestimated during most recent years (Mohn's rho 30%), while rho's for SSB and TSB are much smaller (3-4%).

3.9.2 Comparison to prediction

The changes in the advice are large compared to last year. The advice for 2021 is 885 600 t, while the advice for 2020 given by ICES was 689 672 tonnes and the value according to the AFWG assessment last year was 766 732 tonnes.

There has been an upwards revision of the assessed stock in 2020 in comparison with the assessment in 2019. The abundance of age groups 5-10 in particular was revised upwards, and these make up most of the catches in the prediction. The difference from last year's assessment is higher in numbers than biomass, because the weight at age of younger age groups in 2020 is lower than predicted last year. Due to the use of a two-step hockey stick HCR, the upwards revision in biomass results in an increase in the target F to 0.597 (almost at the second plateau value of 0.6) in comparison with last year's 0.533. The average catch predicted for the coming 3 years, using the mentioned target level of exploitation (Ftr) resulted in TAC advice equal to 885 600 t. The latter corresponds to the + 20 % limit stated in the HCR, and is slightly lower than the value without such a constraint (891 536 t).

3.10 Concerns with the assessment

SAM settings

When exploring SAM settings last year, the results for abundance and selection pattern for the oldest age groups, for which no tuning data were available, was discussed at length. The alternative settings used at AFWG-2019 improved model diagnostics and increased the 13+ biomass in 2019 by 200 kt compared to the current (IBP 2017) settings. This difference was 2/3 of the total difference in 2019 biomass between the assessments. The total biomass and reference fishing mortality in this year's assessment is closer to the biomass from the run with alternative settings last year than to the run made last year with the current settings. The difference between the runs made last year were mainly in abundance of age 4 and ages 11+. However, the current assessment gives a slight *downward* revision of the abundance of age 13+ compared to the assessment with the same settings last year. The abundance of age 12+ for the two surveys (BESS and acoustic winter+Lofoten) where age 12 is used in the assessment shows a stronger downwards trend from 2017 onwards than the assessment shows.

Several additional features are now included in the SAM model (software), as described e.g. in the 2020 WKDEM report for NEA haddock. One feature of particular interest for the issue mentioned above is the possibility of using a plus group in the tuning data which is not the same as the plus group in the assessment (i.e. the age 12 tuning series for this stock can be replaced by age 12+). It is hoped that this and other additional new SAM features, investigations of all SAM settings, together with revision of the input data, will improve the retrospective pattern for cod during the upcoming benchmark, as was the case for haddock benchmark at WKDEM this year.

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

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

3.11 Additional predictions and 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. We also give here additional prediction from the SAM model assuming lower weight at age in the catch.

3.11.1 Changing weight at age in catch in SAM predictions

As described in section 3.8.1 alternative predictions with lower weight at age in the catch in 2020-2023 were run. The weights used are given in the text table below.

Year/age	3	4	5	6	7	8	9	10	11	12	13	14	15+
2020	0.375	0.951	1.468	2.011	2.904	4.453	5.809	7.232	8.387	11.420	12.800	14.180	15.550
2021	0.584	0.843	1.409	2.022	2.830	4.128	5.697	7.106	8.523	11.420	12.800	14.180	15.550
2022	0.609	0.977	1.329	1.973	2.840	4.057	5.388	6.922	8.408	11.420	12.800	14.180	15.550
2023	0.609	0.977	1.329	1.973	2.840	4.057	5.388	6.922	8.408	11.420	12.800	14.180	15.550

Using these values for weight at age in catch decreased the advised catch for 2021 according to the HCR from 885.6 to 801 kt if assuming status quo F in 2020. Status quo F in 2020 for this prediction corresponds to a catch of 631 kt in 2020.

3.11.2 XSA

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

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

This year the TISVPA model was applied to NEA cod with the same settings as last year and using the same data as SAM except that natural mortality values from cannibalism were taken from the SAM runs. During AFWG 2019 the results of exploratory runs using the TISVPA model were discussed (WD 12). The residuals of the model approximation of catch-at-age and “fleets” data are presented in Figure 3.8a. Likelihood profiles for different data source are presented in Figure 3.8b. Retrospective run results are shown in Figure 3.8c. The results (Tables 3.22-3.24) generally support the results of SAM model giving an estimate of SSB in 2020 of about 1.36 million tonnes.

3.11.4 Model comparisons (Figures 3.2a, 3.8a, 3.9a)

Figure 3.9a compares the results of SAM, XSA and TISVPA, showing F, SSB, TSB and recruitment. F and TSB is very similar for all models but deviate from each other for the most recent years. XSA tends to estimate TSB slightly higher in 2019 while TSB and SSB is very similar to SAM and TISVPA in most recent years. Recruitment in recent years is higher in XSA than in the other models. TISVPA and SAM demonstrate rather similar patterns in catch residuals (Figure 3.2a, 3.8a) while in previous assessments they were opposite.

3.11.5 SAM with settings chosen by AFWG-2019 (Figure 3.9b)

This approach that gave better diagnostics at AFWG 2019 (ICES, 2019) was rejected by ACOM on the basis of ADG stating that it was mostly an ad hoc solution and that it would not necessarily work in the future when the cohorts move on. At the AFWG 2020, it was observed that this approach gave predictions of total biomass and SSB in 2020 closer to the current assessment (Figure 3.9b) and SAM settings need to be explored deeper in the next benchmark.

An alternative assessment using this year data for this version of the model estimates F5-10 in 2019 as equal to 0.34; the spawning stock biomass in 2020 is estimated as 1,565 kt and total stock biomass in 2020 is estimated as 2,855 kt.

3.12 New and revised data sources

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

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

Consistency between the catch data used for NEA cod and coastal cod should also be ensured. The catch figures used in the coastal cod assessment are not equal to the difference between the total cod catch and the catch used in the NEA cod assessment (Table 3.2). These discrepancies will be adjusted when the ECA-results for the period 1984—2019 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, new data on age groups were not available in time for AFWG 2019. Revised bycatch estimates in numbers for the period 2005-2019 are described in Section 0.6. At WKARCT in 2015 it was, however, decided not to include those data in the catch-at-age matrix.

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

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

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

Year	Subarea 1	Division 2.a	Division 2.b	Unreported catches	Total catch
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
2004	177 888	219 261	92 296	117 000	606 445
2005	159 573	194 644	121 059	166 000	641 276
2006	159 851	204 603	104 743	67 100	537 642
2007	152 522	195 383	97 891	41 087	486 883
2008	144 905	203 244	101 022	15 000	464 171
2009	161 602	207 205	154 623		523 431
2010	183 988	271 337	154 657		609 983
2011	198 333	328 598	192 898		719 829
2012	247 938	331087	148 638		727 663
2013	360 673	421678	183 858		966 209
2014	320 347	468 934	197 168		986 449
2015	272 405	375 328	216 651		864 384
2016	321 347	351 468	176 607		849 422
2017	309 902	360 477	197 898		868 276
2018	249 397	321 548	207 681		778 627

Year	Subarea 1	Division 2.a	Division 2.b	Unreported catches	Total catch
2019[1]	234 985	318 539	139 084		692 609

Data provided by Working Group members

[1]Provisional figure

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

Year	Coastal cod catch used in NCC-assess	Coastal cod catch from ECA-model	Norwegian catches of cod in areas 06+07 whole yr plus q3&4 in areas 00+05	Norwegian catches of cod removed from the NEAC-assessment
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

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
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	35.5
2013	22.5	30.1	16.8	30.1
2014	23.2	33.6	15.5	33.6
2015	39.4	35.8	13.2	35.8
2016	44.6	54.9	10.0	54.9
2017	52.9	51.0	7.6	51.0
2018	-	36.3	7.3	36.3
2019	-	40.1	6.4	40.1

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

	Subarea 1		Division 2.a		Division 2.b	
Year	Trawl	Others	Trawl	Others	Trawl	Others
1967	238	84.8	38.7	90	121.1	-
1968	588.1	54.4	44.2	118.3	269.2	-
1969	633.5	45.9	119.7	135.9	262.3	-
1970	524.5	79.4	90.5	153.3	85.6	-
1971	253.1	59.4	74.5	245.1	56.9	-
1972	158.1	38.9	49.9	285.4	33	-
1973	459	33.7	39.4	172.4	88.2	-

	Subarea 1		Division 2.a		Division 2.b	
Year	Trawl	Others	Trawl	Others	Trawl	Others
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

	Subarea 1		Division 2.a		Division 2.b	
Year	Trawl	Others	Trawl	Others	Trawl	Others
2002	147.4	37.4	83.4	105.6	69.9	1.3
2003	146	17.1	107.8	114.2	50.1	1.8
2004	154.4	23.5	100.3	118.9	88.8	3.5
2005	132.4	27.2	87	107.7	115.4	5.6
2006	141.8	18.1	91.2	113.4	100.1	4.6
2007	129.6	22.9	84.8	110.6	91.6	6.3
2008	123.8	21.1	94.8	108.4	95.3	5.7
2009	130.1	31.5	102	105.2	142.1	11.4
2010	151.1	32.9	130	141.4	149.2	5.4
2011	158.1	38.4	163.5	167	181	11.9
2012	212.1	35.9	172.7	158.4	133.8	14.9
2013	308.5	52.2	216.9	204.7	159.7	24.1
2014	268.8	51.5	246.8	222.1	177.9	19.3
2015	224.3	48.1	192.2	183.2	197.7	19.0
2016	285.5	35.8	181.7	169.8	156.3	20.3
2017	265.4	44.5	189.5	171.0	180.0	17.9
2018	204.7	44.7	156.7	164.9	192.0	15.6
2019 [1]	199.4	35.6	177.8	140.7	128.9	10.1

Data provided by Working Group members

[1] **Provisional figures**

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

Year	Faroe Islands	France	German Dem.Rep.	Fed.Rep. Germany	Norway	Poland	United Kingdom	Russia[2]		Others	Total all countries
1961	3 934	13 755	3 921	8 129	268 377	-	158 113	325 780		1 212	783 221
1962	3 109	20 482	1 532	6 503	225 615	-	175 020	476 760		245	909 266
1963	-	18 318	129	4 223	205 056	108	129 779	417 964		-	775 577
1964	-	8 634	297	3 202	149 878	-	94 549	180 550		585	437 695
1965	-	526	91	3 670	197 085	-	89 962	152 780		816	444 930
1966	-	2 967	228	4 284	203 792	-	103 012	169 300		121	483 704
1967	-	664	45	3 632	218 910	-	87 008	262 340		6	572 605
1968	-	-	225	1 073	255 611	-	140 387	676 758		-	1 074 084
1969	29 374	-	5 907	5 543	305 241	7 856	231 066	612 215		133	1 197 226
1970	26 265	44 245	12 413	9 451	377 606	5 153	181 481	276 632		-	933 246
1971	5 877	34 772	4 998	9 726	407 044	1 512	80 102	144 802		215	689 048
1972	1 393	8 915	1 300	3 405	394 181	892	58 382	96 653		166	565 287
1973	1 916	17 028	4 684	16 751	285 184	843	78 808	387 196		276	792 686
1974	5 717	46 028	4 860	78 507	287 276	9 898	90 894	540 801		38 453	1 102 434
1975	11 309	28 734	9 981	30 037	277 099	7 435	101 843	343 580		19 368	829 377
1976	11 511	20 941	8 946	24 369	344 502	6 986	89 061	343 057		18 090	867 463
1977	9 167	15 414	3 463	12 763	388 982	1 084	86 781	369 876		17 771	905 301
1978	9 092	9 394	3 029	5 434	363 088	566	35 449	267 138		5 525	698 715
1979	6 320	3 046	547	2 513	294 821	15	17 991	105 846		9 439	440 538
1980	9 981	1 705	233	1 921	232 242	3	10 366	115 194		8 789	380 434
						Spain					
1981	12 825	3 106	298	2 228	277 818	14 500	5 262	83 000		-	399 037
1982	11 998	761	302	1 717	287 525	14 515	6 601	40 311		-	363 730
1983	11 106	126	473	1 243	234 000	14 229	5 840	22 975		-	289 992
1984	10 674	11	686	1 010	230 743	8 608	3 663	22 256		-	277 651
1985	13 418	23	1 019	4 395	211 065	7 846	3 335	62 489		4 330	307 920
1986	18 667	591	1 543	10 092	232 096	5 497	7 581	150 541		3 505	430 113
1987	15 036	1	986	7 035	268 004	16 223	10 957	202 314		2 515	523 071
1988	15 329	2 551	605	2 803	223 412	10 905	8 107	169 365		1 862	434 939
1989	15 625	3 231	326	3 291	158 684	7 802	7 056	134 593		1 273	332 481
1990	9 584	592	169	1 437	88 737	7 950	3 412	74 609		510	187 000
1991	8 981	975	**Greenland**	2 613	126 226	3 677	3 981	119 427 [3]		3 278	269 158
1992	11 663	2	3 337	3 911	168 460	6 217	6 120	182 315	**Iceland**	1 209	383 234
1993	17 435	3 572	5 389	5 887	221 051	8 800	11 336	244 860	9 374	3 907	531 611
1994	22 826	1 962	6 882	8 283	318 395	14 929	15 579	291 925	36 737	28 568	746 086
1995	22 262	4 912	7 462	7 428	319 987	15 505	16 329	296 158	34 214	15 742	739 999
1996	17 758	5 352	6 529	8 326	319 158	15 871	16 061	305 317	23 005	14 851	732 228
1997	20 076	5 353	6 426	6 680	357 825	17 130	18 066	313 344	4 200	13 303	762 403
1998	14 290	1 197	6 388	3 841	284 647	14 212	14 294	244 115	1 423	8 217	592 624
1999	13 700	2 137	4 093	3 019	223 390	8 994	11 315	210 379	1 985	5 898	484 910
2000	13 350	2 621	5 787	3 513	192 860	8 695	9 165	166 202	7 562	5 115	414 870
2001	12 500	2 681	5 727	4 524	188 431	9 196	8 698	183 572	5 917	5 225	426 471
2002	15 693	2 934	6 419	4 517	202 559	8 414	8 977	184 072	5 975	5 484	445 045
2003	19 427	2 921	7 026	4 732	191 977	7 924	8 711	182 160	5 963	6 149	436 990
2004	19 226	3 621	8 196	6 187	212 117	11 285	14 004	201 525	7 201	6 082	489 445
2005	16 273	3 491	8 135	5 848	207 825	9 349	10 744	200 077	5 874	7 660	475 276
2006	16 327	4 376	8 164	3 837	201 987	9 219	10 594	203 782	5 972	6 271	470 527
2007	14 788	3 190	5951	4619	199 809	9 496	9298	186 229	7316	5 101	445 796
2008	15 812	3 149	5 617	4 955	196 598	9 658	8 287	190 225	7 535	7 336	449 171
2009	16 905	3 908	4 977	8 585	224 298	12 013	8 632	229 291	7 380	7 442	523 431
2010	15 977	4 499	6 584	8 442	264 701	12 657	9 091	267 547	11 299	9 185	609 983
2011	13 429	1 173	7 155	4 621	331 535	13 291	8 210	310 326	12 734	17 354 [4]	719 829
2012 [5]	17523	2841	8520	8 500	315 739	12814	11166	329 943	9536	11 081	727 663
2013	13833	7858	7885	8 010	438 734	15042	12536	432 314	14734	15 263	966 209
2014	33298	8149	10864	6 225	431 846	16378	14762	433 479	18205	13 243	986 449
2015	26568	7480	7055	6 427	377 983	19905	11778	381 188	16120	9 880	864 384
2016	24084	7946	8607	6 336	348 949	14640	13583	394 107	16031	15 139	849 422
2017	28637	9554	13638	5 977	357 419	14414	16731	396 180	11925	13 802	868 276
2018	26152	6605	12743	9 768	333 539	13143	11533	340 364	10708	14 071	778 627
2019 [1]	22270	6371	7553	8 470	282 120	13939	11214	316 813	12294	11 565	692 609

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

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

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

Year	Area covered	Additional area implied in adjustment	Adjustment method
2019	207.1		
2020	181.6	25.1	Index ratio by age

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

SAM. Sat Apr 18 11:47:15 2020

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

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

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTAL-NUM
1982	8948	20933	19345	28084	42496	8395	2878	708	271	260	27	5	5	132355
1983	3108	19594	20473	17656	17004	18329	2545	646	229	74	58	20	5	99741
1984	6942	14240	18807	20086	15145	8287	5988	783	232	153	49	12	8	90732
1985	24634	45769	27806	19418	11369	3747	1557	768	137	36	31	32	8	135312
1986	28968	70993	78672	25215	11711	4063	976	726	557	136	28	34	14	222093
1987	13648	137106	98210	61407	13707	3866	910	455	187	227	21	59	20	329823
1988	9828	22774	135347	54379	21015	3304	1236	519	106	69	43	14	5	248639
1989	5085	17313	32165	81756	27854	5501	827	290	41	13	1	11	16	170873
1990	1911	7551	12999	17827	30007	6810	828	179	59	15	6	5	2	78199
1991	4963	10933	16467	20342	19479	25193	3888	428	48	12	1	1	2	101757
1992	21835	36015	27494	23392	18351	13541	18321	2529	264	82	3	9	1	161837
1993	10094	46182	63578	33623	14866	9449	6571	12593	1749	377	63	22	1	199168
1994	6531	59444	102548	59766	32504	10019	6163	3671	7528	995	121	19	4	289313
1995	4879	42587	115329	98485	32036	7334	3014	1725	1174	1920	222	41	1	308747
1996	7655	28782	80711	100509	54590	10545	2023	930	462	230	809	84	1	287331
1997	12827	36491	69633	83017	65768	28392	4651	1151	373	213	144	238	1	302899
1998	31887	88874	48972	40493	34513	26354	6583	965	197	69	42	22	53	279024
1999	7501	77714	92816	31139	15778	15851	8828	1837	195	40	34	8	30	251771
2000	4701	33094	93044	47210	12671	6677	4787	1647	321	71	11	1	14	204249
2001	5044	35019	62139	62456	22794	5266	1773	1163	343	85	6	7	22	196117

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTAL-NUM
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
2017	6535	13128	28365	66504	46136	28507	15307	10073	12169	6465	1927	399	285	235800
2018	6120	28569	27128	33816	54328	28323	16208	9722	7132	3740	2295	840	271	218492
2019	4389	21405	48422	29849	26548	39759	17395	8883	4606	2109	715	564	322	204966

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

Norway														
Year			Age											
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	0.41	0.82	1.32	2.05	2.82	3.94	5.53	7.70	9.17	11.46	16.59	16.42	16.96	24.46
1984	1.16	1.47	1.97	2.53	3.13	3.82	4.81	5.95	7.19	7.86	8.46	7.99	9.78	10.64
1985	0.34	0.99	1.43	2.14	3.27	4.68	6.05	7.73	9.86	11.87	14.16	14.17	13.52	15.33
1986	0.30	0.67	1.34	2.04	3.14	4.60	5.78	6.70	7.52	9.74	10.68	12.86	9.59	16.31
1987	0.24	0.48	0.88	1.66	2.72	4.35	6.21	8.78	9.78	12.50	13.75	15.12	10.43	19.95
1988	0.36	0.56	0.83	1.31	2.34	3.84	6.50	8.76	9.97	11.06	14.43	19.02	12.89	10.16
1989	0.53	0.75	0.90	1.17	1.95	3.20	4.88	7.82	9.40	11.52	11.47		19.47	14.68
1990	0.40	0.81	1.22	1.59	2.14	3.29	4.99	7.83	10.54	14.21	17.63	7.97	14.64	
1991	0.63	1.37	1.77	2.31	3.01	3.68	4.63	6.06	8.98	12.89	17.00		14.17	16.63
1992	0.41	1.10	1.79	2.45	3.22	4.33	5.27	6.21	8.10	10.51	11.59		15.81	6.52
1993	0.30	0.83	1.70	2.41	3.35	4.27	5.45	6.28	7.10	7.82	10.10	16.03	19.51	17.68
1994	0.30	0.82	1.37	2.23	3.35	4.27	5.56	6.86	7.45	7.98	9.53	12.16	11.45	19.79
1995	0.44	0.78	1.26	1.87	2.80	4.12	5.15	5.96	7.90	8.67	9.20	11.53	17.77	21.11
1996	0.29	0.90	1.15	1.67	2.58	4.08	6.04	6.62	7.96	9.36	10.55	11.41	9.51	24.24
1997	0.35	0.78	1.14	1.56	2.25	3.48	5.35	7.38	7.55	8.30	11.15	8.64	12.80	
1998	0.38	0.68	1.03	1.64	2.23	3.24	4.85	6.88	9.18	9.84	15.78	14.37	13.77	15.58
1999	0.46	0.88	1.16	1.65	2.40	3.12	4.26	6.00	6.52	10.64	14.05	12.67	9.20	17.22
2000	0.31	0.65	1.23	1.80	2.54	3.58	4.49	5.71	7.54	7.86	12.71	14.71	15.40	20.26
2001	0.30	0.77	1.18	1.83	2.75	3.64	4.88	5.93	7.43	8.90	10.22	11.11	13.03	18.85
2002	0.31	0.90	1.40	1.90	2.60	3.55	4.60	5.80	7.40	9.56	8.71	12.92	8.42	17.61
2003	0.55	0.88	1.39	2.01	2.63	3.59	4.83	5.57	7.26	9.36	9.52	9.52	10.68	21.66
2004	0.54	1.08	1.41	1.95	2.69	3.46	4.77	6.72	7.90	8.66	12.21	14.02	16.50	11.37
2005	0.58	0.92	1.38	1.86	2.61	3.54	4.57	6.41	8.24	9.89	11.04	14.08	11.81	20.08
2006	0.51	0.97	1.45	2.06	2.71	3.56	4.57	5.53	6.61	7.53	8.55	8.44	9.82	12.31
2007	0.53	1.07	1.70	2.37	3.26	4.36	5.45	6.71	8.08	8.56	9.75	11.72	12.72	15.58
2008	0.65	1.12	1.70	2.44	3.32	4.41	5.61	6.84	8.25	9.31	10.54	12.45	13.59	21.15
2009	0.56	0.98	1.47	2.10	2.83	3.90	5.06	5.76	7.31	7.79	7.81	10.68	11.83	14.76

Norway													
Year			Age										
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2010	0.55	0.95	1.46	2.06	2.93	4.02	5.40	6.44	7.19	8.43	9.11	10.46	11.39	15.55
2011	0.53	1.09	1.50	2.06	2.85	3.70	5.01	6.26	7.33	8.34	9.87	13.23		
2012		0.83	1.32	1.92	2.65	3.52	4.71	6.34	8.11	9.92	11.31	13.45	15.75	
2013	0.43	0.95	1.40	2.00	2.64	3.44	4.51	5.67	7.29	8.80	10.33	11.38	12.56	
2014	0.59	1.07	1.55	2.15	2.80	3.70	4.57	5.78	6.97	8.35	9.46	10.99	12.28	15.49
2015	0.64	0.96	1.42	1.96	2.57	3.30	4.13	5.49	6.46	7.18	8.63	10.37	12.24	14.60
2016	0.59	0.96	1.46	1.99	2.71	3.57	4.56	5.78	6.82	8.08	9.33	10.01	11.68	14.79
2017	0.55	0.99	1.53	2.06	2.69	3.64	4.72	5.91	6.91	7.88	9.41	10.93	11.78	15.07
2018	0.62	1.05	1.51	2.11	2.80	3.48	4.54	5.80	6.97	7.64	9.11	10.29	11.35	14.05
2019	0.51	0.96	1.43	2.02	2.72	3.60	4.51	5.80	6.91	7.94	8.89	10.94	11.55	14.49

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

Russia (trawl only)														
Year			Age											
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	0.65	1.05	1.58	2.31	3.39	4.87	6.86	8.72	10.40	12.07	14.43			
1984	0.53	0.88	1.45	2.22	3.21	4.73	6.05	8.43	10.34	12.61	14.95			
1985	0.33	0.77	1.31	1.84	2.96	4.17	5.94	6.38	8.58	10.28				
1986	0.29	0.61	1.14	1.75	2.45	4.17	6.18	8.04	9.48	11.33	12.35	14.13		
1987	0.24	0.52	0.88	1.42	2.07	2.96	5.07	7.56	8.93	10.80	13.05	18.16		
1988	0.27	0.49	0.88	1.32	2.06	3.02	4.40	6.91	9.15	11.65	12.53	14.68		
1989	0.50	0.73	1.00	1.39	1.88	2.67	4.06	6.09	7.76	9.88				
1990	0.45	0.83	1.21	1.70	2.27	3.16	4.35	6.25	8.73	10.85	13.52			
1991	0.36	0.64	1.05	2.03	2.85	3.77	4.92	6.13	8.36	10.44	15.84	19.33		
1992	0.55	1.20	1.44	2.07	3.04	4.24	5.14	5.97	7.25	9.28	11.36			
1993	0.48	0.78	1.39	2.06	2.62	4.07	5.72	6.79	7.59	11.26	14.79	17.71		
1994	0.41	0.81	1.24	1.80	2.55	2.88	4.96	6.91	8.12	10.28	12.42	16.93		

Russia (trawl only)													
Year			Age										
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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	12.42		
2008	0.28	0.64	1.16	1.74	2.65	3.58	4.74	5.73	7.32	8.07	9.52	12.52		
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	13.53		
2011	0.25	0.62	1.05	1.56	2.18	2.95	4.33	6.21	8.04	10.13	12.25	15.18		
2012	0.29	0.60	1.07	1.66	2.25	2.95	4.17	6.23	8.58	11.08	12.24	14.07	15.22	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	15.54	17.05	
2014	0.32	0.61	1.05	1.61	2.26	3.15	4.00	5.24	7.13	9.46	11.18	14.47		
2015	0.30	0.60	0.97	1.49	2.11	3.13	4.64	5.78	7.13	9.53	12.12	16.71	17.37	
2016	0.26	0.55	0.97	1.53	2.20	3.19	4.50	6.12	7.97	9.55	10.95	14.35	14.74	17.25
2017	0.33	0.63	1.03	1.56	2.24	3.24	4.67	6.34	7.74	9.40	11.12	14.43	16.67	11.91
2018	0.33	0.68	1.06	1.62	2.40	3.22	4.66	6.23	7.79	8.91	10.26	11.26	13.41	10.14
2019	0.29	0.62	1.10	1.60	2.33	3.22	4.44	6.45	8.10	9.60	11.02	13.83	10.65	10.65

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

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	1.5	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	3.9	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	8.8		
1998		0.23	0.73	1.17	1.89	2.72	3.25	4.13	5.63	6.5	8.57	8.42	11.45	8.79	
1999	1		0.853	1.448	1.998	2.65	3.473	4.156	5.447	6.82	5.902		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	7.77	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	4.00	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	4.40	5.43	7.18	8.39	10.15	10.03	10.99	14.26
2009	3	0.35	0.60	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	3.30	3.28	4.13	4.99	6.61	7.91	9.38	10.79	14.67	14.91

Germany (Division IIa and IIb)															
Year		**Age**													
		2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
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	4.50	5.41	6.20	6.39					
2016	[1]		1.38	2.60	3.55	4.81	6.33	7.61	8.90	9.26	10.83	13.41	16.84	17.03	17.76
2017	[1]		1.58	2.79	3.93	3.93	4.77	6.35	8.16	9.09	10.39	11.24	12.48	14.39	13.04
2018	[3]	0.58	1.16	1.76	2.45	3.34	4.13	5.81	7.16	8.99	9.96	10.85	11.73	14.01	17.79
2019	[1]		0.82	1.37	1.80	2.26	3.49	4.45	5.44	7.08	9.25	9.39	13.30	12.24	15.25

[1]Division IIa onl

[2]IIa and IIb combined

[3]I,IIa and IIb combined

[4]Division IIb only

Table 3.7. Northeast 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				
2017	2	0.12	0.42	0.75	1.17	1.69	2.50	3.39	4.47	5.69	5.93	6.00	10.91	13.57	10.52
2018	2	0.19	0.45	0.83	1.30	1.86	2.57	3.55	4.92	5.51	7.84	7.08	7.28		
2019	2	0.19	0.39	0.90	1.30	1.85	2.65	3.48	4.83	5.96	5.67	7.04	8.36		
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
2017	2		0.71	1.23	1.52	2.47	3.52	4.78	6.97	9.193	9.95	10.9	14.1		
2018	3		0.74	1.15	1.66	2.45	3.55	4.48	6.06	6.31	7.59	7.91	8.28	8.52	9.40
2019	1				1.57	2.00	2.69	4.04	5.61	7.23	9.13	11.62	12.41	13.46	11.47
	1	Division IIa													
	2	Division IIa and IIb													
	3	I and IIb combined													

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

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

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

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
2017	0.71	1.15	1.66	2.32	3.32	4.67	6.13	7.15	8.14	11.42	12.8	14.18	15.55
2018	0.86	1.17	1.71	2.5	3.31	4.61	6.03	7.32	8.06	11.42	12.8	14.18	15.55
2019	0.68	1.15	1.66	2.39	3.33	4.45	6.11	7.29	8.41	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

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

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1983	0.37	0.92	1.6	2.44	3.82	4.76	6.17	7.7	9.25	12.621	14.544	16.466	18.388
1984	0.42	1.16	1.81	2.79	3.78	4.57	6.17	7.7	9.25	12.621	14.544	16.466	18.388
1985	0.413	0.875	1.603	2.81	4.059	5.833	7.685	10.117	14.29	12.621	14.544	16.466	18.388
1986	0.311	0.88	1.47	2.467	3.915	5.81	6.58	6.833	11.004	12.621	14.544	16.466	18.388
1987	0.211	0.498	1.254	2.047	3.431	5.137	6.523	9.3	13.15	12.621	14.544	16.466	18.388
1988	0.212	0.404	0.79	1.903	2.977	4.392	7.812	12.112	13.107	12.621	14.544	16.466	18.388
1989	0.299	0.52	0.868	1.477	2.686	4.628	7.048	9.98	9.25	12.621	14.544	16.466	18.388
1990	0.398	0.705	1.182	1.719	2.458	3.565	4.71	7.801	8.956	12.621	14.544	16.466	18.388
1991	0.518	1.136	1.743	2.428	3.214	4.538	6.88	10.719	9.445	12.621	14.544	16.466	18.388
1992	0.44	0.931	1.812	2.716	3.895	5.176	6.774	9.598	12.427	12.621	14.544	16.466	18.388
1993	0.344	1.172	1.82	2.823	4.031	5.497	6.765	8.571	10.847	12.621	14.544	16.466	18.388
1994	0.235	0.753	1.42	2.413	3.825	5.416	6.631	7.63	8.112	12.621	14.544	16.466	18.388
1995	0.201	0.485	1.14	2.118	3.47	4.938	7.16	9.119	10.101	12.621	14.544	16.466	18.388
1996	0.195	0.487	0.971	2.054	3.527	5.503	7.767	10.159	10.669	12.621	14.544	16.466	18.388
1997	0.202	0.521	1.079	1.878	3.369	5.263	8.927	12.154	11.204	12.621	14.544	16.466	18.388
1998	0.217	0.533	1.161	1.939	2.945	4.574	7.423	10.367	11.738	12.621	14.544	16.466	18.388
1999	0.203	0.52	1.174	2.031	3.034	4.464	6.482	10.269	10.882	12.621	14.544	16.466	18.388
2000	0.194	0.465	1.208	1.972	3.048	4.096	5.724	7.457	9.582	12.621	14.544	16.466	18.388
2001	0.285	0.522	1.196	2.239	3.313	5.118	6.376	9.241	11.322	12.621	14.544	16.466	18.388
2002	0.251	0.605	1.189	2.138	3.333	4.766	6.859	9.333	10.186	12.621	14.544	16.466	18.388

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
2003	0.23	0.537	1.31	2.009	3.241	4.971	6.739	8.706	15.026	12.621	14.544	16.466	18.388
2004	0.25	0.546	1.087	2.035	2.921	4.384	6.254	8.543	9.735	12.621	14.544	16.466	18.388
2005	0.231	0.624	1.118	1.932	3.046	3.955	5.811	8.289	13.44	12.621	14.544	16.466	18.388
2006	0.256	0.602	1.201	2.009	3.114	4.427	6.03	8.037	9.928	12.621	14.544	16.466	18.388
2007	0.262	0.699	1.341	2.121	3.167	4.64	6.495	9.123	11.78	12.621	14.544	16.466	18.388
2008	0.286	0.734	1.37	2.367	3.29	4.82	6.548	8.483	8.902	12.621	14.544	16.466	18.388
2009	0.26	0.641	1.343	2.36	3.763	5.111	6.554	9.098	9.432	12.621	14.544	16.466	18.388
2010	0.257	0.589	1.183	2.052	3.181	4.8	6.759	7.859	10.008	12.621	14.544	16.466	18.388
2011	0.224	0.589	1.088	1.915	2.776	4.319	6.495	8.489	10.016	12.621	14.544	16.466	18.388
2012	0.21	0.561	1.108	1.76	2.775	4.056	6.117	8.718	11.676	12.621	14.544	16.466	18.388
2013	0.256	0.589	1.151	2.019	2.857	4.049	5.631	8.146	10.378	12.621	14.544	16.466	18.388
2014	0.22	0.588	1.146	1.827	2.835	3.828	5.142	6.953	9.015	12.621	14.544	16.466	18.388
2015	0.231	0.546	1.165	1.938	2.853	3.946	5.258	6.821	8.957	12.621	14.544	16.466	18.388
2016	0.229	0.53	1.037	1.805	2.712	3.964	5.537	7.073	8.648	12.621	14.544	16.466	18.388
2017	0.261	0.649	1.168	1.966	2.93	4.627	5.966	7.279	9.3	12.621	14.544	16.466	18.388
2018	0.277	0.631	1.21	1.943	2.742	4.041	5.701	7.485	9.406	12.621	14.544	16.466	18.388
2019	0.239	0.574	1.079	1.838	3.03	4.344	5.874	7.438	9.64	12.621	14.544	16.466	18.388
2020	0.12	0.475	0.99	1.633	2.56	4.135	5.773	7.548	9.511	12.621	14.544	16.466	18.388

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

Norway

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

Russia

	Percentage mature							
	Age							
Year	3	4	5	6	7	8	9	10
1984	0	5	18	31	56	90	99	100
1985	0	1	10	33	59	85	92	100
1986	0	2	9	19	56	76	89	100
1987	0	1	9	23	27	61	81	80
1988	0	1	3	25	53	79	100	100
1989	0	0	2	15	39	59	83	100
1990	0	2	6	20	47	62	81	95
1991	0	3	1	23	66	82	96	100
1992	0	1	8	31	73	92	95	100
1993	0	3	7	21	56	89	95	99
1994	0	1	8	30	55	84	95	98
1995	0	0	4	23	61	75	94	97
1996	0	0	1	22	56	82	95	100
1997	0	0	1	10	48	73	90	100
1998	0	0	2	15	47	87	97	96
1999	0	0.2	1.3	9.9	38.4	74.9	94	100
2000	0	0	6	19.2	51.4	84	95.5	100
2001	0.1	0.1	3.9	27.9	62.3	89.4	96.3	100
2002	0.1	1.9	10.9	34.4	68.1	82.8	97.6	100
2003	0.2	0	11	29.2	65.9	89.6	95.1	100
2004	0	0.7	8	33.8	63.3	83.4	96.4	96.4
2005	0	0.6	4.6	24.2	61.5	84.9	95.3	98.1
2006	0	0	6.1	29.6	59.6	89.5	96.4	100
2007	0	0.4	5.7	20.8	60.4	83.5	96	100
2008	0	0.5	4	24.6	48.3	84.4	94.7	98.7
2009	0	0	6	28	66	85	97	100
2010	0	0.2	1.5	22.8	47	77.4	90.2	95.5
2011	0	0	2.2	20.7	50.4	73.7	90.6	95.6
2012	0.2	0	1.5	10.8	43.9	76.1	90.8	96.4
2013	0	0	0.6	10.6	41.8	70.6	89.8	96.9
2014	0	0	1.9	14.1	45.9	76	92	97.5
2015	0	0.2	0.2	7.9	27	60.8	83.4	93.7
2016	0	0	0.2	5.2	22.4	44.1	74.8	92.5
2017*	0	0	0.8	6.3	20.8	51.6	80.4	98.6
2018	0	0.5	2.5	23.6	53.9	79.4	92.5	96.0
2019**	0	0	4.5	11.9	56.4	91.8	95.1	100
2020**	0	0.4	1.7	15.8	43.8	71.2	74.9	84.9

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

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

Norway

	Percentage mature							
	Age							
Year	3	4	5	6	7	8	9	10
1985	0.31	1.36	8.94	38.33	51.27	85.13	100	79.2
1986	2.92	7	7.85	18.85	49.72	66.52	35.59	80.09
1987	0	0.07	4.49	12.42	16.28	31.23	19.32	
1988	0	2.35	6.16	40.54	53.63	45.36	100	100
1989	1.52	0.67	3.88	30.65	70.36	82.02	100	100
1990	1.52	0.67	4.18	22	57.45	80.95	100	100
1991	0.1	3.4	13.93	38.03	75.52	90.12	95.39	100
1992	0.22	1.85	21.04	52.83	86.95	96.52	99.83	100
1993	0	2.6	10.37	52.6	84.8	97.25	99.3	99.73
1994	0.51	0.33	15.78	36.92	62.84	88.44	97.56	100
1995	0	0.62	8.19	51.48	63.75	81.11	98.01	99.34
1996	0.03	0	2.82	29.56	70.22	82.06	100	100
1997	0	0	1.48	17.91	73.31	93.01	99.12	100
1998	0.12	0.68	3.17	15.42	47.31	75.73	94.3	100
1999	0.42	0.16	1.6	27.46	70.48	94.57	98.99	100
2000	0	0.11	8.15	30.23	77.3	81.95	100	100
2001	0.49	0.51	9.03	43.81	62.52	74.36	94.13	100
2002	0.27	0.73	5.94	43.22	68.4	85.31	92.52	100
2003	0.02	0.18	6.5	35.97	68.56	87.97	96.3	100
2004	0.24	1.36	10.23	54.56	81.84	90.94	98.76	98.91
2005	0	0.27	9	55.16	81.77	93.51	98.03	100
2006	0	0.22	5.92	44.25	69.85	89.89	96.65	100
2007	0.12	0.33	8.7	47.88	84.29	91.68	99.11	100
2008	0	0.27	9.27	34.13	61.39	88.04	91.17	100
2009	0	0	9	46	85	86	98	99
2010	0	0.36	7.5	41.75	67.7	90.1	95.29	98.55
2011	0	0.2	5.2	48	77.7	89.7	97.3	97.2
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	0.2	1.0	6.4	28.5	71.3	86.1	98.6
2017	0	0.2	0.5	18	54.8	81.4	95.9	100
2018	0	0.1	3.0	16.2	38.3	61.0	93.7	98.9
2019	0	0.4	4.0	24.0	68.6	93.2	96.7	99.8
2020	0	0.44	3.18	13.68	42.51	80.06	91.18	94.03

Table 3.11. Northeast Arctic cod. Proportion mature-at-age

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

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

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
2003	0.001	0.001	0.088	0.326	0.672	0.888	0.957	1	1	1	1	1	1
2004	0.001	0.01	0.091	0.442	0.726	0.872	0.976	0.977	1	1	1	1	1
2005	0	0.004	0.068	0.397	0.716	0.892	0.967	0.991	1	1	1	1	1
2006	0	0.001	0.06	0.369	0.647	0.897	0.965	1	1	1	1	1	1
2007	0	0.004	0.072	0.343	0.723	0.876	0.976	1	1	1	1	1	1
2008	0	0.004	0.062	0.282	0.538	0.863	0.928	0.994	1	1	1	1	1
2009	0	0	0.076	0.372	0.755	0.857	0.977	0.997	0.981	1	1	1	1
2010	0	0.003	0.045	0.323	0.573	0.838	0.927	0.97	0.974	0.986	1	1	1
2011	0	0.001	0.037	0.343	0.64	0.817	0.94	0.964	0.991	0.989	1	1	1
2012	0.001	0	0.046	0.215	0.557	0.786	0.909	0.964	0.99	0.989	1	1	1
2013	0	0.002	0.008	0.154	0.486	0.753	0.908	0.981	0.989	1	1	1	1
2014	0	0.002	0.019	0.137	0.513	0.805	0.929	0.981	0.998	1	1	1	1
2015	0	0.001	0.011	0.094	0.281	0.7	0.883	0.967	0.988	0.994	1	1	1
2016	0	0.001	0.006	0.058	0.255	0.577	0.804	0.955	0.986	1	1	1	1
2017	0	0.002	0.004	0.148	0.493	0.781	0.94	0.99	1	0.996	1	1	1
2018	0	0.003	0.027	0.199	0.461	0.702	0.931	0.974	1	0.989	0.991	1	1
2019	0	0.003	0.033	0.199	0.624	0.894	0.947	0.988	0.997	1	1	1	1
2020	0	0.004	0.026	0.114	0.387	0.769	0.894	0.931	1	1	1	1	1

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

Year/age	0	1	2	3	4	5	6
1984	0.000	430.697	21.334	0.188	0.000	0.000	0.000
1985	1602.184	354.850	68.317	0.189	0.000	0.000	0.000
1986	59.161	1041.218	318.545	81.642	0.000	0.000	0.000
1987	644.616	176.710	309.847	13.362	0.000	0.000	0.000
1988	32.542	503.062	27.578	1.828	0.000	0.000	0.000
1989	1013.198	157.889	0.000	0.000	0.000	0.000	0.000
1990	0.000	128.083	27.535	0.000	0.000	0.000	0.000
1991	127.457	159.522	216.192	1.845	0.000	0.000	0.000
1992	3502.487	975.416	160.309	4.532	0.000	0.000	0.000

Year/age	0	1	2	3	4	5	6
1993	3764.192	18803.842	509.990	54.112	1.380	0.434	0.000
1994	7820.202	6915.905	641.353	126.927	48.953	8.158	0.439
1995	7962.948	14781.906	748.177	205.060	65.166	3.552	0.216
1996	9943.654	21531.847	1469.280	133.743	51.579	17.896	1.038
1997	2979.493	16715.590	1837.155	164.019	15.438	1.169	0.206
1998	86.220	5309.872	555.817	204.236	23.530	1.485	0.476
1999	611.611	2033.647	294.157	49.208	3.976	0.004	0.000
2000	1786.894	2430.777	186.570	37.827	13.640	3.757	0.041
2001	94.894	2389.546	115.472	24.003	11.828	1.825	0.945
2002	7578.041	471.472	414.936	42.300	5.426	0.824	0.017
2003	5463.859	4336.099	113.459	25.654	0.000	0.000	0.000
2004	6533.068	2399.187	579.572	21.506	11.283	1.480	0.252
2005	2474.904	2998.989	133.624	82.615	4.727	5.780	0.537
2006	3632.277	2094.158	150.302	6.433	2.107	0.078	0.000
2007	2381.526	1147.731	190.796	74.527	3.382	0.124	0.000
2008	16584.374	812.326	90.968	100.918	33.117	4.359	0.000
2009	11213.946	8404.966	165.057	76.318	23.314	5.723	0.253
2010	5008.421	8464.908	345.533	61.930	31.976	19.324	2.562
2011	15058.553	5179.981	519.842	196.405	46.426	12.177	5.719
2012	24356.509	14081.218	1183.578	120.465	36.949	5.251	0.000
2013	30280.217	5596.784	1807.891	207.186	20.297	9.064	1.372
2014	36631.750	6458.317	844.305	228.391	62.500	6.130	0.075
2015	1676.025	10891.576	339.713	77.226	46.735	19.884	1.959
2016	12632.174	2722.775	535.776	14.264	22.197	32.131	7.579
2017	22070.330	1705.822	430.106	133.912	9.295	5.192	3.541
2018	7745.320	14463.885	296.922	40.939	2.572	0.315	0.000

Table 3.13. Northeast Arctic COD. Tuning data

North-East Arctic cod (Sub-areas I and II) (run name: XSAASA01)									
104									
FLT15: NorBarTrSur									
1981	2020								
1	1	0.085	0.189						
4	12								
1	2330	4000	3840	480	100	30	NA	NA	NA
1	2770	2360	1550	1600	140	20	NA	NA	NA
1	5234	4333	1696	582	321	97	NA	NA	NA
1	2828	2144	1174	407	40	8	NA	NA	NA
1	12598	1992	767	334	21	7	NA	NA	NA
1	14393	6414	830	191	34	4	NA	NA	NA
1	39115	5435	1570	200	45	3	NA	NA	NA
1	8049	17331	2048	358	53	3	NA	NA	NA
1	7586	3779	9019	982	94	10	NA	NA	NA
1	3487	3459	2056	2723	161	38	NA	NA	NA
1	3367	2565	2149	1215	1267	61	NA	NA	NA
1	5771	1782	1283	767	429	272	NA	NA	NA
1	14013	7248	1583	624	389	223	NA	NA	NA
1	30760	15260	4680	813	259	132	55	52	11
1	24210	25230	7710	1790	233	113	55	59	19
1	11670	14070	11120	2480	279	37	16	8	8
1	6920	7500	6070	2680	495	63	68	46	0
1	16740	3170	2640	1750	826	79	52	65	0
1	18190	6130	1280	683	519	98	27	2	3
1	13000	11200	2700	473	182	123	36	10	3
1	19450	8160	3800	958	119	45	19	4	0
1	13770	10860	4650	1450	219	34	19	5	0
1	12540	9520	6660	1790	472	102	16	4	0
1	18610	5360	4320	3090	692	166	29	8	1
1	5480	10270	2240	1640	380	88	30	4	2
1	11400	2810	4330	1400	519	134	22	21	8
1	12730	6890	1370	2360	685	220	40	31	8
1	30000	11560	4080	1800	829	186	35	2	2
1	19610	21800	5820	1750	844	527	50	18	3
1	11490	15550	14450	3980	1120	370	164	57	5
1	5070	12990	13800	10310	1670	434	117	79	20
1	7030	3640	9390	13630	4960	938	233	87	60
1	11980	6400	4100	6500	7620	3360	221	283	41
1	8510	6790	4780	3260	4690	3170	936	101	97
1	17020	13570	9980	7120	2740	5280	1700	286	72
1	11230	15130	10900	6610	2660	1280	1500	643	96
1	3970	4870	5660	2780	1890	763	301	222	349
1	14870	4610	5570	5340	2390	748	541	113	224
1	13200	18860	6640	2700	2880	760	172	34	17
1	14013	10375	9643	4680	1887	1486	382	113	31
FLT16: NorBarLofAcSur									
1985	2020								
1	1	0.085	0.26						
4	12								
1	1416	204	151	157	33	13	10	5	NA
1	1343	684	116	77	31	3	NA	4	NA
1	2049	502	174	14	30	7	NA	NA	NA
1	355	578	109	40	3	NA	1	NA	NA
1	344	214	670	166	32	5	2	NA	NA
1	206	262	269	668	73	6	3	NA	NA
1	346	293	339	367	500	37	2	2	NA
1	658	215	184	284	254	824	43	17	NA
1	1911	1131	354	255	252	277	442	49	NA
1	4045	2175	895	225	119	94	39	180	NA
1	1598	2166	1040	290	44	43	30	26	NA
1	705	872	891	446	65	11	4	9	NA
1	517	497	422	499	205	22	5	NA	NA
1	1826	424	338	340	247	49	7	2	NA
1	964	454	122	112	187	92	10	2	NA
1	1589	1457	493	129	69	52	12	6	NA
1	1716	816	573	198	24	8	6	3	NA
1	1122	1043	661	345	95	12	5	6	NA
1	1144	1315	1445	643	212	38	5	1	NA
1	928	327	451	468	222	88	22	2	NA
1	337	661	299	432	172	75	18	1	NA
1	591	157	381	169	155	88	24	3	NA
1	371	318	130	427	138	75	33	8	NA
1	3061	1410	754	246	329	58	28	17	NA
1	1783	1405	495	401	133	260	37	17	NA
1	1219	1759	1949	709	375	111	88	17	NA
1	291	824	1587	2843	656	226	61	78	5
1	527	381	828	2244	1547	309	108	48	20
1	850	710	575	1194	2249	1756	209	126	49
1	1178	918	679	529	1354	1751	977	142	66
1	1542	1193	996	965	362	1112	663	300	68
1	583	969	646	587	339	341	481	292	170
1	404	486	766	498	503	285	180	147	172
1	1361	473	546	678	462	186	143	59	59
1	977	1248	563	480	677	264	212	65	29
1	1039	695	852	496	494	455	197	82	25

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

FLT18: RusSweptArea										
1982	2019									
1	1	0.9	1							
3	12									
1	1413	1525	721	198	551	174	37	19	15	1
1	520	642	506	358	179	252	94	NA	NA	NA
1	1189	700	489	357	154	69	61	17	15	6
1	1188	1592	1068	365	165	37	8	16	1	21
1	1622	1532	1493	481	189	42	2	6	NA	NA
1	557	3076	900	701	184	60	25	4	1	3
1	993	938	2879	583	260	47	24	NA	NA	NA
1	490	978	1062	1454	1167	299	112	47	18	7
1	167	487	627	972	1538	673	153	49	9	2
1	1077	484	532	583	685	747	98	14	3	NA
1	675	308	239	273	218	175	25	25	4	NA
1	1604	1135	681	416	354	87	3	7	1	1
1	1363	1309	1019	354	128	49	21	11	6	2
1	589	1065	1395	849	251	83	19	18	9	6
1	733	784	1035	773	348	132	19	5	12	2
1	1342	835	613	602	348	116	32	30	NA	NA
1	2028	1363	788	470	259	130	48	5	NA	1
1	1587	2072	980	301	123	94	42	4	NA	NA
1	1839	1286	1786	773	114	52	23	9	4	NA
1	1224	1557	1290	1061	304	50	14	5	25	13
1	980	1473	1473	896	600	182	29	8	1	1
1	1246	1057	1166	1203	535	241	40	9	3	NA
1	329	1576	880	1111	776	279	93	23	4	2
1	1408	631	1832	744	605	244	88	28	6	1
1	927	1613	777	1801	662	342	161	43	17	7
1	2579	1617	1903	846	1525	553	226	86	49	11
1	2203	3088	1635	1472	830	863	291	115	33	17
1	974	2317	3687	2016	1175	620	413	205	65	32
1	334	1070	2505	3715	1817	789	395	299	156	55
1	882	508	1432	3065	3300	917	439	176	175	70
1	815	1114	839	2122	3358	1878	432	195	46	57
1	747	1174	1177	884	2349	3132	1367	306	92	54
1	1399	1368	1725	1483	1111	1929	1297	383	93	35
1	657	1583	1742	1932	1610	925	1158	761	242	65
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1	1456	884	1063	1952	1231	567	266	120	120	75
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FLT007: Ecosystem_2018corr										
2004	2019									
1	1	0.65	0.75							
3	12									
1	1477	4215	1502	798	402	101	22	5	1	1
1	2166	558	1009	280	156	57	12	5	1	NA
1	1861	2056	599	698	176	81	26	6	2	NA
1	5862	1592	791	246	269	60	22	9	1	2
1	6526	4834	1323	511	128	175	33	9	2	2
1	2023	2806	2896	1017	319	127	73	26	8	3
1	568	1770	3972	4249	1427	385	105	68	16	3
1	1236	1015	2402	3004	1784	323	77	18	13	6
1	2291	1464	700	1508	1652	845	127	44	16	14
1	2491	1836	1257	632	1182	1302	538	91	33	15
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1	1744	2252	1413	726	486	262	353	266	79	17
1	772	937	1216	701	444	272	138	132	54	17
1	3750	1415	1049	1209	626	280	112	64	44	45
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1	4166	2323	2151	766	422	444	161	49	22	11

Table 3.14 –SAM parameter settings used in SAM run

```
# 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 the fishing mortality states (normally only first row is used).

  0  1  2  3  4  5  6  7  8  9 10 11 11

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)

 2

# Coupling of the survey catchability parameters (nomally first row is not used, as that is covered by fishing mortality).

  1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

 -1  0  1  2  3  4  5  6  7  7 -1 -1 -1

 -1  8  9 10 11 12 13 14 15 15 -1 -1 -1

 16 17 18 19 20 21 22 23 24 24 -1 -1 -1

 25 26 27 28 29 30 31 32 33 33 -1 -1 -1

# Density dependent catchability power parameters (if any).

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

# Coupling of process variance parameters for log(F)-process (nomally only first row is used)

  0  0  0  0  0  0  0  0  0  0  0  0  0

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

# Coupling of process variance parameters for log(N)-process

 0 1 1 1 1 1 1 1 1 1 1 1 1

# Coupling of the variance parameters for the observations.
```

```
 0  0  0  0  0  0  0  0  0  0  0  0  0
-1  1  1  1  1  1  1  1  1  1 -1 -1 -1
-1  2  2  2  2  2  2  2  2  2 -1 -1 -1
 3  3  3  3  3  3  3  3  3  3 -1 -1 -1
 4  4  4  4  4  4  4  4  4  4 -1 -1 -1
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"
 "ID" "AR" "AR" "AR" "AR"
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#3-4 4-5 5-6 6-7 7-8 8-9 9-10 10-11 11-12 12-13 13-14 14-15
 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
# Stock recruitment model code (0=RW, 1=Ricker, 2=BH)
0
 # Years in which catch data are to be scaled by an estimated parameter
0
 # lowest and higest age included in Fbar
 5 10
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "LN" "LN" "LN" "LN" "LN"
```

Table 3.15. Northeast Arctic cod. Fishing mortality

SAM, Sat Apr 18 11:47:16 2020

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
1946	0.0018	0.0182	0.0682	0.1391	0.2436	0.2156	0.2996	0.3108	0.4386	0.4046	0.4068	0.4414	0.4414	0.2128
1947	0.0017	0.0196	0.0857	0.1952	0.3598	0.3202	0.4478	0.4783	0.7192	0.6797	0.7023	0.7874	0.7874	0.3145
1948	0.0013	0.0163	0.0771	0.1902	0.361	0.3277	0.4484	0.4749	0.7156	0.7208	0.7804	0.9506	0.9506	0.3132
1949	0.0023	0.0284	0.1223	0.2675	0.4362	0.3723	0.474	0.5067	0.7557	0.7601	0.8186	1.0381	1.0381	0.3632
1950	0.0033	0.0388	0.1445	0.2796	0.4148	0.3679	0.4849	0.5599	0.8512	0.8942	0.934	1.2303	1.2303	0.3753
1951	0.0086	0.0859	0.248	0.3809	0.4721	0.4	0.4969	0.5629	0.7892	0.8423	0.8915	1.1951	1.1951	0.4268
1952	0.0136	0.1227	0.3246	0.4749	0.5396	0.4702	0.5923	0.7184	0.9985	1.0622	1.0761	1.4044	1.4044	0.52
1953	0.0147	0.1139	0.2697	0.3735	0.4015	0.354	0.4379	0.5392	0.7141	0.7259	0.7151	0.8953	0.8953	0.396
1954	0.015	0.1119	0.2699	0.3866	0.4137	0.3739	0.4606	0.5956	0.7719	0.7753	0.744	0.8685	0.8685	0.4167
1955	0.0152	0.1116	0.2923	0.463	0.5096	0.4851	0.56	0.6996	0.8897	0.8712	0.7912	0.8503	0.8503	0.5016
1956	0.0195	0.1393	0.3623	0.5808	0.6331	0.6111	0.6677	0.8217	1.0402	1.096	0.9584	0.9217	0.9217	0.6128
1957	0.0198	0.1311	0.3114	0.4844	0.5307	0.5326	0.5748	0.7164	0.9026	0.9312	0.8254	0.7495	0.7495	0.525
1958	0.0292	0.1841	0.3916	0.5337	0.5299	0.5103	0.5388	0.6579	0.7673	0.7399	0.5954	0.5255	0.5255	0.527
1959	0.0324	0.2015	0.4206	0.5349	0.5173	0.5077	0.5443	0.6652	0.7407	0.7012	0.5982	0.5488	0.5488	0.5316
1960	0.0321	0.1971	0.4051	0.4966	0.4741	0.488	0.5351	0.6796	0.7877	0.7403	0.6614	0.6446	0.6446	0.5131
1961	0.0367	0.2341	0.5085	0.6193	0.5823	0.6187	0.703	0.8502	0.958	0.9068	0.8278	0.7794	0.7794	0.647
1962	0.0383	0.2564	0.6082	0.7648	0.6998	0.7169	0.8112	0.9456	0.9675	0.8464	0.7888	0.7139	0.7139	0.7577
1963	0.0319	0.2242	0.5948	0.8233	0.8224	0.8751	0.991	1.1275	1.1556	0.9365	0.8711	0.7514	0.7514	0.8724

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
1964	0.0224	0.1483	0.3837	0.5408	0.594	0.7116	0.8718	0.9501	1.0017	0.9019	0.981	0.843	0.843	0.6753
1965	0.0225	0.1331	0.3194	0.4281	0.4741	0.5883	0.7385	0.7838	0.7773	0.7108	0.9015	0.8188	0.8188	0.5554
1966	0.0246	0.1306	0.2831	0.3697	0.4295	0.5531	0.6945	0.7063	0.6557	0.5724	0.6888	0.6086	0.6086	0.506
1967	0.0259	0.1347	0.2772	0.3509	0.429	0.5907	0.7762	0.7954	0.7498	0.6264	0.7219	0.5748	0.5748	0.5366
1968	0.0294	0.1589	0.3399	0.4213	0.4822	0.6327	0.8052	0.7923	0.727	0.5936	0.7386	0.6075	0.6075	0.5789
1969	0.0347	0.1834	0.4148	0.542	0.6507	0.8594	1.069	1.017	0.9108	0.6882	0.7791	0.6185	0.6185	0.7588
1970	0.0362	0.1659	0.3633	0.4844	0.6004	0.8245	0.9948	0.912	0.7778	0.5664	0.6505	0.5486	0.5486	0.6966
1971	0.0324	0.1288	0.2617	0.3432	0.4558	0.7025	0.9073	0.8407	0.7334	0.5331	0.5902	0.4929	0.4929	0.5852
1972	0.051	0.176	0.321	0.3904	0.4784	0.7712	1.092	1.0898	1.0126	0.7476	0.8225	0.649	0.649	0.6905
1973	0.0875	0.2541	0.4042	0.4367	0.4632	0.6423	0.8553	0.8451	0.8087	0.6156	0.6744	0.5294	0.5294	0.6078
1974	0.1185	0.3351	0.5159	0.5364	0.522	0.629	0.7624	0.8484	0.9567	0.7912	0.9288	0.6758	0.6758	0.6357
1975	0.1057	0.3017	0.5089	0.5813	0.5898	0.6779	0.7341	0.7206	0.8816	0.7659	0.868	0.5953	0.5953	0.6354
1976	0.118	0.3363	0.5539	0.6336	0.6477	0.7364	0.7559	0.6255	0.6882	0.6398	0.7559	0.5996	0.5996	0.6588
1977	0.1238	0.3805	0.6539	0.7519	0.7707	0.8906	0.9726	0.795	0.8314	0.729	0.9353	0.8347	0.8347	0.8058
1978	0.0996	0.3205	0.6245	0.8131	0.8734	1.0516	1.2777	1.1892	1.4322	1.2958	1.5975	1.4409	1.4409	0.9716
1979	0.0558	0.1953	0.4138	0.6182	0.7112	0.8412	1.0586	1.053	1.2823	1.2358	1.5176	1.7277	1.7277	0.7827
1980	0.0394	0.1487	0.3484	0.5976	0.7474	0.8696	1.0325	1.0692	1.2543	1.1798	1.3832	1.6699	1.6699	0.7775
1981	0.0319	0.1279	0.3116	0.5859	0.7955	0.9363	1.0234	0.9372	1.0114	0.9038	0.8532	0.8829	0.8829	0.765
1982	0.0372	0.1561	0.3679	0.7026	0.9433	1.0205	1.0052	0.844	0.8272	0.8356	0.7366	0.8628	0.8628	0.8139
1983	0.0298	0.1372	0.3318	0.6224	0.9269	1.0392	0.9592	0.783	0.6997	0.6923	0.6502	0.8839	0.8839	0.7771

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
1984	0.0291	0.141	0.3642	0.6908	1.0922	1.2091	1.0641	0.8984	0.7543	0.69	0.5657	0.8565	0.8565	0.8864
1985	0.0344	0.1609	0.4025	0.7132	0.9842	1.0761	0.8528	0.7122	0.6172	0.5366	0.4099	0.7355	0.7355	0.7902
1986	0.0376	0.1838	0.4835	0.8148	1.0149	1.162	0.9891	0.974	0.9189	0.8512	0.5323	1.0001	1.0001	0.9064
1987	0.0414	0.1987	0.5391	0.9144	1.1058	1.2179	1.1059	1.2471	1.3166	1.3295	0.7461	1.4647	1.4647	1.0217
1988	0.0325	0.1502	0.3906	0.7132	0.9885	1.1122	1.1146	1.3999	1.4301	1.5323	0.7712	1.389	1.389	0.9532
1989	0.0236	0.1076	0.2634	0.4806	0.673	0.8008	0.7629	0.9144	0.9195	0.9769	0.5456	1.337	1.337	0.6492
1990	0.0145	0.0669	0.156	0.2681	0.3655	0.4404	0.4534	0.532	0.6052	0.7358	0.4804	1.2289	1.2289	0.3692
1991	0.0153	0.0773	0.1793	0.2895	0.3551	0.3757	0.3574	0.3439	0.3383	0.394	0.2694	0.8293	0.8293	0.3168
1992	0.0197	0.1099	0.267	0.4288	0.5082	0.5183	0.5034	0.4601	0.4481	0.5187	0.3773	1.1786	1.1786	0.4476
1993	0.016	0.1039	0.2917	0.5047	0.6266	0.6605	0.703	0.6741	0.7211	0.8469	0.7072	1.8156	1.8156	0.5768
1994	0.0154	0.1117	0.3475	0.6612	0.8823	0.9417	0.9942	0.9581	1.0521	1.2555	1.2261	3.1321	3.1321	0.7975
1995	0.0154	0.1138	0.3478	0.6369	0.8545	0.9234	0.9759	0.9553	1.0073	1.1502	1.2939	3.3215	3.3215	0.7823
1996	0.0184	0.1349	0.386	0.6443	0.801	0.9156	0.9128	0.9447	0.9673	1.115	1.1733	2.7804	2.7804	0.7674
1997	0.0235	0.184	0.5088	0.7763	0.9168	1.1258	1.1817	1.173	1.1355	1.1868	0.9519	1.3347	1.3347	0.9471
1998	0.0253	0.2058	0.5497	0.8056	0.8857	1.0925	1.1781	1.2565	1.1122	1.1737	0.8685	0.93	0.93	0.9613
1999	0.0182	0.1634	0.4936	0.7605	0.8951	1.1037	1.233	1.281	1.076	1.1554	0.8605	0.8119	0.8119	0.9612
2000	0.0118	0.1104	0.361	0.6125	0.7907	0.9783	1.0822	1.1183	0.8442	0.8813	0.5722	0.5928	0.5928	0.8238
2001	0.0099	0.0897	0.2925	0.5299	0.7223	0.8612	0.8963	0.9479	0.7097	0.7276	0.5146	0.7382	0.7382	0.7084
2002	0.0092	0.0836	0.2725	0.5056	0.7229	0.8359	0.8042	0.7987	0.6015	0.6218	0.4241	0.6854	0.6854	0.6566
2003	0.0097	0.0835	0.2584	0.4562	0.66	0.7394	0.6944	0.6617	0.4743	0.4398	0.2749	0.4078	0.4078	0.5783

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
2004	0.0109	0.0928	0.2856	0.5132	0.794	0.9333	0.9119	0.8994	0.6543	0.5403	0.2876	0.3637	0.3637	0.7229
2005	0.0131	0.1085	0.3121	0.5179	0.777	0.9274	0.9204	0.8799	0.6661	0.5557	0.2785	0.3148	0.3148	0.7224
2006	0.0149	0.1133	0.2969	0.4648	0.6651	0.8136	0.8645	0.8697	0.7623	0.7357	0.4438	0.5332	0.5332	0.6624
2007	0.0137	0.0962	0.2372	0.3415	0.4619	0.5374	0.5673	0.5869	0.5717	0.5833	0.3644	0.3894	0.3894	0.4553
2008	0.0089	0.0608	0.1505	0.2317	0.3263	0.3837	0.4082	0.4236	0.4509	0.4633	0.2949	0.2682	0.2682	0.3207
2009	0.0073	0.048	0.1164	0.1828	0.2698	0.3267	0.3623	0.3844	0.4496	0.4939	0.3198	0.2369	0.2369	0.2737
2010	0.0061	0.0396	0.0963	0.1572	0.2495	0.3373	0.3866	0.4466	0.5364	0.5368	0.3836	0.2432	0.2432	0.2789
2011	0.0053	0.0355	0.0877	0.1428	0.2294	0.3291	0.3875	0.4428	0.4768	0.4031	0.2762	0.1518	0.1518	0.2699
2012	0.0055	0.036	0.0883	0.1379	0.2059	0.2894	0.3451	0.3958	0.4119	0.3296	0.2243	0.1256	0.1256	0.2437
2013	0.0062	0.0404	0.1005	0.16	0.2288	0.3161	0.3787	0.4451	0.4495	0.3412	0.2287	0.1381	0.1381	0.2715
2014	0.0079	0.0508	0.1258	0.1989	0.2653	0.3403	0.3879	0.474	0.4821	0.3576	0.2266	0.1383	0.1383	0.2987
2015	0.0093	0.0582	0.1423	0.2277	0.2874	0.3489	0.3841	0.5015	0.5609	0.4055	0.2382	0.141	0.141	0.3153
2016	0.0085	0.0526	0.1323	0.2189	0.2861	0.3596	0.3953	0.534	0.6095	0.4439	0.2534	0.147	0.147	0.321
2017	0.0096	0.0591	0.1468	0.2437	0.3198	0.4169	0.4518	0.6061	0.7027	0.4915	0.2606	0.1428	0.1428	0.3642
2018	0.0102	0.0622	0.1508	0.2469	0.3248	0.4216	0.4634	0.6354	0.7432	0.5081	0.2453	0.125	0.125	0.3738
2019	0.0091	0.0573	0.1386	0.2225	0.2975	0.3868	0.4174	0.5658	0.6584	0.4398	0.1935	0.0931	0.0931	0.3381
FBAR	0.0113	0.064	0.1707	0.2853	0.3656	0.4218	0.4126	0.482	0.5641	0.2997	0.1609	0.0943		

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

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Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTAL
1946	1423343	681703	383964	180553	85029	89654	241747	85628	36528	32420	18290	8018	2534	3269411
1947	617235	823387	495310	292291	132449	55792	59366	145848	50889	19653	17769	9995	5824	2725807
1948	404564	358163	554464	353970	198821	75928	34159	31135	74119	19473	8259	7125	6003	2126185
1949	576298	273124	267977	396856	234906	110068	44393	17759	16064	30222	7566	3105	4095	1982433
1950	875549	374545	221035	190707	236313	120554	60595	22814	8855	6188	11947	2685	2085	2133873
1951	2469380	675460	290941	169549	117500	123702	67177	30115	10728	3036	2026	3964	1119	3964697
1952	2328260	1155885	417309	178912	104277	60235	66496	32988	14028	4127	1076	672	1259	4365524
1953	2588386	1109590	666524	232910	90013	53351	30952	29873	12966	4217	1158	302	376	4820621
1954	850213	1459176	704441	400426	132371	49759	32286	16326	14279	5163	1691	468	228	3666826
1955	388395	557107	965442	426431	224530	72329	29217	17398	7148	5436	1951	658	239	2696282
1956	743782	250861	386572	564170	213608	110997	36023	13946	7239	2314	1916	736	313	2332478
1957	1416452	405599	154914	211203	248813	90858	49025	15070	5100	2165	599	606	344	2600749
1958	1032979	701969	246044	91836	106348	116374	42067	22719	6096	1691	721	200	371	2369414
1959	1326289	542517	423461	135453	44853	51414	56682	19777	9640	2318	639	342	280	2613666
1960	1481044	627029	286550	216231	66427	21981	25575	26499	8124	3860	950	279	309	2764858
1961	1528761	701496	346684	147581	108908	34581	10985	12808	10852	2917	1547	413	248	2907781
1962	1250787	797519	383752	163202	65701	51107	15265	4361	4678	3405	924	559	245	2741506
1963	839041	707565	443363	161964	60892	27207	21176	5545	1341	1524	1206	336	324	2271485

Year_age	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**+gp**	**TOTAL**
1964	482566	385527	371434	183880	55845	21137	9338	6695	1448	327	501	430	257	1519385
1965	904964	262218	244467	201577	86707	24656	8269	3136	2221	433	103	152	250	1739152
1966	1901765	584719	179013	144035	107656	44541	11173	3187	1158	870	182	32	141	2978473
1967	1264851	1291320	406515	113742	81830	56878	20978	4558	1267	503	411	79	73	3243005
1968	186263	959389	889027	262900	71161	43769	25339	7825	1678	476	215	165	73	2448281
1969	110972	143275	658929	498674	143661	38718	19403	9221	2897	677	221	81	107	1626836
1970	213425	88351	95473	344166	230364	60738	13990	5472	2735	933	274	84	83	1056089
1971	388223	152327	61226	52851	165134	100236	21535	4366	1790	1042	441	117	78	949366
1972	992240	299922	109745	39791	31486	80852	38856	7010	1577	709	504	209	97	1602999
1973	1870935	702389	202973	65509	22768	17019	29337	10281	1887	465	276	178	132	2924148
1974	642931	1328808	463839	113661	35335	12201	7699	9547	3557	701	204	122	149	2618755
1975	598946	428869	728969	230631	55283	17581	5656	3238	3088	1094	268	63	114	2073800
1976	612521	434927	256845	341485	104535	24698	7342	2369	1417	950	404	90	85	1787667
1977	374504	424773	258455	122867	145225	44090	9344	2795	1115	651	369	157	81	1384425
1978	625994	250051	221140	109000	48991	54785	14627	2773	1014	425	292	113	84	1329289
1979	209854	448091	148779	91494	39279	17364	15666	3309	692	189	97	47	39	974902
1980	129779	161756	299159	81449	39064	15832	6426	4370	949	159	44	18	12	739016
1981	160267	101934	116892	170947	36355	14770	5529	1983	1180	221	42	9	4	610133
1982	176481	131953	81855	62701	78251	13816	4653	1615	660	328	74	14	5	552406
1983	157359	130808	93820	48149	25510	24595	4171	1401	583	238	109	30	7	486778

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTAL
1984	415597	123941	85766	55401	21532	8546	7138	1247	531	247	103	43	13	720104
1985	564693	366624	83297	45752	23990	5395	2194	2057	393	206	102	49	19	1094771
1986	1123445	440771	248674	43379	18882	7053	1444	812	851	180	99	56	26	1885671
1987	330792	976620	267098	104829	14852	6060	1704	486	244	283	63	49	25	1703105
1988	300608	243934	628926	115653	29803	4366	1478	462	121	54	59	25	13	1325503
1989	190122	223986	154580	343365	49497	8501	1302	398	90	25	9	21	9	971905
1990	156070	147999	144471	105617	165651	20659	2928	533	125	29	8	5	6	744100
1991	398889	134665	109008	98478	66981	94546	11110	1516	266	53	11	3	3	915529
1992	744428	318674	107282	75567	57510	37898	53028	6494	950	163	29	7	2	1402033
1993	935483	537960	252984	70885	38101	28074	17579	27492	3340	526	80	18	2	1912524
1994	738692	725615	400480	146912	35422	16713	11824	7114	11714	1341	182	31	3	2096041
1995	503553	503064	528977	223046	57350	12074	5335	3530	2276	3513	303	43	1	1843066
1996	416490	299474	333475	292153	97901	18884	4153	1573	1105	650	1035	65	1	1466962
1997	679661	228365	203859	176849	121537	37139	5831	1508	508	333	181	291	3	1456065
1998	969301	443973	130993	95113	69673	41312	9902	1420	395	126	80	57	69	1762414
1999	550901	587185	255263	59719	32775	25538	11454	2570	320	105	30	27	44	1525932
2000	678770	402402	379004	116250	23023	11121	7046	2608	622	89	27	9	28	1621001
2001	557105	532248	296071	184184	50788	8750	3453	1892	688	228	28	13	18	1635465
2002	413451	423622	377086	188583	82043	19945	3115	1186	612	267	94	13	12	1510028
2003	698613	307019	298227	246737	86925	32316	6919	1165	440	299	111	55	9	1678834

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTAL
2004	249125	568958	214403	192733	122943	36279	12634	2805	491	246	171	67	34	1400889
2005	635063	190295	403238	134815	98609	41401	11644	4219	892	206	120	114	56	1520672
2006	541999	462706	137225	235588	70216	36003	13425	3730	1420	401	93	78	118	1503004
2007	1423088	451396	295776	87233	124109	30900	12881	4351	1282	576	162	48	95	2431897
2008	1250005	1061087	365933	165466	52517	65496	15735	5986	1851	656	246	95	77	2985150
2009	708305	927340	849106	264485	94376	35674	34220	8872	3288	1024	339	146	107	2927281
2010	288945	535118	739089	637674	184018	58927	21497	18143	5301	1844	472	205	164	2491398
2011	480333	221292	448584	604637	446819	97556	35063	11921	9346	2453	999	234	235	2359471
2012	569721	336164	175480	355057	463244	264669	53082	19155	6400	4673	1364	648	323	2249980
2013	640235	395814	250035	148109	268771	312815	159285	28549	10627	3504	2705	882	747	2222080
2014	777674	441130	309867	196346	114965	188900	180616	81094	14478	5410	1963	1756	1175	2315374
2015	454913	528830	337737	218828	142893	77266	113857	95095	37869	7536	2974	1255	2069	2021122
2016	303634	306207	410645	238281	144367	87460	48282	61211	45832	16591	4120	1887	2314	1670832
2017	836999	245614	233626	293434	161984	86794	48828	27098	27474	20945	8823	2611	2815	1997047
2018	541513	549622	191149	177242	191233	99751	46182	25253	12099	11043	10627	5606	3618	1864938
2019	674702	384439	420252	160190	102904	119278	54211	24015	10536	4795	5329	6827	6315	1973794
2020		460180	290834	284657	111145	64750	66937	29396	11276	4364	2529	3595	9803	2014168

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

1974	0.2168	0.2	0.2013	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1975	0.2317	0.2035	0.2027	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1976	0.2238	0.2004	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1977	0.2487	0.2101	0.2042	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1978	0.2342	0.2045	0.2029	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1979	0.2081	0.2	0.2005	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1980	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1981	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1982	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1983	0.2031	0.2	0.2001	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1984	0.2	0.2099	0.2122	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1985	0.2039	0.2145	0.2158	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1986	0.249	0.2209	0.2603	0.2268	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.244	0.209	0.2211	0.2629	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.2145	0.2045	0.2095	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.2016	0.2171	0.2	0.2164	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.2	0.2029	0.2074	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1991	0.2012	0.2	0.2019	0.2113	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.2087	0.2	0.2	0.2172	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.2443	0.2	0.2159	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.342	0.2525	0.2178	0.2321	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.5187	0.3108	0.2157	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.5045	0.3166	0.2303	0.2157	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.4179	0.2699	0.2212	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1998	0.4255	0.2638	0.2134	0.228	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.2583	0.229	0.2292	0.2025	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.2457	0.2092	0.2464	0.2089	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2001	0.2356	0.217	0.2011	0.2312	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.2817	0.2083	0.2	0.2231	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2003	0.2398	0.2015	0.2	0.2136	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

2004	0.2517	0.2134	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.2989	0.2148	0.2067	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2006	0.2026	0.2305	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2007	0.2432	0.2	0.2435	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2008	0.2559	0.212	0.2	0.2242	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2009	0.2803	0.2134	0.2029	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.301	0.242	0.2112	0.2045	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.4318	0.3217	0.2072	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2012	0.3776	0.3226	0.2238	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2013	0.405	0.2446	0.2169	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2014	0.3904	0.3065	0.2195	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2015	0.3664	0.2689	0.2458	0.2076	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2016	0.2185	0.2604	0.2823	0.2288	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2017	0.4398	0.2209	0.2011	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2018	0.2845	0.2077	0.2	0.2191	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2019	0.3384	0.2277	0.2064	0.2	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, Sat Apr 18 11:47:16 2020

Year	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
1946	1423343	4199325	990609	706000	0.7127	0.2128
1947	617235	3642007	1021068	882017	0.8638	0.3145
1948	404564	3524255	837031	774295	0.925	0.3132
1949	576298	3003160	624864	800122	1.2805	0.3632
1950	875549	2827763	562163	731982	1.3021	0.3753
1951	2469380	3651316	511069	827180	1.6185	0.4268
1952	2328260	4052439	498837	876795	1.7577	0.52
1953	2588386	4131038	395700	695546	1.7578	0.396
1954	850213	4264867	409262	826021	2.0183	0.4167
1955	388395	3567594	331294	1147841	3.4647	0.5016
1956	743782	3334981	284209	1343068	4.7256	0.6128
1957	1416452	2818520	206967	792557	3.8294	0.525
1958	1032979	2416650	204255	769313	3.7664	0.527
1959	1326289	2764008	442905	744607	1.6812	0.5316
1960	1481044	2422909	402781	622042	1.5444	0.5131
1961	1528761	2398322	405816	783221	1.93	0.647
1962	1250787	2165088	319994	909266	2.8415	0.7577
1963	839041	1960792	214337	776337	3.622	0.8724
1964	482566	1499197	192205	437695	2.2772	0.6753
1965	904964	1471758	106572	444930	4.1749	0.5554
1966	1901765	2279538	121928	483711	3.9672	0.506
1967	1264851	2781268	133496	572605	4.2893	0.5366
1968	186263	3226283	228850	1074084	4.6934	0.5789
1969	110972	2743177	151247	1197226	7.9157	0.7588
1970	213425	2079779	230661	933246	4.046	0.6966
1971	388223	1628945	319457	689048	2.1569	0.5852
1972	992240	1619985	365215	565254	1.5477	0.6905
1973	1870935	2276632	324433	792685	2.4433	0.6078

Year	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
1974	642931	2211727	159570	1102433	6.9088	0.6357
1975	598946	2117752	130495	829377	6.3556	0.6354
1976	612521	2015645	167868	867463	5.1675	0.6588
1977	374504	1978696	352518	905301	2.5681	0.8058
1978	625994	1596936	234876	698715	2.9748	0.9716
1979	209854	1108308	165182	440538	2.667	0.7827
1980	129779	835530	102563	380434	3.7093	0.7775
1981	160267	954418	151331	399038	2.6369	0.765
1982	176481	732266	309233	363730	1.1762	0.8139
1983	157359	707797	280971	289992	1.0321	0.7771
1984	415597	812684	227446	277651	1.2207	0.8864
1985	564693	993470	187581	307920	1.6415	0.7902
1986	1123445	1354261	162605	430113	2.6451	0.9064
1987	330792	1212364	110373	523071	4.7391	1.0217
1988	300608	1008056	179294	434939	2.4258	0.9532
1989	190122	1001859	234927	332481	1.4153	0.6492
1990	156070	1019322	332203	212000	0.6382	0.3692
1991	398889	1529167	706951	319158	0.4515	0.3168
1992	744428	1880012	909485	513234	0.5643	0.4476
1993	935483	2319654	777317	581611	0.7482	0.5768
1994	738692	2117002	592996	771086	1.3003	0.7975
1995	503553	1822128	524650	739999	1.4105	0.7823
1996	416490	1684558	547659	732228	1.337	0.7674
1997	679661	1501034	544858	762403	1.3993	0.9471
1998	969301	1275457	377941	592624	1.568	0.9613
1999	550901	1158724	282913	484910	1.714	0.9612
2000	678770	1189540	239293	414868	1.7337	0.8238
2001	557105	1467249	364097	426471	1.1713	0.7084
2002	413451	1623962	507144	535045	1.055	0.6566

Year	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
2003	698613	1724129	596107	551990	0.926	0.5783
2004	249125	1631435	709766	606445	0.8544	0.7229
2005	635063	1562704	614977	641276	1.0428	0.7224
2006	541999	1568359	601333	537642	0.8941	0.6624
2007	1423088	1957075	651662	486883	0.7471	0.4553
2008	1250005	2702921	687443	464171	0.6752	0.3207
2009	708305	3438822	1095497	523430	0.4778	0.2737
2010	288945	3817975	1396260	609983	0.4369	0.2789
2011	480333	4021782	2011119	719830	0.3579	0.2699
2012	569721	4148412	2328107	727663	0.3126	0.2437
2013	640235	4369952	2639228	966209	0.3661	0.2715
2014	777674	3963783	2499243	986449	0.3947	0.2987
2015	454913	3707509	2059938	864384	0.4196	0.3153
2016	303634	3265551	1689689	849422	0.5027	0.321
2017	836999	3335324	1845399	868276	0.4705	0.3642
2018	541513	3018800	1593377	778627	0.4887	0.3738
2019	674702	2924923	1677851	692609	0.4128	0.3381
Arith. Mean	**755250**	**2312711**	**613494**	**672200**	**2.0447**	**0.5916**

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

2020								
Age	N	M	Mat	PF	PM	SWT	Sel	CWT
3	583000	0.3542	0	0	0	0.12	0.0093	0.7572
4	460180	0.2188	0.004	0	0	0.475	0.0579	1.0896
5	290834	0.2025	0.026	0	0	0.99	0.1422	1.6561
6	284657	0.2064	0.114	0	0	1.633	0.2319	2.3181
7	111145	0.2	0.387	0	0	2.56	0.3031	3.2894
8	64750	0.2	0.769	0	0	4.135	0.3868	4.5461
9	66937	0.2	0.894	0	0	5.773	0.4224	5.8086
10	29396	0.2	0.931	0	0	7.548	0.5686	7.467
11	11276	0.2	1	0	0	9.511	0.6549	8.647
12	4364	0.2	1	0	0	12.621	0.4578	11.42
13	2529	0.2	1	0	0	14.544	0.2382	12.8
14	3595	0.2	1	0	0	16.466	0.1298	14.18
15	9803	0.2	1	0	0	18.388	0.1298	15.55
2021								
Age	N	M	Mat	PF	PM	SWT	Sel	CWT
3	635000	0.3542	0	0	0	0.187	0.0093	0.8007
4		0.2188	0.003	0	0	0.421	0.0579	1.1678
5		0.2025	0.029	0	0	0.95	0.1422	1.5997
6		0.2064	0.171	0	0	1.642	0.2319	2.3152
7		0.2	0.491	0	0	2.495	0.3031	3.2175
8		0.2	0.788	0	0	3.833	0.3868	4.5025
9		0.2	0.924	0	0	5.58	0.4224	5.9017
10		0.2	0.964	0	0	7.416	0.5686	7.164
11		0.2	0.999	0	0	9.666	0.6549	8.822
12		0.2	0.996	0	0	12.621	0.4578	11.42
13		0.2	1	0	0	14.544	0.2382	12.8
14		0.2	1	0	0	16.466	0.1298	14.18
15		0.2	1	0	0	18.388	0.1298	15.55
2022								
Age	N	M	Mat	PF	PM	SWT	Sel	CWT
3	512000	0.3542	0	0	0	0.195	0.0093	0.8007
4		0.2188	0.003	0	0	0.488	0.0579	1.1678
5		0.2025	0.029	0	0	0.896	0.1422	1.5997
6		0.2064	0.171	0	0	1.602	0.2319	2.3152
7		0.2	0.491	0	0	2.504	0.3031	3.2175
8		0.2	0.788	0	0	3.767	0.3868	4.5025
9		0.2	0.924	0	0	5.278	0.4224	5.9017
10		0.2	0.964	0	0	7.224	0.5686	7.164
11		0.2	0.999	0	0	9.535	0.6549	8.822
12		0.2	0.996	0	0	12.621	0.4578	11.42
13		0.2	1	0	0	14.544	0.2382	12.8
14		0.2	1	0	0	16.466	0.1298	14.18
15		0.2	1	0	0	18.388	0.1298	15.55

Table 3.20. Northeast Arctic COD. Management option table.

2020					
Biomass (t)	SSB (t)	FMult	FBar		Landings (t)
2640455	1367955	1	0.338	674200	
2021				2022	
Biomass	SSB	FBar	Landings	Biomass	SSB
2579235	1373132	0.00	0	3242131	1898191
		0.05	114744	3119245	1799856
		0.10	223732	3003052	1707469
		0.15	327317	2893125	1620631
		0.20	425823	2789066	1538970
		0.25	519557	2690506	1462142
		0.30	608800	2597101	1389826
		0.35	693819	2508530	1321725
		0.40	774860	2424497	1257564
		0.45	852154	2344724	1197086
		0.50	925917	2268952	1140053
		0.55	996349	2196941	1086245
		0.60	1063639	2128467	1035455
		0.65	1127963	2063319	987491
		0.70	1189486	2001303	942176
		0.75	1248361	1942237	899344
		0.80	1304735	1885948	858840
		0.85	1358741	1832280	820519
		0.90	1410507	1781081	784249
		0.95	1460151	1732214	749904
		1.00	1507786	1685548	717366
Tonnes	Tonnes		Tonnes	Tonnes	Tonnes

Table 3.21. Northeast Arctic COD. Detailed prediction output assuming Fsq in 2020 and HCR in 2021.

Fbar	age						
range:	5-10						
Year:	2020						
F	multiplier:	1					
Fbar:	0.3381						
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.009	4507	3	583000	70	0	0
4	0.057	22978	25	460180	219	1841	1
5	0.140	34554	57	290834	288	7562	7
6	0.229	52843	122	284657	465	32451	53
7	0.299	26182	86	111145	285	43013	110
8	0.382	18743	85	64750	268	49793	206
9	0.417	20829	121	66937	386	59842	345
10	0.561	11550	86	29396	222	27368	207
11	0.647	4918	43	11276	107	11276	107
12	0.452	1449	17	4364	55	4364	55
13	0.235	482	6	2529	37	2529	37
14	0.128	393	6	3595	59	3595	59
15+	0.128	1071	17	9803	180	9803	180
Total	NA	200499	674	1922466	2640	253436	1368
		Thous	Thou. tonnes	Thous	Thou. tonnes	Thous	Thou. tonnes
Fbar	age						
range:	5-10						
Year:	2021						
F	multiplier:	1.40					
Fbar:	0.4724						
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.013	6847	5	635000	119	0	0
4	0.080	27975	33	405343	171	1216	1
5	0.196	56474	90	349224	332	10127	10
6	0.320	51345	119	206420	339	35298	58
7	0.418	57438	185	184187	460	90436	226
8	0.533	25503	115	67464	259	53162	204
9	0.583	14623	86	36188	202	33438	187
10	0.784	18022	129	36117	268	34817	258
11	0.903	7512	66	13730	133	13716	133
12	0.631	2073	24	4836	61	4817	61
13	0.329	580	7	2274	33	2274	33
14	0.179	244	3	1637	27	1637	27
15+	0.179	1438	22	9650	177	9650	177
Total	NA	270074	886	1952071	2579	290588	1373
		Thous	Thou. tonnes	Thous	Thou. tonnes	Thous	Thou. tonnes

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

Year	B(3+)	SSB	R(3)	F(5-10)
1984	809586	249869	409794	0.802
1985	985863	199092	579422	0.636
1986	1356910	181467	1014253	0.782
1987	1217033	134397	283132	1.015
1988	1001566	224335	214512	0.986
1989	912984	237449	180292	0.468
1990	995120	335331	210025	0.311
1991	1564633	723618	404885	0.227
1992	1958328	965373	684120	0.408
1993	2440273	853096	985953	0.617
1994	2213293	642260	719449	0.816
1995	1902837	576346	431787	0.747
1996	1833844	651925	389451	0.711
1997	1697306	713522	604263	1.036
1998	1276192	437677	786630	1.050
1999	1083050	285996	444026	0.964
2000	1055287	229214	553323	0.674
2001	1285059	349191	454658	0.535
2002	1416465	471533	407334	0.519
2003	1507070	530186	648718	0.512
2004	1471639	619783	273719	0.615
2005	1473972	577811	523508	0.622
2006	1506750	593781	538902	0.652
2007	1847705	618866	1328474	0.514
2008	2550027	623291	1295767	0.367
2009	3246987	965332	894311	0.353
2010	3564521	1163437	529199	0.390
2011	3653648	1627961	668755	0.337
2012	3710766	1853477	722864	0.300

2013	3949417	2074203	873627	0.304
2014	3692190	1972477	1116870	0.326
2015	3550303	1620049	478818	0.338
2016	3240280	1389724	342851	0.298
2017	3403634	1755441	747395	0.336
2018	3042954	1601519	531535	0.349
2019	2861021	1734618	525804	0.330

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

Year\age	3	4	5	6	7	8	9	10	11	12	13	14	15
1984	409794	138678	72723	41646	24416	12056	8962	1471	682	456	208	37	24
1985	579422	328609	98706	42232	18163	7028	3359	2492	475	392	178	116	29
1986	1014253	456717	229303	56569	20034	6799	2328	1322	1068	221	272	108	45
1987	283132	769747	309228	114267	23290	7140	2193	722	433	369	77	166	56
1988	214512	213031	518961	154289	36334	6215	2076	712	146	143	112	41	14
1989	180292	166556	150062	283948	59276	9110	1502	609	184	33	51	55	80
1990	210025	144038	120660	95127	156610	26002	3500	627	284	104	16	36	14
1991	404885	170392	110807	84961	60661	96485	14581	2030	358	177	69	10	19
1992	684120	327872	131974	78421	54093	35760	58870	8739	1271	239	127	52	6
1993	985953	542679	243750	87626	44340	28162	17244	30725	4451	712	128	92	4
1994	719449	762404	405521	146795	45227	20164	11581	6780	12507	1786	281	65	14
1995	431787	503895	533727	241039	65879	14565	6160	3325	1838	3858	557	142	3
1996	389451	253007	331569	320055	117609	25305	5208	1948	972	510	1398	288	3
1997	604263	229882	162924	193251	156936	49065	9268	2030	610	314	176	629	3
1998	786630	387245	145255	80384	77752	47367	12951	2133	474	112	60	58	140
1999	444026	493752	235050	71068	30766	24142	10457	3685	504	140	25	22	84
2000	553323	335522	323752	110407	25391	10386	5842	2050	1136	157	53	4	52
2001	454658	426162	241723	170659	48270	9070	3659	1694	589	549	66	32	101
2002	407334	354219	309805	147564	79877	20291	3303	1642	628	241	323	44	29
2003	648718	304212	261753	190058	70342	31491	7755	1302	849	318	112	223	5
2004	273719	503676	229669	164989	96292	30775	12784	3560	598	503	173	72	36
2005	523508	210290	370574	145024	82167	37194	11206	4520	1369	240	276	107	31
2006	538902	382766	153149	216601	72239	33384	12831	4155	1525	574	106	186	639
2007	1328474	432596	267808	95113	106976	31201	12790	4107	1597	519	247	63	170
2008	1295767	1023914	320070	160610	53577	52480	14703	6098	1786	769	202	159	80
2009	894311	994878	778881	222359	95892	30419	25842	7560	3259	866	422	132	126
2010	529199	671086	764811	548660	138756	55885	16710	13330	4225	1819	206	281	201
2011	668755	389528	505247	548104	352072	77301	28800	8870	6718	1643	855	74	0
2012	722864	432250	273267	370017	367912	209404	42480	14295	3926	3181	882	454	156
2013	873627	492614	302788	200673	256042	230332	120989	23479	7401	1906	1708	525	856
2014	1116870	579572	371043	221376	141455	158011	126447	61258	11741	3689	1006	1071	801
2015	478818	751018	408425	261819	148703	88809	83594	64286	29673	5968	1893	599	1136
2016	342851	328535	544043	279643	166023	90849	51704	44628	30875	12234	2744	1150	1422
2017	747395	273157	240384	360585	180441	101105	53599	29839	21392	13940	5904	1601	1143
2018	531535	475311	205559	165900	229142	105181	55188	30073	15975	9070	6351	3329	1074
2019	525804	393981	355914	141366	99065	133439	58912	29865	16370	8018	4423	3487	1990
2020	0	371279	294473	245778	88619	56980	73156	32446	16395	9227	4653	2972	2343

Table 3.24. NEA cod TISVPA estimates of fishing mortality coefficients

F(a,y)	3	4	5	6	7	8	9	10	11	12	13	14	15	F(5-10)
1984	0.023	0.138	0.326	0.562	1.008	0.973	0.998	0.948	0.276	0.882	0.448	0.448	0.448	0.802
1985	0.020	0.124	0.315	0.454	0.621	0.911	0.739	0.774	0.675	0.212	0.365	0.365	0.365	0.636
1986	0.021	0.151	0.399	0.644	0.747	0.876	1.117	0.910	0.865	0.736	0.427	0.427	0.427	0.782
1987	0.026	0.156	0.497	0.856	1.145	1.081	1.060	1.450	1.017	0.946	0.499	0.499	0.499	1.015
1988	0.024	0.164	0.428	0.889	1.236	1.331	1.011	1.020	1.215	0.868	0.481	0.481	0.481	0.986
1989	0.014	0.089	0.245	0.374	0.567	0.610	0.549	0.463	0.431	0.480	0.250	0.250	0.250	0.468
1990	0.008	0.059	0.158	0.264	0.320	0.404	0.375	0.348	0.277	0.256	0.166	0.166	0.166	0.311
1991	0.006	0.038	0.113	0.187	0.251	0.260	0.285	0.270	0.235	0.187	0.122	0.122	0.122	0.227
1992	0.009	0.067	0.167	0.318	0.442	0.522	0.469	0.531	0.462	0.390	0.211	0.211	0.211	0.408
1993	0.015	0.085	0.252	0.405	0.659	0.808	0.828	0.747	0.786	0.660	0.309	0.309	0.309	0.617
1994	0.017	0.115	0.281	0.546	0.725	1.061	1.107	1.174	0.933	0.969	0.391	0.391	0.391	0.816
1995	0.016	0.111	0.310	0.469	0.750	0.835	1.022	1.097	1.037	0.822	0.386	0.386	0.386	0.747
1996	0.021	0.106	0.303	0.537	0.651	0.893	0.832	1.047	1.006	0.936	0.389	0.389	0.389	0.711
1997	0.027	0.180	0.388	0.744	1.153	1.169	1.421	1.338	1.589	1.466	0.541	0.541	0.541	1.036
1998	0.030	0.182	0.521	0.686	1.092	1.420	1.144	1.435	1.190	1.356	0.540	0.540	0.540	1.050
1999	0.025	0.192	0.493	0.902	0.907	1.197	1.240	1.047	1.143	0.955	0.502	0.502	0.502	0.964
2000	0.021	0.121	0.395	0.605	0.842	0.692	0.737	0.775	0.621	0.654	0.353	0.353	0.353	0.674
2001	0.015	0.107	0.261	0.528	0.631	0.720	0.514	0.556	0.535	0.433	0.276	0.276	0.276	0.535
2002	0.013	0.087	0.267	0.403	0.664	0.662	0.642	0.473	0.471	0.448	0.255	0.255	0.255	0.519
2003	0.013	0.079	0.219	0.421	0.509	0.714	0.606	0.601	0.412	0.404	0.240	0.240	0.240	0.512
2004	0.015	0.099	0.244	0.429	0.694	0.710	0.868	0.744	0.674	0.450	0.281	0.281	0.281	0.615
2005	0.015	0.094	0.271	0.415	0.597	0.832	0.716	0.900	0.701	0.626	0.286	0.286	0.286	0.622
2006	0.016	0.106	0.275	0.503	0.626	0.773	0.924	0.810	0.928	0.709	0.312	0.312	0.312	0.652
2007	0.013	0.086	0.238	0.380	0.557	0.578	0.604	0.726	0.591	0.655	0.259	0.259	0.259	0.514
2008	0.009	0.065	0.175	0.301	0.383	0.471	0.423	0.449	0.489	0.401	0.199	0.199	0.199	0.367
2009	0.008	0.055	0.165	0.278	0.387	0.422	0.450	0.413	0.405	0.434	0.193	0.193	0.193	0.353
2010	0.007	0.056	0.158	0.298	0.411	0.496	0.468	0.511	0.431	0.417	0.214	0.214	0.214	0.390
2011	0.006	0.040	0.132	0.235	0.360	0.425	0.443	0.428	0.430	0.361	0.196	0.196	0.000	0.337
2012	0.006	0.037	0.098	0.202	0.293	0.387	0.397	0.422	0.377	0.375	0.187	0.187	0.187	0.300
2013	0.007	0.045	0.104	0.173	0.295	0.372	0.431	0.451	0.443	0.390	0.207	0.207	0.207	0.304
2014	0.008	0.048	0.134	0.195	0.265	0.397	0.439	0.523	0.506	0.490	0.244	0.244	0.244	0.326
2015	0.010	0.058	0.143	0.250	0.296	0.349	0.463	0.525	0.578	0.550	0.284	0.284	0.284	0.338
2016	0.010	0.064	0.144	0.223	0.317	0.322	0.333	0.448	0.468	0.507	0.274	0.274	0.274	0.298
2017	0.014	0.071	0.195	0.273	0.345	0.427	0.377	0.397	0.499	0.515	0.322	0.322	0.322	0.336
2018	0.016	0.093	0.188	0.325	0.367	0.398	0.428	0.386	0.377	0.465	0.327	0.327	0.327	0.349
2019	0.010	0.063	0.164	0.267	0.353	0.401	0.396	0.400	0.373	0.344	0.198	0.198	0.198	0.330

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

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

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

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

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

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

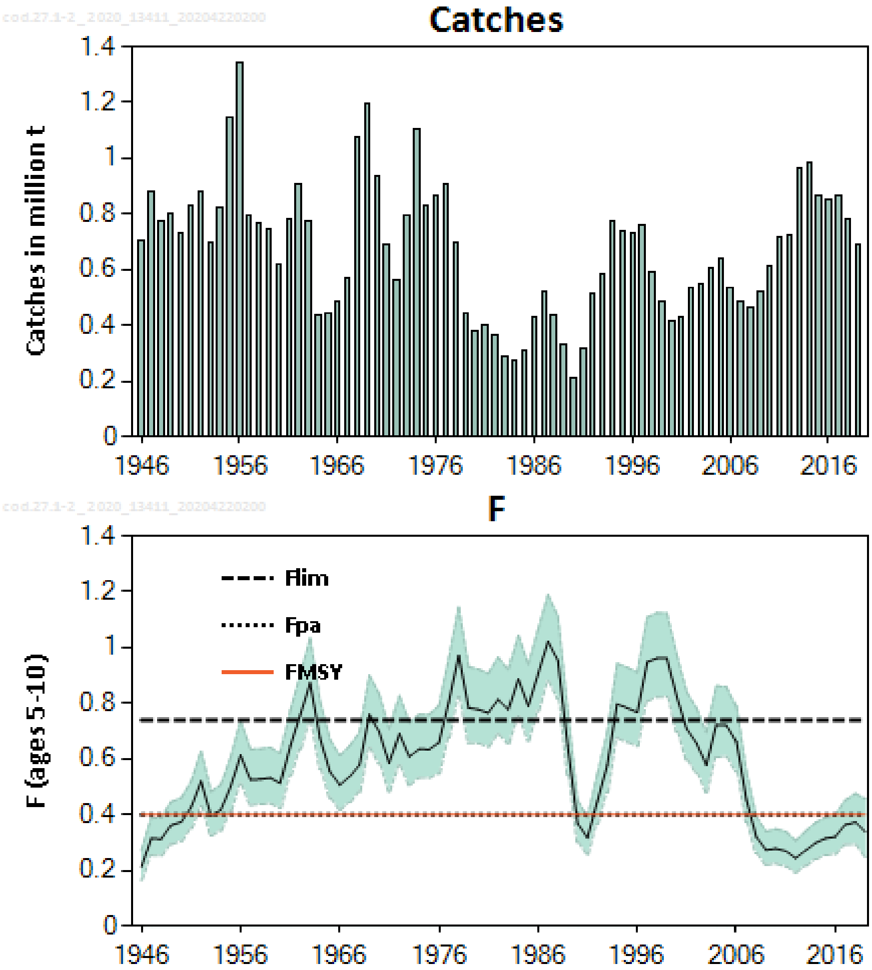
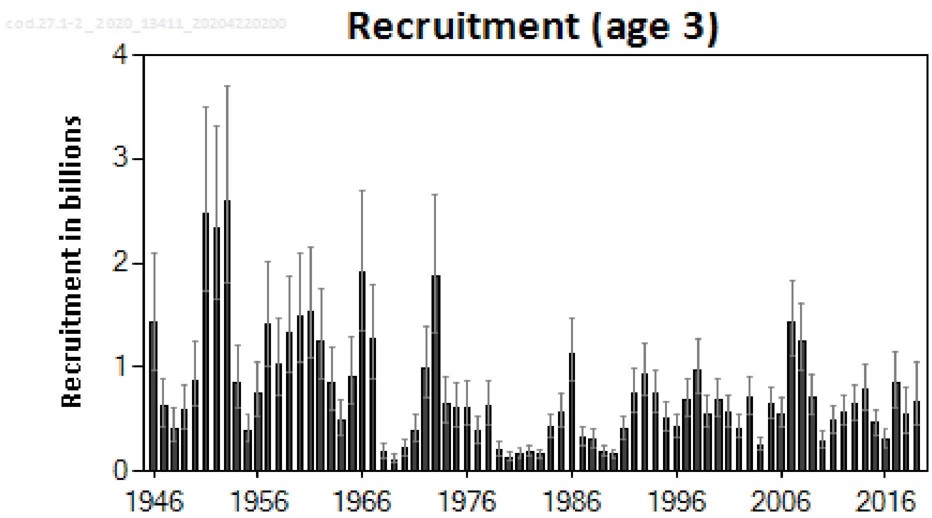


Figure 3.1. ICES Standard plots for Northeast Arctic cod (subareas 1 and 2)



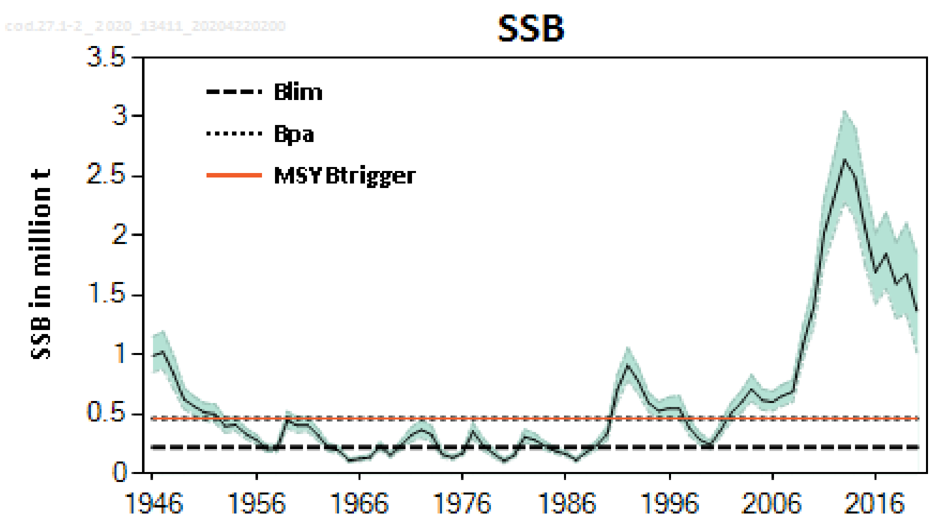


Figure 3.1 (continued). ICES Standard plots for Northeast Arctic cod (subareas 1 and 2)

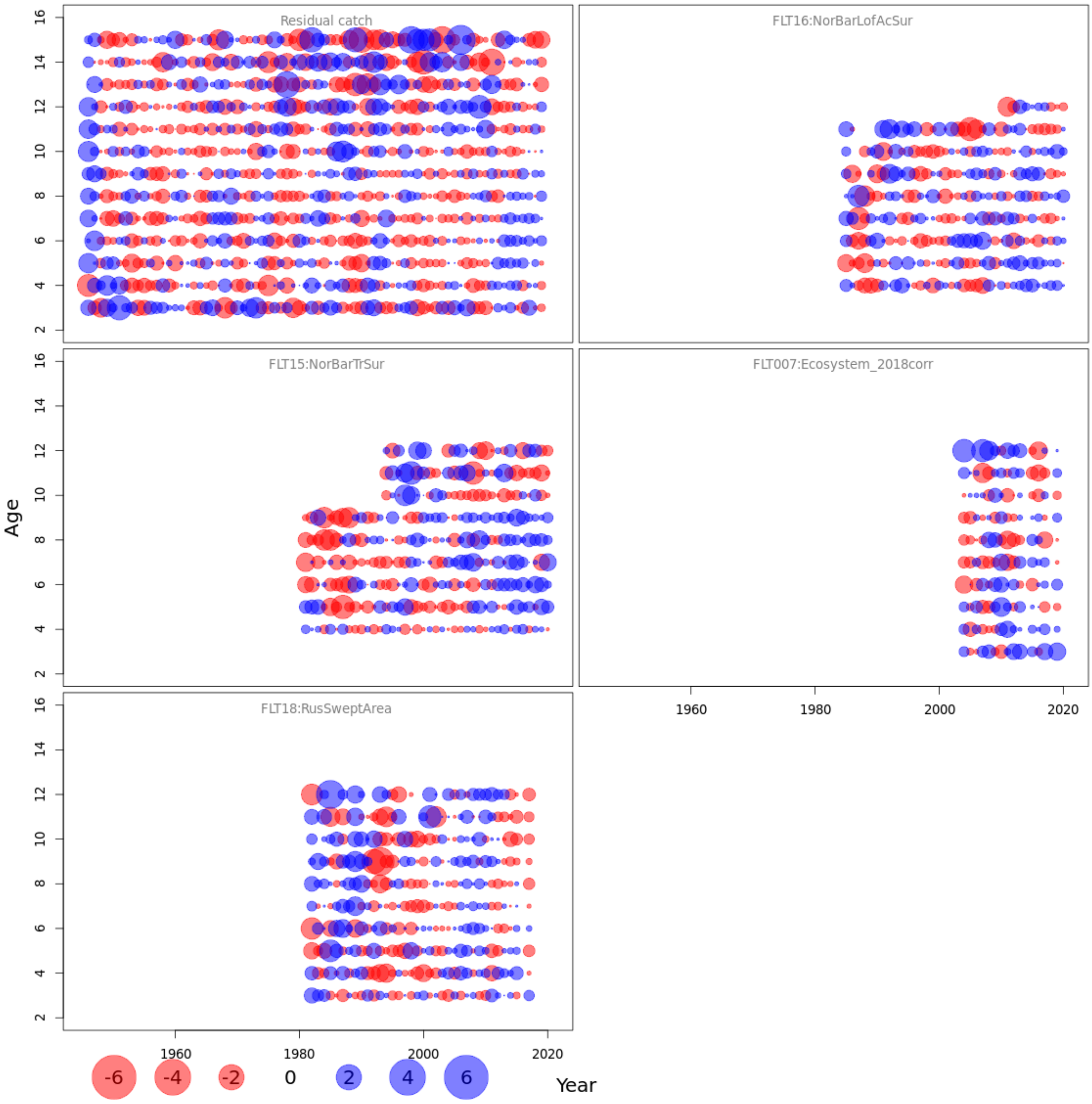


Figure 3.2a. Standardized one-observation-ahead residuals for log-catches and log-indices (Thygesen *et al*. 2017) in the final SAM run

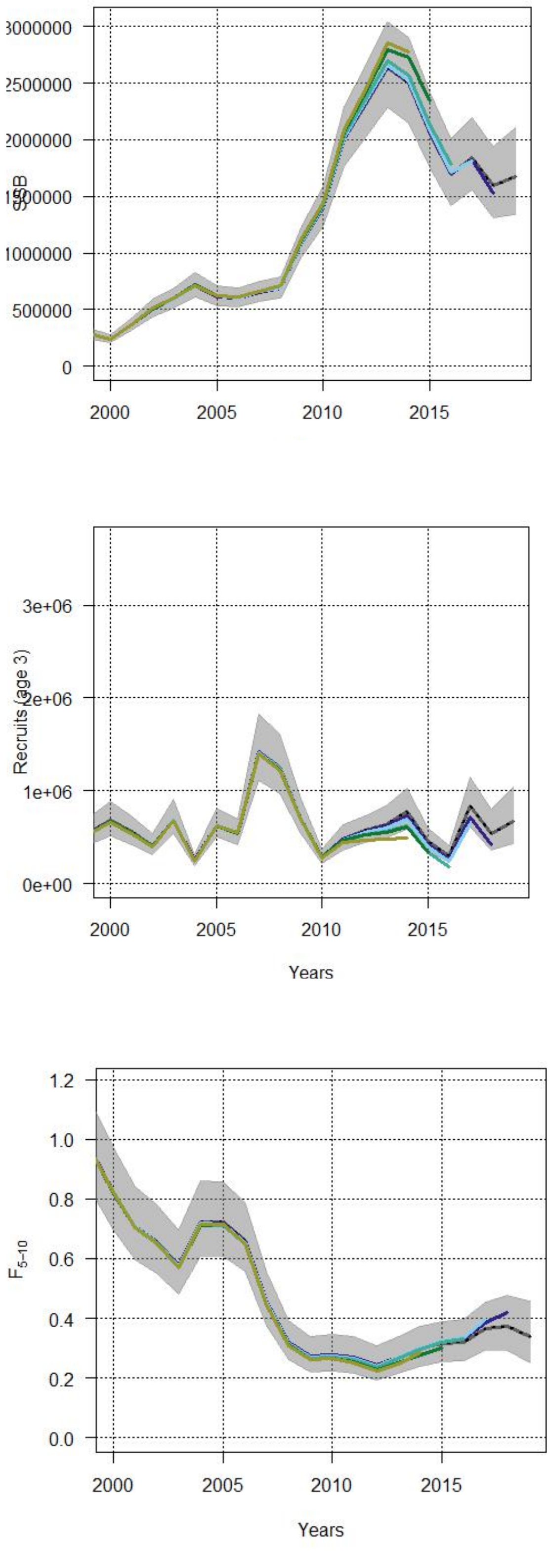


Figure 3.2b. NEA cod SSB, R and F_{bar} retrospective pattern for final SAM run.

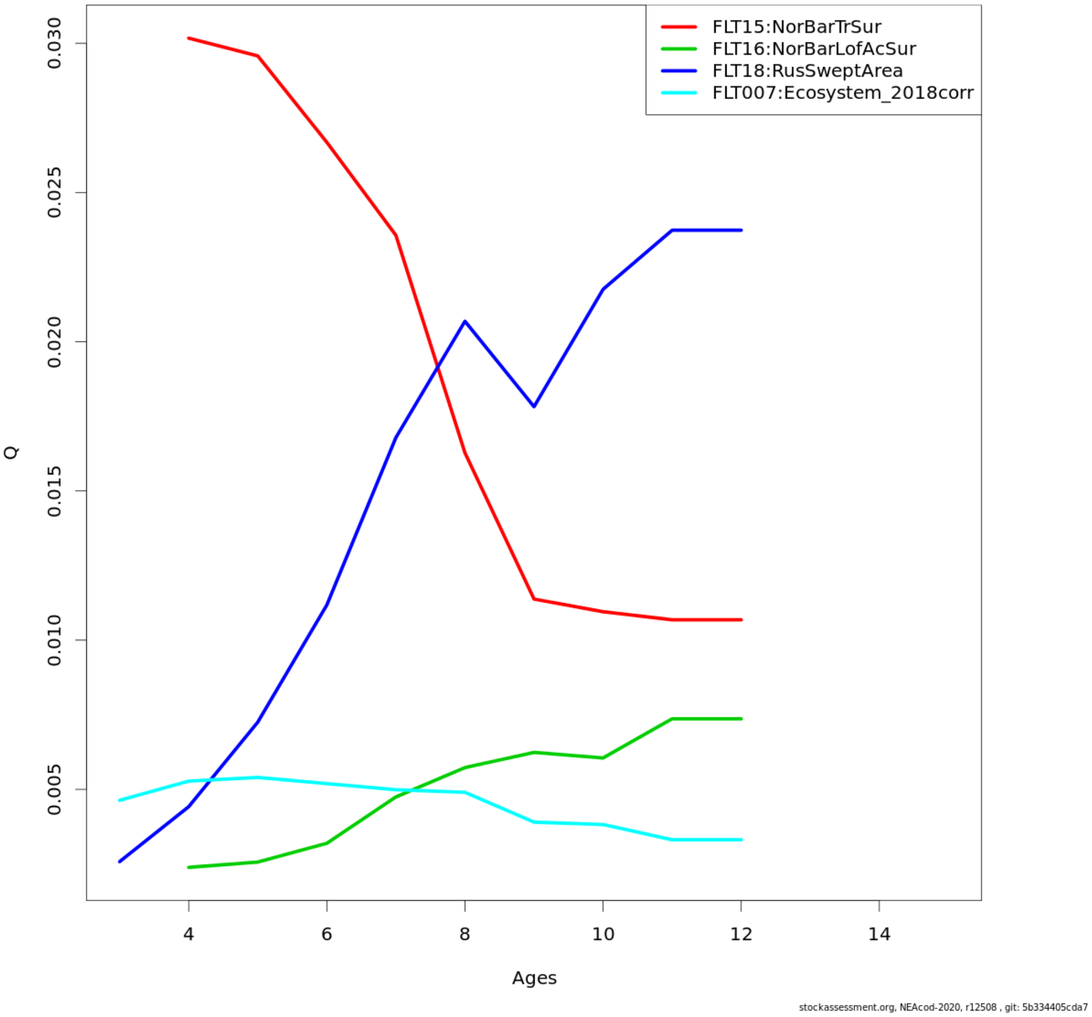


Figure 3.2c. NEA cod. Catchability of different fleets used for final SAM run fit.

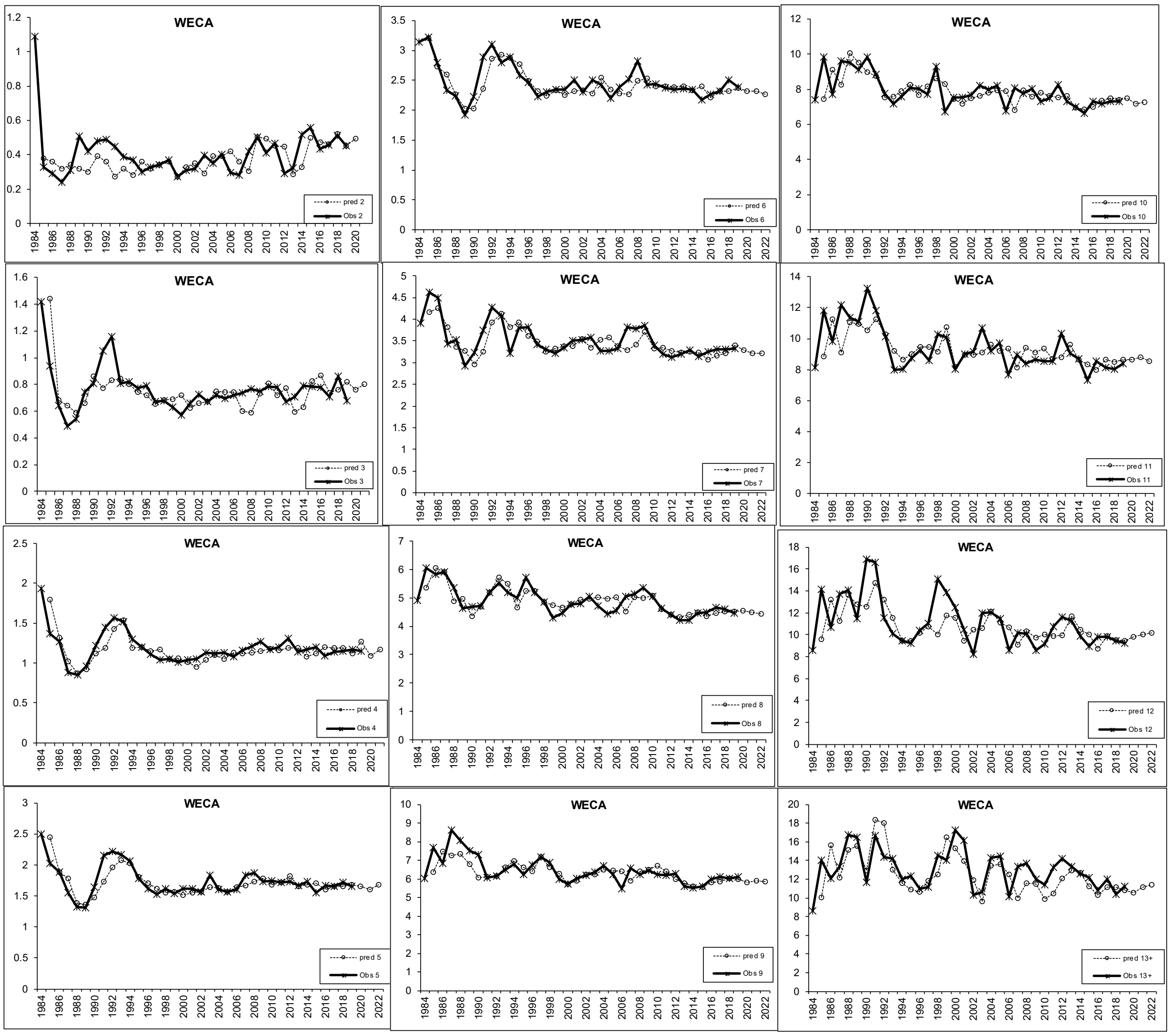


Figure 3.3. Northeast Arctic cod. Weight in catch predictions.

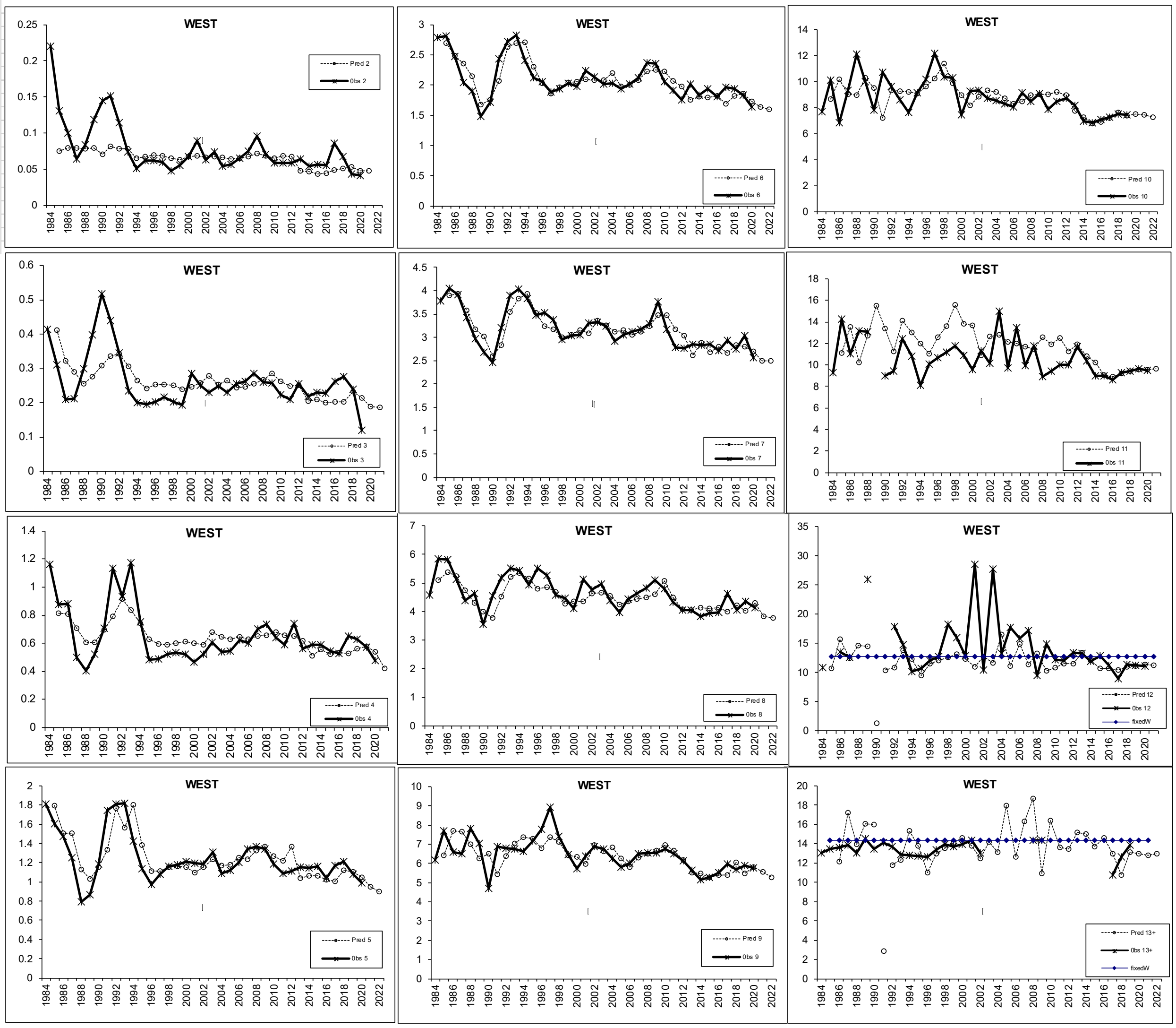


Figure 3.4. Northeast Arctic cod. Weight in stock projections.

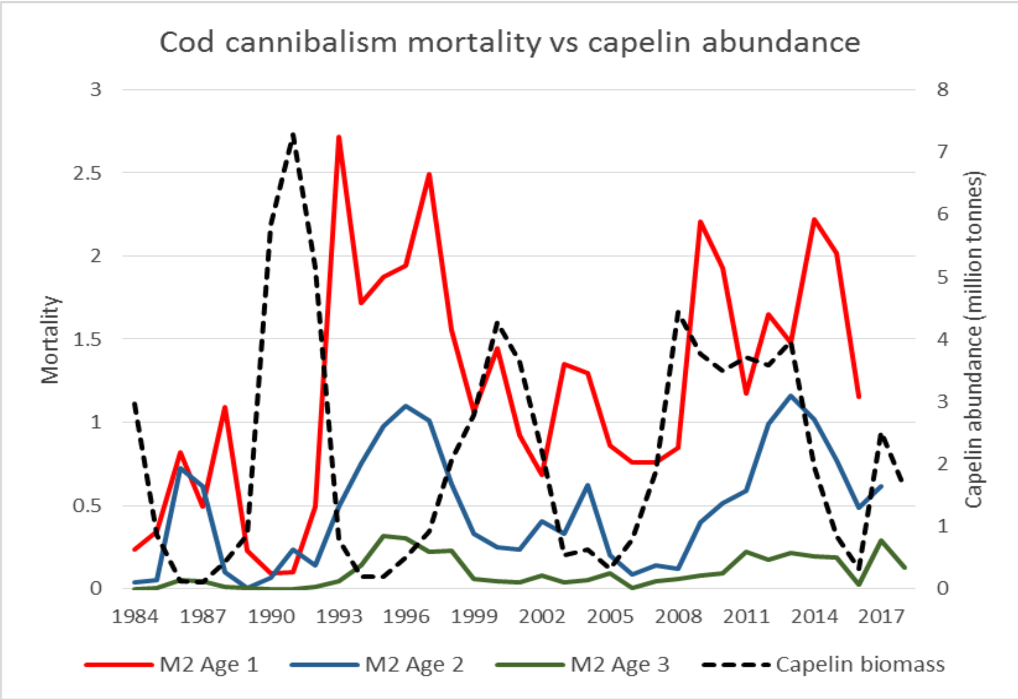


Figure 3.5. NEA cod cannibalism mortality vs. capelin abundance.

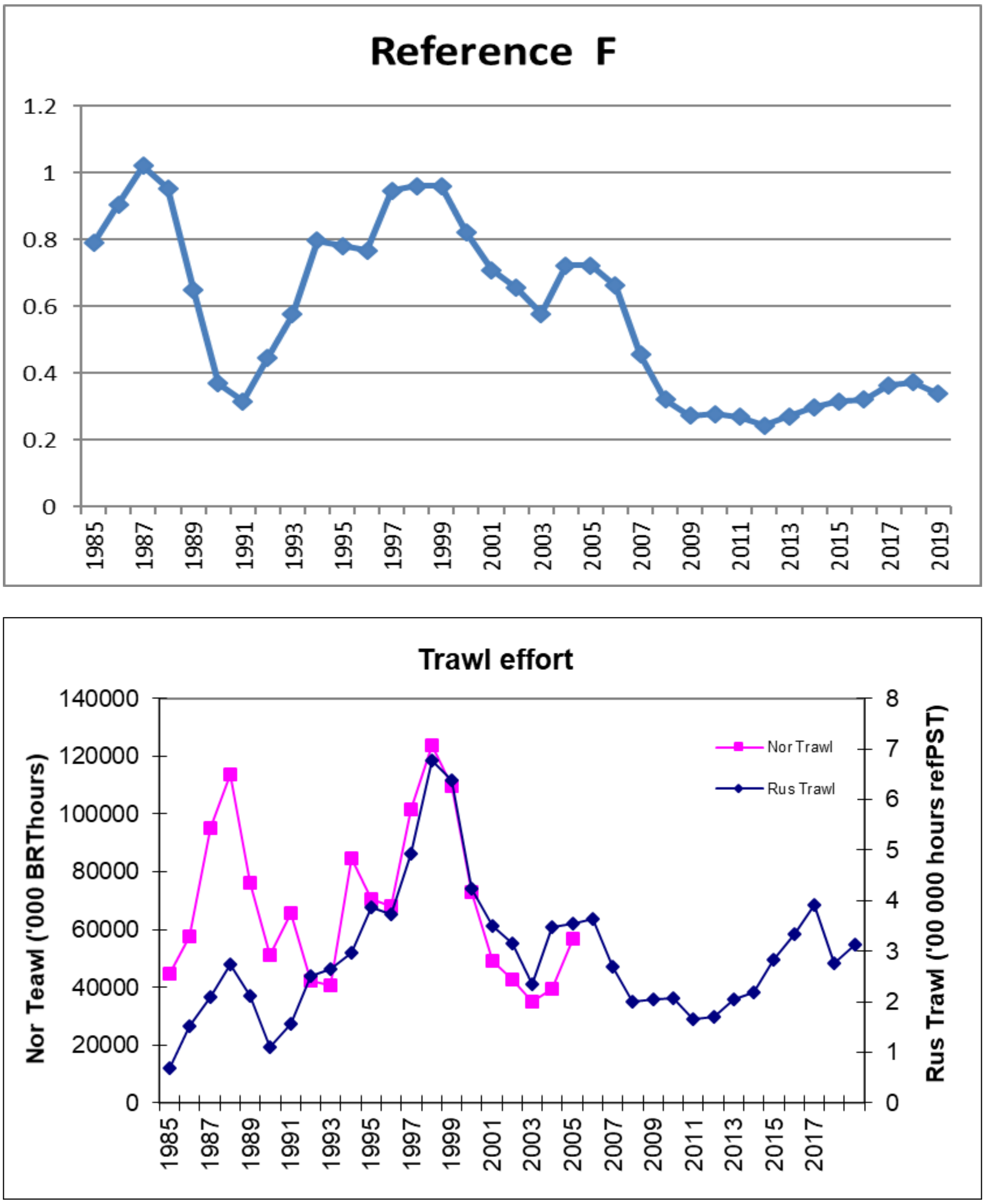


Figure 3.6a. Northeast Arctic cod. Fishing mortality (F5-10) (top panel) and trawl efforts in 1985–2019 (bottom panel).

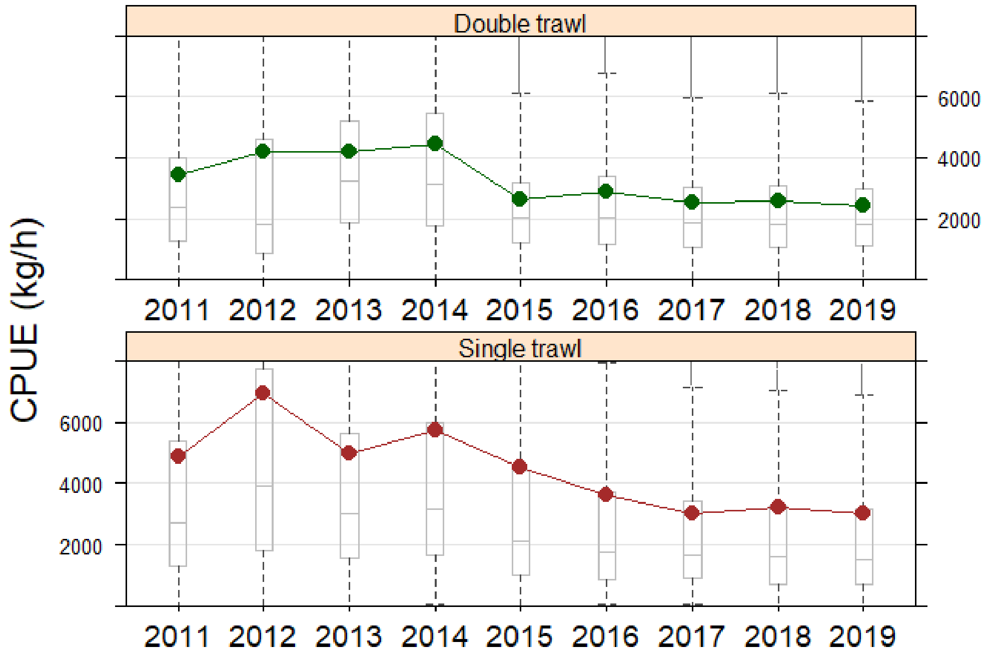


Figure 3. 6b. Cod CPUE in Norwegian trawl catches where cod is the main species (double and single trawl). Connected line shows mean, line inside the box shows the median, and the box shows 25 and 75 percentiles.

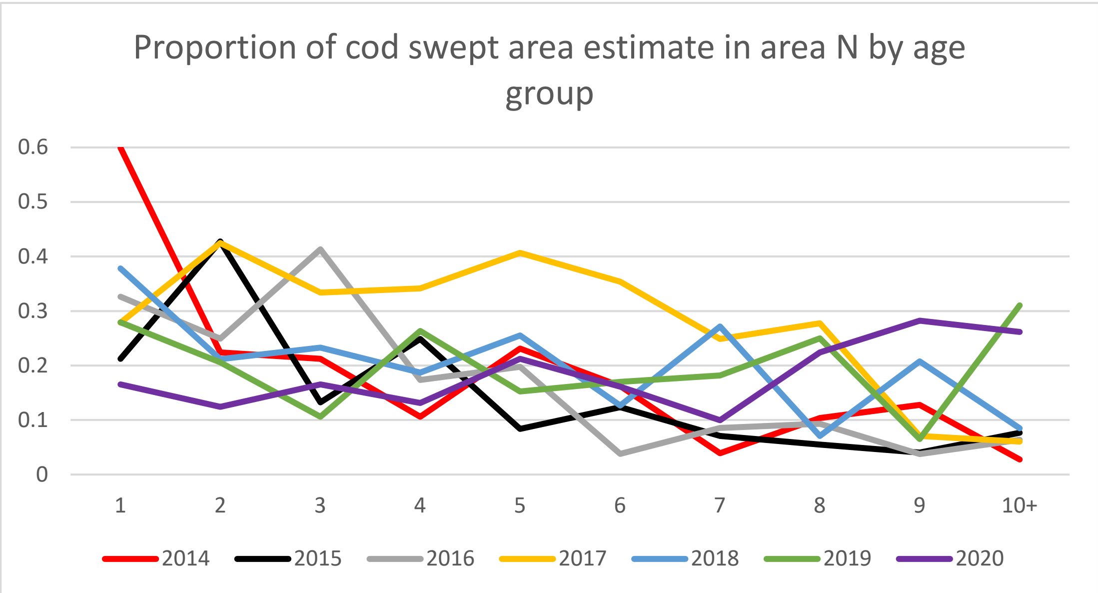


Figure 3.7. Proportion of NEA cod swept area estimate in area N during the Joint winter survey in 2014–2020, by age group.

