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ICES
International Council for the Exploration of the Sea

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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 1995-2009 as well as catch at age data. This year, a new catch series for recreational and tourist fisheries was presented to the Working Group.

- 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.
- Norwegian authorities have proposed a rebuilding plan for this stock, and this plan was tested by the Working Group.

Cod in Sub-areas I and II (Northeast Arctic) was assessed using XSA with the same settings as in the 2009 assessment.

- The fishing mortality (F_{5-10}) has declined since 2005 and is estimated to 0.28 for 2009. This is the lowest since 1990. Estimated SSB for 2009 is 1,070,000 t. This assessment represents 1% downward revision of the 2009 SSB and a 10% upward revision of F in 2008.
- The new "hybrid" recruitment model, introduced in 2008, was used, resulting in recruitment at age 3 of 384 million in 2010, 465 million in 2011 and 484 million in 2012.
- The managers introduced a new element in the HCR when setting the TAC for 2010: A lower limit on F (0.30) when SSB is above B_{pa}. This amended HCR was tested and found to be consistent with the precautionary approach.
- A catch in 2011 corresponding to the amended HCR is 703,000 t. This catch corresponds to a fishing mortality of 0.30 in 2011. SSB is estimated to increase from 1,145,000 t at the beginning of 2010 to 1,488,000 t in 2011. Such high SSBs have previously only been observed in the late 1940s. Earlier maturation means that a larger proportion of the total stock is spawners now compared to these early years.

IUU-catches amounted to near 30% of the international reported catch in 2005 but have since declined and were set to zero in 2009.

Haddock in Sub-areas I and II (Northeast Arctic) was assessed using XSA with the same settings as in the 2009 assessment.

- Previously (1950-2000) the fluctuation in the haddock stock have shown strong cyclic pattern caused by spasmodic recruitment, where 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 (F4-7) in the last three years has declined somewhat and is in 2009 estimated to 0.31. The current assessment estimated the total stock to be about 6 % lower and SSB 17 % lower in 2009, compared to the previous assessment.
- In the projection RCT3 was used to estimate recruiting year classes from 2007 and onwards. The results indicate that the 2007 and 2008 year classes are below average, while the 2009 year class is above average.
- A catch in 2011 corresponding to the evaluated and agreed HCR is 303,000 t. This catch is likely to keep the fishing mortality in 2011 at ap-

proximately 0.31. SSB is expected to increase considerably until 2012, while the total stock biomass will decrease from 2010 onwards. The 2010 total stock biomass of 1.1 million is the highest observed in the time series, which goes back to 1950.

The assessment of haddock is uncertain, and XSA is sensitive to settings which can give different perception of 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.

IUU-catches have been high in recent years, but have since declined and were set to zero in 2009.

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

The last benchmark assessment was done at WKROUND February 2010. 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 downweighting

This resulted in changes in estimated fishing mortality, spawning stock biomass and recruitment, especially in the last part of the time series.

- In the projections the GM age 3 recruitment of 169 million was used for the 2006 and subsequent year classes.
- A catch in 2011 corresponding to the evaluated and implemented HCR is 173,000 t. This catch corresponds to a fishing mortality of 0.31 in 2011. SSB is estimated to decrease from 416,000 t at the beginning of 2010 to 357,000 t in 2011.

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.

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 sixth 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 1986–2009 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

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 was repeated. Stock trends in recent years indicate a slight increase in stock size. There is no accepted analytical assessment for the time being. It is hoped that the age reading workshop to be held in 2011 will lead to agreement on age reading methodology

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

0 Introduction

0.1 Participants

Asgeir Aglen	Norway
Ricardo Alpoim	Portugal
Matthias Bernreuther	Germany
Mette Bertelsen	ICES
Bjarte Bogstad (Chair)	Norway
Vladimir Borisov	Russia
Oleg Bulatov	Russia
Tatiana Bulgakova	Russia
Mikel Casas	Spain
Anatoly Chetyrkin	Russia
Gjert Endre Dingsør	Norway
Konstantin Drevetnyak	Russia
Anatoly Filin	Russia
Åge Fotland	Norway
Harald Gjøsæter	Norway
Elvar Halldor Hallfredsson	Norway
Daniel Howell	Norway
Yuri Kovalev	Russia
Sigbjørn Mehl	Norway
Kjell H. Nedreaas	Norway
Dmitry Prozorkevich	Russia
Jon Ruiz Gondra	Spain
Alexey Russkikh	Russia
Oleg Smirnov	Russia
Jan Erik Stiansen	Norway
Knut Sunnanå	Norway
Ross Tallman	Canada
Oleg Titov	Russia
Natalia Yaragina	Russia

0.2 Locations of the meting

Due to the problems with air traffic in Europe in April 2010 caused by ash from the volcanic eruption in Iceland, only some members of the WG managed to reach the meeting venue in Lisbon. A number of participants, including the Chairman, met in Bergen, while other participants stayed at home at the national laboratories. The meeting was carried out using communication via Internet (e-mail, Sharepoint, the ICES WebEx conference system). We are very grateful to the ICES secretariat for their assistance with use of WebEx. It is not recommended to carry out WG meetings in this way.

0.3 Terms of reference

The **Arctic Fisheries Working Group** [AFWG]: (Chaired by: Bjarte Bogstad, Norway) will meet in Lisbon, Portugal, 22–28 April 2010 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.

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 6 May 2010 (and 7 October 2010 for Barents Sea capelin) for the attention of ACOM.

FishStock	**Stock Name**	**Advice**
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
sai-arct	Saithe in Subareas I and II (Northeast Arctic)	Update
cap-bars	Capelin in Subareas I and II (Barents Sea), excluding Division IIa west of 5°W	Update
ghl-arct	Greenland halibut in Sub-areas I & II	Same advice as last year
smn-arct	Redfish *Sebastes mentella* Subareas I and II	Update
smr-arct	Redfish *Sebastes marinus* Subareas I and II	Same advice as last year

In addition, AFWG has received the following two requests from the Norwegian Ministry of Fisheries and Coastal Affairs:

1) According to paragraph 5.1 of the protocol of 38th session of the JNRFC, the parties discussed the possibility of an amendment of the management plan for the Northeast Arctic cod, to secure a more suitable management regime in periods of strong growth or reassessments of the stock size.

The parties agreed to:

a) a) Establish a management criterion which introduces a minimum fishing mortality rate (F) of 0.30 - effective from 2010.

b) b) Request the ICES to confirm that the additional criterion is in line with the precautionary approach, and provide future advice according to the revised management plan.

This new management criterion does not apply if the spawning stock biomass falls below B_{pa}. For further details regarding the management plan and implementation of the new criterion we refer to Annex 14 of the protocol of the 38th session of the Joint Norwegian-Russian Fisheries Commission.

The Norwegian Ministry of Fisheries and Coastal Affairs - representing the Norwegian party in the JNRFC - would like ICES to comment on the agreed upon amendment to the Northeast Arctic cod management plan, as anchored in the protocol and described above.

2: To evaluate whether the adopted rebuilding plan for Norwegian coastal cod is consistent with the Precautionary Approach. If this is not the case, or if the basis for evaluation is unsatisfactory, further advice for modifications or alternative plans is requested. The rebuilding plan is as follows:

"The overarching aim is to rebuild the stock complex to full reproductive capacity, as well as 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.

Generic ToRs for Regional and Species Working Groups

The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGHMM, and WGANSA.
The working group should focus on:
ToRs a) to h) 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 and the regional overview according to ACOM guidelines.
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).

1 The average survey index in the years 1995-1998
2 Ages 4-7

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

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 2011 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

h) Set MSY reference points (F_{MSY} and MSY $B_{trigger}$) according to the ICES MSY framework and following the guidelines developed by WKFRAME.

0.4 Unreported landings

In previous years, estimates of unreported landings of cod and haddock have been made separately by Norway and Russia. This year, a report from the Norwegian-Russian analysis group dealing with estimation of total catch of cod and haddock in the Barents Sea in 2009 was presented to AFWG (WD13). The report present 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 2009 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.

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.

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.

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 have again been 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 2008-2010.

From 2004 onwards, a new 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 a bottom trawl survey and an acoustic survey for the all species, witch available for assessment, include not 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 (WD20). 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 all area of fish distribution in the Barents Sea, and addition data on 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, Greenland halibut and capelin otoliths. Once a year (for capelin every second year) 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 <u>within</u> 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 bi-annual, while otolith exchange will take place annually.

The otoliths of Greenland halibut are not easy to read especially for older fish. Consequently the readers have difficulties in interpreting real age zones when the fish become older than 5 years (e.g., AFWG 2005, WD 8). Previous comparative readings among three Norwegian age readers, and also between Russian and Norwegian age readers show good agreement and low CV. However, even with acceptable between reader precisions, there are strong evidences of low accuracy of the age estimates displayed by IMR (Norway). Since 2006, validation work has been continued (Albert et al. 2009) and the Norwegian age readings have been done using the new approach described in the AFWG 2006 report. The validation work continues and in the future the historic time series might eventually be converted to the new age understanding. However, this work is very time consuming and it is difficult to estimate when a full assessment can be conducted using the new approach.

This has caused that only the recent Russian age readings provided by PINRO have been comparable with the historic data series and used for "illustrative" assessment in 2006-2010. It should be noted that VNIRO (Russia) consider that traditional age readings are valid for fish up to 60 cm length (Kuznetsova, WD 25).

An ICES Workshop on Greenland halibut age reading will take place in February 2011. Hopefully, during this workshop scientists from different institutes will get an agreement on Greenland halibut growth rate.

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.

From 2009 onwards, an exchange of *Sebastes mentella* otoliths is conducted annually between the Norwegian and Russian laboratories.

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.

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.

0.6 Climate included in advice of NEA cod

For the third 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 2011–2012

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

FishStock	Stock Name	Advice in 2011*	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	-	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	Same advice as last year	-	-
smn-arct	Redfish *Sebastes mentella* Subareas I and II	Same advice as last year	-	2012
smr-arct	Redfish *Sebastes marinus* Subareas I and II	Same advice as last year	-	2012

A benchmark assessment will be planned for Greenland halibut after the age reading workshop, which will be held in February 2011. Such a benchmark assessment should also include the other Greenland halibut stocks.

0.8 ICES Quality Handbook

Quality Handbooks for all stocks except Barents Sea capelin are presented in this report as annexes (no. 2-8). For capelin, the stock annex is being updated following the comments made during WKSHORT in 2009 and will be ready before the capelin assessment in autumn 2010. The stock annex for saithe has been updated after the benchmark at WKROUND 2010. For *S. mentella*, some information on the fishery in International waters in the Norwegian Sea has been added.

0.9 InterCatch

The assessment of NEA cod, haddock and saithe was based on output from InterCatch. In the future, AFWG will consider using Intercatch also for the other stocks. It was noted that Intercatch at present does not allow for catches of more than one stock of a given species in a given area (e.g. Coastal cod and Northeast Arctic cod in ICES area IIa).

0.10 MSY-related reference points and advice

Summary

The AFWG has no difficulty in principle with moving to an MSY based fishery, and considers this to be a valuable extension to the existing precautionary-based approach. However we note that the ICES advice for conducting such assessments has only been available recently (and indeed may still be subject to change). We feel that conducting MSY assessments is an involved and complex task, which requires a consideration of the management rule as a whole, and not merely “target F”. As such we feel that insufficient time has been available to conduct such assessments at the 2010 WG. The volcano-related travel difficulties that affected this WG have further reduced the time available. We present below the background to our conclusions, and highlight the work that has already been done which could lead to MSY advice in future years, together with the areas that have been identified as requiring detailed consideration for each stock. We would also note that the stocks covered by the AFWG are managed by the Russian and Norwegian governments, neither of whom has requested a move to MSY-based advice in 2011. We believe, in keeping with the view of the Norwegian government, that a move to MSY advice is valuable, but that such a change needs to be well thought out and planned, and not rushed through without due consideration. This is especially important in the AFWG context given that successful management plans are in place for the most commercially important species, and we would be reluctant to provide hasty and under-researched advice that could jeopardize the current successful management of these stocks.

Background

The generic ToR h) says: Set MSY reference points (F_{MSY} and MSY $B_{trigger}$) according to the ICES MSY framework and following the guidelines developed by WKFRAME. In general terms, ICES is aiming at changing the basis for its advice from F_{pa} - B_{pa} to F_{MSY}, combined with a trigger spawning biomass ($B_{trigger}$). The significance of $B_{trigger}$ is that, if a stock is assessed to be below this level, the F for the advice is reduced linearly with SSB.

WKFRAME has given guidelines for calculating FMSY and MSY $B_{trigger}$. Also, AFWG has been requested by the ICES secretariat to provide catch options according to F_{MSY}/ MSY $B_{trigger}$ as well as catch options in accordance with the adopted EU plan to move stepwise towards these reference points in such a way that they are reached in 2015. However the complete set of guidelines from WKFRAME was not available until just before the start of the meeting, giving little time for consideration of MSY issues.

Also, in early May 2010 there will be an advisory group meeting on MSY advice (ADGMSY) which will further consider how to incorporate MSY-based approaches into the ICES advice giving process.

AFWG specific issues

In contrast to some other areas, many of the major stocks in AFWG are currently at or near historical maximums, and are successfully managed by existing harvest control rules. There is therefore a desire among both scientists and managers to be cautious in moving away from what has proved to be highly successful management regimes

The stocks assessed by AFWG are managed either by Norway alone (coastal cod and saithe) or through the joint Norwegian-Russian Fisheries Commission (NEA cod and haddock, *S. marinus* and *S. mentella*, Greenland halibut, Barents Sea capelin).

In a letter sent to ICES in April 2010, The Royal Norwegian Ministry of Fisheries and Coastal Affairs states that

"…When management authorities request advice according to a management plan which ICES considers being consistent with the precautionary approach, ICES provides such advice. This is the existing situation for the majority of stocks managed by Norway in cooperation with other parties, and Norway has not signaled that any of these plans have yet ceased to exist.

Norway will, in collaboration with the relevant partners, evaluate which revisions are necessary to ensure that the long term management plans provide for maximum sustainable yield. To this end we would welcome any information ICES may have to guide us in the right direction. But as the existing management plans still remain in force, such new information should be given as information or catch options.

Furthermore, as there is a need to anchor the MSY-concept stronger and discuss the short-term consequences amongst the relevant management authorities, I believe it is premature to change the default advisory framework in the advices for 2011."

AFWG has not received any requests from the Russian Federation on the transition to MSY-based advice. AFWG has been informed by ICES that for stocks for which there are agreed management plans the advice for 2011 should be given in accordance with those management plans.

In addition it should be noted that the way the AFWG was carried out this year, with people distributed around Europe, limited the amount of work that could be carried out by the WG.

MSY-related studies for AFWG stocks

Although we have not been able to give MSY advice during the time period of this meeting, it should be noted that for some stocks, a notable amount of MSY-related studies have already been carried out. This work provides the basis on which the WG could move towards giving MSY based advice, if required by the Norwegian and Russian governments. The AFWG stocks can for the purpose of calculating MSY reference points be divided into 4 groups:

- Stocks for which there is an accepted analytical assessment and an agreed HCR: NEA cod, haddock, saithe
- Stocks for which there are catch-at-age data and reasonable confidence in age readings, but no accepted assessment: Coastal cod, *S. marinus*, *S. mentella*
- Stocks for which the age reading methodology is under revision (Age Reading Workshop to be held in 2011): Greenland halibut
- A short-lived stock with survey-based assessment and an agreed HCR, and for which a single-species MSY is meaningless since predation from cod and other predators is much larger than the fishery: Barents Sea capelin.

For NEA cod, haddock and saithe, there is an accepted analytical assessment and an agreed HCR. All HCRs are similar: F=constant above B_{pa}, and F is reduced linearly from this value at B_{pa} to 0 at SSB=0. In addition there is a constraint on annual variation in TAC (cod: 10%, saithe, 15%, haddock: 25%). This constraint is suspended when SSB is below B_{pa}. For cod and saithe, the anticipated stock development 3 years into the future is taken into account when calculating the TAC. For all stocks, long-term simulations (100 years) using a detailed biological model with stochastic stock/recruitment and density-dependent growth and maturation were used to evaluate whether the HCR is precautionary. For cod, cannibalism was also included in the model. Such simulation models seem to be appropriate to use for MSY studies of these stocks, rather than calculating MSY based on Y/R and SSB/R analyses.

For cod, Kovalev and Bogstad (2005) found that FMSY is in the range 0.25-0.60, where the yield curve is fairly flat (yield in this range within about 80% of maximum yield), the exact shape is dependent on the biological model used (density-dependent or not, choice of cannibalism model etc.). It should also be noted that Kovalev and Bogstad (2005) found that shifting the exploitation pattern one age group upward would increase the yield, this finding is consistent with other studies (see Kvamme and Bogstad 2007 and references therein). Skagen (2010 WKFRAME WD) found similar results. For this stock, and several other cod stocks, WGSAM (ICES 2008) found that the high yields predicted at low F by single-species models are almost certainly unrealistic, as these will be 'eroded' by predation pressure and density-dependent growth reductions. For NEA cod, using the SSB/R at $F_{0.1}$ and mean recruitment when the SSB is above B_{lim} (Figures from 2007 advice report used by ICES WGSAM 2008), gives a SSB of 4.9 million t. This is about four times the historical maximum of 1.2 million t, so $F_{0.1}$ should not be considered a candidate F_{MSY} reference point. Also for F_{max} values considerably above the historical maximum were obtained (Section 3). For this cod stock much work has also been done on estimating fecundity and thus total egg production (see recent overview in Morgan et al. 2009) which may affect both fishing mortality reference points and biomass reference/trigger points. This body of work neatly encapsulates the idea that blindly running different values of F through simulations models without considering the wider issues can give results that are highly misleading, and could risk damaging the currently successful management of this stock.

For haddock and saithe, MSY information can similarly be derived from simulations done during the evaluation of whether the HCR for these stocks are precautionary (see AFWG 2006 for haddock and AFWG 2007 for saithe). The yield vs. F curve is rather flat on the top for both stocks. Also, for both stocks, the biological model should be re-visited before any MSY reference points for advisory use are calculated. The reason for this for haddock is the recent strong recruitment and following all-time high biomass level, which may alter our perception of the stock dynamics. For saithe, the PA reference points were recalculated at AFWG 2010 due to the extended age range to be used in the assessment (see WKROUND 2010), and this may also alter our perception of the stock dynamics and require new simulations to be made. For saithe we advise not to change the numerical F_{pa} and B_{pa} values used in the HCR this year, but rather revisit the HCR next year and evaluate it both from a precautionary and MSY point of view.

For the redfish stocks, there are no biomass-based reference or trigger points or management plans. Development of U-type (survey based) biomass reference points has been supported by ACOM. F-based reference points for *S. mentella* were estimated by WKFRAME. For both stocks, AFWG chose not to suggest any of these as F_{MSY}. One reason for this is that the shape of the growth curve at older ages is uncertain, and this shape strongly affects the yield calculated at low fishing mortalities. It should also be noted that current exploitation rates are well above F_{pa}, and thus well above the lower F_{msy} levels. It is of questionable utility to provide F_{msy} estimates for fisheries in which even the more modest F_{pa} targets cannot be met.

For coastal cod, there are reasonable data for weight and maturity at age so F-based reference points have been calculated, but no reliable stock/recruitment data. For this stock we have evaluated the proposed rebuilding plan this year. This plan is not linked to a TAC-based or effort-based management, but MSY studies will give knowledge on whether the rebuilding plan is appropriate. Again, providing F_{MSY} values is not urgent given that a rebuilding process is required before the stock can even approach MSY levels.

For Greenland halibut, the managers have agreed upon a fixed yearly quota for the period 2010-2012, and the advice should not be updated this year. The calculation of MSY reference points for this stock will be postponed until after the upcoming age reading workshop in 2011.

For capelin, the agreed HCR is that with 95% probability, at least 200 000 tonnes (B_{lim}) should be allowed to spawn (see Chapter 9 for details). There is no B_{pa} and no F-based reference points. MSY has been investigated by Tjelmeland (2005), using the multispecies model Bifrost. He found that the MSY reference point of capelin (target SSB) depends markedly on the harvesting strategy chosen for cod and herring, which both have strong biological interactions with capelin. Thus, calculating a single-species MSY for capelin is meaningless. The capelin MSY could be calculated given on the agreed HCRs for cod and herring, and one could then investigate whether the MSY for capelin would change considerably if the harvesting strategies for cod and herring vary e.g. within the intervals corresponding to yields > 80% of the MSY for herring and cod. In the MSY concept paper (WD to WKFRAME 2010), it was stated that the framework outlined there for calculating MSY-based reference points was not applicable for short-lived stocks with a target escapement strategy. WKFRAME did not touch upon this issue.

General comments on the MSY approach

AFWG also has some comments on the MSY approach in addition to the contents of the WKFRAME report. Most of these are taken from the final report of the EU UNCOVER project (2006-2010).

It should be noted that MSY should by definition mean the maximum sustainable yield that can be obtained from a given stock. An approach that merely involves varying the target F and BMSY trigger within existing management rules will not, in general, give a MSY fishery. We would also be concerned at an approach that focused only on SSB; when looking at e.g. carrying capacity and not only reproductive potential, total stock biomass (TSB) is just as relevant as SSB and should also be considered in the analysis.

The first point that needs to be made explicit in each and every MSY management rule is that MSY management does not replace the precautionary approach to fisheries management, rather it incorporates and extends it. A management rule that leads to long term reductions of the stock will also lead to reductions in the catches, and is thus by definition not a MSY strategy. A logical consequence of this is that a MSY-based rule should include definitions of where the stock is considered to be at risk of being depleted (i.e. of causing recruitment overfishing), and what remedial action should be taken in this case. This is especially important given the increased uncertainties involved in MSY assessments. MSY fishing should be considered to be "precautionary plus", incorporating and extending the precautionary approach to fisheries, and retaining precautionary biomass limits.

The recommendation, in the absence of an estimated F_{MSY} or lack of a stock-recruitment relationship is to utilise F_{max} or $F_{0.1}$ as a proxy does not appear to be justified. F_{max} is at present determined by ICES WGs ignoring density dependent effects on growth and mortality (including cannibalism) making its utilization questionable. Additionally it is usually very hard to determine the exact value of F_{max} in any given model simulation, as curves tend to be very flat topped. Taking a point where the upward slope tends to the asymptote (such as $F_{0.1}$, the point at the slope is 10% of the maximum), could seem like a good alternative to F_{MSY} in terms of yield, while being precautionary in terms of the stock dynamics. However, for several stocks, combining Y/R at $F_{0.1}$ with average recruitment for spawning stock size above B_{lim} would give a stock size way above what has been observed (see e.g. ICES C.M. 2008/RMC:06) and thus the yield and biomass indicated by such calculations may not be realistic to reach.

We suggest that the default approach to calculating F_{MSY} should be to base it on simulations of long-term stock dynamics incorporating stock recruitment relationships, density dependent growth and mortality, including uncertainty, environmental issues and possible multispecies effects. Work is therefore required which effects are likely to be of significance for a given stock (environment change, multi-species, mixed fishery,…), and how to include these in the simulations. These simulation results should then also be used to deduce the time intervals for re-assessing target F and B's. It may be questionable whether it is justified to calculate point estimates of FMSY, giving a range for which the yield is within 80-90% of the maximum yield (taking into account model uncertainty, choice of length of time series in calculation etc.) could be more appropriate.

0.11 Recommendations

AFWG has two recommendations:

A benchmark meeting for all redfish stocks should be held in 2012.

A workshop on methods estimating recruitment for Northeast arctic cod should be held before the AFWG meeting in 2011.

0.12 Time and place of Next Meeting

The Working Group proposes to meet next time in Hamburg in the period 5-11 May (alternatively 28 April-4 May) 2011.

1 Ecosystem considerations (Figures 1.1–1.18, 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 a steadily 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 participate in the development of an ecosystem based management of the Barents Sea.

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 contributes 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, inter-species 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 a preliminary version of the 2009 update (Stiansen *et al.*, WD23) of the "Joint Norwegian-Russian environmental statutes 2008, report on the Barents Sea Ecosystem" (Stiansen *et al.*, 2009), affiliating more than 100 scientists from 24 institutions in Norway and Russia. This report is the successor to the "Joint PINRO/IMR report on the state of the Barents Sea ecosystem in 2007, with expected situation and considerations for management" (Stiansen and Filin, 2008). Text, figures and tables taken from these reports (i.e. Stiansen *et al.*, 2009, or Stiansen *et al*, WD23) are in general not further cited in this chapter.

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

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. 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 500m at the western end of Bear Island Trough (Figure 1.1). Its topography is characterized by troughs and basins (300 m – 500m 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.

Climate

The general pattern of circulation (Figure 1.1) is strongly influenced by this topography, and is characterised by inflow of relatively warm Atlantic water, and coastal water from the west. This 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 freshwater 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. 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.

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 do not differ qualitatively from those at lower latitudes. Both bacteria and viruses show highly variable abundance in the Barents Sea, and in general, the dynamics of these groups in this area do not differ from other parts of the ocean. 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 different 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, predominate the spring bloom in different years.

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 and crustaceans are important. The calanoid copepods of the genus *Calanus* play a key role in this ecosystem. *Calanus finmarchicus*, is most abundant in Atlantic waters and *C. glacialis* is most abundant in Arctic waters. Both form the largest component of zooplankton biomass.

Calanoid copepods are largely herbivorous, and feed particularly on diatoms (Mauchline, 1998). 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 species that occupy different niches in the community of Barents Sea euphausiids 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 were found abundant in the Barents Sea; *Themisto abyssorum* and *T. libellula* in the western and central Barents Sea, and *T. compressa* is found, albeit less abundant, 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 restricted to combined 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 term often used by non-specialists in reference 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*. Neither of these terms implies any systematic relationship to vertebrate fish. The term "jellyfish" is also often used in reference 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.

Benthos

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. Many feed by actively or passively, sieving food particles or small organisms from the water. Others eat the bottom sediments (detritus feeders), eat carrion (scavengers) or hunt other animals (carnivores). The high diversity among bottom animals is presumed to be due to the abundance of micro-habitats that organisms can adapt. In shallow waters, kelp forests are feeding and nursery habitats for many species of fish, birds, and mammals. Below the sublittoral zone, sea anemones, sponges, hydrozoans, tunicates, echinoderms, crustaceans, molluscs and many other animal groups abound on hard substrates. These large conspicuous animals are not abundant on sand or muddy bottoms, and in fact some of these habitats may at first look rather lifeless. However, most of the benthic animals in these habitats live buried in the sediments. *Polychaete* worms, crustaceans and bivalves are found in the sediments well as a myriad of other taxa. Some muddy areas might have dense aggregations of brittle stars, sea stars or bivalves.

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.

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 meter. 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.

Fish

More than 200 fish species are registered in trawl catches during surveys of the Barents Sea, and nearly 100 of them occur regularly. Even so, the Barents Sea is a relatively simple ecosystem, with few fish species of potentially high abundance. Different species of fish are not evenly distributed throughout the Barents Sea. Rather, they exhibit highest abundance in areas with suitable environmental conditions. Commercially important fish species include Northeast Arctic cod, Northeast Arctic haddock, 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. Species distribution largely depends on positioning of the Polar Front. There have been significant variations in abundance of these species. These variations are due to a combination of fishing pressure and environmental variability Cod, capelin, and herring are key species in the Barents Sea trophic system.

In general the four pelagic species (herring, capelin, polar cod and blue whiting) have minor overlapping distributions; with the blue whiting in the west, the herring in the south, the polar cod in the east (except for an overlapping part of the stock in the Svalbard region) and the capelin in the north and central areas. In southwestern areas blue whiting and herring partly overlap. However, they occupy different parts of the water column.

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 prey on capelin, herring, and smaller cod; while herring prey on capelin larvae. 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 (Table 1.3-

Table 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 capelin has showed large variations in abundance.

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. 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 years with warm Atlantic water masses the blue whiting may enter the Barents Sea in large numbers, and the blue whiting 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 it has decreased strongly again. 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).

Mammals and seabirds

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).

Fish and mammals have seasonal feeding migrations so that the stocks in the area will have their most northern and eastern distribution in August-September and be concentrated in the southern and south-western areas in February-March. 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.

Rare, threatened and invasive species and infectious 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.

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.

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 the 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. The best known examples of introduced species in the Barents Sea are red king crab *(Paralithodes camtschaticus)* and snow crab *(Chionoecetes opilio)*.

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 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 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. In the near-term, observed levels of contaminants in the marine environment should not have significant impact on commercially important stocks and on the Barents Sea ecosystem as a whole.

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.

Transport of oil and other petroleum products from ports and terminals in NW-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.

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.

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.

Ocean acidification is greater and happening faster than any previous acidification process experienced in millions of years. The absorption of CO_2 generally goes faster in colder waters and thus will rapidly affect the Barents Sea.

1.2 State and expected situation of the ecosystem (Figures 1.2–1.10, Tables 1.3–1.6, 1.9)

1.2.1 Climate

Atmospherical conditions

In 2009, the weather over the North Atlantic was determined by cyclonic activity throughout the year, and northerly and easterly winds prevailed over the Barents and northern Norwegian Seas. In winter, spring and autumn, air temperature averaged over the western and eastern parts of the Barents Sea was higher than normal, with maximum positive anomalies (3.9-4.1°C) in the eastern Barents Sea in January and March. In summer, positive anomalies did not exceed 1°C, and small negative anomalies were observed in some months

Water temperature

In general the temperatures in the entire Barents Sea in 2009 was still high (about 0.5-1.0°C above the long-term average), and at about the same levels as in 2008. At the end of the year the temperature in the Atlantic water masses was increasing again. In the beginning of 2010 the temperature decreased again, but is still above the long-term mean.

Sea surface temperature (SST) in the Barents Sea showed much of the same variations as the air temperatures. In winter, due to the warmer-than-usual air masses over the central and eastern Barents Sea and therefore the less-than-usual atmospheric cooling, the SST was higher than normal, with maximum positive anomalies (1.0°C) in the central part of the sea. In the western and north-western Barents Sea, on the contrary, the SST was lower than normal throughout most of the year, with maximum negative anomalies (–0.5°C) in April and July. The weaker-than-usual spring-and-summer warming caused decreasing SST anomalies. From June to August, negative anomalies of SST were observed in most of the sea. In autumn, SST anomalies increased due to the intensification of cyclonic activity and warm air-masses transport; maximum positive anomalies of SST (up to 1.6°C) were found in the southern areas in November.

Development in the coastal waters is measured at the Ingøy fixed station, and show that during 2009 the surface temperature was only slightly above normal through most of the year except in late fall/early winter 2009/2010. In the deeper waters (at 250 m), which is strongly influenced by Atlantic Water, the temperature was above normal throughout the year. In both the surface and deeper layers, the temperature increased (relative to the normal) in late fall 2009/early winter 2010, but decreased again in spring 2010, with surface temperatures around and deeper layers still slightly above the long term mean.

The Fugløya-Bear Island and Vardø-North sections, which capture all the Atlantic Water entering the Barents Sea from south-west, showed temperatures close to 0.5°C above the long-term mean in early 2009 (Figure 1.2). This is lower than the last 5-6 winter, and is due to lower air temperatures causing more intense heat loss in combination with weak inflow of Atlantic Water. Over the year the temperatures increased, and in October 2009 the temperature in south-west was 0.9°C above the long-term mean. The annual mean temperature in 2009 was close to the year of 2008. In the beginning the temperature at the Vardø-North decreased again to ~0.5 °C above the long term mean.

Temperature in the upper 200 m layer in the southern Barents Sea (Kola section) was higher than normal throughout the year of 2009, and, during the second half of the year, it was higher than in 2008 (Figure 1.3). At the beginning of the year, the weaker-than-usual seasonal cooling caused an increase in positive temperature anomalies (by 0.1-0.3°C) in the Atlantic water compared to December of 2008. The positive anomalies changed slightly during the first half of the year, then they decreased to September due to easterly and northeasterly winds prevailed in spring and summer. During autumn, temperature anomalies in the main warm currents increased again due to the intensification of cyclonic activity and air-mass transport from the west. By December, temperature anomalies exceeded 1.0°C in all parts of the Kola Section, and the highest December temperature for the period from 1951 to the present was observed in the Murman Current. The annual temperature in the Murman Current in 2009 was typical of anomalous warm years and close to that of 2008.

Temperature in the bottom layer of the Barents Sea in August-September 2009 was typical of warm and anomalous warm years. Positive temperature anomalies were observed in most of the surveyed area and were, on average, 0.3-1.0°C. The largest positive temperature anomalies (> 1.5°C) were observed in the eastern Barents Sea, in the areas adjacent to the Eastern Basin (Figure 1.4). Compared to 2008, the volume of cold Arctic waters increased significantly in the northern Barents Sea, and for the first time in the last three years waters with negative temperature were found in the Eastern Basin. So, in comparison with the previous year, it caused decrease in the spatially averaged bottom temperature of the surveyed area except the southern Barents Sea occupied by the Murman Current and the Central branch of the North Cape Current. In the beginning of 2010 the bottom temperatures in the south and southwestern parts were higher than in the same period in 2009, while they were lower in the deep central parts.

According to computations with a prediction model, based on harmonic analysis of the Kola Section temperature time series, the temperature of the Atlantic water in the Murman Current in 2010-2011 is expected to decrease to values typical of warm years, namely to 4.5±0.5°C (with anomaly of + 0.6°C) in 2010 and to 4.4±0.5°C (with anomaly of + 0.5°C) in 2011. The years of 2010 and 2011 are similar to 1989, 1991, 2001 and 2002.

Salinity

The salinity variations show a close resemblance to temperature, although not completely. In Fugløya-Bear Island the salinity has been decreasing since 2006, while in Vardø-N it has increased over the last years. Salinity in the Atlantic water masses in 2009 was still high compared to the long term trend.

Inflow of Atlantic water

The volume flux of Atlantic Water flowing into the Barents Sea is predominantly barotropic, with large fluctuations in both current speed and lateral structure. In general, the current is wide and slow during summer and fast, with possibly several cores, during winter. The mean transport of Atlantic Water into the Barents Sea for the period 1997-2009 is 2 Sv (Sv = 10^6 m^3s^{-1}) with an average of 2.2 Sv during winter and 1.8 Sv during summer. During years in which the Barents Sea changes from cold to warm marine climate, the seasonal cycle can be inverted. Moreover, an annual event of northerly wind causes a pronounced spring minimum inflow to the western Barents Sea; at times even an outward flow.

The time series of volume transport reveals fluxes with strong variability on time scales ranging from one to several months (Figure 1.5). The strongest fluctuations, especially in the inflow, occur in late winter and early spring, with both maximum and minimum in this period. The recirculation seems to be more stable at a value of something near 1 Sv, but with interruptions of high outflow episodes.

The volume flux varies with periods of several years, and was significantly lower during 1997-2002 than during 2003-2006. The year of 2006 was a special year as the volume flux both had a maximum (in winter 2006) and minimum (in fall 2006). Since then the inflow has been low, particularly during spring and summer. The inflow in 2009 was much as in 2007 and 2008; moderate during winter followed by a strong decrease in spring. In early summer 2009 the flux was close to 1.5 Sv below the average. As the observational series still only have data until summer 2009, it cannot give information about the situation in fall 2009 and early winter 2010. There is no significant trend in the observed volume flux from 1997 to summer 2010.

Ice conditions

The variability in the ice coverage in the Barents Sea is linked to the temperature of the inflowing Atlantic water, the northerly winds, and import of ice from the Arctic Ocean and the Kara Sea. The ice has a response time on temperature changes in the Atlantic inflow (one-two years), but usually the sea ice distribution in the western Barents Sea respond a bit quicker than in the eastern part. Due to the high temperatures there has been little ice in the last years (Figure 1.6). During the period 2003-2006 the winter ice edge had a substantial retreat towards north-east, but since then the ice area has increased.

For the first eight months of the year of 2009, the sea ice extent in the Barents Sea was less than normal, but more than in 2008. In comparison with the previous year, the ice coverage (expressed as a percentage of the sea area) was 10-18% more in January-May, 5-9% more in June and August and the same in July. Ice melting in summertime was more intensive than in 2008. By July, the south-eastern Barents Sea was ice-free, which is almost one month earlier than in 2008. Ice formation started in the northernmost sea only at the end of October. In October, the ice coverage was 13% less than normal and 5% less than in 2008. By December, the ice coverage of the Barents Sea was still lower than normal but higher than in 2008, a situation that continued into the beginning of 2010.

It is expected that there will be slightly less or around average ice conditions in 2010.

Hydrochemical conditions

According to the chemical observations along the Kola Section in 2009, some decrease in oxygen saturation of the bottom layer was found in the southern Barents Sea compared to 2008: the oxygen saturation anomaly averaged from January to October was –0.24% in 2009, and 0.78% in 2008. Negative anomalies prevailed at the beginning of the year, while small positive anomalies prevailed in summer and autumn.

1.2.2 Phytoplankton

In Norwegian waters there was not observed any large aberration in the annual succession in the phytoplankton along the fixed transect (Vardø – North and Fugløya-Bear Island) in 2009. The spring bloom occurred from mid March to mid April within the "normal" period of the spring bloom at the Bear Island transect. The bloom starts in the coastal waters "spreading" out into the open areas. In April the diatoms were dominating. During summer the phytoplankton was compound of small flagellates, dinoflagellates, and at some stations diatoms. During autumn larger dinoflagellates was common, however, at some stations diatoms had moderate to high abundance.

1.2.3 Zooplankton

The mesoplankton biomass measured in August–September 2009 was clearly below the long-term mean in the Norwegian sector but with slightly higher values along the border to the Russian zone. A particular feature in 2009 is the very high biomass found in the Russian sector north of 75°N and east of 40°E. The average zooplankton biomass in the western and central Barents Sea in 2009 was 5.87 g dry weight m^{-2} compared to 6.48 g in 2008 and 7.13 g in 2007 (Figure 1.7).

The macroplankton survey conducted in autumn and winter 2009 showed that on average, abundance of euphausiids in the west and northwest of the sea was close to the level of 2008 (Figure 1.8). However, in the center, east and coast areas the abundance indices of krill increased 1.5-2 times compared to 2008. In total the macroplankton survey showed that the abundance indices of euphausiids were above than the long-term mean.

The average zooplankton abundance in 2009, together with the considerable decline observed since 2006, suggest that the condition for local production is less favourable for 2010. The total production will probably depend largely on the magnitude of zooplankton advection from the Norwegian Sea. The macroplankton feeding conditions for planktivorous fish in 2010 is expected to be similar to 2009.

The abundance of gelatinous zooplankton, caught by pelagic trawling, show a lower abundance of gelatinous zooplankton in 2009 compared to 2008. Both in 2008 and in 2009, the distribution of "jellyfish" also showed a considerable overlap with regions poor in mesozooplankton biomass.

1.2.4 Northern shrimp

According to the Russian-Norwegian ecosystem survey in August – September 2009 the largest catches of the northern shrimp were recorded in the eastern and northern Barents Sea and north of Spitsbergen. The investigations of 2009 showed that the total stock of the northern shrimp increased compared to last year.

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 1984-2009, 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 2009 were capelin, polar cod, krill, haddock, herring, shrimp, cod and amphipods. In comparison with 2008 the importance of capelin and herring has increased while the importance of krill and shrimp has decreased. The consumption calculations made by IMR show that the total consumption by age 1 and older cod in 2009 was about 6 million tonnes (Table 1.3), while similar calculations by PINRO gave about 5 million tonnes. According to calculations by IMR and PINRO the consumption per cod was about the same in 2009 as in 2008 (Tables 1.5-1.6).

Blue whiting and polar cod

Based on the most recent estimates of fishing mortality and SSB, ICES classifies the stock as having full reproductive capacity, and being harvested sustainably. SSB increased to a historical high in 2004 but has decreased since, and is expected to be just above B_{pa} in 2011. The estimated fishing mortality is slightly below F_{pa}. Recruitment in 1995-2004 was at a much higher level than earlier, but the 2005 and later year classes seem to be poor. Total landings in 2008 were 1.3 mill. tonnes, which is lower than in 2007. Blue whiting is not fished in the Barents Sea.

The high abundance of blue whiting in the Barents Sea in 2004-2007 may be due to a large stock size in this period combined with high temperature. Blue whiting has been observed in the western and southern Barents Sea for many years, but never in such quantities, and never as far east and north in this area as in 2004-2007. In autumn 2009, the acoustic abundance of blue whiting was estimated to 0.3 million tonnes, which is higher than in 2008, but still low. Also, the swept area estimate of blue whiting in winter 2010 was the lowest in the time series, which go back to 2001. Thus, the abundance of blue whiting in the Barents Sea is expected to stay at a low level until the recruitment to the stock increases again.

The polar cod stock is presently at a high level. Norway took some catches of polar cod in the 1970s and Russia has fished on this stock more or less on a regular basis since 1970. The stock size has been measured acoustically since 1986 and the stock has fluctuated between 0.1-1.9 million t. In 2009, the stock size was measured to about 0.9 million t., which is below the estimate obtained in 2008. The natural mortality rate in this stock seems to be very high, and this is explained by the importance of polar cod as prey for cod and different stocks of seals.

Herring and capelin

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as having full reproductive capacity and being harvested sustainably. The 1998, 1999, 2002 and 2004 year classes dominate the current spawning stock which is estimated to 12.2 million t in 2010. Preliminary indications show that the year classes 2005-2009 are below average. Therefore the abundance of herring in the Barents Sea is believed to be at a relatively low level in 2010. This stock has shown a large dependency on the occasional appearance of very strong year classes. In recent years the stock has tended to produce strong year classes more regularly. However, as no strong year classes have been produced since 2004, the stock is expected to decline. Norwegian spring-spawning herring is fished along the Norwegian coast and in the Norwegian Sea, but not in the Barents Sea. However, juveniles from this stock play an important part role in the ecosystem in the Barents Sea.

The capelin stock size is at a level somewhat above average. Based on the most recent estimates of SSB and recruitment ICES classifies the stock as having full reproductive capacity. The maturing component in autumn 2009 was estimated to be 2.3 mill t., and SSB 1st April 2010 was predicted to be at 0.52 mill t. The spawning stock in 2010 consisted of fish from the 2006 and 2007 year classes, but the 2006 year class dominated. The survey estimate at age 1 of the 2008 year class is somewhat below the long-term average. Observations during the international 0-group survey in August-September 2009 indicated that the 2009 year class is below average.

The estimated annual consumption of capelin by cod has varied between 0.2 and 3.0 million t over the period 1984-2009. Young herring consume capelin larvae, and this predation pressure is thought to be one of the causes for the poor year classes of capelin in the periods 1984-1986, in 1992-1994, and from 2002-2005.

Non-commercial species

Thorny skate (*Amblyraja radiata*) was quite widely distributed in the Barents Sea except for the south eastern and north eastern regions, as in 2008. The observed abundance of this species was higher than in 2008. The thorny skate preferred to keep in a wide range of depths from 50 down to 300 meters.

Northern skate (*Amblyraja hyperborea*) was distributed in the northeast part of the Barents Sea and along the shelf slope to the west of Spitsbergen. It was mainly found in the depth range 200 to 300 meters.

Plaice (*Pleuronectes platessa*) was distributed in a range of depths from 50 down to 100 meters) on northwest from Kanin peninsula.

According to observations in 2009 the tendency of expansion of Norway pout (*Trisopterus esmarkii)* in the Barents Sea is continuing. Main density concentrations of Norway pout were registered in the south-western areas. At the same time, along the warm Spitsbergen current, Norway pout was observed until 81° N. Along coastal North Cape current Norway pout were distributed eastward up to 47° E. It seems like Norway pout have occupied the blue whiting distribution area after this species declined.

In the ecosystem survey in 2009 there were both new species to the area and recordings of rare species in the area of observation. Some of these species have their main distribution in the warm waters of the Norwegian Sea (*Molva molva, Schedophilus medusophagus*) or in the cold waters of the Kara Sea (*Arctogadus glacialis*) bordering the Barents Sea.

1.2.6 Marine mammals

Harp Seal

Since 1998 the abundance of harp seal pup production in the White Sea has been sharply reduced, according to the PINRO aerial surveys. However the decrease in the harp seal pup production abundance has become slower recently and even some slight increase has been observed. The abundance of harp seal pups in the whelping patches in 2009 calculated using the data from aerial surveys was more than two times lower, compared to the data obtained for 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 in 2005-2009 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 2009 – 1.2 million animals).

Predation by mammals

Analyses of consumptions by marine mammals in the Barents Sea for 2009 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. Models predict that air temperatures will continue to increase considerably. With the 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 that temperate zooplankton would shift 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.

Similarly, the many complex ways in which species interact creates considerable uncertainty in any set of predictions as to what the overall response of climate warming to the ecosystem will be. If warming causes phytoplankton to increase, this is expected to result in an overall increase in fish production. For example, model studies show that higher primary production tends to lead to an increase in cod recruitment in the Barents Sea (Svendsen *et al*., 2007). 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). With increasing temperatures, temperate benthic species are expected to become more frequent and the species composition of the benthos will change. Such changes will affect benthic production (i.e. food for demersal fishes and other vertebrates) and may therefore have considerable management implications. Polar bears, ringed seals, bearded seals, harp seals and hooded seals are all dependent on sea ice. It is the primary foraging habitat for polar bears, and a resting and breeding habitat for all of these seals. Additionally, some of the seals feed on ice-associated prey. As a result of climate warming and the associated loss of sea ice, distribution and abundance of these species are expected to decrease in the Barents Sea.

Along with climate change should mention 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 ofo the Barents Sea fisheries and its effect on the ecosystem (Tables 1.10–1.11, Figures 1.11–1.16

Description of the Barents Sea fisheries and its effect on the ecosystem (Tables 1.10-1.11, Figures 1.11-1.16)

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 predation. 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 (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. Overcoming these problems and further developing our understanding of the effects of fisheries in an ecosystem context are important challenges for management.

1.4 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 2008, catches of nearly 900 thousand tonnes are reported from the stocks of cod, haddock, saithe, redfish, and Greenland halibut, which is an increase of 10% as compared to the year before. An additional catch of about 40 000 tonnes was taken from the stocks of wolffish and shrimp. 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 1.11a). The current harvest rate relative to the maximum levels above which the fishing mortality over time may impair the recruitment is shown in Figure 1.11b. 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 and 2010 the stock is again sufficiently sound to support a quota of 390 000 and 360 000 tonnes, respectively.

Russia, as the only nation currently fishing polar cod, fished 8 190 tonnes polar cod in 2008. Norwegian spring spawning herring is the largest stock inhabiting the Northeast Arctic with its spawning stock estimated to 12.6 million tonnes in 2009. 1.5 million tonnes were fished from this stock in 2008, 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 2007 about 65 000 tonnes mackerel and 120 000 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 will be 130 mm for the entire Barents Sea (at present the minimum mesh size is 135 mm in the Norwegian EEZ and 125 mm in the Russian EEZ). This change is 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.

1.4.1 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 1.12). 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 1.13-1.16). 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 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.

Fleet composition (groundfish and pelagic species)

Figure 1.17 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.

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 has organised retrieval surveys annually since 1980. All together 10 784 gill nets of 30 metres standard length (approximately 320 km) have been removed from Norwegian fishing grounds during the period from 1983 to 2003.

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.

1.5 Management improvement issues (Tables 1.12–1.15)

1.5.1 Overview

The availability of necessary ecosystem information is only one of the needed items for implementation of an ecosystem approach to management. Another needed element is the development of appropriate methods and instruments for incorporation of ecosystem information into stock assessment and harvest control rules.

This section summarizes ecosystem information that has the potential of being implemented in, and therefore improves, the advice for sustainable fishery management.

Management of fisheries is always based on decision-making under levels of uncertainty. Incorporating data on ocean climate, lower trophic level bio-production, as well as species interactions on higher trophic levels in catch recommendations for target species, should reduce the uncertainty of scientific recommendations for sustainable harvest levels.

1.5.2 Multispecies models

Development of multispecies models designed to improve fisheries management in the Barents Sea based on species interactions started in the mid-1980s. The first models developed were MULTSPEC, AGGMULT and SYSTMOD in IMR and MSVPA in PINRO (Tjelmeland and Bogstad, 1998; Hamre and Hatlebakk, 1998, Korzhev and Dolgov, 1999). In total, these models contained the species cod, capelin, herring, haddock, polar cod, shrimp, harp seal and minke whale. Even though further development of these models has been discontinued, they serve as predecessors to newly developed models, such as EcoCod, Bifrost, Gadget and STOCOBAR. Benefits of multispecies models include: improved estimates of natural mortality and recruitment; better understanding of stock-recruit relationships and variability in growth rates; alternatives views on biological reference points. Brief descriptions of the multispecies models are given below.

EcoCod

The development of this model started in 2005 as the main task in the first stage of the joint PINRO-IMR Programme on Estimation of Maximum Long-Term Yield of North-East Arctic cod, taking into account the effect of ecosystem factors. This 10-year research programme was initiated following a request from the Russian-Norwegian Fishery Commission (Filin and Tjelmeland, 2005). EcoCod is a stepwise extension of a single species model for cod (CodSim; Kovalev and Bogstad, 2005), where cod growth, maturation, cannibalism and recruitment is modeled in a multispecies setting. Preliminary sub-models for cod growth, fecundity and malformation of eggs have been implemented in EcoCod.

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

The STOCOBAR describes stock dynamics of cod in the Barents Sea, taking into account trophic interactions and environmental influence (Filin, 2007). It is designed as a tool for prediction and exploration of cod stock development as well as for evaluation of harvest strategies and recovery plans under different ecosystem scenarios. 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 first version of STOCOBAR was created at PINRO in 2001 and development of this model is continuing. The work on the development of the STOCOBAR model is 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.

1.5.3 Statistical models

Recruitment of commercial fish

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

Maturation of cod

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.

Condition of fish

Relative body condition (the quantity of stored energy) is an important tool in understanding demographic variation and the ability of a population to respond to environmental stressors, varying food availability and competition. A high-resolution database was used to examine causes of variation in the condition of North-east arctic cod for the period 1967–2004, over annual and monthly timescales. Temperature was shown to have a positive impact on condition at both inter- and intra-annual timescales. Interannually, temperature may affect stock distribution, in particular its overlap with the capelin stock. At shorter timescales it is likely that temperature directly affects the metabolism of the cod. Intra-annually, the quantity of capelin in cod stomachs positively affected cod condition in the current and the preceding month for all lengths of cod. This indicated a time lag between a change in food consumption and a subsequent change in condition, or 'latency'.

Results presented by Sandeman *et al.* (2008) point to the importance of the impact of varying temperature on condition. The effects of climate are likely to be particularly important where the species is close to its outer distribution area or where the animal is an ectotherm.

Growth of fish

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. Regressions of weight at age of cod on temperature, capelin and the cod stock itself are used in EcoCod model.

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 have low determination coefficient, and are therefore not presented here. However, they may prove useful in the future when further developed.

Reproductive potential

Morgan *et al*. (2009) explore the impact of four alternative indices of reproductive potential (RP) on perceptions of population productivity for eight fish populations across the North Atlantic. The four indices of RP included increasing biological complexity, adding variation in maturation, sex ratio, and fecundity. Perceptions of stock productivity were greatly affected by the choice of index of RP. Population status relative to reference points, RP per recruit, and projections of population size all varied when alternative indices of RP were used. There was no consistency in which index of RP gave the highest or lowest estimate of population productivity, but rather, this varied depending on how much variation there was in the reproductive biology of the population and the age composition. Estimates of sustainable harvest levels and recovery time for depleted populations can vary greatly depending on the index of RP.

1.5.4 Other models

Consumption models

When calculating the prey consumption by a given predator, both the overall consumption level and the prey composition in the diet are used. The prey composition is usually derived from stomach content data, while the overall consumption level can be calculated using two approaches:

- A bioenergetic approach (as is usually the case for marine mammals and seabirds as predators)
- By combining data on stomach content weight with models for stomach evacuation rate, based on experiments.

Ecosystem models

Ecosystem models may be useful for looking at how change in one species or ecosystem component is affecting whole or other parts an ecosystem, thereby identifying the most important inter-species/ functional group links and sensitivity of the ecosystem to changes to those. They are also useful for scenario testing (change in fishery pressure, climate change, and sudden pollution events. Special interesting are those models that have spatial resolution, like ATLANTIS and ECOPATH/ECOSIM.

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 kilometers) in Australia and the United States. In autumn 2010 it will be implemented at IMR, and cover the area of the Barents Sea and the Norwegian Sea.

Another model that may have some utility for the future would be ECOPATH/ECOSIM. This model can use ecosystem survey data and expected biomass conversion rates to model systems. As a mass-balance model it can detect if there may be overlooked components to the ecosystem. The ECOPATH model system is used in many systems around the world. Versions of it have also been applied to the Barents Sea ecosystem (Blanchard *et al*. 2002, Dommasnes *et al*. 2002), though they are not run on an operational level.

1.5.5 Expected impact of ecosystem factors on stock dynamics

Evaluation of natural potential of cod stock biomass changes based on temperature and capelin data

STOCOBAR long-term simulations show that impact of capelin on cod stock dynamics is dependent on temperature and cod stock state (WD21). Using these simulations the natural potential for changes in cod stock size may be identified based on temperature conditions and the state of cod and capelin stocks in the Barents Sea. A table for evaluating the level of natural potential for annual changes in fishable cod stock biomass was produced based on the simulated data (Table 1.12).

According to Table 1.12 and available data on temperature, cod and capelin stocks the potential for annual changes of cod fishable stock biomass in 2009 was low. The same situations will be in 2010 and 2011 based on expected temperature and capelin stock size. The resistance of cod stock to fishing pressure under these conditions will be medium and this does not imply high contributions to cod stock dynamics from capelin and temperature.

Prediction of NEA cod recruitment.

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.

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 have 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 were not updated this year.

Titov (WD 22) and Titov et al. (WD 16 AFWG 2005) 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:

TITOV0: $R3^1$ ~$DOxSat^2$(t-13)+ DOxSat(t-13)+ ITa(t-39) + CodA3(t+1) + Tw(t-17)

TITOV1: $R3^1$ ~$DOxSat^2$(t-13)+ DOxSat(t-13)+ ITa(t-39) +CodA2(t-11) + Tw(t-17)

TITOV2: $R3^2 \sim DOxSat^2(t\text{-}13) - DOxSat(t\text{-}13) + ITa(t\text{-}39) + CodA1(t\text{-}23) + Tw(t\text{-}17)$

TITOV3: $R3^3 \sim OxSat^2(t\text{-}44) + ITa(t\text{-}39) + lgCodC0(t\text{-}28)$

TITOV4: $R3^4 \sim OxSat^2(t\text{-}44) + ITa(t\text{-}39) + SSB(t\text{-}36)$

Where $DOxSat(t\text{-}13) \sim Exp(OxSat(t\text{-}13)) - OxSat(t-38)$, $ITa(t\text{-}39) \sim I(t\text{-}39) + Ta(t-44)$.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). Some changes were brought in 2009 (AFWG 2009 WD 12). New equation (TITOV0) was added, 0-group abundance indices, corrected for capture efficiency (CodC0) was entered instead of former indices in TITOV3.

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

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

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

H4: $\log(R3) \sim Temp(-1) + Age3(0)$

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, $BM_{cod3\text{-}6}$ 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.

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 meeting this year a WD by Dingsør *et al*. (WD 19) was presented, which investigated the performance of some of the mentioned recruitment models. Even though this work was well received by the working group it was decided not to change the procedure this year. However, it was strongly recommended that a Study Group should be appointed to look at criteria's for choosing/rejecting recruitment models suitable for use in stock assessment (see also chap 0.11).

