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Hamburg, Germany

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

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Executive Summary

Cod in subareas I and II (Norwegian coastal waters)

The cod in subareas I and II, Norwegian coastal waters was assessed on the basis of a survey time series 1995-2010 as well as catch at age data (including recreational and tourist fisheries).

- The stock has varied without a clear trend since 2002. Both the stock biomass and the recruitment are at a low level compared to the first years in the time series.
- A rebuilding plan for this stock has now been approved by ICES and adopted by Norwegian authorities.

Cod in Sub-areas I and II (Northeast Arctic) was assessed using XSA. The age range for stock size dependent catchability was extended from 3-5 to 3-6 as this gave a better fit to the data.

- The fishing mortality (F_{5-10}) has declined since 2005 and is estimated to 0.27 for 2009 and 0.29 for 2010. In the time series from 1946 to present, such low values have only been calculated for 1990 and 1946. Estimated SSB for 2010 is 1,134,000 t, which is the highest since 1947. Compared to last years' assessment, this assessment represents a 1% downward revision of the 2010 SSB and a 4% downward revision of F in 2009. Unchanged XSA settings would have given a higher present stock size.
- The new "hybrid" recruitment model, introduced in 2008, was used, resulting in recruitment at age 3 of 433 million in 2011, 607 million in 2012 and 683 million in 2013.
- A catch in 2012 corresponding to the amended HCR is 751,000 t. This catch corresponds to a fishing mortality of 0.35 in 2012. SSB is estimated to increase from 1,311,000 t at the beginning of 2011 to 1,551,000 t in 2012. These values are the highest in the time series. Earlier maturation means that a larger proportion of the total stock is spawners now compared to the late 1940s when SSB also was calculated to be above 1,000,000 t.

Haddock in Sub-areas I and II (Northeast Arctic) was assessed using XSA with some changes in the settings from last year based on discussions at the 2011 benchmark meeting (WKBENCH) and at the AFWG meeting.

- Previously (1950-2000) the fluctuation in the haddock stock has shown a strong cyclic pattern caused by occasionally strong recruitment, where the stock biomass has been dominated by single cohorts. This picture has changed in recent years where three subsequent cohorts (2004-2006) all are very abundant.
- The fishing mortality (F_{4-7}) in the last three years has declined somewhat and is in 2010 estimated to 0.25. The current assessment estimated the total stock to be about 13 % higher and SSB 23 % higher in 2010 compared to the previous assessment. F in 2009 is very close to the estimate from last year.
- In the projection RCT3 was used to estimate recruiting year classes from 2008 and onwards. The results indicate that all the

year classes 2008-2010 are intermediate, with the 2009 year class being the strongest of those three.

- The evaluated and agreed HCR gives a catch in 2012 of 317,000 t, corresponding to F=0.35. The only year with a higher catch than this was 1973. The SSB is expected to reach a peak and all-time high in 2012 (414,000 tonnes) and then decline, while the total stock biomass already has started to decrease from the 2010 peak. The 2010 total stock biomass of 1.3 million is the highest observed in the time series, which goes back to 1950.
- $\mathbf{F}_{lim}$ and $\mathbf{F}_{pa}$ were revised because of revision of the time series. The new values of $\mathbf{F}_{lim}$=0.77 and $\mathbf{F}_{pa}$=0.47 are higher than the previous values (0.49 and 0.35, respectively). In the current HCR management is based on $\mathbf{F}_{pa}$. However, F_{MSY} is now estimated at 0.35, and it seems very appropriate to continue using the HCR with value of target F=0.35. This will correspond to the goal of the management strategy for this stock and will provide maximum sustainable yield.

The assessment of haddock is uncertain, and XSA is sensitive to settings which can give different perception of the long time trend in stock dynamics. However, the short time trends seem to be captured and agree well with results from surveys. Difficulties in estimating initial stock size are additional problems in the forecast.

Saithe in Sub-areas I and II (Northeast Arctic) was assessed using XSA with the same settings as last year. These are based on the analysis done at WKROUND in February 2010.

- In the projections the geometric mean age 3 recruitment of 168 million was used for the 2008 and subsequent year classes.
- A catch in 2012 corresponding to the evaluated and implemented HCR is 164,000 t. This catch corresponds to a fishing mortality of 0.32 in 2012. SSB is estimated to decrease from 358,000 t at the beginning of 2011 to 313,000 t in 2012.

Difficulties in estimating initial stock size are the major problem in the forecast. This is due to divergent indices of abundance used in the tuning of the XSA, in addition to lack of reliable recruitment estimates. Prediction of catches beyond the TAC year will, to a large extent, be dependent on assumptions of average recruitment.

In 2011 the evaluation of the harvest control rule made in 2007 was repeated taking into account the changes made to the assessment after the 2010 benchmark assessment. The analyses indicate that the HCR still is in agreement with the precautionary approach.

Long-term stochastic simulations made in 2011 showed that the highest long-term yield was obtained for F=0.20, but the curve was almost flat between F=0.15 and F=0.25 and the decrease in long-term yield going from F=0.25 to F=0.35 (F_{pa}, and also the value used in the present harvest control rule) was rather small (about 5%). However, SSB was reduced by almost 50% between F=0.20 and F=0.35 and approached B_{pa}.

Beaked redfish (*Sebastes mentella*) in Sub-areas I and II (Northeast Arctic) was assessed on the basis of available trends in the fisheries and surveys, as there is no accepted analytical assessment for this stock. There are signs of improved recruitment, but the stock is still at a low level and will remain there for a considerable period irrespective of current management actions. No directed fishery is advised.

Golden redfish (*Sebastes marinus*) in Sub-areas I and II (Northeast Arctic) was assessed on the basis of available trends in the fisheries and surveys. There is no accepted analytical assessment for this stock but the Gadget model was used for the seventh time as an experimental analytical assessment model.

- Since 1993, recruitment of *S. marinus* has been extremely low
- commercial data and surveys show consistent declining trends in the spawning biomass
- the exploratory assessment conducted using the Gadget simulation model covering the period 1986–2010 showed a reduction of the spawning stock to about 50% of the level in the early 1990s, and a more severe reduction of the recruitment and the immature stock
- present available information confirms last year's evaluation of the very poor status of the stock
- catches have been stable in recent years, and with a declining stock size this indicates that the fishing mortality is increasing

Greenland halibut in Sub-areas I and II (Northeast Arctic) is in the category "same advice as last year" this year and last year's advice (catches should not exceed 13,000 t) was repeated. Stock trends in recent years indicate a slight increase in stock size. There is no accepted analytical assessment for the time being. The age reading workshop held in February 2011 (WKARGH) did not lead to agreement on the age reading methodology. Several new age reading methodologies all indicate considerably slower growth after age 4-5 than the old methodology gives.

According to ToR b), the data on Barents Sea capelin were updated.

Before the next AFWG meeting, there will be a benchmark meeting for all redfish stocks, including the two assessed by AFWG.

0 Introduction

0.1 Participants

Asgeir Aglen	Norway
Matthias Bernreuther	Germany
Mette Bertelsen (part-time)	ICES
Bjarte Bogstad (Chair)	Norway
Oleg Bulatov	Russia
Jose Miguel Casas	Spain
Anatoly Chetyrkin	Russia
Gjert Endre Dingsør	Norway
Konstantin Drevetnyak	Russia
Anne Maria Eikeset	Norway (by correspondence)
Anatoly Filin	Russia
Åge Fotland	Norway
Elvar Halldor Hallfredsson	Norway
Daniel Howell	Norway
Yuri Kovalev	Russia
Sigbjørn Mehl	Norway
Kjell H. Nedreaas	Norway
Alexey Russkikh	Russia
Oleg Smirnov	Russia
Jan Erik Stiansen	Norway
Ross Tallman	Canada
Oleg Titov	Russia
Natalia Yaragina	Russia

0.2 Locations of the meeting

The meeting was held in Hamburg, Germany, at the Johann Heinrich von Thünen-Institut (vTI), Institute of Sea Fisheries, who provided excellent facilities for the meeting. It was noted that the previous time the AFWG met in Hamburg was in 1965.

0.3 Terms of reference

The **Arctic Fisheries Working Group** [AFWG]: (Chaired by: Bjarte Bogstad, Norway) will meet in Hamburg, Germany 28 April- 4 May 2011 to:

a) Address generic ToRs for Fish Stock Assessment Working Groups (see table below).

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

c) Address request from Norway on monitoring of migratory patterns of fish stocks in the Arctic

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting. This will be coordinated as indicated in the table below.

Material and data relevant for the meeting must be available to the group no later than 14 days prior to the starting date.

AFWG will report by 11 May 2011 (and 7 October 2011 for Barents Sea capelin) for the attention of ACOM.

Fish Stock	**Stock Name**	**Stock Coord.**	**Assesss. Coord. 1**	**Assess. Coord.2**	**Perform assessment**	**Advice**
cod-arct	Cod in Subareas I and II (Northeast Arctic)	Russia	Norway	Norway	Y	Update
cod-coas	Cod in Subareas I and II (Norwegian coastal waters)	Norway	Norway		Y	Update
had-arct	Haddock in Subareas I and II (Northeast Arctic)	Russia	Norway		Y	Update
sai-arct	Saithe in Subareas I and II (Northeast Arctic	Norway	Norway		Y	Update
cap-bars	Capelin in Subareas I and II (Barents Sea), excluding Division IIa west of 5°W	Norway	Russia	Norway	Y	Update
ghl-arct	Greenland halibut in Subareas I & II	Russia	Norway		Y	Same advice as last year
smn-arct	Red fish *Sebastes mentella* Subareas I and II	Russia	Norway		Y	Update
smr-arct	Red fish *Sebastes marinus* Subareas I and II	Norway	Russia		Y	Same advice as last year

ToR a) and b) are addressed in the sections for the respective stocks, while ToR c) is addressed in Section 0.11.

Generic ToRs for Regional and Species Working Groups

The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGHMM, WGEF and WGANSA.

The working group should focus on:

ToRs a) to g) for stocks that will have advice,

ToRs b) to f) and h) for stocks with same advice as last year.

ToRs b) to c) and f) for stocks with no advice.

a) Produce a first draft of the advice on the fish stocks and fisheries under considerations according to ACOM guidelines and implementing recommendations from WKMSYREF.

b) Update, quality check and report relevant data for the working group:

   i) Load fisheries data on effort and catches (landings, discards, bycatch, including estimates of misreporting when appropriate) in the INTERCATCH database by fisheries/fleets. Data should be provided to the data coordinators at deadlines specified in the ToRs of the individual groups. Data submitted after the deadlines can be incorporated in the assessments at the discretion of the Expert Group chair;
   ii) Abundance survey results;
   iii) Environmental drivers.
   iv) Propose specific actions to be taken to improve the quality of the data (including improvements in data collection).

c) Produce an overview of the sampling activities on a national basis based on the INTERCATCH database and report the use of InterCatch;

d) In cooperation with the Secretariat, update the description of major regulatory changes (technical measures, TACs, effort control and management plans) and comment on the potential effects of such changes including the effects of newly agreed management and recovery plans.

e) For each stock update the assessment by applying the agreed assessment method (analytical, forecast or trends indicators) as described in the stock annex. If no stock annex is available this should be prepared prior to the meeting.

f) Produce a brief report of the work carried out by the Working Group. This report should summarise for the stocks and fisheries where the item is relevant:

   i) Input data (including information from the fishing industry and NGO that is pertinent to the assessments and projections);
   ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
   iii) Stock status and 2012 catch options;
   iv) Historical performance of the assessment and brief description of quality issues with the assessment;
   v) Mixed fisheries overview and considerations;

vi) Species interaction effects and ecosystem drivers;

vii) Ecosystem effects of fisheries;

viii) Effects of regulatory changes on the assessment or projections;

g) Where appropriate, check for the need to reopen the advice in autumn based on the new survey information and the guidelines in AGCREFA (2008 report).

h) For the stocks where the advice is marked 'collate data', available data should be collected and presented as far as possible. If information is available for more than or only part of the area, the header for the stock can be adapted (please discuss with the secretariat).

i) Identify elements of the EGs work that may help determine status for the 11 Descriptors set out in the Commission Decision (available at http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:232:0014:0024:EN:PDF;

j) Provide views on what good environmental status (GES) might be for those descriptors, including methods that could be used to determine status.

k) take note of and comment on the Report of the Workshop on the Science for area-based management: Coastal and Marine Spatial Planning in Practice (WKCMSP) http://www.ices.dk/reports/SSGHIE/2011/WKCMSP11.pdf

l) provide information that could be used in setting pressure indicators that would complement biodiversity indicators currently being developed by the Strategic Initiative on Biodiversity Advice and Science (SIBAS). Particular consideration should be given to assessing the impacts of very large renewable energy plans with a view to identifying/predicting potentially catastrophic outcomes.

m) identify spatially resolved data, for e.g. spawning grounds, fishery activity, habitats, etc.

The generic terms of reference g-m are answered in Section 1.1

0.4 Unreported landings

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, however, that discards are negligible for all stocks, but the WG has no information on the possible extent of discarding.

As last year, a report from the Norwegian-Russian analysis group dealing with estimation of total catch of cod and haddock in the Barents Sea in 2010 was presented to AFWG (WD09). 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 2010 to zero.

It should, however, be noted that there is some disagreement between the Parties in the analysis Group on the interpretation of mandate of the Group and the approach to be used. Mutual inspection of the other Parties’ data, has, for instance, not been carried out. Thus one of the Parties has asked the Joint Norwegian-Russian Fisheries Commission for a clarification of how the mandate should be interpreted.

Unreported landings will reduce the effect of management measures and will undermine the intended objectives of the harvest control rule. It is therefore important that management agencies ensure that all catches are counted against the TAC. The AFWG therefore expects that Norway and Russia will continue the work to secure the necessary quality and accuracy of the catch statistics. Inspections at sea need to be an important part of this work, and Norway and Russia have check-points in their respective economic zones where all fishing vessels have to pass. There are at present, however, no such operative check-points for the fisheries in Spitsbergen waters, and it is suggested by the WG that check-points also should be deployed in this area. The working group also believes that mutual exchange of satellite-tracking (VMS) data from each country's vessels, also when operating in its own economic zone or in international waters, may improve the quality of the catch data used for stock assessments of joint stocks, and suggests that the Joint Norwegian-Russian Fisheries Commission opens up for that in the future.

0.5 Uncertainties in the data

Catch data

At recent AFWG meetings it has been recognized that there is considerable evidence of both substantial mis-/unreporting of catches and discarding throughout the Barents Sea for most groundfish stocks having taken place (ICES CM 2002/ACFM:18, ICES CM 2001/ACFM:02, ICES CM 2001/ACFM:19, Dingsør WD 13 2002 WG, Hareide and Garnes WD 14 2002 WG, Nakken WD 10 2001 WG, Nakken WD8 2000 WG, Schöne WD4 1999 WG, Sokolov, WD 9 2003 WG, Ajiad *et al*. WD18 2005 WG, WD 24 2004 WG and WD2 2008 WG). In addition to these WDs, Dingsør (2001) estimated discards in the commercial trawl fishery for Northeast Arctic cod (*Gadus morhua* L.) and some effects on assessment, and Sokolov (2004) estimated cod discard in the Russian bottom trawl fishery in the Barents Sea in 1983-2002. This work should be continued, updated and presented annually to the AFWG.

During the present AFWG meeting specific concerns were expressed about discarding of small haddock on the nursery grounds in the Russian economic zone, and discarding of cod related to big catches when the skipper hauls the next trawl before the previous catch is processed. The combination of great amounts and fishable concentrations of cod and haddock, reduced minimum legal fish size limits in the Norwegian Economic zone and in the Svalbard area (Spitsbergen archipelago), may due to large amounts of large and better paid fish and a reduced possibility for the enforcement agencies to close small-fish areas (due to more liberal legal catch sizes), lead to a greater risk for discarding. Discarding has the last year again arisen in the Norwegian management and media debate, and quantification of the problem, whether insignificant or not, should be done routinely. The Norwegian Institute of Marine Research has hence designed a project to do this, but has so far not got it financed.

The capelin catch is not considered misreported. Discarding is considered negligible.

Survey data

While the area coverage of the winter surveys for demersal fish was incomplete in 1997 and 1998, the coverage was normal for these surveys in 1999-2002. In the autumn 2002, 2006 and winter 2003, 2007 however, surveys were again incomplete due to lack of access to both the Norwegian and Russian Economic Zones. This affects the reliability of some of the most important survey time series for cod and haddock and consequently also the quality of the assessments. In some years, the permission to work in the Norwegian and Russian Economic Zones, respectively, has been received so late that the work has been severely hampered, e.g., the Russian survey in autumn 2003 and 2006. There is no acceptable way around this problem except asking the Norwegian and Russian authorities to give each other's research vessels full access to the respective economical zones when assessing the joint resources, as, e.g., was the case for Norwegian winter surveys in 2004-2005 and 2008-2011.

From 2004 onwards, a joint Norwegian-Russian survey has been conducted in August-September. This is a multi-purpose survey termed an "ecosystem survey" because most part of the ecosystem is covered; including an acoustic survey for the pelagic species, which is used for capelin assessment, and a bottom trawl survey which include non-commercial species. Ongoing work is considering the performance of these new index series for inclusion in the assessment of cod and haddock, and they seem to be fairly consistent with the other series available. The ecosystem survey is now included in the haddock assessment. The survey is also utilised in the assessment of redfish and Greenland halibut. However, this survey may be discontinued or downscaled for economical reasons. This is highly regrettable, since this survey has been shown to be valuable for sampling of synoptic ecosystem information, cover the entire area of fish distribution in the Barents Sea, and provide additional data on geographical distribution of demersal fish, which could prove valuable in future inclusion of more ecosystem information in the fish stock assessments.

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, Greenland halibut and *S. mentella* otoliths. Once a year (for capelin every second year, no exchanges of redfish age readers so far) the age readers have come together and evaluated discrepancies, which are seldom more than 1 year, and the results show an improvement over the time period, despite still observing discrepancies for cod in the magnitude of 15-30%. An observation that is supported by the results of a NEA cod otolith exchange between Norway, Russia and Germany (Høie *et al*. 2009, AFWG 2009, WD 6). 100 cod otoliths were read by 3 Norwegian, 2 Russian and 1 German reader, reaching nearly 83% agreement (coefficient of variation 8%). The age reading comparisons of these 100 cod otoliths show that there are no reading biases between readers within each country. However, there is a clear trend of bias between the readers from different countries, Russian age readers assign higher ages than the Norwegian and German age readers. This systematic difference is a source of concern and is also discussed in Yaragina *et al*. (2009b). This seems to be a persistent trend and will be revealed in the following annual otolith and age reader exchanges.

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

The exchange meeting in 2009 (WD14), found that the percent disagreement between the PINRO and IMR readings have stabilized in recent years at around 20% for cod, and around 10% for haddock, which suggests that annual meetings are not necessary. For the future meetings will be every second year, while otolith exchange will take place annually.

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. An international (Russia, Norway, Iceland, Canada) age reading workshop on capelin was conducted in May 2009 (WD 1). Otoliths from 20 samples (390 otoliths) where discussed. Some of these samples had been exchanged earlier, according to the program of annual otolith exchange between Norway and Russia. Other samples were read for the first time during the workshop, including samples from Iceland and Newfoundland.

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 will continue to meet at Workshops every second year. Readers from all labs involved will meet less frequently. Details will be discussed and decided by correspondence.

An ICES Workshop on Greenland halibut age reading (WKARGH) was held in February 2011 (ICES CM 2011/ACOM:41). The results of that workshop are discussed in Chapter 8.

From 2009 onwards, an exchange of *Sebastes mentella* otoliths is conducted annually between the Norwegian and Russian laboratories (See Section 6.2.2), but it is also important that age readers from the two countries work together.

Sampling error – catch and survey data

Estimates of sampling error are to a large degree lacking or are incomplete for the input data used in the assessment. However, the uncertainty has been estimated for some parts of the input data:

Catch data

For the Norwegian estimates of catch at age for cod and other demersal species 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). 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 are in the range 5-40% depending on age and year. It is evident that the estimates of the oldest fish are the most imprecise due to the low numbers in the catches and resulting small number of samples on these age groups. From 2006 onwards, the Norwegian catch at age in the assessment has been calculated using the method described by Hirst *et al*. (2005).

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

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

Survey data

For the Barents Sea winter survey, the sampling error is estimated per length group, but not per age group. Since the ages are sampled stratified per length groups in this survey, it is not straightforward to estimate the sampling error per age group. However, this is possible by for example using similar methods as for the catch data (see Hirst *et al*. 2004).

The capelin stock is estimated at the August-September survey. After the survey became a multipurpose survey in 2004, there is a possibility that the amount of trawl catches directed on capelin acoustic registrations has been less than before, as the total number of trawl stations increased. The effect of this on the quality of the capelin estimate has not been quantified. The survey coverage is considered adequate. The uncertainty in the survey has been evaluated by resampling (Tjelmeland 2002), and used as basis for the CV (0.2) chosen for the survey uncertainty in the tool used for calculating the effect of the catch (CapTool) on the spawning stock.

Work on quantifying uncertainties also for other input data sets should be encouraged.

Sampling effort - commercial fishery

Concerns about commercial sampling: The main Norwegian sampling program for demersal fish in ICES areas I and II has been port sampling, carried out on board a vessel travelling from port to port for approximately 6 weeks each quarter. A detailed description of this sampling program is given in Hirst *et al*. (2004). However, this program was, for economic reasons, terminated 1 July 2009. Although sampling by the 'reference fleet' and the Coast Guard has increased somewhat in recent years, this change seems to have increased the uncertainty in the catch-at-age estimates (WD6). For the 2009 data, the effect is strongest for saithe, where the fishery is fairly evenly distributed by quarters. Cod and haddock are mainly fished in the first half of the year, so the effect of the change will for those stocks show up much stronger in the 2010 data. Nevertheless, there are already concerns that the commercial sampling could become so poor that analytical assessments cannot be made in the future. The split between coastal cod and NEA cod will affected by this, but no analysis of this is yet available.

Table 0.1 and Figure 0.1 show one way of presenting the Norwegian commercial catch sampling in 2010 compared with 2009. The main reason for the general decrease in numbers of samples is the termination of the port sampling program in northern Norway. Since this program terminated in the middle of 2009, it would have even been better to compare 2010 with 2008, the last year when all seasons were covered. The samples and data basis behind each stock assessment are discussed more in detail under each stock chapter (e.g., the coastal cod), but some general aspects may be mentioned here. The cod age sampling has been reduced by nearly 50% per 1000 t caught, and haddock and saithe by about 20% dependent on whether the number of samples or the number of aged individuals per 1000 t caught are looked at. The number of aged individuals per 1000 t is now well below the standard set by EU in their Data collection regulations. It is therefore to be expected that the current assessments of these stocks may be less precise than in recent years. In addition to this overall reduction in sampling which mainly is related to the coastal areas, Figure 0.1-0.2 shows some bias in the sampling coverage of seasons, areas and gears relative to the catch taken. This is elaborated more in detail in each stock chapter.

Table 0.x. Age sampling by Norway of commercial landings in 2008-2010. Number of samples and average number of fish per sample. Also number of age samples and aged individuals per 1000 t caught. For comparison is also the EU DCF requirements shown.

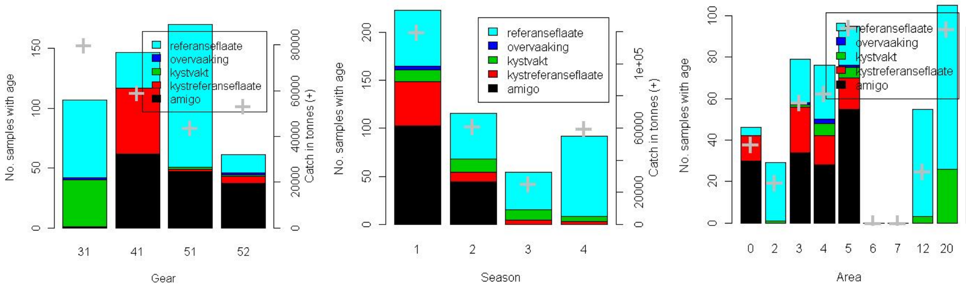
Stock	Year	Age samples	Average number per sample	Landings, tonnes	Age samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison, per 1000 t
NEA-cod	2008	453	62	196067	2.3	144	125
	2009	485	58	224816	2.2	125	125
	2010	311	50	263816	1.2	59	125
Coastal cod *)	2008	356	11	25777	13.8	152	-
	2009	359	7	24821	14.5	101	-
	2010	275	8	22925	12.0	96	-
NEA-haddock	2008	212	54	72553	2.9	159	125
	2009	263	45	104882	2.5	114	125
	2010	275	34	123517	2.2	76	125
NEA-saithe	2008	169	56	165998	1.0	57	125
	2009	118	57	144570	0.8	46	125
	2010	180	35	173969	1.0	36	125
S. marinus	2008	104	41	6180	16.8	683	125
	2009	110	38	6215	17.7	665	125
	2010	107	28	6515	16.4	460	125
S. mentella **)	2009	3	40	2567	1.2	46	125
	2010	5	64	2245	2.2	143	125

*) in addition to age the otoliths are also used for identification of coastal cod

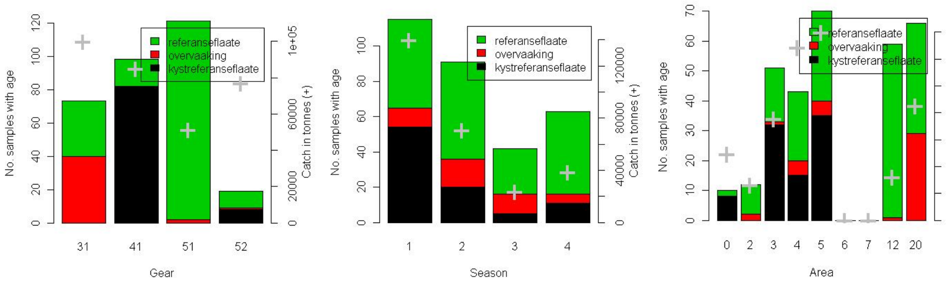
**) age samples from surveys with commercial trawl come in addition

Port sampling along the Norwegian coast should hence be increased. The cut in sampling effort of coastal fisheries (composing nearly 70% of the Norwegian cod fisheries) is even worse than it looks like from Table 0.1 and Figures 0.1-0.2 since the previous port sampling program managed to sample 200-300 different vessels per year, while the current sampling only manage to cover about 5% of this number.

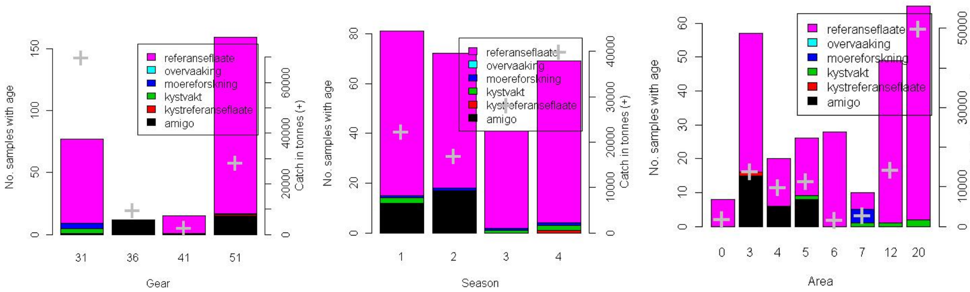
NEA-cod 2009



NEA-cod 2010



NEA-haddock 2009



NEA-haddock 2010

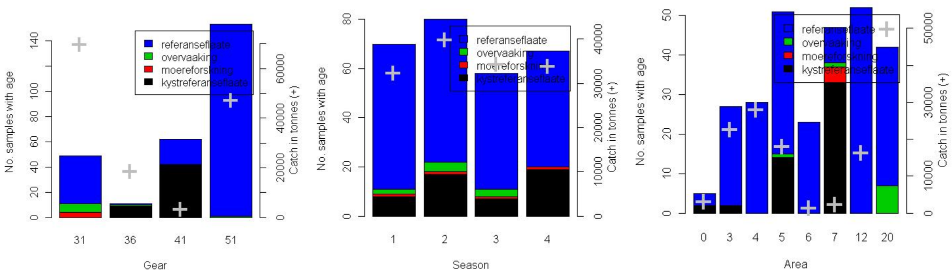
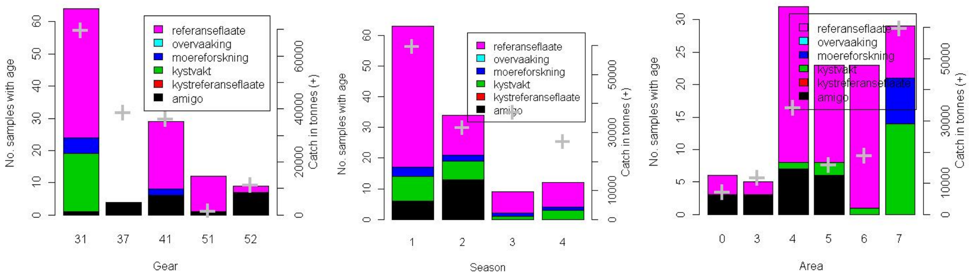
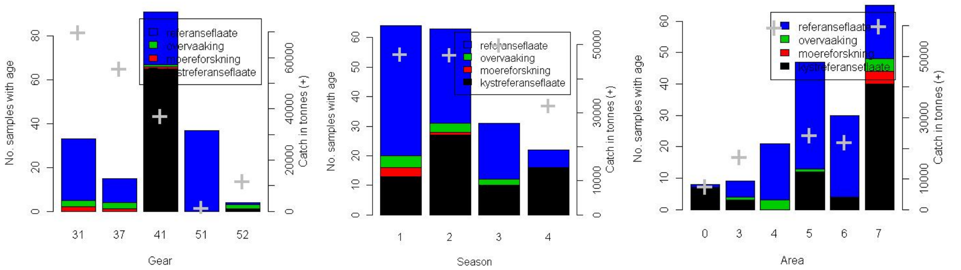


Figure 0.1. Norwegian AGE samples of commercial catches of NEA-cod and -haddock in 2009 and 2010. Note the different axes and colours. The different sampling platforms are shown by different colours, unfortunately with different colours each year.

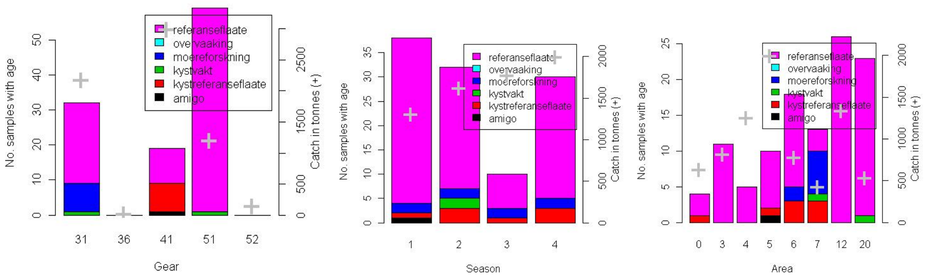
NEA-saithe 2009



NEA-saithe 2010



S. marinus 2009



S. marinus 2010

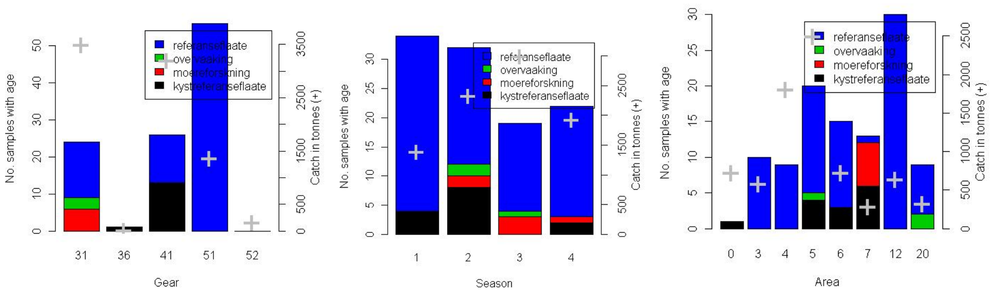


Figure 0.2. Norwegian AGE samples of commercial catches of NEA-saithe and *Sebastes marinus* in 2009 and 2010. Note the different axes and colours. The different sampling platforms are shown by different colours, unfortunately with different colours each year.

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 in 2010 (age sample numbers and mass measurements of fish) onboard fishing vessels were reduced, especially in ICES Sub-areas IIa and IIb, which may result in greater uncertainty of the stock assessments due to possible biases in the age-length distributions of the commercial catch.

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

As most stock assessment models used at present in ICES (such as standard VPA and the XSA) work with the assumption that the Catch-At-Age data are unbiased, and know exactly, it seems very important to actually be able to assess if this assumption is reasonable by measuring the accuracy of the estimated catch-at-age based on data from sampling programs. Some of the recommendations from different assessment working groups are further related to assessment of the quality of different estimates such as catch-at–age data. To be able to give validation on the data quality it is crucial that the sampling program is set up in a transparent, statistical sound way. Stock assessments need proper sampling designs and estimation processes that are well documented.

ICES' Planning Group of Commercial Catches, Discards and Biological Sampling (PGCCDBS; ICES CM 2011/ACOM:40) was requested by WGCHAIRS 2011 to develop some templates for reporting on quality of input data for stock assessments, e.g., based on the recommendations from the above mentioned ICES workshops. This implies a need for easily comprehended overviews of how data quality has varied over time. A range of such templates would be needed according to the nature of the data (e.g. landings; discards quantities; length or age compositions). Developing time-series of precision and bias values is, however, extremely complex due to the propagation of errors through multi-stage sampling for length/age or discards at the national fleet level and then through the aggregation across fleets and countries. PGCCDBS has in their report (ICES CM 2011/ACOM:40) suggested that data quality templates for assessment Review Groups should be based around informative summaries of sampling coverage and intensity, and should include relative standard errors (RSE) or bias estimates only where the standard errors and bias indicators can be reliably estimated and combined across countries and/or fleets. PGCCDBS suggests formats for documenting international sampling coverage and intensity over the full time period of data available for use in stock assessment. Suggested example of a detailed summary of sampling coverage, intensity and bias indicators (WKACCU traffic lights) for a single year is also presented.

And furthermore, a suggested template for how to present the precision (relative standard error) of estimated total international catch-at-age (retained and discarded), and effective sample size is given. Precision of estimated mean length in the catches is also given as an additional indicator.

The AFWG supports the suggestions by PGCCDBS and will now await a decision by ACOM on which templates and parameters that should be estimated and included in future WG reports as standard.

0.6 Climate included in advice of NEA cod

For the fourth time climate 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.

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

0.7 Proposals for status of assessments in 2012–2013

The AFWG propose to set the following status for assessments for each stock:

FishStock	Stock Name	Advice in 2012*	Previous benchmark	Next benchmark
cod-arct	Cod in Subareas I and II (Northeast Arctic)	Update	-	-
cod-coas	Cod in Subareas I and II (Norwegian coastal waters)	Update	-	-
had-arct	Haddock in Subareas I and II (Northeast Arctic)	Update	WKBENCH 2011	-
sai-arct	Saithe in Subareas I and II (Northeast Arctic)	Update	WKROUND 2010	-
cap-bars	Capelin in Subareas I and II (Barents Sea), excluding Division IIa west of 5°W	Update	WKSHORT 2009	-
ghl-arct	Greenland halibut in Sub-areas I & II	Update	-	2013
smn-arct	Redfish *Sebastes mentella* Subareas I and II	Update	-	2012
smr-arct	Redfish *Sebastes marinus* Subareas I and II	Update	-	2012

Any benchmark assessment for Greenland halibut should also include the other stocks of this species in the ICES area and it should also include experts on Greenland halibut stocks outside the ICES area.

0.8 ICES Quality Handbook

Quality Handbooks for all stocks are presented in this report as annexes (no. 2-9). The stock annex for haddock has been updated after the benchmark at WKBENCH 2011, and the stock annex for capelin is new.

0.9 InterCatch

The assessment of NEA cod, haddock and saithe was partly based on output from InterCatch. In the future, AFWG will consider using Intercatch also for the other stocks.

0.10 MSY-related reference points and advice

AFWG has followed the guidelines for MSY-based advice outlined by WKFRAME2 (ICES C. M. 2011/ACOM:33). This year, new analyses of MSY have been made for haddock and saithe, and preliminary MSY analyses for capelin are described in the new stock Annex.

0.11 Answer to request from Norway on monitoring of migratory patterns of fish stocks in the Arctic

ICES has received the following request from the Joint Russian-Norwegian Fisheries Commission (JRNFC) (ToR c)

"According to paragraph 14.1 of the protocol of the 38th session of JRNFC, the parties agreed to "make a request to ICES on continuous monitoring of the extensiveness in the Arctic Ocean of fish stocks managed by the Commission". The joint management of fish stocks under the JRNFC encompasses the species of Northeast Arctic cod, Northeast Arctic haddock, Barents Sea capelin and Northeast Arctic halibut.

In view of the above described agreement in the protocol of the 38-th session of the JRNFC, the chairmen would hereby request ICES to:

a) Report on the possibility of conducting continuous monitoring of the migratory pattern in the Arctic Ocean of fish stocks (referred to above) managed by the JRNFC.

b) Facilitate future monitoring and research of fish stocks in the Arctic Ocean by anchoring the matter in the mandate of an existing ICES Working Group or in the establishment of a new Working Group. "

Our answer is as follows:

We assume that "Northeast Arctic halibut" should be "Northeast Arctic Greenland halibut".

Concerning a), it is possible to monitor the geographic distribution of these stocks in the ice-free parts of the Arctic Ocean once a year, using existing survey methodology. The Joint Ecosystem Survey in August/September (Anon. 2010) already covers the Barents Sea north to 80-81°N, and there is also additional Russian coverage of the Greenland halibut distribution in the Northeastern Kara Sea. These surveys could be extended into the Arctic Ocean if possible (depending on ice conditions) and if additional funding is provided.

Concerning b), we advise that future requests to ICES concerning monitoring and research of fish stocks in the part of the Arctic Ocean adjacent to the Barents Sea should be handled by the Arctic Fisheries Working Group, since the stocks handled by AFWG are those that are most likely to migrate into the Arctic Ocean. A new organization might be appropriate if there are fisheries issues that engage more countries around the Arctic Ocean.

0.12 Recommendations

A benchmark meeting for all Greenland halibut stocks should be held in 2013.

Sampling effort and coverage should be improved.

Estimation of international discards in the Arctic fisheries should be conducted and presented to the AFWG annually

0.13 Time and place of Next Meeting

The Working Group proposes to meet next time in Copenhagen (WD 25) in the period 19-25 April 2012.

1 Ecosystem considerations (Figures 1.1–1.19, Tables 1.1–1.17)

The aim of this chapter is to identify important ecosystem information influencing the fish stocks, and further show how this knowledge may be implemented into the fish stock assessment and predictions. There has been steady development in this aspect over the last few years and the work is still in a developing phase. Hopefully, the gathering of information on the ecosystem in this chapter will lead to a better understanding of the complex dynamics and interactions that takes place in the ecosystem, and also supports the development of an ecosystem based management of the Barents Sea.

At the end of this chapter (Section 1.7) we also answer the ICES "Generic Terms of Reference for Regional and Species Working Groups".

The ecosystem approach to management is variously defined, but in principle it puts emphasis on a management regime that maintains the health of the ecosystem alongside appropriate use of the marine environment, for the benefit of current and future generations (Jennings, 2004).

Along with fishery, changes in the Barents Sea ecosystem are mainly caused by variations in the ocean climate. A warm period is characterized of increased impact of warm Atlantic water in the Barents Sea contributing to advection of zooplankton, faster growth rate in fish and emergence of abundant year classes (Dalpadado *et al.* 2002). A cold period is, conversely, characterized by reduced primary biological production in the Barents Sea and emergence of weak year classes of commercial species. Climatic conditions govern the formation of primary biological production and feeding conditions for fish, as well as the survival of their offspring. In addition, interspecies trophic relations are an important factor that influences the abundance dynamics of commercial species.

Movement towards an ecosystem approach to the fishery management in the Barents Sea should include (Filin and Røttingen, 2005):

- More extensive use of ecosystem information in the population parameters applied in assessment and prognosis,
- Expansion of the use of multi-species models for fishing management.

This chapter is in general based on the "Joint Norwegian-Russian environmental status 2008, report on the Barents Sea Ecosystem" (Stiansen *et al.*, 2009), affiliating more than 100 scientists from 24 institutions in Norway and Russia. It is further based on Stiansen *et al.*, (WD24), which is an update of the current situation chapter of the Stiansen *et al.* (2009) report. Additional information is also gathered from other ICES WG's reports and WD's to this AFWG assessment. Text, figures and tables taken from these reports (i.e. Stiansen *et al.*, 2009, and Stiansen *et al.* WD24) are in general not further cited in this chapter.

1.1 General description of the Barents Sea ecosystem (Figure 1.1–1.2, Tables 1.1–1.7)

1.1.1 Geographical description

The Barents Sea is on the continental shelf surrounding the Arctic Ocean. It connects with the Norwegian Sea to the west and the Arctic Ocean to the north and the Kara Sea to the east. Its contours are delineated by the continental slope between Norway and Spitsbergen to the west, the top of the continental slope towards the Arctic Ocean to the north, Novaya Zemlya archipelago to the east, and the coasts of both Norway and Russia to the south (Figure 1.1). It covers an area of approximately 1.4 million km^2, has an average depth of 230 m, and a maximum depth of about 500 m at the western end of Bear Island Trough (Figure 1.1). Its topography is characterized by troughs and basins (300 m – 500 m deep), separated by shallow bank areas, with depths ranging from 100-200 m. The three largest banks are Central Bank, Great Bank and Spitsbergen Bank. Several troughs over 300 m deep run from central Barents Sea to the northern (e.g. Franz Victoria Trough) and western (e.g. Bear Island Trough) continental shelf break. These troughs allow the influx of Atlantic waters to the central Barents Sea.

1.1.2 Climate

The general pattern of circulation (Figure 1.1) is strongly influenced by the topography, and is characterised by inflow of relatively warm Atlantic water, and coastal water from the west. This Atlantic water current divides into two branches: 1) a southern branch that flows parallel to the coast and eastwards towards Novaya Zemlya; and 2) a northern branch that flows into the Hopen Trench. The Coastal Water has more fresh-water runoff and a lower salinity than the Atlantic water; it also has a stronger seasonal temperature signal. In the northern region of the Barents Sea, fresh and cold Arctic waters flow from northeast to southwest. Atlantic and Arctic water masses are separated by the Polar Front, which is characterised by strong gradients in both temperature and salinity. In the east the Polar Front is controlled by topography and quite stationary while it is much weaker and varying in the east. There is large inter-annual variability in ocean climate related to variable strength of the Atlantic water inflow, and exchange of cold Arctic water. Thus, seasonal variations in hydrographic conditions can be quite large. Ice cover has a strong seasonal and inter-annual variation, ranging from almost ice free conditions to cover more than half the sea.

1.1.3 Bacteria and phytoplankton

In the biogeochemical cycles of the ocean, a multitude of processes are catalyzed by *Bacteria* and *Archaea*, and the functioning of these cycles in the Barents Sea does not differ qualitatively from those at lower latitudes. Both bacteria and viruses show highly variable abundance in the Barents Sea. The situation in the ice-covered areas in the north remains to be investigated.

The Barents Sea is a spring bloom system. During winter, primary production is close to zero. Timing of the phytoplankton bloom varies throughout the Barents Sea and there may also be a high inter-annual variability. The spring bloom starts in the south-western areas and spreads north and east with the retracting ice. In early spring, the water is mixed from surface to bottom. Despite adequate nutrient and light conditions for production, the main bloom does not occur until the water becomes stratified.

Stratification of water masses in different areas of the Barents Sea may occur in several ways; 1) through fresh surface water from melting ice along the marginal ice zone; 2) through solar heating of surface layers in Atlantic water masses; or 3) through lateral dispersion of waters in the southern coastal region (Rey, 1981). As in other areas, diatoms are also the dominant phytoplankton groups in the Barents Sea (Rey, 1993). Diatoms particularly dominate the first part of the spring bloom, and the concentration of diatoms can reach up to several million cells per litre. They require silicate for growing, and when this is consumed, other phytoplankton groups, such as flagellates, take over. An important flagellate species in the Barents Sea is *Phaeocystis pouchetii* but other species may, however, dominate the spring bloom in different years.

1.1.4 Zooplankton

In the Barents Sea ecosystem, zooplankton forms a link between phytoplankton (primary producers) and fish, mammals and other organisms at higher trophic levels. Zooplankton biomass in the Barents Sea can vary significantly between years Crustaceans play a key role in the ecosystem, especially the calanoid copepods of the genus *Calanus*. *Calanus finmarchicus*, is most abundant zooplankton species in Atlantic waters and *C. glacialis* is most abundant zooplankton species in Arctic waters.

Calanoid copepods are largely herbivorous, and feed particularly on diatoms (Mauchline, 1998). They can account for more than 80 % of the zooplankton biomass in some regions, especially in the spring. Krill (euphausiids), another group of crustaceans, also play a significant role in the Barents Sea ecosystem as food for fish, seabirds, and marine mammals. Krill species are believed to be omnivorous: filter-feeding on phytoplankton during the spring bloom; while feeding on small zooplankton during other times of the year (Melle *et al*., 2004). Four dominant euphausiids species that occupy different niches in the community of Barents Sea are: *Meganyctiphanes norvegica* (neritic shelf boreal); *Thysanoessa longicaudata* (oceanic arcto-boreal); *T. inermis* (neritic shelf arcto-boreal); and *T. raschii* (neritic coastal arcto-boreal) (Drobysheva, 1994). The two latter species comprise 80-98% of total euphausiid abundance, but species composition may vary between years relative to climate (Drobysheva, 1994). After periods with cold climate, observed abundance of *T. raschii* increased while abundance of *T. inermis* decreased (Drobysheva, 1967). Advection from the Norwegian Sea is influenced by the intensity of Atlantic water inflow, which also influences the composition of species (Drobysheva, 1967; Drobysheva *et al*., 2003).

Three amphipod species are abundant in the Barents Sea; *Themisto abyssorum* and *T. libellula* in the western and central Barents Sea, and *T. compressa* in central and northern regions. *T. abyssorum* is most abundant in sub-Arctic waters. In contrast, the largest of the *Themisto* species, *T. libellula*, is largely mostly found in mixed Atlantic and Arctic water masses. High abundance of *T. libellula* was observed adjacent to the Polar Front. Amphipods feed on small zooplankton and copepods form an important component of their diet (Melle *et al*., 2004).

"Gelatinous zooplankton" is a common language term that often refers to classes of organism that are jelly-like in appearance. The term "jellyfish" is commonly used in reference to marine invertebrates belonging to the class *Scyphozoa*, phylum *Cnidaria*, and to relatives of true scyphozoans, particularly the *Hydrozoa* and the *Cubozoa*. Both comb-jellies (*Ctenophora*) and "true" jellyfish are predators, and they compete with plankton-eating fish, because copepods often are significant prey items.

1.1.5 Benthos and shellfish

The sea floor is inhabited by a wide range of organisms. Some are buried in sediment, others are attached to a substrate, some are slow and sluggish, others roving and rapid. More than 3050 species of benthic invertebrates inhabit the Barents Sea (Sirenko, 2001). The benthic ecosystems in the Barents Sea have considerable value, both in direct economic terms, and in their ecosystem functions. Scallops, shrimp, king crab, and snow crab are benthic residents which are harvested in the region. Many species of benthos are also interesting for bio-prospecting or as a future food resource, such as sea cucumber, snails and bivalves. Several of them are crucial to the ecosystem. Important fish species such as haddock, catfish and most flatfishes primarily feed on benthos. Many benthic animals, primarily bivalves, filter particles from the ocean and effectively clean it up. Others scavenge on dead organisms, returning valuable nutrients to the water column. Detritus feeders and other active diggers regularly move the bottom sediments around and therefore increase sediment oxygen content and overall productivity – much like earthworms on land.

There was a decline in the total biomass of benthos from 1924-1935 to 1968-1970 (Antipova, 1975). This happened almost throughout the Barents Sea, and has been attributed to climate change by many investigators. The mechanism behind this biomass reduction is not clear, however.

The northern shrimp (*Pandalus borealis*) is distributed in most deep areas of the Barents Sea and Spitsbergen waters. The densest concentrations are found in depths between 200 and 350 meters. The shrimp mainly feed on detritus, but may also be a scavenger. Shrimp is also important as a food item for many fish species and seals.

Red king crab (*Paralithodes camtschatica*) was introduced to the Barents Sea in the 1960s. Presently it is an important commercial species. Adult red king crabs are opportunistic omnivores.

The snow crab (*Chionoecetes opilio*) is an invasive species in the Barents Sea. The first recordings of this species in the Barents Sea were in 1996. Since 2003 snow crab have been found in the stomachs of cod, haddock, catfishes and thorny skates that indicates that the crab abundance and settlement density substantially increased.

The Iceland scallop is a slow growing species common in all shallow areas (< ca 150 m) It is usually associated with hard bottom substrate and most commonly in areas with strong currents (Wiborg, 1962). The scallop is a filter feeder and is therefore highly dependent on the seasonal phytoplankton production, which also impact on its growth (Sundet and Vahl, 1981). The lifespan is 30 years and over. Iceland scallop mature at age 7-8 years (Denisenko, 1989).

There are 8 species of squid inhabiting the Barents Sea (Golikov *et al*., 2008). The flying squid *Todarodes sagittatus* was a significant fishing resource in Norwegian waters during several periods up about 1988 (Borges, 1990). However, since then this squid has almost been absent from our waters and only sporadic catches have been recorded. *Gonatus fabricii* is another abundant squid species in the off shore waters of the Barents and the Norwegian Sea (Bjørke, 1995). Although this species has not been a subject of stock assessment, the total biomass is probably several million tonnes. This squid is important food for several bird and cetacean species, but could probably also be seen as a potential fishing resource.

1.1.6 Fish

More than 200 fish species are registered in trawl catches during surveys of the Barents Sea, and nearly 100 of them occur regularly. The different water masses, together with bottom type and depth, are important factors determining the distribution of the fish species. For pelagic species the distribution and abundance of zooplankton is additionally important factors. Commercially important fish species include Northeast Arctic cod, Northeast Arctic haddock, redfish (mainly deep-sea redfish, *Sebastes mentella*), Greenland halibut, long rough dab, wolffish, European plaice (*Pleuronectes* *platessa*), Barents Sea capelin, polar cod and immature Norwegian spring-spawning herring. In warm years, increased numbers of young blue whiting have migrated into the Barents Sea. There have been significant variations in abundance of these species. These variations are due to a combination of fishing pressure and environmental variability.

The recruitment of the Barents Sea fish species has shown a large year-to-year variability (Tables 1.1-1.2). The most important reasons for this variability are variations in the spawning biomass, climate conditions, food availability and predator abundance and distribution. Variation in the recruitment of some species, like cod, haddock and herring, has been associated with changes in the influx of Atlantic waters into the Barents Sea.

Cod is the most important predator fish species in the Barents Sea, and feeds on a wide range of prey, including larger zooplankton, most available fish species and shrimp (Tables 1.3-1.6). Cod prefer capelin as a prey, and fluctuations of the capelin stock (Table 1.7) have a strong effect on growth, maturation and fecundity of cod, as well as on cod recruitment because of cannibalism. The role of euphausiids for cod feeding increases in the years when capelin stock is at a low level (Ponomarenko and Yaragina 1990). Also, according to Ponomarenko (1973, 1984) interannual changes of euphausiid abundance is important for the survival rate of cod during the first year of life.

Capelin feed on zooplankton produced near the ice edge. Farther south, capelin is the most important prey species in the Barents Sea as it transports biomass from northern to southern regions (von Quillfeldt and Dommasnes, 2005). The Barents Sea capelin stock underwent drastic changes in stock size during the last three decades. Three stock collapses occurred in 1985-1989, 1993-1997, and 2003-2006. The collapses had effects both downwards and upwards in the food web (Gjøsæter *et al.*, 2009). The release in predation pressure from the capelin stock led to increased amounts of zooplankton during the two first collapse periods. When capelin biomass was drastically reduced, its predators were affected in various ways. Cod experienced increased cannibalism, growth was reduced and maturation delayed. Sea birds experienced increased rates of mortality and total recruitment failures, and breeding colonies were abandoned for several years. Harp seals experienced food shortage, increased mortality because they invaded the coastal areas and were caught in fishing gears, and recruitment failures. There is evidence for differences in how the three capelin collapses affected the predators. The effects were most serious during the 1985-1989 collapse, but much less during the second and third collapse. This was probably related with increased availability of alternative food sources during the two last periods of collapse.

Herring is also a major predator on zooplankton. The herring spawns along the Norwegian western coast and the larvae drifts into the Barents Sea. The juveniles of the Norwegian spring-spawning herring stock are distributed in the southern parts of the Barents Sea. They stay in this area for about three years before they migrate west and southwards along the Norwegian coast and mix with the adult part of the stock. The presence of young herring in the area has a profound effect on the recruitment of capelin, and it has been shown that when rich year classes of herring enters to the Barents Sea, the recruitment to the capelin stock is poor, and in the following years the capelin stock collapses (Gjøsæter and Bogstad, 1998).

Haddock is also a common species, and migrates partly out of the Barents Sea. The stock has large natural variations in stock size. Water temperature at the first years of the life cycle may be used as an indicator of year class strength. Food composition of haddock consists mainly of benthic organisms.

Saithe is found mainly along the Norwegian coast, but also occurs in the Norwegian Sea and in the southern Barents Sea. The 0-group saithe drifts from the spawning grounds to inshore waters. The smaller individuals feed on crustaceans, while larger saithe depends more on fish as prey (Dolgov, WD 29, AFWG 2006; Mehl, WD7, AFWG 2005). The main fish prey is young herring, Norway pout, haddock, blue whiting and capelin, while the dominating crustacean prey is krill.

Polar cod is a cold-water species found particularly in the eastern Barents Sea and in the north. It seems to be an important forage fish for several marine mammals, but to some extent also for cod. There is little fishing on this stock.

Deep-sea redfish and golden redfish used to be important elements in the fish fauna in the Barents Sea, but due to heavy overfishing these stocks declined strongly during the 1980's, and has since then stayed at a low level. Young redfish are plankton eaters, but larger individuals take larger prey, including fish.

Greenland halibut is a large and voracious fish predator with the continental slope between the Barents Sea and the Norwegian Sea as its most important area, but it is also found in the deeper parts of the Barents Sea. Investigations in the period 1980-1990 showed that cephalopods (squids, octopuses) dominated in the Greenland halibut stomachs, as well as fish, mainly capelin and herring. Ontogenetic shift in prey preference was clear with decreasing proportion of small prey (shrimps and small capelin) and increasing proportion of larger fish with increasing predator length. The largest Greenland halibut (length more than 65-70 cm) had a rather big portion of cod and haddock in the diet.

The blue whiting has its main distribution area in the Norwegian Sea and Northeast Atlantic, and the marginal northern distribution is at the entrance to the Barents Sea. Usually the blue whiting population in the Barents Sea is small. In some years the blue whiting may enter the Barents Sea in large numbers, and can be a dominant species in the western areas. This situation occurred from 2001 onwards, and blue whiting were found in great numbers for the period 2003-2007. Since then the abundance has decreased strongly again, and are at present very low. This rise and fall is probably due to a combination of variation in stock size and environmental conditions. In the diet of blue whiting zooplankton(copepods, hyperiids and euphausiids) is dominant in the younger age groups, while fish is increasingly important as the blue whiting gets older(Dolgov, WD 29, AFWG 2006).

Long rough dab is a typical ichthyobenthophage, which mainly eats benthos (ophiura, polychaetes etc.) and different fish species (Dolgov, WD 29, AFWG 2006). At older stages the proportion of fish in the diet increases (polar cod and cod, capelin and juvenile redfish). The larger long rough dab also feed on their own juveniles and juvenile haddock.

Thorny skate preys primarily on large crustaceans, shrimps and crabs (Dolgov, WD 29, AFWG 2006), but may also in a lesser extent feed on fish. The most common fish species are young cod and capelin. Round skate fed mainly on benthos, especially Polychaeta and *Gammaridae*. Arctic skate feed mainly on fish and shrimp (herring, capelin, redfish and northern shrimp). Blue skate diet consists largely of fish, mainly young cod and haddock, redfish, and long rough dab). Spinytail skate also prey mostly on fish, which included haddock, redfish and long rough dab. Total yearly food consumption by thorny skate is estimated to be around 160 thousand tonnes, of which around 75 thousand tonnes comprised commercial fishes and invertebrates. Total yearly food consumption by all other skate species was estimated to be around 30 thousand tonnes, of which around 20 thousand tonnes was commercial species (Dolgov, WD 29, AFWG 2006).

1.1.7 Mammals

Marine mammals, as top predators, are keystone species significant components of the Barents Sea ecosystem. About 25 species of marine mammals regularly occur in the Barents Sea, including: 7 pinnipeds (seals and walruses); 12 large cetaceans (large whales); 5 small cetaceans (porpoises and dolphins); and the polar bear (*Ursus maritimus*). Some of these species are not full-time residents in the Barents Sea, and use temperate areas for mating, calving, and feeding (e.g. minke whale *Balaenoptera acutorostrata*). Others reside in the Barents Sea all year round (e.g. white-beaked dolphin *Lagenorhynchus albirostris,* and harbour porpoise *Phocoena phocoena*). Some marine mammals are naturally rare, such as the beluga whale *Delphinapterus leucas.* Others are rare due to historic high exploitation, such as bowhead whale *Balaena mysticetus* and blue whale *Balaenoptera musculus*.

Marine mammals may consume up to 1.5 times the amount of fish caught in fisheries. Minke whales and harp seals may each year consume 1.8 million and 3-5 million tons of prey of crustaceans, capelin, herring, polar cod, and gadoid fish respectively (Folkow *et al*., 2000; Nilssen *et al.,* 2000). Functional relationships between marine mammals and their prey seem closely related to fluctuations in marine ecosystems. Both minke whales and harp seals are thought to switch between krill, capelin and herring depending on availability of the different prey species (Lindstrøm *et al*., 1998; Haug *et al*., 1995; Nilssen *et al*., 2000).

The only marine mammal species in the Barents Sea that are commercially harvested are harp seals and minke whale.

1.1.8 Seabirds

The Barents Sea has one of the largest concentrations of seabirds in the world (Norderhaug *et al*., 1977; Anker-Nilssen *et al*., 2000); its 20 million seabirds harvest annually approximately 1.2 million tonnes of biomass from the area (Barrett *et al*., 2002). Nearly 40 species are thought to breed regularly in northern regions of the Norwegian Sea and the Barents Sea. Abundant species belong to the auk and gull families. Seabirds play an important role in transporting organic matter and nutrients from the sea to the land (Ellis, 2005). This transport is of great importance especially in the Arctic, where lack of nutrients is an important limiting factor.

Many seabirds are specialised top predators and changes in their behaviour or population dynamics may therefore reflect changes in the lower trophic levels at an early stage. This position makes them suitable as indicators of changes in the marine environment (e.g. Cairns, 1992; Furness and Camphuysen, 1997; Tasker and Furness, 2003). The high density of seabirds is a consequence of high primary production and large stocks of pelagic fish species such as capelin *Mallotus villosus*, herring *Clupea harengus* and polar cod *Boreogadus saida*. In the north and east, the marginal ice-zone is an important feeding habitat where seabirds forage on migrating capelin, polar cod and zooplankton (Mehlum and Gabrielsen, 1993, Mehlum *et al*., 1996, Mehlum *et al*., 1998). The seabird communities in south and west depend on juvenile gadoids, juvenile herring, sandeels (*Ammodytes sp*.) and capelin (e.g. Anker-Nilssen, 1992, Barrett and Krasnov, 1996, Barrett *et al*., 1997, Fauchald and Erikstad, 2002).

1.1.9 Parasitic organisms

There are 10 types of parasites found in the fish of the Barents Sea, but it is hard to determine which groups of parasitic organisms that play an important role in the population dynamics of their hosts. The Barents Sea parasites considered to be most damaging to the human health are larvae stages of *Cestoda* (*Diphyllobothrium* and *Pyramicocephalus* genera), *Nematoda* (*Anisakis* and *Pseudoterranova* genera) and *Palaeacanthocephala* (*Corynosoma* genera). 82 species of helminthes are recorded from 18 bird species. The Barents Sea birds' helminthofauna mostly consists of the species with the life cycle dependent on coastal ecosystems. Invertebrates and fish from the littoral and upper sub littoral complex serve as their intermediate hosts. There are 32 species of helminthes found in the pinnipeds and cetaceans of the Barents Sea.

1.1.10 Rare and threatened species

The Barents Sea includes species that either have very small populations or species that have recently undergone considerable population decline (or are expected to do so in the close future). The assessments are done by use of the IUCN criteria (IUCN, 2001; 2003), but the Global, the Russian and the Norwegian lists available cannot be directly compared. All these lists are closely related and have high relevance for the conservation of biodiversity, and the list from the Barents Sea include a total of 56 species comprising of 28 fish species, 9 bird species, and 18 mammal species.

1.1.11 Invasive species

Invasions of alien species – spread of the representatives of various groups of living organisms beyond their primary habitats – are global in nature. Their introduction and further spread often leads to undesirable environmental, economic and social consequences. Different modes of biological invasions can be natural movement associated with the population dynamics and climatic changes, intentional introduction and reintroduction, and accidental introduction with the ballast waters and along with the intentionally introduced species, etc. Bioinvasion includes all cases of introduction of living organisms into the ecosystem outside of their original range. The best known examples of invasive species in the Barents Sea are red king crab *(Paralithodes camtschaticus)* and snow crab *(Chionoecetes opilio)*.

1.1.12 Human activity

The Barents Sea is strongly influenced by human activity; historically involving the fishing and hunting of marine mammals. More recently, human activities also involve transportation of goods, oil and gas, tourism and aquaculture. In the last years interest has increases on the evaluation of the most likely response of the Barents Sea ecosystem to the future climate changes due to anthropogenic effects on climate warming.

Fishing is the largest human impact on the fish stocks in the Barents Sea, and thereby on the functioning of the whole ecosystem. However, the observed variation in both fish species and ecosystem is also impacted by other effects such as climate and predation. The most widespread gear used in the central Barents Sea is bottom trawl, but also long line and gillnets are used in the demersal fisheries. The pelagic fisheries use purse seine and pelagic trawl.

The Barents Sea remains relatively clean, however, when compared to marine areas in many industrialized parts of the world. Major sources of contaminants in the Barents Sea are natural processes, long-range transport, accidental releases from local activities, and ship fuel emissions. Results of recent studies indicate low level of contaminants in the Barents Sea marine environment and confirm results of earlier studies on bottom sediments in the same areas.

Traditionally, fishing having been the most important and far-reaching human activity in the ecosystem has been given most of the attention with analyses of impacts and risks. This need has increased in importance as oil- and gas industries have begun to develop new off-shore fields in the Barents Sea, and ship transport of oil and gas from the region has increased exponentially over the last 5 years.

The Barents Sea can become an important region for oil and gas development. Currently offshore development is limited both in the Russian and Norwegian economic zones (to the Snøhvit field north of Hammerfest in the Norwegian zone), but this may increase in the future with development of new oil- and gas fields. In Russia there are plans for the development of Stockman, a large gas-field west of Novaya Zemlja. The environmental risk of oil and gas development in the region has been evaluated several times, and is a key environmental question facing the region (Figure 1.2).

Transport of oil and other petroleum products from ports and terminals in northwest-Russia have been increasing over the last decade. In 2002, about 4 million tons of Russian oil was exported along the Norwegian coastline, in 2004, the volume reached almost 12 million tons, but the year after it dropped, and from 2005 to 2008 was on the levels between 9.5 and 11.5 million tons per year. In a five-ten years perspective, the total available capacity from Russian arctic oil export terminals can reach the level of 100 million tons/year (Bambulyak and Frantsen, 2009). Therefore, the risk of large accidents with oil tankers will increase in the years to come, unless considerable measures are imposed to reduce such risk.

Tourism is one of the largest and steadily growing economic sectors world-wide. Travels to the far north have increased considerable during the last 15 years, and there are currently nearly one million tourists annually to the Barents Region.

The high biodiversity of the oceans represents a correspondingly rich source of chemical diversity, and there is a growing scientific and commercial interest in the biotechnology potential of Arctic biodiversity. Researchers from several nations are currently engaged in research that could be characterised as bio-prospecting. However, bio-prospecting is not considered to pose a threat to the ecosystem.

Aquaculture is growing along the coasts of northern Norway and Russia, and there are several commercial fish farms producing salmonids (salmon, trout), white fish (mainly cod) and shellfish.

Human induced climate change and ocean acidification may have large influence on the Barents Sea in the future.

1.2 State and expected situation of the ecosystem (Figures 1.3–1.9, Tables 1.3–1.7, 1.9)

1.2.1 Climate

Atmospheric conditions

In winter 2009/2010 the patterns of air pressure and wind fields caused positive air temperature anomalies dominating most of the northern part of the Barents Sea with maximum anomalies of about 6-7°C over the northeastern Barents Sea, close to the long-term mean air temperatures prevailed over southern and southeastern parts of the sea. In summer 2010, air temperatures were close to the long-term mean over most of the Barents Sea.

Water temperature

Sea surface temperature (SST) in the Barents Sea showed much of the same variations as the air temperatures. Due to the warmer-than-usual air masses over the central and western Barents Sea at the end of 2009 and beginning of 2010, there was the less-than-usual atmospheric cooling. The SST was therefore still higher-than-normal with maximum positive anomalies (1.0-1.2°C) in the central part of the sea. In the eastern Barents Sea, on the contrary, the SST was lower-than-normal throughout most of the year, with maximum negative anomalies (–1.5°C) in summer and autumn. The weaker-than-usual spring-and-summer warming caused decreasing anomalies of SST.

In the bottom layer, positive temperature anomalies (0.1-0.6°C) were observed in most of the surveyed area in August-September 2010 (Figure 1.5). Negative temperature anomalies were found only in some areas near Novaya Zemlya and around Spitsbergen Archipelago. Compared to the previous year (2009), the bottom temperature decreased by 0.2-0.3°C in most of the surveyed area, and the volume of cold bottom waters increased in the northern Barents Sea in 2010.

The Fugløya-Bear Island and Vardø-North sections, which capture all the Atlantic Water entering the Barents Sea from south-west, showed temperatures 0.6-1°C above the long-term mean in early 2010 (Figure 1.3). This is lower than the last 5-6 winters. During winter the temperature anomalies decreased even more, and in March 2010 they were only 0.2-0.5°C above the long-term mean. This was due to lower air temperatures causing more intense heat loss in combination with weak inflow of Atlantic Water. During spring and summer the temperature anomalies were 0.3-0.6°C.

According to the observations along the Kola Section in 2010, at the beginning of the year, positive temperature anomalies in the Atlantic water were 0.7-1.2°C. It was typical of anomalously warm years and higher than in the previous year (Figure 1.4). In spring and summer, some increase in temperature anomalies was observed in the Murman Current and in the Central branch of the North Cape Current. From April to June, the most significant increase in temperature anomalies (by 0.5-0.8°C) was observed in the northern part of the section, in the Central branch of the North Cape Current. In the Coastal waters, the opposite situation – decrease in temperature anomalies – was observed in all layers. At the end of the year of 2010, temperature anomalies in the main warm currents decreased due to stronger-than-usual both seasonal cooling and easterly winds. By December, temperatures in the Coastal waters were close to normal and lower than in 2009 by more than 1°C. Temperature anomalies in the Murman Current were 0.5°C, which was 0.8°C lower than in 2009 and typical of warm years (Figure 1.4).

On the whole, the 2010 annual mean temperature in the 0-200 m layer of the Kola Section was typical of anomalously warm years and close to that of 2009.

The temperatures in the Barents Sea in the beginning of 2011 continued to decrease towards the long term mean.

Salinity

The 2010 annual mean salinity in the 0-200 m layer of the Kola section, as well as in the Fugløya-Bear Island and Vardø-North sections, was higher than normal and than in 2009 (Figures 1.3-1.4). The salinity variations usually show a close resemblance to temperature, but this relation broke down in 2008-2010 and the salinity has been high despite decreasing temperatures (Figures 1.3-1.4).

Inflow of Atlantic water

The temperature and the volume flux of the inflowing Atlantic Water in the Fugløya-Bear Island Section do not always vary in phase. The temperature is mainly determined by variations upstream in the Norwegian Sea, while the volume flux to a large degree varies with the wind conditions in the western Barents Sea. There is no significant trend in the observed volume flux from 1997 to summer 2010. The inflow in 2010 was much like in 2007-2009 (Figure 1.6); moderate during winter followed by a strong decrease in spring. In late spring/early summer 2010 the flux was below the average, thereafter increasing toward the average. The current rigs are retrieved once a year at the end of summer, and therefore no data are available for the fall 2010.

Ice conditions

At the end of 2009 and beginning of 2010, meteorological conditions over the Barents Sea resulted in increasing the sea ice coverage. From February to April, the ice coverage (expressed as a percentage of the sea area) was less-than-normal (1951-2000), but 2-13% more than in 2009 (Figure 1.7). In January and May, it was similar to 2009. Ice melting started in June and was more intensive than in the previous year. By the end of June, the south-eastern Barents Sea was ice-free, this occurred two weeks earlier than in 2009. From June to August, the ice coverage was 5-22% less than in the previous year. Ice formation started in the northernmost sea in October. In September and October, the ice coverage was 2 and 3% respectively, that was 6-11% less-than-normal and similar to 2009. In November, the ice formation was more intensive, and, as a result, by the end of November, the ice coverage of the Barents Sea was near normal and 9% more than in 2009.

Hydrochemical conditions

In 2010, oxygen saturation of the bottom layer in the southern Barents Sea decreased compared to the previous years. The largest negative anomalies prevailed in the first half of the year of 2010. The oxygen saturation anomaly in the bottom layer was –0.85 % during the first ten months of 2010, while during the same period in 2009 the anomaly was –0.24 %.

1.2.2 Phytoplankton

In the southwestern Barents Sea (the Kola Section) in May-June 2010 were registered 44 species of microalgae from 4 taxons, *Bacillariophyta, Dynophyta, Prasinophyta* and *Haptophyta.* Phytocomplex primarily consisted of the two main components, diatom algae and *Phaeocystis pouchetii.* There were no arctic species observed on the Kola Section to 72°N. The maximums biomasses of diatoms were noticed over the pycnocline, the minimums – in the bottom layer. The daily total primary production in the surface layer of the Kola Section in May-June 2010 was 5.2 mg O_2/m^3 per day. Phytoplankton community development in May-June 2010, as a whole, corresponded to the annual succession in phytoplankton.

1.2.3 Zooplankton

The data obtained during the joint Russian-Norwegian ecosystem survey in the second half of August-early September 2009-2010 showed that the highest biomasses of zooplankton were formed in the northeastern Barents Sea (Figure 1.8). In the northeastern Barents Sea, the most abundant copepod species were the Arctic *C. glacialis*, *Pseudocalanus minutus*, *M. longa*, as well as the North Atlantic *C. finmarchicus.*

The mesoplankton biomass measured in August–September 2010 (Figure 1.9) was around average levels, which is a small increase from 2009.

The macroplankton survey conducted in autumn and winter 2010 showed that in the west and northwest areas of the Barents Sea the abundance and biomass of krill (euphausiids) in 2010 were higher than in 2009 and higher than the long-term means. Arctoboreal *Thysanoessa inermis* has been a dominant species. In the recent years, the area and abundance of *Th. raschii* are reduced, because of the water temperature increase in the Barents Sea. The average krill abundance in 2010 suggests that the condition for its local production is favourable for 2011. The total production will also depend on the magnitude of zooplankton advection from the Norwegian Sea. The macroplankton feeding conditions for planktivorous fish in 2011 is expected to be favourable.

The abundance of gelatinous zooplankton, measured in August–September 2010, show a much lower abundance of gelatinous zooplankton than in the previous two years.

1.2.4 Northern shrimp

According to the Russian-Norwegian ecosystem survey in August – September 2010 the largest catches of the northern shrimp were recorded in the eastern and northern Barents Sea and north of Spitsbergen. The investigations of 2010 showed that the total stock of the northern shrimp increased compared to last year, a conclusion that was confirmed by the assessment done by the NAFO/ICES *Pandalus* Working Group (NIPAG, ICES CM 2010/ACOM:14).

1.2.5 Fish

The current and expected situation of the commercial stocks in the Barents Sea addressed by the AFWG is given in later chapters. Therefore focus in this subchapter is on other main species that interacts with the AFWG stocks, and on the role of the AFWG species in an ecosystem perspective (e.g. as predators). Special attention is given when there are deviations from the general situation. An overview of the development of pelagic and demersal stocks is given in Figures 1.9 and 1.10.

NEA cod consumption

The food consumption of cod in 1984-2010, based on data from the Joint Russian-Norwegian stomach content data base, is presented in Table 1.3-1.4. The main prey items in 2010 were capelin, krill (Euphausiids), polar cod, shrimp, amphipods, haddock and cod. In comparison with 2009 the importance of capelin, krill, redfish and cod has increased while the importance of herring, polar cod and haddock has decreased. The consumption calculations made by IMR show that the total consumption by age 1 and older cod in 2010 was about 6.9 million tonnes (Table 1.3), while similar calculations by PINRO gave 6.1 million tons (Table 1.4). According to calculations by

IMR and PINRO the consumption per cod was about the same in 2010 as in 2009 (Tables 1.5-1.6).

Blue whiting and polar cod

In the western part of the Barents Sea blue whiting were observed during the ecosystem survey as in previous years. Total biomass of blue whiting in the Barents Sea was estimated to 183,000 t. Since 2004-2005, when more than one million tonnes of blue whiting was found in this area, there has been a steady decrease in biomass and the age distribution has been shifted towards older fish. The main bulk of this stock component in 2010 consisted of 2001-2005 year-classes at age 5-9. Only one specimen of 0-group of blue whiting was registered during the international survey of 0-group fish in the Barents Sea in 2010.

According to the ecosystem survey the distribution of polar cod in the Barents Sea in 2010 was continuous, and not split into an eastern and a western component. Polar cod was distributed from the western and southern coast of Novaja Zemlja to Spitsbergen. A dense concentration was observed close to the western coast of Novaja Zemlya, while scattered concentrations occurred around Spitsbergen and in the northern parts of the Barents Sea. The 2010 year class of polar cod (summing the two components) seems to be poor. The total stock, estimated at 1.4 million tonnes, is 1.6 times higher to that found in 2009, due to good recruitment, high individual growth and good survival. The present estimate indicates that the polar cod stock is in good condition now.

Herring and capelin

In 2010 no herring was found in the eastern Barents Sea. In the western part herring in age groups 1-11 was registered. This is the first year since 2002 that no young Norwegian spring spawning herring has been distributed in the eastern Barents Sea.

Since 2004 no strong year classes has been observed in the Barents Sea. In 2010 the occupation area of herring in the Barents Sea was much smaller than in previous years. 0-group herring were distributed in the central part of the sea. The 2010 year-class of herring is lower than the average level, and can be characterized as poor. The total herring biomass in the Barents Sea was estimated to be 150,000 t in 2010, which is less than one third of what was found in 2009.

The capelin stock size is at a level somewhat above average (Figure 1.9, Table 1.7). Based on the most recent estimates of SSB and recruitment ICES classifies the stock as having full reproductive capacity. In August-September 2010 the 0-group capelin was distributed over a wide area - from the Norwegian and Russian coast until 77˚N and between 15 -57˚E and the boundary of capelin distribution was found in all directions. Highest densities of 0-group capelin were observed in the central and south-eastern part of the Barents Sea, between 25-35˚E˚ and 42-48 ˚E. The 2010 year class is weaker than 4 previous year classes (2006-2009), although it is higher than long term average and can be characterized as relatively strong.

The total distribution area of capelin at age 1+ in the Barents Sea in August-September 2010 was wider than in 2009. The total stock is estimated during ecosystem survey at about 3.5 million tonnes. It is about 7% lower than the stock estimated last year but higher than the long term mean level. About 59 % (2.1 million tonnes) of this stock was above 14 cm and considered to be maturing.

Skates

In 2010 thorny skate was quite widely distributed in the Barents Sea, except for the southeastern and northeastern regions. Most large catches were in the central area, around Bear Island and to the west of Spitsbergen and on shallow sites in the southeast corner of the Barents Sea. The thorny skate preferred to stay in depths from 50 m to 150 m.

Northern skate was distributed in the northeast part of the Barents Sea and along the shelf slope to the west of Spitsbergen. The main catches were from depth ranges between 200 m and 300 m.

1.2.6 Marine mammals

Harp Seal

Harp seal pup production estimates are based on data collected during the traditional Russian multispectral aerial survey. Since 2004 the abundance of harp seal pup production in the White Sea has been sharply reduced, according to these surveys. However the decrease in the harp seal pup production abundance has become slower recently and even some slight increase has been observed. In 2010 the total estimate (163 ±32 thousands) is slightly higher than in 2009 and higher than in 2005 and 2008, but still less than observed in 2004 and in 2000-2003. One of the key factors, which caused the reduction in the harp seal pup abundance in 2004-2009, was the diminished ice extent due to warming. The changed ice conditions were responsible for the redistribution of animals in the pup period. Abnormal ice conditions in the White Sea possibly also led to higher natural mortality of pups.

The decrease in the abundance of harp seal pup production leads to a reduction of the whole harp seal population (the model estimate for 2010 – 1.3 million animals).

Predation by mammals

Analyses of consumptions by marine mammals in the Barents Sea for 2009-2010 are not available. Last estimates are shown in Table 1.9.

1.2.7 Future long-term trends

This section is a short version of Stiansen *et al.* (2009).

Air temperatures have increased almost twice as fast in the Arctic than the global average over the last 50 years. With an accelerated increase in air temperatures it is predicted that summer sea ice will disappear. Polar Front that separates the cold Arctic and warm Atlantic waters will move farther north and east. Although long-term climate projections are associated with considerable uncertainty, it is highly likely, however, that any significant warming will cause shifts in species ranges and changes in their production. The expected northward extension of warm Atlantic water will lead in general to temperate zooplankton being shifted northward while ice fauna, such as the large amphipods would diminish due to a massive loss of habitat because of the disappearance of multi-year ice (Skjoldal *et al.*, 1987; Loeng *et al.*, 2005). Ellingsen *et al.* (2008) also predicted that the Atlantic zooplankton production, primarily *Calanus finmarchicus*, would increase by about 20% and spread farther eastward while the Arctic zooplankton biomass would decrease significantly (by 50%) resulting in an overall decrease in zooplankton production in the Barents Sea.

A number of fish species, e.g. cod and capelin, will likely have a more northern and/or eastern distribution and boreal species such as blue whiting and mackerel may become common in the Barents Sea. These changes will likely result in potentially large changes in community composition and it is possible that the structure of the ecosystem may shift irreversibly. In addition, sea ice extent will be reduced, and this will have a negative impact on ice-dependent flora and fauna, such as polar bears. Reduction in sea ice extent may also lead to increased primary productivity, if nutrient supply is not reduced significantly due to increased stratification in the water column. An increase in primary productivity coupled with other positive effects of increased temperature on fish growth and reproduction, may cause productivity of cod, haddock and other commercially important species to increase. However, negative effects on prey species may also occur. Thus, overall effects on fish productivity are hard to predict.

Higher temperatures should also lead to improved growth rates of the fish and together with increased recruitment is expected to lead to increased fish yields (Drinkwater, 2005; Stenevik and Sundby, 2007). The results of long-term simulations by the STOCOBAR model show that a temperature increase of 1-4C° in the Barents Sea will lead not only to acceleration of cod growth and maturation rates, but also to increase in cannibalism (Stiansen *et al*. 2009). Increased overall production is expected to produce increased catches of cod, haddock and other species (ACIA, 2005). Cod are expected to spawn farther north and new spawning sites will likely be established (Sundby and Nakken, 2008; Drinkwater 2005).

Along with climate change it should also be mentioned that anthropogenic emissions of CO_2 are causing acidification of the world oceans because CO_2 reacts with seawater to form carbonic acid. Currently, acidity has increased by about 30% (reduction in pH by about 0.1 units). In 2100, pH reductions in the order of 0.2-0.3 units are predicted. This will significantly reduce the ability of organisms to build calcium carbonate shells and skeletons and it might also have other effects on organisms. The direct effects are expected to be most pronounced for phytoplankton, zooplankton and benthos. Fish, seabirds and marine mammals can be affected indirectly, possibly making ocean acidification one of the most important anthropogenic drivers in the Barents Sea in the future.

1.3 Description of the Barents Sea fisheries and its effect on the ecosystem (Tables 1.10-1.11, Figures 1.12-1.18)

Fishing is the largest human impact to the fish stocks in the Barents Sea, and thereby the functioning of the whole ecosystem. However, the observed variation in both fish species and ecosystem is also impacted by other effects such as climate and interaction between species. Open ocean fisheries in the Barents Sea started in the beginning of the 20th century with the development of trawling technology. At present there is a multinational fishery operating in the Barents Sea using different fishing gears and targeting several species. The largest commercially exploited fish stocks (capelin, Northeast Arctic cod, haddock and saithe) are now harvested within sustainable limits and have full reproductive capacity. However, some of the smaller stocks (golden redfish, beaked redfish and coastal cod) are overfished, and damage to benthic organisms and habitats from trawling has been documented. Work is currently going on to estimate any unavoidable by-catch of marine mammals and sea birds in the Arctic fisheries, and this will later be reported to the AFWG. Overcoming these problems and further developing our understanding of the effects of fisheries in an ecosystem context are important challenges for management.

1.3.1 General description of the fisheries

The major demersal stocks in the Northeast Arctic include cod, haddock, saithe, and shrimp. In addition, redfish, Greenland halibut, wolffish, and flatfishes (e.g. long rough dab, plaice) are common on the shelf and at the continental slope, and ling and tusk at the slope and in deeper waters. In 2010, catches of about 1110 thousand tonnes are reported from the stocks of cod, haddock, saithe, redfish, and Greenland halibut, which is an increase of 23% as compared to 2009. An additional catch of about 15 000 tonnes and 22 000 tonnes were taken from the stocks of wolffish and shrimp, respectively. The annual fishing mortalities F (the mortality rate is linked to the proportion of the population being fished by $1\text{-}e^{-F}$) for the assessed demersal fish stocks show large temporal variation within species and large differences across species from 0.1 (≈10% mortality) for some years for *Sebastes marinus* to above 1 (≈63% mortality) for some years for cod (Figure 1.12a). The current harvest rate relative to the maximum levels above which the fishing mortality over time may impair the recruitment is shown in Figure 1.12b. Of the analytically assessed demersal stocks in the Barents Sea it is currently only golden redfish (*Sebastes marinus*) which is harvested above this critical level.

The major pelagic stocks are capelin, herring, and polar cod. There was no fishery for capelin in the area in 2004-2008 due to the stock's poor condition, but in 2009-2011 the stock was again sufficiently sound to support a quota between 350 000 and 400 000 tonnes.

Russia, as the only nation currently fishing polar cod, fished 27 400 tonnes polar cod in 2010. Norwegian spring spawning herring is the largest stock inhabiting the Northeast Arctic with its spawning stock estimated to 8.0 million tonnes in 2011. About 1.5 million tonnes were fished from this stock in 2010, of which about 280 000 tonnes were caught near the Norwegian coast in the south-western part of the Barents Sea. The highly migratory species blue whiting and mackerel extend their feeding migrations into this region, and in 2009 about 160 000 tonnes mackerel and 46 000 tonnes blue whiting were caught in the area, none of this, however, within the Barents Sea. Species with relatively small landings include salmon, Atlantic halibut, hake, pollack, whiting, Norway pout, anglerfish, lumpsucker, argentines, grenadiers, flatfishes, dogfishes, skates, crustaceans, and molluscs.

The most widespread gear used in the central Barents Sea is bottom trawl, but also long line and gillnets are used in the demersal fisheries. The pelagic fisheries use purse seine and pelagic trawl. Other gears more common along the coast include handline and Danish seine. Less frequently used gears are float line (used in a small but directed fishery for haddock along the coast of Finnmark, Norway) and various pots and traps for fish and crabs. The gears used vary with time, area and country, with Norway having the largest variety because of the coastal fishery. For Russia, the most common gear is bottom trawl, but a longline fishery mainly directed at cod and wolffish is also present. The other countries mainly use bottom trawl.

For most of the exploited stocks an agreed quota is decided (TAC), and also a number of additional regulations are applied. The regulations differ among gears and species and may be different from country to country, and a non-exhaustive list as well as a description of the major fisheries in the Barents Sea by species can be found in Table 1.10.

From 2011 onwards, the minimum mesh size for bottom trawl fisheries for cod and haddock is 130 mm for the entire Barents Sea (previously the minimum mesh size was 135 mm in the Norwegian EEZ and 125 mm in the Russian EEZ). It is still mandatory to use sorting grids. In an area in the Economic Zone of Norway delimited in the south by 62°N and in the north by straight lines drawn in the southwestern Barents Sea (see www.fiskeridir.no) the minimum distance between the bars of the sorting grids shall be 50 mm. North and east of these lines the minimum distance between the bars of the sorting grids shall be 55 mm. The change in mesh size of the cod-end is hence not expected to have a significant impact on the total exploitation pattern for these stocks, thus a recent average exploitation pattern is used in the predictions.

A change/harmonization from 2011 onwards of the minimum legal catch size for cod from 47 cm (Norway) and 42 cm (Russia) to 44 cm for all, and for haddock from 44 cm (Norway) and 39 cm (Russia) to 40 cm for all may lead to more fishing in areas that previously would be closed, and hence more discards when the availability of larger fish are good. The effect of these regulatory changes should therefore be carefully monitored.

1.3.2 Mixed fisheries

The demersal fisheries are highly mixed, usually with a clear target species dominating, and with low linkage to the pelagic fisheries (Table 1.11). Although the degree of mixing may be high, the effect of the fisheries varies among the species. More specifically, the coastal cod stock and the two redfish stocks are presently at very low levels. Therefore, the effect of the mixed fishery will be largest for these stocks. In order to rebuild these stocks, further restrictions in the regulations should be considered (e.g. closures, moratorium, and restrictions in gears).

Successful management of an ecosystem includes being able to predict the effect of a mixed fishery on the individual stocks, and ICES is requested to provide advice which is consistent across stocks for mixed fisheries. Work on incorporating mixed fishery effects in ICES advice is ongoing and various approaches have been evaluated (ICES 2006/ACFM:14). At present such approaches are largely missing due to a need for improving methodology combined with lack of necessary data. However, technical interactions between the fisheries can be explored by the correlation in fishing mortalities among species (Figure 1.13). The correlation in fishing mortality is positive for Northeast Arctic cod and coastal cod, and for haddock and coastal cod confirming the linkage in these fisheries. There is also a significant relationship between saithe and Greenland halibut although the linkage in these fisheries is believed to be low (Table 1.11). The relationships between the other fishing mortalities are scattered and inconclusive. In case of strong dependencies in fishing mortalities this method can, in principle, be used to produce consistent advice across species concerning fishing mortality. It is however too simple since this correlation is influenced by too many confounding factors whose effect cannot be removed without a detailed analysis of data with a higher resolution (e.g. saithe and Greenland halibut, and changes in stock distribution (ICES 2006/ACFM:14).

A further quantification of the degree of mixing and impact on individual stocks requires detailed information about the target species and mix per catch/landing and gear. Such data exist for some fleets (e.g. the trawler fleet), but is incomplete for other fleets. The Russian and Norwegian trawl fleet catches show spatial and temporal differences in both composition and size as well as large differences between countries (Figures 1.14-1.17). In the north eastern part of the Barents Sea the major part of the Russian catches consists of cod, whereas the Norwegian catches include a large proportion of other species (mainly shrimp). In the most western part of the Barents Sea, the Norwegian catches consist of *Sebastes mentella* and Greenland halibut in addition to cod, whereas the Russian catches mainly consist of cod and haddock. The main reason for this disparity is the difference in spatial resolution of the data; the Norwegian strata system extends further west and thus covers the fishing grounds of Greenland halibut, whereas the Russian strata does not. The Norwegian trawl fishery along the Norwegian coast includes areas closer to the coast and is also more southerly distributed where other species are more dominant in the catches (e.g. saithe).

Estimates of unreported catches of cod and haddock in 2002-2008 indicate that this has been a considerable problem which now seems to be decreasing. According to the report from the Norwegian-Russian analytical group the total catches of both cod and haddock reported to AFWG are very close (within 1%) to the estimates made by this group. Thus it was decided to set the IUU catches for 2009 and 2010 to zero (see chapter 0.4). A continuous control and surveillance of this problem is necessary. Discarding of cod and haddock (and in some years also saithe) is thought to be significant in periods, although discarding of these, and a number of other species, is illegal in Norway and Russia. Data on discards are scarce, but attempts to obtain better quantification are ongoing.

1.3.3 Fleet composition

Figure 1.18 shows the main fleets catching bottom and pelagic fishes in the Barents Sea and Svalbard (Spitsbergen archipelago) areas. The pelagic fishery is only conducted by Russia and Norway where both countries target the capelin. Russia has, in addition, fished polar cod with pelagic trawl (Norway has not fished this species since the early 1980s), and Norway has in recent years fished some legal sized herring in a restricted coastal purse seine fishery inside 4 nautical miles off Finnmark. Further in the south western part of the Barents Sea (south-west of a line between Sørøya and Bear Island), extending into the Norwegian Sea, an international herring fishery has been open in some seasons.

The Norwegian groundfish fishery is much more diverse compared to Russia and other countries regarding the number of fleets. The trawler fleet itself is also rather diverse both within and between countries. In the Norwegian groundfish fishery several other gears are also used in addition to trawl. The gear composition also depends on which groundfish species the fishery targets. The Norwegian bottom trawl fleet catch about 30% of the Norwegian cod catch, about 40% of the haddock, and more than 40% of the Norwegian saithe and Greenland halibut catches. The Russian bottom trawl fleet catch about 100% of the Russian saithe catch, about 95% of cod and haddock, 90% of the Russian Greenland halibut catch and about 37% of wolffishes. Other countries fishing groundfish in these waters only use trawl, incl. some pair-trawling. It is mandatory in all groundfish trawl fisheries to use sorting grid to avoid catching undersized fish. The one and only exception from this rule is within an area in the southwestern part of the Barents Sea during 1 January – 30 April where trawling without sorting grids is permitted to catch haddock.

1.3.4 Impact of fisheries on the ecosystem

In order to conclude on the total impact of trawling, an extensive mapping of fishing effort and bottom habitat would be necessary. In general, the response of benthic organisms to disturbance differs with substrate, depth, gear, and type of organism (Collie *et al*. 2000). Seabed characteristics from the Barents Sea are only scarcely known (Klages *et al*. 2004) and the lack of high-resolution (±100 m) maps of benthic habitats and biota is currently the most serious impediment to effective protection of vulnerable habitats from fishing activities (Hall 1999). An assessment of fishing intensity on fine spatial scales is critically important in evaluating the overall impact of fishing gear on different habitats and may be achieved, for example, by satellite tracking of fishing vessels (Jennings *et al*. 2000). The challenge for management is to determine levels of fishing that are sustainable and not degradable for benthic habitats in the long run.

Fisheries in the Barents Sea do not only influence the targeted stocks. Due to strong species interactions fisheries removal of one stock may influence the abundance of other stocks. For example, herring collapses have positively influenced capelin abundance. Reduced stock sizes due to fisheries removal may also lead to changing migration patterns. Due to density dependent migrations, fish stocks cover greater areas and migrate longer distances when abundances are high compared to low. Fisheries also reduce the average fish size, age and age at maturity. The reduced size and age of the cod stock may actually have altered the ecological role of cod as top predators in the Barents Sea.

The qualitative effects of trawling have been studied to some degree. The most serious effects of otter trawling have been demonstrated for hard-bottom habitats dominated by large sessile fauna, where erected organisms such as sponges, anthozoans and corals have been shown to decrease considerably in abundance in the pass of the ground gear. Barents Sea hard bottom substrata, with associated attached large epifauna should therefore be identified.

Effects on soft bottom have been less studied, and consequently there are large uncertainties associated with what any effects of fisheries on these habitats might be. Studies on impacts of shrimp trawling on clay-silt bottoms have not demonstrated clear and consistent effects, but potential changes may be masked by the more pronounced temporal variability in these habitats (Løkkeborg 2005). The impacts of experimental trawling have been studied on a high seas fishing ground in the Barents Sea (Kutti *et al*. 2005) Trawling seems to affect the benthic assemblage mainly through resuspension of surface sediment and through relocation of shallow burrowing infaunal species to the surface of the seafloor.

Work is currently going on in the Arctic, jointly between Norway and Russia, exploring the possibility of using pelagic trawls when targeting demersal fish. The purpose is to avoid impact on bottom fauna and to reduce the mixture of other species. It will be mandatory to use sorting grids to avoid catches of undersized fish.

Lost gears such as gillnets may continue to fish for a long time (ghost fishing). The catch efficiency of lost gillnets has been examined for some species and areas (*e.g.* Humborstad *et al*. 2003; Misund *et al*. 2006; Large *et al*. 2009), but at present no estimate of the total effect is available. Ghost fishing in depths shallower than 200 m is usually not a significant problem because lost, discarded, and abandoned nets have a limited fishing life owing to their high rate of biofouling and, in some areas, their tangling by tidal scouring. Investigations made by the Norwegian Institute of Marine Research of Bergen in 1999 and 2000 showed that the amount of gillnets lost increases with depth and out of all the Norwegian gillnet fisheries, the Greenland halibut fishery is the metier where most nets are lost. The effect of ghost fishing in deeper water, e.g. for Greenland halibut, may be greater since such nets may continue to "fish" for periods of at least 2–3 years, and perhaps even longer (D. M. Furevik and J. E. Fosseidengen, unpublished data), largely as a result of lesser rates of biofouling and tidal scouring in deep water. The Norwegian Directorate of Fisheries also conducts organized retrieval surveys. All together, 14 150 gillnets of 30 meters standard length (approximately 425 km) have been removed from Norwegian fishing grounds during the period from 1983 to 2010. Several kilometres of lost longline have also been retrieved and the retrieval surveys are considered important (Anon. 2011c: www.fiskeridir.no).

Other types of fishery-induced mortality include burst net, and mortality caused by contact with active fishing gear, such as escape mortality (Suuronen 2005; Broadhurst *et al*. 2006; Ingólfsson *et al*. 2007). Some small-scale effects are demonstrated, but the population effect is not known.

The harbour porpoise is common in the Barents Sea region south of the polar front and is most abundant in coastal waters. The harbour porpoise is subject to by-catches in gillnet fisheries (Bjørge and Kovacs 2005). In 2004 Norway initiated a monitoring program on by-catches of marine mammals in fisheries.

Fisheries impact seabird populations in two different ways: 1) Directly through by-catch of seabirds in fishing equipment and 2) Indirectly through competition with fisheries for the same food sources.

Documentation of the scale of by-catch of seabirds in the Barents Sea is fragmentary. Special incidents like the by-catch of large numbers of guillemots during spring cod fisheries in Norwegian areas have been documented (Strann *et al*. 1991). Gillnet fishing affects primarily coastal and pelagic diving seabirds, while the surface-feeding species will be most affected by long-line fishing (Furness 2003). The population impact of direct mortality through by-catch will vary with the time of year, the status of the affected population, and the sex and age structure of the birds killed. Even a numerically low by-catch may be a threat to red-listed species such as Common guillemot, White-billed diver and Steller's eider.

Several bird scaring devices has been tested for long-lining, and a simple one, the bird-scaring line (Løkkeborg 2003), not only reduces significantly bird by-catch, but also increases fish catch, as bait loss is reduced. This way there is an economic incentive for the fishermen to use it, and where bird by-catch is a problem, the bird-scaring line is used without any forced regulation.

In 2009, the Norwegian Institute for Nature Research (NINA) and the Institute of Marine Research in Norway started a cooperation to develop methods for estimation of bird by-catch. Preliminary reports from observers at sea trained by the institutes show that most of the fisheries have a minor impact on bird mortality.

1.4 Ecosystem based management issues and potential assessment improvements (Tables 1.12–1.15)

Management of fisheries is always based on decision-making under levels of uncertainty. Incorporating data on physical environmental, primary and secondary production, as well as species interactions on higher trophic levels in management advice should reduce the uncertainty of scientific recommendations for sustainable harvest levels. To achieve this it is not enough of availability of ecosystem information only. Development of appropriate methods and tools for incorporation of this information into stock assessment and harvest control rules is needed.

1.4.1 Multispecies and ecosystem models

Development of multispecies models designed to improve fisheries management in the Barents Sea started in the mid-1980s. The first models developed were MULTSPEC, AGGMULT, SYSTMOD and MSVPA (Tjelmeland and Bogstad, 1998; Hamre and Hatlebakk, 1998, Korzhev and Dolgov, 1999). These models serve as predecessors to newly developed models, such as Bifrost, Gadget and STOCOBAR that are presently used. Benefits of multispecies models include: improved estimates of natural mortality and recruitment; better understanding of stock-recruit relationships as well as variability in growth and maturation rates; testing of alternative harvesting strategies.

Ecosystem models may be useful for looking at how change in one ecosystem component is affecting the whole or parts of an ecosystem, thereby identifying the most important inter-species/ functional group links and sensitivity of the ecosystem to changes. They are also useful for scenario testing (change in fishery pressure, climate change, and sudden pollution events). The ECOPATH/ECOSIM is the most used ecosystem model. Versions of it have been applied to the Barents Sea ecosystem (Blanchard *et al*. 2002, Dommasnes *et al*. 2002), but they are not run on an operational level Also, the spatial aspect is limited. Currently, a spatial end-to-end spatial ecosystem model, ATLANTIS, is being implemented at IMR for the Norwegian and Barents Sea. Another modelling tool under development with participation from IMR is the SYMBIOSES model.

Brief descriptions of the currently developing multispecies and ecosystem models are given below.

Bifrost

Bifrost (Boreal integrated fish resource optimization and simulation tool) is a multispecies model for the Barents Sea (Tjelmeland and Lindstrøm, 2005) with main emphasis on the cod-capelin dynamics. The prey items for cod are younger cod, capelin and other food. The predation model is estimated by comparing simulated consumption to that calculated from individual stomach content data using the dos Santos evacuation rate model with a parameterization where the initial meal size is excluded. The capelin availability partly shields the cod juveniles from cannibalism, and by including this effect, the recruitment relation for cod is significantly improved.

In prognostic mode, Bifrost is coupled to the assessment model for herring – SeaStar (Tjelmeland and Lindstrøm, 2005) – and the negative effect of herring juveniles on capelin recruitment is modeled through the recruitment function for capelin. Bifrost is also used to evaluate cod-capelin-herring multispecies harvest control rules.

STOCOBAR

STOCOBAR (Stock of cod in the Barents Sea ecosystem) is a multispecies model, first developed at PINRO in 2001, which describes stock dynamics of cod in the Barents Sea, taking into account trophic interactions and environmental influence (Filin, 2007). The STOCOBAR is an age-structured, a single-area and a single-fleet model with one year time steps. It includes a cod as predator on up to eight prey items: capelin, shrimp, polar cod, herring, krill, haddock, own young and other food. Species structure of the model is not permanent and it can be reduced from seven-species version to a simple version, which includes cod and capelin only. Recruitment function is used for cod only. Impact assessment of ecosystem factors on cod stock dynamics are based on «what if» scenarios. STOCOBAR is able to take uncertainties in future scenarios of temperature and capelin stock dynamics, in abundance and individual weight of cod at age 1 and in its fishing mortality rate into account. The work on the development of the STOCOBAR model was part of the Barents Sea Case Study within the EU project UNCOVER (2006-2010) and the joint PINRO-IMR project (2004-2013) Optimal long-term harvest in the Barents Sea.

GADGET

A multi-species Gadget age-length structured model (www.hafro.is/gadget ; Begley and Howell, 2004, developed during the EU project dst[2] (2000-2003)), is being used for modeling the interactions between cod, herring, capelin and minke whale in the Barents Sea as part of the EU projects BECAUSE, UNCOVER, DEFINEIT and FACTS. This is a multi-area, multi-species model, focusing on predation interactions within the Barents Sea. The predator species are minke whale, cod and herring, with capelin, immature cod, and juvenile herring as prey species. Krill is included as an exogenous food for minke whales (Lindstrøm *et al*. 2009). The cod model employed is based on the model presented at AFWG each year.

The modeling approach taken has many similarities to the MULTSPEC approach (Bogstad *et al*., 1997). Work is ongoing to enhance the modeling of recruitment processes during the EU projects FACTS and DEFINEIT. An FLR routine has been written that can run Gadget models as FLR Operating Models. This also gives the possibility of using Gadget as an operating model to test the performance of various assessment programs under a range of scenarios (Howell and Bogstad, 2010). In addition the Gadget multi-species model is being developed to assess the likely impact on medium-term population dynamics of oil-spill induced larval mortalities.

ATLANTIS

Atlantis (Fulton *et al*., 2004a) is an ecosystem 3D box-model intended for use in management strategy evaluation (as described in de la Mare 1996, Cochrane *et al*. 1998, Butterworth and Punt 1999, Sainsbury *et al*. 2000). The overall structure of Atlantis is based around having multiple alternative submodels to represent each step in the management strategy and adaptive management cycles. It has been applied to multiple marine systems (from single bays to millions of square kilometres) in Australia and the United States. In autumn 2010 IMR started to implement this model for the Barents Sea and the Norwegian Sea, and it is expected to be operational at the end of 2011.

SYMBIOSES

A new modelling tool, SYMBIOSES, is being developed combining oceanography, ecotoxicology, plankton, larvae and adult fish population models (De Leander *et al*. 2011) involving IMR, SINTEF, Akvaplan-Niva, STATOIL, IMARES and the universities of Nijmegen and Ghent, and others. The combined tool will focus on the impacts on egg- and larval-mortalities of a potential oil spill near the main fish spawning grounds. The model will include cod, capelin and herring, with initial focus on cod mortalities. By focusing on larval mortalities as the only link between the fish and lower levels of the ecosystem, it is hoped that the model will be able to avoid some of uncertainty issues surrounding "whole ecosystem models" and become an operational tool in risk management in the oil industry. By using pre-existing sub-models work can progress rapidly, and the sub-models can be updated in line with state of the art work in each area. The tool will also provide a platform in which different stressors can be compared in a common framework. The physical oceanography uses the ROMS model, the ecotoxicology section is a development of the OMEGA/DEBtox (De Leander *et al*. 2008), the chemical fate model is MEMW, phyto- and zoo-plankton are modelled with SINMOD (Slagstad *et al*. 2008, Wassmann *et al*. 2009), the fish larvae and eggs use LARMOD (Vikebø *et al*. 2007), and the fish part of the model is the multi-species Gadget model described above (Howell and Bogstad 2010). The current timetable calls for a first working version to be finished by the end of 2013, with tuning and refinements thereafter.

1.4.2 Operational use of ecosystem information in stock state assessments and prognosis

Recruitment

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

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

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

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

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

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

Temp is the Kola yearly temperature (0-200m), Age1 is the winter survey bottom trawl index for cod age 1, and MatBio the maturing biomass of capelin. The number in parenthesis is the time lag in years. Two other similar models (JES2, JES3) can be made by substituting the term Age1(-2) with Age2(-1) and Age3(0), respectively (winter survey bottom trawl index for cod age 2 and age 3, respectively), This gives 1 and 0 year predictions, respectively. Using winter survey estimates the same year as the AFWG assessment and with a prediction for the capelin maturing biomass it is possible to extend the prognoses Svendsen *et al*. (2007) used a model (SV) based only data from the ROMS numerical hydro-dynamical model, with 3 year prognosis possibility:

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

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

The recruitment model (TB) suggested by T. Bulgakova (AFWG 2005 WD14, WD9) is a modification of Ricker's model for stock-recruitment defined by:

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

Where R3 is the number of age3 recruits for NEA cod, m is an index of population fecundity, SSB is the spawning stock biomass and N is equal to the numbers of months with positive temperature anomalies (TA) on the Kola Section in the birth year for the year class. The number in parenthesis is the time lag in years. For the years before 1998 TA was calculated relatively to monthly average for the period 1951-2000. For intervals after 1998, the TA was calculated with relatively linear trend in the temperature for the period 1998-present. The model was run using two time intervals (using cod year classes 1984-2000 and year classes 1984-2004) for estimating the model coefficients. The models have not been updated since 2009.

Titov (Titov, AFWG 2010, WD 22) and Titov *et al*. (AFWG 2005, WD 16) developed models with 1 to 4 year prediction possibility (TITOV1, TITOV2, TITOV3, TITOV4, respectively), based on the oxygen saturation at bottom layers of the Kola section stations 3-7 (OxSat), air temperature at the Murmansk station (Ta), water temperature: 3-7 stations of the Kola section (layer 0-200m) (Tw), ice coverage in the Barents Sea (I), spawning stock biomass (SSB), and the acoustic abundance of cod at age 1 and 2, derived from the joint winter Barents Sea acoustic survey. At the 2010 AFWG assessment it was suggested (Dingsør *et al* 2010, WD 19, and related discussions in the working group) to try to simplify these models. This has been conducted and has improved the statistical performance (details are shown in Titov, WD 23):

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

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

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

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

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

Where DOxSat(t-13)~ Exp(OxSat(t-13)) − OxSat(t–38), ITa(t-39) ~ I(t-39) +Ta(t–44). The number in parenthesis is the time lag in months, relative to 1 January at age 3. The ITa index coincides in time with the increase of horizontal gradients of water temperatures in the area of the Polar Front (Titov, 2001). The changed from the 2010 assessment are:. In TITOV1 the ITa_{t-39} term was taken out of the model, in TITOV 2 the $DOxSat_{t-13}$ term was taken out of the model, and in TITOV3 the $OxSat_{t-44}$ term was replaced by a Tw_{t-26} term.

Hjermann *et al*. (2007) developed a model with a one year prognosis, which have been modified by Dingsør *et al* (WD 19) to four models with 1-2 year projection possibility.

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

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

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

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

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

At AFWG 2008, Subbey *et al*. presented a comparative study (AFWG 2008 WD27) on the ability of some of the above models in predicting stock recruitment for NEA cod (Age 3). At the assessment in 2010 a WD by Dingsør *et al*. (AFWG, WD 19) 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's for choosing/rejecting recruitment models suitable for use in stock assessment. The "Study Group on Recruitment Forecasting"

(SGRF) has now been appointed, and their meeting is scheduled to be in October 2011.

The 2008 assessment agreed on using a combination of the best performing models according to Subbey at (AFWG 2008 WD27) for the age 3 predictions, named the "Hybrid" model. One-year-ahead prognoses was given by the hybrids (TITOV 1, TITOV 3 and JES1), two-year-ahead (TITOV 2, TITOV3 and JES1) and three-year-ahead (TITOV 3) for the number of age 3 cod. For each "hybrid" the average value of the chosen models are given as the prognoses value. Following the recommendation of the review group in 2008 this procedure was also conducted in the 2009 assessment.

At the 2010 assessment the model JES 1 was removed from the hybrid for the 2010 estimate only, due to a low age 1 index and thereby the model being out of its valid range for that prognosis year. Otherwise the hybrid model approach was similar to last year.

The 2011 assessment used the same Hybrid model as previous year, with the earlier mentioned adjustments of the terms in the Titov models. Table 1.12 show the available estimates from the models, along with last year estimates.

The regression models, with coefficients, used in the hybrid model are:

TITOV1: $R3_t = 37.44*DOxSat_{t-13}\ \text{^}2 - 95.66*DOxSat_{t-} + 0.39*CodA2_{t-11} + 284.06*Tw_{t-17} + 373.20$

$R^2 = 0.80$; n =27

TITOV2: $R3_t = 13.30*DOxSat_{t-13}\ \text{^}2 + 15.42*ITa_{t-39} + 0.13*CodA1_{t-23} + 321.84*Tw_{t-17} + 337.68$

$R^2 = 0.89$; n =27

TITOV3: $R3_t = 26.73*ITa_{t-39} + 70.90*\log(CodC0_{t-28}) + 179.11*Tw_{t-26} - 173.87$

$R^2 = 0.65$; n=26

JES1: $R3 = 2.16*10^5 Temp_{(-3)} + 6.85*10^{-5} Age1_{(-2)} + 5.43*10^4 MatBio_{(-2)} - 1.13*10^6$

R2= 0.56; n=27

Growth rate

Large interannual variations in growth rate are observed for all commercial fish species in the Barents Sea. The most important causes are temperature change, density dependence and changes in prey availability. Variation in growth rate can contribute substantially to variability in stock biomass and can have a large impact on reproductive output.

Growth of NEA cod depends on its weight at the previous age, capelin abundance, stock numbers of cod and temperature. Growth of the youngest capelin is correlated with abundance of the smallest zooplankton, whereas growth of older capelin is more closely correlated with abundance of the larger zooplankton. The developed regression equations for cod and capelin growth have low determination coefficient, but may prove useful in the future when further developed.

Maturation and condition factor

The decrease in capelin stock biomass potentially impacts the maturation dynamics of Northeast Arctic cod by delaying the onset of maturation and/or increasing the incidence of skipped spawning. The relationship between weight- and length-at age shows that for a given length, weight-at-length is positively correlated with proportion mature-at-length for the period 1985-2001 (Marshall *et al*., 2004).

Estimates of weight-at-length were multiplied by the Russian liver condition index at length (Yaragina and Marshall, 2000) to derive estimates of liver weights in grams for cod at a standard length (see Marshall *et al*. 2004 for details of the calculation). This analysis indicated that for the period 1985-2001 there is a consistently significant, positive relationship between liver weight and proportion mature.

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

Stock Reproductive potential issues

Stock Reproductive potential (SRP) variables of populations are changing in connection with environment changes and fishing. Fishing has severely depleted several commercial stocks resulted in truncated age structures and small sizes at maturity in many stocks compared to historic times. Incorporating greater biological realism into the SRP metrics that are used by stock assessment and management advice should enhance our ability to quantify the true effect of fishing on reproductive potential and reduce probability of stock to lose resilience.

Attempts to replace the traditional SSB with more appropriate measures of cod SRP started in the 1990s (Marshall *et al*. 1998). Marshall *et al*. (2006) provided an updated time series of total egg production (TEP) for Northeast Arctic cod. In that work, a length-based approach was taken to account for that fecundity is primarily dependent on length not age. The following factors were included in the calculations (using 5cm length groups): number at length, proportion females at length, proportion mature fish at length, weight at length, fecundity for given length and weight. Marshall *et al*. (2006) found that the alternative indices of reproductive potential did not substantially increase or decrease the explanatory power of the stock–recruit relationship when compared with SSB. However, the continued use of a flawed estimator of stock reproductive potential that can give a different perception of productivity of stock might not be scientifically defensible.

In general, there are different ways to improve SRP indices for different species updating (and hindcasting, expanding) time series on maturity ogives (taking into account skipped spawning issues), sex ratios and fecundity estimates (see e.g. Table 1.14 for the AFWG stocks). More complex indices of SRP will result in an improved S-R relationship or ability to predict recruitment.

Another aspect is reference points and perceptions of stock status relative to these reference points that could be affected by using different indices of RP and related issues in determining whether or not to incorporate more reproductive biology into assessments improves an advice. There are many examples of trends in reproductive biology, particularly as population size decreases under exploitation. Efforts to incorporate this information into our scientific advice are likely to be beneficial in many cases. This can take the form of SSB, Female SB, or TEP, depending on what data are available. The best S-R model for each index of RP should be determined. Similarly, if one is evaluating the status of a stock relative to reference points using different indices of RP, the reference points should be derived from the relevant index of RP, rather than using a single set of reference points that are applicable to only one index. Further work is needed also to compare different sets of reference points and respective stock status (or behaviour of a stock related to RPs).

Natural mortality

The direct application of results from the trophic investigations in the Barents Sea for management there is inclusion of predator's consumption into fish stock assessment. Predation on cod and haddock by cod has since 1995 been included in the assessment of these two species. Currently AFWG estimates of cod natural mortality caused by cannibalism based on data of the cod proportion in the cod diet is shown in Table 1.13. These data are used for estimation of cod consumed by cod and further for estimation of its natural mortality within the XSA (see section 3.4.2). Averaged natural mortality for last 3 years is used as predicted M for next 4 years (section 3.7.1).

An alternative approach for prediction of NEA cod cannibalism was proposed by Kovalev (2004), based on the linear relationship between the natural mortality of cod at ages 3-5 and the biomass of cod spawning stock with minus 3-year lag. This approach, including cannibalism for recent years, seems to give a higher natural mortality than the "standard" assessment and prediction (Tab 1.15). Because the mechanisms of cod SSB influence on the level of own young natural mortality on age 3-4 years is unclear, and because this relationship seems not to be in correspondence with observations over the last few years, the assessment group decided that this approach should not to be used for prediction before it will be further tested. Values for the years 2010 to 2013, predicted by the regression, are given in the Table 1.15.

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 C.M. 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.

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; Tjelmeland and Lindstrøm in prep.).

1.4.3 Fishery induced evolution

There is a vital need for the fisheries-science community to promote sustainable fisheries by ensuring the effective conservation, management and development of living aquatic resources. The precautionary approach was proclaimed and applied within the ICES community to address these aims. This approach takes into account uncertainties relating to the size and productivity of stocks, and ultimately should also tackle uncertainties relating to fisheries-induced evolution. The Study Group on Fisheries Induced Adaptive Change (SGFIAC) has therefore proposed to conduct evolutionary impact assessments (EvoIAs), quantifying the evolutionary effects of alternative management measures (Jørgensen *et al*. 2007; ICES 2008/RMC:01; ICES 2009/RMC:03). The work of SGFIAC is now being continued by the Working Group on Fisheries-Induced Evolution (WGEVO).

The papers published by the SGFIAC/WGEVO members and many others on putative examples of fisheries-induced evolution are mostly concerned with estimating probabilistic maturation reaction norms (PMRNs) for different commercial stocks/species; a shift in cohort-specific PMRNs is interpreted as indicative of a genetic change at the population level. It is rather difficult to test these findings directly, as the traits governing maturation are highly polygenic. The strengths and weaknesses of the PMRNs approach were discussed in detail in a Theme Section of the journal Marine Ecology Progress Series, 2007, vol. 335, 249-310.

The North-East Arctic cod stock demonstrates long-term trends in maturation, demography, and weight at length. These historical trends could be caused by genetic and/or plastic effects on maturation. Population density and environmental conditions can affect feeding success, resulting in changing maturation dynamics in North-East Arctic cod during the time period investigated (Marshall and McAdam, 2007; Kovalev and Yaragina, 2009). The causes of a discontinuity in the decreasing trend observed for length at 50% maturation probability in the beginning of the 1980s are unknown, but were most likely non-genetic, given that they occurred synchronously across age classes (Marshall and McAdam, 2007). Recent data analyses utilizing PMRNs support the role of density dependence and environmental factors in driving changes in the maturation of cod, but also highlight a long-term trend that cannot be explained by known environmental drivers (Heino, Dieckmann, and Godø, in preparation). In the absence of more plausible explanations of this trend, this finding supports the hypothesis that fishing has caused evolution of earlier maturation in North-East Arctic cod.

Maturation trends have also been analyzed for the stocks of Barents Sea capelin and North-East Arctic haddock. For capelin, the nature of the fisheries is such that no marked evolutionary responses were expected, and this prediction was confirmed through the analysis of long-term patterns in the PMRNs of this stock (Baulier *et al*. 2011). For haddock, selection on maturation was a priori expected, but contrary to this expectation, haddock does not exhibit long-term trends in its PMRNs (Devine and Heino 2011).

More research is needed to evaluate the relative importance of, and interactions among, the physiological, ecological, and genetic mechanisms underlying the observed changes in population dynamics and structure.

It takes a lot of time and efforts for the ICES community to implement the precautionary approach into a scientific/management practice. Efforts to conduct an EvoIA for North-East Arctic cod are ongoing and should be bolstered. Some more time will be needed before WGEVO can present recommendations for or against particular management measures in relation to fisheries-induced evolution.

It is thus premature for AFWG to evaluate proposals of management measures (or reference points for fisheries management) in terms of their effects on fisheries-induced evolution; instead, the dialogue with scientists involved in WGEVO should be intensified.

1.5 Monitoring of the ecosystem (Figure 1.19, Tables 1.16–1.17)

Monitoring of the Barents Sea started already in 1900 (initiated by Nicolai Knipovich), with regular measurement of temperature in the Kola section. In the last 50 years regular observations of ecosystem components in the Barents Sea have been conducted both at sections and by area covering surveys. In addition, there are conducted many long and short time special investigations, designed to study specific processes or knowledge gaps. Also, the quality of large hydro-dynamical numeric models is now at a level where they are useful for filling observation gaps in time and space for some parameters. Satellite data and hindcast global reanalysed datasets are also useful information sources.

1.5.1 Standard sections and fixed stations

Some of the longest ocean time series in the world are along standard sections (Figure 1.19) in the Barents Sea. The monitoring of basic oceanographic variables for most of the sections goes back 30-50 years, with the longest time series stretching over one century. In the last decades also zooplankton is sampled at some of these sections. An overview of length, observation frequency and present measured variables for the standard sections in the Barents Sea is given in Table 1.16.

IMR operates one fixed station, Ingøy, related to the Barents Sea. The Ingøy station is situated in the coastal current along the Norwegian coast. Temperature and salinity is monitored 1-4 times a month. The observations were obtained in two periods, 1936-1944 and 1968-present.

1.5.2 Area coverage

Area surveys are conducted throughout the year. An overview of the measured parameters/species on each main survey is given in Table 1.17. Specific considerations for the most important surveys are given in the following text.

Norwegian/Russian winter survey Acronym: BS-NoRu-Q1 (BTr)

The survey is carried out during February-early March, and covers the main cod distribution area in the Barents Sea. The coverage is in some years limited by the ice distribution. Three vessels are normally applied, two Norwegian and one Russian. The main observations are made with bottom trawl, pelagic trawl, echo sounder and CTD. Plankton studies have been done in some years. Cod and haddock are the main targets for this survey. Swept area indices are calculated for cod, haddock, Greenland halibut, *S. marinus* and *S. mentella*. Acoustic observations are made for cod, haddock, capelin, redfish, polar cod and herring. The survey started in 1981.

Lofoten survey Acronym: Lof-Aco-Q1

The current time series of survey data starts in 1985. Due to the change in echo sounder equipment in 1990 results obtained earlier are not directly comparable with later results. The survey is designed as equidistant parallel acoustic transects covering 3 strata (North, South and Vestfjorden). In most surveys previous to 1990 thetransects were not parallel, but more as parts of a zig-zag pattern across the spawning grounds aimed at mapping the distribution of cod. Trawl samples are not taken according to a proper trawl survey design. This is due to practical reasons. The spawning concentrations can be located with echosounder thus effectively reduce the number of trawl stations needed. The ability to properly sample the composition of the stock (age, sex, maturity stage etc.) is limited by the amount of fixed gear (gillnets and longlines) in the different areas.

Norwegian coastal surveys Acronym: NOcoast-Aco-Q4

In 1985-2002 a Norwegian acoustic survey specially designed for saithe was conducted annually in October-November (Nedreaas 1998). The survey covered the near coastal banks from the Varangerfjord close to the Russian border and southwards to 62° N. The whole area has been covered since 1992, and the major parts since 1988. The aim of conducting an acoustic survey targeting Northeast Arctic saithe was to support the stock assessment with fishery-independent data of the abundance of the youngest saithe. The survey mainly covered the grounds where the trawl fishery takes place, normally dominated by 3 - 5(6) year old fish. 2-year-old saithe, mainly inhabiting the fjords and more coastal areas, were also represented in the survey, although highly variable from year to year. In 1995-2002 a Norwegian acoustic survey for coastal cod was conducted along the coast and in the fjords from Varanger to Stad in September, just prior to the saithe survey described above. This survey covered coastal areas not included in the regular saithe survey. Autumn 2003 the saithe- and coastal cod surveys were combined. The survey now also covers 0-group herring in fjords north of Lofoten.

Joint Norwegian/Russian ecosystem autumn survey (Acronym: Eco-NoRu-Q3 (Aco) and Eco-NoRu-Q3 (Btr))

The survey is carried out from early August to early October, and covers the whole Barents Sea. Four or five vessels are normally applied, three Norwegian and one or two Russian. Most components of the ecosystem are covered: physical and chemical oceanography, plankton, benthos, fish (both young and adult stages), shellfish, sea mammals and birds. Many kinds of methods and gears are used, water sampling, plankton nets, pelagic and demersal trawls, grabs and sledges, acoustics, directs observations (birds and sea mammals). The survey has developed from joint surveys on 0-group, capelin and juvenile Greenland halibut, through general acoustic surveys including observations of physical oceanography and plankton, gradually developing into the ecosystem survey carried out in recent years. The predecessor of the survey dates back to 1972 and has been carried out every fall since. From 2003 these surveys were called “ecosystem surveys”.

Associated with this survey Russia also covers parts of the Northern Kara Sea during autumn.

The working group considers this to be an important survey, both for the actual assessment work (presently used in haddock assessment, potential useful for cod assessment), but also because is supplies additional ecosystem information that are necessary for evaluating external impact on and by the assessed stocks, which is also a part of the assessments “Terms of Reference”. Especially useful for the assessment and for studies on species interactions is the simultaneous information on geographical distribution of pelagic fish, demersal fish and 0-group abundance, plankton abundance etc. In addition, ecosystem information may give early warning of changes relating to the stocks, which is not captured in the present assessment models. The WG is concerned about the future of this survey, and urges the responsible institutions to ensure continuation, broadness and quality of the survey.

Russian Autumn-winter trawl-acoustic survey Acronym: RU-BTr-Q4

The survey is carried out in October-December, and cover the whole Barents Sea up to the continental slope. Two Russian vessels are usually used. The survey has developed from a young cod and haddock trawl survey, started in 1946. The current trawl-acoustic time series of survey data starts in 1984, targeting both young and adult stages of bottom fish. The surveys include observations of physical oceanography and meso- and macro-zooplankton.

Norwegian Greenland halibut survey Acronym: NO-GH-Btr-Q3

The survey is carried out in August, and cover the continental slope from 68 to 80ºN, in depths of 400–1500 m north of 70º30'N, and 400–1000 m south of this latitude. This survey was run the first time in 1994, and is now part of the Norwegian Combined survey index for Greenland halibut. This survey was not conducted in 2010, but will be continued biennially starting in 2011.

Russian young herring survey

This survey is conducted in May and takes 2-3 weeks. It is including also observations of physical oceanography and plankton. In 1991-1995 it was a joint survey, since 1996 the survey is carried out only by PINRO.

1.5.3 Other information sources

Large 3D hydrodynamic numeric models for the Barents Sea are run at both IMR and PINRO (e.g. Lien *et al*. 2006). These models have, through validation with observations, proved to be a useful tool for filling observation gaps in time and space. The hydrodynamic models have also proved useful for scenario testing, and for study of drift patterns of various planktonic organisms.

Sub-models for phytoplankton and zooplankton are now implemented in some of the hydrodynamic models. However, due to the present assumptions in these sub-models care must be taken in the interpretation of the model results.

Satellites can be for several monitoring tasks. Ocean color specter can be used to identify and estimate the amount of phytoplankton in the skin (~1 m) layer. Several climate variables can be monitored (e.g. ice cover, cloud cover, heat radiation, sea surface temperature). Marine mammals, polar bears and seabirds can be traced with attached transmitters.

Aircraft surveys also are used for monitoring several physical parameters associated with the sea surface as well as observations of mammals at the surface and estimations of harp seal pup production in the White Sea.

Several international hindcast databases (e.g.. NCEP, ERA40) are available. They use a combination of numerical models and available observations to estimate several climate variables, covering the whole world.

Along the Norwegian coast ship-of-opportunity supply weekly the surface temperature along their path.

1.5.4 Spatial data in the Barents Sea

There exist many spatial resolved data sets relevant for the AFWG in the Barents Sea.

In general most these data are available at the national institutes IMR and PINRO, but some data are also collected by other organisations (such as National fishing authorities, ICES and other national and international data centres).

The most relevant data sets are derived from spatial sampling/reporting; from the fishing fleet (catches, effort, etc) and from data from scientific surveys (temperature, salinity, fish catches by length groups and derived parameters, as well as ecosystem parameters such as whales, seabird, pollution, zooplankton). In addition, satellites data are interesting spatial data sets (sea surface temperature, phytoplankton abundance etc).

Spatial data are also generated by re-analyses, numerical models and aggregated datasets. In particular IMR have just launched an aggregated spatial database for ecosystem datasets in the Barents Sea, presently called "the FishExChange database", with an open service mapping generator (see http://www.imr.no/fishexchange/fishexchangedatabase/nb-no). Status and survey reports also show the variety of spatial datasets (e.g. Stiansen *et al*. 2009, Aglen *et al*. WD03) show examples of the wide span of spatial available data.

Next year the working group will start on a list of available spatial datasets, and where they are stored.

1.6 Main conclusions

State and expected situation in the ecosystem (section 1.2), except the stocks assessed by the working group (capelin is still mentioned for its key ecosystem function).

Climate

- The air temperature was above the long-term mean in 2010.
- The sea temperature in the Barents Sea in 2010 was still high, and about the same level as in 2009. In the next few years the temperature is expected to further decrease towards the long-term mean.
- Salinity in 2010 is still higher than the long term mean
- Inflow of Atlantic waters at the western entrance in the first half of 2010 was quite similar to the last years, with moderate variability; Data for second half of 2010 is not available.
- Oxygen levels in the southern Barents Sea were slightly less than normal in 2010.
- Ice extent in 2010 was less than normal, and similar to 2009. In 2011 the ice conditions are expected to be slightly less or around the long term mean.

Plankton and northern shrimp

- The mesozooplankton biomass measured in August–September 2010 was similar to 2009, and around the long-term mean.
- Abundance of krill in autumn and winter 2010 were higher than in 2009 in the western and northwestern areas. In total the abundance in 2010 is above the long-term mean.
- The abundance of gelatinous zooplankton, caught by pelagic trawling, show a lower abundance in 2010 compared to 2009.
- The shrimp stock in the Barents Sea and Spitsbergen area in 2010 increased compared to 2009.

Fish

- Capelin stock size is at around average level, with a slight decrease from last year. The survey estimate at age 1 of the 2009 year class is somewhat above the long-term mean. 0-group estimates indicate that the 2010 year class is around average.
- The abundance of young herring in the Barents Sea in 2010 decrease compared to 2009 and was at a low level. In autumn 2010 for the first time since 2002 young herring didn't occur in the eastern and central parts of the Barents Sea.

- Blue whiting abundance in the Barents Sea is at a very low level. The abundance is expected to remain low in 2011.
- The polar cod stock increased in 2010 compared to 2009. The levels have been fairly stable over last years.

Harp Seal

- The harp seal pup production in the White Sea in 2010 increased slightly compared to 2009 and is higher than in 2008, but it is still at a low level.

Impact of fisheries on the ecosystem (section 1.3)

- The most widespread gear is trawl.
- The demersal fisheries are mixed, and currently have largest effect on coastal cod and *Sebastes marinus* (Golden redfish) due to the poor condition of these stocks.
- The pelagic fisheries are less mixed, and are weakly linked to the demersal fisheries (however, by-catches of young pelagic stages of demersal species have been reported in some pelagic fisheries)
- Trawling has largest effect on hard bottom habitats; whereas the effects on other habitats are not clear and consistent.
- Work is currently going on exploring the possibility of using pelagic trawls when targeting demersal fish. The purpose is to avoid impact on bottom fauna and to reduce the mixture of other species. It will be mandatory to use sorting grids to avoid catches of undersized fish.
- Fishery induced mortality (lost gillnets, contact with active fishing gears, etc.) on fish is a potential problem but not quantified at present.

Management improvement issues (section 1.4)

- Several methods, which take ecosystem information into account, are presently under development. These methods should in the future be valuable for the improvement of the stock assessment and advice.
- The cod recruitment (age 3) in 2011 is expected to be low compared to the long-term mean. In 2012 and 2013 it is expected to increase to medium levels.

1.7 Response to "Generic Terms of Reference" and review group

1.7.1 Concerning Generic Terms of Reference for Regional and Species Working Groups

Response to ToR a) – f) is given in the respective species chapters.

g) Where appropriate, check for the need to reopen the advice in autumn based on the new survey information and the guidelines in AGCREFA (2008 report).

This point is not relevant for AFWG.

h) For the stocks where the advice is marked 'collate data', available data should be collected and presented as far as possible. If information is available for more than or only part of the area, the header for the stock can be adapted (please discuss with the secretariat).

This point is not relevant for AFWG.

i) Identify elements of the EGs work that may help determine status for the 11 Descriptors set out in the Commission Decision (available at http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:232:0014:0024:EN:PDF;

j) Provide views on what good environmental status (GES) might be for those descriptors, including methods that could be used to determine status.

Points i) and j) concerns the same issue, and are here answered together.

The working group went through the 11 descriptors, from the EU Commission Decision "on criteria and methodological standards on good environmental status of marine waters" resulted from the EU "Marine Strategy Framework Directive (MSFD)", and debated their content. In many aspects related to both the descriptors and to the "Good Environmental Status" the Barents Sea is in a special situation.

The Norwegian government launched a white paper on a holistic management plan for the Barents Sea in 2006 (Anon. 2006), which includes management objectives and indicators in line with the descriptors and indicators of the Commission Decision. A body has been set up in conjunction with this plan, involving all major scientific and management stakeholders in order to ensure monitoring, implementation and management of this plan. A white paper update of the plan was launched in March 2011 (Anon. 2011b). A specially appointed monitoring forum, led by IMR, reports annually on the indicators, and raises suggestions for adjustments (Sunnanå et al. 2010).

The work on a similar holistic management plan for the Russian areas in the Barents Sea has recently started, and the Joint Russian - Norwegian Commission on Environmental Cooperation has launched several bilateral working groups designed to transfer experience from the Norwegian work to the Russian work on their plan, and also to try to generate a basis for a joint plan in the future. This includes joint ecosystem status reporting (e.g. Stiansen et al. 2009) and monitoring (e.g. Anon. 2010), giving the basis for the indicators and good environmental status.

Since the management of Barents Sea depends mainly on these two countries, and these countries already have bodies that handles the question asked by (ICES/STGMSFD), the working group feels that these issues should be handled directly between STGMSFD and the above mentioned bodies. However, several members of the working group are also members of these national bodies, and will be able to put forward the MSFD/GES/descriptors issues to the relevant bodies.

k) Take note of and comment on the Report of the Workshop on the Science for area-based management: Coastal and Marine Spatial Planning in Practice (WKCMSP)

The working group endorses the work undertaken by the Strategic Initiative Group on Marine Spatial Planning (STIG-MSP) and the conclusions reached at the Workshop on the Science for area-base management: Coastal and Marine Spatial Planning in practice (WKCMSP).

l) Provide information that could be used in setting pressure indicators that would complement biodiversity indicators currently being developed by the Strategic Initiative on Biodiversity Advice and Science (SIBAS). Particular consideration should be given to assessing the impacts of very large renewable energy plans with a view to identifying/predicting potentially catastrophic outcome.

The working group discussed this point. It is difficult to give information on pressure indicators that may influence biodiversity indicators that are "currently being developed". We therefore feel that it is a little premature for AFWG to relate to this request. However, the working group is happy to get a new request in the future, when the SIBAS work has matured.

Drivers that relate to the AFWG stocks are Fishing mortality (F) and Fishing effort (e.g. CPUE).

Concerning renewable energy plans the working group has no knowledge of any major such installations planned for the Barents Sea, neither are there any there at present.

m) Identify spatially resolved data, for e.g. spawning grounds, fishery activity, habitats, etc.

A new subchapter (1.5.4) have addressed this.

1.7.2 Concerning Review Group comments

There were no comments from the review group on chapter 1 last year.

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

Year	Capelin			Cod			Haddock			Herring			Redfish		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	197278	131674	262883	72	38	105	59	38	81	4	1	8	277873	0	701273
1981	123870	71852	175888	48	33	64	15	7	22	3	0	8	153279	0	363283
1982	168128	35275	300982	651	466	835	649	486	812	202	0	506	106140	63753	148528
1983	100042	56325	143759	3924	1749	6099	1356	904	1809	40557	19526	61589	172392	33352	311432
1984	68051	43308	92794	5284	2889	7679	1295	937	1653	6313	1930	10697	83182	36137	130227
1985	21267	1638	40896	15484	7603	23365	695	397	992	7237	646	13827	412777	40510	785044
1986	11409	98	22721	2054	1509	2599	592	367	817	7	0	15	91621	0	184194
1987	1209	435	1983	167	86	249	126	76	176	2	0	5	23747	12740	34755
1988	19624	3821	35427	507	296	718	387	157	618	8686	3325	14048	107027	23378	190675
1989	251485	201110	301861	717	404	1030	173	117	228	4196	1396	6996	16092	7589	24595
1990	36475	24372	48578	6612	3573	9651	1148	847	1450	9508	0	23943	94790	52658	136922
1991	57390	24772	90007	10874	7860	13888	3857	2907	4807	81175	43230	119121	41499	0	83751
1992	970	105	1835	44583	24730	64437	1617	1150	2083	37183	21675	52690	13782	0	36494
1993	330	125	534	38015	15944	60086	1502	911	2092	61508	2885	120131	5458	0	13543
1994	5386	0	10915	21677	11980	31375	1695	825	2566	14884	0	31270	52258	0	121547
1995	862	0	1812	74930	38459	111401	472	269	675	1308	434	2182	11816	3386	20246
1996	44268	22447	66089	66047	42607	89488	1049	782	1316	57169	28040	86299	28	8	47
1997	54802	22682	86922	67061	49487	84634	600	420	780	45808	21160	70455	132	0	272
1998	33841	21406	46277	7050	4209	9890	5964	3800	8128	79492	44207	114778	755	23	1487
1999	85306	45266	125346	1289	135	2442	1137	368	1906	15931	1632	30229	46	14	79
2000	39813	1069	78556	26177	14287	38068	2907	1851	3962	49614	3246	95982	7530	0	16826
2001	33646	0	85901	908	152	1663	1706	1113	2299	844	177	1511	6	1	10
2002	19426	10648	28205	19157	11015	27300	1843	1276	2410	23354	12144	34564	130	20	241
2003	94902	41128	148676	17304	10225	24383	7910	3757	12063	28579	15504	41653	216	0	495
2004	16701	2541	30862	19157	13987	24328	19144	12649	25638	133350	94873	171826	849	0	1766
2005	41808	12316	71300	21532	14732	28331	33283	24377	42190	26332	1132	51532	12332	631	24034
2006	166400	102749	230050	7860	3658	12061	11421	7553	15289	66819	22759	110880	20864	10057	31671
2007	157913	87370	228456	9707	5887	13527	2826	1787	3866	22481	4556	40405	159159	44882	273436
2008	288799	178860	398738	52975	31839	74111	2742	830	4655	15915	4477	27353	9962	0	20828
2009	189767	113154	266379	54579	37311	71846	13040	7988	18093	18916	8249	29582	66671	29636	103706
2010	91730	57545	125914	40635	20307	60963	7267	4529	10005	20367	4099	36636	66392	3114	129669
Mean	78158			20550			4144			28314			64800		

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

Year	Saithe			Gr halibut			Long rough dab			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	3	0	6	111	35	187	1273	883	1664	28958	9784	48132	9650	0	20622
1981	0	0	0	74	46	101	556	300	813	595	226	963	5150	1956	8345
1982	143	0	371	39	11	68	1013	698	1328	1435	144	2725	1187	0	3298
1983	239	83	394	41	22	59	420	264	577	1246	0	2501	9693	0	20851
1984	1339	407	2271	31	18	45	60	43	77	127	0	303	3182	737	5628
1985	12	1	23	48	29	67	265	110	420	19220	4989	33451	809	0	1628
1986	1	0	2	112	60	164	6846	4941	8752	12938	2355	23521	2130	180	4081
1987	1	0	1	35	23	47	804	411	1197	7694	0	17552	74	31	117
1988	17	4	30	8	3	13	205	113	297	383	9	757	4634	0	9889
1989	1	0	3	1	0	3	180	100	260	199	0	423	18056	2182	33931
1990	11	2	20	1	0	2	55	26	84	399	129	669	31939	0	70847
1991	4	2	6	1	0	2	90	49	131	88292	39856	136727	38709	0	110568
1992	159	86	233	9	0	17	121	25	218	7539	0	15873	9978	1591	18365
1993	366	0	913	4	2	7	56	25	87	41207	0	96068	8254	1359	15148
1994	2	0	5	39	0	93	1696	1083	2309	267997	151917	384078	5455	0	12032
1995	148	68	229	15	5	24	229	39	419	1	0	2	25	1	49
1996	131	57	204	6	3	9	41	2	79	70134	43196	97072	4902	0	12235
1997	78	37	120	5	3	7	97	44	150	33580	18788	48371	7593	623	14563
1998	86	39	133	8	3	12	27	13	42	11223	6849	15597	10311	0	23358
1999	136	68	204	14	8	21	105	1	210	129980	82936	177023	2848	407	5288
2000	206	111	301	43	17	69	233	120	346	116121	67589	164652	22740	14924	30556
2001	20	0	46	51	20	83	162	78	246	3697	658	6736	13490	0	28796
2002	553	108	998	51	0	112	731	342	1121	96954	57530	136378	27753	4184	51322
2003	65	0	146	13	0	34	78	45	110	11211	6100	16323	1627	0	3643
2004	1395	860	1930	70	28	113	36	20	52	37156	19040	55271	367	125	610
2005	55	36	73	9	4	14	200	109	292	6540	3196	9884	3216	1269	5162
2006	142	60	224	11	1	20	710	437	983	26016	9996	42036	2078	464	3693
2007	51	6	96	1	1	0	262	45	478	25883	8494	43273	2532	0	5134
2008	45	22	69	6	0	13	956	410	1502	6649	845	12453	91	0	183
2009	22	0	46	7	4	10	115	51	179	23570	9661	37479	21433	5642	37223
2010	402	126	678	14	8	21	130	19	241	31338	13644	49032	1500	0	4153
Mean	188			28			572			35751			8755		

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

	Capelin			Cod			Haddock			Herring		
Year	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	740289	495187	985391	276	131	421	265	169	361	77	12	142
1981	477260	273493	681026	289	201	377	75	34	117	37	0	86
1982	599596	145299	1053893	3480	2540	4421	2927	2200	3655	2519	0	5992
1983	340200	191122	489278	19299	9538	29061	6217	3978	8456	195446	69415	321477
1984	275233	161408	389057	24326	14489	34164	5512	3981	7043	27354	3425	51284
1985	63771	5893	121648	66630	32914	100346	2457	1520	3393	20081	3933	36228
1986	41814	642	82986	10509	7719	13299	2579	1621	3537	93	27	160
1987	4032	1458	6607	1035	504	1565	708	432	984	49	0	111
1988	65127	12101	118153	2570	1519	3622	1661	630	2693	60782	20877	100687
1989	862394	690983	1033806	2775	1624	3925	650	448	852	17956	8252	27661
1990	115636	77306	153966	23593	13426	33759	3122	2318	3926	15172	0	36389
1991	169455	74078	264832	40631	29843	51419	13713	10530	16897	267644	107990	427299
1992	2337	250	4423	166276	92113	240438	4739	3217	6262	83909	48399	119419
1993	952	289	1616	133046	58312	207779	3785	2335	5236	291468	1429	581506
1994	13898	70	27725	70761	39933	101589	4470	2354	6586	103891	0	212765
1995	2869	0	6032	233885	114258	353512	1203	686	1720	11018	4409	17627
1996	136674	69801	203546	280916	188630	373203	2632	1999	3265	549608	256160	843055
1997	189372	80734	298011	294607	218967	370247	1983	1391	2575	463243	176669	749817
1998	113390	70516	156263	24951	15827	34076	14116	9524	18707	476065	277542	674589
1999	287760	143243	432278	4150	944	7355	2740	1018	4463	35932	13017	58848
2000	140837	6551	275123	108093	58416	157770	10906	6837	14975	469626	22507	916746
2001	90181	0	217345	4150	798	7502	4649	3189	6109	10008	2021	17996
2002	67130	36971	97288	76146	42253	110040	4381	2998	5764	151514	58954	244073
2003	340877	146178	535575	81977	47715	116240	30792	15352	46232	177676	52699	302653
2004	53950	11999	95900	65969	47743	84195	39303	26359	52246	773891	544964	1002819
2005	148466	51669	245263	72137	50662	93611	91606	67869	115343	125927	20407	231447
2006	515770	325776	705764	25061	11469	38653	28505	18754	38256	294649	102788	486511
2007	480069	272313	687825	42628	26652	58605	8401	5587	11214	144002	25099	262905
2008	995101	627202	1362999	234144	131081	337208	9864	1144	18585	201046	68778	333313
2009	673027	423386	922668	185457	123375	247540	33339	19707	46970	104233	31009	177458
2010	318569	201973	435166	135355	68199	202511	23669	14503	32834	117087	32045	202129
Mean	268582			78552			11644			167484		

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

	Saithe			Polar cod (east)			Polar cod (west)		
Year	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	21	0	47	203226	69898	336554	82871	0	176632
1981	0	0	0	4882	1842	7922	46155	17810	74500
1982	296	0	699	1443	154	2731	10565	0	29314
1983	562	211	912	1246	0	2501	87272	0	190005
1984	2577	725	4430	871	0	2118	26316	6097	46534
1985	30	7	53	143257	39633	246881	6670	0	13613
1986	4	0	9	102869	16336	189403	18644	125	37164
1987	4	0	10	64171	0	144389	631	265	996
1988	32	11	52	2588	59	5117	41133	0	89068
1989	10	0	23	1391	0	2934	164058	15439	312678
1990	29	4	55	2862	879	4846	246819	0	545410
1991	9	4	14	823828	366924	1280732	281434	0	799822
1992	326	156	495	49757	0	104634	80747	12984	148509
1993	1033	0	2512	297397	0	690030	70019	12321	127716
1994	7	1	12	2139223	1230225	3048220	49237	0	109432
1995	415	196	634	6	0	14	195	0	390
1996	430	180	679	588020	368361	807678	46671	0	116324
1997	341	162	521	297828	164107	431550	62084	6037	118131
1998	182	91	272	96874	59118	134630	95609	0	220926
1999	275	139	411	1154149	728616	1579682	24015	3768	44262
2000	851	446	1256	916625	530966	1302284	190661	133249	248072
2001	47	0	106	29087	5648	52526	119023	0	252146
2002	2112	134	4090	829216	496352	1162079	215572	36403	394741
2003	286	0	631	82315	42707	121923	12998	0	30565
2004	4779	2810	6749	290686	147492	433879	2892	989	4796
2005	176	115	237	44663	22890	66436	25970	9987	41953
2006	280	116	443	182713	73645	291781	15965	3414	28517
2007	286	3	568	191111	57403	324819	22803	0	46521
2008	142	68	216	42657	5936	79378	619	25	1212
2009	62	0	132	168990	70509	267471	154687	37022	272351
2010	1066	362	1769	267430	111697	423162	12045	0	33370
Mean	538			291012			71432		

Table 1.3. The North-east arctic cod stock's consumption of various prey species (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 dab	Total
1984	479	27	113	436	722	78	15	22	50	364	0	0	24	2330
1985	1112	170	58	156	1620	183	3	31	47	225	0	1	40	3647
1986	606	1236	111	142	836	133	141	82	110	315	0	0	55	3767
1987	670	1085	67	191	229	32	205	25	4	323	1	0	9	2843
1988	401	1237	318	129	339	8	92	9	3	223	0	4	5	2769
1989	656	800	241	131	572	3	32	8	10	228	0	0	57	2739
1990	1343	137	85	195	1609	7	6	19	15	243	0	87	95	3842
1991	760	65	76	188	2891	8	12	26	20	312	7	10	270	4645
1992	907	102	158	373	2456	331	97	55	106	188	20	2	93	4887
1993	750	253	714	315	3030	163	278	285	71	100	2	2	26	5988
1994	623	562	703	517	1084	147	582	223	48	78	0	1	39	4607
1995	842	980	516	362	628	115	253	367	113	190	1	0	33	4400
1996	599	631	1158	341	538	47	104	536	69	97	0	10	34	4164
1997	443	382	519	316	907	5	113	338	41	36	0	33	14	3146
1998	411	363	455	325	714	86	151	155	33	9	0	13	15	2730
1999	377	145	271	250	1720	128	220	62	26	16	1	31	7	3255
2000	385	167	464	450	1727	53	194	76	51	8	0	38	18	3633
2001	689	173	378	278	1730	71	251	67	49	6	1	151	29	3873
2002	365	97	264	234	1948	87	273	109	124	1	0	226	15	3742
2003	554	285	537	243	2180	216	275	116	169	3	0	75	49	4702
2004	648	567	352	255	1286	214	360	131	207	3	11	57	61	4151
2005	769	555	485	261	1377	132	393	121	320	3	4	118	50	4589
2006	785	205	965	317	1683	176	94	81	345	12	1	167	102	4933
2007	1129	288	956	376	1907	278	252	97	359	40	0	44	71	5797
2008	1375	143	768	322	2491	95	467	184	300	51	12	18	82	6308
2009	1278	200	605	227	3196	109	592	185	251	29	3	5	92	6772
2010	1230	295	865	246	3209	43	223	228	267	147	13	7	96	6870

Table 1.4. The North-east arctic cod stock's consumption of various prey species (1000 tonnes), based on Russian consumption calculations.

Year	Euphausiids	Hyperids	Shrimp	Herring	Capelin	Polar cod	Cod	Haddock	Blue whiting	Norway pout	Redfish	Long rough dab	Greenland halibut	Other fish	Other food	Total consumption
1984	93.0	31.1	351.1	33.3	591.9	17.1	13.2	49.7	4.7	1.2	194.9	51.5	0.0	269.4	285.7	1987.7
1985	30.0	431.6	202.1	24.4	989.3	0.0	97.7	34.3	17.6	14.8	97.1	22.7	0.0	518.9	198.0	2678.7
1986	56.7	859.6	147.7	47.0	806.7	159.4	28.0	102.5	3.5	26.9	157.7	24.3	0.7	371.5	169.7	2961.9
1987	69.3	508.1	201.0	7.5	161.4	104.6	26.5	1.8	10.2	14.6	117.5	5.6	0.4	268.2	188.4	1685.1
1988	209.0	168.4	117.8	18.5	291.5	0.0	19.7	92.5	0.0	0.0	126.7	20.0	0.0	238.4	241.6	1544.0
1989	166.5	290.0	103.7	3.8	678.9	33.7	34.1	2.1	0.0	0.0	157.4	56.0	0.0	201.2	247.7	1975.1
1990	100.7	29.5	270.0	64.3	1252.9	7.5	21.4	16.4	39.1	14.7	231.7	78.5	0.0	101.1	166.4	2394.1
1991	54.3	83.4	286.4	28.1	3285.9	43.6	52.1	22.3	6.6	6.0	143.6	45.5	5.5	132.4	157.6	4353.4
1992	210.5	37.7	261.8	373.8	2019.9	190.0	82.9	37.6	0.0	76.7	120.6	43.2	0.8	294.4	415.1	4165.1
1993	176.0	174.9	219.1	176.7	2772.1	170.0	146.5	151.8	3.8	25.3	40.7	47.3	4.9	159.4	380.2	4648.7
1994	358.2	293.7	465.3	104.1	1292.7	486.7	384.3	71.0	1.1	1.5	55.9	40.0	0.1	98.7	347.0	4000.3
1995	390.3	458.1	541.9	189.8	678.9	198.6	548.9	128.0	0.4	0.6	112.0	53.0	2.6	164.5	352.3	3819.8
1996	972.8	360.8	200.2	76.4	478.5	78.6	473.2	60.3	8.9	36.5	70.6	47.4	0.1	470.1	174.7	3509.0
1997	509.0	132.2	260.1	54.2	522.5	110.3	387.1	35.1	16.7	0.1	31.2	16.8	1.6	96.7	366.3	2540.0
1998	615.6	204.8	264.6	69.7	851.9	128.8	128.7	22.6	23.3	18.3	15.0	19.1	0.0	52.5	225.6	2640.4
1999	450.4	76.8	241.5	73.7	1399.6	164.1	47.4	14.2	24.8	0.8	13.0	8.4	0.5	57.5	107.4	2680.2
2000	409.3	111.0	366.1	48.2	1659.9	157.0	56.6	28.5	26.2	8.3	4.1	20.3	0.1	35.3	180.6	3111.7
2001	412.5	73.7	305.7	87.2	1427.3	139.8	58.7	48.6	136.4	28.5	4.0	30.3	2.2	144.7	188.5	3088.0
2002	304.4	44.9	195.6	53.9	2308.9	279.5	98.4	76.0	101.1	3.5	3.4	16.6	0.0	43.6	168.9	3698.8
2003	235.1	138.2	209.5	142.6	1139.5	201.4	125.6	318.5	25.4	5.0	1.5	38.0	0.0	86.0	266.6	2932.8
2004	344.0	369.8	237.9	120.1	1027.0	342.4	81.2	148.1	46.8	19.9	6.8	57.4	14.7	174.9	261.6	3252.6
2005	529.0	130.7	220.1	165.3	937.6	308.3	110.3	266.9	65.9	40.4	6.8	43.8	2.1	159.3	197.9	3184.5
2006	902.5	60.0	211.3	231.4	1176.0	106.5	91.3	257.9	101.1	85.5	16.1	92.4	0.5	91.6	334.2	3758.4
2007	912.3	155.1	288.2	264.1	1448.5	242.8	69.9	311.4	31.5	21.0	22.0	62.3	0.8	203.3	389.1	4422.4
2008	662.4	38.7	243.0	102.5	2418.9	520.2	132.6	318.3	16.0	16.1	43.6	106.8	12.6	312.1	438.5	5382.6
2009	531.9	105.9	197.6	163.2	2344.8	591.9	108.7	306.0	7.6	80.6	24.3	185.7	0.5	129.6	527.8	5306.0
2010	1078.4	182.2	198.7	99.0	2867.3	382.9	143.7	227.6	8.3	53.7	143.0	120.2	1.2	178.2	436.7	6121.1
Mean	399.4	205.6	252.1	104.5	1364.1	191.3	132.2	116.7	26.9	22.2	72.6	50.1	1.9	187.2	274.6	3401.6

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

Year/Age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.247	0.814	1.684	2.513	3.948	5.203	7.973	8.486	9.139	9.867	9.941
1985	0.304	0.761	1.829	3.101	4.671	7.357	11.172	11.892	12.416	13.660	13.773
1986	0.160	0.488	1.347	3.158	5.604	6.834	10.989	11.899	12.701	13.461	13.694
1987	0.219	0.601	1.275	2.055	3.537	5.457	7.044	8.111	8.922	9.343	9.295
1988	0.164	0.703	1.149	2.148	3.744	5.875	10.096	11.218	12.570	13.122	13.345
1989	0.223	0.716	1.606	2.705	3.973	5.601	7.648	8.464	9.559	10.156	10.599
1990	0.363	0.905	1.889	3.027	4.156	5.323	6.249	6.666	6.698	7.039	7.738
1991	0.293	0.969	2.168	3.500	5.281	7.026	9.392	10.154	11.200	12.239	11.886
1992	0.215	0.663	2.095	3.133	4.142	5.093	7.832	8.965	9.352	10.071	10.115
1993	0.112	0.528	1.546	3.044	4.809	6.285	9.421	11.239	11.763	12.253	12.876
1994	0.130	0.408	0.922	2.521	3.504	4.511	6.396	8.846	9.672	9.977	10.176
1995	0.103	0.296	0.921	1.840	3.361	5.252	7.697	10.405	12.333	12.734	13.180
1996	0.108	0.356	0.929	1.847	3.068	4.429	7.381	11.143	14.702	14.876	15.265
1997	0.140	0.319	0.940	1.768	2.710	3.536	5.253	8.149	12.582	13.484	13.091
1998	0.117	0.397	0.983	1.942	2.923	4.186	5.746	8.061	11.339	11.850	11.903
1999	0.163	0.505	1.093	2.717	3.717	5.442	6.965	9.179	11.004	12.007	12.109
2000	0.170	0.499	1.243	2.461	4.252	5.651	7.951	9.364	12.485	13.258	13.299
2001	0.171	0.456	1.309	2.439	3.682	5.294	7.523	11.085	13.422	14.117	14.435
2002	0.199	0.551	1.167	2.441	3.380	4.719	6.357	9.039	10.224	11.538	10.928
2003	0.207	0.653	1.312	2.390	3.995	5.946	8.411	10.405	12.786	13.397	14.346
2004	0.222	0.478	1.306	2.296	3.357	5.569	7.409	11.380	17.307	19.278	18.668
2005	0.203	0.661	1.387	2.743	4.251	6.405	7.662	10.232	13.486	14.433	15.225
2006	0.202	0.626	1.591	2.808	4.251	6.356	7.867	11.612	14.017	15.034	15.971
2007	0.255	0.653	1.747	3.087	4.459	6.213	8.230	10.221	12.547	13.132	13.716
2008	0.204	0.717	1.464	2.874	4.077	7.069	8.376	11.340	15.487	16.023	16.245
2009	0.192	0.617	1.479	2.753	4.440	5.794	8.432	11.485	12.696	13.647	13.683
2010	0.203	0.635	1.403	2.492	3.978	5.721	8.432	11.981	15.271	15.924	16.348
Average	0.196	0.592	1.399	2.585	3.973	5.635	7.922	10.038	12.062	12.812	13.031

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

Age	1	2	3	4	5	6	7	8	9	10	11	12	13
1984	0.262	0.893	1.612	2.748	3.848	5.486	6.99	8.563	10.574	13.166	12.437	14.282	15.272
1985	0.295	0.752	1.656	2.683	4.264	6.601	8.242	9.743	10.975	14.447	16.499	16.061	17.343
1986	0.179	0.515	1.461	3.467	4.956	5.913	6.477	8.156	9.766	11.455	12.5	13.577	14.772
1987	0.145	0.431	0.844	1.561	3.078	4.346	7.279	9.683	12.703	14.482	15.014	15.115	16.377
1988	0.183	0.704	1.075	1.627	2.392	4.387	8.208	9.978	10.867	16.536	14.352	15.765	16.511
1989	0.282	0.91	1.468	2.207	3.244	4.799	6.581	8.725	11.134	15.799	15.95	17.909	17.643
1990	0.288	1.007	1.696	2.694	3.278	3.833	5.584	6.871	10.716	11.428	12.66	15.053	16.064
1991	0.241	0.936	2.67	4.473	6.038	7.846	9.59	11.542	14.97	19.294	17.509	20.109	22.109
1992	0.178	0.969	2.475	2.866	3.995	5.138	6.724	7.414	8.754	12.304	13.518	13.744	14.908
1993	0.133	0.476	1.512	2.865	3.944	5.108	7.372	8.945	10.343	11.6	14.067	14.893	15.922
1994	0.18	0.512	1.212	2.402	3.517	5.359	7.56	10.001	11.818	12.896	13.554	15.902	16.806
1995	0.194	0.497	0.962	1.801	3.204	4.847	7.332	9.688	13.835	15.247	16.96	18.23	19.202
1996	0.17	0.498	1.028	1.916	3.059	4.189	6.987	10.212	12.185	13.614	14.581	16.214	16.876
1997	0.119	0.341	0.992	1.908	2.668	3.503	4.954	7.98	12.174	16.762	16.766	18.352	19.155
1998	0.232	0.528	1.081	2.016	2.823	4.089	5.469	7.346	9.586	13.012	14.455	15.579	16.201
1999	0.261	0.431	1.128	2.49	3.676	5.222	6.398	8.22	9.194	13.364	15.325	16.918	17.567
2000	0.186	0.545	1.288	2.551	4.387	6.559	8.833	10.483	11.522	15.132	17.155	19.717	20.514
2001	0.15	0.413	1.163	2.11	3.43	5.571	6.835	10.233	12.457	15.13	17.374	19.322	20.559
2002	0.252	0.677	1.303	2.699	3.847	5.591	7.846	10.796	13.238	18.787	17.902	20.202	21.027
2003	0.228	0.618	1.296	2.028	3.547	4.716	6.684	8.905	13.418	14.492	19.54	19.239	20.036
2004	0.25	0.654	1.412	2.567	3.857	5.66	7.73	11.126	15.907	20.77	21.687	24.852	25.892
2005	0.255	0.687	1.514	2.504	3.896	5.264	7.192	9.395	13.163	15.981	20.699	21.355	24.181
2006	0.354	0.925	1.881	2.813	4.019	5.332	7.45	10.328	13.111	17.759	19.562	22.234	23.126
2007	0.234	0.681	1.874	3.128	4.459	5.893	7.563	9.178	12.032	15.919	20.031	21.561	22.427
2008	0.223	0.719	1.697	2.959	4.194	6.073	7.809	10.464	13.627	17.254	21.662	23.295	24.295
2009	0.217	0.626	1.518	2.581	4.403	5.778	7.933	11.42	13.743	15.71	18.841	21.786	22.687
2010	0.235	0.67	1.423	2.687	4.254	6.117	8.684	11.906	16.297	17.341	19.834	22.939	23.891

Table 1.7. Capelin stock history from 1972-present. M output biomass is the estimated biomass of capelin removed from the stock by natural mortality.

Year	Total stock number, billions (Oct. 1)	Total stock biomass in 1000 tonnes (Oct. 1)	Maturing biomass in 1000 tonnes (Oct. 1)	M output biomass (MOB) during year (1000 tonnes)
1972	488	4286	2182	927
1973	961	5146	1350	3083
1974	1029	5738	907	2687
1975	921	7816	2916	2659
1976	696	6420	3200	3353
1977	681	4803	2676	2634
1978	561	4248	1402	2240
1979	464	4161	1227	2038
1980	654	6723	3913	2858
1981	660	3892	1551	3945
1982	901	5349	2132	3229
1983	754	4225	1329	2989
1984	393	2964	1208	2590
1985	109	857	285	1190
1986	14	120	65	289
1987	39	100	17	135
1988	50	427	200	275
1989	209	869	174	440
1990	894	5838	2617	1484
1991	1016	7282	2248	4732
1992	678	5155	2228	5417
1993	75	797	330	2168
1994	28	199	94	458
1995	17	194	118	145
1996	96	502	248	194
1997	140	910	312	408
1998	263	2055	932	718
1999	285	2774	1718	1372
2000	595	4274	2097	2179
2001	364	3629	2019	2877
2002	201	2209	1290	2310
2003	104	534	280	1176
2004	82	627	293	520
2005	42	324	174	404
2006	88	787	437	281
2007	280	1882	844	538
2008	571	4426	2468	1333
2009	352	3756	2323	2973
2010	438	3498	2052	2841

Table 1.8. Diet composition of main fish species in 2005, % by weight (Data from Dolgov, WD 28 and WD 29, AFWG 2006)

Prey species	Predators species						
	Cod (3+)	haddock	Greenland halibut	Thorny skate	Long rough dab	Saithe	Blue whiting
Euphausiidae	5,2	21,7	0,4	0,8	0,1	24,4	44,4
Hyperiidae	4,1	0,2	3,8	0	0	0,3	18,2
Cephalopoda	0	0	2,1	0	0	0	0
Pandalus borealis	4,6	1,2	1,4	15,8	1,4	0,2	1,4
Echinodermata	0	24,1	0	0	4,7	0	0
Mollusca	0	7,9	0	0	3,6	0	0
Polychaeta	0	9,2	0	4,2	2,9	0	0
Cod	4,5	0,4	0,2	0	0,5	0,3	1,7
Herring	8,9	0,2	1,3	0,5	0,6	3,0	0
Capelin	11,6	2,1	8,7	30,8	17,5	54,9	0,9
Haddock	10,7	0,2	6,6	0,6	10,1	8,0	0
Polar cod	10,4	0	16,5	0	11,6	0,2	4,7
Blue whiting	4,8	0	2,6	0	0	0	0
Greenland halibut	0,2	0	1,4	0	0	0	0
Redfish	0,4	0	0,1	0	0	0	0
Long rough dab	1,8	0,1	4,8	2,9	0	0	0
Other fish	23,6	3,7	31,9	31,6	7,8	7,0	25,5
Other food	8,9	22,4	0,3	7,9	7,2	0	2,6
Fishery waste	0	4,1	17,7	4,9	31,4	0,9	0
Undetermined	0	2,4	0,2	1,4	0,7	0,5	0,3
Total number of stomachs	12209	7078	5223	432	2221	776	575
Percentage of empty stomachs	28,9	21,1	71,5	23,8	54,4	34,1	33,4
Average filling degree	1,7	1,6	0,7	1,9	1,1	1,6	1,7
Mean index of stomach fullness	213,8	110,5	84,4	182,7	139,0	116,3	111,2

Table 1.9. Annual consumption by minke whale and harp seal (thousand tonnes). The figures for minke whales are based on data from 1992-1995, while the figures for harp seals are based on data for 1990-1996.

Prey	Minke whale consumption	Harp seal consumption (low capelin stock)	Harp seal consumption (high capelin stock)
Capelin	142	23	812
Herring	633	394	213
Cod	256	298	101
Haddock	128	47	[1]
Krill	602	550	605
Amphipods	0	304	313 [2]
Shrimp	0	[1]	[1]
Polar cod	[1]	880	608
Other fish	55	622	406
Other crustaceans	0	356	312
Total	1817	3491	3371

[1] the prey species is included in the relevant 'other' group for this predator.

[2] only Parathemisto

Table 1.10. Description of the fisheries by gears. The gears are abbreviated as: trawl roundfish (TR), trawl shrimp (TS), longline (LL), gillnet (GN), handline (HL), purse seine (PS), Danish seine (DS) and trawl pelagic (TP). The regulations are abbreviated as: Quota (Q), mesh size (MS), sorting grid (SG), minimum catching size (MCS), maximum by-catch of undersized fish (MBU), maximum by-catch of non-target species (MBN), maximum as by-catch (MB), closure of areas (C), restrictions in season (RS), restrictions in area (RA), restriction in gear (RG), maximum by-catch per haul (MBH), as by-catch by maximum per boat at landing (MBL), number of effective fishing days (ED), number of vessels (EF).

Species	Directed fishery by gear	Type of fishery	Landings in 2010[a] (thousand tonnes)	As by-catch in fleet(s)	Location	Agreements and regulations
Capelin	PS, TP	seasonal	360	TR, TS	Northern coastal areas to south of 74°N	Bilateral agreement, Norway and Russia
Coastal cod	GN, LL, HL, DS	all year	23	TS, PS, DS, TP	Norwegian coast (inside 12 naut.miles) north of 62°N	Q, MS, MCS, MBU, MBN, C, RS, RA
NEA Cod	TR, GN, LL, HL	all year	610	TS, PS, TP, DS	North of 62°N, Barents Sea, Svalbard	Q, MS, SG, MCS, MBU, MBN, C, RS, RA
Wolffish	LL	all year	15	TR, (GN), (HL)	North of 62°N, Barents Sea, Svalbard	Q, MB
Haddock	TR, GN, LL, HL	all year	249	TS, PS, TP, DS	North of 62°N, Barents Sea, Svalbard	Q, MS, SG, MCS, MBU, MBN, C, RS, RA
Saithe	PS, TR, GN	seasonal	193	TS, LL, HL, DS, TP	Coastal areas north of 62°N, southern Barents Sea	Q, MS, SG, MCS, MBU, MBN, C, RS, RA
Greenland halibut	LL, GN	seasonal	16	TR	Deep shelf and at the continental slope	Q, MS, RS, RG, MBH, MBL
Sebastes mentella	No directed fishery	all year	12	TR	Pelagic in the Norwegian Sea, and as bycatch on the deep shelf and the continental slope	C, SG, MB
Sebastes marinus	GN, LL, HL	all year	8	TR	Norwegian coast and southwestern Barents Sea	SG, MB MCS, MBU, C
Shrimp	TS	all year	22		Svalbard, Barents Sea, Coastal north of 62°N	ED, EF, SG, C, MCS

[A] **Provisional figures**

Table 1.11. Flexibility in coupling between the fisheries. Fleets and impact on the other species (H, high, M, medium, L, low and 0, nothing). The table below the diagonal indicates what gears couples the species, and the strength of the coupling is given above the diagonal. The gears are abbreviated as: trawl roundfish (TR), trawl shrimp (TS), longline (LL), gillnet (GN), handline (HL), purse seine (PS), Danish seine (DS) and trawl pelagic (TP). The figure is not updated this year.

Species	Cod	Coastal cod	Haddock	Saithe	Wolffish	S. mentella	S. marinus	Greenland halibut	Capelin	Shrimp
Cod		H	H	H	M	M	M	M	L	M-H juvenile cod
Coastal cod	TR, PS, GN, LL, HL, DS		H	H	L	L	M-L	L	0-L	L
Haddock	TR, PS, GN, LL, HL, DS	TR, PS, GN,LL, HL, DS		H	M	M	M	L	0-L	M-H juvenile haddock
Saithe	TR, PS, GN, LL, HL, DS	TR, PS, GN,LL, HL, DS	TR, PS, GN, LL, HL, DS		L	L	M	0	0	0
Wolffish	TR, GN, LL, HL	TR,GN, LL, HL	TR, GN, LL, HL	TR, GN, LL, HL		M	M	M	0	M juvenile wolffish
S. mentella	TR	TR	TR	TR	TR		M	H	H juvenile Sebastes	H juvenile Sebastes
S. marinus	TR,GN, LL	TR,GN, LL	TR,GN, LL	TR,GN	TR, LL	TR		L	0	L-M juvenile Sebastes
Greenland halibut	TR, GN, LL,DS	TR,GN, LL	TR, GN, LL,DS	TR, GN, LL,DS	TR, LL	TR	TR		0	M-H juvenile
Capelin	TR, PS, TS, TP	PS, TP	TR, PS, TS, TP	PS	TP	TP	TP	None		L
Shrimp	TS	TS	TS	TS	TS	TS	TS	TS	TS	

Table 1.12. Overview of available prognoses of NEA cod recruitment (in million individuals of age 3) from different models (section 1.4.2) together with the 2010 assessment estimates (ICES AFWG 2010, Table 1.13). Please note that the H1, H2 and the TB models were not updated at this assessment.

Model	Prognostic years	Updated	2011 Prognoses	2012 Prognoses	2013 Prognoses	2014 prognoses
Titov0	0	At assessment	461			
Titov1	1 (2 [1])	At assessment	**516***	470		
Titov2	2	At assessment	292	**510***		
Titov3	3	At assessment	**350***	**569***	**683***	
Titov4	4	At assessment	373	797	971	1004
TB (1984-2000)	3	Last year assessment	553			
TB (1984-2004)	3	Last year assessment	551			
JES1	2 (3 [2])	At assessment	695	743*	708	
JES2	1 (2 [2])	At assessment	604	670		
JES3	0 (1 [2])	At assessment	557			
H1	2	At assessment	889			
H2	2	At assessment	636			
RCT3 2011	3	At assessment	474	675	670	
Hybrid Model (Assessment 2010)		Last year assessment	465	484		
Hybrid model (Assessment 2011)		At assessment	433	607	683	

[1] Based on calculation of data from 2011

[2] Based on prognosis estimate of capelin maturing biomass for October 1 2011, thereby allowing for an additional year.

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

Table 1.13. Proportion of cod in the diet of cod, based on Norwegian consumption calculations.

Year/Cod (predator)age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.0000	0.0000	0.0032	0.0000	0.0437	0.0263	0.0328	0.0359	0.0367	0.0390	0.0374
1985	0.0015	0.0009	0.0014	0.0017	0.0314	0.0076	0.0827	0.0834	0.0842	0.0847	0.0854
1986	0.0000	0.0022	0.0015	0.0004	0.0130	0.1761	0.1767	0.1766	0.1762	0.1757	0.1751
1987	0.0000	0.0000	0.0007	0.0051	0.0103	0.0246	0.0377	0.0400	0.0418	0.0405	0.0441
1988	0.0000	0.0000	0.0000	0.0002	0.0058	0.0014	0.0038	0.0036	0.0032	0.0038	0.0036
1989	0.0000	0.0006	0.0016	0.0019	0.0027	0.0040	0.0035	0.0035	0.0040	0.0038	0.0042
1990	0.0000	0.0000	0.0000	0.0012	0.0017	0.0019	0.0268	0.0268	0.0268	0.0268	0.0268
1991	0.0000	0.0005	0.0000	0.0003	0.0032	0.0020	0.0224	0.0232	0.0235	0.0239	0.0241
1992	0.0000	0.0021	0.0037	0.0129	0.0250	0.0475	0.0120	0.0159	0.0232	0.0232	0.0230
1993	0.0000	0.0413	0.0368	0.0515	0.0536	0.1156	0.0498	0.0801	0.0801	0.0801	0.0805
1994	0.0000	0.0038	0.0917	0.0347	0.0285	0.0784	0.1247	0.1339	0.2617	0.2634	0.2606
1995	0.0069	0.0811	0.0745	0.0802	0.0925	0.1123	0.1389	0.2533	0.2553	0.2561	0.2581
1996	0.0000	0.1493	0.2549	0.2060	0.1322	0.1267	0.1850	0.2082	0.2459	0.2471	0.2465
1997	0.0000	0.0704	0.0767	0.1140	0.1552	0.1554	0.2329	0.2267	0.2882	0.2815	0.2832
1998	0.0000	0.0135	0.0272	0.0418	0.1041	0.0981	0.1081	0.1492	0.2758	0.2767	0.2778
1999	0.0000	0.0000	0.0049	0.0137	0.0148	0.0338	0.0620	0.1117	0.1937	0.1940	0.1840
2000	0.0000	0.0000	0.0286	0.0147	0.0134	0.0266	0.0499	0.0566	0.2757	0.2726	0.2738
2001	0.0000	0.0158	0.0116	0.0082	0.0131	0.0241	0.0496	0.0381	0.3296	0.3272	0.3307
2002	0.0000	0.0387	0.0591	0.0142	0.0187	0.0285	0.0359	0.0626	0.1601	0.1572	0.1572
2003	0.0000	0.0194	0.0198	0.0199	0.0206	0.0188	0.0457	0.1043	0.2259	0.2285	0.2277
2004	0.0082	0.0234	0.0280	0.0269	0.0299	0.0320	0.0382	0.0666	0.1075	0.1072	0.1080
2005	0.0000	0.0266	0.0229	0.0265	0.0143	0.0277	0.0441	0.0773	0.1523	0.1499	0.1521
2006	0.0000	0.0102	0.0007	0.0128	0.0288	0.0158	0.0394	0.0368	0.0829	0.0833	0.0824
2007	0.0000	0.0000	0.0011	0.0117	0.0119	0.0304	0.0284	0.0906	0.1444	0.1462	0.1430
2008	0.0000	0.0556	0.0251	0.0099	0.0157	0.0098	0.0771	0.0876	0.0969	0.0953	0.0939
2009	0.0121	0.0233	0.0261	0.0250	0.0151	0.0139	0.0219	0.0954	0.1082	0.1087	0.1086
2010	0.0000	0.0342	0.0525	0.0266	0.0242	0.0237	0.0202	0.0386	0.1383	0.1382	0.1344
Average	0.0011	0.0227	0.0316	0.0282	0.0342	0.0468	0.0648	0.0862	0.1423	0.1420	0.1417

Table 1.14. Stock reproductive potential variables used for the AFWG assessments and advice

AFWG stocks	Number	Weight	Maturity	Sex ratio	Fecundity
NEA Cod/Coastal Cod	VPA estimates	catch/survey data; year-specific	survey data; year-specific	potentially available; not used	modelled; not used
Haddock	VPA estimates	catch/survey data; year-specific; smoothed	survey data; year-specific; smoothed	potentially available; not used	not formulated; not used
Saithe	VPA estimates	constant at age from 1960-1979; year-specific afterwards, based on L-W relationships	constant ogive 1960-1984; 3 year running average afterwards	potentially available; not used	not formulated; not used
Greenland halibut	At the moment, no accepted VPA estimates because of ageing problems	catch=survey; year-specific	1964-present; survey data; 3 year running average	available; used for Female SSB estimates	not formulated; not used
Sebastes marinus	trends in the fisheries and surveys; the Gadget model simulations	catch data; year-specific , based on L-W relationships	A knife-edge maturity at age 15 (age 15 as 100% mature); since 2006 -modelled and estimated by the GADGET model ogives	not available	not formulated; not used
Sebastes mentella	trends in the fisheries and surveys	survey data; year-specific	survey data;average ogives for 1966-1972 and 1975-1983;smoothed ogive for 1984-1992 (3 year running average); year-specific or 1992-2001; none afterwards	survey data;potentially available for 1966-2001; none afterwards; not used	not formulated; not used

Table 1.15. Cannibalism mortality in cod, approach by Kovalev (2004) compared to the actual assessment.

Year	M at age 3	M at age 4
	by regression	
2010	0.431	0.285
2011	0.456	0.295
2012	0.625	0.365
2013	0.652	0.377
	values used in assessment	
2011-2013	0.349	0.266

Table 1.16. Overview of the standard sections monitored by IMR and PINRO in the Barents Sea, with observed parameters. Parameters are: T-temperature, S-Salinity, N-nutrients, chla-chlorophyll, zoo-zooplankton, O-oxygen.

Section	Institution	Time period	Observation frequency	parameters
Fugløya-Bear Island	IMR	1977-present	6 times pr year	T,S,N,chla,zoo
North cape-Bear Island	PINRO	1950's-present	yearly	T,S
Bear Island-East	PINRO	1950's-present	yearly	T,S
Vardø-North	IMR	1977-present	4 times pr year	T,S,N,chla
Kola	PINRO	1921-present	monthly	T,S,O,N
Kanin	PINRO	1950's-present	yearly	T,S
Sem Islands	IMR	1970's-present	Intermittently*	T,S

*** The Sem Island section is not observed each year, and have not been observed the last 3-4 years.**

Table 1.17. Overview of conducted monitoring surveys by IMR and PINRO in the Barents Sea, with observed parameters and species. For zooplankton, mammals and benthos abundance and distribution for many species are investigated. Therefore, in the table it is only indicated whether sampling is conducted. Climate and phytoplankton parameters are: T-temperature, S-Salinity, N-nutrients, chla-chlorophyll.

Survey	InSTitution	Period	Climate	Phyto-plankton	Zoo-plankton	Juvenile fish	Target fish stocks	Mammals	Benthos
Winter survey	Joint	Feb-Mar	T,S	N, chla	intermittent	All commercial species and some additional	Cod, Haddock	-	-
Lofoten survey	IMR	Mar-Apr	T,S	-	-		Cod, haddock, saithe	-	-
Ecosystem survey	Joint	Aug-Oct	T,S	N,chla	Yes	All commercial species and some additional	All commercial species and some additional	Yes	Yes
Norwegian coastal surveys	IMR	Oct-Nov	T,S	N,chla	Yes	Herring, sprat, demersal species	Saithe, coastal cod	-	-
Autumn-winter trawl-acoustic survey	PINRO	Oct-Des	T,S	-	Yes	Demersal species	Demersial species	-	-
Norwegian Greenland halibut survey	IMR	Aug, biennial	-	-	-	-	Greenland halibut, redfish	-	-
Russian young herring survey	PINRO	May	T,S		Yes		Herring	-	-

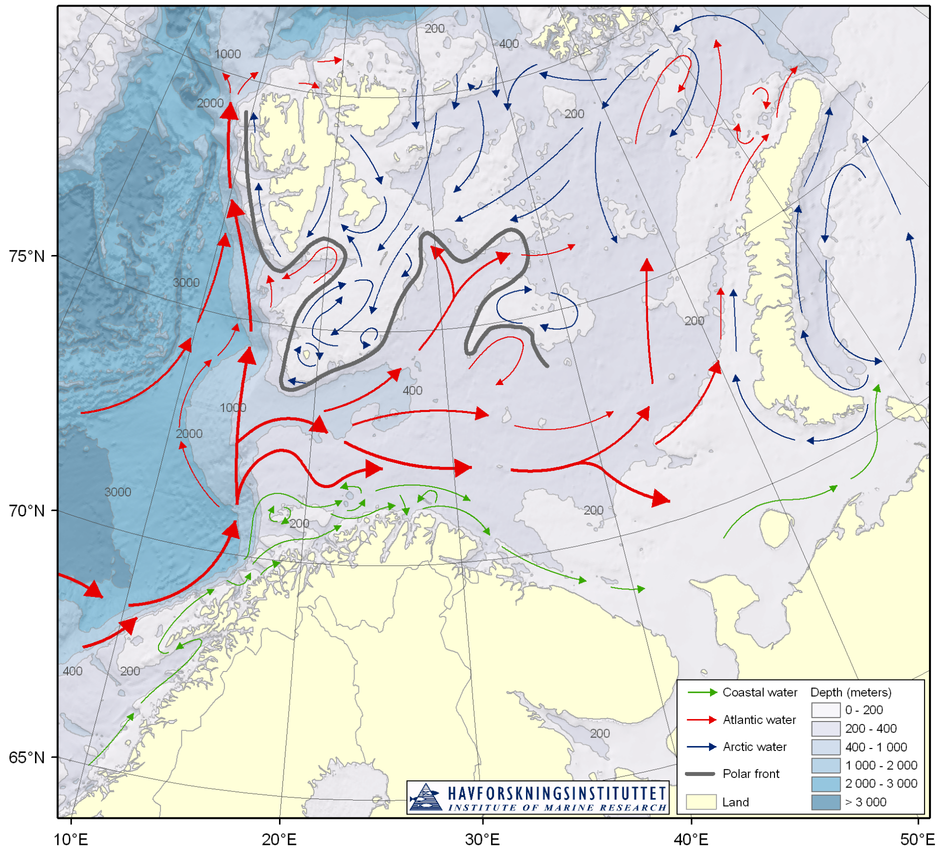


Figure 1.1. The main features of the circulation and bathymetry of the Barents Sea.

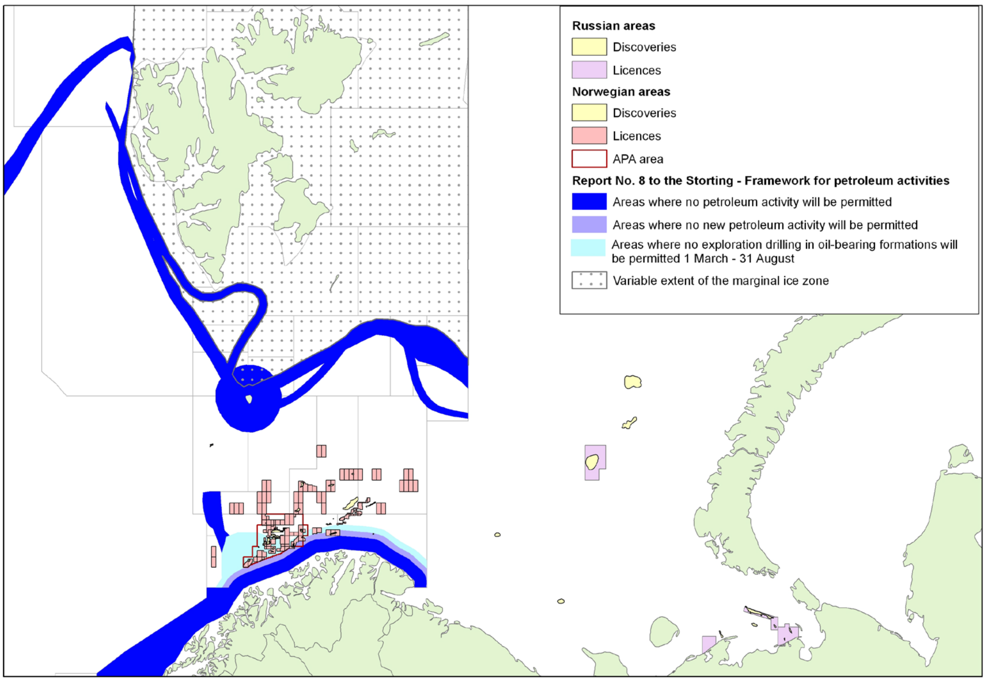


Figure 1.2. Map reflecting current status of petroleum activities in the Barents Sea (source: the Norwegian Petroleum Directorate and Official report Sevmorgeo for Ministry of Natural Resources "Cadastre of the Russian offshore zone", 2007.

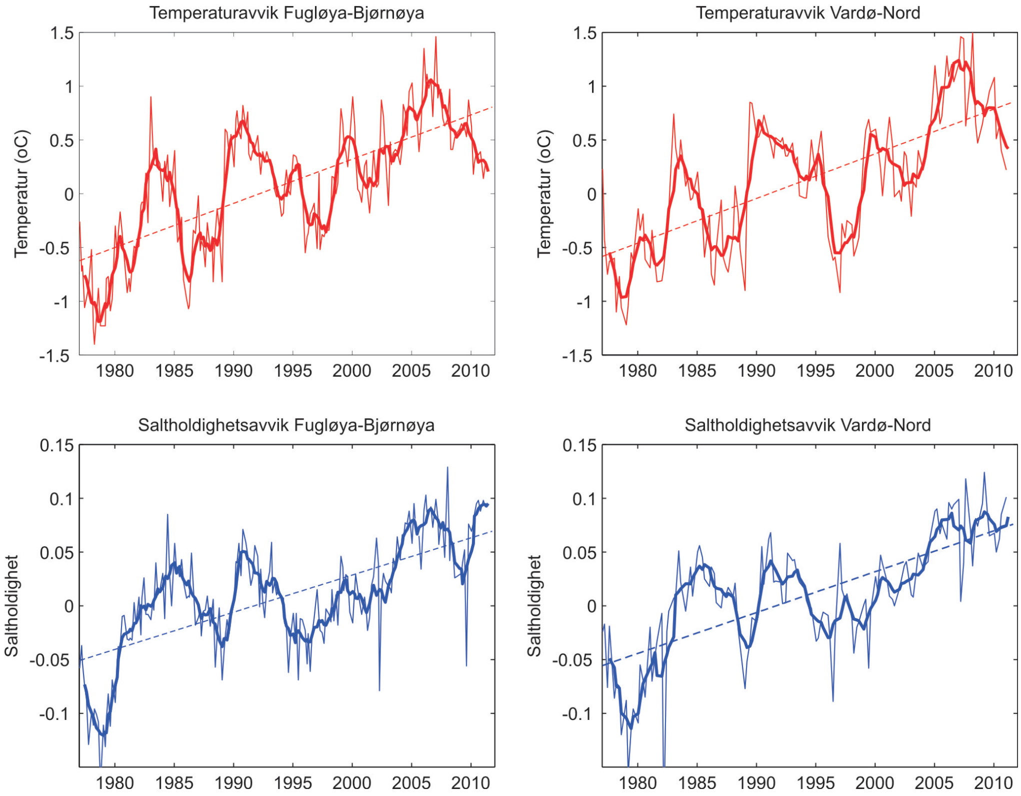


Figure 1.3. Temperature (upper) and salinity (lower) anomalies in the 50-200 m layer of the Fugløya-Bear Island Section (left panels) and Vardø-N Section (right panels).

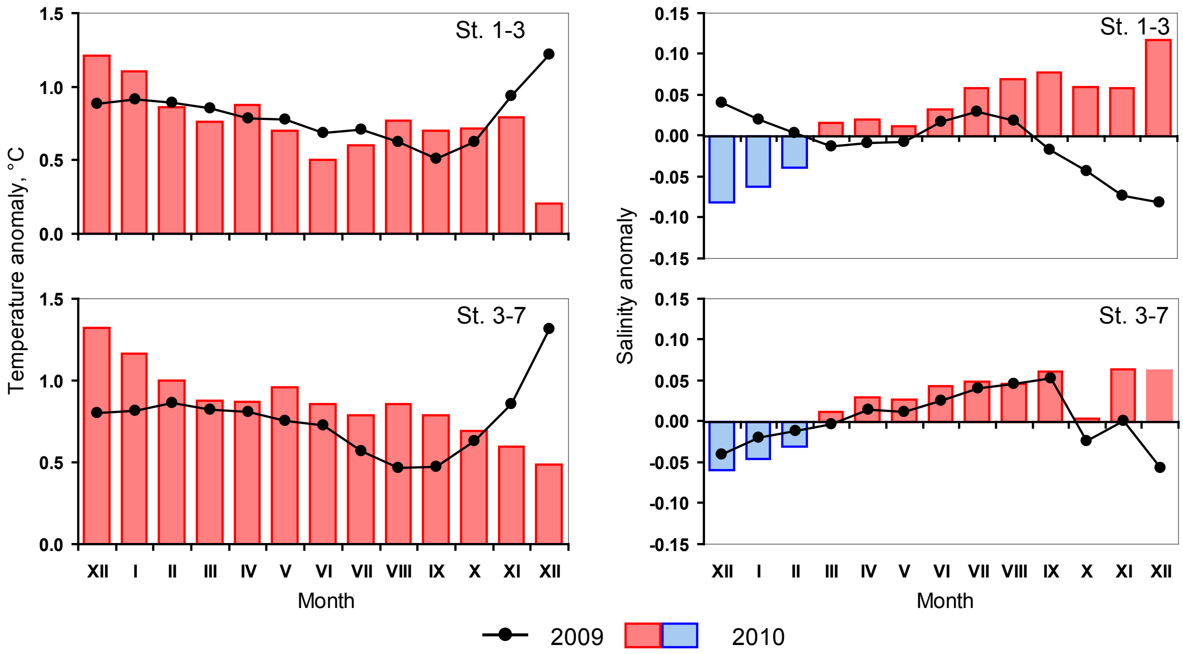


Figure 1.4. Monthly mean temperature (left) and salinity (right) anomalies in the 0-200 m layer of the Kola Section in 2009 and 2010. St. 1-3 – Coastal waters, St. 3-7 – Murman Current (Anon., 2011a).

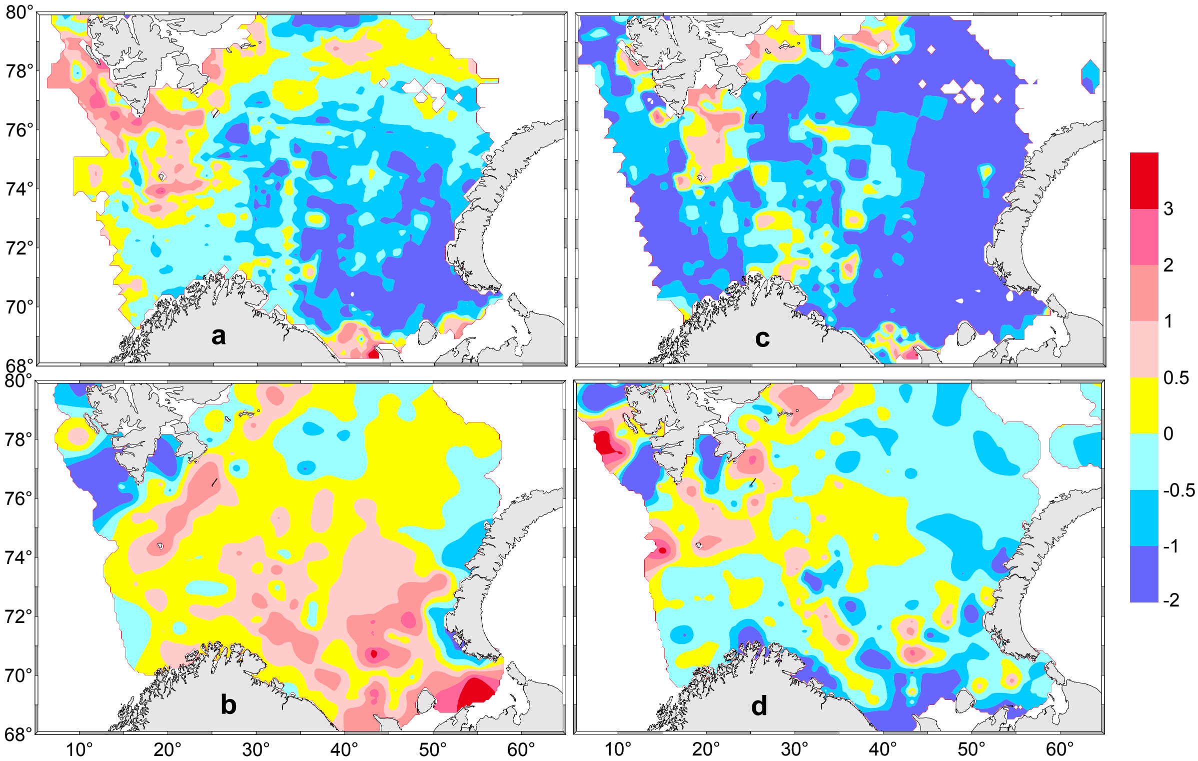


Figure 1.5 Surface (a) and bottom (b) temperature anomalies in August-September 2010 and differences in surface (c) and bottom (d) temperatures between 2010 and 2009.

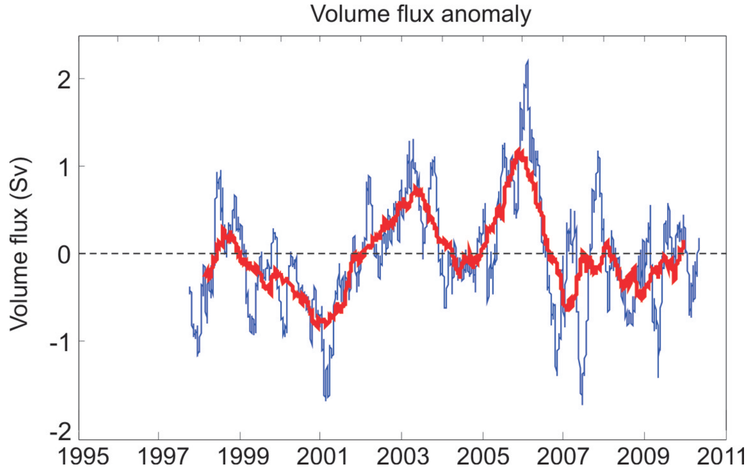


Figure 1.6. Observed Atlantic Water volume flux through the Fugløya-Bear Island Section estimated from current meter moorings. Three months (blue line) and 12-months (red line) running means are shown.

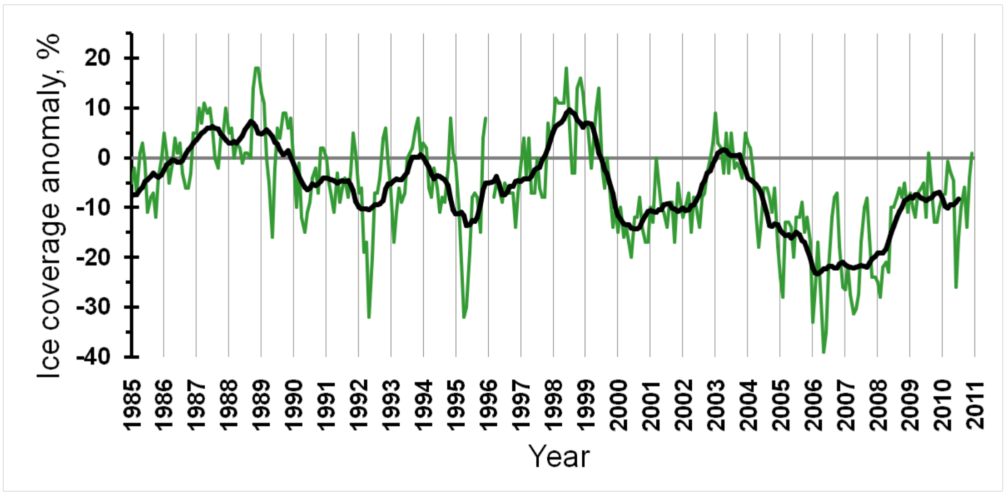


Figure 1.7. Anomalies of mean monthly ice extent in the Barents Sea in 1985-2010. The green line shows monthly values, the black one – 11-month moving average values (Anon., 2011a).

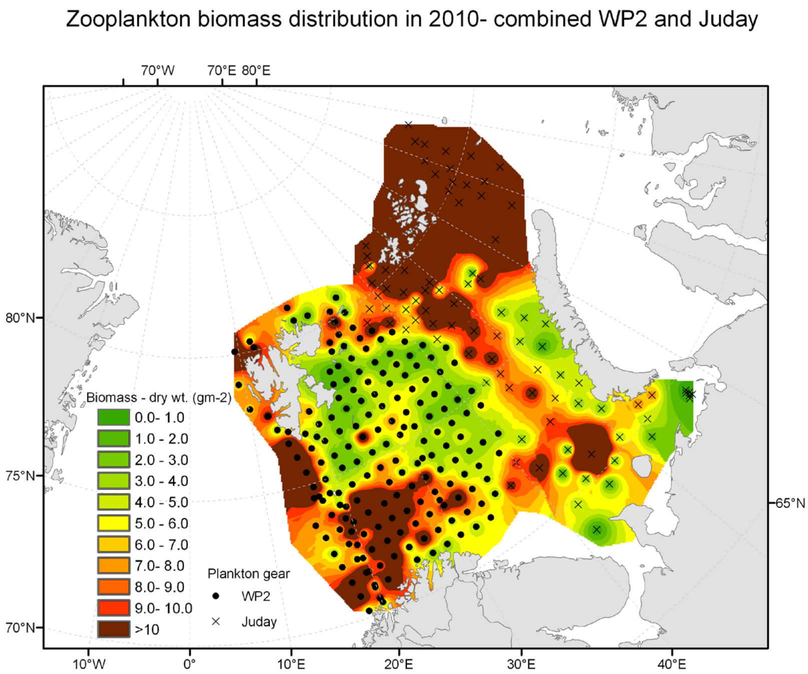


Figure 1.8. Distribution of zooplankton biomass (g/m^{-2} dry weight) in the Barents Sea in 2010 (by the catches by the Juday net and WP2).

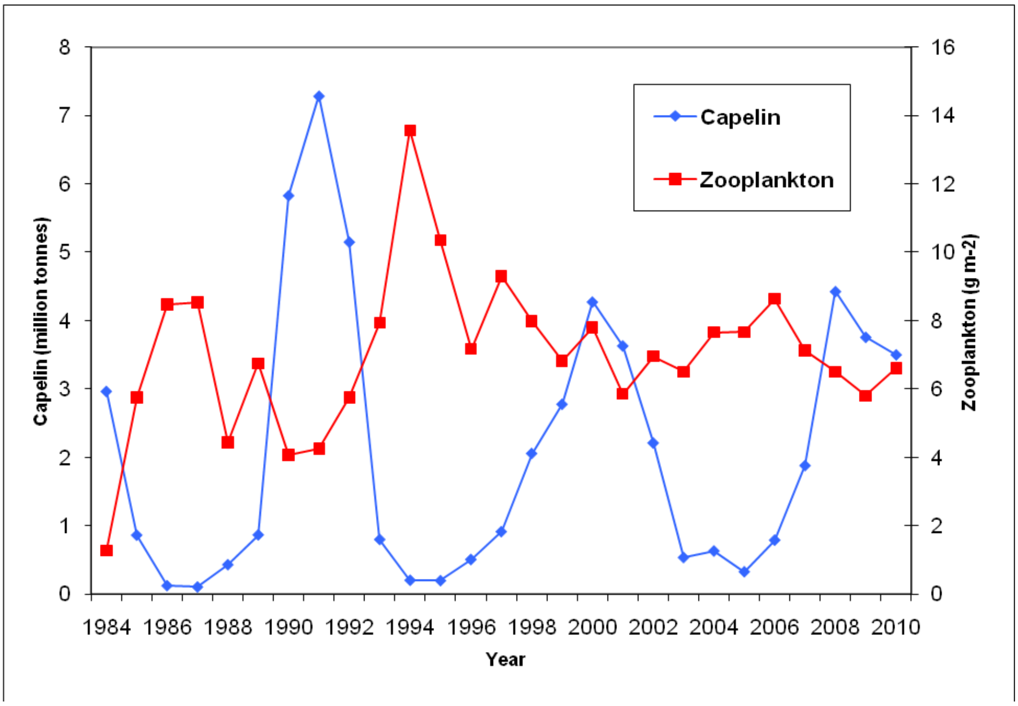


Figure 1.9. Annual variations in zooplankton biomass and the capelin stock in the Barents Sea (From Dalpadado *et al.* 2002, updated with data for 2001-present).

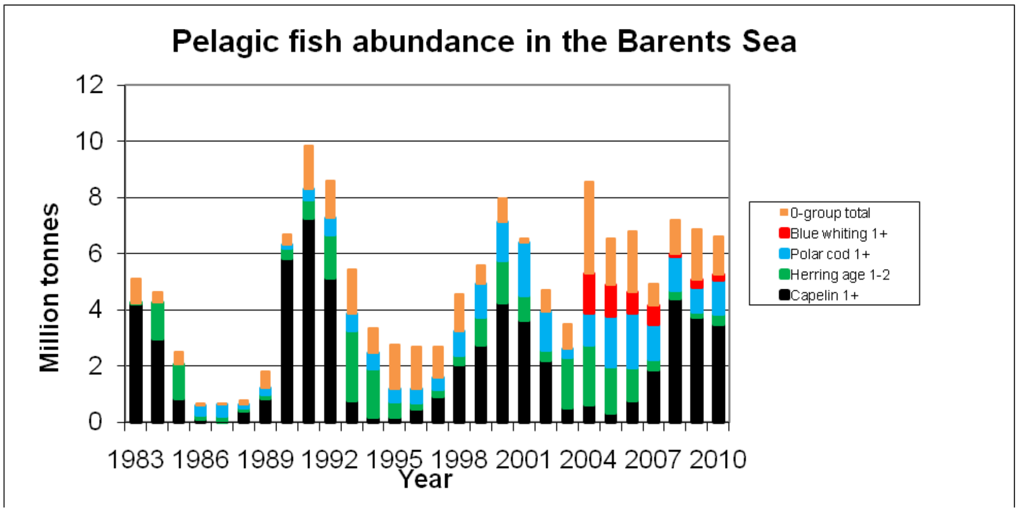


Figure 1.10. Biomass of pelagic fish species in the Barents Sea. Data are taken from; capelin: Acoustic estimates in September, age 1+ (ICES AFWG 2011), herring: VPA estimates of age 1 and 2 herring (ICES C.M. 2010/ACOM:15), using standard weights at age (9 g for age 1 and 20 g for age 2); polar cod and blue whiting: Acoustic estimates in September, age 1+ (Anon. 2010), 0-group: estimates of biomass of cod, haddock, herring and capelin 0-group, corrected for catching efficiency (Eriksen *et al.* 2011).

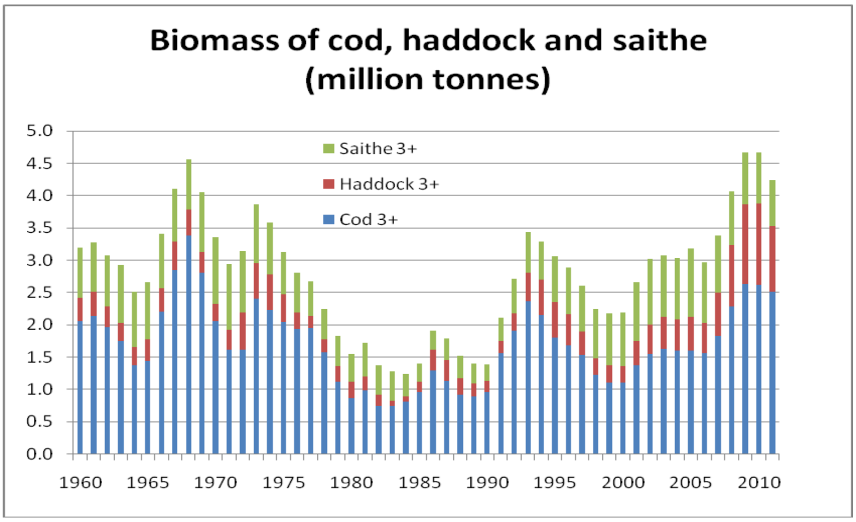


Figure 1.11. Biomass of cod, haddock and saithe, from the 2011 assessments.

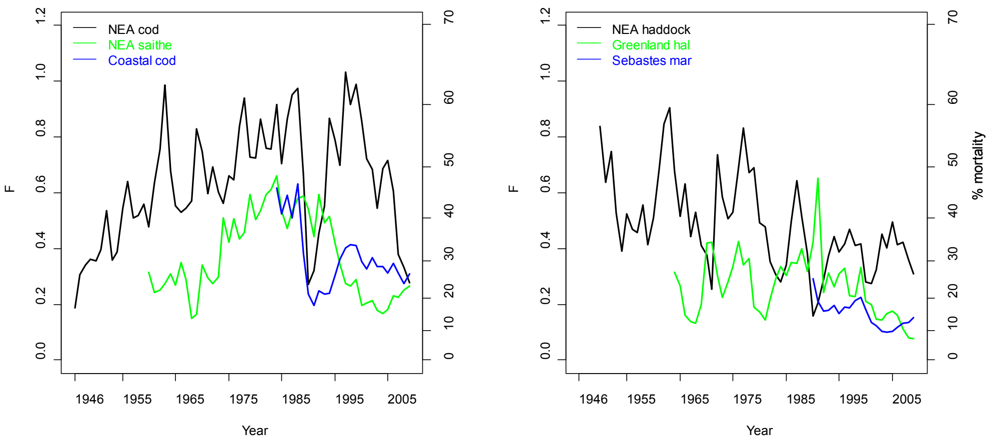


Figure 1.12a. Time series of annual average fishing mortalities for Northeast Arctic cod (time period 1946-2009, average for ages 5-10), Northeast Arctic saithe (time period 1960-2009, average for ages 4-7), coastal cod (1984-2009, average for ages 4-7), Northeast Arctic haddock (time period 1950-2009, average for ages 4-7), Greenland halibut (time period 1964-2009, average for ages 6-10) and *Sebastes marinus* (time period 1990-2009, average for ages 12-19).

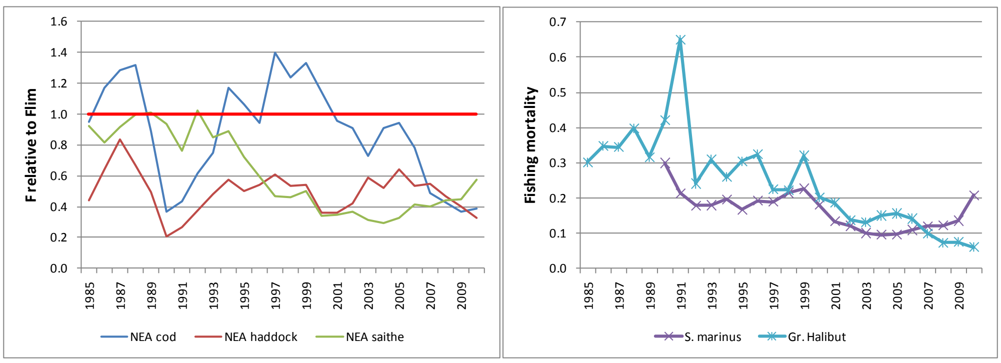


Figure 1.12b. Left panel - annual fishing mortalities of the Northeast Arctic cod, haddock and saithe stocks relative to the critical levels above which the fishing mortality will impair the recruitment. Right panel - annual fishing mortalities of Golden redfish (*Sebastes marinus*) and Greenland halibut (*Reinhardtius hippoglossoides*). No formal reference points have yet been adopted for the two latter stocks.

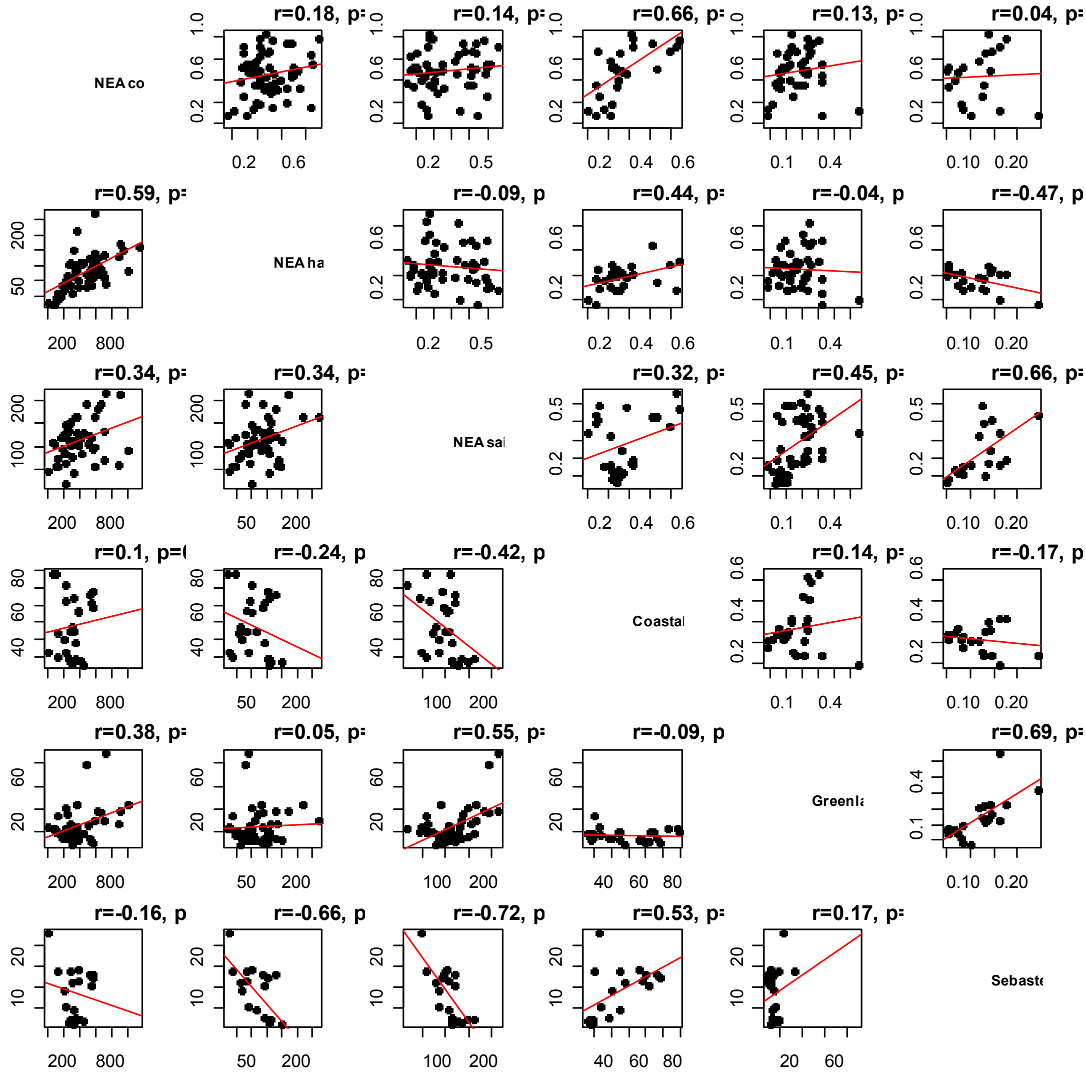


Figure 1.13. Pair-wise plots of annual average fishing mortalities (above diagonal) and landings (below diagonal) for overlapping time periods for Northeast Arctic cod (time period 1946-2009, average for ages 5-10), Northeast Arctic haddock (time period 1950-2009, average for ages 4-7), Northeast Arctic saithe (time period 1960-2009, average for ages 4-7), coastal cod (1984-2009, average for ages 4-7), Greenland halibut (time period 1964-2009, average for ages 6-10) and *Sebastes marinus* (time period 1990-2009, average for ages 12-19). The correlation and the corresponding p-value are given in the legend.