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

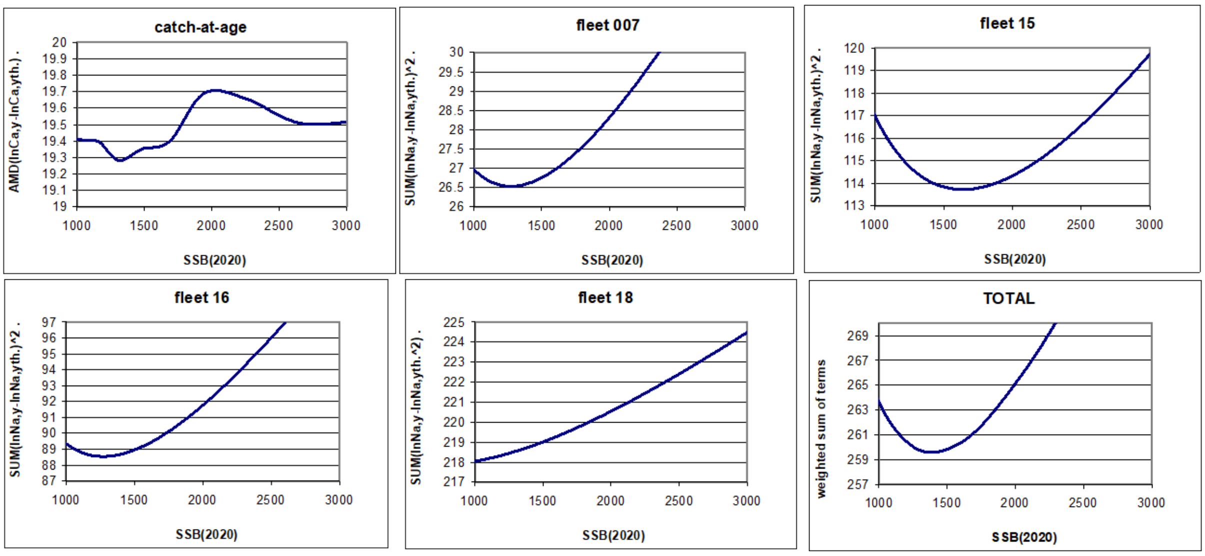


Figure 3.8b. Profiles of the components of the TISVPA objective function

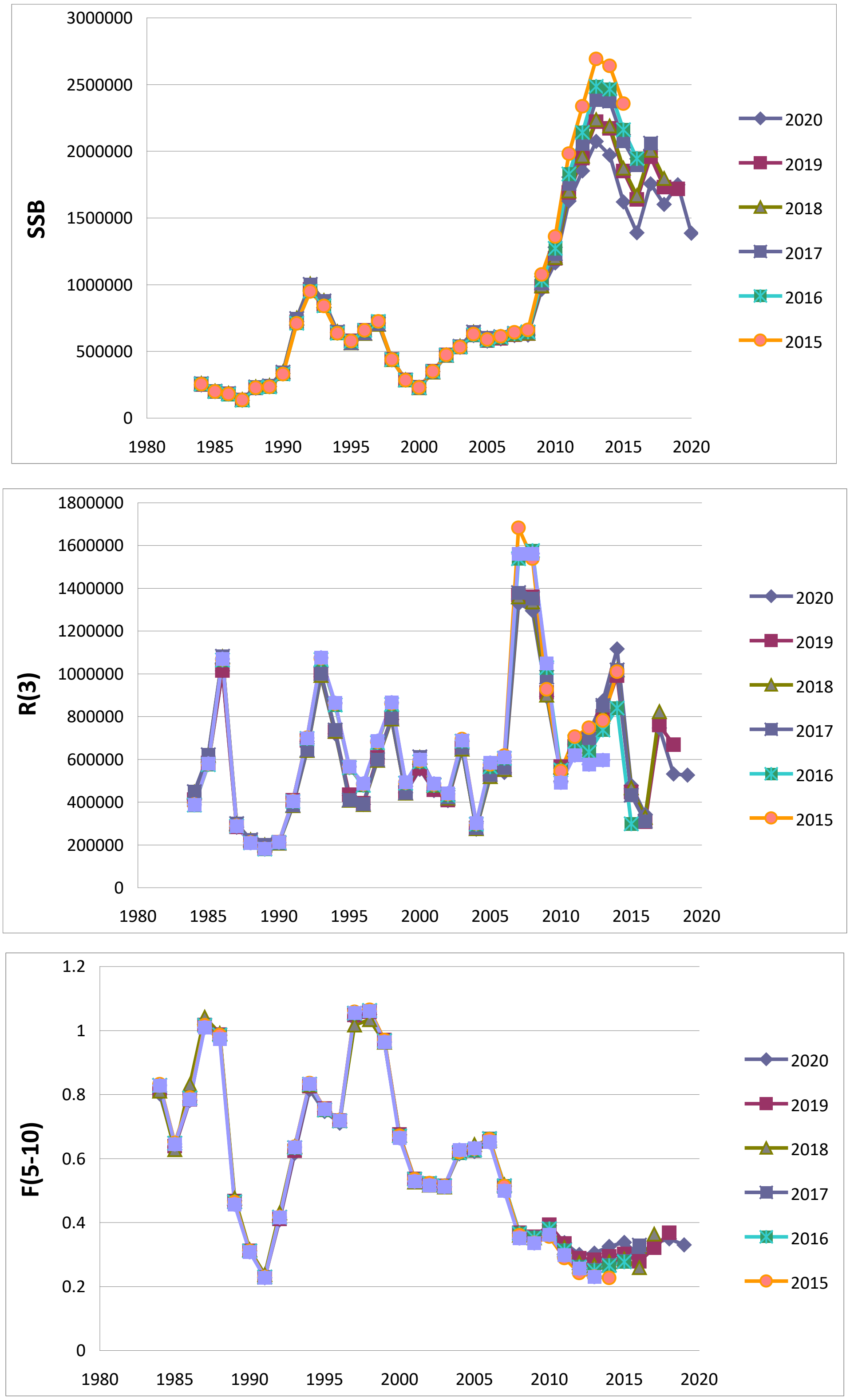


Figure 3.8c. TISVPA retrospective runs

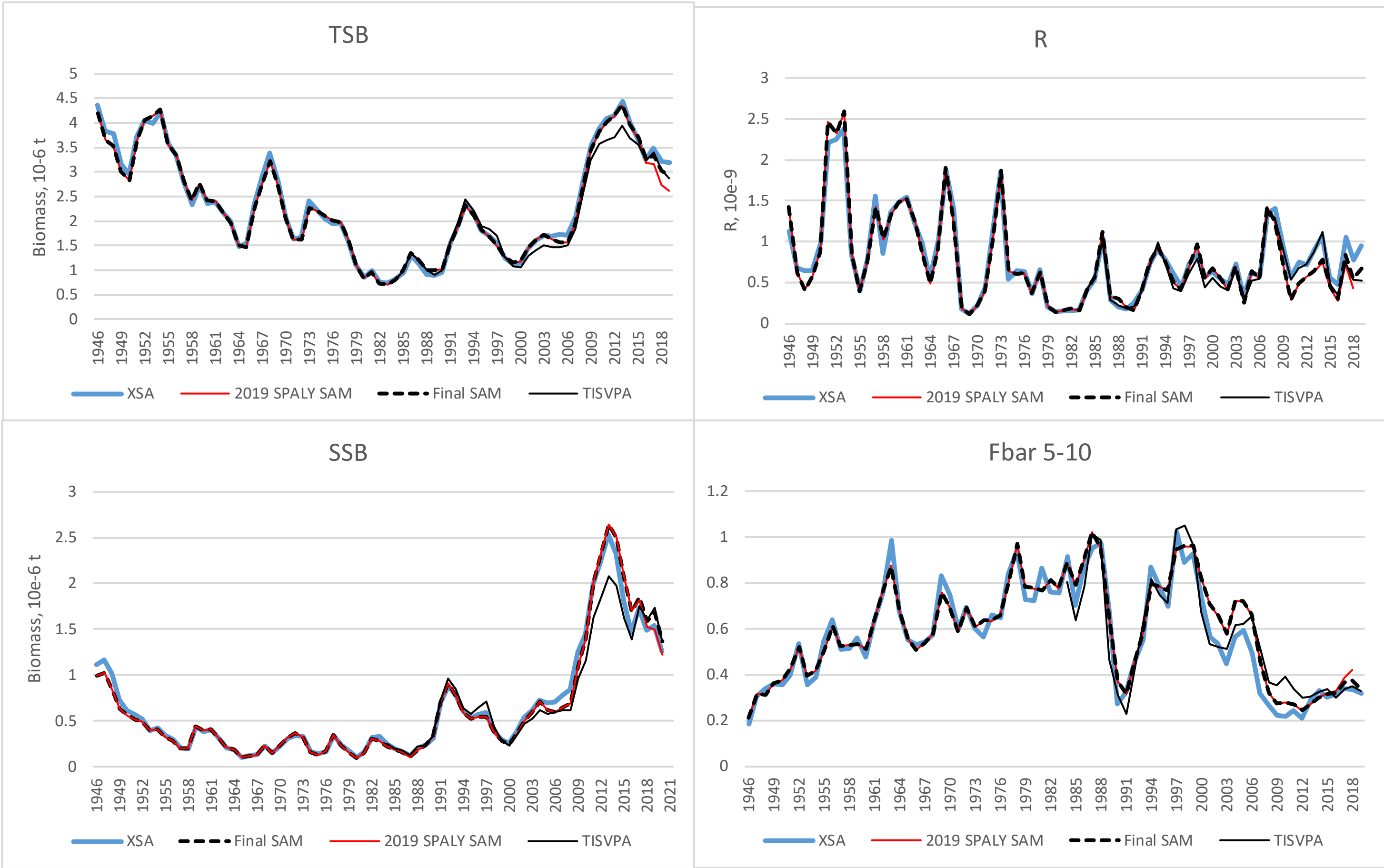


Figure 3.9a. Model comparison. F, SSB, TSB and recruitment in SAM, XSA and TISVPA.

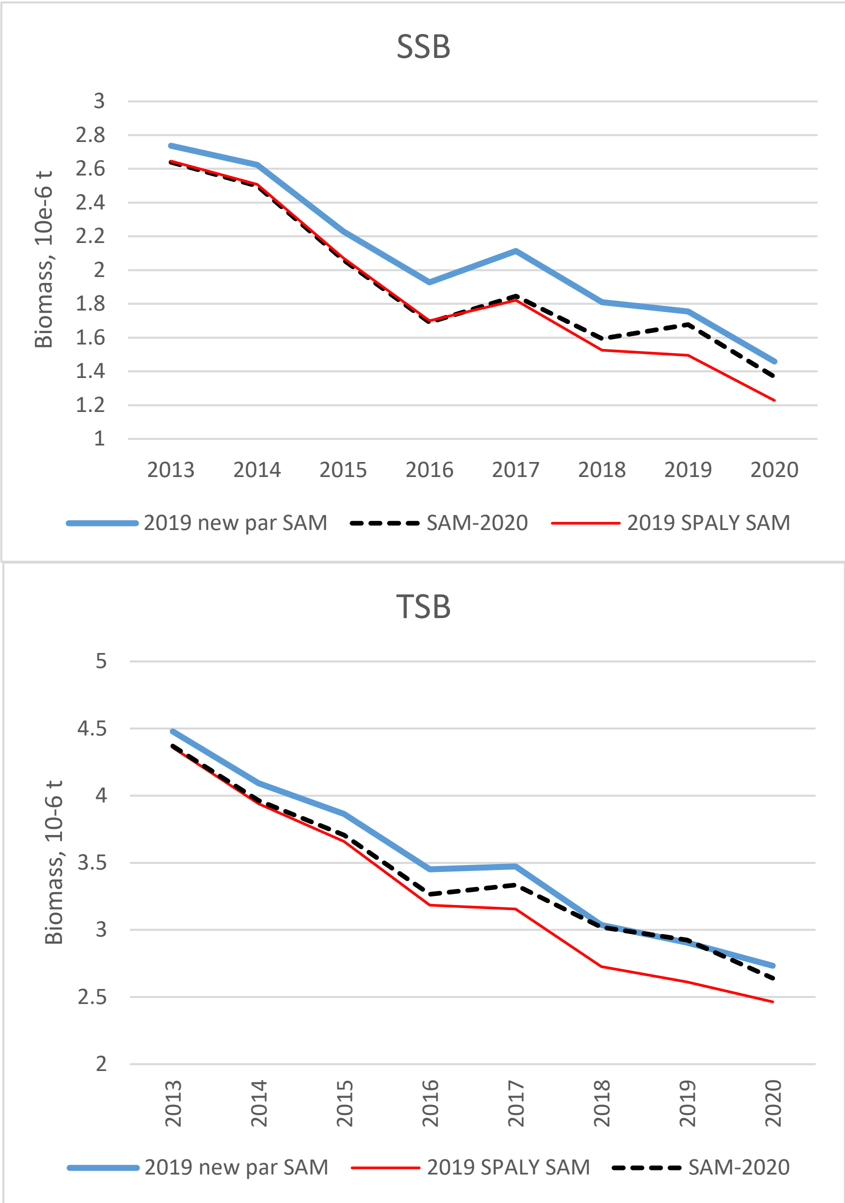


Figure 3.9b. NEA cod biomass dynamic assessed (2013–2018) and predicted (2019–2020) by SAM using two alternative settings from AFWG-2019 and SAM from AFWG-2020.

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

2015	1.06	1.38	1.93	4.54[6]
2016	1.15	1.06	1.39	3.64[6]
2017	1.00	1.00	1.05	3.01[6]
2018	1.06	1.40	1.31	3.20[6]
2019[1]	1.01	0.89	1.16	3.02[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] 2011-2019 Norwegian data on t per hr fishing are from single-trawl only, not comparable to data from previous years

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

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

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

Year	Age														10+	Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	
1981	8.00	82.00	40.00	63.00	106.00	103.00	16.00	3.00	1.00							1.00	423.0
1982	4.00	5.00	49.00	43.00	40.00	26.00	28.00	2.00	+							0.00	197.0
1983	60.49	2.78	5.34	14.27	17.37	11.13	5.58	2.98	0.45							0.06	120.5
1984	745.44	146.11	39.13	13.59	11.26	7.44	2.81	0.19	0.02							0.00	966.0
1985	69.06	446.29	153.04	141.59	19.66	7.58	3.32	0.22	0.09							0.04	840.9
1986	353.63	243.90	499.61	134.27	65.90	8.28	2.15	0.37	0.06							0.02	1308.2
1987	1.62	34.07	62.80	204.93	41.41	10.40	1.22	0.19	0.66							0.00	357.3
1988	1.98	26.25	50.42	35.53	56.20	6.48	1.35	0.15	0.01							0.00	178.4
1989	7.53	7.98	17.00	34.39	21.38	53.82	6.88	0.97	0.10							0.05	150.1
1990	81.13	24.92	14.82	20.63	26.08	24.30	39.78	2.37	0.06							0.03	234.1
1991	181.04	219.51	50.23	34.64	29.33	28.87	16.89	17.33	0.86							0.03	578.7
1992	241.38	562.13	176.48	65.79	18.84	13.23	7.58	4.50	2.78							0.21	1092.9
1993	1074.04	494.68	357.24	191.05	108.24	20.84	8.12	4.98	2.25							2.51	2264.0
1994	823.50	586.90	307.20	384.40	207.00	68.00	12.10	3.53	2.55	0.81	1.11	0.11	0.12	0.00	0.00	2.15	2397.4
1995	2106.60	217.90	143.00	138.00	198.30	67.00	16.10	2.46	0.90	0.32	0.53	0.16	0.00	0.00	0.00	1.01	2891.2
1996	1748.90	261.10	110.00	89.50	115.00	83.30	23.00	2.20	0.27	0.08	0.05	0.05	0.06	0.01	0.00	0.25	2433.4
1997 [1]	2832.90	842.90	209.20	49.20	51.50	43.10	24.90	5.73	1.00	0.23	0.22	0.00	0.00	0.03	0.00	0.48	4060.9
1998 [1]	2633.10	555.80	444.50	210.80	46.60	44.40	28.60	16.90	1.85	0.46	0.16	0.00	0.02	0.00	0.07	0.71	3983.2
1999	351.10	227.00	151.60	133.30	51.80	12.00	7.02	3.98	1.54	0.32	0.02	0.01	0.01	0.00	0.00	0.36	939.6
2000	142.40	248.10	301.10	168.80	147.10	49.00	12.10	4.48	2.85	0.80	0.18	0.12	0.03	0.00	0.00	1.13	1077.0
2001	348.30	50.80	179.00	162.30	81.10	44.00	11.30	1.73	0.47	0.18	0.10	0.00	0.00	0.00	0.01	0.29	879.4
2002	18.40	208.80	62.40	105.50	98.00	53.40	20.20	2.96	0.30	0.53	0.12	0.00	0.00	0.00	0.02	0.67	570.6
2003	1399.70	52.00	307.00	120.60	121.80	118.70	39.10	9.32	1.84	0.33	0.07	0.00	0.07	0.05	0.00	0.52	2170.5
2004	147.10	111.20	33.30	85.20	33.50	28.50	18.00	5.35	1.15	0.36	0.06	0.01	+	0.00	0.00	0.43	463.8
2005	438.20	123.20	129.80	34.90	69.10	21.20	15.00	4.95	0.95	0.27	0.04	0.06	0.05	0.03	0.00	0.45	837.7
2006 [2]	369.50	158.30	64.40	54.50	18.60	29.70	9.57	4.83	1.22	0.19	0.11	0.22	0.00	0.00	0.00	0.52	711.2
2007 [1]	88.90	53.70	63.90	35.70	32.70	9.68	18.80	6.57	2.74	0.51	0.24	0.09	0.04	0.00	0.00	0.88	313.6
2008	48.50	91.90	196.10	292.00	116.00	73.70	21.10	14.10	2.62	0.72	0.05	0.02	0.01	0.00	0.00	0.80	856.8
2009	195.50	23.20	104.60	191.60	139.70	40.90	14.10	4.70	4.38	0.48	0.13	0.02	0.01	0.00	0.00	0.64	719.4
2010	696.10	41.80	21.80	86.90	161.80	153.80	46.20	14.40	3.87	2.86	0.91	0.11	0.14	0.09	0.01	4.12	1230.9
2011	248.50	88.70	39.10	28.70	65.40	106.60	102.40	19.40	6.71	1.49	1.07	0.28	0.13	0.10	0.02	3.09	708.5
2012 [2]	508.10	45.30	87.80	47.60	35.10	70.90	135.80	60.30	8.19	5.19	1.26	0.66	0.45	0.01	0.10	7.67	1006.7
2013	293.30	82.40	59.10	85.40	70.60	50.20	100.00	129.90	57.00	5.37	3.98	1.63	0.70	0.21	0.05	11.94	939.8
2014	582.20	154.20	234.00	115.90	96.00	68.40	37.70	84.70	55.30	24.10	2.46	1.51	0.17	0.04	0.16	28.44	1456.8
2015	1183.00	107.60	110.20	188.00	119.50	130.20	84.90	33.80	51.70	23.00	6.27	0.57	0.14	0.04	0.01	30.03	2038.9
2016	106.20	111.50	35.20	61.60	101.20	64.50	49.20	23.10	11.90	16.30	7.37	2.25	0.69	0.25	0.09	26.95	591.4
2017 [2]	381.50	42.80	80.60	33.00	37.60	58.00	33.00	22.30	10.30	3.81	3.00	3.15	0.59	0.20	0.10	10.85	710.0
2018	1492.00	221.20	93.30	134.00	46.70	51.90	56.10	35.10	10.00	6.65	1.38	2.14	1.55	0.14	0.25	12.11	2152.4
2019	1000.30	287.40	182.10	97.70	124.30	53.40	33.70	31.60	8.70	2.83	0.38	0.33	0.20	0.23	0.16	4.13	1823.3
2020 [2]	77.80	148.90	97.15	103.90	68.92	81.45	41.35	25.14	17.45	6.44	1.60	0.56	0.64	0.50	0.51	10.25	1372.0

[1] Survey covered a larger area

[2] Adjusted indices

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

				Age														
Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	10+	Total
1981		4.60	34.30	16.40	23.30	40.00	38.40	4.80	1.00	0.30							0.00	163.1
1982		0.80	2.90	28.30	27.70	23.60	15.50	16.00	1.40	0.20							0.00	116.4
1983		152.90	13.40	24.95	52.34	43.33	16.96	5.82	3.21	0.97							0.05	313.9
1984		2755.04	379.11	97.49	28.28	21.44	11.74	4.07	0.40	0.08							0.08	3297.7
1985		49.49	660.04	166.79	125.98	19.92	7.67	3.34	0.21	0.07							0.05	1033.6
1986		665.79	399.61	805.00	143.93	64.14	8.30	1.91	0.34	0.04							0.03	2089.1
1987		30.72	444.98	240.38	391.15	54.35	15.70	2.00	0.45	0.03							0.00	1179.8
1988		3.21	72.83	148.03	80.49	173.31	20.48	3.58	0.53	0.03							0.00	502.5
1989		8.24	15.62	46.36	75.86	37.79	90.19	9.82	0.94	0.10							0.07	285.0
1990		207.17	56.72	28.35	34.87	34.59	20.56	27.23	1.61	0.38							0.03	411.5
1991		460.45	220.14	45.85	33.67	25.65	21.49	12.15	12.67	0.61							0.02	832.7
1992		126.56	570.92	158.26	57.71	17.82	12.83	7.67	4.29	2.72							0.22	959.0
1993		534.48	420.40	273.89	140.13	72.48	15.83	6.24	3.89	2.23							2.36	1471.9
1994		1044.50	545.50	296.80	307.60	152.60	46.80	8.13	2.59	1.32	0.55	0.52	0.11	0.05	0.00	0.00	1.23	2407.0
1995		5343.80	540.20	280.40	242.10	252.30	77.10	17.90	2.33	1.13	0.55	0.59	0.19	0.00	0.00	0.00	1.33	6758.7
1996		5908.30	778.60	164.00	116.70	140.70	111.20	24.80	2.79	0.37	0.16	0.08	0.08	0.05	0.02	0.00	0.39	7247.9
1997	1	5122.80	1413.70	315.40	69.20	75.00	60.70	26.80	4.95	0.63	0.68	0.46	0.00	0.00	0.00	0.00	1.14	7090.2
1998	1	2512.10	492.50	355.20	167.40	31.70	26.40	17.50	8.26	0.79	0.52	0.65	0.00	0.35	0.00	0.04	1.56	3613.4
1999		479.70	353.60	189.60	181.90	61.30	12.80	6.83	5.19	0.98	0.27	0.02	0.03	0.02	0.00	0.00	0.34	1292.2
2000		128.20	242.80	247.50	130.00	112.00	27.00	4.73	1.82	1.23	0.36	0.10	0.03	0.02	0.00	0.00	0.51	895.8
2001		715.80	77.60	182.00	194.50	81.60	38.00	9.58	1.19	0.45	0.19	0.04	0.00	0.00	0.00	0.01	0.24	1300.9
2002		34.20	416.20	118.00	137.70	108.60	46.50	14.50	2.19	0.34	0.19	0.05	0.00	0.00	0.00	0.02	0.26	878.5
2003		3021.40	61.20	380.80	125.40	95.20	66.60	17.90	4.72	1.02	0.16	0.04	0.00	0.02	0.02	0.00	0.24	3774.3
2004		321.30	236.30	65.50	186.10	53.60	43.20	30.90	6.92	1.66	0.29	0.08	0.01	0.01	0.00	0.00	0.39	945.8
2005		846.80	216.40	244.80	54.80	102.70	22.40	16.40	3.80	0.88	0.30	0.04	0.02	0.03	0.04	0.00	0.43	1509.5
2006	2	676.90	283.80	115.60	114.00	28.10	43.30	14.00	5.19	1.34	0.22	0.21	0.08	0.00	0.00	0.00	0.51	1282.6
2007	1	584.20	369.90	365.80	127.30	68.90	13.70	23.60	6.85	2.20	0.40	0.31	0.08	0.00	0.00	0.00	0.79	1563.2
2008		69.00	103.30	192.50	300.00	115.60	40.80	18.00	8.29	1.86	0.35	0.02	0.02	0.01	0.00	0.00	0.40	850.0
2009		389.40	35.50	124.30	196.10	218.00	58.20	17.50	8.44	5.27	0.50	0.18	0.03	0.03	0.00	0.00	0.74	1053.4
2010		1031.50	96.50	37.00	114.90	155.50	144.50	39.80	11.20	3.70	1.64	0.57	0.05	0.02	0.03	0.02	2.33	1637.0
2011		615.30	225.60	85.40	50.70	129.90	138.00	103.10	16.70	4.34	1.17	0.79	0.20	0.17	0.04	0.02	2.39	1371.4
2012	3	728.40	124.80	83.10	70.30	36.40	93.90	136.30	49.60	9.38	2.33	0.87	0.60	0.47	0.02	0.05	4.34	1336.6
2013		439.10	147.20	70.30	119.80	64.00	41.00	65.00	76.20	33.60	2.21	2.83	0.41	0.35	0.06	0.03	5.89	1062.0
2014		499.80	148.80	180.60	85.10	67.90	47.80	32.60	46.90	31.70	9.36	1.01	0.97	0.15	0.04	0.07	11.60	1153.0
2015		1295.00	196.80	125.40	170.20	135.70	99.80	71.20	27.40	52.80	17.00	2.86	0.72	0.10	0.07	0.04	20.79	2194.8
2016		212.30	232.90	53.40	112.30	151.30	109.00	66.10	26.60	12.80	15.00	6.43	0.96	0.50	0.17	0.14	23.20	1000.0
2017	3	471.50	71.00	116.10	39.70	48.70	56.60	27.80	18.90	7.63	3.01	2.22	3.49	0.53	0.17	0.06	9.48	867.5
2018		1686.20	394.80	107.60	148.70	46.10	55.70	53.40	23.90	7.48	5.41	1.13	2.24	1.19	0.13	0.39	10.49	2529.3
2019		1291.70	446.00	253.70	132.00	188.60	66.40	27.00	28.80	7.60	1.72	0.34	0.17	0.14	0.13	0.10	2.60	2444.3
2020	3	139.71	259.02	193.71	140.13	103.75	96.43	46.80	18.87	14.86	3.82	1.13	0.31	0.40	0.26	0.33	6.25	1019.5

1 Indices raised to also represent the Russian EEZ.

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

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

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

Year	5	6	7	8	9	10	11	12	13	14+	12+	Sum
1985	0.68	7.45	12.36	3.11	1.15	1.01	0.45					26.21
1986	2.49	3.30	5.54	2.71	0.16		0.40				0.08	14.68
1987	8.77	7.04	0.23	2.83	0.04		0.03				0.03	18.97
1988	1.57	4.43	2.56	0.05	0.01	0.05						8.67
1989	0.04	13.20	9.73	2.20	0.38	0.12					0.06	25.73
1990	0.13	2.60	27.02	4.85	0.49	0.32						35.41
1991	0.00	5.00	19.83	32.67	2.75	0.19	0.17					60.61
1992	2.74	5.23	20.80	20.87	79.60	4.17	1.61				0.22	135.24
1993	4.87	14.58	17.35	20.22	25.44	41.95	4.74				0.71	129.86
1994	23.78	25.85	10.36	8.21	7.68	3.49	17.53				2.61	99.51
1995	6.49	35.24	12.34	2.27	3.60	2.56	2.15				7.96	72.61
1996	1.41	14.43	24.00	3.65	0.79	0.25	0.80				1.30	46.63
1997	0.40	4.95	27.56	16.50	1.50	0.42					0.75	52.08
1998	0.05	0.30	7.06	11.05	3.24	0.51	0.18				0.02	22.41
1999	0.25	1.92	4.84	14.58	8.42	0.75	0.19				0.10	31.05
2000	3.61	3.85	3.25	2.15	2.23	0.45	0.39				0.05	15.98
2001	4.33	17.61	8.03	0.96	0.33	0.36	0.26				0.09	31.97
2002	2.30	19.11	16.50	6.49	0.83	0.31	0.47				0.01	46.02
2003	2.49	29.56	30.01	13.46	1.90	0.11	0.04				0.02	77.59
2004	1.96	17.52	29.82	16.34	7.67	2.04	0.15				0.68	76.18
2005	3.33	12.93	28.75	13.06	6.51	1.55	0.06				0.16	66.35
2006	0.20	12.50	8.11	10.98	7.42	2.12	0.16				0.66	42.14
2007	1.46	3.88	28.52	8.69	5.35	2.80	0.68				0.36	51.72
2008	0.45	5.96	2.95	20.72	2.70	2.02	1.66				0.71	37.17
2009	3.42	14.48	27.64	8.10	22.31	3.07	1.56				0.37	80.95
2010	1.22	32.60	26.50	23.68	7.56	6.32	0.81				1.54	100.22
2011	2.02	51.01	178.92	48.47	18.10	4.58	6.98				0.44	310.50
2012	0.37	13.43	98.37	77.69	20.53	7.37	3.18				1.80	222.74
2013	0.22	5.84	33.44	101.10	105.50	15.91	7.01				6.38	275.40
2014	0.25	2.83	15.42	58.13	111.90	75.33	12.25				8.84	284.95
2015	0.96	1.58	16.09	15.66	42.91	44.45	26.80				11.01	159.46
2016	0.15	1.21	7.50	12.00	19.09	32.63	22.84	15.85	7.97	1.89	25.70	121.11
2017	0.18	8.94	12.86	24.07	14.76	12.58	11.58	12.01	3.72	3.51	19.24	104.20
2018	0.62	3.48	11.45	11.21	8.48	7.78	4.44	3.73	2.82	3.06	9.61	57.25
2019	0.54	2.88	14.33	36.09	17.67	18.41	6.10	2.54	2.44	5.03	10.01	106.02
2020	0.58	3.72	8.22	24.29	28.07	13.31	6.63	1.97	1.43	1.92	6.32	90.15

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

	Age													
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1981	17.0	26.1	35.5	44.7	52.0	61.3	69.6	77.9						
1982	14.8	25.8	37.6	46.3	54.7	63.1	70.8	82.9						
1983	12.8	27.6	34.8	45.9	54.5	62.7	73.1	78.6						
1984	14.2	28.4	35.8	48.6	56.6	66.2	74.1	79.7						
1985	16.5	23.7	40.3	48.7	61.3	71.1	81.2	85.7						
1986	11.9	21.6	34.4	49.9	59.8	69.4	80.3	93.8						
1987	13.9	21.0	31.8	41.3	56.3	66.3	77.6	87.9						
1988	15.3	23.3	29.7	38.7	47.6	56.8	71.7	79.4						
1989	12.5	25.4	34.7	39.9	46.8	56.2	67.0	83.3						
1990	14.4	27.9	39.4	47.1	53.8	60.6	68.2	79.2						
1991	13.6	27.2	41.6	51.7	59.5	67.1	72.3	77.6						
1992	13.2	23.9	41.3	49.9	60.2	68.4	76.1	82.8						
1993	11.3	20.3	35.9	50.8	59.0	68.2	76.8	85.8						
1994	11.3	17.9	30.2	44.6	55.1	65.5	73.8	78.5	87.5	97.9	97.7	100.8	122.1	-
1995	12.2	18.0	28.8	42.1	54.0	63.7	75.7	80.2	83.9	99.1	+	109.0	-	-
1996	12.1	18.9	28.7	40.6	49.3	60.9	71.7	84.8	92.2	92.2	99.5	104.6	108.7	121.0
1997	10.9	15.9	26.8	39.9	49.5	59.2	69.9	81.6	91.8	+	+	-	-	-
1998	9.8	18.0	29.3	40.0	50.9	58.9	67.7	76.7	87.4	+	+	-	+	-
1999	12.0	18.3	29.0	39.9	50.4	59.4	70.4	78.5	88.7	88.4	+	+	+	-
2000	12.9	20.7	28.4	39.7	51.5	61.4	70.5	76.2	84.8	81.8	99.7	+	+	-
2001	11.6	22.6	33.0	41.1	52.2	63.3	70.2	77.7	86.0	96.2	103.8	-	-	-
2002	12.0	19.5	28.6	43.6	52.1	62.0	71.3	79.5	91.0	89.3	102.3	-	-	-
2003	11.4	18.0	28.9	39.4	53.4	61.7	70.6	80.8	89.1	90.6	104.5	-	105.8	111.6
2004	10.6	18.4	31.7	40.6	51.7	61.6	68.6	79.7	90.9	88.5	91.7	+	+	-
2005	11.2	18.3	29.5	43.5	51.1	60.3	71.0	79.6	88.9	96.2	109.4	+	+	+
2006	12.0	19.5	30.9	42.1	53.6	60.2	66.4	76.5	84.5	98.8	93.2	96.3	-	-
2007	13.1	21.0	29.4	40.2	53.1	62.9	68.7	76.6	87.6	94.9	102.4	+	-	-
2008	12.1	22.4	33.1	43.2	51.7	64.1	69.0	81.3	88.4	94.6	108.9	+	+	-
2009	11.2	21.2	32.1	42.6	53.1	61.7	76.5	81.8	89.3	97.9	99.9	+	+	-
2010	11.2	18.2	31.5	42.7	52.4	60.7	70.6	80.4	88.5	96.2	102.7	+	+	+
2011	11.9	19.4	29.5	41.9	51.0	60.7	68.1	78.3	85.9	95.2	101.3	111.1	111.7	119.0
2012	10.6	18.4	29.7	41.0	52.4	58.0	66.5	75.7	86.0	91.4	106.2	113.4	119.7	+
2013	11.2	19.2	31.0	41.0	51.6	62.1	69.7	76.5	81.1	95.2	92.2	110.7	110.7	+
2014	9.8	17.3	29.1	40.1	51.8	59.5	70.3	77.0	81.9	87.1	96.7	98.1	110.5	+
2015	10.5	16.2	30.0	39.9	51.2	60.5	69.0	77.6	80.1	88.9	95.4	101.4	+	+
2016	12.2	18.5	29.9	40.6	50.0	60.6	68.3	76.7	85.6	86.0	90.0	92.6	111.8	122.2
2017	12.4	21.8	31.4	42.3	51.9	60.8	69.7	79.5	85.9	90.6	96.3	91.9	106.9	108.7
2018	11.2	18.6	31.9	42.2	51.1	61.5	68.9	77.6	83.7	87.9	97	98.8	100.1	105.8
2019	11.8	17.2	31.1	41.6	50.8	59.6	69.6	77.0	83.6	89.6	100.1	102.1	107.3	104.5
2020	11.9	17.4	24.4	39.1	49.7	58.4	66.5	75.5	83.3	90.1	94.6	100.8	109.2	113.9

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

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

Year \ Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1983	20	190	372	923	1597	2442	3821	4758						
1984	23	219	421	1155	1806	2793	3777	4566						
1985	20	171	576	1003	2019	3353	5015	6154						
1986	20	119	377	997	1623	2926	3838	7385						
1987	21	65	230	490	1380	2300	3970	6000						
1988	24	114	241	492	892	1635	3040	4373						
1989	16	158	374	604	947	1535	2582	4906	10943	5226				
1990	26	217	580	1009	1435	1977	2829	4435	10772	11045	9615			
1991	18	196	805	1364	2067	2806	3557	4502	7404	13447				
1992	20	136	619	1118	1912	2792	3933	5127	6420	8103	17705	22060		
1993	9	71	415	1179	1743	2742	3977	5758	7068	7515	7521	10744		
1994	12	55	260	796	1463	2372	3477	4624	6782	8420	8530	13516	20786	-
1995	15	53	239	656	1341	2194	3628	4577	5315	8907	+	12176	-	-
1996	15	62	232	632	1079	1979	3327	5479	7655	8192	9760	13013	13614	14650
1997	13	46	181	592	1097	1785	2917	4928	7290	+	+	-	-	-
1998	8	50	256	608	1184	1749	2601	4040	6383	+	+	-	+	-
1999	14	58	231	588	1178	1827	2994	4123	6343	7326	+	+	+	-
2000	16	74	210	558	1210	1961	3042	3842	5384	5727	9960	+	+	-
2001	14	106	336	642	1288	2233	3090	4332	5727	8571	11022	-	-	-
2002	14	67	233	747	1225	2065	3189	4577	7472	6431	11645	-	-	-
2003	13	59	229	586	1313	2013	2982	4725	6511	7552	12467	-	12885	16112
2004	10	59	276	607	1142	1946	2618	4139	6684	6988	7957	+	+	-
2005	13	61	245	724	1145	1857	2953	4224	6418	8607	12488	+	+	+
2006	13	69	280	663	1413	1965	2599	4244	5783	10131	8620	10735	-	-
2007	17	71	226	638	1370	2270	2918	4254	6556	8727	11130	+	-	-
2008	15	90	336	799	1410	2449	3144	5218	6793	9494	12918	+	+	-
2009	13	84	294	704	1293	2030	4061	5082	6884	9504	9614	+	+	-
2010	11	64	307	702	1297	2031	3165	4736	6501	9016	10417	+	+	+
2011	15	65	247	667	1129	1940	2725	4003	5914	8233	9888	13213	13814	+
2012	13	62	251	609	1278	1673	2480	3772	5923	7783	12298	14876	17868	+
2013	11	65	264	591	1201	2064	2804	3839	4814	8433	8759	15101	14729	+
2014	8	49	238	592	1234	1776	2849	3942	4946	6181	8368	9212	12578	+
2015	10	47	242	574	1250	1971	2760	4077	4621	6901	8096	11366	+	+
2016	13	54	239	602	1063	1952	2701	3855	5553	6034	6963	8061	15330	21950
2017	16	92	297	737	1253	2016	3091	4645	6088	7403	9186	8412	12416	14916
2018	12	66	305	687	1237	2074	2867	4180	5536	6793	9222	10497	11164	12268
2019	12	46	272	652	1157	1883	2916	3994	5303	6926	10034	11535	13243	11926
2020	13	44	137	540	1050	1671	2482	3764	5158	6838	8405	11259	14441	15785

1987: Estimated weights

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

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

Year/age	5	6	7	8	9	10	11	12	13	14	12+
1985	59.6	71.1	79.0	88.2	97.3	105.2	114.0				
1986	62.7	70.0	80.0	89.4	86.6		105.8				115.0
1987	58.2	64.5	76.7	86.2	88.0		118.5				116.0
1988	53.1	67.1	71.6	94.0	97.0	119.6					
1989	54.0	59.0	69.8	80.8	96.6	103.0					125.0
1990	56.9	65.1	69.2	79.5	83.7	100.1					
1991	59.0	67.3	74.4	81.0	91.3	99.8	85.0				
1992	66.3	68.7	78.3	83.9	89.2	92.2	101.9				127.0
1993	58.3	66.1	72.8	83.6	87.4	92.7	95.4				111.2
1994	64.3	70.6	82.0	87.3	90.0	95.3	92.4				101.4
1995	61.5	69.7	77.8	84.4	92.6	96.7	100.3				99.5
1996	62.2	67.1	75.9	81.0	93.6	100.9	97.4				104.1
1997	63.7	68.6	74.2	83.8	99.9	108.4					109.0
1998	55.0	62.6	70.2	80.0	92.0	98.0	96.7				115.0
1999	52.7	67.0	69.4	78.6	85.8	100.3	102.0				125.0
2000	58.4	66.5	72.6	77.0	83.9	90.6	93.7				112.4
2001	59.3	66.9	73.2	87.1	88.7	102.8	98.5				128.2
2002	58.6	66.0	73.2	80.8	88.2	101.8	91.0				101.4
2003	62.3	65.0	73.2	80.9	88.9	86.4	120.0				122.0
2004	58.8	64.7	71.2	80.1	85.6	97.0	102.6				115.8
2005	56.3	65.4	72.3	76.0	85.3	95.5	110.5				117.8
2006	56.2	63.7	72.6	77.5	82.9	88.3	89.2				116.3
2007	63.0	66.4	72.4	82.5	88.2	99.8	103.7				115.0
2008	63.8	69.1	73.6	80.9	90.0	94.9	94.9				96.5
2009	60.5	69.3	76.5	82.7	88.7	98.8	92.9				111.6
2010	60.6	64.2	75.0	82.8	93.9	93.7	102.8				108.1
2011	56.8	64.5	70.0	79.9	91.1	96.7	101.1				104.8
2012	59.6	65.4	69.9	77.0	85.4	99.0	105.2				106.0
2013	63.6	68.8	73.1	78.2	83.5	90.9	99.1				96.6
2014	57.2	65.8	74.3	77.9	82.8	86.8	93.3				99.0
2015	60.4	67.8	73.0	78.3	83.0	88.3	94.7				99.2
2016	58.2	63.0	74.4	80.1	89.1	92.9	95.7				97.1
2017	57.6	64.9	70.7	80.9	87.3	94.7	98.6	99.3	102.6	106.6	
2018	67.9	66.8	72.8	79.5	89.4	93.6	99.3	104.9	104.3	109.2	
2019	58.8	68.6	74.7	81.4	87.9	93.9	98.1	106.2	111.1	109.6	
2020	66.1	68.2	74.9	81.8	88.9	95.1	96.3	106.0	109.5	111.6	

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

Year	5	6	7	8	9	10	11	12	13	14+	12+
1985	2.00	3.42	4.61	6.67	8.89	10.73	14.29				
1986	2.22	3.22	4.74	6.40	5.80		10.84				13.48
1987	1.44	1.94	3.61	5.40	5.64		13.15				12.55
1988	1.46	2.82	3.39	6.63	7.27	13.64					
1989	1.30	1.77	2.89	4.74	8.28	9.98					26.00
1990	1.54	2.32	2.55	3.78	4.77	8.80					
1991	2.21	2.52	3.51	5.18	7.40	11.36	5.35				
1992	2.56	2.85	3.99	5.43	6.35	8.03	9.50				17.80
1993	1.79	2.58	3.55	5.31	6.21	7.69	9.28				14.71
1994	2.31	3.27	5.06	6.39	6.64	7.92	7.73				10.10
1995	2.20	3.24	4.83	5.98	7.80	10.03	10.39				10.68
1996	2.22	2.75	4.11	5.63	7.92	10.53	10.58				12.08
1997	2.42	2.92	3.86	5.71	9.65	13.41					12.67
1998	1.88	2.09	2.98	4.85	7.92	9.91	11.05				18.34
1999	1.51	2.80	2.96	4.22	5.92	9.33	9.17				16.00
2000	1.71	2.50	3.16	3.85	5.32	7.07	7.62				12.84
2001	1.90	2.72	3.49	6.23	6.82	10.95	10.29				28.58
2002	1.87	2.57	3.52	4.71	6.18	10.56	8.70				10.48
2003	2.30	2.34	3.48	4.59	5.89	8.07	24.50				27.70
2004	1.74	2.30	3.02	4.50	5.77	7.81	9.95				13.25
2005	1.56	2.40	3.20	3.71	5.79	8.52	16.27				18.63
2006	1.54	2.35	3.44	4.19	5.43	6.57	6.19				18.15
2007	2.34	2.67	3.53	5.30	6.70	9.95	11.24				16.62
2008	2.21	2.97	3.63	4.88	6.74	8.18	7.70				9.07
2009	2.04	2.98	4.10	5.19	6.56	9.38	8.58				15.67
2010	1.91	2.28	3.60	4.70	7.03	7.11	9.09				12.50
2011	1.61	2.29	2.89	4.51	6.79	8.30	9.46				10.54
2012	2.34	2.46	2.93	3.93	5.39	8.91	11.68				12.56
2013	2.49	3.04	3.51	4.43	5.54	7.56	10.25				11.69
2014	2.00	2.45	3.76	4.05	5.06	5.97	7.34				10.37
2015	2.14	2.66	3.44	3.91	5.06	6.27	7.89				11.32
2016	2.55	2.23	3.65	4.80	6.67	7.74	8.68	8.83	12.63	18.02	10.68
2017	1.96	2.48	2.94	4.80	5.74	7.12	8.16	9.12	10.43	12.31	
2018	3.25	2.72	3.41	4.53	6.51	7.94	9.69	12.06	12.05	13.14	
2019	1.90	2.89	3.72	4.82	6.07	7.43	8.68	11.07	13.87	13.42	
2020	2.75	2.78	3.60	4.69	6.06	7.78	8.71	10.86	12.94	15.00	

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

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

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

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

Year				Age												
		0	1	2	3	4	5	6	7	8	9	10	11	12	13+	Sum
				Total (Sub-area I and Division IIa and IIb)												
1982		849.3	1905.3	33.2	141.3	152.5	72.1	19.8	55.1	17.4	3.7	1.9	1.5	0.1	0.0	3253.3
1983		1872.2	2003.4	73.2	52.0	64.2	50.6	35.8	17.9	25.2	9.4	0	0	0	0	4203.9
1984		363.3	180.5	104.4	118.9	70.0	48.9	35.7	15.4	6.9	6.1	1.7	1.5	0.6	0.2	954.0
1985		284.6	15.6	129.0	118.8	159.2	106.8	36.5	16.5	3.7	0.8	1.6	0.1	2.1	0.0	875.3
1986		329.9	7.6	31.7	162.2	153.2	149.3	48.1	18.9	4.2	0.2	0.6	0.0	0.0	0.0	905.9
1987		7.7	1.3	46.9	55.7	307.6	90.0	70.1	18.4	6.0	2.5	0.4	0.1	0.3	0.0	607.0
1988		92.5	2.9	31.3	99.3	93.8	287.9	58.3	26.0	4.7	2.4	0.1	0.0	0.0	0.0	699.2
1989		355.8	3.0	14.7	49.0	97.8	106.2	145.4	116.7	29.9	11.2	4.7	1.8	0.7	0.5	937.4
1990		1248.4	31.1	51.0	16.7	48.7	62.7	97.2	153.8	67.3	15.3	4.9	0.9	0.2	0.0	1798.2
1991		974.0	64.0	91.1	107.7	48.4	53.2	58.3	68.5	74.7	9.8	1.4	0.3	0.0	0.0	1551.4
1992		1204.8	157.7	151.1	67.5	30.8	23.9	27.3	21.8	17.5	2.5	2.5	0.4	0.0	0.0	1707.8
1993		484.8	38.0	158.6	160.4	113.5	68.1	41.6	35.4	8.7	0.3	0.7	0.1	0.1	0.0	1110.3
1994		1606.6	833.2	69.9	136.3	130.9	101.9	35.4	12.8	4.9	2.1	1.1	0.6	0.2	0.0	2935.9
1995		5703.5	471.9	36.9	58.9	106.5	139.5	84.9	25.1	8.3	1.9	1.8	0.9	0.6	0.0	6640.8
1996		2660.3	396.5	128.5	73.3	78.4	103.5	77.3	34.8	13.2	1.9	0.5	1.2	0.2	0.0	3569.6
1997		1371.4	353.9	135.3	134.2	83.5	61.3	60.2	34.8	11.6	3.2	3.0	0.0	0.0	0.0	2252.4
1998		304.8	276.8	89.6	202.8	136.3	78.8	47.0	25.9	13.0	4.8	0.5	0.0	0.1	0.0	1180.4
1999		266.9	40.1	118.4	158.7	207.2	98.0	30.1	12.3	9.4	4.2	0.4	0.0	0.0	0.0	945.7
2000		1436.5	37.7	103.6	183.9	128.6	178.6	77.3	11.4	5.2	2.3	0.9	0.4	0.0	0.0	2166.4
2001		321.6	233.8	77.3	122.4	155.7	129.0	106.1	30.4	5.0	1.4	0.5	2.5	1.3	0.0	1187.1
2002		1797.9	26.7	135.6	98.0	147.3	147.3	89.6	60.0	18.2	2.9	0.8	0.1	0.1	0.0	2524.4
2003		489.5	517.5	26.8	124.6	105.7	116.6	120.3	53.5	24.1	4.0	0.9	0.3	0.0	0.1	1583.9
2004		1770.4	158.4	87.5	32.9	157.6	88.0	111.1	77.6	27.9	9.3	2.3	0.4	0.2	0.0	2523.6
2005		2298.0	323.9	61.7	140.8	63.1	183.2	74.4	60.5	24.4	8.8	2.8	0.6	0.1	0.0	3242.4
2006		427.4	52.4	63.2	92.7	161.3	77.7	180.1	66.2	34.2	16.1	4.3	1.7	0.7	0.0	1178.1
2007		177.5	37.0	148.6	257.9	161.7	190.3	84.6	152.5	55.3	22.6	8.6	4.9	1.1	0.7	1303.3
2008		1468.6	45.2	86.3	220.3	308.8	163.5	147.2	83.0	86.3	29.1	11.5	3.3	1.7	0.2	2654.9
2009		1877.7	287.8	21.9	97.4	231.7	368.7	201.6	117.5	62.0	41.3	20.5	6.5	3.2	0.9	3338.7
2010	*	2210.4	214.9	47.0	33.4	107.0	250.5	371.5	181.7	78.9	39.5	29.9	15.6	5.5	2.0	3587.7
2011		2296.1	125.9	80.0	88.2	50.8	143.2	306.5	330.0	91.7	43.9	17.6	17.5	7.0	3.5	3602.1
2012		1096.0	196.2	45.1	81.5	111.4	83.9	212.2	335.8	187.8	43.2	19.5	4.6	5.7	1.9	2424.8
2013		297.1	654.0	107.6	74.7	117.4	117.7	88.4	234.9	313.2	136.7	30.6	9.2	5.4	4.5	2191.5
2014		909.7	211.0	72.1	139.9	136.8	172.5	148.3	111.1	192.9	129.7	38.3	9.3	3.5	2.0	2277.1
2015		572.9	465.4	51.5	65.7	158.3	174.2	193.2	161.0	92.5	115.8	76.1	24.2	6.5	4.9	2162.0
2016		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
2017		4325.9	5257.4	94.5	145.6	88.4	106.3	195.2	123.1	56.7	26.6	12.0	12.0	7.5	2.8	10454.0
2018		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
2019		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
*	corrected															

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

Year	Age												
	0	1	2	3	4	5	6	7	8	9	10	11	12
1984	15.7	22.3	30.7	44.3	51.7	63.6	73.4	82.5	88.4	97.0	-	-	-
1985	15.0	21.1	30.6	43.2	53.7	61.2	72.8	83.0	92.8	101.3	-	-	-
1986	15.2	19.7	28.3	39.0	51.8	62.2	70.9	83.0	91.3	104.0	-	-	-
1987	-	19.2	27.9	33.4	41.4	59.1	69.2	80.1	95.7	102.6	-	-	-
1988	11.3	21.3	28.7	36.2	43.9	53.3	65.3	79.5	85.0	-	-	-	-
1989	-	20.8	28.8	34.8	46.0	53.9	61.8	69.8	78.7	88.6	-	-	-
1990	16.0	24.0	30.4	46.5	54.9	62.5	69.7	77.6	87.8	102.0	-	-	-
1991	11.5	22.4	30.6	43.0	55.9	64.6	72.8	78.5	87.9	101.8	-	-	-
1992	11.3	21.3	31.9	50.1	59.8	69.1	78.6	84.0	90.8	97.5	-	-	-
1993	12.1	17.4	29.1	43.4	52.7	64.3	73.9	81.2	89.1	91.8	-	-	-
1994	12.2	20.3	26.3	33.7	47.4	58.7	70.6	80.8	90.1	96.1	-	-	-
1995	11.6	19.8	27.6	33.8	45.2	60.5	71.1	83.5	92.9	99.1	-	-	-
1996	10.2	20.0	28.1	36.7	48.7	58.9	70.5	80.0	93.6	102.7	-	-	-
1997	9.6	18.5	28.8	38.2	50.8	62.0	70.5	80.1	88.9	103.5	-	-	-
1998	11.4	19.0	28.0	36.4	50.5	61.0	70.7	80.3	91.1	102.5	-	-	-
1999	11.7	19.7	27.9	35.3	51.6	60.6	70.6	78.9	86.8	94.3	-	-	-
2000	10.7	20.8	30.1	34.7	49.8	61.1	71.6	82.0	88.3	85.7	104,2	-	-
2001	10.6	19.4	29.8	37.3	50.4	61.9	71.9	81.4	91.0	98.7	103,8	-	-
2002	10.7	19.2	29.9	38.2	52.5	60.4	70.6	82.2	91.3	97.2	104.1	-	-
2003	9.8	18.9	28.3	34.9	49.2	62.2	71.0	81.5	92.3	100.9	104.3	-	-
2004	9.8	19.6	29.3	38.4	49.1	60.0	70.5	80.0	91.0	98.0	106.0	-	-
2005	11.2	19.4	29.7	38.5	48.7	59.3	69.3	79.2	87.7	96.1	104.4	-	-
2006	13.0	21.9	31.6	42.7	53.2	60.1	70.2	79.1	88.3	95.2	107.7	-	-
2007	10.7	21.5	30.8	42.2	53.6	63.7	71.0	79.6	87.3	95.9	-	-	-
2008	10.2	20.0	30.3	40.2	53.7	64.5	74.6	82.7	89.5	98.2	102.3	110.2	111.9
2009	12.9	19.3	29.5	38.4	50.7	61.5	70.7	81.7	89.9	94.7	101.8	105.9	109.4
2010	11.1	19.3	28.7	38.5	48.9	59.1	68.0	78.4	88.2	97.3	102.5	108.4	117.7
2011	11.2	20.3	29.2	38.5	49.5	58.6	68.7	78.2	90.0	97.9	106.9	109.3	116.0
2012	11.0	20.3	31.1	40.8	50.8	60.7	68.4	77.6	87.4	97.7	105.2	111.7	116.6
2013	9.5	19.5	29.0	40.3	50.4	59.3	67.3	75.3	84.4	95.3	104.5	111.9	119.4
2014	10.1	20.1	29.8	39.2	50.7	60.9	69.4	77.9	85.1	93.6	102.7	113.3	122.8
2015	11.5	19.0	28.5	37.5	48.0	58.4	67.4	76.3	83.5	91.0	98,8	107,1	117,9
2016	-	-	-	-	-	-	-	-	-	-	-	-	-
2017	14.6	20.6	30.6	40.2	51.5	59.3	67.1	76.2	84.9	92.6	97.9	104	110.1
2018	-	-	-	-	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-	-	-	-	-

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

Year	Age												
	0	1	2	3	4	5	6	7	8	9	10	11	12
1984	26	90	250	746	1187	2234	3422	5027	6479	9503	-	-	-
1985	26	80	245	762	1296	1924	3346	5094	7360	6833	11167	-	-
1986	25	63	191	506	1117	1940	2949	4942	7406	9300	-	-	-
1987	-	54	182	316	672	1691	2688	3959	8353	10583	13107	-	-
1988	15	78	223	435	789	1373	2609	4465	5816	-	-	-	-
1989	-	73	216	401	928	1427	2200	3133	4649	6801	8956	-	-
1990	28	106	230	908	1418	2092	2897	4131	6359	10078	13540	-	-
1991	26	93	260	743	1629	2623	3816	4975	7198	11165	15353	-	-
1992	10	76	273	1165	1895	2971	4377	5596	7319	9452	12414	-	-
1993	11	46	211	717	1280	2293	3509	4902	6621	7339	8494	-	-
1994	12	69	153	316	919	1670	2884	4505	6520	8207	9812	-	-
1995	11	61	180	337	861	1987	3298	5427	7614	9787	10757	-	-
1996	7	64	191	436	1035	1834	3329	5001	8203	10898	11358	-	-
1997	6	48	203	487	1176	2142	3220	4805	6925	10823	12426	-	-
1998	11	55	187	435	1186	2050	3096	4759	7044	11207	12593	-	-
1999	10	58	177	371	1214	1925	3064	4378	6128	7843	11543	-	-
2000	8	74	232	379	1101	2128	3341	5054	6560	8497	12353	-	-
2001	9	58	221	459	1125	2078	3329	4950	7270	9541	11672	-	-
2002	8	65	232	505	1299	1964	3271	5325	7249	9195	11389	-	-
2003	6	49	205	492	972	1993	2953	4393	6638	9319	11085	-	-
2004	6	55	231	543	1079	1798	2977	4110	5822	8061	12442	-	-
2005	10	59	223	521	1034	1910	3036	4619	6580	9106	12006	-	-
2006	13	72	270	707	1332	1953	2969	4340	6410	8622	12436	-	-
2007	10	96	252	669	1344	2277	3140	4691	6178	8567	10014	-	-
2008	7	58	228	558	1332	2305	3527	5001	6519	8848	10339	13276	15196
2009	15	54	214	495	1116	2024	3090	4876	6592	8087	10262	11472	13268
2010	9	54	191	794	989	1784	2719	4246	6384	8747	10499	12117	14199
2011	10	63	206	486	1037	1691	2827	4312	6698	8979	11557	12915	15694
2012	9	62	237	561	1087	1877	2688	3974	5930	8495	11000	13377	14826
2013	5	55	202	546	1062	1718	2541	3667	5258	7821	10509	13161	16581
2014	7	64	221	508	1079	1849	2734	3994	5418	7480	10100	14163	18404
2015	11	55	198	452	947	1735	2588	3728	5081	6827	8877	11623	15626
2016	-	-	-	-	-	-	-	-	-	-	-	-	-
2017	22	69	248	571	1150	1771	2539	3819	5426	7554	9236	11220	13536
2018	-	-	-	-	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-	-	-	-	-

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

					Age									
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	12+
1985	69.1	446.3	153.0	141.6	20.4	15.1	15.7	3.3	1.3	1.0	0.5	na	na	0.0
1986	353.6	243.9	499.6	134.3	68.4	11.6	7.7	3.1	0.3	0.0	0.4	na	na	0.1
1987	1.6	34.1	62.8	204.9	50.2	17.4	1.4	3.0	0.7	0.0	0.0	na	na	0.0
1988	2.0	26.3	50.4	35.5	57.8	10.9	4.0	0.3	0.0	0.1	0.0	na	na	0.0
1989	7.5	8.0	17.0	34.4	21.4	67.0	16.6	3.2	0.5	0.2	0.0	na	na	0.1
1990	81.1	24.9	14.8	20.6	26.2	26.9	66.8	7.3	0.6	0.3	0.0	na	na	0.0
1991	181.0	219.5	50.2	34.6	29.3	33.9	36.7	50.0	3.7	0.2	0.2	na	na	0.0
1992	241.4	562.1	176.5	65.8	21.5	18.4	28.4	25.4	82.4	4.3	1.7	na	na	0.2
1993	1074.0	494.7	357.2	191.1	113.1	35.4	25.5	25.2	27.7	44.2	4.9	na	na	0.8
1994	858.3	577.2	349.8	404.5	217.5	89.5	22.5	11.9	9.4	3.9	18.0	na	na	2.7
1995	2619.2	292.9	166.2	159.8	216.6	104.0	29.0	4.4	4.3	3.0	2.6	na	na	8.1
1996	2396.0	339.8	92.9	70.5	87.2	89.1	44.6	6.5	1.1	0.4	0.9	na	na	1.4
1997	1623.5	430.5	188.3	51.7	49.7	42.2	49.9	20.5	2.2	0.5	0.0	na	na	0.8
1998	3401.3	632.9	427.7	182.6	42.4	33.8	34.0	24.7	4.9	0.7	0.2	na	na	0.1
1999	358.3	304.3	150.0	96.4	45.4	12.2	11.2	18.7	9.2	1.0	0.2	na	na	0.2
2000	154.1	221.4	245.2	158.9	145.7	49.3	12.9	6.9	5.2	1.2	0.6	na	na	0.2
2001	629.9	63.9	138.2	171.6	81.6	57.3	19.8	2.4	0.8	0.6	0.3	na	na	0.1
2002	18.2	215.5	69.3	112.2	104.3	66.1	34.5	9.5	1.2	0.5	0.6	na	na	0.0
2003	1693.9	61.5	303.4	114.4	131.5	144.5	64.3	21.2	3.8	0.5	0.1	na	na	0.1
2004	157.7	105.2	33.6	92.8	32.7	45.1	46.8	22.2	8.8	2.2	0.2	na	na	0.7
2005	465.3	119.6	123.9	33.7	66.1	29.9	43.2	17.2	7.5	1.8	0.1	na	na	0.2
2006	544.6	216.6	79.8	59.1	15.7	38.1	16.9	15.5	8.8	2.4	0.3	na	na	0.8
2007	125.0	61.7	80.3	37.1	31.8	13.0	42.7	13.8	7.5	3.3	0.8	na	na	0.4
2008	68.8	97.6	210.2	306.1	141.0	75.4	24.6	32.9	5.8	2.8	1.7	na	na	0.8
2009	321.5	30.6	182.6	178.3	140.5	49.5	40.1	13.3	26.0	3.7	1.7	na	na	0.4
2010	485.4	59.4	34.7	121.9	175.9	194.9	70.9	37.5	11.1	8.8	1.7	na	na	1.7
2011	389.3	124.8	47.1	29.1	82.4	158.7	284.3	65.6	22.6	6.1	7.8	0.5	0.6	1.0
2012	950.6	72.7	133.9	52.7	38.1	82.8	224.4	154.7	30.9	10.8	4.8	2.0	0.8	2.7
2013	470.6	110.8	64.1	85.0	71.0	57.5	119.4	224.9	175.6	20.9	12.6	4.9	3.3	8.2
2014	630.1	139.1	220.0	117.8	91.8	67.9	52.9	135.4	175.1	97.7	14.2	6.6	4.0	10.6
2015	1141.0	127.0	94.9	154.2	119.3	99.6	96.5	36.2	111.2	66.3	30.0	6.8	5.2	12.0
2016	142.9	120.7	41.0	58.3	96.9	64.6	58.7	33.9	34.1	48.1	29.2	17.0	11.3	28.1
2017	396.6	48.5	91.2	40.4	48.6	76.6	49.8	50.3	28.5	18.0	14.7	17.2	8.5	25.6
2018	1492.4	221.3	90.0	136.1	47.3	54.6	67.8	46.2	18.6	14.3	5.9	5.9	7.8	13.7
2019	1000.3	287.4	182.1	97.7	124.8	56.3	48.0	67.7	26.4	21.2	6.5	2.9	8.1	10.9
2020	777.5	148.9	97.1	103.9	69.5	85.2	49.6	49.4	45.5	19.7	8.2	2.5	5.0	7.5

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

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
2004	543.0	330.6	329.7	147.7	421.5	150.2	79.8	40.2	10.1	2.2	0.5	0.1	0.1	0.1
2005	180.2	440.7	146.6	216.6	55.8	100.9	28.0	15.6	5.7	1.2	0.5	0.1	0.0	0.1
2006	276.0	479.0	509.7	186.1	205.6	59.9	69.8	17.6	8.1	2.6	0.6	0.2	0.0	0.0
2007	101.0	333.3	505.4	586.2	159.2	79.1	24.6	26.9	6.0	2.2	0.9	0.1	0.2	0.0
2008	483.4	130.9	372.6	652.6	483.4	132.3	51.1	12.8	17.5	3.3	0.9	0.2	0.2	0.2
2009	903.3	569.7	93.5	202.3	280.6	289.6	101.7	31.9	12.7	7.3	2.6	0.8	0.3	0.2
2010	652.6	310.3	84.2	56.8	177.0	397.2	424.9	142.7	38.5	10.5	6.8	1.6	0.3	0.3
2011	2083.0	509.8	160.0	123.6	101.5	240.2	300.4	178.4	32.3	7.7	1.8	1.3	0.6	0.3
2012	1412.7	1454.3	255.9	229.1	146.4	70.0	150.8	165.2	84.5	12.7	4.4	1.6	1.4	0.6
2013	2281.8	914.2	659.0	249.1	183.6	125.7	63.2	118.2	130.2	53.8	9.1	3.3	1.5	0.9
2014	2445.2	308.2	155.1	190.0	108.6	93.9	52.8	30.4	50.2	36.3	12.1	3.4	1.0	1.4
2014 *	***2445.2***	***339.0***	***184.0***	***226.3***	***122.2***	***103.4***	***67.7***	***42.1***	***81.3***	***78.9***	***28.1***	***4.7***	***1.3***	***1.5***
2015	350.9	725.3	154.0	174.4	225.2	141.3	72.6	48.6	26.2	35.3	26.6	7.9	1.7	1.0
2016	1164.8	350.8	341.3	77.2	93.7	121.6	70.1	44.4	27.2	13.8	13.2	5.4	1.7	1.4
2017	2316.3	757.5	260.6	375.0	141.5	104.9	120.9	62.6	28.0	11.2	6.4	4.4	4.5	2.7
2018*	***1841.2***	***2100.3***	***413.8***	***183.6***	***148.9***	***60.0***	***37.6***	***57.1***	***20.2***	***14.4***	***5.8***	***3.6***	***3.5***	***2.8***
2019	313.4	560.2	475.2	416.6	232.3	215.1	76.6	42.2	44.4	16.1	4.9	2.2	1.1	1.8
*data adjasted taking into account not complete area covarage														

4 Northeast Arctic haddock (subareas 1 and 2)

4.1 Introductory note

The haddock input data, SAM model configuration and short-term forecast data input were revised during a benchmark in 2020 (WKDEM2020).

4.2 Status of the Fisheries

4.2.1 Historical development of the fisheries

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

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

The exceptionally strong year classes 2005—2006 have contributed to the strong increase to all-time high levels of stock size and SSB that we have seen in last decade. Their importance in the catches is now decreasing rapidly. The following year classes have been at a much lower level. The 2016 year-class is strong, and the catches are expected to increase.

4.2.2 Landings prior to 2020 (Tables 4.1–4.3, Figure 4.1)

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

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

Provisional official landings for 2019 is about 175 kt which is 4% below the realized TAC (about 10 kt transfers included).

4.2.3 Unreported catches (Table 4.1)

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

We continue to include the estimates of IUU catches as in previous years (see Section 4.2.3), but the IUU is negligible for 2009–2019 and therefore set to zero.

4.2.4 Catch advice and TAC for 2020

The catch advice for 2020 was 215 kt (max 25% higher than TAC at 2019) and the Joint Norwegian-Russian Fisheries Commission set TAC in accordance to the HCR. Furthermore, Russia and Norway can transfer 10% of unused part of own quotas from 2019 to 2020 and 10% of unused part own quotas from 2020 to the quota in 2021.

4.3 Status of Research

4.3.1 Survey results

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

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

The swept area estimates and acoustic estimates from the Joint winter survey of cod and haddock in the Barents Sea in winter 2020 are given in WD 10. The survey area has been extended the last years with additional northern areas (N) covered. The extended area is now included in total and standard survey index calculations for haddock (WKDEM 2020).

Like in previous years, the distribution of haddock extends further to the north and to the east than what was common in the 1990s. Overall, this survey tracks both strong and poor year classes well. At the survey in 2020 young haddock (<35 cm) was aggregated in the south-eastern Barents Sea (WD 10). These are from the year classes 2015–2017.

Joint Barents Sea ecosystem survey (Eco-NoRu-Q3 (Btr)

The bottom-trawl estimates from the joint ecosystem survey in August-September started in 2004. This survey covers the main distribution area of haddock. At the benchmark in 2011 it was decided to include this survey as tuning series. Estimates of the abundance of age groups from the joint ecosystem survey are presented in WD 1 (all years 2004-2019 except 2018). The survey in 2019 covered the haddock distribution well.

4.4 Data Used in the Assessment

4.4.1 Catch-at-age (Table 4.4)

Age and length compositions of the landings in 2019 were available from Norway and Russia in Subarea 1 and Division 2.b, from Norway, Russia, and Germany in Division 2.a. The biological sampling of NEA haddock catches is considered good for the most important ages in the fisheries (Table 1 and 2 chapter 02).

Relevant data of estimated catch-at-age obtained from InterCatch for the period 2008–2019 and historical values from 1950-2007 is listed in Table 4.4.

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

The mean weight-at-age in the catch (Table 4.5) was obtained from InterCatch as a weighted average of the weight-at-age in the catch for Norway, Russia, and Germany.

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

Since 1983 the stock weights at age (Table 4.6) are calculated taking the average of the weight-at-age estimate from the Joint Barents Sea winter survey and the Russian bottom-trawl survey. These averages are assumed to give representative values for the beginning of the year (see stock annex for details). However, the Russian bottom-trawl survey has been discontinued and therefor stock weights-at-age were calculated using a correction factor (WKDEM2020). Since the benchmark in 2006 stock weight at age has been smoothed (ICES 2006, see stock annex for details).

4.4.4 Maturity-at-age (Table 4.7)

The estimates of maturity-at-age are shown in Table 4.7. Since the benchmark 2006, smoothed estimates were produced separately for the Russian autumn survey and the joint winter survey and then combined using arithmetic average. These averages are assumed to give representative values for the beginning of the year. However, the Russian bottom-trawl survey has been discontinued and therefore stock weights-at-age were calculated using a correction factor (see WKDEM2020 and stock annex).

4.4.5 Natural mortality (Table 4.8)

Natural mortality used in the assessment was 0.2. For ages 3-6 mortality predation by cod are added (see stock annex). For the period from 1984 to 2019 actual estimates of predation by cod have been used (see Table 4.8).

For the previous years (1950–1983) the average natural mortality for 1984–2019 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.

4.4.6 Data for tuning (Table 4.9)

The following survey series are included in the data for tuning both for SAM, the last age for all survey is a plus group. Data is lacking for FLT01 in 2016 and 2018, and for FLT007 in 2018.

Name	ICES Acronym	Place	Season	Age	Year	prior weight
FLT01: Russian bottom trawl	RU-BTr-Q4	Barents Sea	October-December	3–8	1991–2018	1
FLT02: Joint Barents Sea survey – acoustic	BS-NoRU-Q1(Aco)	Barents Sea	February-March	3–9	1993–2020	1
FLT04: Joint Barents Sea survey - bottom trawl	BS-NoRu-Q1 (BTr)	Barents Sea	February-March	3–10	1994–2020	1
FLT007: Joint Russian-Norwegian ecosystem autumn survey in the Barents Sea -bottom trawl	Eco-NoRu-Q3 (Btr)	Barents Sea	August - September	3-9	2004-2019	1

4.4.7 Changes in data from last year (Tables 4.6-4.7, 4.9)

As stock weights and maturity are modelled (see above) and due to the revision undertaken at the last benchmark (WKDEM2020) the values of these variables have changed for 1994 and the years thereafter. The values for 1950-1993 has not been changed since last working group. At the benchmark (WKDEM2020) it was decided that historic values (1950–1993) of weight and maturity should not be updated in the following years.

Historic M estimates are not updated prior to 1984. The data from 1984 and onwards are updated every year after the update of the cod assessment.

Following the decisions made at the last benchmark (WKDEM2020) a plus group has been added to all tuning series.

The tuning indices from the NORU winter survey (FLT02 and FLT04) now also include age 3 and new strata has been included in index calculations from this survey for the years from 2014 and onwards. The bottom trawl indices series from the winter survey (FLT02) from 1994 and onwards have been revised and updated (WKDEM2020).

The Russian bottom trawl survey (FLT01) has been discontinued. Last year with survey was in 2017. The data set is still used for tuning but will not be updated.

4.5 Assessment models and settings

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

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

4.5.1 SAM model settings (Table 4.10)

The configuration and tuning of SAM were decided on during the benchmark process (WKDEM2020). These new settings were used in this assessment. The configuration file is given in Table 4.10 and the stock annex.

4.6 Results of the Assessment (Tables 4.11–4.14 and Figures 4.1-4.3)

The stock summary table estimated by SAM (predation included) is given in Table 4.11, the fishing mortality in Table 4.12, stock numbers-at-age in Table 4.13 and natural mortality M in Table 4.14.

Standard stock graphs are given in Figure 4.1, the retrospective plots in Figure 4.2 and residuals plot is presented in Figure 4.3.

The estimate of fishing mortality of main ages (4–7) in 2019 was 0.38 and above F_{MSY} = 0.35.

The dominating feature of this assessment is that the stock reached an all-time high level around 2011 due to the strong 2004–2006 year classes. The SSB peaked in 2013: Both TSB and SSB have decreased since the all-time high, but SSB is still well above MSY Btrigger. Fishing mortality (F) has increased since 2013 and was slightly above FMSY in 2018 - 2019. Figures 4.2 a-d show that the retrospective bias is small ≤±5%.

4.7 Comparison with last year's assessment

The text table below compares this year's estimates with last year's estimates. Compared to last year's assessment the current estimates by SAM model of the total stock (TSB) and spawning stock (SSB) are higher for 2019. The F in 2018 is estimated a bit lower.

Year of assessment, model	F (2018)	Numbers 2019 (ages)											SSB (2019)	TSB (2019)
		3	4	5	6	7	8	9	10	11	12	13+		
2019 SAM	0.38	336	232	75	57	17	18	6	7	3	4	5	215	524
2020 SAM	0.37	875	259	100	69	19	20	7	9	4	4	5	259	752
Ratio 2020/2019	0.99	2.6	1.1	1.3	1.2	1.1	1.1	1.2	1.3	1.2	1.2	1	1.2	1.4

4.8 Additional assessment methods (Table 4.15, Figures 4.4-4.6)

4.8.1 XSA (Figure 4.4)

The Extended Survivors Analysis (XSA) was used to tune the VPA by available index series. As last years, FLR was used for the assessment of haddock (see stock annex), and thus all results concerning XSA are obtained using FLR. The settings used were the same as set in the benchmark in 2015 (WKARCT 2015). The biomass estimates of XSA with these settings significantly deviated from estimates of main model SAM. During the WKDEM2020 it was found that changing S.E. of the mean survivor estimates shrinkage F from 1.5 to 0.5 gives estimates of biomass dynamics close to SAM estimates. Furthermore, this change improved XSA retrospective pattern. At AFWG 2020 this comparison also done and confirmed that usage of survivor estimates shrinkage 0.5 gave the similar result with SAM estimates.

The estimated consumption of NEA haddock by NEA cod is incorporated into the XSA analysis by first constructing a catch number-at-age matrix, adding the numbers of haddock eaten by cod to the catches for the years where such data are available (1984–2019). The summary of XSA stock estimates with shrinkage value 0.5 are presented in Table 4.15. A retrospective plot for XSA is given in Figure 4.4.

4.8.2 TISVPA (Figure 4.5)

The TISVPA (Triple Instantaneous Separable VPA) model (Vasilyev, 2005; 2006) represents fishing mortality coefficients (more precisely – exploitation rates) as a product of three parameters: f(year)*s(age)*g(cohort). The generation-dependent parameters, which are estimated within the model, are intended to adapt traditional separable representation of fishing mortality to situations when several year classes may have peculiarities in their interaction with fishing fleets caused by different spatial distribution, higher attractiveness of more abundant schools to fishers, or by some other reasons. To NEA haddock stock the TISVPA model was at benchmark group for arctic stocks (WKARCT) in 2015 and this year it was decided to apply to NEA haddock using the same data as SAM except that natural mortality values from cannibalism were taken from the SAM runs. All the input data, including catch-at-age, weight-at-age in stock and in catches, maturity-at-age were taken the same as for stock assessment by means of SAM. During AFWG 2020 the results of exploratory runs using the TISVPA model were presented. The results are presented in WD04. In generally biomass estimates of this model much higher than SAM, which can be explained different assumptions about indices catchability. A retrospective plot for TISVPA is given in Figure 4.5

4.8.3 Model comparisons (Figure 4.6)

Results from SAM, XSA and TISVPA are compared in Figure 4.6. Comparison of results of SAM, TISVPA and XSA with previous year settings shows that the models demonstrate similar trends. The TSVPA model is more flexible for settings than the others and taking in account a possible decreasing in survey data consistency, it was attempted to do tuning of surveys not at abundance but to age proportions because the probable change in effective survey catchability.

4.9 Predictions, reference points and harvest control rules (Tables 4.16- 4.21)

4.9.1 Recruitment (Tables 4.16, 4.17)

SAM was used to estimate the recruitment at age 3 of the 2017 year-class in 2020. The RCT3 program translation in R was used to estimate the recruiting year-classes 2018–2019 in 2021 and 2022 with survey data for ages 1-2 from the ecosystem survey (not available for 2018), and ages 1-2 for the winter survey. Input data and results are shown in Tables 4.16 and 4.17, respectively. Age 3 for the winter survey was used in RCT3 together with the indices for ages 1-2 (ecosystem survey and winter survey) to predict recruitment of the year-class 2017 and compare the estimate to the recruitment estimate from SAM in the intermediate year. The results were relatively similar (Recruitment year-class 2017: SAM=497, RCT3=575), but somewhat higher for RCT3. SAM recruitment estimates for the intermediate year are based mainly on the winter survey indices at age 3, whereas the RCT3 estimates are also based on indices for age 1 and 2 from the ecosystem and winter surveys.

4.9.2 Prediction data (Table 4.18)

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

Stock numbers for 2021–2022 at age 3 are taken from RCT3, and abundance at ages 3–13+ in 2020 from the SAM assessment. The average fishing pattern observed in 2017–2019 scaled to F status quo was used for distribution of fishing mortality-at-age for 2020–2022. The proportion of M and F before spawning was set to 0.

Weight at age in the stock: for intermediate year (2020) smoothed actual data used for all ages. For the 2021 weight at age 4 and older and is calculated using the fitted parameters and lengths at age of each cohort as input, and the weight - length relationship. For the 2022 weight at age 4 is calculated using the average from the 3 previous years and the weight at age 5 + is calculated using the fitted parameters and lengths at age of each cohort as input, and the weight - length relationship. Weight at age 3 in the 2021 and 2022 is predicted using the coefficient from the regression on the average of the recruitment in the actual year and the two previous years.

Weight at age 3-7 in the catch (weca) is calculated using a linear regression between stock weight (west) at age and catch weight at age.

$weca_{a,\ y} \sim west_{\ a,\ y}$

weight at age 8-13+ in catches are predicted from the coefficients of the regression:

$weca_{a,\ y} \sim weca_{\ a-1,\ y-1}$

Maturity: for 2020 using the predictions from fitted parameters for 2021 age 4 and older, and for 2022 age 5 and older. For age 3 in 2021 and 2022 and age 4 in 2022 used average for the 3 previous years.

4.9.3 Biomass reference points (Figure 4.1)

Biological and fisheries reference points for NEA haddock were last set following a thorough analysis as part of the WKNEAMP-2 (ICES, 2016) Harvest Control Rule evaluation in 2016. The revised model developed during the 2020 benchmark produced better fits to the data but only a small change in the reconstructed stock (WKDEM2020). A brief analysis at WKDEM2020 indicated that the reference points from the current model are very similar to the previously estimated values. Given the more thorough analysis at WKNEAMP-2 (ICES, 2016), this is taken as indicating that there was no evidence to deviate from the reference points set in 2016.

At the last benchmark (WKDEM2020) it was proposed to keep B_{lim} = 50 000 t and B_{pa} = 80 000 t with the rationale that B_{lim} is equal to B_{loss}, and $B_{pa} = B_{lim}*\exp(1.645*\sigma)$, where $\sigma = 0.3$. This gives a 95% probability of maintaining SSB above B_{lim} taking into account the uncertainty in the assessments and stock dynamics. B_{MSY} trigger was proposed equal B_{pa}, $B_{trigger}$ was then selected as a biomass that is encountered with low probability if F_{MSY} is implemented, as recommended by WKFRAME2 (ICES CM 2011/ACOM:33). Values of reference points compared with current stock values are reflected in Figure 4.1.

4.9.4 Fishing mortality reference points (Figure 4.1)

Biological and fisheries reference points for NEA haddock were last set following a thorough analysis as part of the WKNEAMP-2 (ICES, 2016) Harvest Control Rule evaluation in 2016. The revised model developed during the 2020 benchmark produced better fits to the data but only a small change in the reconstructed stock (WKDEM2020). A brief analysis at WKDEM2020 indicated that the reference points from the current model are very similar to the previously estimated values. Given the more thorough analysis at WKNEAMP-2 (ICES, 2016), this is taken as indicating that there was no evidence to deviate from the reference points set in 2016.

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

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

4.9.5 Harvest control rule

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

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

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

In 2014, JNRFC decided that from 2015 onwards, Norway and Russia can transfer to next year or borrow from last year 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). Six HCRs for NEA haddock including the existing one were tested. At its 46th session in October 2016, the JNRFC decided not to change the HCR.

4.9.6 Prediction results and catch options for 2021 (Tables 4.19 - 4.21)

The projection shows an increase in SSB in 2021 to 272 kt (Table 4.19). TAC constraint F is used for 2020. The TAC for 2021 is established using the current one-year HCR, in accordance of the management plan. F_{MSY} = 0.35 would give a quota for 2021 of 233 kt, this is an 8% increase from the TAC and advice for 2020. Yield per recruit is given in Table 4.21.

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

Basis	Total catch (2021)	F ages 4-7 (2021)	SSB (2022)	% SSB change *	% TAC change **	% Advice change ***
ICES advice basis						
Management plan	232537	0.35	272210	9.1	8.2	8.2
Other scenarios						
MSY approach: F_{MSY}	232537	0.35	272210	9.1	8.2	8.2
F = 0	0	0	394626	58.1	-100.0	-100.0
F = F2020	245410	0.3732	265779	6.5	14.1	14.1
F_{pa}	296269	0.4700	240780	-3.5	37.8	37.8
F_{lim}	428690	0.7700	179103	-28.2	99.4	99.4

*** SSB 2022 relative to SSB 2021.**

**** Catch in 2021 relative to TAC in 2020 (215000 tonnes).**

***** Catch value for 2021 relative to advice value for 2020 (215000 tonnes).**

Detailed information about expected catches by following HCR in 2021 and 2022 is given in Table 4.20. This catch forecast covers all catches. It is then implied that all types of catches are to be counted against this TAC. It also means that if any overfishing is expected to take place, the above calculated TAC should be reduced by the expected amount of overfishing.

4.9.7 Comments to the assessment and predictions (Figures 4.7, 4.8 and 4.9)

This year, there was a haddock benchmark (WKDEM2020). The previous benchmark was in 2015 (ICES 2015). The motivation for the benchmark was the poor retrospective (text table below).

Retrospective bias (Mohn's Rho), 5-year peel	R	SSB	F	TSB
AFWG 2018	-3%	24%	-7%	14%
AFWG2019	-5%	18%	-7%	7%
WKDEM2020	-2%	3%	-3%	1%
AFWG2020	-4%	-3%	0%	-5%

At the benchmark input data and SAM settings were modified. These modifications (detailed in the benchmark report) improved the retrospective pattern. The greatest improvement was due to the modification of the assessment model SAM to allow for plus groups in tuning series and the increase in the age span of all tuning series by adding plus groups. By adding a new year of data, the retrospective bias increased for TSB and R, decreased for F and switched from positive to negative for TSB and SSB compared to WKDEM2020. The estimates from this year's assessment agree well with WKDEM2020 estimates (Figure 4.7).

The 2017 year-class now appears to be weaker than we predicted last year. This reduction in perceived year-class strength is mainly due to the results from the winter survey in 2020. The decline in winter survey indices from age 2 to age 3 was stronger for the 2017 year-class compared to the 2016 year-class, indicating a lower survival at age 2 for the 2017 year-class compared to the 2016 year-class.

According to this year's assessment, the 2016 year-class is the fifth strongest year-class in the time series back to 1950 (strongest year-class: 1950, followed by the year-classes 2005, 2006 and 1969). The 2017 year-class is above the average for year-classes 1990-2017. The 2018 and 2019 year-classes are estimated as below average of the year-classes 1990-2017. The 2019 year-class is estimated as the weakest for the time series back to 1990.

The F's were above F_{msy} in both 2018 and 2019. This might partly be due to overestimation of the stock at the start of the intermediate year for the short-term predictions, as seen from the retrospective bias (see above). Furthermore, the selection pattern traditionally used for the short-term forecast (Figure 4.8) was different from the actual fishing pattern in 2019 (Figure 4.9). The F_{bar} range for NEA haddock is 4-7. A lower proportion of 3-year-old haddock (outside the F_{bar} range), and a higher proportion of 6-year-old haddock was fished than assumed in the forecast (Figure 4.9). This contributed to the F_{bar} estimate in 2019 to be higher than assumed in the prediction last year, and higher than F_{msy}

Catch predictions for 3-year-olds are very uncertain because they depend on individual growth relative to the minimum fishing size limit and gear selectivity. Because the 2017 year-class now appear to be weaker than earlier assumed, and the very strong 2016 year-class is 4-year-old in the intermediate year 2020, we expect the uncertainty in the fishing pattern to be less of an issue in the coming years.

Table 4.1. North-East Arctic HADDOCK. Total nominal catch (t) by fishing areas

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

Year	Subarea 1	Division 2.a	Division 2.b	un-reported (2	Total (3	Norw. stat.areas 06 and 07 (4
1975	121692	44337	9729	-	175758	6000
1976	94054	37562	5648	-	137264	2000
1977	72159	28452	9547	-	110158	2000
1978	63965	30478	979	-	95422	2000
1979	63841	39167	615	-	103623	6000
1980	54205	33616	68	-	87889	5098
1981	36834	39864	455	-	77153	4767
1982	17948	29005	2	-	46955	3335
1983	5837	16859	1904	-	24600	3112
1984	2934	16683	1328	-	20945	3803
1985	27982	14340	2730	-	45052	3583
1986	61729	29771	9063	-	100563	4021
1987	97091	41084	16741	-	154916	3194
1988	45060	49564	631	-	95255	3756
1989	29723	28478	317	-	58518	4701
1990	13306	13275	601	-	27182	2912
1991	17985	17801	430	-	36216	3045
1992	30884	28064	974	-	59922	5634
1993	46918	32433	3028	-	82379	5559
1994	76748	50388	8050	-	135186	6311
1995	75860	53460	13128	-	142448	5444
1996	112749	61722	3657	-	178128	5126
1997	78128	73475	2756	-	154359	5987
1998	45640	53936	1054	-	100630	6338
1999	38291	40819	4085	-	83195	5743
2000	25931	39169	3844	-	68944	4536
2001	35072	47245	7323	-	89640	4542
2002	40721	42774	12567	18736/5310	114798/101372	6898
2003	53653	43564	8483	33226/9417	138926/115117	4279

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

1) Provisional figures, Norwegian catches on Russian quotas are included.

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

3) In 2002–2008, the Norwegian IUU estimates were used in final assessment. 4) Included in total landings and in landings in region 2.a.

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

	Subarea 1		Division 2.a		Division 2.b		Unreported[2]
Year	Trawl	Others	Trawl	Others	Trawl	Others	
1967	73.7	34.3	20.5	7.5	0.4	-	-
1968	98.1	42.9	31.4	8.6	0.7	-	-
1969	41.4	47.8	33.2	7.1	1.3	-	-
1970	37.4	23.2	20.6	6.5	0.5	-	-
1971	27.5	29.2	15.1	6.7	0.4	-	-
1972	193.9	27.9	34.5	7.6	2.2	-	-
1973	242.9	42.8	14	9.5	13.1	-	-

	Subarea 1		Division 2.a		Division 2.b		Unreported[2]
Year	Trawl	Others	Trawl	Others	Trawl	Others	
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	-

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

1) Provisional

2) Figures based on Norwegian/Russian IUU estimates.

Table 4.3 North-East Arctic Haddock. Nominal catch (t) by countries. Subarea 1 and Divisions 2.a and 2.b combined. (Data provided by Working Group members).

Year	Faroe Islands	France	German Dem.Re	Germany	Norway[4]	Poland	United Kingdom	Russia[2]	Oth-ers	Total[3]
1960	172	-	-	5597	46263	-	45469	57025	125	154651
1961	285	220	-	6304	60862	-	39650	85345	558	193224
1962	83	409	-	2895	54567	-	37486	91910	58	187408
1963	17	363	-	2554	59955	-	19809	63526	-	146224
1964	-	208	-	1482	38695	-	14653	43870	250	99158

Year	Faroe Islands	France	German Dem.Re	Germany	Norway[4]	Poland	United Kingdom	Russia[2]	Oth-ers	Total[3]
1965	-	226	-	1568	60447	-	14345	41750	242	118578
1966	-	1072	11	2098	82090	-	27723	48710	74	161778
1967	-	1208	3	1705	51954	-	24158	57346	23	136397
1968	-	-	-	1867	64076	-	40129	75654	-	181726
1969	2	-	309	1490	67549	-	37234	24211	25	130820
1970	541	-	656	2119	37716	-	20423	26802	-	88257
1971	81	-	16	896	45715	43	16373	15778	3	78905
1972	137	-	829	1433	46700	1433	17166	196224	2231	266153
1973	1212	3214	22	9534	86767	34	32408	186534	2501	322226
1974	925	3601	454	23409	66164	3045	37663	78548	7348	221157
1975	299	5191	437	15930	55966	1080	28677	65015	3163	175758
1976	536	4459	348	16660	49492	986	16940	42485	5358	137264
1977	213	1510	144	4798	40118	-	10878	52210	287	110158
1978	466	1411	369	1521	39955	1	5766	45895	38	95422
1979	343	1198	10	1948	66849	2	6454	26365	454	103623
1980	497	226	15	1365	66501	-	2948	20706	246	92504
1981	381	414	22	2402	63435	Spain	1682	13400	-	81736
1982	496	53	-	1258	43702	-	827	2900	-	49236
1983	428	-	1	729	22364	139	259	680	-	24600
1984	297	15	4	400	18813	37	276	1103	-	20945
1985	424	21	20	395	21272	77	153	22690	-	45052
1986	893	12	75	1079	52313	22	431	45738	-	100563
1987	464	7	83	3105	72419	59	563	78211	5	154916
1988	1113	116	78	1323	60823	72	435	31293	2	95255
1989	1217	-	26	171	36451	1	590	20062	-	58518
1990	705	-	5	167	20621	-	494	5190	-	27182
1991	1117	-	Greenland	213	22178	-	514	12177	17	36216
1992	1093	151	1719	387	36238	38	596	19699	1	59922

Year	Faroe Islands	France	German Dem.Re	Germany	Norway[4]	Poland	United Kingdom	Russia[2]	Oth-ers	Total[3]
1993	546	1215	880	1165	40978	76	1802	35071	646	82379
1994	2761	678	770	2412	71171	22	4673	51822	877	135186
1995	2833	598	1097	2675	76886	14	3111	54516	718	142448
1996	3743	6	1510	942	94527	669	2275	74239	217	178128
1997	3327	540	1877	972	103407	364	2340	41228	304	154359
1998	1903	241	854	385	75108	257	1229	20559	94	100630
1999	1913	64	437	641	48182	652	694	30520	92	83195
2000	631	178	432	880	42009	502	747	22738	827	68944
2001	1210	324	553	554	49067	1497	1068	34307	1060	89640
2002	1564	297	858	627	52247	1505	1125	37157	682	114798
2003	1959	382	1363	918	56485	1330	1018	41142	1103	138926
2004	2484	103	1680	823	62192	54	1250	54347	1569	158279
2005	2138	333	15	996	60850	963	1899	50012	1262	158298
2006	2390	883	1830	989	69272	703	1164	53313	1162	153157
2007	2307	277	1464	1123	71244	125	1351	66569	2511	161525
2008	2687	311	1659	535	72779	283	971	68792	1759	155604
2009	2820	529	1410	1957	104354	317	1315	85514	1845	200061
2010	3173	764	1970	3539	123384	379	1758	111372	2862	249201
2011	1759	268	2110	1724	158202	502	1379	139912	4763	310619
2012	2055	322	3984	1111	159602	441	833	143886	3393	315627
2013	1886	342	1795	500	99215	439	639	85668	3260	193744
2014	1470	198	1150	340	91306	187	355	78725	3791	177522
2015	2459	145	1047	124	95094	246	450	91864	3327	194756
2016	2460	340	1401	170	108718	200	575	115710	3838	233412
2017	2776	108	1810	170	113132	228	372	106714	2279	227588
2018	2333	183	1317	385	93839	169	453	90486	2111	191276
2019 [1]	1515	143	1208	204	93860	280	456	76125	1611	175402

1) Provisional figures.

2) USSR prior to 1991.

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

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

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

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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
2005	102	865	11452	19369	22887	37067	24461	2393	2997	990	201	263	1059
2006	271	2496	4539	35040	27571	15033	16023	8567	1259	1298	222	175	321
2007	575	3914	30707	15213	45992	18516	10642	7889	2570	678	605	197	185
2008	440	2089	14536	44192	15926	31173	9145	4520	2846	1181	274	214	166
2009	483	1364	15379	55013	52498	13679	15382	3800	1669	887	285	353	321
2010	457	620	6545	52006	80622	50306	9273	5324	1954	1114	533	242	621
2011	909	806	1277	8501	90394	100522	39496	4397	2340	668	437	269	708
2012	268	611	7814	4206	18007	93055	82721	14445	1325	448	217	216	568
2013	402	904	1778	12780	3805	12297	58024	29930	4976	957	331	212	535
2014	528	649	6948	4503	14563	6833	16304	39620	16439	2431	619	440	545
2015	303	1334	1645	27317	8526	16624	7950	20538	25534	6677	1556	295	312
2016	294	655	5774	3482	33177	9563	18045	12030	21875	13492	4757	876	248
2017	724	1898	30744	46463	16895	48927	10518	14992	9 485	8447	6 640	1872	317
2018	679	1438	9424	16291	34060	8466	18882	5123	8902	4125	3564	4504	1040
2019	797	968	13908	28572	24171	32555	6278	6803	2601	3618	1225	1715	1400

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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1950	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1951	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1952	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1953	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1954	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1955	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1956	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1957	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1958	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1959	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1960	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1961	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1991	0.216	0.616	0.941	1.281	1.556	1.797	2.044	2.079	2.311	2.788	3.408	2.896	3.274
1992	0.055	0.458	0.906	1.263	1.535	1.747	2.043	2.2	2.298	2.494	2.49	2.673	2.923
1993	0.381	0.64	0.94	1.204	1.487	1.748	1.994	2.237	2.417	2.654	2.906	3.184	3.363
1994	0.278	0.521	0.614	0.906	1.287	1.602	1.968	2.059	2.39	2.545	2.881	2.918	3.222
1995	0.258	0.446	0.739	0.808	1.107	1.556	1.838	2.234	2.416	2.602	2.965	3.163	3.786
1996	0.287	0.427	0.683	0.868	1.045	1.363	1.71	1.886	2.214	2.37	2.438	2.707	2.896
1997	0.408	0.575	0.682	1.028	1.151	1.369	1.637	1.856	2.073	2.5	2.279	2.532	2.609
1998	0.409	0.593	0.748	0.974	1.262	1.433	1.641	1.863	2.069	2.335	2.511	2.8	2.849
1999	0.435	0.695	0.826	1.079	1.261	1.485	1.634	1.798	2.032	2.237	2.339	2.611	2.865
2000	0.378	0.577	0.853	1.186	1.395	1.588	1.808	1.989	2.264	2.415	2.587	2.647	3.098
2001	0.391	0.647	0.751	1.104	1.459	1.709	1.921	2.182	2.331	2.609	2.757	3.376	3.338
2002	0.159	0.407	0.687	1.001	1.363	1.643	1.975	2.086	2.294	2.487	2.612	2.847	3.501
2003	0.198	0.384	0.594	0.875	1.113	1.364	1.361	1.972	1.636	1.877	2.088	2.351	2.842
2004	0.328	0.429	0.636	0.886	1.183	1.508	1.821	2.075	2.339	2.58	2.527	3.153	3.197
2005	0.285	0.492	0.722	0.906	1.121	1.343	1.619	2.036	2.177	2.382	2.527	2.496	2.81
2006	0.311	0.567	0.745	1.041	1.287	1.504	1.72	2.082	2.377	2.738	3.082	3.02	3.43
2007	0.329	0.431	0.652	0.899	1.197	1.435	1.722	1.99	2.309	2.715	2.987	2.947	3.591
2008	0.383	0.484	0.658	0.901	1.242	1.515	1.781	2.18	2.33	2.664	3.019	3.326	3.829
2009	0.378	0.508	0.707	1.024	1.28	1.538	1.806	2.107	2.398	2.531	2.606	3.089	3.541
2010	0.317	0.499	0.642	0.887	1.137	1.396	1.702	1.907	2.095	2.404	2.534	3.064	3.249
2011	0.423	0.513	0.811	0.953	1.093	1.254	1.462	1.715	1.978	2.328	2.305	2.55	2.76
2012	0.271	0.506	0.756	1.004	1.174	1.371	1.514	1.715	2.051	2.444	2.414	2.615	2.932
2013	0.469	0.542	0.821	1.014	1.217	1.401	1.571	1.714	1.914	2.168	2.24	2.516	2.807
2014	0.469	0.645	0.792	1.033	1.253	1.417	1.625	1.793	1.941	2.081	2.479	2.703	3.011
2015	0.473	0.647	0.876	1.054	1.327	1.571	1.777	1.934	2.025	2.216	2.481	2.99	3.455
2016	0.497	0.743	0.882	1.115	1.369	1.662	1.917	2.089	2.301	2.567	3.076	3.286	3.331
2017	0.449	0.608	0.874	1.088	1.378	1.666	1.879	2.146	2.258	2.476	2.72	2.98	3.713
2018	0.443	0.663	0.820	1.051	1.339	1.629	1.927	2.156	2.372	2.588	2.728	2.773	3.175
2019	0.341	0.508	0.729	0.955	1.275	1.581	1.834	2.151	2.378	2.607	2.868	2.934	3.382

Table 4.6. Northeast Arctic haddock. Stock weights-at-age (kg). The data from 1950-1993 is unchanged since A, the data from 1994 and onward have been updated this year.

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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1977	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1978	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1979	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1980	0.063	0.262	0.454	0.878	1.159	1.675	2.292	3.134	3.31	3.553	3.792	3.792	3.792
1981	0.051	0.274	0.603	0.805	1.315	1.582	2.118	2.728	3.51	3.679	3.904	3.904	3.904
1982	0.036	0.224	0.631	1.049	1.217	1.782	2.017	2.553	3.14	3.853	4.016	4.016	4.016
1983	0.035	0.164	0.524	1.098	1.558	1.663	2.255	2.448	2.97	3.524	4.165	4.165	4.165
1984	0.028	0.158	0.391	0.926	1.632	2.093	2.121	2.718	2.865	3.363	3.878	3.878	3.878
1985	0.03	0.127	0.379	0.700	1.394	2.195	2.626	2.572	3.158	3.261	3.728	3.728	3.728
1986	0.035	0.136	0.311	0.682	1.069	1.898	2.761	3.138	3.005	3.568	3.632	3.632	3.632
1987	0.042	0.161	0.331	0.569	1.047	1.473	2.411	3.307	3.616	3.412	3.946	3.946	3.946
1988	0.039	0.189	0.383	0.603	0.887	1.452	1.895	2.915	3.822	4.054	3.787	3.787	3.787
1989	0.037	0.175	0.445	0.689	0.936	1.248	1.878	2.317	3.395	4.297	4.449	4.449	4.449
1990	0.031	0.169	0.413	0.789	1.054	1.312	1.635	2.308	2.728	3.844	4.73	4.73	4.73
1991	0.025	0.141	0.402	0.737	1.193	1.458	1.714	2.035	2.732	3.122	4.256	4.256	4.256
1992	0.023	0.114	0.34	0.721	1.119	1.63	1.881	2.127	2.437	3.142	3.491	3.491	3.491
1993	0.025	0.107	0.279	0.616	1.100	1.537	2.08	2.308	2.54	2.831	3.531	3.531	3.531
1994	0.024	0.104	0.249	0.505	0.935	1.646	2.159	2.701	2.840	2.805	2.966	3.612	4.134
1995	0.030	0.112	0.260	0.468	0.799	1.318	2.102	2.622	3.154	3.282	3.200	3.151	3.909
1996	0.030	0.140	0.277	0.484	0.743	1.138	1.714	2.570	3.066	3.581	3.690	3.376	3.454
1997	0.034	0.140	0.342	0.515	0.771	1.065	1.498	2.123	3.008	3.517	3.997	3.842	3.693
1998	0.026	0.149	0.342	0.626	0.812	1.095	1.412	1.873	2.535	3.453	3.927	4.134	4.152
1999	0.027	0.119	0.362	0.626	0.975	1.154	1.446	1.772	2.264	2.945	3.858	4.064	4.441
2000	0.024	0.123	0.292	0.661	0.975	1.360	1.517	1.822	2.148	2.657	3.354	4.012	4.368
2001	0.021	0.110	0.304	0.537	1.022	1.360	1.763	1.895	2.193	2.527	3.038	3.532	4.313
2002	0.025	0.100	0.272	0.559	0.847	1.427	1.774	2.191	2.287	2.592	2.910	3.225	3.825
2003	0.025	0.116	0.247	0.505	0.878	1.199	1.844	2.191	2.599	2.683	2.966	3.093	3.532
2004	0.026	0.115	0.285	0.460	0.799	1.238	1.572	2.274	2.611	3.016	3.067	3.151	3.407
2005	0.018	0.120	0.283	0.527	0.737	1.131	1.618	1.958	2.691	3.030	3.416	3.255	3.469

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
2006	0.018	0.087	0.295	0.527	0.835	1.052	1.498	2.023	2.360	3.118	3.431	3.596	3.564
2007	0.021	0.087	0.222	0.541	0.830	1.184	1.394	1.873	2.421	2.765	3.527	3.596	3.909
2008	0.025	0.100	0.222	0.417	0.854	1.176	1.553	1.751	2.252	2.819	3.155	3.693	3.909
2009	0.026	0.116	0.249	0.414	0.668	1.207	1.544	1.936	2.125	2.657	3.215	3.331	3.995
2010	0.034	0.120	0.289	0.464	0.668	0.964	1.580	1.936	2.335	2.515	3.038	3.407	3.644
2011	0.030	0.153	0.295	0.532	0.737	0.956	1.279	1.979	2.324	2.738	2.881	3.225	3.710
2012	0.036	0.140	0.368	0.545	0.841	1.052	1.279	1.626	2.372	2.724	3.126	3.079	3.532
2013	0.030	0.159	0.342	0.666	0.860	1.191	1.394	1.617	1.981	2.778	3.111	3.300	3.392
2014	0.034	0.138	0.382	0.621	1.037	1.214	1.563	1.761	1.970	2.352	3.171	3.300	3.612
2015	0.030	0.151	0.339	0.692	0.969	1.445	1.589	1.958	2.137	2.341	2.717	3.346	3.612
2016	0.026	0.140	0.365	0.616	1.071	1.360	1.865	1.979	2.347	2.515	2.703	2.909	3.661
2017	0.025	0.120	0.342	0.666	0.961	1.489	1.763	2.298	2.385	2.751	2.895	2.895	3.210
2018	0.024	0.113	0.295	0.626	1.029	1.343	1.917	2.180	2.718	2.778	3.141	3.079	3.210
2019	NA	0.112	0.280	0.545	0.975	1.436	1.753	2.357	2.599	3.148	3.171	3.331	3.392
2020	NA	NA	0.277	0.519	0.860	1.360	1.854	2.168	2.785	3.016	3.542	3.361	3.628

Table 4.7. Northeast Arctic haddock. Proportion mature-at-age. The data from 1950-1993 is unchanged since AFWG2019, the data from 1994 and onward have been updated this year.

Year	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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
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

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
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	0.024	0.080	0.264	0.645	0.854	0.953	0.967	0.966	1	1	1
1995	0	0	0.026	0.071	0.205	0.508	0.843	0.946	0.985	0.987	1	1	1
1996	0	0	0.028	0.075	0.182	0.420	0.737	0.941	0.980	0.995	1	1	1
1997	0	0	0.038	0.083	0.193	0.384	0.656	0.877	0.977	0.993	1	1	1
1998	0	0	0.038	0.115	0.210	0.399	0.619	0.823	0.943	0.992	1	1	1
1999	0	0	0.041	0.115	0.282	0.428	0.634	0.795	0.913	0.973	1	1	1
2000	0	0	0.030	0.126	0.282	0.526	0.664	0.809	0.897	0.957	1	1	1
2001	0	0	0.032	0.088	0.303	0.526	0.753	0.828	0.903	0.947	1	1	1
2002	0	0	0.028	0.094	0.225	0.557	0.756	0.888	0.916	0.952	1	1	1
2003	0	0	0.024	0.080	0.238	0.450	0.777	0.888	0.949	0.958	1	1	1
2004	0	0	0.030	0.069	0.205	0.470	0.686	0.902	0.951	0.977	1	1	1
2005	0	0	0.029	0.086	0.179	0.416	0.703	0.842	0.957	0.977	1	1	1
2006	0	0	0.031	0.086	0.220	0.377	0.656	0.857	0.925	0.981	1	1	1
2007	0	0	0.021	0.090	0.217	0.443	0.612	0.823	0.932	0.963	1	1	1
2008	0	0	0.021	0.060	0.227	0.439	0.678	0.790	0.911	0.966	1	1	1
2009	0	0	0.024	0.059	0.153	0.454	0.675	0.838	0.893	0.957	1	1	1
2010	0	0	0.030	0.070	0.153	0.332	0.689	0.838	0.923	0.946	1	1	1
2011	0	0	0.031	0.087	0.179	0.329	0.558	0.848	0.921	0.962	1	1	1
2012	0	0	0.043	0.091	0.222	0.377	0.558	0.751	0.927	0.961	1	1	1
2013	0	0	0.038	0.127	0.230	0.446	0.612	0.747	0.868	0.964	1	1	1
2014	0	0	0.046	0.113	0.310	0.457	0.682	0.792	0.866	0.932	1	1	1
2015	0	0	0.038	0.136	0.279	0.564	0.693	0.842	0.895	0.931	1	1	1
2016	0	0	0.042	0.112	0.326	0.526	0.783	0.848	0.924	0.946	1	1	1
2017	0	0	0.038	0.127	0.276	0.584	0.753	0.905	0.928	0.962	1	1	1
2018	0	0	0.031	0.115	0.307	0.519	0.798	0.886	0.959	0.964	1	1	1

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
2019	0	0	0.029	0.091	0.282	0.561	0.749	0.914	0.949	0.982	1	1	1
2020	0	0	0.028	0.084	0.230	0.526	0.780	0.884	0.964	0.977	1	1	1

Table 4.8. Northeast Arctic haddock. Consumption of Haddock by NEA Cod (mln. spec).

Age	0	1	2	3	4	5	6	Biomass consumed
1984	2011.01	995.57	15.52	0.08	0.00	0.00	0.00	52.3
1985	1794.21	1248.77	5.20	0.00	0.00	0.00	0.00	48.4
1986	99.55	600.20	217.97	179.89	0.00	0.00	0.00	114.0
1987	0.00	1001.62	0.00	0.00	0.00	0.00	0.00	5.5
1988	0.00	14.28	0.46	8.51	0.00	0.19	0.00	2.4
1989	18.66	197.02	0.00	0.00	0.00	0.00	0.00	8.8
1990	55.82	156.63	39.28	3.81	0.00	0.00	0.00	16.2
1991	0.00	425.45	14.99	0.00	0.00	0.00	0.00	18.8
1992	139.50	1995.17	141.65	1.09	0.00	0.00	0.00	101.9
1993	794.46	1414.25	151.53	34.84	3.59	3.05	0.00	70.7
1994	1324.15	1467.31	73.09	23.96	7.35	0.85	0.01	48.2
1995	188.34	2883.66	166.86	11.96	26.87	26.65	0.31	112.9
1996	353.18	1567.51	151.85	37.25	5.05	2.37	3.07	66.1
1997	0.00	910.60	36.78	25.78	1.60	0.71	0.48	41.5
1998	0.00	1641.45	27.59	1.79	2.63	0.46	0.00	34.2
1999	0.00	989.24	24.28	0.34	0.00	0.00	0.00	28.2
2000	774.32	1348.50	70.54	2.23	1.17	0.19	0.08	56.2
2001	1058.63	596.09	53.53	4.75	0.08	0.00	0.00	51.6
2002	461.00	2491.55	245.80	40.23	2.31	0.38	0.17	129.8
2003	1170.67	3710.83	227.73	42.08	13.61	1.29	0.00	174.3
2004	5423.01	2906.80	314.71	41.84	10.61	2.65	0.00	201.5
2005	7573.96	6566.44	276.76	56.65	9.73	2.36	0.94	320.4
2006	13698.48	8433.58	375.52	5.56	4.50	1.18	0.48	365.5
2007	1310.49	10853.40	660.84	71.78	3.85	2.20	0.22	391.7
2008	1549.58	1069.70	947.04	239.24	45.53	5.84	3.32	311.4

Age	0	1	2	3	4	5	6	Biomass consumed
2009	6543.26	2146.75	313.99	292.99	78.17	25.06	1.72	288.4
2010	2340.64	6603.25	202.93	75.00	76.43	69.89	13.10	305.4
2011	2788.43	3085.51	513.66	63.79	85.73	98.80	22.10	322.3
2012	268.70	8436.87	158.19	126.68	17.80	8.07	5.10	259.7
2013	2466.70	1843.46	455.99	37.86	26.74	6.67	5.07	237.5
2014	1378.75	2266.37	162.76	31.84	2.07	0.72	0.00	100.7
2015	5123.77	2718.79	149.24	15.74	52.30	1.73	0.27	192.5
2016	8419.85	2815.58	289.17	25.34	2.90	9.11	2.10	236.1
2017	4674.22	7940.25	246.07	25.80	14.62	7.09	15.62	292.7
2018	2468.65	7379.06	639.33	72.10	7.96	0.67	0.02	296.0
2019	596.33	4719.58	440.02	137.70	9.64	0.39	0.00	229.1
1984-2019	2135.23	2928.92	216.97	48.29	14.25	7.74	2.06	153.7

Table 4.9. Northeast Arctic haddock. Survey indices for SAM tuning. The last age is a plus group.

North-East Arctic haddock

104

RU-BTr-Q4

1991 2019

1 1 0.9 1.00

3 8

1	62	9	3	6	18	17
1	346	50	4	6	9	9
1	1985	356	48	8	4	4
1	442	1014	116	15	1	6
1	31	123	370	40	5	4
1	28	49	362	334	29	6
1	32	32	10	27	10	8
1	38	46	8	5	15	5
1	196	39	37	8	3	14
1	60	109	26	11	2	5
1	334	40	65	11	4	4
1	399	450	47	24	4	3

1	221	299	231	34	16	3
1	113	94	107	87	5	6
1	240	86	48	57	24	3
1	113	119	57	26	24	13
1	838	73	137	38	14	15
1	2557	1051	124	111	17	11
1	1647	1704	631	57	32	9
1	299	1697	1589	466	34	17
1	47	268	1087	783	165	13
1	209	49	160	720	480	70
1	61	175	50	104	374	272
1	250	46	175	56	142	416
1	22	199	40	74	28	171
1	-1	-1	-1	-1	-1	-1
1	71	99	9	38	6	27
1	-1	-1	-1	-1	-1	-1
1	-1	-1	-1	-1	-1	-1

BS-NoRU-Q1(Aco)

1994 2020

1 1 0.077 0.189

3 9

1	348.70	626.60	121.40	8.55	0.70	0.33	2.71
1	41.50	121.50	395.40	47.60	2.80	0.05	0.83
1	30.00	22.10	68.70	143.70	5.67	0.94	0.07
1	57.30	22.20	15.50	56.10	62.80	4.68	0.19
1	33.80	58.80	24.20	7.70	14.10	20.70	1.62
1	83.70	21.60	22.10	6.17	1.55	3.88	2.77
1	36.40	75.50	14.00	12.60	1.57	0.53	3.02
1	233.50	40.20	41.40	2.20	1.61	0.16	0.71
1	255.20	201.80	18.50	11.70	1.59	0.29	0.56
1	203.70	184.60	136.00	12.30	6.01	0.26	0.90
1	151.00	101.80	107.80	57.70	7.62	1.15	0.55
1	221.30	115.70	57.40	56.70	12.70	0.38	0.33
1	56.30	123.80	47.40	19.30	13.60	3.23	0.35

1	209.30	46.10	80.60	28.90	10.00	5.05	2.79
1	812.40	303.00	90.00	74.10	7.41	12.80	2.11
1	883.70	630.00	266.60	38.90	14.60	1.26	1.71
1	128.10	631.00	604.00	167.00	12.10	2.94	2.11
1	54.20	84.20	313.00	292.20	54.90	1.72	1.47
1	191.60	48.80	88.10	310.60	172.50	30.10	1.01
1	67.30	146.80	35.40	53.00	223.80	102.70	14.35
1	334.80	39.12	108.71	23.20	34.76	86.34	38.80
1	24.31	189.40	26.60	46.17	9.22	22.41	31.97
1	71.82	12.06	59.67	12.50	17.31	7.48	33.27
1	81.13	65.08	4.80	34.80	6.24	7.93	17.73
1	170.40	62.87	64.18	6.88	15.77	2.75	14.52
1	507.61	146.22	31.73	21.88	4.90	3.27	4.11
1	290.48	302.91	81.91	23.06	11.49	1.80	6.22

BS-NoRu-Q1 (BTr)

1994 2020

1 1 0.077 0.189

3 10

1	314.53	436.25	46.18	3.54	0.16	0.13	0.20	0.65
1	54.86	167.10	343.38	29.62	1.44	0.03	0.04	0.40
1	55.84	31.33	150.77	238.11	16.13	1.15	0.00	0.07
1	79.63	39.86	18.26	61.57	88.41	3.28	0.08	0.04
1	21.68	36.75	11.84	1.29	9.20	7.21	0.65	0.09
1	56.92	15.87	9.42	2.83	0.81	1.28	0.77	0.03
1	24.08	35.24	6.79	4.13	0.68	0.08	0.80	0.29
1	294.00	26.25	23.00	1.63	0.75	0.06	0.06	0.33
1	312.87	185.45	12.42	8.04	0.85	0.22	0.01	0.33
1	352.24	174.45	72.71	5.10	1.68	0.12	0.10	0.22
1	173.13	100.52	77.02	51.28	7.41	0.91	0.13	0.23
1	317.89	141.06	50.66	61.19	10.08	0.25	0.08	0.01
1	78.80	130.76	46.05	20.87	16.21	3.18	0.09	0.27
1	443.27	81.78	84.67	26.28	5.41	2.20	1.38	0.90
1	1591.03	583.61	53.08	54.73	6.79	10.25	0.23	0.17
1	1230.43	751.01	368.33	25.41	12.44	0.85	0.09	0.36

1	102.45	510.45	443.76	139.32	7.99	1.02	0.39	0.57
1	52.88	123.63	469.48	290.04	65.24	1.42	1.12	0.18
1	316.08	28.79	74.71	267.95	154.60	24.77	3.12	0.39
1	57.44	143.98	22.02	33.62	191.15	69.39	6.11	0.08
1	381.17	32.73	104.40	23.26	50.04	97.54	38.69	2.43
1	30.62	187.04	43.60	39.44	14.67	18.74	30.74	10.20
1	163.39	34.34	115.60	22.41	41.95	12.44	32.40	33.16
1	134.90	105.50	7.55	55.34	9.69	15.60	2.53	23.86
1	336.31	86.66	65.76	7.77	15.59	3.62	2.56	11.93
1	1075.55	187.22	49.40	17.00	4.04	2.95	0.74	1.91
1	424.23	586.99	99.12	22.08	6.06	2.61	1.04	2.83

FLT007: Eco-NoRu-Q3 (Btr)

2004 2019

1 1 0.65 0.75

3 9

1	123.37	70.30	69.12	31.48	2.99	1.72	0.22
1	324.56	89.53	30.44	32.25	15.04	0.47	1.12
1	107.47	124.64	41.60	18.98	17.48	7.29	1.38
1	1282.94	88.50	90.37	19.23	5.88	7.10	3.21
1	1154.87	406.00	43.13	35.52	4.94	2.51	2.54
1	650.74	619.09	305.88	21.05	6.55	0.87	0.58
1	184.00	865.32	666.44	147.72	15.84	2.73	0.59
1	40.45	73.80	392.93	301.37	37.36	2.97	0.51
1	92.47	20.35	67.61	214.05	152.03	12.74	2.00
1	25.78	65.23	19.58	50.85	150.13	76.43	7.56
1	261.63	40.77	70.16	25.78	60.45	85.77	19.65
1	42.15	213.64	25.13	37.11	20.58	47.87	42.90
1	209.30	34.43	184.09	47.97	56.79	40.37	125.91
1	70.31	70.31	11.47	20.54	3.96	4.03	15.27
1	-1	-1	-1	-1	-1	-1	-1
1	896.98	160.74	38.07	15.13	5.30	5.04	11.56

Table 4.10 North East Arctic haddock. SAM model configuration used. Updated at WKDEM2020

```
#Configuration saved: Wed Feb 12 12:57:09 2020
# Where a matrix is specified rows corresponds to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive
$minAge
# The minimum age class in the assessment
 3
$maxAge
# The maximum age class in the assessment
 13
$maxAgePlusGroup
# Is last age group considered a plus group for each fleet (1 yes, or 0 no).
 1 1 1 1 1
$keyLogFsta
# Coupling of the fishing mortality states (nomally only first row is used).
  0  1  2  3  4  5  5  5  5  5  5
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, 2 AR(1), 3 separable AR(1).
 2
$keyLogFpar
# Coupling of the survey catchability parameters (nomally first row is not used, as that is covered by fishing mortality).
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
  0  1  1  1  1  1 -1 -1 -1 -1 -1
  2  3  3  3  3  4  4 -1 -1 -1 -1
  5  6  6  6  6  7  7  7 -1 -1 -1
  8  9  9  9  9  9  9 -1 -1 -1 -1
$keyQpow
# Density dependent catchability power parameters (if any).
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
```

```
 0  0  0  0  0  0 -1 -1 -1 -1 -1
 1  1  1  1  1  2  2 -1 -1 -1 -1
 3  3  3  3  3  4  4  4 -1 -1 -1
 5  5  5  5  5  5  5 -1 -1 -1 -1
$keyVarF
# Coupling of process variance parameters for log(F)-process (nomally only first row is used)
 0  1  1  1  1  1  1  1  1  1  1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1 1 1 1
$keyVarObs
# Coupling of the variance parameters for the observations.
 0  1  2  2  2  2  2  2  2  2  2
 3  3  3  3  3  3 -1 -1 -1 -1 -1
 4  4  4  4  4  4  4 -1 -1 -1 -1
 5  5  5  5  5  5  5  5 -1 -1 -1
 6  6  6  6  6  6  6 -1 -1 -1 -1
$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"
 "ID" "AR" "AR" "AR" "AR"
$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
 NA  NA  NA  NA  NA  NA  NA  NA  NA  NA
 0  1  1  1  2 -1 -1 -1 -1 -1
 3  3  3  3  3  4 -1 -1 -1 -1
 5  5  5  5  5  6  6 -1 -1 -1
 7  7  7  7  7  7 -1 -1 -1 -1
$stockRecruitmentModelCode
```

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

0

$noScaledYears

Number of years where catch scaling is applied.

0

$keyScaledYears

A vector of the years where catch scaling is applied.

$keyParScaledYA

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

$fbarRange

lowest and higest age included in Fbar

4 7

$keyBiomassTreat

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

-1 -1 -1 -1 -1

$obsLikelihoodFlag

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

"LN" "LN" "LN" "LN" "LN"

$fixVarToWeight

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

0

$fracMixF

The fraction of t(3) distribution used in logF increment distribution

0

$fracMixN

The fraction of t(3) distribution used in logN increment distribution

0

$fracMixObs

A vector with same length as number of fleets, where each element is the fraction of t(3) distribution used in the distribution of that fleet

0 0 0 0 0

$constRecBreaks

This option is only used in combination with stock-recruitment code 3)

$predVarObsLink

Coupling of parameters used in a mean-variance link for observations.