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, names the "hybrid" model. One-year-ahead prognoses was given by the hybrids (Titov1, Titov3 and JES1), two-year-ahead (Titov2, Titov 3 and JES1) and three-year-ahead (Titov3) for the number of age 3 cod. 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.

Table 1.13 show the estimates of all the available models, along with last year estimates.

Cannibalism mortality for cod

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 1.14. 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. Using this approach the predicted natural mortality coefficient for cod, including cannibalism for recent years, seems to be higher compared to "the standard" assessment and prediction (Table 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 of 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 2009 to 2012, predicted by the regression, are given in the Table 1.15.

1.5.6 Fishery induced evolution

There is a vital need for the fisheries science community to maintain sustainable fisheries ensuring the effective conservation, management and development of living aquatic resources. The precautionary approach was proclaimed and applied within the ICES community to meet (promote) these aims. This approach takes into account uncertainties relating to the size and productivity of the stocks. Uncertainties relating to fisheries induced evolution are most likely taken into consideration in case of a proper implementation of precautionary approach into responsible fishery.

The Study Group on Fisheries Induced Adaptive Change (SGFIAC) proposed to create evolutionary impact assessment (EvoIA), quantifying the evolutionary effects of management measures (ICES 2008/RMC:01; ICES 2009/RMC:03). It is a very complicated but promising task given that commercial fishery could act as a selective factor resulting in evolutionary response of exploited populations.

The papers published by the SGFIAC Group members concern basically probabilistic maturation reaction norms (PMRNs) estimations for different commercial stocks/species, and shift in cohort-specific PMRNs interpreted as a genetic change at the population level. It is rather difficult to test that findings directly as the genes associated with maturation have a polygenic nature. The strength and weakness of the PMRNs approach were discussed in detail in Theme Session issue of the Marine ecology progress series, 2007, vol. 335, 249- 310.

North east arctic cod stock demonstrates long-term trends in maturation as well as in demography of the stock and weight at length of fish. The historical trends could be caused both by genetic and plastic effects on maturation. Population density factors and environmental conditions can contribute to feeding success resulting in changing maturation rates in NEA cod for the time period investigated (Marshall and McAdam, 2007; Kovalev and Yaragina, 2009). The causes in a discontinuity of the decreasing trend observed in length for 50% maturation probability in the beginning of the 80's are unknown, but they are most likely non-genetic given that they occurred synchronously across age-classes (Marshall and McAdam, 2007).

More research is needed to evaluate underlined mechanisms of population changes including biological, physiological, ecological studies, not to mention genetic ones.

It takes a lot of time and efforts for the ICES community to implement the precautionary approach into a scientific/management practice. It is likely to take some time before the SGFIAC can evaluate and present some results applicable to test on real management measures recommendations. AFWG considers it premature at present to discuss any proposals of management measures (or reference points for fisheries management) in terms of fisheries induced evolution. Dialogues with scientists of the mentioned WG could also be carried out through the ICES Sharepoint.

1.6 Monitoring of the ecosystem (Figure 1.18, 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 from ship and airplanes. 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 hydrodynamical 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.

1.6.1 Standard sections and fixed stations

Some of the longest ocean time series in the world are along standard sections (Figure 1.18) 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.

1.6.2 Area coverage

Area surveys are conducted throughout the year. The number of vessels in each survey differs, not only between surveys but may also change from year to year for the same survey. However, most surveys are conducted with only one vessel. It is not possible to measure all ecosystem components during each survey. Effort is always put on measuring as many parameters as possible on each survey, but available time put restrictions on what is possible to accomplish. Also, an investigation should not take too long time in order to give a synoptic picture of the conditions. Therefore the surveys must focus on a specific set of parameters/species. Other measured parameters may therefore not have optimal coverage and thereby increased uncertainty, but will still give important information. An overview of the measured parameters/species on each main survey is given in Table 1.16. Specific considerations for the most important surveys are given in the following text.

Norwegian/Russian winter survey

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

The main spawning grounds of North East Arctic cod are in the Lofoten area. Echo-sounder equipment was first used in 1935 to detect concentrations of spawning cod, and the first attempt to map such concentrations was made in 1938 (Sund, 1938). Later investigations have provided valuable information on the migratory patterns, the geographical distribution and the age composition and abundance of the stock.

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 the transects 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

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 ecosystem autumn survey

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 aspects of the ecosystem are covered, from physical and chemical oceanography, primary and secondary production, fish (both young and adult stages), sea mammals, benthos 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".

In 2009 not all components of the ecosystem were covered during the survey, and a further reduction will probably take place in 2010; the coverage of e.g. Greenland halibut will be less complete than in previous years. Also, the future of this ecosystem survey is still undetermined.

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

Russian Autumn-winter trawl-acoustic survey

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

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 will not be conducted in 2010, and its future design is being revised.

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 joint survey, since 1996 the survey is carried out only by PINRO.

1.6.3 Other information sources

Large 3D hydrodynamic numeric models for the Barents Sea are run at both IMR and PINRO. 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.

1.7 Main conclusions

State and expected situation in the ecosystem (section 1.2)

Climate

- The air temperature was above the long-term mean during 2009.
- The sea temperature in the Barents Sea is still high, and about the same level as in 2008. There was an increase in the end of the year, with the highest December temperature in the Kola section. In 2010 the temperature is expected to further decrease, but still be higher than the long-term mean.
- Salinity in 2009 is still high , and at about the same levels as in 2008
- Inflow of Atlantic waters at the western entrance in 2009 was quite similar to 2008; moderate during winter followed by a strong decrease in spring. Data for second half of 2009 is not available.
- Oxygen levels were about normal in 2009.
- Ice extent in 2008 was less than normal, but more than in 2008. In 2010 ice conditions is expected to be slightly less or around the long term mean.

Plankton and northern shrimp

- The mesozooplankton biomass measured in August–September 2009 was less compared to 2008, and below the long-term mean.
- Abundance euphausiids (krill) in autumn and winter 2009 were close to the level in 2008 in the western and northwestern areas and increased in the centre, eastern and coastal areas. In total the abundance in 2010 is slightly above the long-term mean.
- The abundance of gelatinous zooplankton, caught by pelagic trawling, show a lower abundance in 2009 compared to 2008.
- The shrimp stock in the Barents Sea and Spitsbergen area in 2009 increased compared to both 2007 and 2008.

Fish

- Capelin stock size is at around average level, with a slight decrease from last year. The survey estimate at age 1 of the 2008 year class is slightly below the long-term mean. 0-group estimates indicate that the 2009 year class is below average.
- For young herring there are indications that the year classes 2005-2009 are below average. Therefore the abundance of herring in the Barents Sea is believed to be at a relatively low level in 2010.
- Blue whiting is still at a very low level, with a slight increase from 2008. The abundance is expected to remain low in 2009.
- The polar cod stock is presently at a high level, similar to 2008.

Harp Seal

- The decrease in the harp seal pup production in the White Sea has become slower recently and even some slight increase has been observed, 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 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.
- According to STOCOBAR simulations there is a low probability to expect any tendency of decline or increase in the fishable cod stock biomass in 2010 and 2011, based on predicted temperature and capelin stock size.
- The cod recruitment (age 3) in 2010 is expected to be low compared to the long-term mean. In 2011 and 2012 it is expected to increase slightly, but still be below the long-term mean.

1.8 Response to technical minutes

There were no specific comments from the review group to ecosystem consideration chapter (Chapter 1).

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
Mean	77706			19880			4040			28579			64744		

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
Mean	181			29			587			35898			8997		

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
Mean	266916			76659			11243			169164		

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
Mean	520			291798			73411		

Table 1.3. The North-east arctic cod stock's consumption of various prey species in 1984-2009 (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	1621	183	3	32	47	225	0	1	41	3649
1986	606	1236	111	142	837	133	141	83	111	315	0	0	55	3769
1987	671	1085	67	191	229	32	206	25	4	324	1	0	9	2844
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	4646
1992	907	102	158	373	2457	331	97	55	106	188	20	2	93	4889
1993	751	253	714	315	3033	163	278	285	71	100	2	2	26	5994
1994	625	563	704	518	1085	147	582	224	49	79	0	1	39	4614
1995	845	982	516	362	628	115	254	371	116	193	1	0	34	4417
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	378	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	685	172	376	277	1722	71	250	66	49	6	1	151	29	3853
2002	362	96	261	232	1934	86	270	108	123	1	0	224	15	3713
2003	548	282	529	240	2157	214	272	114	168	3	0	74	48	4649
2004	671	679	318	247	1296	196	338	122	193	3	12	74	62	4212
2005	685	411	521	264	1238	187	354	116	342	2	3	111	46	4282
2006	780	169	957	313	1511	201	118	70	361	15	1	122	104	4721
2007	1141	293	935	373	1881	272	228	94	355	40	1	39	61	5712
2008	1384	146	787	316	2443	102	476	182	303	55	11	29	90	6325
2009	1250	159	427	211	2762	219	478	175	295	35	1	5	91	6109

Table 1.4. The North-east arctic COD stock's consumption of various prey species in 1984-2009 (1000 tonnes), based on Russian consumption calculations.

Year	Euphausids	Hyperiids	Shrimp	Herring	Capelin	Polar cod	Cod	Haddock	Blue whiting	Norway pout	Redfish	Long rough dab	Greenland halibut	Other fish	Other food	Total consumption
1984	93	31	351	33	592	17	13	50	5	1	195	51	0	269	286	1988
1985	30	432	202	24	989	0	98	34	18	15	97	23	0	519	198	2679
1986	57	860	148	47	807	159	28	103	3	27	158	24	1	372	170	2962
1987	69	508	201	8	162	105	27	2	10	15	118	6	0	268	188	1686
1988	209	169	118	19	292	0	20	93	0	0	127	20	0	239	242	1545
1989	167	290	104	4	680	34	34	2	0	0	158	56	0	201	248	1977
1990	101	30	270	64	1254	8	21	16	39	15	232	79	0	101	167	2396
1991	54	83	287	28	3286	44	52	22	7	6	144	46	6	132	158	4354
1992	213	38	263	374	2021	191	84	38	0	77	121	44	1	295	418	4175
1993	186	177	223	177	2791	171	147	153	4	25	41	48	5	160	384	4691
1994	362	298	472	105	1303	492	391	72	1	2	56	40	0	100	353	4046
1995	396	465	550	192	691	203	557	130	0	1	113	53	3	169	356	3878
1996	973	361	200	76	478	79	473	60	9	37	71	47	0	470	175	3509
1997	386	85	207	54	523	110	409	35	3	0	37	33	2	97	399	2380
1998	615	205	265	70	852	129	129	23	23	18	15	19	0	53	226	2641
1999	454	77	242	74	1402	165	48	14	25	1	13	8	0	58	107	2688
2000	413	111	367	48	1662	157	57	29	26	8	4	20	0	36	181	3119
2001	418	74	308	88	1433	140	59	49	137	29	4	31	2	145	190	3106
2002	309	45	198	55	2330	281	100	77	102	3	4	17	0	44	170	3734
2003	240	140	213	144	1155	204	127	323	26	5	1	38	0	87	270	2974
2004	350	378	243	122	1046	350	83	151	48	20	7	58	15	179	267	3317
2005	543	135	226	170	962	318	114	275	68	42	7	45	2	162	203	3272
2006	887	62	210	239	1186	108	95	268	104	86	17	95	1	92	333	3781
2007	860	153	280	259	1408	239	73	319	33	21	22	65	1	194	376	4304
2008	617	36	229	102	2324	498	138	333	16	16	42	109	13	301	416	5191
2009	511	105	199	158	2380	575	115	306	7	82	27	185	0	133	510	5293
Mean	366	206	253	105	1308	184	134	114	27	21	70	48	2	188	269	3296

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	7.675
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	14.434
2002	0.199	0.551	1.167	2.441	3.380	4.719	6.357	9.039	10.224	11.538	10.921
2003	0.207	0.653	1.312	2.390	3.995	5.946	8.411	10.405	12.786	13.397	14.343
2004	0.194	0.474	1.280	2.529	3.882	5.588	7.323	11.213	16.665	18.557	17.980
2005	0.194	0.653	1.376	2.592	3.918	5.588	7.182	9.771	13.090	14.012	14.784
2006	0.181	0.595	1.589	2.796	4.185	5.870	7.482	11.255	13.695	14.692	15.613
2007	0.213	0.621	1.742	3.178	4.704	6.231	7.802	9.621	12.636	13.223	13.808
2008	0.189	0.665	1.460	3.047	4.336	6.667	8.135	10.842	14.166	14.673	14.883
2009	0.182	0.586	1.414	2.888	4.568	5.789	8.074	10.195	12.252	13.203	13.286
Average	0.191	0.584	1.396	2.606	4.001	5.564	7.822	9.835	11.821	12.589	12.780

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

Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13+
1984	0.262	0.893	1.612	2.748	3.848	5.486	6.990	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	12.500	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	12.361
1989	0.282	0.910	1.468	2.207	3.244	4.799	6.581	8.725	11.134	15.799	15.950	17.909	14.023
1990	0.288	1.007	1.696	2.694	3.278	3.833	5.584	6.871	10.716	11.428	12.660	15.053	16.064
1991	0.241	0.936	2.670	4.473	6.038	7.846	9.590	11.542	14.970	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	11.600	14.067	14.893	15.922
1994	0.180	0.512	1.212	2.402	3.517	5.359	7.560	10.001	11.818	12.896	13.554	15.902	16.806
1995	0.194	0.497	0.962	1.819	3.204	4.847	7.332	9.688	13.835	15.247	16.960	18.230	19.202
1996	0.170	0.498	1.028	1.916	3.075	4.189	6.987	10.212	12.185	13.426	14.581	16.214	16.876
1997	0.119	0.341	0.992	1.908	2.668	3.503	4.954	7.980	12.174	21.523	20.666	21.822	24.237
1998	0.232	0.528	1.081	2.016	2.823	4.089	5.469	7.346	9.586	13.012	14.455	15.579	16.201
1999	0.261	0.431	1.128	2.490	3.676	5.222	6.398	8.220	9.194	13.364	15.325	16.918	17.567
2000	0.186	0.545	1.288	2.551	4.387	6.559	8.833	10.483	11.522	15.132	17.155	19.717	20.514
2001	0.150	0.413	1.163	2.110	3.430	5.571	6.835	10.233	12.457	15.130	17.374	19.322	20.559
2002	0.252	0.677	1.303	2.699	3.847	5.591	7.846	10.796	13.238	18.787	17.902	20.202	21.207
2003	0.228	0.618	1.296	2.028	3.547	4.716	6.684	8.905	13.418	14.492	19.540	19.239	20.036
2004	0.250	0.654	1.412	2.567	3.857	5.660	7.730	11.126	15.907	20.770	21.687	24.852	25.892
2005	0.255	0.687	1.514	2.504	3.896	5.264	7.192	9.395	13.163	15.981	22.656	23.387	24.181
2006	0.354	0.921	1.833	2.763	3.986	5.317	7.396	10.202	12.762	16.462	21.563	25.940	26.875
2007	0.234	0.666	1.803	3.018	4.295	5.810	7.444	9.017	11.754	15.961	20.903	25.154	26.064
2008	0.223	0.706	1.641	2.881	4.071	6.006	7.705	10.317	13.471	17.596	22.968	27.431	27.328
2009	0.217	0.627	1.503	2.542	4.266	5.530	7.617	10.986	13.258	15.637	21.532	25.632	25.586

Table 1.7. Capelin stock history from 1973-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)
1973	961	5144	1350	5504
1974	1029	5733	907	4542
1975	921	7806	2916	4669
1976	696	6417	3200	5633
1977	681	4796	2676	4174
1978	561	4247	1402	3782
1979	464	4162	1227	5723
1980	654	6715	3913	5708
1981	660	3895	1551	5658
1982	735	3779	1591	3729
1983	754	4230	1329	3884
1984	393	2964	1208	3051
1985	109	860	285	1975
1986	14	120	65	681
1987	39	101	17	200
1988	50	428	200	80
1989	209	864	175	537
1990	894	5831	2617	415
1991	1016	7287	2248	3307
1992	678	5150	2228	7745
1993	75	796	330	4631
1994	28	200	94	982
1995	17	193	118	163
1996	96	503	248	261
1997	140	911	312	828
1998	263	2056	931	915
1999	285	2776	1718	2070
2000	595	4273	2099	2464
2001	364	3630	2019	3906
2002	201	2210	1290	2939
2003	104	533	280	3195
2004	82	628	293	812
2005	42	324	174	817
2006	88	787	437	733
2007	280	1885	836	2033
2008	570	4426	2468	3285
2009	352	3756	2322	*

*** M output biomass is not calculated for 2009**

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 2008[A] (tonnes)	As by-catch in fleet(s)	Location	Agreements and regulations
Capelin	PS, TP	seasonal	10 000[B]	TR, TS	Northern coastal areas to south of 74°N	Bilateral agreement, Norway and Russia
Coastal cod	GN, LL, HL, DS	all year	25 777[C]	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	464 171[C]	TS, PS, TP, DS	North of 62°N, Barents Sea, Svalbard	Q, MS, SG, MCS, MBU, MBN, C, RS, RA
Wolffish	LL	all year	11 355	TR, (GN), (HL)	North of 62°N, Barents Sea, Svalbard	Q, MB
Haddock	TR, GN, LL, HL	all year	155 604	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	183 443	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	13 144	TR	Deep shelf and at the continental slope	Q, MS, RS, RG, MBH, MBL
Sebastes mentella	No directed fishery	all year	13 860	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	6 300	TR	Norwegian coast and southwestern Barents Sea	SG, MB MCS, MBU, C
Shrimp	TS	all year	21 053		Svalbard, Barents Sea, Coastal north of 62°N	ED, EF, SG, C, MCS

[A] Provisional figures

[B] On a research quota

[C] The total cod catch north of 62°N (480,814 t) is the sum of the NEA cod catch given in the table above (464,171 t) and the total cod catches between 62ºN and 67ºN for the whole year and between 67ºN and 69ºN for the second half of the year (16,643 t).

[D] The directed fishery for wolffish is mainly in ICES area IIb and the Russian EEZ, and the regulations are mainly restricted to this fishery

[E] Norwegian and Russian landings

[F] The only directed fishery for Greenland halibut is by a limited Norwegian fleet, comprising vessels less than 28 m.

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).

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. The averaged annual relative changes (%) of cod fishable stock biomass under various combinations of cod stock size, capelin stock size and water temperature according to STOCOBAR long-term simulations (the harvesting strategy is based on Fpa=0,5, Bpa=460 thousand tonnes). Different colours denotes different natural potential of cod to stock changes: red is high potential to stock decline, yellow is low potential to stock change, and red is high potential to stock increase.

Temperature , C°	Cod FSB* averaged for 3 previous years, millions t	Capelin stock biomass, millions t			
		< 1	1-3	3-5	>5
< 3,6 C°	<1,4	-8,96	-1,73	4,90	5,60
	1,4-1,8	-11,60	-7,28	-3,89	2,98
	>1,8	-16,89	-12,56	-7,94	-3,61
3,6 – 4,2 C°	<1,4	1,17	5,14	12,82	15,99
	1,4-1,8	-7,29	-3,96	2,91	6,72
	>1,8	-12,24	-8,52	-5,24	-0,27
>4,2 C°	<1,4	3,77	7,14	16,78	20,94
	1,4-1,8	-2,53	1,36	8,34	16,96
	>1,8	-3,62	-0,95	1,25	1,31

*Fishable stock biomass

Table 1.13. Overview of available prognoses of NEA cod recruitment (in million individuals of age 3) from different models (sections 1.4.5) together with the 2009 assessment estimates (ICES AFWG 2009 Table 1.12).

Model	Prognostic years	Updated	2010 Prognoses	2011 Prognoses	2012 Prognoses	2013 prognoses
Titov0	0	At assessment	480			
Titov1	1 (2 [1])	At assessment	518*	470		
Titov2	2	At assessment	451	323*		
Titov3	3	At assessment	250*	276*	484*	
Titov4	4	At assessment	425	362	780	946
TB (1984-2000)	3	Last year assessment	632	553		
TB (1984-2004)	3	Last year assessment	627	551		
JES1	2 (3 [2])	At assessment	878	797*	827	
JES2	1 (2 [2])	At assessment	714	669		
JES3	0 (1 [2])	At assessment	568			
H1	2	At assessment	890	889		
H2	2	At assessment	566	636		
H3	1	At assessment	500			
H4	1	At assessment	475			
RCT3 2010	3	At assessment	289	558	675	
Hybrid Model (Assessment 2009)		Last year assessment	487	184		
Hybrid model (Assessment 2010)		At assessment	384	465	484	

[1] **Based on calculation of data from 2010.**

[2] **Based on prognosis estimate of capelin maturing biomass for October 1 2010, thereby allowing for an additional year.**

*** Models that are used in the Hybrid model at the 2010 assessment**

Table 1.14. Proportion of cod in the diet of cod, based on Norwegian consumption calculations.

Cod (predator)age	1	2	3	4	5	6	7	8	9	10	11+
Year											
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	0.0853
1986	0.0000	0.0022	0.0015	0.0004	0.0130	0.1761	0.1767	0.1766	0.1762	0.1757	0.1748
1987	0.0000	0.0000	0.0007	0.0051	0.0103	0.0246	0.0377	0.0400	0.0418	0.0405	0.0436
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	0.0041
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	0.2608
1995	0.0069	0.0811	0.0745	0.0802	0.0925	0.1123	0.1389	0.2533	0.2553	0.2561	0.2574
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	0.3294	0.3264	0.3301
2002	0.0000	0.0387	0.0591	0.0142	0.0187	0.0285	0.0359	0.0627	0.1603	0.1575	0.1581
2003	0.0000	0.0193	0.0198	0.0199	0.0206	0.0188	0.0456	0.1043	0.2257	0.2281	0.2269
2004	0.0230	0.0223	0.0294	0.0214	0.0184	0.0294	0.0391	0.0710	0.1059	0.1056	0.1061
2005	0.0000	0.0261	0.0229	0.0258	0.0155	0.0241	0.0487	0.0830	0.1688	0.1667	0.1693
2006	0.0000	0.0051	0.0007	0.0130	0.0285	0.0124	0.0397	0.0316	0.0841	0.0845	0.0834
2007	0.0000	0.0000	0.0010	0.0108	0.0137	0.0314	0.0336	0.0724	0.1518	0.1543	0.1504
2008	0.0000	0.0821	0.0243	0.0068	0.0089	0.0110	0.0820	0.1004	0.1223	0.1212	0.1198
2009	0.0238	0.0376	0.0353	0.0227	0.0137	0.0147	0.0250	0.0981	0.0918	0.0920	0.0919
Average	0.0021	0.0236	0.0312	0.0278	0.0339	0.0474	0.0673	0.0881	0.1437	0.1434	0.1432

Table 1.15. Cannibalism mortality in cod.

Year	M at age 3	M at age 4
	by regression	
2009	0.40	0.27
2010	0.43	0.28
2011	0.46	0.29
2012	0.64	0.36
	values used in assessment	
2010-2012	0.3335	0.227

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	Joint	Feb-Mar	T,S	N, chla	intermittent	All commercial species and some additional	Cod, Haddock	-	-
Lofoten	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	-	-	-	-	Greenland halibut, redfish	-	-
Russian young herring survey	PINRO	May	T,S		Yes		Herring	-	-

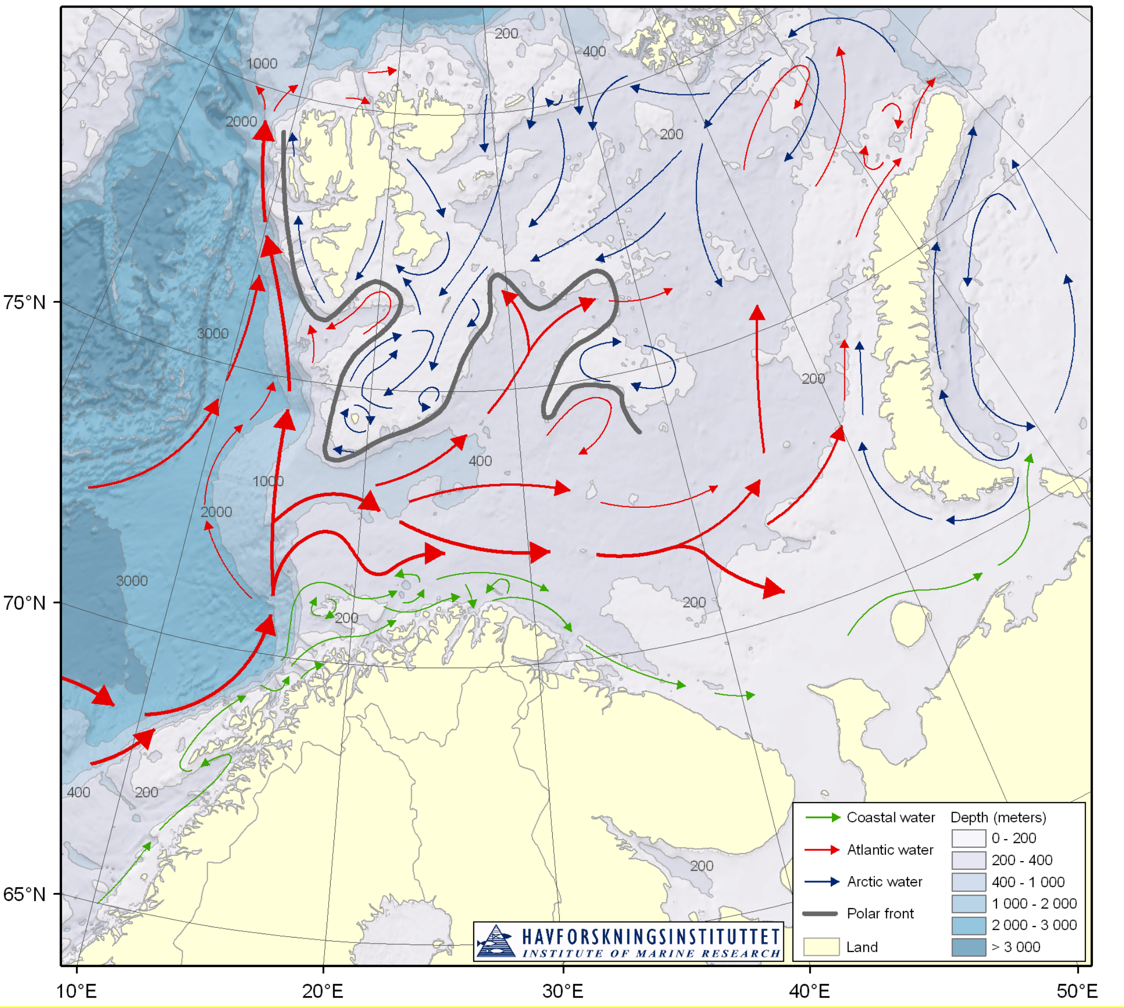


Figure 1.1. The main features of the circulation and bathymetry of the Barents Sea.

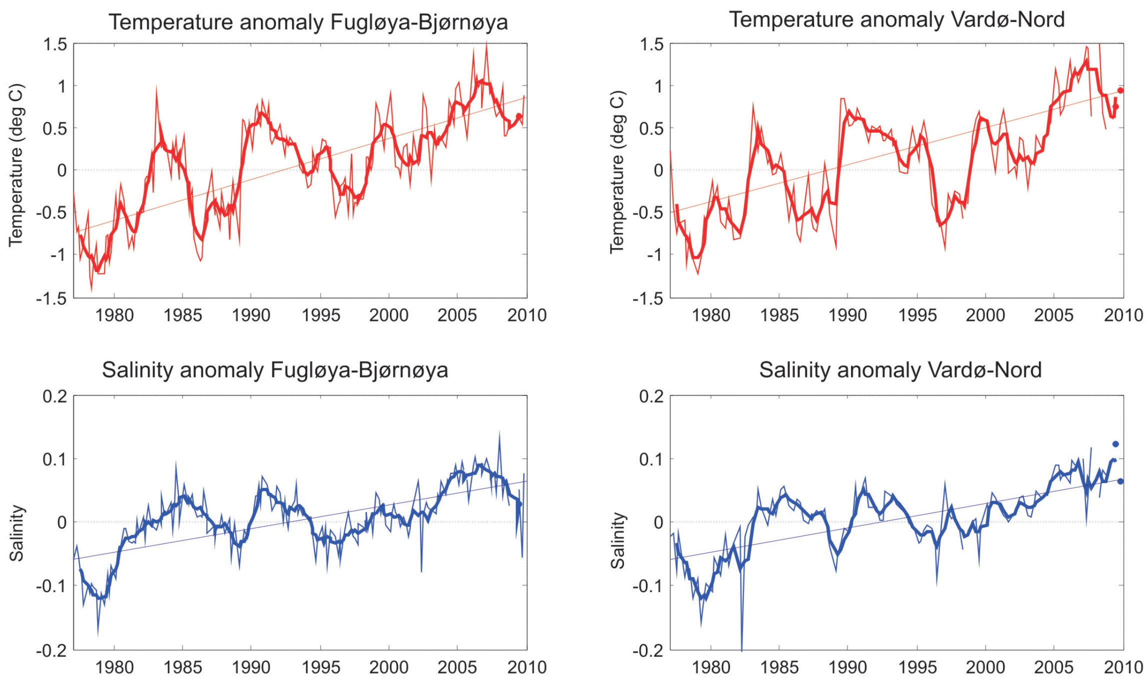


Figure 1.2. Temperature (upper) and salinity (lower) anomalies in the 50-200 m layer of the Fugløya-Bear Island section (left) and the Vardø-North section (right).

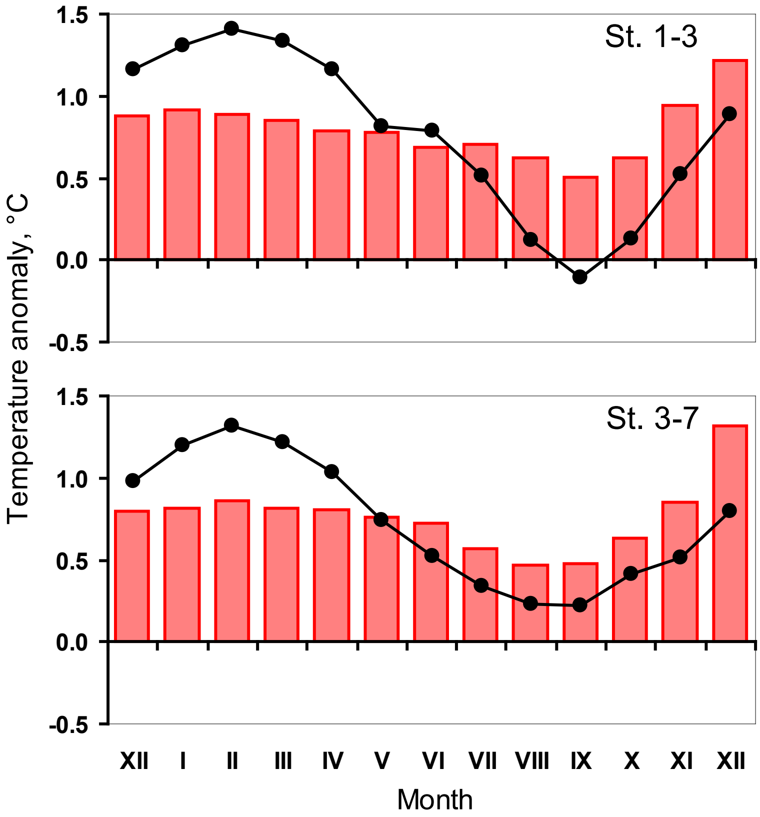


Figure 1.3. Monthly temperature anomalies in the 0-200 m layer of the Kola Section in 2008 (black dots) and 2009 (red bars). St. 1-3 – Coastal waters, St. 3-7 – Murman Current (Anon., 2010).

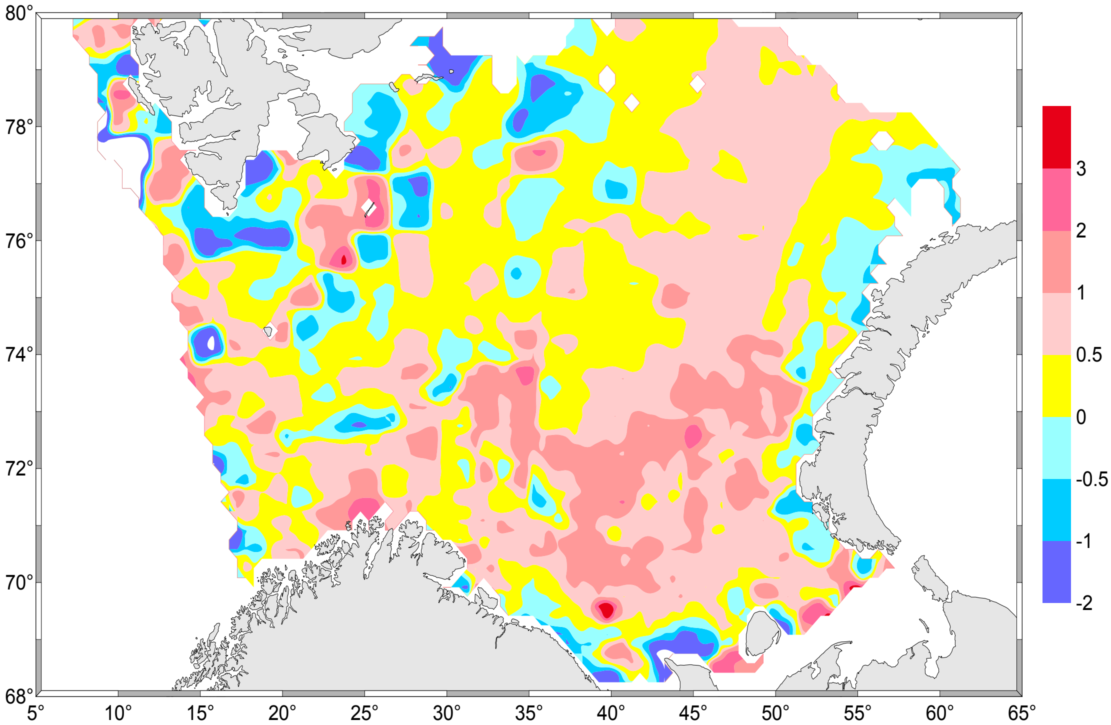


Figure 1.4. Bottom temperature anomalies in the Barents Sea in August-September 2009 (Anon., 2010).

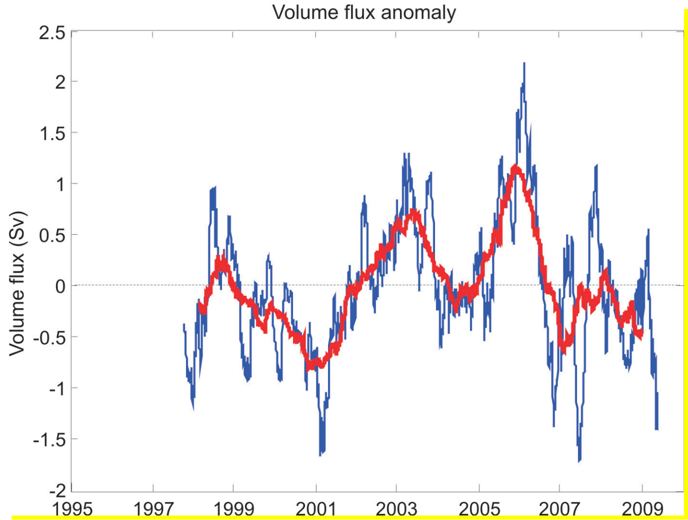


Figure 1.5. Observed Atlantic Water volume flux through the Fugløya-Bear Island section estimated from current meter moorings. Three months (blue line) and 12-months (red line) running means are shown.

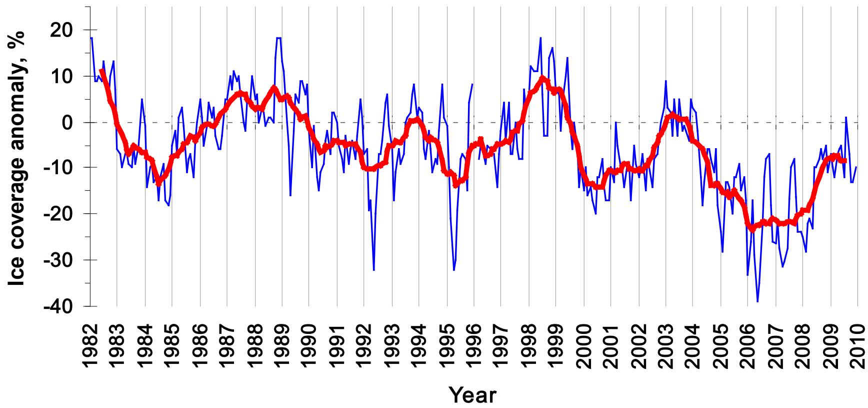


Figure 1.6. Ice extent anomalies in the Barents Sea in 1982-2009 (Anon., 2010). The blue line shows monthly values, the red one – 11-month moving average values.

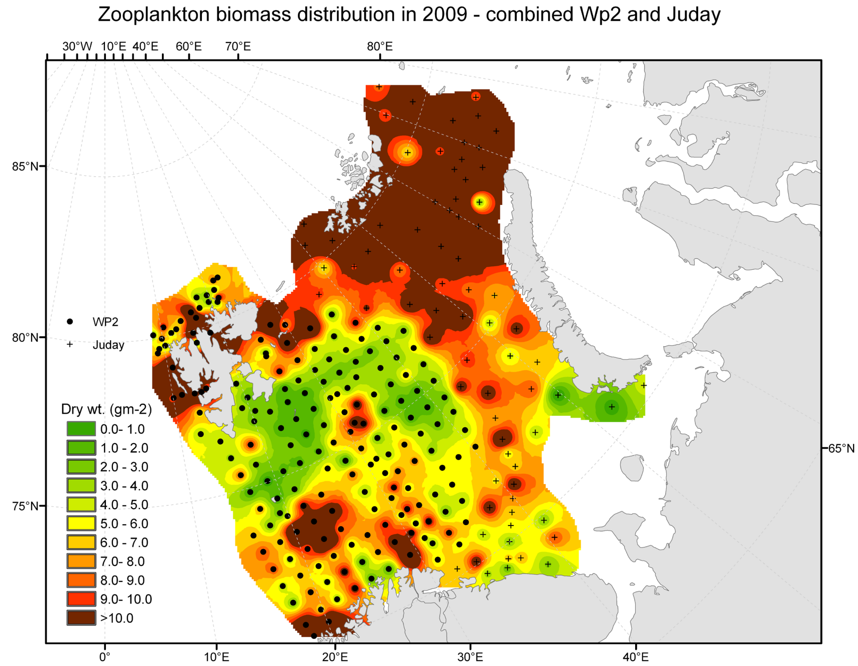


Figure 1.7. Horizontal distribution of zooplankton in 2009 (g m-2 of dry weight from bottom-0 m).

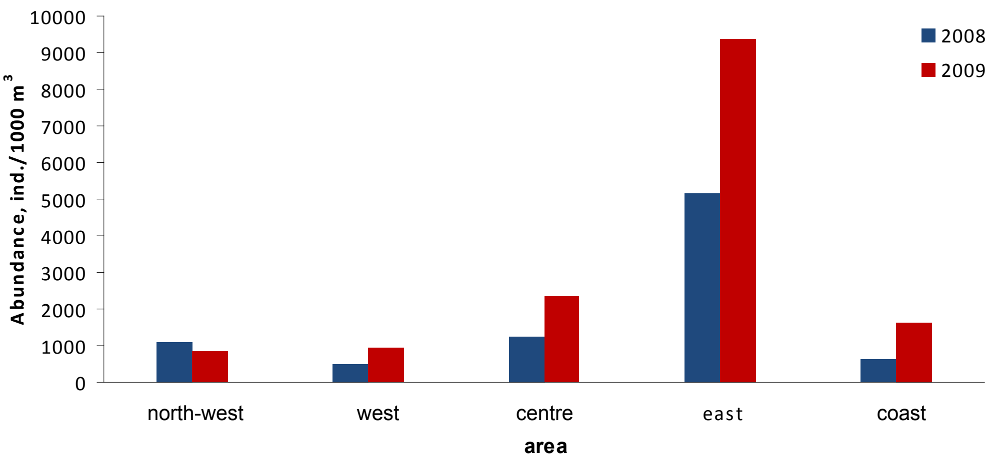


Figure 1.8. The mean abundance of euphausiids in the north-western and western areas of the Barents Sea in 2008 and 2009.

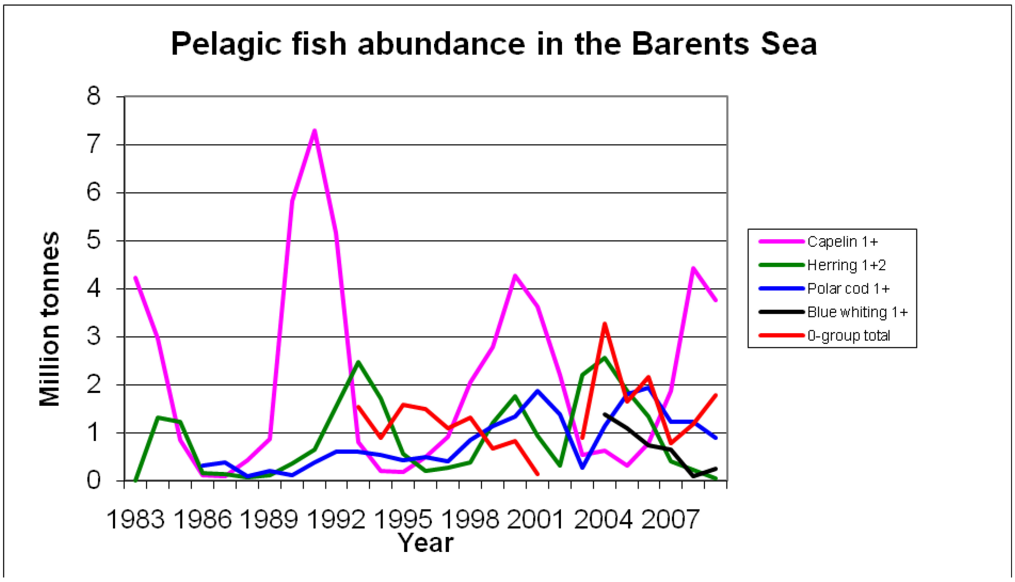


Figure 1.9. Biomass of pelagic fish species in the Barents Sea. Data are taken from; capelin: Acoustic estimates in September, age 1+ (ICES AFWG 2010), herring: VPA estimates of age 1 and 2 herring (ICES C.M. 2009/ACOM:12), using standard weights at age (9g for age 1 and 20g for age 2); polar cod and 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*. 2010).

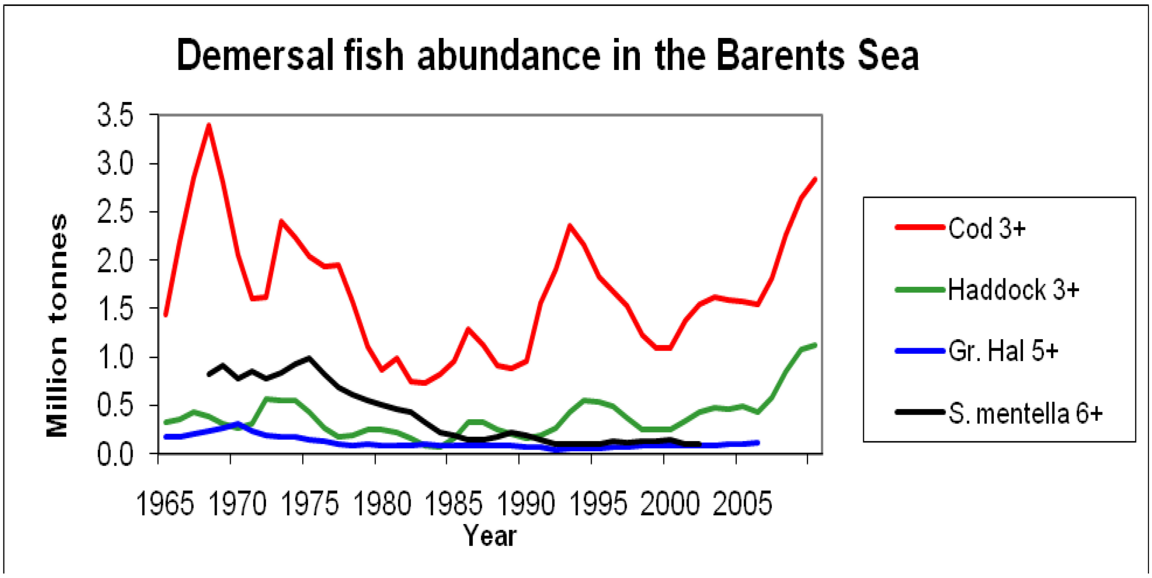


Figure 1.10. Biomass of demersal fish species in the Barents Sea. Data are taken from; cod: VPA estimates, age 3+ (ICES AFWG 2010); haddock: VPA estimates, age 3+ (ICES, 2010); Greenland halibut: VPA estimates, age 5+ (ICES, 2007); Sebastes mentella: VPA estimates, age 6+ (ICES, 1995 for the years 1968-1990; ICES, 2003 for the years 1991-2002).

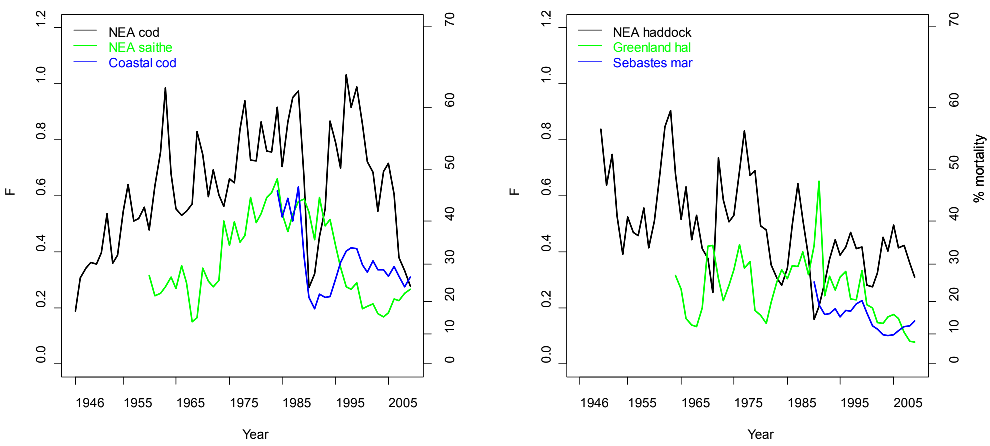


Figure 1.11a. Time series of annual average fishing mortalities for Northeast Arctic cod (time period 1946-2009, average for ages 5-10), Northeast Arctic saithe (time period 1960-2009, average for ages 4-7), coastal cod (1984-2009, average for ages 4-7), Northeast Arctic haddock (time period 1950 -2009, 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).

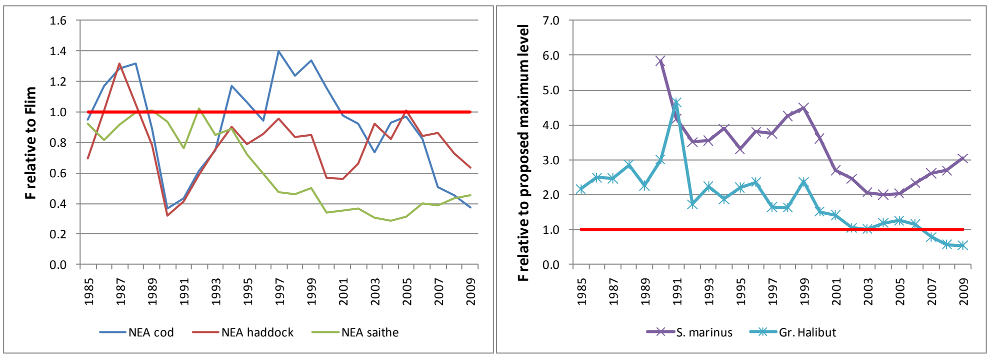


Figure 1.11b. Left panel - annual fishing mortalities of the Northeast Arctic cod, haddock and saithe stocks relative to the critical levels above which the fishing mortality will impair the recruitment. Right panel - annual fishing mortalities of Golden redfish (*Sebastes marinus*) and Greenland halibut (*Reinhardtius hippoglossoides*) relative to the proposed maximum levels above which the fishing mortality over time most probably will impair the recruitment.

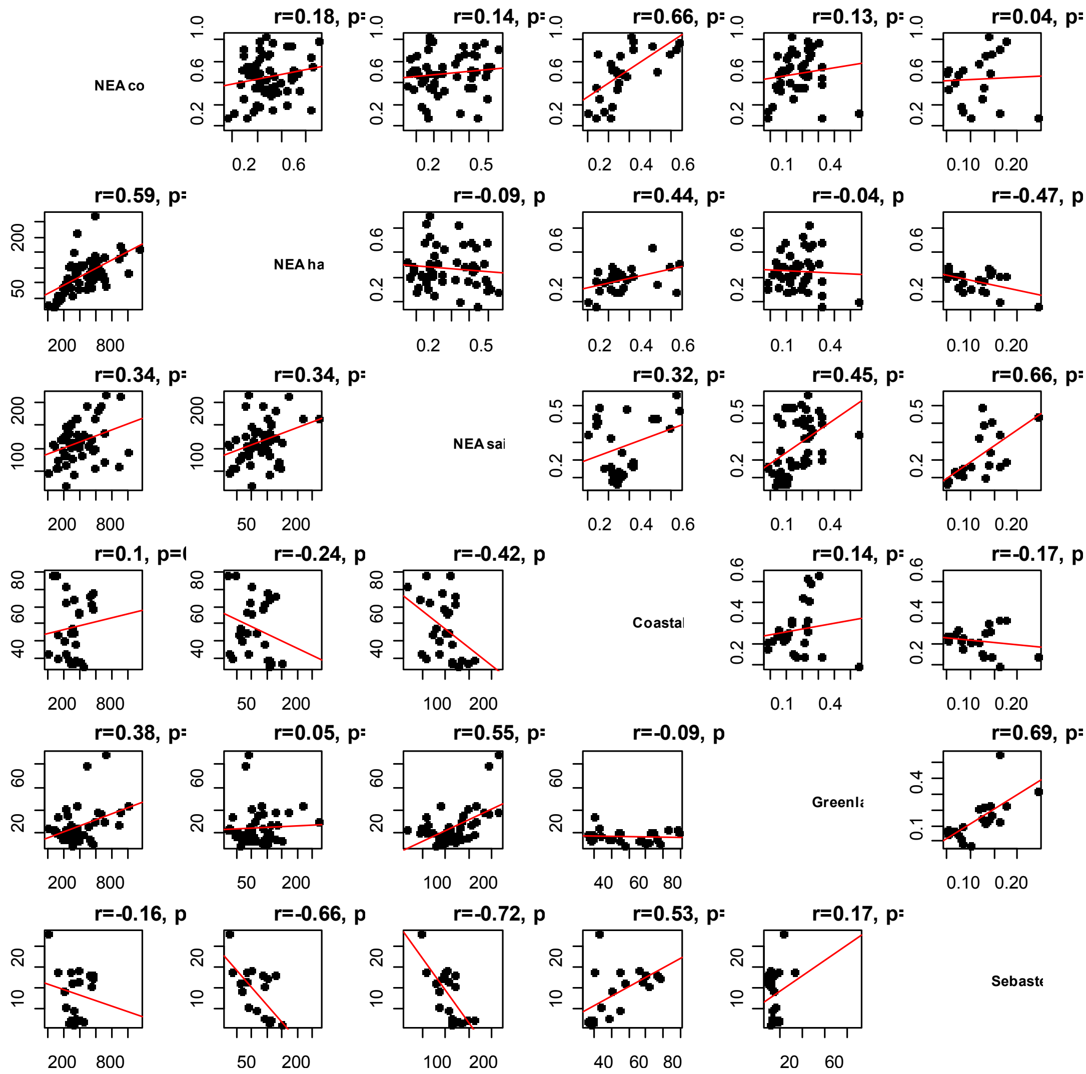


Figure 1.12. Pair-wise plots of annual average fishing mortalities (above diagonal) and landings (below diagonal) for overlapping time periods for Northeast Arctic cod (time period 1946-2009, average for ages 5-10), Northeast Arctic haddock (time period 1950-2009, average for ages 4-7), Northeast Arctic 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 pvalue are given in the legend.

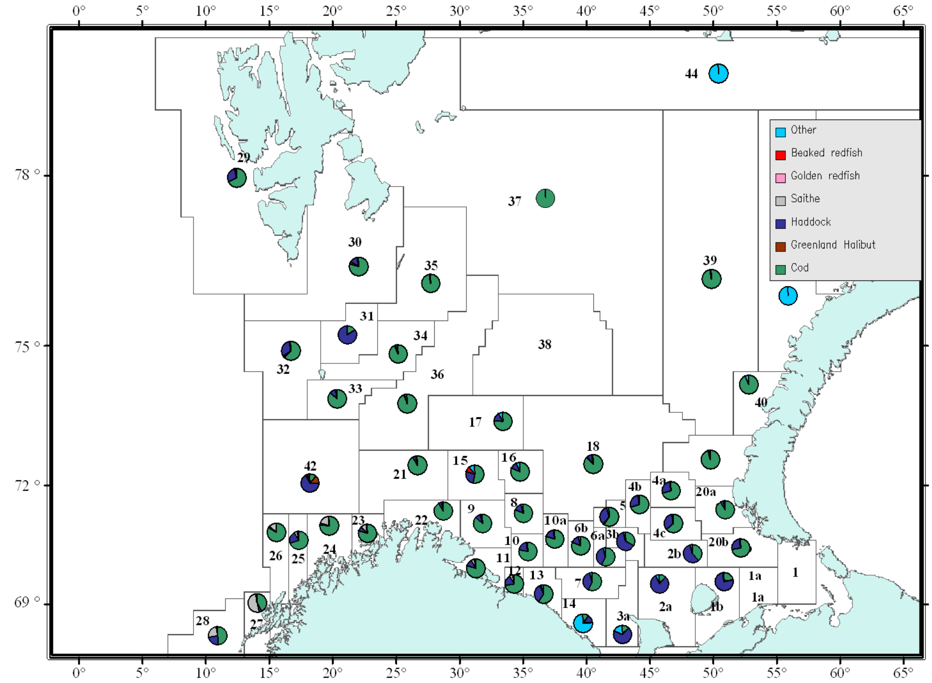


Figure 1.13. Relative distribution by weight of cod, haddock, saithe, Greenland halibut, golden redfish (*Sebastes marinus*), beaked redfish (*Sebastes mentella*) and other species taken by Russian bottom trawl in 2009 per main area for the Russian strata system.