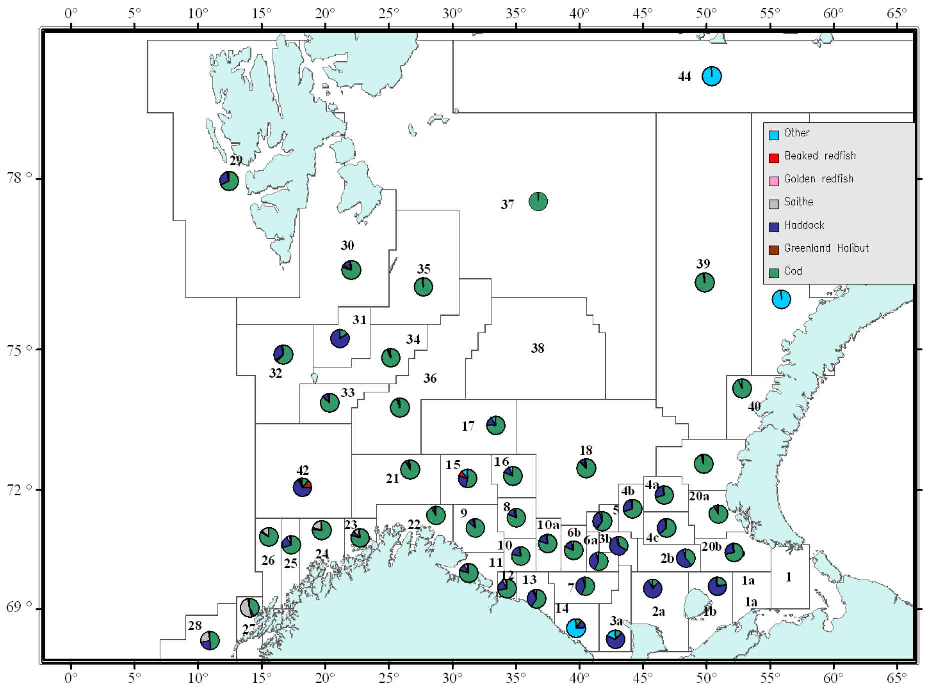


Figure 1.14. Relative distribution by weight of cod, haddock, saithe, Greenland halibut, golden redfish (*Sebastes marinus*), beaked redfish (*Sebastes mentella)* and other species taken by Russian bottom trawl in 2009 per main area for the Russian strata system. ***The Figure was not updated this year.***

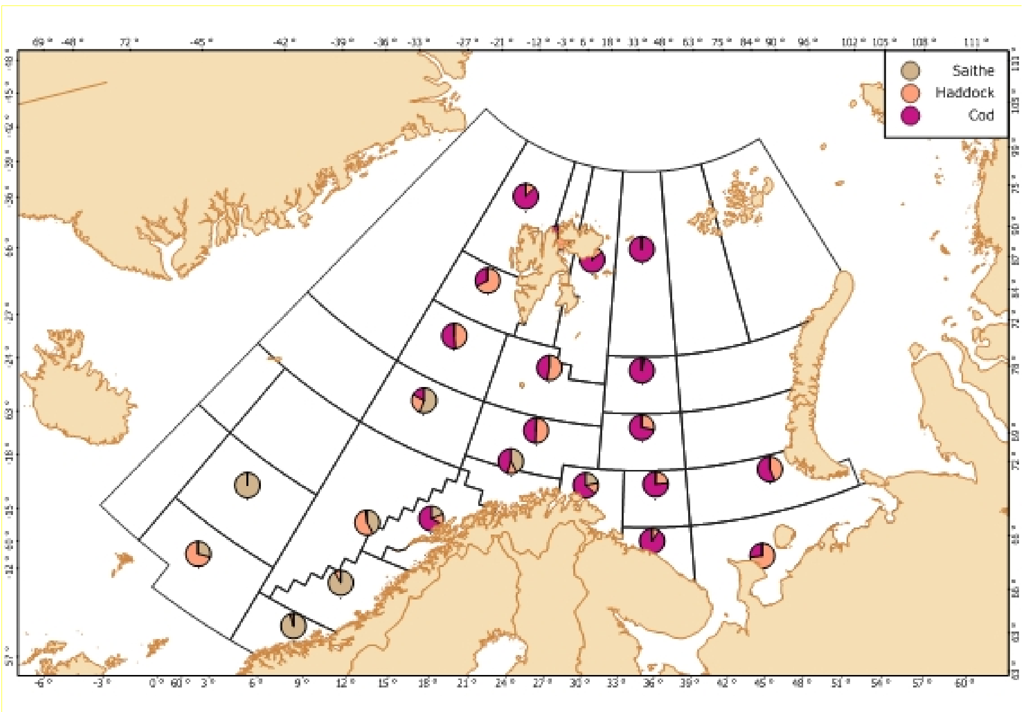


Figure 1.15. Relative distribution by weight of Norwegian catches of cod, haddock, and saithe per main area in 2009 for the Norwegian strata system. ***The Figure was not updated this year.***

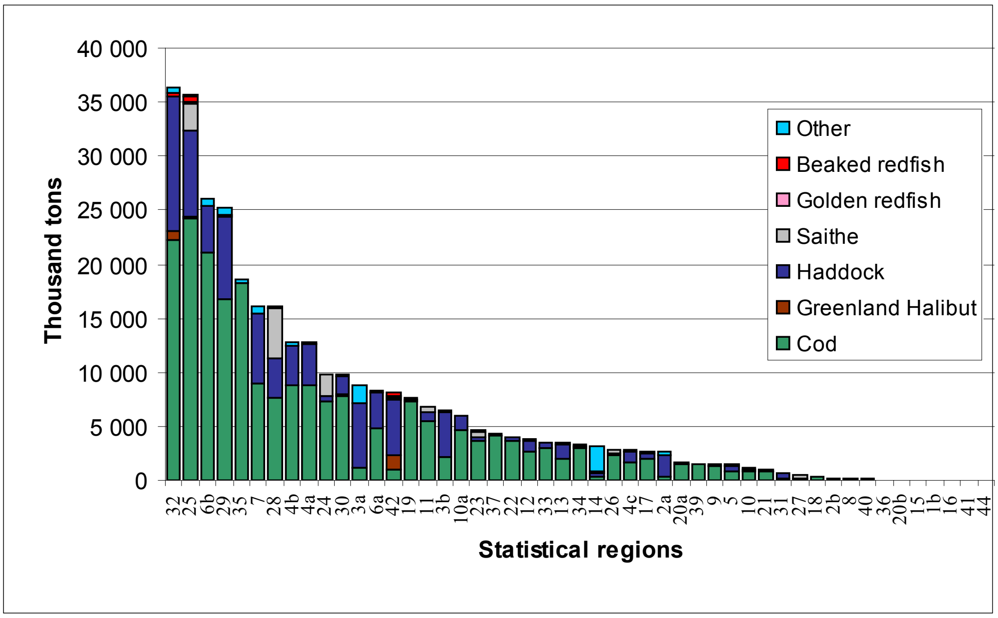


Figure 1.16. The Russian catch of cod, haddock, saithe, Greenland halibut, *Sebastes marinus*, *Sebastes mentella* and other species taken by bottom trawl by main statistical areas in 2009, thousand tonnes. The statistical areas correspond to the areas shown in Figure 1.14. *The Figure was not updated this year.*

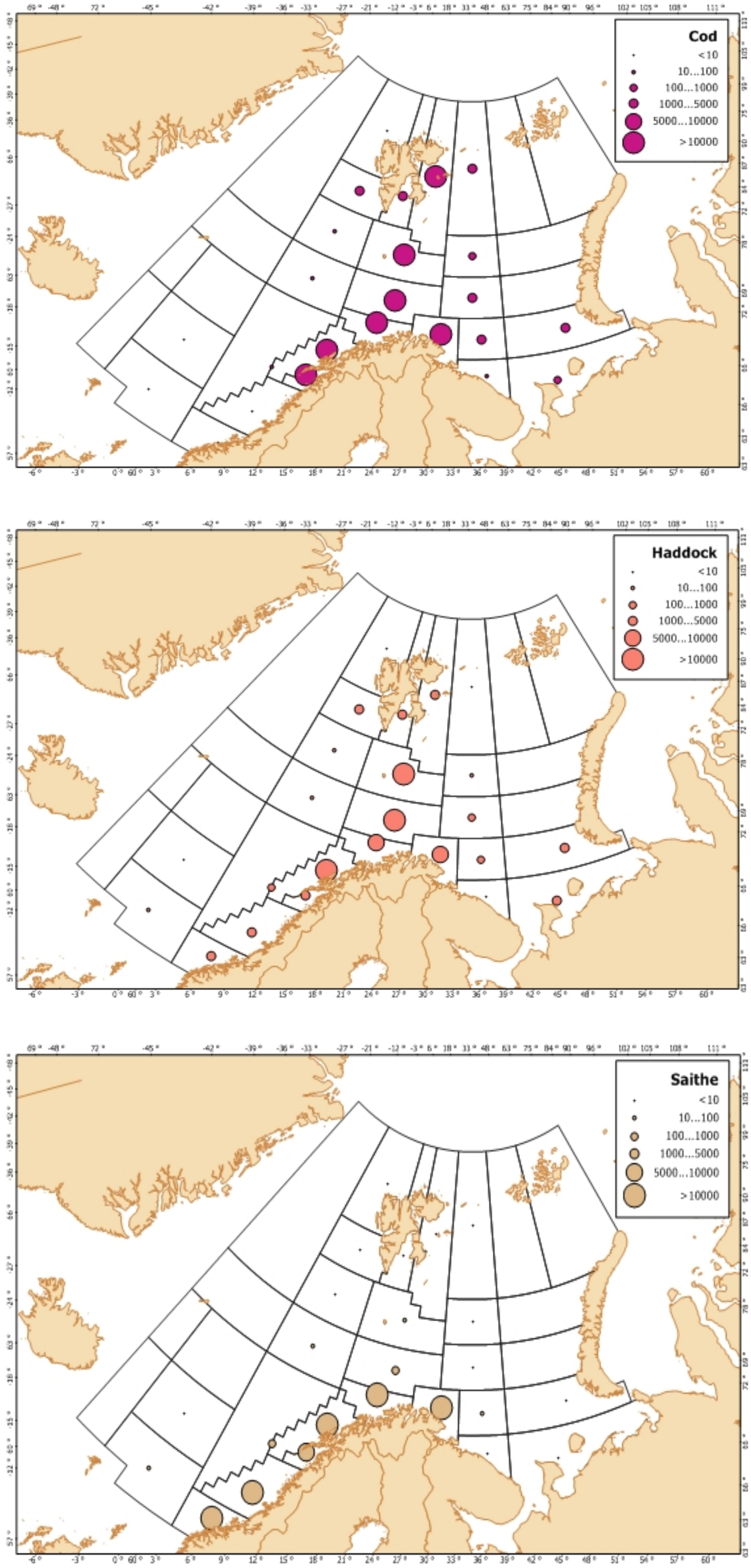


Figure 1.17. The Norwegian catch of cod, haddock and saithe by main statistical areas in 2009, thousand tonnes. The statistical areas correspond to the areas shown in Figure 1.15. ***The Figure was not updated this year.***

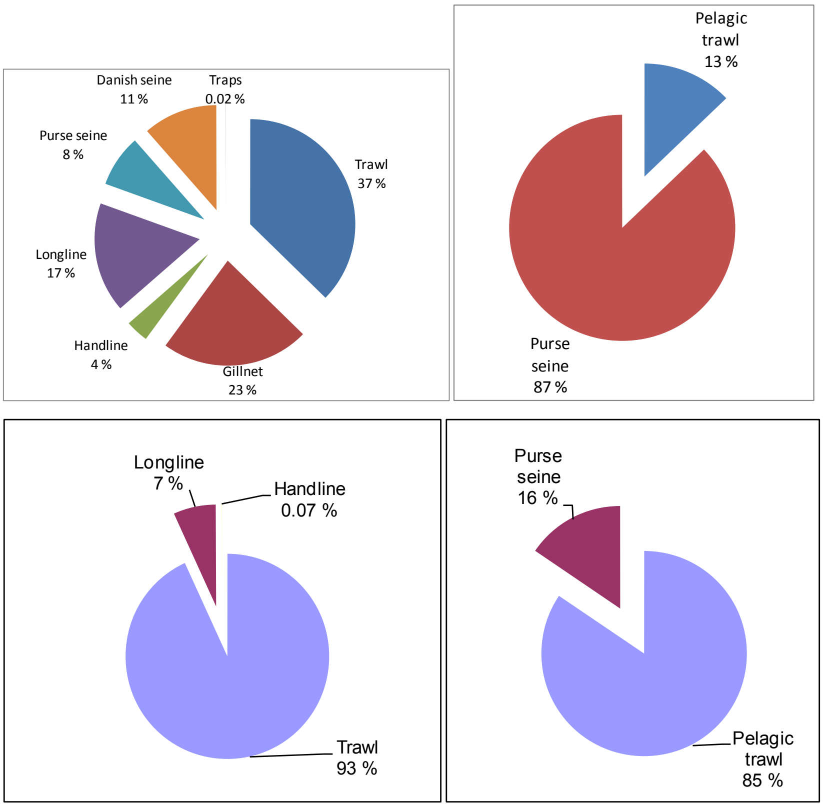


Figure 1.18. Upper panel - gear composition of the Norwegian groundfish (2007; left) and pelagic capelin (2000-2008; right) fisheries in the Northeast Arctic. Note that the purse seine in the groundfish fishery is solely used in a coastal fishery for saithe. Lower panel - gear composition of the Russian groundfish (2007; left) and pelagic capelin (2000-2008; right) fisheries in the Northeast Arctic. ***The Figure was not updated this year.***

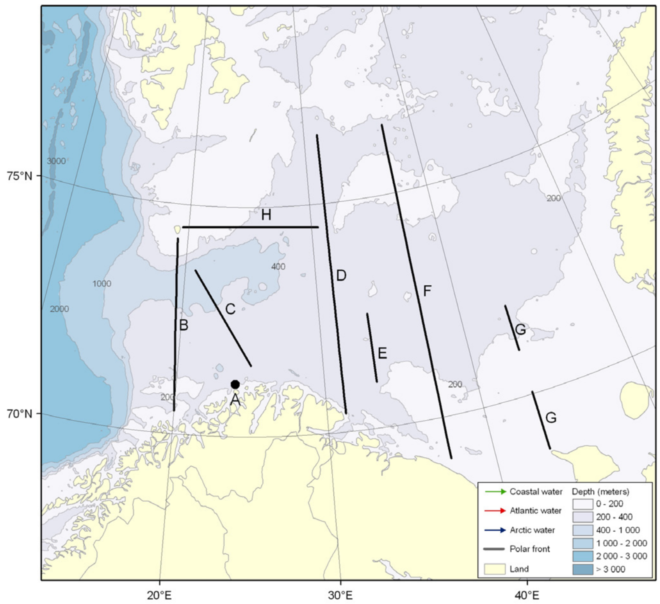


Figure 1.19. Positions of the standard sections monitored in the Barents Sea. A is fixed station Ingøy, B is Fugløya-Bear Island, C is North cape-Bear Island, D is Vardø-North, E is Kola, F is Sem Island-North G is Kanin section and H is Bear Island-East section.

2 Cod in subareas I and II (Norwegian coastal waters)

Type of assessment: "Update"

2.1 Fisheries

Coastal cod is to a variable extent fished throughout the year and within nearly all the distribution area (inside the 12 n.mile zone in the Norwegian statistical areas 03, 04, 05, 00, 06, 07, Figures 2.1- 2.3). The main fishery for coastal cod takes place in the first half of the year. The main fishing areas are along the coast from Varangerfjord to Lofoten (areas 03, 04, 05, 00).

Except for the open fjords in eastern Finnmark, the quantities fished inside fjords are quite low. The total share between gear types in the estimated coastal cod commercial landings has in recent years been around 50% for gillnet, 20% for Danish seine, 20% for long-line/hand-line and less than 5% for bottom trawl.

Recreational fisheries take an important fraction of the catches in some local areas, especially near the coastal cities and in some fjords where commercial fishing activity is low. There is no reporting system for the amount of Norwegian coastal cod (NCC) taken by recreational or tourist fishers in Norway. However, there are a few reports trying to assess the amount in certain years. In 2010 these reports were used to construct a time series (ICES CM 2010/ACOM:05) of recreational/tourist catches. These catch estimates are considered to be rather uncertain. No additional information was reported this year, and the recreational/tourist catch in 2010 was assumed equal to the one estimated for 2009 (12,700 t). The total catch number at age (Table 2.1c) was upscaled according to the added amount in tonnes.

2.1.1 Sampling fisheries and estimating catches (Tables 2.1-2.4, Figures 2.1-2.5)

The commercial catches of Norwegian Coastal cod (NCC) have been calculated back to 1984 (Table 2.1a). For this period the estimated landings have been between 22,000 and 75,000 t. The estimated commercial landings of NCC in 2009 are 24,821 t and in 2010 they are estimated to 22,925 t (Table 2.1a, Figure 2.4). Table 2.1b shows the estimated catch by gears, area and quarters in 2010.

Commercial catches of cod are separated to types of cod by the structure of the otoliths in commercial samples. Figure 2.5 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 north-east Arctic cod, and the distance between the first and the second translucent zone is larger* (Fig. 2.5). *The shape of the first translucent zone in north-east Arctic cod is similar to the outer edge of the broken otolith and to the subsequent established translucent zones. This pattern is established at an age of 2 years, and error in differentiating between the two major types does not increase with age since the established growth zones do not change with age*. The precision and accuracy of the separation method has been investigated by comparison of different otolith readers and results from genetic investigation of cod. The results indicate high accuracy using in the otolith method (Berg *et al*., 2005). Nevertheless, in cases with a low percentage misclassification of large catches of pure NEA cod, the catches of coastal cod could be severely overestimated.

The basis for estimating coastal cod catches is the total landings of cod inside the 12 n. mile zone in the Norwegian statistical areas 03, 04, 05, 00, 06, 07 (Figures 2.1-2.3), combined with the sampling of these fisheries. Tables 2.2a,b show the sampling of the cod fishery by quarters and areas in 2010 and 2009. Table 2.3 compares the samples by quarters for the period 1985-2010. The total number of age samples in 2010 was 275. 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. A total of 5,554 fish were aged. 2,097 of these otoliths were classified as coastal cod. The sampling has decreased in 2010 in all statistical areas except area 6+7 (Table 2.2a,b).

Table 2.4 shows the estimated catches of coastal cod by statistical area and quarter for the years 2007-2010. The corresponding fractions of coastal cod in cod catches are also shown. In the southern areas (06/07) the proportions are close to 1.0 in all quarters, except for some years when some NEA cod spawn far to the south in quarter 1 and 2. In the other areas the proportions are lower in quarter 1 and 2 in all years due to the spawning migration of NEA cod. In area 03 (eastern Finnmark) a considerable proportion of NEA cod is present also during autumn. Table 2.4 shows lower fractions of coastal cod in all areas in quarter 1 and 2 in 2010 compared to previous years. This is due to increased availability of NEA cod in coastal areas in 2010. The total cod catches in coastal areas increased by 28% in 2010 compared 2009.

The calculation of coastal cod landings for recent years has been problematic for parts of the Lofoten area. This relates to the Norwegian statistical area 00 (outer Vestfjord, the area south of Lofoten archipelago, Figure 2.3) in quarter 1 and 2. This area has historically been an important spawning area for Northeast Arctic cod. In the period 2004-2010 a major part of the Northeast Arctic cod was spawning in the outer, south-western part of the area, and almost nothing in the north-eastern part. Most of the commercial catches in the area were taken in the south-western part (locations 03 and 04, Figure 2.3) where the density of cod was much higher than in the north-eastern part. In the same period the sampling intensity has been highest for the catches in the north-eastern part (locations 46 and 48) where coastal cod dominated. (In most of this north-eastern area the fishery was restricted to vessels below 15m and use of Danish seine was not allowed). The catch sampling has not been sufficiently accurate to split the catches between those locations. In addition, the catch reporting to locations has in some years been inaccurate (while the recorded positions of the samples are considered to be accurate). Merging all samples in the whole area is therefore considered to overestimate landings of coastal cod. In order to obtain a more realistic catch in the area for the years 2004-2009, the working group has in the years from 2007 used only the samples taken from the south-western part for separating the total catch in the area between coastal cod and Northeast Arctic cod.

In mid-2009 the Institute of Marine Research closed down an important part of the coastal landings sampling programme. This was meant to be compensated by increased sampling by the "reference fleet". This was not fully achieved, and thereby too few cod samples were obtained from the Lofoten area (Area 00) in 2010. The samples from Vesterålen (Area 05) were therefore applied to the catches in Lofoten. The estimated catches of coastal cod are thus even more uncertain than in previous years.

2.1.2 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. The fishery is regulated by the same minimum catch size, minimum mesh size on the fishing gears as for the Northeast Arctic cod, maximum by-catch of undersized fish, closure of areas having high densities of juveniles, and by 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 except for about 10 fresh fish trawlers which in a few areas have a dispensation to fish between the 4 and 6-mile line in the period 15 April – 15 September. Since the mid-1990s the fjords in Finnmark and northern Troms (areas 03 and 04) have been closed for fishing with Danish seine. Since 2000, the large longliners have been restricted to fish outside the 4-nautical mile line. To achieve a reduction in landings of coastal cod additional technical regulations in coastal areas were introduced in May 2004 (after the main fishing season) and continued with small modifications in 2005 and 2006. In the new regulations "fjord-lines" are drawn along the coast to close the fjords for direct cod fishing with vessels larger than 15 meters. A box closed to all fishing gears except hand-line and fishing rod is defined in the Henningsvær–Svolvær area. This is an area where spawning concentrations of coastal cod are usually observed and where the catches of coastal cod has been high. Since the coastal cod is fished under a merged coastal cod/northeast Arctic cod quota, these regulations are aimed at moving parts of the traditional coastal fishery from the catching of coastal cod in the fjords to a cod fishery outside the fjords, where the proportion of northeast Arctic cod is higher. Further restrictions were introduced in 2007 by not allowing pelagic gillnet fishing for cod and by reducing the allowed bycatch of cod when fishing for other species inside fjord lines from 25% to 5%, and outside fjord lines from 25% to 20%. The regulations were maintained in 2008. Since 2009 the most important spawning area in the southern part of the stock distribution area (Borgundfjorden near Ålesund) has been closed to fishing (except for hand line and fishing rod) during the spawning season.

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

10,000 t of the Norwegian cod quota was in 2010 and 2011 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).

Additional regulations in 2011: No dispensations for fresh fish trawlers to fish inside 6 mile. In the recreational fishery the maximum gill net length per person is 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.

2.2 Survey data

A trawl-acoustic survey along the Norwegian coast from the Russian border to 62°N was started in the 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. This new survey covers a larger area than the coastal surveys in 1995-2002. However, the survey indices for cod to be used in this report are calculated using the same area coverage and the same method as in the years previous to 2003.

2.2.1 Indices of abundance and biomass (Tables 2.5–2.11, Figures 2.7–2.12)

The results of the 2010 survey (Mehl *et al.* 2010) are presented in Tables 2.5-2.11 for the area inside the 12 n. miles border in the Norwegian statistical areas 03, 04, 05, 00, 06, and 07 (Figures 2.1 and 2.2). The survey time series of estimated numbers of NCC per age group is given in Table 2.6 and in Figure 2.6. For most age groups the estimates are close to the lowest ever observed. In 2010 both the total biomass (Table 2.9) and the spawning biomass (Table 2.11 and Figure 2.14) was the lowest observed.

The pattern seen (Figure 2.6) over the full time series of abundance at age is that ages 2 and 3 have declined more, and over a longer period, compared to the older fish. The series now indicates a rather stable stock at a low level. The period since 2002 shows considerable variation, however, without any trend.

Figures 2.7-2.12 show the time series of stock number within each statistical area. In areas 03, 04 and 05 the decline since the late 1990s is rather parallel. In the other three areas the year-to- year variation is larger, but similar trends are indicated. These latter, southern areas contribute less to the total estimate.

2.2.2 Age reading and stock separation (Tables 2.4, 2.5, 2.8–2.12)

A total of 2271 cod otoliths were sampled during the 2010 survey.

As in previous years, NCC was found throughout the survey area. The 2010 survey data on the stock separation are similar to the 2007-2009 data and shows the same pattern as the whole 1995-2010 time series. The sampling showed a higher proportion of NCC in the fjords and to the south compared with the northern and outer areas. The proportion of the NCC increases going from north to south along the Norwegian coast. Table 2.12 shows the proportions of coastal cod in the survey samples by age for 6 previous years. The proportion is rather stable between years, but is consistently higher for young fish compared to old. Nearly all otoliths collected south of 67° N (Norwegian statistical areas 06 and 07) were NCC type. Although the proportions are lower, the total abundance of NCC is higher north of 67° N (Table 2.5).

It must be emphasised that the Norwegian coastal surveys is conducted in October-November, and there is usually more NEA cod in the coastal areas at other times of the year, especially during the spawning season in the late winter. This is reflected in the commercial sampling as shown in Table 2.4.

2.2.3 Weights at age (Table 2.8)

As observed in the earlier surveys, there is a general tendency for coastal cod to have higher weight at age when caught in the southernmost area. Table 2.8 shows the time series of mean weights at age for the whole survey.

2.2.4 Maturity-at-age (Table 2.10, Figure 2.13)

The fraction of mature fish in the autumn survey (Table 2.10) show rather large variation between years. Parts of this variation could be caused by the difficulty of distinguishing mature and immature cod in the autumn. Based on the records of spawning zones in the otoliths a back-calculation of proportion mature at age (Gulland, 1964) has been done. The analysis was based on samples from the spawning fisheries in March-April. The preliminary results are shown in Figure 2.13. 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.

2.3 Data available for the Assessment

2.3.1 Catch at age (Table 2.1 and table 2.14)

The estimated commercial catch at age (2-10+) for the period 1984-2010 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.

2.3.2 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 will, however, overestimate the stock biomass at the start of the year (Table 2.13).

2.3.3 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).

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

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

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

Earlier attempts to assess the stock using XSA analysis have shown retrospective problems. For several years the main basis for assessing the stock was the survey time series (plotted in Figures 2.6-2.13), and SURBA was used for further analysing the survey trends. Before the 2010 assessment a warning about errors in the SURBA software was received, and the program was not used.

In the 2010 WG mortality signals from the survey and from the catch at age data were analysed and an SVPA were run using the survey based estimate of F2009 (details described in Annex 10 in ICES CM 2010/ACOM:05). The same procedure was used this year: By using the survey indices for ages 2 to 8 (Table 2.6) a trial xsa (Tables 2.13-2.15) was run to obtain historic values of F(4-7). Calculated survey mortalities (Table 2.17 and Figure 2.15) were regressed with xsa Fs for the years 1996-2006 (Fig. 2.15). This regression was used for converting the 2010 survey mortality to a vpa F(4-7) (Table 2.16). A selection pattern for 2010 was estimated as the average pattern over the years 2008-2010 in the trial xsa, and Fs on oldest true age was taken from the trial xsa. The SVPA, which is considered as the final assessment, was run by using the survey based F(4-7) for 2010 combined with the selection pattern and oldest true Fs described above. The same procedure was repeated for catch at age data including estimates of recreational catches, but the trial xsa for that data set is not shown here.

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

Additionally, the mortality signal in the catch at age matrix was calculated (Figure 2.18), in a similar way, utilising the fact that the ratio between catch numbers of a cohort in two successive years is functionally related to the total mortality in the two years involved (details described in Annex 10 in ICES CM 2010/ACOM:05).

2.5 Results of the Assessment

2.5.1 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 2010 survey results are for most ages lower than in the 2009 survey, but more similar to the 2008 survey (Table 2.6, Figure 2.6). For the period after 2003 there is no obvious trend in the indices.

The survey based estimate of the F2010 relating to commercial catch is 0.38 and F2010 relating to total catch data is 0.37. The text table below compares those inputs (bold) and the resulting SVPA estimates with corresponding values last year. The agreement of the F-estimates seems better for the analysis based on commercial catch than for the one based on total catch.

	F2008	F2009	F2010	SSB 08	SSB 09	SSB 10
Com.catch 2010 assess	0.32	**0.37**		48	46	
Com.catch 2011 assess	0.32	0.38	**0.38**	56	50	44
Tot.catch 2010 assess	0.27	**0.31**		85	80	
Tot.catch 2011 assess	0.30	0.37	**0.37**	82	77	73

Some further comparisons are shown in Figures 2.16. The SVPA indicate a continued declining trend for SSB, while F seems variable without any clear trend. Figure 2.17 shows the SSB-series from VPA and survey, both scaled to their average over the years 1995-2010. Figure 2.18 compares the various time series of F.

2.5.2 Recruitment (Table 2.6, Figure 2.16)

The 2010 survey value for age 1 is the highest since 2001 (Table 2.6), but the index of age 1 has historically shown poor relation to year-class strength of the same cohort observed in the survey at older ages. Ages 2-4 in the survey are among the lowest in the time series. The SVPA results (Figure 2.16) indicate that the recruitment decline stopped around 2006, but this has to be regarded highly uncertain.

It is worth noting that the recruitment started to decline a few years before the spawning stock, indicating that the recruitment failure is the cause for the stock decline.

2.5.3 Catches in 2011

No catch predictions have been made. Assuming a slowly declining stock, the availability of coastal cod in 2011 is expected to decrease.

In the winter/ spring fishery in 2011 North-east arctic cod was even more available in coastal waters than in 2010. This has most likely lead to low by-catches of coastal cod so far in the year. Some additional conservation measures are in operation, and one would expect some reduction in total catch of coastal cod in 2011.

2.6 Comments to the Assessment

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

Reduced sampling of commercial catches in most areas in 2010 has increased the uncertainty.

The new 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.

2.7 Reference points

The analyses made for evaluating the Rebuilding Plan (Annex 10 in ICES CM 2010/ACOM:05) also gave some information regarding reference points. The assessment based on commercial catch plus recreational catch gives a stock-recruit break point at 139,000 t SSB. The corresponding F_{crash} is estimated to 0.38.

The stock-recruit development may indicate that recruitment conditions may have changed. Assuming that increased SSB will not give recruitments higher than those observed for the year classes 2000-2005, we get a break point at 103,000 t SSB. This is a reasonable candidate for B_{lim}. The corresponding F_{crash} is 0.32, which is a candidate for F_{lim}. $F_{0.1}$ is estimated to 0.16. The highest yield was modelled close to F_{crash}. Thus a safe long term F_{msy}-target could be considered in the range 0.16-0.32. A corresponding MSY Btrigger would be in the range 150,000 – 200,000 t. These MSY considerations are still preliminary.

2.8 Management considerations

Catches have remained rather stable since 2004. The regulations seem to have reduced the catches compared to pre-2004 level but have not been sufficient to cause further reduction. The time series of recreational catch show rather stable catches, and they represent thereby a higher fraction (about 35%) after 2004 compared to before.

2.9 Rebuilding plan for coastal cod

The following rebuilding plan was suggested by Norway in 2010:

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

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

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

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

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

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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 at 1 October 2010. The conclusions are:

Based on simulations, ICES concludes 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. Whilst not fully quantifiable, the needed reductions in fishing mortality will require accompanying reductions in the catches.

ICES considers the proposed rule to be provisionally consistent with the Precautionary Approach. The basis of this evaluation is the precautionary approach, and not the new ICES MSY framework. However, it is anticipated that ongoing work will provide a basis for revisiting the consistency of the proposed rule with the ICES MSY framework in the next year or two. ICES notes that there is no basis at present for deriving absolute estimates of F_{msy}*. However, it is likely that the current F is above any candidate values of* F_{msy} *and the plan therefore represents a step towards MSY.*

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

2.10 Recent ICES advice

Since 2004 the advice has been; No catch should be taken from this stock and a recovery plan should be developed and implemented.

2.11 Response to the comments from the review group

The comments below refer to points and headings in the Technical Minutes from the 2010 review group (Annex 11 in ICES CM 2010/ACOM:05)

Point 7c: The TAC set for recreational fishery (10 kt) in 2010 was not set in addition to the quota for commercial fishery. It was allocated from the commercial fishery to the recreational fishery.

Under the General comments heading:

- No further analysis are made on accuracy of the estimated catches.
- Some additional information on maturity given in section 2.2.4 in this report.
- The WG agrees on the RG's comments on regarding comparing effects of various changes in input data and xsa-settings.

Under the Technical comments heading:

- 1. Agrees that benchmarking is needed
- 5. Acoustic survey results (not cpue) are now plotted relative to the average of the time series (Figures 2.7-2.13), as proposed by the RG.
- 7. In the vpa-analysis SSB is calculated at 1. January (specified in Table 2.13 in this report)
- 9-11. The methods used for estimating recreational and tourist catch is still considered tenuous.
- 12. The reason for not using SURBA was that the WG has been advised not to use it due to bugs in the program.

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

	Age									Tonnes
	2	3	4	5	6	7	8	9	10+	Landed
1984	829	3478	6954	7278	6004	4964	2161	819	624	74824
1985	396	7848	7367	8699	7085	3066	705	433	264	75451
1986	4095	4095	12662	8906	5750	3868	1270	342	407	68905
1987	170	940	8236	12430	4427	2649	1127	313	149	60972
1988	110	1921	3343	6451	6626	4687	1461	497	333	59294
1989	41	1159	1434	2299	5197	2720	949	236	86	40285
1990	7	349	1233	1330	1129	3456	773	141	73	28127
1991	125	607	1452	3114	1873	1297	873	132	94	24822
1992	40	665	3160	4422	2992	1945	898	837	279	41690
1993	4	369	1706	2343	2684	3072	1871	627	690	52557
1994	332	573	1693	4302	2467	3337	1514	777	798	54562
1995	810	896	2345	5188	5546	3270	1455	557	433	57207
1996	1193	2376	2480	4930	4647	4160	2082	898	543	61776
1997	1326	3438	3150	2258	2490	3935	3312	959	684	63319
1998	554	2819	4786	4023	2272	1546	1826	975	343	51572
1999	252	1322	2346	4263	2773	1602	751	774	320	40732
2000	156	971	3664	3807	2671	1104	326	132	152	36715
2001	44	505	1837	2974	1998	1409	542	187	119	29699
2002	192	893	2331	2822	2742	1538	915	325	377	40994
2003	81	1107	2094	2506	2158	1374	598	258	99	34635
2004	12	306	924	1713	1820	1444	609	226	264	24547
2005	15	474	1299	1828	1436	1115	513	188	143	22432
2006	71	315	1656	1695	1695	1246	671	326	224	26134
2007	88	515	1396	1846	1252	824	391	256	196	23841
2008	92	670	1438	1635	1232	862	440	215	170	25777
2009	3	238	1052	1280	1388	1065	545	172	276	24821
2010	14	710	1617	1895	1040	703	420	198	175	22925

Table 2.1b. Estimated commercial catch of coastal cod in 2010 by gear and area (tonnes).

Year		2010				
Area	03	04	00	05	06/07	Total
Gillnet	831	1 842	1 861	2 360	4 732	11 626
L.line/Jig	1 518	780	986	1 668	719	5 672
Danish seine	1 067	1 050	417	2 210	305	5 049
Trawl	420	108	1	44	5	578
Total	3 836	3 781	3 265	6 282	5 761	22 925

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

	AGE									Tonnes
	2	3	4	5	6	7	8	9	10+	landed
1984	1479	5209	9070	8945	7198	5561	2397	952	624	88124
1985	3558	10438	9733	10444	7732	3291	835	512	264	88851
1986	4722	7128	15330	10565	6889	4303	1521	481	407	82405
1987	278	2912	12244	14611	5076	3080	1236	351	149	74472
1988	744	3328	4910	8159	8714	5237	1590	591	333	72894
1989	459	1984	2917	4057	6610	3238	1057	270	86	53985
1990	408	1843	2485	2012	3838	3906	846	141	73	42627
1991	1308	3305	4448	4456	2681	1880	977	203	94	40122
1992	469	1946	5509	5913	3622	2459	1744	921	279	57790
1993	51	1645	2994	3156	3530	3768	2073	995	690	67357
1994	389	1274	3416	5017	3755	4008	1907	901	798	69262
1995	818	1228	3149	6639	7131	4050	1868	737	433	71907
1996	1214	2967	2989	5547	6144	5533	2543	1125	543	76276
1997	1377	4145	4173	3021	3225	5124	4000	1091	684	77819
1998	803	3956	7113	5339	2857	1956	2155	1230	343	66172
1999	301	1788	3791	6202	3693	1959	949	995	320	54632
2000	219	1525	4817	5322	3715	1448	453	241	152	50315
2001	44	848	2572	4020	2962	2282	740	321	119	43099
2002	248	1191	3161	3877	3681	2134	1250	490	377	54594
2003	166	1449	2758	3422	3076	1824	842	584	99	48535
2004	38	560	1407	2637	2919	2271	967	388	264	37947
2005	36	744	1957	2686	2289	1830	936	364	143	35632
2006	90	551	2672	2562	2678	1858	986	453	224	39134
2007	137	861	2155	2805	1858	1355	718	413	196	36841
2008	107	1065	2181	2473	1882	1262	701	349	170	38577
2009	3	322	1628	2007	2251	1665	825	262	276	37521
2010	21	1103	2512	2945	1616	1092	652	308	272	35625

Table 2.2a. Sampling from cod fisheries in 2009 in the statistical areas 00, 03,04,05, 06+07. Number of age samples of cod by quarter, total number of cod otoliths.

Quarter	3	4	0	5	6+7	Tot
1	23	36	28	73	24	184
2	33	18	0	15	6	72
3	11	2	1	0	0	14
4	21	28	5	19	16	89
Total samples	88	84	34	107	46	359
Total otoliths	2933	2765	976	3404	981	11059
Coastal cod type otoliths	492	599	276	508	765	2640

Table 2.2b. Sampling from cod fisheries in 2010 in the statistical areas 00, 03,04,05, 06+07. Number of age samples of cod by quarter, total number of cod otoliths.

Quarter	3	4	0	5	6+7	Tot
1	15	23	9	48	38	133
2	21	14	3	22	19	79
3	7	4	0	9	13	33
4	11	2	0	11	6	30
Total samples	54	43	12	90	76	275
Total otoliths	1057	858	267	1774	1598	5554
Coastal cod type otoliths	130	109	100	459	1299	2097

Table 2.3 Number of otoliths sampled by quarter from commercial catches in the period 1985-2010. CC=coastal cod, NEAC=Northeast Arctic cod.

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

Table 2.4. Landings in tonnes of Coastal cod by area and quarter 2007-2010 (upper 4 tables) Proportion (of total) coastal cod in landings by area and quarter 2007-2010 (lower 4 tables).

Year	2007					
Qu./Area	03	04	00	05	06-07	Total
1	664	1812	3787	2274	3843	12380
2	2962	1762	679	803	1324	7530
3	416	393	537	279	423	2049
4	557	343	346	354	283	1883
Total	4599	4311	5349	3709	5873	23841

Year	2008					
Qu./Area	03	04	00	05	06-07	Total
1	653	2206	3964	2222	4090	13134
2	2005	2162	1116	979	1640	7902
3	513	647	287	332	434	2212
4	356	793	424	657	299	2529
Total	3526	5807	5791	4190	6463	25777

Year	2009					
Qu./Area	03	04	00	05	06-07	Total
1	1122	1073	4537	3006	3581	13318
2	723	1195	715	1461	985	5079
3	640	394	340	633	398	2405
4	1009	1161	286	1196	367	4019
Total	3494	3824	5877	6295	5331	24821

Year	2010					
Qu./Area	03	04	00	05	06-07	Total
1	425	1141	1585	3442	3334	9939
2	1564	1341	1262	1385	1711	7263
3	853	603	225	480	362	2523
4	993	696	192	975	343	3199
Total	3836	3781	3625	6282	5761	22925

Year	2007					
Qu./Area	03	04	00	05	06-07	Total
1	0.08	0.09	0.24	0.07	0.79	0.16
2	0.28	0.13	0.24	0.23	0.95	0.23
3	0.33	0.49	0.98	0.50	1.00	0.57
4	0.23	0.36	0.98	0.52	0.90	0.40
Total	0.20	0.12	0.28	0.11	0.84	0.20

Year	2008					
Qu./Area	03	04	00	05	06-07	Total
1	0.10	0.10	0.23	0.08	0.86	0.17
2	0.22	0.19	0.29	0.27	0.92	0.26
3	0.30	0.60	0.95	0.60	1.00	0.54
4	0.14	0.65	0.95	0.57	1.00	0.44
Total	0.18	0.16	0.27	0.12	0.89	0.22

Year	2009					
Qu./Area	03	04	00	05	06-07	Total
1	0.14	0.07	0.25	0.09	0.77	0.17
2	0.06	0.14	0.25	0.32	0.87	0.17
3	0.25	0.35	1.00	0.81	0.98	0.46
4	0.50	0.70	0.96	0.81	0.98	0.69
Total	0.14	0.15	0.27	0.16	0.81	0.21

Year	2010					
Qu./Area	03	04	00	05	06-07	Total
1	0.05	0.05	0.09	0.09	0.68	0.10
2	0.11	0.09	0.23	0.23	0.91	0.17
3	0.42	0.61	0.78	0.78	1.00	0.59
4	0.38	0.77	0.78	0.78	1.00	0.60
Total	0.14	0.09	0.13	0.13	0.77	0.15

Table 2.5. Coastal cod. Acoustic abundance indices by sub areas and in total in 2010 (in thousands).

Area	Age (Year class) 1 (08)	2 (07)	3 (06)	4 (05)	5 (04)	6 (03)	7 (02)	8 (01)	9 (00)	10+ (99+)	Sum
03	2618	336	610	804	713	262	122	190	94	62	5811
04	3000	1513	1362	1095	970	503	193	199	89	187	9112
05	1979	445	247	142	219	49	0	9	12	12	3125
00	19	11	181	260	142	77	99	14	47	19	870
06	129	198	272	484	314	179	87	0	10	25	1698
07	24		56	35	59	26	0	13	7	0	221
Total	7768	2513	2729	2820	2417	1098	501	426	260	305	20837

Table 2.6. Coastal cod. Acoustic abundance indices by age 1995 – 2010 (in thousands).

Year	*Age* 1	2	3	4	5	6	7	8	9	10+	Sum
1995	28707	20191	13633	15636	16219	9550	3174	1158	781	579	109628
1996	1756	17378	22815	12382	12514	6817	3180	754	242	5	77843
1997	30694	18827	28913	17334	12379	10612	3928	1515	26	663	124891
1998	14455	13659	15003	13239	7415	3137	1578	315	169	128	69099
1999	6850	11309	12171	10123	7197	3052	850	242	112	54	51960
2000	9587	11528	11612	8974	7984	5451	1365	488	85	97	57171
2001	8366	6729	7994	7578	4751	2567	1493	487	189	116	40270
2002	1329	2990	4103	4940	3617	2593	1470	408	29	128	21607
2003	2084	2145	3545	3880	2788	2389	1144	589	364	80	19008
2004	3217	3541	3696	4320	2758	1940	783	448	98	110	20914
2005	1443	1843	3525	3198	3217	1700	1120	552	330	78	17006
2006	1929	2525	4049	3783	3472	2509	1811	399	229	13	20719
2007	2202	3300	4080	5518	3259	2447	1444	760	197	34	23241
2008	2128	2181	2475	2863	2101	1219	815	403	319	177	14681
2009	3442	2059	2722	3959	2536	1603	1259	793	443	141	18955
2010	7768	2513	2729	2820	2417	1098	501	426	260	305	20837

Table 2.7. Coastal cod. Mean length (cm) at age 1995 – 2010.

	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

Table 2.8. Coastal cod. Mean weight (grams) at age 1995-2010.

	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

Table 2.9. Coastal cod. Acoustic biomass indices (tonnes) in 1995 – 2010.

	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

Table 2.10. Coastal cod. Maturity at age as determined from maturity stages observed in the surveys over the period 1995 – 2010.

						Age				
Year	1	2	3	4	5	6	7	8	9	10+
1995	0.00	0.00	0.01	0.21	0.48	0.71	0.87	0.87	1.00	1.00
1996	0.00	0.00	0.03	0.25	0.56	0.81	0.92	0.99	1.00	1.00
1997	0.00	0.00	0.06	0.29	0.45	0.76	0.97	1.00	1.00	1.00
1998	0.00	0.02	0.15	0.25	0.53	0.74	0.87	0.89	1.00	1.00
1999	0.00	0.02	0.03	0.21	0.43	0.66	0.74	1.00	1.00	1.00
2000	0.00	0.00	0.00	0.16	0.31	0.61	0.76	0.64	0.99	1.00
2001	0.00	0.00	0.00	0.04	0.37	0.78	0.98	0.99	0.97	1.00
2002	0.00	0.02	0.02	0.26	0.88	0.93	0.90	0.97	1.00	1.00
2003	0.00	0.00	0.00	0.05	0.29	0.49	0.90	0.98	0.96	1.00
2004	0.00	0.00	0.01	0.09	0.37	0.76	0.95	0.98	1.00	1.00
2005	0.00	0.00	0.00	0.07	0.40	0.56	0.89	0.98	1.00	1.00
2006	0.00	0.00	0.00	0.14	0.52	0.75	0.91	0.87	0.96	1.00
2007	0.00	0.00	0.00	0.14	0.54	0.76	0.96	0.83	1.00	1.00
2008	0.00	0.00	0.03	0.12	0.48	0.72	0.89	0.94	0.96	1.00
2009	0.00	0.00	0.02	0.06	0.26	0.35	0.59	0.74	0.60	0.92
2010	0.00	0.00	0.00	0.08	0.38	0.66	0.83	0.88	0.95	0.97

Table 2.11. Coastal cod. Acoustic spawning biomass indices (tonnes) corresponding to maturities in Table 2.10.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Sum
1995	0	0	96	4925	17424	19614	12573	7648	4933	7779	74992
1996	0	0	468	4467	14320	15130	14365	4311	3130	46	56237
1997	0	0	1185	6857	10546	22712	14608	8860	249	8643	73660
1998	0	92	2026	4870	8252	6804	5774	1461	1329	2083	32691
1999	0	56	315	3544	6778	5716	3478	2097	1220	567	23771
2000	0	0	0	2366	6354	10426	4486	2798	916	1232	28579
2001	0	0	15	508	4102	6662	5398	2978	1650	1917	23230
2002	0	20	87	2240	7702	7551	5650	1747	225	1663	26885
2003	0	0	0	269	1670	3428	3778	2686	2554	1136	15521
2004	0	0	28	679	2252	5253	2853	1736	434	722	13959
2005	0	0	0	447	2844	2670	3247	1898	1315	288	12709
2006	0	0	0	925	4386	6275	6072	1779	1538	571	21546
2007	0	0	0	1554	4400	5877	5879	4294	2177	508	24689
2008	0	0	107	734	3189	3012	3049	1902	1434	2066	15493
2009	0	0	61	476	1907	2037	3621	3169	1624	612	13508
2010	0	0	0	450	2608	2656	2024	1835	1404	1924	12901

Table 2.12. Proportion coastal cod among sampled cod during the coastal survey by age and statistical areas in the years 2004-2010.

Year	Area/Age	2	3	4	5	6	7	8	9	10+
2004	3	0.61	0.62	0.35	0.43	0.39	0.34	0.45	0.33	0.69
2004	4	0.84	0.83	0.74	0.76	0.77	0.47	0.77	0.44	0.44
2004	5	0.80	0.89	0.82	0.79	0.62	0.85	0.75	0.50	0.20
2004	0	1.00	0.94	0.94	0.60	0.85	1.00	1.00	1.00	0.07
2004	6	0.85	0.94	0.86	0.85	0.74	0.77	0.64	1.00	
2004	7	0.98	0.96	0.99	0.97	0.90	0.91	0.75	1.00	
2005	3	0.63	0.54	0.54	0.45	0.35	0.30	0.20	0.48	0.03
2005	4	0.96	0.91	0.76	0.74	0.71	0.60	0.76	0.81	0.50
2005	5	0.00	0.54	0.65	0.68	0.52	1.00	1.00	0.67	
2005	0	0.11	0.39	0.70	0.61	0.70	0.85	0.50	1.00	
2005	6	1.00	1.00	0.93	0.87	0.81	0.81	0.59	0.96	
2005	7	1.00	1.00	1.00	1.00	1.00	0.86	0.67	0.00	
2006	3	0.79	0.77	0.63	0.59	0.45	0.37	0.30	0.39	0.00
2006	4	1.00	0.88	0.84	0.79	0.68	0.63	0.82	0.40	0.42
2006	5	1.00	0.98	0.81	0.88	0.77	0.63	0.80	0.00	0.50
2006	0	0.99	0.99	0.95	0.87	0.86	0.89	0.85	0.33	
2006	6	1.00	1.00	0.95	0.99	0.80	0.72	1.00	0.67	
2006	7	1.00	0.97	0.95	0.98	0.89	1.00	0.50		
2007	3	0.83	0.38	0.40	0.59	0.27	0.32	0.00	1.00	
2007	4	0.91	0.92	0.92	0.80	0.80	0.90	0.71	0.67	1.00
2007	5	0.97	1.00	0.97	0.94	0.94	0.95	0.86	0.67	0.00
2007	0	1.00	0.88	1.00	1.00	1.00	0.00	1.00	1.00	
2007	6	1.00	1.00	0.95	0.87	0.91	0.81			
2007	7	1.00	1.00	1.00	0.89	0.86	0.86	1.00	1.00	1.00
2008	3	0.98	0.97	0.80	0.83	0.79	0.72	0.53	1.00	0.40
2008	4	1.00	0.99	0.80	0.88	0.84	0.78	0.88	0.88	0.86
2008	5	1.00	1.00	0.93	0.96	1.00	0.80	0.67	1.00	1.00
2008	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
2008	6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2008	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2009	3	0.90	0.72	0.54	0.44	0.48	0.57	0.79	0.67	0.58
2009	4	0.95	0.89	0.78	0.62	0.69	0.92	0.72	0.78	0.79
2009	5	1.00	1.00	0.95	0.84	0.78	0.82	0.88	0.67	1.00
2009	0	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	
2009	6	1.00	1.00	1.00	1.00	0.82	1.00	1.00	1.00	0.50
2009	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00
2010	3	0.86	0.78	0.56	0.47	0.36	0.37	0.81	0.89	0.95
2010	4	0.98	0.96	0.87	0.71	0.49	0.77	0.87	1.00	1.00
2010	5	1.00	0.98	1.00	1.00	0.84	0.88	1.00	0.73	1.00
2010	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2010	6	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
2010	7	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00

Table 2.13. Norwegian Coastal Cod. 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.

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Table 2 Catch weights at age (kg)

YEAR	1984	1985	1986	1987	1988	1989	1990
AGE							
2	0.248	0.214	0.227	0.331	0.246	0.3	0.345
3	0.619	0.712	0.525	0.673	0.634	0.661	1.174
4	1.149	1.415	1.08	1.12	1.17	1.836	1.515
5	1.734	2.036	1.706	1.693	1.727	2.17	1.678
6	2.325	2.737	2.256	2.359	2.328	2.448	2.708
7	3.486	4.012	3.353	3.743	3.256	4.391	3.898
8	4.845	6.116	4.838	5.326	4.7	4.899	6.515
9	5.608	6.46	5.838	6.129	5.45	6.661	7.299
+gp	8.84	10.755	7.053	11.623	8.202	11.608	13.924
SOPC	1.0002	1	1.0001	1.0001	1.0001	1	1.0002

Table 2 Catch weights at age (kg)

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
2	0.164	0.168	0.241	0.254	0.302	0.274	0.277	0.376	0.467	0.515
3	0.922	0.556	0.645	0.805	0.71	0.921	0.97	0.978	1.155	1.305
4	1.608	1.359	1.71	1.476	1.335	1.464	1.554	1.518	1.633	2.272
5	2.108	2.267	2.591	2.097	1.842	1.979	1.97	2.281	2.171	2.555
6	2.507	2.957	3.588	3.287	2.467	2.516	2.897	3.125	3.249	3.283
7	3.469	3.903	4.366	4.095	4.191	3.461	3.716	3.9	4.095	4.504
8	4.976	5.317	5.899	5.592	5.778	4.866	4.829	5.52	5.013	5.4
9	5.734	4.558	6.494	7.217	6.376	5.391	6.349	6.333	6.018	6.379
+gp	11.059	7.032	7.509	8.331	9.903	8.854	9.267	9.337	6.255	6.42
SOPC	1.0003	1.0001	1	1	1.0001	1.0001	1.0003	0.9919	1.0002	0.9999

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Table 2 Catch weights at age (kg)

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
2	0.164	0.491	0.944	0.824	0.82	1.274	1.241	0.977	1.219	0.813
3	0.952	1.179	1.552	1.374	1.317	1.599	1.744	1.882	1.47	1.576
4	1.637	1.8	2.146	1.877	2.094	1.894	2.143	2.444	2.348	2.344
5	2.881	2.485	3.082	2.679	2.795	2.687	2.718	3.747	3.331	3.114
6	3.424	3.86	3.594	3.365	3.493	3.562	4.098	4.165	4.251	4
7	4.038	4.76	4.953	4.013	4.087	4.029	4.884	4.989	4.824	5.025
8	5.397	5.195	5.736	4.847	4.836	5.182	5.939	5.992	5.807	4.911
9	7.208	5.507	6.477	5.554	6.264	5.905	6.89	6.143	6.776	5.873
+gp	6.881	9.183	9.686	6.343	5.115	6.213	8.098	8.229	8.571	6.809
SOPC	1.0004	1.0181	1.0001	0.9997	1.0001	0.9999	0.9998	0.9999	1	0.9997

Table 2.13 cont... Norwegian Coastal Cod. Input data to all the VPA-analysis.

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Table 3 Stock weights at age (kg)

YEAR	1984	1985	1986	1987	1988	1989	1990
AGE							
2	0.321	0.321	0.321	0.321	0.321	0.321	0.321
3	0.758	0.758	0.758	0.758	0.758	0.758	0.758
4	1.479	1.479	1.479	1.479	1.479	1.479	1.479
5	2.137	2.137	2.137	2.137	2.137	2.137	2.137
6	2.814	2.814	2.814	2.814	2.814	2.814	2.814
7	4.722	4.722	4.722	4.722	4.722	4.722	4.722
8	6.685	6.685	6.685	6.685	6.685	6.685	6.685
9	6.98	6.98	6.98	6.98	6.98	6.98	6.98
+gp	9.723	9.723	9.723	9.723	9.723	9.723	9.723

Table 3 Stock weights at age (kg)

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
2	0.321	0.321	0.321	0.321	0.298	0.27	0.232	0.323	0.318	0.346
3	0.758	0.758	0.758	0.758	0.7	0.717	0.677	0.834	0.804	0.777
4	1.479	1.479	1.479	1.479	1.338	1.435	1.363	1.366	1.559	1.458
5	2.137	2.137	2.137	2.137	1.973	2.044	1.903	2.075	2.042	2.296
6	2.814	2.814	2.814	2.814	2.649	2.694	2.816	3.013	2.798	2.735
7	4.722	4.722	4.722	4.722	4.164	4.817	3.833	4.255	4.678	4.048
8	6.685	6.685	6.685	6.685	7.051	6.28	5.849	5.305	7.151	7.011
9	6.98	6.98	6.98	6.98	6.413	11.365	9.6	8.35	8.959	9.224
+gp	9.723	9.723	9.723	9.723	14.326	15.67	13.037	18.016	18.34	12.277

Table 3 Stock weights at age (kg)

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
2	0.347	0.43	0.308	0.339	0.407	0.49	0.518	0.508	0.434	0.419
3	0.878	0.88	0.686	0.834	0.846	1.125	1.185	1.208	1.116	1.026
4	1.543	1.698	1.299	1.614	1.748	1.812	2.011	2.095	2.003	1.996
5	2.213	2.452	2.149	2.269	2.2	2.559	2.5	2.987	2.894	2.839
6	2.862	3.538	3.135	3.29	2.693	3.579	3.16	3.671	3.632	3.665
7	3.321	4.397	4.048	4.124	3.817	3.964	4.241	3.976	4.875	4.868
8	4.849	4.191	5.008	4.718	3.797	4.822	6.806	4.387	5.4	4.895
9	7.339	7.046	5.789	4.976	5.344	7.332	11.051	5.415	6.125	5.685
+gp	11.542	15.619	10.069	6.358	14.829	14.65	14.931	11.558	4.719	6.504

Table 2.13 cont... Norwegian Coastal Cod. Input data to all the VPA-analysis.

Table 5 Proportion mature at age

	YEAR	1984	1985	1986	1987	1988	1989	1990
	AGE							
2		0	0	0	0	0	0	0
3		0.02	0.02	0.02	0.02	0.02	0.02	0.02
4		0.16	0.16	0.16	0.16	0.16	0.16	0.16
5		0.46	0.46	0.46	0.46	0.46	0.46	0.46
6		0.69	0.69	0.69	0.69	0.69	0.69	0.69
7		0.87	0.87	0.87	0.87	0.87	0.87	0.87
8		0.91	0.91	0.91	0.91	0.91	0.91	0.91
9		0.96	0.96	0.96	0.96	0.96	0.96	0.96
	+gp	1	1	1	1	1	1	1

Table 5 Proportion mature at age

	YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE										
2		0	0	0	0	0	0	0	0	0	0
3		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
4		0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
5		0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
6		0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
7		0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
8		0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
9		0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
	+gp	1	1	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

	YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	AGE										
2		0	0	0	0	0	0	0	0	0	0
3		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
4		0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
5		0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
6		0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
7		0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
8		0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
9		0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
	+gp	1	1	1	1	1	1	1	1	1	1

Table 2.14. Norwegian Coastal Cod. Diagnostic output from XSA trial run based on commercial catch.

Lowestoft VPA Version 3.1
30/04/2011 16:45
Extended Survivors Analysis
Norwegian Coastal CodCOMBSEXPLUSGROUP

CPUE data from file coast-9.txt
Catch data for 27 years. 1984 to 2010. Ages 2 to 10.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
Norw. Coast. survey	1995	2010	0	8	.750	.850

Time series weights :
Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :
Catchability dependent on stock size for ages < 4
Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 4
Catchability independent of age for ages >= 8

Terminal population estimation :
Survivor estimates shrunk towards the mean F
of the final 2 years or the 4 oldest ages.
S.E. of the mean to which the estimates are shrunk = 1.000
Minimum standard error for population
estimates derived from each fleet = .300
Prior weighting not applied

Tuning had not converged after 310 iterations
Total absolute residual between iterations
309 and 310 = .00292

Final year F values

Age	2	3	4	5	6	7	8	9
Iteration **	.0010	.0633	.2332	.3821	.4071	.5883	.4296	.2976
Iteration **	.0010	.0633	.2330	.3817	.4065	.5878	.4293	.2970

Regression weights

.751	.820	.877	.921	.954	.976	.990	.997	1.000	1.000

Table 2.14, cont…
Fishing mortalities

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2	.002	.012	.005	.001	.001	.006	.007	.008	.000	.001
3	.031	.058	.086	.024	.037	.030	.054	.064	.025	.063
4	.137	.192	.187	.096	.137	.174	.183	.208	.135	.233
5	.316	.323	.325	.231	.280	.268	.300	.339	.290	.382
6	.370	.543	.441	.417	.309	.457	.324	.335	.541	.407
7	.492	.546	.582	.602	.490	.484	.421	.389	.545	.588
8	.406	.701	.423	.558	.444	.625	.272	.418	.457	.429
9	.275	.456	.431	.278	.331	.569	.519	.236	.285	.297

XSA population numbers (Thousands)

	AGE							
YEAR	2	3	4	5	6	7	8	9
2001	2.14E+04	1.86E+04	1.58E+04	1.21E+04	7.14E+03	4.01E+03	1.80E+03	8.61E+02
2002	1.83E+04	1.75E+04	1.48E+04	1.13E+04	7.23E+03	4.04E+03	2.01E+03	9.80E+02
2003	1.72E+04	1.48E+04	1.35E+04	9.97E+03	6.69E+03	3.44E+03	1.92E+03	8.15E+02
2004	1.77E+04	1.40E+04	1.11E+04	9.19E+03	5.90E+03	3.53E+03	1.57E+03	1.03E+03
2005	1.42E+04	1.45E+04	1.12E+04	8.26E+03	5.97E+03	3.18E+03	1.58E+03	7.38E+02
2006	1.34E+04	1.16E+04	1.15E+04	7.98E+03	5.11E+03	3.59E+03	1.59E+03	8.31E+02
2007	1.48E+04	1.09E+04	9.22E+03	7.88E+03	5.00E+03	2.65E+03	1.81E+03	6.99E+02
2008	1.33E+04	1.20E+04	8.45E+03	6.29E+03	4.78E+03	2.96E+03	1.42E+03	1.13E+03
2009	1.56E+04	1.08E+04	9.22E+03	5.62E+03	3.67E+03	2.80E+03	1.64E+03	7.67E+02
2010	1.55E+04	1.28E+04	8.60E+03	6.60E+03	3.44E+03	1.75E+03	1.33E+03	8.52E+02

Estimated population abundance at 1st Jan 2011

0.00E+00	1.27E+04	9.84E+03	5.58E+03	3.69E+03	1.88E+03	7.96E+02	7.10E+02

Taper weighted geometric mean of the VPA populations:

1.81E+04	1.54E+04	1.25E+04	9.27E+03	5.92E+03	3.46E+03	1.85E+03	9.64E+02

Standard error of the weighted Log(VPA populations) :

.3036	.3267	.3406	.3534	.3720	.4055	.3953	.3976

Log catchability residuals.

Fleet : Norw. Coast. survey

Age	1995	1996	1997	1998	1999	2000
2	.06	-.18	.06	-.01	.10	.20
3	.19	.19	.15	.04	-.04	.12
4	.62	.64	.77	.41	.27	.19
5	.39	.90	.97	.36	.25	.45
6	.03	.03	1.38	.17	.15	.58
7	-.09	-.39	.34	.35	-.24	.05
8	-.13	-.45	.08	-.95	-.27	.04

Table 2.14, cont…

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2	.05	-.12	-.20	-.03	-.07	.12	.13	.07	-.12	-.03
3	.02	-.23	-.12	-.07	-.12	.16	.24	-.09	.05	-.11
4	.12	-.20	-.36	-.12	-.40	-.23	.38	-.17	.01	-.19
5	-.06	-.26	-.39	-.40	-.10	.00	-.02	-.21	.06	-.08
6	-.16	-.02	-.11	-.21	-.44	.22	.12	-.53	.18	-.25
7	.01	.03	-.03	-.41	-.04	.31	.34	-.37	.25	-.17
8	-.12	-.17	.02	.05	.17	-.02	.21	-.06	.50	.07

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	-.5833	-.4594	-.4108	-.4491	-.7054
S.E(Log q)	.3240	.3400	.3916	.2675	.2896

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
2	.41	4.724	6.35	.87	16	.12	-1.37
3	.48	3.591	5.43	.83	16	.15	-.92

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
4	.67	1.709	3.49	.73	16	.20	-.58
5	.71	1.358	2.99	.69	16	.23	-.46
6	.81	.671	1.95	.57	16	.33	-.41
7	1.00	.022	.49	.68	16	.28	-.45
8	1.46	-1.432	-2.43	.49	16	.40	-.71

Terminal year survivor and F summaries :

Age 2 Catchability dependent on age and year class strength

Year class = 2008

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	12283.	.300	.000	.00	1	.517	.001
P shrinkage mean	15374.	.33				.436	.001
F shrinkage mean	3189.	1.00				.047	.004

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
12722.	.22	.23	3	1.070	.001

Table 2.14, cont…

Age 3 Catchability dependent on age and year class strength

Year class = 2007

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	8752.	.212	.005	.02	2	.684	.071
P shrinkage mean	12529.	.34				.283	.050
F shrinkage mean	14184.	1.00				.033	.044

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
9841.	.18	.12	4	.684	.063

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

```
 Year class = 2006
 Fleet                    Estimated    Int       Ext    Var    N Scaled  Estimated
                          Survivors    s.e       s.e   Ratio     Weights    F
 Norw. Coast. survey         5505.   .180       .078    .43   3  .960     .236
   F shrinkage mean          7784.   1.00                         .040     .172
 Weighted prediction :
 Survivors        Int      Ext    N    Var     F
 at end of year   s.e      s.e        Ratio
      5582.       .18      .07    4    .419   .233

 Age  5   Catchability constant w.r.t. time and dependent on age
 Year class = 2005
 Fleet                    Estimated    Int       Ext    Var    N Scaled  Estimated
                          Survivors    s.e       s.e   Ratio     Weights    F
 Norw. Coast. survey         3658.   .161       .053    .33   4  .958     .384
   F shrinkage mean          4609.   1.00                         .042     .316
 Weighted prediction :
 Survivors        Int      Ext    N    Var     F
 at end of year   s.e      s.e        Ratio
      3693.       .16      .05    5    .317   .382


 Age  6   Catchability constant w.r.t. time and dependent on age
 Year class = 2004
 Fleet                    Estimated    Int       Ext    Var    N Scaled  Estimated
                          Survivors    s.e       s.e   Ratio     Weights    F
 Norw. Coast. survey         1888.   .153       .091    .60   5  .952     .404
   F shrinkage mean          1696.   1.00                         .048     .441
 Weighted prediction :
 Survivors        Int      Ext    N    Var     F
 at end of year   s.e      s.e        Ratio
      1879.       .15      .08    6    .523   .407
```

Table 2.14, cont…

```
Age  7   Catchability constant w.r.t. time and dependent on age
 Year class = 2003
 Fleet                    Estimated    Int       Ext    Var    N Scaled  Estimated
                          Survivors    s.e       s.e   Ratio     Weights    F
 Norw. Coast. survey          781.   .151       .089    .59   6  .940     .596
   F shrinkage mean          1059.   1.00                         .060     .470
 Weighted prediction :
 Survivors        Int      Ext    N    Var     F
 at end of year   s.e      s.e        Ratio
       796.       .15      .08    7    .546   .588


 Age  8   Catchability constant w.r.t. time and dependent on age
 Year class = 2002
 Fleet                    Estimated    Int       Ext    Var    N Scaled  Estimated
                          Survivors    s.e       s.e   Ratio     Weights    F
 Norw. Coast. survey          711.   .144       .085    .59   7  .951     .428
   F shrinkage mean           686.   1.00                         .049     .441
 Weighted prediction :
 Survivors        Int      Ext    N    Var     F
 at end of year   s.e      s.e        Ratio
       710.       .15      .08    8    .528   .429


 Age  9   Catchability constant w.r.t. time and age (fixed at the value for
age)  8
 Year class = 2001
 Fleet                    Estimated    Int       Ext    Var    N Scaled  Estimated
                          Survivors    s.e       s.e   Ratio     Weights    F
 Norw. Coast. survey          536.   .139       .148   1.06   7  .940     .288
   F shrinkage mean           311.   1.00                         .060     .455
 Weighted prediction :
 Survivors        Int      Ext    N    Var     F
 at end of year   s.e      s.e        Ratio
       519.       .14      .14    8    .988   .297
```

Table 2.15. Norwegian Coastal Cod. Summary output from trial XSA run based on commercial catch

At 30/04/2011 16:48

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1984	1985	1986	1987	1988	1989	1990
2	0.0105	0.0059	0.1361	0.0051	0.003	0.001	0.0002
3	0.0744	0.1298	0.0776	0.0417	0.0738	0.0401	0.0109
4	0.2169	0.223	0.3191	0.221	0.2047	0.0723	0.0546
5	0.3337	0.4622	0.4602	0.5992	0.2701	0.2117	0.0888
6	0.6283	0.6367	0.6432	0.4381	0.7642	0.364	0.1525
7	1.3096	0.7884	0.9005	0.709	1.2414	0.8561	0.441
8	1.0724	0.6333	0.934	0.7337	1.1878	0.9376	0.6349
9	0.8447	0.6358	0.7416	0.6255	0.8751	0.5975	0.3313
+gp	0.8447	0.6358	0.7416	0.6255	0.8751	0.5975	0.3313
F4- 7	0.6221	0.5276	0.5807	0.4918	0.6201	0.376	0.1842

Table 8 Fishing mortality (F) at age

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
2	0.0023	0.0009	0.0001	0.0146	0.0271	0.0336	0.0458	0.0203	0.0111	0.0076
3	0.0195	0.0151	0.0102	0.0259	0.0497	0.1036	0.1282	0.1299	0.0615	0.054
4	0.0575	0.1338	0.0488	0.0591	0.1408	0.1892	0.1944	0.2646	0.152	0.2418
5	0.1899	0.2489	0.1389	0.1672	0.2584	0.4915	0.2634	0.4076	0.3998	0.3935
6	0.1741	0.2817	0.2351	0.2127	0.3377	0.3895	0.4969	0.4626	0.551	0.4719
7	0.2629	0.276	0.5242	0.5148	0.484	0.4589	0.6783	0.6695	0.7064	0.4422
8	0.1875	0.2933	0.4674	0.5359	0.4441	0.6618	0.8353	0.7986	0.8339	0.2946
9	0.2045	0.2765	0.3435	0.3599	0.3835	0.5472	0.7506	0.6338	1.0022	0.3279
+gp	0.2045	0.2765	0.3435	0.3599	0.3835	0.5472	0.7506	0.6338	1.0022	0.3279
F4- 7	0.1711	0.2351	0.2367	0.2384	0.3052	0.3823	0.4082	0.4511	0.4523	0.3873

Table 8 Fishing mortality (F) at age

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	FBAR
AGE											2008-10
2	0.0023	0.0117	0.0052	0.0007	0.0012	0.0059	0.0066	0.0077	0.0002	0.001	0.003
3	0.0305	0.058	0.0863	0.0245	0.0367	0.0304	0.0537	0.0637	0.0247	0.0633	0.0506
4	0.1373	0.1919	0.1875	0.0964	0.1374	0.174	0.183	0.2083	0.1347	0.233	0.192
5	0.3163	0.3232	0.3254	0.2307	0.2805	0.2676	0.2995	0.3388	0.2901	0.3817	0.3369
6	0.3698	0.5429	0.4405	0.4173	0.3089	0.4568	0.3242	0.335	0.5414	0.4065	0.4276
7	0.4919	0.5458	0.582	0.6022	0.4902	0.4837	0.4212	0.3886	0.545	0.5878	0.5071
8	0.4057	0.7011	0.4228	0.5578	0.4439	0.6255	0.2724	0.418	0.4568	0.4293	0.4347
9	0.2745	0.4564	0.4306	0.2783	0.3307	0.5686	0.5192	0.2361	0.2847	0.297	0.2726
+gp	0.2745	0.4564	0.4306	0.2783	0.3307	0.5686	0.5192	0.2361	0.2847	0.297	
F4- 7	0.3288	0.4009	0.3839	0.3367	0.3042	0.3455	0.307	0.3177	0.3778	0.4022	

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

At 30/04/2011 16:48

Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1984	1985	1986	1987	1988	1989	1990
AGE							
2	87920	74434	35570	36659	39969	43330	42428
3	53600	71233	60583	25417	29860	32624	35438
4	39412	40737	51219	45896	19959	22709	25662
5	28350	25976	26687	30478	30124	13316	17295
6	14223	16626	13396	13791	13706	18826	8822
7	7514	6213	7201	5765	7285	5226	10711
8	3631	1661	2312	2396	2323	1724	1818
9	1587	1017	722	744	942	580	553
+gp	1191	613	847	350	621	209	284
TOTAL	237429	238509	198537	161495	144790	138545	143011

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
2	60111	49213	30212	25300	33498	39899	32704	30526	25198	22865
3	34730	49102	40256	24732	20414	26693	31587	25576	24491	20402
4	28699	27886	39599	32625	19731	15903	19704	22751	18389	18855
5	19895	22183	19972	30877	25179	14032	10776	13282	14296	12933
6	12957	13471	14160	14231	21388	15921	7028	6780	7235	7847
7	6201	8913	8322	9165	9419	12493	8830	3501	3495	3414
8	5643	3904	5538	4033	4484	4753	6464	3669	1467	1412
9	789	3830	2383	2841	1932	2355	2008	2295	1352	522
+gp	559	1269	2604	2896	1490	1409	1412	798	549	597
TOTAL	169583	179769	163046	146701	137535	133457	120513	109177	96471	88847

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE											
2	21449	18281	17180	17746	14202	13380	14763	13251	15632	15544	0
3	18579	17521	14793	13992	14518	11614	10891	12007	10766	12796	12722
4	15825	14754	13537	11110	11179	11458	9223	8450	9225	8599	9841
5	12122	11294	9971	9188	8260	7977	7882	6288	5617	6601	5582
6	7144	7234	6694	5896	5973	5109	4998	4783	3669	3441	3693
7	4008	4041	3441	3528	3180	3591	2649	2959	2801	1748	1879
8	1796	2007	1917	1574	1582	1595	1812	1423	1642	1330	796
9	861	980	815	1028	738	831	699	1130	767	852	710
+gp	544	1127	310	1194	557	565	529	889	1223	748	974
TOTAL	82328	77239	68657	65256	60189	56119	53447	51181	51344	51658	36197

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

At 4/05/2011 0:38

Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 2	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 4-7
1984	87920	310158	140792	74824	0.5315	0.6221
1985	74434	293927	116933	75451	0.6453	0.5276
1986	35570	290555	122005	68905	0.5648	0.5807
1987	36659	254685	114629	60972	0.5319	0.4918
1988	39969	230470	117811	59294	0.5033	0.6201
1989	43330	195939	93385	40285	0.4314	0.376
1990	42428	209570	102267	28127	0.275	0.1842
1991	60111	244984	122553	24822	0.2025	0.1711
1992	49213	286822	153667	41690	0.2713	0.2351
1993	30212	299573	166269	52557	0.3161	0.2367
1994	25300	299376	175458	54562	0.311	0.2384
1995	33498	261587	162595	57207	0.3518	0.3052
1996	39899	263167	174105	61776	0.3548	0.3823
1997	32704	205460	128574	63319	0.4925	0.4082
1998	30526	178153	95615	51572	0.5394	0.4511
1999	25198	154822	77837	40732	0.5233	0.4523
2000	22865	138267	66160	36715	0.5549	0.3873
2001	21449	130067	62536	29699	0.4749	0.3288
2002	18281	152299	82053	40994	0.4996	0.4009
2003	17180	106804	55857	34635	0.6201	0.3839
2004	17746	110543	57993	24547	0.4233	0.3367
2005	14202	102212	50905	22432	0.4407	0.3042
2006	13380	115367	59089	26134	0.4423	0.3455
2007	14763	113794	59502	23841	0.4007	0.307
2008	13251	109680	55940	25777	0.4608	0.3177
2009	15632	99857	50106	24821	0.4954	0.3778
2010	15544	92880	43169	22925	0.531	0.4022
Arith. Mean	32269	194482	100289	43282	0.4515	0.3769
Units	thousan	(Tonnes)	(Tonnes)	(Tonnes)		

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

	av. survey Z ages 4-9	com. Catch F(4-7)	all catch F(4-7)
1996	0.881	0.388	0.364
1997	0.850	0.385	0.361
1998	1.604	0.452	0.415
1999	1.018	0.400	0.373
2000	0.538	0.357	0.339
2001	0.912	0.390	0.366
2002	1.084	0.406	0.378
2003	0.482	0.352	0.335
2004	0.725	0.374	0.353
2005	0.355	0.341	0.326
2006	0.324	0.338	0.324
2007	0.386	0.343	0.328
2008	0.925	0.392	0.367
2009	-0.030	0.306	0.299
2010	0.776	0.378	0.356

Table 2.17. Norwegian Coastal Cod. Stock summary for SVPA based on commercial catch at age and survey derived F in 2010.

At 1/05/2011 13:59

Table 16 Summary (without SOP correction)

Traditional vpa using file input for terminal F

	RECRUITS Age 2	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 4-7
1984	87038	306253	150053	74824	0.4987	0.6215
1985	73960	290537	126636	75451	0.5958	0.5289
1986	35370	287259	132299	68905	0.5208	0.5819
1987	36427	251912	123582	60972	0.4934	0.4936
1988	39669	228054	123938	59294	0.4784	0.6185
1989	42983	194353	99624	40285	0.4044	0.3751
1990	42052	208036	108748	28127	0.2586	0.1842
1991	59552	243164	130707	24822	0.1899	0.1715
1992	48702	284527	162527	41690	0.2565	0.2358
1993	29923	297033	175931	52557	0.2987	0.2371
1994	25105	296733	184119	54562	0.2963	0.2391
1995	33236	259108	169141	57207	0.3382	0.3065
1996	39584	260498	179929	61776	0.3433	0.3835
1997	32474	203323	133975	63319	0.4726	0.4093
1998	30281	176475	101159	51572	0.5098	0.4513
1999	24991	153404	82736	40732	0.4923	0.4515
2000	22680	137156	70791	36715	0.5186	0.3876
2001	21315	129003	66830	29699	0.4444	0.3294
2002	18155	151115	86486	40994	0.474	0.4009
2003	17227	105981	59201	34635	0.585	0.384
2004	17453	109757	61338	24547	0.4002	0.3369
2005	14504	101716	54216	22432	0.4137	0.3043
2006	12785	114675	62815	26134	0.416	0.3449
2007	15606	113552	63295	23841	0.3767	0.3054
2008	15156	110808	59565	25777	0.4328	0.3162
2009	18764	103468	53823	24821	0.4612	0.3751
2010	4990	94831	48048	22925	0.4771	0.3783
Arith. Mean	31851	193064	106352	43282	0.424	0.376
Units	Thousands	Tonnes	Tonnes	Tonnes		

Table 2.18. Norwegian Coastal Cod. Stock summary for SVPA based on total catch at age and survey derived F in 2010.

At 4/05/2011 0:23

Table 16 Summary (without SOP correction)

Traditional vpa using file input for terminal F

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 4-7
	Age 2					
1984	108386	359078	159494	88124	0.5525	0.6178
1985	97427	344458	132856	88851	0.6688	0.525
1986	62379	347764	138802	82405	0.5937	0.5905
1987	48770	313697	131560	74472	0.5661	0.5084
1988	54084	291209	137852	72894	0.5288	0.6323
1989	62661	258584	117002	53985	0.4614	0.3821
1990	61262	277923	130315	42627	0.3271	0.2367
1991	81379	323376	157175	40122	0.2553	0.1942
1992	67328	369845	193208	57790	0.2991	0.2491
1993	39054	383292	208458	67357	0.3231	0.2359
1994	33296	379085	217648	69262	0.3182	0.2406
1995	44987	333603	205341	71907	0.3502	0.3021
1996	57385	341186	223325	76276	0.3415	0.362
1997	47145	272335	165959	77819	0.4689	0.3998
1998	42098	247720	129762	66172	0.5099	0.413
1999	37030	219885	108769	54632	0.5023	0.409
2000	34044	200928	96746	50315	0.5201	0.3509
2001	32347	190485	91332	43099	0.4719	0.3239
2002	27785	220190	115767	54594	0.4716	0.3654
2003	26511	161429	83900	48535	0.5785	0.3358
2004	27539	168703	87065	37947	0.4358	0.333
2005	23149	154039	74196	35632	0.4802	0.3061
2006	20270	175591	87583	39134	0.4468	0.3362
2007	25361	175451	89251	36841	0.4128	0.3025
2008	24933	170069	81772	38577	0.4718	0.2979
2009	31312	164253	76998	37521	0.4873	0.3651
2010	10543	157024	72636	35625	0.4905	0.3561
Arith.						
Mean	45499	259304	130177	57130	0.4568	0.3693
Units	Thousands	Tonnes	Tonnes	Tonnes		

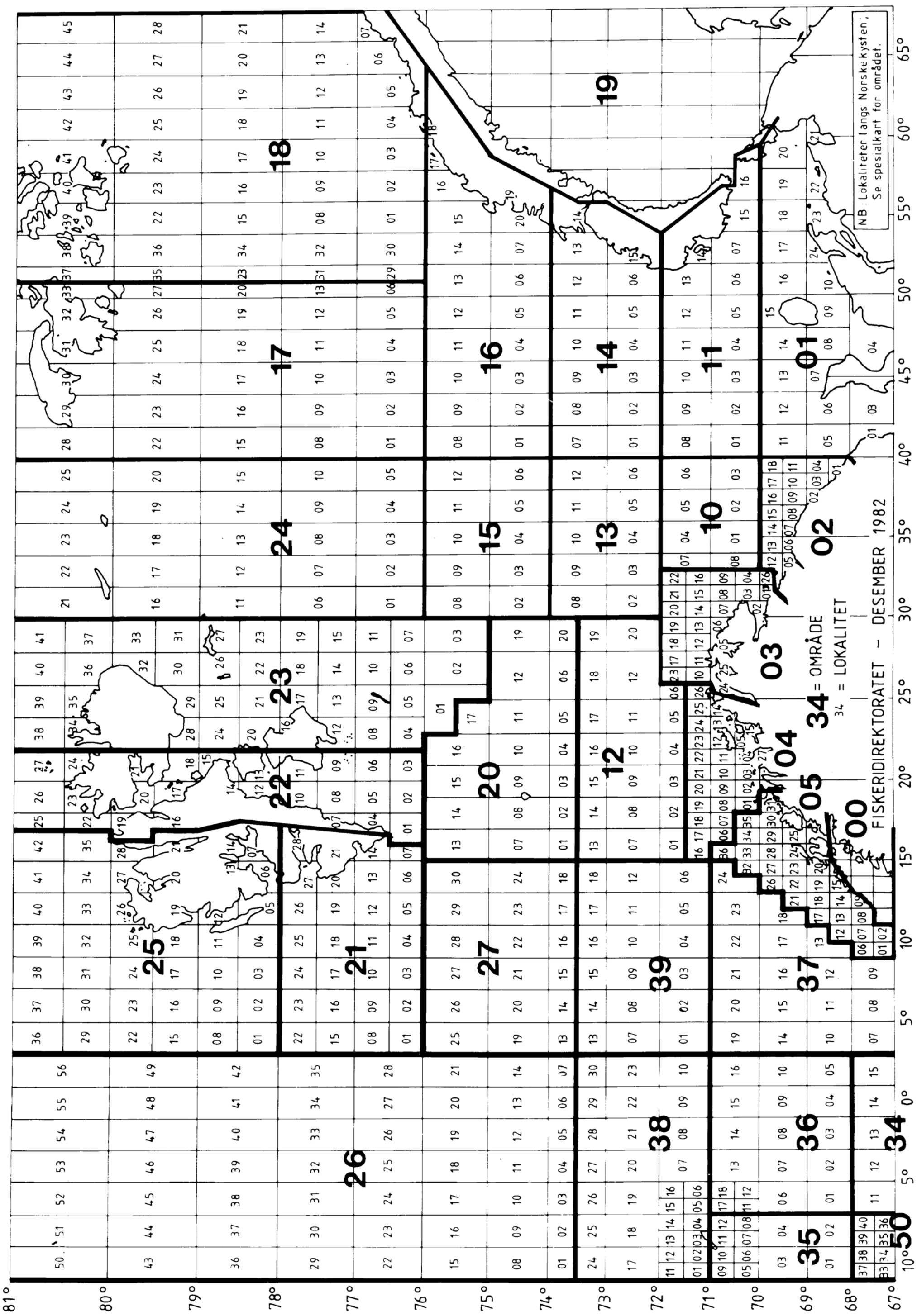


Figure 2.1. Norwegian statistical rectangles in the Barents Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 03 and 04. The same areas are also referred to in the survey results (sec. 2.3).

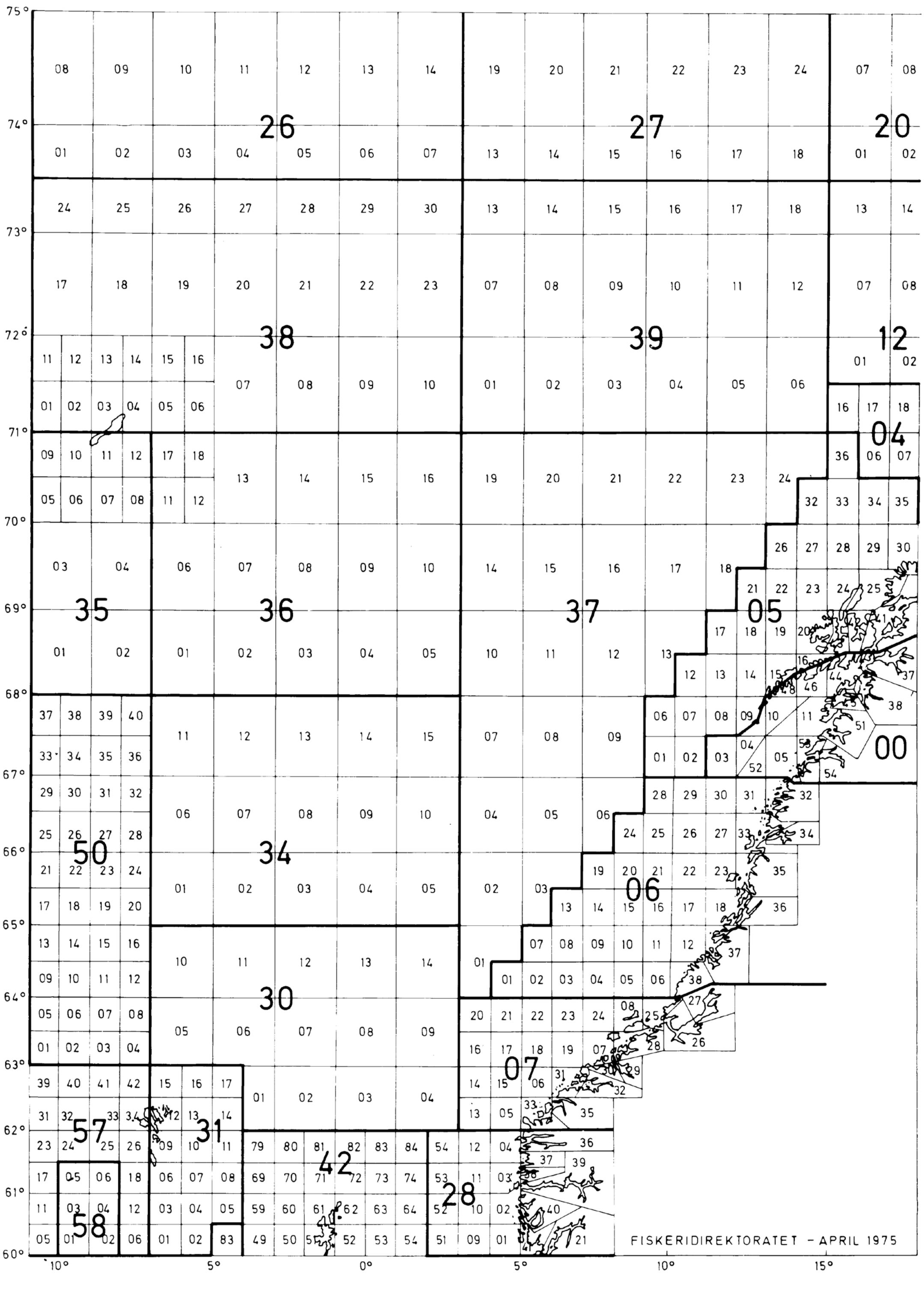


Figure 2.2. Norwegian statistical rectangles in the Norwegian Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 05, 00, 06 and 07. The same areas are also referred to in the survey results (sec. 2.3).

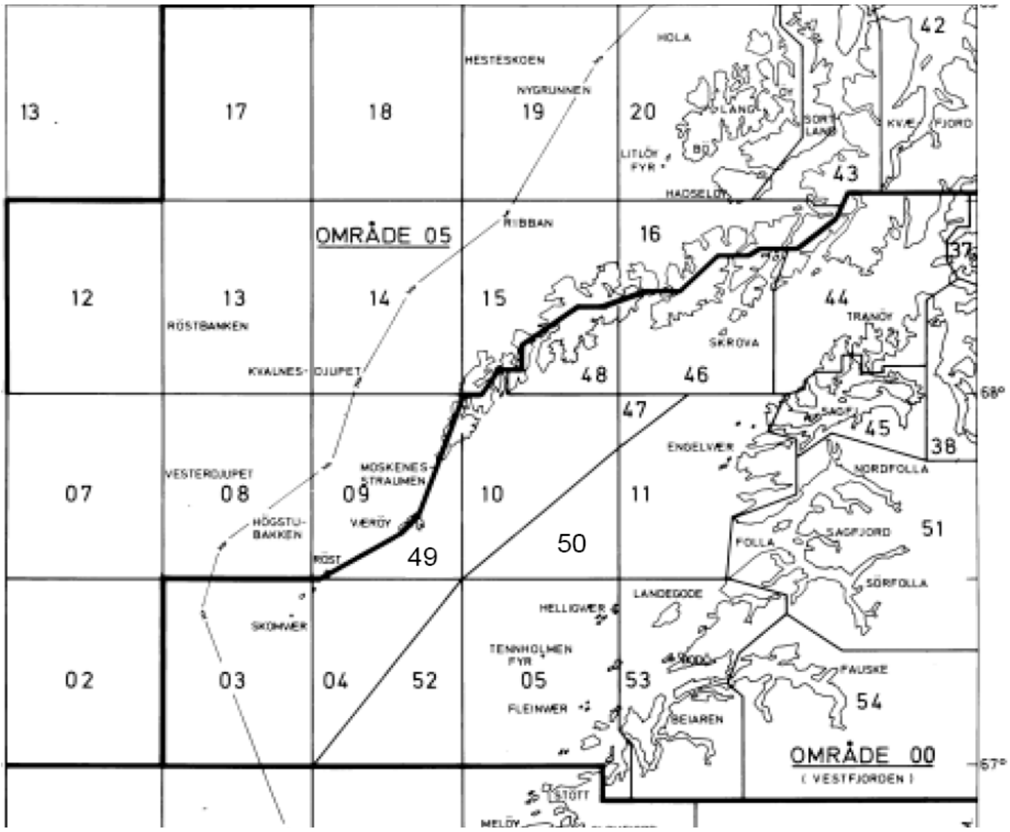


Figure 2.3. Map showing Vestfjorden, the Norwegian statistical area 00 ("OMRÅDE 00") with the south-western location 03 and 04 and the north-eastern locations 46 and 48.

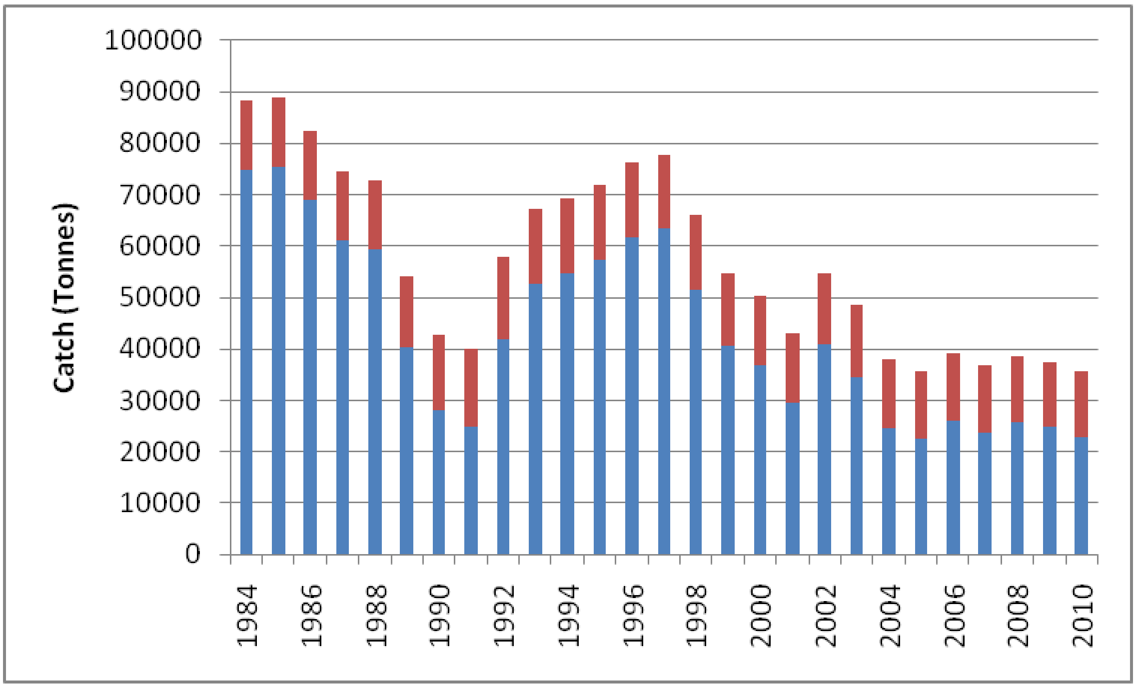


Figure 2.4. Estimated catch of Norwegian coastal cod. Commercial catch in blue and recreational catches in red.

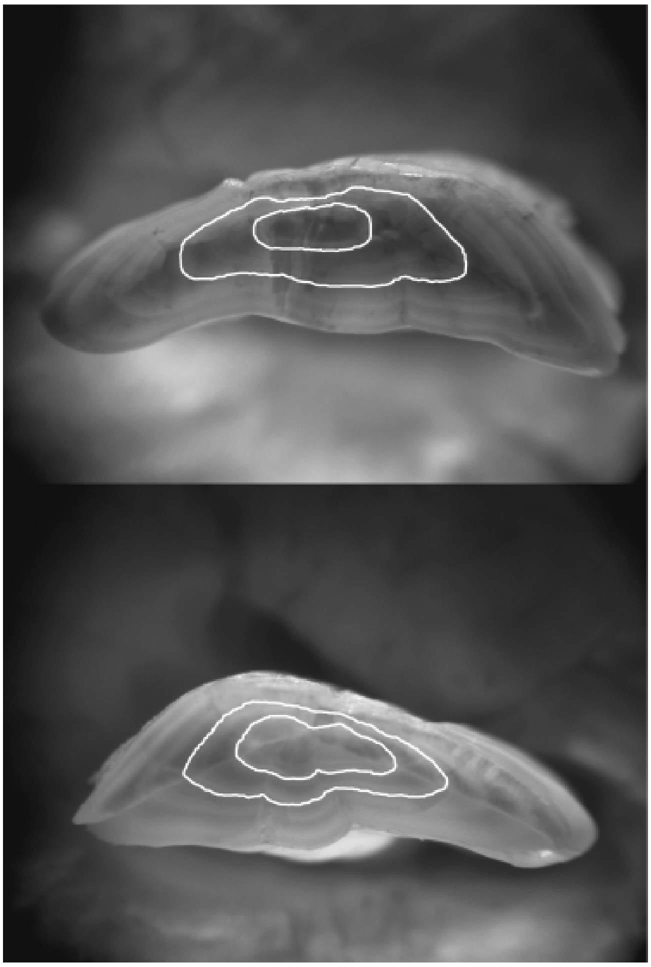
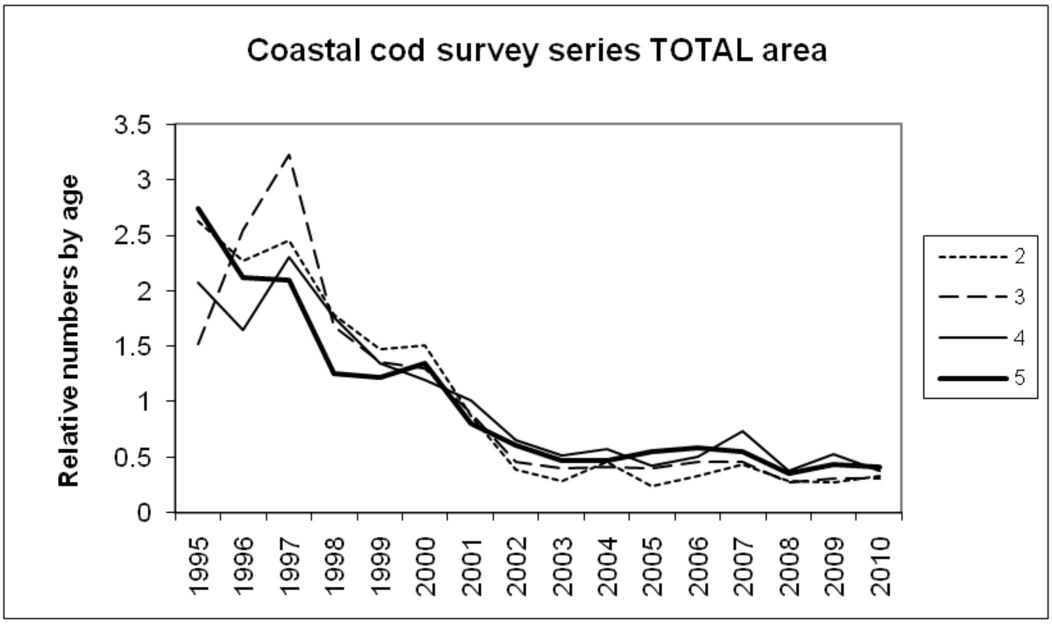


Figure 2.5. An image of a coastal cod otolith (top) and a north-east Arctic cod otolith (bottom). The two first translucent zones are highlighted. (from Berg *et al*. 2005)



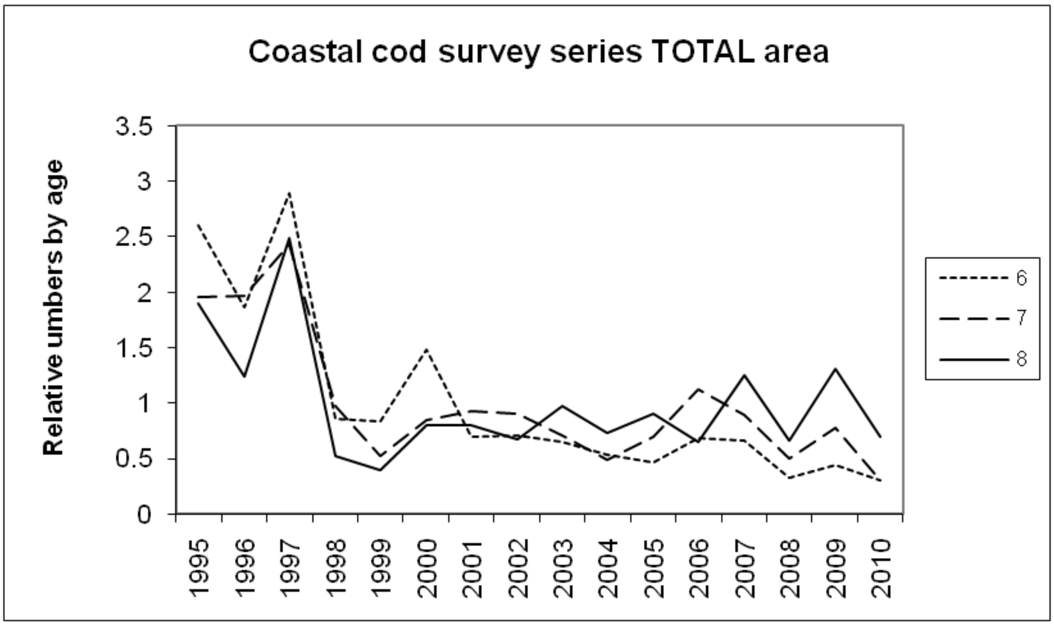
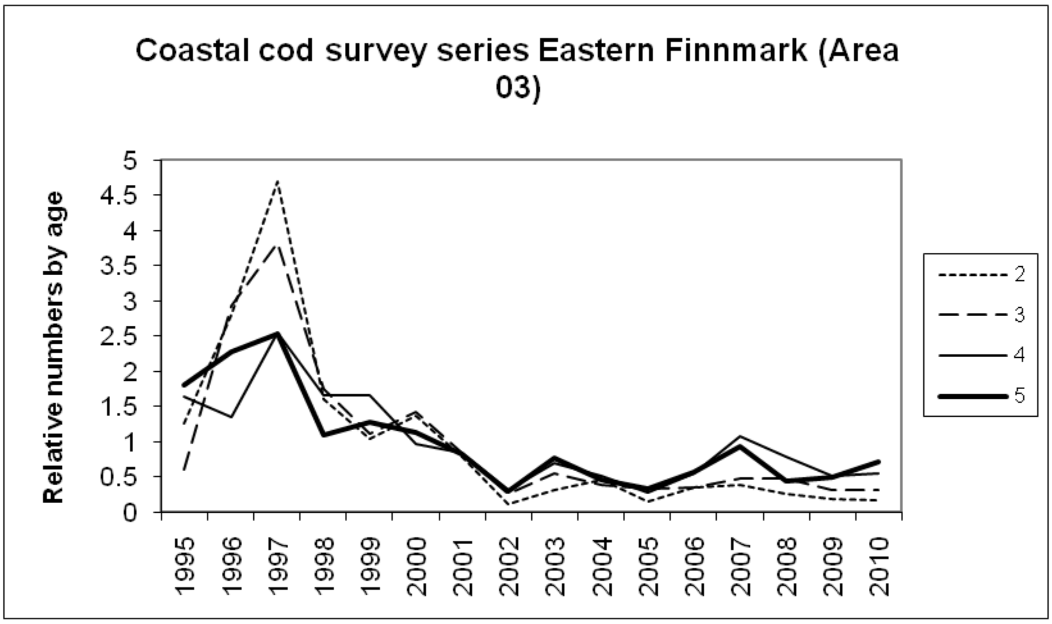


Figure 2.6. Coastal cod survey. Abundance at age relative to time series average in total survey.

Upper: ages 2-5, Lower: ages 6-8.



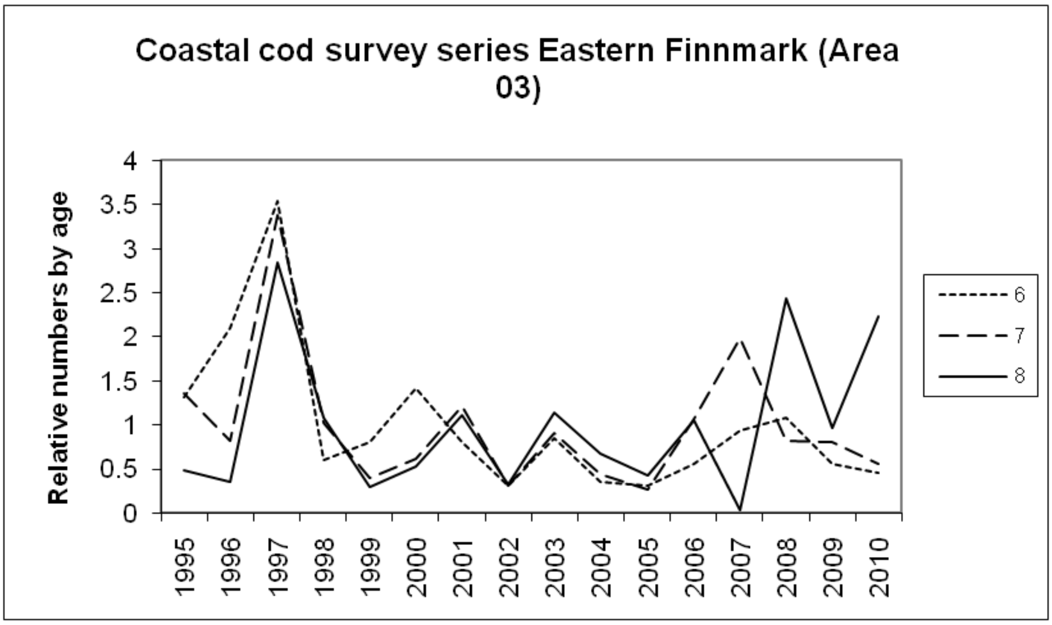


Figure 2.7. Coastal cod survey. Abundance at age relative to time series average in statistical area 03.

Upper: ages 2-5, Lower: ages 6-8.

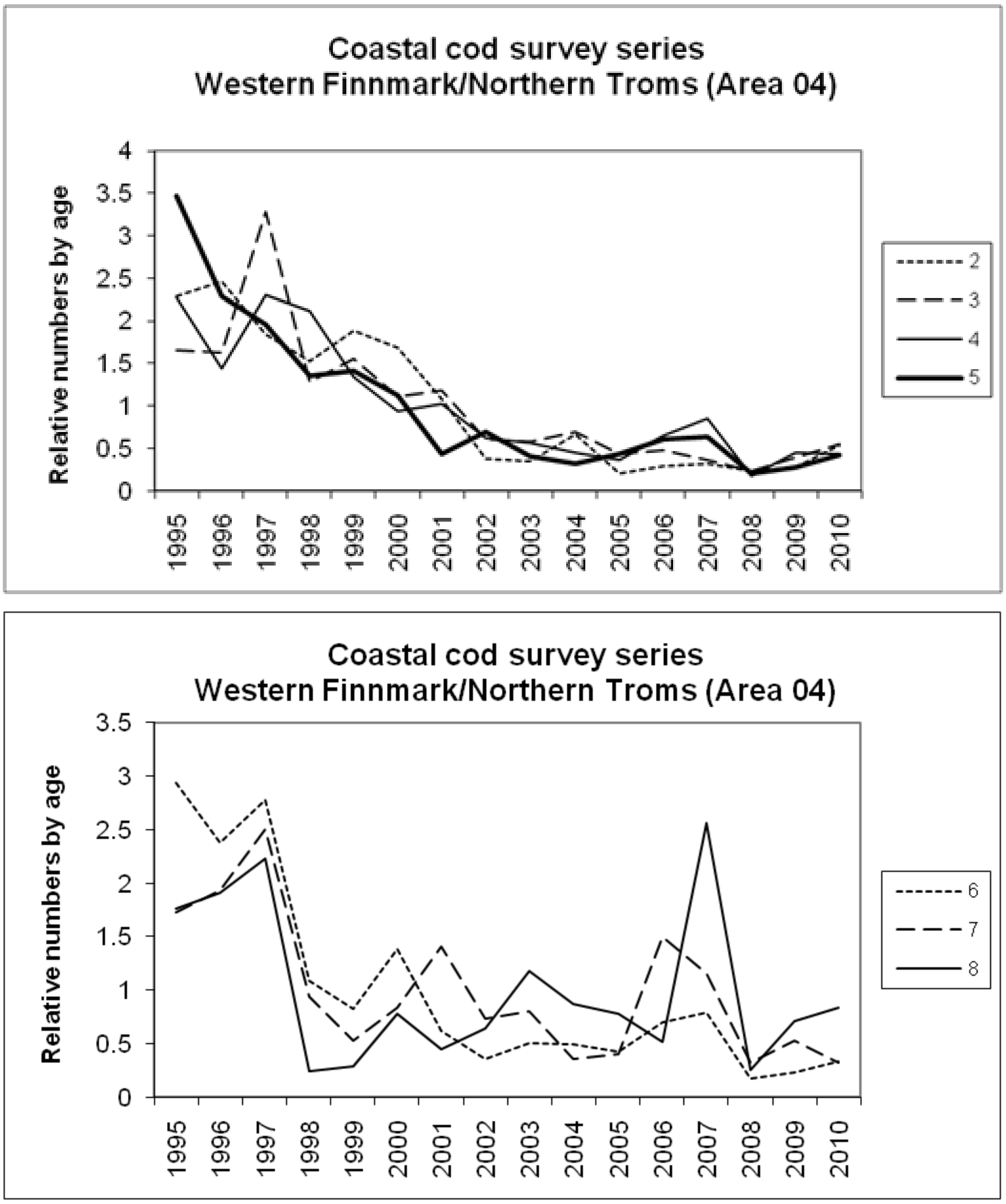
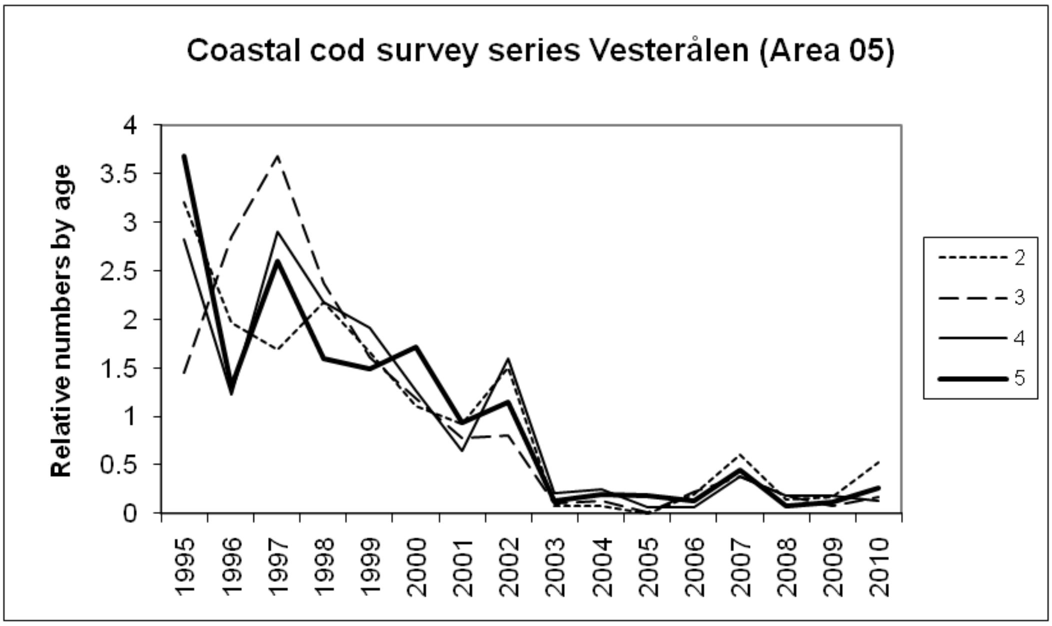


Figure 2.8. Coastal cod survey. Abundance at age relative to time series average in statistical area 04.

Upper: ages 2-5, Lower: ages 6-8.



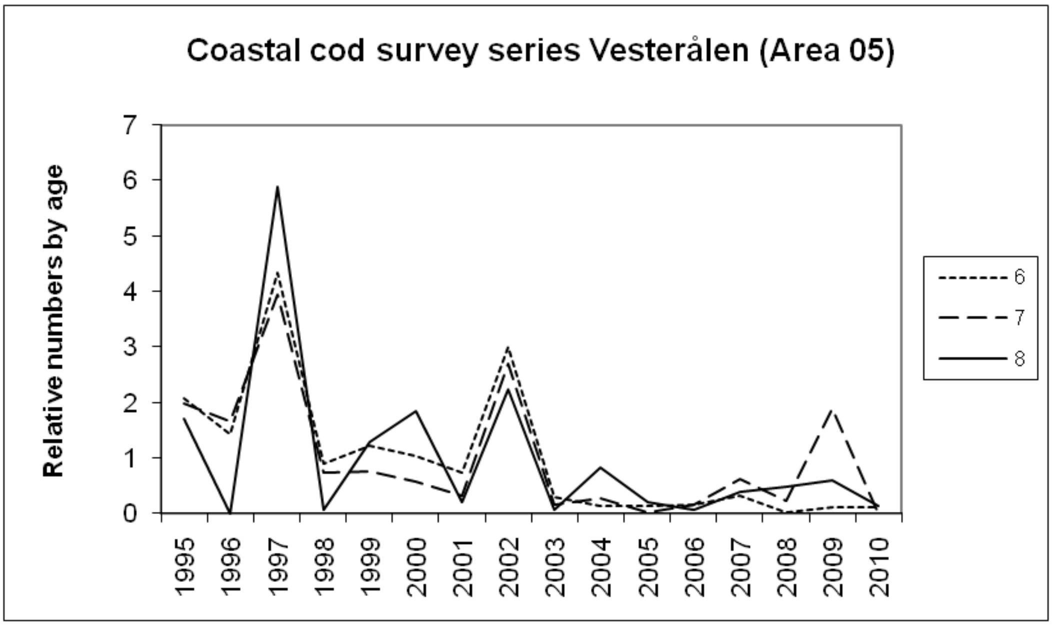
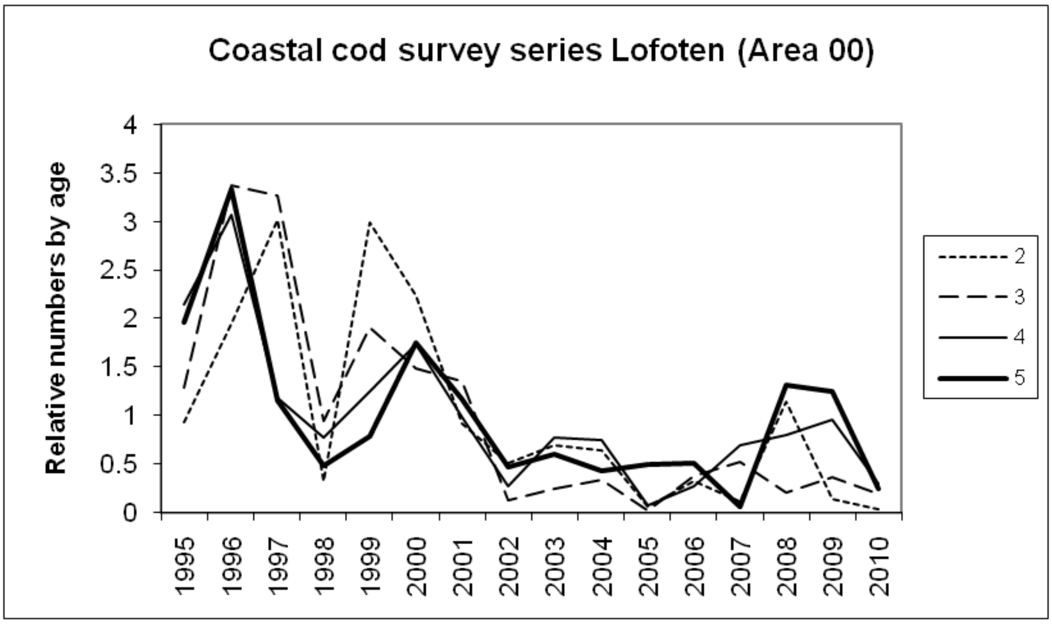


Figure 2.9. Coastal cod survey. Abundance at age relative to time series average in statistical area 05.

Upper: ages 2-5, Lower: ages 6-8.



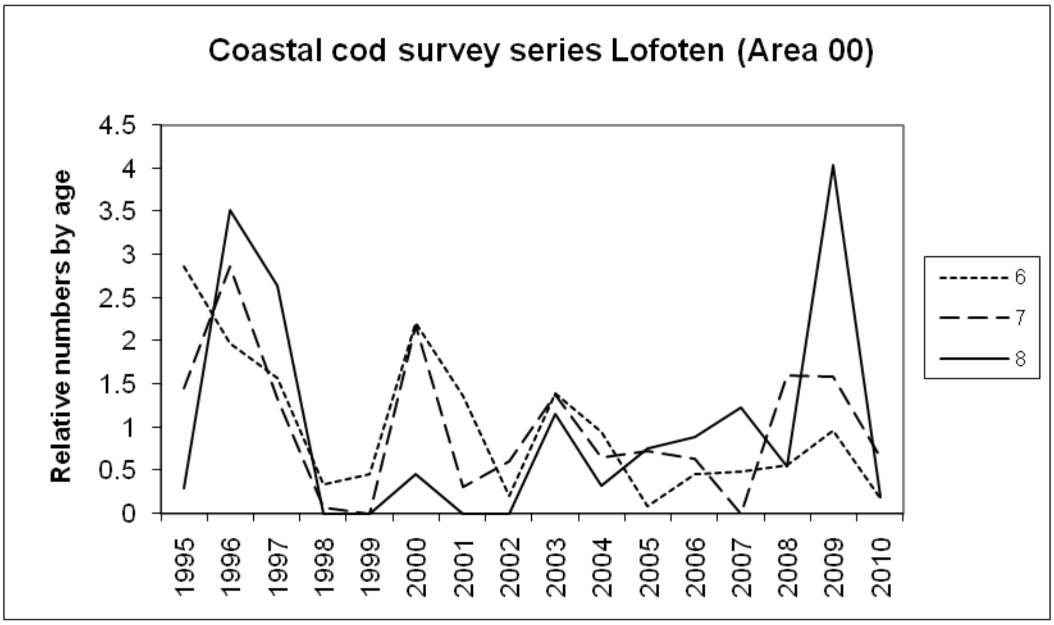
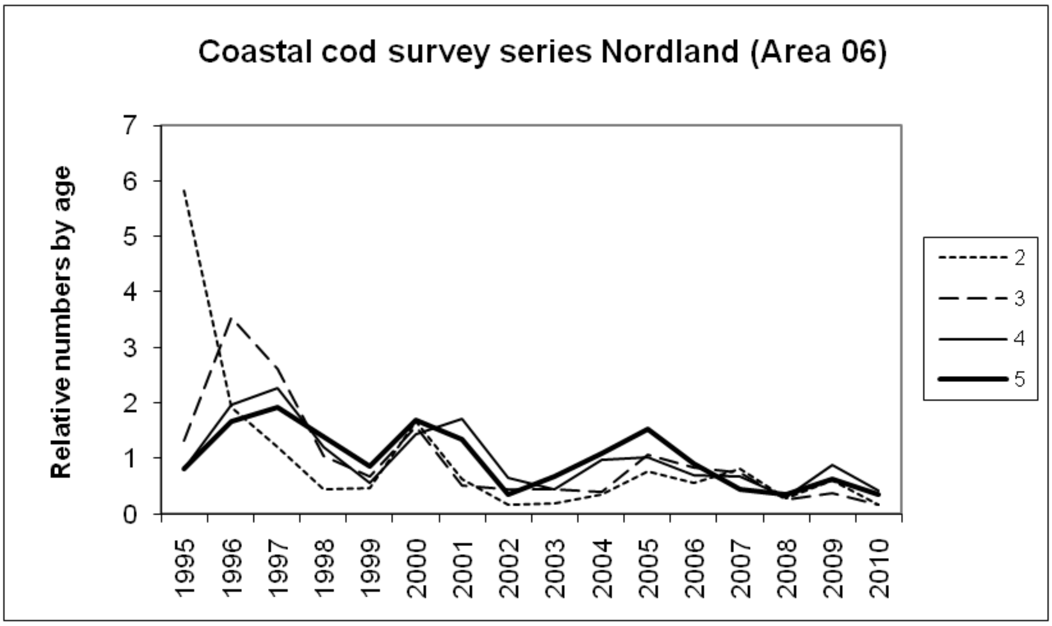


Figure 2.10. Coastal cod survey. Abundance at age relative to time series average in statistical area 00.

Upper: ages 2-5, Lower: ages 6-8.



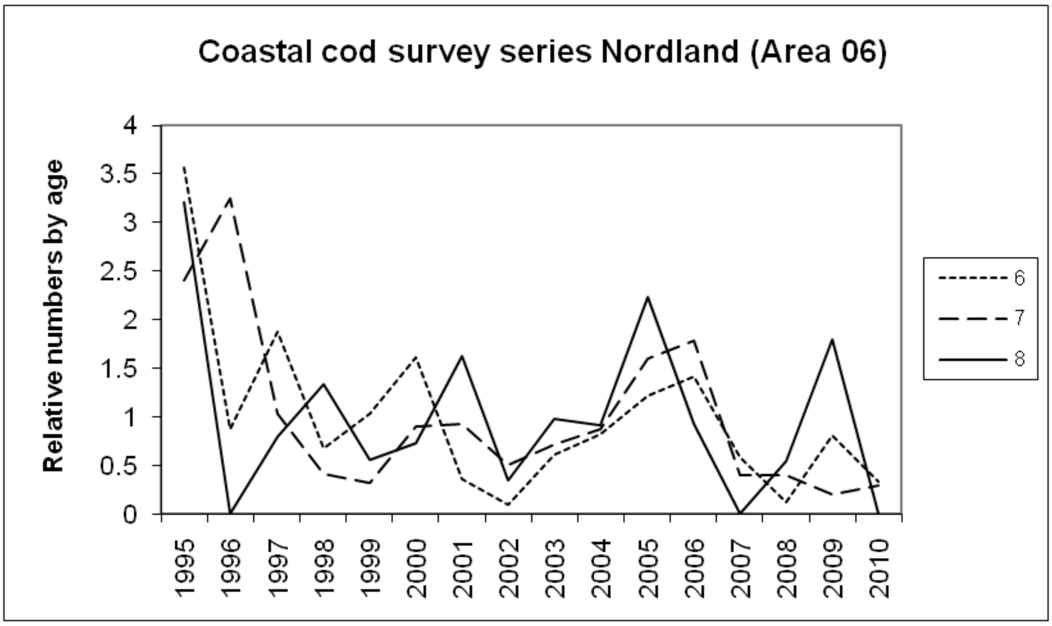
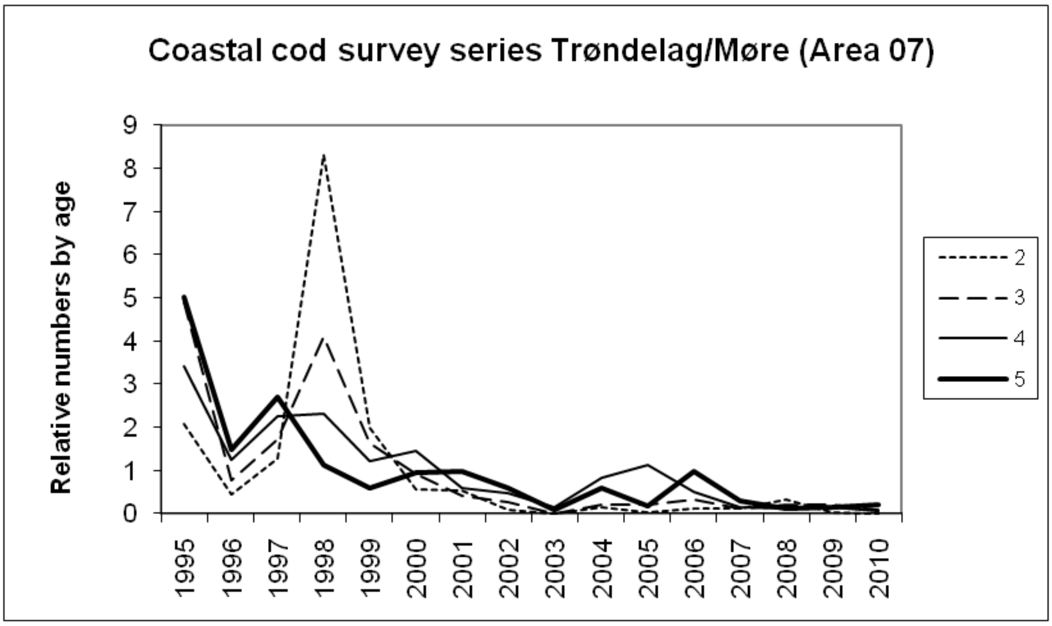


Figure 2.11 Coastal cod survey. Abundance at age relative to time series average in statistical area 06.

Upper: ages 2-5, Lower: ages 6-8.



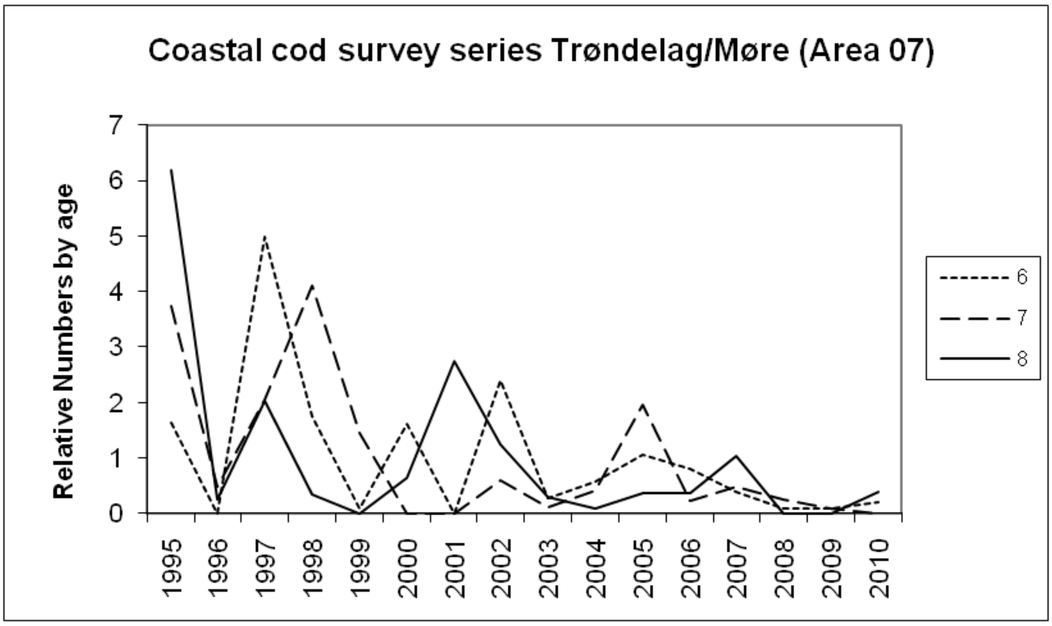


Figure 2.12. Coastal cod survey. Abundance at age relative to time series average in statistical area 07.

Upper: ages 2-5, Lower: ages 6-8.

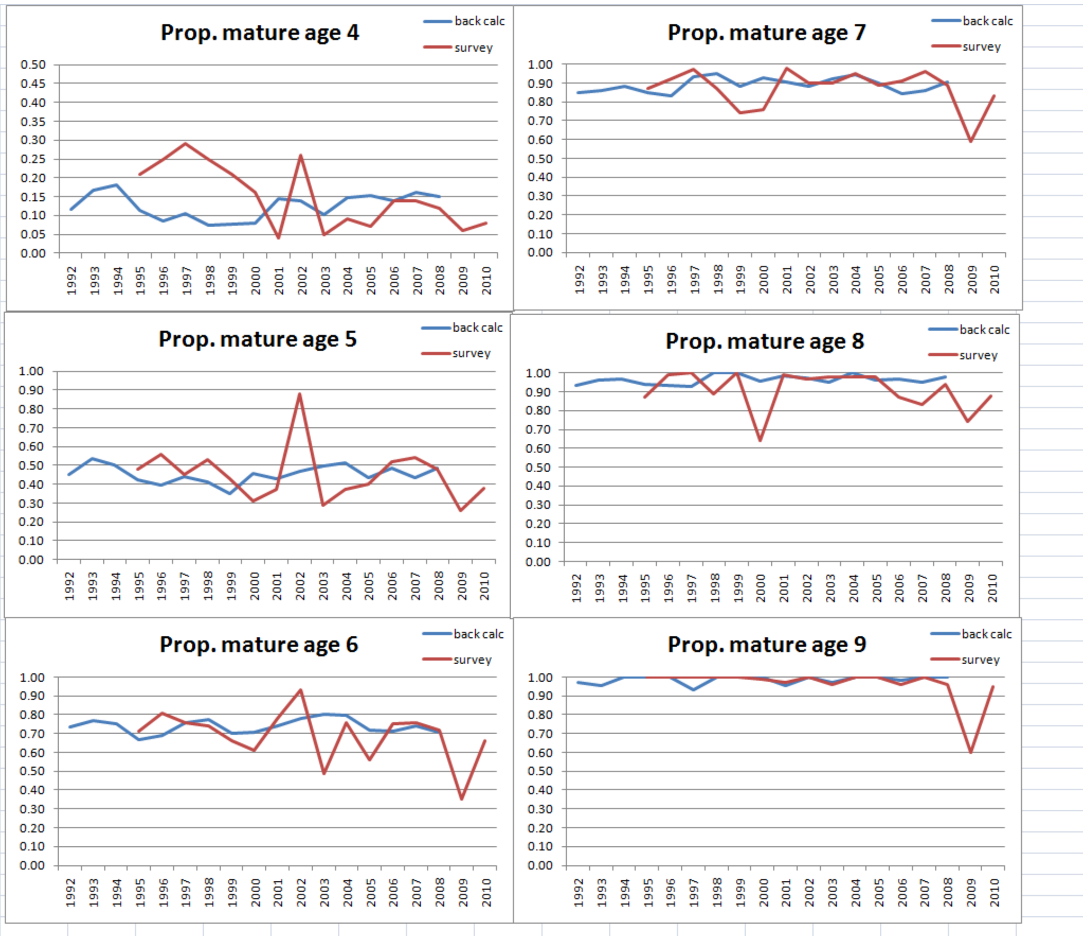


Figure 2.13. Proportions mature at age as observed in the surveys (red), and as estimated by back-calculation from spawning zones recorded from otoliths (blue).

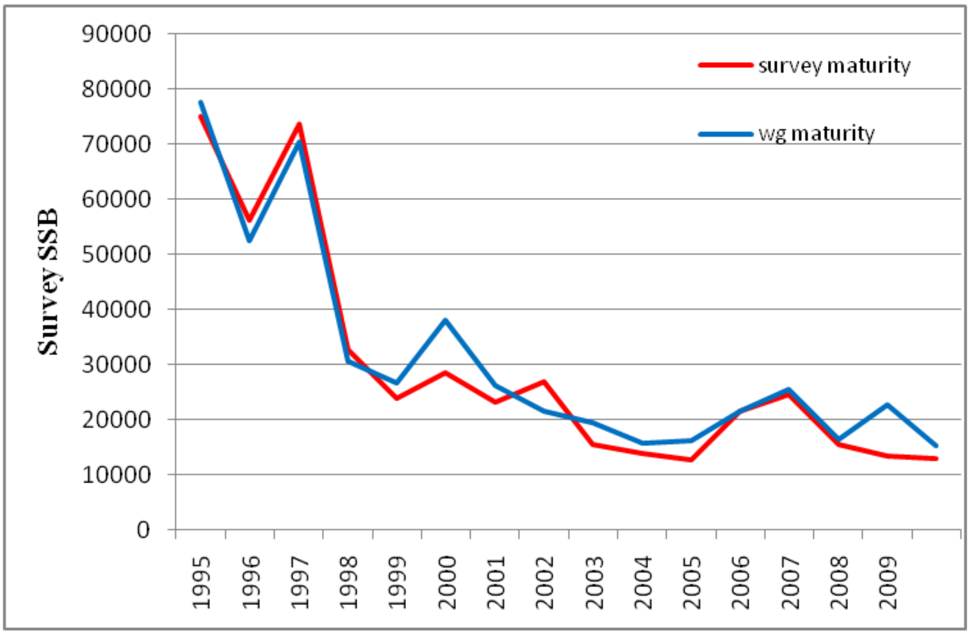


Figure 2.14. Survey SSB calculated by maturity observed in the surveys (red) and by maturity used in the VPA.

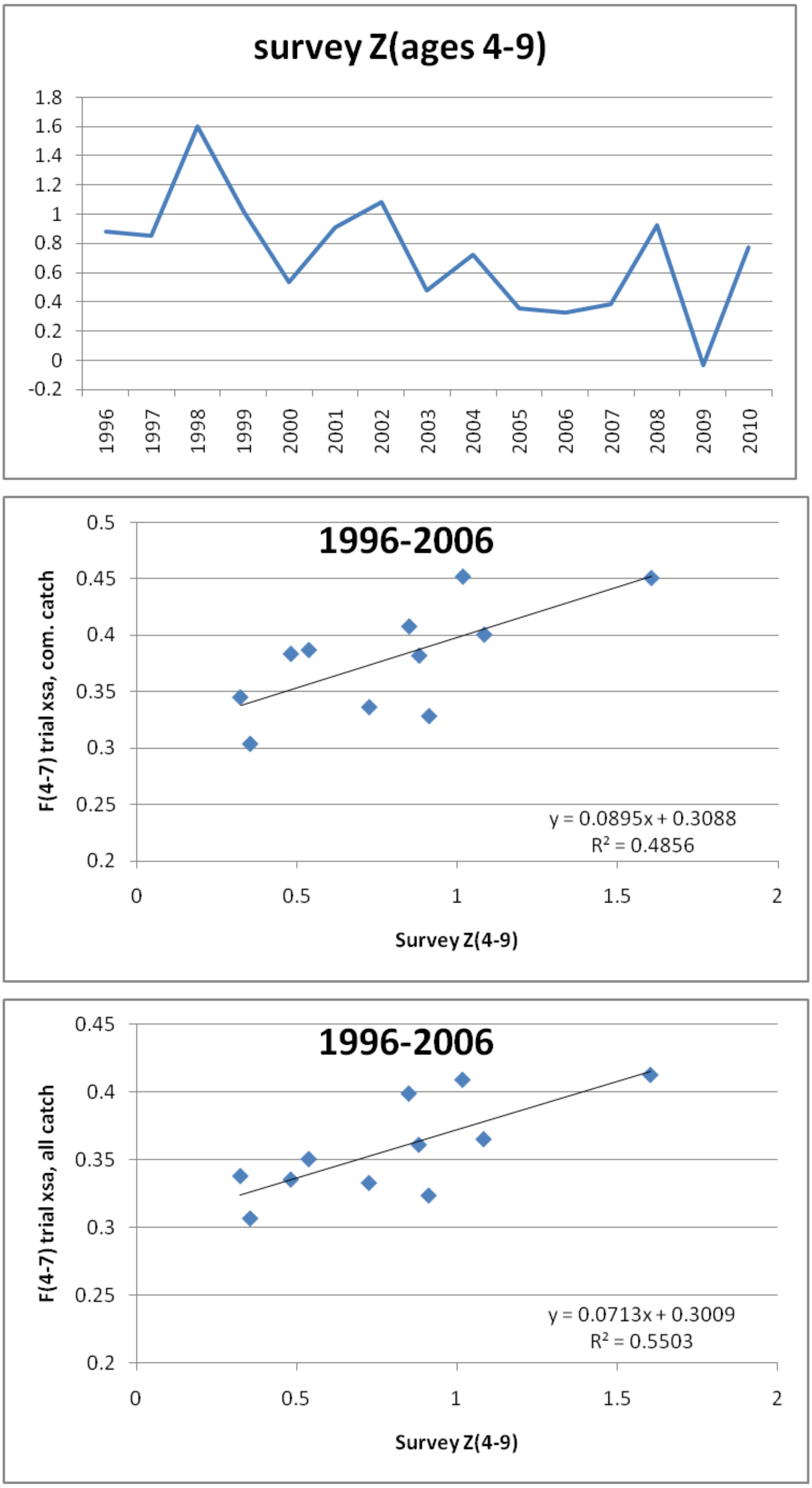


Figure 2.15. Survey mortality Z (upper) and relation to VPA values of F(4-7) over the period 1996-2006 for a VPA based on commercial catch (middle) and a VPA based on all catch (bottom).

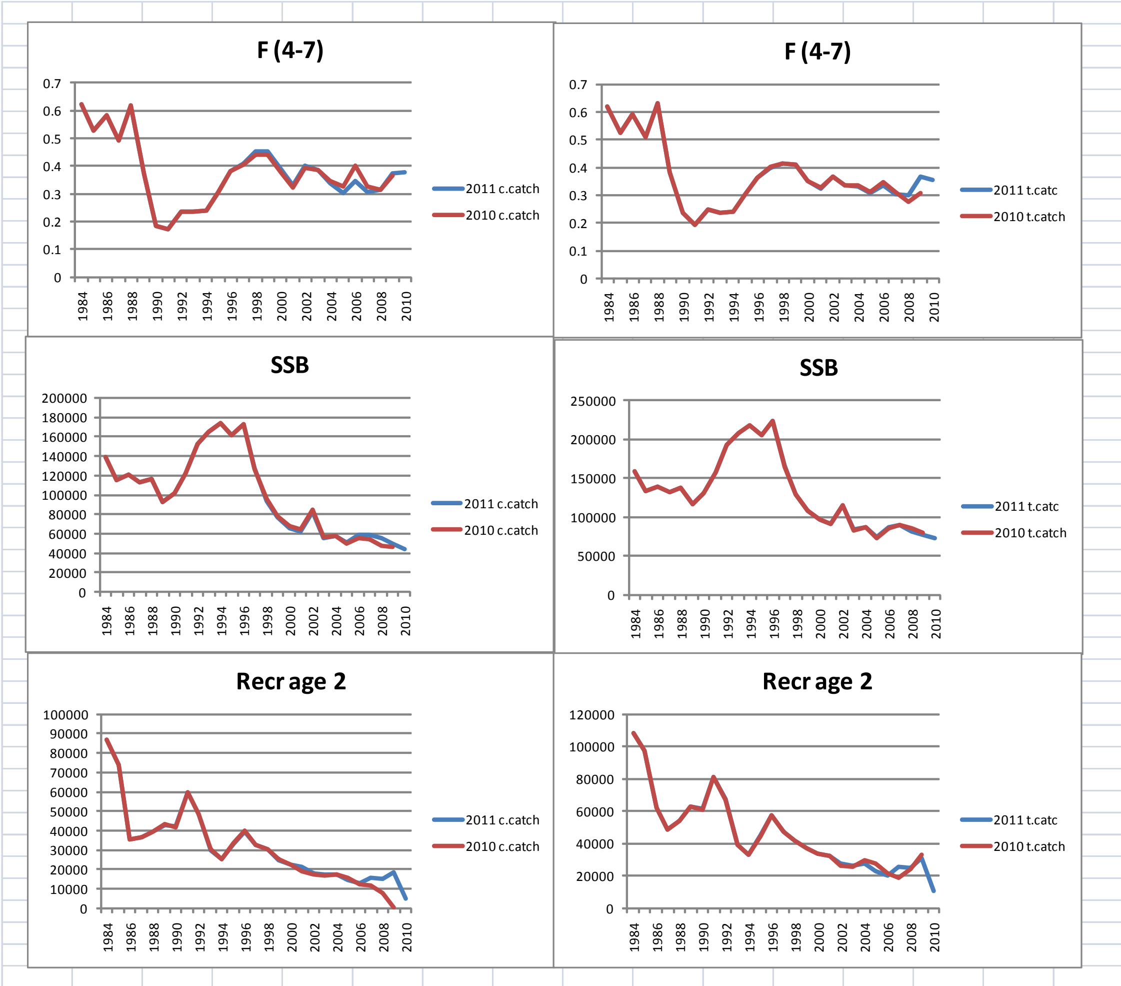


Figure 2.16. Comparisons of SVPA outputs with the 2010 assessment for analyses based on commercial catch (left) and total catch (right).

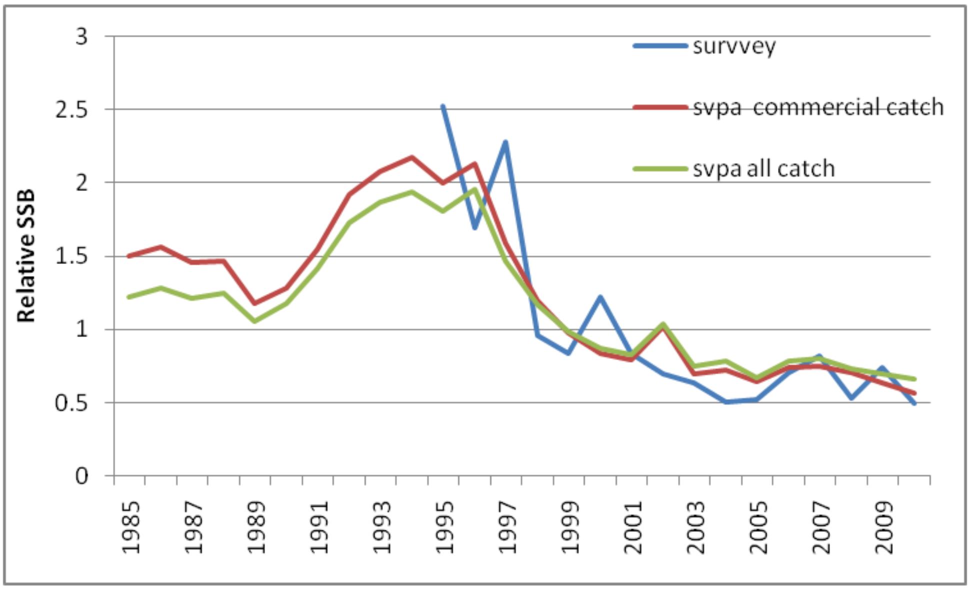


Figure 2.17. Coastal cod. Trends in spawning biomass. Each series are shown relative to its 1995-2010 average. The survey ssb is calculated with the same maturity ogive as in the vpa.

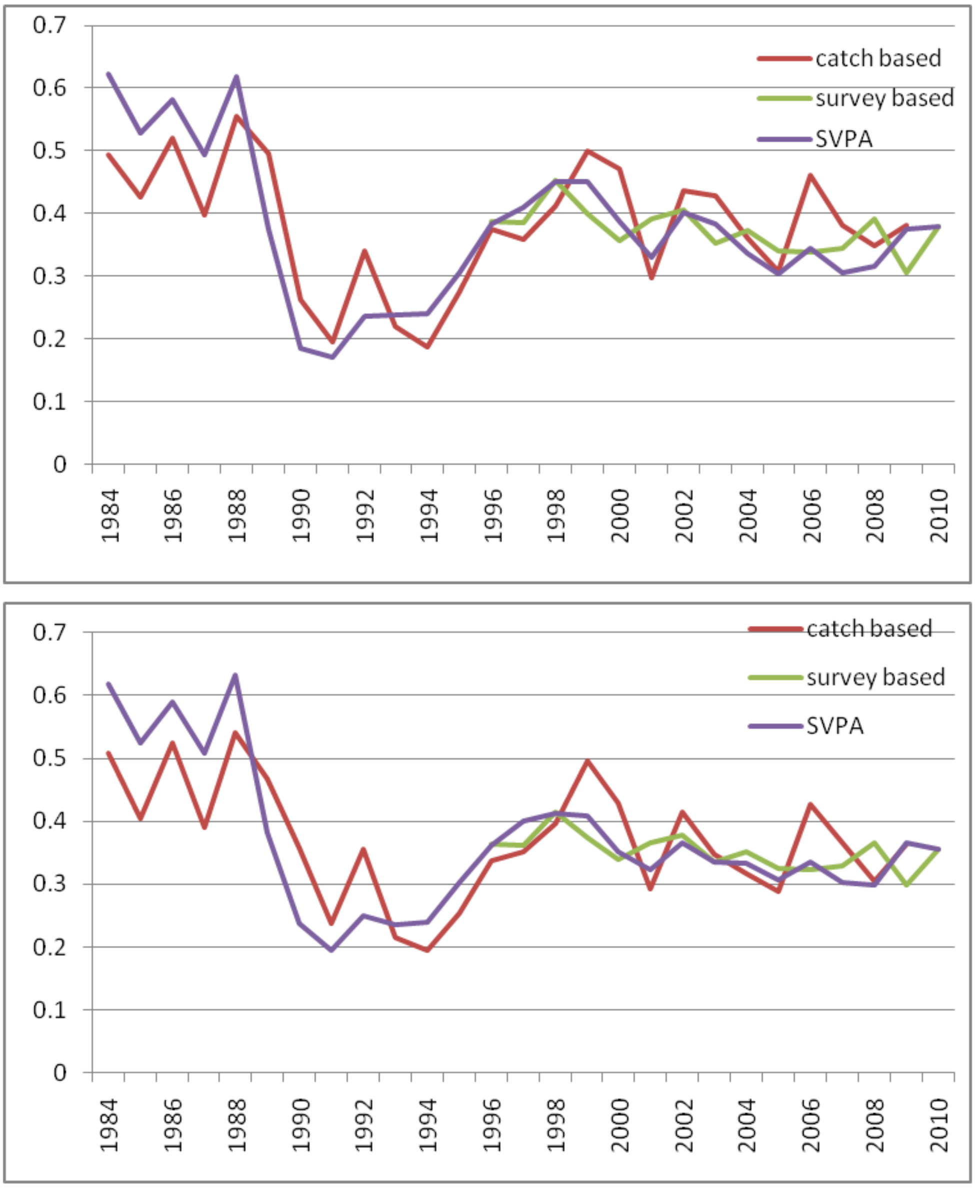


Figure 2.18. Time series of F-estimates corresponding to commercial catch at age (upper) and total catch at age (lower).

3 North-East Arctic Cod (Subareas I and II)

3.1 Status of the fisheries

3.1.1 Historical development of the fisheries (Table 3.1a)

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 3.1a). 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. After 2000, the reported catches have been between 400,000 and 520,000 t, in addition there have been unreported catches (see below). The fishery is conducted both with an international trawler fleet and with coastal vessels using traditional fishing gears. Quotas were introduced in 1978 for the trawler fleets and in 1989 for the coastal fleets. In addition to quotas, the fishery is regulated by a minimum catch size, a minimum mesh size in trawls and Danish seines, a maximum by-catch of undersized fish, closure of areas having high densities of juveniles and by seasonal and area restrictions.

3.1.2 Reported catches prior to 2011 (Tables 3.1-3.3, Figure 3.1)

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

Final official catch for 2009 amounts to 523,431 t. The provisional catch for 2010 reported to the working group is 609,983 t.

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

The historical practice (considering catches between 62ºN and 67ºN for the whole year and catches between 67ºN and 69ºN for the second half of the year to be Norwegian coastal cod) leads to reported landings of North-East Arctic cod of 523,431 t in 2009 and 609,983 t in 2010 (Table 3.3). The coastal cod catches calculated this way in 2009 and 2010 were 15,229 t and 16,269 t, respectively. The catches of coastal cod calculated this way for the period 1960-2010 are given in Table 3.1b together with the coastal cod catches calculated based on otolith types as described in Section 2.

The catch by area, are shown in Table 3.1a, and further split into trawl and other gears in Table 3.2. The distribution of catches by areas and gears in 2010 was similar to 2009. The nominal landings by country are given in Table 3.3.

There is information on cod discards (see section 0.5) 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 recent period and inclusion of these estimates in the assessment should not change our perception on NEA cod stock size.

3.1.3 Unreported catches of Northeast Arctic cod in 2002-2010

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 Section 0.4. The Norwegian and Russian estimates of IUU for this period are given in Table 3.1a. In according to reports from the Norwegian-Russian analytical group on estimation of total catches the total catches of cod in 2009 and 2010 were very close (within 1%) to officially reported landings. The Working Group decided not to include IUU catches in 2009 and 2010.

3.1.4 TACs and advised catches for 2010 and 2011

The Joint Norwegian-Russian Fisheries Commission (JNRFC) agreed on a cod TAC of 628,000 t for 2010, including 21,000 t Norwegian coastal cod. The total reported catch of 609,983+16,269 t in 2010 was 1,748 t below the agreed TAC.

The advice for 2011 given by ACOM in 2010 was based on the assessment made by AFWG in 2010. The JNRFC used the agreed rule (see section 3.6.3), applying the lower limit on F (0.30) when the spawning stock biomass is above B_{pa}. This rule gave a NEA cod TAC for 2011 of 703,000 tonnes, which was the quota set by JNRFC for 2011. In addition, the TAC for Norwegian Coastal Cod was set to the same value for 2011 as for 2010: 21,000 t.

The Working Group has no information on the size of expected unreported landings in 2011.

3.2 Status of research

3.2.1 Fishing effort and CPUE (Table A1)

Updated 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 (Table A1).

3.2.2 Survey results – abundance and size at age (Tables 3.4, A2–A14)

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

The preliminary swept area estimates and acoustic estimates from the Joint winter survey on demersal fish in the Barents Sea in winter 2011 are given in Tables A2 and A3. More details on this survey are given in Aglen *et al*. (WD 03). The coverage was fairly good within the strata system defined for the survey. There has been a pattern in recent years to have concentrations of cod near the borders of the strata system. This could indicate an increasing amount of fish being distributed outside the strata system.

Before 2000 this survey was made without participation from Russian vessels, while in 2001-2005 and 2008-2011 Russian vessels have covered important parts of the Russian zone. In 2006-2007 the survey was carried out only by Norwegian vessels. In 2007 the 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 3.4 shows areas covered in the time series and the additional 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.

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 the time are described by Jakobsen *et al*. (1997). Note that the change from 35 to 22 mm mesh size in the codend in 1994 is not corrected for in the time series. This mainly affects the age 1 indices.

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 2011 survey showed an increase in numbers compared to the 2010 survey approximately by a factor of three, while the biomass increased by a factor of 2.7. The biomass was estimated to 1.08 mill. tonnes. This is the highest in the time series, 40% above the second highest (1992-survey). The percentage of repeat spawners in 2011 was 43 %, compared to 50% in 2010. The decrease in percentage repeat spawners is mainly caused by the high abundance of age 7. This age group contributed by 66% to the first-time spawners and by 52% to the repeat spawners.

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 IIa and IIb were adequately investigated in the survey in contrast to Sub-area I, where the survey covered approximately 40% of the long-term average area coverage. The Subarea I 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.

The Russian autumn 2010 survey was conducted in the standard period and under the standard methods. An area of 206 $*10^3$ sq. miles was covered, which is somewhat larger than the standard area. The 2010 abundance indices were calculated based on the standard area adopted at the two previous AFWG (2007 and 2006) (Golovanov *et al.*, WD 3 in 2007; WD 21 in 2006).

Overall increase of cod numbers was observed in the last survey, especially for cod at age 5 and for ages 9 and older. Estimates for ages 9 and 10 were the highest ones over the time series. Rather wide distribution of cod was registered, and besides, delaying of return migrations of maturing fish from the eastern feeding grounds was observed.

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 2004-2010 are given in Table A14. The new index values were calculated at first in 2010 (AFWG 2010, WD 20). This time series have been tested as new tuning fleet in XSA (AFWG 2010, section 3.11.3). Using this survey in tuning is postponed until benchmark meeting.

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.

Both the Joint winter survey in 2011 and the Russian autumn survey in 2010 show a continued slight tendency on reduction of size-at-age compared to the previous surveys (Table A6 and A12).

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*. (2009b). Zuykova *et al*. (2009) re-read old otoliths and found no significant difference in contemporary and historical age determination and subsequent length at age. However, age at first maturation in the historical material as determined by contemporary readers is younger than that determined by historical readers. Taking this difference into account would thus have effect on the spawning stock-recruitment relationship and thus on the biological reference points.

3.3 Data used in the assessment

3.3.1 Catch at age (Tables 3.5–3.6)

For 2010, age compositions from all areas were available from Russia, Germany, Spain and Norway. Poland provided age compositions from Division IIb. Unsampled catches were distributed on age by using data from Russian trawl in Sub-area I and Division IIa, and by using data from Norwegian trawl in Division IIb. Tables 3.5 shows available catch at age data for all ages 1-15+. The 2010 catch at age data was calculated using Intercatch (Table 3.6).

3.3.2 Weight at age (Tables 3.7 and 3.8–3.9, A2, A4, A6, A8, A12).

Catch weights

For 2010, 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, Germany, Spain and Poland. The weight at age in the catch for these countries is given in Table 3.7.

Stock weights

Since ages 12 and 13+ are scarce in the survey samples, fixed values for these ages have formerly been used (set equal to typical weights for these ages observed in catches). Since the 2000 working group the assessment has applied 13 as plus group. For the years 1946-1984 the 13+ weights are calculated year by year as a weighted mean of the former fixed values for older ages. For later years they are calculated from the average observed weight for age 11 in the years 1995-2008 increased by 1.58 kg for age 12 and 2x1.58 kg for age 13+.

For ages 1-11 stock weights at age at the start of year y ($W_{a,y}$) for 1983-2011 (Table 3.9) were calculated as follows:

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

where

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

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

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

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

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

3.3.3 Natural mortality

A natural mortality of 0.2 was used. In addition, cannibalism was taken into account as described in Section 3.4.2. The proportion of F and M before spawning was set to zero.

3.3.4 Maturity at age (Tables 3.10 and 3.11)

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

Since 1982 Russian and Norwegian survey data have been used (Table 3.10). For the years 1985-2011, 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.

3.3.5 Cannibalism (Table 3.12)

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 XSA. 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 9,000 cod stomachs from the Barents Sea have been analyzed annually in the period 1984-2010. The estimates of cod consumption by cod have been revised by including data from the ecosystem survey from 2004-2010 on geographical distribution of cod (west/east/north, three areas) and age/length keys and length/weight relationships for cod and haddock. These data are used in the consumption calculations for the second half of the year. Previously, fixed values (not varying by year) were used for such data in the second half of the year.

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.

The number of cod predators at age is taken from the VPA, and thus an iterative procedure has to be applied (Section 3.4.2). All occurrences of intra-cohort predation were removed from the data set as these could possibly cause problems with convergence.

3.4 Assessment using VPA model (Tables 3.13, A13)

The XSA was also this year used as the main assessment method, as an update assessment was carried out. Additional assessment methods (survey calibration of VPA and Gadget) are presented in Section 3.9.

The following surveys and commercial CPUE data series were used for tuning of both models:

XSA name	Name	Place	Season	Age	Years
Fleet 09	Russian trawl CPUE	Total area	All year	9-11	1985-2010
Fleet 15	Joint bottom trawl survey	Barents Sea	Feb-Mar	3-8	1981-2011
Fleet 16	Joint acoustic survey	Barents Sea+Lofoten	Feb-Mar	3-9	1985-2011
Fleet 18	Russian bottom trawl surv.	Total area	Oct-Dec	3-9	1994-2010

As in earlier assessments the surveys that were conducted during winter were allocated to the end of the previous year. This was done so that data from the surveys in 2011 could be included in the assessment. 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.

3.4.1 XSA settings (Figure 3.2a, Table 3.13a)

The output tables from the tuning include ages 1 and 2, just to show the year class abundance at age 1 and 2 created by the cannibalism numbers (Section 3.4.2). These age groups are not included in the tuning, however.

Some of the survey indices have been multiplied by a factor 10. This was done to keep the dynamics of the surveys even for very low indices, because XSA adds 1.0 to the indices before the logarithm is taken.

XSA was run using default settings with the following exceptions:

Tapered time weighting power 3 over 10 years

Catchability dependent of stock size for ages less than 7

F of the final 5 years and the 2 oldest age groups used in F shrinkage

Standard error of the mean to which estimates are shrunk set to 1.0

These settings are identical to those used by last years' Working Group except "Catchability dependent of stock size" parameter. Since the assessments in August 2000, few changes in model settings and data choices have been made but in this year some corrections were needed.

As a result of the successful management of the stock in recent years, the survivorship to older ages is now higher than has been seen for many years. As a result the stock is moving into a state where some previous model settings may need to be re-examined. In particular, the previous strategy of including stock size dependent catchability (ssdq) for age 3-5 and not older ages may no longer be valid.

In several surveys (Fleet 15 and Fleet 16) the WG has identified that the most recent results for age 6 fish appear as outliers when compared to the existing linear (non-ssdq) catchability (Figure 3.2a, red line). Figure 3.2a also presents a comparison of including ssdq for age 6 (black line). As can be seen the power model (i.e. with ssdq) is a good fit to all data, including the most recent point. This indicates that the new points are not outliers, but rather that the previous linear catchability is no longer appropriate, suggesting that the ssdq should be extended to age 6 within XSA.

Table 3.13a shows that the conflict between surveys becomes weaker (the survey residuals in the terminal year becomes smaller) if a power model is used also for age 6. The sum of squares measure of misfit for each survey and each parameter set demonstrate that SSQ is visibly lower for case where power model for age 6 is used than linear. These indicate that moving to ssdq for age 6 gives a large benefit in model fit, whereas the gains for including this for older ages is much less clear cut.

Figure 3.2a also demonstrates that the effects of a misfit between model and reality are magnified if the most recent year's data is the extreme point in the data series, as is the case here. Furthermore the effects of a model misfit in a large year class (as here) will have a large effect on the modeled stock size. It is therefore important that the modification to use ssdq for age 6 be implemented this year, rather than waiting for a benchmark meeting. Without this change the stock assessment for the current year (and resulting short term projections) are likely to be seriously flawed.

The WG has therefore concluded that the stock size dependent catchability (ssdq) should be extended from ages 3-5 to ages 3-6 with immediate effect. The WG also recommends that the development of the high survivorship yearclasses be monitored, and that the issue is examined in depth at the next benchmark meeting. Several more years of data will be available by the benchmark, facilitating this analysis.

3.4.2 Including cannibalism in XSA (Tables 3.7, 3.12)

The catch numbers shown in Table 3.7 together with cannibalism numbers (Tables 3.12) were used in the XSA tuning.

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 following procedure was followed: As a starting point the number of cod consumed by cod was estimated from the stock estimates in the last assessment and the per capita estimates of consumption of cod by cod. Then the number consumed was added to the catches used for tuning. The resulting stock then leads to new estimates of consumption. This procedure was repeated until the consumed numbers for the latest year differed less than 1% from the previous iteration. The final numbers of cod eaten by cod are given in Table 3.12.

It would be promising to include cannibalism to the historical period (1946-1983) data to make the VPA time series consistent. There have been some approaches proposed (Yaragina *et al*. 2009a).

3.4.3 XSA tuning diagnostics (Table 3.14–3.15, Figure 3.2b–3.4)

The tuning diagnostics from XSA with cannibalism are given in Table 3.15. Figure 3.2b shows the log catchability residuals of the tuning series. It is observed a slight positive trend in residuals of the winter bottom trawl survey (Fleet 15) for ages 6-8. Most of the residuals are negative in 2006 and positive in 2007 for the combined winter+Lofoten acoustic survey (Fleet 16). The residuals in 2010 are close to zero except relatively high (0.45) positive residual for age 6 in Fleet 16 and have no particular pattern.

Figure 3.3 and Table 3.14 compares the estimated survivors (by end of 2010) and Fs before shrinkage in single fleet tunings. (The single fleet runs applies the same shrinkage settings as the standard run, but the tabulated values of F and survivors are the pure survey predictions in the diagnostics output). Survivors' estimates from single fleet runs for all ages are in a fair agreement between fleets. Final XSA run including all fleets tends to give close to average estimates of survivors at all ages compare to single fleet runs.

Retrospective plots of F, SSB and recruitment, going back to 2001 as the last year in the assessment, are shown in Figure 3.4. Cannibalism is taken into account, but the number of cod consumed by cod was not recalculated year by year in the retrospective analysis. The retrospective pattern seems satisfactory.

3.4.4 Results (Table 3.16–3.26, Figure 3.1)

The total fishing mortalities (true fishing mortality plus mortality from cannibalism) and population numbers are given in Tables 3.16 and 3.17.

In order to build a matrix of natural mortality which includes predation, the fishing mortality estimated in the final XSA analyses was split into the mortality caused by the fishing fleet (real F) and the mortality caused by cod cannibalism (M2 in MSVPA terminology) by using the number caught by fishing and by cannibalism. The new natural mortality matrix was prepared by adding 0.2 (M1) to the M2. This new M matrix (Table 3.18) was used together with the new real Fs (Table 3.20) to run the final VPA on ages 3-13+. M2 and F values for ages 1-6 in 1984-2010 are given in Tables 3.19 and 3.21.

The stock numbers from the final run are given in Tables 3.22, while the corresponding stock biomass at age and the spawning stock biomass at age are given in Tables 3.23-3.24. Summaries of landings, fishing mortality, stock biomass, spawning stock biomass and recruitment since 1946 runs are given in Table 3.25 and Figure 3.1.

Cannibalism on cod age 3 and older may of course also have occurred before 1984. Thus, there is an inconsistency in the recruitment time series. For comparison with the historic time series an additional VPA with the same terminal Fs and fixed natural mortality (0.2) is presented (Table 3.26).

3.5 Results of the assessment

3.5.1 Fishing mortalities and VPA

The estimated $F_{5\text{-}10}$ in 2010 from the SVPA is 0.29, which is below F_{pa} and is close to the lowest since 1990. Fishing mortality has gradually declined since 2005. The spawning stock biomass in 2011 is estimated to be 1,311,000 t, which is the highest since 1947. Total stock biomass in 2011 is estimated to 2,507,000 tonnes which is not that outstanding in the time series. One should bear in mind that in the early part of the time series the fraction mature was lower.

3.5.2 Recruitment (Table 1.13)

Since survey data for the youngest ages are not used in the XSA, these ages are estimated by other models. At the 2008 it was decided to use a hybrid model, which is an arithmetic mean of different recruitment models (Section 1.6). It was agreed to use the same approach this year. The input data for those models are the following time series; survey data for ages 0, 1 and 2 (Russian autumn survey) and ages 1, 2 and 3 (Joint winter survey), 0-group from the ecosystem survey, capelin biomass, ice coverage, temperature and oxygen saturation at the Kola section, air temperature at Murman coast. Prognosis from all the models, including the hybrid is presented in Table 1.13. Here also the results from the earlier used RCT3 model are shown. The numbers at age 3 calculated by the hybrid method were: 433 million for the 2008 year class, 607 million for the 2009 year class and 683 million for the 2010 year class.

3.6 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 38th session of JRNFC a new version of the management rule was adopted (see section 3.6.3). It has been evaluated at the AFWG-2010 and considered to be in accordance with precautionary approach. The results of investigation indicated that the F=0.40 currently used in the Harvest control provide a long term yield corresponding to the maximum (see section 3.6.4).

TAC advice for 2012 is based on the management rule.

3.6.1 Biomass reference points (Figure 3.1)

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

3.6.2 Fishing mortality reference points

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

3.6.3 Harvest control rule

At the 31st session of The Joint Norwegian-Russian Fishery Commission (JRNFC) in autumn 2002, the Parties agreed on a new harvest control rule. This rule was applied for the first time when setting quotas for 2004. The rule was somewhat amended at the 33rd session of The Joint Norwegian-Russian Fishery Commission in autumn 2004. The amended rule was evaluated by ICES in 2005 and found to be precautionary.

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

conditions for high long-term yield from the stocks

achievement of year-to-year stability in TACs

full utilization of all available information on stock development

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

estimate the average TAC level for the coming 3 years based on F_{pa}. TAC for the next year will be set to this level as a starting value for the 3-year period.

the year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development, however the TAC should not be changed by more than +/- 10% compared with the previous year's TAC.

if the spawning stock falls below B_{pa}, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from F_{pa} at B_{pa}, to F= 0 at SSB equal to zero. At SSB-levels below B_{pa} in any of the operational years (current year, a year before and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.

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

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

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

-estimate the average TAC level for the coming 3 years based on F_{pa}. TAC for the next year will be set to this level as a starting value for the 3-year period.

-the year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development, however the TAC should not be changed by more than +/- 10% compared with the previous year's TAC. **If the TAC, by following such a rule, corresponds to a fishing mortality (F) lower than 0.30 the TAC should be increased to a level corresponding to a fishing mortality of 0.30.**

-if the spawning stock falls below B_{pa}, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from F_{pa} at B_{pa}, to F= 0 at SSB equal to zero. At SSB-levels below B_{pa} in any of the operational years (current year, a year before and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC."

ICES has evaluated the rule and considered it to be in accordance with the precautionary approach (AFWG-2010, section 3.12).

3.6.4 Target reference points

The Russian-Norwegian Fishery Commission has requested an evaluation of the maximum sustainable yield (MSY) from the Barents Sea, taking into account species interactions and the influence from the environment. The work starts with cod and will incorporate other species. A first step towards this was to study the MSY of cod in a single-species context (Kovalev and Bogstad, 2005). They studied the long-term yield of cod using the same biological model as used in the evaluation of the harvest control rule. Thus, mean weight at age in the stock was modelled as a function of total stock size, and mean weight at age in the catch and maturity at age was modelled as a function of mean weight at age in the stock. Cannibalism was included, and a stochastic segmented regression SSB-recruitment relationship was used. **The results indicated that the F=0.40 currently used in the Harvest control rule provides a long term yield corresponding to the maximum. Based on this long term simulations F_{msy} is defined to be at F=0.40.**

In according to the same simulations if stock is exploited at F=0.4 level SSB will be well above B_{pa}, and as B_{pa} already is used in management rule then $B_{trigger}$ could be set at B_{pa} level.

3.7 Prediction

3.7.1 Prediction input (Tables 3.22, 3.27, Figure 3.5a-b, 3.6, 3.7)

The input data to the short-term prediction with management option table (2011-2014) are given in Table 3.27. For 2011 stock weights and maturity were taken from surveys as described in Sections 3.3.2 and 3.3.4.

Catch weights in 2011 onwards and stock weights in 2012 onwards 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.

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

This method was introduced in the cod prediction in the 2003 working group. Then it was decided that for Catch Weights average annual increments by age were calculated for the period 1994-2001, and for Stock Weights average annual increments by age were calculated for the period 1995-2002. At the 2004 working group it was decided to follow the same procedure, except that for stock weights the period (2001-2003) was chosen for calculating average annual increment. The reason was that those years indicate a declining trend that could be associated with declining capelin stock. The same argument was considered valid at the 2005 and later working groups and only the 3 most recent values of annual increments were used for predicting stock weights. For catch weights, we use a 10-year period (2001-2010) for averaging the increments. Figures 3.5a and 3.5b show how these predictions perform back in history.

The maturity ogive for the years 2012 and 2013 was predicted by using the 2009-2011 average. The exploitation pattern in 2011 and later years was set equal to the 2008-2010 average.

The stock number at age in 2011 was taken from the final VPA (Table 3.22) for ages 4 and older. The recruitment at age 3 in the years 2011-2013 was estimated as described in section 1.6. Figure 3.6 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 1984-2010. The recent 3 years average M was used as input for the years 2011-2013 in the prediction.

For 2014, the 2013 values were used for all input data, except for recruitment, where the long-term arithmetic mean (606 million at age 3) was used.

The assessment does not show clear pattern in F from 2008 to 2010. Effort also was relatively stable (Figure 3.7). There is practically no difference between last three year average F and last year F, and thus similar to last year's assessment F in terminal year 2010 is considered to be used for F in the intermediate year (2011). Table 3.27 shows input data to the predictions.

3.7.2 Prediction results (Tables 3.28, 3.29a-b)

The catches corresponding to F_{sq} in 2011 is 628 142 tonnes (Table 3.28). This is lower than the TAC for 2011 (703 000 tonnes). The resulting SSB in 2012 is 1,551,000 tonnes. Table 3.28 also shows the short-term consequences over a range of F-values in 2012. The detailed outputs corresponding to F_{sq} in 2011, the F corresponding to the HCR in 2012 and F_{pa} in 2013-2014 is given in Table 3.29a and 3.29b. Summarised results are shown in the text table below.

Rationale	Landings [1] (2012)	Basis	F (2012)	SSB (2013)	%SSB change [2]	% TAC change [3]
Zero catch	0	$0*F_{sq}$	0	2123	+37	-100
Agreed management Plan[4]	751	$1.23*F_{sq}$	0.35	1446	-7	+7
Status quo	631	$1.00*F_{sq}$	0.29	1552	0	-10
Precautionary Limits	834	F_{pa}	0.40	1373	-11	+19

Weights in '000 t.

1) Landings are total landings without IUU landings. If this figure is taken as TAC, no implementation error is assumed.

2) SSB 2013 relative to SSB 2012.

3) TAC 2012 relative to TAC 2011.

4) Forecast based on catch equal to average catch in 2012-2014 corresponding to F=0.4.

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.

3.8 Comparison with last year's assessment

The text table below compares this year's estimates with last year's estimates for the year 2010 numbers at age (millions), total biomass, spawning biomass (thousand tonnes), as well as reference F for the year 2009.

		N(2010)										
Assessment year (specification)	F(2009)	age3	age4	age5	age6	age7	age8	age9	age10	TSB (2010)	SSB (2010)	F (2010)
2010 WG	0.28	384*	423	417	297	144	72	24	18	2645	1145	0.28**
2011 WG	0.27	358	410	426	290	142	64	26	17	2613	1134	0.29
Ratio 2011 WG/ 2010 WG	0.96	0.93	0.97	1.02	0.98	0.99	0.90	1.07	1.00	0.99	0.99	1.02

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

The final assessment values for all ages are fairly close (within 10%) of the 2010 assessment. The F in 2009 is 4% higher last year's estimate. The total stock biomass and SSB in 2010 are very close to the previous estimates.

3.9 Additional assessment methods

3.9.1 Survey calibration method (Figures 3.8–3.9)

A "calibrated" prediction method of stock numbers from the Joint bottom trawl survey against VPA numbers, using data from the period 1981-1995 to scale the survey series to absolute numbers, was carried out. The method is described in Pennington and Nakken (WD14, 2008). The regression is done for ages 4-6 and 7+ separately. The results, using a regression method with intercept, are shown in Figures 3.8-3.9. The method compares well to the VPA results for stock abundance in 2011 for ages 4-6: Calibration method 866 millions, vs. 825 millions from VPA. For age 7+: Calibration method gives 558 millions, which is much higher than the 319 millions from VPA. The figures show a shift for ages 4-6 occurring around 2006 for the relation between the survey calibration and the VPA.

3.9.2 Gadget (Figure 3.10)

The biological Gadget model used for Northeast Arctic cod is described in Bogstad *et al*. (2004). The same model as last year was run, updated with an additional year of data. Model runs are now performed using Gadget version 2.1.06. The trends obtained last year are also seen this year, with continuing increases in overall and spawning stock biomass, but low to moderate recruitment (Figure 3.10). The modelled historical stock is very similar to that from the previous year, with very slight upwards revisions in some years, mostly in the modelled SSB. The Gadget model is in broad agreement with the XSA model in that that current stock is close to the highest values seen over the last 20 years. There is some indication in the model results that recruitment may now be dropping from the recent high levels.

In contrast to previous years, the age-length distributions in the catches were not updated for 2010. This is because the ECA program used for data extraction gave unreliable results when run in 2011. Some files were not produced at all, and others had age-length tables that were not compatible with previous years, despite using the same settings. Work will be undertaken before the next AFWG to investigate and rectify this problem. However for this meeting the most recent years in the Gadget model is lacking in fleet data, and may thus be overly sensitive to variations in the most recent surveys.

3.10 Comments to the assessment

The magnitude of IUU catches has decreased considerably from around 30% of official landings to 3% in 2008. No any IUU catches were registered for 2009 and 2010. The uncertainty relating to total catch for the years 2002-2006 could still have significant influence on the assessment of the current stock.

XSA has for several years been used for the assessment of cod, but in recent years additional assessment models have been tried, e.g. the "survey calibration model" and "Gadget". These models have given results characterized by differences in level of stock size and exploitation, although the trends have in most cases been similar.

The WG realizes that imprecise input data, in particular the catch-at-age matrix, could be a main obstacle to producing precise stock assessments, irrelevant of which model is used. The WG observed a negative tendency in catch sampling both in Russia and Norway (see sec. 0.5) and therefore, recognizes the need for improvement.

Based on the analysis of surveys the modification of XSA model using stock size dependent q for age 6 was implemented this year (see sec. 3.4.1). It allows avoiding a serious misfit of the model to observed indices. The WG will monitor the development of the high survivorship year classes, and that issue will be examined in depth at the next benchmark meeting.

3.11 New data sources

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

3.11.1 Catch data (Tables 3.30, 3.31, 3.1b)

Discard and bycatch data series (Table 3.30, 3.31) should be updated and then included in the catch at age matrix. Table 3.31 (taken from Ajiad *et al.*, WD2, 2008) presents by-catch in the Norwegian shrimp fishery by cod age (previously this has been given by cod length). The by-catch mainly consists of age 1 and 2 fish, but the bycatch is generally small compared to other reported sources of mortality: catches, discards and the number of cod eaten by cod. From 1992 onwards, by-catches of age 3 and older fish are negligible, because use of sorting grids was made mandatory. However, in 1985, by-catches of age 5 and 6 cod were about one third of the reported catches for those age groups. The year class for which the by-catches were highest, was the 1983 year class (total by-catch of age 2 and older fish of about 60 million, compared to a stock estimate of about 1000 million at age 3).

Also the time series described by Hylen (2002), extending the VPA back to 1932, should be reviewed. Consistency between the catch data used for NEA cod and coastal cod should also be ensured. At present, 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 3.1b).

It could also be considered to take the difference in age at maturation determined by contemporary and historic age readers (Section 0.5) into account.

Updating the catch data series as indicated here will affect the reference points, but only to a small extent estimate of present stock size. These updates should all be carried out at the same time.

3.11.2 Consumption data

Work on extending the cannibalism time series back to 1947 is ongoing (Yaragina *et al*. 2009a).

3.11.3 Survey data (Table A14)

The bottom trawl estimates from the joint ecosystem survey in August-September, starting in 2004. This survey covers the entire distribution area of cod. The new index values for period 2004-2010 become available for AFWG since last year (Table A14, AFWG-2010 WD 20). This time series have been tested as new tuning fleet in XSA in WG at 2010 and this index could be considered for use as a tuning series on next benchmark.

3.12 Answering to last year comments from Reviewers:

The minutes of the review of the 2010 AFWG report contained a number of comments to the NEA cod assessment. Below is a summary how AFWG has responded to this:

Comment regarding terminology (landings/ catches) was taken into account. Tables were renumbered and other technical errors have been corrected.

The other comments need to be considered during the next benchmark meeting.

Table 3.1a North-East Arctic COD. Total catch (t) by fishing areas and unreported catch. (Data provided by Working Group members.)

Year		Sub-area I	Division IIa	Division IIb	Unreported catches	Total catch
1961		409 694	153 019	220 508		783 221
1962		548 621	139 848	220 797		909 266
1963		547 469	117 100	111 768		776 337
1964		206 883	104 698	126 114		437 695
1965		241 489	100 011	103 430		444 983
1966		292 253	134 805	56 653		483 711
1967		322 798	128 747	121 060		572 605
1968		642 452	162 472	269 254		1 074 084
1969		679 373	255 599	262 254		1 197 226
1970		603 855	243 835	85 556		933 246
1971		312 505	319 623	56 920		689 048
1972		197 015	335 257	32 982		565 254
1973		492 716	211 762	88 207		792 685
1974		723 489	124 214	254 730		1 102 433
1975		561 701	120 276	147 400		829 377
1976		526 685	237 245	103 533		867 463
1977		538 231	257 073	109 997		905 301
1978		418 265	263 157	17 293		698 715
1979		195 166	235 449	9 923		440 538
1980		168 671	199 313	12 450		380 434
1981		137 033	245 167	16 837		399 037
1982		96 576	236 125	31 029		363 730
1983		64 803	200 279	24 910		289 992
1984		54 317	197 573	25 761		277 651
1985		112 605	173 559	21 756		307 920
1986		157 631	202 688	69 794		430 113
1987		146 106	245 387	131 578		523 071
1988		166 649	209 930	58 360		434 939
1989		164 512	149 360	18 609		332 481
1990		62 272	99 465	25 263	25 000	212 000
1991		70 970	156 966	41 222	50 000	319 158
1992		124 219	172 532	86 483	130 000	513 234
1993		195 771	269 383	66 457	50 000	581 611
1994		353 425	306 417	86 244	25 000	771 086
1995		251 448	317 585	170 966		739 999
1996		278 364	297 237	156 627		732 228
1997		273 376	326 689	162 338		762 403
1998		250 815	257 398	84 411		592 624
1999		159 021	216 898	108 991		484 910
2000		137 197	204 167	73 506		414 870
2001		142 628	185 890	97 953		426 471
2002	[2]	184 789	189 013	71 242	90000/21716	535045/466760
2003	[2]	163 109	222 052	51 829	115000/27748	551990/464738
2004	[2]	177 888	219 261	92 296	117000/30000	606445/519445
2005	[2]	159 573	194 644	121 059	166000/41000	641276/516276
2006	[2]	159 851	204 603	104 743	67100/28000	537642/497197
2007	[2]	152 522	195 383	97 891	41087/8757	486883/454553
2008		144905	203244	101022	15000/0	464171/449171
2009		161602	207205	154623		523 431
2010	[1]	183988	271337	154657		609 983

[1] Provisional figures.

[2] two alternative estimates (see Chapter 3.1.3 of the 2008 AFWG Report for further details)

Table 3.1b Landings of Norwegian Coastal Cod in Sub-areas I and II

	Landings in '000 t	
Year	As calculated from samples and reported to AFWG	By area and time of capture
1960	-	43
1961	-	32
1962	-	30
1963	-	40
1964	-	46
1965	-	24
1966	-	29
1967	-	33
1968	-	47
1969	-	52
1970	-	49
1971	-	*)
1972	-	*)
1973	-	*)
1974	-	*)
1975	-	*)
1976	-	*)
1977	-	*)
1978	-	*)
1979	-	*)
1980	-	40
1981	-	49
1982	-	42
1983	-	38
1984	74	33
1985	75	28
1986	69	26
1987	61	31
1988	59	22
1989	40	17
1990	28	24
1991	25	25
1992	42	35
1993	53	44
1994	55	48
1995	57	39
1996	62	32
1997	63	36
1998	52	29
1999	41	23
2000	37	19
2001	30	14
2002	41	20
2003	35	19
2004	25	14
2005	22	13
2006	26	15
2007	24	13
2008**	26	13
2009	25	15
2010	23	16
Average 1984-2010	43	25

*) No data
** Corrected

Table 3.2 North-East Arctic COD. Total nominal catch ('000 t) by trawl and other gear for each area, data provided by Working Group members.

	Sub-area I		Division IIa		Division IIb	
Year	Trawl	Others	Trawl	Others	Trawl	Others
1967	238.0	84.8	38.7	90.0	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	33.0	-
1973	459.0	33.7	39.4	172.4	88.2	-
1974	677.0	46.5	41.0	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	110.0	-
1978	360.4	57.9	117.0	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	171.0	21.0	-
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	122.0	88.0	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	73.0	84.0	40.0	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	159.0	147.7	6.8
1997	235.6	37.7	150.5	176.2	154.7	7.6
1998	219.8	31.0	127.0	130.4	82.7	1.7
1999	133.3	25.7	101.9	115.0	107.2	1.8
2000	111.7	25.5	105.4	98.8	72.2	1.3
2001	119.1	23.5	83.1	102.8	95.4	2.5
2002	147.4	37.4	83.4	105.6	69.9	1.3
2003	146.0	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	87.0	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	102.0	105.2	142.1	11.4
2010[1]	151.1	32.9	130.0	141.4	149.2	5.4

[1] Provisional figures.

Table 3.3 North-East Arctic COD. Nominal catch (t) by countries
(Sub-area I and Divisions IIa and IIb combined, data provided by Working Group members.)

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

[1] Provisional figures.
[2] USSR prior to 1991.
[3] Includes Baltic countries.

Table 3.4. 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	Are 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
1998	99.2	78.0	Index ratio
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
2008	164.4		
2009	170.9		
2010	159.9		
2011	173.1		

Table 3.5
NE Arctic cod. International catch (thousands) at age for ages 1-15+

	A G E														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1946	1	16	4008	10387	18906	16596	13843	15370	59845	22618	10093	9573	5460	1927	750
1947	1	1	710	13192	43890	52017	45501	13075	19718	47678	31392	9348	9330	4622	4103
1948	1	16	140	3872	31054	55983	77375	21482	15237	9815	30041	7945	4491	3899	4205
1949	1	7	991	6808	35214	100497	83283	29727	13207	5606	8617	13154	3657	1895	2167
1950	1	79	1281	10954	29045	45233	62579	30037	19481	9172	6019	4133	6750	1662	1450
1951	1615	1625	24687	77924	64013	46867	37535	33673	23510	10589	4221	1288	1002	3322	611
1952	1	1202	24099	120704	113203	73827	49389	20562	24367	15651	8327	3565	647	467	1044
1953	1	81	47413	107659	112040	55500	22742	16863	10559	10553	5637	1752	468	173	156
1954	1	9	11473	155171	146395	100751	40635	10713	11791	8557	6751	2370	896	268	123
1955	1	322	3902	37652	201834	161336	84031	30451	13713	9481	4140	2406	867	355	128
1956	81	1498	10614	24172	129803	250472	86784	51091	14987	7465	3952	1655	1292	448	166
1957	987	3487	17321	33931	27182	70702	87033	39213	17747	6219	3232	1220	347	299	173
1958	1	2600	31219	133576	71051	40737	38380	35786	13338	10475	3289	1070	252	40	141
1959	590	2601	32308	77942	148285	53480	18498	17735	23118	9483	3748	997	254	161	98
1960	465	7147	37882	97865	64222	67425	23117	8429	7240	11675	4504	1843	354	102	226
1961	1	1699	45478	132655	123458	51167	38740	17376	5791	6778	5560	1682	910	280	108
1962	1	1713	42416	170566	167241	89460	28297	21996	7956	2728	2603	1647	392	280	103
1963	1	4	13196	106984	205549	95498	35518	16221	11894	3884	1021	1025	498	129	157
1964	103	675	5298	45912	97950	58575	19642	9162	6196	3553	783	172	387	264	131
1965	1	2522	15725	25999	78299	68511	25444	8438	3569	1467	1161	131	67	91	179
1966	1	869	55937	55644	34676	42539	37169	18500	5077	1495	380	403	77	9	70
1967	1	151	34467	160048	69235	22061	26295	25139	11323	2329	687	316	225	40	14
1968	1	1	3709	174585	267961	107051	26701	16399	11597	3657	657	122	124	70	46
1969	1	275	2307	24545	238511	181239	79363	26989	13463	5092	1913	414	121	23	46
1970	1	591	7164	10792	25813	137829	96420	31920	8933	3249	1232	260	106	39	35
1971	38	2210	7754	13739	11831	9527	59290	52003	12093	2434	762	418	149	42	25
1972	1	4701	35536	45431	26832	12089	7918	34885	22315	4572	1215	353	315	121	40
1973	1	8277	294262	131493	61000	20569	7248	8328	19130	4499	677	195	81	59	55
1974	115	21347	91855	437377	203772	47006	12630	4370	2523	5607	2127	322	151	83	62
1975	1	1184	45282	59798	226646	118567	29522	9353	2617	1555	1928	575	231	15	37
1976	706	1908	85337	114341	79993	118236	47872	13962	4051	936	558	442	139	26	53
1977	1	11288	39594	168609	136335	52925	61821	23338	5659	1521	610	271	122	92	54
1978	3	802	78822	45400	88495	56823	25407	31821	9408	1227	913	446	748	48	51
1979	0	224	8600	77484	43677	31943	16815	8274	10974	1785	427	103	59	38	45
1980	31	403	3911	17086	81986	40061	17664	7442	3508	3196	678	79	24	26	8
1981	1	212	3407	9466	20803	63433	21788	9933	4267	1311	882	109	37	3	1
1982	2	94	8948	20933	19345	28084	42496	8395	2878	708	271	260	27	5	5
1983	13	86	3108	19594	20473	17656	17004	18329	2545	646	229	74	58	20	5
1984	11	999	6942	14240	18807	20086	15145	8287	5988	783	232	153	49	12	8
1985	92	1805	24634	45769	27806	19418	11369	3747	1557	768	137	36	31	32	8
1986	41	855	28968	70993	78672	25215	11711	4063	976	726	557	136	28	34	14
1987	14	390	13648	137106	98210	61407	13707	3866	910	455	187	227	21	59	20
1988	4	178	9828	22774	135347	54379	21015	3304	1236	519	106	69	43	14	5
1989	3	237	5085	17313	32165	81756	27854	5501	827	290	41	13	1	11	16
1990	6	170	1911	7551	12999	17827	30007	6810	828	179	59	15	6	5	2
1991	24	663	4963	10933	16467	20342	19479	25193	3888	428	48	12	1	1	2
1992	844	1184	21835	36015	27494	23392	18351	13541	18321	2529	264	82	3	9	1
1993	42	634	10094	46182	63578	33623	14866	9449	6571	12593	1749	377	63	22	1
1994	32	312	6531	59444	102548	59766	32504	10019	6163	3671	7528	995	121	19	4
1995	9	212	4879	42587	115329	98485	32036	7334	3014	1725	1174	1920	222	41	1
1996	184	895	7655	28782	80711	100509	54590	10545	2023	930	462	230	809	84	1
1997	79	1228	12827	36491	69633	83017	65768	28392	4651	1151	373	213	144	238	1
1998	97	1596	31887	88874	48972	40493	34513	26354	6583	965	197	69	42	22	53
1999	13	313	7501	77714	92816	31139	15778	15851	8828	1837	195	40	34	8	30
2000	32	215	4701	33094	93044	47210	12671	6677	4787	1647	321	71	11	1	14
2001	23	237	5044	35019	62139	62456	22794	5266	1773	1163	343	84	6	7	22
2002	47	130	2348	31033	76175	67656	42122	11527	1801	529	223	120	21	9	5
2003	6	187	7263	20885	64447	71109	36706	14002	2887	492	142	97	21	43	1
2004	8	183	2090	38226	50826	68350	50838	18118	6239	1746	295	127	39	16	8
2005	11	453	5815	19768	113144	61665	44777	20553	6285	2348	562	100	21	24	7
2006	112	1164	8548	47207	33625	78150	31770	15667	7244	1788	737	210	26	45	155
2007	1438	2625	25473	43817	62877	26304	34392	11240	4080	1381	505	285	44	13	35
2008	42	667	8459	51704	40656	35072	14037	20676	5503	1794	715	229	42	26	12
2009	12	335	4866	38711	83998	46639	20789	8417	8920	1957	872	987	76	21	20
2010	20	133	1778	16193	53855	75853	36797	17062	4784	4325	3034	913	189	49	35

Table 3.6. North-East Arctic COD. Catch numbers at age

Run title : Arctic Cod (run: SVPASA15/V15)

At 30/04/2011 20:40

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1946	1947	1948	1949	1950
AGE					
3	4008	710	140	991	1281
4	10387	13192	3872	6808	10954
5	18906	43890	31054	35214	29045
6	16596	52017	55983	100497	45233
7	13843	45501	77375	83283	62579
8	15370	13075	21482	29727	30037
9	59845	19718	15237	13207	19481
10	22618	47678	9815	5606	9172
11	10093	31392	30041	8617	6019
12	9573	9348	7945	13154	4133
+gp	8137	18055	12595	7719	9862
0 TOTALNUM	189376	294576	265539	304823	227796
TONSLAND	706000	882017	774295	800122	731982
SOPCOF %	103	91	89	99	109

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
AGE										
3	24687	24099	47413	11473	3902	10614	17321	31219	32308	37882
4	77924	120704	107659	155171	37652	24172	33931	133576	77942	97865
5	64013	113203	112040	146395	201834	129803	27182	71051	148285	64222
6	46867	73827	55500	100751	161336	250472	70702	40737	53480	67425
7	37535	49389	22742	40635	84031	86784	87033	38380	18498	23117
8	33673	20562	16863	10713	30451	51091	39213	35786	17735	8429
9	23510	24367	10559	11791	13713	14987	17747	13338	23118	7240
10	10589	15651	10553	8557	9481	7465	6219	10475	9483	11675
11	4221	8327	5637	6751	4140	3952	3232	3289	3748	4504
12	1288	3565	1752	2370	2406	1655	1220	1070	997	1843
+gp	4935	2158	797	1287	1350	1906	819	433	513	682
0 TOTALNUM	329242	455852	391515	495894	550296	582901	304619	379354	386107	324884
TONSLAND	827180	876795	695546	826021	1147841	1343068	792557	769313	744607	622042
SOPCOF %	115	93	105	93	106	105	100	112	93	104

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
AGE										
3	45478	42416	13196	5298	15725	55937	34467	3709	2307	7164
4	132655	170566	106984	45912	25999	55644	160048	174585	24545	10792
5	123458	167241	205549	97950	78299	34676	69235	267961	238511	25813
6	51167	89460	95498	58575	68511	42539	22061	107051	181239	137829
7	38740	28297	35518	19642	25444	37169	26295	26701	79363	96420
8	17376	21996	16221	9162	8438	18500	25139	16399	26989	31920
9	5791	7956	11894	6196	3569	5077	11323	11597	13463	8933
10	6778	2728	3884	3553	1467	1495	2329	3657	5092	3249
11	5560	2603	1021	783	1161	380	687	657	1913	1232
12	1682	1647	1025	172	131	403	316	122	414	260
+gp	1298	775	784	782	337	156	279	240	190	180
0 TOTALNUM	429983	535685	491574	248025	229081	251976	352179	612679	574026	323792
TONSLAND	783221	909266	776337	437695	444930	483711	572605	1074084	1197226	933246
SOPCOF %	110	124	102	103	129	123	109	108	105	112

Table 3.6. (continued).

Table 1 Catch numbers at age			Numbers*10**-3							
YEAR	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AGE										
3	7754	35536	294262	91855	45282	85337	39594	78822	8600	3911
4	13739	45431	131493	437377	59798	114341	168609	45400	77484	17086
5	11831	26832	61000	203772	226646	79993	136335	88495	43677	81986
6	9527	12089	20569	47006	118567	118236	52925	56823	31943	40061
7	59290	7918	7248	12630	29522	47872	61821	25407	16815	17664
8	52003	34885	8328	4370	9353	13962	23338	31821	8274	7442
9	12093	22315	19130	2523	2617	4051	5659	9408	10974	3508
10	2434	4572	4499	5607	1555	936	1521	1227	1785	3196
11	762	1215	677	2127	1928	558	610	913	427	678
12	418	353	195	322	575	442	271	446	103	79
+gp	216	476	195	296	283	218	268	847	142	58
0 TOTALNUM	170067	191622	547596	807885	496126	465946	490951	339609	200224	175669
TONSLAND	689048	565254	792685	1102433	829377	867463	905301	698715	440538	380434
SOPCOF %	124	118	130	137	115	127	107	109	121	127

Table 1 Catch numbers at age			Numbers*10**-3							
YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE										
3	3407	8948	3108	6942	24634	28968	13648	9828	5085	1911
4	9466	20933	19594	14240	45769	70993	137106	22774	17313	7551
5	20803	19345	20473	18807	27806	78672	98210	135347	32165	12999
6	63433	28084	17656	20086	19418	25215	61407	54379	81756	17827
7	21788	42496	17004	15145	11369	11711	13707	21015	27854	30007
8	9933	8395	18329	8287	3747	4063	3866	3304	5501	6810
9	4267	2878	2545	5988	1557	976	910	1236	827	828
10	1311	708	646	783	768	726	455	519	290	179
11	882	271	229	232	137	557	187	106	41	59
12	109	260	74	153	36	136	227	69	13	15
+gp	41	37	83	69	71	76	100	62	28	13
0 TOTALNUM	135440	132355	99741	90732	135312	222093	329823	248639	170873	78199
TONSLAND	399038	363730	289992	277651	307920	430113	523071	434939	332481	212000
SOPCOF %	118	125	90	95	102	102	102	100	99	101

Table 1 Catch numbers at age			Numbers*10**-3							
YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
3	4963	21835	10094	6531	4879	7655	12827	31887	7501	4701
4	10933	36015	46182	59444	42587	28782	36491	88874	77714	33094
5	16467	27494	63578	102548	115329	80711	69633	48972	92816	93044
6	20342	23392	33623	59766	98485	100509	83017	40493	31139	47210
7	19479	18351	14866	32504	32036	54590	65768	34513	15778	12671
8	25193	13541	9449	10019	7334	10545	28392	26354	15851	6677
9	3888	18321	6571	6163	3014	2023	4651	6583	8828	4787
10	428	2529	12593	3671	1725	930	1151	965	1837	1647
11	48	264	1749	7528	1174	462	373	197	195	321
12	12	82	377	995	1920	230	213	69	40	71
+gp	4	13	86	144	264	894	383	117	72	26
0 TOTALNUM	101757	161837	199168	289313	308747	287331	302899	279024	251771	204249
TONSLAND	319158	513234	581611	771086	739999	732228	762403	592624	484910	414868
SOPCOF %	95	103	101	101	100	101	100	101	100	100

Table 1 Catch numbers at age			Numbers*10**-3							
YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
3	5044	2348	7263	2090	5815	8548	25473	8459	4866	1778
4	35019	31033	20885	38226	19768	47207	43817	51704	38711	16193
5	62139	76175	64447	50826	113144	33625	62877	40656	83998	53855
6	62456	67656	71109	68350	61665	78150	26303	35072	46639	75853
7	22794	42122	36706	50838	44777	31770	34392	14037	20789	36797
8	5266	11527	14002	18118	20553	15667	11240	20676	8417	17062
9	1773	1801	2887	6239	6285	7245	4080	5503	8920	4784
10	1163	529	492	1746	2348	1788	1381	1794	1957	4325
11	343	223	142	295	562	737	505	715	872	3034
12	85	120	97	127	100	210	285	229	987	913
+gp	35	36	65	63	52	226	92	81	117	273
0 TOTALNUM	196117	233570	218095	236918	275069	225173	210445	178926	216273	214867
TONSLAND	426471	535045	551990	606445	641276	537642	486883	464171	523430	609983
SOPCOF %	100	100	100	100	100	100	100	100	100	100

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

Norway

Year	Age 2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	0.41	0.82	1.32	2.05	2.82	3.94	5.53	7.70	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
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

Russia (trawl only)

Year	Age 2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	0.65	1.05	1.58	2.31	3.39	4.87	6.86	8.72	10.40	12.07	14.43			
1984	0.53	0.88	1.45	2.22	3.21	4.73	6.05	8.43	10.34	12.61	14.95			
1985	0.33	0.77	1.31	1.84	2.96	4.17	5.94	6.38	8.58	10.28				
1986	0.29	0.61	1.14	1.75	2.45	4.17	6.18	8.04	9.48	11.33	12.35	14.13		
1987	0.24	0.52	0.88	1.42	2.07	2.96	5.07	7.56	8.93	10.80	13.05	18.16		
1988	0.27	0.49	0.88	1.32	2.06	3.02	4.40	6.91	9.15	11.65	12.53	14.68		
1989	0.50	0.73	1.00	1.39	1.88	2.67	4.06	6.09	7.76	9.88				
1990	0.45	0.83	1.21	1.70	2.27	3.16	4.35	6.25	8.73	10.85	13.52			
1991	0.36	0.64	1.05	2.03	2.85	3.77	4.92	6.13	8.36	10.44	15.84	19.33		
1992	0.55	1.20	1.44	2.07	3.04	4.24	5.14	5.97	7.25	9.28	11.36			
1993	0.48	0.78	1.39	2.06	2.62	4.07	5.72	6.79	7.59	11.26	14.79	17.71		
1994	0.41	0.81	1.24	1.80	2.55	2.88	4.96	6.91	8.12	10.28	12.42	16.93		
1995	0.37	0.77	1.21	1.74	2.37	3.40	4.71	6.73	8.47	9.58	12.03	16.99		
1996	0.30	0.64	1.09	1.60	2.37	3.42	5.30	7.86	8.86	10.87	11.80			
1997	0.30	0.57	1.00	1.52	2.18	3.30	4.94	7.15	10.08	11.87	13.54			
1998	0.33	0.68	1.06	1.60	2.34	3.39	5.03	6.89	10.76	12.39	13.61	14.72		
1999	0.24	0.58	0.98	1.41	2.17	3.26	4.42	5.70	7.27	10.24	14.12			
2000	0.18	0.48	0.85	1.44	2.16	3.12	4.44	5.79	7.49	9.66	10.36			
2001	0.12	0.31	0.62	1.00	1.53	2.30	3.31	4.57	6.55	8.11	9.52	11.99		
2002	0.20	0.60	1.05	1.46	2.14	3.27	4.47	6.23	8.37	10.06	12.37			
2003	0.23	0.63	1.06	1.78	2.40	3.41	4.86	6.28	7.55	11.10	13.41	12.12	14.51	
2004	0.30	0.57	1.09	1.55	2.37	3.20	4.73	6.92	8.41	9.77	11.08			
2005	0.33	0.65	0.98	1.50	2.10	3.08	4.31	5.81	8.42	10.37	13.56	14.13		
2006	0.27	0.68	1.05	1.49	2.25	3.16	4.54	5.90	8.59	10.31	12.31			
2007	0.23	0.67	1.12	1.66	2.25	3.31	4.57	6.27	8.20	10.02	12.36	12.4		
2008	0.28	0.64	1.16	1.74	2.65	3.58	4.74	5.73	7.32	8.07	9.52	12.5		
2009	0.31	0.64	1.09	1.58	2.11	3.19	4.80	6.58	7.97	9.84	11.51			
2010	0.25	0.57	1.00	1.64	2.28	3.14	4.53	5.98	8.03	9.71	10.70	13.5		

Table 3.7. (continued).

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
Germany (Division IIa and IIb)														
1994		0.68	1.04	2.24	3.49	4.51	5.79	6.93	8.16	8.46	8.74	9.48	15.25	
1995		0.44	0.84	1.50	2.72	3.81	4.46	4.81	7.37	7.69	8.25	9.47		
1996		0.84	1.15	1.64	2.53	3.58	4.13	3.90	4.68	6.98	6.43	11.32		
1997		0.43	0.92	1.42	2.01	3.15	4.04	5.16	4.82	3.96	7.04	8.80		
1998	0.23	0.73	1.17	1.89	2.72	3.25	4.13	5.63	6.50	8.57	8.42	11.45	8.79	
1999 [1]		0.85	1.45	2.00	2.65	3.47	4.16	5.45	6.82	5.90		8.01		
2000 [2]	0.26	0.73	1.36	2.04	2.87	3.67	4.88	5.78	7.05	8.45	8.67	9.33	6.88	
2001	0.38	0.80	1.21	1.90	2.74	3.90	4.99	5.69	7.15	7.32	11.72	9.11	6.60	
2002	0.35	1.00	1.31	1.80	2.53	3.64	4.38	5.07	6.82	9.21	7.59	13.18	19.17	19.20
2003	0.22	0.44	1.04	1.71	2.31	3.27	4.93	6.17	7.77	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	4.95	6.55	7.54	9.71	11.40	11.57	23.34	15.61
2008 [3]	0.23	0.51	1.14	1.76	2.57	3.15	4.4	5.43	7.18	8.39	10.15	10.03	10.99	14.26
2009 [3]	0.35	0.6	1.19	1.83	2.96	4.08	5.61	6.97	8.55	9.13	10.54	13.34	10.30	17.06
2010 [3]	0.36	0.67	0.93	1.71	2.46	3.21	4.93	6.75	7.80	8.70	8.53	10.17	12.36	14.11
[1] Division IIa only														
[2] IIa and IIb combined														
[3] I,IIa and IIb combined														
Spain (Division IIb)														
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			
[1] IIa and IIb combined														
[2] I,IIa 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	8.48	11	10.8	15.6	18.9	
2008		0.49	0.90	1.45	2.24	2.79	3.82	4.68	5.01	6.45	7.02	7.22	5.99	6.91
2009			1.02	1.72	2.65	3.81	5.23	6.91	8.86	11.1	13.6	16.5		
2010			1.39	1.66	2.29	2.98	3.92	5.18	6.31	6.66	8.72	9.05		

Table 3.8. North-East Arctic COD. Catch weights at age

Run title : Arctic Cod (run: SVPASA15/V15)

At 30/04/2011 20:40

Table 2 Catch weights at age (kg)

YEAR		1946	1947	1948	1949	1950
AGE						
	3	0.35	0.32	0.34	0.37	0.39
	4	0.59	0.56	0.53	0.67	0.64
	5	1.11	0.95	1.26	1.11	1.29
	6	1.69	1.5	1.93	1.66	1.7
	7	2.37	2.14	2.46	2.5	2.36
	8	3.17	2.92	3.36	3.23	3.48
	9	3.98	3.65	4.22	4.07	4.52
	10	5.05	4.56	5.31	5.27	5.62
	11	5.92	5.84	5.92	5.99	6.4
	12	7.2	7.42	7.09	7.08	7.96
+gp		8.146	8.848	8.43	8.218	8.891
0 SOPCOFAC		1.03	0.9143	0.8915	0.992	1.088

Table 2 Catch weights at age (kg)

YEAR		1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
AGE											
	3	0.4	0.44	0.4	0.44	0.32	0.33	0.33	0.34	0.35	0.34
	4	0.83	0.8	0.76	0.77	0.57	0.58	0.59	0.52	0.72	0.51
	5	1.39	1.33	1.28	1.26	1.13	1.07	1.02	0.95	1.47	1.09
	6	1.88	1.92	1.93	1.97	1.73	1.83	1.82	1.92	2.68	2.13
	7	2.54	2.64	2.81	3.03	2.75	2.89	2.89	2.94	3.59	3.38
	8	3.46	3.71	3.72	4.33	3.94	4.25	4.28	4.21	4.32	4.87
	9	4.88	5.06	5.06	5.4	4.9	5.55	5.49	5.61	5.45	6.12
	10	5.2	6.05	6.34	6.75	7.04	7.28	7.51	7.35	6.44	8.49
	11	7.14	7.42	7.4	7.79	7.2	8	8.24	8.67	7.17	7.79
	12	8.22	8.43	8.67	10.67	8.78	8.35	9.25	9.58	8.63	8.3
+gp		9.389	10.185	10.238	9.68	10.077	9.944	10.605	11.631	11.621	11.422
0 SOPCOFAC		1.1483	0.9348	1.0485	0.9294	1.0634	1.0455	1.0004	1.1232	0.9305	1.0416

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Table 2 Catch weights at age (kg)

YEAR		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
AGE											
	3	0.31	0.32	0.32	0.33	0.38	0.44	0.29	0.33	0.44	0.37
	4	0.55	0.55	0.61	0.55	0.68	0.74	0.81	0.7	0.79	0.91
	5	1.05	0.93	0.96	0.95	1.03	1.18	1.35	1.48	1.23	1.34
	6	2.2	1.7	1.73	1.86	1.49	1.78	2.04	2.12	2.03	2
	7	3.23	3.03	3.04	3.25	2.41	2.46	2.81	3.14	2.9	3
	8	5.11	5.03	4.96	4.97	3.52	3.82	3.48	4.21	3.81	4.15
	9	6.15	6.55	6.44	6.41	5.73	5.36	4.89	5.27	5.02	5.59
	10	8.15	7.7	7.91	8.07	7.54	7.27	7.11	6.65	6.43	7.6
	11	8.68	9.27	9.62	9.34	8.47	8.63	9.03	9.01	8.33	8.97
	12	9.6	10.56	11.31	10.16	11.17	10.66	10.59	9.66	10.71	10.99
+gp		11.952	12.717	12.737	12.886	13.722	14.148	13.829	14.848	14.211	14.074
0 SOPCOFAC		1.097	1.2356	1.0226	1.0277	1.2903	1.2327	1.0911	1.0785	1.052	1.117

Table 3.8 (continued).

Table 2 Catch weights at age (kg)

YEAR		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AGE											
	3	0.45	0.38	0.38	0.32	0.41	0.35	0.49	0.49	0.35	0.27
	4	0.88	0.77	0.91	0.66	0.64	0.73	0.9	0.81	0.7	0.56
	5	1.38	1.43	1.54	1.17	1.11	1.19	1.43	1.45	1.24	1.02
	6	2.16	2.12	2.26	2.22	1.9	2.01	2.05	2.15	2.14	1.72
	7	3.07	3.23	3.29	3.21	2.95	2.76	3.3	3.04	3.15	3.02
	8	4.22	4.38	4.61	4.39	4.37	4.22	4.56	4.46	4.29	4.2
	9	5.81	5.83	6.57	5.52	5.74	5.88	6.46	6.54	6.58	5.84
	10	7.13	7.62	8.37	7.86	8.77	9.3	8.63	7.98	8.61	7.26
	11	8.62	9.52	10.54	9.82	9.92	10.28	9.93	10.15	9.22	8.84
	12	10.83	12.09	11.62	11.41	11.81	11.86	10.9	10.85	10.89	9.28
+gp		12.945	13.673	13.904	13.242	13.107	13.544	13.668	13.177	14.344	14.448
0 SOPCOFAC		1.2405	1.1822	1.3003	1.366	1.152	1.2688	1.0683	1.089	1.2139	1.2723

Table 2 Catch weights at age (kg)

YEAR		1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE											
	3	0.49	0.37	0.84	1.42	0.94	0.64	0.49	0.54	0.74	0.81
	4	0.98	0.66	1.37	1.93	1.37	1.27	0.88	0.85	0.96	1.22
	5	1.44	1.35	2.09	2.49	2.02	1.88	1.55	1.32	1.31	1.64
	6	2.09	1.99	2.86	3.14	3.22	2.79	2.33	2.24	1.92	2.22
	7	2.98	2.93	3.99	3.91	4.63	4.49	3.44	3.52	2.93	3.24
	8	4.85	4.24	5.58	4.91	6.04	5.84	5.92	5.35	4.64	4.68
	9	6.57	6.46	7.77	6.02	7.66	6.83	8.6	8.06	7.52	7.3
	10	9.16	8.51	9.29	7.4	9.81	7.69	9.6	9.51	9.12	9.84
	11	10.82	12.24	11.55	8.13	11.8	9.81	12.17	11.36	11.08	13.25
	12	10.77	10.78	16.2	8.57	14.16	10.71	13.72	14.09	11.47	16.88
+gp		13.932	14.041	17.034	8.609	14.008	12.051	13.38	16.706	16.484	11.617
0 SOPCOFAC		1.1809	1.2521	0.8953	0.9483	1.0182	1.016	1.0224	1.0001	0.9879	1.0108

Table 2 Catch weights at age (kg)

YEAR		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE											
	3	1.05	1.16	0.81	0.82	0.77	0.79	0.67	0.68	0.63	0.572
	4	1.45	1.57	1.52	1.3	1.2	1.11	1.04	1.05	1.01	1.036
	5	2.15	2.21	2.16	2.06	1.78	1.61	1.53	1.62	1.54	1.609
	6	2.89	3.1	2.79	2.89	2.59	2.46	2.22	2.3	2.34	2.344
	7	3.75	4.27	4.07	3.21	3.81	3.82	3.42	3.3	3.21	3.341
	8	4.71	5.19	5.53	5.2	4.99	5.72	5.2	4.86	4.29	4.476
	9	6.08	6.14	6.47	6.8	6.23	6.74	7.19	6.87	6	5.724
	10	8.82	7.77	7.19	7.57	8.05	8.04	7.73	9.3	6.73	7.523
	11	11.8	10.12	7.98	8.01	8.74	9.28	8.61	10.3	10.08	8.021
	12	16.58	11.54	10.11	9.48	9.22	10.4	11.07	15.05	13.88	12.478
+gp		16.69	14.332	14.183	11.978	12.319	10.966	11.117	14.524	14.036	17.241
0 SOPCOFAC		0.9521	1.027	1.0127	1.009	1.003	1.0147	1.0004	1.0072	0.9967	1.0039

Table 2 Catch weights at age (kg)

YEAR		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE											
	3	0.66	0.723	0.672	0.72	0.693	0.721	0.736	0.769	0.747	0.783
	4	1.05	1.133	1.119	1.13	1.081	1.145	1.214	1.273	1.173	1.202
	5	1.62	1.56	1.827	1.607	1.566	1.603	1.832	1.866	1.735	1.744
	6	2.51	2.306	2.499	2.429	2.205	2.388	2.511	2.818	2.419	2.442
	7	3.51	3.52	3.575	3.274	3.263	3.318	3.822	3.786	3.864	3.397
	8	4.78	4.784	5.039	4.725	4.443	4.535	5.043	5.122	5.346	5.045
	9	6.04	6.2	6.355	6.712	6.228	5.466	6.584	6.223	6.428	6.247
	10	7.54	7.659	8.196	7.984	8.187	6.777	8.077	7.752	8.008	7.318
	11	9	9.14	10.711	9.192	9.724	7.699	8.942	8.405	8.667	8.525
	12	10.48	8.197	11.958	12.024	11.496	8.578	10.173	10.117	8.547	9.15
+gp		16.18	10.325	10.657	14.245	14.417	10.155	13.364	13.674	12.022	11.382
0 SOPCOFAC		0.9994	1.0025	1.0014	1.0017	0.9993	0.9981	0.9978	1.0011	1.0002	1.0001

Table 3.9. North-East Arctic COD. Stock weights at age

Run title : Arctic Cod (run: SVPASA15/V15)

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Table 3 Stock weights at age (kg)

YEAR		1946	1947	1948	1949	1950
AGE						
	3	0.35	0.32	0.34	0.37	0.39
	4	0.59	0.56	0.53	0.67	0.64
	5	1.11	0.95	1.26	1.11	1.29
	6	1.69	1.5	1.93	1.66	1.7
	7	2.37	2.14	2.46	2.5	2.36
	8	3.17	2.92	3.36	3.23	3.48
	9	3.98	3.65	4.22	4.07	4.52
	10	5.05	4.56	5.31	5.27	5.62
	11	5.92	5.84	5.92	5.99	6.4
	12	7.2	7.42	7.09	7.08	7.96
+gp		8.146	8.848	8.43	8.218	8.891

Table 3 Stock weights at age (kg)

YEAR		1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
AGE											
	3	0.4	0.44	0.4	0.44	0.32	0.33	0.33	0.34	0.35	0.34
	4	0.83	0.8	0.76	0.77	0.57	0.58	0.59	0.52	0.72	0.51
	5	1.39	1.33	1.28	1.26	1.13	1.07	1.02	0.95	1.47	1.09
	6	1.88	1.92	1.93	1.97	1.73	1.83	1.82	1.92	2.68	2.13
	7	2.54	2.64	2.81	3.03	2.75	2.89	2.89	2.94	3.59	3.38
	8	3.46	3.71	3.72	4.33	3.94	4.25	4.28	4.21	4.32	4.87
	9	4.88	5.06	5.06	5.4	4.9	5.55	5.49	5.61	5.45	6.12
	10	5.2	6.05	6.34	6.75	7.04	7.28	7.51	7.35	6.44	8.49
	11	7.14	7.42	7.4	7.79	7.2	8	8.24	8.67	7.17	7.79
	12	8.22	8.43	8.67	10.67	8.78	8.35	9.25	9.58	8.63	8.3
+gp		9.389	10.185	10.238	9.68	10.077	9.944	10.605	11.631	11.621	11.422

Table 3 Stock weights at age (kg)

YEAR		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
AGE											
	3	0.31	0.32	0.32	0.33	0.38	0.44	0.29	0.33	0.44	0.37
	4	0.55	0.55	0.61	0.55	0.68	0.74	0.81	0.7	0.79	0.91
	5	1.05	0.93	0.96	0.95	1.03	1.18	1.35	1.48	1.23	1.34
	6	2.2	1.7	1.73	1.86	1.49	1.78	2.04	2.12	2.03	2
	7	3.23	3.03	3.04	3.25	2.41	2.46	2.81	3.14	2.9	3
	8	5.11	5.03	4.96	4.97	3.52	3.82	3.48	4.21	3.81	4.15
	9	6.15	6.55	6.44	6.41	5.73	5.36	4.89	5.27	5.02	5.59
	10	8.15	7.7	7.91	8.07	7.54	7.27	7.11	6.65	6.43	7.6
	11	8.68	9.27	9.62	9.34	8.47	8.63	9.03	9.01	8.33	8.97
	12	9.6	10.56	11.31	10.16	11.17	10.66	10.59	9.66	10.71	10.99
+gp		11.952	12.717	12.737	12.886	13.722	14.148	13.829	14.848	14.211	14.074

Table 3.9 (continued).