0 1 2 2 2 2 2 2 2 2 2

3 3 3 3 3 3 -1 -1 -1 -1 -1

4 4 4 4 4 4 4 -1 -1 -1 -1

5 5 5 5 5 5 5 5 -1 -1 -1

6 6 6 6 6 6 6 -1 -1 -1 -1

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

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
1950	72765	45993	115120	214657	192015	239968	0.753	0.634	0.894	388527	347863	433944
1951	657821	418643	1033644	126320	112029	142434	0.682	0.572	0.812	433665	337405	557389
1952	89596	56731	141501	101702	88528	116836	0.71	0.593	0.851	424647	335841	536935
1953	1239918	801946	1917083	120740	103933	140266	0.536	0.441	0.65	735111	556694	970710
1954	134460	85206	212187	174445	147108	206864	0.43	0.352	0.525	827393	647336	1057534
1955	58888	36937	93883	314997	267616	370767	0.443	0.366	0.537	851794	714523	1015436
1956	231056	146096	365425	369541	313644	435399	0.469	0.388	0.567	692500	592623	809210
1957	60568	38153	96153	253899	216986	297092	0.424	0.352	0.512	435673	377107	503334
1958	73117	46330	115390	182231	157966	210224	0.517	0.428	0.624	315707	277078	359722
1959	391038	253665	602806	125313	108538	144680	0.444	0.365	0.541	333699	272878	408075
1960	323444	208742	501174	112797	99260	128179	0.54	0.449	0.649	419713	347580	506816
1961	146436	94828	226130	124952	111084	140551	0.663	0.559	0.787	403369	349317	465785
1962	296047	192049	456361	125437	111265	141415	0.789	0.668	0.933	377926	323971	440867
1963	317406	207377	485815	94457	82963	107544	0.755	0.631	0.904	354361	294789	425971
1964	355853	231180	547763	84600	74142	96534	0.631	0.522	0.764	387095	318371	470654
1965	127776	81986	199141	103209	89784	118642	0.524	0.431	0.636	387159	325519	460472
1966	315718	203789	489123	146049	126751	168286	0.556	0.461	0.671	452697	384785	532595
1967	342444	220270	532380	151400	130057	176245	0.44	0.362	0.536	465282	389014	556503
1968	18020	11063	29351	168447	145349	195215	0.481	0.395	0.586	427510	360859	506471
1969	20779	12870	33549	168230	143981	196563	0.41	0.334	0.504	317598	270886	372364
1970	211495	135036	331245	155651	131527	184199	0.382	0.308	0.474	287788	241428	343050
1971	110588	69914	174927	127727	107269	152088	0.326	0.259	0.409	264321	223738	312265

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
1972	1048060	658218	1668794	128660	111456	148520	0.653	0.532	0.801	600811	448925	804084
1973	312636	202372	482978	124977	106936	146061	0.531	0.432	0.653	635036	503512	800916
1974	66576	42831	103487	153559	133455	176692	0.505	0.415	0.615	462543	397738	537905
1975	59783	38456	92938	194787	166283	228178	0.497	0.413	0.597	379050	327901	438178
1976	62392	39554	98416	196521	168413	229320	0.721	0.605	0.858	296779	259344	339619
1977	121398	76071	193733	118741	99835	141228	0.734	0.604	0.892	201636	172491	235705
1978	215993	140029	333165	81314	67122	98508	0.621	0.503	0.768	200221	164244	244079
1979	162376	105052	250980	62698	52610	74721	0.579	0.465	0.722	207431	171492	250901
1980	22032	13487	35993	63105	53417	74551	0.47	0.375	0.589	213898	177788	257343
1981	10230	6043	17318	73239	61677	86967	0.431	0.344	0.54	168959	141951	201106
1982	16883	10332	27587	68902	56749	83657	0.379	0.3	0.479	123108	102628	147675
1983	8795	5165	14974	58318	47705	71291	0.352	0.275	0.45	87975	73441	105384
1984	13327	8158	21771	53231	43213	65571	0.314	0.243	0.406	71914	59810	86466
1985	358965	231533	556533	49235	40836	59363	0.394	0.308	0.503	191650	139542	263217
1986	486470	314406	752699	55064	46501	65205	0.535	0.424	0.675	377650	294656	484020
1987	90234	57394	141865	78142	66567	91730	0.626	0.501	0.782	356834	296686	429177
1988	38764	24122	62293	80270	67278	95772	0.508	0.405	0.637	254162	214533	301112
1989	29093	17939	47182	84794	69520	103423	0.371	0.293	0.47	193696	161392	232465
1990	38095	24272	59788	85992	69607	106234	0.21	0.164	0.269	154164	128142	185471
1991	112770	78840	161301	100964	84393	120790	0.238	0.189	0.299	187883	159686	221059
1992	335839	237002	475895	111689	96175	129705	0.292	0.235	0.364	295031	246182	353573
1993	871351	625838	1213178	126952	111529	144507	0.314	0.254	0.387	536204	440271	653041
1994	408416	327301	509634	155819	138690	175064	0.368	0.302	0.448	662645	576108	762180
1995	102594	79526	132352	191555	169940	215920	0.294	0.246	0.352	654997	575535	745430
1996	101731	79190	130688	223524	198460	251755	0.361	0.305	0.426	566330	502208	638639
1997	122399	95439	156974	194677	172844	219266	0.439	0.37	0.521	407568	364509	455715
1998	65113	50035	84733	134694	118864	152631	0.447	0.373	0.535	270371	241480	302718
1999	155882	124082	195832	97103	85722	109995	0.458	0.379	0.553	237659	211382	267203
2000	85278	66389	109540	79831	70369	90566	0.338	0.276	0.413	217989	192085	247387

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
2001	378004	307448	464752	92654	82379	104211	0.364	0.301	0.439	324082	285357	368062
2002	407536	330699	502227	110733	98489	124499	0.348	0.289	0.42	444240	390717	505095
2003	351769	281167	440099	140388	125583	156938	0.42	0.354	0.499	517551	459109	583433
2004	268081	217849	329896	159937	143007	178871	0.383	0.324	0.452	502422	448883	562347
2005	377498	308112	462510	171108	153062	191282	0.399	0.339	0.471	518865	464191	579979
2006	161291	129781	200452	155919	139309	174511	0.364	0.307	0.431	447052	400071	499551
2007	557313	450582	689328	157825	141192	176416	0.378	0.318	0.449	514747	458006	578518
2008	1148507	938634	1405307	167069	148208	188331	0.309	0.257	0.372	758179	661712	868709
2009	1063274	872984	1295042	187975	166808	211827	0.255	0.212	0.307	1026124	894148	1177580
2010	248645	201139	307370	255386	226372	288119	0.24	0.202	0.286	1160660	1013806	1328787
2011	122124	96149	155117	368859	326583	416607	0.251	0.213	0.296	1208916	1063729	1373919
2012	355908	288429	439175	496499	436152	565197	0.216	0.182	0.256	1203184	1060967	1364464
2013	124281	98323	157091	546646	478736	624190	0.145	0.121	0.174	1025928	905514	1162353
2014	424667	345604	521818	544815	480199	618127	0.151	0.126	0.183	1001042	892221	1123136
2015	74893	58233	96319	516995	460419	580522	0.186	0.155	0.223	891008	798768	993900
2016	219046	175116	273996	507532	451563	570437	0.253	0.212	0.303	819532	733422	915752
2017	202078	161953	252145	424640	379553	475083	0.336	0.281	0.402	719573	645647	801963
2018	383993	306983	480320	320136	281963	363476	0.374	0.309	0.454	645597	571708	729036
2019	875345	705907	1085453	259244	222378	302222	0.376	0.297	0.477	752268	651130	869115
2020	497416	386918	639470	243132	196489	300848				797765	664344	957980

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

Year	3	4	5	6	7	8	9	10	11	12	13+
1950	0.096	0.41	0.704	0.848	1.05	0.886	0.886	0.886	0.886	0.886	0.886
1951	0.085	0.357	0.617	0.773	0.98	0.883	0.883	0.883	0.883	0.883	0.883
1952	0.092	0.377	0.64	0.796	1.028	0.932	0.932	0.932	0.932	0.932	0.932
1953	0.066	0.281	0.473	0.588	0.801	0.737	0.737	0.737	0.737	0.737	0.737
1954	0.047	0.206	0.357	0.468	0.689	0.648	0.648	0.648	0.648	0.648	0.648
1955	0.045	0.198	0.367	0.5	0.708	0.598	0.598	0.598	0.598	0.598	0.598

Year	3	4	5	6	7	8	9	10	11	12	13+
1956	0.05	0.209	0.389	0.548	0.731	0.618	0.618	0.618	0.618	0.618	0.618
1957	0.047	0.197	0.367	0.492	0.642	0.546	0.546	0.546	0.546	0.546	0.546
1958	0.057	0.234	0.45	0.601	0.781	0.689	0.689	0.689	0.689	0.689	0.689
1959	0.058	0.228	0.409	0.521	0.62	0.566	0.566	0.566	0.566	0.566	0.566
1960	0.089	0.316	0.536	0.634	0.673	0.617	0.617	0.617	0.617	0.617	0.617
1961	0.117	0.404	0.681	0.783	0.784	0.695	0.695	0.695	0.695	0.695	0.695
1962	0.146	0.499	0.851	0.94	0.866	0.722	0.722	0.722	0.722	0.722	0.722
1963	0.132	0.468	0.803	0.907	0.843	0.68	0.68	0.68	0.68	0.68	0.68
1964	0.096	0.359	0.634	0.768	0.764	0.647	0.647	0.647	0.647	0.647	0.647
1965	0.076	0.292	0.513	0.635	0.656	0.566	0.566	0.566	0.566	0.566	0.566
1966	0.089	0.328	0.563	0.666	0.669	0.554	0.554	0.554	0.554	0.554	0.554
1967	0.071	0.267	0.446	0.515	0.535	0.464	0.464	0.464	0.464	0.464	0.464
1968	0.083	0.296	0.489	0.553	0.587	0.513	0.513	0.513	0.513	0.513	0.513
1969	0.078	0.266	0.427	0.468	0.48	0.415	0.415	0.415	0.415	0.415	0.415
1970	0.081	0.261	0.401	0.427	0.439	0.38	0.38	0.38	0.38	0.38	0.38
1971	0.072	0.232	0.35	0.354	0.366	0.323	0.323	0.323	0.323	0.323	0.323
1972	0.192	0.501	0.759	0.696	0.655	0.545	0.545	0.545	0.545	0.545	0.545
1973	0.197	0.482	0.639	0.528	0.475	0.38	0.38	0.38	0.38	0.38	0.38
1974	0.178	0.431	0.549	0.516	0.523	0.461	0.461	0.461	0.461	0.461	0.461
1975	0.194	0.458	0.548	0.494	0.486	0.416	0.416	0.416	0.416	0.416	0.416
1976	0.288	0.645	0.785	0.724	0.728	0.641	0.641	0.641	0.641	0.641	0.641
1977	0.321	0.709	0.851	0.719	0.658	0.559	0.559	0.559	0.559	0.559	0.559
1978	0.221	0.543	0.724	0.643	0.576	0.504	0.504	0.504	0.504	0.504	0.504
1979	0.159	0.441	0.669	0.651	0.556	0.502	0.502	0.502	0.502	0.502	0.502
1980	0.1	0.314	0.523	0.562	0.48	0.458	0.458	0.458	0.458	0.458	0.458
1981	0.084	0.272	0.471	0.537	0.443	0.427	0.427	0.427	0.427	0.427	0.427
1982	0.075	0.243	0.411	0.476	0.385	0.38	0.38	0.38	0.38	0.38	0.38
1983	0.078	0.247	0.389	0.428	0.342	0.341	0.341	0.341	0.341	0.341	0.341
1984	0.068	0.226	0.347	0.376	0.308	0.292	0.292	0.292	0.292	0.292	0.292

Year	3	4	5	6	7	8	9	10	11	12	13+
1985	0.075	0.256	0.411	0.48	0.429	0.411	0.411	0.411	0.411	0.411	0.411
1986	0.087	0.314	0.54	0.665	0.619	0.588	0.588	0.588	0.588	0.588	0.588
1987	0.096	0.357	0.641	0.783	0.723	0.657	0.657	0.657	0.657	0.657	0.657
1988	0.071	0.277	0.51	0.654	0.591	0.536	0.536	0.536	0.536	0.536	0.536
1989	0.055	0.219	0.387	0.465	0.413	0.361	0.361	0.361	0.361	0.361	0.361
1990	0.029	0.126	0.214	0.254	0.247	0.23	0.23	0.23	0.23	0.23	0.23
1991	0.03	0.135	0.242	0.29	0.285	0.261	0.261	0.261	0.261	0.261	0.261
1992	0.031	0.145	0.289	0.364	0.371	0.339	0.339	0.339	0.339	0.339	0.339
1993	0.025	0.127	0.288	0.404	0.437	0.396	0.396	0.396	0.396	0.396	0.396
1994	0.023	0.123	0.301	0.472	0.577	0.542	0.542	0.542	0.542	0.542	0.542
1995	0.018	0.097	0.227	0.361	0.493	0.485	0.485	0.485	0.485	0.485	0.485
1996	0.024	0.121	0.281	0.432	0.609	0.615	0.615	0.615	0.615	0.615	0.615
1997	0.031	0.155	0.367	0.525	0.708	0.676	0.676	0.676	0.676	0.676	0.676
1998	0.037	0.175	0.396	0.545	0.671	0.67	0.67	0.67	0.67	0.67	0.67
1999	0.044	0.2	0.427	0.555	0.649	0.62	0.62	0.62	0.62	0.62	0.62
2000	0.032	0.156	0.321	0.408	0.466	0.437	0.437	0.437	0.437	0.437	0.437
2001	0.033	0.16	0.351	0.453	0.49	0.449	0.449	0.449	0.449	0.449	0.449
2002	0.03	0.148	0.317	0.449	0.479	0.422	0.422	0.422	0.422	0.422	0.422
2003	0.035	0.166	0.361	0.527	0.627	0.571	0.571	0.571	0.571	0.571	0.571
2004	0.034	0.155	0.324	0.477	0.575	0.547	0.547	0.547	0.547	0.547	0.547
2005	0.036	0.16	0.33	0.488	0.62	0.602	0.602	0.602	0.602	0.602	0.602
2006	0.035	0.155	0.311	0.437	0.552	0.545	0.545	0.545	0.545	0.545	0.545
2007	0.036	0.155	0.313	0.457	0.585	0.567	0.567	0.567	0.567	0.567	0.567
2008	0.025	0.11	0.225	0.376	0.525	0.519	0.519	0.519	0.519	0.519	0.519
2009	0.02	0.087	0.175	0.301	0.458	0.474	0.474	0.474	0.474	0.474	0.474
2010	0.019	0.082	0.165	0.282	0.432	0.483	0.483	0.483	0.483	0.483	0.483
2011	0.021	0.086	0.181	0.298	0.439	0.482	0.482	0.482	0.482	0.482	0.482
2012	0.02	0.08	0.156	0.26	0.366	0.392	0.392	0.392	0.392	0.392	0.392
2013	0.015	0.06	0.106	0.168	0.247	0.305	0.305	0.305	0.305	0.305	0.305

Year	3	4	5	6	7	8	9	10	11	12	13+
2014	0.017	0.068	0.118	0.176	0.244	0.338	0.338	0.338	0.338	0.338	0.338
2015	0.022	0.088	0.156	0.22	0.28	0.388	0.388	0.388	0.388	0.388	0.388
2016	0.028	0.113	0.217	0.306	0.377	0.496	0.496	0.496	0.496	0.496	0.496
2017	0.037	0.147	0.29	0.427	0.481	0.567	0.567	0.567	0.567	0.567	0.567
2018	0.036	0.151	0.321	0.495	0.531	0.595	0.595	0.595	0.595	0.595	0.595
2019	0.033	0.146	0.324	0.534	0.501	0.525	0.525	0.525	0.525	0.525	0.525

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

Year	3	4	5	6	7	8	9	10	11	12	13+
1950	72765	101082	76215	37154	47009	16698	4865	2683	1382	1460	2060
1951	657821	47705	46108	27504	12801	12528	5446	1949	1017	446	1089
1952	89596	437418	30778	19210	8983	4364	3850	1635	746	360	505
1953	1239918	52291	209646	14030	6350	2640	1336	1048	533	257	311
1954	134460	914469	26034	91232	6888	2333	1093	552	385	198	231
1955	58888	84566	633279	14592	52626	3100	917	454	238	159	168
1956	231056	40688	55886	326034	7237	17862	1446	401	215	115	154
1957	60568	151826	27770	36103	111070	3113	6149	710	167	100	132
1958	73117	39704	93137	15482	20995	40123	1653	2505	357	84	122
1959	391038	51244	26022	39982	7340	7296	14869	736	896	149	89
1960	323444	266325	35784	15685	16922	3490	3691	6130	368	366	110
1961	146436	193339	145366	17688	6983	8051	1601	1508	2786	159	203
1962	296047	86674	92671	59850	6742	2712	3287	660	609	1157	139
1963	317406	177452	38043	26425	17599	2657	1090	1224	274	243	536
1964	355853	199908	75552	12286	7673	5851	1235	440	508	124	347
1965	127776	240740	115078	30338	4164	2785	2262	539	199	218	213
1966	315718	82783	159612	62450	12377	1703	1275	938	275	92	187
1967	342444	201497	43631	72723	24836	4865	790	602	449	135	132
1968	18020	248143	118750	21870	36278	12562	2344	410	314	233	139
1969	20779	11637	142805	55516	10704	15805	5757	1162	197	157	175

Year	3	4	5	6	7	8	9	10	11	12	13+
1970	211495	12615	7421	70740	25218	5949	8041	3010	645	106	187
1971	110588	135519	7120	4474	33481	12314	3377	4541	1696	373	164
1972	1048060	80445	82708	4571	3113	17576	6740	2027	2779	1033	317
1973	312636	606027	47102	23183	1700	1559	7626	2893	927	1384	612
1974	66576	169362	249030	16615	10664	888	1030	4482	1687	551	1238
1975	59783	37520	90437	140336	6781	4937	449	570	2143	813	944
1976	62392	33835	16455	44289	79287	3138	2774	247	340	1149	976
1977	121398	32068	13792	6423	17622	30304	1275	1183	103	152	805
1978	215993	55584	9818	4426	2912	7736	15156	626	564	44	430
1979	162376	118425	23440	3261	2041	1413	4109	7091	338	273	225
1980	22032	103231	59034	8330	1148	1054	720	2176	3498	175	239
1981	10230	15467	64001	26516	3452	549	562	383	1148	1722	215
1982	16883	6658	11057	32002	10548	1717	277	310	220	630	959
1983	8795	11465	4602	6841	13493	5615	983	146	179	129	803
1984	13327	5174	6739	2731	3901	8852	2863	577	79	106	517
1985	358965	8927	2898	3610	1791	2584	5381	1838	370	51	399
1986	486470	278068	5178	1605	1857	997	1484	2797	1027	207	264
1987	90234	250147	157806	2531	659	793	472	682	1204	471	209
1988	38764	69583	135636	46932	1073	234	319	206	304	507	280
1989	29093	25796	49311	71295	12173	557	95	152	100	147	365
1990	38095	21181	17055	26033	32886	5464	363	59	87	57	277
1991	112770	25379	13677	14147	20344	20352	3122	256	40	57	205
1992	335839	85127	16147	10170	10486	12690	12706	1881	170	26	158
1993	871351	227706	58650	10863	5952	6287	7715	7307	1047	105	107
1994	408416	597622	157203	32263	4755	3142	3794	4868	4377	596	118
1995	102594	229209	442382	79122	14909	2131	1430	1899	2234	2180	343
1996	101731	62967	172826	252242	32402	7333	1110	717	957	1128	1295
1997	122399	56555	38980	97909	104076	14050	2528	507	318	426	1125
1998	65113	82240	35416	18473	36996	39616	5250	999	218	135	737

Year	3	4	5	6	7	8	9	10	11	12	13+
1999	155882	49300	48565	17601	9044	15938	14093	1924	416	98	408
2000	85278	122946	31345	21559	6959	4406	6581	5526	818	192	246
2001	378004	69567	96485	16994	10199	3566	2645	3531	2698	442	250
2002	407536	305093	52629	49155	9211	5543	1929	1479	1940	1413	364
2003	351769	266492	199534	34843	25408	4620	3550	1262	851	1102	1013
2004	268081	175299	168651	114357	16354	11211	2158	1689	637	404	1089
2005	377498	174786	96274	111629	52076	6654	5685	1169	746	323	819
2006	161291	223140	111542	52751	45541	21267	3252	2894	574	353	560
2007	557313	123353	171424	62572	27150	19815	8295	1794	1525	297	463
2008	1148507	476941	100302	107129	22444	14304	7429	3362	930	749	379
2009	1063274	745965	391325	64091	41336	10550	5529	3271	1492	527	637
2010	248645	705082	625084	241464	33024	15629	4926	2834	1674	808	707
2011	122124	200095	576013	440898	125589	14656	6343	2186	1402	871	894
2012	355908	75685	141865	411159	277940	56496	6333	2645	1078	740	1028
2013	124281	206980	59364	97624	283462	133183	24365	3313	1471	625	1081
2014	424667	75256	149601	50831	90363	152287	64069	11174	1964	934	1090
2015	74893	298745	67325	94965	41407	72166	77047	26543	5524	1071	1106
2016	219046	50477	174994	47316	63583	34654	52148	39585	13310	2655	1062
2017	202078	182743	35235	114621	28921	37908	19680	22904	18788	5848	1541
2018	383993	143713	131948	26240	46660	15154	19360	9299	9949	9211	3350
2019	875345	258755	99549	68848	18690	19859	7192	8922	3873	4484	4886
2020	497416	531880	171000	60331	29429	10839	9746	3557	4436	1896	4665

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

Year	3	4	5	6	7	8	9	10	11	12	13+
1950	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1951	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1952	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1953	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Year	3	4	5	6	7	8	9	10	11	12	13+
1954	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1955	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1956	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1957	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1958	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1959	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1960	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1961	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1962	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1963	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1964	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1965	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1966	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1967	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1968	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1969	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1970	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1971	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1972	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1973	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1974	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1975	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1976	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1977	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1978	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1979	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1980	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1981	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1982	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Year	3	4	5	6	7	8	9	10	11	12	13+
1983	0.353	0.259	0.246	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1984	0.216	0.225	0.215	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1985	0.209	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1986	0.664	0.262	0.2	0.21	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.2	0.206	0.422	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.375	0.2	0.2	0.394	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.2	0.2	0.2	0.233	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.346	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1991	0.202	0.217	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.217	0.204	0.203	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.257	0.252	0.283	0.261	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.29	0.218	0.298	0.228	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.374	0.336	0.318	0.292	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.715	0.318	0.255	0.285	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.496	0.266	0.257	0.288	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1998	0.232	0.294	0.268	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.2	0.209	0.282	0.262	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.214	0.201	0.218	0.247	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2001	0.211	0.2	0.228	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.324	0.214	0.2	0.204	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2003	0.429	0.255	0.211	0.206	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.423	0.307	0.205	0.23	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.4	0.307	0.236	0.272	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2006	0.223	0.216	0.278	0.213	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2007	0.295	0.2	0.241	0.32	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2008	0.374	0.279	0.268	0.34	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2009	0.418	0.256	0.291	0.261	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.368	0.255	0.283	0.293	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.554	0.497	0.327	0.234	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Year	3	4	5	6	7	8	9	10	11	12	13+
2012	0.637	0.334	0.212	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2013	0.498	0.362	0.262	0.203	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2014	0.289	0.209	0.219	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2015	0.354	0.422	0.214	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2016	0.306	0.2	0.251	0.235	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2017	0.34	0.289	0.242	0.42	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2018	0.433	0.259	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2019	0.433	0.259	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 4.15. Northeast Arctic haddock. Summary XSA (p-shrinkage not applied, F shrinkage= 0.5)
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YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR 4-7
1950	83209	243113	134683	132125	0.981	1.5897	0.8298
1951	674472	357861	101236	120077	1.1861	1.2272	0.6228
1952	77621	236352	57606	127660	2.2161	1.7404	0.723
1953	1287368	515705	82856	123920	1.4956	1.4279	0.5148
1954	154318	540572	117711	156788	1.332	1.474	0.3795
1955	69422	487633	179329	202286	1.128	1.536	0.511
1956	210669	476505	244137	213924	0.8762	1.2623	0.4325
1957	66900	327146	186436	123583	0.6629	1.2455	0.432
1958	87974	277808	157131	112672	0.7171	1.1252	0.518
1959	401986	366814	133490	88211	0.6608	0.9405	0.3665
1960	291801	402785	114828	154651	1.3468	1.0411	0.483
1961	131755	392762	130253	193224	1.4835	0.9942	0.6358
1962	293071	347781	119095	187408	1.5736	1.0518	0.799
1963	344184	312241	82787	146224	1.7663	1.1458	0.8632
1964	402123	303671	64018	99158	1.5489	1.3572	0.6515
1965	125515	359695	95756	118578	1.2383	1.1507	0.4928
1966	296535	389504	127902	161778	1.2649	1.1621	0.5825
1967	365674	470175	154872	136397	0.8807	0.9984	0.414

YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR 4-7
1968	24218	422724	169787	181726	1.0703	0.9976	0.5022
1969	21655	343545	184471	130820	0.7092	0.882	0.3965
1970	204105	287609	156279	88257	0.5647	0.9762	0.357
1971	123601	346657	168684	78905	0.4678	0.7638	0.2462
1972	1261322	622918	123216	266153	2.1601	1.0883	0.6908
1973	344673	606289	114977	322226	2.8025	1.1656	0.5352
1974	69781	606367	201413	221157	1.098	0.8946	0.431
1975	60615	494562	256873	175758	0.6842	0.8957	0.426
1976	67283	307817	206852	137264	0.6636	1.12	0.5698
1977	135087	229350	141862	110158	0.7765	1.09	0.6825
1978	215011	256797	130643	95422	0.7304	0.9219	0.5105
1979	177676	319558	129640	103623	0.7993	0.7684	0.5505
1980	35156	344463	133388	87889	0.6589	0.7568	0.397
1981	13550	293845	148498	77153	0.5196	0.7174	0.4008
1982	17496	212396	127407	46955	0.3685	0.7224	0.3085
1983	9609	104480	71525	24600	0.3439	1.0373	0.2712
1984	13428	83500	64118	20945	0.3267	1.0547	0.2498
1985	288301	182801	62013	45052	0.7265	0.9761	0.32
1986	542267	347476	62386	100563	1.6119	1.0484	0.4388
1987	109762	333914	75054	154916	2.0641	0.992	0.5958
1988	54640	259953	78420	95255	1.2147	0.9955	0.499
1989	26591	212727	91991	58518	0.6361	0.9774	0.3892
1990	37459	171015	95319	27182	0.2852	1.0159	0.1562
1991	104977	195642	110536	36216	0.3276	1.0374	0.2082
1992	208436	269893	125820	59922	0.4763	0.9797	0.2835
1993	663211	443430	130662	82379	0.6305	1.0031	0.3582
1994	290335	542285	145094	135186	0.9317	1.0056	0.425
1995	97081	538430	160732	142448	0.8862	1.0247	0.3828
1996	100984	472224	188383	178128	0.9456	1.0175	0.4238

YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR 4-7
1997	115000	350210	167547	154359	0.9213	1.0519	0.4862
1998	58397	249894	126520	100630	0.7954	1.0113	0.4235
1999	231036	252757	94205	83195	0.8831	1.021	0.421
2000	90497	251643	86439	68944	0.7976	1.026	0.28
2001	366772	358100	111421	89640	0.8045	0.9903	0.279
2002	346197	445522	130488	114798	0.8798	1.011	0.3158
2003	229741	478814	153437	138926	0.9054	1.019	0.4258
2004	228464	459209	161158	158279	0.9821	1.0192	0.3747
2005	349830	474525	171469	158298	0.9232	1.0029	0.4868
2006	157911	420018	146868	153157	1.0428	0.9938	0.4005
2007	680433	504557	144157	161525	1.1205	0.9916	0.4175
2008	1382074	760397	150268	155604	1.0355	0.9928	0.3862
2009	1517989	1115041	173722	200061	1.1516	1.0019	0.3478
2010	551466	1293797	240463	249200	1.0363	0.9994	0.29
2011	252477	1307849	348837	309785	0.8881	0.9978	0.314
2012	412542	1176153	433005	315627	0.7289	0.9994	0.2662
2013	161938	994005	478142	193744	0.4052	0.9967	0.1345
2014	413707	996444	521592	177522	0.3403	0.9968	0.1122
2015	110043	940053	533808	194756	0.3648	0.9953	0.157
2016	286048	854389	500606	233183	0.4658	1.0006	0.2175
2017	230441	747515	417450	227588	0.5452	0.994	0.3262
2018	457421	665803	309877	191276	0.6173	0.9943	0.3625
2019	912622	785956	252171	175402	0.6956	0.9963	0.38

Table 4.16. Northeast Arctic haddock. Input data for recruitment prediction (RCT3) - recruits as 3 year-olds.

yearclass	Recr	NT1	NT2	NT3	NAK1	NAK2	NAK3	EC01	ECO2
1990	871351	NA	NA	NA	NA	NA	NA	NA	NA
1991	408416	NA	NA	314.5	NA	NA	348.700	NA	NA
1992	102594	NA	224.785	54.9	NA	188	41.500	NA	NA

yearclass	Recr	NT1	NT2	NT3	NAK1	NAK2	NAK3	EC01	ECO2
1993	101731	604.2	199.5	55.8	887.8	88.6	30.000	NA	NA
1994	122399	1429.0	265.1	79.6	1198.2	94.5	57.300	NA	NA
1995	65113	300.8	90.8	21.7	132.6	26.5	33.800	NA	NA
1996	155882	1117.8	196.7	56.9	508.9	151	83.700	NA	NA
1997	85278	248.3	83.2	24.1	211	30.1	36.400	NA	NA
1998	378004	1208.0	437.2	294.0	653.4	404.8	233.500	NA	NA
1999	407536	832.3	446.8	312.9	1063	266.1	255.200	NA	NA
2000	351769	1231.0	475.3	352.2	753	267.9	203.700	NA	NA
2001	268081	1700.2	471.7	173.1	1315.2	362.3	151.000	NA	NA
2002	377498	3327.3	706.6	317.9	2743.7	466.5	221.300	NA	268.5
2003	161291	700.9	386.4	78.8	529	144	56.3	189.0	114.2
2004	557313	4473.2	1310.2	443.3	2276.5	624.8	209.3	603.8	929.1
2005	1148507	4944.6	1684.8	1591.0	2091.1	953.5	812.4	2270.2	1818.9
2006	1063274	3731.2	2042.0	1230.4	2015.7	1753.5	883.7	988.4	1291.9
2007	248645	853.1	317.1	102.5	778.4	209.1	128.1	322.0	143.8
2008	122124	562.6	79.9	52.9	443.9	86	54.2	134.8	65.1
2009	355908	1634.8	353.9	316.1	1559.4	288.3	191.6	274.4	113.6
2010	124281	676.3	137.4	57.4	428.5	94.5	67.3	105.3	41.5
2011	424667	1867.0	490.3	381.2	1583.4	407.2	334.8	591.1	223.0
2012	74893	344.6	124.0	30.6	292.7	109.88	24.3	155.9	75.1
2013	219046	1281.4	342.0	163.4	1838.7	246.6	71.8	264.8	145.2
2014	202078	1134.0	562.0	134.9	1593.1	107.17	81.1	320.0	144.9
2015	383993	2299.4	770.0	336.3	1276	331.4	170.4	793.8	189.3
2016	875345	5065.4	1675.6	1075.6	3343.9	805.6	507.6	935.8	NA
2017	497416	3823.3	1125.3	424.2	2930.5	687.8	290.5	NA	585.3
2018	NA	1898.2	267.8	NA	1544.96	260.883	NA	379.4	NA
2019	NA	119,6	NA	NA	272.6	NA	NA	NA	NA

Recr: recruitment estimate from SAM 2020

NT1: Norwegian Russian winter bottom trawl survey age 1

NT2: Norwegian Russian winter bottom trawl survey age 2

NT3: Norwegian Russian winter bottom trawl survey age 3

NAK1: Norwegian Russian winter acoustic survey age 1

NAK2: Norwegian Russian winter acoustic survey age 2

NAK3: Norwegian Russian winter acoustic survey age 3

ECO1: Ecosystem survey age 1

ECO2: Ecosystem survey age 2

The Russian survey (RT) was discontinued in 2017 and has not been used for recruitment.

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

Data for 8 surveys over 30 year classes : 1990 - 2019

Regression type = C

Tapered time weighting applied

power = 3 over 20 years

Survey weighting not applied

Final estimates shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as 0.2

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2017

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
NT1	1.0041	5.267	0.2487	0.9249	20	8.249	13.55	0.2979	0.14235
NT2	0.8938	7.132	0.3497	0.8641	20	7.027	13.41	0.4124	0.07430
NAK1	1.2631	3.675	0.5234	0.7356	20	7.983	13.76	0.6320	0.03163
NAK2	0.9581	7.218	0.2973	0.8979	20	6.535	13.48	0.3532	0.10130
NAK3	0.8085	8.560	0.1885	0.9558	20	5.675	13.15	0.2187	0.26426
NT3	0.6901	8.895	0.1164	0.9827	20	6.053	13.07	0.1345	0.31586
EC01	NA	NA	NA	NA	NA	NA	NA	NA	NA
ECO2	0.8257	8.229	0.4018	0.8139	14	6.374	13.49	0.4938	0.05181
VPA Mean	NA	NA	NA	NA	27	NA	12.60	0.8268	0.01848

yearclass:2018

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
NT1	0.9725	5.460	0.2473	0.9230	20	7.549	12.80	0.2822	0.33499

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
NT2	0.8767	7.212	0.3405	0.8659	20	5.594	12.12	0.3936	0.17228
NAK1	1.1997	4.061	0.5044	0.7423	20	7.343	12.87	0.5763	0.08035
NAK2	0.9410	7.289	0.3006	0.8923	20	5.568	12.53	0.3427	0.22728
NAK3	NA	NA	NA	NA	NA	NA	NA	NA	NA
NT3	NA	NA	NA	NA	NA	NA	NA	NA	NA
EC01	1.0637	6.275	0.3704	0.8513	14	5.941	12.60	0.4297	0.14455
ECO2	NA	NA	NA	NA	NA	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	28	NA	12.63	0.8112	0.04055

yearclass:2019

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
NT1	0.9668	5.496	0.2365	0.9297	19	4.715	10.05	0.3726	0.6569
NT2	NA	NA	NA	NA	NA	NA	NA	NA	NA
NAK1	1.1832	4.161	0.4984	0.7488	19	5.612	10.80	0.6674	0.2047
NAK2	NA	NA	NA	NA	NA	NA	NA	NA	NA
NAK3	NA	NA	NA	NA	NA	NA	NA	NA	NA
NT3	NA	NA	NA	NA	NA	NA	NA	NA	NA
EC01	NA	NA	NA	NA	NA	NA	NA	NA	NA
ECO2	NA	NA	NA	NA	NA	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	28	NA	12.62	0.8116	0.1384

	WAP	logWAP	int.se
yearclass:2017	574466	13.26	0.09558
yearclass:2018	293623	12.59	0.16336
yearclass:2019	38636	10.56	0.30197

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

"MFDP version 1a"

"Run: Manage2020"

"Time and date: 15:02 27.04.2020"

"Fbar age range: 4-7

2020

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	497416	0.402	0.028	0	0	0.277	0.037	0.716

4	531880	0.269	0.084	0	0	0.519	0.154	0.950
5	171000	0.238	0.230	0	0	0.860	0.324	1.224
6	60331	0.273	0.526	0	0	1.360	0.504	1.604
7	29429	0.2	0.780	0	0	1.854	0.524	1.895
8	10839	0.2	0.884	0	0	2.168	0.584	2.077
9	9746	0.2	0.964	0	0	2.785	0.584	2.380
10	3557	0.2	0.977	0	0	3.016	0.584	2.626
11	4436	0.2	1	0	0	3.542	0.584	2.790
12	1896	0.2	1	0	0	3.361	0.584	3.045
13	4665	0.2	1	0	0	3.628	0.584	3.329

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	293623	0.402	0.029	0	0	0.269	0.037	0.708
4	.	0.269	0.083	0	0	0.515	0.154	0.946
5	.	0.238	0.215	0	0	0.823	0.324	1.192
6	.	0.273	0.457	0	0	1.214	0.504	1.471
7	.	0.2	0.756	0	0	1.774	0.524	1.846
8	.	0.2	0.904	0	0	2.285	0.584	2.128
9	.	0.2	0.948	0	0	2.585	0.584	2.311
10	.	0.2	0.985	0	0	3.222	0.584	2.627
11	.	0.2	1	0	0	3.416	0.584	2.806
12	.	0.2	1	0	0	3.726	0.584	2.993
13	.	0.2	1	0	0	3.677	0.584	3.417

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	38636	0.402	0.029	0	0	0.303	0.037	0.744
4	.	0.269	0.086	0	0	0.526	0.154	0.957
5	.	0.238	0.21	0	0	0.812	0.324	1.182
6	.	0.273	0.436	0	0	1.168	0.504	1.430
7	.	0.2	0.693	0	0	1.589	0.524	1.736
8	.	0.2	0.888	0	0	2.191	0.584	2.087
9	.	0.2	0.959	0	0	2.718	0.584	2.358
10	.	0.2	0.976	0	0	3.001	0.584	2.573
11	.	0.2	1	0	0	3.624	0.584	2.807

12	.	0.2	1	0	0	3.596	0.584	3.004
13	.	0.2	1	0	0	4.029	0.584	3.376

Table 4.19. Northeast Arctic haddock. Prediction with management option table for 2019-2021 (TAC constraint applied for intermediate year

MFDP version 1a

Run: Manage2020

2020MFDP Index file 22.04.2020

Time and date: 15:02 27.04.2020

Fbar age range: 4-7

2020				
Bio-mass	SSB	FMult	FBar	Land-ings
797763	243131	0.9912	0.3732	215000

2021					2022	
Bio-mass	SSB	FMult	FBar	Land-ings	Biomass	SSB
783694	249570	0	0	0	882323	394626
.	249570	0.1	0.0377	28926	855824	378815
.	249570	0.2	0.0753	56810	830369	363719
.	249570	0.3	0.113	83695	805912	349302
.	249570	0.4	0.1506	109624	782409	335533
.	249570	0.5	0.1883	134637	759817	322380
.	249570	0.6	0.2259	158771	738098	309813
.	249570	0.7	0.2636	182063	717212	297806
.	249570	0.8	0.3012	204548	697124	286330
.	249570	0.9	0.3389	226258	677798	275361
.	249570	1	0.3765	247226	659202	264875
.	249570	1.1	0.4142	267481	641305	254849
.	249570	1.2	0.4518	287053	624077	245260
.	249570	1.3	0.4895	305968	607488	236090
.	249570	1.4	0.5271	324254	591512	227317
.	249570	1.5	0.5648	341936	576122	218923
.	249570	1.6	0.6024	359037	561295	210891
.	249570	1.7	0.6401	375581	547005	203203

.	249570	1.8	0.6777	391589	533231	195844

Table 4.20. Northeast Arctic haddock. Prediction single option table for 2020-2022 based on HCR

MFDP version 1a

Run: HCR2020

Time and date: 15:05 27.04.2020

Fbar age range: 4-7

Year:	2020	F multiplier:	0.9912	Fbar:	0.3732

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0367	14767	10573	497416	137730	13848	3834	13848	3834
4	0.1526	66243	62931	531880	275997	44818	23257	44818	23257
5	0.3211	42065	51487	171000	147056	39409	33891	39409	33891
6	0.4996	20995	33676	60331	82030	31747	43165	31747	43165
7	0.5194	10899	20653	29429	54567	22951	42555	22951	42555
8	0.5788	4359	9053	10839	23503	9583	20780	9583	20780
9	0.5788	3919	9327	9746	27142	9394	26162	9394	26162
10	0.5788	1430	3756	3557	10727	3474	10475	3474	10475
11	0.5788	1784	4977	4436	15715	4436	15715	4436	15715
12	0.5788	762	2322	1896	6372	1896	6372	1896	6372
13	0.5788	1876	6245	4665	16925	4665	16925	4665	16925
Total		169099	215000	1325195	797763	186221	243131	186221	243131

Year:	2021	F multiplier:	0.9296	Fbar:	0.35

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0344	8184	5794	293623	78985	8515	2291	8515	2291
4	0.1432	37634	35602	320779	165201	26625	13712	26625	13712
5	0.3012	81226	96821	348897	287142	75013	61736	75013	61736
6	0.4685	32342	47575	97761	118681	44677	54237	44677	54237
7	0.4871	9816	18121	27863	49429	21064	37368	21064	37368
8	0.5429	5491	11686	14334	32752	12958	29608	12958	29608
9	0.5429	1906	4404	4974	12859	4716	12190	4716	12190
10	0.5429	1714	4502	4473	14411	4406	14195	4406	14195
11	0.5429	625	1755	1632	5576	1632	5576	1632	5576
12	0.5429	780	2334	2036	7586	2036	7586	2036	7586
13	0.5429	1154	3942	3011	11072	3011	11072	3011	11072
Total		180873	232537	1119383	783694	204652	249570	204652	249570

Year:	2022	F multiplier:	0.9296	Fbar:	0.35

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0344	1077	801	38636	11707	1120	339	1120	339
4	0.1432	22266	21309	189787	99828	16322	8585	16322	8585
5	0.3012	49455	58455	212427	172491	44610	36223	44610	36223
6	0.4685	67319	96266	203485	237670	88719	103624	88719	103624

7	0.4871	16408	28484	46573	74004	32275	51285	32275	51285
8	0.5429	5370	11207	14016	30709	12446	27269	12446	27269
9	0.5429	2612	6160	6819	18534	6540	17774	6540	17774
10	0.5429	907	2333	2367	7102	2310	6932	2310	6932
11	0.5429	815	2288	2128	7711	2128	7711	2128	7711
12	0.5429	298	894	777	2793	777	2793	777	2793
13	0.5429	920	3105	2401	9674	2401	9674	2401	9674
Total		167446	231303	719414	672222	209647	272210	209647	272210

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

MFYPR version 2a"

Run: 2020ypr

Time and date: 15:30 27.04.2020

Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0	0	0	0	4.2749	6.5205	1.9978	5.1147	1.9978	5.1147
0.1	0.0459	0.1041	0.2102	3.7726	4.9545	1.528	3.5973	1.528	3.5973
0.2	0.0918	0.1724	0.3249	3.4489	4.0043	1.2342	2.6909	1.2342	2.6909
0.3	0.1376	0.2214	0.3936	3.2206	3.3746	1.0339	2.1011	1.0339	2.1011
0.4	0.1835	0.2587	0.4376	3.0496	2.9309	0.889	1.6937	0.889	1.6937
0.5	0.2294	0.2885	0.4674	2.9158	2.6036	0.7795	1.3997	0.7795	1.3997
0.6	0.2753	0.313	0.4885	2.8074	2.3534	0.6941	1.1801	0.6941	1.1801
0.7	0.3212	0.3337	0.504	2.7173	2.1566	0.6257	1.0115	0.6257	1.0115

0.8	0.3671	0.3516	0.5157	2.6409	1.998	0.5698	0.879	0.5698	0.879
0.9	0.4129	0.3673	0.5247	2.5749	1.8676	0.5232	0.7729	0.5232	0.7729
1	0.4588	0.3812	0.5319	2.5172	1.7586	0.4839	0.6866	0.4839	0.6866
1.1	0.5047	0.3937	0.5377	2.466	1.6661	0.4503	0.6152	0.4503	0.6152
1.2	0.5506	0.405	0.5424	2.4203	1.5865	0.4212	0.5555	0.4212	0.5555
1.3	0.5965	0.4153	0.5463	2.3789	1.5174	0.3959	0.5051	0.3959	0.5051
1.4	0.6423	0.4248	0.5496	2.3414	1.4568	0.3736	0.4619	0.3736	0.4619
1.5	0.6882	0.4336	0.5524	2.307	1.403	0.3538	0.4248	0.3538	0.4248
1.6	0.7341	0.4418	0.5548	2.2753	1.3551	0.3362	0.3925	0.3362	0.3925
1.7	0.78	0.4494	0.5569	2.2459	1.312	0.3204	0.3642	0.3204	0.3642
1.8	0.8259	0.4566	0.5587	2.2187	1.273	0.3061	0.3393	0.3061	0.3393
1.9	0.8718	0.4633	0.5602	2.1932	1.2375	0.2932	0.3173	0.2932	0.3173
2	0.9176	0.4697	0.5616	2.1693	1.2051	0.2814	0.2976	0.2814	0.2976

Reference point	F multiplier	Absolute F
Fbar(3-13)	1	0.4588
FMax	>=1000000	
F0.1	0.4555	0.209
F35%SPR	0.3731	0.1712

Weights in kilograms

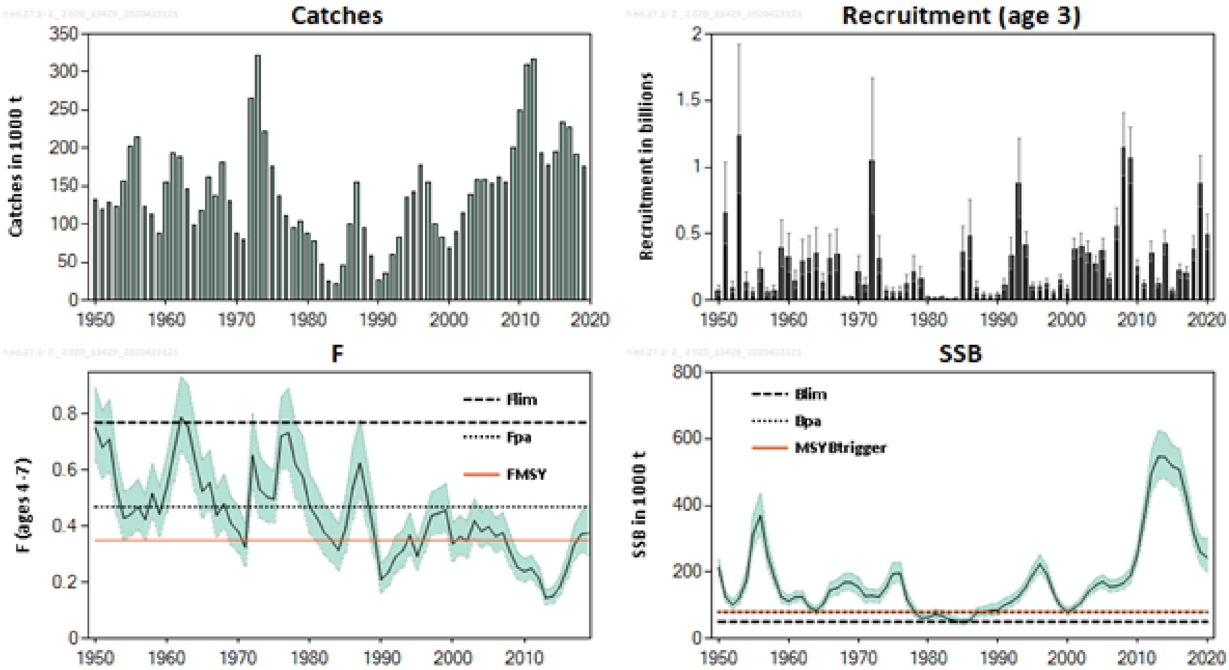


Figure 4.1 Landings, fishing mortality, recruitment (2018 prediction unshaded), and spawning-stock biomass of Northeast Arctic haddock 1950–2019. Fishing mortality and spawning-stock biomass are given with point wise 95% confidence intervals (shaded areas).

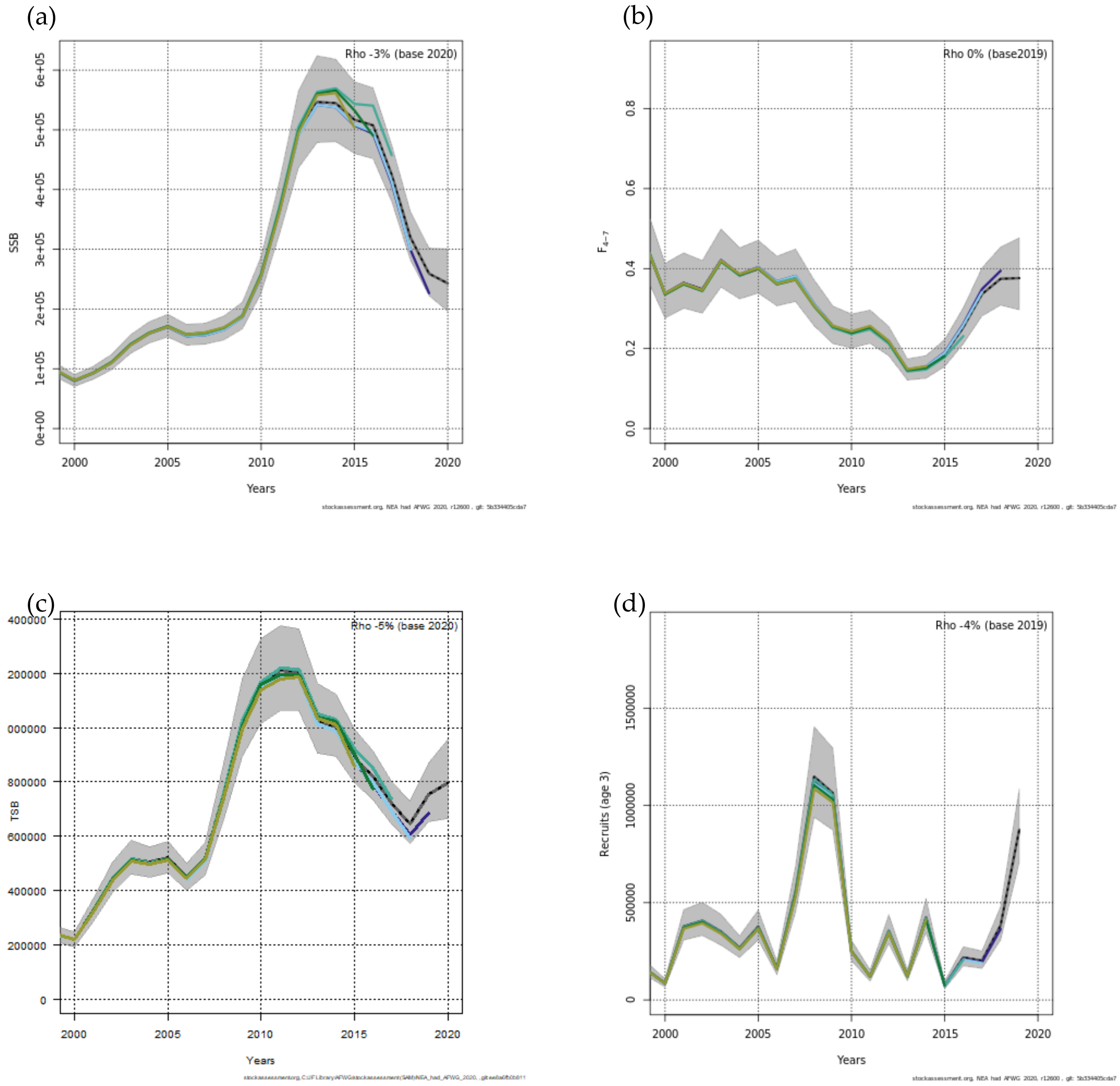


Figure 4.2. Northeast Arctic haddock. 5 year retrospective plots of SSB (a), fishing mortality (b), TSB (c), and recruitment (d) for years 2000–2019 (SAM with 95% confidence intervals).

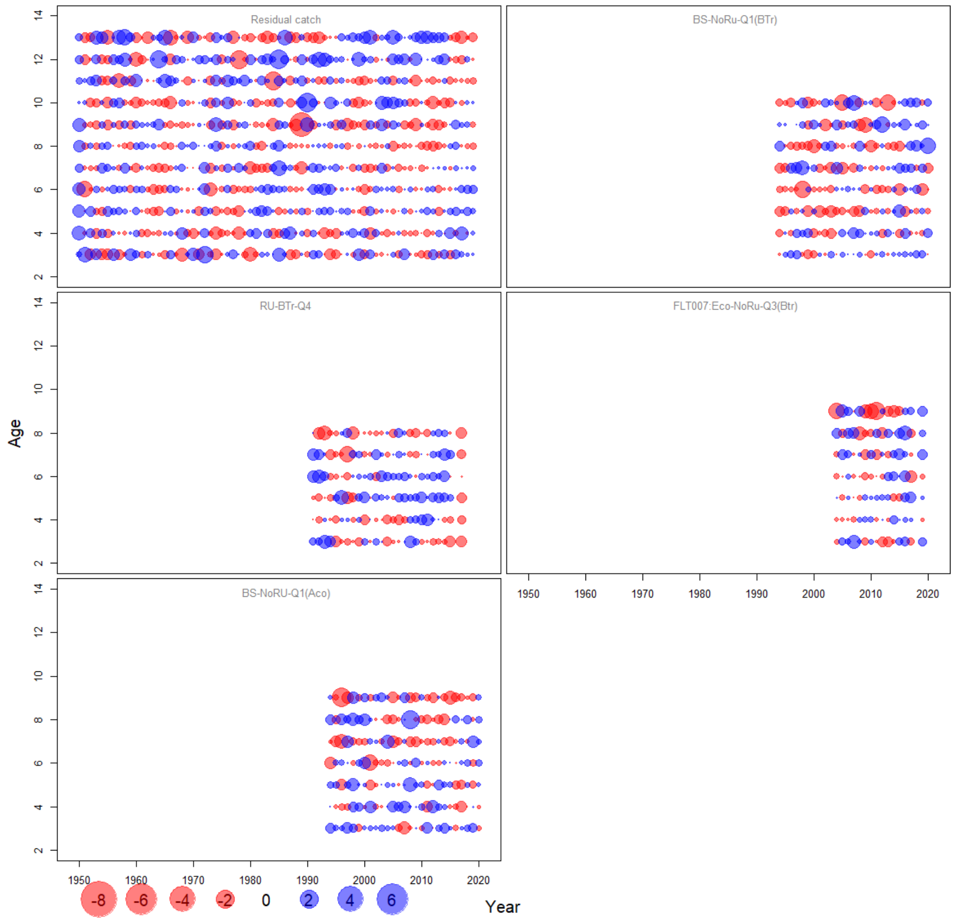


Figure 4.3. Northeast Arctic haddock; Normalized residuals for the final SAM run. Blue circles indicate positive residuals (observations larger than predicted) and red circles indicate negative residuals.

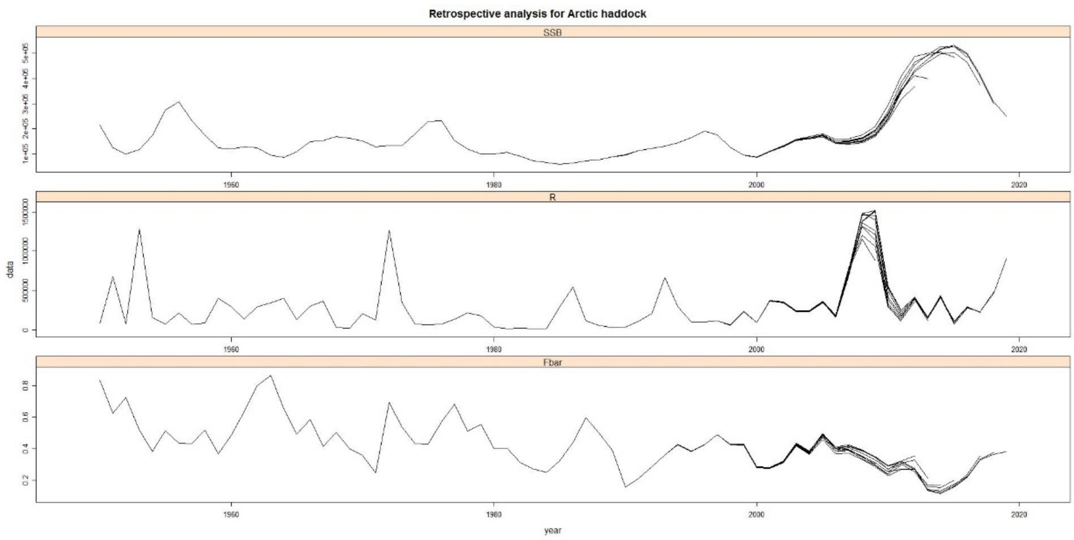


Figure 4.4. Northeast Arctic haddock. Retrospective plots of SSB, fishing mortality and recruitment for assessment years 1950–2019 (XSA without P shrinkage, F shrinkage= 0.5)

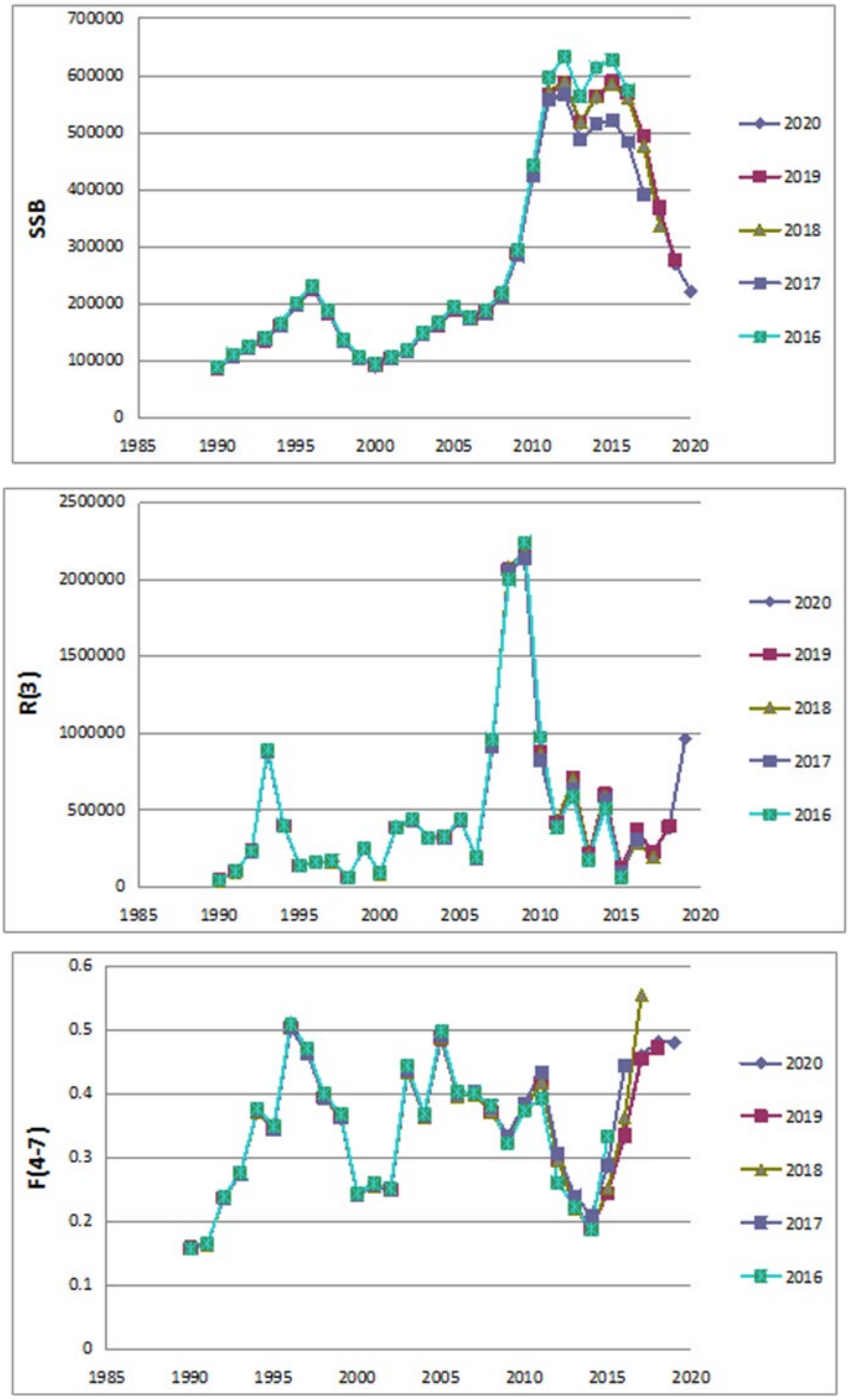


Figure 4.5. Northeast Arctic haddock. Retrospective plots of SSB, fishing mortality and recruitment for assessment years 1990–2019 from TSVPA model (see WD 04).

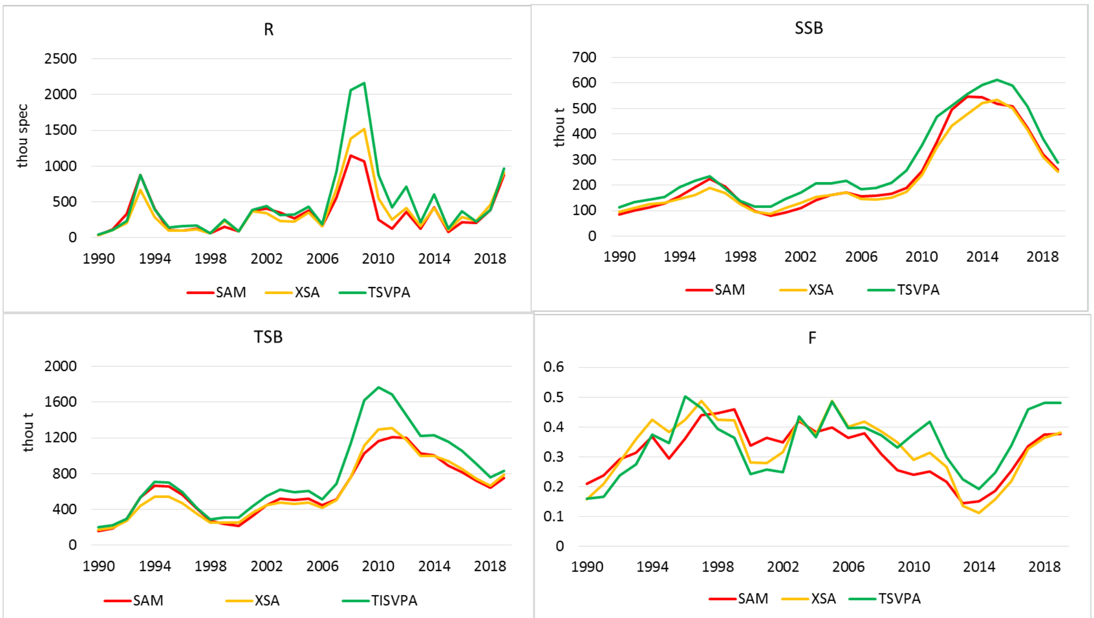


Figure 4.6. Results of assessment of NEA haddock - Recruits, biomass, spawning biomass and F in 1990-2019 by different models: medium SAM estimates, XSA with setting mentioned at chapter 4.9 and TISVPA with settings as mentioned at WD4.

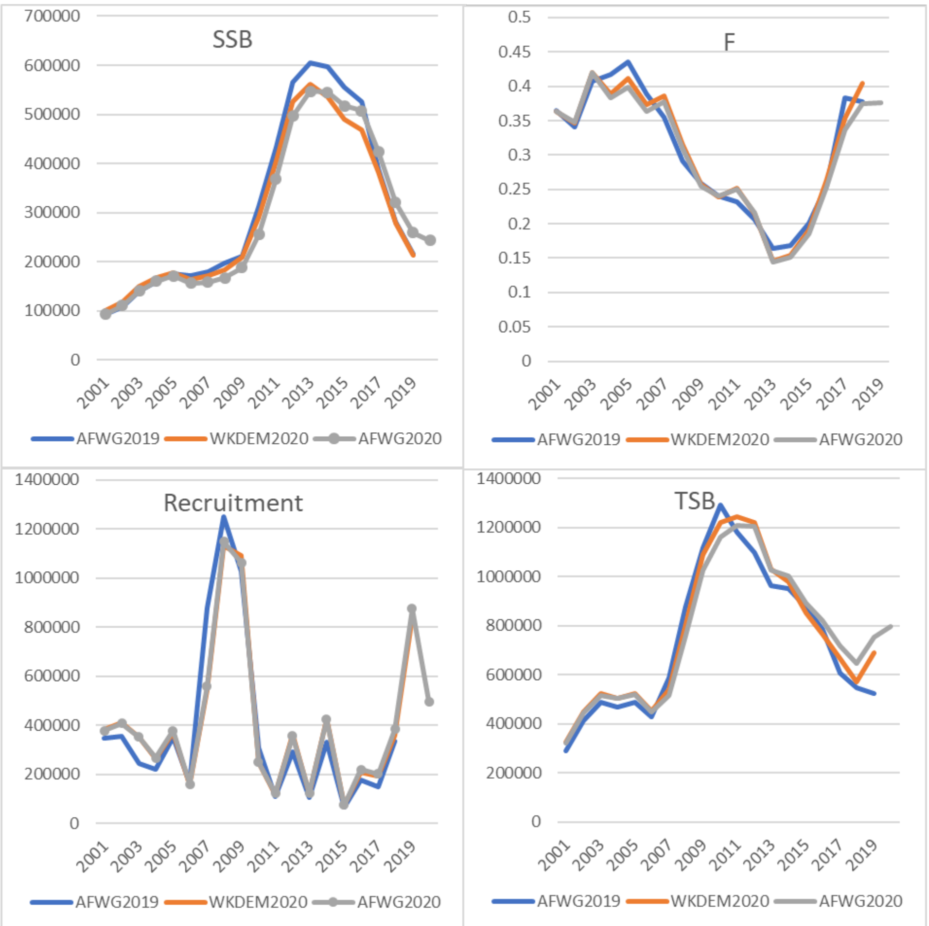


Figure 4.7 Results of assessment of NEA haddock. Fbar, TSB, recruits and SSB from AFWG 2019 (last year), AFWG 2020 (this year) and last benchmark (WKDEM2020) from 2001 and onwards.

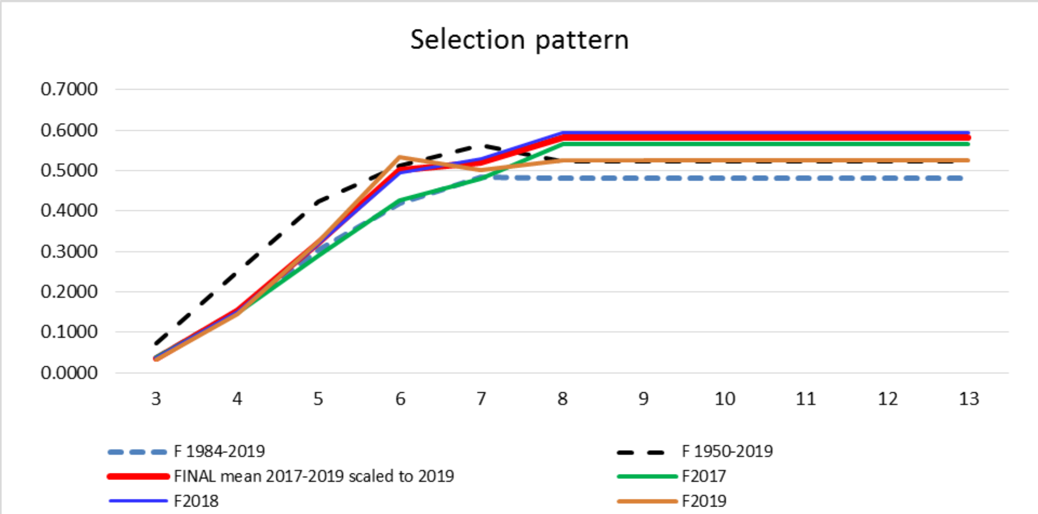


Figure 4. 8 Standard selection pattern model(red) used for short term forecasts at AFWG.

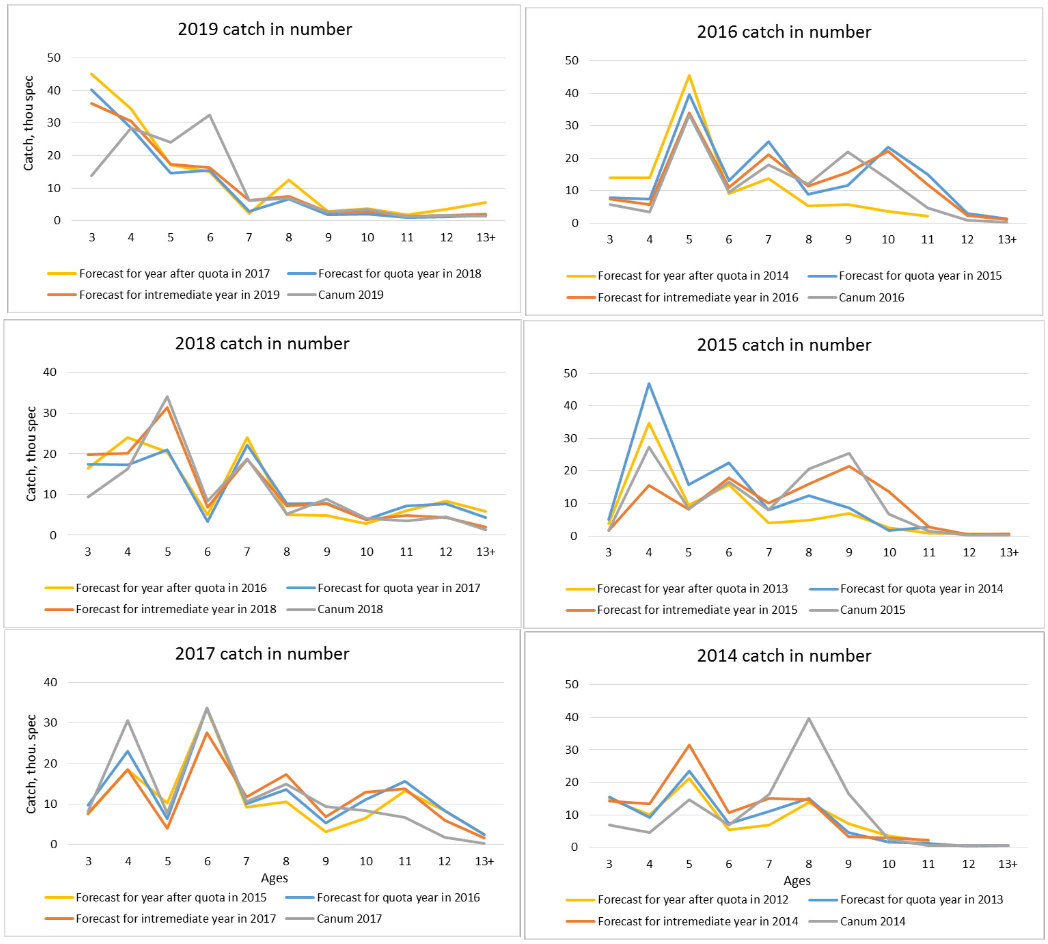


Figure 4.9 Comparisons of real catches in numbers (CANUM) with forecasts catches for same year from previous WG, predicted using current settings for selection pattern.

5 Saithe in subareas 1 and 2 (Northeast Arctic)

An assessment based on the decisions of the Inter-Benchmark Protocol (IBP) on Northeast Arctic saithe from March/April 2014 (ICES CM 2014/ACOM: 53) is presented for this stock. The main decisions were to change model from XSA to the state–space assessment model SAM (Nielsen and Berg, 2014) and to leave out the CPUE time-series in its current form.

The last benchmark assessment was done at WKROUND February 2010 (ICES CM 2010/ACOM: 36).

The 2020 assessment (ICES CM 2015/ACOM: 05) showed that the SSB has been above B_{pa} since 1996, declined considerably from 2007 to 2011, then increased again and is currently (2020) estimated to be well above B_{pa}. The fishing mortality was below F_{pa} from 1997 to 2009, started to increase in 2005 and was above F_{pa} from 2010 to 2012, but is currently estimated to be below F_{pa}. The 2007, 2010, 2013, and 2016 year classes were above average, with the 2013 year class presently contributing a large proportion of the biomass. The 2008, 2009, 2011, 2012 and 2015 year classes were below average strength.

ICES advised that catches in 2020 should be no more than 171 982 t, and The Norwegian Ministry of Trade, Industry and Fisheries set the final TAC at 171 982 t. ICES evaluated the management plan (harvest control rule, HCR) in 2007 and again in 2011 due to changes introduced at the 2010 benchmark and concluded that it is consistent with the precautionary approach. The HCR has not yet been evaluated for the new assessment model that the NEA saithe IBP decided to use.

More details and general information is given in (ICES CM 2010/ACOM: 36) and the Stock Annex (Quality Handbook).

5.1 The Fishery (Tables 5.1-5.2, Figure 5.1)

Currently the main fleets targeting saithe include trawl, purse-seine, gillnet, handline, and Danish seine. Landings of saithe were highest in 1970-1976 with an average of 239 000 t and a maximum of 265 000 t in 1970. This period was followed by a sharp decline to a level of about 160 000 t in the years 1978–1984, while in 1985 to 1991 the landings ranged from 67 000-123 000 t. After 1991 landings increased, ranging between 136 000 t (in 2000) and 212 000 t (in 2006), followed by a decline to 132 000 t in 2015. In 2018 landings were 181 282 t and 163 180 t in 2019.

Discarding, although illegal, occurs in the saithe fishery, but is not considered a major problem in the assessment. Due to its nearshore distribution saithe is virtually inaccessible for commercial gears during the first couple of years of life and there are no reports indicating overall high discard rates in the Norwegian fisheries. There are reported incidents of slipping in the purse-seine fishery, mainly related to minimum landing size. Observations from non-Norwegian commercial trawlers indicate that discarding may occur when vessels targeting other species catch saithe, for which they may not have a quota or have filled it. However, there are no quantitative estimates of the level of discarding available.

5.1.1 ICES advice applicable to 2019 and 2020

The advice from ICES for 2019 was as follows:

ICES advised that catches in 2019 should be no more than 149 550 t.

The advice from ICES for 2020 was as follows:

ICES advised that catches in 2020 should be no more than 171 982 t.

5.1.2 Management applicable in 2019 and 2020

Management of Saithe in subareas 1 and 2 is by TAC and technical measures. For 2019, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 149 550 t.

For 2020, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 171 982 t.

5.1.3 The fishery in 2019 and expected landings in 2020

Provisional figures show that the landings in 2019 were approximately 163 180 t, approximately 13 500 t higher than the TAC of 149 550 t.

Since the WG does not have any prognosis of total landings in 2020 available, the TAC of 171 982 t is used in the projections. Here it should be mentioned that the Norwegian quota for 2020 was adjusted, based on quota flexibility, down from 156 482 t to 142 740 t, which means that the total quota of 171 892 t will not be caught in 2020.

5.2 Commercial catch-effort data and research vessel surveys

5.2.1 Catch-per-unit-effort

The NEA saithe IBP (ICES CM 2014/ACOM: 53) recommended leaving out the CPUE time-series in the model tuning (see Section 5.3.5). A detailed description of the Norwegian trawl CPUE and its previous use is given in the stock annex.

5.2.2 Survey results (Figure 5.2-5.3)

An *ad hoc* subgroup of the AFWG was held to review proposed changes to several survey series using the new "StoX" survey computation methodology on 16 and 17 April 2017 at the JRC, Italy. The survey series reviewed included the coastal survey for saithe for the period 2003 to 2017. StoX is a new program developed at IMR Norway, to produce a more robust, transparent, and automated method of computing survey series. The method is currently used in ICES assessments (for example for NSS herring). For the saithe survey series, a WD was presented to the group (Mehl *et al.*, 2018a), examining the differences between the previous survey series and those resulting from StoX in survey indices by age, as well as mean weight and mean length. During the meeting consistency plots were produced for each survey and showed to have a better fit with the StoX series compared to the old series. The meeting concluded that the new StoX survey series should be used to replace the previous survey series in AFWG stock assessment, but that once the assessment model is run the residuals and fits to the data should be examined to check for unexpected detrimental impacts on model performance. The resulting SAM model fits using the old and the StoX survey series (using data for both survey series up to 2016, but excluding the 2003 StoX estimate, as this was considered abnormally high) were practically the same, without any detrimental impacts on model performance.

The echo abundance observed in 2019 (Staby *et al.*, 2020) decreased by 6.5% compared to 2018 and was about 91% of the average for 2003–2018. The abundance estimated using StoX increased by 12% compared to 2018. This increase is the result of a high estimate of 3 year old saithe (2016 year class), which was 176% higher than in 2018. Estimates for 4, 5 and 7year old saithe were below the long term average, while estimated abundance of 6 year old fish (2013 year class), was well above the long term average. The proportion of saithe in the southern part of the survey area (south of the Lofoten islands between 62^0-67^0N) increased from about 20% in 1997 to above 60% in 2008, decreased in later years and was 21% in 2019.

5.2.3 Recruitment indices

Owing to the nearshore distribution of juvenile saithe, obtaining early estimates of recruitment for ages 0-2 has not been possible so far. The survey recruitment indices are strongly dependent on the extent to which 2-4 year old saithe have migrated from the coastal areas and become available to the acoustic saithe survey on the banks, and this varies between years. Also, observations from an observer programme, established in 2000 to start a 0-group index series (Borge and Mehl, WD 21 2002). did not seem to reflect the dynamics in year-class strength very well. (Mehl, WD 6 2007; Mehl, WD 7 to WKROUND 2010). The programme was consequently terminated in 2010.

5.3 Data used in the Assessment

5.3.1 Catch numbers-at-age (Table 5.3)

Total Norwegian landings by gear and landings data for all other countries from 2019 were updated based on the official total catch (preliminary) reported to ICES or to Norwegian authorities.

Age composition data for 2019 were available for Norwegian and German landings. An age-length key estimated for Norwegian trawl catches in area 1, 2.b and 2.a was applied to Russian length data from those subareas respectively. Landings from other countries were assumed to have the same age composition as the combined Norwegian trawl catches. The biological sampling of some vessel groups, periods and areas had become critically low after the termination of the Norwegian port-sampling program in 2009. Sampling of age data from purse-seine catches had improved by 2016 but catches from areas 3 and 4 and quarter 3 in 2019 were not sampled adequately. Age data from the Danish seine and bottom trawl fishery were combined to increase the number of samples by area and quarter, thereby improving the estimate of catch at age numbers.

Catch-at-age data were estimated by ECA for the 2020 assessment of NEA saithe. This is the fourth year that catch-at-age estimates from ECA are used as input in the SAM assessment. In previous years catch-at-age was estimated manually, as described in the NEA saithe stock annex.

In 2016, it was not possible due to time constraints to apply the manual method to 2017 to compare the 2016 data. A comparison of ECA and manual allocation data using 2015 catch data, showed that ECA produced somewhat lower estimates of number of younger fish, while it produced slightly higher estimates for older fish. However, a comparison of two respective SAM runs with 2016 ECA and manually allocated data showed that estimates of numbers by age for the intermediate year (2016) did not differ substantially. They also showed very similar trends in SSB and estimated fishing mortality (F_{bar}), though the SSB estimated with ECA data showed a slightly higher SSB estimate than the estimate based on manually allocated data.

5.3.2 Weight-at-age (Table 5.4)

Constant weights-at-age values for age groups 3-11 are used for the period 1960–1979, whereas estimated values for the 12+ group vary during this period. For subsequent years, annual estimates of weight-at-age in the catches are used. Weight-at-age in the stock is assumed to be the same as weight-at-age in the catch. Compared to 2018, estimated weight-at-age for age groups 3–12+ differed only slightly in 2019, with the most notable difference being that estimated weights for ages 5+ all increased slightly.

5.3.3 Natural mortality

A fixed natural mortality of 0.2 for all age groups was used both in the assessment and the forecast.

5.3.4 Maturity-at-age (Table 5.5)

A 3-year running average is used for the period from 1985 and onwards (2-year average for the first and last year). Inconsistencies between proportion mature fish and trends in SSB and recruitment since 2008 resulted in the NEA saithe IBP to recommend the use of a constant maturity ogive for the years from 2007 and onwards based on the average 2005–2007 (ICES CM 2014/ACOM: 53). Table 5.3.3 presents the maturity ogives used in the present assessment. It needs to be clarified why the above mentioned inconsistencies occurred, e.g. are spawning zones not a robust indicator for maturity.

5.3.5 Tuning data (Table 5.6)

Until the 2005 WG, the XSA tuning was based on three dataseries: CPUE from Norwegian purse-seine and Norwegian trawl and indices from a Norwegian acoustic survey. The 2005 WG found rather large and variable log q residuals and large S.E. log q for the purse-seine fleet, as well as strong year effects, and in the combined tuning the fleet got low scaled weights. The WG decided not to include the purse-seine tuning fleet in the analysis. This was confirmed by new analyses at the 2010 benchmark assessment (ICES CM 2010/ACOM:36). The trawl CPUE series on the other hand does not show the trends in stock size abundance of NEA saithe in later years (Figure 5.3.2). In the most recent years there are signs of changes in fishing strategy, with fewer and shorter fishing periods and a smaller proportion of directed saithe fishery (Mehl and Fotland, WD 20 2013).

Analyses of the two remaining tuning series done at the 2010 benchmark assessment indicated that there had been a shift in catchability around year 2002. The survey was redesigned in 2003, and the fishery to a larger degree targeted older ages. Permanent breaks were made in both tuning series in 2002. The acoustic survey, compared with the trawl CPUE time-series, seems to track the stock changes better, both in abundance and distribution.

The trawl CPUE series does not show the trends in stock size abundance of NEA saithe in later years. In the most recent years there are signs of changes in fishing strategy, with fewer and shorter fishing periods and a smaller proportion of directed saithe fishery (Mehl and Fotland, WD 20 2013). The acoustic survey, on the other hand, seems to track the stock changes better, both in abundance and distribution. The sensitivity runs presented to the IBP (Fotland WD 30 2014 IBP NEA saithe) clearly show that the residual pattern get worse (strong year effects) when using both tuning series in SAM. It becomes obvious that SAM tries to fit something in between both contradicting data sources. Therefore, it had to be decided whether one data source is more reliable or whether both data sources should be taken into account leading to a fit in between both extremes. Given that CPUE series should not be used when larger changes in fishing patterns occur (selectivity, spatial distribution of the fleet, change between targeted and bycatch fishery) it was recommended to leave out the CPUE time-series in its current form for now (ICES CM 2014/ACOM: 53). Another reason was that the proportion of catches covered by the index has decreased steadily between 2002 and 2011 further questioning the representativeness of the CPUE index. However, it may be worth trying alternative CPUE indices (e.g. one index for the targeted fishery only and one index for the fishery with saithe bycatches) until the next benchmark.

The following two tuning fleets are thus used in the present assessment:

- NOcoast-Aco-4Q: Indices from the Norwegian acoustic survey 1994–2001, age groups 3 to 7.
- NOcoast-Aco-4Q: Indices from the Norwegian acoustic survey 2002–2019, age groups 3 to 7.

5.4 SAM runs and settings (Table 5.7)

In connection with the NEA saithe IBP a number of exploratory SAM runs were performed. Model settings and results are presented in working documents included in the IBP report (ICES CM 2014/ACOM: 53).

SAM model settings and configuration in 2020 were the same as in previous simulations, but two exploratory runs, using different tuning series data, were done in addition to the final run. The additional runs either excluded the 2018 or the 2017 survey estimate. This was done to get an overview of the impact of each of those estimates on the stock estimators. Both the exploratory runs and the final run showed the same trend of an increasing SSB, but the exploratory run with the 2018 survey estimate excluded estimated a lower SBB as well as higher fishing mortality in recent years. Further investigations into the 2018 survey estimate, which included a comparison of cvs and abundance estimates by strata and age - did not produce sufficient reasons for it to be excluded from the tuning time series, and the final run was therefore performed using the entire tuning time series.

- Catch data age 3–12+;
- Tuning data: Acoustic survey series (age 3–7) only, time-series split (1994–2001 and 2002–present);
- Maturity data: Ogives for the years 2007 and later based on the average of the 2005–2007 data;
- Flat exploitation pattern for age groups 8+;
- Correlated Fs between age groups and time;
- Beverton–Holt stock–recruitment relationship used to estimate recent recruitment.

5.5 Final assessment run (Tables 5.8-5.11, Figures 5.4-5.7)

The state–space assessment model (SAM) was used for the final. SAM catchabilities and negative log likelihood values are given in Table 5.8. The predictive power (AIC) of the model was estimated to 1140.64, compared to 1128.45 for the 2019 run.

Figure 5.4 presents normalized residuals for the total catches and the two parts of the acoustic tuning series. There are both year- and age effects and the second part of the series seems to perform better than the first part. Figure 5.5 shows plots of the stock numbers from the SAM vs. tuning indices, a circle indicates last year's result.

5.5.1 SAM F, N, and SSB results (Tables 5.9-5.11, Figures 5.6-5.7)

The estimated fishing mortality ($F_{4–7}$) in 2018 was 0.231 (AFWG 2019), which is below 0.239 from this year's assessment and below the F_{pa} of 0.35. The fishing mortality ($F_{4–7}$) in 2019 was estimated at 0.225. From 1997 to 2009 fishing mortality was below F_{pa}, but started to increase in 2005 and was above F_{pa} in 2010–2012.

Fishing mortality and stock size have in the last decade generally been considerably over- and underestimated respectively. Due to the changes made to the assessment following the benchmark assessment workshop in 2010 (ICES CM 2010/ACOM: 36) and later the NEA saithe IBP in 2014 (ICES CM 2014/ACOM: 53), the retrospective patterns have improved considerably, as is illustrated in Figure 5.7. Based on the 2019 assessment the SSB has in recent years been underestimated and F_{4-7} overestimated.

The SAM-estimate of the 2014 year class was considered to be reliable enough to be used in the projections. In previous assessments the value of the 3-year olds in the last data year has been set to the long-term geometrical mean, and the value of the year class at age 4 were obtained by applying Pope's approximation. Since 2007 the 2008, 2010, and 2013 have been above the long-term geometric mean, while in the other years, year-class strength has been considered average or below.

The total biomass (ages 3+) was above the long-term (1960–2018) average from 1996 to 2010, reached a maximum in 2005, declined below the average level between 2011 and 2015, and has been above the long-term average since 2016. The SSB was above the long-term mean from 2000 to 2009, decreased below the average between 2010 to 2013, and has been above since 2014. SSB has been above B_{pa} (220 000 t) since 1996 (Figure 5.1).

5.5.2 Recruitment (Table 5.10, Figure 5.1)

Catches of age group 3 have varied considerably during the period 2004−2017 (Table 5.10). Until the 2005 WG, RCT3-runs were conducted to estimate the corresponding year classes, with 2 and 3 year olds from the acoustic survey as input together with XSA numbers. However, it was stated several times in the ACOM Technical Minutes that it would be more transparent to use the long-term geometric mean (GM) recruitment. GM values were therefore used in the 2005–2014 since the issue was not discussed at the IBP when SAM was adopted as assessment model. During the 2015 AFWG assessment, analyses were performed to investigate if the last year recruitment value from SAM could be used instead of the long-term GM (for method description refer to Stock Annex). Results from this analysis showed that the retrospective runs of SAM gave better estimates of recruitment than the geometric mean and consequently estimates of the recruiting year class (3 year olds in the last data year) from the SAM were accepted for the last year.

5.6 Reference points (Figure 5.1)

In 2010 the age span was expanded from 11+ to 15+ and important XSA parameter settings were changed (ICES CM 2010/ACOM: 36). LIM reference points were re-estimated at the 2010 WG according to the methodology outlined in ICES CM 2003/ACFM: 15, while the PA reference point estimation was based on the old procedure (ICES CM 1998/ACFM: 10). The results were not very much different from the previous analyses performed in 2005 (ICES CM 2005/ACFM: 20), and it was decided not to change the existing LIM and PA reference points. The shift from XSA to SAM resulted in only minor changes in estimated fishing mortality, spawning-stock-biomass and recruitment and no new reference points were estimated.

5.6.1 Harvest control rule

In 2007 ICES evaluated the harvest control rule for setting the annual fishing quota (TAC) for Northeast Arctic saithe. ICES concluded that the HCR was consistent with the precautionary approach for all simulated data and settings, including a rebuilding situation under the condition that the assessment uncertainty and error are not greater than those calculated from historic data. This also held true when an implementation error (difference between TAC and catch) equal to the historic level was included. The HCR was implemented the same year. It contains the following elements:

- Estimate the average TAC level for the coming 3 years based on F_{mp}. TAC for the next year will be set to this level as a starting value for the 3-year period.
- The year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development. However, the TAC should not be changed by more than 15% compared with the previous year's TAC.
- If the spawning-stock-biomass (SSB) at the beginning of the year for which the quota is set (first year of prediction), is below B_{pa}, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from F_{mp} at SSB = B_{pa} to 0 at SSB equal

to zero. At SSB levels below B_{pa} in any of the operational years (current year and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.

In 2011 the evaluation was repeated taking into account the changes made to the assessment after the 2010 benchmark assessment (ICES CM 2010/ACOM: 36). The analyses indicate that the HCR still is in agreement with the precautionary approach (Mehl and Fotland, WD 11 2011).

The fishing mortality used in the harvest control rule (F_{mp}) was in 2007 set to F_{pa} = 0.35. In June 2013, after the ICES advice for 2014 for this stock had been given, F_{mp} was reduced to 0.32.

5.7 Predictions

5.7.1 Input data (Table 5.12)

The input data to the predictions based on results from the final model run are given in Table 5.12. The estimates for stock number-at-age in 2020 were taken from the final SAM run for ages 4+ (2016 year class). The geometric mean (GM) for recruitment (age 3) of 160 million was used in 2020 and subsequent year classes. The natural mortality of 0.2 is the same as used in the assessment. For exploitation pattern the average of the 2017-2019 fishing mortalities for ages 3 to 12 was used, with mortalities for 8+ being constant. For weight-at-age in stock and catch the average of the last three years (2017-2019) from the final SAM run was used. For maturity-at-age the average of the 2005–2007 annual ogives was applied.

5.7.2 Catch options for 2021 (short-term predictions; Tables 5.13-14)

The management option table (Table 5.13) shows that the expected catch of 171 982 t in 2020 will increase the fishing mortality compared to 2019 from 0.23 to 0.24, which well below the F_{pa} of 0.35. A catch in 2020 corresponding to the $F_{status\ quo}$ level (3-year average 2017–2019) of 0.23 will be 165 840 t, while a catch in 2021 corresponding to the evaluated and implemented HCR of 197 779 t will result in F of 0.28 (Table 5.13).

For a catch in 2020 corresponding to the TAC of 171982, the SSB is expected to decrease from about 552 168 t at the beginning of 2020 to 529 169 t at the beginning of 2021. At $F_{status\ quo}$ in 2021 SSB is estimated to decrease to 518 726 t at the beginning of 2022 and for a catch corresponding to the HCR it will decrease to about 489 730 t.

5.7.3 Comparison of the present and last year's assessment

The current assessment estimated the total stock in 2019 to be 7% higher and the SSB at the same level, compared to the previous assessment. The F in 2018 is estimated slightly higher than the estimate from the previous assessment, and the realized F in 2019 is 4% higher compared to the predicted one based on the TAC.

	Total stock (3+) by 1 January 2019 (tonnes)	SSB by 1 January 2019 (tonnes)	F_{4-7} in 2019	F_{4-7} in 2018
WG 2019	890462	555377	0.216	0.231
WG 2020	951274	555359	0.225	0.239

5.8 Comments to the assessment and the forecast (Figure 5.7).

A statistical model is less sensitive to +group setting than XSA. In addition, the results from XSA were more dependent on the input data (use or no use of CPUE, split of the tuning survey time-series), the shrinkage parameter and whether the number of iterations is capped or not. XSA only converged at a large number of iterations. In contrast results from SAM are much more robust and depend to a lesser degree on subjective choice of model settings (such as shrinkage). In addition, SAM as a stochastic model is not treating catches as known without error. The fishing mortality rates could be considered correlated in time, and to reflect that neighboring age groups have more similar fishing mortalities.

The retrospective pattern has been a major concern in the assessment, but due to the changes done at the benchmark assessment in 2010 (ICES CM 2010/ACOM: 36) and later at the NEA saithe IBP in 2014 (ICES CM 2014/ACOM: 53), the assessment has become somewhat more stable (Figure 5.7)

The biological sampling from the fishery got critically low after the termination of the original Norwegian port-sampling program in 2009. In 2015 this was in particular the case for samples from trawl in quarter two and three in ICES area 1 and age samples from purse-seine fishery south of Lofoten (ICES area 2.a). In 2019 particularly catches from the saithe purse seine fishery in Norwegian statistical areas 3 and 4 (ICES area 2.a) were not sampled adequately, which may affect the precision of the catch and weight at age estimates.

Lack of reliable recruitment estimates is a major problem. Prediction of catches will still, to a large extent, be dependent on assumptions of average recruitment in the intermediate year and the forecast period, since fish from age four to seven constitute major parts of the catches. Since the saithe HCR is a three-year-rule, the estimation of average F_{mp} catch in the HCR will affect stock numbers up to age five, and thereby affect the total prognosis of the fishable stock and the quotas derived from it. The recruitment-at-age 3 estimated by the SAM has on average been at about the long-term geometric mean level since 2005.

Table 5.1. Saithe in subareas 1 and 2 (Northeast Arctic). Nominal catch (t) by countries as officially reported to ICES.

Year	Faroe Islands	France	Germany Dem.Rep	Fed.Rep. Germany	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others [5]	Total all countries
1960	23	1 700		25 948		96 050					9 780	14	133 515
1961	61	3 625		19 757		77 875					4 615	18	105 951
1962	2	544		12 651		101 895			912		4 699	4	120 707
1963		1 110		8 108		135 297					4 112		148 627
1964		1 525		4 420		184 700			84		6 511	186	197 426
1965		1 618		11 387		165 531			137		6 746	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			1248	4 753		96 641					8 782		111 424
1969	20	193	6 744	4 355		115 140					13 585	23	140 060
1970	1 097		29 200	23 466		151 759			43 550		15 690		264 924
1971	215	14 536	16 840	12 204		128 499	6 017		39 397	13 097	10 467		241 272
1972	109	14 519	7 474	24 595		143 775	1 111		1 278	9 247	8 348		210 456
1973	7	11320	12 015	30 338		148 789	23		2 411	2 115	6 841		213 859
1974	46	7119	29 466	33 155		152 699	2521		28 931	7 075	3 104	5	264 121
1975	28	3156	28 517	41 260		122 598	3860	6430	13 389	11 397	2 763	55	233 453
1976	20	5609	10 266	49 056		131 675	3164	7233	9 013	21 661	4 724	65	242 486
1977	270	5658	7 164	19 985		139 705	1	783	989	1 327	6 935		182 817
1978	809	4345	6 484	19 190		121 069	35	203	381	121	2 827		155 464
1979	1117	2601	2 435	15 323		141 346			3	685	1 170		164 680
1980	532	1016		12 511		128 878			43	780	794		144 554
1981	236	218		8 431		166 139			121		395		175 540
1982	339	82		7 224		159 643			14		732		168 034
1983	539	418		4 933		149 556			206	33	1 251		156 936
1984	503	431	6	4 532		152 818			161		335		158 786
1985	490	657	11	1 873		103 899			51		202		107 183
1986	426	308		3 470		63 090			27		75		67 396
1987	712	576		4 909		85 710			426		57	1	92 391
1988	441	411		4 574		108 244			130		442		114 242

Year	Faroe Islands	France	Germany Dem.Rep	Fed.Rep. Germany	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others [5]	Total all countries
1989	388	460 [2]		606		119 625			506	506	726		122 817
1990	1207	340 [2]		1 143		92 397			52		709		95 848
1991	963	77 [2]	**Greenland**	2 003		103 283			504 [4]		492	5	107 327
1992	165	1980	734	3 451		119 763			964	6	541		127 604
1993	31	566	78	3 687	3	140 604		1	9 509	4 [2]	415	5	154 903
1994	67 [2]	557	15	1 863	4 [2]	141 589		1 [2]	1640 [2]	655 [2]	557	2	146 950
1995	172 [2]	358	53	935		165 001		5	1 148		688	18	168 378
1996	248 [2]	346	165	2 615		166 045		24	1 159	6	707	33	171 348
1997	193 [2]	560	363 [2]	2 915		136 927		12	1 774	41	799	45	143 629
1998	366	932	437 [2]	2 936		144 103		47	3 836	275	355	40	153 327
1999	181	638 [2]	655 [2]	2 473	146	141 941		17	3 929	24	339	32	150 375
2000	224 [2]	1438	651 [2]	2 573	33	125 932		46	4 452	117	454	8 [2]	135 928
2001	537	1279	701 [2]	2 690	57	124 928		75	4 951	119	514	2	135 853
2002	788	1048	1393	2 642	78	142 941		118	5 402	37	420	3	154 870
2003	2056	1022	929 [2]	2 763	80 [2]	150 400		147	3 894	18	265	18 [2]	161 592
2004	3071	255	891 [2]	2 161	319	147 975		127	9 192	87	544	14	164 636
2005	3152	447	817 [2]	2 048	395	162 338		354	8 362	25	630		178 568
2006	1795	899,7	779 [2]	2 780	255	195 462	88,9	101	9 823	0	532	42	212 557
2007	2048	965,6	801 [2]	3 019	219	178 644	99,3	412	12 168	22	557	11,8	198 967
2008	2405	1008,6	513 [2]	2 264	113	165 998	65,8	348	11 577	33	506	9,7	184 840
2009	1611	378,6	697	2 021	69	144 570	30,6	184,01	11 899	2	379	24	161 865
2010	1632	677,2	954	1 592	124	175 246	278,9	93	14 664	8	283	2,5	195 554
2011	306	504,2	445	1 371	66	143 314	0	45,34	10 007	2	972	15,14	157 048
2012	146	780,55	658	1 371	126	143 174	0	7,65	13 607	4	1 087	0	160 960
2013	80	1900,92	972	1 212	245	111 961	2,21	17,24	14 796	5	415	21,93	131 629
2014	273	1 674	407	259	659	115 864	0,86	8,25	12 396	12	518	0	132 070
2015	766	515	393	424	248	115 157	1 143	10,42	13 181	34	403	0	132 275
2016	1 148	526	613	952	702	121 705	530	52	15 203	26	301	10	141 768
2017 [1]	639	680	407	865	589	126 947	504	86	14 551	88	439	24	145 819

Year	Faroe Islands	France	Germany Dem.Rep	Fed.Rep. Germany	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total all countries
2018	626	937	448	1 642		162 460	404	51	14 171	60	464	17	181 280
2019	618	1 472	424	1 371		144 076	46	131	13 990	199	419	434	163 180

1 Provisional figures.

2 As reported to Norwegian authorities.

3 USSR prior to 1991.

4 Includes Estonia.

5 Includes Denmark, Netherlands, Ireland, and Sweden

6 As reported by Working Group members

Table 5.2 Saithe in subareas 1 and 2 (Northeast Arctic). Catch by fishing gear.

Year	Purse-seine	Trawl	Gillnet	Others	Total
1977	75,2	69,5	19,3	12,7	176,7
1978	62,9	57,6	21,1	13,9	155,5
1979	74,7	52,5	21,6	15,9	164,7
1980	61,3	46,8	21,1	15,4	144,6
1981	64,3	72,4	24,0	14,8	175,5
1982	76,4	59,4	16,7	15,5	168,0
1983	54,1	68,2	19,6	15,0	156,9
1984	36,4	85,6	23,7	13,1	158,8
1985	31,1	49,9	14,6	11,6	107,2
1986	7,9	36,2	12,3	8,2	64,6
1987	34,9	27,7	19,0	10,8	92,4
1988	43,5	45,4	15,3	10,0	114,2
1989	49,5	45,0	16,9	11,4	122,8
1990	24,6	44,0	19,3	7,9	95,8
1991	38,9	40,1	18,9	9,4	107,3
1992	27,1	67,0	22,3	11,2	127,6
1993	33,1	84,9	21,2	15,7	154,9
1994	30,2	82,2	21,1	13,5	147,0
1995	21,8	103,5	26,9	16,1	168,4
1996	46,9	72,5	31,6	20,3	171,3
1997	44,4	55,9	24,4	19,0	143,6

1998	44,4	57,7	27,6	23,6	153,3
1999	39,2	57,9	29,7	23,6	150,4
2000	28,3	54,5	29,6	23,5	135,9
2001	28,1	58,1	28,2	21,5	135,9
2002	27,4	75,5	30,4	21,5	154,8
2003	43,3	73,8	25,2	19,3	161,6
2004	41,8	74,6	26,9	21,3	164,6
2005	42,1	91,8	25,6	19,1	178,6
2006	73,5	87,1	29,7	22,5	212,8
2007	41,8	100,7	33,3	23,2	199,0
2008	39,4	91,2	37,0	17,1	184,7
2009	35,5	81,1	33,2	12,1	161,9
2010	54,9	89,8	36,9	13,2	194,8
2011	45,3	67,1	32,1	12,2	156,7
2012	44,2	73,9	28,3	14,5	160,9
2013	34,7	65,2	19,2	12,7	131,8
2014	29,3	54,8	26,7	21,2	132,0
2015	30,4	55,4	23,5	22,5	131,8
2016	28,9	64,1	21,4	26,9	141,3
2017 [1]	32,4	65,0	21,4	27,3	146,1
2018	36,0	83,6	28,8	33,2	181,5
2019	28,7	68,6	29,4	36,6	163,1

1 Provisional figures.

2 Unresolved discrepancies between Norwegian catch by gear figures and the total reported to ICES for these years.

3 Includes 4300 tonnes not categorized by gear, proportionally adjusted.

4 Reduced by 1200 tonnes not categorized by gear, proportionally adjusted.

Table 5.3 Catch numbers-at-age ('000) Northeast Arctic saithe

	Age groups								
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1960	13517	16828	17422	6514	6281	3088	1691	956	481	1481
1961	25237	12929	17707	5379	1886	1371	736	573	538	1202
1962	45932	13720	5449	10218	2991	1262	1156	556	611	1518
1963	51171	35199	7165	5659	4699	1337	1308	848	550	1612
1964	10925	72344	15966	3299	4214	3223	1518	1482	1282	3038
1965	42578	5737	30171	11635	3282	2421	3135	802	1136	2986
1966	25127	61199	14727	14475	5220	1542	1047	1083	530	2724
1967	28457	23826	34493	3957	5388	2797	1356	1340	814	2536
1968	29955	21856	6065	9846	936	2274	1070	686	465	922
1969	76011	11745	16650	4666	4716	1107	1682	663	199	303
1970	43834	63270	14081	16298	5157	8004	2521	3722	1103	1714
1971	61743	47522	21614	7661	7690	2326	3489	1760	2514	1888
1972	55351	44490	24752	8650	4769	3012	1584	1817	1044	1631
1973	62938	20793	22199	13224	5868	3246	2368	2153	1291	1947
1974	36884	44149	15714	20476	12182	4815	3267	2512	1440	2392
1975	70255	13502	18901	5123	9018	7841	3365	2714	2237	2544
1976	135592	33159	8618	9448	3725	3483	2905	1870	1183	1940
1977	105935	36703	10845	2205	4633	1557	1718	1030	495	718
1978	56505	31946	14396	5232	1694	2132	1082	1126	756	1726
1979	75819	28545	17280	5384	3550	1178	1659	536	373	1086
1980	40303	36202	9100	6302	3161	1322	145	721	406	1204
1981	85966	22345	22044	3706	2611	2056	378	286	258	385
1982	35853	67150	13481	8477	1088	1291	476	271	124	338
1983	18216	25108	34543	3408	3178	1243	803	261	215	587
1984	43579	34927	12679	11775	1193	1862	589	585	407	537
1985	48989	11992	7200	5287	3746	776	879	134	274	427
1986	21322	12433	5845	4363	2704	1349	338	438	123	152
1987	18555	51742	4506	3238	3624	784	644	267	263	565

	Age groups									
Year	3	4	5	6	7	8	9	10	11	12+
1988	8144	35928	32901	4570	2333	1222	968	321	73	30
1989	12607	19400	33343	18578	1762	352	177	189	1	205
1990	23792	16930	9054	10238	7341	1076	160	112	150	118
1991	68682	13630	5752	4883	3877	2381	383	61	90	89
1992	44627	33294	5987	5412	4751	3176	1462	286	93	350
1993	22812	61931	31102	3747	1759	1378	1027	797	76	71
1994	7063	32671	49410	19058	2058	724	421	278	528	129
1995	17178	52109	40145	30451	4177	483	125	259	31	263
1996	10510	54886	18499	18357	17834	2849	485	214	148	325
1997	11789	11698	35011	13567	13452	7058	812	55	48	98
1998	3091	16215	11946	31818	8376	5539	2873	727	111	282
1999	9655	12236	22872	10347	18930	3374	3343	2290	419	170
2000	9175	22768	7747	10676	6123	8303	2530	2652	1022	197
2001	3816	7946	26960	8769	7120	3146	4687	1935	1406	528
2002	6582	17492	11573	25671	5312	4276	2382	3431	965	1420
2003	2345	50653	13600	7123	9594	5494	3545	2519	2327	1813
2004	1002	6129	33840	10613	7494	8307	2792	3088	2377	3072
2005	26093	12543	9841	23141	10799	5659	7852	2674	713	1588
2006	1590	68137	12328	10098	16757	8080	5671	5127	1815	2529
2007	3144	4115	39889	15301	7963	11302	7749	4138	2157	849
2008	25259	18953	5969	24363	9712	5624	7697	4705	1606	1572
2009	9050	34311	9954	6628	15930	4766	3021	4224	2471	1426
2010	26382	43436	28514	7988	3129	12444	2749	1314	1212	1431
2011	6239	45213	13307	15157	6622	2901	5934	1730	647	1115
2012	30742	17841	33911	10496	7058	3522	1570	2586	557	890
2013	17151	15491	15946	21980	5512	3298	1149	729	885	653
2014	7650	24769	13822	9343	12331	3284	2130	904	378	763
2015	13185	15459	30159	9271	7324	7133	1697	723	433	620
2016	8278	20955	13044	15532	6621	4774	4363	1053	718	1382

Year	Age groups 3	4	5	6	7	8	9	10	11	12+
2017	5421	34736	12901	7324	9032	3885	2562	1924	376	1999
2018	5260	19260	41425	12618	5903	5667	2843	1956	1112	1567
2019	12421	15078	15388	25177	8327	3243	2848	1357	619	1171

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

Year	Age groups 3	4	5	6	7	8	9	10	11	12+
1960	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,55
1961	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,75
1962	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,52
1963	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,33
1964	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,35
1965	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,54
1966	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,43
1967	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,49
1968	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,36
1969	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,16
1970	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,03
1971	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	7,87
1972	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,14
1973	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,01
1974	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	7,69
1975	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	7,73
1976	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	7,86
1977	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,05
1978	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,00
1979	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,28
1980	0,79	1,27	2,03	2,55	3,29	4,34	5,15	5,75	6,11	7,22
1981	0,73	1,40	2,05	2,76	3,30	4,38	5,95	6,39	6,61	7,00

	Age groups									
Year	3	4	5	6	7	8	9	10	11	12+
1982	0,77	1,12	2,02	2,61	3,27	3,91	4,69	5,63	7,18	7,69
1983	1,05	1,33	1,86	2,80	4,00	4,18	5,33	5,68	7,31	9,16
1984	0,71	1,26	2,02	2,70	3,88	4,47	5,36	6,06	6,28	7,88
1985	0,75	1,33	2,07	2,63	3,28	3,96	4,54	5,55	6,88	8,74
1986	0,59	1,22	1,97	2,30	2,87	3,72	4,30	4,69	5,84	7,21
1987	0,53	0,84	1,66	2,32	2,97	4,00	4,72	5,44	5,79	7,42
1988	0,62	0,87	1,31	2,43	3,87	5,38	5,83	5,36	6,92	8,82
1989	0,74	0,95	1,40	1,78	2,96	3,73	4,62	4,66	8,34	7,69
1990	0,71	1,00	1,45	2,09	2,49	3,75	3,90	6,74	4,94	7,34
1991	0,68	1,05	1,85	2,39	3,08	3,35	4,48	4,66	5,62	7,31
1992	0,67	1,01	1,92	2,28	2,77	3,20	3,73	6,35	6,90	7,83
1993	0,61	0,99	1,65	2,46	2,85	3,03	3,71	4,49	5,56	7,13
1994	0,52	0,76	1,24	2,12	3,22	3,83	4,69	5,31	5,66	7,29
1995	0,56	0,79	1,19	1,71	2,87	3,78	4,06	5,30	6,86	7,65
1996	0,59	0,82	1,33	1,84	2,48	3,73	4,32	5,34	5,98	7,58
1997	0,62	0,95	1,24	1,72	2,35	3,10	4,19	5,79	6,77	7,75
1998	0,68	1,00	1,48	1,87	2,58	3,07	4,13	5,44	6,70	8,59
1999	0,67	1,05	1,45	1,93	2,27	2,97	3,61	4,10	4,93	6,97
2000	0,60	1,03	1,63	2,10	2,67	3,14	3,81	4,41	5,76	8,07
2001	0,75	1,12	1,54	2,04	2,60	3,14	3,63	4,54	5,05	6,17
2002	0,69	1,01	1,50	1,97	2,54	3,25	3,77	4,31	4,91	6,11
2003	0,66	0,91	1,42	1,89	2,54	2,58	3,49	3,75	4,12	5,90
2004	0,70	1,03	1,37	1,90	2,41	2,98	3,44	3,73	4,14	5,47
2005	0,59	0,89	1,49	2,09	2,16	2,99	3,24	3,82	3,92	6,19
2006	0,63	0,83	1,43	1,78	2,27	2,73	3,02	3,90	4,06	5,82
2007	0,73	1,08	1,41	1,86	2,43	2,94	3,35	3,66	4,17	5,54
2008	0,63	0,98	1,38	1,92	2,31	2,83	3,16	3,43	3,82	4,75
2009	0,73	1,03	1,65	2,00	2,37	2,69	3,23	3,38	3,46	4,67
2010	0,70	0,99	1,45	2,14	2,50	3,13	3,34	3,81	3,99	5,17

	Age groups									
Year	3	4	5	6	7	8	9	10	11	12+
2011	0,70	0,82	1,42	2,07	2,68	3,25	3,62	3,97	4,52	5,84
2012	0,59	1,07	1,35	2,15	2,82	3,20	3,67	4,16	4,60	5,70
2013	0,57	1,01	1,50	1,83	2,74	3,33	3,91	4,61	4,50	6,13
2014	0,66	0,92	1,58	2,12	2,54	3,49	4,01	4,22	4,71	5,80
2015	0,61	0,85	1,24	1,91	2,45	3,02	3,97	4,74	4,51	6,05
2016	0,84	1,04	1,46	2,02	2,36	3,12	3,53	4,14	4,65	6,03
2017	0,89	1,12	1,68	2,18	2,63	3,13	3,63	4,16	4,5	5,9
2018	0,91	1,21	1,56	2,02	2,51	3,04	3,44	3,89	4,50	5,60
2019	0,83	1,17	1,64	2,06	2,62	3,18	3,71	4,13	4,88	6,14

Table 5.5. 3-year running average maturity ogive 1985–2006, values for 2007–2017 average of 2005–2007.

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

Year	3	4	5	6	7	8	9	10	11	12+
2002	0	0	0.13	0.78	0.95	0.98	0.98	0.99	0.98	0.97
2003	0	0	0.14	0.82	0.96	0.98	0.98	0.99	1	0.99
2004	0	0	0.21	0.8	0.97	0.99	0.99	1	1	0.98
2005	0	0.03	0.3	0.82	0.97	0.99	0.99	1	1	1.00
2006	0	0.04	0.4	0.86	0.98	0.99	1	1	1	1.00
2007	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2008	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2009	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2010	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2011	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2012	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2013	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2014	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2015	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2016	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2017	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2018	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2019	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00

Table 5.6 Northeast Arctic saithe. Tuning datasets applied in final SAM run

```
FLT13: Norway Ac Survey (Catch: Unknown) (Effort: Unknown)
1994 2001
1 1 0.75 0.85
3  7
1    87.1   108.9    41.4     8.1     0.7
1   166.1    86.5    46.5    16.5     2.4
1   122.6   207.4    31.7    15.1     4.0
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 2019
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   196.0   144.7    48.2    16.9     4.3
1   211.5    49.9    16.1    11.9     7.2
1    42.2   132.1    13.6     4.4     8.9
1    90.1    25.8    58.3     6.8     4.1
1    58.2    17.0     8.2     9.9     3.0
1    97.4    61.5     7.1     4.1     6.1
1   143.0    22.5    17.2       4     1.7
1    42.7    59.6     4.6     4.2     1.1
1    68.6    29.6    18.8     3.5     2.8
1    78.0    16.7    13.0    11.6     2.2
1    40.1    70.8     8.7     5.6     5.4
1    72.4    22.7    30.1     6.0     4.2
1   145.7    32.0    10.5    11.2     4.2
1    91.1    63.9    13.3     2.8     5.4
1    30.6    61.1    45.4    12.3     4.2
1    84.4    50.6    24.2   17.75    3.54
```

Table 5.7 SAM parameter settings.

Model used: State-space assessment model SAM (https://www.stockassessment.org).

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

Visible stock on (https://www.stockassessment.org) "afwg_saithe_ 2018_001".

Model Options agreed upon at IBP saithe winter 2014.

$minAge

The minimium age class in the assessment

3

$maxAge

```
# The maximum age class in the assessment
 12
$maxAgePlusGroup
# Is last age group considered a plus group (1 yes, or 0 no).
1
$keyLogFsta
# Coupling of the fishing mortality states (nomally only first row is used).
  0  1  2  3  4  5  5  5  5  5
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)
 2
$keyLogFpar
# Coupling of the survey catchability parameters (nomally first row is not used, as that is covered
by fishing mortality).
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
  0  1  2  3  3 -1 -1 -1 -1 -1
  4  5  6  7  7 -1 -1 -1 -1 -1
$keyQpow
# Density dependent catchability power parameters (if any).
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarF
# Coupling of process variance parameters for log(F)-process (nomally only first row is used)
  0  0  0  0  0  0  0  0  0  0
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1 1 1

$keyVarObs
# Coupling of the variance parameters for the observations.
  0  0  0  0  0  0  0  0  0  0
```

1 1 1 1 1 -1 -1 -1 -1 -1

2 2 2 2 2 -1 -1 -1 -1 -1

Table 5.7 SAM parameter settings continued

$obsCorStruct

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

"ID" "ID" "ID"

$keyCorObs

Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.

NA's indicate where correlation parameters can be specified (-1 where they cannot).

#3-4 4-5 5-6 6-7 7-8 8-9 9-10 10-11 11-12

NA NA NA NA NA NA NA NA NA

NA NA NA NA -1 -1 -1 -1 -1

NA NA NA NA -1 -1 -1 -1 -1

$stockRecruitmentModelCode

Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt).

2

$noScaledYears

Number of years where catch scaling is applied.

0

$keyScaledYears

A vector of the years where catch scaling is applied.

$keyParScaledYA

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

$fbarRange

lowest and higest age included in Fbar

4 7

$keyBiomassTreat

To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).

-1 -1 -1

$obsLikelihoodFlag

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

"LN" "LN" "LN"

$fixVarToWeight

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

0

Table 5.8. SAM catchabilities, negative log likelihood values, and number of parameters.

Index	Fleet number	Age	Catchability	Low	High
1	2	3	0.869	0.592	1.276
2	2	4	1.17	0.799	1.714
3	2	5	0.607	0.414	0.89
4	2	6	0.375	0.279	0.504
5	2	7	0.375	0.279	0.504
6	3	3	0.626	0.51	0.769
7	3	4	0.504	0.411	0.619
8	3	5	0.276	0.225	0.34
9	3	6	0.182	0.152	0.219
10	3	7	0.182	0.152	0.219

Model fitting.

Model	log(L)	#par	AIC
Current	-553.32	17	1140.64
base	-547.23	17	1128.45

Table 5.9 Estimated fishing mortalities.

Year Age	3	4	5	6	7	8	9	10	11	12
1960	0.237	0.284	0.321	0.277	0.221	0.163	0.163	0.163	0.163	0.163
1961	0.223	0.260	0.273	0.227	0.174	0.127	0.127	0.127	0.127	0.127
1962	0.222	0.262	0.268	0.226	0.177	0.133	0.133	0.133	0.133	0.133
1963	0.225	0.273	0.282	0.239	0.194	0.154	0.154	0.154	0.154	0.154
1964	0.238	0.298	0.319	0.277	0.241	0.208	0.208	0.208	0.208	0.208
1965	0.235	0.292	0.326	0.288	0.254	0.231	0.231	0.231	0.231	0.231
1966	0.260	0.320	0.342	0.288	0.245	0.224	0.224	0.224	0.224	0.224
1967	0.260	0.309	0.318	0.264	0.224	0.217	0.217	0.217	0.217	0.217
1968	0.221	0.241	0.229	0.185	0.153	0.147	0.147	0.147	0.147	0.147
1969	0.230	0.241	0.221	0.175	0.143	0.132	0.132	0.132	0.132	0.132
1970	0.328	0.361	0.340	0.283	0.250	0.239	0.239	0.239	0.239	0.239
1971	0.359	0.384	0.356	0.294	0.269	0.258	0.258	0.258	0.258	0.258

Year Age	3	4	5	6	7	8	9	10	11	12
1972	0.380	0.391	0.350	0.283	0.259	0.245	0.245	0.245	0.245	0.245
1973	0.419	0.429	0.386	0.317	0.299	0.284	0.284	0.284	0.284	0.284
1974	0.542	0.561	0.513	0.429	0.416	0.395	0.395	0.395	0.395	0.395
1975	0.596	0.621	0.567	0.478	0.488	0.477	0.477	0.477	0.477	0.477
1976	0.649	0.683	0.611	0.499	0.495	0.470	0.470	0.470	0.470	0.470
1977	0.576	0.615	0.541	0.431	0.417	0.377	0.377	0.377	0.377	0.377
1978	0.574	0.653	0.597	0.488	0.475	0.430	0.430	0.430	0.430	0.430
1979	0.554	0.678	0.638	0.529	0.508	0.451	0.451	0.451	0.451	0.451
1980	0.494	0.639	0.620	0.519	0.481	0.420	0.420	0.420	0.420	0.420
1981	0.458	0.631	0.621	0.521	0.460	0.391	0.391	0.391	0.391	0.391
1982	0.423	0.622	0.623	0.527	0.450	0.374	0.374	0.374	0.374	0.374
1983	0.403	0.631	0.656	0.596	0.533	0.452	0.452	0.452	0.452	0.452
1984	0.444	0.716	0.733	0.725	0.684	0.591	0.591	0.591	0.591	0.591
1985	0.352	0.593	0.614	0.652	0.683	0.590	0.590	0.590	0.590	0.590
1986	0.243	0.452	0.499	0.574	0.650	0.592	0.592	0.592	0.592	0.592
1987	0.226	0.456	0.532	0.665	0.806	0.746	0.746	0.746	0.746	0.746
1988	0.215	0.456	0.537	0.659	0.766	0.652	0.652	0.652	0.652	0.652
1989	0.201	0.422	0.470	0.525	0.533	0.398	0.398	0.398	0.398	0.398
1990	0.223	0.478	0.525	0.595	0.602	0.451	0.451	0.451	0.451	0.451
1991	0.192	0.428	0.481	0.556	0.571	0.430	0.430	0.430	0.430	0.430
1992	0.172	0.431	0.543	0.692	0.754	0.600	0.600	0.600	0.600	0.600
1993	0.130	0.355	0.476	0.622	0.680	0.540	0.540	0.540	0.540	0.540
1994	0.100	0.296	0.418	0.567	0.627	0.502	0.502	0.502	0.502	0.502
1995	0.081	0.247	0.336	0.437	0.470	0.372	0.372	0.372	0.372	0.372
1996	0.072	0.225	0.312	0.419	0.485	0.415	0.415	0.415	0.415	0.415
1997	0.053	0.163	0.226	0.297	0.338	0.292	0.292	0.292	0.292	0.292
1998	0.046	0.154	0.221	0.297	0.347	0.322	0.322	0.322	0.322	0.322
1999	0.045	0.157	0.228	0.298	0.338	0.322	0.322	0.322	0.322	0.322
2000	0.039	0.140	0.204	0.266	0.295	0.291	0.291	0.291	0.291	0.291

Year Age	3	4	5	6	7	8	9	10	11	12
2001	0.030	0.115	0.176	0.236	0.264	0.272	0.272	0.272	0.272	0.272
2002	0.027	0.109	0.167	0.227	0.260	0.289	0.289	0.289	0.289	0.289
2003	0.025	0.104	0.157	0.215	0.261	0.323	0.323	0.323	0.323	0.323
2004	0.023	0.097	0.149	0.207	0.261	0.349	0.349	0.349	0.349	0.349
2005	0.033	0.128	0.181	0.241	0.290	0.379	0.379	0.379	0.379	0.379
2006	0.040	0.157	0.214	0.285	0.344	0.455	0.455	0.455	0.455	0.455
2007	0.047	0.175	0.230	0.299	0.356	0.464	0.464	0.464	0.464	0.464
2008	0.072	0.251	0.298	0.364	0.420	0.532	0.532	0.532	0.532	0.532
2009	0.081	0.279	0.321	0.371	0.417	0.520	0.520	0.520	0.520	0.520
2010	0.099	0.330	0.369	0.403	0.428	0.504	0.504	0.504	0.504	0.504
2011	0.098	0.315	0.363	0.404	0.432	0.486	0.486	0.486	0.486	0.486
2012	0.102	0.305	0.347	0.378	0.400	0.432	0.432	0.432	0.432	0.432
2013	0.085	0.252	0.289	0.312	0.331	0.347	0.347	0.347	0.347	0.347
2014	0.075	0.224	0.262	0.283	0.306	0.321	0.321	0.321	0.321	0.321
2015	0.069	0.212	0.251	0.269	0.290	0.301	0.301	0.301	0.301	0.301
2016	0.061	0.194	0.241	0.269	0.301	0.325	0.325	0.325	0.325	0.325
2017	0.054	0.172	0.216	0.248	0.284	0.310	0.310	0.310	0.310	0.310
2018	0.057	0.179	0.223	0.257	0.296	0.323	0.323	0.323	0.323	0.323
2019	0.057	0.175	0.212	0.241	0.273	0.289	0.289	0.289	0.289	0.289

Table 5.10 Estimated stock numbers.

Year Age	3	4	5	6	7	8	9	10	11	12
1960	84991	103912	53212	28381	25883	14181	10447	7310	3637	12143
1961	114460	57068	68504	29905	17461	15981	8965	7018	5130	11309
1962	204117	67756	36797	44128	18580	12664	11382	6223	5183	12478
1963	272094	131483	38848	25372	28413	11908	9814	8232	4504	13305
1964	81824	189926	77166	22710	17495	18772	8047	7404	6111	13615
1965	254833	50830	111615	44924	14524	11523	12221	5047	5122	13707
1966	134115	180069	34641	62997	26280	9313	7491	7295	3201	12471

Year Age	3	4	5	6	7	8	9	10	11	12
1967	175432	83342	109711	20362	36814	16027	6275	5176	4572	10014
1968	143854	116944	47671	63767	13167	23992	10080	4088	3333	8342
1969	262910	89166	80164	31929	42246	10740	17848	7018	2684	6991
1970	222611	166949	58717	54450	22573	29674	9104	13973	5139	7228
1971	230059	143991	87177	35668	32780	14419	17688	6440	9201	7949
1972	153182	138307	85817	46671	23051	19664	9618	10457	4224	10167
1973	201676	80411	79108	52165	27952	15445	12734	6751	6435	8945
1974	100459	111158	41967	45815	32599	16864	10237	8243	4243	9095
1975	167810	44390	53057	20047	23712	17769	9325	5987	4754	7187
1976	218122	75074	19391	25721	10555	11398	8676	4711	3053	5796
1977	201499	89956	30963	8451	13287	5475	5706	4285	2325	4251
1978	135581	89889	38640	14995	4599	7285	3202	3105	2408	3964
1979	196411	59883	38762	17229	7663	2362	4007	1756	1560	3428
1980	118511	95037	23569	16870	8545	3656	1143	2062	958	2679
1981	228438	57050	43360	10037	8274	4399	1851	687	1072	1845
1982	129186	122262	24408	19463	4730	4372	2259	1041	396	1649
1983	102059	69081	52655	9992	9337	2582	2502	1256	607	1285
1984	93223	58461	31023	20189	4362	4546	1304	1334	711	1053
1985	102418	42140	23310	12984	6922	1936	2089	561	610	826
1986	181566	49450	17696	11000	6014	2396	948	955	270	635
1987	144313	132713	22892	8341	5447	2789	853	477	427	462
1988	81537	100593	75935	11210	3440	2032	1316	238	200	302
1989	77433	55360	54925	38810	4890	1197	827	613	58	285
1990	85631	47732	29879	26245	18822	2436	604	465	366	214
1991	223415	48201	22211	15184	11141	8518	1241	302	264	321
1992	283454	141989	22626	10948	7776	4975	4704	650	170	367
1993	213556	212979	75658	10183	4281	3102	1966	2313	283	237
1994	152657	163716	131524	37141	4355	1727	1485	774	1233	268
1995	278265	132204	111972	74780	15629	1855	806	776	316	815

Year Age	3	4	5	6	7	8	9	10	11	12
1996	159118	244229	88261	68577	40064	7972	1038	486	446	700
1997	163556	120946	177570	57710	39982	21332	4171	512	261	628
1998	104035	134210	84288	126565	32952	24058	12795	2555	333	620
1999	240367	78888	94643	53933	73572	18492	14961	7615	1480	574
2000	157007	192201	51511	55783	31552	40695	11336	9514	4363	1138
2001	212157	107297	139333	35575	33225	19207	24194	7212	5998	3206
2002	348589	176882	78898	93717	24041	20610	12677	15003	4476	5864
2003	147196	306433	124675	52337	57187	17091	12698	8559	9140	6445
2004	150696	119017	206886	86945	35876	36559	10857	7408	5412	9107
2005	418616	117434	79027	125756	57181	23911	22167	6782	3850	7612
2006	72429	333890	79887	48944	74453	35156	14748	12495	3854	6129
2007	109679	53831	213602	52577	29976	40277	19787	8188	6255	4473
2008	193623	75165	38073	115870	30326	16633	20079	10714	4151	5155
2009	141211	150402	46151	25134	63231	15846	7918	9328	5256	4278
2010	263607	96750	90086	28656	14321	33454	7816	3791	4208	4403
2011	112152	196685	50709	47061	15762	8183	16116	3941	1861	4013
2012	148281	91264	123138	31198	24988	9093	4409	7842	1934	2913
2013	205714	91545	63521	77460	18459	13476	5045	2452	4002	2550
2014	105708	168482	60570	42696	46075	11106	7795	3149	1453	3781
2015	159992	79319	120312	42147	28576	27199	6522	4548	1962	3294
2016	250262	117629	54093	74516	27901	17684	15813	3833	2937	3763
2017	168424	217957	81167	34323	43373	16943	10423	8817	2162	4659
2018	110415	139342	177749	59001	24193	25309	10316	6218	5099	4372
2019	189791	95520	98762	121952	35613	14644	14538	6085	3498	5528
pred		146802	65658	65387	78432	22195	8982	8916	3732	5536

Table 5.11. Estimated recruitment, total-stock-biomass (TBS), spawning-stock-biomass (SSB), and average fishing mortality for ages 4 to 7 (F47).

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
1960	84991	53424	135210	461614	340307	626163	0.276	0.198	0.385	686732	537323	877686
1961	114460	75617	173258	454968	338405	611681	0.233	0.171	0.318	660750	519795	839928
1962	204117	135558	307351	459886	345273	612544	0.233	0.173	0.314	722854	577738	904419
1963	272094	180940	409169	456511	346285	601824	0.247	0.185	0.330	833342	675428	1028176
1964	81824	53940	124121	479952	369435	623531	0.284	0.214	0.377	812401	657252	1004174
1965	254833	169608	382883	518941	403722	667043	0.290	0.219	0.384	854219	695753	1048778
1966	134115	89496	200980	480035	371088	620966	0.299	0.226	0.396	822222	669652	1009553
1967	175432	116803	263488	492393	383764	631771	0.279	0.210	0.371	798451	651982	977824
1968	143854	95922	215738	471092	366310	605846	0.202	0.151	0.270	759823	621143	929465
1969	262910	174601	395885	510928	405477	643804	0.195	0.147	0.259	868208	720301	1046487
1970	222611	148554	333585	565922	458064	699177	0.308	0.237	0.401	970961	818201	1152242
1971	230059	154278	343061	554204	453495	677278	0.326	0.252	0.421	954260	808900	1125741
1972	153182	102840	228167	537212	443054	651380	0.321	0.250	0.412	878671	747746	1032521
1973	201676	135364	300472	537060	447901	643967	0.358	0.281	0.456	846637	724757	989014
1974	100459	67147	150298	491991	412199	587230	0.480	0.380	0.605	734324	631478	853919
1975	167810	112522	250263	398102	334594	473665	0.539	0.429	0.676	613449	527316	713651

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
1976	218122	145846	326213	281760	235292	337405	0.572	0.456	0.717	543005	460830	639832
1977	201499	135129	300466	209817	174600	252138	0.501	0.398	0.630	478238	402760	567861
1978	135581	90814	202414	189243	158540	225892	0.553	0.442	0.692	418158	354464	493298
1979	196411	131763	292779	170615	142872	203745	0.588	0.471	0.735	410810	343927	490700
1980	118511	79524	176613	150432	125881	179771	0.565	0.452	0.706	392092	328431	468092
1981	228438	152260	342730	154651	128719	185807	0.558	0.447	0.698	445184	366930	540125
1982	129186	86397	193168	135906	113168	163214	0.556	0.443	0.697	401060	332136	484288
1983	102059	68069	153023	162642	134312	196948	0.604	0.484	0.753	409779	342473	490313
1984	93223	61884	140432	146275	121158	176598	0.715	0.576	0.887	322101	271165	382606
1985	102418	68019	154215	110818	92092	133352	0.636	0.509	0.793	269642	225409	322555
1986	181566	120487	273610	83483	69295	100576	0.544	0.434	0.681	268502	218820	329463
1987	144313	96629	215528	72124	59981	86725	0.615	0.496	0.762	285175	233063	348941
1988	81537	54012	123090	88261	72887	106878	0.605	0.487	0.752	302025	248831	366592
1989	77433	51176	117162	103382	80188	133286	0.488	0.387	0.614	284163	235011	343594
1990	85631	56148	130594	119687	95580	149874	0.550	0.438	0.691	271574	227579	324074
1991	223415	147965	337338	114732	94097	139892	0.509	0.405	0.640	353563	287596	434660
1992	283454	188268	426764	95052	79918	113052	0.605	0.484	0.755	464902	374120	577713

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
1993	213556	143251	318367	97144	80926	116612	0.533	0.426	0.667	533548	432523	658169
1994	152657	104298	223438	147692	120052	181696	0.477	0.378	0.602	486274	403288	586336
1995	278265	188514	410744	196641	158077	244613	0.372	0.293	0.474	589051	490414	707527
1996	159118	108547	233249	245799	200688	301050	0.360	0.282	0.460	681862	571233	813916
1997	163556	111813	239245	244842	200602	298840	0.256	0.198	0.331	722906	604247	864868
1998	104035	71389	151608	293322	240548	357673	0.255	0.197	0.330	799552	668684	956031
1999	240367	164861	350454	309213	250514	381665	0.255	0.196	0.332	803662	678048	952546
2000	157007	107744	228794	369362	299642	455304	0.226	0.174	0.294	824773	699428	972581
2001	212157	146844	306521	375395	308712	456482	0.198	0.152	0.257	883779	753606	1036436
2002	348589	246332	493295	450236	376111	538971	0.191	0.147	0.246	1020467	876245	1188426
2003	147196	103802	208732	438966	369956	520848	0.184	0.143	0.238	993421	851810	1158574
2004	150696	105289	215686	519196	441762	610203	0.178	0.137	0.232	1009327	865043	1177677
2005	418616	294826	594383	603514	511156	712560	0.210	0.162	0.272	1086987	933687	1265456
2006	72429	51298	102263	536744	457303	629985	0.250	0.194	0.322	933676	802790	1085901
2007	109679	77995	154233	545160	466132	637586	0.265	0.206	0.340	875563	750229	1021836
2008	193623	138012	271641	470919	396475	559340	0.333	0.261	0.425	728311	627447	845390
2009	141211	100876	197674	363745	305994	432396	0.347	0.274	0.439	672170	580756	777972

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
2010	263607	188808	368039	328870	277524	389717	0.383	0.302	0.485	692887	595025	806844
2011	112152	79499	158216	293880	247409	349079	0.379	0.297	0.482	583861	500162	681565
2012	148281	105636	208142	302570	254915	359133	0.358	0.281	0.455	592327	506969	692056
2013	205714	146779	288313	324307	269257	390612	0.296	0.231	0.380	606876	517168	712144
2014	105708	75263	148468	350144	289143	424014	0.269	0.208	0.347	640085	543701	753555
2015	159992	114100	224342	359134	294080	438579	0.256	0.197	0.331	623065	525387	738904
2016	250262	176283	355288	394026	316701	490229	0.251	0.192	0.330	791448	661369	947110
2017	168424	118255	239876	406588	321556	514105	0.230	0.173	0.306	883999	732904	1066245
2018	110415	75217	162084	467110	364963	597846	0.239	0.176	0.325	908773	740430	1115391
2019	189791	118578	303772	555359	417153	739352	0.225	0.158	0.322	951274	751416	1204289

Table 5.12 Northeast Arctic saithe. Prediction input data

MFDP version 1a
Run: in Excel
Time and date: 10:15 29.04.2019
F_{bar} age range: 4-7

2020

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	160022	0.2	0	0	0	0.876	0.0560	0.876
4	146802	0.2	0.05	0	0	1.164	0.1753	1.164
5	65658	0.2	0.42	0	0	1.625	0.2170	1.625
6	65387	0.2	0.87	0	0	2.085	0.2487	2.085
7	78432	0.2	0.97	0	0	2.584	0.2843	2.584
8	22195	0.2	0.98	0	0	3.118	0.3073	3.118
9	8982	0.2	0.98	0	0	3.595	0.3073	3.595
10	8916	0.2	0.97	0	0	4.059	0.3073	4.059
11	3732	0.2	0.97	0	0	4.626	0.3073	4.626
12	5536	0.2	0.994	0	0	5.879	0.3073	5.879

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	160022,9	0,2	0	0	0	0,876	0,0560	0,876
4	.	0,2	0,05	0	0	1,164	0,1753	1,164
5	.	0,2	0,42	0	0	1,625	0,2170	1,625
6	.	0,2	0,87	0	0	2,085	0,2487	2,085
7	.	0,2	0,97	0	0	2,584	0,2843	2,584
8	.	0,2	0,98	0	0	3,118	0,3073	3,118
9	.	0,2	0,98	0	0	3,595	0,3073	3,595
10	.	0,2	0,97	0	0	4,059	0,3073	4,059
11	.	0,2	0,97	0	0	4,626	0,3073	4,626
12	.	0,2	0,994	0	0	5,879	0,3073	5,879

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	160022,9	0,2	0	0	0	0,876	0,0560	0,876
4	.	0,2	0,05	0	0	1,164	0,1753	1,164
5	.	0,2	0,42	0	0	1,625	0,2170	1,625
6	.	0,2	0,87	0	0	2,085	0,2487	2,085
7	.	0,2	0,97	0	0	2,584	0,2843	2,584
8	.	0,2	0,98	0	0	3,118	0,3073	3,118
9	.	0,2	0,98	0	0	3,595	0,3073	3,595
10	.	0,2	0,97	0	0	4,059	0,3073	4,059
11	.	0,2	0,97	0	0	4,626	0,3073	4,626
12	.	0,2	0,994	0	0	5,879	0,3073	5,879

Input units are thousands and kg - output in tonnes

Table 5.13 Northeast Arctic saithe. Short-term prediction

MFDP version 1a
Run: In Excel
North-East Arctic saithe
Time and date: 20.04.2020
F_{bar} age range: 4-7

2020

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
944239	552168	1.0199	0.236	171983

2021–2022

2021					2022	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
921391	529 169	0	0	0	1084374	671555
.	529 169	0.1	0.0231	18482	1063950	654359
.	529 169	0.2	0.0463	36509	1044034	637620
.	529 169	0.3	0.0694	54098	1024614	621325
.	529 169	0.4	0.0925	71258	1005675	605462

2021					2022	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
.	529 169	0.5	0.1157	88002	987205	590020
.	529 169	0.6	0.1388	104340	969193	574986
.	529 169	0.7	0.1619	120283	951625	560351
.	529 169	0.8	0.1851	135840	934490	546103
.	529 169	0.9	0.2082	151023	917778	532231
.	529 169	1	0.2313	165840	901475	518726
.	529 169	1.1	0.2545	180302	885573	505577
.	529 169	1.2	0.2776	194417	870060	492775
.	529 169	1.3	0.3007	208195	854927	480310
.	529 169	1.4	0.3239	221644	840162	468173
.	529 169	1.5	0.347	234773	825758	456356
.	529 169	1.6	0.3701	247590	811704	444849
.	529 169	1.7	0.3933	260103	797990	433645
.	529 169	1.8	0.4164	272320	784610	422734
.	529 169	1.9	0.4395	284283	771552	412110
.	529 169	2	0.4627	295897	758810	401764

Input units are thousands and kg - output in tonnes

Table 5.14 Northeast arctic saithe. Short-term projection output HCR landings

MFDP version 1a
Run: in Excel
Time and date: 20.04.2020
F_{bar} age range: 4-7

2020							
						Fmp (0.32)	
Biomass	SSB	FMult	FBar	Landings		landings	SSB
944239	552168	1.0199	0.236	171982			
						219418	529169
2021						196530	470180
Biomass	SSB	FMult	FBar	Landings		180275	420273
921391	529169	1.2242	0.283	197779	average	198741	
The TAC should not be changed by more than 15% compared with the previous year’s TAC.							
						197779	

2022					**2023**	
Biomass	**SSB**	**F_{Mult}**	**F_{Bar}**	**Landings**	**Biomass**	**SSB**
866366	489730	0	0	0	1027541	619355
.	489730	0.1	0.023	17098	1008684	603631
.	489730	0.2	0.046	33782	990291	588321
.	489730	0.3	0.069	50064	972350	573415
.	489730	0.4	0.093	65953	954849	558900
.	489730	0.5	0.116	81461	937776	544768
.	489730	0.6	0.139	96596	921121	531006
.	489730	0.7	0.162	111368	904872	517606
.	489730	0.8	0.185	125788	889020	504558
.	489730	0.9	0.208	139864	873553	491852
.	489730	1	0.231	153604	858461	479478
.	489730	1.1	0.254	167018	843735	467429
.	489730	1.2	0.278	180115	829366	455694
.	489730	1.3	0.301	1929010	815343	444267
.	489730	1.4	0.324	205386	801659	433138
.	489730	1.5	0.347	217577	788304	422299
.	489730	1.6	0.37	229481	775269	411743
.	489730	1.7	0.393	241106	762548	401462

2022					2023	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
.	489730	1.8	0.416	252459	750130	391448
.	489730	1.9	0.44	263547	738010	381695
.	489730	2	0.463	274377	726178	372196

Input units are thousands and kg - output in tonnes

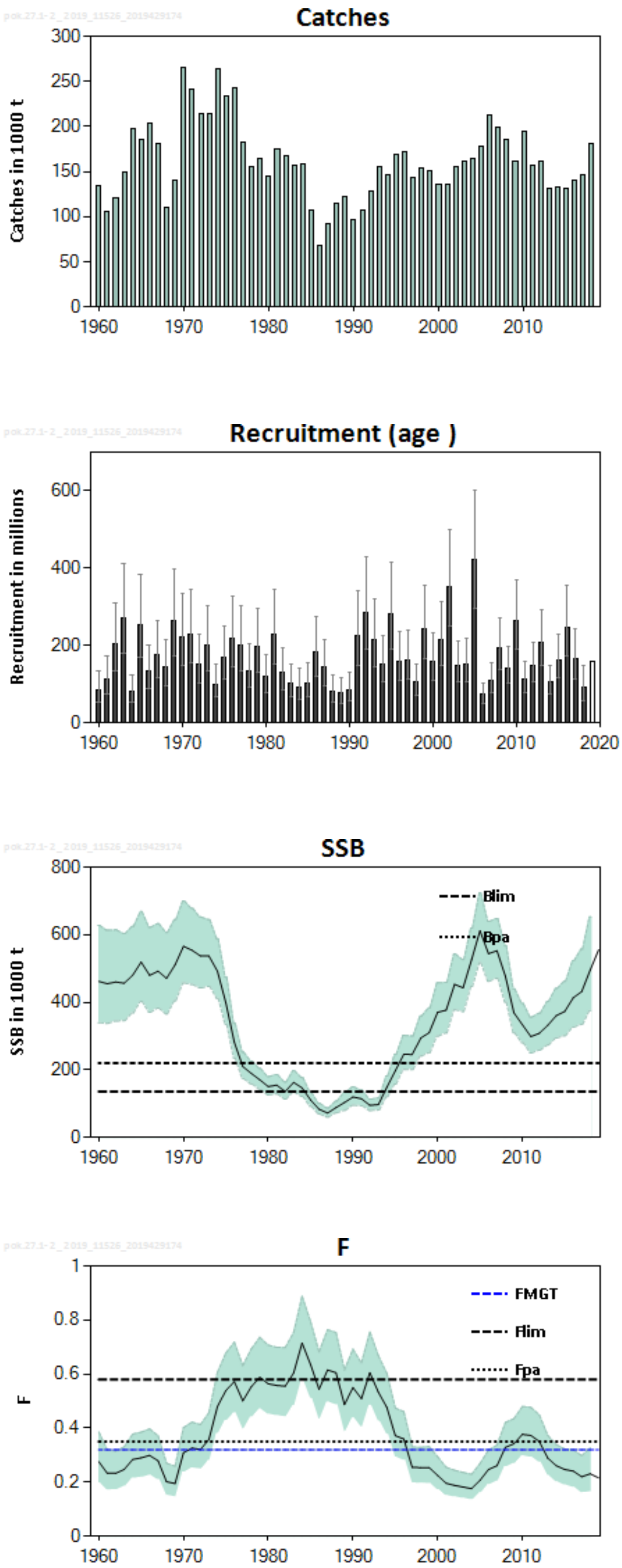
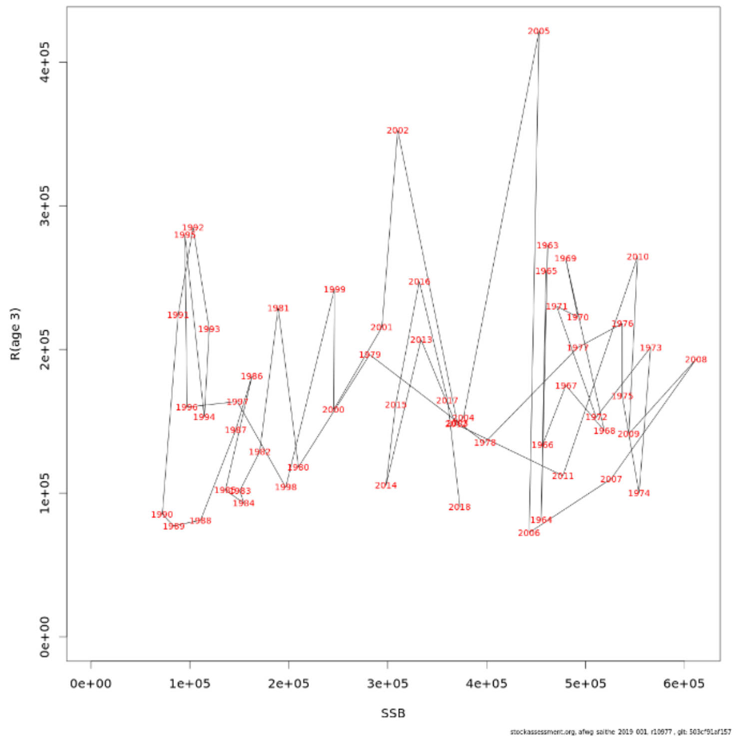


Figure 5.1. Northeast Arctic saithe (subareas 1 and 2).



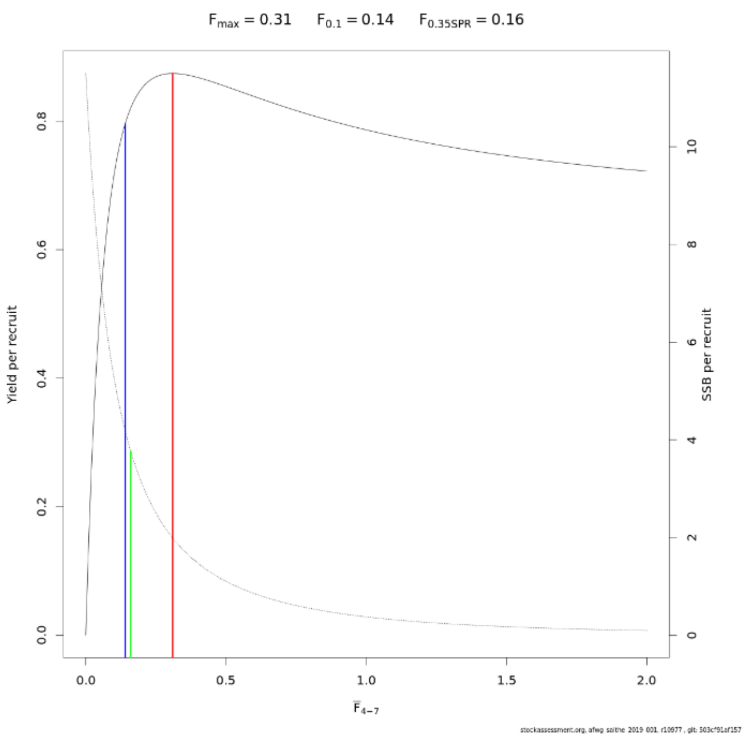


Figure 5.1. continued.