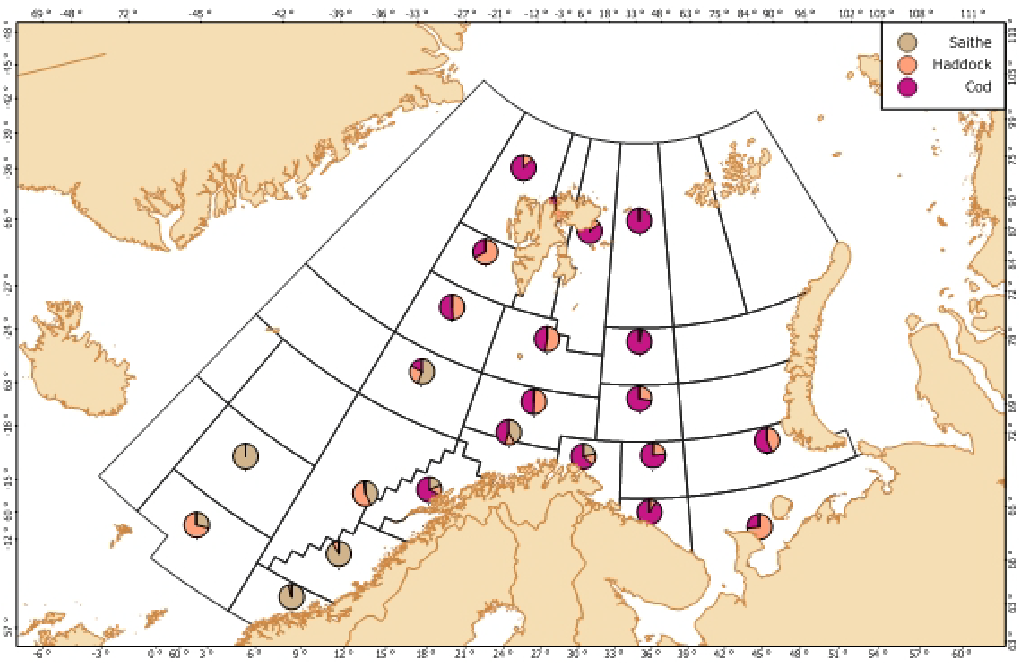


Figure 1.14. Relative distribution by weight of Norwegian catches of cod, haddock, and saithe per main area for the Norwegian strata system.

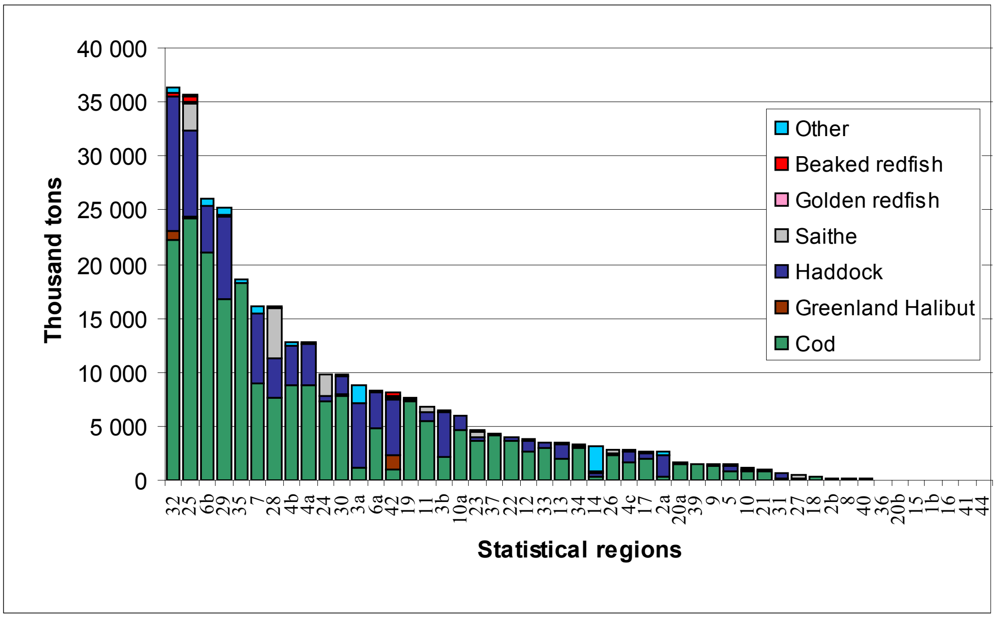
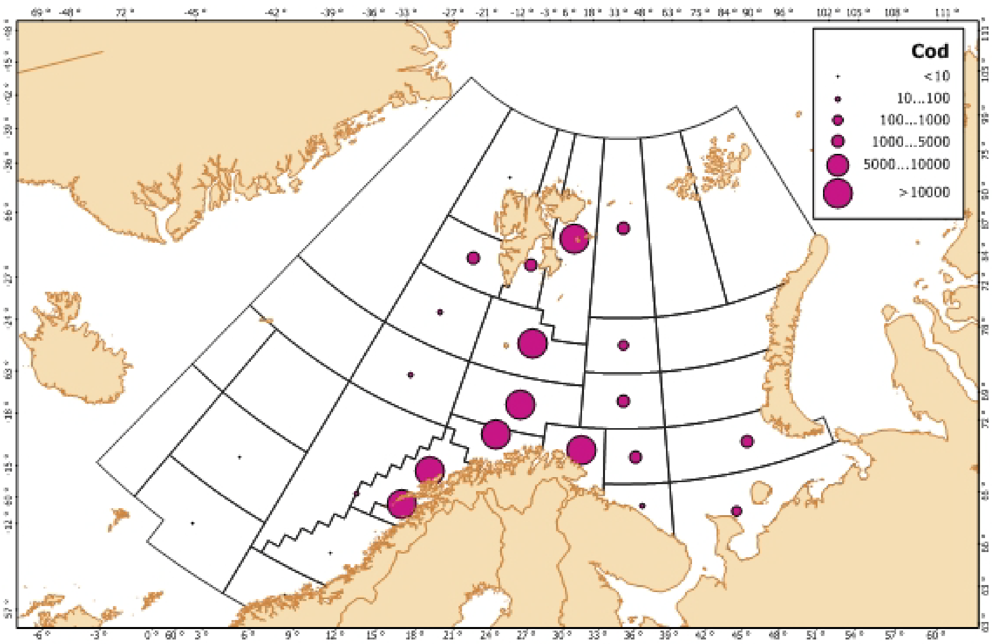
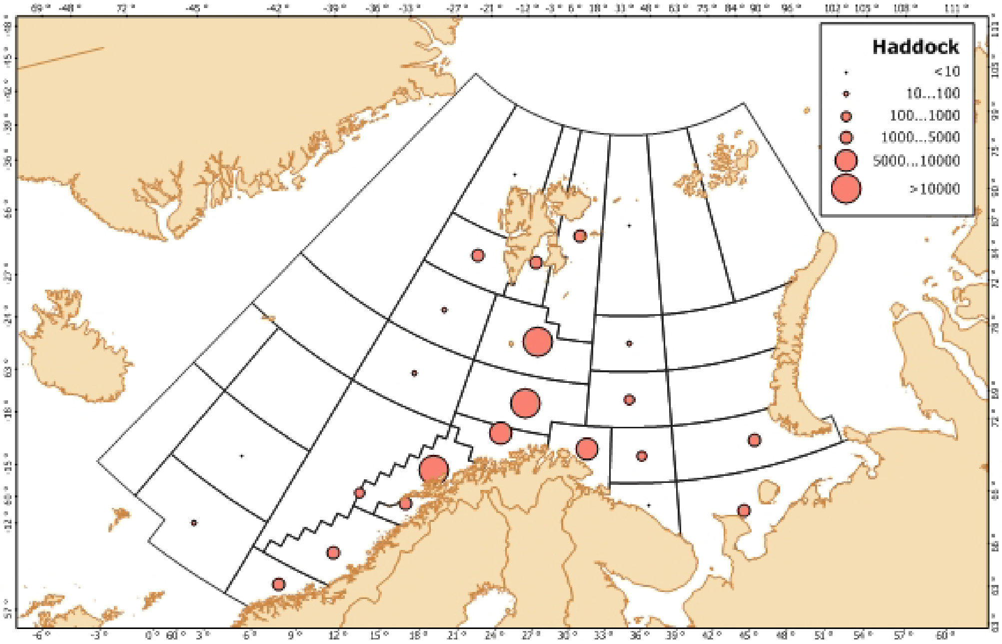


Figure 1.15. The Russian catch of cod, haddock, saithe, Greenland halibut, *Sebastes marinus*, *Sebastes mentella* and other species taken by bottom trawl by main statistical areas in 2009, thousand tonnes. The statistical areas correspond to the areas shown in Figure 1.13.





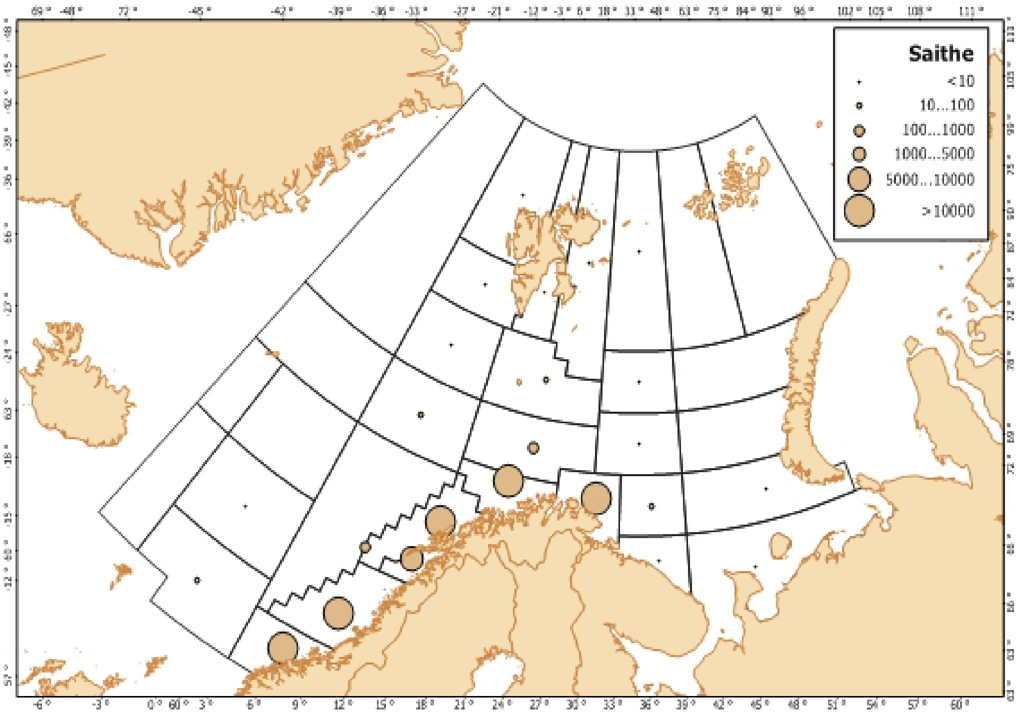


Figure 1.16. The Norwegian catch of cod, haddock and saithe by main statistical areas in 2009, thousand tonnes. The statistical areas correspond to the areas shown in Figure 1.14.

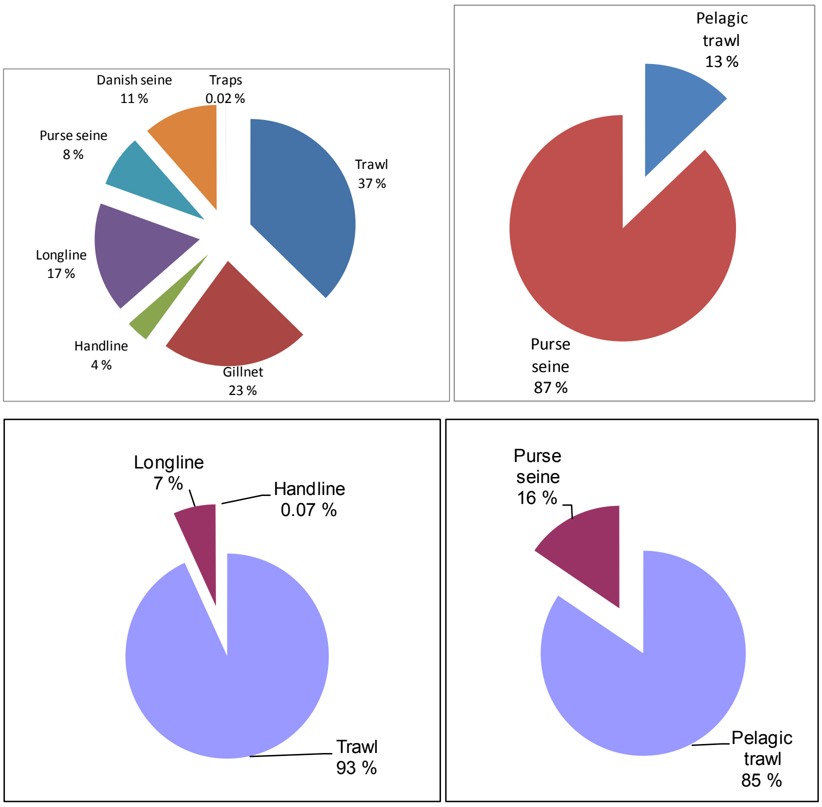


Figure 1.17. Upper panel - gear composition of the Norwegian groundfish (2007; left) and pelagic capelin (2000-2008; right) fisheries in the Northeast Arctic. Note that the purse seine in the groundfish fishery is solely used in a coastal fishery for saithe. Lower panel - gear composition of the Russian groundfish (2007; left) and pelagic capelin (2000-2008; right) fisheries in the Northeast Arctic.

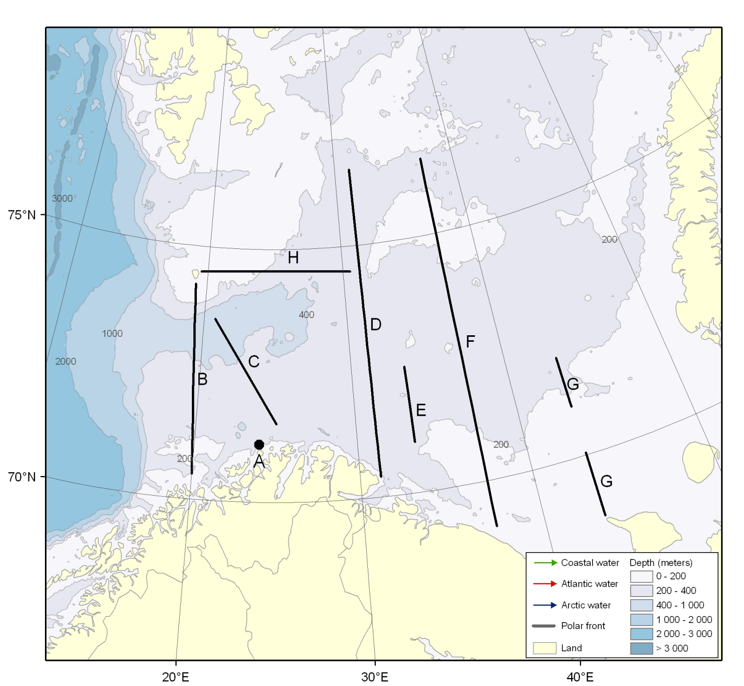


Figure 1.18. Positions of the standard sections monitored in the Barents Sea. A is fixed station Ingøy, B is Fugløya-Bear Island, C is North cape-Bear Island, D is Vardø-North, E is Kola, F is Sem Island-North G is Kanin section and H is Bear Island-East section.

1 Ecosystem considerations (Figures 1.1–1.18, 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 a steadily 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 participate in the development of an ecosystem based management of the Barents Sea.

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 contributes 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, inter-species 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 a preliminary version of the 2009 update (Stiansen *et al.*, WD23) of the "Joint Norwegian-Russian environmental statutes 2008, report on the Barents Sea Ecosystem" (Stiansen *et al.*, 2009), affiliating more than 100 scientists from 24 institutions in Norway and Russia. This report is the successor to the "Joint PINRO/IMR report on the state of the Barents Sea ecosystem in 2007, with expected situation and considerations for management" (Stiansen and Filin, 2008). Text, figures and tables taken from these reports (i.e. Stiansen *et al.*, 2009, or Stiansen *et al*, WD23) are in general not further cited in this chapter.

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

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. 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 km², has an average depth of 230 m, and a maximum depth of about 500m at the western end of Bear Island Trough (Figure 1.1). Its topography is characterized by troughs and basins (300 m – 500m 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.

Climate

The general pattern of circulation (Figure 1.1) is strongly influenced by this topography, and is characterised by inflow of relatively warm Atlantic water, and coastal water from the west. This 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 freshwater 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. 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.

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 do not differ qualitatively from those at lower latitudes. Both bacteria and viruses show highly variable abundance in the Barents Sea, and in general, the dynamics of these groups in this area do not differ from other parts of the ocean. 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 different 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, predominate the spring bloom in different years.

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 and crustaceans are important. The calanoid copepods of the genus *Calanus* play a key role in this ecosystem. *Calanus finmarchicus*, is most abundant in Atlantic waters and *C. glacialis* is most abundant in Arctic waters. Both form the largest component of zooplankton biomass.

Calanoid copepods are largely herbivorous, and feed particularly on diatoms (Mauchline, 1998). 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 species that occupy different niches in the community of Barents Sea euphausiids 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 were found abundant in the Barents Sea; *Themisto abyssorum* and *T. libellula* in the western and central Barents Sea, and *T. compressa* is found, albeit less abundant, 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 restricted to combined 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 term often used by non-specialists in reference 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*. Neither of these terms implies any systematic relationship to vertebrate fish. The term "jellyfish" is also often used in reference 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.

Benthos

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. Many feed by actively or passively, sieving food particles or small organisms from the water. Others eat the bottom sediments (detritus feeders), eat carrion (scavengers) or hunt other animals (carnivores). The high diversity among bottom animals is presumed to be due to the abundance of micro-habitats that organisms can adapt. In shallow waters, kelp forests are feeding and nursery habitats for many species of fish, birds, and mammals. Below the sublittoral zone, sea anemones, sponges, hydrozoans, tunicates, echinoderms, crustaceans, molluscs and many other animal groups abound on hard substrates. These large conspicuous animals are not abundant on sand or muddy bottoms, and in fact some of these habitats may at first look rather lifeless. However, most of the benthic animals in these habitats live buried in the sediments. *Polychaete* worms, crustaceans and bivalves are found in the sediments well as a myriad of other taxa. Some muddy areas might have dense aggregations of brittle stars, sea stars or bivalves.

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.

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 meter. 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.

Fish

More than 200 fish species are registered in trawl catches during surveys of the Barents Sea, and nearly 100 of them occur regularly. Even so, the Barents Sea is a relatively simple ecosystem, with few fish species of potentially high abundance. Different species of fish are not evenly distributed throughout the Barents Sea. Rather, they exhibit highest abundance in areas with suitable environmental conditions. Commercially important fish species include Northeast Arctic cod, Northeast Arctic haddock, 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. Species distribution largely depends on positioning of the Polar Front. There have been significant variations in abundance of these species. These variations are due to a combination of fishing pressure and environmental variability Cod, capelin, and herring are key species in the Barents Sea trophic system.

In general the four pelagic species (herring, capelin, polar cod and blue whiting) have minor overlapping distributions; with the blue whiting in the west, the herring in the south, the polar cod in the east (except for an overlapping part of the stock in the Svalbard region) and the capelin in the north and central areas. In southwestern areas blue whiting and herring partly overlap. However, they occupy different parts of the water column.

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 prey on capelin, herring, and smaller cod; while herring prey on capelin larvae. 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 (Table 1.3-

Table 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 capelin has showed large variations in abundance.

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. 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 years with warm Atlantic water masses the blue whiting may enter the Barents Sea in large numbers, and the blue whiting 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 it has decreased strongly again. 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).

Mammals and seabirds

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).

Fish and mammals have seasonal feeding migrations so that the stocks in the area will have their most northern and eastern distribution in August-September and be concentrated in the southern and south-western areas in February-March. 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.

Rare, threatened and invasive species and infectious 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.

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.

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 the 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. The best known examples of introduced species in the Barents Sea are red king crab *(Paralithodes camtschaticus)* and snow crab *(Chionoecetes opilio)*.

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 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 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. In the near-term, observed levels of contaminants in the marine environment should not have significant impact on commercially important stocks and on the Barents Sea ecosystem as a whole.

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.

Transport of oil and other petroleum products from ports and terminals in NW-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.

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.

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.

Ocean acidification is greater and happening faster than any previous acidification process experienced in millions of years. The absorption of CO_2 generally goes faster in colder waters and thus will rapidly affect the Barents Sea.

1.2 State and expected situation of the ecosystem (Figures 1.2–1.10, Tables 1.3–1.6, 1.9)

1.2.1 Climate

Atmospherical conditions

In 2009, the weather over the North Atlantic was determined by cyclonic activity throughout the year, and northerly and easterly winds prevailed over the Barents and northern Norwegian Seas. In winter, spring and autumn, air temperature averaged over the western and eastern parts of the Barents Sea was higher than normal, with maximum positive anomalies (3.9-4.1°C) in the eastern Barents Sea in January and March. In summer, positive anomalies did not exceed 1°C, and small negative anomalies were observed in some months

Water temperature

In general the temperatures in the entire Barents Sea in 2009 was still high (about 0.5-1.0°C above the long-term average), and at about the same levels as in 2008. At the end of the year the temperature in the Atlantic water masses was increasing again. In the beginning of 2010 the temperature decreased again, but is still above the long-term mean.

Sea surface temperature (SST) in the Barents Sea showed much of the same variations as the air temperatures. In winter, due to the warmer-than-usual air masses over the central and eastern Barents Sea and therefore the less-than-usual atmospheric cooling, the SST was higher than normal, with maximum positive anomalies (1.0°C) in the central part of the sea. In the western and north-western Barents Sea, on the contrary, the SST was lower than normal throughout most of the year, with maximum negative anomalies (–0.5°C) in April and July. The weaker-than-usual spring-and-summer warming caused decreasing SST anomalies. From June to August, negative anomalies of SST were observed in most of the sea. In autumn, SST anomalies increased due to the intensification of cyclonic activity and warm air-masses transport; maximum positive anomalies of SST (up to 1.6°C) were found in the southern areas in November.

Development in the coastal waters is measured at the Ingøy fixed station, and show that during 2009 the surface temperature was only slightly above normal through most of the year except in late fall/early winter 2009/2010. In the deeper waters (at 250 m), which is strongly influenced by Atlantic Water, the temperature was above normal throughout the year. In both the surface and deeper layers, the temperature increased (relative to the normal) in late fall 2009/early winter 2010, but decreased again in spring 2010, with surface temperatures around and deeper layers still slightly above the long term mean.

The Fugløya-Bear Island and Vardø-North sections, which capture all the Atlantic Water entering the Barents Sea from south-west, showed temperatures close to 0.5°C above the long-term mean in early 2009 (Figure 1.2). This is lower than the last 5-6 winter, and is due to lower air temperatures causing more intense heat loss in combination with weak inflow of Atlantic Water. Over the year the temperatures increased, and in October 2009 the temperature in south-west was 0.9°C above the long-term mean. The annual mean temperature in 2009 was close to the year of 2008. In the beginning the temperature at the Vardø-North decreased again to ~0.5 °C above the long term mean.

Temperature in the upper 200 m layer in the southern Barents Sea (Kola section) was higher than normal throughout the year of 2009, and, during the second half of the year, it was higher than in 2008 (Figure 1.3). At the beginning of the year, the weaker-than-usual seasonal cooling caused an increase in positive temperature anomalies (by 0.1-0.3°C) in the Atlantic water compared to December of 2008. The positive anomalies changed slightly during the first half of the year, then they decreased to September due to easterly and northeasterly winds prevailed in spring and summer. During autumn, temperature anomalies in the main warm currents increased again due to the intensification of cyclonic activity and air-mass transport from the west. By December, temperature anomalies exceeded 1.0°C in all parts of the Kola Section, and the highest December temperature for the period from 1951 to the present was observed in the Murman Current. The annual temperature in the Murman Current in 2009 was typical of anomalous warm years and close to that of 2008.

Temperature in the bottom layer of the Barents Sea in August-September 2009 was typical of warm and anomalous warm years. Positive temperature anomalies were observed in most of the surveyed area and were, on average, 0.3-1.0°C. The largest positive temperature anomalies (> 1.5°C) were observed in the eastern Barents Sea, in the areas adjacent to the Eastern Basin (Figure 1.4). Compared to 2008, the volume of cold Arctic waters increased significantly in the northern Barents Sea, and for the first time in the last three years waters with negative temperature were found in the Eastern Basin. So, in comparison with the previous year, it caused decrease in the spatially averaged bottom temperature of the surveyed area except the southern Barents Sea occupied by the Murman Current and the Central branch of the North Cape Current. In the beginning of 2010 the bottom temperatures in the south and southwestern parts were higher than in the same period in 2009, while they were lower in the deep central parts.

According to computations with a prediction model, based on harmonic analysis of the Kola Section temperature time series, the temperature of the Atlantic water in the Murman Current in 2010-2011 is expected to decrease to values typical of warm years, namely to 4.5±0.5°C (with anomaly of + 0.6°C) in 2010 and to 4.4±0.5°C (with anomaly of + 0.5°C) in 2011. The years of 2010 and 2011 are similar to 1989, 1991, 2001 and 2002.

Salinity

The salinity variations show a close resemblance to temperature, although not completely. In Fugløya-Bear Island the salinity has been decreasing since 2006, while in Vardø-N it has increased over the last years. Salinity in the Atlantic water masses in 2009 was still high compared to the long term trend.

Inflow of Atlantic water

The volume flux of Atlantic Water flowing into the Barents Sea is predominantly barotropic, with large fluctuations in both current speed and lateral structure. In general, the current is wide and slow during summer and fast, with possibly several cores, during winter. The mean transport of Atlantic Water into the Barents Sea for the period 1997-2009 is 2 Sv (Sv = 10^6 m^3s^{-1}) with an average of 2.2 Sv during winter and 1.8 Sv during summer. During years in which the Barents Sea changes from cold to warm marine climate, the seasonal cycle can be inverted. Moreover, an annual event of northerly wind causes a pronounced spring minimum inflow to the western Barents Sea; at times even an outward flow.

The time series of volume transport reveals fluxes with strong variability on time scales ranging from one to several months (Figure 1.5). The strongest fluctuations, especially in the inflow, occur in late winter and early spring, with both maximum and minimum in this period. The recirculation seems to be more stable at a value of something near 1 Sv, but with interruptions of high outflow episodes.

The volume flux varies with periods of several years, and was significantly lower during 1997-2002 than during 2003-2006. The year of 2006 was a special year as the volume flux both had a maximum (in winter 2006) and minimum (in fall 2006). Since then the inflow has been low, particularly during spring and summer. The inflow in 2009 was much as in 2007 and 2008; moderate during winter followed by a strong decrease in spring. In early summer 2009 the flux was close to 1.5 Sv below the average. As the observational series still only have data until summer 2009, it cannot give information about the situation in fall 2009 and early winter 2010. There is no significant trend in the observed volume flux from 1997 to summer 2010.

Ice conditions

The variability in the ice coverage in the Barents Sea is linked to the temperature of the inflowing Atlantic water, the northerly winds, and import of ice from the Arctic Ocean and the Kara Sea. The ice has a response time on temperature changes in the Atlantic inflow (one-two years), but usually the sea ice distribution in the western Barents Sea respond a bit quicker than in the eastern part. Due to the high temperatures there has been little ice in the last years (Figure 1.6). During the period 2003-2006 the winter ice edge had a substantial retreat towards north-east, but since then the ice area has increased.

For the first eight months of the year of 2009, the sea ice extent in the Barents Sea was less than normal, but more than in 2008. In comparison with the previous year, the ice coverage (expressed as a percentage of the sea area) was 10-18% more in January-May, 5-9% more in June and August and the same in July. Ice melting in summertime was more intensive than in 2008. By July, the south-eastern Barents Sea was ice-free, which is almost one month earlier than in 2008. Ice formation started in the northernmost sea only at the end of October. In October, the ice coverage was 13% less than normal and 5% less than in 2008. By December, the ice coverage of the Barents Sea was still lower than normal but higher than in 2008, a situation that continued into the beginning of 2010.

It is expected that there will be slightly less or around average ice conditions in 2010.

Hydrochemical conditions

According to the chemical observations along the Kola Section in 2009, some decrease in oxygen saturation of the bottom layer was found in the southern Barents Sea compared to 2008: the oxygen saturation anomaly averaged from January to October was –0.24% in 2009, and 0.78% in 2008. Negative anomalies prevailed at the beginning of the year, while small positive anomalies prevailed in summer and autumn.

1.2.2 Phytoplankton

In Norwegian waters there was not observed any large aberration in the annual succession in the phytoplankton along the fixed transect (Vardø – North and Fugløya-Bear Island) in 2009. The spring bloom occurred from mid March to mid April within the "normal" period of the spring bloom at the Bear Island transect. The bloom starts in the coastal waters "spreading" out into the open areas. In April the diatoms were dominating. During summer the phytoplankton was compound of small flagellates, dinoflagellates, and at some stations diatoms. During autumn larger dinoflagellates was common, however, at some stations diatoms had moderate to high abundance.

1.2.3 Zooplankton

The mesoplankton biomass measured in August–September 2009 was clearly below the long-term mean in the Norwegian sector but with slightly higher values along the border to the Russian zone. A particular feature in 2009 is the very high biomass found in the Russian sector north of 75°N and east of 40°E. The average zooplankton biomass in the western and central Barents Sea in 2009 was 5.87 g dry weight m^{-2} compared to 6.48 g in 2008 and 7.13 g in 2007 (Figure 1.7).

The macroplankton survey conducted in autumn and winter 2009 showed that on average, abundance of euphausiids in the west and northwest of the sea was close to the level of 2008 (Figure 1.8). However, in the center, east and coast areas the abundance indices of krill increased 1.5-2 times compared to 2008. In total the macroplankton survey showed that the abundance indices of euphausiids were above than the long-term mean.

The average zooplankton abundance in 2009, together with the considerable decline observed since 2006, suggest that the condition for local production is less favourable for 2010. The total production will probably depend largely on the magnitude of zooplankton advection from the Norwegian Sea. The macroplankton feeding conditions for planktivorous fish in 2010 is expected to be similar to 2009.

The abundance of gelatinous zooplankton, caught by pelagic trawling, show a lower abundance of gelatinous zooplankton in 2009 compared to 2008. Both in 2008 and in 2009, the distribution of "jellyfish" also showed a considerable overlap with regions poor in mesozooplankton biomass.

1.2.4 Northern shrimp

According to the Russian-Norwegian ecosystem survey in August – September 2009 the largest catches of the northern shrimp were recorded in the eastern and northern Barents Sea and north of Spitsbergen. The investigations of 2009 showed that the total stock of the northern shrimp increased compared to last year.

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 1984-2009, 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 2009 were capelin, polar cod, krill, haddock, herring, shrimp, cod and amphipods. In comparison with 2008 the importance of capelin and herring has increased while the importance of krill and shrimp has decreased. The consumption calculations made by IMR show that the total consumption by age 1 and older cod in 2009 was about 6 million tonnes (Table 1.3), while similar calculations by PINRO gave about 5 million tonnes. According to calculations by IMR and PINRO the consumption per cod was about the same in 2009 as in 2008 (Tables 1.5-1.6).

Blue whiting and polar cod

Based on the most recent estimates of fishing mortality and SSB, ICES classifies the stock as having full reproductive capacity, and being harvested sustainably. SSB increased to a historical high in 2004 but has decreased since, and is expected to be just above B_{pa} in 2011. The estimated fishing mortality is slightly below F_{pa}. Recruitment in 1995-2004 was at a much higher level than earlier, but the 2005 and later year classes seem to be poor. Total landings in 2008 were 1.3 mill. tonnes, which is lower than in 2007. Blue whiting is not fished in the Barents Sea.

The high abundance of blue whiting in the Barents Sea in 2004-2007 may be due to a large stock size in this period combined with high temperature. Blue whiting has been observed in the western and southern Barents Sea for many years, but never in such quantities, and never as far east and north in this area as in 2004-2007. In autumn 2009, the acoustic abundance of blue whiting was estimated to 0.3 million tonnes, which is higher than in 2008, but still low. Also, the swept area estimate of blue whiting in winter 2010 was the lowest in the time series, which go back to 2001. Thus, the abundance of blue whiting in the Barents Sea is expected to stay at a low level until the recruitment to the stock increases again.

The polar cod stock is presently at a high level. Norway took some catches of polar cod in the 1970s and Russia has fished on this stock more or less on a regular basis since 1970. The stock size has been measured acoustically since 1986 and the stock has fluctuated between 0.1-1.9 million t. In 2009, the stock size was measured to about 0.9 million t., which is below the estimate obtained in 2008. The natural mortality rate in this stock seems to be very high, and this is explained by the importance of polar cod as prey for cod and different stocks of seals.

Herring and capelin

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as having full reproductive capacity and being harvested sustainably. The 1998, 1999, 2002 and 2004 year classes dominate the current spawning stock which is estimated to 12.2 million t in 2010. Preliminary indications show that the year classes 2005-2009 are below average. Therefore the abundance of herring in the Barents Sea is believed to be at a relatively low level in 2010. This stock has shown a large dependency on the occasional appearance of very strong year classes. In recent years the stock has tended to produce strong year classes more regularly. However, as no strong year classes have been produced since 2004, the stock is expected to decline. Norwegian spring-spawning herring is fished along the Norwegian coast and in the Norwegian Sea, but not in the Barents Sea. However, juveniles from this stock play an important part role in the ecosystem in the Barents Sea.

The capelin stock size is at a level somewhat above average. Based on the most recent estimates of SSB and recruitment ICES classifies the stock as having full reproductive capacity. The maturing component in autumn 2009 was estimated to be 2.3 mill t., and SSB 1st April 2010 was predicted to be at 0.52 mill t. The spawning stock in 2010 consisted of fish from the 2006 and 2007 year classes, but the 2006 year class dominated. The survey estimate at age 1 of the 2008 year class is somewhat below the long-term average. Observations during the international 0-group survey in August-September 2009 indicated that the 2009 year class is below average.

The estimated annual consumption of capelin by cod has varied between 0.2 and 3.0 million t over the period 1984-2009. Young herring consume capelin larvae, and this predation pressure is thought to be one of the causes for the poor year classes of capelin in the periods 1984-1986, in 1992-1994, and from 2002-2005.

Non-commercial species

Thorny skate (*Amblyraja radiata*) was quite widely distributed in the Barents Sea except for the south eastern and north eastern regions, as in 2008. The observed abundance of this species was higher than in 2008. The thorny skate preferred to keep in a wide range of depths from 50 down to 300 meters.

Northern skate (*Amblyraja hyperborea*) was distributed in the northeast part of the Barents Sea and along the shelf slope to the west of Spitsbergen. It was mainly found in the depth range 200 to 300 meters.

Plaice (*Pleuronectes platessa*) was distributed in a range of depths from 50 down to 100 meters) on northwest from Kanin peninsula.

According to observations in 2009 the tendency of expansion of Norway pout (*Trisopterus esmarkii)* in the Barents Sea is continuing. Main density concentrations of Norway pout were registered in the south-western areas. At the same time, along the warm Spitsbergen current, Norway pout was observed until 81° N. Along coastal North Cape current Norway pout were distributed eastward up to 47° E. It seems like Norway pout have occupied the blue whiting distribution area after this species declined.

In the ecosystem survey in 2009 there were both new species to the area and recordings of rare species in the area of observation. Some of these species have their main distribution in the warm waters of the Norwegian Sea (*Molva molva, Schedophilus medusophagus*) or in the cold waters of the Kara Sea (*Arctogadus glacialis*) bordering the Barents Sea.

1.2.6 Marine mammals

Harp Seal

Since 1998 the abundance of harp seal pup production in the White Sea has been sharply reduced, according to the PINRO aerial surveys. However the decrease in the harp seal pup production abundance has become slower recently and even some slight increase has been observed. The abundance of harp seal pups in the whelping patches in 2009 calculated using the data from aerial surveys was more than two times lower, compared to the data obtained for 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 in 2005-2009 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 2009 – 1.2 million animals).

Predation by mammals

Analyses of consumptions by marine mammals in the Barents Sea for 2009 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. Models predict that air temperatures will continue to increase considerably. With the 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 that temperate zooplankton would shift 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.

Similarly, the many complex ways in which species interact creates considerable uncertainty in any set of predictions as to what the overall response of climate warming to the ecosystem will be. If warming causes phytoplankton to increase, this is expected to result in an overall increase in fish production. For example, model studies show that higher primary production tends to lead to an increase in cod recruitment in the Barents Sea (Svendsen *et al*., 2007). 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). With increasing temperatures, temperate benthic species are expected to become more frequent and the species composition of the benthos will change. Such changes will affect benthic production (i.e. food for demersal fishes and other vertebrates) and may therefore have considerable management implications. Polar bears, ringed seals, bearded seals, harp seals and hooded seals are all dependent on sea ice. It is the primary foraging habitat for polar bears, and a resting and breeding habitat for all of these seals. Additionally, some of the seals feed on ice-associated prey. As a result of climate warming and the associated loss of sea ice, distribution and abundance of these species are expected to decrease in the Barents Sea.

Along with climate change should mention 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 ofo the Barents Sea fisheries and its effect on the ecosystem (Tables 1.10–1.11, Figures 1.11–1.16

Description of the Barents Sea fisheries and its effect on the ecosystem (Tables 1.10-1.11, Figures 1.11-1.16)

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 predation. 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 (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. Overcoming these problems and further developing our understanding of the effects of fisheries in an ecosystem context are important challenges for management.

1.4 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 2008, catches of nearly 900 thousand tonnes are reported from the stocks of cod, haddock, saithe, redfish, and Greenland halibut, which is an increase of 10% as compared to the year before. An additional catch of about 40 000 tonnes was taken from the stocks of wolffish and shrimp. The annual fishing mortalities F (the mortality rate is linked to the proportion of the population being fished by 1-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 1.11a). The current harvest rate relative to the maximum levels above which the fishing mortality over time may impair the recruitment is shown in Figure 1.11b. 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 and 2010 the stock is again sufficiently sound to support a quota of 390 000 and 360 000 tonnes, respectively.

Russia, as the only nation currently fishing polar cod, fished 8 190 tonnes polar cod in 2008. Norwegian spring spawning herring is the largest stock inhabiting the Northeast Arctic with its spawning stock estimated to 12.6 million tonnes in 2009. 1.5 million tonnes were fished from this stock in 2008, 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 2007 about 65 000 tonnes mackerel and 120 000 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 will be 130 mm for the entire Barents Sea (at present the minimum mesh size is 135 mm in the Norwegian EEZ and 125 mm in the Russian EEZ). This change is 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.

1.4.1 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 1.12). 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 1.13-1.16). 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 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.

Fleet composition (groundfish and pelagic species)

Figure 1.17 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.

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 has organised retrieval surveys annually since 1980. All together 10 784 gill nets of 30 metres standard length (approximately 320 km) have been removed from Norwegian fishing grounds during the period from 1983 to 2003.

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.

1.5 Management improvement issues (Tables 1.12–1.15)

1.5.1 Overview

The availability of necessary ecosystem information is only one of the needed items for implementation of an ecosystem approach to management. Another needed element is the development of appropriate methods and instruments for incorporation of ecosystem information into stock assessment and harvest control rules.

This section summarizes ecosystem information that has the potential of being implemented in, and therefore improves, the advice for sustainable fishery management.

Management of fisheries is always based on decision-making under levels of uncertainty. Incorporating data on ocean climate, lower trophic level bio-production, as well as species interactions on higher trophic levels in catch recommendations for target species, should reduce the uncertainty of scientific recommendations for sustainable harvest levels.

1.5.2 Multispecies models

Development of multispecies models designed to improve fisheries management in the Barents Sea based on species interactions started in the mid-1980s. The first models developed were MULTSPEC, AGGMULT and SYSTMOD in IMR and MSVPA in PINRO (Tjelmeland and Bogstad, 1998; Hamre and Hatlebakk, 1998, Korzhev and Dolgov, 1999). In total, these models contained the species cod, capelin, herring, haddock, polar cod, shrimp, harp seal and minke whale. Even though further development of these models has been discontinued, they serve as predecessors to newly developed models, such as EcoCod, Bifrost, Gadget and STOCOBAR. Benefits of multispecies models include: improved estimates of natural mortality and recruitment; better understanding of stock-recruit relationships and variability in growth rates; alternatives views on biological reference points. Brief descriptions of the multispecies models are given below.

EcoCod

The development of this model started in 2005 as the main task in the first stage of the joint PINRO-IMR Programme on Estimation of Maximum Long-Term Yield of North-East Arctic cod, taking into account the effect of ecosystem factors. This 10-year research programme was initiated following a request from the Russian-Norwegian Fishery Commission (Filin and Tjelmeland, 2005). EcoCod is a stepwise extension of a single species model for cod (CodSim; Kovalev and Bogstad, 2005), where cod growth, maturation, cannibalism and recruitment is modeled in a multispecies setting. Preliminary sub-models for cod growth, fecundity and malformation of eggs have been implemented in EcoCod.

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

The STOCOBAR describes stock dynamics of cod in the Barents Sea, taking into account trophic interactions and environmental influence (Filin, 2007). It is designed as a tool for prediction and exploration of cod stock development as well as for evaluation of harvest strategies and recovery plans under different ecosystem scenarios. 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 first version of STOCOBAR was created at PINRO in 2001 and development of this model is continuing. The work on the development of the STOCOBAR model is 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.

1.5.3 Statistical models

Recruitment of commercial fish

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

Maturation of cod

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.

Condition of fish

Relative body condition (the quantity of stored energy) is an important tool in understanding demographic variation and the ability of a population to respond to environmental stressors, varying food availability and competition. A high-resolution database was used to examine causes of variation in the condition of North-east arctic cod for the period 1967–2004, over annual and monthly timescales. Temperature was shown to have a positive impact on condition at both inter- and intra-annual timescales. Interannually, temperature may affect stock distribution, in particular its overlap with the capelin stock. At shorter timescales it is likely that temperature directly affects the metabolism of the cod. Intra-annually, the quantity of capelin in cod stomachs positively affected cod condition in the current and the preceding month for all lengths of cod. This indicated a time lag between a change in food consumption and a subsequent change in condition, or 'latency'.

Results presented by Sandeman *et al.* (2008) point to the importance of the impact of varying temperature on condition. The effects of climate are likely to be particularly important where the species is close to its outer distribution area or where the animal is an ectotherm.

Growth of fish

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. Regressions of weight at age of cod on temperature, capelin and the cod stock itself are used in EcoCod model.

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 have low determination coefficient, and are therefore not presented here. However, they may prove useful in the future when further developed.

Reproductive potential

Morgan *et al*. (2009) explore the impact of four alternative indices of reproductive potential (RP) on perceptions of population productivity for eight fish populations across the North Atlantic. The four indices of RP included increasing biological complexity, adding variation in maturation, sex ratio, and fecundity. Perceptions of stock productivity were greatly affected by the choice of index of RP. Population status relative to reference points, RP per recruit, and projections of population size all varied when alternative indices of RP were used. There was no consistency in which index of RP gave the highest or lowest estimate of population productivity, but rather, this varied depending on how much variation there was in the reproductive biology of the population and the age composition. Estimates of sustainable harvest levels and recovery time for depleted populations can vary greatly depending on the index of RP.

1.5.4 Other models

Consumption models

When calculating the prey consumption by a given predator, both the overall consumption level and the prey composition in the diet are used. The prey composition is usually derived from stomach content data, while the overall consumption level can be calculated using two approaches:

- A bioenergetic approach (as is usually the case for marine mammals and seabirds as predators)
- By combining data on stomach content weight with models for stomach evacuation rate, based on experiments.

Ecosystem models

Ecosystem models may be useful for looking at how change in one species or ecosystem component is affecting whole or other parts an ecosystem, thereby identifying the most important inter-species/ functional group links and sensitivity of the ecosystem to changes to those. They are also useful for scenario testing (change in fishery pressure, climate change, and sudden pollution events. Special interesting are those models that have spatial resolution, like ATLANTIS and ECOPATH/ECOSIM.

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 kilometers) in Australia and the United States. In autumn 2010 it will be implemented at IMR, and cover the area of the Barents Sea and the Norwegian Sea.

Another model that may have some utility for the future would be ECOPATH/ECOSIM. This model can use ecosystem survey data and expected biomass conversion rates to model systems. As a mass-balance model it can detect if there may be overlooked components to the ecosystem. The ECOPATH model system is used in many systems around the world. Versions of it have also been applied to the Barents Sea ecosystem (Blanchard *et al*. 2002, Dommasnes *et al*. 2002), though they are not run on an operational level.

1.5.5 Expected impact of ecosystem factors on stock dynamics

Evaluation of natural potential of cod stock biomass changes based on temperature and capelin data

STOCOBAR long-term simulations show that impact of capelin on cod stock dynamics is dependent on temperature and cod stock state (WD21). Using these simulations the natural potential for changes in cod stock size may be identified based on temperature conditions and the state of cod and capelin stocks in the Barents Sea. A table for evaluating the level of natural potential for annual changes in fishable cod stock biomass was produced based on the simulated data (Table 1.12).

According to Table 1.12 and available data on temperature, cod and capelin stocks the potential for annual changes of cod fishable stock biomass in 2009 was low. The same situations will be in 2010 and 2011 based on expected temperature and capelin stock size. The resistance of cod stock to fishing pressure under these conditions will be medium and this does not imply high contributions to cod stock dynamics from capelin and temperature.

Prediction of NEA cod recruitment.

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.

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 have 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 were not updated this year.

Titov (WD 22) and Titov et al. (WD 16 AFWG 2005) 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:

TITOV0: $R3^1$ ~$DOxSat^2$(t-13)+ DOxSat(t-13)+ ITa(t-39) + CodA3(t+1) + Tw(t-17)

TITOV1: $R3^1$ ~$DOxSat^2$(t-13)+ DOxSat(t-13)+ ITa(t-39) +CodA2(t-11) + Tw(t-17)

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

TITOV3: $R3^3$~ $OxSat^2$(t -44) + ITa(t -39) + lgCodC0(t-28)

TITOV4: $R3^4$~ $OxSat^2$ (t-44) + 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). Some changes were brought in 2009 (AFWG 2009 WD 12). New equation (TITOV0) was added, 0-group abundance indices, corrected for capture efficiency (CodC0) was entered instead of former indices in TITOV3.

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) +$BM_{cod3\text{-}6}$ /$ABM_{capelin}$(-2,-1)

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

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

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

Temp is the Kola yearly temperature (0-200m), 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, $BM_{cod3\text{-}6}$ 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.

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 meeting this year a WD by Dingsør *et al*. (WD 19) was presented, which investigated the performance of some of the mentioned recruitment models. Even though this work was well received by the working group it was decided not to change the procedure this year. However, it was strongly recommended that a Study Group should be appointed to look at criteria's for choosing/rejecting recruitment models suitable for use in stock assessment (see also chap 0.11).

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, names the "hybrid" model. One-year-ahead prognoses was given by the hybrids (Titov1, Titov3 and JES1), two-year-ahead (Titov2, Titov 3 and JES1) and three-year-ahead (Titov3) for the number of age 3 cod. 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.

Table 1.13 show the estimates of all the available models, along with last year estimates.

Cannibalism mortality for cod

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 1.14. 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. Using this approach the predicted natural mortality coefficient for cod, including cannibalism for recent years, seems to be higher compared to "the standard" assessment and prediction (Table 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 of 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 2009 to 2012, predicted by the regression, are given in the Table 1.15.

1.5.6 Fishery induced evolution

There is a vital need for the fisheries science community to maintain sustainable fisheries ensuring the effective conservation, management and development of living aquatic resources. The precautionary approach was proclaimed and applied within the ICES community to meet (promote) these aims. This approach takes into account uncertainties relating to the size and productivity of the stocks. Uncertainties relating to fisheries induced evolution are most likely taken into consideration in case of a proper implementation of precautionary approach into responsible fishery.

The Study Group on Fisheries Induced Adaptive Change (SGFIAC) proposed to create evolutionary impact assessment (EvoIA), quantifying the evolutionary effects of management measures (ICES 2008/RMC:01; ICES 2009/RMC:03). It is a very complicated but promising task given that commercial fishery could act as a selective factor resulting in evolutionary response of exploited populations.

The papers published by the SGFIAC Group members concern basically probabilistic maturation reaction norms (PMRNs) estimations for different commercial stocks/species, and shift in cohort-specific PMRNs interpreted as a genetic change at the population level. It is rather difficult to test that findings directly as the genes associated with maturation have a polygenic nature. The strength and weakness of the PMRNs approach were discussed in detail in Theme Session issue of the Marine ecology progress series, 2007, vol. 335, 249- 310.

North east arctic cod stock demonstrates long-term trends in maturation as well as in demography of the stock and weight at length of fish. The historical trends could be caused both by genetic and plastic effects on maturation. Population density factors and environmental conditions can contribute to feeding success resulting in changing maturation rates in NEA cod for the time period investigated (Marshall and McAdam, 2007; Kovalev and Yaragina, 2009). The causes in a discontinuity of the decreasing trend observed in length for 50% maturation probability in the beginning of the 80’s are unknown, but they are most likely non-genetic given that they occurred synchronously across age-classes (Marshall and McAdam, 2007).

More research is needed to evaluate underlined mechanisms of population changes including biological, physiological, ecological studies, not to mention genetic ones.

It takes a lot of time and efforts for the ICES community to implement the precautionary approach into a scientific/management practice. It is likely to take some time before the SGFIAC can evaluate and present some results applicable to test on real management measures recommendations. AFWG considers it premature at present to discuss any proposals of management measures (or reference points for fisheries management) in terms of fisheries induced evolution. Dialogues with scientists of the mentioned WG could also be carried out through the ICES Sharepoint.

1.6 Monitoring of the ecosystem (Figure 1.18, 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 from ship and airplanes. 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 hydrodynamical 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.

1.6.1 Standard sections and fixed stations

Some of the longest ocean time series in the world are along standard sections (Figure 1.18) 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.

1.6.2 Area coverage

Area surveys are conducted throughout the year. The number of vessels in each survey differs, not only between surveys but may also change from year to year for the same survey. However, most surveys are conducted with only one vessel. It is not possible to measure all ecosystem components during each survey. Effort is always put on measuring as many parameters as possible on each survey, but available time put restrictions on what is possible to accomplish. Also, an investigation should not take too long time in order to give a synoptic picture of the conditions. Therefore the surveys must focus on a specific set of parameters/species. Other measured parameters may therefore not have optimal coverage and thereby increased uncertainty, but will still give important information. An overview of the measured parameters/species on each main survey is given in Table 1.16. Specific considerations for the most important surveys are given in the following text.

Norwegian/Russian winter survey

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

The main spawning grounds of North East Arctic cod are in the Lofoten area. Echosounder equipment was first used in 1935 to detect concentrations of spawning cod, and the first attempt to map such concentrations was made in 1938 (Sund, 1938). Later investigations have provided valuable information on the migratory patterns, the geographical distribution and the age composition and abundance of the stock.

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 the transects 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

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 ecosystem autumn survey

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 aspects of the ecosystem are covered, from physical and chemical oceanography, primary and secondary production, fish (both young and adult stages), sea mammals, benthos 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”.

In 2009 not all components of the ecosystem were covered during the survey, and a further reduction will probably take place in 2010; the coverage of e.g. Greenland halibut will be less complete than in previous years. Also, the future of this ecosystem survey is still undetermined.

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

Russian Autumn-winter trawl-acoustic survey

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

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 will not be conducted in 2010, and its future design is being revised.

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 joint survey, since 1996 the survey is carried out only by PINRO.

1.6.3 Other information sources

Large 3D hydrodynamic numeric models for the Barents Sea are run at both IMR and PINRO. 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.

1.7 Main conclusions

State and expected situation in the ecosystem (section 1.2)

Climate

- The air temperature was above the long-term mean during 2009.
- The sea temperature in the Barents Sea is still high, and about the same level as in 2008. There was an increase in the end of the year, with the highest December temperature in the Kola section. In 2010 the temperature is expected to further decrease, but still be higher than the long-term mean.
- Salinity in 2009 is still high , and at about the same levels as in 2008
- Inflow of Atlantic waters at the western entrance in 2009 was quite similar to 2008; moderate during winter followed by a strong decrease in spring. Data for second half of 2009 is not available.
- Oxygen levels were about normal in 2009.
- Ice extent in 2008 was less than normal, but more than in 2008. In 2010 ice conditions is expected to be slightly less or around the long term mean.

Plankton and northern shrimp

- The mesozooplankton biomass measured in August–September 2009 was less compared to 2008, and below the long-term mean.
- Abundance euphausiids (krill) in autumn and winter 2009 were close to the level in 2008 in the western and northwestern areas and increased in the centre, eastern and coastal areas. In total the abundance in 2010 is slightly above the long-term mean.
- The abundance of gelatinous zooplankton, caught by pelagic trawling, show a lower abundance in 2009 compared to 2008.
- The shrimp stock in the Barents Sea and Spitsbergen area in 2009 increased compared to both 2007 and 2008.

Fish

- Capelin stock size is at around average level, with a slight decrease from last year. The survey estimate at age 1 of the 2008 year class is slightly below the long-term mean. 0-group estimates indicate that the 2009 year class is below average.
- For young herring there are indications that the year classes 2005-2009 are below average. Therefore the abundance of herring in the Barents Sea is believed to be at a relatively low level in 2010.
- Blue whiting is still at a very low level, with a slight increase from 2008. The abundance is expected to remain low in 2009.
- The polar cod stock is presently at a high level, similar to 2008.

Harp Seal

- The decrease in the harp seal pup production in the White Sea has become slower recently and even some slight increase has been observed, 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 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.
- According to STOCOBAR simulations there is a low probability to expect any tendency of decline or increase in the fishable cod stock biomass in 2010 and 2011, based on predicted temperature and capelin stock size.
- The cod recruitment (age 3) in 2010 is expected to be low compared to the long-term mean. In 2011 and 2012 it is expected to increase slightly, but still be below the long-term mean.

1.8 Response to technical minutes

There were no specific comments from the review group to ecosystem consideration chapter (Chapter 1).

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
Mean	77706			19880			4040			28579			64744		

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
Mean	181			29			587			35898			8997		

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
Mean	266916			76659			11243			169164		

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
Mean	520			291798			73411		

Table 1.3. The North-east arctic cod stock's consumption of various prey species in 1984-2009 (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	1621	183	3	32	47	225	0	1	41	3649
1986	606	1236	111	142	837	133	141	83	111	315	0	0	55	3769
1987	671	1085	67	191	229	32	206	25	4	324	1	0	9	2844
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	4646
1992	907	102	158	373	2457	331	97	55	106	188	20	2	93	4889
1993	751	253	714	315	3033	163	278	285	71	100	2	2	26	5994
1994	625	563	704	518	1085	147	582	224	49	79	0	1	39	4614
1995	845	982	516	362	628	115	254	371	116	193	1	0	34	4417
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	378	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	685	172	376	277	1722	71	250	66	49	6	1	151	29	3853
2002	362	96	261	232	1934	86	270	108	123	1	0	224	15	3713
2003	548	282	529	240	2157	214	272	114	168	3	0	74	48	4649
2004	671	679	318	247	1296	196	338	122	193	3	12	74	62	4212
2005	685	411	521	264	1238	187	354	116	342	2	3	111	46	4282
2006	780	169	957	313	1511	201	118	70	361	15	1	122	104	4721
2007	1141	293	935	373	1881	272	228	94	355	40	1	39	61	5712
2008	1384	146	787	316	2443	102	476	182	303	55	11	29	90	6325
2009	1250	159	427	211	2762	219	478	175	295	35	1	5	91	6109

Table 1.4. The North-east arctic COD stock's consumption of various prey species in 1984-2009 (1000 tonnes), based on Russian consumption calculations.