Table 3 Stock weights at age (kg)

YEAR		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AGE											
	3	0.45	0.38	0.38	0.32	0.41	0.35	0.49	0.49	0.35	0.27
	4	0.88	0.77	0.91	0.66	0.64	0.73	0.9	0.81	0.7	0.56
	5	1.38	1.43	1.54	1.17	1.11	1.19	1.43	1.45	1.24	1.02
	6	2.16	2.12	2.26	2.22	1.9	2.01	2.05	2.15	2.14	1.72
	7	3.07	3.23	3.29	3.21	2.95	2.76	3.3	3.04	3.15	3.02
	8	4.22	4.38	4.61	4.39	4.37	4.22	4.56	4.46	4.29	4.2
	9	5.81	5.83	6.57	5.52	5.74	5.88	6.46	6.54	6.58	5.84
	10	7.13	7.62	8.37	7.86	8.77	9.3	8.63	7.98	8.61	7.26
	11	8.62	9.52	10.54	9.82	9.92	10.28	9.93	10.15	9.22	8.84
	12	10.83	12.09	11.62	11.41	11.81	11.86	10.9	10.85	10.89	9.28
+gp		12.945	13.673	13.904	13.242	13.107	13.544	13.668	13.177	14.344	14.448

Table 3 Stock weights at age (kg)

YEAR		1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE											
	3	0.49	0.37	0.37	0.42	0.413	0.311	0.211	0.212	0.299	0.398
	4	0.98	0.66	0.92	1.16	0.875	0.88	0.498	0.404	0.52	0.705
	5	1.44	1.35	1.6	1.81	1.603	1.47	1.254	0.79	0.868	1.182
	6	2.09	1.99	2.44	2.79	2.81	2.467	2.047	1.903	1.477	1.719
	7	2.98	2.93	3.82	3.78	4.059	3.915	3.431	2.977	2.686	2.458
	8	4.85	4.24	4.76	4.57	5.833	5.81	5.137	4.392	4.628	3.565
	9	6.57	6.46	6.17	6.17	7.685	6.58	6.523	7.812	7.048	4.71
	10	9.16	8.51	7.7	7.7	10.117	6.833	9.3	12.112	9.98	7.801
	11	10.82	12.24	9.25	9.25	14.29	11.004	13.15	13.107	9.25	8.956
	12	10.77	10.78	10.85	10.85	12.731	12.731	12.731	12.731	12.731	12.731
+gp		13.932	14.041	12.988	13.033	14.311	14.311	14.311	14.311	14.311	14.311

Table 3 Stock weights at age (kg)

YEAR		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE											
	3	0.518	0.44	0.344	0.235	0.201	0.195	0.202	0.217	0.203	0.194
	4	1.136	0.931	1.172	0.753	0.485	0.487	0.521	0.533	0.52	0.465
	5	1.743	1.812	1.82	1.42	1.14	0.971	1.079	1.161	1.174	1.208
	6	2.428	2.716	2.823	2.413	2.118	2.054	1.878	1.939	2.031	1.972
	7	3.214	3.895	4.031	3.825	3.47	3.527	3.369	2.945	3.034	3.048
	8	4.538	5.176	5.497	5.416	4.938	5.503	5.263	4.574	4.464	4.096
	9	6.88	6.774	6.765	6.631	7.16	7.767	8.927	7.423	6.482	5.724
	10	10.719	9.598	8.571	7.63	9.119	10.159	12.154	10.367	10.269	7.457
	11	9.445	12.427	10.847	8.112	10.101	10.669	11.204	11.738	10.882	9.582
	12	12.731	12.731	12.731	12.731	12.731	12.731	12.731	12.731	12.731	12.731
+gp		14.311	14.311	14.311	14.311	14.311	14.311	14.311	14.311	14.311	14.311

Table 3 Stock weights at age (kg)

YEAR		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE											
	3	0.285	0.251	0.23	0.25	0.231	0.256	0.262	0.286	0.26	0.257
	4	0.522	0.605	0.537	0.546	0.624	0.602	0.699	0.734	0.641	0.589
	5	1.196	1.189	1.31	1.087	1.118	1.201	1.341	1.37	1.343	1.183
	6	2.239	2.138	2.009	2.035	1.932	2.009	2.121	2.367	2.36	2.052
	7	3.313	3.333	3.241	2.921	3.046	3.114	3.167	3.29	3.763	3.181
	8	5.118	4.766	4.971	4.384	3.955	4.427	4.64	4.82	5.111	4.8
	9	6.376	6.859	6.739	6.254	5.811	6.03	6.495	6.548	6.554	6.759
	10	9.241	9.333	8.706	8.543	8.289	8.037	9.123	8.483	9.098	7.859
	11	11.322	10.186	15.026	9.735	13.44	9.928	11.78	8.902	9.432	10.008
	12	12.731	12.731	12.731	12.731	12.731	12.731	12.731	12.731	12.731	12.731
+gp		14.311	14.311	14.311	14.311	14.311	14.311	14.311	14.311	14.311	14.311

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

Norway

	Percentage mature							
	Age							
Year	3	4	5	6	7	8	9	10
1982	-	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	-	5	18	31	56	90	99	100
1985	-	1	10	33	59	85	92	100
1986	-	2	9	19	56	76	89	100
1987	-	1	9	23	27	61	81	80
1988	-	1	3	25	53	79	100	100
1989	0.0	0.0	2.0	15.0	39.0	59.0	83.0	100.0
1990	0.0	2.0	6.0	20.0	47.0	62.0	81.0	95.0
1991	0.0	3.0	1.0	23.0	66.0	82.0	96.0	100.0
1992	0.0	1.0	8.0	31.0	73.0	92.0	95.0	100.0
1993	0.0	3.0	7.0	21.0	56.0	89.0	95.0	99.0
1994	0.0	1.0	8.0	30.0	55.0	84.0	95.0	98.0
1995	0.0	0.0	4.0	23.0	61.0	75.0	94.0	97.0
1996	0.0	0.0	1.0	22.0	56.0	82.0	95.0	100.0
1997	0.0	0.0	1.0	10.0	48.0	73.0	90.0	100.0
1998	0.0	0.0	2.0	15.0	47.0	87.0	97.0	96.0
1999	0.0	0.2	1.3	9.9	38.4	74.9	94.0	100.0
2000	0.0	0.0	6.0	19.2	51.4	84.0	95.5	100.0
2001	0.1	0.1	3.9	27.9	62.3	89.4	96.3	100.0
2002	0.1	1.9	10.9	34.4	68.1	82.8	97.6	100.0
2003	0.2	0.0	11.0	29.2	65.9	89.6	95.1	100.0
2004	0.0	0.7	8.0	33.8	63.3	83.4	96.4	96.4
2005	0.0	0.6	4.6	24.2	61.5	84.9	95.3	98.1
2006	0.0	0.0	6.1	29.6	59.6	89.5	96.4	100.0
2007	0.0	0.4	5.7	20.8	60.4	83.5	96.0	100.0
2008	0.0	0.5	4.0	24.6	48.3	84.4	94.7	98.7
2009	0.0	0.0	6.0	28.0	66.0	85.0	97.0	100.0
2010	0.0	0.2	1.5	22.8	47.0	77.4	90.2	95.5
2011	0.0	0.0	2.2	20.7	50.4	73.7	90.6	95.6

Norway

	Percentage mature							
	Age							
Year	3	4	5	6	7	8	9	10
1985	-	1	9	38	51	85	100	79
1986	3	7	8	19	50	67	36	80
1987	-	0	4	12	16	31	19	-
1988	-	2	6	41	54	45	100	100
1989	1.5	0.7	3.9	30.7	70.4	82.0	100.0	100.0
1990	1.5	0.7	4.2	22.0	57.5	80.9	100.0	100.0
1991	0.1	3.4	13.9	38.0	75.5	90.1	95.4	100.0
1992	0.2	1.9	21.0	52.8	87.0	96.5	99.8	100.0
1993	0.0	2.6	10.4	52.6	84.8	97.2	99.3	99.7
1994	0.5	0.3	15.8	36.9	62.8	88.4	97.6	100.0
1995	0.0	0.6	8.2	51.5	63.8	81.1	98.0	99.3
1996	0.0	0.0	2.8	29.6	70.2	82.1	100.0	100.0
1997	0.0	0.0	1.5	17.9	73.3	93.0	99.1	100.0
1998	0.1	0.7	3.2	15.4	47.3	75.7	94.3	100.0
1999	0.4	0.2	1.6	27.5	70.5	94.6	99.0	100.0
2000	0.0	0.1	8.2	30.2	77.3	81.9	100.0	100.0
2001	0.5	0.5	9.0	43.8	62.5	74.4	94.1	100.0
2002	0.3	0.7	5.9	43.2	68.4	85.3	92.5	100.0
2003	0.0	0.2	6.5	36.0	68.6	88.0	96.3	100.0
2004	0.2	1.4	10.2	54.6	81.8	90.9	98.8	98.9
2005	0.0	0.3	9.0	55.2	81.8	93.5	98.0	100.0
2006	0.0	0.2	5.9	44.3	69.8	89.9	96.7	100.0
2007	0.1	0.3	8.7	47.9	84.3	91.7	99.1	100.0
2008	0.0	0.3	8.4	31.8	59.3	88.2	90.9	100.0
2009	0.0	0.0	9.2	46.3	85.0	86.4	98.4	99.3
2010	0.0	0.4	7.5	41.8	67.7	90.1	95.3	98.6
2011	0.0	0.2	5.2	48.0	77.7	89.7	97.3	97.2

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

Run title : Arctic Cod (run: SVPASA15/V15)

At 30/04/2011 20:40

Table 5 Proportion mature at age

YEAR	1946	1947	1948	1949	1950
AGE					
3	0	0	0	0	0
4	0	0	0	0	0
5	0.01	0.01	0.01	0.01	0.01
6	0.03	0.03	0.03	0.03	0.03
7	0.06	0.06	0.07	0.09	0.09
8	0.11	0.13	0.13	0.17	0.23
9	0.18	0.16	0.25	0.29	0.35
10	0.44	0.42	0.47	0.54	0.52
11	0.65	0.75	0.73	0.79	0.79
12	0.86	0.91	0.91	0.88	0.95
+gp	0.96	0.95	0.97	0.97	0.97

Table 5 Proportion mature at age

YEAR	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0.01
5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03
6	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.06
7	0.1	0.08	0.07	0.08	0.07	0.06	0.06	0.06	0.12	0.1
8	0.24	0.22	0.19	0.16	0.13	0.12	0.09	0.1	0.34	0.19
9	0.4	0.41	0.4	0.37	0.26	0.14	0.12	0.1	0.49	0.45
10	0.58	0.63	0.64	0.68	0.53	0.41	0.22	0.3	0.67	0.69
11	0.72	0.82	0.84	0.87	0.83	0.67	0.6	0.5	0.84	0.77
12	0.85	0.92	0.94	0.93	0.92	0.91	0.82	0.82	0.87	0.85
+gp	0.96	0.97	0.97	0.96	0.97	0.96	0.97	0.97	1	0.99

Table 5 Proportion mature at age

YEAR	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0.01	0	0	0	0	0	0	0.01
5	0.01	0.01	0.01	0	0	0.01	0	0.03	0	0
6	0.06	0.05	0.03	0.03	0.01	0.02	0.03	0.05	0.02	0.01
7	0.12	0.15	0.07	0.13	0.06	0.06	0.07	0.09	0.04	0.07
8	0.31	0.34	0.28	0.37	0.2	0.22	0.14	0.19	0.12	0.23
9	0.65	0.61	0.42	0.66	0.55	0.35	0.38	0.39	0.34	0.58
10	0.91	0.81	0.81	0.89	0.73	0.74	0.64	0.58	0.55	0.81
11	0.98	0.92	0.98	0.95	0.99	0.94	0.89	0.82	0.74	0.89
12	0.98	0.97	0.98	0.99	0.98	0.94	0.9	1	0.95	0.91
+gp	1	1	1	1	1	1	1	1	1	1

Table 3.11. (continued).

Table 5 Proportion mature at age

YEAR	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AGE										
3	0	0.01	0	0	0	0	0	0	0	0
4	0	0.02	0	0	0	0	0	0	0	0
5	0.01	0.02	0	0	0.01	0	0.02	0	0	0
6	0.05	0.01	0.02	0.01	0.02	0.05	0.08	0.02	0.03	0.02
7	0.11	0.1	0.16	0.03	0.09	0.12	0.26	0.13	0.13	0.13
8	0.3	0.34	0.53	0.21	0.21	0.29	0.54	0.44	0.39	0.35
9	0.59	0.64	0.81	0.5	0.56	0.45	0.76	0.71	0.77	0.65
10	0.79	0.81	0.92	0.96	0.78	0.84	0.87	0.77	0.89	0.82
11	0.86	0.94	0.95	1	0.79	0.83	0.93	0.81	0.83	1
12	0.88	1	0.98	0.96	0.95	1	0.94	0.89	0.78	0.9
+gp	1	1	1	1	1	0.9	0.9	0.8	0.9	0.9

Table 5 Proportion mature at age

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE										
3	0	0	0.01	0	0	0	0	0	0.008	0.008
4	0	0.05	0.08	0.05	0.01	0.05	0.01	0.02	0.003	0.013
5	0.02	0.1	0.1	0.18	0.09	0.08	0.07	0.05	0.029	0.051
6	0.07	0.34	0.3	0.31	0.36	0.19	0.18	0.33	0.228	0.21
7	0.2	0.65	0.73	0.56	0.55	0.53	0.22	0.53	0.547	0.522
8	0.54	0.82	0.88	0.9	0.85	0.71	0.46	0.62	0.705	0.715
9	0.8	0.92	0.97	0.99	0.96	0.62	0.5	1	0.915	0.905
10	0.97	1	1	1	0.9	0.9	0.75	1	1	0.975
11	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1
+gp	1	1	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
3	0.001	0.001	0	0.003	0	0	0	0.001	0.002	0
4	0.032	0.014	0.028	0.007	0.003	0	0	0.003	0.002	0.001
5	0.075	0.145	0.087	0.119	0.061	0.019	0.012	0.026	0.014	0.071
6	0.305	0.419	0.368	0.335	0.372	0.258	0.14	0.152	0.187	0.247
7	0.708	0.8	0.704	0.589	0.624	0.631	0.607	0.472	0.544	0.643
8	0.861	0.943	0.931	0.862	0.781	0.82	0.83	0.814	0.847	0.83
9	0.957	0.974	0.972	0.963	0.96	0.975	0.946	0.957	0.965	0.978
10	1	1	0.994	0.99	0.979	1	1	0.98	1	1
11	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1
+gp	1	1	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
3	0.003	0.002	0.001	0.001	0	0	0	0	0	0
4	0.003	0.013	0.001	0.01	0.004	0.001	0.004	0.004	0	0.003
5	0.065	0.084	0.088	0.091	0.068	0.06	0.072	0.062	0.076	0.045
6	0.359	0.388	0.326	0.442	0.397	0.369	0.343	0.282	0.372	0.323
7	0.624	0.683	0.672	0.726	0.716	0.647	0.723	0.538	0.755	0.573
8	0.819	0.841	0.888	0.872	0.892	0.897	0.876	0.863	0.857	0.838
9	0.952	0.951	0.957	0.976	0.967	0.965	0.976	0.928	0.977	0.927
10	1	1	1	0.977	0.991	1	1	0.994	0.997	0.97
11	1	1	1	1	1	1	1	1	1	0.974
12	1	1	1	1	1	1	1	1	1	0.986
+gp	1	1	1	1	1	1	1	1	1	1

Table 3.12. Northeast arctic cod. Total number of cod (million) consumed by cod, by year and prey age group

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1984	0	417	21	0	0	0	0
1985	1510	375	66	0	0	0	0
1986	53	968	391	98	0	0	0
1987	681	182	280	14	0	0	0
1988	29	411	22	2	0	0	0
1989	918	144	0	0	0	0	0
1990	0	126	28	0	0	0	0
1991	123	152	215	2	0	0	0
1992	4305	1028	155	4	0	0	0
1993	3832	20270	511	51	1	0	0
1994	8336	6944	644	129	52	8	0
1995	8304	15353	757	205	64	4	0
1996	9921	21754	1503	143	56	20	1
1997	2938	15998	1858	174	17	1	0
1998	79	4850	536	211	25	2	1
1999	584	1811	291	52	4	0	0
2000	1676	2234	171	37	14	4	0
2001	89	2272	113	24	12	2	1
2002	7632	460	395	41	6	1	0
2003	5607	4394	107	23	0	0	0
2004*	5941	2323	534	20	11	2	0
2005*	2484	3062	140	86	5	6	1
2006*	2760	2199	155	6	2	0	0
2007*	2174	1225	204	87	4	0	0
2008*	12448	610	93	109	36	5	0
2009*	8600	6560	117	70	24	6	0
2010*	4929	6703	170	45	29	23	3

* corrected data on cod consumption

Table 3.13. North-East Arctic COD. Tuning data

North-East Arctic cod (Sub-areas I and II) (run name: XSAASA01)

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FLT09: Russian trawl catch and effort ages 9 - 11 (Catch: Thousa (Catch: Unknown) (Effort: Unknown)

1 985	2 010			
1	1	0	1	
9	11			
	0.7	291	77	30
	1.52	87	59	22
	2.1	127	95	37
	2.75	442	215	53
	2.12	140	47	11
	1.11	204	49	14
	1.56	791	71	16
	2.5	3852	689	62
	2.64	2019	1778	68
	2.96	1237	595	167
	3.88	684	345	146
	3.73	364	164	34
	4.92	488	99	34
	6.77	559	88	34
	6.39	882	171	0
	4.25	742	185	25
	3.5	235	95	35
	3.15	336	61	18
	2.34	319	83	19
	3.47	710	262	56
	3.54	588	203	57
	3.64	1182	183	102
	2.69	554	244	83
	2	1741	556	175
	2.05	1075	529	147
	2.08	1533	627	222

FLT15: NorBarTrSur rev99 (Catch: Unknown) (Effort: Unknown)

1 980	2010						
1	1	0.99	1				
3	8						
1980	1	233	400	384	48	10	3
1981	1	277	236	155	160	14	2
1982	1	523	433	170	58	32	10
1983	1	283	214	117	41	4	1
1984	1	1260	199	77	33	2	1
1985	1	1439	641	83	19	3	0
1986	1	3911	543	157	20	5	0
1987	1	805	1733	205	36	5	0
1988	1	759	378	902	98	9	1
1989	1	349	346	206	272	16	4
1990	1	337	257	215	122	127	6
1991	1	577	178	128	77	43	27
1992	1	1401	725	158	62	39	22
1993	1	3102	1474	506	93	24	16
1994	1	2414	2559	767	185	24	8
1995	1	1154	1372	1061	240	29	4
1996	1	640	704	527	283	57	9
1997	1	1813	365	259	178	86	10
1998	1	1732	581	134	65	51	12
1999	1	1321	1083	269	43	20	12
2000	1	1828	834	382	89	11	4
2001	1	1350	1096	425	151	24	3
2002	1	1297	911	673	183	49	10
2003	1	1725	569	447	273	76	17
2004	1	621	981	247	155	45	11
2005	1	1115	287	437	102	49	14
2006	1	850	629	148	179	48	18
2007	1	3336	910	472	130	88	20
2008	1	2196	1939	586	196	68	49
2009	1	1069	1608	1407	400	119	35
2010	1	541	1221	1399	956	168	39

Table 3.13 (continued)

FLT16: NorBarLofAcSur rev99 (Catch: Unknown) (Effort: Unknown)

1 984	2010							
1	1	0.99	1					
3	9							
1984	1	1416	204	154	157	33	13	10
1985	1	1343	684	116	77	31	3	0
1986	1	2049	502	174	14	30	7	0
1987	1	355	578	109	40	3	0	1
1988	1	344	214	670	166	32	5	2
1989	1	206	262	269	668	73	6	3
1990	1	346	293	339	367	500	37	2
1991	1	658	215	184	284	254	824	43
1992	1	1911	1131	354	255	252	277	442
1993	1	4045	2175	895	225	119	94	39
1994	1	1598	2166	1040	290	44	43	30
1995	1	705	872	891	446	65	11	4
1996	1	517	497	422	499	205	22	5
1997	1	1826	424	338	340	247	49	7
1998	1	964	454	122	112	187	92	10
1999	1	1589	1457	493	129	69	52	12
2000	1	1716	816	573	198	24	8	6
2001	1	1122	1043	661	345	95	12	5
2002	1	1144	1315	1445	643	212	38	5
2003	1	928	327	451	468	222	88	22
2004	1	337	661	299	432	172	75	18
2005	1	591	157	381	169	155	88	24
2006	1	371	318	130	426	137	75	35
2007	1	3061	1410	754	246	329	58	28
2008	1	1783	1405	495	401	133	260	37
2009	1	1219	1759	1949	709	375	111	88
2010	1	291	824	1587	2843	656	226	61

FLT18: RusSweptArea rev05 (ages 3-9) (Catch: Unknown) ((Catch: Unknown) (Effort: Unknown)

1 982	2010						
1	1	0.9	1				
3	9						
1982	1413	1525	721	198	551	174	37
1983	520	642	506	358	179	252	94
1984	1189	700	489	357	154	69	61
1985	1188	1592	1068	365	165	37	8
1986	1622	1532	1493	481	189	42	2
1987	557	3076	900	701	184	60	25
1988	993	938	2879	583	260	47	24
1989	490	978	1062	1454	1167	299	112
1990	167	487	627	972	1538	673	153
1991	1077	484	532	583	685	747	98
1992	675	308	239	273	218	175	25
1993	1604	1135	681	416	354	87	3
1994	1363	1309	1019	354	128	49	21
1995	589	1065	1395	849	251	83	19
1996	733	784	1035	773	348	132	19
1997	1342	835	613	602	348	116	32
1998	2028	1363	788	470	259	130	48
1999	1587	2072	980	301	123	94	42
2000	1839	1286	1786	773	114	52	23
2001	1224	1557	1290	1061	304	50	14
2002	980	1473	1473	896	600	182	29
2003	1246	1057	1166	1203	535	241	40
2004	329	1576	880	1111	776	279	93
2005	1408	631	1832	744	605	244	88
2006	927	1613	777	1801	662	342	161
2007	2579	1617	1903	846	1525	553	226
2008	2203	3088	1635	1472	830	863	291
2009	974	2317	3687	2016	1175	620	413
2010	543	1385	3668	2698	1455	603	446

Table 3.13a. Northeast arctic cod. Final xsa compared with xsa tunings run with last year settings. Upper part of table shows F in terminal year (including cannibalism mortality M2), as far as Fbar, total biomass, SSB and number of survivors. Lower part of the table shows survey residuals at terminal year and sum of squares for each survey for period 2001-2010.

		Final XSA	run 3	Last year settings
1st age q is indep. on pop. size		**7**	**8**	**6**
tuning window, years		**10**	**10**	**10**
F(+M2) at age3		**0.12**	**0.12**	**0.13**
F(+M2) at age4		**0.12**	**0.13**	**0.10**
F(+M2) at age5		**0.22**	**0.25**	**0.16**
F(+M2) at age6		**0.36**	**0.43**	**0.20**
F(+M2) at age7		**0.33**	**0.44**	**0.29**
F(+M2) at age8		**0.35**	**0.38**	**0.32**
F(+M2) at age9		**0.23**	**0.23**	**0.24**
F(+M2) at age10		**0.32**	**0.35**	**0.30**
F(+M2) at age11		**0.71**	**0.72**	**0.70**
F(+M2) at age12		**0.49**	**0.52**	**0.47**
2010	F(5-10)	0.30	0.35	0.25
TSB2010	incl Age1-2	2788	2565	3531
SSB2010	('000 T)	1083	1030	1333
N2011	yc2007	325070	321006	307708
N*10^-3	yc2006	325369	303342	374777
with	yc2005	279908	244472	394212
shrinkage	yc2004	167264	131382	325813
	yc2003	83958	61157	99582
	yc2002	37532	33755	41094
	yc2001	16764	17079	15984
	yc2000	10477	9396	11427
		FLT15: NorBarTrSur residuals at 2010		
age 3		-0.13	-0.13	-0.13
age 4		0.13	0.12	0.19
age 5		0.12	0.13	0.11
age 6		0.26	0.32	0.38
age 7		0.22	0.27	0.09
age 8		-0.14	-0.06	-0.21
SSQ (ages 3-8, years 2001-2010)		**1.74**	**1.68**	**2.26**
		FLT16: NorBarLofAcSu residuals at 2010		
age 3		-0.13	-0.12	-0.11
age 4		0.04	0.04	0.06
age 5		0.1	0.11	0.07
age 6		0.29	0.33	0.71
age 7		0.45	0.14	0.32
age 8		0.11	0.19	0.04
age 9		-0.2	-0.24	-0.14
SSQ (ages 3-9, years 2001-2010)		**3.57**	**3.07**	**5.48**
		FLT18: RusSweptArea residuals at 2010		
age 3		-0.06	-0.07	-0.04
age 4		-0.1	-0.09	-0.15
age 5		0.13	0.14	0.13
age 6		0.05	0.11	-0.35
age 7		-0.1	0.04	-0.23
age 8		-0.33	-0.26	-0.4
age 9		0.09	0.05	0.14
SSQ (ages 3-9, years 2001-2010)		**2.91**	**2.94**	**3.39**
All surveys SSQ		**8.21**	**7.69**	**11.13**

Table 3.14. Northeast arctic cod. Final xsa compared with single fleet tunings run with standard shrinkage settings. Upper part of table shows the weight given to shrinkage at the various runs. Pshrink is population shrinkage and Fshrink is F-shrinkage. Values above 0.3 are shown in bold. Lower part of the table shows population and F at age as estimated before shrinkage (prediction values listed in xsa diagnostics) compared to final run (ALL) with shrinkage. Fs for the youngest ages (3-5) includes cannibalism mortality.

		FLT 09 Rus trawl CPUE	FLT 15 Joint BT survey	FLT 16 Joint+Lof Ac survey	FLT 18 Rus BT survey	Final run ALL Fleets
Ages with fleet data		9 to 11	3 to 8	3 to 9	3 to 9	3 to 11
age3	PshrinkW	0.94	0.56	0.48	0.59	0.24
	FshrinkW	0.06	0.04	0.05	0.04	0.03
age4	PshrinkW	0.93	0.40	0.31	0.44	0.13
	FshrinkW	0.07	0.03	0.04	0.03	0.02
age5	PshrinkW	0.94	0.39	0.29	0.44	0.12
	FshrinkW	0.06	0.03	0.03	0.03	0.01
age6	PshrinkW	0.96	0.46	0.36	0.53	0.16
	FshrinkW	0.04	0.03	0.04	0.02	0.01
age7	FshrinkW	1	0.04	0.04	0.04	0.01
age8	FshrinkW	1	0.04	0.04	0.04	0.01
age9	FshrinkW	0.15	0.04	0.04	0.03	0.01
age10	FshrinkW	0.15	0.11	0.06	0.06	0.02
age11	FshrinkW	0.09	0.19	0.17	0.08	0.04
age12	FshrinkW	0.13	0.35	0.24	0.11	0.06
2010	F(5-10)	0.459	0.319	0.311	0.311	0.300
TSB2010	incl Age1-2	2159	2710	2772	2781	2883
SSB2010	('000 T)	856	1146	1124	1262	1143
N2011	yc2008	551109	610221	624872	602541	652979
N*10^-3	yc2007	372858	370265	356030	381820	325048
with	yc2006	266437	313487	335292	292556	323747
shrinkage	yc2005	164523	224361	250474	218682	280727
	yc2004	86867	124090	138305	116909	167959
	yc2003	50758	84631	92638	74719	84180
	yc2002	20272	37603	40455	38144	37608
	yc2001	14898	19972	12326	22860	16780
		No	shrinkage			Shrinkage
Survivors	yc2007		303714	288853	328913	325048
end of 10	yc2006		320871	350973	283143	323747
direct	yc2005		254328	285420	247764	280727
predic.	yc2004		150428	169818	135780	167959
by the	yc2003		85849	94617	75141	84180
survey	yc2002		38312	41506	38611	37608
N*10^-3	yc2001	17960	20992	12684	23582	16780
	yc2000	6499	11024	13119	16168	10495
F2010	yc2007		0.131	0.137	0.121	0.154
	yc2006		0.120	0.110	0.135	0.129
direct	yc2005		0.242	0.219	0.248	0.222
predic.	yc2004		0.389	0.351	0.423	0.355
by the	yc2003		0.328	0.302	0.367	0.334
survey	yc2002		0.339	0.316	0.336	0.344
	yc2001	0.216	0.187	0.294	0.169	0.230
	yc2000	0.471	0.304	0.261	0.217	0.318
2010	F(5-10)		0.253	0.283	0.283	0.301

Table 3.15 . Northeast Arctic Cod. Diagnostics for final XSA.

Lowestoft VPA Version 3.1

30/04/2011 17:09

Extended Survivors Analysis

Arctic Cod (run: XSAASA01/X01)

CPUE data from file fleet

Catch data for 27 years. 1984 to 2010. Ages 1 to 13.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLT09: Russian trawl	1985	2010	9	11	0	1
FLT15: NorBarTrSur r	1984	2010	3	8	0.99	1
FLT16: NorBarLofAcSu	1984	2010	3	9	0.99	1
FLT18: RusSweptArea	1984	2010	3	9	0.9	1

Time series weights :

Tapered time weighting applied
Power = 3 over 10 years

Catchability analysis :

Catchability dependent on stock size for ages < 7

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 7

Catchability independent of age for ages >= 10

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 2 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 30 iterations

Total absolute residual between iterations
29 and 30 = .00667

Final year F values

Age	1	2	3	4	5	6	7	8	9	10
Iteration 29	2.0288	0.2929	0.1545	0.1295	0.222	0.355	0.3338	0.3447	0.2301	0.3182
Iteration 30	2.0284	0.2928	0.1544	0.1294	0.2218	0.3546	0.3335	0.3443	0.2298	0.3175

Age	11	12
Iteration 29	0.7089	0.4908
Iteration 30	0.707	0.4888

1

Regression weights										
	0.02	0.116	0.284	0.482	0.67	0.82	0.921	0.976	0.997	1

Fishing mortalities

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.949	0.607	1.409	1.248	1.154	0.943	0.819	0.653	2.029	2.028
2	0.2	0.411	0.272	0.616	0.202	0.143	0.202	0.13	0.247	0.293
3	0.062	0.11	0.049	0.082	0.196	0.029	0.145	0.167	0.155	0.154
4	0.117	0.106	0.071	0.105	0.123	0.153	0.125	0.161	0.127	0.129
5	0.285	0.287	0.273	0.254	0.393	0.247	0.299	0.167	0.247	0.222
6	0.519	0.555	0.469	0.524	0.543	0.487	0.311	0.271	0.259	0.355
7	0.671	0.804	0.677	0.739	0.795	0.598	0.412	0.271	0.255	0.334
8	0.838	0.893	0.695	0.875	0.777	0.732	0.436	0.468	0.259	0.344
9	0.878	0.794	0.582	0.791	0.899	0.706	0.421	0.396	0.378	0.23
10	1.071	0.718	0.519	0.874	0.807	0.706	0.273	0.33	0.237	0.318
11	0.761	0.596	0.422	0.689	0.796	0.646	0.437	0.221	0.264	0.707
12	0.926	0.669	0.568	0.852	0.529	0.811	0.561	0.362	0.539	0.489

Table 3.15 (continued)

XSA population numbers (Thousands)

AGE YEAR	1	2	3	4	5	6	7	8	9	10
2001	4.10E+06	6.89E+05	5.27E+05	4.69E+05	2.85E+05	1.73E+05	5.15E+04	1.03E+04	3.35E+03	1.96E+03
2002	1.12E+06	1.30E+06	4.62E+05	4.05E+05	3.42E+05	1.76E+05	8.43E+04	2.16E+04	3.63E+03	1.14E+03
2003	6.44E+06	4.99E+05	7.05E+05	3.39E+05	2.98E+05	2.10E+05	8.25E+04	3.09E+04	7.24E+03	1.34E+03
2004	3.62E+06	1.29E+06	3.12E+05	5.50E+05	2.58E+05	1.86E+05	1.08E+05	3.43E+04	1.26E+04	3.31E+03
2005	5.05E+06	8.52E+05	5.70E+05	2.35E+05	4.05E+05	1.64E+05	9.02E+04	4.20E+04	1.17E+04	4.68E+03
2006	4.01E+06	1.30E+06	5.70E+05	3.83E+05	1.70E+05	2.24E+05	7.80E+04	3.33E+04	1.58E+04	3.90E+03
2007	2.47E+06	1.28E+06	9.25E+05	4.53E+05	2.69E+05	1.09E+05	1.13E+05	3.51E+04	1.31E+04	6.40E+03
2008	1.70E+06	8.92E+05	8.56E+05	6.55E+05	3.27E+05	1.63E+05	6.53E+04	6.11E+04	1.86E+04	7.05E+03
2009	9.92E+06	7.24E+05	6.41E+05	5.93E+05	4.57E+05	2.27E+05	1.02E+05	4.08E+04	3.13E+04	1.02E+04
2010	1.01E+07	1.07E+06	4.63E+05	4.50E+05	4.28E+05	2.92E+05	1.43E+05	6.47E+04	2.58E+04	1.76E+04

Estimated population abundance at 1st Jan 2011

	0.00E+00	1.08E+06	6.53E+05	3.25E+05	3.24E+05	2.81E+05	1.68E+05	8.42E+04	3.76E+04	1.68E+04

Taper weighted geometric mean of the VPA populations:

	4.43E+06	9.87E+05	6.17E+05	4.56E+05	3.22E+05	1.90E+05	9.61E+04	4.28E+04	1.69E+04	6.37E+03

Standard error of the weighted Log(VPA populations) :

	0.7316	0.285	0.3339	0.3254	0.3444	0.3271	0.2728	0.3176	0.4941	0.7264

AGE YEAR	11	12
2001	7.11E+02	1.56E+02
2002	5.49E+02	2.72E+02
2003	4.56E+02	2.47E+02
2004	6.55E+02	2.45E+02
2005	1.13E+03	2.69E+02
2006	1.71E+03	4.18E+02
2007	1.58E+03	7.34E+02
2008	3.99E+03	8.34E+02
2009	4.15E+03	2.62E+03
2010	6.61E+03	2.61E+03

Estimated population abundance at 1st Jan 2011

	1.05E+04	2.68E+03

Taper weighted geometric mean of the VPA populations:

	2.25E+03	8.00E+02

Standard error of the weighted Log(VPA populations) :

	0.8771	0.9922

1

Log catchability residuals.

Fleet : FLT09: Russian trawl

Age	1984	1985	1986	1987	1988	1989	1990
3	No data for this fleet at this age						
4	No data for this fleet at this age						
5	No data for this fleet at this age						
6	No data for this fleet at this age						
7	No data for this fleet at this age						
8	No data for this fleet at this age						
9	99.99	99.99	99.99	99.99	99.99	99.99	99.99
10	99.99	99.99	99.99	99.99	99.99	99.99	99.99
11	99.99	99.99	99.99	99.99	99.99	99.99	99.99

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3	No data for this fleet at this age									
4	No data for this fleet at this age									
5	No data for this fleet at this age									
6	No data for this fleet at this age									
7	No data for this fleet at this age									
8	No data for this fleet at this age									
9	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
10	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
11	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99

Table 3.15 (continued)

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	No data for this fleet at this age									
4	No data for this fleet at this age									
5	No data for this fleet at this age									
6	No data for this fleet at this age									
7	No data for this fleet at this age									
8	No data for this fleet at this age									
9	0.08	0.43	-0.11	-0.17	-0.26	0.03	-0.36	0.72	-0.32	0.15
10	-0.08	-0.03	0.33	0.33	-0.32	-0.31	-0.4	0.64	0.15	-0.19
11	-0.2	-0.57	-0.11	0.33	-0.17	-0.09	-0.01	0.01	-0.21	-0.08

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

Age	9	10	11
Mean Log q	-3.4985	-3.6244	-3.6244
S.E(Log q)	0.397	0.4	0.1811

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
9	0.96	0.106	3.75	0.63	10	0.42	-3.5
10	1.04	-0.154	3.41	0.75	10	0.46	-3.62
11	1.04	-0.45	3.52	0.96	10	0.19	-3.69
1							

Fleet : FLT15: NorBarTrSur r

Age	1984	1985	1986	1987	1988	1989	1990
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	99.99	99.99	99.99	99.99	99.99	99.99	99.99
9	No data for this fleet at this age						
10	No data for this fleet at this age						
11	No data for this fleet at this age						

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
9	No data for this fleet at this age									
10	No data for this fleet at this age									
11	No data for this fleet at this age									

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	0.18	0.31	0.01	0.29	0.07	-0.17	0.15	0.01	-0.1	-0.14
4	0.03	0.07	-0.02	-0.2	0	-0.05	-0.03	0.03	0.01	0.14
5	0.01	0.04	-0.02	-0.16	-0.28	0.02	0.12	-0.04	0.07	0.12
6	-0.08	0.02	0	-0.14	-0.22	-0.27	0.2	-0.02	0.01	0.26
7	-0.37	-0.01	0.32	-0.4	-0.09	-0.16	-0.11	0.04	0.14	0.22
8	-0.37	0.14	0.12	-0.24	-0.3	0.14	-0.1	0.27	0.13	-0.14
9	No data for this fleet at this age									
10	No data for this fleet at this age									
11	No data for this fleet at this age									

Table 3.15 (continued)

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

Age	7	8
Mean Log q	-6.4398	-6.7343
S.E(Log q)	0.2028	0.2092

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
3	0.55	1.999	9.28	0.82	10	0.17	-5.9
4	0.54	3.501	9.14	0.93	10	0.1	-5.82
5	0.46	2.812	9.57	0.86	10	0.15	-5.9
6	0.51	1.683	9.04	0.74	10	0.22	-6.08

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
7	0.86	0.476	7.16	0.72	10	0.19	-6.44
8	0.93	0.227	7	0.73	10	0.22	-6.73
1							

Fleet : FLT16: NorBarLofAcSu

Age	1984	1985	1986	1987	1988	1989	1990
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	99.99	99.99	99.99	99.99	99.99	99.99	99.99
9	99.99	99.99	99.99	99.99	99.99	99.99	99.99
10	No data for this fleet at this age						
11	No data for this fleet at this age						

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
9	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
10	No data for this fleet at this age									
11	No data for this fleet at this age									

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	0.25	0.41	-0.12	0.29	-0.04	-0.3	0.13	0	0.13	-0.14
4	0.1	0.34	-0.09	-0.26	-0.01	-0.19	0.26	-0.09	0.09	0.04
5	0.15	0.31	-0.06	-0.1	-0.39	-0.04	0.27	-0.16	0.13	0.1
6	-0.03	0.24	-0.11	0	-0.27	-0.21	0.2	-0.01	-0.1	0.29
7	-0.13	0.31	0.26	-0.2	-0.07	-0.25	0.07	-0.43	0.15	0.45
8	-0.49	-0.03	0.25	0.17	0.03	0.05	-0.55	0.43	-0.23	0.11
9	-0.02	-0.18	0.4	-0.15	0.32	0.2	-0.12	-0.21	0.12	-0.2
10	No data for this fleet at this age									
11	No data for this fleet at this age									

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

Age	7	8	9
Mean Log q	-5.3015	-5.2241	-5.4158
S.E(Log q)	0.3097	0.3254	0.2268

Table 3.15 (continued)

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
3	0.41	2.152	10.43	0.76	10	0.21	-6.27
4	0.42	2.236	10.07	0.78	10	0.19	-6.06
5	0.43	1.921	9.73	0.72	10	0.24	-5.78
6	0.43	1.854	9.19	0.71	10	0.23	-5.32

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
7	0.51	3.322	8.33	0.91	10	0.09	-5.3
8	0.67	1.168	7.05	0.74	10	0.21	-5.22
9	1.12	-0.491	4.9	0.8	10	0.27	-5.42
1							

Fleet : FLT18: RusSweptArea

Age	1984	1985	1986	1987	1988	1989	1990
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	99.99	99.99	99.99	99.99	99.99	99.99	99.99
9	99.99	99.99	99.99	99.99	99.99	99.99	99.99
10	No data for this fleet at this age						
11	No data for this fleet at this age						

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
9	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
10	No data for this fleet at this age									
11	No data for this fleet at this age									

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	0.17	0.21	-0.12	0.04	0.23	-0.06	0.02	0.03	-0.1	-0.07
4	-0.07	0.03	-0.05	-0.23	-0.02	0.18	0	0.11	-0.02	-0.1
5	-0.1	-0.19	-0.22	-0.27	-0.16	0.07	0.22	-0.16	0.08	0.13
6	-0.04	-0.17	-0.18	-0.08	-0.26	0.09	0.08	0.08	0	0.05
7	-0.32	-0.01	-0.22	-0.05	-0.07	-0.03	0.26	0.07	-0.05	-0.1
8	-0.51	0.09	-0.18	0.03	-0.4	0.13	0.28	0.2	0.08	-0.33
9	-0.72	-0.15	-0.72	-0.24	-0.11	0.01	0.26	0.14	-0.05	0.09
10	No data for this fleet at this age									
11	No data for this fleet at this age									

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

Age	7	8	9
Mean Log q	-3.9857	-3.8251	-3.7338
S.E(Log q)	0.1389	0.2618	0.2337

Table 3.15 (continued)

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
3	0.5	3.115	9.63	0.9	10	0.12	-6
4	0.71	1.641	7.57	0.88	10	0.13	-5.32
5	0.64	1.437	7.55	0.79	10	0.2	-4.72
6	0.79	1.132	5.95	0.87	10	0.14	-4.33

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
7	1.03	-0.111	3.78	0.79	10	0.16	-3.99
8	1.3	-0.611	1.74	0.48	10	0.36	-3.83
9	0.84	0.908	4.69	0.88	10	0.2	-3.73

1

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 2009

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	1	0	0	0	0	0	0
FLT16: NorBarLofAcSu	1	0	0	0	0	0	0
FLT18: RusSweptArea	1	0	0	0	0	0	0
P shrinkage mean	987195	0.29				0.925	2.109
F shrinkage mean	3396792	1				0.075	1.133

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1083233	0.27	13.9	2	50.71	2.028

1

Age 2 Catchability dependent on age and year class strength

Year class = 2008

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	1	0	0	0	0	0	0
FLT16: NorBarLofAcSu	1	0	0	0	0	0	0
FLT18: RusSweptArea	1	0	0	0	0	0	0
P shrinkage mean	616828	0.33				0.9	0.307
F shrinkage mean	1088346	1				0.1	0.186

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
652979	0.32	13.39	2	42.28	0.293

Table 3.15 (continued)

Age 3 Catchability dependent on age and year class strength

Year class = 2007

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	281669	0.3	0	0	1	0.244	0.176
FLT16: NorBarLofAcSu	283296	0.3	0	0	1	0.244	0.175
FLT18: RusSweptArea	303872	0.3	0	0	1	0.244	0.164
P shrinkage mean	456192	0.33				0.242	0.112
F shrinkage mean	363621	1				0.026	0.139

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
325048	0.15	0.11	5	0.755	0.154

1

Age 4 Catchability dependent on age and year class strength

Year class = 2006

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	332843	0.213	0.116	0.54	2	0.284	0.126
FLT16: NorBarLofAcSu	350845	0.213	0.042	0.2	2	0.284	0.12
FLT18: RusSweptArea	292632	0.213	0.003	0.01	2	0.284	0.142
P shrinkage mean	321592	0.34				0.132	0.13
F shrinkage mean	301482	1				0.016	0.138

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
323747	0.12	0.04	8	0.317	0.129

Age 5 Catchability dependent on age and year class strength

Year class = 2005

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	295226	0.175	0.037	0.21	3	0.29	0.212
FLT16: NorBarLofAcSu	299500	0.175	0.03	0.17	3	0.29	0.209
FLT18: RusSweptArea	295936	0.175	0.045	0.26	3	0.29	0.211
P shrinkage mean	189714	0.33				0.117	0.313
F shrinkage mean	222810	1				0.013	0.272

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
280727	0.1	0.05	11	0.537	0.222

Age 6 Catchability dependent on age and year class strength

Year class = 2004

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	192369	0.155	0.054	0.35	4	0.277	0.316
FLT16: NorBarLofAcSu	191370	0.157	0.081	0.52	4	0.271	0.317
FLT18: RusSweptArea	179278	0.155	0.018	0.12	4	0.277	0.335
P shrinkage mean	96083	0.27				0.162	0.556
F shrinkage mean	156087	1				0.012	0.377

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
167959	0.09	0.08	14	0.908	0.355

Table 3.15 (continued)

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

Year class = 2003

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	86847	0.142	0.067	0.47	5	0.335	0.325
FLT16: NorBarLofAcSu	89083	0.144	0.14	0.97	5	0.317	0.318
FLT18: RusSweptArea	78550	0.142	0.029	0.2	5	0.335	0.353
F shrinkage mean	55530	1				0.012	0.47

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
84180	0.08	0.05	16	0.603	0.334

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

Year class = 2002

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	37603	0.139	0.05	0.36	6	0.343	0.344
FLT16: NorBarLofAcSu	40404	0.145	0.059	0.4	6	0.3	0.324
FLT18: RusSweptArea	36097	0.139	0.097	0.69	6	0.343	0.356
F shrinkage mean	21610	1				0.013	0.539

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
37608	0.08	0.04	19	0.515	0.344

Age 9 Catchability constant w.r.t. time and dependent on age

Year class = 2001

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT09: Russian trawl	19508	0.427	0	0	1	0.053	0.2
FLT15: NorBarTrSur r	18613	0.145	0.036	0.25	6	0.252	0.209
FLT16: NorBarLofAcSu	14566	0.143	0.082	0.57	7	0.324	0.26
FLT18: RusSweptArea	17986	0.136	0.01	0.07	7	0.359	0.216
F shrinkage mean	5704	1				0.012	0.565

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
16780	0.08	0.04	22	0.55	0.23

Table 3.15 (continued)

Age 10 Catchability constant w.r.t. time and dependent on age

Year class = 2000

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimatec F
FLT09: Russian trawl	8208	0.309	0.06	0.2	2	0.161	0.39
FLT15: NorBarTrSur r	10631	0.166	0.103	0.62	6	0.193	0.313
FLT16: NorBarLofAcSu	11566	0.167	0.091	0.54	7	0.295	0.291
FLT18: RusSweptArea	11169	0.158	0.06	0.38	7	0.327	0.3
F shrinkage mean	6450	1				0.024	0.474

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
10495	0.1	0.05	23	0.508	0.318

Age 11 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1999

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimatec F
FLT09: Russian trawl	2944	0.22	0.201	0.92	3	0.357	0.659
FLT15: NorBarTrSur r	2353	0.19	0.03	0.16	6	0.134	0.773
FLT16: NorBarLofAcSu	2009	0.184	0.064	0.35	7	0.222	0.861
FLT18: RusSweptArea	2992	0.173	0.065	0.37	7	0.247	0.651
F shrinkage mean	4497	1				0.04	0.477

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2679	0.11	0.06	24	0.539	0.707

Age 12 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1998

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimatec F
FLT09: Russian trawl	1254	0.224	0.261	1.16	3	0.449	0.506
FLT15: NorBarTrSur r	1380	0.226	0.051	0.22	6	0.088	0.469
FLT16: NorBarLofAcSu	1224	0.22	0.032	0.14	7	0.195	0.516
FLT18: RusSweptArea	1560	0.206	0.052	0.25	7	0.213	0.425
F shrinkage mean	1222	1				0.055	0.516

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1317	0.13	0.06	24	0.435	0.489

Table 3.16. Northeast Arctic cod. Fishing mortality for XSA run down to age 1. Number of cod eaten by cod included in catch matrix

Run title : Arctic Cod (run: XSAASA01/X01)

At 30/04/2011 17:09

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1984	1985	1986	1987	1988	1989	1990
AGE							
1	0.246	0.3593	0.9388	0.5245	0.8055	0.2162	0.0964
2	0.0373	0.0573	0.8002	0.8018	0.1104	0.0009	0.0596
3	0.0199	0.0533	0.1443	0.1137	0.0629	0.0327	0.0086
4	0.1235	0.1701	0.2122	0.2285	0.127	0.1284	0.0622
5	0.3075	0.3763	0.4933	0.5097	0.3704	0.266	0.1342
6	0.6274	0.6051	0.7052	0.9363	0.5971	0.4016	0.231
7	1.1361	0.9248	0.948	1.1398	1.0446	0.7156	0.2504
8	1.2111	1.0189	1.0909	1.0143	0.9834	0.8891	0.3742
9	1.2623	0.7786	0.8281	0.7784	1.1591	0.7166	0.3058
10	0.9579	0.5057	1.112	1.3241	1.718	0.9855	0.3242
11	1.0876	0.4205	0.8745	1.027	1.5371	0.5821	0.54
12	1.0345	0.4665	1.0045	1.1899	1.6497	0.7917	0.4352
+gp	1.0345	0.4665	1.0045	1.1899	1.6497	0.7917	0.4352
0 FBAR 5	0.9171	0.7016	0.8629	0.9504	0.9788	0.6624	0.27

Table 8 Fishing mortality (F) at age

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
1	0.1022	0.4762	2.6048	1.7156	1.8653	1.9952	2.5167	1.6238	1.0881	1.3696
2	0.237	0.1455	0.4634	0.6658	0.934	1.0582	1.0885	0.6301	0.3549	0.2579
3	0.0182	0.0405	0.0783	0.2122	0.4737	0.4714	0.3371	0.3769	0.1253	0.0771
4	0.0624	0.1265	0.0962	0.1978	0.2574	0.3528	0.2994	0.3525	0.2096	0.1395
5	0.1875	0.2205	0.3466	0.3384	0.3373	0.4115	0.569	0.5216	0.5476	0.4104
6	0.321	0.4428	0.4597	0.6454	0.5769	0.5424	0.7232	0.779	0.7237	0.6041
7	0.4259	0.5396	0.5663	1.1681	0.8906	0.7492	0.8419	0.7706	0.8083	0.7505
8	0.3451	0.5993	0.5976	0.9862	0.9433	0.8618	1.2329	1.0398	1.0535	1.0302
9	0.3805	0.4558	0.6665	1.0541	0.9616	0.7517	1.3341	1.1662	1.3789	1.1679
10	0.256	0.4586	0.6631	1.0398	1.0192	0.939	1.5084	1.2335	1.3991	1.1298
11	0.134	0.2482	0.6763	1.1611	1.2529	0.8658	1.4393	1.3308	0.9178	1.0535
12	0.1959	0.3556	0.6759	1.1135	1.1497	0.9122	1.4933	1.2984	1.1725	1.1047
+gp	0.1959	0.3556	0.6759	1.1135	1.1497	0.9122	1.4933	1.2984	1.1725	1.1047
0 FBAR 5	0.3193	0.4528	0.55	0.872	0.7881	0.7093	1.0349	0.9184	0.9852	0.8488
1										

Run title : Arctic Cod (run: XSAASA01/X01)

At 30/04/2011 17:09

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	FBAR **-**
AGE											
1	0.9494	0.6068	1.4093	1.248	1.1539	0.9427	0.8193	0.6529	2.0289	2.0284	1.5701
2	0.2004	0.4108	0.2717	0.616	0.2018	0.1431	0.2023	0.1301	0.247	0.2928	0.2233
3	0.0623	0.1099	0.049	0.0815	0.1965	0.0295	0.145	0.1672	0.1547	0.1544	0.1588
4	0.117	0.1055	0.0706	0.1047	0.1235	0.1532	0.1248	0.1609	0.1265	0.1294	0.1389
5	0.2849	0.2868	0.2727	0.2538	0.3933	0.247	0.2995	0.1665	0.2469	0.2218	0.2117
6	0.5191	0.5552	0.469	0.5237	0.5434	0.4872	0.3108	0.2708	0.2593	0.3546	0.2949
7	0.6708	0.8038	0.6768	0.7392	0.7953	0.5979	0.4116	0.2713	0.2551	0.3335	0.2866
8	0.8382	0.8926	0.6952	0.8754	0.7773	0.7325	0.4363	0.4684	0.2591	0.3443	0.3572
9	0.8777	0.7944	0.5816	0.7908	0.8992	0.7055	0.421	0.3962	0.378	0.2298	0.3347
10	1.0709	0.7178	0.5188	0.874	0.8073	0.7062	0.2726	0.33	0.2372	0.3175	0.2949
11	0.7613	0.5964	0.4219	0.6892	0.7963	0.6465	0.437	0.2209	0.2642	0.707	0.3974
12	0.9264	0.6686	0.5679	0.8519	0.529	0.811	0.5608	0.3617	0.5392	0.4888	0.4632
+gp	0.9264	0.6686	0.5679	0.8519	0.529	0.811	0.5608	0.3617	0.5392	0.4888	
0 FBAR 5	0.7103	0.6751	0.5357	0.6761	0.7026	0.5794	0.3586	0.3172	0.2726	0.3003	
1											

Table 3.17. Northeast Arctic cod. Stock number at age

Run title : Arctic Cod (run: XSAASA01/X01)

At 30/04/2011 17:09

Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-4

	YEAR	1984	1985	1986	1987	1988	1989	1990
	AGE							
	1	211470	137398	175715	49154	82176	81864	151819
	2	67035	135377	78540	56264	23819	30065	53992
	3	40282	52873	104666	28886	20660	17463	24593
	4	13543	32331	41043	74178	21109	15883	13838
	5	7852	9800	22329	27180	48326	15222	11438
	6	4763	4727	5507	11163	13367	27319	9552
	7	2465	2082	2113	2227	3583	6023	14969
	8	1304	648	676	670	583	1032	2411
	9	923	318	192	186	199	179	347
	10	140	214	120	69	70	51	71
	11	39	44	106	32	15	10	16
	12	26	11	24	36	9	3	5
	+gp	12	21	13	16	8	6	4
0	TOT	349855	375844	431044	250060	213924	195119	283055

Table 10 Stock number at age (start of year) Numbers*10**-4

	YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE										
	1	172538	300018	2418948	935704	2007643	2782545	1923323	667687	301781	330985
	2	112876	127543	152573	146393	137787	254522	309791	127121	107773	83230
	3	41649	72913	90282	78588	61587	44331	72327	85405	55425	61873
	4	19963	33486	57326	68348	52043	31399	22654	42271	47967	40036
	5	10646	15355	24157	42630	45916	32940	18064	13749	24327	31847
	6	8188	7226	10084	13986	24884	26831	17871	8372	6682	11518
	7	6207	4863	3800	5213	6005	11442	12771	7099	3145	2653
	8	9541	3320	2321	1766	1327	2018	4429	4505	2690	1148
	9	1358	5532	1493	1045	539	423	698	1057	1304	768
	10	209	760	2871	628	298	169	163	150	270	269
	11	42	133	393	1211	182	88	54	30	36	54
	12	7	30	85	164	311	42	30	10	6	12
	+gp	2	5	19	23	42	162	53	17	11	4
0	TOT	383227	571182	2764351	1295700	2338563	3186913	2382229	957474	551417	564397
	1										

Run title : Arctic Cod (run: XSAASA01/X01)

At 30/04/2011 17:09

Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-4

	YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	GMST 84-**	AMST 84-**
	AGE													
	1	409960	111902	644207	362457	504985	401290	247231	169935	992488	1005488	0	340183	623309
	2	68885	129881	49940	128855	85193	130401	127998	89216	72420	106842	108323	96866	112603
	3	52654	46155	70513	31160	56980	57003	92533	85601	64135	46316	65298	52434	57856
	4	46899	40507	33856	54971	23514	38329	45314	65531	59292	44984	32505	35199	39053
	5	28510	34157	29843	25830	40534	17016	26924	32748	45678	42775	32375	22790	25494
	6	17298	17555	20992	18602	16407	22395	10882	16339	22699	29217	28073	12451	14100
	7	5154	8427	8249	10753	9021	7802	11264	6530	10204	14339	16796	5590	6555
	8	1025	2158	3088	3433	4204	3334	3513	6110	4076	6473	8418	2075	2690
	9	335	363	724	1262	1171	1582	1312	1859	3132	2575	3761	699	1007
	10	196	114	134	331	468	390	640	705	1024	1757	1678	232	380
	11	71	55	46	65	113	171	158	399	415	661	1050	72	142
	12	16	27	25	24	27	42	73	83	262	261	268	24	45
	+gp	6	8	16	12	14	44	23	29	31	77	170		
0	TOT	631010	391311	861633	637755	742632	679799	567865	475084	1275856	1301766	298714		
	1													

Table 3.18. Northeast Arctic cod. Natural mortality used in final VPA.

Table 4 Natural Mortality (M) at age

YEAR	1946 - 1983	1984	1985	1986	1987	1988	1989	1990
AGE								
3	0.2	0.2006	0.2004	0.3115	0.2585	0.2087	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
10	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
11	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
12	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 4 Natural Mortality (M) at age

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
3	0.2049	0.2067	0.2655	0.402	0.6627	0.6475	0.514	0.5274	0.3094	0.2684
4	0.2	0.2	0.2028	0.2919	0.3548	0.4326	0.2934	0.2768	0.2111	0.2416
5	0.2	0.2	0.2024	0.225	0.2102	0.2812	0.2103	0.2164	0.2	0.2167
6	0.2	0.2	0.2	0.2045	0.2013	0.206	0.202	0.2095	0.2	0.2006
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
10	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
11	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
12	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 4 Natural Mortality (M) at age

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
3	0.2514	0.304	0.2373	0.2738	0.384	0.2126	0.312	0.3552	0.3447	0.3485
4	0.2295	0.2163	0.2	0.2237	0.2246	0.2063	0.211	0.2661	0.2487	0.283
5	0.2081	0.2033	0.2	0.2075	0.2201	0.2005	0.2008	0.2173	0.2176	0.2668
6	0.2075	0.2002	0.2	0.202	0.2049	0.2	0.2	0.2	0.2015	0.2139
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
10	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
11	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
12	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 3.19 Northeast arctic cod. Natural mortality of cod (M2) due to cannibalism

Year	M2 age 1	M2 age 2	M2 age 3	M2 age 4	M2 age 5	M2 age 6
1984	0.2460	0.0356	0.0006	0.0000	0.0000	0.0000
1985	0.3592	0.0558	0.0004	0.0000	0.0000	0.0000
1986	0.9388	0.7985	0.1115	0.0000	0.0000	0.0000
1987	0.5245	0.8007	0.0585	0.0000	0.0000	0.0000
1988	0.8055	0.1095	0.0087	0.0000	0.0000	0.0000
1989	0.2162	0.0000	0.0000	0.0000	0.0000	0.0000
1990	0.0964	0.0592	0.0000	0.0000	0.0000	0.0000
1991	0.1022	0.2363	0.0049	0.0000	0.0000	0.0000
1992	0.4758	0.1444	0.0067	0.0000	0.0000	0.0000
1993	2.6048	0.4628	0.0655	0.0028	0.0024	0.0000
1994	1.7156	0.6655	0.2020	0.0919	0.0250	0.0045
1995	1.8653	0.9337	0.4627	0.1548	0.0102	0.0013
1996	1.9952	1.0576	0.4475	0.2326	0.0812	0.0060
1997	2.5167	1.0878	0.3140	0.0934	0.0103	0.0020
1998	1.6238	0.6282	0.3274	0.0768	0.0164	0.0095
1999	1.0881	0.3545	0.1094	0.0111	0.0000	0.0000
2000	1.3696	0.2576	0.0684	0.0416	0.0167	0.0006
2001	0.9494	0.2000	0.0514	0.0295	0.0081	0.0075
2002	0.6067	0.4107	0.1040	0.0163	0.0033	0.0002
2003	1.4093	0.2712	0.0373	0.0000	0.0000	0.0000
2004*	1.2480	0.6158	0.0738	0.0237	0.0075	0.0020
2005*	1.1539	0.2011	0.1840	0.0246	0.0201	0.0049
2006*	0.9427	0.1420	0.0126	0.0063	0.0005	0.0000
2007*	0.8183	0.1997	0.1120	0.0110	0.0008	0.0000
2008*	0.6529	0.1292	0.1552	0.0661	0.0173	0.0000
2009*	2.0289	0.2463	0.1447	0.0487	0.0176	0.0015
2010*	2.0284	0.2926	0.1485	0.0830	0.0668	0.0139

* corrected data on cod consumption

Table 3.20. Northeast Arctic cod. Fishing mortality, final VPA

Run title : Arctic Cod (run: SVPASA15/V15)

At 30/04/2011 20:40

Traditional vpa using file input for terminal F

Table 8 Fishing mortality (F) at age

YEAR	1946	1947	1948	1949	1950
AGE					
3	0.0061	0.0018	0.0003	0.0023	0.002
4	0.02	0.0249	0.0124	0.0209	0.0321
5	0.0532	0.1101	0.0751	0.1484	0.1167
6	0.0973	0.2024	0.1997	0.3662	0.2882
7	0.1781	0.416	0.5201	0.5101	0.4096
8	0.1932	0.2545	0.3536	0.3869	0.348
9	0.3125	0.4047	0.5286	0.3832	0.4741
10	0.2798	0.4405	0.3617	0.3766	0.5031
11	0.3432	0.7827	0.5536	0.6259	0.9031
12	0.312	0.6182	0.4604	0.5039	0.7111
+gp	0.312	0.6182	0.4604	0.5039	0.7111
0 FBAR 5-10	0.1857	0.3047	0.3398	0.3619	0.3566

YEAR	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
AGE										
3	0.0254	0.0225	0.0334	0.0199	0.0159	0.027	0.024	0.0718	0.0535	0.0543
4	0.1612	0.1667	0.1325	0.1457	0.084	0.1291	0.1128	0.2589	0.2564	0.2266
5	0.2637	0.37	0.2299	0.2676	0.2859	0.4568	0.2094	0.3626	0.5093	0.3477
6	0.2787	0.5501	0.3125	0.3333	0.5297	0.69	0.4862	0.5517	0.5121	0.4607
7	0.4122	0.5311	0.3243	0.3969	0.5139	0.6129	0.5494	0.5357	0.5251	0.4363
8	0.4046	0.4175	0.3469	0.2494	0.588	0.688	0.6287	0.4593	0.5111	0.4855
9	0.5057	0.579	0.3932	0.4364	0.5805	0.6551	0.5463	0.4535	0.6141	0.4053
10	0.5149	0.7613	0.5364	0.6441	0.7645	0.738	0.6333	0.7388	0.686	0.7381
11	0.4585	1.026	0.698	0.8035	0.7621	0.8756	0.8584	0.8415	0.6511	0.8449
12	0.4879	0.9056	0.6217	0.7304	0.7704	0.8152	0.7529	0.799	0.6734	0.7981
+gp	0.4879	0.9056	0.6217	0.7304	0.7704	0.8152	0.7529	0.799	0.6734	0.7981
0 FBAR 5-10	0.3966	0.5348	0.3572	0.3879	0.5437	0.6401	0.5089	0.5169	0.5596	0.4789

YEAR	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
AGE										
3	0.0562	0.0663	0.0313	0.0174	0.0226	0.0398	0.0298	0.0251	0.023	0.0409
4	0.2717	0.3063	0.2366	0.1449	0.111	0.1037	0.1525	0.2064	0.2292	0.1422
5	0.4944	0.6498	0.742	0.3537	0.3909	0.2119	0.1814	0.4087	0.4792	0.4004
6	0.5168	0.8279	1.0069	0.4854	0.4494	0.3818	0.2026	0.4683	0.5382	0.568
7	0.5279	0.6094	0.9764	0.5787	0.4033	0.4713	0.432	0.4019	0.7725	0.6211
8	0.6931	0.6564	0.8798	0.7409	0.5303	0.5797	0.6844	0.5291	0.9302	0.8479
9	0.7389	0.8167	0.9416	1.0674	0.7389	0.7183	0.8781	0.8041	1.1783	0.9682
10	0.8379	0.9855	1.3731	0.8476	0.8074	0.8182	0.885	0.8105	1.0769	1.09
11	1.0011	0.9522	1.4366	1.2968	0.7617	0.5024	1.2253	0.6772	1.5554	0.8533
12	0.9284	0.9756	1.4264	1.0883	0.7927	0.6634	1.0696	0.7458	1.3377	0.9829
+gp	0.9284	0.9756	1.4264	1.0883	0.7927	0.6634	1.0696	0.7458	1.3377	0.9829
0 FBAR 5-10	0.6348	0.7576	0.9866	0.6789	0.5533	0.5302	0.5439	0.5704	0.8292	0.7493

YEAR	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AGE										
3	0.0214	0.0394	0.1959	0.2141	0.0837	0.166	0.1338	0.146	0.0489	0.0318
4	0.1028	0.1673	0.1996	0.4959	0.2106	0.3121	0.5671	0.2234	0.209	0.1296
5	0.2285	0.2976	0.3536	0.5375	0.5211	0.48	0.7544	0.6703	0.3475	0.3562
6	0.2517	0.3849	0.3917	0.5078	0.7021	0.5715	0.6857	0.8497	0.5478	0.6225
7	0.5144	0.3427	0.421	0.4451	0.705	0.6973	0.6763	0.8581	0.6643	0.6766
8	0.833	0.6583	0.7375	0.4863	0.7032	0.8908	0.9121	0.9296	0.7789	0.7123
9	0.9584	1.1338	0.9698	0.5192	0.6109	0.7746	1.2298	1.3057	1.0352	0.939
10	0.7876	1.3393	0.7386	0.8842	0.7149	0.46	0.7689	1.0301	0.9848	1.038
11	0.8388	1.2904	0.7222	0.9905	0.9079	0.6132	0.6231	1.8042	1.4314	1.4798
12	0.8179	1.3377	0.7358	0.9492	0.8218	0.5389	0.6958	1.4375	1.2219	1.2775
+gp	0.8179	1.3377	0.7358	0.9492	0.8218	0.5389	0.6958	1.4375	1.2219	1.2775
0 FBAR 5-10	0.5956	0.6928	0.602	0.5633	0.6595	0.6457	0.8379	0.9406	0.7264	0.7241

Table 3.20 (continued).

Table 8 Fishing mortality (F) at age

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE										
3	0.0252	0.0672	0.0208	0.0194	0.0533	0.033	0.0555	0.0546	0.033	0.0087
4	0.1003	0.2121	0.205	0.1247	0.1716	0.2133	0.2293	0.1277	0.1292	0.0627
5	0.23	0.3045	0.3308	0.3096	0.3788	0.496	0.5104	0.371	0.2671	0.1352
6	0.5163	0.5518	0.5033	0.6301	0.6078	0.7078	0.9362	0.5974	0.4023	0.2324
7	0.8475	0.7996	0.7821	1.135	0.9264	0.9487	1.1362	1.0411	0.7142	0.2518
8	1.0788	0.9846	1.0295	1.2083	1.0191	1.091	1.0143	0.9788	0.8851	0.3755
9	1.2764	1.1588	0.9701	1.2572	0.7818	0.8325	0.7841	1.1546	0.7134	0.3067
10	1.2299	0.7507	0.9203	0.9564	0.5088	1.1134	1.3245	1.7027	0.9791	0.3242
11	0.9557	0.9516	0.5853	1.081	0.4237	0.8774	1.0329	1.5282	0.581	0.5377
12	1.1082	0.8607	0.759	1.0345	0.4665	1.0045	1.1899	1.6497	0.7917	0.4352
+gp	1.1082	0.8607	0.759	1.0345	0.4665	1.0045	1.1899	1.6497	0.7917	0.4352
0 FBAR 5-10	0.8632	0.7583	0.756	0.9161	0.7038	0.8649	0.951	0.9743	0.6602	0.271

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
3	0.0134	0.0341	0.013	0.0103	0.011	0.024	0.0232	0.0496	0.016	0.0088
4	0.0631	0.1276	0.0942	0.1067	0.1033	0.1209	0.2071	0.2768	0.1996	0.0985
5	0.1888	0.2226	0.3463	0.3154	0.3291	0.3321	0.5604	0.5066	0.5485	0.395
6	0.3228	0.4449	0.4635	0.6433	0.5784	0.5392	0.7227	0.7703	0.724	0.6045
7	0.4277	0.5417	0.5693	1.1663	0.892	0.7532	0.8444	0.7731	0.8095	0.7507
8	0.347	0.6013	0.6009	0.9866	0.9446	0.8656	1.2326	1.0421	1.0538	1.0279
9	0.3823	0.4585	0.6697	1.0542	0.9631	0.7574	1.3322	1.1676	1.3745	1.165
10	0.2572	0.4612	0.6668	1.041	1.0202	0.9433	1.5058	1.2309	1.3946	1.1255
11	0.1345	0.2497	0.6797	1.161	1.2492	0.8714	1.4377	1.329	0.9195	1.0522
12	0.1959	0.3556	0.6759	1.1135	1.1497	0.9122	1.4933	1.2984	1.1725	1.1047
+gp	0.1959	0.3556	0.6759	1.1135	1.1497	0.9122	1.4933	1.2984	1.1725	1.1047
0 FBAR 5-10	0.321	0.455	0.5528	0.8678	0.7879	0.6985	1.033	0.9151	0.9842	0.8448

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	FBAR **-**
AGE											
3	0.011	0.006	0.0117	0.0077	0.0124	0.0169	0.0328	0.0119	0.0099	0.0059	0.0092
4	0.088	0.0898	0.0711	0.0814	0.099	0.1472	0.114	0.0947	0.0769	0.0464	0.0727
5	0.2783	0.2848	0.2741	0.2473	0.3733	0.2465	0.2987	0.1493	0.2296	0.155	0.178
6	0.5131	0.5564	0.4705	0.5228	0.5384	0.4866	0.3105	0.271	0.2581	0.3407	0.2899
7	0.672	0.8031	0.6779	0.7387	0.7934	0.5972	0.4115	0.2711	0.2554	0.3335	0.2867
8	0.8369	0.8911	0.6957	0.8743	0.7755	0.7298	0.4369	0.4675	0.259	0.3443	0.3569
9	0.8762	0.7925	0.5834	0.7901	0.8958	0.7033	0.4209	0.3973	0.3777	0.2298	0.3349
10	1.0658	0.7177	0.5194	0.8733	0.8055	0.7035	0.2734	0.3305	0.2388	0.3175	0.2956
11	0.7605	0.5962	0.4243	0.688	0.7964	0.6458	0.4365	0.2219	0.265	0.707	0.398
12	0.9264	0.6686	0.5679	0.8519	0.529	0.811	0.5608	0.3617	0.5392	0.4888	0.4632
+gp	0.9264	0.6686	0.5679	0.8519	0.529	0.811	0.5608	0.3617	0.5392	0.4888	
0 FBAR 5-10	0.7071	0.6743	0.5368	0.6744	0.697	0.5778	0.3587	0.3145	0.2698	0.2868	

Table 3.21 Northeast arctic cod. Fishing mortality of age 1-6 cod

Year	F age 1	F age 2	F age 3	F age 4	F age 5	F age 6
1984	0.0000	0.0017	0.0193	0.1235	0.3075	0.6274
1985	0.0001	0.0015	0.0529	0.1701	0.3763	0.6051
1986	0.0000	0.0017	0.0328	0.2122	0.4933	0.7052
1987	0.0000	0.0011	0.0552	0.2285	0.5097	0.9363
1988	0.0000	0.0009	0.0542	0.1270	0.3704	0.5971
1989	0.0000	0.0009	0.0327	0.1284	0.2660	0.4016
1990	0.0000	0.0004	0.0086	0.0622	0.1342	0.2310
1991	0.0000	0.0007	0.0133	0.0624	0.1875	0.3210
1992	0.0004	0.0011	0.0338	0.1265	0.2205	0.4428
1993	0.0000	0.0006	0.0128	0.0934	0.3442	0.4597
1994	0.0000	0.0003	0.0102	0.1059	0.3134	0.6409
1995	0.0000	0.0003	0.0110	0.1026	0.3271	0.5756
1996	0.0000	0.0006	0.0239	0.1202	0.3303	0.5364
1997	0.0000	0.0007	0.0231	0.2060	0.5587	0.7212
1998	0.0000	0.0019	0.0495	0.2757	0.5052	0.7695
1999	0.0000	0.0004	0.0159	0.1985	0.5476	0.7237
2000	0.0000	0.0003	0.0087	0.0979	0.3937	0.6035
2001	0.0000	0.0004	0.0109	0.0875	0.2768	0.5116
2002	0.0001	0.0001	0.0059	0.0892	0.2835	0.5550
2003	0.0000	0.0005	0.0117	0.0706	0.2727	0.4690
2004	0.0000	0.0002	0.0077	0.0810	0.2463	0.5217
2005	0.0000	0.0007	0.0125	0.0989	0.3732	0.5385
2006	0.0000	0.0011	0.0169	0.1469	0.2465	0.4872
2007	0.0010	0.0026	0.0330	0.1138	0.2987	0.3108
2008	0.0000	0.0009	0.0120	0.0948	0.1492	0.2708
2009	0.0000	0.0007	0.0100	0.0778	0.2293	0.2578
2010	0.0000	0.0002	0.0059	0.0464	0.1550	0.3407

Table 3.22. Northeast Arctic cod. Stock number at age. Final VPA

Run title : Arctic Cod (run: SVPASA15/V15)
At 30/04/2011 20:40
Traditional vpa using file input for terminal F

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1946	1947	1948	1949	1950
AGE					
3	728139	425311	442592	468348	704908
4	577860	592530	347574	362238	382556
5	402060	463732	473210	281072	290427
6	197212	312115	340097	359415	198391
7	93323	146496	208708	228044	204032
8	96213	63939	79121	101579	112107
9	244722	64933	40588	45487	56484
10	101777	146581	35470	19586	25387
11	38117	62991	77255	20227	11003
12	39205	22142	23578	36361	8856
+gp	33324	42765	37377	21337	21133
0 TOTAL	2551952	2343535	2105569	1943694	2015284

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
AGE										
3	1083753	1193111	1590377	641584	272778	439602	804781	496824	683690	789653
4	575973	865011	955076	1259285	514924	219807	350332	643259	378598	530599
5	303320	401364	599477	684912	891184	387619	158175	256234	406511	239862
6	211595	190765	226975	389987	429102	548181	200984	105033	145989	199996
7	121764	131099	90099	135956	228785	206850	225110	101196	49529	71623
8	110900	66016	63110	53333	74845	112048	91748	106395	48488	23986
9	64808	60583	35603	36525	34028	34036	46105	40060	55027	23813
10	28785	32000	27799	19673	19329	15591	14474	21860	20840	24380
11	12568	14083	12237	13311	8459	7368	6103	6291	8550	8592
12	3651	6506	4133	4985	4880	3232	2513	2118	2220	3650
+gp	13989	3938	1880	2707	2738	3722	1687	857	1142	1351
0 TOTAL	2531108	2964476	3606766	3242259	2481052	1978057	1902013	1780129	1800584	1917505

YEAR	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
AGE										
3	916842	728338	472064	338678	776941	1582560	1295416	164955	112039	197105
4	612324	709603	558039	374580	272501	621906	1245195	1029477	131705	89647
5	346346	382037	427678	360621	265306	199663	458995	875269	685697	85743
6	138702	172949	163321	166726	207288	146941	132256	313440	476187	347649
7	103298	67732	61876	48854	84015	108284	82121	88421	160667	227600
8	37908	49883	30149	19083	22424	45954	55340	43651	48433	60756
9	12084	15518	21185	10240	7448	10803	21072	22854	21054	15642
10	13000	4726	5614	6764	2883	2913	4313	7170	8373	5306
11	9541	4605	1444	1164	2373	1053	1052	1457	2610	2335
12	3022	2871	1455	281	261	907	522	253	606	451
+gp	2332	1351	1113	1278	670	351	461	498	278	312
0 TOTAL	2195401	2139612	1743938	1328269	1642109	2721334	3296742	2547445	1647648	1032545

YEAR	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AGE										
3	404774	1015319	1818949	523916	621616	613942	348054	638490	198490	137735
4	154909	324399	799193	1224278	346265	468089	425778	249276	451722	154747
5	63671	114439	224670	535936	610486	229669	280485	197708	163230	300088
6	47037	41482	69576	129164	256342	296843	116349	108004	82807	94414
7	161288	29940	23112	38504	63643	104000	137232	47987	37806	39202
8	100131	78947	17401	12421	20199	25746	42398	57130	16658	15929
9	21306	35642	33463	6815	6253	8186	8650	13943	18463	6259
10	4863	6690	9391	10388	3320	2779	3089	2070	3093	5368
11	1461	1811	1435	3673	3513	1330	1436	1172	605	946
12	815	517	408	571	1117	1160	590	631	158	118
+gp	421	697	408	525	550	572	583	1198	218	87
0 TOTAL	960676	1649883	2998007	2486189	1933304	1752317	1364643	1317608	973250	754893

Table 3.22 (continued).

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE										
3	150868	151830	166831	397831	523674	1038010	286372	204645	172783	242751
4	109237	120444	116234	133783	319254	406349	735515	209194	157268	136872
5	111295	80899	79769	77525	96695	220157	268787	478808	150745	113154
6	172067	72401	48848	46916	46570	54207	109763	132094	270501	94492
7	41481	84063	34138	24176	20455	20763	21867	35238	59509	148106
8	16316	14551	30937	12785	6362	6632	6583	5747	10186	23854
9	6397	4542	4451	9048	3127	1880	1824	1954	1768	3442
10	2004	1461	1167	1381	2107	1171	669	682	504	709
11	1557	480	565	381	435	1037	315	146	102	155
12	176	490	152	258	106	233	353	92	26	47
+gp	66	70	170	116	209	130	156	82	56	40
0 TOTAL	611465	531231	483261	704200	1018994	1750567	1432204	1068681	823447	763623

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
3	411739	720703	892370	776251	608066	438359	715454	845476	548551	612599
4	197022	330985	566477	675479	513993	309995	223981	418110	474785	396177
5	105247	151442	238523	420905	453420	325100	178227	135787	240362	314874
6	80927	71341	99246	137790	245192	264422	176055	82463	65896	113704
7	61322	47980	37433	51115	59024	112431	125511	69834	30956	26155
8	94266	32734	22853	17345	13037	19805	43345	44166	26392	11280
9	13417	54551	14690	10259	5295	4150	6824	10346	12754	7533
10	2074	7495	28238	6156	2927	1655	1593	1474	2635	2641
11	420	1313	3869	11868	1780	864	527	289	352	535
12	74	301	837	1605	3043	418	296	103	63	115
+gp	25	48	191	232	418	1624	532	174	113	42
0 TOTAL	966533	1418893	1904728	2109005	1906195	1478823	1472344	1608220	1402859	1485656

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	GMST 46-**	AMST 46-**
AGE													
3	521360	457346	699345	309769	566089	566293	918598	851328	583950	357904	0	506824	610587
4	464297	401032	335449	545178	233757	380814	450167	650709	589766	409615	251103	380762	457330
5	281946	337982	295276	255799	401842	169135	267428	325256	453644	425865	294659	261515	311481
6	170790	173347	207440	183799	162325	221991	108165	162283	225429	290054	279310	150404	179974
7	50829	83079	81346	106101	89038	77192	111722	64920	101327	142373	166579	73970	91016
8	10108	21251	30468	33811	41499	32973	34782	60614	40529	64260	83508	32673	43318
9	3304	3584	7137	12440	11548	15645	13013	18397	31093	25611	37287	13509	23222
10	1924	1126	1328	3260	4622	3860	6340	6994	10124	17449	16664	5219	12125
11	702	543	450	647	1115	1691	1564	3949	4114	6528	10400	1947	6188
12	153	269	245	241	266	412	726	827	2590	2584	2635	704	3122
+gp	63	81	164	120	138	443	234	293	307	773	1686		
0 TOTAL	1505476	1479639	1658648	1451164	1512240	1470449	1912738	2145569	2042873	1743016	1143831		

Table 3.23. Northeast Arctic cod. Stock biomass at age. Final VPA

Run title : Arctic Cod (run: SVPASA15/V15)
At 30/04/2011 20:40
Traditional vpa using file input for terminal F

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR		1946	1947	1948	1949	1950
AGE						
	3	0	0	0	0	0
	4	0	0	0	0	0
	5	4021	4637	4732	2811	2904
	6	5916	9363	10203	10782	5952
	7	5599	8790	14610	20524	18363
	8	10583	8312	10286	17268	25785
	9	44050	10389	10147	13191	19769
	10	44782	61564	16671	10576	13201
	11	24776	47243	56396	15979	8692
	12	33716	20149	21456	31998	8414
+gp		31991	40627	36256	20697	20499

YEAR		1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
AGE											
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	5306
	5	3033	4014	5995	6849	8912	3876	1582	2562	4065	7196
	6	6348	5723	6809	11700	12873	16445	6030	3151	5840	12000
	7	12176	10488	6307	10876	16015	12411	13507	6072	5943	7162
	8	26616	14523	11991	8533	9730	13446	8257	10640	16486	4557
	9	25923	24839	14241	13514	8847	4765	5533	4006	26963	10716
	10	16695	20160	17791	13378	10245	6392	3184	6558	13963	16822
	11	9049	11548	10279	11581	7021	4937	3662	3145	7182	6616
	12	3103	5985	3885	4636	4489	2941	2061	1736	1931	3103
+gp		13430	3820	1824	2599	2656	3573	1637	831	1142	1337
	1										

YEAR		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
AGE											
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	5580	0	0	0	0	0	0	896
	5	3463	3820	4277	0	0	1997	0	26258	0	0
	6	8322	8647	4900	5002	2073	2939	3968	15672	9524	3476
	7	12396	10160	4331	6351	5041	6497	5748	7958	6427	15932
	8	11752	16960	8442	7061	4485	10110	7748	8294	5812	13974
	9	7855	9466	8898	6759	4096	3781	8007	8913	7158	9072
	10	11830	3828	4547	6020	2105	2155	2760	4158	4605	4298
	11	9351	4236	1415	1106	2349	990	936	1195	1931	2078
	12	2962	2784	1426	278	255	853	469	253	576	411
+gp		2332	1351	1113	1278	670	351	461	498	278	312

YEAR		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AGE											
	3	0	10153	0	0	0	0	0	0	0	0
	4	0	6488	0	0	0	0	0	0	0	0
	5	637	2289	0	0	6105	0	5610	0	0	0
	6	2352	415	1392	1292	5127	14842	9308	2160	2484	1888
	7	17742	2994	3698	1155	5728	12480	35680	6238	4915	5096
	8	30039	26842	9223	2608	4242	7466	22895	25137	6496	5575
	9	12571	22811	27105	3407	3502	3684	6574	9899	14216	4068
	10	3842	5419	8639	9973	2589	2335	2687	1594	2753	4402
	11	1256	1703	1363	3673	2775	1104	1336	949	502	946
	12	717	517	400	548	1061	1160	554	561	123	107
+gp		421	697	408	525	550	515	525	958	196	78

Table 3.23 (continued).

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE										
3	0	0	1668	0	0	0	0	0	1382	1942
4	0	6022	9299	6689	3193	20317	7355	4184	472	1779
5	2226	8090	7977	13954	8703	17613	18815	23940	4372	5771
6	12045	24616	14654	14544	16765	10299	19757	43591	61674	19843
7	8296	54641	24921	13539	11250	11004	4811	18676	32551	77311
8	8811	11932	27225	11507	5408	4708	3028	3563	7181	17056
9	5118	4178	4317	8957	3002	1166	912	1954	1618	3115
10	1944	1461	1167	1381	1896	1054	502	682	504	692
11	1557	480	565	381	435	1037	315	146	102	155
12	176	490	152	258	106	233	353	92	26	47
+gp	66	70	170	116	209	130	156	82	56	40

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
3	412	721	0	2329	0	0	0	845	1097	0
4	6305	4634	15861	4728	1542	0	0	1254	950	396
5	7894	21959	20752	50088	27659	6177	2139	3530	3365	22356
6	24683	29892	36523	46160	91212	68221	24648	12534	12323	28085
7	43416	38384	26353	30107	36831	70944	76185	32962	16840	16818
8	81163	30869	21277	14951	10182	16240	35976	35951	22354	9363
9	12840	53133	14278	9880	5083	4047	6455	9901	12308	7367
10	2074	7495	28069	6095	2866	1655	1593	1445	2635	2641
11	420	1313	3869	11868	1780	864	527	289	352	535
12	74	301	837	1605	3043	418	296	103	63	115
+gp	25	48	191	232	418	1624	532	174	113	42

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
3	1564	915	699	310	0	0	0	0	0	0
4	1393	5213	335	5452	935	381	1801	2603	0	1229
5	18327	28390	25984	23278	27325	10148	19255	20166	34477	19164
6	61314	67259	67625	81239	64443	81915	37101	45764	83860	93687
7	31717	56743	54665	77029	63751	49943	80775	34927	76502	81580
8	8279	17872	27055	29483	37017	29577	30469	52310	34733	53850
9	3145	3408	6830	12142	11167	15098	12700	17072	30378	23742
10	1924	1126	1328	3186	4580	3860	6340	6952	10093	16926
11	702	543	450	647	1115	1691	1564	3949	4114	6358
12	153	269	245	241	266	412	726	827	2590	2548
+gp	63	81	164	120	138	443	234	293	307	773

Table 3.24. Northeast Arctic cod. Spawning stock biomass at age

Run title : Arctic Cod (run: SVPASA15/V15)
At 30/04/2011 20:40
Traditional vpa using file input for terminal F

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR	1946	1947	1948	1949	1950
AGE					
3	0	0	0	0	0
4	0	0	0	0	0
5	4463	4405	5962	3120	3747
6	9999	14045	19692	17899	10118
7	13271	18810	35939	51310	43336
8	33550	24271	34560	55777	89730
9	175319	37921	42820	53688	89358
10	226148	280733	88522	55738	74190
11	146673	275901	333864	95716	55632
12	242756	149506	152120	226543	66972
+gp	260598	359467	305634	170088	182256
0 TOTSPBIO	1112776	1165059	1019114	729879	615339

YEAR	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	2706
5	4216	5338	7673	8630	10070	4148	1613	2434	5976	7843
6	11934	10988	13142	23048	22270	30095	10974	6050	15650	25559
7	30928	27688	17722	32956	44041	35868	39034	17851	21337	24209
8	92091	53882	44606	36949	38336	57144	35341	44792	71220	22194
9	126506	125685	72060	72976	43352	26446	30374	22474	146950	65582
10	86815	121968	112796	90299	72122	46535	23914	48202	89921	142819
11	64611	85686	76066	90213	50549	39492	30172	27270	51492	51539
12	25511	50457	33681	49467	39416	24559	19063	16635	16668	25753
+gp	126093	38907	18670	25156	26763	35534	17356	9668	13275	15274
0 TOTSPBIO	568705	520599	396417	429694	346919	299823	207840	195377	432489	383479
1										

YEAR	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	0	0	3404	0	0	0	0	0	0	816
5	3637	3553	4106	0	0	2356	0	38862	0	0
6	18309	14701	8476	9303	3089	5231	8094	33225	19333	6953
7	40038	30784	13167	20641	12149	15983	16153	24988	18637	47796
8	60050	85309	41870	35091	15786	38620	26962	34917	22144	57992
9	48308	62004	57300	43323	23471	20267	39155	46973	35935	50714
10	96417	29476	35970	48583	15870	15669	19624	27653	29611	32662
11	81163	39269	13616	10332	19897	8542	8455	10766	16089	18644
12	28433	29404	16125	2828	2853	9089	4972	2444	6167	4512
+gp	27875	17178	14173	16470	9201	4967	6369	7389	3953	4396
0 TOTSPBIO	404228	311678	208207	186570	102315	120722	129784	227215	151870	224482

YEAR	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AGE										
3	0	3858	0	0	0	0	0	0	0	0
4	0	4996	0	0	0	0	0	0	0	0
5	879	3273	0	0	6776	0	8022	0	0	0
6	5080	879	3145	2867	9741	29833	19081	4644	5316	3248
7	54467	9671	12166	3708	16897	34445	117745	18964	15481	15391
8	126766	117567	42516	11451	18536	31508	104400	112112	27870	23415
9	73036	132988	178082	18808	20100	21659	42466	64741	93543	23759
10	27394	41292	72313	78385	22708	21713	23191	12721	23705	31960
11	10827	16210	14370	36074	27530	11345	13266	9637	4630	8362
12	7763	6248	4647	6251	12532	13760	6041	6090	1342	989
+gp	5449	9529	5674	6947	7206	6975	7173	12626	2812	1130
0 TOTSPBIO	311662	346511	332913	164491	142028	171238	341385	241536	174699	108253

Table 3.24 (continued).

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE										
3	0	0	617	0	0	0	0	0	413	773
4	0	3975	8555	7759	2793	17879	3663	1690	245	1254
5	3205	10921	12763	25258	13950	25890	23594	18913	3795	6821
6	25173	48986	35756	40578	47110	25408	40443	82953	91093	34111
7	24723	160097	95196	51176	45665	43081	16506	55598	87433	190031
8	42732	50592	129590	52586	31544	27356	15555	15650	33233	60804
9	33622	26992	26639	55265	23068	7669	5948	15268	11403	14670
10	17804	12436	8986	10636	19184	7204	4670	8256	5034	5395
11	16843	5870	5224	3521	6210	11412	4142	1910	941	1389
12	1899	5283	1645	2794	1346	2965	4496	1169	330	593
+gp	924	979	2209	1514	2984	1863	2226	1181	798	578
0 TOTSPBIO	166926	326133	327181	251087	193856	170729	121243	202589	234717	316419

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
3	213	317	0	547	0	0	0	183	223	0
4	7162	4314	18590	3560	748	0	0	669	494	184
5	13758	39790	37768	71124	31531	5998	2308	4099	3951	27006
6	59930	81186	103103	111383	193186	140126	46288	24304	25027	55384
7	139539	149506	106229	115159	127803	250220	256667	97072	51093	51261
8	368317	159776	116957	80974	50279	89370	189343	164440	99788	38349
9	88338	359922	96592	65513	36392	31430	57624	73496	79778	42168
10	22227	71935	240576	46501	26132	16809	19364	14978	27063	19697
11	3966	16313	41967	96273	17978	9218	5909	3397	3836	5126
12	944	3826	10659	20438	38742	5319	3768	1306	799	1465
+gp	354	682	2733	3325	5988	23242	7616	2488	1616	603
0 TOTSPBIO	704748	887567	775174	614799	528780	571732	588888	386431	293666	241243

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
3	446	230	161	77	0	0	0	0	0	0
4	727	3154	180	2977	583	229	1259	1910	0	724
5	21919	33756	34039	25303	30550	12188	25821	27627	46303	22671
6	137281	143799	135860	165322	124504	164567	78690	108323	197909	192247
7	105079	189124	177168	225002	194187	155523	255814	114909	287876	259504
8	42371	85180	134491	129255	146403	130938	141376	252132	177521	258478
9	20055	23378	46029	75935	64893	91040	82489	111789	199097	160471
10	17777	10512	11565	27214	37967	31024	57841	58974	91829	133021
11	7946	5526	6760	6299	14981	16789	18422	35154	38808	63631
12	1947	3419	3115	3068	3389	5239	9240	10535	32969	32441
+gp	901	1153	2347	1711	1981	6338	3353	4189	4393	11059
0 TOTSPBIO	356449	499231	551716	662161	619438	613874	674305	725543	1076703	1134247

Table 3.25. Northeast Arctic cod. Summary Table. Final VPA.

Run title : Arctic Cod (run: SVPASA15/V15)
At 30/04/2011 20:40
Table 16 Summary (without SOP correction)
Traditional vpa using file input for terminal F

	RECRUITS Age 3	TOTALBIO	TOTSPBIO	LANDIN	YIELD/SS	FBAR 5-10
1946	728139	4168882	1112776	706000	0.6344	0.1857
1947	425311	3692801	1165059	882017	0.7571	0.3047
1948	442592	3665819	1019114	774295	0.7598	0.3398
1949	468348	3065111	729879	800122	1.0962	0.3619
1950	704908	2830103	615339	731982	1.1896	0.3566
1951	1083753	3141009	568705	827180	1.4545	0.3966
1952	1193111	3407679	520599	876795	1.6842	0.5348
1953	1590377	3557376	396417	695546	1.7546	0.3572
1954	641584	4039204	429694	826021	1.9223	0.3879
1955	272778	3488383	346919	1147841	3.3087	0.5437
1956	439602	3189831	299823	1343068	4.4795	0.6401
1957	804781	2495895	207840	792557	3.8133	0.5089
1958	496824	2164149	195377	769313	3.9376	0.5169
1959	683690	2415826	432489	744607	1.7217	0.5596
1960	789653	2050805	383479	622042	1.6221	0.4789
1961	916842	2137149	404228	783221	1.9376	0.6348
1962	728338	1957006	311678	909266	2.9173	0.7576
1963	472064	1747579	208207	776337	3.7287	0.9866
1964	338678	1374529	186570	437695	2.346	0.6789
1965	776941	1440693	102315	444930	4.3486	0.5533
1966	1582560	2198418	120722	483711	4.0068	0.5302
1967	1295416	2852164	129784	572605	4.412	0.5439
1968	164955	3387455	227215	1074084	4.7272	0.5704
1969	112039	2805591	151870	1197226	7.8832	0.8292
1970	197105	2057698	224482	933246	4.1573	0.7493
1971	404774	1610969	311662	689048	2.2109	0.5956
1972	1015319	1621485	346511	565254	1.6313	0.6928
1973	1818949	2401955	332913	792685	2.3811	0.602
1974	523916	2236387	164491	1102433	6.7021	0.5633
1975	621616	2037430	142028	829377	5.8395	0.6595
1976	613942	1931396	171238	867463	5.0658	0.6457
1977	348054	1950748	341385	905301	2.6518	0.8379
1978	638490	1576565	241536	698715	2.8928	0.9406
1979	198490	1114381	174699	440538	2.5217	0.7264
1980	137735	863862	108253	380434	3.5143	0.7241
1981	150868	983658	166926	399038	2.3905	0.8632
1982	151830	750871	326133	363730	1.1153	0.7583
1983	166831	738675	327181	289992	0.8863	0.756
1984	397831	817596	251087	277651	1.1058	0.9161
1985	523674	957513	193856	307920	1.5884	0.7038
1986	1038010	1294195	170729	430113	2.5193	0.8649
1987	286372	1126282	121243	523071	4.3142	0.951
1988	204645	915460	202589	434939	2.1469	0.9743
1989	172783	890362	234717	332481	1.4165	0.6602
1990	242751	962678	316419	212000	0.67	0.271
1991	411739	1561700	704748	319158	0.4529	0.321
1992	720703	1912033	887567	513234	0.5782	0.455
1993	892370	2358452	775174	581611	0.7503	0.5528
1994	776251	2145717	614799	771086	1.2542	0.8678
1995	608066	1804224	528780	739999	1.3994	0.7879
1996	438359	1687600	571732	732228	1.2807	0.6985
1997	715454	1532694	588888	762403	1.2946	1.033
1998	845476	1230812	386431	592624	1.5336	0.9151
1999	548551	1101982	293666	484910	1.6512	0.9842
2000	612599	1103592	241243	414868	1.7197	0.8448
2001	521360	1380326	356449	426471	1.1964	0.7071
2002	457346	1553273	499231	535045	1.0717	0.6743
2003	699345	1631526	551716	551990	1.0005	0.5368
2004	309769	1602075	662161	606445	0.9159	0.6744
2005	566089	1600612	619438	641276	1.0353	0.697
2006	566293	1563413	613874	537642	0.8758	0.5778
2007	918598	1831963	674305	486883	0.7221	0.3587
2008	851328	2286239	725543	464171	0.6398	0.3145
2009	583950	2631618	1076703	523430	0.4861	0.2698
2010	357904	2613101	1134247	609983	0.5378	0.2868
Arith. Mean	606289	2019178	425275	650605	2.224	0.6242
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 3.26. Northeast Arctic cod. Summary table, run without cannibalism

Run title : Arctic Cod (run: SVPASA15/V15)
At 30/04/2011 19:45
Table 17 Summary (with SOP correction)
Traditional vpa using file input for terminal F

	RECRUITS Age 3	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 5-10
1946	728139	4293811	1146123	706000	0.616	1.03	0.1857
1947	425311	3376257	1065191	882017	0.828	0.9143	0.3047
1948	442592	3267954	908506	774295	0.8523	0.8915	0.3398
1949	468348	3040708	724068	800122	1.105	0.992	0.3619
1950	704908	3079079	669472	731982	1.0934	1.088	0.3566
1951	1083753	3606886	653056	827180	1.2666	1.1483	0.3966
1952	1193111	3185494	486655	876795	1.8017	0.9348	0.5348
1953	1590377	3730060	415660	695546	1.6734	1.0485	0.3572
1954	641584	3754130	399368	826021	2.0683	0.9294	0.3879
1955	272778	3709457	368905	1147841	3.1115	1.0634	0.5437
1956	439602	3334938	313462	1343068	4.2846	1.0455	0.6401
1957	804781	2496915	207925	792557	3.8117	1.0004	0.5089
1958	496824	2430865	219456	769313	3.5055	1.1232	0.5169
1959	683690	2247829	402414	744607	1.8504	0.9305	0.5596
1960	789653	2136130	399434	622042	1.5573	1.0416	0.4789
1961	916842	2344489	443445	783221	1.7662	1.097	0.6348
1962	728338	2418125	385116	909266	2.361	1.2356	0.7576
1963	472064	1787090	212915	776337	3.6462	1.0226	0.9866
1964	338678	1412595	191737	437695	2.2828	1.0277	0.6789
1965	776941	1858862	132013	444930	3.3704	1.2903	0.5533
1966	1582560	2710018	148816	483711	3.2504	1.2327	0.5302
1967	1295416	3111880	141602	572605	4.0438	1.0911	0.5439
1968	164955	3653238	245042	1074084	4.3833	1.0785	0.5704
1969	112039	2951436	159764	1197226	7.4937	1.052	0.8292
1970	197105	2298385	250740	933246	3.722	1.117	0.7493
1971	404774	1998392	386613	689048	1.7823	1.2405	0.5956
1972	1015319	1916935	409649	565254	1.3799	1.1822	0.6928
1973	1818949	3123373	432902	792685	1.8311	1.3003	0.602
1974	523916	3054971	224699	1102433	4.9063	1.366	0.5633
1975	621616	2347143	163618	829377	5.069	1.152	0.6595
1976	613942	2450566	217268	867463	3.9926	1.2688	0.6457
1977	348054	2084056	364715	905301	2.4822	1.0683	0.8379
1978	638490	1716831	263025	698715	2.6565	1.089	0.9406
1979	198490	1352781	212072	440538	2.0773	1.2139	0.7264
1980	137735	1099099	137731	380434	2.7621	1.2723	0.7241
1981	150868	1161595	197121	399038	2.0243	1.1809	0.8632
1982	151830	940172	408354	363730	0.8907	1.2521	0.7583
1983	166831	661357	292934	289992	0.99	0.8953	0.756
1984	397595	775255	238112	277651	1.1661	0.9483	0.9161
1985	523471	974888	197391	307920	1.5599	1.0182	0.7038
1986	930302	1280839	173456	430113	2.4797	1.016	0.8649
1987	270554	1148110	123960	523071	4.2197	1.0224	0.951
1988	202921	915195	202612	434939	2.1467	1.0001	0.9743
1989	172783	879580	231874	332481	1.4339	0.9879	0.6602
1990	242751	973053	319829	212000	0.6629	1.0108	0.271
1991	408196	1485178	671003	319158	0.4756	0.9521	0.321
1992	700444	1953332	911523	513234	0.5631	1.027	0.455
1993	759472	2325123	784436	581611	0.7414	1.0127	0.553
1994	516912	2041613	617890	771086	1.2479	1.009	0.8686
1995	306902	1695286	529681	739999	1.3971	1.003	0.7884
1996	257438	1621334	579060	732228	1.2645	1.0147	0.7009
1997	491828	1474924	589021	762403	1.2944	1.0004	1.034
1998	601050	1168637	388890	592624	1.5239	1.0072	0.9162
1999	470412	1076491	292644	484910	1.657	0.9967	0.9842
2000	555078	1081590	241673	414868	1.7166	1.0039	0.8456
2001	487303	1357821	355229	426471	1.2006	0.9994	0.7075
2002	408679	1539629	500264	535045	1.0695	1.0025	0.6743
2003	649020	1620131	552423	551990	0.9992	1.0014	0.5369
2004	281110	1583289	662685	606445	0.9151	1.0017	0.6748
2005	468556	1564995	618035	641276	1.0376	0.9993	0.6977
2006	545331	1553458	612673	537642	0.8775	0.9981	0.5778
2007	743150	1773813	672753	486883	0.7237	0.9978	0.3587
2008	505378	2134189	725690	464171	0.6396	1.0011	0.3147
2009	184765	2381717	1074501	523430	0.4871	1.0002	0.2715
2010	13676	2194935	1119476	609983	0.5449	1.0001	0.3003
Arith. Mean	557481	2103359	436744	650605	2.0405		.6246
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)			

Table 3.27. Northeast Arctic cod. Input for the short-term prediction

MFDP version 1a
Run: out
Time and date: 14:11 02.05.2011
Fbar age range: 5-10

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	433000	0.3495	0	0	0	0.224	0.0091	0.78
4	251103	0.2659	0.001	0	0	0.739	0.0718	1.235
5	294659	0.2339	0.037	0	0	1.088	0.1758	1.762
6	279310	0.2051	0.343	0	0	1.915	0.2864	2.513
7	166579	0.2	0.64	0	0	2.776	0.2832	3.53
8	83508	0.2	0.817	0	0	4.319	0.3526	4.758
9	37287	0.2	0.94	0	0	6.495	0.3309	6.476
10	16664	0.2	0.964	0	0	8.489	0.292	7.678
11	10400	0.2	0.991	0	0	10.016	0.3931	8.749
12	2635	0.2	0.989	0	0	12.731	0.4576	9.956
13	1686	0.2	1	0	0	14.311	0.4576	10.581

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	607000	0.3495	0	0	0	0.231	0.0091	0.78
4	.	0.2659	0.001	0	0	0.646	0.0718	1.231
5	.	0.2339	0.053	0	0	1.139	0.1758	1.794
6	.	0.2051	0.346	0	0	1.993	0.2864	2.531
7	.	0.2	0.656	0	0	3.033	0.2832	3.601
8	.	0.2	0.837	0	0	4.513	0.3526	4.891
9	.	0.2	0.948	0	0	6.492	0.3309	6.189
10	.	0.2	0.977	0	0	8.621	0.292	7.907
11	.	0.2	0.982	0	0	9.198	0.3931	9.109
12	.	0.2	0.992	0	0	12.731	0.4576	10.18
13	.	0.2	1	0	0	14.311	0.4576	11.387

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	683000	0.3495	0	0	0	0.236	0.0091	0.78
4	.	0.2659	0.001	0	0	0.62	0.0718	1.231
5	.	0.2339	0.053	0	0	1.196	0.1758	1.791
6	.	0.2051	0.346	0	0	1.949	0.2864	2.564
7	.	0.2	0.656	0	0	2.974	0.2832	3.619
8	.	0.2	0.837	0	0	4.364	0.3526	4.962
9	.	0.2	0.948	0	0	6.205	0.3309	6.322
10	.	0.2	0.977	0	0	8.354	0.292	7.62
11	.	0.2	0.982	0	0	9.959	0.3931	9.338
12	.	0.2	0.992	0	0	12.731	0.4576	10.54
13	.	0.2	1	0	0	14.311	0.4576	11.611

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	606000	0.3495	0	0	0	0.236	0.0091	0.78
4	.	0.2659	0.001	0	0	0.62	0.0718	1.231
5	.	0.2339	0.053	0	0	1.196	0.1758	1.791
6	.	0.2051	0.346	0	0	1.949	0.2864	2.564
7	.	0.2	0.656	0	0	2.974	0.2832	3.619
8	.	0.2	0.837	0	0	4.364	0.3526	4.962
9	.	0.2	0.948	0	0	6.205	0.3309	6.322
10	.	0.2	0.977	0	0	8.354	0.292	7.62
11	.	0.2	0.982	0	0	9.959	0.3931	9.338
12	.	0.2	0.992	0	0	12.731	0.4576	10.54
13	.	0.2	1	0	0	14.311	0.4576	11.611

Input units are thousands and kg - output in tonnes

Table 3.28. Northeast Arctic cod. Management option table.

MFDP version 1a
Run: out-v2
preMFDP Index file 25.04.2005
Time and date: 14:20 02.05.2011
Fbar age range: 5-10

2011				
Biomass	SSB	FMult	FBar	Landings
2506600	1310681	1	0.2868	628142

2012					2013	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
2611363	1551040	0	0	0	3293722	2122828
.	1551040	0.1	0.0287	71665	3214050	2057118
.	1551040	0.2	0.0574	141266	3136798	1993507
.	1551040	0.3	0.086	208867	3061889	1931927
.	1551040	0.4	0.1147	274529	2989247	1872310
.	1551040	0.5	0.1434	338314	2918801	1814593
.	1551040	0.6	0.1721	400278	2850481	1758714
.	1551040	0.7	0.2008	460478	2784219	1704611
.	1551040	0.8	0.2295	518969	2719949	1652228
.	1551040	0.9	0.2581	575802	2657609	1601508
.	1551040	1	0.2868	631030	2597138	1552397
.	1551040	1.1	0.3155	684702	2538475	1504843
.	1551040	1.2	0.3442	736864	2481565	1458794
.	1551040	1.3	0.3729	787564	2426352	1414202
.	1551040	1.4	0.4015	836847	2372782	1371019
.	1551040	1.5	0.4302	884754	2320803	1329200
.	1551040	1.6	0.4589	931329	2270366	1288701
.	1551040	1.7	0.4876	976612	2221421	1249478
.	1551040	1.8	0.5163	1020642	2173923	1211491
.	1551040	1.9	0.545	1063457	2127825	1174699
.	1551040	2	0.5736	1105094	2083084	1139064

Input units are thousands and kg - output in tonnes

Table 3.29a. Northeast arctic cod. Detailed prediction output assuming Fpa in 2012-2014

MFDP version 1a
Run: out
Time and date: 14:11 02.05.2011
Fbar age range: 5-10

Year:	2011	F multiplier:	1	Fbar:	0.2868				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0091	3311	2583	433000	96992	0	0	0	0
4	0.0718	15301	18896	251103	185565	251	186	251	186
5	0.1758	42502	74888	294659	320589	10902	11862	10902	11862
6	0.2864	63197	158813	279310	534879	95803	183463	95803	183463
7	0.2832	37411	132062	166579	462423	106611	295951	106611	295951
8	0.3526	22622	107634	83508	360671	68226	294668	68226	294668
9	0.3309	9573	61996	37287	242179	35050	227648	35050	227648
10	0.292	3843	29508	16664	141461	16064	136368	16064	136368
11	0.3931	3084	26981	10400	104166	10306	103229	10306	103229
12	0.4576	884	8797	2635	33546	2606	33177	2606	33177
13	0.4576	565	5982	1686	24128	1686	24128	1686	24128
Total		202293	628142	1576831	2506600	347506	1310681	347506	1310681

Year:	2012	F multiplier:	1.3947	Fbar:	0.4				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0127	6463	5041	607000	140217	0	0	0	0
4	0.1001	25368	31228	302517	195426	303	195	303	195
5	0.2452	34898	62607	179139	204040	9494	10814	9494	10814
6	0.3994	58636	148407	195609	389849	67681	134888	67681	134888
7	0.395	50862	183154	170856	518207	112082	339944	112082	339944
8	0.4918	36470	178377	102747	463697	85999	388115	85999	388115
9	0.4615	16224	100411	48055	311972	45556	295749	45556	295749
10	0.4073	6693	52924	21928	189038	21423	184690	21423	184690
11	0.5483	3933	35823	10188	93713	10005	92026	10005	92026
12	0.6382	2483	25281	5747	73167	5701	72582	5701	72582
13	0.6382	967	11015	2239	32038	2239	32038	2239	32038
Total		242999	834269	1646025	2611363	360483	1551040	360483	1551040

Year:	2013	F multiplier:	1.3947	Fbar:	0.4				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0127	7272	5672	683000	161188	0	0	0	0
4	0.1001	35435	43621	422562	261989	423	262	423	262
5	0.2452	40869	73196	209788	250907	11119	13298	11119	13298
6	0.3994	33258	85274	110949	216241	38389	74819	38389	74819
7	0.395	31813	115131	106866	317820	70104	208490	70104	208490
8	0.4918	33451	165983	94240	411263	78879	344227	78879	344227
9	0.4615	17368	109803	51444	319211	48769	302612	48769	302612
10	0.4073	7570	57684	24800	207178	24229	202413	24229	202413
11	0.5483	4612	43063	11947	118982	11732	116840	11732	116840
12	0.6382	2083	21957	4821	61377	4782	60886	4782	60886
13	0.6382	1492	17328	3454	49426	3454	49426	3454	49426
Total		215224	738712	1723872	2375580	291880	1373273	291880	1373273

Year:	2014	F multiplier:	1.3947	Fbar:	0.4				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0127	6452	5033	606000	143016	0	0	0	0
4	0.1001	39872	49082	475470	294791	475	295	475	295
5	0.2452	57087	102242	293037	350472	15531	18575	15531	18575
6	0.3994	38948	99863	129932	253237	44956	87620	44956	87620
7	0.395	18044	65302	60614	180267	39763	118255	39763	118255
8	0.4918	20923	103818	58945	257234	49337	215305	49337	215305
9	0.4615	15930	100712	47185	292782	44731	277557	44731	277557
10	0.4073	8104	61753	26549	221790	25938	216689	25938	216689
11	0.5483	5216	48704	13512	134567	13269	132145	13269	132145
12	0.6382	2443	25747	5653	71972	5608	71396	5608	71396
13	0.6382	1546	17955	3579	51215	3579	51215	3579	51215
Total		214565	680211	1720475	2251343	243188	1189052	243188	1189052

Input units are thousands and kg - output in tonnes

Table 3.29b. Northeast arctic cod. Detailed prediction output assuming HCR in 2012 and Fpa in 2013

MFDP version 1a
Run: corr
Time and date: 11:22 03.05.2011
Fbar age range: 5-10

Year:	2011	F multiplier:	1	Fbar:	0.2868				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0091	3311	2583	433000	96992	0	0	0	0
4	0.0718	15301	18896	251103	185565	251	186	251	186
5	0.1758	42502	74888	294659	320589	10902	11862	10902	11862
6	0.2864	63197	158813	279310	534879	95803	183463	95803	183463
7	0.2832	37411	132062	166579	462423	106611	295951	106611	295951
8	0.3526	22622	107634	83508	360671	68226	294668	68226	294668
9	0.3309	9573	61996	37287	242179	35050	227648	35050	227648
10	0.292	3843	29508	16664	141461	16064	136368	16064	136368
11	0.3931	3084	26981	10400	104166	10306	103229	10306	103229
12	0.4576	884	8797	2635	33546	2606	33177	2606	33177
13	0.4576	565	5982	1686	24128	1686	24128	1686	24128
Total		202293	628142	1576831	2506600	347506	1310681	347506	1310681

Year:	2012	F multiplier:	1.2276	Fbar:	0.3521				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0112	5693	4440	607000	140217	0	0	0	0
4	0.0881	22455	27642	302517	195426	303	195	303	195
5	0.2158	31136	55858	179139	204040	9494	10814	9494	10814
6	0.3516	52739	133481	195609	389849	67681	134888	67681	134888
7	0.3477	45737	164700	170856	518207	112082	339944	112082	339944
8	0.4329	32954	161178	102747	463697	85999	388115	85999	388115
9	0.4062	14638	90595	48055	311972	45556	295749	45556	295749
10	0.3585	6023	47621	21928	189038	21423	184690	21423	184690
11	0.4826	3563	32458	10188	93713	10005	92026	10005	92026
12	0.5617	2260	23003	5747	73167	5701	72582	5701	72582
13	0.5617	880	10023	2239	32038	2239	32038	2239	32038
Total		218078	751000	1646025	2611363	360483	1551040	360483	1551040

Year:	2013	F multiplier:	1.3947	Fbar:	0.4				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0127	7272	5672	683000	161188	0	0	0	0
4	0.1001	35489	43687	423205	262387	423	262	423	262
5	0.2452	41362	74080	212320	253935	11253	13459	11253	13459
6	0.3994	34250	87816	114257	222687	39533	77050	39533	77050
7	0.395	33372	120775	112105	333400	73541	218710	73541	218710
8	0.4918	35072	174027	98807	431193	82701	360909	82701	360909
9	0.4615	18423	116467	54566	338585	51729	320978	51729	320978
10	0.4073	8000	60964	26210	218956	25607	213920	25607	213920
11	0.5483	4842	45216	12545	124931	12319	122682	12319	122682
12	0.6382	2225	23448	5148	65544	5107	65020	5107	65020
13	0.6382	1611	18705	3728	53354	3728	53354	3728	53354
Total		221918	770857	1745892	2466161	305941	1446345	305941	1446345

Table 3.30. 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 3.31. 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

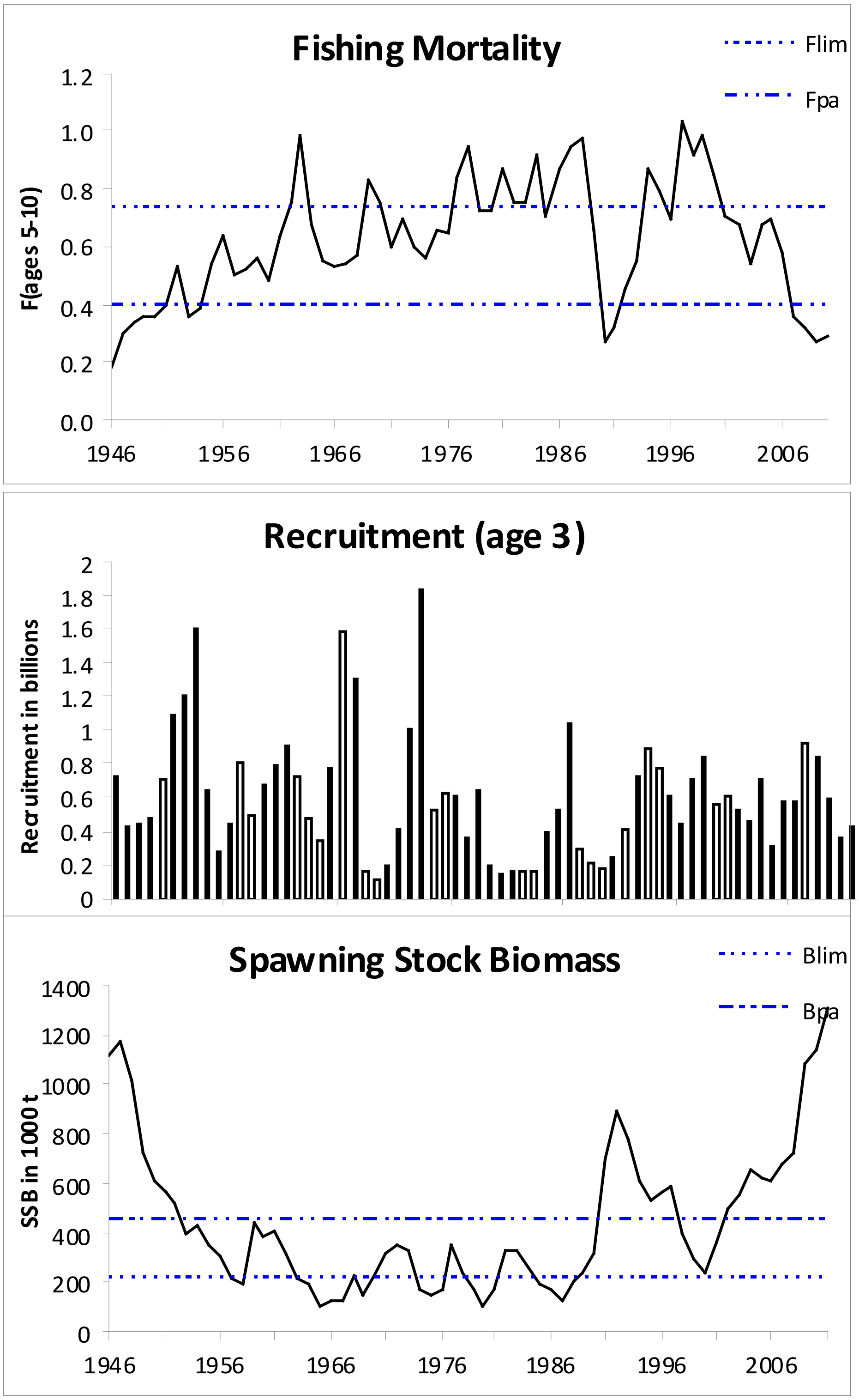
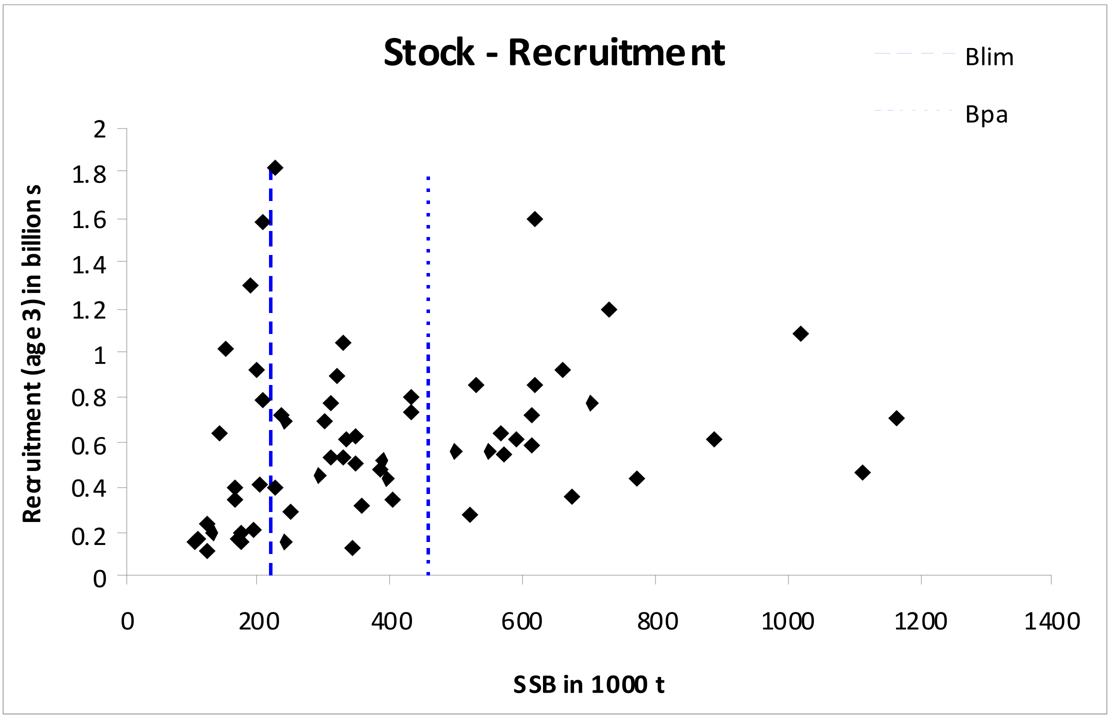


Figure 3.1. ICES Standard plots for Northeast Arctic cod (sub-area I and II)



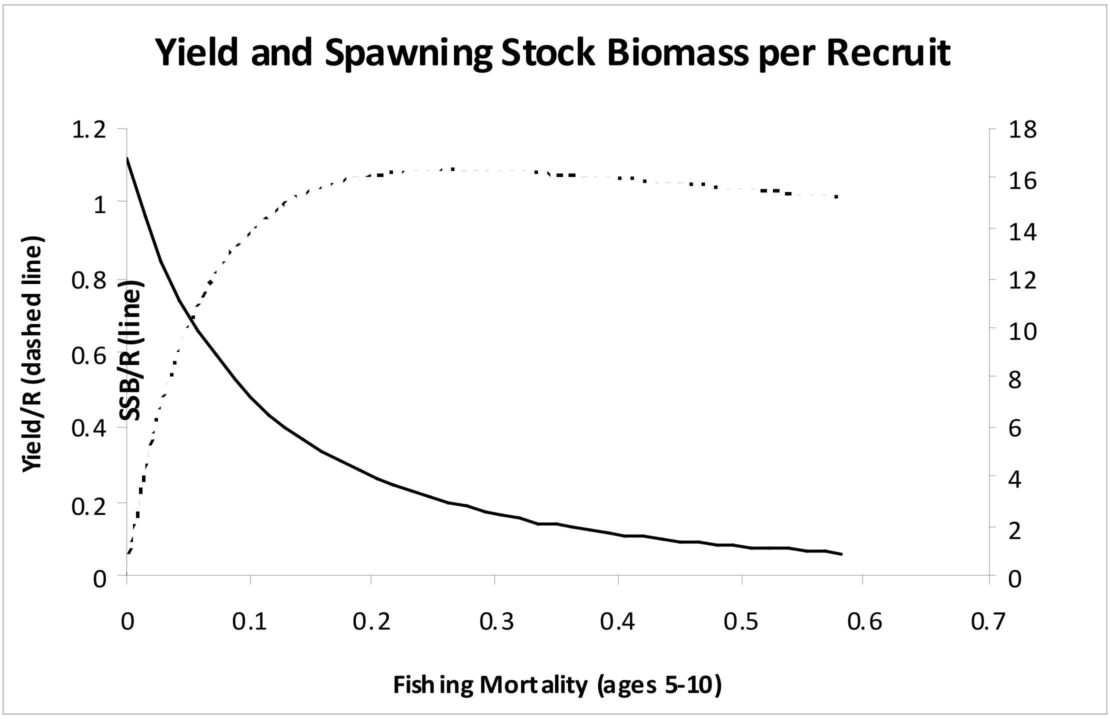


Fig. 3.1. Continued. ICES Standard plots for Northeast Arctic cod (sub-area I and II)

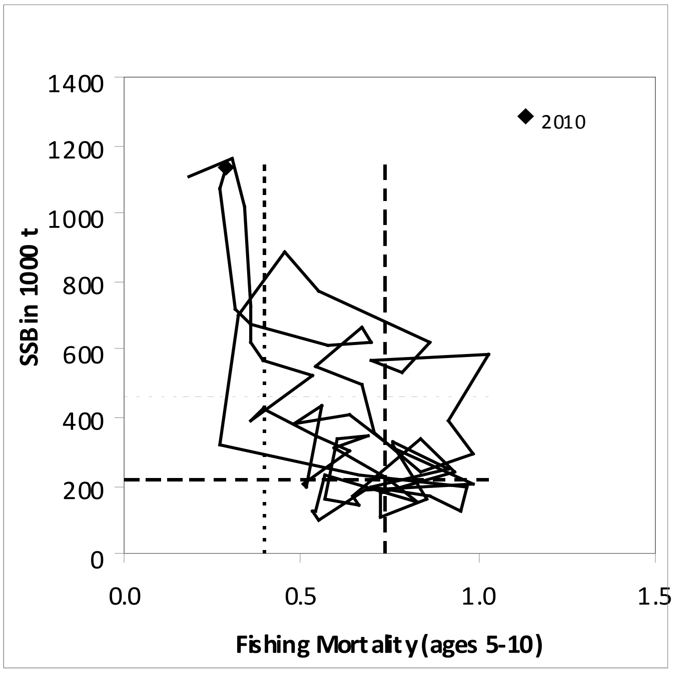


Figure. 3.1. Continued. ICES Standard plots for Northeast Arctic cod (sub-area I and II)

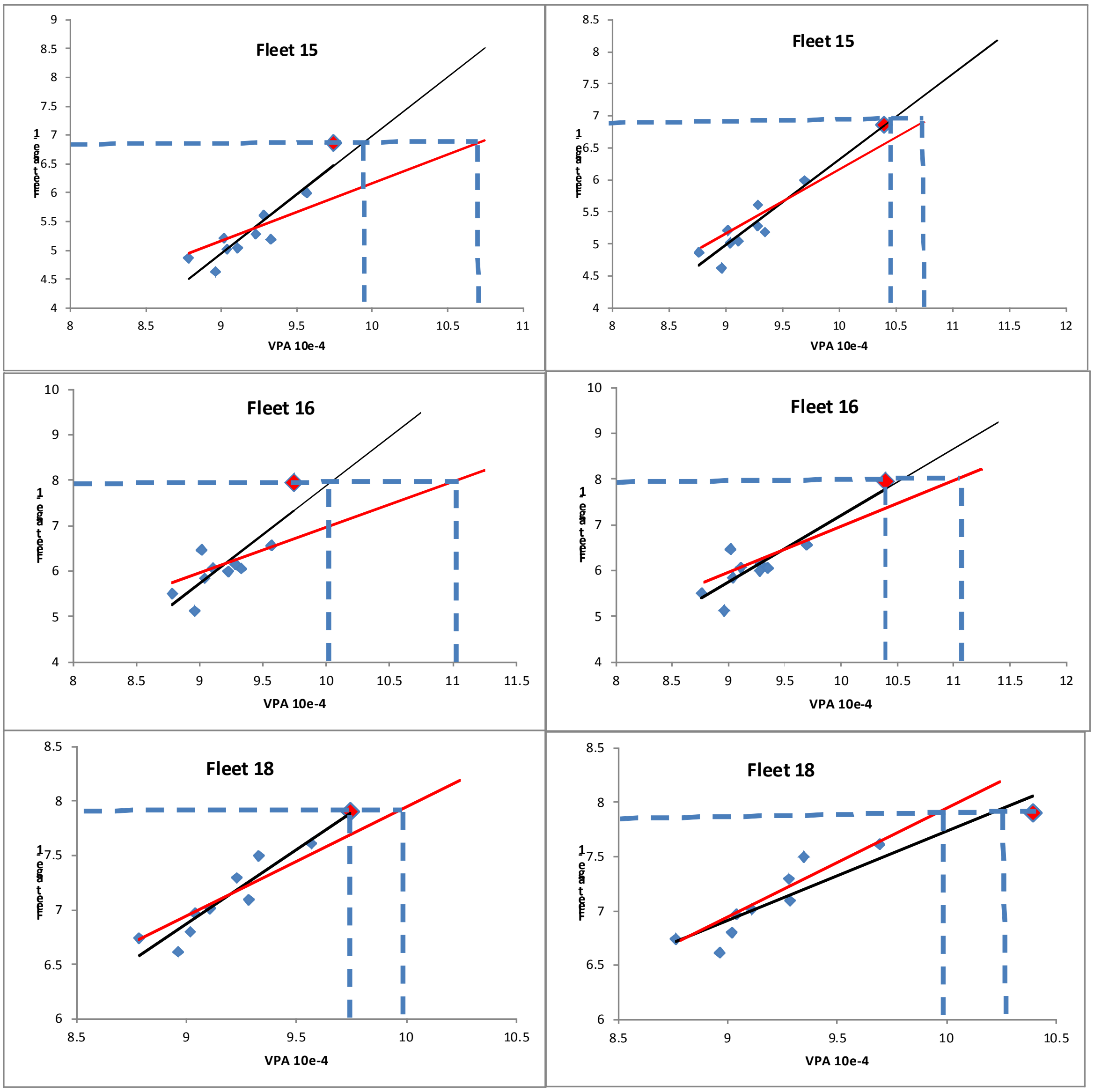


Figure 3.2a. **Northeast arctic cod**. Linear (red) and power (black) fits for age 6 for three surveys, Fleet 15, 16 and 18 (log scale). The power law corresponds to having stock-size dependent catchability (ssdq) for that age class. The most recent data point is shown in red on all three graphs. Left plots correspond to XSA where age 6 fitted to power model, right – linear model.

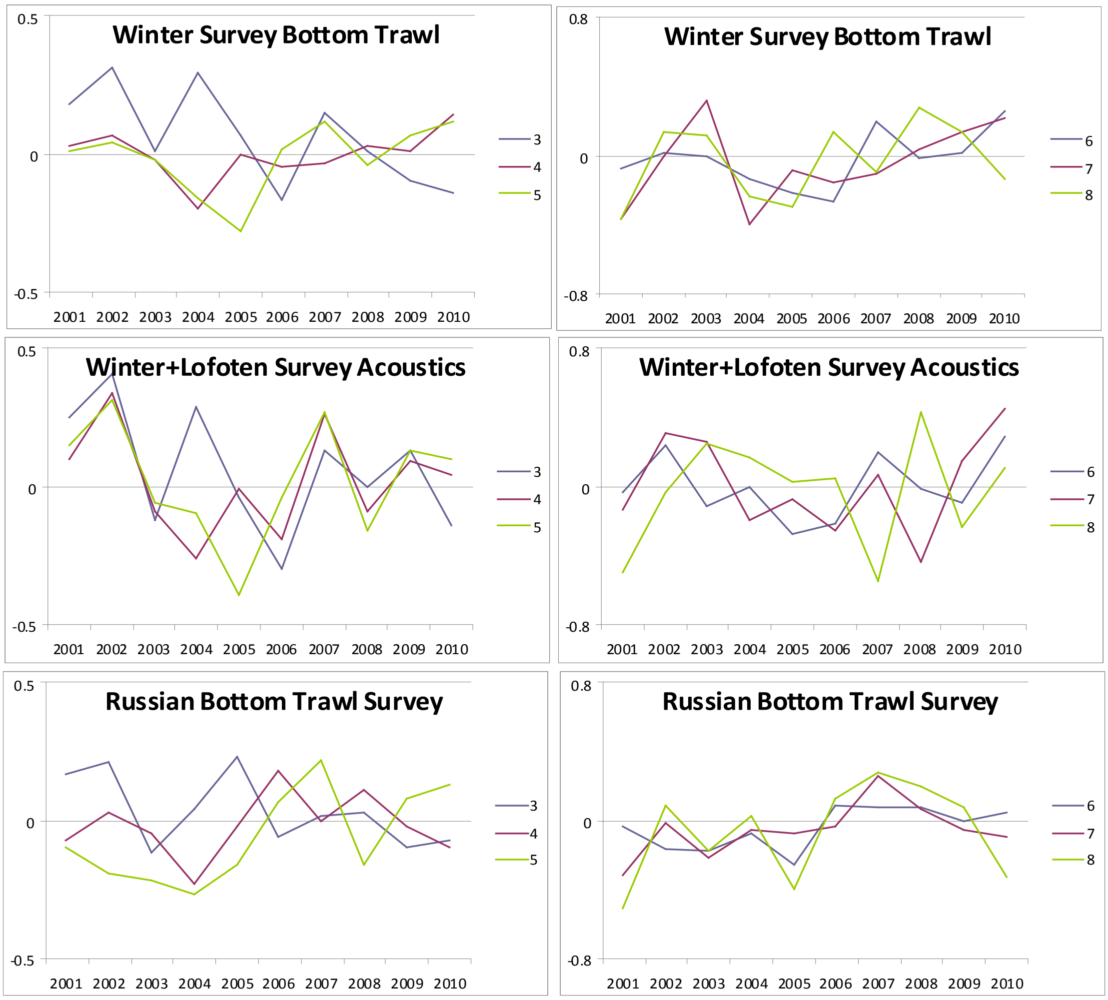


Figure 3.2b. **Northeast arctic cod**. Log catchability residual (y-axis) by fleets for the tuning data used in xsa. Ages 3-5 in left hand panel and 6-8 in right hand panel.

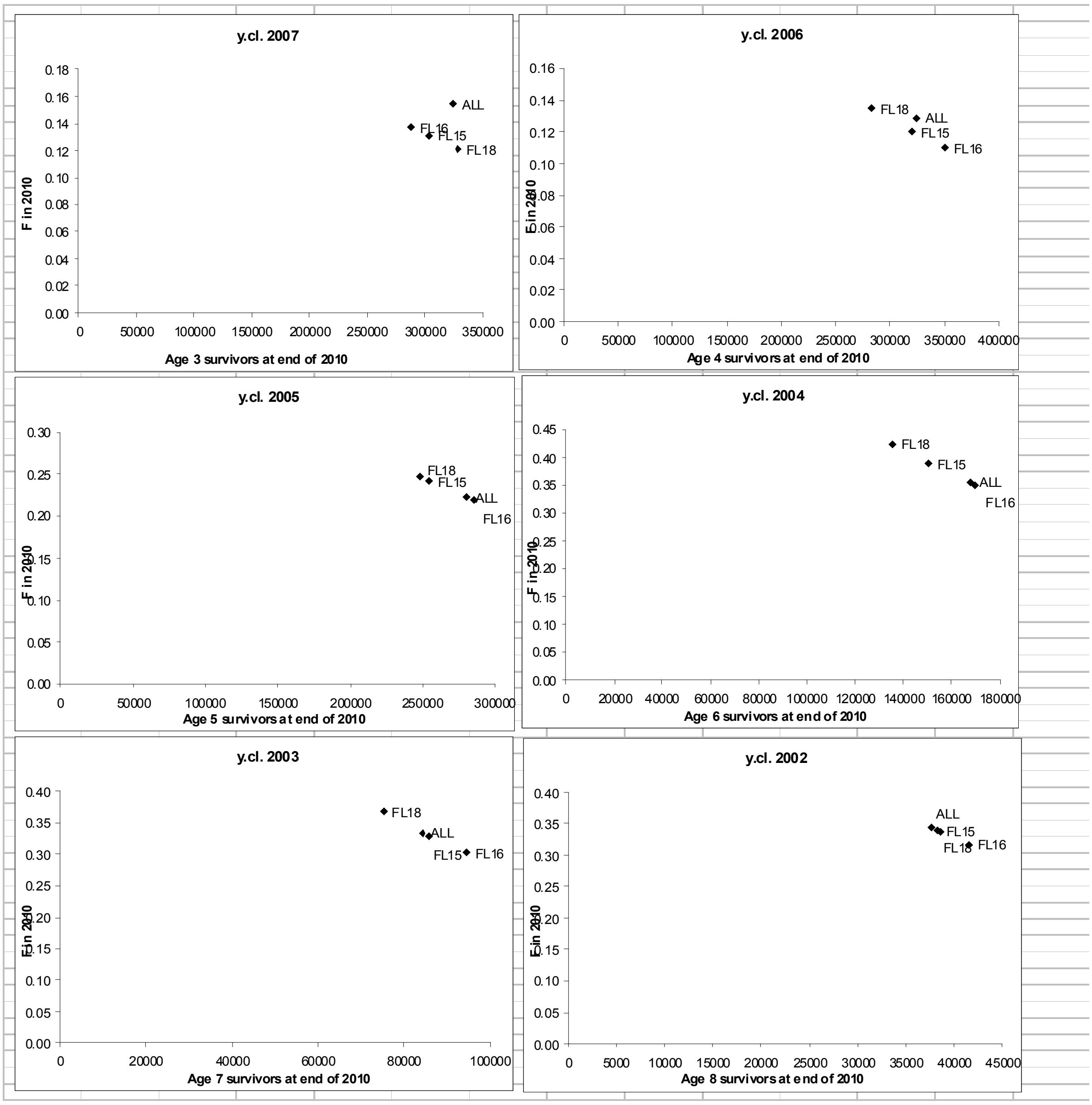


Figure 3.3. **Northeast arctic cod**. Single fleet estimates (before shrinkage) of F2010 and survivors at the end of 2010 taken from xsa-diagnostics of single fleet runs. "ALL" are the estimates from the final xsa (with shrinkage, including all fleets). The Fs for ages 3-5 includes cannibalism mortality.

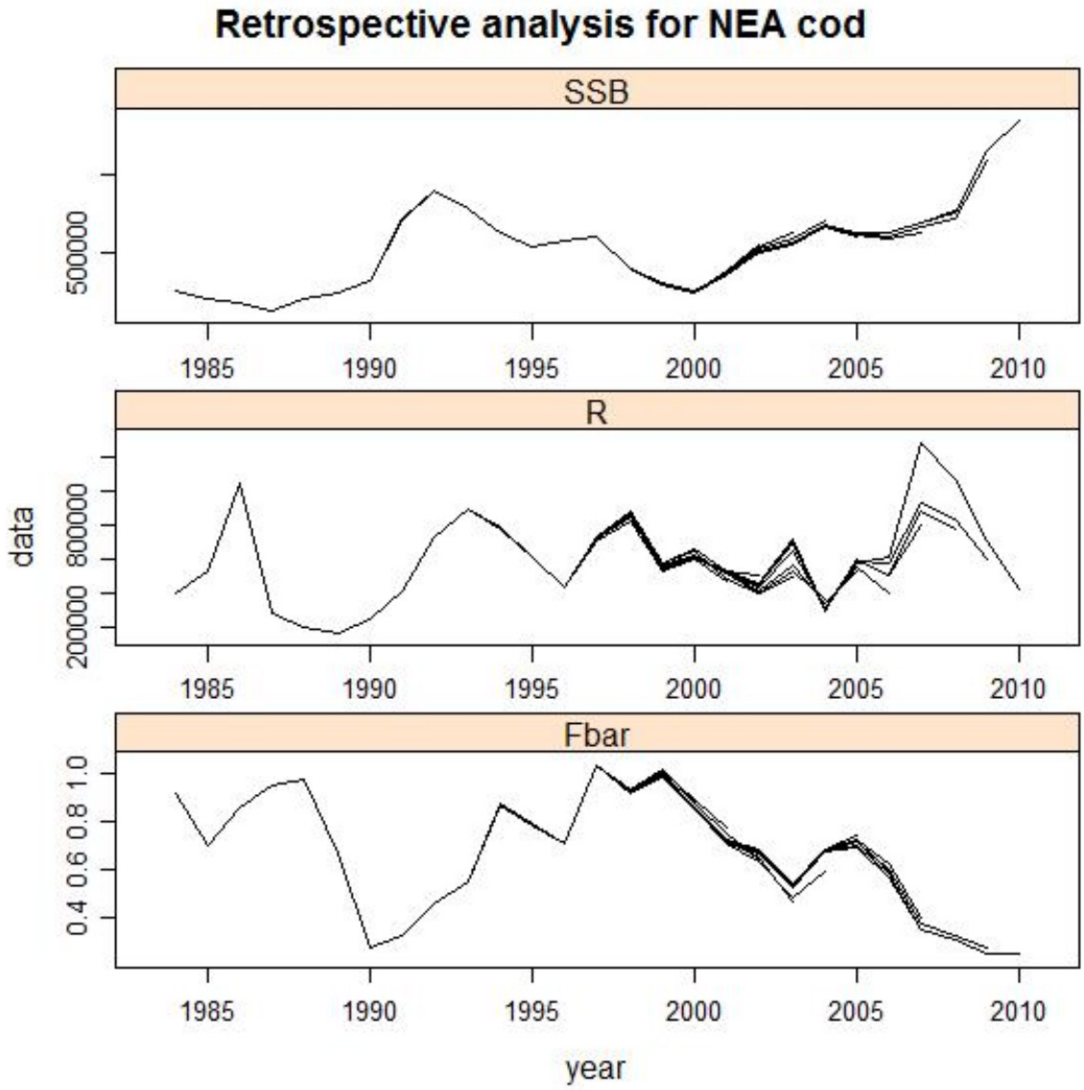


Figure 3.4. Northeast Arctic cod. Retrospective plots with catchability dependent on stock size for ages < 7.

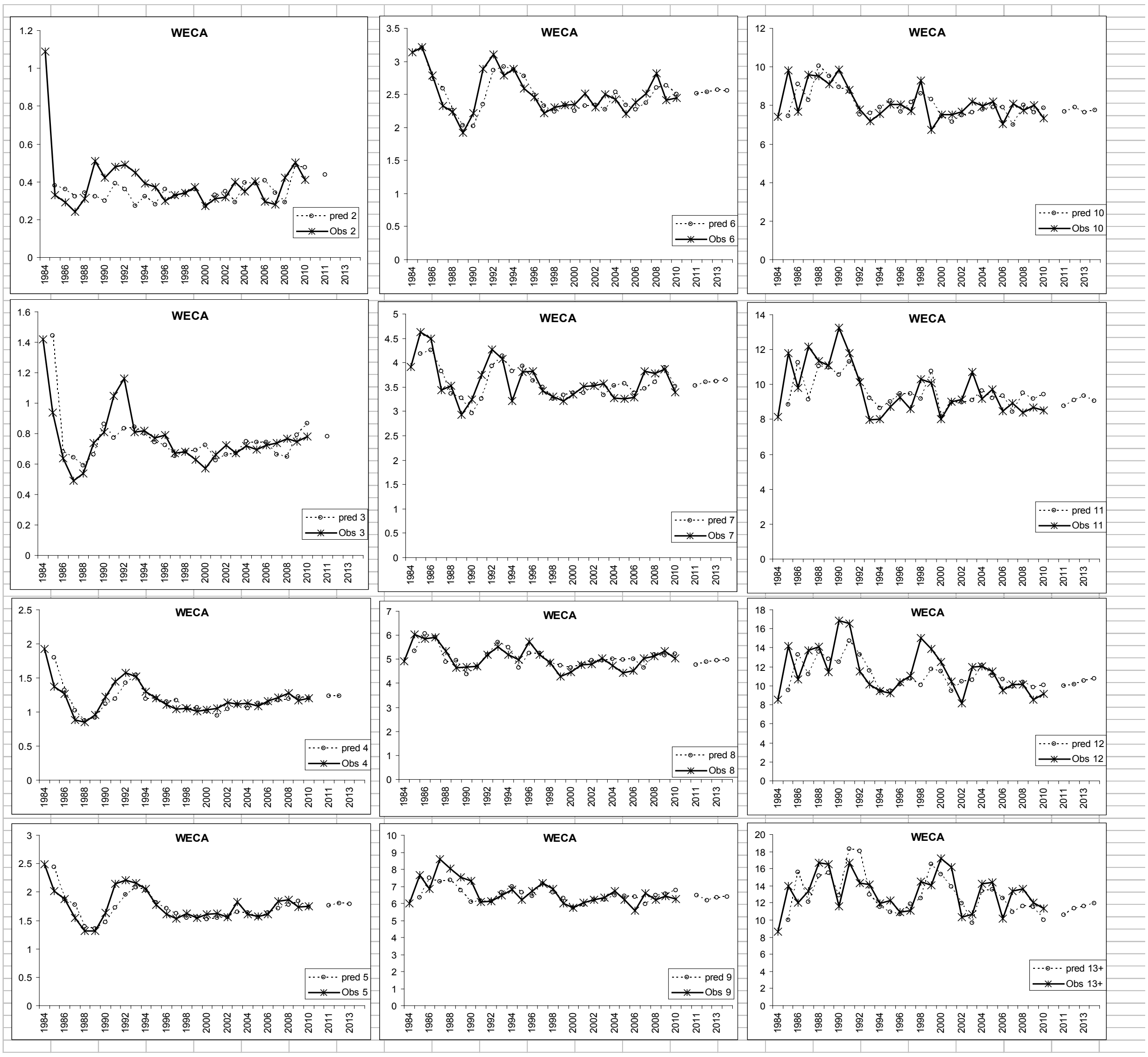


Figure 3.5a. Northeast Arctic cod. Weight in catch predictions.

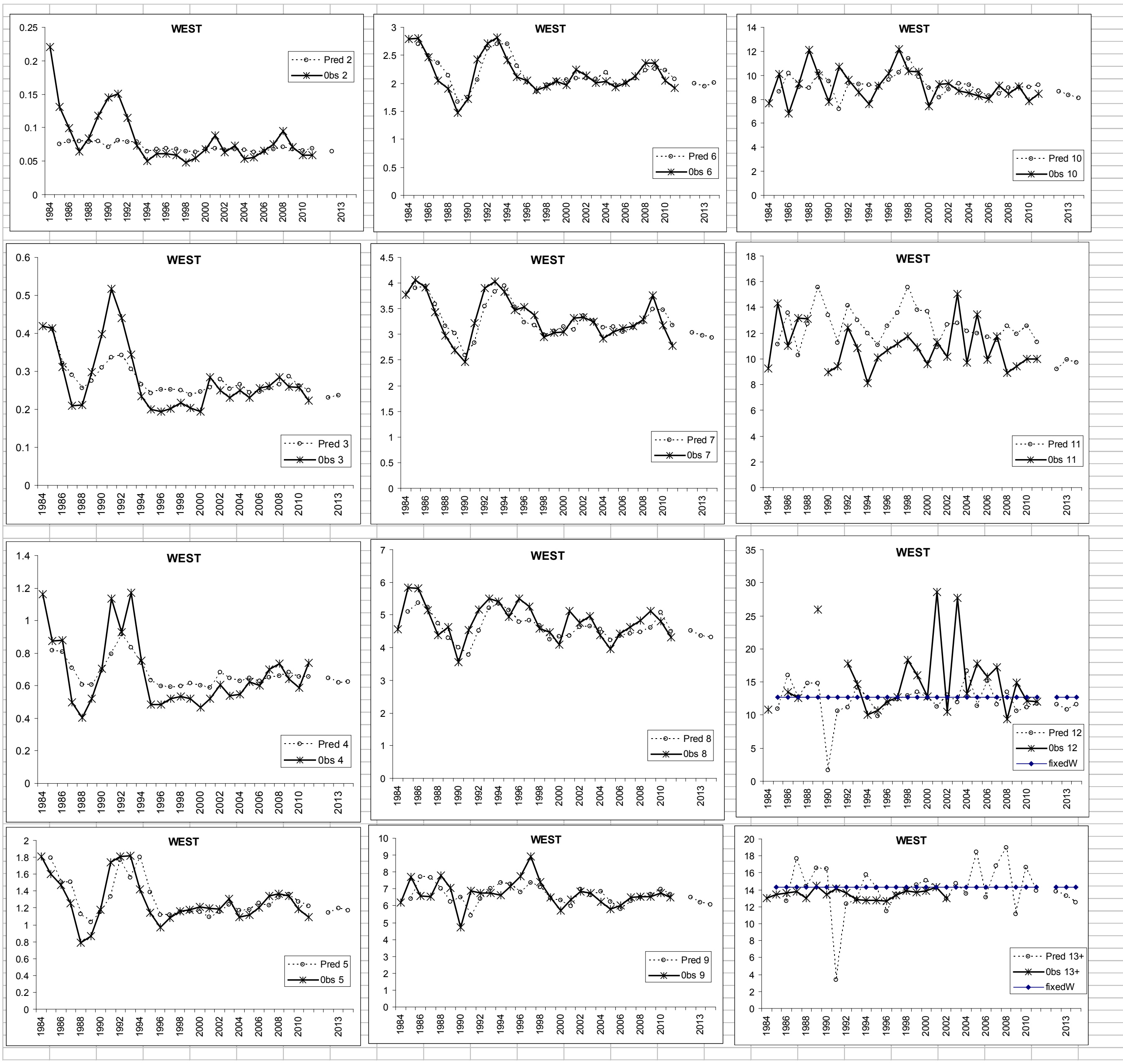


Figure 3.5b. Northeast Arctic cod. Weight in stock projections

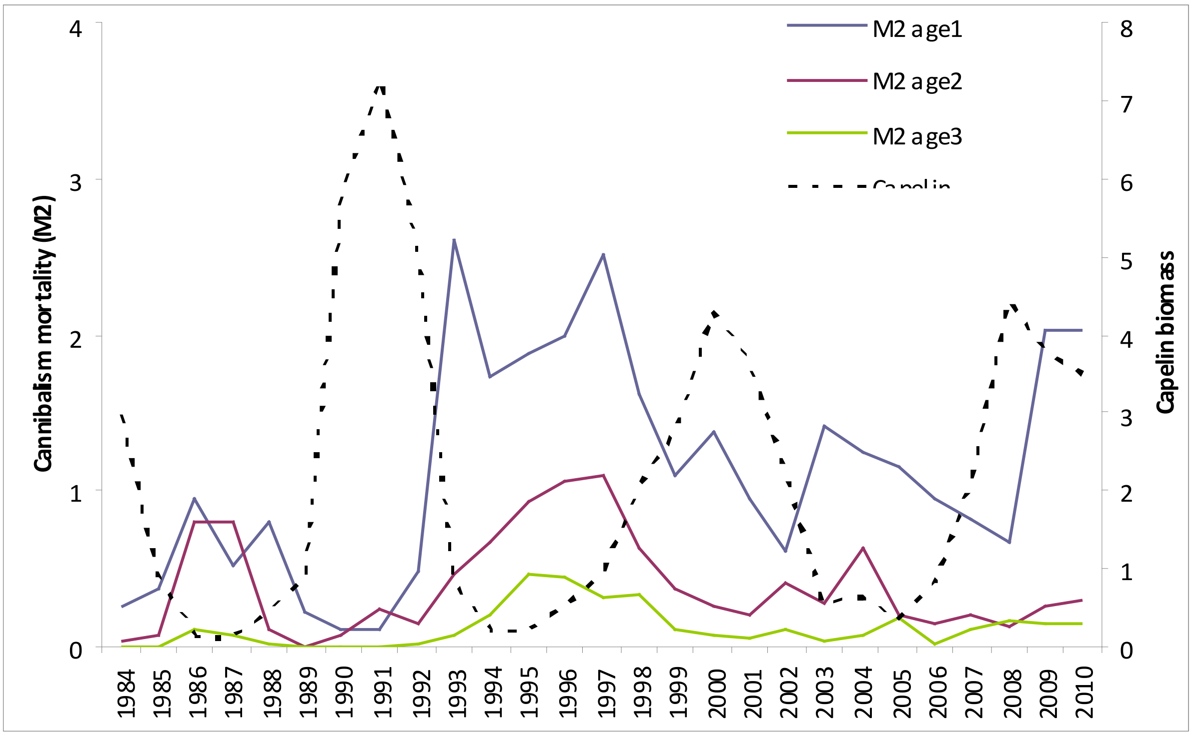
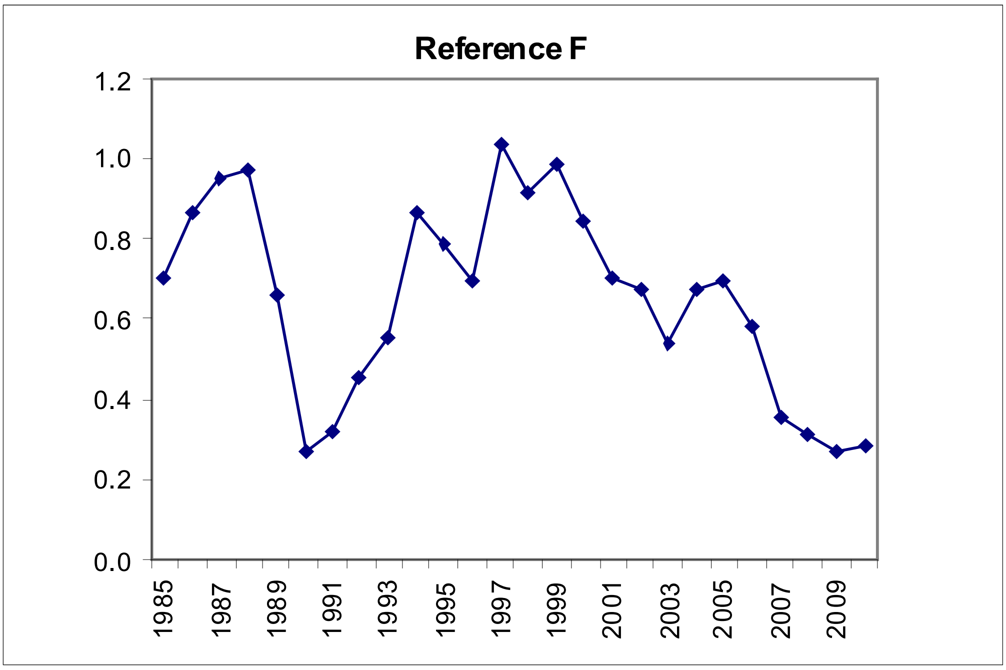


Figure 3.6. Capelin biomass and cannibalism mortality on cod age 1, 2 and 3.



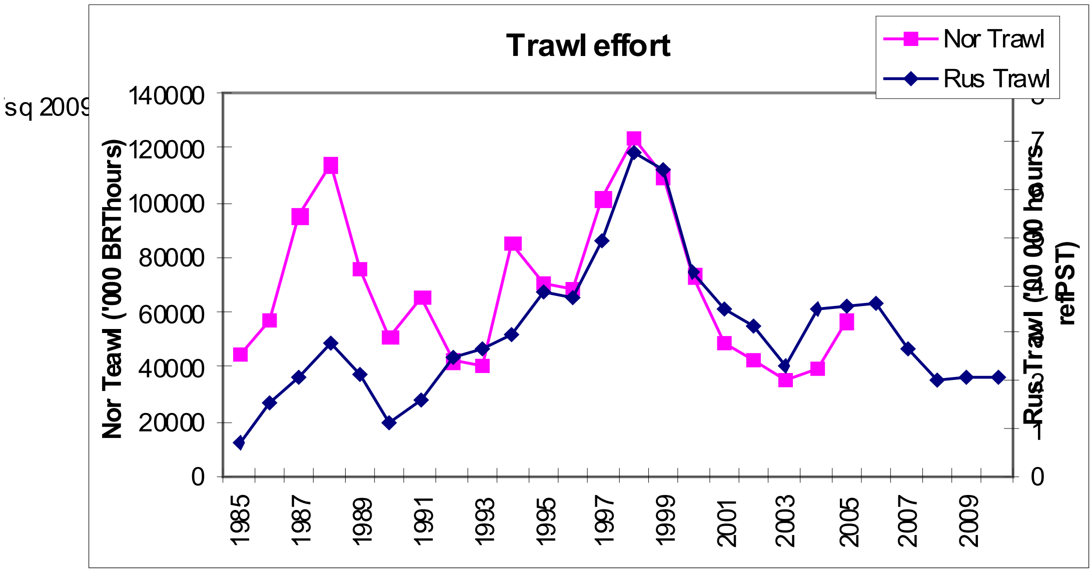


Figure 3.7. Northeast Arctic cod. Fishing mortality ($F_{5\text{-}10}$) (top panel) and trawl efforts in 1985-2010 (bottom panel).

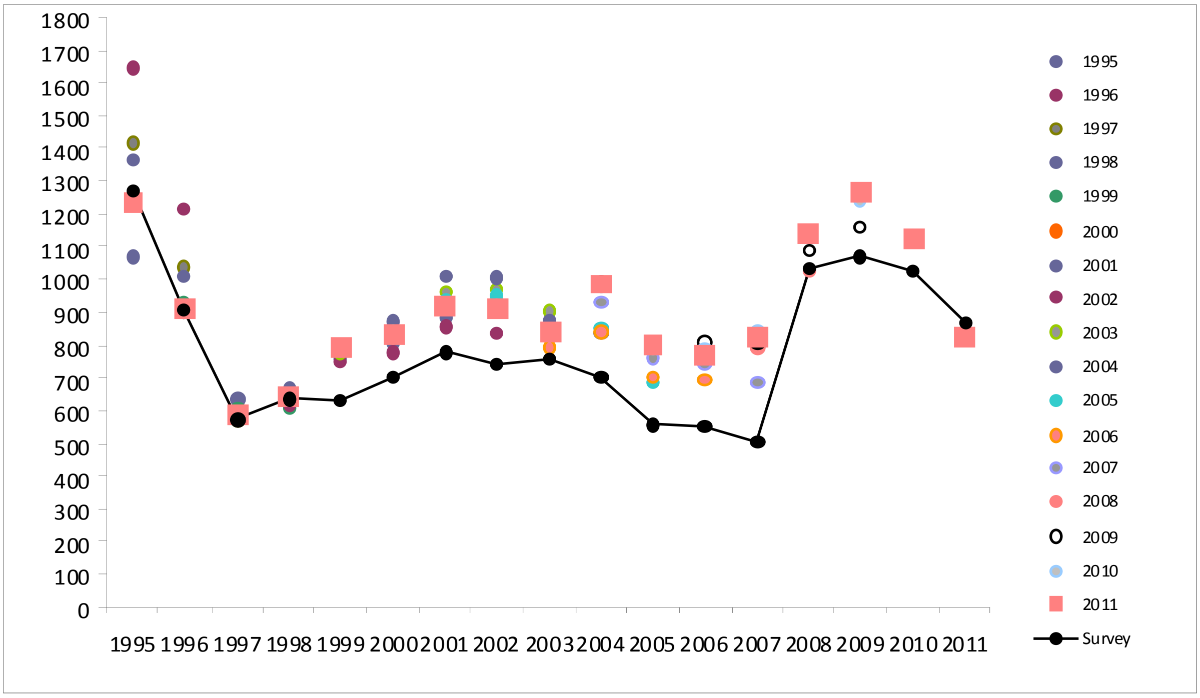


Figure 3.8. Calibrated (with intercept) bottom trawl survey estimates (connected solid circles), ICES 2011 estimates (connected open diamonds) and the 1995-2010 ICES annual assessments (unconnected symbols) of the total numbers of Northeast Arctic cod ages 4 to 6.

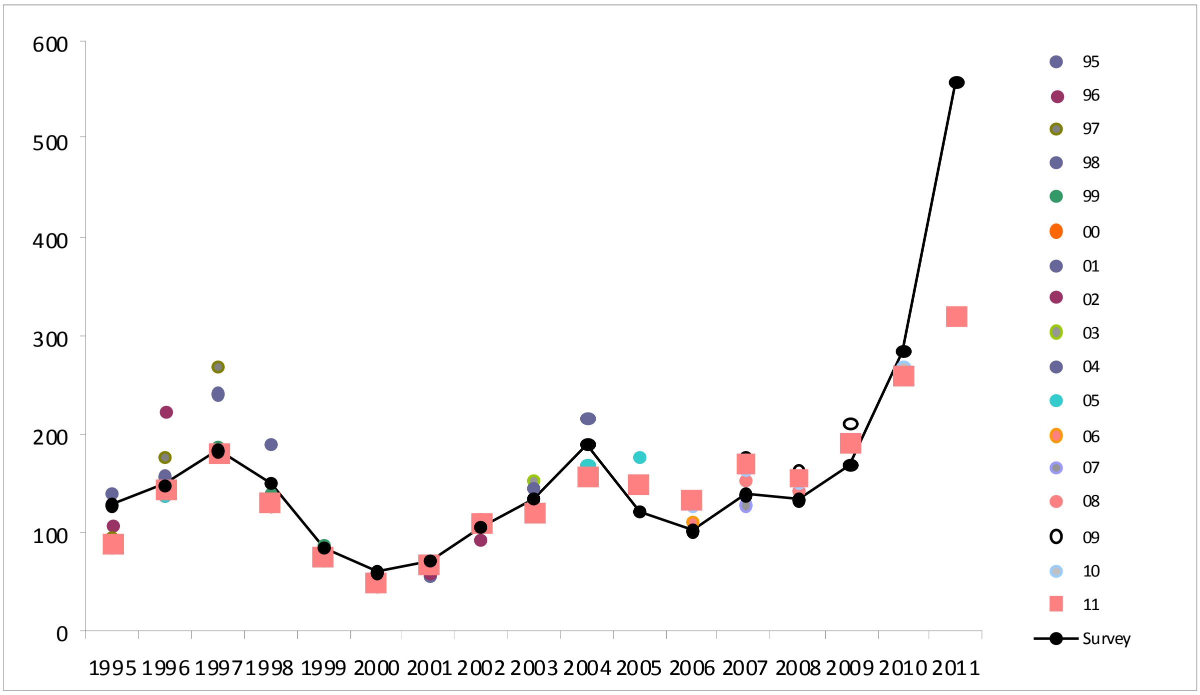


Figure 3.9. Calibrated (with intercept) bottom trawl survey estimates (connected solid circles), ICES 2011 estimates (connected open diamonds) and the 1995-2010 ICES annual assessments (unconnected symbols) of the total numbers of Northeast Arctic cod ages 7 and older.

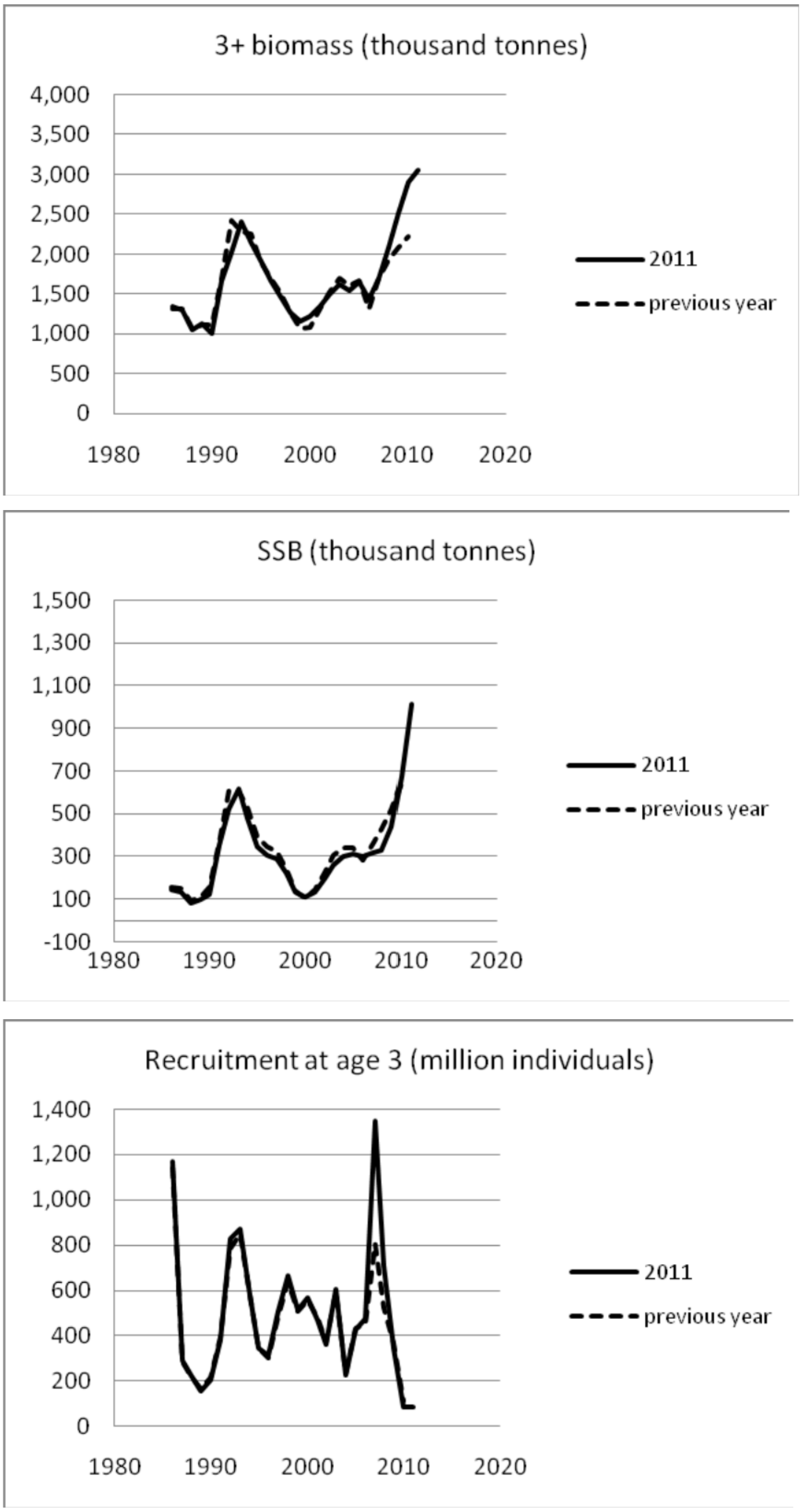


Figure 3.10. Spawning stock biomass, stock biomass (3+) and recruitment from the 2010 Gadget run for Northeast Arctic Cod, compared with the 2009 model run.

.Table A1. North-East Arctic COD. Catch per unit effort.

	Sub-area |I			Division IIb			Division IIa		Total
Year	Norway[2]	UK[3]	Russia[4]	Norway[2]	UK[3]	Russia[4]	Norway[2]	UK[3]	Norway
1960	-	0.075	0.42	-	0.105	0.31	-	0.067	
1961	-	0.079	0.38	-	0.129	0.44	-	0.058	
1962	-	0.092	0.59	-	0.133	0.74	-	0.066	
1963	-	0.085	0.60	-	0.098	0.55	-	0.066	
1964	-	0.056	0.37	-	0.092	0.39	-	0.070	
1965	-	0.066	0.39	-	0.109	0.49	-	0.066	
1966	-	0.074	0.42	-	0.078	0.19	-	0.067	
1967	-	0.081	0.53	-	0.106	0.87	-	0.052	
1968	-	0.110	1.09	-	0.173	1.21	-	0.056	
1969	-	0.113	1.00	-	0.135	1.17	-	0.094	
1970	-	0.100	0.80	-	0.100	0.80	-	0.066	
1971	-	0.056	0.43	-	0.071	0.16	-	0.062	
1972	0.90	0.047	0.34	0.59	0.051	0.18	1.08	0.055	
1973	1.05	0.057	0.56	0.43	0.054	0.57	0.71	0.043	
1974	1.75	0.079	0.86	1.94	0.106	0.77	0.19	0.028	
1975	1.82	0.077	0.94	1.67	0.100	0.43	1.36	0.033	
1976	1.69	0.060	0.84	1.20	0.081	0.30	1.69	0.035	
1977	1.54	0.052	0.63	0.91	0.056	0.25	1.16	0.044	1.17
1978	1.37	0.062	0.52	0.56	0.044	0.08	1.12	0.037	0.94
1979	0.85	0.046	0.43	0.62	-	0.06	1.06	0.042	0.85
1980	1.47	-	0.49	0.41	-	0.16	1.27	-	1.23
					Spain[5]			**Russia[4]**	
1981	1.42	-	0.41	(0.96)	-	0.07	1.02	0.35	1.21
1982	1.30	-	0.35	-	0.86	0.26	1.01	0.34	1.09
1983	1.58	-	0.31	(1.31)	0.92	0.36	1.05	0.38	1.11
1984	1.40	-	0.45	1.20	0.78	0.35	0.73	0.27	0.96
1985	1.86	-	1.04	1.51	1.37	0.50	0.90	0.39	1.29
1986	1.97	-	1.00	2.39	1.73	0.84	1.36	1.14	1.70
1987	1.77	-	0.97	2.00	1.82	1.05	1.73	0.67	1.77
1988	1.58	-	0.66	1.61	(1.36)	0.54	0.97	0.55	1.03
1989	1.49	-	0.71	0.41	2.70	0.45	0.78	0.43	0.76
1990	1.35	-	0.70	0.39	2.69	0.80	0.38	0.60	0.49
1991	1.38	-	0.67	0.29	4.96	0.76	0.50	0.90	0.44
1992	2.19	-	0.79	3.06	2.47	0.23	0.98	0.65	1.29
1993	2.33	-	0.85	2.98	3.38	1.00	1.74	1.03	1.87
1994	2.50	-	1.01	2.82	1.44	1.14	1.27	0.86	1.59
1995	1.57	-	0.59	2.73	1.65	1.10	1.00	1.01	1.92
1996			0.74		1.11	0.85		0.99	1.81
1997			0.61			0.57		0.74	1.36
1998			0.37			0.29		0.40	0.83
1999			0.29			0.34		0.39	0.74
2000			0.34			0.37		0.53	0.92
2001			0.46			0.46		0.69	1.21
2002			0.58			0.66		0.57	1.35
2003			0.70			1.22		0.73	1.67
2004			0.48			0.78		0.84	1.67
2005			0.45			0.62		0.81	1.23
2006			0.49			0.54		0.84	0.88
2007			0.71			0.51		0.88	1.16
2008			0.93			0.79		1.21	
2009			1.33			1.16		0.83	
2010[1]			1.47			1.18		1.16	

[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.

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

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

Table A2. North-east Arctic COD. Abundance indices (millions) from the Norwegian acoustic survey in the Barents Sea in January-March. New TS and rock-hopper gear (1981-1988 back-calculated from bobbins gear). Corrected for length-dependent effective spread of trawl.

Year	Age										
	1	2	3	4	5	6	7	8	9	10+	Total
1981	8.0	82.0	40.0	63.0	106.0	103.0	16.0	3.0	1.0	1.0	423.0
1982	4.0	5.0	49.0	43.0	40.0	26.0	28.0	2.0	+	0.0	197.0
1983	60.5	2.8	5.3	14.3	17.4	11.1	5.6	3.0	0.5	0.1	120.5
1984	745.4	146.1	39.1	13.6	11.3	7.4	2.8	0.2	0.0	0.0	966.0
1985	69.1	446.3	153.0	141.6	19.7	7.6	3.3	0.2	0.1	0.0	840.9
1986	353.6	243.9	499.6	134.3	65.9	8.3	2.2	0.4	0.1	0.0	1308.2
1987	1.6	34.1	62.8	204.9	41.4	10.4	1.2	0.2	0.7	0.0	357.3
1988	2.0	26.3	50.4	35.5	56.2	6.5	1.4	0.2	0.0	0.0	178.4
1989	7.5	8.0	17.0	34.4	21.4	53.8	6.9	1.0	0.1	0.1	150.1
1990	81.1	24.9	14.8	20.6	26.1	24.3	39.8	2.4	0.1	0.0	234.1
1991	181.0	219.5	50.2	34.6	29.3	28.9	16.9	17.3	0.9	0.0	578.7
1992	241.4	562.1	176.5	65.8	18.8	13.2	7.6	4.5	2.8	0.2	1092.9
1993 [1]	1074.0	494.7	357.2	191.1	108.2	20.8	8.1	5.0	2.3	2.5	2264.0
1994 [1]	858.3	577.2	349.8	404.5	193.7	63.6	12.1	3.7	1.7	0.9	2465.4
1995 [1]	2619.2	292.9	166.2	159.8	210.1	68.8	16.7	2.1	0.7	1.0	3537.4
1996 [1]	2396.0	339.8	92.9	70.5	85.8	74.7	20.6	2.8	0.3	0.4	3083.8
1997 [1,2]	1623.5	430.5	188.3	51.7	49.3	37.2	22.3	4.0	0.7	0.1	2407.5
1998 [1,2]	3401.3	632.9	427.7	182.6	42.3	33.5	26.9	13.6	1.7	0.3	4762.8
1999 [1]	358.3	304.3	150.0	96.4	45.1	10.3	6.4	4.1	0.8	0.3	976.1
2000 [1]	154.1	221.4	245.2	158.9	142.1	45.4	9.6	4.7	3.0	1.1	985.5
2001 [1]	629.9	63.9	138.2	171.6	77.3	39.7	11.8	1.4	0.5	0.2	1134.5
2002 [1]	18.2	215.5	69.3	112.2	102.0	47.0	18.0	3.0	0.4	0.3	585.9
2003 [1]	1693.9	61.5	303.4	114.4	129.0	114.9	34.3	7.7	1.9	0.5	2461.5
2004 [1]	157.6	105.2	33.6	92.8	30.7	27.6	17.0	5.9	1.2	0.2	471.8
2005 [1]	465.3	119.6	123.9	33.7	62.8	16.9	14.5	4.2	1.0	0.4	842.4
2006 [1]	544.6	216.6	79.8	59.1	15.5	25.6	8.8	4.5	1.4	0.5	956.5
2007 [1,2]	125.0	61.7	80.3	37.1	30.4	9.1	14.1	5.0	2.1	0.7	365.6
2008 [1]	68.8	97.6	210.2	306.1	140.6	69.4	21.6	12.2	3.1	0.8	930.4
2009 [1]	321.5	30.6	182.6	178.3	137.1	35.0	12.5	5.2	3.7	0.9	907.3
2010 [1]	485.4	59.4	34.7	121.9	174.7	162.3	44.4	13.8	3.5	3.5	1103.6
2011 [1]	389.3	124.8	47.1	29.1	80.4	107.7	105.4	17.1	4.5	3	908.4

[1] Survey covered a larger area

[2] Adjusted indices

Table A3. North-East Arctic COD. Abundance indices (millions) from the Norwegian bottom trawl survey in the Barents Sea in January-March. Rock-hopper gear (1981-1988 back-calculated from bobbins gear). Corrected for length-dependent effective spread of trawl.

	Age											Biomass
Year	1	2	3	4	5	6	7	8	9	10+	Total	('000 t)
1981	4.6	34.3	16.4	23.3	40.0	38.4	4.8	1.0	0.3	0	163	203
1982	0.8	2.9	28.3	27.7	23.6	15.5	16.0	1.4	0.2	0	116	174
1983	152.9	13.4	25.0	52.3	43.3	17.0	5.8	3.2	1.0	0.1	314	220
1984	2755.0	379.1	97.5	28.3	21.4	11.7	4.1	0.4	0.1	0.1	3298	310
1985	49.5	660.0	166.8	126.0	19.9	7.7	3.3	0.2	0.1	0.1	1034	421
1986	665.8	399.6	805.0	143.9	64.1	8.3	1.9	0.3	0	0	2089	639
1987	30.7	445.0	240.4	391.1	54.3	15.7	2.0	0.5	0	0	1180	398
1988	3.2	72.8	148.0	80.5	173.3	20.5	3.6	0.5	0	0	502	285
1989	8.2	15.6	46.4	75.9	37.8	90.2	9.8	0.9	0.1	0.1	285	271
1990	207.2	56.7	28.4	34.9	34.6	20.6	27.2	1.6	0.4	0	412	246
1991	460.5	220.1	45.9	33.7	25.7	21.5	12.2	12.7	0.6	0	833	352
1992	126.6	570.9	158.3	57.7	17.8	12.8	7.7	4.3	2.7	0.2	959	383
1993	534.5	420.4	273.9	140.1	72.5	15.8	6.2	3.9	2.2	2.4	1472	565
1994	1035.9	535.8	296.5	310.2	147.4	50.6	9.3	2.4	1.6	1.3	2391	761
1995	5253.1	541.5	274.6	241.4	255.9	76.7	18.5	2.4	0.8	1.1	6666	943
1996	5768.5	707.6	170.0	115.4	137.2	106.1	24.0	2.9	0.4	0.5	7033	701
1997*	4815.5	1045.1	238.0	64.0	70.4	52.7	28.3	5.7	0.9	0.5	6321	495
1998*	2418.5	643.7	396.0	181.3	36.5	25.9	17.8	8.6	1.0	0.5	3730	429
1999	484.6	340.1	211.8	173.2	58.1	13.4	6.5	5.1	1.2	0.4	1294	318
2000	128.8	248.3	235.2	132.1	108.3	26.9	4.3	2.0	1.2	0.4	888	356
2001	657.9	76.6	191.1	182.8	83.4	38.2	8.9	1.1	0.4	0.2	1241	428
2002	35.3	443.9	88.3	135.0	109.6	42.5	15.1	2.4	0.3	0.2	873	441
2003	2991.7	79.1	377.0	129.7	91.1	67.3	18.3	4.9	1.0	0.2	3760	546
2004	328.5	235.4	76.6	172.5	56.9	44.7	27.3	7.6	1.7	0.4	952	413
2005	824.3	224.6	246.9	62.1	98.1	24.7	15.5	4.5	1.1	0.4	1502	355
2006	862.7	288.4	118.1	111.5	28.7	43.7	10.2	4.9	1.4	0.6	1470	335
2007*	485.9	393.9	367.7	85.0	62.9	14.8	17.9	4.8	1.8	0.7	1435	397
2008	70.4	95.1	190.2	333.6	91.0	47.2	13.0	8.8	2.0	0.4	852	684
2009	382.7	39.1	118.3	219.6	193.9	58.6	19.6	6.8	4.9	0.9	1044	741
2010	1020.2	104.4	36.0	106.9	160.8	140.7	40.0	11.9	3.5	2.2	1627	813
2011	618.6	223.0	88.1	54.1	122.1	139.9	95.6	16.8	3.9	2.4	1365	874

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+	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

Table A5. North-east Arctic COD. Mean length at age(cm) from Norwegian surveys in January-March 1983-1999 values re-calculated from raw data.

Year	1	2	3	4	5	6	7	8
1978	14.2	23.1	32.1	45.9	54.2	64.6	67.6	76.9
1979	12.8	22.9	33.1	40.0	52.3	64.4	74.7	83.0
1980	17.6	24.8	34.2	40.5	52.5	63.5	73.6	83.6
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	12.0	18.3	30.5	44.7	55.4	64.3	73.5	82.4
1995	12.7	18.7	29.9	42.0	54.1	64.1	74.8	80.6
1996	12.6	19.6	28.1	41.0	49.3	61.4	72.2	85.3
1997 [1]	11.4	18.8	28.0	40.4	49.9	59.3	69.1	80.6
1998 [1]	10.9	17.4	28.7	40.0	50.5	58.9	67.5	76.3
1999	12.1	18.8	29.0	40.6	50.6	59.9	70.3	78.0
2000	13.0	21.0	28.7	39.7	51.5	61.6	70.5	75.7
2001	12.0	22.5	33.1	41.6	52.2	63.1	71.2	79.2
2002	12.2	19.9	30.1	43.6	52.2	61.7	71.6	79.1
2003	12.0	21.2	29.1	39.2	53.3	61.6	70.3	80.7
2004	11.0	18.9	32.0	40.9	52.0	61.8	69.0	79.0
2005	11.5	18.6	29.3	43.0	51.1	60.3	71.1	78.4
2006	12.2	19.9	31.3	42.1	53.5	60.8	68.9	77.7
2007	13.4	21.3	30.7	42.2	52.8	62.3	70.5	77.9
2008	12.5	22.3	32.5	43.7	52.4	63.6	71.6	80.8
2009	11.7	21.4	32.2	43.2	53.6	63.3	76.0	84.4
2010	11.4	19.1	31.2	42.3	52.0	61.3	70.5	80.6
2011	12.5	19.9	30.3	42.3	51.3	60.8	68.5	78.4

1) *Adjusted lengths*

Table A6. North-east Arctic COD. Weight (g) at age from Norwegian surveys in January-March

Year	Age							
	1	2	3	4	5	6	7	8
1983		190	372	923	1597	2442	3821	4758
1984	23	219	421	1155	1806	2793	3777	4566
1985		171	576	1003	2019	3353	5015	6154
1986		119	377	997	1623	2926	3838	7385
1987 [2]	21	65	230	490	1380	2300	3970	
1988	24	114	241	492	892	1635	3040	4373
1989	16	158	374	604	947	1535	2582	4906
1990	26	217	580	1009	1435	1977	2829	4435
1991	18	196	805	1364	2067	2806	3557	4502
1992	20	136	619	1118	1912	2792	3933	5127
1993	9	71	415	1179	1743	2742	3977	5758
1994	13	55	259	788	1468	2233	3355	4908
1995	16	54	248	654	1335	2221	3483	4713
1996	15	62	210	636	1063	1999	3344	5514
1997 [1]	12	54	213	606	1112	1790	2851	4761
1998 [1]	10	47	231	579	1145	1732	2589	3930
1999	13	55	219	604	1161	1865	2981	3991
2000	17	77	210	559	1189	1978	2989	3797
2001	14	103	338	664	1257	2188	3145	4463
2002	15	68	256	747	1234	2024	3190	4511
2003	14	82	228	569	1302	1980	2975	4666
2004	11	58	294	600	1167	1934	2657	4025
2005	13	57	230	705	1135	1817	2948	4081
2006	15	71	288	682	1366	1991	2959	4354
2007	19	78	253	691	1302	2128	3032	4327
2008	16	94	319	798	1393	2412	3413	5067
2009	13	83	291	724	1337	2180	3775	5267
2010	12	63	300	683	1246	2041	3076	4765
2011	15	64	257	684	1175	1930	2735	4055

[1] Adjusted weights
[2] Estimated weights

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

Year/age	5	6	7	8	9	10	11	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

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

Year	5	6	7	8	9	10	11	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

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

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

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

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

Year	Age											
	0	1	2	3	4	5	6	7	8	9	10+	Total
		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	3251.6
1983	1872.2	2003.4	73.2	52.0	64.2	50.6	35.8	17.9	25.2	9.4	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	951.8
1985	284.6	15.6	129.0	118.8	159.2	106.8	36.5	16.5	3.7	0.8	1.6	873.1
1986	329.9	7.6	31.7	162.2	153.2	149.3	48.1	18.9	4.2	0.2	0.6	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	606.6
1988	92.5	2.9	31.3	99.3	93.8	287.9	58.3	26.0	4.7	2.4	0.1	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	934.4
1990	1248.4	31.1	51.0	16.7	48.7	62.7	97.2	153.8	67.3	15.3	4.9	1797.1
1991	974.0	64.0	91.1	107.7	48.4	53.2	58.3	68.5	74.7	9.8	1.4	1551.1
1992	1204.8	157.7	151.1	67.5	30.8	23.9	27.3	21.8	17.5	2.5	0.4	1705.3
1993	484.8	38.0	158.6	160.4	113.5	68.1	41.6	35.4	8.7	0.3	0.7	1110.1
1994	1606.6	833.2	69.9	136.3	130.9	101.9	35.4	12.8	4.9	2.1	1.1	2935.1
1995	5703.5	471.9	36.9	58.9	106.5	139.5	84.9	25.1	8.3	1.9	1.8	6639.2
1996	2660.3	396.5	128.5	73.3	78.4	103.5	77.3	34.8	13.2	1.9	0.5	3568.2
1997	1371.4	353.9	135.3	134.2	83.5	61.3	60.2	34.8	11.6	3.2	1.5	2250.9
1998	304.8	276.8	89.6	202.8	136.3	78.8	47.0	25.9	13.0	4.8	0.5	1180.3
1999	266.9	40.1	118.4	158.7	207.2	98.0	30.1	12.3	9.4	4.2	0.4	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	2166.0
2001	321.6	233.8	77.3	122.4	155.7	129.0	106.1	30.4	5.0	1.4	0.5	1183.2
2002	1797.9	26.7	135.6	98.0	147.3	147.3	89.6	60.0	18.2	2.9	0.8	2524.3
2003	489.5	517.5	26.8	124.6	105.7	116.6	120.3	53.5	24.1	4.0	0.9	1583.5
2004	1770.4	158.4	87.5	32.9	157.6	88.0	111.1	77.6	27.9	9.3	2.3	2523.0
2005	2298.0	323.9	61.7	140.8	63.1	183.2	74.4	60.5	24.4	8.8	2.8	3241.6
2006 corr	427.4	52.4	63.2	92.7	161.3	77.7	180.1	66.2	34.2	16.1	6.8	1178.1
2007	177.5	37.0	148.6	257.9	161.7	190.3	84.6	152.5	55.3	22.6	15.3	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	2638.2
2009	1877.7	287.8	21.9	97.4	231.7	368.7	201.6	117.5	62.0	41.3	31.1	3338.7
2010	2091.2	335.2	35.3	54.3	138.5	366.8	269.8	145.5	60.3	44.6	45.0	3586.7

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

Year	Age									
	0	1	2	3	4	5	6	7	8	9
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
2001	10.6	19.4	29.8	37.3	50.4	61.9	71.9	81.4	91.0	98.7
2002	10.7	19.2	29.9	38.2	52.5	60.4	70.6	82.2	91.3	97.2
2003	9.8	18.9	28.3	34.9	49.2	62.2	71.0	81.5	92.3	100.9
2004	9.8	19.6	29.3	38.4	49.1	60.0	70.5	80.0	91.0	98.0
2005	11.2	19.4	29.7	38.5	48.7	59.3	69.3	79.2	87.7	96.1
2006	13.0	21.9	31.6	42.7	53.2	60.1	70.2	79.1	88.3	95.2
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
2009	12.9	19.3	29.5	38.4	50.7	61.5	70.7	81.7	89.9	94.7
2010	11.1	19.3	28.7	38.5	48.9	59.1	68.0	78.4	88.2	97.3

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

Year	Age										
	0	1	2	3	4	5	6	7	8	9	10
1984	26	90	250	746	1,187	2,234	3,422	5,027	6,479	9,503	-
1985	26	80	245	762	1,296	1,924	3,346	5,094	7,360	6,833	11,167
1986	25	63	191	506	1,117	1,940	2,949	4,942	7,406	9,300	-
1987	-	54	182	316	672	1,691	2,688	3,959	8,353	10,583	13,107
1988	15	78	223	435	789	1,373	2,609	4,465	5,816	-	-
1989	-	73	216	401	928	1,427	2,200	3,133	4,649	6,801	8,956
1990	28	106	230	908	1,418	2,092	2,897	4,131	6,359	10,078	13,540
1991	26	93	260	743	1,629	2,623	3,816	4,975	7,198	11,165	15,353
1992	10	76	273	1,165	1,895	2,971	4,377	5,596	7,319	9,452	12,414
1993	11	46	211	717	1,280	2,293	3,509	4,902	6,621	7,339	8,494
1994	12	69	153	316	919	1,670	2,884	4,505	6,520	8,207	9,812
1995	11	61	180	337	861	1,987	3,298	5,427	7,614	9,787	10,757
1996	7	64	191	436	1,035	1,834	3,329	5,001	8,203	10,898	11,358
1997	6	48	203	487	1,176	2,142	3,220	4,805	6,925	10,823	12,426
1998	11	55	187	435	1,186	2,050	3,096	4,759	7,044	11,207	12,593
1999	10	58	177	371	1,214	1,925	3,064	4,378	6,128	7,843	11,543
2000	8	74	232	379	1,101	2,128	3,341	5,054	6,560	8,497	12,353
2001	9	58	221	459	1,125	2,078	3,329	4,950	7,270	9,541	11,672
2002	8	65	232	505	1,299	1,964	3,271	5,325	7,249	9,195	11,389
2003	6	49	205	492	972	1,993	2,953	4,393	6,638	9,319	11,085
2004	6	55	231	543	1,079	1,798	2,977	4,110	5,822	8,061	12,442
2005	10	59	223	521	1,034	1,910	3,036	4,619	6,580	9,106	12,006
2006	13	72	270	707	1,332	1,953	2,969	4,340	6,410	8,622	12,436
2007	10	96	252	669	1,344	2,277	3,140	4,691	6,178	8,567	10,014
2008	7	58	228	558	1,332	2,305	3,527	5,001	6,519	8,848	10,339
2009	15	54	214	495	1,116	2,024	3,090	4,876	6,592	8,087	10,262
2010	9	54	191	794	989	1,784	2,719	4,246	6,384	8,747	10,499

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

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11	12+
1985	69.1	446.3	153.0	141.6	20.4	15.1	15.7	3.3	1.3	1.0	0.5	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	1.0

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

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
2004	543.0	330.6	329.7	147.7	421.5	150.2	79.8	40.2	10.1	2.2	0.5	0.1	0.1	0.0
2005	182.2	458.5	143.2	241.7	95.9	159.9	35.5	16.2	5.8	1.0	0.5	0.2	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	494.4	130.9	372.9	654.3	486.2	133.0	51.7	12.9	17.6	3.3	0.9	0.2	0.2	0.1
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	0.2

4 Northeast Arctic Haddock (Subareas I and II)

4.1 Status of the Fisheries

4.1.1 Historical development of the fisheries

Haddock is mainly fished by trawl as by-catch in the fishery for cod. Also a directed trawl fishery for haddock is conducted and the proportion of total catches taken by this fishery varies between years. On average approximately 33% of the catch is with conventional gears, mostly longline, which in the past was used almost exclusively by Norway. Some of the longline catch are from a directed fishery, which is restricted by national quotas. In the Norwegian management the quotas are set separately for trawl and other gears. The fishery is also regulated by a minimum landing size, a minimum mesh size in trawls and Danish seine, a maximum by-catch of undersized fish, closure of areas with high density/catches of juveniles and other seasonal and area restrictions.

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

4.1.2 Landings prior to 2011 (Tables 4.1–4.3, Figure 4.1A)

The official landings (those reported to ICES and contained in the Statlant statistics) for 2009 amount to 199,402 t, and the provisional official landings for 2010 are 249,334 t.

In recent years, estimates of unreported catches (IUU catches) of haddock have been added to reported landings for the years 2002 and onwards. In 2007 to 2009 two estimates of IUU catches were available, one Norwegian and one Russian. At the benchmark assessment it was decided to base the final assessment on the Norwegian IUU estimates (ICES CM 2011/ACOM:38). From 2009 and onwards, a joint Norwegian-Russian Analysis Group under the Mixed Norwegian-Russian Fisheries Commission has provided joint estimates of IUU catches. Based on these, the AFWG decided to set the IUU estimate for haddock in 2009 and 2010 to 0 (WD 09). More details on this issue are given in Sections 0.4. Before 2002 the Working Group has no information about IUU catches on haddock, but the WG consider the IUU fisheries prior to 2002 to be low.

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

4.1.3 Catch advice and landings for 2010 and 2011

ACOM recommended to set a TAC lower than 243,000 t for 2010 and the agreed TAC for 2010 was 243,000 t, applying the agreed harvest control rule. The provisional reported catch in 2010 is 249,334 t. For 2011, the mixed Norwegian-Russian Fisheries Commission agreed on a TAC of 303,000 t, which corresponds to the agreed 1-year harvest control rule (see Section 4.7.3) according to the assessment. The assessment shows a decreasing trend in F from 2007 to 2010. The F in 2010 was thus considered to be a better estimate for F in the present year (2011) than using a three year average. In predictions for 2011-2013, a three year average scaled to F-status quo (F_{sq}) was used for the distribution of fishing mortality at age (fishing pattern). A F_{sq} predicts the catch for 2011 to be 263,000 t, which is lower than the TAC (303,000 t). The low 2011 catch corresponding to F_{sq} should not be interpreted as that the TAC will not be reached in 2011.

4.2 Status of Research

4.2.1 Survey results (Tables B1-B4, 4.9-4.11)

The overall picture seen in the surveys is summarized as follows: the last poor year class is 1997 and the following six year classes all appear to be at or above average abundance. These are followed by three year classes 2004-2006, which all seem to rank among the 6-7 most abundant year classes in the VPA time series. The surveys indicate that the 2007, 2008, and 2010 year-classes are slightly below average while the 2009 year class seems to be a little stronger than average.

Joint Barents Sea winter survey (bottom trawl BS-NoRu-Q1 (BTr) and acoustics 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 2010 are given in Aglen *et al.* (WD 03).

Before 2000 this survey was made without participation from Russian vessels, while in 2001-2005 Russian vessels covered important parts of the Russian zone. In 2006-2007 only Norwegian vessels carried out the survey again and permit to cover the Russian EEZ was not given in 2007, which meant that the 2007 indices had to be adjusted to take into account the incomplete coverage. These adjustments are described in detail in the 2007 report. However, since 2008, Norwegian survey vessels have received permits to enter the Russian zone and the survey was conducted according to the standard area coverage. The survey indices and areas covered are given in Tables B1 and B3.

Strong year classes, like the 1990 and 2004-2006 year classes, can be tracked from year to year in both series and the 1990 year class was the strongest for age groups 3–8 until the 2004-2006 year classes arrived. Both in the 2011 bottom trawl and acoustic survey indices, the 2004-2006 year classes (ages 5-7) were still among the highest indices ever recorded.

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

Russia provided indices from the 2010 Barents Sea trawl and acoustic survey (Tables B2 and B4), which was carried out in October-December. The Russian survey shows similar main trends as the Norwegian survey.

From 1995 onwards there has been a substantial change in the method for calculating acoustic indices. The acoustic survey is therefore presented in 2 tables, Table B4a and B4b, for the old and the new method of calculating indices, respectively.

The survey coverage was reduced in 2006, but from 2007, the survey area covered was again the standard coverage. See report from 2007 for details.

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

Estimates of the abundance of 0-group haddock from the International 0-group survey are presented in Tables 1.1 -1.2. Both indicate that the 2002-2006 year classes are very strong, whereas the 2007-2008 year classes are below average. The 2009 and 2010 year classes are again above the long term average.

The bottom trawl estimates from the joint ecosystem survey in August-September started in 2004. This survey covers a larger proportion of the distribution area of haddock. At the benchmark assessment it was decided to include this survey in the tuning of XSA (ages 3-8, Fleet 007).

4.2.2 Weight-at-age (Tables B5, B6)

Length- and weight-at-age from the surveys are given in Tables B5 and B6, respectively. Weights-at-age in the Norwegian survey has decreased for the older ages compared to the long-term average, whereas the Russian survey shows a decrease for all ages.

4.3 Data Used in the Assessment

4.3.1 Estimates of unreported catches (Tables 4.1-4.3)

We continue to include the estimates of IUU catches as in previous years (see Section 0.4 and Section 4.1.2), but the IUU estimate is zero for 2009 and 2010.

4.3.2 Catch-at-age (Table 4.4)

Age and length compositions of the landings in 2010 were available from Norway and Russia in Subarea I and from Norway, Russia, and Germany in Division IIa and Division IIb. The biological sampling of NEA haddock catches is considered to be fairly good. However, the present Norwegian sampling is believed to be less precise because of the termination of a Norwegian port sampling program in Q3 2009 and poor sampling caused problems in estimating Norwegian age-length keys for the oldest ages (see section 0.5). Estimated catch-at-age obtained from Intercatch is listed in Table 4.4.

4.3.3 Weight-at-age (Tables 4.5-4.6, Table B.6)

The mean weight-at-age in the catch (Table 4.5) was obtained from Intercatch as a weighted average of the weight at age in the catch for Norway, Russia and Germany. The weights-at-age in the catch in 2010 have decreased slightly for all age groups compared to 2009.

Stock weights (Table 4.6) used from 1985 to 2010 are averages of values derived from Russian surveys in autumn (mostly October-December) and Norwegian surveys in January-March the following year (Table B6). These averages are assumed to give representative values for the beginning of the year (see stock annex for details).

4.3.4 Natural mortality (Table 4.7)

Natural mortality used in the assessment was 0.2 + mortality from predation by cod (see Section 4.4.2). The proportion of F and M before spawning was set to zero. For the period from 1984 to 2010 actual data from predation for cod have been used (see Table 4.7) while for the previous years (1950-1983) the average natural mortality for 1984-2010 was used (age groups 3-6).

4.3.5 Maturity-at-age (Table 4.8)

The estimates of maturity-at-age are shown in Table 4.8. The proportions mature at age are presently lower than historic averages (see stock annex for estimation details).

4.3.6 Changes in data from last year (Tables 4.1–4.3)

As stock weights are modelled (See Section 4.3.3) the values of this parameter have been changed slightly both in 1950-1984 for which average values are used and in 1985-2009. There are also small changes in natural mortality and maturity at age. However, at the benchmark it was decided that these (weight, M, and maturity) historic values (1950-1979) should be kept constant from the 2011 assessment and onwards (ICES CM 2011/ACOM:38).

4.4 Assessment Using VPA

The assessment method was also this year XSA.

4.4.1 Data for tuning (Table 4.9)

The following surveys series are included in the data for tuning:

Name	ICES Acronym	Place	Season	Age	Year	prior weight
FLT01: Russian bottom trawl	RU-BTr-Q4	Barents Sea	October-December	3–7	1991–2010	1
FLT02: Joint Barents Sea survey - acoustic	BS-NoRU-Q1(Aco)	Barents Sea	February-March	3–7	1990–2010	1
FLT04: Joint Barents Sea survey - bottom trawl	BS-NoRu-Q1 (BTr)	Barents Sea	February-March	3–8	1990–2010	1
FLT007: Joined Russian-Norwegian ecosystem autumn survey in the Barents Sea -bottom trawl	Eco-NoRu-Q3 (Btr)	Barents Sea	August - September	3-8	2004-2010	1

The indices for the Russian BT survey in the 1990 were not used for tuning the XSA. Since the 2004 WG meeting the survey data before 1990 have not been used in the XSA run. This decision was based on the analysis of survey residuals and changes in survey methodology (see the 2004 report).

The joint ecosystem survey was not used in past assessments, but was selected for inclusion by the WKBENCH. This index shows reasonably good internal consistency for ages 1–8 and correlated well with catch-at-age data and other surveys.

WKBENCH agreed to include ages 1 and 2 in XSA tuning based on internal survey consistency and a reasonably good relationship with cod consumption estimates which is included in assessment. During the WG it was decided to not to include ages 1 and 2 in final tuning due the changing in retrospective patterns (Fig 4.5) and worsening of the relationships between indices and VPA estimates (Fig 4.6). Although indices for ages 1 and 2 used in estimation of natural mortality (predation run).

4.4.2 VPA and tuning (Table 4.9)

The Extended Survivors Analysis (XSA) was used to tune the VPA by available index series (Table 4.9). 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 by the AFWG were analyzed during the benchmark (ICES CM

2011/ACOM:38) and some of the settings were changed. Based on the results of evaluation it was concluded to set XSA parameters with following values:

Time series weights :

Tapered time weighting applied

Power = 3 over 20 years

Catchability analysis :

Catchability independent of size for ages > 8

Catchability independent of age for ages > 8

Terminal population estimation :

Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = 0.5 or 1.5

Minimum standard error for population estimates derived from each fleet = 0.3

Prior weighting not applied

Based on benchmark results of exploratory runs it was found that here is no reason to assume q is independent of age for any ages. The last age in the survey data is 8, so the XSA parameter "Catchability independent of age or ages >= 9" was chosen. Previously the last age with q is independent of age for any ages was 6.

Due to time constraints, the decision about F shrinkage level war postponed to the AFWG to decide. Two working documents (WDs 8 and 17) were presented and the AFWG decided to use the following settings:

The F shrinkage was given a weight corresponding to SE=1.5

Low F shrinkage weight (s.e.=1.5) reduces residuals (Fig. 4.6, WD 17) and improve the retro pattern (Fig 4.5) for the most recent years, which is presumably more reliable for stock management. It is clear from survey indexes that the stock has rapidly increased in recent years, at the same time F has been going down. Using strong shrinkage at such a stock development means systematic underestimation of age groups with higher abundance (they usually have lower F) than previous ones. As this is the case now, it should be expected that decreasing weight of shrinkage will give more accurate estimates of year-class strengths.

The XSA model estimates with s.e.= 1.5 become dependent on the number of iterations required to reach convergence; the additional iterations required in the XSA model with s.e.=1.5 for F shrinkage increases SSB estimates considerably. (such an effect does not to appear in the model with s.e.=0.5, see WD 08 for details) , further analysis using SSQ "likelihood function criteria" demonstrates that s.e.=1.5 is a better model fit (lower SSQ) and it goodness is increasing with increasing of numbers of iteration (WD 17). Based on this observation the "s.e.=1.5 model" has more support.

Mortality estimation

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 (1984–2010). The consumption of NEA haddock by NEA cod is given in table B8.

The fishing mortality estimated by the XSA was split into the mortality caused by the fishing fleet (F) and the mortality caused by the cod's predation (M2) according to the ratio of fleet catch and predation "catch". The new natural mortality data set were then prepared by adding 0.2 (M1) to the predation mortality. This new M matrix (Table 4.7) was used in the final XSA.

The proportion of M and F before spawning was set to 0.

4.4.3 Recruitment indices (Table 4.10, Table 4.11, Figure 4.1C)

The traditional procedure to predict recruitment at age-3 has been to use the RCT3 program, where the predictions are based on survey indices. Other recruitment functions, including cod predation and temperature, were tested and compared with RCT3 in preparation for the benchmark (ICES CM 2011/ACOM:38). All models had a tendency to underestimate the largest year classes. The models produced fairly good predictions, but the new models seemed to be more precise than the RCT3 predictions, especially for year t+2. Taking into account the similarities in the predictions and the fact NEA haddock has a one year HCR (HCR is calculated on basis only of the stock in the prediction year, not including stock size in two following years as is done for NEA cod and saithe) it was recommended that the use of RCT3 is continued and be the main source of predicted values.

The RCT3 program has been used to estimate the recruiting year-classes 2008-2010 with survey data for ages 0-2 as input data (Russian autumn survey, joint winter survey and ecosystem survey). Input data and results are shown in Table 4.10 and 4.11, respectively. Similar to XSA tuning, data points from the 1990 Russian BT were removed from recruitment estimation.

The numbers marked with * are XSA estimates, and the rest are RCT results (Table 4.11). The recruitment time series is shown in Table 4.18 and Figure 4.1C.

N	Year of assessment						
Year Class	2005	2006	2007	2008	2009	2010	2011
2000	197*	237*	236*	249*	236*	222*	232*
2001	176*	219*	224*	257*	245*	237*	241*
2002	295	313*	339*	367*	365*	371*	352*
2003	156	183	135*	161*	171*	185*	189*
2004	462	755	672	665*	668*	610*	765*
2005		521	731	943	975*	1028*	1193*
2006			463	832	1036	811*	1057*
2007				202	208	212	284*
2008					149	101	120
2009						303	315
2010							188

4.4.4 Prediction data (Table 4.11, Table 4.19)

At WKHAD 2006 (ICES CM 2006/ACFM:19) it was decided that weight-at-age and maturity-at-age in stock should be based on smoothed observations. Method details are described in stock annex. At the benchmark in 2011 it was decided to use fitted values of weight at-age and maturity-at-age two years ahead in the short term predictions, using the fitted parameters and last year lengths as input. The Norwegian and Russian weight-at-age and maturity-at-age are then combined as arithmetic averages.

Different methods have been tested to predict weight-at-age in catches during the benchmark. The quality of prediction using these tested methods was not enough to warrant replacing the current AFWG routine (average weight for period with similar abundant year classes). Weight-at-age in catches is much more affected by year-effects and cohort-based models are not suitable. Average weight-at-age in catch from similar year-class strengths has been observed in previous periods following good recruitment is used in predictions.

The Working Group decided to keep last year procedure for estimation of natural mortality and selection pattern. The input data for making the prediction are presented in Table 4.19:

- The estimated recruitment from RCT3 for 2011-2013 is given in Table 4.19.
- The assessment shows a decreasing trend in F from 2009 to 2010 and the F in 2010 is thus considered to be a better estimate for F in the present year (2011) than using a three year average F.
- The average fishing pattern observed in the 3 last years, scaled to F status quo was used for distribution of fishing mortality at age for 2011-2013.
- Smoothed observed average maturity-at-age are used for 2011, predicted maturity estimates, using the fitted parameters and last year lengths as input, are used for 2012-2013.
- Smoothed observed average weight in stock at age used for 2011, predicted stock weights at age, using the fitted parameters and last year lengths as input, are used for 2012-2013.
- The average weights at age in catch for the 1992-1995 year classes are used for 2011-2013.
- Natural mortality – average for the 3 last years (2008-2010).
- Stock numbers and fishing mortalities from the standard VPA.

4.5 Results of the Assessments

4.5.1 Comparison of assessments

The IUU catch estimates equal to zero this year, thus there are no comparison between assessment with and without IUU estimates as in previous reports.

The current assessment estimated the total stock to be about 13 % higher and SSB 23 % higher in 2010 compared to the previous assessment. F in 2009 is close to the estimate from last year.

Compared to last year short term projection, total stock estimate is about 1 % higher and SSB 7 % lower in 2011.

4.5.2 Fishing mortality and VPA (Tables 4.12-4.18 and Figures 4.1A-D, 4.5-4.6)

The tuning diagnostics of the final XSA (predation included) is given in Table 4.12, the retrospective plot in Figure 4.5 and the log catchability residuals plot is presented in Figure 4.6.

The proportion of M and F before spawning was set to 0. Fishing mortality are given in Table 4.13, while the stock numbers and spawning stock numbers, stock biomass at age and the spawning biomass at age of the final VPA are given in Tables 4.14-4.17. A summary of landings, fishing mortality, spawning stock biomass, and recruitment since 1950 are given in Table 4.18 and Figures 4.1A-D.

The assessments shows the fishing mortalities for the most recent years have been estimated higher this year than last year. Fishing mortality is currently decreasing and estimated well below the long term mean and below F_{pa}.

The dominating feature of this assessments is that we have reached the end of a rapid increasing stock biomass and a decrease is expected to start in 2011 and further in 2012. This is mainly the effect of more normal recruitment levels since 2007. The increase in spawning stock biomass is still present mainly from the individual growth of species of high abundant year classes 2004-2006, but the rate of increase appears slightly lower compared to last year.

4.5.3 Catch options for 2012 (Tables 4.20 – 4.22)

The deterministic projection shows a further increase in SSB in the beginning of 2012 to an all-time high of 461,000 tonnes (Table 4.20).

The TAC for 2012 is established using one-year HCR (see Section 4.7.3), and the management plan that will be in force next 4 years. Fishing according to the management rule in 2012 corresponds to total landings about 318,000 t, decreasing the SSB at the beginning of 2013 to 380,000 t (Table 4.21). This corresponds to a 5 % increase of the TAC.

According to the management plan TAC for 2013 is expected to be equal to 238,500 t (corresponding to 25 % decreasing of catch in accordance to HCR) (Table 4.22).