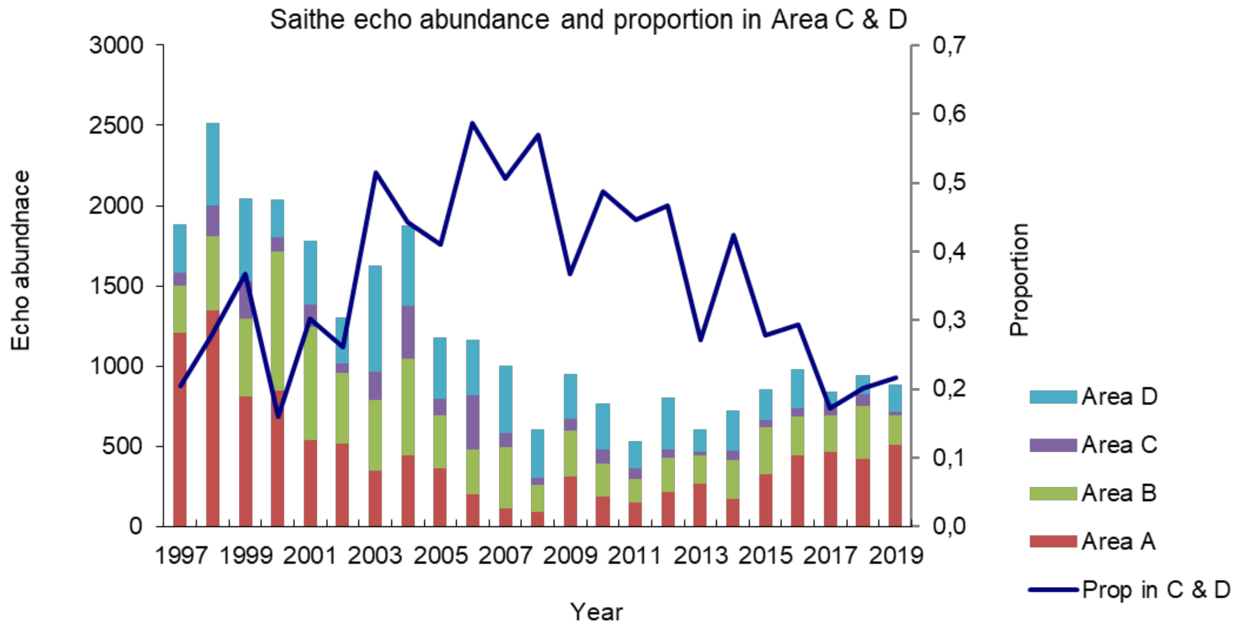


Figure 5.2. Northeast Arctic saithe. Proportion of saithe in the southern half of the survey area (subarea C+D).

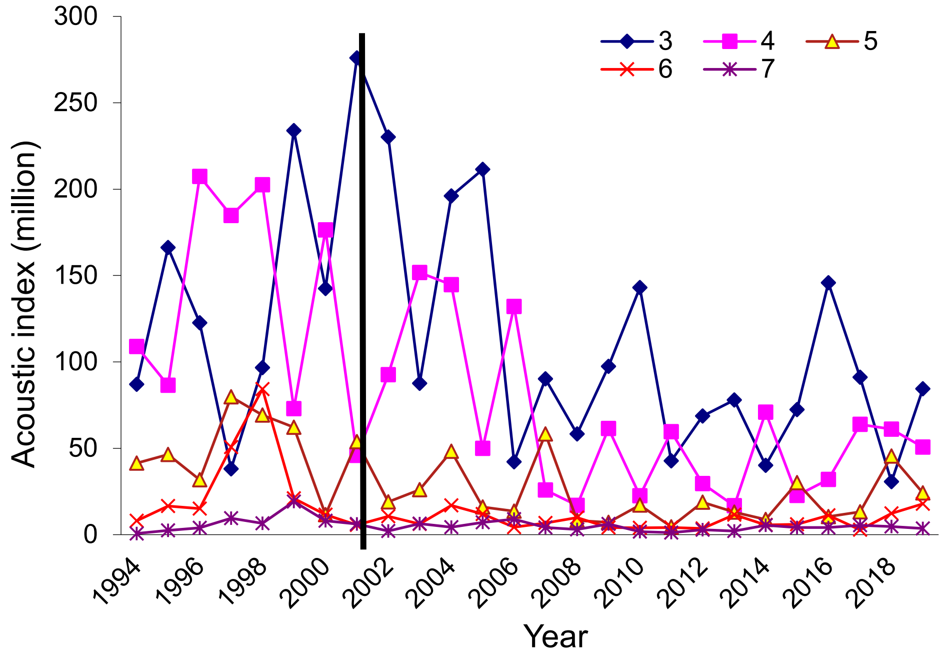


Figure 5.3. Northeast Arctic saithe, acoustic survey tuning indices, break in 2002 black line.

Figure 5.4. Northeast Arctic saithe. Final run normalized residuals. Blue circles indicate positive residuals (larger than predicted) and filled red circles indicate negative residuals.

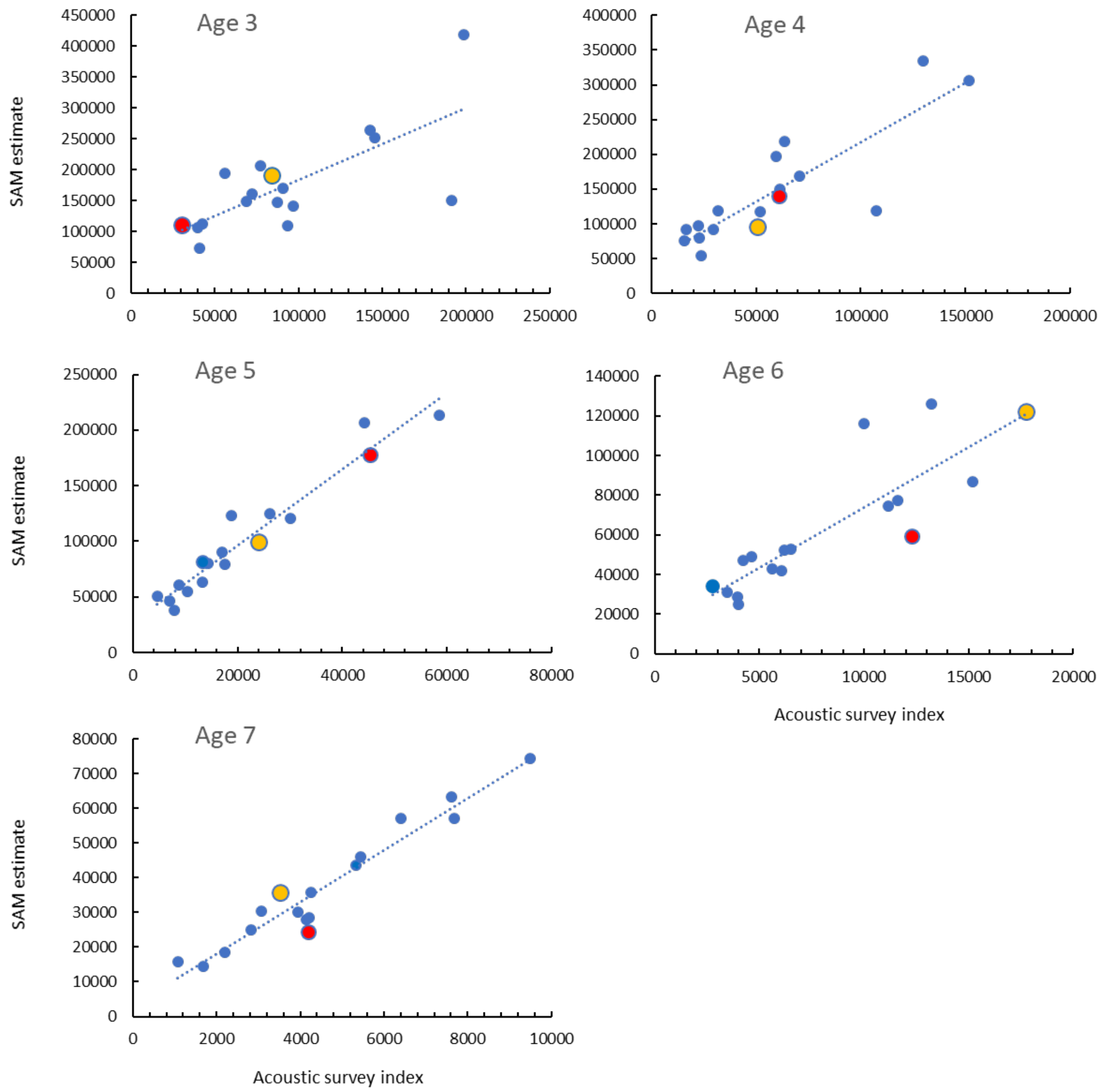
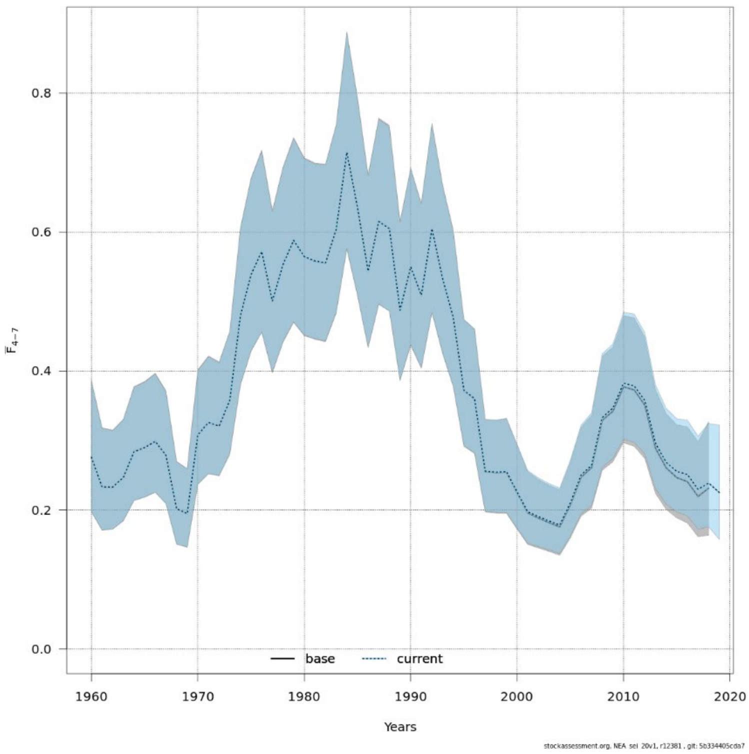


Figure 5.5. NEA saithe - Acoustic survey vs. SAM, red circles show 2018 data and orange circles 2019 data.



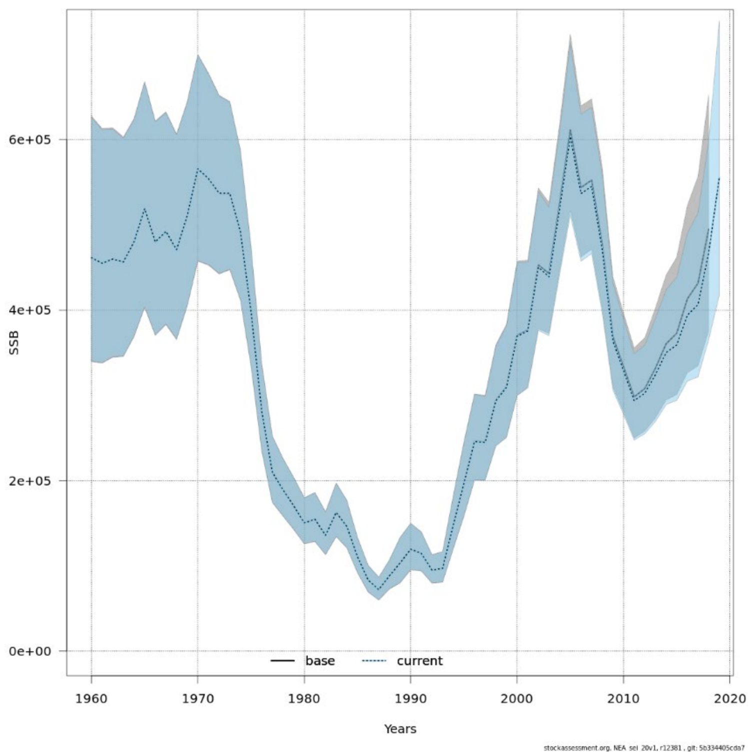


Figure 5.6. F_{4-7} and SSB. Estimates from the current run and point wise 95% confidence intervals are shown by black line and shaded area.

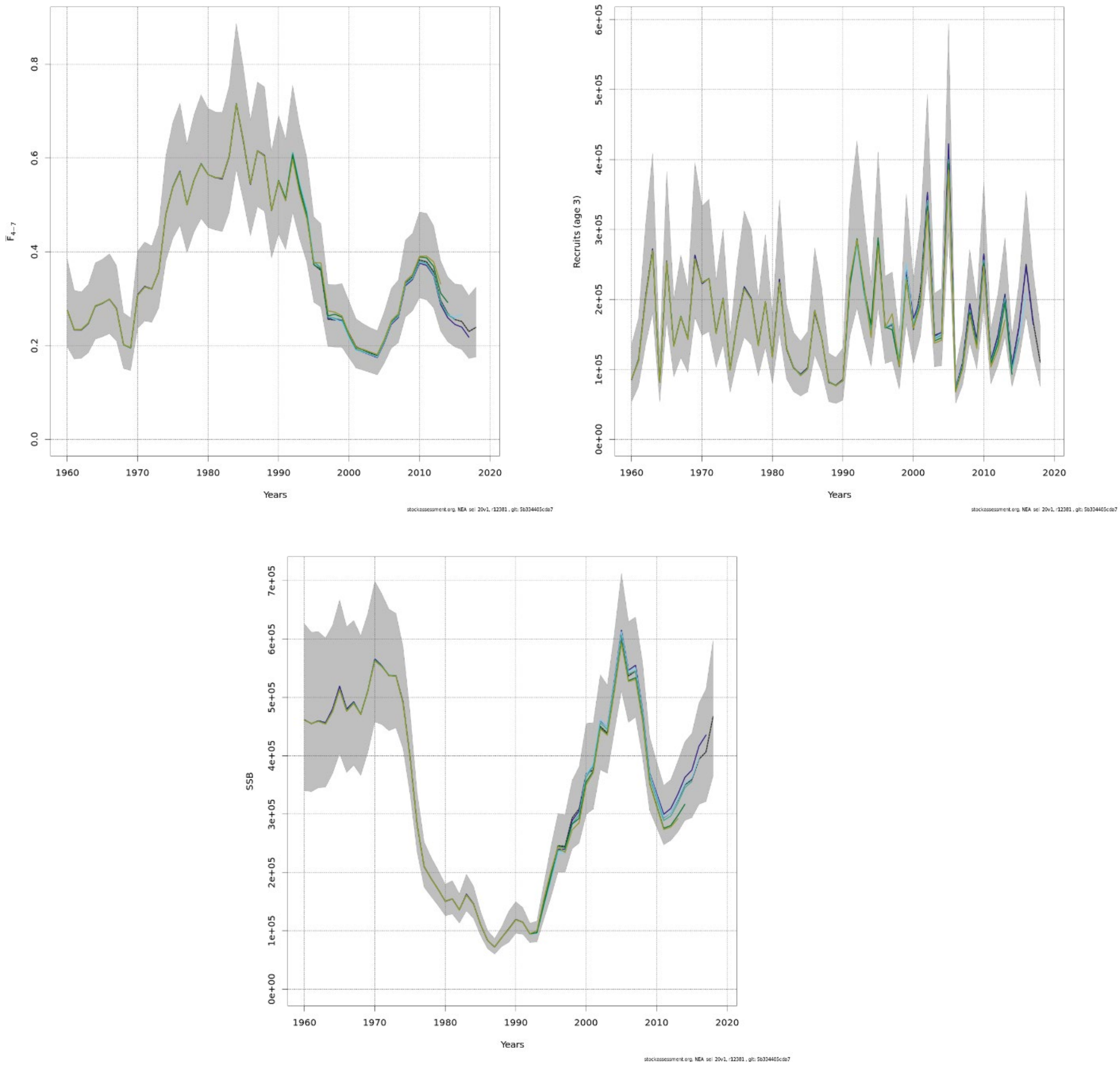


Figure 5.7. Saithe in subareas 1 and 2 (Northeast Arctic) RETROSPECTIVE SAM SSB, F_{4-7}, and recruits.

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

Following the recommendation from the benchmark assessment for redfish stocks in January 2018 (WKREDFISH, ICES 2018a) the analytical assessment is conducted using a statistical catch-at-age model (SCAA, for the period 1992–2019). Following a further recommendation of the benchmark, the advice cycle for beaked redfish in subareas 1 and 2 was changed to a two-year cycle and advice should be provided in 2020. The present report therefore updates the assessment and provides advice for the next two years.

6.1 Status of the Fisheries

6.1.1 Development of the fishery

A description of the historical development of the fishery in subareas 1 and 2 is found in the stock annex for this stock.

An international pelagic fishery for *S. mentella* in the Norwegian Sea outside EEZs has developed since 2004 (Figure 6.1). This pelagic fishery, which is further described in the quality handbook for this stock, is managed by the Northeast Atlantic Fisheries Commission (NEAFC). The directed demersal and pelagic fisheries are reopened in the Norwegian Economic Zone and in the Fisheries Protection Zone around Svalbard since 2014. The spatial regulation for this fishery is illustrated in Figures 6.2 and 6.3. In 2019, most of the catches of *S. mentella* from the Russian and Norwegian fisheries were taken in the Norwegian Exclusive Economic Zone or as bycatch in the Fisheries Protection Zone around Svalbard. Catches in international waters were mainly taken by EU nations.

Figure 6.2 shows the distribution of catch among national fishing fleets for 2018 and 2019 and the location of *S. mentella* catches in the Norwegian EEZ in 2019. The 44th Session of the Joint Norwegian-Russian Fisheries Commission decided to split the total TAC among countries as follows: Norway: 72%, Russia: 18%, Third countries: 10% (as bycatch in the fishery protection zone at Svalbard (Spitsbergen): 4.1%, and international waters of the Norwegian Sea (NEAFC-area): 5.9%). This split was reconducted at the 49th session of the commission in 2019.

6.1.2 Bycatch in other fisheries

During 2003–2013, all catches of *S. mentella*, except the pelagic fishery in the Norwegian Sea outside EEZ, were taken as bycatches in other fisheries. Some of the pelagic catches are taken as bycatches in the blue whiting and herring fisheries. From 2014 onwards most of the catch is taken as targeted catch and no longer as bycatch, following the opening of a targeted fishery in the Norwegian EEZ and Svalbard Fisheries Protection Zone. When fishing for other species it has since 2013 been allowed to have up to 20% redfish (both species together) in round weight as bycatch outside 12 nautical miles and only 10% bycatch inside 12 nautical miles in order to give a higher protection to *S. norvegicus*.

6.1.3 Landings prior to 2020 (Tables 6.1—6.7, Figure 6.1)

Nominal catches of *S. mentella* by country for subareas 1 and 2 combined are presented in Table 6.1, while they are presented for Subarea 1 and divisions 2.a and 2.b in Tables 6.2—6.4. The pelagic catch of *S. mentella* in the Norwegian Sea outside EEZs reported to NEAFC and/or ICES amounted to 6 852 in 2017, 7 739 in 2018 and 6 060 in 2019 and is shown by country in Table 6.5. Nominal catches for both redfish species combined (i.e. *S. mentella* and *S. norvegicus*) by country are presented in Table 6.6. The sources of information used are catches reported to ICES, NEAFC, Norwegian 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 correlation between official catches of these two species in the considered areas. All tables have been updated for 2018 and new figures presented for 2019. Total international landings in 1952–2019 are also shown in Figure 6.1.

In 2014, ICES advised that the annual catch in 2015, 2016, and 2017 should be set at no more than 30 000 t and in 2017, ICES advised that the annual catch in 2018 should not exceed 32 658 t. Following the benchmark (WKREDFISH, ICES 2018a) and the subsequent evaluation of a management plan for the stock (WKREBMSE, ICES 2018b) ICES advised an annual catch of no more than 53 757 t for 2019 and 55 860 t in 2020, corresponding to a fishing mortality of F = 0.06.

Because of the novelty of the situation, related with reopening fisheries after 10 years of its ban, the total landings of *S. mentella* in subareas 1 and 2 in 2014, demersal and pelagic catches, amounted to only 18 780 t. The total landings of the demersal and pelagic fishery increased to 25 856 t in 2015, to 35 646 t in 2016, 30 934 t in 2017, 38 739 t in 2018 and 45 955 t in 2019. Of this, 6 060 t were reported from the pelagic fishery in international waters of the Norwegian Sea. The total landings in 2016 to 2018 were respectively 5429 t, 1201 t and 6107 t above the TAC advised by ICES, but were 7 802 t below TAC in 2019. Norway caught the major share of the demersal catches, but Russian demersal catches increased substantially, particularly in ICES Division 2.b.

The redfish population in Subarea 4 (North Sea) is believed to belong to the Northeast Arctic stock. Since this area is outside the traditional areas handled by this Working Group, the catches are not included in the assessment. The total redfish landings (golden and beaked redfish combined) from Subarea 4 have up to 2003 been 1000–3000 t per year. Since 2005 the annual landings from this area have varied between 90 and 333 t (Table 6.7).

6.1.4 Expected landings in 2020

ICES has advised on the basis of precautionary considerations that the annual catch should be set at no more than 55 860 t in 2020. The 49th sessions of the Joint Norwegian-Russian Fisheries Commission decided to follow these advices.

In 2020 Norwegian fishing vessels can catch and land up to 36 219 t of redfish in the Norwegian economic zone (NEZ) in a limited area north of 65°20′N (see map in Figure 6.3), in international waters and the fisheries zone around Jan Mayen. Of this quantity, 100 t are allocated to cover bycatch in other fisheries and 34 t for research/surveillance and education purposes, while the remaining 36 085 t can be taken in a directed fishery. Only vessels with cod and saithe trawl permits can participate in the directed fishery for redfish. Each vessel which has the right to participate is assigned a maximum quota of 1200 t. This quota must also cover catches of redfish (both species) in other fisheries. It is prohibited to fish for redfish with bottom trawls in the period from 1 March until 10 May. Investigations were conducted in 2015–2016 to see if the protection of females during the main time of larvae release should be improved by extending the period of prohibited fishing until later in May and to see if the area south of Bear Island (Area 20 in Figure 6.3) can be opened for directed fishing, either with or without sorting grid. The hitherto conclusion is that males dominated the catches (more than 70%) in the main fishing areas south and southwest of Bear Island during the investigations from late April until the directed fishery started on 10 May, and that the area south of Bear Island should stay closed during January-February due to smaller *S. mentella* inhabiting this area at the beginning of the year.

Since 2015, Russia has had access to the NEZ when fishing their quota share. In 2020 Russia may fish 10 055 t (18%) plus 2000 t transferred from Norway to Russia. Apart from this as well as an additional 2000 t were transferred from Norway to Russia to cover bycatch of redfish (both species) in Russian fisheries targeting other species. The remaining 5586 t are divided between third countries in the NEZ and Svalbard Zone (2290 t) and the NEAFC areas (3296 t). Catch in the NEAFC areas in 2019 amounted to 5917 t while the catch in the NEZ and Svalbard zone amounted to 40 038 t. The total catch in 2019 was by 7 802 lower than the advised TAC. It is assumed that the total catch in 2020 should not exceed the TAC of 55 860 t set by ICES.

6.2 Data used in the Assessment

Analytical assessment was conducted for this stock following recommendation from the benchmark assessment working group (WKREDFISH, ICES 2018a). Input datasets were updated with the most recently available data. The analytical assessment, based on a statistical catch-at-age model (SCAA), covers the period 1992—2019. The input data consists of the following tables:

- Total catch in tonnes (Table 6.1)
- Catch in tonnes in the pelagic fishery Norwegian Sea outside EEZs (Table 6.5)
- Total catch numbers-at-age 6—19+ (Table 6.8)
- Catch numbers-at-age 7—19+ in the pelagic fishery (Table 6.9)
- Weight-at-age 2—19+ in the population (Table 6.12)
- Maturity-at-age 2—19+ in the population (Table 6.14)
- Russian autumn survey numbers-at-age 0—11 (Table 6.15)
- Ecosystem survey numbers-at-age 2—15 (Table 6.17)
- Winter survey numbers-at-age 2—15 (Table 6.18b)
- Deep pelagic ecosystem survey proportions-at-age (Table 6.19)

There was no direct observation of catch numbers-at-age for the pelagic fishery in the Norwegian Sea outside EEZs in 2012–2018. Instead, numbers-at-age were estimated based on catch-at-age from previous or following year, and weight-at-age and fleet selectivities (section 6.2.2 in AFWG report 2013). In 2013, 2016 and 2019, observations from the scientific survey in the Norwegian Sea were used to derive numbers-at-age in the pelagic fishery. This was considered appropriate given that the survey operates in the area of the fishery, with a commercial pelagic trawl and at the time of the start of the fishery.

6.2.1 Length- composition from the fishery (Figure 6.4)

Length distributions of the pelagic and demersal catches of *S. mentella* are shown in Figure 6.4. In 2019, data were available from the Spanish and Lithuanian pelagic fleets and the Polish, Russian and Norwegian demersal fleets.

6.2.2 Catch-at-age (Tables 6.8-6.11, Figure 6.5)

Catch-at-age in the Norwegian fishery was estimated using ECA for 2014. For 2015 and 2018, it was not possible to run ECA and the catch-at-age for the Norwegian Fishery was estimated using the older Biomass program in SAS (Table 6.8). Not enough age readings were available to estimate catch-at-age in 2016 and 2017. For the demersal fisheries 2016, 2017 and 2019 as well as the pelagic fisheries 2017 and 2018 (Table 6.9) proportions-at-age in the catch were derived from proportions at-age in earlier years, weight-at-age and fleet selectivity (section 6.2.2 in AFWG report 2013).

The procedure for estimating catch-at-age for recent years in which age data are not available is somewhat problematic. This is because the last year of observation has a large impact on the estimated catch-at-age for several years. At the assessment working group in 2017 and at the benchmark assessment in January 2018, the last year of observations for the catch-at-age was 2014 and the values for the years 2015 and 2016 were extrapolated. The new data available for 2015 (demersal) and 2016 (pelagic) were substantially different from these earlier extrapolations.

Catch-at-age in the Russian demersal fishery were calculated using age reading. The estimated Age-Length-Key was then used to estimate the age distribution of the Russian demersal catches depicted in Figure 6.5. Age-Length-Keys for *S. mentella* are uncertain because of the slow growth rate of individuals and therefore these data should be used with caution. They were not used in the current assessment but may be considered in future. Given that age is difficult to derive from length it is important that age readings are available for the most recent years, at the time of the working group.

6.2.3 Weight-at-age (Tables 6.12, 6.13, Figures 6.6, 6.7)

In earlier assessment, weight-at-age in the stock was set equal to the weight-at-age in the catch. This turned out to be problematic because of important fluctuations in reported weight-at-age in the catch that cannot be explained biologically (i.e. these are noisy data). In 2015, it was advised to either use a fixed weight-at-age for the 19+ group, or use a modelled weight-at-age based on catch and survey records (Planque, 2015). The second option was chosen. Weight-at-age in the population was modelled for each year using mixed-effect models of a von Bertalanffy growth function (in weight). In 2018 an attempt was made to model weight-at-age for each cohort (rather than each year of observation). This showed that the growth function is nearly invariant between cohorts. As a result, it was decided to use a fixed (i.e. common to all years) weight-at-age as input to the Statistical Catch-at-age model. The observed and modelled weight-at-age are presented in Table 6.12 as well as Figures 6.6 and 6.7.

6.2.4 Maturity-at-age (Table 6.14, Figure 6.8)

The proportion maturity-at-age was estimated for individual years using a mixed-effect statistical model (Table 6.14, Figure 6.8). The modelled values of maturity-at-age for individual years are used in the analytical assessment models, except in 2008, 2011 and 2016-2019 when the fixed effects only were considered, at least for 2019 because of an insufficient number of age readings.

6.2.5 Natural mortality

In previous years, natural mortality for *S. mentella* was set to 0.05 for all ages and all years. This was based on life-history correlates presented in Hoenig (1983). Thirty-nine alternative mortality estimates were explored during the benchmark workshop, based on the review work by Kenchington (2014) and several additional papers published recently (Then *et al.*, 2014; Hamel, 2014; Charnov *et al.*, 2013). Overall, the mode of these natural mortality estimates is 0.058 which departs only slightly from the original estimate of 0.050 (Figure 6.9). WKREDFISH_2018 decided to continue using 0.050 as the value of M in the assessment model.

Figure 6.10 shows cod's predation on juvenile (5–14 cm) redfish during 1984—2019. This time-series confirms the presence of redfish juveniles and may be used as an indicator of redfish abundance. A clear difference is seen between the abundance/consumption ratio in the 1980s and at present. A change in survey trawl catchability (smaller meshes) from 1993 onwards (Jakobsen *et al*., 1997) and/or a change in the cod's prey preference may cause this difference. As long as the trawl survey time-series has not been corrected for the change in catchability, the abundance index of juvenile redfish less than 15 cm during the 1980s might have been considerably higher, if this change in catchability had been corrected for. The decrease in the abundance of young redfish in the surveys during the 1990s is consistent with the decline in the consumption of redfish by cod. It is important that the estimation of the consumption of redfish by cod is being continued.

6.2.6 Scientific surveys

Following a dedicated review, AFWG approves the use of the new SToX versions of the winter and ecosystem surveys for use in the *Sebastes mentella* assessment (WD 17 and WD 18 in Annex 4). The group recommends that the data be monitored annually to identify if a significant portion of the mentella stock moves east of the strata system. The group further recommends that work continues to investigate redfish-specific strata systems for the winter survey.

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

6.2.6.1 Surveys in the Barents Sea and Svalbard area (Tables 1.1, 1.2, 6.15-6.18, Figures 6.11–6.12)

Russian bottom-trawl survey in the Svalbard and Barents Sea areas in October-December for 1978–2015 in fishing depths of 100—900 m (Table 6.15, Figure 6.11). ICES acronym: RU-BTr-Q4

Russian-Norwegian Barents Sea 'Ecosystem survey' (bottom-trawl survey, August-September) from 1986—2016 in fishing depths of 100—500 m (Figures 6.11—6.12). Data disaggregated by age for the period 1992—2016 (Table 6.16a,b-6.17). ICES acronym: since 2003 part of Eco-NoRu-Q3 (BTr)

Winter Barents Seabed-trawl survey (February) from 1986—2014 (jointly with Russia since 2000, except 2006 and 2007) in fishing depths of 100—500 m (Figures 6.11—6.12). Data disaggregated by age for the period 1992—2011 and 2013 (Table 6.18b). ICES acronym: BS-NoRu-Q1 (BTr)

The Norwegian survey initially designed for redfish and Greenland halibut is now part of the ecosystem survey and covers the Norwegian Economic Zone (NEZ) and Svalbard incl. north and east of Spitsbergen during August 1996—2012 from less than 100 m to 800 m depth. This survey includes survey no. 2 above, and has been a joint survey with Russia since 2003, and since then called the Ecosystem survey. ICES acronym: Eco-NoRu-Q3 (Btr)

6.2.6.2 Pelagic survey in the Norwegian Sea (Table 6.19, Figures 6.13—6.14)

The international deep pelagic ecosystem survey in the Norwegian Sea (WGIDEEPS, ICES 2016, no ICES-acronym) monitors deep pelagic ecosystems, with a particular focus on beaked redfish (*Sebastes mentella*). The latest survey was conducted in the open Norwegian Sea from 11 August until 28 August 2019, following similar surveys in 2008, 2009, 2013 and 2016. The spatial coverage of the survey and the catch rates of beaked redfish in the trawl are presented in Figure 6.13. The survey is scheduled every third year. Estimated numbers-at-age from this survey were presented at the benchmark assessment in 2018 and used in the SCAA model. Data for 2016 was updated in 2019, using additional age readings and numbers-at-age for the 2019 survey were presented during AFWG 2020 and also used in the assessment. The details of the data preparation, using

StoX, are available from WD7 of AFWG 2018 (Planque *et al.*, 2018). The data used as input to the analytical assessment consists of proportions-at-age from age 2 to 75 y (Figure 6.14).

6.2.6.3 Additional surveys (Figures 6.15—6.17)

The international 0-group survey in the Svalbard and Barents Sea areas in August-September 1980–2019, now part of the Ecosystem survey (Figures 6.15 and 6.16). ICES acronym: Eco-NoRu-Q3

A slope survey "Egga-sør survey" was carried out by IMR from 07 March to 07 April 2020, following similar surveys ran in 2009, 2012, 2014,2016 and 2018. The spatial coverage of the 2018 survey and the distribution of beaked redfish registered by acoustic is presented in Figure 6.17. An update for the 2020 survey was not available for AFWG 2020. Egga-Sør and Egga-Nord surveys operate on a biennial basis. The length and age distributions of beaked redfish from these surveys show consistent ageing in the population and gradual incoming of new cohorts after the recruitment failure period. These surveys are considered as candidates for data input to the analytical assessment of *S. mentella* (see also Planque, 2016).

6.3 Assessment

The group performed the analytical assessment using the statistical catch-at-age (SCAA) model reviewed at the benchmark in January 2018 (WKREDFISH, ICES 2018a). The model was configured as the benchmark baseline model which includes 53 parameters to be estimated and the model converged correctly.

6.3.1 Results of the Assessment (Tables 6.20—6.21, Figures 6.18—6.24)

6.3.1.1 Stock trends

The temporal patterns in recruitment-at-age 2 (Figures 6.18, 6.21) confirm the previously reported recruitment failure for the year-classes 1996 to 2003 and indicate a return to high levels of recruitment. The estimates of year-class strength for recent years are uncertain due to limited age data from the Winter and ecosystem surveys. Modelled spawning-stock biomass (SSB) has increased from 1992 to 2007 (Table 6.21). In the late 2000s the total-stock biomass (TSB) consisted of a larger proportion of mature fish than in the 1990s. This is reversing as individuals from new successful year classes, but still immature, are growing. TSB has increased from 1.0 to approximately 1.4 million tonnes in the last 10 years (Table 6.21 and Figures 6.21-6.22). The concurrent decline in SSB from 2007 to 2014 can be attributed to the weak year classes (1996—2003) entering the mature stock. This trend has levelled off and SSB increases again. SSB at the start of 2020 is estimated at 917 578 t.

6.3.1.2 Fishing mortality (Tables 6.20a,b – 6.21, Figure 6.19)

The patterns of fleet selectivity-at-age indicate that most of the fish captured by the demersal fleet in 2019 are of age 9 years and older, while the pelagic fleet mostly captures fish of age 14 and older (Tables 6.20a,b and Figure 6.19). While model results at the benchmark workshop showed a gradual shift in the demersal selectivity towards older ages in recent years, this is no longer observed after the 2015 catch-at-age data were incorporated in the model. The demersal fleet selectivity appears shifted towards later ages only in 2014. In 2019 F19+ is estimated at 0.045 (Table 6.21), with 0.036 for the demersal and 0.008 for the pelagic fleets (Table 6.20a), respectively.

6.3.1.3 Survey selectivity patterns (Figure 6.20)

Winter and ecosystem surveys selectivity at age are very similar and show reduced selectivity for age 8 years and older, which is consistent with the known geographical distribution of different life stages of *S. mentella* (Figure 6.20). Conversely, the Russian survey shows a reduced selectivity for age 7 years and younger. This is believed to result from gear selectivity.

6.3.1.4 Residual patterns (Figure 6.23)

Residual patterns in catch and survey indices are presented in Figure 6.23a-e. There is generally no visible trend in the residuals for the Russian groundfish survey neither by age nor by year. Trends in residuals are visible in recent years for winter and ecosystem surveys and will need to be investigated further. Alternative methods for the estimation of the survey selectivity patterns will be investigated in the forthcoming benchmark assessment and could resolve the issue. Residual patterns for the demersal fleet indicate a similar fit of the model compared AFWG2018, when a time varying selectivity-at-age for this fleet was introduced.

6.3.1.5 Retrospective patterns (Figure 6.24)

The historical retrospective patterns for the years 2007 to 2016 are presented in Figure 6.24. All model parameters were estimated in each individual run. The most recent model run (last year of data 2019) is consistent with previous runs. As in 2018 the SSB time-series is smoother than before, due to fixed weight-at-age for every year. The new estimates for the winter and Ecosystem surveys led to an increase in estimated SSB, up to 19% in the early years and later on around 7% to 9%. Retrospective bias (Mohn's rho) over the last 5 assessments was -38% for recruitment, 1% for F(19+) and -1% for SSB. Note that for F(19+) the average rho was calculated with 4 peels, since F(12-18) was used earlier. The benchmark run stands out and this is due to the unavailability of recent catch-at-age data during the benchmark assessment (see section 6.2.2). The estimate of SSB in the early years is revised upward and this results from the use of new number-at-age indices from the WGIDEEPS survey.

6.3.1.6 Projections

F_{MSY} at age 19+ is approximated using $F_{0.1}$ and estimated at 0.084 (section 1.4 of the WKREBMSE report 2018b).

The estimated fishing mortality in 2019 is: $F_{19+} = 0.045$.

If the fishing mortality is maintained, this is expected to lead to a catch of 48 305 t in 2020, well below the advised TAC of 55 860 t. This would lead to an SSB of 948 178 t in early 2021, catches of 49 703 t in 2021 and SSB of 978 137 t in 2022.

Raising F_{19+} to F_{MSY} ($F_{19+} = 0.084$) in 2021—2023 would lead to average catches of 91 378 t during that period and a SSB of 943 950 t by 2023 (SSB at the start of 2019 is estimated at 855 553 t).

These projections assume that the selectivity patterns of the demersal and pelagic fleets are identical with those estimated for 2019. It is also assumed that the ratio of fishing mortality between these two fleets remains unchanged.

6.3.1.7 Additional considerations

Historical fluctuations in the recruitment-at-age 2 (Figures 6.18 and 6.21) are consistent with the 0-group survey index (Figure 6.16), although the 0-group survey index is not used as an input to the SCAA.

The population age structure derived from the model outputs for the old individuals (beyond 19+, Figure 6.22) is consistent with the age structure reported from the slopes surveys although these are not used (yet) as input to the model.

Recent recruitment levels estimated with SCAA are highly uncertain since they rely on only few years of observations and since the age readings from the winter survey were not available for years 2014-2019. The use of the autoregressive model for recruitment (random effects in the SCAA) which was introduced in this assessment allows for a projection of the recruitment in recent years, despite the current lack of age data.

6.3.1.8 Assessment summary (Table 6.21, Figure 6.21)

The history of the stock as described by the SCAA model for the period 1992–2019 is summarized in Table 6.21 and Figure 6.21. The key elements are as follows:

- upward trend in Total-stock biomass from 1992 to 2006 followed by stabilization until 2011 and new upward trend until the present,
- upward trend in spawning-stock biomass from 1992 to 2007 followed by stabilization (or slight decline) until 2014,
- recruitment failure for year classes 1996—2003 (2y old fish in 1998—2005),
- good (although uncertain) recruitment for year classes born after 2005. Age data for recruits (at age 2y) after 2014 is limited.
- Annual fishing mortality for the 19+ group throughout the assessment period.

6.4 Comments to the assessment

Currently, the survey series used in the SCAA do not appropriately cover the geographical distribution of the adult population. Data from the pelagic survey in the Norwegian Sea has been reviewed in the last benchmark and is now included in the assessment model. Priority should be given to including additional data from the slope surveys that include older age groups, in the analytical assessment in future (WD 5 in 2016).

The SCAA model relies on the availability of reliable age data in surveys and in the catch. Although additional age reading since the last assessment has improved reliability, it requires a continuous effort to keep these data at an appropriate level.

6.5 Biological reference points

The proposed reference points estimated during the workshop on the management plan for *S. mentella* in (ICES 2018b) were:

Reference point	Value
B_{lim}	227 000 t
B_{pa}	315 000 t
F_{MSY19+}= $F_{0.1}$	0.084

Which are revised from those set during the benchmark in the same year (ICES 2018a) which were B_{pa} = 450 kt, B_{lim} = 324 kt and F_{MSY19+} = $F_{0.1}$ = 0.08.

6.6 Management advice

The present report updates the assessment and advises that that when the precautionary approach is applied, catches in 2021 should be no more than 66 158 tonnes, and catches in 2022 should be no more than 67 210 tonnes. This would correspond to a fishing mortality of F = 0.06 that is considered as precautionary.

6.7 Possible future development of the assessment

Many developments suggested in earlier years were presented and evaluated at the benchmark in January 2018. These include integrating a stochastic process model i) for recruitment-at-age 2, ii) for the annual component of fishing mortalities, and iii) to account for annual changes in fleet selectivities-at-age. In addition, iv) a right trapezoid population matrix, v) coding of older ages into flexible predefined age-blocks, and vi) integrating of data from pelagic surveys in the Norwegian Sea were implemented. The purpose of these new features was to reduce the number of parameters to estimate (i, ii), include new data on the older age fraction of the population (iv, v, vi) and account for possible temporal changes in selectivity linked to changes in the national and international fisheries and their regulations (iii).

Recommendations that have been followed since comprise:

- An increase in the number of age readings from surveys and from the fishery, in particular for recent years.
- Use of a standardized method (StoX) for the determination of numbers-at-age in the surveys. The use of StoX for survey indices was evaluated at the beginning of AFWG 2020.

Future developments for the assessment of *S. mentella* may possibly include:

- Use of a standardized method (ECA) for the determination of numbers-at-age in the catch.
- A genetic-based method for rapidly identifying Sebastes species (*S. norvegicus*, *S. mentella*, *S. viviparus*);
- Direct use of length information (as in GADGET);
- Development of a joint model for *S. mentella* and *S. norvegicus* which can include uncertainty in species identification and reporting of catch of *Sebastes sp*.

Implementing the current model in a more generic framework (SAM or XSAM) would provide a set of diagnostic tools and the wider expertise shared by the groups developing these models.

Further studies of redfish mortality at young age, including a scientific publication, should be carried out. These studies should also take account of historic estimates of bycatch. Variable M by age and possibly time period could then be incorporated in the assessment.

Table 6.1. ***Sebastes mentella*** **in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1, divisions 2.a and 2.b combined.**

Year		Estonia	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
1998		-	20	73	100	14	-	9	-	-	-	9 733	13	125	3 646	177	134	14 045
1999		-	73	26	202	50	-	3	-	-	-	7 884	6	65	2 731	29	140	11 209
2000		-	50	12	62	29	48	1	-	-	-	6 020	2	115	3 519	87	130	10 075
2001		-	74	16	198	17	3	4	-	-	-	13 937	5	179	3 775	90	120	18 418
2002		15	75	58	99	18	41	4	-	-	-	2 152	8	242	3 904	190	188	6 993
2003		-	64	22	32	8	5	5	-	-	-	1 210	7	44	952	47	124	2 520
2004	**Sweden** - 1	-	588	13	10	4	10	3	-	-	-	1 375	42	235	2 879	257	76	5 493
2005		5	1 147	46	33	39	4	4	-	-	7	1 760	-	140	5 023	163	95	8 465
2006	**Canada** - 433	396	3 808	215	2 483	63	2 513	4	341	845	-	4 710	2 496	1 804	11 413	710	1 027	33 261
2007		684	2 197	234	520	29	1 587	17	349	785	-	3 209	1 081	1 483	5 660	2 181	202	20 219
2008		-	1 849	187	16	25	9	9	267	117	13	2 220	8	713	7 117	463	83	13 096
2009	**EU** - 889	-	1 343	15	42	-	33	-	-	-	3	2 677	338	806	3 843	177	80	10 246
2010		-	979	175	21	12	2	-	243	457	-	2 065	-	293	6 414	1 184	79	11 924
2011		-	984	175	835	-	2	-	536	565	-	2 471	11	613	5 037	1 678	55	12 962
2012		-	259	-	517	-	36	-	447	449	-	2 114	318	1 038	4 101	1 780	-	11 059
2013		-	697	-	80	21	1	-	280	262	-	1 835	84	1 078	3 677	1 459	-	9 474

2014	-	743	215	446	15	-	-	215	167	3	13 503	103	505	1 704	1 162	-	18 780
2015	-	657	49	242	48	3	-	537	192	3	19 720	5	678	1 142	2 529	52	25 857
2016	-	502	134	493	74	24	0	1 243	1 065	-	19 083	208	1 066	8 419	3 213	122	35 646
2017	4	443	45	763	66	3	-	562	790	-	17 228	102	1060	6 593	2 838	436	30 934
2018	-	425	67	2 473	82	10	-	1 020	1 010	374	19 287	275	699	10 497	2 457	63	38 739
2019[1]	-	148	371	1 599	615	10		0	653	243	24 160	471	1 426	13 444	2 226	590	45 955

[1] **Provisional figures.**

Table 6.2. *Sebastes mentella* in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1.

Year	Faroe Islands	France	Germany	Greenland	Iceland	Lithuania	Norway	Poland	Russia	Spain	UK	Total
1998	20		-	-	-		26	-	378	-	-	424
1999	69		-	-	-		69	-	489	-	-	627
2000	-		-	-	482		47	-	406	-	-	501
2001	-		-	-	32		8	-	296	-	-	307
2002	-		-	-	-		4	-	587	-	-	591
2003	-		-	-	-		6	-	292	-	-	298
2004	-		-	-	-		2	-	355	-	-	357
2005	-		-	-	-		3	-	327	-	-	330
2006	2		-	-	-		12	-	460	-	2	476
2007	-		-	-	8		11	-	210	-	20	249
2008	-		-	-	-		5	-	155	-	2	162
2009	-		-	-	8		3	-	80	-	-	91
2010	-		-	-	-		20	-	10	-	-	30
2011	-		-	-	-		48	-	13	-	-	61
2012	-		-	-	-		34	-	17	-	-	51
2013	-		-	-	-		61	-	27	-	-	88
2014	-		-	-	-		36	-	63	-	-	99
2015	-		-	18	-		76	1	125	-	-	220
2016	-		-	-	-		176	1	229	342	-	748
2017	-		-	12	-		165	3	196	-	-	376
2018	-		19	26	3		195	-	376	-	-	619
2019[1]	75	3	0	13	-	1	278	16	206	19	3	614

[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	Green-land	Iceland	Ireland	Lithuania	Latvia	Norway	Portugal	Poland	Russia	Spain	UK	Total
1998		-	73	58	14	-	6	-	-	9186	118	-	2626	55	106	12 242
1999		-	16	160	50	-	3	-	-	7358	56	-	1340	14	120	9117
2000		50	11	35	29	-	-	-	-	5892	98	-	2167	18	103	8403
2001		63	12	161	17	-	4	-	-	13 636	105	-	2716	18	95	16 827
2002		37	54	59	18	41	4	-	-	1937	124	-	2615	8	157	5054
2003		58	18	17	8	5	5	-	-	1014	17	-	448	8	102	1700
2004	**Sweden** - 1	555	8	4	4	10	3	-	-	987	86	-	2081	7	18	3764
2005		1101	36	17	38	2	4	-	-	1083	71	-	3307	20	15	5694
2006	**Estonia** - 396 **Canada** – 433	3793	199	2475	52	2513	3	845	-	4010	1731	2467	10 110	589	958	30 574
2007	**Estonia** - 684	2157	226	519	29	1579	16	785	349	3043	1395	1079	5061	2159	120	19 201
2008	**Netherland** - 13	1821	179	9	24	9	9	117	267	1952	666	1	6442	430	62	12 001
2009	**EU** – 889	1316	7	23	-	25	-	-	-	2208	764	338	3305	137	62	9074
2010		961	175	13	12	2	-	457	243	1705	246	-	5903	1183	55	10 955
2011		932	175	697	-	2	-	561	536	1682	599	-	4326	1656	19	11 185
2012		259	-	469	-	32	-	449	447	1500	1038	311	3478	1770	-	9753

Year		Faroe Islands	France	Germany	Green-land	Iceland	Ireland	Lithuania	Latvia	Norway	Portugal	Poland	Russia	Spain	UK	Total
2013	**Netherland**	675	-	24	21	1	-	262	280	921	1055	68	3293	1435	-	8035
2014	2	728	209	411	15	-	-	167	215	4367	505	100	1334	1159	-	9212
2015	3	657	49	236	25	3	-	192	537	11 214	678	3	480	2508	47	16 632
2016		495	107	493	61	-	24	1065	1243	9546	1052	183	3949	2862	71	21 151
2017		425	38	763	44	3	-	790	562	7405	1059	94	3922	2813	429	18 347
2018	374	400	47	2 440	51	7	-	1 010	876	14 643	699	272	4 721	2 435	62	28 037
2019[1]	243	74	363	1 599	59	10	-	652	-	18 354	1 425	455	7 366	2 188	570	33 357

[1] Provisional figures

Table 6.4. *Sebastes mentella* in subareas 1 and 2. Nominal catch (t) by countries in Division 2.b.

Year	Netherland	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Poland	Portugal	Russia	Spain	Denmark	UK	Total
1998	-	-	-	42	-	3	521	13	7	642	122	-	29	1379
1999	-	4	10	42	-	-	457	6	9	902	15	-	20	1465
2000	-	-	1	27	-	1	82	2	17	946	69	-	27	1172
2001	-	11	4	37	-	-	293	5	74	763	72	**Estonia**	25	1284
2002	-	38	4	40	-	-	210	8	118	702	182	15	31	1348
2003	-	6	4	15	-	-	190	7	27	212	39	-	22	522

Year		Netherland	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Poland	Portugal	Russia	Spain	Denmark	UK	Total
2004		-	33	5	6	-	-	386	42	149	443	250	-	58	1372
2005	**Iceland** - 2	7	46	10	17	1	-	673	-	69	1389	143	5	80	2442
2006		-	13	16	8	11	1	688	29	73	843	121	-	67	1870
2007		-	40	8	1	-	1	155	2	88	389	22	-	62	768
2008		-	28	8	7	1	-	263	6	47	520	33	-	19	932
2009	**Canada** - 3	3	27	8	19	-	-	466	1	42	458	41	-	17	1082
2010		-	18	-	8	-	-	339	-	47	501	1	-	24	938
2011	**Lithuania** - 4	-	52	-	139	-	-	741	11	14	698	23	-	36	1717
2012	**Iceland** - 4	-	-	-	48	-	-	581	7	-	606	10	-	-	1256
2013		-	22	-	56	-	-	854	16	23	357	23	-	-	1351
2014		1	15	6	34	-	-	9 099	3	-	307	3	-	-	9 468
2015		-	-	-	6	5	-	8 429	1	-	536	21	-	5	9 003
2016		-	7	27	-	14	-	9 361	24	14	4 241	9	-	50	13 747
2017		-	18	7	1	10	-	9 658	5	1	2 476	25	4	7	12 211
2018	Lithuania - 144	-	25	20	14	6	-	4 449	3	-	5 400	22	-	1	10 083
2019[1]	-	-	-	4	-	543	-	5 528	-	-	5 873	19	-	17	11 983

[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		-	393	-	493	-	1 243	1 065	9	-	821	512	2 862	-	7 398
2017	**Netherland**	-	296	-	761	-	562	790	-	14	791	1 014	2 624	-	6 852
2018	374	-	400	-	2 192	-	876	1 010	-	116	372	-	2 399	-	7 739

Year		Estonia	Faroe Islands	France	Germany	Iceland	Latvia	Lithuania	Norway	Poland	Portugal	Russia	Spain	UK	Total
2019[1]	244	-	-	298	1 157	-	-	652	1	364	1 096	117	1 908	223	6 060

[1] Provisional figures.

Table 6.6. REDFISH in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1, divisions 2.a and 2.b combined for both *Sebastes mentella* and *S. norvegicus*.

Year	Canada	Denmark	Estonia	Faroe Islands	France	Germany[4]	Greenland	Iceland	Ireland	Nethelands	Norway	Poland	Portugal	Russia[5]	Spain	UK (E&W)	UK (Scot.)	Total
1984	-	-	-	-	2970	7457	-	-	-	-	18 650	-	1806	69689	25	716	-	101 313
1985	-	-	-	-	3326	6566	-	-	-	-	20 456	-	2056	59943	38	167	-	92 552
1986	-	-	-	29	2719	4884	-	-	-	-	23 255	-	1591	20694	-	129	14	53 315
1987	-	+	-	450[3]	1611	5829	-	-	-	-	18 051	-	1175	7215	25	230	9	34 595
1988	-	-	-	973	3349	2355	-	-	-	-	24 662	-	500	9139	26	468	2	41 494
1989	-	-	-	338	1849	4245	-	-	-	-	25 295	-	340	14344	5[2]	271	1	46 688
1990	-	37[3]	-	386	1821	6741	-	-	-	-	34 090	-	830	18918	-	333	-	63 156
1991	-	23	-	639	791	981	-	-	-	-	49 463	-	166	15354	1	336	13	67 768
1992	-	9	-	58	1301	530	614	-	-	-	23 451	-	977	4335	16	479	3	31 773
1993	8[3]	4	-	152	921	685	15	-	-	-	18 319	-	1040	7573	13	734	1	29 465
1994	-	28	-	26	771	1026	6	4	3	-	21 466	-	985	6220	34	259	13	30 841
1995	-	-	-	30	748	693	7	1	5	1	16 162	-	936	6985	67	252	13	25 900

Year	Canada	Denmark	Estonia	Faroe Islands	France	Germany[4]	Greenland	Iceland	Ireland	Nethelands	Norway	Poland	Portugal	Russia[5]	Spain	UK (E&W)	UK (Scot.)	Total
1996	-	-	-	42[3]	746	618	37	-	2	-	21 675	-	522	1641	409	305	121	26 118
1997	-	-	-	7	1011	538	39[2]	-	11	-	18 839	1	535	4556	308	235	29	26 109
1998	-	-	-	98	567	231	47[3]	-	28	-	26 273	13	131	5278	228	211	94	33 200
1999	-	-	-	108	61[3]	430	97	14	10	-	24 634	6	68	4422	36	247	62	30 195
2000	-	-	-	67[3]	25	222	51	65	1	-	19 052	2	131	4631	87	-	203[6]	24 536
2001	-	-	**Est**	111[3]	46	436	34	3	5	-	23 071	5	186	4738	91	**-**	239[6]	28 965
2002	-	-	15	135[3]	89	141	49	44	4	-	10 713	8[3]	276	4736	193[2]	-	234[6]	16 636
2003	**Swe**	-	-	173[3]	30	154	44[3]	9	5[3]	89	8063	7	50	1431	47[2]	-	258[6]	10 360
2004	1	-	-	607	17[3]	78	24[3]	40	3	33	7608[12]	42	240	3601[2]	260[2]	-	145[6]	12 699
2005	**Can**	**Lith**	5	1194	56	105	75[3]	12[2]	4[3]	55[2]	7845[12]	-	196	5637	171[3]	-	147[6]	15 502
2006	433	845	396	3919	223	2518	107[3]	2544[3]	12[3]	21	11 015	2496[2]	1873	12126	719[2]	-	1066[6]	40 649
2007	**Latv**	785	684	2343	249	587	84[3]	1655[2]	7[3]	20	8993[2]	1081[2]	1708	6550	2186[2]	-	257[6]	27 591
2008	267	117	-	2123[3]	250	46	96[3]	36[3]	15[3]	15	7436[1]	8	785	7866	467[2]	**EU[7]**	168[6]	19 695
2009	-	-	-	1413	16	100	81	99	-	4	8128	338	836	4541	177	889	111	16 733
2010	243[3]	457[3]	-	1150	226	52	84[3]	24[3]	-	-	8059	1[3]	321	6979	1187	-	123	18 906
2011	536	565	-	1008[2]	228	844	51	24	-	1	7152	59	638	5956	1684[2]	-	68	18 814
2012	447	449	-	346	182	588	58	59	12	5	6361	352	1055	4782	1780[2]	**Denm**	100	16 576

Year	Canada	Denmark	Estonia	Faroe Islands	France	Germany[4]	Greenland	Iceland	Ireland	Nethelands	Norway	Poland	Portugal	Russia[5]	Spain	UK (E&W)	UK (Scot.)	Total
2013	280	262	-	780	353	81	66	9	1	-	5606	103	1114	4474	1459	1	493	15 082
2014	215	167	-	810	434	452	35	29	-	4	16 556	124	510	2510	1162	-	211	23 219
2015	537	192	-	733	102	266	259	38	-	3	22 208	22	678	1806	2531	1	109	29 485
2016	1243	1065	-	685	164	497	161	79	-	-	22 322	234	1066	9283	32013	7	198	40 217
2017	562	790	4	566	62	782	127	68	-	2	20 581	129	1150	7890	2882	-	596	36 192
2018	1020	1010	-	571	104	2539	159	77	-	374	23 563	311	766	12 331	2469	1	100	45 395
2019[1]	-	656	-	392	395	1692	671	93	-	244	29 835	491	1495	15 373	2287	-	615	54 239

[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 6.8. ***S. mentella*** **in subareas 1 and 2. Catch numbers-at-age 6 to 18 and 19+ (in thousands) and total landings (in tonnes). For the period 2012–2016 age data are missing from the pelagic fishery. For the period 2015–2018, age data are missing from all fisheries. The numbers-at-age have been estimated following the method outlined in section 6.2.2.**

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	+gp	Total No.	Tons Land.
1992	1873	2498	1898	1622	1780	1531	2108	2288	2258	2506	2137	1512	677	9258	33 946	15 590
1993	159	159	174	512	2094	3139	2631	2308	2987	1875	1514	1053	527	6022	25 154	12 814
1994	738	730	722	992	2561	2734	3060	1535	2253	2182	3336	1284	734	3257	26 118	12 721
1995	662	941	1279	719	740	1230	2013	4297	3300	2162	1454	757	794	2404	22 752	10 284
1996	223	634	1699	1554	1236	1078	1146	1413	1865	880	621	498	700	2247	15 794	8075
1997	125	533	1287	1247	1297	1244	876	1416	1784	1217	537	1177	342	3568	16 650	8598
1998	37	882	2904	4236	3995	2741	1877	1373	1277	1595	1117	784	786	6241	29 845	14 045
1999	9	83	441	1511	2250	3262	1867	1454	1447	1557	1418	1317	658	3919	21 193	11 209
2000	1	24	390	1235	2460	2149	1816	1205	1001	993	932	505	596	5705	19 012	10 075
2001	117	372	542	976	925	1712	2651	2660	1911	1773	1220	714	814	16 234	32 621	18 418
2002	2	40	252	572	709	532	1382	1893	1617	855	629	163	237	4082	12 965	6993
2003	6	37	103	93	132	220	384	391	434	466	513	199	231	1193	4402	2520
2004	7	16	70	96	278	429	611	433	1063	813	830	841	607	3076	9170	5493
2005	2	20	57	155	244	262	295	754	783	1896	817	1087	1023	6065	13 460	8465
2006	0	4	3	38	64	121	423	1461	1356	2835	4271	3487	3969	32 084	50 116	33 261
2007	0	1	3	22	33	86	235	631	2194	2825	3657	4359	3540	15 824	33 410	20 219

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	+gp	Total No.	Tons Land.
2008	0	0	1	10	46	100	197	469	612	1502	1384	894	1886	11 906	19 007	13 095
2009	0	1	16	22	42	39	254	258	577	364	823	692	1856	11 706	16 650	10 246
2010	10	4	6	19	34	55	61	241	267	390	566	655	667	13 879	16 854	11 924
2011	4	4	4	25	55	114	11	103	286	394	408	479	567	15 223	17 677	12 962
2012	4	24	29	24	26	66	69	78	80	279	387	365	409	13 332	15 172	11 056
2013	0	3	19	92	88	41	42	42	10	167	144	174	299	11 726	12 847	9474
2014	14	28	346	97	124	96	152	55	111	69	252	293	197	23 744	25 578	18 780
2015	43	41	135	569	849	1384	1259	724	388	952	291	593	875	29 590	37 693	25 856
2016	26	173	180	760	2918	3804	4145	2970	1322	723	1661	832	962	36 360	56 836	35 646
2017	0	22	190	260	1384	5782	6581	5523	3245	1317	697	1567	789	25 404	52 761	30 934
2018	1173	4126	4511	4873	7166	4952	2448	2963	3553	6921	1956	2313	2650	30 536	80 141	38 739
2019	0	791	4578	7795	10 691	15 847	8687	2132	3466	4362	9900	2682	3154	19 642	93 727	45 955

Table 6.9. Pelagic *Sebastes mentella* in the Norwegian Sea (outside the EEZ). Catch numbers-at-age.

	Numbers 10^3								Age				
YEAR	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19+**
2006	0	0	0	0	23	93	1083	323	1563	3628	2514	3756	29704
2007	0	0	9	18	25	154	444	1642	2302	3021	3394	3156	12684
2008	0	0	0	0	28	146	115	143	214	594	752	753	13258
2009	0	0	0	0	9	1314	294	471	889	999	869	1150	2981
2010	0	0	0	0	0	0	130	336	254	466	467	508	11510
2011	0	0	0	0	0	223	83	83	168	136	166	136	13182
2012[1]	0	0	0	22	29	19	294	146	132	217	288	126	8939
2013[2]	11	137	98	465	123	158	96	169	246	196	238	598	7968
2014[3]	0	10	125	88	406	103	125	70	113	151	112	130	4398
2015[3]	0	0	0	0	190	59	54	0	0	0	78	21	6323
2016[3]	0	0	138	276	244	248	121	81	97	215	401	206	9607
2017	0	0	0	250	481	399	369	160	95	103	216	388	8349
2018	0	0	0	0	774	1397	1052	865	332	180	184	370	12672
2019	25	4	199	399	219	241	196	278	182	154	135	160	6708

1 no age data in 2012, catch numbers-at-age are estimated from proportions at age in 2011 and in 2013.

2 no age data from the catches in 2013. Age readings from the research survey conducted in September 2013 are used to derive catch numbers-at-age.

3no age data in 2014 – 2018, catch numbers-at-age are estimated from previous year according to protocol described in section 6.2.2.

Table 6.10. *S. mentella* in subareas 1 and 2. Total catch numbers-at-length, in thousands, for 2011–2019.

	Length group																
Year	**18–20**	**20–22**	**22–24**	**24–26**	**26–28**	**28–30**	**30–32**	**32–34**	**34–36**	**36–38**	**38–40**	**40–42**	**42–44**	**44–46**	**46–48**	**48–50**	**50–52**
2011	0	12	0	0	1	8	249	2544	6481	6528	3620	829	95	18	1	0	0
2012	0	0	23	19	26	28	41	287	1898	5030	5385	1911	451	197	43	23	0
2013	0	0	4	32	154	137	90	69	1382	4214	4480	1633	497	197	0	0	0
2014	0	5	0	25	29	235	660	697	3358	7667	8544	3808	787	34	0	0	0
2015	Data not available at the time of the working group																
2016	Data not available at the time of the working group																
2017	Data not available at the time of the working group																
2018	Data not available at the time of the working group																
2019	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 2011–2019.

	Length group																
Year	**18–20**	**20–22**	**22–24**	**24–26**	**26–28**	**28–30**	**30–32**	**32–34**	**34–36**	**36–38**	**38–40**	**40–42**	**42–44**	**44–46**	**46–48**	**48–50**	**50–52**
2011	0	0	0	0	1	8	244	2562	5887	4425	1537	287	13	0	1	0	0
2012	0	0	0	0	0	0	106	2014	5092	3681	952	48	0	0	0	0	0
2013	0	0	0	0	0	0	75	1352	4791	2967	730	87	6	0	0	0	0
2014	0	0	0	0	0	3	14	349	2408	2454	827	80	6	1	0	0	0
2015	Data not available at the time of the working group																
2016	Data not available at the time of the working group																
2017	Data not available at the time of the working group																
2018	Data not available at the time of the working group																
2019	Data not available at the time of the working group																

Table 6.12. *S.mentella* in subareas 1 and 2. Observed mean weights-at-age (kg) from the Norwegian data (Catches and surveys combined). Weights-at-age used in the statistical catch-at-age model are identical for every year and given at the bottom line of the table. Modelled numbers and those for 2016 are updated using additional age data.

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1992	0.167	0.164	0.211	0.241	0.309	0.324	0.378	0.366	0.428	0.454	0.487	0.529	0.571	0.805
1993	0.141	0.181	0.217	0.254	0.306	0.357	0.349	0.400	0.450	0.436	0.460	0.499	0.462	0.846
1994	0.174	0.188	0.235	0.298	0.361	0.396	0.415	0.480	0.492	0.562	0.642	0.636	0.720	0.846
1995	0.158	0.185	0.226	0.261	0.324	0.360	0.432	0.468	0.496	0.519	0.566	0.573	0.621	0.758
1996	0.175	0.189	0.224	0.272	0.323	0.337	0.377	0.518	0.536	0.603	0.690	0.800	0.683	0.958
1997	0.152	0.191	0.228	0.280	0.324	0.367	0.435	0.492	0.521	0.615	0.601	0.611	0.671	0.911
1998	0.120	0.148	0.192	0.261	0.326	0.373	0.427	0.496	0.537	0.566	0.587	0.625	0.658	0.809
1999	0.133	0.170	0.226	0.286	0.343	0.382	0.441	0.483	0.537	0.565	0.620	0.644	0.672	0.757
2000	0.109	0.144	0.199	0.276	0.332	0.392	0.437	0.490	0.540	0.585	0.631	0.650	0.671	0.872
2001	0.115	0.137	0.183	0.262	0.310	0.356	0.400	0.434	0.484	0.534	0.581	0.615	0.624	0.819
2002	0.114	0.139	0.182	0.253	0.329	0.372	0.392	0.434	0.476	0.520	0.545	0.587	0.601	0.833
2003	0.109	0.124	0.196	0.245	0.312	0.371	0.422	0.434	0.477	0.516	0.551	0.591	0.623	0.817
2004	0.104	0.129	0.180	0.264	0.308	0.376	0.413	0.444	0.478	0.521	0.579	0.614	0.688	0.835
2005	0.104	0.136	0.196	0.263	0.322	0.370	0.408	0.451	0.478	0.523	0.550	0.551	0.640	0.797
2006	0.107	0.143	0.200	0.266	0.314	0.374	0.419	0.462	0.489	0.527	0.570	0.602	0.590	0.796
2007	0.115	0.131	0.180	0.252	0.305	0.364	0.409	0.449	0.485	0.513	0.523	0.554	0.569	0.737
2008	-	0.158	0.177	0.242	0.304	0.402	0.465	0.486	0.511	0.546	0.600	0.596	0.635	0.803

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
2009	0.129	0.179	0.206	0.249	0.326	0.394	0.510	0.550	0.542	0.583	0.609	0.594	0.595	0.809
2010	0.129	0.128	0.175	0.263	0.375	0.447	0.501	0.541	0.582	0.602	0.593	0.608	0.592	0.706
2011	0.136	0.156	0.183	0.261	0.316	0.435	0.512	0.604	0.655	0.609	0.671	0.647	0.677	0.795
2012	0.135	0.178	0.225	0.246	0.249	0.356	0.474	0.582	0.530	0.626	0.654	0.730	0.699	0.833
2013	0.129	0.145	0.189	0.230	0.270	0.282	0.345	0.384	0.534	0.559	0.634	0.627	0.661	0.720
2014	0.129	0.149	0.193	0.168	0.192	0.239	0.333	0.277	0.364	0.516	0.713	0.780	0.797	0.875
2015	0.160	0.167	0.232	0.294	0.346	0.383	0.457	0.436	0.474	0.538	0.665	0.690	0.724	0.824
2016[1]	-	-	-	0.405	0.394	0.409	0.497	0.488	0.662	0.575	0.618	0.605	0.669	0.730
2017	0.154	0.196	0.254	0.270	0.306	0.413	0.425	0.458	0.533	0.472	0.562	0.650	0.692	0.796
2018[1]	-	0.233	0.135	0.371	0.323	0.280	0.379	0.452	0.524	0.633	0.483	0.589	0.457	0.821
2019[1]	0.127	0.191	0.212	0.274	0.374	0.371	0.497	0.416	-	-	-	0.688	-	0.800
Modelled	**0.141**	**0.188**	**0.237**	**0.286**	**0.335**	**0.381**	**0.425**	**0.466**	**0.503**	**0.538**	**0.570**	**0.598**	**0.624**	**0.757**

[1] - Provisional figures

Table 6.14. Proportion of maturity-at-age 6–19+ in *Sebastes mentella* in subareas 1 and 2 derived from Norwegian commercial and survey data. The proportions were derived from samples with at least 5 individuals. a50 w1 and w2 are the annual coefficients for modelled maturity ogives using a double half sigmoid of the form 0.5 ((1+tanh(age- a50)/w1)) for age < a50 and 0.5 (1+tanh((age- a50)/w2) for age > a50. a50 equals the age at 50% maturity.

year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1992	0.00	0.01	0.01	0.02	0.05	0.09	0.18	0.32	0.50	0.57	0.63	0.69	0.75	1.00
1993	0.01	0.02	0.04	0.08	0.15	0.27	0.45	0.55	0.61	0.67	0.73	0.77	0.82	1.00
1994	0.02	0.04	0.08	0.15	0.27	0.45	0.59	0.72	0.81	0.88	0.93	0.96	0.97	1.00
1995	0.03	0.06	0.13	0.24	0.40	0.57	0.71	0.83	0.90	0.94	0.97	0.98	0.99	1.00
1996	0.01	0.01	0.02	0.05	0.10	0.19	0.33	0.50	0.59	0.66	0.73	0.80	0.84	1.00
1997	0.02	0.04	0.08	0.16	0.29	0.46	0.55	0.61	0.66	0.71	0.76	0.80	0.84	1.00
1998	0.02	0.04	0.07	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	0.20	0.34	0.51	0.57	0.64	0.70	0.75	0.80	0.84	0.87	1.00
2000	0.03	0.06	0.11	0.21	0.36	0.52	0.63	0.73	0.81	0.87	0.91	0.94	0.96	1.00
2001	0.01	0.02	0.04	0.09	0.16	0.29	0.47	0.56	0.62	0.69	0.74	0.79	0.83	1.00
2002	0.02	0.05	0.10	0.19	0.33	0.50	0.55	0.59	0.63	0.67	0.71	0.74	0.77	1.00
2003	0.03	0.06	0.11	0.21	0.37	0.52	0.57	0.63	0.68	0.73	0.78	0.82	0.85	1.00
2004	0.03	0.06	0.12	0.22	0.37	0.51	0.55	0.59	0.63	0.66	0.70	0.73	0.76	1.00
2005	0.02	0.05	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	0.13	0.23	0.39	0.53	0.59	0.64	0.70	0.75	0.79	1.00
2007	0.02	0.04	0.09	0.17	0.30	0.48	0.64	0.77	0.87	0.93	0.96	0.98	0.99	1.00
2008[1]	0.02	0.04	0.07	0.14	0.26	0.43	0.54	0.61	0.68	0.73	0.79	0.83	0.87	1.00

year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
2009	0.02	0.04	0.09	0.17	0.30	0.47	0.61	0.72	0.81	0.87	0.92	0.95	0.97	1.00
2010	0.02	0.04	0.08	0.16	0.28	0.45	0.55	0.60	0.66	0.71	0.76	0.80	0.83	1.00
2011[1]	0.02	0.04	0.07	0.14	0.26	0.43	0.54	0.61	0.68	0.73	0.79	0.83	0.87	1.00
2012	0.02	0.05	0.09	0.18	0.32	0.50	0.59	0.68	0.75	0.81	0.86	0.90	0.93	1.00
2013	0.00	0.01	0.02	0.04	0.08	0.15	0.27	0.44	0.63	0.78	0.88	0.94	0.97	1.00
2014	0.00	0.00	0.01	0.01	0.03	0.06	0.11	0.21	0.36	0.52	0.61	0.68	0.75	1.00
2015	0.01	0.02	0.04	0.09	0.17	0.31	0.49	0.54	0.59	0.63	0.67	0.71	0.74	1.00
2016[1]	0.02	0.04	0.07	0.14	0.26	0.43	0.54	0.61	0.68	0.73	0.79	0.83	0.87	1.00
2017[1]	0.02	0.04	0.07	0.14	0.26	0.43	0.54	0.61	0.68	0.73	0.79	0.83	0.87	1.00
2018[1]	0.02	0.04	0.07	0.14	0.26	0.43	0.54	0.61	0.68	0.73	0.79	0.83	0.87	1.00
2019[1]	0.02	0.04	0.07	0.14	0.26	0.43	0.54	0.61	0.68	0.73	0.79	0.83	0.87	1.00

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

Table 6.15. *Sebastes mentella*. Average catch (numbers of specimens) per hour trawling of different ages of *Sebastes mentella* in the Russian groundfish survey in the Barents Sea and Svalbard areas (1976–1983 published in "Annales Biologiques"). The survey was not conducted in 2016 took place in 2017 with insufficient coverage and was terminated after that year.

Year class	0	1	2	3	4	5	6	7	8	9	10	11
1974	-	-	4.8	-	4.9	22.8	4.8	4.8	-	-	-	3
1975	-	7.4	-	1.7	6.4	2.4	3.5	5	-	-	4	-
1976	7	-	8.1	1.2	2.5	6.8	4.9	5	1	13	-	-
1977	-	0.2	0.2	0.2	0.9	5.1	3.7	1	19	2	-	-
1978	0.8	0.02	0.9	1	5	3.8	2	20	6	-	-	-
1979	-	1.9	1.4	3.6	2.3	9	11	16	1	-	-	0.1
1980	0.3	0.4	2	2.5	16	6	11	25	2	-	1.5	2
1981	-	2.2	3.9	20	6	12	47	18	6.3	1.6	0.5	1
1982	19.8	13.2	13	15	34	44	39	32.6	4.3	3.1	4.9	+
1983	12.5	3	5	6	31	34	32.3	13.3	4	4.2	0.6	1.1
1984	-	10	2	-	5	18.3	19	2.2	2.4	0.2	1.7	2.4
1985	107	7	-	1	5.2	16.2	1.7	1.7	0.6	2.8	3.8	0.3
1986	2	-	1	1.8	8.4	3.6	2.1	1.2	5.6	8.2	0.9	0.7
1987	-	3	37.9	1.3	8	4.1	2	10.6	9.6	1.4	2	1.3
1988	4	58.1	4.3	13.3	25.8	3.9	8.6	11.2	2.8	4.2	3	4.7
1989	8.7	9	17	23.4	4.6	5.4	4	6.6	6.6	4.1	7.7	5.3
1990	2.5	6.3	6.1	1	4.3	1.7	11.5	6.5	5.5	6.7	7.4	3.6

Year class	0	1	2	3	4	5	6	7	8	9	10	11
1991	0.3	1	0.5	1.5	1.2	11.3	3.9	3.3	4.6	5.8	2.7	1.9
1992	0.6	+	0.2	0.1	4.3	1.3	2	2.3	4.9	2.3	1	4.1
1993[1]	-	+	1.5	1.8	1	1.2	3	4.2	2.6	2	3.2	2.1
1994	0.3	3.5	1.7	1.7	0.9	3.6	5.2	4.3	3.1	3.3	1.8	1.2
1995	2.8	1	1.1	0.4	2.2	2.6	3.5	3.4	2.9	1.2	1	8.5
1996[2]	+	0.1	0.1	0.4	0.7	1.1	1	1.4	1	0.8	3.7	0.6
1997	-	-	+	0.4	0.5	0.3	0.9	0.6	1	1.1	0.5	0.4
1998	-	0.1	0.2	0.3	0.2	1.1	0.5	0.7	1	0.4	0.4	0.7
1999	0.1	-	0.1	+	0.1	0.3	0.5	0.8	0.5	0.2	0.4	0.6
2000	-	0.6	0.1	0.5	0.3	0.3	0.6	0.4	0.1	0.1	0.7	0.3
2001	-	0.1	0.4	-	0.1	0.2	0.2	0.3	0.2	0.8	0.1	1
2002[3]	0.1	0.5	0.1	-	-	0.1	0.5	0.4	1.5	0.5	1	1.1
2003	-	-	0.1	-	0.3	1.0	0.5	4.8	2.1	3.7	1.3	1.9
2004	-	0.2	0.3	0.5	1.5	0.9	4.4	3.7	7.5	4.1	3.1	3.3
2005	-	-	1.4	1.9	1.4	2.3	3.9	7.2	6.1	6.8	3.1	
2006[4]	0.1	1.8	1.2	1.1	0.8	2.1	4.1	3.0	6.1	5.9		
2007	2.5	0.4	0.1	1.2	1.7	2.4	3.6	4.3	7.4			
2008	0.1	0.1	1.6	1.8	4.1	2.9	5.8	5.5				

Year class	0	1	2	3	4	5	6	7	8	9	10	11
2009	1.6	1.9	1.1	4.4	4.8	2.9	4.8					
2010	7.5	0.7	1.2	1.5	1.9	1.6						
2011	0.1	0.3	0.6	1.6	1.6							
2012	0.2	0.7	0.5	0.3								
2013	0.1	0.1	0.4									
2014	3.6	1.0										
2015	6.6											

1 - Not complete area coverage of Division 2.b.

2 - Area surveyed restricted to Subarea 1 and Division 2.a only.

3 - Area surveyed restricted to Subarea 1 and Division 2.b only

4- Area surveyed restricted to Division 2.a and 2.b only.

Table 6.16a. *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 1986–2019 (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	0	337
1987[2]	20	14	140	19	6	2	1	2	0	204
1988[2]	33	23	82	77	7	3	2	2	0	229
1989	556	225	24	72	17	2	2	8	4	910
1990	184	820	59	65	111	23	15	7	3	1287
1991	1533	1426	563	55	138	38	30	7	1	3791
1992	149	446	268	43	22	15	4	7	4	958
1993	9	320	272	89	16	13	3	1	0	723
1994	4	284	613	242	10	9	2	2	1	1167
1995	33	33	417	349	77	18	5	1	0	933
1996	56	69	139	310	97	8	4	1	1	685
1997	3	44	13	65	57	9	5	0	0	195
1998	0	37	35	28	132	73	45	2	0	352
1999	3	3	124	62	260	169	42	1	0	664
2000	0	10	30	59	126	143	21	1	0	391
2001	1	5	3	32	57	227	50	3	0	378

	Length group (cm)									
Year	5.0-9.9	10.0-14.9	15.0-19.9	20.0-24.9	25.0-29.9	30.0-34.9	35.0-39.9	40.0-44.9	>45.0	Total
2002	1	4	6	21	62	266	47	4	0	410
2003	1	5	7	11	51	244	45	1	0	364
2004	0	2	8	6	14	78	49	2	0	160
2005	22	1	4	4	10	70	47	1	0	158
2006	85	6	5	7	43	200	108	3	0	457
2007	101	55	1	5	10	98	109	3	0	381
2008	127	47	22	3	8	24	78	4	0	313
2009	9	122	88	14	3	27	219	5	0	486
2010	96	18	44	37	2	20	91	7	0	315
2011	126	91	81	48	10	7	67	5	1	436
2012	29	75	69	82	47	8	94	10	0	413
2013	33	43	127	106	67	19	89	13	0	497
2014[3]	3	10	59	49	38	24	66	20	0	268
2015	85	7	28	157	115	65	69	25	0	552
2016	244	33	44	205	138	139	142	48	0	993

	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
2017	41	39	8	20	59	76	57	17	0	317
2018	66	62	55	35	100	65	80	26	0	489
2019	3	25	84	31	59	82	72	25	1	381

1 - Includes some unidentified Sebastes specimens mostly less than 15 cm.

2 - Old trawl equipment (bobbins gear and 80 m sweep length)

3 - Poor survey coverage in 2014

Table 6.16b. *Sebastes mentella*[1] in Division 2.b. Norwegian bottom-trawl survey indices (on age) in the Svalbard area (Division 2.b) in summer/fall 1992–2019 (numbers in millions).

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992	283	419	484	131	58	45	14	8	5	2	7	2	1	3	1462
1993	2	527	117	202	142	8	23	6	13	1	7	1	1	0	1050
1994	7	280	290	202	235	42	94	1	1	3	4	1	1	0	1161
1995	4	50	365	237	132	61	19	17	11	0	1	3	0	0	900
1996	13	32	10	36	103	135	78	16	50	28	32	8	21	2	564
1997	8	43	6	7	38	18	29	19	6	2	0	2	1	1	180
1998	0	25	27	13	10	12	61	52	41	15	0	5	13	0	274
1999	3	16	108	25	28	39	106	59	54	26	35	14	18	12	543
2000	4	6	5	13	30	21	28	44	66	48	21	19	9	6	320
2001	1	4	2	0	12	15	18	36	28	46	45	80	53	14	354

2002	3	2	4	1	5	22	34	23	90	35	54	65	17	22	377
2003	0	4	3	3	5	3	29	25	25	25	11	164	55	23	375
2004	1	1	4	4	1	4	2	9	4	15	14	17	15	15	106
2005	15	1	1	3	1	2	2	8	4	5	14	7	30	21	114
2006	35	1	3	3	2	6	5	37	3	20	46	69	8	22	260
2007	22	30	0	0	3	1	5	4	6	4	3	7	27	17	129
2008	6	25	19	11	2	2	2	4	3	3	3	3	6	8	97
2009	9	69	50	29	26	25	7	1	1	1	4	20	11	8	261
2010	No age readings														
2011	125	42	61	42	12	49	31	4	1	0	2	0	0	1	370
2012	27	61	31	28	34	48	27	33	19	9	0	1	0	0	318
2013	30	4	29	36	7	93	72	43	40	7	8	3	3	3	378
2014[2]	0	3	2	7	21	40	13	27	5	30	13	11	3	2	177
2015	63	1	10	56	36	54	33	95	28	21	12	4	5	3	421
2016	No age readings available														
2017	39	26	10	13	14	20	39	16	29	8	6	19	1	28	268
2018	No age readings available														
2019[3]	0	32	53	0	24	21	21	46	52	76	0	0	0	0	325

1 - Includes some unidentified Sebastes specimens mostly less than 15 cm.

2 - Poor survey coverage in 2014

3 – Provisional figures

Table 6.17. ***Sebastes mentella*** **in subareas 1 and 2. Abundance indices (on age) from the Ecosystem survey in August-September 1996–2019 covering the Norwegian Economic Zone (NEZ) and Svalbard incl. the area north and east of Spitsbergen (numbers in thousands and total biomass in thousand tonnes) and the continental slope down to 1000 m.**

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total N	Total B
1996	146198	112742	22353	53507	165531	181980	108738	43328	65310	40546	38254	19843	29446	10931	17414	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	4036	8613	7002	3135	7911	7980	43544	62831	51793	34642	61698	168687	107721	39232	27193	636 017	213
2004	8554	15793	11443	7399	3554	7560	6164	11686	8566	22973	25920	23199	20392	19472	50960	243 635	111
2005	32526	6856	5546	5616	3772	5980	6985	13151	5803	5700	16554	34393	34987	34336	53165	265 370	103
2006	125437	4833	6844	6602	4255	8486	7424	38309	3983	24756	48733	71491	13957	37991	159909	563 010	184
2007	335297	199057	15305	4867	10970	2862	8387	9973	14017	6320	4686	8295	52422	18971	223524	914 953	172
2008	56276	210594	140764	29365	7581	3775	2810	6479	6160	3681	3668	5473	7405	10175	105726	599 932	89
2009	122459	176405	231265	82701	109509	45607	15812	2775	5807	2950	3929	22097	12431	9299	331974	1 175 019	200
2010	No age reading																
2011	423987	378581	236404	62437	55643	77076	48239	12383	3128	2012	2878	831	100	2938	103438	1 410 075	120[2]
2012	354863	261115	352468	171535	132263	74859	58937	41526	21794	12670	3552	1051	1559	3376	140270	1 631 839	186[2]

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total N	Total B
2013	299841	203094	189851	194068	164206	178236	112427	103262	92160	13848	13956	8579	2784	2857	144033	1 723 202	271[2]
2014[1]	2247	20884	33295	82052	52428	94324	93771	68765	35193	56728	40647	19047	16518	3335	163869	783 104	239[2]
2015	404973	86648	53046	95737	53022	109686	46714	126156	73141	25441	19583	6569	5284	3335	119261	1 228 596	207[2]
2016	No age reading																
2017	534647	244469	213984	215852	33595	45809	61428	62449	37597	33901	39670	37492	10364	40052	85250	1 696 557	213[2]
2018	No age reading																
2019[3]	93518	77195	125457	81499	62447	38668	61615	91672	178887	124876	0	0	0	0	60931	996 765	211[2]

1 - Poor survey coverage in 2014

2 – Calculated using modelled weight-at-age

3 – Provisional figures

Table 6.18a. *Sebastes mentella*[1]. Abundance indices (on length) from the bottom-trawl survey in the Barents Sea in the winter 1986–2019 (numbers in millions). The area coverage was extended from 1993 onwards. Numbers from 1994 onwards were recalculated while numbers for 1986–1993 are as in previous reports.

	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	14	950
1987	72	25	227	56	35	11	5	1	0	433
1988	587	25	133	182	40	50	48	4	0	1068
1989	623	55	28	177	58	9	8	2	0	961
1990	324	305	36	56	80	13	13	2	0	828
1991	395	449	86	39	96	35	24	3	0	1127

	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
1992	139	367	227	35	55	34	8	2	1	867
1993	31	593	320	116	24	25	6	1	0	1117
1994	8	296	479	488	74	74	17	3	0	1440
1995	310	84	571	390	83	58	24	3	0	1522
1996	215	102	198	343	136	42	17	1	0	1054
1997[2]	63	121	26	281	272	71	40	5	0	879
1998[2]	1	87	63	101	204	41	13	2	0	511
1999	2	7	69	37	173	74	22	3	0	388
2000	9	13	40	78	143	97	27	7	2	415
2001	10	23	7	57	78	75	10	1	0	260
2002	17	7	19	36	96	116	24	1	0	317
2003	4	4	10	13	70	198	46	6	0	351
2004	2	3	7	19	33	86	32	2	0	183
2005	0	6	7	11	28	154	86	4	0	296
2006	100	2	10	15	23	104	83	3	1	339
2007	382	121	3	7	12	121	121	7	0	773
2008	858	359	27	5	12	104	165	5	0	1533

	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**
2009	95	325	136	5	9	67	163	6	0	806
2010	652	276	215	64	7	74	191	6	0	1485
2011	501	230	212	149	14	47	157	5	0	1315
2012	129	280	86	125	47	14	154	18	0	855
2013	249	226	245	159	143	35	193	27	0	1278
2014	91	174	250	114	125	51	115	14	0	989
2015	174	110	216	302	290	215	171	18	0	1555
2016	615	105	149	332	213	163	124	14	1	1790
2017	568	185	68	197	286	310	231	11	0	1973
2018	190	252	83	109	191	270	217	23	1	1478
2019	42	294	270	92	158	255	211	20	0	1377

1 - Includes some unidentified Sebastes specimens mostly less than 15 cm.

2 - Adjusted indices to account for not covering the Russian EEZ in Subarea 1.

Table 6.18b. *Sebastes mentella*[1] in subareas 1 and 2. Preliminary Norwegian bottom-trawl indices (on age) from the annual Barents Sea survey in February 1992–2019 (numbers in millions). The area coverage was extended from 1993 onwards.

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992															
1993															
1994	4	100	320	168	337	263	92	56	5	31	13	12	24	6	1431
1995	316	49	158	230	319	227	80	24	10	17	19	9	9	9	1476
1996	193	105	78	108	140	144	134	65	22	24	13	7	9	4	1046
1997[2]	60	120	21	51	105	100	135	104	44	48	29	26	8	7	858
1998[2]	2	70	47	24	11	51	112	115	35	17	6	7	4	3	504
1999	0	1	36	39	29	26	54	64	57	38	17	6	6	2	375
2000	19	1	4	31	36	23	28	70	73	47	24	15	10	3	384
2001	1	18	8	2	7	26	36	30	42	18	21	27	5	3	244
2002	18	4	12	8	2	10	42	56	25	13	36	20	37	13	296
2003	0	3	2	4	6	6	14	36	24	17	48	30	61	32	283
2004	2	1	4	2	4	10	11	16	14	12	15	25	26	14	156
2005	0	4	2	3	6	6	8	14	17	9	17	26	42	56	210
2006	75	22	5	4	6	7	10	11	7	14	15	9	43	29	257
2007	242	66	5	1	2	2	5	8	9	5	8	22	33	68	476
2008	703	180	105	13	0	2	4	6	4	6	4	21	20	29	1097
2009	106	108	96	87	68	32	21	14	5	5	20	2	24	7	595
2010	160	250	178	167	91	68	25	22	2	10	4	8	12	18	1015

2011	362	226	131	129	103	65	41	23	2	6	1	2	2	28	1121
2012	No age readings														
2013	0	178	249	145	142	124	120	14	32	11	4	25	37	13	1094
2014	No age readings														
2015	No age readings														
2016	No age readings														
2017	No age readings														
2018	No age readings														
2019	No age readings														

1 - Includes some unidentified Sebastes specimens mostly less than 15 cm.

2 - Adjusted indices to account for not covering the Russian EEZ in Subarea 1

Table 6.19. Comparison of results on *Sebastes mentella* from the Norwegian Sea pelagic surveys in 2008, 2009, 2013, 2016 and 2019. Acoustic results for the 2019 survey were not available at the time of AFWG 2020.

	2008	2009	2013	2016	2019
mean length (cm) All/M/F[1]	37.0/36.4/37.5	36.6/36.0/37.1	37.5/37.0/38.1	37.7/37.0/38.3	37.6/37.2/38.0
mean length (cm) S/DSL/D[2]	37.2/36.8/39.1	37.2/36.5/38.3	37.1/37.4/38.9	38.1/37.6/38.4	37.4/37.6/37.7
mean weight (g) All/M/F	619/585/648	625/609/666	659/625/706	656/619/694	683/644/724
Mean age (y) All/M/F	25 / 25 / 25	25 / 25 / 24	28 / 29 / 28	27 / 27 / 26	- / - / -
Sex ratio (M/F)	45% / 55%	45% / 55%	59% / 41%	50% / 50%	51% / 49%
Occurrence	96%	100%	95%	80%	99%
Catch rates	3.80 t/NM2	3.94 t/NM2	3.47 t/NM2	1,01 t/NM2	3.40 t/NM2

mean s_A	33 m2/NM2	34 m2/NM2	19 m2/NM2	5.2 m2/NM2	-
Total Area	53 720 NM2	69 520 NM2	69 520 NM2	67 150 NM2	73 364 NM2
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	499 000 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 6.20a: *S. mentella* in subareas 1 and 2. Population matrix with numbers-at-age (in thousands) for each year and separable fishing mortality coefficients for the demersal and pelagic fleet by year (Fy) and selectivity at age for the pelagic fleet (Sa). Numbers are estimated from the statistical catch-at-age model.

sa (demersal)	**Varies over time**																	
sa (pelagic)	0.000	0.000	0.000	0.000	0.000	0.011	0.021	0.039	0.074	0.135	0.233	0.372	0.537	0.693	0.815	0.896	0.944	1.00

Fy (demer-sal)	**Fy (pe-lagic)**	**Year \ age**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19+**
0.044	0	1992	417 153	402 877	364 870	237 695	142 559	97 537	95 796	101 604	126 583	86 789	98 368	73 544	75 579	64 565	46 468	30 447	20 258	201 571
0.031	0	1993	278 015	396 893	383 310	347 149	223 449	133 771	91 346	89 530	94 756	117 795	80 588	91 147	68 008	69 756	59 486	42 744	27 967	202 201
0.027	0	1994	194 668	264 512	377 617	364 693	330 230	212 491	127 100	86 600	84 479	88 751	109 534	74 600	84 202	62 775	64 370	54 887	39 438	212 361
0.021	0	1995	183 773	185 213	251 666	359 277	346 726	313 664	201 430	120 041	81 350	78 904	82 538	101 612	69 120	77 973	58 118	59 588	50 807	233 075
0.014	0	1996	146 256	174 848	176 218	239 443	341 586	329 378	297 477	190 486	113 070	76 317	73 799	77 059	94 781	64 446	72 686	54 172	55 541	264 593
0.014	0	1997	102 907	139 153	166 356	167 659	227 756	324 761	312 774	281 750	179 741	106 348	71 654	69 239	72 279	88 893	60 440	68 168	50 804	300 232

Fy (demer-sal)	Fy (pe-lagic)	Year \ age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.019	0	1998	52 516	97 909	132 394	158 276	159 483	216 563	308 480	296 409	266 059	169 174	99 908	67 262	64 976	67 822	83 409	56 711	63 961	329 375
0.015	0	1999	45 519	49 965	93 154	125 964	150 575	151 671	205 637	291 467	278 056	248 646	157 939	93 252	62 778	60 644	63 300	77 848	52 930	367 111
0.012	0	2000	34 891	43 308	47 539	88 630	119 844	143 250	144 241	195 250	275 438	261 368	233 226	148 071	87 418	58 849	56 848	59 338	72 975	393 750
0.021	0	2001	36 120	33 196	41 205	45 230	84 325	114 022	136 272	137 025	184 391	259 142	245 777	219 302	139 231	82 198	55 335	53 454	55 795	438 859
0.007	0	2002	40 387	34 366	31 584	39 203	43 008	80 125	108 180	128 933	129 122	173 003	242 326	229 375	204 466	129 752	76 587	51 553	49 799	460 819
0.003	0	2003	42 998	38 425	32 697	30 050	37 299	40 916	76 205	102 765	122 150	122 060	163 420	228 864	216 625	193 099	122 539	72 329	48 687	482 231
0.006	0	2004	54 143	40 910	36 559	31 109	28 587	35 479	38 911	72 444	97 645	116 008	115 878	155 106	217 193	205 564	183 233	116 276	68 632	503 777
0.008	0	2005	133 043	51 514	38 923	34 783	29 595	27 192	33 737	36 978	68 775	92 586	109 884	109 690	146 776	205 499	194 484	173 352	110 005	541 532
0.005	0.034	2006	244 520	126 582	49 012	37 033	33 092	28 153	25 861	32 062	35 089	65 119	87 497	103 734	103 506	138 479	193 870	183 475	163 538	614 651
0.005	0.019	2007	368 760	232 644	120 434	46 631	35 233	31 484	26 774	24 581	30 443	33 249	61 499	82 265	97 007	96 225	128 036	178 497	168 458	712 241
0.005	0.013	2008	360 302	350 850	221 345	114 585	44 366	33 522	29 948	25 461	23 363	28 902	31 501	58 093	77 438	90 994	89 981	119 448	166 271	818 945
0.003	0.010	2009	368 411	342 803	333 810	210 594	109 019	42 211	31 889	28 484	24 205	22 180	27 364	29 744	54 730	72 794	85 364	84 281	111 766	920 736
0.003	0.010	2010	455 484	350 518	326 154	317 597	200 365	103 723	40 155	30 328	27 073	22 978	21 026	25 905	28 117	51 653	68 600	80 351	79 271	970 221
0.005	0.010	2011	603 049	433 362	333 494	310 313	302 170	190 629	98 667	38 189	28 828	25 708	21 787	19 902	24 477	26 520	48 639	64 515	75 505	985 192
0.004	0.009	2012	436 063	573 760	412 315	317 297	295 241	287 491	181 346	93 846	36 306	27 375	24 359	20 593	18 773	23 047	24 931	45 670	60 529	994 194
0.004	0.009	2013	253 115	414 884	545 894	392 289	301 884	280 896	273 490	172 489	89 236	34 502	25 987	23 086	19 475	17 714	21 705	23 447	42 915	990 107
0.015	0.009	2014	222 022	240 822	394 734	519 381	373 236	287 222	267 227	260 157	164 049	84 839	32 780	24 660	21 865	18 402	16 702	20 435	22 055	970 733
0.026	0.009	2015	346 890	211 239	229 125	375 562	494 140	355 088	273 215	254 148	247 336	155 864	80 514	31 050	23 294	20 580	17 255	15 608	19 049	921 959

Fy (demer-sal)	Fy (pe-lagic)	Year \ age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.036	0.009	2016	443 804	330 042	200 979	217 997	357 312	470 105	337 744	259 766	241 404	234 419	147 081	75 474	28 904	21 571	18 996	15 898	14 366	865 196
0.030	0.009	2017	511 637	422 250	314 013	191 218	207 404	339 930	447 113	321 010	246 414	227 842	219 125	135 999	69 282	26 430	19 681	17 309	14 474	800 057
0.034	0.009	2018	445 345	486 788	401 742	298 762	181 930	197 328	323 368	425 186	304 892	233 038	213 330	203 062	125 375	63 710	24 265	18 049	15 862	745 774
0.036	0.008	2019	423 351	423 715	463 145	382 230	283 234	172 174	186 284	304 316	398 643	284 684	216 679	197 549	187 329	115 274	58 418	22 205	16 495	694 660

Table 6.20b. *S. mentella* in subareas 1 and 2. Fisheries selectivity at age for the demersal fleet by age (Sa). Numbers are estimated from the statistical catch-at-age model.

Year \age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1992	0.000	0.000	0.000	0.276	0.318	0.363	0.410	0.460	0.510	0.559	0.608	0.655	0.698	0.739	0.776	0.809	0.838	1.000
1993	0.000	0.000	0.000	0.006	0.016	0.044	0.116	0.270	0.510	0.746	0.892	0.959	0.985	0.995	0.998	0.999	1.000	1.000
1994	0.000	0.000	0.000	0.027	0.061	0.134	0.268	0.464	0.672	0.829	0.920	0.965	0.985	0.994	0.997	0.999	1.000	1.000
1995	0.000	0.000	0.000	0.034	0.075	0.155	0.295	0.488	0.684	0.831	0.918	0.962	0.983	0.992	0.997	0.999	0.999	1.000
1996	0.000	0.000	0.000	0.018	0.050	0.135	0.315	0.575	0.799	0.922	0.972	0.990	0.997	0.999	1.000	1.000	1.000	1.000
1997	0.000	0.000	0.000	0.015	0.043	0.118	0.284	0.540	0.777	0.911	0.968	0.989	0.996	0.999	1.000	1.000	1.000	1.000
1998	0.000	0.000	0.000	0.005	0.023	0.103	0.361	0.736	0.932	0.985	0.997	0.999	1.000	1.000	1.000	1.000	1.000	1.000
1999	0.000	0.000	0.000	0.001	0.006	0.030	0.138	0.456	0.815	0.959	0.992	0.998	1.000	1.000	1.000	1.000	1.000	1.000
2000	0.000	0.000	0.000	0.000	0.001	0.013	0.130	0.631	0.951	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2001	0.000	0.000	0.000	0.027	0.062	0.133	0.264	0.457	0.663	0.821	0.915	0.962	0.983	0.993	0.997	0.999	0.999	1.000

Year \age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2002	0.000	0.000	0.000	0.002	0.011	0.051	0.212	0.574	0.871	0.971	0.994	0.999	1.000	1.000	1.000	1.000	1.000	1.000
2003	0.000	0.000	0.000	0.044	0.090	0.174	0.310	0.490	0.672	0.814	0.903	0.952	0.977	0.989	0.995	0.998	0.999	1.000
2004	0.000	0.000	0.000	0.018	0.042	0.096	0.205	0.384	0.601	0.785	0.898	0.955	0.981	0.992	0.997	0.999	0.999	1.000
2005	0.000	0.000	0.000	0.006	0.018	0.050	0.133	0.311	0.569	0.795	0.919	0.971	0.990	0.997	0.999	1.000	1.000	1.000
2006	0.000	0.000	0.000	0.003	0.007	0.020	0.055	0.141	0.315	0.563	0.783	0.910	0.966	0.988	0.996	0.998	0.999	1.000
2007	0.000	0.000	0.000	0.001	0.003	0.009	0.025	0.068	0.173	0.374	0.631	0.830	0.933	0.976	0.991	0.997	0.999	1.000
2008	0.000	0.000	0.000	0.000	0.000	0.002	0.011	0.056	0.232	0.609	0.889	0.976	0.995	0.999	1.000	1.000	1.000	1.000
2009	0.000	0.000	0.000	0.001	0.005	0.018	0.066	0.215	0.512	0.801	0.939	0.983	0.996	0.999	1.000	1.000	1.000	1.000
2010	0.000	0.000	0.000	0.003	0.008	0.023	0.064	0.165	0.365	0.626	0.830	0.934	0.976	0.992	0.997	0.999	1.000	1.000
2011	0.000	0.000	0.000	0.000	0.002	0.006	0.021	0.074	0.230	0.527	0.806	0.939	0.983	0.995	0.999	1.000	1.000	1.000
2012	0.000	0.000	0.000	0.002	0.004	0.010	0.023	0.052	0.113	0.227	0.404	0.610	0.783	0.893	0.950	0.978	0.990	1.000
2013	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.009	0.025	0.066	0.161	0.344	0.589	0.797	0.915	0.967	0.988	1.000
2014	0.000	0.000	0.000	0.002	0.004	0.007	0.014	0.026	0.048	0.087	0.152	0.253	0.390	0.547	0.695	0.811	0.890	1.000
2015	0.000	0.000	0.000	0.001	0.003	0.008	0.020	0.051	0.125	0.275	0.500	0.726	0.875	0.949	0.980	0.992	0.997	1.000
2016	0.000	0.000	0.000	0.001	0.002	0.007	0.023	0.073	0.204	0.456	0.732	0.899	0.967	0.990	0.997	0.999	1.000	1.000
2017	0.000	0.000	0.000	0.000	0.001	0.002	0.011	0.047	0.181	0.500	0.819	0.953	0.989	0.998	0.999	1.000	1.000	1.000
2018	0.000	0.000	0.000	0.107	0.159	0.230	0.321	0.427	0.541	0.651	0.747	0.823	0.880	0.921	0.948	0.967	0.979	1.000
2019	0.000	0.000	0.000	0.032	0.073	0.157	0.307	0.513	0.715	0.856	0.934	0.971	0.988	0.995	0.998	0.999	1.000	1.000

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

Year	Rec (age 2) in millions	Rec (age 6) in millions	Stock Biomass (tonnes)	SSB (tonnes)	F (12-18)	F(19+)
1992	417	143	563660	254448	0.032	0.044
1993	278	223	608531	316887	0.030	0.031
1994	195	330	664832	398183	0.027	0.027
1995	184	347	727678	457415	0.020	0.021
1996	146	342	791056	379363	0.014	0.014
1997	103	228	852457	465175	0.014	0.014
1998	53	159	908539	525004	0.019	0.019
1999	46	151	953483	590128	0.015	0.015
2000	35	120	991438	683117	0.012	0.012
2001	36	84	1022777	634228	0.021	0.021
2002	40	43	1035047	714557	0.007	0.007
2003	43	37	1049859	786173	0.003	0.003
2004	54	29	1061966	790256	0.006	0.006
2005	133	30	1067330	844035	0.008	0.008
2006	245	33	1069352	831383	0.027	0.039
2007	369	35	1048755	965725	0.016	0.023
2008	360	44	1043712	904291	0.013	0.018

2009	368	109	1048703	939826	0.009	0.012
2010	455	200	1063700	894833	0.010	0.013
2011	603	302	1083723	882102	0.011	0.015
2012	436	295	1112560	876057	0.009	0.013
2013	253	302	1154682	829231	0.008	0.012
2014	222	373	1212913	777639	0.014	0.024
2015	347	494	1263331	802654	0.028	0.034
2016	444	357	1304112	832279	0.040	0.045
2017	512	207	1336487	835969	0.034	0.038
2018	445	182	1381075	856590	0.036	0.042
2019	423	283	1424633	885553	0.041	0.045

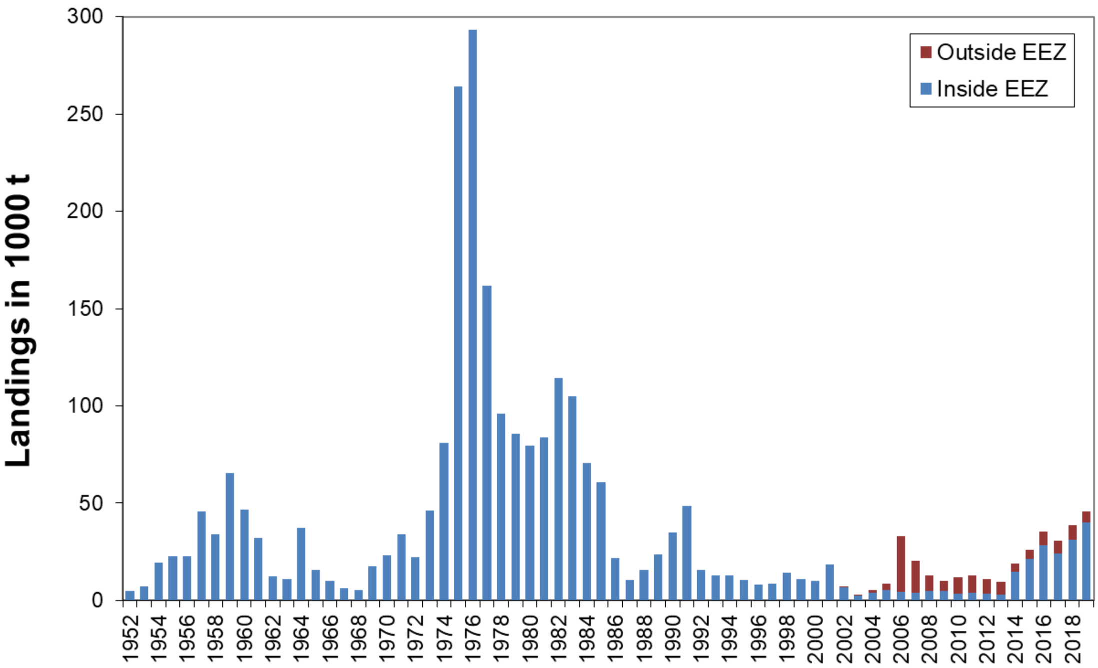
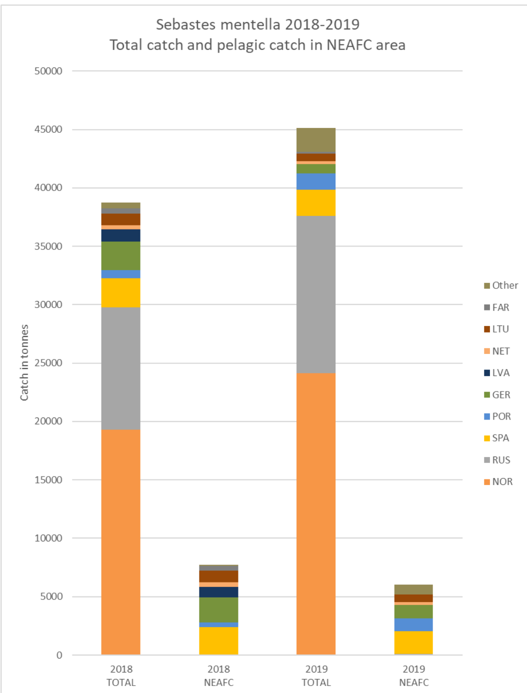


Figure 6.1. ***Sebastes mentella*** **in subareas 1 and 2. Total international landings 1952–2019 (thousand tonnes).**



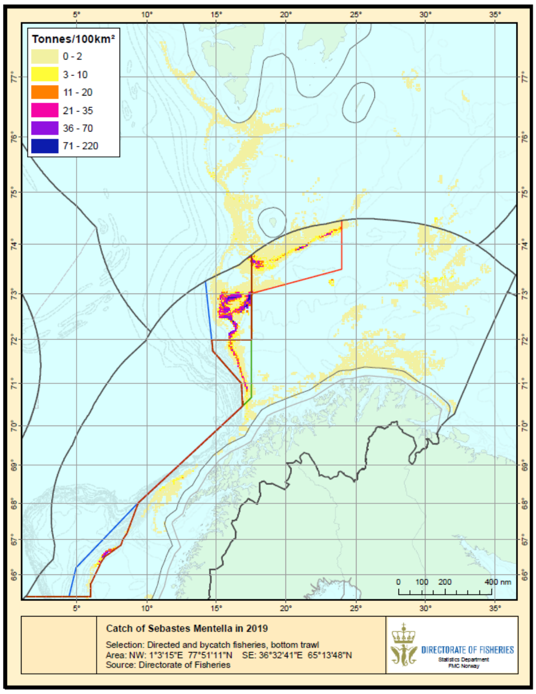


Figure 6.2. ***Sebastes mentella*** **in subareas 1 and 2. Left panel: Catch in tonnes reported by national fleets for the Subarea 27.1 and 27.2 and in the NEACF regulatory area. Right panel: Geographical location of the directed Norwegian fishing within the Norwegian Exclusive Economic Zone and bycatches by Norwegian vessels in all areas. Directed fishing with bottom trawl is not permitted to the east of the red line. Directed fishing with pelagic trawl is not permitted to the east of the blue line. Directed fishing is not permitted in the Fishery Protection Zone around Svalbard.**

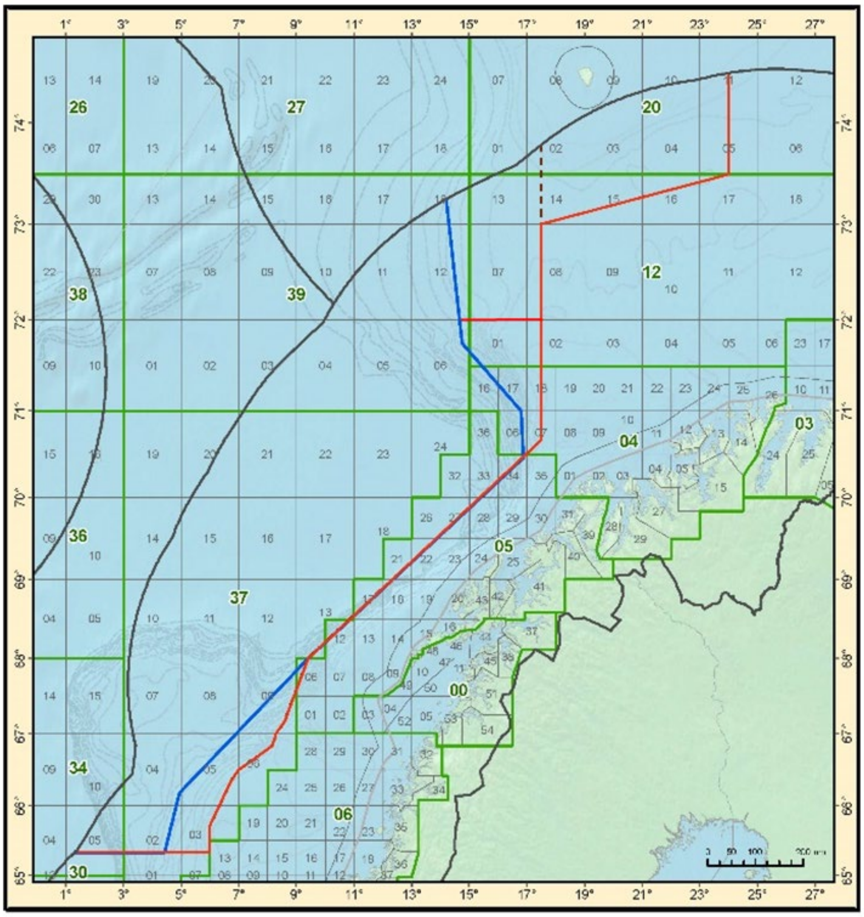
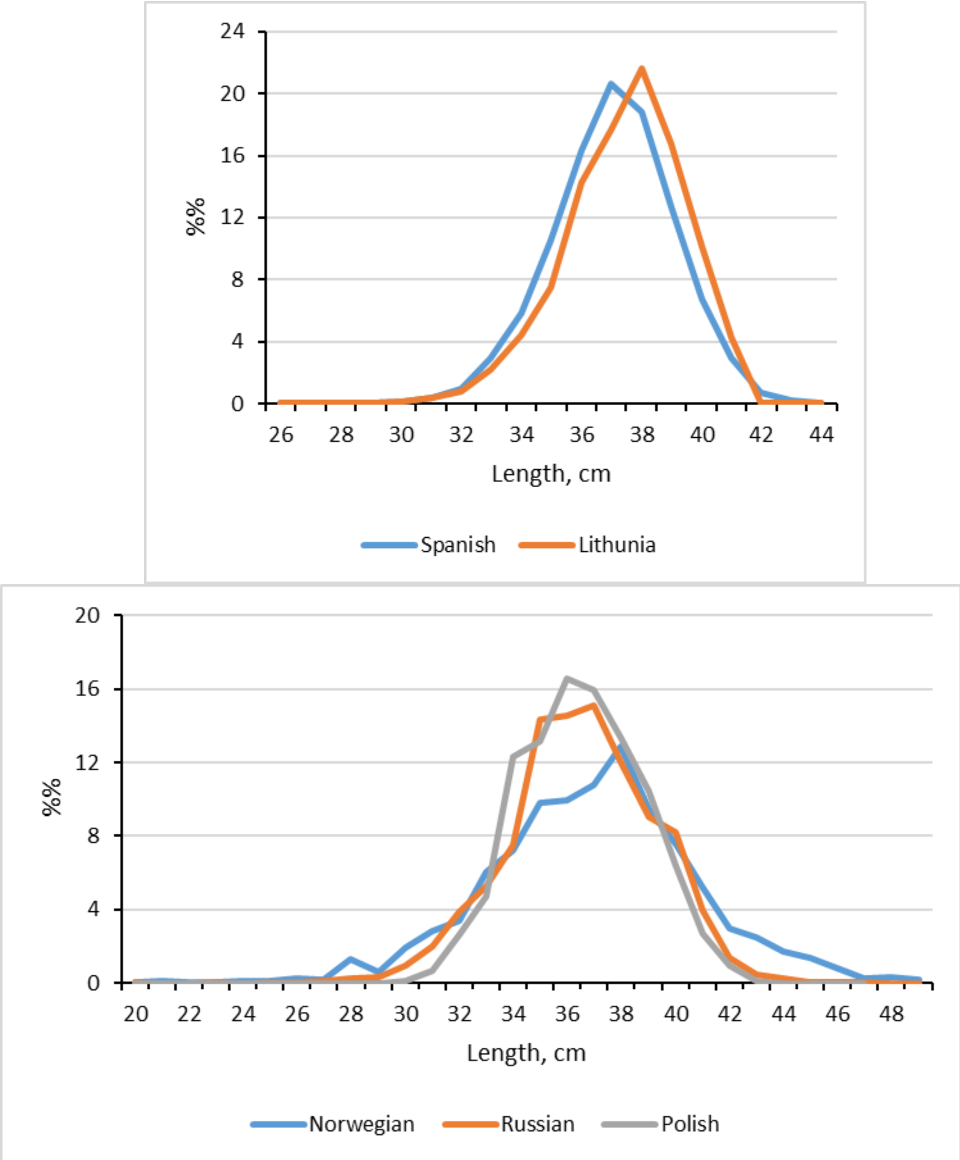
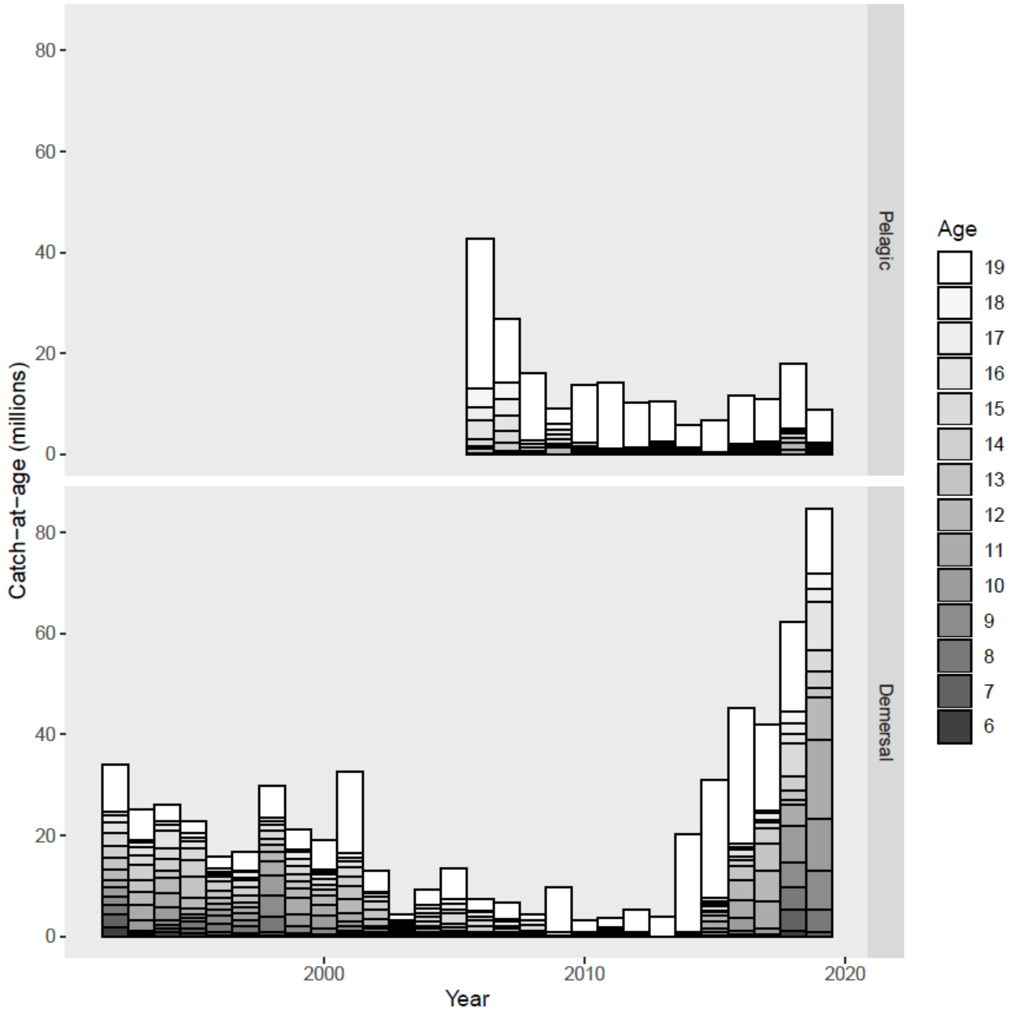


Figure 6.3. Delineation of the geographical limits for directed fishing in the Norwegian Economic Zone in 2014–2018. Directed pelagic trawling is only allowed west of the blue line. Directed demersal trawling is only allowed between the blue and the red line. The area east of the stippled line inside NEZ south of Bear Island is only open for directed demersal trawling after 10 May. The other areas for directed fishing are also open during 1 January-last February. Due to high bycatch ratios of golden redfish 72°N was suggested as southern limit for directed demersal fishing marked by the red line along that latitude to the Norwegian directorate of fisheries in November 2018.



w1

Figure 6.4. Upper panel: *Sebastes mentella* in Subarea 2. Length-distributions of the commercial pelagic catches by Spain and Lithuania in 2019. Lower panel: *Sebastes mentella* in subareas 1 and 2. Length-distributions of the commercial demersal catches by Norway, Russia and Poland in 2019.



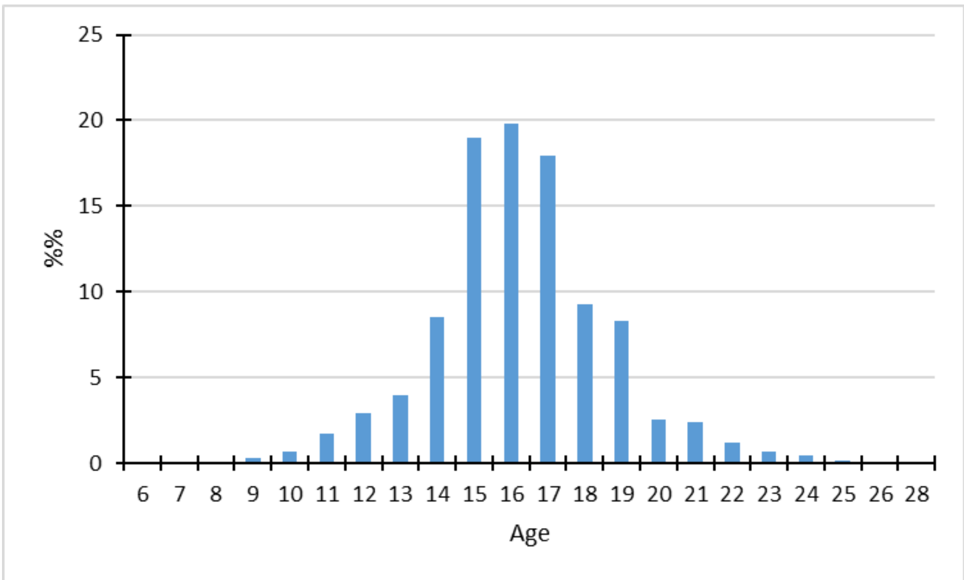


Figure 6.5. ***Sebastes mentella*** **in subareas 1 and 2. Upper panels: Catch numbers-at-age for the pelagic and demersal fleets 1992–2019. Lower panel: Age composition of the commercial demersal catches by Russia in 2019 (calculated using ALK).**

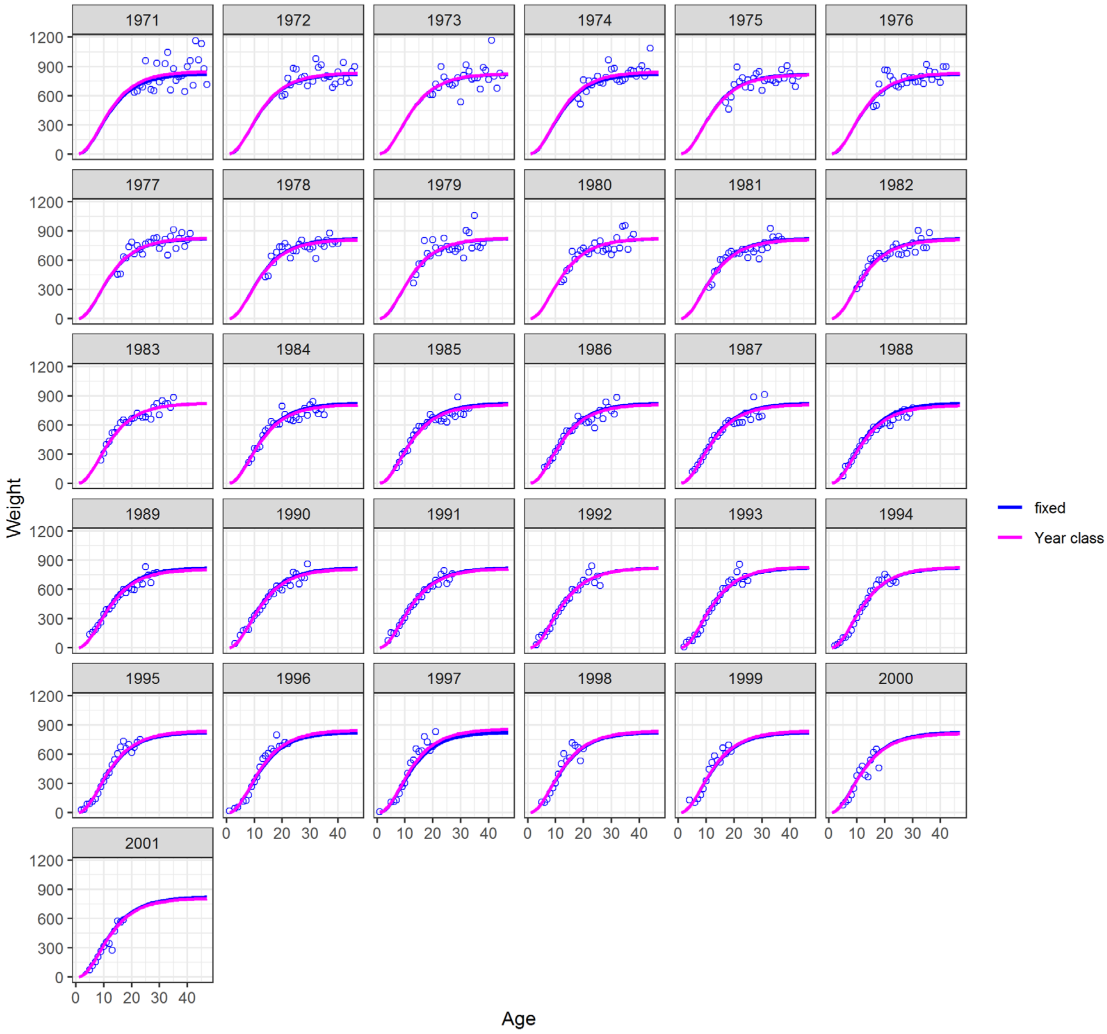


Figure 6.6. Weight-at-age of *S. mentella* per year class in subareas 1 and 2 derived from Norwegian commercial and survey data (Table 6.7). The weights were derived from samples with at least five individuals and are expressed in grams. The blue and purple lines show the fitted mixed-effect models.

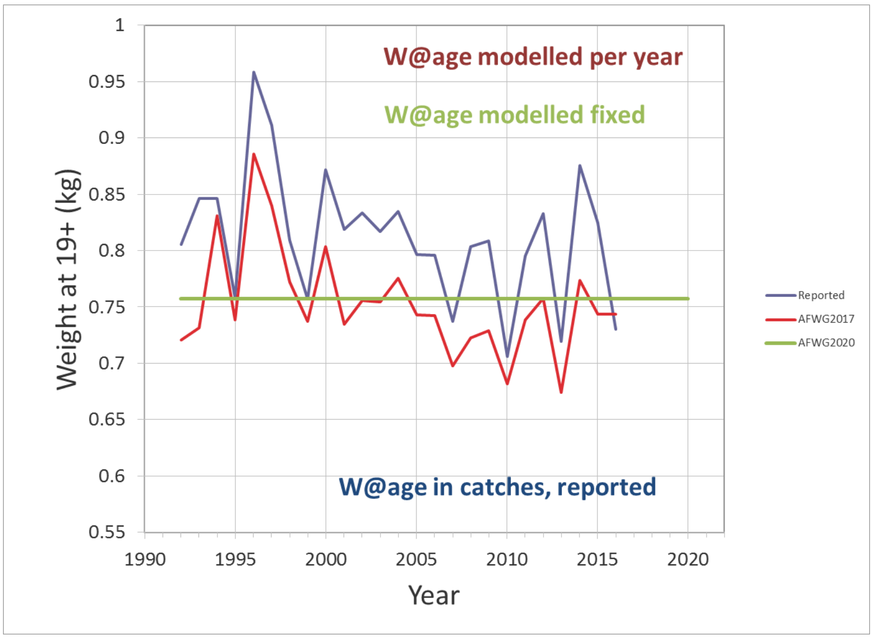


Figure 6.7. ***S. mentella*** **in subareas 1 and 2. Weight-at-age 19+ as reported from catches (blue) or modelled from catches and survey observations (red) using a mixed effect model (Figure 6.5). The weights-at-age used in the assessment were based on the fixed effects model and are therefore the same for every year. These weights were updated in 2020 and differ only slight from those estimated in 2018 and 2019.**

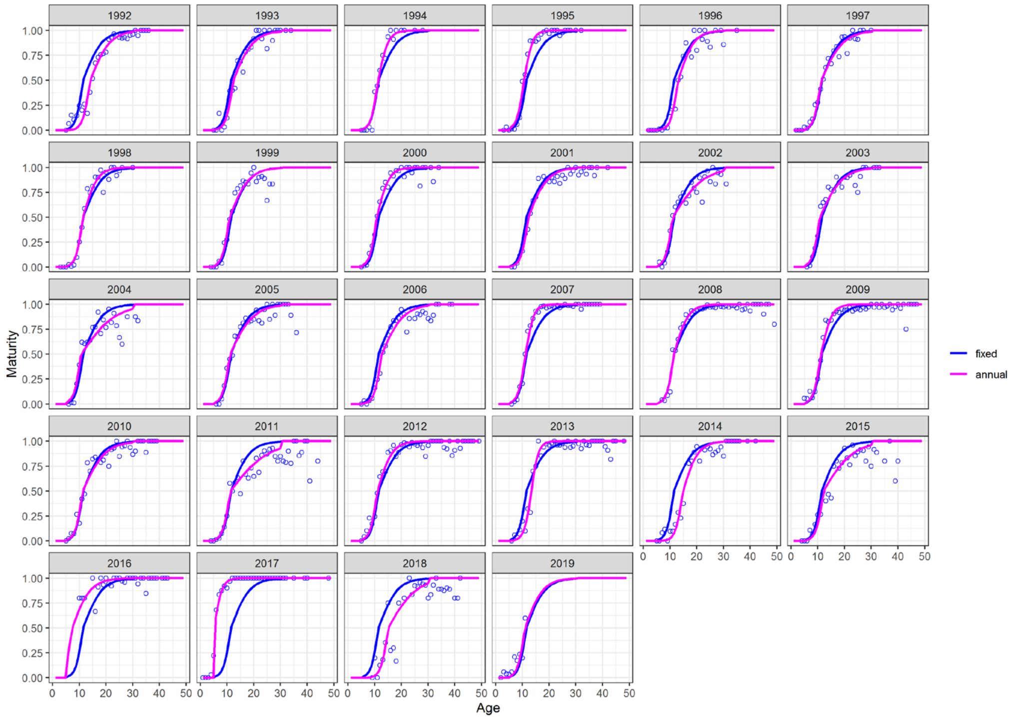


Figure 6.8. Proportion maturity-at-age of ***S. mentella*** **in subareas 1 and 2 derived from Norwegian commercial and survey data (Table D7). The proportions were derived from samples with at least five individuals. The blue and purple lines show the fitted mixed-effect models. For 2008,2011 and 2016-2019 the common model (fixed effects blue) was used for other years the annual models (random effects purple) were used. Available data for 2019 was insufficient at the time of the meeting and the fixed effect model was used.**

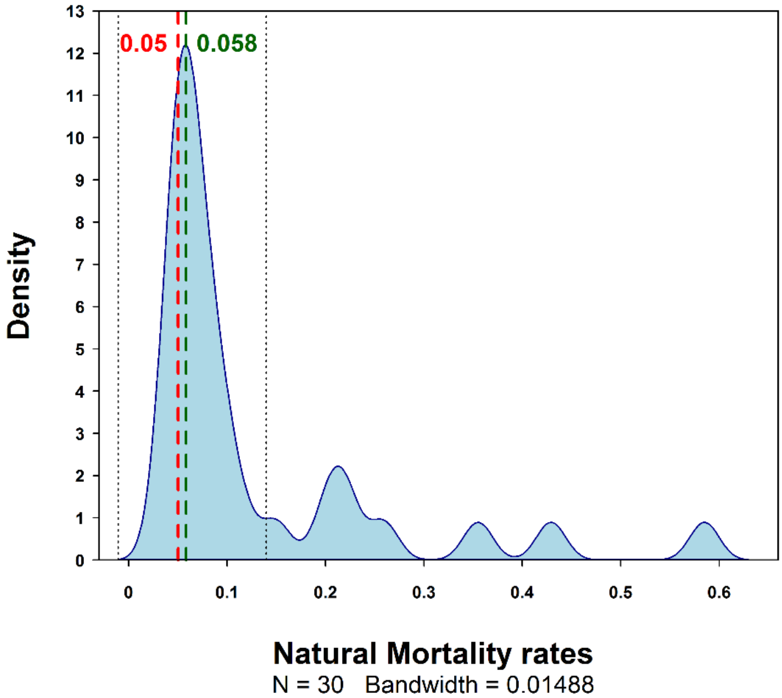


Figure 6.9. Density distribution of natural mortality rates calculated with 30 of the 39 compared methods. The excluded methods are those based on certain taxa or areas. The broken red line indicates the currently used value; the broken green line the most frequent one and the black dotted lines indicate the beginning and end of the distribution's peak.

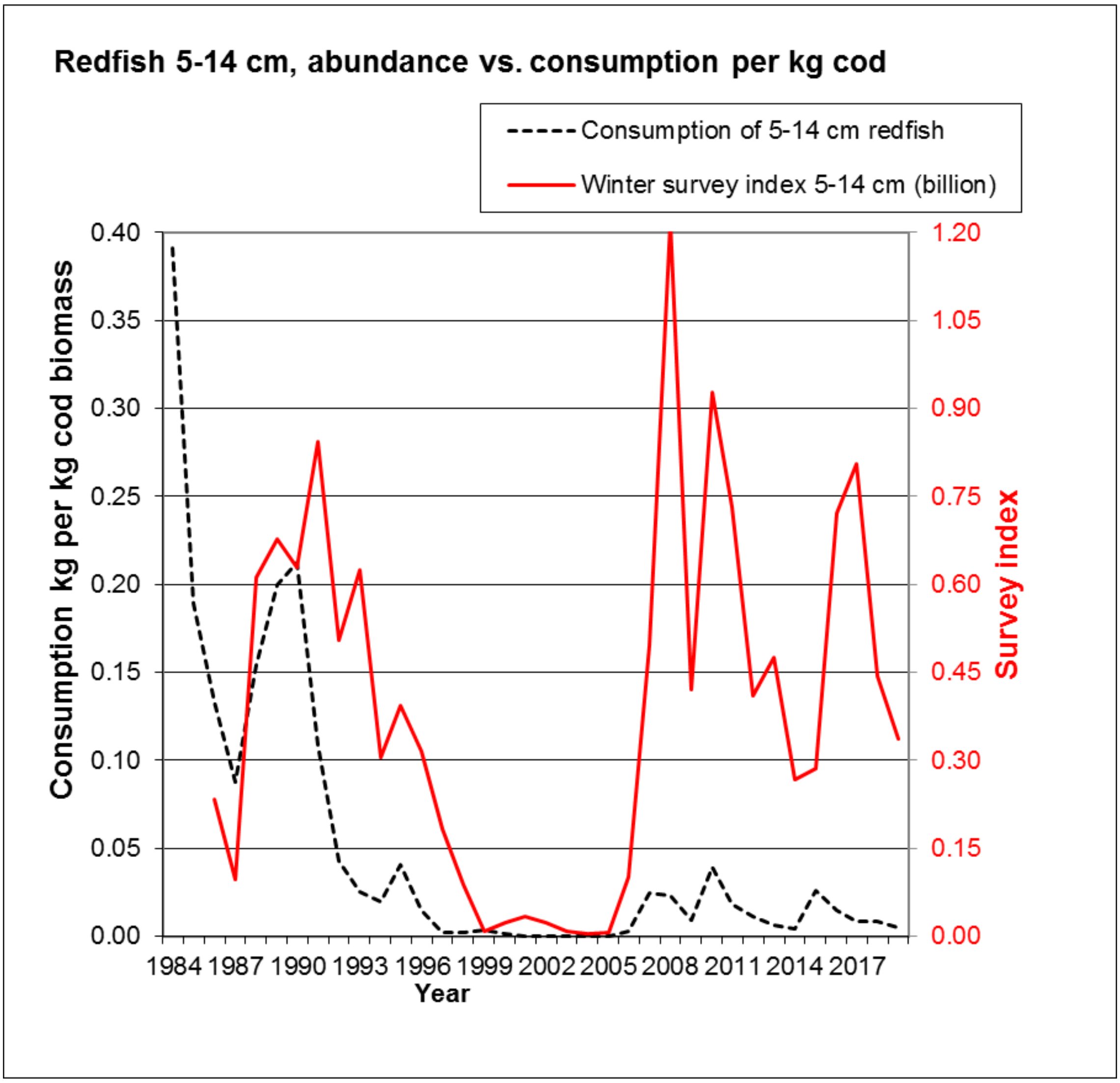


Figure 6.10. Abundance of *S. mentella* (5–14 cm) during the winter survey (February) in the Barents Sea compared with the consumption of redfish (mainly *S. mentella*) by cod (See Chapter 1 Table 1.1).