Year	Euphausids	Hyperiids	Shrimp	Herring	Capelin	Polar cod	Cod	Haddock	Blue whiting	Norway pout	Redfish	Long rough dab	Greenland halibut	Other fish	Other food	Total consumption
1984	93	31	351	33	592	17	13	50	5	1	195	51	0	269	286	1988
1985	30	432	202	24	989	0	98	34	18	15	97	23	0	519	198	2679
1986	57	860	148	47	807	159	28	103	3	27	158	24	1	372	170	2962
1987	69	508	201	8	162	105	27	2	10	15	118	6	0	268	188	1686
1988	209	169	118	19	292	0	20	93	0	0	127	20	0	239	242	1545
1989	167	290	104	4	680	34	34	2	0	0	158	56	0	201	248	1977
1990	101	30	270	64	1254	8	21	16	39	15	232	79	0	101	167	2396
1991	54	83	287	28	3286	44	52	22	7	6	144	46	6	132	158	4354
1992	213	38	263	374	2021	191	84	38	0	77	121	44	1	295	418	4175
1993	186	177	223	177	2791	171	147	153	4	25	41	48	5	160	384	4691
1994	362	298	472	105	1303	492	391	72	1	2	56	40	0	100	353	4046
1995	396	465	550	192	691	203	557	130	0	1	113	53	3	169	356	3878
1996	973	361	200	76	478	79	473	60	9	37	71	47	0	470	175	3509
1997	386	85	207	54	523	110	409	35	3	0	37	33	2	97	399	2380
1998	615	205	265	70	852	129	129	23	23	18	15	19	0	53	226	2641
1999	454	77	242	74	1402	165	48	14	25	1	13	8	0	58	107	2688
2000	413	111	367	48	1662	157	57	29	26	8	4	20	0	36	181	3119
2001	418	74	308	88	1433	140	59	49	137	29	4	31	2	145	190	3106
2002	309	45	198	55	2330	281	100	77	102	3	4	17	0	44	170	3734
2003	240	140	213	144	1155	204	127	323	26	5	1	38	0	87	270	2974
2004	350	378	243	122	1046	350	83	151	48	20	7	58	15	179	267	3317
2005	543	135	226	170	962	318	114	275	68	42	7	45	2	162	203	3272
2006	887	62	210	239	1186	108	95	268	104	86	17	95	1	92	333	3781
2007	860	153	280	259	1408	239	73	319	33	21	22	65	1	194	376	4304
2008	617	36	229	102	2324	498	138	333	16	16	42	109	13	301	416	5191
2009	511	105	199	158	2380	575	115	306	7	82	27	185	0	133	510	5293
Mean	366	206	253	105	1308	184	134	114	27	21	70	48	2	188	269	3296

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	7.675
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	14.434
2002	0.199	0.551	1.167	2.441	3.380	4.719	6.357	9.039	10.224	11.538	10.921
2003	0.207	0.653	1.312	2.390	3.995	5.946	8.411	10.405	12.786	13.397	14.343
2004	0.194	0.474	1.280	2.529	3.882	5.588	7.323	11.213	16.665	18.557	17.980
2005	0.194	0.653	1.376	2.592	3.918	5.588	7.182	9.771	13.090	14.012	14.784
2006	0.181	0.595	1.589	2.796	4.185	5.870	7.482	11.255	13.695	14.692	15.613
2007	0.213	0.621	1.742	3.178	4.704	6.231	7.802	9.621	12.636	13.223	13.808
2008	0.189	0.665	1.460	3.047	4.336	6.667	8.135	10.842	14.166	14.673	14.883
2009	0.182	0.586	1.414	2.888	4.568	5.789	8.074	10.195	12.252	13.203	13.286
Average	0.191	0.584	1.396	2.606	4.001	5.564	7.822	9.835	11.821	12.589	12.780

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

Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13+
1984	0.262	0.893	1.612	2.748	3.848	5.486	6.990	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	12.500	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	12.361
1989	0.282	0.910	1.468	2.207	3.244	4.799	6.581	8.725	11.134	15.799	15.950	17.909	14.023
1990	0.288	1.007	1.696	2.694	3.278	3.833	5.584	6.871	10.716	11.428	12.660	15.053	16.064
1991	0.241	0.936	2.670	4.473	6.038	7.846	9.590	11.542	14.970	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	11.600	14.067	14.893	15.922
1994	0.180	0.512	1.212	2.402	3.517	5.359	7.560	10.001	11.818	12.896	13.554	15.902	16.806
1995	0.194	0.497	0.962	1.819	3.204	4.847	7.332	9.688	13.835	15.247	16.960	18.230	19.202
1996	0.170	0.498	1.028	1.916	3.075	4.189	6.987	10.212	12.185	13.426	14.581	16.214	16.876
1997	0.119	0.341	0.992	1.908	2.668	3.503	4.954	7.980	12.174	21.523	20.666	21.822	24.237
1998	0.232	0.528	1.081	2.016	2.823	4.089	5.469	7.346	9.586	13.012	14.455	15.579	16.201
1999	0.261	0.431	1.128	2.490	3.676	5.222	6.398	8.220	9.194	13.364	15.325	16.918	17.567
2000	0.186	0.545	1.288	2.551	4.387	6.559	8.833	10.483	11.522	15.132	17.155	19.717	20.514
2001	0.150	0.413	1.163	2.110	3.430	5.571	6.835	10.233	12.457	15.130	17.374	19.322	20.559
2002	0.252	0.677	1.303	2.699	3.847	5.591	7.846	10.796	13.238	18.787	17.902	20.202	21.207
2003	0.228	0.618	1.296	2.028	3.547	4.716	6.684	8.905	13.418	14.492	19.540	19.239	20.036
2004	0.250	0.654	1.412	2.567	3.857	5.660	7.730	11.126	15.907	20.770	21.687	24.852	25.892
2005	0.255	0.687	1.514	2.504	3.896	5.264	7.192	9.395	13.163	15.981	22.656	23.387	24.181
2006	0.354	0.921	1.833	2.763	3.986	5.317	7.396	10.202	12.762	16.462	21.563	25.940	26.875
2007	0.234	0.666	1.803	3.018	4.295	5.810	7.444	9.017	11.754	15.961	20.903	25.154	26.064
2008	0.223	0.706	1.641	2.881	4.071	6.006	7.705	10.317	13.471	17.596	22.968	27.431	27.328
2009	0.217	0.627	1.503	2.542	4.266	5.530	7.617	10.986	13.258	15.637	21.532	25.632	25.586

Table 1.7. Capelin stock history from 1973-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)
1973	961	5144	1350	5504
1974	1029	5733	907	4542
1975	921	7806	2916	4669
1976	696	6417	3200	5633
1977	681	4796	2676	4174
1978	561	4247	1402	3782
1979	464	4162	1227	5723
1980	654	6715	3913	5708
1981	660	3895	1551	5658
1982	735	3779	1591	3729
1983	754	4230	1329	3884
1984	393	2964	1208	3051
1985	109	860	285	1975
1986	14	120	65	681
1987	39	101	17	200
1988	50	428	200	80
1989	209	864	175	537
1990	894	5831	2617	415
1991	1016	7287	2248	3307
1992	678	5150	2228	7745
1993	75	796	330	4631
1994	28	200	94	982
1995	17	193	118	163
1996	96	503	248	261
1997	140	911	312	828
1998	263	2056	931	915
1999	285	2776	1718	2070
2000	595	4273	2099	2464
2001	364	3630	2019	3906
2002	201	2210	1290	2939
2003	104	533	280	3195
2004	82	628	293	812
2005	42	324	174	817
2006	88	787	437	733
2007	280	1885	836	2033
2008	570	4426	2468	3285
2009	352	3756	2322	*

*** M output biomass is not calculated for 2009**

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 2008[A] (tonnes)	As by-catch in fleet(s)	Location	Agreements and regulations
Capelin	PS, TP	seasonal	10 000[B]	TR, TS	Northern coastal areas to south of 74°N	Bilateral agreement, Norway and Russia
Coastal cod	GN, LL, HL, DS	all year	25 777[C]	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	464 171[C]	TS, PS, TP, DS	North of 62°N, Barents Sea, Svalbard	Q, MS, SG, MCS, MBU, MBN, C, RS, RA
Wolffish	LL	all year	11 355	TR, (GN), (HL)	North of 62°N, Barents Sea, Svalbard	Q, MB
Haddock	TR, GN, LL, HL	all year	155 604	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	183 443	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	13 144	TR	Deep shelf and at the continental slope	Q, MS, RS, RG, MBH, MBL
Sebastes mentella	No directed fishery	all year	13 860	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	6 300	TR	Norwegian coast and southwestern Barents Sea	SG, MB MCS, MBU, C
Shrimp	TS	all year	21 053		Svalbard, Barents Sea, Coastal north of 62°N	ED, EF, SG, C, MCS

[A] Provisional figures

[B] On a research quota

[C] The total cod catch north of 62°N (480,814 t) is the sum of the NEA cod catch given in the table above (464,171 t) and the total cod catches between 62ºN and 67ºN for the whole year and between 67ºN and 69ºN for the second half of the year (16,643 t).

[D] The directed fishery for wolffish is mainly in ICES area IIb and the Russian EEZ, and the regulations are mainly restricted to this fishery

[E] Norwegian and Russian landings

[F] The only directed fishery for Greenland halibut is by a limited Norwegian fleet, comprising vessels less than 28 m.

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).

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. The averaged annual relative changes (%) of cod fishable stock biomass under various combinations of cod stock size, capelin stock size and water temperature according to STOCOBAR long-term simulations (the harvesting strategy is based on Fpa=0,5, Bpa=460 thousand tonnes). Different colours denotes different natural potential of cod to stock changes: red is high potential to stock decline, yellow is low potential to stock change, and red is high potential to stock increase.

Temperature , C°	Cod FSB* averaged for 3 previous years, millions t	Capelin stock biomass, millions t			
		< 1	1-3	3-5	>5
< 3,6 C°	<1,4	-8,96	-1,73	4,90	5,60
	1,4-1,8	-11,60	-7,28	-3,89	2,98
	>1,8	-16,89	-12,56	-7,94	-3,61
3,6 – 4,2 C°	<1,4	1,17	5,14	12,82	15,99
	1,4-1,8	-7,29	-3,96	2,91	6,72
	>1,8	-12,24	-8,52	-5,24	-0,27
>4,2 C°	<1,4	3,77	7,14	16,78	20,94
	1,4-1,8	-2,53	1,36	8,34	16,96
	>1,8	-3,62	-0,95	1,25	1,31

*Fishable stock biomass

Table 1.13. Overview of available prognoses of NEA cod recruitment (in million individuals of age 3) from different models (sections 1.4.5) together with the 2009 assessment estimates (ICES AFWG 2009 Table 1.12).

Model	Prognostic years	Updated	2010 Prognoses	2011 Prognoses	2012 Prognoses	2013 prognoses
Titov0	0	At assessment	480			
Titov1	1 (2 [1])	At assessment	518*	470		
Titov2	2	At assessment	451	323*		
Titov3	3	At assessment	250*	276*	484*	
Titov4	4	At assessment	425	362	780	946
TB (1984-2000)	3	Last year assessment	632	553		
TB (1984-2004)	3	Last year assessment	627	551		
JES1	2 (3 [2])	At assessment	878	797*	827	
JES2	1 (2 [2])	At assessment	714	669		
JES3	0 (1 [2])	At assessment	568			
H1	2	At assessment	890	889		
H2	2	At assessment	566	636		
H3	1	At assessment	500			
H4	1	At assessment	475			
RCT3 2010	3	At assessment	289	558	675	
Hybrid Model (Assessment 2009)		Last year assessment	487	184		
Hybrid model (Assessment 2010)		At assessment	384	465	484	

[1] Based on calculation of data from 2010.

[2] Based on prognosis estimate of capelin maturing biomass for October 1 2010, thereby allowing for an additional year.

*** Models that are used in the Hybrid model at the 2010 assessment**

Table 1.14. Proportion of cod in the diet of cod, based on Norwegian consumption calculations.

Cod (predator)age	1	2	3	4	5	6	7	8	9	10	11+
Year											
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	0.0853
1986	0.0000	0.0022	0.0015	0.0004	0.0130	0.1761	0.1767	0.1766	0.1762	0.1757	0.1748
1987	0.0000	0.0000	0.0007	0.0051	0.0103	0.0246	0.0377	0.0400	0.0418	0.0405	0.0436
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	0.0041
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	0.2608
1995	0.0069	0.0811	0.0745	0.0802	0.0925	0.1123	0.1389	0.2533	0.2553	0.2561	0.2574
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	0.3294	0.3264	0.3301
2002	0.0000	0.0387	0.0591	0.0142	0.0187	0.0285	0.0359	0.0627	0.1603	0.1575	0.1581
2003	0.0000	0.0193	0.0198	0.0199	0.0206	0.0188	0.0456	0.1043	0.2257	0.2281	0.2269
2004	0.0230	0.0223	0.0294	0.0214	0.0184	0.0294	0.0391	0.0710	0.1059	0.1056	0.1061
2005	0.0000	0.0261	0.0229	0.0258	0.0155	0.0241	0.0487	0.0830	0.1688	0.1667	0.1693
2006	0.0000	0.0051	0.0007	0.0130	0.0285	0.0124	0.0397	0.0316	0.0841	0.0845	0.0834
2007	0.0000	0.0000	0.0010	0.0108	0.0137	0.0314	0.0336	0.0724	0.1518	0.1543	0.1504
2008	0.0000	0.0821	0.0243	0.0068	0.0089	0.0110	0.0820	0.1004	0.1223	0.1212	0.1198
2009	0.0238	0.0376	0.0353	0.0227	0.0137	0.0147	0.0250	0.0981	0.0918	0.0920	0.0919
Average	0.0021	0.0236	0.0312	0.0278	0.0339	0.0474	0.0673	0.0881	0.1437	0.1434	0.1432

Table 1.15. Cannibalism mortality in cod.

Year	M at age 3	M at age 4
	by regression	
2009	0.40	0.27
2010	0.43	0.28
2011	0.46	0.29
2012	0.64	0.36
	values used in assessment	
2010-2012	0.3335	0.227

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	Joint	Feb-Mar	T,S	N, chla	intermittent	All commercial species and some additional	Cod, Haddock	-	-
Lofoten	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	-	-	-	-	Greenland halibut, redfish	-	-
Russian young herring survey	PINRO	May	T,S		Yes		Herring	-	-

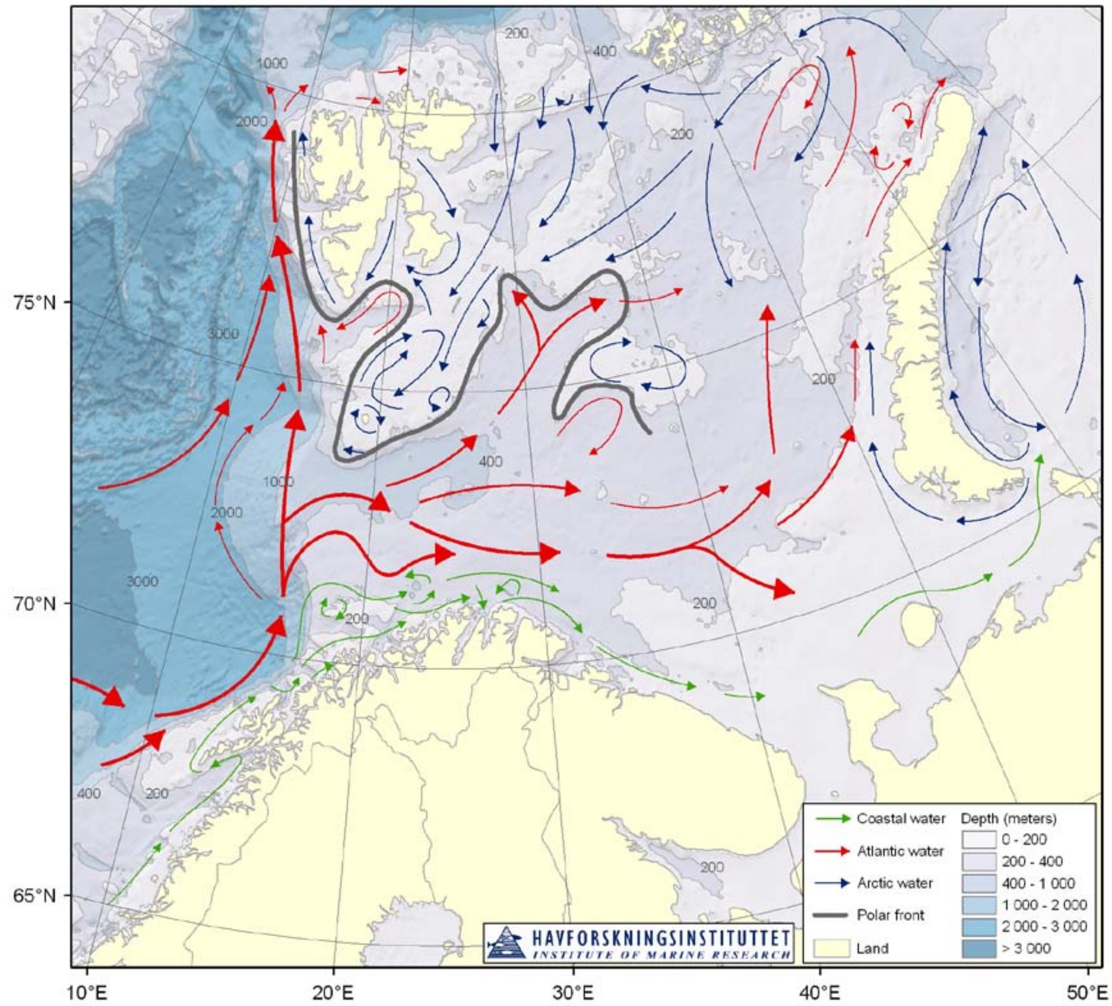


Figure 1.1. The main features of the circulation and bathymetry of the Barents Sea.

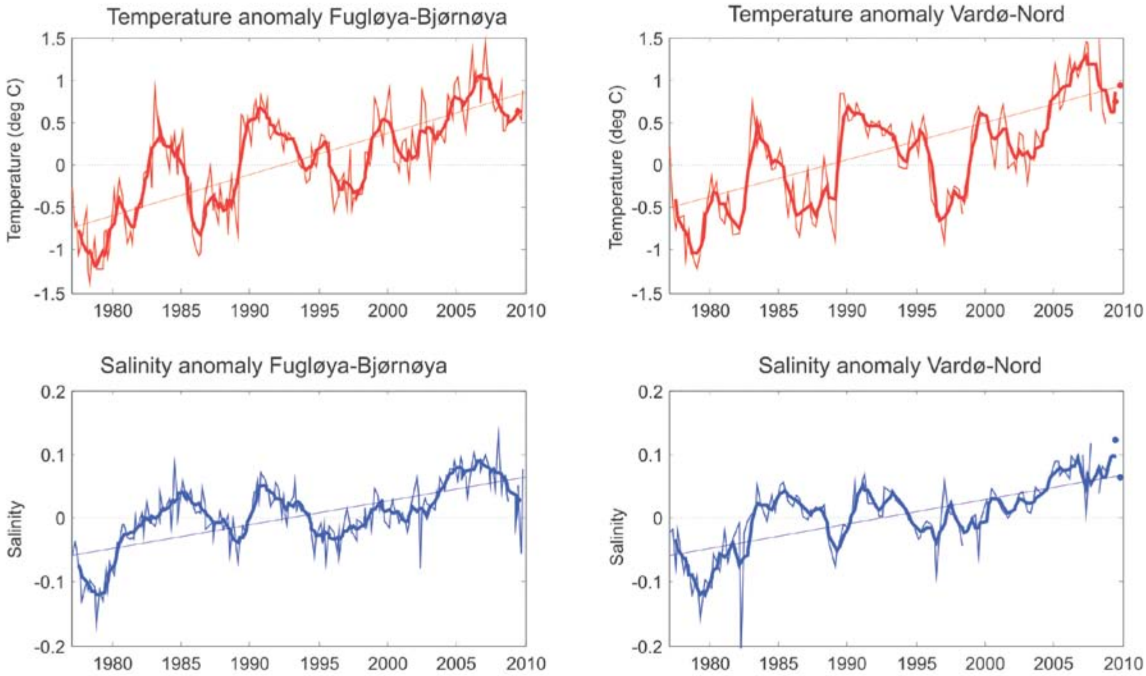


Figure 1.2. Temperature (upper) and salinity (lower) anomalies in the 50-200 m layer of the Fugløya-Bear Island section (left) and the Vardø-North section (right).

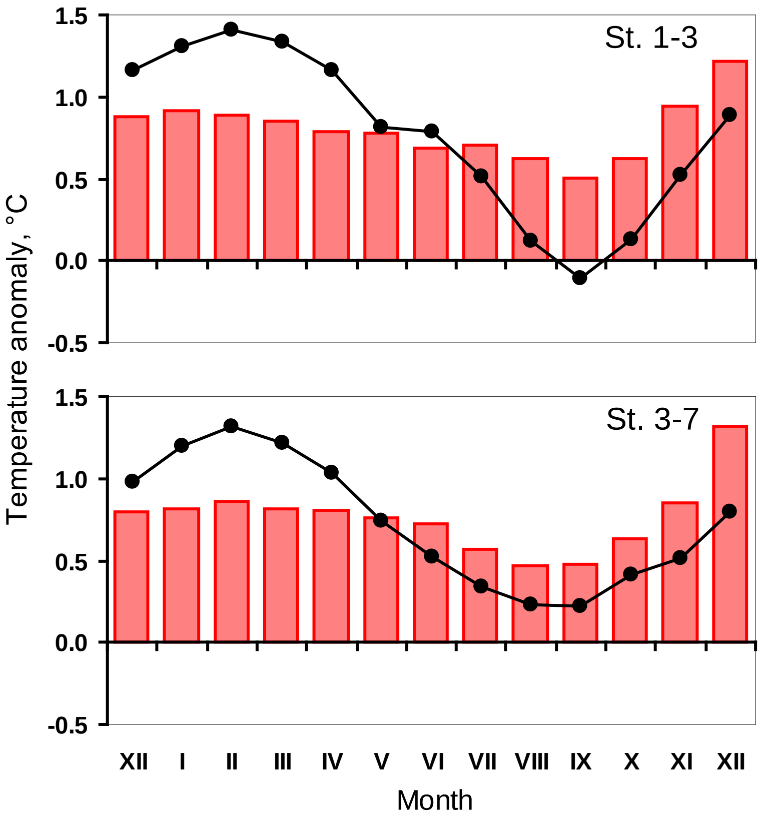


Figure 1.3. Monthly temperature anomalies in the 0-200 m layer of the Kola Section in 2008 (black dots) and 2009 (red bars). St. 1-3 – Coastal waters, St. 3-7 – Murman Current (Anon., 2010).

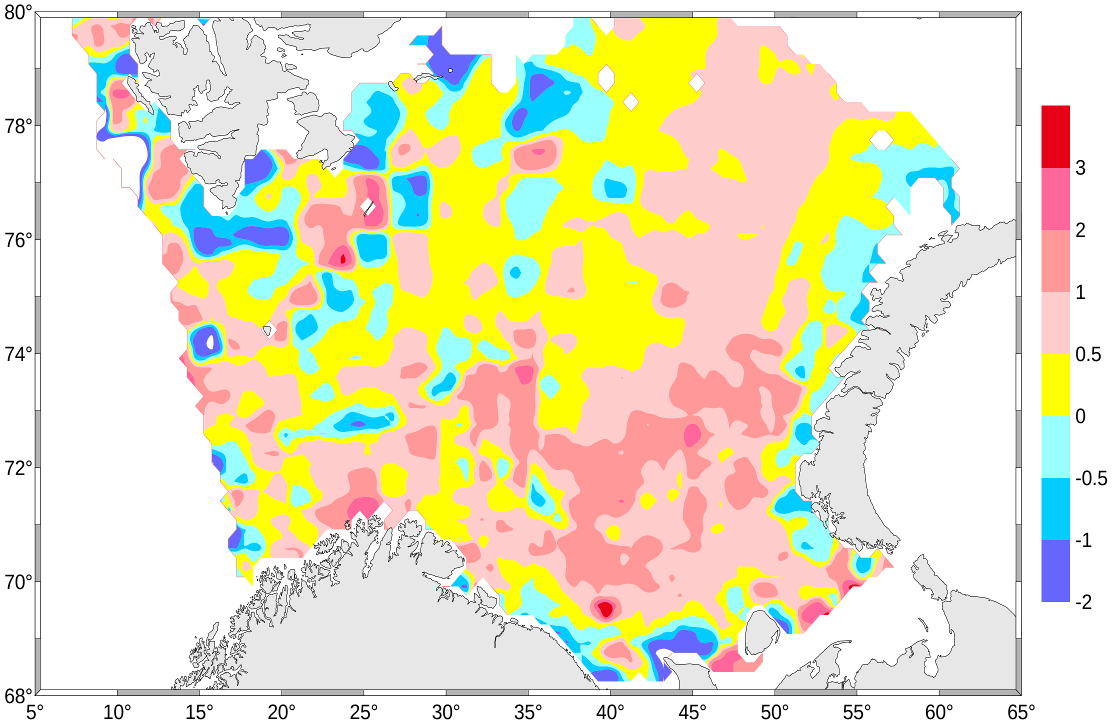


Figure 1.4. Bottom temperature anomalies in the Barents Sea in August-September 2009 (Anon., 2010).

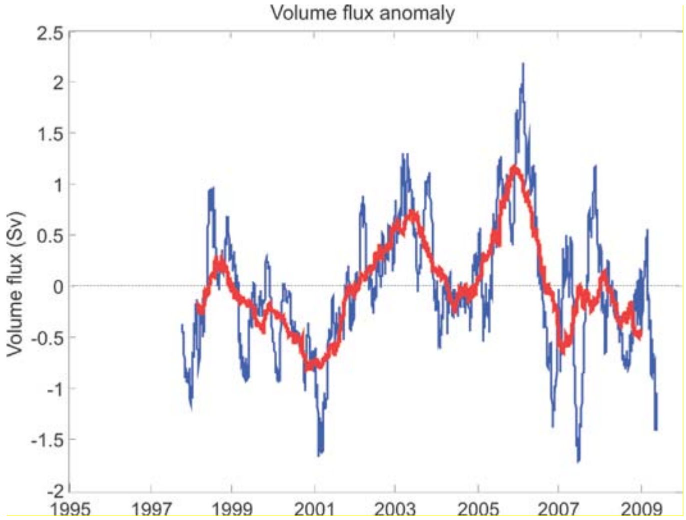


Figure 1.5. Observed Atlantic Water volume flux through the Fugløya-Bear Island section estimated from current meter moorings. Three months (blue line) and 12-months (red line) running means are shown.

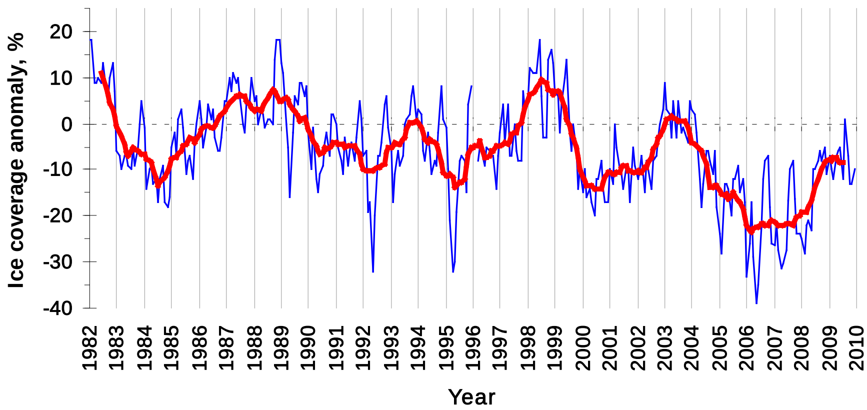


Figure 1.6. Ice extent anomalies in the Barents Sea in 1982-2009 (Anon., 2010). The blue line shows monthly values, the red one – 11-month moving average values.

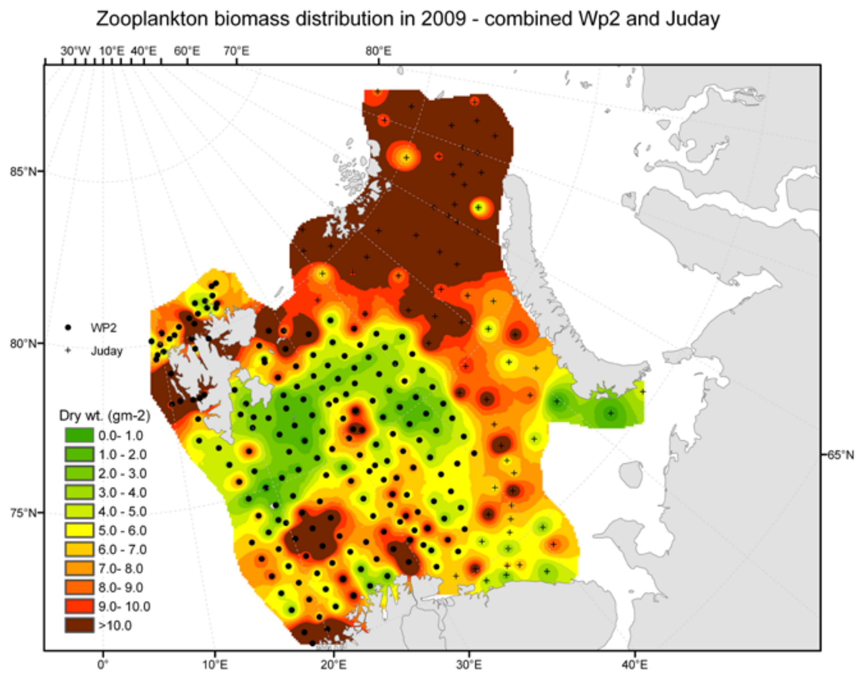


Figure 1.7. Horizontal distribution of zooplankton in 2009 (g m^{-2} of dry weight from bottom-0 m).

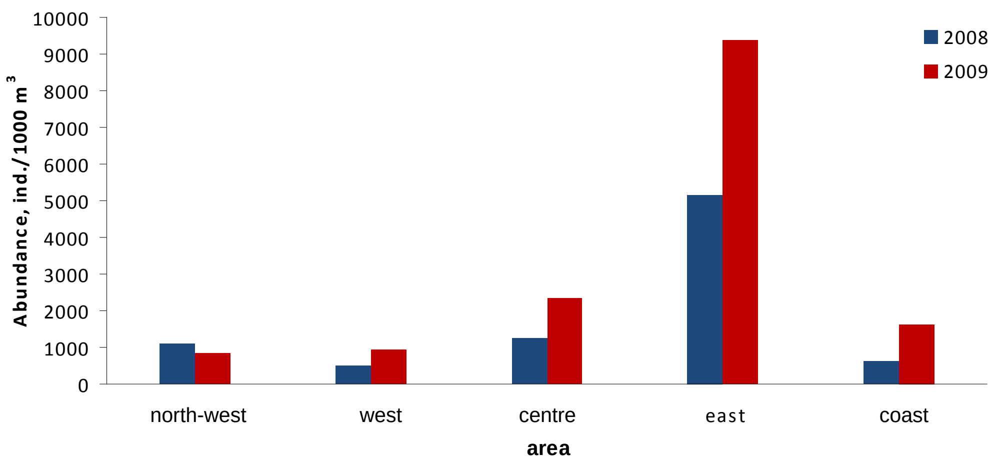


Figure 1.8. The mean abundance of euphausiids in the north-western and western areas of the Barents Sea in 2008 and 2009.

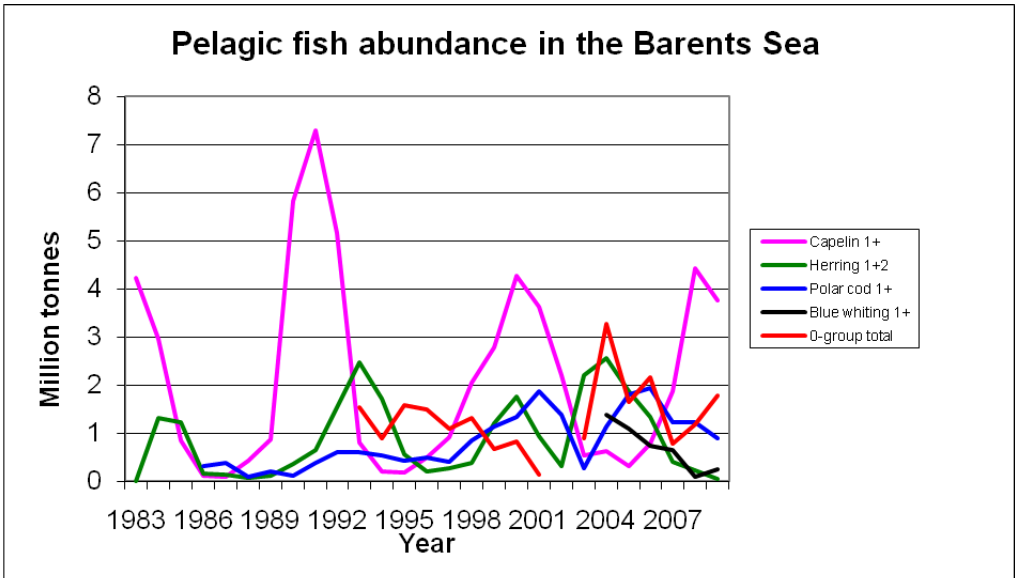


Figure 1.9. Biomass of pelagic fish species in the Barents Sea. Data are taken from; capelin: Acoustic estimates in September, age 1+ (ICES AFWG 2010), herring: VPA estimates of age 1 and 2 herring (ICES C.M. 2009/ACOM:12), using standard weights at age (9g for age 1 and 20g for age 2); polar cod and 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*. 2010).

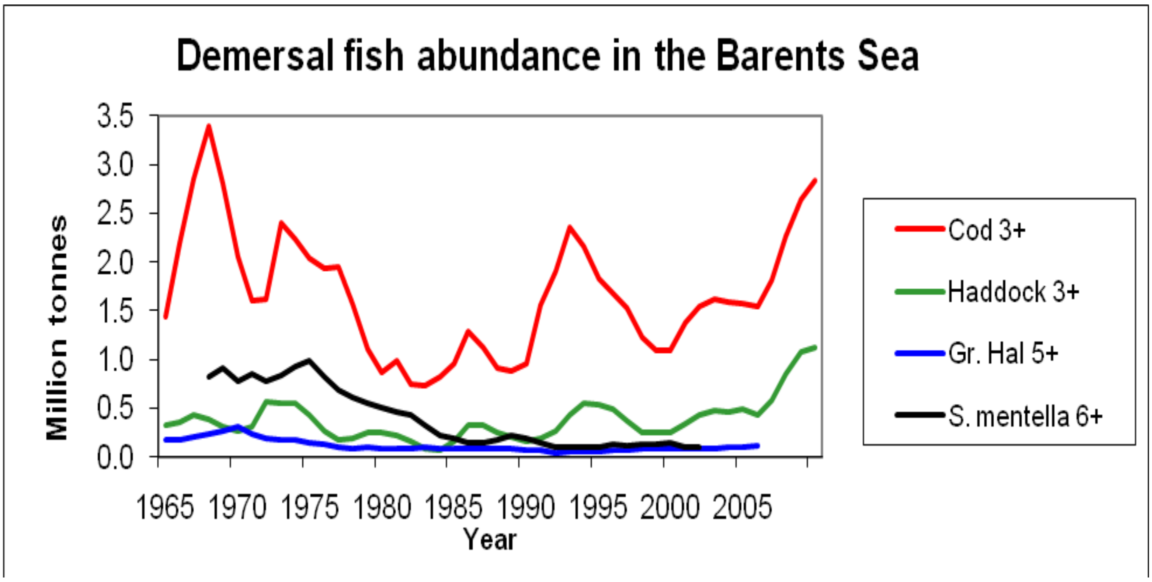


Figure 1.10. Biomass of demersal fish species in the Barents Sea. Data are taken from; cod: VPA estimates, age 3+ (ICES AFWG 2010); haddock: VPA estimates, age 3+ (ICES, 2010); Greenland halibut: VPA estimates, age 5+ (ICES, 2007); Sebastes mentella: VPA estimates, age 6+ (ICES, 1995 for the years 1968-1990; ICES, 2003 for the years 1991-2002).

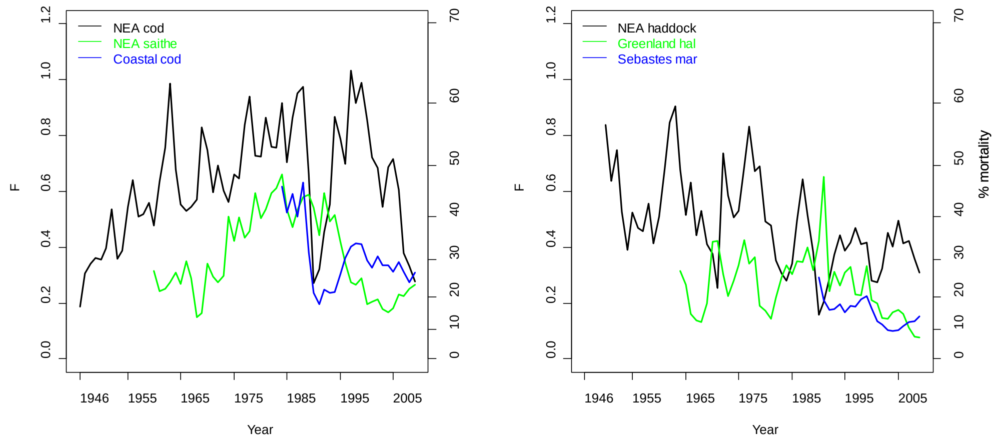


Figure 1.11a. Time series of annual average fishing mortalities for Northeast Arctic cod (time period 1946-2009, average for ages 5-10), Northeast Arctic saithe (time period 1960-2009, average for ages 4-7), coastal cod (1984-2009, average for ages 4-7), Northeast Arctic haddock (time period 1950-2009, 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).

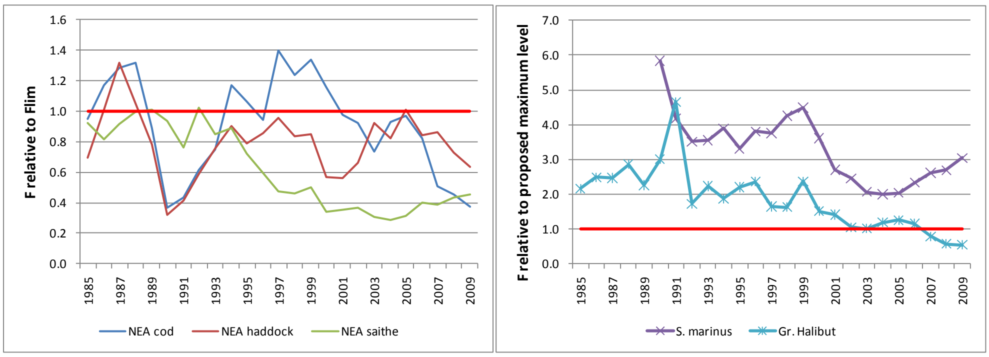


Figure 1.11b. Left panel - annual fishing mortalities of the Northeast Arctic cod, haddock and saithe stocks relative to the critical levels above which the fishing mortality will impair the recruitment. Right panel - annual fishing mortalities of Golden redfish (*Sebastes marinus*) and Greenland halibut (*Reinhardtius hippoglossoides*) relative to the proposed maximum levels above which the fishing mortality over time most probably will impair the recruitment.

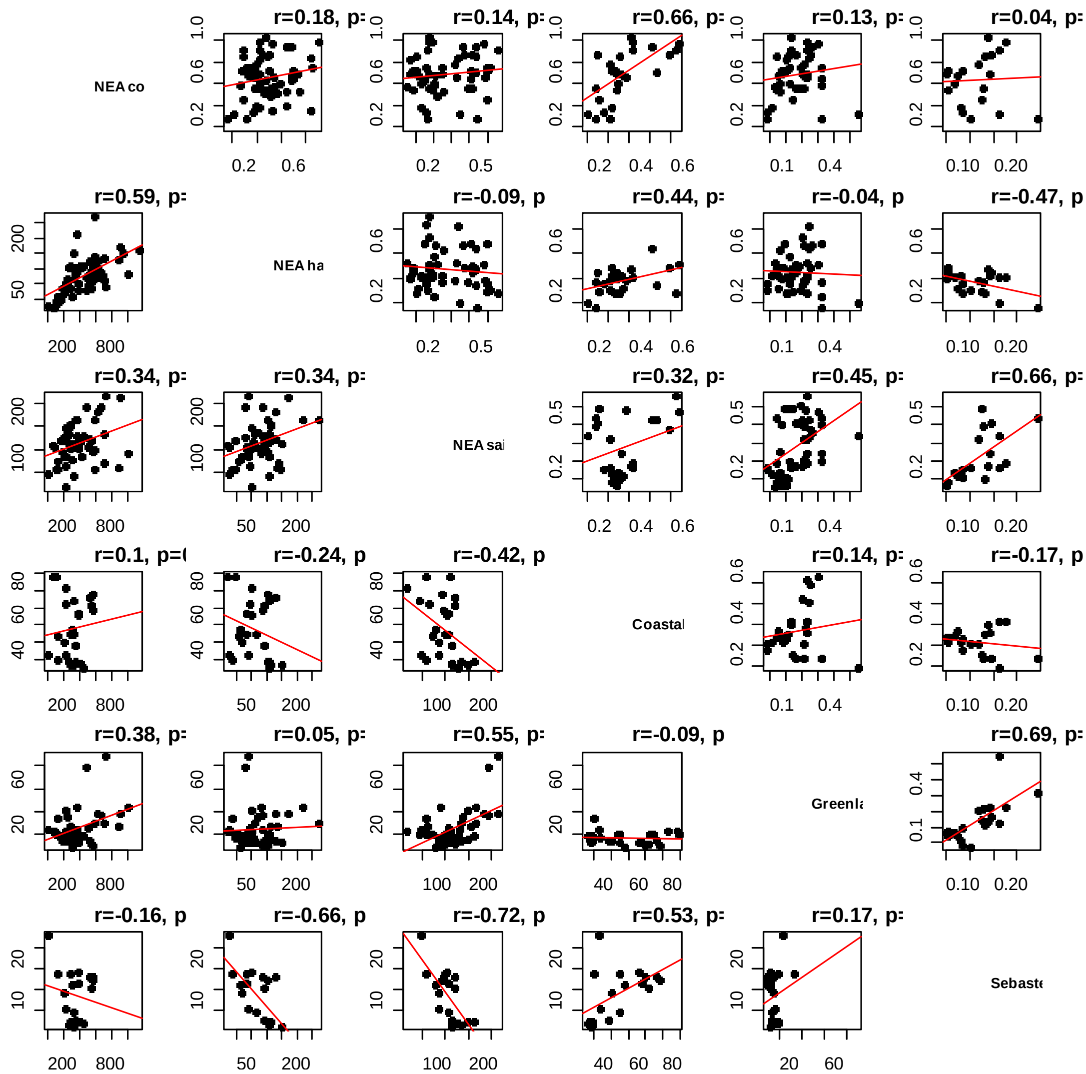


Figure 1.12. Pair-wise plots of annual average fishing mortalities (above diagonal) and landings (below diagonal) for overlapping time periods for Northeast Arctic cod (time period 1946-2009, average for ages 5-10), Northeast Arctic haddock (time period 1950-2009, average for ages 4-7), Northeast Arctic 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 pvalue are given in the legend.

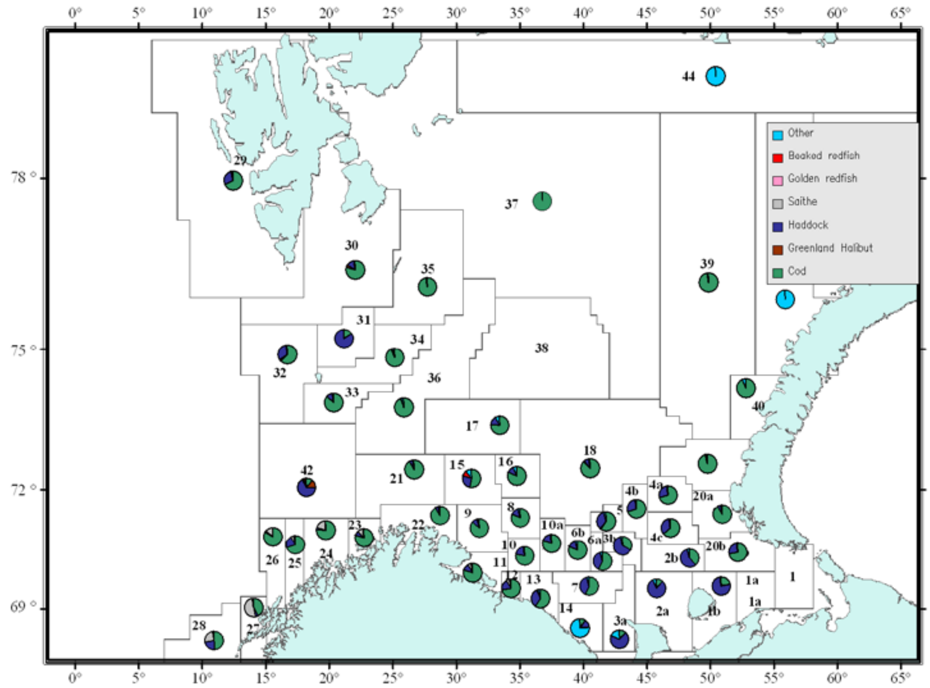


Figure 1.13. Relative distribution by weight of cod, haddock, saithe, Greenland halibut, golden redfish (*Sebastes marinus*), beaked redfish (*Sebastes mentella)* and other species taken by Russian bottom trawl in 2009 per main area for the Russian strata system.

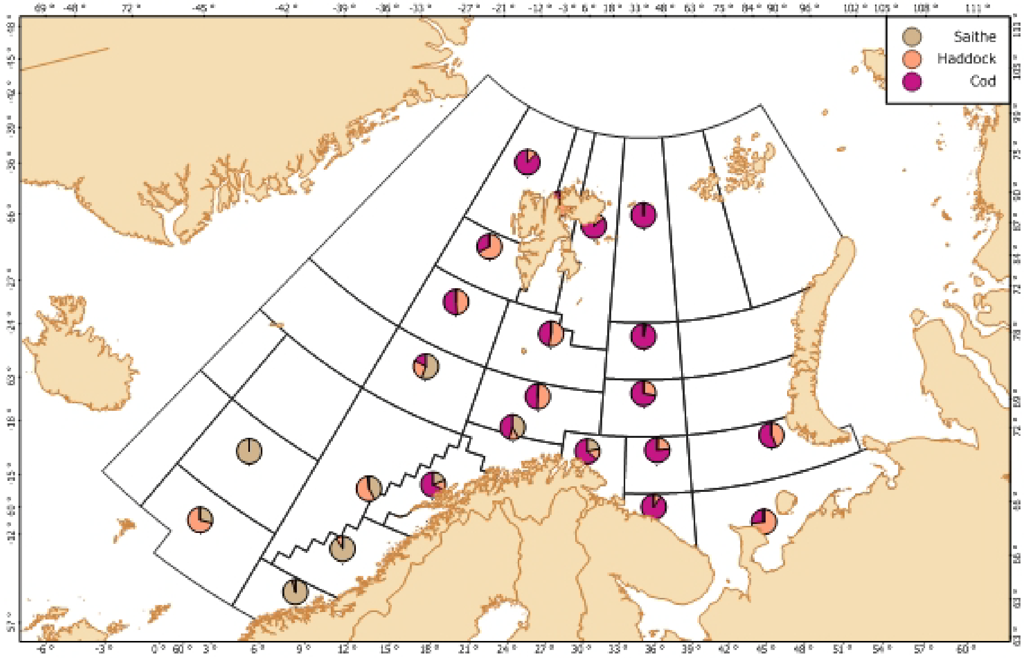


Figure 1.14. Relative distribution by weight of Norwegian catches of cod, haddock, and saithe per main area for the Norwegian strata system.

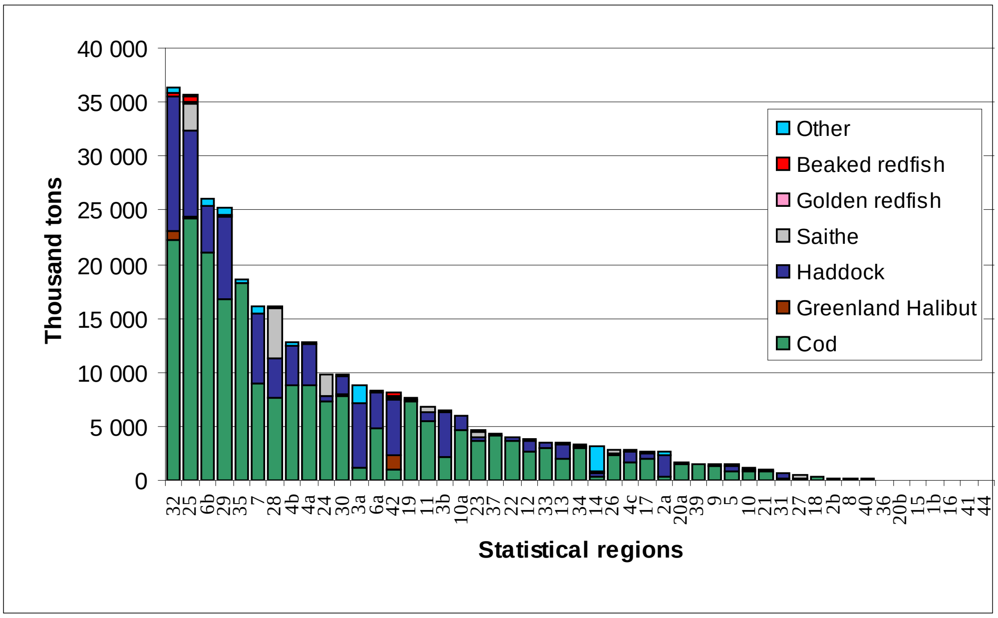


Figure 1.15. The Russian catch of cod, haddock, saithe, Greenland halibut, *Sebastes marinus*, *Sebastes mentella* and other species taken by bottom trawl by main statistical areas in 2009, thousand tonnes. The statistical areas correspond to the areas shown in Figure 1.13.

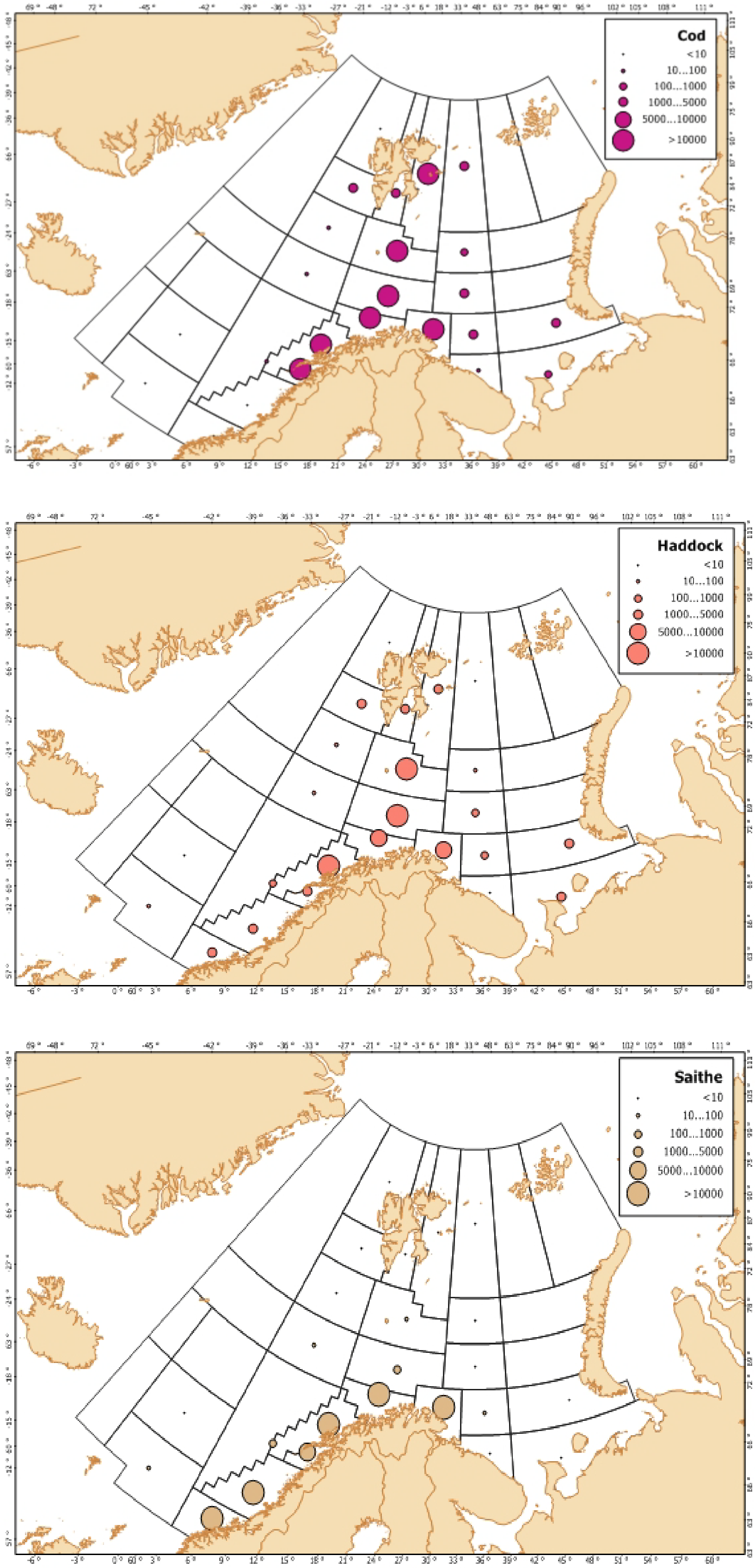


Figure 1.16. The Norwegian catch of cod, haddock and saithe by main statistical areas in 2009, thousand tonnes. The statistical areas correspond to the areas shown in Figure 1.14.

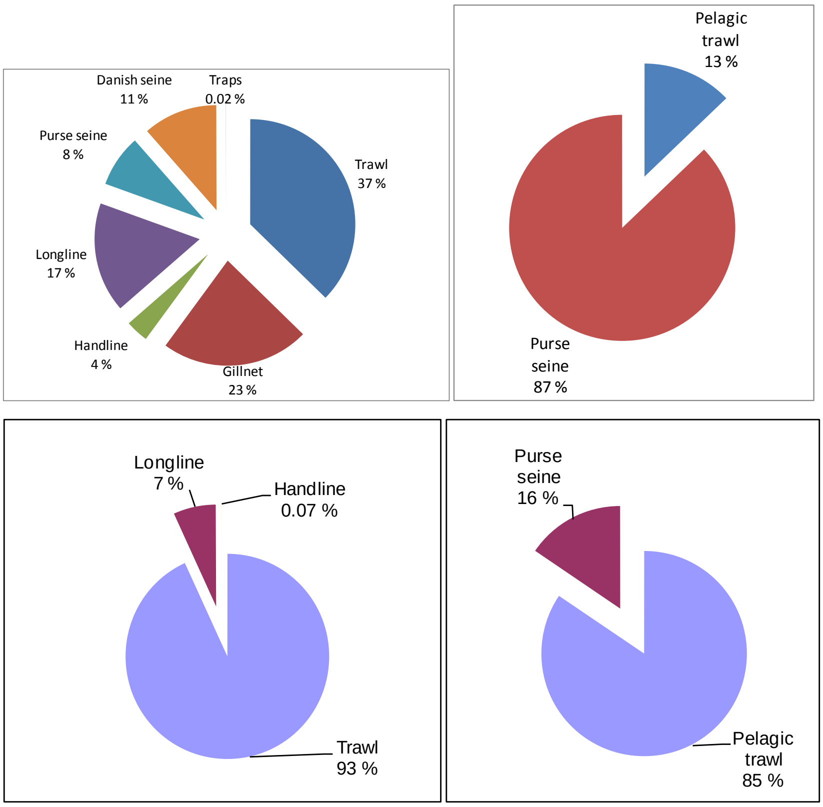


Figure 1.17. Upper panel - gear composition of the Norwegian groundfish (2007; left) and pelagic capelin (2000-2008; right) fisheries in the Northeast Arctic. Note that the purse seine in the groundfish fishery is solely used in a coastal fishery for saithe. Lower panel - gear composition of the Russian groundfish (2007; left) and pelagic capelin (2000-2008; right) fisheries in the Northeast Arctic.