4.6 Comments to the assessment and forecasts

The problems using XSA on the Northeast Arctic haddock stock was discussed in 2011 on the benchmark meeting (ICES CM 2011/ACOM:38). The main conclusion was to change XSA settings.

The table below mainly reflects uncertainties in assessment and forecasts.

Source of uncertainty	Description	Comments
Incomplete survey coverage (1)	Since 1997 all of the surveys used for tuning have been affected by an incomplete coverage for some of the years. (Due to Norwegian vessels not been given access to REZ, Russian vessels not been given access to NEZ).	All indices affected have been corrected using a factor based on geographical distributions observed before and after the incomplete coverage. This procedure is likely to introduce increased uncertainty to the indices (see AFWG 2007 and 4.2).
Incomplete survey coverage (2)	None of the surveys have a complete coverage of the stock. The proportion of a year class being outside the coverage varies between year classes (see also the WG report from 2002).	May appear as year class dependent changes in survey catchability. Catches of haddock in Norwegian statistical areas 06 and 07 (coastal areas) are added to the NEA haddock. These include haddock of older ages compared to the landings of NEA haddock. Since the surveys do not cover the coastal regions the coverage of older ages may be poorer.
Correlated error structures	Year effects in a survey are quite common. The year effect introduces correlated errors between the age groups, but in this case also between survey series.	
Discards	The level of discarding is not known.	Discarding is known to be a (varying) problem in the longline and trawl fisheries related to the abundance of haddock close to, but below the minimum landing size.
Unreported catches	This year, estimates for unreported catches were provided for 2002-2010, 2009-2010 estimates equal to zero.	The estimates were considered quite uncertain, but the uncertainty has decreased in recent years.
Predation on young age groups	The mortality due to predation (to a large extent by cod) varies substantially from year to year.	The predictions of young age groups are very uncertain.
Sampling error	Estimation of catch at age is based on sampling of catches. The error in the estimates caused by sampling can be considerable even if the total catch is known. The estimation of the abundance indices from surveys will also be affected by sampling error. Poorer Norwegian catch-sampling caused problems in estimating age-length keys for 2010.	The effect of not taking sampling error into account when fitting models to data may introduce bias in the resulting estimates. This bias is likely to increase with sampling error.

4.7 Reference points and harvest control rules (Tables 4.23 and Figures 4.2-4.3)

4.7.1 Biomass reference points

In February 2011 it was performed a benchmark assessment on Northeast Arctic haddock (ICES CM 2011/ACOM:38). At the benchmark it was decided to change XSA settings which caused changes in SSB and recruitment estimates. In addition, in 2006 the data used in the assessment were revised for the entire time series, and some additional catches previously not included into statistic (Norwegian statistical regions 06 and 07) have been added (see AFWG 2006 report (ICES CM 2006/ACFM: 25) and WKHAD report (ICES CM 2006/ACFM:19) for a detailed description) without changing the reference points. It was therefore a need to evaluate the biological reference points (WD 16). Segmented regression has been carried out, but the SSB recruitment relationship did not result in a clear candidate for $\mathbf{B}_{lim}$. Based on the analysis of stock recruitment plot (WD 16) it is proposed to keep $\mathbf{B}_{lim}$=50,000 t and $\mathbf{B}_{pa}$ =80,000 t with the rationale that $\mathbf{B}_{lim}$ is equal to $\mathbf{B}_{loss}$, and $\mathbf{B}_{pa} = \mathbf{B}_{lim}*\exp(1.645*\sigma)$, where σ=0.3. This gives a 95% probability of maintaining SSB above **B**lim taking into account the uncertainty in the assessments and stock dynamics (PA Software Users' Guide, http://www.ices.dk/committe/acom/wg/asoft/Pasoft/).

For BMSY trigger we propose B_{pa}, $B_{trigger}$ is 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).

4.7.2 Fishing mortality reference points

There was also a need to update the fishing mortality reference points. Previous values were $\mathbf{F}_{lim}$=0.49 and $\mathbf{F}_{pa}$ =0.35. A plot of SSB versus recruitment is shown in Figure 4.2. There is no standard method of estimating $\mathbf{F}_{lim}$ nor $\mathbf{F}_{pa}$, but the AFWG 2011 propose to use geometric mean recruitment (146 million) and $\mathbf{B}_{lim}$ as basis for the $\mathbf{F}_{lim}$ estimate. $\mathbf{F}_{lim}$ is then based on the slope of line from origin at SSB=0 to the geometric mean recruitment (146 million) and SSB=$\mathbf{B}_{lim}$. The SPR value of this slope give $\mathbf{F}_{lim}$ value on SPR curve; $\mathbf{F}_{lim}$ =0.77 (found using Pasoft). Using the same approach as for $\mathbf{B}_{pa}$; $\mathbf{F}_{pa} = \mathbf{F}_{lim}*\exp(-1.645*\sigma)$= 0.47.

$\mathbf{F}_{msy}$=0.35 has been estimated by long-term stochastic simulation (WD 16).

Yield and SSB per recruit (YPR and SPR) are presented in Table 4.23 and Figure 4.3.

4.7.3 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 is as follows (Protocol of the 36th Session of The Joint Norwegian Russian Fishery Commission, 10 October 2007):

- *TAC for the next year will be set at level corresponding to F_{pa}.*
- *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_{pa} at B_{pa} to F= 0 at SSB equal to zero. At SSB-levels below B_{pa} in any of the operational years (current year and a year ahead) there should be no limitations on the year-to-year variations in TAC.*

We propose to revise $\mathbf{F}_{lim}$ and $\mathbf{F}_{pa}$ because of revision of the time series. The new values of $\mathbf{F}_{lim}$=0.77 and $\mathbf{F}_{pa}$=0.47 are higher than the previous values (0.49 and 0.35, respectively). In the current HCR management is based on $\mathbf{F}_{pa}$. However, F_{MSY} is now estimated at 0.35, and it seems very appropriate to continue using the HCR with value of target F=0.35. This will correspond to the goal of the management strategy for this stock and will provide maximum sustainable yield.

4.8 Comments to Technical Minutes from reviewers

Our comments to Technical Minutes from reviewers are in *italics* below each comment that requires a response.

Technical comments

1) The review was restricted to checking whether the procedures described in the technical annex (Stock Annex) were applied. This was the case. No deviations were spotted.

2) Also, a comparison with the assessment in last year's report was made. The procedures used were the same as last year. The results of the assessment are in line with last year's assessment

3) The RCT3 procedure for predicting recruitment in the short term forecasts is not described well in the annex.

This is corrected.

4) Catch at ages 1-2 are not used in the assessment, although the annex indicates they should be. Also, survey indices at ages 1-2 are not used to tune the XSA, and again the annex indicates they are. However, this is consistent with last year's assessment procedures. These procedures should be clarified in the annex.

This is clarified in the annex, ages 1-2 are used in the predation run to estimate M2, but is not used in the final XSA run.

5) The annex should describe why 0-group survey indices are not used as a tuning index.

Neither of the indices for the youngest ages are used in tuning since they are considered uncertain, based on tuning residual analysis.

6) The year-classes mentioned in the first line of section 4.4.3 should be 2007-2009.

Ok.

7) There is inconsistency in the numbers between Table 4.18 and Fig 4.1. Accordingly, Table 4.18 has been revised by the WG.

8) The prediction Table 4.20 indicates an SSB in 2009 of 285 kt. This is actually the SSB in start of the year 2010. Corrected by the WG.

9) Weights at age in the Norwegian survey has decreased for the oldest ages compared to last year, while the Russian survey shows decrease for all ages. It is suggested to review data on weight at age matrices. There might be problems with the age reading presented by different nations. The Norwegian sampling program was terminated in Q3 2009 which might give less precise estimates of weight at age in the catch compared to previous years.

We take this into account and the Norwegian sampling program will be evaluated autumn 2011 and improvements to the Norwegian catch allocation software are planned.

10) The XSA is very sensitive to settings. There are several reasons for this: incomplete and variable between years survey coverage (both for Russian and Norwegian bottom trawl surveys), correlated error structures, biased catch statistics in relation to unknown discard and un-reported landings (IUU), predation on young age groups, and sampling error. The basis for this and key sources of this should be further investigated in a future

benchmark assessment. The time series of un-reported landings was included this year as well, but the un-reported landings in 2009 was zero. Decreasing estimated IUU catches are explained in the Quality handbook. There are no estimates of discarding. Both Russian (2006) and Norwegian (2007) bottom trawl surveys coverage were reduced compared to previous years. There has been performed sensitivity analyses according to various XSA settings (Fig. 4.7).

XSA settings have been analyzed and changed, which have improved the retrospective pattern and tuning residuals.

11) The swept area bottom trawl estimates from the joint Norwegian-Russian ecosystem survey have been tested as a new survey tuning time series in single fleet runs. The estimates from this were slightly lower compared to other single fleet runs. A run combining all time series was very close to the final XSA run, and inclusion of the new time series should be considered in a near future benchmark assessment.

This survey is now included as tuning series.

12) The assessment indicates that the increasing of the SSB is relative with decreasing F and due to the high level of recruitment. In general, there is consistency between different survey indices.

13) The precautionary reference points are set based on an assessment carried out in 2000. The present assessment indicates that the historical biomasses estimates have been revised and that the technical basis for the biomass reference points is no longer valid. ICES needs to reconsider the MSY (and PA) reference points in a benchmark assessment in near future (2011).

Biological reference points are revised and changes are proposed.

14) The technical review comments given to last years assessment has been addressed in this years working group report and assessment.

15) There are different estimates of unreported catches/landings by Norway and Russian. As IUU catch estimates for 2009 is zero, the WG decided to make no comparisons and exploratory runs investigating the differences between assessments including each of the two time series. This years assessment only include the Norwegian data. As time series are still used with different perception of and assumptions associated to IUU it is recommended that these comparisons are still made in the assessment.

The AFWG stick to our decision to only show the assessment with the Norwegian IUU estimates for 2002-2008 and joint estimates since 2009.

16) There is a tendency that XSA estimates the peaks in abundance at age smoother than the surveys, which is consistent with aging error. This should be investigated in a near future benchmark assessment.

This was discussed at the benchmark, we are aware of aging errors but it is difficult to include such errors in XSA. It was advised by the benchmark group that alternative (statistical) models, where such errors can be included, should be investigated. Such investigations are planned.

17) Reference points were not revised due to time constraints by the WG, and this should be done at the next benchmark assessment.

Reference points are revised and changes are proposed.

18) Retrospective runs for 2000-2002 show strong trends and look strange. Such a retro needs additional investigation in the next benchmark.

This was addressed at the benchmark and improvements are done.

19) Residuals for ages 7-8 for all surveys are high. There are also pronounced year effects in residuals. This should be investigated in the next benchmark assessment.

This was investigated at the benchmark, but we have not managed to reduce the patterns seen in the residual plots.

20) An "index ratio by age" method was used to adjust for incomplete Joint Barents Sea winter survey coverage in some years (e.g. 2007). This should be revisited in time, because data before and after years with incomplete coverage can and should be used to fill in the missing data. It would also be desirable to reflect in survey standard errors the additional uncertainty caused by incomplete coverage. This may be more important in the future if more statistically rigorous state-space approaches are used, where process and measurement error are separated and it helps for this to have good information on within-survey error.

This is noted and will be investigated using a SAM model.

21) Why are years not specified in Table 4.9A?

These are standard XSA input tables, years are specified in line 2 of each fleet.

22) The titles of Tables B1 and B3 should be changed to Joint Surveys.

This is corrected.

23) The annex contains insufficient detail in some aspects. For example, the annex and report are unclear if maturities are modelled by year or cohort?

The annex is revised.

24) Section 4.3.6 is confusing. How has the same approach been used for predation and maturities? Are the changes to data important? If so, this should be described better.

This is clarified.

25) The annex does not specify the inputs to the RCT3 analyses. The procedures used were the same as last year.

This is now stated in the annex.

26) There are substantial differences in biomass and SSB in Table 4.18 of the this year's report and Table 4.18 of last year's report.

We will not characterize these changes as substantial and they are probably caused by updates of values in weight-at-age in stock, natural mortality-at-age, and proportions mature-at-age. At the benchmark it was decided that these (weight, M, and mat) historic values (1950-1979) should be kept constant from this year and onwards.

27) Table 4.12 does not indicate if the XSA has converged.

XSA is run until convergence and the number of iterations is now included.

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

Year	Sub-area I	Division IIa	Division IIb	un-reported[2]	Total[3]	Norw. stat. areas 06 and 07[4]
1960	12502	27781	1844	-	154651	6000
1961	16515	25641	2427	-	193224	4000
1962	16056	25125	1723	-	187409	3000
1963	12433	20956	936	-	146224	4000
1964	79262	18784	1112	-	99158	6000
1965	98921	18719	943	-	118583	6000
1966	12500	35143	1626	-	161778	5000
1967	10799	27962	440	-	136398	3000
1968	14097	40031	725	-	181726	3000
1969	89948	40306	566	-	130820	2000
1970	60631	27120	507	-	88258	-
1971	56989	21453	463	-	78905	-
1972	22188	42111	2162	-	266153	-
1973	28564	23506	13077	-	322227	-
1974	15905	47037	15069	-	221157	10000
1975	12169	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	11274	61722	3657	-	178128	5126
1997	78128	73475	2756	-	154359	5987
1998	45640	53936	1054	-	100630	6338
1999	38291	40819	4085	-	83195	5743
2000	25931	39169	3844	-	68944	4536
2001	35072	47245	7323	-	89640	4542
2002	40721	42774	12567	18736/5310	114798/101372	6898
2003	53653	43564	8483	33226/9417	138926/115117	4279
2004	64873	47483	12146	33777/8661	158279/133163	3743
2005	53518	48081	16416	40283/9949	158298/127964	5538
2006	51124	47291	33291	21451/8949	153157/140655	5410
2007	62904	58141	25927	14553/3102	161525/150074	7110
2008	58379	60178	31219	5828/-	155604/149776	6629
2009	57723	66045	76293	0	200061	4498
2010[1]	62617	85809	100907	0	249334	3649

1 Provisional figures, Norwegian catches on Russian quotas are included

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

3 Figures based on Norwegian/Russian IUU estimates. During the period 2002-2008, the Norwegian IUU-estimates were included in the final assessments

4 Included in total landings and in landings in region IIa

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

	Sub-area I		Division IIa		Division IIb		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	14.0	9.5	13.1	-	-
1974	133.1	25.9	39.9	7.1	15.1	-	-
1975	103.5	18.2	34.6	9.7	9.7	-	-
1976	77.7	16.4	28.1	9.5	5.6	-	-
1977	57.6	14.6	19.9	8.6	9.5	-	-
1978	53.9	10.1	15.7	14.8	1.0	-	-
1979	47.8	16.0	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	14.0	15.8	0.8	8.3	-
1987	79.0	18.1	23.0	18.1	3.0	13.8	-
1988	28.7	16.4	34.3	15.3	0.6	0.0	-
1989	20.0	9.7	13.5	15.0	0.3	0.0	-
1990	4.4	8.9	5.1	8.2	0.6	0.0	-
1991	9.0	8.9	8.9	8.9	0.2	0.2	-
1992	21.3	9.6	11.9	16.1	1.0	0.0	-
1993	35.3	11.6	14.5	17.9	3.0	0.0	-
1994	58.6	18.2	26.1	24.3	7.9	0.2	-
1995	63.9	12.0	29.6	23.8	12.1	1.0	-
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	26.0	19.6	27.1	26.9	0.7	0.3	-
1999	29.4	8.9	19.1	21.8	4.0	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	0.3	-
2002	30.5	10.2	19.5	23.3	12.5	0.1	18.7/5.3
2003	42.7	10.9	21.9	21.7	8.1	0.4	33.2/9.4
2004	52.4	12.5	27.0	20.5	11.5	0.6	33.8/8.7
2005	38.5	15.0	24.9	20.9	13.0	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	49.0	8.8	40.1	25.3	67.1	7.8	0/0
2010[1]	43.6	19.0	49.6	35.6	87.6	10.4	0/0

1 Provisional 2 Figures based on Norwegian/Russian IUU estimates

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

Year	Faroe Islands	France	German Dem.Re.	Fed. Re. Germ.	Norway[4]	Poland	United Kingdom	Russia[2]	Others	Unreported catches[3]	Total[3]
1960	172	-	-	5597	46263	-	45469	57025	125	-	154651
1961	285	220	-	6304	60862	-	39650	85345	558	-	193224
1962	83	409	-	2895	54567	-	37486	91910	58	-	187408
1963	17	363	-	2554	59955	-	19809	63526	-	-	146224
1964	-	208	-	1482	38695	-	14653	43870	250	-	99158
1965	-	226	-	1568	60447	-	14345	41750	242	-	118578
1966	-	1072	11	2098	82090	-	27723	48710	74	-	161778
1967	-	1208	3	1705	51954	-	24158	57346	23	-	136397
1968	-	-	-	1867	64076	-	40129	75654	-	-	181726
1969	2	-	309	1490	67549	-	37234	24211	25	-	130820
1970	541	-	656	2119	37716	-	20423	26802	-	-	88257
1971	81	-	16	896	45715	43	16373	15778	3	-	78905
1972	137	-	829	1433	46700	1433	17166	196224	2231	-	266153
1973	1212	3214	22	9534	86767	34	32408	186534	2501	-	322226
1974	925	3601	454	23409	66164	3045	37663	78548	7348	-	221157
1975	299	5191	437	15930	55966	1080	28677	65015	3163	-	175758
1976	536	4459	348	16660	49492	986	16940	42485	5358	-	137264
1977	213	1510	144	4798	40118	-	10878	52210	287	-	110158
1978	466	1411	369	1521	39955	1	5766	45895	38	-	95422
1979	343	1198	10	1948	66849	2	6454	26365	454	-	103623
1980	497	226	15	1365	66501	-	2948	20706	246	-	92504
1981	381	414	22	2402	63435	Spain	1682	13400	-	-	81736
1982	496	53	-	1258	43702	-	827	2900	-	-	49236
1983	428	-	1	729	22364	139	259	680	-	-	24600
1984	297	15	4	400	18813	37	276	1103	-	-	20945
1985	424	21	20	395	21272	77	153	22690	-	-	45052
1986	893	12	75	1079	52313	22	431	45738	-	-	100563

1987	464	7	83	3105	72419	59	563	78211	5	-	154916
1988	1113	116	78	1323	60823	72	435	31293	2	-	95255
1989	1217	-	26	171	36451	1	590	20062	-	-	58518
1990	705	-	5	167	20621	-	494	5190	-	-	27182
1991	1117	-	Greenland	213	22178	-	514	12177	17	-	36216
1992	1093	151	1719	387	36238	38	596	19699	1	-	59922
1993	546	1215	880	1165	40978	76	1802	35071	646	-	82379
1994	2761	678	770	2412	71171	22	4673	51822	877	-	135186
1995	2833	598	1097	2675	76886	14	3111	54516	718	-	142448
1996	3743	6	1510	942	94527	669	2275	74239	217	-	178128
1997	3327	540	1877	972	103407	364	2340	41228	304	-	154359
1998	1903	241	854	385	75108	257	1229	20559	94	-	100630
1999	1913	64	437	641	48182	652	694	30520	92	-	83195
2000	631	178	432	880	42009	502	747	22738	827	-	68944
2001	1210	324	553	554	49067	1497	1068	34307	1060	-	89640
2002	1564	297	858	627	52247	1505	1125	37157	682	18736/5310	114798/101372
2003	1959	382	1363	918	56485	1330	1018	41142	1103	33226/9417	138926/115117
2004	2484	103	1680	823	62192	54	1250	54347	1569	33777/8661	158279/133163
2005	2138	333	15	996	60850	963	1899	50012	1262	40283/9949	158751/128417
2006	2390	883	1830	989	69272	703	1164	53313	1162	21451/8949	153157/140/655
2007	2307	277	1464	1123	71244	125	1351	66569	2511	14553/3102	161525/150074
2008	2687	311	1659	535	72779	283	971	68792	1759	5828/-	155604/149776
2009	2820	529	1410	1957	104354	317	1315	85514	1845	0/0	200061
2010[1]	3173	764	1970	3539	123517	379	1758	111372	2862	0/0	249334

1 Provisional figures. 2 USSR prior to 1991. 3 Figures based on Norwegian/Russian IUU estimates
4 included landings in Norwegian statistical areas 06 and 07 (from 1983)

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

Age year	3	4	5	6	7	8	9	10	11+	TOTNU	TONS	SOPCOF%
1950	3189	37949	35344	18849	28868	9199	1979	1093	2977	139447	132125	62
1951	65643	9178	18014	13551	6808	6850	3322	1182	1348	125896	120077	81
1952	6012	151996	13634	9850	4693	3237	2434	606	880	193342	127660	57
1953	64528	13013	70781	5431	2867	1080	424	315	1005	159444	123920	69
1954	6563	154696	5885	27590	3233	1302	712	319	543	200843	156788	67
1955	1154	10689	176678	4993	28273	1445	271	100	100	223703	202286	64
1956	16437	5922	14713	127879	3182	8003	450	200	185	176971	213924	78
1957	2074	24704	7942	12535	46619	1087	1971	356	176	97464	123583	79
1958	1727	5914	31438	5820	12748	17565	822	1072	601	77707	112672	88
1959	20318	7826	7243	14040	3154	2237	5918	285	500	61521	88211	105
1960	39910	70912	13647	7101	6236	1579	2340	2005	606	144336	154651	95
1961	15429	56855	63351	8706	3578	4407	788	527	1434	155075	193224	99
1962	39503	30868	48903	33836	3201	1341	1773	242	756	160423	187408	94
1963	28466	72736	18969	13579	9257	1239	559	409	375	145589	146224	86
1964	22363	49290	30672	5815	3527	2716	833	104	633	115953	99158	73
1965	5936	46356	40201	12631	1679	974	897	123	802	109599	118578	86
1966	26345	22631	63176	29048	5752	582	438	189	242	148403	161778	85
1967	15907	41346	13496	25719	8872	1616	218	175	271	107620	136397	99
1968	657	67632	41267	7748	15599	5292	655	182	286	139318	181726	99
1969	1524	1968	44634	19002	3620	4937	1628	316	109	77738	130820	112
1970	23444	2454	1906	22417	8100	2012	2016	740	293	63382	88257	101
1971	1978	24358	1257	918	9279	3056	826	1043	534	43249	78905	129
1972	230942	22315	42981	3206	1611	6758	2638	900	1652	313003	266153	91
1973	70679	260520	24180	6919	422	426	1692	529	584	365951	322226	85
1974	9685	41706	88120	5829	4138	382	618	2043	1870	154391	221157	110
1975	10037	14088	33871	49711	2135	1236	92	131	934	112235	175758	110
1976	13994	13454	6810	20796	40057	1247	1350	193	1604	99505	137264	88
1977	55967	22043	7368	2586	7781	11043	311	388	379	107866	110158	91
1978	47311	18812	4076	1389	1626	2596	6215	162	400	82587	95422	108
1979	17540	35290	10645	1429	812	546	1466	2310	323	70361	103623	129
1980	627	22878	21794	2971	250	504	230	842	1460	51556	87889	130
1981	486	2561	22124	10685	1034	162	162	72	963	38249	77153	137
1982	883	900	3372	12203	2625	344	75	80	649	21131	46955	137
1983	1173	2636	1360	2394	2506	1799	267	37	292	12464	24600	95
1984	1271	1019	1899	657	950	2619	352	87	77	8931	20945	95
1985	29624	1695	564	1009	943	886	1763	588	281	37353	45052	102
1986	23113	68429	1565	783	896	393	702	1144	987	98012	100563	95
1987	5031	87170	64556	960	597	376	212	230	738	159870	154916	101
1988	1439	12478	47890	20429	397	178	74	88	446	83419	95255	100
1989	2157	4986	16071	25313	3198	147	1	28	177	52078	58518	102

Table 4.4 (continued).

Age year	3	4	5	6	7	8	9	10	11+	TOTNU	TONS	SOPCOF%
1990	1015	2580	2142	4046	6221	840	134	42	71	17091	27182	98
1991	4421	3564	2416	3299	4633	3953	461	83	54	22884	36216	96
1992	11571	11567	4099	2642	2894	3327	3498	486	84	40168	59922	102
1993	13487	19457	13704	4103	1747	1886	2105	1965	323	58777	82379	100
1994	3374	47821	36333	13264	2057	903	1453	2769	2110	110084	135186	99
1995	2003	16109	72644	19145	6417	746	361	770	1576	119771	142448	98
1996	1662	6818	36473	73579	13426	2944	573	365	1897	137737	178128	98
1997	2280	5633	12603	32832	49478	5636	778	245	748	110233	154359	95
1998	1701	11304	9258	8633	13801	19469	2113	330	490	67099	100630	99
1999	16839	8039	15365	6073	4466	6355	6204	647	446	64434	83195	98
2000	1520	29986	6496	5149	2406	1657	1570	1744	437	50965	68944	97
2001	12971	5230	32049	5279	2941	1137	1161	1169	1204	63141	89640	101
2002	7132	46335	11084	21985	2602	1602	482	448	1029	92699	114798	99
2003	6803	31448	56480	11736	14541	1637	2178	858	1219	126900	138926	98
2004	7993	21116	41310	41226	4939	4914	598	1252	901	124249	158279	98
2005	11452	19369	22887	37067	24461	2393	2997	990	1524	123140	158298	100
2006	4539	35040	27571	15033	16023	8567	1259	1298	718	110048	153157	101
2007	30707	15213	45992	18516	10642	7889	2570	678	988	133195	161525	101
2008	14536	44192	15926	31173	9145	4520	2846	1181	654	124173	155604	101
2009	15313	54795	52371	13693	15409	3789	1643	882	961	158856	200061	100
2010	5805	49709	80302	56192	8477	3725	1092	902	3520	209724	249334	99

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

Age year	3	4	5	6	7	8	9	10	11+
1950	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1951	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1952	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1953	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1954	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1955	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1956	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1957	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1958	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1959	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1960	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1961	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1962	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1963	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1964	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1965	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1966	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1967	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1968	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1969	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1970	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1971	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1972	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1973	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1974	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1975	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1976	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1977	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1978	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1979	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1980	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1981	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1982	0.752	1.049	1.337	1.639	1.893	2.17	2.44	2.73	3.219
1983	1.033	1.408	1.71	2.149	2.469	2.748	3.069	3.687	4.516
1984	1.218	1.632	2.038	2.852	2.845	3.218	3.605	4.065	4.667
1985	0.835	1.29	1.816	2.174	2.301	2.835	3.253	3.721	4.416
1986	0.612	1.064	1.539	1.944	2.362	2.794	3.25	3.643	5.283
1987	0.497	0.765	1.179	1.724	2.135	2.551	3.009	3.414	4.213
1988	0.55	0.908	1.097	1.357	1.537	1.704	2.403	2.403	2.571
1989	0.684	0.84	0.998	1.176	1.546	1.713	1.949	2.14	2.685

Table 4.5 (continued).

Age year	3	4	5	6	7	8	9	10	11+
1990	0.793	1.172	1.397	1.624	1.885	2.112	2.653	3.102	3.338
1991	0.941	1.281	1.556	1.797	2.044	2.079	2.311	2.788	3.219
1992	0.906	1.263	1.535	1.747	2.043	2.2	2.298	2.494	2.652
1993	0.94	1.204	1.487	1.748	1.994	2.237	2.417	2.654	3.026
1994	0.614	0.906	1.287	1.602	1.968	2.059	2.39	2.545	2.893
1995	0.739	0.808	1.107	1.556	1.838	2.234	2.416	2.602	3.13
1996	0.683	0.868	1.045	1.363	1.71	1.886	2.214	2.37	2.675
1997	0.682	1.028	1.151	1.369	1.637	1.856	2.073	2.5	2.554
1998	0.748	0.974	1.262	1.433	1.641	1.863	2.069	2.335	2.81
1999	0.826	1.079	1.261	1.485	1.634	1.798	2.032	2.237	2.712
2000	0.853	1.186	1.395	1.588	1.808	1.989	2.264	2.415	2.892
2001	0.751	1.104	1.459	1.709	1.921	2.182	2.331	2.609	2.981
2002	0.687	1.001	1.363	1.643	1.975	2.086	2.294	2.487	2.778
2003	0.594	0.875	1.113	1.364	1.361	1.972	1.636	1.877	2.409
2004	0.636	0.886	1.183	1.508	1.821	2.075	2.339	2.58	2.991
2005	0.722	0.906	1.121	1.343	1.619	2.036	2.177	2.382	2.768
2006	0.745	1.041	1.287	1.504	1.72	2.082	2.377	2.738	3.212
2007	0.652	0.899	1.197	1.435	1.722	1.99	2.309	2.715	3.028
2008	0.658	0.901	1.242	1.515	1.781	2.18	2.33	2.664	3.328
2009	0.707	1.024	1.28	1.538	1.806	2.107	2.398	2.531	3.172
2010	0.622	0.89	1.124	1.377	1.665	1.982	2.136	2.687	3.009

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

Age year	3	4	5	6	7	8	9	10	11+
1950-1979	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1980	0.451	0.875	1.16	1.676	2.294	3.139	3.317	3.561	3.814
1981	0.601	0.802	1.311	1.583	2.12	2.733	3.517	3.688	3.915
1982	0.628	1.047	1.214	1.778	2.019	2.557	3.147	3.862	4.027
1983	0.522	1.095	1.556	1.66	2.252	2.452	2.976	3.533	4.176
1984	0.39	0.923	1.628	2.092	2.118	2.715	2.871	3.371	3.889
1985	0.377	0.698	1.391	2.193	2.626	2.571	3.156	3.27	3.74
1986	0.309	0.68	1.066	1.895	2.759	3.14	3.005	3.569	3.643
1987	0.329	0.567	1.045	1.471	2.409	3.307	3.621	3.413	3.948
1988	0.382	0.601	0.885	1.45	1.892	2.914	3.823	4.062	3.791
1989	0.444	0.687	0.934	1.246	1.876	2.315	3.396	4.301	4.46
1990	0.412	0.787	1.052	1.31	1.634	2.307	2.728	3.846	4.736
1991	0.401	0.735	1.19	1.455	1.712	2.034	2.733	3.122	4.261
1992	0.338	0.719	1.117	1.628	1.879	2.126	2.437	3.143	3.493
1993	0.278	0.614	1.098	1.534	2.079	2.307	2.54	2.832	3.534
1994	0.262	0.51	0.95	1.515	1.967	2.526	2.729	2.946	3.215
1995	0.281	0.483	0.798	1.325	1.95	2.399	2.959	3.136	3.337
1996	0.312	0.519	0.759	1.126	1.722	2.387	2.82	3.37	3.523
1997	0.332	0.574	0.815	1.074	1.479	2.126	2.814	3.221	3.754
1998	0.354	0.607	0.897	1.154	1.417	1.846	2.525	3.222	3.597
1999	0.36	0.645	0.945	1.265	1.521	1.774	2.215	2.912	3.606
2000	0.292	0.654	1.001	1.326	1.661	1.904	2.137	2.578	3.28
2001	0.291	0.54	1.011	1.401	1.733	2.07	2.292	2.496	2.931
2002	0.272	0.538	0.848	1.41	1.827	2.152	2.481	2.677	2.847
2003	0.281	0.505	0.844	1.201	1.833	2.262	2.57	2.885	3.051
2004	0.299	0.52	0.796	1.194	1.581	2.263	2.695	2.978	3.275
2005	0.316	0.552	0.818	1.131	1.571	1.977	2.688	3.116	3.37
2006	0.301	0.58	0.866	1.16	1.494	1.962	2.376	3.099	3.52
2007	0.307	0.555	0.907	1.225	1.53	1.873	2.357	2.769	3.49
2008	0.28	0.566	0.872	1.277	1.611	1.914	2.258	2.745	3.15
2009	0.297	0.519	0.889	1.233	1.675	2.012	2.303	2.638	3.121
2010	0.29	0.548	0.817	1.256	1.623	2.085	2.415	2.687	3.009

Table 4.7. Northeast Arctic haddock. Natural mortality (M) at age

Age									
Year	3	4	5	6	7	8	9	10	11+
1950-1983	0.3334	0.2422	0.2297	0.2111	0.2	0.2	0.2	0.2	0.2
1984	0.2073	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1985	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1986	0.6432	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.3976	0.2	0.2023	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.3179	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1991	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.2055	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.2627	0.2235	0.2653	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.2949	0.2173	0.2102	0.2005	0.2	0.2	0.2	0.2	0.2
1995	0.3421	0.3565	0.2989	0.2065	0.2	0.2	0.2	0.2	0.2
1996	0.7473	0.2980	0.2244	0.2236	0.2	0.2	0.2	0.2	0.2
1997	0.4805	0.2424	0.2233	0.2096	0.2	0.2	0.2	0.2	0.2
1998	0.2354	0.2517	0.2200	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.2017	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.2241	0.2082	0.2072	0.2044	0.2	0.2	0.2	0.2	0.2
2001	0.2150	0.2012	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.3289	0.2103	0.2088	0.2042	0.2	0.2	0.2	0.2	0.2
2003	0.4091	0.2614	0.2080	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.4152	0.2898	0.2214	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.3759	0.2760	0.2325	0.2145	0.2	0.2	0.2	0.2	0.2
2006	0.2333	0.2244	0.2174	0.2134	0.2	0.2	0.2	0.2	0.2
2007	0.3130	0.2350	0.2220	0.2069	0.2	0.2	0.2	0.2	0.2
2008	0.4238	0.3262	0.2867	0.2774	0.2	0.2	0.2	0.2	0.2
2009	0.4792	0.3469	0.3355	0.2386	0.2	0.2	0.2	0.2	0.2
2010	0.4493	0.3713	0.4174	0.2997	0.2	0.2	0.2	0.2	0.2

Table 4.8. Northeast Arctic haddock. Proportion mature at age

Age year	3	4	5	6	7	8	9	10	11+
1950-1980	0.027	0.077	0.244	0.649	0.859	0.95	0.984	0.995	1
1981	0.056	0.104	0.304	0.55	0.857	0.948	0.984	0.995	1
1982	0.054	0.162	0.333	0.577	0.77	0.946	0.983	0.995	1
1983	0.057	0.184	0.472	0.665	0.8	0.906	0.983	0.995	1
1984	0.044	0.197	0.51	0.801	0.862	0.92	0.966	0.995	1
1985	0.027	0.15	0.522	0.796	0.927	0.952	0.973	0.989	1
1986	0.021	0.103	0.454	0.758	0.928	0.977	0.983	0.991	1
1987	0.021	0.076	0.294	0.713	0.917	0.976	0.993	0.993	1
1988	0.025	0.075	0.24	0.576	0.898	0.975	0.993	0.998	1
1989	0.032	0.09	0.25	0.534	0.822	0.966	0.992	0.998	1
1990	0.046	0.128	0.305	0.578	0.797	0.936	0.99	0.997	1
1991	0.041	0.164	0.359	0.622	0.82	0.925	0.98	0.997	1
1992	0.031	0.147	0.449	0.703	0.855	0.935	0.976	0.994	1
1993	0.019	0.114	0.396	0.74	0.877	0.95	0.979	0.992	1
1994	0.017	0.073	0.329	0.702	0.903	0.959	0.984	0.993	1
1995	0.016	0.059	0.227	0.633	0.885	0.969	0.987	0.995	1
1996	0.018	0.07	0.214	0.497	0.854	0.963	0.991	0.996	1
1997	0.023	0.066	0.205	0.496	0.76	0.948	0.989	0.997	1
1998	0.03	0.085	0.24	0.502	0.749	0.907	0.983	0.997	1
1999	0.041	0.113	0.298	0.582	0.76	0.897	0.968	0.995	1
2000	0.027	0.139	0.341	0.617	0.806	0.899	0.965	0.99	1
2001	0.028	0.094	0.39	0.668	0.862	0.928	0.967	0.989	1
2002	0.02	0.103	0.307	0.72	0.89	0.95	0.977	0.989	1
2003	0.019	0.074	0.316	0.626	0.898	0.959	0.982	0.993	1
2004	0.023	0.071	0.244	0.623	0.844	0.967	0.987	0.995	1
2005	0.025	0.08	0.235	0.557	0.849	0.949	0.989	0.996	1
2006	0.026	0.092	0.255	0.557	0.803	0.95	0.984	0.997	1
2007	0.013	0.089	0.302	0.578	0.818	0.935	0.983	0.996	1
2008	0.01	0.058	0.261	0.618	0.833	0.934	0.977	0.995	1
2009	0.007	0.041	0.181	0.59	0.843	0.942	0.98	0.993	1
2010	0.008	0.039	0.157	0.459	0.839	0.949	0.981	0.993	1

Table 4.9. Northeast Arctic haddock. Survey indices used in tuning XSA

North-East Arctic haddock

104

FLT01: RU-BTr-Q4

1983 2010

1 1 0.9 1

1 7

1	592	95	5	4	0.1	NA	NA
1	586	584	15	2	1	0.1	NA
1	144	1343	900	4	1	1	NA
1	14	107	363	164	1	0.1	0.1
1	9	17	83	225	57	0.1	0.1
1	3	7	17	40	76	8	0.1
1	18	24	4	14	41	81	11
1	NA	NA	NA	NA	NA	NA	NA
1	429	176	62	9	3	6	18
1	282	1286	346	50	4	6	9
1	48	357	1985	356	48	8	4
1	49	58	442	1014	116	15	1
1	72	42	31	123	370	40	5
1	23	57	28	49	362	334	29
1	46	19	32	32	10	27	10
1	29	115	38	46	8	5	15
1	289	61	196	39	37	8	3
1	207	262	60	109	26	11	2
1	149	261	334	40	65	11	4
1	193	189	399	450	47	24	4
1	328	251	221	299	231	34	16
1	110	206	113	94	107	87	5
1	792	136	240	86	48	57	24
1	792	1227	113	119	57	26	24
1	839	2142	838	73	137	38	14
1	127	2327	2557	1051	124	111	17
1	29	158	1647	1704	631	57	32
1	197	43	299	1697	1589	466	34

Table 4.9 (continued).

FLT02: BS-NoRU-Q1(Aco)

1980 2010

1 1 0.99 1

1 7

1	140	50	210	600	180	10	NA
1	20	30	40	40	100	60	NA
1	50	20	30	10	10	40	20
1	1730	60	20	10	NA	NA	NA
1	7760	2150	50	NA	NA	NA	NA
1	2660	4520	1890	NA	NA	NA	NA
1	170	490	1710	500	NA	NA	NA
1	40	80	230	460	70	NA	NA
1	50	60	110	200	210	20	NA
1	350	30	30	40	70	110	20
1	2520	450	80	30	30	30	60
1	8680	1340	230	20	NA	NA	10
1	6260	5630	1300	130	NA	NA	NA
1	1930	2550	6310	1110	120	NA	NA
1	2850	360	1110	3870	420	20	NA
1	2290	440	310	760	1510	80	NA
1	240	510	170	120	430	430	20
1	1220	200	280	120	50	130	160
1	460	570	130	140	40	10	20
1	5090	320	650	190	110	20	10
1	3160	2100	230	220	10	10	NA
1	2820	2160	1490	140	120	10	NA
1	2790	1450	1980	1690	170	50	NA
1	4740	1270	760	760	660	70	20
1	2090	2190	1020	360	400	90	NA
1	8040	540	860	300	120	90	20
1	8680	3790	540	880	220	60	50
1	18352	7234	2517	573	742	102	58
1	2463	10217	7730	4021	313	149	16
1	818	1380	5930	5574	1914	103	29
1	4080	476	681	3130	2626	524	16

Table 4.9 (continued).

FLT04: BS-NoRu-Q1 (BTr)

1982 2010

1 1 0.99 1

1 8

1	48	31	24	9	19	25	7	NA
1	5146	189	15	8	2	1	4	1
1	15938	4759	147	5	5	1	1	4
1	3703	3846	1108	6	2	1	1	1
1	799	1544	2902	529	NA	NA	NA	NA
1	153	253	689	1164	138	1	NA	NA
1	95	141	216	340	327	34	1	NA
1	546	45	34	50	92	118	18	NA
1	3003	334	51	42	27	17	42	NA
1	13755	1505	244	21	6	7	16	23
1	5990	5077	1056	105	6	4	3	4
1	2280	3395	4366	497	34	2	1	2
1	1793	536	1711	3395	345	28	NA	1
1	2636	525	481	1486	2528	116	9	NA
1	679	861	280	194	467	622	35	1
1	1379	227	332	132	34	80	81	7
1	576	598	122	102	28	10	17	11
1	4522	272	354	84	40	8	3	7
1	4603	2960	293	251	17	9	1	1
1	5347	3147	1853	176	82	8	3	NA
1	5131	3174	1820	736	55	23	2	1
1	7112	1881	1027	804	462	59	11	2
1	4204	3465	1333	668	522	123	6	2
1	13131	774	1405	482	196	152	31	1
1	15938	5077	660	860	233	75	37	14
1	21294	15224	6009	868	489	62.7	25.1	8.2
1	3280	12704	7732	3654	385	106	14	1
1	1112	1028	5086	4796	1312	70	10	6
1	3435	649	951	4683	3381	621	16	4

Table 4.9 (continued).

FLT007: Eco-NoRu-Q3 (Btr)

1990	2010							
1	1	0.65	0.75					
1	8							
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	NA	NA	NA	NA	NA	NA	NA	NA
1	189	268	123	70	69	31	3	2
1	626	114	323	89	29	31	15	NA
1	2270	929	107	125	42	19	17	7
1	988	1819	1283	88	94	19	6	7
1	322	1292	1155	406	43	36	5	3
1	136	144	651	618	306	21	7	1
1	274	65	184	865	666	148	16	3

Table 4.10. Northeast Arctic haddock. Input data for recruitment prediction (RCT3)

NORTHEAST ARCTIC HADDOCK: recruits as 3 year-olds
12 21 2

'Year-class'	'VPA'	'NT1'	'NT2'	'NT3'	'NAK1'	'NAK2'	'NAK3'	'RT1'	'RT2'	'RT3'	'ECO1'	'ECO2'	'ECO3'
1990	673	2006	1375.5	507.7	1890	868	563	-11	42.9	128.6	-11	-11	-11
1991	302	1659.4	599	339.5	1135	626	255	16.7	28.2	35.7	-11	-11	-11
1992	99	727.9	228	53.6	947	193	36	16.4	4.8	5.8	-11	-11	-11
1993	106	603.2	179.3	52.5	562	285	44	3.5	4.9	4.2	-11	-11	-11
1994	116	1463.6	263.6	86.1	1379	229	51	9.1	7.2	5.7	-11	-11	-11
1995	64	309.5	67.9	22.7	249	24	20	6.4	2.3	1.9	-11	-11	-11
1996	229	1268	137.9	59.8	693	122	57	6	4.6	11.5	-11	-11	-11
1997	97	212.9	57.6	27.2	220	46	32	1.8	2.9	6.1	-11	-11	-11
1998	375	1244.9	452.2	296	856	509	210	10.7	28.9	26.2	-11	-11	-11
1999	352	847.2	460.3	314.7	1024	316	216	11.7	20.7	26.1	-11	-11	-11
2000	232	1220.5	534.7	317.4	976	282	145	15.1	14.9	18.9	-11	-11	-11
2001	241	1680.3	513.1	188.1	2062	279	127	20.8	19.3	25.1	-11	-11	-11
2002	352	3332.1	711.2	346.5	2394	474	219	33.2	32.8	20.6	-11	-11	268
2003	189	715.9	420.4	77.4	752	209	54	19.8	11	13.6	-11	189	114
2004	765	4630.2	1313.1	507.7	3364	804	379	50	79.2	122.7	104	626	929
2005	1193	5141.3	1593.8	1522.4	2767	868	723.4	62	79.2	214.2	155	2270	1819
2006	1057	3874.4	2129.4	1270	3197	1835.2	1021.7	53.4	83.9	232.7	283	988	1292
2007	284	860.2	328	102.8	1266.6	246.3	138	6.5	12.7	15.8	114	322	144
2008	-11	564.7	111.2	64.9	849	81.8	47.6	5.7	2.9	4.3	60	136	65
2009	-11	1619.5	343.5	-11	2035.8	408	-11	10	19.7	-11	169	274	-11
2010	-11	685.4	-11	-11	786.5	-11	-11	7.7	-11	-11	154	-11	-11

1990 RT was removed from XSA tuning

RT1 Russian bottom trawl survey (RU-BTr-Q4) age 1

RT2 Russian bottom trawl survey (RU-BTr-Q4) age 2

RT3 Russian bottom trawl survey (RU-BTr-Q4) age 3

NT1 Norwegian bottom trawl survey BS-NoRu-Q1 (BTr) age 1

NT2 Norwegian bottom trawl survey BS-NoRu-Q1 (BTr)) age 2

NT3 Norwegian bottom trawl survey BS-NoRu-Q1 (BTr) age 3

NA1 Norwegian acoustic survey BS-NoRU-Q1(Aco) age 1

NA2 Norwegian acoustic survey BS-NoRU-Q1(Aco) age 2

NA3 Norwegian acoustic survey BS-NoRU-Q1(Aco) age 3

ECO1 Ecosystem survey Eco-NoRu-Q3 (Btr) age 1

ECO2 Ecosystem survey Eco-NoRu-Q3 (Btr) age 2

ECO3 Ecosystem survey Eco-NoRu-Q3 (Btr) age 3

Table 4.11. Northeast Arctic haddock. Analysis by RCT3 ver.3.1

Data for 12 surveys over 21 years : 1990 – 2010 Regression type = C Tapered time weighting applied
power = 3 over 20 years Survey weighting not applied Final estimates shrunk towards mean
Minimum S.E. for any survey taken as 0.20 Minimum of 3 points used for regression
Forecast/Hindcast variance correction used.

Yearclass	=	2005	I-----------Regression----------I				I-----------Prediction---------I		
Survey/	Slope	Inter-	Std	Rsquare	No.	Index	Predicted	Std	WAP
Series		cept	Error		Pts	Value	Value	Error	Weights
NT1	1	-1.63	0.52	0.664	15	8.55	6.95	0.676	0.029
NT2	0.86	0.37	0.42	0.756	15	7.37	6.75	0.532	0.047
NT3	0.73	1.79	0.34	0.825	15	7.33	7.16	0.465	0.062
NAK1	1.13	-2.35	0.59	0.606	15	7.93	6.59	0.726	0.025
NAK2	0.85	0.73	0.46	0.717	15	6.77	6.52	0.568	0.041
NAK3	0.78	1.8	0.23	0.909	15	6.59	6.93	0.312	0.138
RT1	1.18	2.31	0.69	0.526	14	4.14	7.19	0.904	0.016
RT2	0.77	3.35	0.27	0.884	15	4.38	6.74	0.344	0.113
RT3	0.72	3.37	0.2	0.932	15	5.37	7.22	0.283	0.167
EC01									
ECO2									
ECO3	0.67	2.11	0.04	0.998	3	7.51	7.1	0.124	0.334
VPA	Mean	=					5.42	0.7	0.027

Yearclass	=	2006	I-----------Regression----------I				I-----------Prediction---------I		
Survey/	Slope	Inter-	Std	Rsquare	No.	Index	Predicted	Std	WAP
Series		cept	Error		Pts	Value	Value	Error	Weights
NT1	1.02	-1.7	0.51	0.741	16	8.26	6.69	0.612	0.033
NT2	0.93	0.03	0.44	0.795	16	7.66	7.13	0.555	0.041
NT3	0.72	1.85	0.32	0.878	16	7.15	7	0.404	0.077
NAK1	1.24	-3.06	0.63	0.647	16	8.07	6.91	0.774	0.021
NAK2	0.96	0.2	0.51	0.742	16	7.52	7.42	0.664	0.028
NAK3	0.81	1.69	0.23	0.932	16	6.93	7.28	0.307	0.133
RT1	1.14	2.4	0.63	0.649	15	4	6.96	0.776	0.021
RT2	0.83	3.23	0.29	0.899	16	4.44	6.9	0.359	0.097
RT3	0.7	3.41	0.19	0.954	16	5.45	7.23	0.248	0.203
EC01									
ECO2	0.81	1.07	0.44	0.906	3	6.9	6.67	0.895	0.016
ECO3	0.66	2.14	0.03	0.999	4	7.16	6.87	0.053	0.312
VPA	Mean	=					5.58	0.817	0.019

Table 4.11 (continued).

Yearclass	=	2007	I-----------Regression----------I				I-----------Prediction---------I		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.04	-1.88	0.5	0.769	17	6.76	5.17	0.579	0.03
NT2	0.91	0.15	0.41	0.835	17	5.8	5.39	0.466	0.046
NT3	0.72	1.87	0.3	0.901	17	4.64	5.19	0.351	0.081
NAK1	1.23	-3.04	0.6	0.698	17	7.14	5.77	0.686	0.021
NAK2	0.9	0.54	0.45	0.805	17	5.51	5.48	0.515	0.038
NAK3	0.77	1.84	0.23	0.942	17	4.93	5.65	0.258	0.15
RT1	1.13	2.42	0.59	0.708	16	2.01	4.7	0.699	0.02
RT2	0.83	3.21	0.28	0.917	17	2.62	5.39	0.316	0.1
RT3	0.67	3.48	0.19	0.96	17	2.82	5.38	0.214	0.218
EC01	0.74	3.09	0.42	0.378	3	4.74	6.62	0.916	0.012
ECO2	0.87	0.77	0.38	0.883	4	5.78	5.79	0.644	0.024
ECO3	0.68	2.05	0.05	0.996	5	4.98	5.42	0.087	0.249
VPA	Mean	=					5.72	0.872	0.013

Yearclass	=	2008	I-----------Regression----------I				I-----------Prediction---------I		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.02	-1.7	0.49	0.762	18	6.34	4.8	0.579	0.032
NT2	0.9	0.18	0.39	0.833	18	4.72	4.44	0.481	0.046
NT3	0.71	1.94	0.32	0.883	18	4.19	4.91	0.375	0.076
NAK1	1.22	-2.99	0.57	0.704	18	6.75	5.27	0.651	0.025
NAK2	0.89	0.61	0.41	0.818	18	4.42	4.53	0.502	0.042
NAK3	0.77	1.84	0.22	0.942	18	3.88	4.84	0.257	0.161
RT1	1.11	2.56	0.61	0.671	17	1.9	4.67	0.729	0.02
RT2	0.83	3.23	0.27	0.912	18	1.36	4.37	0.34	0.092
RT3	0.67	3.52	0.19	0.953	18	1.67	4.64	0.237	0.189
EC01	2.59	-6.41	1.18	0.313	4	4.11	4.22	2.719	0.001
ECO2	0.9	0.55	0.33	0.895	5	4.92	4.97	0.567	0.033
ECO3	0.64	2.29	0.1	0.985	6	4.19	4.99	0.168	0.266
VPA	Mean	=					5.76	0.831	0.015

Yearclass	=	2009	I-----------Regression----------I				I-----------Prediction---------I		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.01	-1.58	0.48	0.768	18	7.39	5.88	0.551	0.097
NT2	0.9	0.18	0.38	0.836	18	5.84	5.46	0.447	0.148
NT3									
NAK1	1.22	-2.95	0.56	0.71	18	7.62	6.34	0.65	0.07
NAK2	0.88	0.65	0.39	0.833	18	6.01	5.96	0.449	0.146
NAK3									
RT1	1.09	2.6	0.6	0.677	17	2.4	5.22	0.704	0.06
RT2	0.83	3.23	0.27	0.913	18	3.03	5.75	0.309	0.309
RT3									
EC01	2.58	-6.4	1.18	0.315	4	5.14	6.87	1.898	0.008
ECO2	0.9	0.55	0.33	0.894	5	5.62	5.6	0.499	0.119
ECO3									
VPA	Mean	=					5.81	0.825	0.043

Table 4.11 (continued).

Yearclass	=	2010	I-----------Regression----------I				I-----------Prediction---------I		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	0.99	-1.46	0.47	0.774	18	6.53	5.03	0.568	0.34
NT2									
NT3									
NAK1	1.22	-2.96	0.55	0.714	18	6.67	5.17	0.657	0.254
NAK2									
NAK3									
RT1	1.08	2.64	0.59	0.68	17	2.16	4.98	0.721	0.211
RT2									
RT3									
EC01	2.58	-6.39	1.19	0.317	4	5.04	6.62	1.904	0.03
ECO2									
ECO3									
VPA	Mean	=					5.86	0.815	0.165

Year Class Prediction	Weighted Average	Log WAP	Int Std Error	Ext Std Error	Var	VPA Ratio	Log VPA
2005	1052	6.96	0.12	0.1	0.79	1194	7.09
2006	1100	7	0.11	0.08	0.55	1058	6.96
2007	229	5.44	0.1	0.06	0.41	285	5.65
2008	120	4.8	0.1	0.07	0.5		
2009	315	5.75	0.17	0.1	0.32		
2010	188	5.24	0.33	0.2	0.35		

Table 4.12. Northeast Arctic haddock. Extended Survivors Analysis

FLR XSA Diagnostics 2011-05-01 14:28:23
CPUE data from mystock.tun
Catch data for 61 years. 1950 to 2010. Ages 3 to 11.

fleet	first age	last age	first year	last year
1 FLT01: RU-BTr-Q4	3	7	1990	2010
2 FLT02: BS-NoRU-Q1(Aco)	3	7	1990	2010
3 FLT04: BS-NoRu-Q1 (BTr)	3	8	1990	2010
4 FLT007: Eco-NoRu-Q3 (Btr)	3	8	1990	2010

Time series weights :
Tapered time weighting applied
Power = 3 over 20 years
Catchability analysis :
Catchability independent of size for ages > 8
Catchability independent of age for ages > 8
Terminal population estimation :
Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.
S.E. of the mean to which the estimates are shrunk = 1.5
Minimum standard error for population
estimates derived from each fleet = 0.3
prior weighting not applied

Regression weights

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
all	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	0.039	0.024	0.037	0.042	0.04	0.027	0.048	0.015	0.019	0.026
4	0.079	0.195	0.157	0.18	0.158	0.185	0.125	0.103	0.089	0.098
5	0.379	0.239	0.391	0.333	0.324	0.373	0.406	0.2	0.196	0.222
6	0.332	0.489	0.433	0.559	0.583	0.377	0.47	0.572	0.284	0.386
7	0.27	0.27	0.714	0.327	0.781	0.546	0.508	0.452	0.662	0.292
8	0.24	0.231	0.273	0.562	0.259	0.707	0.573	0.421	0.341	0.325
9	0.456	0.151	0.563	0.151	0.826	0.211	0.472	0.417	0.265	0.155
10	0.282	0.318	0.439	0.757	0.399	1.139	0.168	0.413	0.218	0.227
11	0.282	0.318	0.439	0.757	0.399	1.139	0.168	0.413	0.218	0.227

XSA population number (Thousand)

year \ age	3	4	5	6	7	8	9	10	11
2001	374717	76432	112332	20656	13752	5887	3505	5261	5384
2002	351908	290567	57773	62970	12135	8598	3791	1819	4150
2003	231970	247219	193739	36902	31489	7581	5590	2668	3757
2004	240625	148542	162762	106459	19593	12624	4726	2606	1849
2005	351707	152368	92903	93455	49859	11573	5889	3328	5081
2006	188696	232014	98746	53258	42114	18688	7310	2110	1144
2007	765028	145387	154050	54719	29513	19982	7548	4845	7030
2008	1192518	533195	101413	82219	27796	14534	9222	3855	2116
2009	1056821	768813	347251	62332	35168	14482	7809	4975	5392
2010	284421	642384	497388	204006	36949	14850	8429	4907	19046

Table 4.12 (continued).

Estimated population abundance at 1st Jan 2011

	age								
year	3	4	5	6	7	8	9	10	11
2011	0	176852	401842	262473	102802	22582	8789	5913	3202

Fleet: FLT01: RU-BTr-Q4
Log catchability residuals.

	year										
age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3	NA	0.031	0.278	0.295	0.199	-0.157	-0.089	-0.194	0.171	0.034	0.076
4	NA	0.081	0.019	0.333	0.05	-0.21	0.156	0.181	0.129	0.272	-0.105
5	NA	-0.14	-0.098	0.151	0.057	-0.216	0.352	-0.273	-0.185	0.25	0.23
6	NA	-0.14	0.285	0.422	0.027	-0.085	0.032	-0.309	-0.259	0.071	0.024
7	NA	0.02	0.278	0.455	0.023	0.099	0.236	-0.81	-0.071	-0.074	-0.172

	year									
age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	-0.076	0.076	0.137	-0.16	-0.108	-0.08	-0.113	0.093	0.012	0.142
4	-0.043	0.109	0.056	-0.056	-0.119	-0.264	-0.181	0.068	0.03	0.152
5	-0.141	0.098	0.007	-0.19	-0.146	-0.107	-0.038	0.13	0.002	0.166
6	0.091	-0.241	0.197	-0.054	-0.12	-0.145	0.013	0.229	0.03	0.153
7	-0.115	-0.033	0.108	-0.228	0.007	0.023	0.012	0.11	0.307	0.153

Regression statistics
Ages with q dependent on year class strength

	slope	intercept
Age 3	0.642503	8.826527
Age 4	0.621835	8.716072
Age 5	0.611223	8.511613
Age 6	0.614165	8.301534
Age 7	0.648111	8.164353

Fleet: FLT02: BS-NoRU-Q1(Aco)
Log catchability residuals.

	year										
age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3	0.165	-0.105	0.284	0.322	0.002	0.172	0.014	0.074	-0.017	-0.088	-0.039
4	0.05	-0.25	-0.185	0.305	0.126	-0.005	-0.062	0.141	0.007	0.367	-0.405
5	0.035	NA	NA	0.131	0.152	-0.087	0.036	-0.01	0.078	0.289	-0.415
6	-0.211	NA	NA	NA	-0.065	-0.012	-0.041	0.11	-0.213	0.22	-0.233
7	0.398	-0.805	NA	NA	NA	NA	-0.2	0.584	-0.242	0.13	NA

	year									
age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	-0.028	0.219	0.066	0.2	-0.186	-0.06	-0.214	0.094	0.073	-0.124
4	-0.13	0.158	-0.09	-0.063	-0.179	0.015	0.113	0.153	0.058	-0.068
5	-0.254	0.207	0.013	-0.07	-0.151	0.03	0.195	0.099	0.011	-0.055
6	-0.163	-0.16	0.288	-0.231	-0.134	-0.022	0.207	0.17	0.067	0.032
7	NA	NA	-0.008	NA	-0.353	0.294	0.681	-0.257	0.133	-0.618

Table 4.12 (continued).

Regression statistics
Ages with q dependent on year class strength

	slope	intercept
Age 3	0.72471	7.31702
Age 4	0.6738	7.53409
Age 5	0.58139	8.07495
Age 6	0.63207	7.8885
Age 7	0.8578	6.99865

Fleet: FLT04: BS-NoRu-Q1 (BTr)
Log catchability residuals.

	year										
age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3	-0.175	-0.178	0.071	0.023	0.124	0.299	0.171	0.059	-0.154	-0.511	-0.016
4	0.167	-0.267	-0.319	-0.091	0.039	0.272	0.123	0.151	-0.173	-0.039	-0.38
5	0.098	-0.029	-0.089	-0.187	0.113	0.07	0.088	-0.044	0.052	0.032	-0.114
6	-0.252	-0.104	0.103	-0.08	0.136	0.132	0.02	-0.048	-0.051	0.019	-0.09
7	0.151	-0.002	0.013	0.137	NA	0.293	0.167	-0.098	-0.022	0.08	-0.108
8	NA	0.241	-0.183	0.116	0.373	NA	0.179	0.137	-0.075	0.123	0.069

	year									
age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	-0.018	0.069	0.12	0.236	-0.033	-0.059	0.138	-0.011	-0.112	-0.053
4	-0.06	-0.251	-0.096	0.188	0.005	-0.026	0.273	0.083	-0.037	0.089
5	-0.287	-0.083	-0.073	0.044	0.062	0.089	0.076	0.191	-0.103	0.009
6	-0.066	-0.313	0.236	-0.085	0.059	0.095	0.054	0.037	-0.03	0.016
7	-0.025	-0.058	-0.02	-0.022	0.014	0.082	0.154	0.035	-0.107	-0.108
8	NA	-0.147	0.126	-0.063	-0.296	0.315	0.093	-0.371	0.111	-0.021

Regression statistics
Ages with q dependent on year class strength

	slope	intercept
Age 3	0.72415	7.17671
Age 4	0.67719	7.46517
Age 5	0.53932	8.40896
Age 6	0.54215	8.3997
Age 7	0.48093	8.72454
Age 8	0.52954	8.55563

Table 4.12 (continued).

Fleet: FLT007: Eco-NoRu-Q3 (Btr)

Log catchability residuals.

	year										
age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

year										
age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	NA	NA	NA	-0.103	0.145	-0.077	0.323	-0.041	-0.254	0.008
4	NA	NA	NA	-0.045	0.049	-0.087	0.05	-0.067	-0.11	0.207
5	NA	NA	NA	-0.084	-0.046	0.047	0.064	0.016	-0.038	0.034
6	NA	NA	NA	-0.158	-0.061	0.034	0.043	0.105	-0.047	0.07
7	NA	NA	NA	0.013	-0.028	0.037	-0.01	-0.025	-0.036	0.049
8	NA	NA	NA	0.03	NA	0.02	-0.004	0.015	-0.062	0.004

Regression statistics

Ages with q dependent on year class strength

	slope	intercept
Age 3	0.755288	8.37852
Age 4	0.721503	8.54382
Age 5	0.569738	9.21828
Age 6	0.659648	8.71995
Age 7	0.434648	9.27619
Age 8	0.259527	9.2422

Terminal year survivor and F summaries:

Age 3 Year class =2007

1 FLT01: RU-BTr-Q4	0.24	220551	2007
2 FLT02: BS-NoRU-Q1(Aco)	0.24	149072	2007
3 FLT04: BS-NoRu-Q1 (BTr)	0.24	164359	2007
4 FLT007: Eco-NoRu-Q3 (Btr)	0.24	178668	2007
fshk	0.01	151507	2007
nshk	0.03	206528	2007

Age 4 Year class =2006

source	scaledWts	survivors	yrcls
1 FLT01: RU-BTr-Q4	0.247	513172	2006
2 FLT02: BS-NoRU-Q1(Aco)	0.247	363224	2006
3 FLT04: BS-NoRu-Q1 (BTr)	0.247	458433	2006
4 FLT007: Eco-NoRu-Q3 (Btr)	0.247	535463	2006
fshk	0.011	290073	2006

Table 4.12 (continued).

Age 5 Year class =2005			
source	scaledWts	survivors	yrcls
1 FLT01: RU-BTr-Q4	0.224	344104	2005
2 FLT02: BS-NoRU-Q1(Aco)	0.199	238683	2005
3 FLT04: BS-NoRu-Q1 (BTr)	0.282	267061	2005
4 FLT007: Eco-NoRu-Q3 (Btr)	0.282	278710	2005
fshk	0.014	183157	2005
Age 6 Year class =2004			
1 FLT01: RU-BTr-Q4	0.227	131857	2004
2 FLT02: BS-NoRU-Q1(Aco)	0.209	108212	2004
3 FLT04: BS-NoRu-Q1 (BTr)	0.274	105957	2004
4 FLT007: Eco-NoRu-Q3 (Btr)	0.274	114385	2004
fshk	0.016	82193	2004
Age 7 Year class =2003			
source	scaledWts	survivors	yrcls
1 FLT01: RU-BTr-Q4	0.22	28582	2003
2 FLT02: BS-NoRU-Q1(Aco)	0.088	10991	2003
3 FLT04: BS-NoRu-Q1 (BTr)	0.337	18055	2003
4 FLT007: Eco-NoRu-Q3 (Btr)	0.337	25302	2003
Age 8 Year class =2002			
source	scaledWts	survivors	yrcls
3 FLT04: BS-NoRu-Q1 (BTr)	0.321	8447	2002
4 FLT007: Eco-NoRu-Q3 (Btr)	0.644	8937	2002
fshk	0.036	5712	2002
Age 9 Year class =2001			
source	scaledWts	survivors	yrcls
fshk	1	1780	2001
Age 10 Year class =2000			
source	scaledWts	survivors	yrcls
fshk	1	2766	2000

Table 4.13. Northeast Arctic haddock. Fishing mortality at age

Age										
year	3	4	5	6	7	8	9	10	11+	FBAR(4-7)
1950	0.048	0.571	0.811	0.808	1.158	1.002	0.647	0.946	0.946	0.837
1951	0.125	0.209	0.622	0.910	0.803	1.002	1.428	1.090	1.090	0.636
1952	0.103	0.527	0.575	0.887	0.997	1.256	1.378	1.225	1.225	0.746
1953	0.063	0.375	0.526	0.487	0.714	0.655	0.513	0.633	0.633	0.526
1954	0.054	0.234	0.302	0.410	0.614	0.864	1.366	0.958	0.958	0.390
1955	0.022	0.128	0.479	0.466	1.015	0.622	0.429	0.695	0.695	0.522
1956	0.101	0.166	0.272	0.809	0.625	0.936	0.397	0.659	0.659	0.468
1957	0.040	0.238	0.366	0.403	0.816	0.450	0.628	0.637	0.637	0.456
1958	0.025	0.166	0.568	0.518	0.966	0.870	0.744	0.869	0.869	0.554
1959	0.063	0.166	0.330	0.554	0.601	0.429	0.845	0.630	0.630	0.413
1960	0.180	0.363	0.508	0.648	0.518	0.701	1.150	0.798	0.798	0.509
1961	0.152	0.468	0.684	0.748	0.832	0.880	0.964	0.902	0.902	0.683
1962	0.179	0.574	1.049	1.059	0.698	0.901	1.183	0.937	0.937	0.845
1963	0.108	0.655	0.925	1.026	1.002	0.649	1.362	1.016	1.016	0.902
1964	0.071	0.305	0.681	0.870	0.846	0.961	1.389	1.078	1.078	0.676
1965	0.059	0.229	0.458	0.696	0.677	0.596	1.053	0.783	0.783	0.515
1966	0.115	0.371	0.586	0.742	0.826	0.528	0.593	0.655	0.655	0.631
1967	0.054	0.295	0.414	0.518	0.532	0.581	0.383	0.503	0.503	0.440
1968	0.037	0.380	0.569	0.457	0.704	0.718	0.495	0.645	0.645	0.528
1969	0.089	0.161	0.489	0.580	0.404	0.503	0.502	0.473	0.473	0.409
1970	0.151	0.223	0.242	0.502	0.530	0.413	0.395	0.449	0.449	0.374
1971	0.021	0.256	0.176	0.180	0.402	0.389	0.296	0.365	0.365	0.254
1972	0.257	0.375	1.059	0.950	0.551	0.581	0.696	0.615	0.615	0.734
1973	0.303	0.581	0.980	0.475	0.296	0.271	0.275	0.283	0.283	0.583
1974	0.201	0.327	0.411	0.693	0.591	0.480	0.803	0.630	0.630	0.506
1975	0.230	0.567	0.506	0.443	0.597	0.348	0.200	0.384	0.384	0.528
1976	0.292	0.621	0.629	0.703	0.801	0.874	0.811	0.837	0.837	0.688
1977	0.695	1.247	0.909	0.535	0.632	0.533	0.555	0.578	0.578	0.831
1978	0.316	0.597	0.868	0.428	0.790	0.445	0.662	0.638	0.638	0.671
1979	0.130	0.461	0.880	0.927	0.483	0.681	0.488	0.555	0.555	0.688
1980	0.025	0.277	0.613	0.675	0.398	0.637	0.697	0.582	0.582	0.491
1981	0.045	0.151	0.495	0.729	0.532	0.488	0.430	0.487	0.487	0.477
1982	0.066	0.119	0.317	0.580	0.391	0.336	0.440	0.392	0.392	0.352
1983	0.163	0.314	0.277	0.401	0.221	0.512	0.476	0.405	0.405	0.303
1984	0.122	0.224	0.404	0.213	0.275	0.379	0.174	0.277	0.277	0.279
1985	0.118	0.239	0.186	0.390	0.537	0.447	0.476	0.490	0.490	0.338
1986	0.062	0.437	0.363	0.427	0.727	0.449	0.788	0.661	0.661	0.488
1987	0.047	0.454	0.997	0.397	0.685	0.794	0.467	0.654	0.654	0.633
1988	0.031	0.159	0.489	1.080	0.282	0.443	0.344	0.359	0.359	0.503
1989	0.087	0.160	0.316	0.523	0.465	0.160	0.004	0.211	0.211	0.366

Table 4.13 (continued).

Age year	3	4	5	6	7	8	9	10	11+	FBAR(4-7)
1990	0.033	0.142	0.096	0.121	0.231	0.211	0.214	0.220	0.220	0.147
1991	0.047	0.164	0.191	0.209	0.199	0.225	0.171	0.199	0.199	0.191
1992	0.059	0.166	0.288	0.330	0.287	0.215	0.318	0.275	0.275	0.268
1993	0.023	0.136	0.314	0.525	0.380	0.307	0.205	0.298	0.298	0.339
1994	0.013	0.111	0.414	0.600	0.550	0.345	0.413	0.454	0.454	0.419
1995	0.024	0.091	0.263	0.405	0.666	0.392	0.225	0.402	0.402	0.356
1996	0.023	0.123	0.339	0.505	0.561	0.757	0.599	0.372	0.372	0.382
1997	0.025	0.138	0.376	0.599	0.789	0.487	0.454	0.559	0.559	0.476
1998	0.031	0.202	0.366	0.488	0.551	0.860	0.339	0.354	0.354	0.402
1999	0.085	0.201	0.480	0.443	0.507	0.533	0.757	0.163	0.163	0.408
2000	0.018	0.216	0.250	0.291	0.315	0.356	0.239	0.492	0.492	0.268
2001	0.039	0.079	0.379	0.332	0.270	0.240	0.456	0.282	0.282	0.265
2002	0.024	0.195	0.239	0.489	0.270	0.231	0.151	0.318	0.318	0.298
2003	0.037	0.157	0.391	0.433	0.714	0.273	0.563	0.439	0.439	0.424
2004	0.042	0.180	0.333	0.559	0.327	0.562	0.151	0.757	0.757	0.350
2005	0.040	0.158	0.324	0.583	0.781	0.259	0.826	0.399	0.399	0.461
2006	0.027	0.185	0.373	0.377	0.546	0.707	0.211	1.139	1.139	0.370
2007	0.048	0.125	0.406	0.470	0.508	0.573	0.472	0.168	0.168	0.378
2008	0.015	0.103	0.200	0.572	0.452	0.421	0.417	0.413	0.413	0.332
2009	0.019	0.089	0.196	0.284	0.662	0.341	0.265	0.218	0.218	0.308
2010	0.026	0.098	0.222	0.386	0.292	0.325	0.155	0.227	0.227	0.249

Table 4.14. Northeast Arctic haddock. Stock numbers at age (start of year). Numbers ´000

Age year	3	4	5	6	7	8	9	10	11+	TOTAL
1950	80445	98417	71366	37786	46516	16065	4591	1975	5287	362448
1951	662258	54936	43625	25212	13635	11963	4830	1968	2201	820627
1952	72667	418917	34987	18613	8220	5003	3596	948	1348	564299
1953	1245502	46974	194139	15653	6208	2484	1167	742	2339	1515208
1954	147984	837730	25340	91198	7787	2488	1056	572	957	1115112
1955	62332	100469	520463	14894	49017	3450	859	221	218	751923
1956	203088	43682	69386	256150	7567	14550	1517	458	418	596815
1957	63225	131591	29038	42030	92336	3316	4671	835	408	367450
1958	82692	43543	81397	15999	22753	33416	1731	2041	1126	284697
1959	390902	57784	28936	36666	7717	7094	11465	674	1168	542404
1960	286901	262866	38420	16541	17055	3465	3784	4032	1201	634264
1961	129579	171771	143494	18369	7004	8321	1408	980	2624	483550
1962	285093	79778	84449	57570	7040	2497	2825	440	1350	521042
1963	329333	170821	35269	23522	16168	2867	831	709	638	580157
1964	383645	211859	69634	11121	6827	4861	1226	174	1040	690387
1965	122085	255937	122615	28000	3772	2398	1522	250	1609	538188
1966	285944	82444	159810	61614	11306	1569	1082	435	550	604753
1967	355684	182567	44659	70694	23751	4052	758	490	751	683404
1968	21570	241368	106663	23463	34098	11418	1855	423	657	441515
1969	21172	14898	129527	47985	12026	13803	4560	926	316	245212
1970	197328	13879	9949	63155	21755	6571	6834	2260	887	322617
1971	114719	121533	8719	6209	30965	10482	3559	3771	1916	301873
1972	1204665	80517	73809	5809	4201	16956	5817	2166	3930	1397871
1973	319222	667613	43426	20345	1819	1982	7768	2375	2606	1067157
1974	62741	168884	293190	12958	10247	1107	1237	4829	4367	559560
1975	57677	36753	95604	154465	5247	4645	561	454	3209	358615
1976	65272	32827	16366	45789	80340	2364	2685	376	3078	249096
1977	132035	34919	13846	6936	18363	29532	807	977	943	238358
1978	206306	47225	7879	4436	3289	7994	14186	380	926	292620
1979	169860	107764	20399	2628	2342	1222	4196	5991	829	315231
1980	29524	106851	53316	6723	842	1183	506	2109	3615	204669
1981	13188	20622	63596	22946	2770	463	512	206	2733	127038
1982	16435	9037	13917	30822	8965	1333	233	273	2195	83210
1983	9206	11028	6296	8055	13976	4964	780	123	960	55388
1984	12259	5603	6320	3792	4368	9175	2437	397	349	44699
1985	293827	8818	3665	3456	2510	2716	5142	1677	793	322604
1986	533760	213760	5686	2491	1917	1202	1422	2615	2228	765079
1987	120186	263804	113095	3239	1331	759	628	529	1677	505248
1988	57121	93848	137110	34182	1783	549	281	322	1622	326818
1989	28765	37200	65545	68716	9501	1101	289	163	1025	212305

Table 4.14 (continued).

Age year	3	4	5	6	7	8	9	10	11+	TOTAL
1990	36967	21599	25945	39122	33356	4885	768	235	396	163275
1991	107013	26034	15350	19304	28370	21680	3239	508	329	221826
1992	222307	83615	18090	10381	12820	19035	14174	2235	384	383040
1993	673447	170566	57992	11102	6109	7877	12574	8439	1378	949484
1994	302155	506052	118999	32479	5377	3421	4743	8390	6335	987950
1995	98786	222081	364310	63730	14579	2541	1984	2568	5213	775793
1996	106472	68481	142010	207628	34574	6130	1405	1297	6690	574686
1997	116281	49286	44957	80861	100233	16159	2355	632	1909	412673
1998	63564	70127	33688	24689	36005	37295	8130	1224	1804	276525
1999	228580	48721	44553	18742	12402	16991	12918	4744	3256	390908
2000	97331	171613	32616	22574	9850	6113	8161	4963	1231	354451
2001	374717	76432	112332	20656	13752	5887	3505	5261	5384	617927
2002	351908	290567	57773	62970	12135	8598	3791	1819	4150	793713
2003	231970	247219	193739	36902	31489	7581	5590	2668	3757	760915
2004	240625	148543	162762	106459	19593	12624	4726	2606	1849	699786
2005	351707	152368	92903	93455	49859	11573	5889	3328	5081	766163
2006	188696	232014	98746	53258	42114	18688	7310	2110	1144	644079
2007	765028	145387	154050	54719	29513	19982	7548	4845	7030	1188101
2008	1192518	533195	101413	82219	27796	14534	9222	3855	2116	1966866
2009	1056821	768813	347251	62332	35168	14482	7809	4975	5392	2303043
2010	284421	642384	497388	204006	36949	14850	8429	4907	19046	1712380

Table 4.15. Northeast Arctic haddock. Spawning stock numbers at age (spawning time). Num ´000

Age year	3	4	5	6	7	8	9	10	11+
1950	2172	9940	22195	23503	39306	15166	4508	1963	5287
1951	17881	5549	13567	15682	11521	11293	4743	1956	2201
1952	1962	42311	10881	11577	6946	4723	3532	943	1348
1953	33629	4744	60377	9736	5245	2345	1146	738	2339
1954	3996	84611	7881	56725	6580	2349	1037	568	957
1955	1683	10147	161864	9264	41420	3257	844	219	218
1956	5483	4412	21579	159325	6394	13735	1490	455	418
1957	1707	13291	9031	26143	78024	3130	4587	830	408
1958	2233	4398	25314	9951	19226	31544	1700	2028	1126
1959	10554	5836	8999	22806	6521	6696	11259	670	1168
1960	7746	26550	11948	10288	14412	3271	3715	4008	1201
1961	3499	17349	44627	11426	5918	7855	1382	975	2624
1962	7698	8058	26264	35808	5948	2357	2774	437	1350
1963	8892	17253	10969	14631	13662	2707	816	704	638
1964	10358	21398	21656	6917	5769	4589	1204	173	1040
1965	3296	25850	38133	17416	3187	2264	1495	249	1609
1966	7720	8327	49701	38324	9553	1481	1063	432	550
1967	9603	18439	13889	43971	20069	3825	744	487	751
1968	582	24378	33172	14594	28813	10778	1822	421	657
1969	572	1505	40283	29846	10162	13030	4477	921	316
1970	5328	1402	3094	39282	18383	6203	6711	2246	887
1971	3097	12275	2712	3862	26166	9895	3495	3748	1916
1972	32526	8132	22955	3613	3550	16007	5712	2153	3930
1973	8619	67429	13506	12654	1537	1871	7628	2361	2606
1974	1694	17057	91182	8060	8659	1045	1215	4800	4367
1975	1557	3712	29733	96077	4434	4385	551	451	3209
1976	1762	3316	5090	28481	67887	2232	2637	374	3078
1977	3565	3527	4306	4314	15516	27878	793	971	943
1978	5570	4770	2450	2759	2779	7546	13931	377	926
1979	4586	10884	6344	1635	1979	1153	4120	5955	829
1980	797	8228	13009	4363	723	1124	498	2098	3615
1981	739	2145	19333	12620	2374	439	504	205	2733
1982	888	1464	4634	17784	6903	1261	229	271	2195
1983	525	2029	2972	5356	11181	4498	766	122	960
1984	539	1104	3223	3037	3765	8441	2354	395	349
1985	7933	1323	1913	2751	2327	2586	5003	1658	793
1986	11209	22017	2581	1888	1779	1174	1398	2591	2228
1987	2524	20049	33250	2309	1220	740	624	526	1677
1988	1428	7039	32906	19689	1601	535	279	322	1622
1989	920	3348	16386	36694	7809	1063	286	163	1025

Table 4.15 (continued).

Age year	3	4	5	6	7	8	9	10	11+
1990	1701	2765	7913	22613	26585	4572	760	235	396
1991	4388	4270	5511	12007	23263	20054	3174	506	329
1992	6892	12291	8122	7298	10961	17798	13833	2221	384
1993	12795	19444	22965	8215	5357	7483	12310	8372	1378
1994	5137	36942	39151	22800	4855	3280	4667	8331	6335
1995	1581	13103	82698	40341	12903	2462	1958	2556	5213
1996	1916	4794	30390	103191	29526	5903	1393	1292	6690
1997	2674	3253	9216	40107	76177	15318	2329	630	1909
1998	1907	5961	8085	12394	26968	33826	7992	1221	1804
1999	9372	5506	13277	10908	9425	15241	12505	4721	3256
2000	2628	23854	11122	13928	7939	5495	7875	4913	1231
2001	10492	7185	43809	13798	11854	5463	3390	5203	5384
2002	7038	29928	17736	45339	10800	8168	3704	1799	4150
2003	4407	18294	61222	23100	28278	7270	5489	2649	3757
2004	5534	10547	39714	66324	16537	12208	4664	2593	1849
2005	8793	12189	21832	52055	42330	10983	5825	3315	5081
2006	4906	21345	25180	29665	33818	17753	7193	2104	1144
2007	9945	12939	46523	31628	24142	18683	7420	4826	7030
2008	11925	30925	26469	50811	23154	13575	9009	3835	2116
2009	7398	31521	62852	36776	29646	13642	7653	4940	5392
2010	2275	25053	78090	93639	31000	14093	8269	4873	19046

Table 4.16. Northeast Arctic haddock. Stock biomass at age with SOP (start of year). Tonnes

Age year	3	4	5	6	7	8	9	10	11+	TSBSOP
1950	17718	39985	45113	33548	54033	23259	7915	3925	11833	237329
1951	189300	28966	35789	29050	20554	22478	10806	5077	6393	348413
1952	14617	155435	20198	15092	8721	6615	5663	1722	2755	230815
1953	305900	21281	136848	15497	8041	4010	2244	1645	5838	501304
1954	35160	367160	17280	87347	9758	3886	1965	1226	2310	526092
1955	14197	42212	340231	13675	58882	5166	1531	454	504	476852
1956	56240	22313	55146	285938	11051	26485	3289	1145	1177	462785
1957	17777	68251	23433	47638	136925	6128	10280	2119	1165	313716
1958	25730	24992	72688	20067	37337	68346	4216	5731	3560	262667
1959	145600	39702	30933	55053	15160	17368	33427	2264	4419	343926
1960	96569	163211	37115	22443	30276	7666	9969	12249	4107	383604
1961	45564	111415	144814	26037	12988	19233	3875	3112	9377	376414
1962	94893	48983	80674	77244	12358	5462	7360	1321	4567	332860
1963	100739	96385	30963	29004	26083	5765	1989	1956	1983	294866
1964	99030	100877	51588	11571	9294	8248	2478	406	2729	286221
1965	37152	143668	107090	34347	6054	4797	3626	687	4974	342395
1966	86124	45805	138146	74807	17959	3106	2551	1182	1682	371362
1967	124707	118075	44939	99914	43918	9338	2080	1549	2674	447195
1968	7569	156225	107414	33186	63101	26335	5095	1340	2342	402608
1969	8396	10898	147418	76705	25152	35980	14153	3315	1275	323291
1970	70802	9186	10246	91345	41167	15497	19193	7319	3233	267987
1971	52529	102651	11458	11460	74779	31550	12756	15583	8913	321678
1972	389072	47969	68417	7563	7156	35999	14706	6315	12897	590094
1973	96006	370372	37484	24665	2885	3918	18287	6448	7963	568027
1974	24539	121844	329113	20430	21137	2847	3788	17045	17354	558097
1975	22513	26463	107102	243042	10802	11919	1714	1598	12727	437879
1976	20417	18941	14692	57736	132537	4861	6574	1062	9782	266602
1977	42542	20754	12804	9009	31203	62547	2036	2840	3089	186823
1978	78617	33196	8617	6814	6611	20023	42316	1306	3585	201084
1979	77471	90663	26703	4832	5633	3663	14979	24662	3840	252446
1980	17310	121546	80403	14649	2512	4826	2183	9761	17925	271116
1981	10892	22727	114571	49915	8071	1740	2476	1046	14703	226140
1982	14120	12944	23113	74970	24761	4661	1002	1441	12094	169106
1983	4582	11514	9341	12749	30012	11607	2213	413	3823	86255
1984	4538	4908	9766	7528	8780	23643	6640	1270	1288	68362
1985	113457	6304	5222	7763	6750	7153	16622	5615	3039	171927
1986	156824	138211	5763	4488	5028	3587	4064	8874	7717	334556
1987	39849	150743	119105	4801	3230	2528	2292	1821	6674	331044
1988	21918	56656	121888	49786	3389	1608	1078	1316	6176	263816
1989	13065	26144	62626	87588	18233	2607	1003	717	4676	216657

Table 4.16.(continued).

Age year	3	4	5	6	7	8	9	10	11+	TSBSOP
1990	14992	16732	26866	50446	53648	11092	2063	891	1845	178576
1991	41364	18444	17607	27074	46816	42507	8533	1528	1350	205221
1992	76698	61365	20625	17251	24588	41307	35257	7170	1369	285629
1993	186635	104401	63476	16977	12661	18116	31839	23825	4855	462784
1994	78727	256658	112423	48933	10518	8593	12872	24581	20254	573557
1995	27089	104675	283700	82404	27743	5948	5728	7860	16977	562124
1996	32661	34944	105973	229857	58536	14386	3896	4299	23172	507724
1997	36696	26891	34828	82550	140913	32654	6299	1935	6811	369578
1998	22248	42088	29878	28170	50446	68072	20297	3900	6416	271516
1999	80575	30771	41226	23215	18471	29514	28018	13528	11497	276815
2000	27686	109332	31804	29160	15937	11338	16988	12463	3935	258642
2001	110108	41677	114678	29222	24065	12306	8113	13259	15935	369362
2002	94671	154613	48455	87816	21928	18300	9303	4817	11686	451590
2003	63972	122525	160477	43495	56647	16830	14099	7554	11249	496848
2004	70580	75774	127097	124697	30389	28026	12493	7613	5940	482608
2005	110767	83826	75740	105344	78066	22803	15778	10335	17065	519724
2006	57155	135414	86051	62167	63314	36895	17477	6580	4052	469105
2007	236937	81402	140957	67623	45553	37756	17949	13536	24750	666462
2008	336327	303977	89073	105755	45103	28019	20973	10658	6715	946601
2009	313872	399008	308702	76854	58905	29138	17985	13123	16827	1234415
2010	81502	347843	401537	253187	59255	30595	20113	13029	56628	1263689

Table 4.17. Northeast Arctic haddock. Spawning stock biomass at age with SOP (spawning time). Tonnes.

Age										
year	3	4	5	6	7	8	9	10	11+	SSBSOP
1950	478	4038	14030	20867	45658	21957	7772	3902	11833	130535
1951	5111	2926	11130	18069	17369	21219	10612	5046	6393	97875
1952	395	15699	6282	9387	7369	6244	5561	1711	2755	55402
1953	8259	2149	42560	9639	6794	3786	2203	1635	5838	82864
1954	949	37083	5374	54330	8245	3668	1929	1219	2310	115108
1955	383	4263	105812	8506	49756	4876	1504	451	504	176055
1956	1518	2254	17151	177854	9338	25002	3230	1138	1177	238661
1957	480	6893	7288	29631	115702	5785	10095	2106	1165	179145
1958	695	2524	22606	12482	31550	64519	4140	5696	3560	147772
1959	3931	4010	9620	34243	12810	16395	32826	2251	4419	120505
1960	2607	16484	11543	13960	25583	7236	9789	12175	4107	103485
1961	1230	11253	45037	16195	10975	18156	3805	3093	9377	119121
1962	2562	4947	25089	48046	10442	5156	7228	1313	4567	109350
1963	2720	9735	9630	18040	22040	5442	1953	1945	1983	73487
1964	2674	10189	16044	7197	7853	7786	2433	403	2729	57308
1965	1003	14510	33305	21364	5115	4528	3561	683	4974	89044
1966	2325	4626	42963	46530	15175	2932	2505	1175	1682	119915
1967	3367	11926	13976	62147	37111	8815	2043	1540	2674	143598
1968	204	15779	33406	20642	53320	24860	5003	1332	2342	156889
1969	227	1101	45847	47710	21253	33965	13898	3295	1275	168571
1970	1912	928	3186	56817	34786	14629	18847	7275	3233	141613
1971	1418	10368	3564	7128	63188	29783	12527	15489	8913	152378
1972	10505	4845	21278	4704	6047	33983	14441	6277	12897	114977
1973	2592	37408	11658	15341	2438	3699	17957	6409	7963	105465
1974	663	12306	102354	12708	17861	2688	3719	16943	17354	186596
1975	608	2673	33309	151172	9128	11252	1683	1589	12727	224139
1976	551	1913	4569	35912	111993	4589	6456	1055	9782	176821
1977	1149	2096	3982	5603	26367	59044	2000	2823	3089	106153
1978	2123	3353	2680	4238	5586	18902	41554	1298	3585	83319
1979	2092	9157	8305	3005	4760	3458	14709	24514	3840	73840
1980	467	9359	19618	9507	2157	4585	2148	9713	17925	75480
1981	610	2364	34830	27453	6917	1649	2436	1040	14703	92002
1982	762	2097	7696	43258	19066	4410	985	1434	12094	91802
1983	261	2119	4409	8478	24009	10516	2175	411	3823	56202
1984	200	967	4981	6030	7569	21752	6414	1263	1288	50464
1985	3063	946	2726	6180	6258	6810	16174	5553	3039	50748
1986	3293	14236	2616	3402	4666	3505	3995	8794	7717	52224
1987	837	11456	35017	3423	2962	2467	2276	1808	6674	66921
1988	548	4249	29253	28677	3043	1567	1071	1313	6176	75898

Table 4.17. (continued).

Age year	3	4	5	6	7	8	9	10	11+	SSBSOP
1989	418	2353	15657	46772	14987	2518	995	716	4676	89091
1990	690	2142	8194	29158	42758	10382	2042	888	1845	98099
1991	1696	3025	6321	16840	38389	39319	8363	1523	1350	116825
1992	2378	9021	9261	12127	21022	38622	34411	7127	1369	135338
1993	3546	11902	25137	12563	11103	17211	31170	23635	4855	141121
1994	1338	18736	36987	34351	9497	8241	12666	24409	20254	166479
1995	433	6176	64400	52161	24553	5764	5653	7821	16977	183938
1996	588	2446	22678	114239	49989	13854	3861	4281	23172	235110
1997	844	1775	7140	40945	107094	30956	6230	1929	6811	203724
1998	667	3577	7171	14141	37784	61741	19952	3888	6416	155338
1999	3304	3477	12285	13511	14038	26474	27121	13460	11497	125167
2000	748	15197	10845	17991	12845	10193	16394	12338	3935	100486
2001	3083	3918	44724	19520	20744	11420	7845	13114	15935	140302
2002	1893	15925	14876	63228	19516	17385	9089	4764	11686	158363
2003	1215	9067	50711	27228	50869	16140	13845	7501	11249	187825
2004	1623	5380	31012	77686	25648	27101	12331	7574	5940	194295
2005	2769	6706	17799	58677	66278	21640	15604	10294	17065	216831
2006	1486	12458	21943	34627	50841	35051	17197	6560	4052	184216
2007	3080	7245	42569	39086	37263	35302	17643	13481	24750	220419
2008	3363	17631	23248	65357	37571	26170	20491	10604	6715	211150
2009	2197	16359	55875	45344	49657	27448	17625	13031	16827	244365
2010	652	13566	63041	116213	49715	29035	19731	12938	56628	361519

Table 4.18. Northeast Arctic haddock. Summary.

YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR4_7
1950	80445	237329	130535	132125	1.0122	0.6222	0.8371
1951	662258	348413	97875	120077	1.2268	0.8074	0.6358
1952	72667	230815	55402	127660	2.3042	0.5682	0.7463
1953	1245502	501304	82864	123920	1.4955	0.6938	0.5255
1954	147983	526092	115108	156788	1.3621	0.6712	0.3898
1955	62332	476852	176055	202286	1.1490	0.6434	0.5220
1956	203088	462785	238661	213924	0.8964	0.7823	0.4680
1957	63225	313716	179145	123583	0.6898	0.7943	0.4559
1958	82692	262667	147772	112672	0.7625	0.8790	0.5544
1959	390902	343926	120505	88211	0.7320	1.0522	0.4127
1960	286901	383604	103485	154651	1.4944	0.9508	0.5093
1961	129579	376414	119121	193224	1.6221	0.9933	0.6827
1962	285093	332860	109350	187408	1.7138	0.9403	0.8449
1963	329333	294866	73487	146224	1.9898	0.8641	0.9019
1964	383645	286221	57308	99158	1.7303	0.7292	0.6756
1965	122085	342395	89044	118578	1.3317	0.8596	0.5150
1966	285944	371362	119915	161778	1.3491	0.8508	0.6313
1967	355684	447195	143598	136397	0.9499	0.9904	0.4399
1968	21570	402608	156889	181726	1.1583	0.9912	0.5277
1969	21172	323291	168571	130820	0.7761	1.1202	0.4086
1970	197328	267987	141613	88257	0.6232	1.0136	0.3741
1971	114719	321678	152377	78905	0.5178	1.2935	0.2537
1972	1204665	590094	114977	266153	2.3148	0.9123	0.7339
1973	319222	568027	105465	322226	3.0553	0.8495	0.5828
1974	62740	558097	186596	221157	1.1852	1.1049	0.5055
1975	57677	437879	224139	175758	0.7841	1.1027	0.5283
1976	65272	266602	176821	137264	0.7763	0.8836	0.6883
1977	132035	186823	106152	110158	1.0377	0.9102	0.8305
1978	206306	201084	83319	95422	1.1453	1.0764	0.6709
1979	169860	252446	73840	103623	1.4033	1.2883	0.6880
1980	29524	271116	75480	87889	1.1644	1.3001	0.4908
1981	13188	226140	92002	77153	0.8386	1.3742	0.4766
1982	16435	169106	91802	46955	0.5115	1.3680	0.3518
1983	9206	86255	56202	24600	0.4377	0.9536	0.3034
1984	12259	68362	50464	20945	0.4150	0.9491	0.2789
1985	293827	171927	50748	45052	0.8878	1.0243	0.3378
1986	533759	334556	52224	100563	1.9256	0.9508	0.4883
1987	120186	331044	66921	154916	2.3149	1.0078	0.6332
1988	57121	263816	75898	95255	1.2550	1.0045	0.5026
1989	28765	216657	89091	58518	0.6568	1.0230	0.3661

Table 4.18. (continued).

YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR4_7
1990	36968	178576	98099	27182	0.2771	0.9843	0.1474
1991	107013	205221	116825	36216	0.3100	0.9639	0.1909
1992	222307	285629	135338	59922	0.4428	1.0207	0.2679
1993	673447	462784	141121	82379	0.5837	0.9969	0.3390
1994	302155	573557	166479	135186	0.8120	0.9944	0.4189
1995	98786	562124	183938	142448	0.7744	0.9759	0.3564
1996	106472	507724	235110	178128	0.7576	0.9832	0.3817
1997	116281	369578	203724	154359	0.7577	0.9506	0.4756
1998	63564	271516	155338	100630	0.6478	0.9887	0.4019
1999	228580	276815	125167	83195	0.6647	0.9791	0.4080
2000	97331	258642	100486	68944	0.6861	0.9742	0.2678
2001	374717	369362	140302	89640	0.6389	1.0098	0.2648
2002	351908	451590	158363	114798	0.7249	0.9890	0.2984
2003	231970	496848	187825	138926	0.7397	0.9815	0.4236
2004	240625	482608	194295	158279	0.8146	0.9810	0.3495
2005	351707	519724	216831	158298	0.7301	0.9966	0.4614
2006	188696	469105	184216	153157	0.8314	1.0062	0.3701
2007	765028	666461	220419	161525	0.7328	1.0089	0.3775
2008	1192518	946601	211150	155604	0.7369	1.0073	0.3316
2009	1056821	1234415	244365	200061	0.8187	1.0000	0.3079
2010	284421	1263689	361519	249334	0.6897	0.9881	0.2494

Table 4.19. Northeast Arctic haddock. Prediction with management option table: Input data

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	120000	0.451	0.014	0	0	0.264	0.0167	0.713
4	176852	0.348	0.043	0	0	0.527	0.0811	0.987
5	401842	0.347	0.143	0	0	0.841	0.1735	1.267
6	262473	0.272	0.475	0	0	1.164	0.3485	1.554
7	102802	0.200	0.779	0	0	1.560	0.3946	1.835
8	22582	0.200	0.950	0	0	2.060	0.3050	2.057
9	8789	0.200	0.974	0	0	2.372	0.2347	2.150
10	5913	0.200	0.993	0	0	2.773	0.2409	2.332
11	3202	0.200	1.000	0	0	3.049	0.2409	2.845

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	315000	0.451	0.024	0	0	0.308	0.0167	0.713
4	.	0.348	0.055	0	0	0.490	0.0811	0.987
5	.	0.347	0.161	0	0	0.828	0.1735	1.267
6	.	0.272	0.374	0	0	1.187	0.3485	1.554
7	.	0.200	0.767	0	0	1.533	0.3946	1.835
8	.	0.200	0.928	0	0	1.949	0.3050	2.057
9	.	0.200	0.981	0	0	2.465	0.2347	2.150
10	.	0.200	0.994	0	0	2.759	0.2409	2.332
11	.	0.200	1.000	0	0	3.148	0.2409	2.845

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	188000	0.451	0.023	0	0	0.301	0.0167	0.713
4	.	0.348	0.087	0	0	0.565	0.0811	0.987
5	.	0.347	0.185	0	0	0.774	0.1735	1.267
6	.	0.272	0.396	0	0	1.171	0.3485	1.554
7	.	0.200	0.599	0	0	1.558	0.3946	1.835
8	.	0.200	0.914	0	0	1.916	0.3050	2.057
9	.	0.200	0.976	0	0	2.341	0.2347	2.150
10	.	0.200	0.994	0	0	2.860	0.2409	2.332
11	.	0.200	1.000	0	0	3.133	0.2409	2.845

Table 4.20. Northeast Arctic haddock. Prediction with management option table for 2011-2013

Biomass 2011	SSB 2011	FMult	FBar		Corresponding	landings 2011
1022246	413372	1	0.2494			262722

2012					2013	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
907292	461267	0	0	0	981428	596095
.	461267	0.1	0.0249	27594	956283	577096
.	461267	0.2	0.0499	54324	931966	558739
.	461267	0.3	0.0748	80219	908447	541004
.	461267	0.4	0.0998	105308	885699	523868
.	461267	0.5	0.1247	129618	863696	507311
.	461267	0.6	0.1497	153174	842412	491312
.	461267	0.7	0.1746	176002	821822	475852
.	461267	0.8	0.1995	198127	801903	460912
.	461267	0.9	0.2245	219572	782632	446475
.	461267	1	0.2494	240359	763987	432522
.	461267	1.1	0.2744	260511	745946	419038
.	461267	1.2	0.2993	280049	728488	406005
.	461267	1.3	0.3243	298993	711594	393408
.	461267	1.4	0.3492	317363	695245	381233
.	461267	1.5	0.3741	335177	679421	369464
.	461267	1.6	0.3991	352456	664106	358088
.	461267	1.7	0.424	369215	649281	347091
.	461267	1.8	0.449	385473	634930	336460
.	461267	1.9	0.4739	401246	621038	326182

Table 4.21. Northeast Arctic haddock. Prediction single option table for 2011-2013

Year:	2011	F multiplier:	1	Fbar:	0.2494		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0167	1601	1141	120000	31680	1680	444
4	0.0811	11662	11511	176852	93201	7605	4008
5	0.1735	54353	68865	401842	337949	57463	48327
6	0.3485	68154	105912	262473	305519	124675	145121
7	0.3946	30579	56112	102802	160371	80083	124929
8	0.305	5408	11124	22582	46519	21453	44193
9	0.2347	1673	3597	8789	20848	8560	20305
10	0.2409	1152	2686	5913	16397	5872	16282
11	0.2409	624	1775	3202	9763	3202	9763
Total		175205	262722	1104455	1022246	310592	413372

Year:	2012	F multiplier:	1.4033	Fbar:	0.35		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0234	5878	4191	315000	97020	7560	2328
4	0.1138	6852	6763	75173	36835	4135	2026
5	0.2435	21173	26826	115147	95342	18539	15350
6	0.489	81757	127051	238784	283436	89305	106005
7	0.5537	54887	100718	141125	216345	108243	165937
8	0.428	18029	37085	56724	110556	52640	102596
9	0.3294	3485	7493	13628	33594	13369	32956
10	0.3381	1488	3469	5691	15700	5656	15606
11	0.3381	1533	4362	5865	18463	5865	18463
Total		195082	317958	967138	907292	305313	461267

Year:	2013	F multiplier:	1.4033	Fbar:	0.35		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0234	3508	2501	188000	56588	4324	1302
4	0.1138	17865	17633	196005	110743	17052	9635
5	0.2435	8710	11036	47370	36664	8763	6783
6	0.489	21844	33946	63799	74709	25265	29585
7	0.5537	43386	79614	111554	173802	66821	104107
8	0.428	21108	43420	66414	127249	60702	116306
9	0.3294	7741	16643	30271	70865	29545	69164
10	0.3381	2099	4894	8027	22957	7979	22819
11	0.3381	1764	5019	6747	21139	6747	21139
Total		128025	214705	718187	694716	227198	380839

Table 4.22. Northeast Arctic haddock. Prediction using HCR catch constraint for 2012-2013

Year:	2011	F multiplier:	1	Fbar:	0.2494		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0167	1601	1141	120000	31680	1680	444
4	0.0811	11662	11511	176852	93201	7605	4008
5	0.1735	54353	68865	401842	337949	57463	48327
6	0.3485	68154	105912	262473	305519	124675	145121
7	0.3946	30579	56112	102802	160371	80083	124929
8	0.305	5408	11124	22582	46519	21453	44193
9	0.2347	1673	3597	8789	20848	8560	20305
10	0.2409	1152	2686	5913	16397	5872	16282
11	0.2409	624	1775	3202	9763	3202	9763
Total		175205	262722	1104455	1022246	310592	413372

Catch corresponding Fpa, Changing TAC from 2011 (303000) = +5%

Year:	2012	F multiplier:	1.4033	Fbar:	0.35		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0234	5878	4191	315000	97020	7560	2328
4	0.1138	6852	6763	75173	36835	4135	2026
5	0.2435	21173	26826	115147	95342	18539	15350
6	0.489	81758	127051	238784	283436	89305	106005
7	0.5537	54887	100718	141125	216345	108243	165937
8	0.428	18029	37085	56724	110556	52640	102596
9	0.3294	3485	7493	13628	33594	13369	32956
10	0.3381	1488	3469	5691	15700	5656	15606
11	0.3381	1533	4362	5865	18463	5865	18463
Total		195082	317958	967138	907292	305313	461267

Catch constraint 317958*0.75=238500 Changing TAC from 2012 (318000) = -25%

Year:	2013	F multiplier:	1.6011	Fbar:	0.3994		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0267	3996	2849	188000	56588	4324	1302
4	0.1298	20233	19970	196005	110743	17052	9635
5	0.2778	9786	12398	47370	36664	8763	6783
6	0.558	24188	37588	63799	74709	25265	29585
7	0.6318	47851	87806	111554	173801	66821	104107
8	0.4883	23445	48226	66414	127249	60702	116306
9	0.3758	8648	18593	30271	70865	29545	69164
10	0.3857	2343	5464	8027	22957	7979	22819
11	0.3857	1970	5604	6747	21139	6747	21139
Total		142460	238500	718187	694715	227198	380839

Table 4.23. Northeast Arctic haddock.Yield per recruit. Input data and results.

MFYPR	version	2a					
Run:	2011						
Time	and	date:	16:22		02.05.2011		
Age	M	Mat	PF	PM	SWt	Sel	CWt
3	0.451	0.014	0	0	0.264	0.0167	0.713
4	0.348	0.043	0	0	0.527	0.0811	0.987
5	0.347	0.143	0	0	0.841	0.1735	1.267
6	0.272	0.475	0	0	1.164	0.3485	1.554
7	0.2	0.779	0	0	1.56	0.3946	1.835
8	0.2	0.95	0	0	2.06	0.305	2.057
9	0.2	0.974	0	0	2.372	0.2347	2.15
10	0.2	0.993	0	0	2.773	0.2409	2.332
11	0.2	1	0	0	3.049	0.2409	2.845
Yield per							
MFYPR	version	2a					
Run:	2011						
Time	and	date:	16:22		02.05.2011		
Yield	per	results					
FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan
0	0	0	0	3.7408	4.7185	1.5242	3.502
0.1	0.0249	0.0495	0.0925	3.5066	4.0923	1.3041	2.8933
0.2	0.0499	0.0893	0.1619	3.3208	3.6075	1.1319	2.4251
0.3	0.0748	0.1221	0.2151	3.1702	3.2244	0.9942	2.0578
0.4	0.0998	0.1494	0.2565	3.0458	2.9164	0.8824	1.7649
0.5	0.1247	0.1728	0.2895	2.9415	2.6652	0.7903	1.528
0.6	0.1497	0.1929	0.316	2.8529	2.4576	0.7134	1.3342
0.7	0.1746	0.2105	0.3376	2.7767	2.2842	0.6486	1.1739
0.8	0.1995	0.226	0.3555	2.7105	2.1378	0.5934	1.0402
0.9	0.2245	0.2399	0.3705	2.6524	2.0132	0.5461	0.9277
1	0.2494	0.2523	0.3832	2.6011	1.9061	0.5051	0.8323
1.1	0.2744	0.2636	0.394	2.5553	1.8135	0.4694	0.7508
1.2	0.2993	0.274	0.4033	2.5143	1.7328	0.4381	0.6809
1.3	0.3243	0.2834	0.4114	2.4772	1.662	0.4105	0.6204
1.4	0.3492	0.2922	0.4185	2.4435	1.5995	0.386	0.5679
1.5	0.3741	0.3003	0.4248	2.4127	1.544	0.3642	0.5221
1.6	0.3991	0.3079	0.4304	2.3844	1.4945	0.3447	0.4819
1.7	0.424	0.315	0.4354	2.3583	1.45	0.3271	0.4464
1.8	0.449	0.3217	0.44	2.3341	1.4099	0.3113	0.415
1.9	0.4739	0.328	0.4441	2.3116	1.3735	0.2969	0.3871
2	0.4989	0.334	0.4479	2.2905	1.3404	0.2838	0.3622
Reference	point	F	Absolute F				
Fbar(4-7)	1	0.2494					
FMax	>=1000000						
F0.1	1.0535	0.2628					
F35%SPR	0.6657	0.166					
Weights	in	kilograms					

Table B1 Northeast Arctic haddock. Results from the Joint Barents Sea bottom trawl survey (BS-NoRu-Q1 (BTr)) in the Barents Sea in January-March. Indices of numbers of fish at age. Indices for 1983-1998 revised August 1999.

	Age											Area covered
Year	1	2	3	4	5	6	7	8	9	10+	Total	(1000 nm^2)
1981	3.1	7.3	2.3	7.8	1.8	5.3	0.5	0.2	0	0	28.3	88.1
1982	3.9	1.5	1.7	1.8	1.9	4.8	2.4	0.2	0	0	18.2	88.1
1983	2919.3	4.8	3.1	2.4	0.9	1.9	2.5	0.7	0	0	2935.6	88.1
1984	3832.6	514.6	18.9	1.5	0.8	0.2	0.1	0.4	0.1	0	4369.2	88.1
1985	1901.1	1593.8	475.9	14.7	0.5	0.5	0.1	0.1	0.4	0.3	3987.4	88.1
1986	665.0	370.3	384.6	110.8	0.6	0.2	0.1	0.1	0.1	0.1	1531.9	88.1
1987	163.8	79.9	154.4	290.2	52.9	0.0	0	0	0	0.3	741.5	88.1
1988	35.4	15.3	25.3	68.9	116.4	13.8	0.1	0	0	0	275.2	88.1
1989	81.2	9.5	14.1	21.6	34.0	32.7	3.4	0.1	0	0	196.6	88.1
1990	644.1	54.6	4.5	3.4	5.0	9.2	11.8	1.8	0	0	734.4	88.1
1991	2006.0	300.3	33.4	5.1	4.2	2.7	1.7	4.2	0	0	2357.6	88.1
1992	1659.4	1375.5	150.5	24.4	2.1	0.6	0.7	1.6	2.3	0	3217.1	88.1
1993	727.9	599.0	507.7	105.6	10.5	0.6	0.4	0.3	0.4	1.1	1953.5	137.6
1994	603.2	228.0	339.5	436.6	49.7	3.4	0.2	0.1	0.2	0.6	1661.5	143.8
1995	1463.6	179.3	53.6	171.1	339.5	34.5	2.8	0	0.1	0	2244.5	186.6
1996	309.5	263.6	52.5	48.1	148.6	252.8	11.6	0.9	0	0.1	1087.7	165.3
1997[1]	1268.0	67.9	86.1	28.0	19.4	46.7	62.2	3.5	0.1	0	1581.9	87.5
1998[1]	212.9	137.9	22.7	33.2	13.2	3.4	8.0	8.1	0.7	0.1	440.2	99.2
1999	1244.9	57.6	59.8	12.2	10.2	2.8	1.0	1.7	1.1	0	1391.3	118.3
2000	847.2	452.2	27.2	35.4	8.4	4.0	0.8	0.3	0.7	0.2	1376.4	162.4
2001	1220.5	460.3	296.0	29.3	25.1	1.7	0.9	0.1	0.1	0.3	2034.3	164.1
2002	1680.3	534.7	314.7	185.3	17.6	8.2	0.8	0.3	0	0.3	2742.2	156.7
2003	3332.1	513.1	317.4	182	73.6	5.5	2.3	0.2	0.1	0.2	4426.5	146.6
2004	715.9	711.2	188.1	102.7	80.4	46.2	5.9	1.1	0.2	0.1	1852	164.6
2005	4630.2	420.4	346.5	133.3	66.8	52.2	12.3	0.6	0.2	0	5662.4	178.9
2006	5141.3	1313.1	77.4	140.5	48.2	19.6	15.2	3.1	0.1	0.3	6758.8	1691
2007[1]	3874.4	1593.8	507.7	66	86	23.3	7.5	3.7	1.4	0.2	6164	122.2
2008	860.2	2129.4	1522.4	600.9	86.8	48.9	6.27	2.51	0.82	0.13	7257	164.4
2009	564.7	328	1270.4	773.2	365.4	38.5	10.6	1.4	0.1	0.3	998	170.9
2010	1619.5	111.2	102.8	508.6	479.6	131.2	7	1	0.6	0.6	2962	159.9
2011	685.4	343.5	64.9	95.1	468.3	338.1	62.1	1.6	0.4	0.2	2456	173.1

[1]Indices adjusted to account for limited area coverage.

Survey areas extended from 1993 onwards.

Table B2 Northeast Arctic haddock. Results from the Russian trawl survey (RU-BTr-Q4) in the Barents Sea and adjacent waters in late autumn (numbers per hour trawling).

Year \Age	0	1	2	3	4	5	6	7	8	9	10+	Total
					Sub-area I							
1983	39.9	97.3	16.5	0.8	0.7	+	-	-	-	-	1.1	156.3
1984	9.7	100.2	110.6	2.8	0.4	0.2	+	-	-	-	0.7	224.6
1985	3.9	19.1	213.4	168.8	0.8	0.2	0.1	-	-	-	0.3	406.6
1986	0.2	2.3	16.6	58.1	27.6	0.1	+	+	+	-	-	105
1987	0.4	1.4	2.5	12.5	34.2	8.6	+	+	-	+	-	59.8
1988	1.9	0.4	1.1	2.8	6.2	11.6	1.1	+	+	+	-	25.2
1989	3.3	3	3.6	0.7	2.5	7.1	13.9	1.8	0.1	+	-	36
1990	71.7	22.2	18.6	13.2	7.5	13.2	13.3	10.3	0.6	0.1	-	170.7
1991	15.9	61.5	27.5	10.8	1.6	0.6	1	3.3	2.6	0.3	-	125.1
1992	19.6	44.2	180.6	52.1	8.4	0.7	1	1.6	1.3	0.2	-	309.7
1993	5.5	8.1	69.2	371.5	78.4	10.2	1.4	0.7	0.8	1.8	-	547.7
1994	13.5	6.7	8	65.9	146	15.9	1.7	0.1	0.2	0.7	-	258.8
1995	9.9	12.7	6.5	4	26.8	77.6	7.3	1	0.1	0.5	-	146.3
1996	5	3.1	5.6	3.4	7.7	62.3	56.5	4.8	0.4	0.6	-	149.3
1997[1]	2.7	6.9	3.2	5.3	5.5	1.5	4.5	1.7	1.5	-	-	32.7
1998	10.5	2.9	17.2	6.7	7.8	0.6	0.9	2.1	0.7	+	-	49.4
1999	6.9	34.9	8.8	34	5.3	5.6	1.2	0.3	0.9	0.3	-	98.2
2000	18	25.4	37.5	9.3	13	3.2	1.1	0.2	0.1	0.4	-	108.3
2001	30.5	18.6	42.3	58.9	5.8	6.8	0.8	0.5	0.1	0.1	-	164.5
2002	39.7	29.2	29.4	69.2	74.7	6.7	3.2	0.6	0.1	0.2	-	252.7
2003	28.1	38.9	35.4	28.1	43	28	3.5	0.8	0.1	0.1	-	206
2004	47.9	12	27.9	18.6	12.8	16.1	12.4	0.8	0.3	0.1	-	148.9
2005	62.7	109.6	20.7	34.4	12.4	6.5	7.1	2.5	0.1	0.1	-	256.1
2006[3]	48	168.7	157.9	15.2	25.5	7.3	3.1	2.7	0.8	0.2	-	429.4
2007	4.3	90.2	153.6	98.7	9.1	9	2.3	0.7	0.4	0.1	-	368.5
2008	5.9	14.6	284.4	283.4	153	17.2	11.8	1.5	0.3	0.3	-	772.5
2009	14.7	3.2	25.2	243.8	264.8	102.5	8.8	4.3	0.6	0.4	-	668.4
2010	6.6	25.6	4.7	46.2	223.3	204.5	60.0	2.4	1.2	0.3	-	574.8
					Division IIa							
1983	5.4	5.5	0.1	0.2	0.3	0.1	-	-	-	-	1	12.6
1984	4.9	14.4	5.6	0.1	0.1	0.1	-	-	-	-	0.2	25.4
1985	3.8	7	11.7	4.1	0.1	-	+	-	-	-	0.1	26.8
1986	0.4	0.3	3.5	10.4	2.9	0.1	+	+	-	-	-	17.6
1987	-	-	-	-	0.3	0.3	-	-	-	-	-	0.6
1988	1	0.1	-	+	0.2	0.5	0.2	-	-	-	-	2.1
1989	0.1	0.7	2.7	+	0.1	0.1	0.1	-	-	-	-	3.8
1990	6.1	0.9	0.9	0.1	0.1	0.1	0.1	0.1	-	-	-	8.4
1991	5.7	3.8	0.6	0.1	+	-	-	-	-	-	-	10.2
1992	1.2	2.3	5.6	2.3	3	0.3	0.3	0.4	0.4	-	-	15.8
1993	1.8	1.1	1.5	4.5	2.5	0.8	0.2	0.1	0.2	0.2	-	12.8
1994	1	0.6	0.5	3.1	15.9	4.4	1.5	+	0.1	0.1	-	27.2
1995	5	8.5	6.3	5.3	6.2	23.9	4.1	0.6	+	0.2	-	60.1
1996	29.2	4.1	25	8.1	4.9	9.1	13.4	1.3	0.4	0.1	-	95.7
1997	1.2	2.8	0.8	1.3	0.7	0.6	0.9	0.5	0.1	-	-	8.9
1998	23.2	7.8	15.5	1.1	2.4	3.2	0.5	2.8	0.8	0.1	-	57.3
1999	34.8	34.1	4.3	16.9	3.9	6.3	1.7	0.9	1.2	0.5	-	104.6
2000	27.9	23.9	13.5	1.8	9.3	2	0.9	0.2	0.2	0.4	-	80.1
2001	39	13.5	7.6	8.4	2.2	7.9	1.4	0.3	0.1	0.4	-	80.8
2002[2]	61.9	16.6	5.3	10.2	29.9	6	3.3	0.3	0.1	0.2	-	133.7
2003	20.6	30.8	9.8	8.3	10.4	16.1	2.4	2.1	0.2	+	-	100.7
2004	100.2	32.8	18.1	4.5	5.5	7.2	8.1	0.7	1.1	0.3	-	178.4
2005	61.6	23.9	4.6	10.9	2.1	2.7	5.3	2.9	0.5	0.2	-	114.6
2006	33.3	36.9	15.2	1.9	8.2	3.4	2.5	1.8	1.8	0.3	-	105.5
2007	28.2	96	33.9	14.1	2.1	5.1	2.2	0.6	0.9	0.4	-	183.4
2008	13.6	23.8	64.3	26.8	9.6	1.8	2.6	0.4	0.3	0.3	-	143.6
2009	8.6	5.7	7.6	34.5	23.2	9.2	1.2	1.7	0.2	0.1	-	91.9
2010	19.9	31.2	9.6	7.4	29.3	22.3	10.8	1.0	1.1	0.2	-	132.8

Table B2 (continued)

Year \ Age	0	1	2	3	4	5	6	7	8	9	10+	Total
Division IIb												
1983	22.1	9.9	0.2	0.1	+	+	-	-	-	-	0.1	32.4
1984	2.2	14.3	1.8	-	-	-	-	-	-	-	+	18.3
1985	1.4	10.2	61.4	5.1	+	+	+	-	-	-	+	78.1
1986	+	0.2	3.1	7.2	1.4	-	+	-	-	-	-	12
1987	-	-	0.1	0.7	1.4	0.5	+	-	-	-	-	2.8
1988	0.2	-	-	+	0.3	1.1	0.2	-	+	-	-	1.8
1989	0.7	0.1	0.2	+	0.1	0.3	0.6	0.1	+	-	-	2.1
1990	12.9	5.4	0.8	+	+	0.2	0.1	0.1	+	-	-	19.5
1991	20	22.9	6.2	0.4	0.1	0.1	0.1	+	+	-	-	49.8
1992	13.3	9.1	69.8	13.9	0.5	+	+	-	+	+	-	106.6
1993	0.7	0.9	1.9	24.7	1.9	0.2	+	+	+	+	-	30.4
1994	0.4	1.7	1.7	2.3	15.7	2.7	0.8	0.2	+	+	-	25.5
1995	0.1	0.4	0.4	0.8	0.6	1.6	0.4	+	+	+	-	4.3
1996[1]	4.3	0.6	0.5	0.3	0.2	0.4	0.5	0.3	-	-	-	7.1
1997[1]	0.4	1.1	0.1	0.1	0.1	0.1	0.1	0.1	+	+	-	2.1
1998	5.8	1.1	0.2	+	0.1	0.1	+	0.1	+	-	-	7.5
1999	8.6	20.1	1.8	1.2	0.5	0.3	0.1	-	0.2	0.1	-	32.9
2000	7.9	10	13.4	1.3	5.5	2.2	1.2	0.4	0.2	0.3	-	42.4
2001	2.7	13.1	15.9	11.4	0.8	4.7	1.2	0.4	0.1	0.6	-	51
2002[2]	9	4.2	7.7	5.1	2.6	0.7	0.8	0.1	0.1	0.1	-	30.4
2003	3.6	21.5	10.4	15.5	11.3	15.9	3.6	3	0.4	0.3	-	85.7
2004	34.9	5.6	6.4	1.3	2.6	1.8	2.9	0.1	0.2	0.1	-	56
2005	60.9	43.5	4.1	10.3	4.1	2.7	3.6	2.2	0.1	0.3	-	131.7
2006[3]	75.4	110.6	71.6	4.6	6.1	2.4	1.4	2	1.8	0.3	-	276.2
2007	3.3	67.3	396.4	78.7	5.5	26	7.3	2.9	2.6	0.8	-	590.9
2008	1.5	3.8	204.1	304.3	50.7	7.4	13.6	2.9	2	0.7	-	591.9
2009	2.6	1.1	3.5	93.6	81	22	2.4	2.1	0.3	0.5	-	209
2010	4.3	4.5	1.3	11.1	136.5	138.4	38.6	6.3	1.7	0.6	-	343.2
Total-Sub-area I and Divisions IIa and IIb												
1983	29.8	59.2	9.5	0.5	0.4	+	-	-	-	-	0.8	100.2
1984	6.4	58.6	58.4	1.5	0.2	0.1	+	-	-	-	0.3	125.5
1985	3	14.4	134.3	90	0.4	0.1	0.1	-	-	-	0.2	242.7
1986	0.2	1.4	10.7	36.3	16.4	0.1	+	+	+	-	+	65.1
1987	0.3	0.9	1.7	8.3	22.5	5.7	+	+	-	+	-	39.4
1988	1.3	0.3	0.7	1.7	4	7.6	0.8	+	+	+	-	16.4
1989	2.2	1.8	2.4	0.4	1.4	4.1	8.1	1.1	0.1	+	-	21.6
1990	44.8	14.3	10.6	7.3	4.2	7.3	7.4	5.7	0.3	0.1	-	102
1991	16.7	42.9	17.6	6.2	0.9	0.3	0.6	1.8	1.5	0.2	-	88.7
1992	16.4	28.2	128.6	34.6	5	0.4	0.6	0.9	0.8	0.1	-	215.6
1993	3.5	4.8	35.7	198.5	35.6	4.8	0.8	0.4	0.4	-	-	284.5
1994	9.1	4.9	5.8	44.2	101.4	11.6	1.5	0.1	0.1	0.5	-	179.2
1995	6.4	7.2	4.2	3.1	12.3	37	4	0.5	0.1	0.3	-	75.1
1996[1]	6	2.3	5.7	2.8	4.9	36.2	33.4	2.9	0.3	0.3	-	94.8
1997[1]	1.8	4.6	1.9	3.2	3.2	1	2.7	1	0.8	-	-	20.2
1998	10.7	2.9	11.5	3.8	4.6	0.8	0.5	1.5	0.5	+	-	36.8
1999	11.7	28.9	6.1	19.6	3.9	3.7	0.8	0.3	0.7	0.7	-	76.4
2000	15.1	20.7	26.2	6	10.9	2.6	1.1	0.2	0.1	0.4	-	83.3
2001	20.8	14.9	26.1	33.4	4	6.5	1.1	0.4	0.1	0.3	-	107.5
2002[2]	33.2	19.3	18.9	39.9	45	4.7	2.4	0.4	0.1	0.2	-	164
2003	19.8	32.8	25.1	22.1	29.9	23.1	3.4	1.6	0.2	0.1	-	158.3
2004	50	11	20.6	11.3	9.4	10.7	8.7	0.5	0.4	0.2	-	122.8
2005	62	79.2	13.6	24	8.6	4.8	5.7	2.4	0.1	0.2	-	200.7
2006[3]	53.4	79.2	122.7	11.3	11.9	5.7	2.6	2.4	1.1	0.2	-	290.5
2007	6.5	83.9	214.2	83.8	7.3	13.7	3.8	1.4	1.1	0.4	-	416
2008	5.7	12.7	232.7	255.7	105.1	12.4	11.1	1.7	0.7	0.4	-	638.7
2009	10	2.9	15.8	164.7	170.4	63.1	5.7	3.2	0.5	0.4	-	436.7
2010	7.7	19.7	4.3	29.9	169.7	158.9	46.6	3.4	1.4	0.3	-	441.9

[1]Adjusted data based on average 1985-1995 distribution.

[2]Adjusted based on 2001 distribution.

[3]Adjusted based on 2004-2006 distribution.

+ means value <0.1; - means 0 value

Table B3 Northeast Arctic HADDOCK. Results from the Joint Barents Sea acoustic survey (BS-NoRu-Q1 (Aco)) **in the Barents Sea in January-March. Stock numbers in millions. New TS and rock-hopper gear (1981-1988 back-calculated from bobbins gear). Corrected for length dependent effective spread of the trawl.**

	Age											Area covered
Year	1	2	3	4	5	6	7	8	9	10	Total	(1000 nm^2)
1981	7	14	5	21	60	18	1	0	0	0	126	88.1
1982	9	2	3	4	4	10	6	0	0	0	38	88.1
1983	0	5	2	3	1	1	4	2	0	0	18	88.1
1984	1685	173	6	2	1	0	0	0	0	0	1867	88.1
1985	1530	776	215	5	0	0	0	0	0	0	2526	88.1
1986	556	266	452	189	0	0	0	0	0	0	1463	88.1
1987	85	17	49	171	50	0	0	0	0	0	372	88.1
1988	18	4	8	23	46	7	0	0	0	0	106	88.1
1989	52	5	6	11	20	21	2	0	0	0	117	88.1
1990	270	35	3	3	4	7	11	2	0	0	335	88.1
1991	1890	252	45	8	3	3	3	6	0	0	2210	88.1
1992	1135	868	134	23	2	0	0	1	2	0	2165	88.1
1993	947	626	563	130	13	0	0	0	0	3	2282	137.6
1994	562	193	255	631	111	12	0	0	0	0	1764	143.8
1995	1379	285	36	111	387	42	2	0	0	0	2242	186.6
1996	249	229	44	31	76	151	8	0	0	0	788	165.3
1997[1]	693	24	51	17	12	43	43	2	0	0	885	87.5
1998[1]	220	122	20	28	12	5	13	16	1	0	437	99.2
1999	856	46	57	13	14	4	1	2	2	0	994	118.3
2000	1024	509	32	65	19	11	2	1	2	0	1664	162.4
2001	976	316	210	23	22	1	1	0	0	1	1549	164.1
2002	2062	282	216	149	14	12	1	0	0	1	2737	156.7
2003	2394	279	145	198	169	17	5	0	0	1	3208	146.6
2004	752	474	127	76	76	66	7	2	0	0	1580	164.6
2005	3364	209	219	102	36	40	9	0	0	0	3979	178.9
2006	2767	804	54	86	30	12	9	2	0	0	3764	1691
2007[1]	3197	868	379	54	88	22	6	5	2	0	4621	122.2
2008	1266.6	1835	723	252	57	74	10	6	0	1	4226	164.4
2009	849	246.3	1021.7	773	402.1	31.3	14.9	1.6	0.13	0.53	3341	170.9
2010	2035.8	81.8	138	593	557.4	191.4	10.3	2.9	0.68	0.72	3612	159.9
2011	786.5	408.0	47.6	68.1	313.0	262.6	52.4	1.6	0.45	0.63	1941	173.1

[1]Indices adjusted to account for limited area coverage.

Survey areas extended from 1993 onwards.

Table B4. Northeast Arctic HADDOCK. Results from the Russian trawl-acoustic survey (RU-Aco-Q4) in the Barents Sea and adjacent waters in late autumn (new method). Index of number of fish at age (+ means value <1; - means 0 value).

	Age											
Year	0	1	2	3	4	5	6	7	8	9	10+	Total
1995[5]	163	170	79	71	230	404	41	5	1	1	2	1168
1996[1,3]	992	245	291	91	63	206	187	17	1	+	+	2092
1997[1,3]	185	104	21	121	94	48	47	31	20	+	+	671
1998[2]	257	44	83	20	20	6	2	7	2	+	+	442
1999[1]	632	499	60	123	14	16	4	1	4	1	+	1355
2000[1]	524	395	287	54	57	14	6	1	1	1	1	1340
2001[1]	491	160	227	221	19	35	5	2	1	1	1	1163
2002[1,4,5]	1045	209	139	268	239	27	17	2	1	+	1	1947
2003	1168	473	217	116	134	94	14	6	1	+	+	2223
2004	8529	1141	342	116	54	55	44	3	4	1	1	10289
2005	17782	2903	123	205	62	33	38	16	1	1	+	21165
2006[6]	9396	1286	308	30	31	10	-	5	5	4	1	11075
2007	812	1473	2226	745	53	75	22	8	7	2	1	5423
2008	245	203	2134	1947	728	88	83	13	6	4	2	5455
2009	1650	204	243	1455	1258	485	46	30	4	2	1	5380
2010	1033	643	133	267	1032	923	274	19	9	1	1	4335

[1]October-December
[2]September-October
[3]November-January
[4]Adjusted based on average 1985-1995 distribution
[5]Adjusted based on 2001 distribution
[6]Adjusted data in 2004
[7]Not adjusted data to the whole area

Table B5 Northeast Arctic HADDOCK. Results from the joint ecosystem survey (Eco-NoRu-Q3 (Btr)) in August-September in the Subareas I and II . Indices of numbers (in millions) of fish at age (+ means value <1; - means 0 value).

	Age											
Year	0	1	2	3	4	5	6	7	8	9	10+	Total
2004	104	189	268	123	70	69	31	3	2	-	+	861
2005	155	626	114	323	89	29	31	15	+	+	+	1383
2006	283	2270	929	107	125	42	19	17	7	1	+	3802
2007	114	988	1819	1283	88	94	19	6	7	2	1	4421
2008	60	322	1292	1155	406	43	36	5	3	2	+	3323
2009	169	136	144	651	618	306	21	7	1	1	-	2053
2010	154	274	65	184	865	666	148	16	3	-	+	2376

Table B6 Northeast Arctic HADDOCK. Length data (cm) from Joint Barents Sea surveys (BS-NoRu-Q1 (BTr)) in January-March and Russian surveys (RU-BTr-Q4) in November-December.

		Age									
Norway	Year	1	2	3	4	5	6	7			
	1983	16.8	25.2	34.9	44.7	52.5	58	62.4			
	1984	16.6	27.5	32.7	-	56.6	62.4	61.8			
	1985	15.7	23.9	35.6	41.9	58.5	61.9	63.9			
	1986	15.1	22.4	31.5	43	54.6	-	-			
	1987	15.4	22.4	29.2	37.3	46.5	-	-			
	1988	13.5	24	28.7	34.7	41.5	47.9	54.6			
	1989	16	23.2	31.1	36.5	41.7	46.4	52.9			
	1990	15.7	24.7	32.7	43.4	46.1	50.1	52.4			
	1991	16.8	24	35.7	44.4	52.4	54.8	55.6			
	1992	15.1	23.9	33.9	45.5	53.1	59.2	60.6			
	1993	14.5	21.4	31.8	42.4	50.6	56.1	59.4			
	1994	14.7	21	29.7	38.5	47.8	54.2	56.9			
	1995	15.4	20.1	28.7	34.2	42.8	51.2	55.8			
	1996	15.4	21.6	28.6	37.8	42	46.7	55.3			
	1997	16.1	21.2	27.7	35.4	39.7	47.5	50.1			
	1998	14.4	22.9	29.2	35.8	41.3	48.4	50.9			
	1999	14.7	20.8	32.3	39.4	45.5	52.3	54.6			
	2000	15.8	22.5	30.3	41.6	47.7	50.8	51.1			
	2001	14.5	22.2	32.2	37.8	47.2	51.2	58.7			
	2002	15.4	21.1	29.6	40.2	44.2	50.9	58.4			
	2003	16.5	24.1	28	37.2	46.5	49.6	54.7			
	2004	14.2	22.3	30.6	36.3	43.4	49.8	51.4			
	2005	15.1	20.8	30	36.6	41.5	47.9	51.9			
	2006	14.7	22.6	31.3	37.8	43.2	48	50.8			
	2007[1]	15.7	23.2	28.7	37.4	45.5	48.5	53.5			
	2008	15.9	23.8	30.1	38.1	39.7	48.6	53.4			
	2009	14.5	22.5	29.6	36	41.9	46.9	51.7			
	2010	14.7	20.2	30.4	37.1	41.2	45.9	50			
	2011	13.9	23.4	27.7	37.2	42.8	46.1	48.6			
Russia	Year	0	1	2	3	4	5	6	7	8	9
	1982	14.5	21.3	33.4	37.0	-	-	-	-	-	-
	1983	18.1	26.2	30.9	44.9	53.3	62.0	65.5	67.6	68.0	73.1
	1984	-	24.0	35.8	42.7	53.7	63.1	68.1	68.1	71.0	75.2
	1985	-	21.1	31.7	43.4	53.6	62.2	64.2	-	73.1	74.1
	1986	18.1	21.0	28.7	37.0	46.6	58.8	63.1	68.1	-	73.1
	1987	-	21.7	27.6	33.3	40.9	49.4	-	-	-	-
	1988	-	19.9	29.9	35.1	40.4	46.6	52.0	-	-	-
	1989	-	20.5	25.1	40.2	45.0	48.5	52.2	58.8	63.5	-
	1990	-	20.5	29.8	37.3	48.7	50.8	54.7	58.8	63.3	68.1
	1991	-	23.2	31.7	40.3	52.7	56.7	58.8	60.3	63.2	69.1
	1992	-	22.0	32.2	41.6	52.6	59.7	61.9	65.7	68.3	70.3
	1993	18.1	20.8	28.0	38.6	48.8	55.0	61.2	64.1	63.2	65.0
	1994	15.5	20.8	28.9	36.2	44.6	53.6	60.0	66.2	67.7	67.0
	1995	14.9	21.8	28.6	36.6	42.0	48.3	56.6	62.5	66.1	66.8
	1996[1]	15.7	20.2	28.6	36.8	43.9	49.3	54.7	63.3	67.3	70.8
	1997[1]	13.7	23.3	29.5	36.6	44.6	50.0	54.7	58.7	69.1	68.1
	1998	14.4	19.3	33.1	39.2	45.9	47.9	53.5	56.1	62.0	74.1
	1999	13.5	22.6	28.0	41.9	46.6	49.2	53.1	56.3	59.8	63.5
	2000	14.2	22.3	31.7	37.0	48.6	52.5	54.8	60.8	62.0	60.5
	2001	14.8	21.9	30.7	40.3	45.1	53.0	57.3	60.7	62.2	62.5
	2002	14.7	23.5	29.4	38.2	46.4	50.8	56.2	56.0	64.6	66.9
	2003	13.8	22.7	29.4	37.5	43.9	50.5	55.2	61.1	63.3	63.5
	2004	14.3	22.5	30.0	37.9	43.6	48.4	53.7	58.4	63.5	69.1
	2005	14.9	23.5	30.0	36.9	44.8	49.9	54.7	59.2	65.9	66.6
	2006[1]	15.3	24.1	32.6	39.8	46.7	51.8	54.9	59.0	62.4	65.3
	2007	15.4	23.7	30.6	39.2	46.6	52.0	54.4	58.4	61.3	65.8
	2008	14.5	22.3	30.8	38.1	47.3	52.8	55.8	59.1	62.8	65.0
	2009	15.4	21.8	29.4	36.0	43.9	51.0	55.3	59.2	62.3	63.3
	2010	13.0	23.9	28.3	35.5	42.8	47.8	53.7	60.0	61.8	66.9

[1]Limited area coverage, lengths are not adjusted to account for limited area coverage.

Table B7 Northeast Arctic HADDOCK. Weight data (g) from Joint Barents Sea surveys (BS-NoRu-Q1 (BTr)) in January-March and Russian surveys (RU-BTr-Q4) in November-December.

Norway	Year /Age	1	2	3	4	5	6	7
	1983	52	133	480	1043	1641	2081	2592
	1984	36	196	289	964	1810	2506	2240
	1985	35	138	432	731	1970	2517	-
	1986	47	100	310	734	-	-	-
	1987	24	91	273	542	934	-	-
	1988	23	139	232	442	743	1193	1569
	1989	43	125	309	484	731	1012	1399
	1990	34	148	346	854	986	1295	1526
	1991	41	138	457	880	1539	1726	1808
	1992	32	136	392	949	1467	2060	2274
	1993	26	93	317	766	1318	1805	2166
	1994	25	86	250	545	1041	1569	1784
	1995	30	71	224	386	765	1286	1644
	1996	30	93	220	551	741	1016	1782
	1997	35	88	200	429	625	1063	1286
	1998	25	112	241	470	746	1169	1341
	1999	27	85	333	614	947	1494	1616
	2000	32	108	269	720	1068	1341	1430
	2001	28	106	337	556	1100	1429	2085
	2002	30	84	144	623	848	1341	2032
	2003	38	127	202	493	981	1189	1613
	2004	23	98	266	459	780	1167	1328
	2005	29	84	253	469	699	1054	1378
	2006	26	107	303	540	821	1111	1332
	2007[1]	32	112	237	539	970	1195	1608
	2008	33	115	250	538	692	1259	1609
	2009	25	98	230	440	718	1029	1402
	2010	28	76	273	473	656	945	1249
	2011	21	114	198	491	737	932	1152

Russia	Year /Age	0	1	2	3	4	5	6	7	8	9	10
	1982	32	102	364	500	-	-	-	-	-	-	-
	1983	57	170	271	916	1625	2346	2751	3153	3217	4290	5200
	1984	-	124	434	722	1410	2296	3071	2942	3224	3747	5408
	1985	-	94	302	788	1533	2275	2650	-	3400	4076	3943
	1986	40	91	220	470	905	1759	2300	2500	-	3550	4100
	1987	-	96	193	353	612	1101	-	-	-	-	-
	1988	-	84	250	409	641	1036	1451	-	-	-	-
	1989	-	94	160	718	926	1254	1548	2106	2781	-	7160
	1990	-	97	264	530	1250	1474	1812	2188	2626	3080	5520
	1991	-	122	342	702	1518	1915	2244	2324	2649	3249	3810
	1992	-	103	310	726	1505	2101	2386	2977	3315	3773	4800
	1993	55	84	197	543	1120	1568	2125	2474	2476	2803	3324
	1994	34	91	217	435	850	1498	2167	2875	2880	2963	3742
	1995	32	90	210	445	708	1123	1776	2398	2847	3032	3781
	1996	37	80	210	468	854	1186	1643	2429	3038	2991	4413
	1997	27	113	226	458	882	1191	1579	1963	3155	2815	3565
	1998	38	72	340	593	972	1226	1593	1803	2389	3681	4494
	1999	27	103	196	730	1003	1182	1522	1748	2148	2547	2807
	2000	24	105	313	480	1197	1502	1713	2375	2445	2286	3065
	2001	25	98	264	632	930	1534	1935	2383	2589	2631	3210
	2002	26	127	302	586	1077	1470	2029	2127	1954	2933	3986
	2003	21	103	229	498	797	1241	1649	2308	2617	3061	3390
	2004	24	87	253	518	846	1130	1571	1959	2633	3366	3859
	2005	27	115	259	511	933	1289	1670	2079	2833	2965	-
	2006[1]	26	105	269	444	867	1307	1604	1922	2274	2520	-
	2007	30	117	274	600	1012	1436	1647	2018	2314	2885	-
	2008	25	94	267	545	1046	1445	1755	2126	2458	2735	3289
	2009	28	91	241	448	841	1335	1666	2048	2438	2498	3132
	2010	17	123	208	425	764	1071	1546	2116	2317	2827	-

[1]Limited area coverage, weights are not adjusted to account for limited area coverage.

Table B8 Northeast Arctic HADDOCK. Consumption of Haddock by NEA Cod.

	Consumption of Haddock by NEA Cod						
	millions						1000' Tonnes
	1	2	3	4	5	6	
1984	980.7	14.7	0.1	0.0	0.0	0.0	50.335
1985	1206.2	5.2	0.0	0.0	0.0	0.0	46.996
1986	566.3	244.2	168.1	0.0	0.0	0.0	110.436
1987	768.4	0.0	0.0	0.0	0.0	0.0	4.226
1988	17.1	0.5	9.1	0.0	0.2	0.0	2.620
1989	230.4	0.0	0.0	0.0	0.0	0.0	10.288
1990	144.0	37.9	3.7	0.0	0.0	0.0	15.479
1991	457.8	14.2	0.0	0.0	0.0	0.0	20.205
1992	2111.4	150.8	1.1	0.0	0.0	0.0	106.083
1993	1376.4	165.3	36.6	3.4	2.9	0.0	70.896
1994	1412.3	80.0	24.6	7.4	0.9	0.0	48.293
1995	2899.5	163.0	11.7	27.9	27.4	0.3	112.823
1996	1594.1	161.4	40.2	5.5	2.6	3.4	68.694
1997	906.5	35.5	25.5	1.7	0.8	0.5	41.302
1998	1534.8	28.2	2.0	2.9	0.5	0.0	32.515
1999	898.2	23.4	0.3	0.0	0.0	0.0	25.816
2000	1216.4	65.0	2.1	1.1	0.2	0.1	51.104
2001	554.9	52.8	5.0	0.1	0.0	0.0	48.875
2002	2395.7	230.2	38.3	2.5	0.4	0.2	123.885
2003	3654.3	221.8	39.1	12.4	1.2	0.0	169.237
2004	3083.0	312.8	41.4	10.6	2.7	0.0	207.382
2005	6664.0	265.2	50.4	9.4	2.3	0.9	320.400
2006	8060.1	374.0	5.5	4.6	1.3	0.5	344.837
2007	9154.3	658.6	71.7	4.2	2.5	0.3	358.696
2008	908.6	880.3	214.8	54.0	6.9	4.3	299.854
2009	4972.3	502.2	239.8	91.1	35.9	1.8	251.102
2010	4368.6	149.6	50.1	90.9	79.3	14.4	267.038

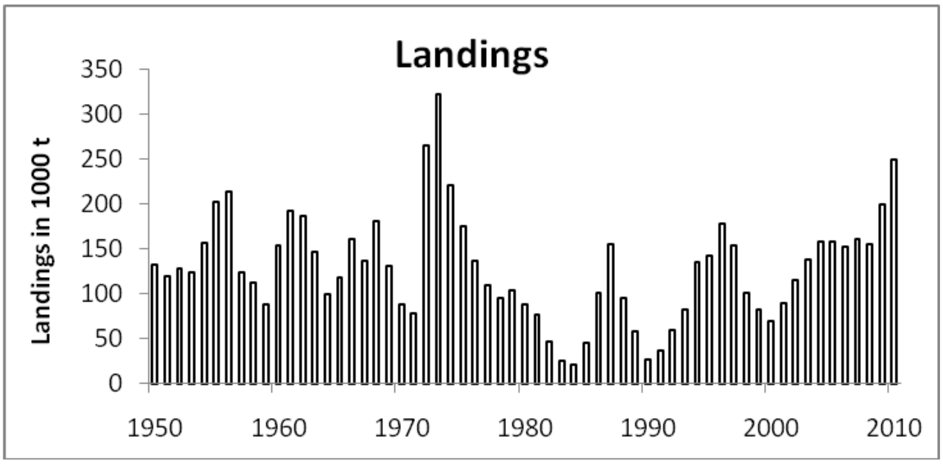


Figure 4.1A Landings of Northeast Arctic haddock 1950-2010

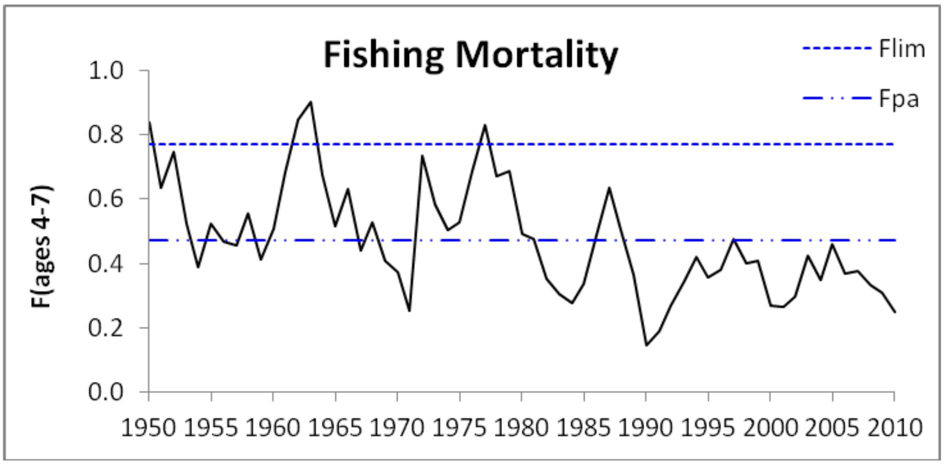


Figure 4.1B Fishing mortality of Northeast Arctic haddock 1950-2010

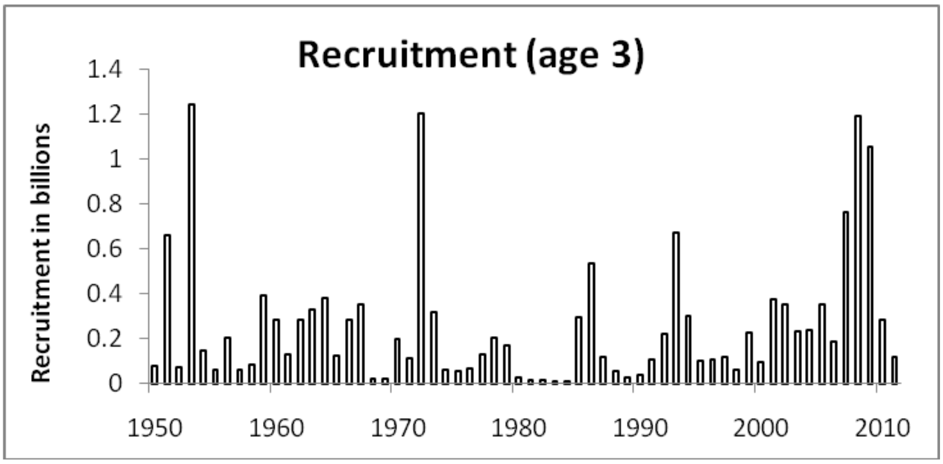


Figure 4.1C Recruitment of Northeast Arctic haddock 1950-2011

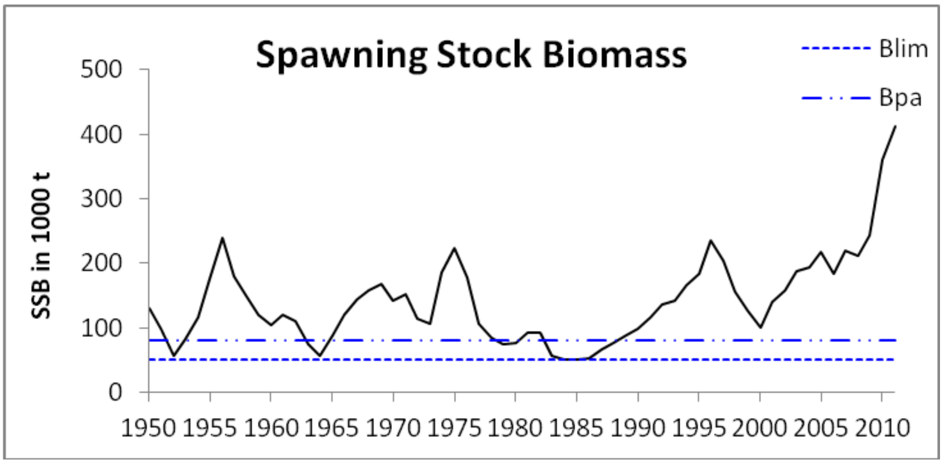


Figure 4.1D Spawning stock biomass of Northeast Arctic haddock 1950-2011

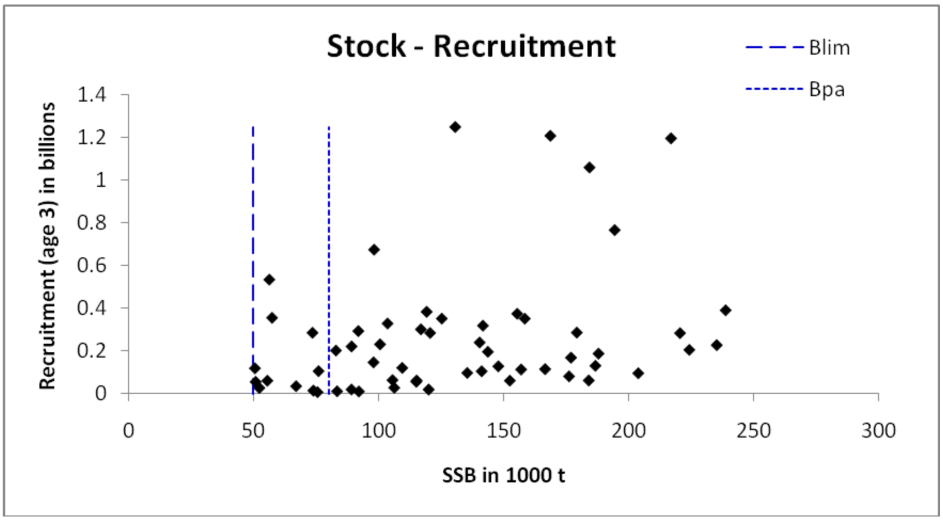


Figure 4.2 Stock-Recruitment relationship of Northeast Arctic haddock 1950-2010

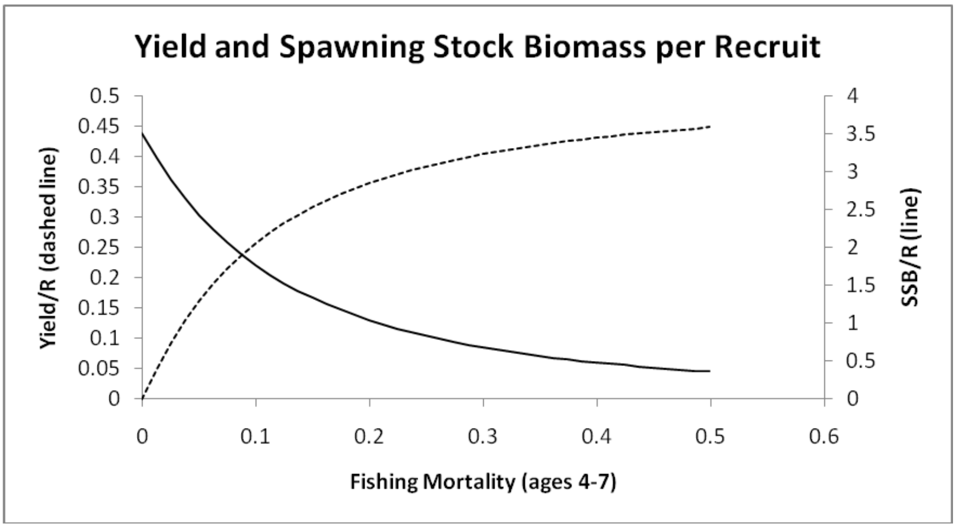


Figure 4.3 Yield and Spawning Stock Biomass per Recruit of Northeast Arctic haddock

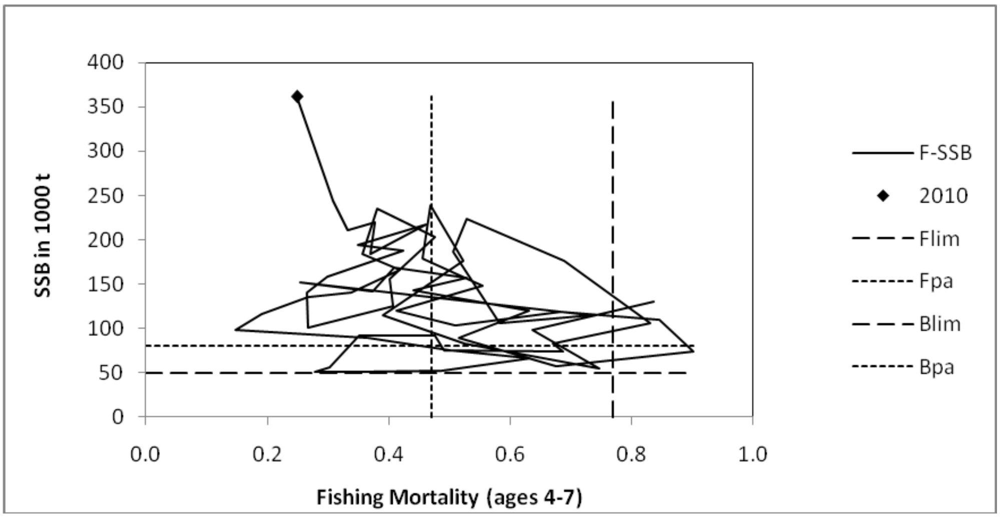


Figure 4.4 Spawning stock biomass – fishing mortality relationship of Northeast Arctic haddock 1950- 2010

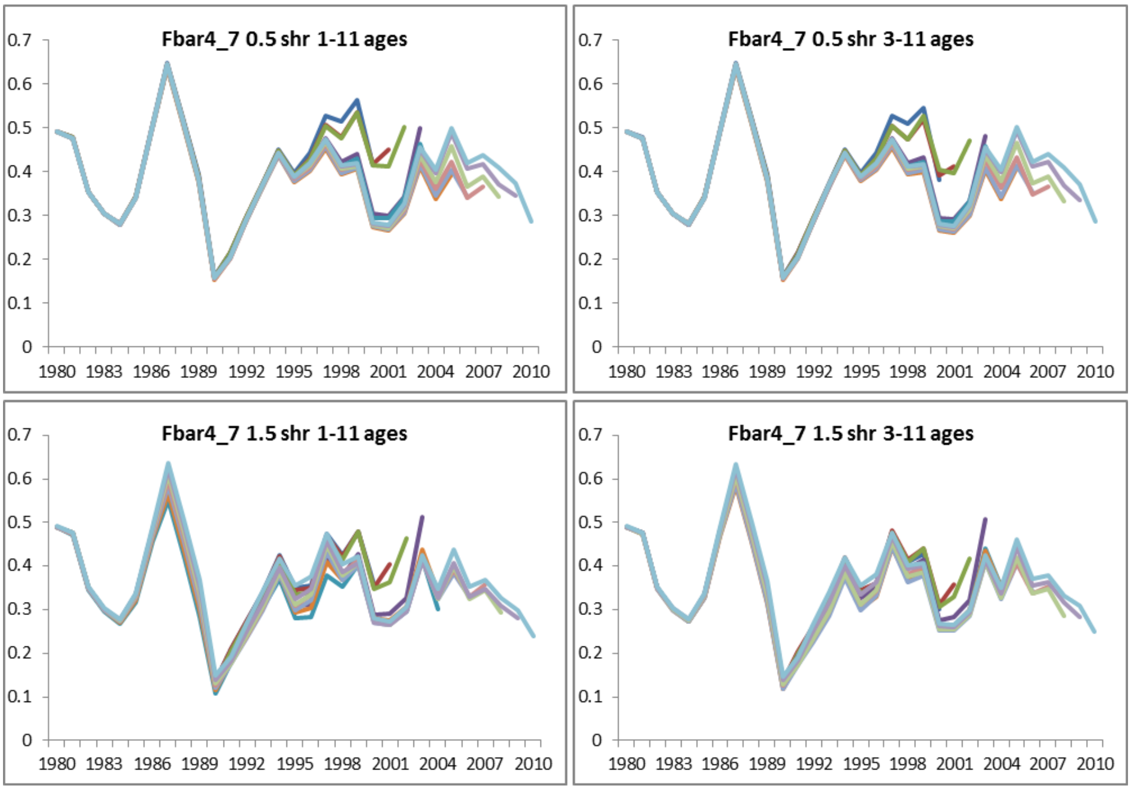


Figure 4.5A. Northeast Arctic haddock. Retrospective plots of fishing mortality for assessment years 2001-2011 using standard settings, but varying F shrinkage and age ranges in the XSA runs, keeping weight, maturity and natural mortality as estimated in 2011 for all runs.

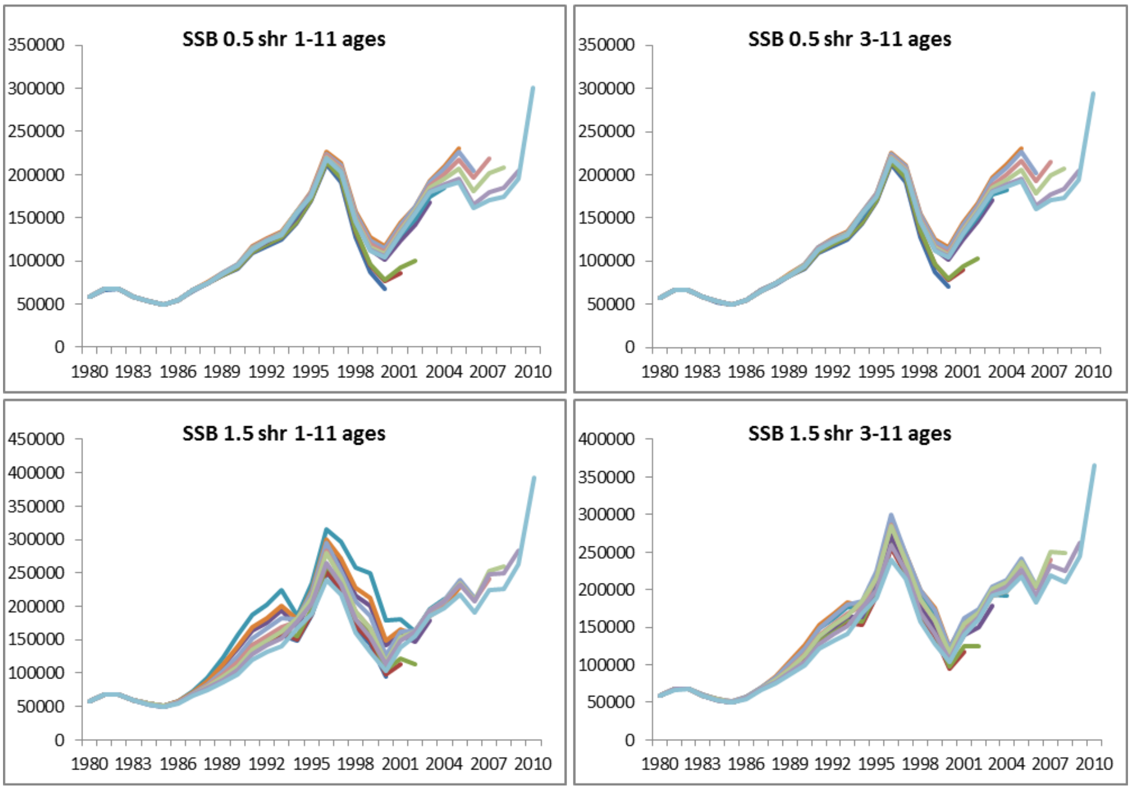


Figure 4.5B. Northeast Arctic haddock. Retrospective plots of SSB for assessment years 2001-2011 using standard settings, but varying F shrinkage and age ranges in the XSA runs, keeping weight, maturity and natural mortality as estimated in 2011 for all runs.

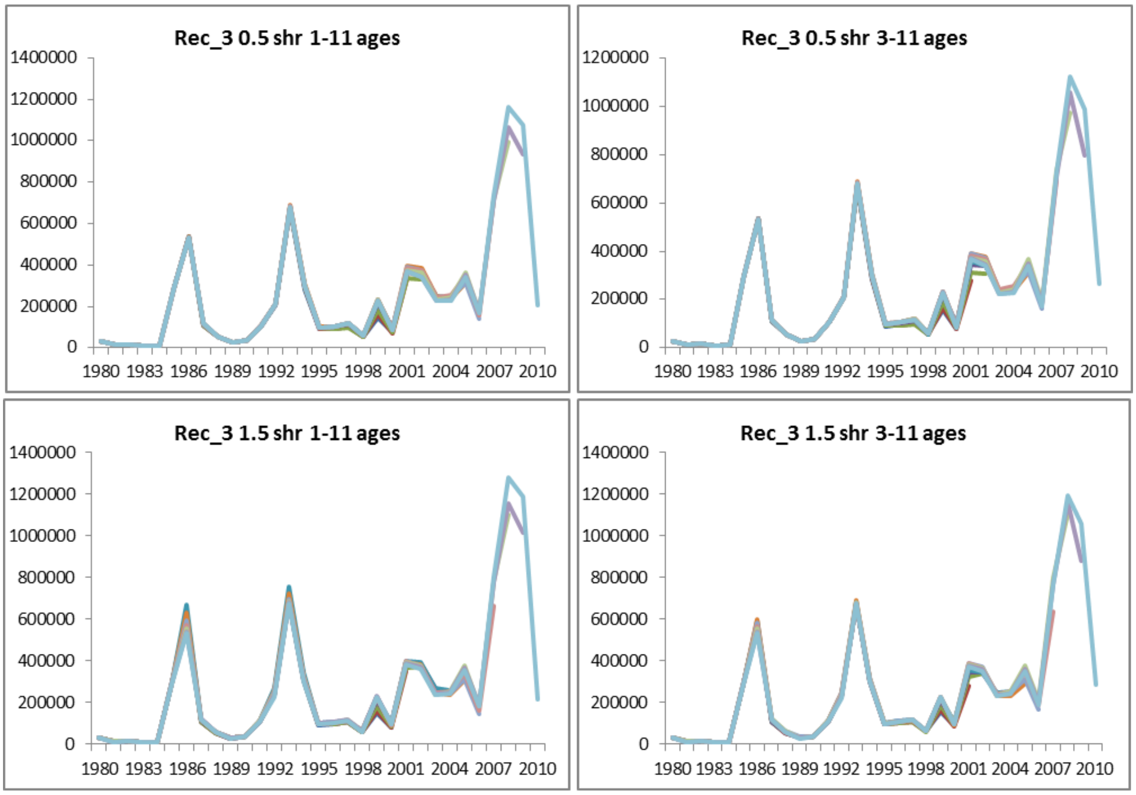
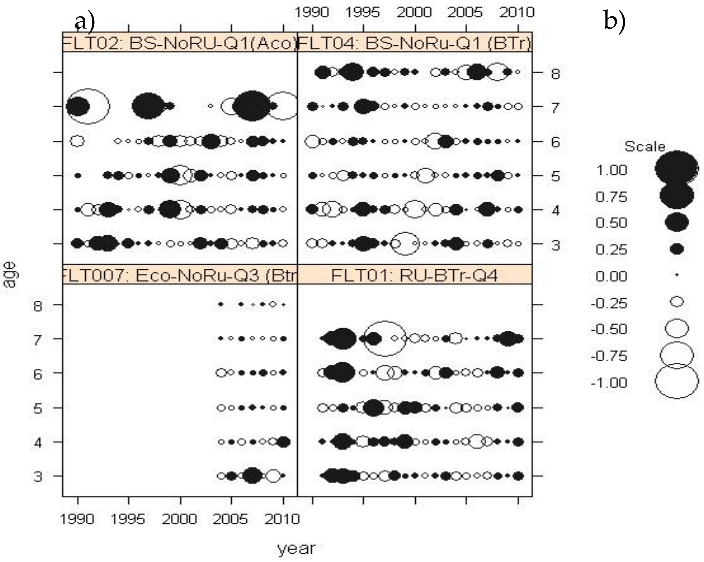


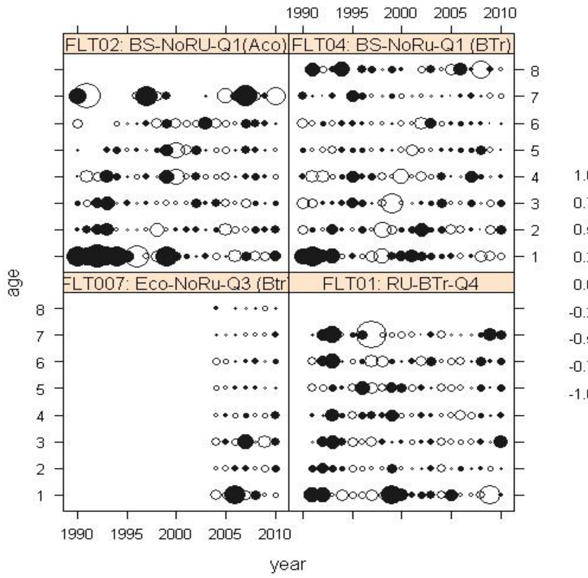
Figure 4.5C. Northeast Arctic haddock. Retrospective plots of recruitment for assessment years 2001-2011 using standard settings but varying F shrinkage and age ranges in the XSA runs, keeping weight, maturity and natural mortality as estimated in 2011 for all runs.

a)



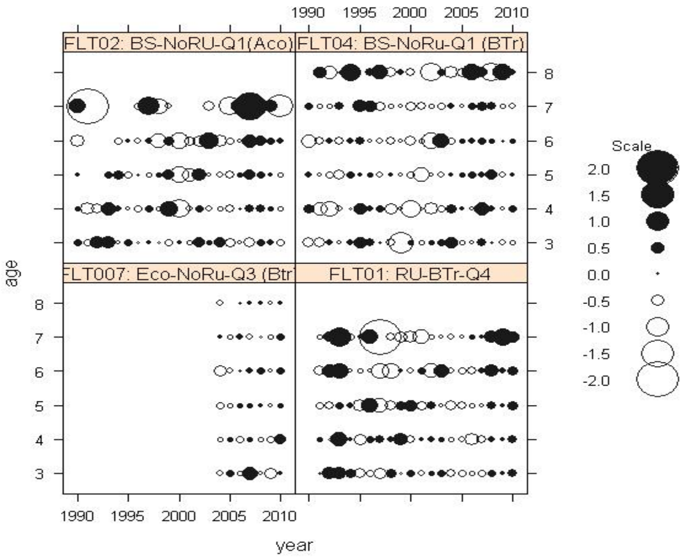
SSQ (ages 3-8) = 10.89

b)



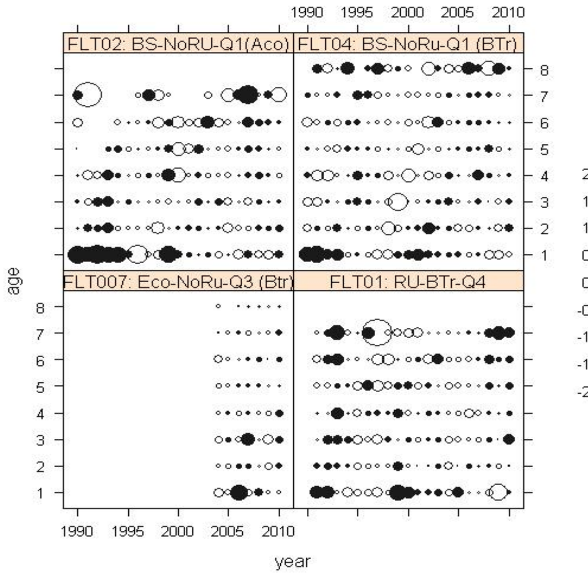
SSQ (ages 3-8) = 13.08

c)



SSQ (ages 3-8) = 14.63

d)



SSQ (ages 3-8) = 14.97

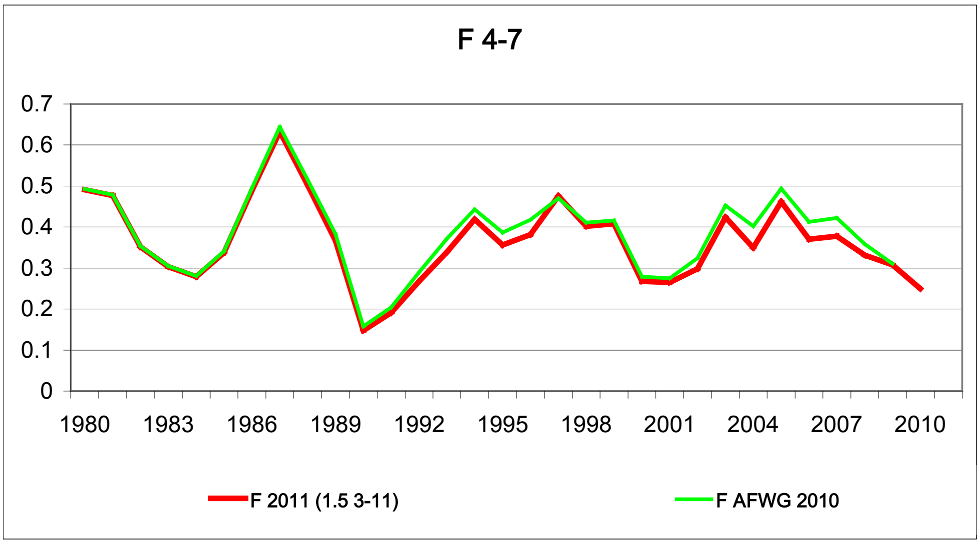
Figure 4.6. Northeast Arctic haddock; log catchability residual plots with values of residual sum of square (SSQ), fleets combined, with different settings in the XSA runs.

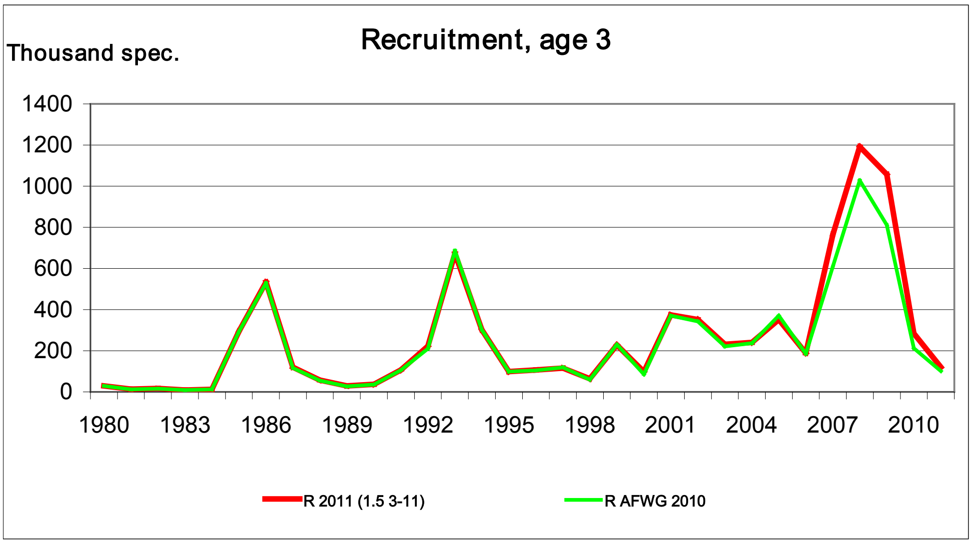
a) run with S.E. of F shrinkage = 1.5, ages 3-8 in tuning

b) run with S.E. of F shrinkage = 1.5, ages 1-8 in tuning

c) run with S.E. of F shrinkage = 0.5, ages 3-8 in tuning

d) run with S.E. of F shrinkage = 0.5, ages 1-8 in tuning





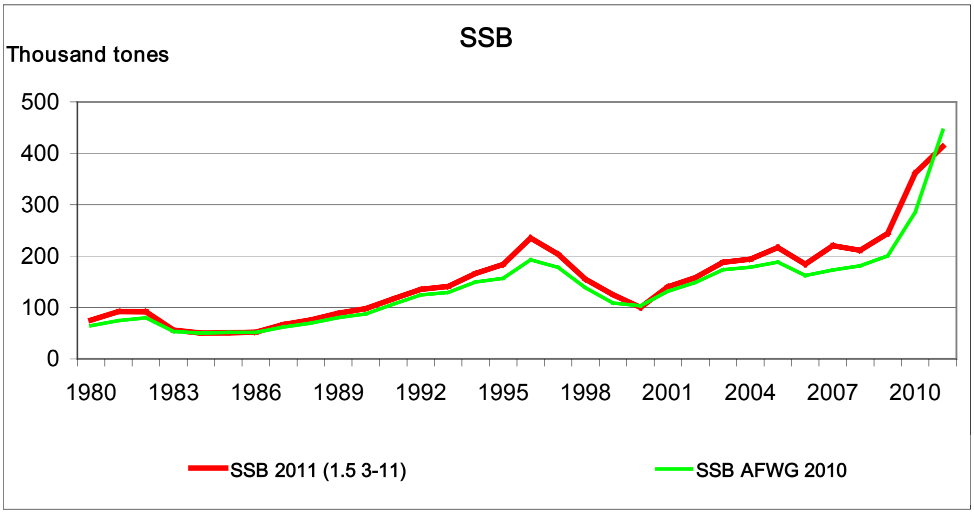


Figure 4.7 Northeast Arctic haddock. Dynamics of fishing mortality, recruitment at age 3 and spawning stock biomass from this year's assessment (F shr.=1.5 ages 3-11), compared with AFWG 2010 estimates for the time period 1980 to 2011 (the WG 2010 values for 2011 are from forecast).

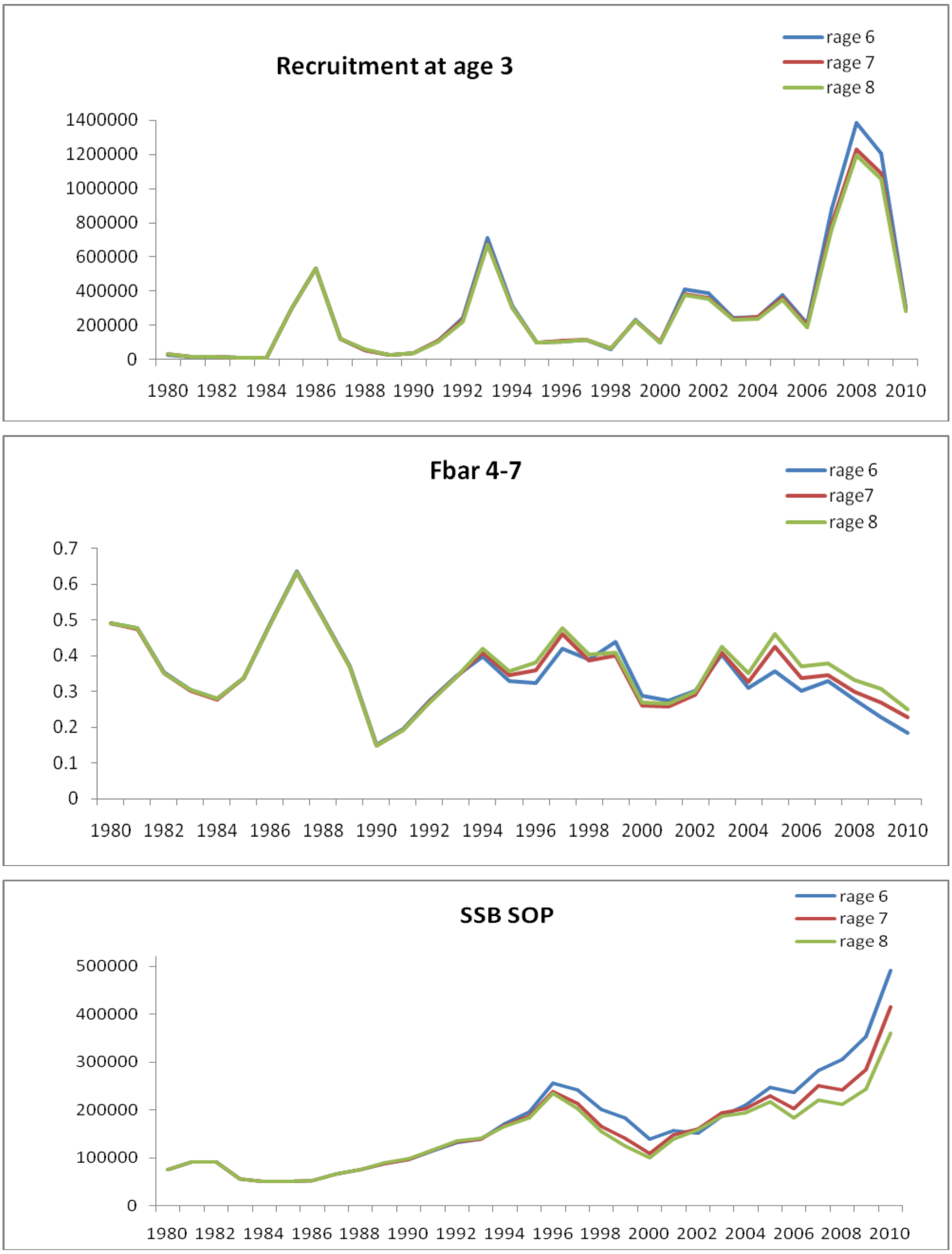


Figure 4.8 Northeast Arctic haddock. Sensitivity analysis of XSA to settings (Catchability independent of size for ages > 6,7,8) for Recruitment at age 3, Fishing mortality and Spawning stock biomass, for the time period 1980 to 2010

5 Saithe in Subareas I and II (Northeast Arctic)

An update assessment is presented for this stock. The last benchmark assessment was done at WKROUND February 2010 (ICES CM 2010/ACOM:36). The main conclusions of the benchmark assessment were:

- Expand the catch matrix from 3-11+ to 3-15+
- Base the Norwegian trawl CPUE on data from all quarters and from days with > 20% but < 80% saithe in the catches
- Split the two tuning series in 2002
- Reduce the shrinkage in the XSA and remove the time tapered weighting

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

5.1 The Fishery (Tables 5.1.1–5.1.2, Figure 5.1.1)

Currently the main fleets targeting saithe include trawl, purse seine, gillnet, hand line and Danish seine. Landings of saithe were highest in 1970-1976 with an average of 239,000 t and a maximum of 265,000 t in 1970. This period was followed by a sharp decline to a level of about 160,000 t in the years 1978-1984. Another decline followed and from 1985 to 1991 the landings ranged from 67,000-123,000 t. After 1990 landings increased and reached 171,000 t in 1996, followed by a new decline to 136,000 t in 2000 and 2001. The landings increased gradually again to 212,000 t in 2006, decreased to 162,000 t in 2009 and increased to 193,000 t in 2010.

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

5.1.1 ICES advice applicable to 2010 and 2011

The advice from ICES for 2010 was as follows:

Exploitation boundaries in relation to proposed and evaluated management plan: The implemented management plan implies a TAC based on the average catches for the coming 3 years based on F_{pa}. This results in a TAC of 204,000 t in 2010, and a fishing mortality of 0.30.

Exploitation boundaries in relation to high long-term yield, low risk of depletion of production potential, and considering ecosystem effects: The current fishing mortality is lower than the F associated with high long-term yield when applied within the agreed HCR.

Exploitation boundaries in relation to precautionary limits: The implemented management plan has been found to be consistent with the precautionary approach and ICES therefore advises according to this plan. This results in a TAC of 204,000 t in 2010.

The advice from ICES for 2011 was as follows:

MSY approach: For saithe, MSY information can be derived from simulations done during the evaluation of whether the HCR for these stocks are precautionary (see ICES CM 2007/ACFM:16). The highest long-term yield was then obtained for an exploitation level of 0.32, i.e. a little below F_{pa}, and ICES then recommended using a lower value than F_{pa} in the HCR. However the basis for the simulations needs to be revised according to the revision of the time series for this stock, before any MSY reference points for advisory use are calculated. Work is in progress to evaluate the current management plan in relation to the MSY framework.

PA approach: The fishing mortality in 2011 should be no more than F_{pa} corresponding to landings of less than 191,000 t in 2011. This is expected to keep SSB above B_{pa} in 2012.

Management plan: Following the agreed client management plan implies a TAC of 173,000 t in 2011. The SSB is expected to decrease by 9% in 2011 and to remain above B_{pa} at the beginning of 2012.

5.1.2 Management applicable in 2010 and 2011

Management of Saithe in Sub-areas I and II is by TAC and technical measures. Norwegian authorities set the TACs for 2010 and 2011 to 204,000 t and 173,000 t, respectively. The Institute of Marine Research, Bergen, Norway (IMR), advised a TAC for 2010 of 193,000 t, estimated by applying a fishing mortality of 0.32 to the HCR, i.e. a little below the target F of 0.35 (F_{pa}) specified in the HCR. ICES, in the evaluation of the management plan, also recommended using 0.32, corresponding to the highest long-term yield, in the HCR (ICES Advice 2007).

5.1.3 The fishery in 2010 and expected landings in 2011

Provisional figures show that the landings in 2010 were approximately 193,000 t, about 11,000 t less than the TAC of 204,000 t, which also were expected landings in the forecast last year.

Since the WG does not have any prognosis of total landings in 2011 available, the TAC of 173,000 t is used in the projections.

5.2 Commercial catch-effort data and research vessel surveys

5.2.1 Fishing Effort and Catch-per-unit-effort (Table 5.2.1)

In the Norwegian trawl CPUE indices, all quarters and all days with more than 20 % but less than 80 % saithe in the catches from vessels larger than the median length were included. The 80 % limit was set to get a more consistent time series regarding bycatch or direct saithe fishery (Fotland *et al.*, WD 12 WKROUND 2010). Since the 2007 WG double and triple trawl catches have been excluded from the data because such trawls have a much higher efficiency and the use of them have increased over the last few years. The CPUE observations were averaged over each quarter, and then a yearly index was calculated by averaging over the year. The total CPUE index was finally divided on age groups applying yearly catch in numbers and weight at age data from the trawl fishery.

5.2.2 Survey results (Table 5.2.2, Figure 5.2.1)

In autumn 2003 the saithe and coastal cod surveys were combined (Berg *et al*., WD 11 2004). Exploratory runs with new tuning time series from the combined survey (ICES acronym: NOcoast-Aco-Q4) were prepared to the benchmark assessment 2010 (Mehl and Fotland, WD 8 WKROUND 2010). The XSA diagnostics and results showed that the new tuning series did not perform as well as the one presently used. The new ones are still too short for tuning of the XSA and the old one will be applied. The estimation of abundance indices is as far as possible done as before the combination of the two surveys. The total index for 2010 (Mehl *et al*. 2010) decreased by almost 10 % compared to 2009, and is one of the lowest since 1991. Except for 3 year olds, the indices for all age groups, especially 2, 4 and 6 year olds (2008, 2006 and 2004-year classes), were well below the 1992-2009 average. The 2006-year class was above average level as 3 year olds in 2009, but was considerably reduced to well below average as 4 year olds in 2010. This result is supported by the high purse seine catch of this age group in 2010. In recent years the proportion of saithe echo abundance found in the southern part of the survey area (sub areas C+D) has increased, from about 30% in 1997-2002 to around 50 % in later years (Figure 5.2.1).

5.2.3 Recruitment indices

Owing to the near-shore distribution of juvenile saithe, obtaining early estimates of recruitment is a common problem in saithe stocks. Attempts at establishing year class strength at ages 0-2 for the Northeast Arctic saithe stock have so far failed. 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. An observer programme for establishing a 0-group index series started in 2000 (Borge and Mehl, WD 21 2002). However, these observations do not seem to reflect the dynamics in year class strength very well and are probably not suitable for improving future recruitment estimates for this stock (Mehl, WD 6 2007; Mehl, WD 7 to WKROUND 2010). It was therefore decided to terminate the programme in 2010.

5.3 Data used in the Assessment

5.3.1 Catch numbers at age (Tables 5.3.1–5.3.2)

Landings data, logbook adjusted for trawl, and allocation of biological samples of catch numbers, mean length and mean weight at age from the Norwegian fishery in 2009 was updated applying the same method as previously used. For all other countries the landings data for 2009 were updated to the official total catch reported to ICES or to Norwegian authorities. These revisions resulted in only minor changes in catch numbers-at-age and weight-at-age.

Age composition data for 2010 were available from Norway and Germany (Subarea IIa). Russian length composition data were available for all areas, but only the data for area I was used together ALK for Norwegian trawl. Other areas and countries were assumed to have the same age composition as Norwegian trawlers. Table 5.3.1 presents the Norwegian sampling level in 2010. The biological sampling of some vessel groups, periods and areas may have become critically low after the termination of the Norwegian port sampling program in mid-2009, e.g. for all gears in the Lofoten area and for purse seine and hand line in all areas in 2010. The revised 2009 and new 2010 catch and sample data were uploaded to the InterCatch database, and there were only minor discrepancies between data allocated and aggregated in InterCatch and data from the spreadsheets used until now.

5.3.2 Weight at age (Table 5.3.3)

Constant weights at age values are used for the period 1960-1979. For subsequent years, annual estimates of weight at age in the catches are used. Weight at age in the stock is assumed to be the same as weight at age in the catch. Compared to the previous years, there were only small differences in weight at age for the most important age groups in 2010.

5.3.3 Natural mortality

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

5.3.4 Maturity at age (Table 5.3.4)

A constant maturity ogive was used until the 2005 WG, when these estimates were evaluated. In later years the maturity at age had decreased somewhat, and the WG decided to use a 3-year running average for the period from 1985 and onwards (2-year average for the first and last year). New analyses were only available back to 1985. Table 5.3.3 presents the 3-year running average maturity ogive. Since 2009 a rather large reduction in maturity at age 5 has been observed.

5.3.5 Tuning data (Table 5.3.5, Figure 5.3.1)

Until the 2005 WG, the tuning was based on three data series: CPUE from Norwegian purse seine and Norwegian trawl and indices from a Norwegian acoustic survey. The 2005 WG found rather large and variable log q residuals and large S.E. log q for the purse seine fleet, as well as strong year effects, and in the combined tuning the fleet got low-scaled weights. The WG decided not to include the purse seine tuning fleet in the analysis. This was confirmed by new analyses at the 2010 benchmark assessment (ICES CM 2010/ACOM:36).

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 following four tuning fleets are used in the present assessment:

> Fleet 11: CPUE data from the Norwegian trawl fisheries 1994-2001, age groups 4 to 8, quarter 1-4.
>
> Fleet 12: CPUE data from the Norwegian trawl fisheries 2002-2010, age groups 4 to 8, quarter 1-4.
>
> Fleet 13: Indices from the Norwegian acoustic survey 1994-2001, age groups 3 to 7.
>
> Fleet 14: Indices from the Norwegian acoustic survey 2002-2010, age groups 3 to 7.

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

5.4 Exploratory runs (Table 5.4.1, Figure 5.4.1)

The settings of the different runs are shown in Table 5.4.1 and the results are given in Figure 5.4.1. The recommendation from the benchmark assessment in 2010 (ICES CM 2010/ACOM:36) was to run the XSA with a 15+ catch matrix, tuning time series broken in 2002, reduced shrinkage (S.E. of the mean to which the estimate are shrunk increased from 0.5 to 1.5) and no tapered time weighting.

Based on the update of catch statistics and allocation of biological samples, a SPALY (Same Procedure As Last Year) XSA (run 1) was performed, giving slightly different results compared to the 2010 assessment. F_{4-7} in 2009 was estimated to 0.27 in 2010, while the updated run gave an F_{bar} of 0.26. SSB in 2009 decreased from 457,000 t to 451,000 t (Figure 5.4.1).

Two single fleet tuning runs were performed; one with the Norwegian trawl CPUE (run 2) and one with the Norwegian acoustic survey (run 3). The last run (4) was with combined fleets.

Figure 5.4.1 compares estimates of SSB and F_{4-7} in 2010 from the two single fleet XSA-runs and the combined tuning runs, in addition to the 2009 result of the updated SPALY run. The single fleet tuning run based on the CPUE give the lowest F_{4-7} and highest SSB in the last assessment year (2010), while the run based on the acoustic indices gave slightly lower SSB but considerable higher F_{4-7} (0.41 compared to 0.18). The combined run gave SSB about in the middle of the single fleet runs, but F_{4-7} closer to the acoustic indices runs (0.33). This run was used as the final run. Compared to the final run made at the 2010 assessment, F_{4-7} in the final assessment year is now higher (0.33 compared to 0.26) and SSB lower (390,000 t compared to 451,000 t).

5.5 Final assessment run (Tables 5.5.1–5.5.7, Figures 5.5.1–5.5.4)

Extended Survivors Analysis (XSA) was used for the final assessment with settings shown in Table 5.4.1. The settings are in accordance with the recommendations from the benchmark assessment in February 2010 (ICES CM 2010/ACOM:36). Full tuning fleet diagnostics are given in Table 5.5.1.

Figure 5.5.1 presents log q residuals for the tuning fleets with the two parts combined. There are some year and age effects in both fleets, especially for the CPUE series. The second part of the acoustic survey series seems to perform better then the first part. Figure 5.5.2 presents S.E. log q for the different age groups in the fleets used for tuning. The two oldest tuning series have higher S.E. log q, except for age 4 of the latest trawl CPUE series. Figure 5.5.3 shows estimates of survivors from different fleets and shrinkage, as well as their different weighting in the final XSA-run. The second part of the survey series get the highest weights for age groups 3-6, the second part of the CPUE series get the highest weights for the older, while shrinkages get some weights for ages 12-14. Figure 5.5.4a-b shows plots of the tuning indices versus stock numbers from the XSA.

5.5.1 Fishing mortalities and VPA (Tables 5.5.2–5.5.7, 5.7.1, Figure 5.5.5)

The fishing mortality (F_{4-7}) in 2009 was 0.26, which is close to the value of 0.27 from last year's assessment. The fishing mortality (F_{4-7}) in 2010 was 0.33, i.e. considerably above the corresponding figure for 2009, but below the F_{pa} of 0.35. The increase was mainly caused by an increase in F of age group 4 (2006 year-class), and to some extent of age group 5. The large F on age group 4 may be explained by low catches of the 2006 year-class in 2009 and high catches in 2010, especially in the purse seine fishery, combined with a high survey mortality (1.39) of the same year-class from 2009 to 2010.

Fishing mortality and stock size have in the last decade been considerably over- and underestimated, respectively, in the last assessment year. Due to the changes made to the assessment, the retrospective patterns have improved considerably, as is illustrated in Figure 5.5.5., and now show weak signs of an opposite retrospective trend.

The XSA-estimates of the 2007-2008 year classes are not considered to be reliable and are therefore shaded (Tables 5.5.3 and 5.5.5). In the projections, both were set to the long-term geometrical mean, the value of the 2005 year class at age 4 being obtained by applying Pope's approximation. The figures are given in input data for prediction (Table 5.7.1). The 2002 year class was the most numerous in the landings for several years and is estimated to be the strongest in the time series, above the strong 1989, 1992 and 1999-year classes. The 2003 year class is confirmed to be one of the weakest in the time series, and the 2004 year class is also poor, the 2005 year class is well above average level while the 2006 year class seems to be slightly below average strength. Survey indices and purse seine catches in 2010 indicates that the 2007 year class is above average strength, while little information is available on the strength of recent year classes.

The total biomass (ages 3+) has been above the long-term (1960-2010) mean since 1995, reached a maximum in 2005, and is presently declining. The SSB has been above the long-term mean since 2001 and above B_{pa} since 1995 (Tables 5.5.5-5.5.7). It has declined since 2005, but is still estimated to be well above B_{pa}.

5.5.2 Recruitment (Table 5.3.2, Figure 5.1.1)

Estimates of the recruiting year classes up to the 2006-year class (4 year olds) from the XSA were accepted. Catches of age group 3 were low in 2006 and 2007, increased considerably in 2008, decreased in 2009 and increased again in 2010 to the same level as in 2005 and 2008 (Table 5.3.2). 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. These estimates were, however, strongly weighted towards the mean value of the input XSA-numbers, which due to the short survey time series also contained year classes that were still not converged. It has therefore been stated several times in the ACOM Technical Minutes that it would be more transparent to use the long-term GM (geometric mean) recruitment. The GM recruitment 1960-2009 is 168 million 3 year olds, and this value is used for the 2007-year class.

5.6 Reference points (Figure 5.6.1)

In 2010 the age span was expanded from 11+ to 15+ and important XSA parameter settings were changed (ICES CM 2010/ACOM:36). This resulted in changes in estimated fishing mortality, spawning stock biomass and recruitment, especially in the last part of the time series (Figure 5.6.1). Therefore the LIM and PA 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 since the HCR is based on the PA reference points, it was decided to not change the existing LIM and PA reference points. The re-estimations are presented below.

5.6.1 Biomass reference points

At the 2010 WG, parameter values, including the change-point, were computed using segmented regression on the 1960-2005 time series of SSB-recruitment pairs. The maximum likelihood estimate of the spawning stock biomass at which recruitment is impaired was 118,542 t. Applying the "magic formula" $B_{pa} = B_{lim} \exp(1.645*\sigma)$, with a value of 0.3 for σ, gave a B_{pa} of 194,176 t. However, as explained above, it was decided to still use the existing values of B_{lim} = 136,000 t and B_{pa} = 220,000 t.

5.6.2 Fishing mortality reference points (Tables 5.6.1, 5.7.1, Figure 5.1.1)

F_{lim} was set on the basis of B_{lim} (ICES CM 2003/ACFM:15). The functional relationship between spawner-per-recruit and F gave the F associated with the R/SSB slope derived from the B_{lim} estimate obtained from the segmented regression. Arithmetic means of proportion mature 1960-2009, weight in stock and weight in catch 1980-2009 (weights were constant before 1980), natural mortality and fishing pattern 1960-2009 were at the 2010 WG used for re-calculating the spawner-per-recruit function using ICES Secretariat yield-per-recruit software. R/SSB = 1.48 from the B_{lim} estimation gave SSB/R = 0.676 and a F_{lim} = 0.59. Applying the "magic formula" $F_{pa} = F_{lim} \exp(-1.645*\sigma)$, gave a F_{pa} of 0.36. As explained above, it was decided to still use the existing values of F_{lim} = 0.58 and F_{pa} = 0.35.

Yield and SSB per recruit were based on the parameters in Table 5.7.1 and are presented in Table 5.6.1. $F_{0.1}$, F_{max} and $F_{35\%SPR}$ were estimated to be 0.10, 0.32 and 0.12, respectively, which is close to last year's estimates. The plot of SSB versus recruitment is shown in Figure 5.1.1. These points are F_{MSY} candidates, but the estimates, especially of F_{max}, are unstable for this stock. When the HCR was re-evaluated (see below), the highest long-term yield was obtained for an exploitation level of 0.20.

5.6.3 Harvest control rule (Figures 5.6.2-3)

In 2007 ICES evaluate the harvest control rule for setting the annual fishing quota (TAC) for Northeast Arctic saithe. ICES concluded that the HCR was consistent with the precautionary approach for all simulated data and settings, including a rebuilding situation under the condition that the assessment uncertainty and error are not greater than those calculated from historic data. This also held true when an implementation error (difference between TAC and catch) equal to the historic level was included. The HCR was implemented the same year. It contains the following elements:

- Estimate the average TAC level for the coming 3 years based on $\mathbf{F_{pa}}$. TAC for the next year will be set to this level as a starting value for the 3-year period.
- The year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development. However, the TAC should not be changed by more than 15% compared with the previous year's TAC.
- If the spawning stock biomass (SSB) in the beginning of the year for which the quota is set (first year of prediction), is below $\mathbf{B_{pa}}$, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from $\mathbf{F_{pa}}$ at SSB=$\mathbf{B_{pa}}$ to 0 at SSB equal to zero. At SSB levels below $\mathbf{B_{pa}}$ in any of the operational years (current year and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.

In 2011 the evaluation was repeated taking into account the changes made to the assessment after the 2010 benchmark assessment (ICES CM 2010/ACOM:36). The analyses indicate that the HCR still is in agreement with the precautionary approach (Mehl and Fotland, WD 11).

In the 2007 simulations the highest long-term yield was obtained for an exploitation level of 0.32, i.e. a little below the target F used in the HCR (F_{pa}), and ICES recommended using a lower value in the HCR. In the 2011 simulations the highest long-term yield was obtained for F = 0.20 (Figure 5.6.2), but the curve was almost flat between F=0.15 and F=0.25 and the decrease in long-term yield going from F=0.25 to F=0.35 was rather small (about 5%). However, SSB was reduced by almost 50% between F=0.20 and F=0.35 and approached B_{pa} (Figure 5.6.3).

5.7 Predictions

5.7.1 Input data (Table 5.7.1)

The input data to the predictions based on results from the final XSA are given in Table 5.7.1. The stock number at age in 2011 was taken from the XSA for age 5 (2006 year class) and older. The recruitment at age 3 in the last assessment year (2010) was calculated as the long-term GM (geometric mean) recruitment 1960-2009 (Section 5.5.2), and the corresponding numbers at age 4 in the intermediate year (2011) was calculated applying a natural mortality of 0.2 and using Pope's approximation (as recommended by the ACOM reviewers in 2008). The GM age 3 recruitment of 168 million was also used for the 2008 and subsequent year classes. The natural mortality of 0.2 is the same as used in the assessment. For exploitation pattern the average of 2008-2010 was used for age groups 3-10, while for age groups 11-15+ the 2008-2010 average for ages 11-13 was applied for all ages. For weight at age in stock and catch the average of the last three years in the XSA was used. For maturity at age the average of the 2009-2010 annual determinations was applied.

5.7.2 Catch options for 2012 (short-term predictions) (Tables 5.7.2-5.7.4)

The management option table (Table 5.7.2) shows that the expected catch of 173,000 t in 2011 will decrease the fishing mortality slightly compared to 2010 from 0.33 to 0.31, which is below the F_{pa} of 0.35. A catch in 2012 corresponding to the $F_{status\ quo}$ level (3-year average 2008-2010) of 0.28 will be 149,000 t, while a catch in 2012 corresponding to the evaluated and implemented HCR (average TAC level for the coming 3 years based on F_{pa}, see Table 5.7.3) is 164,000 t. This catch corresponds to a fishing mortality of 0.32 in 2012.

For a catch in 2011 corresponding to the HCR, i.e. 173,000 t, the SSB is expected to decrease from about 358,000 t at the beginning of 2011 to 313,000 t at the beginning of 2012. At $F_{status\ quo}$ in 2012 SSB is estimated to decrease to 291,000 t at the beginning of 2013 and for a catch corresponding to the HCR it will decrease to about 280,000 t. Higher fishing mortalities and incoming year classes of below average strength mainly explain this predicted reduction in SSB. Table 5.7.4 presents detailed output for fishing according to the HCR in 2012.

5.7.3 Comparison of the present and last year's assessment

The current assessment estimated the total stock in 2010 to be 3 % higher and the SSB 6 % lower, compared to the previous assessment. The F in 2009 is estimated to be slightly lower than in the previous assessment and the realized F in 2010 is just a little higher compared to the predicted one based on the TAC.

	Total stock (3+) by 1 January 2010 (tonnes)	SSB by 1 January 2010 (tonnes)	F_{4-7} in 2010	F_{4-7} in 2009
WG 2010	774856	416334	0.31 (TAC constraint)	0.27
WG 2011	795149	393155	0.33	0.26

5.8 Comments to the assessment and the forecast (Figure 5.5.5).

The retrospective pattern has been a major concern in the assessment, but due to the changes done at the benchmark assessment (ICES CM 2010/ACOM:36), the assessment has become more stable. The tendency to overestimate F and underestimate SSB in the last assessment year seems to have changed to an opposite situation, but the differences are less than in previous assessments.

The biological sampling may have become critically low after the termination of the Norwegian port sampling program in 2009. This may affect the precession of the catch, weight and maturity at age data. Lack of reliable recruitment estimates is still a major problem. Prediction of catches beyond the TAC year will, to a large extent, be dependent on assumptions of average recruitment.

5.9 Response to ACOM technical minutes

The major comments made by the five previous reviews were handled with during the benchmark assessment in February 2010 (ICES CM 2010/ACOM:36).

The 2010 reviewers commented that there are still trends (age and year effects) in the residuals of the assessment. These tendencies should be explored and explained further in future assessments. This was not analysed in the present assessment, and it is partly connected to the next issue (see below). Longer time series in the second period of the tuning series will probably give more information about trends in catchability.

Lack of reliable recruitment estimates is still a major problem. 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. The assessment and the forecast are sensitive to this, and the variability in this should be explored and discussed further. This issue has neither been explored further. To improve the survey indices of the youngest age groups the survey must be redesigned and perhaps smaller vessels and other data sampling methods need to be introduced. A specific sampling scheme for the purse seine fishery could also improve the data basis for recruitment indices of 3-year olds.

The biological sampling of some vessel groups may have become critically low after the termination of the Norwegian port sampling program in 2009. The effect of this should be explored further in future assessments. The Norwegian sampling program will be evaluated autumn 2011 and this may lead to improvements in the sampling regime.

Graphs of the tuning indices should be provided. These plots were removed in the 2010 report, but are now included again in Figure 5.3.1.

Table 5.1.1 Saithe in Sub-areas I and II (Northeast Arctic).

Nominal catch (t) by countries as officially reported to ICES.

Year	Faroe Islands	France	Germany Dem.Rep	Fed.Rep. Germany	Iceland	Norway	Poland	Portugal	Russia3	Spain	UK	Others 5	Total all countries
1960	23	1 700		25 948		96 050					9 780	14	133 515
1961	61	3 625		19 757		77 875					4 595	18	105 951
1962	2	544		12 651		101 895			912		4 699	4	120 707
1963		1 110		8 108		135 297					4 112		148 627
1964		1 525		4 420		184 700			84		6 511	186	197 426
1965		1 618		11 387		165 531			137		6 741	181	185 600
1966		2 987	813	11 269		175 037			563		13 078	41	203 788
1967		9 472	304	11 822		150 860			441		8 379	48	181 326
1968			70	4 753		96 641					8 781		110 247
1969	20	193	6 744	4 355		115 140					13 585	23	140 060
1970	1 097		29 362	23 466		151 759			43 550		15 469		264 924
1971	215	14 536	16 840	12 204		128 499	6 017		39 397	13 097	10 361		241 272
1972	109	14 519	7 474	24 595		143 775	1 111		1 278	13 125	8 223		214 334
1973	7	11320	12 015	30 338		148 789	23		2 411	2 115	6 841		213 859
1974	46	7119	29 466	33 155		152 699	2521		28 931	7 075	3 104	5	264 121
1975	28	3156	28 517	41 260		122 598	3860	6430	13 389	11 397	2 763	55	233 453
1976	20	5609	10 266	49 056		131 675	3164	7233	9 013	21 661	4 724	65	242 486
1977	270	5658	7 164	19 985		139 705	1	783	989	1 327	6 935		182 817
1978	809	4345	6 484	19 190		121 069	35	203	381	121	2 827		155 464
1979	1117	2601	2 435	15 323		141 346			3	685	1 170		164 680
1980	532	1016		12 511		128 878			43	780	794		144 554
1981	236	218		8 431		166 139			121		395		175 540
1982	339	82		7 224		159 643			14		732		168 034
1983	539	418		4 933		149 556			206	33	1 251		156 936
1984	503	431	6	4 532		152 818			161		335		158 786
1985	490	657	11	1 873		103 899			51		202		107 183
1986	426	308		3 470		63 090			27		75		67 396
1987	712	576		4 909		85 710			426		57	1	92 391
1988	441	411		4 574		108 244			130		442		114 242
1989	388	460 [2]		606		119 625			506	506	726		122 817
1990	1207	340 [2]		1 143		92 397			52		709		95 848
1991	963	77 [2]	**Greenland**	2 003		103 283			504 [4]		492	5	107 327
1992	165	1980	734	3 451		119 763			964	6	541		127 604
1993	31	566	78	3 687	3	140 604		1	9 509	4 [2]	415	5 [2]	154 903
1994	67 [2]	557	15	1 863	4 [2]	141 589		1 [2]	1 640 [2]	655 [2]	557	2	146 950
1995	172 [2]	358	53	935		165 001		5	1 148		688	18	168 378
1996	248 [2]	346	165	2 615		166 045		24	1 159	6	707	33	171 348
1997	193 [2]	560	363 [2]	2 915		136 927		12	1 774	41	799	45	143 629
1998	366	932	437 [2]	2 936		144 103		47	3 836	275	355	40	153 327
1999	181	638 [2]	655 [2]	2 473	146	141 941		17	3 929	24	339	32	150 375
2000	224 [2]	1438	651 [2]	2 573	33	125 932		46	4 452	117	454	8 [2]	135 928
2001	537	1279	701 [2]	2 690	57	124 928		75	4 951	119	514	2	135 853
2002	788	1048	1393	2 642	78	142 941		118	5 402	37	420	3	154 870
2003	2056	1022	929 [2]	2 763	80 [2]	150 400		147	3 894	18	265	18 [2]	161 592
2004	3071	255	891 [2]	2 161	319	147 975		127	9 192	87	544	14	164 636
2005	3152	447	817 [2]	2 048	395	162 338		354	8 362	25	630		178 568
2006	1795	899	786 [2]	2 779	255	195 462	89	339 [2]	9 823	21 [2]	532	42	212 822
2007	2048	966	810 [2]	3 019	219	178 644	99	412	12 168	53 [2]	558	12	199 008
2008	2314	1009	503 [2]	2 263	113	165 998	66	348	11 577	33	506	10	184 740
2009	1611	326	697	2 021	69	144 570	30	204 [2]	11 899	2 [2]	379	45 [2]	161 853
2010 [1]	817 [2]	678	956 [2]	1 559 [2]	109 [2]	173 971	251 [2]	99 [2]	14 664	8 [2]	283	4 [2]	193 399

1 Provisional figures.

2 As reported to Norwegian authorities.

3 USSR prior to 1991.

4 Includes Estonia.

5 Includes Denmark,Netherlands, Ireland and Sweden

Table 5.1.2 Saithe in Sub-areas I and II (Northeast Arctic).
Landings ('000 tonnes) by gear category.

Year	Purse Seine	Trawl	Gill Net	Others	Total
1977	75.2	69.5	19.3	12.7	176.7 [2]
1978	62.9	57.6	21.1	13.9	155.5
1979	74.7	52.5	21.6	15.9	164.7
1980	61.3	46.8	21.1	15.4	144.6
1981	64.3	72.4	24.0	14.8	175.5
1982	76.4	59.4	16.7	15.5	168.0
1983	54.1	68.2	19.6	15.0	156.9
1984	36.4	85.6	23.7	13.1	158.8
1985	31.1	49.9	14.6	11.6	107.2
1986	7.9	36.2	12.3	8.2	64.6 [2]
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 [3]
1995	21.8	103.5	26.9	16.1	168.4 [4]
1996	46.9	72.5	31.6	20.3	171.3
1997	44.4	55.9	24.4	19.0	143.6
1998	44.4	57.7	27.6	23.6	153.3
1999	39.2	57.9	29.7	23.6	150.4
2000	28.3	54.5	29.6	23.5	135.9
2001	28.1	58.1	28.2	21.5	135.9
2002	27.4	75.5	30.4	21.5	154.8
2003	43.3	73.8	25.2	19.3	161.6
2004	41.8	74.6	26.9	21.3	164.6
2005	42.1	91.8	25.6	19.1	178.6
2006	73.5	87.1	29.7	22.5	212.8
2007	41.8	100.7	33.3	23.2	199.0
2008	39.4	91.2	37.0	17.1	184.7
2009	35.5	81.1	33.2	12.1	161.9
2010 [1]	54.9	88.5	36.8	13.2	193.4

[1] Provisional figures.
[2] Unresolved discrepancy between Norwegian catch by gear figures and the total reported to ICES for these years.
[3] Includes 4,300 tonnes not categorized by gear, proportionally adjusted.
[4] Reduced by 1,200 tonnes not categorized by gear, proportionally adjusted.

Table 5.2.1 Saithe in Sub-areas I and II (Northeast Arctic).
Norwegian trawl CPUE by agegroup (Catch in numbers per trawlhour).
Shaded area shows indices applied in the assessment.

Year	Agegroup									Total CPUE (kg/h)
	effort	3	4	5	6	7	8	9	10	Quarter 1-4
1994	1	3.4	83.2	280.2	174.0	24.0	5.3	1.7	3.3	575
1995	1	28.1	150.0	208.3	226.3	35.9	5.9	0.2	1.5	656
1996	1	17.0	84.7	113.2	164.7	217.1	24.9	5.3	0.5	628
1997	1	10.7	28.5	148.3	151.1	194.4	122.3	12.9	1.3	670
1998	1	2.4	24.5	41.1	181.6	69.2	42.1	12.1	5.7	379
1999	1	11.0	26.6	74.9	56.8	131.6	30.2	22.1	6.3	359
2000	1	5.4	58.8	62.9	117.9	91.3	122.6	46.4	52.4	558
2001	1	5.4	32.2	176.1	126.8	119.8	50.7	72.3	34.7	618
2002	1	6.9	52.2	84.9	264.3	59.6	61.2	28.0	52.1	609
2003	1	4.0	105.9	161.7	107.3	154.7	99.8	82.6	51.1	767
2004	1	2.4	5.8	141.8	105.4	135.3	169.6	54.5	74.8	690
2005	1	13.4	38.6	103.3	305.7	145.9	82.1	145.8	49.0	884
2006	1	0.3	53.5	99.2	86.9	202.3	116.9	103.9	97.7	761
2007	1	3.5	11.2	206.8	161.8	109.1	165.6	110.7	58.0	827
2008	1	15.8	81.1	46.3	266.0	149.1	90.8	135.6	83.9	868
2009	1	51.1	158.6	134.4	79.0	196.5	55.0	34.0	78.9	787
2010 [1]	1	45.7	156.6	180.8	90.5	34.2	162.9	33.6	16.8	721

[1] Provisional figures.