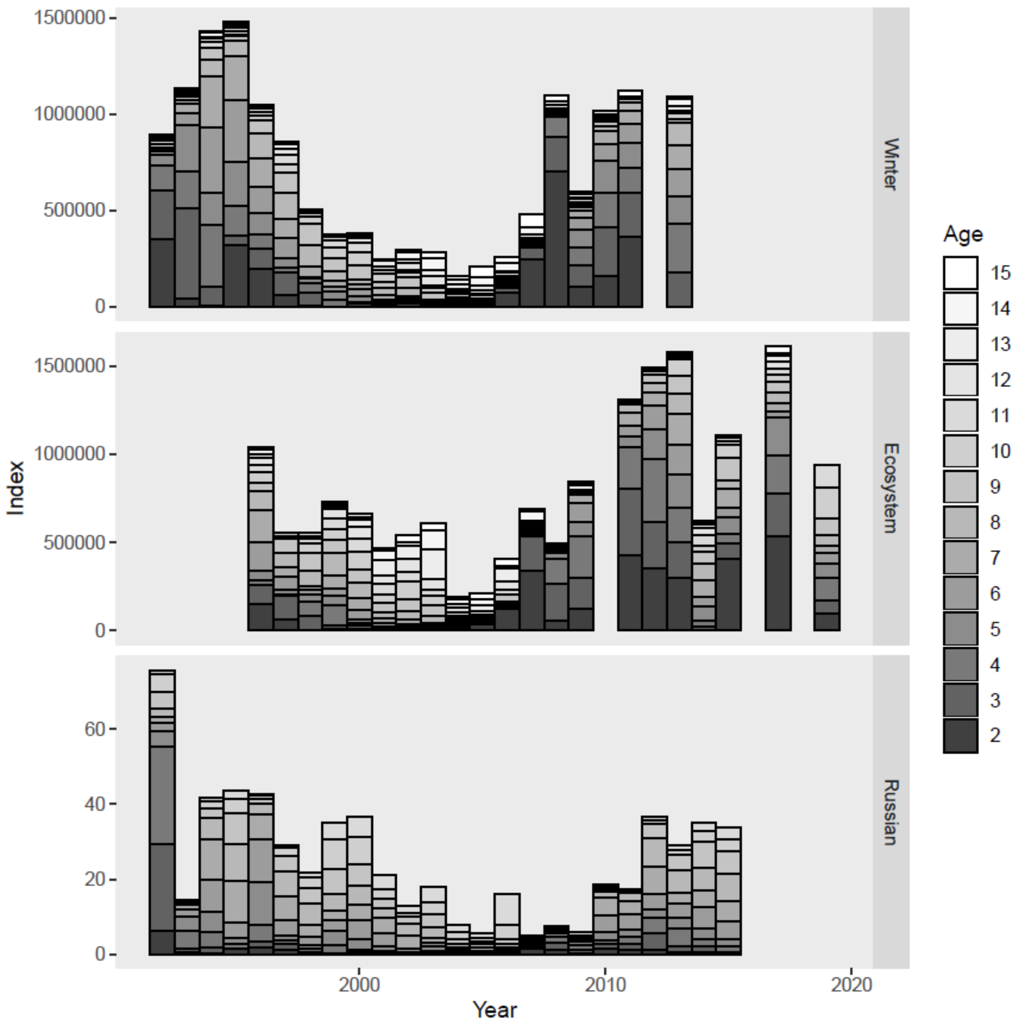
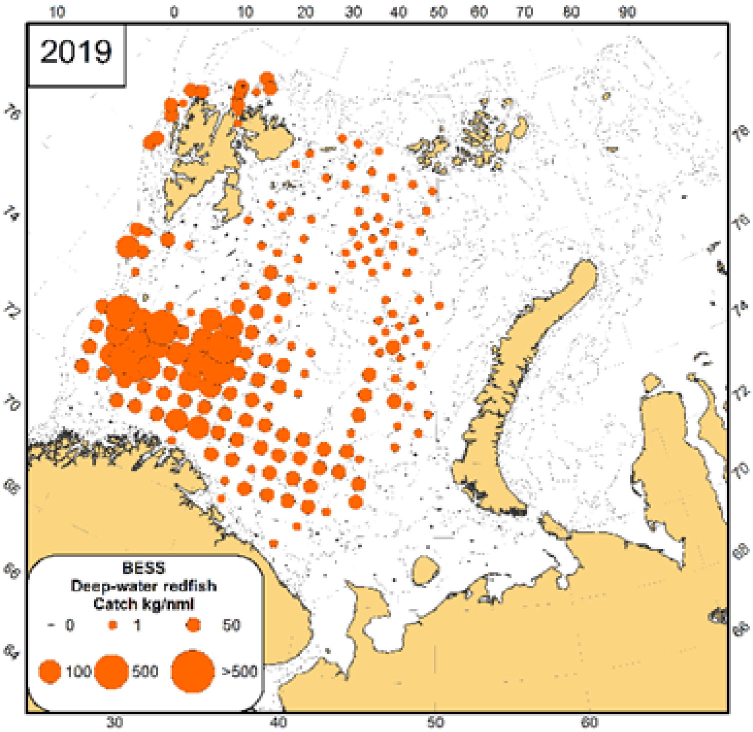


Figure 6.11. ***Sebastes mentella*** **in subareas 1 and 2. Age disaggregated abundance indices for bottom-trawl surveys 1992–2018 in the Barents Sea in winter (winter survey top) in summer (Ecosystem survey middle) and in autumn (Russian groundfish survey bottom).**



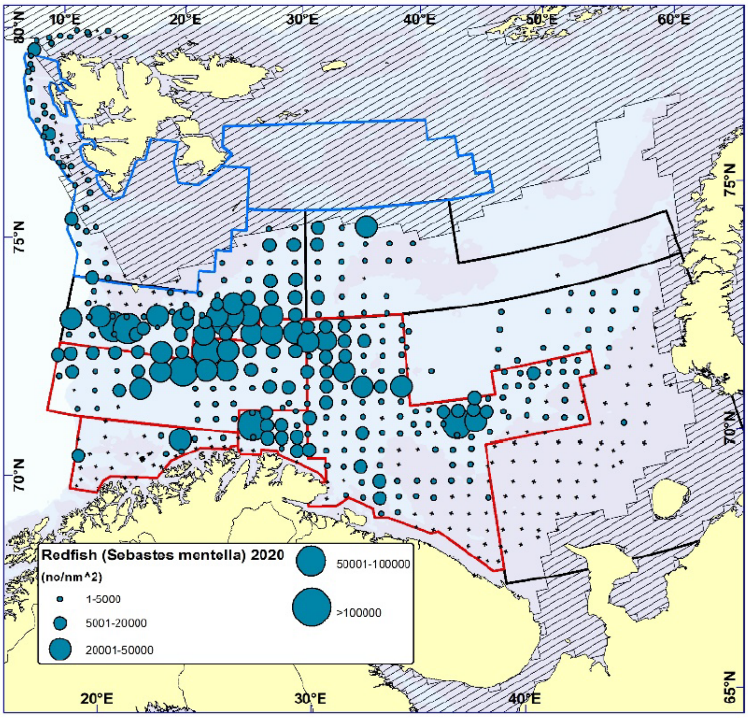


Figure 6.12. ***Sebastes mentella*** **in subareas 1 and 2. Abundance indices for individual trawl stations during the ecosystem survey in autumn 2018 (top) and winter survey 2020 (bottom).**

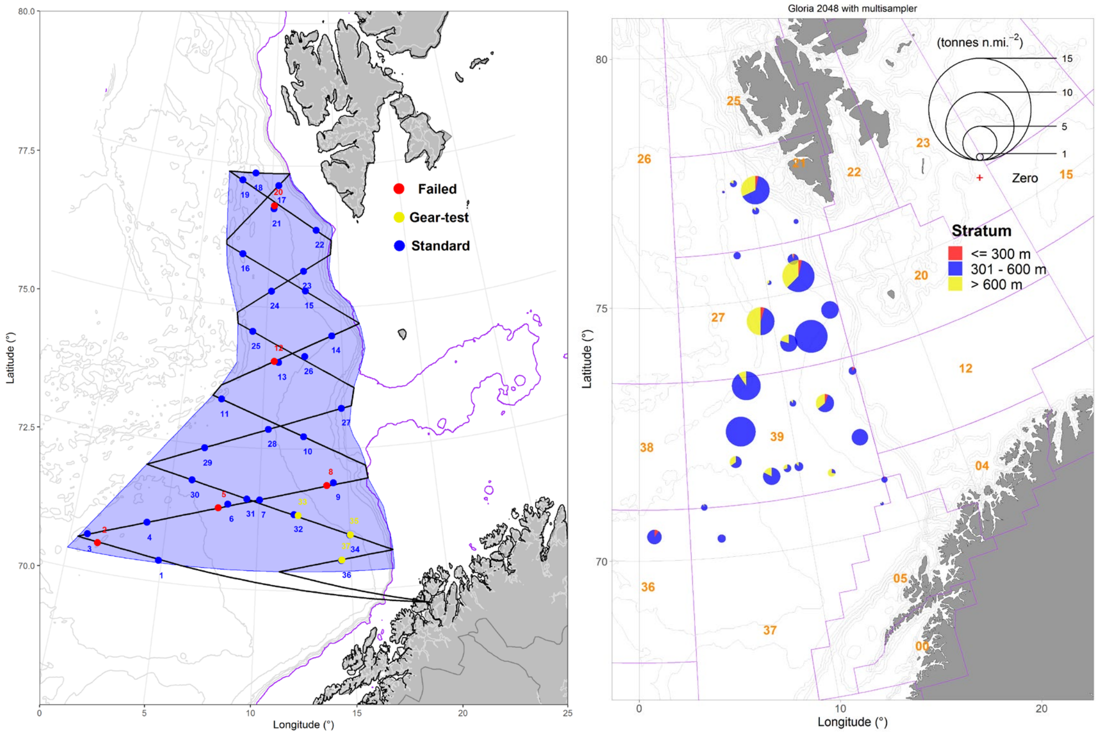


Figure 6.13. Sebastes mentella in subareas 1 and 2. Left panel: Survey track of the Deep Pelagic Ecosystem Survey in 2019 and categorized trawls. Only trawls in the category "Standard" served as input for the survey index. Right panel: Catch rates in tonnes per square nautical mile for the surveyed depth layers (<=300 m, 301-600 m and >600 m).

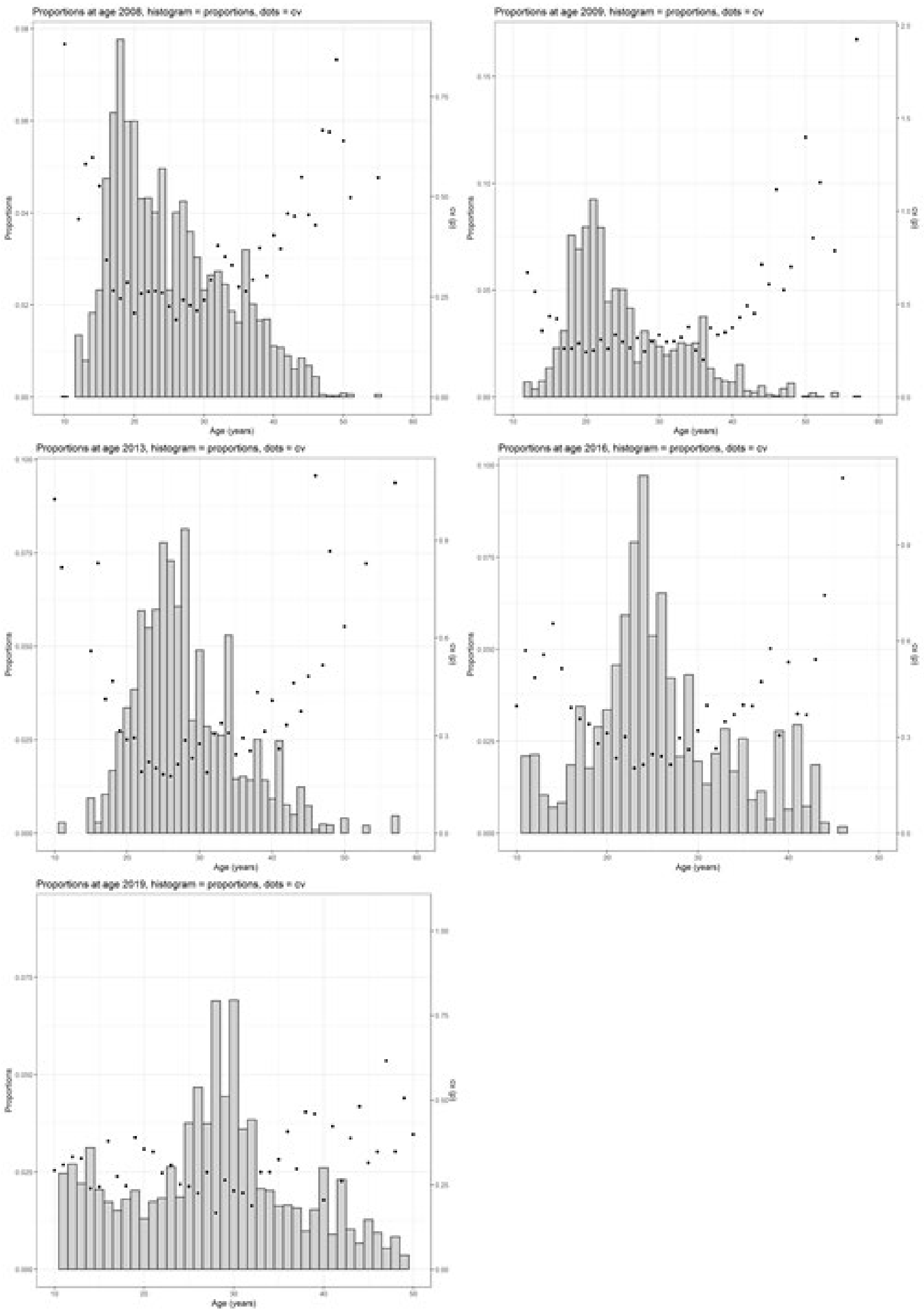
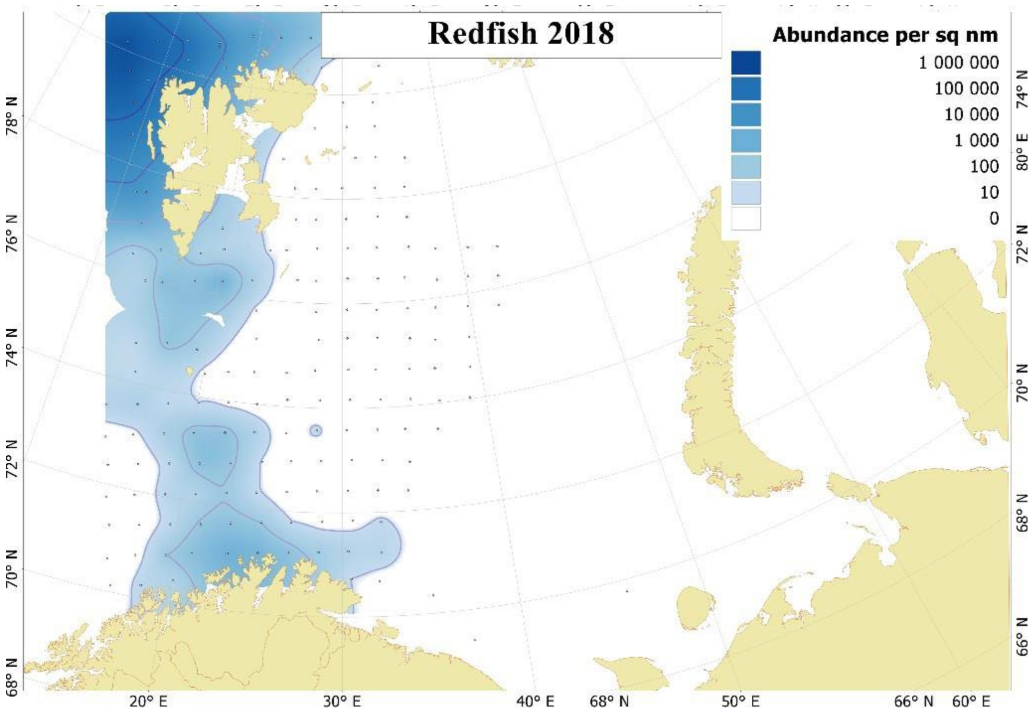


Figure 6.14. ***Sebastes mentella*** **in subareas 1 and 2. Proportions at age during the International Deep Pelagic Ecosystem Survey (WGIDEEPS) in the Norwegian Sea. Bars show proportions at age and dots shows the coefficient of variation for each age. Estimated with RStoX.**



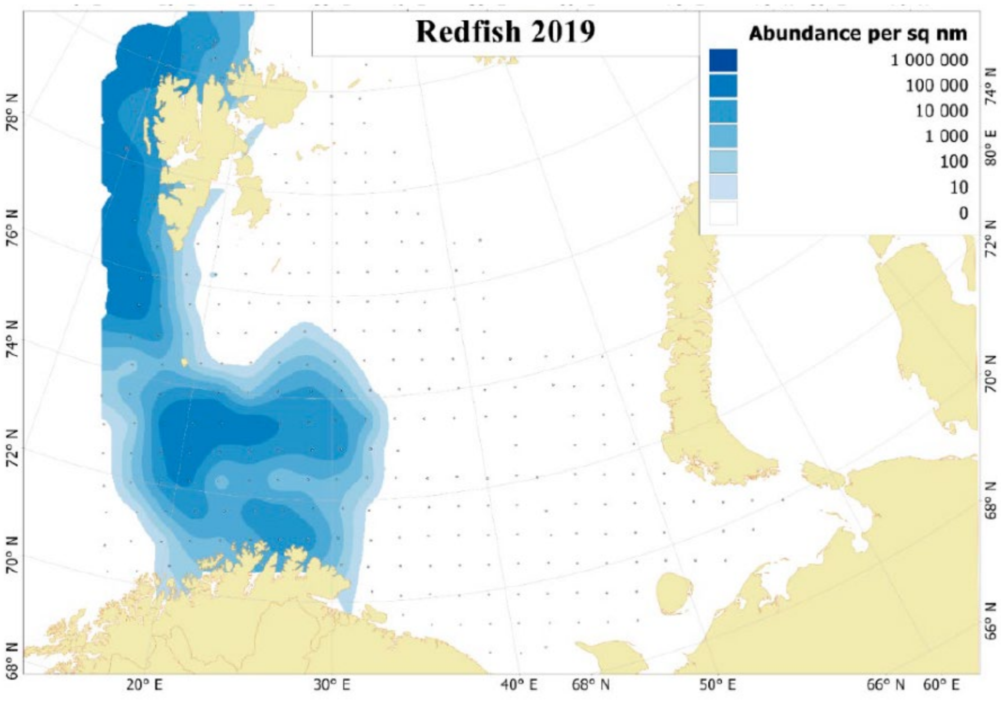


Figure 6.15. Map showing the specific pelagic 0-group trawl stations and the abundance of 0-group *Sebastes mentella* during the joint Norwegian-Russian Ecosystem survey in the Barents Sea and Svalbard in 2018 (upper panel) and 2019 (lower panel).

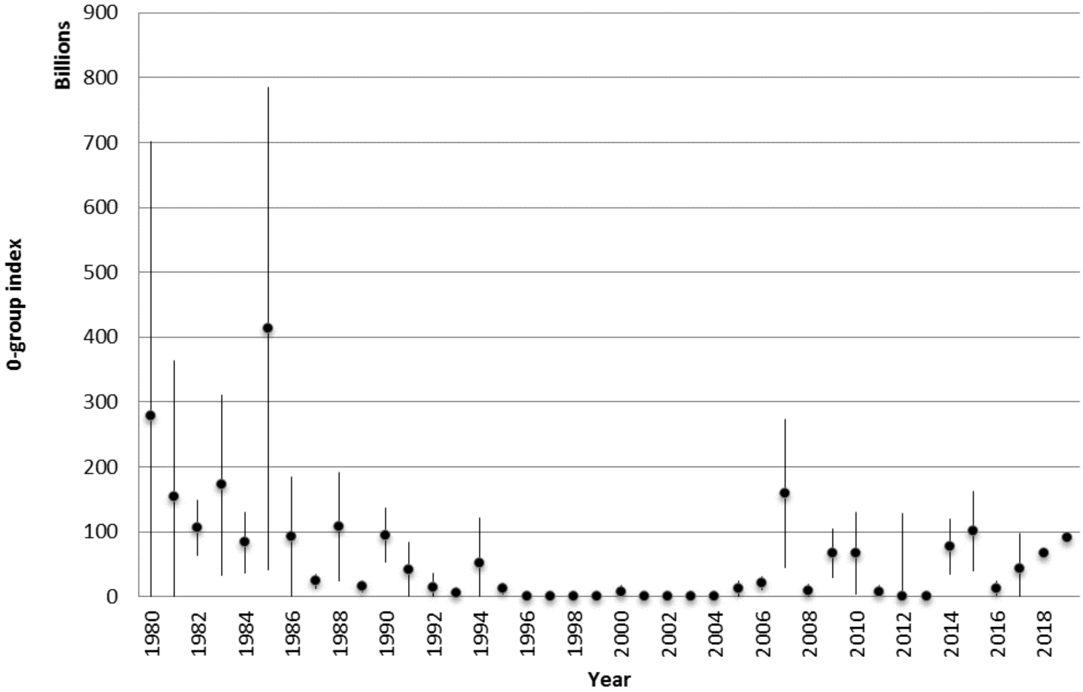


Figure 6.16. *Sebastes mentella* in subareas 1 and 2. Abundance indices (in billions) with 95% confidence limits of 0-group redfish (believed to be mostly *S. mentella*) in the international 0-group survey in the Barents Sea and Svalbard areas in August-September 1980–2019. Since 2018 the method of estimation has changed and does not provide confidence limits.

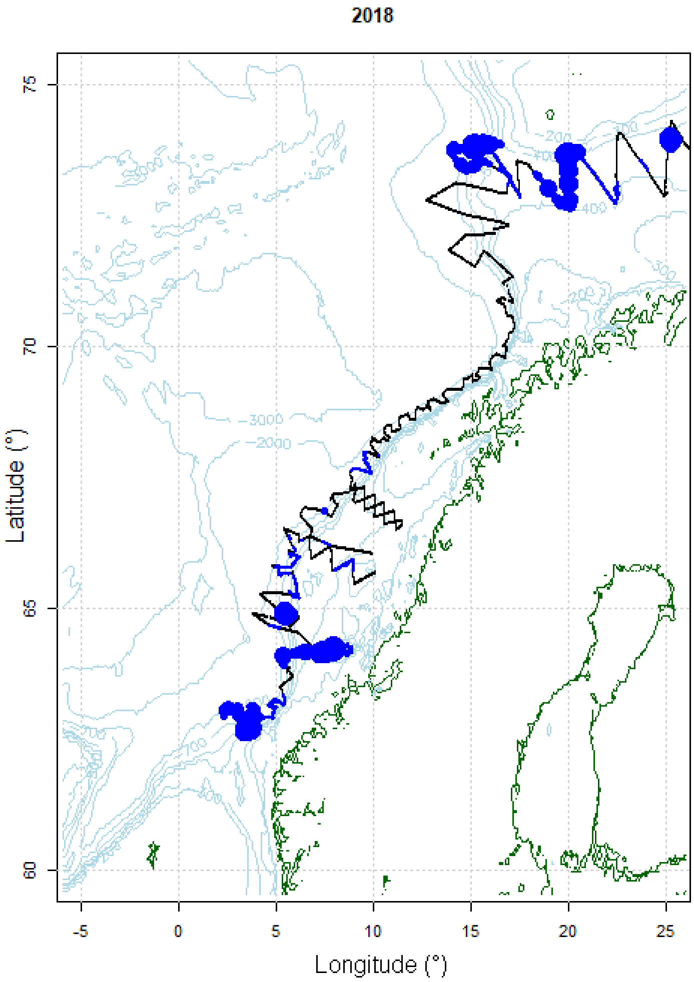
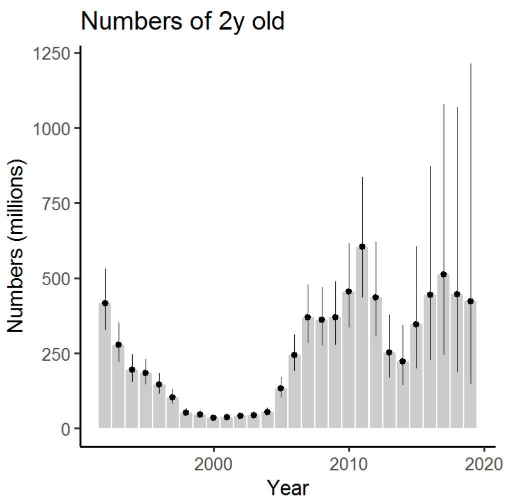
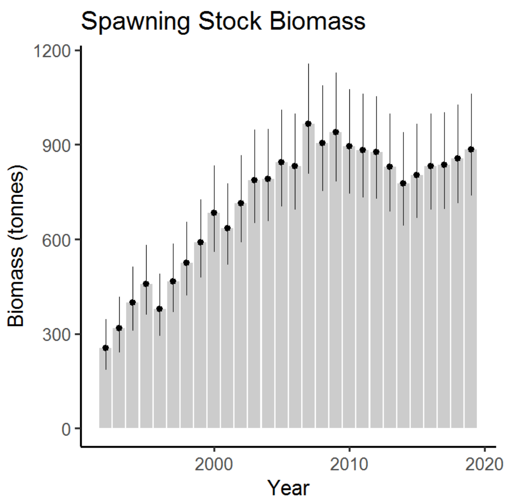


Figure 6.17. *Sebastes mentella* in subareas 1 and 2. Horizontal distribution of *S. mentella* hydroacoustic backscattering (sA) during the Norwegian slope survey in spring 2018. The circles are proportional to the sA assigned to redfish along the vessel track. The survey in spring 2020 was too close in time to provide an update for AFWG 2020.

Recruitment-at-age 2	Spawning-stock biomass





Fishing mortality – year component

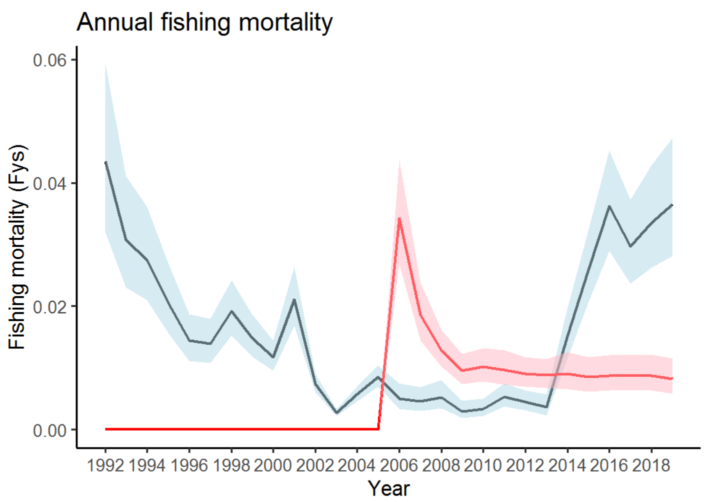
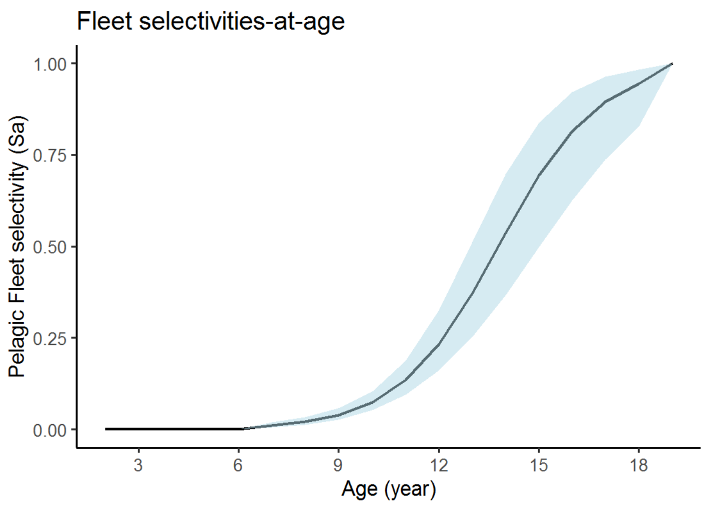


Figure 6.18. *Sebastes mentella* in subareas 1 and 2. Results from the statistical catch-at-age assessment run showing the estimated recruitment-at-age 2 spawning-stock biomass from 1992 to 2019 and annual fishing mortality coefficients by year (Fy) from the demersal (blue) and pelagic (red) fleets. Error bars (top) and the colored envelope (bottom) indicate 95% confidence limits.

Fleet selectivity – age component



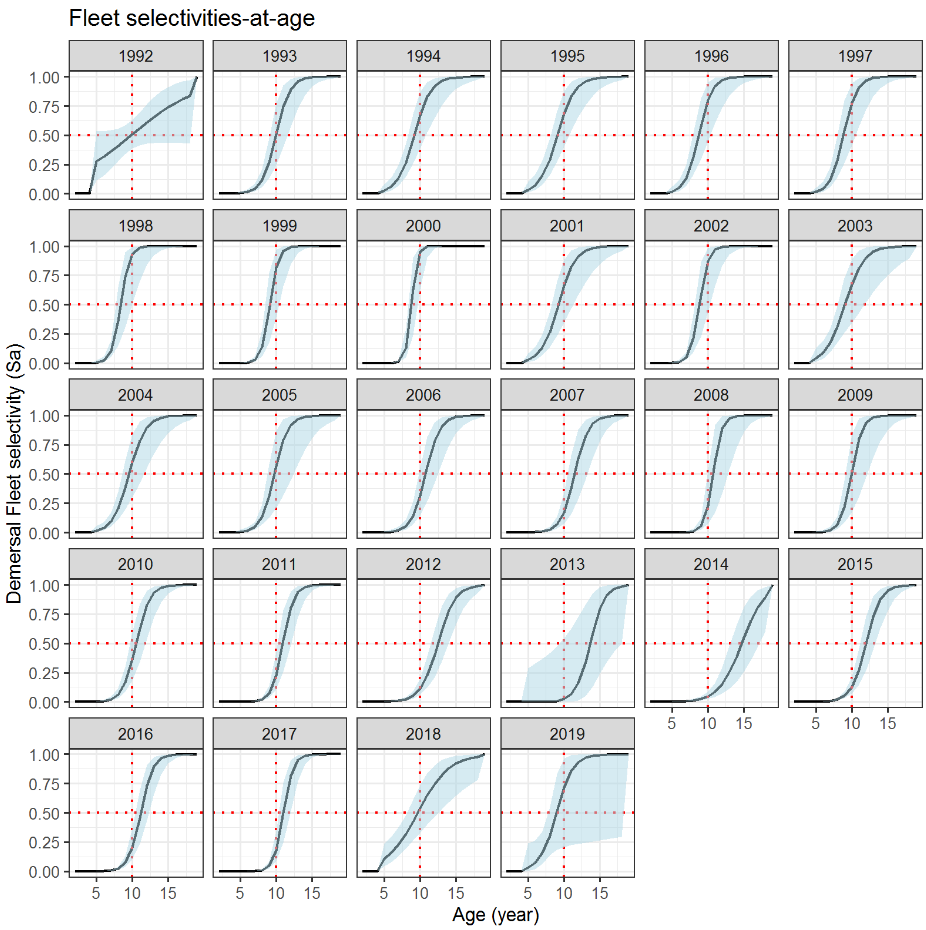


Figure 6.19. *Sebastes mentella* in subareas 1 and 2. Results from the statistical catch-at-age assessment run showing the estimated annual fleet selectivity by age (Fa) from the pelagic (top panel) and demersal (lower panels) fleets. Colored envelopes indicate 95% confidence limits.

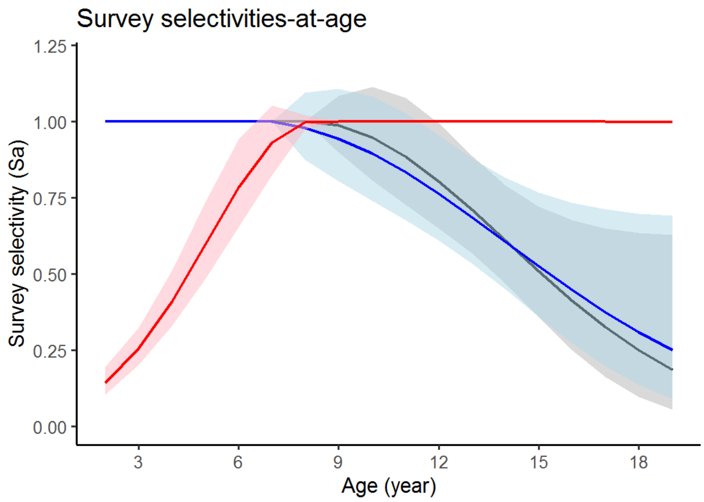


Figure 6.20. ***Sebastes mentella*** **in subareas 1 and 2. Results from the statistical catch-at-age assessment run showing the selectivity-at-age for winter (blue) ecosystem (grey) and Russian groundfish (red) surveys.**

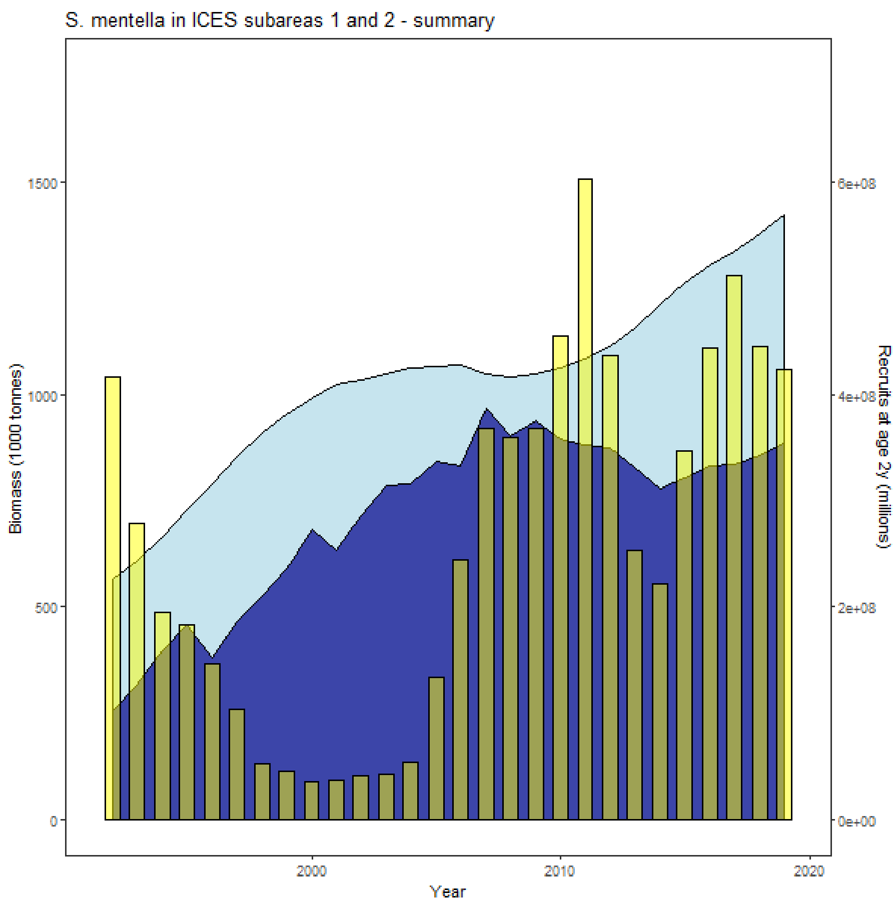


Figure 6.21. ***Sebastes mentella*** **in subareas 1 and 2. Results from the statistical catch-at-age model showing the evolution of total biomass (in tonnes light blue left axis) spawning-stock-biomass (in tonnes dark blue left axis) and recruitment-at-age 2 (in numbers yellow right axis) for the period 1992–2019 for** ***S. mentella*** **in subareas 1 and 2.**

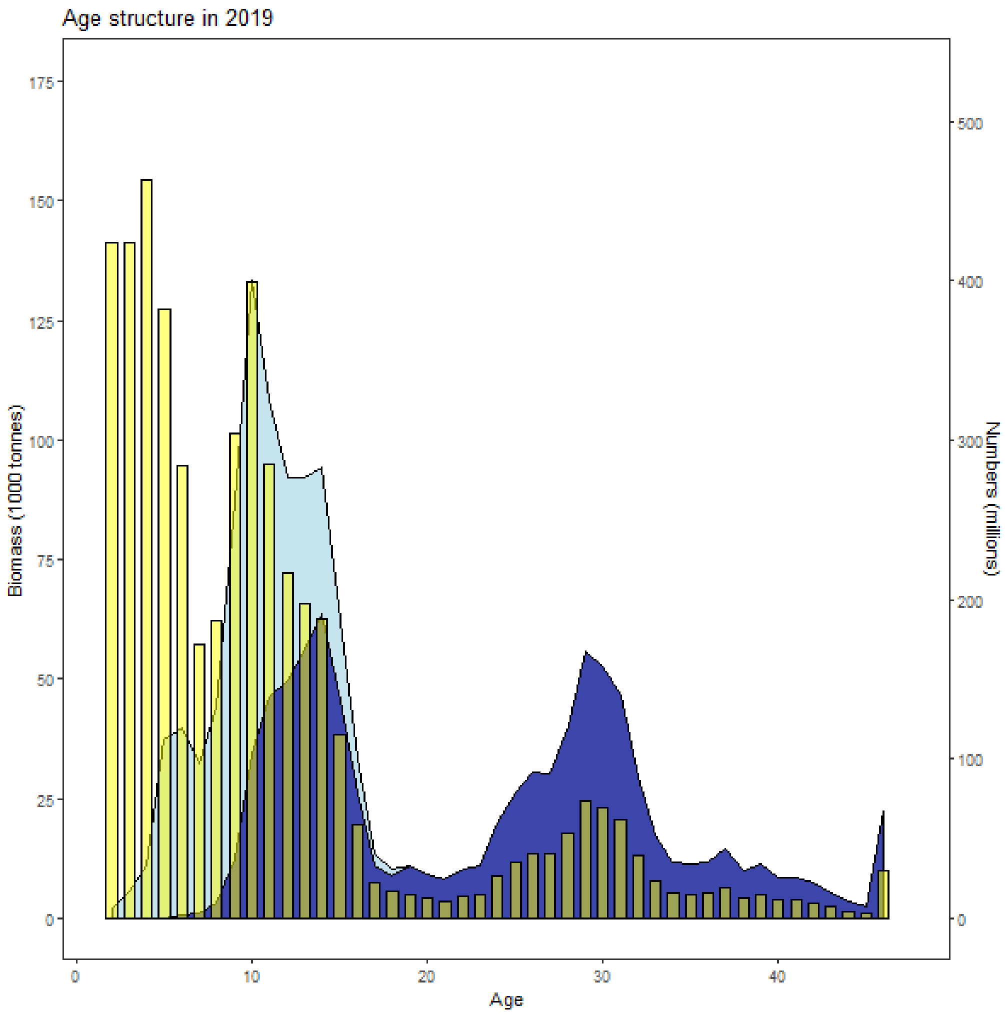


Figure 6.22. ***Sebastes mentella*** **in subareas 1 and 2. Modelled distribution of numbers (yellow bars right *y*-axis) biomass (light blue left *y*-axis) and spawning-stock-biomass (dark blue left *y*-axis) at age 2-45+ in 2019.**

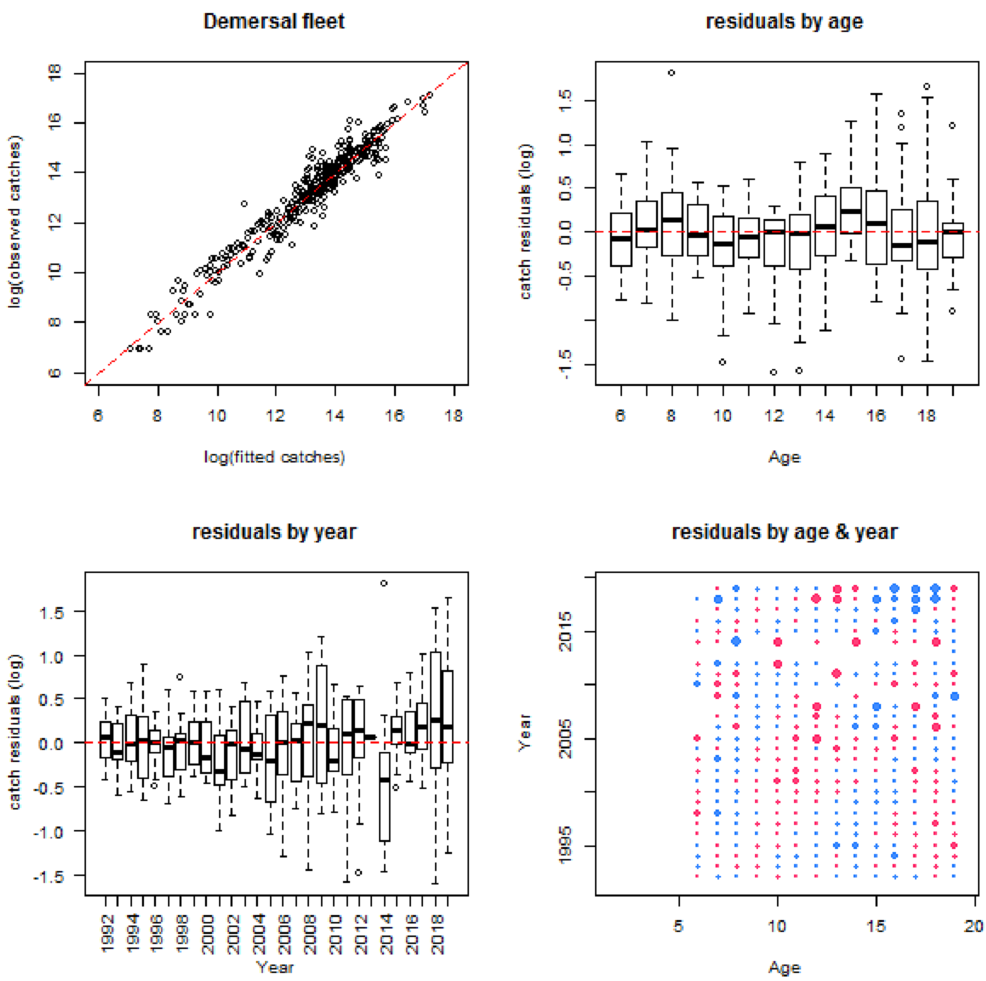


Figure 6.23a. Diagnostic plots for the demersal fleet catch-at-age data. Top-left: scatterplot of observed vs. fitted indices the dotted red line indicates 1:1 relationship. Top right: boxplot of residuals (observed-fitted) for each age. Bottom left: boxplot of residuals for each year. Bottom right: bubble plot of residuals for each age/year combination bubble size is proportional to mean residuals blue are positive and red are negative residuals.

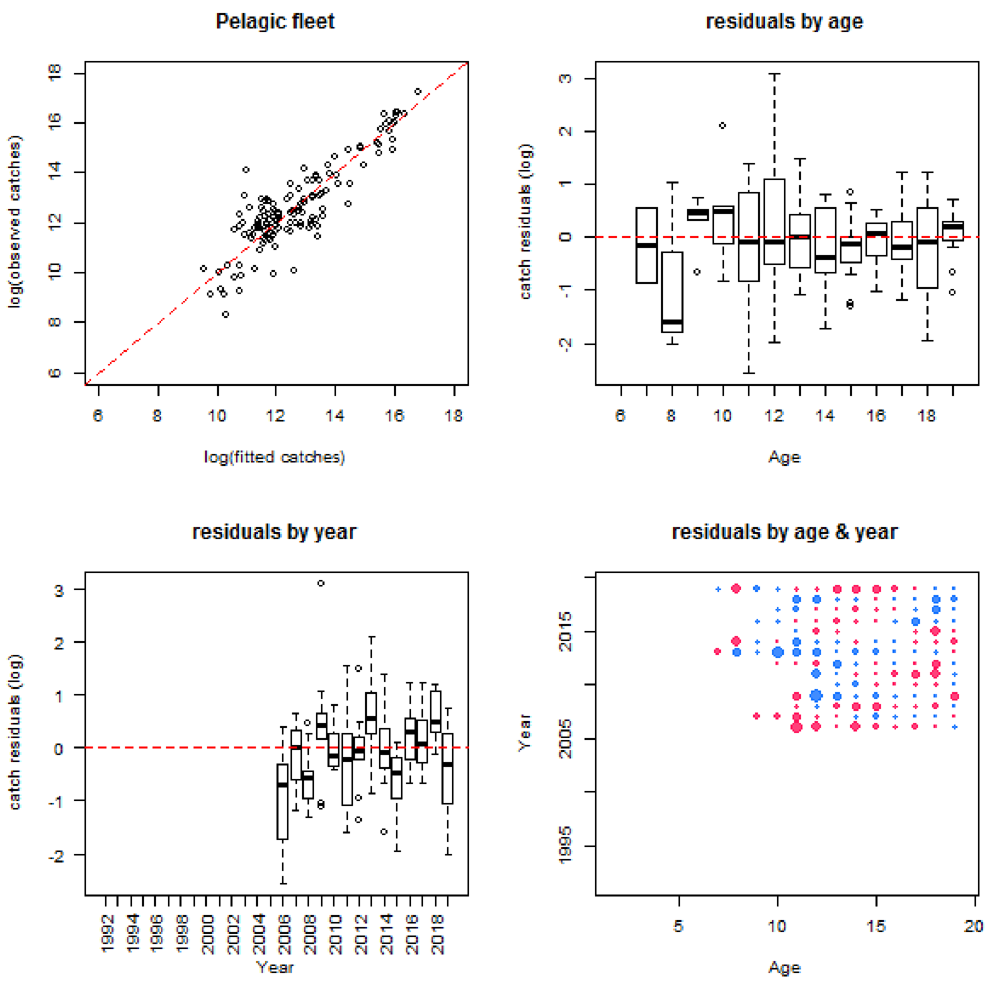


Figure 6.23b. Diagnostic plots for the pelagic fleet catch-at-age data. See legend from Figure 6.23a.

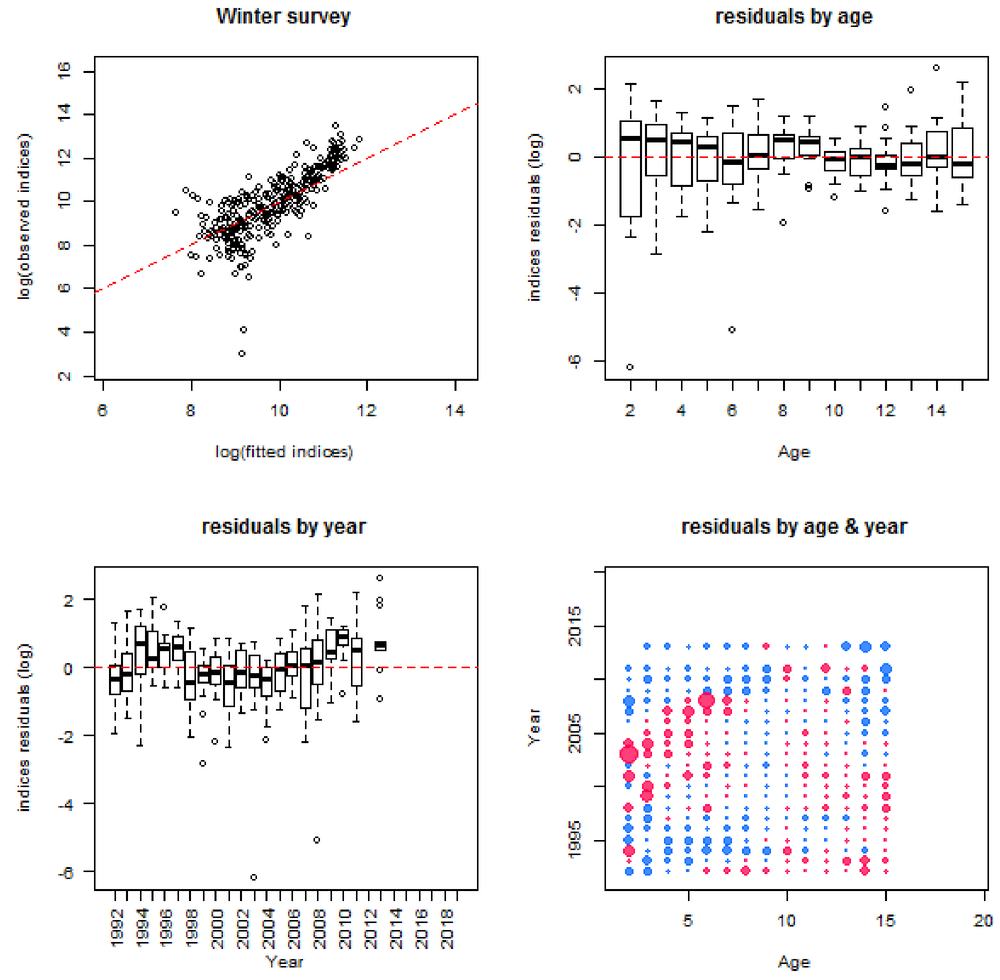


Figure 6.23c. Diagnostic plots for the Winter survey data. See legend from Figure 6.23a.

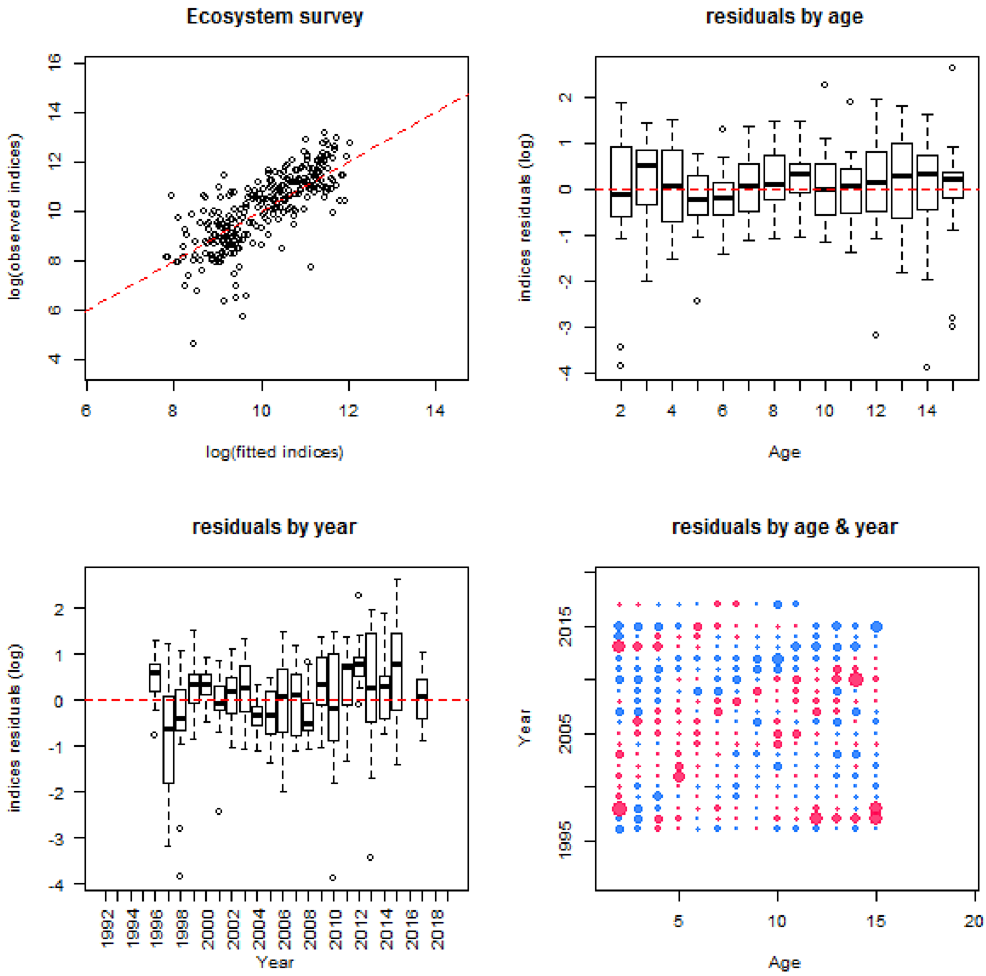


Figure 6.23d. Diagnostic plots for Ecosystem survey data. See legend from Figure 6.23a.

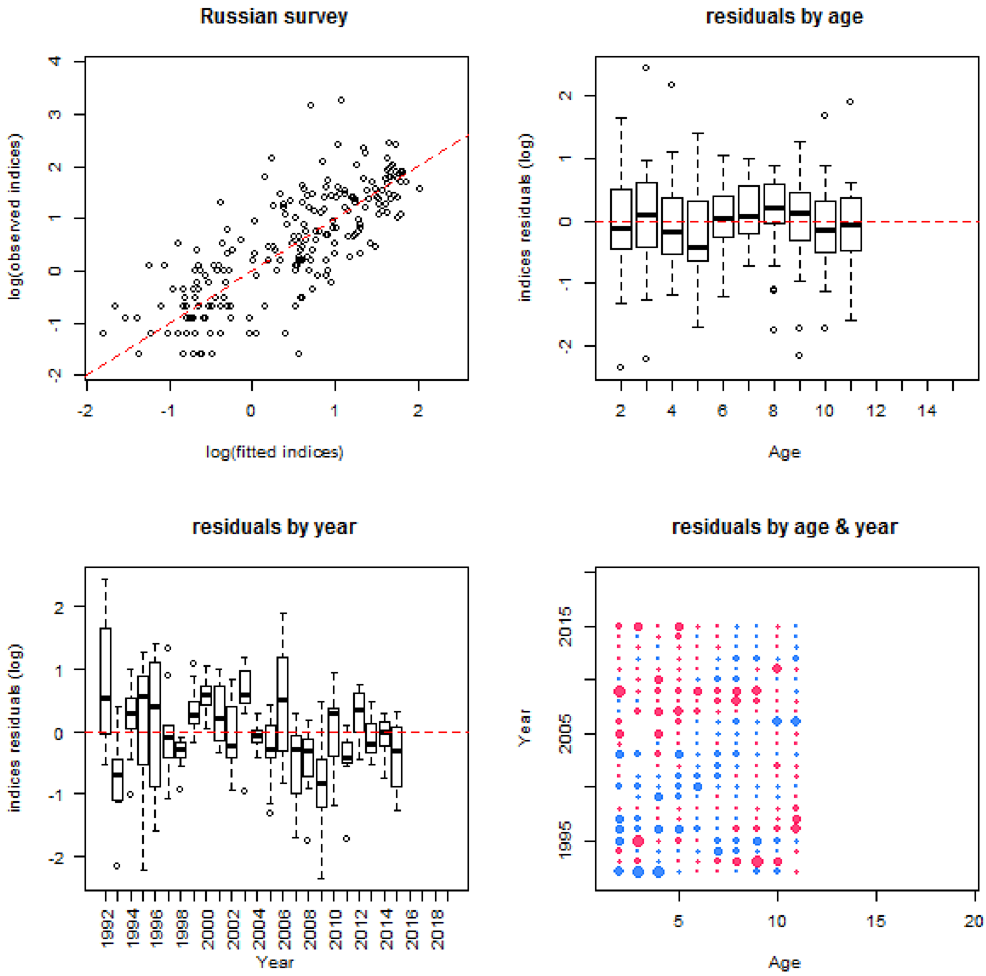


Figure 6.23e. Diagnostic plots for the Russian groundfish survey data. See legend from Figure 6.23a.

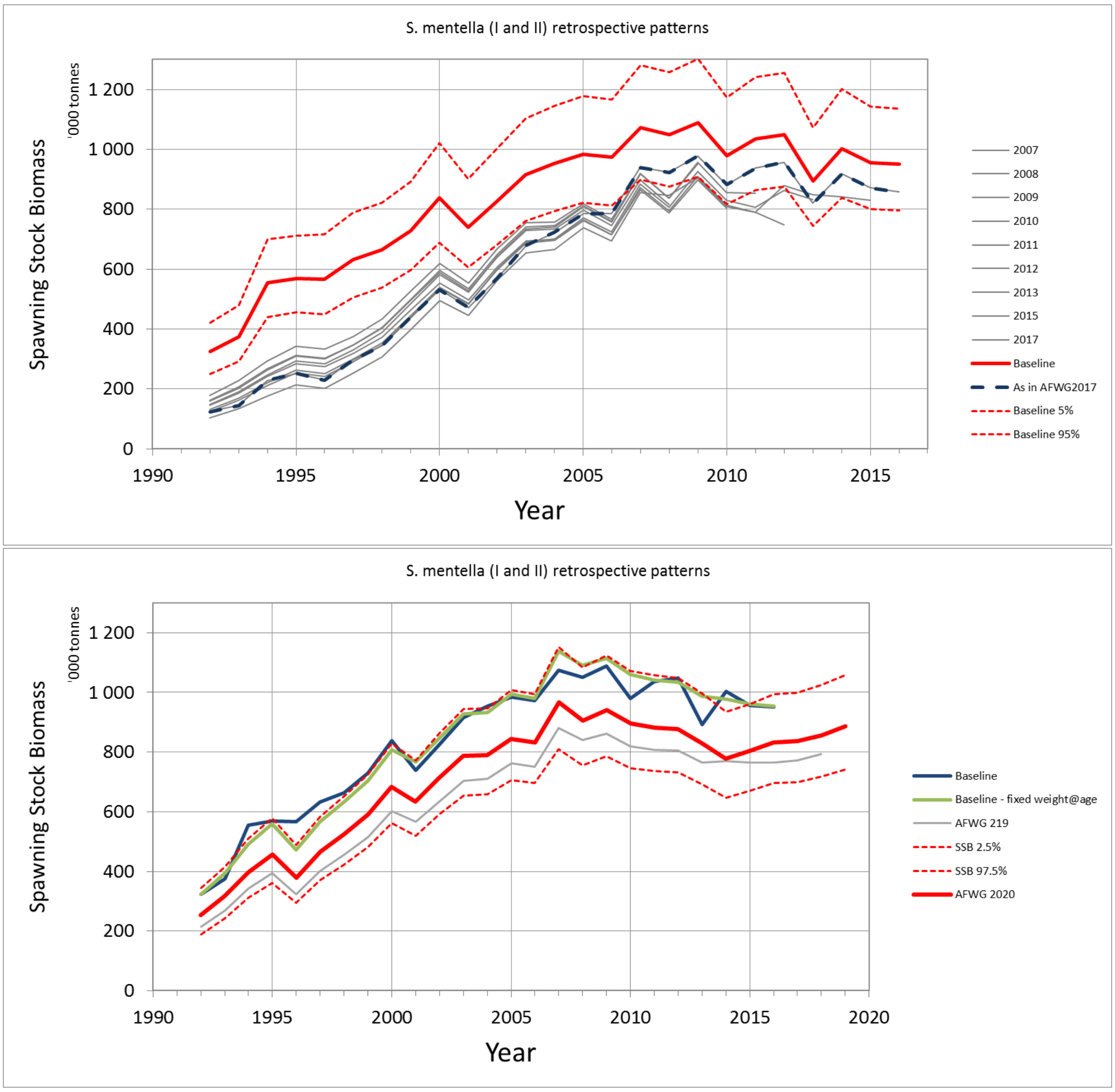


Figure 6.24. The upper panel shows the retrospective patterns of the spawning-stock biomass of *S. mentella* estimated by the SCAA model for runs up to years 2007–2017 and the baseline model of the 2018 benchmark. The lower panel presents the baseline the baseline model with fixed weights-at-age and the assessment models for 2019 and 2020. Confidence Intervals are shown for the latest assessment.

7 Golden redfish (*Sebastes norvegicus*) in subareas 1 and 2

Following the recommendation from the benchmark assessment for redfish stocks in January 2018 (WKREDFISH, ICES 2018a) the GADGET model was used in the configuration approved during the benchmark, for the period 1990-2019. Following a further recommendation of the benchmark, the advice cycle for golden redfish in subareas 1 and 2 was changed to a two-year cycle to be provided in 2020. The present report therefore updates the assessment and provides advice for the next two years.

7.1 Status of the Fisheries

7.1.1 Recent regulations of the fishery

A description of the historical development of the fishery and regulations is found in the Stock Annex for this stock. The Stock Annex was last updated in February 2018.

Prior to 1 January 2003 there were no regulations particularly for the *S. norvegicus* fishery, and the regulations aimed at *S. mentella* had only marginal effects on the *S. norvegicus* stock. After this date, all directed trawl fishery for redfish (both *S. norvegicus* and *S. mentella*) outside the permanently closed areas were forbidden in the Norwegian Economic Zone north of 62°N and in the Svalbard area. When fishing for other species it was legal to have up to 15% redfish (both species together) in round weight as bycatch per haul and on board at any time. Until 14 April 2004 there were no regulations of the other gears/fleets fishing for *S. norvegicus*. After this date, a minimum legal catch size of 32 cm has been set for all fisheries, with the allowance to have up to 10% undersized (i.e. less than 32 cm) specimens of *S. norvegicus* (in numbers) per haul. In addition, a time-limited moratorium (up to 8 months) was enforced in the conventional fisheries (gillnet, longline, handline, Danish seine) except for handline vessels less than 11 metres. From 2016, when trawling outside 12 nm, vessels can have up to 20% by weight of redfish in each catch and upon landing. When trawling inside 12 nm, it is permitted to have up to 10% bycatch. Since 2015 it has been prohibited to fish for redfish with conventional gears north of 62°N. The ban does not, however, apply to vessels less than 15 metres fishing with handline during 1 June - 31 August. When fishing with conventional gears for other species, it is permitted to have up to 10% by weight of redfish. Vessels less than 21 metres can still have up to 30% by weight of redfish in the period 1 August to 31 December. Bycatch of redfish is calculated in live weight per week.

7.1.2 Landings prior to 2020 (Tables 7.1–7.4 and Figures 7.1-7.2)

Nominal catches of *S. norvegicus* for the years 1998-2019 by country for subareas 1 and 2 combined, and for each subarea and division are presented in tables 7.1—7.4. The total landings for both *S. norvegicus* and *S. mentella* are presented in section 6 (Tables 6.6 and 6.7). The sources of information used are catches reported to ICES, NEAFC, Norwegian 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. Then the landings decreased further, and the total landings figures for *S. norvegicus* in 2003–2013 were low but remarkably stable, between 5500–8000 t. In 2014 the landings decreased to

4436 t, followed by a further decrease in 2015 with landings of 3629 t, mainly due to stronger regulations. This has since reversed with 6656 tonnes in 2018 and 8284 tonnes in 2019 (provisional), the latter increase likely due to the increased quota for beaked redfish and therefore increased bycatch of golden redfish. The time-series of *S. norvegicus* landings is given in Figure 7.1. A map of *Sebastes norvegicus* catches from Norwegian vessels' logbooks in 2019 is shown in Figure 7.2. Note that species identification from landings and logbooks is not always trusted when the Norwegian final landings data are prepared (see Stock Annex).

The Norwegian landings are presented by gear and month/year in figures 7.3a,b. Reported landings continued to decrease in 2015 and were then at the lowest level since World War II. Since 2015 only bycatches of *S. norvegicus* are allowed except for a limited amount caught by vessels less than 15 metres fishing with handline during 1 June to 31 August.

The reported Russian catches of *S. norvegicus* have been around 600–900 t since 2001, but increased to 1834 tonnes and 1929 tonnes in 2018 and 2019, respectively. Twelve other countries together usually report catches in the 300-600 t range or less (Table 7.1).

The bycatch of redfish (*Sebastes* spp.) in the Norwegian Barents Sea shrimp fisheries during 1983–2017 were dominated by *S. mentella*, and hence influenced the *S. norvegicus* to a much lesser extent. However, these bycatches probably inflicted an extra mortality on *S. norvegicus* in the coastal areas before the sorting grid was enforced in 1990. From 1 January 2006, the maximum legal bycatch of redfish juveniles in the international shrimp fisheries in the northeast Arctic has been reduced from ten to three redfish per 10 kg shrimp.

Information describing the splitting of the redfish landings by species and area is given in the Stock Annex.

7.1.3 Expected landings in 2020

New regulations were designed and implemented in the Norwegian coastal fisheries with conventional gears in 2016. No directed fishery is allowed, but the bycatch-regulations are currently rather liberal with vessels less than 21 metres being allowed to have up to 30% by weight of redfish in the period 1. August – 31. December and calculated in live weight per week. An observed increase of *S. norvegicus* in the trawl catches in 2016-2018 continued in 2019 indicating a peak at age 16, corresponding to the 2003 recruitment. As expected total landings in 2019 increased due to the raised quota for *S.mentella*, and thus an increase in bycatch of *S. norvegicus*. This trend is expected to continue in 2020.

7.2 Data Used in the Assessment (Table 0.1 and Figure E1)

An overview of the sampling levels (by season, area and gear) of the data used in the assessment is presented in Figure E1 for 2013. Although Table 0.1 (see Section 0) shows a reasonably good total sampling level for this stock, the number of different boats sampled, and the gear and area coverage should be improved.

7.2.1 Catch-at-length and age (Table 7.5 and Figure 7.4)

Age composition data for 2017 and 2018 were only provided by Norway, accounting for >60% of the total landings. Norwegian data for 2017 was updated with revised data and 2018 was added new. Weight-at-age in the catches was not available for 2018 and 2019. Other countries were assumed to have the same relative age distribution and mean weight as Norway. The updated catch numbers-at-age matrix is shown in Table 7.5. Catch at length data were also only available from Norway, revised for 2017 (Figure 7.4), new for 2018 and preliminary for 2019. For these two years catch-at-length was only available split by gear but not by gear and ICES subareas.

7.2.2 Catch weight-at-Age (Table 7.6)

Weight-at-age data for ages 7–24+ were not available from the Norwegian landings in 2018 and 2019 during the working group (Table 7.6). 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 7.5a-b)

A maturity ogive has previously not been available for *S. norvegicus*, and knife-edge maturity-at-age 15 (age 15 as 100% mature) had hence been assumed. Maturity-at-age and length is available from Norwegian surveys and landings up to 2019, as reported in Table E4 and presented in Figure 7.5a. Only the data up to 2016 was considered in the model, due to insufficient age readings in the later years. The maturity ogive modelled by Gadget is presented (Figure 7.5b). This analysis shows that 50% of the fish at age 12 are mature.

7.2.4 Survey results (Tables E1a,b-E2a,b-E3, Figures 7.6a,b–7.8)

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 2019 (joint with Russia some of the years since 2000) in fishing depths of 100—500 m. Length compositions for the years 1986—2019 are shown in Table E1a and Figure 7.6a. Age compositions for the years 1992—2016 and 2018 are shown in Table E1b and Figure 7.6b. This survey covers important nursery areas for the stock. As described in the stock annex, this survey is used in model tuning.

Norwegian Svalbard (Division 2.b) bottom-trawl survey (August-September) from 1985 to 2017 in fishing depths of 100—500 m (depths down to 800 m incl. in the swept-area). Since 2005 this is part of the Ecosystem survey (Eco-NoRu-Q3 (BTr)). Length compositions for the years 1985—2016 and age compositions for the years 1992—2008, 2012, 2013 and 2016 are shown in Table E2a and E2b, respectively. Data for 2017-2019 were not available in time for AFWG 2020. 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 as well as for the period 2014-2015 and 2019. This survey is not currently included in the model tuning.

Data on length and age from the winter and ecosystem surveys have been combined and are shown in Figures 7.7a,b.

Norwegian Coastal and Fjord survey in 1998—2019 from Finnmark to Møre (NOcoast-Aco-Q4). Length composition from catch rates (numbers/nm^2 averaged for all stations within subareas and finally averaged, weighted by subarea, for the total surveyed area) are shown in Figure 7.8 and Table E3. The survey is an acoustic survey designed to obtain indices of abundance and estimates of length and weight-at-age of saithe and cod north of 62°N. The index for golden redfish was previously used in the assessment, but was considered unreliable and stopped in 2010. A new index series was recalculated for the benchmark in 2018 (WKREDFISH 2018a). The aggregated survey index varied too much year-to-year to be driven by the population dynamics, but the length distribution was included in the assessment.

Following a dedicated review, AFWG approves the use of the new SToX versions of the winter survey in the *Sebastes norvegicus* assessments (WD 17 in Annex 4). The group recommends that work continues to investigate redfish-specific strata systems for the survey. The coastal survey for *S. norvegicus* should be converted to SToX in a similar manner, with special attention to the strata system to see if a coherent index of abundance and/or biomass can be obtained for this survey (which is currently only used for annual length distributions).

The bottom-trawl surveys covering the Barents Sea and the Svalbard areas show that the abundance indices over the commercial size range (>25 cm) were relatively stable up to 1998 but declined to lower levels afterwards. Abundance of prerecruits (<25 cm) has steadily decreased since 1991 and has dropped to very low levels after 2000 (Figure 7.6a). An increase in the number of prerecruits is visible from 2008 onwards. Although this could originally partly result from taxonomic misidentification, the confirmation of increased numbers for individuals of size 15 cm and greater gives some confidence that at least some of the increasing numbers are *S. norvegicus*.

7.3 Assessment with the GADGET model

7.3.1 Description of the model

Since AFWG2005, the GADGET model has been used for this stock, first with experimental runs, and then as analytical assessments following its adoption by WKRED (2012) benchmark (ICES CM 2012/ACOM:48). The model was then approved again at WKREDFISH (2018a), where it was also recommended to switch to a two-year advice cycle. A number of changes have been made to the model at the benchmark WKREDFISH (2018a); the model is moved to a one-year time-step; the fleet structure has been revised to better reflect recent fishing patterns; age–length data are used for tuning in 5 cm (rather than the previous 1 cm) bins to reduce the extensive noise in this series; proportions (but not absolute abundance) by length in the coastal survey is used for tuning; the model weights have been re-calculated; a number of minor errors in the model and data were fixed. Full details are in the WKREDFISH benchmark report (ICES 2018a).

The GADGET model used for the assessment of *S. norvegicus* in subareas 1 and 2 is closely related to the GADGET model that currently is used by the ICES Northwestern WG on *S. norvegicus* (Björnsson and Sigurdsson, 2003). The functioning of a Gadget model, including parameter estimation and data used for tuning, is described in Bogstad *et al.* (2004) and in the stock annex for *S. norvegicus*. In brief, the model is a single species forward simulation age–length structured model, split into mature and immature components. There are three commercial fleets (a gillnet, a trawl and a combined longline and handline fleet). Prior to 2009 the trawl and longline fleets are combined into one, due to difficulties in obtaining data on a finer resolution. The gillfleet has different selectivity from 2009 compared to 2008 and earlier. There are two surveys used in the model, the winter survey and coastal survey. The winter survey tunes to total survey index, the coastal survey to length distributions only. Growth and fishing selectivity within each fleet and survey are assumed constant over time (except for the gilfleet), and recruitment is estimated on annual basis (no SSB-recruit relationship).

The weighting scheme for combining the different datasets into a single likelihood score is a method where weights are selected so that the catch and survey data have approximately equal contribution to the overall likelihood score in the optimized model, and that each dataset within each group gives approximately equal contributions to each other. This ensures that both noise and bias (actually divergence from the consensus) are taken account of in the weighting of datasets. The parameters in the model are estimated using a combination of Simulated Annealing (wide area search) and Hooke and Jeeves (local search) repeated in sequence until a converged solution is found.

7.3.2 Data used for tuning

- Annual catch in tonnes from the commercial fishing fleets, i.e. Norwegian gillnet, and trawl fleet, longline since 2009 and "combined trawl and longline" prior to 2009.
- Annual length distribution of total international commercial landings from the commercial fishing fleets to 2019. Due to late data submissions, there is one-year time-lag in the inclusion of length distributions from other countries than Norway.
- Annual age–length data (1 year by 5 cm resolution) from the same fishing fleets, up to 2018
- Length disaggregated frequencies from the Barents Sea (Division 2.a) bottom-trawl survey (February) from 1990—2019 (Table E1a)
- Age–length data and aggregated survey indices from the same survey up to 2018, excluding 2017 (Table E1b)
- Length disaggregated frequencies from the Barents Sea (Division 2.a) coastal survey (February) from 1998—2019 (Table E3, Figure 7.8)

7.3.3 Assessment results using the Gadget model (Figures 7.9-7.13)

The general patterns in the stock dynamics of *S. norvegicus* are similar to those modelled for the past several years, but the recruitment event in 2003 is now beginning to have a noticeable positive effect on the overall stock. The overall stock numbers and biomass have shown a decline over a number of years, but the recent recruitment means that immature numbers and biomass are now starting to improve. Some of the 2003 year class are now starting to mature, and the mature stock numbers are therefore stabilizing. The mature biomass is not responding yet, since the maturing fish are still relatively small.

As in previous years we note that there has been a tendency for some recruitment signal to be reduced in subsequent years, possibly due to misidentification of small *S. mentella* (which is a larger stock and has had good recent recruitment) as *S. norvegicus*, and the model has repeatedly revised down the estimates of this recruitment, although not to zero. The largest fish from the 2003 year class are now entering the mature stock and the fishery, and this is providing multiple sources of information that this was a genuinely good recruitment. The WG stresses that the subsequent recruitment signals (for example the high estimated 2009 year class) should be treated with extreme caution until they enter the fishery (c. 12–15 years after recruiting).

The most important conclusions to be drawn from the current assessment using the Gadget model are:

- The recruitment to the stock has been very poor for a long period, and especially prior to 2005 (Figure 7.10)
- There has been somewhat better estimated recruitment in recent years, with a reasonably good recruitment in 2003 (Figure 7.13). Indications of a second pulse of good recruitment in 2009 have strengthened in the current assessment, but are still highly uncertain, and will need to be tracked for some years to come, to reduce this uncertainty.
- The estimated fishing mortality (F_{15+}) declined between 1990 and 2005 but remained relatively stable until around 2015, (Figure 7.11, Table 7.7). The current mortality is estimated to F = 0.46 (Figure 7.11), well above a sustainable level for a redfish species, and above the F_{MSY} = 0.05 estimated at WKREDFISH (ICES 2018a). Note that the F estimate is based on the 2003 year class being a good one, and the estimate would be higher if this is not the case.

According to the model the total-stock biomass (3+) of *S. norvegicus* has decreased from about 119 000 tonnes in the early 1990s to just under 40 000 tonnes in 2019 (Figure 7.12, Table 7.8). Due to the improved recruitment from the 2003 year class the total biomass is beginning to stabilize, although the SSB is continuing to decline. This reduction is primarily the result of prolonged low recruitment, combined with excessively high fishing pressure.

The average assessment bias (Mohn's Rho) over the last 5 assessments was 1% for recruit.ment, 56% for F(15+) and -29% for SSB. The retrospective plots (Figure 7.13) exhibit a sharp rise in the estimate of mature biomass compared to earlier assessments and a corresponding decline in F(15+), the reason for which is unclear. Whether these changes persist or are eliminated by updated input data in future assessments will have to be monitored.

7.3.4 State of the stock

Survey observations and the Gadget assessment update confirm previous diagnostics that this stock is currently in a very poor situation. This is confirmed by the production model run as a check at WKRED (ICES 2012), which produced similar trends. Indications are that the SSB is continuing to fall. This has led to an upwards trend in F to a level which may place an increasing burden on an already poorly performing stock. Furthermore, in the absence of a substantial population of fish in the 10—18 age range, the fishery has become increasingly concentrated on the oldest (18 years and older) individuals, reducing the reproductive capacity of the stock.

There are indications that new recruits from the 2003 year class may have entered the population in recent years as noted in previous AFWG reports. The estimated immature biomass is now beginning to increase, but SSB still declines. However, the total level of this recruitment is still uncertain, and although the 2003 year class is estimated to have been the best since the late 1990s, it is not the largest year class seen in the time-series. Consequently, any rebuilding from this year class is likely to be slow. Rebuilding of this stock is therefore dependent on protecting both the existing SSB and any fish recruiting to it. Note that there are significant uncertainties from misidentification between the redfish species in the Barents Sea, and thus the exact values of both stock and F are uncertain, although the trends are clearly defined.

Sebastes norvegicus is currently on the Norwegian Redlist as a threatened (EN) species according to the criteria given by the International Union for Conservation of Nature (IUCN).

Red-listing is understood to mean that a species (or stock) is at risk of extinction. ICES convened two workshops in 2009. The first Workshop WKPOOR1 (ICES CM 2009/ACOM:29) addressed methods for evaluating extinction risk and outlined approaches that could support advice on how to avoid potential extinction. The second Workshop WKPOOR2 (ICES CM 2009/ACOM:49) applied the results of the first workshop to four stocks selected as being of interest to Norway and ICES.

There are three general methods for evaluating extinction risk: (1) screening methods, such as the IUCN redlisting criteria; (2) simple population viability analysis (PVA) based on time-trends; and (3) age structured population viability analysis. None of the methods are considered reliable for accurately estimating the absolute probability of extinction, but they may be useful to evaluate the relative probability of extinction between species or between management options.

The fishery is largely concentrated on the mature individuals. With a currently estimated SSB of around 24 000 tonnes, and a F_{MSY} of 0.05, one would expect a sustainable catch to be in the order of 1000 to 1500 tonnes. The current catches are well above this level.

7.3.5 Biological reference points

Reference point calculations were conducted at WKREDFISH benchmark (2018a), based on a B_{LOSS} with reasonable recruitment, and a forecast with constant recruitment to produce a F_{MSY} candidate. Note that the benchmark used preliminary data, and that the results presented here are slightly changed from those at WKREDFISH (2018). We therefore follow the methodology presented at WKREDFISH (2018a), but adjust the B_{lim} based on the revised SSB estimate for 2002. This has the effect of raising the proposed B_{lim} from 44 000 tonnes to 49 000 tonnes. The F_{MSY} calculations are unaffected, as these are based on steady state forecasts.

No stock recruitment relationship is presented for this stock. Within the model, recruitment is modelled as an annual recruitment value with no relationship with the SSB.

- B_{lim}: B_{lim} is based on the Lowest Observed Stock Size at which reasonable recruitment was observed. This is assumed to be the 2003 year class, at which time the SSB is estimated to be 49 000 tonnes (or 44 000 tonnes using the benchmark values)
- B_{pa}: Using the ICES default multiplier of 1.4 for B_{pa} gives a B_{pa} value of 68 600 tonnes (61 000 tonnes using the benchmark values)

The stock is currently well below the biomass limit reference point, and thus F_{MSY} is not recommended as the current fishing level. However, it was considered useful to try to estimate a candidate F_{MSY} reference point, which can be used to compare against management performance. Using yield-per-recruit analysis WKREDFISH (2018a) proposes $F_{0.1}$(15+), estimated to be 0.0525, as a candidate F_{MSY} (Figure E2).

Given the poor state of this stock, management should be based on the need to protect and recover the stock, not on F_{MSY}.

7.3.6 Management advice

AFWG considers that the stock is severely depleted. There are signs that recruitment in 2003 is now beginning to stabilize and, for the immature fish, improve the stock status. However, the stock remains in a poor state, and as of now there are only weak indications that the mature stock is improving. AFWG therefore recommends that current area closures and low bycatch limits should be maintained. No directed fishery should be conducted on this stock at the moment, and the percent legal bycatch should be set as low as possible for other fisheries to continue. There will be no directed fishery for *S. norvegicus* in 2020. It is critical that the bycatch regulations do not allow the catch to increase, as this would impair prospects for recovery.

7.3.7 Implementing the ICES F_{MSY} framework

As a long-lived species, *S. norvegicus* has many year classes contributing to the population, and consequently a relatively stable stock level from year-to-year. This makes it relatively simple to manage to some proxy of MSY (e.g. $F_{0.1}$) once the biomass has reached close to B_{MSY}, provided adequate measures can be implemented to reduce fishing pressure to an appropriate level. It should be noted that the current fishery is well above the preliminary F_{MSY} for the stock. The main focus should therefore be on reducing total F. The current priority is to stabilize the stock and prevent further decline, and allow the recruiting 2003 year class to grow and reproduce. Only then could a recovery strategy and eventually an MSY fishery be implemented. The recent upturn in immature biomass gives some hope that such recovery may be possible, given low fishing pressure.

Table 7.1 *Sebastes norvegicus* in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1 and divisions 2.a and 2.b combined.

Year	Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
1998	-	78	494	131	33	-	19	-	-	16 540	-	6	1 632	51	171	19 155
1999	-	35	35	228	47	14	7	-	-	16 750	-	3	1 691	7	169	18 986
2000	-	17	13	160	22	16	-	-	-	13 032	-	16	1 112	-	73	14 461
2001	-	37	30	238	17	-	1	-	-	9 134	-	7	963	1	119	10 547
2002	-	60	31	42	31	3	-	-	-	8 561	-	34	832	3	46	9 643
2003	-	109	8	122	36	4	-	-	89	6 853	-	6	479	-	134	7 840
2004	-	19	4	68	20	30	-	-	33	6 233	-	5	722	3	69	7 206
2005	-	47	10	72	36	8	-	-	48	6 085	-	56	614	8	52	7 037
2006	-	111	8	35	44	31	3	-	21	6 305	-	69	713	9	39	7 388
2007	-	146	15	67	84	68	13	-	20	5 784	-	225	890	5	55	7 372
2008	-	274	63	30	71	27	6	-	2	5 216	-	72	749	4	85	6 599
2009	-	70	1	58	81	66	-	-	1	5 451	-	30	698	-	31	6 487
2010	-	171	51	31	72	22	-	-	-	5 994	1	28	565	3	44	6 981
2011	-	24	53	9	51	22	-	-	1	4 681	48	25	919	6	13	5 852
2012	-	87	182	71	58	23	12	-	5	4 247	34	17	681	-	100	5 517
2013	-	83	353	1	45	8	1	-	-	3 771	19	36	797	-	493	5 609

Year	Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
2014	-	67	219	6	20	29	-	-	1	3 053	21	5	806	-	211	4 436
2015	1	76	53	24	211	35	-	-	-	2 488	17	-	664	2	57	3 629
2016	7	183	30	4	87	55	-	-	-	3 239	26	-	864	-	76	4 572
2017	-	123	17	19	61	65	-	-	2	3 353	27	90	1 297	44	160	5 258
2018	1	146	37	66	77	67	-	-	-	4 276	36	67	1 834	12	37	6 656
2019[1]	-	244	24	93	56	83	-	3	1	5 675	20	69	1 929	61	25	8 283

[1] - Provisional figures.

Table 7.2 *Sebastes norvegicus* in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1.

Year	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Norway	Poland	Portugal	Russia	Spain	UK	Total
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	2	-	546	-	-	27	-	18	623
2013	28	2	1	-	+	-	-	574	-	-	41	-	4	651
2014	59	10	6	17	4	-	-	403	2	-	27	-	17	542
2015	57	4	9	211	13	-	-	514	2	-	51	2	10	871
2016	161	7	4	74	-	51	-	782	4	-	136	-	60	1 275
2017	81	5	-	8	4	-	-	8 44	2	2	211	2	23	1182
2018	146	28	35	29	-	-	-	926	5	3	302	5	25	1 504
2019[1]	228	11	32	22	30	-	2	1 055	4	2	422	31	11	1 822

[1] - Provisional figures.

+ Less than 1 t

Table 7.3 *Sebastes norvegicus* in subareas 1 and 2. Nominal catch (t) by countries in Division 2.a.

Year	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Netherland	Norway	Poland	Portugal	Russia	Spain	UK	Total
1998	-	494	116	33		19	-	14 326	-	6	1 078	51	137	16 260
1999	-	35	210	38		7	-	14 598	-	3	976	7	156	16 030
2000	17	13	159	22		-	-	11 038	-	16	658	-	61	11 984
2001	33	30	227	17		1	-	8 002	-	6	612	1	103	9 031
2002	45	30	37	31	3	-	-	7 761	-	18	192	2	32	8 151
2003	94	9	122	35	4	-	89	5 970	-	6	264		130	6 722
2004	12	4	68	20	30	-	33	4 872	-	5	396	3	58	5 500
2005	37	9	60	36	8	-	48	4 855	-	56	265	8	48	5 430
2006	60	8	35	44	31	3	21	4 404	-	59	293	9	39	5 006
2007	119	15	55	69	68	13	20	4 101	-	70	599	3	35	5 168
2008	229	56	28	71	27	6	2	4 456	-	68	450	4	70	5 467
2009	70	1	55	79	60	-	1	4 543	-	17	500	-	7	5 333
2010	113	51	31	72	22	-	-	5 414	1	26	287	2	38	6 056
2011	-	51	9	49	20	-	1	3 942	-	-	695	2	13	4 782

Year	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Netherland	Norway	Poland	Portugal	Russia	Spain	UK		Total
2012	49	182	33	57	13	2	2	3 599	-	1	427	-	33		4 398
2013	55	343	-	45	8	-	-	3 076	-	9	475	-	466	**Denmark** - 1	4 478
2014	8	209	-	3	25	-	1	2 465	-	2	559	-	178		3 449
2015	18	49	15	-	22	-	-	1 946	12	-	439	-	47		2 548
2016	22	23	-	13	4	-	-	2 417	8	-	545	-	15		3 047
2017	41	12	19	36	61	-	2	2 455	22	88	680	38	137		3 591
2018	-	9	17	43	67	-	-	3 275	12	64	489	7	12	-	3 995
2019[1]	15	14	61	34	53	-	1	4 498	16	68	794	57	13	**Lithuania - 1**	5 625

[1] - Provisional figures.

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

Year	Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
1998	-	-	-	10	-				105	-	-	246	-	3	364
1999	-	-	-	-	-				38	-	-	355	-	2	395
2000	-	-	-	-	-				10	-	-	308	-	-	318
2001	-	-	-	-	-				79	-	1	223	-	-	303
2002	-	-	-	-	-				107	-	16	420	1	5	549
2003	-	-	-	-	-				68	-	-	75	-	-	143
2004	-	-	-	-	-				124	-	-	113	-	-	237
2005	-	-	-	13	-				2281	-	-	288	-	-	529
2006	-	5	-	-	-				1211	-	10	284	-	-	1510
2007	-	12	-	-	-				649	-	155	242	-	-	1057
2008	-	-	-	-	-				126	-	1	250	-	-	377
2009	-	-	-	-	-				207	-	-	179	-	-	386
2010	-	-	-	-	-				83	-	22	257	-	-	342
2011	-	-	2	-	-	1	-	-	65	48	25	217	4	-	362
2012	-	21	-	35	-	1	8	3	102	34	16	227	-	49	496
2013	-	-	9	-	-	-	1	-	120	19	27	281	-	23	480
2014	-	-	-	-	-	-	-	-	185	19	3	221	-	16	444
2015	1	-	-	-	-	-	-	-	28	3	-	175	-	-	207
2016	7	-	-	-	-	-	-	-	40	14	-	183	-	-	244
2017	-	-	-	-	18	-	-	-	54	2	-	405	4	-	483
2018	1	-	-	14	6	-	-	-	75	19	-	1043	-	-	1158
2019[1]	-	-	-	-	-	-	-	-	122	-	-	712	1	1	836

[1] -Provisional figures.

Table 7.5. *Sebastes norvegicus* in subareas 1 and 2. Catch numbers-at-age (in thousands).

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp	Total Num.	Tonnes Land.
1992	5	22	78	114	394	549	783	1718	3102	2495	2104	1837	998	858	688	547	268	3110	19670	16185
1993	0	24	193	359	406	1036	1022	1523	2353	1410	1655	1678	745	716	534	528	576	3482	18240	16651
1994	46	7	292	640	816	1930	2096	2030	1601	2725	2668	1409	617	733	514	256	177	1508	20065	18120
1995	60	85	230	672	908	1610	2038	2295	1783	1406	785	563	670	593	419	368	250	3232	17967	15616
1996	9	119	313	361	879	1234	1638	2134	1675	1614	1390	952	679	439	560	334	490	3135	17955	18043
1997	9	98	156	321	686	1065	1781	2276	2172	1848	1421	851	804	608	511	205	334	2131	17277	17511
1998	28	51	206	470	721	968	1512	1736	1582	1045	1277	970	1018	846	443	764	486	3389	17512	19155
1999	78	593	855	572	1006	1230	1618	1480	1612	1239	1407	1558	1019	394	197	459	174	2131	17622	18986
2000	4	13	70	245	902	958	1782	1409	2121	2203	1715	753	483	458	132	230	224	895	14597	14460
2001	23	23	44	199	347	482	1120	1342	1674	1653	1243	568	119	183	154	112	135	254	9675	10547
2002	14	36	71	143	414	686	1199	1943	1377	1274	1196	388	313	99	104	117	113	253	9740	9643
2003	22	25	30	44	204	359	705	1687	1338	1071	937	481	367	146	84	51	18	69	7637	7841
2004	19	47	46	65	198	277	504	590	677	963	1059	787	436	169	183	108	79	186	6390	7320
2005	40	55	94	80	165	173	393	779	741	916	926	743	376	210	189	129	111	220	6338	7037
2006	45	32	56	70	245	204	201	809	549	779	794	747	496	332	310	188	165	397	6419	7348

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp	Total Num.	Tonnes Land.
2007	15	21	31	68	138	306	448	495	523	637	892	616	510	396	225	322	170	630	6443	7306
2008	1	4	14	12	49	139	265	366	361	443	442	538	547	479	281	223	144	1032	5342	6557
2009	0	11	2	4	9	23	144	277	315	248	406	374	509	404	331	323	253	911	4544	6487
2010	1	0	10	7	4	20	75	261	291	529	359	311	531	502	385	295	247	776	4605	6982
2011	2	1	3	0	2	5	64	304	466	266	312	223	378	289	247	229	253	985	4028	5852
2012	15	10	5	12	0	2	228	226	322	295	191	169	184	283	266	268	262	1152	3891	5517
2013	31	88	138	57	10	44	58	202	241	437	321	205	213	270	258	196	322	1216	4309	5608
2014	5	4	8	8	8	15	26	49	67	204	197	148	167	184	165	156	213	1197	2821	4438
2015	15	16	14	17	26	43	29	96	113	128	170	147	159	115	99	96	220	1156	2661	3628
2016	53	59	60	88	88	147	293	217	266	81	178	176	110	162	110	182	191	1103	3563	4674
2017[1]	106	82	132	69	132	165	311	455	225	132	105	83	85	102	88	138	182	1169	3760	5257
2018	Data not available during AFWG 2020.																			
2019	Data not available during AFWG 2020.																			

[1] - Provisional figures. Catch at age for 2017 was updated at AFWG 2020, but an update of weight-at-age in the catches was not available during AFWG 2020. Therefore, the weights from AFWG 2018 were used. Weight-at-age in the catches was not available for 2018 or 2019.

Table 7.6. *Sebastes norvegicus* in subareas 1 and 2. Catch weights at age (kg).

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp
1992	0.18	0.29	0.48	0.42	0.50	0.59	0.58	0.65	0.65	0.71	0.82	0.84	0.94	1.02	1.03	1.15	1.27	1.27
1993	0.2	0.33	0.36	0.43	0.51	0.51	0.64	0.64	0.76	0.86	0.89	0.98	1	1.03	1.21	1.03	1.2	1.14
1994	0.25	0.37	0.38	0.49	0.51	0.64	0.74	0.76	0.86	0.95	1.03	1.07	1.11	1.16	1.15	1.13	1.02	1.36
1995	0.33	0.43	0.64	0.61	0.59	0.65	0.74	0.79	0.84	0.92	1.12	1.01	1.01	1.21	1.14	1.09	1.3	1.01
1996	0.22	0.49	0.56	0.65	0.71	0.81	0.84	0.88	0.96	1	1.02	1.01	1	1.03	1.04	1.14	1.09	1.16
1997	0.23	0.51	0.53	0.74	0.72	0.78	0.8	0.86	0.91	0.99	1.16	1.18	1.21	1.34	1.28	1.54	1.19	1.29
1998	0.37	0.21	0.47	0.62	0.67	0.77	0.77	0.85	1.05	0.96	1.25	1.28	1.3	1.23	1.87	1.46	1.73	1.29
1999	0.14	0.26	0.44	0.57	0.69	0.78	0.86	1.04	1.07	1.12	1.18	1.71	1.09	1.18	1.04	1.34	1.18	1.34
2000	0.19	0.24	0.32	0.44	0.53	0.64	0.73	0.84	0.96	1.11	1.25	1.32	1.53	1.06	1.29	1.32	1.12	1.2
2001	0.15	0.26	0.45	0.55	0.58	0.67	0.8	0.89	1.01	1.14	1.33	1.43	1.62	1.6	1.47	2	2.7	2.31
2002	0.17	0.25	0.33	0.42	0.54	0.67	0.72	0.84	0.98	1.09	1.2	1.3	1.44	1.78	1.68	1.88	2.12	1.84
2003	0.19	0.22	0.31	0.39	0.49	0.58	0.69	0.84	0.96	1.05	1.29	1.36	1.65	1.74	2.09	1.85	2.3	2.38
2004	0.21	0.26	0.36	0.45	0.51	0.59	0.68	0.8	0.96	1.07	1.22	1.34	1.57	1.67	1.75	2.09	1.9	2.04
2005	0.16	0.21	0.36	0.45	0.52	0.58	0.68	0.82	0.94	1.03	1.16	1.36	1.46	1.51	1.67	1.91	2.23	2.27
2006	0.13	0.15	0.28	0.41	0.51	0.58	0.66	0.74	0.83	1	1.14	1.27	1.39	1.46	1.37	1.47	1.64	2.03
2007	0.15	0.21	0.33	0.39	0.5	0.59	0.65	0.77	0.9	1	1.09	1.27	1.42	1.32	1.53	1.47	1.69	1.81

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp
2008	0.41	0.55	0.55	0.57	0.52	0.58	0.65	0.81	0.9	1.07	1.14	1.36	1.51	1.81	1.99	2.01	2.26	1.93
2009	0.00	1.01	0.34	0.59	0.61	0.66	0.82	0.92	0.94	1.09	1.22	1.35	1.40	1.57	1.68	1.74	1.73	2.25
2010	0.15	0.00	0.10	0.32	0.52	0.73	0.77	0.89	0.98	1.09	1.25	1.40	1.48	1.64	1.77	1.99	1.82	1.86
2011	0.16	0.20	0.21	0.00	0.54	0.52	0.72	0.91	1.08	1.14	1.20	1.45	1.40	1.43	1.54	1.60	1.74	1.93
2012	0.19	0.25	0.33	0.72	0.61	0.88	0.70	0.86	0.95	1.02	1.13	1.18	1.33	1.48	1.31	1.55	1.50	2.59
2013	0.20	0.27	0.32	0.44	0.47	0.55	0.63	0.88	0.96	1.08	1.08	1.19	1.21	1.39	1.38	1.62	1.41	1.81
2014	0.20	0.26	0.39	0.41	0.56	0.61	0.71	0.87	0.95	1.07	1.14	1.28	1.46	1.35	1.51	1.62	1.69	1.84
2015	0.16	0.22	0.30	0.50	0.51	0.60	0.66	0.88	0.93	1.04	1.15	1.18	1.23	1.34	1.51	1.50	1.48	1.62
2016	0.17	0.21	0.34	0.62	0.53	0.66	0.68	0.86	0.94	1.03	1.11	1.32	1.43	1.29	1.42	1.43	1.48	2.67
2017[1]	0.18	0.23	0.29	0.38	0.55	0.59	0.70	0.80	0.92	1.06	1.15	1.35	1.40	1.56	1.37	1.74	1.83	2.92
2018	Data not available during AFWG 2020.																	
2019	Data not available during AFWG 2020.																	

[1] - Provisional figures.

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

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.05	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
10	0.08	0.07	0.05	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.01	0.01
11	0.11	0.09	0.08	0.08	0.05	0.04	0.04	0.04	0.05	0.05	0.04	0.03	0.03	0.02	0.02
12	0.15	0.12	0.11	0.11	0.11	0.06	0.07	0.07	0.08	0.08	0.06	0.05	0.05	0.04	0.04
13	0.20	0.15	0.13	0.13	0.14	0.12	0.10	0.10	0.11	0.11	0.09	0.07	0.07	0.06	0.06
14	0.25	0.19	0.16	0.16	0.17	0.14	0.16	0.13	0.15	0.15	0.13	0.10	0.09	0.08	0.07
15	0.31	0.23	0.19	0.19	0.19	0.16	0.19	0.18	0.18	0.19	0.16	0.12	0.12	0.10	0.09
16	0.38	0.27	0.22	0.21	0.22	0.18	0.21	0.21	0.24	0.23	0.19	0.15	0.14	0.12	0.11
17	0.44	0.32	0.26	0.24	0.25	0.20	0.23	0.22	0.26	0.28	0.22	0.17	0.16	0.13	0.12
18	0.48	0.36	0.29	0.27	0.27	0.22	0.25	0.24	0.27	0.30	0.25	0.19	0.17	0.15	0.13
19	0.51	0.38	0.32	0.29	0.30	0.24	0.26	0.25	0.29	0.32	0.26	0.20	0.18	0.15	0.14

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
20	0.54	0.40	0.33	0.31	0.31	0.25	0.28	0.27	0.30	0.33	0.27	0.21	0.19	0.16	0.15
21	0.56	0.42	0.34	0.32	0.33	0.26	0.29	0.28	0.31	0.34	0.28	0.21	0.19	0.16	0.15
22	0.58	0.43	0.34	0.32	0.33	0.26	0.29	0.28	0.32	0.34	0.28	0.21	0.19	0.15	0.14
23	0.59	0.43	0.34	0.32	0.33	0.26	0.29	0.28	0.32	0.34	0.28	0.20	0.18	0.15	0.14
24	0.58	0.42	0.33	0.31	0.32	0.25	0.28	0.27	0.31	0.33	0.27	0.20	0.18	0.14	0.13
25	0.57	0.41	0.32	0.30	0.30	0.24	0.27	0.26	0.29	0.31	0.25	0.19	0.17	0.13	0.12
26	0.55	0.38	0.30	0.28	0.28	0.23	0.26	0.25	0.28	0.29	0.23	0.17	0.16	0.12	0.12
27	0.52	0.36	0.27	0.26	0.26	0.21	0.24	0.23	0.26	0.27	0.20	0.16	0.15	0.11	0.11
28	0.50	0.34	0.25	0.24	0.24	0.19	0.22	0.21	0.24	0.24	0.19	0.14	0.13	0.10	0.10
29	0.47	0.31	0.23	0.22	0.22	0.17	0.20	0.19	0.22	0.22	0.17	0.12	0.11	0.09	0.09
30	0.43	0.27	0.19	0.17	0.17	0.13	0.14	0.13	0.14	0.14	0.10	0.10	0.09	0.06	0.06
15+	0.500	0.358	0.283	0.266	0.270	0.217	0.242	0.235	0.264	0.280	0.225	0.171	0.156	0.126	0.118

Age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
9	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02
10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.03	0.05
11	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.02	0.03	0.04	0.06	0.09
12	0.04	0.04	0.04	0.04	0.03	0.05	0.04	0.04	0.05	0.04	0.04	0.06	0.07	0.10	0.14
13	0.05	0.06	0.06	0.06	0.05	0.07	0.06	0.06	0.07	0.06	0.05	0.08	0.10	0.14	0.20
14	0.07	0.08	0.08	0.08	0.07	0.09	0.08	0.09	0.10	0.09	0.07	0.11	0.13	0.19	0.27
15	0.09	0.09	0.10	0.10	0.09	0.12	0.10	0.11	0.12	0.11	0.09	0.13	0.16	0.24	0.35
16	0.11	0.11	0.12	0.11	0.11	0.14	0.12	0.13	0.15	0.13	0.11	0.15	0.19	0.28	0.42
17	0.12	0.13	0.13	0.13	0.12	0.16	0.14	0.15	0.17	0.15	0.12	0.17	0.22	0.32	0.49
18	0.13	0.14	0.14	0.14	0.13	0.18	0.15	0.16	0.18	0.16	0.14	0.19	0.24	0.36	0.55
19	0.14	0.14	0.15	0.15	0.14	0.19	0.16	0.17	0.19	0.17	0.14	0.20	0.25	0.38	0.59
20	0.14	0.15	0.15	0.15	0.15	0.19	0.17	0.17	0.20	0.18	0.15	0.20	0.26	0.39	0.62
21	0.14	0.15	0.15	0.15	0.15	0.20	0.17	0.18	0.20	0.18	0.15	0.21	0.26	0.39	0.62
22	0.14	0.15	0.15	0.15	0.15	0.19	0.16	0.17	0.20	0.17	0.15	0.20	0.25	0.38	0.60

Age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
23	0.13	0.14	0.15	0.14	0.14	0.19	0.16	0.17	0.19	0.17	0.14	0.19	0.24	0.36	0.56
24	0.12	0.13	0.14	0.13	0.14	0.18	0.15	0.16	0.18	0.16	0.13	0.18	0.23	0.33	0.52
25	0.12	0.13	0.13	0.12	0.13	0.17	0.15	0.15	0.17	0.15	0.13	0.17	0.21	0.31	0.47
26	0.11	0.12	0.12	0.11	0.12	0.16	0.14	0.14	0.16	0.14	0.12	0.16	0.19	0.28	0.42
27	0.11	0.11	0.12	0.10	0.11	0.15	0.13	0.13	0.15	0.13	0.11	0.15	0.18	0.25	0.37
28	0.10	0.11	0.11	0.09	0.10	0.13	0.12	0.12	0.14	0.12	0.10	0.14	0.16	0.23	0.33
29	0.09	0.10	0.10	0.09	0.10	0.12	0.10	0.11	0.13	0.11	0.09	0.13	0.15	0.21	0.30
30	0.06	0.07	0.07	0.06	0.07	0.09	0.08	0.09	0.10	0.08	0.07	0.09	0.10	0.13	0.18
15+	0.115	0.123	0.127	0.120	0.122	0.160	0.137	0.144	0.163	0.142	0.122	0.167	0.207	0.302	0.462

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

	total stock			mature			immature				recruit
year	Number (millions)	mean wt (kg)	biomass (1000t)	number (millions)	mean wt (kg)	biomass	number (millions)	mean wt (kg)	biomass (1000t)	F(15+)	age 3 (millions)
1986	384	0.37	141.98	112	0.67	75.09	271	0.25	66.88		3.79
1987	372	0.37	138.88	111	0.66	73.16	261	0.25	65.72		2.97
1988	347	0.38	133.09	108	0.63	68.34	239	0.27	64.75		1.67
1989	324	0.40	129.33	105	0.62	64.98	219	0.29	64.34		1.57
1990	299	0.40	119.60	100	0.58	57.94	199	0.31	61.65	0.50	1.66
1991	281	0.42	118.20	100	0.59	58.40	182	0.33	59.80	0.36	1.58
1992	266	0.45	119.00	101	0.61	61.70	165	0.35	57.30	0.28	1.46
1993	250	0.47	118.50	101	0.64	65.03	149	0.36	53.47	0.27	1.39
1994	237	0.49	115.64	99	0.68	66.98	138	0.35	48.65	0.27	1.69
1995	221	0.52	114.30	97	0.72	69.98	124	0.36	44.31	0.22	1.09
1996	201	0.54	109.31	93	0.75	70.05	108	0.36	39.26	0.24	0.75
1997	182	0.57	103.72	88	0.79	69.03	95	0.37	34.69	0.24	0.76
1998	160	0.59	95.12	80	0.81	65.00	80	0.37	30.12	0.26	0.40
1999	140	0.61	85.40	71	0.83	59.33	69	0.38	26.07	0.28	0.41

		total stock			mature			immature			recruit
year	Number	mean wt	biomass	number	mean wt	biomass	number	mean wt	biomass	F(15+)	age 3
	(millions)	(kg)	(1000t)	(millions)	(kg)		(millions)	(kg)	(1000t)		(millions)
2000	124	0.64	79.18	65	0.86	56.08	58	0.40	23.10	0.23	0.31
2001	112	0.68	76.15	61	0.90	55.28	51	0.41	20.87	0.17	0.40
2002	102	0.72	73.44	57	0.95	54.70	45	0.42	18.74	0.16	0.32
2003	93	0.78	71.76	55	1.01	54.99	38	0.44	16.77	0.13	0.19
2004	86	0.81	70.10	52	1.07	55.18	35	0.43	14.92	0.12	0.44
2005	80	0.85	68.16	49	1.13	55.01	31	0.42	13.15	0.11	0.31
2006	82	0.80	65.69	45	1.19	53.90	37	0.32	11.79	0.12	1.16
2007	75	0.83	62.67	42	1.24	52.16	33	0.32	10.51	0.13	0.24
2008	70	0.85	60.06	39	1.30	50.48	32	0.30	9.57	0.12	0.38
2009	65	0.88	57.39	36	1.34	48.48	29	0.31	8.91	0.12	0.27
2010	59	0.90	53.11	33	1.37	44.81	27	0.31	8.30	0.16	0.21
2011	65	0.78	50.65	30	1.40	42.32	35	0.24	8.33	0.14	1.27
2012	81	0.60	48.88	28	1.40	39.83	53	0.17	9.05	0.14	2.27
2013	75	0.62	46.64	27	1.35	37.15	47	0.20	9.49	0.16	0.10
2014	69	0.66	45.51	27	1.31	35.54	42	0.24	9.97	0.14	0.03

		total stock			mature			immature			recruit
year	Number	mean wt	biomass	number	mean wt	biomass	number	mean wt	biomass	F(15+)	age 3
	(millions)	(kg)	(1000t)	(millions)	(kg)		(millions)	(kg)	(1000t)		(millions)
2015	63	0.71	45.14	27	1.28	34.75	36	0.29	10.39	0.12	0.04
2016	84	0.53	44.56	27	1.25	33.13	58	0.20	11.43	0.17	2.68
2017	103	0.43	43.91	26	1.18	31.13	76	0.17	12.78	0.21	2.64
2018	99	0.42	41.73	26	1.06	28.11	73	0.19	13.62	0.30	0.61
2019	136	0.29	39.49	26	0.94	23.89	110	0.14	15.60	0.46	4.73

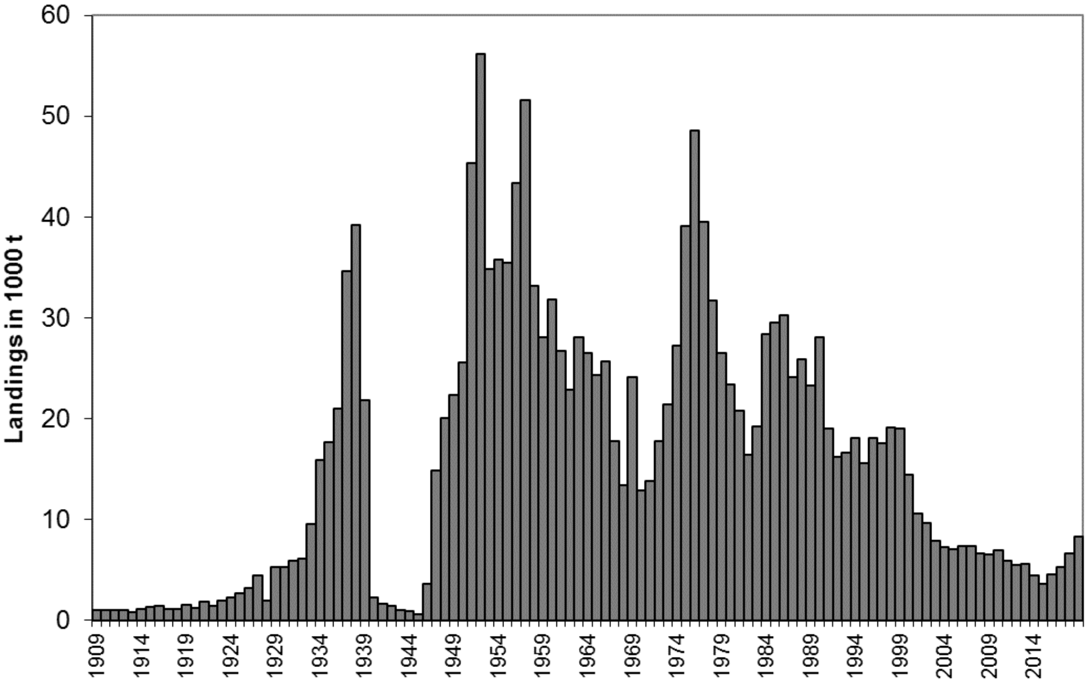


Figure 7.1. ***Sebastes norvegicus*** **in subareas 1 and 2. Total international landings 1908–2019 (in thousand tonnes).**

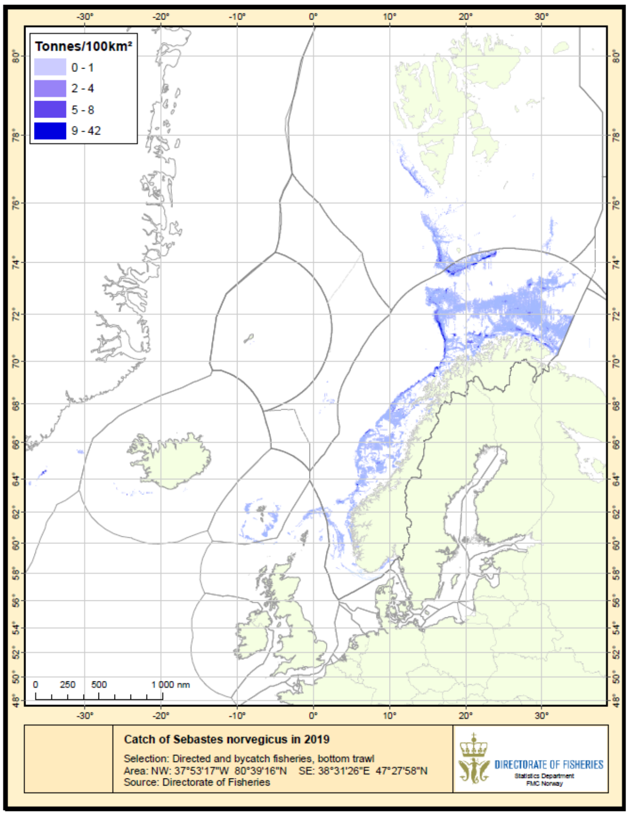


Figure 7.2. ***Sebastes norvegicus*** **in subareas 1 and 2. Catches (including bycatch) of** ***Sebastes norvegiucs*** **in 2019 from Norwegian logbooks. Due to reporting on the genus level these catches may contain a considerable amount of** ***Sebastes mentella*****.**

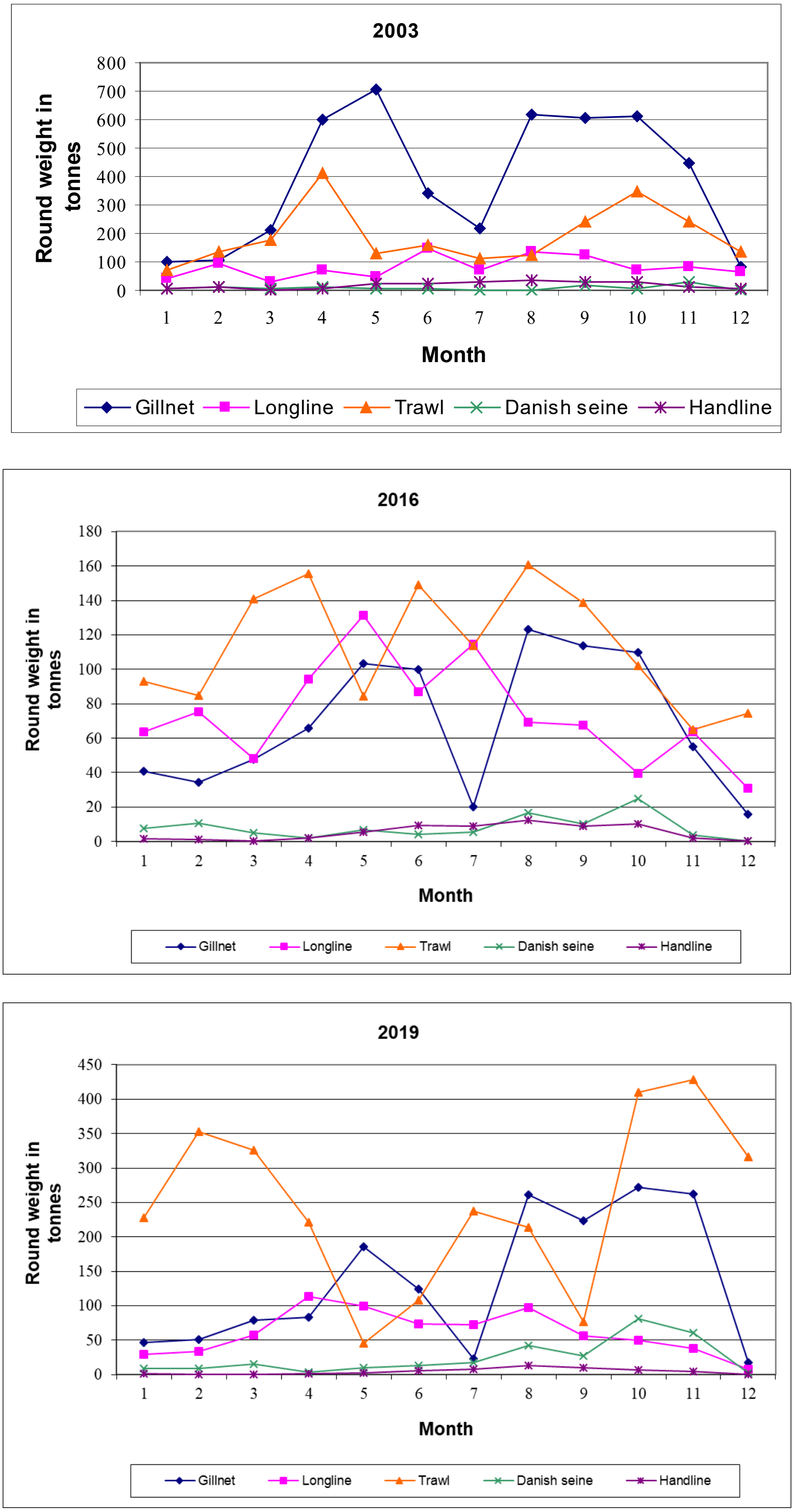


Figure 7.3a. Illustration of the seasonality in the different Norwegian *S. norvegicus* fisheries in 2003, 2016 and 2019, also illustrating how the current regulations are working.

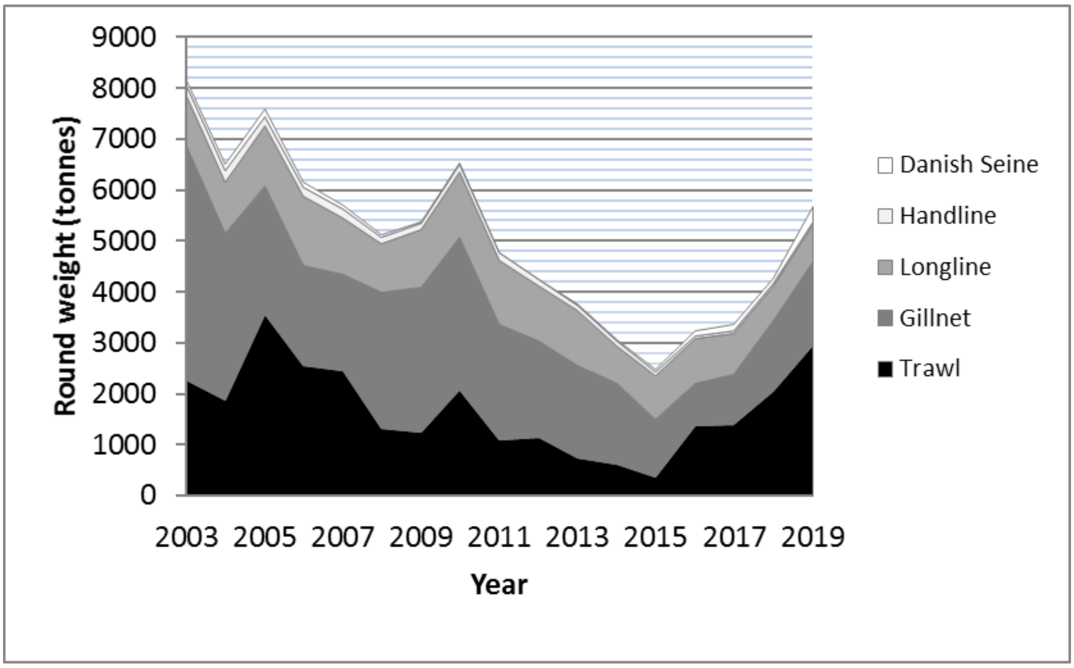


Figure 7.3b. Interannual changes in the Norwegian catches by fleet of *S. norvegicus* fisheries (2003–2019).

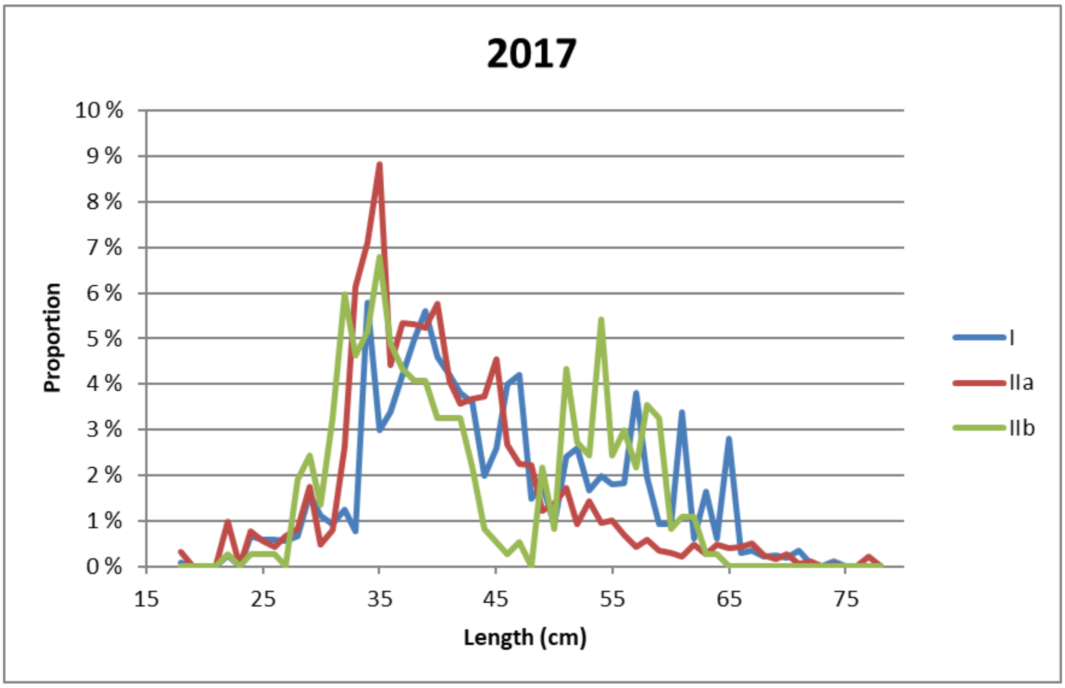


Figure 7.4. *Sebastes norvegicus*. Length frequency of *S. norvegicus* reported from Norwegian catches in Subarea 1, 2.a and 2.b in 2017, all gears combined. Data separated by gears and areas was not available for 2018 and 2019 during AFWG 2020.

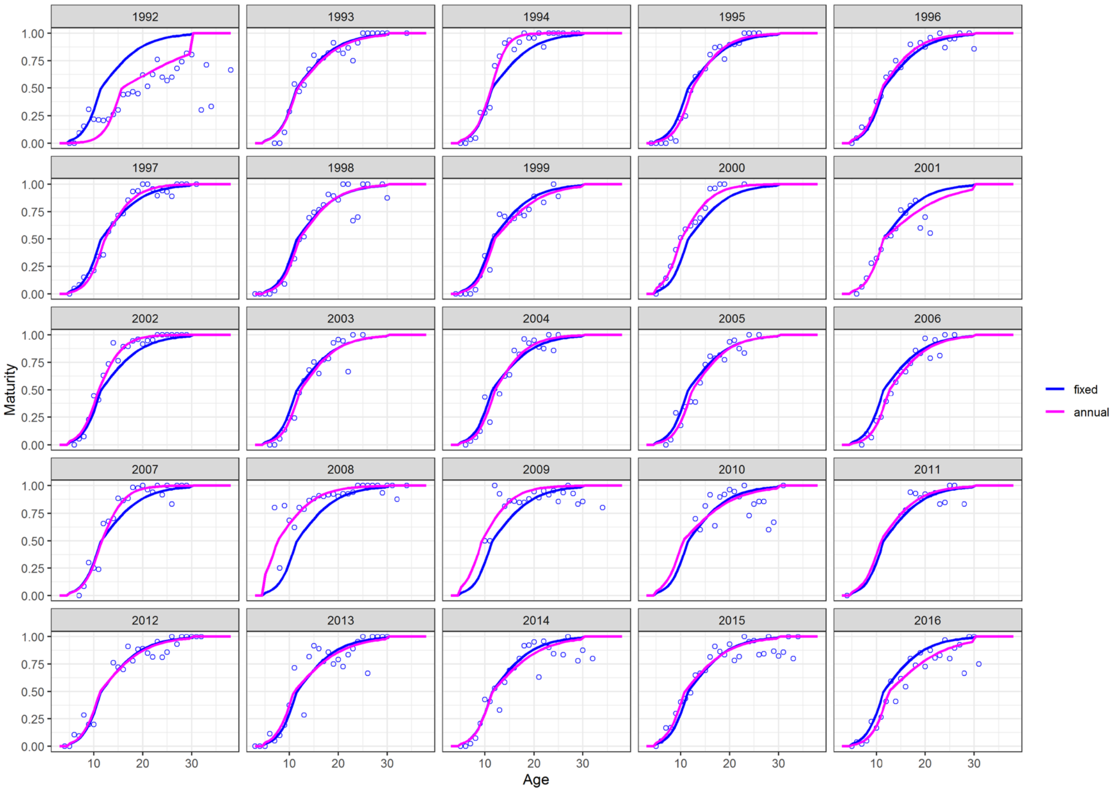
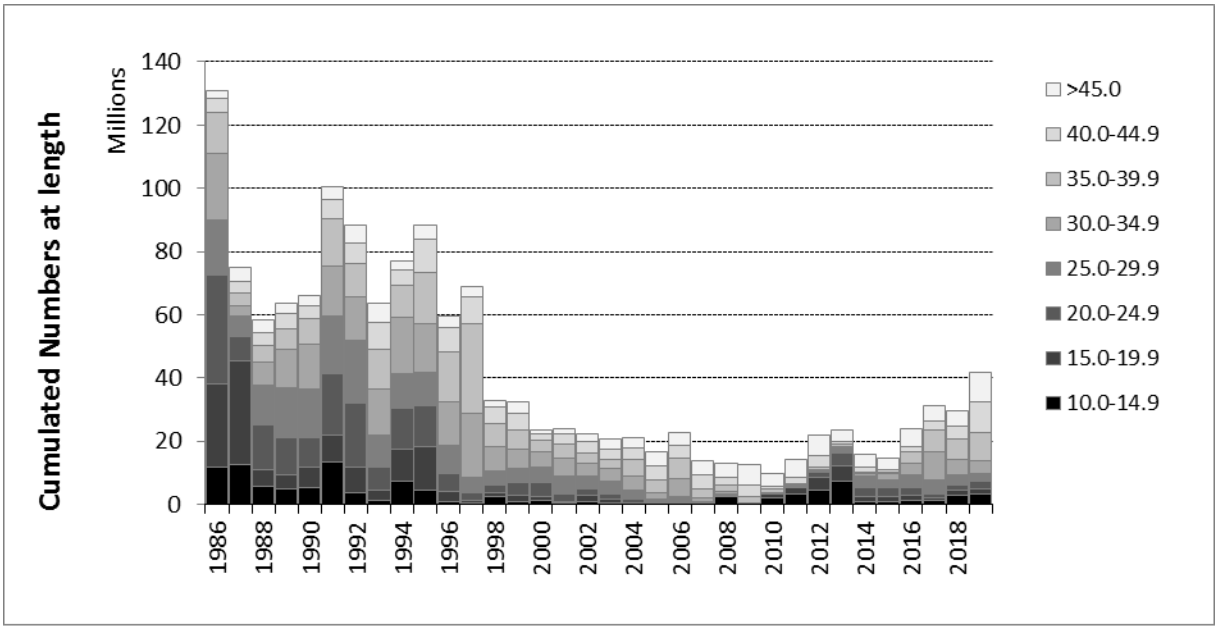


Figure 7.5a. Proportion maturity-at-age of *S. norvegicus* in subareas 1 and 2 derived from Norwegian commercial and survey data (Table E4). The proportions were derived from samples with at least five individuals. Updated for the 2020 assessment, but due to a lack of data in 2017-2019 only the data up to 2016 was used in the model.

Figure 7.5b. *Sebastes norvegicus* in subareas 1 and 2. Estimates of maturity-at-age by Gadget. Input data have been proportions of *S. norvegicus* mature both at age and length as collected and classified from Norwegian commercial landings and surveys.



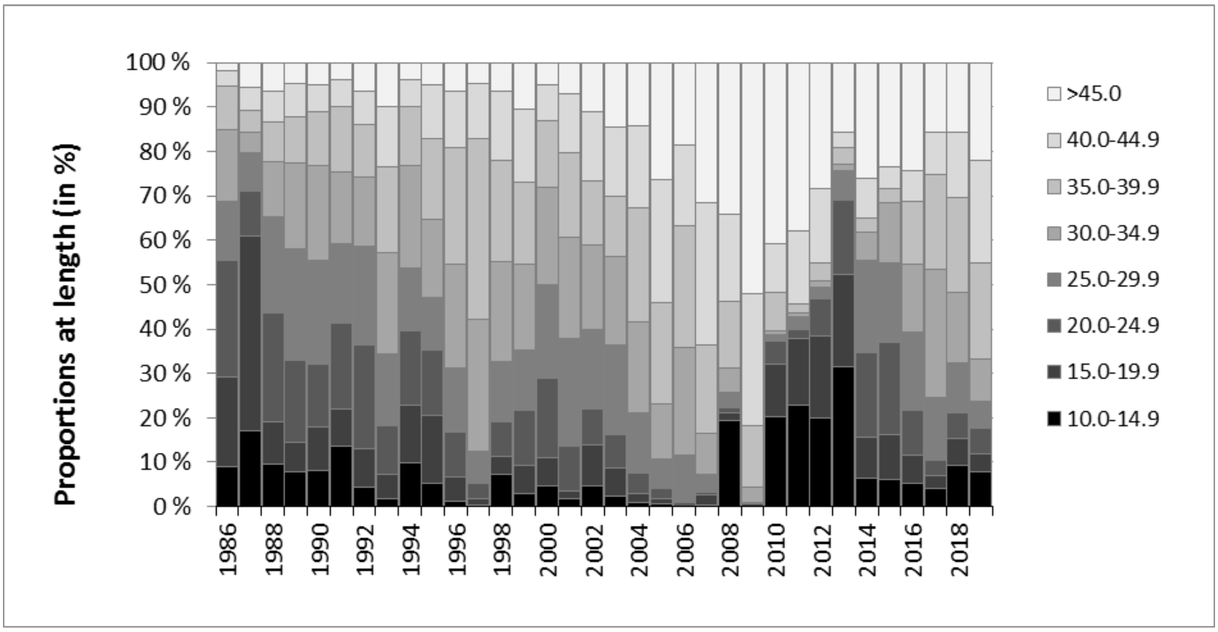


Figure 7.6a. *Sebastes norvegicus*. Abundance indices disaggregated by length for the winter Norwegian Barents Sea (Division 2.a) bottom-trawl survey (BS-NoRu-Q1 (BTr)) (joint with Russia some of the years since 2000), for 1986–2019 (ref. Table E1a). Top: absolute index values, bottom: relative frequencies.