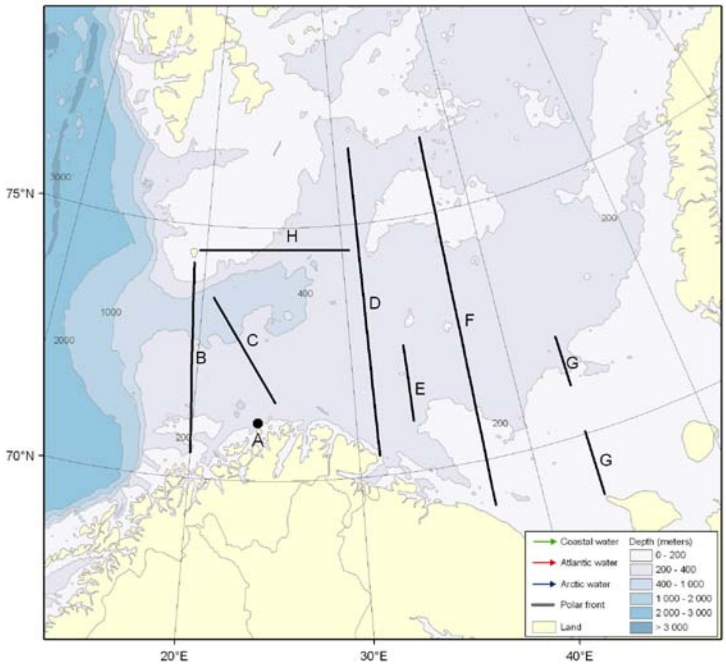


Figure 1.18. Positions of the standard sections monitored in the Barents Sea. A is fixed station Ingøy, B is Fugløya-Bear Island, C is North cape-Bear Island, D is Vardø-North, E is Kola, F is Sem Island-North G is Kanin section and H is Bear Island-East section.

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

Type of assessment: The schedule says "Update", but several revisions are presented. The main reason for the revisions has been to have some additional basis for evaluating the proposed rebuilding plan.

A new catch series for recreational and tourist fisheries is presented and added to the commercial catch. The combined data series is found to fit better with the survey, using stock dependent catchability for ages 2 and 3 in a XSA otherwise set to standard values given in the Quality Handbook Stock Annex. General information regarding the stock and earlier assessments are given in an updated Quality Handbook Stock Annex.

A rebuilding plan has been proposed by Norwegian authorities and has been evaluated by the working group.

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 measurements of 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 and these reports have been used to construct time series based on assumptions made in the reports of temporal trends.

A survey for mapping recreational fisheries was conducted in 2003 (Hallenstvedt and Wulff, 2004) and the results from this report gives reason to assume that there were fished app. 13,000 t of cod by recreational fishers in 2003 north of 62°N. This is based on 50% of the catches in the area being cod and that due to the fishing season almost all of the cod is coastal cod. Nedreaas (2005) discuss this assumption and assumes that the winter fishery by recreational fishers only consists of North east arctic cod. This is probably not the case – since the winter fishery is small and is probably conducted close to home.

The effort used in recreational fisheries is monitored through surveys of questionnaires mapping the amount of the population that has conducted recreational fisheries during the last year and to what extent they have fished in salt water or freshwater. Based on interpolating these surveys onto the development of the population in Norway, it is possible to give an index of effort in recreational fisheries in the sea. It is assumes that recreational fisheries are conducted to catch a desired amount of fish – and that the effort is not restricted in time. This gives the quantity taken to be proportionate to the effort – and not influenced by the stock size.

Some recreational fishers deliver their catches to the sales organisations. In this working document it is assumed that this group is not included in the interview material and that these landings are already included in the reported catches from the commercial fisheries. This is also contradictory to the conclusions from Nedreaas (2005).

Thus, the quantity of 13,000 t NCC is assumed to be taken by the recreational fishers in Norway in 2003 has been extrapolated to the years before and after using the product of population numbers and the fraction of the people conducting recreational sea fisheries. It is assumed that the amount of cod is 50% throughout all the years.

There is one report available to indicate the level of tourist fisheries in Norway. The report is by the consultant company Essens management (Anon, 2005) and is based partly on Hallenstvedt and Wulff, 2004 and partly by surveys on the number of tourists who say they have been fishing in the sea.

This report estimates the tourist fishery north of 62°N for cod to amount to 1,100 t in 2004. They also assume that the increase in tourism for sea fishing increased with 19% per year from 1995 until 2000, then increased with 16% per year until 2004. In this working document it is assumed that the increase until 2009 has been 10% per year. This gives a quantity in 2009 of 1,800 t cod. It also gives a time series back to the beginning of the 1990s assuming that the catch is proportional to the number of tourists fishing in the sea.

There are ongoing investigations of tourist fisheries and the results of these investigations will only be available at a later time. However, there is reason to believe that the figure of 1800 t cod is not out of scale with the ongoing investigations (pers. comm. Nedreaas, 2010).

The constructed time series may not be as accurate as desired, however, the level of catch to be added to the commercial catches is assumed to be fairly well documented. Also the trend in both the recreational fisheries and tourist fisheries seem to be consistent with what has been presented in later years.

2.1.1 Sampling fisheries and estimating catches (Tables 2.1–2.2)

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 landings of NCC in 2008 are 25,777 t and in 2009 they are 24,821 t (Table 2.1a, Figure 2.4). Table 2.1b shows the estimated catch by gears, area and quarters in 2009.

In table 2.1c is shown the age distribution for long line and hand line raised to the combined estimates of recreational and tourist fisheries, together with the two estimated time series for these two fisheries.

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 2.2 and 2.3 show the sampling of the cod fishery by quarters and areas in 2009 and earlier. The total number of age samples was 359. 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 about 11,000 fish were aged. More than 2,600 of these otoliths were classified as coastal cod.

Table 2.4 shows the estimated catches of coastal cod by statistical area and quarter for the years 2006-2009. 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.

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 2004-2009 a major part of the Northeast Arctic cod was spawning in the outer, southwestern 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. 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 in the years from 2007 has 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. The recorded positions of the samples are considered to be accurate.

2.1.2 Regulations

The Norwegian cod TAC is a combined TAC for both NEAC stock and NCC stock. The coastal cod part of this combined quota was set 40,000t in 2003 and earlier years. In 2004 it was set to 20,000t, and in the following years to 21,000t. There are no separate quotas given for the coastal cod for the different groups of the fishing fleet.

Trawl fishing for cod is not allowed inside the 6-n.mile. Since the mid 1990 the fjords in Finnmark and northern Troms (areas 03 and 04) has been closed for fishing with Danish seine. Since 2000 the large longliners have been restricted to fish outside the 4 n.mile.

For the fisheries in 2010 there were also set a quota for recreational and tourist fisheries together with the quota for young fishers, to be 10,000 t and allocated from the agreed TAC.

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 meter. Further restrictions were introduced in 2007, 2008 and continued in 2009, 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%. A box closed for all fishing gears except hand-line and fishing rod has since 2005 been defined in the Henningsvær-Svolvær area. A similar box has in 2009 and 2010 been closed during the spawning season in Borgundfjord near Ålesund. These are areas 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 merged 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 Northeast Arctic cod is higher.

2.2 Survey data

A trawl-acoustic survey along the Norwegian coast from the Russian boarder 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 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, Figs 2.7 to 2.13)

The results of the 2009 survey (Mehl *et al*. WD 8 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 groups is given in Table 2.6. For most age groups the estimates are close to the lowest ever observed, and the total number is the third lowest observed. The 2009 estimate of survey biomass is about 39,100 t (Table 2.9) and this is an increase from last year, and is mainly due to an increase in most age groups except 2 and 3 year olds. The estimated spawning biomass is 13,500 t, and this is the lowest observed (Tables 2.11). However, this is mainly due to a downward change in the maturity at age, which may have been influenced by an earlier start of the survey this year, by two weeks. The bulk of the spawning biomass is comprised of ages 5-7.

Similar changes in maturity have been observed at earlier surveys. Variable timing of the survey and annual variation of the onset of the maturation process could be parts of the reason for this. Since the rebuilding plan is made conditional to the survey estimate of SSB, it would be more robust to use a more smoothed, or even fixed ogive for calculating the survey SSB. This approach will give an increased biomass from 2008 to 2009.

The 4+ biomass (summed from Table 2.9) is plotted together with total biomass and spawning biomass in Figure 2.13.

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 2.2, 2.3, 2.8–2.10)

A total of 2341 cod otoliths were sampled during the 2009 survey.

As in previous years, NCC was found throughout the survey area. The 2009 survey data on the stock separation are similar to the 2007 and 2008 data and shows the same pattern as the whole 1995-2008 surveys. 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 show the proportions of coastal cod in the survey samples by age and statistical areas in 2008. 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).

Table 2.12 also show the proportions of coastal cod in the survey samples by age for 5 previous years. The proportion is rather stable between years, but is consistently higher for young fish compared to old.

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 costal cod to have higher weight at age when caught in the southernmost area. Table 2.8 show the time series of mean weights at age for the whole survey.

2.2.4 Maturity-at-age (Table 2.10)

The maturity-at-age is estimated annual from the data collected at the coastal survey. The age at 50% maturity (M_{50}) for the NCC was near 5 in 2006, 2007 and 2008 surveys (Table 2.10), but increased to almost 7 years of age in 2009. Both the estimated weights at age and the estimate of maturities are influenced by uncertain values in areas where few fish are sampled. In addition, the survey is conducted in the period October/November, a period when maturation stages are difficult to interpret. Therefore, much of the year to year variation observed might not be real, and a fixed long term average could be a reasonable alternative. In 2009 the survey was started two weeks earlier than the years before, and this may also have influenced the sampling of mature fish.

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 1984-2009 is given in Table 2.1a. Also, the estimated catches from recreational and tourist fisheries are given in table 2.1c. The combined catches as are given in table 2.14.

The total catches of coastal cod have been severely underestimated in earlier reports. In addition to the official landings from commercial vessels, an unknown amount of coastal cod is landed both from tourist fishing and from recreational fishing activity by Norwegian citizens. Two different investigations have estimated the amount of cod landed from these two activities and the reports were published in 2004 (in Norwegian). A summary of these two reports was presented as a WD to the 2005 WG (WD 23).

In this year's report, a new evaluation of the catches from recreational and tourist fisheries are given, based on the same reports but giving slightly different figures than in the 2005 WG report. The catch of coastal cod in 2003 is estimated to approximately 13,000 tonnes from the recreational fishing activity and in 2004 to be 1,100 tonnes from the tourist fishing. These figures sum up close to 50% of the official landings of coastal cod in 2004.

There have also 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 the discard was calculated and the report from the 2000-investigation concluded there was both discard and misreport by species in 2000. Landings of cod with gillnet should be increased by approximately 8-10%. 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.

From Hallenstvedt and Wulff (2004) it is seen that in the northern part of Norway almost no gill net fishing is included in the recreational fisheries. It is therefore reasonable to use the samples from long line and hand line to split the catches into age. The available material for coastal cod is for the whole year and this is used to split the estimated figures in tonnes to numbers at age.

For the early part of the time series for long line and hand line there are a large portion of the samples being aged 10 year and older. It is assumed that this is mainly from the winter fisheries for cod and therefore the 10+ group is excluded from the material used to raise the numbers at age to the recreational and tourist catches.. This is also supported by a fairly low numbers of 9 year olds in that part of the material. In view of this it is assumed that it would be reasonable to assume that most of the recreational fishery is for fish younger than 10 year of age.

It seems to be clear that the commercial catches using hook and line reflect a severe failure in recruitment during the time series and anecdotal information seem to support this also for the recreational fishery. Recreational fishers frequently say that fishing grounds are no longer giving any yield, and that smaller cod is not available to fishers using fishing rod from land.

This matrix of recreational and tourist catches is proposed as a first solution to the problem that the commercial catches do not reflect the total amount being caught.

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 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 and otters (Pedersen *et al.*, 2007). Young saithe (ages 2-4) has been observed to consume postlarvae and 0-group cod during summer/autumn.

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

The average maturity at age observed over the whole survey period (1995-2009) has been used in the assessment (Table 2.13).

2.4 Methods used for assessing stock trends

Earlier attempts to assess the stock using XSA analysis have not given reliable results. In the two last years the main basis for assessing the stock is the survey time series plotted in Figures 2.6-2.13, and a SURBA was used for further analysing the survey trends. However, this method is not recommended and did not give reliable results.

In this year's WG with the updated catch figures for recreational and tourist catches an attempt to use the XSA method was again tried. Four set of runs were performed. First, last year's data was updated with only the commercial catches and an XSA with the standard settings from the stock annex was run. Secondly, the new time series of catch on numbers and catch in tonnes were applied and the settings were as in the first run. Thirdly, an attempt to use stock dependant catchability for the two youngest ages (age 2 and 3) were done, and this XSA run was then taken to be the basic run for the assessment.

An additional analysis of trends in fishing mortality is presented in Annex 9. Mortality from log catch ratios in the canum matrix was calculated and survey mortalities were calculated from the coastal survey. These mortalities were regressed with the xsa-Fs and thereby used for estimating Fs.

The result of these evaluations was that F had remained fairly stable over the last 5 years, and an average value just above 0.35 was indicated for the analysis relating to commercial catch. The analysis relating to the new total catch data show a stable or slightly declining trend with F2009 close to 0.30. On this basis it was decided to use the Fold from the third XSA together with the Fnew set as the average values of the years 2005 to 2008 in the same XSA for ages 3 and older to run a Standard VPA. For age 2 the value from the XSA in 2009 was used. This fourth run, the SVPA, was then used as the final stock trends and further used in the predictions.

2.4.1 Input, diagnostics and results for the XSA tuning (Table 2.6, tables 2.13 – 2.20)

The data for the tuning is the survey indices given in Table 2.6. The diagnostic outputs from the three XSA runs are given in tables 2.15, 2.17 and 2.19. The summary tables are given in tables 2.16, 2.18 and 2.20. SSB-values refer to 1 January.

2.4.2 Input for the predictions (Tables 2.23 and 2.24)

Input to the predictions is set as the standard choices in the MFDP program. The fishing pattern is raised to F4-7 level in year 2009. Two sets of prediction are made, one with a fixed fishing pattern, and one with a fishing pattern in 2011 and onwards set with reduced F values on ages 2, 3, 4 and 5 to accomplish a reduction in F4-7 of 15%. This fishing pattern will allow less small fish to be caught. In order to give management options tables corresponding to the proposed rebuilding plan for Norwegian Coastal Cod, the factors for the intervals of F is set to vary by 0.15, approximating a 15% change from one year to the next. The two input scenarios are given in tales 2.26 and 2.29.

2.5 Results of the Assessment (Tables 2.21 – 2.22)

2.5.1 Comparing with last year's assessment (Figures 2.13 and 14)

Last year's assessment was based on the survey. In figure 2.13 is shown the development of total biomass, biomass of age 4 and older and the spawning biomass. Also figure 2.14 show the ratio of yield to the biomass of 4 year and older ion the survey.

In these figures are also added the SSB and F from this year assessment for comparison. The biomass development seem to be similar, however, the SSB in the SVPA is calculated with constant maturity ogive, whereas the maturity in the survey show a declining trend with time. The F4-7 from the VPA is more stable then the Yield/Biomass4+ in the survey. In addition to the survey variability, this may be due to an increase of ages 2, 3 and 4 in the catches in the years 2002, 2003 and 2008, where high values for Yield/Biomass4+ is found.

2.5.2 Fishing mortalities and final Standard VPA (standard plots)

The fishing mortality (F4-7) shows a declining trend since 1999 and is now close to 0.30. The VPA analysis reflects the increase in F4-7 in the years before 1999, which is also seen from the Yield/Biomass4+ in the survey.

From the retrospective plots of the XSA (Figure 2.15) one may see that there is a tendency for the F4-7 in the last year to be overestimated, and this is dealt with in the final SVPA by setting a terminal F based on external analysis (Annex 10). The terminal values used just happened to fit with the average values of the years 2005-2008 in the XSA.

2.5.3 Recruitment

The survey estimates of young age groups (1-3) in 2009 are among the lowest in the series, as were in particular the values in 2008. For ages 1, 2 and 3 the 2008 value was only about 1/10 of the peak values in 1995, 1996 and 1997. At present there are therefore poor prospects for any rapid rebuilding of the stock in near future.

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. Whether this recruitment is now at a stable level and will be maintained or if there is going to be a further decrease, is difficult to say. In the prediction is used a resent average of 21.5 millions (taken as the average of the 4 last years in the SVPA) and no further attempt to estimate the recruitment was made.

2.5.4 Catch options for 2011 and 2012 (Tables 2.25 and 2.26)

The results of the predictions are given in tables 2.25 and 2.26. The second option where the fishing pattern is changed towards larger fish seems to give comparable results to the first option where the fishing pattern was kept constant. Both options give an increase of the SSB by reducing $F_{4\text{-}7}$ by 15% each year over two years.

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 can be difficult to define exactly and might influence the estimation of maturity-at-age and hence the estimation of SSB.

The new series with recreational and tourist fisheries included may be said to scale the stock to an more realistic level and give reason to believe that regulations according to this level may affect the stock in the desired direction.

The XSA tuning with stock dependant catchability on ages 2and 3 gave better fit to the survey data. The average survey biomass for the years 1995 to 1998 is defined as a preliminary target for a rebuilding plan.

2.7 Reference points

The analyses made for evaluating the Rebuilding Plan (Annex 10) also give some information regarding reference points. The assessment based on commercial catch plus recreational catch gives a stock-recruit break point at 139 kt SSB. The corresponding Fcrash 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 kt. This is a reasonable candidate for Blim. The corresponding F crash is 0.32, which is a candidate for Flim. F0.1 is estimated to 0.16. A safe long term Fmsy-target also has to be rather close to 0.16. A corresponding MSY Btrigger would be in the range 150-200 kt. These MSY considerations are quite preliminary (see also section 0.10).

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 Evaluation of Rebuilding plan for coastal cod

Annex 10 describes the analysis made for evaluation and presents the results of various simulations. The conclusions are;

If the plan is fully implemented it will lead to a safe rebuilding. Under presumed realistic errors a rather long rebuilding period is required, but the fishing mortality comes down to fairly safe levels within few years. On this basis the proposed rule is considered to be in accordance with the Precautionary Approach. Increasing the F step or aiming for annual reduction unconditional to survey results for the first 3-5 years will contribute to a faster and safer rebuilding. If future observations show recruitment declines stronger than assumed in the current stock-recruit model, the plan may need revisions. The new data on recreational fisheries also highlights the need to consider further regulation on these activities to obtain the F-reductions specified in the plan.

The current regulations aiming for protection of local stock components should be maintained. This should be improved when the scientific basis is improved.

Analyses were made both using input from the assessment based on only commercial catch and the one using all catches. For each of these data sets two recruitment scenarios were assumed; one with continued low recruitment near the recent average (2000-2005 year-classes), and one using the full historic recruitment series. In terms of rebuilding period needed to reach a safe F level, the analysis seemed fairly robust against choice of data sets and recruitment assumptions. The resulting stock size and catches was however higher in the cases where higher recruitment was assumed.

The main findings are that uncertainty in the survey and uncertainty in the implementation of F-reductions are both contributing to slow down reduction rate for the realized F and corresponding slow growth in stock. The general patterns were similar in all these simulation (see tables 4-9 in Annex 10). The series based on all catches and assuming recruitment restricted to recent levels were considered most relevant. With 15% reduction steps for F the resulting time span from now (2010) was (Table 4 in Annex 10):

-about 7 years were needed to have high probability for F being below F crash

-about 10 years needed for average SSB above rebuilding target

-about 15 years to have high probability for SSB>B_{lim}

Larger steps in the reduction rates or making the reduction every year (unconditional to the survey result) will speed up the process somewhat.

The unconditional case gives (Table 8 in Annex 10):

-about 4 years were needed to have high probability for F being below F crash

-about 10 years needed for average SSB above rebuilding target

-about 10 years to have high probability for SSB>B_{lim}

The precautionary criteria of high probability of F below Fcrash and SSB above Blim seem achievable within a reasonable time frame. Provided that the management is able to enforce regulations that are efficient in reducing F, the plan is considered to be in accordance with the precautionary approach. Further actions will be needed if there are signs that recruitment declines further.

The new data on recreational fisheries also highlights the need for further regulation on these activities to follow the planned F-reduction.

In these quantitative simulations and analyses no direct attempts have been made to take account of the stock complexity. Genetic studies indicate that the cod in some fjords could be separate stocks isolated from neighboring stocks. An assessment of the merged stock is not likely to detect fluctuations of the smaller components, and thereby the current assessment approach involves some risk to local stocks. The stock complex is still not fully mapped, but the existence of local stocks also calls for special attention for protecting genetic diversity. Full monitoring and research on small local stocks requires large efforts and may not be realistic. A possible approach could be to obtain information from local fisheries and look for data that could be appropriate indicators for at least detecting sharp declines of local stocks. The established strategy of more strict regulations inside the fjords than outside should be continued.

A fixed natural mortality of 0.2 is used both in the assessment and the simulations. Some fjord studies (Pedersen and Pope, 2003a and b, Mortensen 2007, Pedersen *et al*., 2007, Aas, 2007) indicate that the main predators on young cod are larger cod, cormorants and saithe. There are no estimates of annual predation mortality for the stock complex. Thus, the development of the cod predators, mentioned in the request, is not taken into account. Reduced predator stocks may enhance the rebuilding of cod, while an increase of predators may inhibit the process and require prolonged strong regulations of the fishery for obtaining the rebuilding target.

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 SSB values from the VPA runs refer to 1. January

Recent ICES advice is described in section 2.10

A comparison of results with last year’s assessment is given in section 2.5.1

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

Table 2.1b. Estimated commercial catch of coastal cod in 2008 by gear and area (tonnes).

Year	2009					
Area	03	04	00	05	06/07	Total
Gillnet	832	1 615	3 356	2 475	4 341	**12 619**
L.line/Jig	1 365	696	1 527	1 390	672	**5 650**
Danish seine	912	1 120	987	2 384	304	**5 708**
Trawl	385	393	8	46	13	**844**
Total	**3 494**	**3 824**	**5 877**	**6 295**	**5 331**	**24 821**

Table 2.1c. Norwegian coastal cod. Estimated recreational and tourist catches in numbers ('000) at age, and total tonnes by year.

	Numbers at age								Total	Recr.	Tourist
Year	2	3	4	5	6	7	8	9	(tonnes)	(tonnes)	(tonnes)
1984	650	1731	2116	1667	1194	597	236	133	13300	13300	0
1985	3162	2590	2366	1745	647	225	130	79	13400	13400	0
1986	627	3033	2668	1659	1139	435	251	139	13500	13500	0
1987	108	1972	4008	2181	649	431	109	38	13500	13500	0
1988	634	1407	1567	1708	2088	550	129	94	13600	13600	0
1989	418	825	1483	1758	1413	518	108	34	13700	13600	100
1990	401	1494	1252	682	2709	450	73	0	14500	14400	100
1991	1183	2698	2996	1342	808	583	104	71	15300	15200	100
1992	429	1281	2349	1491	630	514	846	84	16100	16000	100
1993	47	1276	1288	813	846	696	202	368	14800	14700	100
1994	57	701	1723	715	1288	671	393	124	14700	14600	100
1995	8	332	804	1451	1585	780	413	180	14700	14500	200
1996	21	591	509	617	1497	1373	461	227	14500	14300	200
1997	51	707	1023	763	735	1189	688	132	14500	14200	300
1998	249	1137	2327	1316	585	410	329	255	14600	14300	300
1999	49	466	1445	1939	920	357	198	221	13900	13500	400
2000	63	554	1153	1515	1044	344	127	109	13600	13100	500
2001	0	343	735	1046	964	873	198	134	13400	12700	700
2002	56	298	830	1055	939	596	335	165	13600	12800	800
2003	85	342	664	916	918	450	244	326	13900	13000	900
2004	26	254	483	924	1099	827	358	162	13400	12300	1100
2005	21	270	658	858	853	715	423	176	13200	12000	1200
2006	19	236	1016	867	983	612	315	127	13000	11700	1300
2007	49	346	759	959	606	531	327	157	13000	11500	1500
2008	15	395	743	838	650	400	261	134	12800	11200	1600
2009	0	84	576	727	863	600	280	90	12700	10900	1800

Table 2.2. 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 2.3 Number of otoliths sampled by quarter from commercial catches in the period 1985-2009. 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

Table 2.4. Landings in tonnes of Coastal cod by area and quarter 2006-2009 (upper 4 tables) Proportion (of total) coastal cod in landings by area and quarter 2006-2009 (lower 4 tables).

Year	2006					
Qu./Area	03	04	00	05	06-07	Total
1	291	3483	2677	3150	4169	**13769**
2	1485	2298	601	507	1388	**6279**
3	343	893	338	635	564	**2774**
4	253	1232	444	1071	312	**3312**
Total	**2372**	**7906**	**4059**	**5363**	**6434**	**26134**

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	2006					
Qu./Area	03	04	00	05	06-07	Total
1	0.05	0.20	0.13	0.13	0.88	**0.19**
2	0.20	0.16	0.13	0.10	0.96	**0.19**
3	0.35	0.81	0.91	0.95	0.98	**0.75**
4	0.10	0.85	0.91	0.95	0.99	**0.56**
Total	**0.15**	**0.23**	**0.15**	**0.17**	**0.91**	**0.23**

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**

Table 2.5. Coastal cod. Acoustic abundance indices by sub areas and in total in 2009 (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	1356	347	629	736	499	321	174	83	47	39	4230
04	1082	758	954	1142	630	350	312	167	75	62	5533
05	623	146	114	194	95	50	458	39	0	0	1717
00	141	52	338	833	716	440	244	302	229	0	3295
06	240	742	563	987	556	432	59	202	91	31	3905
07	0	13	124	68	39	10	12	0	0	9	275
Total	3442	2059	2722	3959	2536	1603	1259	793	443	141	18955

Table 2.6. Coastal cod. Acoustic abundance indices by age 1995 – 2009 (in thousands).

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

Table 2.7. Coastal cod. Mean length (cm) at age 1995 – 2009.

	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

Table 2.8. Coastal cod. Mean weight (grams) at age 1995-2009.

	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

Table 2.9. Coastal cod. Acoustic biomass indices (tonnes) in 1995 – 2009.

	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

Table 2.10. Coastal cod. Maturity ogives by age in the period 1995 – 2009.

						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

Table 2.11. Coastal cod. Acoustic spawning biomass indices (tonnes) in 1995 – 2009.

	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

Table 2.12. Proportion coastal cod among sampled cod during the coastal survey by age and statistical areas in the years 2004-2009.

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

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

Table 2 Catch weights at age (kg)

	YEAR	1984	1985	1986	1987	1988	1989				
	AGE										
2		0.248	0.214	0.227	0.331	0.246	0.3				
3		0.619	0.712	0.525	0.673	0.634	0.661				
4		1.149	1.415	1.08	1.12	1.17	1.836				
5		1.734	2.036	1.706	1.693	1.727	2.17				
6		2.325	2.737	2.256	2.359	2.328	2.448				
7		3.486	4.012	3.353	3.743	3.256	4.391				
8		4.845	6.116	4.838	5.326	4.7	4.899				
9		5.608	6.46	5.838	6.129	5.45	6.661				
	+gp	8.84	10.755	7.053	11.623	8.202	11.608				
0	SOPCOFAC	1.0002	1	1.0001	1.0001	1.0001	1				
	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
2		0.345	0.164	0.168	0.241	0.254	0.302	0.274	0.277	0.376	0.467
3		1.174	0.922	0.556	0.645	0.805	0.71	0.921	0.97	0.978	1.155
4		1.515	1.608	1.359	1.71	1.476	1.335	1.464	1.554	1.518	1.633
5		1.678	2.108	2.267	2.591	2.097	1.842	1.979	1.97	2.281	2.171
6		2.708	2.507	2.957	3.588	3.287	2.467	2.516	2.897	3.125	3.249
7		3.898	3.469	3.903	4.366	4.095	4.191	3.461	3.716	3.9	4.095
8		6.515	4.976	5.317	5.899	5.592	5.778	4.866	4.829	5.52	5.013
9		7.299	5.734	4.558	6.494	7.217	6.376	5.391	6.349	6.333	6.018
	+gp	13.924	11.059	7.032	7.509	8.331	9.903	8.854	9.267	9.337	6.255
0	SOPCOFAC	1.0002	1.0003	1.0001	1	1	1.0001	1.0001	1.0003	0.9919	1.0002
	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
2		0.515	0.164	0.491	0.944	0.824	0.82	1.274	1.241	0.977	1.219
3		1.305	0.952	1.179	1.552	1.374	1.317	1.599	1.744	1.882	1.47
4		2.272	1.637	1.8	2.146	1.877	2.094	1.894	2.143	2.444	2.348
5		2.555	2.881	2.485	3.082	2.679	2.795	2.687	2.718	3.747	3.331
6		3.283	3.424	3.86	3.594	3.365	3.493	3.562	4.098	4.165	4.251
7		4.504	4.038	4.76	4.953	4.013	4.087	4.029	4.884	4.989	4.824
8		5.4	5.397	5.195	5.736	4.847	4.836	5.182	5.939	5.992	5.807
9		6.379	7.208	5.507	6.477	5.554	6.264	5.905	6.89	6.143	6.776
	+gp	6.42	6.881	9.183	9.686	6.343	5.115	6.213	8.098	8.229	8.571
0	SOPCOFAC	0.9999	1.0004	1.0181	1.0001	0.9997	1.0001	0.9999	0.9998	0.9999	1

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

Table 3 Stock weights at age (kg)

YEAR	1984	1985	1986	1987	1988	1989
AGE						
2	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
4	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
6	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
8	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
+gp	9.723	9.723	9.723	9.723	9.723	9.723

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
2	0.321	0.321	0.321	0.321	0.321	0.298	0.27	0.232	0.323	0.318
3	0.758	0.758	0.758	0.758	0.758	0.7	0.717	0.677	0.834	0.804
4	1.479	1.479	1.479	1.479	1.479	1.338	1.435	1.363	1.366	1.559
5	2.137	2.137	2.137	2.137	2.137	1.973	2.044	1.903	2.075	2.042
6	2.814	2.814	2.814	2.814	2.814	2.649	2.694	2.816	3.013	2.798
7	4.722	4.722	4.722	4.722	4.722	4.164	4.817	3.833	4.255	4.678
8	6.685	6.685	6.685	6.685	6.685	7.051	6.28	5.849	5.305	7.151
9	6.98	6.98	6.98	6.98	6.98	6.413	11.365	9.6	8.35	8.959
+gp	9.723	9.723	9.723	9.723	9.723	14.326	15.67	13.037	18.016	18.34

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
2	0.346	0.347	0.43	0.308	0.339	0.407	0.49	0.518	0.508	0.434
3	0.777	0.878	0.88	0.686	0.834	0.846	1.125	1.185	1.208	1.116
4	1.458	1.543	1.698	1.299	1.614	1.748	1.812	2.011	2.095	2.003
5	2.296	2.213	2.452	2.149	2.269	2.2	2.559	2.5	2.987	2.894
6	2.735	2.862	3.538	3.135	3.29	2.693	3.579	3.16	3.671	3.632
7	4.048	3.321	4.397	4.048	4.124	3.817	3.964	4.241	3.976	4.875
8	7.011	4.849	4.191	5.008	4.718	3.797	4.822	6.806	4.387	5.4
9	9.224	7.339	7.046	5.789	4.976	5.344	7.332	11.051	5.415	6.125
+gp	12.277	11.542	15.619	10.069	6.358	14.829	14.65	14.931	11.558	4.719

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

Table 5 Proportion mature at age

	YEAR	1984	1985	1986	1987	1988	1989
	AGE						
2		0	0	0	0	0	0
3		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
5		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
7		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
9		0.96	0.96	0.96	0.96	0.96	0.96
	+gp	1	1	1	1	1	1

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	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

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	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. Catch numbers at age (thousands) and total catch i(tones) as input to the VPA-analysis including recreational and tourist fisheries.

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

YEAR	1984	1985	1986	1987	1988	1989
AGE						
2	1479	3558	4722	278	744	459
3	5209	10438	7128	2912	3328	1984
4	9070	9733	15330	12244	4910	2917
5	8945	10444	10565	14611	8159	4057
6	7198	7732	6889	5076	8714	6610
7	5561	3291	4303	3080	5237	3238
8	2397	835	1521	1236	1590	1057
9	952	512	481	351	591	270
+gp	624	264	407	149	333	86
0 TOTALNUM	41435	46807	51346	39937	33606	20678
TONSLAND	88124	88851	82405	74472	72894	53985
SOPCOF %	100	100	100	100	100	100

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
2	408	1308	469	51	389	818	1214	1377	803	301
3	1843	3305	1946	1645	1274	1228	2967	4145	3956	1788
4	2485	4448	5509	2994	3416	3149	2989	4173	7113	3791
5	2012	4456	5913	3156	5017	6639	5547	3021	5339	6202
6	3838	2681	3622	3530	3755	7131	6144	3225	2857	3693
7	3906	1880	2459	3768	4008	4050	5533	5124	1956	1959
8	846	977	1744	2073	1907	1868	2543	4000	2155	949
9	141	203	921	995	901	737	1125	1091	1230	995
+gp	73	94	279	690	798	433	543	684	343	320
0 TOTALNUM	15552	19352	22862	18902	21465	26053	28605	26840	25752	19998
TONSLAND	42627	40122	57790	67357	69262	71907	76276	77819	66172	54632
SOPCOF %	100	100	100	100	100	100	100	100	99	100

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
2	219	44	248	166	38	36	90	137	107	3
3	1525	848	1191	1449	560	744	551	861	1065	322
4	4817	2572	3161	2758	1407	1957	2672	2155	2181	1628
5	5322	4020	3877	3422	2637	2686	2562	2805	2473	2007
6	3715	2962	3681	3076	2919	2289	2678	1858	1882	2251
7	1448	2282	2134	1824	2271	1830	1858	1355	1262	1665
8	453	740	1250	842	967	936	986	718	701	825
9	241	321	490	584	388	364	453	413	349	262
+gp	152	119	377	99	264	143	224	196	170	276
0 TOTALNUM	17892	13908	16409	14220	11451	10985	12074	10498	10190	9239
TONSLAND	50315	43099	54594	48535	37947	35632	39134	36841	38577	37521
SOPCOF %	100	100	101	100	100	100	100	100	100	100

Table 2.15. Norwegian Coastal Cod. Diagnostic output from XSA run for 2009 updated.

Lowestoft VPA Version 3.1

26/04/2010 15:29

Extended Survivors Analysis

Norwegian Coastal Cod COMBSEX PLUSGROUP

CPUE data from file coast-9.txt

Catch data for 26 years. 1984 to 2009. Ages 2 to 10.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
Norw. Coast. survey	1995	2009	0	8	0.75	0.85

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 >= 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 30 iterations

Total absolute residual between iterations

29 and 30 = .00525

Final year F values

Age	2	3	4	5	6	7	8	9
Iteration 29	0.001	0.0426	0.1797	0.3381	0.5365	0.6032	0.4827	0.3102
Iteration 30	0.001	0.0426	0.1795	0.3378	0.5359	0.6021	0.4808	0.3089

Regression weights

	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2	0.008	0.002	0.012	0.005	0.001	0.001	0.006	0.008	0.013	0.001
3	0.054	0.031	0.059	0.087	0.025	0.038	0.03	0.059	0.082	0.043
4	0.243	0.138	0.193	0.191	0.098	0.139	0.18	0.182	0.234	0.18
5	0.396	0.318	0.327	0.328	0.236	0.285	0.272	0.313	0.337	0.338
6	0.471	0.373	0.548	0.447	0.422	0.318	0.468	0.332	0.357	0.536
7	0.442	0.49	0.554	0.591	0.619	0.498	0.505	0.437	0.402	0.602
8	0.304	0.406	0.695	0.434	0.573	0.464	0.644	0.29	0.443	0.481
9	0.314	0.286	0.457	0.424	0.288	0.345	0.614	0.547	0.256	0.309

XSA population numbers (Thousands)

	AGE							
YEAR	2	3	4	5	6	7	8	9
2000	2.28E+04	2.03E+04	1.88E+04	1.29E+04	7.87E+03	3.41E+03	1.38E+03	5.42E+02
2001	2.11E+04	1.85E+04	1.57E+04	1.21E+04	7.09E+03	4.02E+03	1.80E+03	8.31E+02
2002	1.81E+04	1.73E+04	1.47E+04	1.12E+04	7.19E+03	3.99E+03	2.02E+03	9.80E+02
2003	1.70E+04	1.46E+04	1.33E+04	9.91E+03	6.61E+03	3.40E+03	1.88E+03	8.25E+02
2004	1.72E+04	1.38E+04	1.10E+04	9.01E+03	5.85E+03	3.46E+03	1.54E+03	9.97E+02
2005	1.43E+04	1.41E+04	1.10E+04	8.14E+03	5.83E+03	3.14E+03	1.53E+03	7.12E+02
2006	1.21E+04	1.17E+04	1.11E+04	7.86E+03	5.01E+03	3.47E+03	1.56E+03	7.85E+02
2007	1.16E+04	9.87E+03	9.27E+03	7.58E+03	4.90E+03	2.57E+03	1.71E+03	6.71E+02
2008	7.81E+03	9.38E+03	7.62E+03	6.32E+03	4.54E+03	2.88E+03	1.36E+03	1.05E+03
2009	3.21E+03	6.31E+03	7.07E+03	4.93E+03	3.70E+03	2.60E+03	1.58E+03	7.15E+02

Estimated population abundance at 1st Jan 2010

	0.00E+00	2.62E+03	4.95E+03	4.84E+03	2.88E+03	1.77E+03	1.17E+03	8.02E+02

Taper weighted geometric mean of the VPA populations:

	1.54E+04	1.49E+04	1.29E+04	9.71E+03	6.37E+03	3.75E+03	1.94E+03	9.85E+02

Standard error of the weighted Log(VPA populations) :

	0.6542	0.4597	0.3982	0.3963	0.3799	0.407	0.4436	0.4498

1

Fleet : Norw. Coast. survey

Age	1995	1996	1997	1998	1999
2	0.76	0.44	0.74	0.46	0.46
3	0.57	0.85	0.94	0.5	0.28
4	0.54	0.57	0.69	0.33	0.19
5	0.33	0.84	0.92	0.31	0.2
6	-0.01	-0.02	1.32	0.13	0.09
7	-0.13	-0.42	0.29	0.29	-0.26
8	-0.13	-0.44	0.1	-0.97	-0.31

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2	0.57	0.11	-0.54	-0.82	-0.33	-0.8	-0.32	0	-0.02	0.81
3	0.41	0.11	-0.46	-0.42	-0.37	-0.43	-0.11	0.09	-0.34	0.12
4	0.12	0.04	-0.27	-0.42	-0.19	-0.47	-0.27	0.29	-0.13	0.22
5	0.4	-0.11	-0.3	-0.44	-0.43	-0.14	-0.03	-0.03	-0.27	0.17
6	0.53	-0.2	-0.06	-0.14	-0.25	-0.46	0.2	0.09	-0.51	0.11
7	0	-0.03	0.01	-0.05	-0.43	-0.07	0.32	0.34	-0.38	0.32
8	0.06	-0.12	-0.19	0.04	0.08	0.21	0.01	0.27	-0.01	0.55

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

Age	2	3	4	5	6	7	8
Mean Log q	-1.0887	-0.765	-0.5018	-0.4048	-0.3572	-0.4057	-0.6964
S.E(Log q)	0.5618	0.4264	0.3395	0.3723	0.3995	0.2815	0.3319

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
2	1.04	-0.143	0.74	0.55	15	0.61	-1.09
3	0.68	1.756	3.61	0.75	15	0.26	-0.76
4	0.78	0.945	2.42	0.67	15	0.27	-0.5
5	0.75	1.031	2.57	0.64	15	0.28	-0.4
6	0.86	0.465	1.55	0.52	15	0.36	-0.36
7	1.17	-0.618	-0.91	0.58	15	0.34	-0.41
8	1.54	-1.536	-2.98	0.46	15	0.48	-0.7

Terminal year survivor and F summaries :

Age 2 Catchability constant w.r.t. time and dependent on age

Year class = 2007

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	5875	0.585	0	0	1	0.745	0
F shrinkage mean	250	1				0.255	0.011

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2623	0.51	1.6	2	3.158	0.001

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2006

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	5307	0.354	0.065	0.18	2	0.884	0.04
F shrinkage mean	2927	1				0.116	0.071

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4953	0.33	0.15	3	0.449	0.043

Age 4 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
Norw. Coast. survey	4907		0.25	0.176	0.7	3	0.928	0.177
F shrinkage mean	4094		1				0.072	0.209

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4843	0.24	0.14	4	0.58	0.18

Age 5 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
Norw. Coast. survey	2876		0.212	0.098	0.46	4	0.931	0.338
F shrinkage mean	2995		1				0.069	0.327

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2885	0.21	0.08	5	0.391	0.338

1

Age 6 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
Norw. Coast. survey	1693		0.193	0.153	0.79	5	0.921	0.555
F shrinkage mean	3035		1				0.079	0.346

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1774	0.19	0.15	6	0.772	0.536

Age 7 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
Norw. Coast. survey	1132		0.171	0.153	0.89	6	0.932	0.616
F shrinkage mean	1834		1				0.068	0.422

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1169	0.17	0.14	7	0.832	0.602

Age 8 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
Norw. Coast. survey	786		0.16	0.178	1.11	7	0.941	0.487

F shrinkage mean	1106		1				0.059	0.369

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
802	0.16	0.16	8	1.008	0.481

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

Year class = 2000

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	454	0.166	0.097	0.59	7	0.918	0.295
F shrinkage mean	244	1				0.082	0.493

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
432	0.17	0.11	8	0.631	0.309

Table 2.16. Norwegian Coastal Cod. Summary output from XSA run for 2009 updated.

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 2	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 4- 7
1984	87915	310202	140813	74824	0.5314	1.0002	0.6221
1985	74401	293915	116933	75451	0.6452	1	0.5276
1986	35543	290530	122006	68905	0.5648	1.0001	0.5808
1987	36610	254620	114620	60972	0.5319	1.0001	0.4919
1988	39928	230358	117782	59294	0.5034	1.0001	0.6203
1989	43226	195737	93316	40285	0.4317	1	0.3763
1990	42297	209288	102157	28127	0.2753	1.0002	0.1845
1991	59811	244532	122385	24822	0.2028	1.0003	0.1714
1992	49295	286162	153360	41690	0.2718	1.0001	0.2356
1993	30294	298765	165785	52557	0.317	1	0.2375
1994	25179	298482	174761	54562	0.3122	1	0.2396
1995	33496	260753	161869	57207	0.3534	1.0001	0.3064
1996	39939	261957	173001	61776	0.3571	1.0001	0.383
1997	32577	204456	127641	63319	0.4961	1.0003	0.4071
1998	30422	175637	93903	51572	0.5492	0.9919	0.4502
1999	25013	154934	78153	40732	0.5212	1.0002	0.4557
2000	22754	138094	66319	36715	0.5536	0.9999	0.3879
2001	21125	129059	61969	29699	0.4793	1.0004	0.3299
2002	18070	154004	83131	40994	0.4931	1.0181	0.4054
2003	16965	105703	55358	34635	0.6257	1.0001	0.3893
2004	17204	108573	56881	24547	0.4315	0.9997	0.3435
2005	14265	100189	49732	22432	0.4511	1.0001	0.3102
2006	12136	112080	57270	26134	0.4563	0.9999	0.3564
2007	11555	108338	57439	23841	0.4151	0.9998	0.3161
2008	7808	99441	53352	25777	0.4831	0.9999	0.3322
2009	3206	81276	46617	24821	0.5324	1	0.4139
Arith. Mean	31963	196426	101790	44065	.4533		.3798
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)			

Table 2.17. Norwegian Coastal Cod. Diagnostic output from XSA run for 2010 with recreational and tourist fisheries included.

Lowestoft VPA Version 3.1
26/04/2010 15:31
Extended Survivors Analysis
Norwegian
Coastal Cod COMBSEX PLUSGROUP
CPUE data from file coast-9.txt
Catch data for 26 years. 1984 to 2009. Ages 2 to 10.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
Norw. Coast. survey	1995	2009	0	8	0.75	0.85

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 >= 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 30 iterations
Total absolute residual between iterations
29 and 30 = .00475
Final year F values

Age	2	3	4	5	6	7	8	9
Iteration 29	0.0008	0.0401	0.1885	0.355	0.5703	0.6075	0.4717	0.3113
Iteration 30	0.0008	0.0401	0.1884	0.3548	0.5697	0.6066	0.47	0.3102

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2	0.007	0.002	0.01	0.007	0.002	0.002	0.005	0.009	0.011	0.001
3	0.058	0.034	0.052	0.074	0.03	0.038	0.034	0.066	0.088	0.04
4	0.228	0.131	0.174	0.163	0.096	0.139	0.188	0.183	0.236	0.188
5	0.377	0.303	0.298	0.288	0.231	0.268	0.273	0.309	0.33	0.355
6	0.417	0.373	0.504	0.41	0.428	0.323	0.468	0.326	0.351	0.57
7	0.383	0.49	0.508	0.505	0.611	0.526	0.474	0.46	0.385	0.607
8	0.259	0.344	0.551	0.384	0.555	0.551	0.609	0.338	0.46	0.47
9	0.297	0.295	0.404	0.543	0.306	0.417	0.57	0.56	0.272	0.31

XSA population numbers (Thousands)

	AGE							
YEAR	2	3	4	5	6	7	8	9
2000	3.41E+04	3.00E+04	2.61E+04	1.87E+04	1.21E+04	5.03E+03	2.19E+03	1.04E+03
2001	3.19E+04	2.77E+04	2.32E+04	1.70E+04	1.05E+04	6.51E+03	2.81E+03	1.39E+03
2002	2.76E+04	2.61E+04	2.19E+04	1.66E+04	1.03E+04	5.92E+03	3.26E+03	1.63E+03
2003	2.58E+04	2.24E+04	2.03E+04	1.51E+04	1.01E+04	5.08E+03	2.92E+03	1.54E+03
2004	2.67E+04	2.09E+04	1.70E+04	1.41E+04	9.26E+03	5.49E+03	2.51E+03	1.63E+03
2005	2.21E+04	2.18E+04	1.66E+04	1.26E+04	9.17E+03	4.94E+03	2.44E+03	1.18E+03
2006	1.84E+04	1.80E+04	1.72E+04	1.19E+04	7.92E+03	5.44E+03	2.39E+03	1.15E+03
2007	1.72E+04	1.50E+04	1.43E+04	1.17E+04	7.38E+03	4.06E+03	2.77E+03	1.06E+03
2008	1.12E+04	1.40E+04	1.15E+04	9.73E+03	7.02E+03	4.36E+03	2.10E+03	1.62E+03
2009	3.91E+03	9.06E+03	1.05E+04	7.43E+03	5.73E+03	4.05E+03	2.43E+03	1.09E+03

Estimated population abundance at 1st Jan 2010

0.00E+00	3.20E+03	7.13E+03	7.11E+03	4.27E+03	2.66E+03	1.81E+03	1.25E+03

Taper weighted geometric mean of the VPA populations:

2.25E+04	2.21E+04	1.91E+04	1.43E+04	9.48E+03	5.61E+03	2.96E+03	1.56E+03

Standard error of the weighted Log(VPA populations) :

0.6908	0.4456	0.3708	0.3576	0.3349	0.3543	0.3776	0.3851

Log catchability residuals.

Fleet : Norw. Coast. survey

Age	1995	1996	1997	1998	1999
2	0.84	0.45	0.74	0.52	0.46
3	0.68	0.93	0.93	0.51	0.35
4	0.69	0.67	0.76	0.32	0.21
5	0.47	0.94	1.03	0.37	0.18
6	0.12	0.12	1.39	0.21	0.13
7	0.06	-0.28	0.46	0.3	-0.27
8	0	-0.25	0.18	-0.87	-0.46

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2	0.55	0.08	-0.58	-0.85	-0.39	-0.85	-0.35	-0.01	0.01	0.99
3	0.42	0.11	-0.49	-0.46	-0.39	-0.47	-0.14	0.07	-0.34	0.15
4	0.18	0.05	-0.29	-0.46	-0.23	-0.48	-0.3	0.26	-0.14	0.24
5	0.42	-0.06	-0.32	-0.49	-0.48	-0.19	-0.04	-0.06	-0.3	0.18
6	0.47	-0.18	-0.04	-0.18	-0.29	-0.5	0.15	0.09	-0.54	0.11
7	0	-0.08	0.01	-0.09	-0.46	-0.07	0.28	0.33	-0.38	0.31
8	0.02	-0.16	-0.32	0.02	0.04	0.27	0.01	0.29	0.03	0.57

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

Age	2	3	4	5	6	7	8
Mean Log q	-1.4723	-1.1627	-0.9001	-0.8096	-0.7698	-0.8352	-1.1554
S.E(Log q)	0.6103	0.4521	0.3729	0.4143	0.4176	0.2866	0.3371

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
2	1.18	-0.556	-0.1	0.49	15	0.75	-1.47
3	0.69	1.466	3.89	0.7	15	0.3	-1.16
4	0.79	0.781	2.79	0.58	15	0.3	-0.9
5	0.76	0.79	2.89	0.53	15	0.32	-0.81
6	0.83	0.495	2.2	0.46	15	0.36	-0.77
7	1.04	-0.131	0.54	0.56	15	0.31	-0.84
8	1.37	-0.934	-1.35	0.4	15	0.46	-1.16

Terminal year survivor and F summaries :

Age 2 Catchability constant w.r.t. time and dependent on age

Year class = 2007

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	8622	0.636	0	0	1	0.712	0
F shrinkage mean	277	1				0.288	0.01

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3203	0.54	1.85	2	3.439	0.001

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2006

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	7882	0.379	0.07	0.18	2	0.87	0.036
F shrinkage mean	3638	1				0.13	0.077

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7127	0.35	0.2	3	0.572	0.04
1					

Age 4 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
Norw. Coast. survey	7188	0.271	0.18	0.66	3	0.915	0.186
F shrinkage mean	6299	1				0.085	0.21

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7108	0.26	0.14	4	0.543	0.188

Age 5 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
Norw. Coast. survey	4223	0.232	0.104	0.45	4	0.917	0.358
F shrinkage mean	4796	1				0.083	0.321

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4268	0.23	0.09	5	0.387	0.355

Age 6 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
Norw. Coast. survey	2487	0.209	0.156	0.75	5	0.906	0.598
F shrinkage mean	5018	1				0.094	0.341

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2656	0.21	0.16	6	0.776	0.57

Age 7 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
Norw. Coast. survey	1746	0.18	0.16	0.89	6	0.927	0.622
F shrinkage mean	2842	1				0.073	0.425

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1810	0.18	0.15	7	0.824	0.607

Age 8 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
Norw. Coast. survey	1234	0.167	0.183	1.1	7	0.938	0.473
F shrinkage mean	1511	1				0.062	0.402

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1250	0.17	0.17	8	0.983	0.47

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 8
Year class = 2000

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	694	0.174	0.098	0.57	7	0.911	0.294
F shrinkage mean	362	1				0.089	0.504

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
654	0.18	0.11	8	0.627	0.31

Table 2.18. Norwegian Coastal Cod. Summary output from XSA run for 2010 with recreational and tourist fisheries included.

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 2	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 4- 7
1984	109445	363616	161708	88124	0.545	1.0001	0.6182
1985	98043	348434	134544	88851	0.6604	1	0.5235
1986	62696	351708	140662	82405	0.5858	1	0.5895
1987	49015	317004	133299	74472	0.5587	1	0.5067
1988	54425	294097	139624	72894	0.5221	1	0.6342
1989	62998	260422	117973	53985	0.4576	1	0.3834
1990	61657	279615	131106	42627	0.3251	1.0001	0.2371
1991	81509	325149	158032	40122	0.2539	1.0002	0.1941
1992	68237	371918	194241	57790	0.2975	1	0.249
1993	39633	385526	209475	67357	0.3216	1	0.2361
1994	33297	381398	218590	69262	0.3169	1.0001	0.2409
1995	45300	335804	206391	71907	0.3484	1.0001	0.3018
1996	57977	343119	224269	76276	0.3401	1	0.3616
1997	47218	274036	166813	77819	0.4665	1.0002	0.3962
1998	42205	246837	128856	66172	0.5135	0.9937	0.4108
1999	36936	222467	110823	54632	0.493	1.0001	0.413
2000	34100	202305	97923	50315	0.5138	0.9999	0.3512
2001	31920	190167	91132	43099	0.4729	1.0002	0.3244
2002	27591	222777	117369	54594	0.4651	1.0134	0.3708
2003	25759	160469	83672	48535	0.5801	1.0001	0.3416
2004	26727	165996	85725	37947	0.4427	0.9997	0.3415
2005	22064	150333	72584	35632	0.4909	1.0001	0.314
2006	18390	168916	84497	39134	0.4631	0.9998	0.3508
2007	17217	163168	85363	36841	0.4316	1	0.3192
2008	11181	145804	76271	38577	0.5058	0.9998	0.3254
2009	3914	119962	68660	37521	0.5465	1.0001	0.4299
Arith. Mean	44979	261194	132292	57957	.4584	.3756	
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)			

Table 2.19. Norwegian Coastal Cod. Diagnostic output from XSA run for 2010 with recreational and tourist fisheries included, and stock dependant catchabilities for ages 2 and 3.