Table 5.2.2 Saithe in Sub-areas I and II (Northeast Arctic).
Acoustic abundance indices from Norwegian surveys in October-November.
In 1985 - 1991 the area coverage was incomplete. Numbers in millions.
Shaded area shows indices applied in the assessment

Year	Age									
	2	3	4	5	6/6+	7	8	9	10+	Total
1985	3.1	4.9	2.4	0.5	0.0					10.9
1986	19.5	40.8	3.6	1.8	1.8					67.5
1987	1.8	22.0	48.4	1.8	1.7					75.7
1988	15.7	22.5	19.0	7.1	0.6					64.9
1989	24.8	28.4	17.0	10.1	12.4					92.7
1990	99.6	31.9	14.7	5.1	7.4					158.7
1991	87.8	104.0	4.6	4.0	7.1					207.5
1992	163.5	273.6	57.5	6.2	8.8					509.6
1993	106.9	227.7	103.9	12.7	3.2					454.4
1994	35.1	87.1	108.9	41.4	8.1	0.7	1.0	0.5	1.0	283.8
1995	38.4	166.1	86.5	46.5	16.5	2.4	0.0	0.0	1.0	357.5
1996	48.8	122.6	207.4	31.7	15.1	4.0	0.5	0.0	0.0	430.0
1997	5.5	38.0	184.8	79.8	50.6	9.6	1.2	0.0	0.3	369.8
1998	44.0	96.7	202.6	69.3	84.3	6.6	3.8	0.7	0.1	508.1
1999	61.1	233.8	72.9	62.2	21.0	19.2	5.9	1.4	0.4	477.8
2000	164.8	142.5	176.3	11.6	11.5	8.0	4.0	1.0	2.0	521.7
2001	104.7	275.9	45.9	53.8	5.6	6.1	3.2	3.4	1.9	500.5
2002	25.5	230.2	92.6	18.9	10.6	2.2	0.9	0.8	1.2	382.9
2003	31.0	87.5	151.7	26.1	6.2	6.4	1.2	0.7	1.3	312.1
2004	152.2	212.4	118.7	49.1	19.2	4.7	3.0	3.1	3.1	565.5
2005	22.2	228.1	67.2	20.3	16.5	7.7	2.2	1.7	0.9	366.7
2006	98.2	42.6	142.9	19.4	4.6	8.5	5.6	2.1	3.5	327.3
2007	45.4	111.0	27.1	61.1	7.9	5.8	4.1	4.3	1.1	267.9
2008	55.6	97.2	29.2	13.8	11.9	4.0	1.0	1.0	1.6	215.3
2009	52.9	139.8	80.2	7.7	5.2	6.8	0.9	0.7	1.7	295.9
2010	7.8	185.7	31.0	22.2	4.0	1.9	3.3	0.3	1.4	257.7

Table 5.3.1 Northeast Arctic saithe. Norwegian sampling level in 2010 by ICES area and quarter.

	NeA SAITHE										
2010		research vessels				commercial vessels					
										Norwegian	Commercial
ICES/NAFO		specimen samples		length samples		specimen samples		length samples		Landings in	samples
region	Q	samples	no	samples	no	samples	no	samples	no	Tonnes	per 1000 t
I	**1**	1	1	13	166	11	120	21	337	176.6	181.2
	2	0	0	0	0	21	276	123	4535	3424.5	42.0
	3	13	135	57	528	6	29	47	4823	8600.2	6.2
	4	1	3	2	4	3	3	31	849	3293.5	10.3
	total	15	139	72	698	41	428	222	10544	15494.8	17.0
IIa	**1**	36	232	64	810	337	8415	504	13839	54812.3	15.3
	2	2	11	4	105	197	3805	351	12626	45473.4	12.1
	3	0	0	20	76	150	2161	305	17157	39818.4	11.4
	4	90	982	96	3041	65	1246	129	6844	18116.8	10.7
	total	128	1225	184	4032	749	15627	1289	50466	158220.8	12.9
IIb	**1**	0	0	1	1	0	0	0	0	0.0	
	2	0	0	0	0	1	1	3	3	229.2	17.5
	3	0	0	9	24	1	1	8	23	15.4	584.4
	4	0	0	0	0	1	1	4	5	8.7	574.7
	total	0	0	10	25	3	3	15	31	253.4	71.0

Table 5.3.2 Northeast Arctic saithe. Catch numbers at age

Run title : North-East Arctic saithe

At 28/04/2011 12:17

Table 1 Catch numbers at age Numbers*10**-3

YEAF	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
AGE											
3	13517	25237	45932	51171	10925	42578	25127	28457	29955	76011	43834
4	16828	12929	13720	35199	72344	5737	61199	23826	21856	11745	63270
5	17422	17707	5449	7165	15966	30171	14727	34493	6065	16650	14081
6	6514	5379	10218	5659	3299	11635	14475	3957	9846	4666	16298
7	6281	1886	2991	4699	4214	3282	5220	5388	936	4716	5157
8	3088	1371	1262	1337	3223	2421	1542	2797	2274	1107	8004
9	1691	736	1156	1308	1518	3135	1047	1356	1070	1682	2521
10	956	573	556	848	1482	802	1083	1340	686	663	3722
11	481	538	611	550	1282	1136	530	814	465	199	1103
12	363	275	369	467	965	652	628	603	284	138	762
13	260	112	282	399	561	509	670	528	168	30	325
14	185	89	224	166	443	802	497	391	156	47	278
+gp	673	726	643	580	1069	1023	929	1014	314	88	349
0 TOTAL	68259	67558	83413	109548	117291	103883	127674	104964	74075	117742	159704
TONSL	133515	105951	120707	148627	197426	185600	203788	181326	110247	140060	264924
SOPC(	100	100	100	100	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

YEAF	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AGE										
3	61743	55351	62938	36884	70255	135592	105935	56505	75819	40303
4	47522	44490	20793	44149	13502	33159	36703	31946	28545	36202
5	21614	24752	22199	15714	18901	8618	10845	14396	17280	9100
6	7661	8650	13224	20476	5123	9448	2205	5232	5384	6302
7	7690	4769	5868	12182	9018	3725	4633	1694	3550	3161
8	2326	3012	3246	4815	7841	3483	1557	2132	1178	1322
9	3489	1584	2368	3267	3365	2905	1718	1082	1659	145
10	1760	1817	2153	2512	2714	1870	1030	1126	536	721
11	2514	1044	1291	1440	2237	1183	495	756	373	406
12	1045	676	653	1448	1438	924	261	786	344	449
13	284	281	670	433	530	530	226	328	206	254
14	186	222	365	264	300	152	62	267	272	236
+gp	373	452	259	247	276	334	169	345	264	265
0 TOTAL	158207	147100	136027	143831	135500	201923	165839	116595	135410	98866
TONSL	241272	214334	213859	264121	233453	242486	182817	155464	164680	144554
SOPC(	100	100	100	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

YEAF	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE										
3	85966	35853	18216	43579	48989	21322	18555	8144	12607	23792
4	22345	67150	25108	34927	11992	12433	51742	35928	19400	16930
5	22044	13481	34543	12679	7200	5845	4506	32901	33343	9054
6	3706	8477	3408	11775	5287	4363	3238	4570	18578	10238
7	2611	1088	3178	1193	3746	2704	3624	2333	1762	7341
8	2056	1291	1243	1862	776	1349	784	1222	352	1076
9	378	476	803	589	879	338	644	968	177	160
10	286	271	261	585	134	438	267	321	189	112
11	258	124	215	407	274	123	263	73	1	150
12	91	116	130	158	214	65	164	12	149	37
13	147	78	170	123	55	30	154	2	0	31
14	97	100	99	179	126	54	102	15	36	0
+gp	50	44	188	77	32	3	145	1	20	50
0 TOTAL	140035	128549	87562	108133	79704	49067	84188	86490	86614	68971
TONSL	175540	168034	156936	158786	107183	67396	92391	114242	122817	95848
SOPC(	100	100	100	100	100	100	100	100	105	102

Table 5.3.2 continue

	Table 1	Catch numbers at age			Numbers*10**-3					
	YEAF	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE										
	3	68682	44627	22812	7063	17178	10510	11789	3091	9655	9175
	4	13630	33294	61931	32671	52109	54886	11698	16215	12236	22768
	5	5752	5987	31102	49410	40145	18499	35011	11946	22872	7747
	6	4883	5412	3747	19058	30451	18357	13567	31818	10347	10676
	7	3877	4751	1759	2058	4177	17834	13452	8376	18930	6123
	8	2381	3176	1378	724	483	2849	7058	5539	3374	8303
	9	383	1462	1027	421	125	485	812	2873	3343	2530
	10	61	286	797	278	259	214	55	727	2290	2652
	11	90	93	76	528	31	148	48	111	419	1022
	12	68	46	35	92	176	68	42	65	103	151
	13	1	163	1	13	2	196	27	19	24	8
	14	12	0	17	15	42	59	21	0	11	25
	+gp	8	141	18	9	43	2	8	198	32	13
0	TOTAL	99828	99438	124700	112340	145221	124107	93588	80978	83636	71193
	TONSL	107327	127604	154903	146950	168378	171348	143629	153327	150375	135928
	SOPC(	101	105	101	100	100	100	100	100	100	101

	Table 1	Catch numbers at age			Numbers*10**-3					
	YEAF	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	AGE										
	3	3816	6582	2345	1002	26093	1590	3144	25259	9050	26382
	4	7946	17492	50653	6129	12543	68137	4115	18953	34311	43436
	5	26960	11573	13600	33840	9841	12328	39889	5969	9954	28514
	6	8769	25671	7123	10613	23141	10098	15301	24363	6628	7988
	7	7120	5312	9594	7494	10799	16757	7963	9712	15930	3129
	8	3146	4276	5494	8307	5659	8080	11302	5624	4766	12444
	9	4687	2382	3545	2792	7852	5671	7749	7697	3021	2749
	10	1935	3431	2519	3088	2674	5127	4138	4705	4224	1314
	11	1406	965	2327	2377	713	1815	2157	1606	2471	1212
	12	433	1016	1112	2057	387	1013	505	1163	993	786
	13	60	281	420	338	465	733	254	145	234	396
	14	8	68	170	536	357	506	52	108	96	119
	+gp	27	55	111	141	379	277	38	156	103	130
0	TOTAL	66313	79104	99013	78714	100903	132132	96607	105460	91781	128599
	TONSL	135853	154870	161592	164636	178568	212822	199008	184740	161853	193399
	SOPC(	100	100	100	100	100	100	100	102	100	100

Table 5.3.3 Northeast Arctic saithe. Catch weight at age

Table 2 Catch weights at age (kg)

	YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
	AGE											
	3	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
	4	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
	5	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63
	6	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33
	7	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16
	8	4.03	4.03	4.03	4.03	4.03	4.03	4.03	4.03	4.03	4.03	4.03
	9	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.87
	10	5.63	5.63	5.63	5.63	5.63	5.63	5.63	5.63	5.63	5.63	5.63
	11	6.44	6.44	6.44	6.44	6.44	6.44	6.44	6.44	6.44	6.44	6.44
	12	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11
	13	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82
	14	8.92	8.92	8.92	8.92	8.92	8.92	8.92	8.92	8.92	8.92	8.92
	+gp	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
0	SOPC	1	1	1.0001	1	1	1	1	1	0.9999	1	1

Table 2 Catch weights at age (kg)

	YEAR	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	AGE										
	3	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.79
	4	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.27
	5	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	2.03
	6	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.55
	7	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.29
	8	4.03	4.03	4.03	4.03	4.03	4.03	4.03	4.03	4.03	4.34
	9	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.87	5.15
	10	5.63	5.63	5.63	5.63	5.63	5.63	5.63	5.63	5.63	5.75
	11	6.44	6.44	6.44	6.44	6.44	6.44	6.44	6.44	6.44	6.11
	12	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	5.94
	13	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	6.64
	14	8.92	8.92	8.92	8.92	8.92	8.92	8.92	8.92	8.92	7.73
	+gp	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.47
0	SOPC	0.9999	1	0.9996	1	1	1	1	1	1	1

Table 2 Catch weights at age (kg)

	YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	AGE										
	3	0.73	0.77	1.05	0.71	0.75	0.59	0.53	0.62	0.74	0.71
	4	1.4	1.12	1.33	1.26	1.33	1.22	0.84	0.87	0.95	1
	5	2.05	2.02	1.86	2.02	2.07	1.97	1.66	1.31	1.4	1.45
	6	2.76	2.61	2.8	2.7	2.63	2.3	2.32	2.43	1.78	2.09
	7	3.3	3.27	4	3.88	3.28	2.87	2.97	3.87	2.96	2.49
	8	4.38	3.91	4.18	4.47	3.96	3.72	4	5.38	3.73	3.75
	9	5.95	4.69	5.33	5.36	4.54	4.3	4.72	5.83	4.62	3.9
	10	6.39	5.63	5.68	6.06	5.55	4.69	5.44	5.36	4.66	6.74
	11	6.61	7.18	7.31	6.28	6.88	5.84	5.79	6.92	8.34	4.94
	12	6.88	7.21	8.68	6.89	8.14	6.39	6.28	8.72	6.77	4.93
	13	6.75	7	8.54	8.2	6.06	8.11	7.02	7.88	10.04	8.2
	14	7.13	8.03	8.57	9.14	9.66	7.55	8.36	8.94	9.13	8.2
	+gp	7.66	9.44	10.37	6.47	13.72	10.08	8.48	10	11.95	8.59
0	SOPC	0.9999	1	1	0.9999	0.9997	1	0.9999	0.9999	1.0469	1.0235

Table 5.3.3 continue

Table 2 Catch weights at age (kg)

	YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE										
	3	0.68	0.67	0.61	0.52	0.56	0.59	0.62	0.68	0.67	0.6
	4	1.05	1.01	0.99	0.76	0.79	0.82	0.95	1	1.05	1.03
	5	1.85	1.92	1.65	1.24	1.19	1.33	1.24	1.48	1.45	1.63
	6	2.39	2.28	2.46	2.12	1.71	1.84	1.72	1.87	1.93	2.1
	7	3.08	2.77	2.85	3.22	2.87	2.48	2.35	2.58	2.27	2.67
	8	3.35	3.2	3.03	3.83	3.78	3.73	3.1	3.07	2.97	3.14
	9	4.48	3.73	3.71	4.69	4.06	4.32	4.19	4.13	3.61	3.81
	10	4.66	6.35	4.49	5.31	5.3	5.34	5.79	5.44	4.1	4.41
	11	5.62	6.9	5.56	5.66	6.86	5.98	6.77	6.7	4.93	5.76
	12	6.3	7.18	6.56	6.91	6.59	6.26	6.62	4.97	6.59	7.3
	13	6.73	6.88	10.56	6.3	7.88	7.36	7.3	5.23	7.52	9.95
	14	11.55	7.5	6.73	9.45	9.16	9.61	9.15	6.8	7.88	10.56
	+gp	9.58	9.14	8.41	8.95	10.53	13.64	11.48	10.1	7.46	11.08
0	SOPC	1.0087	1.0517	1.0107	1	0.999	1.0019	1.0011	1.0015	1.0015	1.0051

Table 2 Catch weights at age (kg)

	YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	AGE										
	3	0.75	0.69	0.66	0.7	0.59	0.63	0.73	0.63	0.73	0.7
	4	1.12	1.01	0.91	1.03	0.89	0.83	1.08	0.98	1.03	0.99
	5	1.54	1.5	1.42	1.37	1.49	1.43	1.41	1.38	1.65	1.45
	6	2.04	1.97	1.89	1.9	2.09	1.78	1.86	1.92	2	2.14
	7	2.6	2.54	2.54	2.41	2.16	2.27	2.43	2.31	2.37	2.5
	8	3.14	3.25	2.58	2.98	2.99	2.73	2.94	2.83	2.69	3.13
	9	3.63	3.77	3.49	3.44	3.24	3.02	3.35	3.16	3.23	3.34
	10	4.54	4.31	3.75	3.73	3.82	3.9	3.66	3.43	3.38	3.81
	11	5.05	4.91	4.12	4.14	3.92	4.06	4.17	3.82	3.46	3.99
	12	5.82	5.69	5.27	5.09	5.14	5.05	5.04	4.09	4.25	4.33
	13	6.4	6.19	5.94	5.96	6.26	5.79	6.07	5.03	4.88	5.38
	14	7.88	7.56	6.49	5.99	6.76	6.01	5.23	5.97	5.65	8.46
	+gp	10.84	11.71	11.21	7.91	6.62	8.35	9.14	8.56	7.33	6.63
0	SOPC	1.001	1.001	1.0033	1.0031	1.0026	1.0017	1.0009	1.0155	1.0025	1.0015

Table 5.3.4. Saithe in Sub-areas I and II (Northeast Arctic). 3-year running average maturity ogive 1985-2010.

Year	3	4	5	6	7	8	9	10	11+	12	13	14	15+
1985		0.02	0.50	0.92	0.99	1.00	1	1	1	1	1	1	1
1986		0.02	0.51	0.94	0.99	1.00	1	1	1	1	1	1	1
1987			0.35	0.98	1.00	1.00	1	1	1	1	1	1	1
1988			0.25	0.96	1.00	1	1	1	1	1	1	1	1
1989			0.15	0.92	1.00	1	1	1	1	1	1	1	1
1990			0.20	0.85	0.99	1.00	1	1	1	1	1	1	1
1991		0.02	0.25	0.84	0.98	1.00	1	1	1	1	1	1	1
1992		0.02	0.30	0.83	0.93	0.92	0.90	0.95	1	1	1	1	1
1993		0.02	0.26	0.88	0.92	0.89	0.87	0.89	1	0.98	1	1	1
1994		0.02	0.26	0.84	0.90	0.82	0.87	0.89	1	0.98	1	1	1
1995		0.02	0.22	0.80	0.92	0.90	0.97	0.94	1	0.98	1	1	1
1996		0.03	0.21	0.65	0.91	0.93	1	1	1	1	1	1	1
1997		0.03	0.14	0.45	0.83	0.94	0.93	0.97	1	1	1	1	1
1998		0.04	0.07	0.33	0.74	0.93	0.92	0.96	1	1	1	1	1
1999			0.08	0.32	0.74	0.92	0.92	0.96	0.99	0.97	1	1	1
2000			0.08	0.46	0.82	0.96	0.98	0.99	0.97	0.94	1	1	1
2001			0.11	0.64	0.93	0.97	0.98	0.99	0.97	0.93	1	1	1
2002			0.13	0.78	0.95	0.98	0.98	0.99	0.98	0.96	1	1	1
2003			0.14	0.82	0.96	0.98	0.98	0.99	1.00	0.98	1	1	1
2004			0.21	0.80	0.97	0.99	1	1	1	1	1	1	1
2005		0.03	0.30	0.82	0.97	0.99	1	1	1	1	1	1	1
2006		0.04	0.40	0.86	0.98	0.99	1	1	1	1	1	1	1
2007		0.05	0.42	0.87	0.97	0.98	1	0.97	1	1	1	1	1
2008		0.05	0.34	0.83	0.95	0.98	1	0.97	1	1	1	1	1
2009		0.04	0.27	0.70	0.91	0.97	1	0.97	1	1	1	1	1
2010		0.02	0.19	0.65	0.89	0.97	1	1.00	1	1	1	1	1

Table 5.3.5 Northeast Arctic saithe. Tuning data sets applied in final XSA run

```
North-East Arctic saithe (Sub-areas I and II)
104
FLT11: Nor trawl revised 2010 (Catch: Unknown) (Effort: Un-
known)
1994 2001
1 1 0.00 1.00
4  8
   1     83.2   280.2   174.0    24.0     5.3
   1    150.0   208.3   226.3    35.9     5.9
   1     84.7   113.2   164.7   217.1    24.9
   1     28.5   148.3   151.1   194.4   122.3
   1     24.5    41.1   181.6    69.2    42.1
   1     26.6    74.9    56.8   131.6    30.2
   1     58.8    62.9   117.9    91.3   122.6
   1     32.2   176.1   126.8   119.8    50.7
FLT12: Nor trawl revised 2010 (Catch: Unknown) (Effort: Un-
known)
2002 2010
1 1 0.00 1.00
4  8
   1     52.2    84.9   264.3    59.6    61.2
   1    105.9   161.7   107.3   154.7    99.8
   1      5.8   141.8   105.4   135.3   169.6
   1     38.6   103.3   305.7   145.9    82.1
   1     53.5    99.2    86.9   202.3   116.9
   1     11.2   206.8   161.8   109.1   165.6
   1     81.1    46.3   266.0   149.1    90.8
   1    158.6   134.4    79.0   196.5    55.0
   1    156.6   180.8    90.5    34.2   162.9
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 2010
1 1 0.75 0.85
3  7
   1   230.2    92.6    18.9    10.6     2.2
   1    87.5   151.7    26.1     6.2     6.4
   1   212.4   118.7    49.1    19.2     4.7
   1   228.1    67.2    20.3    16.5     7.7
   1    42.6   142.9    19.4     4.6     8.5
   1   111.0    27.1    61.1     7.9     5.8
   1    97.2    29.2    13.8    11.9     4.0
   1   139.8    80.2     7.7     5.2     6.8
   1   185.7    31.0    22.0     4.0     1.9
```

Table 5.4.1. Northeast Arctic saithe. Data and parameter settings of exploratory and final XSA-runs.

Run No.	1	2	3	4
Ass. type	SPALY	SFT	SFT	FINAL
Catch data	1960-2009	1960-2010	1960-2010	1960-2010
Age range	3-15+	3-15+	3-15+	3-15+
F bar	4-7	4-7	4-7	4-7
Fleet 11 Norw. trawl	1994-2001 age 4-8 Q1-4	1994-2001 age 4-8 Q1-4		1994-2001 age 4-8 Q1-4
Fleet 12 Norw. trawl	2002-2009 age 4-8 Q1-4	2002-20010 age 4-8 Q1-4		2002-2010 age 4-8 Q1-4
Fleet 13 ac. survey	1994-2001 age 3-7		1994-2001 age 3-7	1994-2001 age 3-7
Fleet 14 ac. survey	2002-2009 age 3-7		2002-2010 age 3-7	2002-2010 age 3-7
Time series weights	No	No	No	No
Power model	No	No	No	No
Catchability (q) plateau	8	8	8	8
Survivor est. shrunk tow. Mean of	5 years 5 oldest ages	5 years 5 oldest ages	5 years 5 oldest ages	5 years 5 oldest ages
SE of mean	1.5	1.5	1.5	1.5
Min. fleet SE for pop. Est.	0.3	0.3	0.3	0.3
Prior weight.	None	None	None	None

Table 5.5.1. NeA saithe, Tuning diagnostics

Lowestoft VPA Version 3.1
28/04/2011 12:16

Extended Survivors Analysis

North-East Arctic saithe

CPUE data from file flt-split.dat

Catch data for 51 years. 1960 to 2010. Ages 3 to 15.

Fleet	Fi year	Last year	First age	Last age	Alpha	Beta
FLT11: Nc	1994	2010	4	8	0	1
FLT12: Nc	2002	2010	4	8	0	1
FLT13: Nc	1994	2010	3	7	0.75	0.85
FLT14: Nc	2002	2010	3	7	0.75	0.85

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 8

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1.500

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

Prior weighting not applied

Tuning had not converged after 30 iterations

Total absolute residual between iterations
29 and 30 = .02301

Final year F values

Age	3	4	5	6	7	8	9	10	11	12
Iteration 2	0.1103	0.5013	0.338	0.2736	0.2211	0.3626	0.2387	0.1744	0.1813	0.6972
Iteration 3	0.1102	0.5006	0.3376	0.2732	0.2207	0.3617	0.2379	0.1738	0.1788	0.6901

Age	13	14
Iteration 2	1.0295	0.4109
Iteration 3	1.026	0.4054

1

Regression weights

	1	1	1	1	1	1	1	1	1	1

Table 5.5.1. Continued

Fishing mortalities

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	0.022	0.022	0.02	0.007	0.075	0.026	0.031	0.125	0.065	0.11
4	0.08	0.131	0.229	0.066	0.117	0.287	0.086	0.267	0.249	0.501
5	0.224	0.16	0.143	0.236	0.144	0.161	0.271	0.173	0.218	0.338
6	0.23	0.345	0.14	0.159	0.252	0.216	0.307	0.264	0.295	0.273
7	0.278	0.213	0.208	0.215	0.24	0.292	0.264	0.326	0.276	0.221
8	0.2	0.268	0.355	0.281	0.25	0.285	0.327	0.302	0.263	0.362
9	0.276	0.229	0.373	0.308	0.47	0.427	0.488	0.389	0.263	0.238
10	0.313	0.335	0.404	0.655	0.547	0.651	0.645	0.629	0.383	0.174
11	0.309	0.253	0.4	0.853	0.302	0.927	0.637	0.561	0.825	0.179
12	0.272	0.386	0.521	0.756	0.312	0.947	0.731	0.884	0.84	0.69
13	0.159	0.284	0.271	0.292	0.374	1.872	0.66	0.475	0.43	1.026
14	0.201	0.272	0.278	0.666	0.577	0.924	0.647	0.664	0.676	0.405

1

XSA population numbers (Thousands)

	AGE									
YEAR	3	4	5	6	7	8	9	10	11	12
2001	1.96E+05	1.14E+05	1.49E+05	4.71E+04	3.24E+04	1.92E+04	2.15E+04	7.96E+03	5.84E+03	2.01E+03
2002	3.41E+05	1.57E+05	8.63E+04	9.72E+04	3.07E+04	2.01E+04	1.29E+04	1.33E+04	4.77E+03	3.51E+03
2003	1.32E+05	2.73E+05	1.13E+05	6.02E+04	5.63E+04	2.03E+04	1.26E+04	8.38E+03	7.80E+03	3.03E+03
2004	1.55E+05	1.06E+05	1.78E+05	8.00E+04	4.28E+04	3.74E+04	1.16E+04	7.10E+03	4.58E+03	4.28E+03
2005	3.98E+05	1.26E+05	8.11E+04	1.15E+05	5.59E+04	2.83E+04	2.31E+04	7.01E+03	3.02E+03	1.60E+03
2006	6.94E+04	3.02E+05	9.18E+04	5.75E+04	7.32E+04	3.60E+04	1.80E+04	1.18E+04	3.32E+03	1.83E+03
2007	1.13E+05	5.54E+04	1.86E+05	6.40E+04	3.80E+04	4.48E+04	2.22E+04	9.62E+03	5.06E+03	1.08E+03
2008	2.38E+05	8.95E+04	4.16E+04	1.16E+05	3.86E+04	2.39E+04	2.64E+04	1.11E+04	4.13E+03	2.19E+03
2009	1.59E+05	1.72E+05	5.61E+04	2.87E+04	7.29E+04	2.28E+04	1.45E+04	1.47E+04	4.86E+03	1.93E+03
2010	2.79E+05	1.22E+05	1.10E+05	3.69E+04	1.75E+04	4.53E+04	1.44E+04	9.10E+03	8.18E+03	1.74E+03

Estimated population abundance at 1st Jan 2011

0.00E+00	2.05E+05	6.06E+04	6.43E+04	2.30E+04	1.15E+04	2.59E+04	9.29E+03	6.29E+03	5.68E+03

Taper weighted geometric mean of the VPA populations:

1.70E+05	1.06E+05	6.02E+04	3.33E+04	1.88E+04	1.07E+04	6.08E+03	3.56E+03	1.97E+03	1.08E+03

Standard error of the weighted Log(VPA populations) :

0.4783	0.5547	0.6389	0.7184	0.81	0.9334	1.0345	1.1126	1.2231	1.3507

	AGE	
YEAR	13	14
2001	4.51E+02	4.87E+01
2002	1.26E+03	3.15E+02
2003	1.95E+03	7.74E+02
2004	1.47E+03	1.22E+03
2005	1.65E+03	9.00E+02
2006	9.57E+02	9.27E+02
2007	5.81E+02	1.21E+02
2008	4.24E+02	2.46E+02
2009	7.41E+02	2.16E+02
2010	6.82E+02	3.95E+02

Estimated population abundance at 1st Jan 2011

7.25E+02	2.01E+02

Taper weighted geometric mean of the VPA populations:

5.99E+02	4.07E+02

Table 5.5.1. Continued

Standard error of the weighted Log(VPA populations) :

	1.7933	2.0688
1		

Log catchability residuals.

Fleet : FLT11: Nor trawl rev

Age	1994	1995	1996	1997	1998	1999	2000
3	No data for this fleet at this age						
4	0.21	1.13	-0.05	-0.18	-0.54	-0.17	-0.18
5	0.53	0.41	0.21	-0.24	-0.65	-0.18	-0.17
6	0.86	0.12	-0.1	0.16	-0.36	-0.72	-0.05
7	0.58	-0.26	0.42	0.25	-0.45	-0.47	-0.14
8	0.01	0.09	0.21	0.75	-0.55	-0.61	0.21

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	No data for this fleet at this age									
4	-0.21	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	0.09	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	0.09	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	0.07	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	-0.11	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99

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	-7.827	-6.6276	-5.802	-5.4409	-5.6347
S.E(Log q	0.5006	0.387	0.455	0.3957	0.4369

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
4	0.73	0.722	8.92	0.55	8	0.38	-7.83
5	0.65	1.574	8.36	0.77	8	0.23	-6.63
6	1.9	-1.032	1.08	0.18	8	0.86	-5.8
7	1.25	-1.137	4.26	0.78	8	0.48	-5.44
8	1.04	-0.242	5.49	0.86	8	0.49	-5.63
1							

Fleet : FLT12: Nor trawl rev

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	No data for this fleet at this age									
4	99.99	-0.1	0.1	-1.93	-0.18	-0.65	-0.61	0.97	0.98	1.43
5	99.99	-0.26	0.11	-0.44	-0.01	-0.17	-0.09	-0.13	0.66	0.33
6	99.99	0.28	-0.24	-0.54	0.21	-0.37	0.19	0.07	0.27	0.14
7	99.99	-0.34	0	0.15	-0.03	0.05	0.08	0.4	0.02	-0.33
8	99.99	-0.15	0.37	0.25	-0.21	-0.08	0.07	0.09	-0.39	0.06

Table 5.5.1. Continued

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	-7.7523	-6.4877	-5.9233	-5.7052	-5.4169
S.E(Log q	1.0315	0.3286	0.3026	0.2276	0.2334

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
4	0.9	0.154	8.16	0.25	9	0.99	-7.75
5	1.33	-1.04	4.85	0.59	9	0.43	-6.49
6	1.04	-0.173	5.7	0.7	9	0.34	-5.92
7	0.81	1.387	6.64	0.89	9	0.17	-5.71
8	0.89	0.483	5.97	0.72	9	0.22	-5.42
1							

Fleet : FLT13: Norway Ac Sur

Age	1994	1995	1996	1997	1998	1999	2000
3	-0.48	-0.36	0.34	-1.05	0.18	0.28	0.37
4	-0.4	-0.22	-0.02	0.79	0.68	-0.06	0.02
5	-0.35	-0.07	-0.09	0.11	0.83	0.63	-0.92
6	-0.01	-0.42	-0.47	1.09	0.91	0.3	-0.38
7	0.01	-0.11	-0.65	0.1	0.04	0.47	0.24
8	No data for this fleet at this age						

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	0.72	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	-0.77	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	-0.13	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	-1.03	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	-0.09	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	No data for this fleet at this age									

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

Age	3	4	5	6	7
Mean Log	-7.1102	-6.8208	-7.4558	-7.6614	-8.1088
S.E(Log q	0.5782	0.5193	0.5478	0.7283	0.324

Table 5.5.1. Continued

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	1.5	-0.525	4.6	0.16	8	0.92	-7.11
4	1.47	-0.609	4.4	0.22	8	0.8	-6.82
5	1.16	-0.24	6.8	0.28	8	0.68	-7.46
6	0.69	0.587	8.71	0.37	8	0.53	-7.66
7	0.96	0.233	8.18	0.88	8	0.34	-8.11
1							

Fleet : FLT14: Norway Ac Sur

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	99.99	-0.09	-0.11	0.61	-0.21	-0.18	0.3	-0.51	0.21	-0.03
4	99.99	0.11	0.13	0.7	0	0.01	-0.11	-0.37	-0.03	-0.44
5	99.99	-0.11	-0.07	0.18	0.01	-0.14	0.39	0.32	-0.53	-0.06
6	99.99	-0.06	-0.28	0.58	0.14	-0.48	0.03	-0.19	0.41	-0.13
7	99.99	-0.45	0	-0.03	0.22	0.09	0.34	0	-0.14	-0.03
8	No data for this fleet at this age									

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

Age	3	4	5	6	7
Mean Log	-7.0364	-7.2814	-8.0306	-8.6236	-8.7575
S.E(Log q	0.3276	0.3283	0.2748	0.3317	0.2242

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	1.2	-0.802	6.01	0.69	9	0.4	-7.04
4	0.9	0.458	7.72	0.77	9	0.31	-7.28
5	0.83	1.024	8.61	0.84	9	0.23	-8.03
6	1.07	-0.244	8.46	0.65	9	0.38	-8.62
7	0.91	0.566	8.94	0.84	9	0.21	-8.76
1							

Terminal year survivor and F summaries :

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2007

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: Nc	1	0	0	0	0	0	0
FLT12: Nc	1	0	0	0	0	0	0
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	198474	0.345	0	0	1	0.944	0.114
F shrinka	358131	1.5				0.056	0.065

Table 5.5.1. Continued

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of y	s.e	s.e		Ratio	
205128	0.34	0.14	2	0.414	0.11

1

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

Year class = 2006

Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
FLT11: Nc	1	0	0	0	0	0	0
FLT12: Nc	251527	1.087	0	0	1	0.048	0.145
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	53590	0.245	0.324	1.32	2	0.911	0.55
F shrinka	175824	1.5				0.041	0.202

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of y	s.e	s.e		Ratio	
60573	0.24	0.29	4	1.229	0.501

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

Year class = 2005

Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
FLT11: Nc	1	0	0	0	0	0	0
FLT12: Nc	94044	0.331	0.168	0.51	2	0.272	0.242
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	54681	0.192	0.141	0.73	3	0.709	0.387
F shrinka	120429	1.5				0.019	0.194

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of y	s.e	s.e		Ratio	
64335	0.17	0.14	6	0.86	0.338

1

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

Year class = 2004

Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
FLT11: Nc	1	0	0	0	0	0	0
FLT12: Nc	33220	0.231	0.192	0.83	3	0.38	0.197
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	18327	0.17	0.171	1	4	0.607	0.332
F shrinka	23509	1.5				0.013	0.268

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of y	s.e	s.e		Ratio	
23047	0.14	0.15	8	1.116	0.273

Table 5.5.1. Continued

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

Year class = 2003

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: Nc	1	0	0	0	0	0	0
FLT12: Nc	10264	0.186	0.153	0.82	4	0.414	0.244
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	12515	0.15	0.111	0.74	5	0.577	0.204
F shrinka	8722	1.5				0.009	0.281

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
11490	0.12	0.09	10	0.745	0.221

1

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

Year class = 2002

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: Nc	1	0	0	0	0	0	0
FLT12: Nc	26423	0.162	0.041	0.25	5	0.548	0.355
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	25084	0.154	0.112	0.73	5	0.44	0.371
F shrinka	33879	1.5				0.012	0.287

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
25902	0.11	0.05	11	0.461	0.362

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

Year class = 2001

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: Nc	1	0	0	0	0	0	0
FLT12: Nc	8999	0.163	0.168	1.03	5	0.534	0.244
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	9845	0.15	0.114	0.76	5	0.452	0.225
F shrinka	4905	1.5				0.014	0.41

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
9294	0.11	0.1	11	0.855	0.238

Table 5.5.1. Continued

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 2000

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	5959	0.16	0.142	0.89	5	0.515	0.182
FLT13: No	1	0	0	0	0	0	0
FLT14: No	6995	0.148	0.188	1.27	5	0.469	0.157
F shrinka	1526	1.5				0.016	0.576

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
6289	0.11	0.12	11	1.096	0.174

Age 11 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 1999

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	5749	0.162	0.094	0.58	5	0.532	0.175
FLT13: No	1	0	0	0	0	0	0
FLT14: No	6203	0.152	0.039	0.26	5	0.439	0.163
F shrinka	1182	1.5				0.029	0.656

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
5678	0.12	0.1	11	0.847	0.179

1

Age 12 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 1998

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	626	0.159	0.108	0.68	5	0.479	0.759
FLT13: No	1472	0.613	0	0	1	0.02	0.394
FLT14: No	878	0.163	0.13	0.8	4	0.377	0.593
F shrinka	637	1.5				0.124	0.75

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
725	0.21	0.09	11	0.419	0.69

Table 5.5.1. Continued

Age 13 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 1997

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: Nc	162	0.531	0	0	1	0.025	1.165
FLT12: Nc	177	0.16	0.099	0.62	4	0.413	1.107
FLT13: Nc	151	0.41	0.566	1.38	2	0.041	1.216
FLT14: Nc	177	0.183	0.074	0.4	3	0.276	1.105
F shrink	309	1.5				0.244	0.769

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
201	0.38	0.1	11	0.277	1.026

1

Age 14 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 1996

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: Nc	216	0.325	0.129	0.4	2	0.063	0.405
FLT12: Nc	255	0.181	0.086	0.48	3	0.388	0.352
FLT13: Nc	223	0.336	0.114	0.34	3	0.056	0.393
FLT14: Nc	211	0.231	0.031	0.13	2	0.207	0.413
F shrink	182	1.5				0.287	0.465

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
219	0.44	0.06	11	0.131	0.405

Table 5.5.2 Northeast Arctic saithe. Fishing mortality

Table 8 Fishing mortality (F) at age

YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
AGE											
3	0.1764	0.3116	0.2866	0.2035	0.1355	0.1784	0.2218	0.1719	0.2385	0.34	0.2034
4	0.1981	0.2554	0.2781	0.3719	0.4937	0.0977	0.4199	0.3391	0.1935	0.1381	0.5305
5	0.4885	0.3307	0.1622	0.2288	0.2872	0.3933	0.3884	0.4451	0.1341	0.2215	0.2444
6	0.2605	0.2712	0.3233	0.2528	0.1561	0.3511	0.3318	0.1693	0.2175	0.1448	0.3516
7	0.312	0.1112	0.2377	0.2413	0.3033	0.2298	0.262	0.1971	0.0548	0.1533	0.2362
8	0.2064	0.1027	0.1011	0.1584	0.2595	0.2859	0.1605	0.2182	0.1191	0.0848	0.4207
9	0.1229	0.0691	0.1181	0.1446	0.2718	0.434	0.1922	0.207	0.121	0.1214	0.2828
10	0.1318	0.0556	0.0683	0.1192	0.2424	0.2251	0.2604	0.4023	0.1533	0.1024	0.4288
11	0.127	0.1019	0.0774	0.0892	0.2661	0.2968	0.2279	0.3189	0.2356	0.0605	0.2473
12	0.0948	0.0994	0.0941	0.0781	0.2232	0.21	0.2657	0.4395	0.1745	0.1013	0.3448
13	0.1557	0.0382	0.1402	0.1397	0.127	0.1756	0.3471	0.3748	0.208	0.0249	0.366
14	0.1269	0.073	0.0999	0.1145	0.2272	0.2698	0.26	0.3507	0.1792	0.0823	0.336
+gp	0.1269	0.073	0.0999	0.1145	0.2272	0.2698	0.26	0.3507	0.1792	0.0823	0.336
0 FBAR 4	0.3148	0.2421	0.2503	0.2737	0.3101	0.268	0.3505	0.2876	0.15	0.1644	0.3407

Table 8 Fishing mortality (F) at age

YEAR	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AGE										
3	0.3009	0.5092	0.3911	0.5762	0.6076	0.88	0.7566	0.6175	0.5215	0.4996
4	0.3548	0.3696	0.3633	0.5277	0.4283	0.6577	0.6282	0.5388	0.7489	0.5096
5	0.3453	0.316	0.3181	0.5182	0.4517	0.5393	0.4646	0.5427	0.6381	0.5692
6	0.2033	0.2252	0.2777	0.5481	0.3152	0.4286	0.2528	0.4284	0.3992	0.5071
7	0.2782	0.188	0.2347	0.4466	0.4987	0.3991	0.3864	0.3145	0.5857	0.4337
8	0.1588	0.1666	0.1887	0.3081	0.5845	0.3639	0.2883	0.308	0.3768	0.4496
9	0.3264	0.1544	0.1912	0.2947	0.3682	0.4452	0.3071	0.3335	0.4198	0.0713
10	0.3266	0.2817	0.3247	0.3189	0.4274	0.3598	0.2782	0.3394	0.2738	0.3242
11	0.5829	0.3283	0.3318	0.376	0.5251	0.334	0.1508	0.3391	0.1785	0.3444
12	0.3924	0.3009	0.3523	0.7743	0.8135	0.4284	0.113	0.3794	0.254	0.3388
13	0.2075	0.1718	0.5534	0.4186	0.7395	0.8332	0.1741	0.2029	0.1598	0.3022
14	0.3696	0.2487	0.3529	0.4397	0.5797	0.4838	0.2056	0.3207	0.2585	0.2777
+gp	0.3696	0.2487	0.3529	0.4397	0.5797	0.4838	0.2056	0.3207	0.2585	0.2777
0 FBAR 4	0.2954	0.2747	0.2985	0.5102	0.4235	0.5062	0.433	0.4561	0.593	0.5049

Table 8 Fishing mortality (F) at age

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE										
3	0.4079	0.3942	0.2178	0.7575	0.7822	0.1106	0.1289	0.1193	0.233	0.4509
4	0.5778	0.6549	0.5334	0.8439	0.4793	0.4584	0.4255	0.3937	0.4599	0.5629
5	0.6817	0.8588	0.8703	0.5702	0.4061	0.4559	0.2977	0.5309	0.7915	0.4047
6	0.4804	0.6144	0.5447	0.8622	0.4968	0.4632	0.4956	0.5612	0.6599	0.6026
7	0.4068	0.25	0.4919	0.3705	0.7586	0.514	0.9107	0.8312	0.4378	0.5998
8	0.5644	0.3612	0.5046	0.6064	0.4405	0.6919	0.2718	0.9469	0.2729	0.5271
9	0.221	0.2414	0.4013	0.4778	0.6555	0.3488	0.8714	0.6367	0.3273	0.1914
10	0.196	0.2441	0.2019	0.5787	0.1866	0.8292	0.5153	1.8736	0.2386	0.3556
11	0.1832	0.1218	0.3118	0.5554	0.5949	0.2613	2.9415	0.2551	0.0212	0.3028
12	0.1194	0.117	0.1813	0.3981	0.648	0.2685	0.6662	15.8004	1.2885	3.4434
13	0.1759	0.1425	0.2512	0.261	0.2331	0.1697	2.2204	0.0142	0	1.1015
14	0.1798	0.1741	0.271	0.4576	0.4671	0.378	1.4619	3.7668	0.3776	0
+gp	0.1798	0.1741	0.271	0.4576	0.4671	0.378	1.4619	3.7668	0.3776	0
0 FBAR 4	0.5367	0.5945	0.6101	0.6617	0.5352	0.4729	0.5324	0.5793	0.5873	0.5425

Table 5.5.2 continue

Table 8 Fishing mortality (F) at age

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
3	0.376	0.1393	0.0961	0.0382	0.0545	0.0899	0.0816	0.0292	0.0414	0.0702
4	0.5085	0.315	0.2921	0.194	0.4322	0.2469	0.1368	0.1541	0.1548	0.1299
5	0.3763	0.4395	0.5491	0.4014	0.3877	0.2671	0.2462	0.2019	0.3383	0.1386
6	0.3985	0.7446	0.548	0.7931	0.4648	0.3072	0.3206	0.3708	0.27	0.2607
7	0.4819	0.8717	0.5778	0.6725	0.3916	0.5503	0.3884	0.3354	0.3948	0.2537
8	0.3939	0.9664	0.6788	0.4996	0.3215	0.5097	0.4381	0.2727	0.2183	0.3002
9	0.3591	0.4494	1.0305	0.4503	0.1469	0.6255	0.2632	0.3193	0.2628	0.2528
10	0.1034	0.501	0.4745	0.9061	0.5575	0.4019	0.1283	0.3993	0.456	0.3443
11	0.5433	0.2267	0.2371	0.6759	0.2242	0.7359	0.1456	0.4116	0.4239	0.3782
12	0.2179	0.5988	0.1244	0.5036	0.4996	1.1191	0.473	0.3002	0.8608	0.2644
13	13.5155	1.2478	0.022	0.062	0.0175	2.1325	16.8113	0.4067	0.1718	0.1387
14	2.9899	0	0.3802	0.5238	0.2908	1.0145	3.6136	0	0.4383	0.2725
+gp	2.9899	0	0.3802	0.5238	0.2908	1.0145	3.6136	0	0.4383	0.2725
0 FBAR 4	0.4413	0.5927	0.4917	0.5152	0.4191	0.3429	0.273	0.2655	0.2895	0.1957

Table 8 Fishing mortality (F) at age

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	FBAR
AGE											
3	0.0217	0.0216	0.0198	0.0072	0.0752	0.0257	0.0313	0.1246	0.065	0.1102	0.0999
4	0.0801	0.1313	0.2293	0.0661	0.1165	0.2866	0.0857	0.2667	0.2486	0.5006	0.3387
5	0.2239	0.1605	0.1431	0.2361	0.1439	0.1606	0.2709	0.1727	0.2182	0.3376	0.2428
6	0.2301	0.3452	0.1403	0.1585	0.2516	0.2157	0.3067	0.2641	0.2952	0.2732	0.2775
7	0.2779	0.2125	0.2085	0.2151	0.2401	0.2918	0.2637	0.3261	0.2762	0.2207	0.2743
8	0.1999	0.2679	0.3554	0.2812	0.2501	0.2851	0.3273	0.3015	0.2628	0.3617	0.3087
9	0.2763	0.229	0.3726	0.3077	0.4699	0.4274	0.4884	0.3887	0.2625	0.2379	0.2964
10	0.3129	0.3349	0.4041	0.6546	0.5474	0.6508	0.645	0.6292	0.3833	0.1738	0.3954
11	0.3094	0.2534	0.3998	0.853	0.302	0.9267	0.6372	0.5612	0.8255	0.1788	0.5218
12	0.2716	0.3858	0.5206	0.7564	0.3117	0.9465	0.7312	0.8842	0.8403	0.6901	0.8049
13	0.1589	0.2842	0.2714	0.2925	0.3742	1.8715	0.6595	0.4747	0.4296	1.026	0.6434
14	0.2005	0.2723	0.2782	0.6655	0.5768	0.9242	0.647	0.6635	0.6758	0.4054	0.5816
+gp	0.2005	0.2723	0.2782	0.6655	0.5768	0.9242	0.647	0.6635	0.6758	0.4054	
0 FBAR 4	0.203	0.2124	0.1803	0.169	0.1881	0.2387	0.2317	0.2574	0.2596	0.333	

Table 5.5.3 Northeast Arctic saithe. Stock number at age

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAF	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
	AGE											
	3	92382	104182	203732	307190	95252	287982	139613	199107	156042	291446	263215
	4	103487	63406	62462	125240	205205	68100	197253	91569	137266	100652	169838
	5	49826	69501	40213	38725	70689	102548	50565	106122	53412	92608	71780
	6	31392	25030	40881	27994	25222	43428	56659	28073	55675	38242	60756
	7	25900	19808	15625	24225	17799	17665	25028	33291	19404	36674	27088
	8	18298	15522	14511	10087	15582	10759	11493	15768	22381	15040	25759
	9	16160	12187	11468	10738	7048	9841	6618	8015	10379	16267	11312
	10	8556	11701	9312	8343	7608	4397	5220	4471	5335	7530	11796
	11	4457	6140	9061	7121	6063	4888	2874	3294	2448	3747	5565
	12	4435	3214	4540	6866	5332	3804	2974	1874	1961	1584	2888
	13	1993	3303	2382	3383	5199	3493	2525	1867	989	1348	1172
	14	1716	1397	2603	1695	2409	3749	2399	1461	1051	657	1077
	+gp	6218	11360	7446	5902	5781	4753	4457	3760	2105	1227	1342
0	TOT/	364820	346749	424236	577509	469190	565407	507680	498674	468448	607022	653587

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAF	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	AGE										
	3	262608	153304	214898	93077	170518	256069	220593	135546	206194	113271
	4	175840	159138	75431	118995	42831	76039	86963	84753	59848	100214
	5	81803	100966	90035	42944	57477	22850	32252	37989	40484	23170
	6	46027	47417	60267	53628	20941	29956	10910	16593	18077	17510
	7	34995	30752	30995	37377	25379	12509	15977	6937	8851	9928
	8	17512	21694	20862	20067	19579	12619	6871	8889	4147	4034
	9	13847	12233	15036	14144	12073	8935	7180	4217	5348	2329
	10	6980	8180	8582	10168	8624	6840	4687	4324	2473	2878
	11	6290	4122	5053	5078	6052	4605	3908	2905	2521	1540
	12	3558	2875	2431	2969	2855	2931	2700	2751	1695	1727
	13	1675	1967	1742	1399	1121	1036	1563	1974	1541	1076
	14	665	1114	1357	820	754	438	369	1075	1319	1076
	+gp	1324	2256	955	760	686	953	1000	1380	1273	1200
0	TOT/	653124	546018	527645	401426	368888	435780	394973	309333	353772	279953

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAF	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	AGE										
	3	283643	121615	102847	90673	99780	225093	169531	80035	67026	72449
	4	56271	154442	67129	67721	34805	37366	164998	122011	58158	43469
	5	49291	25852	65686	32242	23842	17645	19343	88271	67385	30062
	6	10736	20410	8968	22524	14925	13005	9158	11759	42500	25000
	7	8633	5437	9040	4258	7786	7435	6700	4568	5493	17986
	8	5268	4706	3467	4526	2407	2985	3641	2206	1629	2903
	9	2107	2453	2685	1714	2020	1269	1224	2272	701	1015
	10	1776	1383	1578	1471	870	859	733	419	984	414
	11	1704	1195	887	1056	675	591	307	358	53	635
	12	894	1161	866	532	496	305	373	13	227	42
	13	1007	649	846	592	292	212	191	157	0	51
	14	651	692	461	539	373	190	147	17	127	0
	+gp	334	303	870	230	94	10	203	1	70	0
0	TOT/	422316	340298	265329	228076	188366	306966	376547	312086	244351	194025

Table 5.5.3 continue

	Table 10	Stock number at age (start of year)				Numbers*10**-3					
	YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE										
	3	242213	379341	275265	208260	357604	135152	166302	118608	262946	149548
	4	37788	136161	270198	204727	164118	277238	101144	125489	94311	206545
	5	20270	18606	81354	165182	138054	87219	177321	72225	88070	66144
	6	16420	11391	9816	38464	90531	76704	54670	113499	48323	51410
	7	11205	9025	4429	4646	14248	46568	46190	32484	64135	30201
	8	8083	5665	3090	2035	1942	7885	21989	25645	19017	35380
	9	1403	4463	1765	1283	1011	1153	3878	11617	15985	12517
	10	686	802	2331	516	670	715	505	2440	6912	10062
	11	237	507	398	1188	171	314	391	364	1340	3587
	12	384	113	331	257	495	112	123	277	197	718
	13	1	253	51	239	127	246	30	63	168	68
	14	14	0	59	41	184	102	24	0	34	116
	+gp	9	0	62	24	187	3	9	0	99	60
0	TOTAL	338713	566327	649149	626861	769342	633411	572575	502711	601536	566357

	Table 10	Stock number at age (start of year)				Numbers*10**-3							
	YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	GMST 60-**	AMST 60-**
	AGE													
	3	196047	340904	131912	155028	397982	69368	112763	238313	158868	279455	0	168548	188091
	4	114138	157057	273153	105879	126019	302230	55355	89477	172259	121882	205128	104586	121468
	5	148504	86258	112760	177806	81140	91827	185792	41597	56108	109988	60573	59573	72157
	6	47144	97190	60150	80014	114956	57528	64026	116021	28656	36931	64335	33326	42488
	7	32431	30664	56344	42802	55907	73179	37963	38576	72945	17464	23047	18281	24174
	8	19186	20110	20299	37450	28262	36001	44751	23876	22795	45309	11490	10188	14406
	9	21454	12862	12595	11648	23145	18019	22164	26413	14459	14351	25902	5865	8902
	10	7959	13324	8375	7105	7010	11845	9621	11135	14660	9105	9294	3392	5316
	11	5839	4765	7804	4578	3023	3320	5059	4133	4859	8181	6289	1877	3106
	12	2012	3508	3028	4284	1597	1830	1076	2190	1931	1743	5678	1053	1906
	13	451	1255	1953	1473	1646	957	581	424	741	682	725	397	1158
	14	49	315	774	1219	900	927	121	246	216	395	201	124	766
	+gp	163	253	502	317	945	499	87	351	229	427	452		
0	TOTAL	595377	768466	689650	629602	842534	667530	539359	592752	548727	645912	413115		

Table 5.5.4 Northeast Arctic saithe. Spawning stock number at age

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
AGE											
3	0	0	0	0	0	0	0	0	0	0	0
4	1035	634	625	1252	2052	681	1973	916	1373	1007	1698
5	27404	38226	22117	21299	38879	56401	27811	58367	29377	50934	39479
6	26684	21275	34749	23794	21439	36914	48160	23862	47324	32506	51642
7	25382	19412	15313	23740	17443	17312	24528	32625	19016	35940	26546
8	18298	15522	14511	10087	15582	10759	11493	15768	22381	15040	25759
9	16160	12187	11468	10738	7048	9841	6618	8015	10379	16267	11312
10	8556	11701	9312	8343	7608	4397	5220	4471	5335	7530	11796
11	4457	6140	9061	7121	6063	4888	2874	3294	2448	3747	5565
12	4435	3214	4540	6866	5332	3804	2974	1874	1961	1584	2888
13	1993	3303	2382	3383	5199	3493	2525	1867	989	1348	1172
14	1716	1397	2603	1695	2409	3749	2399	1461	1051	657	1077
+gp	6218	11360	7446	5902	5781	4753	4457	3760	2105	1227	1342

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	1758	1591	754	1190	428	760	870	848	598	1002
5	44991	55531	49519	23619	31612	12568	17739	20894	22266	12744
6	39123	40305	51227	45583	17800	25463	9274	14104	15365	14883
7	34296	30137	30375	36630	24872	12259	15657	6799	8674	9730
8	17512	21694	20862	20067	19579	12619	6871	8889	4147	4034
9	13847	12233	15036	14144	12073	8935	7180	4217	5348	2329
10	6980	8180	8582	10168	8624	6840	4687	4324	2473	2878
11	6290	4122	5053	5078	6052	4605	3908	2905	2521	1540
12	3558	2875	2431	2969	2855	2931	2700	2751	1695	1727
13	1675	1967	1742	1399	1121	1036	1563	1974	1541	1076
14	665	1114	1357	820	754	438	369	1075	1319	1076
+gp	1324	2256	955	760	686	953	1000	1380	1273	1200

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	563	1544	671	677	696	747	0	0	0	0
5	27110	14219	36128	17733	11921	8999	6770	22068	10108	6012
6	9126	17348	7623	19145	13731	12225	8974	11289	39100	21250
7	8461	5328	8859	4173	7709	7361	6700	4568	5493	17806
8	5268	4706	3467	4526	2407	2985	3641	2206	1629	2903
9	2107	2453	2685	1714	2020	1269	1224	2272	701	1015
10	1776	1383	1578	1471	870	859	733	419	984	414
11	1704	1195	887	1056	675	591	307	358	53	635
12	894	1161	866	532	496	305	373	13	227	42
13	1007	649	846	592	292	212	191	157	0	51
14	651	692	461	539	373	190	147	17	127	0
+gp	334	303	870	230	94	10	203	1	70	0

Table 5.5.4 continue

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	756	2723	5404	4095	3282	8317	3034	5020	0	0
5	5068	5582	21152	42947	30372	18316	24825	5056	7046	5292
6	13793	9455	8638	32310	72425	49858	24601	37455	15463	23649
7	10980	8393	4075	4181	13108	42376	38338	24038	47460	24765
8	8083	5212	2750	1669	1747	7333	20670	23850	17495	33965
9	1403	4017	1535	1116	981	1153	3607	10688	14706	12266
10	686	762	2075	459	630	715	490	2343	6635	9962
11	237	507	398	1188	171	314	391	364	1327	3479
12	384	113	324	252	485	112	123	277	191	675
13	1	253	51	239	127	246	30	63	168	68
14	14	0	59	41	184	102	24	0	34	116
+gp	9	0	62	24	187	3	9	0	99	60

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	3781	12089	2768	4474	6890	2438
5	16335	11214	15786	37339	24342	36731	78033	14143	15149	20898
6	30172	75808	49323	64011	94264	49474	55703	96297	20059	24005
7	30161	29131	54091	41518	54230	71715	36824	36647	66380	15543
8	18611	19708	19893	37075	27980	35641	43856	23398	22111	43949
9	21025	12605	12343	11648	23145	18019	22164	26413	14459	14351
10	7879	13191	8291	7105	7010	11845	9333	10801	14221	9105
11	5664	4670	7804	4578	3023	3320	5059	4133	4859	8181
12	1871	3368	2968	4284	1597	1830	1076	2190	1931	1743
13	451	1255	1953	1473	1646	957	581	424	741	682
14	49	315	774	1219	900	927	121	246	216	395
+gp	163	253	502	317	945	499	87	351	229	427

Table 5.5.5 Northeast Arctic saithe. Stock biomass at age

Table 12 Stock biomass at age (start of year) Tonnes

	YEAF	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
	AGE											
	3	65591	73969	144649	218105	67629	204467	99125	141366	110790	206927	186883
	4	114871	70380	69332	139017	227777	75591	218951	101642	152366	111724	188520
	5	81216	113287	65548	63122	115223	167153	82420	172979	87062	150951	117001
	6	73144	58319	95253	65225	58767	101188	132016	65411	129723	89104	141561
	7	81844	62593	49376	76551	56244	55822	79090	105200	61317	115889	85598
	8	73740	62553	58478	40649	62795	43360	46318	63546	90196	60610	103808
	9	78701	59350	55848	52296	34326	47926	32232	39031	50546	79218	55089
	10	48169	65877	52425	46971	42835	24757	29391	25174	30035	42391	66412
	11	28701	39540	58356	45858	39048	31480	18512	21215	15767	24131	35837
	12	31534	22848	32280	48818	37913	27048	21147	13323	13940	11261	20532
	13	15587	25828	18629	26457	40655	27312	19743	14599	7731	10543	9164
	14	15304	12458	23216	15121	21487	33440	21398	13031	9373	5864	9604
	+gp	59070	107924	70741	56068	54923	45150	42344	35722	19999	11657	12748
0	TOTAL	767473	774927	794132	894257	859622	884694	842688	812239	778843	920271	1032756

Table 12 Stock biomass at age (start of year) Tonnes

	YEAF	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	AGE										
	3	186451	108846	152578	66085	121068	181809	156621	96237	146398	89484
	4	195182	176643	83729	132084	47543	84403	96529	94075	66431	127271
	5	133338	164574	146756	69998	93688	37246	52571	61922	65988	47036
	6	107244	110482	140423	124952	48792	69797	25421	38661	42118	44649
	7	110586	97176	97945	118112	80198	39529	50487	21922	27969	32664
	8	70572	87425	84076	80870	78904	50854	27691	35822	16713	17509
	9	67436	59573	73225	68880	58794	43514	34966	20536	26046	11997
	10	39299	46054	48317	57244	48552	38507	26388	24343	13925	16547
	11	40507	26548	32543	32704	38973	29655	25166	18711	16237	9410
	12	25297	20441	17281	21110	20297	20836	19195	19563	12049	10257
	13	13097	15386	13624	10941	8764	8102	12225	15438	12055	7146
	14	5935	9939	12101	7316	6723	3907	3289	9592	11770	8315
	+gp	12577	21428	9076	7225	6513	9055	9500	13109	12094	11367
0	TOTAL	1007521	944517	911672	797521	658808	617215	540047	469932	469793	433652

Table 12 Stock biomass at age (start of year) Tonnes

	YEAF	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	AGE										
	3	207059	93643	107989	64378	74835	132805	89851	49621	49599	51439
	4	78779	172975	89281	85329	46290	45586	138598	106149	55250	43469
	5	101047	52221	122177	65128	49353	34760	32109	115634	94339	43589
	6	29632	53270	25110	60814	39252	29912	21246	28575	75650	52250
	7	28490	17778	36159	16523	25539	21340	19899	17677	16258	44785
	8	23075	18400	14491	20230	9532	11106	14564	11871	6075	10885
	9	12536	11505	14309	9185	9173	5455	5776	13243	3238	3958
	10	11348	7786	8961	8917	4829	4028	3986	2247	4585	2788
	11	11261	8582	6484	6629	4647	3452	1777	2480	440	3135
	12	6148	8374	7520	3663	4037	1949	2340	116	1539	208
	13	6800	4545	7224	4852	1772	1722	1340	1235	0	421
	14	4644	5555	3951	4924	3605	1431	1227	152	1155	0
	+gp	2560	2860	9022	1486	1288	105	1725	11	833	0
0	TOTAL	523380	457494	452679	352057	274151	293653	334438	349011	308960	256927

Table 5.5.5 continue

	Table 12	Stock biomass at age (start of year)			Tonnes					
	YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE										
	3	164705	254158	167912	108295	200258	79740	103107	80654	176174	89729
	4	39678	137523	267496	155592	129653	227336	96086	125489	99027	212742
	5	37500	35723	134233	204825	164284	116001	219878	106892	127701	107815
	6	39244	25972	24146	81545	154809	141136	94032	212242	93264	107961
	7	34510	25000	12624	14960	40891	115488	108547	83809	145586	80638
	8	27078	18129	9364	7794	7339	29413	68167	78732	56480	111095
	9	6285	16649	6547	6019	4105	4979	16250	47978	57705	47689
	10	3198	5093	10468	2738	3550	3816	2923	13276	28338	44375
	11	1334	3496	2212	6722	1170	1878	2650	2436	6607	20659
	12	2418	810	2169	1776	3260	699	815	1377	1300	5243
	13	7	1739	536	1506	1002	1809	218	329	1263	679
	14	161	0	400	384	1685	983	218	0	270	1223
	+gp	85	0	525	216	1970	46	99	0	737	663
0	TOTAL	356203	524292	638632	592372	713976	723322	712991	753214	794451	830510

	Table 12	Stock biomass at age (start of year)			Tonnes					
	YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	AGE										
	3	147035	235224	87062	108520	234810	43702	82317	150137	115974	195619
	4	127834	158627	248569	109055	112157	250851	59783	87688	177427	120663
	5	228696	129387	160119	243594	120899	131312	261967	57404	92579	159482
	6	96174	191465	113684	152027	240257	102399	119089	222760	57312	79032
	7	84320	77886	143115	103153	120759	166116	92249	89109	172880	43661
	8	60246	65357	52372	111601	84505	98284	131569	67569	61319	141816
	9	77879	48490	43958	40070	74990	54417	74251	83465	46703	47931
	10	36132	57428	31407	26500	26780	46194	35214	38193	49552	34689
	11	29486	23396	32155	18952	11849	13480	21094	15788	16813	32642
	12	11709	19962	15958	21807	8209	9239	5423	8956	8205	7546
	13	2889	7770	11600	8779	10306	5544	3529	2133	3614	3670
	14	383	2383	5020	7301	6085	5572	631	1469	1220	3338
	+gp	1771	2967	5626	2504	6256	4168	796	3005	1677	2834
0	TOTAL	904554	1020343	950645	953863	1057862	931278	887911	827677	805276	872923

Table 5.5.6 Northeast Arctic saithe. Spawning stock biomass at age

	Table 13	Spawning stock biomass at age (spawning time)				Tonnes					
	YEAF	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
	AGE											
	3	0	0	0	0	0	0	0	0	0	0	0
	4	1149	704	693	1390	2278	756	2190	1016	1524	1117	1885
	5	44669	62308	36051	34717	63372	91934	45331	95139	47884	83023	64351
	6	62173	49571	80965	55441	49952	86010	112214	55599	110264	75739	120326
	7	80208	61341	48389	75020	55119	54705	77508	103096	60090	113571	83886
	8	73740	62553	58478	40649	62795	43360	46318	63546	90196	60610	103808
	9	78701	59350	55848	52296	34326	47926	32232	39031	50546	79218	55089
	10	48169	65877	52425	46971	42835	24757	29391	25174	30035	42391	66412
	11	28701	39540	58356	45858	39048	31480	18512	21215	15767	24131	35837
	12	31534	22848	32280	48818	37913	27048	21147	13323	13940	11261	20532
	13	15587	25828	18629	26457	40655	27312	19743	14599	7731	10543	9164
	14	15304	12458	23216	15121	21487	33440	21398	13031	9373	5864	9604
	+gp	59070	107924	70741	56068	54923	45150	42344	35722	19999	11657	12748
0	TOTSF	539004	570302	536072	498806	504704	513878	468328	480490	457349	519126	583641

	Table 13	Spawning stock biomass at age (spawning time)				Tonnes				
	YEAF	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	1952	1766	837	1321	475	844	965	941	664	1273
	5	73336	90516	80716	38499	51528	20485	28914	34057	36294	25870
	6	91157	93910	119359	106209	41473	59328	21608	32862	35801	37952
	7	108374	95233	95986	115750	78594	38739	49477	21484	27410	32011
	8	70572	87425	84076	80870	78904	50854	27691	35822	16713	17509
	9	67436	59573	73225	68880	58794	43514	34966	20536	26046	11997
	10	39299	46054	48317	57244	48552	38507	26388	24343	13925	16547
	11	40507	26548	32543	32704	38973	29655	25166	18711	16237	9410
	12	25297	20441	17281	21110	20297	20836	19195	19563	12049	10257
	13	13097	15386	13624	10941	8764	8102	12225	15438	12055	7146
	14	5935	9939	12101	7316	6723	3907	3289	9592	11770	8315
	+gp	12577	21428	9076	7225	6513	9055	9500	13109	12094	11367
0	TOTSF	549539	568220	587140	548068	439590	323825	259383	246457	221057	189652

	Table 13	Spawning stock biomass at age (spawning time)				Tonnes				
	YEAF	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	788	1730	893	853	926	912	0	0	0	0
	5	55576	28722	67197	35820	24677	17728	11238	28909	14151	8718
	6	25187	45279	21343	51692	36112	28118	20821	27432	69598	44413
	7	27920	17423	35436	16192	25284	21126	19899	17677	16258	44337
	8	23075	18400	14491	20230	9532	11106	14564	11871	6075	10885
	9	12536	11505	14309	9185	9173	5455	5776	13243	3238	3958
	10	11348	7786	8961	8917	4829	4028	3986	2247	4585	2788
	11	11261	8582	6484	6629	4647	3452	1777	2480	440	3135
	12	6148	8374	7520	3663	4037	1949	2340	116	1539	208
	13	6800	4545	7224	4852	1772	1722	1340	1235	0	421
	14	4644	5555	3951	4924	3605	1431	1227	152	1155	0
	+gp	2560	2860	9022	1486	1288	105	1725	11	833	0
0	TOTSF	187843	160760	196833	164444	125880	97133	84693	105371	117871	118862

Table 5.5.6 continue

	Table 13	Spawning stock biomass at age (spawning time)				Tonnes				
	YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	794	2750	5350	3112	2593	6820	2883	5020	0	0
	5	9375	10717	34901	53255	36143	24360	30783	7482	10216	8625
	6	32965	21557	21249	68497	123847	91739	42315	70040	29844	49662
	7	33820	23250	11614	13464	37619	105094	90094	62018	107734	66123
	8	27078	16679	8334	6391	6605	27354	64077	73220	51961	106651
	9	6285	14984	5696	5236	3981	4979	15112	44140	53089	46735
	10	3198	4838	9317	2437	3337	3816	2835	12745	27204	43931
	11	1334	3496	2212	6722	1170	1878	2650	2436	6541	20040
	12	2418	810	2126	1740	3195	699	815	1377	1261	4928
	13	7	1739	536	1506	1002	1809	218	329	1263	679
	14	161	0	400	384	1685	983	218	0	270	1223
	+gp	85	0	525	216	1970	46	99	0	737	663
0	TOTSP	117520	100820	102259	162961	223147	269576	252099	278808	290121	349261

	Table 13	Spawning stock biomass at age (spawning time)				Tonnes				
	YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	3365	10034	2989	4384	7097	2413
	5	25157	16820	22417	51155	36270	52525	110026	19517	24996	30302
	6	61552	149342	93221	121622	197011	88063	103608	184891	40118	51371
	7	78418	73992	137390	100058	117136	162794	89481	84654	157321	38858
	8	58438	64050	51324	110485	83659	97301	128938	66217	59479	137561
	9	76321	47520	43079	40070	74990	54417	74251	83465	46703	47931
	10	35770	56853	31093	26500	26780	46194	34157	37048	48066	34689
	11	28601	22928	32155	18952	11849	13480	21094	15788	16813	32642
	12	10889	19163	15639	21807	8209	9239	5423	8956	8205	7546
	13	2889	7770	11600	8779	10306	5544	3529	2133	3614	3670
	14	383	2383	5020	7301	6085	5572	631	1469	1220	3338
	+gp	1771	2967	5626	2504	6256	4168	796	3005	1677	2834
0	TOTSP	380190	463790	448564	509233	581916	549331	574923	511528	415311	393155

Table 5.5.7 Northeast Arctic saithe. XSA summary

Table 16 Summary (without SOP correction)

	RE Age 3	TOTALE	TOTSPI	LANDIN	YIELD/S	FBAR 4- 7
1960	92382	767473	539004	133515	0.2477	0.3148
1961	104182	774927	570302	105951	0.1858	0.2421
1962	203732	794132	536072	120707	0.2252	0.2503
1963	307190	894257	498806	148627	0.298	0.2737
1964	95252	859622	504704	197426	0.3912	0.3101
1965	287982	884694	513878	185600	0.3612	0.268
1966	139613	842688	468328	203788	0.4351	0.3505
1967	199107	812239	480490	181326	0.3774	0.2876
1968	156042	778843	457349	110247	0.2411	0.15
1969	291446	920271	519126	140060	0.2698	0.1644
1970	263215	1032756	583641	264924	0.4539	0.3407
1971	262608	1007521	549539	241272	0.439	0.2954
1972	153304	944517	568220	214334	0.3772	0.2747
1973	214898	911672	587140	213859	0.3642	0.2985
1974	93077	797521	548068	264121	0.4819	0.5102
1975	170518	658808	439590	233453	0.5311	0.4235
1976	256069	617215	323825	242486	0.7488	0.5062
1977	220593	540047	259383	182817	0.7048	0.433
1978	135546	469932	246457	155464	0.6308	0.4561
1979	206194	469793	221057	164680	0.745	0.593
1980	113271	433652	189652	144554	0.7622	0.5049
1981	283643	523380	187843	175540	0.9345	0.5367
1982	121615	457494	160760	168034	1.0452	0.5945
1983	102847	452679	196833	156936	0.7973	0.6101
1984	90673	352057	164444	158786	0.9656	0.6617
1985	99780	274151	125880	107183	0.8515	0.5352
1986	225093	293653	97133	67396	0.6939	0.4729
1987	169531	334438	84693	92391	1.0909	0.5324
1988	80035	349011	105371	114242	1.0842	0.5793
1989	67026	308960	117871	122817	1.042	0.5873
1990	72449	256927	118862	95848	0.8064	0.5425
1991	242213	356203	117520	107327	0.9133	0.4413
1992	379341	524292	100820	127604	1.2657	0.5927
1993	275265	638632	102259	154903	1.5148	0.4917
1994	208260	592372	162961	146950	0.9018	0.5152
1995	357604	713976	223147	168378	0.7546	0.4191
1996	135152	723322	269576	171348	0.6356	0.3429
1997	166302	712991	252099	143629	0.5697	0.273
1998	118608	753214	278808	153327	0.5499	0.2655
1999	262946	794451	290121	150375	0.5183	0.2895
2000	149548	830510	349261	135928	0.3892	0.1957
2001	196047	904554	380190	135853	0.3573	0.203
2002	340904	1020343	463790	154870	0.3339	0.2124
2003	131912	950645	448564	161592	0.3602	0.1803
2004	155028	953863	509233	164636	0.3233	0.169
2005	397982	1057862	581916	178568	0.3069	0.1881
2006	69368	931278	549331	212822	0.3874	0.2387
2007	112763	887911	574923	199008	0.3461	0.2317
2008	238313	827677	511528	184740	0.3612	0.2574
2009	158868	805276	415311	161853	0.3897	0.2596
2010	168349	795149	393155	193399	0.4919	0.333
Arith. Mean	187131	697840	351742	163049	0.5932	0.3725
0 Units	(Thousar	(Tonnes	(Tonnes	(Tonnes)		

Table 5.6.1 Northeast arctic saithe. Yield per recruit

MFYPR version 2a

Run: y01

Time and date: 10:04 30.04.2011

Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpw	SSBSpwn
0.0000	0.0000	0.0000	0.0000	5.5167	14.2457	2.9188	11.4077	2.9188	11.4077
0.1000	0.0283	0.1331	0.3994	4.8538	10.8650	2.3056	8.1098	2.3056	8.1098
0.2000	0.0567	0.2236	0.5878	4.4038	8.8617	1.9029	6.1847	1.9029	6.1847
0.3000	0.0850	0.2913	0.6871	4.0677	7.5329	1.6118	4.9298	1.6118	4.9298
0.4000	0.1133	0.3449	0.7436	3.8017	6.5818	1.3885	4.0484	1.3885	4.0484
0.5000	0.1417	0.3890	0.7777	3.5831	5.8631	1.2105	3.3956	1.2105	3.3956
0.6000	0.1700	0.4263	0.7991	3.3986	5.2978	1.0649	2.8926	1.0649	2.8926
0.7000	0.1983	0.4584	0.8127	3.2401	4.8396	0.9433	2.4935	0.9433	2.4935
0.8000	0.2266	0.4865	0.8213	3.1018	4.4595	0.8404	2.1694	0.8404	2.1694
0.9000	0.2550	0.5112	0.8265	2.9800	4.1385	0.7522	1.9015	0.7522	1.9015
1.0000	0.2833	0.5333	0.8294	2.8717	3.8636	0.6760	1.6769	0.6760	1.6769
1.1000	0.3116	0.5530	0.8305	2.7746	3.6253	0.6097	1.4864	0.6097	1.4864
1.2000	0.3400	0.5709	0.8303	2.6871	3.4169	0.5516	1.3234	0.5516	1.3234
1.3000	0.3683	0.5871	0.8291	2.6079	3.2331	0.5005	1.1828	0.5005	1.1828
1.4000	0.3966	0.6019	0.8272	2.5357	3.0700	0.4553	1.0608	0.4553	1.0608
1.5000	0.4250	0.6155	0.8248	2.4697	2.9243	0.4152	0.9542	0.4152	0.9542
1.6000	0.4533	0.6280	0.8220	2.4092	2.7936	0.3794	0.8607	0.3794	0.8607
1.7000	0.4816	0.6395	0.8189	2.3535	2.6758	0.3474	0.7784	0.3474	0.7784
1.8000	0.5099	0.6501	0.8156	2.3020	2.5691	0.3188	0.7056	0.3188	0.7056
1.9000	0.5383	0.6600	0.8122	2.2544	2.4723	0.2930	0.6410	0.2930	0.6410
2.0000	0.5666	0.6692	0.8086	2.2101	2.3840	0.2698	0.5835	0.2698	0.5835

Reference point	F multiplier	Absolute F
Fbar(4-7)	1.0000	0.2833
FMax	1.1322	0.3207
F0.1	0.3391	0.0961
F35%SPR	0.4075	0.1154

Weights in kilograms

Table 5.7.1 Northeast arctic saithe. Prediction input data

MFDP version 1a
Run: 001
Time and date: 16:46 29.04.2011
Fbar age range: 4-7

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	168349	0.2	0	0	0	0.687	0.0999	0.687
4	113961	0.2	0.02	0	0	1.000	0.3386	1.000
5	60573	0.2	0.19	0	0	1.493	0.2428	1.493
6	64335	0.2	0.65	0	0	2.020	0.2775	2.020
7	23047	0.2	0.89	0	0	2.393	0.2743	2.393
8	11490	0.2	0.97	0	0	2.883	0.3087	2.883
9	25902	0.2	1	0	0	3.243	0.2964	3.243
10	9294	0.2	1	0	0	3.540	0.3954	3.540
11	6289	0.2	1	0	0	3.757	0.6567	3.757
12	5678	0.2	1	0	0	4.223	0.6567	4.223
13	725	0.2	1	0	0	5.097	0.6567	5.097
14	201	0.2	1	0	0	6.693	0.6567	6.693
15	452	0.2	1	0	0	7.507	0.6567	7.507

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	168349	0.2	0	0	0	0.687	0.0999	0.687
4	.	0.2	0.02	0	0	1.000	0.3386	1.000
5	.	0.2	0.19	0	0	1.493	0.2428	1.493
6	.	0.2	0.65	0	0	2.020	0.2775	2.020
7	.	0.2	0.89	0	0	2.393	0.2743	2.393
8	.	0.2	0.97	0	0	2.883	0.3087	2.883
9	.	0.2	1	0	0	3.243	0.2964	3.243
10	.	0.2	1	0	0	3.540	0.3954	3.540
11	.	0.2	1	0	0	3.757	0.6567	3.757
12	.	0.2	1	0	0	4.223	0.6567	4.223
13	.	0.2	1	0	0	5.097	0.6567	5.097
14	.	0.2	1	0	0	6.693	0.6567	6.693
15	.	0.2	1	0	0	7.507	0.6567	7.507

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	168349	0.2	0	0	0	0.687	0.0999	0.687
4	.	0.2	0.02	0	0	1.000	0.3386	1.000
5	.	0.2	0.19	0	0	1.493	0.2428	1.493
6	.	0.2	0.65	0	0	2.020	0.2775	2.020
7	.	0.2	0.89	0	0	2.393	0.2743	2.393
8	.	0.2	0.97	0	0	2.883	0.3087	2.883
9	.	0.2	1	0	0	3.243	0.2964	3.243
10	.	0.2	1	0	0	3.540	0.3954	3.540
11	.	0.2	1	0	0	3.757	0.6567	3.757
12	.	0.2	1	0	0	4.223	0.6567	4.223
13	.	0.2	1	0	0	5.097	0.6567	5.097
14	.	0.2	1	0	0	6.693	0.6567	6.693
15	.	0.2	1	0	0	7.507	0.6567	7.507

Input units are thousands and kg - output in tonnes

Table 5.7.2 Northeast Arctic saithe. Short term prediction

MFDP version 1a
Run: 001
North-East Arctic saithe
Time and date: 16:46 29.04.2011
Fbar age range: 4-7

2011				
Biomass	SSB	FMult	FBar	Landings
711210	358114	1.0939	0.3099	173000

2012					2013	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
666181	313236	0.0000	0.0000	0	824425	403141
.	313236	0.1000	0.0283	17222	804667	389993
.	313236	0.2000	0.0567	33876	785571	377328
.	313236	0.3000	0.0850	49986	767111	365127
.	313236	0.4000	0.1133	65572	749263	353369
.	313236	0.5000	0.1417	80654	732003	342036
.	313236	0.6000	0.1700	95251	715308	331111
.	313236	0.7000	0.1983	109383	699157	320576
.	313236	0.8000	0.2266	123066	683529	310415
.	313236	0.9000	0.2550	136318	668405	300613
.	313236	1.0000	0.2833	149154	653765	291156
.	313236	1.1000	0.3116	161590	639592	282030
.	313236	1.2000	0.3400	173641	625867	273221
.	313236	1.3000	0.3683	185321	612576	264717
.	313236	1.4000	0.3966	196643	599701	256506
.	313236	1.5000	0.4250	207621	587228	248576
.	313236	1.6000	0.4533	218266	575142	240916
.	313236	1.7000	0.4816	228591	563429	233516
.	313236	1.8000	0.5099	238607	552077	226366
.	313236	1.9000	0.5383	248325	541071	219456
.	313236	2.0000	0.5666	257755	530400	212778

Input units are thousands and kg - output in tonnes

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

MFDP version 1a
Run: 004
003MFDP Index file 30.04.2011
Time and date: 10:23 30.04.2011
Fbar age range: 4-7

2011				
Biomass	SSB	FMult	FBar	Landings
711210	358114	1.0939	0.3099	173000

2012						
						Average
Biomass	SSB	FMult	FBar	Landings	2012	177810
666181	313236	1.1211	0.3176	164167	2013	163766
					2014	150925

2013					2014	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
636656	280144	0	0	0	796990	373940
.	280144	0.1	0.0283	16353	778143	361741
.	280144	0.2	0.0567	32162	759931	349997
.	280144	0.3	0.085	47449	742329	338689
.	280144	0.4	0.1133	62235	725312	327798
.	280144	0.5	0.1417	76540	708858	317306
.	280144	0.6	0.17	90383	692944	307195
.	280144	0.7	0.1983	103780	677550	297449
.	280144	0.8	0.2266	116751	662654	288054
.	280144	0.9	0.255	129311	648240	278993
.	280144	1	0.2833	141476	634287	270255
.	280144	1.1	0.3116	153261	620778	261824
.	280144	1.2	0.34	164679	607698	253688
.	280144	1.3	0.3683	175746	595029	245836
.	280144	1.4	0.3966	186473	582757	238256
.	280144	1.5	0.425	196874	570866	230937
.	280144	1.6	0.4533	206960	559344	223869
.	280144	1.7	0.4816	216742	548177	217041
.	280144	1.8	0.5099	226233	537351	210444
.	280144	1.9	0.5383	235441	526855	204070
.	280144	2	0.5666	244378	516676	197909

Input units are thousands and kg - output in tonnes

Table 5.7.4. Northeast arctic saithe. Detailed short term projection output HCR landings

MFDP version 1a
Run: 004
Time and date: 10:23 30.04.2011
Fbar age range: 4-7

Year:	2011	F multiplier	1.0939	Fbar:	0.3099				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan	SSB(Jan)	SSNos(ST	SSB(ST)
3	0.1093	15825	10866	168349	115600	0	0	0	0
4	0.3704	32169	32169	113961	113961	2279	2279	2279	2279
5	0.2656	12863	19208	60573	90456	11509	17187	11509	17187
6	0.3036	15344	30994	64335	129957	41818	84472	41818	84472
7	0.3001	5442	13025	23047	55159	20512	49092	20512	49092
8	0.3377	3001	8654	11490	33130	11145	32136	11145	32136
9	0.3242	6536	21199	25902	84009	25902	84009	25902	84009
10	0.4325	2979	10546	9294	32901	9294	32901	9294	32901
11	0.7184	2956	11104	6289	23626	6289	23626	6289	23626
12	0.7184	2669	11270	5678	23980	5678	23980	5678	23980
13	0.7184	341	1737	725	3695	725	3695	725	3695
14	0.7184	94	632	201	1345	201	1345	201	1345
15	0.7184	212	1595	452	3393	452	3393	452	3393
Total		100431	173000	490296	711210	135804	358114	135804	358114

Year:	2012	F multiplier	1.1211	Fbar:	0.3176				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan	SSB(Jan)	SSNos(ST	SSB(ST)
3	0.112	16197	11122	168349	115600	0	0	0	0
4	0.3796	35598	35598	123563	123563	2471	2471	2471	2471
5	0.2722	13977	20873	64422	96203	12240	18279	12240	18279
6	0.3111	9262	18710	38025	76810	24716	49927	24716	49927
7	0.3075	9377	22443	38882	93058	34605	82822	34605	82822
8	0.3461	3728	10748	13978	40303	13558	39094	13558	39094
9	0.3323	1729	5609	6711	21767	6711	21767	6711	21767
10	0.4433	5013	17747	15334	54283	15334	54283	15334	54283
11	0.7362	2360	8867	4937	18548	4937	18548	4937	18548
12	0.7362	1200	5068	2510	10602	2510	10602	2510	10602
13	0.7362	1083	5522	2266	11551	2266	11551	2266	11551
14	0.7362	138	926	289	1937	289	1937	289	1937
15	0.7362	125	935	261	1957	261	1957	261	1957
Total		99789	164167	479528	666181	119901	313236	119901	313236

Input units are thousands and kg - output in tonnes

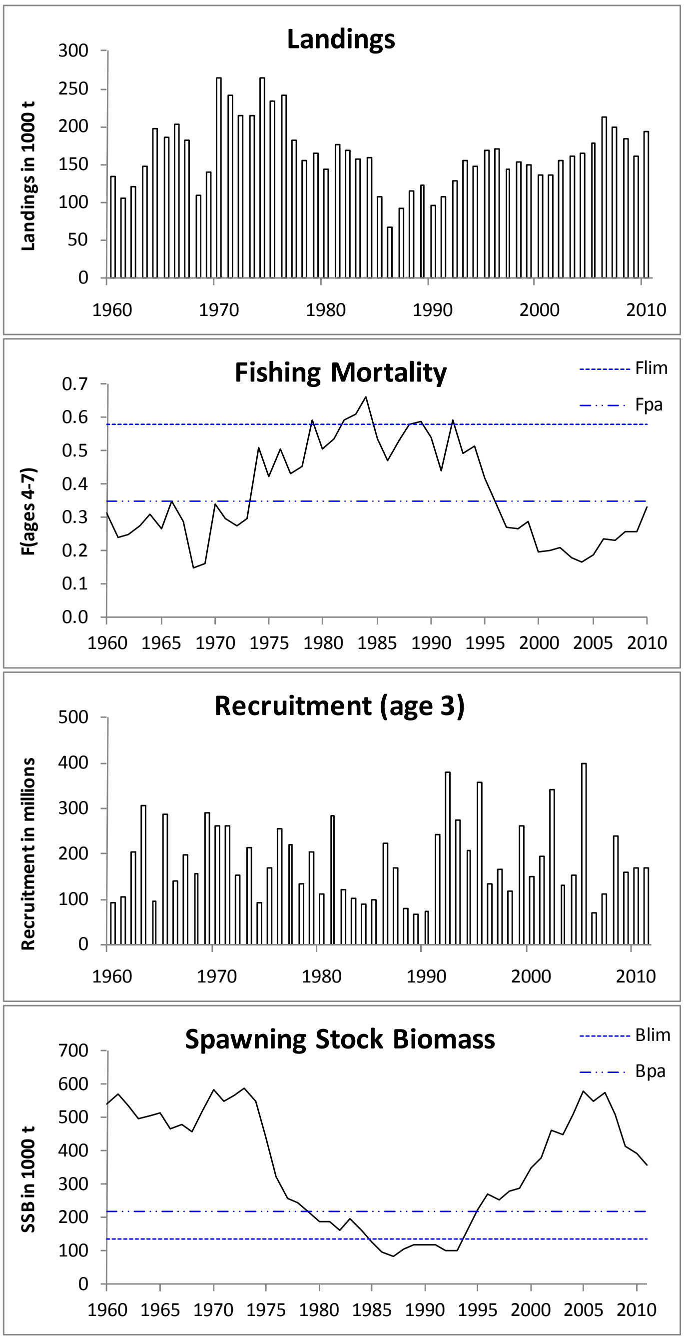


Figure 5.1.1 Northeast Arctic saithe (Subareas I and II)

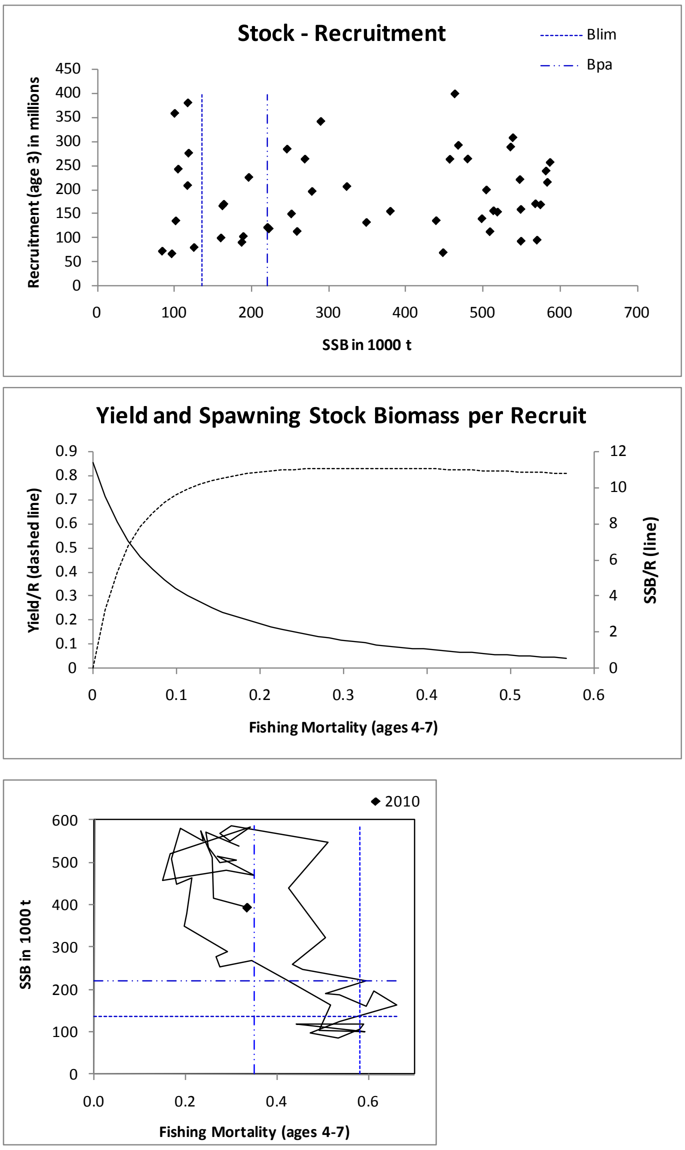


Figure 5.1.1 continued

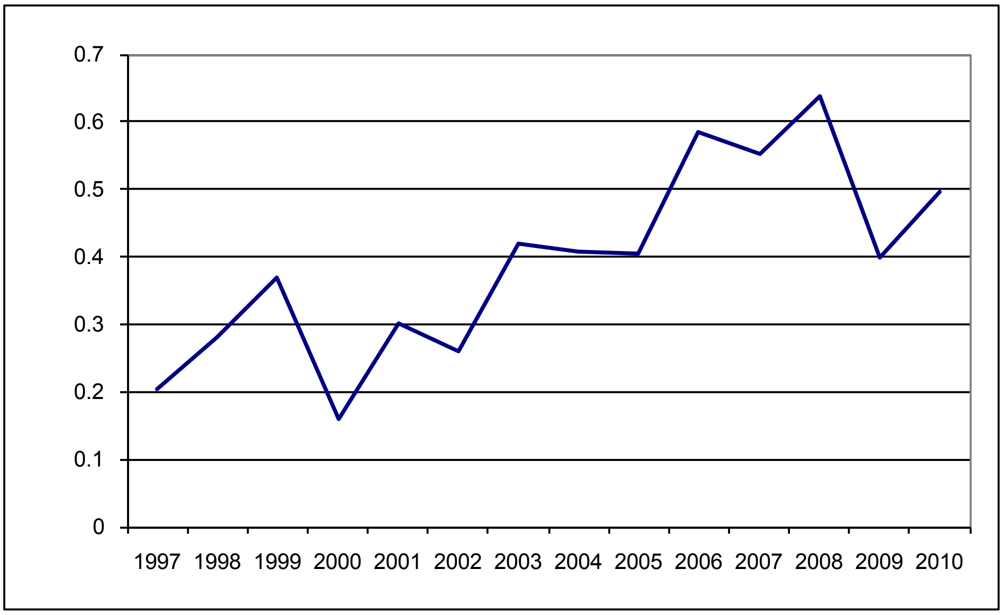


Figure 5.2.1. Northeast Arctic saithe. Proportion of saithe echo abundance found in the southern half of the survey area (sub area C+D).

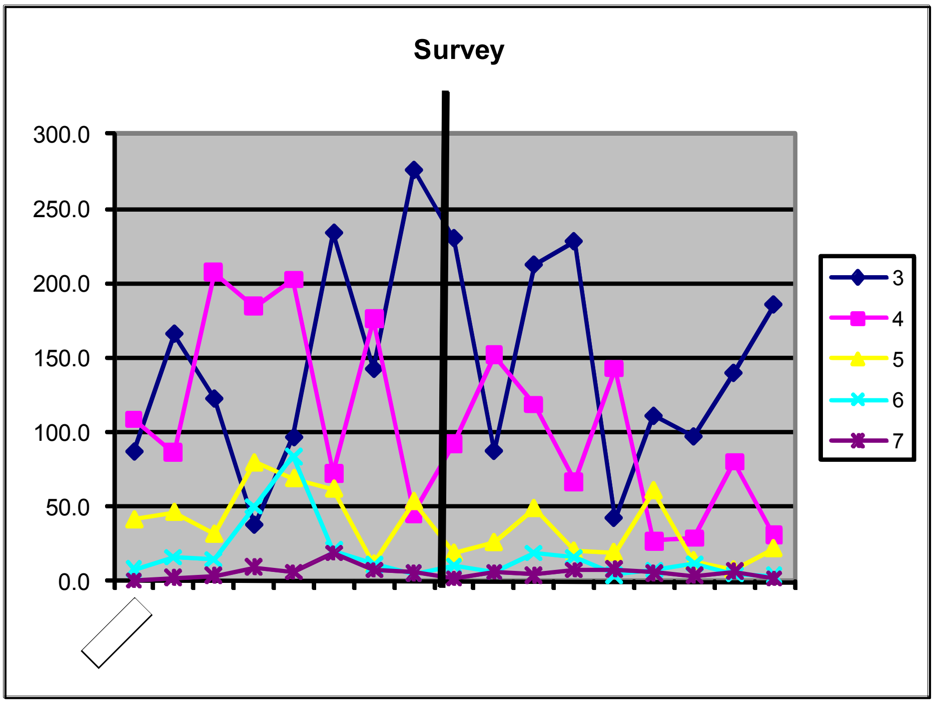


Figure 5.3.1 Northeast Arctic saithe, acoustic survey tuning indices, break in 2002 black line

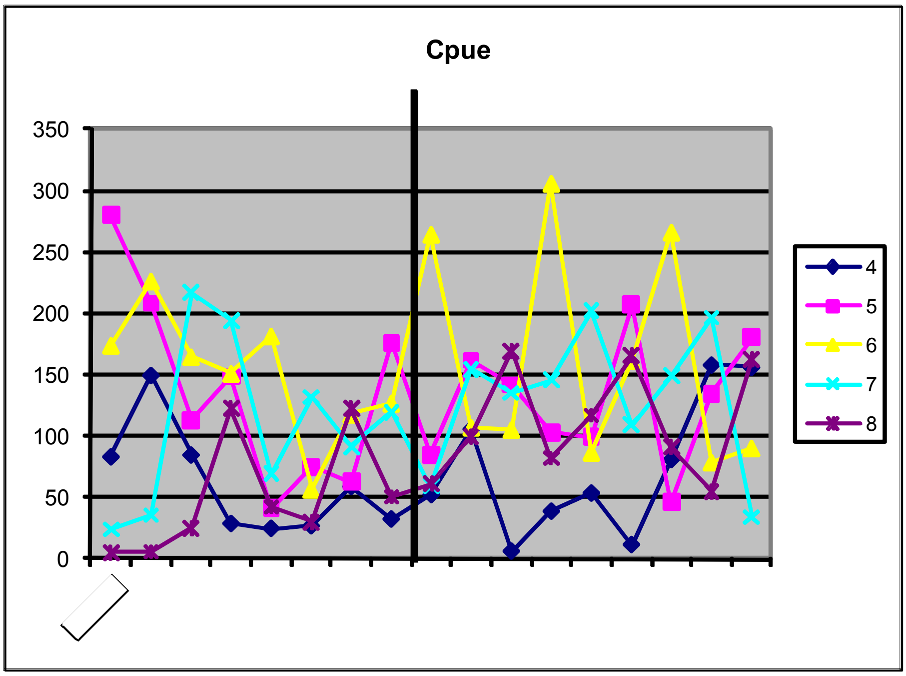


Figure 5.3.1 Northeast Arctic saithe, CPUE tuning indices, break in 2002 black line

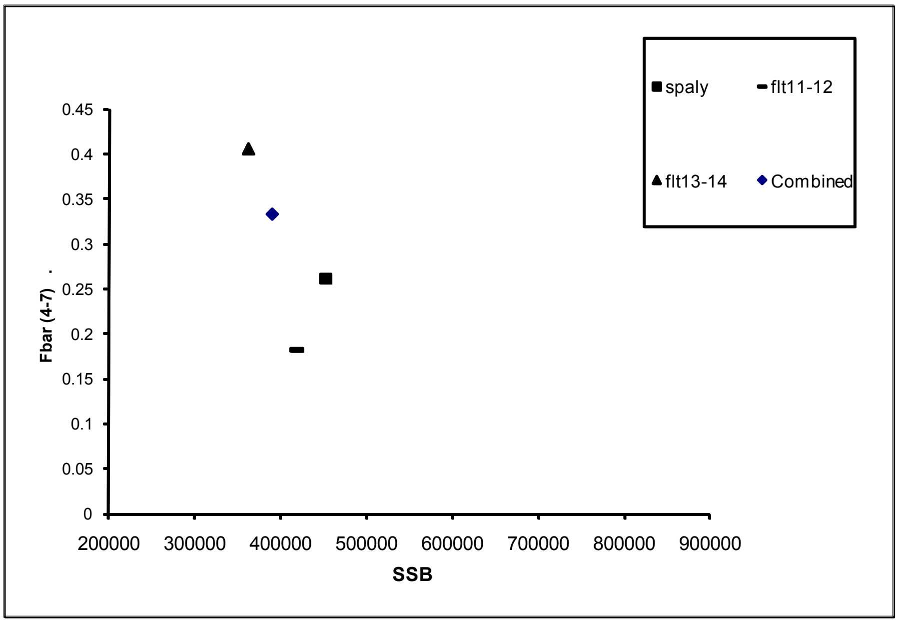


Figure 5.4.1 Northeast Arctic saithe. Comparison of SSB and F_{4-7} in 2010 from single fleet and combined XSA runs. SSB and F_{4-7} in 2009 from an updated 2009 SPALY run is also presented.

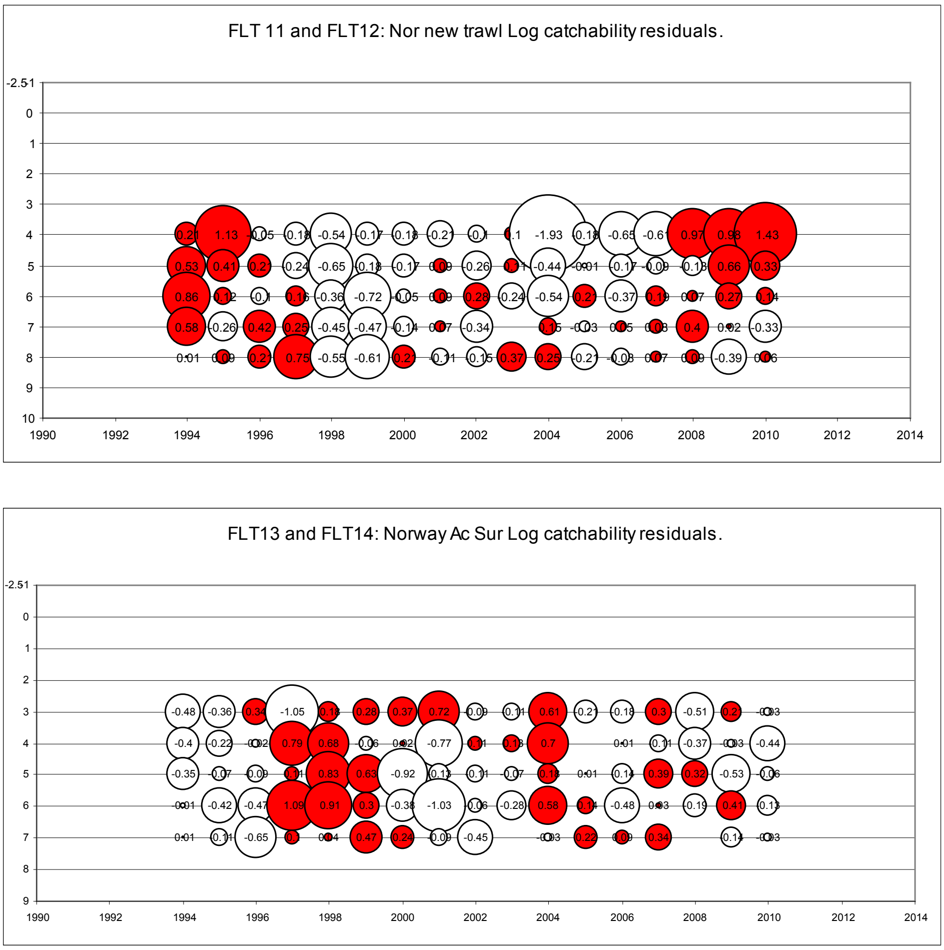


Figure 5.5.1. Northeast Arctic saithe. Final run log Q residuals.

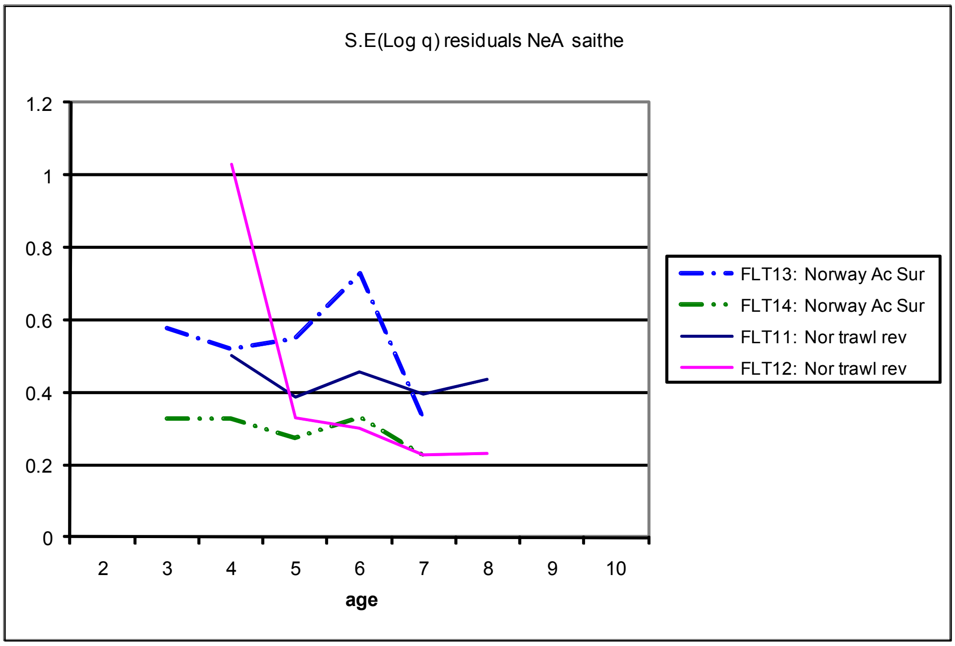
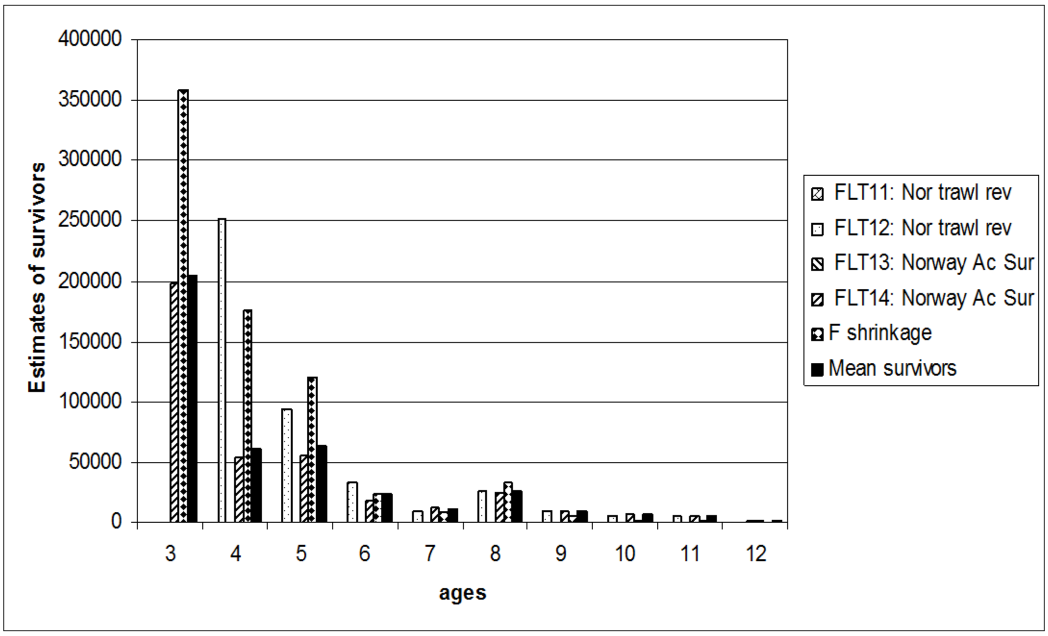


Figure 5.5.2. Northeast arctic saithe. S.E log. Catchability from the four XSA fleet tuning series, final run.



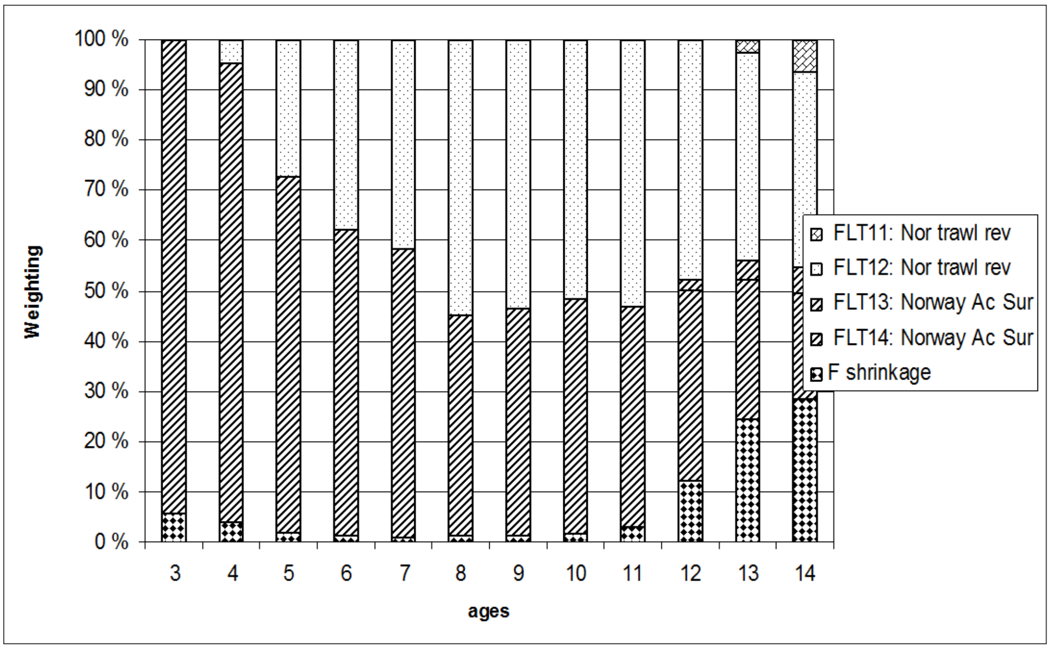


Figure 5.5.3 Northeast Arctic saithe. Estimates of survivors from different fleets and shrinkage and weighting in the final XSA-run.

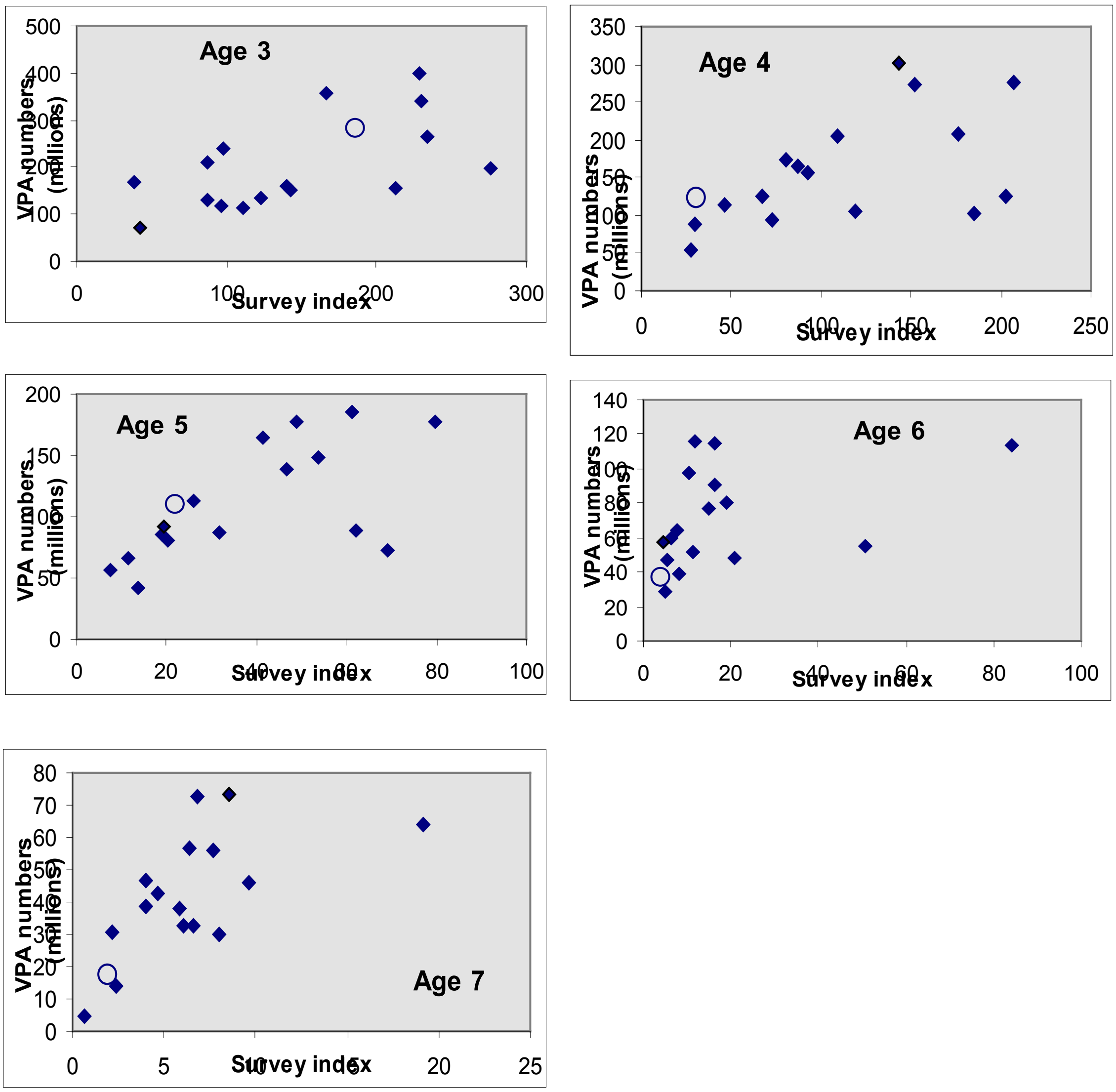


Figure 5.5.4A. NEA Saithe - Acoustic survey vs. VPA, circle shows last data year.

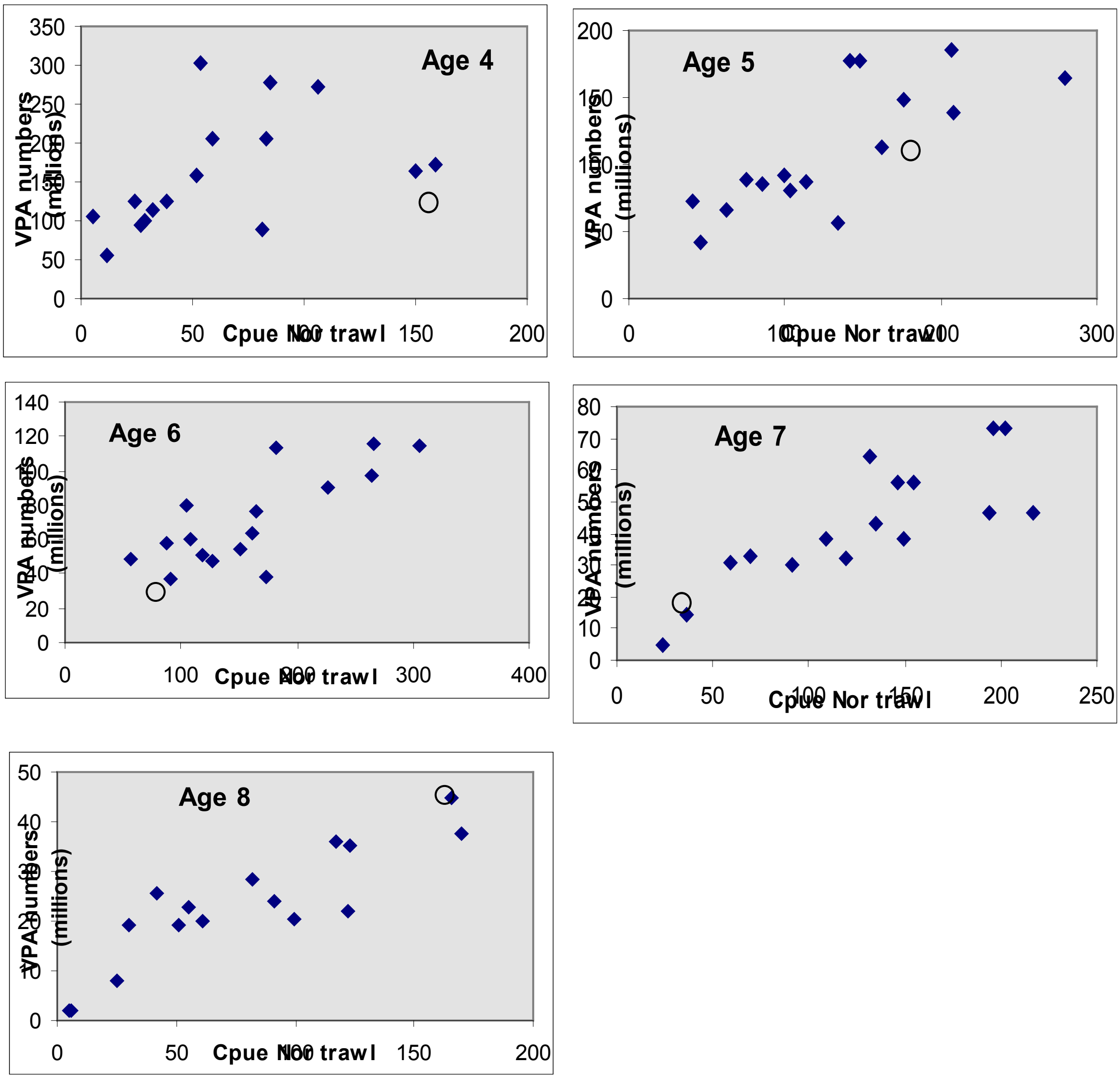


Figure 5.5.4B. NEA Saithe - Acoustic survey vs. VPA, circle shows last data year.

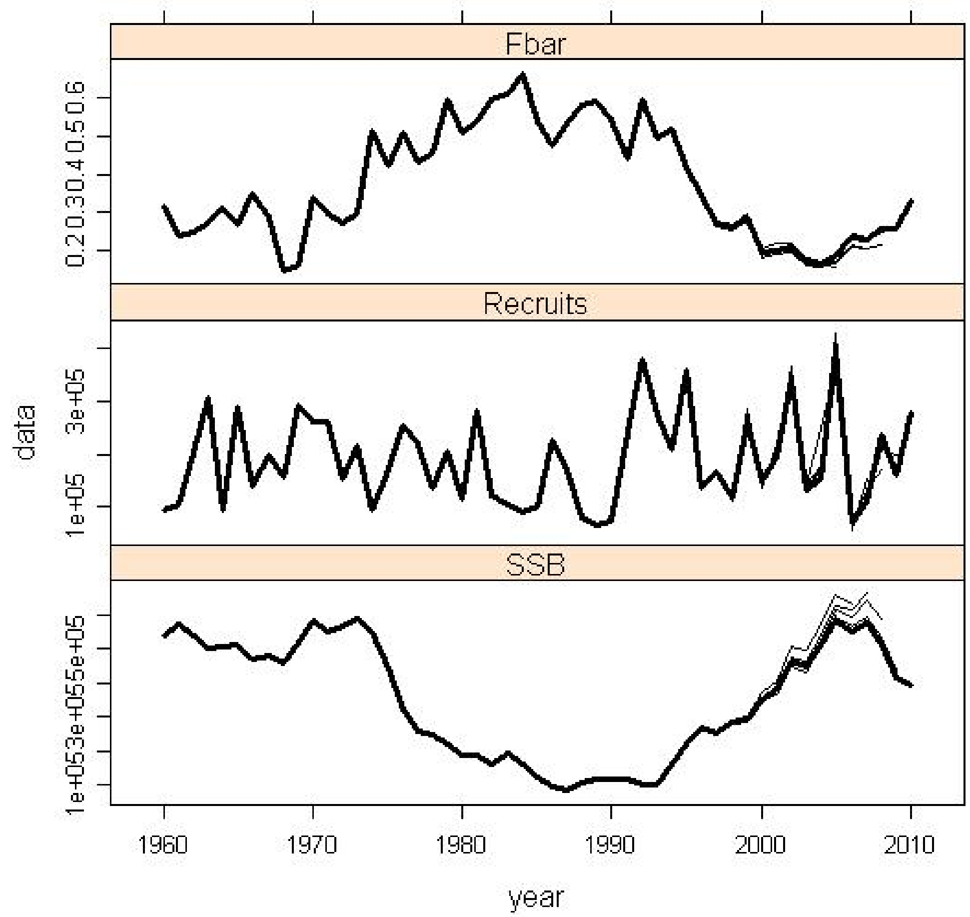


Figure 5.5.5 Saithe in Sub-areas I and II (Northeast Arctic) RETROSPECTIVE XSA F_{4-7}, recruits and SSB for all fleets.

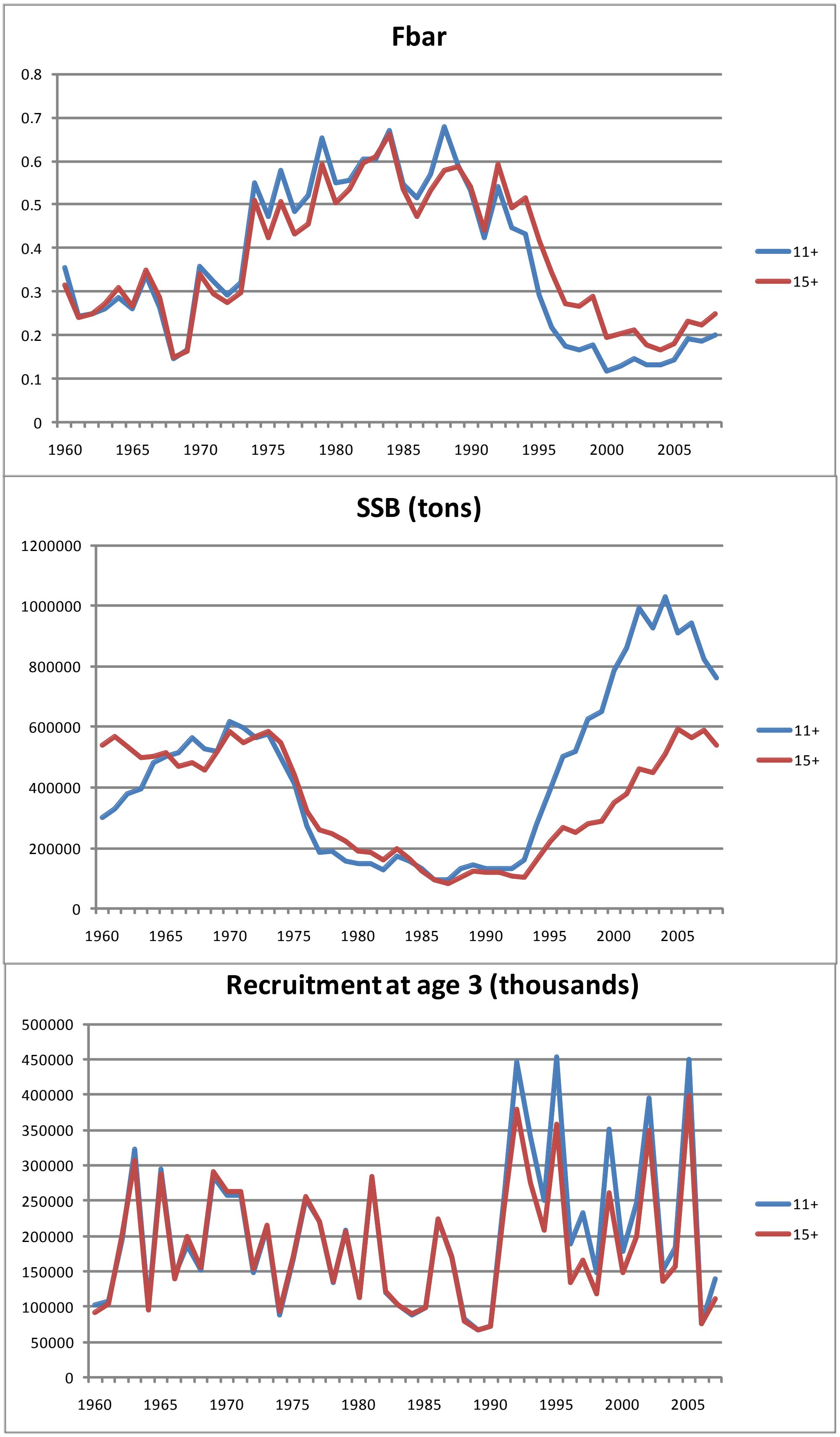


Figure 5.6.1. Northeast Arctic saithe. Fbar, SSB and recruitment for XSA analysis with age span 3-11+ and 3-15+, 2010 assessment.

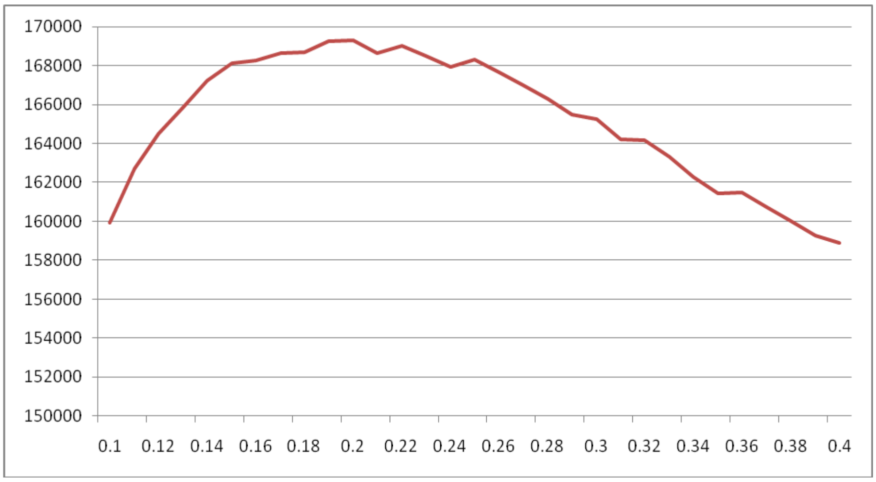


Figure 5.6.2. Long-term yield versus exploitation level in Northeast Arctic saithe simulations

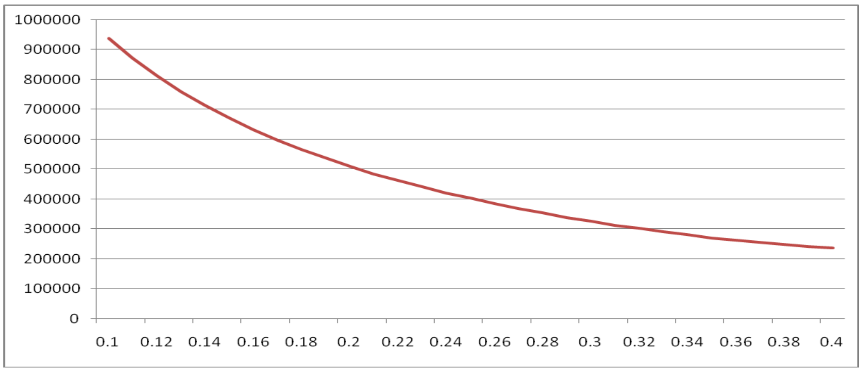


Figure 5.6.3. SSB versus exploitation level in Northeast Arctic saithe simulations

6 Beaked redfish *(Sebastes mentella)* in Subareas I and II

ACOM considers any analytical assessments for this stock to be experimental. Until an analytical assessment has been prepared and tested the status of the stock has been deducted from the surveys. A benchmark assessment is planned for this stock in 2012.

6.1 Status of the Fisheries

6.1.1 Development of the fishery

A description of the historical development of the fishery in Subareas I and II is found in the Quality handbook for this stock.

Since 1 January 2003 the regulations for this stock have been enlarged since from this date all directed trawl fishery for redfish (both *S. marinus* and *S. mentella*) outside the permanently closed areas is forbidden in the Norwegian Economic Zone north of 62°N and in the Svalbard area. When fishing for other species it is legal to have up to 15% redfish (both species together) in round weight as bycatch per haul and on board at any time. From 1 January 2006, the maximum 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.

A pelagic fishery, for *S. mentella*, has developed in the Norwegian Sea outside EEZs since 2004 (Figure 6.1). This fishery, which is further described in Quality handbook for this stock, is managed by the North-East Atlantic Fisheries Commission (NEAFC), and during its 29th annual meeting in November 2010 NEAFC adopted by consensus a TAC for 2011 of 7,900 t. Figure 6.1 shows the location of pelagic *S. mentella* catches by Russian fishing vessels in 2010. This fishing pattern is considered representative for the whole international fleet of 21 vessels fishing in this Olympic fishery in 2010, and indicates a movement of the redfish eastwards into the Norwegian Economic Zone and the Fishery Protection Zone at Svalbard (Spitsbergen archipelago) towards the end of the fishery in October.

6.1.2 Bycatch in other fisheries

All catches of *S. mentella*, except the pelagic fishery in the Norwegian Sea outside EEZ, are currently taken as by-catches in other fisheries. Some of the pelagic catches reported on are taken as by-catches in the blue whiting and herring fisheries.

Numbers and weights of the redfish (fully dominated by *S. mentella*) taken as by-catch in the shrimp fishery in the Barents Sea during two decades have previously been presented to the AFWG. The results show that shrimp trawlers removed significant numbers of juvenile redfish during the beginning of the 1980's with a peak during 1985 amounting to about 200 million individuals. As sorting grids became mandatory in 1993, by-catches of redfish reduced drastically during the 1990's. The results also show that closure of areas is necessary to protect the smallest redfish juveniles since these smallest redfish size groups are not sufficiently protected by the sorting grid alone.

6.1.3 Landings prior to 2011 (Tables 6.1–6.5, D1–D2, Figure 6.2)

Nominal catches of *S. mentella* by country for Subareas I and II combined are presented in Table 6.1, and for both redfish species (i.e., *S. mentella* and *S. marinus*) in Table D1. The nominal catches by country for Subarea I and Divisions IIa and IIb are shown in Tables 6.2–6.4, while Table 6.5 shows the catches by country for the pelagic fishery in the Norwegian Sea. Total international landings in 1965-2010 are also shown in Figure 6.2.

The total landings show a continuous decrease from 48,727 t in 1991 to a historical low at about 8,000 t in 1996 and 1997. Apart from a temporary increase to 18,418 t in 2001, caused by Norwegian trawlers obtaining very good catch rates along the continental slope outside the closed areas in winter 2001, the catches decreased to 2,471 t in 2003 due to stronger regulations enforced.

With the beginning in 2004 of a direct fishery of pelagic redfish in international waters total catches increase considerably. This fishery peaked in 2006 with 28,770 t, but has since declined due to the NEAFC regulations. Nevertheless, contrary to the ICES advice of no directed trawl fishery, NEAFC set a TAC of 7,900 t (incl. all by-catches) to be taken in the pelagic trawl fisheries in international waters of the Norwegian Sea in 2011. This is, however, a reduction in TAC from 8,600 t in 2010.

The total landings of *S. mentella* in Subareas I and II in 2010, demersal and pelagic catches, amounts to 11,751 t. This is a slight increase compared with the year before due to increased by-catches in the demersal fisheries.

The redfish population in Subarea IV (North Sea) is believed to belong to the Northeast Arctic stock. Since this area is outside the traditional areas handled by this Working Group, the catches are not included in the assessment. The total redfish landings from Subarea IV have up to 2003 been 1,000–3,000 t per year. Since 2004 the annual landings from this area have been about 150-300 t (Table D2).

6.1.4 Expected landings in 2011

In 2011 there will be no directed demersal fishery for *S. mentella*, and all the current regulations will be continued in 2011, including the protection of juveniles from being caught in the shrimp fisheries. Based on the present regulations, the experience from recent years and an increase in the cod and haddock TACs, the total reported demersal by-catches of *S. mentella* for 2011 are expected to be maximum 4,000 t.

In addition to this comes, however, the pelagic catches in the Norwegian Sea outside the EEZs. The Northeast Atlantic Fisheries Commission (NEAFC) has set a TAC of 7,900 t for an Olympic fishery in these international waters starting 15 August 2011. In total this may lead to landings in 2011 of up to 12,000 t.

6.2 Data used in the Assessment

No analytical assessment was attempted for this stock this year. All input data sets were, however, updated up to and including 2010.

6.2.1 Length- composition from the fishery (Figures 6.3-6.4)

Length distributions of the demersal by-catches of *S. mentella* in the Barents Sea and adjacent waters are shown in Figure 6.3. Length compositions from Norway and Portugal of the commercial pelagic catches of *S. mentella* in the Norwegian Sea outside EEZ in ICES Subareas IIa show a similar distribution pattern and size range (Figure 6.4).

6.2.2 Catch at age (Tables 6.6 and 6.8, Figure 6.14 and D4)

Catch at age for 2009 was revised according to new catch data. Age data for 2010 for demersal *S. mentella* were available from Norway for all areas, and from Russia in Division IIb. For the pelagic *S.mentella* fishery in 2010, age data based on recommended otolith readings were available only from Norway. Despite the fact that both laboratories base the age reading on otoliths, there are still severe discrepancies in the age readings of *S. mentella* collected in the same area at about the same time. As the difference is related to the ability of reading age of fish of 20 years and more, the problem is believed to be related to the fact that the proximal zone of the otolith sections is not considered by the Russian readers. This problem which also was reported by the ICES Workshop on Age Determination of Redfish (ICES 2006/RMC:09) in 2006 must soon be solved through regular otolith exchanges and comparative age readings between international experienced age readers. Norway and Russia has started an exchange of otoliths to harmonize the age reading (Figure D4), and ICES PGCCDBS will in 2011 also conduct an international exchange of *S. mentella* otoliths among laboratories involved in age reading of this species (ICES CM 2011/ACOM:40).

Russian and other countries total catch-at-length of the demersal fishery in Subarea I and Division IIa were assumed to have the same relative age distribution and mean weight as Norway. According to the Norwegian age readings, 72% of all demersal catches of *S. mentella* are composed of fish older than 18 years. A similar age composition is also seen in the last pelagic Norwegian Sea survey in 2009 (Figure 6.14), while samples of the fishery in 2010 show that 84% of the caught fish were older than 18 years (Table 6.8).

In connection with the first attempt to design a Gadget model for the assessment of the *S. mentella* stock (see chapter 6.8), the Norwegian landings of *S. mentella* are now available on a much wider age (2-30+) and length (up to 52 cm) scale for the years 1990-2009 (WD 02). This should be better tabulated and presented to the benchmark assessment in 2012.

6.2.3 Weight at age (Tables 6.7 and 6.9)

Catch weight-at-age data for 2010 were available from Norway for all areas, and from Russia from the demersal fishery in Division IIb. The weight at age in the stock was set equal to the weight at age in the catch. It should be investigated further whether it would be better to use a constant weight-at-age series (e.g., based on survey information) instead of catch weight-at-age which may vary due to changes and selections in the fisheries and not due to growth changes in the stock.

6.2.4 Maturity at age (Tables D8a,b)

Age-based maturity ogives for *S. mentella* (sexes combined) were available for the period 1988 to 2001 from Russian research vessel observations in spring (Table D8a). Norwegian data collected in recent years (2004-2008) were used to provide an update of the maturity ogive for the recent period (Table D8b). This indicates an age-at-50% maturity of 11 years. The details of the ogive calculation are provided in the report of the NEAFC working group on zonal attachment of *S. mentella* (Anon., 2009).

6.2.5 Scientific surveys (Figures D1 and D2)

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

6.2.5.1 Surveys in the Barents Sea and Svalbard area (Tables 1.1, 1.3–1.4, D3–D7, Figures 6.5–6.8, 6.10)

1) The international 0-group survey in the Svalbard and Barents Sea areas in August-September, now part of the Ecosystem survey (Table 1.1 and Figures 6.5 and D1). *ICES acronym: Eco-NoRu-Q3*

2) Russian bottom trawl survey in the Svalbard and Barents Sea areas in October-December from 1978–2010 in fishing depths of 100–900 m (Table D3, Figures 6.6 and D2F). *ICES acronym: RU-BTr-Q4*

3) Norwegian Svalbard (Division IIb) bottom trawl survey (August-September) from 1986–2010 in fishing depths of 100–500 m (swept area down to 800 m). Data disaggregated by age only for the years 1992–2009 (Table D4a,b, Figure D2C). *ICES acronym: since 2003 part of Eco-NoRu-Q3 (BTr)*

4) Norwegian Barents Sea bottom trawl survey (February) from 1986–2011 (joint with Russia since 2000, except 2006 and 2007) in fishing depths of 100–500 m. Data disaggregated by age only for the years 1992–2010 (Tables D5a,b, Figure D2A). *ICES acronym: BS-NoRu-Q1 (BTr)*

Although the Norwegian Svalbard (August-September) and Barents Sea (February) groundfish surveys are conducted at different times of the year and may overlap in the area south of Bear Island, the two series can be combined to get an approximate total estimate for the whole area by length back to 1986 and by age back to 1992. This has been done in Figures 6.7 a,b.

5) 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 1996-2010 from less than 100 m to 800 m depth (Table D6, Figures 6.8-6.9 and D2C). This survey includes survey no. 3 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) Russian acoustic survey in April-May from 1992–2001 (except 1994 and 1996) on *S. mentella* spawning grounds in the western Barents Sea (Table D7).

A considerable reduction in the abundance of 0-group redfish was observed after 1991: abundance decreased to only 20% of the 1979–1990 average. With the exception of an abundance index of twice the 1991-level in 1994, the indices have remained very low. Record low levels of less than 20% of the 1991–1995 average was observed for the 1996-1999 year classes. A promising increase has, however, been observed since 2005 with the 2007, 2009, and 2010 year classes being the strongest observed since 1990, while survey data indicate lower abundance of the 2008 year class (Figure 6.5).

No age data were available from the autumn 2010 and winter 2011 surveys since no *S. mentella* otoliths were collected during the Ecosystem survey (*Eco-NoRu-Q3 (Btr))* in 2010, and the age reading of the collected otoliths during the *BS-NoRu-Q1 (BTr)* survey in winter 2011 has not yet been completed.

Results from the Ecosystem survey (Table D6 and Figures 6.8-6.9) confirm the stock development as interpreted from the 0-group survey (Figures 6.5), i.e., relative strong 1988-1990 year classes, followed by weaker 1991-1995 year classes, very weak year classes during 1996-2003, and confirming an improved recruitment since then. It also shows how the year-classes born before 1991 have grown in biomass. A sudden decrease of *S. mentella* for ages 9 and older (i.e., larger than about 28 cm) after 2003 was observed. The WG has earlier reported this decrease as likely related to the increase of *S. mentella* observed in the pelagic fisheries in the Norwegian Sea happening at the same time (see also Figures 6.4a and b). Some later improvement in the abundance indices of these year classes may have been caused by fish returning from the pelagic and back to the continental slope.

Planque *et al*. (WD 7) provides a quantitative estimate of the historical fluctuations in the year-class strength of beaked redfish in the Barents Sea, based on scientific survey data collected by Norway and Russia during the past three decades. Correlations between the different age group series clearly indicate that there is little correspondence between the 0-group index series and abundances of age-2 fish recorded two years later, in any of the other surveys. Conversely, there appear to be a general agreement between time series for the following ages. The reconstructed series indicate clear periods of high recruitment (late 1980s and early 1990s) and eight years of near complete recruitment failure (1996-2003) (Figure D3). The apparent recovery in recent years is highly uncertain and will need to be confirmed by collection of additional data in the near future. Measures of internal consistency of individual surveys and mortality estimates are also provided.

Bottom trawl survey estimates for the 2003 and later year classes indicate an improved recruitment (Tables D5, D6, Figure 6.5, 6.7 and 6.9) except for the 2008 year class. The overall picture of the relative strength of the year classes is similar in the Russian and Norwegian surveys. However, both the Russian survey back to 1977 and results from combining the Norwegian Barents Sea February and the Svalbard August surveys back to 1986 (Figure 6.7) show lower and more variable abundance of *S. mentella* in the 1980s than could be expected from the 0-group indices and when compared with the abundance observed at present.

Figure 6.9 shows the cod's predation on juvenile (5-14 cm) redfish during 1986-2010. This time series confirms the presence of redfish juveniles and may be used as an indicator of small 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 (Tables 1.3, 1.4; Figure 6.4a). It is important that the estimation of the consumption of redfish by cod is being continued. See also chapter 1.

Russian acoustic surveys estimating the commercial sized and mature part of the *S. mentella* stock have been conducted in April-May on the Malangen, Kopytov, and Bear Island Banks since 1992. Until the pelagic surveys in 2007, and with the exception of a trial Norwegian survey between 62-70°N in spring 1992, this Russian survey has been the only survey targeting commercial sized *S. mentella*, though on a limited area of its distribution. The survey has unfortunately not been run since 2001. Table D7 shows a 43% decrease in the estimated spawning stock biomass from 1992 to 1997 to a low level that was observed up to 2000 inclusive before a three-fold increase in the survey abundance of mature fish was seen in 2001 (Table D7). The strong 1982-

year class migrating west-southwest and out of the surveyed area could explain this intermediate low level. The next, and to date last, year classes contributing significantly to the spawning stock are the 1987–1990 year classes. These are now almost 100% mature and are likely responsible for the improved recruitment currently seen in the Barents Sea.

6.2.5.2 Surveys along the Norwegian and Barents Seas continental slope (Figures 6.11–6.12)

A slope survey was carried out by IMR (survey number 2009814) from 18th March to 5th April 2009. The survey was dedicated to the joint study of *Sebastes mentella* and greater argentine (*Argentina silus*). The survey included trawling (67 stations in total) and hydroacoustics carried out from the commercial trawler "Atlantic Star". For few stations, a multisampler cod-end was used allowing for the collection of trawl samples at 3 different depths, during the same haul. Hydroacoustics was performed at 38kHz, after standard calibration procedure. Allocation of acoustic energy to different fish species was done during the scrutinizing, on the basis of trawl catch composition. The equation used for length-dependent target strength of *S. mentella* was TS=20log(L)-68. The survey track and the spatial distribution of s_A allocated to redfish are illustrated in Figure 6.11. Redfish was found in three regions: 1) between 62°N and 63°N at bottom depth of 400-700m, 2) between 65°30'N and 67°N at bottom depth of 400-700m and 3) between 70°N and 74°N at bottom depths greater than 400m. *S. mentella* tends to distribute in a well defined depth layer, and high concentrations are found between 450 and 650m, almost independently of the bottom depth (Figure 6.11). High concentrations of beaked redfish can be found along the slope these can locally reach s_A values up or above 1000m^2/NM^2, indicating a highly aggregated spatial distribution. This is contrasting with the pelagic summer distribution, which is more evenly spread and where s_A values do not generally exceed 100m^2/NM^2.

Age/length distribution: All fish sampled were older than 11 years, the maximum recorded age was 53 years and mean age was 22.5 years. Males and females have similar age distribution, although female mean length and length-at-age are higher. Fish sampled in the shallow waters (<450m) were generally larger and older than the average whilst fish sampled in deeper waters (>600m and pelagic samples) were generally smaller, but not younger than the average. Size distribution tended to decrease with latitude but this is not true for mean age which was highest at mid-latitude (68°N to 70°N). The cumulated length and age distribution are illustrated in Figure 6.12. The mean length (37.5 cm) and mean age (22.5 years) are consistent with observations from the open Norwegian Sea in summer (36.6 cm, 25 years).

6.2.5.3 Pelagic surveys in the Norwegian Sea in 2009 (Tables 6.10, Figures 6.13–6.14).

Investigation on the distribution and abundance of redfish in the pelagic Norwegian Sea was coordinated by the ICES Planning Group on Redfish Surveys (ICES CM 2009/RMC:01). Unfortunately, among the five expected participants (EU, Faroes, Iceland, Norway and Russia) only Norway was capable of carrying out the survey (ICES acronym: BS-NoRu-Q1 (BTr)). The observations were confined to the Northern area of redfish distribution in the Norwegian Sea and the results suffer from serious limitations in area coverage. Despite these limitations, the results from the survey provide confirmation of the observations made in the same area in 2008 and additional work carried out on trawl catchability allow for better abundance estimate. Biological sampling confirms the observations made in 2008 about length (mean length = 36.5

cm), age (mean age = 25 years) maturity (all individuals mature) and sex-ratio (45% males, 55% females) (Table 6.10). The vertical distribution is very similar to that observed in the same area in 2008, with maximum concentrations between 400 and 550 m (350-550 m in 2008). This is shallower than what was observed along the slope in spring 2009 (450-650 m, see section 6.2.5.2 above). The horizontal distribution wasn't extensively analysed but visual inspection of the geographical distribution of s_A indicates that only a fraction of the population is located in international waters and this is limited to the Atlantic waters found south of the Mohn Ridge (which separates the Norwegian Sea (south) from the Greenland Sea (north) at 72-73°N).

As in 2008, an attempt to derive abundance estimates was made, based on both hydroacoustics and trawl catches. The catchability of *S. mentella* by the Gloria trawl 2048 which was previously assumed to be 100% (by default) was revised on the basis of recent catchability estimates provided by Bethke *et al*. (2010). When the same TS equation and catchability coefficients are used for the 2008 and 2009 surveys (i.e., TS=20log(L)-68.0) , the results are highly consistent (Table 6.10). The estimated total biomass is around half a million tonnes. This is likely to be an under-estimate, because the total area covered by the stock is wider than that covered by the survey.

In June 2010, ICES conducted a workshop to propose a target strength equation for redfish (*Sebastes mentella*) in the North Atlantic based on the best available scientific knowledge (ICES CM 2010/SSGESSG:15). This was achieved through an extensive review of published and ongoing studies. Data from these studies were evaluated, ranked, and served as input to a meta-analysis. The meta-analysis results indicated that the best candidate for a general model of *S. mentella* TS-length equation at 38 kHz is the free slope model: TS = 10.6 log(L) - 55.4. However, the meta-analysis revealed important departures from this equation in individual studies and the reasons for such discrepancies are generally undetermined or at best very poorly documented. To address this problem the following three actions were recommended: 1) ensure that high quality acoustic/biological data for TS determination are collected during redfish surveys, 2) perform simultaneous comparative measurements between EK500 & EK60 echosounders for Target Strength determination and 3) pursue TS analysis during a new workshop WKTAR-II.

6.3 Results of the Assessment

The signals of the various surveys are in agreement. The improved recruitment of 0-group and juveniles are confirmed by a couple of surveys from 2007 to 2010, which also confirm lower values of the 2008 year class. It is of vital importance that these younger recruiting year classes be given the strongest possible protection from being taken as by-catch in any fishery, e.g., the shrimp fisheries in the Barents Sea and Svalbard area. This will ensure that they can contribute as much as possible to the stock rebuilding after almost 15 years of very poor recruitment.

It is likely that the strong protection of the last previous good year-classes (i.e., those born before 1991) as these were growing has caused the increased abundance of fish larger than 30 cm seen in both demersal and pelagic surveys (e.g., Figure 6.7a).

The WG has previously concluded that any improvement of the stock condition is not expected until a significant increase in spawning stock biomass has been detected in surveys with a following increase in the number of juveniles. Positive signs in that direction are now seen. The only year classes that can contribute to the spawning stock in near future are, however, those prior to 1991 as the following fifteen year classes are very poor. These adult year classes need to be protected as the SSB will continue to be composed mainly from these year classes in the next decade.

As shown in Figure 6.9 and Table 1.3 the cod's consumption of small redfish (mainly 5-9 cm) is currently increasing in the Barents Sea, and has for 2010 been estimated to nearly 150 000 t. Although there are great uncertainties related to this number, this increased natural mortality must also be taken into account when managing the stock and securing that as much as possible of the promising, new, year classes will recruit to the spawning stock in future.

The presented new approaches to model population dynamics of *S. mentella* (see chapter 6.8) are due to individual limitations (e.g. no consideration of recruitment, limited age ranges, i.e., no or relatively low '+group' used), not suited for a proper assessment of the stock status of the redfish species in ICES subareas I and II at this stage. However, in the light of the upcoming benchmark assessment on redfish in 2012, these approaches represent valuable input to the process of developing a more accurate assessment model for *S. mentella*. The authors were also able to model the mortality. According to one of the contributions the total mortality estimates were low ($z<0.05$) for fish younger than seven years, whereas for older individuals the mortality estimates were highly uncertain (very large 95% confidence intervals), but appeared to be higher. In one of the models, the mortality is decomposed into mortality caused by reported catches and natural mortality, M. Here the M averaged over ages 6-14 and over years was 0.08. It should be pointed out that sufficient area coverage of the complete distribution area of this stock, and corresponding abundance indices as input to the assessment models, is an absolute prerequisite for correct estimation of stock status.

6.4 Comments to the assessment

Since ACFM/ACOM for many years considered it not necessary to assess this stock every year as long as the status of the stock could be clearly deducted from the demersal surveys, no experimental analytical assessment was attempted. However, in the current context of a change in the fisheries dynamics since 2004, a promising improved recruitment since 2005 and possible changes in the contribution of the pelagic and demersal components of the stock, management plans and harvesting strategies will suffer from lacking an analytical assessment.

Several European research institutes are currently involved in an EU-project on Management And Monitoring Of Deep-sea Fisheries And Stocks (DEEPFISHMAN) which aims at developing a range of strategy options for the exploitation of deep-sea species in the NE Atlantic. One of the tasks is to develop a GADGET Operating model for *S. mentella* and to use this to test a suite of possible assessment models. The Gadget model will be based on that developed for *S. marinus* within this WG, with a single stock split into an immature and mature component, and will be tuned to data surveys and commercial fleets (see WD06 and chapter 6.8).

Future appropriate assessment methods for this stock will be discussed and recommended at the benchmark assessment workshop together with other *Sebastes* stocks in 2012.

The survey series may still be improved further, and it is imperative for good results that valuable research survey time series are continued, and that Norwegian and Russian research vessels get full access to each other's exclusive economic zones for that purpose. In addition, it is necessary to pursue pelagic surveys in the Norwegian Sea to cover the whole distribution area, incl. the areas where the bulk of the catches have been taken in recent years. New continental slope surveys may also provide better data to the assessment provided these surveys will continue.

Documentation of the fishing effort involved and the catches taken in the international fishery is very important, and NEAFC is requested to continue to provide such information for future stock assessments and advice.

Furthermore, it is important that the age reading of mature fish of 20 years or more follow the ICES recommendations, and that the current discrepancies are solved before the benchmark assessment next year.

6.5 Biological reference points

Until an analytical assessment is available and used as basis for reference points calculations for this stock, candidate reference points for the biomass could be set at the average biomass level, or at a certain percentage of this level, estimated by the Russian and Norwegian trawl surveys since 1986. ACFM supported these suggestions and stated that U-type (survey index-based) reference points could be developed provided that a sufficient long time series demonstrating a dynamic range is available. Also the reference point should be expressed in biomass units (SSB or fishable stock). This should be done before the planned benchmark assessment in 2012. The WG also finds the proposed reference points $F_{0.1}$ and an appropriate Spawning-stock-per-recruit (SPR) level to be useful reference points for management (see chapter 6.7) and recommends preparing this for the benchmark assessment. Gadget and other assessment models that eventually will be evaluated during a benchmark assessment should also contribute to the establishment of appropriate reference points.

6.6 Management advice

In the Barents Sea and Svalbard area, the stock is still historically low taking all age groups into consideration and this situation is expected to remain for a considerable period irrespective of current management actions. Year-classes recruit to the SSB at old age (>10-15 years old) and surveys indicate failure of recruitment over a long time period. However, positive signs in the recruitment have been seen in recent years but it is still uncertain how persistent these might be, as exemplified by the weak year-class in 2008, and the likely increase in natural mortality (e.g., the consumption by cod). An estimate of the spawning stock biomass (SSB) in recent years, based on weight-at-age and maturity-at-age data from Anon. (2009b) indicates that this might currently follow an increasing trend:

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
SSB ('000 tons) from demersal surveys	78	95	99	127	80	75	134	137	76	140

However, the large fluctuations in the biomass estimates suggest that the stock is not adequately monitored and that biomass estimates may be highly dependent on fish seasonal migration patterns, accessibility to the survey gear and/or change in the vertical distribution. The protective measures introduced in 2003 should be continued, i.e. the area closures and low by-catch limits should be retained, until a significant increase in the spawning stock biomass (and a subsequent increase in the number of juveniles) has been detected in surveys. Recruitment failure has been observed in surveys for more than a decade. In this connection it is of vital importance that the juvenile age classes be given the strongest protection from being caught as by-catch in any fishery, e.g., the shrimp fisheries in the Barents Sea and Svalbard area. This will ensure that the recruiting year classes can contribute as much as possible to the stock rebuilding.

In the Norwegian Sea, no data is available to describe the historical development of the stock. Results from the pelagic surveys conducted in 2008 and 2009 indicate a possible spawning biomass of at least 500,000 t but such estimate should be handled with caution. Furthermore, it is necessary to preserve this spawning biomass close to the current level since very few new mature individuals will enter the stock for at least the next 12-15 years.

Anticipated increases in TACs for cod and haddock in the Barents Sea will likely result in higher by-catches of redfish. This should be taken into consideration in the management of the stock of *S. mentella*. By-catches in the pelagic trawl fisheries for blue whiting, herring, and mackerel in the Norwegian Sea should be avoided.

The AFWG has earlier (Drevetnyak 1991, ICES 1996) estimated the minimum acceptable spawning stock level (MBAL) for *S. mentella* in ICES Subareas I and II to be at least 300 000 tons without impairing the recruitment. If this still holds, and how the current SSB is in relation to this is uncertain. It should therefore be the observed recruitment in the Barents Sea that should be decisive when evaluating the spawning and recruitment success. The current size of the mature stock, as estimated from surveys, may at present sustain a small fishery, but will inevitably be reduced in the future due to natural mortality and, for the next ten years, expected poor new recruitment to the mature stock, and may within some years reach the MBAL level. How persistent the current promising recruitment might be is unknown, and also taking the increased consumption by cod into account indicates a need for great caution when monitoring this stock.

The WG considers therefore that the new data (landings and survey) available for this stock do not change the perception of the stock from last year. Therefore, the advice for this fishery in 2012 should be the same as the advice given in 2010 for the 2011 fishery. In order to assess the state of the stock, it is necessary that the whole distribution area of *S. mentella* in Areas I and II is surveyed, both the pelagic and the demersal components. Coordinated pelagic and demersal surveys should be pursued and particular effort should be put on reducing the uncertainties associated with survey estimates.

A reliable assessment of the stock and proper understanding of the fisheries dynamics are dependent on that complete and detailed catch and landings data from all nations fishing on the resource, as well as accompanying biological data, are provided to ICES and the AFWG.

6.7 Implementing the ICES F_{msy} framework

During the ICES Workshop on Implementing the ICES F_{msy} framework (WKFRAME), the *Sebastes mentella* stock in Subareas I and II was used as a case study (ICES CM 2010/ACOM:54). WKFRAME recommends that the bounds for F_{MSY} proxies should be evaluated in function of the YPR and SPR curves, and that the reproductive capacity of the *S. mentella* stock be at least above 30% of the SPR at F=0. The YPR curve left of the plateau can be used as low bound ($F_{0.1}$ proxy) and a prescribed per-cent SPR as upper bound. The WKFRAME also illustrates by examples why it is informative and important to carry out sensitivity analyses, particularly assumptions regarding natural mortality, selection pattern, growth (density dependence) and maturity. According to the sensitivity analyses by WKFRAME, the estimate of $F_{0.1}$ seems to be rather sensitive to the value of natural mortality, e.g., increasing the natural mortality from 0.05 to 0.10 leads to an increase in $F_{0.1}$ from 0.065 to 0.145.

The AFWG supports the above recommendation by WKFRAME, and that spawner per recruit curves should be provided. The WG found it premature to adopt the values estimated by WKFRAME directly since the input data, including growth parameters need to be better evaluated before being used for this important purpose. The WG recommends, however, that this should be done as an intersessional work until the benchmark assessment in 2012, also including an evaluation of the most appropriate SPR level to be used as reference point for the management of this stock. Evaluations of long lived species with relatively low productivity such as rockfish (*Sebastes* spp.) in the Pacific west coast, concluded that higher SPR values (50% to 60%) were required to maintain sustainable exploitation of these stocks (e.g., Dorn 2002).

6.8 New approaches to modeling population dynamics of redfish

There is currently no analytical assessment for *S. mentella* (trial XSA assessments were done by the AFWG until 2003) and the advice for this stock is based on survey trends. Hence, alternative approaches for stock assessments have to be developed and tested. During AFWG 2011, three WD´s were presented, showing alternative methods of assessing the stock status of *S. mentella* and eventually *S. marinus* in the Barents and Norwegian Seas. In WD20 by Bjørkvoll *et al.*, estimates of the abundance at age and other important population dynamical parameters for *S. mentella* and *S. marinus* were presented. This was achieved by fitting an age-structured stochastic population model to data on reported catches and survey indices within a Bayesian framework. The applied Bayesian hierarchical model was originally developed for NEA Cod (Aanes *et al.* 2007). The results showed a similar abundance trend as indicated from the survey indices. In the model, mortality is decomposed into mortality caused by reported catches and natural mortality, M. However, the estimates of M are very imprecise and the resulting abundances of the model are difficult to verify. Nevertheless, one of the advantages of using this approach is that it provides an estimate of the uncertainty in the estimated quantities.

In WD 15 by Bogstad a VPA was run on *S. mentella* and the resulting estimates compared with other available sources of information. Natural mortality is assumed to decrease linearly from age 1 to 9, and to be constant (=0.1) for age 9 and older fish. This is done in order to be able to see how information on predation by cod on redfish (see Table 1.3) compare to the biomass removal associated by M (M Output Biomass - MOB; Hamre, 1994). The ratios between the VPA results and estimations from other sources indicate that information from different sources show considerable consistency. With a low F the convergence of VPA is poor and Bogstad hence relates the VPA to absolute numbers from these other sources, e.g., that the VPA estimated SSB in 2008-2009 should be at least on the same level as the acoustic estimates from the Norwegian Sea these years. The ratios between the survey 0-group index and the estimated VPA age 1 numbers and the ratio between the survey derived biomass for 5-24 cm and the VPA age 1-8 *S. mentella* are fluctuating but encouraging. The ratio between the consumption of redfish by its most important predator, NEA Cod, and MOB leads to the conclusion that the estimation of natural mortality caused by predation of its main predator(s) can lead to a better approximation of M on younger ages in a future analytical assessment.

In WD07 Planque *et al*. present the quantitative estimate of the historical fluctuations in the year class strengths of *S. mentella* in the Norwegian and Barents Seas, based on scientific survey data collected by Norway and Russia during the past three decades. The results indicate periods of high recruitment (late 1980s early 1990s) and eight years of near complete recruitment failure (1996-2003). Another interesting result is that the Year-class strength appears to be already determined to a large extent at age 2. The authors were also able to model total mortality (Z). The total mortality estimates were low (Z<0.05) for fish below seven years, whereas for older individuals the mortality estimates were highly uncertain (very large 95% confidence intervals), but appeared to be higher. Despite the unrealistic assumption of stable mortality from year-to-year, the results provide a first baseline for the mean mortality-at-age required for full age-structure population models.

Howell & Planque present in WD 06 a *S. mentella*-GADGET model and an assessment attempt of the *S. mentella* stock in ICES subareas I and II. This approach, which since 2003 has made an important basis for the *S. marinus* assessment, resulted in promising estimates. The model results reflect the observed survey trends for *S. mentella* over the last twenty years. This indicates that the recent increase in stock numbers is due to an increasing number of small fish towards the end of the time period. The authors have also identified issues related to biology, fishery and monitoring, e.g., stock migrations, ageing problems and missing data on older fishes (older than age 15), and sensitivity testing on the weighting of each data set. The model is currently at a state where it produces "*S. mentella*-like" biology, and can therefore be used as an operating model to test assessment models. Further work would be required before the results from the model could be used as a stock assessment.

The presented approaches are due to individual limitations (e.g. no consideration of recruitment, limited age ranges, i.e., no or relatively low '+group' used), not suited for a proper assessment of the stock status of the redfish species in ICES subareas I and II at this stage. However, in the light of the upcoming benchmark assessment on redfish in 2012, these approaches represent valuable input to the process of developing a more accurate assessment model for *S. mentella*. It should be pointed out that sufficient area coverage of the complete distribution area of this stock, and corresponding abundance indices as input to the assessment models is an absolute prerequisite for correct estimation of stock status.

6.9 Response to RGAFNW Technical minutes

It is very unsatisfactory that there are no reference points for this stock in the current rebuilding situation, which, because of its biological characteristics, is very vulnerable. A rebuilding plan should be developed. The AFWG recommends that the benchmark assessment in 2012 contributes to the establishment of appropriate reference points.

The WG agree that some of the catch tables should be re-constructed to a more readable format. This can e.g. be done by importing them in Excel and combining some of the minor countries into an "others" group for printing (report) purposes, while the spreadshe*et al*so contains the data for each single country for 'book-keeping' purposes.

All tables and figures in the D-section are considered to be supplementary. It is also useful to put temporary information into this section to avoid violating the structure of the redfish chapter. From this year onwards the supplementary tables and figures belonging to Ch. 6 and *S. mentella* will be denoted by the letter 'D', while similar tables and figures supplementary to Ch. 7 and *S. marinus* will get the letter 'E'. Supplementary tables and figures belonging to Ch. 8 (Greenland halibut) will then get letter 'F'.

Concerning the slope surveys (chapter 6.2.5.2) and the international pelagic survey in the Norwegian Sea (6.2.5.3) the plan is to conduct these surveys every 2-3 years.

Table 6.1. ***Sebastes mentella*** **in Subareas I and II. Nominal catch (t) by countries in Subarea I, Divisions IIa and IIb combined.**

Year	**Canada**	**Denmark**	**Faroe Islands**	**France**	**Germany**[3]	**Greenland**	**Ireland**
1993	8	4	13	50	35	1	-
1994	-	28	4	74	18	1	3
1995	-	-	3	16	176	2	4
1996	-	-	4	75	119	3	2
1997	-	-	4	37	81	16	6
1998	-	-	20	73	100	14	9
1999	**Iceland**	-	73	26	202	50	3
2000	48	**Estonia**	50	12	62	29	1
2001	3	-	74	16	198	17	4
2002	41	15	75	58	99	18	4
2003	5	-	64	22	32	8	5
2004	10	-	588	13	10	4	3
2005	4	5	1,147	46	33	39	4
2006	2,513	396	3,808	215	2,483	63	4
2007	1,587	684	2,197	234	520	29	17
2008	9	-	1,849	187	16	25	9
2009	33	-	1,343	15	42	-	-
2010[1]	2	-	979	175	21	12	-

Table 6.1 Cont'd

Year	**Norway**	**Poland**	**Portugal**	**Russia**	**Spain**	**UK (Eng. & Wales)**	**UK (Scotland)**	**Total**
1993	5,182	-	963	6,260	5	293	-	12,814
1994	6,511	-	895	5,021	30	124	12	12,721
1995	2,646	-	927	6,346	67	93	4	10,284
1996	6,053	-	467	925	328	76	23	8,075
1997	4,657	1	474	2,972	272	71	7	8,598
1998	9,733	13	125	3,646	177	93	41	14,045
1999	7,884	6	65	2,731	29	112	28	11,209
2000	6,020	2	115	3,519	87		130[3]	10,075
2001	13,937	5	179	3,775	90		120[3]	18,418
2002	2,152	8	242	3,904	190	**Sweden**	188[3]	6,993
2003	1,210	7	44	952	47	-	124[3]	2,520
2004	1,375	42	235	2,879	257	1	76[3]	5,493
2005	1,760	-	140	5,023	163	**Netherl** -7	95[3]	8,465
2006	4,710	2,496	1,804	11,413	710	**Lithu** -845 **Latv**-341 **Can** - 433	1,027[3]	33,261
2007	3,209	1,081	1,483	5,660	2,181	**Lithu** -785 **Latvia**-349	202[3]	20,219
2008	2,214	8	713	7,117	463	**Lithu** -117 **Latvia**-267 **Netherl** -13	83[3]	13,089
2009	2,567[1]	338	806	3,843	177	**Netherl** -3 **EU**-889	80[3]	10,135
2010[1]	2,245	-	293	6,414	831	**Lithu** -457 **Latvia**-243	79[3]	11,751

[1] Provisional figures.

[2] Including 1,414 tonnes in Division IIb not split on countries.

[3] UK(E&W)+UK(Scot.)

Table 6.2. ***Sebastes mentella*** **in Subareas I and II. Nominal catch (t) by countries in Subarea I.**

Year	Faroe Islands	Germany	Greenland	Norway	Russia	UK(Eng.&Wales)	Iceland	Total
1993	2[2]	-	-	16	588	-	-	606
1994	2[2]	2	-	36	308	-	-	348
1995	2[2]	-	-	20	203	-	-	225
1996	-	-	-	5	101	-	-	106
1997	-	-	3[2]	12	174	1[2]	-	190
1998	20[2]	-	-	26	378	-	-	424
1999	69[2]	-	-	69	489	-	-	627
2000	-	-	-	47	406	-	48[2]	501
2001	-	-	-	8	296	-	3[2]	307
2002	-	-	-	4	587	-	-	591
2003	-	-	-	6	292	-	-	298
2004	-	-	-	2	355	-	-	357
2005	-	-	-	3	327	-	-	330
2006	2[3]	-	-	12	460	2	-	476
2007	-	-	-	11	210	20	8	249
2008	-	-	-	5	155	2	-	162
2009	-	-	-	3[1]	80	-	8	91
2010[1]	-	-	-	22	10	-	-	32

[1] Provisional figures.

[2] Split on species according to reports to Norwegian authorities.

[3] Based on preliminary estimates of species breakdown by area.

Table 6.3. ***Sebastes mentella*** **in Subareas I and II. Nominal catch (t) by countries in Division IIa (including landings from the pelagic trawl fishery in the international waters).**

Year	Estonia	Faroe Islands	France	Germany	Greenland	Ireland	Norway
1993		11[2]	15[2]	35	1[2]	-	5,029
1994		2[2]	33[2]	16[2]	1[2]	2[2]	6,119
1995		1[2]	16[2]	176[2]	2[2]	2[2]	2,251
1996		-	75[2]	119[2]	3[2]	-	5,895
1997		-	37[2]	77	12[2]	2[2]	4,422
1998		-	73[2]	58[2]	14[2]	6[2]	9,186
1999		-	16[2]	160[2]	50[2]	3[2]	7,358
2000		50[2]	11[2]	35[2]	29[2]	-	5,892
2001		63[2]	12[2]	161[2]	17[2]	4[2]	13,636
2002		37[2]	54[2]	59[2]	18[2]	4[2]	1,937
2003		58[2]	18[2]	17[2]	8[2]	5[2]	1,014
2004		555[2]	8[2]	4[2]	4[2]	3[2]	987
2005		1,101[2]	36[2]	17[2]	38[2]	4[2]	1,083[1]
2006	396	3,793	199	2,475	52[2]	3	4,010
2007	684	2,157	226	519	29[2]	16	3,043
2008	-	1,821	179[2]	9[2]	24[2]	9	1,947
2009	-	1,316	7[2]	23[2]	-	-	2,117[1]
2010[1]	-	961	175[2]	13[2]	12[2]	-	1,854

Table 6.3 (Cont'd)

Year	Sweden	Portugal	Poland	Russia	Spain	UK (Eng.& Wales)	UK (Scotland)	Total
1993		648[2]		5,328	-	2[2]	-	11,069
1994		687[2]		4,692	8[2]	4[2]	-	11,564
1995		715[2]		5,916	65[2]	41[2]	2[2]	9,187
1996		429[2]		677	5[2]	42[2]	19[2]	7,264
1997		410[2]		2,341	9[2]	48[2]	7[2]	7,365
1998		118[2]		2,626	55[2]	65[2]	41[2]	12,242
1999		56[2]		1,340	14[2]	94[2]	26[2]	9,117
2000		98[2]		2,167	18[2]	Iceland	103[2,3]	8,403
2001		105[2]		2,716	18[2]	-	95[2,3]	16,827
2002		124[2]		2,615	8[2]	41[2]	157[2,3]	5,055
2003		17[2]		448	8[2]	5[2]	102[2,3]	1,700
2004	1[2]	86[2]		2,081	7[2]	10[2]	18[2,3]	3,765
2005	-	71[2]		3,307	20[2]	2[2]	15[2,3]	5,693
2006	Lithu -845 Can – 433[4]	1,731	2,467	10,110	589	2,513	958[2,3]	30,915
2007	Lithu -785 Latvia -349	1,395	1,079	5,061	2,159	1,579[4]	120[2,3]	19,200
2008	Lithu -117 Latvia -267 Nether -13[2]	666	1	6,442	430	9[2]	62[2,3]	11,996
2009	EU-889[4]	764	338	3,305	137	25	62[2,3]	8,982
2010[1]	Lithu -457[4] Latvia -243[4]	246	-	5,903	825	2[2]	55[2,3]	10,746

[1] Provisional figures.

[2] Split on species according to reports to Norwegian authorities.

[3] UK(E&W)+UK(Scot.)

[4]As reported to NEAFC

Table 6.4. ***Sebastes mentella*** **in Subareas I and II. Nominal catch (t) by countries in Division IIb.**

Year	Canada	Denmark	Faroe Islands	France	Germany	Greenland	Ireland
1993	8[2]	4[2]	-	35[2]	-	-	-
1994	-	28[2]	-	41[2]	-	-	1[2]
1995	-	-	-	-	-	-	2[2]
1996	-	-	4[2]	-	-	-	2[2]
1997	-	-	4[2]	-	3	1[2]	4[2]
1998	-	-	-	-	42[2]	-	3[2]
1999	-	-	4[2]	10[2]	42[2]	-	-
2000	-	-	-	1[2]	27[2]	-	1[2]
2001	-	-	11[2]	4[2]	37[2]	-	-
2002	-	-	38[2]	4[2]	40[2]	-	-
2003	-	-	6[2]	4[2]	15[2]	-	-
2004	-	-	33[2]	5[2]	6[2]	-	-
2005	Netherl -7[2]	Iceland - 2[2]	46[2]	10[2]	17[2]	1[2]	-
2006	-	-	13[2]	16[2]	8[2]	11[2]	1[2]
2007	-	-	40	8[2]	1	-	1[2]
2008	-	-	28[2]	8[2]	7[2]	1[2]	-
2009	3[2]	-	27[2]	8[2]	19[2]	-	-
2010[1]	-	-	18[2]	-	8[2]	-	-

Table 6.4 (Cont'd)

Year	Norway	Poland	Portugal	Russia	Spain	UK(Eng. & Wales)	UK (Scotland)	Total
1993	137	-	315[2]	344	57[3]	291[2]	-	1,191
1994	356	-	208[2]	21	22[3]	120[2]	12[2]	809
1995	375	-	212[2]	227	2[3]	52[2]	2[2]	872
1996	153	-	38[2]	147	323[2]	34[2]	4[2]	705
1997	223	1[2]	64[2]	457	263[2]	22[2]	-	1,042
1998	521	13[2]	7[2]	642	122[2]	28[2]	1[2]	1,379
1999	457	6[2]	9[2]	902	15[2]	18[2]	2[2]	1,465
2000	82	2[2]	17[2]	946	69[2]		27[2,4]	1,172
2001	293	5[2]	74[2]	763	72[2]	Estonia	25[2,4]	1,284
2002	210	8[2]	118[2]	702	182[2]	15	31[2,4]	1,348
2003	190	7	27[2]	212	39[2]	-	22[2,4]	522
2004	386	42[2]	149[2]	443	250[2]	-	58[2,4]	1,372
2005	673	-	69[2]	1,389	143[2]	5	80[2,4]	2,442
2006	688	29	73[2]	843	121[2]	-	67[2,4]	1,870
2007	155	2	88	389	22[2]	-	62[2,4]	769
2008	262	6	47[2]	520	33[2]	-	19[2,4]	931
2009	447[1]	1	42	458	41	-	17[2,4]	1,062
2010[1]	369	-	47[2]	501	5[2]	-	24[2,4]	973

[1] **Provisional figures.**

[2] **Split on species according to reports to Norwegian authorities.**

[3] **Split on species according to the 1992 catches.**

[4] **UK(E&W)+UK(Scot.)**

Table 6.5. ***Sebastes mentella*** **in Subareas I and II. Nominal catch (t) by countries of the pelagic fishery in international waters of the Norwegian Sea (see text for further details)**

Year	Can	Estonia	Faroe Islands	France	Germany	Iceland	Latvia	Lithuania
2002					9			
2003					40			
2004			500		2			
2005			1,083		20			
2006	433	396	3,766	192	2,475	2,510[2]	341	845
2007	-	684	1,968[2]	226	497	1,579[2]	349	785
2008	-	-	1,797[2]	-	-	-	267	117
2009	-	-	1,253	-	-	-	-	-
2010[1]	-	-	912	-	-	-	243	457

Year	Norway	Poland	Portugal	Russia	Spain	UK	Total
2002							9
2003							40
2004				1,510			2,012
2005				3,299			4,402
2006	2,862	2,447	1,697	9,390	575	841	28,770
2007	1,813[2]	1,079	1,377	3,645	2,155	-	16,157
2008	330[2]	-	641	4,901	390[1]	**EU**[3]	8,443
2009	-	337	701	1,975	135	889	5,290
2010[1]	450	-	244	5,103	820		8,229

[1] Provisional figures.

[2] As reported to NEAFC

[3] EU not split on countries.

Table 6.6. *S.mentella* in Subareas I and II. Catch numbers at age.

Catch numbers at age (thous.)

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010[1]
AGE																		
6	159	738	662	223	125	37	9	1	117	2	6	11	5	0	0	0	0	10
7	159	730	941	634	533	882	83	24	372	40	37	24	44	10	1	0	1	4
8	174	722	1279	1699	1287	2904	441	390	542	252	103	108	128	8	5	1	16	6
9	512	992	719	1554	1247	4236	1511	1235	976	572	93	148	347	89	32	10	22	19
10	2094	2561	740	1236	1297	3995	2250	2460	925	709	132	427	540	153	52	44	42	34
11	3139	2734	1230	1078	1244	2741	3262	2149	1712	532	220	624	567	256	151	128	48	55
12	2631	3060	2013	1146	876	1877	1867	1816	2651	1382	384	931	432	877	314	186	1507	61
13	2308	1535	4297	1413	1416	1373	1454	1205	2660	1893	391	580	1607	1980	1025	492	520	237
14	2987	2253	3300	1865	1784	1277	1447	1001	1911	1617	434	1385	1332	2774	2466	541	983	540
15	1875	2182	2162	880	1217	1595	1557	993	1773	855	466	1047	3174	4580	2836	1444	1136	532
16	1514	3336	1454	621	537	1117	1418	932	1220	629	513	937	1041	5154	3570	1423	1623	848
17	1053	1284	757	498	1177	784	1317	505	714	163	199	927	1216	4823	4002	923	1292	828
18	527	734	794	700	342	786	658	596	814	237	231	549	1024	4261	2866	1730	2347	792
+gp	6022	3257	2404	2247	3568	6241	3919	5705	16234	4082	1193	2055	4266	35350	17148	16389	7389	14659
TOTALNUM	25154	26118	22752	15794	16650	29845	21193	19012	32621	12965	4400	9754	15725	60313	34469	23311	16925	18625
TONSLAND	12866	12721	10284	8075	8597	14045	11209	10075	18418	6993	2520	5493	8466	32895	19837	13089	10135	11751

[1] preliminary figures

Table 6.7. *S.mentella* in Subareas I and II. Catch weights at age (kg).

Catch weights at age (kg)

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010[1]
AGE																				
6	0,13	0,19	0,17	0,16	0,14	0,2	0,18	0,14	0,15	0,1	0,11	0,13	0,09	0,13	0,13	-	-	-	0,21	0,21
7	0,18	0,22	0,23	0,22	0,16	0,2	0,21	0,19	0,22	0,15	0,15	0,17	0,14	0,17	0,17	0,14	0,14	0,29	0,20	0,14
8	0,21	0,26	0,25	0,24	0,19	0,25	0,25	0,23	0,22	0,22	0,20	0,22	0,22	0,22	0,21	0,23	0,25	0,30	0,35	0,23
9	0,27	0,28	0,28	0,3	0,21	0,31	0,29	0,29	0,28	0,26	0,25	0,29	0,28	0,27	0,28	0,29	0,33	0,30	0,43	0,40
10	0,34	0,31	0,33	0,34	0,28	0,42	0,33	0,33	0,33	0,31	0,30	0,34	0,33	0,33	0,34	0,34	0,19	0,32	0,43	0,49
11	0,35	0,33	0,38	0,37	0,32	0,44	0,38	0,38	0,37	0,36	0,34	0,38	0,39	0,38	0,38	0,42	0,33	0,36	0,47	0,54
12	0,42	0,38	0,44	0,4	0,37	0,47	0,46	0,43	0,44	0,42	0,39	0,43	0,43	0,43	0,43	0,45	0,30	0,49	0,52	0,56
13	0,46	0,46	0,47	0,44	0,41	0,59	0,48	0,48	0,49	0,44	0,44	0,44	0,45	0,43	0,45	0,46	0,29	0,43	0,54	0,61
14	0,51	0,43	0,5	0,45	0,47	0,67	0,51	0,54	0,53	0,51	0,48	0,52	0,50	0,50	0,50	0,49	0,48	0,63	0,55	0,57
15	0,58	0,43	0,57	0,49	0,53	0,69	0,55	0,59	0,56	0,56	0,53	0,56	0,54	0,54	0,55	0,53	0,48	0,56	0,62	0,56
16	0,59	0,45	0,58	0,55	0,58	0,71	0,6	0,61	0,62	0,62	0,59	0,57	0,59	0,58	0,56	0,54	0,51	0,55	0,62	0,60
17	0,58	0,52	0,62	0,58	0,66	0,74	0,66	0,64	0,66	0,63	0,62	0,60	0,57	0,61	0,59	0,55	0,61	0,64	0,64	0,65
18	0,59	0,57	0,65	0,67	0,71	0,74	0,65	0,66	0,67	0,67	0,65	0,59	0,62	0,64	0,61	0,56	0,59	0,32	0,65	0,60
+gp	0,7	0,67	0,66	0,79	0,81	0,85	0,79	0,75	0,81	0,77	0,70	0,73	0,75	0,72	0,70	0,66	0,68	0,64	0,67	0,64

[1] preliminary figures

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

Numbers*10**-3					Age				
YEAR	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19+**
2006	23	93	1083	323	1563	3628	2514	3756	29704
2007	75	440	1331	2909	3347	4138	3692	3437	9114
2008	28	146	115	143	214	594	752	753	13258
2009	9	1314	294	471	889	999	869	1150	2981
2010[1]	0	0	130	336	254	466	467	508	11510

[1] preliminary figures

Table 6.9 Pelagic *Sebastes mentella* in the Norwegian Sea (outside the EEZ). Catch weights at age (kg).

					Age				
YEAR	11	12	13	14	15	16	17	18	19+
2006	0,44	0,44	0,52	0,44	0,49	0,55	0,53	0,56	0,61
2007	0,39	0,43	0,41	0,48	0,50	0,52	0,55	0,57	0,64
2008	0,36	0,47	0,56	0,50	0,56	0,54	0,56	0,55	0,64
2009	0,38	0,44	0,45	0,48	0,54	0,59	0,64	0,58	0,69
2010[1]	-	-	0,62	0,56	0,54	0,59	0,59	0,56	0,61

[1] preliminary figures

Table 6.10. ***Sebastes mentella*****. Comparison of results from the Norwegian Sea pelagic surveys in 2008 and 2009.**

	2009	2008[1]
mean length (cm) All/M/F[2]	36.6 / 36.0 / 37.1	37.0 / 36.4 / 37.5
mean length (cm) S/DSL/D[3]	37.2 / 36.5 / 38.3	37.2 / 36.8 / 39.1
mean weight (cm) All/M/F	625 / 609 / 666	619 / 585 / 648
Mean age (y) All/M/F	25 / 25 / 24	25 / 25 / 25
Sex ratio	45% (M) / 55% (F)	45% (M) / 55% (F)
Occurrence *S. mentella*	100%	96%
Catch rates	3.94 t/NM^2	3.80 t/NM^2
mean s_A	34 m^2/NM^2	33 m^2/NM^2
Total Area	69,520 NM^2	53,720 NM^2
Abundance (Acoustics)[4]	532,000 t	395,000 t
Abundance (Trawl)[5]	548,000 t	406,000 t

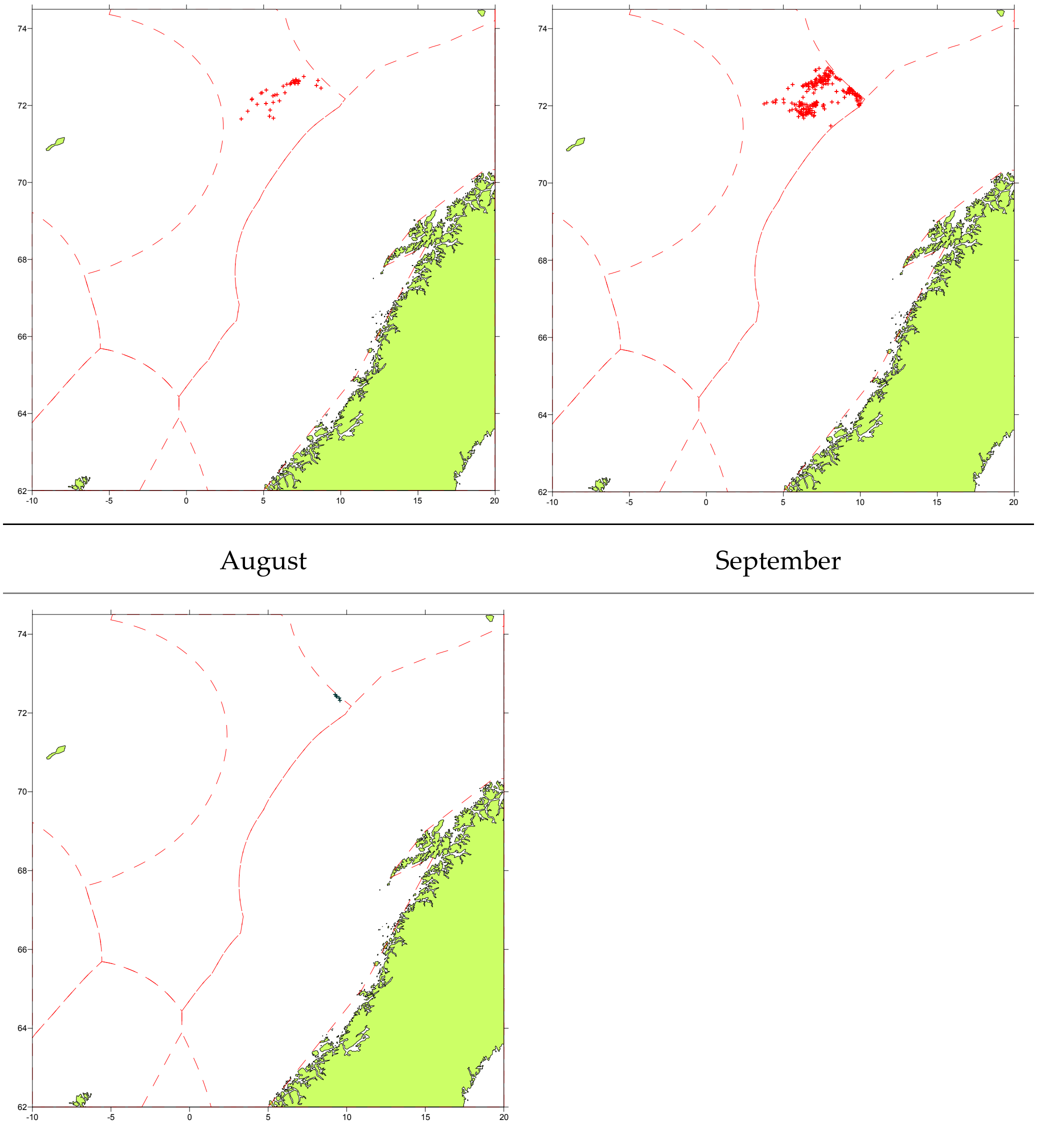
1 The result for 2008 only concern the northern part of the Norwegian Sea which was surveyed by Norway

2 M = males only, F = females only

3 S = shallower than DSL, DSL = deep scattering layer, D = deeper than DSL

4 The abundance derived from hydroacoustics is calculated assuming a Length-dependent target strength equation of TS=20log(L)-68. The alternative equation 20log(L)-71.3 would result in abundance estimates raised by a factor of 2.

5 The abundance derived from the trawl catches is corrected for the catchability of redfish by Gloria trawl 2048. This is estimated to be 0.5, from Bethke *et al*. (2010).



August

September

October

Figure 6.1. ***Sebastes mentella*** **in Subareas I and II. Location of pelagic** ***S. mentella*** **catches by Russian fishing vessels in 2010.**

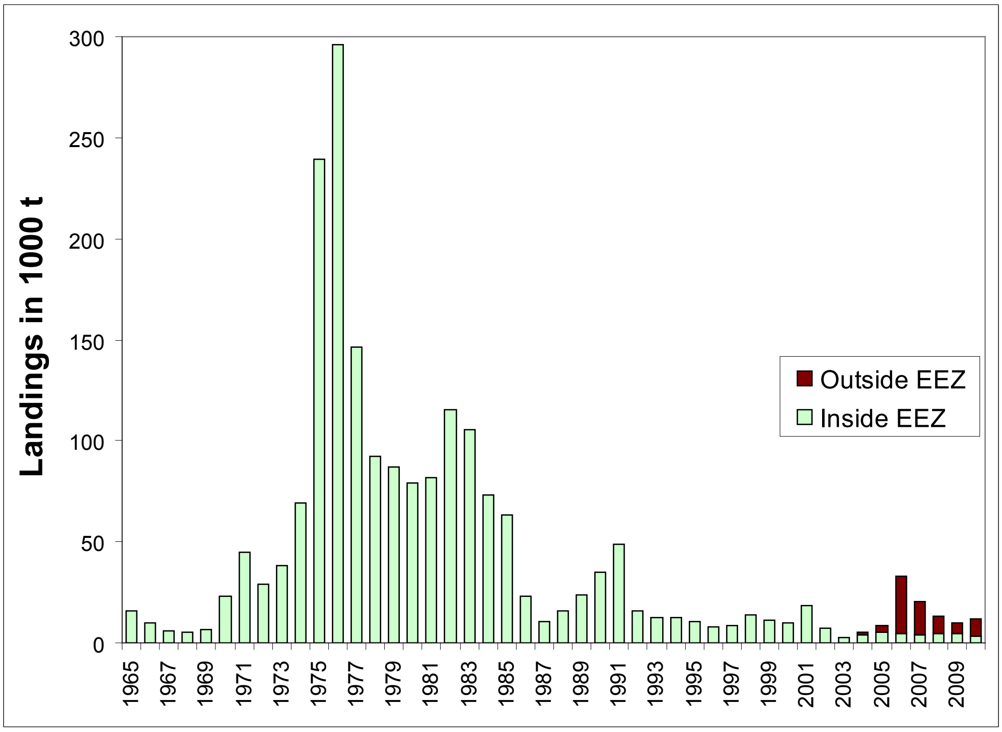


Figure 6.2. *Sebastes mentella* in Subareas I and II. Total international landings 1965-2010 (thousand tonnes).

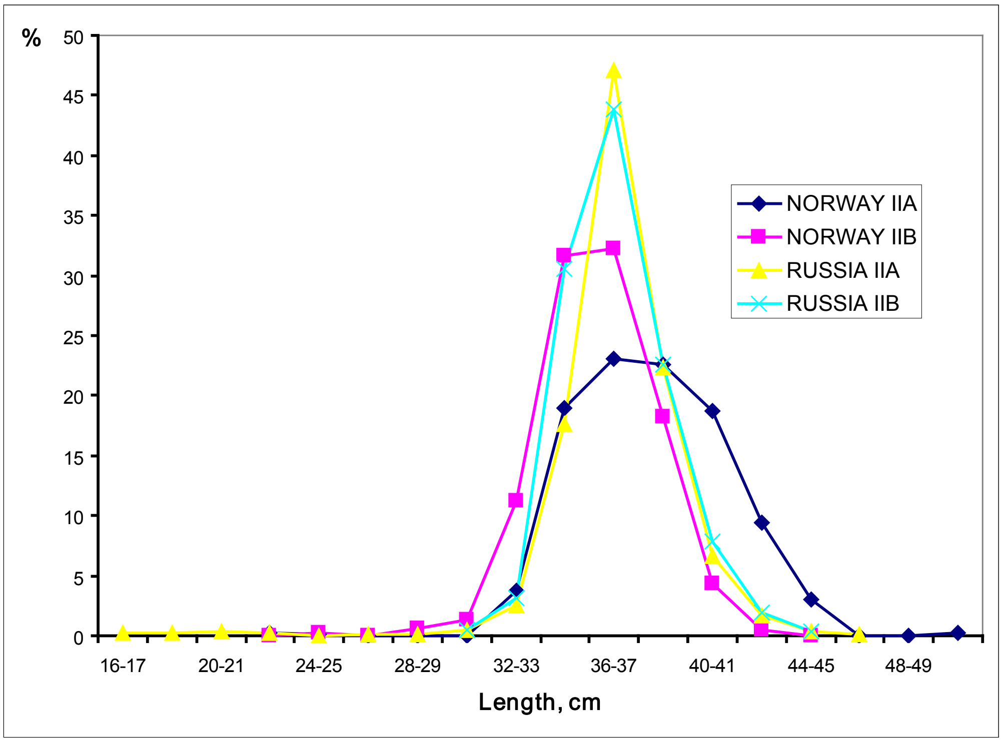


Figure 6.3. ***Sebastes mentella*** **in Subareas I and II. Length-distributions of the commercial demersal catches inside EEZ in ICES Subareas IIa and IIb by those countries providing length data from their demersal by-catches of** ***S. mentella*** **in 2010.**

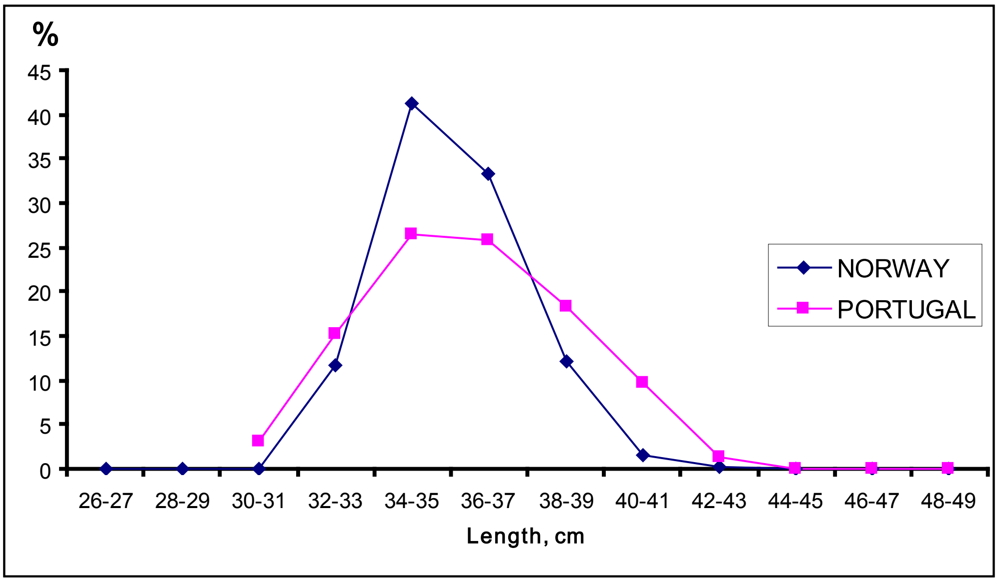


Figure 6.4. ***Sebastes mentella*** **in Subareas I and II. Length-distributions of the commercial pelagic catches in the Norwegian Sea outside EEZ in ICES Subarea IIa by those countries providing length data from their pelagic fisheries in 2010.**

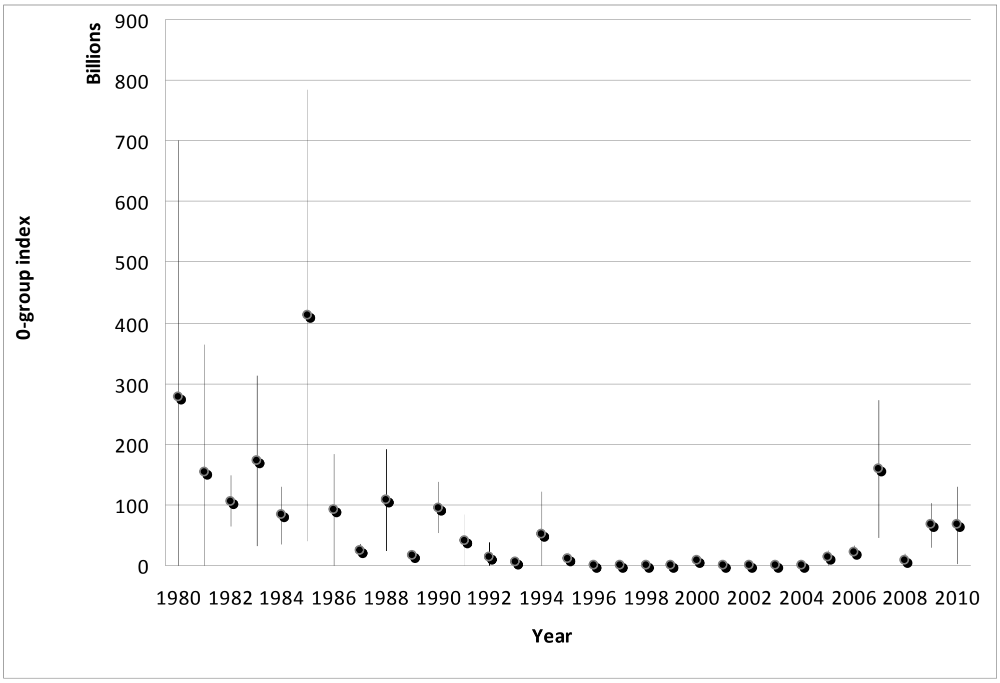


Figure 6.5. ***Sebastes mentella*** **in Subareas I and II. Abundance indices (in millions) with 95% confidence limits of 0-group redfish (believed to be mostly** ***S. mentella*****) in the international 0-group survey in the Barents Sea and Svalbard areas in August-September 1980-2010. Numbers are given in Table 1.1.**

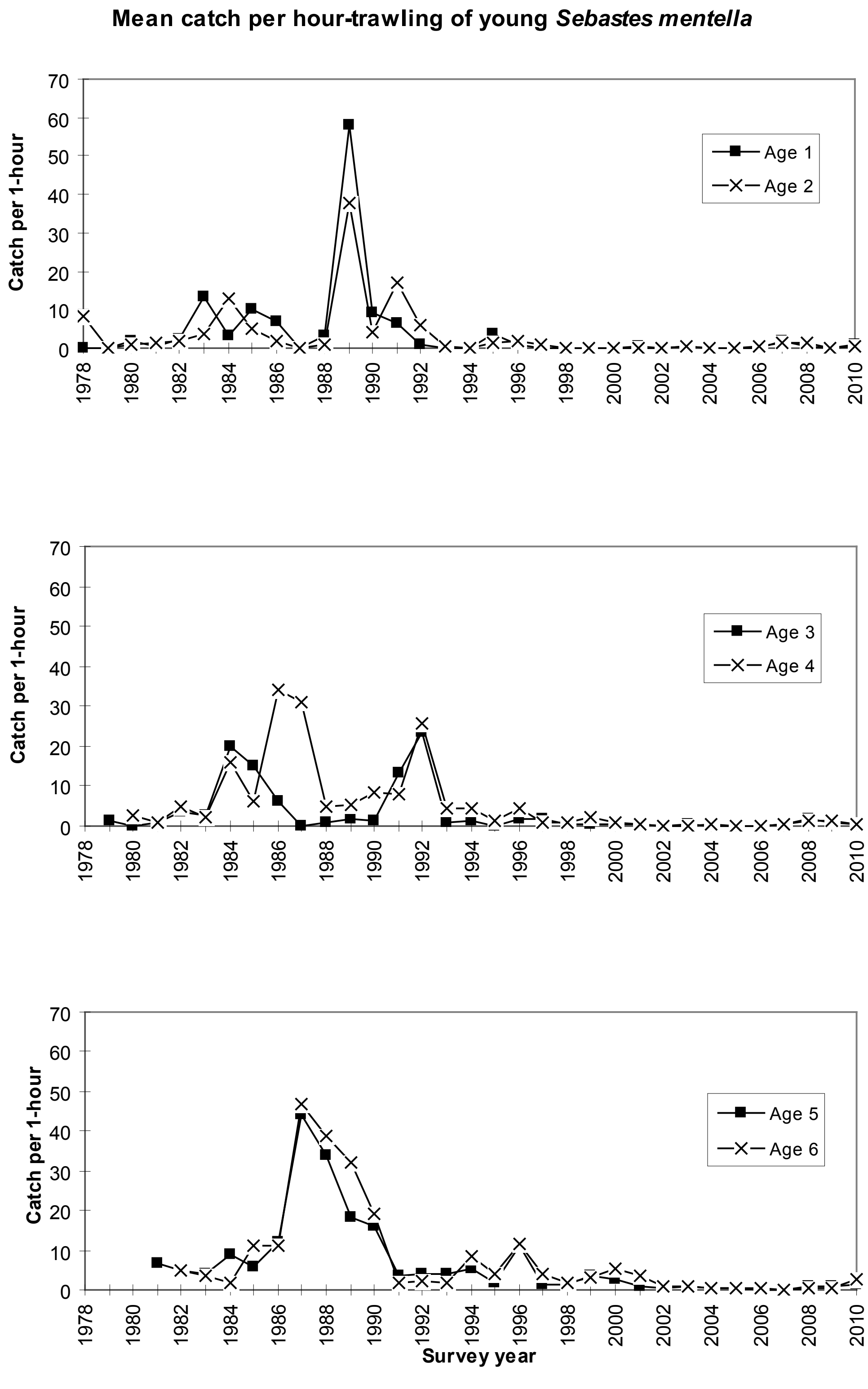


Figure 6.6. ***Sebastes mentella*** **in Subareas I and II. Catch (numbers of specimens) per hour trawling of different ages of** ***S. mentella*** **in the Russian groundfish survey in the Barents Sea and Svalbard areas (ref. Table D3).**

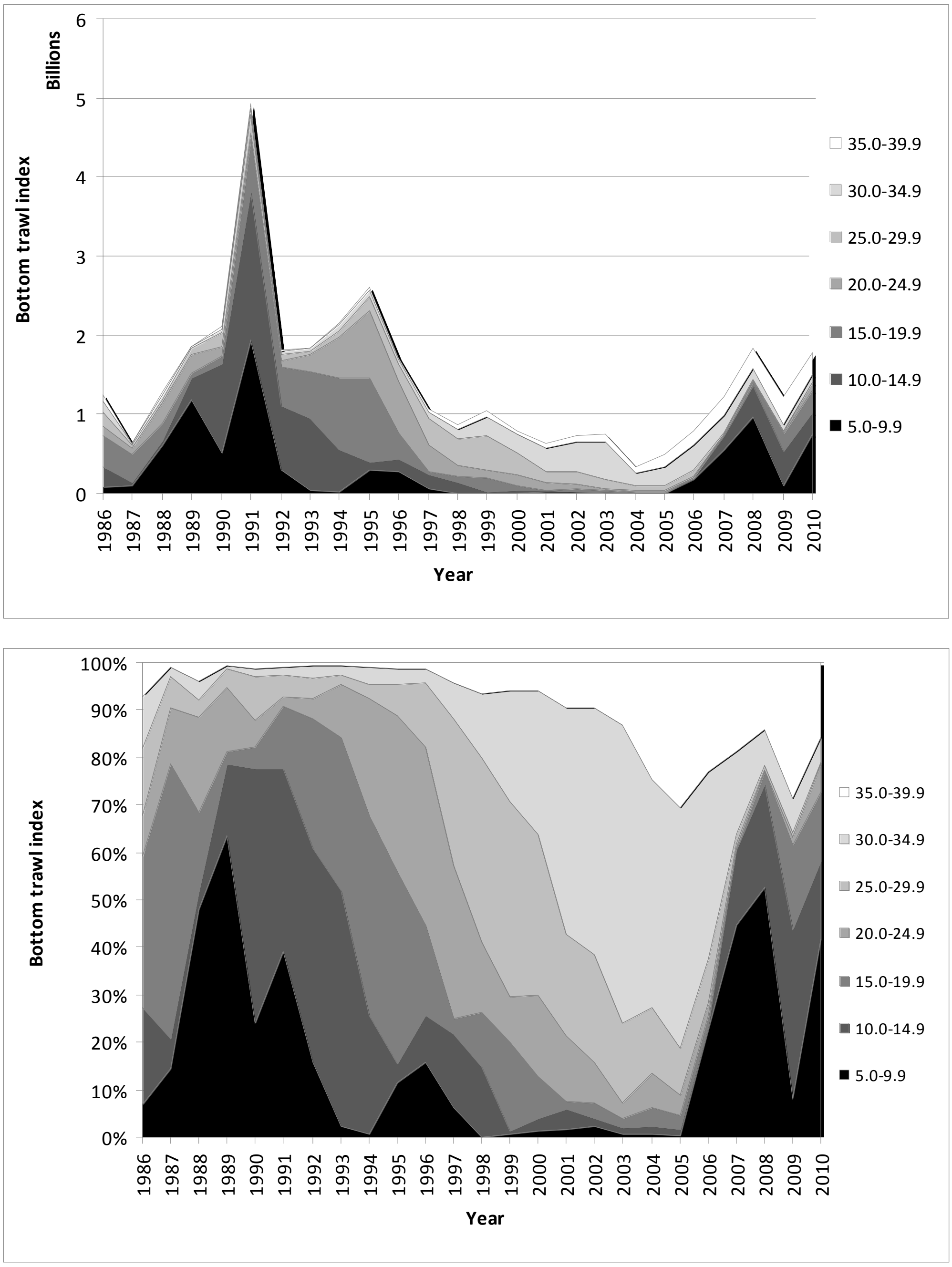


Figure 6.7a. *Sebastes mentella* in Subareas I and II. Abundance indices disaggregated by length when combining the Norwegian bottom trawl surveys 1986-2010 in the Barents Sea (winter) and at Svalbard (summer/fall). Top: absolute index values. Bottom: relative frequencies. Horizontal line indicates the median length in the surveyed population.

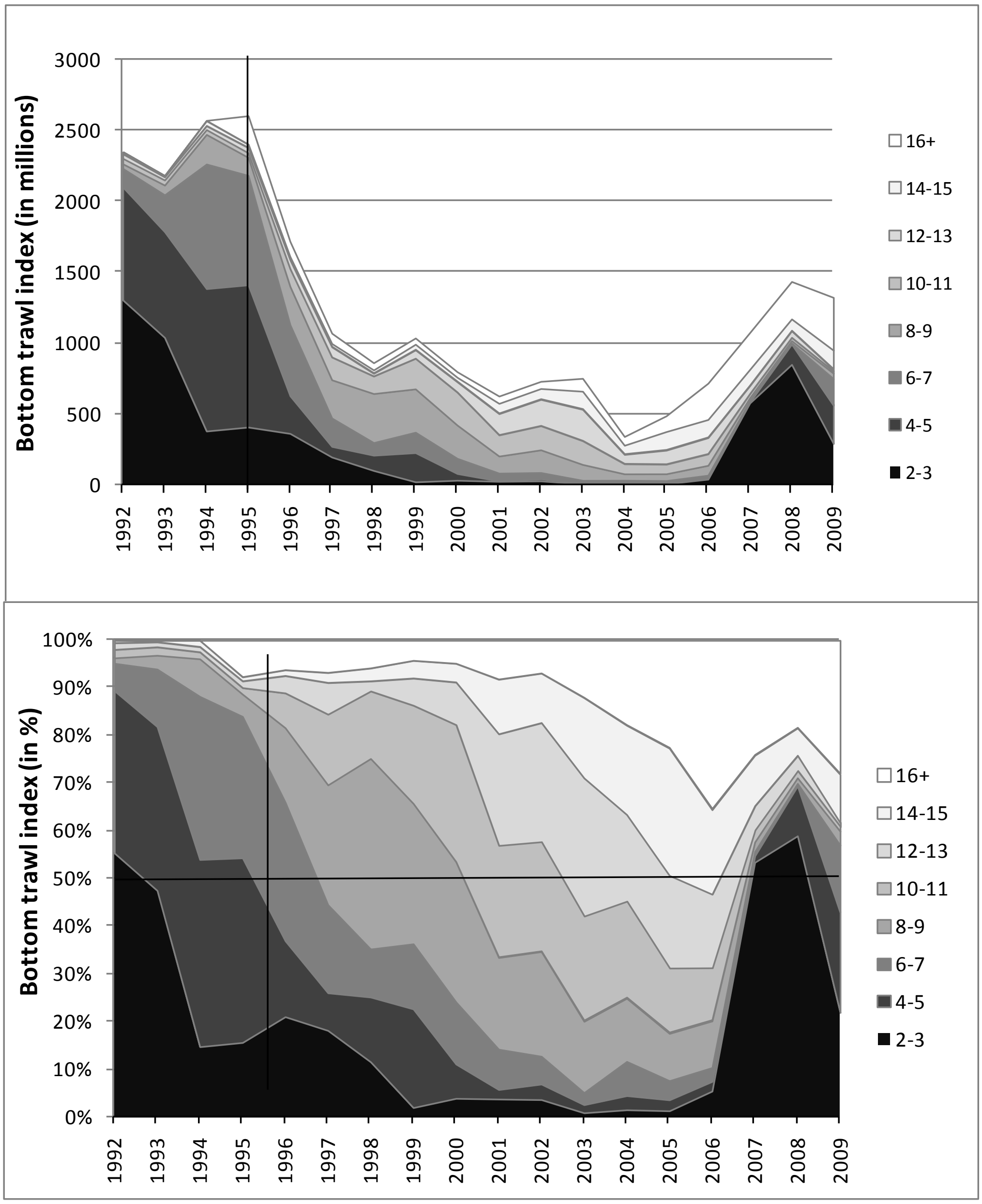


Figure 6.7b. ***Sebastes mentella*** **in Subareas I and II. Age disaggregated abundance indices for combined Norwegian bottom trawl surveys 1992-2009 at Svalbard (summer/fall) and in the Barents Sea (winter). Top: absolute numbers. Bottom: relative frequencies. Vertical black line indicates the start of recording for age 16+ group. Horizontal line indicates the median age in the population (50% frequency).**

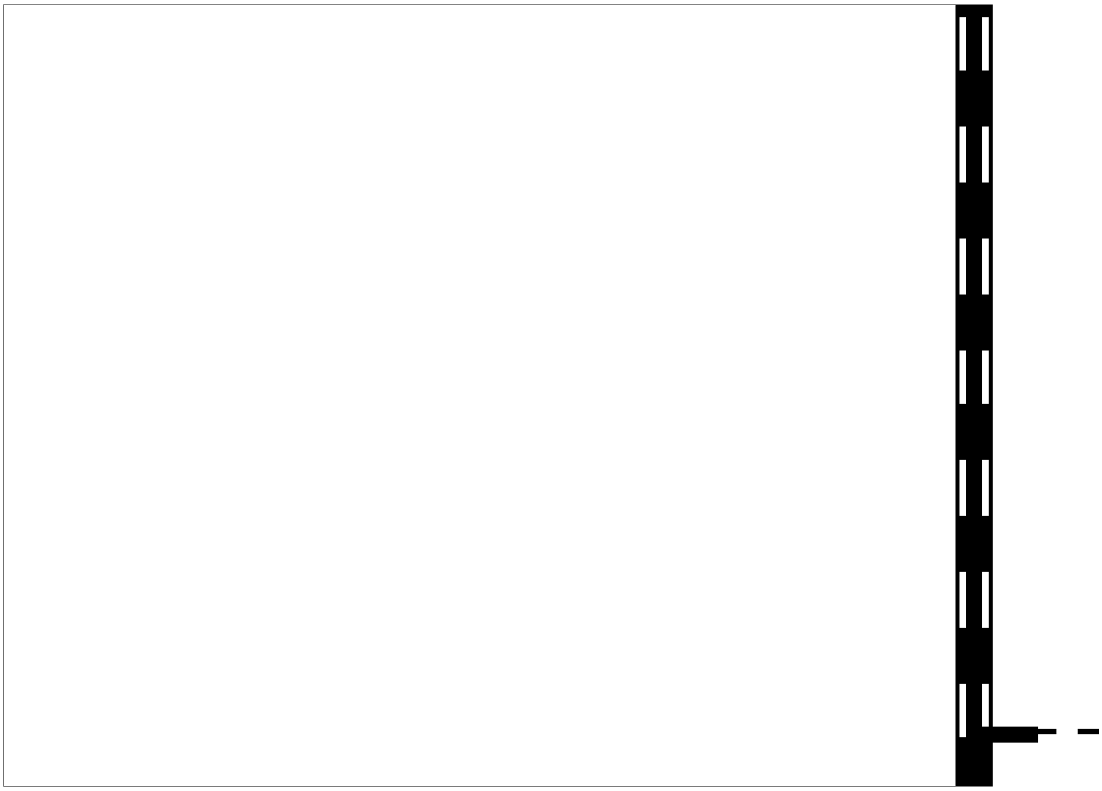


Figure 6.8. Survey regions and subareas in the ecosystem survey in the Barents Sea and adjacent areas as covered in August-September 2007 by the standard 1800 Campelen research trawl (22 mm codend) shallower than about 500 m, and the Alfredo 5 trawl (60 mm codend) from 500-1500 m along the continental slope from 68-80°N. The Subareas are further depth stratified (ref. Table D6).