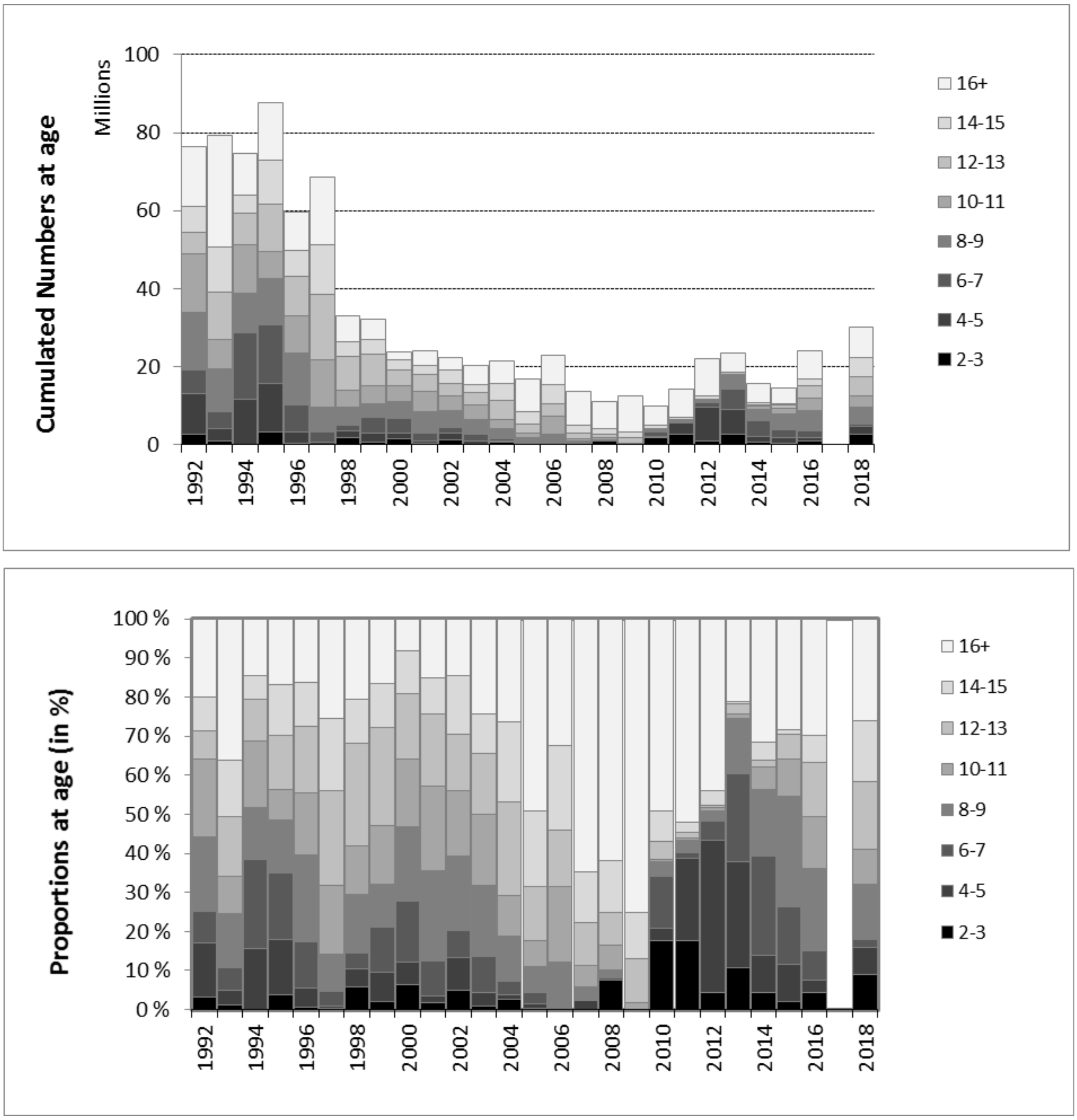
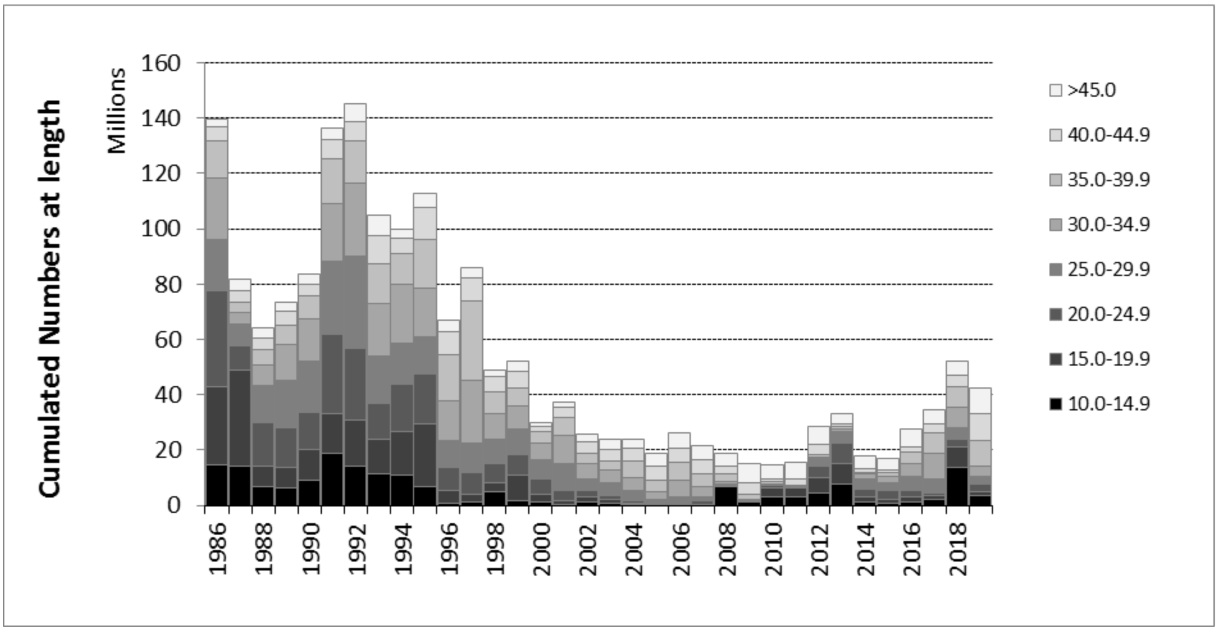


Figure 7.6b. *Sebastes norvegicus.* Abundance indices by age from the winter Norwegian Barents Sea (Division 2.a) bottom-trawl survey (BS-NoRu-Q1 (BTr)) (joint with Russia some of the years since 2000), for 1992-2018 (ref. Table E1b). Age readings for 2017 and 2019 were insufficient to derive numbers at age. Top: absolute index, bottom: relative frequencies.



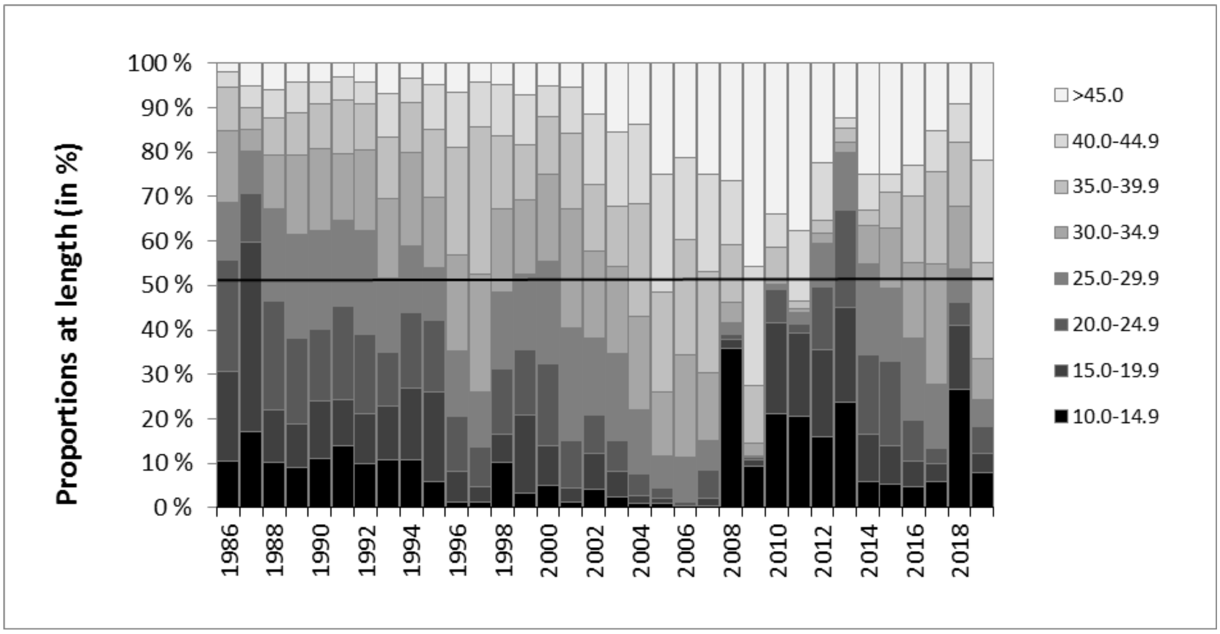


Figure 7.7a. *Sebastes norvegicus.* Abundance indices disaggregated by length when combining the Norwegian bottom-trawl surveys 1986–2019 in the Barents Sea (winter) and at Svalbard (summer/fall). Top: absolute index values. Bottom: relative frequencies. Horizontal line indicates the median length in the surveyed population.

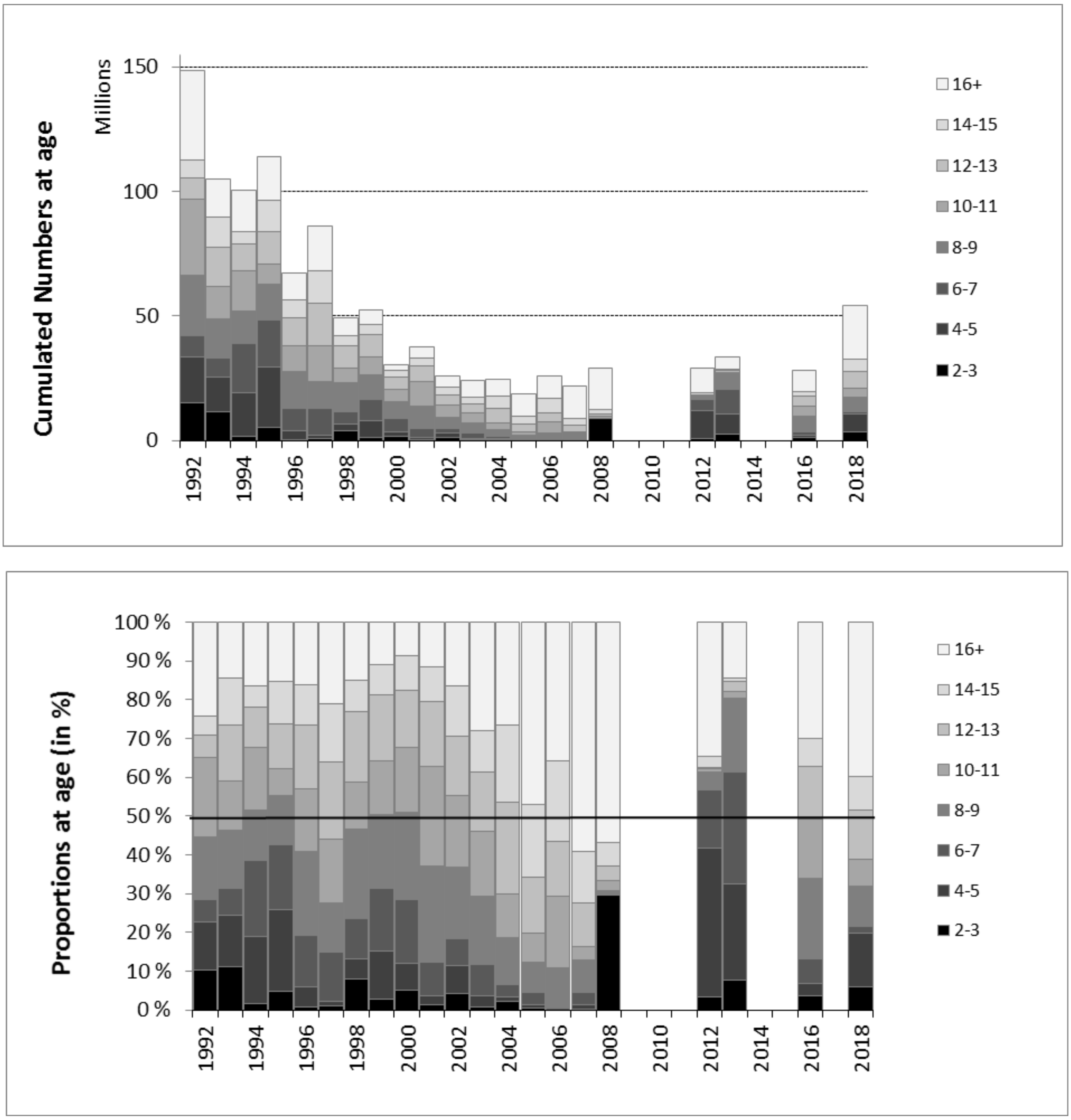


Figure 7.7b. *Sebastes norvegicus*. Abundance indices disaggregated by age. Combined Norwegian bottom-trawl surveys 1992–2016 in the Barents Sea (winter) and Svalbard survey (summer/fall). Top: absolute index values, bottom: relative frequencies. Horizontal line indicates median age of the surveyed population. In 2009–2011, 2014–2015, 2017 and 2019 there was insufficient number of age readings to derive numbers-at-age.

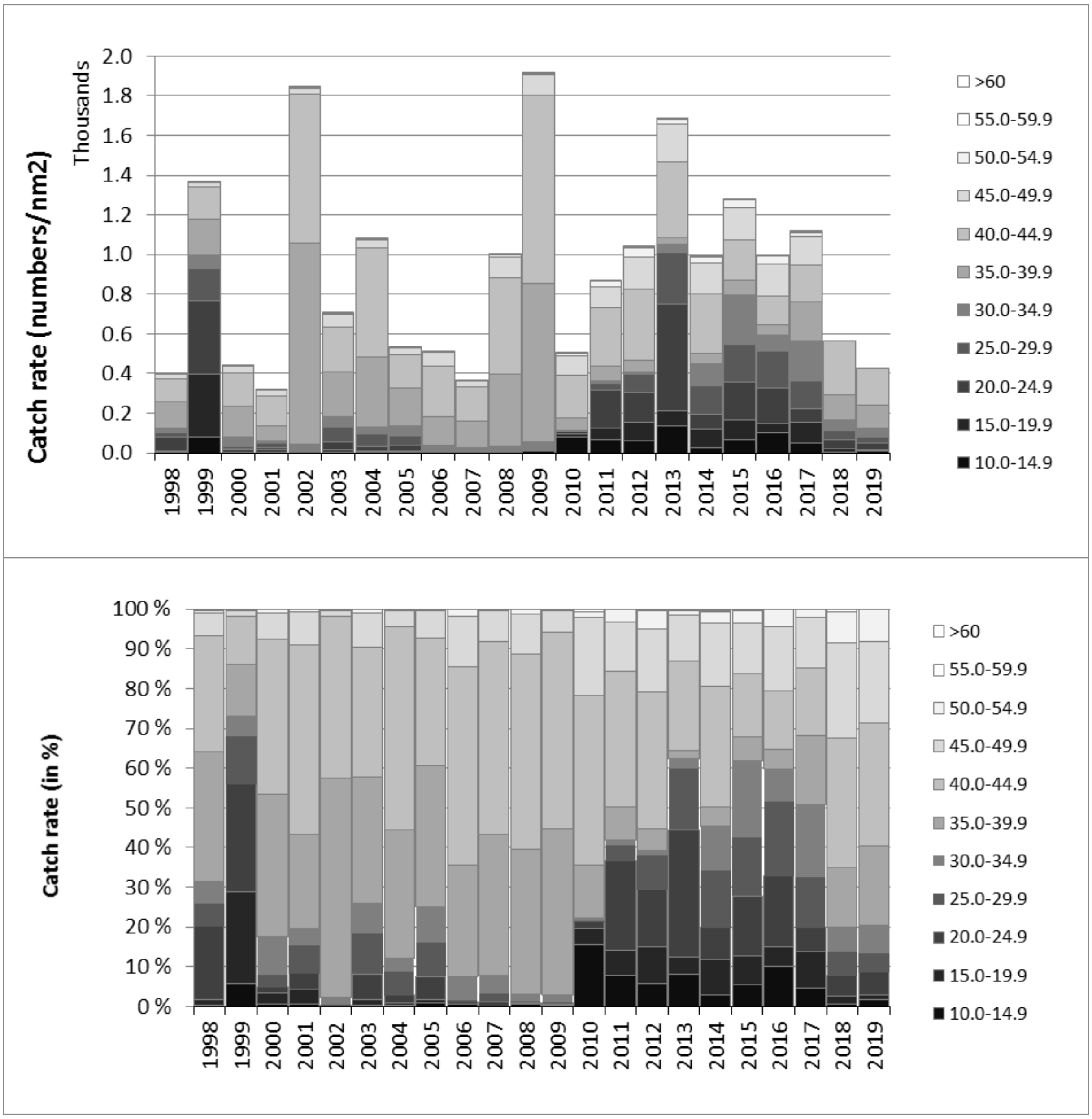


Figure 7.8. ***Sebastes norvegicus.*** **Catch rates (numbers/nm) disaggregated by length for the Barents Sea coastal survey 1998–2019. Top: absolute catch rates. Bottom: relative values.**

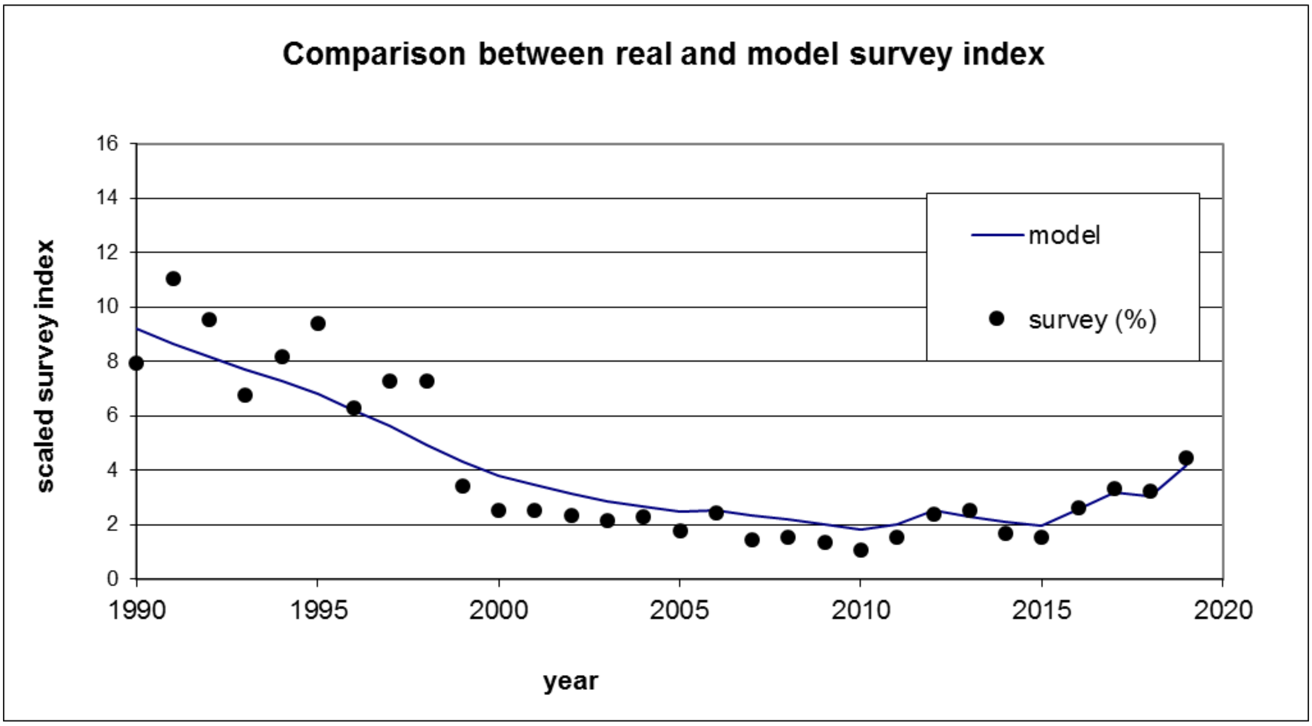


Figure 7.9. ***Sebastes norvegicus*** **in subareas 1 and 2. Comparison of observed and modelled survey indices (total number scaled to sum=100 during the period) for the Barents Sea winter survey in February. Dots: survey indices. Plain lines: survey indices estimated by the model.**

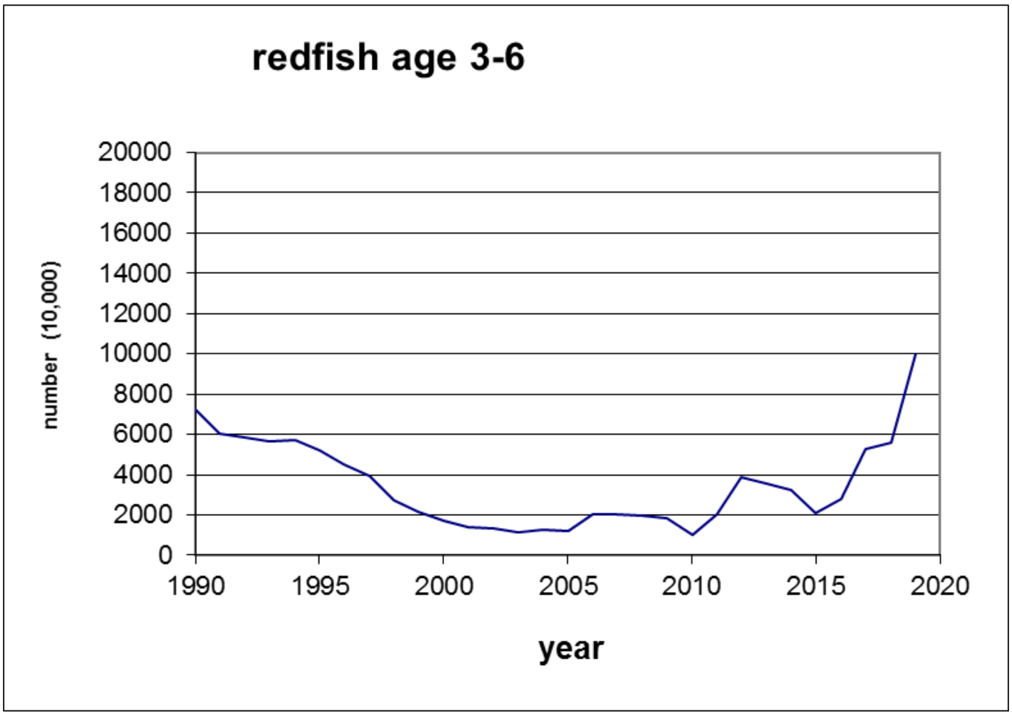


Figure 7.10. ***Sebastes norvegicus*** **in subareas 1 and 2. Estimates of abundance at age 3–6 by Gadget. Note that recent year (since 2015) have very little tuning data behind them.**

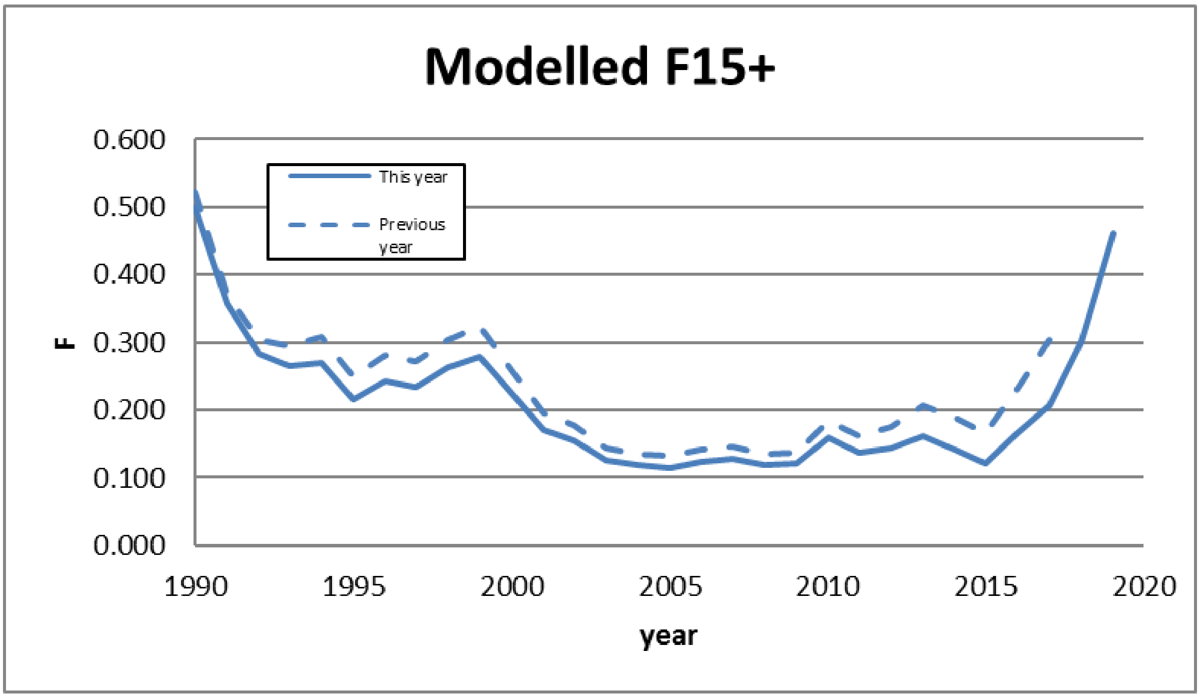


Figure 7.11. ***Sebastes norvegicus*** **in subareas 1 and 2. Unweighted average fishing mortality of ages 15+. Solid line shows this years assessment and the dached line shows last assessment.**

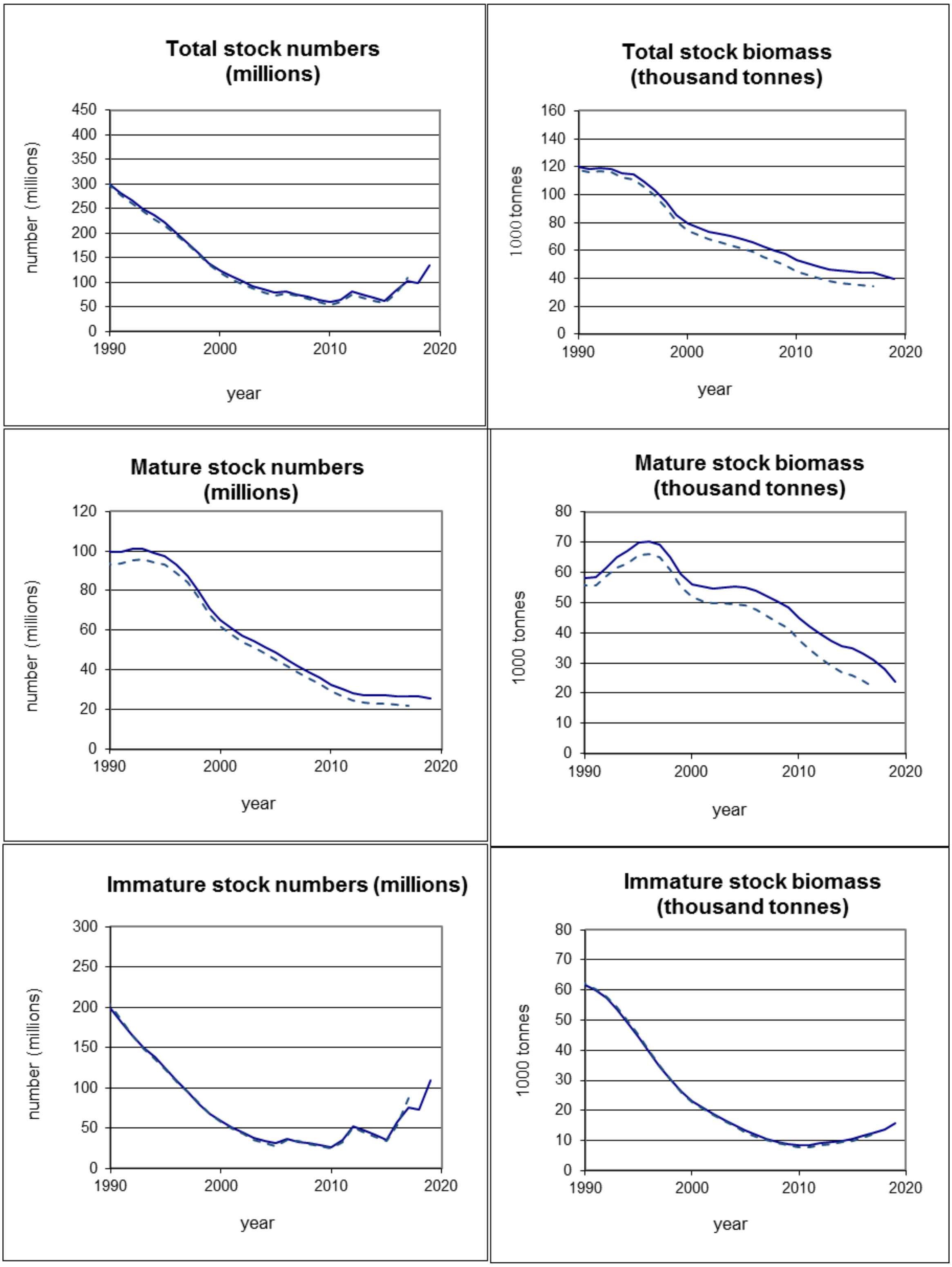


Figure 7.12. ***Sebastes norvegicus*** **in subareas 1 and 2. Stock numbers (in thousands) and biomass (in tonnes) for the total stock (3+) (upper panel), and the fishable and mature stock (middle panel), and the immature stock (lower panel), as estimated by Gadget using two surveys as input. Solid line shows this years assessment and the dached line shows last assessment.**

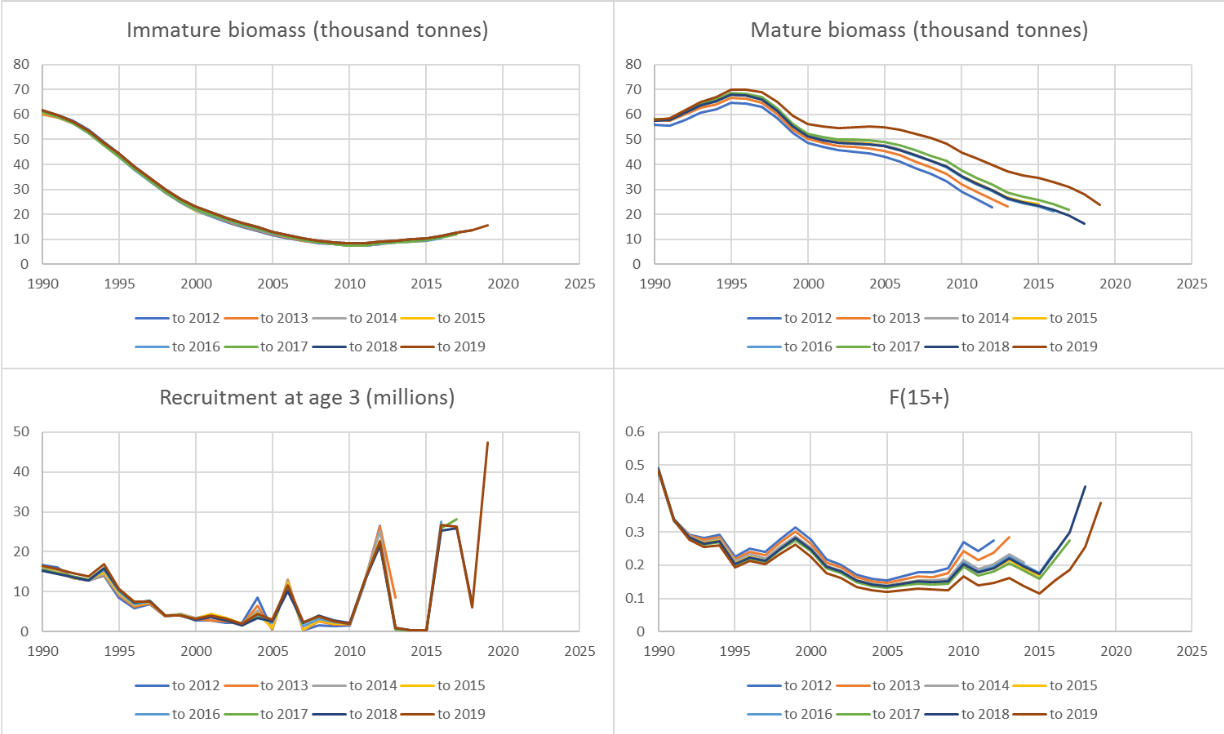


Figure 7.13. Gadget retrospective trends 2012 to 2019, immature biomass, mature biomass, recruitment-at-age 3, and F(15+).

Table E1b. *Sebastes norvegicus* in subareas 1 and 2. Norwegian bottom-trawl indices (numbers in thousands) - on age - from the annual Winter Norwegian Barents Sea (Division 2.a) bottom-trawl survey (BS-NoRu-Q1 (BTr)) from 1986 to 2018. The area coverage was extended from 1993 onwards.

Year/AGE	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1992	2 509	4 070	6 395	2 375	3 757	10 392	4 299	3 567	11 526	2 276	3 239	3 070	3 666	15 183	76 324
1993	996	1 308	1 661	3 005	1 559	7 689	3 346	4 801	2 712	5 480	6 568	2 735	8 801	28 737	79 398
1994	0	9 311	2 441	5 722	11 251	6 422	3 609	7 824	4 775	2 032	6 095	1 825	2 651	10 838	74 796
1995	3 222	4 925	7 594	9 150	5 735	8 496	3 529	2 029	4 800	8 077	3 967	5 353	6 072	14 877	87 826
1996	336	689	2 157	2 902	4 158	7 448	5 816	3 082	6 290	4 122	6 158	3 136	3 518	9 656	59 468
1997	154	37	512	832	1 670	2 893	3 614	3 063	9 084	5 669	10 848	10 393	2 351	17 500	68 620
1998	1 658	859	664	392	1 032	2 323	2 567	2 256	1 897	3 595	5 099	999	2 703	6 804	32 848
1999	552	1 036	1 300	2 557	1 241	1 577	1 938	2 966	1 848	3 407	4 704	1 786	1 884	5 306	32 102
2000	376	545	814	1 567	2 129	2 621	1 902	2 228	1 907	1 506	2 448	2 096	484	1 957	22 580
2001	350	117	241	611	1 589	2 634	2 885	2 686	2 514	2 529	1 853	1 214	1 000	3 630	23 853
2002	904	1 182	685	972	592	1 706	2 549	2 032	1 742	2 286	919	1 053	2 308	3 235	22 165
2003	165	157	539	1 340	533	1 204	2 469	1 610	2 071	1 350	1 796	825	1 204	4 935	20 198
2004	0	181	91	219	536	1 039	1 426	1 093	1 145	2 060	3 066	1 780	2 606	5 668	20 910
2005	57	96	74	114	394	483	636	435	689	1 131	1 166	1 592	1 661	8 287	16 815

Year/AGE	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
2006	0	0	0	0	48	955	1 766	2 516	1 918	1 343	1 984	3 163	1 822	7 403	22 918
2007	19	39	256	39	0	297	154	411	324	823	709	866	909	8 881	13 727
2008	826	0	0	0	76	69	144	217	476	340	575	881	606	6 800	11 010
2009	0	0	0	0	0	0	12	53	156	220	1 189	469	1 013	9 429	12 541
2010	0	0	290	1 051	250	0	364	62	0	140	325	278	467	4 793	8 020
2011	1 873	1 635	1 391	134	64	0	439	0	103	0	213	119	249	7 421	13 641
2012	939	3 726	4 933	620	442	267	291	113	102	86	0	465	382	9 715	22 081
2013	1 806	1 633	4 722	2 784	2 570	2 139	1 208	275	0	483	99	166	0	4 970	22 855
2014	676	887	604	1 255	2 735	1 774	943	446	455	53	228	94	621	4 970	15 741
2015	125	441	946	898	1 267	1 585	2 515	349	1 062	442	471	104	53	4 136	14 394
2016	511	487	302	533	1 213	2 366	2 722	2 018	1 178	883	2 425	1 101	555	7 169	23 463
2017	Age data not available during AFWG 2020														
2018	1 624	1 044	998	259	318	1 759	2 501	1 042	1 707	2 467	2 690	3 495	1 202	7 892	28 998

16+ group is considered in the calculation since 2005. Values prior to this date were derived by subtracting the sum of abundance in groups 1-15 to the total abundance, available in Table E1a.

Table E2a. *Sebastes norvegicus* in subareas 1 and 2. Abundance indices (numbers in thousands) - on length – from the Norwegian Svalbard (Division 2.b) bottom-trawl survey (August-September) from 1985 to 2019. Since 2005 this is part of the Ecosystem survey (Eco-NoRu-Q3 (BTr)).

	Length group (cm)									
Year	**5.0-9.9**	**10.0-14.9**	**15.0-19.9**	**20.0-24.9**	**25.0-29.9**	**30.0-34.9**	**35.0-39.9**	**40.0-44.9**	**>45.0**	**Total**
1985[1]	-	1 307	795	1 728	2 273	1 417	311	142	194	8 325
1986[1]	200	2 961	1 768	547	643	1 520	639	467	196	8 941
1987[1]	100	1 343	1 964	1 185	1 367	652	352	29	44	7 060
1988[1]	500	1 001	1 953	1 609	684	358	158	68	95	6 450
1989	200	1 629	2 963	2 374	1 320	846	337	323	104	10 100
1990	1 700	3 886	4 478	4 047	2 972	1 509	365	140	122	19 185
1991	100	5 371	5 821	9 171	8 523	4 499	1 531	982	395	36 420
1992	1 700	10 228	8 858	5 330	13 960	12 720	4 547	494	346	58 172
1993	200	10 160	9 078	5 855	7 071	4 327	2 088	1 552	948	41 284
1994	100	3 340	5 883	4 185	3 922	3 315	1 021	845	423	22 985
1995	470	2 000	9 100	5 070	3 060	2 400	1 040	920	780	24 840
1996	80	130	1 260	2 480	1 030	480	550	990	400	7 400
1997	0	810	1 980	5 470	5 560	2 340	590	190	450	17 430
1998	180	2 698	1 741	4 620	4 053	1 761	535	545	241	16 403

	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**
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	87	87	104	84	534	635	459	759	738	3 488
2004	0	8	9	192	581	667	607	395	213	2 672
2005	0	52	0	84	267	608	411	274	283	1 980
2006	0	0	75	74	138	437	470	668	1 264	3125
2007	0	47	83	1 251	938	2 012	2 254	373	1 135	8093
2008	8 603	4 255	211	25	50	169	525	180	536	1 4555
2009	216	1 403	108	108	0	0	197	214	220	2 466
2010	868	1 117	1 845	607	0	123	189	0	996	5 745
2011	0	0	850	50	0	0	0	159	578	1 637
2012	0	111	1 565	2 242	2 217	285	0	0	154	6 574
2013	56	489	2 155	3 307	2 738	433	136	34	349	9697

	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
2014	64	0	425	167	296	531	74	0	312	1 870
2015	0	0	0	216	198	303	877	18	810	2 421
2016	0	0	121	119	813	1 007	754	300	498	3 612
2017	838	675	577	93	585	291	476	288	262	4 085
2018	826	11 129	5 619	1 000	677	2 741	1 134	127	110	23 362
2019	78	90	104	219	68	0	115	131	182	987

1 - Old trawl equipment (bobbins gear and 80 m sweep length)

Table E2b. Sebastes *norvegicus* in subareas 1 and 2. Norwegian bottom-trawl survey indices - on age - from the Norwegian Svalbard (Division 2.b) bottom-trawl survey (August-September) from 1985 to 2016. Since 2005 this is part of the Ecosystem survey (Eco-NoRu-Q3 (BTr)). In 2009–2011, 2014–2015 and 2019, 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	0	0	0	0	95	0	283	227	93	296	285	189	228	341	2 035
2004	0	0	0	0	0	0	359	144	362	152	343	315	316	220	2 209
2005	0	50	0	0	0	73	25	286	106	191	271	167	125	152	1 447
2006	0	0	0	0	0	71	0	0	233	106	174	194	305	179	1 261
2007	0	0	0	0	0	617	1 006	398	0	0	155	799	799	303	4 078

	Age														
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
2008	7 844	0	0	0	0	0	0	37	98	16	18	148	86	164	8 412
2009	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2012	0	40	123	2445	2105	1205	642	92	35	0	0	0	0	0	6 687
2013	0	56	383	1532	3963	377	1910	1029	214	121	250	0	0	166	10 000
2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2016	0	0	124	0	0	0	0	813	455	739	0	483	136	263	3 015
2017	356	187	322	97	145	130	193	205	79	292	205	176	278	0	2 667
2018[1]	543	0	1 363	4 066	0	367	885	422	0	970	1 625	0	0	0	10 239
2019	Not available for AFWG 2020														

1 – Provisional figures

Table E3. *Sebastes norvegicus* in Sub-area 1 and 2. Mean catch rates (numbers/nm) of *Sebastes norvegicus* from the Norwegian Coastal Surveys (NOcoast-Aco-Q4) (Division 2.a) in 1998-2017.

Length range (cm)	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	>60	# Hauls	Total.Dist-ance (nm)	# Fish Caught	# Fish Sampled	Area (nm^2)
1998	0	0	692	6 632	73 075	22 255	22 430	130 161	116 216	23 519	2 547	880	0	89	139	778	NA	43 574

Length range (cm)	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	>60	# Hauls	Total.Dist-ance (nm)	# Fish Caught	# Fish Sampled	Area (nm^2)
1999	0	7 587	77 067	317 802	369 258	165 769	67 222	178 802	163 919	20 445	3 642	1 520	0	103	138	2 144	NA	43 574
2000	0	0	1 856	13 048	6 459	13 065	42 990	156 418	171 407	29 117	3 036	331	191	99	144	756	503	43 574
2001	0	295	2 031	11 787	12 305	22 408	14 127	74 790	150 763	26 573	1 787	345	191	81	113	460	325	43 574
2002	0	0	0	0	2 321	7 588	34 283	1 011 273	754 947	26 769	3 195	513	0	109	172	3 289	332	43 574
2003	0	0	2 579	10 118	44 506	72 473	52 479	224 734	228 374	62 121	5 536	481	0	123	160	1 367	1 053	43 574
2004	0	937	3 139	5 591	21 042	66 182	34 613	351 154	552 183	41 851	2 666	1 345	0	104	130	1 290	950	43 574
2005	0	554	5 209	4 627	30 272	46 072	48 379	189 993	170 639	37 468	1 450	0	0	99	132	833	780	43 574
2006	0	0	2 884	496	1 738	3 065	29 933	144 743	256 394	65 959	9 272	0	0	112	112	771	680	43 574
2007	0	0	0	0	4 335	7 308	17 338	129 412	177 332	29 042	1 182	0	0	131	140	637	637	43 574
2008	0	3 644	4 555	955	3 957	4 679	17 440	362 633	490 611	99 469	11 772	1 630	0	110	139	1 156	850	43 574
2009	0	0	6 976	2 285	2 984	4 530	39 275	800 208	945 004	106 479	6 244	663	1 122	114	136	2 947	598	43 574
2010	0	39 758	77 542	20 364	8 814	1 378	2 582	66 948	214 182	99 061	7 417	2 454	0	117	136	833	690	43 574
2011	0	3 654	67 407	55 725	193 640	35 323	10 043	72 244	296 697	107 318	27 832	286	0	113	104	998	571	43 574
2012	0	39 530	59 337	95 227	150 260	89 534	12 686	58 890	356 556	163 645	46 792	4 640	263	98	96	1 191	778	43 574
2013	0	5 176	137 751	72 253	540 679	260 689	38 079	34 628	384 207	190 595	21 534	3 528	2 091	93	95	2 231	1 105	43 574
2014	0	524	28 653	89 876	78 267	144 543	109 523	47 736	302 185	157 358	30 251	2 343	3 361	107	108	1 717	777	43 574
2015	0	5 081	69 615	93 690	193 721	189 891	246 181	77 869	202 765	163 442	41 838	3 335	0	97	103	1 886	984	43 574

Length range (cm)	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	>60	# Hauls	Total.Dist-ance (nm)	# Fish Caught	# Fish Sampled	Area (nm^2)
2016	0	0	100 206	49 233	177 926	186 202	81 997	49 197	145 043	163 426	41 278	869	567	99	101	1 648	1 153	43 574
2017	0	1 789	51 611	101 305	67 426	140 593	205 389	193 380	187 158	141 478	22 447	1 130	515	108	144	2 996	1 866	43 574
2018	0	509	5 230	16 112	43 173	50 831	52 728	124 778	273 489	200 310	67 433	4 181	988	154	220	2 182	1 837	43 574
2019	0	646	10 371	6 780	34 448	29 026	41 674	119 672	183 459	122 349	48 964	263	263	139	162	1 185	1 021	43 574

Table E4. Proportion of maturity-at-age 5 – 30 in *S. norvegicus* in subareas 1 and 2 derived from Norwegian commercial and survey data. The proportions were derived from samples with at least five individuals. Data for years after 2016 was considered insufficient until further age reading.

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1992	0.00	0.00	0.09	0.15	0.31	0.22	0.21	0.20	0.22	0.26	0.30	0.44	0.45	0.47
1993	-	-	0.00	0.00	0.10	0.29	0.54	0.47	0.53	0.67	0.80	0.75	0.78	0.82
1994	0.00	0.00	0.03	0.05	0.28	0.28	0.32	0.70	0.79	0.91	0.94	0.85	0.92	1.00
1995	0.00	0.00	0.00	0.05	0.02	0.22	0.25	0.48	0.61	0.64	0.68	0.80	0.87	0.88
1996	0.00	0.05	0.14	0.13	0.22	0.38	0.43	0.60	0.64	0.75	0.69	0.77	0.90	0.85
1997	0.00	0.05	0.08	0.15	0.17	0.21	0.34	0.35	0.57	0.64	0.72	0.73	0.85	0.93
1998	0.00	0.00	0.03	0.11	0.09	0.26	0.32	0.49	0.52	0.69	0.74	0.77	0.81	0.91
1999	0.00	0.00	0.00	0.04	0.17	0.35	0.22	0.53	0.73	0.71	0.67	0.69	0.74	0.71
2000	0.00	0.08	0.14	0.25	0.40	0.51	0.59	0.62	0.65	0.69	0.78	0.96	0.96	1.00
2001	-	0.00	0.06	0.14	0.28	0.32	0.40	0.52	0.53	0.60	0.76	0.74	0.81	0.85
2002	-	0.00	0.05	0.07	0.23	0.44	0.41	0.63	0.74	0.93	0.77	0.89	0.90	0.94
2003	-	0.00	0.00	0.05	0.13	0.24	0.24	0.47	0.58	0.68	0.75	0.65	0.77	0.78
2004	-	0.00	0.03	0.07	0.13	0.43	0.21	0.51	0.46	0.63	0.64	0.86	0.82	0.96
2005	-	-	0.00	0.05	0.29	0.18	0.34	0.39	0.39	0.56	0.73	0.81	0.79	0.82
2006	-	-	0.00	0.10	0.06	0.22	0.25	0.39	0.47	0.57	0.67	0.67	0.74	0.86
2007	-	-	0.00	0.08	0.30	0.25	0.24	0.66	0.68	0.70	0.88	0.86	0.89	0.99
2008	-	-	0.80	0.25	0.82	0.68	0.62	0.80	0.79	0.86	0.88	0.91	0.90	0.92
2009	-	-	-	-	-	0.50	0.50	1.00	0.93	0.81	0.86	0.86	0.85	0.85
2010	-	-	-	-	-	-	-	-	0.70	0.60	0.81	0.92	0.64	0.90
2011	-	-	-	-	-	-	-	-	-	-	0.73	0.78	0.94	0.93
2012	0.00	0.11	0.10	0.29	0.20	0.20	-	-	-	0.76	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
2014	0.00	0.00	0.02	0.08	0.21	0.43	0.41	0.53	0.33	0.58	0.69	0.71	0.80	0.92
2015	0.00	0.05	0.17	0.17	0.30	0.41	0.44	0.49	0.65	0.67	0.69	0.81	0.91	0.86
2016	0.00	0.04	0.02	0.05	0.23	0.17	0.27	0.41	0.59	0.41	0.62	0.55	0.80	0.74

Year/Age	19	20	21	22	23	24	25	26	27	28	29	30
1992	0.45	0.62	0.51	0.63	0.76	0.60	0.57	0.60	0.68	0.74	0.82	0.80
1993	0.91	0.85	0.82	0.87	0.75	0.91	1.00	1.00	1.00	1.00	1.00	1.00
1994	0.96	0.96	1.00	0.88	1.00	1.00	1.00	1.00	-	1.00	1.00	-
1995	0.76	0.89	0.90	0.91	1.00	1.00	1.00	1.00	-	-	-	-
1996	0.91	0.88	0.96	0.93	1.00	0.87	0.95	0.95	1.00	-	1.00	0.86
1997	0.94	1.00	1.00	0.95	0.89	0.94	0.93	0.89	1.00	1.00	1.00	-
1998	0.89	0.86	1.00	1.00	0.67	0.70	1.00	1.00	-	-	1.00	0.88
1999	0.77	0.89	-	0.83	-	1.00	0.89	-	-	-	-	-
2000	1.00	-	-	-	1.00	-	-	-	-	-	-	-
2001	0.60	0.70	0.56	-	-	-	-	-	-	-	-	-
2002	0.96	0.92	0.95	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-
2003	0.93	0.96	0.94	0.67	1.00	-	1.00	-	-	-	-	-
2004	0.92	0.95	0.89	0.88	1.00	0.86	1.00	-	-	-	-	-
2005	0.77	0.94	0.95	0.88	0.83	1.00	-	1.00	-	-	-	-
2006	0.83	0.97	0.79	0.95	0.81	1.00	-	1.00	-	-	-	-
2007	0.98	1.00	0.96	0.94	1.00	0.92	1.00	0.83	1.00	1.00	1.00	-
2008	0.92	0.90	0.93	0.93	0.94	1.00	1.00	1.00	1.00	1.00	0.93	1.00
2009	0.88	0.95	0.89	0.95	0.92	0.95	0.86	0.94	1.00	0.93	0.83	0.86
2010	0.92	0.96	0.95	0.90	1.00	0.73	0.83	0.86	0.86	0.60	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	0.73	0.83	0.89	0.95	1.00	0.67	1.00	1.00	1.00	1.00
2014	0.92	0.95	0.63	0.96	0.90	0.84	0.95	0.83	1.00	-	0.78	0.88
2015	0.83	0.93	0.78	0.82	1.00	0.95	0.96	0.83	0.84	1.00	0.87	0.82
2016	0.85	0.73	0.88	0.81	0.83	0.97	0.80	0.89	0.92	0.67	1.00	1.00

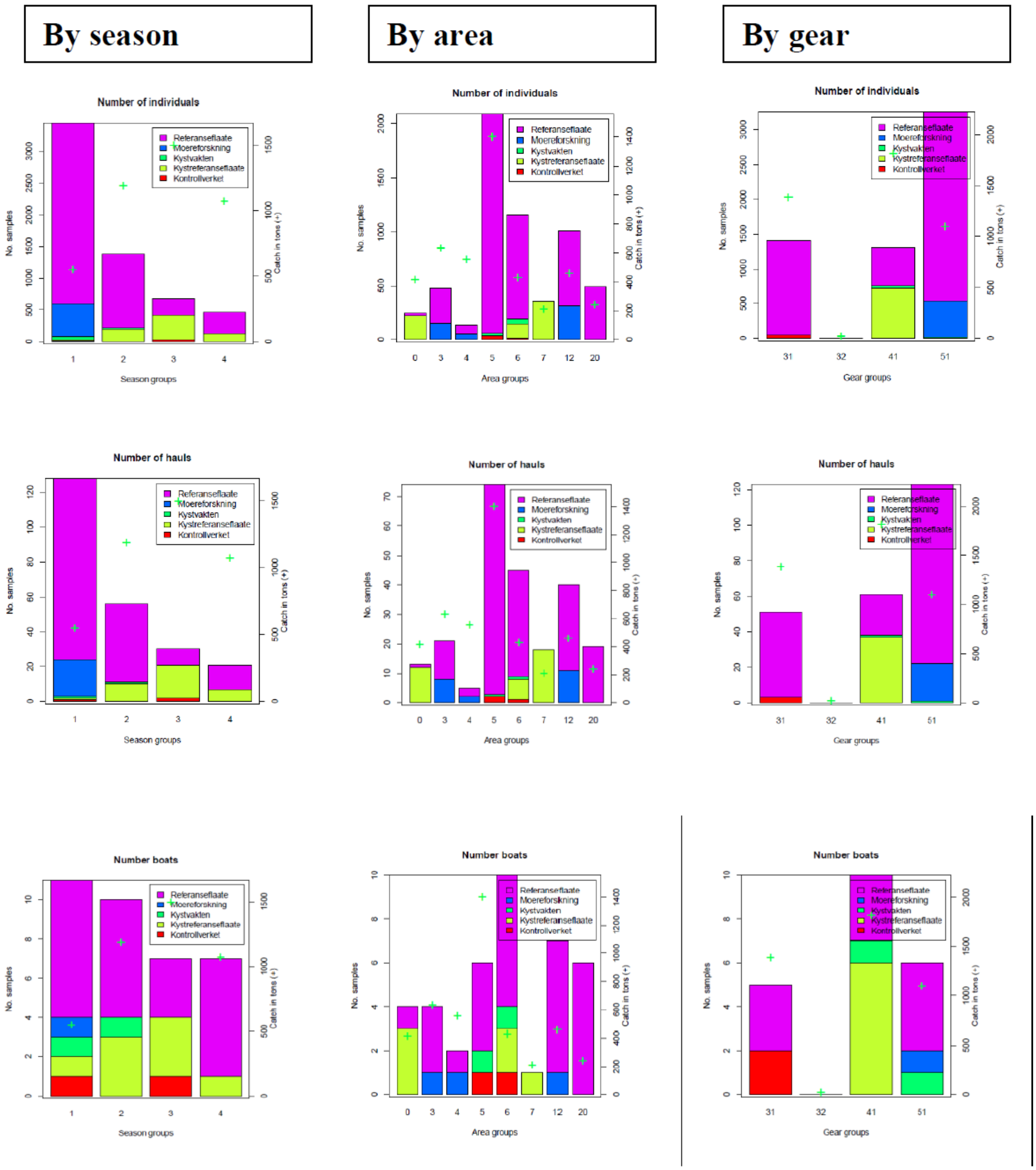


Figure E1. Overview of the Norwegian biological age samples (number individuals, number hauls/sets, number of boats) from the commercial fisheries for *S. norvegicus* in 2013 representing more than 80% of the catches and which the input data to the Gadget model are based upon. The colours denote which sampling platform has been used: High Seas Reference fleet, port sampling, Coast guard, Coastal Reference Fleet, or inspectors/observers at sea. The green crosses show the catch in tonnes for the different seasons, areas and gears.

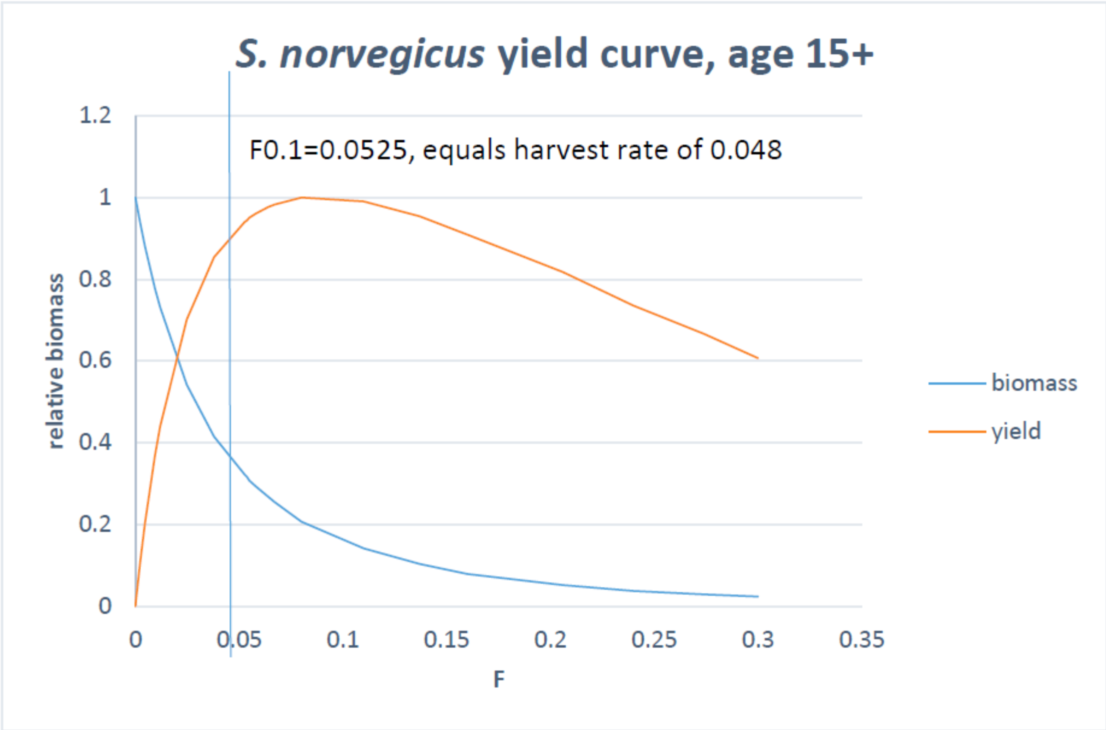


Figure E2. *Sebastes norvegicus* in subareas 1 and 2. Yield-per-recruit for *S. norvegicus*, computed from the GADGET assessment model presented at the benchmark assessment in January 2018 (WKREDFISH, ICES 2018a).

8 Greenland halibut in subareas 1 and 2

The stock is assessed by a GADGET length-based model since 2015. The stock has biennial advice and a draft for advice was last given in 2019 for 2020 and 2021. The draft advice sheet was rejected by ADGANW and a roll-over advice was used for advice in 2020. ADGANW issued a request to repeat the advice process in 2020 with HR_{pa} reference points for use in the 2021 advice. A HR_{pa} proposal is available and was presented to AFWG 2020. However, due to the need for a simplified approach related to the 2020 coronavirus outbreak ACOM decided, in agreement with Advice Requestors, that roll-over advice should be used in 2020 to provide advice on fishing opportunities in 2021. Work on adopting a HRpa is therefore postponed until AFWG 2021. General information about this stock is in the Stock Annex, which was updated after the last benchmark.

8.1 Status of the fisheries

8.1.1 Landings prior to 2020 (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 2a and 2b separately, and landings separated by gear type are presented in Table 8.5. For most countries, the landings listed in the tables are similar to those officially reported to ICES. Some of the values in the tables vary slightly from the official statistics and represent those presented to the Working Group by the members. Catch per unit of effort is presented in Table 8.6 and total catch from 1935-till now in Table 8.7 and Figure 8.1.

The preliminary estimate of the total landings for 2019 is 28 832 t. This is 288 t more than the landings in 2018 and about 5 832 t more than the ICES advised maximum catch for 2019 (23 000 t). The catches from most countries remained fairly stable, compared to 2018.Combined landings exceeded the quotas set by the Joint Russian-Norwegian Fisheries Commission for 2019 by 1 832 t (total TAC 27 000 t). One explanation is the difficulties in bycatch regulation.

Some fishing for Greenland halibut has taken place in the northern part of Division 4a during the past 20–30 years, varying between a few tonnes and up to 1 670 t in 1995. From 2005 to 2011 this catch was mostly below 200 t, taken mostly by Norway, France, and UK. Preliminary numbers show 279 t in 2019, mainly due to the Norwegian trawl fleets (Table 8.8, figures 8.2 and 8.3). Although there is a continuous distribution of this species from the southern part of Division 2a along the continental slope towards the Shetland area, the stock structure is unclear in this area and these landings have therefore not been added to the total from Subareas 1 and 2. Recent mark-recapture and genetic investigations indicate that the stock might have a more south and westward distribution than the current ICES definition of the stock boundaries (Albert and Vollen, 2015, Westgaard *et al.*, 2016).

8.1.2 ICES advice applicable to 2020

The roll over advice from ICES for 2020 was as follows:

ICES advises that when the precautionary approach is applied, catches in 2020 should be no more than 23 000 tonnes. This corresponds to a harvest rate of ≈0.036. All catches are assumed to be landed.

Additional considerations

The benchmark and data workshop process led to an agreed analytic assessment in 2015.

A benchmark meeting (WKBUT; ICES 2013/ACOM:44) was held for the Northeast Arctic (NEA) Greenland halibut in 2013, but the benchmark process was prolonged due to problems with data. A data workshop was conducted in November 2014 (DCWKNGHD ICES CM 2014/ACOM:65), followed by a benchmark by correspondence that ended in 2015. The assessment is reported in the benchmark by correspondence (IBPHALI; ICES CM 2015/ACOM:54) and in the stock annex.

8.1.3 Management

The 38th JRNFC's session in 2009 decided to cancel the ban against targeted Greenland halibut fishery and established the TAC at 15 000 t for the next three years (2010–2012). The 40th JRNFC Session in 2011 decided to increase the TAC for 2012 up to 18 000 t, and at the 42nd JRNFC Session in 2012, the TAC for 2013 was increased to 19 000 t. The 43rd and 44th session kept the same TAC for 2014 and 2015. For 2016 and 2017 TAC was set to 22 and 24 thousand tonnes, respectively. The TAC for 2018 was 27 thousand tonnes and the same for 2019 and 2020.

The TAC for Greenland halibut set by JNRFC applies to catches in ICES areas 1, 2a and 2b, except the Jan Mayen EEZ and the part of the EU EEZ which is north of 62°N.

In 2019 catches of 91 tonnes were taken in the Jan Mayen area (within ICES Subarea 2), where Greenland halibut fisheries are not regulated by TAC.

Norway has a quota for Greenland halibut in the EU EEZ which in 2019 and 2020 is set to 1250 t each year, and can be fished in ICES areas 2a and 6. Thus this TAC is given partly within and partly outside the stock boundary. In 2019, 844 t of this TAC was caught, assumingly mainly in ICES area 2a. Catches in 2018 were 916 t. There is no ICES separate advice for the fishery in this area. However, this quota has until recently not been reported in the advice sheet and when comparing TAC and the total catches in ICES Subareas 1 and 2 this should be kept in mind.

Further information on regulations is found in the Stock Annex.

8.1.4 Expected landings in 2020

Catches in 2019 exceeded the TAC and were 28 832 t. The total Greenland halibut landings in the Barents Sea and adjacent waters (ICES Subarea 1 and Divisions 2a and 2b) in 2020 may thus be higher than the TAC of 27 000 t. Discards at present are not regarded as a problem.

8.2 Status of research

8.2.1 Survey results (Tables 8.9-8.13, Figures 8.4-8.14)

Survey indices from the Russian autumn survey (Figures 8.4-8.6), the Norwegian slope survey (Figures 8.4-8.5 and 8.7-8.8), the Joint Norwegian-Russian Ecosystem survey (Eco-juv and Eco-south indices) (Figures 8.9-8.10) and the Joint Norwegian-Russian Winter Survey are given here (Figure 8.11). Length distributions from these surveys, along with the Spanish survey are presented in Tables 8.9-8.13.

The Russian bottom-trawl surveys in October-December (ICES acronym: *RU-BTr-Q4*) are important since they usually cover large parts of the total known distribution area of the Greenland halibut within 100–900 m depth. However, it has been considered imprudent to use the 2002, 2003 and 2013 data from this survey series. During the 2002 survey, no observations were available from the Exclusive Economic Zone of Norway (NEEZ). In 2003, observations on the main spawning grounds were conducted three weeks later than usual because access to NEEZ was obtained too late. The number of trawl stations was also insufficient due to the same reason. Due to technical problems indices in 2013 were not obtained. Technical and practical changes were made in 2003. In 2019 the coverage was insufficient. To include 2019 will imply a recalculation of the index, and this will be addressed before 2021 AFWG. Length distributions by year for this survey are given in Table 8.9. The biomass indices for this survey increased steeply from 2005 to

2011, fell again until 2014, but showed a steep increase until the last survey was conducted in 2017 (Figures 8.4 and 8.5).

Total biomass indices from the Norwegian autumn slope survey (ICES acronym: *NO-GH-Btr-Q3*) showed an upward trend in biomass estimates between 1994 and 2003, then a downward trend until 2008 until it increased again in 2009 but leveled out again in 2011, 2013, and 2015 (Figures 8.4, 8.5, and 8.7). Since then there is a downward trend and the index for 2019 is the lowest since the start of the survey. The length distributions from this survey show modes that can be followed through the years with marked changes between 2006 and 2007 and also between 2017 and 2019 (Figure 8.12, Tables 8.10 and 8.11). This survey was conducted every year during 1994—2009, but is now run biennially.

The Joint Ecosystem Survey in autumn covers a large part of the Barents Sea down to 500 m and concerning Greenland halibut it can be regarded to be in the areas where mainly juveniles and immature fish are found. Two indices for Greenland halibut are based on the Joint Ecosystem Survey in the Barents Sea and previous juvenile survey, one for juvenile areas (Figure 8.9) denoted Eco-juv index in the northernmost survey area, and another denoted Eco-south index for adults defined by the survey area south from 76.5°N and west of Spitsbergen (Figure 8.10). The juvenile index, covering the juvenile area (see section 8.3), indicates a highly variable recruitment success with years between good year classes. The 2015 and 2016 estimates are the lowest registered so far, followed by an increase in 2017. The 2018 estimate, however, dropped down to the 2016 level and further down in 2019. The Eco-south index for females showed an increasing trend towards 2012, followed by a decrease towards 2015. The index has since shown an increasing trend until 2018 but is at a lower level in 2019. The male index shows a similar trend except the increase started a year later, in 2016 - 2018, but is also down in 2019. Length distributions by year for this survey are given in Table 8.11.

The joint winter survey int the Barents Sea (ICES acronym: *BS-NoRu-Q1*) has been run from 1986 to present (jointly with Russia since 2000, except 2006 and 2007). The vertical coverage is in depths of 100—500 m, so it does not cover the deeper slope areas. The horizontal coverage is the central Barents Sea, and west of Svalbard for some years. The northward coverage is limited by ice in some years. It is conducted in February and can thus give information on the stock at different times of year, as the other surveys are run in autumn. The main trend in the biomass index from the survey was downward until 2004, rather steeply upwards until 2008 and a varying and more slowly upward trend since then.

The Spanish bottom-trawl survey (ICES acronym: *SP-Svalbard-Q4*), (Table 8.13, Figure 8.13) is carried out on a new hired commercial vessel and some changes have been done in the initial standard protocol. 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 to present). The conclusion is that it is considered not possible to obtain a reliable standardization of the surveys. This means that biomass estimates from the survey are only available for years 2008 and onwards. The Spanish survey has since 2015 only been run in autumn. The biomass index from the Spanish survey shows a downward trend since around 2012.

Polish bottom-trawl surveys on Greenland halibut were carried out in the Svalbard-Bear Island area (ICES 2b) in October 2006, April 2007, April 2008, June 2009, and March 2011. The main objectives of the survey were to determine the biological structure, distribution, density and standing biomass of Greenland halibut in the survey area (Trella and Janusz, WD6 ICES AFWG 2012). Polish survey index is shown in Figure 8.14, no new data were presented to the meeting.

8.2.2 Commercial catch-per-unit-effort (Table 8.6, Figure 8.15)

The CPUE series for the stock has been a subject to the benchmark and following data workshops (see reports from WKBUT 2013, DCWKNGHD 2014 and IBPHALI 2015, and working documents by Bakanev (WD14 WKBUT 2013) and Nedreaas (WD 2 DCWKNGHD 2014)) (Figure 8.15). An alternative CPUE series for the Russian fisheries for the years 2004–2015 was presented to the 2016 meeting (Mikhaylov, WD14 ICES AFWG 2016). It shows some discrepancies compared to previous CPUE series used for the Russian fisheries for the same years. See Stock Annex for further comments.

8.2.3 Age readings

Based on the scientific understanding that the species is more slow growing and vulnerable than the previous age readings suggest, the Norwegian age reading methods were changed in 2006. The new Norwegian age readings are not comparable with older data or the Russian age readings.

The report from Workshop on Age Reading of Greenland Halibut (WKARGH) 14—17 February 2011 (ICES CM 2011/ACOM:41) described and evaluated several age reading methods for Greenland Halibut.

The different methods can be classified into two groups: A) Those that produce age–length relationships that broadly compare with the traditional methods described by the joint NAFO-ICES workshop in 1996 (ICES CM 1997/G:1); and B) Several recently developed techniques that show much higher longevity and approximately half the growth rate from 40–50 cm onwards compared to the traditional method.

A second workshop on age reading of Greenland halibut (WKARGH 2) was conducted in August 2016 and worked on further validation on new age reading methods. The workshop recommended that two of the new methods can be used to provide age estimations for stock assessments. Further, recognizing some bias and low precision in methods, the WKARGH2 suggested that an aging error matrix or growth curve with error be provided for use in future stock assessments (WKARGH2 report 2016, ICES CM 2016/SSGIEOM:16).

WKARGH2 recommends regular interlab calibration exercises to improve precision (i.e. exchange of digital images between readers for each method and between methods). AFWG suggests that Russian and Norwegian scientists and age readers meet to work out issues of disagreements on Greenland halibut aging.

8.3 Data used in the assessment

Catch data are split into four aggregated fleets. Longline/gillnet fleet includes landings from gillnet, longline, and handline. Trawl fleet includes landings from bottom trawl, purse-seine (very minor catches, can be bycatch or misreporting) and Danish seine. Catch in tonnes and length distributions per quarter per fleet per sex from 1992–2018 are used in the assessment. Fleets are split between Norwegian (including 3rd countries) and Russian catches, and selectivities are allowed to vary by sex (logistic for gill fleets, asymmetric dome-shaped for trawl fleets), to account for sexually dimorphism influencing vulnerability to fishing. For each fleet listed below, length distributions and reported catch in tonnes are split by quarter and sex (although length distributions are not available for all quarters for some fleets).

- Russian, trawl and minor gears (split by sex)
- Russian, gillnet and longline (split by sex)
- Norwegian and 3rd countries, trawl and minor gears (split by sex)
- Norwegian and 3rd countries, gillnet and longline (split by sex)

In addition, the model has four surveys, all modeled with asymmetric dome-shaped selectivities (note that in a model context “selectivity” encompasses all aspects of vulnerability to the fishery, including gear effects, vessel effects, area effects etc.). In each case, data are used as length distribution and biomass index. The biomass index was not available split by sex for all years, so a combined sex index is used. Four survey indices go into the current assessment:

- Norway slope – based on the Norwegian Greenland halibut slope survey *(NO-GH-Btr-Q3)* (yearly 1996–2009, biennially since then). Split by sex.
- EcoJuv - a juvenile index based on data from the northern/northeastern areas of the Joint Ecosystem survey (Eco-NoRu-Q3 (Btr)) (2003–present) and the precursory Norwegian juvenile Greenland halibut survey north and east of Svalbard (1996—2002) (Hallfredsson and Vollen, WD 1 ICES IBPhali 2015). Split by sex.
- EcoSouth - an index for the Barents Sea south of 76.5°N, based on data from the Joint Ecosystem survey (Eco-NoRu-Q3 (Btr) (2003—present) (Hallfredsson and Vollen, ICES AFWG, WD 20, April 2015). Split by sex.
- Russian - Russian bottom-trawl survey in the Barents Sea (*RU-Btr-Q4*) (1992-2015 and 2017). Sex aggregated (can be split by sex in future work).

No age data or CPUE indices are used in the tuning.

8.4 Methods used in the assessment

A new assessment method with a length-based GADGET model was benchmarked in 2015 (IPHALI 2015) and accepted by ACOM the same year. The model is further described in the IPHALI report and the Stock Annex.

8.4.1 Model settings

Model used: Gadget (see ICES, 2015).

Time period: 1992–2018, monthly time-steps

Model structure:

- 1 cm length classes (1—114+ cm) and 1-year age classes (1—30+)
- Two sexes, split into mature and immature
- Logistic maturity estimated for each sex
- Von Bertanlanffy growth estimated separately for males and females
- L-W relationship fixed based on data from the Norwegian slope (Females: a = 1.4E-6 and b = 3.47. Males: a = 5.7E-6 and b = 3.12)
- Natural mortality set to 0.1 for all fish
- Initial size of recruits fixed at 8.5 cm (necessary to fix this in the absence of age data)
- Recruitment modeled as annual numbers, no relationship with SSB
- Four aggregated fleets (as described above), each with sex-specific selectivity (logistic for gillnet and longline fleets, asymmetric dome-shaped for trawl)
- Four surveys (as described above), all with asymmetric dome-shaped selectivity

Note that to avoid the problem of modeled fish not covered by any fleet (and therefore not tuned to any data) the gillnet and longline fleets have been assumed to have logistic (flat topped) selectivity.

Estimated parameters:

Estimated parameters are L_{50} and slope for the maturation (male and female separately), two growth parameters per sex, two maturation parameters per sex, one annual recruitment parameter per year, two parameters for s.d. of length of recruits, parameters governing commercial selectivity (two per sex per gillfleet and three per sex per trawlfleet), one effort parameter per year for each fleet, three parameters per survey per sex governing selectivity, initial population numbers for male and female fish by age, initial population s.d. of lengths by sex and age.

Data used for tuning are:

- Quarterly length distribution of the landings from commercial fishing fleets (by sex)

- Quarterly catch in tonnes for each fleet (by sex)
- Length disaggregated survey indices from the four surveys (by sex except for the Russian survey)
- Overall survey index (by biomass) for the four surveys (by sex except for the Russian survey)
- Estimated maturity ogives (maturity at length in the population) for 1992—2014 (by sex)

Note that no age data are used in tuning the model. Although age readings are available for some years there is not a full agreement on which age-reading methodology should be used, and these data are thus not suitable for inclusion in an assessment model yet.

Concerning the recruitment, it should be noted that age 1 is the age for recruitment to the stock, NOT the age for recruitment to the fishery, which is the quantity normally used to describe recruitment. But since age 1 recruitment is the quantity estimated by the model and the age of recruitment to the fishery can't be defined due to lack of age data, we use age 1 as the recruitment age for this stock. Even if adequate age data were available, the strong sexual dimorphism in growth would make it very difficult to define an appropriate recruitment age to the fishery.

8.5 Results of the Assessment

The assessment is conducted every two years and advice was given in 2019 for catches in 2020 and 2021. Model results are shown in Figures 8.16 and 8.17, and Table 8.14. The stock abundance and biomass are presented for fish larger than 45 cm, this corresponds to the minimum legal size and is slightly larger than L_{50} maturity for males. Both 45 cm+ abundance and biomass peaks around 2013-2014 and show a slow downward trend since then. There is a retrospective trend to reduce the stock estimate over time. However, the last 4 years of the retrospective for the 45cm+ biomass are very consistent (Figure 8.18). The modeled recruitment is spiky (Figure 8.17), and this is likely exaggerated due to the lack of age data. However, although the real recruitment is likely more spread out, the modeled peaks show reasonably good agreement to the data from the juvenile survey. This stock is dominated by sporadic recruitment events, and the model does a reasonable job of capturing this. The model has been consistently estimating reasonably good recruitment in 2009-2010, which should be entering the fishery in the coming years.

8.5.1 Biological reference points

The last observed year with good recruitment occurred in 1995 at 487 000 tonnes of fishable (45+ cm) biomass. There is evidence (in the estimated initial population for the assessment model) that an earlier good recruitment event occurred in the 1980s from lower biomass, but the exact biomass level is unknown as this is before the model period. The precautionary reference point is therefore taken at 487 000 tonnes, with a note that this is likely to be on the high (precautionary) side. Using 45+ cm biomass (rather than total or female SSB) avoids uncertainty around maturation sizes and the different distributions of males and females, and relates directly to the fishable stock, but does not directly relate to the most vulnerable or critical female SSB.

8.5.2 NEA Greenland halibut surplus production models

Results of the assessment of the Barents Sea Greenland halibut stock based on a Bayesian surplus production model was provided by Bakanev in 2013, (WKBUT WD 14). Different sets of abundance indices were used for tuning the model. The analysis of model run results has shown that K is estimated within the range of 810 to 1139 kilotonnes, B_{MSY} of 405 to 570 kilotonnes and MSY of 23 to 47 kilotonnes. However, the model was sensitive to the choice of prior on K. Taking into consideration a high probability of the stock size being at the level which was quite a bit above B_{MSY}, the risk of the biomass being below this optimal one was very small in 2002–2012 (<1%). The risk analysis of the stock size in the prediction years (2013–2020) under the catch of 0 to

30 kilotonnes indicated that the probability of the stock size being under the threshold levels (B_{MSY}, B_{lim}) was also minor (less than 1%). It was concluded that further work was needed on the historical CPUE series. Based on scrutiny of the CPUE series it was recommended to examine runs with the surplus production model for the period 1964—1991 and 1964—2005, in addition to runs for the whole 1964—2013 period. Fisheries CPUE series were considered less reliable to reflect stock dynamics than survey indices in the period after regulations of the fishery were introduced in 1992. The Bayesian surplus model was not updated for presentation at the current meeting.

A production model was presented to the 2016 meeting (Mikhaylov, 2016, WD 14), although this model has not been reviewed at a benchmark, nor were biomass trends presented at this meeting. The model has been proposed as a possible method for estimation of long-term reference points. An update was presented to the 2019 meeting (Mikhaylov 2019, AFWG 2019 WD21). In the current version, the MSY would be around 34 ktonnes, the BMSY around 500 ktonnes and F_{MSY} on the level 0.069. It should be noted that these values are not directly transferable to a different model with different biomass levels and in any case a long-term average. The WD concludes that, in general, the stock can withstand the current fishing load and the fishing regime is approaching optimum, indicating that the results of the exploratory surplus production model are in general alignment with the assessment and advice presented here.

F_{MSY} is not appropriate to this stock given the recent extended run of poor recruitment, and such values have not been evaluated for precautionarity. In a plenary, it was concluded that it would be useful for further development of the production model to conduct separate exploratory runs for CPUE split into before and after 1992 and run with CPUE only before 1992 and survey data after 1992. This production model was not updated for presentation at the current meeting.

At the 2018 meeting, AFWG results from SPiCT production model were presented (AFWG report 2018). In the run that is presented in this report, all available data up to 2016 were used. For run with default priors applied K = 995 421 t and deterministic reference points were B_{MSY} = 419 955 t, F = 0.07 and MSY = 29 742 t. Stochastic reference points for this run were in a similar range. Run with default priors deactivated gives similar MSY estimate but otherwise rather different estimates; K = 2 504 006, B_{MSY} = 609 410 t, F = 0.05 and MSY = 28 097 t. Further utilization of this approach demands closer scrutiny of model settings in relation to diagnostics. The SPiCT model can be a flexible tool to examine production model approach to Greenland halibut, however, concerns highlighted below still apply.

In principle, a production model could be used in conjunction with the GADGET assessment model in order to extend the simulations back in time and provide better estimates for B_{lim}. However, the inability of production models to follow variable recruitment, and especially runs of above or below average recruitment, limits their ability to give advice for this stock.

In the benchmark report (IBPHALI 2015) Table 3.3 gives CPUE series and survey estimates that can be helpful for this task (Figure 8.15).

8.6 Comments to the assessment

The draft advice sheet was rejected by ADGANW and a roll-over advice was used for advice in 2020. ADGANW issued a request to repeat the advice process in 2020 with HR_{pa} reference points for use in the 2021 advice (ICES 2017). A working document (Howel 2020, WD 15) was presented to address the definition of a HRpa for the stock. However, due to the need for a simplified approach related to the 2020 corona virus outbreak ACOM decided, in agreement with Advice Requestors, that roll-over advice should be used in 2020 to provide advice on fishing opportunities in 2021.

The ongoing reduction in sex-split length samples in two survey indices, EcoJuv and EcoSouth required a change in methodology for computing the tuning indices used in the assessment. The change was implemented in the 2019 assessment. This increased the absolute biomass estimates by about 10% but did not affect the trend in biomass through years. This change has also acted to reduce the retrospective pattern differences in recent years, likely as a result of the model no longer chasing noise in the data. We stress once again that the absolute biomass levels for this model are rather uncertain. Without age data in the model tuning there is little information on total mortality (Z) at age (number-at-age x in year y minus number-at-age x-1 in year y-1 gives information on Z). Without this, there is little information for the model to translate catch information into F, and hence inform biomass levels. Furthermore, the conflicting survey signals translate into an uncertainty range of several hundred thousand tonnes (IBPHALI 2015). All the exploratory work suggests that the overall trends are robust, but that care should be taken in interpreting the absolute abundance estimates (and hence absolute estimates of harvest rate).

Although there is little retrospective pattern differences over the last four years, the model exhibits a retrospective pattern in earlier years associated with the biomass peak around 2014 (Figure 8.18). The two coastal shelf surveys (the ecosystem survey and the Russian survey) showed a more rapid rise than the other surveys, and then a more rapid reduction. The Russian survey had a very rapid rise and then a rapid decline. The model, therefore, had a series of downward revisions as the peak was passed, where the model now estimates that it had previously been over-optimistic about the size of the peak. It should be noted (ICES IBPHALI REPORT 2015; ICES CM 2015\ACOM:54) that there is an issue with this stock where different surveys give different signals and choosing one survey over the others could affect the biomass level by several hundred thousand tonnes. Given this, a retrospective pattern is probably to be expected as the different surveys evolve. Note also that one of the surveys is run every two years (in odd-numbered years), this accounts for the grouping of lines in the retrospective pattern into pairs.

To facilitate the calculation of spawning-stock biomass, maturity ogives from the Norwegian Slope survey were derived for years 1994–2015. These ogives give approximately identical length at 50% maturation (L_{50}) for males compared L_{50} based on Russian fisheries data (Figures 8.19-8.22). L_{50} for females is higher in the Norwegian data due to new definition on when females are considered mature/immature in accordance to recent research (Kennedy *et al.*, 2009, 2011 and 2014, Nunez *et al.*, 2015). GLM fitted ogives can be used in future assessments.

Future work

Further development of the assessment is needed and, in consistency with conclusions of the IBPHALI benchmark and report of the external benchmark reviewer.

AFWG suggest a new benchmark on the stock in 2022, and intersessional work will commence on a possible issues list. Such a benchmark, especially if it can extend the model back in time to a period of lower stock biomass, would allow a more accurate determination of precautionary biomass reference points. It would, therefore, be a precursor to a potential MSE to generate an HCR for this stock and move away from precautionary advice.

At ADGANW 2019 it was suggested that an inter benchmark process should be undertaken where a simple F_{msy} proxy is developed as well as $B_{trigger}$, or failing that a F_{pa} to provide precautionary advice.

The working document (Howel 2020, WD 15) proposed an interim HRpa (harvest rate pa) until such time as the stock next undergoes a full benchmark followed by a HCR evaluation to come with a full management plan for this stock. Ideally, such a benchmark would take place in 2022.

The HRpa is based on the method proposed in the 2017 ICES fisheries management reference points for category 1 and 2 stocks (ICES 2017). This method involved projecting the stock forward under average recruitment to identify the fishing level F_{lim} that drives the stock to Blim under equilibrium. This method was chosen because the lack of age tuning data makes the variability of recruitment unreliable, and using averages is a more robust approach. There is a modification to allow for the fact that in light of the lack of contrast in the data this stock has B_{pa} set equal to B_{lim}, and hence the method gives HR_{pa} directly, and there is no need to first compute an HR_{lim} and then adjust this for an HR_{pa}. In using this approach it is necessary to select the recruitment average to use, and the method chosen was to use the full-time series of recruitment, but excluding the extra high peak in 2003, with the justification that such a recruitment peak has not been repeated since and therefore this level of recruitment cannot be expected to enter the fishery in the coming years.

The overall proposal from the WD is: The proposed HR_{pa} for Greenland halibut in areas 1 and 2 is 0.035, with the provison that if a large recruitment event is observed in the surveys then the HRpa should be revised before the incoming good recruitment entering the fishery.

This solution for HR_{pa}, if accepted by ACOM, would apply until a suggested benchmark. The meeting decided to revisit this at the 2021 AFWG meeting, to consider the use of this HR_{pa} in advice for 2022 and 2023.

Further work on biological reference points is a topic to be addressed towards a benchmark.

Table 8.1. GREENLAND HALIBUT in Subareas 1 and 2. Nominal Catch (t) by countries (Subarea 1, Divisions 2a, and 2b combined) as officially reported to ICES.

Year	Denmark	Estonia	Faroe Islands	France	Fed. Rep. Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
1984	0	0	0	138	2 165	0	0	0	0	0	4 376	0	0	15 181	0	0	23	0	21 883
1985	0	0	0	239	4 000	0	0	0	0	0	5 464	0	0	10 237	0	0	5	0	19 945
1986	0	0	42	13	2 718	0	0	0	0	0	7 890	0	0	12 200	0	0	10	2	22 875
1987	0	0	0	13	2 024	0	0	0	0	0	7 261	0	0	9 733	0	0	61	20	19 112
1988	0	0	186	67	744	0	0	0	0	0	9 076	0	0	9 430	0	0	82	2	19 587
1989	0	0	67	31	600	0	0	0	0	0	10 622	0	0	8 812	0	0	6	0	20 138
1990	0	0	163	49	954	0	0	0	0	0	17 243	0	0	4 764	0	0	10	0	23 183
1991	11	2 564	314	119	101	0	0	0	0	0	27 587	0	0	2 490	132	0	0	2	33 320
1992	0	0	16	111	13	13	0	0	0	0	7 667	0	31	718	23	0	10	0	8 602
1993	2	0	61	80	22	8	56	0	0	30	10 380	0	43	1 235	0	0	16	0	11 933
1994	4	0	18	55	296	3	15	5	0	4	8 428	0	36	283	1	0	76	2	9 226
1995	0	0	12	174	35	12	25	2	0	0	9 368	0	84	794	1106	0	115	7	11 734
1996	0	0	2	219	81	123	70	0	0	0	11 623	0	79	1 576	200	0	317	57	14 347
1997	0	0	27	253	56	0	62	2	0	0	7 661	12	50	1 038	157	0	67	25	9 410

Year	Denmark	Estonia	Faroe Islands	France	Fed. Rep. Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
1998	0	0	57	67	34	0	23	2	0	0	8 435	31	99	2 659	259	0	182	45	11 893
1999	0	0	94	0	34	38	7	2	0	0	15 004	8	49	3 823	319	0	94	45	19 517
2000	0	0	0	45	15	0	16	1	0	0	9 083	3	37	4 568	375	0	111	43	14 297
2001	0	0	0	122	58	0	9	1	0	0	10 896	2	35	4 694	418	0	100	30	16 365
2002	0	219	0	7	42	22	4	6	0	0	7 143	5	14	5 584	178	0	41	28	13 293
2003	0	0	459	2	18	14	0	1	0	0	8 216	5	19	4 384	230	0	41	58	13 447
2004	0	0	0	0	9	0	9	0	0	0	13 939	1	50	4 662	186	0	43	0	18 899
2005	0	170	0	32	8	0	0	0	0	0	13 011	0	23	4 883	660	0	29	18	18 834
2006	0	0	204	46	8	0	8	0	0	196	11 119	201	26	6055	29	0	10	2	17 904
2007	0	0	203	41	8	198	15	0	0	0	8230	200	47	6484	8	0	11	8	15 453
2008	0	0	663	42	5	0	28	0	0	0	7393	201	46	5294	94	0	16	10	13 792
2009	0	0	422	16	19	16	15	2	0	0	8 446	204	237	3 335	210	0	9	60	12 990
2010	0	0	272	102	14	15	16	0	0	0	7 700	3	11	6 888	182	0	4	22	15 229
2011	0	0	538	46	80	4	7	0	0	234	8 270	169	21	7 053	144	0	36	4	16 606
2012	0	0	564	40	40	12	13	0	0	0	9 331	22	1	10 041	190	0	21	14	20 288
2013	0	0	783	168	49	22	106	1	0	0	10 403	30	7	10 310	196	0	17	75	22 167
2014	0	0	887	269	33	20	86	0	0	0	11 232	19	0	10 061	206	0	28	184	23 025
2015	0	0	312	227	33	14	53	0	0	5	10 874	13	1	12 953	159	0	25	79	24 748
2016	0	359	483	229	9	17	79	0	0	0	12 932	8	19	10 576	198	0	20	19	24 948
2017	0	523	917	177	21	26	10	0	1	72	13 741	27	13	10 714	56	0	83	0	26 380
2018*	2	574	409	150	51	32	0	0	4	177	14 874	27	6	12 072	60	108	0	0	28 544
2019*	0	588	350	105	44	23	9	0	32	377	14 813	122	8	12 198	87	75	0	0	28 832

*** Provisional figures.**

Table 8.2. GREENLAND HALIBUT in Subareas 1 and 2. Nominal catch (t) by countries in Subarea 1 as officially reported to ICES.

Year	Estonia	Faroe Islands	Fed. Rep. Germany	France	Latvia	Lithuania	Greenland	Iceland	Ireland	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (England & Wales)	UK (Scot land)	Total
1984	0	0	0	0	0	0	0	0	0	593	0	0	81	0	0	17	0	691
1985	0	0	0	0	0	0	0	0	0	602	0	0	122	0	0	1	0	725
1986	0	0	1	0	0	0	0	0	0	557	0	0	615	0	0	5	1	1 179
1987	0	0	2	0	0	0	0	0	0	984	0	0	259	0	0	10	0	1 255
1988	0	9	4	0	0	0	0	0	0	978	0	0	420	0	0	7	0	1 418
1989	0	0	0	0	0	0	0	0	0	2 039	0	0	482	0	0	0	0	2 521
1990	0	7	0	0	0	0	0	0	0	1 304	0	0	321	0	0	0	0	1 632
1991	164	0	0	0	0	0	0	0	0	2 029	0	0	522	0	0	0	0	2 715
1992	0	0	0	0	0	0	0	0	0	2 349	0	0	467	0	0	0	0	2 816
1993	0	32	0	0	0	0	0	56	0	1 754	0	0	867	0	0	0	0	2 709
1994	0	17	217	0	0	0	0	15	0	1 165	0	0	175	0	0	0	0	1 589
1995	0	12	0	0	0	0	0	25	0	1 352	0	0	270	84	0	0	0	1 743
1996	0	2	0	0	0	0	0	70	0	911	0	0	198	0	0	0	0	1 181
1997	0	15	0	0	0	0	0	62	0	610	0	0	170	0	0	0	0	857
1998	0	47	0	0	0	0	0	23	0	859	0	0	491	0	0	2	0	1 422
1999	0	91	0	0	0	0	13	7	0	1 101	0	0	1 203	0	0	0	0	2 415
2000	0	0	0	0	0	0	0	16	0	1 021	0	0	1 169	0	0	0	0	2 206
2001	0	0	0	0	0	0	0	9	0	925	0	0	951	0	0	2	0	1 887
2002	0	0	3	0	0	0	0	0	0	834	0	0	1 167	0	0	0	0	2 004
2003	0	48	0	0	0	0	2	0	1	962	1	0	735	0	0	0.3	0	1 749
2004	0	0	0	0	0	0	0	0.3	0	866	0	0	633	0	0	3	0	1 503
2005	0	0	0	1	0	0	0	0	0	572	0	0	595	0	0	3	0	1 171
2006	0	17	1	0	0	0	0	1	0	575	0	0	626	2	0	2	0	1 224
2007	0	18	0	1	0	0	198	3	0	514	0	3	438	0	0	4	0	1 179
2008	0	13	0	1	0	0	0	5	0	599	0	0	390	0	0	0	0	1 008
2009	0	33	0	0	0	0	16	5	0	734	0	0	483	0	0	1	0	1 272

Year	Estonia	Faroe Islands	Fed. Rep. Germany	France	Latvia	Lithuania	Greenland	Iceland	Ireland	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (England & Wales)	UK (Scot land)	Total
2010	0	15	0	0	0	0	0	16	0	659	0	0	708	2	0	0	0	1 399
2011	0	63	0	0	0	0	0	6	0	867	0	0	782	0	0	0	0	1 718
2012	0	8	5	0	0	0	0	7	0	921	0	0	1 368	1	0	7	0	2 318
2013	0	39	1	8	0	0	0	100	0	1 055	4	0	1 442	4	0	8	0	2 661
2014	0	143	8	11	0	0	19	38	0	1 271	7	0	1 261	10	0	14	0	2 782
2015	0	96	14	3	0	5	12	47	0	1 424	5	0	1 681	8	0	4	0	3 299
2016	353	84	2	3	0	0	3	38	0	1 265	7	0	1 172	7	0	20	0	2 954
2017	519	125	4	4	1	72	2	8	0	1 389	9	1	1 124	13	0	21	0	3 293
2018*	574	111	9	6	0	169	2	0	0	1 008	4	1	1 083	2	97	0	0	3 076
2019*	588	116	27	9	32	377	6	6	0	939	119	0	932	16	49	0	0	3 216

*** Provisional figures.**

Table 8.3. GREENLAND HALIBUT in Subareas 1 and 2. Nominal catch (t) by countries in Division 2a as officially reported to ICES.

Year	Estonia	Faroe Islands	Fed. Rep. Germ.	France	Lithuania	Greenland	Ireland	Iceland	Norway	Poland	Portugal	Russia[5]	Spain	GB	UK (Engl. & Wales)	UK (Scot-land)	Total
1984	0	0	265	138	0	0	0	0	3 703	0	0	5 459	0	0	1	0	9 566
1985	0	0	254	239	0	0	0	0	4 791	0	0	6 894	0	0	2	0	12 180
1986	0	6	97	13	0	0	0	0	6 389	0	0	5 553	0	0	5	1	12 064
1987	0	0	75	13	0	0	0	0	5 705	0	0	4 739	0	0	44	10	10 586
1988	0	177	150	67	0	0	0	0	7 859	0	0	4 002	0	0	56	2	12 313
1989	0	67	104	31	0	0	0	0	8 050	0	0	4 964	0	0	6	0	13 222
1990	0	133	12	49	0	0	0	0	8 233	0	0	1 246	0	0	1	0	9 674
1991	1 400	314	21	119	0	0	0	0	11 189	0	0	305	0	0	0	1	13 349
1992	0	16	1	108	0	13	0	0	3 586	0	15	58	0	0	1	0	3 798
1993	0	29	14	78	0	8	0	0	7 977	0	17	210	0	0	2	0	8 335
1994	0	0	33	47	0	3	4	0	6 382	0	26	67	0	0	14	0	6 576
1995	0	0	30	174	0	12	2	0	6 354	0	60	227	0	0	83	2	6 944
1996	0	0	34	219	0	123	0	0	9 508	0	55	466	4	0	278	57	10 744
1997	0	0	23	253	0	0	0	0	5 702	0	41	334	1	0	21	25	6 400
1998	0	0	16	67	0	0	1	0	6 661	0	80	530	5	0	74	41	7 475
1999	0	0	20	0	0	25	2	0	13 064	0	33	734	1	0	63	45	13 987
2000	0	0	10	43	0	0	0	0	7 536	0	18	690	1	0	65	43	8 406
2001	0	0	49	122	0	0	1	9	8 740	0	13	726	5	0	56	30	9 751
2002	0	0	9	7	0	22	0	4	5 877	0	3	849	0	0	12	28	6 811
2003	0	390	5	2	0	12	0	0	6 713	0	10	1 762	14	0	5	58	8 971
2004	0	0	4	0	0	0	0	9	11 704	0	24	810	4	0	1	0	12 556
2005	0	0	3	31	0	0	0	0	11 216	0	11	1 406	0	0	5	18	12 690
2006	0	175	0	38	0	0	0	7	8 897	0	6	950	0	0	6	2	10 081
2007	0	162	2	37	0	0	0	12	6 761	0	2	489	1	0	2	8	7 475
2008	0	646	4	38	0	0	0	23	5 566	1	1	1 170	0	0	6	10	7 465
2009	0	379	0	13	0	0	0	10	6 456	0	9	1 531	0	0	0	60	8 459

Year	Estonia	Faroe Islands	Fed. Rep. Germ.	France	Lithuania	Greenland	Ireland	Iceland	Norway	Poland	Portugal	Russia[5]	Spain	GB	UK (Engl. & Wales)	UK (Scot-land)	Total
2010	0	255	0	102	0	15	0	0	6 426	0	0	4 757	0	0	0	22	11 577
2011	0	467	0	45	0	4	0	1	6 637	0	0	3 643	2	0	0	4	10 803
2012	0	553	0	37	0	12	0	6	7 934	0	0	3 878	0	0	0	14	12 434
2013	0	739	0	150	0	22	0	6	8 215	0	2	4 143	0	0	0	75	13 352
2014	0	741	0	255	0	1	0	48	8 640	0	0	4 800	0	0	0	184	14 669
2015	0	215	2	221	0	2	0	6	8 166	0	1	3 691	0	0	0	79	12 383
2016	6	380	6	216	0	14	0	41	10 073	0	6	1 797	7	0	0	19	12 566
2017	0	773	0	161	0	20	0	2	10 122	0	7	1 852	1	0	16	0	12 955
2018*	0	297	1	104	1	21	0	0	11 255	2	5	1 399	0	5	0	0	13 092
2019*	0	232	15	95	0	16	0	4	12 121	3	7	2 755	3	12	0	0	15 263

* **Provisional figures.**

Table 8.4. GREENLAND HALIBUT in Subareas 1 and 2. Nominal catch (t) by countries in Division 2b as officially reported to ICES.

Year	Denmark	Estonia	Faroe Islands	France	Fed. rep. Germ.	Greenland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[4]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
1984	0	0	0	0	1 900	0	0	0	0	80	0	0	9 641	0	0	5	0	11 626
1985	0	0	0	0	3 746	0	0	0	0	71	0	0	3 221	0	0	2	0	7 040
1986	0	0	36	0	2 620	0	0	0	0	944	0	0	6 032	0	0	0	0	9 632
1987	0	0	0	0	1 947	0	0	0	0	572	0	0	4 735	0	0	7	10	7 271
1988	0	0	0	0	590	0	0	0	0	239	0	0	5 008	0	0	19	0	5 856
1989	0	0	0	0	496	0	0	0	0	533	0	0	3 366	0	0	0	0	4 395
1990	0	0	23	0	942	0	0	0	0	7 706	0	0	3 197	0	0	9	0	11 877
1991	11	1 000	0	0	80	0	0	0	0	14 369	0	0	1 663	132	0	0	1	17 256
1992	0	0	0	3	12	0	0	0	0	1 732	0	16	193	23	0	9	0	1 988
1993	2	0	0	2	8	0	0	0	30	649	0	26	158	0	0	14	0	889
1994	4	0	1	8	46	0	1	0	4	881	0	10	41	1	0	62	2	1 061
1995	0	0	0	0	5	0	0	0	0	1 662	0	24	297	1022	0	32	5	3 047
1996	0	0	0	0	47	0	0	0	0	1 204	0	24	912	196	0	39	0	2 422
1997	0	0	12	0	33	0	2	0	0	1 349	12	9	534	156	0	46	0	2 153
1998	0	0	10	0	18	0	1	0	0	915	31	19	1 638	254	0	106	4	2 996
1999	0	0	3	0	14	0	0	0	0	839	8	16	1 886	318	0	31	0	3 115
2000	0	0	0	2	5	0	1	0	0	526	3	19	2 709	374	0	46	0	3 685
2001	0	0	0	0	9	0	0	0	0	1 231	2	22	3 017	413	0	42	0	4 736
2002	0	219	0	0	30	0	6	0	0	432	5	11	3 568	178	0	29	0	4 478
2003	0	0	21	0	13	0	0	0	0	541	4	9	1 887	216	0	35	0	2 726
2004	0	0	0	0	5	0	0	0	0	1 369	1	26	3 219	182	0	39	0	4 840
2005	0	170	0	0	5	0	0	0	0	1 223	0	12	2 882	660	0	21	0	4 973
2006	0	0	12	8	7	0	0	0	196	1 647	201	20	4 479	27	0	2	0	6 600
2007	0	0	23	3	6	0	0	0	0	955	200	45	5 557	7	0	5	0	6 801
2008	0	0	4	3	1	0	0	0	0	1 228	200	45	3 734	94	0	10	0	5 319
2009	0	0	10	3	19	0	2	0	0	1 256	204	228	1 321	210	0	8	0	3 260

2010	0	0	2	0	14	0	0	0	0	615	3	11	1 423	180	0	4	0	2 252
2011	0	0	8	1	80	0	0	0	234	766	169	21	2 628	142	0	36	0	4 085
2012	0	0	2	3	35	0	0	0	0	476	22	1	4 795	189	0	14	0	5 537
2013	0	0	5	10	48	0	1	0	0	1 133	26	5	4 725	192	0	9	0	6 154
2014	0	0	3	3	25	0	0	0	0	1 321	12	0	4 000	196	0	14	0	5 574
2015	0	0	1	3	17	0	0	0	0	1 284	8	0	7 581	151	0	21	0	9 066
2016	2	0	19	10	1	0	0	0	0	1 594	1	13	7 608	183	0	0	0	9 431
2017	0	4	19	12	17	3	0	0	0	2 230	17	5	7 737	42	0	46	0	10 132
2018*	2	0	1	30	40	9	0	4	6	2 611	21	0	9 590	58	6	0	0	12 376
2019*	0	0	2	1	2	1	0	0	0	1 753	0	1	8 511	68	14	0	0	10 353

*** Provisional figures.**

Table 8.5. GREENLAND HALIBUT in Subareas 1 and 2. Landings by gear (tonnes). Approximate figures, the total may differ slightly from Table 8.1.

Year	Gillnet	Longline	Trawl	Danish seine	Other
1980	1 189	336	11 759	-	-
1981	730	459	13 829	-	-
1982	748	679	15 362	-	-
1983	1 648	1 388	19 111	-	-
1984	1 200	1 453	19 230	-	-
1985	1 668	750	17 527	-	-
1986	1 677	497	20 701	-	-
1987	2 239	588	16 285	-	-
1988	2 815	838	15 934	-	-
1989	1 342	197	18 599	-	-
1990	1 372	1 491	20 325	-	-
1991	1 904	4 552	26 864	-	-
1992	1 679	1 787	5 787	-	-
1993	1 497	2 493	7 889	-	-
1994	1 403	2 392	5 353	-	-
1995	1 500	4 034	5 494	-	-
1996	1 480	4 616	7 977	-	-
1997	998	3 378	5 198	-	-
1998	1 327	7 395	6 664	-	-
1999	2 565	6 804	10 177	-	-
2000	1 707	5 029	7 700	-	-
2001	2 041	6 303	7 968	-	-
2002	1 737	5 309	6 115	-	-
2003	2 046	5 483	6 049	-	-
2004	2 290	7 135	8 778	599	-
2005	1 842	7 539	9 420	447	-
2006	1 503	6 146	10 042	205	-
2007	997	4 503	9 618	119	-

Year	Gillnet	Longline	Trawl	Danish seine	Other
2008	901	3 575	9 285	9	8
2009	1 409	4 952	6 583	34	18
2010	1 449	5 427	8 165	170	10
2011	1 583	5 039	9 351	239	15
2012	1 929	5 602	12 130	413	5
2013	2 398	5 805	13 791	176	0
2014	2 647	6 166	13 673	183	0
2015	2 508	6 287	15 445	489	18
2016	2 646	7 290	14 333	650	304
2017	2 677	7 221	15 774	679	29
2018*	3 021	6 542	17 367	842	20
2019*	3 323	7 028	17 046	1 119	0

Table 8.6. GREENLAND HALIBUT in Subareas 1 and 2. Catch per unit of effort and total effort.

Year	USSR catch/hour trawling (t)		Norway[10] catch/hour trawling (t)		Average CPUE		Total effort (in '000 hrs trawling)[5]	CPUE 7+[6]	GDR[7] (catch/day tonnage (kg)
	RT[1]	PST[2]	A[8]	B[9]	A[3]	B[4]			
1965	0.80	-	-	-	0.80	-	-	-	-
1966	0.77	-	-	-	0.77	-	-	-	-
1967	0.70	-	-	-	0.70	-	-	-	-
1968	0.65	-	-	-	0.65	-	-	-	-
1969	0.53	-	-	-	0.53	-	-	-	-
1970	0.53	-	-	-	0.53	-	169	0.50	-
1971	0.46	-	-	-	0.46	-	172	0.43	-
1972	0.37	-	-	-	0.37	-	116	0.33	-
1973	0.37	-	0.34	-	0.36	-	83	0.36	-
1974	0.40	-	0.36	-	0.38	-	100	0.36	-
1975	0.39	0.51	0.38	-	0.39	0.45	99	0.37	-
1976	0.40	0.56	0.33	-	0.37	0.45	100	0.34	-

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]			
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	-	-	-	-	-

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]			
2004	0.63 [13]	-	1.16	1.79	-	-	-	-	-
2005	0.61 [12]	-	1.30	2.29	-	-	-	-	-
2006	0.57 [12]	-	0.96	2.09	-	-	-	-	-
2007	0.64 [12]	-	-	-	-	-	-	-	-
2008	0.48 [12]	-	-	-	-	-	-	-	-
2009	0.77 [13]	-	-	-	-	-	-	-	-
2010		1.57 [12]	-	-	-	-	-	-	-
2011		2.32 [12]							
2012		2.06 [12]							
2013		2.25 [12]							
2014		2.52 [12]							

[1] Side trawlers, 800–1000 hp. From 1983 onwards, stern trawlers (SRTM), 1000 hp. From 1997 based on research fishing.

[2] Stern trawlers, up to 2000 HP.

[3] Arithmetic average of CPUE from USSR RT (or SRTM trawlers) and Norwegian trawlers.

[4] Arithmetic average of CPUE from USSR PST and Norwegian trawlers.

[5] For the years 1981–1990, based on average CPUE type B. For 1991–1993, based on the Norwegian CPUE, type A.

[6] Total catch (t) of seven years and older fish divided by total effort.

[7] For the years 1988–1989, frost-trawlers 995 BRT (FAO Code 095). For 1990, factory trawlers 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 Subareas 1 and 2. Catch history back to 1935. Note two year columns.

Year	Norway	Russia	Others	Total	Year	Norway	Russia	Others	Total
1935	1 534	n/a	-	1 534	1979	2 843	10 311	4 088	17 312
1936	830	n/a	-	830	1980	3 157	7 670	2 457	13 284
1937	616	n/a	-	616	1981	4 201	9 276	1 541	15 018
1938	329	n/a	-	329	1982	3 206	12 394	1 189	16 789
1939	459	n/a	-	459	1983	4 883	15 152	2 112	22 147
1940	846	n/a	-	846	1984	4 376	15 181	2 326	21 883
1941	1 663	n/a	-	1 663	1985	5 464	10 237	4 244	19 945
1942	955	n/a	-	955	1986	7 890	12 200	2 785	22 875
1943	824	n/a	-	824	1987	7 261	9 733	2 118	19 112
1944	678	n/a	-	678	1988	9 076	9 430	1 081	19 587
1945	1 148	n/a	-	1 148	1989	10 622	8 812	704	20 138
1946	1 337	25	-	1 362	1990	17 243	4 764	1 176	23 183
1947	1 409	28	-	1 437	1991	27 587	2 490	3 243	33 320
1948	1 877	110	-	1 987	1992	7 667	718	217	8 602
1949	198	177	-	375	1993	10 380	1235	318	11 933
1950	1 853	221	-	2 074	1994	8 428	283	515	9 226
1951	2 438	423	-	2 861	1995	9 368	794	1 572	11 734
1952	2 576	377	-	2 953	1996	11 623	1 576	1 148	14 347
1953	2 208	393	-	2 601	1997	7 661	1 038	711	9 410
1954	3 674	416	-	4 090	1998	8 435	2 659	799	11 893
1955	3 010	290	-	3 300	1999	15 004	3 823	690	19 517
1956	3 493	446	-	3 939	2000	9 083	4 568	646	14 297
1957	4 130	505	-	4 635	2001	10 896	4 694	775	16 365
1958	2 931	1 261	-	4 192	2002	7 143	5 584	566	13 293
1959	4 307	3 632	-	7 939	2003	8 216	4 384	847	13 447
1960	6 662	4 299	-	10 961	2004	13 939	4 662	298	18 899
1961	7 977	3 836	-	11 813	2005	13 011	4 883	940	18 834
1962	11 600	1 760	-	13 360	2006	11 119	6 055	730	17 904
1963	11 300	3 240	-	14 540	2007	8 230	6 484	739	15 453

Year	Norway	Russia	Others	Total	Year	Norway	Russia	Others	Total
1964	14 200	26 191	-	40 391	2008	7 393	5 294	1 105	13 792
1965	18 000	16 682	-	34 751	2009	8 446	3 335	1 210	12 990
1966	16 434	9 768	119	26 321	2010	7 700	6 888	641	15 229
1967	17 528	5 737	1 002	24 267	2011	8 270	7 053	1 283	16 606
1968	22 514	3 397	257	26 168	2012	9 331	10 041	916	20 288
1969	14 856	19 760	9 173	43 789	2013	10 403	10 310	1 454	22 167
1970	15 871	35 578	38 035	89 484	2014	11 232	10 061	1 732	23 025
1971	9 466	54 339	15 229	79 034	2015	10 874	12 953	921	24 748
1972	15 983	16 193	10 872	43 055	2016	12 932	10 576	1 440	24 948
1973	13 989	8 561	7 349	29 938	2017	13 741	10 714	1 925	26 380
1974	8 791	16 958	11 972	37 763	2018*	14 874	12 072	1 598	28 544
1975	4 858	20 372	12 914	38 172	2019*	14813	12 198	14 71	28 482
1976	6 005	16 580	13 469	36 074					
1977	4 217	15 045	9 613	28 827					
1978	4082	14 651	5884	24 617					

*** Provisional figures.**

Table 8.8. GREENLAND HALIBUT in ICES Division 4a (North Sea). Nominal catch (t) by countries as officially reported to ICES. Not included in the assessment.

Year	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Russia	GB	UK England & Wales	UK Scotland	Netherlands	Total
1973	0	0	0	4	0	0	9	8	0	28	0	0	49
1974	0	0	0	2	0	0	2	0	0	30	0	0	34
1975	0	0	0	1	0	0	4	0	0	12	0	0	17
1976	0	0	0	1	0	0	2	0	0	18	0	0	21
1977	0	0	0	2	0	0	2	0	0	8	0	0	12
1978	0	0	2	30	0	0	0	0	0	1	0	0	33
1979	0	0	2	16	0	0	2	0	0	1	0	0	21
1980	0	177	0	34	0	0	5	0	0	0	0	0	216
1981	0	0	0	0	0	0	7	0	0	0	0	0	7
1982	0	0	2	26	0	0	17	0	0	0	0	0	45
1983	0	0	1	64	0	0	89	0	0	0	0	0	154
1984	0	0	3	50	0	0	32	0	0	0	0	0	85
1985	0	1	2	49	0	0	12	0	0	0	0	0	64
1986	0	0	30	2	0	0	34	0	0	0	0	0	66
1987	0	28	16	1	0	0	35	0	0	0	0	0	80
1988	0	71	62	3	0	0	19	0	0	1	0	0	156
1989	0	21	14	1	0	0	197	0	0	5	0	0	238
1990	0	10	30	3	0	0	29	0	0	4	0	0	76
1991	0	48	291	1	0	0	216	0	0	2	0	0	558
1992	1	15	416	3	0	0	626	0	0	+	1	0	1 062
1993	1	0	78	1	0	0	858	0	0	10	+	0	948
1994	+	103	84	4	0	0	724	0	0	6	0	0	921
1995	+	706	165	2	0	0	460	0	0	52	283	0	1 668
1996	+	0	249	1	0	0	1 496	0	0	105	159	0	514
1997	+	0	316	3	0	0	873	0	0	1	162	0	1 355
1998	+	0	71	10	0	10	804	0	0	35	435	0	1 365
1999	+	0		1	0	18	2 157	0	0	43	358	0	2577

Year	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Russia	GB	UK England & Wales	UK Scotland	Netherlands	Total
2000	+		41	10	0	19	498	0	0	67	192	0	827
2001	+		43	0	0	10	470	0	0	122	202	0	847
2002	+		8	+	0	2	200	0	0	10	246	0	466
2003	0	0	1	+	+	+	453	0	0	+	122	0	576
2004	0	0	0	0	0	0	413	0	0	90	0	0	503
2005	0	0	2	0	0	0	58	0	0	4	0	0	64
2006	0	0	3	0	0	0	90	0	0	0	7	0	100
2007	0	1	0	0	0	0	133	0	0	1	6	0	141
2008	0	0	0	0	0	0	14	0	0	0	22	0	36
2009	0	9	22	0	0	0	5	0	0	0	129	0	165
2010	+	1	38	0	0	0	10	0	0	0	49	0	98
2011	0	1	39	0	0	0	94	0	0	0	44	0	178
2012	0	0	14	0	0	0	788	0	0	0	43	0	845
2013	0	0	25	0	0	0	122	0	0	0	174	0	321
2014	0	2	27	0	0	0	723	0	0		104	0	856
2015	0	0	34	1	0	0	1 151	0	0	0	127	0	1 313
2016	0	0	31	0	0	0	983	0	0	0	120	0	1 134
2017	0	0	20	0	0	0	753	0	0	0	73	0	846
2018	0	0	15	0	0	0	472	0	42	0	0	0	532
2019*	0	0	21	+	0	0	241	0	14	0	0	1	277

Table 8.9. Abundance indices of different length groups in 1984–2017 (in thousands), Russian autumn survey.

Year/Length (cm)	≤30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	>80	Total
1984	4 837	5 078	11 690	21 171	15 167	10 886	7 370	6 549	3 751	1 786	1 128	483	89 896
1985	4 003	6 748	16 858	24 897	23 244	15 702	8 376	5 704	3 776	2 054	1 028	698	113 088
1986	3 482	6 062	13 765	18 945	15 997	10 369	4 839	3 022	2 534	1 325	440	205	80 985
1987	2 010	4 828	7 228	10 490	8 831	5 513	2 123	1 784	1 437	645	481	421	45 791
1988	3 374	5 111	9 022	10 147	10 128	5 828	2 265	1 862	1 218	511	361	341	50 168
1989	2 030	7 055	13 962	17 252	16 790	10 028	3 789	1 916	1 279	415	200	388	75 104
1990	2 762	6 056	12 802	13 061	9 527	9 829	4 967	2 094	589	312	115	119	62 233
1991	1 036	5 012	16 237	20 998	17 418	11 728	8 012	4 562	814	181	122	174	86 294
1992	184	2 153	17 185	32 399	22 481	12 977	6 229	3 473	1 869	502	182	106	99 740
1993	-	290	3 593	14 782	21 080	16 013	6 743	3 341	2 031	859	269	164	69 165
1994	49	17	1 651	12 582	16 203	12 566	5 391	3 320	2 019	819	188	106	54 911
1995	-	38	1 245	13 193	20 571	12 445	5 432	2 717	1 587	579	187	82	58 076
1996*	-	11	786	13 012	30 573	18 294	5 730	1 795	773	534	169	12	71 689
1997	140	152	1 318	7 744	18 504	17 221	6 932	3 079	1 952	465	195	142	57 844
1998	2 449	2 238	2 949	10 847	24 266	19 640	11 112	5 946	2 158	440	172	90	82 307

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
1999	1 070	2 815	4 632	7 886	17 734	18 489	10 158	4 827	2 043	529	196	74	70 453
2000	1 274	1 698	5 184	14 996	24 170	20 721	12 805	5 675	3 100	1 228	240	143	91 234
2001	1 399	2 887	7 496	18 136	34 752	29 886	13 463	6 759	3 772	1 511	593	369	121 024
2002**	662	2 033	6 395	13 329	19 810	13 135	7 180	3 406	1 311	381	129	58	67 828
2003***	955	2 396	7 420	13 006	17 160	11 630	7 978	5 332	3 541	985	485	238	71 126
2004	1 431	2 705	11 945	16 937	20 155	18 274	12 594	6 948	4 783	2 087	813	536	99 209
2005	830	3 970	10 726	17 850	17 547	15 164	9 726	5 859	3 343	1 150	453	545	87 163
2006****	293	1 981	18 471	35 224	36 563	26 335	14 138	7 248	4 943	1 669	668	488	148 021
2007	376	1 431	6 937	24 330	26 780	26 086	22 157	15 586	7 480	3 786	932	628	136 510
2008	463	4 626	19 991	28 799	30 062	32 159	23 175	11 326	8 368	4 198	1 872	1 089	166 129
2009	152	4 919	29 389	48 321	45 833	33 915	24 484	10 227	6 568	3 032	881	616	208 338
2010	146	5 097	37 901	66 086	57 863	46 321	25 428	10 058	8 612	3 983	1 587	1 610	264 692
2011	456	1 285	22 470	61 115	78 247	64 186	49 620	19 412	11 607	7 226	3 529	874	320 025
2012	213	798	12 051	49 062	56 704	52 393	36 362	13 622	7 533	4 213	1 944	1 611	236 506
2013*****													
2014	17	1697	10 296	34 074	45 287	35 861	22 621	8613	5505	2227	929	427	167 553
2015	318	2 099	13 542	35 864	43 551	36 082	21 114	10 924	4 472	1 342	850	339	170 497

Year/Length (cm)	≤30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	>80	Total
2016*****													
2017	158	2 198	10 687	32 464	61 577	71 590	40 700	16 830	7 449	3 483	1 206	1 245	249 585

*** Only half of the standard area was investigated**

**** No observations in NEEZ**

***** Observations in the NEEZ on the main spawning grounds were conducted considerably later than usual**

****** Survey was conducted by one vessel with a reduced number of trawls at depths less than 500 m**

*******No indices for 2013 and 2016**

Table 8.10. Abundance indices of different length groups in 1994–2017 (in thousands), Norwegian autumn slope 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	1 225	1 611	2 432	3 431	3 511	3 830	3 519	3 940	3 724	2 896	3 020
1995	0	0	1	3	6	15	29	86	141	242	472	931	1 210	2 294	3 092	3 840	4 475	4 540	4 633	4 321	3 836	3 856
1996	0	2	1	6	6	2	18	49	54	166	321	772	957	1 787	2 912	3 769	4 728	5 199	5 944	5 644	5 224	5 132
1997	7	5	11	4	33	27	49	186	250	297	443	862	1 009	1 814	2 888	3 578	5 451	5 402	6 132	5 206	4 125	5 455
1998	7	2	6	15	17	22	51	103	174	219	372	504	727	1 061	1 491	2 103	2 941	3 092	3 609	3 735	3 851	4 850
1999	10	4	18	15	20	40	61	75	110	174	202	377	476	862	1 175	1 655	2 397	2 543	3 485	4 214	3 694	5 274
2000	2	7	11	30	34	46	128	122	163	264	383	677	739	932	1 183	1 439	2 038	2 030	2 268	2 644	2 846	3 888
2001	21	20	35	37	77	147	274	270	440	462	724	986	1 176	1 373	1 630	1 720	2 724	2 655	3 349	3 128	3 973	3 999
2002	97	75	107	122	180	267	399	404	723	669	869	1 026	1 097	1 360	1 883	1 870	2 560	2 185	3 322	3 450	3 597	4 032
2003	38	27	65	97	172	270	383	692	783	894	1 214	1 100	1 481	1 561	2 082	1 792	2 468	2 104	3 193	3 360	3 506	3 117
2004	27	15	47	125	191	402	636	639	951	1 042	1 092	1 206	1 337	1 319	1 398	1 546	2 013	1 967	2 638	2 646	3 337	3 373
2005	66	104	285	317	517	765	861	1 220	1 492	1 540	2 053	2 295	2 293	2 588	2 262	2 677	3 041	2 446	2 854	2 095	3 056	2 336
2006	12	50	80	158	258	456	849	1 022	1 429	1 579	1 603	1 900	1 823	1 824	2 015	1 974	2 529	2 359	2 350	2 137	2 338	2 175
2007	157	96	161	359	766	1 423	2 508	3 142	4 411	5 679	5 346	5 639	5 502	5 038	4 600	3 632	3 667	3 628	3 278	2 571	2 882	2 597
2008	378	384	723	1 323	1 763	1 793	2 441	2 911	3 249	3 685	4 229	4 300	4 257	3 568	3 911	3 534	3 020	3 066	2 769	2 582	2 639	2 284
2009	31	36	93	349	505	934	1 663	2 660	3 050	3 680	4 138	4 885	5 567	4 148	5 327	4 639	3 688	3 752	3 682	3 410	3 553	3 215

2011	0	0	20	36	57	124	288	563	646	1 414	1 454	2 228	2 680	3 174	3 649	3 750	3 532	3 031	3 299	3 991	3 251	2 454
2013	17	5	3	1	13	64	103	122	324	582	1 022	1 266	2 138	2 207	3 553	3 748	3 476	4 124	3 717	3 045	3 718	3 052
2015	3	24	24	36	131	318	439	721	757	1 043	1 253	1 473	2 602	2 444	3 776	4 459	4 602	4 598	4 371	3 962	4 156	3 694
2017	6	20	45	54	63	144	184	328	593	365	928	955	1 267	1 457	1 764	1 983	2 367	2 465	2 651	2 569	2 816	3 011
2019	0	0	28	43	128	362	372	569	874	1 322	1 290	1 424	1 667	2 285	2 210	2 168	2 208	2 229	2 434	2 119	2 305	2 405

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	2 545	2 729	2 398	2 092	1 975	1 547	1 488	1 103	920	788	565	702	576	523	577	370	367	386
1995	3 165	3 152	2 963	2 647	2 272	1 756	1 586	1 153	970	880	764	690	680	592	525	461	387	334
1996	4 106	3 638	3 571	2 752	2 177	1 568	1 443	1 017	867	782	512	449	538	404	391	356	281	248
1997	3 644	3 427	3 018	2 302	2 111	1 502	1 131	1 042	617	849	585	576	537	403	446	481	294	230
1998	4 211	3 824	3 166	2 988	2 857	1 974	1 714	1 515	981	1 172	783	613	598	668	641	569	479	364
1999	4 092	5 196	4 136	3 909	4 122	2 631	2 299	1 787	1 374	1 388	895	1 037	865	886	923	791	807	594
2000	3 692	3 681	3 512	3 016	3 197	2 388	2 007	1 545	1 227	1 327	915	1 028	734	630	732	517	509	505
2001	3 649	4 512	4 106	3 005	3 358	2 552	2 589	2 147	1 293	1 350	1 099	939	1 187	684	787	612	751	603
2002	4 241	3 516	3 966	3 602	3 855	2 837	2 511	2 248	1 672	1 787	1 239	1 237	1 139	808	882	604	679	474
2003	4 400	3 465	3 808	3 512	3 907	3 368	3 035	2 319	1 896	1 705	1 612	1 384	1 542	1 130	1 350	972	994	675
2004	3 535	4 405	3 614	3 801	3 249	2 751	2 252	1 911	1 493	1 455	1 372	1 360	1 284	1 162	962	763	891	590
2005	2 400	2 734	2 413	2 084	2 295	1 882	1 681	1 492	1 458	1 168	1 241	1 057	1 065	984	903	782	865	479

2006	2 493	2 125	2 290	2 025	2 189	1 790	1 668	1 542	1 337	1 159	1 188	1 009	925	1 036	807	798	647	678
2007	2 109	2 249	2 123	2 142	1 758	1 609	1 581	1 070	1 008	1 044	625	938	672	558	537	526	394	469
2008	2 288	2 248	2 229	1 815	1 751	1 514	1 150	1 019	861	668	652	657	508	582	629	523	484	361
2009	2 668	2 944	2 850	2 441	2 372	2 233	1 837	1 698	1 503	1 135	845	962	647	858	715	607	653	609
2011	2 905	2 746	2 602	2 713	2 387	1 709	1 704	1 529	978	1 179	577	649	554	440	466	315	440	550
2013	2 498	2 035	1 905	1 631	1 710	1 573	1 424	1 009	790	671	503	506	400	456	234	266	227	176
2015	3 469	2 384	2 546	2 084	2 142	1 734	1 336	1 108	1 020	899	713	621	605	495	274	289	341	291
2017	2 890	2 547	2 501	2 091	1 792	1 786	1 532	1 274	1 269	1 029	765	579	481	446	294	299	247	245
2019	1 653	1 799	1 617	1 490	1 057	1 185	846	840	670	568	461	313	304	312	231	242	179	130

Year	**69.5**	**70.5**	**71.5**	**72.5**	**73.5**	**74.5**	**75.5**	**76.5**	**77.5**	**78.5**	**79.5**	**>80**	**SUM**
1994	256	253	151	136	122	74	113	47	39	40	30	97	59 436
1995	339	244	181	179	97	100	137	56	53	53	34	101	66 568
1996	232	168	118	123	93	97	61	28	40	39	21	74	70 886
1997	171	207	216	119	109	111	104	61	32	35	40	185	69 818
1998	308	320	235	222	229	144	102	64	65	61	43	192	62 052
1999	478	406	385	319	182	205	223	125	109	145	51	328	69 570
2000	341	376	232	210	168	153	141	77	96	77	47	233	57 187
2001	490	375	279	170	207	178	157	85	133	69	49	306	68 944

2002	469	383	297	251	183	163	134	104	130	48	65	251	72 073
2003	563	632	464	249	244	170	242	201	128	125	114	356	76 964
2004	654	420	373	325	521	248	181	135	121	100	109	431	70 415
2005	523	508	400	262	196	159	156	162	109	82	61	426	69 195
2006	474	508	397	285	185	276	185	140	136	81	96	497	61 893
2007	289	254	261	101	140	130	75	52	80	59	47	278	92 269
2008	313	258	226	201	138	107	59	62	89	66	76	508	82 860
2009	574	541	271	386	219	171	191	112	121	89	100	407	95 773
2011	415	409	200	285	235	193	225	204	175	51	87	503	69 075
2013	162	173	124	114	109	112	66	72	79	34	43	260	57 674
2015	252	265	176	195	186	205	89	78	73	141	53	286	71 252
2017	178	185	88	98	77	51	61	50	35	40	46	184	49193
2019	144	117	71	81	50	44	32	31	9	13	12	113	43046

***Biennial surveys since 2009**

Table 8.11. Abundance indices of females of different length groups in 1994–2017 (in thousands), Norwegian autumn slope 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	1 223	1 611	2 429	3 426	3 503	3 824	3 510	3 934	3 716	2 886	3 018
1995	0	0	1	3	6	15	29	86	141	242	472	930	1 210	2 291	3 088	3 837	4 470	4 537	4 629	4 317	3 835	3 855
1996	0	0	0	4	0	1	10	26	28	64	123	228	233	424	415	773	937	1020	1 185	1 151	1 037	1 374
1997	6	5	7	4	17	14	36	134	139	146	187	337	331	419	569	685	899	852	1 169	1 058	828	1 226
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	1 049
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	1 321	1 539	2 259	2 654	2 515	2 403	2 454	2 145	1 580	1 242	1 132	988	851	727	640	554
2008	216	210	432	698	829	958	1 190	1 372	1 529	1 597	1 720	1 516	1 625	1 069	1 180	9 28	889	948	834	677	773	615
2009	13	19	33	146	210	343	662	1 001	1 263	1 470	1 491	1 814	1 979	1 441	1 752	1 533	1 044	1 195	1 037	988	922	878
2011	0	0	8	22	24	31	103	175	195	469	311	538	642	722	623	645	686	664	528	665	751	298

Year	<30	30.5	31.5	33	33.5	34.5	35.5	36.5	37.5	38.5	39.5	40.5	41.5	42.5	43.5	44.5	45.5	46.5	47.5	48.5	49.5	51
2013	0	0	0	0	3	11	49	30	50	186	261	246	521	286	650	509	621	693	626	664	745	576
2015	0	7	7	19	67	149	183	304	380	358	391	377	491	387	549	490	682	904	632	689	761	766
2017	4	17	16	43	44	79	83	120	267	117	395	312	365	373	288	411	524	444	6 277	453	439	579
2019	0	0	16	25	92	119	183	300	360	500	527	498	604	609	512	517	426	558	489	503	541	479

***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	####	####	2 384	2 088	1 969	1 545	1 482	1 098	917	785	560	700	571	522	573	368	364	385	254	253	151	136	122
1995	####	####	2 958	2 646	2 271	1 752	1 586	1 152	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	1 056	903	758	754	831	667	907	615	543	569	639	638	567	453	362	308	307	235	222	225
1999	830	####	928	1 042	1 287	1 019	1 002	955	845	1 106	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	1 062	594	772	577	746	598	488	370	279	170	207
2002	610	438	638	694	823	672	824	779	780	989	780	1 024	813	705	827	598	656	443	458	383	295	251	183
2003	604	582	662	611	968	854	1 111	964	1 057	1 126	1 260	1 165	1 314	1 085	1 278	938	962	670	555	625	462	249	242
2004	461	638	570	693	760	937	876	839	966	998	1 202	1 186	1 227	1 116	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

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
2006	490	458	461	392	537	523	545	678	805	796	893	865	820	927	775	768	637	633	468	499	376	285	178
2007	476	499	471	491	469	533	607	549	566	776	494	790	587	534	517	515	394	469	278	254	261	101	133
2008	509	481	515	495	443	547	441	543	466	490	530	572	482	539	610	514	483	361	309	252	226	201	138
2009	640	665	738	639	733	724	698	783	814	605	653	765	534	776	701	525	616	587	561	526	263	378	219
2011	557	468	480	472	466	369	329	469	324	378	341	523	477	348	450	300	415	550	393	409	192	285	235
2013	518	381	477	308	375	529	526	304	296	334	324	377	329	390	218	260	227	174	159	173	120	114	109
2015	826	770	744	579	811	649	471	494	553	537	470	462	420	450	270	283	339	283	251	265	176	195	186
2017	530	438	516	448	392	555	578	498	563	530	473	330	378	371	271	286	243	245	178	185	88	98	77
2019	401	481	431	494	351	391	324	458	402	367	277	254	260	257	210	218	174	123	143	114	71	81	50

***Biennial surveys since 2009**

Year	74.5	75.5	76.5	77.5	78.5	79.5	>80	SUM
1994	74	113	47	39	40	30	95	59 284
1995	100	137	56	53	53	34	99	66 505
1996	92	61	28	40	39	21	74	21 998
1997	111	104	61	29	35	40	185	22 385
1998	144	102	64	65	61	43	192	22 881
1999	205	223	125	109	140	47	328	26 047
2000	153	141	77	96	77	47	233	19 913
2001	178	157	85	131	69	49	306	24 071
2002	163	131	104	130	48	65	251	23 984
2003	170	242	201	128	125	114	356	30 383
2004	241	181	135	119	100	109	431	27 731
2005	149	156	152	109	82	61	426	27 000
2006	259	185	138	136	81	96	491	26 528
2007	124	75	52	80	59	47	275	40 026
2008	107	59	62	89	66	76	506	34 926
2009	171	191	104	121	80	100	385	38 542
2011	193	225	204	175	51	87	503	20 780
2013	112	66	72	79	34	43	260	16 424

Year	74.5	75.5	76.5	77.5	78.5	79.5	>80	SUM
2015	205	89	78	73	141	53	286	22 019
2017	51	61	50	35	40	46	184	14738
2019	44	32	31	9	13	12	113	14443

***Biennial surveys since 2009**

Table 8.12. Abundance indices (numbers in thousands) from bottom-trawl surveys in the Barents Sea standard area winter 1994-2019 (Mehl *et al.*, WD4 AFWG 2019).

	Length group (cm)															Biomass
Year	≤14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	≥80	Total	(tonnes)
1994	0	0	21	76	148	1 117	3 139	4 740	3 615	1 941	889	541	21	0	0	16 248	19 228
1995	298	0	0	0	90	129	2 877	7 182	5 739	2 027	1 622	839	489	86	0	21 378	27 459
1996	4 121	0	0	0	62	124	1 214	4 086	4 634	1 871	1 112	638	337	74	12	18 285	20 256
1997[1]	0	68	0	0	55	163	949	4 313	5 629	2 912	1 609	643	300	65	21	16 728	24 214
1998[1]	68	220	945	578	481	487	1 088	4 016	6 591	3 076	1 798	707	326	93	44	20 518	27 248
1999	43	84	241	436	566	269	784	1 701	3 097	1 669	1 094	491	89	75	0	10 640	14 681
2000	140	184	344	836	1 722	3 857	2 253	1 560	2 144	1 714	1 191	615	249	76	0	16 883	17 246
2001	68	49	147	179	737	1 525	3 716	3 271	2 302	2 010	1 088	529	160	50	39	15 871	18 224
2002	271	0	70	34	382	1 015	1 916	3 803	3 250	2 279	1 138	976	242	159	114	15 648	21 198
2003	51	0	74	19	304	715	1 842	3 008	4 765	2 235	714	561	245	146	0	14 678	19 635
2004	106	104	15	0	319	1 253	1 229	1 717	2 277	1 227	798	298	148	94	26	9615	11 872
2005	263	70	159	1 139	2 235	2 621	4 206	3 782	3 847	2 037	917	585	336	118	0	22 314	22 293
2006[2]	0	72	94	414	1 968	5 149	4 613	5 743	4 283	2 132	891	449	258	34	18	26 118	25 579
2007[1]	0	18	146	1 869	1 418	3 114	5 710	5 947	4 287	2 205	963	658	391	80	89	26 896	28 006
2008	0	0	0	243	1 708	5 974	4 654	6 136	5 198	3 403	827	638	174	82	50	29 088	30 153
2009	55	0	0	26	1 044	4 327	8 133	4 551	4 084	2 266	996	627	442	253	154	26 960	28 919

Year	Length group (cm)															Biomass (tonnes)
	≤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	
2010	0	0	0	99	678	3 648	5 729	6 560	4 897	2 467	1 064	552	229	128	41	26 092	25 979
2011	51	0	0	0	216	4 396	5 864	5 498	5 237	3 698	699	936	327	252	97	27 271	31 552
2012[3]	77	0	0	0	51	1 145	4 524	5 366	4 517	2 774	1 147	195	73	0	48	19 917	22 656
2013	0	0	0	0	0	511	5 368	4 868	5 374	3 687	1 944	939	348	131	154	23 504	31 748
2014	0	0	46	92	156	368	2 271	5 587	5 903	3 555	2 251	1 369	154	260	79	22 090	31 112
2015	367	0	61	0	284	1 612	3 187	6 452	7 249	6 752	3 350	1 936	587	334	0	32 172	46 828
2016	205	0	124	511	950	1 953	3 486	4 539	5 479	5 613	1 999	1 973	646	98	80	27 657	35 831
2017[4]	52	0	0	78	592	1 328	1 885	3 850	4 852	4 550	1 721	1 455	317	190	23	20 827	29 756
2018	0	0	62	0	383	1 333	2 049	3 445	4 258	3 573	1 904	1 366	736	196	20	19 325	28 688
2019	0	0	0	375	272	1 6 71	3 285	4 034	5 177	4 265	3 570	2 526	1 328	535	137	27 176	45 912

[1] Indices raised to also represent the Russian EEZ

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

[3] Indices not raised to also represent uncovered parts of the Russian EEZ.

[4] Indices raised to also represent uncovered parts of the Russian EEZ

able 8.13. GREENLAND HALIBUT catch in weight, numbers, and biomass (in tonnes) and abundance (in thousands) estimated from Spanish autumn and spring surveys 1997–2013. NB. Absolute biomass and abundance values must not be compared between spring and autumn surveys due to different gears. The trawl used during the spring surveys is considered less efficient on benthic species as Greenland halibut and skates, and better to catch species less associated with bottom.