Lowestoft VPA Version 3.1
26/04/2010 16:18
Extended Survivors Analysis
Norwegian Coastal Cod COMBSEX PLUSGROUP
CPUE data from file coast-9.txt
Catch data for 26 years. 1984 to 2009. Ages 2 to 10.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
Norw. Coast. survey	1995	2009	0	8	0.75	0.85

Time series weights :
Tapered time weighting applied
Power = 3 over 20 years
Catchability analysis :
Catchability dependent on stock size for ages < 4
Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 4
Catchability independent of age for ages >= 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 30 iterations
Total absolute residual between iterations
29 and 30 = .00808

Final year F values

Age	2	3	4	5	6	7	8	9

Iteration 29	0.0001	0.0181	0.1321	0.2646	0.4794	0.5589	0.412	0.2794		
Iteration 30	0.0001	0.018	0.1318	0.264	0.4781	0.5574	0.4092	0.2779		
Regression weights										
	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2	0.007	0.001	0.01	0.007	0.002	0.002	0.004	0.007	0.005	0
3	0.057	0.034	0.051	0.073	0.029	0.037	0.032	0.054	0.064	0.018
4	0.227	0.13	0.172	0.159	0.094	0.134	0.183	0.167	0.188	0.132
5	0.375	0.301	0.294	0.286	0.224	0.262	0.26	0.297	0.294	0.264
6	0.422	0.371	0.5	0.402	0.422	0.31	0.453	0.305	0.333	0.478
7	0.384	0.5	0.502	0.498	0.591	0.515	0.446	0.438	0.351	0.557
8	0.251	0.346	0.569	0.377	0.541	0.52	0.586	0.309	0.426	0.409
9	0.318	0.283	0.407	0.576	0.298	0.401	0.517	0.523	0.242	0.278

XSA population numbers (Thousands)

	AGE							
YEAR	2	3	4	5	6	7	8	9
2000	3.43E+04	3.03E+04	2.62E+04	1.88E+04	1.19E+04	5.01E+03	2.26E+03	9.79E+02
2001	3.26E+04	2.79E+04	2.34E+04	1.71E+04	1.06E+04	6.41E+03	2.79E+03	1.44E+03
2002	2.80E+04	2.67E+04	2.21E+04	1.68E+04	1.03E+04	5.97E+03	3.18E+03	1.62E+03
2003	2.67E+04	2.27E+04	2.08E+04	1.52E+04	1.03E+04	5.14E+03	2.96E+03	1.47E+03
2004	2.74E+04	2.17E+04	1.73E+04	1.45E+04	9.36E+03	5.62E+03	2.56E+03	1.66E+03
2005	2.39E+04	2.24E+04	1.73E+04	1.29E+04	9.50E+03	5.02E+03	2.55E+03	1.22E+03
2006	2.23E+04	1.95E+04	1.77E+04	1.24E+04	8.12E+03	5.70E+03	2.46E+03	1.24E+03
2007	2.33E+04	1.82E+04	1.55E+04	1.21E+04	7.81E+03	4.22E+03	2.99E+03	1.12E+03
2008	2.44E+04	1.90E+04	1.41E+04	1.07E+04	7.34E+03	4.71E+03	2.23E+03	1.80E+03
2009	2.25E+04	1.99E+04	1.46E+04	9.56E+03	6.55E+03	4.31E+03	2.72E+03	1.19E+03

Estimated population abundance at 1st Jan 2010

	0.00E+00	1.85E+04	1.60E+04	1.05E+04	6.03E+03	3.33E+03	2.03E+03	1.49E+03

Taper weighted geometric mean of the VPA populations:

	2.93E+04	2.50E+04	2.03E+04	1.49E+04	9.74E+03	5.73E+03	3.04E+03	1.60E+03

Standard error of the weighted Log(VPA populations) :

	0.2765	0.2875	0.2962	0.3053	0.309	0.3405	0.3642	0.3761

Log catchability residuals.
Fleet : Norw. Coast. survey

Age	1995	1996	1997	1998	1999
2	0.09	-0.21	0.02	0.02	0.08
3	0.25	0.17	0.03	-0.01	-0.01
4	0.77	0.74	0.84	0.4	0.28
5	0.53	1.01	1.07	0.43	0.24
6	0.14	0.18	1.45	0.23	0.17
7	0.1	-0.27	0.51	0.36	-0.26
8	0.02	-0.21	0.18	-0.78	-0.37

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2	0.17	0.03	-0.09	-0.15	-0.01	-0.1	0.08	0.13	-0.06	0
3	0.08	0.01	-0.2	-0.09	-0.04	-0.09	0.1	0.19	-0.05	-0.07
4	0.24	0.11	-0.23	-0.42	-0.18	-0.45	-0.26	0.23	-0.31	-0.06
5	0.47	-0.02	-0.28	-0.45	-0.46	-0.16	-0.04	-0.05	-0.37	-0.09
6	0.52	-0.15	-0.02	-0.17	-0.27	-0.5	0.16	0.05	-0.56	-0.06
7	0.04	-0.03	0.03	-0.08	-0.47	-0.06	0.24	0.31	-0.44	0.24
8	0.02	-0.12	-0.25	0.04	0.04	0.24	0	0.23	-0.02	0.45

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	-0.9725	-0.863	-0.8087	-0.8689	-1.1934
S.E(Log q)	0.3834	0.4277	0.4314	0.2915	0.2828

Regression statistics :
Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
2	0.34	5.401	7.36	0.87	15	0.11	-1.75
3	0.39	4.482	6.7	0.85	15	0.12	-1.29

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	0.55	2.071	5	0.69	15	0.18	-0.97

5	0.59	1.524	4.46	0.59	15	0.24	-0.86
6	0.75	0.72	2.9	0.46	15	0.33	-0.81
7	0.98	0.058	1	0.56	15	0.3	-0.87
8	1.17	-0.554	0.06	0.53	15	0.34	-1.19

Terminal year survivor and F summaries :

Age 2 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	18430	0.3	0	0	1	0.459	0
P shrinkage mean	25017	0.29				0.5	0
F shrinkage mean	475	1				0.041	0.006

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
18460	0.2	0.55	3	2.693	0

Age 3 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
Norw. Coast. survey	14971	0.212	0.006	0.03	2	0.637	0.019
P shrinkage mean	20309	0.3				0.334	0.014
F shrinkage mean	4786	1				0.029	0.059

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
16030	0.17	0.15	4	0.893	0.018

Age 4 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
Norw. Coast. survey	10618	0.188	0.063	0.33	3	0.959	0.13

F shrinkage mean	7557		1				0.041	0.178

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
10473	0.18	0.06	4	0.346	0.132

Age 5 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
Norw. Coast. survey	6065	0.174	0.105	0.6	4	0.955	0.262
F shrinkage mean	5247	1				0.045	0.297

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
6025	0.17	0.09	5	0.522	0.264

Age 6 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
Norw. Coast. survey	3236	0.165	0.091	0.55	5	0.942	0.488
F shrinkage mean	5379	1				0.058	0.321

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3333	0.17	0.1	6	0.581	0.478

Age 7 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
Norw. Coast. survey	1975	0.154	0.117	0.76	6	0.943	0.567
F shrinkage mean	3091	1				0.057	0.397

Weighted prediction :

Survivors	Int	Ext	N	Var	F

at end of year	s.e		s.e		Ratio			
2026	0.16		0.11	7	0.72	0.557		

Age 8 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
Norw. Coast. survey	1478	0.144	0.148	1.03	7	0.956	0.409
F shrinkage mean	1668	1				0.044	0.37

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1486	0.14	0.13	8	0.933	0.409

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

Year class = 2000

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	773	0.151	0.067	0.45	7	0.934	0.268
F shrinkage mean	441	1				0.066	0.43

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
745	0.16	0.08	8	0.521	0.278

Table 2.20. Norwegian Coastal Cod. Summary output from XSA run for 2010 with recreational and tourist fisheries included, and stock dependant catchabilities for age 2 and 3.

	RECRUITS Age 2	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 4- 7
1984	109449	363619	161709	88124	0.545	1.0001	0.6182
1985	98065	348446	134546	88851	0.6604	1	0.5235
1986	62717	351735	140665	82405	0.5858	1	0.5895
1987	49052	317058	133307	74472	0.5587	1	0.5066
1988	54447	294183	139647	72894	0.522	1	0.6341
1989	63187	260596	118018	53985	0.4574	1	0.3832
1990	61580	279849	131193	42627	0.3249	1.0001	0.2369
1991	82057	325629	158187	40122	0.2536	1.0002	0.1938
1992	67797	372453	194505	57790	0.2971	1	0.2486
1993	39399	386057	209853	67357	0.321	1	0.2356
1994	33502	381945	219214	69262	0.316	1.0001	0.24
1995	45252	336241	206936	71907	0.3475	1.0001	0.3021
1996	57711	344132	225387	76276	0.3384	1	0.3616
1997	47356	273803	166706	77819	0.4668	1.0002	0.4007
1998	42360	247695	129784	66172	0.5099	0.9937	0.4134
1999	37294	220704	108943	54632	0.5015	1.0001	0.4109
2000	34327	201992	97181	50315	0.5177	0.9999	0.3522
2001	32649	191514	91632	43099	0.4703	1.0002	0.3254
2002	28028	224158	117483	54594	0.4647	1.0134	0.367
2003	26701	162358	84164	48535	0.5767	1.0001	0.3361
2004	27436	169673	87444	37947	0.434	0.9997	0.333
2005	23885	155231	74689	35632	0.4771	1.0001	0.3051
2006	22278	178062	88247	39134	0.4435	0.9998	0.3356
2007	23323	178055	90142	36841	0.4087	1	0.3017
2008	24427	172120	83113	38577	0.4642	0.9998	0.2915
2009	22511	161482	78773	37521	0.4763	1.0001	0.3578
Arith.							
Mean	46800	265338	133518	57957	.4515		.3694
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)			

Table 2.21. Norwegian Coastal Cod. Output from final standard VPA run for 2010.

Table 8 Fishing mortality (F) at age

	YEAR	1984	1985	1986	1987	1988	1989
	AGE						
2		0.0152	0.0411	0.0871	0.0063	0.0153	0.0081
3		0.0945	0.1409	0.1082	0.071	0.097	0.0515
4		0.2393	0.2555	0.3157	0.2732	0.1641	0.1154
5		0.3664	0.476	0.4854	0.5628	0.2952	0.1984
6		0.6625	0.6259	0.6725	0.457	0.7948	0.4143
7		1.2029	0.7425	0.8887	0.7407	1.2752	0.8007
8		1.0048	0.565	0.9661	0.7009	1.1625	1.0172
9		0.8193	0.6062	0.7607	0.6187	0.8948	0.6159
	+gp	0.8193	0.6062	0.7607	0.6187	0.8948	0.6159
0	FBAR 4- 7	0.6178	0.525	0.5906	0.5084	0.6323	0.3822

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
2		0.0074	0.0179	0.0077	0.0014	0.013	0.0203	0.0237	0.0328	0.0213	0.009
3		0.0407	0.0762	0.0333	0.0338	0.045	0.0517	0.0951	0.1051	0.1243	0.0603
4		0.0842	0.1304	0.1754	0.0658	0.0912	0.1492	0.1712	0.1876	0.2634	0.1682
5		0.1088	0.2132	0.2558	0.1442	0.1496	0.2562	0.4227	0.2615	0.3878	0.3861
6		0.2919	0.2067	0.2688	0.239	0.2548	0.3277	0.3995	0.4672	0.4221	0.5099
7		0.4623	0.2269	0.2968	0.4951	0.4669	0.4794	0.4567	0.6889	0.5805	0.5776
8		0.5	0.1989	0.3397	0.4384	0.5041	0.4141	0.636	0.7114	0.7115	0.6273
9		0.3436	0.212	0.2916	0.3312	0.3461	0.3712	0.4732	0.6271	0.4956	0.8755
	+gp	0.3436	0.212	0.2916	0.3312	0.3461	0.3712	0.4732	0.6271	0.4956	0.8755
0	FBAR 4- 7	0.2368	0.1943	0.2492	0.236	0.2406	0.3031	0.3625	0.4013	0.4135	0.4104

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	FBAR **-**
	AGE											
2		0.0071	0.0015	0.0104	0.0071	0.0014	0.0014	0.0047	0.008	0.0048	0.0002	0.0043
3		0.0576	0.0344	0.0508	0.0776	0.03	0.0345	0.027	0.056	0.0796	0.018	0.0512
4		0.228	0.1302	0.1729	0.159	0.1005	0.139	0.1665	0.14	0.1959	0.1678	0.1679
5		0.3754	0.3021	0.2947	0.2866	0.2245	0.2822	0.2716	0.2639	0.2362	0.2782	0.2594
6		0.4224	0.3707	0.4995	0.4028	0.4231	0.3099	0.5035	0.3233	0.2843	0.3504	0.3193
7		0.3845	0.5006	0.501	0.4978	0.5905	0.5153	0.4452	0.5182	0.3802	0.4376	0.4453
8		0.251	0.3465	0.5694	0.3769	0.5403	0.5203	0.5854	0.3083	0.5599	0.4603	0.4428
9		0.3175	0.2834	0.4074	0.5759	0.2984	0.4008	0.5166	0.5234	0.2416	0.4206	0.3952
	+gp	0.3175	0.2834	0.4074	0.5759	0.2984	0.4008	0.5166	0.5234	0.2416	0.4206	
0	FBAR 4- 7	0.3526	0.3259	0.367	0.3366	0.3346	0.3116	0.3467	0.3113	0.2741	0.3085	

Table 2.21. Norwegian Coastal Cod. Output from final standard VPA run for 2010 continued.

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

	YEAR	1984	1985	1986	1987	1988	1989
	AGE						
2		108384	97422	62363	48753	54062	62736
3		63659	87401	76550	46799	39664	43591
4		46837	47422	62151	56247	35689	29473
5		31977	30186	30071	37109	35041	24796
6		16215	18150	15354	15153	17306	21355
7		8600	6844	7947	6417	7855	6400
8		4104	2115	2667	2675	2505	1797
9		1853	1230	984	831	1087	641
	+gp	1215	634	833	353	612	204
0	TOTAL	282845	291404	258920	214336	193821	190992

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
2		61090	81382	67144	39068	33267	44916	57255	47031	42033	36994
3		50949	49648	65448	54549	31940	26885	36036	45780	37262	33689
4		33898	40050	37666	51828	43176	25000	20903	26828	33744	26942
5		21500	25512	28781	25877	39731	32268	17631	14422	18207	21230
6		16649	15789	16876	18245	18342	28009	20447	9459	9090	10114
7		11554	10181	10513	10560	11762	11639	16525	11228	4854	4880
8		2353	5958	6643	6397	5270	6037	5900	8569	4616	2224
9		532	1168	3998	3872	3379	2606	3267	2557	3444	1855
	+gp	275	541	1211	2685	2992	1531	1577	1603	960	597
0	TOTAL	198800	230228	238282	213082	189858	178893	179541	167477	154211	138524

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	GMST
	AGE												
2		34051	32448	26396	25708	29632	27864	21374	18883	24436	22068	0	43594
3		30016	27681	26526	21387	20898	24226	22780	17419	15336	19910	18065	37294
4		25968	23199	21897	20643	16203	16604	19163	18153	13484	11595	16010	30090
5		18643	16926	16675	15081	14416	11997	11830	13282	12921	9076	8027	21579
6		11815	10486	10245	10168	9271	9430	7407	7382	8352	8353	5626	13415
7		4973	6341	5926	5090	5564	4972	5663	3666	4374	5146	4818	7364
8		2242	2772	3147	2940	2533	2524	2431	2971	1788	2449	2720	3435
9		972	1428	1605	1458	1651	1208	1228	1109	1787	836	1265	1572
	+gp	613	530	1235	247	1123	475	607	526	870	881	923	
0	TOTAL	129294	121810	113652	102721	101291	99299	92486	83390	83348	80314	57454	

Table 2.21. Norwegian Coastal Cod. Output from final standard VPA run for 2010 continued.

Table 12 Stock biomass at age (start of year) Tonnes

	YEAR	1984	1985	1986	1987	1988	1989
	AGE						
2		34791	31272	20019	15650	17354	20138
3		48254	66250	58025	35474	30065	33042
4		69272	70137	91922	83189	52784	43590
5		68336	64508	64261	79303	74882	52989
6		45629	51073	43207	42639	48700	60092
7		40610	32318	37525	30299	37092	30219
8		27438	14136	17827	17885	16745	12011
9		12934	8588	6868	5800	7585	4476
	+gp	11810	6168	8095	3429	5954	1986
0	TOTALBIO	359074	344451	347749	313668	291160	258544

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
2		19610	26123	21553	12541	10679	13385	15459	10911	13577	11764
3		38620	37633	49610	41348	24211	18820	25838	30993	31077	27086
4		50136	59234	55709	76653	63857	33450	29996	36566	46094	42002
5		45946	54519	61505	55298	84906	63666	36038	27445	37779	43351
6		46849	44430	47490	51342	51614	74195	55085	26637	27389	28300
7		54556	48072	49644	49864	55539	48467	79600	43035	20653	22828
8		15728	39827	44410	42765	35229	42567	37052	50119	24487	15903
9		3713	8155	27907	27030	23582	16713	37127	24550	28760	16620
	+gp	2678	5260	11776	26110	29094	21936	24708	20902	17304	10942
0	TOTALBIO	277835	323254	369604	382952	378710	333198	340903	271159	247120	218796

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
2		11782	11259	11350	7918	10045	11341	10473	9781	12413	9578
3		23323	24304	23343	14671	17429	20495	25628	20641	18526	22219
4		37862	35796	37182	26815	26152	29024	34723	36507	28249	23225
5		42804	37458	40888	32409	32710	26393	30274	33206	38594	26266
6		32313	30011	36246	31875	30500	25394	26511	23327	30660	30339
7		20131	21057	26056	20604	22947	18977	22449	15545	17393	25086
8		15721	13441	13189	14723	11951	9584	11725	20218	7842	13223
9		8969	10483	11307	8439	8216	6456	9006	12251	9676	5121
	+gp	7529	6112	19285	2488	7143	7038	8898	7855	10060	4156
0	TOTALBIO	200434	189920	218845	159943	167093	154703	179687	179332	173413	159214

Table 2.21. Norwegian Coastal Cod. Output from final standard VPA run for 2010 continued.

Table 13 Spawning stock biomass at age (spawning time) Tonnes

	YEAR	1984	1985	1986	1987	1988	1989
	AGE						
2		0	0	0	0	0	0
3		965	1325	1161	709	601	661
4		11084	11222	14707	13310	8445	6974
5		31435	29674	29560	36479	34446	24375
6		31484	35240	29813	29421	33603	41463
7		35330	28117	32647	26360	32270	26290
8		24969	12863	16223	16275	15238	10930
9		12417	8244	6593	5568	7282	4297
	+gp	11810	6168	8095	3429	5954	1986
0	TOTSPBIO	159493	132854	138799	131553	137838	116978

Table 13 Spawning stock biomass at age (spawning time) Tonnes

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
2		0	0	0	0	0	0	0	0	0	0
3		772	753	992	827	484	376	517	620	622	542
4		8022	9477	8913	12265	10217	5352	4799	5851	7375	6720
5		21135	25079	28292	25437	39057	29286	16577	12625	17378	19942
6		32326	30657	32768	35426	35614	51194	38009	18380	18899	19527
7		47464	41823	43190	43382	48319	42166	69252	37441	17968	19860
8		14312	36243	40413	38916	32058	38736	33717	45608	22283	14472
9		3565	7829	26791	25949	22639	16045	35642	23568	27610	15955
	+gp	2678	5260	11776	26110	29094	21936	24708	20902	17304	10942
0	TOTSPBIO	130274	157120	193136	208312	217481	205091	223221	164994	129439	107960

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
2		0	0	0	0	0	0	0	0	0	0
3		466	486	467	293	349	410	513	413	371	444
4		6058	5727	5949	4290	4184	4644	5556	5841	4520	3716
5		19690	17230	18808	14908	15047	12141	13926	15275	17753	12082
6		22296	20707	25010	21994	21045	17522	18292	16096	21155	20934
7		17514	18320	22669	17925	19964	16510	19531	13525	15132	21825
8		14307	12231	12002	13398	10875	8721	10669	18399	7136	12033
9		8610	10064	10855	8102	7887	6198	8646	11761	9289	4916
	+gp	7529	6112	19285	2488	7143	7038	8898	7855	10060	4156
0	TOTSPBIO	96470	90878	115044	83399	86494	73185	86030	89164	85416	80107

Table 2.22. Norwegian Coastal Cod. Summary utput from final standard VPA run for 2010 continued.

Traditional vpa using file input for terminal F

	RECRUITS Age 2	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 4- 7
1984	108384	359074	159493	88124	0.5525	0.6178
1985	97422	344451	132854	88851	0.6688	0.525
1986	62363	347749	138799	82405	0.5937	0.5906
1987	48753	313668	131553	74472	0.5661	0.5084
1988	54062	291160	137838	72894	0.5288	0.6323
1989	62736	258544	116978	53985	0.4615	0.3822
1990	61090	277835	130274	42627	0.3272	0.2368
1991	81382	323254	157120	40122	0.2554	0.1943
1992	67144	369604	193136	57790	0.2992	0.2492
1993	39068	382952	208312	67357	0.3233	0.236
1994	33267	378710	217481	69262	0.3185	0.2406
1995	44916	333198	205091	71907	0.3506	0.3031
1996	57255	340903	223221	76276	0.3417	0.3625
1997	47031	271159	164994	77819	0.4716	0.4013
1998	42033	247120	129439	66172	0.5112	0.4135
1999	36994	218796	107960	54632	0.506	0.4104
2000	34051	200434	96470	50315	0.5216	0.3526
2001	32448	189920	90878	43099	0.4743	0.3259
2002	26396	218845	115044	54594	0.4745	0.367
2003	25708	159943	83399	48535	0.582	0.3366
2004	29632	167093	86494	37947	0.4387	0.3346
2005	27864	154703	73185	35632	0.4869	0.3116
2006	21374	179687	86030	39134	0.4549	0.3467
2007	18883	179332	89164	36841	0.4132	0.3113
2008	24436	173413	85416	38577	0.4516	0.2741
2009	22068	159214	80107	37521	0.4684	0.3085
Arith. Mean	46414	263106	132336	57957	0.4555	0.3682
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 2.23. Norwegian Coastal Cod. Input to the predictions using fixed fishing pattern.

MFDP version 1a
Run: Pred2
Time and date: 20:23 26.04.2010
Fbar age range: 4-7

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	21500	0.2	0	0	0	0.4867	0.0045	1.1457
3	18065	0.2	0.02	0	0	1.1697	0.0530	1.6987
4	16010	0.2	0.16	0	0	2.0363	0.1738	2.3117
5	8027	0.2	0.46	0	0	2.7937	0.2686	3.2653
6	5626	0.2	0.69	0	0	3.4877	0.3306	4.1713
7	4818	0.2	0.87	0	0	4.3640	0.4610	4.8990
8	2720	0.2	0.91	0	0	5.5310	0.4584	5.9127
9	1265	0.2	0.96	0	0	7.5303	0.4091	6.6030
10	923	0.2	1	0	0	10.4027	0.4091	8.2993

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	21500	0.2	0	0	0	0.4867	0.0045	1.1457
3	.	0.2	0.02	0	0	1.1697	0.0530	1.6987
4	.	0.2	0.16	0	0	2.0363	0.1738	2.3117
5	.	0.2	0.46	0	0	2.7937	0.2686	3.2653
6	.	0.2	0.69	0	0	3.4877	0.3306	4.1713
7	.	0.2	0.87	0	0	4.3640	0.4610	4.8990
8	.	0.2	0.91	0	0	5.5310	0.4584	5.9127
9	.	0.2	0.96	0	0	7.5303	0.4091	6.6030
10	.	0.2	1	0	0	10.4027	0.4091	8.2993

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	21500	0.2	0	0	0	0.4867	0.0045	1.1457
3	.	0.2	0.02	0	0	1.1697	0.0530	1.6987
4	.	0.2	0.16	0	0	2.0363	0.1738	2.3117
5	.	0.2	0.46	0	0	2.7937	0.2686	3.2653
6	.	0.2	0.69	0	0	3.4877	0.3306	4.1713
7	.	0.2	0.87	0	0	4.3640	0.4610	4.8990
8	.	0.2	0.91	0	0	5.5310	0.4584	5.9127
9	.	0.2	0.96	0	0	7.5303	0.4091	6.6030
10	.	0.2	1	0	0	10.4027	0.4091	8.2993

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	21500	0.2	0	0	0	0.4867	0.0045	1.1457
3	.	0.2	0.02	0	0	1.1697	0.0530	1.6987
4	.	0.2	0.16	0	0	2.0363	0.1738	2.3117
5	.	0.2	0.46	0	0	2.7937	0.2686	3.2653
6	.	0.2	0.69	0	0	3.4877	0.3306	4.1713
7	.	0.2	0.87	0	0	4.3640	0.4610	4.8990
8	.	0.2	0.91	0	0	5.5310	0.4584	5.9127
9	.	0.2	0.96	0	0	7.5303	0.4091	6.6030
10	.	0.2	1	0	0	10.4027	0.4091	8.2993

Table 2.24. Norwegian Coastal Cod. Input to the predictions using variable fishing pattern.

MFDP version 1a
Run: Pred4
Time and date: 20:37 26.04.2010
Fbar age range: 4-7

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	21500	0.2	0	0	0	0.4867	0.0045	1.1457
3	18065	0.2	0.02	0	0	1.1697	0.0530	1.6987
4	16010	0.2	0.16	0	0	2.0363	0.1738	2.3117
5	8027	0.2	0.46	0	0	2.7937	0.2686	3.2653
6	5626	0.2	0.69	0	0	3.4877	0.3306	4.1713
7	4818	0.2	0.87	0	0	4.3640	0.4610	4.8990
8	2720	0.2	0.91	0	0	5.5310	0.4584	5.9127
9	1265	0.2	0.96	0	0	7.5303	0.4091	6.6030
10	923	0.2	1	0	0	10.4027	0.4091	8.2993

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	21500	0.2	0	0	0	0.4867	0.0009	1.1457
3	.	0.2	0.02	0	0	1.1697	0.0158	1.6987
4	.	0.2	0.16	0	0	2.0363	0.0782	2.3117
5	.	0.2	0.46	0	0	2.7937	0.1868	3.2653
6	.	0.2	0.69	0	0	3.4877	0.3029	4.1713
7	.	0.2	0.87	0	0	4.3640	0.4581	4.8990
8	.	0.2	0.91	0	0	5.5310	0.4602	5.9127
9	.	0.2	0.96	0	0	7.5303	0.4102	6.6030
10	.	0.2	1	0	0	10.4027	0.4102	8.2993

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	21500	0.2	0	0	0	0.4867	0.0009	1.1457
3	.	0.2	0.02	0	0	1.1697	0.0158	1.6987
4	.	0.2	0.16	0	0	2.0363	0.0782	2.3117
5	.	0.2	0.46	0	0	2.7937	0.1868	3.2653
6	.	0.2	0.69	0	0	3.4877	0.3029	4.1713
7	.	0.2	0.87	0	0	4.3640	0.4581	4.8990
8	.	0.2	0.91	0	0	5.5310	0.4602	5.9127
9	.	0.2	0.96	0	0	7.5303	0.4102	6.6030
10	.	0.2	1	0	0	10.4027	0.4102	8.2993

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	21500	0.2	0	0	0	0.4867	0.0009	1.1457
3	.	0.2	0.02	0	0	1.1697	0.0158	1.6987
4	.	0.2	0.16	0	0	2.0363	0.0782	2.3117
5	.	0.2	0.46	0	0	2.7937	0.1868	3.2653
6	.	0.2	0.69	0	0	3.4877	0.3029	4.1713
7	.	0.2	0.87	0	0	4.3640	0.4581	4.8990
8	.	0.2	0.91	0	0	5.5310	0.4602	5.9127
9	.	0.2	0.96	0	0	7.5303	0.4102	6.6030
10	.	0.2	1	0	0	10.4027	0.4102	8.2993

Table 2.25. Norwegian Coastal Cod. Predictions using fixed fishing pattern.

MFDP version 1a
Run: Pred1
Norwegian Coastal Cod
Time and date: 20:10 26.04.2010
Fbar age range: 4-7

2010

Biomass	SSB	FMult	FBar	Landings
161439	80222	1	0.3085	36815

2011					2012	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
159005	78871	0.4	0.1234	15621	177543	94316
.	78871	0.55	0.1697	20973	171856	89803
.	78871	0.7	0.216	26074	166451	85533
.	78871	0.85	0.2622	30935	161311	81492
.	78871	1	0.3085	35570	156422	77667
.	78871	1.15	0.3548	39991	151771	74047
.	78871	1.3	0.4011	44209	147344	70618

MFDP version 1a
Run: Pred2
Pred2MFDP Index file 26.04.2010
Time and date: 20:23 26.04.2010
Fbar age range: 4-7

2010

Biomass	SSB	FMult	FBar	Landings
161439	80222	1	0.3085	36815

2011

Biomass	SSB	FMult	FBar	Landings
159005	78871	0.85	0.2622	30935

2012					2013	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
161311	81492	0.4	0.1234	15839	178711	96035
.	81492	0.55	0.1697	21270	172980	91463
.	81492	0.7	0.216	26447	167531	87135
.	81492	0.85	0.2622	31383	162347	83036
.	81492	1	0.3085	36091	157415	79154
.	81492	1.15	0.3548	40582	152720	75477
.	81492	1.3	0.4011	44869	148250	71992

Input units are thousands and kg - output in tonnes

Table 2.26. Norwegian Coastal Cod. Predictions using variable fishing pattern.

MFDP version 1a
Run: Pred3
Pred1MFDP Index file 26.04.2010
Time and date: 20:34 26.04.2010
Fbar age range: 4-7

2010				
Biomass	SSB	FMult	FBar	Landings
161439	80222	1	0.3085	36815

2011					2012	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
159005	78871	0.4	0.1026	12958	180280	95719
.	78871	0.55	0.1411	17397	175533	91678
.	78871	0.7	0.1796	21627	171023	87854
.	78871	0.85	0.218	25658	166735	84233
.	78871	1	0.2565	29501	162658	80804
.	78871	1.15	0.295	33168	158780	77555
.	78871	1.3	0.3335	36668	155090	74476

MFDP version 1a
Run: Pred4
Pred3MFDP Index file 26.04.2010
Time and date: 20:37 26.04.2010
Fbar age range: 4-7

2010				
Biomass	SSB	FMult	FBar	Landings
161439	80222	1	0.3085	36815

2011				
Biomass	SSB	FMult	FBar	Landings
159005	78871	1	0.2565	29501

2012					2013	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
162658	80804	0.4	0.1026	13183	183053	97853
.	80804	0.55	0.1411	17711	178276	93804
.	80804	0.7	0.1796	22030	173731	89965
.	80804	0.85	0.218	26152	169405	86325
.	80804	1	0.2565	30088	165285	82872
.	80804	1.15	0.295	33846	161361	79596
.	80804	1.3	0.3335	37438	157622	76486

Input units are thousands and kg - output in tonnes

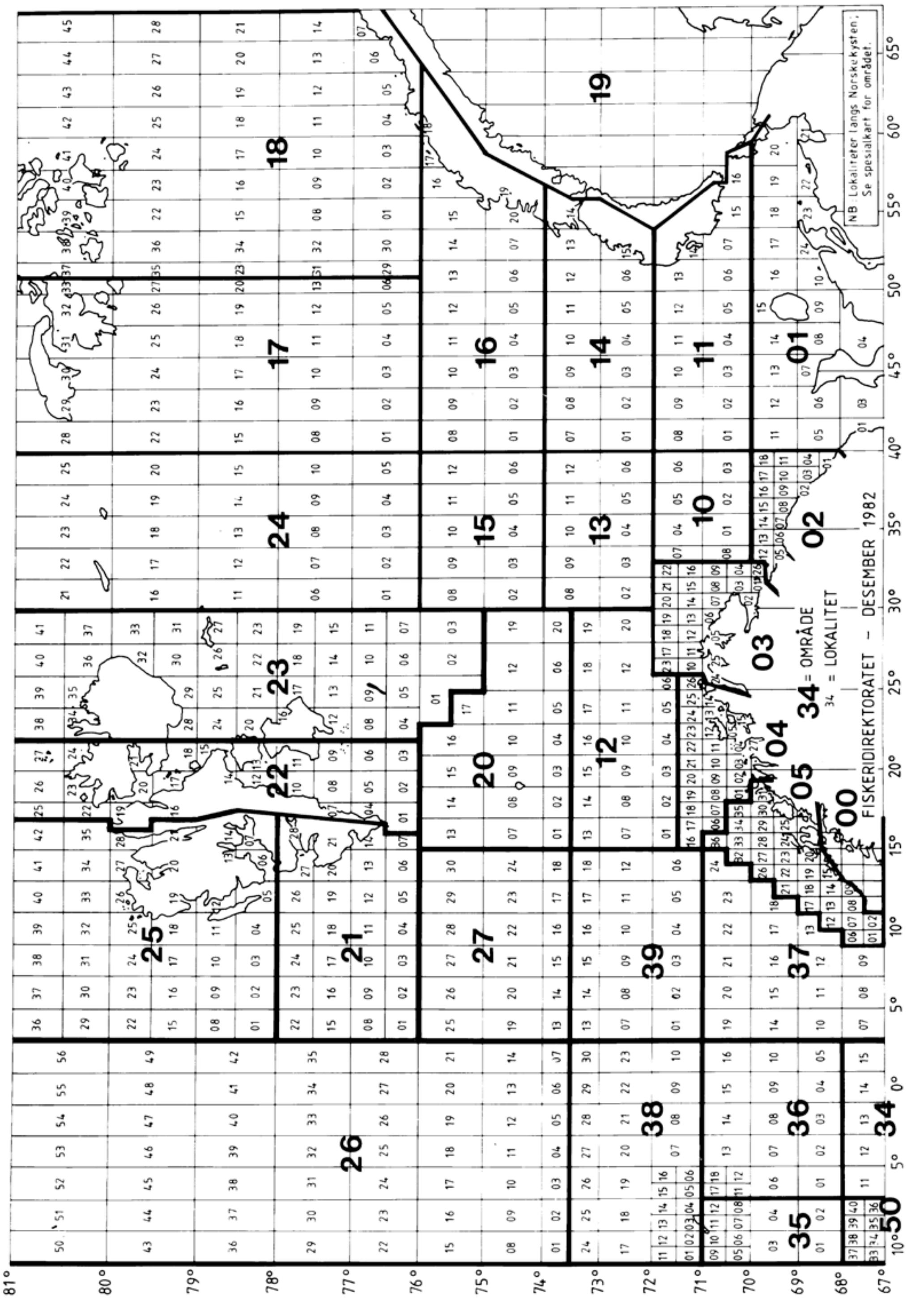


Figure 2.1. Norwegian statistical rectangles in the Barents Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 03 and 04. The same areas are also referred to in the survey results (sec. 2.3).

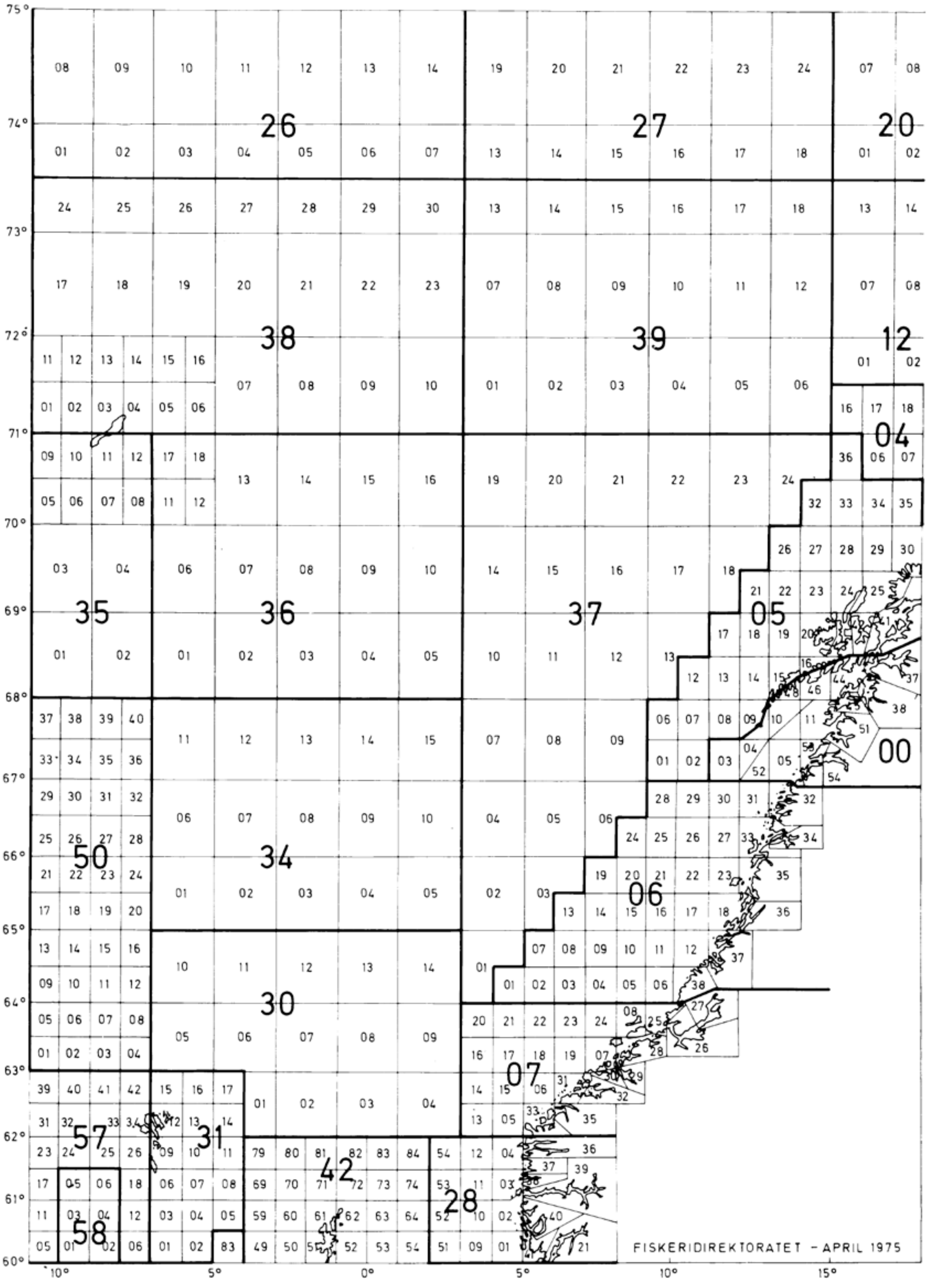


Figure 2.2. Norwegian statistical rectangles in the Norwegian Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 05, 00, 06 and 07. The same areas are also referred to in the survey results (sec. 2.3).

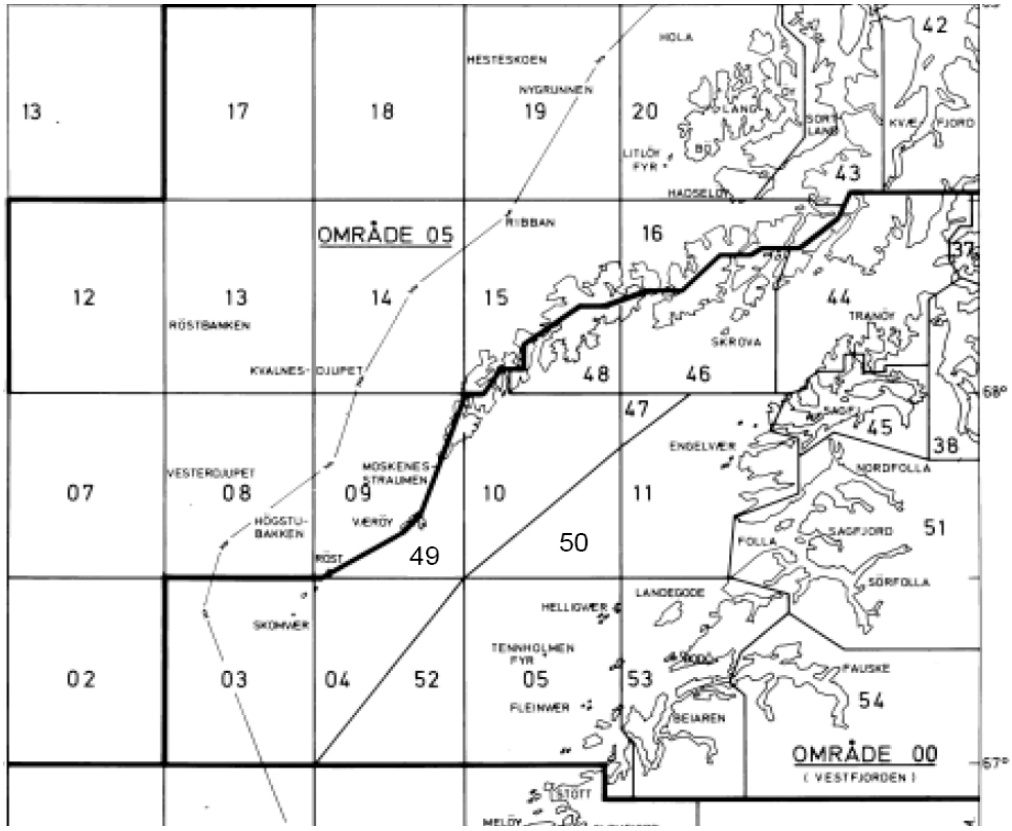


Figure 2.3. Map showing Vestfjorden, the Norwegian statistical area 00 ("OMRÅDE 00") with the south-western location 03 and 04 and the north-eastern locations 46 and 48.

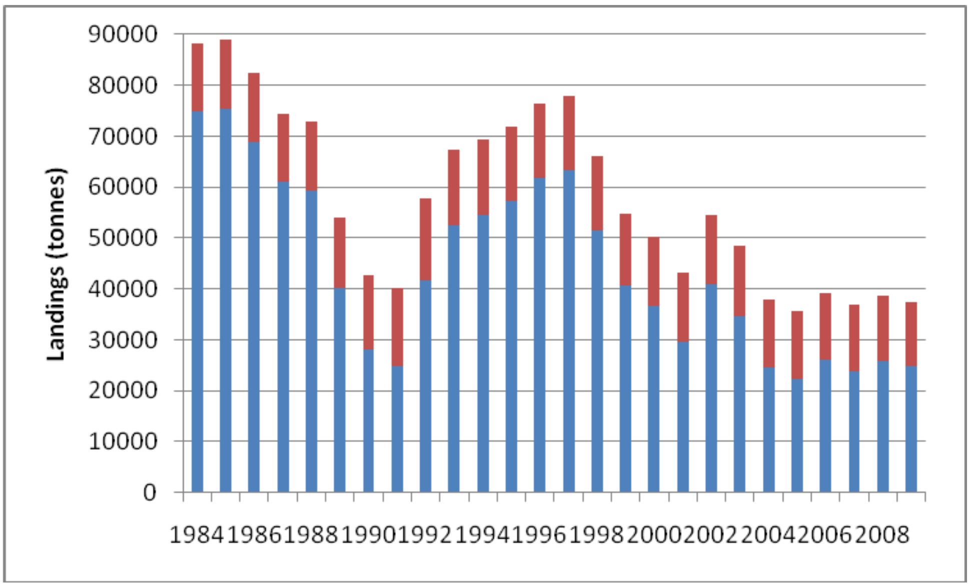


Figure 2.4. Estimated landings of Norwegian coastal cod. Commercial landings in blue and recreational catches in red.

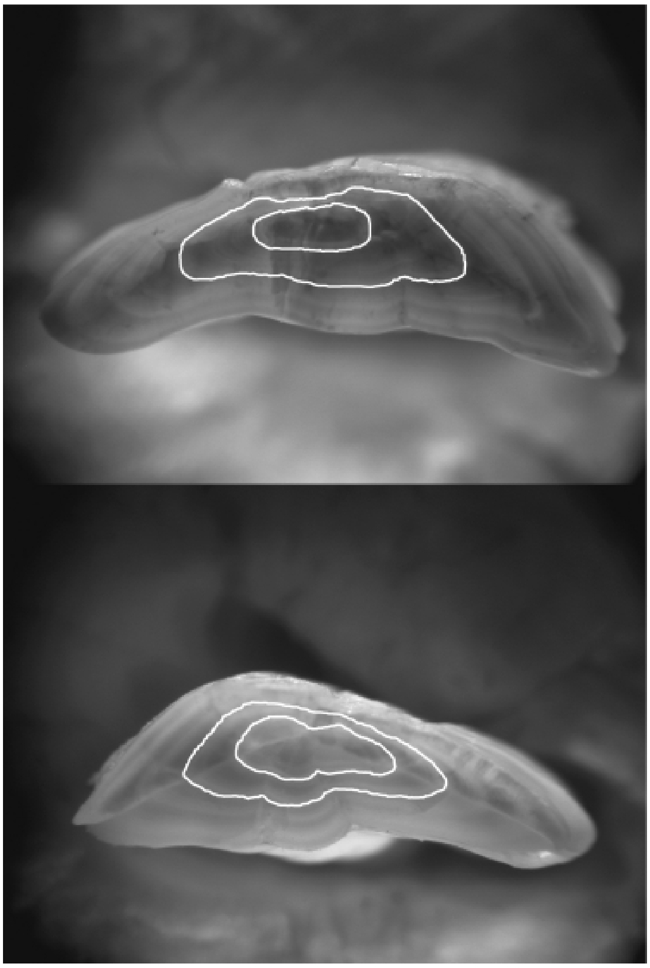
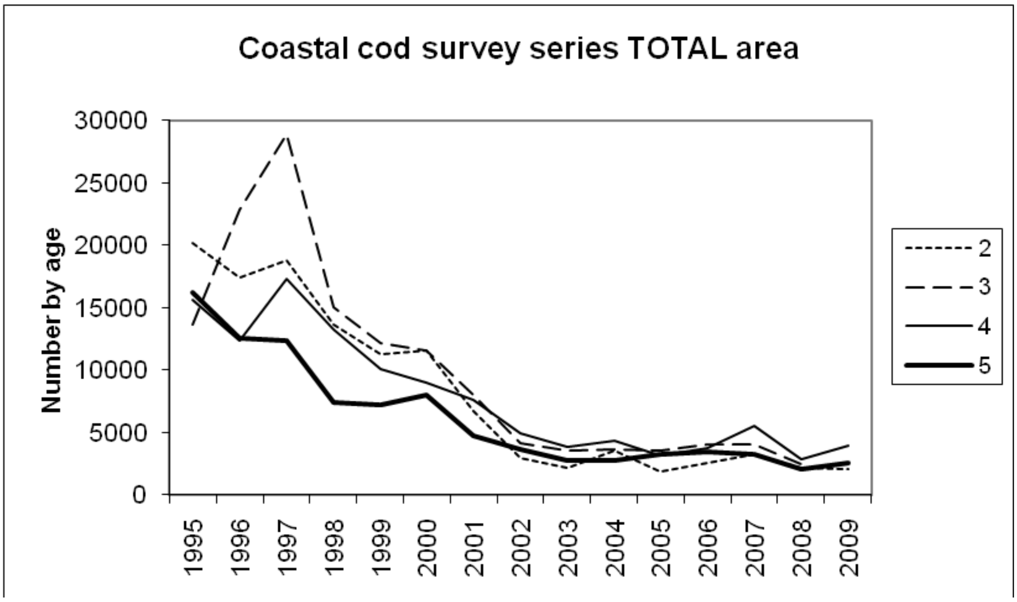


Figure 2.5. An image of a coastal cod otolith (top) and a north-east Arctic cod otolith (bottom). The two first translucent zones are highlighted. (from Berg *et al*. 2005)



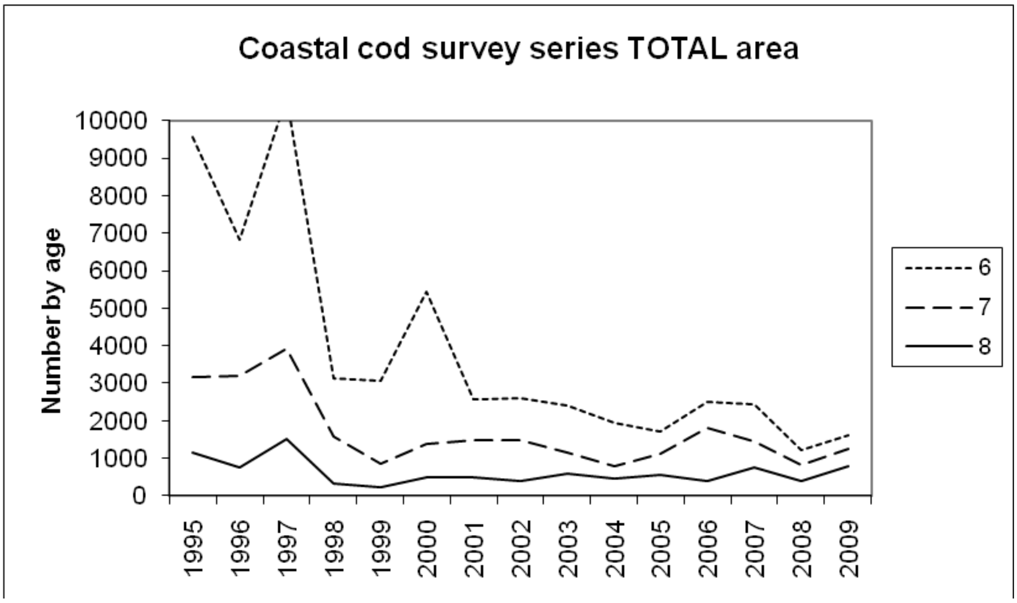
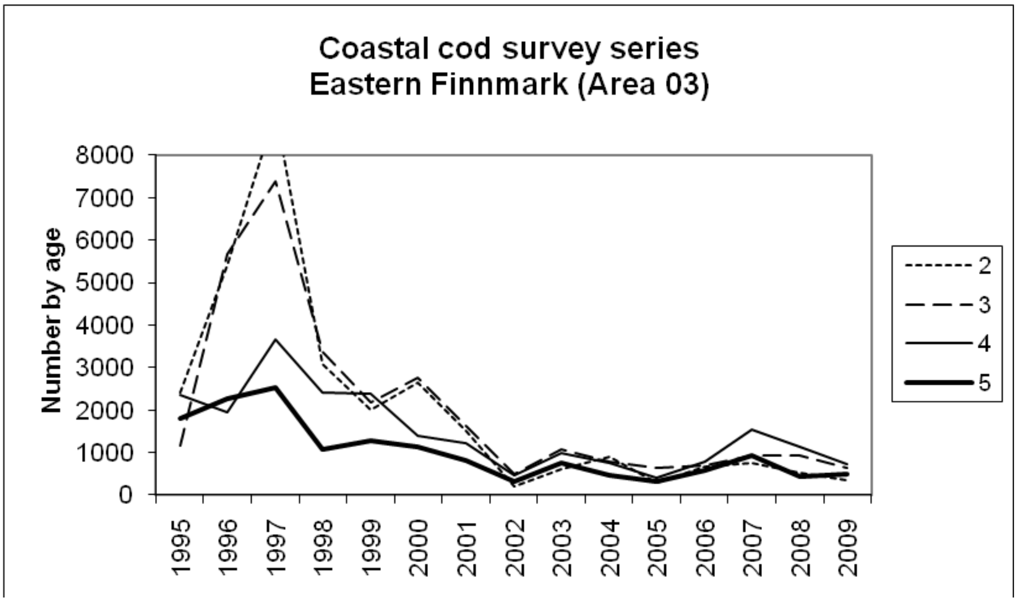


Figure 2.6 Coastal cod. Abundance at age in the total survey.

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



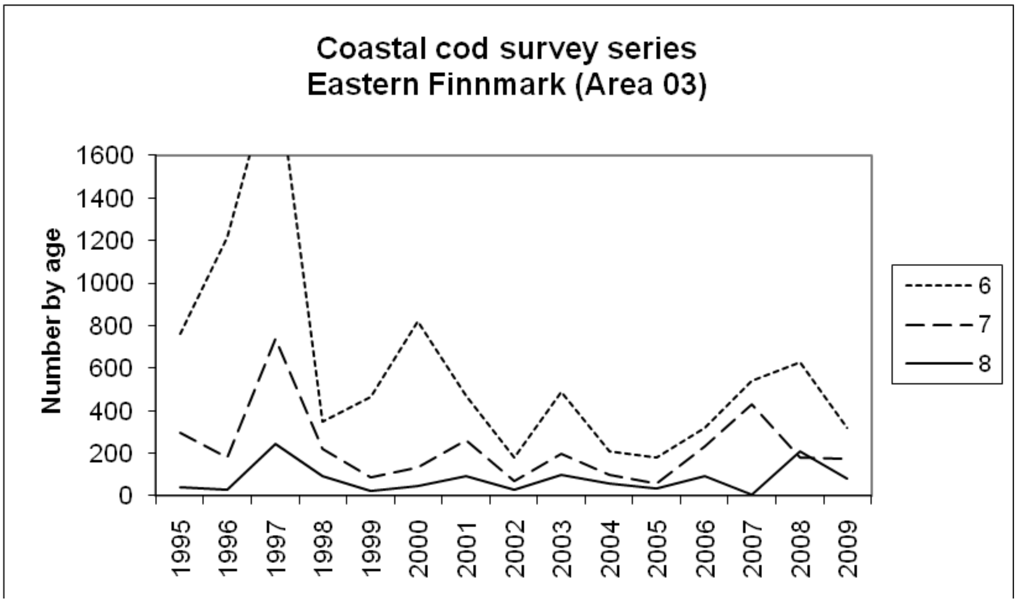
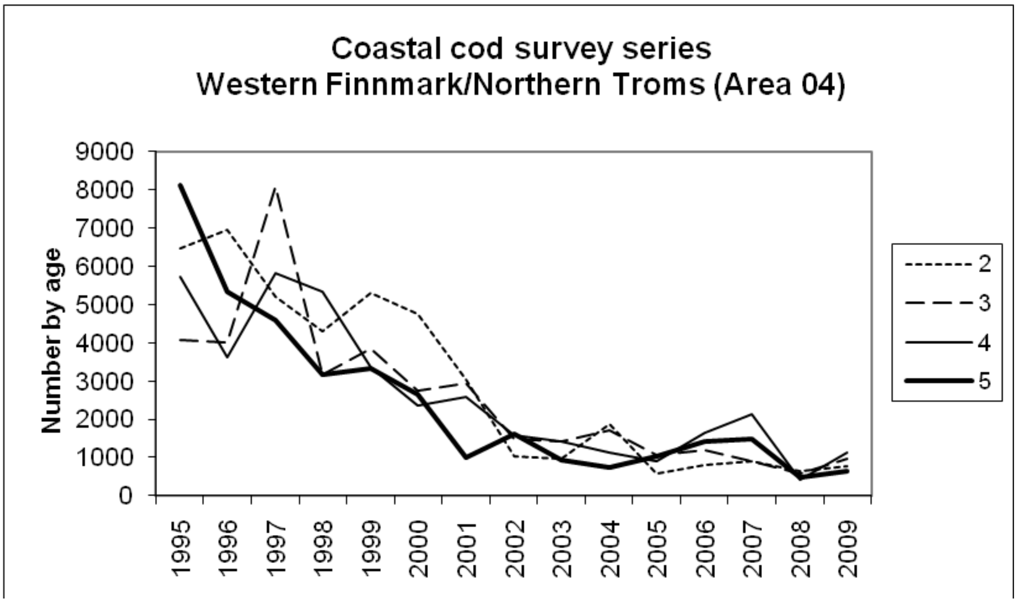


Figure 2.7 Coastal cod. Abundance at age in the survey, statistical area 03.