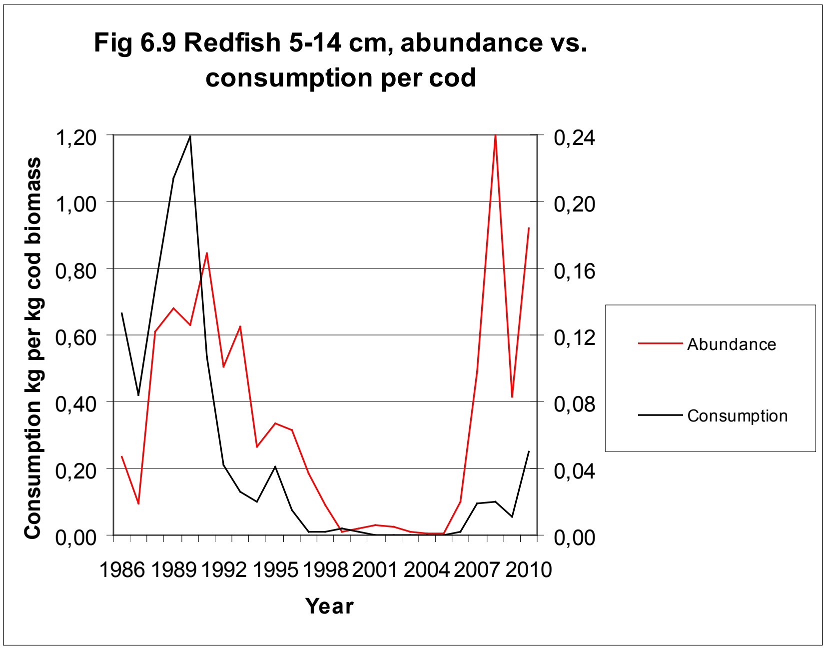
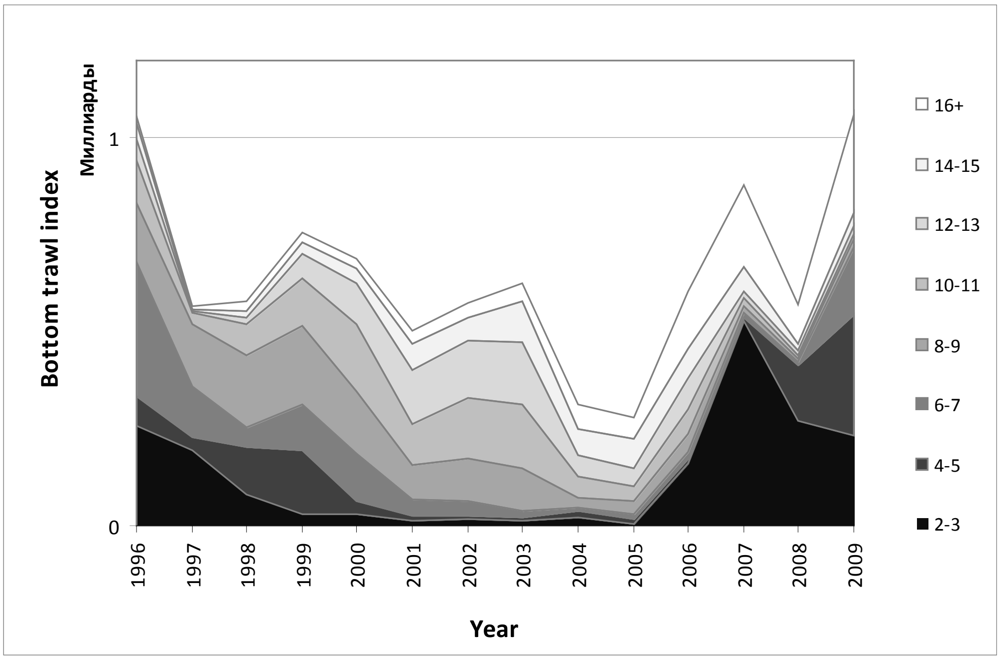


Figure 6.9. Abundance of *S. mentella* during the winter survey (February) in the Barents Sea compared with the consumption of redfish (mainly *S. mentella*) by cod (See Chapter 1, Table 1.3).



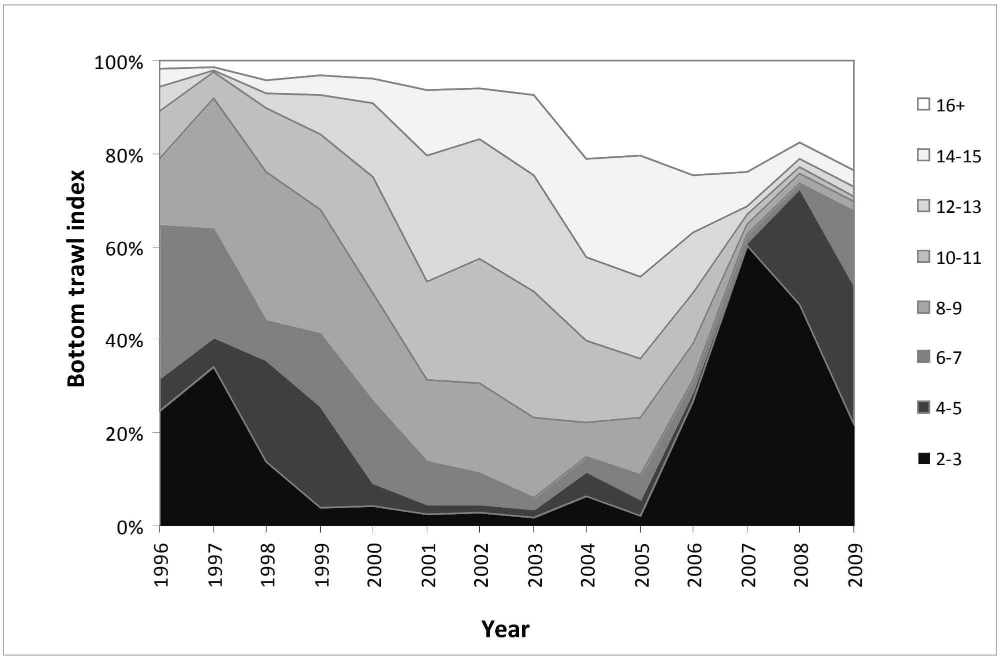


Figure 6.10. ***Sebastes mentella*** **in Subareas I and II. Abundance indices (in billions) disaggregated by age from the Ecosystem survey in August-September 1996-2009 covering the Norwegian Economic Zone (NEZ) and Svalbard including the area north and east of Spitsbergen (ref. Table D6). . Top: absolute index values. Bottom: relative frequencies. The group 16+ is only recorded from 1996 onwards.**

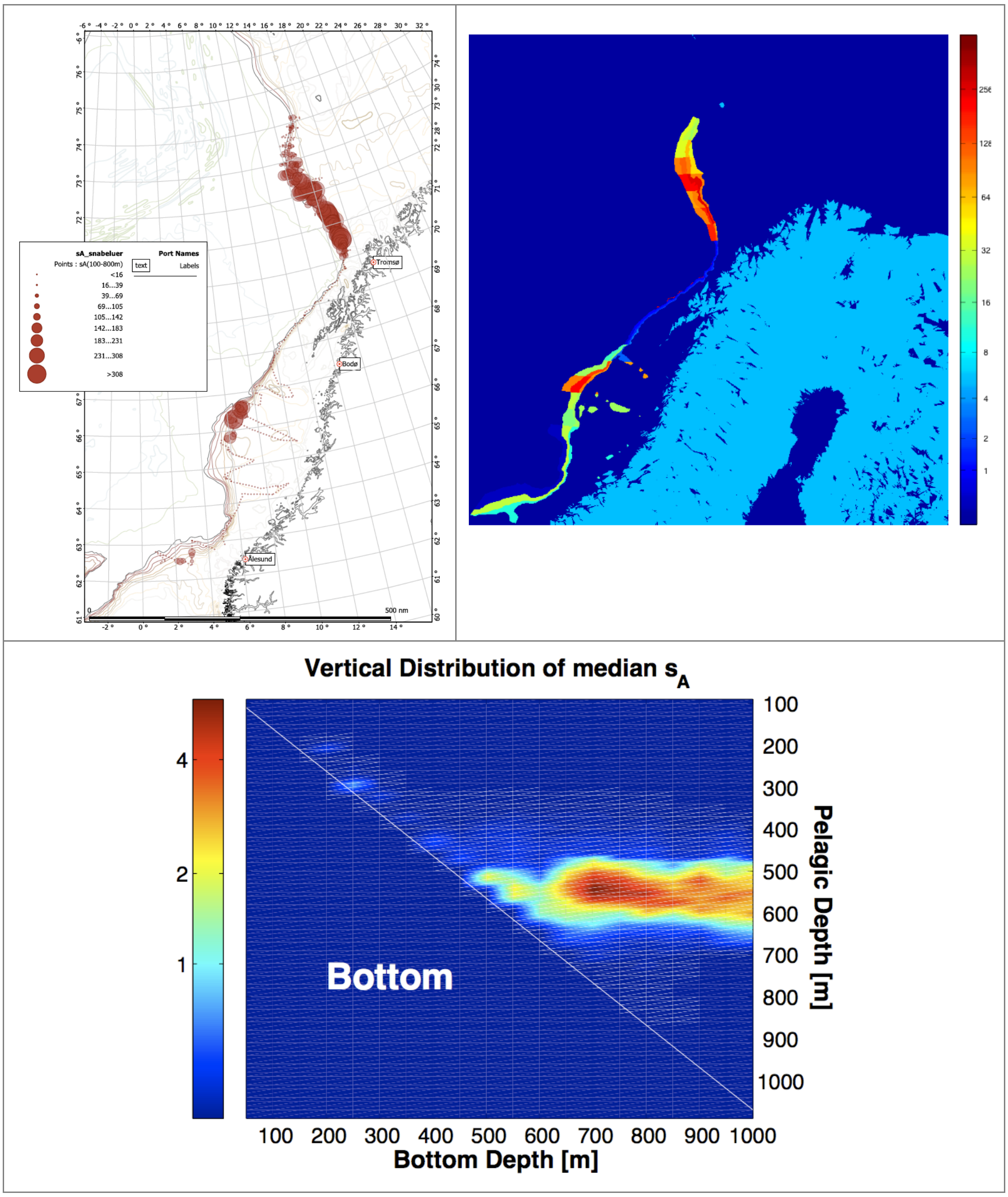


Figure 6.11. ***Sebastes mentella*** **in Subareas I and II. Horizontal and vertical distribution of *S.mentella* hydroacoustic backscattering (sA) during the Norwegian slope survey in spring 2009. On the top-left panel, circles are proportional to the sA assigned to redfish along the vessel track. The top-right panel shows the distribution of mean sA by depth and latitude strata (dark blue = no data). The bottom panel shows the vertical distribution of median sA as a function of bottom depth, revealing a preferred depth range for *S. mentella* of 450-650m and dominance of pelagic *vs.* demersal distributions.**

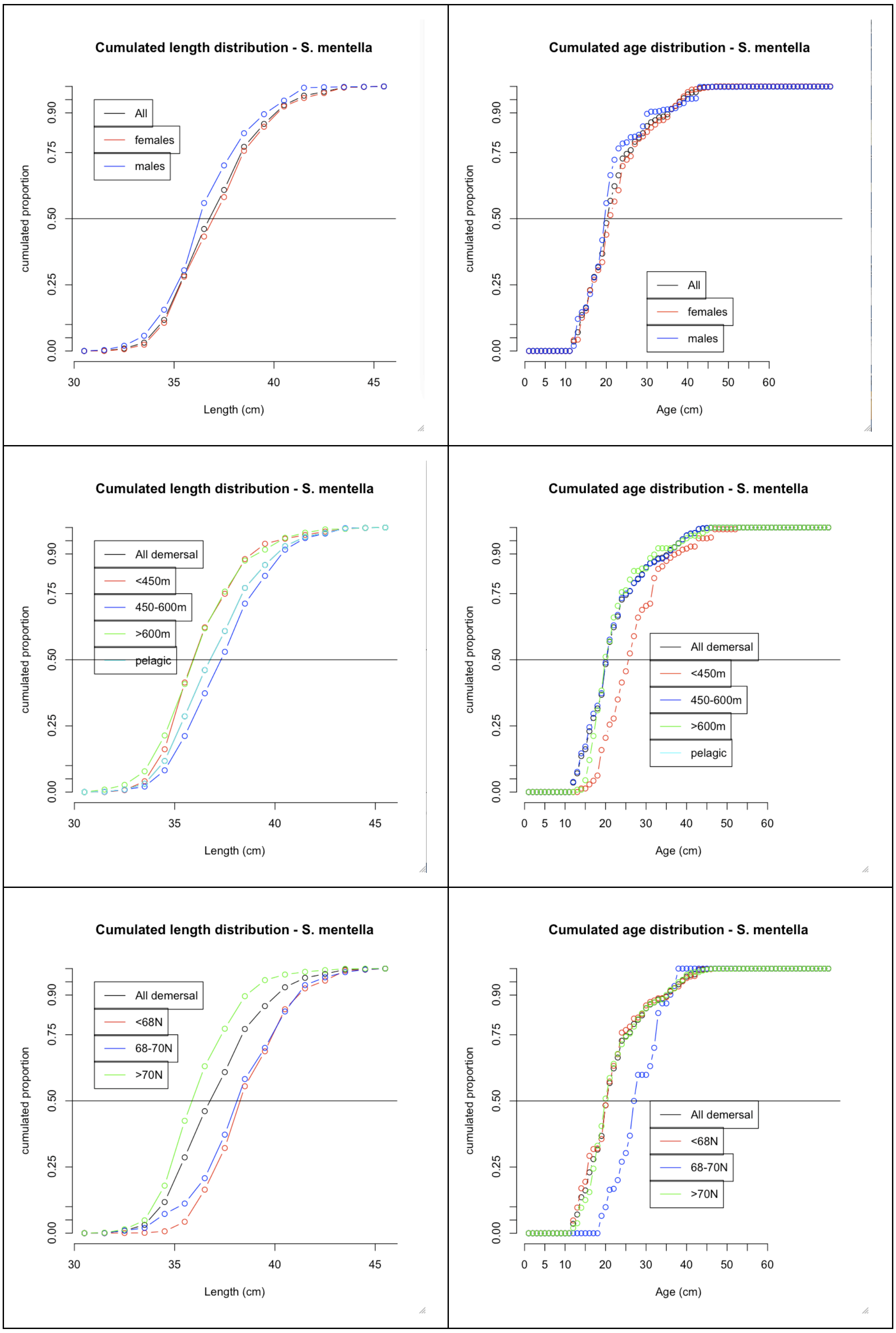


Figure 6.12. ***Sebastes mentella*** **in Subareas I and II. Cumulated distribution of length (left) and age (right) of** ***S. mentella*** **as a function of sex (top), depth (middle) and latitude (bottom).**

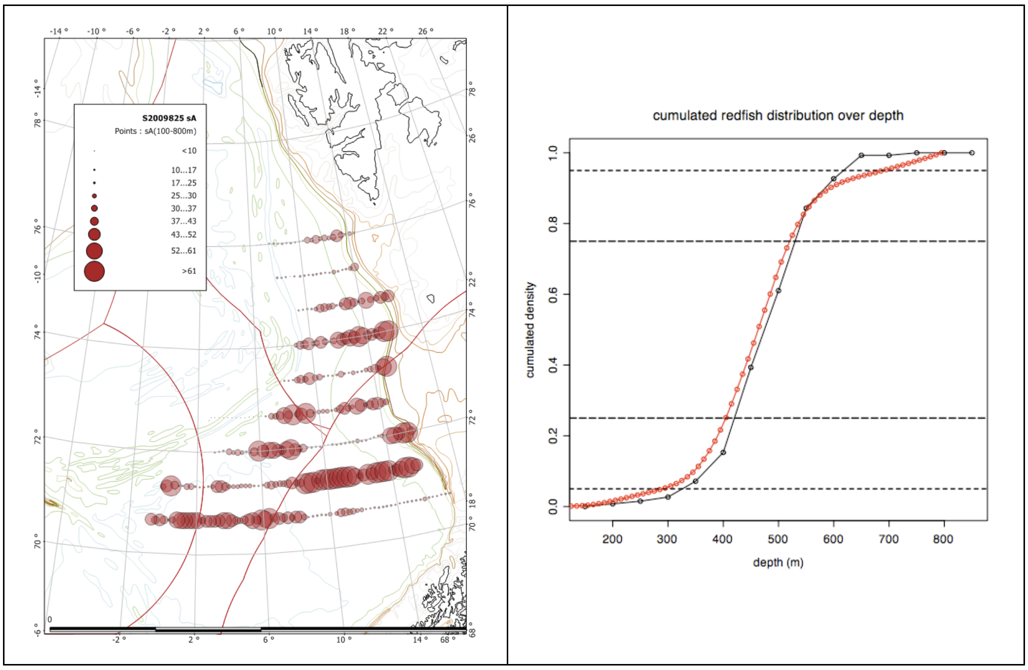


Figure 6.13. ***Sebastes mentella*** **in Subareas I and II. Left: Spatial distribution of area backscattering coefficient (s_A) of *S. mentella* (m^2/NM^2) during the Norwegian Sea pelagic survey in summer 2009. Right: cumulated density distribution of catch rates (black) and area backscattering coefficient (s_A, red) as a function of depth. Dotted lines indicate the 5 and 95% probability levels. Dashed lines indicate the 25% and 75% probability levels.**

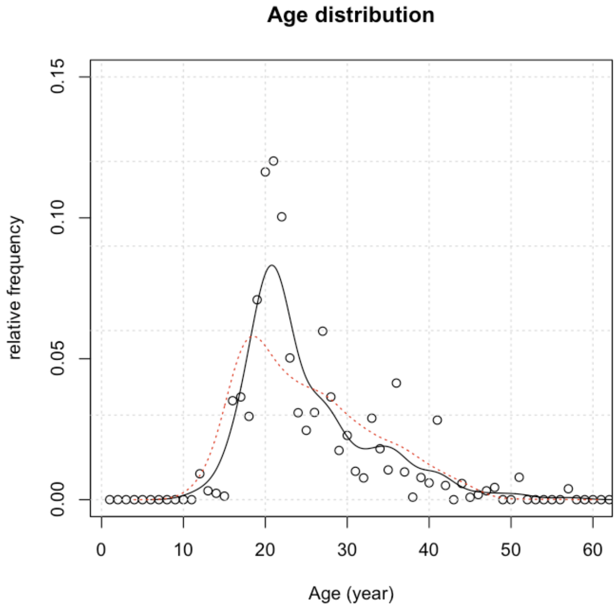


Figure 6.14. ***Sebastes mentella*** **in Subareas I and II. Age distribution of** ***S. mentella*** **sampled during the open Norwegian Sea survey in July-August 2009. Dots show the proportion at age for individual age. The black line is a smooth fit, which is believed to be more reliable when precision in age reading is uncertain. The sampled population is dominated by individuals of 16 years and over with 20-22 years dominating. The estimated smoothed age distribution in the same area in 2008 is indicated as a red dotted line.**

Table D1 REDFISH in Subareas I and II. Nominal catch (t) by countries in Subarea I, Divisions IIa and IIb combined as officially reported to ICES.

Year	Canada	Denmark	Faroe Islands	France	Germany[4]	Greenland	Iceland	Ireland	Netherlands	Norway	Poland	Portugal	Russia[5]	Spain	UK (E&W)	UK (Scot.)	Total
1984	-	-	-	2,970	7,457	-	-	-	-	18,650	-	1,806	69,689	25	716	-	101,313
1985	-	-	-	3,326	6,566	-	-	-	-	20,456	-	2,056	59,943	38	167	-	92,552
1986	-	-	29	2,719	4,884	-	-	-	-	23,255	-	1,591	20,694	-	129	14	53,315
1987	-	+	450[3]	1,611	5,829	-	-	-	-	18,051	-	1,175	7,215	25	230	9	34,595
1988	-	-	973	3,349	2,355	-	-	-	-	24,662	-	500	9,139	26	468	2	41,494
1989	-	-	338	1,849	4,245	-	-	-	-	25,295	-	340	14,344	5[2]	271	1	46,688
1990	-	37[3]	386	1,821	6,741	-	-	-	-	34,090	-	830	18,918	-	333	-	63,156
1991	-	23	639	791	981	-	-	-	-	49,463	-	166	15,354	1	336	13	67,768
1992	-	9	58	1,301	530	614	-	-	-	23,451	-	977	4,335	16	479	3	31,773
1993	8[3]	4	152	921	685	15	-	-	-	18,319	-	1,040	7,573	65	734	1	29,517
1994	-	28	26	771	1026	6	4	3	-	21,466	-	985	6,220	34	259	13	30,841
1995	-	-	30	748	692	7	1	5	1	16,162	-	936	6,985	67	252	13	25,899
1996	-	-	42[3]	746	618	37	-	2	-	21,675	-	523	1,641	408	305	121	26,118
1997	-	-	7	1,011	538	39[2]	-	11	-	18,839	1	535	4,556	308	235	29	26,109
1998	-	-	98	567	231	47[3]	-	28	-	26,273	13	131	5,278	228	211	94	33,199
1999	-	-	108	61[3]	430	97	14	10	-	24,634	6	68	4,422	36	247	62	30,195
2000	-	-	67[3]	25	222	51	65	1	-	19,052	2	131	4,631	87		203[6]	24,537
2001	-	-	111[3]	46	436	34	3	5	-	23,071	5	186	4,738	91	**Estonia**	239[6]	28,965
2002	-	-	135[3]	89	141	49	44	4	-	10,713	8[3]	276	4,736	193[2]	15	234[6]	16,637
2003	**Swed**	-	173[3]	31	154	44[3]	9	5[3]	89	8,063	7	50	1,431	47[2]	-	258[6]	10,361
2004	1	-	607	17[3]	78	24[3]	40	3	33	7,608[1,2]	42	240	3,601[2]	260[2]	-	146[6]	12,699
2005	**Can**	**Lith**	1,194	56	106	75[3]	12[2]	4[3]	55[2]	7,844[1,2]	-	196	5,637	171[3]	5	147[6]	15,501
2006	433	845	3,919	223	2,518	107[3]	2,544[3]	12[3]	21	11,015	2,496[2]	1,873	12,126	719[2]	396	1,066[6]	40,313
2007	**Latv**	785	2,343	249	587	84[3]	1,647[2]	7[3]	20	8,993[2]	1,081[2]	1,708	6,550	2,186[2]	684	257[6]	27,181
2008	267	117	2,123[3]	250	46	74[3]	36[3]	2[3]	15	7,416[1]	8	785	7,866	1,183[2]	**EU[7]**	168[6]	20,356
2009	-	-	1,413	19	100	72	76	-	4	8,149	338	836	4,541	177	889	113	16,727
2010[1]	243[3]	457[3]	1,150	226	52	84[3]	24[3]	-	-	8,760	1[3]	321	7,220	835		123	19,495

[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 D2. REDFISH in Subarea IV (North Sea). Nominal catch (t) by countries as officially reported to ICES. Not included in the assessment.

Year	Belgium	Denmark	Faroe Islands	France	Germany	Ireland	Netherlands	Norway	Sweden	UK (England & Wales)	UK (Scotl)	Total
1986	-	24	-	578	183	-	-	1,048	-	35	1	1,869
1987	-	16	3	833	70	-	-	411	-	16	55	1,404
1988	-	32	90	915	188	-	-	696	-	125	9	2,055
1989	1	23	13	554	111	-	-	500[2]	-	134	6	1,342
1990	+	41	25	554	47	-	-	483[2]	-	369	6	1,525
1991	5	29	144	914	213	-	2	415[2]	-	43	38	1,803
1992	4	22	23	1,960	170	-	1	416	-	65	122	2,783
1993	28	14	4	1,211	33	-	1	373	-	138	71	1,873
1994	4	13	1	863	324	-	8	371	-	38	66	1,688
1995	16	12	65	1,120	80	-	16	297	-	46	241	1,893
1996	20	20	1	932	74	-	41	363	-	37	146	1,634
1997	16	23	-	1,049	45	-	53	595	-	21	528	2,330
1998	2	27	12	570	370	4	21	1,113	-	68	681	2,868
1999	3	52	1	-	58	39	16	862	-	67	465	1,563
2000	5	41	-	224	19	28	19	443	-	132	486	1,397
2001	4	96	-	272	13	19	+	421	-	80	458	1,363
2002	2	40	2	98	11	7	+	241	-		524[3]	925
2003	1	71	2	26	2	-	-	474	-	Portugal	463[3]	1,071
2004	+	42	3	26	1	-	-	287	-	-	214[3]	578
2005	2	34	-	10	1	-	-	84	-	-	28[3]	159
2006	1	49	1	12	3	-	-	155	-	33	79[3]	333
2007[1]	+	27	-	8	1	-	-	107	+	-	78[3]	221
2008[1]	+	3	-	35	1	-	-	77	+	-	54[3]	170
2009	-	-	-	-	-	-	-	120	+	-	87[3]	207
2010[1]	-	6	-	112	-	-	-	67	-	-	149[3]	335

[1] Provisional figures.

[2] Working Group figure.

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

+ less than 0.5 ton.

Table D3. *Sebastes mentella*. Average catch (numbers of specimens) per hour trawling of different ages of *Sebastes mentella* in the Russian groundfish survey in the Barents Sea and Svalbard areas (1976-1983 published in "Annales Biologiques").

Year class	0	1	2	3	4	5	6	7	8	9	10	11
1974	-	-	4.8	-	4.9	22.8	4.8	4.8	-	-	-	3
1975	-	7.4	-	1.7	6.4	2.4	3.5	5	-	-	4	-
1976	7	-	8.1	1.2	2.5	6.8	4.9	5	1	13	-	-
1977	-	0.2	0.2	0.2	0.9	5.1	3.7	1	19	2	-	-
1978	0.8	0.02	0.9	1	5	3.8	2	20	6	-	-	-
1979	-	1.9	1.4	3.6	2.3	9	11	16	1	-	-	0.1
1980	0.3	0.4	2	2.5	16	6	11	25	2	-	1.5	2
1981	-	2.2	3.9	20	6	12	47	18	6.3	1.6	0.5	1
1982	19.8	13.2	13	15	34	44	39	32.6	4.3	3.1	4.9	+
1983	12.5	3	5	6	31	34	32.3	13.3	4	4.2	0.6	1.1
1984	-	10	2	-	5	18.3	19	2.2	2.4	0.2	1.7	2.4
1985	107	7	-	1	5.2	16.2	1.7	1.7	0.6	2.8	3.8	0.3
1986	2	-	1	1.8	8.4	3.6	2.1	1.2	5.6	8.2	0.9	0.7
1987	-	3	37.9	1.3	8	4.1	2	10.6	9.6	1.4	2	1.3
1988	4	58.1	4.3	13.3	25.8	3.9	8.6	11.2	2.8	4.2	3	4.7
1989	8.7	9	17	23.4	4.6	5.4	4	6.6	6.6	4.1	7.7	5.3
1990	2.5	6.3	6.1	1	4.3	1.7	11.5	6.5	5.5	6.7	7.4	3.6
1991	0.3	1	0.5	1.5	1.2	11.3	3.9	3.3	4.6	5.8	2.7	1.9
1992	0.6	+	0.2	0.1	4.3	1.3	2	2.3	4.9	2.3	1	4.1
1993[1]	-	+	1.5	1.8	1	1.2	3	4.2	2.6	2	3.2	2.1
1994	0.3	3.5	1.7	1.7	0.9	3.6	5.2	4.3	3.1	3.3	1.8	1.2
1995	2.8	1	1.1	0.4	2.2	2.6	3.5	3.4	2.9	1.2	1	8.5
1996[2]	+	0.1	0.1	0.4	0.7	1.1	1	1.4	1	0.8	3.7	0.6
1997	-	-	+	0.4	0.5	0.3	0.9	0.6	1	1.1	0.5	0.4
1998	-	0.1	0.2	0.3	0.2	1.1	0.5	0.7	1	0.4	0.4	0.7
1999	0.1	-	0.1	+	0.1	0.3	0.5	0.8	0.5	0.2	0.4	0.4
2000	-	0.6	0.1	0.5	0.3	0.3	0.6	0.4	0.1	0.1	0.5	
2001	-	0.1	0.4	-	0.1	0.2	0.2	0.3	0.2	0.5		
2002[3]	0.1	0.5	0.1	-	-	0.1	0.5	0.4	0.9			
2003	-	-	0.1	-	0.3	1.0	0.5	2.6				
2004	-	0.2	0.3	0.5	1.5	0.9	2.6					
2005	-	-	1.4	1.9	1.4	1.2						
2006[4]	0.1	1.8	1.2	1.1	0.7							
2007	2.5	0.4	0.1	0.5								
2008	0.1	0.1	0.5									
2009	1.6	1.8										
2010	5.7											

[1] - Not complete area coverage of Division IIb.
[2] - Area surveyed restricted to Subarea I and Division IIa only.
[3] - Area surveyed restricted to Subarea I and Division IIb onl
[4] - Area surveyed restricted to Division IIa and IIb only.

Table D4a. *Sebastes mentella*[1] in Division IIb. Abundance indices (on length) from the bottom trawl survey in the Svalbard area (Division IIb) in summer/fall 1986-2010 (numbers in millions).

				Length group (cm)					
Year	5.0-9.9	10.0-14.9	15.0-19.9	20.0-24.9	25.0-29.9	30.0-34.9	35.0-39.9	40.0-44.9	>45.0	Total
1986[2]	6	101	192	17	10	5	2	4	+	338
1987[2]	20	14	140	19	6	2	1	2	+	208
1988[2]	33	23	82	77	7	3	2	2	+	228
1989	566	225	24	72	17	2	2	8	4	921
1990	184	820	59	65	111	23	15	7	3	1,287
1991	1,533	1,426	563	55	138	38	30	7	1	3,791
1992	149	446	268	43	22	15	4	7	4	958
1993	9	320	272	89	16	13	3	1	+	722
1994	4	284	613	242	10	9	2	2	1	1,165
1995	33	33	417	349	77	18	5	1	+	933
1996	56	69	139	310	97	8	4	1	1	685
1997	3	44	13	65	57	9	5	+	+	195
1998	+	37	35	28	132	73	45	2	+	353
1999	4	3	121	62	259	169	42	1	0	661
2000	+	10	31	59	126	143	21	1	0	391
2001	1	5	3	32	57	228	50	3	0	378
2002	1	4	6	21	62	266	47	4	+	410
2003	1	5	7	11	56	271	50	1	0	403
2004	0	2	7	6	14	78	53	2	0	163
2005	1	1	6	11	19	93	63	1	0	196
2006	82	6	5	7	49	211	101	3	0	463
2007	98	68	1	5	11	95	109	3	0	387
2008	119	45	20	3	9	25	79	4	0	303
2009	8	114	83	14	3	23	191	5	0	440
2010	96	19	46	39	2	20	88	7	0	317

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

[2] - Old trawl equipment (bobbins gear and 80 meter sweep length)

Table D4b. *Sebastes mentella*[1] in Division IIb. Norwegian bottom trawl survey indices (on age) in the Svalbard area (Division IIb) in summer/fall 1992-2009 (numbers in millions).

	Age														
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992	283	419	484	131	58	45	14	8	5	2	7	2	1	3	1,462
1993	2	527	117	202	142	8	23	6	13	1	7	1	1	+	1,050
1994	7	280	290	202	235	42	94	1	1	3	4	1	1	+	1,161
1995	4	50	365	237	132	61	19	17	11	+	1	3	0	0	900
1996	23	47	15	37	105	144	84	17	51	32	34	9	6	2	605
1997	8	43	6	6	40	20	30	25	7	3	1	2	2	1	194
1998	+	26	28	14	10	13	69	66	49	15	1	6	15	5	317
1999	3	16	114	27	36	53	117	78	67	41	45	11	19	13	640
2000	4	6	6	14	35	22	31	54	81	60	24	24	10	8	379
2001	2	4	3	1	9	16	22	30	34	57	57	50	54	6	344
2002	3	2	4	2	5	22	34	23	88	36	62	64	15	21	379
2003	0.3	3	4	3	5	4	29	31	50	59	45	70	38	23	365
2004	1	1	3	3	1	4	2	9	9	18	15	17	19	9	113
2005	1	1	2	3	3	6	9	15	14	16	14	21	22	25	152
2006	33	1	3	3	2	9	17	27	24	35	29	45	25	34	287
2007	23	45	0	0	3	2	5	5	8	5	5	9	29	19	158
2008	6	22	22	12	1	2	2	5	4	4	3	5	10	6	102
2009	14	43	55	41	34	19	7	1	2	2	9	10	26	7	270
2010	No age readings														

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

Table D5a. ***Sebastes mentella*[1]. Abundance indices (on length) from the bottom trawl surveys in the Barents Sea in the winter 1986-2011 (numbers in millions). The area coverage was extended from 1993 onwards.**

								Length group (cm)	
Year	5.0-9.9	10.0-	15.0-	20.0-	25.0-	30.0-	35.0-	40.0-	>45.0	Total
1986	81	152	205	88	169	130	88	24	13.8	950
1987	72	25	227	56	35	11	5	1	0.1	433
1988	587	25	133	182	40	50	48	4	0.1	1068
1989	623	55	28	177	58	9	8	2	0.3	961
1990	324	305	36	56	80	13	13	2	0.2	828
1991	395	449	86	39	96	35	24	3	0.2	1127
1992	139	367	227	35	55	34	8	2	0.5	867
1993	31	593	320	116	24	25	6	1	+	1117
1994	7	259	289	284	51	70	20	1	0.1	982
1995	264	71	638	506	91	69	31	4	0.5	1674
1996	213	100	191	338	134	42	17	1	0.3	1037
1997[2]	63	121	25	278	274	72	41	5	0.2	879
1998[2]	1	91	63	101	203	41	13	2	0.2	514
1999	2	7	68	37	167	72	21	3	0.1	377
2000	9	13	39	77	142	97	27	7	1.5	412
2001	9	22	7	55	77	73	9	1	0.1	254
2002	16	7	19	42	104	114	23	1	+	326
2003	4	4	10	13	71	200	47	6	0.3	354
2004	2	3	7	19	33	87	32	2	0.1	184
2005	+	6	7	11	28	153	87	4	0.2	297
2006	99	2	10	15	23	103	82	3	0.7	336
2007	446	125	3	6	12	119	120	7	0.2	838
2008	846	354	26	5	12	114	180	5	0.1	1542
2009	94	322	134	5	9	66	160	6	0	797
2010	647	273	213	64	7	73	190	6	0	1474
2011	496	228	211	148	14	46	157	5	0	1304

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

[2] - Adjusted indices to account for not covering the Russian EEZ in Subarea I.

Table D5b. *Sebastes mentella*[1] in Subareas I and II. Preliminary Norwegian bottom trawl indices (on age) from the annual Barents Sea survey in February 1992-2010 (numbers in millions). The area coverage was extended from 1993 onwards.

														Age
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992	351	252	132	56	14	11	3	9	18	16	12	11	2	5	892
1993	38	473	192	242	62	45	19	22	13	11	10	4	2	3	1,136
1994	7	85	332	189	370	228	73	42	3	30	8	14	25	7	1,413
1995	308	45	146	264	364	211	69	23	7	17	23	9	11	10	1,507
1996	173	119	109	114	128	122	106	64	24	19	12	7	8	4	1,009
1997[2]	43	101	19	54	96	43	44	171	76	74	39	29	10	9	808
1998[2]	1	73	49	27	13	52	107	104	41	18	7	4	3	3	502
1999	1	+	32	43	30	24	30	81	79	28	2	1	6	+	357
2000	9	12	21	17	9	39	77	73	50	41	14	10	7	6	385
2001	1	17	8	1	7	22	39	30	34	23	24	17	9	3	236
2002	18	4	12	7	4	14	49	55	27	19	34	24	28	11	306
2003	0	2	2	4	6	6	14	39	24	34	39	65	46	20	301
2004	0	2	3	1	9	12	15	20	36	8	28	3	25	12	172
2005	0	4	3	3	6	6	11	15	23	14	21	40	35	49	229
2006	4	1	5	5	5	8	15	12	6	15	21	17	32	36	180
2007	428	82	13	1	2	2	5	7	8	8	21	20	31	35	144
2008	648	173	107	11	0	2	5	7	5	10	10	28	27	40	1073
2009	107	112	104	82	63	32	14	9	9	6	16	7	21	11	593
2010	150	239	172	161	103	71	27	13	4	7	13	12	21	33	1027

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

[2] - Adjusted indices to account for not covering the Russian EEZ in Subarea I.

Table D6. ***Sebastes mentella*** **in Subareas I and II. Abundance indices (on age) from the Ecosystem survey in August-September 1996-2009 covering the Norwegian Economic Zone (NEZ) and Svalbard incl. the area north and east of Spitsbergen (numbers in thousands and total biomass in thousand tonnes) and the continental slope down to 1500 m.**

Year	Age															
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total N	Total B
1996	146198	112742	22353	53507	165531	181980	108738	43328	65310	40546	38254	19843	29446	10931	17414	1 056 120	171
1997	62682	130816	12492	23452	74342	55880	76607	82503	17640	14274	675	2238	1723	633	8765	564 723	73
1998	313	78767	85715	39849	25805	23413	84825	100332	54287	24329	11334	7457	15250	576	25212	577 464	105
1999	5359	23240	117170	47851	41608	76797	128677	73306	58018	64781	49890	13565	18458	12171	24672	755 562	155
2000	5964	23169	14336	19960	52666	68081	83857	77513	100442	72294	71148	36599	17183	20590	26501	690 304	178
2001	5026	6541	10957	1093	19766	25591	36594	51644	44407	61704	50083	86122	53952	15699	31877	501 057	162
2002	9112	6646	7379	3821	8635	28215	47456	63903	103368	49964	76133	71970	25241	36765	34957	573 565	181
2003	3954	7394	6142	3540	8030	9388	48564	59051	98554	69901	83192	73521	69970	37162	47323	625 687	213
2004	9068	10837	9008	7292	2510	7896	8193	15268	25544	29654	35249	21142	39581	25976	66792	314 010	111
2005	1310	4406	5241	5031	5722	8740	13452	20672	16207	19353	17430	32028	37564	34815	57103	279 072	103
2006	156578	5162	6695	5217	3768	10754	18771	29174	25278	38958	31869	46885	30895	44299	147951	602 255	184
2007	302988	224153	290	7686	11346	2031	7903	10770	12182	6578	6367	9998	41425	22090	211178	876 986	172
2008	86880	183796	121430	21430	4178	3009	3334	6991	5120	4441	3581	6008	10352	10172	99808	570 530	89
2009	98726	133218	196908	118322	131668	37586	18194	3679	8633	3494	9736	14091	25949	8384	251370	1 059 960	200

Table D7. ***Sebastes mentella*** **in Subareas I and II. Results of the Russian trawl/acoustic redfish survey in the western Barents Sea in April-May 1992-2001. Abundance indices in millions.**

Year	Period of survey	Age																		Total				Area of survey
		1-4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21+	Numbers 10^6	Biomass t 10^3	SSN 10^6	SSB t 10^3	in n.m.^{2}
1992	April	29	27	27	37	36	50	78	39	34	40	44	43	28	17	13	4	7	3	566	218	191	114	25300
1993	April	31	15	13	6	6	20	56	56	38	28	29	27	19	12	7	3	1	2	396	150	151	90	23500
1994	No Data																							
1995	May	+	32	51	83	90	41	31	31	41	94	73	48	30	10	9	4	1	+	669	202	211	102	23300
1996	No Data																							
1997	Apr-May	86	6	24	102	150	53	48	24	20	26	36	28	11	9	4	2	1	+	630	170	111	58	22400
1998	April	1	+	8	47	77	63	71	46	27	19	23	23	25	6	3	2	1	+	442	153	106	57	22931
1999	Apr-May	11	1	9	14	57	75	63	73	31	25	17	15	11	8	3	1	1	1	415	134	120	55	19333
2000	Apr-May	2	2	14	15	62	100	143	122	54	34	24	29	12	11	7	2	1	1	635	208	114	53	22000
2001	Apr-May	11	1	11	22	24	84	123	134	144	115	78	40	27	19	10	4	+	3	850	316	339	152	23000
2002	No Data																							
2003	No Data																							
2004	No Data																							
2005	No Data																							
2006	No Data																							
2007	No Data																							
2008	No Data																							
2009	No Data																							
2010	No Data																							

Table D8a. ***Sebastes mentella*** **in Subareas I and II. Maturity ogives from Russian research vessels. Sexes combined. Data collected during April-June in the Kopytov area (western Barents Sea) and adjacent waters.**

Age	1988	1989	1990	1991	1992	1993	1995	1997	1998	1999	2000	2001
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.021	0.000	0.000	0.000
8	0.000	0.000	0.000	0.046	0.000	0.000	0.000	0.000	0.014	0.016	0.000	0.000
9	0.000	0.000	0.012	0.139	0.013	0.033	0.000	0.027	0.000	0.059	0.048	0.082
10	0.028	0.074	0.131	0.174	0.092	0.133	0.055	0.130	0.074	0.110	0.087	0.196
11	0.125	0.178	0.300	0.138	0.169	0.364	0.111	0.312	0.171	0.333	0.202	0.405
12	0.297	0.473	0.688	0.358	0.396	0.480	0.368	0.281	0.276	0.579	0.375	0.442
13	0.562	0.684	0.714	0.470	0.452	0.696	0.587	0.566	0.622	0.689	0.489	0.442
14	0.760	0.716	0.824	0.637	0.761	0.925	0.696	0.736	0.714	0.788	0.742	0.648
15	0.855	0.794	0.848	0.762	0.939	0.962	0.729	0.831	0.871	0.813	0.833	0.775
16	1.000	1.000	1.000	1.000	0.886	0.953	0.789	0.958	0.919	0.903	0.904	0.865
17	1.000	1.000	1.000	1.000	1.000	0.977	1.000	0.950	1.000	0.923	1.000	0.909
18	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table D8b. ***Sebastes mentella*** **in Subareas I and II. Modelled maturity ogive from Norwegian research vessels. Sexes combined. Data collected during the pelagic summer surveys (2007/2008), the slope survey (October 2008), the Norwegian part of the ecosystem surveys in the Barents Sea (summer 2004-2008) and the winter surveys (2004-2008).**

Age	Maturity
1	0.00
2	0.00
3	0.00
4	0.00
5	0.00
6	0.01
7	0.03
8	0.06
9	0.13
10	0.27
11	0.48
12	0.60
13	0.71
14	0.79
15	0.86
16	0.91
17	0.94
18	0.96
19	0.98
20	0.98
21	0.99
22	0.99
23+	1.00

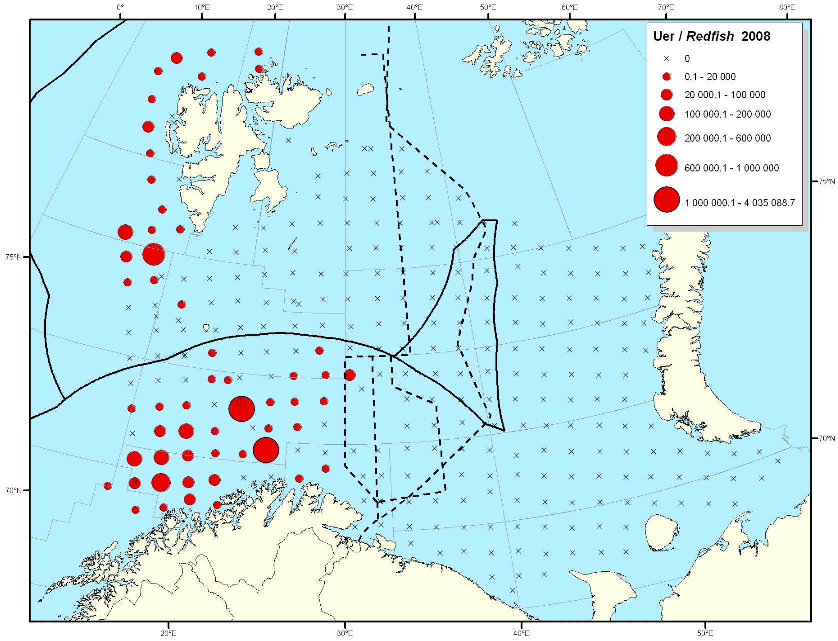


Figure D1. Map showing the strata system, the specific pelagic 0-group trawl stations and the abundance of 0-group *Sebastes mentella* during the joint Norwegian-Russian Ecosystem survey in the Barents Sea and Svalbard. Example from 2008.

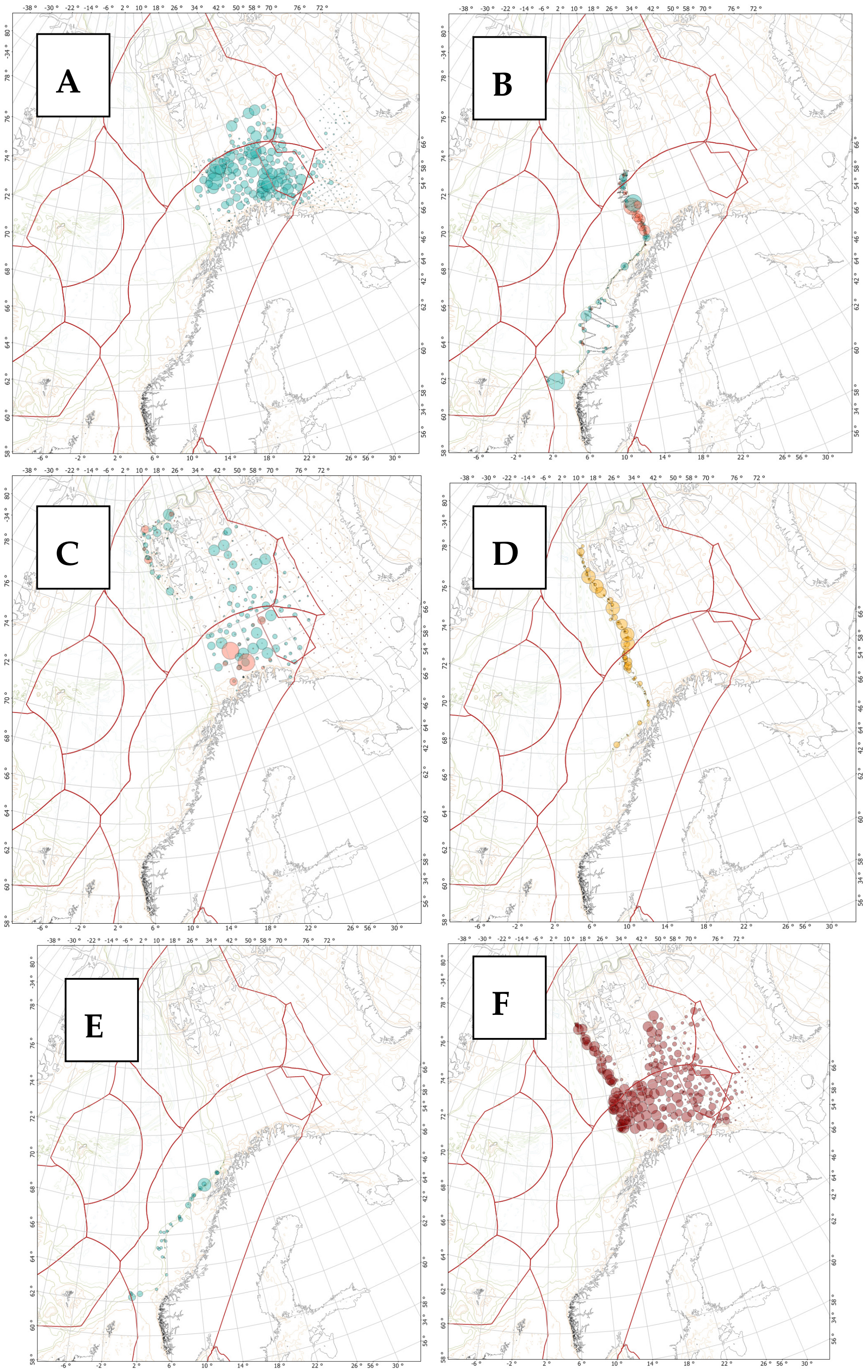


Figure D2. Overview of different scientific surveys contributing with information about the *Sebastes mentella* stock in Subarea I and II in 2008-2009. A: Norwegian-Russian survey in winter 2008, B: Norwegian slope survey in March/April 2009, C: Norwegian-Russian ecosystem survey in summer 2008, D: Norwegian slope survey in August 2008, E: Norwegian slope survey in November 2008, F: Russian survey in October/December 2008.

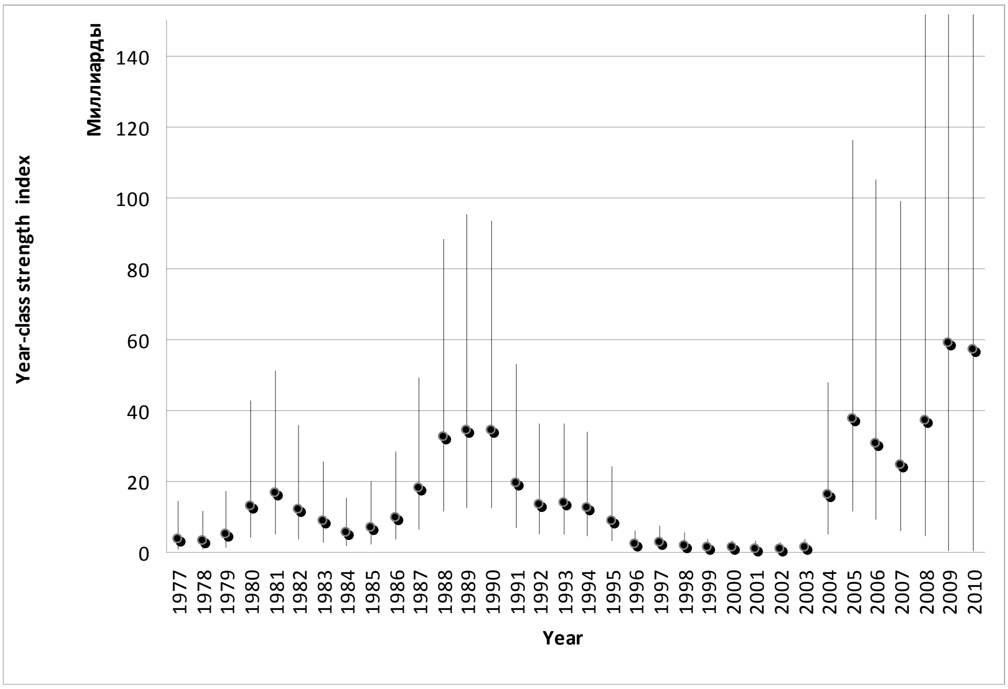


Figure D3. Modelled index of year-class strength of *Sebastes mentella* for the period 1977-2010 (from WD7). The median estimate is indicated in bold black and the 95% confidence intervals are indicated by the vertical bars between the 2.5 and 97.5 percentiles. Upper limits of the confidence intervals for 2007-2010 exceed the scale on the y-axis.

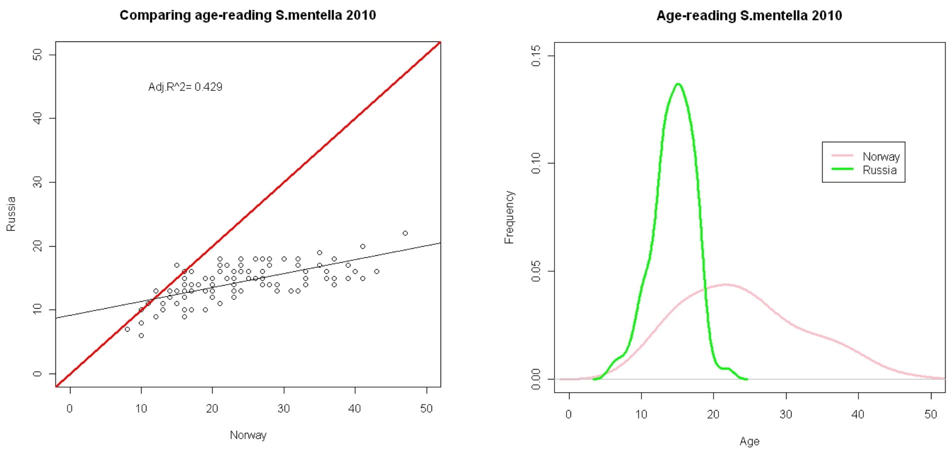


Figure D4. Comparative age reading results from the exchange of *S. mentella* otoliths (collected from 35-47 cm fish) between age readers from Russia and Norway in 2010.

7 Golden redfish *(Sebastes marinus)* in Subareas I and II

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 Quality handbook for this stock. The Handbook was last updated in 2010 (see Annex in this report).

Prior to 1 January 2003 there were no regulations particularly for the *S. marinus* fishery, and the regulations aimed at *S. mentella* (see chapter 6.1.1) had only marginal effects on the *S. marinus* stock. After this date, all directed trawl fishery for redfish (both *S. marinus* and *S. mentella*) outside the permanently closed areas have been forbidden in the Norwegian Economic Zone north of 62°N and in the Svalbard area. When fishing for other species it is currently 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. marinus*. 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. marinus* (in numbers) per haul. In addition, a time-limited moratorium has been enforced in the conventional fisheries (gillnet, longline, handline, Danish seine) except for handline vessels less than 11 meters. Since 2007 this moratorium has been during 5 months, i.e., March-June and September. When fishing for other species (also during the moratorium) it is allowed to have up to 15% bycatch of redfish (in round weight) summarized during a week fishery from Monday to Sunday. No new regulations were imposed on the fishery in 2010 or 2011.

7.1.2 Landings prior to 2011 (Tables 7.1–7.4, D1 & D2, Figures 7.1–7.2)

Nominal catches of *S. marinus* by country for Sub-areas I and II combined, and for each Sub-area and Division are presented in Tables 7.1 - 7.4. The total landings for both *S. marinus* and *S. mentella* are presented in Tables D1 and D2. Landings of *S. marinus* showed a decrease from a level of 23,000–30,000 t in 1984–1990 to a stable level of about 16,000-19,000 t in the years 1991–1999. Since then the landings have decreased further, and the total landings figures for *S. marinus* in 2003-2010 have been low but remarkably stable between 6,000-8,000 t. The 2009 level of 6,293 t was the lowest since the 1940s, but the provisional figures for 2010 show an increase to 7,744 t. This is mainly attributable to increasing catches in Division IIa. The time series of *S. marinus* landings is given in Figure 7.1 and shows a long-term (1908-2010) mean of 16,647 t.

The Norwegian landings are presented by gear and month in Figures 7.2a,b. Reported landings increase in 2010 for all gears except Danish seine. The increase was greatest for trawl, nearly 850 tons compared to the year before. Since 2003, the limited moratorium for conventional gears reduced the catches taken by these gears from about 5,900 t to about 3,200 t in 2007, but this trend has halted due to the increase in gillnet catches since 2008. The increase in landings is due to increased effort/greater catchability and not new year classes contributing to the landings (ref. Table 7.5).

The reported Russian catches of *S. marinus* have been around 600 - 900 t since 2001, while ten other countries together usually report catches of less than 300 t per year (Table 7.1).

The bycatch of redfish (*Sebastes* spp.) in the Norwegian Barents Sea shrimp fisheries during 1983-2002 were completely dominated by *S. mentella*, and hence influenced the *S. marinus* to a much lesser extent. However, these by-catches probably inflicted an extra mortality on *S. marinus* 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 Quality handbook.

7.1.3 Expected landings in 2011

Under similar assumptions as before (i.e., reports from the first months of the year, a legal by-catch of 15% in all trawl fisheries, and a continuation of the regulations for the other gears, i.e., free fishing during seven months of the year) the Norwegian and Russian landings in 2011 are expected to be similar to those reported in 2010.

7.2 Data Used in the Assessment (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 2010. The sampling of *S. marinus* commercial catches should be improved, not so much the numbers of samples as a better temporal, spatial and gear distribution of the samples. In 2009, only 36% of the metiers (area-quarter-gear combinations) responsible for more than 50% of the Norwegian landings were properly covered with age samples.

7.2.1 Catch-per-unit-effort (Table E1, Figure 7.3)

The CPUE-series for *S. marinus* from Norwegian 32-50 meter freezer trawlers and Factory trawlers (>53m) is presented from 1992 onwards (Table E1, Figure 7.3). Only data from days with more than 10% *S. marinus* in the catches (in weight) are included in the annual averages. Mean CPUEs with standard errors together with number of vessel days meeting the 10% criterion are presented in Table E1. This indicates an important reduction in the effort of freezer trawlers since 2006 in comparison with the previous decade. The effort of factory trawlers has remained stable between 100 and 180 vessel fishing days (with >10% *S. marinus* in haul) per year since 2003. The 2010 preliminary CPUE value for the 41 freezer vessel days is very high, 760 kg/hour, and with 2 st. errors equal 740 kg/hours it was decided to omit this point from Figure 7.3.

Although the trawl fishery until 2003 was almost unregulated, the trawlers experienced fewer and fewer fishing days with more than 10% of their catches composed of *S. marinus* (Figure 7.3). During 2001-2005 both the catch-rates and the number of vessel-days were rapidly decreasing, and this is worrying since the criterion for defining it to be a *S. marinus* vessel-day have not been more than 20% (since 2003) or 10% (since 2004) *S. marinus* in each trawl haul. Since 2005 a slight improvement of the catch-rates is seen for both trawler fleets, but it is worrying that the number of vessel days containing a minimum of 10% redfish still is decreasing in one of the fleets. With some variation, the average annual catch-rates for the freezer trawlers have decreased from an average level of 350 kg/trawl hour during the mid-1990s to about 150 kg/h since 2003, i.e., less than 40% of the former recent level. Corresponding values for the factory trawlers are 600 kg/h until 2001 and about 200-300 kg/h since 2002. The decrease seems though to have halted for both fleets.

7.2.2 Catch at length and age (Table 7.5)

Catch at age data for 2009-2010 were revised. Age composition data for 2010 were only provided by Norway, accounting for 84% of the total landings. Other countries were assumed to have the same relative age distribution and mean weight as Norway. The updated catch-in-numbers at age matrix is shown in Table 7.5. Catch at length data were available from Norway and Portugal.

7.2.3 Weight at Age (Table 7.6)

Weight-at-age data for ages 7–24+ were available from the Norwegian landings in 2010. 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.

7.2.4 Maturity at age (Figure 7.7)

A maturity ogive has previously not been available for *S. marinus,* and knife-edge maturity at age 15 (age 15 as 100% mature) has hence been assumed. The improved maturity ogive modelled by the Gadget model, and based on maturation data (by length and age) collected from Norwegian surveys and landings, is presented (Figure 7.7). This analysis shows that 50% of the fish are mature at age 12. In previous years the maturity ogive was stable from the mid-1990s, however it was less reliable early in the modelled period. This was due to the maturity data the model was tuned to beginning in 1993. Large immature fish in the model before this would become mature before the data series started, and thus incur no penalty during optimisation. As a result the model over-predicted large immature fish in the early part of the time series, and under-predicted large mature fish for the same period. To rectify this, the maturity at age data for 1993-1995 was averaged and input as "data" between 1986 and 1992. This was found to produce consistent maturity ogives in the model, as shown in Figure 7.7. Testing showed that this did not otherwise alter the model dynamics (note that no SSB-recruitment relationship is used in the model), and has therefore been adopted from the 2009 WG onwards.

7.2.5 Survey results (Tables E2a,b–E3a,b–E4, Figures 7.4a,b–7.5a,b)

The results from the following research vessel survey series were evaluated by the Working Group; any discrepancies between figures and tables from the same survey are due to different age- and length-groups being presented:

1) Norwegian Barents Sea (Division IIa) bottom trawl survey (BS-NoRu-Q1 (BTr)) from 1986–2011 (joint with Russia some of the years since 2000) in fishing depths of 100–500 m. Length compositions for the years 1986–2011 are shown in Table E2a and Fig 7.4a. Age compositions for the years 1992–2010 are shown in Table E2b and Figure 7.4b. This survey covers important nursery areas for the stock.
2) Norwegian Svalbard (Division IIb) bottom trawl survey (August-September) from 1985–2010 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 1985–2010 and age compositions for the years 1992–2008 are shown in Table E3a and E3b, respectively. This survey covers the northernmost part of the species' distribution. Insufficient number of age readings in 2009, and no age

samples collected in 2010 did not allow for updating the age composition in 2009 and 2010.

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

4) Age disaggregated catch rates (numbers/nm^2 averaged for all stations within subareas and finally averaged, weighted by subarea, for the total surveyed area) of *Sebastes marinus* from the Norwegian Coastal and Fjord survey in 1995-2010 from Finnmark to Møre (NOcoast-Aco-Q4) (Table E4). The estimated catch rates in 2008 and 2009 were particularly high due to one trawl station with an exceptional high catch.

The bottom trawl surveys covering the Barents Sea and the Svalbard areas show that the abundance indices over the commercial size range (> 25 cm) were relatively stable up to 1998 but declined to lower levels afterwards. Abundance of pre-recruits (<25cm) has steadily decreased since 1986 and has remained at very low levels since 2000 (Fig 7.4a).

Results from the Norwegian Coastal and Fjord survey confirm poor recruitment up to 2010. Variation in the results from year to year may be due to a variable number of trawl stations taken in some of the areas from year to year, and annual variations in local fish migrations (Table E4). The distribution of *S. marinus* is spatially very clustered and the catch rates-at-length estimates are sensitive to few (or even one) station where catches are high. The sharp increase in 2008 and 2009 should hence be interpreted with great caution (see next chapter). Observations in 2010 indicate reduced catch rates for the dominating 35-44 cm length group, and with signs of some improved recruitment that should be confirmed by future surveys before we can rely on it.

7.3 Assessment with the GADGET model

7.3.1 Description of the model

Since AFWG2005, experimental analytical assessments have been conducted on this stock using GADGET, and results presented for the years 1990 – last year.

The GADGET model used for the assessment of *S. marinus* in areas I and II is closely related to the GADGET model that currently is used by the ICES North-Western WG on *S. marinus* (Björnsson and Sigurdsson 2003). The functioning of a Gadget model, including parameter estimation and data used for tuning, is described in Bogstad et al. (2004b) and in the latest Quality Handbook for *S. marinus* (2010). In brief, the model is a single species forward simulation age-length structured model, split into mature and immature components. There are two commercial fleets (a gillnet fleet and a combined trawl and other gears fleet), and two surveys. Growth and fishing selectivity are assumed constant over time, and recruitment is estimated on annual basis (no SSB-recruit relationship).

The weighting scheme for combining the different datasets into a single likelihood score is an ad hoc method where weights are selected so that the catch and survey data have approximately equal contribution to the overall likelihood score in the optimised model, and that each dataset within each group gives approximately equal contributions to each other. This scheme will be evaluated at the planned benchmark in 2012. It is expected that the stock assessment results will be somewhat sensitive to the weighting scheme, given the noisy and sometimes inconsistent datasets. The parameters in the model are estimated using a combination of Simulated Annealing (wide area search) and Hooke and Jeeves (local search) repeated in sequence until a converged solution is found.

7.3.2 Data used for tuning

- Quarterly length distribution of total international commercial landings from two commercial fishing fleets, i.e., Norwegian gillnet and 'all others'. Due to late data submissions, there is one year time lag in the inclusion of length distributions from other countries than Norway.
- Quarterly age-length keys from the same fishing fleets, up to 2010
- Length disaggregated survey indices from the Barents Sea (Division IIa) bottom trawl survey (February) from 1990–2010 (Table E2a)
- Age-length keys and aggregated survey indices from the same survey up to 2010 (Table E2b)
- Length disaggregated catch rates (numbers/nautical mile) of *Sebastes marinus* from the Norwegian Coastal and Fjord survey in 1995-2007 from Finnmark to Møre (Division IIa) (Table E4). As noted in the 2010 report, this survey has only been used as a tuning series from 1995-2007.

7.3.3 Changes made to the model and in input data compared with last year's Working Group

Model configuration and settings are identical to that of 2010. Commercial catch data have been revised for years 2009 and updated with year 2010. The proportion mature has been extended to 2010. The winter survey has been extended to 2010. The coastal survey has not been updated, in line with the previous decision to exclude data since 2007. No changes have been made to the model other than extending and revising the input data.

7.3.4 Assessment results using the Gadget model

The text table below compares the results from this year's Gadget model with the four previous years.

	Total stock (3+) by 1 January 1990 (tons)	Mean weight in stock 1990 (kg)	SSB (15+) by 1 January 1990[1] (tons)	Total stock (3+) by 1 January 2003 (tons)	Mean weight in stock 2003 (kg)	SSB (15+) by 1 January 2003[1] (tons)
WG 2006	179 313	0.39	64 019	71 013	0.71	38 927
WG 2007	163 536	0.35	66 712	64 240	0.64	43 096
WG 2008	158 851	0.35	64 838	74 717	0.78	47 693
WG 2009	149 763	0.34	66 153	73 673	0.77	51 683
WG 2010	152 419	0.34	58 774	80 073	0.79	55 995
WG 2011	148 727	0.33	56 271	80 808	0.78	55 810

1) Since WG2007 based on modeled maturation and not 15+, data series used for estimation of maturity modified in 2010

The general patterns in the stock dynamics of *S. marinus* are similar to those modelled for the past several years (Figure 7.10). The overall stock numbers and biomass continue to show a decline, with possible sporadic moderate year classes recruited in recent years. Mature biomass and numbers are in steady decline, while modelled immature numbers and biomass show signs of flattening out.

It should be noted that it is possible that the improved recruitment signal may be due to misidentification of small *S.mentella* (which is a larger stock and has had good recent recruitment) as *S.marinus*. If this were the case then one would expect to see the recruitment numbers progressively revised downwards as the fish grow larger and become easier to identify and begin to enter the fishery. In this context it should be noted that the recruitment spike of 3-year olds in 2004 (i.e. the 2001 year class) has been revised downwards this year. The estimated recruitment number for recent years is highly uncertain and would be expected to vary as new data is available, hence it will take some time to distinguish between noise and trend. The number of recent recruits was also revised downwards in the 2010 report. This will be monitored in the coming years.

The overall trend of the model fits well to the Barents Sea winter survey (Figure 7.6), especially in recent years. The fit to coastal survey is presented, with the hollow points representing years in which this survey was not used for tuning. Note that the 2009 point presented in the figure for the coastal survey has had several outlying data points from large hauls removed, revising this down from the raw data. This year is not used in model tuning, so this has no effect other than on the comparison graph. As can be seen the recent trends in the coastal survey do not match those in the model, nor those in the Svalbard winter survey. Also note that the recent upwards trend in the coastal survey have been reversed in 2010, and it is difficult to see how the survey pattern could represent the actual trajectory of a long lived species such as *S. marinus.*

Figure 7.11 presents the retrospective pattern for the current model for the past five years. There has been a noticeable trend in the older years, with 2005, 2006 and, to a lesser extent 2007, exhibiting a retrospective pattern. However once the coastal survey values are no longer updated (2008 onwards), there has been very little year-to-year retrospective pattern. The earlier years of coastal survey are still present, however their contribution has been reduced by the extension of the other data series.This indicates that the coastal survey should be investigated in more detail in the benchmark in 2012. Note that a forward simulation model, such as GADGET exhibits different retrospective behaviour than a VPA, and there is not always a tendency to have complete convergence between runs in the early part of the model. In particular fish which die during the early part of the model (due to high fishing pressure or natural mortality) will have little contribution to the overall likelihood, and it is therefore not uncommon to see greater retrospective patterns in the early or mid parts of the model run than at the end.

The most important conclusions to be drawn from the current assessment using the Gadget model are:

- The recruitment to the stock is very poor (Figure 7.9) but may possibly be increasing, although estimated abundance for new year classes are highly uncertain.
- The estimated fishing mortality has declined between 1990 and 2005 and steadily increased since 2005. The current mortality is estimated to 0.208

(Figure 7.8). This upwards trend in F has been continuing for five years, and is a potential source of concern.

- According to the model the total stock biomass (3+) of *S. marinus* has decreased from about 150,000 tonnes in 1992-1993 to less than 40,000 tonnes in 20010 (Figure 7.10, Table 7.8).
- The spawning stock biomass of *S. marinus* has decreased from a maximum of about 60 thousand tonnes in 1996 to approximately 30 thousand tonnes in 2010 (-5%, Figure 7.10, Table 7.8). The spawning stock in numbers (SSN) is declining faster than spawning stock biomass (SSB). This is primarily the result of low recruitment in the last 10-15 years.

7.4 State of the stock

Survey observations and Gadget assessment update confirm previous diagnostics that this stock is currently in a very poor situation. This situation is expected to remain for several years irrespective of current management actions. However indications are that the stock is continuing to fall while the total catch has remained relatively constant. This has led to an upwards trend in F, which may place an increasing burden on an already poorly performing stock. Year-classes recruit to the SSB at old age (~12 years) and surveys indicate failure of recruitment over a long period. There are indications that new recruits (<15cm) may have entered the population in recent years as noted in previous AFWG reports. However it is not clear if this trend genuinely reflects increased *S. marinus* recruitment, or if it results from species misidentification (with *S. mentella*).

The analytical assessment using the Gadget model confirms the poor stock situation, and quantifies the development of this stock during the last decade. It is also meant to be an aid for managers to better quantify necessary stronger regulations.

Clearly the stock has at present a reduced reproductive potential and the model suggests that the declining trend in biomass is still going on. In order to reverse this negative development, no directed fishery should be conducted on this stock until a clear increase in the number of juveniles has been detected in surveys, and an improved situation of the mature stock is confirmed by the assessment. Furthermore it is imperative that actions be taken to prevent F increasing further, and reduce F to at least the levels seen in 2005.

Sebastes marinus 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).

Redlisting is understood to mean that a species (or stock) is at risk of extinction. ICES convened two workshops in 2009. The first Workshop WKPOOR1 (ICES CM 2009/ACOM:29) addressed methods for evaluating extinction risk, and outlined approaches that could support advice on how to avoid potential extinction. The second Workshop WKPOOR2 (ICES CM 2009/ACOM:49) applied the results of the first workshop to four stocks selected as being of interest to Norway and ICES.

There are three general methods for evaluating extinction risk: (1) screening methods, such as the IUCN redlisting criteria; (2) simple population viability analysis (PVA) based on time trends; and (3) age structured population viability analysis. None of the methods are considered reliable for accurately estimating the absolute probability of extinction, but they may be useful to evaluate the relative probability of extinction between species or between management options.

Simulations were performed on the *Sebastes marinus* stock using the assumption that the poor recruitment observed during the 1999–2002 period (an average of 26.8 million recruits) would apply in the future, with recruitment independent of the spawning biomass. Simulations done by WKPOOR2 indicate that a constant catch above about 6500 tonnes will lead to a progressive reduction of the stock, and a collapse within 10 - 15 years if recruitment remains low. However, small changes in recruitment and other parameters that enter the assessment will alter these limits. Nevertheless, it seems clear that the current level of catches is at best marginal, and most likely will lead to a stock collapse without a substantial increase in recruitment. These results are in line with the Gadget modelling conducted in this report.

7.5 Comments on the Assessment

The current model assumes constant selectivity through time. It may be possible to extend this to allow for varying selectivity. The model may also be used for comparing modeled mean length at age with the actual data as a contribution to the age reading validation.

S. marinus is considered to be an easier species to age than *S. mentella*, and it is possible to follow year classes through the input survey data series. An annual updated database on catch-in-numbers at age and length, weight-at-age, and trawl survey indices both by length and age should be continued to be used in future assessment methods.

The current DEEPFISHMAN EU-funded project will aim to use a Gadget *S. mentella* model as an operating model to assess different simpler assessment methodologies. The approach, if successful, may have implications for producing a simplified assessment model for *S. marinus*.

Further investigation is required into the changing signal from the coastal survey. In addition it is unclear to what extent the slight increase in recruitment in recent years is genuine *S. marinus* recruitment, and how much is due to species misidentification.

7.6 Biological reference points

Until an analytical assessment can be accepted and used as basis for reference points calculations for this stock, candidate reference points for the biomass could be set at the average biomass level, or at a certain percentage of this level, estimated by the Russian and Norwegian trawl surveys since 1986. ACOM is supporting this suggestion and states that U-type reference points could be developed provided that a sufficient long time series demonstrating a dynamic range is available. Also the reference point should be expressed in biomass units (SSB or fishable stock), and work has hence been initiated to present the survey time series also in biomass units (also as SSB and fishable stock).

A maximum exploitation rate of 5% has been suggested sustainable for long lived species like *Sebastes* spp. when the stocks show no sign of reduced reproductive potential (corresponding to keeping SPR at 60% of the level when no fishing occurs; see chapter 7.8 and Dorn 2002). Based on the selection curves for the fleets, a reasonable classification of the fishable biomass would be the mature biomass. A corresponding 5% harvest of this would yield not more than 1,600 t, which is well below the current landings.

7.7 Management advice

AFWG considers that the area closures and low bycatch limits should be retained, but stronger regulations than those recently enforced are needed given the continued decline in SSB and low recruitment. Despite the extended ban on the directed fishery by conventional gears from 3 months in 2006 to 5 months in 2007, the current measures are considered insufficient to stop the stock from declining to such low levels that any *S. marinus* fisheries in future will be difficult to conduct. More stringent protective measures should thus be implemented. 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. Several different lines of evidence suggest that continuing fishing pressure at the current level will drive the stock towards actual or commercial extinction.

7.8 Implementing the ICES Fmsy framework

As a long lived species, *S. marinus* 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. $F_{0.1}$) provided adequate measures can be implemented to reduce fishing pressure to an appropriate level. It should be noted that the current fishery (F=0.2) is well above the suggested F_{pa} of 5% of the stock (Section 7.6). The main focus should therefore be on reducing total F to no higher than $F_{pa.}$

During the ICES Workshop on Implementing the ICES F_{msy} framework (WKFRAME), the closely related beaked redfish *Sebastes mentella* stock in Sub-areas I and II was used as a case study (ICES CM 2010/ACOM:54) for a data limited situation. The results of this Workshop refer also to *Sebastes marinus* in the Barents Sea, where the AFWG is faced with a data limited situation. WKFRAME recommends that the bounds for F_{msy} proxies should be evaluated in function of the YPR and SPR curves, and that the reproductive capacity of the *S. mentella* (in this case *S. marinus*) stock be at least above 30% of the SPR at F=0. The YPR curve left of the plateau can be used as lower bound ($F_{0.1}$ proxy) and a prescribed per-cent SPR as upper bound. The WKFRAME also illustrates by examples why it is informative and important to carry out sensitivity analyses, particularly assumptions regarding natural mortality, selection pattern, growth (density dependence) and maturity. The WG did some preliminary analyses of the sensitivity of $F_{0.1}$ for different natural mortalities. In comparison with *S. mentella*, $F_{0.1}$ for *S. marinus* is much less sensitive towards changes in natural mortality. This issue will be revisited during the benchmark in 2012.

The AFWG supports the above recommendation by WKFRAME, and that spawner per recruit curves should be provided. The WG did some preliminary estimations ($F_{0.1}$ and $F_{SPR40\%}$ in the order of 0.09-0.12), provided the exploitation pattern avoiding targeting immature fish is maintained, but recommends that this should be part of the intersessional work until the benchmark assessment in 2012, including improving the input data for such calculations and evaluating the most appropriate SPR level to be used as reference point for the management of this stock. Given the long lived, late maturing, nature of the stock, it would be expected that the F_{msy} would need to be maintained for an extended period of time before any resulting changes in stock biomass were observed. Evaluations of long lived species with relatively low productivity such as rockfish (*Sebastes* spp.) in the Pacific west coast, concluded that higher SPR values (50% to 60%) were required to maintain sustainable exploitation of these stocks (e.g., Dorn 2002).

7.9 Response to RGAFNW Technical Minutes

Concerning accuracy and precision of redfish age reading, the AFWG refers to the ICES Redfish age reading workshops in 2006 and 2008 (ICES CM 2006/RMC:09, ICES CM 2009/ACOM:57) and Stransky et al. (2005) which also recommends how to proceed with age reading of *Sebastes* spp. for assessment purpose. The AFWG is convinced that accurate and precise age reading of *Sebastes marinus* is possible provided that agreed procedures are followed and necessary focus and labour is put into this important basic work for stock assessments. An implementation of QA/QC in the different laboratories involved in age reading of redfish needs to be done, and for stock assessment and regular precision monitoring, a confidence index is proposed. Intercalibration of redfish ageing is urgently needed in order to provide consistent input data for stock assessment. At present, age reading of *S. marinus* in Sub-areas I and II is only conducted by Norway on a routine basis and for assessment purpose. This is considered sufficient as long as Norway is responsible for the relevant research surveys and about 85% of the landings. A high quality assessment of this stock in future is completely dependent on that the age reading is continued. Proper quality assurance of the age reading is dependent on having more than one reader, and regular intercalibration among national and international readers should be conducted.

The review group shares the view of the AFWG and stated that a benchmark assessment is needed for this stock (will be conducted early 2012). Until then, due to the expected low recruitment, the review group further recommended that the advice for this stock can be based on the current assessment method.

The review group mentions that the recruitment estimates may be biased due to species misidentification. Abundance indices from surveys covering the same area in the Barents Sea show that *S. mentella* may be 50 times more abundant than *S. marinus*. A small percentage of *S. mentella* wrongly identified as *S. marinus* will hence have a great impact on the abundance indices for *S. marinus*, but will hardly matter at all for *S. mentella*. Equally, a trained and careful eye is needed to pick out few *S. marinus* juveniles from a catch where *S. mentella* may dominate by such a high factor. However, for juveniles larger than about 10 cm (age 1 and older) it is possible to identify the species according to morphological and visual criteria which also have been verified by genetics. In order to reduce misidentification, the Norwegian Institute of Marine Research are also conducting regular workshops for survey technicians and train them in identifying the *Sebastes* juveniles. If unexpected uncertainties should occur during the surveys then the personnel freeze down the samples for identification at the institute prior to any abundance estimation. We hence consider this potential bias to be adequately handled at the moment, although it needs careful and regular monitoring. We also note that if the recent recruitment spikes were due to species misidentification then this should become clear in the Gadget model results as the fish grow and enter the fishery. This provides a useful, albeit delayed, diagnostic to investigate the severity of this issue.

Responses to comments on the Gadget model are partly given directly in the text in Chapter 7.3. As noted in the 2010 and 2011 reports, the coastal survey data since 2007 have been excluded from the model. The hollow circles in Figure 7.6 are not included in model tuning precisely because they are so much at odds with the other datasets. A section on weighting has been introduced into the report, as requested. The issue of misidentification of species has been discussed in this report, as requested. It has only been a problem at younger ages, and this makes the potentially encouraging recent recruitment estimates rather uncertain. Regarding retrospective plots, Figures 7.8-7.10

in previous reports present a comparison of the current years assessment with the previous one, rather than a retrospective using the current model (which may have been adjusted since the previous year). A better figure for the retrospective patterns for the Gadget model has therefore been included in this year's report as requested (see Figure 7.11).

It should be noted that a benchmark assessment is planned for this stock early next year (2012). This will provide the opportunity to address some of the modelling issues mentioned in more detail.

Table 7.1 ***Sebastes marinus*** **in Sub-areas I and II. Nominal catch (t) by countries in Sub-area I and Divisions IIa and IIb combined.**

Year	Faroe Islands	France	Germany[2]	Greenland	Iceland	Ireland	Netherlands
1989	3	796	412	-	-	-	-
1990	278	1,679	387	1	-	-	-
1991	152	706	981	-	-	-	-
1992	35	1,289	530	623	-	-	-
1993	139	871	650	14	-	-	-
1994	22	697	1,008	5	4	-	-
1995	27	732	517	5	1	1	1
1996	38	671	499	34	-	-	-
1997	3	974	457	23	-	5	-
1998	78	494	131	33	-	19	-
1999	35	35	228	47	14	7	-
2000	17	13	160	22	16	-	-
2001	37	30	238	17	-	1	-
2002	60	31	42	31	3	-	-
2003	109	8	122	36	4	-	89
2004	19	4	68	20	30	-	33
2005	47	10	72	36	8	-	48
2006	111	8	35	44	31	3	21
2007	146	15	67	84	68	13	20
2008	274	63	30	71	27	6	2
2009	70	1	58	81	66	-	1
2010[1]	171	51	31	72	22	-	-

Year	Norway	Portugal	Russia[3]	Spain	UK (Eng. & Wales)	UK (Scotl)[4]	Total
1989	20,662	-	1,264	-	97	-	23,234
1990	23,917	-	1,549	-	261	-	28,072
1991	15,872	-	1.052	-	268	10	19,041
1992	12,700	5	758	2	241	2	16,185
1993	13,137	77	1,313	8	441	1	16,651
1994	14,955	90	1,199	4	135	1	18,120
1995	13,516	9	639	-	159	9	15,616
1996	15,622	55	716	81	229	98	18,043
1997	14,182	61	1,584	36	164	22	17,511
1998	16,540	6	1,632	51	118	53	19,155
1999	16,750	3	1,691	7	135	34	18,986
2000	13,032	16	1,112	-		73	14,461
2001	9,134	7	963	1		119	10,547
2002	8,561	34	832	3		46	9,643
2003	6,853	6	479	-		134	7,840
2004	6,233	5	722	3		69	7,206
2005	6,085	56	614	8		52	7,037
2006	6,305	69	713	9		39	7,388
2007	5,784	225	890	5		55	7,372
2008	5,202	72	749	4		85	6,585
2009	5,225[1]	30	698	-	Poland	31	6,261
2010[1]	6,515	28	806	4	1	44	7,744

[1] Provisional figures.

[2] Includes former GDR prior to 1991.

[3] USSR prior to 1991.

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

Table 7.2 ***Sebastes marinus*** **in Sub-areas I and II. Nominal catch (t) by countries in Sub-area I.**

Year	Faroe Islands	Germany[4]	Greenland	Iceland	Norway	Russia[5]	UK(Eng&Wales)	UK(Scot)[6]	Total
1989	-	-	-	-	1,763	110	4[2]	-	1,877
1990	5	-	-	-	1,263	14	-	-	1,282
1991	-	-	-	-	1,993	92	-	-	2,085
1992	-	-	-	-	2,162	174	-	-	2,336
1993	24[2]	-	-	-	1,178	330	-	-	1,532
1994	12[2]	72	-	4	1,607	109		-	1,804
1995	19[2]	1[2]	-	1[2]	1,947	201	1[2]	-	2,170
1996	7[2]	-	-	-	2,245	131	3[2]	-	2,386
1997	3[2]	-	5[2]	-	2,431	160	2[2]	-	2,601
1998	78[2]	5[2]	-	-	2,109	308	30[2]	-	2,530
1999	35[2]	18[2]	9[2]	14[2]	2,114	360	11[2]	-	2,561
2000	-	1[2]	-	16[2]	1,983	146		12	2,159
2001	4	11[2]	-	-	1,053	128		16	1,212
2002	15	5[2]	-	-	693	220		9[2]	
2003	15[2]	-	1	-	815	140		4	
2004	7	-	-	-	1,237	213		12	
2005	10	-	-	-	1,002	61		4	
2006	46	-	-	-	690	136		-	
2007	15	12	15	--	1,034	49		20	
2008	45	2	-		632	49		15	
2009	-	3[2]	2	6	672	19		24	
2010[1]	58[2]	-	-	-	541	19		6	

Year	Spain	Portugal	France	Total
2002			1[2]	943
2003			-	975
2004			-	1,469
2005			1	1,078
2006			-	872
2007	2		-	1,147
2008		3	7	754
2009		13	-	739
2010[1]	1			625

[1] Provisional figures.

[2] Split on species according to reports to Norwegian authorities.

[3] Based on preliminary estimates of species breakdown by area.

[4] Includes former GDR prior to 1991.

[5] USSR prior to 1991.

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

Table 7.3 ***Sebastes marinus*** **in Sub-areas I and II. Nominal catch (t) by countries in Division IIa.**

Year	Faroe Islands	France	Germany[5]	Greenland	Ireland	Netherlands	Norway	Portugal	Russia[6]	Spain	UK (Eng. & Wales)	UK (Scotl.)[7]	Total
1989	3[2]	784[2]	412	-	-	-	18,833	-	912	-	93[2]	-	21,037
1990	273	1,684[2]	387	-	-	-	22,444	-	392	-	261	-	25,441
1991	152[2]	706[2]	678	-	-	-	13,835	-	534	-	268[2]	10[2]	16,183
1992	35[2]	1,294[2]	211	614	-	-	10,536	-	404	-	206[2]	2[2]	13,302
1993	115[2]	871[2]	473	14[2]	-	-	11,959	77[2]	940	-	431[2]	1[2]	14,881
1994	10[2]	697[2]	654[2]	5[2]	-	-	13,330	90[2]	1,030	-	129[2]	-	15,945
1995	8[2]	732[2]	328[2]	5[2]	1[2]	1	11,466	2[2]	405	-	158[2]	9[2]	13,115
1996	27[2]	671[2]	448[2]	34[2]	-	-	13,329	51[2]	449	5[2]	223[2]	98[2]	15,335
1997	-	974[2]	438	18[2]	5[2]	-	11,708	61[2]	1,199	36[2]	162[2]	22[2]	14,623
1998	-	494[2]	116[2]	33[2]	19[2]	-	14,326	6[2]	1,078	51[2]	85[2]	52[2]	16,260
1999	-	35[2]	210[2]	38[2]	7[2]	-	14,598	3[2]	976	7[2]	122[2]	34[2]	16,030
2000	17[2]	13[2]	159[2]	22[2]	-	-	11,038	16[2]	658	-		61	11,984
2001	33[2]	30[2]	227[2]	17[2]	1[2]	-	8,002	6[2]	612	1[2]	**Iceland**	103[2]	9,031
2002	45[2]	30[2]	37[2]	31[2]	-	-	7,761	18[2]	192	2[2]	3[2]	32[2]	8,151
2003	94[2]	9[2]	122[2]	35[2]	-	89[2]	5,970	6[2]	264		4[2]	130[2]	6,722
2004	12[2]	4[2]	68[2]	20[2]	-	33[2]	4,872	5[2]	396	3[2]		58[2]	5,500
												30[2]	
2005	37[2]	9[2]	60[2]	36[2]	-	48	4,855	56[2]	265	8[2]	8[2]	48[2]	5,430
2006	60[2]	8[2]	35[2]	44[2]	3[2]	21[2]	4,404	59[2]	293	9[2]	31[2]	39[2]	5,006
2007	119[2]	15[2]	55[2]	69	13	20[2]	4,101	70	599	3[2]	68	35[2]	5,168
2008	229[2]	56[2]	28[2]	71	6	2[2]	4,444	68[2]	450	4[2]	27	70[2]	5,454
2009	70[2]	1	55[2]	79	**Pol**	1[2]	4,355[1]	17[2]	500	-	60	7[2]	5,145
2010[1]	113[2]	51[2]	31[2]	72[2]	1[2]	-	5,885	26[2]	287	2[2]	22[2]	38[2]	6,527

Table 7.4 *Sebastes marinus* in Sub-areas I and II. Nominal catch (t) by countries in Division IIb.

Year	Faroe Islands	Germany[5]	Greenland	Norway	Portugal	Russia[6]	Spain	UK(Eng. & Wales)	UK (Scotl.)[7]	Total
1989	-	-	-	66	-	242	-	-	-	308
1990	-	-	1[2]	210	-	1157	-	-	-	1,368
1991	-	303	-	44	-	426	-	-	-	773
1992	-	319	9[2]	2	5[2]	180	2	35[2]	-	552
1993	-	177	-	-	-	43	8[3]	10[2]	-	238
1994	-	282	-	18	-	60	4[3]	6[2]	1[2]	371
1995	-	187	-	103	7	33	-	-	-	330
1996	4	51[2]	-	27	5	136	76[2]	3[2]	-	302
1997	-	20	-	43	-	225	-	-	-	288
1998	-	10[2]	-	105	-	246	-	3[2]	-	364
1999	-	-	-	38	-	355	-	2[2]	-	395
2000	-	-	-	10	-	308	-	-	-	318
2001	-	-	-	79	1[2]	223	-	-	-	303
2002	-	-	-	107	16[2]	420	1[2]		5[2]	549
2003	-	-	-	68	-	75	-		-	143
2004	-	-	-	124	-	113	-		-	237
2005	-	13[2]	-	228[1]	-	288	-		-	529
2006	5[2]	-	-	1,211	10[2]	284	-		-	1,510
2007	12	-	-	649	155	242	-		-	1,057
2008	-	-	-	126	1[2]	250	-		-	377
2009	-	-	-	199		179	-		-	378
2010[1]		-	-	90	2[2]	500	1[2]		-	593

[1] Provisional figures.

[2] Split on species according to reports to Norwegian authorities.

[3] Split on species according to the 1992 catches.

[4] Based on preliminary estimates of species breakdown by area.

[5] Includes former GDR prior to 1991.

[6] USSR prior to 1991.

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

Table 7.5. ***Sebastes marinus*** **in Sub-areas I and II. Catch numbers at age (in thousands).**

Year/Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
7	0	46	60	9	9	28	78	4	23	14	22	19	40	45	15	1	0	0
8	24	7	85	119	98	51	593	13	23	36	25	47	55	32	21	4	0	0
9	193	292	230	313	156	206	855	70	44	71	30	46	94	56	31	14	1	0
10	359	640	672	361	321	470	572	245	199	143	44	65	80	70	68	12	3	9
11	406	816	908	879	686	721	1006	902	347	414	204	198	165	245	138	49	9	8
12	1036	1930	1610	1234	1065	968	1230	958	482	686	359	277	173	204	306	139	31	36
13	1022	2096	2038	1638	1781	1512	1618	1782	1120	1199	705	504	393	201	448	265	144	92
14	1523	2030	2295	2134	2276	1736	1480	1409	1342	1943	1687	590	779	809	495	366	245	336
15	2353	1601	1783	1675	2172	1582	1612	2121	1674	1377	1338	677	741	549	523	361	272	437
16	1410	2725	1406	1614	1848	1045	1239	2203	1653	1274	1071	963	916	779	637	443	270	489
17	1655	2668	785	1390	1421	1277	1407	1715	1243	1196	937	1059	926	794	892	442	416	420
18	1678	1409	563	952	851	970	1558	753	568	388	481	787	743	747	616	538	391	336
19	745	617	670	679	804	1018	1019	483	119	313	367	436	376	496	510	547	536	610
20	716	733	593	439	608	846	394	458	183	99	146	169	210	332	396	479	431	537
21	534	514	419	560	511	443	197	132	154	104	84	183	189	310	225	281	332	498
22	528	256	368	334	205	764	459	230	112	117	51	108	129	188	322	223	332	319
23	576	177	250	490	334	486	174	224	135	113	18	79	111	165	170	144	266	317
+gp	3482	1508	3232	3135	2131	3389	2131	895	254	253	69	186	220	397	630	1032	954	884
TOTALNUM	18240	20065	17967	17955	17277	17512	17622	14597	9675	9740	7637	6390	6338	6419	6443	5342	4633	5328
TONSLAND	16651	18120	15616	18043	17511	19155	18986	14460	10547	9643	7841	7320	7037	7,348	7306	6557	6261	7744

Table 7.6. ***Sebastes marinus*** **in Sub-areas I and II. Catch weights at age (kg).**

Year/Age	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
7	0.20	0.25	0.33	0.22	0.23	0.37	0.14	0.19	0.15	0.17
8	0.33	0.37	0.43	0.49	0.51	0.21	0.26	0.24	0.26	0.25
9	0.36	0.38	0.64	0.56	0.53	0.47	0.44	0.32	0.45	0.33
10	0.43	0.49	0.61	0.65	0.74	0.62	0.57	0.44	0.55	0.42
11	0.51	0.51	0.59	0.71	0.72	0.67	0.69	0.53	0.58	0.54
12	0.51	0.64	0.65	0.81	0.78	0.77	0.78	0.64	0.67	0.67
13	0.64	0.74	0.74	0.84	0.80	0.77	0.86	0.73	0.80	0.72
14	0.64	0.76	0.79	0.88	0.86	0.85	1.04	0.84	0.89	0.84
15	0.76	0.86	0.84	0.96	0.91	1.05	1.07	0.96	1.01	0.98
16	0.86	0.95	0.92	1.00	0.99	0.96	1.12	1.11	1.14	1.09
17	0.89	1.03	1.12	1.02	1.16	1.25	1.18	1.25	1.33	1.20
18	0.98	1.07	1.01	1.01	1.18	1.28	1.71	1.32	1.43	1.30
19	1.00	1.11	1.01	1.00	1.21	1.30	1.09	1.53	1.62	1.44
20	1.03	1.16	1.21	1.03	1.34	1.23	1.18	1.06	1.60	1.78
21	1.21	1.15	1.14	1.04	1.28	1.87	1.04	1.29	1.47	1.68
22	1.03	1.13	1.09	1.14	1.54	1.46	1.34	1.32	2.00	1.88
23	1.20	1.02	1.30	1.09	1.19	1.73	1.18	1.12	2.70	2.12
+gp	1.14	1.36	1.01	1.16	1.29	1.29	1.34	1.20	2.31	1.84

Year/Age	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
7	0.19	0.21	0.16	0.13	0.15	0.41	-	-
8	0.22	0.26	0.21	0.15	0.21	0.55	-	-
9	0.31	0.36	0.36	0.28	0.33	0.55	0.62	-
10	0.39	0.45	0.45	0.41	0.39	0.57	0.55	0.33
11	0.49	0.51	0.52	0.51	0.50	0.52	0.54	0.46
12	0.58	0.59	0.58	0.58	0.59	0.58	0.51	0.79
13	0.69	0.68	0.68	0.66	0.65	0.65	0.77	0.71
14	0.84	0.80	0.82	0.74	0.77	0.81	0.88	0.85
15	0.96	0.96	0.94	0.83	0.90	0.90	0.90	0.95
16	1.05	1.07	1.03	1.00	1.00	1.07	1.06	1.11
17	1.29	1.22	1.16	1.14	1.09	1.14	1.16	1.24
18	1.36	1.34	1.36	1.27	1.27	1.36	1.25	1.38
19	1.65	1.57	1.46	1.39	1.42	1.51	1.36	1.45
20	1.74	1.67	1.51	1.46	1.32	1.81	1.53	1.60
21	2.09	1.75	1.67	1.37	1.53	1.99	1.59	1.71
22	1.85	2.09	1.91	1.47	1.47	2.01	1.66	2.00
23	2.30	1.90	2.23	1.64	1.69	2.26	1.72	1.78
+gp	2.38	2.04	2.27	2.03	1.81	1.93	1.55	1.86

Table 7.7. *Sebastes marinus* in Sub-areas I and II. Fishing mortalities as estimated by Gadget.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
7	0.005	0.004	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.003	0.002
8	0.036	0.011	0.009	0.009	0.009	0.007	0.008	0.008	0.009	0.009	0.007
9	0.066	0.048	0.021	0.021	0.021	0.018	0.020	0.019	0.022	0.023	0.018
10	0.090	0.075	0.065	0.040	0.042	0.035	0.040	0.038	0.043	0.044	0.035
11	0.119	0.095	0.089	0.092	0.069	0.058	0.066	0.064	0.072	0.074	0.059
12	0.152	0.117	0.107	0.116	0.130	0.085	0.097	0.094	0.106	0.110	0.087
13	0.191	0.142	0.126	0.134	0.153	0.136	0.129	0.126	0.142	0.148	0.118
14	0.233	0.170	0.146	0.152	0.171	0.153	0.183	0.157	0.177	0.185	0.148
15	0.280	0.199	0.167	0.170	0.189	0.167	0.200	0.204	0.209	0.219	0.175
16	0.328	0.229	0.188	0.189	0.207	0.180	0.214	0.218	0.254	0.249	0.200
17	0.379	0.260	0.210	0.207	0.224	0.193	0.226	0.229	0.267	0.290	0.220
18	0.404	0.291	0.231	0.224	0.240	0.205	0.238	0.240	0.277	0.300	0.246
19	0.429	0.306	0.251	0.241	0.255	0.216	0.249	0.249	0.286	0.309	0.253
20	0.453	0.321	0.261	0.257	0.269	0.226	0.259	0.258	0.295	0.317	0.258
21	0.476	0.335	0.271	0.264	0.283	0.236	0.268	0.265	0.302	0.324	0.263
22	0.498	0.349	0.280	0.272	0.289	0.244	0.276	0.272	0.309	0.330	0.267
23	0.518	0.362	0.289	0.278	0.295	0.248	0.283	0.278	0.314	0.336	0.271
24	0.535	0.373	0.296	0.285	0.300	0.252	0.286	0.283	0.319	0.340	0.274
25	0.550	0.383	0.303	0.290	0.305	0.255	0.289	0.285	0.324	0.344	0.277
26	0.562	0.392	0.310	0.295	0.310	0.258	0.292	0.287	0.325	0.347	0.279
27	0.572	0.399	0.315	0.300	0.313	0.261	0.295	0.289	0.327	0.349	0.281
28	0.580	0.404	0.319	0.303	0.317	0.263	0.297	0.291	0.329	0.350	0.282
29	0.585	0.409	0.322	0.306	0.320	0.265	0.299	0.293	0.330	0.351	0.282
30	0.593	0.415	0.328	0.309	0.322	0.267	0.301	0.294	0.332	0.353	0.284
model 2011											
12 - 19	0.299	0.214	0.178	0.179	0.196	0.167	0.192	0.190	0.215	0.226	0.181
model previous year											
12 - 19	0.291	0.209	0.175	0.177	0.194	0.165	0.190	0.187	0.212	0.224	0.180

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
7	0.002	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003
8	0.005	0.005	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.009
9	0.013	0.012	0.010	0.010	0.010	0.012	0.013	0.012	0.013	0.021
10	0.026	0.024	0.020	0.019	0.020	0.024	0.025	0.025	0.026	0.042
11	0.043	0.041	0.033	0.033	0.034	0.039	0.042	0.041	0.045	0.070
12	0.065	0.060	0.050	0.049	0.050	0.057	0.062	0.062	0.067	0.104
13	0.087	0.081	0.067	0.065	0.067	0.076	0.083	0.083	0.091	0.139
14	0.110	0.101	0.084	0.081	0.082	0.094	0.103	0.103	0.113	0.174
15	0.130	0.119	0.099	0.095	0.096	0.109	0.120	0.122	0.134	0.205
16	0.148	0.134	0.112	0.107	0.108	0.122	0.134	0.137	0.152	0.232
17	0.164	0.147	0.123	0.117	0.117	0.132	0.146	0.149	0.166	0.254
18	0.176	0.157	0.131	0.124	0.124	0.140	0.154	0.158	0.176	0.271
19	0.191	0.166	0.138	0.130	0.130	0.145	0.161	0.165	0.184	0.283
20	0.195	0.175	0.143	0.135	0.134	0.150	0.165	0.170	0.190	0.292
21	0.198	0.177	0.149	0.138	0.137	0.153	0.169	0.173	0.194	0.298
22	0.201	0.179	0.150	0.142	0.139	0.155	0.171	0.176	0.196	0.302
23	0.203	0.181	0.151	0.142	0.142	0.157	0.173	0.177	0.198	0.305
24	0.205	0.183	0.152	0.143	0.142	0.158	0.174	0.179	0.200	0.307
25	0.207	0.184	0.153	0.144	0.143	0.159	0.175	0.180	0.200	0.308
26	0.208	0.185	0.154	0.144	0.143	0.159	0.176	0.181	0.201	0.309
27	0.209	0.186	0.154	0.145	0.143	0.159	0.176	0.181	0.202	0.310
28	0.210	0.186	0.155	0.145	0.144	0.160	0.176	0.181	0.202	0.311
29	0.211	0.187	0.155	0.145	0.144	0.160	0.176	0.181	0.202	0.311
30	0.212	0.188	0.156	0.146	0.144	0.160	0.177	0.181	0.202	0.311
model 2011										
	0.134	0.121	0.101	0.096	0.097	0.109	0.120	0.122	0.135	0.208
model previous year										
	0.135	0.123	0.103	0.100	0.102	0.117	0.130	0.135	0.152	

Table 7.8. *Sebastes marinus* in Sub-areas I and II. Stock numbers, biomass, mean weight and maturity ogives as estimated by GADGET using two survey series as input.

	total stock			mature			immature			recruit (age 3)
	number	mean wei	biomass	number	mean wei	biomass	number	mean wei	biomass	number
year	(millions)	(kg)	('1000 t)	(millions)	(kg)	('1000 t)	(millions)	(kg)	('1000 t)	(1000')
1986	519	0.33	172	108	0.81	88	411	0.20	84	76,810
1987	512	0.32	165	101	0.80	81	410	0.20	83	66,074
1988	492	0.32	160	93	0.77	72	399	0.22	88	52,032
1989	471	0.33	155	86	0.73	63	385	0.24	92	48,359
1990	453	0.33	149	81	0.69	56	372	0.25	92	52,062
1991	441	0.34	148	82	0.68	56	360	0.26	92	50,475
1992	425	0.35	149	85	0.69	58	340	0.27	91	42,012
1993	406	0.37	150	87	0.71	62	319	0.28	88	37,465
1994	377	0.39	148	88	0.73	64	289	0.29	84	27,290
1995	342	0.42	145	88	0.75	66	254	0.31	79	17,910
1996	305	0.46	141	88	0.78	68	218	0.34	73	11,379
1997	271	0.49	134	85	0.80	68	186	0.36	66	11,837
1998	236	0.53	125	81	0.82	66	155	0.38	59	7,154
1999	201	0.57	114	74	0.84	62	126	0.41	51	4,961
2000	169	0.61	103	69	0.86	59	100	0.44	44	2,342
2001	141	0.66	93	63	0.89	56	78	0.47	37	1,654
2002	121	0.72	87	60	0.93	56	61	0.51	31	1,602
2003	104	0.78	81	57	0.98	56	47	0.53	25	1,544
2004	102	0.73	74	53	1.03	54	49	0.41	20	14,380
2005	87	0.79	68	49	1.08	53	38	0.41	16	514
2006	101	0.62	62	44	1.13	49	57	0.22	13	27,737
2007	90	0.62	55	38	1.17	45	51	0.21	11	4,496
2008	77	0.64	49	33	1.20	40	43	0.22	10	300
2009	66	0.66	44	28	1.21	34	38	0.24	9	1,719
2010	56	0.69	39	24	1.21	29	32	0.29	9	300

	Proportion mature					
age	1991-1993	1994-1996	1997-1999	2000-2002	2003-2005	2006-2009
4	0.03	0.03	0.03	0.03	0.03	0.03
5	0.05	0.05	0.05	0.05	0.05	0.05
6	0.08	0.08	0.08	0.08	0.08	0.08
7	0.12	0.12	0.12	0.12	0.12	0.12
8	0.17	0.17	0.17	0.17	0.17	0.17
9	0.23	0.24	0.24	0.24	0.24	0.24
10	0.30	0.32	0.32	0.32	0.32	0.32
11	0.39	0.42	0.42	0.42	0.42	0.42
12	0.51	0.52	0.53	0.53	0.53	0.53
13	0.64	0.63	0.64	0.64	0.64	0.64
14	0.76	0.74	0.75	0.75	0.75	0.75
15	0.86	0.84	0.84	0.85	0.85	0.85
16	0.93	0.92	0.91	0.92	0.92	0.92
17	0.97	0.96	0.96	0.96	0.96	0.96
18	0.99	0.99	0.99	0.99	0.99	0.99
19	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00	1.00
21	1.00	1.00	1.00	1.00	1.00	1.00
22	1.00	1.00	1.00	1.00	1.00	1.00
23	1.00	1.00	1.00	1.00	1.00	1.00
24	1.00	1.00	1.00	1.00	1.00	1.00
25	1.00	1.00	1.00	1.00	1.00	1.00
26	1.00	1.00	1.00	1.00	1.00	1.00
27	1.00	1.00	1.00	1.00	1.00	1.00
28	1.00	1.00	1.00	1.00	1.00	1.00
29	1.00	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00	1.00

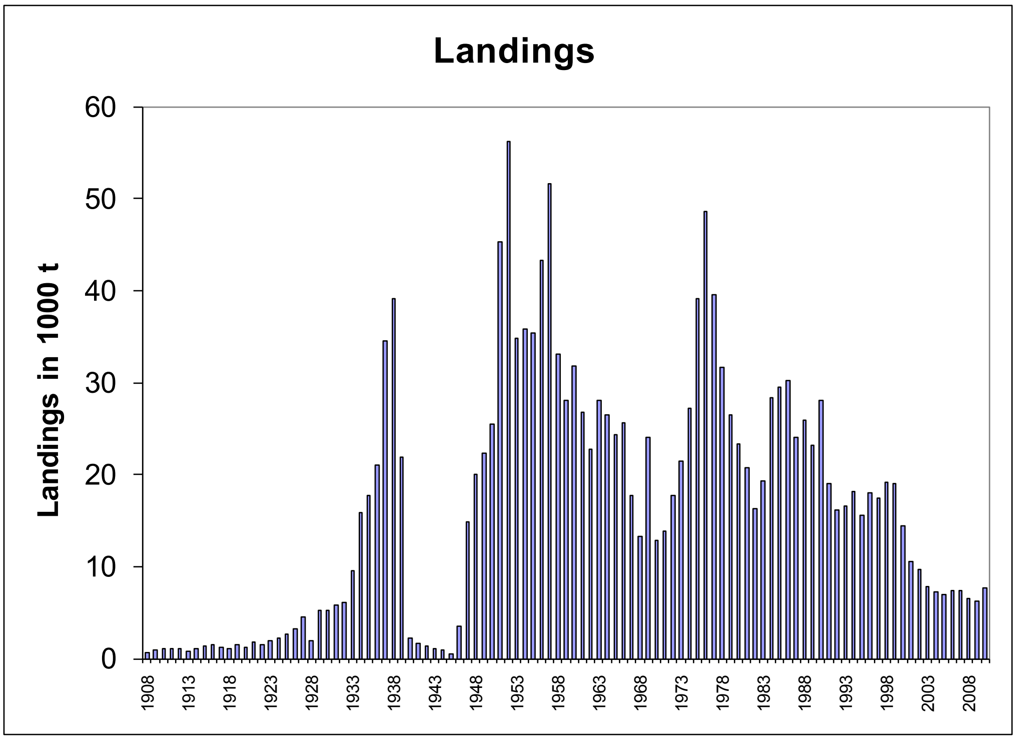
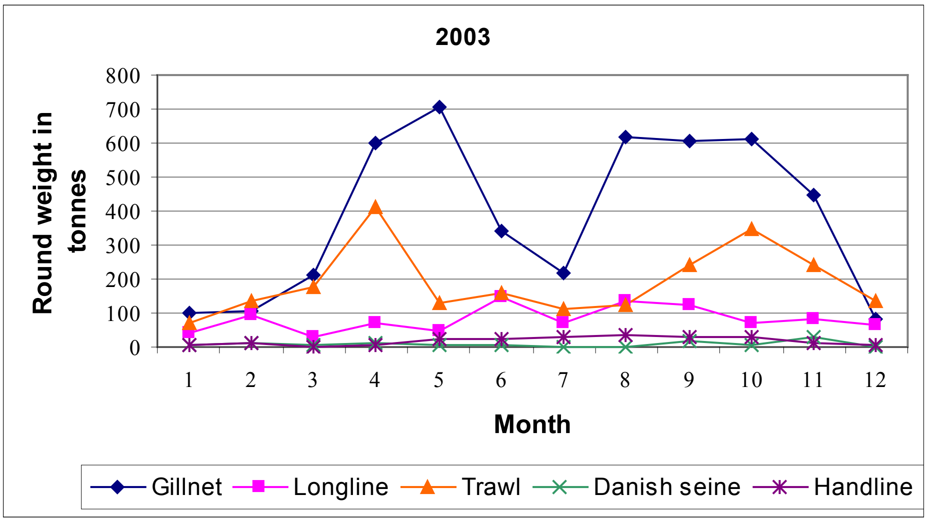
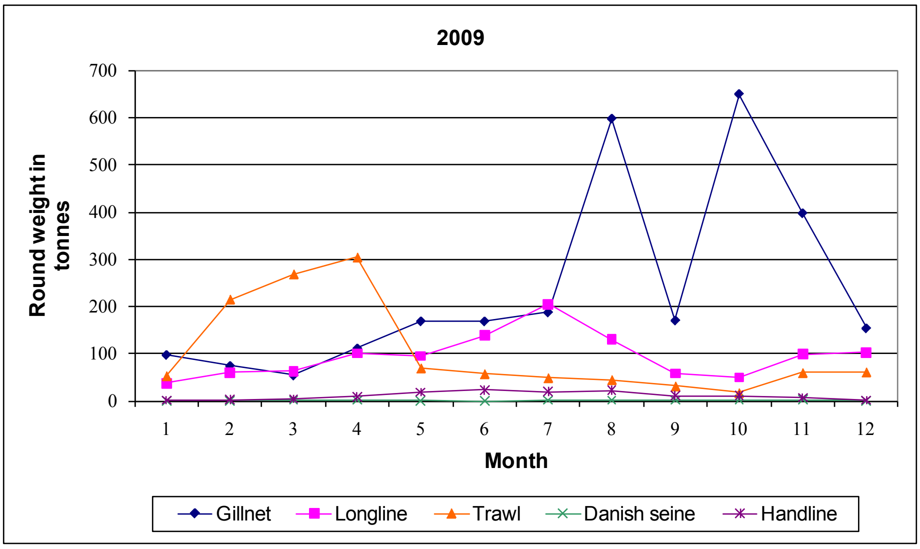


Figure 7.1. ***Sebastes marinus*** **in Sub-areas I and II. Total international landings 1965-2010 (in thousand tonnes)**





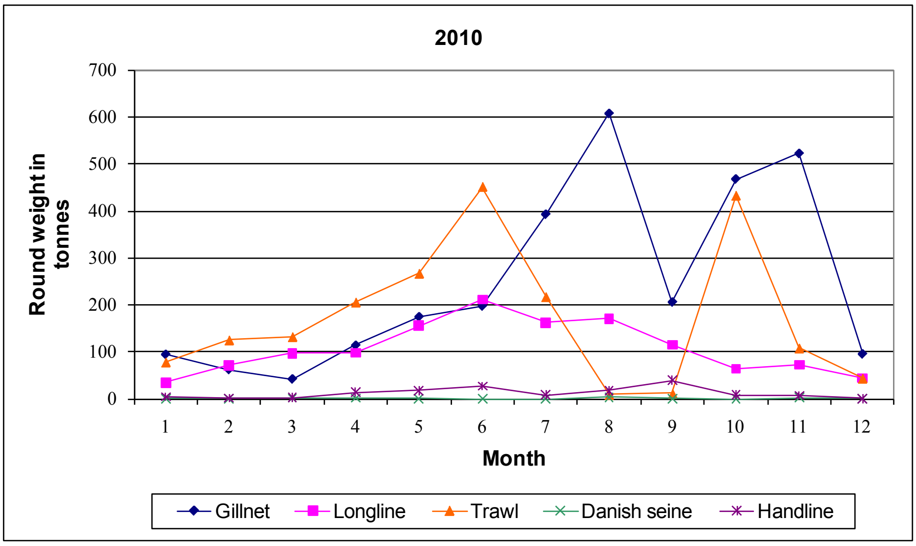


Figure 7.2a. Illustration of the seasonality in the different Norwegian *S. marinus* fisheries in 2003, 2009 and 2010, also illustrating how the current regulations are working.

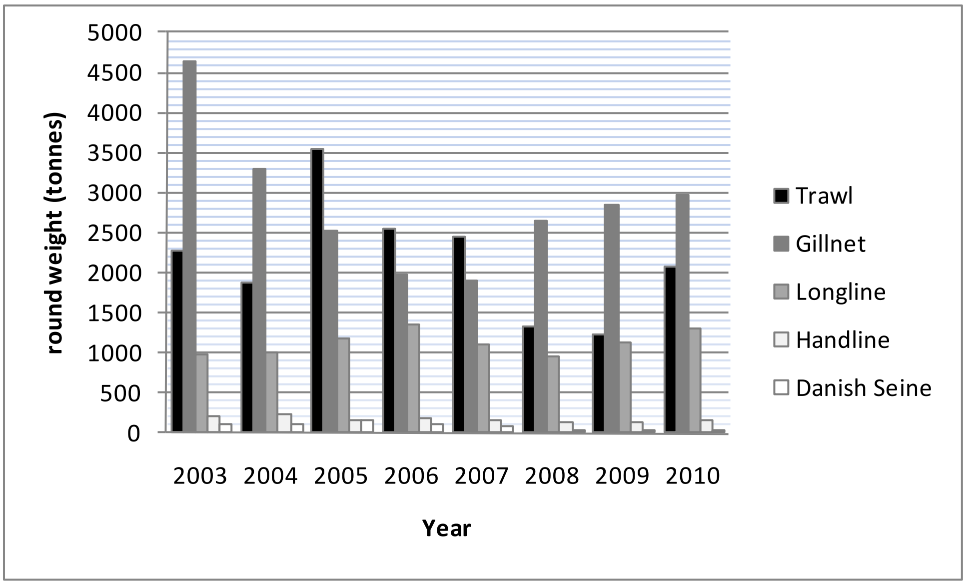


Figure 7.2b. Inter annual changes in the catches reported by different Norwegian *S. marinus* fisheries (2003-2010).

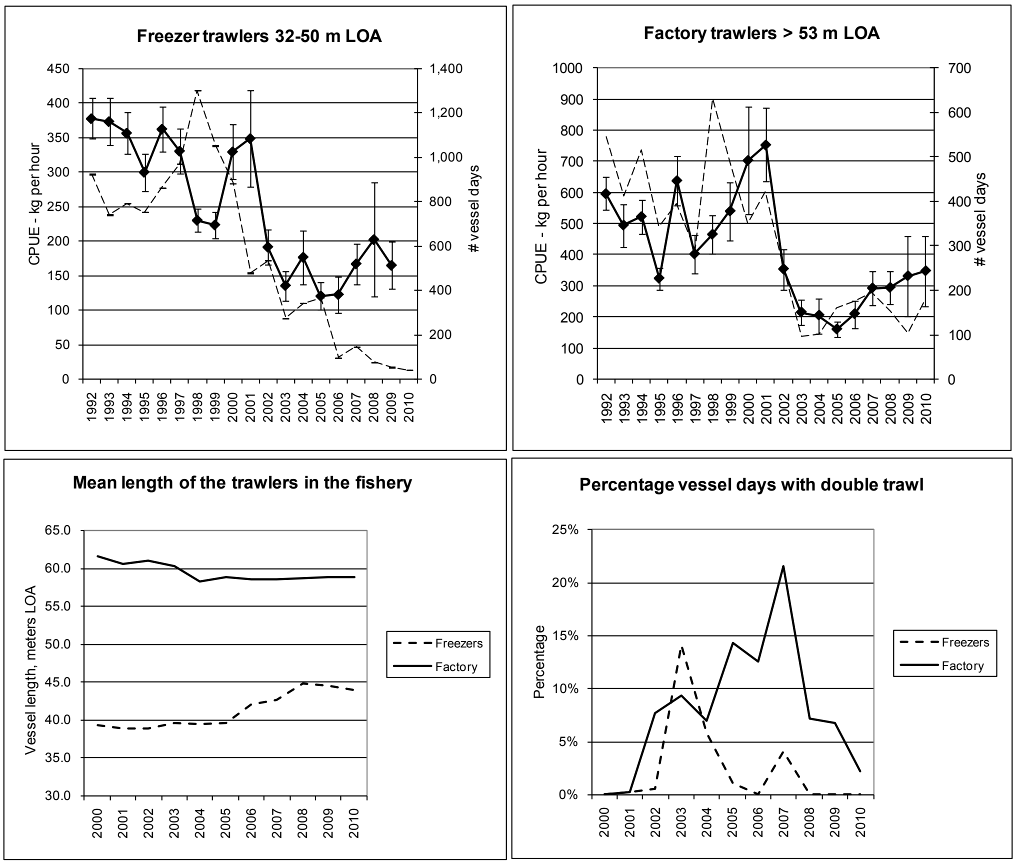


Figure 7.3. ***Sebastes marinus*. Plot of simple mean CPUEs with 2 st. errors from the Norwegian trawl fishery, and numbers of vessel days (stippled curve) meeting the criterion of minimum 10% *S. marinus* in the catch per day. Upper panel shows data from the logbooks of freezer trawlers (left) and factory trawlers (right). The lower panel shows how the vessel length and use of double trawl have developed through the time series. The figure is an illustration of the data given in Table E1.**

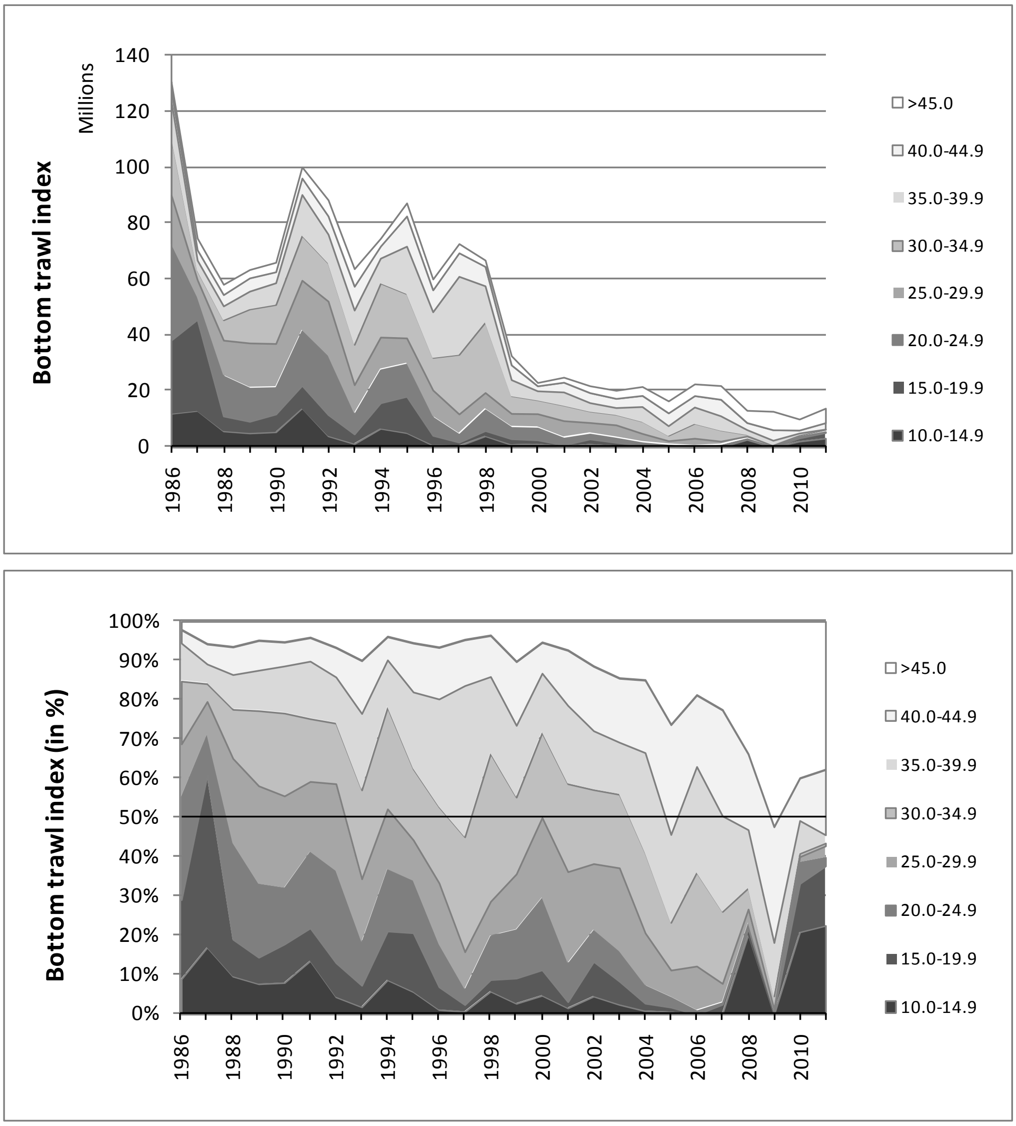


Figure 7.4a. ***Sebastes marinus*****. Abundance indices disaggregated by length for the Norwegian bottom trawl survey in the Barents Sea in winter 1986-2011 (ref. Table E2a). Top: absolute index values, bottom: relative frequencies. Horizontal line in lower panel indicates the median length in the surveyed population.**

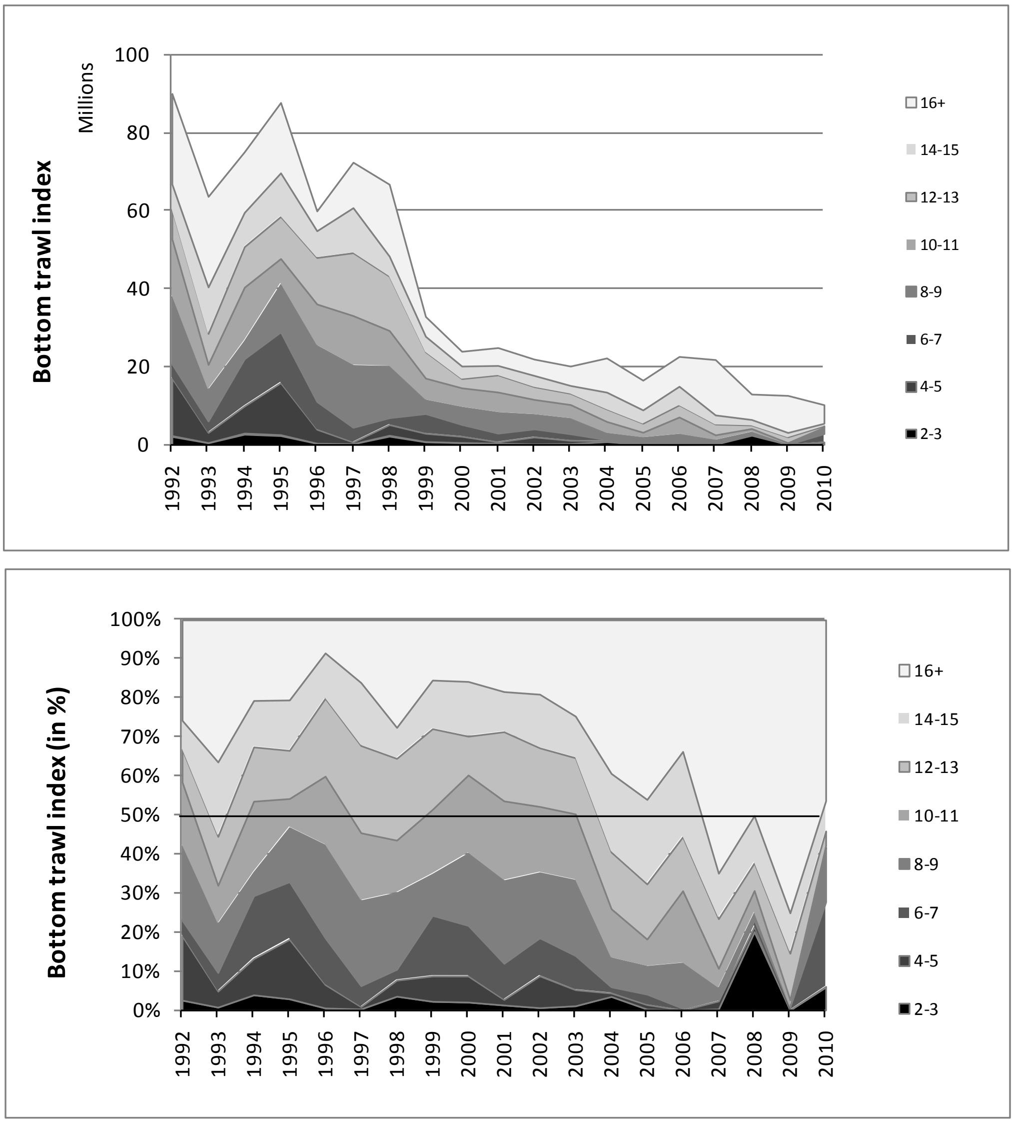
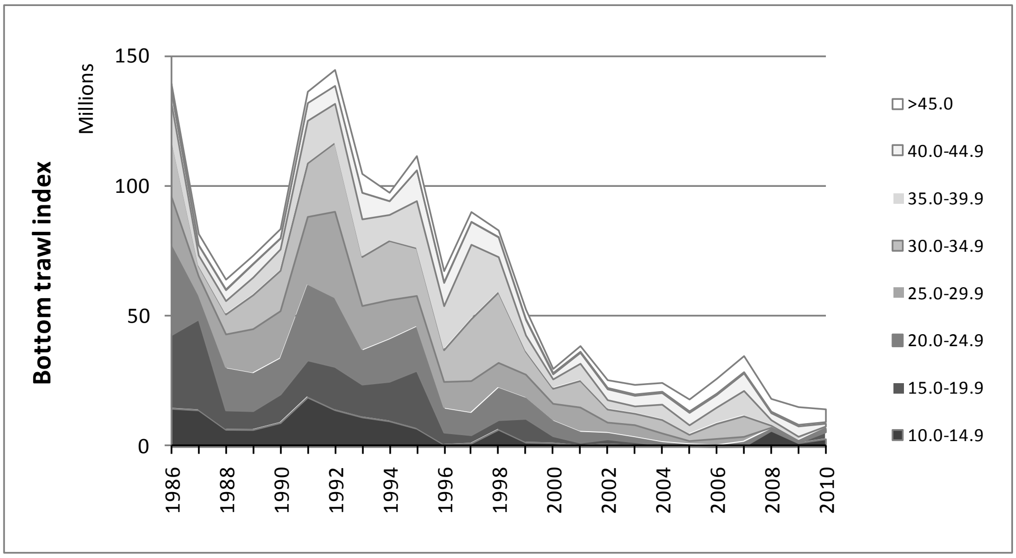


Figure 7.4b. ***Sebastes marinus*****. Abundance indices (by age) from the Norwegian bottom trawl surveys 1992-2010 in the Barents Sea (ref. Table E2b). Top: absolute index, bottom: relative frequencies. Horizontal line indicates the median age of the surveyed population.**



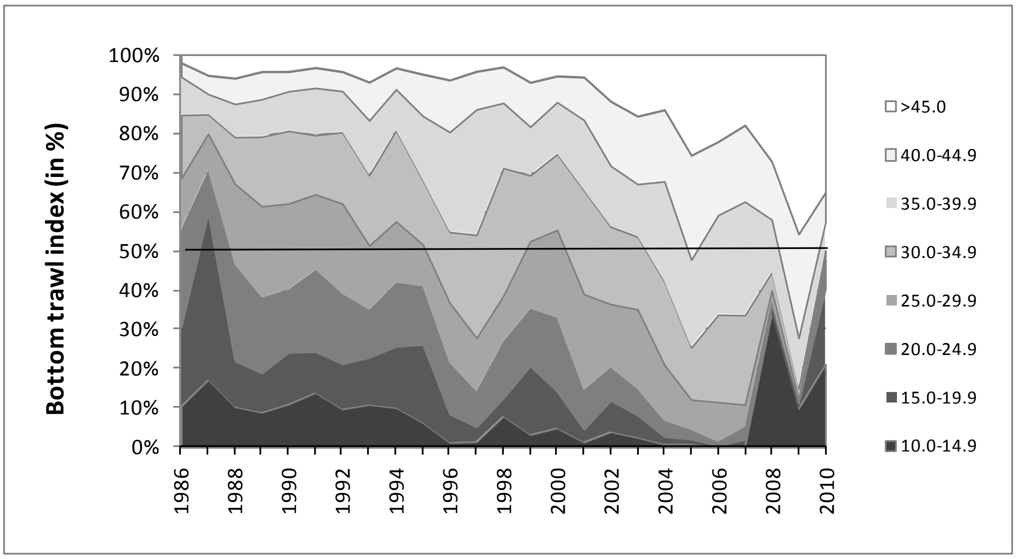
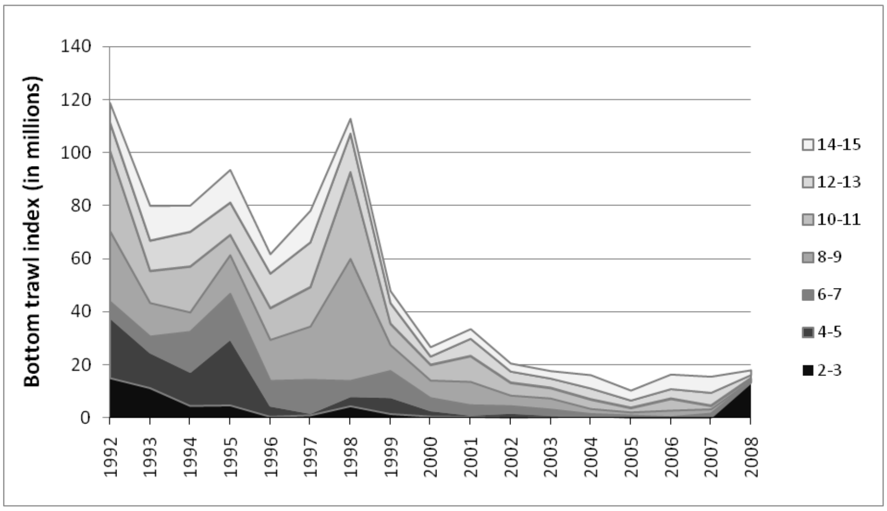


Figure 7.5a. ***Sebastes marinus.*** **Abundance indices disaggregated by length when combining the Norwegian bottom trawl surveys 1986-2010 in the Barents Sea (winter) and at Svalbard (summer/fall). Top: absolute index values. Bottom: relative frequencies. Horizontal line indicates the median length in the surveyed population.**



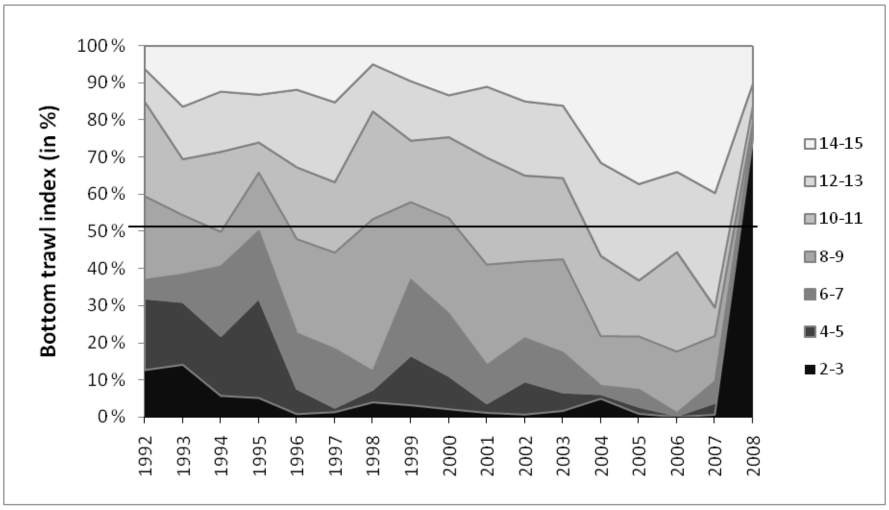
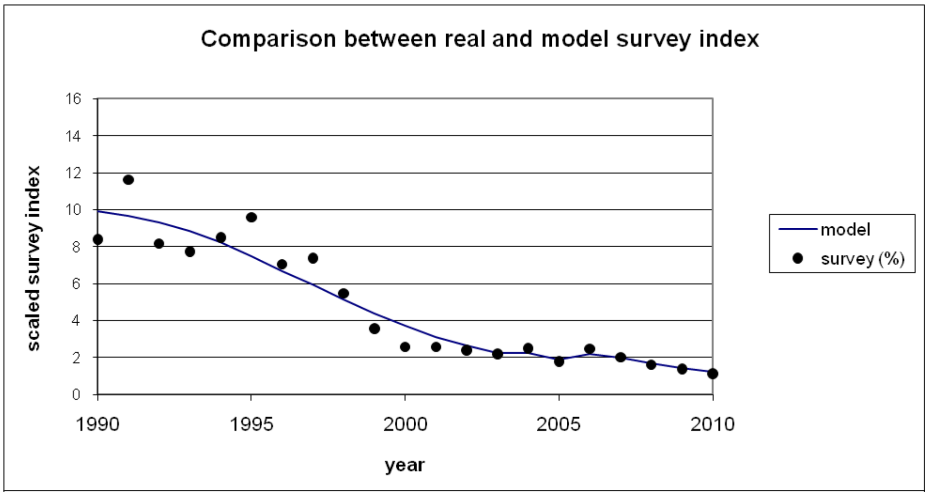


Figure 7.5b. *Sebastes marinus*. Abundance indices disaggregated by age. Combined Norwegian bottom trawl surveys 1992-2008 in the Barents Sea (winter) and Svalbard survey (summer/fall). Top: absolute index values, bottom: relative frequencies. Horizontal line indicates median age of the surveyed population. ***No age readings have been done of the Svalbard part of the survey in 2009 and 2010.***



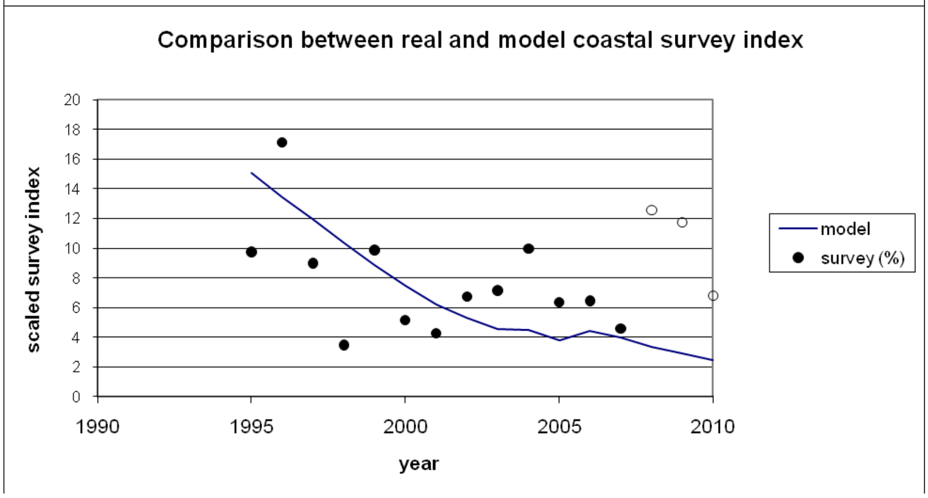


Figure 7.6. Sebastes marinus in Sub-areas I and II. Results from the Gadget assessment using two scientific surveys as input. The Figure shows comparison of observed and modelled survey indices (total number scaled to sum=100 during the time period) – the traditional Barents Sea February survey (top), and the coastal and fjord survey (bottom). Dots: survey indices. Plain lines: survey indices estimated by the model. Note that the 2008-2010 years in the coastal survey (hollow circles) have been excluded from the model tuning and the scaling.

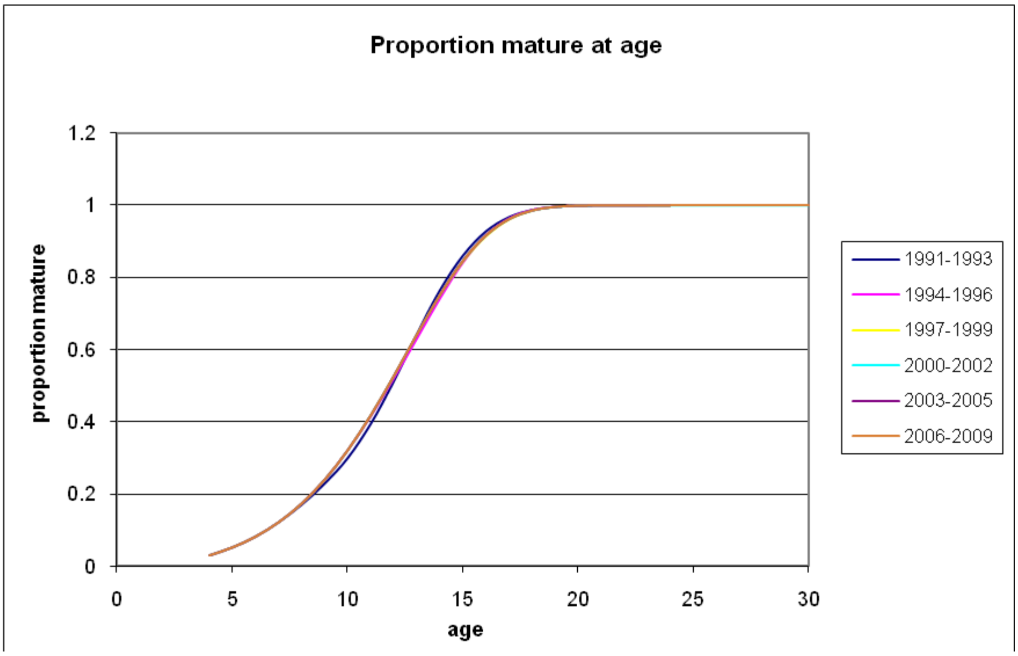


Figure 7.7. ***Sebastes marinus*** **in Sub-areas I and II. Estimates of maturity at age by Gadget. Input data have been proportions of** ***S. marinus*** **mature both at age and length as collected and classified from Norwegian commercial landings and surveys.**

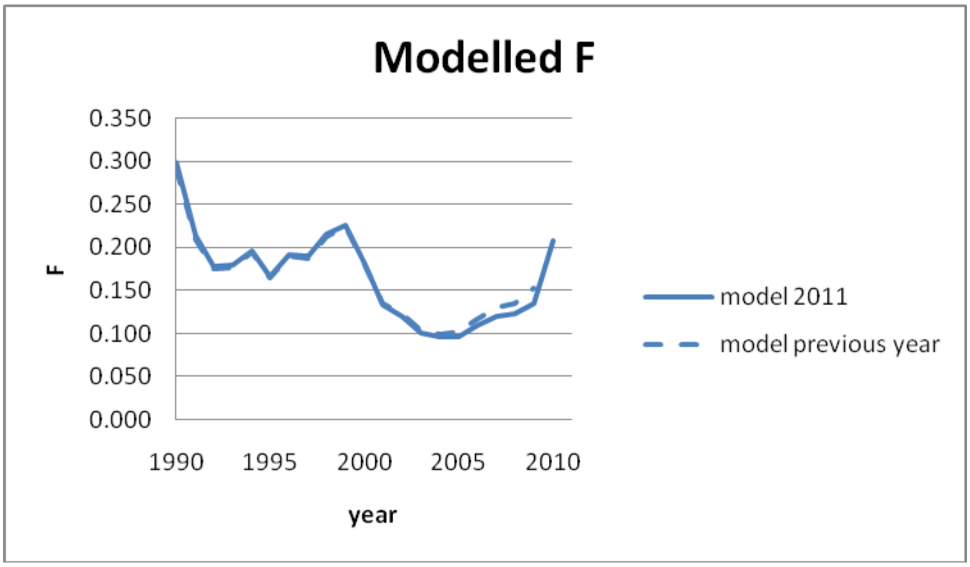


Figure 7.8. ***Sebastes marinus*** **in sub-areas I & II. Unweighted average fishing mortality of ages 12-19 as estimated by Gadget in 2011 (solid line) and in 2010 (dashed line).**

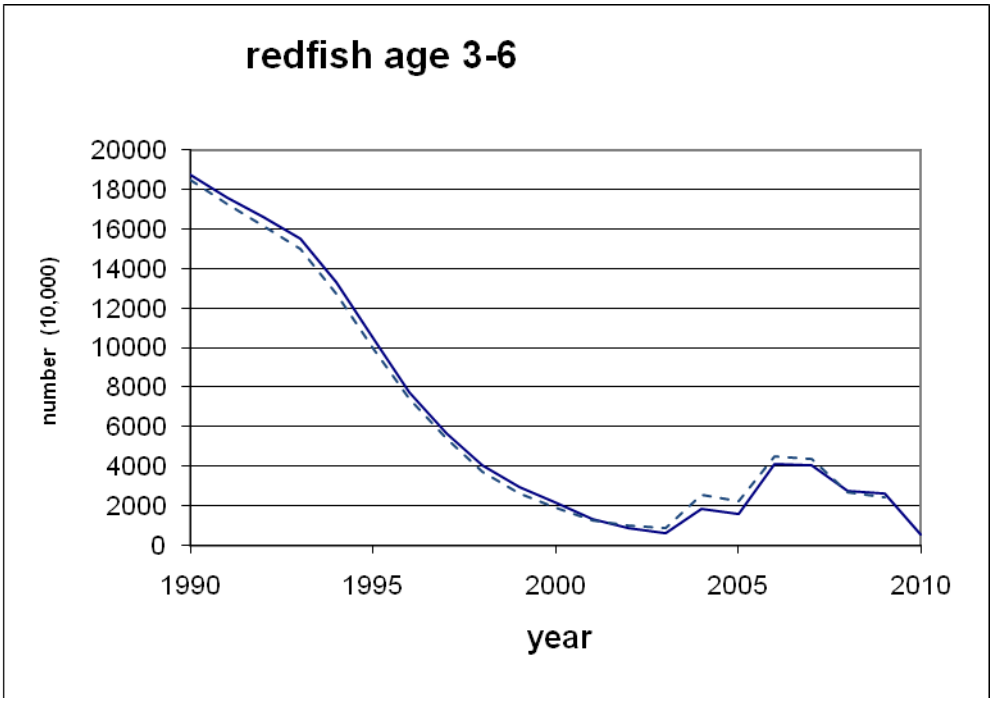


Figure 7.9. ***Sebastes marinus*** **in Sub-areas I and II. Estimates of abundance at age 3-6 by Gadget using two surveys as input. Gadget outputs provided at the 2010 AFWG are shown as dotted line. Current results are shown as plain lines.**

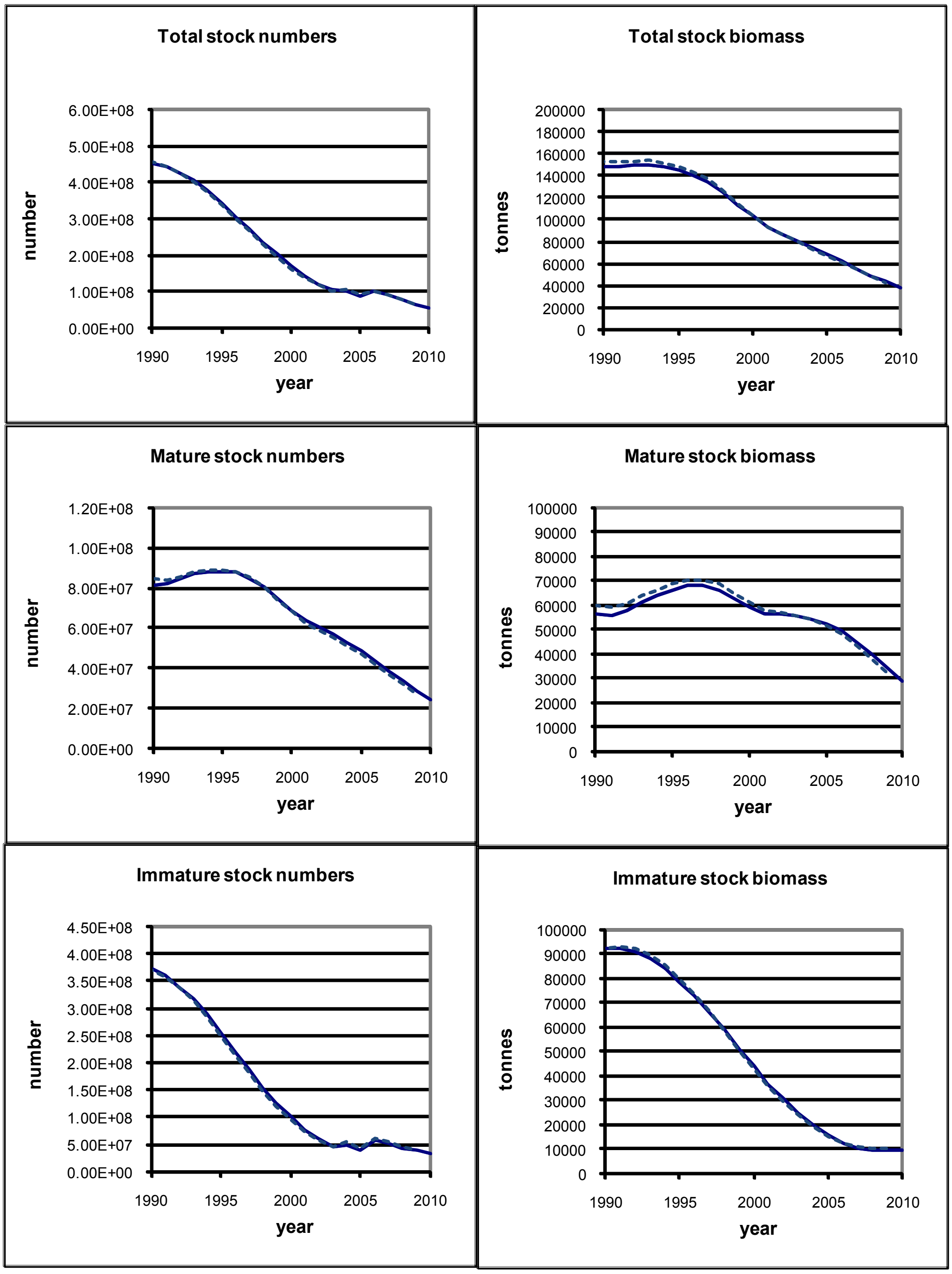


Figure 7.10. ***Sebastes marinus*** **in Sub-areas I and II. Stock numbers (in thousands) and biomass (in tonnes) for the total stock (3+) (upper panel), and the fishable and mature stock (middle panel), and the immature stock (lower panel), as estimated by Gadget using two surveys as input. Gadget outputs provided in the previous AFWG report are shown as dotted lines. Current results are shown as plain lines.**

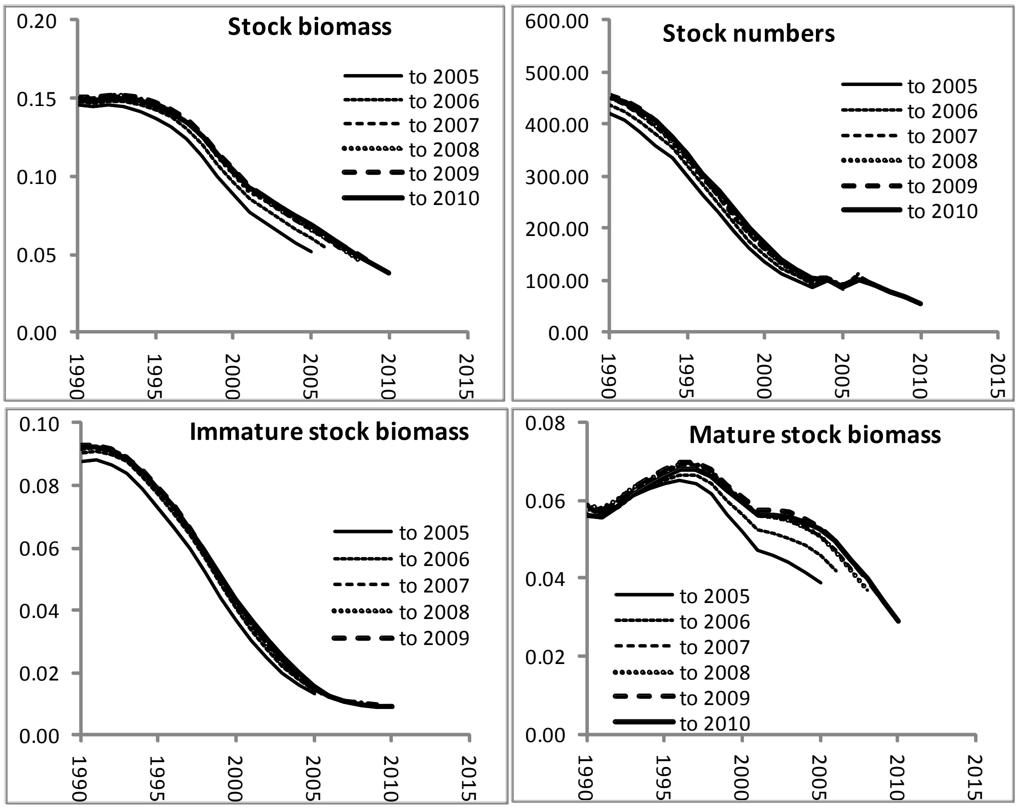


Figure 7.11. Retrospective plot from the gadget model. Top left: total stock biomass in million tonnes, top right: total stock numbers in millions, bottom left: immature biomass and bottom right: mature biomass, both in million tonnes. Note that the coastal survey is only used up to 2007.

Table E1. *Sebastes marinus*. Effort (vessel days) and catch per unit effort (kg per trawl hour) with 2 x st.error for Norwegian trawlers.[1]

	Freezer trawlers (32-50m)			**Factory trawlers (>53m)**		
Year	Number of vessel days meeting the 10% requirement	Mean CPUE per year (kg/hour)	2 x standard error of the mean	Number of vessel days meeting the 10% requirement	Mean CPUE per year (kg/hour)	2 x standard error of the mean
1992	926	378	29.4	545	596	53.1
1993	743	374	34.4	411	495	68.9
1994	793	357	30.1	516	522	53.9
1995	754	300	26.7	343	323	35.9
1996	864	363	32.1	395	638	78.4
1997	972	331	31.9	291	402	60.3
1998	1 303	230	17.2	631	465	62.1
1999	1 054	224	18.8	486	540	93.1
2000	884	330	39.9	349	703	172.6
2001	481	349	70.5	421	753	118.4
2002	536	192	26.0	246	353	65.8
2003	276	136	21.4	96	214	40.7
2004	344	177	38.5	101	204	56.2
2005	368	120	20.2	160	160	24.2
2006	98	123	26.0	175	209	43.9
2007	147	167	29.4	195	292	53.5
2008	78	202	82.5	153	294	53.2
2009	55	165	34.4	104	331	129.2
2010[2]	41	*776*	*740.5*	180	347	112.9

[1] Only including days with more than 10% *S. marinus* in the catches. Only including areas with low mixing of *S. mentella.*

[2] Provisional figures.

Table E2a. Sebastes marinus in Sub-areas I and II. Abundance indices - on length - from the bottom trawl surveys in the Barents Sea (Division IIa) in the winter 1986-2011 (numbers in millions). The area coverage was extended from 1993.

Year	Length group (cm)									Total
	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	
1986	3.0	11.7	26.4	34.3	17.7	21.0	12.8	4.4	2.6	133.9
1987	7.7	12.7	32.8	7.7	6.4	3.4	3.8	3.8	4.2	82.5
1988	1.0	5.6	5.5	14.2	12.6	7.3	5.2	4.1	3.7	59.2
1989	48.7	4.9	4.3	11.8	15.9	12.2	6.6	4.8	3.0	112.2
1990	9.2	5.3	6.5	9.4	15.5	14.0	8.0	4.0	3.4	75.3
1991	4.2	13.6	8.4	19.4	18.0	16.1	14.8	6.0	4.0	104.5
1992	1.8	3.9	7.7	20.6	19.7	13.7	10.5	6.6	5.8	90.3
1993	0.1	1.2	3.5	6.9	10.3	14.5	12.5	8.6	6.3	63.9
1994	0.7	6.5	9.3	11.7	11.5	19.4	9.1	4.4	2.8	75.4
1995	0.6	5.0	13.1	11.5	9.1	15.9	17.2	10.9	4.7	88.0
1996	+	0.7	3.5	6.4	9.4	11.7	16.6	7.9	3.9	60.1
1997[1]	-	0.5	1.3	2.7	6.9	21.4	28.2	8.5	3.3	72.7
1998[1]	0.1	3.9	2.0	7.4	5.8	25.3	13.2	7.0	2.3	67.0
1999	0.2	0.9	2.1	4.0	4.6	6.4	6.0	5.3	3.5	33.0
2000	0.5	1.1	1.5	4.2	4.7	5.0	3.5	1.8	1.2	24.0
2001	0.1	0.4	0.4	2.4	5.8	5.6	5.0	3.5	1.8	25.0
2002	0.1	1.0	1.9	1.7	3.7	4.1	3.3	3.6	2.5	22.0
2003	0.0	0.5	1.2	1.5	4.3	3.8	2.7	3.3	2.9	20.2
2004	0.7	0.2	0.4	1.0	2.9	4.4	5.5	4.0	3.2	22.3
2005	+	0.1	0.2	0.4	1.1	2.0	3.7	4.6	4.3	16.4
2006	0.0	0.0	0.0	0.2	2.5	5.4	6.1	4.1	4.2	22.5
2007	0.0	0.1	0.5	0.1	1.0	4.0	5.4	5.9	4.9	21.9
2008	1.8	2.6	0.2	0.2	0.4	0.7	1.9	2.5	4.4	14.8
2009	0.0	0.0	0.1	0.0	0.0	0.4	1.7	3.7	6.6	12.7
2010	0.4	2.0	1.2	0.6	0.1	0.1	0.8	1.1	3.9	10.3
2011	0.3	3.1	2.1	0.3	0.4	0.1	0.3	2.3	5.2	14.1

1 - Adjusted indices to account for not covering the Russian EEZ in Subarea I

Table E2b. ***Sebastes marinus*** **in Sub-areas I and II. Norwegian bottom trawl indices - on age - from the annual Barents Sea survey in February 1992-2010 (numbers in thousands). The area coverage was extended from 1993 onwards.**

	Age													
Year	3	4	5	6	7	8	9	10	11	12	13	14	15	**Total 1-15**	16+[1]
1992	2,295	4,261	10,760	2,043	1,474	13,178	4,230	6,302	8,251	3,751	3,865	3,064	3,568	**67,042**	*23,300*
1993	468	1,218	1,424	2,020	979	5,048	2,968	4,230	2,142	4,634	3,338	2,951	9,148	**40,568**	*23,300*
1994	2,951	4,485	2,573	3,801	8,338	3,254	1,297	7,231	6,443	248	10,192	6,341	2,612	**59,766**	*15,600*
1995	2,540	7,450	6,090	7,150	5,820	6,590	5,670	2,000	4,440	6,500	4,320	5,330	6,030	**69,930**	*18,100*
1996	310	1,300	2,340	3,520	3,660	8,720	5,650	3,960	6,590	5,730	6,230	4,070	2,950	**55,030**	*5,100*
1997	190	80	360	1,320	2,530	5,370	10,570	6,840	5,810	7,390	8,790	9,740	1,980	**60,980**	*11,700*
1998	2,380	1,930	850	660	1,140	7,090	6,124	4,962	4,091	5,190	8,790	2,730	2,560	**48,487**	*18,500*
1999	737	916	1,246	3,469	1,650	1,826	1,679	3,084	2,371	2,953	3,837	2,132	1,979	**27,879**	*5,100*
2000	490	720	900	1,310	1,800	2,440	2,020	2,710	2,090	940	1,440	2,940	430	**20,230**	*3,800*
2001	320	170	190	940	1,360	2,220	3,110	2,400	2,690	2,230	2,180	1,200	1,370	**20,380**	*4,600*
2002	130	910	902	1,590	544	1,546	2,153	1,822	1,900	2,220	1,073	1,294	1,730	**17,814**	*4,200*
2003	220	250	590	1,080	680	1,020	2,910	1,180	2,250	1,370	1,530	840	1,310	**15,230**	*5,000*
2004	780	100	100	90	240	540	1,130	1,260	1,590	1,740	1,490	2,570	1,890	**13,520**	*8,800*
2005	39	85	107	110	321	524	669	497	697	820	1,517	1,905	1,653	**8,944**	*7,652*
2006	0	0	0	24	52	1,011	1,641	1,999	2,246	1,578	1,550	3,487	1,444	**15,030**	*7,666*
2007	58	202	248	50	51	185	422	582	592	1,747	1,030	1,127	1,359	**7,652**	14,248
2008	2637	0	0	0	203	72	175	272	476	369	553	850	700	**6,306**	6,543
2009	0	0	0	0	85	0	14	77	192	358	1,146	532	737	**3,141**	9,539
2010	0	0	16	1,966	267	0	1,450	35	0	117	268	285	494	**5,510**	4,779

16+ group is considered in the calculation since 2005. Values prior to this date were derived by subtracting the sum of abundance in groups 1-15 to the total abundance, available in Table E2a.

Table E3a. *Sebastes marinus* in Subarea I and II. Abundance indices - on length - from the bottom trawl survey in the Svalbard area (Division IIb) in summer/fall 1985-2010 (numbers in thousands).

	Length group (cm)									
Year	5.0-9.9	10.0-14.9	15.0-19.9	20.0-24.9	25.0-29.9	30.0-34.9	35.0-39.9	40.0-44.9	>45.0	Total
1985[1]	-	1,307	795	1,728	2,273	1,417	311	142	194	8,325
1986[1]	200	2,961	1,768	547	643	1,520	639	467	196	8,941
1987[1]	100	1,343	1,964	1,185	1,367	652	352	29	44	7,060
1988[1]	500	1,001	1,953	1,609	684	358	158	68	95	6,450
1989	200	1,629	2,963	2,374	1,320	846	337	323	104	10,100
1990	1,700	3,886	4,478	4,047	2,972	1,509	365	140	122	19,185
1991	100	5,371	5,821	9,171	8,523	4,499	1,531	982	395	36,420
1992	1,700	10,228	8,858	5,330	13,960	12,720	4,547	494	346	58,172
1993	200	10,160	9,078	5,855	7,071	4,327	2,088	1,552	948	41,284
1994	100	3,340	5,883	4,185	3,922	3,315	1,021	845	423	22,985
1995	470	2,000	9,100	5,070	3,060	2,400	1,040	920	780	24,840
1996	80	130	1,260	2,480	1,030	480	550	990	400	7,400
1997	0	810	1,980	5,470	5,560	2,340	590	190	450	17,430
1998	180	2,698	1,741	4,620	4,053	1,761	535	545	241	16,403
1999	0	794	7,057	3,698	4,563	2,449	467	619	369	20,017
2000	40	360	1,240	1,390	2,010	760	400	160	390	6,750
2001	10	110	790	1,470	3,710	4,600	1,880	680	370	13,660
2002	0	0	64	415	459	880	620	565	519	3,522
2003	90	90	108	83	525	565	447	760	769	3,437
2004	0	0	10	50	650	740	670	430	190	2,740
2005	0	45	0	30	315	384	307	159	274	1,513
2006	0	0	70	64	167	376	473	735	1,514	3,398
2007	0	32	58	1,003	1,049	3,875	4,656	811	1,267	12,751
2008	7,009	3,573	175	21	42	142	475	162	529	12,130
2009	227	1,476	114	114	0	0	185	213	193	2,522
2010	666	917	1,506	522	0	117	172	0	985	4,885

1 - Old trawl equipment (bobbins gear and 80 meter sweep length)

Table E3b. ***Sebastes marinus*** **in Sub-areas I and II. Norwegian bottom trawl survey indices - on age - in the Svalbard area (Division IIb) in summer/fall 1992-2008 (numbers in thousands). No age data available for 2009 and 2010.**

	Age														
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992	284	12,378	5,576	2,279	371	2,064	3,687	5,704	9,215	6,413	1,454	1,387	696	22	51,530
1993	32	10,704	5,710	5,142	1,855	1,052	1,314	3,520	2,847	2,757	2,074	1,245	844	119	39,215
1994	429	1,150	3,418	2,393	1,723	1,106	1,714	1,256	1,938	1,596	2,039	484	550	319	20,155
1995	600	1,600	6,400	5,100	1,800	2,200	1,800	700	700	400	700	500	400	500	23,400
1996	40	110	+	560	1,050	940	930	400	1,050	280	320	590	160	70	6,500
1997	320	490	+	480	1,500	6,950	2,720	1,680	800	1,310	550	30	+	120	16,950
1998	210	1,817	881	202	1,555	2,187	4,551	1,913	1,010	797	49	264	73	187	15,696
1999	0	760	2,893	1,339	3,534	1,037	3,905	2,603	762	1,663	481	361	258	152	19,748
2000	40	20	400	350	840	480	730	1,670	620	340	510	100	80	70	6,250
2001	0	40	50	450	330	790	1,760	1,970	3,300	1,200	1,810	150	660	430	12,940
2002	0	0	+	+	65	160	204	326	364	614	442	328	15	0	2,518
2003	30	30	30	+	108	+	219	263	126	259	306	199	248	411	2,229
2004	0	0	0	+	+	20	360	120	430	160	410	360	370	200	2,430
2005	0	45	0	0	0	30	48	228	138	187	194	93	105	109	1,177
2006	0	0	23	23	23	21	22	21	84	0	84	279	194	376	1,148
2007	0	33	19	19	19	764	764	525	0	0	21	1,927	1,927	1,683	7,702
2008	10583	44	88	44	11	11	0	42	88	13	13	118	63	174	11,292

Table E4. ***Sebastes marinus*** **in Sub-area I and II. Mean catch rates (N/nm2) of** ***Sebastes marinus*** **from Norwegian Coastal Surveys (Division IIa) in 1995-2010 within 100-350 m depth. Catch rates for the total area.**

Length range (cm)	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	# Hauls	Total.Distance (nm)	# Fish Caught	# Fish Sampled	Area (nm^2)
1995	0	41	118	59	54	38	69	214	157	21	2	1	0					
1996	0	34	87	124	151	67	210	415	209	64	0	0	0					
1997	0	4	9	12	64	112	96	178	190	45	2	1	0					
1998	0	0	0	4	12	16	17	110	96	18	3	0	0					
1999	0	0	19	242	160	34	43	151	117	15	4	2	0					
2000	0	0	2	13	7	10	30	160	155	30	4	0	0					
2001	0	0	2	11	14	22	15	83	160	30	2	0	0					
2002	0	0	0	0	2	6	29	259	213	26	4	1	0					
2003	0	0	6	10	43	66	49	219	225	55	6	1	2	123	160	1367	1053	43574
2004	0	1	3	6	21	66	35	351	552	42	3	1	0	104	130	1290	950	43574
2005	0	1	5	5	30	46	48	190	171	37	1	0	0	99	132	833	780	43574
2006	0	0	3	0	2	3	30	145	256	66	9	0	0	112	112	771	680	43574
2007	0	0	0	0	4	7	17	129	177	29	1	0	0	131	140	637	637	43574
2008	0	4	5	1	4	5	17	363	490	99	12	2	0	110	140	1156	850	43574
2009	**0**	0	8	3	10	19	45	808	945	109	14	1	0	109	127	2945	581	43574
2010	**0**	40	78	20	9	1	3	67	214	99	7	2	0	117	136	833	690	43574

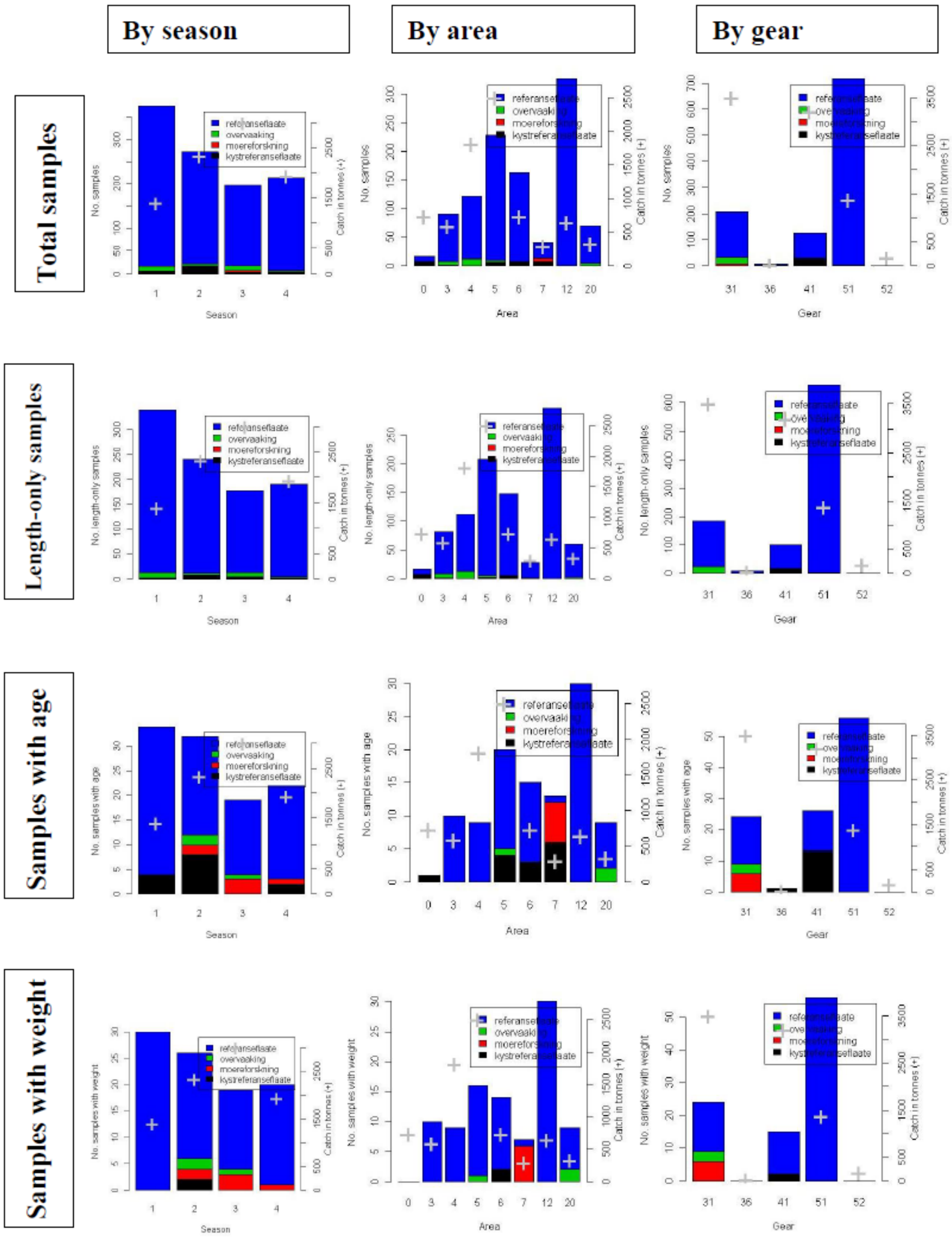


Figure E 1. Overview of the Norwegian biological samples from the commercial fisheries for *S. marinus* in 2010 representing 84% of the catches and which the input data to the Gadget model are based upon. The colors denote which sampling platform has been used: port sampling (red), High Seas Reference fleet (blue), Coastal Reference Fleet (black), inspectors/observers at sea (green). The crosses show the catch in tonnes for the different seasons, areas and gear.

8 Greenland halibut in subareas I and II

An update assessment is presented for this stock. This should be regarded as an exploratory run and just used to view trends in the stock. The work on the age reading problems was addressed at the ICES WKARGH workshop in February 2011 (ICES CM 2011/ACOM:41). Scientists still need time before a thorough benchmark assessment can be carried out. General information about this stock is located in the Quality Handbook.

8.1 Status of the fisheries

8.1.1 Landings prior to 2011 (Tables 8.1 – 8.5, F10)

Nominal catches by country for Subareas I and II combined are presented in Table 8.1. Tables 8.2–8.4 give the catches for Subarea I and Divisions IIa and IIb separately, and landings separated by gear type are presented in Table 8.5. For most countries the catches listed in the tables are similar to those officially reported to ICES. Some of the values in the tables vary slightly from the official statistics, and represents those presented to the Working Group by the members.

The preliminary estimate of the total catch for 2010 is 15,705 t. This is 2,707 t more than catches in 2009 and about 20% more than ICES advised maximum catch for 2010 (13,000 t). The increase in catches in 2010 compared to 2009 are due to increase in Russian catches in accordance to new TAC regulations. Both Norwegian and Russian catches exceeded the TAC set by the joint Russian-Norwegian Fisheries Commission (total TAC 15,000 t). Some fishing for Greenland halibut has taken place in the northern part of Division IVa during the past 20-30 years, varying between a few tonnes and up to 2,500 t in 1999. Since 2005 this catch has been mostly below 100 t, and in 2010 it was 126 t taken mostly by UK (Table F10). This fishery is in another management area, and is not restricted by any TAC regulations. Although there is a continuous distribution of this species from the southern part of Division IIa along the continental slope towards the Shetland area, little is known about the stock structure and the catch taken from this area has therefore not been added to the catch from Subareas I and II.

Around Jan Mayen, small catches of Greenland halibut have been taken in some years. 21 t were reported from this area in 2006, whereas in 2007-2010 no catches were reported. Jan Mayen is within Subarea IIa, but little is known about the relationship with the stock assessed by the Arctic Fisheries Working Group. Catches from this area have therefore not been included in the catches given for Subarea II.

8.1.2 ICES advice applicable to 2010 and 2011

The advice from ICES for 2010 was as follows:

Single-stock exploitation boundaries

The new data (landings, survey and CPUE) available for this stock do not change the perception of the stock and give no reason to change the advice from that given last year in 2008. Therefore, the advice for the fishery in 2010 is the same as the advice given in 2008 for the 2009 fishery: *"The stock has remained at a relatively low size in the last 25 years at catch levels of 15 000–25 000 t. In order to increase the SSB, catches should be kept well below that range. Catches should be below 13 000 t as advised since 2003; this is the level below which SSB has increased in the past"*.

Additionally, ICES notes that the evaluation of this stock is uncertain due to age-reading problems and lack of contrast in the data. The age-reading issue is being addressed and should be resolved in the not too distant future. Corrections to the whole time-series are required.

The advice from ICES for 2011 was as follows:

Advice summary for 2011

The 2009 data (landings, survey and cpue) available for this stock do not change the perception of the stock and give no reason to change the advice from that given in 2009.

The advice for the fishery in 2011 is the same as the advice given in 2009 for the 2010 fishery: "The stock has remained at a relatively low size in the last 25 years at catch levels of 15 000–25 000 t. In order to increase the SSB, catches should be kept well below that range. Catches should be below 13 000 t as advised since 2003; this is the level below which SSB has increased in the past".

Additionally, ICES notes that the evaluation of this stock is uncertain due to age-reading problems and lack of contrast in the data. The age-reading issue is being addressed and should be resolved in the not too distant future. Corrections to the whole time-series are required.

The 38th Session of the Joint Norwegian-Russian Fisheries Commission in 2009 decided to cancel the ban against targeted Greenland halibut fishery and established a TAC at 15 000 t for next three years (2010-2012). The TAC was allocated between Norway, Russia and other countries with shares of 51, 45 and 4% respectively.

Reference points

No reference points are defined for this stock.

8.1.3 Management applicable in 2010 and 2011

The 38th JRNFC's Session in 2009 decided to cancel the ban against targeted Greenland halibut fishery and established the TAC at 15,000 t for next three years (2010-2012).

During fishing for other species, it is permitted to have an intermixture of Greenland halibut of up to 7% by weight on board at the end of fishing operations and in the catch landed. Nevertheless, a bycatch of up to 12% by weight of Greenland halibut is permitted in individual catches.

From early 2004 the Norwegian Ministry of Fisheries and Coastal affairs decided that for Norwegian vessels in the NEEZ allowable bycatch at any time on board and by landing should not exceed 7 %. In addition, the annual catch for each trawler are not allowed to exceed 4 % of the sum of the vessels quota on cod, haddock and saithe, and limited by a maximum annual catch of 40 t pr. vessel.

The Norwegian conventional fleet, vessels smaller than 28 m, are allowed to conduct a target fishery with longlines and gillnets in a limited area in approximately one month each year. For these vessels the TAC is set to 10, 12 and 14 t, dependent of size of the vessel.

Minimum size regulation for Greenland halibut is 45 cm. Bycatch of undersized Greenland halibut shall not exceed 15% by number in each haul.

8.1.4 Expected landings in 2011

Due to new regulation measures established in 2009 for 2010-2012, the total Greenland halibut catch in the Barents Sea and adjacent waters (ICES Subarea I and Divisions IIa and IIb) in 2011 is expected to be about 15,000 t. Discards at present is not regarded as a problem, but it is believed that there may be additional landings that are not reported. The catches from Division IVa are expected to be maintained at a low level (below 100 t).

8.2 Status of research

8.2.1 Survey results (Tables 1.1, F1–F8)

For several years the Working Group was concerned about trends in catchability within individual surveys used for tuning of the XSA. The trends were seen for younger ages of year classes in the late 80's and early 90's that were initially estimated very low in abundance. With increasing age these year classes were estimated much closer to the mean abundance. In previous meetings the Working Group therefore increased the minimum age used in tuning to five years in order to reduce the problem. This only partly solved the problem, and in all subsequent assessments estimated recruitment of the last 2-3 years increased from one year to the next.

Most of the surveys considered by the Working Group covered either the adult population in the slope area or juvenile distribution in northern areas. The problem of underestimation of recruitment in the last few years included in the analyses was attributed to shortcomings in survey coverage. At previous meetings, the Working Group had noted the need for annual surveys that sample most of the population within a short period of time. Prior to the 2002 Working Group meeting, effort was therefore made to combine some of these surveys into a new total index. The new index was termed the Norwegian Combined Survey Index and was established back to 1996, the first year with survey coverage northeast of Svalbard. It includes bottom trawl indices from the Norwegian bottom trawl survey in August in the Barents Sea and Svalbard (Tables F1 and F2), the Norwegian Greenland halibut survey in August along the continental slope (Table F3), and the Norwegian bottom trawl survey in August-September north and east of Svalbard that now is a part of the Barents Sea ecosystem survey ICES acronym*: Eco-NoRu-Q3 (Btr)* (Table F4). With exception of the Norwegian Greenland halibut survey, all these surveys were from 2004 conducted as one major joint survey between Norway and Russia. Prior to the meeting in 2003, work was done to evaluate the combination of these survey series into one index, and this was reported to the Working Group (Pennington, WD 5#2003). Based on these results it was decided to use the combined index in the assessment. Although representing a larger part of the stock, the new combined survey indices were not successful in establishing consistency in the relative size of year classes at age. Future inclusion of northern parts of the Russian zone may improve the index. The Working Group has later advised that further work should be done to improve the combined index with regards to pooling different surveys using different gears.

Also in the Russian bottom trawl surveys in October-December (ICES acronym: *RU-BTr-Q4*) (Table F6) it has been difficult to identify year classes that appear consistently either strong or weak across ages. In previous Working Group reports this survey series was the one with the clearest and strongest trends in catchability with age in the XSA calibrations. These surveys 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 and 2003 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.

The Norwegian CPUE survey (Table F9) was stopped from 2005. This was one of the tuning fleets, but an evaluation of this survey revealed a lot of inconsistencies in the series. Since 2006, none of the age structured tables of the Norwegian surveys have been updated due to changes in the age reading procedure.

During the last ten years before the Norwegian CPUE survey ended in 2006 there was a slowly increasing trend in biomass estimates in this series. Total biomass index from Russian autumn survey showed a slowly increasing trend from 1992 to 2005 but has shown a sharply increasing trend since then (Figure 8.4). The biomass indices of mature females from different surveys showed a slight upward trend in last years (Figure 8.5).

Total biomass indices from the Norwegian autumn slope survey (ICES acronym: *NO-GH-Btr-Q3*) has shown an upward trend in biomass estimates between 1994 and 2003, then a downward trend until 2008 untll it increased again in 2009 (Figure 8.6). The length distributions from this survey show modes that can be followed through the years with marked change between 2006 and 2007. This survey was not conducted in 2010, but will be continued biennially starting in 2011.

The Spanish bottom trawl survey from 1997 to 2005 (Table F7), ICES acronym: *SP-Svalbard-Q4*, showed an increase of Greenland halibut abundance and biomass in the Svalbard-Bear Island area from 2002 after three years with a declining trend. From 2008 the Spanish autumn survey is carried out on a new hired commercial trawler vessel and some changes have been done in the initial standard protocol. One of the most important changes is the increasing of the bridle's length now being 300 m instead of 175 m before 2008. This new features increased the swept area in the trawl stations making the comparison of the biomass and abundance index before and after 2008 difficult. The biomass index in 2010 has increased compared to the 2008 index. Effort should be made to see if it is possible to recalculate the index for 1997 to 2005 to be comparable to 2008 and 2010 values (WD#12).

Polish bottom trawl surveys on Greenland halibut were carried out in the Svalbard-Bear Island area (ICES IIb) in October 2006, April 2007, April 2008, June 2009 and March 2011. The main objectives of the survey are to determine the biological structure, distribution, density and standing biomass of Greenland halibut in the survey area. In the future this new survey probably can be treated as an additional tuning series.

Abundance indices of 0-group Greenland halibut are shown in Table 1.1. The increase in 0-group abundance after 1996 seems to have stopped, and the 2007-2010 indices were very low. It should be noted that the Ecosystem survey is not optimal for surveying 0-group Greenland halibut.

Based on the decision of the 34th session of the Joint Russian-Norwegian Fisheries Commission (JRNFC), a joint research program aimed at improvement of Greenland halibut stock assessment methods and elaboration of optimal management strategy was developed at the meeting of PINRO and IMR scientists (21-27 March 2006). The research program was structured in six sub-projects and run for the three years 2007-2009, and final results were reported to the JRNFC by their meeting in October 2010. The final report (Albert et al. 2010) gives a brief description of the main findings from the three-year program and summarizes the present level of knowledge within each of the six sub-projects. The work has been organized in two main projects, one at each institution, led by O. Smirnov and O.T. Albert, respectively. The subprojects were:

1) Subproject on age determination
2) Subproject on improving survey methods and aggregation of data from different surveys
3) Subproject on pelagic occurrence
4) Subproject on sexual dimorphism and effects of fisheries on population structure
5) Subproject on improving methods of stock assessment
6) Subproject on developing optimal long-term harvesting strategy

Some of the results are already published in international refereed journals, while other are intended for publication. This represents important quality controls of the conclusions that can be made on basis of the activities of the research program. Some of the conclusions presented in thie report should therefore be considered as preliminary until final publication. Some of the research themes covered by the research program are also included in other scientific processes within ICES and NAFO, and these may lead to new or updated understanding on important aspects (e.g. on migration and connectivity, and on age and growth). Moreover scientists and students in both countries will continue to use data sampled during the program period in future work. However, results from this program should be included in evaluation of the NEA Greenland halibut stock assessment.

8.2.2 Commercial catch-per-unit-effort (Table 8.6 and F9)

The CPUE from the experimental fishery was found to be considerably higher than in the traditional fishery and exhibited an increasing trend from 1992–1996. After 1996 the Norwegian CPUE series varied between 1200 and 1800 kg/h with the highest value in 2005 (Table F9). The Norwegian CPUE survey was terminated in 2006. The Russian experimental CPUE series shows an increasing trend since 1997, and this series shows the highest value in 2003. A significant decline was observed in 2004-2008 (Table 8.6) and in 2009 the indices jump up again. Results of the Russian commercial trawl fishery in 2010 showed high level of CPUE in comparison with 1975-1990, but comparisons of commercial CPUE between periods several decades apart may probably not be valid because of the ‘technology creep’ in fisheries (Table 8.6).

When comparing the CPUE between years the effort level should also be taken into account.

8.2.3 Age readings

Based on scientific presentiment that the species is more slow growing and vulnerable than the previous age readings suggest, the Norwegian age reading 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) was presented to the meeting. Several age reading methods for Greenland Halibut were described and evaluated together with available validation and corroboration results.

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 (Figure 8.8).

Information concerning validation and corroboration techniques was reviewed by WKARGH. There is still work to be done to determine the best methods, although considerable progress has been made.

AFWG plans to follow the recommendations of WKARGH and study the influence of different age reading methods on stock assesment results.

8.3 Data used in the assessment

Based on the arguments in Section 8.2.1 the Working Group also this year considers the survey indices for ages below age 5 not appropriate for inclusion in the tuning data. Consequently, a standard XSA was run for age 5 and above.

8.3.1 Catch-at-age (Table 8.7)

The catch-at-age data for 2009 were updated using revised catch figures. Catch-at-age data for 2006-2010 were available only from the Russian fisheries. The Russian age-length keys were used to allocate catches from the other countries by age groups. Also Norwegian catches were alocated using Russian ALKs along with Norwegian length distributions. Total international catch-at-age is given in Table 8.7. Greenland halibut are usually caught in the range of 3–16 years old, but the catch is mainly dominated by ages 6–10. Generally, fish older than age 10 comprise a low proportion of the catches.

8.3.2 Weight-at-age (Table 8.8)

For the years 1964-1969 separate weight-at-age data were used for the Norwegian and the Russian catches. Both data sets were mean values for the period and were combined as a weighted average for each year. A constant set of weight-at-age data was used for the total catches in the years 1970–1978. For subsequent years annual estimates were used. The Russian weight-at-age data was used in the catch in 2006-2010 (Table 8.8). The weight-at-age in the stock was set equal to the weight-at-age in the catch for all years.

8.3.3 Natural mortality

Natural mortality of Greenland halibut was set to 0.15 for all ages and years. This is the same assumption as was used in previous years.

8.3.4 Maturity-at-age (Tables 8.9)

Annual ogives were derived to estimate the spawning stock biomass based on females only using Russian survey data for the years 1984-2010, except for the year 1991. An average ogive computed for 1984–1987 was applied to 1964–1983. The average of 1990 and 1992 was used to represent the maturity ogive for 1991. For 1984-2002 and 2004-2009 a three-year running average was applied. In previous assessments a similar procedure using the same data set was implemented but was based on sexes combined. The ogive for 2003 was rejected due to the problems with the Russian survey mentioned above (Section 8.2.1) and the data used was the mean value for 2002 and 2004. A decrease was observed in maturation rates in the last few years compared to the previous times. Therefore the ogive for 2010 was constructed as mean for 2009-2010.

8.3.5 Tuning data

The XSA was run with the same tuning series as used in last year's assessment:

Fleet 4: Experimental commercial fishery CPUE from 1992–2005 for ages 5–14.

Fleet 7: Russian trawl survey from 1992-2010 for ages 5-14. The 2002 and 2003 data was not included in this series due to the problems mentioned in section 8.2.1

Fleet 8: Norwegian Combined Survey from 1996-2005 for ages 5-15.

The software XXSA.exe was used.

8.4 Recruitment indices (Tables A14, F1–F9)

In addition to the indices mentioned in Section 8.3.5, all surveys in Section 8.2.1 may provide information on recruitment. However, because the dynamics of migration and distribution patterns are not well understood for this stock, it is not known which age should be used for a reliable recruitment estimate. As outlined in previous Working Group reports there is no longer evidence for a major recruitment failure in the 1990's. Nevertheless, the relative size of the individual year classes is still poorly estimated, especially at ages below 5 years.

8.5 Methods used in the assessment

8.5.1 VPA and tuning (Figure 8.1, Tables 8.7–8.10)

The Extended Survivors Analysis (XSA) was used to tune the VPA to the fleets as mentioned in Section 8.3.5. The analyses used survivor estimates shrunk towards the mean of the final 2 years and 5 ages and the standard error of the mean to which the estimates were shrunk was set to 0.5. The catchability was considered to be independent of stock size for all ages and independent of age for ages 10 and older. These are the same settings as used in last years assessment.

Input data and diagnostics of the final XSA run are given in Tables 8.7-8.10 and log catchability residuals for the three fleets used in the tuning are shown in Figure 8.1.

8.6 Results of the Assessment

The diagnostics of the assessment indicate that it is generally unbiased, and describes the trend in stock development reasonably well. The survivor estimates for 2010 for most of the important year classes are determined primarily from the tuning fleet data and in most instances each tuning fleet contributes significantly to the determinations with little effect from inclusion of F shrinkage means in the tuning process. Nevertheless, the assessment diagnostics also indicated substantial uncertainties in absolute values of the survivor estimates determined by the analysis shown by instances of very high residuals, large S.E. (log q)'s and low R^2's in the regression statistics for certain fleets and ages.

8.6.1 Results of the VPA (Figure 8.2, Tables 8.11–8.15)

The fishing mortality (F) matrix indicates that historically Greenland halibut were fully recruited to the fishery at approximately age 6–7 with F>0.2 for older ages, and F>0.5 in many cases. Since 1991 the age of full recruitment appears closer to age 10 (Table 8.11). This is likely due to a substantial proportional reduction in trawler effort since 1991 combined with reduced catchability of some year classes in the fishing areas. Trawlers catch more young fish compared to gillnetters and longliners. Nevertheless, F on ages 6–10 continues to represent the average fishing mortality on the major age groups prosecuted by the fishery. In 2010 F<=0.2 for all ages included in the analysis (5-15 years).

Until 1976 the female spawning stock estimates varied between 60,000 and 140,000 t, then it was relatively stable at around 40,000 t until the mid 1980's after which it declined markedly. It reached an all time low of 14,800 t by 1995-96 but has been increasing since then to an estimate of 59,000 t by 2004, which is the highest value estimated since 1976 and higher than the long-term average for the whole period 1964-2009. The female spawning stock has decreased in 2005-2009 and increased again in 2010. The total stock decreased from 312,000 t in 1970 to the historical minimum at 46,000 t in 1992 and then shows a positive trend with the highest estimates at about 211,000 t in 2010. The maturity ogives used has shown a very variable maturity by age in the recent years and this affects the SSB.

Prior to the reduction in the early 1990's the fishing mortality had increased continuously for more than a decade and peaked in 1991 at 0.65. The high catch in 1999 resulted in an increase in fishing mortality to 0.34 but has since then declined to 0.14-0.15 by 2002 and 2003. Due to the increased catch in 2004-2006 the fishing mortality again slightly increased (0.17-0.18) but remained lower than average. For the 2010 Fbar was estimated at 0.06 which is the lowest level estimated for all years in the analysis.

Recruitment-at-age 5 in this year assessment shows a marked increase from 2007 to 2009. The 2009 level of 49 millions specimens is about twice the long-term average (Table 8.15). In 2010 the Recruitment-at-age 5 is 32 millions.

8.6.2 Biological reference points

Given the continuing levels of uncertainty in the current assessment no further attempts were made to develop reference points for this stock.

8.6.3 Catch options for 2012

Given the uncertainty around the absolute values of population size at age no catch options are provided.

8.7 Comparison of this year's assessment with last year's assessment

Compared to last year assessment stock size for 2010 has increased while SSB has been slightly reduced, fishing mortality remained at nearly the same level.

	Total stock (5+) by 1 January 2010	SSB by 1 January 2010	F6–10 in 2010	F6–10 in 2009
WG 2010	200143*	74283*	0.07*	0.08
WG 2011	211384	70846	0.06	0.08

*prediction

8.8 Comments to the assessment (Figures 8.3 – 8.7)

The assessment was classified as an update assessment. The current assessment was using the same catch matrix, surveys series and settings as in the previous year with updated data for 2009 and new data for 2010. Fishing mortalities tend to be overestimated while SSB tends to be underestimated in the assessment year as illustrated by the retrospective plots in Figure 8.3. Fishing mortality is rather stable during the last three years.

The assessment is still considered to be uncertain due to the age-reading and input data quality problems. Nevertheless the assessment may be accepted as indicative for stock trends. Although many aspects of the assessment remain uncertain, most fishery independent indices of stock size indicate positive trends in recent years. The biomass indices from the two Norwegian survey series seem to level out in later years (Figure 8.4).

The main result from the assessment is that the total stock has an increasing trend since 1992 and this is also seen in the SSB from 1995 to 2004. In 2004-2009 the SSB show a decreasing signal, whereas it has a significant increase in 2010. The estimate of the SSB is based on maturity ogives from the Russian survey.

Other sources for stock trends beside the exploratory XSA analyses are abundance indices from surveys. Biomass indices of mature females from the Norwegian survey in the slope area (main adult area) shows upward trend in 1994-2003 and then a downward trend until 2008, but showed increase in 2009 (Figure 8.5). SSB estimates from the Russian October-December survey show a general increase in mature female biomass between 1996 and 2010. Total biomass index from Russian autumn survey showed slowly increasing trend from 1992 to 2005 but has shown sharply increasing trend since then (Figure 8.4). It should be mentioned that this survey is the only tuning series with data after 2005, when Norway stopped to update age data, and the XSA results are thus not independent on the results from this survey. Total biomass indices from the Norwegian autumn slope survey has showd an upward trend in biomass estimates between 1994 and 2003, then a downward trend until 2008 until it increased again in 2009 (Figure 8.6). Noticably the abundance in numbers in this survey has showed a marked increase since 2006, reflecting increased proportion of smaller fish in the survey length distributions (Figure 8.6 and 8.7). The length distributions also show modes that can be followed through the years in this survey with marked change towards smaller fish between 2006 and 2007.

Presentations was given on working document considering potential catch of Greenland halibut (Bulatov 2011 WD 22) based on the Russian GIS method, results from the Russian trawl surveys and the exploratory XSA analysis. The working documents notes positive trends in these indicators in resent years regarding growth of the stock. The GIS method on Greenland halibut was discussed in last year's AFWG report and some serious methodological limitations were commentet. The method has not been further developed since last year.

The Working group have stated in several previous reports that catches above the mean in the period 1992-2003 (ca. 13,000 t) reduces the stocks ability to rebuild. Ever since catches were reduced by regulations in 1992 the available stock indices have in general shown increasing trend, and some indexes show strong increase in most recent years. For this long lived species this increase in recent years is a positive sign regarding recruitment into the fisheries.

Average catch during the period 2004-2010 was approximately 16,000 t. At the same time most of the monitored population parameters in general showed positive trends. This supports that such catch level is at least not harmful for the NEA stock.

8.9 Further work on assessment methods

The evaluation of the NEA Greenland halibut stock is uncertain due to age-reading problems and lack of contrast in the data, as also reflected in recent AFWG reports. However, age structured assessment should be the goal for this stock considering data availability and economical importance. This allows for recruitment variability and cohort dynamics to be considered, which would be lost in the less data demanding surplus biomass models. Additionally the peculiar biology for the species needs to be taken into account, such as sexual dimorphism in growth and maturation also noted in the Report on 3-year (2007-2009) joint research program (Albert et al. 2010). This dimorphism will affect both stock assessment, reference points and optimal exploitation pattern.

To revise accepted analytical age structured assessment requires recalculations of catch and survey data back in time that incorporates changes in growth functions. The recent WKARGH workshop recommends: "To reduce the number of fish that will have to be aged for stock assessments, we recommend that carefully constructed and validated growth models be developed for each stock. Using currently available and accepted mixture models, population numbers at age to be use in assessment working groups may be constructed by decomposing length frequency distributions. Such an approach would eliminate the need for routine annual ageing until such time as the population growth rate changes appreciably." (WKARGH recommendation 3, see also in section 8.2.3). This approach can be used to establish best possible available growth model for NEA Greenland halibut to use along with length frequency distributions and some assumptions on variation to reconstruct age specific input matrices back in time. This should be programed in such way that it is easy to compare effect of different growth functions on assessment outputs, including reference points. Preferably an assessment model approach that copes with uncertainty in commercial catch and survey data should be used.

An option that was examined at the meeting and might be useful to achive preliminary reference points is Y/R analysis done separatly for each sex, and for combined sexes. Such analysis could examine effect of different growth functions on estimates of $F_{0.1}$ and SSB/R, and might be possible to accomplish using existing data. It was not possible to complete this analysis within the timeframe of the 2011 AFWG meeting.

All points mentioned above in this subchapter need to be carefully explored and disscussed by experts in order to investigate the possibility of using any new approaches as helpful tools but not as sources of additional uncertainties.

The respective national institutes (IMR, PINRO) need to focus effort to address this challenge before next years AFWG meeting, in particular by making all relevant survey and catch data available by length and sex. Additionally analysis and programming resources need to be made available.

A fixed quota for this stock was agreed by JRNFC for the period 2010-2012. It is urgent with new assessment methods to provide as good assessments and advice as possible at ICES AFWG 2012 to support management decisions for 2013.

8.10 Response to ACOM technical minutes

Comments from 2010 review group and technical minutes

General comments

This was a well ordered and well considered section. There might be some extensive detailing in the assessment report, and parts of this could with advantage be moved to the Stock Annex. The assessment and its results was easy to follow and to interpret. Due to age reading uncertainties as well as uncertainties in recruitment and maturity estimates, the stock assessment and advice is uncertain. The variability in these biological parameters has to be explored further in order to revise estimates for a future benchmark assessment.

Technical comments

There are still retrospective patterns in the assessment. Fishing mortalities tend to be overestimated while SSB tends to be underestimated, and recruitment tends to be overestimated in some recent years.

Retrospective patterns appear in the most of stock's assessments.

Exploratory runs of XSA have shown that there is high sensitivity in the assessment in relation the XSA parameter settings.

This was studied in a working dokument 2010 (Hallfredsson WD 18, 2010) but was not examined further in 2011. The issue should be adressed in revision of stock assessment methods.

Little is known about stock structure, stock delineation, distribution, and migration dynamics of the stock among other into other management areas. There is uncertainty concerning potential exchange between the Greenland halibut stock in the Northeast Arctic and another stock in the Faeroe Islands- Iceland area and Greenland.

Ongoing genetic studies and tagging experiements will better iluminate stock structure and distribution. Preliminary results from these studies were presented in the final report from the joint Russian/Norwegian research program (Albert et al. 2010).

The age structured tables of the Norwegian surveys have not been updated since 2006, due to change in age reading procedure as well as because of great problems and uncertainty in age reading. The new Norwegian age readings are not comparable with older data or the Russian age readings. This also influences estimates of recruitment and the maturity ogive significantly where the latter at present show very much variability. This needs to be considered and solved before a thorough benchmark assessment can be carried out. Age reading is addressed in the joint research program, and in a workshop in 2010. This will eventually end up in a total revision of the input data to the assessment. Russian age-length keys were used in the total catch matrix.

See discussion in section 8.2.3 and 8.9.

It remains unknown which age should be used for a reliable recruitment estimate. The WG evaluates that shortcomings in estimation of recruitment is partly due to survey coverage. Future inclusion of northern parts of the Russian zone may improve the index.

At the present analysis recruitment is at age 5 (see discussion in section 8.3). Survey results in later years have shown that the juvenile area extends eastward to northern Kara Sea.

There are trends in catchability within individual surveys used for tuning of the XSA. Tuning time series for Norwegian surveys do not include the recent years from 2005 due to age reading problems.

See discussion in section 8.9

The assumption of M = 0.15 needs to be explained. Additionally, the proportion of natural mortality before spawning is set to 0. This also needs some explanation.

All these and others questions should be answered at the benchmark meeting.

Response to ACFM technical minutes: The technical review from last year has not been commented on by the WG.

Conclusions

The ongoing age reading issue needs to be solved, and age reading revisions need to be completed before a reliable stock assessment can be performed. Age reading problems are the main concern for the assessment. There is an urgent need that this is solved and consensus on age readings are reached – among other through the 2011 age reading workshop. This is needed among other to have reliable recruitment and maturity estimates as well as reliable catch number and weight at age matrices to be used in the assessment. Also, it is needed in order to include the more recent Norwegian survey tuning time series in the assessment.

In general there is a large uncertainty about the stock size so that conservative measures concerning fishing pressure on this stock are appropriate.

Table 8.1. GREENLAND HALIBUT in Sub-areas I and II. Nominal catch (t) by countries (Sub-area I, Divisions IIa and IIb combined) as officially reported to ICES.

Year	Denmark	Estonia	Faroe Isl.	France	Fed. Rep. Germany	Gre enland	Ice land	Ire land	Lithu ania	Norway	Poland	Portugal	Russia[4]	Spain	UK (England & Wales)	UK (Scotland)	Total
1984	0	0	0	138	2,165	0	0	0	0	4,376	0	0	15,181	0	23	0	21,883
1985	0	0	0	239	4,000	0	0	0	0	5,464	0	0	10,237	0	5	0	19,945
1986	0	0	42	13	2,718	0	0	0	0	7,890	0	0	12,200	0	10	2	22,875
1987	0	0	0	13	2,024	0	0	0	0	7,261	0	0	9,733	0	61	20	19,112
1988	0	0	186	67	744	0	0	0	0	9,076	0	0	9,430	0	82	2	19,587
1989	0	0	67	31	600	0	0	0	0	10,622	0	0	8,812	0	6	0	20,138
1990	0	0	163	49	954	0	0	0	0	17,243	0	0	4,764[2]	0	10	0	23,183
1991	11	2,564	314	119	101	0	0	0	0	27,587	0	0	2,490[2]	132	0	2	33,320
1992	0	0	16	111	13	13	0	0	0	7,667	0	31	718	23	10	0	8,602
1993	2	0	61	80	22	8	56	0	30	10,380	0	43	1,235	0	16	0	11,933
1994	4	0	18	55	296	3	15	5	4	8,428	0	36	283	1	76	2	9,226
1995	0	0	12	174	35	12	25	2	0	9,368	0	84	794	1 106	115	7	11,734
1996	0	0	2	219	81	123	70	0	0	11,623	0	79	1,576	200	317	57	14,347
1997	0	0	27	253	56	0	62	2	0	7,661	12	50	1,038	157[2]	67	25	9,410
1998	0	0	57	67	34	0	23	2	0	8,435	31	99	2,659	259[2]	182	45	11,893
1999	0	0	94	0	34	38	7	2	0	15,004	8	49	3,823	319[2]	94	45	19,517
2000	0	0	0	45	15	0	16	1	0	9,083	3	37	4,568	375[2]	111	43	14,297
2001	0	0	0	122	58	0	9	1	0	10,896[2]	2	35	4,694	418[2]	100	30	16,365
2002	0	219	0	7	42	22	4	6	0	7,011[2]	5	14	5,584	178[2]	41	28	13,161
2003	0	0	459	2	18	14	0	1	0	8,347[2]	5	19	4,384	230[2]	41	58	13,578
2004	0	0	0	0	9	0	9	0	0	13,840[2]	1[2]	50	4,662	186[2]	43	0	18,800
2005	0	170	0	32	8	0	0	0	0	13,011[3]	0[2]	23	4,883	660[2]	29	18	18,834
2006	0	0	204	46	8	0	8	0	196	11,119[3]	201[2]	26[2]	6,055	27[2]	6	0	17,897
2007[1]	0	0	203	40	8	0	15	+	0	8,229[3]	200[2]	47[2]	6,484	11[2]	0	0	15,237
2008[1]	0	0	640	42	5	0	28	0	0	7,394[3]	201	46[2]	5,294	112	16	0	13,778
2009[1]	0	0	422	16	19	0	0	0	0	8,446[3]	204	239	3,335	210[2]	69	0	12,996
2010[1]	0	0	271	102	14	0	0	0	0	8,210[3]	0	11	6,888	182[2]	26	0	15,704

[1] **Provisional figures.**

[2] **Working Group figures.**

[3] **As reported to Norwegian authorities.**

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

TABLE 8.2. GREENLAND HALIBUT in Sub-areas I and II. Nominal catch (t) by countries in Sub-area I as officially reported to ICES.

Year	Estonia	Faroe Islands	Fed. Rep. Germany	France	Greenland	Iceland	Ireland	Norway	Poland	Portugal	Russia[4]	Spain	UK (E & W)	UK (Scot.)	Total
1984	-	-	-	-	-	-	-	593	-	-	81	-	17	-	691
1985	-	-	-	-	-	-	-	602	-	-	122	-	1	-	725
1986	-	-	1	-	-	-	-	557	-	-	615	-	5	1	1,179
1987	-	-	2	-	-	-	-	984	-	-	259	-	10	+	1,255
1988	-	9	4	-	-	-	-	978	-	-	420	-	7	-	1,418
1989	-	-	-	-	-	-	-	2,039	-	-	482	-	+	-	2,521
1990	-	7	-	-	-	-	-	1,304	-	-	321[2]	-	-	-	1,632
1991	164	-	-	-	-	-	-	2,029	-	-	522[2]	-	-	-	2,715
1992	-	-	+	-	-	-	-	2,349	-	-	467	-	-	-	2,816
1993	-	32	-	-	-	56	-	1,754	-	-	867	-	-	-	2,709
1994	-	17	217	-	-	15	-	1,165	-	-	175	-	+	-	1,589
1995	-	12	-	-	-	25	-	1,352	-	-	270	84	-	-	1,743
1996	-	2	+	-	-	70	-	911	-	-	198	-	+	-	1,181
1997	-	15	-	-	-	62	-	610	-	-	170	-[2]	+	-	857
1998	-	47	+	-	-	23	-	859	-	-	491	-[2]	2	-	1,422
1999	-	91	-	-	13	7	-	1,101	-	-	1,203	-[2]	+	-	2,415
2000	-	-	+	-	-	16	-	1,021	+	-	1,169	-[2]	1	-	2,206
2001	-	-	-	-	-	9	-	925[2]	+	-	951	-[2]	2	-	1,887
2002	-	-	3	-	-	+	-	791[2]	-	-	1,167	-[2]	+	-	1,961
2003	-	48	+	+	2	+	1	949[2]	1	-	735	+[2]	+	+	1,736
2004	-	-	-	-	-	+	-	812[2]	-	-	633	-[2]	3	-	1,449
2005	-	-	-	1	-	-	-	572[3]	-	-	595	-[2]	3	-	1,171
2006	-	17	1	-	-	1	-	575[3]	-	-	626	-[2]	2	-	1,222
2007[1]	-	18	+	+	+	3	-	514[3]	-	-	438	+	+	-	973
2008[1]	-	12	-	1	-	5	-	599[3]	-	-	390	-	-	-	1,007
2009[1]	-	33	-	-	-	-	-	734[3]	-	2	483	-	-	-	1,274
2010[1]	-	15	0	-	-	-	-	1036[3]	-	-	708	2[2]	-	-	1,760

[1] Provisional figures.

[2] Working Group figures.

[3] As reported to Norwegian authorities.

[4] USSR prior to 1991.

Table 8.3. GREENLAND HALIBUT in Sub areas I and II. Nominal catch (t) by countries in Division IIa as officially reported to ICES.

Year	Estonia	Faroe Islands	Fed. Rep. Germ.	France	Greenland	Iceland	Ireland	Norway	Poland	Portugal	Russia[5]	Spain	UK (E & W)	UK (Scot.)	Total
1984	-	-	265	138	-		-	3,703	-	-	5,459	-	1	-	9,566
1985	-	-	254	239	-		-	4,791	-	-	6,894	-	2	-	12,180
1986	-	6	97	13	-		-	6,389	-	-	5,553	-	5	1	12,064
1987	-	-	75	13	-		-	5,705	-	-	4,739	-	44	10	10,586
1988	-	177	150	67	-		-	7,859	-	-	4,002	-	56	2	12,313
1989	-	67	104	31	-		-	8,050	-	-	4,964	-	6	-	13,222
1990	-	133	12	49	-		-	8,233	-	-	1,246[2]	-	1	-	9,674
1991	1,400	314	21	119	-		-	11,189	-	-	305[2]	-	+	1	13,349
1992	-	16	1	108	13[4]		-	3,586	-	15[3]	58	-	1	-	3,798
1993	-	29	14	78	8[4]		-	7,977	-	17	210	-	2	-	8,335
1994	-	-	33	47	3[4]		4	6,382	-	26	67	+	14	-	6,576
1995	-	-	30	174	12[4]		2	6,354	-	60	227	-	83	2	6,944
1996	-	-	34	219	123[4]		-	9,508	-	55	466	4	278	57	10,744
1997	-	-	23	253	-[4]		-	5,702	-	41	334	1[2]	21	25	6,400
1998	-	-	16	67	-[4]		1	6,661	-	80	530	5[2]	74	41	7,475
1999	-	-	20	-	25[4]		2	13,064	-	33	734	1[2]	63	45	13,987
2000	-	-	10	43	-[4]		+	7,536	-	18	690	1[2]	65	43	8,406
2001	-	-	49	122	-[4]	9	1	8,740	-	13	726	5[2]	56	30	9,751
2002	-	-	9	7	22[4]	4	-	5,780[2]	-	3	849	-[2]	12	28	6,714
2003	-	390	5	2	12[4]	+	+	6,778[2]	+	10	1,762	14[2]	5	58	9,036
2004	-	-	4	-	-[4]	9	-	11,633[2]	-	24	810	4[2]	1	-	12,485
2005	-	-	3	31	-[4]	-	-	11,216[3]	-	11	1,406	+	5	18	12,690
2006	-	175	-	38	-	7	-	8,897[3]	-[2]	6	950	+	2	-	10,075
2007[1]	-	162	2	37	+	12	-	6,760[3]	-[2]	2	489[2]	-	+	+	7,463
2008[1]	-	626	4	38	-	23	-	5,566[3]	1	1	1,170	3	16	-	7,448
2009[1]	-	379	+	14	4	10	-	6,456[3]	-	9	1,531	-	60	-	8,464
2010[1]	-	255	-	102	-	-		5,676[3]	-	+	4,757	+	22	-	10,813

[1]Provisional figures. [2]Working Group figure. [3]As reported to Norwegian authorities.

[4]Includes Division Iib. [5] USSR prior to 1991.

Table 8.4. GREENLAND HALIBUT in Sub-areas I and II. Nominal catch (t) by countries in Division IIb as officially reported to ICES.

Year	Denmark	Estonia	Faroe Isl.	France	Fed. Rep. Germ.	Ireland	Lithua-nia	Norway	Poland	Portugal	Russia[4]	Spain	UK (E&W)	UK (Scot.)	Total
1984	-	-	-	-	1,900	-	-	80	-	-	9,641	-	5	-	11,626
1985	-	-	-	-	3,746	-	-	71	-	-	3,221	-	2	-	7,040
1986	-	-	36	-	2,620	-	-	944	-	-	6,032	-	+	-	9,632
1987	+	-	-	-	1,947	-	-	572	-	-	4,735	-	7	10	7,271
1988	-	-	-	-	590	-	-	239	-	-	5,008	-	19	+	5,856
1989	-	-	-	-	496	-	-	533	-	-	3,366	-	-	-	4,395
1990	-	-	23[2]	-	942	-	-	7,706	-	-	3,197[2]	-	9	-	11,877
1991	11	1,000	-	-	80	-	-	14,369	-	-	1,663[2]	132	+	1	17,256
1992	-	-	-	3[2]	12	-	-	1,732	-	16	193	23	9	-	1,988
1993	2[3]	-	-	2[3]	8	-	30[3]	649	-	26	158	-	14	-	889
1994	4	-	1[3]	8[3]	46	1	4[3]	881	-	10	41	1	62	2	1,061
1995	-	-	-	-	5	-	-	1,662	-	24	297	1,022	32	5	3,047
1996	+	-	-	-	47	-	-	1,204	-	24	912	196	39	+	2,422
1997	-	-	12	-	33	2	-	1,349	12	9	534	156[2]	46	+	2,153
1998	-	-	10	-	18	1	-	915	31	19	1,638	254[2]	106	4	2,996
1999	-	-	3	-	14	-	-	839	8	16	1,886	318[2]	31	-	3,115
2000	-	-	-	2	5	-	-	526	3	19	2,709	374[2]	46	-	3,685
2001	-	-	-	+	9	-	-	1,231[2]	2	22	3,017	413[2]	42	-	4,736
2002	-	219	-	+	30	6	-	440[2]	5	11	3,568	178[2]	29	-	4,486
2003	+	+	21	-	13	-	-	620[2]	4	9	1,887	216	35	+	2,805
2004	-	-	-	-	5	-	-	1,395[2]	1	26	3,219	182[2]	39	-	4,866
2005	-	170	-	-	5	-	-	1,223[3]	-	12	2,882	660[2]	21	-	4,973
2006	-	-	12	8	7	-	196	1,647[3]	201[2]	20	4,479	27[2]	2	-	6,600
2007[1]	-	-	23	3	6	+	-	955[3]	200[2]	45	5,557	11[2]	+	+	6,800
2008[1]	-	-	2	3	1	-	-	1,229[3]	200	45	3,734	109	0	-	5,323
2009[1]	-	-	10	-	19	2	-	1,256[3]	204	228	1,321	210[2]	8	-	3,259
2010[1]	-	-	1	-	14	-	-	1,497[3]	-	11	1,423	180[2]	4	-	3,130

[1]Provisional figures.