Autumn survey

Year	Catch (Kg)	Catch (numbers)	Biomass™	Abundance (‘000)
1997	195 056	211 533	344 014	379 444
1998	180 974	187 259	351 466	373 149
1999	198 781	172 687	436 956	377 792
2000	169 389	140 355	340 619	291 265
2001	152 681	129 289	283 511	249 219
2002	144 335	115 213	256 460	207 466
2003	151 952	132 117	283 644	256 327
2004	153 859	135 631	320 485	283 965
2005	144 573	134 566	317 320	313 459
2008	91 573	101 578	129 221*	144 561*
2010	167 862	182 464	191 510*	216 731*
2012	178 607	174 670	336 543*	339 697*
2013	172 762	168 619	264 101*	267 548*
2014	175 553	160 557	321 485*	307 679*
2016	176 015	142 413	247 644*	214 778*
2019	50 880	45 631	209 439*	187 830*

No survey in 2006, 2007, 2009, 2011, 2015, 2017, and 2018.

***New swept-area estimation method**

Spring survey

Year	Catch (Kg)	Catch (numbers)	Biomass™	Abundance (‘000)
2008	96 797	109 515	38 406	38 951
2009	200 299	222 018	58 273	65 464
2011	136 610	160 566	98 142	117 666
2015**	111 425	105 385	150 385	155 333

No survey in 2010, 2012, 2013 and 2014

***Different from the one used during the 2014 Spanish “autumn” survey**

Table 8.14. Greenland halibut in Subareas 1 and 2. The catch scenarios. Weights in tonnes. No assessment in 2020.

Basis	Catches (2021)	Harvest rate (2020–2024)	Mean catch (2020–2024)	Biomass 45cm+ 1 January 2025	% 45cm+ Biomass change 2020–2024*
ICES ADVICE BASIS					
Same advice as last year	23 000	0.036	23 000	574 000	-20%
Other scenarios					
HR=0	0	0	0	672 000	-6%
$HR_{2017–2018} \times 0.5$	12 770	0.019	12 500	620 000	-13%
$HR_{2017–2018} \times 0.75$	19 070	0.028	18 340	596 000	-17%
$HR_{2017–2018} \times 1$	25 310	0.037	23 930	573 000	-20%
$HR_{2017–2018} \times 1.5$	37 630	0.053	37 630	532 000	-26%
$HR_{2017–2018} \times 2$	49 730	0.070	44 000	495 000	-31%
$HR_{2017–2018} \times 3$	73 290	0.099	60 870	432 000	-40%

* 45 cm+ biomass in 2025 relative to 2020.

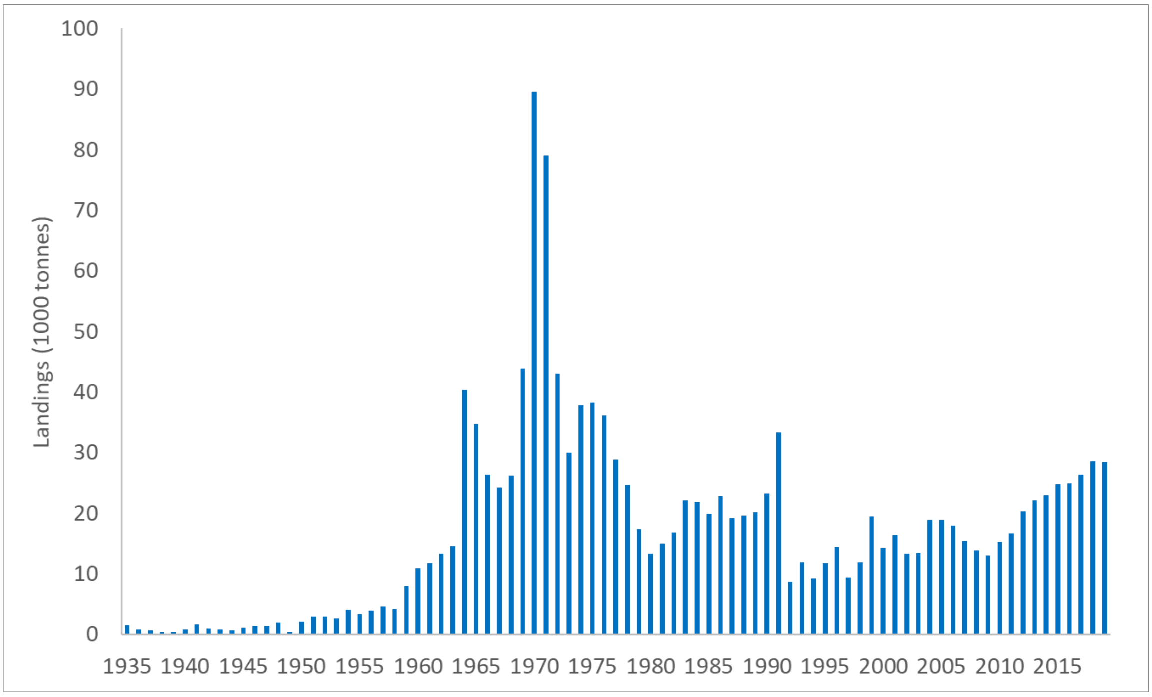


Figure 8.1. NEA Greenland halibut. Historical landings (Nedreaas and Smirnov 2003 and AFWG).

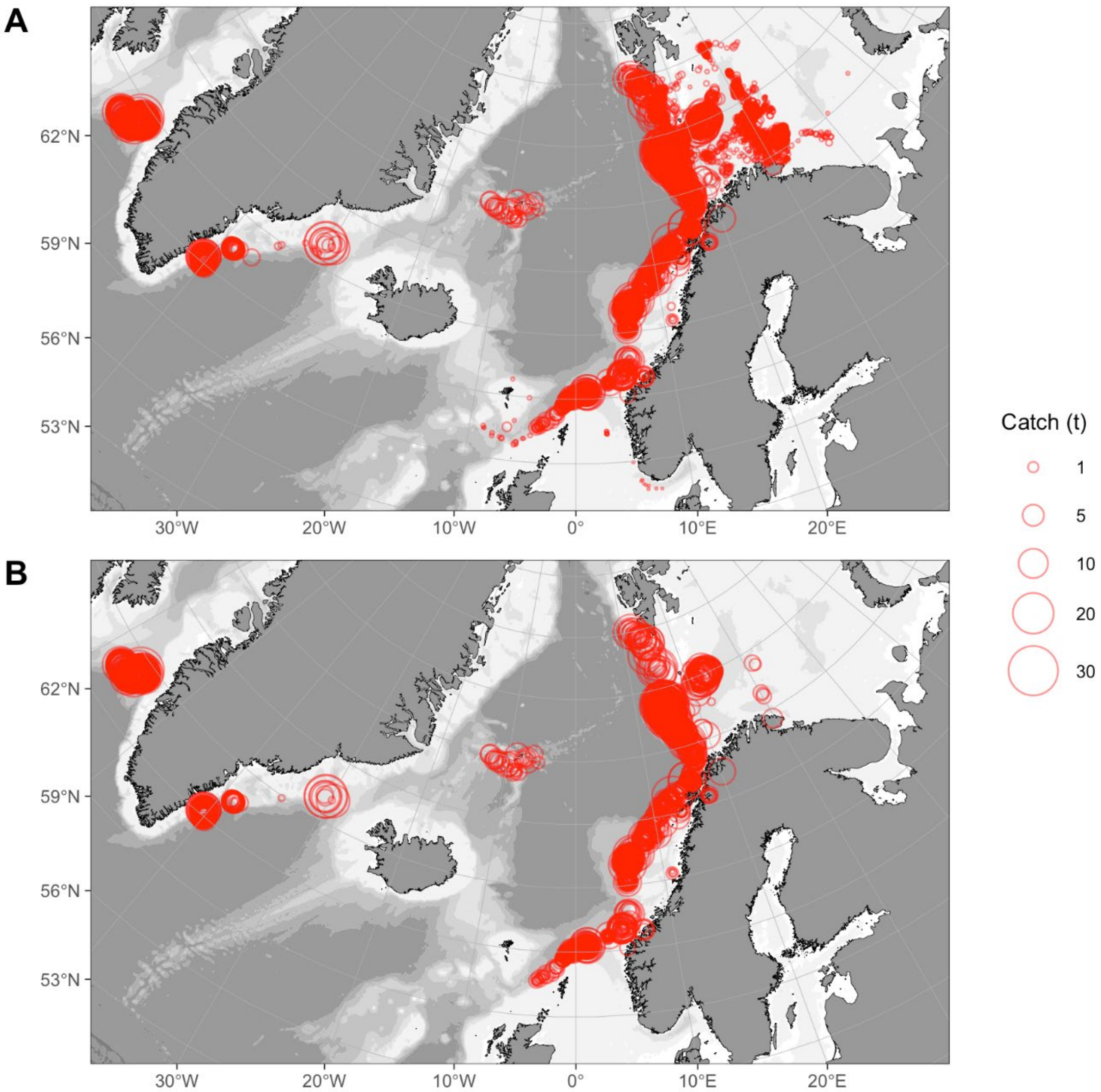


Figure 8.2. Spatial distribution of Greenland halibut catches in 2019 according to Norwegian electronic logbooks. Bubble area is proportional to the size of single catches expressed in metric tonnes. Upper panel (A) shows Greenland halibut catches in all registered fisheries (including bycatch), and lower panel (B) shows catches where G. halibut make more than 50% of the total catches.

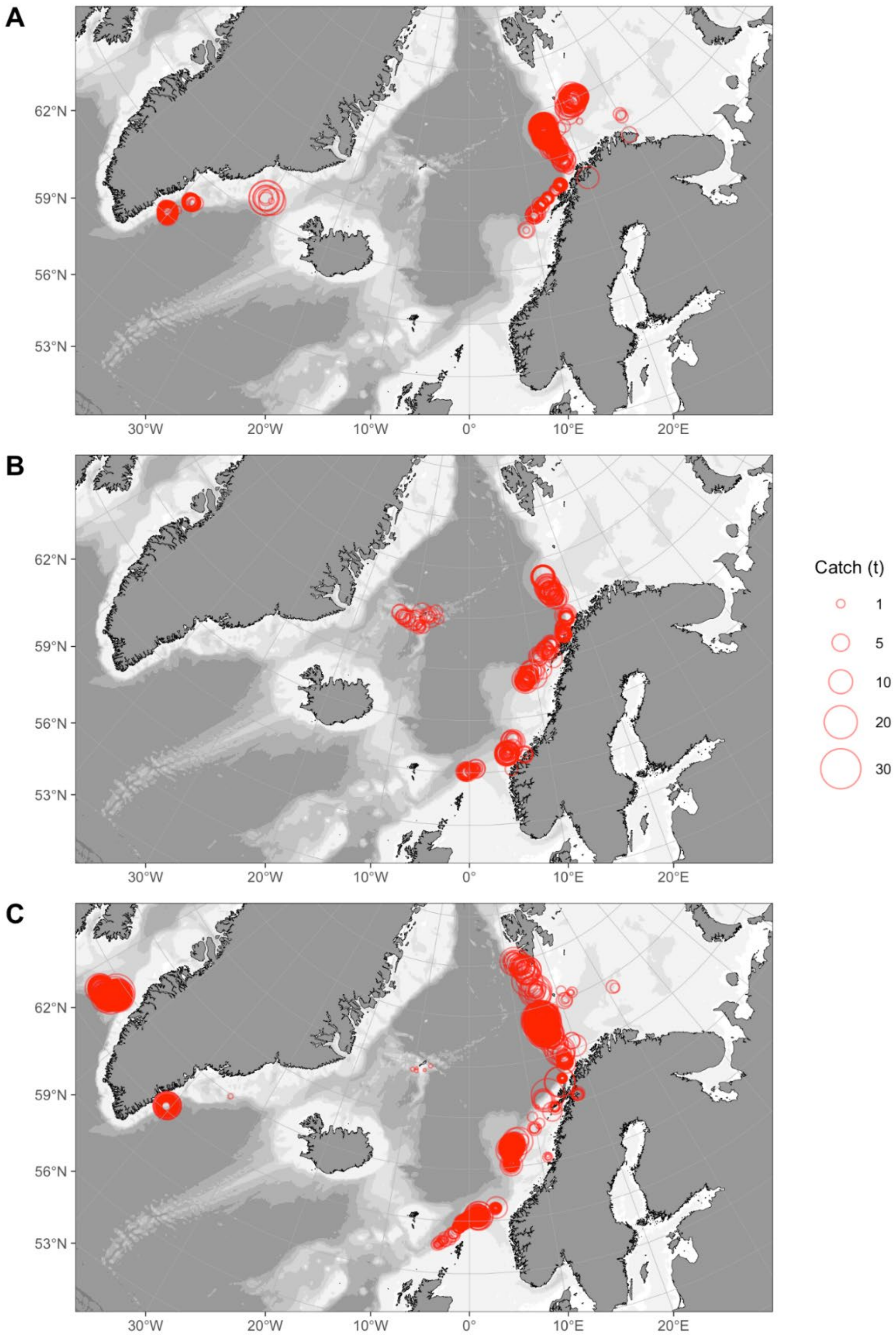


Figure 8.3. Spatial distribution of catches where Greenland halibut make more than 50% of the total catches, according to Norwegian electronic logbooks from 2019. Bubble area is proportional to the size of single catches expressed in metric tonnes. Uppermost (A), middle (B) and lowest (C) panel show longline, gillnet and trawl catches, respectively.

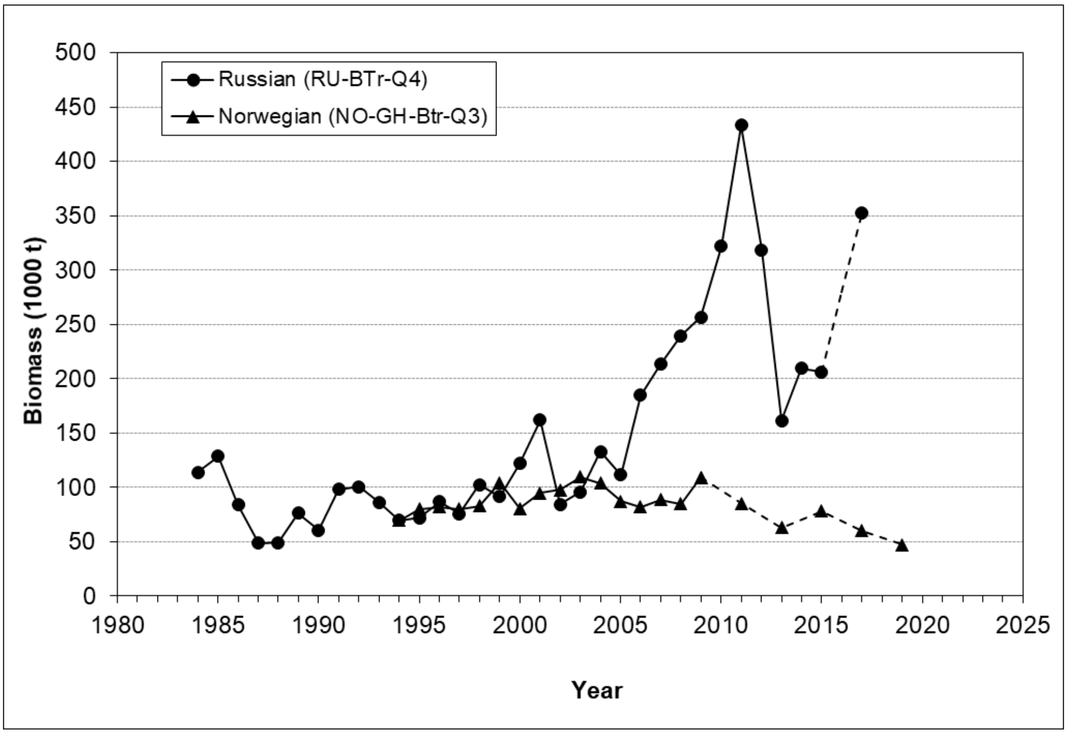


Figure 8.4. NEA Greenland halibut. Total biomass estimates from Russian autumn survey and the Norwegian slope survey. The Norwegian survey is run every other year since 2009. Uncertain estimate for 2013 from the Russian survey.

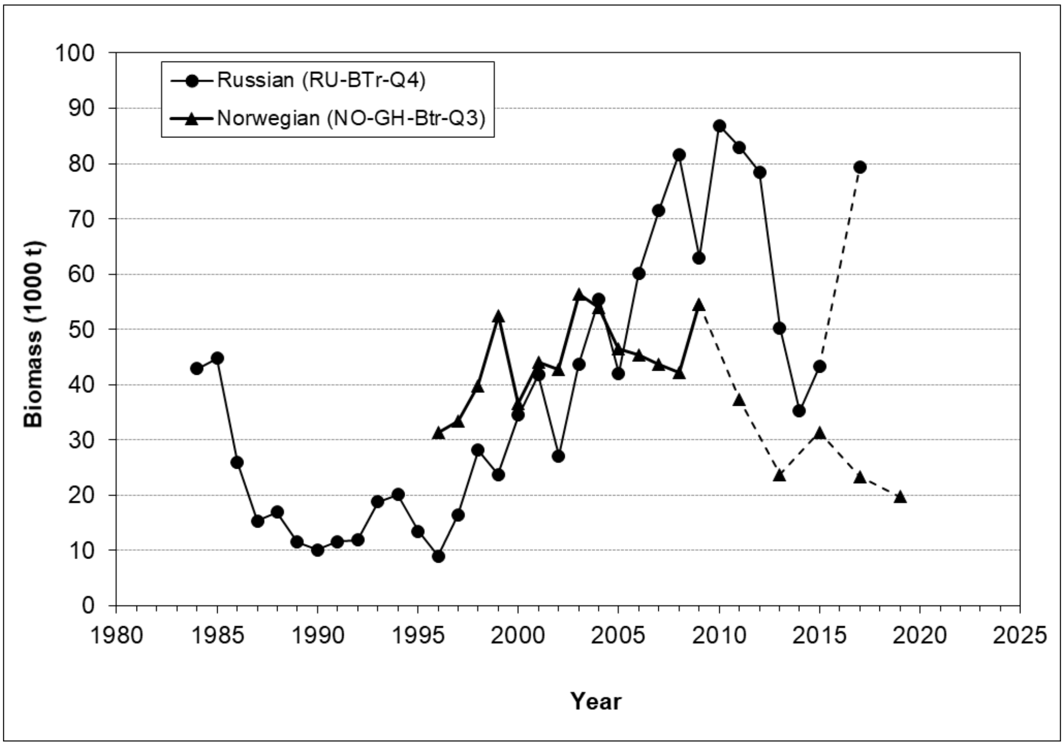


Figure 8.5. NEA Greenland halibut. Swept-area estimate of the mature female biomass based on the data from the Norwegian slope survey in August (every other year since 2009) and the Russian trawl survey in October-December (compared to previous reports, 2007–2008 recalculated using complete data for these years). Uncertain estimate for 2013 from the Russian survey.

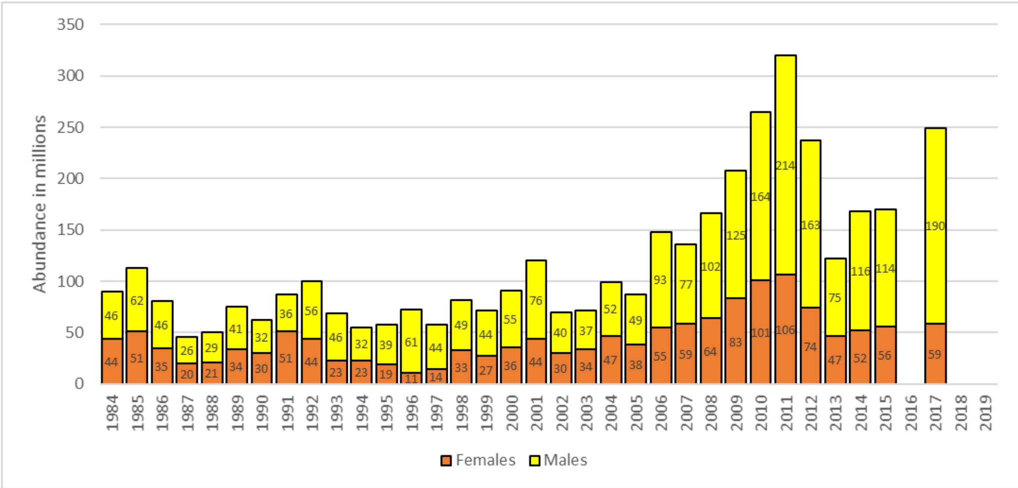


Figure 8.6. Russian autumn survey; Greenland halibut abundance by sex (Russkikh and Smirnov, WD16 AFWG 2016).

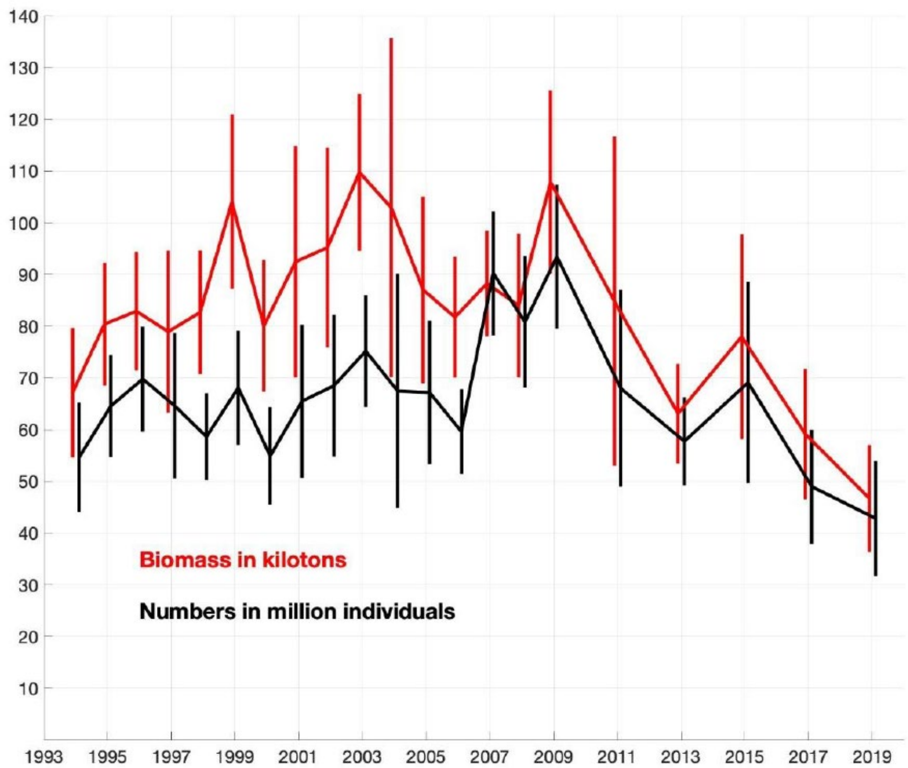


Figure 8.7. Estimated Greenland halibut total abundance in biomass and by number of individuals from the Norwegian slope surveys 1994–2019. The vertical bars show 95% confidence intervals.

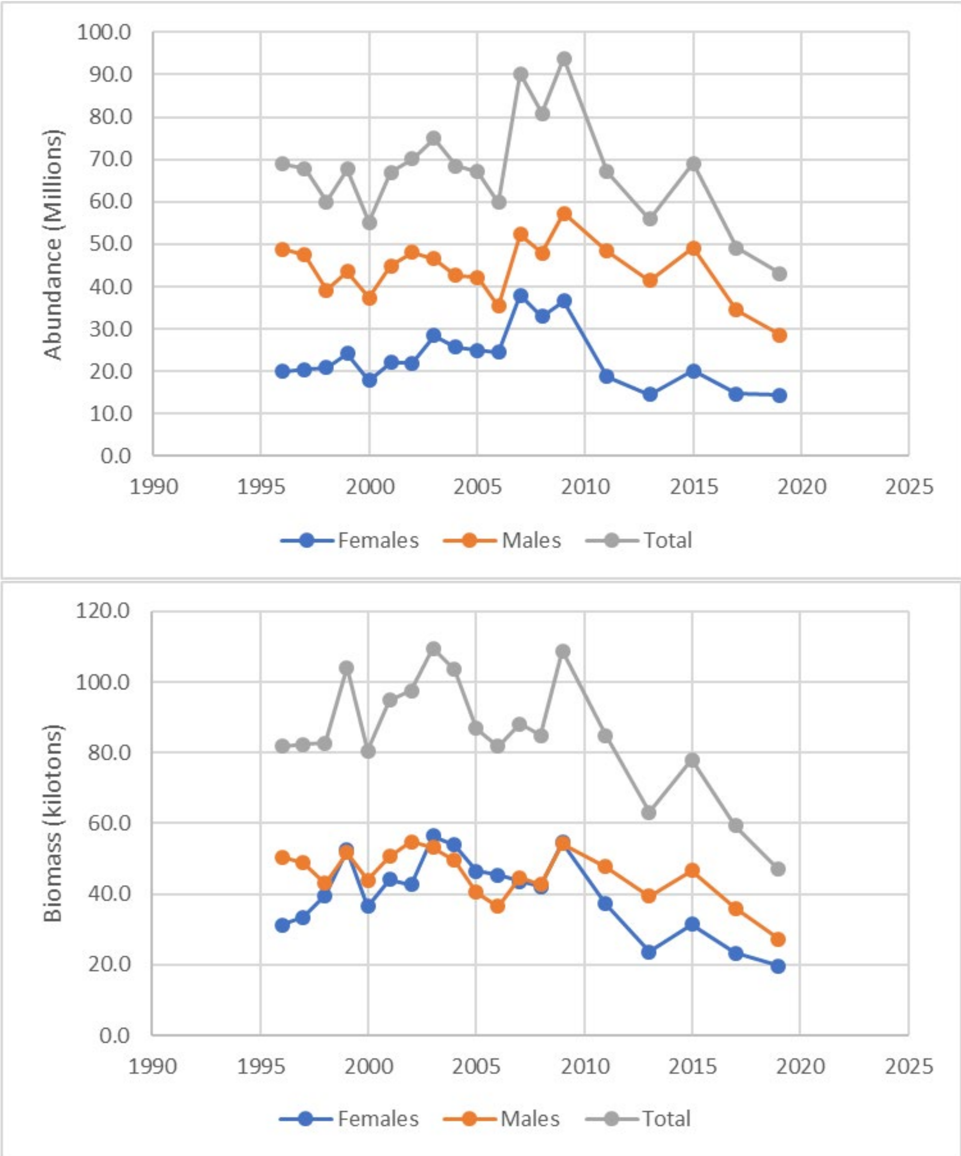


Figure 8.8. Estimated Greenland halibut abundance (upper panel) and biomass (lower panel), by sex, from the Norwegian autumn slope survey.

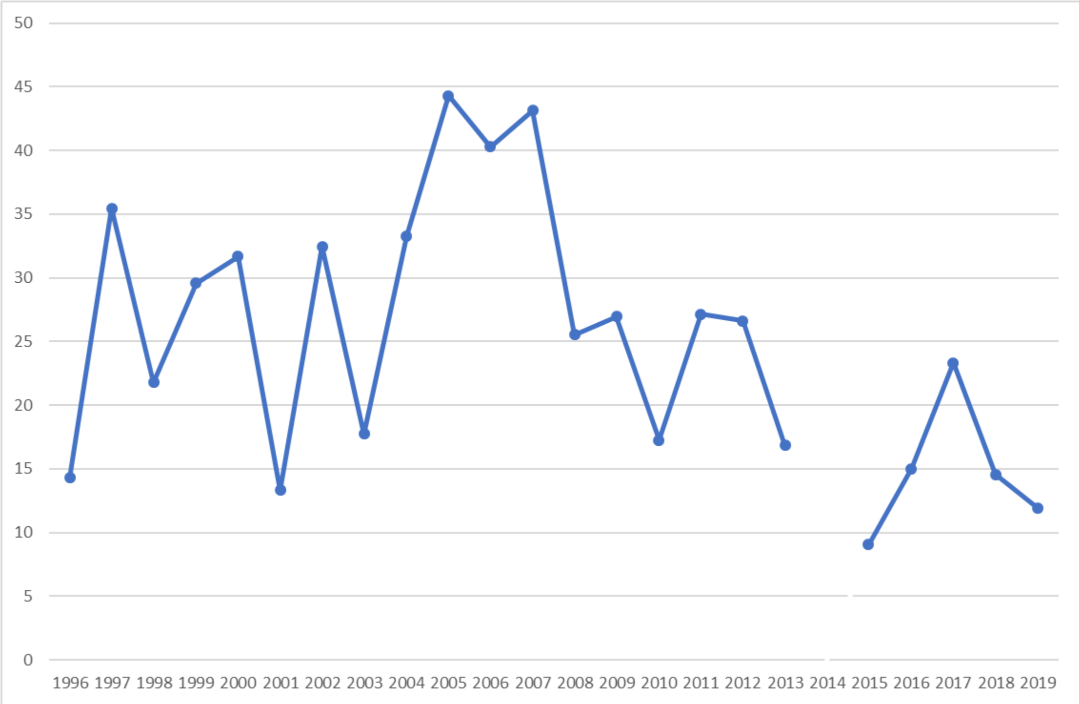


Figure 8.9. Total juvenile biomass index (EcoJuv) (female biomass = male biomass) for Greenland halibut based on the Barents Sea Ecosystem Survey 2003 – 2019 (2014 not included due to poor survey coverage in the juvenile area) and the juvenile survey 1996-2002 (for area see Hallfredsson and Vollen, WD20 AFWG 2015).

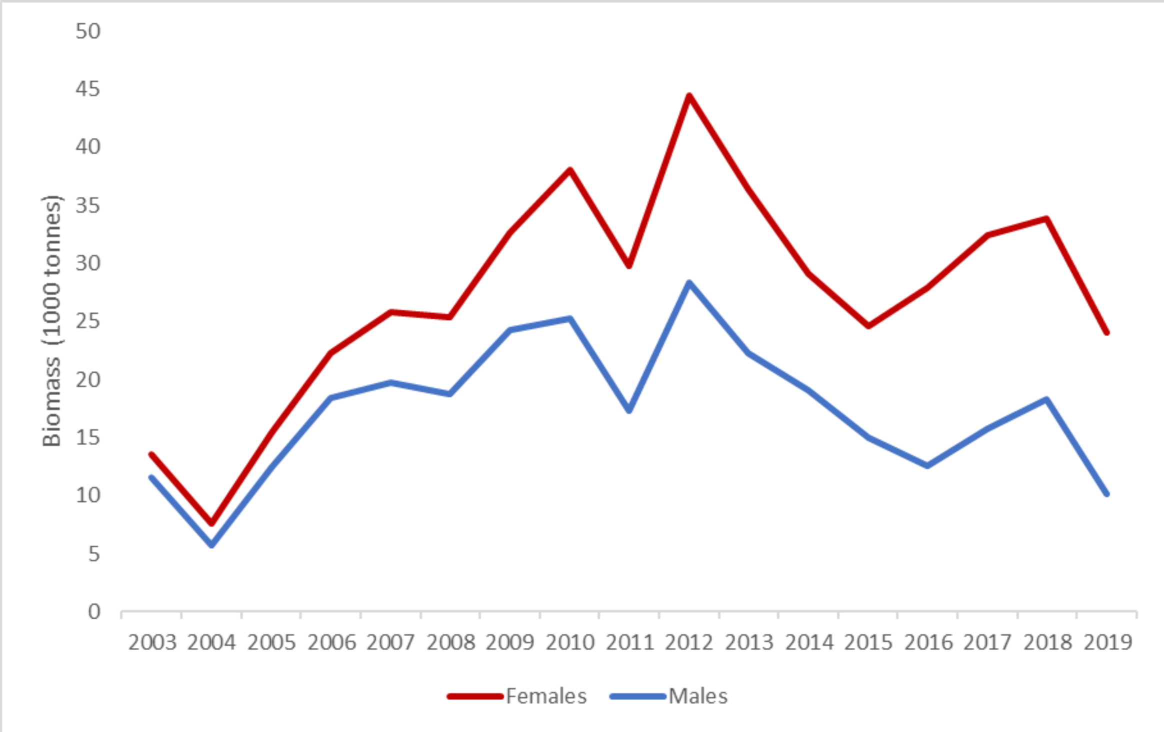


Figure 8.10. Eco-south biomass index by sex for Greenland halibut in the Barents Sea Ecosystem Survey 2003 – 2019, outside the juvenile area (for area see Hallfredsson and Vollen, WD20 AFWG 2015).

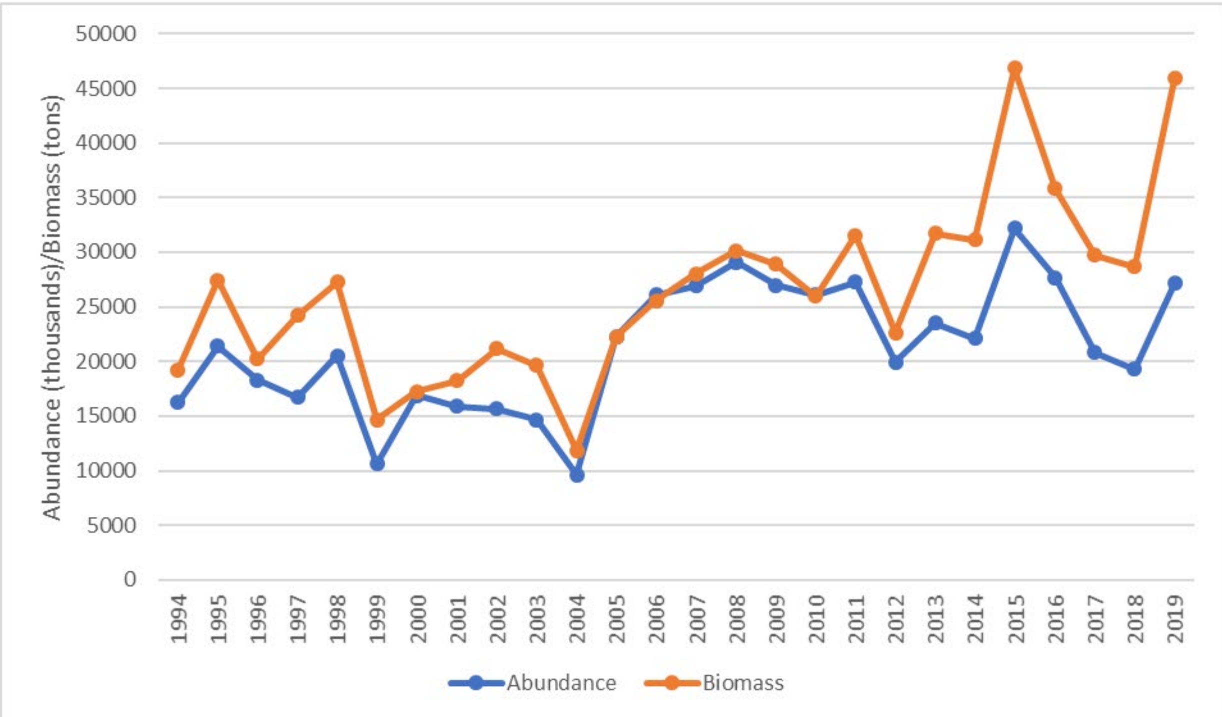


Figure 8.11. Joint Norwegian-Russian winter survey in the Barents Sea 1994-2019; Greenland halibut abundance and biomass estimates.

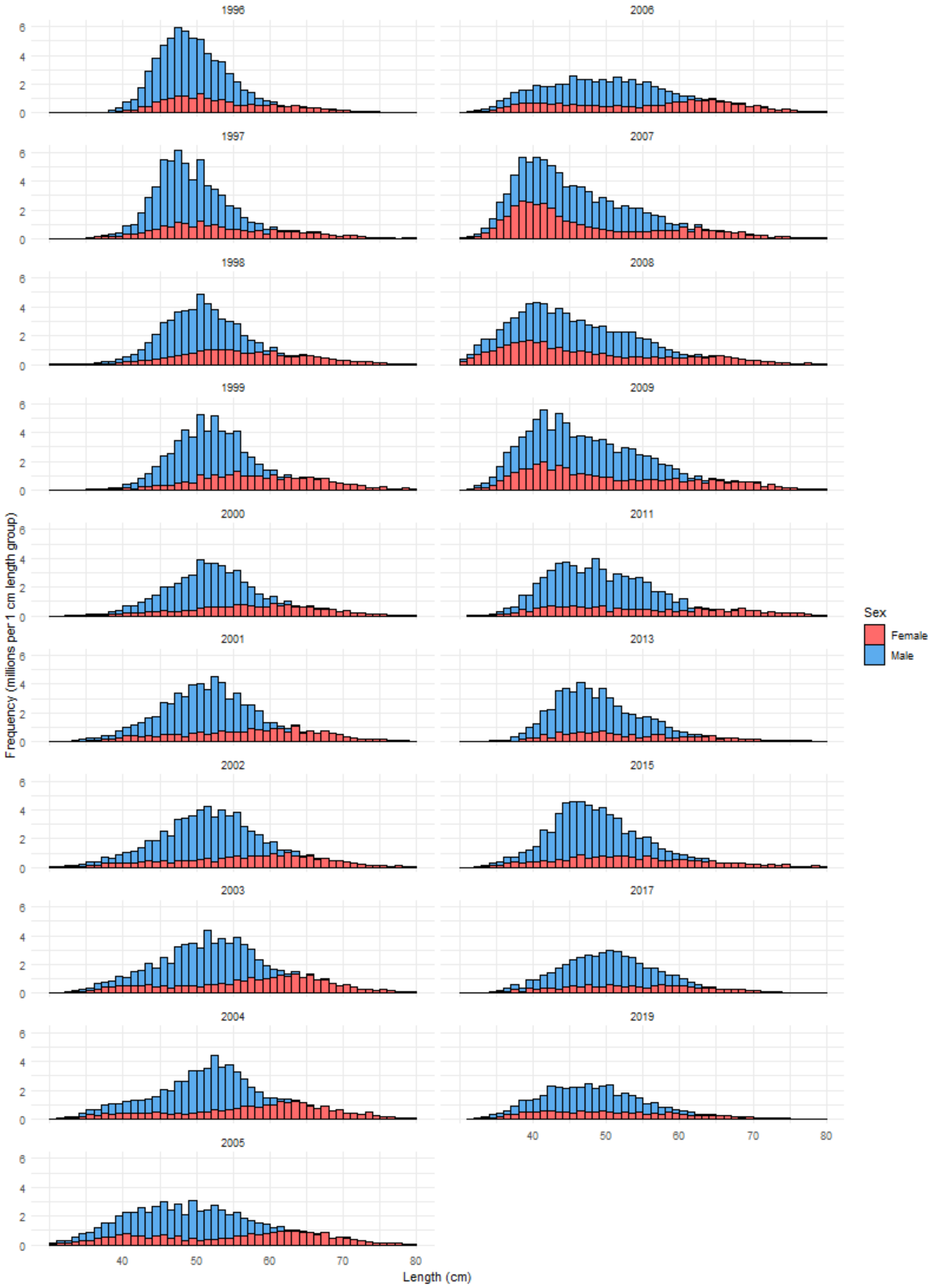


Figure 8.12. Length frequency distribution estimates for the entire area covered by the Norwegian Slope survey during autumns 1996-2019. Note biennial surveys after 2009.

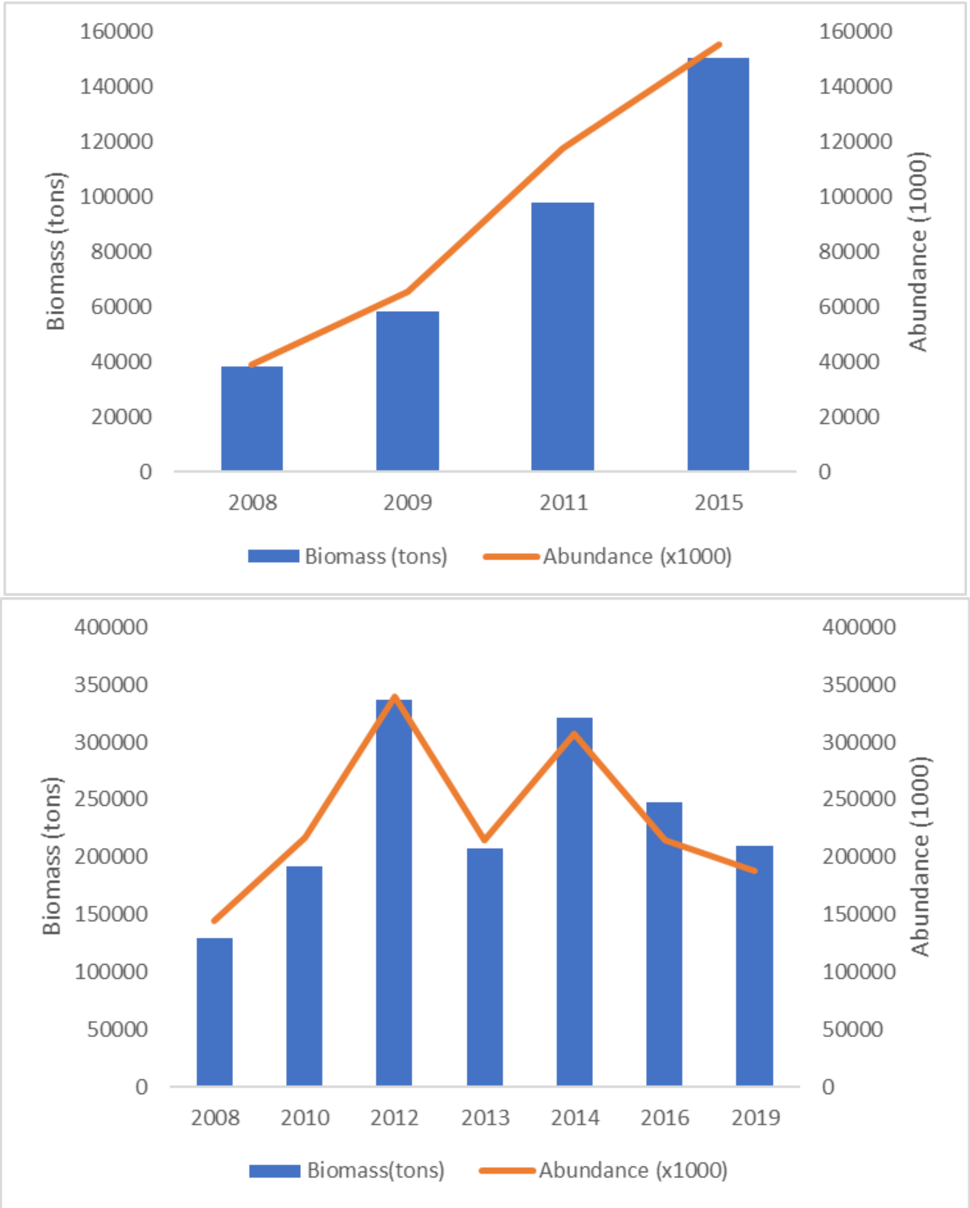


Figure 8.13. Abundance and biomass estimates from Spanish autumn surveys (lower panel) (Muñoz *et al.,* WD7 AFWG 2017), and abundance and biomass estimates from Spanish spring surveys (upper panel) (Muñoz *et al.,* WD10 AFWG 2016). Note that X-axis is not continuous.

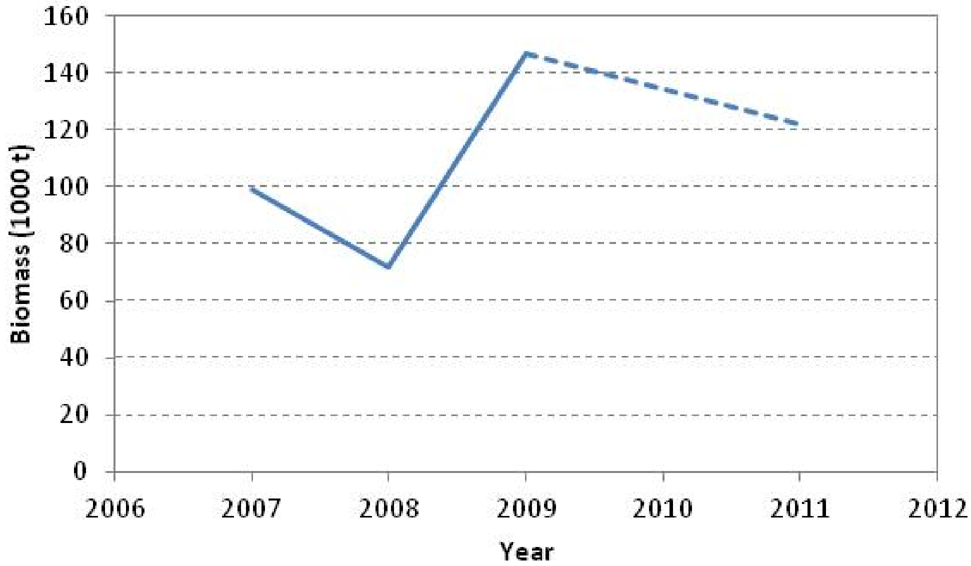


Figure 8.14. Biomass estimates from Polish spring survey (based on: Janusz et al., WD8 AFWG 2008; Janusz and Trella, WD10 AFWG 2009; Trella and Janusz, WD6 AFWG 2012). No update presented to the 2020 AFWG.

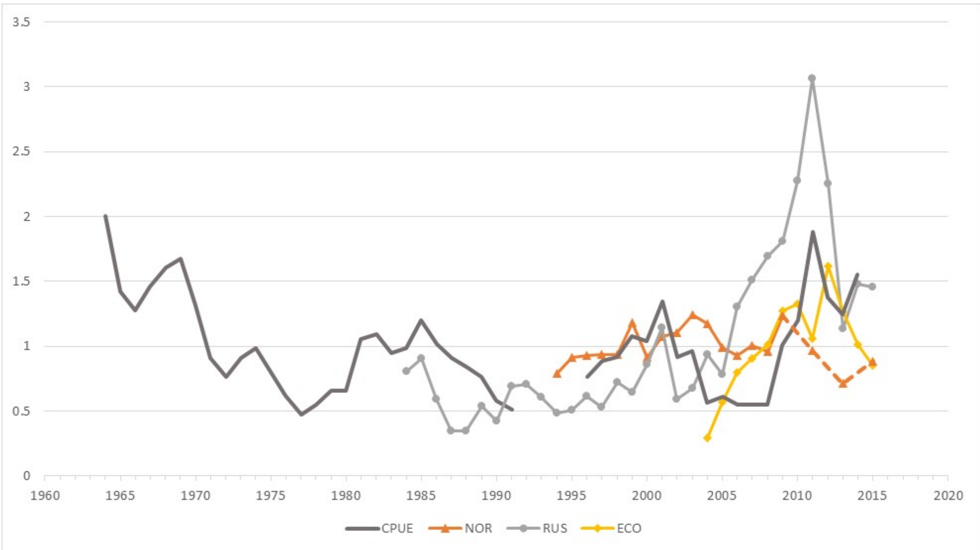


Figure 8.15. Dynamics of indices of the Barents Sea Greenland halibut stock in 1964–2015 (indices are taken divided by corresponding mean to put them in comparable scale; CPUE series divided by two: 1964–1991 and after 1996). In addition to the standardized CPUE three survey indices are shown; the Russian autumn survey (RUS), the Norwegian autumn survey (NOR) and the EcoSouth index (ECO).

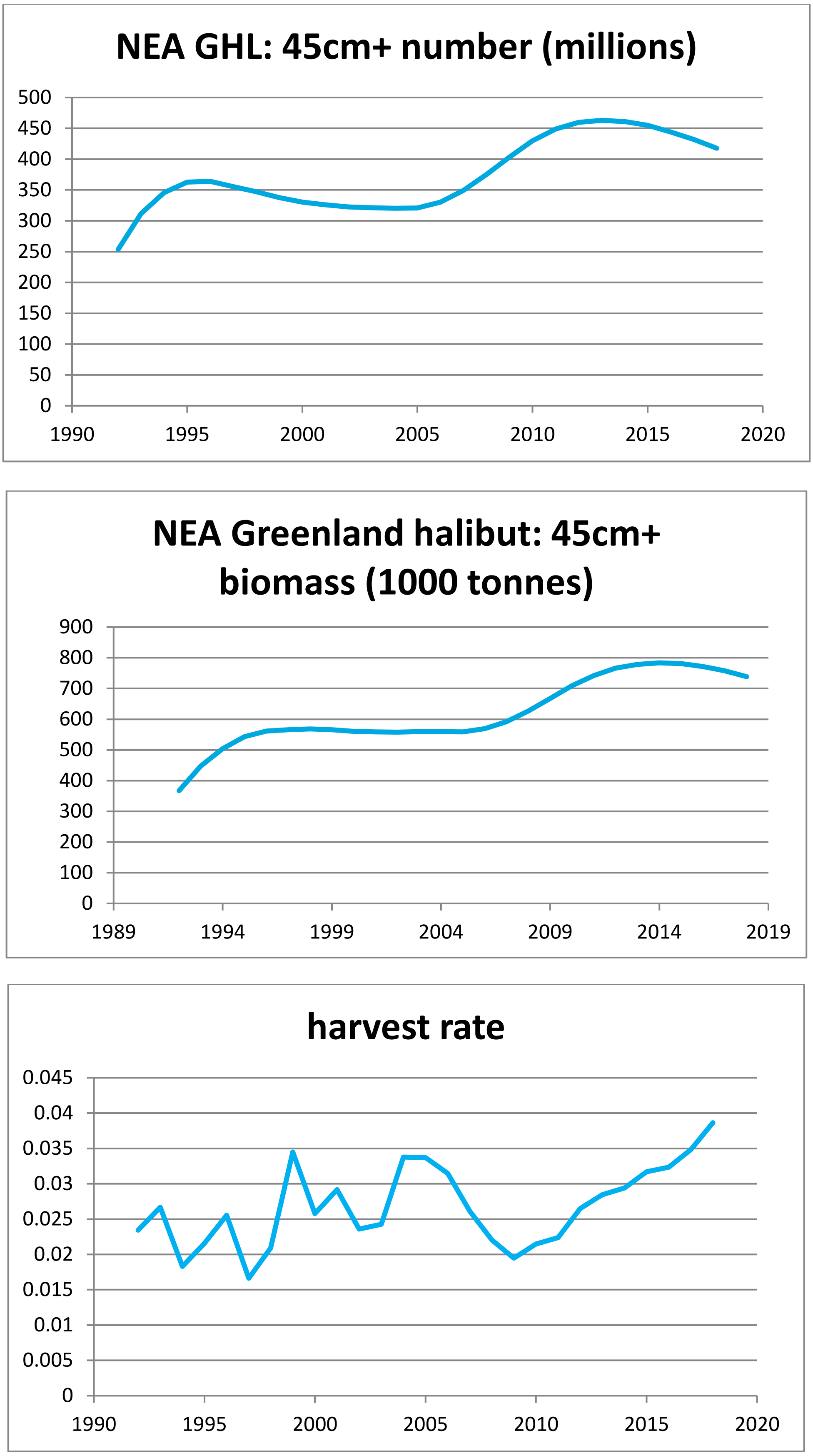


Figure 8.16. Numbers (upper) and biomass (middle) for 45+ cm Greenland halibut as estimated by the GADGET model, and estimated exploitation rates (below). No assessment in 2020, next assessment in 2021.

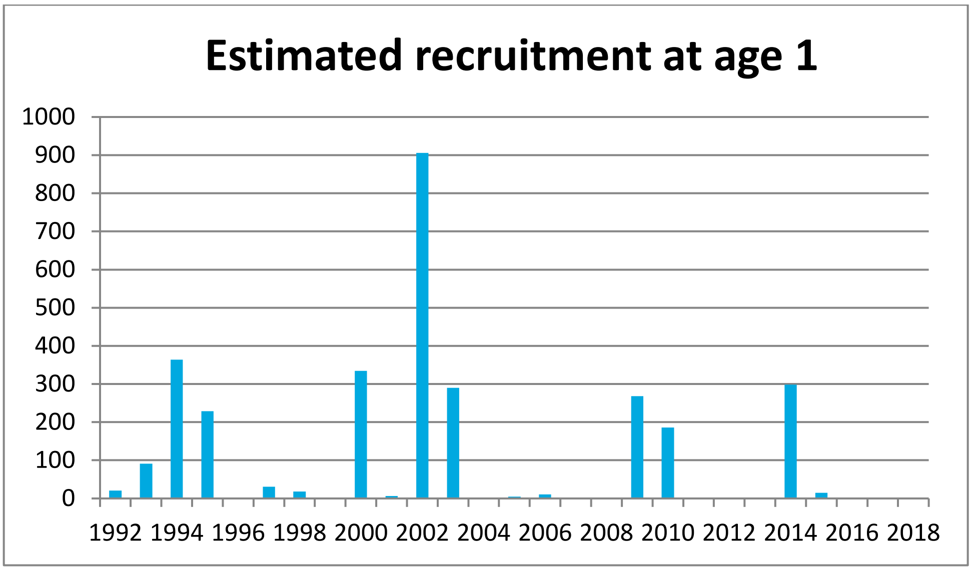


Figure 8.17. Gadget recruitment estimate (in millions) for the Greenland Halibut stock at 1st January. Note that the most recent year(s) of recruitment are tuned by very few data and should be considered tentative. No assessment in 2020, next assessment in 2021.

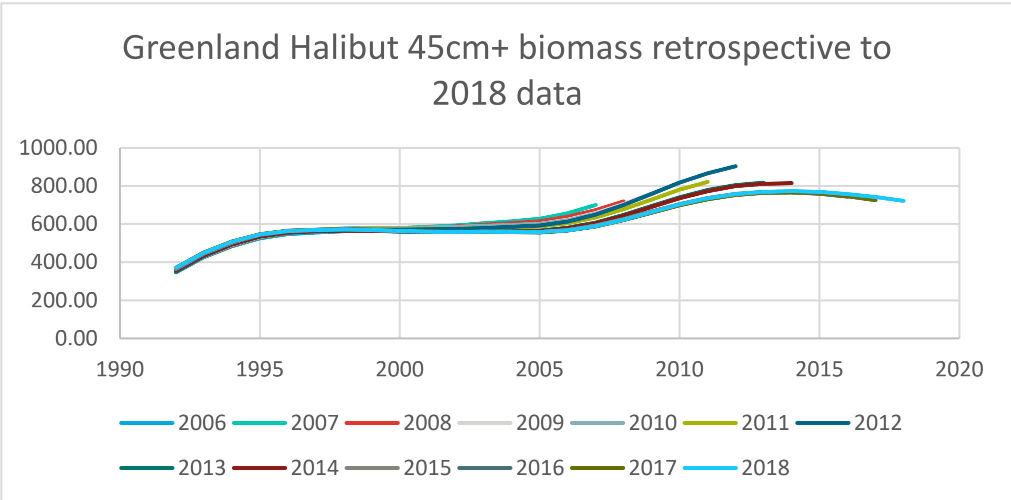


Figure 8.18. Retrospective patterns from the GADGET model run. No assessment in 2020, next assessment in 2021.

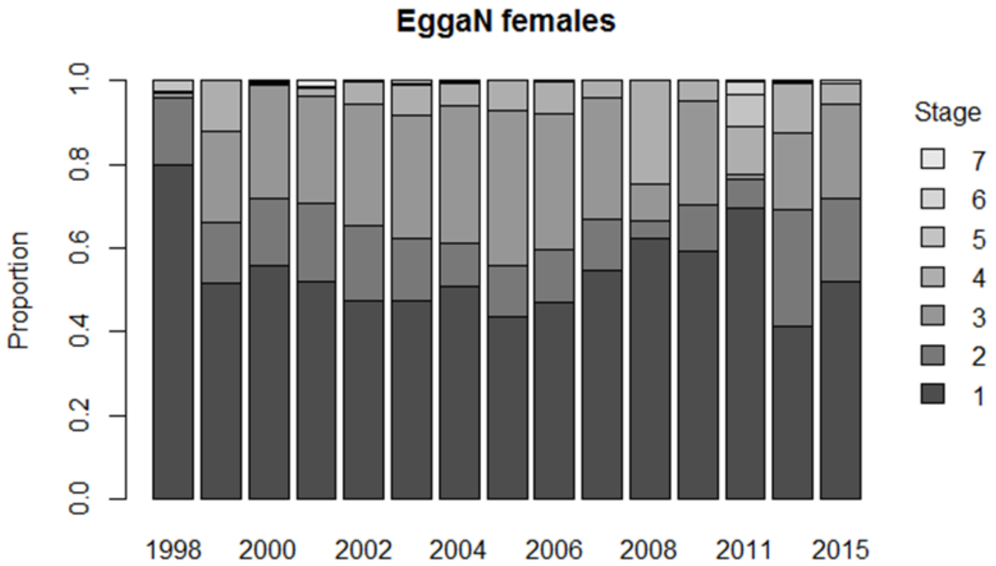


Figure 8.19. Proportion of numbers per maturity stage for Greenland halibut females in the Norwegian slope survey.

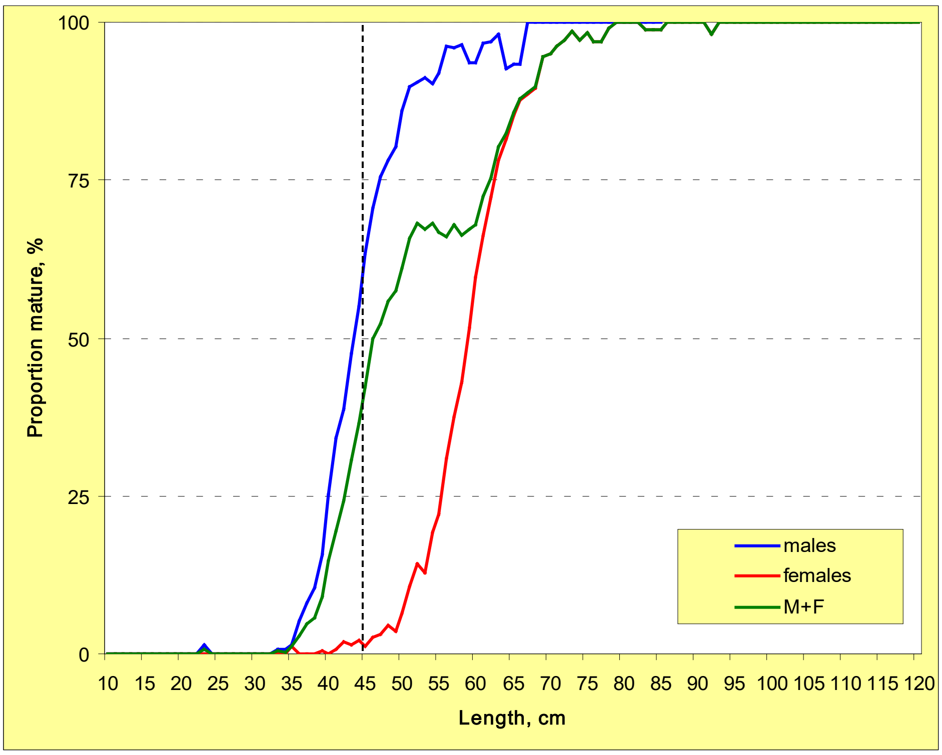


Figure 8.20. Greenland halibut maturity at length (Russian actual data, 2000–2009 combined). L_{50} for males ~43 cm, L_{50} for females ~57 cm (from Smirnov, 2011, WD21 ICES AFWG 2011).

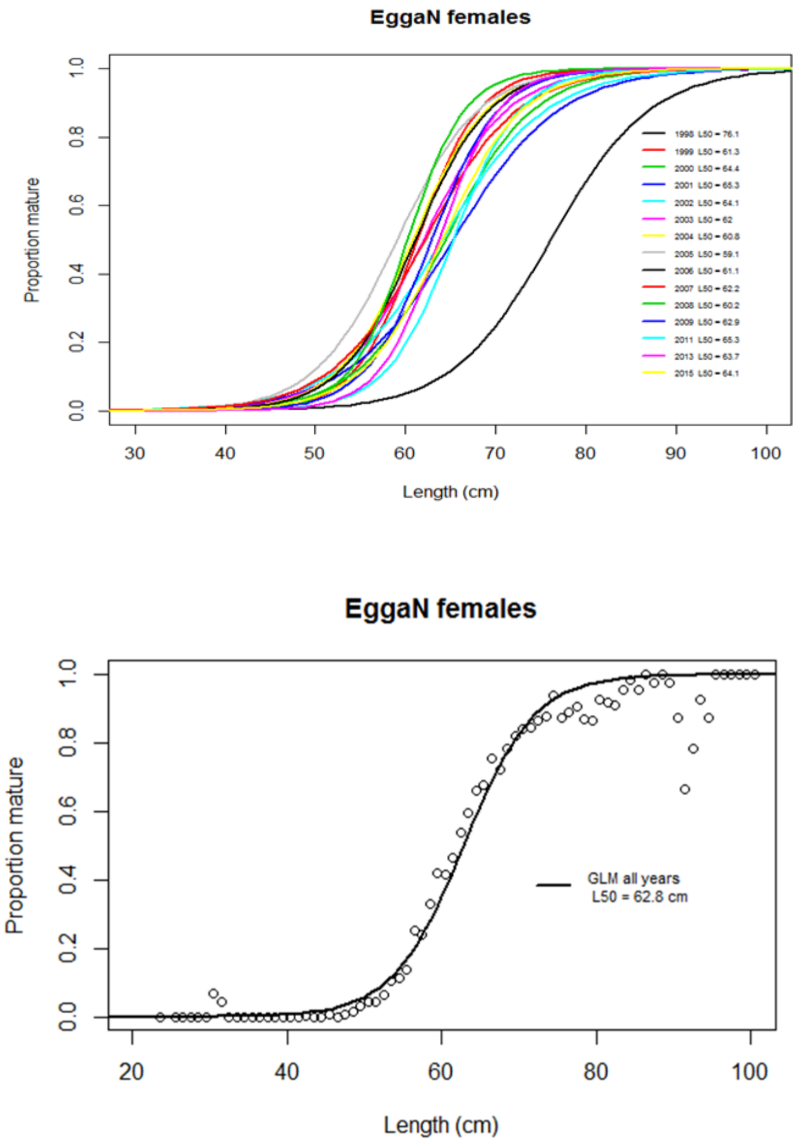


Figure 8.21. Maturity ogives for female Greenland halibut based on data from the Norwegian Slope survey, by year in upper panel and all years together (year 1998 omitted) in lower panel. Stage 1 and 2 on special maturity scale for females are taken as immatures; see Kennedy *et al.,* 2009, 2011, 2014, and Nunez *et al.,* 2015.

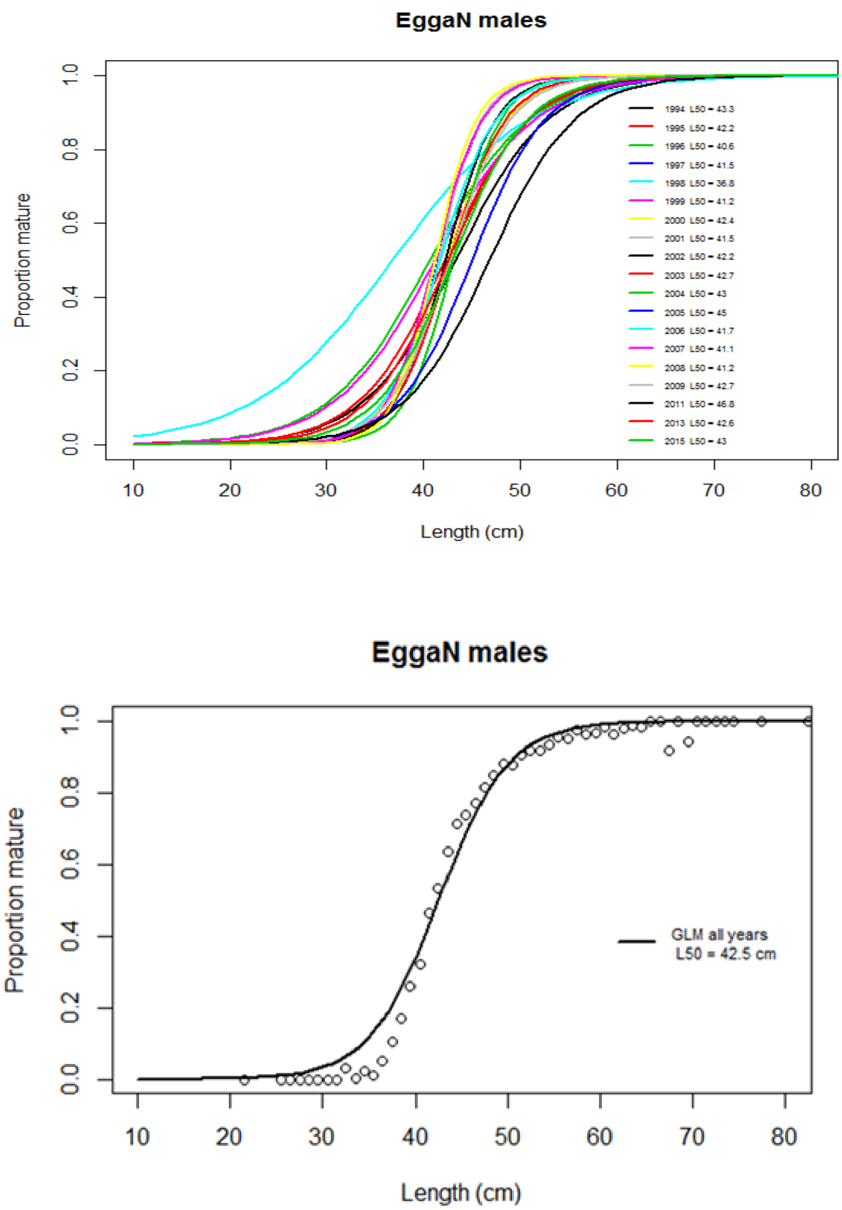


Figure 8.22. Maturity ogives for male Greenland halibut based on data from the Norwegian Slope survey, by year in upper panel and all years together (year 1998 and 2010 omitted) in lower panel.

9 Anglerfish in ICES subareas 1 and 2

9.1 General

Our present knowledge about anglerfish (*Lophius* spp.) in ICES subareas 1 and 2 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, Clegg and Williams 2020). In February 2018, anglerfish in ICES subareas 1 and 2 was subject for a benchmark assessment (WKANGLER 2018). After this benchmark assessment, ICES suggests that this stock (or rather a stock component and a management unit) is considered as a Category 3 stock, for which survey or other indices are available that provide reliable indications of trends in stock metrics, such as total mortality, recruitment, and biomass.

9.1.1 Species composition

Two European anglerfish species of the genus *Lophius* are distributed in the Northeast Atlantic: white (or white-bellied) anglerfish (*L. piscatorius* L.) and black (or black-bellied) anglerfish (*L. budegassa* Spinola). *Lophius budegassa* are rarely caught in Nordic waters. In Norwegian waters, 1 out of about 2600 anglerfish landed from the Møre coast north of 62°N (2a) and 1 out of about 1000 from the North Sea were *L. budegassa* back in 2003 (Dyb 2003; K. Nedreaas, pers. comm.). In recent years (2010-2019) this ratio has some years been up to 1 out of 300 anglerfish being *L. budegassa* in Norwegian waters, but usually about 1 out of 1000.

9.1.2 Stock description and management units

The WGNSDS (Northern Shelf Demersal Stocks) considered the stock structure on a wider European scale in 2004, and found no conclusive evidence to indicate an extension of the stock area northwards to include Division 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 1 and 2) to be recruited from the area west of Scotland including Rockall. This is also supported by research survey data as a migration east-/northeastwards with size is seen in the IBTS- and other survey data (e.g., Dyb 2003).

Results from the use of otolith shape analysis in stock identification of anglerfish (*L. piscatorius*) in the Northeast Atlantic (Cañás *et al.* 2012) and previous references on *L. piscatorius* stock identification find no biological evidence to support the current separation of *Lophius* stocks in the northeast Atlantic, but find substructures within the area.

Anglerfish were tagged during two IBTS surveys in the North Sea and five one-day trips using a small (15 m) Danish seiner off the Norwegian coast at around 62°40'N (Møre) (Thangstad *et al.* 2006; Otte Bjelland, IMR, Norway, pers. comm.). A total of 872 individuals were tagged with conventional Floy dart type tags, 123 in the North Sea (25-78 cm) and 749 at Møre (30-102 cm). Some of this is further described in Thangstad *et al.* (2006). Last year's AFWG report (2019) shows the tagging locations and the hitherto recaptures. There are migrations in all directions, i.e., recaptures from the southern North Sea, at the Shetland/Faroes and northwards to Lofoten. Most of the recaptures were done at Møre where most of the fish were tagged.

In 2000-2001 a total of 1768 trawl caught *L. piscatorius* was tagged using conventional dart tags and released on inshore fishing grounds at Shetland (Laurenson *et al.* 2005). Anglerfish of between 25 and 83 cm total length were tagged. The overall recapture rate was 4.5% and times at liberty ranged from 5 to 1078 days. After this publication, Dr Laurenson reported to www.fishupdate.com about a 104 cm anglerfish caught off the Norwegian coast near Ålesund in 2006. The fish had been tagged and released in the Scalloway Deeps on 13 September 2000 when it was 45cm long and had hence been at liberty for five years and nine months. This is of particular importance as it may indicate a wider mixing of stocks and validate the growth rate of anglerfish.

WKANGLER (2018) considered that most recruitment in subareas 1 and 2 are from the more southerly stock unit, and this would require further R&D work in collaboration with ICES 3a46 looking at egg and larval dispersion and transportation as well as tagging and genetic studies. To address, stock structure, mixing rates, and growth estimates, WKANGLER (2018) recommends a tagging program coordinated between all countries harvesting *Lophius*. Align tagging methods, measurement protocols and outreach to industry. Recommend a shared site for *Lophius* tagging data and other applicable research projects concerning *Lophius*. Until the true biological stock structure is better understood, WKANGLER (2018) recommends keeping the anglerfish in subareas 1 and 2 as a separate management unit for time being.

9.1.3 Biology

Sex ratios in Subarea 2 show that females outnumber males above approximately 75 cm, and above 100 cm all fish were females (Thangstad *et al.* 2006). This is very similar to sex ratios reported from distant Portuguese and Spanish waters (Duarte *et al.* 1997) and hence supports a sex growth difference independent of latitude.

Spawning has been documented to occur in ICES Division 2a in spring, but the present abundance of anglerfish in Subarea 1 and 2 seems to be dependent on influx or migration of juveniles from ICES subareas 4 and 6. Estimation of GSI (gonad-somatic index) for females in Division 2a, indicates developing ovaries from January to June. The highest values of GSI were found in June when some of the ovaries were 20-30% of the round weight. Only females bigger than 90 cm had elevated GSI values indicating developing ovaries. Dyb (2003) found that the length at which 50% of the females were mature (L50) was between 60-65 cm, and that all females above 80 cm were mature.

Some age readings exist of anglerfish in Division 2a, and comparative analyses of different structures, preparations and methods used for age readings were done by Staalesen (1995) and Dyb (2003). The Norwegian Institute of Marine Research adopted the ICES age reading criteria using the first dorsal fin ray (illicium) as its routine method, but few fish have been aged since the above-mentioned projects. The material collected and read was, however, considered sufficient for preliminary yield-per-recruit estimations (ICES 2019). As a very simplified 'rule of thumb' one may divide the fish length by 10 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.

An exploitation using gillnets with 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.

Some basic biological input parameters for the current assessment approaches are shown in Table 9.3. Some of these are further described in WKANGLER (2018).

9.1.4 Scientific 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 2a yields reliable information on the abundance of anglerfish.

9.1.5 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 (Norwegian statistical area 07; Figure 9.1). The anglerfish had previously only been taken as bycatch in trawls and gillnets. Until 2010-2011 there was a geographical expansion of the fishery which was largely due to a northward expansion of the Norwegian gillnet fishery (Figure 9.2). It is not known to what extent this northwards expansion of the fishing area is caused by an expansion of favourable environmental conditions for the anglerfish or the fishers discovering new anglerfish grounds. 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 9.2). The recent increase in landings first happened along the coast of western Norway, but did the last year expand to all subareas north of 62˚N as well.

Norway is by far the largest exploiter of the anglerfish in subareas 1 and 2 accounting for 96-99% of the official landings (Table 9.1). The coastal gillnetting accounts for more than 90% of the landings (Table 9.2). The landings of anglerfish in Subarea 1 and 2 have been about 1/4-1/3 of the total landings from the other Northern Shelf areas (3a, 4 and 6), but was in 2017 only 7% of the total landings in these areas.

No TAC is given for Subarea 1 and 2, Norwegian waters. Catches of anglerfish in Division 2a, EC waters, are taken as a part of the EC anglerfish quota for ICES areas 3, 4 and 6, or as part of the Norwegian 'Others' quota in EC waters. The Norwegian fishery is regulated through:

- A discard ban on anglerfish regardless of size
- A prohibition against targeting anglerfish with other fishing gear than 360 mm (stretc.hed 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 65°N in 2008 and further expanded southwards to 64°N since 2009.
- A maximum of 15% bycatch (in weight) of anglerfish in the trawl- and Danish seine fisheries, and maximum 10% bycatch (in weight) of anglerfish in the shrimp trawl fishery. When fishing for argentines and Norway pout/sandeel a maximum of 0.5% bycatch is allowed within a maximum limit of 500 kg anglerfish per trip
- A maximum of 5% bycatch (in weight) of anglerfish is allowed to be caught in gillnets targeting other species.

9.2 Data

9.2.1 Landings data

The official landings as reported to ICES for subareas 1 and 2 for each country are shown in Table 9.1. Landings decreased rapidly from 2011 to 2015, to the lowest since 1997, but has since shown an increase. It is worth noting that the recent increase in landings first happened along the coast of western Norway, but did the last years also happen in all subareas north of 62˚N as well. Norway has by far the largest reported catches of the anglerfish in subareas 1 and 2, accounting for more than 96-99% of the official international landings. The coastal gillnetting accounts for more than 90% of the landings, of which about 90% is caught by the special designed large-meshed gillnets (360 mm stretc.hed meshes) (Table 9.2).

The Norwegian coastal reference fleet (see Appendix figure H1) provide us with length measurements and catch per gillnet days from ICES subareas 2, from 2007–present, and these have been presented for the AFWG in recent years (ICES 2019). The catch rates vary spatially and temporally, and the WKANGLER (2018) recommended therefore to model and standardize the catch rates to better represent the general abundance trend of anglerfish in the entire ICES Subarea. The available material is shown in Tables 13.4 and 13.5 for the Norwegian statistical coastal areas (Figure 9.1) and total for ICES subareas 1 and 2.

9.2.2 Discards

The absence of a TAC in Norwegian waters probably reduces the incentive to underreport landings. Anecdotal evidence from the industry, observer trips and data from the self-sampling-fleet (the Norwegian reference fleet; Anon. 2013; Clegg and Williams 2020) suggest that up to 89% of the catch (not marketable) is discarded. This happens when the soaking time is too long, mostly due to bad weather. The average percentage discarded anglerfish was higher south of 62°N (ICES 3 and 4) than north of 62°N (ICES 2a). Average length of discarded anglerfish was on average only 6-7 cm smaller than the landed anglerfish. This is also confirmed by Berg and Nedreaas (2020) who estimated the annual discards of anglerfish by the Coastal reference fleet in subareas 1 and 2 to vary between 11 and 32 tons during 2014-2018 (i.e., 1.5-2.5% of total gillnet catch), but was up to 178 tonnes (7.2%) in 2012.

9.2.3 Length composition data

Length distributions are available from the directed gillnet fishery during the period 1992–2019, but data are lacking for 1997–2001 (Figure 9.3). The length data indicates a drop in mean length of 15-20 cm occurring during the period without length samples (Figure 9.3). Since then the mean length increased steadily during the last decade to about 95 cm (about 10 years old and 12 kg) in

2014-2016, i.e., the same size level as seen during the 1990s. One-third of the anglerfish measured during the 1990s were above 100 cm, this proportion was between 1–6% for the early 2000s and 12–17% in 2006-2013. This indicates recruitment into Subarea 2 during 1997—2001 which has not been observed until 2017-2019 when a new drop in mean length is seen, again indicating some recruitment of smaller sized anglerfish to the area.

Length distributions of retained anglerfish (*L. piscatorius*) caught by the Reference fleet as target species during 2007-2019 by the specially-designed-large-meshed gillnets, and as bycatch in other gillnets or other gears are shown in Appendix figures H2-H4. All subsequent analyses (in the methods and results section) have only used the length distributions from the target fishery since 2007 using the large-meshed gillnets which represent more than 80% of the international landings.

9.2.4 Catch per unit effort (CPUE) data

The Norwegian coastal reference fleet (see Appendix Figure H1) has reported catch per gillnet soaking time (CPUE) from their daily catch operations. For the current modelling and hence standardization of the annual CPUE from subareas 1 and 2, we have used the following data:

- Only catch rates of retained anglerfish from the fishery using special large-meshed anglerfish gillnets (stretched meshes=360mm)
- Years 2007-2019
- Discards excluded
- Adding zero catches where gillnets are used, but anglerfish not present
- All coastal areas (i.e. ICES 3a, 4a, 2a and 1) included in the model since it is documented (e.g., WKANGLER 2018) that anglerfish are migrating across the ICES area borders.
- The area (km^2) of each subarea inside 12 nautical miles (covering most of the anglerfish distribution) is calculated and used as a weighing factor when annual CPUEs are estimated for each subarea.

9.3 Methods and results

9.3.1 The length-based-spawning-potential-ratio (LBSPR) approach

The LBSPR method has been developed for data-limited fisheries, where only a few data are available: some representative sample of the size structure of the vulnerable portion of the population (i.e., the catch) and an understanding of the life history of the species (Hordyk *et al.* 2016). The LBSPR method does not require knowledge of the natural mortality rate (M), but instead uses the ratio of natural mortality and the von Bertalanffy growth coefficient (K) (M/K), which is believed to vary less across stocks and species than M (Prince *et al.* 2015) though individual estimates of M and K can be used if available. Like any assessment method, the LBSPR model relies on a number of simplifying assumptions. In particular, the model is equilibrium-based, assumes that the length composition data is representative of the exploited population at steady state, and logistic selectivity (see the results section below for more discussion).

The LBSPR model originally developed by Hordyk *et al.* (2015a, b) used a conventional age-structured equilibrium population model and a size-based selectivity. As a consequence, this approach could not account for "Lee's phenomenon" – the fact that larger specimen at age gets a higher mortality than its cohort of smaller size because of the size-based selectivity. This is because the age-structured model has a 'regeneration assumption' i.e. it redistributes at each time step the length at age using the same distribution. Hordyk *et al.* (2016) since developed a length-structured version of the LBSPR model that used growth-type-groups (GTG) to account for the above phenomenon and showed that the new approach reduced bias related to the "Lee's phenomenon" (https://github.com/AdrianHordyk/LBSPR). GTG LBSPR is therefore used for all subsequent analyses.

Some of the life history parameters for the analysis were taken from WKANGLER (2018). Hordyk *et al.* (2015a,b) showed that the LBSPR approach was sensitive to the input parameters. We, therefore, drew 1000 random samples for each input parameter (i.e. from a bivariate normal distribution for Linf and K, an a univariate normal distribution for M, L50, L95 (see Table 9.3)) and rerun the model in order to account for the effect of uncertainty around the input parameters on the results. We will refer to it as the "stochastic LBSPR approach" hereon.

Once the stochastic LBSPR runs were finished, we conducted some simulations through the LBSPR package to calculate some target SPR value. To do this, we used the mean input values from the stochastic LBSPR, the average estimated parameters values (from the stochastic LBSPR approach), and set the "steepness" to a value between 0.7 and 0.9 to perform a YPR analysis and determine the target reference points (which gives the maximum yield). Steepness values between 0.7 and 0.9 was chosen based on a literature search (values close to 1 are also found in the literature but was not included in the test as it seemed unrealistic for the species). The analysis gave a target reference point of SPR=0.4 (with F/M~1) and SPR=0.25 (with F/M~2) and for a steepness value of 0.7 and 0.9, respectively. What we obtained from the stochastic LBSPR runs instead is a relatively stable annual estimates of SPR (between 0.15 and 0.5 (the IQR range)) and F/M (between 1.5 and 2.5) (Figure 9.4). This would suggest that ¬- while there is a lot of uncertainty - fishing effort is probably slightly above but close to the effort what would lead to maximum yield.

The relationship between the biomass of reproductively mature individuals (spawning stock) and the resulting offspring added to the population (recruitment), the stock recruitment relationship, is a fundamental and challenging problem in all population biology. The steepness of this relationship is the fraction of unfished recruitment obtained when the spawning stock biomass is 20% of its unfished level. Steepness has become widely used in fishery management, where it is usually treated as a statistical quantity. If one has sufficient life history information to construct a density-independent population model then one can derive an associated estimate of steepness (Mace and Doonan 1988, Mangel *et al.* 2010, 2013).

As mentioned in the introduction, the LBSPR approach is an equilibrium-based method (i.e. assumes that the fishery experiences a constant recruitment and F over time) and violation of this assumption can lead to biased SPR estimates. However, some management strategy evaluation conducted by Hordyk *et al.* (2015) on harvest control rules based on SPR-based size targets showed that while annual assessments of SPR may be imprecise due to the transitory dynamics of a population's size structure, smoothed trends estimated over several years may provide a robust metric for harvest control rules. SPR estimates in our study were relatively stable, thus large recruitment fluctuations may not be an issue.

9.3.2 CPUE standardization

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

In the data preparation step, we quickly noticed that there was not enough data from ICES Subarea 1 to perform model inference. Therefore, we decided to omit data from this Subarea from the analyses. ICES subarea 1 is the northern margin of *L. piscatorius* distribution, and only 3 tonnes were caught in this area in 2019, mostly as bycatch in other fisheries.

Below, we defined some important terms we used for the CPUE standardization.

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

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

CPUE standardization was performed using the glmmTMB package (Brooks *et al.* 2017) and the best model was chosen based on AICc and residuals checks using the DHARMa package (Hartig 2020) i.e. the most parsimonious model had the lowest AICc while showing no problematic residuals pattern (i.e. overdispersion, underdispersion, etc.). If problematic residual patterns were found, we tried to address the issue by either reconsidering the input data, changing model parameterization, or changing the model distribution assumption.

The data showed some signs of overdispersion based on residual analysis of simple models (e.g. gaussian, poisson) i.e. the presence of greater variability in the dataset than would be expected based on a given statistical model. The Tweedie distribution was selected as the best model (after model selection) to address this problem. Tweedie distribution belongs to the exponential family and its variance term is modelled as a power function of the mean (μ) i.e. φμ p. The power parameter, p, is restricted to the interval $1<p<2$. The Tweedie distribution is commonly used for generalized linear models (e.g., Jørgensen 1997).

The best model has the following parametrization (for fixed and random effects):

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

The expression (1|vessel) indicates that the vessel effect is considered as a random effect and acts on the intercept. The expression (1|month_year) indicates that the month and year variable was concatenated into a single variable and considered as a random effect. In essence, this treatment models the interaction effect between year and month, but the approach only considers existing interaction (as opposed to all possible combination of year and month which would be un-estimable) – which is an advantage in data-limited situation such as ours.

Further exploration of the residual pattern (more specifically the plot of scaled residual against predictors) indicated some possible issues with the vessel random effect which showed a systematic deviation for some simulated vessel effects (part of the test feature available in DHARMa). These problematic vessels only fished a few times in a single area and time, causing estimation to be less reliable. To address this issue, we filtered the data to keep data from vessels that had more than 5 or 10 observations. Using the 10-minimum-observations criteria greatly improved the residual pattern of the model hence was kept as the final model to produce the standardized annual CPUE index.

The standardized annual CPUE index was created by summing up all predictions based on all possible combination of year (2007-2019), subarea (in ICES area 2a), and month (1-12) after weighting the prediction for each subarea by its surface (in km2 within the 12 nautical miles as shown in Figure 9.5) relative to the total surface (sum of all subarea surfaces in the ICES area 2a). In this process, we removed the vessel random effect (assuming it equals 0, the mean value) as it only affects catch efficiency and does not represent the underlying fish abundance. We note that glmmTMB can handle any missing new levels for random effect variables when making prediction (it assumes it is equal to zero and inflates the prediction error by its associated random effect variance). The standard deviation of the summed prediction was directly calculated in glmmTMB by modifying the source code ('glmmTMB.cpp' file).

Figure 9.6 shows that anglerfish population in ICES Subarea 2a might have declined over the last decade (as well as the raw effort) but there is a lot of year to year variability and uncertainty around the point estimates.

9.3.3 JABBA

JABBA stands for 'Just Another Bayesian Biomass Assessment' and is an open-source modelling software that can be used for biomass dynamic stock assessment applications. It has emerged from the development of a Bayesian State-Space Surplus Production Model framework applied in stock assessments of sharks, tuna, and billfishes around the world (Winker *et al.* 2018). JABBA requires a minimum of two input comma-separated value files (.csv) in the form of catch and abundance indices (and SE) (see Appendix table H1). The Catch input file contains the time series of year and catch by weight, aggregated across fleets for the entire fishery. Missing catch years or catch values are not allowed. JABBA is formulated to accommodate abundance indices from multiple sources (i.e., fleets) in a single CPUE file, which contains all considered abundance indices. The first column of the CPUE input is year, which must match the range of years provided in the Catch file. In contrast to the Catch input, missing abundance index (and SE) values are allowed.

The catch data comes from the different fishing countries' official reporting of annual landings to ICES (see Table 9.1) and the CPUE data (along with its standard deviation) comes from the CPUE standardization process described above and Figure 9.10 for the early years 1992-1994. We assumed that the CPUE index from ICES Subarea 2a calculated using data from the anglerfish targeted fishery is representative of the stock status in ICES areas 1 and 2 together.

In addition to these .csv files, JABBA also require users to define the prior distribution for the model parameters which will be subsequently updated with data to form the posterior distributions (Figure 9.7).

Figure 9.8 shows the trajectory of the population estimates from 1990-2019 based on its estimated biomass and the estimated fishing mortality. In general, population abundance has never fallen below Bmsy (at least the mean trajectory. See also Figure 9.9) but fishing mortality fluctuated above and below the FMSY. Figure 9.8 also shows the credibility intervals of the 2019 estimates of biomass and fishing mortality. The percentage numbers at the top right indicate how much of the 2019 population estimates that falls within the green (not overfished, no overfishing), yellow (overfished, but no overfishing), orange (overfishing, but not overfished), and red (overfished and overfishing) zones, after accounting for all the parameter uncertainty (basically, the area under the oval shaped density plot that falls into each colored quadrant). The model estimates that there is roughly a 40% probability that the 2019 population estimate fall within the red zone, 35% in the orange, and 25% in the green zone. Model sensitivity to prior assumptions (r, K, psi, sigma2 in Figure 6) was also examined but all models showed qualitatively similar results.

9.4 Management considerations and future investigations

The present abundance of anglerfish in subareas 1 and 2 seems to depend on influx or migration of juveniles from ICES subareas 4 and 6. It is therefore expected that an effective discard ban on anglerfish in subareas 4 and 6 will have a positive impact on the abundance north of 62°N. Reduced mean size of the landed anglerfish in recent years (fishing with the same large-meshed gillnets) indicates a new influx of recruitment to the ICES subareas 1 and 2. Monitoring of the fishery will be important in near future to protect the young specimens from recruitment- and growth overfishing.

The AFWG has previously recommended that the anglerfish stock component in subareas 1 and 2 is annually monitored and a 20% reduction in fishing effort per year (also as an uncertainty cap) should be imposed until the decrease in CPUE is stopped. Despite that the decrease in CPUE has stopped for time being, the current exploratory assessment shows that there is nothing to gain in increasing effort.

The three approaches tested in this report, all very different (except that JABBA also uses the CPUE as abundance indices), offer corroborative evidence suggesting that the anglerfish population has declined over time.

The standardized CPUE analysis shows that anglerfish population in ICES Subarea 2a has declined over the last decade (as well as the raw effort) with a slight increase in the two most recent years.

The spawning potential ratio, as calculated by the LBSPR method using input biological parameters and the estimated exploitation parameters suggests that - while there is a lot of uncertainty - fishing effort is probably slightly above but close to the effort what would lead to maximum yield.

The relative population stock status is around BMSY, though fishing intensity seems too high (above FMSY) and should be reduced before the population does fall below the biomass and SPR targets.

The quality of the current exploratory assessment should be further evaluated by analysing more diagnostics, especially the JABBA model sensitivity of priors settings, before being adopted as the routine assessment package to be used for anglerfish in ICES subareas 1 and 2.

When it comes to reference points, it should be further discussed if and which defined values of F/M, F/FMSY, SPR and B/BMSY that may be used.

Any potential harvest control should take account of both recruitment- and growth- overfishing. LBSPR provides measures for both, F/M and SPR, with the SPR values being the transient SPR and thus an estimate of current stock status. While maximum sustainable catch is often a key management objective, it may not be the only one. In that case, it may be worth modifying a reference point to reflect other management objectives.

The AFWG supports that ICES subareas 1, 2, 3, 4 and 6 should be investigated together to get a more complete understanding of migrations and distribution.

Table 9.1. Nominal catch (t) of Anglerfish in ICES Subareas I and II, 1999-2019, as officially reported to ICES

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*
Denmark	+	+	2	+	-	1	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Faroes	+	-	1	1	2	5	11	4	7	4	2	1	+	+	1	+	+	1	1	+	+
France	-	-	-	-	-	-	-	1	-	-	-	-	1	3	2	-	4	2	4	3	8
Germany	4	17	65	59	55	70	55	+	+	0	+	82	70	0	-	+	+	+	1	1	50
Iceland	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-
Norway	1733	2952	3554	2000	2405	2907	2650	4257	4470	4007	4298	5391	5031	3758	2988	1655	933	1355	1473	1884	2750
Portugal	-	-	-	-	-	-	-	-	-	2	6	1	+	-	-	-	-	-	-	-	-
UK	6	30	2	11	15	18	19	86	114	138	152	40	3	3	111	2	105	76	5	15	+
Others														1	1	-	-	+	-	+	-
Total	1743	2999	3624	2071	2477	3001	2735	4348	4591	4151	4458	5515	5112	3765	3103	1657	1043	1435	1484	1903	2809

***Preliminary**

Table 9.2. Anglerfish in ICES Subareas I and II. Norwegian landings (tonnes) by fishery in 2007–2019. The coastal area is here defined as the area inside 12 nautical miles from the baseline.

Fleet NORWAY	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*
Coastal gillnet	4 039	3 574	3 934	4 806	4 557	3 521	2 758	1 506	829	1 231	1 320	1 727	2 567
Offshore gillnet	204	240	171	391	319	115	158	95	52	62	87	68	153
Danish seine	63	75	68	40	26	16	19	11	12	17	23	28	27
Demersal trawl	65	34	36	48	19	11	8	7	3	5	6	10	5
Other gears	98	84	89	106	83	96	45	36	37	40	31	51	63
Total	4 470	4 007	4 298	5 391	5 031	3 759	2 988	1 655	934	1 355	1 468	1 884	2 815

***Preliminary per 4 February 2020**

Table 9.3. Basic input parameters and parameters for resampling as used for the LBSPR analysis

Basic input parameters	Value
Von Bertalanffy K parameter (mean)	0.12
Von Bertalanffy Linf parameter (mean)	146
Von Bertalanffy t0 parameter	-0.34
Length-weight parameter a	0.149
Length-weight parameter b	2.964
Steepness	0.8
Maximum age	25
Length at 50% maturity (L50) (mean)	82
Length at 95% maturity (L95) (mean)	100
ΔMat = L95 - L50 (mean)	18
Length at first capture	40
Length at full selection	60
M (mean)	0.2
M/k (mean)	1.67
Parameters for resampling	
Nsamp	1000
CV(M)	0.15
Cor (Linf_K)	0.9
CV(K)	0.3
CV(Linf)	0.15
CV(L50)	0.05
CV(ΔMat)	0.05

Table 9.4. Number of Coastal reference fleet fishing days with anglerfish, per national stat. subareas (0-7) and total for ICES Subareas 1 and 2. Only large-meshed gillnets included.

Year/Area	0	5	6	7	ICES 1 and 2
2007	106	26		280	412
2008	62	37	6	171	276
2009	86	35	36	176	333
2010	14	41	37	143	235
2011	64	19	51	116	250
2012	49	12	24	21	106
2013	64	20	18	81	183
2014	5		19	107	131
2015	108		5	116	229
2016	92		22	34	148
2017	88			109	197
2018	112			88	200
2019	86	34		60	180

Table 9.5. Number of fishing days with length measured anglerfish (left) and number of length measured fish (right). Only large-meshed gillnets included.

Year	ICES 1 and 2
2007	91
2008	48
2009	57
2010	79
2011	119
2012	50
2013	71
2014	33
2015	78
2016	51
2017	95
2018	79
2019	78

Year	ICES 1 and 2
2007	2197
2008	1407
2009	2325
2010	2171
2011	2423
2012	995
2013	1305
2014	546
2015	1063
2016	654
2017	1593
2018	1441
2019	1462

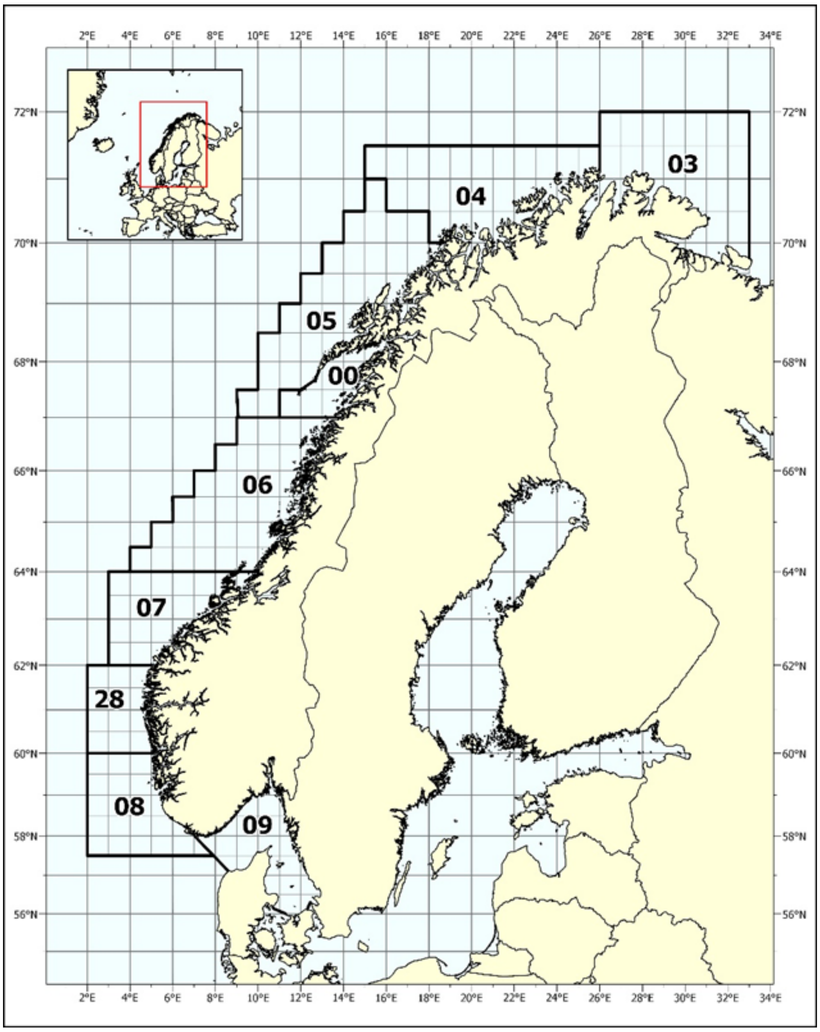


Figure 9.1. Map showing the Norwegian statistical coastal areas. Area 03 is part of ICES Subarea 1, Areas 04, 05, 00, 06 and 07 are part of ICES Subarea 2, Areas 28 and 08 are part of ICES Subarea 4, and Area 09 corresponds roughly with ICES Subarea 3.

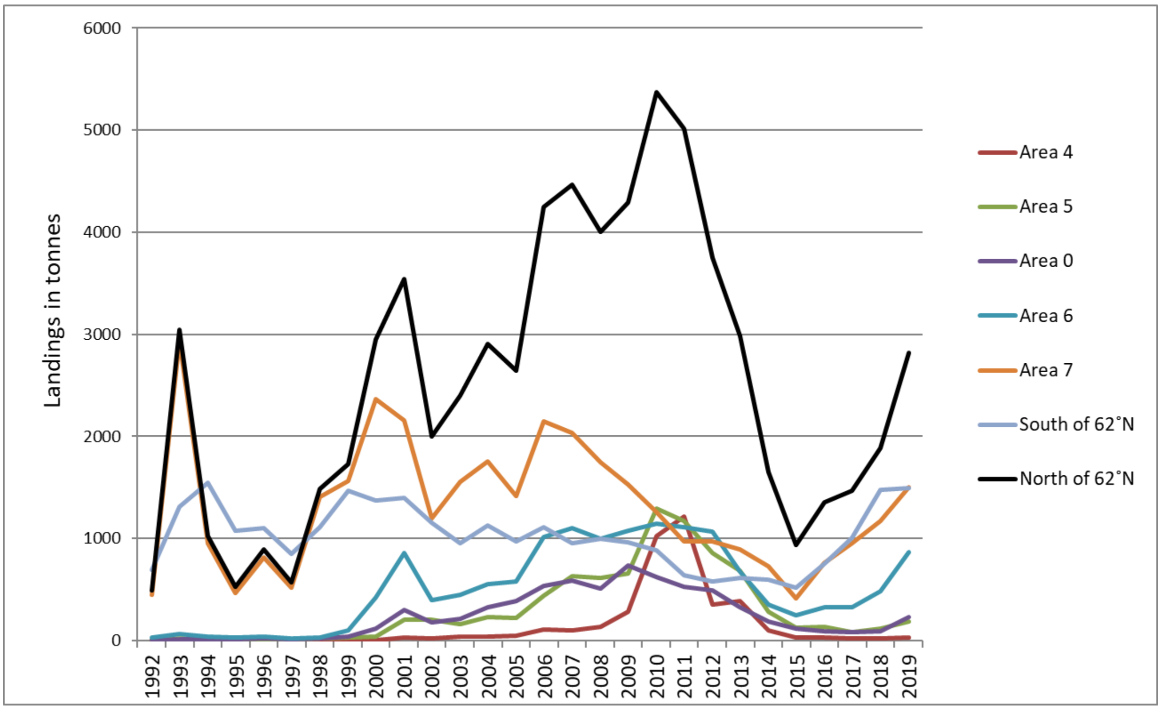


Figure 9.2. Norwegian offical landings (in tonnes) of anglerfish (*Lophius piscatorius*) per statistical area (see Fig. 13.1) within ICES areas 1 and 2 during 1992-2019. Norwegian landings from the area south of 62°N (ICES 4 and 3) are shown for comparison.

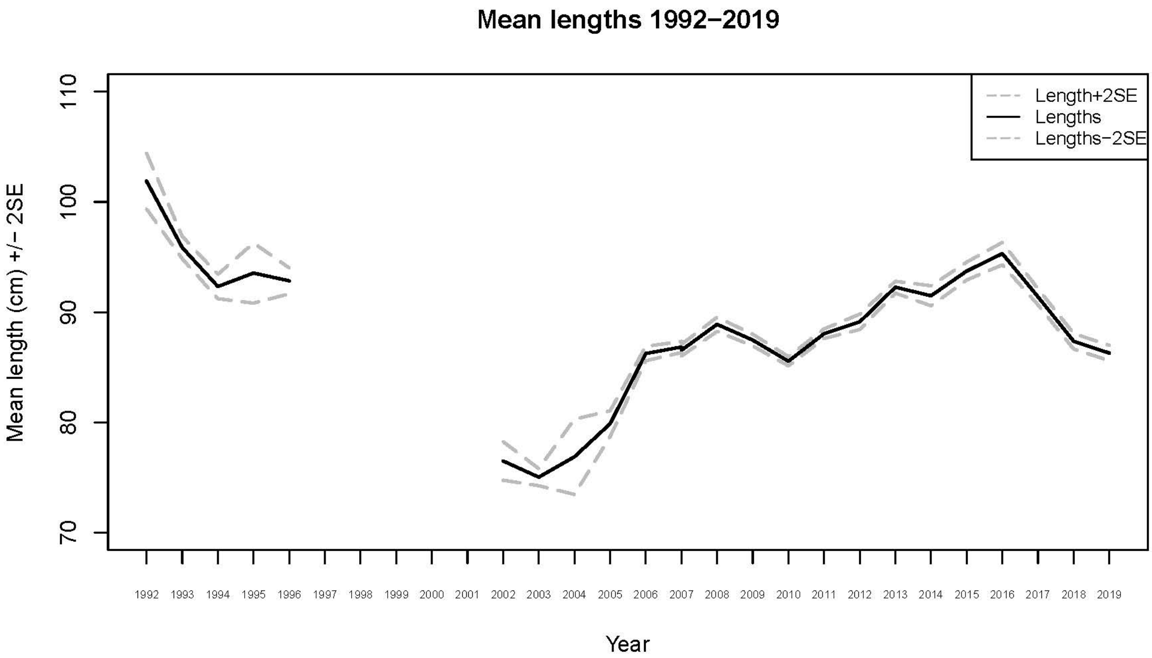


Figure 9.3. Anglerfish (*Lophius piscatorius* in Subarea 1 and 2. Mean lengths for anglerfish caught in the directed coastal gillnetting in Division 2a during 1992-2019, dotted lines represent ±2SE of the mean. Note that data are lacking for 1997-2001. This illustrates pulses of new recruitment entering Division 2a from Subareas 4/6 – last time during 2002-2003, and to a lesser extent in 2017-2019.

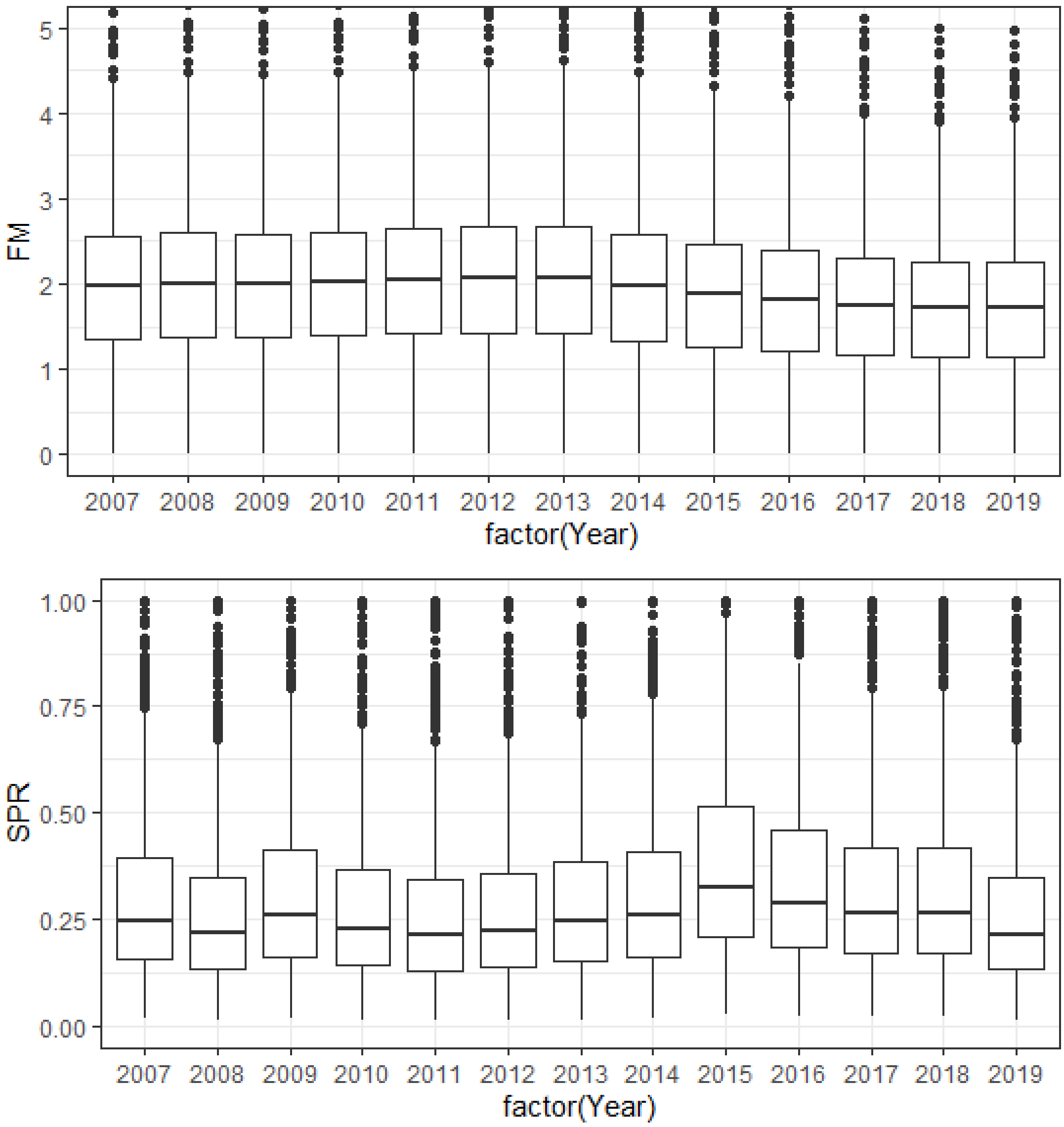


Figure 9.4. Annual estimates of F/M (above) and SPR (below) from the stochastic LBSPR approach using the length composition data from 2007 to 2019.

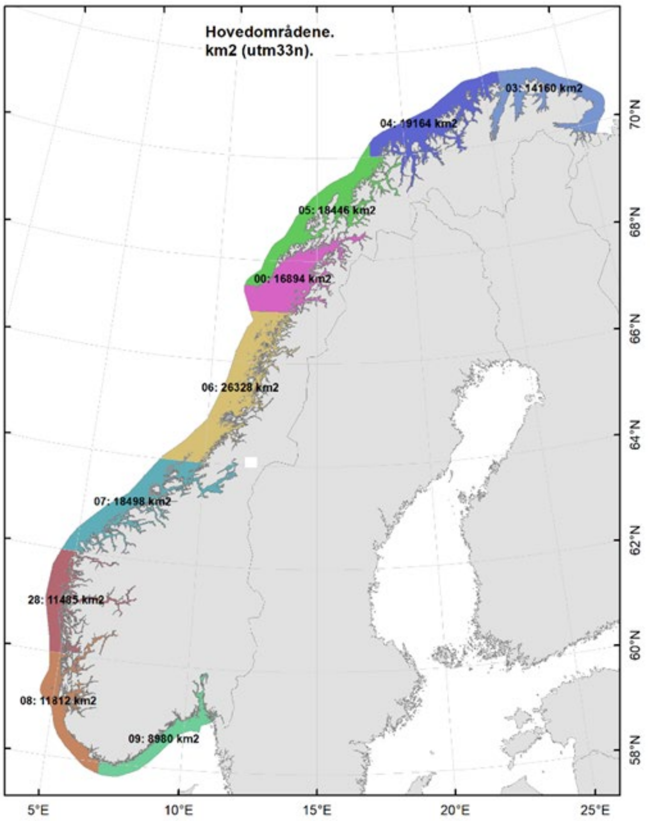


Figure 9.5. Map showing the area (km²) of each Norwegian statistical subarea inside 12 nautical miles. The subareas 4, 5, 0, 6, and 7 belong to the ICES Division 2a.

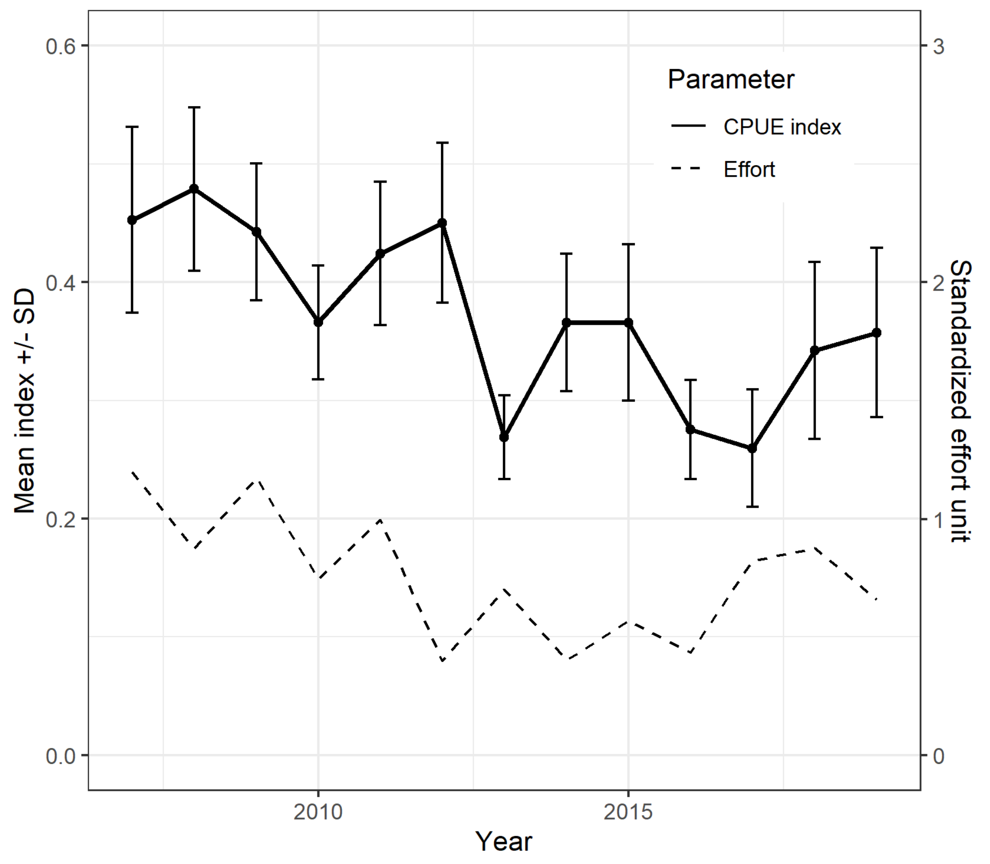


Figure 9.6. Standardized CPUE (kg per gillnet day) +/- SD (solid black line with error bars) and the corresponding standardized effort (dash line) for anglerfish based on the data from the Norwegian coastal reference fleet in ICES Subarea 2a, from vessels targeting anglerfish with large meshed gillnets.

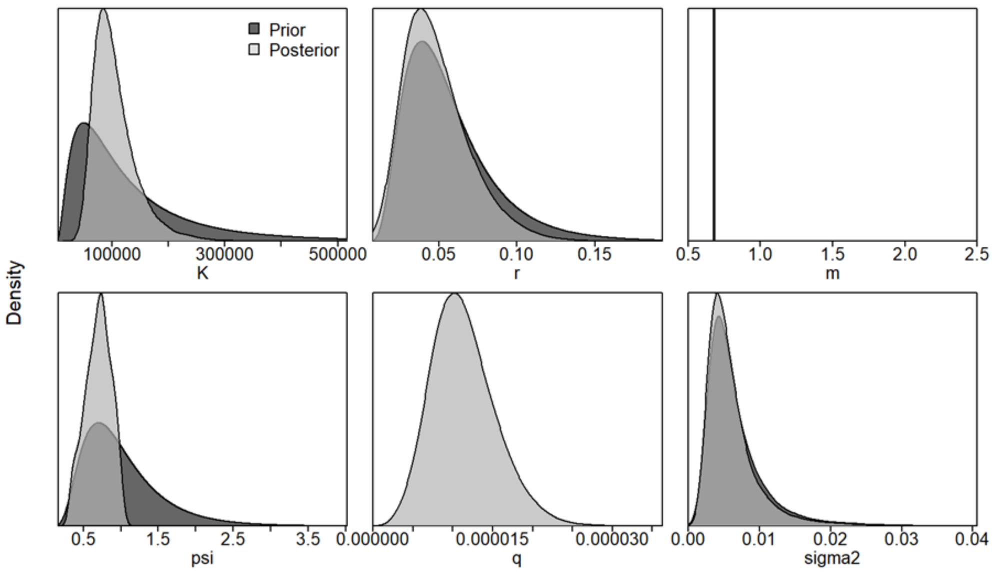


Figure 9.7. Prior and posterior distribution of the model parameters for the anglerfish assessment.

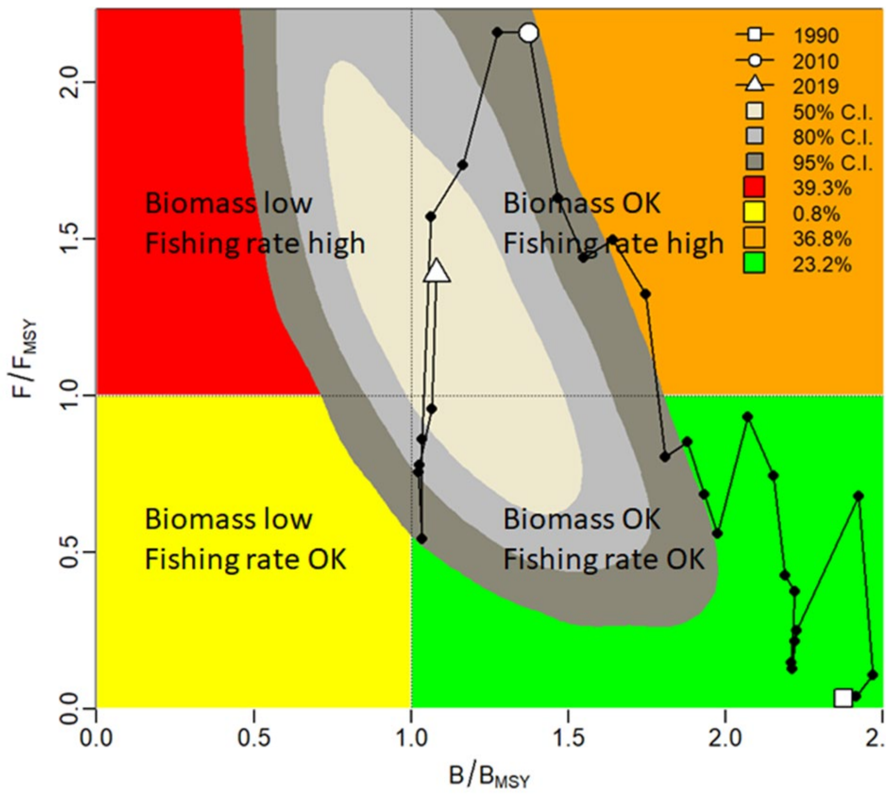


Figure 9.8. Kobe plot for the JABBA scenario showing the estimated trajectories (1990-2019) of B/BMsy and F/FMSY- Different grey shaded areas denote the 50%, 80%, and 95% credibility interval for the terminal assessment year. The probability of terminal year points falling within each quadrant is indicated in the figure legend.

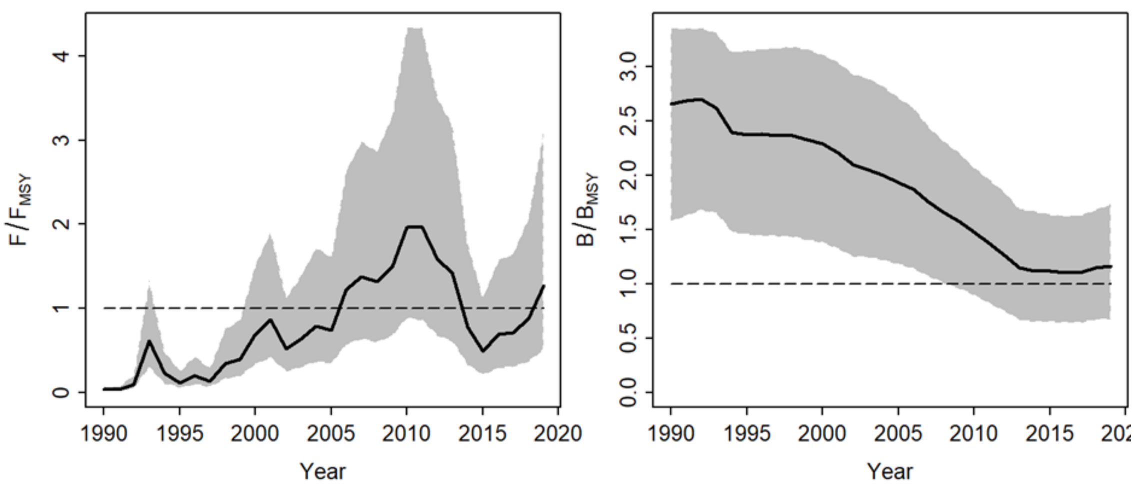


Figure 9.9. Estimated trajectories for F/FMSY (left), and B/BMSY (right) for the ICES Subarea 1-2 anglerfish JABBA scenario. Grey-shaded areas denote 95% confidence intervals.

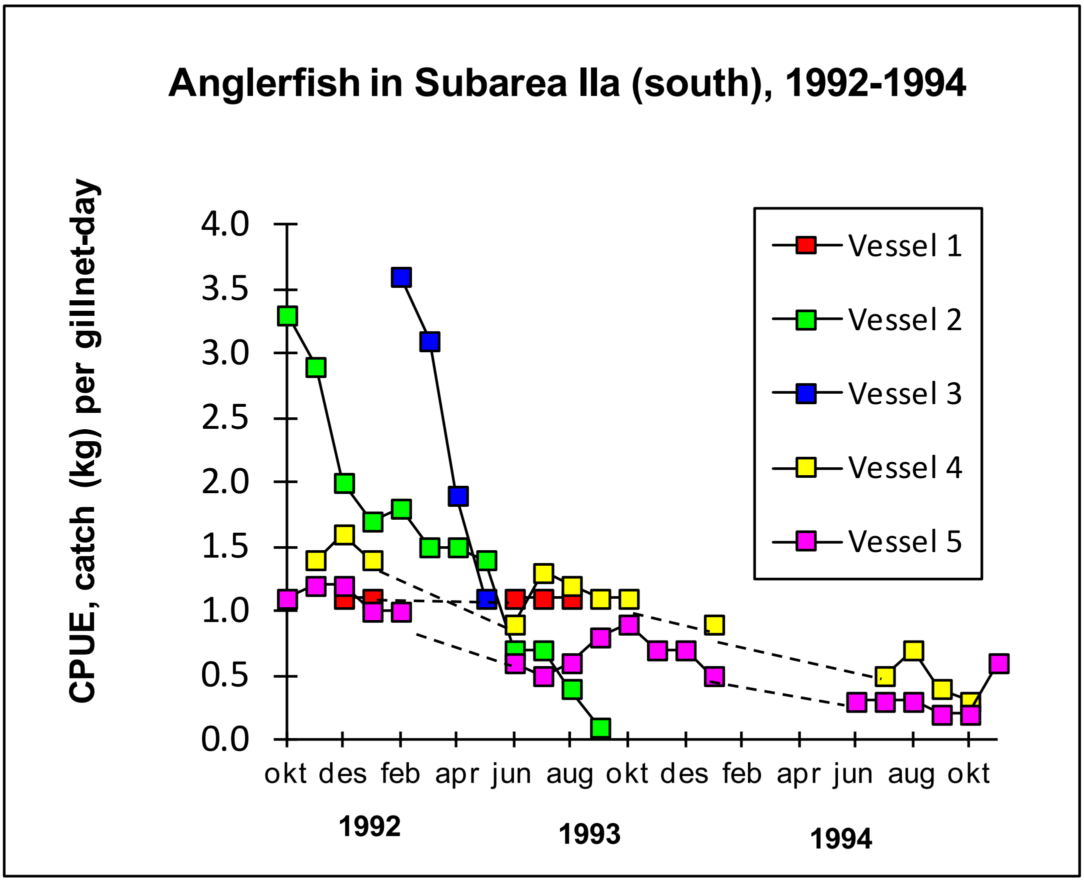
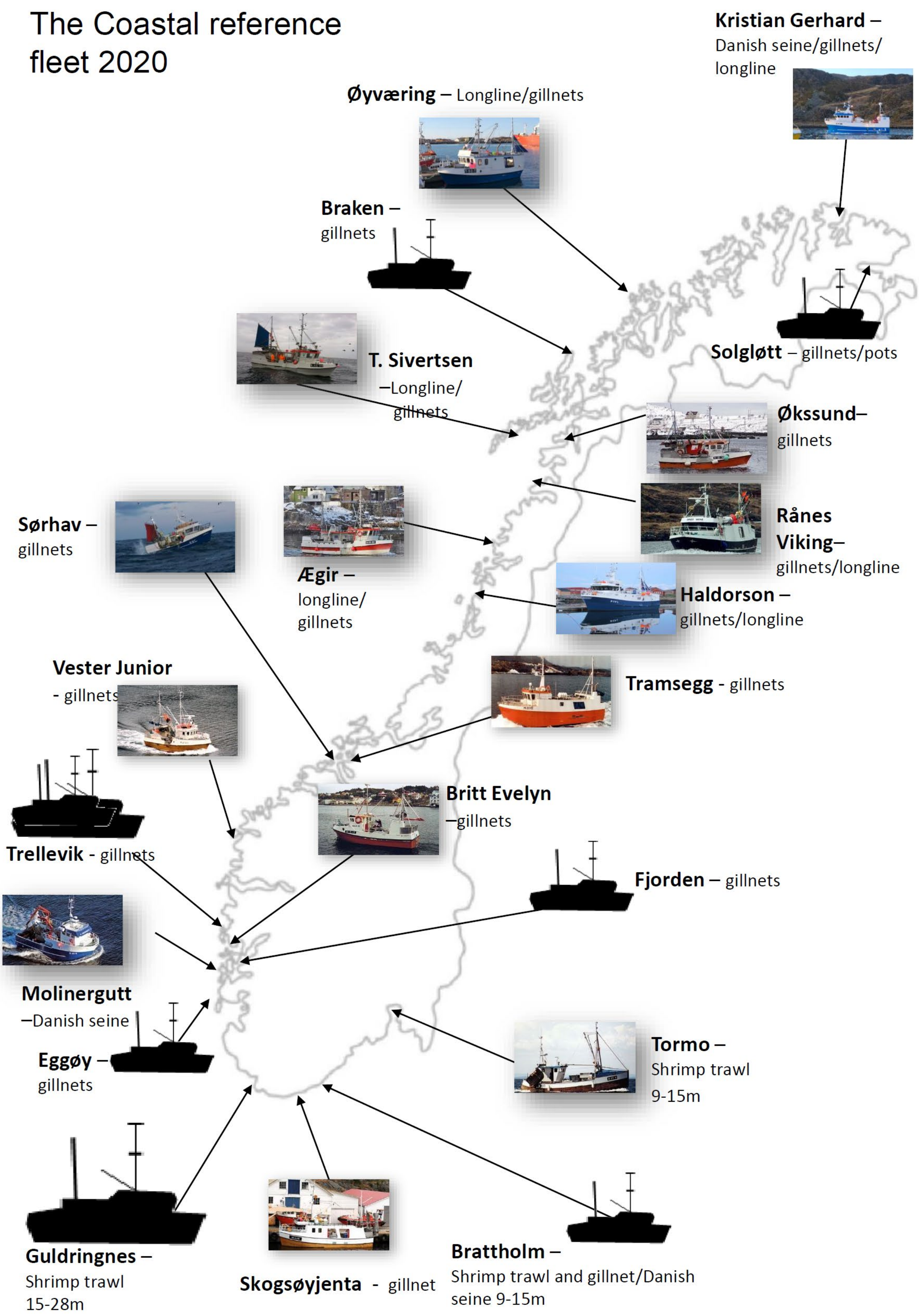


Figure 9.10. Catch per unit effort for five boats in the gillnet fishery for anglerfish in Møre & Romsdal (the same area as vessel A in figure 8 is fishing in) in the period October 1992 - October 1994. Boats 1 > 25m; Boats 2 ca. 20m; Boat 3 ca. 10m; Boat 4 and 5 ca. 16m. Boats 1-4 were fishing with gillnet 360 mm nesh size, boat 5 with 300 mm mesh size.

Appendix figure H1.



Appendix table H1. Input data to the JABBA assessment in the form of catch and abundance indices of anglerfish (*L. piscatorius*) in ICES Subareas 1 and 2.

Year	Catch	CPUE (mean)	CPUE (SE)
1990	151		
1991	180		
1992	488	1.5	0.3
1993	3042	1	0.2
1994	1024	0.5	0.1
1995	526		
1996	887		
1997	601		
1998	1549		
1999	1743		
2000	2999		
2001	3624		
2002	2071		
2003	2477		
2004	3001		
2005	2735		
2006	4348		
2007	4591	0.45	0.07
2008	4151	0.47	0.06
2009	4458	0.44	0.058
2010	5515	0.36	0.048
2011	5112	0.42	0.060
2012	3765	0.45	0.067
2013	3103	0.26	0.035
2014	1657	0.36	0.058
2015	1043	0.36	0.066
2016	1435	0.27	0.042
2017	1484	0.25	0.049

Year	Catch	CPUE (mean)	CPUE (SE)
2018	1903	0.34	0.074
2019	2809	0.35	0.071

10 Barents Sea capelin

10.1 Regulation of the Barents Sea capelin fishery

Since 1979, the Barents Sea capelin fishery has been regulated by a bilateral fishery management agreement between Russia (former USSR) and Norway. A TAC has been set separately for 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.

10.2 TAC and catch statistics (Table 10.1)

The Joint Russian-Norwegian Fishery Commission set a zero TAC for both 2019 and 2020. Both the quotas were in accordance with the ICES advice. The international historical catch by country and season in the years 1965–2020 is given in Table 10.1. There were no landings in 2020, except very small catches during scientific research by Norway and Russia.

10.3 Sampling

The capelin sampling from the Barents Sea ecosystem survey used in the 2019 capelin assessment is summarised below:

Investigation	No. of trawl hauls	Length measurements	Aged individuals
Ecosystem survey in autumn 2019 (Norway)	105	9782	2734
Ecosystem survey in autumn 2019 (Russia)	142	8749	529

10.4 Stock assessment

10.4.1 Acoustic stock size estimates in 2019 (Table 10.2, Figure 10.1)

The geographical survey coverage of the Barents Sea capelin stock during the BESS in 2019 was considered to be complete (Figure 10.1). The north-eastern part of the standard survey area was not covered, but based on the rest of the distribution data, no capelin was expected here.

The stock estimate from the area covered by the 2019 survey was 0.41 million tonnes (Table 10.2). About 73% (0.30 million tonnes) of the estimated stock biomass consisted of maturing fish (>14.0 cm). The mean weight at age in the 2019 survey was similar to 2018 for all age groups (Figure. 10.2).

As decided during the 2016 assessment meeting, the capelin abundance was estimated using the software StoX (Johnsen *et al.* 2019), applying agreed settings.

A fixed sampling variance expressed as Coefficient of Variance (CV) of 0.2 per age group has been applied as input for CapTool in the capelin assessment and was also used this year

(Tjelmeland 2002; Gjøsæter *et al.* 2002). The survey design and estimation software now allows for estimation of a direct CV by age group, and for the 2019 survey this was estimated:

- for age group 1 -0.13;
- for age group 2 - 0.33,
- for age group 3 - 0.36.

These values are higher than previous years for age groups 2 and 3, and lower for age group 1. This can be due to the very patchy distribution of adult capelin this year. Relative sampling error based only on acoustic recordings (Nautical Area Scattering Coefficient (NASC; m^2nmi^{-2}) by nautical mile) was estimated to 25.37% which was very similar to last year. These values are higher than in 2018. Detailed information about previous CV estimates can be found in AFWG WD5, 2018. Future implementation of direct survey CV in the assessment is discussed under future work (10.4.6).

10.4.2 Recruitment estimation in 2019 (Table 10.3)

The survey coverage of 0-group in 2019 was considered complete. Swept volume 0- index (Dingsør, 2005; Eriksen *et al.*, 2009) was calculated both: without correction and with correction for catching efficiency (Table 10.3). The capelin 0-group index for 2019 was above the long-term average. The mean length of 0-group capelin in the areas covered was the lowest since 1993, and well below the long-term average. Table 10.3 also shows the number of fish in the various year classes at age 0-2, and their "survey mortality" from age one to age two.

10.4.3 Forecast

Probabilistic projections of the maturing stock to the time of spawning at 1 April 2020 were made using the spreadsheet model CapTool (implemented in the @RISK add-on for EXCEL, 50 000 simulations were used). The settings were the same as last year. The projection was based on a maturation and predation model with parameters estimated by the model Bifrost and data on cod abundance and size at age in 2020 from the 2019 Arctic Fisheries Working Group (ICES Scientific Reports. 1:30). The assessment which was the basis for advice was used (Tables S_3.15 to S_3.21 in the report.

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 2019 as in 2018 (ICES 2011/ACOM:05, Annex 12).

With no catch, the estimated median spawning stock size at 01 April 2020 is 85 100 tonnes (Figure 10.3), and the probability for the spawning stock to be below B_{lim} (200 000 t) is 97.8%.

Estimates of stock in number by age group and total biomass for the historical period are shown in Table 10.4. Other data which describe the stock development are shown in Table 10.5. Summary plots are given in Figure 10.4.

10.4.4 Recruitment

The 1-group abundance in 2019 was 17.5 billion which is far below the long-term average and the lowest since 1995 (Figure 10.5). The most recent evaluation of the spawning stock and recruitment time series was made by Gjøsæter *et al.* (2016).

Future recruitment conditions: High abundance of young herring (mainly age groups 1 and 2) has been suggested to be a necessary but not a single factor causing recruitment failure in the capelin stock (Hjermann *et al.,* 2010; Gjøsæter *et al.* 2016). Based on survey data from the Barents Sea Ecosystem Survey in 2019, a significant proportion of the young herring is 3-year-olds which are expected to leave the Barents Sea in the year to come, and the abundance of young herring in the Barents Sea in 2020 is expected to be below average.

10.4.5 Comments to the assessment

The survey estimate of abundance at age in 2019 is in correspondence with the 2018 estimate, but the "survey mortality" from age 1 to 2 is very high (Figure 10.6, Table 10.3). This is one of the highest values in the historical period.

Ecological considerations

The number of young herring in the Barents Sea can be an important factor that affects the capelin recruitment. It is not currently taken into account in the assessment model. The benchmark for capelin stocks in the Barents Sea (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 2016-2020 WGIBAR reports (ICES C.M. 2016/SSGIEA:04, ICES C.M. 2017/SSGIEA:04, ICES C.M. 2018/SSGIEA:04; ICES Scientific Reports. 1:42, ICES Scientific Reports. 2:30).

10.4.6 Further work on survey and assessment methodology

Survey

Since the only source of information about the capelin stock abundance and composition comes from the BESS, it is crucial for the assessment that the survey results are reliable. While the survey results of 2016 and 2017 revealed inconsistencies related to monitoring issues (Skaret *et al.* 2018), the results from 2017 and 2018 were consistent—and also the results from 2018 and 2019.

From 26 February to 11 March 2020, IMR carried out a trawl-acoustic monitoring and stock estimation of spawning capelin (Skaret *et al.* 2020). The survey is the second in a planned series of three surveys to evaluate whether such a monitoring can be used in the assessment to improve the advice. The initiative and funding come from the industry, and the idea in the long term is that monitoring closer to when fishery and spawning happens, can reduce uncertainty in stock advice. Monitoring during spawning has been attempted before, last time in 2007–2009, and has proven to be methodologically difficult due to unpredictable timing and location of the spawning migration. The survey was carried out using two fishing vessels 'Vendla' and 'Eros' in collaboration with a scouting vessel, the fishing vessel 'Hovden Viking', so a bigger effort than in 2019. A stratified design using zig-zag transects with randomized starting points were used and the effort was allocated based on historical and recent information about capelin distribution. The fishery sonar was used actively during the whole survey to estimate size distribution of capelin schools, migration speed and direction. Also, TS measurements were carried out and an autonomous sailbuoy was tried for monitoring through remote control. The coverage of the capelin spawning migration was successful and the estimate of 62 000 tonnes was within the expected range from the autumn predictions (Table 10.5, Figure 10.3).

Nevertheless, methodological issues due to timing and patchy distribution of capelin were still very apparent, and this must be handled adequately before such monitoring can be potentially implemented in an advisory process. A similar survey will be carried out again in the winter of 2021, and later the evaluation of the three-year series will be carried out. This could preferably be combined with a benchmark for this stock.

To improve survey methodology, the Deep vision camera system was tested this year onboard 'Johan Hjort' during BESS for the second time. It was mounted on a frame in the trawl opening and towed after the vessel to obtain image samples of fish. The results can help to validate the classification of acoustic data to species groups which was an issue in particular during the 2016 survey, and can potentially provide size distribution of capelin in different depths. The test was promising, but unfortunately, leakage into the camera housing limited the testing to only a few trawl hauls.