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



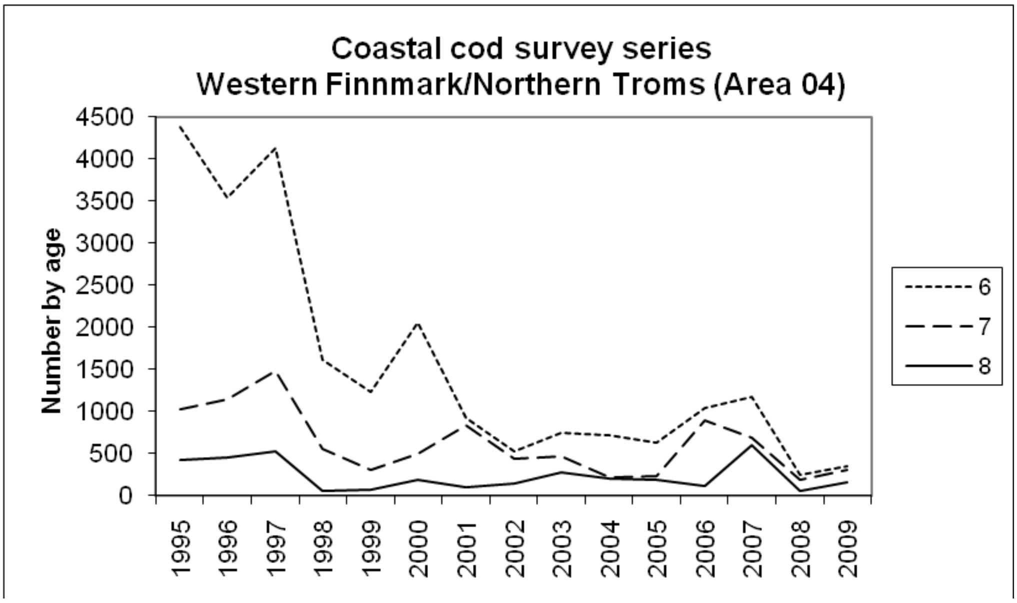
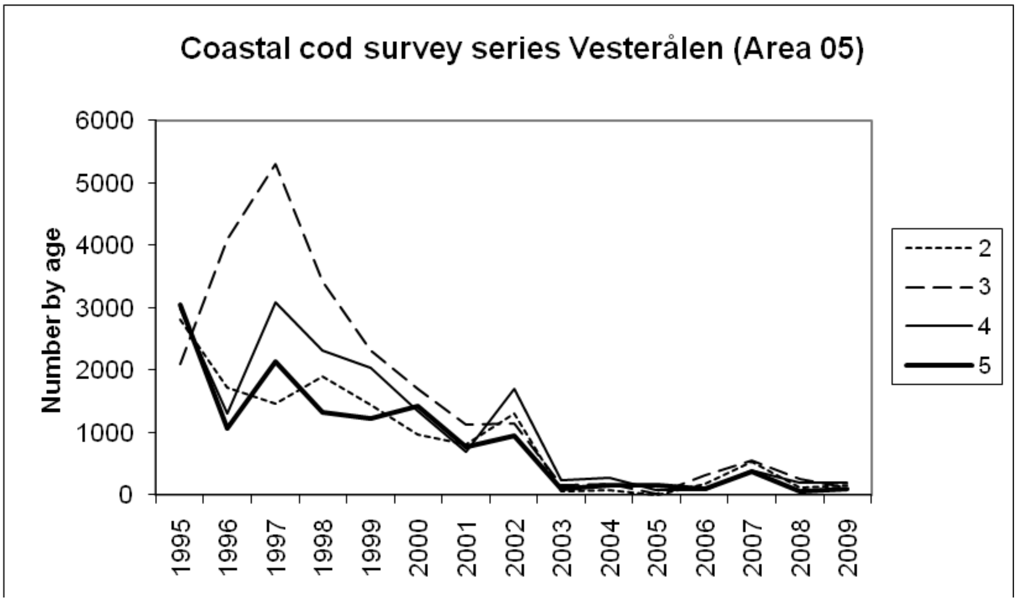


Figure 2.8 Coastal cod. Abundance at age in the survey, statistical area 04.

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



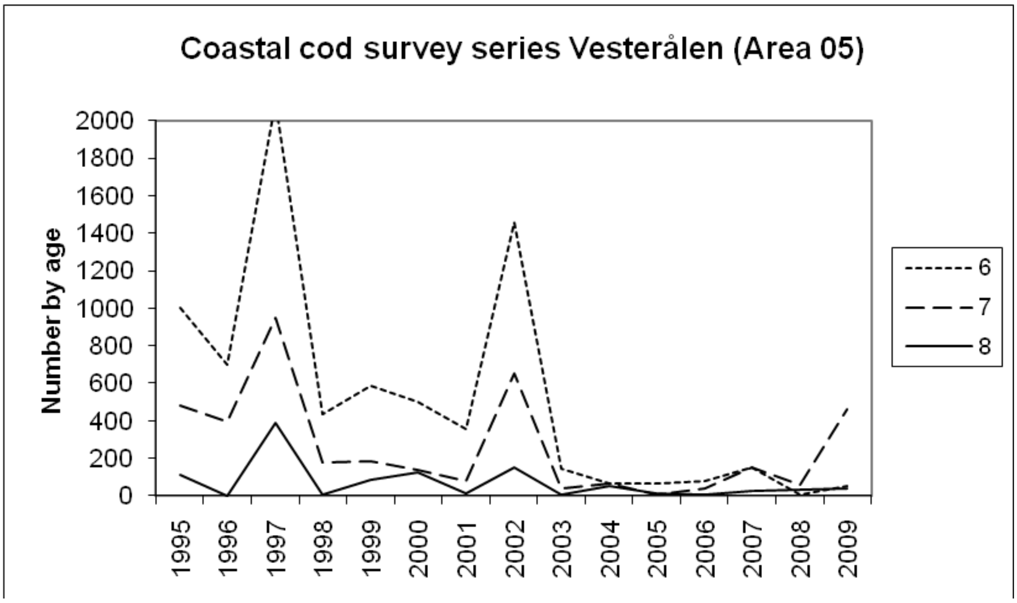


Figure 2.9 Coastal cod. Abundance at age in the survey, statistical area 05.

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

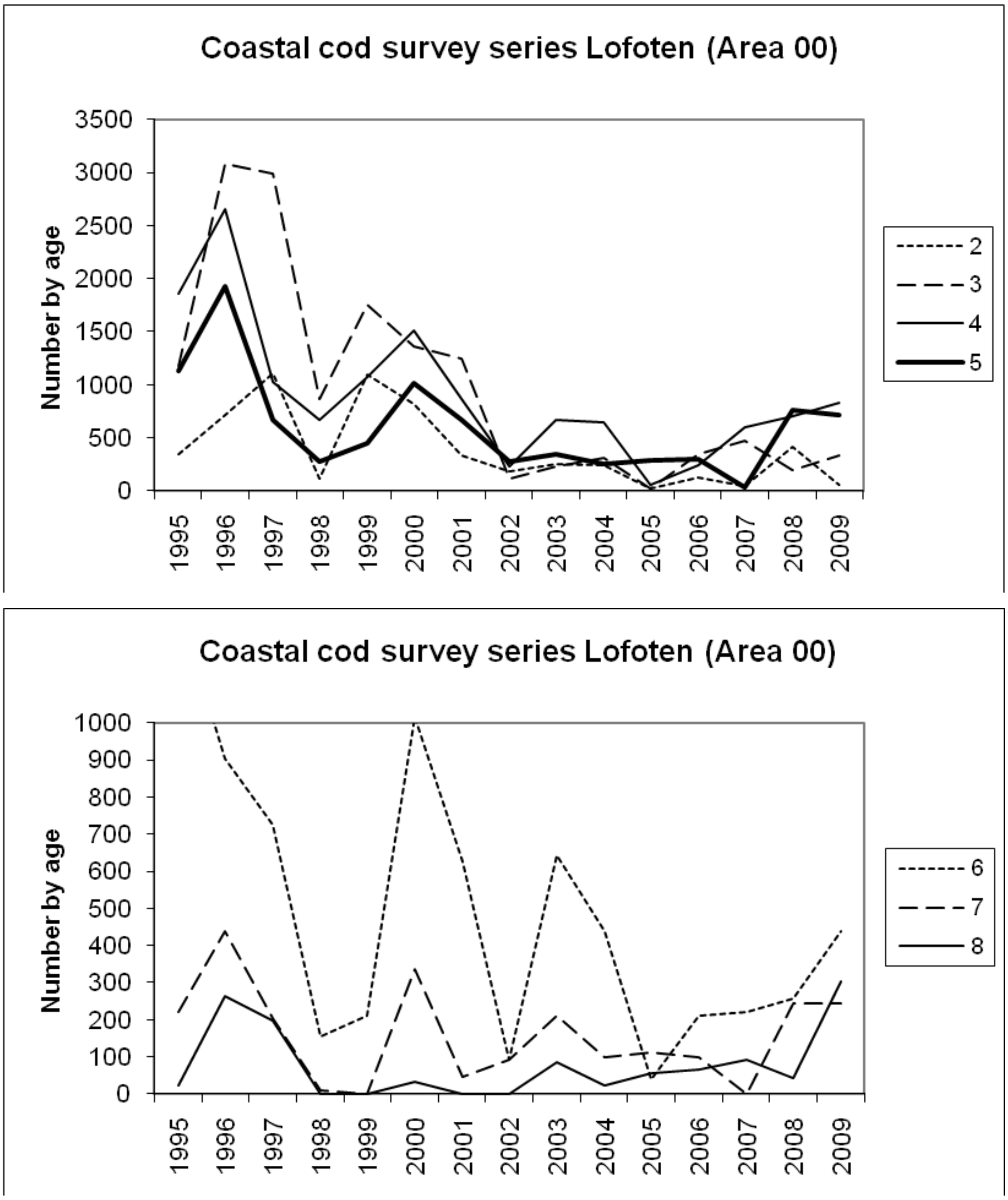


Figure 2.10 Coastal cod. Abundance at age in the survey, statistical rectangle 00.

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

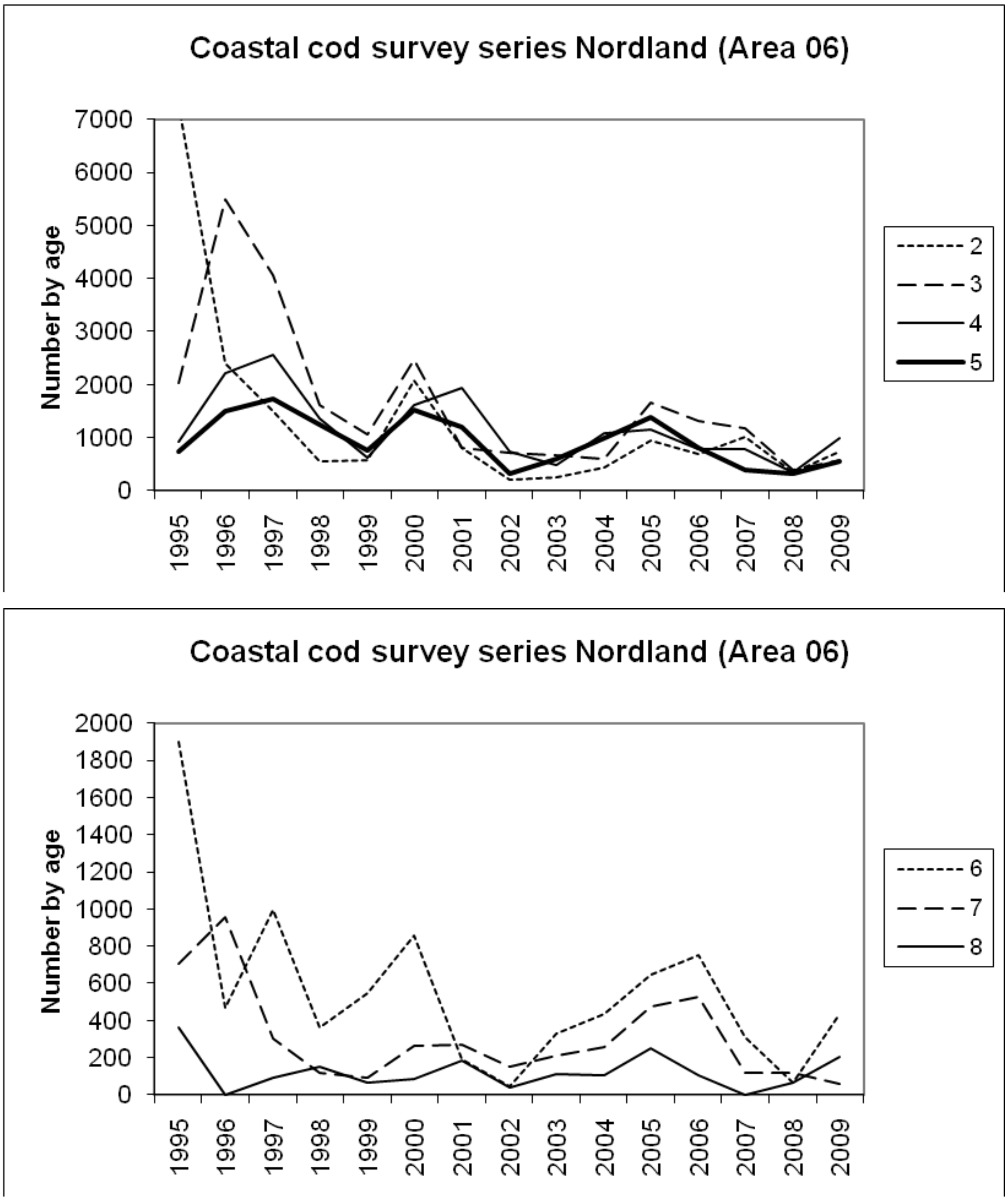
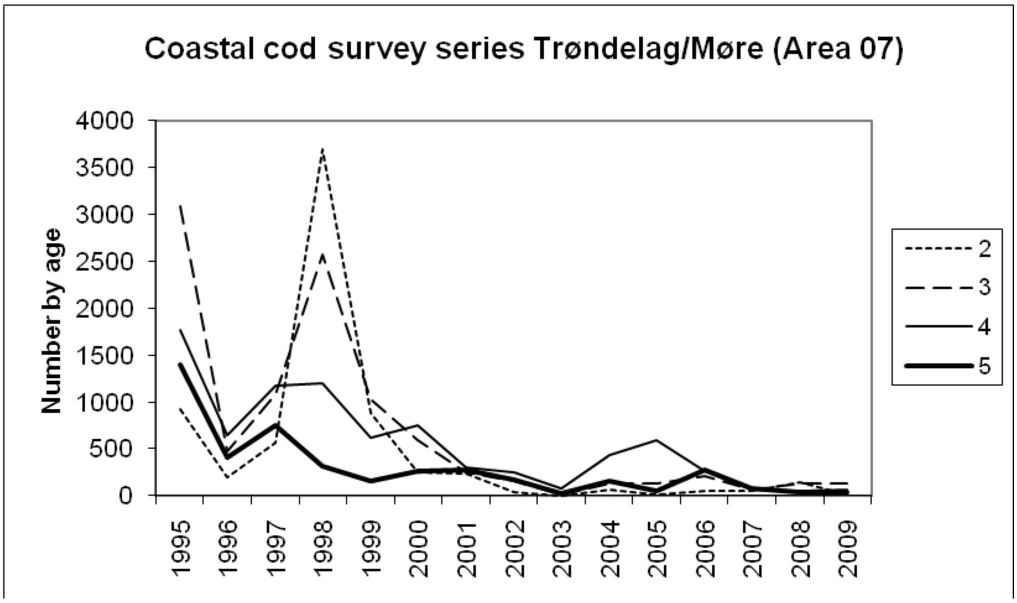


Figure 2.11 Coastal cod. Abundance at age in the survey, statistical area 06.

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



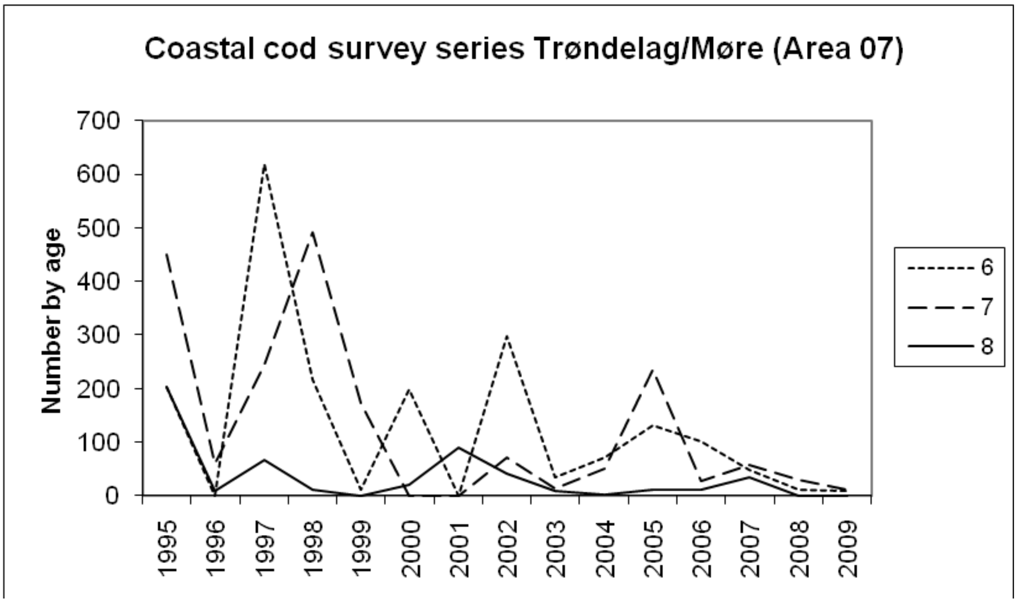


Figure 2.12 Coastal cod. Abundance at age in the survey, statistical area 07.

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

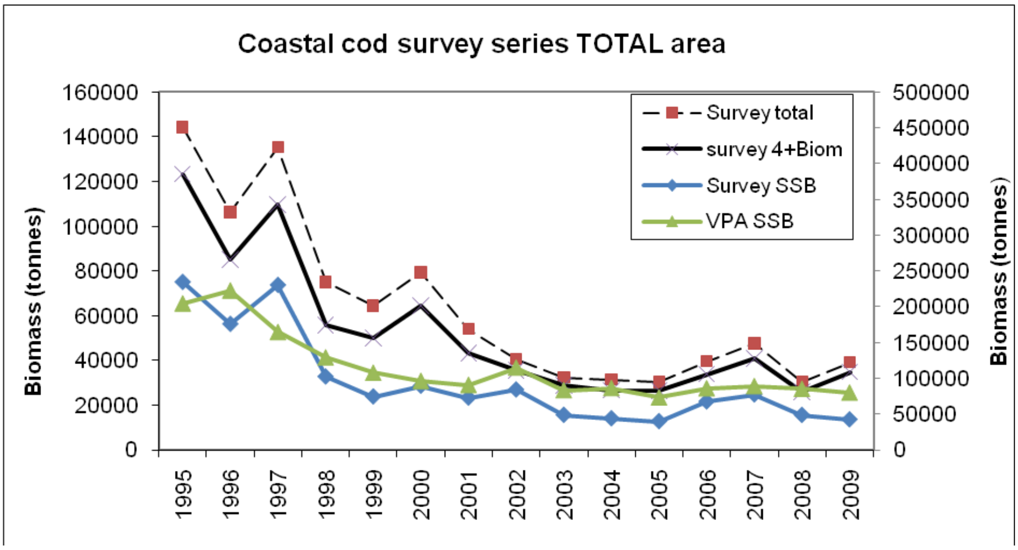


Figure 2.13 Coastal cod. Different biomass estimates from the Norwegian coastal survey: Total biomass, 4+ biomass, and spawning biomass (left axis). Also the SSB from the final VPA is included (right axis).

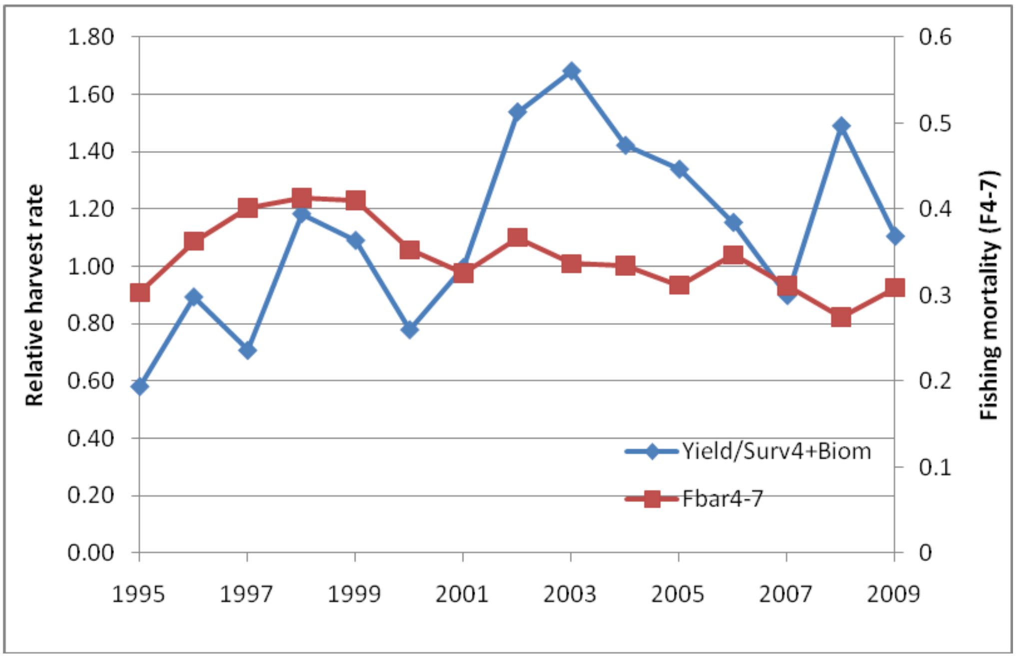


Figure 2.14. Relative harvest rate; Yield relative to the 4+ biomass estimated from the survey (left axis). Also added the F4-7 from the final VPA (right axis).

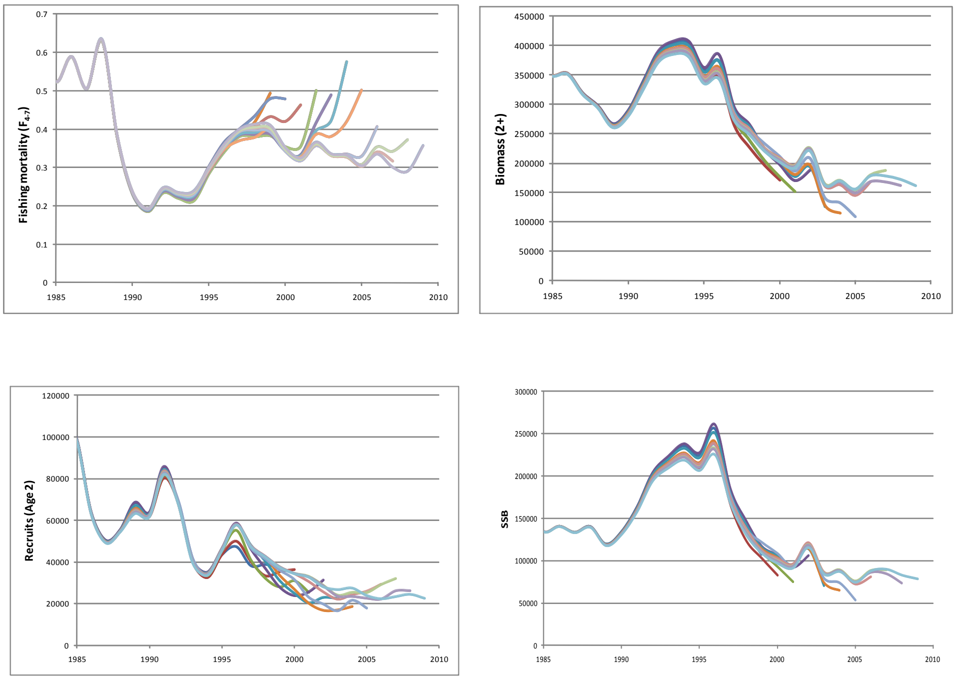


Figure 2.15 Norwegian coastal cod (NCC). Retrospective plots for assessment years 2000-2010 using standard settings except stock dependent catchability for ages 2 and 3, and keeping weight, maturity and natural mortality as estimated in 2010 for all runs.

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, landings declined steadily to around 300,000 t in 1983-1985 (Table 3.1a). Landings 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 landings prior to 2010 (Tables 3.1–3.3, Figure 3.1)

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

Final official landings for 2008 amount to 462,364 t. The provisional landings for 2009 reported to the working group are 538,660 t.

Reported landings 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 449,171 t in 2008 and 523,431 t in 2009 (Table 3.3). The coastal cod catches calculated this way in 2008 and 2009 were 13,193 t and 15,229 t, respectively. The catches of coastal cod calculated this way for the period 1960-2009 are given in Table 3.1b together with the coastal cod catches calculated based on otolith types as described in Section 2.

The landings 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 2009 was similar to 2008. 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 2002–2009

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. For 2009 there was a report from the Norwegian-Russian analytical group on estimation of total catches. According to that report the total catches of cod are very close (within 1%) to officially reported landings. The Working Group decided not to include IUU catches in 2009.

3.1.4 TACs and advised catches for 2009 and 2010

The Joint Norwegian-Russian Fisheries Commission (JNRFC) agreed on a cod TAC of 546,000 t for 2009, including 21,000 t Norwegian coastal cod. The total reported catch of 538,660 t in 2009 was 7,340 t below the agreed TAC.

The advice for 2010 given by ACFM in 2009 was based on the assessment made by AFWG in 2009. The agreed harvest control rule then implied a NEA cod TAC for 2010 of 577,500 tonnes. However, the JNRFC made an amendment to the agreed rule (see section 3.6.3), introducing a lower bound on F (0.30) when the spawning stock biomass is above B_{pa}. This amended rule gave a NEA cod TAC for 2010 of 607,000 tonnes, which was the quota set by JNRFC for 2010. In addition, the TAC for Norwegian Coastal Cod was set to the same value for 2010 as for 2009: 21,000 t.

The Working Group has no information on the size of expected unreported landings in 2010.

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 3.6, A2–A14)

Joint Barents Sea winter survey (bottom trawl and acoustics)

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 Tables A2 and A3. More details on this survey are given in Aglen et al. (WD 15). 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 2008-2010 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 3.6 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

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 2010 survey showed about 20% increase in numbers compared to the 2009 survey, while the biomass was similar. The percentage of repeat spawners was 50 %, compared to 49% in 2009.

Russian autumn survey

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 2009 survey was conducted in the standard period and under the standard methods. An area of 203 $*10^3$ sq. miles was covered, which is somewhat larger than the standard area. The 2009 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 5-7 and for ages 9-10. 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

Swept area bottom trawl estimates from the joint Norwegian-Russian ecosystem survey in August-September for the period 2004-2009 are given in Table A14. The new index values were calculated in 2010 (WD 20). This time series have been tested as new tuning fleet in XSA (section 3.11.3). 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 2010 and the Russian autumn survey in 2009 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 3.7 and 3.9)

For 2009, age compositions from all areas were available from Russia, Germany and Norway. Spain provided age compositions from Divisions IIa and IIb. 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. Table 3.7 shows available catch at age data for all ages 1-15+. The 2009 catch at age data was calculated using Intercatch, see section 0.9.

3.3.2 Weight at age (Tables 3.4 and 3.10–3.11).

Catch weights

For 2009, the mean weight at age in the catch (Table 3.10) 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 3.4.

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 1983-2010 (Table 3.12) 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 3.5 and 3.12)

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 3.5). For the years 1985-2010, 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

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 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 1984-2009. The consumption calculations this year have been updated by data for 2009. Also, the data for 2004-2008 have been revised, as it was discovered that data from the southeastern corner of the Barents Sea (east of 50° E and south of 74° N) were not included in previous calculations. 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 models

The XSA was also this year used as the main assessment method, as an update assessment was carried out. The TISVPA method was also run on the same data. 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	TISVPA name	Name	Place	Season	Age	Years
Fleet 09	Fleet1	Russian trawl CPUE	Total area	All year	9-11	1985-2009
Fleet 15	Fleet2	Joint bottom trawl survey	Barents Sea	Feb-Mar	3-8	1981-2010
Fleet 16	Fleet3	Joint acoustic survey	Barents Sea+Lofoten	Feb-Mar	3-9	1985-2010
Fleet 18	Fleet4	Russian bottom trawl surv.	Total area	Oct-Dec	3-9	1994-2009

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 2010 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

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 3.4.3). 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 6

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. Since the assessments in August 2000, few changes in model settings and data choices have been made.

3.4.2 Including cannibalism in XSA (Table 3.8)

The catch numbers shown in Table 3.9 together with cannibalism numbers (Tables 3.8) 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 (2009) differed less than 1% from the previous iteration. The final numbers of cod eaten by cod are given in Table 3.8.

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 3.2–3.3)

The tuning diagnostics from XSA with cannibalism are given in Table 3.15. Figure 3.2 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 2009 are close to zero and have no particular pattern. For age 9 and 10 in fleet 09 (Russian commercial CPUE) there seem to be big negative (in 2008) and positive (in 2009) residuals.

Figure 3.3 and Table 3.14 compares the estimated survivors (by end of 2009) 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. Nevertheless, final XSA run including all fleets tends to give higher estimates of survivors at ages 3, 5-7 compare to single fleet runs. This could be explained by higher influence of shrinkage in single fleet runs.

ACFM technical minutes have several times commented on the rather unconventional use of "stock size dependant catchability" (ssdq). For NEA cod, this is assumed for age groups 3-5. It is true that this choice involves more parameters to be estimated and a likely less precise parameter fit, in particular when the tuning is restricted to the latest 10 years. It is also observed that the influence of shrinkage is considerably higher for the age groups estimated by this q-assumption (Table 3.14). The 2005 WG argued for keeping this setting on the basis of compared retrospective patterns, and the ACFM reviewers agreed that without ssdq some problems might occur again as soon as some high survey values occur. In spite of rather high survey values for ages 3 and 4 in the previous two years, a test run without stock size dependant catchability gave slightly lower F and higher SSB for 2009.

Several earlier assessments have shown to be sensitive both to the length of the tuning period, and the choice of stock size dependant catchability. The following comparative runs were made to explore the sensitivity to these choices:

Model setting different from the standard run	F(5-10)-09	SSB-09
No stock size dependant catchability	0.253	1153
Stock size dependant catchability for ages 3-7	0.301	987
15 year tuning period	0.260	1123
Minimum SE for fleet weighting reduced from 0.3 to 0.1	0.276	1089
Standard run	0.276	1077

From this it seems that the assessment is rather robust to the above changes of model setting, but the diagnostics discussed above indicate some sensitivity to the choice of tuning data.

Retrospective plots of F, SSB and recruitment, going back to 2000 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)

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 1984-2009 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).

3.4.5 TISVPA (Fig 3.5–3.8)

The TISVPA (Triple Instantaneous Separable VPA) model (Vasilyev, 2006) represents fishing mortality coefficients (more precisely – exploitation rates) as a product of three parameters: f(year)*s(age)*g(cohort). The generation-dependent parameters, which are estimated within the model, are intended to adapt traditional separable representation of fishing mortality to situations when several year classes may have peculiarities in their interaction with fishing fleets caused by different spatial distribution, higher attractiveness of more abundant schools to fishermen, or for some other reasons. The model was first presented and tested at the ICES Working Group on Methods of Fish Stock Assessments (WGMG 2006) and was used for stock assessment for several ICES stocks, including North-East Atlantic mackerel, blue whiting, Norwegian spring spawning herring (WGMHSA 2006, 2007; WGNPBW 2006, 2007) and for NEA cod (AFWG 2008 and 2009). The model is an extension of the ISVPA model (Kizner and Vasilyev, 1997; Vasilyev, 2005).

This year the TISVPA model was applied to NEA cod data too. Natural mortality from cannibalism, variable by age and year values were taken from the XSA runs as. As well as in XSA runs, in trial runs 4 sets of age-structured tuning data were included into analysis: Russian trawl cpue ("fleet 1"); joint bottom trawl surveys ("fleet 2"); joint acoustic surveys (Barents Sea and Lofoten) – "fleet 3", and Russian bottom trawl surveys ("fleet 4").

Settings of the TISVPA model were similar to the previous year assessment, but with some corrections made in order to make more clear the signals from different sources of information: so called "mixed" version, reserving the possibility of errors both in catch-at-age and in separable representation. Additional restriction on the solution was unbiased model description of logarithmic catch-at-age data.

TISVPA model version allows us to include or not the cohort factor into calculations. The generation-dependent factors in triple-separable representation of fishing mortality coefficients were estimated for age groups 4 to 11 to exclude most noisy age groups. The trial run showed that this factor differs significantly from 1, which is the reason for including it in the final run.

The experiments with various versions of loss function component for catch-at age matrix showed that AMD (absolute median deviations) had to be chosen as in the this case minimum was more pronounced.

Preliminary experiments revealed year-specific patterns in residuals for fleets 1 and 4, perhaps, due to different surveys conditions. That is why for these fleets not abundances-at-age, but age proportions were tuned.

For all "fleets", except fleet 4, for which AMD gave a more clear minimum, the simplest measure of closeness of fit of the model to the data - sum of squares of residuals in logarithmic abundance-at-age gave the apparent minima of respective components of the model loss function (Figure 3.5).

Residuals in logarithmic catch-at-age and in abundance-at-age (for fleets) are shown on Fig.3.6.

The retrospective analysis was carried out with the same options as the final TISVPA run. Results of retrospective runs (Figure 3.7) show a reasonable historical stability of the estimates and the absence of systematic shifting tendency.

It is necessary to underline that extremely high estimates of abundance at age 3 in 2007 and 2008 in the results are due to high catch of these age groups as the abundance estimates are directly come from the catch value and average selection. These estimates are always the least reliable ones. Figure 3.6 for C(a,y) demonstrates that residuals in catch-at-age data for age 3 are higher than for other ages. Figure 3.8 compares the estimates of abundance at age 3 for previous years obtained with help of TISVPA to historical catches at age 3 (upper figure) and to index abundance – Fleet 2 (lower figure). As it can be seen, the TISVPA recruitment values at age 3 in 2007-2008 were only a little higher (and in 2009 they are lower), than in 1986.

There are a number of properties of the TISVPA model which make the model a valuable tool for data exploration in NEA cod stock assessment. These properties include the possibility to strictly formulate a statistical meaning of the solution; not to consider as absolutely true the catch-at-age data, survey data, fleet cpue, or the assumption about stability of selection pattern; to take into account the generation-dependent peculiarities in selection pattern; to trace the information about the stock size independently from each source of data (including catch-at-age); attention to robustness of the results (by means of possibility to apply robust measures of the goodness of fit and to ensure the unbiasedness of the solution), as well as the experience in its application to other ICES stocks.

The total stock biomass in 2009 from the TISVPA runs totaled 3,2 million tons, while the spawning stock biomass was 1,145 million tons and F5-10 in 2009 was 0.26.

3.4.6 Comparison of TISVPA and XSA results (Fig 3.9)

A comparison of the results from the TISVPA and XSA are given in Figure 3.9. The trends are similar as seen from the plots. The difference is remarkable after 2006, in terminal (2009) year TISVPA estimates of total stock biomass are higher by about 20%, spawning stock biomass - by 6% as compare with XSA.

The TISVPA run gives an F(5-10) for 2009 of 0.26, while the XSA gives 0.28.

3.5 Results of the assessment

3.5.1 Fishing mortalities and VPA (Tables 3.20–3.25, Figure 3.1)

The estimated $F_{5\text{-}10}$ in 2009 from the SVPA is 0.28, which is below F_{pa} and is the lowest since 1990. Fishing mortality has gradually declined since 2005. The spawning stock biomass in 2010 is estimated to be 1,145,000 t, which is the highest since 1947. Total stock biomass in 2010 is estimated to 2,645,000 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 1.4.5). 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: 384 million for the 2007 year class, 465 million for the 2008 year class and 484 million for the 2009 year class.

3.6 Reference points and harvest control rules

New reference points for Northeast Arctic cod were proposed by SGBRP in January 2003 (ICES CM 2003/ACFM:11) and adopted by ACFM at the May 2003 meeting.

At the 38 session of JRNFC the NEA cod HCR has been revised and a new version of the management rule was adopted (see section 3.6.3). The new HCR has been evaluated during the current meeting and considered to be in accordance with precautionary approach.

In according to the request from the Norwegian Ministry of Fishery and Coastal Affairs, TAC advice for 2011 is based on the new 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).

Calculations of yield per recruit gave the following values: $F_{0.1}$=0.15 and F_{max}=0.28.

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 have been requested to evaluate whether this amended rule is in accordance with the precautionary approach (see section 0.3). The results of this evaluation are given in 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 shall start with cod and gradually incorporate other species. A first step towards this is 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 long-term yield is fairly stable for a range of fishing mortalities between 0.25 and 0.6. Density dependent effects in cannibalism and growth are considered as the main reasons for this rather wide F-range with stable high yield. It should be noted that there are few observations of biological parameters for low fishing mortalities and high stock sizes, so that the results for low Fs are more uncertain than those for higher Fs.

3.7 Prediction (Table 3.27–3.29)

3.7.1 Prediction input (Tables 3.27, Figure 3.10a–b, 3.11)

The input data to the short-term prediction with management option table (2010-2013) are given in Table 3.27. For 2010 stock weights and maturity were taken from surveys as described in Sections 3.3.2 and 3.3.4.

Catch weights in 2010 onwards and stock weights in 2011 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 (2000-2009) for averaging the increments. Figures 3.10a and 3.10b show how these predictions perform back in history.

The maturity ogive for the years 2011 and 2012 was predicted by using the 2008-2010 average. The exploitation pattern in 2010 and later years was set equal to the 2007-2009 average.

The stock number at age in 2010 was taken from the final VPA (Table 3.22) for ages 4 and older. The recruitment at age 3 in the years 2010-2012 was estimated as described in section 1.4.5. Figure 3.11 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 1984-2009. The recent 3 years average M was used as input for the years 2010-2012 in the prediction.

For 2013, the 2012 values were used for all input data, except for recruitment, where the long-term arithmetic mean (600 million at age 3) was used.

The assessment shows a decrease in F from 2006 to 2009. Effort has also decreased (Figure 3.15), and thus similar to last year's assessment F in 2009 is considered to be a better estimate for F in the intermediate year (2010) than the estimate using three year average F. Table 3.27 shows input data to the predictions.

3.7.2 Prediction results (Tables 3.28, 3.29b)

The catches corresponding to F_{sq} in 2010 is 593 000 tonnes (Table 3.28). This is close to the TAC for 2010 (607 000 tonnes). The resulting SSB in 2011 is 1,488,000 tonnes. Table 3.28 also shows the short-term consequences over a range of F-values in 2011. The detailed outputs corresponding to F_{sq} in 2010, the F corresponding to the HCR in 2011 and F_{pa} in 2012-2013 is given in Table 3.29b. Summarised results are shown in text table below.

Rationale	Landings [1] (2011)	Basis	F (2011)	SSB (2012)	%SSB change [2]	% TAC change [3]
Zero catch	0	$0*F_{sq}$	0	2192	+47	-100
Agreed management Plan[4]	703	$1.09*F_{sq}$	0.30	1689	+14	+16
Status quo	654	$1.00*F_{sq}$	0.28	1731	+16	+8
Precautionary Limits	896	F_{pa}	0.40	1527	+3	+48

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 2012 relative to SSB 2011.

[3] TAC 2011 relative to TAC 2010.

[4] Forecast based on F=0.30.

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 over-fishing.

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 2009 numbers at age (millions), total biomass, spawning biomass (thousand tonnes), as well as reference F for the year 2008.

		N(2009)										
Assessment year (specification)	F(2008)	age3	age4	age5	age6	age7	age8	age9	age10	TSB (2009)	SSB (2009)	F (2009)
2009 WG	0.30	564	524	433	195	116	40	36	10	2553	1079	0.30**
2010 WG	0.33	589*	561	455	227	111	39	31	8	2619	1070	0.28
Ratio 2010 WG/ 2009 WG	1.10	1.04	1.07	1.05	1.17	0.95	0.96	0.87	0.89	1.03	0.99	0.93

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

The final assessment values for ages 3, 4, 5, 7 and 8 are fairly close (within 10%) of the 2009 assessment, while age 6 have this year been revised upward by 17% and ages 9 and 10 downwards by 11 and 13%, respectively. The F in 2008 is 0.03 (10%) higher last year's estimate, but the total stock biomass and SSB in 2009 are very close to the previous estimates.

3.9 Additional assessment methods

3.9.1 Survey calibration method (Figures 3.12–13)

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 3.12-3.13 The method compares well to the VPA results for stock abundance in 2010: Ages 4-6: Calibration method 1026 millions, vs. 1137 millions from VPA. Age 7+: Calibration method 284 millions, vs. 266 millions from VPA. The figures show a shift both for ages 4-6 and 7+ occurring around 2006 for the relation between the survey calibration and the VPA.

3.9.2 Gadget (Figure 3.14)

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 3.14). The modeled historical stock is very similar to that from the previous year, with very slight upwards revisions in some years, mostly in the modeled 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.

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. 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", "Gadget", and "TISVPA". 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, therefore, recognizes the need for improvements to the input data, and in particular more reliable catch data (see chapter 0.5).

However, the WG also recognizes the need for a more thorough comparison of assessment methodologies. In particular, the models XSA and TISVPA would be interesting to explore and compare. These two models are related to the same class of cohort analysis models.

XSA model is used in many years by AFWG, that has a big experience to work with this model, but TISVPA has some advantages. In particular, TISVPA allows strictly to formulate a statistical meaning of solution, is more robust and reliable.

Benchmarking of various assessment models is not a trivial task, since criteria for performance are not easy to establish across models. Therefore, some guidance for how to perform such comparisons would be valued. It is also clear that a benchmark workshop should not be planned too early, since most of the work in connection with the benchmarking will have to be done prior to the workshop.

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 (Tables 3.14, 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 2004-2009 become available for AFWG this year (Table A14, WD 20). This time series have been tested as new tuning fleet in XSA (Fleet 007). The single fleet estimates of survivors of all ages, based on this index were slightly lower compare to other single fleet runs (Table 3.14). The results of XSA run including all fleets (as in Final XSA + Fleet 007) were very close to final XSA ones. Analysis of XSA diagnostic from this run (WD 20) demonstrate that fleet 007 has reasonably good quality comparable to best time series (fleet 15 and 18). This index could be considered for use as a tuning series on next benchmark.

3.11.4 New CPUE series

The new biomass indices described in WD11 (2008) and 21 (2008), based on vessels' daily reports, may in the future be included in the tuning of assessment models.

3.12 Evaluation of amended HCR

3.12.1 Introduction

The harvest control rule for NEA cod was amended at the 38th session of The Joint Norwegian-Russian Fishery Commission (see section 3.6.3.) and ICES were requested to evaluate the new rule.

The previous version of the HCR was evaluated by ICES in 2005. The long-term stochastic simulations were done by means of software (PROST) developed for the purpose of evaluating HCRs of this type (Åsnes, WD 2 to AFWG 2005). The same population model as that described in detail in the AFWG 2005 report was used this year for HCR evaluation (ICES 2005).

3.12.2 Mathematical formulation of the amended HCR

Let y denote the year for which the quota is to be set. Let the term 3-year rule (F1, x) denote applying the 3-year average rule described above with $F_{5\text{-}10}$=F1 and an x % limit on year-to-year changes in TAC. The limit on increase of TAC from year to year could be set different from the limit on decrease from year to year, but such asymmetric rules were not tested. It is assumed that SSB(y) is not affected by F(y), which is in line with the current settings used by AFWG (the proportion of F and M before spawning is set to 0).The rule can then be described in the following way:

If SSB(y) > B_{pa} then

if SSB(y-1) > B_{pa} and SSB(y+1) > B_{pa} and SSB(y+2) > B_{pa} :

F(y) set by 3-year rule(0.40, 10)

if F(y) < 0.30, F(y) = 0.30

else

F(y) set by 3-year rule(0.40, unconstrained)

else

F(y) set by 3-year rule (0.40*SSB(y)/B_{pa}, unconstrained)

3.12.3 Evaluation undertaken in 2010

In this evaluation, we choose to repeat the evaluation undertaken in 2005, as far as the biological model, settings, and input data are concerned. Values for distortion on input stock numbers etc. can be found in ICES (2005). The simulation tool (PROST) was however, changed to account for the change in the HCR. Like in 2005, we chose to do two runs with long-term simulation. The settings and the results are described in the text tables below.

Run No.	Target F	M ages 3 and 4 (high: 0.7&0.4, Low: 0.2&0.2)
1	0.40	Low
2	0.40	High

Run No.	Realized F	Catch	TSB	SSB	Recruits	% years SSB<B_{lim}	% years SSB<B_{pa}	Average year-to-year % change in TAC	% years where F 0.3 part of rule is active
1	0.64	896	3036	566	687	0.00	14.95	15	3
2	0.60	477	1813	430	684	0.18	52.57	19	0

If the result table is compared to table 3.36 in ICES (2005), it is seen that the differences in catch, TSB, SSB and recruits are small (mostly within 5%) and the overall results are the same; namely that the number of years in the simulation period where the SSB drops below B_{lim}, is negligible in either case.

The software keeps track of which part of the rule is active in each run. The new part of the rule (if F(y) < 0.30, F(y) = 0.30) is active in about 3 % of the years in run no. 1, while it is not active at all in run no. 2. The average year-to-year change in TAC is approximately the same for both runs.

It is concluded that the change made to the rule by the MRNC in 2009 does not affect the outcome of long-term stochastic simulation runs to any noticeable degree. Consequently, **the amended HCR for NEA cod could be characterised as being in accordance with the precautionary approach to fisheries management**.

3.13 Answering 2009 comments from Reviewers:

The minutes of the review of the 2009 AFWG report contained a number of comments to the NEA cod assessment. Below is a summary how AFWG has responded to this:

No discussion regarding comparisons of TISVPA and XSA models took place at the current meeting because the Group was dispersed around Europe (see Introduction section). Many reviewers' comments are related to this problem.

Comment regarding not inclusion information about discarding was taken into account and appropriate sentences were included in the report.

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	127000/28000	596197/497197
2007 [2]	152,522	195,383	97,891	41087/8757	486883/454553
2008	144,905	203,244	101,022	15000/0	464171/449171
2009 [1]	161,602	207,205	154,623		523,431

[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

Year	Landings in '000 t 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
Average 1984-2009	44	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[1]	130.1	31.5	102.0	105.2	142.1	11.4

[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	5,951	4,619	199,809	9,496	9,298	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[1]	16,905	3,908	4,977	8,585	224,298	12,013	8,632	229,291	7,380	7,442	523,431

[1] Provisional figures.

[2] USSR prior to 1991.

[3] Includes Baltic countries.

Table 3.4 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

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			

Germany (Division IIa and IIb)

Year	Age 2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1994		0.68	1.04	2.24	3.49	4.51	5.79	6.93	8.16	8.46	8.74	9.48	15.25	
1995		0.44	0.84	1.50	2.72	3.81	4.46	4.81	7.37	7.69	8.25	9.47		
1996		0.84	1.15	1.64	2.53	3.58	4.13	3.90	4.68	6.98	6.43	11.32		
1997		0.43	0.92	1.42	2.01	3.15	4.04	5.16	4.82	3.96	7.04	8.80		
1998	0.23	0.73	1.17	1.89	2.72	3.25	4.13	5.63	6.50	8.57	8.42	11.45	8.79	
1999 [1]		0.85	1.45	2.00	2.65	3.47	4.16	5.45	6.82	5.90		8.01		
2000 [2]	0.26	0.73	1.36	2.04	2.87	3.67	4.88	5.78	7.05	8.45	8.67	9.33	6.88	
2001	0.38	0.80	1.21	1.90	2.74	3.90	4.99	5.69	7.15	7.32	11.72	9.11	6.60	
2002	0.35	1.00	1.31	1.80	2.53	3.64	4.38	5.07	6.82	9.21	7.59	13.18	19.17	19.20
2003	0.22	0.44	1.04	1.71	2.31	3.27	4.93	6.17	7.77	9.61	9.99	12.29	13.59	
2004 [2]	0.22	0.73	1.01	1.75	2.58	3.33	4.73	6.32	7.20	8.45	9.20	11.99	10.14	13.11
2005 [3]	0.57	0.77	1.13	1.66	2.33	3.36	4.38	5.92	6.65	7.26	10.01	11.14		
2006 [2]	0.71	0.91	1.39	1.88	2.56	3.77	5.33	6.68	9.14	10.89	11.51	16.83	18.77	
2007 [3]	0.59	1.35	1.79	2.51	3.53	4.00	4.95	6.55	7.54	9.71	11.40	11.57	23.34	15.61
2008 [3]	0.23	0.51	1.14	1.76	2.57	3.15	4.40	5.43	7.18	8.39	10.15	10.03	10.99	14.26
2009 [3]	0.35	0.6	1.19	1.83	2.96	4.08	5.61	6.97	8.55	9.13	10.54	13.34	10.30	17.06

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

Spain (Division IIb)

Year	Age 2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1994	0.43	1.08	1.38	2.32	2.47	2.68	3.46	5.20	7.04	6.79	7.20	8.04	10.46	15.35
1995	0.42	0.51	0.98	1.99	3.41	4.95	5.52	8.62	9.21	11.42	9.78	8.08		
1996		0.66	1.12	1.57	2.43	3.17	3.59	4.44	5.48	6.79	8.10			
1997 [1]	0.51	0.65	1.22	1.68	2.60	3.39	4.27	6.67	7.88	11.34	13.33	10.03	8.69	
1998	0.47	0.74	1.15	1.82	2.44	3.32	3.71	5.00	7.26					
1999 [1]	0.21	0.69	1.06	1.69	2.50	3.32	4.72	5.76	6.77	7.24	7.63			
2000 [1]	0.23	0.61	1.24	1.75	2.47	3.12	4.65	6.06	7.66	10.94	11.40	7.20		
2001	0.23	0.64	1.25	1.95	2.86	3.55	4.95	6.46	8.50	11.07	13.09			
2002	0.16	0.55	1.00	1.48	2.17	3.29	4.47	5.35	8.29	12.23	9.01	12.16	15.2	
2003		0.58	1.05	1.70	2.33	3.33	4.92	6.24	9.98	13.07	14.74	14.17		
2004 [1]	0.31	0.56	0.80	1.28	1.96	2.59	3.72	5.36	5.28	7.41		11.43		
2005 [1]		0.63	1.14	1.85	2.48	3.43	4.25	5.38	8.41	11.19	15.04	16.93		
2006	0.30	0.61	0.99	1.46	2.04	2.55	3.39	3.50	4.70	6.36				
2007	0.42	0.60	1.20	1.76	2.40	3.18	3.96	5.19	6.61	9.48	7.65	12.65	15.74	19.66
2009 [1]	0.12	0.45	0.95	1.60	2.18	3.36	4.52	6.04	7.30	9.42	10.35	11.47	12.54	

[1] IIa and IIb combined

Iceland (Sub-area I)

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

UK (England & Wales)

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1995 [1]			1.47	2.11	3.47	5.57	6.43	7.17	8.12	8.05	10.17	10.08		
1996 [2]			1.55	1.81	2.42	3.61	6.30	6.47	7.83	7.91	8.93	9.38	10.91	
1997 [2]			1.93	2.17	3.07	4.17	4.89	6.46		12.27	8.44			

[1] Division IIa and IIb
[2] Division IIa

Poland (Division IIb)

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2006	0.18	0.51	0.89	1.55	2.23	3.60	5.28	6.95	8.48	10.96	10.82	15.56	18.92	
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	11.10	13.64	16.48		

Table 3.5 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

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

Table 3.6. Northeast arctic cod. Barents Sea winter survey. Area covered ('000 square nautical miles) and areas implied in the method used to adjust for missing coverage in Russian Economic Zone. In 4 of the 5 adjusted years the adjustments were not based on area ratios, but the "index ratio by age" was used. This means that the index by age (for the area outside REZ) was scaled by the observed ratio between total index and the index outside REZ observed in the years prior to the survey.

Year	Area covered	Additional area implied in adjustment	Adjustment method
1981-92	88.1		
1993	137.6		
1994	143.8		
1995	186.6		
1996	165.3		
1997	87.5	78.0	Index ratio
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		

Table 3.7
NE Arctic cod. International catch (thousands) at age for ages 1-15+

	AGE														
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

Table 3.8. 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	376	67	0	0	0	0
1986	53	968	392	99	0	0	0
1987	681	183	281	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	3833	20281	512	52	1	0	0
1994	8340	6947	647	131	52	8	0
1995*	8322	15383	759	211	67	4	0
1996	9921	21754	1503	143	56	20	1
1997	2938	15998	1858	174	17	1	0
1998	79	4853	536	211	25	2	1
1999	592	1833	295	52	4	0	0
2000	1675	2233	171	37	14	4	0
2001	89	2271	113	24	12	2	1
2002	7664	459	395	41	6	1	0
2003	5636	4397	107	23	0	0	0
2004	5768	1540	513	19	10	1	0
2005	2223	2766	159	85	3	5	1
2006	1817	2195	131	5	2	0	0
2007	1664	1266	216	84	5	0	0
2008	9387	1710	108	131	31	5	0
2009	8739	6444	133	63	9	0	0

* corrected data on cod consumption

Table 3.9. North-East Arctic COD. Catch numbers at age

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

At 22/04/2010 19:53

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

	YEAF	1946	1947	1948	1949
	AGE				
	3	4008	710	140	991
	4	10387	13192	3872	6808
	5	18906	43890	31054	35214
	6	16596	52017	55983	100497
	7	13843	45501	77375	83283
	8	15370	13075	21482	29727
	9	59845	19718	15237	13207
	10	22618	47678	9815	5606
	11	10093	31392	30041	8617
	12	9573	9348	7945	13154
	+gp	8137	18055	12595	7719
0	TOTAL	189376	294576	265539	304823
	TONSL	706000	882017	774295	800122
	SOPC(	103	91	89	99

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

	YEAF	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
	AGE										
	3	1281	24687	24099	47413	11473	3902	10614	17321	31219	32308
	4	10954	77924	120704	107659	155171	37652	24172	33931	133576	77942
	5	29045	64013	113203	112040	146395	201834	129803	27182	71051	148285
	6	45233	46867	73827	55500	100751	161336	250472	70702	40737	53480
	7	62579	37535	49389	22742	40635	84031	86784	87033	38380	18498
	8	30037	33673	20562	16863	10713	30451	51091	39213	35786	17735
	9	19481	23510	24367	10559	11791	13713	14987	17747	13338	23118
	10	9172	10589	15651	10553	8557	9481	7465	6219	10475	9483
	11	6019	4221	8327	5637	6751	4140	3952	3232	3289	3748
	12	4133	1288	3565	1752	2370	2406	1655	1220	1070	997
	+gp	9862	4935	2158	797	1287	1350	1906	819	433	513
0	TOTAL	227796	329242	455852	391515	495894	550296	582901	304619	379354	386107
	TONSL	731982	827180	876795	695546	826021	1147841	1343068	792557	769313	744607
	SOPC(	109	115	93	105	93	106	105	100	112	93
	1										

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

	YEAF	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
	AGE										
	3	37882	45478	42416	13196	5298	15725	55937	34467	3709	2307
	4	97865	132655	170566	106984	45912	25999	55644	160048	174585	24545
	5	64222	123458	167241	205549	97950	78299	34676	69235	267961	238511
	6	67425	51167	89460	95498	58575	68511	42539	22061	107051	181239
	7	23117	38740	28297	35518	19642	25444	37169	26295	26701	79363
	8	8429	17376	21996	16221	9162	8438	18500	25139	16399	26989
	9	7240	5791	7956	11894	6196	3569	5077	11323	11597	13463
	10	11675	6778	2728	3884	3553	1467	1495	2329	3657	5092
	11	4504	5560	2603	1021	783	1161	380	687	657	1913
	12	1843	1682	1647	1025	172	131	403	316	122	414
	+gp	682	1298	775	784	782	337	156	279	240	190
0	TOTAL	324884	429983	535685	491574	248025	229081	251976	352179	612679	574026
	TONSL	622042	783221	909266	776337	437695	444930	483711	572605	1074084	1197226
	SOPC(	104	110	124	102	103	129	123	109	108	105

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

	YEAF	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
	AGE										
	3	7164	7754	35536	294262	91855	45282	85337	39594	78822	8600
	4	10792	13739	45431	131493	437377	59798	114341	168609	45400	77484
	5	25813	11831	26832	61000	203772	226646	79993	136335	88495	43677
	6	137829	9527	12089	20569	47006	118567	118236	52925	56823	31943
	7	96420	59290	7918	7248	12630	29522	47872	61821	25407	16815
	8	31920	52003	34885	8328	4370	9353	13962	23338	31821	8274
	9	8933	12093	22315	19130	2523	2617	4051	5659	9408	10974
	10	3249	2434	4572	4499	5607	1555	936	1521	1227	1785
	11	1232	762	1215	677	2127	1928	558	610	913	427
	12	260	418	353	195	322	575	442	271	446	103
	+gp	180	216	476	195	296	283	218	268	847	142
0	TOTAL	323792	170067	191622	547596	807885	496126	465946	490951	339609	200224

Table 3.9 (continued).