[2]Working Group figure.

[3]As reported to Norwegian authorities.

[4] USSR prior to 1991.

Table 8.5. GREENLAND HALIBUT in the Sub-areas I and II. Landings by gear (tonnes). Approximate figures, the total may differ slightly from Table 8.1

Year	Gillnet	Longline	Trawl	Danish seine	Onher	Total
1980	1 189	336	11 759			13 284
1981	730	459	13 829			15 018
1982	748	679	15 362			16 789
1983	1 648	1 388	19 111			22 147
1984	1 200	1 453	19 230			21 883
1985	1 668	750	17 527			19 945
1986	1 677	497	20 701			22 875
1987	2 239	588	16 285			19 112
1988	2 815	838	15 934			19 587
1989	1 342	197	18 599			20 138
1990	1 372	1 491	20 325			23 188
1991	1 904	4 552	26 864			33 320
1992	1 679	1 787	5 787			9 253
1993	1 497	2 493	7 889			11 879
1994	1 403	2 392	5 353			9 148
1995	1 500	4 034	5 494			11 028
1996	1 480	4 616	7 977			14 073
1997	998	3 378	5 198			9 574
1998	1 327	3 891	6 664			11 882
1999	2 565	6 804	10 177			19 546
2000	1 707	5 029	7 700			14 437
2001	2 041	6 303	7 968			16 312
2002	1 737	5 309	6 115			13 161
2003	2 046	5 483	6 049			13 578
2004	2 290	7 135	8 778	599		18 801
2005	1 842	7 539	9 420	447		19 248
2006	1 503	6 146	10 042	205		17 896
2007	997	4503	9 618	119		15 237
2008	901	3575	9 285	9	8	13 778
2009	1 409	4 952	6 583	34	18	12 996
2010	1 449	5 402	8 672	170	10	15 704

Table 8.6. GREENLAND HALIBUT in Sub-areas I and II. Catch per unit effort and total effort.

Year	USSR catch/hour trawling (t)		Norway[10] catch/hour trawling (t)		Average CPUE		Total effort (in '000 hrs trawling)[5]	CPUE 7+[6]	GDR[7] (catch/day tonnage (kg)
	RT[1]	PST[2, 12]	A[8]	B[9]	A[3]	B[4]			
1965	0.80	-	-	-	0.80	-	-	-	-
1966	0.77	-	-	-	0.77	-	-	-	-
1967	0.70	-	-	-	0.70	-	-	-	-
1968	0.65	-	-	-	0.65	-	-	-	-
1969	0.53	-	-	-	0.53	-	-	-	-
1970	0.53	-	-	-	0.53	-	169	0.50	-
1971	0.46	-	-	-	0.46	-	172	0.43	-
1972	0.37	-	-	-	0.37	-	116	0.33	-
1973	0.37	-	0.34	-	0.36	-	83	0.36	-
1974	0.40	-	0.36	-	0.38	-	100	0.36	-
1975	0.39	0.51	0.38	-	0.39	0.45	99	0.37	-
1976	0.40	0.56	0.33	-	0.37	0.45	100	0.34	-
1977	0.27	0.41	0.33	-	0.30	0.37	96	0.26	-
1978	0.21	0.32	0.21	-	0.21	0.27	123	0.17	-
1979	0.23	0.35	0.28	-	0.26	0.32	67	0.19	-
1980	0.24	0.33	0.32	-	0.28	0.33	47	0.25	-
1981	0.30	0.36	0.36	-	0.33	0.36	42	0.28	-
1982	0.26	0.45	0.41	-	0.34	0.43	39	0.37	-
1983	0.26	0.40	0.35	-	0.31	0.38	58	0.32	-
1984	0.27	0.41	0.32	-	0.30	0.37	59	0.30	-
1985	0.28	0.52	0.37	-	0.33	0.45	44	0.37	-
1986	0.23	0.42	0.37	-	0.30	0.40	57	0.32	-
1987	0.25	0.50	0.35	-	0.30	0.43	44	0.35	-
1988	0.20	0.30	0.31	-	0.26	0.31	63	0.26	4.26
1989	0.20	0.30	0.26	-	0.23	0.28	73	0.19	2.95
1990	-	0.20	0.27	-	-	0.24	95	0.16	1.66
1991	-	-	0.24	-	-	-	134	0.18	-
1992	-	-	0.46	0.72	-	-	20	0.29	-
1993	-	-	0.79	1.22	-	-	15	0.65	-
1994	-	-	0.77	1.27	-	-	11	0.70	-
1995	-	-	1.03	1.48	-	-	-	-	-
1996	-	-	1.45	1.82	-	-	-	-	-
1997	0.71	-	1.23	1.60	-	-	-	-	-
1998	0.71	-	0.98	1.35	-	-	-	-	-
1999	0.84	-	0.82	1.77	-	-	-	-	-
2000	0.94	-	1.38	1.92	-	-	-	-	-
2001	0.82 [11]	-	1.18	1.57	-	-	-	-	-
2002	0.85	-	1.07	1.82	-	-	-	-	-
2003	0.97 [12]	-	0.86	2.45	-	-	-	-	-
2004	0.63 [13]	-	1.16	1.79	-	-	-	-	-
2005	0.61 [12]	-	1.30	2.29	-	-	-	-	-
2006	0.57 [12]	-	0.96	2.09	-	-	-	-	-
2007	0.64 [12]	-	-	-	-	-	-	-	-
2008	0.48 [12]	-	-	-	-	-	-	-	-
2009	0.77 [13]	-	-	-	-	-	-	-	-
2010	- [12]	1.57							

[1] Side trawlers, 800-1000 hp. From 1983 onwards, side trawlers (SRTM), 1,000 hp. From 1997 based on research fishing.

[2] Stern trawlers, up to 2,000 HP.

[3] Arithmetic average of CPUE from USSR RT (or SRTM trawlers) and Norwegian trawlers.

[4] Arithmetic average of CPUE from USSR PST and Norwegian trawlers.

[5] For the years 1981-1990, based on average CPUE type B. For 1991-1993, based on the Norwegian CPUE, type A.

[6] Total catch (t) of seven years and older fish divided by total effort.

[7] For the years 1988-1989, frost-trawlers 995 BRT (FAO Code 095). For 1990, factory trawlers FVS IV, 1943 BRT (FAO Code 090).

[8] Norwegian trawlers, ISSCFV-code 07, 250-499.9 GRT.

[9] Norwegian factory trawlers, ISSCFV-code 09, 1000-1999.9 GRT.

[10] From 1992 based on research fishing. 1992-1993: two weeks in May/June and October; 1994-1995: 10 days in May/June.

[11] Based on fishery from april-october only, a period with relatively low CPUE. In previous years fishery was carried out throughout the whole year.

[12] Based on fishery from october-december only, a period with relatively high CPUE.

[13] Based on fishery from october-november only.

Table 8.7. Catch numbers at age Numbers*10-3**

Run title : NEA Greenland halibut (run: 2011/1)

At 1/05/2011 14:01

Table 1 Catch numbers at age Numbers*10**-3

AGE	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
5	372	253	170	156	114	1064	526	80	1109	212	917	840
6	1480	853	563	332	283	2420	2792	4486	3521	1117	2519	2337
7	2808	1735	1106	623	452	3208	10464	12712	9605	3923	6204	6520
8	5674	3868	2715	2006	1976	6288	18562	12283	6438	3515	3838	4118
9	4951	4203	4054	3237	3923	4921	10034	6130	2775	2551	1834	2265
10	3981	3799	2499	2409	2950	4431	6671	4339	1734	1919	1942	1654
11	1853	1799	1284	1718	2234	2381	2517	2703	1368	1536	1622	1857
12	1018	1002	783	871	792	812	1250	1660	1234	1127	1338	1536
13	364	372	246	315	146	229	616	1044	675	716	734	1122
14	251	282	261	155	43	100	1104	300	200	251	531	600
+gp	76	50	28	19	7	30	281	143	80	126	216	368
0 TOTALNUM	22828	18216	13709	11841	12920	25884	54817	45880	28739	16993	21695	23217
TONSLAND	40391	34751	26321	24267	26168	43789	89484	79034	43055	29938	37763	38172
SOPCOF %	100	100	101	100	100	103	94	104	98	92	98	88

Table 1 Catch numbers at age Numbers*10**-3

AGE	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
5	830	2037	1897	2218	731	1896	1304	1543	915	1219	1672	1212
6	2982	3255	3589	3155	1138	1917	1494	1864	3698	2874	3335	2972
7	5824	4200	4118	2727	1665	1919	1276	1851	3350	2561	2712	3572
8	5002	2524	2365	1234	1341	933	1208	2287	1938	1548	1531	1746
9	3000	1610	1509	495	944	484	1493	1491	1064	972	1128	752
10	1350	1104	946	319	473	448	1258	1228	1191	1037	997	828
11	915	1062	934	296	511	482	838	713	602	614	530	362
12	1212	858	438	243	275	380	502	488	340	363	434	202
13	698	595	349	103	242	384	324	247	171	161	314	186
14	526	384	147	45	145	150	108	201	132	120	305	63
+gp	358	180	112	51	78	62	46	64	71	63	239	7
0 TOTALNUM	22697	17809	16404	10886	7543	9055	9851	11977	13472	11532	13197	11902
TONSLAND	36074	28827	24617	17312	13284	15018	16789	22147	21883	19945	22875	19112
SOPCOF %	93	101	105	104	109	107	100	98	100	99	98	101

Table 8.7 (Continued)

Run title : NEA Greenland halibut (run: 2011/1)

At 1/05/2011 14:01

Table 1 Catch numbers at age Numbers*10**-3

	AGE	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	5	907	2080	2139	3312	1098	1140	631	846	1034	330	359	433
	6	2540	4453	5163	3889	1195	1088	708	992	2083	921	1116	1905
	7	3141	3655	4642	4716	1069	1608	1252	1719	3795	1822	2466	3955
	8	2096	1657	1932	2355	778	1118	817	990	1426	953	1464	1810
	9	1182	801	1221	1031	360	140	310	405	262	342	527	914
	10	860	318	499	1284	600	976	642	726	655	822	924	1905
	11	481	228	264	774	188	444	416	461	270	231	237	380
	12	313	126	314	673	150	144	330	371	132	150	122	237
	13	133	120	42	177	79	36	88	154	29	18	15	67
	14	140	140	96	266	89	20	39	56	22	41	29	42
	+gp	47	28	44	517	56	4	3	8	1	1	15	7
0	TOTALNUM	11840	13606	16356	18994	5662	6718	5236	6728	9709	5631	7274	11655
	TONSLAND	19587	20138	23183	33320	8602	11933	9226	11734	14347	9410	11893	19517
	SOPCOF %	100	103	102	105	95	102	99	101	101	99	100	102

Table 1 Catch numbers at age Numbers*10**-3

	AGE	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	5	380	441	277	397	290	429	548	987	449	982	230
	6	735	1347	921	1025	1016	1072	1347	1598	751	1180	654
	7	1926	2338	1475	1827	2316	1962	2067	2202	1231	1448	929
	8	1464	1325	983	928	1392	1766	1584	1134	1277	1834	1431
	9	743	788	631	632	1087	936	1034	629	790	761	940
	10	1318	1140	1097	1045	778	991	691	436	314	268	465
	11	457	519	563	520	675	616	485	426	365	540	433
	12	330	372	301	311	607	622	548	464	412	341	669
	13	49	115	132	77	199	376	466	246	341	316	513
	14	37	54	59	107	155	244	209	169	207	101	169
	+gp	14	12	42	26	105	328	230	224	247	121	282
0	TOTALNUM	7453	8451	6481	6895	8620	9342	9209	8515	6384	7892	6715
	TONSLAND	14437	16307	13161	13578	18800	18834	17897	15237	13778	12996	15704
	SOPCOF %	101	100	100	100	99	97	100	96	101	102	103

Table 8.8. Catch weights at age (kg)

Run title : NEA Greenland halibut (run: 2011/1)

At 1/05/2011 14:01

Table 2 Catch weights at age (kg)

YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE											
5	0.42	0.42	0.42	0.42	0.42	0.42	0.567	0.567	0.567	0.567	0.567
6	0.64	0.64	0.64	0.65	0.66	0.64	0.737	0.737	0.737	0.737	0.737
7	0.9	0.9	0.91	0.93	0.96	0.91	1.079	1.079	1.079	1.079	1.079
8	1.2	1.22	1.24	1.27	1.31	1.25	1.421	1.421	1.421	1.421	1.421
9	1.63	1.66	1.7	1.71	1.74	1.64	1.848	1.848	1.848	1.848	1.848
10	2.26	2.23	2.22	2.2	2.19	2.25	2.281	2.281	2.281	2.281	2.281
11	3.11	3	2.94	2.84	2.79	2.99	2.887	2.887	2.887	2.887	2.887
12	3.74	3.49	3.39	3.3	3.19	3.63	3.247	3.247	3.247	3.247	3.247
13	4.57	4.4	4.38	4.27	4.27	4.68	4.303	4.303	4.303	4.303	4.303
14	5.01	4.91	4.84	4.88	5	5.38	4.931	4.931	4.931	4.931	4.931
+gp	5.94	5.89	5.88	5.8	5.99	5.99	5.794	5.841	6.037	6.006	5.964
0 SOPCOFAC	0.9986	1.0046	1.0054	1.0024	0.9994	1.0262	0.9436	1.0434	0.9752	0.9231	0.9825

Table 2 Catch weights at age (kg)

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
AGE											
5	0.567	0.567	0.567	0.567	0.9	0.702	0.66	0.69	0.75	0.63	0.6
6	0.737	0.737	0.737	0.737	1.2	0.872	0.84	0.84	1.04	0.96	0.89
7	1.079	1.079	1.079	1.079	1.5	1.141	1.15	1.03	1.34	1.18	1.2
8	1.421	1.421	1.421	1.421	1.8	1.468	1.56	1.31	1.57	1.53	1.85
9	1.848	1.848	1.848	1.848	2.2	1.778	2.04	1.74	1.97	2.31	2.59
10	2.281	2.281	2.281	2.281	2.6	2.302	2.57	2.24	2.73	2.87	3.18
11	2.887	2.887	2.887	2.887	3	2.664	2.98	2.77	3.29	3.46	3.62
12	3.247	3.247	3.247	3.247	3.5	3.046	3.43	3.37	4.22	3.77	3.95
13	4.303	4.303	4.303	4.303	4.1	3.368	4.13	4.32	4.71	3.99	4.48
14	4.931	4.931	4.931	4.931	4.8	4.285	4.68	5.35	6.08	4.35	4.25
+gp	5.91	5.923	6.027	5.906	6.176	5.346	5.999	5.833	6.122	4.525	4.825
0 SOPCOFAC	0.8805	0.9255	1.0095	1.0485	1.0364	1.0894	1.068	1.0038	0.9783	1.0009	0.9858

Table 8.8 (Continued)

Table 2 Catch weights at age (kg)

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE											
5	0.62	0.709	0.74	0.76	0.71	0.77	0.68	0.79	0.72	0.73	0.77
6	0.92	1.003	0.962	1.03	1.06	1.05	0.97	1.02	0.94	0.94	0.97
7	1.28	1.266	1.249	1.32	1.29	1.38	1.27	1.35	1.27	1.25	1.31
8	1.9	1.683	1.626	1.8	1.7	1.75	1.76	1.88	1.72	1.74	1.74
9	2.48	2.482	2.164	2.42	2.1	2.2	2.21	2.46	2.19	2.09	2.24
10	3.11	2.982	2.897	3.13	2.61	2.6	2.56	2.67	2.52	2.51	2.59
11	3.35	3.547	3.406	3.37	2.87	2.79	3.11	3.43	2.97	2.95	3.29
12	3.72	3.8	3.661	4.05	3.45	3.28	3.59	4.29	3.29	3.34	4.02
13	4	4.56	4.247	4.29	3.72	3.89	3.83	5.08	3.84	3.83	4.75
14	4.18	5.002	4.187	4.5	4.09	4.38	4.25	6.33	4.95	4.98	6.24
+gp	4.526	5.953	4.463	4.72	4.52	5.29	4.8	8.91	6.68	8.15	6.09
0 SOPCOFAC	0.9782	1.0116	0.9973	1.0346	1.0204	1.047	0.9519	1.0183	0.9937	1.0095	1.0066

Table 2 Catch weights at age (kg)

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
AGE											
5	0.77	0.73	0.7	0.76	0.74	0.69	0.715	0.77	0.669	0.637	0.626
6	0.94	0.93	0.95	0.97	1.03	0.94	1.05	1.095	0.952	0.86	0.903
7	1.28	1.3	1.27	1.33	1.39	1.36	1.428	1.498	1.306	1.149	1.313
8	1.64	1.61	1.55	1.63	1.75	1.68	1.748	1.903	1.653	1.53	1.686
9	2.07	2.12	2	2.11	2.29	2.18	2.318	2.463	2.131	2.122	2.321
10	2.59	2.57	2.46	2.61	2.68	2.68	2.615	2.775	2.544	2.622	2.553
11	3.3	3.25	3.22	3.35	3.33	3.19	3.043	3.128	2.848	2.699	2.925
12	4.01	3.91	3.85	3.97	3.92	3.89	3.694	3.809	3.334	3.315	3.189
13	4.83	4.9	4.61	4.97	4.81	4.46	4.566	4.291	3.734	3.998	3.747
14	5.95	5.66	5.84	5.82	5.81	5.25	5.568	5.453	4.384	4.641	4.539
+gp	6.26	4.91	5.98	7.22	7.41	6.32	6.365	6.355	5.791	6.743	9.078
0 SOPCOFAC	0.9851	0.9983	1.0172	1.0055	1.0014	1	0.996	0.9853	0.9655	1.0042	0.9592

Table 2 Catch weights at age (kg)

YEAR	2008	2009	2010
AGE			
5	0.695	0.567	0 .532
6	0.919	0.802	0.796
7	1.359	1.071	1.117
8	1.756	1.471	1.492
9	2.231	1.928	2.045
10	2.378	2.216	2.437
11	2.855	2.63	2.876
12	3.23	3.082	3.390
13	3.546	3.791	3.897
14	3.915	4.528	5.222
+gp	7.453	7.069	6.798
0 SOPCOFAC	1.0086	1.0157	1.0343

Table 8.9. Proportion mature at age

Run title : NEA Greenland halibut (run: 2010/1)

At 26/04/2010 18:36

Table 5 Proportion mature at age

YEAR		1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
	AGE											
5		0	0	0	0	0	0	0	0	0	0	0
6		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
7		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
8		0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
9		0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
10		0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
11		0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
12		0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
13		1	1	1	1	1	1	1	1	1	1	1
14		1	1	1	1	1	1	1	1	1	1	1
	+gp	1	1	1	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

YEAR		1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
	AGE											
5		0	0	0	0	0	0	0	0	0	0	0
6		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
7		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
8		0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.18	0.18	0.19
9		0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.6	0.61	0.65
10		0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.82	0.83	0.85
11		0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.96	0.97	0.97
12		0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.99
13		1	1	1	1	1	1	1	1	1	1	1
14		1	1	1	1	1	1	1	1	1	1	1
	+gp	1	1	1	1	1	1	1	1	1	1	1

Table 8.9 (Continued)

Table 5 Proportion mature at age

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE											
5	0	0	0	0	0	0	0	0.01	0.01	0.01	0
6	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0
7	0.03	0.02	0.01	0.02	0.02	0.04	0.06	0.08	0.07	0.08	0.07
8	0.24	0.22	0.21	0.18	0.17	0.15	0.28	0.32	0.34	0.29	0.25
9	0.74	0.66	0.53	0.49	0.51	0.54	0.66	0.68	0.69	0.58	0.58
10	0.91	0.9	0.87	0.8	0.77	0.77	0.86	0.83	0.81	0.79	0.88
11	0.99	0.95	0.89	0.89	0.91	0.89	0.87	0.88	0.95	0.96	0.97
12	0.98	0.98	0.98	1	1	1	1	0.94	0.94	0.89	0.94
13	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1
+gp	1	1	1	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
AGE											
5	0	0	0	0	0.01	0.01	0.01	0	0	0	0
6	0	0	0	0.01	0.03	0.03	0.02	0.01	0.01	0.01	0.01
7	0.07	0.04	0.02	0.03	0.06	0.1	0.11	0.08	0.05	0.05	0.04
8	0.21	0.1	0.07	0.1	0.19	0.31	0.34	0.28	0.22	0.18	0.13
9	0.53	0.45	0.33	0.37	0.49	0.66	0.72	0.66	0.57	0.5	0.34
10	0.85	0.82	0.66	0.63	0.65	0.79	0.88	0.91	0.88	0.74	0.53
11	0.94	0.92	0.86	0.87	0.84	0.91	0.92	0.94	0.91	0.85	0.66
12	0.94	1	0.99	0.96	0.96	0.96	0.97	0.96	0.95	0.93	0.8
13	1	1	1	1	1	0.99	0.98	0.98	0.99	0.98	0.86
14	1	1	1	1	1	1	0.98	0.98	0.98	0.99	0.96
+gp	1	1	1	1	1	1	1	1	1	1	0.99

Table 5 Proportion mature at age

YEAR	2008	2009	2010
AGE			
5	0	0	0
6	0.01	0	0
7	0.03	0.02	0.02
8	0.07	0.04	0.05
9	0.24	0.19	0.25
10	0.36	0.34	0.38
11	0.58	0.54	0.63
12	0.73	0.73	0.80
13	0.82	0.83	0.92
14	0.96	0.97	1
+gp	0.99	0.99	1

Table 8.10. Extended Survivors Analysis

LOWESTOFT VPA VERSION 3.1

1/05/2011 14:00

Extended Survivors Analysis

NEA Greenland halibut (run: 2011/1)

CPUE data from file fleet

Catch data for 47 years. 1964 to 2010. Ages 5 to 15.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLT04: Norw. Exp. CP	1992	2010	5	14	0.38	0.44
FLT07: Russ.Surv. ne	1992	2010	5	14	0.75	0.92
FLT08: Norw.Comb.Sur	1996	2010	5	14	0.55	0.72

Time series weights :

Tapered time weighting applied

Power = 3 over 20 years

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 10

Terminal population estimation :

Terminal year survivor estimates shrunk towards the mean F of the final 2 years.

S.E. of the mean to which the estimates are shrunk = .500

Oldest age survivor estimates for the years 1964 to 2010

shrunk towards1.000 * the mean F of ages 9 - 13

S.E. of the mean to which the estimates are shrunk = .500

Minimum standard error for population estimates from each cohort age = .300

Individual fleet weighting not applied

Tuning converged after 69 iterations

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
5	0.025	0.013	0.02	0.014	0.017	0.02	0.036	0.014	0.022	0.008
6	0.092	0.063	0.06	0.063	0.064	0.063	0.072	0.033	0.045	0.017
7	0.215	0.131	0.163	0.177	0.157	0.162	0.133	0.069	0.078	0.043
8	0.155	0.125	0.108	0.17	0.188	0.173	0.119	0.101	0.132	0.098
9	0.138	0.097	0.105	0.169	0.156	0.151	0.091	0.107	0.076	0.088
10	0.333	0.273	0.219	0.172	0.217	0.157	0.083	0.057	0.046	0.058
11	0.309	0.257	0.19	0.203	0.189	0.148	0.13	0.088	0.125	0.092
12	0.458	0.279	0.209	0.334	0.276	0.242	0.195	0.169	0.106	0.213
13	0.349	0.274	0.101	0.189	0.336	0.324	0.154	0.203	0.179	0.217
14	0.353	0.286	0.351	0.285	0.352	0.298	0.176	0.178	0.081	0.13

Table 8.10 (Continued)

XSA POPULATION NUMBERS (THOUSANDS)

	AGE									
YEAR	5	6	7	8	9	10	11	12	13	14
2001	1.93E+04	1.65E+04	1.30E+04	9.94E+03	6.59E+03	4.34E+03	2.11E+03	1.09E+03	4.21E+02	1.96E+02
2002	2.24E+04	1.62E+04	1.29E+04	9.03E+03	7.33E+03	4.94E+03	2.67E+03	1.33E+03	5.94E+02	2.56E+02
2003	2.14E+04	1.90E+04	1.31E+04	9.77E+03	6.86E+03	5.72E+03	3.24E+03	1.78E+03	8.67E+02	3.89E+02
2004	2.18E+04	1.80E+04	1.54E+04	9.60E+03	7.54E+03	5.32E+03	3.96E+03	2.30E+03	1.24E+03	6.74E+02
2005	2.79E+04	1.85E+04	1.46E+04	1.11E+04	6.97E+03	5.49E+03	3.85E+03	2.78E+03	1.42E+03	8.85E+02
2006	2.94E+04	2.36E+04	1.49E+04	1.07E+04	7.93E+03	5.13E+03	3.80E+03	2.75E+03	1.82E+03	8.74E+02
2007	3.01E+04	2.48E+04	1.91E+04	1.09E+04	7.76E+03	5.87E+03	3.77E+03	2.82E+03	1.85E+03	1.13E+03
2008	3.37E+04	2.50E+04	1.99E+04	1.44E+04	8.36E+03	6.09E+03	4.65E+03	2.85E+03	2.00E+03	1.37E+03
2009	4.91E+04	2.86E+04	2.08E+04	1.60E+04	1.12E+04	6.46E+03	4.95E+03	3.66E+03	2.07E+03	1.40E+03
2010	3.25E+04	4.14E+04	2.35E+04	1.65E+04	1.20E+04	8.93E+03	5.31E+03	3.76E+03	2.83E+03	1.49E+03

Estimated population abundance at 1st Jan 2011

	0.00E+00	2.78E+04	3.50E+04	1.94E+04	1.29E+04	9.50E+03	7.26E+03	4.17E+03	2.62E+03	1.96E+03

Taper weighted geometric mean of the VPA populations:

	2.60E+04	2.09E+04	1.54E+04	1.04E+04	7.03E+03	4.86E+03	2.86E+03	1.71E+03	8.96E+02	4.94E+02

Standard error of the weighted Log(VPA populations) :

	0.2935	0.3079	0.2665	0.3247	0.3876	0.4175	0.612	0.7738	0.9702	1.0206

Log catchability residuals.

Fleet : FLT04: Norw. Exp. CP

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000
5	0.55	1.12	0.86	0.97	1.19	1.1	-0.48	-0.17	0.41
6	-0.03	0.23	0.35	0.07	0.88	0.28	-0.06	-0.07	-0.01
7	-0.32	0.25	0.28	0.28	0.5	0.17	0.14	-0.06	0.32
8	0	0.37	0.44	0.45	0.34	-0.06	0.02	-0.1	-0.07
9	-1.48	-1.46	-0.96	0.22	-0.28	-0.07	-0.27	-1.24	-0.02
10	-0.2	0.31	0.51	0.97	0.2	0.67	-0.87	0.38	0.48
11	0.02	0.09	0	0.39	-0.48	0.65	-0.85	-0.99	-1.03
12	0.27	0.03	-0.61	0.32	-0.62	0.59	-0.81	0.62	-0.04
13	-0.2	0.06	-0.57	-0.04	99.99	0.18	99.99	-0.68	0.31
14	-1.43	-0.16	-0.5	0.24	-0.15	-0.11	99.99	-0.07	99.99

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
5	-0.32	-0.22	-0.07	-0.02	-0.59	99.99	99.99	99.99	99.99	99.99
6	-0.06	-0.19	-0.09	-0.15	0.08	99.99	99.99	99.99	99.99	99.99
7	-0.23	0.2	-0.13	-0.24	-0.22	99.99	99.99	99.99	99.99	99.99
8	0.33	-0.22	-0.56	-0.06	0.36	99.99	99.99	99.99	99.99	99.99
9	0.2	0.04	0.24	0.35	0.46	99.99	99.99	99.99	99.99	99.99
10	-0.04	0.04	0.1	-0.67	-0.18	99.99	99.99	99.99	99.99	99.99
11	-0.73	-0.74	-0.33	-0.53	-0.58	99.99	99.99	99.99	99.99	99.99
12	-0.06	-0.68	-0.02	-0.06	0.04	99.99	99.99	99.99	99.99	99.99
13	-0.89	-1.67	-0.33	-0.36	0.09	99.99	99.99	99.99	99.99	99.99
14	-0.53	-0.13	-0.3	-0.18	-0.17	99.99	99.99	99.99	99.99	99.99

Table 8.10 (Continued)

MEAN LOG CATCHABILITY AND STANDARD ERROR OF AGES WITH CATCHABILITY
independent of year class strength and constant w.r.t. time

Age	5	6	7	8	9	10	11	12	13	14
Mean Log q	-5.3336	-4.2457	-3.4494	-3.9087	-4.5187	-3.8491	-3.8491	-3.8491	-3.8491	-3.8491
S.E(Log q)	0.5576	0.2353	0.2476	0.3212	0.5161	0.4876	0.7461	0.4506	0.8086	0.3037

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
5	-1.05	-1.293	14.82	0.07	14	0.55	-5.33
6	2.84	-0.895	-5.87	0.04	14	0.68	-4.25
7	2.4	-1.138	-5.02	0.11	14	0.58	-3.45
8	1.41	-0.563	1.81	0.27	14	0.48	-3.91
9	0.61	1.143	6.12	0.63	14	0.31	-4.52
10	1.74	-0.913	0.57	0.23	14	0.86	-3.85
11	1.22	-0.591	3.7	0.59	14	0.57	-4.41
12	1	0.01	3.95	0.74	14	0.48	-3.94
13	1	0.005	4.29	0.59	12	0.72	-4.29
14	1.01	-0.096	4.04	0.95	12	0.22	-4.06

Fleet : FLT07: Russ.Surv. Ne

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000
5	1.84	0.69	-0.01	-0.53	-0.42	-1.08	-0.38	-0.53	0.02
6	1.08	0.77	0.36	-0.02	0.11	-0.44	-0.36	-0.5	-0.2
7	0.66	0.68	0.18	0.15	0.21	-0.16	-0.21	-0.45	-0.22
8	0.54	0.52	0.24	0.49	0.35	0.14	0.18	0.01	0.18
9	-0.4	0.15	0.22	0.51	0.94	0.04	0.33	0.18	0.22
10	-0.11	0.3	0.58	0.51	-0.58	0.25	0.45	0.34	0.38
11	0.69	0.18	-0.17	0.22	-0.39	0.52	0.97	0	0.73
12	0.52	0.7	0.26	0.27	-0.66	-0.2	0.7	0.39	0.71
13	-0.22	-0.12	-0.13	-0.07	-0.24	0.61	0.59	0.68	-0.71
14	-5.06	0.87	0.62	-1.55	-0.23	-0.28	-0.15	-0.12	0.35

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
5	0.52	99.99	99.99	-0.22	-0.25	0.18	0	-0.38	0.29	0.99
6	0.68	99.99	99.99	0.01	-0.21	0.21	-0.06	-0.37	0.23	0.31
7	0.26	99.99	99.99	-0.14	-0.2	0.38	0.08	-0.13	0.06	0.16
8	-0.33	99.99	99.99	-0.28	-0.41	-0.02	-0.16	0.13	0.17	0.25
9	-0.24	99.99	99.99	-0.12	-0.63	-0.27	-0.09	0.59	-0.1	-0.06
10	0.27	99.99	99.99	-0.13	-0.27	-0.15	0.17	0.15	-0.37	-0.42
11	0.21	99.99	99.99	-0.2	-0.51	-0.23	0.51	0.59	0.57	-0.08
12	0.9	99.99	99.99	0.07	-0.26	0.11	0.84	1.11	0.37	0.7
13	1.15	99.99	99.99	0.04	-0.24	0.26	0.41	1.25	0.92	0.66
14	0.47	99.99	99.99	0.49	-0.1	0.13	0.43	1.08	0.03	0.01

Table 8.10 (Continued)

MEAN LOG CATCHABILITY AND STANDARD ERROR OF AGES WITH CATCHABILITY
independent of year class strength and constant w.r.t. time

Age	5	6	7	8	9	10	11	12	13	14
Mean Log q	-0.4811	0.3581	0.8034	0.9365	0.481	0.0527	0.0527	0.0527	0.0527	0.0527
S.E(Log q)	0.5086	0.3434	0.2393	0.254	0.3705	0.3258	0.4941	0.6628	0.7348	0.5636

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
5	0.67	0.909	3.69	0.47	17	0.34	-0.48
6	0.84	0.524	1.29	0.56	17	0.3	0.36
7	1	0.001	-0.8	0.58	17	0.25	0.8
8	1.05	-0.194	-1.46	0.63	17	0.28	0.94
9	1.48	-1.14	-4.93	0.41	17	0.54	0.48
10	1.55	-1.63	-4.75	0.51	17	0.47	0.05
11	1.16	-0.586	-1.52	0.63	17	0.54	0.24
12	0.92	0.468	0.17	0.79	17	0.46	0.49
13	0.88	0.751	0.4	0.82	17	0.52	0.49
14	0.87	0.938	0.6	0.86	17	0.46	0.25

Fleet : FLT08: Norw.Comb.Sur

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000
5	99.99	99.99	99.99	99.99	0.3	-0.07	-0.3	-0.34	0.06
6	99.99	99.99	99.99	99.99	0.42	0.25	-0.25	0	-0.14
7	99.99	99.99	99.99	99.99	0.48	0.2	0.28	0.04	-0.13
8	99.99	99.99	99.99	99.99	0.64	-0.22	-0.07	0.36	-0.02
9	99.99	99.99	99.99	99.99	0.09	-0.37	-0.6	-0.36	0.41
10	99.99	99.99	99.99	99.99	0.95	0.51	0.48	0.53	-0.18
11	99.99	99.99	99.99	99.99	0.26	0.16	0.19	-0.24	-0.85
12	99.99	99.99	99.99	99.99	0.37	0.53	0.81	0.85	-0.24
13	99.99	99.99	99.99	99.99	-0.32	-1.01	-2.87	0.02	-0.57
14	99.99	99.99	99.99	99.99	0.25	0.1	0.37	0.24	-0.76

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
5	-0.18	-0.03	0.14	-0.04	0.34	99.99	99.99	99.99	99.99	99.99
6	0.06	-0.09	0.06	-0.11	0.08	99.99	99.99	99.99	99.99	99.99
7	0.12	0.18	0.09	-0.05	-0.57	99.99	99.99	99.99	99.99	99.99
8	0.01	0.01	-0.04	-0.06	-0.18	99.99	99.99	99.99	99.99	99.99
9	-0.22	0.31	0.17	-0.06	0.16	99.99	99.99	99.99	99.99	99.99
10	0.19	-0.18	-0.05	-0.52	-0.36	99.99	99.99	99.99	99.99	99.99
11	-0.67	-0.14	-0.75	-0.96	-0.62	99.99	99.99	99.99	99.99	99.99
12	-0.05	0.14	-0.16	0.1	-0.36	99.99	99.99	99.99	99.99	99.99
13	-0.62	-0.17	-0.33	-0.11	-0.31	99.99	99.99	99.99	99.99	99.99
14	-0.25	-0.2	-0.6	0.04	-0.66	99.99	99.99	99.99	99.99	99.99

Table 8.10 (Continued)

MEAN LOG CATCHABILITY AND STANDARD ERROR OF AGES WITH CATCHABILITY
independent of year class strength and constant w.r.t. time

Age	5	6	7	8	9	10	11	12	13	14
Mean Log q	-0.3562	0.1516	0.7418	0.2831	-0.2442	0.484	0.484	0.484	0.484	0.484
S.E(Log q)	0.2272	0.1614	0.2923	0.2079	0.3192	0.4351	0.6793	0.4373	0.9455	0.4797

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
5	0.45	1.974	5.61	0.74	10	0.08	-0.36
6	1.88	-0.499	-8.89	0.06	10	0.33	0.15
7	-1.12	-1.583	21.05	0.11	10	0.29	0.74
8	4.15	-1.623	-29.95	0.05	10	0.76	0.28
9	0.73	0.75	2.52	0.62	10	0.24	-0.24
10	10.45	-2.895	-83.94	0.02	10	3	0.48
11	2.19	-2.622	-9.18	0.51	10	0.67	0
12	1.74	-2.467	-6.21	0.7	10	0.53	0.59
13	0.68	1.325	2.03	0.78	10	0.48	-0.04
14	1.26	-1.001	-1.79	0.76	10	0.52	0.25

Terminal year survivor and F summaries :

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

Year class = 2005

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	1	0	0	0	0	0	0
FLT07: Russ.Surv. ne	75064	0.533	0	0	1	0.467	0.003
FLT08: Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	11660	0.5				0.533	0.018

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
27803	0.36	1.36	2	3.731	0.008

Table 8.10 (Continued)

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

Year class = 2004

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	1	0	0	0	0	0	0
FLT07: Russ.Surv. ne	47501	0.298	0.012	0.04	2	0.733	0.013
FLT08: Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	15147	0.5				0.267	0.039

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
35016	0.26	0.42	3	1.631	0.017

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

Year class = 2003

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	1	0	0	0	0	0	0
FLT07: Russ.Surv. ne	21517	0.212	0.145	0.69	3	0.839	0.039
FLT08: Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	11272	0.5				0.161	0.074

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
19393	0.19	0.18	4	0.949	0.043

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

Year class = 2002

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	1	0	0	0	0	0	0
FLT07: Russ.Surv. ne	13257	0.173	0.133	0.77	4	0.876	0.095
FLT08: Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	10737	0.5				0.124	0.117

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
12916	0.16	0.11	5	0.695	0.098

Table 8.10 (Continued)

Age 9 Catchability constant w.r.t. time and dependent on age

Year class = 2001

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	1	0	0	0	0	0	0
FLT07: Russ.Surv. ne	9559	0.159	0.065	0.41	5	0.886	0.087
FLT08: Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	9055	0.5				0.114	0.092

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
9500	0.15	0.06	6	0.362	0.088

Age 10 Catchability constant w.r.t. time and dependent on age

Year class = 2000

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	4037	0.61	0	0	1	0.034	0.102
FLT07: Russ.Surv. ne	6926	0.145	0.102	0.7	6	0.749	0.06
FLT08: Norw.Comb.Sur	10184	0.307	0	0	1	0.136	0.041
F shrinkage mean	8158	0.5				0.08	0.052

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7258	0.13	0.09	9	0.742	0.058

Age 11 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1999

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	4427	0.275	0.042	0.15	2	0.124	0.087
FLT07: Russ.Surv. ne	4163	0.142	0.139	0.98	7	0.613	0.092
FLT08: Norw.Comb.Sur	4266	0.219	0.06	0.27	2	0.195	0.09
F shrinkage mean	3558	0.5				0.068	0.107

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4170	0.11	0.08	12	0.763	0.092

Table 8.10 (Continued)

Age 12 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1998

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	2197	0.207	0.034	0.16	3	0.185	0.249
FLT07: Russ.Surv. ne	2839	0.145	0.107	0.74	7	0.509	0.198
FLT08: Norw.Comb.Sur	2166	0.184	0.209	1.14	3	0.232	0.252
F shrinkage mean	4199	0.5				0.074	0.138

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2618	0.1	0.08	14	0.833	0.213

Age 13 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1997

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	1946	0.182	0.146	0.8	4	0.218	0.219
FLT07: Russ.Surv. ne	2006	0.156	0.148	0.94	7	0.427	0.213
FLT08: Norw.Comb.Sur	1841	0.161	0.052	0.32	4	0.277	0.23
F shrinkage mean	2250	0.5				0.077	0.192

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1963	0.1	0.07	16	0.725	0.217

Age 14 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1996

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	1060	0.179	0.105	0.59	5	0.214	0.138
FLT07: Russ.Surv. ne	1181	0.172	0.194	1.13	8	0.39	0.125
FLT08: Norw.Comb.Sur	1118	0.151	0.061	0.41	5	0.307	0.131
F shrinkage mean	1095	0.5				0.089	0.134

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1127	0.1	0.08	19	0.809	0.13

Table 8.11. Fishing mortality (F) at age

Run title : NEA Greenland halibut (run: 2011/1)

At 1/05/2011 14:01

Table 8 Fishing mortality (F) at age

YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE											
5	.0094	.0053	.0032	.0024	.0019	.0207	.0139	.0027	.0363	.0074	.0378
6	.0484	.0255	.0138	.0072	.0051	.0484	.0659	.1491	.1510	.0442	.1079
7	.1146	.0699	.0397	.0180	.0116	.0691	.2864	.4473	.5110	.2369	.3446
8	.2531	.2160	.1411	.0891	.0694	.2081	.6556	.6021	.4033	.3335	.3622
9	.4566	.2848	.3476	.2355	.2381	.2332	.5603	.4391	.2444	.2596	.2744
10	.7003	.7254	.2583	.3382	.3302	.4350	.5339	.4738	.1999	.2515	.3041
11	.6375	.7606	.5421	.2684	.5684	.4571	.4457	.4037	.2511	.2585	.3297
12	.5666	.8214	.8585	.8372	.1802	.3905	.4362	.5627	.3063	.3191	.3545
13	.4065	.3910	.4515	1.0092	.2945	.0686	.5465	.7562	.4414	.2765	.3346
14	.5568	.6004	.4943	.5409	.3237	.3182	.5074	.5302	.2897	.2741	.3208
+gp	.5568	.6004	.4943	.5409	.3237	.3182	.5074	.5302	.2897	.2741	.3208
0 FBAR 6-10	.3146	.2643	.1601	.1376	.1309	.1988	.4204	.4223	.3019	.2252	.2786

Table 8 Fishing mortality (F) at age

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
AGE											
5	.0410	.0413	.0971	.1045	.1291	.0431	.1210	.0769	.0905	.0568	.0680
6	.1211	.1894	.2133	.2342	.2393	.0857	.1441	.1253	.1425	.3061	.2401
7	.4196	.4663	.4173	.4301	.2652	.1812	.1928	.1277	.2133	.3853	.3398
8	.3817	.6250	.3555	.4137	.2071	.1906	.1385	.1690	.3334	.3414	.2908
9	.3557	.4999	.3925	.3517	.1331	.2289	.0922	.3233	.3065	.2407	.2706
10	.4017	.3507	.3247	.3978	.1093	.1720	.1529	.3446	.4537	.4048	.3683
11	.5023	.3823	.4844	.4734	.1955	.2419	.2513	.4448	.3160	.3960	.3551
12	.5616	.6827	.7079	.3547	.2021	.2654	.2698	.4241	.4765	.2306	.4162
13	.5354	.5072	.8176	.6667	.1237	.3000	.6794	.3665	.3595	.2857	.1539
14	.4739	.4872	.5487	.4512	.1531	.2425	.2903	.3825	.3843	.3128	.3141
+gp	.4739	.4872	.5487	.4512	.1531	.2425	.2903	.3825	.3843	.3128	.3141
0 FBAR 6-10	.3360	.4263	.3407	.3655	.1908	.1717	.1441	.2180	.2899	.3357	.3019

Table 8.11 (Continued)

Table 8 Fishing mortality (F) at age

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE											
5	.0949	.0694	.0433	.1139	.1717	.3261	.1170	.0975	.0369	.0502	.0587
6	.2533	.2302	.1924	.2908	.4274	.5037	.1763	.1542	.0768	.0712	.1593
7	.3531	.4442	.3826	.4382	.5254	.8346	.2346	.3588	.2521	.2550	.3972
8	.3300	.3809	.4801	.3364	.4120	.5232	.2876	.3876	.2940	.3058	.3284
9	.3366	.2525	.4536	.3197	.4190	.3800	.1302	.0722	.1655	.2192	.1165
10	.4626	.4174	.4807	.1977	.3183	1.0105	.3748	.5764	.5091	.6727	.6173
11	.3071	.2852	.4302	.2109	.2368	1.1252	.3526	.4957	.4878	.8068	.5354
12	.4310	.1734	.4028	.1787	.4710	1.5671	.6321	.4720	.8078	1.0541	.5323
13	.7313	.3124	.1565	.2497	.0788	.5008	.7283	.2821	.5592	1.1204	.1861
14	.4561	.2893	.3866	.2321	.3060	.9241	.4776	.3786	.5280	.8073	.4200
+gp	.4561	.2893	.3866	.2321	.3060	.9241	.4776	.3786	.5280	.8073	.4200
0 FBAR 6-10	.3471	.3450	.3979	.3165	.4204	.6504	.2407	.3098	.2595	.3048	.3237

Table 8 Fishing mortality (F) at age

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
AGE											
5	.0163	.0184	.0249	.0212	.0249	.0134	.0202	.0144	.0167	.0203	.0360
6	.0646	.0668	.1219	.0511	.0922	.0631	.0599	.0627	.0645	.0634	.0719
7	.1929	.2326	.3344	.1652	.2153	.1311	.1626	.1767	.1568	.1616	.1328
8	.1535	.2215	.2528	.1873	.1550	.1248	.1081	.1700	.1878	.1735	.1186
9	.1146	.1127	.1982	.1475	.1379	.0974	.1046	.1688	.1564	.1514	.0915
10	.5986	.4801	.6950	.4578	.3332	.2733	.2191	.1717	.2166	.1569	.0835
11	.4306	.3209	.3487	.3282	.3087	.2573	.1901	.2032	.1891	.1479	.1297
12	.6108	.4008	.5791	.5465	.4578	.2793	.2087	.3339	.2760	.2422	.1951
13	.1181	.1029	.3777	.2088	.3487	.2736	.1007	.1894	.3359	.3239	.1543
14	.4093	.2673	.4349	.3488	.3528	.2860	.3515	.2846	.3524	.2981	.1758
+gp	.4093	.2673	.4349	.3488	.3528	.2860	.3515	.2846	.3524	.2981	.1758
0 FBAR 6-10	.2248	.2227	.3205	.2018	.1867	.1380	.1309	.1500	.1564	.1414	.0996

Table 8.11 (Continued)

Table 8 Fishing mortality (F) at age

YEAR	2008	2009	2010	FBAR **-**
AGE				
5	.0145	.0218	.0076	.0146
6	.0330	.0455	.0172	.0319
7	.0690	.0781	.0435	.0635
8	.1006	.1321	.0978	.1102
9	.1075	.0761	.0878	.0905
10	.0571	.0457	.0577	.0535
11	.0885	.1250	.0920	.1018
12	.1692	.1058	.2128	.1626
13	.2032	.1794	.2171	.1999
14	.1780	.0807	.1302	.1297
+gp	.1780	.0807	.1302	
0 FBAR 6-10	.0734	.0755	.0608	

Table 8.12. Stock number at age (start of year) Numbers*10-3**

Run title : NEA Greenland halibut (run: 2010/1)

At 26/04/2010 18:36

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE											
5	42841	51686	57829	70444	64282	55933	41114	31554	33560	31065	26651
6	33793	36528	44252	49616	60487	55222	47155	34899	27084	27856	26541
7	27961	27712	30649	37566	42397	51799	45285	37996	25876	20045	22940
8	27353	21461	22243	25353	31755	36072	41608	29269	20910	13361	13614
9	14559	18279	14883	16626	19961	25499	25214	18591	13797	12025	8239
10	8521	7938	11834	9049	11307	13541	17382	12393	10315	9300	7983
11	4237	3641	3307	7867	5554	6995	7544	8771	6641	7269	6225
12	2537	1928	1465	1656	5177	2707	3812	4158	5042	4447	4832
13	1175	1239	730	534	617	3721	1577	2121	2039	3195	2782
14	634	673	721	400	168	395	2990	786	857	1129	2086
+gp	190	118	77	49	27	118	756	372	341	564	844
0 TOTAL	163800	171204	187990	219160	241731	252003	234436	180911	146462	130256	122736

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
AGE											
5	22551	22113	23722	20611	19742	18681	17935	18983	19228	17849	19981
6	22088	18631	18262	18528	15980	14934	15401	13678	15129	15118	14514
7	20507	16844	13269	12699	12618	10827	11798	11477	10387	11293	9581
8	13989	11602	9094	7524	7110	8330	7774	8375	8694	7223	6612
9	8157	8220	5345	5486	4282	4974	5926	5826	6087	5362	4419
10	5390	4919	4292	3107	3322	3226	3406	4651	3629	3856	3628
11	5069	3104	2981	2670	1797	2563	2338	2516	2836	1984	2214
12	3853	2641	1823	1581	1431	1272	1732	1565	1388	1780	1149
13	2917	1891	1148	773	954	1006	839	1138	882	742	1216
14	1714	1470	980	436	342	726	642	366	679	530	480
+gp	1044	994	456	330	386	389	264	155	215	284	251
0 TOTAL	107279	92427	81374	73745	67963	66929	68055	68730	69154	66019	64045

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE											
5	19901	19477	23080	20832	14613	12828	10720	13229	18768	18629	19555
6	16067	15577	15639	19024	16000	10593	7968	8208	10329	15569	15250
7	9826	10735	10650	11104	12243	8982	5510	5750	6056	8233	12480
8	5871	5941	5926	6253	6167	6231	3355	3751	3457	4051	5492
9	4255	3633	3494	3156	3845	3515	3178	2166	2191	2217	2568
10	2901	2615	2429	1911	1973	2176	2069	2402	1735	1598	1533
11	2160	1572	1483	1293	1350	1235	682	1224	1162	897	702
12	1336	1368	1017	830	901	917	345	413	642	614	345
13	653	747	990	585	598	484	165	158	221	246	184
14	898	270	471	729	393	475	253	68	102	109	69
+gp	699	30	157	145	179	913	158	14	8	15	3
0 TOTAL	64565	61966	65337	65861	58261	48350	34403	37382	44670	52179	58179

Table 8.12 (Continued)

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	AGE											
5		21998	21171	18947	19558	19339	22388	21367	21806	27919	29439	30064
6		15872	18628	17889	15906	16481	16236	19013	18023	18500	23632	24830
7		11193	12806	14998	13630	13009	12936	13120	15414	14570	14928	19091
8		7221	7944	8735	9239	9945	9027	9766	9597	11118	10720	10931
9		3404	5331	5479	5839	6594	7330	6858	7544	6969	7931	7757
10		1967	2612	4099	3868	4336	4945	5724	5316	5485	5130	5867
11		712	931	1391	1761	2106	2675	3238	3957	3854	3802	3774
12		354	398	581	845	1092	1331	1780	2305	2780	2746	2822
13		174	165	230	280	421	594	867	1243	1421	1815	1855
14		132	133	128	135	196	256	389	674	885	874	1130
	+gp	3	69	21	51	43	181	94	455	1184	957	1493
0	TOTAL	63028	70188	72498	71112	73561	77900	82215	86335	94684	101975	109615

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAR	2008	2009	2010	GMST 64-**	AMST 64-**
	AGE					
5		33725	49142	32547	0	24337
6		24961	28611	41386	27803	19919
7		19889	20787	23531	35016	15084
8		14389	15977	16548	19393	10020
9		8357	11200	12050	12916	6527
10		6093	6460	8934	9500	4405
11		4645	4953	5311	7258	2566
12		2853	3660	3762	4170	1495
13		1999	2074	2833	2618	793
14		1368	1404	1492	1963	455
	+gp	1628	1679	2483	3003	
0	TOTAL	119907	145945	150877	123640	

Table 8.13. Stock biomass at age (start of year) Tonnes

Run title : NEA Greenland halibut (run: 2011/1)

At 1/05/2011 14:01

Table 12 Stock biomass at age (start of year) Tonnes

YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE											
5	17993	21708	24288	29587	26998	23492	23311	17891	19028	17614	15111
6	21627	23378	28321	32251	39922	35342	34753	25720	19961	20530	19561
7	25165	24941	27890	34936	40701	47137	48862	40998	27920	21629	24752
8	32824	26182	27581	32199	41599	45090	59125	41592	29713	18985	19345
9	23731	30343	25301	28430	34732	41818	46596	34357	25496	22222	15225
10	19258	17701	26271	19908	24762	30467	39647	28268	23528	21214	18210
11	13178	10923	9724	22342	15494	20915	21779	25323	19173	20986	17971
12	9488	6729	4965	5463	16515	9828	12376	13501	16371	14440	15688
13	5368	5452	3196	2281	2634	17415	6786	9127	8773	13747	11971
14	3175	3306	3491	1952	838	2128	14746	3875	4226	5565	10284
+gp	1131	697	452	282	163	707	4378	2171	2060	3388	5035
0 TOTALBIO	172937	171360	181481	209630	244358	274340	312360	242824	196251	180320	173152

Table 12 Stock biomass at age (start of year) Tonnes

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
AGE											
5	12787	12538	13450	11686	17768	13114	11837	13098	14421	11245	11989
6	16279	13731	13459	13655	19176	13023	12936	11490	15734	14513	12918
7	22127	18174	14317	13702	18926	12353	13568	11821	13918	13325	11497
8	19878	16486	12923	10692	12797	12229	12128	10971	13650	11051	12232
9	15073	15190	9878	10138	9421	8844	12088	10137	11992	12385	11444
10	12294	11221	9789	7087	8636	7427	8753	10419	9907	11067	11536
11	14636	8962	8608	7707	5390	6828	6968	6968	9331	6866	8015
12	12510	8574	5919	5133	5010	3874	5941	5275	5857	6710	4540
13	12553	8138	4941	3327	3913	3390	3467	4917	4152	2960	5449
14	8450	7249	4833	2152	1640	3110	3004	1960	4129	2304	2039
+gp	6169	5885	2748	1951	2384	2079	1584	905	1316	1283	1210
0 TOTALBIO	152756	126147	100866	87230	105061	86272	92274	87960	104408	93708	92869

Table 12 Stock biomass at age (start of year) Tonnes

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE											
5	12338	13809	17080	15832	10375	9877	7290	10451	13513	13599	15057
6	14781	15624	15045	19595	16960	11123	7729	8373	9709	14634	14792
7	12578	13590	13302	14658	15793	12395	6997	7762	7691	10292	16348
8	11154	10000	9635	11255	10484	10904	5906	7051	5946	7048	9555
9	10551	9016	7561	7637	8074	7734	7024	5329	4798	4634	5752
10	9024	7799	7037	5981	5150	5658	5297	6412	4371	4011	3970
11	7237	5577	5051	4356	3873	3446	2121	4200	3450	2647	2310
12	4970	5197	3725	3362	3109	3007	1239	1770	2112	2050	1386
13	2610	3408	4204	2511	2223	1884	630	802	850	943	875
14	3752	1352	1971	3278	1605	2082	1074	432	507	543	431
+gp	3162	178	701	685	809	4828	758	121	52	125	19
0 TOTALBIO	92158	85550	85311	89151	78456	72939	46065	52702	53000	60529	70496

Table 8.13 (Continued)

Table 12 Stock biomass at age (start of year) Tonnes

	YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	AGE											
5		16939	15455	13263	14864	14311	15448	15278	16791	18678	18753	18820
6		14919	17324	16995	15429	16976	15262	19964	19735	17612	20324	22422
7		14327	16648	19047	18128	18082	17593	18735	23090	19028	17153	25066
8		11842	12789	13539	15060	17403	15166	17070	18264	18378	16402	18430
9		7046	11301	10958	12320	15101	15980	15897	18582	14851	16830	18004
10		5095	6714	10084	10095	11621	13252	14967	14753	13954	13451	14978
11		2348	3024	4480	5899	7014	8532	9854	12377	10977	10261	11040
12		1418	1557	2237	3354	4279	5179	6574	8779	9267	9102	9000
13		842	810	1058	1393	2025	2651	3957	5335	5304	7258	6950
14		783	754	750	788	1137	1342	2167	3678	3882	4055	5130
	+gp	20	337	127	368	321	1145	599	2891	6856	6454	13556
0	TOTALBIO	75578	86713	92537	97698	108269	111549	125061	144273	138787	140041	163397

Table 12 Stock biomass at age (start of year) Tonnes

	YEAR	2008	2009	2010
	AGE			
5		23439	27863	17315
6		22939	22946	32943
7		27029	22263	26284
8		25267	23502	24690
9		18644	21593	24642
10		14489	14315	21771
11		13262	13027	15275
12		9216	11279	12754
13		7087	7861	11042
14		5357	6356	7789
	+gp	12130	11866	16877
0	TOTALBIO	178860	182871	211384

Table 8.14. Spawning stock biomass at age (spawning time) Tonnes

Run title : NEA Greenland halibut (run: 2011/1)

At 1/05/2011 14:01

Table 13 Spawning stock biomass at age (spawning time) Tonnes

	YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
	AGE											
5		0	0	0	0	0	0	0	0	0	0	0
6		649	701	850	968	1198	1060	1043	772	599	616	587
7		755	748	837	1048	1221	1414	1466	1230	838	649	743
8		6893	5498	5792	6762	8736	9469	12416	8734	6240	3987	4062
9		15900	20330	16952	19048	23270	28018	31219	23019	17083	14889	10201
10		16562	15223	22593	17121	21295	26202	34097	24311	20234	18244	15660
11		12914	10704	9529	21895	15185	20497	21344	24817	18790	20567	17611
12		9298	6594	4866	5354	16185	9631	12129	13231	16044	14151	15375
13		5368	5452	3196	2281	2634	17415	6786	9127	8773	13747	11971
14		3175	3306	3491	1952	838	2128	14746	3875	4226	5565	10284
	+gp	1131	697	452	282	163	707	4378	2171	2060	3388	5035
0	TOTSPBIO	72644	69254	68558	76710	90724	116541	139623	111287	94885	95802	91528

Table 13 Spawning stock biomass at age (spawning time) Tonnes

	YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
	AGE											
5		0	0	0	0	0	0	0	0	0	0	0
6		488	412	404	410	575	391	388	345	472	581	517
7		664	545	430	411	568	371	407	355	418	400	460
8		4174	3462	2714	2245	2687	2568	2547	2304	2457	1989	2324
9		10099	10178	6618	6792	6312	5926	8099	6792	7195	7555	7439
10		10572	9650	8419	6095	7427	6388	7527	8960	8124	9186	9806
11		14343	8783	8435	7553	5282	6691	6829	6829	8958	6660	7775
12		12260	8402	5801	5031	4909	3796	5822	5170	5739	6575	4495
13		12553	8138	4941	3327	3913	3390	3467	4917	4152	2960	5449
14		8450	7249	4833	2152	1640	3110	3004	1960	4129	2304	2039
	+gp	6169	5885	2748	1951	2384	2079	1584	905	1316	1283	1210
0	TOTSPBIO	79773	62703	45343	35966	35698	34710	39673	38535	42960	39492	41512

Table 13 Spawning stock biomass at age (spawning time) Tonnes

	YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
	AGE											
5		0	0	0	0	0	0	0	105	135	136	0
6		443	156	150	196	170	111	77	84	97	146	0
7		377	272	133	293	316	496	420	621	538	823	1144
8		2677	2200	2023	2026	1782	1636	1654	2256	2022	2044	2389
9		7808	5951	4007	3742	4118	4176	4636	3624	3311	2688	3336
10		8211	7019	6122	4785	3965	4357	4556	5322	3541	3169	3494
11		7165	5298	4495	3877	3525	3067	1845	3696	3277	2541	2240
12		4871	5093	3651	3362	3109	3007	1239	1664	1985	1825	1303
13		2610	3408	4204	2511	2223	1884	630	802	850	943	875
14		3752	1352	1971	3278	1605	2082	1074	432	507	543	431
	+gp	3162	178	701	685	809	4828	758	121	52	125	19
0	TOTSPBIO	41077	30927	27457	24756	21622	25644	16888	18726	16316	14984	15231

Table 8.14 (Continued)

Table 13 Spawning stock biomass at age (spawning time) Tonnes

	YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	AGE											
5		0	0	0	0	143	154	153	0	0	0	0
6		0	0	0	154	509	458	399	197	176	203	224
7		1003	666	381	544	1085	1759	2061	1847	951	858	1003
8		2487	1279	948	1506	3307	4702	5804	5114	4043	2952	2396
9		3734	5085	3616	4558	7399	10547	11446	12264	8465	8415	6122
10		4331	5505	6655	6360	7554	10469	13171	13425	12279	9954	7939
11		2208	2782	3853	5132	5892	7764	9065	11635	9989	8722	7286
12		1333	1557	2215	3220	4108	4972	6377	8427	8804	8465	7200
13		842	810	1058	1393	2025	2625	3878	5228	5251	7113	5977
14		783	754	750	788	1137	1342	2124	3604	3804	4015	4925
	+gp	20	337	127	368	321	1145	599	2891	6856	6454	13420
0	TOTSPBIO	16740	18776	19603	24023	33480	45937	55077	64633	60619	57150	56491

Table 13 Spawning stock biomass at age (spawning time) Tonnes

	YEAR	2008	2009	2010
	AGE			
5		0	0	0
6		229	0	0
7		811	445	526
8		1769	940	1234
9		4475	4103	6160
10		5216	4867	8273
11		7692	7034	9624
12		6728	8234	10203
13		5811	6525	10159
14		5143	6166	7789
	+gp	12009	11747	16877
0	TOTSPBIO	49883	50061	70846

Table 8.15. Summary (without SOP correction)

Run title : NEA Greenland halibut (run: 2011/1)

At 1/05/2011 14:01

	RECRUITS Age 5	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 6-10
1964	42841	172937	72644	40391	.5560	.3146
1965	51686	171360	69254	34751	.5018	.2643
1966	57829	181481	68558	26321	.3839	.1601
1967	70444	209630	76710	24267	.3163	.1376
1968	64282	244358	90724	26168	.2884	.1309
1969	55933	274340	116541	43789	.3757	.1988
1970	41114	312360	139623	89484	.6409	.4204
1971	31554	242824	111287	79034	.7102	.4223
1972	33560	196251	94885	43055	.4538	.3019
1973	31065	180320	95802	29938	.3125	.2252
1974	26651	173152	91528	37763	.4126	.2786
1975	22551	152756	79773	38172	.4785	.3360
1976	22113	126147	62703	36074	.5753	.4263
1977	23722	100866	45343	28827	.6358	.3407
1978	20611	87230	35966	24617	.6845	.3655
1979	19742	105061	35698	17312	.4850	.1908
1980	18681	86272	34710	13284	.3827	.1717
1981	17935	92274	39673	15018	.3785	.1441
1982	18983	87960	38535	16789	.4357	.2180
1983	19228	104408	42960	22147	.5155	.2899
1984	17849	93708	39492	21883	.5541	.3357
1985	19981	92869	41512	19945	.4805	.3019
1986	19901	92158	41077	22875	.5569	.3471
1987	19477	85550	30927	19112	.6180	.3450
1988	23080	85311	27457	19587	.7134	.3979
1989	20832	89151	24756	20138	.8135	.3165
1990	14613	78456	21622	23183	1.0722	.4204
1991	12828	72939	25644	33320	1.2993	.6504
1992	10720	46065	16888	8602	.5094	.2407
1993	13229	52702	18726	11933	.6372	.3098
1994	18768	53000	16316	9226	.5655	.2595
1995	18629	60529	14984	11734	.7831	.3048
1996	19555	70496	15231	14347	.9419	.3237
1997	21998	75578	16740	9410	.5621	.2248
1998	21171	86713	18776	11893	.6334	.2227
1999	18947	92537	19603	19517	.9956	.3205
2000	19558	97698	24023	14437	.6010	.2018
2001	19339	108269	33480	16307	.4871	.1867
2002	22388	111549	45937	13161	.2865	.1380
2003	21367	125061	55077	13578	.2465	.1309
2004	21806	144273	64633	18800	.2909	.1500
2005	27919	138787	60619	18834	.3107	.1564
2006	29439	140041	57150	17897	.3132	.1414
2007	30064	163397	56491	15237	.2697	.0996
2008	33725	178860	49883	13778	.2762	.0734
2009	49142	182871	50061	12996	.2596	.0755
2010	32547	211384	70846	15704	.2217	.0608
Arith. Mean	27434	130467	51082	24141	.5281	.2569
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table F1. GREENLAND HALIBUT in Sub-area I and II. Norwegian bottom trawl survey indices (numbers in thousands) in the Svalbard area (Division IIb).

Year	Fish<20 cm[2]	Age									Total
		1	2	3	4	5	6	7	8	9+	
1981	2.1										20 100
1982	0.7				No age data						2 600
1983	5.9										26 690
1984	3.2	550	3 042	2 924	8 573	6 847	5 657	4 345	2 796	1 896	36 630
1985	1.6	884	3 921	4 294	6 674	8 793	8 622	3 920	1 817	525	39 450
1986	0.1	49	1 005	1 967	7 314	4 671	1 754	2 301	372	37	19 470
1987	1	630	1 014	3 076	4 409	4 786	3 141	964	364	116	18 500
1988	2.5	818	4 298	6 191	6 696	12 289	2 396	6 015	338	1 277	40 318
1989 [1]	1.4	712	3 232	8 158	7 493	7 069	2 374	1 753	353	744	31 888
1990 [1]	0.4	115	336	5 050	7 130	7 730	4 490	2 330	918	544	28 643
1991 [1]	0.1	71	877	3 080	6 720	9 270	5 450	2 800	1 660	524	30 452
1992 [1]	+	33	30	338	1 190	3 520	4 420	2 280	1 280	474	13 565
1993 [1]	+	25	60	51	1 049	2 369	2 056	2 772	1 114	665	10 161
1994 [1]	+	4	238	296	652	2 775	2 371	2 593	531	844	10 304
1995 [1]	0.1	76	+	+	322	886	1 200	1 950	487	497	5 418
1996 [1]	0.4	410	61	104	171	881	2 052	2 587	862	976	8 104
1997 [1]	0.4	268	484	21	65	284	2 089	2 143	379	295	6 028
1998 [1]	2.5	1 999	2 351	2 715	493	609	2 192	2 814	1 252	822	15 247
1999 [1]	1.3	126	+	995	1 789	415	709	2 501	507	674	7 716
2000 [1]	2	2 009	540	323	1 347	2 135	2 634	1 784	1 197	530	12 499
2001 [1]	4.3	4 258	1 235	873	1 506	2 456	1 718	1 504	558	1 079	15 187
2002 [1]	2.3	1 435	2 019	1 176	2 437	3 413	2 685	3 304	847	2 229	19 545
2003 [1]	0.8	410	638	901	2 937	2 630	3 146	2 602	452	684	14 400

[1]New standard trawl equipment (rockhopper gear and 40 meter sweep length).

[2]In millions.

Not updated from 2004, new ecosystem survey

Table F2. GREENLAND HALIBUT in Sub-area I and II. Abundance indices from bottom trawl surveys in the Barents Sea and Svalbard area in August (in thousands).

A: The Barents Sea area; **B**: The expanded Svalbard area.

A	Age													Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	
1995	42	-	-	596	989	1 239	1 673	1 020	-	195	-	-	-	5 754
1996	12 028	900	-	-	-	415	829	861	85	261	118	82	-	15 579
1997 [1]	143	1 162	53	331	589	1 579	2 736	1 120	550	44	-	-	-	8 307
1998 [1]	46	446	328	416	481	323	1 828	924	432	234	-	-	-	5 458
1999	11 637	5 910	384	280	201	1 508	1 729	215	134	661	255	218	-	23 132
2000	-	619	302	417	816	620	1 163	844	605	270	54	221	-	5 931
2001	-	-	259	203	743	1 120	293	697	-	215	107	-	-	3 637
2002	-	-	-	85	773	2 509	3 047	165	290	839	-	255	-	7 963
2003	-	-	-	420	450	1 630	1 070	840	250	410	-	-	-	5 070

B	Age													Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	
1995	77	-	-	429	1 255	1 720	2 535	665	135	281	136	95	-	7 328
1996	1 760	360	105	291	1 144	2 717	3 525	1 290	309	603	30	92	45	12 271
1997	593	2 357	311	116	593	3 053	3 019	478	312	20	-	-	-	10 852
1998	2 295	2 836	2 918	540	770	2 477	3 248	1 472	340	346	130	-	65	17 437
1999	387	263	1 516	3 095	809	836	2 773	486	333	360	-	87	140	11 085
2000	1 976	818	1 280	2 836	3 946	3 216	2 112	1 560	460	199	-	95	-	18 498
2001	4 659	1 690	1 789	2 517	3 536	2 474	1 889	690	383	773	134	27	50	20 611
2002	2 174	2 475	1 718	2 962	4 291	3 620	4 205	1 031	293	1 267	453	304	212	25 005
2003	1 390	600	1 170	3 510	3 350	4 310	3 470	640	520	150	90	140	-	19 340

[1] Only Norwegian and international zones covered. Adjusted (according to the mean distribution in the period 1991-1999) to include the Russian EEZ.

Not updated from 2004, new ecosystem survey

Table F3. GREENLAND HALIBUT in Sub-area I and II. Abundance indices on age from the Norwegian stratified bottom trawl survey in August using a hired commercial vessel (numbers in thousands). Trawls were made at 400-1500 m depth along the continental slope from 68-80°N.

Year	Age															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	
1994	0	0	1	2 001	16 980	11 008	15 552	6 173	1 241	3 628	1 460	443	129	81	11	58 708
1995	0	0	0	1 432	16 945	12 946	20 925	6 737	1 975	4 393	1 385	648	152	103	21	67 662
1996	0	0	10	704	13 623	18 538	24 908	8 114	1 473	3 223	820	396	131	100	2	72 042
1997	0	0	16	1 446	11 738	17 005	18 927	5 383	1 107	3 261	936	600	87	165	16	60 687
1998	0	0	66	1 726	7 868	12 399	23 487	6 243	1 458	4 317	1 238	969	13	183	14	59 981
1999	0	0	27	1 300	5 901	15 383	20 209	12 019	1 872	5 913	1 167	1 198	273	183	15	65 460
2000	0	0	383	1 920	6 901	10 352	17 885	7 795	5 038	3 284	867	458	204	75	16	55 178
2001	0	10	95	986	6 107	15 068	22 584	10 086	3 130	5 442	1 146	1 147	267	180	67	66 315
2002	0	3	427	2 492	7 730	10 913	21 660	9 847	6 327	4 248	2 468	1 642	619	208	183	68 767
2003	6	18	662	3 972	10 293	14 552	20 438	9 191	4 507	6 388	1 902	1 795	861	253	125	74 963
2004	0	5	328	3 637	6 962	12 909	20 674	8 692	3 771	3 908	1 663	2 886	1 276	865	641	68 217
2005	3	24	2 036	9 170	10 195	13 477	8 785	7 683	4 611	4 388	2 500	2 250	995	401	693	67 210

Not updated from 2006 due to new age reading method

Table F4. GREENLAND HALIBUT in Sub-area I and II. Abundance indices on age from the Norwegian bottom trawl survey north and east of Spitsbergen in September (numbers in thousands).

A: Survey area, Russian EEZ excluded **B:** Including Russian EEZ

A	Age						Total
Year	1	2	3	4	5	6+	
1996	15 655	14 510	10 025	3 487	1 593	3 349	48 619
1997	3 415	15 271	14 140	2 803	403	434	36 466
1998	8 482	18 718	9 463	5 161	1 166	932	43 922
1999	5 370	9 074	3 328	2 271	1 492	954	22 489
2000	9 529	16 844	8 007	6 274	1 746	722	43 122
2001	26 206	15 765	4 515	1 767	802	465	49 520
2002	40 186	34 065	15 441	3 862	1 320	556	95 430
2003	49 146	37 344	6 336	3 188	1 035	327	97 376
2004 [1]	15 257	28 540	48 286	12 598	3 562	1 153	109 396
2005 [1]	138 248	23 689	25 989	32 052	6 735	893	227 606

B	Age						Total
Year	1	2	3	4	5	6+	
1998	10 210	28 020	17 186	6 380	1 551	932	64 279
1999	7 514	16 159	8 045	3 067	2 401	954	38 140
2000			No coverage in Russian EEZ				
2001	38 112	40 377	7 960	4 300	1 215	510	92 475
2002	96 231	58 113	31 500	5 665	1 576	556	193 641
2003			No coverage in Russian EEZ				
2004 [1]	23 560	47 023	77 374	14 081	3 719	1 232	166 989
2005 [1]	253 127	40 975	40 231	40 858	6 955	893	383 039

[1] From 2004 part of the new joint ecosystem survey.

Not updFted from 2006 due to new age reading method

Table F5. GREENLAND HALIBUT in Sub-area I and II. Abundance indices from three Norwegian bottom trawl surveys in the Barents Sea in August - September (from 2004 two of them are part of the joint ecosystem survey covering the whole Barents Sea) combined to one index (in thousands).

A: Old strata system used B: Ecosystem survey combined with Norw. GrHal survey

A	Age														Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	
1996	17 926	14 906	10 134	4 486	16 194	22 217	30 014	10 163	1 857	3 954	957	523	175	100	2	133 608
1997	4 050	18 107	14 547	4 481	12 917	20 753	22 984	6 362	1 563	3 312	936	600	87	165	16	110 880
1998	10 704	21 705	12 521	7 603	9 915	14 680	27 784	7 800	1 937	4 586	1 353	1 027	13	241	14	121 883
1999	5 895	9 451	5 200	7 116	8 412	17 437	24 175	12 857	2 407	6 595	1 294	1 387	273	183	144	102 826
2000	11 474	17 755	9 870	11 359	13 093	14 139	20 608	9 704	5 707	3 548	901	695	204	75	16	119 148
2001	30 631	17 452	6 521	5 115	10 077	17 548	24 465	10 973	3 440	6 280	1 302	1 147	267	180	67	135 464
2002	42 348	36 537	17 472	9 105	13 649	15 040	27 076	10 130	6 679	5 104	2 909	1 893	619	257	183	188 999
2003	50 512	37 972	8 298	11 410	15 428	20 553	24 664	10 521	5 437	6 958	1 992	1 955	861	253	125	196 939
2004	17 233	29 072	50 471	17 112	13 233	16 459	24 970	9 753	4 568	4 170	1 963	3 042	1 460	865	726	195 096
2005	153 834	29 173	32 072	46 345	24 680	20 381	14 189	9 919	5 261	4 929	2 709	2 392	1 242	540	776	348 443

B	Age														Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	
2004	16 513	37 564	56 050	12 858	11 967	18 047	25 933	10 060	4 974	4 413	2 151	3 600	1 276	865	641	206 912
2005	182 754	40 350	40 139	40 760	25 334	21 739	15 320	10 504	5 594	5 131	2 967	2 494	1 249	686	758	395 780

Not updated from 2006 due to new age reading method

Table F6. GREENLAND HALIBUT in Sub-area I and II. Russian autumn bottom trawl surveys: Abundance indices at different age (numbers in thousands).

Year	Age-group													Total
	≤ 3	4	5	6	7	8	9	10	11	12	13	14	15+	
1984	4 124	5 359	7 788	24 951	19 863	11 499	6 750	5 416	2 420	1 196	247	146	143	89 902
1985	3 331	4 371	17 076	35 648	27 826	11 717	5 722	4 090	1 937	895	311	31	131	113 086
1986	2 687	6 600	15 853	25 696	16 468	5 436	3 811	2 660	974	539	184	72	6	80 986
1987	289	6 761	9 724	12 703	7 633	3 867	1 903	1 627	721	416	110	0	38	45 792
1988	2 591	4 409	7 891	14 181	11 311	4 308	2 253	1 756	820	307	125	163	54	50 169
1989	1 429	11 310	13 124	25 881	12 782	5 989	2 381	1 285	334	271	98	102	118	75 104
1990	2 820	8 360	16 252	15 621	11 393	4 120	1 911	1 158	307	198	58	36	0	62 234
1991[1]	1 422	8 455	25 408	21 843	15 235	9 419	2 369	1 211	655	142	95	16	26	86 296
1992	685	7 461	33 341	25 498	17 272	10 178	2 720	1 262	938	318	67	0	0	99 740
1993	114	2 166	13 317	19 752	16 528	10 305	3 370	1 868	903	519	103	111	111	69 167
1994	49	1 604	9 868	17 549	11 533	7 746	3 401	1 876	605	394	114	114	57	54 910
1995	19	467	5 759	18 222	15 296	11 539	4 393	1 413	529	312	84	11	32	58 076
1996[2]	0	1 670	6 680	18 722	21 714	13 354	8 512	476	284	106	115	36	20	71 689
1997	235	1 575	4 023	12 165	15 919	16 452	4 591	1 432	779	162	271	66	88	57 758
1998	3 917	5 542	7 768	15 589	16 842	17 727	9 676	2 548	1 752	535	254	85	72	82 307
1999	4 057	4 961	5 951	12 350	14 255	16 078	7 952	3 009	965	494	307	74	-	70 453
2000	2 841	5 327	10 718	15 719	18 694	21 235	9 155	3 593	2 580	1 011	108	133	120	91 234
2001	1 592	6 884	17 365	37 881	27 661	14 163	6 576	3 988	1 875	1 713	929	217	180	121 024
2002[3]	2 145	7 127	10 771	44 220	33 675	18 747	5 947	5 477	1 216	1 877	1 973	60	120	133 355
2003	1 735	6 479	10 029	19 751	14 160	7 592	3 519	2 555	2 200	1 664	831	141	470	71 126
2004	3 305	8 342	9 461	21 834	22 876	14 187	8 331	3 776	2 544	1 745	1031	811	966	99 209
2005	2 096	7 668	11 657	17 933	20 555	14 140	4 658	3 264	1 844	1 585	789	554	420	87 164
2006	3 099	13 954	18 873	34 869	37 481	20 542	7 631	3 586	2 489	2 329	1 663	720	785	148 021
2007	995	5 713	15 982	27 722	36 544	18 917	9 382	6 033	5 221	5 171	2 297	1 399	1 134	136 510
2008	1 483	11 642	12 475	21 157	32 551	33 844	19 618	6 297	7 262	6 994	5 474	3 240	4 092	166 129
2009	713	13 726	35 041	43 719	40 611	38 274	13 509	4 006	7 371	4 522	4 152	1 257	1 398	208 300
2010	198	11 153	47 621	70 442	52 675	44 081	15 045	5 227	4 217	5 927	4 271	1 263	2 561	264 692

[1] Age composition based on combined age-length-keys for 1990 and 1992.

[2] Only half of standard area investigated.

[3] Adjusted assuming area distibution as in 2001.

Table F7. GREENLAND HALIBUT catch in weight, numbers, and biomass (in tonnes) and abundance (in thousands) estimated from Spanish survey 1997-2008.

Year	Catch (Kg)	Catch (numbers)	Biomass™	Abundance (‘000)
1997	195 056	211 533	344 014	379 444
1998	180 974	187 259	351 466	373 149
1999	198 781	172 687	436 956	377 792
2000	169 389	140 355	340 619	291 265
2001	152 681	129 289	283 511	249 219
2002	144 335	115 213	256 460	207 466
2003	151 952	132 117	283 644	256 327
2004	153 859	135 631	320 485	283 965
2005	144 573	134 566	317 320	313 459
2006*				
2007*				
2008	91 573	101 578	129 221**	144 561**
2009*				
2010	167 862		191 510**	216 731**

***No survey in 2006, 2007 and 2009**

**** New swept area estimation method**

Table F8. GREENLAND HALIBUT in Sub-area I and II. Abundance indices from bottom trawl surveys in the Barents Sea in winter (in thousands).

A: Restricted area surveyed every year; **B**: Enlarged area (includes the restricted one) surveyed since 1993

A	Age													
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	Total
1989	1 078	788	1 056	2 284	3 655	2 655	864	971	210	-	19	76	56	13 712
1990	66	907	2 071	1 716	1 996	2 262	1 046	365	175	-	30	119	165	10 918
1991	-	279	755	1 323	1 257	1 526	2 440	906	450	457	-	55	127	9 575
1992	63	128	719	897	1 554	543	1 069	791	-	648	135	40	53	6 640
1993	-	17	168	502	1 730	868	1 490	758	88	655	382	31	35	6 724
1994	-	16	142	1 178	2 259	1 644	1 750	885	-	506	38	25	-	8 443
1995	-	-	-	168	786	749	1 331	760	359	486	60	199	-	4 898
1996	1 816	-	28	40	709	1 510	2 964	1 000	307	808	154	152	45	9 533
1997	-	21	-	21	176	812	1 788	1 440	653	209	94	73	-	5 287
1998	-	-	-	67	474	1 172	2 491	1 144	302	401	89	19	4	6 163
1999	-	77	276	243	495	485	1 058	555	408	152	75	56	-	3 880
2000	-	40	56	396	719	519	1 187	261	290	531	131	23	55	4 208
2001	19	36	112	558	517	260	497	697	267	478	43	42	30	3 556
2002	-	-	32	609	1 019	1 148	989	362	139	591	106	54	54	5 103

B	Age													
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	Total
1993	-	17	279	1 002	3 129	2 818	3 895	1 632	309	1 406	616	31	35	15 169
1994	-	16	152	1 482	3 768	2 698	3 420	1 615	-	1 171	135	25	-	14 482
1995	-	-	-	216	2 824	6 229	10 624	2 727	1 250	1 902	172	718	57	26 719
1996	3 149	-	28	102	1 547	3 043	4 991	1 599	472	1 211	317	250	72	16 781
1997[1]	-	163	-	203	624	2 742	5 759	4 170	1 653	562	240	181	66	16 363
1998[1]	220	501	2 797	1 011	1 847	3 477	6 539	3 057	867	1 179	301	96	57	21 949
1999	41	195	691	825	829	1 531	3 130	1 496	1 011	500	115	129	101	10 594
2000	169	482	947	5 425	2 575	1 310	3 035	553	796	1 109	284	27	55	16 767
2001	69	250	363	2 046	4 250	2 730	2 983	1 123	416	1 148	111	137	94	15 720
2002	233	104	248	1 373	2 748	3 265	3 641	932	449	1 714	365	177	178	15 427
2003	50	89	151	785	1 786	2 860	5 411	1 313	289	951	356	189	92	14 322
2004	67	118	128	527	1 294	1 099	3 207	1 220	624	504	201	281	266	9 536
2005	259	300	2 318	1 512	4 106	3 554	5 373	2 072	862	278	372	305	824	22 135
2006	45	46	1 119	5 518	6 912	5 640	1 353	603	562	321	365	61	115	22 660

[1]Adjusted (according to the 1996 distribution) to include the Russian EEZ which was not covered by the survey.

Not updated from 2007 due to new age reading method

Table F9 GREENLAND HALIBUT in Sub-areas I and II. Results from a research program using trawlers in a limited commercial fishery 1992-2005. All areas combined. Spring and autumn combined in 1992-1993, otherwise only spring-data.

	Catch in numbers on age (%)													
Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1														
2														
3	0.1			0.1		0.0	0.0	0.0					0.1	0.2
4	4.6	4.2	3.2	0.7	0.5	0.9	0.2	0.7	1.2	1.3	0.7	1.8	1.4	1.8
5	19.1	25.0	24.7	22.5	19.5	24.8	6.6	7.7	10.8	6.3	7.7	8.5	8.9	5.4
6	23.0	18.4	23.8	22.6	31.6	22.9	25.5	23.0	17.1	20.2	16.8	21.7	18.9	20.4
7	25.9	27.1	26.8	30.2	35.6	30.5	44.5	39.6	43.0	28.5	42.5	30.5	31.3	25.4
8	13.3	12.4	11.2	11.0	8.7	10.1	15.5	14.5	12.3	24.5	12.4	9.6	14.8	21.5
9	1.7	0.7	1.0	2.7	1.3	2.6	4.5	1.6	4.5	7.8	7.1	8.1	9.5	8.2
10	6.8	7.4	5.9	6.6	2.0	5.0	2.0	9.7	8.5	7.3	8.8	11.0	4.7	6.5
11	2.9	3.1	2.4	2.0	0.5	1.9	0.8	1.0	0.9	1.9	2.2	4.1	4.0	3.1
12	1.7	1.0	0.6	1.1	0.2	0.8	0.3	1.8	1.1	1.7	1.2	3.1	3.5	4.0
13	0.5	0.4	0.2	0.3	0.0	0.3		0.2	0.6	0.3	0.2	1.2	1.5	2.1
14	0.2	0.2	0.1	0.2	0.1	0.2		0.2	0.0	0.2	0.4	0.5	0.9	1.0
15	0.1					0.0		0.0	0.0	0.2	0.1	0.0	0.4	0.5

	Mean individual weight (kg)													
Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1														
2														
3	0.26			0.40		0.39							0.27	0.24
4	0.50	0.53	0.52	0.47	0.48	0.45	0.41	0.51	0.50	0.60	0.44	0.48	0.44	0.48
5	0.71	0.76	0.73	0.70	0.74	0.69	0.76	0.74	0.69	0.66	0.69	0.68	0.65	0.64
6	0.96	0.98	0.95	0.94	0.94	0.88	0.96	0.92	0.98	0.94	0.93	1.00	0.88	0.84
7	1.29	1.33	1.28	1.24	1.23	1.15	1.19	1.25	1.23	1.12	1.22	1.28	1.17	1.14
8	1.77	1.85	1.79	1.71	1.66	1.55	1.79	1.64	1.57	1.48	1.39	1.67	1.43	1.40
9	2.00	2.28	2.23	2.03	2.00	1.87	2.26	2.18	1.90	1.84	1.69	1.97	1.73	1.67
10	2.46	2.65	2.55	2.50	2.50	2.34	2.54	2.38	2.40	2.30	2.31	2.37	2.14	2.26
11	3.10	3.43	3.37	3.28	3.16	2.95	3.47	3.17	3.13	2.92	3.19	3.20	2.34	2.62
12	3.86	4.32	4.22	3.71	3.70	3.46	4.16	3.79	4.04	3.82	3.91	3.48	2.77	2.87
13	4.44	5.18	5.01	4.62		4.52		5.07	4.47	3.68	5.20	4.28	2.92	2.98
14	6.00	6.44	6.29	5.59		5.47		5.60	6.00	5.74	5.59	4.74	3.89	3.30
15	5.22								8.79	5.52	7.03	9.17	4.65	3.32

Not updated from 2006 due to new age reading method

Table F9 (Continued) GREENLAND HALIBUT in Sub-areas I and II. Results from a research program using trawlers in a limited commercial fishery 1992-2005. All areas combined. Spring and autumn combined in 1992-1993, otherwise only spring-data.

	CPUE (N) on age													
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1														
2														
3	0			1	0	0	0	0	0	0	0	0	1	2
4	19	30	26	7	7	11	2	7	14	12	7	19	15	24
5	80	176	198	219	286	298	59	72	132	63	81	90	96	70
6	97	130	191	220	463	275	229	214	208	201	176	229	203	263
7	109	191	215	294	521	366	400	369	524	284	447	322	337	328
8	56	87	90	107	127	121	139	135	150	244	130	101	159	278
9	7	5	8	26	19	31	40	15	55	78	75	86	102	106
10	29	52	47	64	29	60	18	90	104	73	92	116	51	84
11	12	22	19	19	7	23	7	9	11	18	23	43	43	40
12	7	7	5	11	3	10	3	17	13	17	12	32	38	52
13	2	3	2	3	0	4	0	2	7	3	2	12	16	27
14	1	1	1	2	1	2	0	2	0	2	4	5	10	13
15	0			0	0	0	0	0	0	2	1	0	4	6

	CPUE (kg) on age													
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1														
2														
3	0			0	0	0	0	0	0	0	0	0	0	1
4	10	16	13	3	4	5	1	3	7	7	3	9	6	11
5	57	134	145	153	211	207	45	53	91	41	56	61	63	44
6	93	127	182	207	435	243	220	197	204	189	164	229	179	220
7	140	254	276	364	641	423	476	461	645	318	543	411	396	373
8	99	162	161	183	211	189	249	221	236	361	181	169	228	389
9	14	11	18	53	38	59	91	32	105	143	127	169	177	176
10	70	138	121	161	73	141	46	215	250	167	213	275	109	189
11	38	75	65	64	23	68	25	30	33	54	74	138	101	104
12	28	30	20	40	11	33	11	64	53	66	48	113	105	150
13	9	15	8	13	0	16	0	9	32	11	9	52	48	79
14	5	9	5	11	0	13		10	2	10	24	23	38	43
15	2			0	0	0		0	3	11	4	4	20	20

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Overall mean individual weight (kg)	1.35	1.38	1.27	1.29	1.12	1.16	1.30	1.39	1.35	1.38	1.38	1.57	1.37	1.39
CPUE (kg round weight per trawlhour)**	567	973	1020	1255	1640	1393	1169	1294	1647	1377	1449	1657	1475	1795
CPUE (Number fish per trawlhour)**	420	705	803	973	1464	1201	899	931	1220	998	1050	1055	1077	1291
Catch (in tonnes)	695	862	811	368	436	274	272	269	295	297	288	298	304	292

***) Preliminary**

*** *) Average for freezer- and factorytrawler**

Not updated from 2006 due to new age reading method

Table F10. GREENLAND HALIBUT in ICES Sub-area IV (North Sea. Nominal catch (t) by countries as officially reported to ICES. Not included in the assessment .

Year	Denmark	Faroe Islands	France	Germany	Green-land	Ire-land	Norway	Russia	UK England & Wales	UK Scotland	Total
1973	-	-	-	4	-	-	9	8	28	-	49
1974	-	-	-	2	-	-	2	-	30	-	34
1975	-	-	-	1	-	-	4	-	12	-	17
1976	-	-	-	1	-	-	2	-	18	-	21
1977	-	-	-	2	-	-	2	-	8	-	12
1978	-	-	2	30	-	-	-	-	1	-	33
1979	-	-	2	16	-	-	2	-	1	-	21
1980	-	177	-	34	-	-	5	-	-	-	216
1981	-	-	-	-	-	-	7	-	-	-	7
1982	-	-	2	26	-	-	17	-	-	-	45
1983	-	-	1	64	-	-	89	-	-	-	154
1984	-	-	3	50	-	-	32	-	-	-	85
1985	-	1	2	49	-	-	12	-	-	-	64
1986	-	-	30	2	-	-	34	-	-	-	66
1987	-	28	16	1	-	-	35	-	-	-	80
1988	-	71	62	3	-	-	19	-	1	-	156
1989	-	21	14[1]	1	-	-	197	-	5	-	238
1990	-	10	30[1]	3	-	-	29	-	4	-	76
1991	-	48	291[1]	1	-	-	216	-	2	-	558
1992	1	15	416[1]	3	-	-	626	-	+	1	1 062
1993	1	-	78[1]	1	-	-	858	-	10	+	948
1994	+	103	84[1]	4	-	-	724	-	6	-	921
1995	+	706	165	2	-	-	460	-	52	283	1 668
1996	+	-	249	1	-	-	1 496	-	105	159	2 010
1997	+	-	316	3	-	-	873	-	1	162	1 355
1998	+	-	71[1]	10	-	10	804	-	35	435	1 365
1999	+	-		1	-	18	2 157	-	43	358	2 577
2000	+		41	10	-	19	498[1]	-	67	192	827
2001	+		43	-	-	10	470	-	122	202	847
2002	+		8	+	-	2	200	-	10	246	466
2003	-	-	1	+	+	+	453	-	+	122	576
2004	-	-	-	-	-	-	413	-	90	-	503
2005	-	-	2	-	-	-	58	-	4	-	64
2006	-	-	3	-	-	-	89	-	7	-	99
2007	-	+	+	-	-	-	129	-	+	+	129
2008 [1]	-	-	-	-	-	-	14	-	22	-	36
2009 [1]	-	-	-	-	-	-	5	-	129	-	134
2010 [1]	+	1	38	-	-	-	39	-	49	-	126

[1] Provisional figures

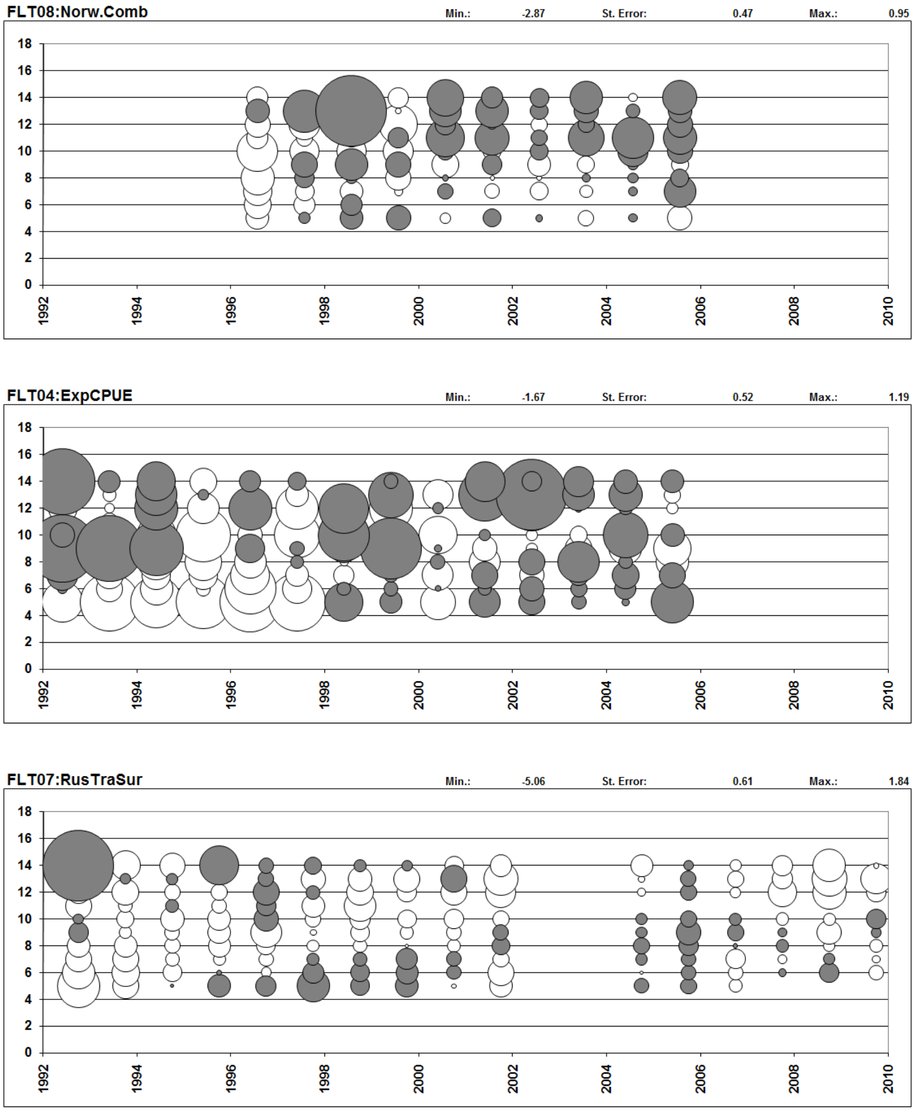


Figure 8.1. <u>NEA Greenland halibut</u>. Log catchability residuals by age and year for the tuning fleets included in the assessments. For each graph all bubbles are normalized to the same maximum bubble-size. Open bubbles represent positive values; filled bubbles represent negative values.

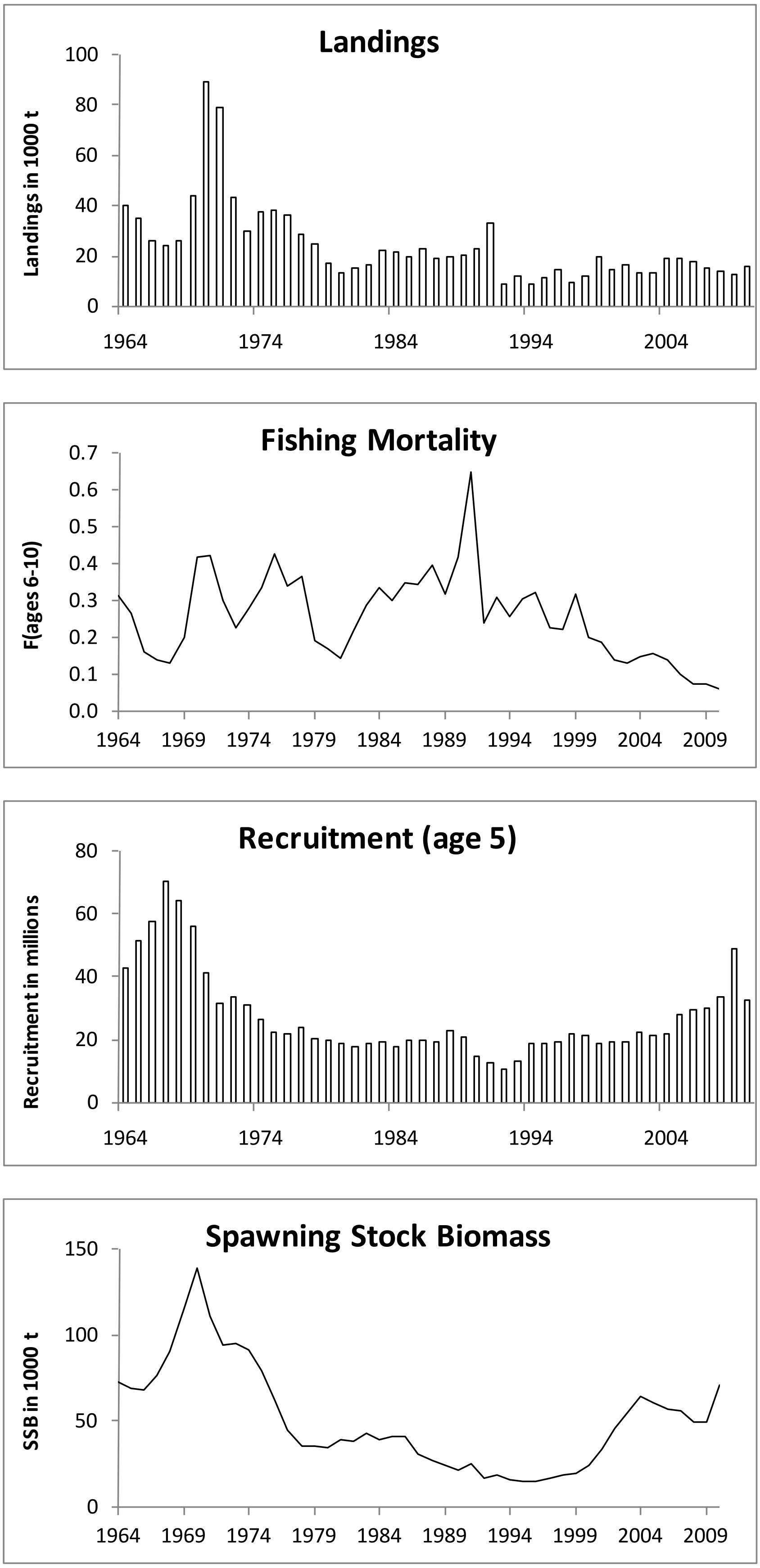


Figure 8.2. NEA Greenland halibut. Historical landings, fishing mortality, recruitment and spawning stock biomass.

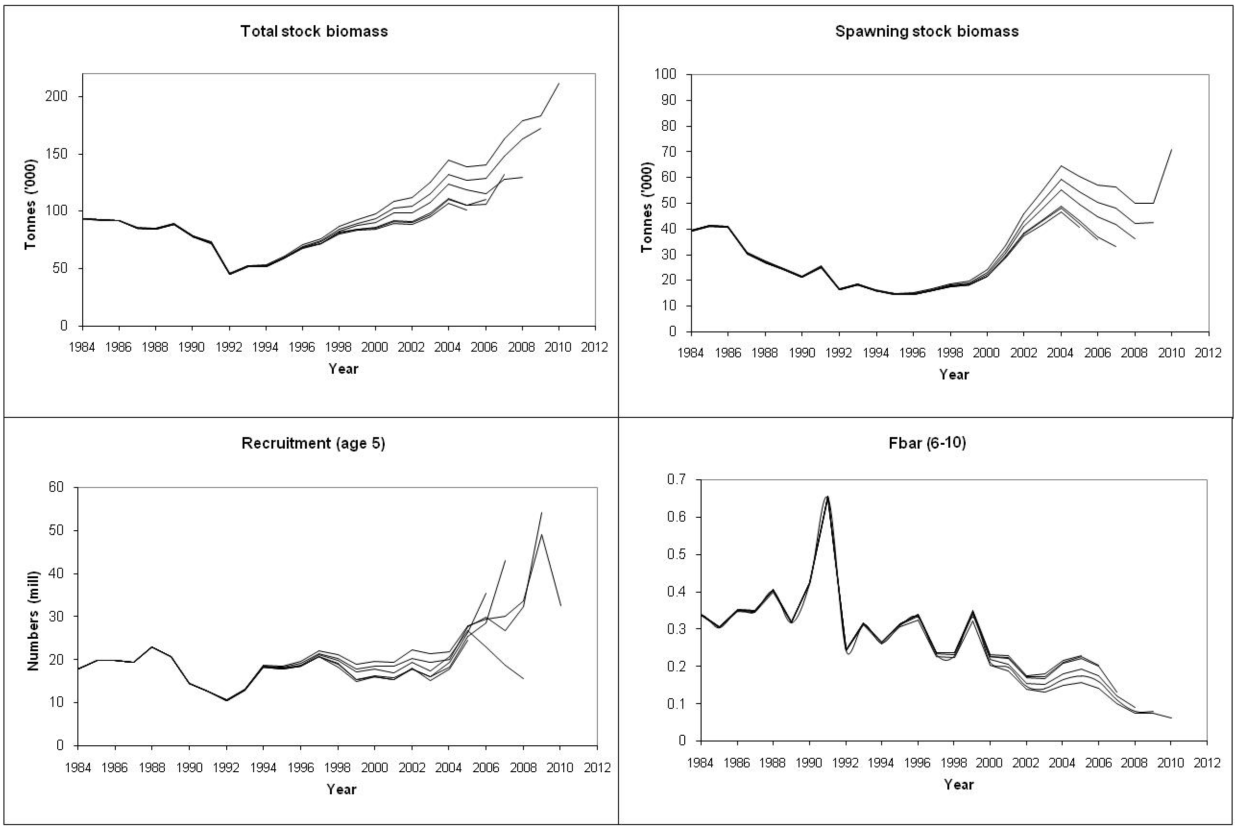


Figure 8.3. NEA Greenland halibut. Retrospective plots.

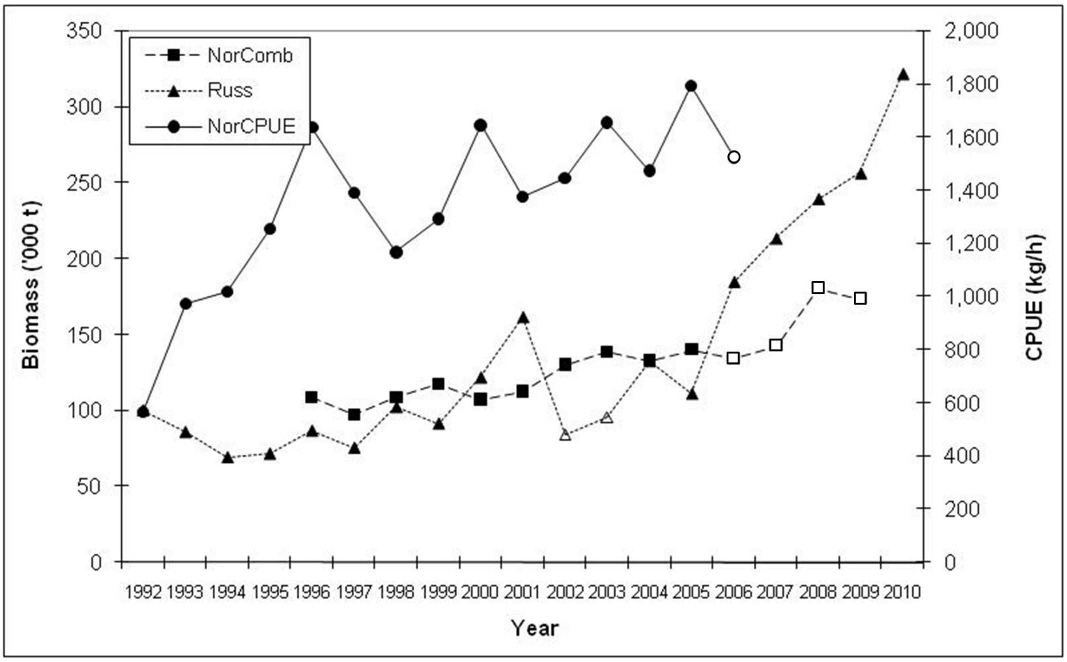


Figure 8.4. NEA Greenland halibut. Biomass estimates from different tuning series used in the trial XSA. Years with open symbols indicate years excluded from the tuning. (Russian survey in 2002 and 2003 excluded due to nonstandard survey coverage/time. Norwegian Combined Survey in 2006-2009 and Norwegian CPUE in 2006 – excluded due to lack of age readings).

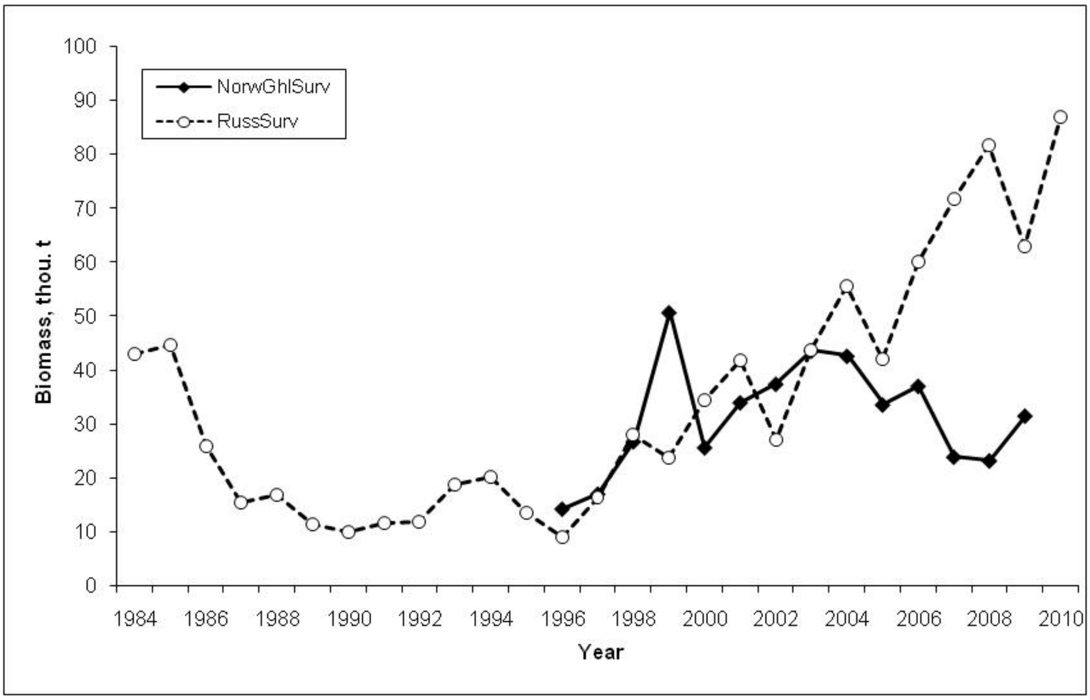


Figure 8.5. NEA Greenland halibut. Swept area estimate of the mature female biomass based on the data from the Norwegian Greenland halibut survey along the continental slope in August (not executed in 2010) and Russian trawl survey in October-December (compared to previous reports, 2007-2008 recalculated with using complete data for these years).

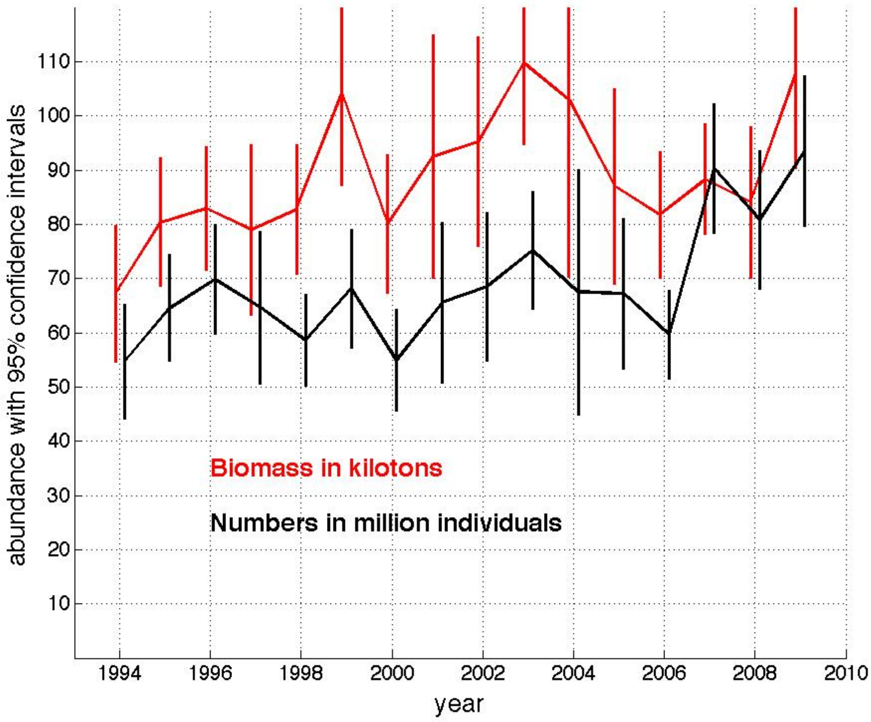


Figure 8.6 Estimated Greenland halibut total abundance in biomass and by number of individuals from the Norwegian slope surveys 1994-2009. The vertical bars show 95% confidence intervals

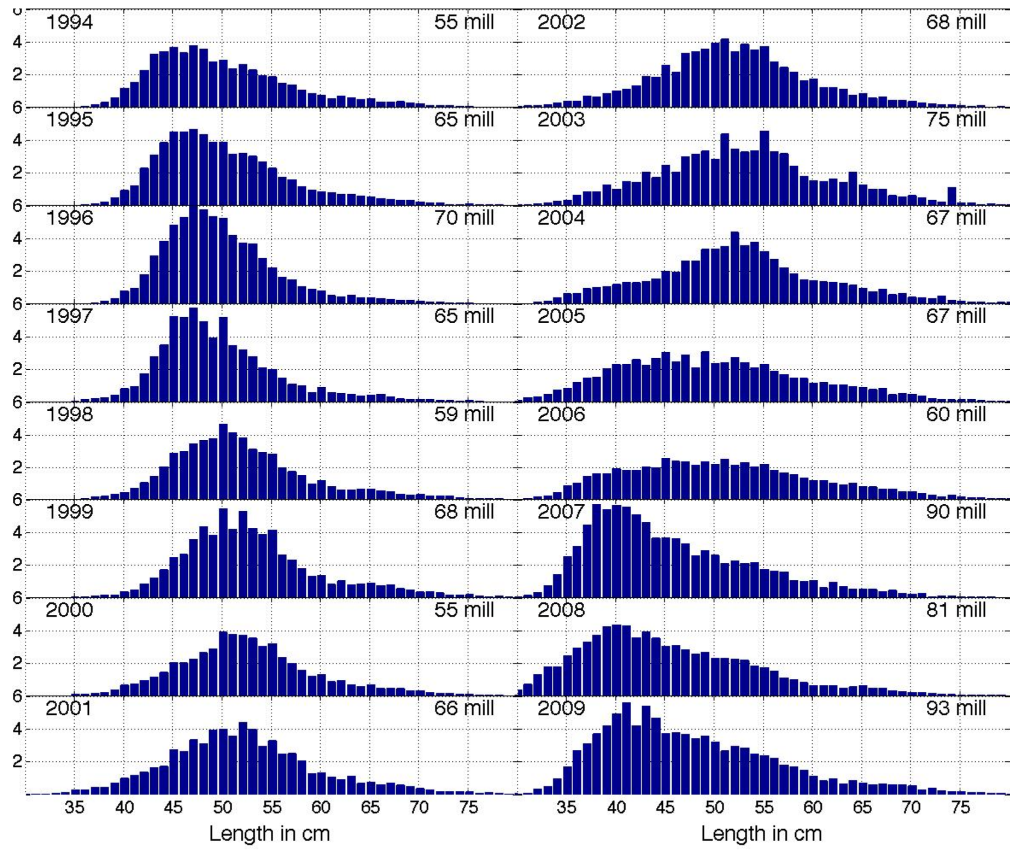


Figure 8.7. Length frequency distributions for Greenland halibut from the Norwegian autumn surveys 1994-2009. Note the abrupt shift in 2007. Vertical axis in million individuals.

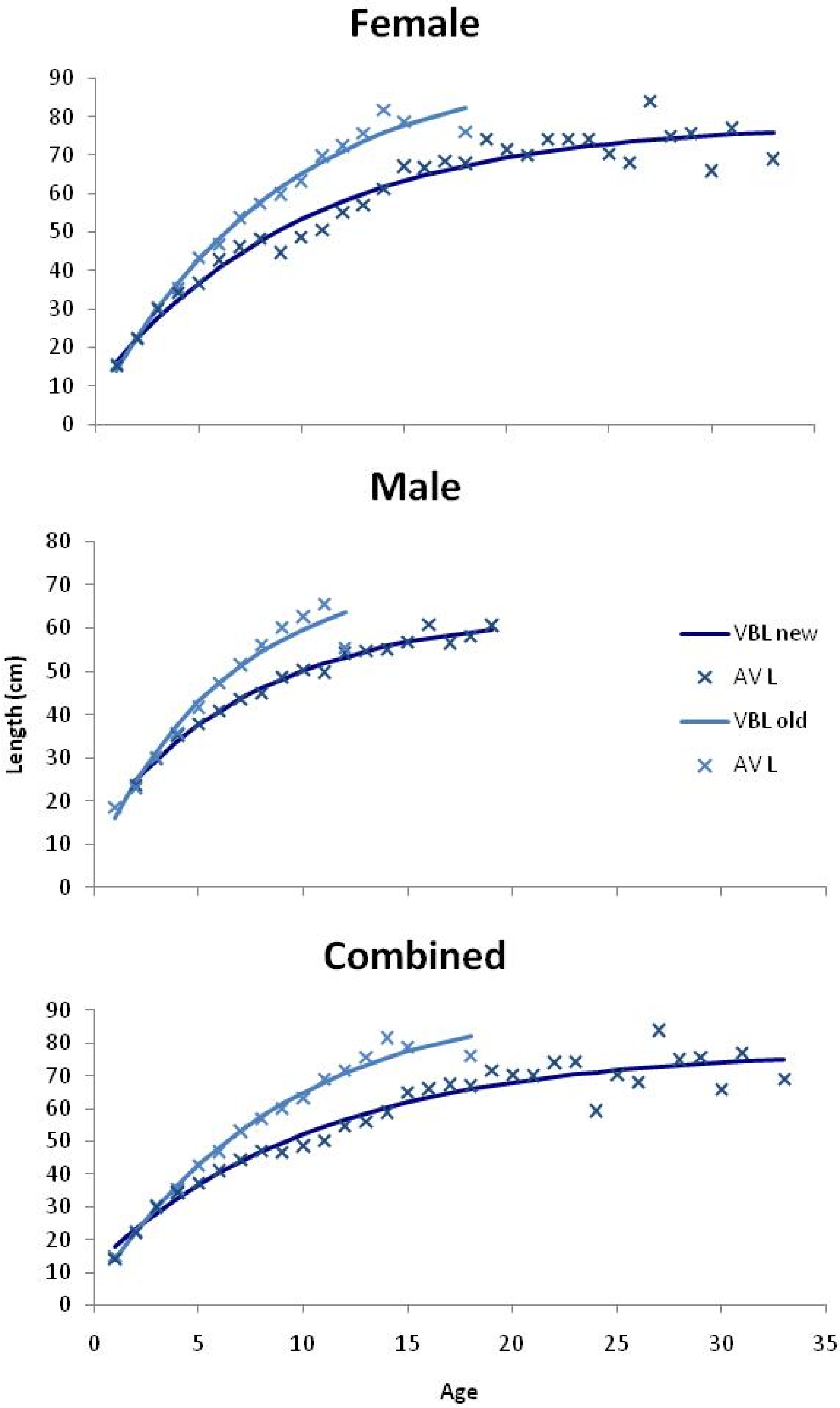


Figure 8.8. Growth according to von Bertalanffy's growth function by sex, and by new (VBL new) vs. old (VBL old) aging method (Hallfredsson and Jørgensen 2011).

9 Barents Sea Capelin

9.1 Regulation of the Barents Sea Capelin Fishery

Since 1979, the Barents Sea capelin fishery has been regulated by a bilateral fishery management agreement between Russia (former USSR) and Norway. A TAC has been set separately for the winter fishery and for the autumn fishery. In recent years (from 1999) no autumn fishery has taken place, except for a small Russian experimental fishery. The fishery was closed from 1 May to 15 August until 1984. After 1984, the fishery was closed from 1 May to 1 September. A minimum landing size of 11 cm has been in force since 1979. From the autumn of 1986 to the winter of 1991, from the autumn 1993 to the winter 1999, and in 2004-2008, no commercial fishery took place. A commercial fishery in the wintering-spring period started again in 2009. AFWG strongly recommends capelin fishery only on mature fish during the period from January to April.

9.2 Catch Statistics (Table 9.1, 9.2)

The total catches that were taken during spring 2011 amounted to 273 070 tonnes by Norway and 86 600 tonnes by Russia, giving a total of 359 670 tonnes. This is about 20 000 tonnes below the agreed TAC. The amount of capelin killed in the fishery carried out by trawl is uncertain due to possibilities of additional mortality connected to the fishing operations.

The age-length composition from Norwegian catches is presented in Table 9.1a and from the Russian fishery in Table 9.1b. The international historical catch by country and seasons in the years 1972-2011 is given in Table 9.2.

9.3 Sampling

The sampling from scientific surveys, exploratory fishing and observers of capelin from September 2010 April 2011 –is summarised below:

Investigation	No. of samples	Length measurements	Aged individuals
Ecosystem survey in autumn 2010 (Norway)	308	16703	3853
Ecosystem survey in autumn 2010 (Russia)	280	16900	1029
Capelin winter investigations 2011 (Russia)	7	1213	40
Observer on fishing vessels in winter-spring 2011(Russia)	171	29968	1275
Sampling from fishing vessels in winter-spring 2011 (Norway)		Samples	not finished
Bottom survey winter 2011 (Norway)	236	7587	999
Bottom survey winter 2011 (Russia)	68	5139	150

9.4 Stock Size Estimates

9.4.1 Acoustic stock size estimates in 2010 (Table 9.3)

Two Russian and three Norwegian vessels jointly carried out the 2010 acoustic survey as part of an ecosystem survey during autumn (Anon., 2010). The geographical coverage of the total stock was considered complete. It was synoptic as in the previous year and the results of estimation are representative. The geographical distribution of capelin is shown in Figure 9.1.

The results from the survey are given in Table 9.3. The total capelin stock was estimated at 3.50 million tonnes. It is about 7% lower than the stock estimated last year but higher than the long term mean. Almost 59% (2.05 million tonnes) of the stock biomass consisted of maturing fish (>14.0 cm). The estimated maturing stock is somewhat smaller than in 2009. The weight at age in the 2010 survey is very close to that in 2009.

9.4.2 Recruitment estimation in 2010 (Table 9.4)

The historical estimated total number of larvae is shown in Table 9.4. These larval abundance estimates should reflect the amount of larvae produced each year (Gundersen and Gjøsæter, 1998). There were some problems with this survey in 1986, 1995 and since 1997 when permission has not been granted to enter the Russian EEZ. The larval surveys based on Gulf III plankton samples, which have been carried out in June each year since 1981, were discontinued in 2007.

A swept volume index (Dingsør, 2005; Eriksen *et al*., 2009) of abundance of 0-group capelin in August-September is given in Table 9.4. This index is calculated both without correction and with correction for catching efficiency. The 0-group index in 2010 is close to the long-term average. Table 9.4 also shows the number of fish in the various year classes, and their "survey mortality" from age one to age two. As there has been no fishing on these age groups, the figures for total mortality constitute natural mortality only, and probably reflect quite well the variation in predation on capelin.

There is negative"survey mortality" (WD14), from age zero to one for several cohorts and also from age one to two for a couple of cohorts with low abundance. This needs to be taken into consideration when making use of the age zero and one estimates as absolute estimates. However, the adjustment method for indices suggested in WD14 is not considered to be appropriate.

9.5 Other surveys and information from 2011

Russian capelin winter-spring investigation

Russian capelin spring investigations were performed on board fishing vessel "Novaya Zemlya" in the period from 15 to 27 January 2011 (figure 9.5). The area of distribution of capelin was not well covered during the survey.

Water temperatures in the surface and intermediate layers inside the surveyed area were characterized as warm. The size of the spawning stock of capelin in the surveyed area of 38,234 square miles was estimated to 160 thousand tonnes, representing about 25% of the simulated spawning stock. There was no evidence of concentrations of mature capelin in the Central part of the sea.

The first commercial concentrations of capelin were found only in the northern slope of the Goose Bank on January 24. Formation of the first of the migratory flows of capelin took place far to the east, and was consistent with a normal pattern in warm years (analogous to the years 1991-1992). The high rate of migration was determined by the size-age structure of the spawning stock. About 84 percent of the fish were aged 4 years old.

Norwegian capelin winter-spring investigation

No special capelin investigation was conducted by Norway in winter-spring 2011. Capelin observations were made during the winter groundfish survey, but no attempt was made to quantify the amount of maturing capelin approaching the coast to spawn.

9.6 Stock assessment

As decided by the Arctic Fisheries Working Group at its 2010 meeting (ICES C.M. 2010/ACOM:05), the assessment of Barents Sea capelin was left to the parties responsible for the autumn survey, i.e. IMR in Bergen and PINRO in Murmansk. In accordance with this, the assessment was made during a meeting in Kirkenes after the survey. The assessment was an update assessment, without changes in the methodology.

Estimates of stock in number by age group and total biomass for the historical period are shown in Table 9.5. Other data which describe the stock development are shown in Table 9.6.

A probabilistic projection of the spawning stock to the time of spawning at 1 April 2011 was made using the spreadsheet model CapTool (implemented in the @RISK add-on for EXCEL, 15000 simulations were used). 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 from the 2010 Arctic Fisheries Working Group. The methodology is described in the 2009 WKSHORT report (ICES C.M. 2009/ACOM:34).

Probabilistic prognoses for the maturing stock from October 1 2010 until April 1 2011 were made, with a CV of 0.20 on the abundance estimate. A CV of 0.20 is slightly higher than the value calculated for most years (see Stock Annex). With no catch, the estimated median spawning stock size in 2011 is 765 000 tonnes. With a catch of 380 000 tonnes, the probability for the spawning stock in 2011 to be below 200 000 t, the B_{lim} value used by ACFM in recent years, is 5 % (Fig. 9.2). The median spawning stock size in 2011 will then be 487 000 tonnes. Figure 9.2 shows the 95 % percentile of the spawning stock biomass 1 April 2011 as a function of the quota, while Fig 9.3 shows the probability of SSB < B_{lim} as a function of the catch. The monthly distribution of the catch was as usually assumed to be 20 % in January, 30 % in February and 50 % in March. In the last two years, the proportion caught in January has been lower and the proportion caught in March has been higher than these values (Section 9.2), and in the future it should be considered whether this monthly distribution of catches used in stock projections should be changed.

The advised catch for 2011 is slightly higher than for 2010 (380 000 tonnes vs. 360 000 tonnes), although the maturing stock biomass is lower. The reason for this is that the predicted immature cod stock in 2011 (ICES C.M. 2010/ACOM:05) is lower than that predicted for 2010 last year (ICES C.M. 2009/ACOM:01), and thus the predicted predation pressure from cod on capelin in January-March will be lower.

The 0-group index for herring in 2010 is low, and the ecosystem survey in 2010 also showed that the abundance of age 1-2 herring in the Barents Sea is very low (Anon., 2010) which is consistent with the most recent stock assessment for herring (ICES C.M. 2010/ACOM:15). The total abundance of 1 year and older herring in the Barents Sea in 2011 will thus be low. High abundance of herring has been suggested to be a necessary but not sufficient factor for recruitment failure in the capelin stock (Hjermann *et al*. 2010). The recruitment conditions for capelin can thus be expected to be average to good in 2011.

The 2010 year class was found to be average at the 0-group stage. If we insert the 2010 value (91.7) in the 1-group vs. 0-group regression shown in Fig. 9.4 we get 177.5 billion as the predicted value of 1-group abundance in 2011.

Being a forage fish in an ecosystem where two of its predators cod and haddock are presently at historic high levels, the capelin stock is now under heavy predation pressure. Consumption estimates from recent years indicate that the amount of capelin consumed by cod (Table 1.3, 1.4) and haddock (Dolgov, ICES AFWG 2010 WD#04) has increased and is at historic high levels. At the same time, capelin have for the last years been at levels at which the current harvest control rule allowed a capelin fishery to take place (Table 9.5). Consequently, the stock is under "double pressure" and should be monitored carefully to look for signs of overexploitation that could, eventually, lead to recruitment failure and a reduced stock size. The fishing operations should also be monitored carefully to check whether additional mortality caused by slipping, sorting through the meshes etc. could be a potential problem.

9.7 Reference points

A B_{lim} (SSB_{lim}) management approach has been suggested for this stock (Gjøsæter *et al*. 2002). In 2002, the Mixed Russian-Norwegian Fishery Commission agreed to adopt a management strategy based on the rule that, with 95% probability, at least 200 000 t of capelin should be allowed to spawn. Consequently, 200 000 t was used as a B_{lim}.

A multispecies model including cod and herring is needed for meaningful calculation of MSY for capelin, because of the strong species interactions. Such studies have been made by Tjelmeland (2005), and should be updated. There is clearly also a need for a target biomass reference point for capelin, and calculations of B_{target} are also in progress.

9.8 Regulation of the fishery for 2011

During its autumn 2010 meeting, the Joint Russian-Norwegian Fishery Commission set the quota for 2011 to 380 000 tonnes, in accordance with the harvest rule. Of this, 10 000 tonnes (5 000 tonnes to Norway and 5 000 tonnes to Russia) is a research quota.

9.9 The Barents Sea capelin benchmark assessment 2009

In August 2009 a benchmark assessment workshop for short-lived species (WKSHORT) was arranged in Bergen, Norway, and the Barents Sea capelin stock was among the stocks dealt with during that workshop (ICES C.M. 2009/ACOM:34). In the report it is stated:

The data and methodology used for the Barents Sea capelin assessment is endorsed by the WKSHORT, based on the combination of available background materials, presentations, discussions, and the draft Report and Stock Annex. Unfortunately, the WKSHORT cannot formally endorse the written version of the approach which appears in the WKSHORT Report *and the Stock Annex as of the completion of the WKSHORT on September 4, 2009, as it is incomplete. The WKSHORT is confident that if the Report and Stock Annex can fully convey in writing the information provided throughout the WKSHORT, the Report and Stock Annex will be acceptable.*

The WKSHORT endorses the way in which the Barents Sea capelin assessment has incorporated predator-prey interactions (specifically having identified the crucial role of cod predation on capelin mortality rate), and we would suggest that this is world-leading in development of an ecosystem approach. Similarly, the incorporation of uncertainty (through bootstrapping simulations) is to be applauded and has clearly been very effective.

Since then, work has been going on to finalize the Stock Annex, scrutinize model assumptions and update the model with recent data, and the New Stock Annex is included in the current (2011) AFWG report.

Table 9.1a Barents Sea Capelin. Age- and length distribution (percentages) of Norwegian catches January-April 2011. The work-up of samples are not finalized but more than 700 aged individuals are included in the table.

Length	Age 3	Age 4	Age 5	Sum
12.0				
12.5				
13.0				
13.5	1.3			0.1
14.0	5.3	0.6		1.1
14.5	18.4	2.9		4.5
15.0	17.1	5.3		6.4
15.5	18.4	12.8		13.0
16.0	13.2	15.0	17.4	14.9
16.5	6.6	15.5	17.4	14.6
17.0	9.2	13.4	13.0	13.0
17.5	7.9	15.4	26.1	14.9
18.0	1.3	12.5	17.4	11.4
18.5	1.3	4.0	8.7	3.9
19.0		2.1		1.8
19.5		0.2		0.1
20.0		0.2		0.1
20.5				
	10.6	86.2	3.2	100.0

Table 9.1b Barents Sea Capelin. Age- and length distribution (millions) of Russian catches January-April 2011.

Length (cm)	Age 2	Age 3	Age 4	Age 5	Sum %
12.0	+				0.0
12.5	+				0.0
13.0	1	1			0.0
13.5		11			0.3
14.0		53	4		1.5
14.5		53	113		4.5
15.0		88	167		7.0
15.5		89	284		10.2
16.0		49	445	3	13.6
16.5		71	501	15	16.0
17.0		48	445	17	13.9
17.5		44	463	23	14.5
18.0		9	288	8	8.3
18.5		19	187	2	5.7
19.0			104	1	2.9
19.5			41	4	1.2
20.0			6	2	0.2
20.5					0.0
Sum	1	535	3048	77	100.0
%	0.0	14.6	83.3	2.1	

Table 9.2 Barents Sea CAPELIN. International catch ('000 t) as used by the Working Group.

Year	Winter				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
1965	217	7	0	**224**	0	0	**0**	**224**
1966	380	9	0	**389**	0	0	**0**	**389**
1967	403	6	0	**409**	0	0	**0**	**409**
1968	460	15	0	**475**	62	0	**62**	**537**
1969	436	1	0	**437**	243	0	**243**	**680**
1970	955	8	0	**963**	346	5	**351**	**1314**
1971	1300	14	0	**1314**	71	7	**78**	**1392**
1972	1208	24	0	**1232**	347	13	**360**	**1591**
1973	1078	34	0	**1112**	213	12	**225**	**1337**
1974	749	63	0	**812**	237	99	**336**	**1148**
1975	559	301	43	**903**	407	131	**538**	**1441**
1976	1252	228	0	**1480**	739	368	**1107**	**2587**
1977	1441	317	2	**1760**	722	504	**1226**	**2986**
1978	784	429	25	**1238**	360	318	**678**	**1916**
1979	539	342	5	**886**	570	326	**896**	**1782**
1980	539	253	9	**801**	459	388	**847**	**1648**
1981	784	429	28	**1241**	454	292	**746**	**1986**
1982	568	260	5	**833**	591	336	**927**	**1760**
1983	751	373	36	**1160**	758	439	**1197**	**2357**
1984	330	257	42	**629**	481	368	**849**	**1477**
1985	340	234	17	**591**	113	164	**277**	**868**
1986	72	51	0	**123**	0	0	**0**	**123**
1987	0	0	0	**0**	0	0	**0**	**0**
1988	0	0	0	**0**	0	0	**0**	**0**
1989	0	0	0	**0**	0	0	**0**	**0**
1990	0	0	0	**0**	0	0	**0**	**0**
1991	528	159	20	**707**	31	195	**226**	**933**
1992	620	247	24	**891**	73	159	**232**	**1123**
1993	402	170	14	**586**	0	0	**0**	**586**
1994	0	0	0	**0**	0	0	**0**	**0**
1995	0	0	0	**0**	0	0	**0**	**0**
1996	0	0	0	**0**	0	0	**0**	**0**
1997	0	0	0	**0**	0	1	**1**	**1**
1998	0	2	0	**2**	0	1	**1**	**3**
1999	50	33	0	**83**	0	22	**22**	**105**
2000	279	94	8	**381**	0	29	**29**	**410**
2001	376	180	8	**564**	0	14	**14**	**578**
2002	398	228	17	**643**	0	16	**16**	**659**
2003	180	93	9	**282**	0	0	**0**	**282**
2004	0	0	0	**0**	0	0	**0**	**0**
2005	1	0	0	**1**	0	0	**0**	**1**
2006	0	0	0	**0**	0	0	**0**	**0**
2007	2	2	0	**4**	0	0	**0**	**4**
2008	5	5	0	**10**	0	2	**0**	**12**
2009	233	73	0	**306**	0	1	**1**	**307**
2010	246	77	0	**323**	0	0	**0**	**323**
2011	273	87	0	**360**				

Table 9.3. Barents Sea CAPELIN. Stock size estimation table. Estimated stock size from the acoustic survey in August-September 2010.

Length (cm)			Age groups / year class 1	2	3	4	5+	Sum	Biomass	Mean weight
			2009	2008	2007	2006	2005-	(10^9)	(10^3 t)	(g)
5.0	-	5.5								
5.5	-	6.0	2.805	0.000	0.000	0.000	0.000	2.805	2.805	1.0
6.0	-	6.5	7.761	0.000	0.000	0.000	0.000	7.761	7.761	1.0
6.5	-	7.0	10.184	0.000	0.000	0.000	0.000	10.184	10.184	1.0
7.0	-	7.5	9.517	0.000	0.000	0.000	0.000	9.517	9.517	1.0
7.5	-	8.0	13.188	0.000	0.000	0.000	0.000	13.188	18.463	1.4
8.0	-	8.5	16.769	0.000	0.000	0.000	0.000	16.769	31.861	1.9
8.5	-	9.0	28.936	0.000	0.000	0.000	0.000	28.936	60.766	2.1
9.0	-	9.5	34.366	0.054	0.000	0.000	0.000	34.420	89.492	2.6
9.5	-	10.0	30.380	0.000	0.000	0.000	0.000	30.380	91.140	3.0
10.0	-	10.5	40.423	0.066	0.000	0.000	0.000	40.489	145.760	3.6
10.5	-	11.0	20.695	0.948	0.000	0.000	0.000	21.643	95.229	4.4
11.0	-	11.5	19.733	2.292	0.000	0.000	0.000	22.025	110.125	5.0
11.5	-	12.0	8.891	8.096	0.000	0.000	0.000	16.987	101.922	6.0
12.0	-	12.5	2.003	13.421	0.000	0.000	0.000	15.424	104.883	6.8
12.5	-	13.0	1.865	20.799	0.103	0.000	0.000	22.767	175.306	7.7
13.0	-	13.5	0.109	23.276	0.847	0.000	0.000	24.232	215.665	8.9
13.5	-	14.0	0.109	16.245	0.801	0.000	0.000	17.155	174.981	10.2
14.0	-	14.5	0.024	20.639	2.499	0.000	0.000	23.162	268.679	11.6
14.5	-	15.0	0.000	8.548	2.608	0.000	0.000	11.156	151.722	13.6
15.0	-	15.5	0.000	5.516	7.028	0.006	0.000	12.550	197.035	15.7
15.5	-	16.0	0.000	3.383	6.377	0.041	0.000	9.801	175.438	17.9
16.0	-	16.5	0.000	1.400	8.652	0.260	0.000	10.312	217.583	21.1
16.5	-	17.0	0.000	2.331	8.298	0.041	0.000	10.670	250.745	23.5
17.0	-	17.5	0.000	0.473	8.362	0.198	0.000	9.033	246.601	27.3
17.5	-	18.0	0.000	0.074	6.400	0.305	0.000	6.779	204.048	30.1
18.0	-	18.5	0.000	0.208	4.470	0.017	0.007	4.702	157.517	33.5
18.5	-	19.0	0.000	0.078	2.823	0.003	0.000	2.904	108.610	37.4
19.0	-	19.5	0.000	0.096	1.335	0.023	0.000	1.454	59.614	41.0
19.5	-	20.0	0.000	0.000	0.264	0.000	0.000	0.264	11.774	44.6
20.0	-	20.5	0.000	0.000	0.025	0.000	0.000	0.025	1.175	47.0
20.5	-	21.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	52.0
TSN (10^9)			247.758	127.943	60.892	0.894	0.007	437.494		
TSB (10^3 t)			740.78	1304.96	1426.94	23.49	0.23		3496.40	
Mean length (cm)			9.38	13.52	16.56	17.10	18.25	11.61		
Mean weight (g)			2.99	10.20	23.43	26.27	33.50			7.99
SSN (10^9)			0.024	42.746	59.141	0.894	0.007	102.812		
SSB (10^3 t)			0.28	616.10	1410.44	23.49	0.23		2050.54	

Table 9.4 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.) Without Keff	With Keff	Acoustic estimate (10^9ind.) 1+ (Y+1)	2+ (Y+2)	Z survey(1-2) %
1980	-	197.3	740	402.6	147.6	63
1981	9.7	123.9	477	528.3	200.2	62
1982	9.9	168.1	600	514.9	186.5	64
1983	9.9	100.0	340	154.8	48.3	69
1984	8.2	68.1	275	38.7	4.7	88
1985	8.6	21.3	64	6.0	1.7	72
1986	0.0	11.4	42	37.6	28.7	24
1987	0.3	1.2	4	21.0	17.7	16
1988	0.3	19.6	65	189.2	177.6	6
1989	7.3	251.5	862	700.4	580.2	17
1990	13.0	36.5	116	402.1	196.3	51
1991	3.0	57.4	169	351.3	53.4	85
1992	7.3	1.0	2	2.2	3.4	--
1993	3.3	0.3	1	19.8	8.1	59
1994	0.1	5.4	14	7.1	11.5	--
1995	0.0	0.9	3	81.9	39.1	52
1996	2.4	44.3	137	98.9	72.6	27
1997	6.9	54.8	189	179.0	101.5	43
1998	14.1	33.8	113	156.0	110.6	29
1999	36.5	85.3	288	449.2	218.7	51
2000	19.1	39.8	141	113.6	90.8	20
2001	10.7	33.6	90	59.7	9.6	84
2002	22.4	19.4	67	82.4	24.8	70
2003	11.9	94.9	341	51.2	13.0	75
2004	2.5	16.7	54	26.9	21.7	19
2005	8.8	41.8	148	60.1	54.7	9
2006	17.1	166.4	516	221.7	231.4	--
2007	-	157.9	480	313.0	166.4	46
2008	-	288.8	995	124.0	127.6	--
2009	-	189.8	673	248.2		
2010	-	91.7	319			
Average	9.0	78.2	269	188.1	101.7	

Table 9.5 Barents Sea CAPELIN. Stock size in numbers by age, total stock biomass, biomass of the maturing component at 1. October.

Year	Stock in numbers (10^9)						Stock in weight	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	Maturing
1973	528	375	40	17	0	961	5144	1350
1974	305	547	173	3	0	1029	5733	907
1975	190	348	296	86	0	921	7806	2916
1976	211	233	163	77	12	696	6417	3200
1977	360	175	99	40	7	681	4796	2676
1978	84	392	76	9	1	561	4247	1402
1979	12	333	114	5	0	464	4162	1227
1980	270	196	155	33	0	654	6715	3913
1981	403	195	48	14	0	660	3895	1551
1982	528	148	57	2	0	735	3779	1591
1983	515	200	38	0	0	754	4230	1329
1984	155	187	48	3	0	393	2964	1208
1985	39	48	21	1	0	109	860	285
1986	6	5	3	0	0	14	120	65
1987	38	2	0	0	0	39	101	17
1988	21	29	0	0	0	50	428	200
1989	189	18	3	0	0	209	864	175
1990	700	178	16	0	0	894	5831	2617
1991	402	580	33	1	0	1016	7287	2248
1992	351	196	129	1	0	678	5150	2228
1993	2	53	17	2	2	75	796	330
1994	20	3	4	0	0	28	200	94
1995	7	8	2	0	0	17	193	118
1996	82	12	2	0	0	96	503	248
1997	99	39	2	0	0	140	911	312
1998	179	73	11	1	0	263	2056	931
1999	156	101	27	1	0	285	2776	1718
2000	449	111	34	1	0	595	4273	2099
2001	114	219	31	1	0	364	3630	2019
2002	60	91	50	1	0	201	2210	1290
2003	82	10	11	1	0	104	533	280
2004	51	25	6	1	0	82	628	294
2005	27	13	2	0	0	42	324	174
2006	60	22	6	0	0	88	787	437
2007	222	55	4	0	0	280	1882	844
2008	313	231	25	2	0	571	4427	2468
2009	124	166	61	0	0	352	3756	2323
2010	248	128	61	1	0	438	3500	2051

Table 9.6 Barents Sea CAPELIN. Summary stock and data for prognoses table.

Year	Estimated stock by autumn acoustic survey (10^3 t) 1 October		Spawning stock biomass, assessment model, April 1 (10^3 t)	Spawning stock biomass, by winter acoustic survey (10^3 t)	Recruitment Age 1+, survey assessment 1 October 10^9 sp.	Young herring biomass age 1 and 2 in the Barents Sea. (10^3 t)	Landing (10^3 t)	Rate of the TSB change
	TSB	SSB						
1972	6600	2727					1591	
1973	5144	1350	33		528	2	1337	0.8
1974	5733	907	*		305	48	1148	**1.1**
1975	7806	2916	*		190	74	1441	**1.4**
1976	6417	3200	253		211	39	2587	0.8
1977	4796	2676	22		360	46	2986	0.7
1978	4247	1402	*		84	52	1916	0.9
1979	4162	1227	*		12	39	1782	1.0
1980	6715	3913	*		270	66	1648	**1.6**
1981	3895	1551	316		403	47	1986	0.6
1982	3779	1591	106		528	9	1760	1.0
1983	4230	1329	100		515	12	2357	**1.1**
1984	2964	1208	109		155	1313	1477	0.7
1985	860	285	*		39	1220	868	0.3
1986	120	65	*		6	155	123	0.1
1987	101	17	34	4	38	145	0	0.8
1988	428	200	*	10	21	102	0	**4.2**
1989	864	175	84	378	189	144	0	**2.0**
1990	5831	2617	92	94	700	365	0	**6.7**
1991	7287	2248	643	1769	402	643	933	**1.2**
1992	5150	2228	302	1735	351	1535	1123	0.7
1993	796	330	293	1498	2	2467	586	0.2
1994	200	94	139	187	20	1715	0	0.3
1995	193	118	60	29	7	554	0	1.0
1996	503	248	60		82	209	0	**2.6**
1997	909	312	85		99	279	1	**1.8**
1998	2056	932	94	414	179	350	3	**2.3**
1999	2775	1718	382		156	990	105	**1.3**
2000	4273	2098	599	700	449	1509	410	**1.5**
2001	3630	2019	626		114	907	578	0.8
2002	2210	1291	496	1417	60	361	659	0.6
2003	533	280	427		82	1783	282	0.2
2004	628	294	94	105	51	2124	0	**1.2**
2005	324	174	122		27	1660	1	0.5
2006	787	437	72		60	1160	0	**2.4**
2007	2119	844	189		277	379	4	**2.7**
2008	4428	2468	330	469	313	259	12	**2.1**
2009	3765	2323	517	180	124	166	307	0.9
2010	3500	2051	504	452	248	352	315	0.9
2011				160			360	

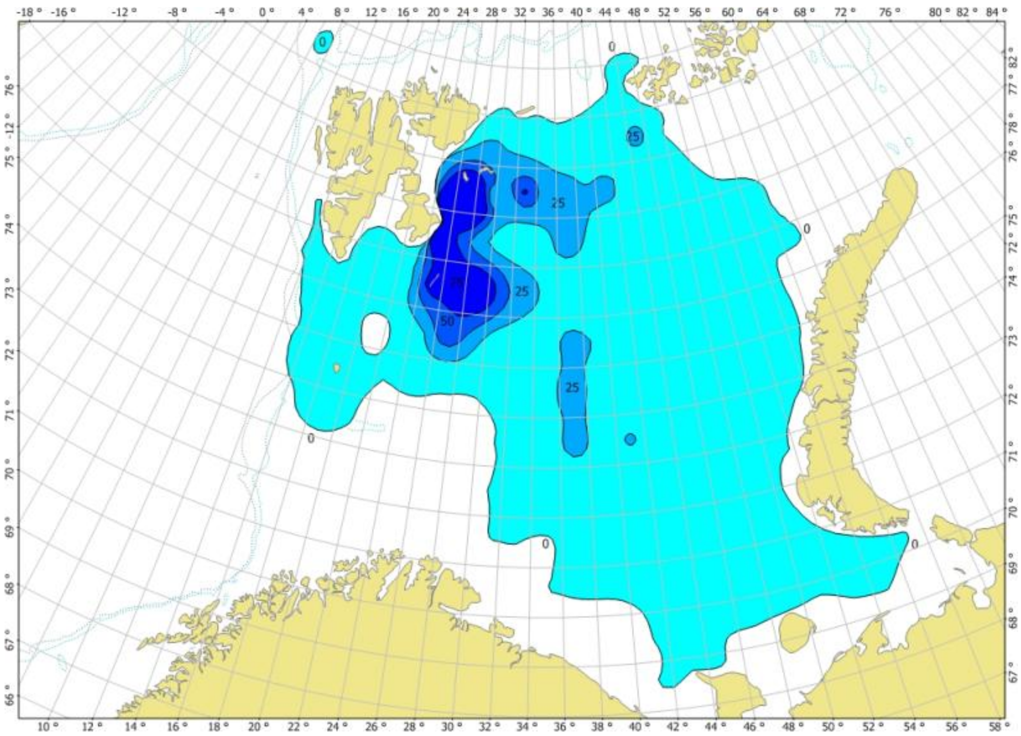


Figure 9.1. Geographical distribution of capelin during the acoustic survey in autumn 2010 (t/nm²)

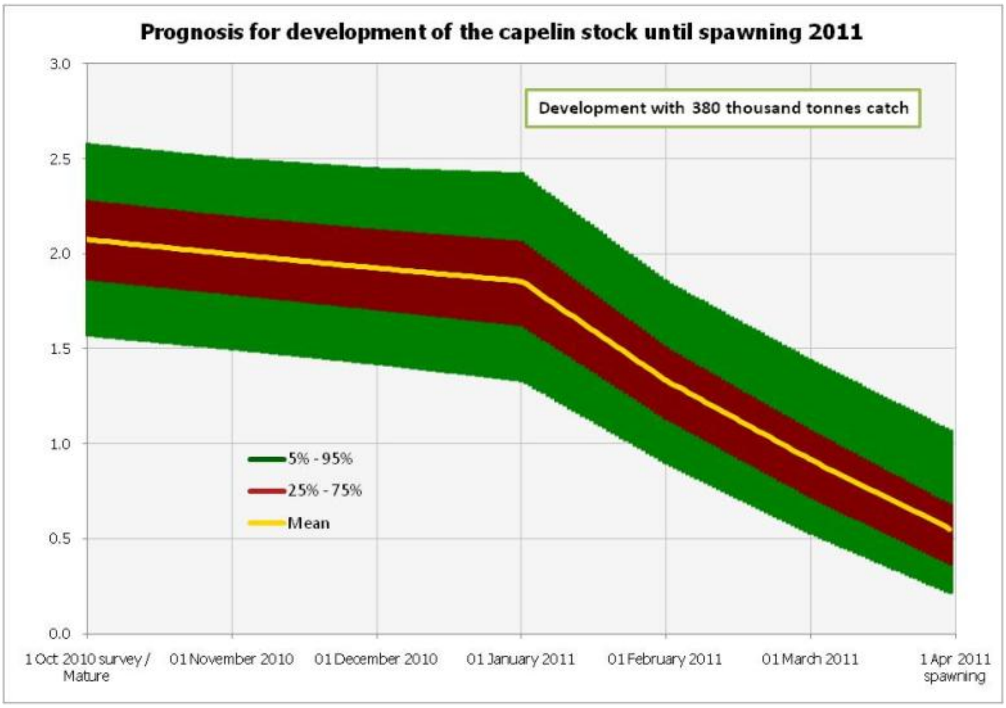


Figure 9.2. Probabilistic prognosis 1 October 2010-1 April 2011 for Barents Sea capelin (maturing stock, catch of 380 000 tonnes).

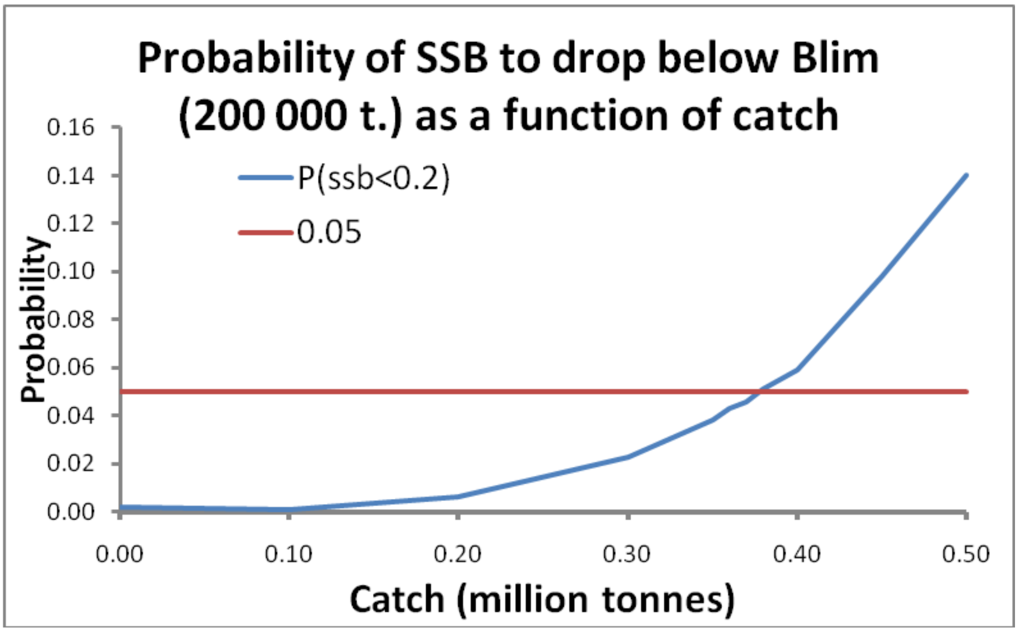


Figure 9.3. Probability of spawning biomass of capelin (1 April 2011) being below B_{lim} (200 000 tonnes), as a function of catch.

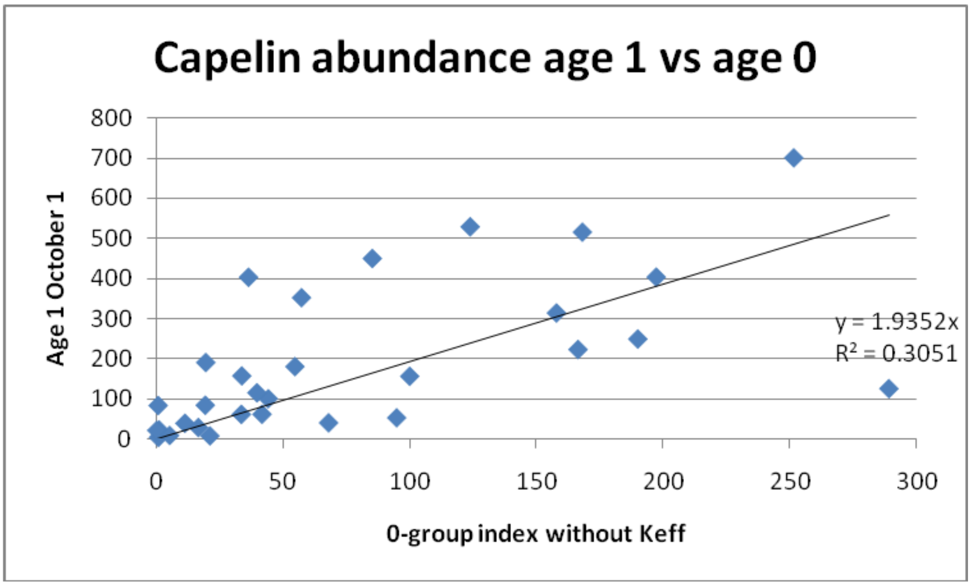


Figure 9.4. Regression of abundance of capelin at age 0 (0-group index without K_{eff}) and age 1 (acoustic estimate) of year classes 1981-2009. The regression line is forced through the origin, to avoid systematic overestimation of weak year classes.

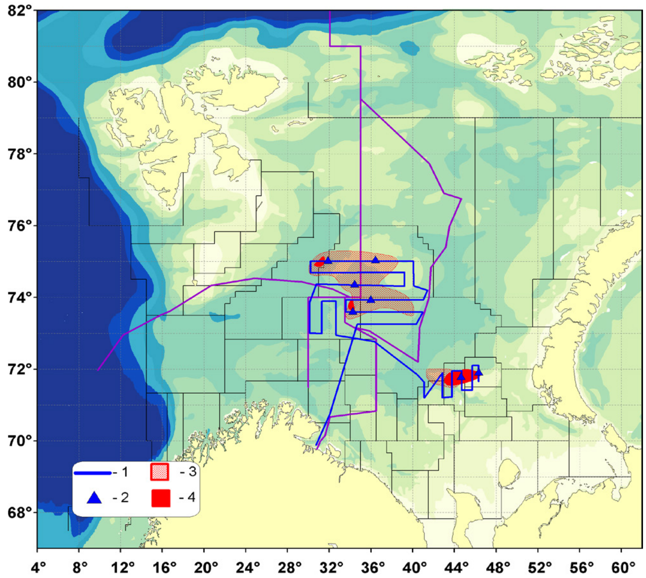


Figure 9.5 Survey route (1), pelagic trawl (2), young capelin (3) and mature capelin (4) location in January 2011. R/V "Novaya Zemlya".

10 Working documents

No	Author	Title
1	Fotland	NEA haddock weight at age
2	Fotland	Gadget files for deep-sea redfish
3	Aglen et al.	Results from the Joint IMR-PINRO Barents Sea demersal fish survey 1 February – 14 March 2011
4	Prozorkevitch	Haddock indices of abundance from the Joint Norwegian-Russian Ecosystem Survey in autumn
5	Prozorkevitch	Cod indices of abundance from the Joint Norwegian-Russian Ecosystem Survey in autumn
6	Howell and Planque	Sebastes mentella Gadget model description
7	Planque et al.	Historical variations in the year-class strength of beaked redfish (Sebastes mentella) in the Barents Sea
8	Kovalev, Tchetyrkin	XSA model settings for North-east Arctic haddock
9	Nor-Rus Analysis Group	Estimation of total catches of cod and haddock in the Barents Sea in 2010 incl. Comparison of vessel information
10	Casas	The Spanish NE Arctic Cod Fishery in 2009
11	Mehl and Fotland	Re-evaluation of the harvest control rule for Northeast Arctic saithe and long-term yield versus exploitation level using Prost
12	Ruiz Gondra & Mugerza	Spanish bottom trawl May survey fletan artico 2010 in sthe slope of Svalbard area, ICES division IIb.
13	Alpoim et al.	Report on the Portuguese fishery 2010:ICES Div. I, IIa, IIb
14	Borisov	On correction of the Barents Sea capelin abundance data
15	Bogstad	Biomass levels of S. mentella in ICES Sub-area I and II
16	Russkikh et al.	Evaluation BPR haddock 2011
17	Kovalev	haddock XSA
18	Dolgov	Consumption of various prey species by cod in 1984-2010
19	Albert	Tagging experiments for Greenland halibut
20	Bjørkvoll et al.	Beaked redfish and golden redfish: estimating abundances at age and population dynamical parameters by fitting a stochastic population model to abundance data within a Bayesian framework
21	Smirnov	Results of the Russian survey of Greenland halibut in the Barents Sea and adjacent waters in 2009
22	Bulatov	Greenland halibut fishery, stock size and potential catch
23	Titov	Assessment of population recruitment abundance of Northeast Arctic cod considering the environment data
24	Stiansen et al.	The current situation of climate, phytoplankton, zooplankton, shrimp, harp seal and fish in the Barents Sea 2009 and beginning of 2010

25	Stiansen et al.	An assessment of the future assessment site
26	Prozorkevitch	Russian capelin catch statistics 2011

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Annex 2 – Stock Annex Cod Coastal

Quality Handbook ANNEX:cod-coastal

Standard Procedure for Assessment

XSA/ICA Type

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Norwegian Coastal cod
Working Group:	Arctic Fisheries Working Group
Date:	11-05-2010

Approach used by the 2010 WG

For several years the xsa-analyses based on this stock annex have shown a retrospective bias. At the same time the trends seen in the survey and the catches have been considered to be a sufficient basis for the advice. The 2010 wg was asked to evaluate a rebuilding plan for coastal cod. It was then a need for a more robust analytical assessment. In addition, a new time series on catch at age in the recreational fishery was presented and added to the canum for commercial catches.

An estimate for F 2009 was obtained from surveys and an estimate for F2008 were obtained directly from catches (details in Annex 10). These estimates were used for deciding on a best estimate of F2009 that were used as terminal F in a traditional vpa. Selection at age in 2009 and Fold for earlier years were taken from a trial xsa. In addition to this, the annual values for maturity were replaced by the average observed over the survey series (1995-2009).

The traditional vpa were then taken as the final assessment.

With the new catch data the xsa showed improved diagnostics, particularly for the younger ages, when assuming catchability dependent on stock numbers for ages 2 and 3.

Some of these changes were rather ad hoc. Some intercessional further work should examine this further, and a benchmark would be relevant in near future.

Chapters A-I is the stock Annex dated 24. April 2009.

A General

A.1. Stock definition

Cod in the Barents Sea, the Norwegian Sea and in the coastal areas living under variable environmental conditions form groups with some peculiarities in geographical distribution, migration pattern, growth, maturation rates, genetics features, etc. The degree of intermingle of different groups is uncertain (Borisov, Ponomarenko and Yaragina, 1999). However, taking into account some biological characteristics of cod in the coastal zone and the specifics of the coastal fishery, the Working Group considered it acceptable to assess the Norwegian coastal cod stock (in the frame of ICES) separately from North-East Arctic cod.

Both types of cod (the Norwegian Coastal cod and the North-East Arctic cod) can be met together on spawning grounds during spawning period as well as in catches all the year round both inshore and offshore in variable proportions.

The Norwegian Coastal cod (NCC) is distributed in the fjords and along the coast of Norway from the Kola peninsula in northeast and south to Møre at 62º N. Spawning areas are located in fjords as well as offshore along the coast. Spawning season extents from March to late June. The 0 and 1-group of NCC inhabit shallow water both in fjords and in coastal areas and are hardly found in deeper trawling areas until reaching about 25 cm. Afterwards they gradually move towards deeper water. NCC starts on average to mature at age 4-6 and migrates towards spawning grounds in early winter. The majority of the biomass (about 75 %) is located in the northern part of the area (North of 67º N).

Tagging experiments of cod inhabiting fjords indicate only short migrations (Jakobsen 1987, Nøstvik and Pedersen 1999, Skreslet, *et al*. 1999). From these experiments very few tagged cod migrated into the Barents Sea (<1%). Investigations based on genetics find large difference between NCC and North-East Arctic cod (NEAC) (Fevolden and Pogson 1995, Fevolden and Pogson 1997, Jørstad and Nævdal 1989, Møller 1969), while others do not find clear differences (Árnason and Pálsson 1996, Mork, *et al*. 1984, Artemjeva and Novikov, 1990). Investigations also indicate that NCC probably consists of several separate populations.

Ongoing microsatellite studies on the genetic structure of cod along the entire Norwegian coast have revealed considerable genetic differences. Two main clusters were indicated: one north of 64 deg north (Trondheimsfjord) and one to the south of this. Differences were also observed between regions within these clusters. The conclusion is that NCC is not a single stock.

A.2. Fishery

Coastal cod is mainly fished by small coastal vessels using traditional fishing gears like gillnet, longline, hand line and danish seine, but some is also fished by trawlers and larger longliners fishing at the coastal banks. The fishery is dominated by gillnet (50%), while longline/hand line account for about 20%, Danish seine 20% and Trawl 10% of the total catch. There was a shift around 1995 in the portion caught by the different gears. Before 1995 the portion taken by longline and hand line was higher, while the portion taken by danish seine was lower. Norwegian vessels take all the reported catch. However, trawlers from other countries probably take a small amount of NCC when fishing near the Norwegian coast fishing for North-East Arctic cod and North-East Arctic haddock.

The TAC set for coastal cod is added to the Norwegian TAC for North-east Arctic cod, giving a total, combined TAC to distribute on fishing vesslels. Cod catches are not identified to stock at landing, and therefore no landings are counted against a separate coastal cod quota. When the fishing year is finished the catches of coastal cod are estimated from otholit sampling. All regulations for North-east Arctic cod also applies to coastal cod. This includes minimum catch size, minimum mesh size , maximum by-catch of undersized fish, and closure of areas having high densities of juveniles. In addition, trawl fishing for cod is not allowed inside the 6-n.mile, and since the mid 90-ies the fjords in Finnmark and northern Troms (areas 03 and 04) has been closed for fishing with Danish seine, and since 2000 the large longliners have been given restrictions, now only allowed to fish outside the 4 n.mile. Since 2004 additional restrictions on coastal fisheries have been introduced to reduce catches of coastal cod. In these new regulations "fjord-lines" are drawn along the coast to close the fjords for direct cod fishing with vessels larger than 15 meter. A box closed for all fishing gears except hand-line and fishing rod is defined in the Henningsvær-Svolvær area. This is an area where spawning concentrations of coastal cod is usually observed and where the catches of coastal cod has been high. Since the coastal cod is fished under a combined coastal cod/north-east arctic cod quota, these regulations are supposed to turn parts of the traditional coastal fishery over from catching coastal cod in the fjords to catch more cod outside the fjords where the proportion of North-east Arctic cod is higher. Further restrictions were introduced in 2007 by not allowing pelagic gill net fishing for cod and by reducing the allowed by-catch of cod when fishing for other species inside fjord lines from 25% to 5%, and outside fjord-lines from 25% to 20%. In 2009 a fjord area off Ålesund was closed in the spawning season for fishing with all gears except handline and fishing rod.

A.3. Ecosystem aspects

Not investigated

B. Data

B.1 Commercial catch

From 1996, cod caught inside the 12 n.mile zone have been separated into Norwegian coastal cod and North-east Arctic cod based on biological sampling (Berg, *et al*. 1998) The method is based on otolith-typing. This is the same method as is used in separating the two stocks in the surveys targeting NEAC. The catches of Norwegian coastal cod (NCC) have been calculated back to 1984using available data on otolith typing. During this period the catches have been between 22,000 and 75,000 t.

The separation of the Norwegian catches into NEAC and NCC is based on:

- No catches outside the 12 n.mile zone have been allocated to the NCC catches.
- The catches inside 12 n.mile zone are separated into quarter, fishing gear and Norwegian statistical areas.
- From the otolith structure, catches inside the 12 n.mile zone have been allocated to NCC and NEAC. The Institute of Marine Research in Bergen has been taking samples of commercial catches along the coast for a long period.

Norwegian commercial catch in tonnes by quarter, area and gear are derived from the sales notes statistics of The Directorate of Fisheries. Data from 8 sub areas are aggregated on 6 main areas for the gears gillnet, long line, hand line, Danish seine and trawl. No discards are reported or accounted for, but there are reports of discards and incorrect landings with respect to fish species and amount of catch. The scientific sampling strategy from the commercial fishing is to have age-length samples from all major gears in each area and quarter. The sampling intensity is determined by knowledge on the distribution of the combined cod catches.

There are at present no defined criteria on how to allocate samples of catch numbers, mean length and mean weight at age to unsampled catches. The following general process has been applied: First look for samples from a neighbouring area if the fishery extends to this area in the same quarter. If there are no samples available in neighbouring areas, search for samples from other gears with the most similar selectivity in the same area or in neighbouring areas. The last option is to search in neighbouring quarters, first from the same gear in the same area, and than from neighbouring areas and similar gears. Age-length keys from research surveys with shrimp trawl (Norwegian coastal survey) are also used to fill holes.

Weight at age is calculated from the commercial catch back to 1984. The mean values are weighted by catches in the respective areas.

Proportions mature at age from 1984 to 1994 are obtained from the commercial catch data. From 1995 onwards the proportions mature at age are obtained from the Norwegian coastal survey.

Norway is assumed to account for all NCC landings. The text table below shows which kind of data are collected:

	Kind of data				
Country	Caton (catch in weight)	Canum (catch at age in numbers)	Weca (weight at age in the catch)	Matprop (proportion mature by age)	Length composition in catch
Norway	X	X	X	X	X

B.2. Biological

Weight at age in the stock is obtained from the Norwegian coastal survey in from 1995 onwards. From 1984 to 1994 weight at age in stock is taken from weight at age in the catch because no survey data from this period are available. The mean values are weighted by biomass in the respective areas. In 2007 a weight at age series of unweighted mean values from the survey was calculated and used in the SURBA analysis.

A fixed natural mortality of 0.2 is used both in the assessment and the forecast. Some fjord studies (Pedersen and Pope, 2003a and b, Mortensen 2007, Pedersen *et al*., 2007). indicate that the main predators on young cod is larger cod, cormorants and saithe. There are no estimates of annual predation mortality for the stock complex.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing moratlity before spawning (Fprop) are to 0.

B.3. Survey

Since 1995 a Norwegian trawl-acoustic survey (Norwegian coastal survey) specially designed for coastal cod has been conducted annually in September (prior to 2003) and in October-November (28 days). The survey covers the fjords and coastal areas from the Varangerfjord close to the Russian border and southwards to 62° N. The aim of conducting a acoustic survey targeting Norwegian coastal cod has been to support the stock assessment with fishery-independent data of the abundance of both the commercial size cod as well as the youngest pre-recruit coastal cod. The survey therefore covers the main areas where the commercial fishery takes place, normally dominated by 4 - 7 year old fish.

The 0- and 1 year-old coastal cod, mainly inhabiting shallow water (0-50 meter) near the coast and in the fjords, are also represented in the survey, although highly variable from year to year. However, the 0-group cod caught in the survey is impossible to classify to NCC or NEAC by the otoliths since the first winter zone is used in this separation. A total number of more than 200 trawl hauls are conducted during the survey (100 bottom trawl, 100 pelagic trawl).

The survey abundance indexes at age are total numbers (in thousands) computed from the acoustics.

Ages 2-8 are used in the XSA-tuning. Ages 2 – 9 are used in a SURBA analysis.

B.4. Commercial CPUE

No commercial CPUE are available for this stock.

B.5. Other relevant data

A number of bottom trawl tows are made during the coastal survey, and since 2003 the survey has aimed for towing at the same fixed positions each year. This might be used to calculate a bottom trawl index.

C. Historical stock development

Acoustic survey

The total acoustic biomass varies between 144,000t (1995) and 30,300t (2005), showing a decline from 1995 until 2003, and flat level since 2003. The indices show considerable year to year variations. The acoustic spawning biomass vary between 75,000t (1995) and 12,700t (2005), showing the same type of trend as the total biomass. The recruitment of 2 year old fish vary from 20 million individuals in 1995 to 2 million in 2005, also showing the same, but stronger trend as the total stock.

SURBA analysis

The SURBA analysis (SURBA 2.10) is run with the same data as input to the XSA (se below). However, the age span is 2 – 9 year in the SURBA analysis. The settings are set similar to the XSA settings. The weight at age for the stock is calculated as unweighted mean values to avoid some of the large fluctuations in the weight at age from the survey calculations.

The history of the stock is reflected in the same way in this analysis as in the survey, showing a drop to a level in the later years about 25% of the level in 1995. The recruitment is down to a 10% level.

VPA analysis

Model used: XSA

Software used: IFAP / Lowestoft VPA suite

Model Options chosen:

Tapered time weighting applied, power = 3 over 20 years

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 8

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 estimate are shrunk = 1.0

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1984 – last data year	2 – 10+	Yes
Canum	Catch at age in numbers	1984 – last data year	2 – 10+	Yes
Weca	Weight at age in the commercial catch	1984 – last data year	2 – 10+	Yes
West	Weight at age of the spawning stock at spawning time.	1984 – last data year	2 – 10+	Yes/No - assumed to be the same as weight at age in the catch from 1984-1994
Mprop	Proportion of natural mortality before spawning	1984 – last data year	2 – 10+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1984 – last data year	2 – 10+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1984 – last data year	2 – 10+	Yes
Natmor	Natural mortality	1984 – last data year	2 – 10+	No – set to 0.2 for all ages in all years
Tuning fleet	Norwegian coastal survey	1995 – last data year	2 – 8	

The results show a variation of the total biomass between 310,000t (1984) and 87,000t (2008) with the value in 1995 being 260,000t. The spawning stock is estimated to 170,000t in 1995, falling to 50,000t in 2008. The fishing mortality is estimated to 0.38 on average. The pattern of stock decline is fairly similar to that of the survey.

D. Short-term projection

No quantative projection but trends in stock biomass, mortality and recruitment obtained from surba (and xsa) are used to indicate stock development. t

E. Medium-term projections

Not done.

F. Long-term projections

Not done.

G. Biological reference points

Not available.

H. Other issues

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Annex 3 – Quality Handbook ANNEX:_NEA Cod

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	North-East Arctic Cod
Working Group:	Arctic Fisheries Working Group (AFWG)
Date:	27. April 2009.

A. General

A.1 Stock definition

The North-East Arctic cod (*Gadus morhua*) is distributed in the Barents Sea and adjacent waters, mainly in waters above 0° Celsius. The main spawning areas are along the Norwegian coast between N 67°30′ and 70°. The 0-group cod drifts from the spawning grounds eastwards and northwards and during the international 0-group survey in August it is observed over wide areas in the Barents Sea.

A.2 Fishery

The fishery for North-east Arctic cod is conducted both by an international trawler fleet operating in offshore waters and by vessels using gillnets, longlines, handlines and Danish seine operating both offshore and in the coastal areas. 60-80% of the annual landings are from trawlers. Catch quotas were introduced in the trawl fishery in 1978 and for the fisheries with conventional gears in 1989. In addition to quotas the fisheries are regulated by mesh size limitations including sorting grids, a minimum catching size, a maximum by-catch of undersized fish, maximum by-catch of non-target species, closure of areas with high densities of juveniles and by seasonal and area restrictions. Since January 1997 sorting grids have been mandatory for the trawl fisheries in most of the Barents Sea and Svalbard area. Discarding is prohibited. The minimum catching size of cod is 42 cm in the Russian Economic zone, 47 cm in Norwegian Economic zone; both minimum landing sizes are used by respective fleets in the Svalbard area pursuant to the Svalbard Treaty 1920. The fisheries are controlled by inspections at sea, requirement of reporting to catch control points when entering and leaving the EEZs and by inspections when landing the fish for all fishing vessels. Keeping a detailed fishing log-book on board is mandatory for most vessels, and large parts of the fleet report to the authorities on a daily basis. There is some evidence that the present catch control and reporting systems are not sufficient to prevent discarding and under-reporting of catches, but it has considerably improved in comparison with historical period.

A.3 Ecosystem aspects

Considerable effort has been devoted to investigate multispecies interactions in the Northeast Arctic. Some of these investigations have reached the stage where quantitative results are available for use in assessments. Growth of cod depends on availability of prey such as capelin (*Mallotus villosus*), and variability in cod growth has had major impacts on the cod fishery. Cod are able to compensate only partially for low capelin abundance, by switching to other prey species. This may lead to periods of high cannibalism on young cod, and may result in impacts on other prey species which are greater than those estimated for periods when capelin is abundant. In a situation with low capelin abundance, juvenile herring (*Clupea harengus)* experience increased predation mortality by cod. The timing of cod spawning migrations is influenced by the presence of spawning herring in the relevant area. The interaction between capelin and herring is illustrated by the recruitment failure of capelin coinciding with years of high abundance of young herring in the Barents Sea. Herring predation on capelin larvae is believed to be partially responsible for the recruitment failure of capelin when young herring are abundant in the Barents Sea.

The composition and distribution of species in the Barents Sea depend considerably on the position of the polar front which separates warm and salty Atlantic waters from colder and fresher waters of arctic origin. Variation in the recruitment of some species including cod and capelin has been associated with the changes in the influx of Atlantic waters to the large areas of the Barents Sea shelf.

The annual consumption of herring, capelin and cod by marine mammals (mainly harp seals and minke whales) has been estimated to be in the order of 1.5-2.0 million t (Bogstad, Haug and Mehl, 2000; See also Section 1.3.4 AFWG Report 2003).

However, estimates of total annual food consumption of Barents Sea harp seals are in the range of about 3.3-5 million tons (depending on choice of input parameters, ICES 2000d). The applied model used different values for the field metabolic rate of the seals (corresponding to two or three times their predicted basal metabolic rate) and under two scenarios: with an abundant capelin stock and with a very low capelin stock.

1) If capelin was abundant the total harp seal consumption was estimated to be about 3.3 million tons (using lowest field metabolic rate). The estimated consumption of various commercially important species was as follows (in tons): capelin approximately 800,000, polar cod (*Boreogadus saida*) 600,000, herring 200,000 and Atlantic cod 100,000.

2) A low capelin stock in the Barents Sea (as it was in 1993-1996) led to switches in seal diet composition, with estimated increased consumption of polar cod (870,000 tons), other codfishes (mainly Atlantic cod; 360,000 tons), and herring (390,000 tons).

B. Data

B.1 Commercial catch

Norway

Norwegian commercial catch in tonnes by quarter, area and gear are derived from the sales notes statistics of The Directorate of Fisheries. Data from about 20 sub areas are aggregated on 6 main areas for the gears gill net, long line, hand line, purse seine, Danish seine, bottom trawl, shrimp trawl and trap. For bottom trawl the quarterly area distribution of the catches is adjusted by logbook data from The Directorate of Fisheries and the total bottom trawl catch by quarter and area is adjusted so that the total annual catch for all gears is the same as the official total catch reported to ICES.

No discards are reported or accounted for, but there are several reports of discards.

The sampling strategy is to have age and length samples from all major gears in each main area and quarter. The main sampling program is sampling the landings. Additional samples from catches are obtained from the IMR reference fleet (fishing vessels contracted for sampling), and the coast guard.

A software (“ECA”, Hirst *et al*. 2005) has been developed to utilize all sampling information to estimate catch at age for areas (I, IIa and IIb), quarters and gears (bottom trawl, gill net, Danish seine and longline/handline).

Russia

Russian commercial catch in tonnes by quarter and area are derived from the All-Russian Institute of fishery and oceanography (Moscow) statistics department. Data from each fishing vessel are aggregated on three ICES sub-Division (I, IIa and IIb).Russian fishery by passive gears was almost stopped by the end of the 1940s. At present bottom trawl fishery constitutes more than 95 % cod catch.

The sampling strategy was to conduct mass measurements and collect age samples directly at sea, onboard of both research and commercial vessels to have age and length distributions from each area and quarter. Data on length distribution of cod in catches were collected in areas of cod fishery all the year round by a "standard" fishery trawl (mesh size is 125 mm in the Russian Economic zone and Svalbard area and 135 mm in the Norwegian Economic zone) and summarized by three ICES sub-areas (1, IIa and IIb). Previously the PINRO area divisions were used, differed from the ICES sub-Divisions.

Age sampling was carried out by two ways: without any selection (otoliths were taken from any fish caught in one trawl, usually from 100-300 sp.) or using a stratified by length sampling method (i.e. approximately 10-15 sp. per each 10-cm length group). The last method has been used since 1988.

All fish taken for age-reading were measured and weighted individually.

Catch at age are reported to ICES AFWG by sub-Division (1, IIa and IIb) and quarter (before 1984 – by sub-Division and year). Data on length distribution of cod in catches, as well as age-length keys, are formed for each quarter and area. In the case when a catch is present in the area/quarter but a length frequency is absent, a length frequency for the corresponding quarter, summarised for the whole sea is used. If there is no data on length composition of cod in catches per a quarter within the whole sea, a frequency summarised for the whole year and whole sea is used. Gaps in age-length distributions in sub-Divisions are filled in with data from the corresponding quarter, summarised for the whole sea. Rest gaps are filled in with information from the age-length key formed for the long-term period (1984-1997) for each quarter and for the whole sea. (Kovalev and Yaragina, 1999). Before 1984 calculation of annually catch cod numbers in sub-Divisions was derived from summarized for both the whole year age-length keys and length distribution in catches.

Germany, Poland and Spain

Catch at age reported to the WG by ICES sub-Division (I, IIa and IIb) and quarter, according to national sampling. Missing quarters/sub-Divisions filled in by use of Russian or Norwegian sampling data.

Other nations

Total annual catch in tonnes is reported by ICES sub-Divisions. All caches by other nations are taken by trawl. The age composition from the sampled trawl fleets is therefore applied to the catches by other nations.

The text table below shows which country supplied which kind of data for 2008:

	Kind of data				
Country	Caton (catch in weight)	Canum (catch at age in numbers)	Weca (weight at age in the catch)	Matprop (proportion mature by age)	Length composition in catch
Norway	x	x	x	x	x
Russia	x	x	x	x	x
Germany	x	x	x		x
United	x				
Kingdom	x				
France[1]	x				
Spain	x				
Portugal	x				x
Poland	x	x	x		
Ireland[1]	x				
Greenland[1]	x				
Faroe Islands[1]	x				
Iceland[1]	x				

[1] As reported to Norwegian and Russian authorities

Since 2008 the catch data has been handled by Intercatch. Earlier the nations that sample the catches, provided the catch at age data and mean weights at age on Excel spreadsheet files, and the national catches were combined in Excel spreadsheet files. Historic data should be found in the national laboratories and with the stock co-ordinator.

For 1983 and later years mean weight at age in the catch is calculated as the weighted average for the sampled catches. For the earlier period (1946-1982) mean weight at age in catches is set equal to mean weight at age in the stock (ICES 2001).

Since 2008 the catch data has been handled by Intercatch.

B.2 Biological

For 1983 and later years weight at age in the stock and maturity at age is calculated as weighted averages from Russian and Norwegian surveys during the winter season. Stock weights at age a (W_a) at the start of year y are calculated as follows:

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

where

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

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

$W_{nbar,a}$: Weight at age a in the Norwegian Barents Sea acoustic survey in year y

$N_{lof,a}$: Abundance at age a in the Lofoten survey in year y

$W_{lof,a}$: Weight at age a in the Lofoten survey in year y

Maturity at age is estimated from the same surveys by the same formulae, replacing weight by proportion mature.

For age groups 12 and older, the stock weights is set equal to the catch weights, since most of this fish is taken during the spawning fisheries, and in most years considerably more fish from these ages are sampled from the catches than from the surveys.

For the earlier period (1946-1982) the maturity at age and weight at age in the stock is based on Russian sampling in late autumn (both from fisheries and from surveys) and Norwegian sampling in the Lofoten spawning fishery. These data were introduced and described in the 2001 assessment report (ICES 2001).

A fixed natural mortality of 0.2 is used both in the assessment and the forecast.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0. The peak spawning in the Lofoten area occurs most years in late March-early April.

B.3 Surveys

Russia

Russian surveys of cod in the southern Barents Sea started in the late 1940s as trawl surveys of young demersal fishes. Since 1957 such surveys have been conducted over the whole feeding area including the Bear Island - Spitbergen area (Baranenkova, 1964; Trambachev, 1981), both young and adult cod have been surveyed simultaneously. In 1984, acoustic methods started to be implemented during surveys of fish stocks (Zaferman, Serebrov, 1984; Lepesevich, Shevelev, 1997; Lepesevich *et al.*, 1999). In 1995 a new acoustic assessment method was applied for the first time, which allowed the differentiation and registration of echo intensities from fish of different length (Shevelev *et al.*, 1998). Methods of calculations of survey indices also changed, e.g. due to the necessity to derive length-based indices for the FLEKSIBEST model (Bogstad *et al.*1999; Gusev, Yaragina, 2000).

Time of survey conducting has reduced from 5-6 months (September-February) in 1946-1981 to 2-2.5 months (October-December) since 1982. The aim of conducting a survey is to investigate both the commercial size cod as well as the young cod and to receive reliable data to compose annual maturity ogives. The survey covers the main areas where fries settle down as well as the commercial fishery takes place, included cod at age 0+ - 10+ years. A total number of more than 400 trawl hauls are conducted during the survey (mainly bottom trawl, a few pelagic trawl).

There are two survey abundance indices at age: 1). absolute numbers (in thousands) computed from the acoustics and 2). trawl swept area indices, calculated as absolute numbers registered in survey standard area (Golovanov et al., 2006, 2007).

Ages 3-9 are used in the XSA-tuning.

Joint Russian-Norwegian winter (February) survey

The survey started in 1981 and covers the ice-free part of the Barents see. Both swept area estimates from bottom trawl and acoustic estimates are produced. The swept area estimates are used in the tuning for ages 3-8, and the acoustic estimate are added to the Norwegian acoustic survey in Lofoten and used for tuning for ages 3-9. The survey is described in Jakobsen *et al* (1997) and Aglen *et al*. (2002).

Norwegian Lofoten survey

Acoustic estimates from the Lofoten survey extends back to 1984. The survey is described by Korsbrekke (1997).

B.4 Commercial CPUE

Russia

Two CPUE data series exist, one is historical series, based on RT vessel type (side trawler, 800-1000 HP), which stopped operating in the Barents Sea in the middle of the 1970-s, and other one is presently used, based on PST vessel type (stern trawler, 2000 HP). Information from each fishing trawler was daily transferred to PINRO, including data on each haul (timing, location, gear and catch by species). Yearly catch f cod by the PST trawlers as well as number of hour trawling were summarized and CPUE index (catch on tons per hour fishing) was calculated.

The effort (hours trawling) was scaled to the whole Russian catch. The CPUE indices are split on age groups by age data from the trawl fishery. Data on ages 9-11 are used in the XSA-tuning.

C. Estimation of historical stock development

Model used: XSA

Software used: IFAP / Lowestoft VPA suite

Model Options chosen:

Tapered time weighting applied, power = 3 over 10 years

Catchability independent of stock size for ages >6

Catchability independent of age for ages >= 10

Survivor estimates shrunk towards the mean F of the final 5 years or the 2 oldest ages

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

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1946 – last data year	3 – 13+	Yes
Canum	Catch at age in numbers	1946 – last data year	3 – 13+	Yes
Weca	Weight at age in the commercial catch	1982 – last data year	3 – 13+	Yes, set equal to west for 1946-1981
West	Weight at age of the spawning stock at spawning time.	1946 – last data year	3 – 13+	Yes
Mprop	Proportion of natural mortality before spawning	1946 – last data year	3 – 13+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1960 – last data year	3 – 13+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1960 – last data year	3 – 13+	yes
Natmor	Natural mortality	1960 – last data year	3 – 13+	Includes annual est. of cannibalism from 1984, otherwise set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Russian com. CPUE, trawl	1985 – last data year	9 –11
Tuning fleet 2	Joint Barents Sea trawl survey, february	1981– last data year	3 - 8
Tuning fleet 3	Joint Barents Sea Acoustic, February+ Lofoten Acoustic survey	1985 – last data year	3 -9
Tuning fleet 4	Russian bottom trawl survey, November	1984 – last data year	3-9

XSA-settings

Type of setting	Settings last year	Used this year (why changed)
Time series weighting	Tapered time weighting power = 3 over 10 years	The same
Recruitment regression model (catchability analysis)	Catchability dependent of stock size for ages < 6 Regression type = C Min. 5 points used Survivor estimates shrunk to the population mean for ages < 6 Catchability independent of age for ages >= 10	The same
Terminal population estimation	Survivor estimates shrunk towards the mean F of the final 5 years or the 2 oldest ages. S.E. of the mean to which the estimate are shrunk = 1.0. Minimum standard error for population estimates derived from each fleet = 0.300.	The same
Prior fleet weighting	Prior weighting not applied	The same

D. Short-term projection

Model used: Age structured

Software used: MFDP (version 1a) prediction with management option table

Initial stock size: Taken from the XSA for age 4 and older. The recruitment at age 3 for the initial stock and the following 2 years are estimated from survey data and environmental data using the "hybrid model" described in section 1.4.5 in ICES CM 2008/ACOM:01

Natural mortality: average of the three last years or set equal to the values estimated for the terminal year.

Maturity: average of the three last years

F and M before spawning: Set to 0 for all ages in all years

Weight at age in the stock: Predicted by applying (10yr average) annual increments by cohort on last year's observation.

Weight at age in the catch: Predicted by applying (10yr average) annual increments by cohort on last year's observation.

Exploitation pattern: Average of the three last years, scaled by the Fbar (5-10) to the level of the last year, or to the average of the latest 3 years, if there is no clear trend in F and effort.

Intermediate year assumptions: F constraint

Stock recruitment model used: None

Procedures used for splitting projected catches: Not relevant

E. Medium-term projections

F. Long-term projections

SPR and YPR calculations

G. Biological reference points

Introduced 1998: Blim=112000t, Bpa=500000t, Flim=0.7, Fpa=0.42

Adopted in 2003: Blim=220000t, Bpa=460000t, Flim=0.74, Fpa=0.40

H. Other issues

Since the 1999 AFWG a new assessment model (Fleksibest-now Gadget) has been used to provide alternative assessments and to describe characteristics of the data for this stock.

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Annex4 – Quality Handbook ANNEX:NEA Haddock

Stock Annex **Haddock in Subareas I and II**

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Haddock in Subareas I and II (Northeast Arctic)
Working Group:	Arctic Fisheries Working Group
Date:	31.01.2011
Revised by:	WKBENCH 2011 / AFWG 2011, Alexey Russkikh (stock coordinator), Gjert En dre Dingsør

A. General

A.1. Stock definition

The North-East Arctic Haddock (*Melanogrammus aeglefinus*) is distributed in the Barents Sea and adjacent waters, mainly in waters above 2° Celsius. Tagging carried out in 1953-1964 showed the contemporary area of the Northeast Arctic haddock inhabits the continental shelf of the Barents Sea, adjacent waters and polar front. The main spawning grounds are located along the Norwegian coast and area between 70°30′ and 73° N along the continental slope, but spawning also occurs as far south as 62°N. Larvae are dispersed in the central and southern Barents Sea by warm currents. The 0-group haddock drifts from the spawning grounds eastwards and northwards and during the international 0-group survey in august it is observed over wide areas in the Barents Sea. Until maturity, haddock are mostly distributed in the southern Barents Sea being their nursery area. Having matured, haddock migrate to the Norwegian Sea.

A.2. Fishery

Haddock are harvested throughout the year; in years when the commercial stock is low, they are mostly caught as bycatch in cod trawl fishery; when the commercial stock abundance and biomass are high, haddock are harvested during their target fishery. On average approximately 25% of the catch is with conventional gears, mostly longline, which are used almost exclusively by Norway. Part of the longline catches are from a directed fishery.

The fishery is restricted by national quotas. In the Norwegian fishery the quotas are set separately for trawl and other gears. The fishery is also regulated by a minimum landing size, a minimum mesh size in trawls and Danish seine, a maximum by-catch of undersized fish, closure of areas with high density/catches of juveniles and other seasonal and areal restrictions.

In recent years Norway and Russia have accounted for more than 90% of the landings. Before the introduction of national economic zones in 1977, UK (mainly England) landings made up 10–30% of the total. Each country fishing for haddock and engaged in the stock assessment provide catch statistic annually. Summary sheets in the AFWG Report indicate total yield of haddock by Subareas I, IIa and IIb, as well as catch by each country by years. Catch information by fishing gear used by Norway in the haddock fishery is used internally when making estimations at AFWG meeting. Catch quotas were introduced in the trawl fishery in 1978 and for the fisheries with conventional gears in 1989. Since January 1997 sorting grids have been mandatory for the trawl fisheries in most of the Barents Sea and Svalbard area. Discarding is prohibited.

From 01.01.2011, the minimum catching size of haddock is 40 cm in the Russian Economic zone, the Norwegian Economic zone, and the Svalbard area. It is allowed that up to 15% (by number) of the fish is below the minimum catching size of (this is counted for cod, haddock and saithe combined), larger proportions of undersized fish leads to closure of areas. The minimum mesh size in trawl cod ends is 130 mm. The fisheries are controlled by inspections at sea, requirement of reporting to catch control points when entering and leaving the EEZs and by inspections when landing the fish for all fishing vessels. Keeping a detailed fishing logbook on board is mandatory for most vessels, and large parts of the fleet report to the authorities on a daily basis. There is some evidence that the present catch control and reporting systems are insufficient to prevent discarding and under-reporting of catches. Although since 2005 Port State Control (PSC) has been implemented, these should prevent IUU catches at Barents Sea.

The historical high catch level of 320,000 t in 1973 divides the time-series into two periods. In the first period, highs were close to 200,000 t around 1956, 1961 and 1968, and lows were between 75,000 and 100,000 t in 1959, 1964 and 1971. The second period showed a steady decline from the peak in 1973 down to the historically low level of 17,300 t in 1984. Afterwards, landings increased to 151,000 t before declining to 26,000 t in 1990. A new increase peaked in 1996 at 174,000 t. Three strong year-classes (2004-2006) are causing peak catches at the present time. The exploitation rate of haddock has been variable (F between 0.2 and 0.5 in the last 20 years).

The highest fishing mortalities for haddock have occurred at intermediate stock levels and show little relationship with the exploitation rate of cod, in spite of haddock being primarily a by-catch in the cod fishery. The exception is the 1990s when more restrictive quota regulations resulted in a similar pattern in the exploitation rate for both species. It might be expected that good year classes of haddock would attract more directed trawl fishing, but this is not reflected in the fishing mortalities.

Since 2007, estimates of unreported catches (IUU catches) of haddock have been added to reported landings for the years 2002 and onwards. In 2007-2008, two assessments were presented, based on Norwegian and Russian estimates of IUU catches, respectively. The basis for the Norwegian IUU estimates (N ‐ IUU) is the annual ratio between cod and haddock in the international reported landings from Sub ‐ area I and Division II b in 2002 ‐ 2008. These ratios are assumed to be representative of the ratios in the IUU catches. The ratio is applied to the estimated IUU catches of cod in order to get the estimate for haddock. The estimates are similar to those made by the Norwegian Directorate of Fisheries for 2005-2008. The Russian estimates of IUU haddock are obtained by applying the same ratio, but using the Russian estimate of IUU catches of cod in 2002-2007. Both approaches show an increase from 2002 to 2005 followed by a decline. In 2010 the Working Group decided to set the IUU estimate for haddock in 2009 to 0. During the benchmark meeting in 2011, as in recent AFWG, it was decided to use Norwegian estimates for the period 2002-2008, because now IUU catches equal Zero and only small differences exist in final estimates using both values of IUU.

A.3. Ecosystem aspects

The composition and distribution of species in the Barents Sea depend considerably on the position of the polar front which separates warm and salty Atlantic waters from colder and fresher waters of arctic origin. Variation in the recruitment of haddock has been associated with the changes in the influx of Atlantic waters to the large areas of the Barents Sea shelf.

Independently from age and season, haddock vary their diet and will prey on plankton or benthic organisms. During spawning migration of capelin (*Mallotus villosus*) haddock prey on capelin and their eggs on the spawning grounds. When the capelin abundance is low or when their areas do not overlap, haddock can compensate by eating other fish species (e.g., young herring) or euphausiids and benthic organisms. Haddock growth rate depends on the population abundance, stock status of main prey species and water temperature.

Water temperature at the first and second years of the haddock life cycle is a fairly reliable indicator of year-class strength. If mean annual water temperature in the bottom layer during the first two years of haddock life does not exceed 3.75 C (Kola-section), the probability that strong year-classes will appear is very low even under favorable effects of other factors. A steep rise or fall of the water temperature shows a marked effect on abundance of year-classes.

Nevertheless, water temperature is not always a decisive factor in the formation of year-class abundance. Strength of year-classes is also determined to a great extent by size and structure of the spawning stock. Under favorable environmental conditions, strong year classes are mainly observed in years when the spawning stock is dominated by individuals from older age groups with abundance at a fairly high level.

Annual consumption of haddock by marine mammals, mostly seals and whales, depends on stock status of capelin as their main prey. In years when the capelin stock is large the importance of haddock in the diet of marine mammals is minimal, while under the capelin stock reduction a considerable increase in consumption by marine mammals of all the rest abundant gadoid species including haddock is observed (Korzhev and Dolgov, 1999; Bogstad et al, 2000).

The appearance of strong haddock year classes usually leads to a substantial increase in natural mortality of juveniles as a result of cod predation.

B. Data

B.1. Commercial catch

Norway

Norwegian commercial catch in tonnes by quarter, area and gear are derived from the sales notes statistics of The Directorate of Fisheries. Data from about 20 sub-areas are aggregated on 6 main areas for the gears gill net, long line, hand line, purse seine, Danish seine, bottom trawl, shrimp trawl and trap. For the bottom trawl, the quarterly area distribution of the catches is adjusted by logbook data from The Directorate of Fisheries and the total bottom trawl catch by quarter and area is adjusted so that the total annual catch for all gears is the same as the official total catch reported to ICES. No discards are reported or accounted for.

The sampling strategy is to have age and length samples from all major gears in each main area and quarter. The main sampling program is sampling the landings. Additional samples from catches are obtained from the coast guard, from observers and from crew members reporting, according to an agreed sampling procedure (reference fleet).

The age distribution and weight at age for the Norwegian catches were estimated using the software based on the method of Hirst *et al*. (2005). In this method, the three different types of available samples (age and weight samples, age and weight stratified by length groups, and length samples) are modelled simultaneously using a previously developed Bayesian hierarchical model (Hirst *et al*., 2004). This method replaced the traditional method in 2006, and the time series of Norwegian catch at age (early 80's and onward) was updated based on the modelling approach. The old method involved allocating unsampled catches to sampled catches based on judgements on "distance criteria's" (in area, time and sometimes gear) and the use of ALK's to fill holes in the sampling frame.

Russia

Russian commercial catch in tonnes by season and area are derived from the Russian Federal Research Institute of Marine Fisheries and Oceanography (VNIRO, Moscow) statistics department. Data from each fishing vessel are aggregated on three ICES sub-Division (I, IIa and IIb). Russian fishery by passive gears was almost stopped by the end of the 1940s. Until late 1990's, relative weight (percentage) of haddock taken by bottom trawls in the total Russian yield exceeded 99%. Only in recent years an upward trend in a proportion of Russian long-line fishery for haddock was observed to be up to 5% on the average and long-line catches were taken into account for estimation catch-at-age matrix.

The sampling strategy was to conduct mass measurements and collect age samples directly at sea, onboard both research and commercial vessels to have age and length distributions from each area and season. Data on length distribution of haddock in catches are collected in areas of cod and haddock fishery all the year round by a "standard" fishery trawl and summarized by three ICES sub-areas (I, IIa and IIb).

Age sampling was carried out in two ways: without any selection (otoliths were taken from any fish caught in one trawl, usually from 100-300 sp.) or using a stratified by length sampling method (i.e. approximately 10-15 sp. per each 10-cm length group). The last method has been used since 1988.

All fish taken for age-reading were measured and weighted individually.

Data on length distribution of haddock catches, as well as age-length keys, are formed for each ICES Subarea, each fishing gear (trawl and longline) for the whole year. Catch at age are reported to ICES AFWG by sub-Division (I, IIa and IIb) for the whole year. In the lack of data by ICES Subareas, information on size-age composition of catches from other areas is used.

Germany

Catch at age were reported to the WG by ICES sub-Division (I, IIa and IIb) according to national sampling. Missing sub-Divisions were filled in by use of Russian or Norwegian sampling data.

Other nations

Total annual catch in tonnes is reported by ICES sub-Divisions or by Russian and Norwegian authorities directly to WG. All catches by other nations are taken by trawl. The age composition from the sampled trawl fleets is therefore applied to the catches by other nations.

Table below shows which country supplied which kind of data:

	Kind of data				
Country	Caton (catch in weight)	Canum (catch at age in numbers)	Weca (weight at age in the catch)	Matprop (proportion mature by age)	Length composition in catch
Norway	X	X	X	X	X
Russia	X	X	X	X	X
Germany	X	X	X		X
United Kingdom	X				
France	X				
Spain	X				
Portugal	X				
Ireland	X				
Greenland	X				
Faroe Islands	X				
Iceland	X				
Poland	X				
Belarus	X				

The combined catch data were previously estimated by the SALLOC program (Patterson, 1998). The national data from 2009 and onwards are available in Intercatch (ICES database); earlier data should be found in the national laboratories and with the stock coordinator.

For 1983 and later years mean weight at age in the catch is calculated as the weighted average for the sampled catches. For the earlier period (1946-1982) mean weight at age in catches is set equal to mean weight at age in the catch for period 1983-2009.

The result files can be found at ICES (sharepoint) and with the stock co-ordinator as ASCII files on the Lowestoft format.

B.2. Biological

Weights and length at age in stock and proportion of mature fish to ages 1–11 derived from Russian surveys in autumn (mostly October-December) and Norwegian surveys in January-March for the period from 1983 and onwards. In 2006 the AFWG, based on WKHAD06 investigations, decided to smooth raw data of stock weight-at-age and maturity-at-age using models in order to remove some of the sampling variability in the estimates.

Mean length-at-age is calculated from the bottom trawl surveys. A von Bertalanffy function is fitted to the data:

$$L = L_\infty - L_\infty \cdot e^{(-K_Y(A-A_0))}$$

with L and A being the length and age variables. L_∞ and A_0 are constants, estimated on the entire time series, while K_Y is dependent on year-class. Weight-at-age is then fitted with:

$W = \alpha \cdot L^\beta$

where α and β are constants and L are smoothed lengths.

Norwegian maturity data is smoothed by fitting a logistic function using both age, A, and length, L, as explanatory variables:

$$\log\left(\frac{m}{1-m}\right) = I + \alpha A + \beta L$$

Russian maturity data is smoothed by fitting a logistic function using age, A, and year-class dependent age at 50% maturity, $A_{50\%}$, as explanatory variables:

$$Mat = \frac{1}{1 + e^{(-\alpha \cdot (A - A_{50\%}))}}$$

Estimates were produced separately for the Russian autumn survey and the joint winter survey and were later combined using an arithmetic average. These averages are assumed to give representative values for the beginning of the year.

Norwegian lengths-at-age are used to estimate mean weights-at-age and maturity-at-age for the period 1980-1982.

The combined data on weight-at-age in stock and proportion of mature fish by age group for the period (1950-1979) are set equal to mean values for period 1980-2010.

Natural mortality used in the assessment is estimated as 0.2 + mortality from predation by cod. The estimated consumption of NEA haddock by NEA cod is incorporated into the XSA analysis on first step by constructing catch-at-age matrix, adding estimated numbers of haddock eaten by cod to the catches for the ages 1-6, for years where such data are available (1984–present). The fishing mortality estimated by the XSA is split into the mortality caused by the fishing fleet (F) and the mortality caused by the cod's predation (M2) according to the ratio of fleet catch and predation "catch". The new natural mortality data set were then prepared by adding 0.2 (M1) to the predation mortality. This new M matrix is used in the final XSA. Natural mortality for period without observations (1950-1983) is replaced by mean values for period 1984-2010.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0. The peak spawning occurs most years in the middle of April.

B.3. Surveys

Russian surveys of cod and haddock in the southern Barents Sea started in the late 1940s as trawl surveys of young demersal fishes. Since 1957 such surveys have been conducted over the whole feeding area including the Bear Island - Spitsbergen area (Baranenkova, 1964; Trambachev, 1981); both young and adult haddock have been surveyed simultaneously. Duration of the survey has declined from 5-6 months (September-February) in 1946-1981 to 2-2.5 months (October-December) since 1982. The aim of the survey is to investigate both the commercial size haddock as well as the young haddock. The survey covers the main areas where juveniles settle to the bottom, as well as the area where the commercial fishery takes place. A total number of more than 400 trawl hauls are conducted during the survey (mainly bottom trawl, a few pelagic trawls). In 1984, acoustic methods started to be implemented during surveys of fish stocks (Zaferman and Serebrov, 1984; Lepesevich and Shevelev, 1997; Lepesevich *et al.*, 1999). From 1995 onwards there has been a substantial change in the method for calculating acoustic indices, which allowed the differentiation and registration of echo intensities from fish of different length (Shevelev *et al.*, 1998).

There are two survey abundance indices at age: 1) absolute numbers (in thousands) computed from the acoustics estimated by the new method (RU-Aco-Q4) for the period 1995-2009 (ages 0-10); 2) trawl index, calculated as relative numbers per hour trawling (RU-BTr-Q4) for the period 1983-2009 (ages 0-9).

The indices (RU-Aco-Q4) were not used for tuning the XSA due to a strong "year effect" observed in years with incomplete area coverage. This index needs further adjusting before it can be used for tuning. Based on internal consistency test the RU-BTr-Q4 index is used in tuning for ages 1-7.

Norwegian winter (February) survey (from 2000 - Joint Barents Sea survey, NoRu-BTr-Q1 and NoRu-Aco-Q1)

The survey started in 1981 and covers the ice-free part of the Barents Sea. Both swept area estimates from bottom trawl and acoustic estimates are produced. The swept area estimates are used in the tuning for ages 1-8. The survey is described in Jakobsen *et al*. (1997) and Aglen *et al*. (2002).

Before 2000 this survey was made without participation from Russian vessels, while in the three latest surveys Russian vessels have covered important parts of the Russian zone. The indices for 1997 and 1998, when the Russian EEZ was not covered, have been adjusted as reported previously (Mehl, 1999). The number of fish (age group by age group) in the Russian EEZ in 1997 and 1998 was interpolated assuming a linear development in the proportion found in the Russian EEZ from 1996 to 1999. These estimates were then added to the numbers of fish found in the Norwegian EEZ and the Svalbard area in 1997 and 1998.

It should be noted that the survey conducted in 1993 and later years covered a larger area compared to previous years (Jakobsen *et al*. 1997). Other changes in the survey methodology through time are described by Jakobsen *et al*. (1997). Note that the change from 35 to 22 mm mesh size in the cod-end in 1994 has not been corrected for in the time series. This mainly affects the age 1 indices. There are two abundance indices at age from that survey used in stock assessment:

1) swept area estimates from bottom trawl NoRu-BTr-Q1 for the period 1981-2010 (ages 1-10);

2) swept area estimates from acoustic NoRu-Aco-Q1 for the period 1981-2010 (ages 1-10).

For tuning XSA used: NoRu-BTr-Q1 for (ages 1-8) and NoRu-Aco-Q1 for ages 1-7.

Joint Norwegian-Russian Ecosystem survey (Eco-NoRu-Btr-Q3)

The bottom trawl estimates from the joint ecosystem survey in August-September, starting in 2004. This survey covers a larger portion of the distribution area of haddock. The new index Eco-NoRu-Btr-Q3 for period 2004-2009 ages 1-8 became available for AFWG 2010. This time series have been tested as new tuning fleet in XSA and it was found that the index was acceptable for use in the NEA haddock assessment.

Based on the test made during WKBENCH 2011 and previous AFWG work it is decided to use only tuning indices for the period 1990 and onwards.

B.4. Commercial CPUE

Russia

No Russian data are used in the stock assessment.

Norway

Historical time series of observations onboard Norwegian trawlers were earlier used for tuning of older age groups in VPA. The basis was catch per unit effort (CPUE) in Norwegian statistical areas 03, 04 and 05 embracing coastal banks north of Lofoten, on which approximately 70% of Norwegian haddock catch was taken. However, the proportion of haddock taken as by-catch is pretty high and thus it is difficult to estimate their actual catch per unit effort. Since 2002, CPUE indices have not been used in XSA tuning.

B.5. Other relevant data

Not used.

C. Assessment: data and method

Model used: XSA

Software used: FLR suite (and VPA95 suite)

Model Options chosen:

Tapered time weighting applied, power = 3 over 20 years

Catchability independent of stock size for ages > 8

Catchability independent of age for ages > 8

Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages

S.E. of the mean to which the estimate are shrunk = 1.500[1]

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

[1] During the benchmark in 2011 (ICES 2011) it was decided that the AFWG 2011should evaluate different options for this value and make the final decision on the appropriate value. The AFWG 2011 decided to change this setting from 0.5 to 1.5.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1950 – last data year	3 – 11+	Yes
Canum	Catch at age in numbers	1950 – last data year	3 – 11+	Yes
Weca	Weight at age in the commercial catch	1983 – last data year	3 – 11+	Yes, set equal to west for 1950-1982
West	Weight at age of the stock at start of year.	1950 – last data year	3 – 11+	Yes
Mprop	Proportion of natural mortality before spawning	1950 – last data year	3 – 11+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1950 – last data year	3 – 11+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1950 – last data year	3 – 11+	Yes, set equal to average for 1950-1980
Natmor	Natural mortality	1950 – last data year	3 – 11+	Includes annual est. of predation by cod from 1984, otherwise set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1 (RU-BTr-Q4)	Russian bottom trawl survey, October-December	1991 – last data year	3-7 (1-7 in predation run)
Tuning fleet 2 (BS-NoRu-BTr-Q1)	Joint Norwegian-Russian trawl survey, February	1990 – last data year	3 – 8 (1-8 in predation run)
Tuning fleet 3 (BS-NoRu-Aco-Q1)	Joint Norwegian-Russian Acoustic survey, February	1990 – last data year	3 – 7 (1-7 in predation run)
Tuning fleet 4 (Eco-NoRu-Btr-Q3)	Joint Norwegian-Russian Ecosystem survey	2004 – last data year	3 – 8 (1-8 in predation run)

D. Short-Term Projection

Model used: Age structured

Software used: R and FLR suite, MFDP with management option table and yield per recruit routines

Initial stock size: Estimated in XSA as abundance of individuals that survive the terminal year for age 3 and older.

Recruitment at age 3 for the start year and the 2 consecutive years is estimated from survey data in RCT3 using the tuning series as input.

F and M before spawning: assumed equal to 0 for all ages in all years

Maturity: for current year smoothed actual data combined by Russian and Norwegian surveys are used; for subsequent years – using the fitted parameters and last year maturity as input.

Weight at age in the stock: for current year smoothed actual data combined by Russian and Norwegian surveys are used, for two years ahead, using the fitted parameters and last year lengths as input.

The Norwegian and Russian weight-at-age and maturity-at-age are then combined as arithmetic averages.

Weight at age in the catch and natural mortality: show strong patterns related to periods of good recruitment. The Working Group believes that the estimated recruitment in the most recent years is so high that it will affect growth. The Working Group therefore decided to use similar trends in weight at age, and natural mortality as has been observed in previous periods following good recruitment.

Exploitation pattern: For current year it is taken to be at the level of previous year ($F_{Status\ quo}$) or to be equal to average for the recent 3 years; for subsequent years method used to determine this parameter and its substantiation are given in the AFWG Reports. In 2010 the average fishing pattern observed in the 3 last years, scaled to F status quo was used for distribution of fishing mortality at age for 2010-2012.

Intermediate year assumptions:

Stock recruitment model used: None

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

Not used in assessment.

F. Long-Term Projections

Not used in assessment.

G. Biological Reference Points

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	80 000 t	$B_{trigger}=B_{pa}$
	F_{MSY}	0.35	Stochastic long-term simulations
Precautionary Approach	B_{lim}	50 000 t	B_{loss}
	B_{pa}	80 000 t	$B_{lim}*\exp(1.645*\sigma)$, where $\sigma=0.3$
	F_{lim}	0.77	SSB=B_{lim}, SPR value of slope of line from origin at SSB=0 to geometric mean recruitment
	F_{pa}	0.47	$F_{lim}*\exp(-1.645*\sigma)$, where $\sigma=0.3$

H. Other Issues

H.1. Historical overview of previous assessment methods (this subsection is optional. See example below.)