Assessment model

In the present capelin assessment model, the only species interaction in the Barents Sea taken explicitly into account is predation by cod on mature capelin. The model does not take into account possible changes in capelin stock dynamics (e.g. maturation), the current state of the environment and stock status of other fish species and mammals in the Barents Sea. The ICES working group of Integrated Assessment of the Barents Sea (WGIBAR) has addressed some of these issues.

Consumption of 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.

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}.

Some points which are planned to be raised in a future benchmark (preferably to help together with one for IGJM capelin) are briefly discussed in the following:

Implementation of survey CV in the stock prediction. The StoX software allows for a rapid calculation of survey CV as part of the capelin biomass estimation process. Potentially this can be included in the stock prediction instead of the fixed CV of 0.2 which is used presently. A more detailed description of the CV estimation and discussion about its implementation is presented in WD5, 2018. The capelin stock projection as currently formulated implements uncertainty in a range of parameters, also related to the cod predation on capelin. A validation of the sensitivity of these uncertainties and their relative contribution to the output of the projection model is needed. At present and from a more practical point of view, the capelin projection model interface in use cannot efficiently run such evaluations and sensitivity tests, but potentially these can be available for the benchmark meeting.

Estimating the maturing part of the capelin stock. Presently a cut-off length of 14 cm is used and the proportion of the stock which is above this length is assumed to represent the maturing stock. There has been work investigating whether the cut-off is appropriate, and this will be presented at the benchmark.

Estimation of capelin mortality from cod predation during autumn. At present, the cod predation from 1 January to 1 April is explicitly modelled in the stock prediction model Bifrost. The cod predation during autumn is implemented as a monthly mortality rate based on a subset of historical estimates of capelin survey mortality. This implementation should be improved.

The parameterization for all processes in Bifrost and CapTool should be updated to include recent data.

10.5 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.

Table 10.1 Barents Sea capelin. International catch ('000 t) as used by the Working Group.

Year	Winter-Spring				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
1965	217	7	0	224	0	0	0	224
1966	380	9	0	389	0	0	0	389
1967	403	6	0	409	0	0	0	409
1968	460	15	0	475	62	0	62	537
1969	436	1	0	437	243	0	243	680
1970	955	8	0	963	346	5	351	1314
1971	1300	14	0	1314	71	7	78	1392
1972	1208	24	0	1232	347	13	360	1591
1973	1078	34	0	1112	213	12	225	1337
1974	749	63	0	812	237	99	336	1148
1975	559	301	43	903	407	131	538	1441
1976	1252	228	0	1480	739	368	1107	2587
1977	1441	317	2	1760	722	504	1226	2986
1978	784	429	25	1238	360	318	678	1916
1979	539	342	5	886	570	326	896	1782
1980	539	253	9	801	459	388	847	1648
1981	784	429	28	1241	454	292	746	1986
1982	568	260	5	833	591	336	927	1760
1983	751	373	36	1160	758	439	1197	2357
1984	330	257	42	629	481	368	849	1477
1985	340	234	17	591	113	164	277	868
1986	72	51	0	123	0	0	0	123
1987-1990	0	0	0	0	0	0	0	0
1991	528	159	20	707	31	195	226	933
1992	620	247	24	891	73	159	232	1123
1993	402	170	14	586	0	0	0	586
1994-1996	0	0	0	0	0	0	0	0

Year	Winter-Spring				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
1997	0	0	0	0	0	1	1	1
1998	0	2	0	2	0	1	1	3
1999	50	33	0	83	0	22	22	105
2000	279	94	8	381	0	29	29	410
2001	376	180	8	564	0	14	14	578
2002	398	228	17	643	0	16	16	659
2003	180	93	9	282	0	0	0	282
2004	0	0	0	0	0	0	0	0
2005	1	0	0	1	0	0	0	1
2006	0	0	0	0	0	0	0	0
2007	2	2	0	4	0	0	0	4
2008	5	5	0	10	0	2	0	12
2009	233	73	0	306	0	1	1	307
2010	246	77	0	323	0	0	0	323
2011	273	87	0	360	0	0	0	360
2012	228	68	0	296	0	0	0	296
2013	116	60	0	177	0	0	0	177
2014	40	26	0	66	0	0	0	66
2015	71	44	0	115	0	0	0	115
2016-2017	0	0	0	0	0	0	0	0
2018	129	66	0	195	0	0	0	195
2019	0	0	0	0	0	0	0	0
2020	0	0	0	0				

Table 10.2. Barents Sea CAPELIN. Stock size estimation table. Estimated stock size (10^9) by age and length, and biomass (10^3 tonnes) from the acoustic survey in August-September 2019. TSN: Total stock number. TSB: Total stock biomass. MSN: Maturing stock number. MSB: Maturing stock biomass.

Length (cm)	Age/year class						Mean weight (g)
	1 2018	2 2017	3 2016	4 2015	Sum (10^9)	Biomass (10^3t)	
7 - 7.5	1.121	0	0	0	1.121	1.46	1.3
7.5 - 8	1.756	0	0	0	1.756	2.509	1.43
8 - 8.5	0.985	0	0	0	0.985	2.004	2.03
8.5 - 9	1.874	0.0088	0	0	1.883	4.649	2.47
9 - 9.5	1.387	0.042	0	0	1.429	4.137	2.9
9.5 - 10	1.452	0.006	0	0	1.459	5.141	3.52
10 - 10.5	1.522	0	0	0	1.522	6.405	4.21
10.5 - 11	1.598	0.016	0	0	1.615	7.914	4.9
11 - 11.5	0.875	0.015	0.053	0	1.077	6.054	5.62
11.5 - 12	1.112	0.122	0	0	1.234	7.785	6.31
12 - 12.5	0.95	0.271	0	0	1.221	9.28	7.6
12.5 - 13	0.512	0.4185	0.018	0	0.949	8.375	8.83
13 - 13.5	0.747	0.865	0.027	0	1.638	16.516	10.08
13.5 - 14	0.554	1.534	0.278	0	2.369	27.303	11.53
14 - 14.5	0.515	1.094	0.043	0	1.651	21.559	13.06
14.5 - 15	0.317	1.395	0.124	0.059	1.895	27.993	14.77
15 - 15.5	0.146	1.045	0.267	0.002	1.461	24.488	16.77
15.5 - 16	0.01	1.002	1.391	0.041	2.444	46.278	18.94
16 - 16.5	0.0194	0.736	1.195	0.116	2.066	43.827	21.21
16.5 - 17	0.003	0.388	1.537	0.343	2.271	52.693	23.21
17 - 17.5	0	0.049	0.801	0.244	1.095	28.896	26.39
17.5 - 18	0	0.101	0.665	0.179	0.945	28.35	29.99
18 - 18.5	0	0.014	0.551	0.149	0.714	23.057	32.31
18.5 - 19	0	0.003	0.06	0.015	0.008	2.752	35.08
19 - 19.5	0	0	0.024	0.008	0.032	1.213	37.9

Length (cm)	**Age/year class**						**Mean weight (g)**
	1 2018	**2 2017**	**3 2016**	**4 2015**	**Sum (10^9)**	**Biomass (10^3t)**	
19.5 - 20	0	0	0	0.006	0.006	0.244	38
20 - 20.5				0.006	0.006	0.264	41
20.5 - 21				0	0	0.002	44
TSN(10^9)	17.455	9.26	7.036	1.169	34.92		
TSB(10^3t)	86.015	134.535	160.425	30.171		411.147	
Mean length (cm)	10.03	14.26	16.22	16.83			
Mean weight (g)	4.93	14.53	22.8	25.71			11.77
MSN (10^9)	1.01	5.828	6.658	1.169	14 593	105.593	
MSB (10^3t)	14.51	100.915	156.141	30.055			301.615

Table 10.3 Barents Sea CAPELIN. Recruitment and natural mortality table. Larval abundance estimate in June, 0-group indices and acoustic estimate in August-September, total mortality from age 1+ to age 2+.

Year class	Larval abundance (10^{12})	0-group Index (10^9 ind.)	Acoustic estimate (10^9ind.)		Mortality survey(1—2)
			1(Y+1)	2(Y+2)	%
1980	-	760	402.6	147.6	63
1981	9.7	536	528.3	200.2	62
1982	9.9	655	514.9	186.5	64
1983	9.9	421	154.8	48.3	69
1984	8.2	295	38.7	4.7	88
1985	8.6	112	6.0	1.7	72
1986	0.0	59	37.6	28.7	24
1987	0.3	4	21.0	17.7	16
1988	0.3	79	189.2	177.6	6
1989	7.3	963	700.4	580.2	17
1990	13.0	130	402.1	196.3	51
1991	3.0	234	351.3	53.4	85
1992	7.3	5	2.2	3.4	--
1993	3.3	2	19.8	8.1	59
1994	0.1	20	7.1	11.5	--
1995	0.0	17	81.9	39.1	52
1996	2.4	172	98.9	72.6	27
1997	6.9	282	179.0	101.5	43
1998	14.1	147	156.0	110.6	29
1999	36.5	428	449.2	218.7	51
2000	19.1	188	113.6	90.8	20
2001	10.7	139	59.7	9.6	84
2002	22.4	100	82.4	24.8	70
2003	11.9	550	51.2	13.0	75
2004	2.5	67	26.9	21.7	19
2005	8.8	231	60.1	54.7	9

Year class	Larval abundance (10^{12})	0-group Index (10^9 ind.)	Acoustic estimate (10^9ind.) 1(Y+1)	2(Y+2)	Mortality survey(1—2) %
2006	17.1	819	221.7	231.4	--
2007	-	760	313.0	166.4	46
2008	-	1251	124.0	127.6	--
2009	-	865	248.2	181.1	27
2010	-	416	209.6	156.4	25
2011	-	767	145.9	216.2	-
2012	-	1141	324.5	106.6	67
2013	-	398	105.1	40.5	62
2014	-	268	39.5	8.1	79
2015	-	592	31.6	123.7	-
2016	-	980	86.4	59.6	31
2017	-	273	58.6	7.0	88
2018	-	-	17.5		
2019	-	564			
Average	9.0	402	175.3	104	

Table 10.4 Barents Sea CAPELIN. Stock size in numbers by age, total stock biomass, biomass of the maturing component (MSB) at 1. October.

Year	Stock in numbers (10^9)						Biomass (10^3 tonnes)	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	MSB
1973	528	375	40	17	0	961	5144	1350
1974	305	547	173	3	0	1029	5733	907
1975	190	348	296	86	0	921	7806	2916
1976	211	233	163	77	12	696	6417	3200
1977	360	175	99	40	7	681	4796	2676
1978	84	392	76	9	1	561	4247	1402
1979	12	333	114	5	0	464	4162	1227
1980	270	196	155	33	0	654	6715	3913
1981	403	195	48	14	0	660	3895	1551
1982	528	148	57	2	0	735	3779	1591
1983	515	200	38	0	0	754	4230	1329
1984	155	187	48	3	0	393	2964	1208
1985	39	48	21	1	0	109	860	285
1986	6	5	3	0	0	14	120	65
1987	38	2	0	0	0	39	101	17
1988	21	29	0	0	0	50	428	200
1989	189	18	3	0	0	209	864	175
1990	700	178	16	0	0	894	5831	2617
1991	402	580	33	1	0	1016	7287	2248
1992	351	196	129	1	0	678	5150	2228
1993	2	53	17	2	2	75	796	330
1994	20	3	4	0	0	28	200	94
1995	7	8	2	0	0	17	193	118
1996	82	12	2	0	0	96	503	248
1997	99	39	2	0	0	140	911	312
1998	179	73	11	1	0	263	2056	931
1999	156	101	27	1	0	285	2776	1718

Year	Stock in numbers (10^9)						Biomass (10^3 tonnes)	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	MSB
2000	449	111	34	1	0	595	4273	2099
2001	114	219	31	1	0	364	3630	2019
2002	60	91	50	1	0	201	2210	1290
2003	82	10	11	1	0	104	533	280
2004	51	25	6	1	0	82	628	294
2005	27	13	2	0	0	42	324	174
2006	60	22	6	0	0	88	787	437
2007	222	55	4	0	0	280	1882	844
2008	313	231	25	2	0	571	4427	2468
2009	124	166	61	0	0	352	3756	2323
2010	248	128	61	1	0	438	3500	2051
2011	209	181	55	8	0	454	3707	2115
2012	146	156	88	2	0	392	3586	1997
2013	324	216	59	7	0	610	3956	1471
2014	105	107	39	2	0	253	1949	873
2015	40	40	13	1	0	94	842	375
2016	32	8	3	0	0	43	328	181
2017	86	124	17	0	0	227	2506	1723
2018	59	60	21	0	0	140	1597	1056
2019	17	9	7	1	0	35	411	302

Table 10.5 Barents Sea CAPELIN. Summary stock and data for prognoses table. Recruitment and total biomass (TSB) are survey estimates back-calculated to 1 August (before 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 year+1, acoustic survey (10^3 t)	Recruitment Age 1, survey assessment 1 October 10^9 sp.	Young herring biomass age 1+2 (10^6 tons) source: WGIBAR	Herring 0-group index (10^9 sp) corr. for catching efficiency	Capelin Landing (10^3 t)
	TSB	MSB						
1972	6600	2727			152	0.002		1591
1973	5144	1350	33		529	0.002		1337
1974	5733	907	*		305	0.048		1148
1975	7806	2916	*		190	0.074		1441
1976	6417	3200	253		211	0.039		2587
1977	4796	2676	22		360	0.046		2986
1978	4247	1402	*		84	0.052		1916
1979	4162	1227	*		12	0.039		1782
1980	6715	3913	*		270	0.066	0.08	1648
1981	3895	1551	316		403	0.047	0.04	1986
1982	3779	1591	106		528	0.009	2.52	1760
1983	4230	1329	100		515	0.012	195.45	2357
1984	2964	1208	109		155	1.467	27.35	1477
1985	860	285	*		39	2.638	20.08	868
1986	120	65	*		6	0.191	0.09	123
1987	101	17	34	4	38	0.287	0.05	0
1988	428	200	*	10	21	0.056	60.78	0
1989	864	175	84	378	189	0.156	17.96	0
1990	5831	2617	92	94	700	0.467	15.17	0
1991	7287	2248	643	1769	402	0.955	267.64	933
1992	5150	2228	302	1735	351	2.037	83.91	1123

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 year+1, acoustic survey (10^3 t)	Recruitment Age 1, survey assessment 1 October 10^9 sp.	Young herring biomass age 1+2 (10^6 tons) source: WGIBAR	Herring 0-group index (10^9 sp) corr. for catching efficiency	Capelin Landing (10^3 t)
	TSB	MSB						
1993	796	330	293	1498	2	3.649	291.47	586
1994	200	94	139	187	20	3.000	103.89	0
1995	193	118	60	29	7	0.821	11.02	0
1996	503	248	60		82	0.300	549.61	0
1997	909	312	85		99	0.349	463.24	1
1998	2056	932	94	414	179	0.620	476.07	3
1999	2775	1718	382		156	1.080	35.93	105
2000	4273	2098	599	700	449	2.136	469.63	410
2001	3630	2019	626		114	1.543	10.01	578
2002	2210	1291	496	1417	60	0.664	151.51	659
2003	533	280	427		82	1.695	177.68	282
2004	628	294	94	105	51	3.108	773.89	0
2005	324	174	122		27	2.105	125.93	1
2006	787	437	72		60	2.153	294.65	0
2007	2119	844	189		222	0.916	144	4
2008	4428	2468	330	469	313	0.865	201.05	12
2009	3765	2323	517	180	124	0.375	104.23	307
2010	3500	2051	504	452	248	0.579	117.09	323
2011	3707	2115	487	160	209	0.843	83.05	360
2012	3586	1997	504		146	0.394	177.19	296
2013	3956	1471	479		324	0.468	289.39	177
2014	1949	873	504		105	0.553	136.31	66
2015	842	375	82		40	0.698	82.75	115
2016	328	181	37		32	0.452	79.44	0

Year	Estimated stock by autumn acoustic survey (10^3 t) 1 October TSB	MSB	SSB, assessment model, April 1 year+1 (10^3 t)	SSB, by winter year+1, acoustic survey (10^3 t)	Recruitment Age 1, survey assessment 1 October 10^9 sp.	Young herring biomass age 1+2 (10^6 tons) source: WGIBAR	Herring 0-group index (10^9 sp) corr. for catching efficiency	Capelin Landing (10^3 t)
2017	2506	1723	462		124	0.703	153.76	0
2018	1597	1056	317	295	59		-	195
2019	411	302	85	62	17			0

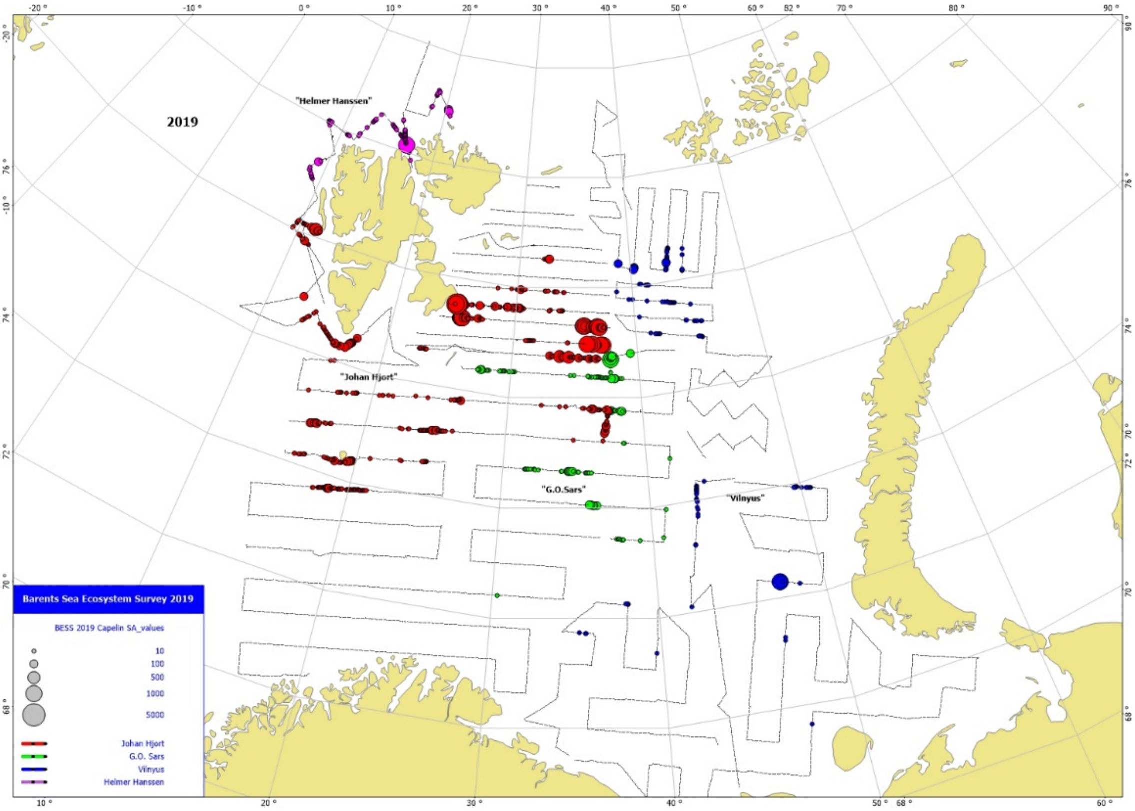


Figure 10.1. Geographical distribution of capelin in autumn 2019.

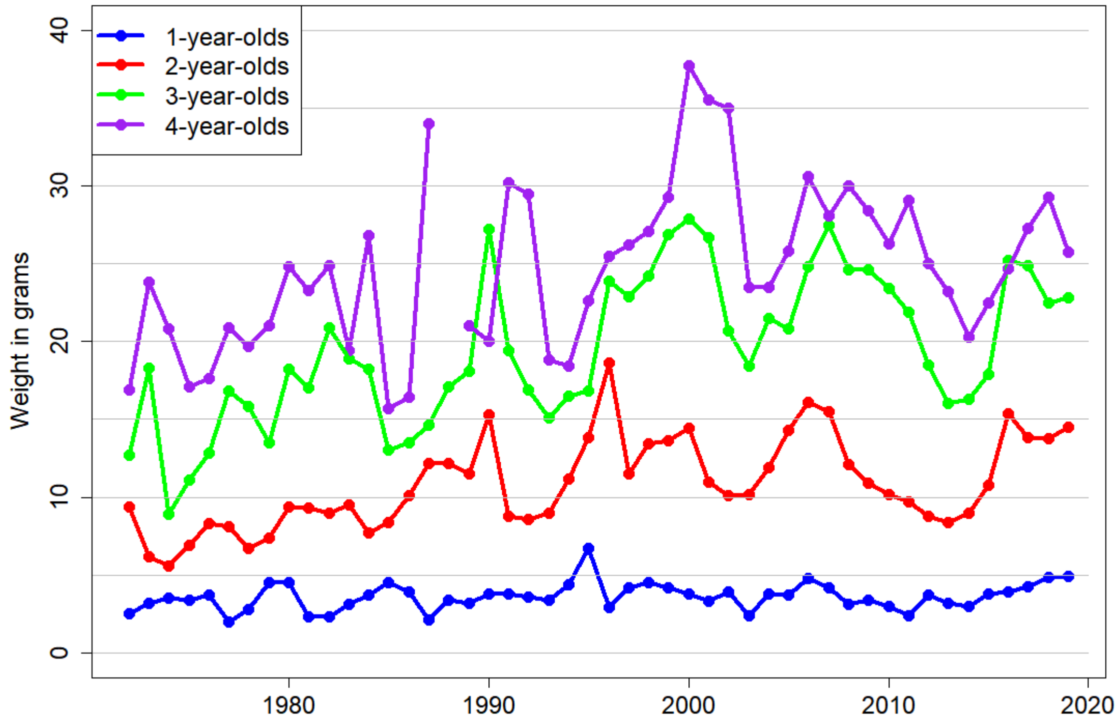


Figure 10.2 Weight-at-age (grams) for capelin from the autumn survey.

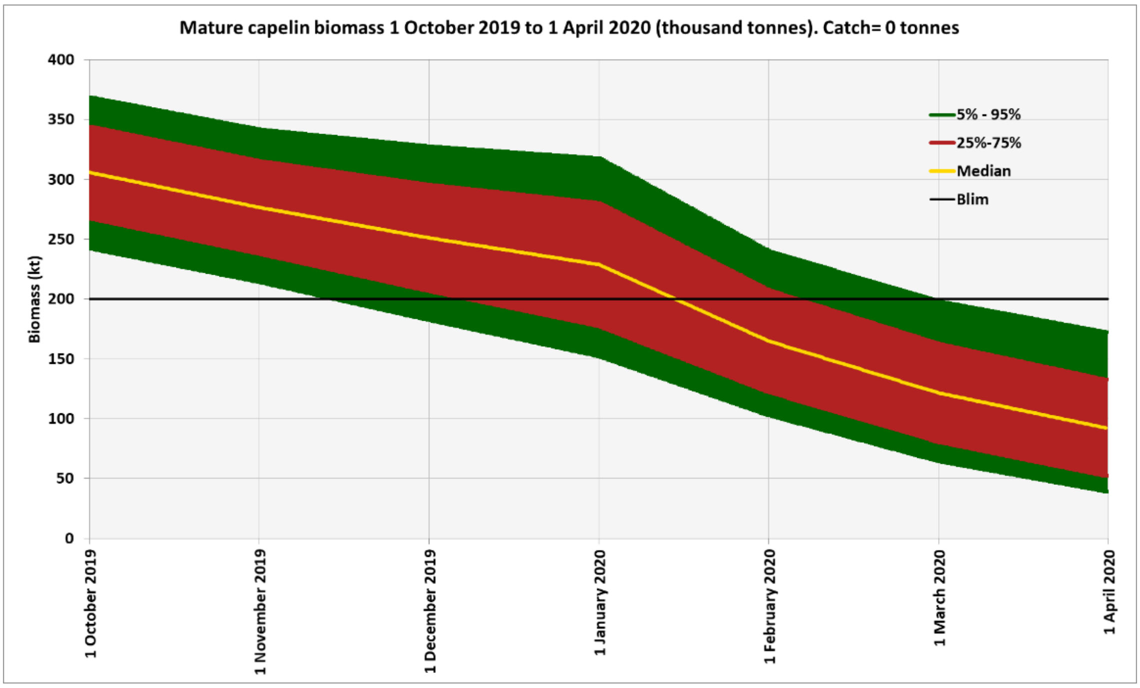


Figure 10.3. Probabilistic prognosis 1 October 2019 to 1 April 2020 for Barents Sea capelin maturing stock, with no catch (model CapTool, 50 000 simulations).

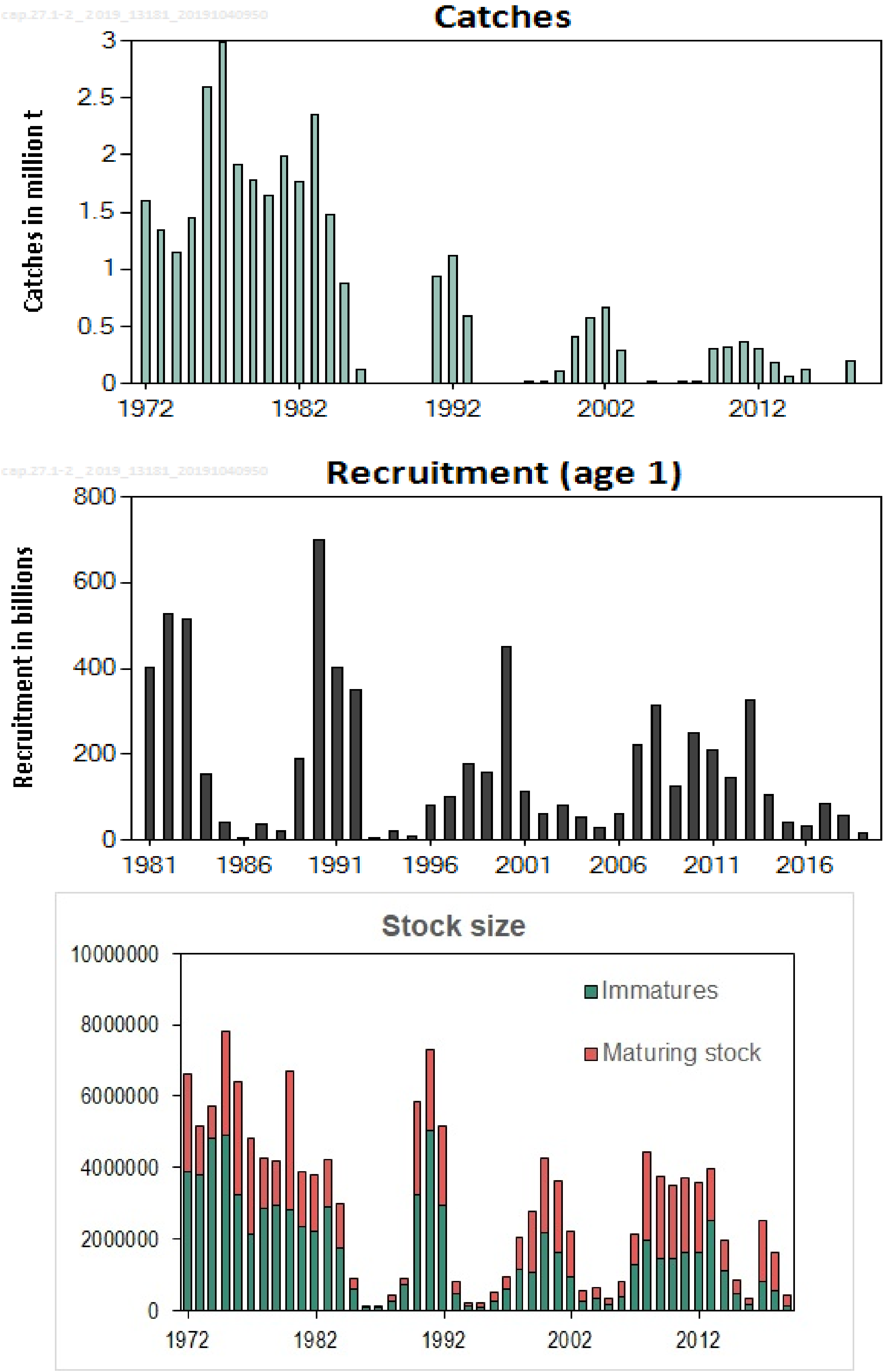


Figure 10.4. Capelin in subareas 1 and 2, excluding Division 2a west of 5°W (Barents Sea capelin). Landing and summary of stock assessment (mature and immature stock biomass in tonnes).

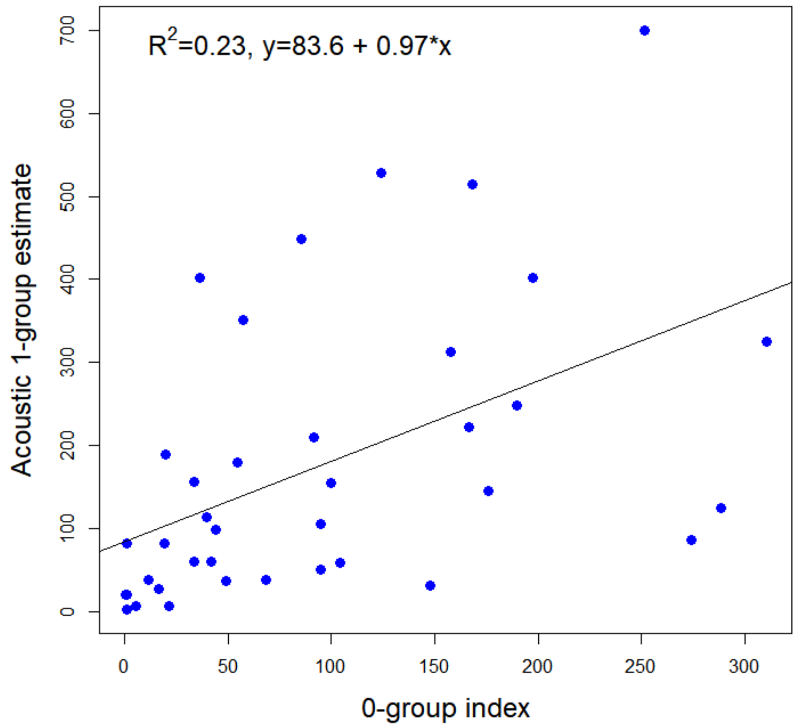


Figure 10.5. Regression of abundance of capelin at age 0 (0-group index without K_{eff}) and age 1 for cohorts 1980—2017. No 0-group estimate was made for the 2018 cohort.

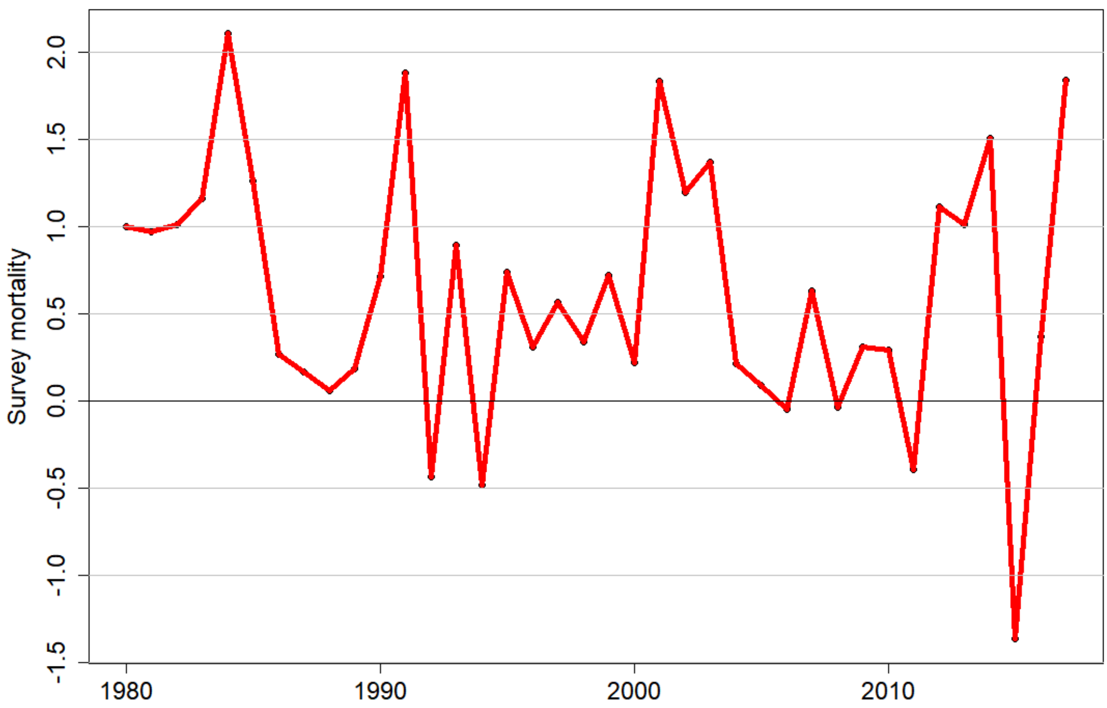


Figure 10.6. Capelin survey mortality from age 1–2. X-axis shows cohort.

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Annex 1: List of participants

Name	Country
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Aglen, Asgeir	Norway
Bernreuther, Matthias	Norway
Bogstad, Bjarte	Norway
Chetyrkin, Anatolii	Russia
Eidset, Elise	Norway
Fall, Johanna	Norway
Filin, Anatolii	Russia
Halldor Hallfredsson, Elvar	Norway
Höffle, Hannes	Russia
Howell, Daniel	Norway
Kovalev, Yuri	Russia
Nedreaas, Kjell	Norway
Nielsen, Anders	Denmark
Russkikh, Aleksei	Russia
Staby, Arved	Norway
Windsland, Kristin	Norway
Yaragina, Natalia	Russia

Annex 2: Resolutions

This resolution was approved 1 October 2019

2019/2/FRSG02 The **Arctic Fisheries Working Group (AFWG)**, chaired by Daniel Howell, Norway, will meet at ICES HQ, Denmark, on 15-22 April 2020 to:

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

The assessments will be carried out on the basis of the Stock Annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group on the dates specified in the 2020 ICES data call.

AFWG will report by 7 May 2020 and XX October 2020 for Barents Sea capelin for the attention of ACOM.

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

Due to the COVID-19 disruption that started early 2020, ACOM drafted a "spring 2020 approach" for recurring fishing opportunities advice. The generic Terms of Reference have been adjusted as described in the letter to ICES chairs below.

Chairs of Expert Groups

Our Ref: C.4.e/MDC/mo 13 March 2020

Subject: **Spring 2020 approach to advice production**

Dear Expert Group Chair,

I am writing this letter to keep you up to date about the approach of ACOM to the COVID-19 disruption. Many of our institutes now have travel bans and/or working from home policies. ACOM has developed a "spring 2020 approach" to this year's spring advice season. This letter covers the recurrent fishing opportunities advice. Any special request processes and non-fisheries advice will be dealt with separately. The expert groups effected are listed in Annex 1.

ACOM is encouraging all expert groups to keep working, and stick broadly to the time line, but clearly this needs to be through virtual meetings. ICES secretariat will support your efforts and make WebEx available. They will also produce a broad training document on WebEx. We know that the use of virtual meetings will result in an increased burden on the Chairs and members of the expert groups, therefore we have made changes to the generic terms of reference (see Annex 2 below) categorizing them as high, medium and low priority for this year's work. We also suggest that the expert group works virtually through smaller subgroups, and only hold larger virtual meetings when necessary.

The requesters of advice have been informed that there will be disruption/change to the delivery of advice for the spring 2020 season.

ACOM will also change the way that ICES gives advice for the spring 2020 season. There will be three types of advice:

- **Standard advice** sheet (the advice sheet following the January 2020 guidelines)
- **Abbreviated advice** sheet (a shortened advice sheet)
- **Rollover advice** (the same advice as in 2019)

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The choice of which type of advice to apply to a stock is based on criteria determined by ACOM:

a. **Standard advice** - stocks with 2020 benchmarked methods
b. **Abbreviated advice** – most stocks, including management plan and MSY advice stocks, and some Cat 3 stocks. The abbreviated advice will contain the advice of the headline advice, catch scenario tables, plots and automated tables (last years' advice will be added as an annex to each sheet). The guidance for abbreviated advice is being written now and you should receive it in a few days.
c. **Rollover advice** – same as 2019 advice. This will be provided for stocks in the following categories:
    - zero TAC has been advised in recent years and no change likely,
    - category 3 or greater roll over advice, except if due to be reviewed in 2020
    - long lived stable stocks, with no strong trends in dynamics in recent years
    - some non-standard stocks (e.g. North Atlantic salmon)

We need to consult both you and the requesters of advice about which type of advice to apply to each stock. Today the ACOM criteria are being used by the secretariat to allocate advice types to stocks. This is the first version. We would like you to consider this list and comment if you think that the allocation needs changing. Please remember that the abbreviated advice is being developed to help your processes and also the ACOM processes during the disruption. The list of allocated advice type for each stock will hopefully be sent to you today or Monday. Please reply with your comments by 19th March so that we can start the dialogue with requesters. ACOM hopes that we could have a definitive list by 25th March. (This is too late for HAWG, so we suggest that HAWG use the list compiled in cooperation with Secretariat expecting requesters of advice to agree).

ACOM is recommending that for North Sea stocks with re-opening of advice in the autumn, the stock assessments be carried out in the spring but not the forecasts (postponed until early autumn). The advice would be delivered in the autumn of 2020.

You will shortly receive the first version of the **list of advice types allocated to stocks** and the **guidelines for abbreviated advice**. Please respond by 19th March with your comments on the first version of the list.
Your professional officer has been briefed about these changes. The changes are designed to reduce both expert group and ACOM workload. Lotte, your professional officer, the ACOM leadership and the FRSG Chair are available for further explanation.

Best regards

Mark

Mark Dickey-Collas
ACOM Chair

Annex 1. Expert groups associated with 2020 spring advice season

Herring Assessment Working Group for the Area South of 62°N
Working Group on North Atlantic Salmon*
Assessment Working Group on Baltic Salmon and Trout*
Baltic Fisheries Assessment Working Group
Arctic Fisheries Working Group
Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak
North-Western Working Group
Working Group on the Biology and Assessment of Deep-sea Fisheries Resources
Working Group for the Bay of Biscay and the Iberian Waters Ecoregion
Working Group for the Celtic Seas Ecoregion
Working Group on Southern Horse Mackerel, Anchovy, and Sardine
Working Group on Elasmobranch Fishes

* These groups already have different approaches.

Annex 2. Spring 2020 adapted generic terms of reference. [Agreed by ACOM 12 March 2020]

In light of the disruptions caused by COVID-19 in 2020, the generic terms of reference for the FRSG stock assessment groups have been re-prioritised. This applies to expert groups that feed into the spring advice season process[1]. ACOM is encouraging expert groups to use virtual meetings (e.g. WebEx) and subgroups to deliver the high priority terms of reference. See letter from the ACOM Chair to expert groups.

High Priority for spring 2020 advice season

c) Conduct an assessment on the stock(s) to be addressed in 2020 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. **Check the list of the stocks to be done in detail and those to roll over.**
   - i) Input data and examination of data quality;
   - ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
   - iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.
   - v) The developments in spawning stock biomass, total stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;
   - vi) The state of the stocks against relevant reference points;
   - vii) Catch scenarios for next year(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;
   - viii) Historical and analytical performance of the assessment and catch options with a succinct description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines. Check list to confirm whether the stock requires a concise advice sheet or a traditional advice sheet.

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

j) Audit all data and methods used to produce stock assessments and projections.

[1] These do not apply to Assessment Working Group on Baltic Salmon and Trout and Working Group on North Atlantic Salmon.

Medium Priority for spring 2020 advice season

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

b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:
   i) descriptions of ecosystem impacts of fisheries
   ii) descriptions of developments and recent changes to the fisheries
   iii) mixed fisheries considerations, and
   iv) emerging issues of relevance for the management of the fisheries;

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

Low Priority for spring 2020 advice season

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

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

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

i) Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice. ACOM would encourage expert groups to carry out this term of reference later in the year through a webex.

Annex 3: Terms of Reference (ToRs)

In 2020 the original ToRs were modified to account for the need to adapt to running AFWG and the ADGby webex. The revision is in this report, after the original ToRs. Also note that the meeting was not held in Copenhagen, but rather by webex. A short summary of challenges posed by this is in the Executive Summary.Generic ToRs for Regional and Species Working Groups

This resolution was approved 1 October 2019

2019/2/FRSG01 The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

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

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

   i) descriptions of ecosystem impacts of fisheries

   ii) descriptions of developments and recent changes to the fisheries

   iii) mixed fisheries considerations, and

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

c) Conduct an assessment on the stock(s) to be addressed in 2020 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 Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.

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

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

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

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

   viii) Historical and analytical performance of the assessment and catch options with a succint description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

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

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

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

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

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

i) Take 15 minutes, and fill a line in the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity'; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice.

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

Adaptions to expert groups' generic terms of reference for spring 2020.

In light of the disruptions caused by COVID 19 in 2020, the generic terms of reference for the FRSG stock assessment groups have been re-prioritised. This applies to expert groups that feed into the spring advice season process[2]. ACOM is encouraging expert groups to use virtual meetings (e.g. webex) and subgroups to deliver the high priority terms of reference.

High Priority for spring 2020 advice season

c) Conduct an assessment on the stock(s) to be addressed in 2020 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. **Check the list of the stocks to be done in detail and those to roll over**.

i) Input data and examination of data quality;

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

iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2019.

[2] These do not apply to WGNAS.

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

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

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

viii) Historical and analytical performance of the assessment and catch options with a succinct description of quality issues with these. For the analytical performance of category 1 and 2 age-structured assessment, report the mean Mohn's rho (assessment retrospective (bias) analysis) values for R, SSB and F. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines. Check list to confirm whether the stock requires a concise advice sheet or a traditional advice sheet.

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

j) Audit all data and methods used to produce stock assessments and projections.

Medium Priority for spring 2020 advice season

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

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

   i) descriptions of ecosystem impacts of fisheries
   ii) descriptions of developments and recent changes to the fisheries
   iii) mixed fisheries considerations, and
   iv) emerging issues of relevance for the management of the fisheries;
   e) Review progress on benchmark processes of relevance to the Expert Group; High for application;

Low Priority for spring 2020 advice season

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

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

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

i) Take 15 minutes, and fill a line in the audit spread sheet ‘Monitor and alert for changes in ecosystem/fisheries productivity’; for stocks with less information that do not fit into this approach (e.g. higher categories >3) briefly note in the report where and how productivity, species interactions, habitat and distributional changes, including those related to climate-change, have been considered in the advice. ACOM would encourage expert groups to carry out this term of reference later in the year through a webex.

Responses to Terms of Reference

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

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

ToR c was addressed with a review of the conversion of redfish data to the SToX system, and is presented in Annex.

Benchmarks

A haddock benchmark was conducted in early 2020, at the WKDEM 2020 (ICES 2020b) benchmark. The haddock work was considered successful in addressing the two main concerns with this stock assessment: the model is now better able to track the years with large catches, and the retrospective pattern has been significantly reduced.

Both NEA cod and coastal cod have been approved for benchmark in 2021.

Tentative plans are being made for proposing Greenland halibut for benchmark in 2022, followed by a HCR evaluation. Capelin will need a benchmark at some point, as work is underway to revise the assessment methodology, however no data were proposed at this meeting, and cooperation with Iceland was thought advisable.

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

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 2019 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 2019 to zero.

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

Discard estimates (1994–2019) of redfish, cod, haddock and Greenland halibut juveniles in the commercial shrimp fishery in the Barents Sea are presented in Figure 0.1. These estimates are new compared to previous AFWG reports, and are obtained with a spatio-temporal model based procedure elaborated in Breivik *et al.* (2017). In Breivik *et al.* (2017) an extensive validation study indicates that the new procedure obtains bycatch estimates with approximately correct uncertainty. Previous estimates for the period 1982–2015 are given in earlier reports (e.g. AFWG 2018), and we have not been able to compare these two time-series in detail. Such a comparison should be performed on a relatively fine spatio-temporal resolution. The bycatch estimates illustrated in Figure 0.1 and are available for each quarter in each main statistical area (not shown in report). Note that it is still work in progress regarding improving the new estimates.

The new time-series in Figure 0.1 are obtained by scaling the estimated bycatch in the Norwegian fishery with the international fishery in each ICES area. The scaling procedure assumes that the Norwegian fishery is representative for the international fishery. This assumption is necessary because the international catch data are available only to a low spatio-temporal resolution. If the international vessels in a relatively high degree trawl at locations not trawled by Norwegian vessels, the bycatch estimates illustrated in figure 0.1 may be biased.
It was observed during AFWG2019 that scaling the fishery logbooks with the landing statistics in year 2016 and 2017 resulted in a large difference between the obtained shrimp catch and the reported shrimp catch from NIPAG (ICES CM 2018/ACOM:08). Because of this inconsistency, only logbooks and *not* the landing statistics are used in year 2016 and 2017 when estimating the bycatch. Before AFWG2020, this inconsistency should be further investigated.

Uncertainty in catch data

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

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

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

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

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

Sampling effort– commercial fishery

Concerns about commercial sampling: The main Norwegian sampling program for demersal fish in ICES subareas 1 and 2 has been port sampling, carried out on board a vessel travelling from port to port for approximately 6 weeks each quarter. A detailed description of this sampling program is given in Hirst *et al.* (2004). However, this program was, for economic reasons, terminated 1 July 2009. Sampling by the 'reference fleet' and the Coast Guard has increased in recent years. However, the reduction in port sampling of many different vessels seems to have increased the uncertainty in the catch-at-age estimates from 2009 onwards (WD6, 2010). A Norwegian port sampling program was restarted in 2011, although with a lower effort, but this improved the basis for the 2011–2017 catch-at-age estimates. From 2014 this program is run by 4-year contracts of a vessel that sails between fish landing sites along the coast from about 66°N to Varanger (70°N, 30°E) three periods a year during the 1st, 2nd and 4th quarters, altogether up to 120 days. This is a reduction compared to about 180 days a year prior to 2009. The catch sampling is done of landed fish, mainly from the fleet fishing in coastal waters, and usually inside the plant, and the rented vessel acts as a transport, accommodation and working (age reading, data work) platform. AFWG recommends that such sampling is also carried out during the third quarter.

Tables 0.1-0.4 show the development of the Norwegian, Russian, Spanish and German sampling of commercial catches in the period 2008–2018. The tables show the total sampling effort, but do not show how well the sampling covers the fishery. Indices of coverage should be developed to indicate this. The main reason for the general strong decrease in numbers of Norwegian samples in the first part of this period is the termination of the port sampling program in northern Norway. This program is now up and running again. It should be considered whether catch sampling carried out by different countries fishing by trawl for the same time and area could be coordinated and data shared on a detailed level.

Cod, haddock and saithe: Previous concerns regarding poor biological sampling from the fishery were less of an issue in 2018, as available catch-at-age and length data covered the largest portion of catches by the respective fisheries. However, the aggregation level (time and space) used when splitting these catches into Northeast arctic cod and Norwegian Coastal Cod is also an important issue. Despite the improvement in sampling coverage in 2016–2018, the number of samples should be increased in coming years, with the aim of covering all quarters and areas contributing highest catches.

S. mentella

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

S. norvegicus

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

NeA Greenland halibut

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

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

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

Age reading

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Assessment method issues

Following an IBP for NEA cod (ICES C. M. 2017/ACOM:29), the assessment method for NEA cod has been altered to the SAM model. In addition, the age range of the data (both catch and survey) has been extended as recommended by the benchmark. However, due to the increasing age structure of the cod, the settings for these older fish recommended by the benchmark were found to be problematic. A suggested revision was rejected at an interbenchmark review in 2019, and there is thus planned a full benchmark in 2021.

For coastal cod, the issues around the difficulties with the assessment model and management implementation of the management plan were noted. Work is ongoing to attempt to address these, and will lead to a benchmark in 2021.

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

Environmental information included in advice of NEA cod

For the thirtennth 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.

Proposals for status of assessments in 2020-2021

For anglerfish there is currently no assessment, however following the benchmark in 2018, work is being conducted with a view to a potential future assessment. This has progressed to producing a number of candidate assessment models, but not yet a full assessment. AFWG proposes to set the following status for assessments for each stock. Greenland halibut, which was not assessed in 2020 will receive an update assessment in 2021. Work on adopting a HRpa for this stock was postponed to 2021 due to the coronavirus.

Fish Stock	Stock Name	Advice in 2019	Previous benchmarks	Next benchmark
cod.27.1-2	Cod in subareas 1 and 2 (Northeast Arctic)	Update	WKARCT 2015, IBP cod 2017	2021
cod.27.1-2coast	Cod in subareas 1 and 2 (Norwegian coastal waters)	Update	WKARCT 2015	2021
had.27.1-2	Haddock in subareas 1 and 2 (Northeast Arctic)	Update	WKDEM 2020	-
pok.27.1-2	Saithe in subareas 1 and 2 (Northeast Arctic)	Update	IBP saithe 2014 WKROUND 2010	-
cap.27.1-2	Capelin in subareas 1 and 2 (Barents Sea), excluding Division 2.a west of 5°W	Update	WKARCT 2015 WKSHORT 2009	?
ghl.27.1-2	Greenland halibut in subareas 1 and 2	Rollover	WKBUT 2013 (finished in 2015)	-
reb.27.1-2	Redfish *Sebastes mentella* subareas 1 and 2	Update	WKREDFISH 2018 (WKREDMP 2014)	
reg.27.1-2	Redfish *Sebastes norvegicus* subareas 1 and 2	Update	WKREDFISH 2018	
anf.27.1-2	Anglerfish in subareas 1 and 2 (Northeast Arctic)	None	WKANGLERFISH 2018	

Stock annexes

There was one relevant benchmark between AFWG 2019 and AFWG 20200, WKDEM. There is thus a new stock annex for NEA haddock. Due to the revision in the data series for the redfish species, these have slightly changed stock annexes.

Audit reports

Audit reports were made for the 5 stocks for which updated advice is provided this year: northeast Arctic cod, haddock and saithe, Greenland halibut, and Norwegian Coastal cod. All audits were conducted successfully.

InterCatch

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

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.

Relationship with WGIBAR

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

Research needs of relevance for the Working Group

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

Agreeing on an age-reading method for Greenland Halibut

Extending Greenland Halibut data back in time

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

Time and place of Next Meeting

The Working Group proposes to meet next time in the period Wednesday 14th April - Tuesday 20th 2021 at a location to be decided.

Annex 4: Working documents

WD_01 arctic BESS indekser Barents Sea ecosystem survey 2019: cod and haddock indices

WD_015 HRpa proposal for GHL

WD_01 AFWG 2020

Barents Sea ecosystem survey 2019: cod and haddock indices

Dmitry Prozorkevich, Edda Johannesen, and Geir Odd Johansen

1. Overview over the survey

1.1 Survey coverage in relation to planned coverage

The survey coverage in 2019 was relatively good, and most of the Barents Sea was covered (Prozorkevich and van der Meeren 2020). Totally 314 demersal stations were taken at predetermined positions, excluding stations with gear problems etc. In total, cod were caught in 271 stations (86% of the stations) and haddock were caught in 161 stations (51% of the stations).

The loop-hole and the areas farthest to the Northeast (Figure 1) was not covered. There was most likely cod in the uncovered area in Northeast (Figure 1, Appendix Figure 1.1).

1.2 Age data

Age data was lacking from 21 stations with haddock and 19 stations with cod (Table 1, Figure 1). It is not clear why age data are missing from some stations.The instruction for handling demersal trawls catches is to age one cod and one haddock from each 5 cm length group.

Table 1. The total number of demersal trawl stations was 314. The table show the total number of stations with cod and haddock, and the number of stations with cod and haddock in each 5 cm length group. The table also show the number of stations with aged cod and haddock. Ideally the number of stations with cod (or haddock) caught and the number of stations with aged cod (or haddock) should be identical.

	Cod		Haddock	
Length group	Stations	With age data	Stations	With a age data
All length groups	271	252	161	140
0-4.9 cm	2	0	36	24
5-9.9 cm	110	70	52	31
10-14.9 cm	173	86	93	81
15-19.9 cm	179	154	98	86
20-24.9 cm	158	143	105	95
25-29.9 cm	148	132	88	80
30-34.9 cm	146	139	79	74
35-39.9 cm	157	149	59	51
40-44.9 cm	147	136	57	51
45-49.9 cm	150	144	57	53
50-54.9 cm	153	142	44	40
55-59.9 cm	145	141	29	27
60-64.9 cm	142	133	20	20
65-69.9 cm	120	116	17	17
70-74.9 cm	117	115	8	8
75-79.9 cm	116	112		
80-84.9 cm	110	107		
85-89.9 cm	93	87		
90-94.9 cm	58	54		
95-99.9 cm	52	51		
>100cm	57	55		

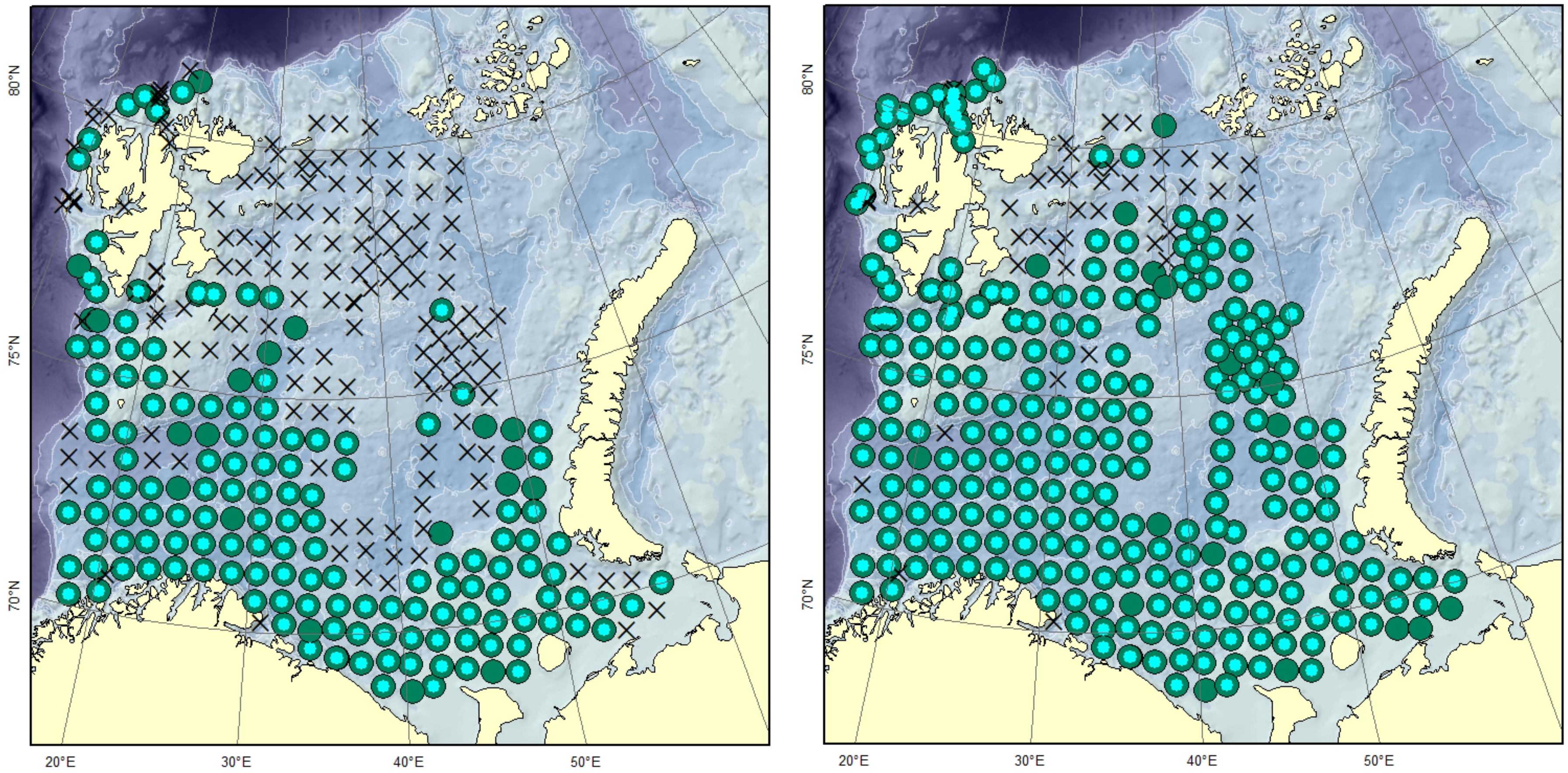

Figure 1. Stations with haddock (left) in green and cod (right). Crosses are demersal stations without haddock (left) and cod (right). Turquoise indicates that age samples has been taken at the station.

2. BIOFOX -estimates

BIOFOX estimates were run using data from 314 demersal stations (Figure 2a). BIOFOX interpolates to neighbour strata. The strata are depth stratified WMO squares (Prozorkevich and Gjøsæter 2014, Figure 2a). Figure 2b shows the planned demersal stations. Table 2 show gives the estimates for cod and Table 3 gives the estimates for haddock.

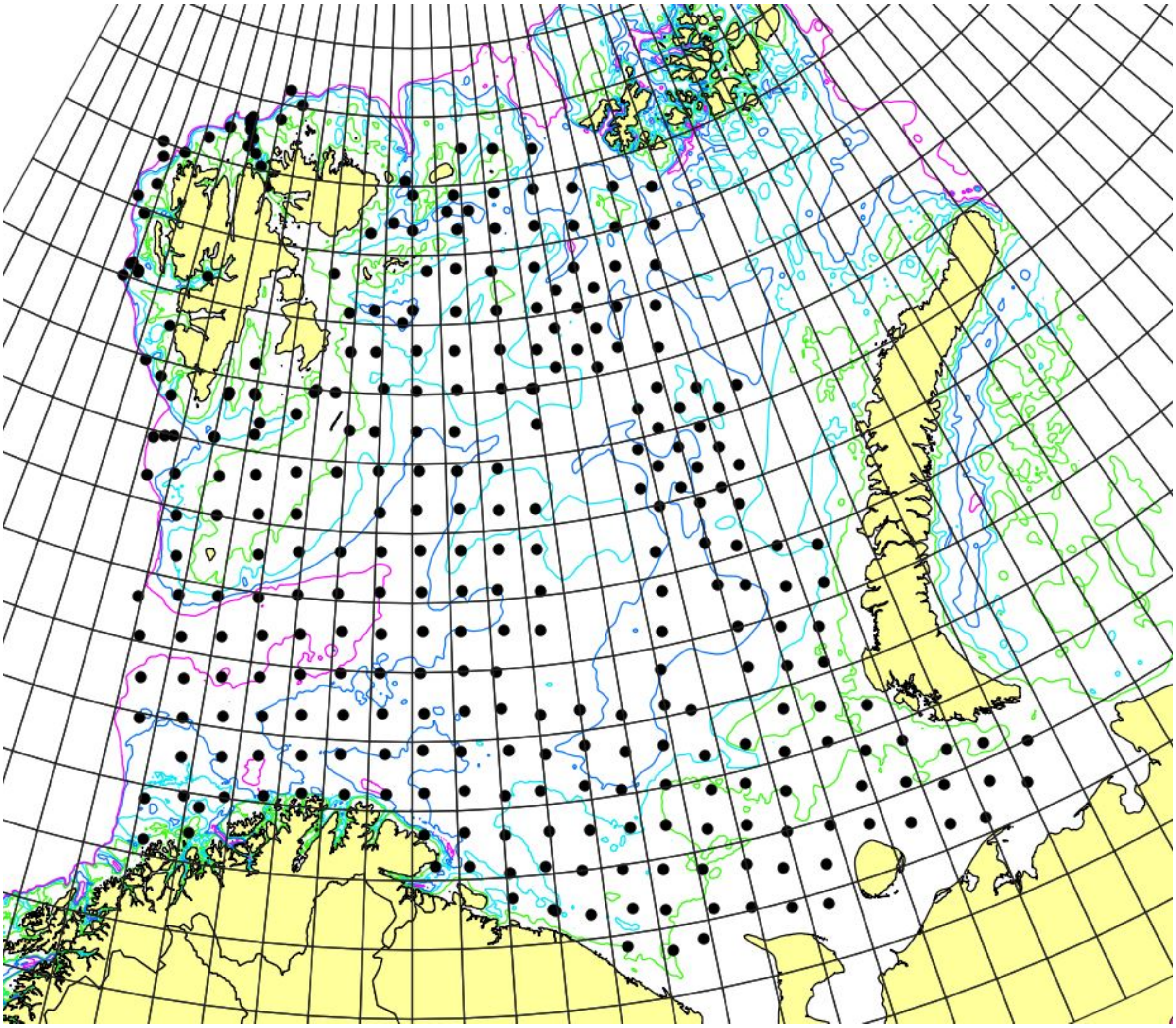

Figure 2.a) Realized bottom trawl stations ecosystem survey 2019 used in BIOFOX (n=314) and BIOFOX strata system.

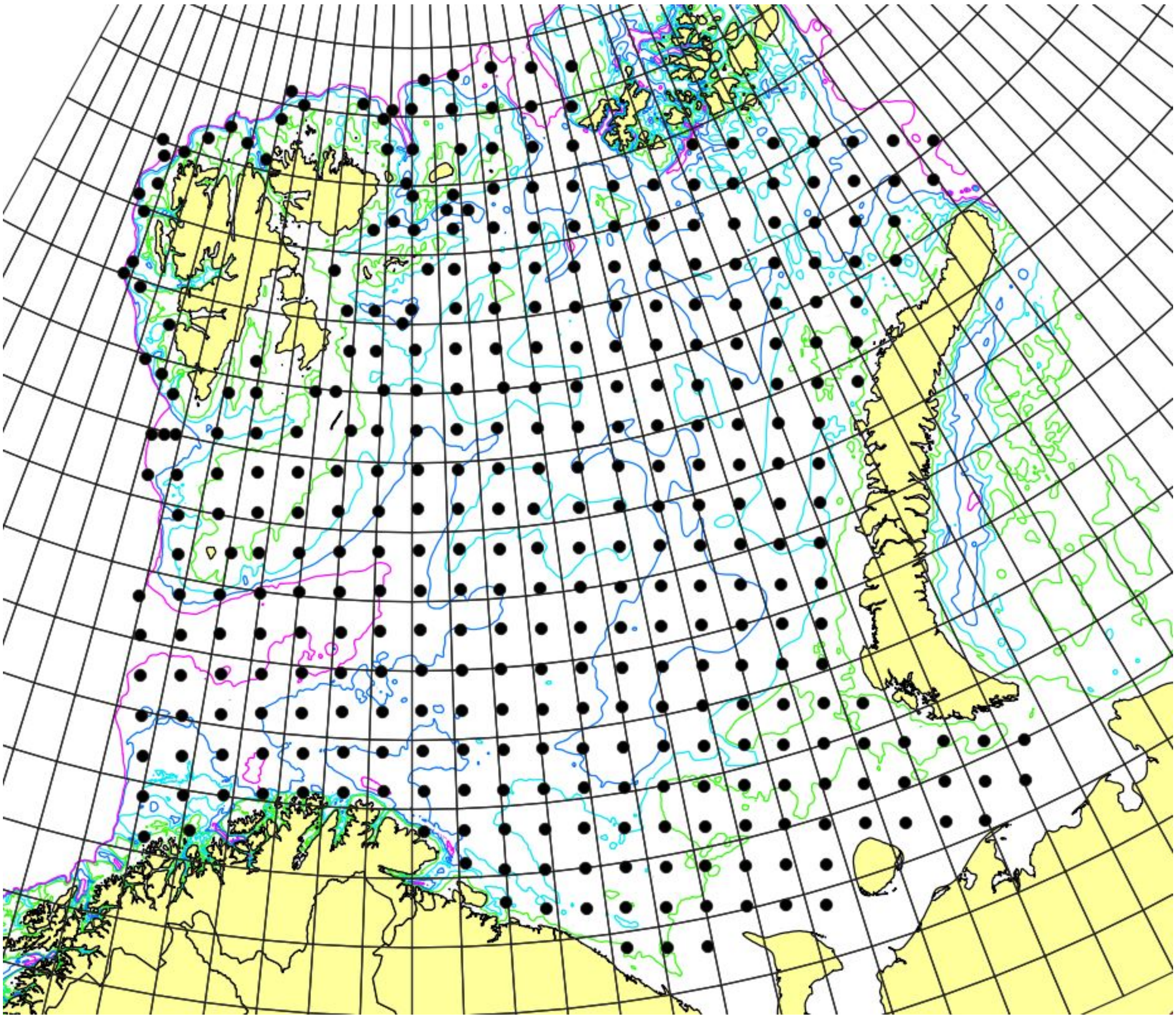

Figure 2.b) Planned bottom trawl stations ecosystem survey 2019 and BIOFOX strata system.

Table 4. BIOFOX estimates of cod numbers in million, swept area estimates. Data in excel format is available at the sharepoint - data folder.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
2004	330.63	329.74	147.72	421.53	150.21	79.76	40.21	10.09	2.21	0.50	0.13	0.07	0.00	0.13	0.00	0.00
2005	440.71	146.60	216.60	55.80	100.86	28.00	15.65	5.65	1.17	0.46	0.12	0.00	0.05	0.00	0.00	0.00
2006	479.02	509.66	186.10	205.59	59.85	69.75	17.64	8.09	2.56	0.65	0.25	0.04	0.00	0.00	0.00	0.00
2007	333.32	505.36	586.19	159.15	79.07	24.57	26.92	5.97	2.16	0.93	0.15	0.21	0.00	0.03	0.00	0.00
2008	130.94	372.61	652.62	483.43	132.27	51.07	12.82	17.45	3.28	0.85	0.23	0.20	0.11	0.00	0.00	0.08
2009	569.71	93.52	202.34	280.64	289.63	101.69	31.88	12.66	7.28	2.57	0.81	0.28	0.17	0.00	0.00	0.05
2010	310.26	84.16	56.81	177.04	397.18	424.93	142.73	38.53	10.55	6.78	1.59	0.31	0.20	0.11	0.00	0.00
2011	509.81	160.00	123.65	101.53	240.17	300.39	178.43	32.28	7.69	1.85	1.34	0.59	0.28	0.00	0.00	0.00
2012	1454.27	255.85	229.09	146.41	69.96	150.77	165.16	84.51	12.70	4.35	1.55	1.43	0.43	0.14	0.08	0.00
2013	914.19	658.99	249.11	183.59	125.69	63.15	118.22	130.20	53.85	9.14	3.32	1.52	0.45	0.33	0.16	0.00
2014*	308.15	155.12	190.02	108.59	93.91	52.81	30.41	50.18	36.34	12.07	3.43	1.02	0.84	0.27	0.20	0.06
2015	725.32	153.99	174.41	225.16	141.29	72.57	48.56	26.24	35.26	26.63	7.87	1.70	0.15	0.81	0.00	0.10
2016	350.79	341.34	77.18	93.72	121.59	70.09	44.44	27.22	13.80	13.20	5.42	1.65	0.49	0.45	0.12	0.32
2017	757.50	260.63	375.00	141.49	104.92	120.88	62.58	27.96	11.21	6.41	4.45	4.49	1.78	0.62	0.28	0.00
2018																
2019	560.24	475.15	416.64	232.31	215.05	76.65	42.22	44.36	16.09	4.86	2.19	1.12	0.97	0.58	0.27	0.13

*2014 and 2018 not used in cod assessment due to poor coverage

Table 5. BIOFOX estimates Haddock numbers at age in millions, swept area estimates. Data in excel format is available at the sharepoint - data folder.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
2004	188.987	268.462	123.368	70.303	69.118	31.482	2.989	1.721	0.000	0.071	0.000	0.032	0.117
2005	603.787	114.244	324.560	89.531	30.440	32.246	15.035	0.472	0.692	0.165	0.094	0.094	0.072
2006	2270.189	929.118	107.467	124.640	41.597	18.980	17.482	7.289	0.754	0.471	0.073	0.087	0.000
2007	988.391	1818.927	1282.940	88.498	90.369	19.227	5.881	7.102	1.896	0.881	0.201	0.096	0.135
2008	322.015	1291.864	1154.869	405.999	43.133	35.517	4.940	2.514	2.251	0.288	0.000	0.000	0.000
2009	134.833	143.819	650.742	619.088	305.883	21.045	6.549	0.870	0.546	0.030	0.000	0.000	0.000
2010	274.353	65.087	184.001	865.318	666.439	147.720	15.840	2.730	0.000	0.136	0.136	0.317	0.000
2011	105.263	113.561	40.446	73.802	392.930	301.368	37.357	2.972	0.277	0.066	0.000	0.106	0.066
2012	591.096	41.529	92.468	20.348	67.607	214.052	152.030	12.739	0.257	0.219	0.000	0.888	0.640
2013	155.943	222.994	25.779	65.228	19.575	50.846	150.131	76.427	7.022	0.361	0.000	0.000	0.178
2014	264.813	75.054	261.631	40.768	70.161	25.781	60.452	85.771	17.968	1.434	0.244	0.000	0.000
2015	319.963	145.248	42.148	213.636	25.132	37.111	20.577	47.868	33.788	8.627	0.244	0.244	0.000
2016	793.772	144.860	209.303	34.430	184.090	47.965	56.787	40.367	65.809	47.460	11.767	0.831	0.040
2017	935.791	189.253	70.313	70.306	11.470	20.537	3.963	4.025	5.382	4.433	4.776	0.674	0.000
2018*													
2019	379.389	585.300	896.982	160.736	38.067	15.133	5.303	5.037	1.868	2.052	2.059	2.922	2.658

* 2018 not used in haddock assessment due to poor coverage

3. Stox estimates

The strata system had to be modified to account for the lack of spatial coverage in the North East. The modified strata borders were set to be approximately half of the inter-stations distance from the outermost stations (17.5 nm). The Svalbard, Great Bank and North East strata were modified (Fig. 3a) and reduced to 77, 84 and 39%, respectively of the area of the basic area system (Fig.3.b). Table 4 gives the cod estimates, table 5 the haddock estimates and table 6 the cv estimates for 2019.

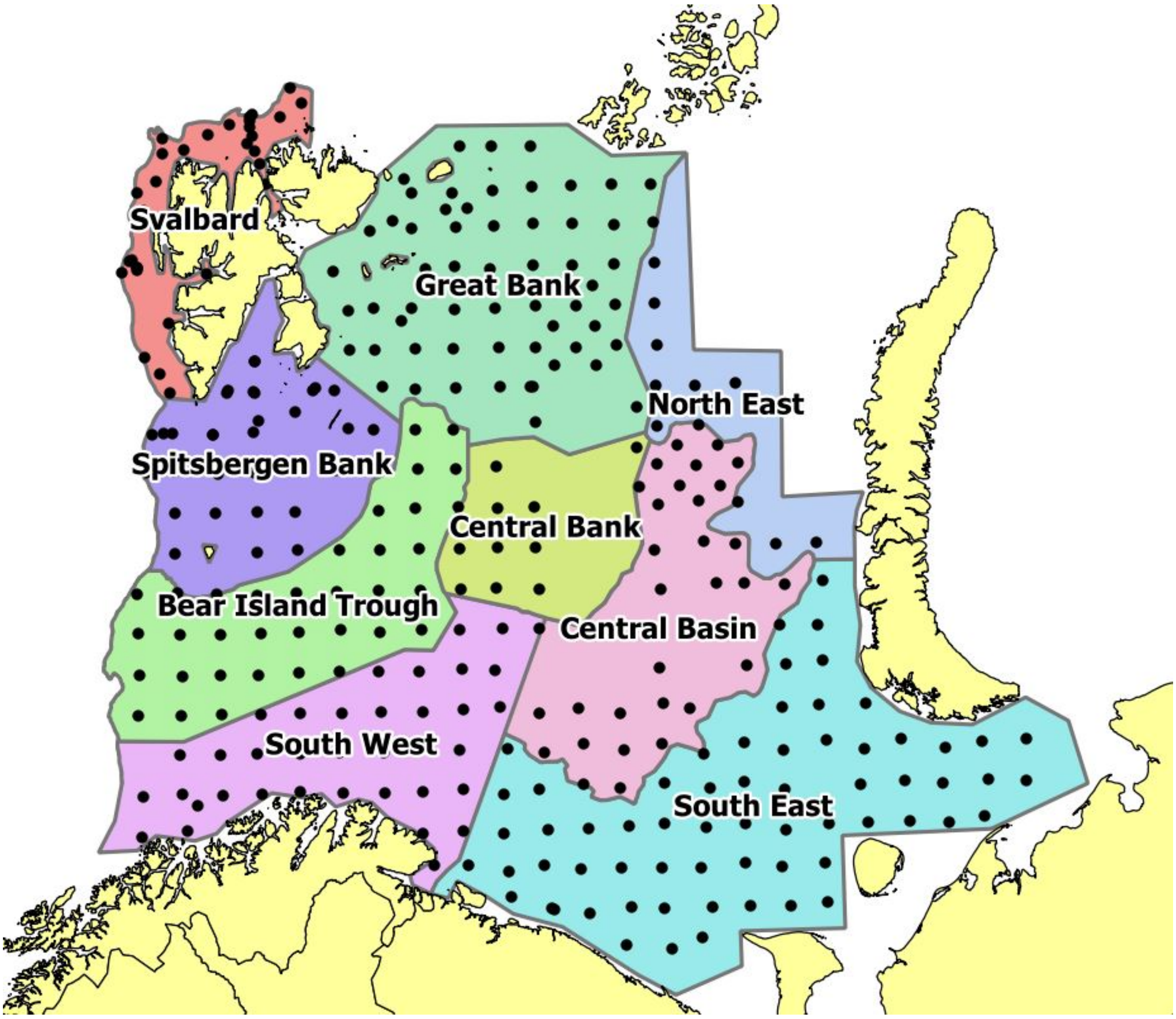

Figure 3. a) Realized bottom trawl stations 2019 (n=314) with modified strata system used in StoX.

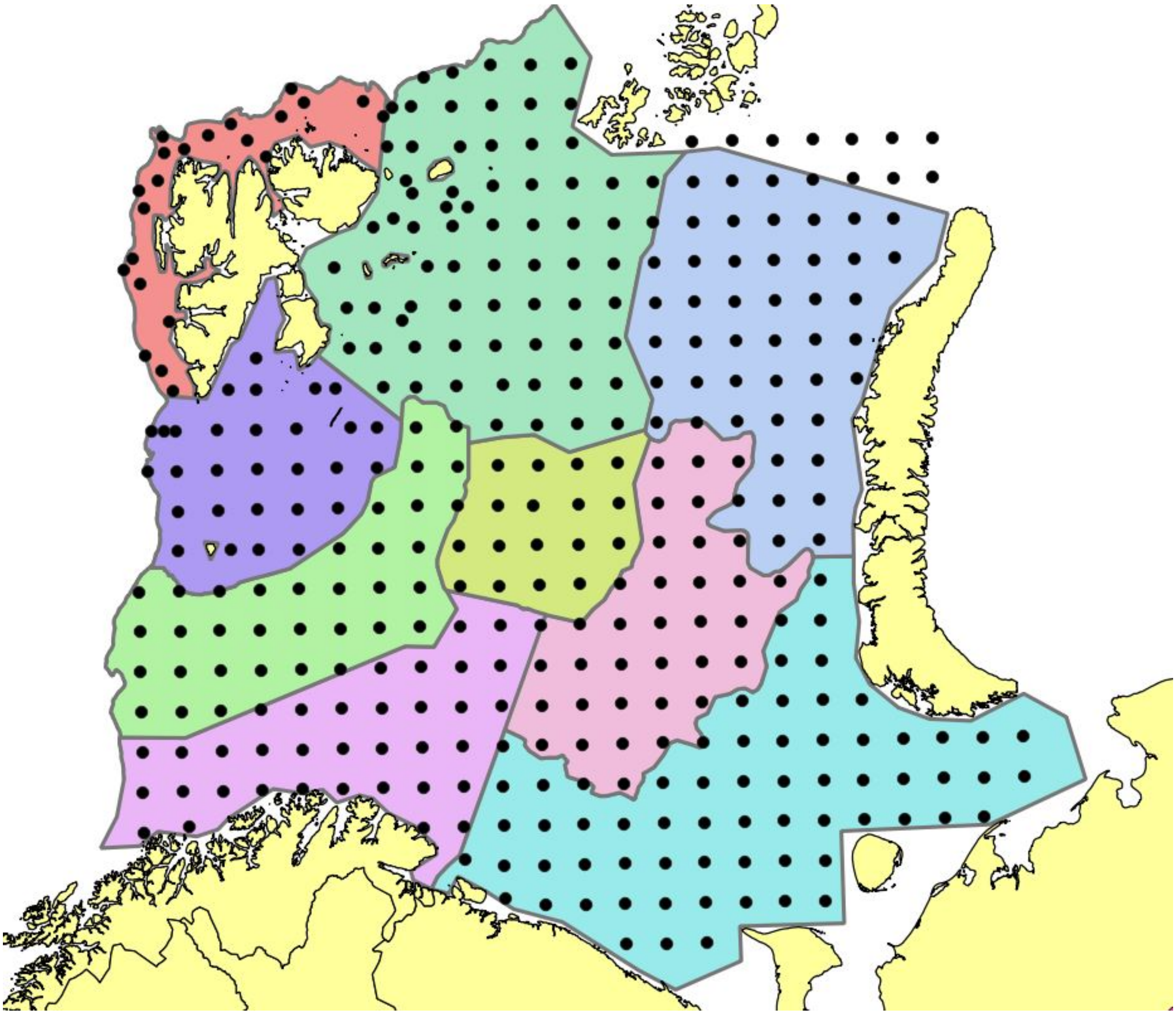

Figure 3. b) Planned bottom trawl stations 2019 (n=314) with basic ecosystem survey strata system used for cod and haddock in StoX.

Table 4.STOX Estimates of cod numbers in million, swept area estimates, mean values from 500 bootstraps. Years 2004-2017 taken from Johannesen et al 2019. The output folder from the StoX estimates can be found at the sharepoint (data folder).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
2004	410.02	290.99	91.39	281.28	155.27	75.82	40.30	10.51	1.97	0.56	0.12	0.05	-	0.16	-	-
2005	359.91	124.19	178.94	35.00	96.52	31.15	18.43	6.89	1.79	0.80	0.13	-	0.09	-	-	-
2006	454.91	432.85	142.67	121.00	36.91	47.49	16.88	8.34	3.32	0.46	0.30	0.03	-	-	-	-
2007	301.31	302.69	301.65	76.16	47.49	9.23	16.47	3.29	1.30	0.31	-	0.29	-	0.05	-	-
2008	107.26	266.04	342.90	350.48	89.60	47.01	10.08	15.35	3.39	0.87	0.38	0.18	0.08	-	-	0.08
2009	538.89	71.40	213.65	236.63	357.16	128.46	27.58	10.63	8.18	2.62	0.85	0.30	0.17	-	-	-
2010	383.76	87.13	59.89	151.12	448.60	513.28	160.50	39.71	10.52	7.21	2.05	0.28	0.26	0.21	-	-
2011	378.05	150.56	112.78	95.19	218.77	319.56	214.58	29.86	7.71	1.84	1.35	0.65	0.29	-	-	-
2012	1301.35	245.25	170.88	131.23	77.53	189.52	162.84	99.89	12.83	3.98	1.60	1.33	0.41	0.14	0.18	-
2013	677.38	670.39	250.75	147.61	110.09	50.77	120.36	131.36	56.14	7.68	2.98	1.92	0.35	0.38	0.12	-
2014*	264.91	117.48	175.73	94.18	82.07	41.56	17.25	32.55	19.73	8.00	2.21	0.79	0.53	0.09	0.10	0.07
2015	600.35	178.31	184.19	219.08	148.61	61.65	61.53	32.26	35.71	25.22	7.68	1.42	0.19	0.89	-	0.06
2016	394.23	386.08	82.06	101.12	128.70	73.23	42.64	26.19	12.86	11.21	4.37	1.37	0.35	0.65	0.08	0.23
2017	744.28	203.72	356.39	94.29	68.18	139.29	72.95	27.24	11.80	5.18	4.67	4.00	1.72	0.81	0.33	-
2018	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2019	521.10	458.27	336.64	188.18	230.67	63.94	49.35	37.65	13.70	3.94	2.12	1.11	1.02	0.65	0.30	0.16

*2014 and 2018 not used in cod assessment due to poor coverage

Table 5 STOX Haddock numbers at age in millions, swept area estimates, mean values from 500 bootstraps. Years 2004-2017 taken from Johannesen et al 2019. The output folder from the StoX estimates 2019 can be found at the sharepoint (data folder).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
2004	149.12	237.63	124.05	53.53	46.42	24.68	2.03	1.75	-	0.16	-	0.05	0.14
2005	575.23	92.64	292.08	133.23	14.24	30.11	10.19	0.33	0.45	0.20	0.10	0.08	-
2006	2190.94	872.46	79.60	99.57	41.93	9.69	12.11	4.46	0.58	1.49	0.06	0.07	-
2007	869.81	978.81	511.18	45.27	36.41	7.04	1.36	3.02	7.23	0.43	0.11	0.11	0.09
2008	333.42	1218.49	984.58	513.63	24.31	34.77	4.15	2.34	1.37	0.26	-	-	-
2009	167.48	103.32	580.40	594.24	153.04	5.60	1.97	0.17	0.64	0.09	-	-	-
2010	350.45	88.98	194.29	686.80	500.73	108.63	5.91	1.48	-	0.08	0.08	0.08	-
2011	78.99	134.80	24.31	121.84	219.85	224.20	20.36	1.19	0.13	0.11	-	0.02	0.06
2012	587.91	38.59	82.48	14.23	82.67	140.85	76.20	20.93	0.02	-	-	0.75	0.23
2013	172.13	231.39	21.15	57.38	24.33	36.46	129.07	58.69	5.13	0.62	-	-	0.18
2014	325.96	68.37	282.63	14.69	59.37	29.24	27.85	32.60	7.55	1.48	0.14	-	-
2015	308.11	131.74	25.23	129.69	13.05	30.66	12.95	31.11	24.02	6.31	0.10	0.11	-
2016	662.38	72.60	131.31	21.84	103.47	19.76	37.52	25.64	32.57	40.62	5.57	0.18	0.17
2017	910.81	215.49	54.35	57.60	9.04	16.37	4.53	1.96	3.80	3.47	2.93	0.54	-
2018*	-	-	-	-	-	-	-	-	-	-	-	-	-
2019	383.94	544.87	663.93	268.24	27.89	19.87	6.43	3.32	0.87	1.02	0.90	1.13	0.95

*2018 not used in haddock assessment due to poor coverage

Table 6 Stox CV estimates for 2019, Barents Sea Ecosystem Survey

Age	Haddock	Cod
0	0.31	0.118
1	0.17	0.11
2	0.27	0.16
3	0.25	0.13
4	0.50	0.16
5	0.41	0.26
6	0.46	0.16
7	0.49	0.30
8	0.31	0.13
9	0.38	0.17
10	0.34	0.19
11	0.32	0.25
12	0.32	0.40
13	0.33	0.40
14		0.40
15	0.98	0.50
16		
17		0.92
18		1.00

4.Comparing Stox and Biofox

Figure 4 compares the BIOFOX and StoX estimates from 2019. The ratios of the estimates are shown in Figure 5.

The largest differences between the two ways of calculating abundance were for the plus group of haddock (9+). The BIOFOX estimates were twice the StoX estimates. The reason for this is unknown. We have previously established (Johannesen et al 2020) that this was not due to the number and size of the strata used in StoX.

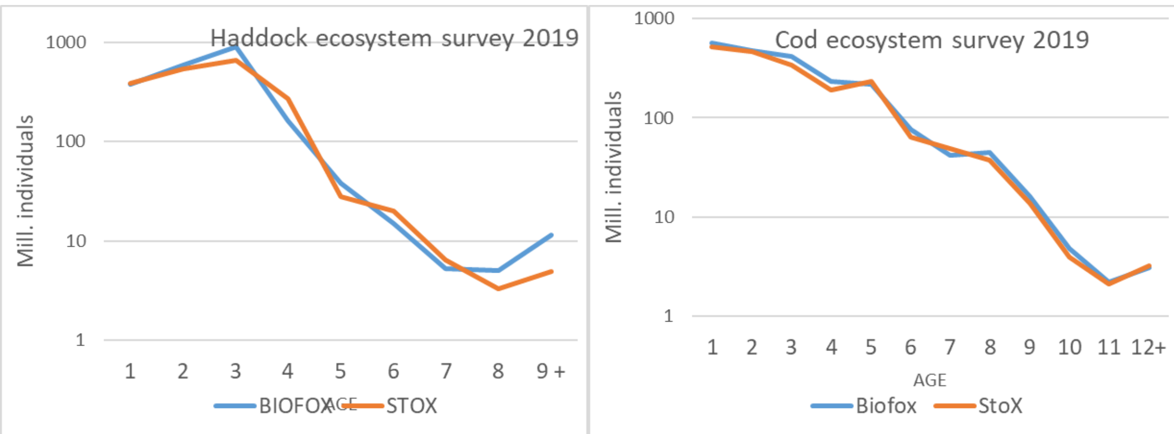

Figure 4. Abundance indices (log scale) Stox and Biofox of haddock (left) and cod (right) by age ecosystem survey 2019.

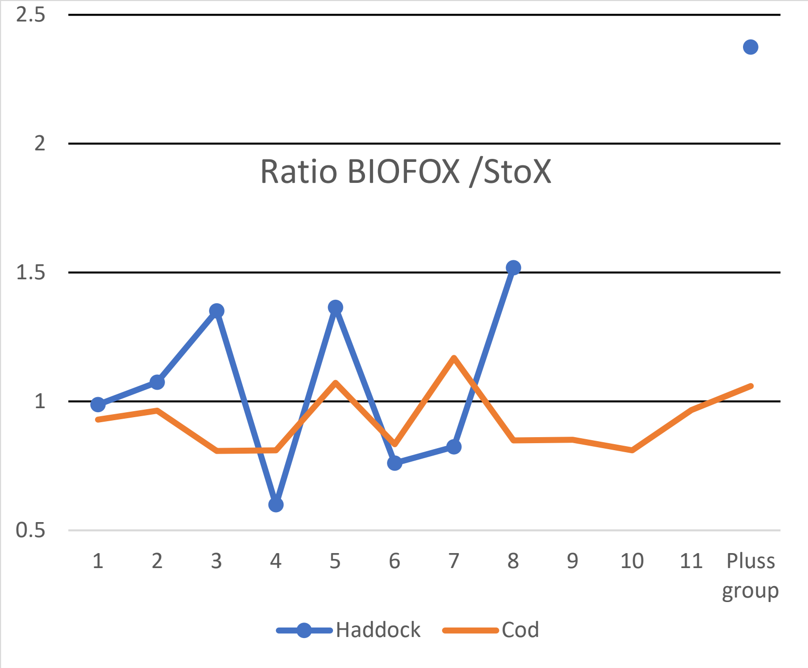

Figure 5. Ratio of BIOFOX to StoX estimates. The plus group is 12 for cod and 9 for haddock.

5. Concluding remarks

More work is needed to establish the best way of extrapolation and interpolation from areas with samples to areas without samples. The survey design should also be evaluated. Higher CVs for haddock than for cod indicates a more patchy distribution, and given the high CV's. that the interstation distance may be to large to give reliable haddock estimates. For haddock the area coverage appears to have been adequate in 2019. For cod, the lack of coverage in the Northeast area likely lead to lack of coverage of an unknown proportion of the cod stock, and hence an underestimation of the cod abundance.

6. References

Johannesen E, Johnsen E, Johansen GO and Korsbrekke K. 2019 StoX applied to cod and haddock data from the Barents Sea Ecosystem survey Fisken og havet 2019:6.

Johannesen E, Russkikh A, Prozorkevich D, Johansen GO and Kovalev Y. 2020. Ecosystem survey bottom trawl indices from StoX and BIOFOX WD7 WKDEM 2020.

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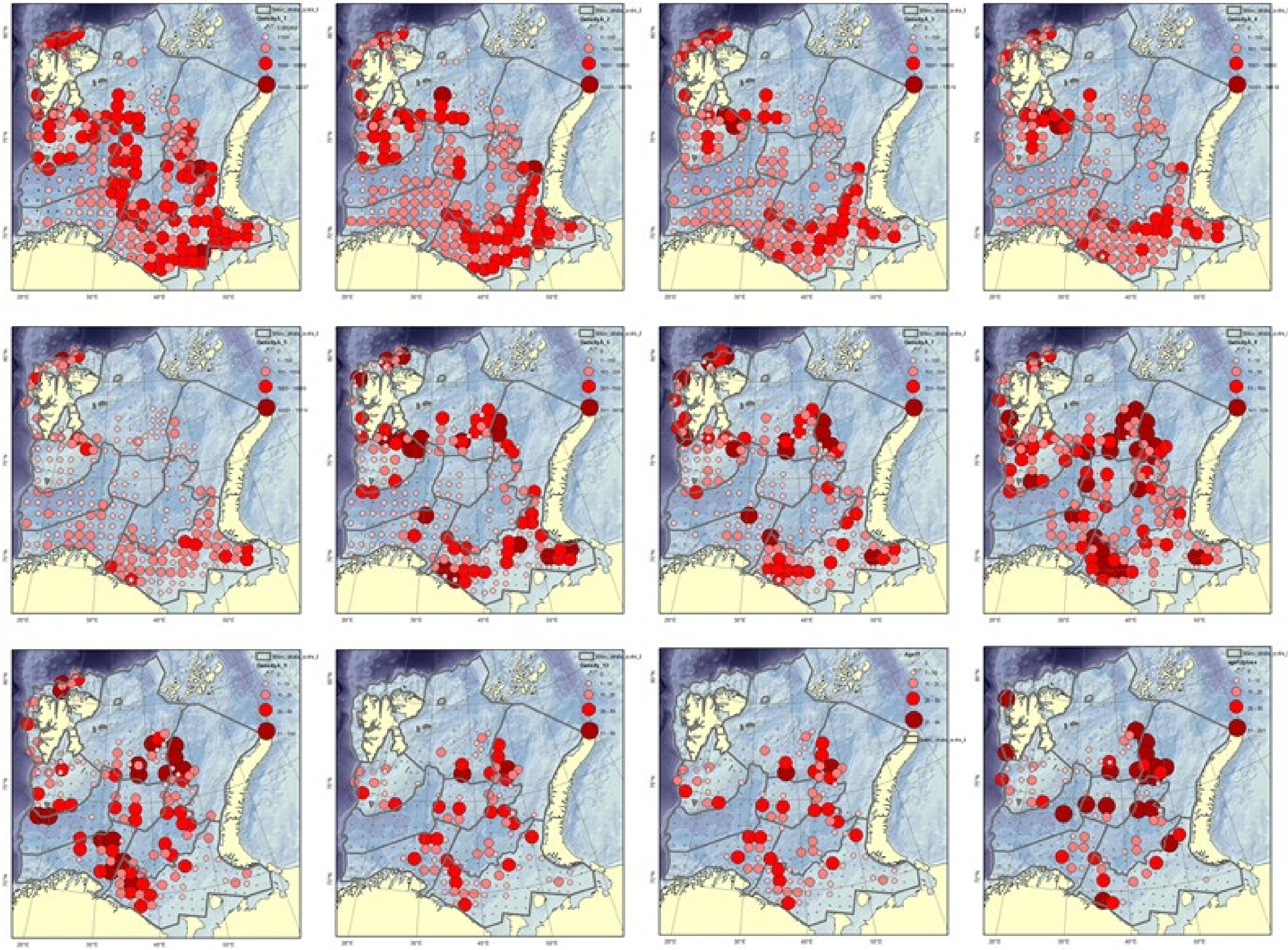
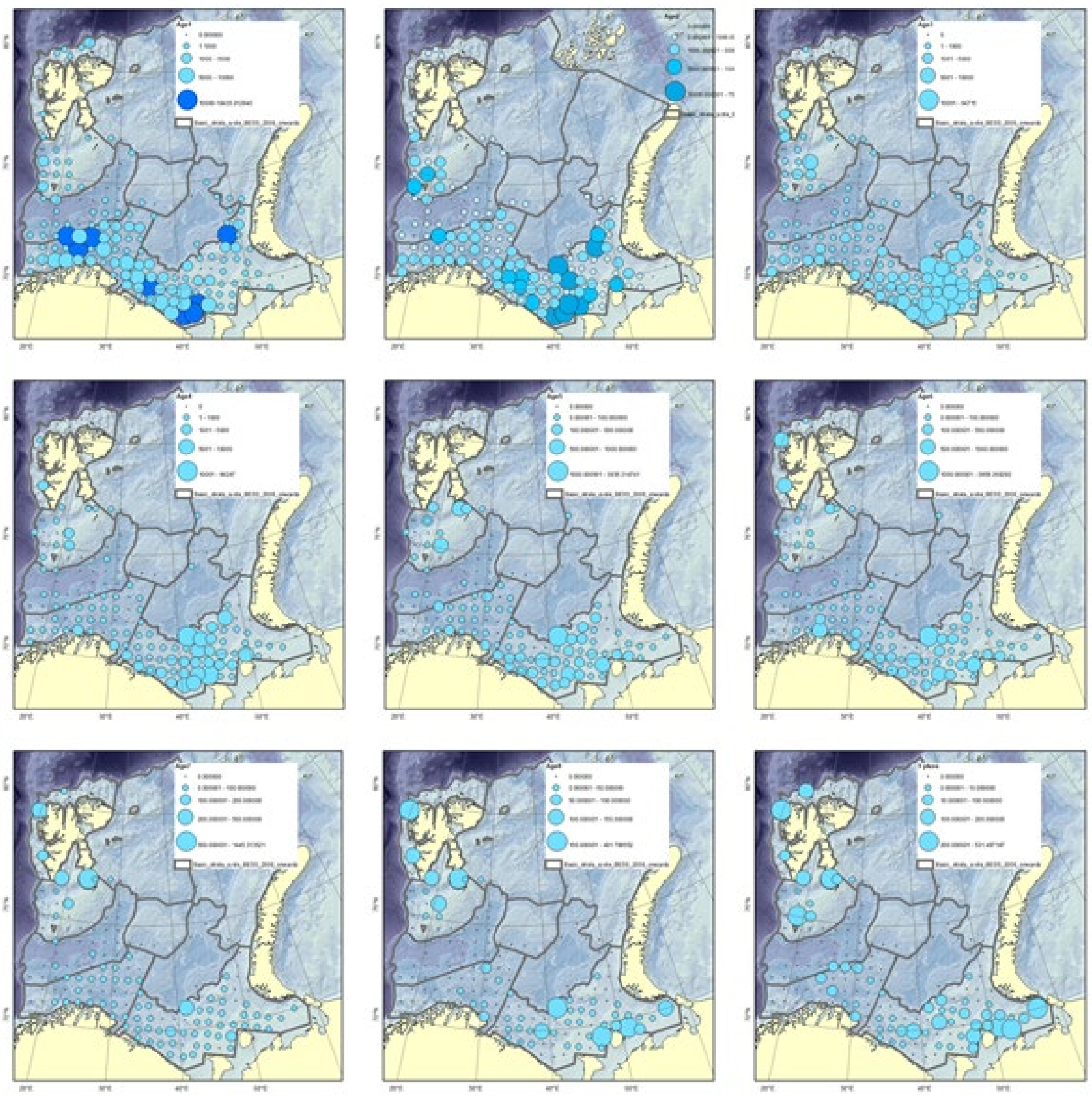
Protozorkevich, D. and Meeren G.I. van der (eds) 2020. Survey report from the joint Norwegian/ Russian ecosystem survey in the Barents Sea and adjacent waters August-October 2019. IMR/PINRO Joint Report Series, 1-2020, 93pp.

Prozorkevich D and Gjøsæter H 2014. WD_02 cod_BESS_assessment. AFWG 2014.

Appendix figure 1.1 Cod catches (ind pr nm2) – top age 1-4 left to right, middle age 5-8 left to right, bottom age 9-12+ left to right. Size of bullets proportional to catch, sorry about the poor legend (cannot be compared across ages).Stations without cod not shown, stations with no catch of cod in that age group=small white dot.



Appendix figure 1.2 Haddock catch rates by age top 1-3 (left to righy) middle 4-6, bottom 7-9+



Greenland Halibut HR_{pa} proposal

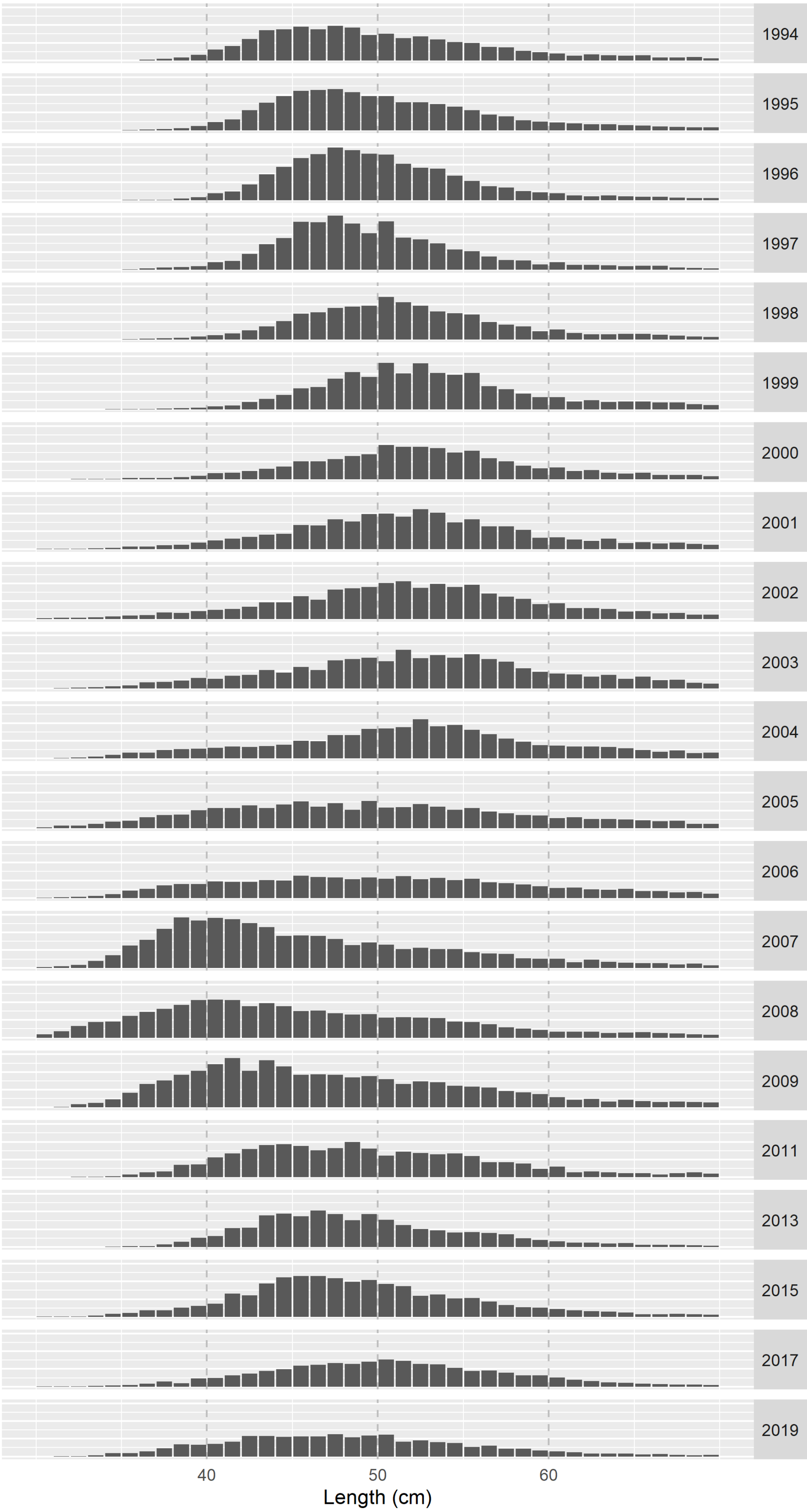
Daniel Howell, daniel.howell@hi.no

In 2019, the advice drafting group, ADGANW, requested a HR_{pa} value for Greenland Halibut. Note that this stock uses Harvest Rate rather F for reporting purposes. This document attempts to provide such a value. Note that this is not a full MSE exercise. There are plans for a benchmark to improve the model followed by a full HCR exercise in the coming years. This is simply an attempt to calculate an interim HR_{pa} as a basis on which to give precautionary advice until a HCR is evaluated and agreed.

Background: model and stock

Greenland Halibut (hereafter GHL) is a relatively long-lived species with pronounced sexual dimorphism, males are smaller and mature earlier than females. The stock is managed on areas I and II jointly by Norway and Russia. Given the dimorphism and the lack of an accepted age-reading methodology one cannot give accurate ages of maturity and entry to the fishery, but these are on the order of c. 10 years for females and perhaps c. 7 for males. The Barents Sea Greenland halibut has nursery areas around Svalbard and Franz Josef Land in the northern Barents Sea. The fish then expand southwards into the Barents Sea, before congregating along the shelf break on the western edge for spawning. This is a deep-sea fish, and there is likely connectivity with other stocks. However, this is not presently considered in the assessment.

The GHL stock in areas I and II (the Barents Sea and adjacent waters) is assessed with a two sex, one area Gadget model, which is described in the stock annex (REF) and the benchmark report (ICES 2015). The 2015 benchmark was the first time that an analytical model was approved for this stock by ICES since age based XSA was abandoned in early 2000, and the model is thus at a relatively early stage of development. At the last AFWG the model was run from 1992-2018. Note that the recruitment estimates are presented up to 2016, even though the model is run to 2018. This is because there is considerable noise in the recruitment series, and there is therefore little information to use in tuning the last two years of recruitment estimates. One should also note that there are conflicting signals from the different surveys, and thus the estimates should be considered uncertain until the fish have entered the fishery, although there are no formal estimates of uncertainty from the Gadget model. The only significant change since the benchmark is that because of reduced sampling the model had to move to time-averaged maturity data, rather than separate estimates for each year. The model period begins during a partial fishing moratorium and covers a period of rising and good stock sizes, there is no data in the model on low stock status. The benchmark agreed on a B_{pa} and B_{lim} value (based on the lowest observed stock size that gave rise to good recruitment) but not an HR_{pa} value. Given the lack of contrast in the stock size data (see below) and the presence of good recruitment events, B_{pa} has been set equal to B_{lim} (as per ICES 2017). There are indications of a good recruitment event at lower stock sizes prior to the start of the model run, since the model begins in during a rising stock trend. The model reports 45cm+ biomass (the minimum catch size) rather than SSB, partly to avoid questions about using male and/or female biomass, and partly to be consistent with earlier work (not used for assessment) using surplus production models. As with a number of other ICES stocks, we report Harvest Rate (HR), rather than F, that catch as a fraction of the modelled fishable biomass on 1st January. The other "non-standard" feature of the model is that it is tuned only to length data, no age data is used in the tuning. This is due to a lack of agreement between Norway and Russia on what age-reading methodology to use. As can be seen in Figure 1, there have been several large recruitment events which can be traced for multiple years in the length data. This allows the model to estimate those recruitment events and growth rates for the GHL based on the length data alone. However, it is not clear that there is sufficient contrast in the data to accurately estimate the recruitment pattern in between the high recruitment events. There is data from catch levels and stock trends measured in the survey to give information on average recruitment level over time, but likely not to estimate the actual recruitment pattern. Note that there is little information on what the recruitment might be below B_{lim}. This is not considered a problem for this analysis. The stock is currently assessed as well over B_{lim}/B_{pa} (Figure 2), and the HR_{pa} being calculated is intended to avoid falling below B_{lim}. There is therefore no need to simulate behavior below B_{lim} in order to estimate a HR_{pa}, although such information would of course be needed to model recovery from any potential overfishing.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Length (cm)

Figure 1. Annual length distributions in the EggaNor survey (from the 2019 cruise report, Vollen et al 2020).

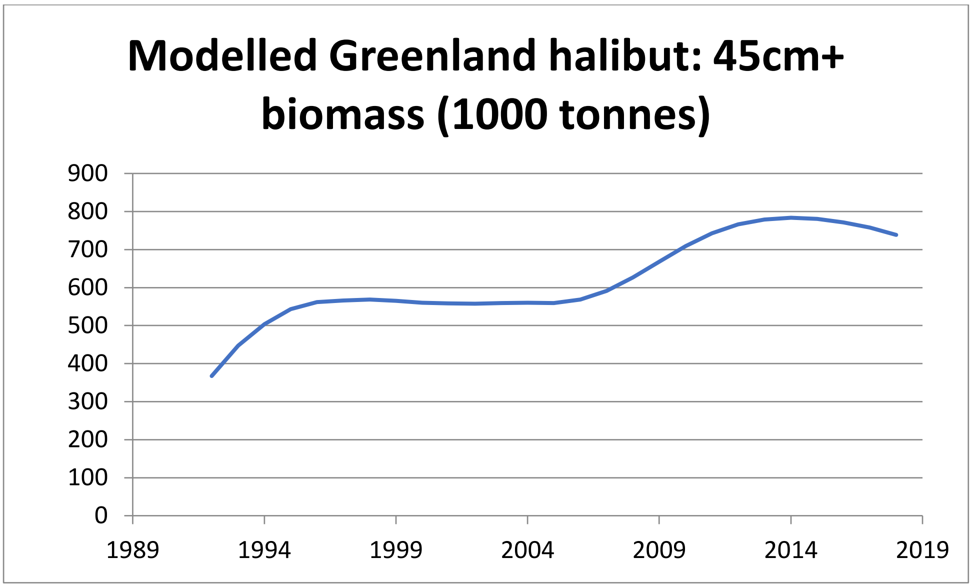

Figure 2. Modelled 45cm+ biomass of Greenland halibut as of the 2018 AFWG assessment.

Methodology

Two different methods have been considered here to compute HR_{pa}. The first method is that described in the ICES guidance of reference points for analytically assessed stocks (ICES 2017), where average recruitment over some time period is used to compute a F_{lim} and hence a HR_{pa}. The second is a $F_{0.05}$ approach, i.e. a stochastic simulation to identify the fishing level that results in no more than a 5% chance of driving the stock below B_{lim}.

In principle this author prefers the $F_{0.05}$ approach, as better capturing the dynamics behind this kind of risk analysis. However, there is a difficulty in this case. The simulations require drawing from the assessed recruitment deviations. As previously mentioned, while it is plausible to suggest that the occasional peaks are well determined by the length data, this is not likely to be the case with the smaller recruitment years. Since the last large recruitment was in 2002 (appearing as age 1 in 2003), the majority of the recent years fall into this poorly determined category. Retrospective analysis gives a similar picture – the average recruitment over recent years is relatively stable under retrospective peels, but the pattern of recruitment between years can change. Given this reasoning, the $F_{0.05}$ is no considered appropriate, and this study therefore choses to use the simpler, average-based approach, detailed in ICES 2017. This is an ICES approved method and will therefore produce a viable basis for ICES advice.

Having chosen the overall method, a question arises over the time period to use for defining the recruitment. Although GHL is a long-lived stock (with significant numbers living to 30+), in areas I and

II this is a stock where the fishery is largely sustained by occasional good yearclasses. Given the absence of agreed age data it is difficult to pin down the exact year that a fish was recruited. However, in 2018 35% of the catch in biomass was modelled as recruiting in the 2002 yearclass, and 45% coming from +/- 1 year around this (many of which may actually be from the same recruitment). The top three yearclasses in the catch (excluding the plus group) contributed over 58% of the catch in biomass (while the plusgroup at 30+ contributed another 10%, with some indication that this may be largely from a single recruitment pulse prior to the model timeseries). As can be seen in the recruitment plot in Figure 3 there are a number of features that make the choice of recruitment period to average over challenging, and of considerable importance to the overall result. One could choose to average over the entire model period (1993-2016), which gives an average recruitment of 127 million individuals per year. However, this value is highly sensitive to the presence of a single large year class. One could choose to exclude the age 1 recruitment spike in 2003, on the grounds that such an event has not been seen recently and that there is a sufficiently long delay between any good yearclass appearing in the data and entering the fishery for there to be time for a HR_{pa} value to revised if such recruitment were to occur. In such a case, average recruitment is estimated as 94 million. Finally, one could say that the recent recruitment is that which will define the short- and medium-term behavior of the stock and fishery, and then take the recruitment since the spike (2004-2016) or a ten-year average (2007-2016). The ten-year average gives 78 million, while the 2004-2016 period gives 82 million. However, there are several sources of uncertainty in this shorter time period. One problem here is that given the presence of sporadic moderate recruitment events (even excluding the largest peaks), taking a short time period to average over makes the results sensitive to small changes in the time range chosen. For example, choosing an 11-year average rather than a ten-year average gives 71.5 million recruits, a decrease of 10% on the 10- Mentella??

year average. Furthermore, these fish have not yet fully recruited to the fishery, and because of the conflicting survey information there is thus considerable doubt as to the actual magnitude of this recruitment. Nor is it obvious from Figure 3 that there has been any change in recruitment productivity during the model timeseries.

This study therefore chooses to base this analysis on the complete time series, but with the large recruitment event in 2003 excluded. Given the uncertainties discussed above, this is considered to best reflect the recruitment to the fishery that can be expected in the coming years. Should a new large yearclass be observed then there would be time to revise the HR_{pa} value before the fish from the large yearclass could enter the fishery.

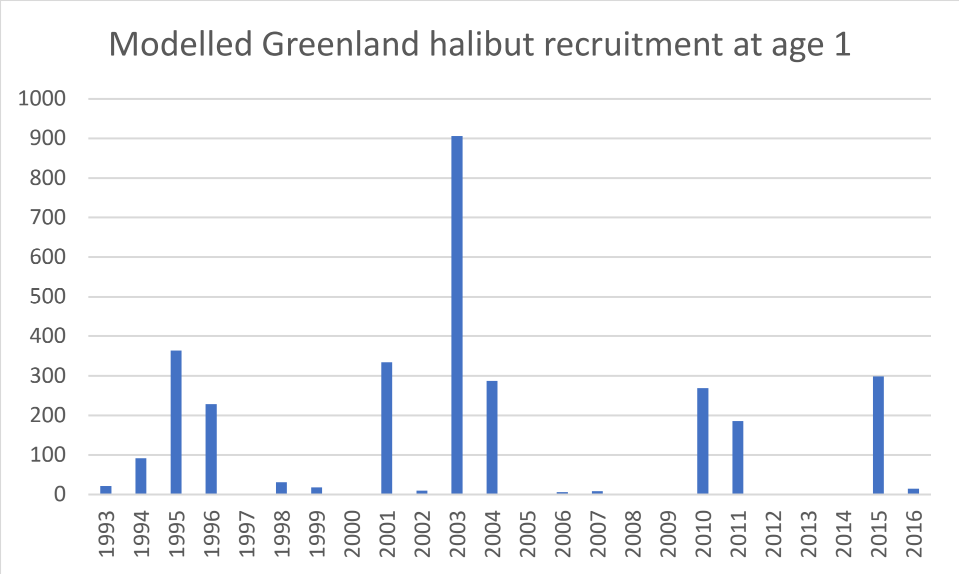

Figure 3. Model estimates of recruitment at age one, in million individuals.

Computations

According to ICES 2017 and ICES 2018, the following sequence of calculations are required to estimate a F_{pa} value for a stock such as this with limited contrast in the tuning series:

1. Find B_{lim} and B_{pa}
    a. These values are set in the benchmark reports as the 45cm+ biomass in year that gave rise to a good recruitment event, noting that this gave a biomass of 500 thousand tonnes.
2. Simulate forward under constant average recruitment to find the F_{lim} level that drives the stock to B_{lim} at equilibrium
    a. The choice of average recruitment is discussed above, and the single large spike is excluded from this analysis. Note that there is no need to simulate recruitment reduction below B_{lim}.
3. Convert the F_{lim} to F_{pa} using the standard ICES precautionary formulae
    a. Given the absence of any explicit uncertainty estimates here, this defaults to dividing F_{lim} by 1.4 to obtain F_{pa}.

Given the long-lived nature of the stock, and the relatively low exploitation rates that this implies, the benchmark chose to report this stock using a harvest rate (HR) rather than a F. That is to say, the fraction of the fishable biomass on 1st January which is taken as a catch over the course of the year. Therefore, the calculations performed here are actually for a HR_{pa}, although the process is identical. At the exploitation levels calculated here this is largely a theoretical issue, the value of HR_{pa} is very close to a $F_{pa.}$

However, there is an issue of precautionarity here. For stocks with data on recruitment behavior at low stock sizes, B_{pa} will be higher than B_{lim} and the method is written accordingly. For this stock, no such data exists – the stock has never been at low stock sizes during the model period. Therefore, following ICES procedures B_{lim} and B_{pa} have been set equal. The question then arises if computing HR_{lim} in this way includes too much precautionarity. The HR computed drives the stock to B_{pa} at equilibrium, and could thus be argued to be a HR_{pa} without further adjustment. For this analysis we omit step three in the above analysis, and present HR_{pa} as the level which is modelled to drive the stock to B_{pa} at equilibrium recruitment.

The model has been projected forward for 100 years, by which time the stock had reached equilibrium, with recruitment set to a constant level equal to 94 million. Different HRs were applied until the equilibrium biomass reached B_{lim}. These calculations have been conducted, and results in a HR_{pa} of 0.035 (which be lowered to a HR_{pa} of 0.025. were one to apply the extra precautionary buffer in step three above). For comparison the Harvest Rate in 2018, based on a fishing level which was above the ICES advice, was assessed to be 0.036.

Assuming that no future good yearclasses occurred, the projected long-term catch at this HR= 0.035 is 17.6kt, while under a HR=0.025 the equilibrium catch is 14kt. Note that this is not directly comparable to the current situation or historical situation because the stock has had occasional large yearclasses which support a larger fishery. In the event of the surveys showing an incoming large yearclass the HR_{pa} should be revised to a higher value to take advantage of this situation.

Results

The headline result is that using the recruitment excluding the good yearclass gives a HR_{pa}=0.035 as the value which produces a biomass of around B_{lim}=B_{pa}, and a HR_{pa} of 0.025 with the additional precautionary buffer. Given that HR=0.035 is the level which is modelled to drive the stock to equilibrium under constant recruitment assuming no large recruitment events, then we believe that this satisfies the precautionarity conditions.

The proposed HR_{pa} for Greenland halibut in areas I and II is 0.035, with the proviso that if a large recruitment event is observed in the surveys then the HR_{pa} should be revised prior to the incoming good recruitment entering the fishery.

Discussion

This analysis explicitly calculates a HR_{pa} value under recent recruitment conditions. Should these recruitment conditions change, then the analysis would need to be revised. However, the presence of a recruitment survey, coupled with relatively late entry to the fishery means that this is not a major problem. There would be some years between a large recruitment event (or a period of recruitment failure) being observed and the fish entering the fishery, allowing for such a revision. In addition, it is not recommended that the HR_{pa} presented here should form the long-term basis for management of this stock, rather it should be considered an intermediated measure prior to the development and testing of a full HCR for this stock.

The length of time since the last large recruitment event means that the stock is now modelled to have passed a recent peak in biomass and is currently headed downwards. No large recruitment to the fishable stock can be expected in the next 5+ years. It is therefore critical that fishing pressure not exceed that which can be supported by the recent recruitment, otherwise the fishery runs the risk of driving the stock into a condition of recruitment overfishing.

Appendix

The computations were repeated using the full time series of recruitment. A further run was taken using the last 10 years of recruitment estimates as the estimate of fish that could recruit to the fishery in the coming years. Using the full time series, including the recruitment spike, gave a recruitment estimate of 127 million, HR_{pa}=0.0716 (HR_{pa}=0.051 with the additional buffer). Using the last 10 years gave a recruitment estimate of 78 million, HR_{pa}=0.017 (HR_{pa}=0.012 with the additional buffer).

As discussed in the document, we explicitly do not recommend either of these as the basis of quota advice in the coming years. In the absence of a new recruitment spike higher value is not precautionary as it is higher than that which can be sustained by recent recruitment. The recruitment survey for this stock indicates that there has not been a particularly high recruitment event since 2003, and the late entry to the fishery gives a high confidence that there will not be strong recruitment to the fishery in at least the coming 5 years. For the 10-year average, the sporadic recruitment to this stock, combined with the poor definition of the recruitment pattern in the model, makes this sensitive to the precise pattern of recruitment and length of time chosen. We therefore do not recommend this is as the basis of management. The values are merely presented here for comparison.

References

ICES. 2015. Report of the Inter Benchmark Process on Greenland Halibut in ICES areas I and II (IBPHALI), August 2015, By correspondence. ICES CM 2015\ACOM:54. 41 pp.

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Vollen T, Harbitz A and Vihtakari M, 2020. EGGA NORD 2019 - Toktrapport fra Havforskningsinstituttets tokt med FF Árni Friðriksson 30. august-19. september 2019. IMR survey report, ISSN 15036294/Nr. 1–2020. In Norwegian with English abstract.

Annex 5: Audit reports

- Audit of Northeast Arctic saithe (AFWG 2020)
- Audit of Northeast Arctic cod
- Audit of Greenland halibut (*Reinhardtius hippoglossoides*) in Subareas 1 and 2 (Northeast Arctic)
- Audit of cod in subareas 1 and 2 (Norwegian coastal waters) (AFWG 2020)
- Audit of beaked redfish (*Sebastes mentella*) in subareas 1 and 2 (AFWG 2020)
- Audit of beaked redfish (*Sebastes mentell*a) in subareas 1 and 2 (AFWG 2020)

Audit of Northeast Arctic saithe (AFWG 2020)

Date: 30 April 2020
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 has become critically low after the termination of the original Norwegian port-sampling program in 2009. In 2015 this was in particular the case for samples from trawl in quarter two and three in ICES subarea 1 and age samples from purse seine fishery south of Lofoten and in quarter two in ICES subarea 1. The biological sampling has improved since 2016, but the relatively low level of sampling may still affect the precision of the catch, weight and maturity at age data. Lack of reliable recruitment estimates is still a major problem. There was apparently an issue with the 2018 Acoustic survey. However, the impact of excluding or including the 2018 survey results in this year´s assessment were investigated in exploratory runs of the model, resulting in the conclusion that the entire tuning time series were to be used.
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 (2019/2020) estimated to be well above B_{pa}. The fishing mortality was below F_{pa} from 1997 to 2009, started to increase in 2005 and was above F_{pa} in 2010 and 2011, but is presently estimated to be most likely below F_{pa}. The recruitment has since 2005 been at about the long-term geometric mean level.
8) **Management Plan**: Agreed 2011 (first time in 2007): F_{MP}=0.32 and SSB above B_{pa}=220 000 t. The TAC is based on an average TAC for the coming three years based on F_{MP}. There is a 15% constrain on TAC change between years. The plan was evaluated by ICES and was found in agreement with the precautionary approach.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret. All data sets described in the stock annex are available.

Technical comments

No technical comments.

Conclusions

The assessment has been performed correctly and gives a valid basis for advice. However, the low level of biological sampling is, despite an improvement since 2016, still a source of uncertainty in the assessment.

Audit of Northeast Arctic cod

Date: 06.05.2020
Auditor: Elise Eidset

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 (XSA and TISVPA as additional assessment methods).
5) **Data issues:**
   Joint Barents Sea winter survey: The total area covered was smaller than in 2019 as the coverage was limited by ice particularly in the area east and north of Bear Island and by time and weather constraints in parts of the Russian zone. 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.

   Lofoten survey: The survey was carried out from south to north, i.e. in the opposite direction to all previous years.

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

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**: TSB in 2020 is estimated to 2.652 kt. Fishing mortality has been stable in recent years. SSB is estimated to 1.368 kt. Recruitment is stable; numbers-at-age 3 is calculated to be 583-, 635-, 551- and 608 millions for the 2017-, 2018-, 2019-, and 2020 year class, respectively. When the management plan is applied, total catch in 2021 should not be more than 885 600 tonnes.

8) **Management Plan**: B_{lim}= 220 000 t, B_{pa}=460 000 t, F_{lim}=0.74, F_{pa}= 0.40.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

No comment.

Conclusions

The assessment has been performed correctly.

Audit of Greenland halibut (*Reinhardtius hippoglossoides*) in Subareas 1 and 2 (Northeast Arctic)

Date: 27/04/2020
Auditor: Kjell Nedreaas

11 General

The stock is assessed by a GADGET length-based model since 2015. There is no agreement on age-reading methodology between Norway and Russia and the model is tuned using only length data. This gives uncertainty on the absolute levels of modelled biomass and F. The peaks of recruitment identified by the model are corroborated by survey length distributions, but the weaker year classes may be poorly modelled. None of the surveys individually covers the complete stock distribution and there are discrepancies between the surveys, leading to high uncertainty and a marked retrospective pattern. The last stock assessment was run in 2019 to provide advice for 2020 and 2021. The draft advice sheet was rejected by ADGANW and a roll-over advice was used for advice in 2020. ADGANW issued a request to repeat the advice process in 2020 with HRpa reference points for use in the 2021 advice. A working document (Howel 2020, WD 15) was presented to address the definition of a HRpa for the stock. A HRpa proposal is available and was presented to AFWG 2020. However, due to the need for a simplified approach related to the 2020 corona virus outbreak ACOM decided, in agreement with Advice Requestors, that roll-over advice should be used in 2020 to provide advice on fishing opportunities in 2021.

12 For single stock summary sheet advice:

1. **Assessment type**: *GADGET length-based model (benchmark in 2015), supplemented with stock production models*
2. **Assessment**: *No new assessment i 2020. Last assessment in 2019.*
3. **Forecast**: *not presented*
4. **Assessment model**: *In addition to GADGET, two production models (one of them SPICT) have been used to assess the stock in the past, however, none of the models was updated for presentation at the current meeting.*
5. **Data issues**: *Data available and used as described in stock annex. There was an update of the commercial fishing data and the survey data including 2019.*
6. **Consistency**: *No new or updated assessment was conducted this year. An updated assessment will be conducted in 2021, and AFWG suggest a new benchmark on the stock in 2022.*
7. **Stock status**: *This stock is assessed in relation to precautionary reference points. On this regard $B>B_{lim}$, however, it is warned that the lack of reliable age estimations involves that the current assessment has important uncertainties in relation to the actual absolute level of biomass and F level. It is concluded that all of the exploratory work indicates that the overall trends are robust, but that care should be taken in interpreting the absolute abundance estimates, and hence absolute estimates of harvest rate.*
8. **Management Plan**: *No*

13General comments

The assessment done in 2019 is well-documented and structured in the report. The draft advice sheet was, however, rejected by ADGANW and a roll-over advice was used for advice in 2020. In 2019, the advice drafting group, ADGANW, requested a HRpa value for Greenland halibut. Note that this stock uses Harvest Rate rather than F for reporting purposes. WD #15 presented at the AFWG 2020 attempts to provide such a value. There are plans for a benchmark to improve the model followed by a full HCR exercise in the coming years. The WD is simply an attempt to calculate an interim HRpa as a basis on which to give precautionary advice until a HCR is evaluated and agreed, and this will hence be prepared for an update assessment in 2021. There is no information about HRpa in the Stock Annex.

14Technical comments

Catch- and survey values in text and tables/figures have been ckecked and corrected when necessary and to the extent possible for the auditor. This has been done directly in the draft report using "track changes" and/or writing short notes.

15Conclusions

No new or updated assessment was conducted this year. An updated assessment will be conducted in 2021, and AFWG suggest a new benchmark on the stock in 2022. The current audit has therefore only checked catch- and survey values in text and tables/figures, and corrected these when necessary.

Checklist for audit process

General aspects

- *Has the EG answered those TORs relevant to providing advice?*
- *Is the assessment according to the stock annex description?*
- *If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?*
- *Have the data been used as specified in the stock annex?*
- *Has the assessment, recruitment and forecast model been applied as specified in the stock annex?*
- *Is there any major reason to deviate from the standard procedure for this stock?*
- *Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?*

Audit of cod in subareas 1 and 2 (Norwegian coastal waters) (AFWG 2020)

Date: 11 May 2020
Auditor: Johanna Fall

General

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

For single stock summary sheet advice:

9) **Assessment type:** update
10) **Assessment**: Based on survey SSB index and estimates of F from an exploratory VPA assessment
11) **Forecast**: not presented
12) **Assessment model**: Trial XSA combined with standard VPA – tuning by one acoustic survey
13) **Data issues:** There are large uncertainties in the catch-at-age data, partly due to limited information about recreational fisheries. The assessment is presented with two alternative catch series, one including recreational fisheries and one without. The former series brings in additional uncertainty but scales the stock size to a more realistic level. The results of the 2019 and 2020 assessment are based on a revised catch number-at-age series, approved by AFWG 2019. This caused an upwards stock revision for several years back in time. There are indications of conflicting signals between the annual catch-at-age and survey numbers-at-age. The survey also has large uncertainty since cod contributes to a small fraction of the total observed acoustic values, and the estimates are therefore sensitive to allocation error. The survey is conducted in a period where it can be difficult to define maturity stages. The survey index for SSB is therefore based on a long-term mean of maturity-at-age. Both survey data and catch sampling data have better quality north of 67 than south of 67, but it is also in the north that most of the fishery takes place. 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. An upcoming benchmark will consider a separate assessment model for the northern stock component, as well as uncertainty in catch and survey data.
14) **Consistency**: Last year´s assessment was accepted by the Working Group. The assessment has been applied as specified in the stock annex.
15) **Stock status**: No biological reference points have been defined for this stock. SSB_{mgt} = 60 000 tonnes (acoustic spawning biomass index, see below). The estimate for 2019 was 34311 t (2018: 18423 t).
16) **Management Plan**: A rebuilding plan for coastal cod, considered provisionally consistent with the precautionary approach, was adopted by Norway in 2010 after evaluation by an ICES expert group. The plan defines the stock as restored when the survey index of SSB is estimated above 60 000 t for two consecutive years. The regulations aim to annually reduce F by 15 % compared to the F in 2009. If the survey index is higher than the preceding year, the regulations remain unchanged. The regulations have not been successful in constraining catches in 2015-2019.

General comments
Some figure and table references were not consistent with descriptions in text and will be corrected. Survey data is available as a survey report (in Norwegian). Catch data and the assessment model itself are not available on SharePoint.

Technical comments
It is noted that the use of mean maturity-at-age from the acoustic survey is not specified in the stock annex.

Conclusions
The assessment has been performed correctly. However, the data issues described above give a high level of uncertainty in the assessment.

Audit – cod.27.1-2coast – AFWG 2020

Audited by: Bjarte Bogstad

In general the assessment is carried out according to the stock annex. There are, however, some places in the text where updates with information from the last year is missing or the text is somewhat confusing.

2.2.1 second to last paragraph: Comments on catches should be about 2017 and 2018, not 2016 and 2017

2.2.1 Last paragraph: No mentioning of 2018 and 2019

2.2.2 Regulations (should be renumbered from 2.2.1): Last paragraph – what happened in 2019 with these new regulations, were they continued or did they stop by the end of 2018?

Fig 2.18: 2018 in figure text should probably be changed to 2019

Fig 2.19: 1995-2017 in text should be changed to 1995-2018.

Audit of beaked redfish (*Sebastes mentella*) in subareas 1 and 2 (AFWG 2020)

Date: 26.05.2020

Auditor: Kristin Windsland

General

The beaked redfish assessment and draft advice have been approved by the Working Group.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: analytical assessment
3) **Forecast**: presented
4) **Assessment model**: Statistical catch-at-age model
5) **Data issues:** There was no direct observation of catch numbers-at-age for the pelagic fishery in the Norwegian Sea outside EEZs in 2012–2018. Instead, numbers-at-age were estimated based on catch-at-age from previous or following year, and weight-at-age and fleet selectivities (section 6.2.2 in AFWG report 2013). In 2013, 2016 and 2019, observations from the scientific survey in the Norwegian Sea were used to derive numbers-at-age in the pelagic fishery. This was considered appropriate given that the survey operates in the area of the fishery, with a commercial pelagic trawl and at the time of the start of the fishery.

   Age-Length-Keys for S. mentella are uncertain because of the slow growth rate of individuals and therefore these data should be used with caution. They were not used in the current assessment but may be considered in future. Given that age is difficult to derive from length it is important that age readings are available for the most recent years, at the time of the working group. In 2018 it was showed that the growth function is nearly invariant between cohorts and it was decided to use a fixed (i.e. common to all years) weight-at-age as input to the Statistical Catch-at-age model.

   The results from the Russian bottom-trawl survey, Russian-Norwegian Barents Sea 'Ecosystem survey' and the Winter Barents Seabed-trawl survey were evaluated and approved by the Working Group for use in the *Sebastes mentella* assessment. Currently, the survey series used in the SCAA do not appropriately cover the geographical distribution of the adult population. The group recommended monitoring every year to identify if a significant portion of the mentella stock moves east of the strata system of the survey design.

6) **Consistency**: Last year´s assessment was accepted by the Working Group. The assessment has been applied as specified in the stock annex.
7) **Stock status**: The SSB for 2020 is 917 578, well above B_{pa}. Fishing mortality is 0.045, well below F_{MSY}. Recruitment is good and has since 2007 been higher than the low-recruitment period (1995-2003).
8) **Management Plan**: Agreed during WKREBMSE in 2018. B_{lim} = 227 000 t, B_{pa}=315 000 t, F_{MSY}=0.084 (F_{MSY}=F0.1 for 19+ group).

General comments

This was a well-documented, well ordered and considered section. It was easy to follow and interpret. Survey data is available as a survey report (in Norwegian). Catch data and the assessment model itself are available on SharePoint.

Technical comments

No comments

Conclusions

The assessment has been performed correctly. The survey series used in the SCAA do not appropriately cover the geographical distribution of the adult population. Priority should be given to including additional data from the slope surveys that include older age groups, in the analytical assessment in future. Furthermore, additional age readings are required to increase reliability.

Audit of beaked redfish (Sebastes mentella) in subareas 1 and 2 (AFWG 2020)

Date: 18 May 2020
Auditor: Alfonso Pérez-Rodríguez

General

The beaked redfish assessment and draft advice have been approved by the Working Group.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: Analytical assessment following recommendation from the benchmark assessment working group (WKREDFISH, ICES 2018a).
3) **Forecast**: presented
4) **Assessment model**: Statistical catch-at-age model.
5) **Data issues:**
   There was no direct observation of catch numbers-at-age for the pelagic fishery operating in 2012–2018. Instead, numbers-at-age were estimated based on catch-at-age from previous or following year, and weight-at-age and fleet selectivity. In 2013, 2016 and 2019, observations from the scientific survey in the Norwegian Sea were used to derive numbers-at-age in the pelagic fishery. This was considered appropriate given that the survey operates in the area of the fishery, with a commercial pelagic trawl and at the time of the start of the fishery. The procedure for estimating catch-at-age for recent years in which age data are not available is somewhat problematic because the last year of observation has a large impact on the estimated catch-at-age for several years.

   Age-Length-Keys for S. mentella are uncertain because of the slow growth rate of individuals and therefore these data should be used with caution. They were not used in the current assessment but may be considered in future. Given that age is difficult to derive from length it is important that age readings are available for the most recent years, at the time of the working group. In 2018 it was showed that the growth function is nearly invariant between cohorts and it was decided to use a fixed (i.e. common to all years) weight-at-age as input to the Statistical Catch-at-age model.

   The results from the Russian bottom-trawl survey, Russian-Norwegian Barents Sea 'Ecosystem survey' and the Winter Barents Seabed-trawl survey were evaluated and approved by the Working Group for use in the *Sebastes mentella* assessment. Currently, the survey series used in the SCAA do not appropriately cover the geographical distribution of the adult population. The group recommended monitoring every year to identify if a significant portion of the mentella stock moves east of the strata system of the survey design.

6) **Consistency**: Last year´s assessment was accepted by the Working Group. The assessment has been applied as specified in the stock annex.

7) **Stock status**: The SSB has been above B_{pa} since 1994 and is presently estimated to be well above B_{pa}. The fishing mortality was below F_{MSY} since 1992. Since 2007 the recruitment has been above the low-recruitment period 1995-2003.

8) **Management Plan**: B_{lim}= 227 000 t, B_{pa}=315 000 t, F_{MSY}=0.086 (F_{MSY}=F0.1 for 19+ group), Fmax = 0.236 (for 19+ group). Agreed during WKREBMSE 2018.

General comments

This was a well-documented, well ordered and considered section. It was easy to follow and interpret. Some figure and table references were not consistent with descriptions in text and will be corrected. Survey data is available as a survey report (in Norwegian). Catch data and the assessment model itself are available on SharePoint.

Technical comments

No comment

Conclusions

The assessment has been performed correctly. However, the data issues described above give a high level of uncertainty in the assessment.