Summary of data ranges used in recent assessments:

Data	2006 assessment	2007 assessment	2008 assessment	2009 assessment	2010 assessment
Catch data	Years:1950–2005 Ages: 1–11+	Years: 1950–2006 Ages: 1–11+	Years: 1950–2007 Ages: 1–11+	Years: 1950–2008 Ages: 1–11+	Years: 1950–2009 Ages: 1–11+
Cod consumption data	Available: Years 1984–2005 Ages: 0–6 Used ages: 1-6	Available: Years1984–2006 Ages: 0–6 Used ages: 1-6	Available: Years1984–2007 Ages: 0–6 Used ages: 1-6	Available: Years1984–2008 Ages: 0–6 Used ages: 1-6	Available: Years1984–2009 Ages: 0–6 Used ages: 1-6
Fleet 01 Survey: RU-BTr-Q4	Available: Years1983-2005 Ages 0+ 9 Used 1991-2005 ages: 1–7	Available: Years1983-2006 Ages 0+ 9 Used 1991-2006 ages: 1–7	Available: Years1983-2007 Ages 0+ 9 Used 1991-2007 ages: 1–7	Available: Years1983-2008 Ages 0+ 9 Used 1991-2008 ages: 1–7	Available: Years1983-2009 Ages 0+ 9 Used 1991-2009 ages: 1–7
Fleet 02 Survey: NoRu-Aco-Q1	Available: Years1980-2006 Ages 1 10+ Used: shifted 1990-2005 ages: 1–7	Available: Years1980-2007 Ages 1 10+ Used: shifted 1990-2006 ages: 1–7	Available: Years1980-2008 Ages 1 10+ Used: shifted 1990-2007 ages: 1–7	Available: Years1980-2009 Ages 1 10+ Used: shifted 1990-2008 ages: 1–7	Available: Years1980-2010 Ages 1 10+ Used: shifted 1990-2009 ages: 1–7
Fleet 04 Survey: NoRu-BTr-Q1	Available: Years1982-2006 Ages 1 10+ Used: shifted 1990-2005 ages: 1–8	Available: Years1982-2007 Ages 1 10+ Used: shifted 1990-2006 ages: 1–8	Available: Years1982-2008 Ages 1 10+ Used: shifted 1990-2007 ages: 1–8	Available: Years1982-2009 Ages 1 10+ Used: shifted 1990-2008 ages: 1–8	Available: Years1982-2010 Ages 1 10+ Used: shifted 1990-2009 ages: 1–8

(The historic perspective, as well as all the other section on the stock annex, should only update in a benchmark workshop. If there is any reason to deviate from the stocks annex, this should be explain in the Working Group report and only update this deviation in the historic perspective after consultation with ICES Secretariat and WG Chair).

Harvest control rule

The harvest control rule (HCR) was evaluated by ICES in 2007 (AFWG 2007) and found to be in agreement with the precautionary approach. The agreed HCR for haddock is as follows (Protocol of the 36th Session of The Joint Norwegian Russian Fishery Commission, 10 October 2007):

- *TAC for the next year will be set at level corresponding to F_{pa}.*
- *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_{pa} at B_{pa} to F= 0 at SSB equal to zero. At SSB-levels below B_{pa} in any of the operational years (current year and a year ahead) there should be no limitations on the year-to-year variations in TAC.*

At the 39th Session of The Joint Norwegian Russian Fishery Commission in 2010 it was agreed that this HCR should be left unchanged for 5 years and then re-evaluated.

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Annex 5 – Stock Annex Northeast Arctic Saithe

Quality Handbook **Annex: Saithe in Subareas I and II**

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Saithe in Subareas I and II (Northeast Arctic)
Working Group:	Arctic Fisheries Working Group
Date:	28.04.2010
Revised by:	Sigbjørn Mehl / Åge Fotland

A. General

A.1. Stock definition

The Northeast Arctic saithe is mainly distributed along the coast of Norway from the Kola Peninsula in northeast and south to Stad at 62º N (Figure 1). The 0-group saithe drifts from the spawning grounds to inshore waters. 2-4 years old the saithe gradually moves to deeper waters, and at age 3-6 it is found at typical saithe grounds. It starts to mature at age 5-7 and in early winter a migration towards the spawning grounds further out and south starts.

The stock boundary 62º N is more for management purposes than a biological basis for stock separation. Tagging experiments show a regular annual migration of mature fish from the North-Norwegian coast to the spawning areas off the west coast of Norway and also to a lesser extent to the northern North Sea (ICES 1965). There is also a substantial migration of immature saithe to the North Sea from the Norwegian coast between 62º and 66º N (Jakobsen 1981). In some years there are also examples of mass migration from northern Norway to Iceland and to a lesser extent to the Faroe Islands (Jakobsen 1987). 0-group saithe, on the other side, drifts from the northern North Sea to the coast of Norway north of 62º N.

A.2. Fishery

Norway accounts for more than 90% of the landings. Over the last ten years about 40% of the Norwegian catch originates from bottom trawl, 25% from purse seine, 20% from gill net and 15% from other conventional gears (long line, Danish sine and hand line). The gill net fishery is most intense during winter, purse seine in the summer months while the trawl fishery takes place more evenly all year around. Landings of saithe were highest in 1970-1976 with an average of 239,000 t and a maximum of 265,000 t in 1974 (Figure 2). Catches declined sharply after 1976 to about 160,000 t in the years 1978-1984. This was partly caused by the introduction of national economic zones in 1977. The stock was accepted as exclusively Norwegian and quota restrictions were put on fishing by other countries while the Norwegian fishery for some years remained unrestricted. Another decline followed and from 1985 to 1991 the landings ranged from 67,000 to 123,000 t. An increasing trend was seen after 1990 to 171,000 t in 1996, followed by a new decline to 136,000 t in 2000. Since then the annual landings have increased gradually to 212,000 t in 2006, followed by a decline to

199 000 t in 2007, 183 000 t in 2008 and 161 000 t in 2009. Quotas can be transferred between gears if the quota allocated to one of the gears will not be taken. The target set for the total landings has generally been consistent with the scientific recommendations.

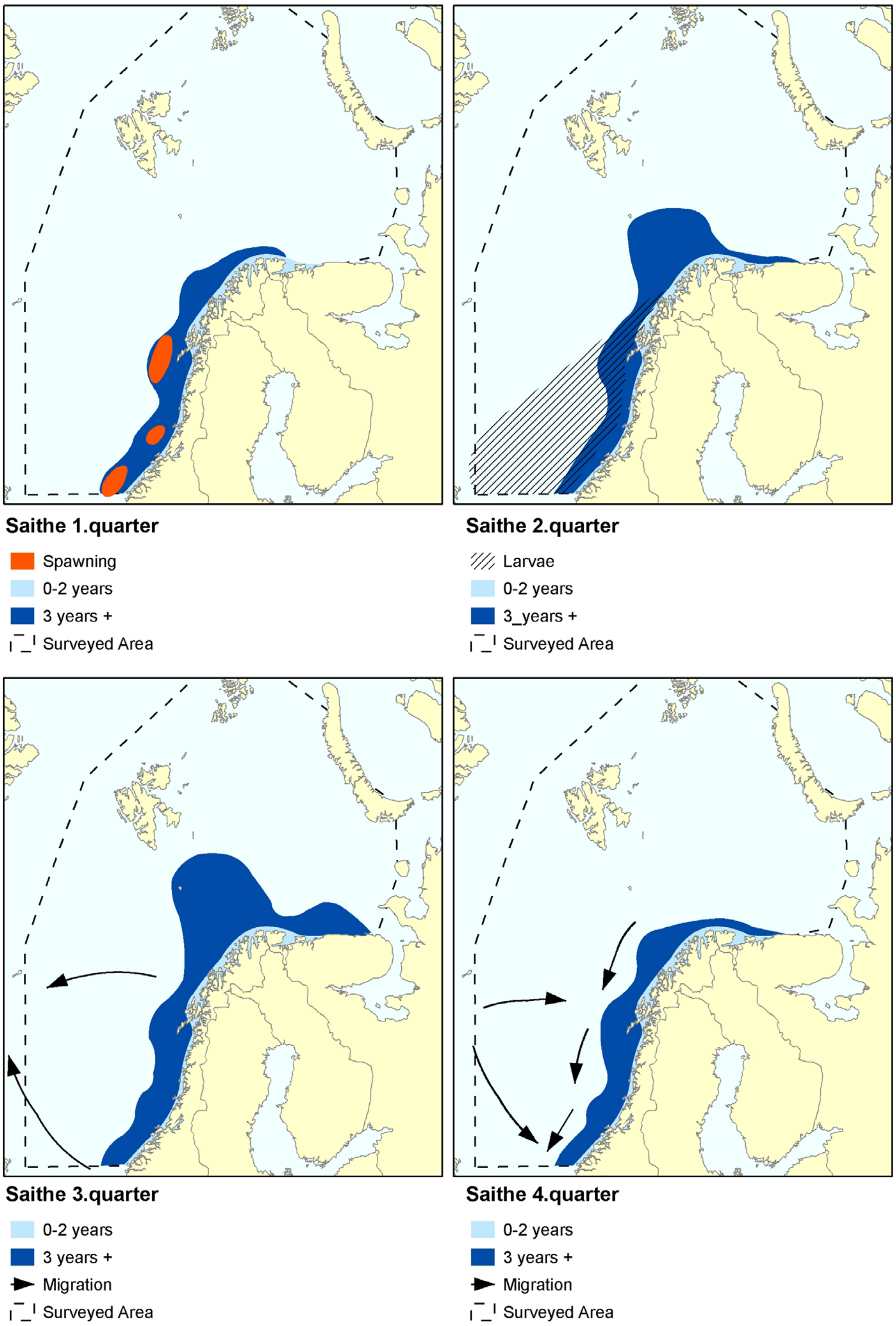

Figure 1. NEA saithe. Distribution of larvae, juveniles, adult spawning areas and the main migration patterns by (a) first quarter, (b) second quarter, (c) third quarter, and (d) fourth quarter.

The number of vessels taking part in the purse seine fishery has varied between 110 and 429 since 1977, with the highest participation in the first part of the period. There have been some variations from year to year, and many of the vessels that have taken part in the fishery the last decade have accounted for only a small fraction of the purse seine catches. The annual effort in the Norwegian trawl fishery has varied between 12 000 and 77 000 hours, with the highest effort from 1989 to 1995. Like in the purse seine fishery there have been rather large changes from year to year.

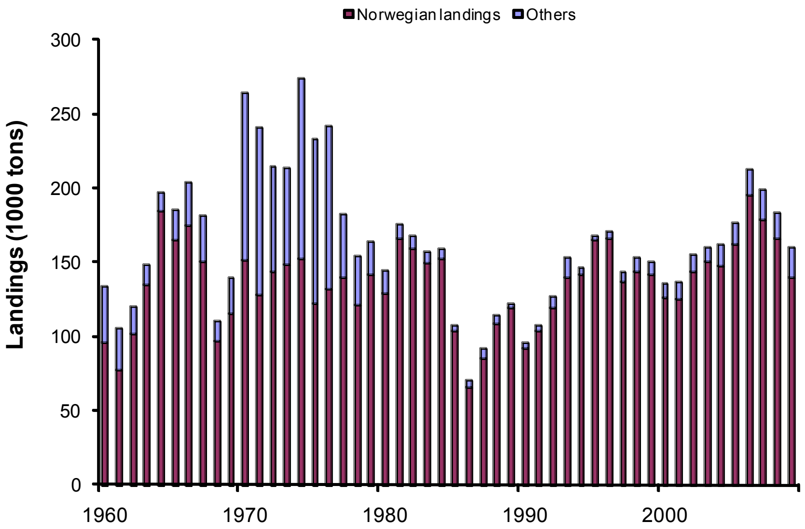

Figure 2. NEA saithe landings 1960-2009. Red part of bars shows the Norwegian landings.

1 March 1999 the minimum landing size was increased from 35-40 cm to 45 cm for trawl and conventional gears, and to 42 cm (north of Lofoten) and 40 cm (between 62° N and Lofoten) for purse seine, with an exception for the first 3000 t purse seine catch between 62° N and 66°33’ 30 N, where the minimum landing size still is 35 cm.

A.3. Ecosystem aspects

The recruitment of saithe may suffer in years with reduced inflow of Atlantic water (Jakobsen 1986).

B. Data

B.1. Commercial catch

Norwegian commercial catch in tonnes by quarter, area and gear are derived from the sales notes statistics of The Directorate of Fisheries. Data from about 20 sub areas are aggregated on 6 main areas for the gears gill net, long line, hand line, purse seine, Danish seine, bottom trawl, shrimp trawl and trap. For bottom trawl the quarterly area distribution of the catches is adjusted by logbook data from The Directorate of Fisheries and the total bottom trawl catch by quarter and area is adjusted so that the total annual catch for all gears is the same as the official total catch reported to ICES. No discards are reported or accounted for, but there are several reports of discards. In later years there are also reports of misreporting, saithe is landed as cod in a period with decreasing quotas and availability of cod and good availability of saithe.

The sampling strategy is to have age-length samples from all major gears in each area and quarter. There are at present no defined criteria on how to allocate samples of catch numbers, mean length and mean weight at age to unsampled catches, but the following general process has been applied: First look for samples from a neighbouring area if the fishery extends to this area in the same quarter. If there are no samples available in neighbouring areas, search for samples from other gears with the most similar selectivity in the same area or in neighbouring areas. The last option is to search in neighbouring quarters, first from the same gear in the same area, and then from neighbouring areas and similar gears. For some gears, areas and quarters length samples taken by the coast guard are applied and combined with an ALK from a neighbouring area, gear or quarter. ALKs from research surveys (shrimp trawl) are also used to fill holes. The alternative method applied for cod and haddock (ECA, Hirst *et al.* 2004, 2005) produce unrealistic high weights at age compared to the method presently applied for NEA saithe (ICES 2007/ACFM:16).

Constant weight at age values is used for the period 1960 – 1979. For subsequent years, Norwegian weights at age in the catch are estimated from length at age by the formula:

$$\text{Weight (kg)} = (l^3 * 5.0 + l^2 * 37.5 + l * 123.75 + 153.125) * 0.0000017,$$

Where

l = length in cm.

Norway has on average accounted for about 95% of the saithe landings. Data on catch in tonnes from other countries are either taken from ICES official statistics (by ICES area) or from reports to Norwegian authorities. A few countries also supply some additional data. The text table below shows which countries supply which kind of data:

	Kind of data				
Country	Caton (catch in weight)	Canum (catch at age in numbers)	Weca (weight at age in the catch)	Matprop (proportion mature by age)	Length composition in catch
Norway	x	x	x	x	x
Russia	x	x	x		x
Germany	x	x	x		
United kingdom	x				
France	x				
Spain[1]	x				
Portugal	x				
Poland	x				
Greenland[1]	x				
Faroe Islands[1]	x				
Iceland[1]	x				

[1] As reported to Norwegian authorities

The Norwegian, Russian and German input files are Excel spreadsheet files. Russian input data earlier than 2002 are supplied on paper and later punched into Excel spreadsheet files before aggregation to international data. The data should be found in the national laboratories and with the Norwegian stock co-ordinator.

The national data have been aggregated to international data on Excel spreadsheet files. Age composition data are normally available from Norway, Russia (some areas) and Germany (Division IIA). In some areas Russian length composition has been applied on the Russian landings together with an age-length-key (ALK) and weight at age data from the Norwegian trawl landings. Catches from the other countries were assumed to have the same age composition and weight at age as the Norwegian trawl landings. In some years the final German and Russian numbers at age have been adjusted to remove SOP discrepancies before aggregation to international data. The Excel spreadsheet files used for age distribution, adjustments and aggregations can be found with the Norwegian stock co-ordinator. Since 2007 the national data have also been uploaded to the ICES InterCatch database.

The result files (FAD data) can be found with the stock co-ordinator and at ICES as ASCII files on the Lowestoft format under **w:\acom\afwg\year\Stock\sai_arct**.

B.2. Biological

Weight at age in the stock is assumed to be the same as weight at age in the catch.

A fixed natural mortality of 0.2 is used both in the assessment and the forecast.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

Regarding the proportion mature at age, until AFWG 1995 knife-edge maturity at age 6 was used for this stock. In the 1996-2004 assessments, an ogive based on analyses of spawning rings in otholiths for the period 1973-1994 was applied for all years. The analysis showed a lower maturation in the last part of the period, and some extra weight was given to this part when an average ogive was calculated. In 2005 a large number of otholiths with missing information on spawning rings were re-read, and new analyses were done for the period 1985-2004. The maturity at age had decreased somewhat in the last part of that period, and the 2005 WG decided to use a 3-year running average, reference year being the middle of the 3-year period, for the years from 1985 and onwards (2-year average for the first and last year) (ICES 2005). The ogives used until AFWG 1995 and in 1996-2004 assessments are presented in the text table below.

Age group	2	3	4	5	6	7	8	9	10	11+
Until 1995	0	0	0	0	1	1	1	1	1	1
1996 - 2004	0	0	0.01	0.55	0.85	0.98	1	1	1	1

B.3. Surveys

In 1985-2002 a Norwegian acoustic survey specially designed for saithe was been conducted annually in October-November (Nedreaas 1997). The survey covers the near coastal banks from the Varangerfjord close to the Russian border and southwards to Stad at 62° N (Figure 3). The whole area has been covered since 1992, and the major parts since 1988. The aim of conducting an acoustic survey targeting Northeast Arctic saithe has been to support the stock assessment with fishery-independent data of the abundance of the youngest saithe. The survey mainly covers the grounds where the trawl fishery takes place, normally dominated by 3 - 5(6) year old fish. 2-year-old saithe, mainly inhabiting the fjords and more coastal areas, are also represented in the survey, although highly variably from year to year. In 1997 and 1998 there was a large increase in the abundance of age 5 and older saithe, confirming reports from the fishery. In 1999 the abundance of these age groups decreased somewhat, but was still at a high level compared to the years before 1997 (Mehl 2000). Abundance indices for ages 2-5 were used for tuning from 1988 onwards, but including older ages as a 6+ group in the tuning series improved the scaled weights a little and at the 2000 WG meeting it was decided to apply the extended series in the assessment. The results from the survey in autumn 2000 showed a further decrease in the abundance of age 5 and older saithe (Korsbrekke and Mehl 2000). It is not known how well the survey covers the oldest age groups from year to year, but at least for precautionary reasons the 6+ group was kept in the tuning series. Before the 2005 WG the 6+ group from the Norwegian acoustic survey was split into individual age groups 6 – 9 by rerunning the original acoustic abundance estimates. However, this was only possible to do for the years back to 1994. Based on further analysis during the 2005 benchmark assessment, indices for ages 3-7 was used for tuning in the 2005 and later assessments.

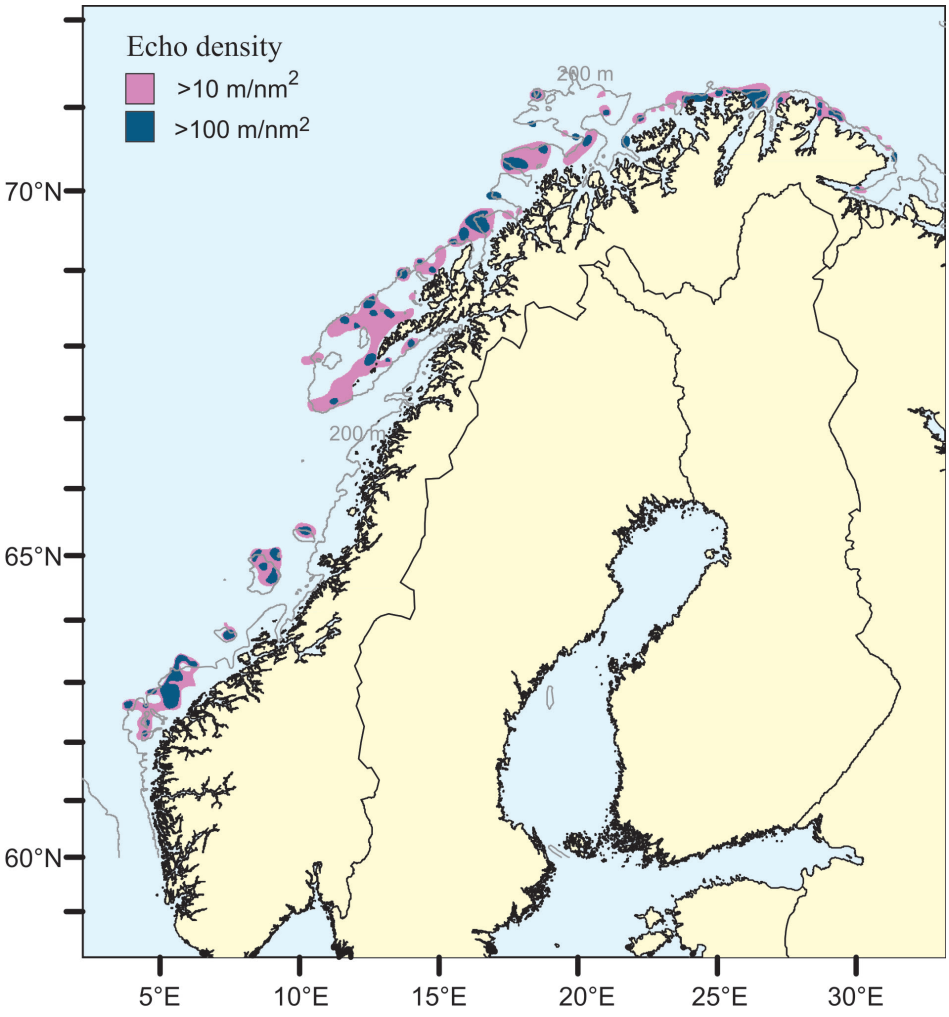

Figure 3. NEA saithe. Distribution of total saithe echo density in the acoustic survey autumn 1998.

In 1995-2002 a Norwegian acoustic survey for coastal cod was conducted along the coast and in the fjords from Varanger to Stad in September, just prior to the saithe survey described above. This survey covers coastal areas not included in the regular saithe survey. Because saithe is also acoustically registered, this survey provides supplementary information, especially about 2- and 3-year-old saithe that have not yet migrated out to the banks. At the WG meeting in 2000 analyses were done on combining these indices with indices from the regular saithe survey in the tuning series, but it did not influence the assessment much. The WG therefore decided, for the time being, to apply only indices from the longer time series of the regular saithe survey in the assessment.

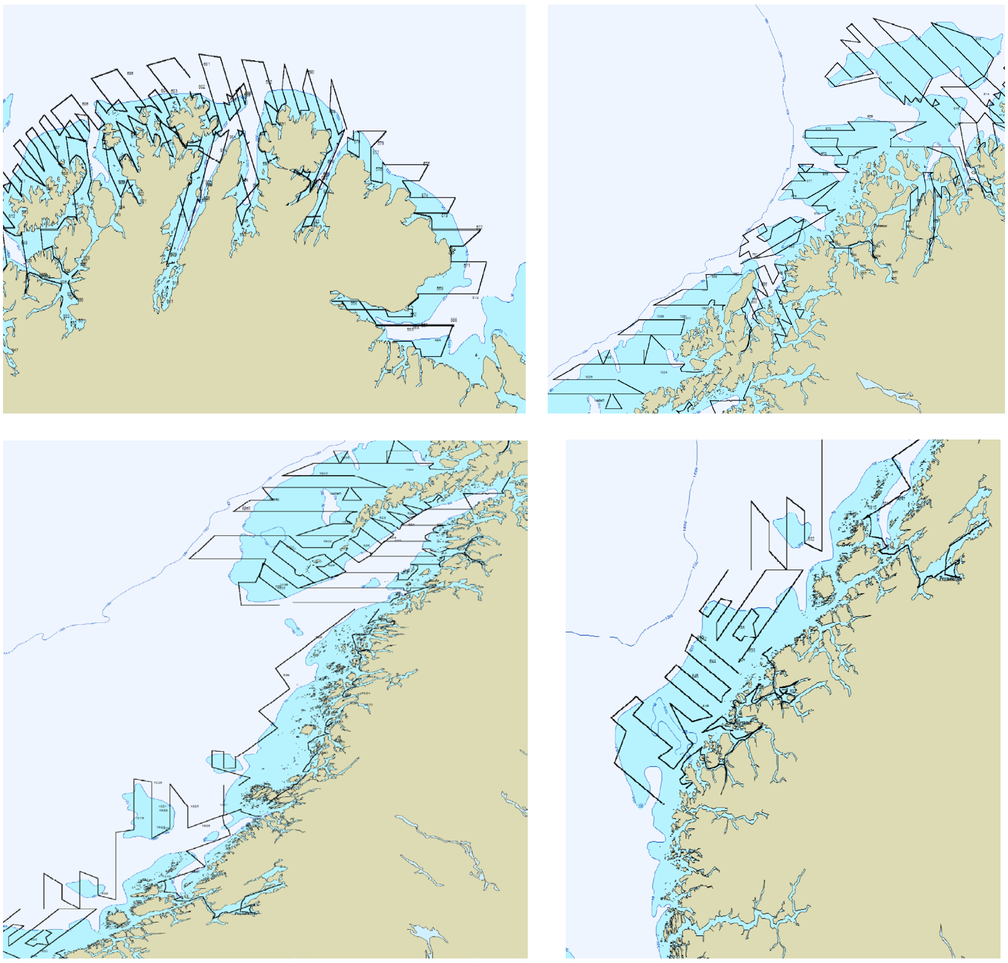

Figure 4. Standard transects in new combined saithe and coastal survey.

In autumn 2003 the saithe- and coastal cod surveys were combined. A new survey was designed, with new stratification and smaller strata based on depth and fish distribution in recent years, and with new and more regular transects (Figure 4). The new course lines had already been partly introduced in the saithe survey in 2001 and 2002. At the 2010 benchmark assessment two alternative survey index series was tested, one for 2001-2008 representing the traditional saithe survey area with new course lines and stratification, and one for 2003-2008 representing the combined saithe and coastal cod survey areas. The new tuning series gave lower and more stable S. E. Log q residuals than the tuning series presently used. However, the retrospective trend was still poor and the estimates of F and SSB in the last assessment year were far away from any other analysis. The new series are probably still too short to be used for tuning of the NEA saithe XSA. Until a longer time series based on the new survey design is established, indices from the whole survey time series, representing the traditional saithe survey area only, will be applied for tuning. The estimation of these abundance indices is done very much in the same way for the whole time series and the results for later years should be comparable with earlier years.

B.4. Commercial CPUE

Two CPUE data series have been used, one from the Norwegian purse seine fishery and one from the Norwegian trawl fishery.

Until 1999 indices of fishing effort in the purse seine fishery were based on the number of vessels of 20-24.9 m length and the effort (number of vessels) of this length category was raised by the catches to represent the total purse seine effort. However, the number of vessels taking part in the fishery almost doubled from 1997 to 1998, but due to regulations the catches were almost the same as in 1997. In such a situation the total number of vessels participating in a fishery is clearly not a good measure of effort. Examination of the data showed that many of the vessels that have taken part in the fishery the last decade have accounted for only a small fraction of the purse seine catches, and these also included most of the vessels that tend not to be involved on a regular basis. Roughly half of the vessels have caught less than 100 tonnes per year, and the sum of these catches represents only about 5 – 10% of the total purse seine catch. Therefore the number of vessels catching more than 100 tonnes annually seems to be a more representative and more consistent measure of effort in the purse seine fishery. These numbers are raised to the total purse seine catch. The new effort series showed a smaller decrease in later years than the old one and in the XSA runs it gets higher scaled weights. The 2000 WG meeting therefore decided to use the new CPUE data series in the assessment.

The quality and performance of the purse seine tuning fleet has been discussed several times in the WG. The effort, measured as number of vessels participating, has been highly variable from year to year. This was partly taken care of by only including vessels with total catch > 100 tonnes. However, with a restricting and changing TAC and transfer of quota, the CPUE may change much from year to year without really reflecting trends in the saithe abundance. This is also reflected in the tuning diagnostics of exploratory runs. There are rather large and variable log q residuals and large S.E. log q for all age groups except age 4, which often is the dominant age group in the purse seine landings. But even for age 4 the S.E. log q is higher than in the Norwegian trawl CPUE and acoustic survey indices single fleet tunings. There are strong year effects, and in the combined tuning the purse seine series get low scaled weights. Mainly based on this the 2005 WG decided to not include the purse seine tuning fleet in the analysis (ICES 2005). In later years with lower availability of young saithe the TAC has been less restricting, and at the 2010 benchmark assessment exploratory runs were done with updated purse seine tuning series. The purse seine tuning series showed the higher S.E_Log q residuals and lower scaled weights than the other tuning series and did not perform any better than in previous analysis, and were not reintroduce as a tuning series in the assessment.

Catch and effort data for Norwegian trawlers were until 2000 taken from hauls where the effort almost certainly had been directed towards saithe, i.e., days with more than 50% saithe and only on trips with more than 50% saithe in the catch. The effort estimated for the directed fishery was raised by the catches to give the total effort of Norwegian trawlers. From 1997 to 1998 the effort increased by more than 50%, but due to regulations the catches were slightly lower in 1998 and the CPUE decreased by almost 40% from 1997 to 1998 and stayed low in 1999. This may at least partly be explained by change in fishing strategies in a period with increasing problems with bycatch of saithe in the declining cod fishery due to good availability of saithe. In 2001 new CPUE indices by age were estimated based on the logbook database of the Directorate of Fisheries, which has a daily resolution (Salthaug and Godø 2000). After some initial analyses it was decided to only include data from vessels larger than the median length since they showed the least noisy trends. One single CPUE observation from a given vessel is the total catch per day divided by the duration of all the trawl hauls that day. To increase the number of observations during a time period with decreasing directed saithe fishery, all days with 20% or more saithe were included. The effort (hours trawling) for each CPUE observation was standardised or calibrated to a standard vessel. Until 2002, first averaging all CPUE observations for each month, and then averaging over the year a yearly index was calculated. The CPUE indices were divided on age groups by quarterly weight, length and age data from the trawl fishery. From 2003, first averaging all CPUE observations for each quarter, and then averaging over the year a yearly index was calculated. The CPUE indices were finally divided on age groups by yearly catch in numbers and weight at age data from the trawl fishery. The new approach was less influenced by short periods with poor data, while it still evens out seasonal variations.

There was an increase in the total CPUE from 1999 to 2003, when it reached the highest level in the time series going back to 1980. In 2004 the total CPUE was almost exactly the same as in 2003, while there was about a 30 % increase from 2004 to 2005. This was caused by an increase in the quarter one CPUE. This increase started already in 2003, but was most pronounced in 2005. The increase may be explained by increased availability and catchability of saithe in spawning areas of Norwegian spring spawning herring, where the saithe feeds on herring during quarter one. A similar increase was not seen in the other areas and quarters. AT the 2005 benchmark assessment an annual CPUE series was calculated without quarter one data. This CPUE series showed much less variations over the last four years, and the WG decided to use a CPUE time series averaged over quarters 2-4 for tuning (ICES 2005). Due to rather large negative log q residuals in the first part of the new time series, it was shortened to only cover the period after 1993. Based on exploratory runs done at the 2005 benchmark assessment the age span was set to 4-8.

The estimates of total CPUE increased considerably both in 2007 and 2008. The survey (Aglen *et al*. 2009) shows a higher proportion of saithe in the southern half of the distribution area in the last years, and logbook data show that the trawl catches included in the CPUE calculations also have become gradually more southerly distributed, i.e. the trawlers follow saithe aggregations that may have become extra available in 2007 and 2008. The biological samples used for dividing total CPUE on age groups are, however, from the whole saithe fishery and therefore include age groups that are not numerous in these aggregations. Based on this and the decline in survey indices in the same years and additional analysis, the WG decided to exclude the 2007 and 2008 CPUE data in the final assessment (ICES 2008, ICES 2009a).

Further analysis and exploratory runs were presents at the 2010 benchmark assessment. Six different options were tested, included a proposal from the industry. The CPUE index based upon 7 vessels proposed by the industry could implement new bias or noise due to lack of quarterly indices and index values out of range. To take account of a time period (2000-2008) with increasing directed saithe fishery (Figure 2b), all days with 80% or more saithe are excluded in some runs. Of the two options A) leaving out quarter 1 in the averaging and use all catches with > 20% saithe for the rest of year (as in the current index) or B) leaving out days with > 20% but < 80% saithe and including quarter 1 in the averaging, option B was chosen because it gave somewhat better diagnostics in the XSA runs and is more consistent regarding how data is selected and direct fishery is treated in the rest of the year. The increase in CPUE at the end of the time period was much less for this option and all data years were included in the analysis.

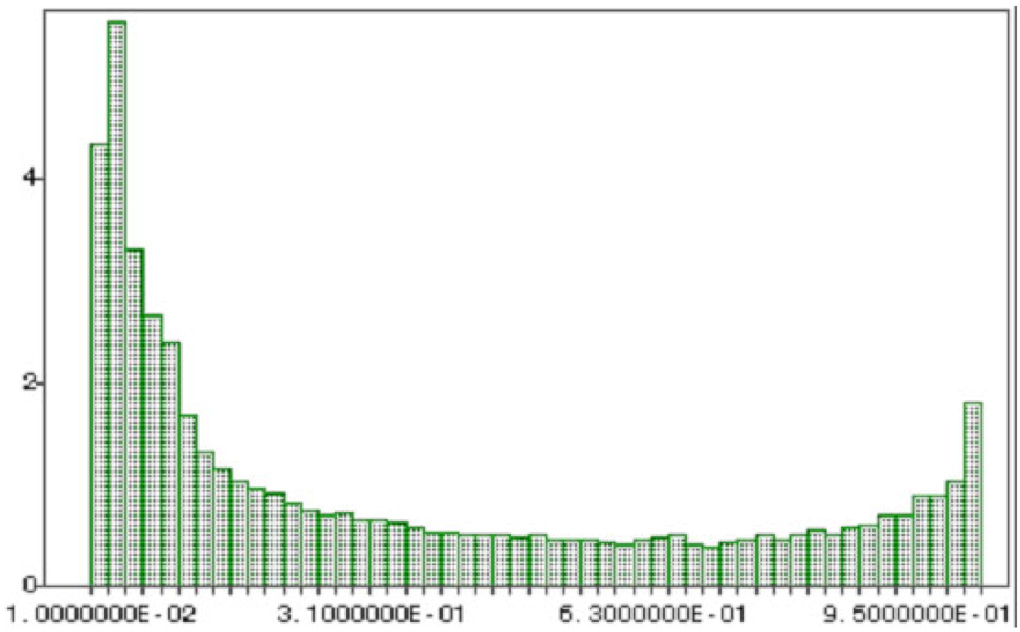

Figure 5a Distribution of small and large trawl catches of NEA saithe (in percent) 1994-1999.

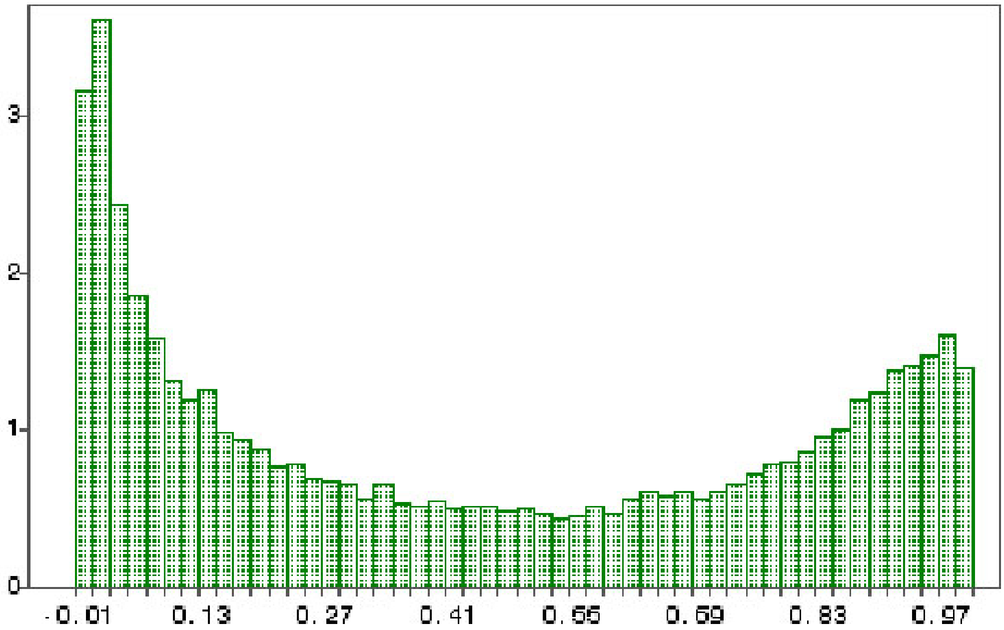

Figure 5a Distribution of small and large trawl catches of NEA saithe (in percent) 2000-2008.

B.5. Other relevant data

None.

C. Historical Stock Development

Until the 2005 assessment age 2 was applied as recruitment age in the XSA runs, projections and calculations of reference points. Since the mid 1990's there has been almost no catch of 2 year olds and this age group should in theory be fully protected by the new minimum landing size. 2-year-old saithe, mainly inhabiting the fjords and more coastal areas, are represented in the survey, but highly variable from year to year. The saithe is normally not fully recruited to the survey before at age 3 and in some years at age 4. It is therefore difficult to estimate good recruitment indices, even at age 2. This especially effects the projections. Retrospective XSA analyses showed that applying age 3 as recruitment age implies that one may include more years in the last part of the recruitment time series. The 2005 WG therefore decided to apply age 3 as recruitment age.

Since about year 2000 the number of old (11+) fish in the catch matrix has been gradually increasing until 2004 and then decreased somewhat, but is still on a high level compared to the years before 2000. VPA based assessment models fitted to data sets with significant numbers in the oldest age and plus group, are extremely sensitive to the method by which fishing mortality at the oldest age is estimated, due to relatively poor VPA convergence at the oldest ages (see ICES 2002, Annex 7). At the 2010 benchmark assessment (WKROUND 2010) the catch matrix was extended to 15+ to avoid some of the potentially plus group problems. At WKROUND this was only possible to do back to 1989. Exploratory XSA runs showed much better retrospective patterns and lower SSB levels and higher F levels at the end of the time period. Prior to AFWG 2010 the whole time series of both catch, weight and maturity at age was extended.

Analysis of the tuning series indicated that there had been a shift in catchability around year 2002 (Figure 6). 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. This allows the XSA freedom to estimate different qs. Exploratory XSA runs showed improvement of retrospective patterns and diagnostics, and some year effects were no more apparent. Additional exploratory runs with reduced shrinkage were done to better allow the model to fit population number to the tuning series. Detailed XSA diagnostics indicated that both tuning indices were relative good in estimating year class strength at different ages. Therefore lowering the shrinkage, allowing the commercial CPUE and survey to determine more of the year classes seemed appropriate (ICES 2009b). The proposed shrinkage of 1.5 lowered the weight of the shrinkage to less than 4 % for all ages. The use of a 20 year tricubic taper against a no-taper was also investigated. Although diagnostics did not substantially improve, it was decided that there were no benefits in keeping the tricubic taper as the splitting up of the tuning series already had a similar impact on the assessment as the 20 year taper and improved substantially the assessment.

The recommendation from WKROUND 2010 therefore was to run the XSA with a 15+ catch matrix, tuning time series broken in 2002, reduced shrinkage (S.E. of the mean to which the estimate are shrunk increased from 0.5 to 1.5) and no tapered time weighting. The new model options are shown below.

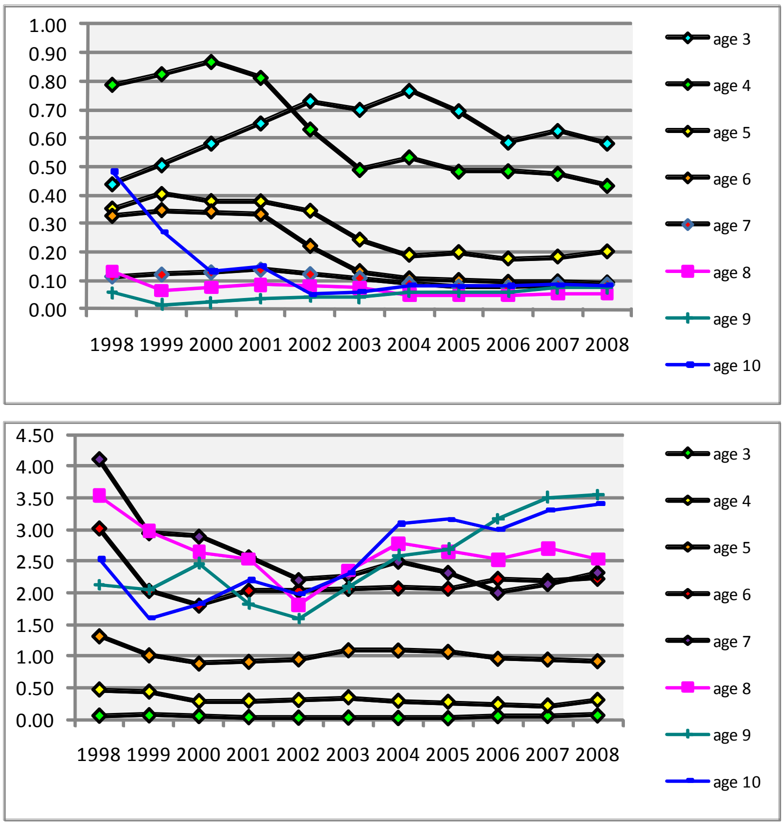

Figure 6 Catchability (index/N) at age in the Norwegian acoustic survey (upper panel) and in the Norwegian trawl CPUE series (lower panel).

Until the 2005 assessment age group 3-6 was the reference age group for Fbar and has been applied in the projections and calculations of fishing mortality reference points. Before the mid 1990's 3 year old fish made up a significant part of the landings, and age group 3-6 contributed about 80 %. Since the mid 1990's there has been a marked reduction in the landings of 3 year olds, and age group 4-7 contributes more than age group 3-6. This is partly related to transference of quota from purse seine to conventional gears and partly to better price for larger saithe. In 1999 the minimum landing size was increased, and most of the 3-year-old fish will be below this size the whole year. The 2005 WG therefore decided to apply age group 4-7 as reference age group for Fbar. The fishing mortality PA-reference points therefore were re-calculated.

Due to the increased number of old fish in the catch matrix the 2010 benchmark assessment also investigated the age span for Fbar. Age groups 4-7 still make up most of the landings, and there are more noisy data in older age groups. Therefore it was decided keep Fbar as current.

Model used: XSA

Software used: Lowestoft VPA suite. In AFWG 2009 exploratory assessment runs were conducted in FLR version 2.8.1.

Model Options chosen:

No tapered time weighting applied

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 8

Survivor estimates shrunk towards the mean F of the final 5 years or the 5 oldest ages

S.E. of the mean to which the estimate are shrunk = 1.500

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1960 – last data year	3 – 15+	Yes
Canum	Catch at age in numbers	1960 – last data year	3 – 15+	Yes
Weca	Weight at age in the commercial catch	1960 – last data year	3 – 15+	Yes/No - constant at age from 1960 - 1979
West	Weight at age of the spawning stock at spawning time.	1960 – last data year	3 – 15+	Yes/No - assumed to be the same as weight at age in the catch
Mprop	Proportion of natural mortality before spawning	1960 – last data year	3 – 15+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1960 – last data year	3 – 15+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1960 – last data year	3 – 15+	Yes/No – constant ogive 1960-1984, three year running average since 1985
Natmor	Natural mortality	1960 – last data year	3 – 15+	No – set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 11	Nor trawl quarter 1-4	1994 – 2001	4 - 8
Tuning fleet 12	Nor trawl quarter 1-4	2002 – last data year	4 - 8
Tuning fleet 13	Norway ac survey	1994 – 2001	3 - 7
Tuning fleet 14	Norway ac survey	2002 – last data year	3 - 7

For analysis of alternative procedures see WG reports from AFWG 1997-2009.

D. Short-Term Projection

Model used: Age structured

Software used: MFDP prediction with management option table and yield per recruit routines, MFYPR.

Initial stock size. Taken from the XSA for age 5 and older. The recruitment at age 3 in the last data year is estimated using the long-term geometric mean, and numbers at age 4 in the intermediate year is calculated applying a natural mortality of 0.2 and the F value estimated by XSA, (advised by RG in 2004).

From AFWG 2009 the numbers at age 4 in the intermediate year is calculated applying a natural mortality of 0.2 and the F value estimated by standard Pope's equation for calculation of this y-c at age 4, i.e. N(4)=[N(3)*exp(-M/2)-C(3)] *exp(-M/2), (advised by RG in 2009).

Natural mortality: Set to 0.2 for all ages in all years

Maturity: Constant ogive 1960-1984, three year running average since 1985, reference year being the middle

F and M before spawning: Set to 0 for all ages in all years

Weight at age in the stock: Assumed to be the same as weight at age in the catch

Weight at age in the catch: For weight at age in stock and catch the average of the last three years in the VPA is normally used.

Exploitation pattern: The average of the last three years for ages 3-10, and a constant value for age 11 to 15+ calculated as the average of ages 11-13 over the last three years.

Selection pattern for yield per recruit: The average selection pattern from the last three years (2006–2008) of the assessment was used.

Intermediate year assumptions: TAC constraint, scaled to a TAC value. If using Sq F for the intermediate year, exploitation patterns described above should be used if there is no trend in F. If a trend in F is observed, the exploitation pattern should be scaled by the Fbar (4-7) to the level of the last year.

Stock recruitment model used: None, the long-term geometric mean recruitment at age 3 is used

Procedures used for splitting projected catches: Not relevant

E. Medium–Term Projections

The issue was not addressed during the 2010 benchmark and no projections were made. Settings previously used are listed below.

Model used: Age structured

Software used: MFDP single option prediction

Initial stock size: Same as in the short-term projections.

Natural mortality: Set to 0.2 for all ages in all years

Maturity: Same as in the short-term projections.

F and M before spawning: Set to 0 for all ages in all years

Weight at age in the stock: Assumed to be the same as weight at age in the catch

Weight at age in the catch: Same as in the short-term projections.

Exploitation pattern: Same as in the short-term projections.

Intermediate year assumptions: F-factor from the management option table corresponding to the TAC

Stock recruitment model used: None, the long-term geometric mean recruitment at age 3 is used

Uncertainty models used: @RISK for Excel, Latin Hyper cubed, 5000 replications, fixed random number generator

- Initial stock size: Lognormal distribution, LOGNORM (mean, standard deviation), with mean as in the short-term projections and standard deviation calculated by multiplying the mean by the external standard error from the XSA diagnostics (except for age 3, see recruitment below)
- Natural mortality: Set to 0.2 for all ages in all years
- Maturity: Constant ogive 1960-1984, three year running average since 1985
- F and M before spawning: Set to 0 for all ages in all years
- Weight at age in the stock: Assumed to be the same as weight at age in the catch
- Weight at age in the catch: Average weight of the three last years
- Exploitation pattern: Average of the three last years, scaled by the Fbar (4-7) to the level of the last year if there is a trend
- Intermediate year assumptions: F-factor from the management option table corresponding to the TAC
- Stock recruitment model used: specified as a PERT distribution (as special form of the beta distribution) with a *minimum* and *maximum* value as specified. The shape parameter is calculated from the defined *most likely* value.

  RiskPertAlt(*arg1type, arg1value, arg2type,arg2value, arg3type,arg3value*). Specifies a PERT distribution with three arguments of the type *arg1type to arg3type*. These arguments can be either a *percentile* between 0 and 1 or *"min"*, *"m. likely"* or *"max"*.

  Examples: *RiskPertAlt(2%; min; 50%; geomean; 98%; max) specifies a PERT distribution with a* minimum *of min and a most likely value of geomean and a 98th percentile of max.*

F. Long-Term Projections

The issue was not addressed during the 2010 benchmark and no projections were made.

G. Biological Reference Points

Due to the change of Fbar from 3-6 to 4-7 and age at recruitment from 2 to 3, the **lim** and **pa** reference points were re-estimated at the 2005 WG. The **lim** reference points were estimated according to the new methodology outlined in ICES CM 2003/ACFM:15. Saithe retrospective XSA-analyses show that in later years there have been an overestimation of F and underestimation of SSB in the assessment year. The trend may have been the opposite in earlier years, but the length of the tuning series do not allow for long enough retrospective analysis to verify this. The new methodology (ICES CM 2003/ACFM:15) does not give any advise on how to deal with such situations. The **pa** reference point estimation was therefore based on the old procedure, applying the "magic formula" $\mathbf{B}_{pa} = \mathbf{B}_{lim}$ exp(1.645*σ) and $\mathbf{F}_{pa}$=$\mathbf{F}_{lim}$*exp(-1.645*σ), where σ is a measure of the uncertainty of F estimates (ICES CM 1998/ACFM:10). For NEA saithe a value of 0.3 was applied in both estimates.

In 2010 the age span was expanded from 11+ to 15+ and important XSA parameter settings were changed (ICES CM 2010/ACOM:36). This resulted in changes in estimated fishing mortality, spawning stock biomass and recruitment, especially in the last part of the time series. Therefore the **lim** and **pa** reference points were re-estimated at the 2010 WG. The results of the segmented regression were not very much different from the previous analyses. The HCR is based on the PA reference points, and if new ones are introduced, the HCR would have to be evaluated again. Due to lack of time to do this during the WG and the transition to MSY based reference points (see Section 0), it was decided to not change the existing LIM and PA reference points. The estimations done at the present WG are, however, presented below.

Biomass reference points

In 1994 the WG proposed a MBAL of 150,000 t, based on the frequent occurrence of poor year classes below this level of SSB. The new maturity ogive introduced in 1995 gave somewhat higher historical SSB estimates. 150,000 t was considered to represent a less restrictive MBAL and 170,000 t was found to correspond better with the arguments used in 1994 (ICES 1996/Assess: 4). The Study Group on the Precautionary Approach to Fisheries Management (SGPAFM, ICES 1998/ACFM: 10) also found this to be a suitable level for B_{pa}. However, based on a visual examination of the stock-recruitment plot ACFM later reduced the B_{pa} to 150,000 t (ICES 1998b).

At the 2005 WG parameter values, including the change-point (**S* =** $\mathbf{B}_{lim}$), slope in the origin ($\hat{\alpha}$) and recruitment plateau (**R***), were computed using segmented regression on the 1960-2000 time series of SSB-recruitment pairs. The values are presented in the text table below.

From algorithm in Julious (2001)		
S*	$\hat{\alpha}$	R*
136378	1.27	173200

Applying the "magic formula" $\mathbf{B}_{pa} = \mathbf{B}_{lim}$ exp(1.645*σ), gives a $\mathbf{B}_{pa}$ of 223,392 t, rounded to 220,000 t.

At the 2010 WG this procedure was repeated based on the results of the new assessment settings, using segmented regression on the 1960-2005 time series of the new SSB-recruitment pairs. The new values were:

From algorithm in Julious (2001)		
S*	$\hat{\alpha}$	R*
118542	1.48	175485

Applying the "magic formula" $\mathbf{B}_{pa} = \mathbf{B}_{lim}$ exp(1.645*σ), gives a $\mathbf{B}_{pa}$ of 194,176 t. However, as explained above, the existing values of B_{lim} = 136,000 t and B_{pa} = 220,000 t will still be used.

Fishing mortality reference points

$F_{0.1}$ and F_{max} are estimated by the MFDP yield per recruit routine, and increased from 0.08 to 0.15 and from 0.14 to 0.30 for $F_{0.1}$ and F_{max}, respectively, in the 1999 - 2005 assessments. In the 2010 assessment $F_{0.1}$ and F_{max} were estimated to 0.08 and 0.33, respectively.

The values of F_{low}, F_{med} and F_{high} obtained by the 2002 WG were 0.11, 0.34 and 0.69, respectively.

The SGPAFM (ICES 1998/ACFM: 10) suggested the limit reference point $F_{lim} = F_{med}$ for Northeast Arctic cod, haddock and saithe. A precautionary fishing mortality (F_{pa}) was defined as $F_{pa} = F_{lim} \cdot e^{-1.645\sigma}$ (σ = 0.2-0.3). The 1998 WG, however, found that setting $F_{lim} = F_{med}$ did not correspond very well with the exploitation history for those fish stocks. It was therefore decided to estimate F_{pa} and other reference points by the PASoft program package (MRAG 1997). The estimates for $F_{0.1}$, F_{max}, and F_{med} were exactly the same as the values already estimated by other routines. The median value for F_{loss} was estimated at 0.43. F_{lim} can be set at F_{loss} (ICES 1998/ACFM:10). The probability of exceeding F_{lim} should be no more than 5 % (ICES 1997/Assess: 7). The 5th percentile of the F_{loss} estimated here was 0.30 and the 1998 WG recommended using this value for F_{pa}. ACFM considered the 5th percentile calculated from the PASoft program package to be too unstable for long term use and re-estimated F_{pa} using the formula $F_{pa} = F_{lim} \cdot e^{-1.645\sigma}$ with σ = 0.3 giving a F_{pa} = 0.26, based on an estimated F_{lim} = 0.45 (ICES 1998c). An updated version of the PASoft program package (CEFAS 1999) was available at the 1999 WG and F_{pa} was re-estimated to 0.26. The WG therefore agreed to use this value for a precautionary fishing mortality for saithe (F_{pa} = 0.26).

ICES CM 2003/ACFM:15 proposed that $\mathbf{F}_{lim}$ should be set on the basis of $\mathbf{B}_{lim}$, and $\mathbf{F}_{lim}$ should be derived deterministically as the fishing mortality that will on average (i.e. with a 50% probability) drive the stock to the biomass limit. The functional relationship between spawner-per-recruit and F will then give the F associated with the R/SSB slope derived from the $\mathbf{B}_{lim}$ estimate obtained from the segmented regression. At the 2005 WG arithmetic means of proportion mature 1960-2004, weight in stock and weight in catch 1980-2004 (weights were constant before 1980), natural mortality and fishing pattern 1960-2004 were used for calculating the spawner-per-recruit function using ICES Secretariat yield-per-recruit software. R/SSB = 1.27 from the $\mathbf{B}_{lim}$ estimation gives SSB/R = 0.7874 and a $\mathbf{F}_{lim}$ = 0.58. Applying the "magic formula" $F_{pa} = F_{lim} \exp(-1.645*\sigma)$, gives a F_{pa} of 0.35.

At the 2010 WG the latter procedure was repeated. Arithmetic means of proportion mature 1960-2009, weight in stock and weight in catch 1980-2009 (weights were constant before 1980), natural mortality and fishing pattern 1960-2009 were used for calculating the spawner-per-recruit function using ICES Secretariat yield-per-recruit software. R/SSB = 1.48 from the $\mathbf{B}_{lim}$ estimation gives SSB/R = 0.676 and a $\mathbf{F}_{lim}$ = 0.59. Applying the "magic formula" $F_{pa} = F_{lim} \exp(-1.645*\sigma)$, gives a F_{pa} of 0.36. As explained above, the existing values of F_{lim} = 0.58 and F_{pa} = 0.35 will still be used.

H. Other Issues

Harvest control rule

In 2007 Norway asked ICES to evaluate whether a proposal for a harvest control rule for setting the annual fishing quota (TAC) for Northeast Arctic saithe was consistent with the precautionary approach. The harvest control rule contains the following elements:

- estimate the average TAC level for the coming 3 years based on $\mathbf{F}_{pa}$. TAC for the next year will be set to this level as a starting value for the 3-year period.
- the year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development. However, the TAC should not be changed by more than +/- 15% compared with the previous year's TAC.
- if the spawning stock biomass (SSB) in the beginning of the year for which the quota is set (first year of prediction), is below $\mathbf{B}_{pa}$, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from $\mathbf{F}_{pa}$ at SSB=$\mathbf{B}_{pa}$ to 0 at SSB equal to zero. At SSB levels below $\mathbf{B}_{pa}$ in any of the operational years (current year and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.

ICES concluded that the HCR is 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 (ICES 2007). This also holds true when an implementation error (difference between TAC and catch) equal to the historic level of 3% is included.

The highest long-term yield was obtained for an exploitation level of 0.32, i.e. a little below the target F used in the HCR (Fpa), and ICES recommended using a lower value in the HCR.

The HCR is expected to rebuild a depleted stock to a level above $\mathbf{B}_{lim}$ within three years.

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Annex 6: Quality Handbook ANNEX:_*Smentella*

Stock specific documentation of standard assessment procedures used by ICES. Since ACFM (now ACOM) considers it not necessary to assess this stock every year since the status of the stock can clearly be deducted from the surveys, no analytical assessment has been made since 2003.

Stock: *Sebastes mentella* (Beaked Redfish) in Subareas I and II

Working Group: Arctic Fisheries Working Group (AFWG)

Date: 06.05.10

A. General

A.1. Stock definition

The stock of *Sebastes mentella* (beaked redfish) in ICES Subareas I and II, also called the Norwegian-Barents Sea stock, is found in the northeast Arctic from 62ºN in the south to the Arctic ice north and east of Spitsbergen. The south-western Barents Sea and the Spitsbergen areas are first of all nursery areas. Although some adult fish may be found in smaller subareas, the main behaviour of *S. mentella* is to migrate westwards and south-westwards towards the continental slope and out in the pelagic Norwegian Sea as it grows and becomes adult. In the Norwegian Sea and along the slope south of 70°N only few specimens less than 28 cm are observed, and on the shelf south of this latitude *S. mentella* are only found along the slope from about 450 m down to about 650 m depth. The southern limit of its distribution is not well defined but is believed to be somewhere on the slope northwest of Shetland. The stock boundary 62º N is therefore more for management purposes than a biological basis for stock separation, although the abundance of this species south of this latitude becomes less. The main areas of larval extrusion are along the slope from north of Shetland to west of Bear Island. The peak of larval extrusion takes place during the first half of April. Genetic studies have not revealed any hybridisation with *S. marinus* or *S. viviparus* in the area. Recent genetic studies revealed no differentiation between *S. mentella* in the Norwegian Sea and the Barents Sea.

A.2. Fishery

The only directed fisheries for *Sebastes mentella* (deep-sea redfish) are trawl fisheries. By-catches are taken in the cod fishery and as juveniles in the shrimp trawl fisheries. Traditionally, the fishery for *S. mentella* was conducted by Russia and other East European countries on grounds located south of Bear Island towards Spitsbergen. The highest landings of *S. mentella* were 269,000 t in 1976. This was followed by a rapid decline to 80,000 t in 1980–1981 then a second peak of 115,000 t in 1982. The fishery in the Barents Sea decreased in the mid-1980s to the low level of 10,500 t in 1987. At this time Norwegian trawlers showed interest in fishing *S. mentella* and started fishing further south, along the continental slope at approximately 500 m depth. These grounds had never been harvested before and were inhabited primarily by mature redfish. After an increase to 49,000 t in 1991 due to this new fishery, landings have been at a level of 10,000–15,000 t, except in 1996-1997 when they dropped to 8,000 t. Since 1991 the fishery has been dominated by Norway and Russia. Since 1997 ACFM has advised that there should be no directed fishery and that the by-catch should be reduced to the lowest possible level.

The redfish population in Subarea IV (North Sea) is believed to belong to the North-east Arctic stock. Since this area is outside the traditional areas handled by this Working Group, the catches are not included in the assessment. The landings from Subarea IV have been 1,000–3,000 t per year. Historically, these landings have been *S. marinus*, but since the mid-1980s trawlers have also caught *S. mentella* in Subarea IV along the northern slope of the North Sea. Approximately 80% of the Norwegian catches are considered to be *S. mentella*.

Strong regulations were enforced in the fishery in 1997. Since then it has been forbidden to fish redfish (both *S.marinus* and *S. mentella*) in the Norwegian EEZ north and west of straight lines through the positions:

1. N 7000′ E 0521′
2. N 7000′ E 1730′
3. N 7330′ E 1800′
4. N 7330′ E 3556′

and in the Svalbard area (Division IIb). When fishing for other species in these areas, a maximum 25% by-catch (in weight) of redfish in each trawl haul is allowed.

To provide additional protection of the adult *S. mentella* stock, two areas south of Lofoten have been closed for all trawl fishing since 1 March 2000. The two areas (A and B) are delineated by straight lines between the following positions:

A	B
1. N 6630′ E 0659′	1. N 6236′ E 0300′
2. N 6621′ E 0644′	2. N 6210′ E 0115′
3. N 6543′ E 0600′	3. N 6240′ E 0052′
4. N 6520′ E 0600′	4. N 6300′ E 0300′
5. N 6520′ E 0530′	
6. N 6600′ E 0530′	
7. N 6630′ E 0634.27′	

Area A has recently been enlarged to include the continental slope north to N 67º10′.

Since 1 January 2003 all directed trawl fishery for redfish (both *S. marinus* and *S. mentella*) is forbidden in the Norwegian Economic Zone north of 62°N. When fishing for other species it is legal to have up to 20% redfish (both species together) in round weight as bycatch per haul and on board at any time. Since 1 January 2005 the bycatch percentage has been reduced to 15% (both species together).

From 1 January 2000 until 31 December 2005 a maximum legal by-catch criterion of 10 juvenile redfish (both *S.marinus*, *S. mentella* and *S. viviparus*) per 10 kg shrimp has been enforced in the shrimp fishery. Since 1 January 2006 this by-catch criterion has been reduced to 3 juvenile redfish (both *S.marinus*, *S. mentella* and *S. viviparus*) per 10 kg shrimp.

Landings of *S. mentella* taken in the pelagic fishery for blue whiting and herring in the Norwegian Sea have for some countries for some years been reported to the working group. In 2004-2006 this fishery developed further to become a directed and free fishery in 2006. Since 2007 NEAFC has decided on a TAC to be fished in an olympic fishery. In 2008, seven countries and 31 trawlers were involved in this fishery. Although sporadic registrations and scattered catches of *S. marinus* may be observed, biological samples of the catches collected by observers and fishers show that the commercial catches are completely dominated by the deep-water redfish *S. mentella*.

Vinnichenko (WD 9, AFWG 2007) gives a good and comprehensive description of the previous abundance of pelagic *S. mentella* in the international waters of the Norwegian Sea, and how by-catches and exploratory fishing have developed during 1979-2006. According to Vinnichenko, in 1998-2000 small by-catches of redfish (no more than 8 t per year) were reported from the blue whiting and herring fisheries in the international waters of the Norwegian Sea and in the Norwegian Economic Zone. In 2001-2003 occurrence of redfish was reported from a larger area and catches increased to 60-118 t.

In 2004 the amount of redfish in catches increased significantly, and in June-August this species was more frequently occurring in the south of the sea. In September catches of redfish (0.5 t per hour haul) were reported from international waters and the NEZ. In October, in the northern part of the international waters, trawlers had a catch of redfish of 0.5-10 t per day, sometimes to 15-40 t. By-catches of redfish were also reported from the Bear Island-Spitsbergen area and the NEZ. The total reported catch of pelagic *S. mentella* in 2004 was 1,512 t.

In summer of 2005 small quantities of redfish were steadily present in catches on the blue whiting and herring fisheries in the international waters of the Norwegian Sea and the Bear Island-Spitsbergen area. In the first half of September some vessels operating in the Bear Island-Spitsbergen reported by-catches of *S. mentella* as large as 6-25 t per day. In the end of September in the north of the international waters of the Norwegian Sea large Russian trawlers for the first time began fishing for redfish in a directed fishery. They fished with a gigantic “Gloria” trawl. The fishery finished in the beginning of November after the redfish dispersed. In 2005 the Russian fleet reported a catch of *S. mentella* of 3 299 t, including the by-catch in the blue whiting and herring fisheries. Fishing for redfish was also conducted by a Faroese trawler. Besides, small quantities of redfish were fished by German vessels in the blue whiting fishery.

In 2006 first small catches of redfish (to 50 kg per haul) were reported from the herring fishery in the NEZ in February. In June-August catches of redfish of 70-120 kg per hour haul were reported in the blue whiting and mackerel fisheries in the international waters south of 70° N. Targeted redfish fishery by the Faroese and Russian trawlers began at the Mona Ridge (i.e., the ridge separating the Norwegian Sea into two main basins) in August. By mid-September the number of fishing vessels operating in that area was as high as 40 vessels, including 8-12 vessels from Russia and up to 30 vessels from Iceland, Faroe Islands, Norway and EU. In October 15-25 vessels continued the fishery. It finished in mid-November as the fish then had disappeared from the area. The Russian catch in the directed *S. mentella* fishery was 9,157 t. Redfish also occurred in catches by trawlers, that fished for blue whiting and herring. The total reported catch of pelagic *S. mentella* by Russian vessels in 2006 was 9,390 t, and a total of 28,429 t by all nations during this non-regulated fishery in 2006.

For 2007, the North East Atlantic Fisheries Commission (NEAFC) agreed to set a TAC of 15 500 t that could be fished in international waters in an olympic fishery (i.e., free competition among vessels until the TAC is taken) starting on 1 September. Information about the fishery in 2007 was presented to the working group in 2008 by several countries. A total catch of 15 808 t *S. mentella* has been reported to ICES and the AFWG, as caught in the pelagic fisheries in the Norwegian Sea, incl. minor by-catches in the blue whiting and herring fisheries.

For 2008, the North East Atlantic Fisheries Commission (NEAFC) agreed to set a TAC of 14,500 t that could be fished in international waters in an olympic fishery starting on 1 September. Only Portugal provided a Working Document about this fishery (WD 2), but in addition, Russia and Spain, provided length distribution of their pelagic catches. Norway distributed their pelagic catches by length and age using data collected during the scientific survey in the fishing area one week before the fishing started. A total catch of 9,183 t *S. mentella* has been reported to ICES and the AFWG as caught in the pelagic fisheries in the Norwegian Sea.

In 2009, NEAFC set a TAC of 10,500t that could be fished in international waters in an olympic fishery starting on 15th August. Preliminary figures indicate that a total catch of only 5,291t was reported to NEAFC for the pelagic fishery in that year.

Some countries have only reported catches taken in Subarea IIa, without information whether the fish were caught pelagic or demersal. For these countries, the WG has considered all catches not reported to Norwegian authorities as being caught in international waters outside the EEZ.

Bycatch of herring could be a problem during day-time trawling in these waters at this time of the year. In some catches with the research survey trawl (40 mm mesh size in codend) up to 30% (in weight) herring was caught as bycatch when targetting the redfish. Even with a commercial trawl (100 mm mesh size in codend) reports from the fishery show that mixed catches of herring may happen. Even if some of the herring is selected out through the meshes, mortality through mesh selection may be high. During the 2007 olympic fishery bycatches of blue whiting were small. Best catch-rates of *S. mentella* were usually done during day-time. According to the skippers they observed and got the best catch-rates of redfish about 50 meters deeper than last year, i.e. at about 400 m. Two tons redfish per trawl hour was considered as a very good catch rate. With a common haul duration of 18 hours, catch rates of 30-40 tons/day were not uncommon. Even catch rates up to 70 tons/day were reported.

A.3. Ecosystem aspect

As 0-group and juvenile this stock is an important plankton eater in the Barents Sea, and when this stock was sound, 0-group were observed in great abundance in the upper layers utilizing the plankton production. Especially during the first five-six years of life *S. mentella* is also preyed upon by other species, of which its contribution to the cod diet is well documented.

B. Data

B.1. Commercial catch

The landings statistics used by the Arctic Fisheries Working Group (AFWG) are those officially reported to ICES. In cases where such reportings to ICES do not exist, reportings made directly to Norwegian authorities during the fishery have been used as preliminary figures. Norwegian commercial catch in tonnes by quarter, area and gear are derived from the sales notes statistics of The Directorate of Fisheries. Data are aggregated on 17 areas for bottom trawl. For bottom trawl the quarterly area distribution of the catches is area adjusted by logbook data from The Directorate of Fisheries. No discards are reported or accounted for. Reliable estimates of species breakdown (*S. mentella* vs. *S. marinus*) by area are available back to 1989. The national landings of redfish for Norway and Russia are split into species by the respective national laboratories. For other countries (and areas) the AFWG has split the landings into *S. mentella* and *S. marinus* based on reports from different fleets to the Norwegian fisheries authorities.

The Norwegian sampling strategy is to have age-length samples from all major gears in each area and quarter. There are at present no defined criteria on how to allocate samples of catch numbers, mean length and mean weight at age to unsampled catches, but the following general process has been applied: First look for samples from a neighbouring area if the fishery extends to this area in the same quarter. If there are no samples available in neighbouring areas, search in neighbouring quarters, first from the same gear in the same area, and than from neighbouring areas and similar gears. The last option is to search for samples from other gears with the most similar selectivity in the same area or in neighbouring areas. For some gears, areas and quarters length samples taken by the coast guard are applied and combined with an ALK from a neighbouring area, gear or quarter. ALKs from research surveys (shrimp trawl) are also used to fill holes.

For Norway, weights at age in the catch are estimated according to the formula which gives the best fit to the length-weight data pairs collected during the year and applied to the mean length at age

The text table below shows which country supplies which kind of data:

	Kind of data					
Country	Caton (catch in weight) on unidentified redfish	Caton (catch in weight) on *S. mentella*	Canum (catch at age in numbers)	Weca (weight at age in the catch)	Matprop (proportion mature by age)	Length composition in catch
Norway		x	x	x		x
Russia		x	x[2)]	x[2)]	x (86-01)	x
Germany	x	x[3)]				x[3)]
United	x	[1)]				
Kingdom	x	[1)]				
France	x	[1)]				
Spain	x	[1)]				
Portugal	x	[1)]				
Ireland	x	[1)]				
Greenland						
Faroe Islands[1)]	x	[1)]				
Iceland						

[1)] As reported to Norwegian authorities during the fishery (only for the Norwegian Economic Zone and Svalbard)

[2)] For main fishing area until 2001

[3)] Irregularly

The Norwegian, Russian and German input files are Excel spreadsheet files. The data should be found in the national laboratories and with the stock co-ordinator. The data will soon be included in InterCatch

The national data have been aggregated to international data on Excel spreadsheet files. The Russian and German length composition has been applied on the Russian and German landings, respectively, using an age-length-key (ALK) and weight at age data from the Norwegian trawl landings. Catches from the other countries were assumed to have the same age composition and weight at age as the Norwegian trawl landings. In some years the final German and Russian numbers at age have been adjusted to remove SOP discrepancies before aggregation to international data. The Excel spreadsheet files used for age distribution, adjustments and aggregations can be found with the stock co-ordinator and for the current and previous year in the ICES AFWG Sharepoint under 'Data'.

Historic result files (FAD data) can be found at ICES and with the stock co-ordinator, either in the IFAP system as SAS datasets or as ASCII files on the Lowestoft format, either under **w:\acfm\afwg\<year>\data\smn_arct** or **w:\ifapdata\eximport\afwg\smn_arct**.

B.2. Biological

Since 1991, the catch in numbers at age of *S. mentella* from Russia is based on otolith readings. The Norwegian catch-at-age is based on otoliths back to 1990. Before 1990, when the Norwegian catches of *S. mentella* were smaller, Russian scale-based age-length keys were used to convert the Norwegian length distribution to age.

As input to trial analytical assessments, weight at age in the stock is assumed to be the same as weight at age in the catch.

A fixed natural mortality of 0.1 is used both in the assessment and the forecast.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

Age-based maturity ogives for *S. mentella* (sexes combined) are available for 1986–1993, 1995 and 1997–2001 from Russian research vessel observations in spring. Average ogives for 1966-1972 and 1975-1983 have been used for the periods 1965-1975 and 1976-1983, respectively. Average ogives for 1975-1983, 1984-1985 and data for 1986-1993 (Table D8) were used to generate a smoothed maturity ogive for 1984-1992 (3 year running average). The 1992-1993 average was used for 1993 and 1994, the 1995 data for 1995, the average for 1995 and 1997 for 1996, and the collected material for the subsequent years up to 2001 were taken as representative for these years.

B.3. Surveys

The results from the following research vessel survey series have annually been evaluated by the AFWG:

1) The international 0-group survey (since 2004 part of the Ecosystem survey) in the Svalbard and Barents Sea areas in August-September since 1980 (incl.).
2) Russian bottom trawl survey in the Svalbard and Barents Sea areas in October-December since 1978 (incl.) in fishing depths of 100–900 m.

3) Norwegian Svalbard (Division IIb) bottom trawl survey (August-September) since 1986 (incl.) in fishing depths of 100–500 m. Data disaggregated on age only since1992.

4) Norwegian Barents Sea bottom trawl survey (February) since 1986 (incl.) in fishing depths of 100–500 m. Data disaggregated on age only since 1992.

Although the Norwegian Svalbard (August-September) and Barents Sea (February) groundfish surveys are conducted at different times of the year and may overlap in the south of Bear Island area, the two series can be combined to get an approximate total estimate for the whole area.

1) 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 1996-2008 from less than 100 m to 800 m depth. This survey includes survey no. 3 above, and has been a joint survey with Russia since 2003, and since then called the Ecosystem survey.

2) Russian acoustic survey in April-May since 1992 (except 1994, 1996 and 2002-2004) on spawning grounds in the western Barents Sea .

The international 0-group fish survey carried out in the Barents Sea in August-September since 1965 does not distinguish between the species of redfish but it is believed to be mostly *S. mentella*. The survey design has improved and the indices earlier than 1980 are not directly comparable with subsequent years.

Russian acoustic surveys estimating the commercially sized and mature part of the *S. mentella* stock have been conducted in April-May on the Malangen, Kopytov, and Bear Island Banks since 1986. In 1992 the area covered was extended, and data on age are available for 1992–1993, 1995 and 1997–2001. This is the only survey targeting commercially sized *S. mentella*, but only a limited area of its distribution.

In order to investigate the distribution and abundance of pelagic *Sebastes mentella* in the Norwegian Sea the following surveys are/have been conducted:

i. Norwegian part of the international ecosystem survey in the Nordic Seas in spring 2007-2009 (PGNAPES).

ii. Norwegian trawl and acoustic survey in September 2007, and ICES coordinated international trawl and acoustic survey conducted by Norway, Russia and the Faroes in August 2008.

B.4. Commercial CPUE

Revised catch-per-hour-trawling data for the *S. mentella* fishery have been available from Russian PST- and BMRT-trawlers fishing in ICES Division IIa in March-May 1975-2002, representative for the directed Russian fishery accounting for 60-80% of the total Russian catch. The Working Group mean that the Russian trawl CPUE series do not represent the trend in stock size but is more a reflection of stock density. This is because the fishery on which these data are based since 1996 was carried out by one or two vessels on localised concentrations in the Kopytov area southwest of Bear Island. This is also reflected by the relative low effort at present. Due to this change in fishing behaviour/effort, CPUEs have been plotted only for the period after 1991.

B.5. Other relevant data

None

C. Historical Stock Development

Model used:

Software used:

Model Options chosen:

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1965-2008	6-19+	yes
Canum	Catch at age in numbers	1965-2008[1]	6-19+	yes
Weca	Weight at age in the commercial catch	1965-2008	6-19+	yes
West	Weight at age of the spawning stock at spawning time.	1965-2008	6-19+	yes
Mprop	Proportion of natural mortality before spawning	1965-2008	6-19+	Constant=0
Fprop	Proportion of fishing mortality before spawning	1965-2008	6-19+	Constant=0
Matprop	Proportion mature at age	1965-2008	6-19+	1965-1975, const. 1976-1983, const. 1984-2001,variable 2002-, const
Natmor	Natural mortality	1965-2008	6-19+	Constant=0.1

[1] Based on otoliths since 1991

Tuning data: files not updated since 2005, but data/results exist also for recent years

Type	Name	Year range	Age range
Tuning fleet 1	FLT10 Rus young	1991-2005	6-8
Tuning fleet 2	FLT13 Rus acous	1995-2001	6-14
Tuning fleet 3	FLT14 Norw bottom	1996-2005	2-11
….			

D. Short-Term Projection

Model used: Visual analysis of survey results.

Software used: none

Initial stock size:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Procedures used for splitting projected catches:

E. Medium-Term Projections

Model used: Visual analysis of survey results.

Software used: none

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Uncertainty models used:

1. Initial stock size:
2. Natural mortality:
3. Maturity:
4. F and M before spawning:
5. Weight at age in the stock:
6. Weight at age in the catch:
7. Exploitation pattern:
8. Intermediate year assumptions:
9. Stock recruitment model used:

F. Long-Term Projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

H. Other Issues

I. References

Annex 7 Quality Handbook ANNEX:afwg-smr

Stock specific documentation of standard assessment procedures used by ICES.

Stock:…	Golden redfish *Sebastes marinus* in ICES Subareas I and II
Working Group	Arctic Fisheries Working Group
Date:	06.05.2010

A. General

A.1. Stock definition

The stock of *Sebastes marinus* (golden redfish) in ICES Subareas I and II is found in the northeast Arctic from 62ºN in the south to north of Spitsbergen. The Barents Sea area is first of all a nursery areas, and relatively few fish are distributed outside Spitsbergen. *S. marinus* are distributed all over the continental shelf southwards to beyond 62ºN, and also along the coast and in the fjords. The main areas of larval extrusion are outside Vesterålen, on the Halten Bank area and on the banks outside Møre. The peak of larval extrusion takes place ca. one month later than *S. mentella*, i.e. during beginning of May. Genetic studies have not revealed any hybridisation with *S. marinus* or *S. viviparus* in the area.

A.2. Fishery

The fishery for *Sebastes marinus* (golden redfish) is mainly conducted by Norway which accounts for 80–90% of the total catch. Germany also has a long tradition of a trawl fishery for this species. The fish are caught mainly by trawl and gillnet, and to a lesser extent by longline and handline. The trawl and gillnet fishery have benefited from the females concentrating on the "spawning" grounds during spring. Some of the catches, and most of the catches taken by other countries, are taken in mixed fisheries together with saithe and cod. Important fishing grounds are the Møre area (Svinøy), Halten Bank, the banks outside Lofoten and Vesterålen, and Sleppen outside Finnmark. Traditionally, *S. marinus* has been the most popular and highest priced redfish species.

Until 1 January 2003 there were no regulations particular for the *S. marinus* fishery, and the regulations aimed at *S. mentella* had only marginal effects on the *S. marinus* stock. After this date, all directed trawl fishery for redfish (both *S. marinus* and *S. mentella*) is forbidden in the Norwegian Economic Zone north of 62°N. During 2003 and 2004, when fishing for other species it was legal to have up to 20% redfish (both species together) in round weight as bycatch per haul and on board at any time. Since 1 January 2005 this percentage has been reduced to 15%.

A minimum legal catch size of 32 cm has been set for all fisheries (since 14 April 2004), with the allowance to have up to 10% undersized (i.e., less than 32 cm) specimens of *S.marinus* (in numbers) per haul.

Until April 2004 there were no regulations of the other gears/fleets than trawl fishing for *S. marinus*. Since then, different limited moratoriums have been enforced in all fisheries except trawl and handline vessels less than 11 meters. The moratorium has been from 1-31 May in 2004, 20 April-19 June in 2005 and during April-May and September in 2006. Since 2007 the moratorium has been during 5 months, i.e., March-June and September. When fishing for other species (also during the moratorium) it is allowed for these fleets to have up to 15% (in 2004, 20%) bycatch of redfish (in round weight) summarized during a week fishery from Monday to Sunday.

Since 1 January 2006 it is forbidden to use gillnets with meshsize less than 120 mm when fishing for redfish.

Since 1 January 2006, the maximum bycatch of redfish (both *S. mentella and S. marinus*) juveniles in the international shrimp fisheries in the northeast Arctic has been reduced from ten to three redfish per 10 kg shrimp.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

The landings statistics used by the Arctic Fisheries Working Group (AFWG) are those officially reported to ICES. In cases where such reportings to ICES do not exist, reportings made directly to Norwegian authorities during the fishery have been used as preliminary figures. Norwegian commercial catch in tonnes by quarter, area and gear are derived from the sales notes statistics of The Directorate of Fisheries. Data from about 20 sub areas are aggregated for the gears gill net, long line, hand line, Danish seine and bottom trawl. For bottom trawl the quarterly area distribution of the catches is area adjusted by logbook data from The Directorate of Fisheries. No discards are reported or accounted for. Reliable estimates of species breakdown (*S. mentella* vs. *S. marinus*) by area are available back to 1989. The national landings of redfish for Norway and Russia are split into species by the respective national laboratories. For other countries (and areas) the AFWG has split the landings into *S. mentella* and *S. marinus* based on reports from different fleets to the Norwegian fisheries authorities.

The Norwegian sampling strategy is to have age-length samples from all major gears in each area and quarter. There are at present no defined criteria on how to allocate samples of catch numbers, mean length and mean weight at age to unsampled catches, but the following general process has been applied: First look for samples from a neighbouring area if the fishery extends to this area in the same quarter. If there are no samples available in neighbouring areas, search in neighbouring quarters, first from the same gear in the same area, and then from neighbouring areas and similar gears. The last option is to search for samples from other gears with the most similar selectivity in the same area or in neighbouring areas. For some gears, areas and quarters <u>length</u> samples taken by the coast guard are applied and combined with an ALK from a neighbouring area, gear or quarter. ALKs from research surveys (shrimp trawl) are also used to fill holes.

For Norway, weights at age in the catch are estimated according to the formula which gives the best fit to the length-weight data pairs collected during the year and applied to the mean length at age.

The text table below shows which country supplies which kind of data:

	Kind of data					
Country	Caton (catch in weight) on unidentified redfish	Caton (catch in weight) on *S. marinus*	Canum (catch at age in numbers)	Weca (weight at age in the catch)	Matprop (proportion mature by age)	Length composition in catch
Norway		x	x	x		x
Russia		x				x
Germany	x	x[2)]				x
United	x	[1)]				
Kingdom	x	[1)]				
France	x	[1)]				
Spain	x	[1)]				
Portugal	x	[1)]				
Ireland	x	[1)]				
Greenland						
Faroe Islands[1)]	x	[1)]				
Iceland						

[1)] As reported to Norwegian authorities during the fishery (only for the Norwegian Economic Zone and Svalbard)

[2)] Irregularly

The Norwegian and German input files are Excel spreadsheet files, while the Russian input data are supplied on paper and later punched into Excel spreadsheet files before aggregation to international data. The data should be found in the national laboratories and with the stock co-ordinator.

The national data have been aggregated to international data on Excel spreadsheet files. The Russian and German length composition has been applied on the Russian and German landings, respectively, using an age-length-key (ALK) and weight at age data from the Norwegian trawl landings. Catches from the other countries were assumed to have the same age composition and weight at age as the Norwegian trawl landings. In some years the final German and Russian numbers at age have been adjusted to remove SOP discrepancies before aggregation to international data. The Excel spreadsheet files used for age distribution, adjustments and aggregations can be found with the Norwegian stock co-ordinator and for the current and previous year in the ICES computer system under **w:\acfm\afwg\<year>\personal\name** (of stock co-ordinator).

The result files (FAD data) can be found at ICES and with the stock co-ordinator, either in the IFAP system as SAS datasets or as ASCII files on the Lowestoft format, either under **w:\acfm\afwg\<year>\data\smr-arct** or **w:\ifapdata\eximport\afwg\smr-arct**.

B.2. Biological

The total catch-at-age data back to 1991 are based on Norwegian otolith readings. In 1989–1990 it was a combination of the German scale readings on the German catches, and Norwegian otolith readings for the rest. In 1984–1989 only German scale readings were available, while in the years prior to 1984 Russian scale readings exist.

Weight at age in the stock is assumed to be the same as weight at age in the catch.

When an analytical assessment is made, a fixed natural mortality of 0.1 is used both in the assessment and the forecast.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

A knife-edge maturity at age 15 (age 15 as 100% mature) has been used for this stock. Since 2006 a maturity ogive has been modelled and estimated by the GADGET model.

B.3. Surveys

The results from the following research vessel survey series have annually been evaluated by the Working Group:

1) Norwegian Barents Sea bottom trawl survey (February) from 1986–2009 in fishing depths of 100–500 m. Data are available on length for the years 1986–2009, and on age for the years 1992–2008. This survey covers important nursery areas for the stock
2) Norwegian Svalbard (Division IIb) bottom trawl survey (August-September) from 1985–2008 in fishing depths of 100–500 m. This survey covers the northernmost part of the species' distribution.
3) Data on length and age from both these surveys have been simply added together and used in the assessments.
4) Catch rates (numbers/nautical mile) and acoustic indices of *Sebastes marinus* from the Norwegian Coastal and Fjord survey in 1995-2008 from Finnmark to Møre. Since 2003, only catch rates are available.

B.4. Commercial CPUE

The former (until 2002) CPUE-series for *S. marinus* from Norwegian 32-50 meter freezer trawlers has been improved (e.g., analysing the trawl data with regards to vessel length instead of vessel tonnage) and presented from 1992 onwards. Only data from days with more than 10% *S. marinus* in the catches (in weight) were included in the annual averages together with data on vessel days (i.e., effort) meeting the 10% criterion.

B.5. Other relevant data

None.

C. Historical Stock Development

The development of the stock has annually been discussed and evaluated based on the research survey series, and information from the fishery.

In some years trial analytical XSA assessments have been made and discussed by the Working Group.

Since WG2005, experimental analytical assessments have been conducted on this stock using GADGET, and results presented for the years 1990 – last year.

The GADGET model used for the assessment of *S. marinus* in areas I and II is closely related to the GADGET model that currently is used by the ICES North-Western WG on *S. marinus* (Björnsson and Sigurdsson 2003). The functioning of a Gadget model, including parameter estimation, is described in Bogstad et al. (2004). The model used on this stock was for the first time presented to ACFM in 2005. The method was more thoroughly reviewed and described in AFWG report 2006. The main model period has been considered to be from 1990, with earlier years acting as a lead-in period to the model. *S. marinus* has been modelled with a single-species, single-area model, with mature and immature fish considered as two population groups. The fish were modelled in 1cm length categories. The age and length ranges were defined as 3-30+ and 1-59+ cm, respectively.

S. marinus was considered to have Von Bertanlanffy growth (Nedreaas 1990) with parameters estimated within the model. The length-weight relationship w=0.000015*l^3.0 (where w is in kilogram and l in cm) was used and kept constant between seasons and years. There has been no cannibalism or modelled predation – mortality has been exclusively due to fishing and residual natural mortality was set initially at 0.1. Recruitment was handled as a number of recruits estimated per year, and no attempt at closure of the life cycle was attempted. Maturity is explicitly modelled, allowing for a direct estimate of the spawning stock. Estimated parameters were: an L50 and slope parameters for the fleets, two growth parameters, annual recruitment, four parameters governing commercial selectivity (two per fleet), several parameters per survey governing selectivity (two per fleet), initial population numbers for mature and immature fish by age.

Data used for tuning are:

- Quarterly length distribution of the landings from two commercial fishing fleets
- Quarterly age-length keys from the same fishing fleets
- Length disaggregated survey indices from the Barents Sea (Division IIa) bottom trawl survey (February) from 1990–2009 (Table D12a).
- Age-length keys from the same survey (Table D12b).
- Length disaggregated catch rates (numbers/nautical mile) of *Sebastes marinus* from the Norwegian Coastal and Fjord survey in 1995-2008 from Finnmark to Møre (Division IIa)

The fishing was handled as two main, and two subsidiary fleets. The Norwegian trawl- and gillnet fleets were both fully modelled, with estimated selectivity for each, accounting for about 70-80% of the total catch in tonnes. The amount fished in each time step of one quarter of the year was input from catch data as a fixed amount. No account of possible errors in the catch-in-tons data was made. Two additional fleets have been considered; the international trawl fleet and a fleet made up by combining all other minor Norwegian fishing methods. Both these fleets have quarterly catch-in-tons specified, and have used the same selectivity as the Norwegian trawl fleet. In addition to catch-in-tons, quarterly catch-in-numbers-at-length and age-length keys have been used. The format of the selectivity (L50) was selected and assumed to remain constant over time for each fleet.

The Barents Sea survey data were used as age-length keys giving the distribution within a single year, and as a purely length based survey index giving year to year variations in numbers by length. Prior to 1992 only length and weight data were recorded; after that data on annual age readings (and hence age-length data) are also available. The time period 1990-2006 was used, and the age-length key for 1992 was also used as age-length key for 1990-1991.

D. Short-Term Projection

Model used: Visual inspection/analysis of survey results together with information from the fishery and Gadget model outputs. No analytical short-term projection has been made for this stock.

E. Medium-Term Projections

Model used: Visual inspection/analysis of survey results together with information from the fishery and Gadget model outputs. No analytical short-term projection has been made for this stock.

Uncertainty models used: None

F. Long-Term Projections

Not done

G. Biological Reference Points

Until an analytical assessment can be accepted and used as basis for reference points calculations for this stock, candidate reference points for the biomass could be set at the average biomass level, or at a certain percentage of this level, estimated by the Russian and Norwegian trawl surveys since 1986. ACFM is supporting this suggestions and states that U-type reference points could be developed provided that a sufficient long time series demonstrating a dynamic range is available. Also the reference point should be expressed in biomass units (SSB or fishable stock), and work has hence been initiated to present the survey time series also in biomass units (also as SSB and fishable stock).

A maximum exploitation rate of 5% has been suggested sustainable for long lived species like *Sebastes* spp. when the stocks show no sign of reduced reproductive potential (ref. pelagic redfish in the Irminger Sea and for several rockfishes in the Pacific). Based on the selection curves for the fleets, a reasonable classification of the fishable biomass would be the mature biomass. A corresponding 5% harvest of this would yield not more than 2.500 tonnes.

F. References

Björnsson, H., and Sigurdsson, T. 2003. Assessment of golden redfish (*Sebastes marinus* L.) in Icelandic waters. Scienta Marina 67 (Suppl. 1):301-314.

Bogstad, B., Howell, D., and Åsnes, M. N. 2004. A closed life-cycle model for Northeast Arctic Cod. ICES C.M.2004/K:26, 26 pp.Björnsson and Sigurdsson 2003

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Annex 8 Quality Handbook ANNEX:_afwg-ghl-arct

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	North-East Arctic Greenland Halibut
Working Group:	Arctic Fisheries Working Group
Date:	27-04-09

A. General

A.1 Stock definition

Greenland halibut (*Reinhardtius hippoglossoides,* Walbaum) is distributed in the Arctic and boreal waters in the North Atlantic and in the North Pacific (Fedorov 1971; Godø and Haug 1989; Bowering and Brodie 1995; Bowering and Nedreaas 2000). In the northeastern Atlantic the distribution is more or less continuous along the continental slope from the Faeroe Islands and Shetland to north of Spitsbergen (Whitehead *et al*. 1986; Godø and Haug 1989), with the highest concentrations from 500 to 800 m depth between Norway and Bear Island, which is also regarded as the main spawning area (Godø and Haug 1987; Albert *et al*. 2001b). Peak spawning occurs in December in the main spawning area, but also in nearby localities during summer (Albert *et al*. 2001b). Atlantic currents transport eggs and larvae northwards and the juveniles are distributed around Svalbard and in the northeastern Barents Sea, to the waters around Franz Josef Land and Novaja Zemlya area (Godø and Haug 1987; Godø and Haug 1989; Albert *et al*. 2001a). As they grow older they gradually move southwards and eventually alternate between the spawning area and feeding areas in the central-western Barents Sea (Nizovtsev, 1989).

The Northeast arctic Greenland halibut stock is a pragmatically defined management unit. The degree of exchange with other stocks is not resolved, but is believed to be low. Potential routes of exchange may be drift of larvae towards Greenland and migration of adults between the Barents Sea and the Iceland-Faeroe Islands area.

A.2 Fishery

Before the mid 1960s the fishery for Greenland halibut was mainly a coastal long line fishery off the coasts of eastern Finnmark and Vesterålen in Norway. The annual catch of the coastal fishery was about 3,000 t. In recent years this fishery has landed 3,000–6,000 t although now gillnets are also used in the fishery. In 1964 dense Greenland halibut concentrations were found by Soviet trawlers in the slope area to the west of the Bear Island (Nizovtsev, 1989). Following the introduction of international trawlers in the fishery in the mid 1960s, the total landings increased to about 80,000 t in the early 1970s.The total Greenland halibut landings decreased steadily to about 20,000 t during the early 1980s. This level was maintained until 1991, when the catch increased sharply to 33,000 t. From 1992 total landings varied between 9 000-19 000 t with a peak in 1999.

From 1992 the fishery has been regulated by allowing only the long line and gillnet fisheries by vessels smaller than 28 m to be directed for Greenland halibut. This fishery is also regulated by seasonal closure. Target trawl fishery has been prohibited and trawl catches are limited to bycatch only. From 1992 to autumn 1994 bycatch in each haul was not to exceed 10% by weight. In autumn 1994 this was changed to 5% bycatch of Greenland halibut onboard at any time. In autumn 1996 it was changed to 5% bycatch in each haul, and from January 1999 this percentage was increased to 10%. In August 1999 it was adjusted further to 10% in each haul but only 5% of the landed catch. From 2001 the bycatch regulations again was changed to 12% in each haul and 7% of the landed catch.

The regulations enforced in 1992 reduced the total landings of Greenland halibut by trawlers from 20,000 to about 6,000 t. Since then and until 1998 annual trawler landings have varied between 5,000 and 8,000 t without any clear trend attributable to changes in allowable bycatch. However, the increase of trawler landings in 1999 to 10 000 t may be attributable partly to the less restrictive bycatch regulations. Landings of Greenland halibut from the directed longline and gillnet fisheries have also increased in recent years to well above the level of 2,500 t set by the Norwegian authorities. This is attributed to the increased difficulties of regulating a fishery that only lasts for a few weeks.

A.3 Ecosystem aspects

As investigations show, among the variety of fish, seabirds and marine mammals Greenland halibut were found in the diet of just three species - Greenland shark (*Somniosus microcephalus*), cod (*Gadus morhua morhua*) and Greenland halibut itself. Besides, killer whale (*Orcinus orca*), grey seal (*Halichoerus grypus*) and narwhal (*Monodon monoceros*) could be its potential predators. However, the presence of Greenland halibut in the diet of the above species was minor. Predators fed mainly on juvenile Greenland halibut up to 30-40 cm long.

The mean annual percentage of Greenland halibut in cod diet in 1984-1999 constituted 0,01-0,35% by weight (0,05% in average) (DOLGOV & SMIRNOV 2001). Low levels of consumption are related to the distribution pattern of juvenile Greenland halibut as they spend the first years of the life mainly in the outlying areas of their distribution, in the northern Barents Sea, where both adult Greenland halibut and other abundant predator species are virtually absent.

Cannibalism was the highest in 1960's (up to 1,2% by frequency of occurrence). During the 1980's, in the Greenland halibut stomachs the frequency of occurrence of their own juveniles did not exceed 0,1 %. During the 1990's, the portion of their own juveniles (by weight) was at the level of 0,6-1,3%.

Food composition of the Greenland halibut in the Barents Sea includes more than 40 prey species (NIZOVTSEV 1989; DOLGOV & SMIRNOV 2001). Investigations over a wide area of the continental slope up to the Novaya Zemlya show that the main food source of Greenland halibut consists of fish, mostly capelin (*Mallotus villosus villosus*) and polar cod (*Boreogadus saida*) followed by cephalopods and shrimp (*Pandalus borealis*). During the 1990's an important component of the diet was waste products from fisheries for other species (heads, guts etc.). With growth, a decrease in the importance of small food items (shrimp, capelin) in Greenland halibut diet and the increase of a portion of large fish such as cod and haddock (*Melanogrammus aeglefinus*) were observed.

With the Greenland halibut stock being nearly 100 000 tonnes, the total food consumption of the population is estimated to be about 280 000 tonnes. The biomass of commercial species consumed (shrimp, capelin, herring, polar cod, cod, haddock, redfish (*Sebastes sp.*), long rough dab (*Hippoglossoides platessoides*) does not exceed 5 000-10 000 tonnes per species (DOLGOV & SMIRNOV 2001).

The Greenland halibut as a species thus has a negligible effect on the other commercial species in the Barents Sea both as predator and prey.

Greenland halibut occurs over a wide range of depths (from 20 to 2200 m) and temperatures (from -1.5 to 10º C) (BOJE & HAREIDE, 1993; SHUNTOV, 1965; NIZOVTSEV, 1989). Young Greenland halibut occur mostly in the northeastern Barents Sea (Spitsbergen archipelago and further east to Franz Josef Land) where the presence adult Greenland halibut or other predators appears minimal. Therefore, Greenland halibut mortality after settling in the area is low and stable and driven mainly by envionmental factors.

B. Data

B.1 Commercial catch

Norwegian commercial catch in tonnes by quarter, area and gear are derived from the sales notes statistics of the Directorate of Fisheries. Data from about 20 sub areas are aggregated on 6 main areas for the gears gill net, long line, bottom trawl and shrimp trawl. For bottom trawl the quarterly area distribution of the catches is adjusted by logbook data from The Directorate of Fisheries and the total bottom trawl catch by quarter and area is adjusted so that the total annual catch for all gears is the same as the official total catch reported to ICES. No discards are reported or accounted for in the catch statistics.

Russian catch based on daily reports from the vessels are combined in the statistics of the All-Russian Research Institute of Fisheries and Oceanography (VNIRO, Moscow). Data are provided separately by ICES areas and gears.

The sampling strategy is to have age-length samples from all major gears in each area and quarter. There are at present no defined criteria on how to allocate samples of catch numbers, mean length and mean weight at age to unsampled catches, but the following general process has been applied: First look for samples from a neighbouring area if the fishery extends to this area in the same quarter. If there are no samples available in neighbouring areas, search for samples from other gears with the most similar selectivity in the same area or in neighbouring areas. The last option is to search in neighbouring quarters, first from the same gear in the same area, and then from neighbouring areas and similar gears. ALKs from research surveys (shrimp trawl) are also used to fill gaps in age sampling data.

Norway and Russia, on average, have accounted for about 90-95% of the Greenland halibut landings during more recent years. Data on catch in tonnes from other countries are either taken from ICES official statistics (by ICES area) or from reports to Norwegian authorities. A few countries also supply some additional data. The text table below indicates the type of data provided by country:

	Kind of data				
Country	**Caton (catch in weight)**	**Canum (catch at age in numbers)**	**Weca (weight at age in the catch)**	**Matprop (proportion mature by age)**	**Length composition in catch**
Norway	x	x	x		x
Russia	x	x	x	x	x
Germany	x				
United	x				
Kingdom	x				
France[1]	x				
Spain[1]	x				
Portugal[1]	x				
Ireland[1]	x				
Greenland[1]	x				
Faroe Islands[1]	x				
Iceland[1]	x				
Poland[1]	x				

[1] As reported to Norwegian authorities

The Norwegian and Russian input files are Excel spreadsheet files before aggregation to international data. The data are archived in the national laboratories and with the Norwegian stock co-ordinator.

The national data have been aggregated with international data on Excel spreadsheet files. The Russian and Norwegian catch-at-age data based on national landings, length composition of catches, age-length-keys (ALK) and weight at age data. Catches from the other countries were assumed to have the same age composition and weight at age as the Norwegian landings. From 2006 Norway stopped to determine the age using the traditional method. Since than the common catch-at-age files constructed on the base of the Russian ALK and weight at age data.

The Excel spreadsheet files used for age distribution, adjustments and aggregations are held by the Norwegian stock co-ordinator and for the current and previous year in the ICES computer system under **w:\acfm\afwg\year\personal\name** (of stock co-ordinator).

The result files (FAD data) can be found at ICES and with the stock co-ordinator, either in the IFAP system as SAS datasets or as ASCII files on the Lowestoft format, under **w:\acom\afwg\year\data\ghl_arct**.

B.2 Biological

For 1964-1969, separate weight at age data are used for the Norwegian and the Russian catches. Both data sets are mean values for the period and are combined as a weighted average for each year. A constant set of weight-at-age data is used for the total catches in 1970–1978. For subsequent years annual estimates are used. The mean weight at age in the catch is calculated as a weighted average of the weight in the catch from Norway and Russia. The weight at age in the stock is set equal to the weight at age in the catch for all years.

A fixed natural mortality of 0.15 is used both in the assessment and the forecast.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

Annual ogives based on sexes combined using Russian survey data are given for the years 1984–1990 and 1992–last data year. An average ogive derived from 1984–1987 is used for 1964–1983. For 1984 to the last data year a three-year running average is used.

B.3 Surveys

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

1. Norwegian bottom trawl survey in August in the Barents Sea and Svalbard from 1984 in fishing depths of less than 100 m and down to 500 m. (Table E1 and E2).
2. Norwegian Greenland halibut surveys in August from 1994. The surveys cover the continental slope from 68 to 80ºN, in depths of 400–1500 m north of 70º30'N, and 400–1000 m south of this latitude. This series has in 2000 been revised to also include depths between 400 – 500 m in all years (Table E3).
3. Norwegian bottom trawl surveys east and north of Svalbard in autumn from 1996 (Table E4).
4. The Norwegian Combined Survey index Table E5, combination of the results from Tables E1-E4.
5. Russian bottom trawl surveys in the Barents Sea from 1984 in fishing depths of 100–900 m. This series has been revised substantially since the 1998 assessment in order to make the years more comparable with respect to area coverage and gear type (Table E6).
6. Spanish bottom trawl survey in the slope of Svalbard area in October, ICES Division IIb: from 1997 (Table E7).
7. Norwegian (from 2000 Joint) Barents Sea bottom trawl survey (winter) from 1989 in fishing depths of less than 100 m and down to 500 m. In order to utilise the last year values in the VPA calibration, this series was adjusted back by one year and one age group to reflect sampling as if it occurred in the autumn of the previous year (Table E8).
8. International pelagic 0-group surveys from 1970. (Table 1.1).

Over the last several years the Working Group has been concerned about trends in catchability within individual surveys used for tuning of the XSA. The trends were seen for younger ages of year classes in the late 80's and early 90's that were initially estimated to be very low in abundance. With increasing age these year classes were estimated to be much closer to the mean abundance. In previous meetings the Working Group therefore increased the lower age used in tuning to five years in order to reduce the problem. This only partly resolved the problem though, and in all subsequent assessments estimated recruitment of the last 2-3 years has increased from one year to the next.

The Norwegian bottom trawl survey in the Barents Sea and Svalbard catch Greenland halibut mainly in the range of ages 1–8, although in most years age 1 is poorly represented and all age group younger than five years are not considered to be well represented in this survey due to the limited depth range covered. The relative strength of the year classes varies considerably with age. In more recent years there has been low but somewhat better representation of young fish in this survey.

The Norwegian juvenile Greenland halibut survey north and east of Svalbard were started in 1996 and from 2000 this survey is conducted as a joint survey between Norway and Russia. As a result it is expected that the area coverage will improve, better representing the distribution of juveniles and will provide a more comparable time series. Only the Norwegian part of these northern surveys is currently included in the Norwegian Combined Survey index (see below) . In future, when the extended coverage in the Russian zone has been repeated for at least five years the Working Group will consider revising the combined index.

The Norwegian Greenland halibut survey along the deep continental slope south and west of Spitsbergen began in 1994. Although Greenland halibut older than 15 years are caught, few fish are represented in the catch over age 12 or less than age 5 (Table E4). Most of the abundance indices are dominated by ages 5–8.

Most of the surveys considered by the Working Group in 2002 cover either the adult population in the slope area or juvenile distribution in northern areas. The problem of underestimation of recruitment in the last few years included in the analyses has been attributed to shortcomings in survey coverage. The Working Group at previous meetings has noted the need for annual surveys that sample most of the population within a short period of time. Prior to the 2002 WG meeting effort was therefore made to combine some of these surveys into a new total index. The new index is termed the Norwegian Combined Survey Index and is established back to 1996, the first year with survey coverage northeast of Svalbard. It includes bottom trawls from the Norwegian bottom trawl survey in August in the Barents Sea and Svalbard (Tables E1 and E2), the Norwegian Greenland halibut survey in August along the continental slope (Table E3), and the Norwegian bottom trawl survey in August-September north and east of Svalbard (Table E4). Prior to the meeting in 2003 work was done to evaluate the combination of these survey series into one index and this was reported in Working Document 5 to the Working Group. Based on these results it was decided to use this combined index in this years assessment.

The Norwegian Combined Survey Index (Table E5) indicates a significant increase in the total stock during the last three years and a stock size in 2002, nearly 40% above last years index. However, there is no clear year class pattern in the data and some ages are consistently underestimated relative to adjacent age groups (e.g. age 9 and partly age 4). The highest indices were observed for age seven, with exception of the two last years when age 1 was most abundant. That indicates that the catchability of younger ages (i.e. those primarily from northern surveys) are not comparable with the older ones (i.e. those primarily from the slope). This is probably a result of pooling different surveys using different gears. These weaknesses reduce the applicability of the combined surveys, and the Working Group advises that further work be done to improve the combined index in the future.

The Russian Barents Sea bottom trawl survey, which extends back to 1984 catch fish mainly in the range of 4–10 years old. The relative abundance of the year classes against age is similar to the surveys above. This survey covers the Barents Sea including the continental slope of the Norwegian Sea. Total abundance indices from this survey show trend to grow since 1996.

The Spanish bottom trawl surveys along the continental slope north of 73°30′ N from 1997 (Table E7) differ from the other survey series indicating reduced abundance in this area since 1999.

The Norwegian bottom trawl survey during winter in the Barents Sea catch Greenland halibut older than 12 years, but are not particularly effective in catching fish older than 7 years. This is likely due to the limited depth distribution of the survey area. Nevertheless, the survey appears very effective at catching Greenland halibut up to age 6. The relative abundance of the year classes against age is comparable with the survey above.

The strengths of the Greenland halibut year classes of 1970–1997 from the International pelagic 0-group surveys in the Barents Sea are shown in Table 1.1. The results are highly variable over the time period. However, most of the 1970's and 1980's year classes are represented in reasonably high numbers. In recent years the 1988–1992 and the 1996 year classes have been well below the long term average. The 1993–1995 and 1997-1999 year classes are closer to the average. Significant increase of 0-group abundance indices with compare to previous years was observed in 2000-2002. Than the increase in 0-group abundance seems to have stopped, and the 2007-2008 indices were very low. It should be noted that the Ecosystem survey is not optimal for surveying 0-group Greenland halibut.

All in all, the surveys seem to indicate that the catchability of the 1990–1995 year classes increased considerably as the fish becomes five years and older. Based on extremely low catch rates in the surveys, these year classes were considered very poor in previous assessments by the Working Group, but improved considerably at older ages. The reason for this change in catchability is not clear. However, it is known that important areas for young Greenland halibut may be found north and east of Svalbard (Table E4). (Albert *et al*. 2001a) showed that the south-western end of the distribution area of age 1 fish was gradually displaced northwards along west Spitsbergen in the period 1989–92 and southwards in the period 1994–1996. These displacements corresponded to changes in hydrography and may be explained by increased migration of the 1990–1995 year classes to areas outside the survey area.

Since 2006, none of the age structured tables of the Norwegian surveys have been updated due to change in age reading procedure.

B.4 Commercial CPUE

The restrictive regulations imposed on the trawl fishery after 1991 disrupted the traditional time series of commercial CPUE data. However, an attempt to continue the series was made through a research program using two Norwegian trawlers in a limited commercial fishery (Tables 8.6 and E9). This comprises fishing during two weeks in May-June and October, representing an effort somewhat less than 20% of the 1991 level. Since 1994 the fishery has been restricted to May-June. This fishery was conducted, as much as possible, in the same way as the commercial fishery in the previous years. The Norwegian CPUE survey was stopped from 2005. This was one of the tuning fleets, but an evaluation of this survey revealed a lot of inconsistencies in the series.

Since 1997 also two Russian trawlers conducted a limited research fishery for Greenland halibut.

The CPUE from the experimental fishery was found, however, to be considerably higher than in the traditional fishery and has exhibited an increasing trend from 1992–1996. After 1996 the Norwegian CPUE series has varied between 1200 and 1650 kg/h with the highest value in 2000 (Table E9). The Russian experimental CPUE series shows an increasing trend since 1997, and this series also shows the highest value in 2000.

B.5 Other relevant data

None

C. Historical stock development

Model used: XSA

Software used: IFAP / Lowestoft VPA suite

Model Options chosen:

Tapered time weighting applied, power = 3 over 20 years

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 10

Survivor estimates shrunk towards the mean F of the final 2 years or the 5 oldest ages

S.E. of the mean to which the estimate are shrunk = 0.500

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1964 – last data year	- (total)	Yes
Canum	Catch at age in numbers	1964 – last data year	5 – 15+	Yes
Weca	Weight at age in the commercial catch	1964 – last data year	5 – 15+	Yes/No - constant at age from 1964 - 1978
West	Weight at age of the spawning stock at spawning time.	1964 – last data year	5 – 15+	Yes/No - assumed to be the same as weight at age in the catch
Mprop	Proportion of natural mortality before spawning	1964 – last data year	5 – 15+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1964 – last data year	5 – 15+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1964 – last data year	5 – 15+	Yes/No – three year running mean, constant at age from 1964 - 1983
Natmor	Natural mortality	1964 – last data year	5 – 15+	No – set to 0.15 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Norwegian Combined survey index	1996 – last data year	5 – 15+
Tuning fleet 2	Norwegian experimental CPUE	1992 – last data year	5 - 14
Tuning fleet 3	Russian trawl survey from 1992	1992 – last data year	5 – 15+

D. Short-term projection

Model used: Age structured

Software used: IFAP prediction with management option table and yield per recruit routines

Initial stock size. Taken from the XSA for age 6 and older. The recruitment at age 5 in the last data year is estimated using the mean from 1990 to two years before the last data year following the argument that recruitment at age 5 shows a sharp reduction in the most recent years in the previous assessments, which is not believed to reflect the true recruitment.

Natural mortality: Set to 0.15 for all ages in all years

Maturity: The same ogive as in the assessment is used for all years

F and M before spawning: Set to 0 for all ages in all years

Weight at age in the stock: Average weight at age for the last three years used in the assessment

Weight at age in the catch: Average weight at age for the last three years used in the assessment

Exploitation pattern: Average of the three last years

Intermediate year assumptions: Catch constraint

Stock recruitment model used: Constant recruitment as described earlier

Procedures used for splitting projected catches: Not relevant

E. Medium-term projections

Not done

F. Long-term projections

Not done

G. Biological reference points

No limit or precautionary reference points for the fishing mortality or the spawning stock biomass are proposed.

Other issues

None

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Annex 9: Barents Sea capelin Stock

Introduction

The present (2009) methodology for Barents Sea capelin, which has remained the same since 2003 was evaluated during the ICES benchmark workshop WKSHORT in Bergen 31 August - 4 September 2009 (ICES, 2009b). Although the method was endorsed, the written documentation provided by the Stock Annex made at the meeting was not accepted, as it was found incomplete. The present document is a rewrite of the WKSHORT Stock Annex, where the essential elements in the methodol- ogy are made clearer, and model assumptions are motivated.

The 2003 methodology was established in an era with less demand for rigid documentation at the level where people com- pletely unfamiliar with either the ecosystem or the essential methodological elements shall be able to understand and repeat the analyses. After 2003, modelling work has concentrated on bringing the management of capelin more firmly into an ecosystem context, and developing methodology for long-term simulations needed to test harvest control rules, with little or no emphasis on documenting the 2003 methodology.

A comprehensive Stock Annex is needed not only for a full ICES endorsement and for meeting the demands on transparency of ICES methodology, but is also needed for facilitating technology transfer in PINRO and IMR. The present version of the underlying model Bifrost provides for consumption of capelin by cod the year around. However, in the context of the present Stock Annex, only consumption during January-March is modelled, in compliance with the management methodology applied since 2003.

Models used

Unlike most other stocks, the management of capelin is founded on one survey, which is considered giving an absolute measurement of the stock, no model to reconstruct history is needed. Also, the precautionary approach is implemented by carrying out simulations with uncertainty, so a precautionary reference point is not needed, only a limit reference point.The Barents Sea capelin assessment is based on the use of two different models. CapTool is an Excel spreadsheet from which the catch quota corresponding to the harvest control rule is calculated using stochastic prognostic simulation from the time of measurement (October 1) to the time of spawning (April 1 the following year). Bifrost is a model which is used to estimate parameters in the two main biological processes behind the simulations: maturation and predation by cod. The relation between the two models is shown in figure 1.

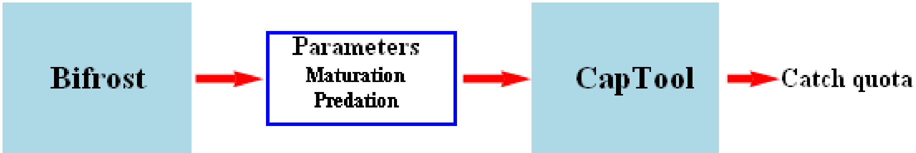


Figure 1. Relation between the models Bifrost and CapTool.

Unlike most other stocks, for which the entire population dynamics is represented by one subjectively chosen parameter (M), the assessment of the Barents Sea capelin rests on a quantitative description of the essential parts of the population dynamics of the stock. Therefore, the Stock Annex gets somewhat more involved in the model description part than most other stocks. Even though the management of Barents Sea capelin is a strictly single species management, it rests on a multispecies model and as such is a small step into an ecosystem based approach to management of the Barents Sea species.

A. General

A.1. Stock definition

Capelin in the Barents Sea spawn in March-April in shallow water off the northern coasts of Norway and Russia (Gjøsæter

1998). The juveniles are transported to the central and eastern parts of the Barents Sea where they grow. The capelin matures and spawns at age 3-5. In recent years, the number spawning at age 5 has been negligible, but during the 1970s spawning capelin of age 5 or even age 6 was not uncommon. The capelin die after spawning (Christiansen et al 2008).The capelin undertakes extensive feeding migration during the summer into the northern and eastern parts of the Barents Sea.

A.2. Fishery

Some fishing for Barents Sea capelin has taken place for centuries. The fishery intensified during the early 1960s, when a Norwegian purse seine fishery started (Gjøsæter 1998). It soon became a large-scale fishery, and was followed by a Russian fishery conducted mainly with pelagic trawl. The fishery took place from January to March on schools of prespawning capelin on or close to the spawning grounds. In the 1970s and early 1980s a fishery also took place on the feeding grounds in the central and northern Barents Sea during August to October. In recent years, this summer and autumn fishery has been banned (ICES, 2009a). The winter fishery has also been banned during periods when the capelin stock was at a low level. This has happened three times, in the mid 1980s, in the mid 1990s and in the early 2000s. During each of these periods the fishery was stopped for 5 years.

In recent years, the fishery has changed from being mostly an industrial fishery to being mostly for human consumption. This is partly because of low TACs, but also because new markets for frozen capelin for human consumption have developed. In the present fishing period a substantial part of the catch has been delivered for meal and oil production, driven by demands from the aquaculture industry. In the future, the part of the capelin catch delivered for meal and oil production will be associated to the international market for fish meal and fish oil. The Russian part of the catch is delivered exclusively to human consumption.

A.3. Ecosystem aspects

A.3.1. Predators

The capelin plays a key role in the marine ecosystem and is by far the most important pelagic fish stock in the Barents Sea. They are the main diet of Northeast arctic cod (Mehl and Yaragina, 1992, Gjøsæter et al 2009). Juvenile herring may feed intensively on capelin larvae (Hallfredsson and Pedersen, 2009). They are prey to several species of marine mammals, e.g. harp seals, humpback whales, minke whales, and seabirds, kittiwakes and guillemots. They are also important food for several other commercial species (Dolgov, 2002).

The main impact on capelin from predators is the consumption by cod, which has expanded its area northwards the latest year, thereby increasing the predation also on immature capelin. Harp seals may also have a significant impact on capelin. There are less data, however, to evaluate the impact of harp seals on capelin.

B. Data

B.1. Commercial catch

B.1.1 Landings

B.1.1.1 Norwegian landings

Most of the Norwegian catch is taken by purse seiners, constituting about half of the vessels in numbers and taking about

75% of the catch. The rest of the catch is taken by smaller coastal vessels, about half of which operating by trawl and half by purse seie. The Norwegian catch in numbers by age and length (larger and smaller than 14 cm) and by ICES areas is calcu- lated by the program FangstFisk using an Excel file of catch in tonnes by month and geographical location from the Direc- torate of Fisheries and a file of biological samples from the fishery in the format SPD. The result is stored on Excel files lo<4-digit year>.xls, from which the catch in numbers and biomass by age and maturation group (divided at 14 cm) are transferred to the Excel file CapCatch, which is used by Bifrost.

B.1.1.2 Russian landings

The Russian catch is taken by trawl.The Russian catch in number and age by length and the division in tonnes on months are reported to the WG. From these data the catch in numbers and biomass by age and maturation group are transferred to CapCatch.

B.1.1.3 Use of catch data in the assessment

The catch data influence the population dynamics parameters transferred from Bifrost to CapTool, but not the current assessment.

Formally, the historic simulation during January-March is made for an age-disaggregated stock. However, the predation mortality is assumed equal for all age groups and the food abundance for cod is expressed as biomass of capelin. Thus, the age distribution of the catch does not influence the estimated predation parameters. Uncertainty in catch is not taken into account.

The uncertainty in catch in tonnes by month connected to registration of catch and biological sampling is not known, but considered to be small and the uncertainty in the catch will then have a small influence on the uncertainty in the estimated predation parameters.

In the fishery some capelin may be killed in the catch operation. The magnitude of this is not known, but considered to be larger in the trawl fishery than in the purse seine fishery.

B.1.2 Discards

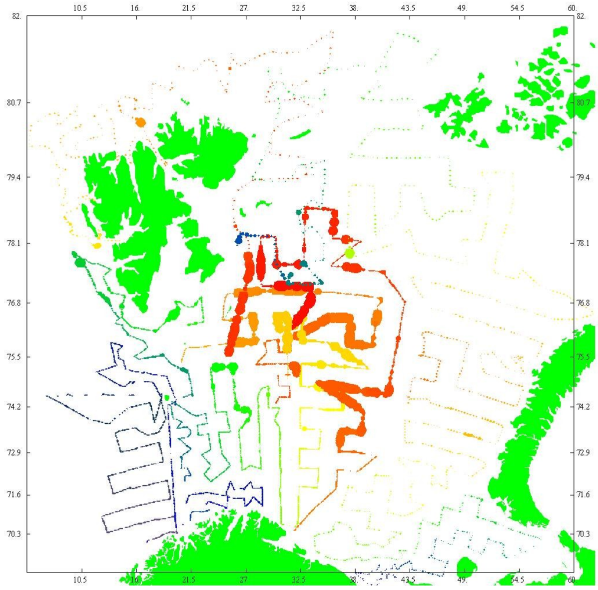
Discarding is considered negligible for this stock

B.2. Biological data

No biological data are used other than those used for converting commercial catch in tonnes to catch in numbers by age and length and the data used in the September survey to calculate the number of capelin by age and length.

B.3. Surveys

One survey is used in the assessment of the Barents Sea capelin stock: a joint Russian-Norwegian trawl-acoustic survey in September, which started in 1972 and is conducted annually. The abundance estimate from this survey is considered an absolute estimate of the stock. Figure B.1 shows the tracks of the 2007 and 2010 surveys. Each nautical mile of Sa data (for the Russian vessel in the east, each 5 nmi) is represented by a filled circle, the radius of which being proportional to the Sa value, with a maximum of 500. The colour denotes the time referred to the start of the survey, with violet at the start and red at the end.



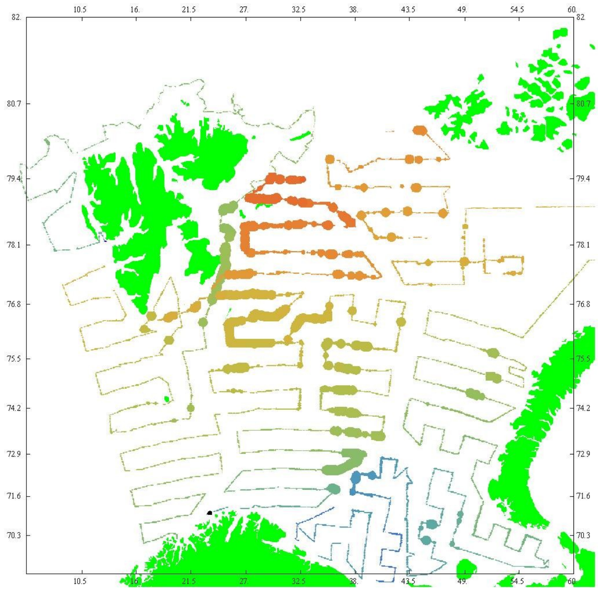


Figure B.1. Survey tracks in 2007 (upper panel) and 2010 (lower panel). Explanations in the text.

Synopticity can be an issue at this survey, where a large area is covered by several vessels that for practical reasons not always can work simultaneously. This is evidently a problem in the 2007 survey, and much less of a problem in the 2010 survey. Migration during the survey will introduce an uncertainty in the estimate that cannot be accounted for. This seems to have been a problem in 2007, as vessels recording nearby registrations at different time encountered different densities of capelin.

In designing the surveys, the 2010 survey might be the model survey, and designs as that of 2007 should be avoided. How- ever, this may be difficult to achieve in practice, as the survey from 2003 has been a multipurpose survey also covering 0-group fish, demersal fish and benthos.

Figure B.2 shows the Sa values by depth for one Norwegian vessel in 2001 and one Norwegian vessel in 2008. Sa values are coloured white and the position of trawl stations are coloured yellow. 0-group stations where the trawling is in different depths during one trawl haul are marked with two yellow dots, one at the surface and one at 40 m. In 2008 the capelin survey was a part of a multipurpose survey also covering 0-group fish and demersal fish. Trawl stations directed at capelin registrations are substantially fewer in 2008 than in 2001. Even if the identification of capelin may not have been seriously ham- pered, the representativity of trawl stations for the most abundant parts of the capelin distribution certainly has.

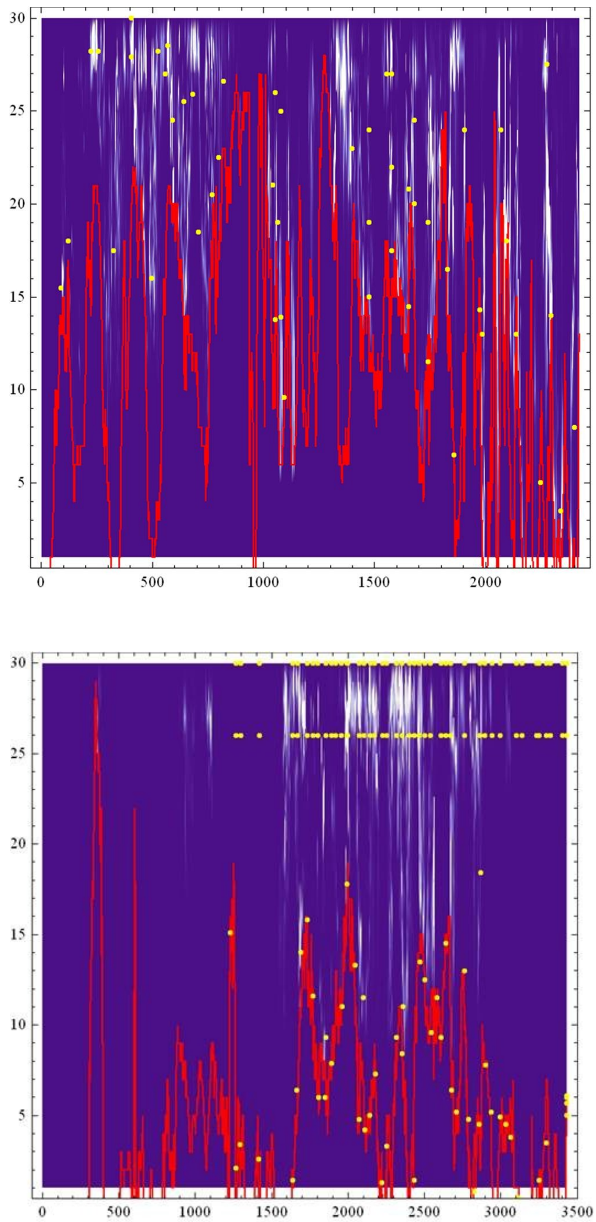


Figure B.2. Sa values (white) by depth and trawl stations (yellow) in 2001 and 2008. Further explanatioms in the text.

Figure B.2 serves is a demonstration of how trawling for obtaining biological samples representative for the main acoustic densities of the capelin can be sacrificed when the survey shall deliver data for many purposes. Care must be exercised by the cruise leader that enough directed trawl samples for capelin are obtained.

Survey uncertainty

The survey uncertainty is a part of the input to CapTool. It would be natural to base the survey uncertainty on the actual survey that has been conducted, so that a poor survey with bad coverage and inadequate sampling resulting in a large uncertainty yielded a more cautious capelin quota. This has not been implemented yet. Instead, a fixed survey CV of 0.2 is used based on the historic replicates for all years, as shown in figure B.3

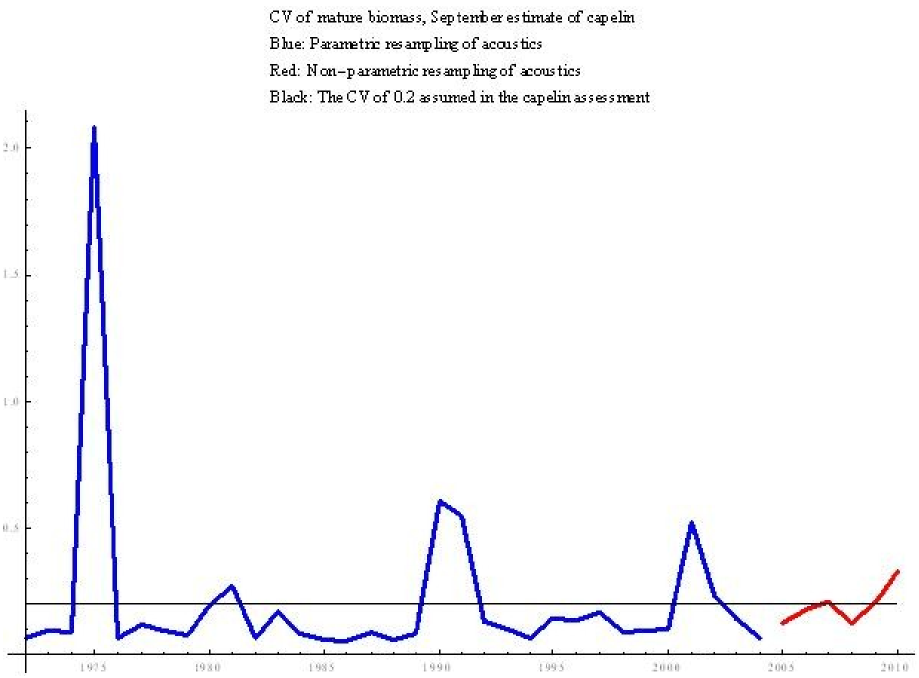


Figure B.3. CV from resampling historic September surveys. The value 0.2 is shown as a horizontal black line. The CV is in most years somewhat below 0.2. The reason for the large spikes is not known.

Area coverage may be an issue, especially during the 1970s where the surveys were primarily directed towards the adult capelin. Figure B.4 shows the development of the year classes 1971-2009, starting from age 1. Most of the year classes prior to 1980 show an increase in abundance from age 1 to age 2. There is an increase in abundance from age 1 to age 2 also for the 2007 year class, which is worrying since the area coverage in later years is considered adequate. However, the observed increase is not highly unlikely in view of the assumed CV on the estimates (0.2).

When recruitment relations are estimated in Bifrost, the number of 1 year old capelin is adjusted so that the cohort matches the observed number of 2 year old capelin when natural mortality on immature capelin is accounted for. This is done in order to avoid the problems of underestimation of the 1-group encountered in earlier years.

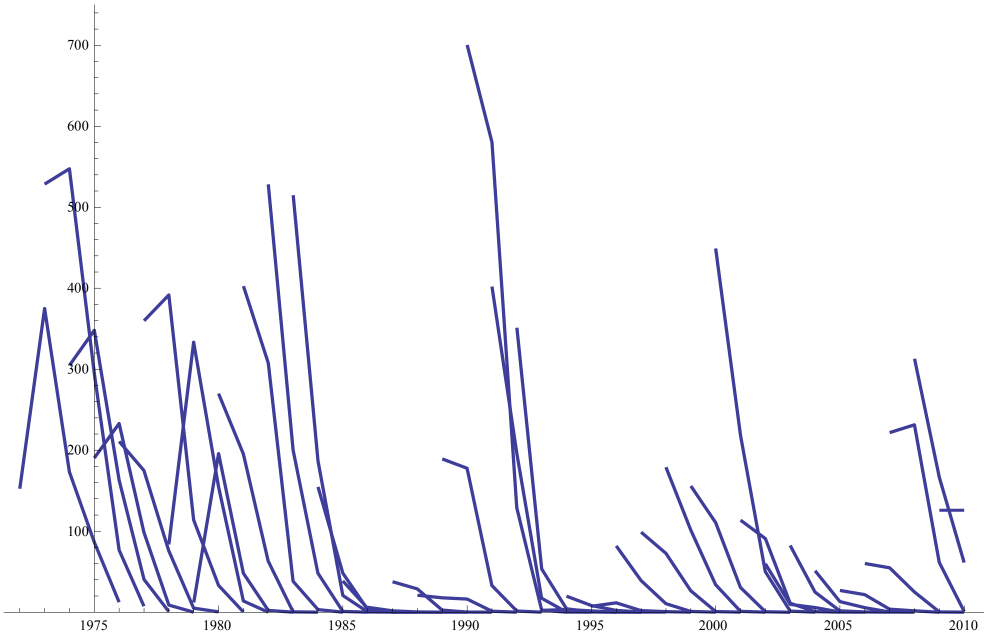


Figure B.4. Development of year classes 1971-2009.

B.3.1. Calculation of capelin abundance from survey data

Based on past experience the available vessels are allocated to areas in such a way that the whole area in which capelin is expected to occur is covered with a spacing between survey tracks of preferrably no less than 30 nmi. The mean Sa value in each WMO (1 by 2 degrees) square is calculated and a length distribution representative for the square is calculated by manually selecting trawl stations within or close to the square that are considered representative for the capelin in the square.

The total number of fish in one WMO square is calculated as

$$\frac{Sa\ areaSize\ 10^{7}}{5.0\ \frac{\sum_i n(i)\, l^{1.91}}{\sum_i n(i)}}$$

where:

Sa	Mean Sa values from all transects through the square
n (i)	Number of fish in each length group i from biological samples in the square or in the vicinity of the square. Care must be taken that the biological samples are representative for the capelin that contributed most to the Sa value.
areaSize	The size of the area in nautical miles squared

The total number of fish is multiplied with the relative length distribution to yield the total length distribution within the square. It is worth noting that the length dependence of the backscattering ability is used only to calculate the total number of fish. It does not affect the calculated length distribution, which only depends on the observed relative length distribution from the samples.

It has usually been taken for granted that it will be possible to find trawl stations in or in the vicinity of a square that are representative of the fish in the square, since trawling as a rule was conducted to identify the registrations. After the multipurpose survey started in 2003 this is no longer as obvious, as the large number of stations in predefined locations have led to a severe decrease in trawl stations on acoustic registrations.

B.3.1.1. Checklist for capelin abundance estimation

Task	Comment
Plot integratorvalues Determine if necessary to reduce size of some squares	Applies near border of distribution
Verify that representative samples are used in each square	If insufficent directed trawls, apply the following rule : Use 0 - group stations if more than 50 kg capelin. Use bottom trawl stations if more than 10 kg capelin

B.4. Commercial CPUE

Commercial CPUE data are not relevant for this stock

B.5. Other data used in the assessment

In addition to capelin data, the modelling of consumption of capelin by cod requires data for the cod stock, abundance data, maturation data, weight data and stomach content data. Parameters in the function for capelin consumption by cod are estimated by constructing a likelihood with modelled consumption as expectation values and consumption calculated exogeneously directly from the stomach content data using laboratory data of the evacuation rate as observation values. Since the evacuation rate depends on the temperature, data in the vicinity of trawl stations where stomachs are samples are needed. Finally, the consumption per cod is scaled with cod abundance data taken from the February bottom trawl survey, in order to correct for a possibly geographically skewed sampling of cod stomachs with respect to the geographical distribution of the cod stock.

Cod weight at age and maturation at age are taken from the Arctic Fisheries WG assessment. When Bifrost is run, number of cod at age have been calculated exogeneously using the catch at age data and terminal F-values from the Arctic Fisheries WG assessment. In these calculations, Pope's approximation is used. When CapTool is run, the number at age of cod is taken directly from the latest Arctic Fisheries WG assessment.

• B.6. Summary of data

Table B.1 shows a summary of the data used in the Barents Sea capelin assessment.

Table B.1. Summary of data used in the Barents Sea capelin assessment.

Type	Origin	Name of file	Year range	Biological division	Used by
Catch at age in numbers	Commercial catch Biological samples	CapCatch.xls	1972 - present	Age 1 - 5 Season Maturation, divided at 14 cm	Bifrost
Stock size * October 1	Survey	CapTab.xls	1972 - present	Age 1 - 5 Length Weight by length	Bifrost CapTool
Stock size replicates October 1	Survey	bootstrapSexAgeLength - AcousticBiology < year >	1972 - present	Age 1 - 5 Length Weight by length	Bifrost
Cod abundance Assessment year + 1	Arctic Fisheries WG assessment	CapTool.xls	Assessment year + 1	· Age 1 - 13	CapTool
Cod abundance Historic	Calculation in MakeVPA.nb		1946 - present	Age 1 - 13	Bifrost
Consumption of capelin per cod	Calculations in StomachData . nb	consumptionPerCod < year > < length group >	1984 - present	Age 1 - 10	Bifrost

***Considered an absolute estimate of the stock**

Summary of data used to calculate consumption of capelin per cod

The consumption per cod data used in Bifrost to estimate parameters in the predation function are calculated exogeneously using stomach content data from the field, stomach content data from an evacuation rate experiment (dos Santos and Jobling

1992), temperature data from stations in the vicinity of trawl stations where stomachs are sampled and cod distribution data from the demersal survey in February. Replicates of the evacuation rate parameters are calculated exogeneously using a model without the stomach content immediately after a meal as a variable, since this quantity is not known in the field (Temming and Andersen 1994). Table B.2 shows an overview of the data used for calculating consumption per cod replicates.

Table B.2. Summary of data used to calculate consumption per cod replicates.

Type	Origin	Name of file	Year range	Biological division	Used by
Stomach content data from the laboratory experiment	Laboratory data University of Tromsø	Evacjsmj.csv			StomachData .nb
Stomach content data from the field	Biological samples from research vessels	nydump	1984 - present	Prey in individual cod stomachs	StomachData .nb
Temperature data	CTD stations from research vessels taken from the IMR tindor data base	tindorCTD < year >	1986 - present	Depth	StomachData .nb
Geographical distribution of cod	February demersal survey	allEstimateArea·DemersalWinter	1984 - 1987 *	Area, age, maturation	StomachData .nb

*** Remains to be updated**

C. Assessment methodology

The models used and the basic assumptions are listed in Table C.1

Table C.1. Models and assumptions used in the Barents Sea capelin assessment

Model	Usage	Assumptions	
FangstFisk	Calculation of catch statistics for use in Bifrost		
BEAM	Calculation of abundance, September survey		
Bifrost	Estimation of maturation and predation parameters	Maturation	Sigmoidal function of length Estimated
		Predation by cod	Type II relationship to capelin biomass by cod Estimated maximum consumption and prey biomass at half maximum consumption Only immature cod preys on capelin during January - March Max predation is a power function of weight, exponent from literature
CapTool	Calculation of limit catch according to HCR	Maturation	Identical to Bifrost Parameters from Bifrost
		Predation by cod	Identical to Bifrost Parameters from Bifrost

C.1 Model formulations

The mathematical formulations are essentially the same in Bifrost and CapTool.

C.1.1. Maturation

The proportion maturing (as of October 1) of capelin is modelled as a function of length using the logistic function:

$$m(l|P_1, P_2) = \frac{1}{1 + e^{4 P_1 (P_2 - l)}}$$

where P_2 is the length at 50% maturation and P_1 is the increase in maturation by length at P_2. l is the length in cm.

Figure C .1 shows the estimated replicate values of the parameters in the maturation function. In 24 % of the replicates P_1

have been estimated to values larger than 2, i.e. approximate cut – off maturation. The mean of the P_2 is 13.816.

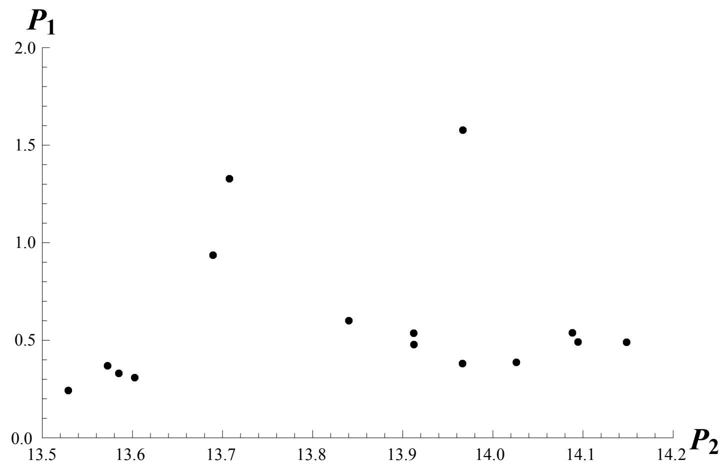


Figure C.1. Estimated replicates of the parameters in the maturation function.

- **C.1.2. Consumption by cod during January-March**

The consumption of capelin by cod is given by:

$$\text{consumption} = P_{17} \frac{\text{capelinBiomass}^{P_{13}}}{P_{10}^{P_{13}} + \text{capelinBiomass}^{P_{13}}} \text{predationAbility}$$

$$\text{predationAbility} = \quad \text{Suit}(i)\, N(i)\;\; W(i)^{0.801}$$

consumption is the consumption of capelin by cod in million tonnes per month and capelinBiomass is the capelin biomass in million tonnes. The suitability of capelin as food for cod is assumed not to be dependent on capelin age. This assumption would be violated of the spatial and temporal migration pattern of young mature capelin differed from that of older mature capelin. Suit(i) is the suitability of capelin as food for cod of age i. N(i) is the number of immature cod at age i in billions and W(i) is the weigth at age i of cod in kg. The exponent 0.801 is taken from the literature (Jobling 1988).

The number of immature cod by age residing in the Svalbard area thus not preying on capelin during January-March is subtracted before the calculations are carried out. The fraction of cod in the Svalbard area is inferred from autumn demersal surveys. It has not been updated since 2004, however. Data on cod area distribution from the autumn (ecosystem) survey are now available and will be used for updating the area distribution before the 2011 capelin assessment. P_{10} and P_{17} are parameters to be estimated from the data.

Figure C.2 shows consumption as function of capelinBiomass for unit predationAbility for the estimated paremeter replicates.

The suitability of capelin as food for cod is dependent on cod age. The stomach content data show that the youngest cod do not eat much capelin, and the oldest cod tend to have a lesser portion of capelin in their diet than cod of intermediate ages. Figure C.3 show the assumed suitability by age.

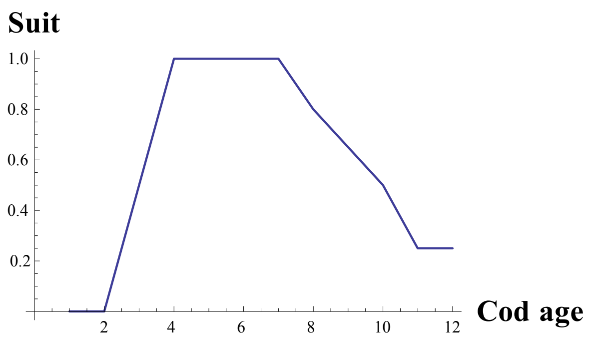


Figure C.3. Suitability of capelin as food for cod by cod age used in Bifrost.

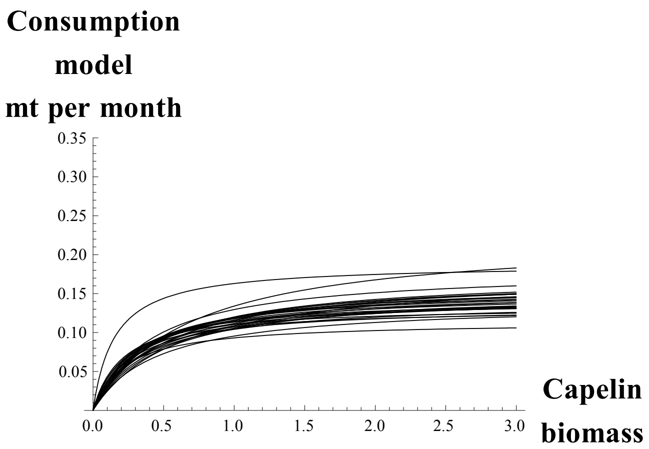


Figure C.2. Replicates of consumption per month as function of unit predation ability.

C.1.3. Simulation

The simulation of capelin in Bifrost is shown in figure C.5. Events are shown in blue boxes and processes in light blue boxes. The model results from each event or process are shown in yellow letters. The yearly simulation period starts October 1, when the stock is initialized as number by age and length from the measurement obtained by the September survey. On these data the maturation model is applied to split the stock into an immature and a mature component on the basis of the length distribution, and both components are summed over length, i.e. the length distribution is not kept during the subsequent simulation - it is used only for the maturation model.

Then the mature component is projected to spawning at 1 April and the immature component to the time of next measure- ment at 1 October.

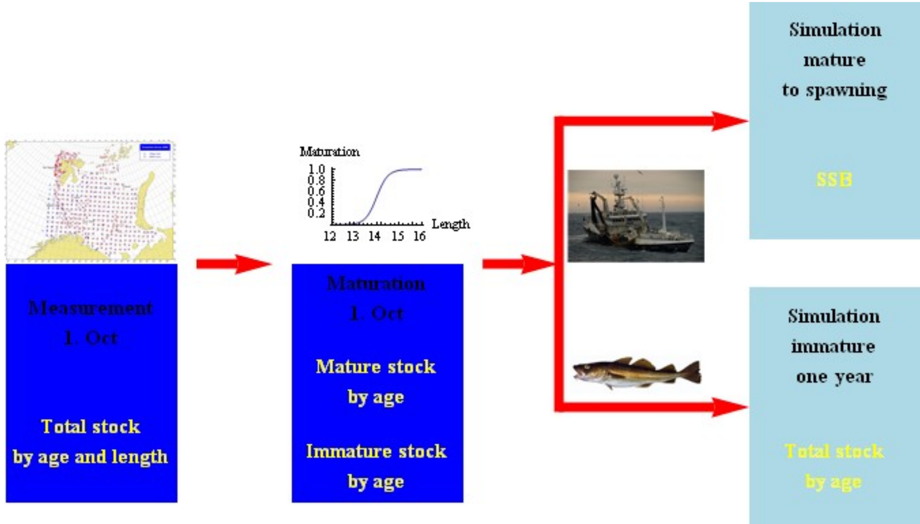


Figure C.5. Overview of Bifrost simulation.

The simulation of both mature and immature capelin from time of measurement 1 October is performed using Pope ' s model for the catch and a natural mortality by month, which is constant during the 12 month simulation period :

$$\text{Cap} = (\text{Cap}\ e^{-0.5\,P_3} - C_i)\ e^{-0.5\,P_3}$$

During the period January – February the consumption of capelin by cod is particularly intense,

as is the fishery. The catch statistics used by Bifrost is given on season only (e.g. January – March), and a constant subdivision of the season is applied to give the catch by month.

The natural mortality for immature capelin P_3

is a constant parameter that is estimated along with the parameters in the maturation function.

C 2. The Bifrost model framework and estimation of parameters

Bifrost is written in Mathematica. Accompanying the Bifrost notebook are several notebooks that are used for data handling and other tasks outside of the Bifrost simulations. Table C.2 gives an overview of the notebooks used. The overview is limited to tasks relevant for the estimation of parameters to be used in CapTool.

Table C.2. Overview of Mathematica notebooks used in Bifrost simulation and estimation

Bifrost	Main notebook
StomachData	Stomach content data handling, calculation of consumption per cod
Temperature	Handling of temperature data
STUVData	Handling of biological data of cod
EstablishingDat·aForMigration	Calculation of cod distribution
MakeVPA	VPA for cod, based on terminal Fs from the WG
SeaStar	Prognostic simulation of herring
BootstrapCapelin	Calculation of September data replicates

C 2.1 Estimation of parameters

C 2.1.1 Historic replicates of estimated parameters – uncertainty in input data

How the uncertainty in the input data affect the uncertainty in the estimated parameters is evaluated by repeated estimation of parameters, each time drawing input data at random from a distribution constructed from the actual measured values. The collection of these replicates of parameters is then transferred to CapTool. Table C.3 shows how the uncertainties in the individual input data sources are treated.

Table C.3. Overview of Mathematica notebooks used in Bifrost simulation and estimation

September data	Data are drawn according to the uncertainty used in CapTool (CV of 0.2)	
Consumption per cod	Stomach content data	No uncertainty for the measured data or for the division of unidentified food
	Evacuation rate parameters	Estimated repeatedly by resampling laboratory data
	Temperature	Drawn from a normal distribution with uncertainty taken from an analysis of using temperature stations not in the immediate vicinity of the trawl stations
	Cod distribution	No uncertainty applied
Cod assessment entities	No uncertainty applied	

C 2.1.2 Estimation of maturation parameters

Figure C.6 gives an overview of the estimation of the maturation parameters.

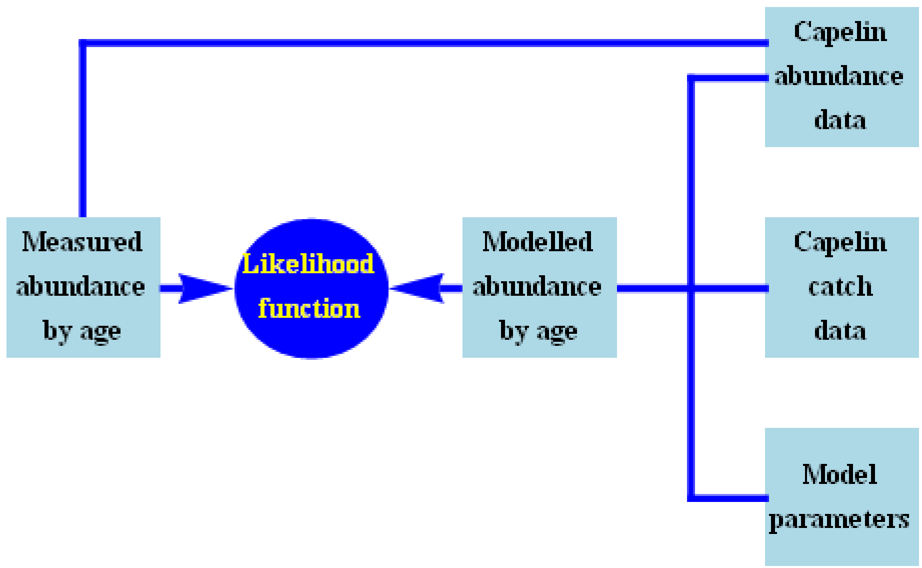


Figure C.6. The estimation of maturation parameters in Bifrost.

The estimation of the maturation parameters relies on projecting the immature part of the population one year, from after the estimate in September until the new estimate in September the following year. The basis for the likelihood function is the projected immature stock, which is the total stock next year since the mature capelin dies after spawning, which is compared to the measured total stock.

The projected immature stock depends not only on the maturation parameters, but also on the monthly natural mortality of immature capelin, which is a parameter in the model.

The trawl-acoustic estimation of Barents Sea capelin started in 1972. Past modelling experience has shown that during the first decade the population dynamics of the capelin remained fairly stable, i.e. the variation in natural mortality from year to year was fairly small. All thre parameters P_1, P_2 and P_3 are estimated simultaneously. Only the 9 first periods are used, i.e.1972-1973, ------, 1980-1981. It is assumed that length at maturity is constant across age groups.The age groups 2-3 and 3-4 years are used in the likelihood.

It is assumed that the measurement of number at age given that the simulated values are the expectation values follow the gamma distribution, and the CV of the distribution is estimated along with the other parameters.

C 2.1.3 Estimation of predation parameters

The maturation parameters must have been estimated before the predation parameters are being estimated.

The main idea behind estimating parameters in the model for consumption is to calculate the consumption by year during January-March outside of the modelled (referred to here as "empirical consumption") and adjust parameters so that the consumption calculated by the model is as close to the empirical consumption as possible. The estimation is done with standard minimizing software that is part of Mathematica.

Figure C.8 gives an overview of the estimation of the predation parameters.

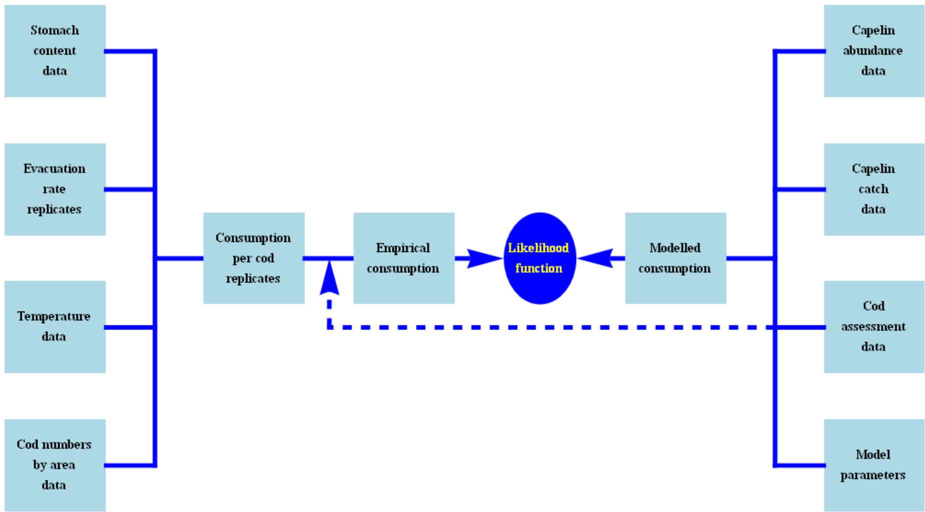


Figure C.8. The estimation of predation parameters in Bifrost.

C 2.1.1.1 Calculation of empirical consumption

The calculation of the empirical consumption is based on an assumption of equilibrium: during the period of calculation (which in this case is January-March) the food eaten equals the food evacuated from the cod stomachs. The total amount of food evacuated is calculated as the average of the food evacuated per time unit for each each stomach times the duration of the period. The evacuation rate is given by Bogstad and Mehl (1997):

$$R = \frac{\ln(2)\, e^{\Gamma T}\, W^{\Delta}\, S^{\Xi}}{A\, S_0{}^{B}}$$

where:

A:	evacuation rate halftime
B:	dependence on initial meal size
Γ:	dependence on ambient temperature
Δ:	dependence on predator body weight in grams
Ξ:	shape parameter
S:	stomach content of prey
S_0:	initial meal size in grams
T:	ambient temperature
R:	consumption in grams per hour

The initial stomach content S0 is not known in the field, so B is set to zero. The other parameters are estimated repeatedly by resampling the laboratory data from an experiment at the University in Tromsø (dos Santos and Jobling 1992). This approach is the same as the approach recommended by Temming and Andersen (1994).The file of estimated evacuation rate parameters is kept on a separate input file, see figure C.8

The consumption per cod in grams per hour is then calculated as:

$$C_a = \frac{\sum_i N_{i,a} \overline{R}_{i,a}}{\sum_i N_{i,a}}$$

where

C_a: consumption of capelin per hour by preying cod of age a

$N_{i,a}$: the number of preying cod of age a in area i

$\overline{R}_{i,a}$: the mean consumption of capelin by preying cod in area i, calculated as $\frac{1}{n}\sum_{j=1}^{n} R_{i,a,j}$

where the summation extends over stomachs of cod of age a in area i and n is the number of sampled stomachs of preying cod of age a in the area.

Weighting with geographical distribution from survey

The empirical consumption is the consumption per cod times the number of cod preying on capelin. It is possible that the geographical distribution of stomach content samples does not equal the geographical distribution of cod preying on capelin. For that reason, the consumption per cod calculated from stomach samples is weighted by the number of cod preying on capelin in sub-areas of the Barents Sea. The area division chosen is the Multspec areas, which were used in connection with the Multspec model (Tjelmeland and Bogstad, 1998), which was used with management of capelin before Bifrost.

Figure C.9 shows the Multspec areas.

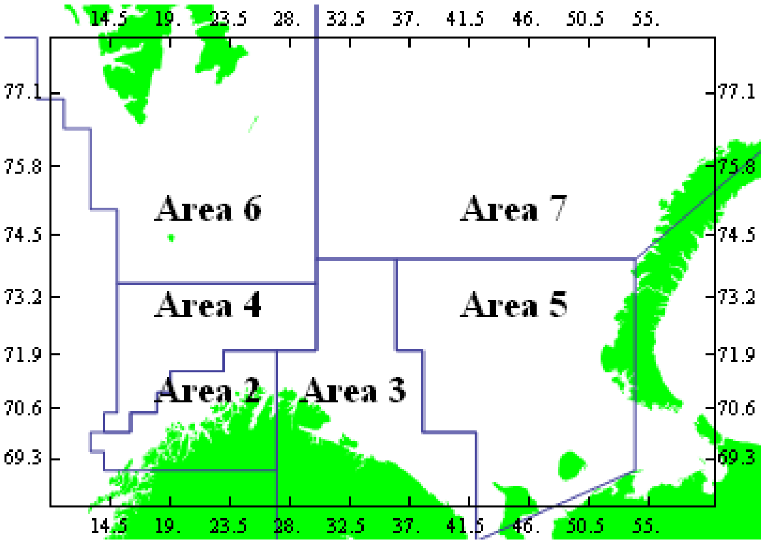


Figure C.9. Multspec areas.

Handling of temperature

A temperature must be connected to each cod stomach, preferrably being indicative of the ambient temperature since time of last ingestion. There are gradients in temperature - the depth gradient ususally being especially strong - which would lead to possibly large inaccuracies using one temperature for a large spatio-temporal area. Unfortunately, the temperature during trawling has not been collected and stored with the stomach content data. As a rule, a CTD station is taken a short time after each trawl station.

In order to find the most appropriate temperature for a given trawl station, first a CTD station in the close spatio-temporal vicinity is sought. If none is found, the search box is increased. If still no CTD station is found, a neighbouring year is tried and the temperature from the CTD station is scaled with the changes in the temperature in the Kola section. The uncertainty connected to not finding a CTD station at the first attempt is evaluated by investigating all CTD data using the same algo- rithm around all CTD stations in the material. The procedure is described more fully in the separate document "Temperature in Bifrost.pdf".

C 2.1.1.2 The likelihood function

The file of consumption per cod replicates is an input file to Bifrost (see figure C.8) and read during initialisation. The total consumption is calculated during the estimation process by multiplying consumption per cod with the number of preying cod from the cod assessment (Arctic Fisheries WG) and the duration of the preying period January-March. The modelled consumption is also summed over January-March before the log-likelihood is evaluated.

It is assumed that the exogeneously calculated consumption follows a gamma distribution when the expectation values are represented by the simulated consumption. The CV of the distribution is estimated along with the parameters in the consumption function.

C 2.1.3 Likelihood estimation and parsimonious models

The estimation of parameters in Bifrost is based on maximum likelihood throughout. The parameters do then have a justification in that they represent a model for which the likelihood of the observed data is the highest possible. Also, using a likeli hood is a powerful tool in seeking models that give the best balance between simplicity and overfitting. The models should be as simple as possible, yet capture the essentials of the population dynamics. The small-sample Akaike Information Criterion (AIC, Burnham and Anderson 2002) is used, defined as:

$$AIC_c = -2\log(L(\hat{\theta})) + K\left(\frac{n}{n-K-1}\right)$$

where L is the likelihood, evaluated at the estimated values of the parameters –

$\hat{\theta}$ – and n is the number of data points and K the number of parameters.

The model with the lowest AIC is the most parsimonious model and to be preferred. This is a model where the parameters represent a biological reality, avoiding superfluous model fit due to overparameterization. Two alternatives to the chosen models were tested: a cut-off maturation function as opposed to the chosen sigmoid maturation, and a three-parameter consumption model enabling a type III feeding relationship. The sigmoid maturation was in itself not an improvement. It had a better fit in terms of a lower log-likelihood, but a higher AIC value. However the fit to the consumption data was signifi- cantly (in terms of AIC) worse using a cutoff maturation than using the sigmoid maturation. Using a three-parameter con- sumption model gave a modest better fit, but an increased AIC.

C3. The CapTool spreadsheet for short term probabilistic projections

C 3.1 The harvesting rule

The harvesting rule adopted by the Norwegian-Russian Fishery Commission is that there shall be a maximum probability of 5% for the SSB at April 1 to be smaller than 200 000 tonnes. This rule was originally devised by the then ACFM.

C 3.1 CapTool

The total Bifrost methodology is quite involved and a simpler tool is needed with the yearly assessment of capelin following the September survey, when only probabilitisc projections from October 1 to April 1 the following year are needed. This is done in an Excel spreadsheet - CapTool - with the @RISK simulation module implemented. The Bifrost model formulations are programmed into CapTool and the replicates of the estimated parameters are copied to a separate page in CapTool. The CapTool spreadsheet, which is self-explanatory, carries out a large number of trajectories and calculates the number of trajectories that leads to a SSB at April 1 of less than 200 000 tonnes.

D. Short term projection - Bjarte

CapTool is used for short term projections. The current September estimate and latest cod assessment are entered manually into CapTool on separate pages. By trial and error a total catch rounded to the nearest 10 000 t for January-March is set so that the harvest rule is satisfied. Figure D.1 shows the simulation output from the assessment the autumn 2010.

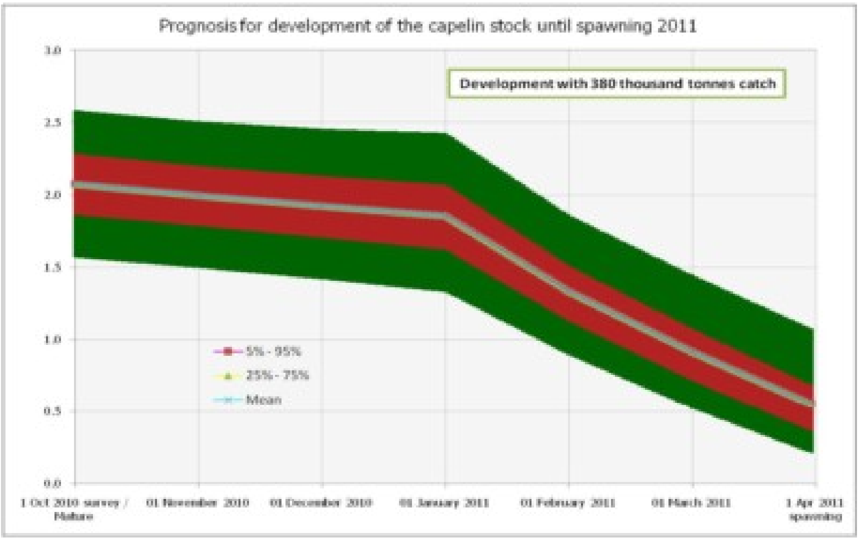


Figure D.1. Simulation output from CapTool, from the assessment of the autumn 2010.

E. Medium term projections

Not relevant.

F. Long term projections

Not relevant.

G. Biological reference points - Sigurd

Blim for Barents Sea capelin is set to 200 000 tonnes by ICES.

H. Other issues

None.

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ANNEX 10 : Stock Data Problems Relevant to Data Collection –AFWG

Stock	Data Problem	How to be addressed in	By who
Stock name	Data problem identification	Description of data problem and recommend solution	Who should take care of the recommended solution and who should be notified on this data issue.
All stocks	the current FishStat software does not operate in the Windows 7 environment.	Please note, however, a new completely reengineered version of the application, called FishStatJ, which will support all the major operating systems (Windows, Linux and Mac). A beta version of the application has been demonstrated in occasion of the past Committee on Fishery (COFI, Jan 31 - Feb 04, 2011). The operational release is scheduled right after the official publication of the updated FAO global fishery and aquaculture production statistical collections.	FAO
NeA saithe	Security Warning Some active content has been disabled (Options, below the table)	New version av graph program should handle the security problem. Preferably incorporate the program in FLR / or write it in R as a separate program.	ICES

Stock	Data Problem	How to be addressed in	By who
NeA- cod	In contrast to previous years, the age-length distributions in the catches were not updated for 2010 for gadget-model. This is because the ECA program used for data extraction gave unreliable results when run in 2011. Some files were not produced at all, and others had age-length tables that were not compatible with previous years, despite using the same settings. Work will be undertaken before the next AFWG to investigate and rectify this problem. However for this meeting the most recent years in the Gadget model is lacking in fleet data, and may thus be overly sensitive to variations in the most recent surveys.	Work will be undertaken before the next AFWG to investigate and rectify this problem. First, the actual differences should be investigated further, e.g. by region, gear-group and season to exclude other possible sources of error.	IMR
Sebastes mentella	It becomes a problem for the Sebastes mentella assessment that some countries fishing S. mentella in international waters of the Norwegian Sea do not report their catches to NEAFC and ICES. EU-reported catches are, for example, not split by individual countries. Lack of consistency between daily reports from the sea to NEAFC and later official reports by delegates to NEAFC is also worrying.		

Annex 11 - Technical Minutes of the Arctic and North-Western Review Group (RGANW) 2011

18-20 May 2011, Fairhaven Massachusetts, USA

Reviewers: Steve Cadrin (co-chair), Lisa Kerr (co-chair), Adam Barkley, Piera Carpi, Greg DeCelles, Dan Goethel, Fiona Hogan, Nikki Jacobson, Emily Keiley, Dave Martins, Sally Roman, Yuying Zhang

Working Groups (WGs):

Arctic Fisheries Working Group (AFWG) Chair: Bjarte Bogstad, Norway

North-Western Working Group (NWWG) Chair: Gudmundur Thordarson, Iceland

Secretariat: Mette Bertelsen, Barbara Schoute

Process: The ICES advisory service quality assurance program requested that a team of graduate and post-doctoral students and their professor serve as a student review group, as specified in Guidelines for Review Groups (ACOM 2009). The group initially met on 6 May to review the ICES advisory process, RG guidelines, to assign several WG report sections to each reviewer, and to review standard ICES assessment models (XSA, ADAPT, etc.). Members reviewed WG report sections independently, then presented their summaries and reviews to the group in a series of meetings from 18 to 20 May to discuss reviewers' draft technical minutes and form RG conclusions.

General Comments: - Stock assessment reports for 24 stocks and one special request were reviewed (Table 1). The WG reports were informative and generally complete. Most WG decisions about data, model choice or configuration and interpretations were clearly explained and justified. The RG concludes that the reports are technically correct, and the RG agrees with WG recommendations, with few exceptions.

An unconventional procedural issue was recognized for many stocks. Both NWWG and AFWG do not strictly adhere to the ICES benchmark/update system. Methods documented in the annex or determined by the benchmark process were frequently revised, and many new methods were explored. WG conclusions on stock status or forecasts were often based on revised methods, including changes in data (e.g., fishery catch, surveys) or new assessment models or model configurations. There are some advantages to exploring new methods each year, and most revisions were well justified. However, the only external review of these methodological revisions is by the RG. Therefore, our review involved more than the typical quality control to determine if the benchmark methods were correctly applied, and our review had elements of external benchmark review. The advice drafting group should be aware of this procedural aspect in the application of results from revised methods for the basis of advice.

Ecosystem considerations were included in each WG report. For example, the Barents Sea ecosystem section was particularly well developed. However, ecosystem information was not considered in for each stock. The RG recommends that the information summarized in the ecosystem section should be more explicitly considered for each stock.

Table 1. Stocks reviewed by working group (WG) and numbered section for AFWG.

	Code	Stock	WG
1	cod-arct	Cod in Subareas I and II (Northeast Arctic cod)	AFWG
2	cod-coas	Cod in Subareas I and II (Norwegian coastal cod)	AFWG
3	had-arct	Haddock in Subareas I and II (Northeast Arctic)	AFWG
4	sai-arct	Saithe in Subareas I and II (Northeast Arctic)	AFWG
5	smn-arct	Beaked Redfish (Sebastes mentella) in Subareas I and II	AFWG
6	smr-arct	Golden Redfish (Sebastes marinus) in Subareas I and II	AFWG
7	ghl-arct	Greenland halibut in Subareas I and II	AFWG
8		Norwegian/Russian request - Arctic fisheries	AFWG

Cod in Subareas I and II (Northeast Arctic cod; cod-arct)

1) **Assessment Type:** Update
2) **Assessment:** Analytical
3) **Forecast:** Short term forecast was presented using multiple values for F in 2012. The TAC agreed upon for 2012 (751,000 tons), is 7% larger than the TAC in 2011 (703,000 tons) and corresponds to an F of 0.35. Forecasts indicate that SSB will decrease slightly in 2013 but remain acceptable under the management plan.
   No medium or long term forecasts were presented.
4) **Assessment model:** XSA with 4 tuning indices. 1 commercial- Russian trawl CPUE and 3 surveys (Joint Bottom Trawl, Joint Acoustic, Russian Bottom Trawl).
   Two additional assessment methods (Survey Calibration method and Gadget) were performed for comparison to XSA.
5) **Consistency:** XSA model used, as in previous assessment and annex with one change. The catchability dependent on stock size (ssdq) parameter was changed this year. In previous assessments, ssdq was applied to fish ages 3-5. This year, ssdq was applied to fish ages 3-6.
6) **Stock Status:** $B>B_{pa}$. SSB has been acceptable since 2000, and estimated SSB in 2011 is at the highest level (1,311,000 t) since 1947. $F<F_{pa}$. $F_{5\text{-}10} = 0.29$ in 2010. F has been acceptable since 2006. R estimated to be 683 million fish in 2010.
7) **Management Plan:** A management plan has been adopted and harvest control rules have been set. The harvest control rules were evaluated by the 2010-AFWG, and were considered to be in accordance with the precautionary approach. TAC for the next three years based on F_{pa} (0.4). TAC in 2011 set at 703,000 t. Agreed TAC for 2012 set at 751,000 t, corresponding to an F=0.35, which is < F_{pa} (0.4).

General Comments

The assessment results indicate that the stock biomass and fishing mortality have been acceptable in recent years. Spawning stock biomass is estimated to be at record levels, and recent landings are comparable to historical catches. The assessment model appears to perform well and provide a solid basis for management advice. The magnitude of retrospective errors is small (Figure 3.4), and there is strong agreement in the results of the single fleet runs (Figure 3.3). With regard to SSB, the Gadget model and the XSA provide similar results, which show that SSB has increased to a time series high in recent years. The estimates of recruitment from the Gadget model (Figure 3.10) were more pessimistic than recruitment estimated in the XSA (Figure 3.1).

The WG concluded that the stock size dependent catchability (ssdq) parameter should be changed to include fish ages 3-6. In the past, ssdq was applied to fish ages 3-5. When ssdq is used, the survey indices are fit using a power model, rather than a linear model. The WG noted that survivorship to older ages classes is higher during recent years, and used the apparent change in survivorship as a justification for the change in ssdq. The indices of age 6 cod were much higher 2009 2010 for the joint acoustic survey and the joint bottom trawl survey than had been seen in recent years. Changing the ssdq parameter reduces the survey residuals in the terminal year, and provides a better model fit (see Table 3.13a at the end of this document). The WG was concerned that unless the ssdq parameter was changed, the residual patterns of the XSA model may have been too severe to allow for the assessment to provide a basis for advice.

Table 3.13a. Northeast arctic cod. Final xsa compared with xsa tunings run with last year settings. Upper part of table shows F in terminal year (including cannibalism mortality M2), as far as Fbar, total biomass, SSB and number of survivors. Lower part of the table shows survey residuals at terminal year and sum of squares for each survey for period 2001-2010.

		Final XSA	run 3	Last year settings
1st age q is indep. on pop. size		**7**	**8**	**6**
tuning window, years		**10**	**10**	**10**
F(+M2) at age3		**0.12**	**0.12**	**0.13**
F(+M2) at age4		**0.12**	**0.13**	**0.10**
F(+M2) at age5		**0.22**	**0.25**	**0.16**
F(+M2) at age6		**0.36**	**0.43**	**0.20**
F(+M2) at age7		**0.33**	**0.44**	**0.29**
F(+M2) at age8		**0.35**	**0.38**	**0.32**
F(+M2) at age9		**0.23**	**0.23**	**0.24**
F(+M2) at age10		**0.32**	**0.35**	**0.30**
F(+M2) at age11		**0.71**	**0.72**	**0.70**
F(+M2) at age12		**0.49**	**0.52**	**0.47**
2010	F(5-10)	0.30	0.35	0.25
TSB2010	incl Age1-2	2788	2565	3531
SSB2010	('000 T)	1083	1030	1333
N2011	yc2007	325070	321006	307708
N*10^-3	yc2006	325369	303342	374777
with	yc2005	279908	244472	394212
shrinkage	yc2004	167264	131382	325813
	yc2003	83958	61157	99582
	yc2002	37532	33755	41094
	yc2001	16764	17079	15984
	yc2000	10477	9396	11427
		FLT15: NorBarTrSur residuals at 2010		
age 3		-0.13	-0.13	-0.13
age 4		0.13	0.12	0.19
age 5		0.12	0.13	0.11
age 6		0.26	0.32	0.38
age 7		0.22	0.27	0.09
age 8		-0.14	-0.06	-0.21
SSQ (ages 3-8, years 2001-2010)		**1.74**	**1.68**	**2.26**
		FLT16: NorBarLofAcSu residuals at 2010		
age 3		-0.13	-0.12	-0.11
age 4		0.04	0.04	0.06
age 5		0.1	0.11	0.07
age 6		0.29	0.33	0.71
age 7		0.45	0.14	0.32
age 8		0.11	0.19	0.04
age 9		-0.2	-0.24	-0.14
SSQ (ages 3-9, years 2001-2010)		**3.57**	**3.07**	**5.48**
		FLT18: RusSweptArea residuals at 2010		
age 3		-0.06	-0.07	-0.04
age 4		-0.1	-0.09	-0.15
age 5		0.13	0.14	0.13
age 6		0.05	0.11	-0.35
age 7		-0.1	0.04	-0.23
age 8		-0.33	-0.26	-0.4
age 9		0.09	0.05	0.14
SSQ (ages 3-9, years 2001-2010)		**2.91**	**2.94**	**3.39**
All surveys SSQ		**8.21**	**7.69**	**11.13**

Discards are not included in the assessment. It is stated that the magnitude of discarding is expected to be small that the discard data is fragmented and often contradictory. However, discard data was not provided in the assessment document. The document states that discarding is discussed in section 0.5, but this section is not available in the document.

Estimates of M due to cannibalism (M2) for age 1 fish changed from 0.65 in 2008 to 2.02 in 2009 and 2010 (Table 3.19). It is unclear why such a large change in M2 occurred between the two years. In the stock annex, it is stated that higher levels of cannibalism are anticipated during years when capelin abundance is low. However, capelin biomass was estimated to be greater in 2008, than in 2009 or 2010 (Figure 3.6, shown below). Therefore, it is uncertain why estimates of M2 increased in the two final years.

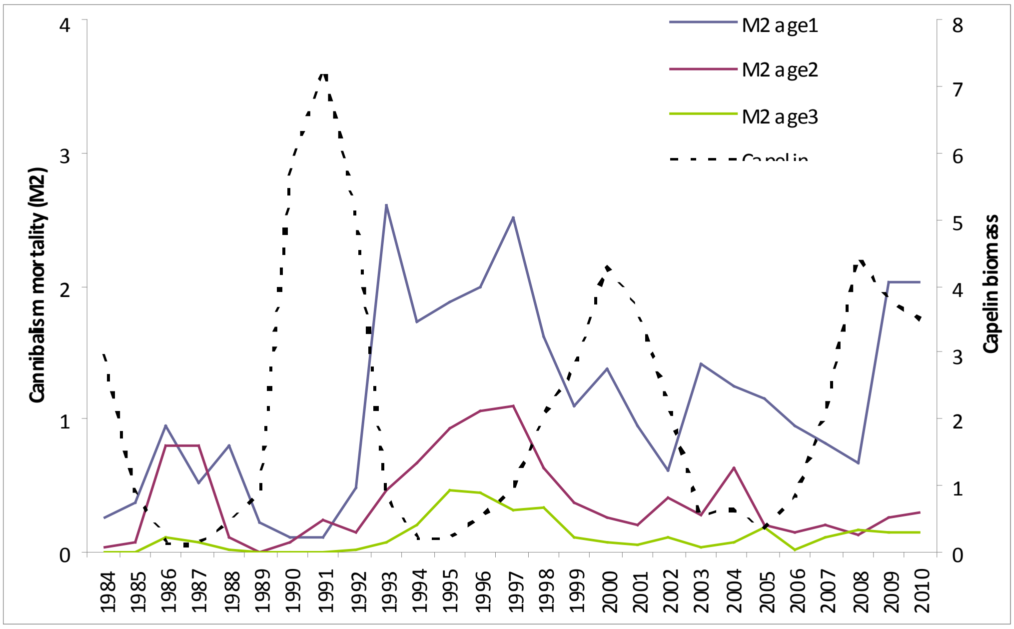


Figure 3.6. Capelin biomass and cannibalism mortality on cod age 1, 2 and 3.

Unreported catches were not included in the assessment. These catches are assumed to be low (<1% of total landings). Unreported catches were included in the assessment from 2002-2008, and were on the order of 15,000 to 166,000 tons per year. It should be noted that the total provisional catch in 2010 was 626,252 tons, which is very close to the 2010 TAC of 628,000 tons. If unreported catches had been included in the assessment (even at low levels) the TAC would likely have been exceeded in 2010.

In the XSA settings section (Section 3.4.1) it was stated that some of the survey indices have been multiplied by a factor of 10, to keep the dynamics of the indices even. However, the document does not state which indices have been changed. This information would be helpful to the RG.

Technical Comments

The fleet dynamics are not well explained in the stock annex or assessment document. Information on the dynamics of the fleet would be useful for the RG.

No maps were provided in the assessment document or the annex. Maps displaying the geographical regions present in the assessment area would be informative. If available, figures documenting the spatial distribution of fishing effort, CPUE and landings would be helpful. Similarly, the spatial coverage of the 3 survey indices used to tune the XSA were not presented in the report. It is difficult for the RG to determine how well the 3 survey indices monitor the resource.

The assessment directs the RG to refer to section 1.6 for a discussion of the "hybrid" recruitment model. This information is located in section 1.4.2, rather than section 1.6.

Conclusions

The assessment has been performed as prescribed in the stock annex (with one exception) and provides a valid basis for management advice. The decision to change the ssdq parameter from ages 3-5 to 3-6 in the current assessment should be reviewed at the next benchmark meeting for this stock. The harvest control rule strategies in place appear to be sufficient to maintain the stock at an acceptable biomass level in the near future.

Cod in Subareas I and II (Norwegian coastal waters cod; cod-coast)

1) **Assessment type:** Update
2) **Assessment**: Analytical
3) **Forecast**: Not Presented
4) **Assessment model**: Separable VPA (SVPA)
5) **Consistency**: The assessment is consistent with last year's assessment, but not with the annex (the recommended approach in the annex is an XSA, this approach was subsequently rejected).
6) **Stock status**: Estimates of total biomass, SSB, and abundance-at-age are close to the lowest levels ever observed. The estimates for 2010 (using only the commercial catches) are: B = 95 kt and SSB = 48 kt.
7) **Management Plan**: There is a combined TAC for both Northeast Arctic cod stock and Norwegian coastal cod stock, since 2005 this has been set = 21 kt. The fishery is regulated by the same minimum catch size, minimum mesh size on the fishing gears as for the Northeast Arctic cod, maximum bycatch of undersized fish, closure of areas having high densities of juveniles, and seasonal and area restrictions. Catches have remained relatively stable since 2004. At the present there is no basis for deriving absolute estimates of F_{msy}. However, it is likely that the current F is above any candidate values of F_{msy}.

General comments

The methods employed in the assessment appear to be consistent with the past year's assessment (SVPA), but the working group didn't follow the methodology suggested in the annex (XSA).

There are a lot of problems and uncertainty associated with the catch estimation and no estimate of this uncertainty has conducted. The assessment is missing a section on ecosystem considerations and there are no forecasts or estimates of reference points.

The comparison of model runs performed with commercial catches only (annex prescribed method) and total catches (commercial and recreational catches) gave very different results. For example, the total biomass estimated for 2010 changed from 94kt (commercial catch model run) up to 157kt (total catch model run). "In 2010 these reports were used to construct a time series (ICES, 2010/ACOM:05) of recreational/tourist catches": it's important to show the trend of this time series and to show the row data. The table presented shows only the total catches and commercial catches. Based on this information it appears that recreational catch may comprise up to 25% of the total catch. The RG is agreed with the WG that recreational catches should be taken in consideration for the following assessments.

Information on reference points is not well documented in the assessment or the annex.

Reconsideration of the value of M (currently M=0.2) could potentially improve the assessment.

Technical comments:

- The annex lacked important information: i.e. detailed description of the assessment method (SVPA); the mortality signal in the catch at age matrix; the analyses made for evaluating the Rebuilding Plan; reconstruction of the time series recreational catches.
- A paragraph summarizing the stock status should be included.
- Plot of the weight at age across years should be revised (the table it's not clear).
- Total biomass estimated from the assessment should be plotted as have been done for SSB, $F_{(4-7)}$, and R.
- It's not clear which is the survey mortality regressed against Fs. Was it $Z_{(4-9)}$ or $F_{(4-7)?}$ In figure 2.15 the regression is between $Z_{(4-9)}$ and $F_{(4-7)}$, but in the text this is confusing and should be clarified.
- "The acoustic survey probably has a larger relative uncertainty in later years compared to earlier *because cod now contributes to a lower fraction of the total observed acoustic values*.". It is not clear to the RG why this is, please clarify this point.
- Xsa should be written in capital letters in the text.
- The model used to fit the stock-recruitment curve should be indicated.

Conclusions:

The assessment is consistent with last year's assessment, but not with the annex (the recommended approach (XSA) was rejected). The RG feels that given the problems with the XSA the current assessment using the SVPA method is the best information for advice at this time. The RG is agrees with the WG that recreational catches should be taken in consideration for the following assessments. As highlighted by the WG, there is a high degree of uncertainty in the catch data as well as in the surveys in later years.

Haddock in Subareas I and II (Northeast Arctic haddock; had-arct)

1) **Assessment Type:** Update
2) **Assessment:** Analytical
3) **Forecast:** Short-term and long-term forecasts are presented
4) **Assessment method:** XSA including 4 tuning indices (Russian Bottom Trawl Q4, Joint Barent Sea Survey-acoustic Q1, Joint Barent Sea survey bottom trawl Q1, and Joined Russian –Norwegian autumn survey Q3).
5) **Consistency:** The methods were consistent with the stock annex with one exception. The benchmark suggested using ages 1-2 in the XSA tuning but this assessment used ages 3+. No major trends are present in the retrospective analysis.
6) **Stock Status:** The stock status appears to be acceptable (B > B_{pa}). The fishing mortality rate in relation to precautionary limits is also acceptable ($F<F_{pa}$)
7) **Management Plan:** Reference points were in need of revision based on recent changes to XSA settings and time series data. The WG proposed to keep $\mathbf{B}_{lim}$=50,000 t and $\mathbf{B}_{pa}$ =80,000 t, and proposed $B_{msy}=B_{pa}$. Previous fishing mortality reference values were F_{lim}=0.49 and F_{pa} =0.35. Reference points were re-estimated as F_{lim} =0.77, F_{pa} = 0.47. $\mathbf{F}_{msy}$=0.35 has been estimated by long-term stochastic simulation.

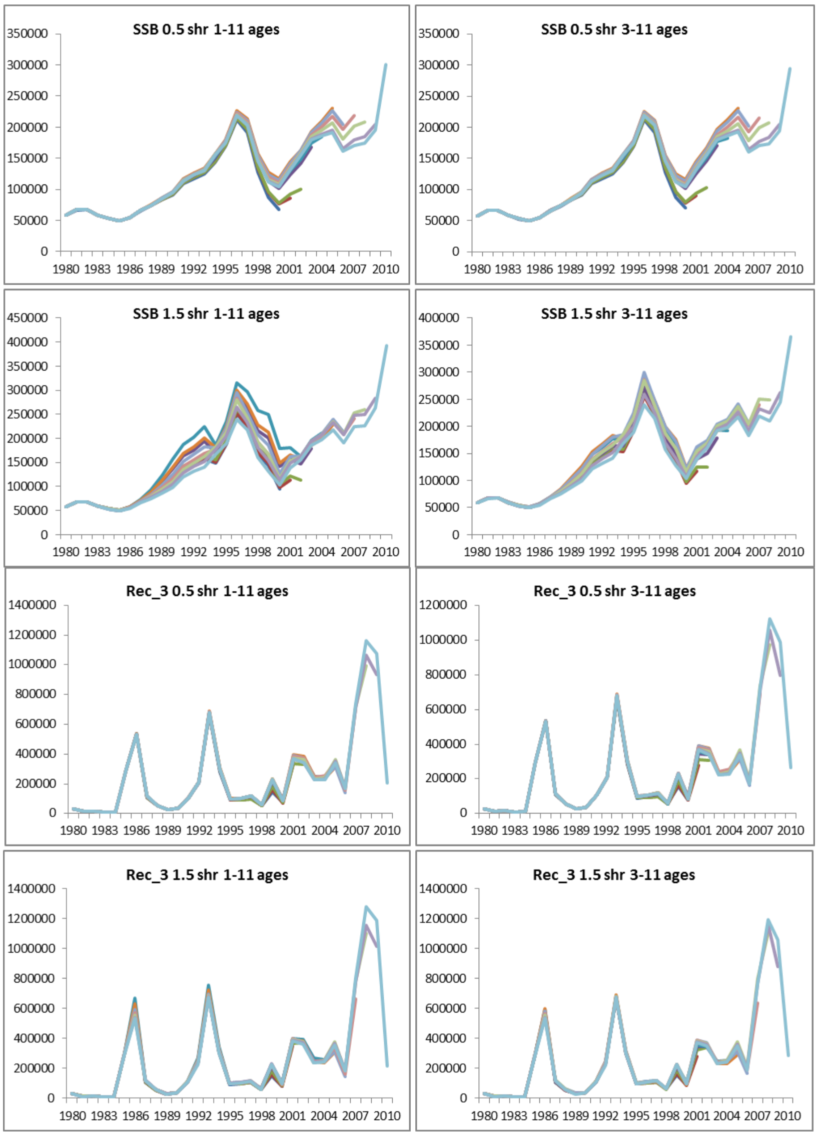
   HCRs state that TAC for the next will be set at level corresponding to F_{pa}, the TAC should not be changed by more than +/- 25% compared with the previous year TAC unless SSB falls below B_{pa}. The current HCR management is based on F_{pa}. However, the WG suggests that since F_{MSY} is now estimated at 0.35, and it seems very appropriate to continue using the HCR with value of target F=0.35. This will correspond to the goal of the management strategy for this stock and will provide maximum sustainable yield.

General Comments:

Overall, most of the relevant information is contained in the document, however the presentation of information was not well organized, which made the assessment hard to follow. Further detail on modelling methods and assumptions is needed.

WG interpretations of the retrospective analyses and stock status are needed. The WG did not discuss the state the status of the stock or retrospective patterns, only figures were provided.

The benchmark agreed to use ages 1-2 in the XSA tuning, but the WG decided not to include these ages in the final model due to changes in retrospective patterns. The WG did not provide strong supporting evidence for this change in method and retrospective patterns did not appear to be improved by excluding ages 1-2 (see figures below). The results of model runs using multiple values for shrinkage are reported, but it was not clear which value was used in the final model run.



Catch at age shows 11+ is larger than 9 and 10 combined with no explanation of why, perhaps extending the age-structure of the model should be investigated.

Weights at age show small growth from 8 to 9 and larger growth from 9 to 10 in recent years (see Table 4.5). This point was not discussed by the WG.

Table 3.1

Age year	3	4	5	6	7	8	9	10	11+
1990	0.793	1.172	1.397	1.624	1.885	2.112	2.653	3.102	3.338
1991	0.941	1.281	1.556	1.797	2.044	2.079	2.311	2.788	3.219
1992	0.906	1.263	1.535	1.747	2.043	2.2	2.298	2.494	2.652
1993	0.94	1.204	1.487	1.748	1.994	2.237	2.417	2.654	3.026
1994	0.614	0.906	1.287	1.602	1.968	2.059	2.39	2.545	2.893
1995	0.739	0.808	1.107	1.556	1.838	2.234	2.416	2.602	3.13
1996	0.683	0.868	1.045	1.363	1.71	1.886	2.214	2.37	2.675
1997	0.682	1.028	1.151	1.369	1.637	1.856	2.073	2.5	2.554
1998	0.748	0.974	1.262	1.433	1.641	1.863	2.069	2.335	2.81
1999	0.826	1.079	1.261	1.485	1.634	1.798	2.032	2.237	2.712
2000	0.853	1.186	1.395	1.588	1.808	1.989	2.264	2.415	2.892
2001	0.751	1.104	1.459	1.709	1.921	2.182	2.331	2.609	2.981
2002	0.687	1.001	1.363	1.643	1.975	2.086	2.294	2.487	2.778
2003	0.594	0.875	1.113	1.364	1.361	1.972	1.636	1.877	2.409
2004	0.636	0.886	1.183	1.508	1.821	2.075	2.339	2.58	2.991
2005	0.722	0.906	1.121	1.343	1.619	2.036	2.177	2.382	2.768
2006	0.745	1.041	1.287	1.504	1.72	2.082	2.377	2.738	3.212
2007	0.652	0.899	1.197	1.435	1.722	1.99	2.309	2.715	3.028
2008	0.658	0.901	1.242	1.515	1.781	2.18	2.33	2.664	3.328
2009	0.707	1.024	1.28	1.538	1.806	**2.107**	**2.398**	2.531	3.172
2010	0.622	0.89	1.124	1.377	1.665	1.982	**2.136**	**2.687**	3.009

- Survey data stops at age 8 with no explanation on why older ages are not included or caught.
- The proportion of M and F before spawning is set to zero (assumes time of spawning is Jan. 1), although the peak spawning occurs in April.

Technical Comments:

- In general, the writing could be improved as there were many typos and unexplained information.
- Ecosystem considerations were not discussed.
- The WG estimated age 3 for recruitment in another program (RTC3) using ages 0-2 from the surveys, but didn't explain how the program was estimating R. Additionally, WG indicated ages 0-2 were not reliable for inclusion in assessment, so it was unclear why this data was used to estimate recruitment.
- $B_{trigger}$ was defined, but not B_{msy}.
- No references and some figures and tables were included but not cited or discussed.
- Figure 4.1B and 4.1D x-axis labels are luttered, the same labels should be used for all plots.
- Figure 4.6 SSQ are mislabelled for b and d, should be SSQ (ages 1-8).

- Table 4.9 is hard to read; there are no labels and no adequate explanation of what is being presented.
- Table 4.10 had -11 values and no explanation of what those indicated.
- Tables 4.11-4.12 and 4.23 had poor print quality
- Table 4.19 didn't define the column labels.

Conclusions:

The assessment has been performed as prescribed in the stock annex (with one exception) and provides a valid basis for management advice. The assessment deviated from the benchmark suggestion to use ages 1-2 in the XSA tuning by using ages 3+. The WG revised F_{lim} and F_{pa} (at the recent benchmark they revised the time series data, but didn't update the reference points) and estimated F_{msy}. The RG agrees with the WG on continuing to use F=0.35 as the HCR target (fishing at F_{msy}) as recommended by the benchmark. There appeared to be some problems with maturity and aging data for this stock and additional sampling could improve this, as well as the catch at age and weight at age information.

Saithe in Subareas I and II (Northeast Arctic; sai-arct)

1) **Assessment type:** Update
2) **Assessment:** Analytical
3) **Forecast:** Short-term forecasts are presented in the assessment (2010-2013) using deterministic recruitment (long-term geometric mean).
4) **Assessment model:** XSA with 4 tuning fleets
5) **Consistency:** The assessment has been performed as prescribed in the stock annex. The stock underwent a benchmark assessment in 2010 and the retrospective patterns (F overestimated and B underestimated) have decreased and moved slightly in the opposite direction after benchmark suggestions were incorporated: (1) expand the catch matrix from 3-11+ to 3-15+, 2) split the tuning series in 2002, and 3) reduce the shrinkage in the XSA and 4) remove the time tapered weighting.
6) **Stock status:** $B>B_{pa}$ (220,000 t) since 1995, $F<F_{pa}$ (0.35) and recruitment is uncertain as fish are inshore to age 3 or 4 and difficult to sample. The WG indicated that "Work is in progress to evaluate the current management plan in relation to the MSY framework."
7) **Management Plan:** Following the advice of ICES, the management plan is a TAC of 173,000t in 2011. The SSB is expected to decrease by 9% in 2011 and to remain above B_{pa} at the beginning of 2012. Reference points are as follows: B_{lim} = 136,000 t and B_{pa} = 220,000 t, F_{lim} = 0.58 and F_{pa} = 0.35.

General comments:

This was a well documented, well ordered and considered section. A section on stock status would be useful as it is of great importance yet this information is spread out in the report and annex.

In the 2010 benchmark several changes were recommended, including expansion of the age span from 11+ to 15+, reconsideration of CPUE data (Norwegian trawl CPUE is now based on data from all quarters and from days with > 20% but < 80% saithe in the catches), split of the two tuning series in 2002, reduction of shrinkage value, and removal of time tapered weighting. These changes resulted in changes in estimated fishing mortality, spawning stock biomass and recruitment, especially in the last part of the time series. Therefore the lim and pa reference points were re-estimated by the 2010 WG. Because the values did not differ much from previous values, the WG decided to continue to use previous estimate of PA reference points to base HCRs. Further, the WG cites that this stock will be transitioning to MSY based reference points (see Section 0-although no section 0 was present in the document). Because the revised reference points are quite similar to the original estimates this does not appear to pose a problem, however the RG does feel that the new values incorporated into management.

As more information is accumulated on the directed fishery for saithe, the directed fishery CPUE should be used, instead of the current basis for CPUE (the Norwegian trawl CPUE on data from all quarters and from days with >20% but <80% saithe in catches).

If discarding is substantial, it may lead to a problem in the assessment and therefore inappropriate management. The information on discards within the assessment was conflicting. The assessment stated that discarding, although illegal, occurs in the saithe fishery, but is not considered a major problem in the assessment. Further text on discards indicates that comparisons of scientific samples from non-Norwegian commercial trawlers indicating that discarding may be substantial in certain areas and seasons. Therefore, it is unclear what impact discards may have on the assessment.

Technical comments:

Two figures (Figure 5.1.1 "last plot to be replaced by correct one" & Figure 5.5.3 "Check if Age can fix legend") need proper descriptions.

Conclusions:

The assessment has been performed as prescribed in the stock annex and provides a valid basis for management advice. The benchmark in 2010 made significant changes to the previous methodology to improve retrospective patterns and more accurately estimate CPUE and these changes were incorporated in this assessment. More information on discarding would be beneficial to future assessments.

Beaked Redfish (*Sebastes mentella*) in Subareas I and II (smn-arct)

1) **Assessment type:** SALY
2) **Assessment**: Trends
3) **Forecast**: Not presented
4) **Assessment model**: N/A – descriptive looked at surveys: (Norwegian-Russian bottom trawl surveys, Norwegian slope survey, Norwegian-Russian ecosystem acoustic survey). A benchmark assessment is scheduled for 2012.
5) **Consistency**: The assessment was performed according to the stock annex. There were no changes from last year – waiting for reference points to be approved and an analytical assessment to be available.
6) **Stock status**: Improved recruitment since 2005 but no official status
7) **Management Plan**: Fishing is banned in Norwegian Economic Zone north of 62N and in the Svalbard area. There are also bycatch restrictions: 15% redfish as bycatch on board at any time. In northeast Arctic 3 redfish/kg shrimp. There is a pelagic fishery in Norwegian Sea outside EEZ 2011, the TAC is 7,900t.

General comments

It is a well organized report. A very detailed description of the surveys is provided. The need for a more detailed assessment approach for managing this species is well argued, considering their vulnerability to fishing pressure with their late age at maturity.

MSY framework should be prepared for review by the benchmark assessment. The WG indicated that F_{MSY} proxies should be in context of YPR and SPR curves and the reproductive capacity of the *S. mentella* stock be at least above 30% of the SPR at F=0. The Review Group agrees that the SPR should be greater than 30%, because meta-analyses of *Sebastes* species suggests that MSY is produced at greater SPR (Dorn 2002 N. Am. J. Fish. Manag. 22: 280-300; Forrest et al. 2010 Can. J. Fish Aquat. Sci. 67: 1611–1634). The discussion of MSY reference points is important and necessary but it is agreed that it is premature as there are no existing reference points.

Potential biological reference points (average biomass level or certain percentage of this level – expressed in biomass units) are discussed but not presented. It is agreed that these need to be constructed before the benchmark in 2012.

Revised catchability of *S. mentella* by the Gloria trawl 2048 not provided – the document states prior to revision it was 100%.

Technical comments

- Information on the GADGET model is given in a completely separate working document not in the stock annex
- In Figure 6.12, the age units on the x-axis are in cm.

Conclusions

The assessment has been performed as prescribed in the stock annex and provides a valid basis for management advice. The recommendation that biological reference point should be constructed is well supported. The unsuitability of XSA and VPA that were experimentally tested is unfortunate, but given the level of survey data available it should be possible to calculate proxies for biological reference points until the GADGET model is examined in the benchmark process.

Golden Redfish (*Sebastes marinus*) in Subareas I and II (smr-arct)

1) **Assessment Type:** Update.
2) **Assessment:** Trends in international catch rates and surveys (Norwegian Barents Sea bottom trawl survey, Norwegian Svalbard bottom trawl survey, and Norway coastal and fjord survey) are analyzed via visual inspection. Additionally, an experimental GADGET model is provided, which is tuned to international landings (1990-2010), Norwegian Barents Sea bottom trawl survey (1990-2010) and the Norwegian coastal and fjord survey (1995-2007). Benchmark to be completed in 2012.
3) **Forecast:** No analytical projections provided.
4) **Assessment model:** Experimental GADGET model reported, but not used for final advice.
5) **Consistency:** The methods are in accordance with the annex and last year's assessment with updates to each of the data sources and revisions of the final landings reported for 2009.
6) **Stock Status:** The status of the golden redfish stock is extremely poor and continues to decline. Surveys and the experimental GADGET model generally show matching trends of steady decline in stock biomass and SSB since the late 1990s. No strong recruitment events have been seen. Landings have been constant over the last 8 years, which has caused an increase in F over that time due to declining biomass. This species is currently on the Norwegian redlist as a threatened species and a population viability analysis done by WKPOOR2 demonstrated that a complete stock collapse was likely in the next 10-15 years with current catch levels.
7) **Management Plan:** No official management plan has been adopted for this species and no regulations existed until 2003. The directed fishery in the Norwegian EEZ is currently banned and a maximum of 15% bycatch is allowed in other fisheries. In international waters a 5 month closed area is enforced from March-April and September, and a 32 cm minimum size is in effect. 2010 landings were calculated at 7,744 tons. It is expected that 2011 landings will be similar as no TAC or new measures have been enacted. The WG suggests that all directed fishing be discontinued for this species.

   No biological reference points have been officially set and no management plan has been developed or reviewed by ICES. Due to redfish being a long-lived species an exploitation rate of 5% of the biomass is presented as a possible PA harvest control rule. Based on experimental GADGET model runs this would correspond to 1,600 tons. MSY reference points were investigated, but final results will not be available until the GADGET model is benchmarked in 2012.

General Comments:

The updated assessment was carried out according to the stock annex for golden redfish. Based on the agreement between survey indices, commercial catch rates, and experimental GADGET model estimates of biomass, the RG agrees with the WG that the update assessment is appropriate. Additionally, since all three sources indicate a steady decline in biomass over the last decade to historically low levels, the RG concurs that the directed fishery should be halted.

The ecosystem document provided for the Barents Sea is extremely thorough and well written. It was quite helpful in understanding the dynamics and interactions between different species and with the environment (this applies to the information provided for all species not just for golden redfish).

One of the main issues facing the assessment for golden redfish is data limitations. For the most part this is due to lack of biological sampling of international fleets (i.e., non-Norwegian fisheries). Although the expansion of Norwegian age-length keys to other fleets and areas is adequate for exploratory analysis, as the WG works to develop an accepted assessment model, an effort should be made to attain age composition, maturity and weight at age samples from other fisheries and geographic zones. The lack of sampling is demonstrated by table 20.1, which shows the data submitted by the various countries that participate in the golden redfish fishery.

Table 20.1

	Kind of data					
Country	Caton (catch in weight) on unidentified redfish	**Caton (catch in weight) on *S. marinus***	Canum (catch at age in numbers)	Weca (weight at age in the catch)	Matprop (proportion mature by age)	Length composition in catch
Norway		**x**	x	x		x
Russia		**x**				x
Germany	x	**x**[2]				x
United	x	[1]				
Kingdom	x	[1]				
France	x	[1]				
Spain	x	[1]				
Portugal	x	[1]				
Ireland	x	[1]				
Greenland						
Faroe Islands[1]	x	[1]				
Iceland						

[1] As reported to Norwegian authorities during the fishery (only for the Norwegian Economic Zone and Svalbard)

[2] Irregularly

The difficulty in species identification, especially at younger ages, between golden redfish and beaked redfish also remains an issue facing future development of stock assessment models for golden redfish. The beaked redfish stock is estimated to be upwards of 50x's larger than that of golden redfish. This discrepancy means that even slight misidentification can cause huge impacts to biomass trends for golden redfish if even small amounts of misidentification occur. False recruitment trends are a particular area of concern if juvenile fish are being misidentified. The WG is well aware of this issue and appears to have a handle on it; however, work should continue on this problem. Also, increased sampling of the catch in international waters should be undertaken so that catch weight by redfish species is submitted by all participants in the fishery instead of submitting catch weight by unidentified redfish species (see table 20.1).

Due to the limit on percent bycatch allowed in non-direct fisheries, the amount of discards and underreporting may become a concern for golden redfish. It is quickly becoming a key choke species within the Barents Sea ecosystem especially in the bottom trawl and shrimp fisheries. It is important that future management measures consider these factors and that future assessments consider the impact of discards/underreporting on projected biomass. Considering the current level of biological sampling on the international fisheries, it is unlikely that there will be a very good handle on discarding rates in the future. If this is the case, future assessments should consider running sensitivity runs to assumed discards.

Even though the GADGET model was not used for the final advice, it would be helpful to provide figures and tables of model fit. It is difficult to assess how well the model is performing without any diagnostic plots of residuals or fit to catch and maturity data. The only diagnostic presented was the fit to the surveys, but even for these no tables were provided with residuals values, etc… In addition, a table of model weights for each of the data components along with total model fit and parameter estimates would be appropriate. It is impossible for a reviewer to determine how the model is behaving when basic estimates (e.g., fishery and survey selectivity) are not presented.

Technical Comments:

- Due to the importance of the biology of redfish to how it is managed and assessed, it would be helpful if a detailed account of its life history is presented. Any information on spawning patterns, maturity rates, and life expectancy would be of use to the reviewer.
- A detailed map explaining the fishing and spawning grounds for redfish in the Arctic/Barents Sea would help reviewers better understand the dynamics and interplay of the redfish's life history, fishing fleet, and surveys. It would also be useful to include spatial closures on the map and a map of fishing effort by the various fleets.
- A graph of the weight at age would be helpful to better discern any trends over time.
- Although the assumptions used for golden redfish within the GADGET framework are well presented, it would be helpful to provide some of the basic formulas/modelling framework within the annex. This would help the reviewer become acquainted with how GADGET generally works without having to become bogged down in the GADGET technical document, and it would help to demonstrate how the model is being tweaked to fit the golden redfish stock.

Conclusions:

The assessment has been completed according to the stock annex provided for golden redfish. Based on the steady biomass decline seen in surveys, commercial catch rates, and the experimental GADGET model, along with relatively constant total catch in the fishery despite these indications of stock decline, the RG agrees with the WG that the directed fishery should be halted. The 2012 benchmark should help in finalizing an analytical assessment framework, which will allow reference points to be developed. Although a number of data issues remain (e.g., species misidentification and low sampling outside of the Norwegian fleets), the WG is aware of these and is working to resolve the issues. However, moving forward it is recommended that consideration of the possibility of discards and underreporting be seriously considered due to the low, and likely decreasing, bycatch allowances of golden redfish in the trawl and shrimp fisheries. It is probable that *S. marinus* will become a key choke stock in the ecosystem, and reporting of actual landings will likely decrease if catch of this species limits fishermen from attaining TACs of targeted species.

Greenland halibut in Subareas I and II (ghl-arct)

1) **Assessment Type:** Update
2) **Assessment:** Trends
3) **Forecast:** Not presented
4) **Assessment Model:** XSA (Ages 5+) - Exploratory run used only to view trends in the stock
5) **Consistency:** The assessment method is generally consistent with the methods presented in the stock annex; however a short term forecast was not presented in the assessment (but was specified in the annex). There are retrospective patterns in the assessment (F tends to be overestimated while SSB tends to be underestimated).
6) **Stock Status:** The primary result from the assessment is that the total stock has been increasing since 1992. No formal reference points have been established.

   The female spawning stock has decreased in 2005-2009 and increased again in 2010. The total stock was at a historical minimum in 1992 (46,000 t) and has been increasing since then, with the highest estimates at about 211,000 t in 2010.
   Recruitment-at-age 5 in this year's assessment shows a marked increase from 2007 to 2009. The 2009 level of 49 millions specimens is about twice the long-term average (table 8.15). In 2010 the Recruitment-at-age 5 is 32 million.
7) **Management Plan:** The advice for the fishery in 2011 is the same as the advice given for the 2010 fishery: "The stock has remained at a relatively low size in the last 25 years at catch levels of 15 000–25 000 t. In order to increase the SSB, catches should be kept well below that range. Catches should be below 13 000 t as advised since 2003; this is the level below which SSB has increased in the past".

   However, the 38th Session of the Joint Norwegian-Russian Fisheries Commission in 2009 decided to cancel the ban against targeted Greenland halibut fishery and established a TAC at 15,000 t for next three years (2010-2012). The TAC was allocated between Norway, Russia and other countries with shares of 51, 45 and 4% respectively.

General Comments

The report is well written and organized. Problems were highlighted, and useful recommendations to improve the assessment were presented. A detailed description of the available data was provided.

Catch in 2010 exceeded the ICES management advice by 20% due to increased Russian catches that were in accordance with a new quota system. Limits set by the joint Russian-Norwegian Fisheries Commission are not consistent with ICES advice.

The WG report states that discards are not regarded as a problem at present, but it is believed that there may be additional landings that are not reported. Greenland halibut is caught in mixed-species fisheries for which the regulations on bycatch are as follows; during fishing for other species it is permitted to have an intermixture of Greenland halibut of up to 7% by weight on board at the end of fishing operations and in the catch landed. Bycatch of up to 12% by weight of Greenland halibut is permitted in individual catches. This implies that up to 5% of the catch is likely discarded. Based on this information the RG is concerned discards may be a problem.

It is not known which age should be used for a reliable recruitment estimate. The relative size of the individual year classes is still poorly estimated, especially at ages below 5 years.

Comparisons of commercial CPUE between periods several decades apart may not be valid because of the 'technology creep' in fisheries. It is not clear if the CPUE data has been standardized.

"When comparing the CPUE between years the effort level should also be taken into account". – This statement is not clear.

"The maturity ogives used has shown a very variable maturity by age in the recent years and this affects the SSB". Further explanation of the problems with the ogives should be presented.

Little is known about stock structure, stock delineation, distribution, and migration dynamics of the stock into other management areas. There is uncertainty concerning potential exchange between the Greenland halibut stock in the NEA and another stock in the Faeroe Islands- Iceland area and Greenland

Although there is a continuous distribution of this species from the southern part of Division IIa along the continental slope towards the Shetland area, little is known about the stock structure and the catch taken from this area has therefore not been added to the catch from Subareas I and II.

The assessment is still considered to be uncertain due to the age-reading and input data quality problems. This is in some part due to change in age reading procedure. New Norwegian age readings are not comparable with older data or the Russian age readings. (Excerpt from assessment; Based on scientific presentiment that the species is more slow growing and vulnerable than the previous age readings suggest, the Norwegian age reading were changed in 2006. The new Norwegian age readings are not comparable with older data or the Russian age readings).

The assessment was "accepted as indicative for stock trends" – it is unclear what this entails with respect to management advice and future assessments. It is unclear to the RG why an age-based assessment, that assumes no error in the catch-at-age, is used when there are significant documented problems with the aging and sampling protocols. The XSA has been accepted "as indicative of trends". Limited explanation of the utility of using the XSA was provided.

There are retrospective patterns in the assessment. Fishing mortalities tend to be overestimated while SSB tends to be underestimated, and recruitment tends to be overestimated in some recent years. (WG made this comment last year the reply was "Retrospective patterns appear in the most of stock's assessments")

Figure 21.1 Retrospective analysis

The assessment states that the peculiar biology for the species needs to be taken into account, such as sexual dimorphism in growth and maturation also noted in the Report on 3-year (2007-2009) joint research program (Albert et al. 2010). No further discussion on this point was pursued.

Natural mortality was assumed to be 0.15, however, no justification or explanation of this decision was made. In general a more detailed description of assumptions should be provided.

Most of the surveys considered by the Working Group covered either the adult population in the slope area or juvenile distribution in northern areas. The problem of underestimation of recruitment in the last few years included in the analyses was attributed to shortcomings in survey coverage.

Although representing a larger part of the stock, the new combined survey indices were not successful in establishing consistency in the relative size of year classes at age. Future inclusion of northern parts of the Russian zone may improve the index. The Working Group has advised that further work should be done to improve the combined index with regards to pooling different surveys using different gears.

The Ecosystem survey is not considered optimal for surveying 0-group Greenland halibut, it is not clear why within the assessment document.

Technical Comments

- In Section 8.1.1 the report suggests that "For most countries the catches listed in the tables are similar to those officially reported to ICES". For what countries are the reported numbers different than those presented in the tables. Is this important to the assessment or management?
- No reference points were provided (none have been defined for this stock)
- It is suggested in the report, section 8.1.4, that there are unreported landings, but no further information is provided.

- Figure 8.8 is not referenced in the text of the assessment document
- A short term forecast was not presented, this is inconsistent with the methods described in the annex

Conclusions

The assessment has been performed as prescribed in the stock annex (with one exception) and provides a valid basis for management advice. The only exception was that no short term projections were presented in the assessment. Based on the acknowledged issues with aging and sampling the utilization of trends seems appropriate for providing advice.

Norwegian/Russian request – Arctic fisheries

The RG endorses the two recommendation of the WG in response to the request from the Joint Russian-Norwegian Fisheries Commission (JRNFC) to a) report on the possibility of conducting continuous monitoring of the migratory pattern in the Arctic Ocean of fish stocks (referred to above) managed by the JRNFC, and b) facilitate future monitoring and research of fish stocks in the Arctic Ocean by anchoring the matter in the mandate of an existing ICES Working Group or in the establishment of a new Working Group.

The WG stated:

Concerning a), it is possible to monitor the geographic distribution of these stocks in the ice-free parts of the Arctic Ocean once a year, using existing survey methodology. The Joint Ecosystem Survey in August/September (Anon. 2010) already covers the Barents Sea north to 80-81°N, and there is also additional Russian coverage of the Greenland halibut distribution in the North-eastern Kara Sea. These surveys could be extended into the Arctic Ocean if possible (depending on ice conditions) and if additional funding is provided.

Concerning b), we advise that future requests to ICES concerning monitoring and research of fish stocks in the part of the Arctic Ocean adjacent to the Barents Sea should be handled by the Arctic Fisheries Working Group, since the stocks handled by AFWG are those that are most likely to migrate into the Arctic Ocean. A new organization might be appropriate if there are fisheries issues that engage more countries around the Arctic Ocean.