Table 1	Catch numbers at age				Numbers*10**-3					
YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	3911	3407	8948	3108	6942	24634	28968	13648	9828	5085
4	17086	9466	20933	19594	14240	45769	70993	137106	22774	17313
5	81986	20803	19345	20473	18807	27806	78672	98210	135347	32165
6	40061	63433	28084	17656	20086	19418	25215	61407	54379	81756
7	17664	21788	42496	17004	15145	11369	11711	13707	21015	27854
8	7442	9933	8395	18329	8287	3747	4063	3866	3304	5501
9	3508	4267	2878	2545	5988	1557	976	910	1236	827
10	3196	1311	708	646	783	768	726	455	519	290
11	678	882	271	229	232	137	557	187	106	41
12	79	109	260	74	153	36	136	227	69	13
+gp	58	41	37	83	69	71	76	100	62	28
0 TOTALNUM	175669	135440	132355	99741	90732	135312	222093	329823	248639	170873
TONSLAND	380434	399038	363730	289992	277651	307920	430113	523071	434939	332481
SOPCOF %	127	118	125	90	95	102	102	102	100	99

Table 1	Catch numbers at age				Numbers*10**-3					
YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
3	1911	4963	21835	10094	6531	4879	7655	12827	31887	7501
4	7551	10933	36015	46182	59444	42587	28782	36491	88874	77714
5	12999	16467	27494	63578	102548	115329	80711	69633	48972	92816
6	17827	20342	23392	33623	59766	98485	100509	83017	40493	31139
7	30007	19479	18351	14866	32504	32036	54590	65768	34513	15778
8	6810	25193	13541	9449	10019	7334	10545	28392	26354	15851
9	828	3888	18321	6571	6163	3014	2023	4651	6583	8828
10	179	428	2529	12593	3671	1725	930	1151	965	1837
11	59	48	264	1749	7528	1174	462	373	197	195
12	15	12	82	377	995	1920	230	213	69	40
+gp	13	4	13	86	144	264	894	383	117	72
0 TOTALNUM	78199	101757	161837	199168	289313	308747	287331	302899	279024	251771
TONSLAND	212000	319158	513234	581611	771086	739999	732228	762403	592624	484910
SOPCOF %	101	95	103	101	101	100	101	100	101	100

Table 1	Catch numbers at age				Numbers*10**-3					
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
3	4701	5044	2348	7263	2090	5815	8548	25473	8459	4866
4	33094	35019	31033	20885	38226	19768	47207	43817	51704	38711
5	93044	62139	76175	64447	50826	113144	33625	62877	40656	83998
6	47210	62456	67656	71109	68350	61665	78150	26303	35072	46639
7	12671	22794	42122	36706	50838	44777	31770	34392	14037	20789
8	6677	5266	11527	14002	18118	20553	15667	11240	20676	8417
9	4787	1773	1801	2887	6239	6285	7245	4080	5503	8920
10	1647	1163	529	492	1746	2348	1788	1381	1794	1957
11	321	343	223	142	295	562	737	505	715	872
12	71	85	120	97	127	100	210	285	229	987
+gp	26	35	36	65	63	52	226	92	81	117
0 TOTALNUM	204249	196117	233570	218095	236918	275069	225173	210445	178926	216273
TONSLAND	414868	426471	535045	551990	606445	641276	537642	486883	464171	523430
SOPCOF %	100	100	100	100	100	100	100	100	100	100
1										

Table 3.10. North-East Arctic COD. Catch weights at age

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

At 22/04/2010 19:53

Table 2 Catch weights at age (kg)

YEAF	1946	1947	1948	1949
AGE				
3	0.35	0.32	0.34	0.37
4	0.59	0.56	0.53	0.67
5	1.11	0.95	1.26	1.11
6	1.69	1.5	1.93	1.66
7	2.37	2.14	2.46	2.5
8	3.17	2.92	3.36	3.23
9	3.98	3.65	4.22	4.07
10	5.05	4.56	5.31	5.27
11	5.92	5.84	5.92	5.99
12	7.2	7.42	7.09	7.08
+gp	8.146	8.848	8.43	8.218
0 SOPC	1.03	0.9143	0.8915	0.992

Table 2 Catch weights at age (kg)

YEAF	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
AGE										
3	0.39	0.4	0.44	0.4	0.44	0.32	0.33	0.33	0.34	0.35
4	0.64	0.83	0.8	0.76	0.77	0.57	0.58	0.59	0.52	0.72
5	1.29	1.39	1.33	1.28	1.26	1.13	1.07	1.02	0.95	1.47
6	1.7	1.88	1.92	1.93	1.97	1.73	1.83	1.82	1.92	2.68
7	2.36	2.54	2.64	2.81	3.03	2.75	2.89	2.89	2.94	3.59
8	3.48	3.46	3.71	3.72	4.33	3.94	4.25	4.28	4.21	4.32
9	4.52	4.88	5.06	5.06	5.4	4.9	5.55	5.49	5.61	5.45
10	5.62	5.2	6.05	6.34	6.75	7.04	7.28	7.51	7.35	6.44
11	6.4	7.14	7.42	7.4	7.79	7.2	8	8.24	8.67	7.17
12	7.96	8.22	8.43	8.67	10.67	8.78	8.35	9.25	9.58	8.63
+gp	8.891	9.389	10.185	10.238	9.68	10.077	9.944	10.605	11.631	11.621
0 SOPC	1.088	1.1483	0.9348	1.0485	0.9294	1.0634	1.0455	1.0004	1.1232	0.9305

1

Table 2 Catch weights at age (kg)

YEAF	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
AGE										
3	0.34	0.31	0.32	0.32	0.33	0.38	0.44	0.29	0.33	0.44
4	0.51	0.55	0.55	0.61	0.55	0.68	0.74	0.81	0.7	0.79
5	1.09	1.05	0.93	0.96	0.95	1.03	1.18	1.35	1.48	1.23
6	2.13	2.2	1.7	1.73	1.86	1.49	1.78	2.04	2.12	2.03
7	3.38	3.23	3.03	3.04	3.25	2.41	2.46	2.81	3.14	2.9
8	4.87	5.11	5.03	4.96	4.97	3.52	3.82	3.48	4.21	3.81
9	6.12	6.15	6.55	6.44	6.41	5.73	5.36	4.89	5.27	5.02
10	8.49	8.15	7.7	7.91	8.07	7.54	7.27	7.11	6.65	6.43
11	7.79	8.68	9.27	9.62	9.34	8.47	8.63	9.03	9.01	8.33
12	8.3	9.6	10.56	11.31	10.16	11.17	10.66	10.59	9.66	10.71
+gp	11.422	11.952	12.717	12.737	12.886	13.722	14.148	13.829	14.848	14.211
0 SOPC	1.0416	1.097	1.2356	1.0226	1.0277	1.2903	1.2327	1.0911	1.0785	1.052

Table 2 Catch weights at age (kg)

YEAF	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
3	0.37	0.45	0.38	0.38	0.32	0.41	0.35	0.49	0.49	0.35
4	0.91	0.88	0.77	0.91	0.66	0.64	0.73	0.9	0.81	0.7
5	1.34	1.38	1.43	1.54	1.17	1.11	1.19	1.43	1.45	1.24
6	2	2.16	2.12	2.26	2.22	1.9	2.01	2.05	2.15	2.14
7	3	3.07	3.23	3.29	3.21	2.95	2.76	3.3	3.04	3.15
8	4.15	4.22	4.38	4.61	4.39	4.37	4.22	4.56	4.46	4.29
9	5.59	5.81	5.83	6.57	5.52	5.74	5.88	6.46	6.54	6.58
10	7.6	7.13	7.62	8.37	7.86	8.77	9.3	8.63	7.98	8.61
11	8.97	8.62	9.52	10.54	9.82	9.92	10.28	9.93	10.15	9.22
12	10.99	10.83	12.09	11.62	11.41	11.81	11.86	10.9	10.85	10.89
+gp	14.074	12.945	13.673	13.904	13.242	13.107	13.544	13.668	13.177	14.344
0 SOPC	1.117	1.2405	1.1822	1.3003	1.366	1.152	1.2688	1.0683	1.089	1.2139

Table 3.10 (continued).

Table 2	Catch weights at age (kg)									
YEAF	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	0.27	0.49	0.37	0.84	1.42	0.94	0.64	0.49	0.54	0.74
4	0.56	0.98	0.66	1.37	1.93	1.37	1.27	0.88	0.85	0.96
5	1.02	1.44	1.35	2.09	2.49	2.02	1.88	1.55	1.32	1.31
6	1.72	2.09	1.99	2.86	3.14	3.22	2.79	2.33	2.24	1.92
7	3.02	2.98	2.93	3.99	3.91	4.63	4.49	3.44	3.52	2.93
8	4.2	4.85	4.24	5.58	4.91	6.04	5.84	5.92	5.35	4.64
9	5.84	6.57	6.46	7.77	6.02	7.66	6.83	8.6	8.06	7.52
10	7.26	9.16	8.51	9.29	7.4	9.81	7.69	9.6	9.51	9.12
11	8.84	10.82	12.24	11.55	8.13	11.8	9.81	12.17	11.36	11.08
12	9.28	10.77	10.78	16.2	8.57	14.16	10.71	13.72	14.09	11.47
+gp	14.448	13.932	14.041	17.034	8.609	14.008	12.051	13.38	16.706	16.484
0 SOPC	1.2723	1.1809	1.2521	0.8953	0.9483	1.0182	1.016	1.0224	1.0001	0.9879

Table 2	Catch weights at age (kg)									
YEAF	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
3	0.81	1.05	1.16	0.81	0.82	0.77	0.79	0.67	0.68	0.63
4	1.22	1.45	1.57	1.52	1.3	1.2	1.11	1.04	1.05	1.01
5	1.64	2.15	2.21	2.16	2.06	1.78	1.61	1.53	1.62	1.54
6	2.22	2.89	3.1	2.79	2.89	2.59	2.46	2.22	2.3	2.34
7	3.24	3.75	4.27	4.07	3.21	3.81	3.82	3.42	3.3	3.21
8	4.68	4.71	5.19	5.53	5.2	4.99	5.72	5.2	4.86	4.29
9	7.3	6.08	6.14	6.47	6.8	6.23	6.74	7.19	6.87	6
10	9.84	8.82	7.77	7.19	7.57	8.05	8.04	7.73	9.3	6.73
11	13.25	11.8	10.12	7.98	8.01	8.74	9.28	8.61	10.3	10.08
12	16.88	16.58	11.54	10.11	9.48	9.22	10.4	11.07	15.05	13.88
+gp	11.617	16.69	14.332	14.183	11.978	12.319	10.966	11.117	14.524	14.036
0 SOPC	1.0108	0.9521	1.027	1.0127	1.009	1.003	1.0147	1.0004	1.0072	0.9967

Table 2	Catch weights at age (kg)									
YEAF	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
3	0.572	0.66	0.723	0.672	0.72	0.693	0.721	0.736	0.769	0.747
4	1.036	1.05	1.133	1.119	1.13	1.081	1.145	1.214	1.273	1.173
5	1.609	1.62	1.56	1.827	1.607	1.566	1.603	1.832	1.866	1.735
6	2.344	2.51	2.306	2.499	2.429	2.205	2.388	2.511	2.818	2.419
7	3.341	3.51	3.52	3.575	3.274	3.263	3.318	3.822	3.786	3.864
8	4.476	4.78	4.784	5.039	4.725	4.443	4.535	5.043	5.122	5.346
9	5.724	6.04	6.2	6.355	6.712	6.228	5.466	6.584	6.223	6.428
10	7.523	7.54	7.659	8.196	7.984	8.187	6.777	8.077	7.752	8.008
11	8.021	9	9.14	10.711	9.192	9.724	7.699	8.942	8.405	8.667
12	12.478	10.48	8.197	11.958	12.024	11.496	8.578	10.173	10.117	8.547
+gp	17.241	16.18	10.325	10.657	14.245	14.417	10.155	13.364	13.674	12.022
0 SOPC	1.0039	0.9994	1.0025	1.0014	1.0017	0.9993	0.9981	0.9978	1.0011	1.0002
1										

Table 3.11. North-East Arctic COD. Stock weights at age

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

At 22/04/2010 19:53

Table 3 Stock weights at age (kg)

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

Table 3 Stock weights at age (kg)

YEAR	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
AGE										
3	0.39	0.4	0.44	0.4	0.44	0.32	0.33	0.33	0.34	0.35
4	0.64	0.83	0.8	0.76	0.77	0.57	0.58	0.59	0.52	0.72
5	1.29	1.39	1.33	1.28	1.26	1.13	1.07	1.02	0.95	1.47
6	1.7	1.88	1.92	1.93	1.97	1.73	1.83	1.82	1.92	2.68
7	2.36	2.54	2.64	2.81	3.03	2.75	2.89	2.89	2.94	3.59
8	3.48	3.46	3.71	3.72	4.33	3.94	4.25	4.28	4.21	4.32
9	4.52	4.88	5.06	5.06	5.4	4.9	5.55	5.49	5.61	5.45
10	5.62	5.2	6.05	6.34	6.75	7.04	7.28	7.51	7.35	6.44
11	6.4	7.14	7.42	7.4	7.79	7.2	8	8.24	8.67	7.17
12	7.96	8.22	8.43	8.67	10.67	8.78	8.35	9.25	9.58	8.63
+gp	8.891	9.389	10.185	10.238	9.68	10.077	9.944	10.605	11.631	11.621
1										

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

At 22/04/2010 19:53

Table 3 Stock weights at age (kg)

YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
AGE										
3	0.34	0.31	0.32	0.32	0.33	0.38	0.44	0.29	0.33	0.44
4	0.51	0.55	0.55	0.61	0.55	0.68	0.74	0.81	0.7	0.79
5	1.09	1.05	0.93	0.96	0.95	1.03	1.18	1.35	1.48	1.23
6	2.13	2.2	1.7	1.73	1.86	1.49	1.78	2.04	2.12	2.03
7	3.38	3.23	3.03	3.04	3.25	2.41	2.46	2.81	3.14	2.9
8	4.87	5.11	5.03	4.96	4.97	3.52	3.82	3.48	4.21	3.81
9	6.12	6.15	6.55	6.44	6.41	5.73	5.36	4.89	5.27	5.02
10	8.49	8.15	7.7	7.91	8.07	7.54	7.27	7.11	6.65	6.43
11	7.79	8.68	9.27	9.62	9.34	8.47	8.63	9.03	9.01	8.33
12	8.3	9.6	10.56	11.31	10.16	11.17	10.66	10.59	9.66	10.71
+gp	11.422	11.952	12.717	12.737	12.886	13.722	14.148	13.829	14.848	14.211

Table 3.11 (continued).

Table 3 Stock weights at age (kg)

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
3	0.37	0.45	0.38	0.38	0.32	0.41	0.35	0.49	0.49	0.35
4	0.91	0.88	0.77	0.91	0.66	0.64	0.73	0.9	0.81	0.7
5	1.34	1.38	1.43	1.54	1.17	1.11	1.19	1.43	1.45	1.24
6	2	2.16	2.12	2.26	2.22	1.9	2.01	2.05	2.15	2.14
7	3	3.07	3.23	3.29	3.21	2.95	2.76	3.3	3.04	3.15
8	4.15	4.22	4.38	4.61	4.39	4.37	4.22	4.56	4.46	4.29
9	5.59	5.81	5.83	6.57	5.52	5.74	5.88	6.46	6.54	6.58
10	7.6	7.13	7.62	8.37	7.86	8.77	9.3	8.63	7.98	8.61
11	8.97	8.62	9.52	10.54	9.82	9.92	10.28	9.93	10.15	9.22
12	10.99	10.83	12.09	11.62	11.41	11.81	11.86	10.9	10.85	10.89
+gp	14.074	12.945	13.673	13.904	13.242	13.107	13.544	13.668	13.177	14.344

Table 3 Stock weights at age (kg)

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	0.27	0.49	0.37	0.37	0.42	0.413	0.311	0.211	0.212	0.299
4	0.56	0.98	0.66	0.92	1.16	0.875	0.88	0.498	0.404	0.52
5	1.02	1.44	1.35	1.6	1.81	1.603	1.47	1.254	0.79	0.868
6	1.72	2.09	1.99	2.44	2.79	2.81	2.467	2.047	1.903	1.477
7	3.02	2.98	2.93	3.82	3.78	4.059	3.915	3.431	2.977	2.686
8	4.2	4.85	4.24	4.76	4.57	5.833	5.81	5.137	4.392	4.628
9	5.84	6.57	6.46	6.17	6.17	7.685	6.58	6.523	7.812	7.048
10	7.26	9.16	8.51	7.7	7.7	10.117	6.833	9.3	12.112	9.98
11	8.84	10.82	12.24	9.25	9.25	14.29	11.004	13.15	13.107	9.25
12	9.28	10.77	10.78	10.85	10.85	12.731	12.731	12.731	12.731	12.731
+gp	14.448	13.932	14.041	12.988	13.033	14.311	14.311	14.311	14.311	14.311

Table 3 Stock weights at age (kg)

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
3	0.398	0.518	0.44	0.344	0.235	0.201	0.195	0.202	0.217	0.203
4	0.705	1.136	0.931	1.172	0.753	0.485	0.487	0.521	0.533	0.52
5	1.182	1.743	1.812	1.82	1.42	1.14	0.971	1.079	1.161	1.174
6	1.719	2.428	2.716	2.823	2.413	2.118	2.054	1.878	1.939	2.031
7	2.458	3.214	3.895	4.031	3.825	3.47	3.527	3.369	2.945	3.034
8	3.565	4.538	5.176	5.497	5.416	4.938	5.503	5.263	4.574	4.464
9	4.71	6.88	6.774	6.765	6.631	7.16	7.767	8.927	7.423	6.482
10	7.801	10.719	9.598	8.571	7.63	9.119	10.159	12.154	10.367	10.269
11	8.956	9.445	12.427	10.847	8.112	10.101	10.669	11.204	11.738	10.882
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 3.11 (continued).

Table 3	Stock weights at age (kg)									
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
3	0.194	0.285	0.251	0.23	0.25	0.231	0.256	0.262	0.286	0.26
4	0.465	0.522	0.605	0.537	0.546	0.624	0.602	0.699	0.734	0.641
5	1.208	1.196	1.189	1.31	1.087	1.118	1.201	1.341	1.37	1.343
6	1.972	2.239	2.138	2.009	2.035	1.932	2.009	2.121	2.367	2.36
7	3.048	3.313	3.333	3.241	2.921	3.046	3.114	3.167	3.29	3.763
8	4.096	5.118	4.766	4.971	4.384	3.955	4.427	4.64	4.82	5.111
9	5.724	6.376	6.859	6.739	6.254	5.811	6.03	6.495	6.548	6.554
10	7.457	9.241	9.333	8.706	8.543	8.289	8.037	9.123	8.483	9.098
11	9.582	11.322	10.186	15.026	9.735	13.44	9.928	11.78	8.902	9.432
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
1										

Table 3.12. Northeast Arctic cod. Proportion mature at age.

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

At 22/04/2010 19:53

Table 5 Proportion mature at age

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

Table 5 Proportion mature at age

YEAR	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
6	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
7	0.09	0.1	0.08	0.07	0.08	0.07	0.06	0.06	0.06	0.12
8	0.23	0.24	0.22	0.19	0.16	0.13	0.12	0.09	0.1	0.34
9	0.35	0.4	0.41	0.4	0.37	0.26	0.14	0.12	0.1	0.49
10	0.52	0.58	0.63	0.64	0.68	0.53	0.41	0.22	0.3	0.67
11	0.79	0.72	0.82	0.84	0.87	0.83	0.67	0.6	0.5	0.84
12	0.95	0.85	0.92	0.94	0.93	0.92	0.91	0.82	0.82	0.87
+gp	0.97	0.96	0.97	0.97	0.96	0.97	0.96	0.97	0.97	1
1										

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

At 22/04/2010 19:53

Table 5 Proportion mature at age

YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	0.01	0	0	0.01	0	0	0	0	0	0
5	0.03	0.01	0.01	0.01	0	0	0.01	0	0.03	0
6	0.06	0.06	0.05	0.03	0.03	0.01	0.02	0.03	0.05	0.02
7	0.1	0.12	0.15	0.07	0.13	0.06	0.06	0.07	0.09	0.04
8	0.19	0.31	0.34	0.28	0.37	0.2	0.22	0.14	0.19	0.12
9	0.45	0.65	0.61	0.42	0.66	0.55	0.35	0.38	0.39	0.34
10	0.69	0.91	0.81	0.81	0.89	0.73	0.74	0.64	0.58	0.55
11	0.77	0.98	0.92	0.98	0.95	0.99	0.94	0.89	0.82	0.74
12	0.85	0.98	0.97	0.98	0.99	0.98	0.94	0.9	1	0.95
+gp	0.99	1	1	1	1	1	1	1	1	1

Table 3.12 (continued)

Table 5 Proportion mature at age

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
3	0	0	0.01	0	0	0	0	0	0	0
4	0.01	0	0.02	0	0	0	0	0	0	0
5	0	0.01	0.02	0	0	0.01	0	0.02	0	0
6	0.01	0.05	0.01	0.02	0.01	0.02	0.05	0.08	0.02	0.03
7	0.07	0.11	0.1	0.16	0.03	0.09	0.12	0.26	0.13	0.13
8	0.23	0.3	0.34	0.53	0.21	0.21	0.29	0.54	0.44	0.39
9	0.58	0.59	0.64	0.81	0.5	0.56	0.45	0.76	0.71	0.77
10	0.81	0.79	0.81	0.92	0.96	0.78	0.84	0.87	0.77	0.89
11	0.89	0.86	0.94	0.95	1	0.79	0.83	0.93	0.81	0.83
12	0.91	0.88	1	0.98	0.96	0.95	1	0.94	0.89	0.78
+gp	1	1	1	1	1	1	0.9	0.9	0.8	0.9

Table 5 Proportion mature at age

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	0	0	0	0.01	0	0	0	0	0	0.008
4	0	0	0.05	0.08	0.05	0.01	0.05	0.01	0.02	0.003
5	0	0.02	0.1	0.1	0.18	0.09	0.08	0.07	0.05	0.029
6	0.02	0.07	0.34	0.3	0.31	0.36	0.19	0.18	0.33	0.228
7	0.13	0.2	0.65	0.73	0.56	0.55	0.53	0.22	0.53	0.547
8	0.35	0.54	0.82	0.88	0.9	0.85	0.71	0.46	0.62	0.705
9	0.65	0.8	0.92	0.97	0.99	0.96	0.62	0.5	1	0.915
10	0.82	0.97	1	1	1	0.9	0.9	0.75	1	1
11	1	1	1	1	1	1	1	1	1	1
12	0.9	1	1	1	1	1	1	1	1	1
+gp	0.9	1	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
3	0.008	0.001	0.001	0	0.003	0	0	0	0.001	0.002
4	0.013	0.032	0.014	0.028	0.007	0.003	0	0	0.003	0.002
5	0.051	0.075	0.145	0.087	0.119	0.061	0.019	0.012	0.026	0.014
6	0.21	0.305	0.419	0.368	0.335	0.372	0.258	0.14	0.152	0.187
7	0.522	0.708	0.8	0.704	0.589	0.624	0.631	0.607	0.472	0.544
8	0.715	0.861	0.943	0.931	0.862	0.781	0.82	0.83	0.814	0.847
9	0.905	0.957	0.974	0.972	0.963	0.96	0.975	0.946	0.957	0.965
10	0.975	1	1	0.994	0.99	0.979	1	1	0.98	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 3.12 (continued)

Table 5	Proportion mature at age									
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
3	0	0.003	0.002	0.001	0.001	0	0	0	0	0
4	0.001	0.003	0.013	0.001	0.01	0.004	0.001	0.004	0.004	0
5	0.071	0.065	0.084	0.088	0.091	0.068	0.06	0.072	0.062	0.076
6	0.247	0.359	0.388	0.326	0.442	0.397	0.369	0.343	0.282	0.372
7	0.643	0.624	0.683	0.672	0.726	0.716	0.647	0.723	0.538	0.755
8	0.83	0.819	0.841	0.888	0.872	0.892	0.897	0.876	0.863	0.857
9	0.978	0.952	0.951	0.957	0.976	0.967	0.965	0.976	0.928	0.977
10	1	1	1	1	0.977	0.991	1	1	0.994	0.997
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
1										

Table 3.13. North-East Arctic COD. Tuning data

North-East	Arctic	cod	(Sub-areas	I	and	II)	(run	name:	XSAASA01)						
104															
FLT09:	Russian	trawl	catch	and	effort	ages	9	-	11	(Catch:	Thousa	(Catch:	Unknown)	(Effort:	Unknown)
1985	2009														
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	909	520	133											
FLT15:	NorBarTrS	rev99	(Catch:	Unknown)	(Effort:	Unknown)									
1980	2009														
1	1	0.99	1												
3	8														
	1	233	400	384	48	10	3								
	1	277	236	155	160	14	2								
	1	523	433	170	58	32	10								
	1	283	214	117	41	4	1								
	1	1260	199	77	33	2	1								
	1	1439	641	83	19	3	0								
	1	3911	543	157	20	5	0								
	1	805	1733	205	36	5	0								
	1	759	378	902	98	9	1								
	1	349	346	206	272	16	4								
	1	337	257	215	122	127	6								
	1	577	178	128	77	43	27								
	1	1401	725	158	62	39	22								
	1	3102	1474	506	93	24	16								
	1	2414	2559	767	185	24	8								
	1	1154	1372	1061	240	29	4								
	1	640	704	527	283	57	9								
	1	1813	365	259	178	86	10								
	1	1732	581	134	65	51	12								
	1	1321	1083	269	43	20	12								
	1	1828	834	382	89	11	4								
	1	1350	1096	425	151	24	3								
	1	1297	911	673	183	49	10								
	1	1725	569	447	273	76	17								
	1	621	981	247	155	45	11								
	1	1115	287	437	102	49	14								
	1	850	629	148	179	48	18								
	1	3336	910	472	130	88	20								
	1	2196	1939	586	196	68	49								
	1	1069	1608	1407	400	119	35								

Table 3.13 (continued)

FLT16:	NorBarLofA	rev99	(Catch:	Unknown)	(Effort:	Unknown)					
1984	2009										
1	1	0.99	1								
3	9										
	1	1416	204	154	157	33	13	10			
	1	1343	684	116	77	31	3	0			
	1	2049	502	174	14	30	7	0			
	1	355	578	109	40	3	0	1			
	1	344	214	670	166	32	5	2			
	1	206	262	269	668	73	6	3			
	1	346	293	339	367	500	37	2			
	1	658	215	184	284	254	824	43			
	1	1911	1131	354	255	252	277	442			
	1	4045	2175	895	225	119	94	39			
	1	1598	2166	1040	290	44	43	30			
	1	705	872	891	446	65	11	4			
	1	517	497	422	499	205	22	5			
	1	1826	424	338	340	247	49	7			
	1	964	454	122	112	187	92	10			
	1	1589	1457	493	129	69	52	12			
	1	1716	816	573	198	24	8	6			
	1	1122	1043	661	345	95	12	5			
	1	1144	1315	1445	643	212	38	5			
	1	928	327	451	468	222	88	22			
	1	337	661	299	432	172	75	18			
	1	591	157	381	169	155	88	24			
	1	371	318	130	426	137	75	35			
	1	3061	1410	754	246	329	58	28			
	1	1783	1405	495	401	133	260	37			
	1	1219	1759	1949	709	375	111	88			
FLT18:	RusSwept/	rev05	(ages	3-9)	(Catch:	Unknown)	(	(Catch:	Unknown)	(Effort:	Unknown)
1982	2009										
1	1	0.9	1								
3	9										
	1	1413	1525	721	198	551	174	37			
	1	520	642	506	358	179	252	94			
	1	1189	700	489	357	154	69	61			
	1	1188	1592	1068	365	165	37	8			
	1	1622	1532	1493	481	189	42	2			
	1	557	3076	900	701	184	60	25			
	1	993	938	2879	583	260	47	24			
	1	490	978	1062	1454	1167	299	112			
	1	167	487	627	972	1538	673	153			
	1	1077	484	532	583	685	747	98			
	1	675	308	239	273	218	175	25			
	1	1604	1135	681	416	354	87	3			
	1	1363	1309	1019	354	128	49	21			
	1	589	1065	1395	849	251	83	19			
	1	733	784	1035	773	348	132	19			
	1	1342	835	613	602	348	116	32			
	1	2028	1363	788	470	259	130	48			
	1	1587	2072	980	301	123	94	42			
	1	1839	1286	1786	773	114	52	23			
	1	1224	1557	1290	1061	304	50	14			
	1	980	1473	1473	896	600	182	29			
	1	1246	1057	1166	1203	535	241	40			
	1	329	1576	880	1111	776	279	93			
	1	1408	631	1832	744	605	244	88			
	1	927	1613	777	1801	662	342	161			
	1	2579	1617	1903	846	1525	553	226			
	1	2203	3088	1635	1472	830	863	291			
	1	974	2317	3687	2016	1175	620	413			

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. *Fleet007 was not included in the final run.

		FLT 09 Rus trawl CPUE	FLT 15 Joint BT survey	FLT 16 Joint+Lof Ac survey	FLT 18 Rus BT survey	FLT 007 Joint Eco * 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	3 to 11
age3	PshrinkW	**0.91**	**0.52**	**0.51**	**0.54**	**0.48**	0.22
	FshrinkW	0.09	0.05	0.06	0.04	0.05	0.03
age4	PshrinkW	**0.89**	**0.38**	**0.35**	**0.40**	**0.33**	0.14
	FshrinkW	0.11	0.03	0.04	0.03	0.04	0.02
age5	PshrinkW	**0.87**	**0.39**	**0.39**	**0.43**	**0.33**	0.16
	FshrinkW	0.13	0.03	0.04	0.03	0.03	0.01
age6	FshrinkW	**1.00**	0.04	0.04	0.04	0.04	0.01
age7	FshrinkW	**1.00**	0.04	0.04	0.04	0.04	0.01
age8	FshrinkW	**1.00**	0.04	0.05	0.03	0.04	0.01
age9	FshrinkW	0.14	0.10	0.05	0.04	0.06	0.02
age10	FshrinkW	0.09	0.24	0.14	0.06	0.05	0.03
age11	FshrinkW	0.07	**0.40**	0.21	0.10	0.10	0.04
age12	FshrinkW	0.10	**0.53**	0.27	0.17	0.17	0.08
2009	F(5-10)	0.496	0.360	0.373	0.255	0.343	0.276
TSB2009	incl Age1-2	1788	2437	2383	2710	2220	2782
SSB2009	('000 T)	725	941	903	1197	871	1077
N2010	yc2007	455027	554053	550594	568507	513105	592242
N*10^-3	yc2006	328920	383236	424956	402101	338144	424117
with	yc2005	233356	340066	352407	339536	314306	418565
shrinkage	yc2004	145304	228717	219978	230583	217330	298379
	yc2003	63245	137799	129958	133276	100273	144949
	yc2002	22045	62301	58441	73049	48191	72212
	yc2001	7814	23874	15425	28350	15061	24121
	yc2000	9783	12465	15839	22325	16199	17680
		No	**shrinkage**				**Shrinkage**
Survivors	yc2006		353082	459119	378731	293981	424117
end of 09	yc2005		383509	410343	376000	344108	418565
direct	yc2004		278913	268260	279021	255536	298379
predic.	yc2003		141014	133655	135596	101840	144949
by the	yc2002		64832	61093	75723	49934	72212
survey	yc2001		25034	16057	29463	15717	24121
N*10^-3	yc2000	9868	13221	16519	23076	16968	17680
	yc1999	13491	2443	2359	9340	6211	5224
F2009	yc2006		0.154	0.121	0.144	0.183	0.13
	yc2005		0.105	0.099	0.107	0.117	0.097
direct	yc2004		0.241	0.250	0.241	0.261	0. 227
predic.	yc2003		0.262	0.274	0.271	0.347	0.256
by the	yc2002		0.255	0.268	0.222	0.320	0.232
survey	yc2001		0.266	0.388	0.230	0.395	0.275
	yc2000	0. 598	0.477	0.398	0.300	0.389	0.376
	yc1999	0. 123	0.545	0.560	0.174	0.251	0.292
2009	F(5-10)		0.341	0.356	0.240	0.327	0.276

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

Lowestoft VPA Version 3.1

24/04/2010 17:49

Extended Survivors Analysis

Arctic Cod (run: XSAASA01/X01)

CPUE data from file fleet

Catch data for 10 years. 2000 to 2009. Ages 1 to 13.

Fleet	Fi year	Last year	First age	Last age	Alpha	Beta
FLT09: Ru	2000	2009	9	11	0	1
FLT15: Nc	2000	2009	3	8	0.99	1
FLT16: Nc	2000	2009	3	9	0.99	1
FLT18: Ru	2000	2009	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 < 6

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 6

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 = .00316

Final year F values

Age	1	2	3	4	5	6	7	8	9	10
Iteration 2	1.8804	0.1892	0.13	0.0968	0.2274	0.2557	0.2317	0.2747	0.3766	0.2928
Iteration 3	1.8803	0.1892	0.13	0.0968	0.2274	0.2556	0.2316	0.2745	0.3763	0.2923

Age	11	12
Iteration 2	0.3391	0.6368
Iteration 3	0.3385	0.6355

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	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	1.381	0.948	0.615	1.408	0.946	1.111	0.938	0.858	1.037	1.88
2	0.26	0.203	0.41	0.276	0.577	0.22	0.117	0.206	0.146	0.189
3	0.077	0.062	0.111	0.049	0.078	0.181	0.026	0.133	0.192	0.13
4	0.14	0.117	0.106	0.072	0.103	0.117	0.146	0.125	0.147	0.097
5	0.411	0.285	0.288	0.276	0.257	0.391	0.253	0.282	0.163	0.227
6	0.605	0.52	0.557	0.472	0.53	0.56	0.487	0.321	0.251	0.256
7	0.753	0.673	0.807	0.68	0.748	0.82	0.633	0.411	0.284	0.232
8	1.038	0.845	0.898	0.701	0.885	0.796	0.783	0.48	0.467	0.275
9	1.188	0.894	0.81	0.589	0.806	0.924	0.743	0.474	0.46	0.376
10	1.156	1.128	0.748	0.538	0.898	0.842	0.751	0.296	0.395	0.292
11	1.078	0.807	0.672	0.454	0.738	0.849	0.706	0.488	0.246	0.338
12	1.13	0.986	0.755	0.712	0.986	0.602	0.943	0.663	0.428	0.636

Table 3.15 (continued)

1

XSA population numbers (Thousands)

YEAR	AGE 1	2	3	4	5	6	7	8	9	10
2000	3.30E+06	8.26E+05	6.16E+05	4.00E+05	3.18E+05	1.15E+05	2.65E+04	1.14E+04	7.61E+03	2.66E+03
2001	4.07E+06	6.78E+05	5.22E+05	4.67E+05	2.85E+05	1.73E+05	5.14E+04	1.02E+04	3.32E+03	1.90E+03
2002	1.10E+06	1.29E+06	4.53E+05	4.01E+05	3.40E+05	1.75E+05	8.40E+04	2.15E+04	3.59E+03	1.11E+03
2003	6.35E+06	4.86E+05	7.03E+05	3.32E+05	2.95E+05	2.09E+05	8.22E+04	3.07E+04	7.17E+03	1.31E+03
2004	2.73E+06	1.27E+06	3.02E+05	5.48E+05	2.53E+05	1.84E+05	1.07E+05	3.41E+04	1.25E+04	3.26E+03
2005	4.60E+06	8.68E+05	5.85E+05	2.29E+05	4.05E+05	1.60E+05	8.84E+04	4.14E+04	1.15E+04	4.56E+03
2006	3.90E+06	1.24E+06	5.70E+05	4.00E+05	1.66E+05	2.24E+05	7.49E+04	3.19E+04	1.53E+04	3.74E+03
2007	2.40E+06	1.25E+06	9.04E+05	4.55E+05	2.83E+05	1.06E+05	1.13E+05	3.26E+04	1.19E+04	5.95E+03
2008	3.01E+06	8.34E+05	8.34E+05	6.47E+05	3.29E+05	1.75E+05	6.28E+04	6.12E+04	1.65E+04	6.08E+03
2009	8.67E+06	8.74E+05	5.90E+05	5.63E+05	4.57E+05	2.29E+05	1.11E+05	3.87E+04	3.14E+04	8.53E+03

Estimated population abundance at 1st Jan 2010

	0.00E+00	1.08E+06	5.92E+05	4.24E+05	4.19E+05	2.98E+05	1.45E+05	7.22E+04	2.41E+04	1.77E+04

Taper weighted geometric mean of the VPA populations:

	3.80E+06	9.72E+05	6.16E+05	4.42E+05	3.03E+05	1.76E+05	8.79E+04	3.65E+04	1.35E+04	4.31E+03

Standard error of the weighted Log(VPA populations) :

	0.5518	0.3015	0.3433	0.349	0.3387	0.2755	0.2543	0.3441	0.573	0.6229

YEAR	AGE 11	12
2000	5.38E+02	1.16E+02
2001	6.85E+02	1.50E+02
2002	5.04E+02	2.50E+02
2003	4.30E+02	2.11E+02
2004	6.24E+02	2.24E+02
2005	1.09E+03	2.44E+02
2006	1.61E+03	3.80E+02
2007	1.45E+03	6.50E+02
2008	3.62E+03	7.27E+02
2009	3.36E+03	2.32E+03

Estimated population abundance at 1st Jan 2010

	5.22E+03	1.96E+03

Taper weighted geometric mean of the VPA populations:

	1.46E+03	5.00E+02

Standard error of the weighted Log(VPA populations) :

	0.779	0.8905

1

Log catchability residuals.

Fleet : FLT09: Russian trawl

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
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	0.33	0.09	0.44	-0.1	-0.15	-0.23	0.08	-0.25	0.86	-0.49
10	-0.01	-0.16	-0.12	0.23	0.23	-0.4	-0.38	-0.45	0.69	0.22
11	-0.45	-0.27	-0.58	-0.17	0.27	-0.24	-0.14	-0.03	-0.01	-0.19

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	-3.4946	-3.4947	-3.4947
S.E(Log q	0.4717	0.4471	0.2269

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	1.23	-0.477	2.13	0.51	10	0.63	-3.49
10	0.93	0.219	3.84	0.69	10	0.46	-3.49
11	0.99	0.06	3.63	0.94	10	0.22	-3.6

1

Table 3.15 (continued)

Fleet : FLT15: NorBarTrSur r

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	0.15	0.12	0.26	-0.03	0.18	-0.05	-0.29	0.19	0.04	-0.11
4	0.07	0.06	0.1	0.01	-0.17	0.03	-0.08	-0.01	0.06	0.07
5	-0.06	0.04	0.09	0.02	-0.13	-0.25	0.02	0.1	0	0.14
6	-0.11	-0.07	0.15	0.29	-0.09	-0.34	-0.19	0.07	-0.08	0.36
7	-0.36	-0.32	0.03	0.37	-0.35	0	-0.04	-0.07	0.13	0.07
8	-0.05	-0.42	0.09	0.07	-0.29	-0.33	0.17	-0.05	0.21	0.13
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									

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

Age	6	7	8
Mean Log	-6.258	-6.4798	-6.6723
S.E(Log q	0.2491	0.19	0.2207

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	0.64	1.418	8.5	0.78	10	0.2	-5.78
4	0.55	3.81	9.08	0.94	10	0.09	-5.89
5	0.51	2.572	9.28	0.86	10	0.15	-6.04

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
6	0.86	0.373	7.06	0.63	10	0.23	-6.26
7	1.24	-0.564	5.28	0.55	10	0.25	-6.48
8	0.84	0.655	7.29	0.79	10	0.2	-6.67
1							

Fleet : FLT16: NorBarLofAcSu

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	0.27	0.21	0.39	-0.19	0.15	-0.17	-0.46	0.21	0.04	0.16
4	0.16	0.11	0.35	-0.08	-0.26	0	-0.24	0.27	-0.08	0.14
5	0.07	0.19	0.37	-0.03	-0.07	-0.37	-0.04	0.25	-0.15	0.18
6	-0.03	0.04	0.68	0.1	0.21	-0.56	-0.05	-0.01	-0.09	0.21
7	-0.69	-0.06	0.38	0.32	-0.12	0.03	-0.11	0.13	-0.31	0.1
8	-0.84	-0.51	-0.05	0.23	0.15	0.03	0.12	-0.46	0.39	-0.19
9	-0.47	-0.11	-0.27	0.3	-0.24	0.24	0.16	-0.08	-0.14	-0.01
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	6	7	8	9
Mean Log	-5.5363	-5.363	-5.191	-5.2997
S.E(Log q	0.3018	0.2179	0.3077	0.1985

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	0.51	1.322	9.67	0.63	10	0.29	-6.14
4	0.44	1.938	10	0.73	10	0.23	-6.1
5	0.46	1.654	9.54	0.69	10	0.25	-5.91

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
6	0.79	0.525	6.92	0.59	10	0.26	-5.54
7	0.67	1.436	7.34	0.82	10	0.13	-5.36
8	0.67	1.368	6.95	0.8	10	0.19	-5.19
9	0.99	0.033	5.32	0.89	10	0.22	-5.3
1							

Table 3.15 (continued)

Fleet : FLT18: RusSweptArea

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	0.19	0.14	0.18	-0.16	-0.01	0.16	-0.12	0.02	0.05	-0.07
4	-0.04	-0.08	0.02	-0.04	-0.24	-0.01	0.12	-0.02	0.1	0
5	0.15	-0.06	-0.14	-0.18	-0.23	-0.09	0.09	0.22	-0.12	0.17
6	0.14	-0.03	-0.18	-0.14	-0.03	-0.27	0.21	0.05	0.03	0.08
7	-0.57	-0.33	-0.01	-0.22	-0.05	-0.04	0.04	0.25	0.11	-0.16
8	-0.48	-0.59	0.01	-0.25	-0.04	-0.45	0.14	0.31	0.11	0.05
9	-0.76	-0.71	-0.14	-0.72	-0.22	-0.08	0.07	0.4	0.31	-0.06
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	6	7	8	9
Mean Log	-4.3816	-3.9758	-3.7383	-3.7231
S.E(Log q	0.1563	0.1671	0.2632	0.3419

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	0.53	2.998	9.39	0.91	10	0.12	-5.92
4	0.71	1.901	7.55	0.91	10	0.12	-5.31
5	0.71	1.144	7.07	0.79	10	0.2	-4.83

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
6	0.89	0.487	5.27	0.81	10	0.15	-4.38
7	0.96	0.148	4.31	0.72	10	0.18	-3.98
8	0.88	0.36	4.52	0.69	10	0.25	-3.74
9	0.82	0.831	4.78	0.83	10	0.29	-3.72
1							

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 2008

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT09: Ru	1	0	0	0	0	0	0
FLT15: Nc	1	0	0	0	0	0	0
FLT16: Nc	1	0	0	0	0	0	0
FLT18: Ru	1	0	0	0	0	0	0
P shrink	972097	0.3				0.917	1.973
F shrink:	3564466	1				0.083	0.989

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
1083239	0.29	13.9	2	48.156	1.88

1

Age 2 Catchability dependent on age and year class strength

Year class = 2007

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT09: Ru	1	0	0	0	0	0	0
FLT15: Nc	1	0	0	0	0	0	0
FLT16: Nc	1	0	0	0	0	0	0
FLT18: Ru	1	0	0	0	0	0	0
P shrink	615780	0.34				0.895	0.183
F shrink:	425486	1				0.105	0.254

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
592242	0.32	13.29	2	40.936	0.189

Table 3.15 (continued)

Age 3 Catchability dependent on age and year class strength							
Year class = 2006							
Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
FLT09: Ru	1	0	0	0	0	0	0
FLT15: No	378684	0.3	0	0	1	0.261	0.145
FLT16: No	499825	0.318	0	0	1	0.232	0.111
FLT18: Ru	393963	0.3	0	0	1	0.261	0.139
P shrink	442009	0.35				0.22	0.125
F shrink	451381	1				0.027	0.123
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of y	s.e	s.e		Ratio			
424117	0.16	0.05	5	0.347	0.13		
1							
Age 4 Catchability dependent on age and year class strength							
Year class = 2005							
Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
FLT09: Ru	1	0	0	0	0	0	0
FLT15: No	442955	0.213	0.014	0.07	2	0.29	0.092
FLT16: No	462439	0.224	0.046	0.21	2	0.266	0.088
FLT18: Ru	427439	0.213	0.022	0.1	2	0.29	0.095
P shrink	303224	0.34				0.138	0.131
F shrink	311246	1				0.016	0.128
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of y	s.e	s.e		Ratio			
418565	0.12	0.06	8	0.496	0.097		
Age 5 Catchability dependent on age and year class strength							
Year class = 2004							
Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
FLT09: Ru	1	0	0	0	0	0	0
FLT15: No	339437	0.175	0.036	0.21	3	0.287	0.202
FLT16: No	326001	0.188	0.092	0.49	3	0.25	0.21
FLT18: Ru	331439	0.175	0.045	0.25	3	0.287	0.207
P shrink	176027	0.28				0.164	0.36
F shrink	244970	1				0.012	0.271
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of y	s.e	s.e		Ratio			
298379	0.1	0.09	11	0.885	0.227		
1							
Age 6 Catchability constant w.r.t. time and dependent on age							
Year class = 2003							
Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
FLT09: Ru	1	0	0	0	0	0	0
FLT15: No	151894	0.153	0.137	0.89	4	0.341	0.245
FLT16: No	146506	0.162	0.155	0.96	4	0.306	0.253
FLT18: Ru	140078	0.153	0.05	0.33	4	0.341	0.263
F shrink	77871	1				0.012	0.433
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of y	s.e	s.e		Ratio			
144949	0.09	0.06	13	0.717	0.256		

Table 3.15 (continued)

Age 7 Catchability constant w.r.t. time and dependent on age										
Year class = 2002										
Fleet		Int	Ext	Var	N	Scaled	Estimated			
		s.e	s.e	Ratio		Weights	F			
FLT09: Ru	1	0	0	0	0	0	0			
FLT15: Nc	72363	0.145	0.039	0.27	5	0.335	0.231			
FLT16: Nc	72695	0.149	0.085	0.57	5	0.318	0.23			
FLT18: Ru	74525	0.145	0.073	0.51	5	0.335	0.225			
F shrink:	23725	1				0.012	0.584			
Weighted prediction :										
Survivors	Int	Ext	N	Var	F					
at end of y	s.e	s.e		Ratio						
72212	0.08	0.05	16	0.566	0.232					
1										
Age 8 Catchability constant w.r.t. time and dependent on age										
Year class = 2001										
Fleet		Int	Ext	Var	N	Scaled	Estimated			
		s.e	s.e	Ratio		Weights	F			
FLT09: Ru	1	0	0	0	0	0	0			
FLT15: Nc	26742	0.139	0.021	0.15	6	0.343	0.251			
FLT16: Nc	21030	0.148	0.063	0.43	6	0.302	0.309			
FLT18: Ru	25604	0.139	0.017	0.12	6	0.343	0.26			
F shrink:	7685	1				0.013	0.689			
Weighted prediction :										
Survivors	Int	Ext	N	Var	F					
at end of y	s.e	s.e		Ratio						
24121	0.08	0.04	19	0.536	0.275					
Age 9 Catchability constant w.r.t. time and dependent on age										
Year class = 2000										
Fleet		Int	Ext	Var	N	Scaled	Estimated			
		s.e	s.e	Ratio		Weights	F			
FLT09: Ru	10798	0.508	0	0	1	0.052	0.558			
FLT15: Nc	17664	0.155	0.078	0.5	6	0.235	0.376			
FLT16: Nc	18783	0.156	0.085	0.55	7	0.36	0.357			
FLT18: Ru	18715	0.154	0.06	0.39	7	0.334	0.359			
F shrink:	8160	1				0.019	0.688			
Weighted prediction :										
Survivors	Int	Ext	N	Var	F					
at end of y	s.e	s.e		Ratio						
17680	0.09	0.05	22	0.575	0.376					
1										
Age 10 Catchability constant w.r.t. time and dependent on age										
Year class = 1999										
Fleet		Int	Ext	Var	N	Scaled	Estimated			
		s.e	s.e	Ratio		Weights	F			
FLT09: Ru	8176	0.358	0.312	0.87	2	0.149	0.196			
FLT15: Nc	4824	0.174	0.051	0.3	6	0.195	0.313			
FLT16: Nc	4155	0.171	0.073	0.43	7	0.329	0.355			
FLT18: Ru	6237	0.171	0.082	0.48	7	0.298	0.25			
F shrink:	1966	1				0.03	0.642			
Weighted prediction :										
Survivors	Int	Ext	N	Var	F					
at end of y	s.e	s.e		Ratio						
5224	0.1	0.08	23	0.737	0.292					

Table 3.15 (continued)

Age 11 Catchability constant w.r.t. time and age (fixed at the value for age) 10										
Year class = 1998										
Fleet		Int	Ext	Var	N	Scaled	Estimated			
		s.e	s.e	Ratio		Weights	F			
FLT09: Ru	1892	0.238	0.246	1.03	3	0.452	0.349			
FLT15: No	2147	0.199	0.044	0.22	6	0.1	0.313			
FLT16: No	1941	0.2	0.043	0.21	7	0.22	0.341			
FLT18: Ru	2430	0.204	0.075	0.37	7	0.188	0.281			
F shrink	937	1				0.041	0.611			
Weighted prediction :										
Survivors	Int	Ext	N	Var	F					
at end of y	s.e	s.e		Ratio						
1963	0.13	0.07	24	0.5	0.338					
1										
Age 12 Catchability constant w.r.t. time and age (fixed at the value for age) 10										
Year class = 1997										
Fleet		Int	Ext	Var	N	Scaled	Estimated			
		s.e	s.e	Ratio		Weights	F			
FLT09: Ru	915	0.241	0.128	0.53	3	0.501	0.681			
FLT15: No	790	0.223	0.093	0.42	6	0.079	0.756			
FLT16: No	1118	0.215	0.04	0.19	7	0.186	0.587			
FLT18: Ru	893	0.221	0.092	0.41	7	0.156	0.693			
F shrink	2392	1				0.078	0.317			
Weighted prediction :										
Survivors	Int	Ext	N	Var	F					
at end of y	s.e	s.e		Ratio						
1008	0.15	0.07	24	0.443	0.636					
1										

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 19/04/2010 16:44

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1984	1985	1986	1987	1988	1989
AGE						
1	0.2457	0.3596	0.938	0.5269	0.8057	0.2162
2	0.0373	0.0577	0.8049	0.8032	0.1104	0.0009
3	0.0199	0.0533	0.1451	0.1142	0.0629	0.0327
4	0.1235	0.1701	0.2122	0.2285	0.1275	0.1284
5	0.3075	0.3763	0.4933	0.5097	0.3704	0.2674
6	0.6274	0.6051	0.7052	0.9363	0.5971	0.4016
7	1.1361	0.9248	0.948	1.1398	1.0446	0.7156
8	1.2111	1.0189	1.0909	1.0143	0.9834	0.8891
9	1.2623	0.7786	0.8281	0.7784	1.1591	0.7166
10	0.9579	0.5057	1.112	1.3241	1.718	0.9855
11	1.0876	0.4205	0.8745	1.027	1.5371	0.5821
12	1.0345	0.4665	1.0045	1.1899	1.6497	0.7917
+gp	1.0345	0.4665	1.0045	1.1899	1.6497	0.7917
0 FBAR 5	0.9171	0.7016	0.8629	0.9504	0.9788	0.6626

Table 8 Fishing mortality (F) at age

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	0.0964	0.102	0.4745	2.5985	1.7148	1.8671	1.9954	2.5173	1.6259	1.0928
2	0.0596	0.237	0.1454	0.4613	0.6638	0.9358	1.0584	1.089	0.6307	0.356
3	0.0086	0.0182	0.0405	0.0792	0.2132	0.4835	0.4716	0.3372	0.3772	0.1254
4	0.0622	0.0624	0.1265	0.0961	0.1987	0.2636	0.353	0.2996	0.3527	0.2098
5	0.1342	0.1875	0.2205	0.3465	0.3391	0.3381	0.4117	0.5693	0.5221	0.5481
6	0.2247	0.321	0.4428	0.4597	0.6456	0.5771	0.5426	0.7239	0.78	0.725
7	0.2504	0.4259	0.5396	0.5663	1.1681	0.8907	0.7494	0.8425	0.7722	0.8106
8	0.3742	0.3451	0.5993	0.5976	0.9863	0.9434	0.862	1.2336	1.0418	1.0593
9	0.3058	0.3805	0.4558	0.6665	1.0541	0.9617	0.7518	1.3352	1.1684	1.388
10	0.3242	0.256	0.4586	0.6631	1.0399	1.0192	0.9391	1.5092	1.2371	1.4088
11	0.54	0.134	0.2482	0.6763	1.1611	1.253	0.866	1.4402	1.3336	0.9253
12	0.4352	0.1959	0.3556	0.6759	1.1136	1.1498	0.9124	1.4942	1.3016	1.1813
+gp	0.4352	0.1959	0.3556	0.6759	1.1136	1.1498	0.9124	1.4942	1.3016	1.1813
0 FBAR 5	0.2689	0.3193	0.4528	0.55	0.8722	0.7884	0.7094	1.0356	0.9202	0.99
1										

Run title : Arctic Cod (run: XSAASA01/X01)

At 19/04/2010 16:44

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	FBAR **-**
AGE											
1	1.381	0.9477	0.6153	1.4084	0.9455	1.1106	0.938	0.8576	1.0373	1.8803	1.2584
2	0.2599	0.203	0.4098	0.2765	0.5769	0.2201	0.1172	0.2056	0.1461	0.1892	0.1803
3	0.0774	0.0624	0.1111	0.0487	0.0781	0.1806	0.0264	0.1335	0.1922	0.13	0.1519
4	0.1397	0.1167	0.1062	0.072	0.1029	0.1172	0.1461	0.1246	0.1475	0.0968	0.123
5	0.411	0.2852	0.2879	0.2758	0.2571	0.3911	0.2532	0.2822	0.1629	0.2274	0.2242
6	0.605	0.5199	0.5567	0.4718	0.5304	0.5604	0.4866	0.3212	0.2512	0.2556	0.276
7	0.7533	0.6728	0.8072	0.6802	0.7476	0.8199	0.6325	0.4109	0.2835	0.2316	0.3087
8	1.0375	0.8453	0.8983	0.7014	0.8852	0.7963	0.7828	0.4801	0.467	0.2745	0.4072
9	1.1876	0.894	0.8098	0.5892	0.8057	0.9241	0.7427	0.4744	0.4597	0.3763	0.4368
10	1.1559	1.1281	0.7478	0.5382	0.8984	0.8421	0.7509	0.2963	0.3945	0.2923	0.3277
11	1.078	0.8068	0.6722	0.4536	0.7384	0.8493	0.7064	0.4877	0.246	0.3385	0.3574
12	1.1304	0.9864	0.7553	0.7118	0.9862	0.6022	0.9434	0.6634	0.4279	0.6355	0.5756
+gp	1.1304	0.9864	0.7553	0.7118	0.9862	0.6022	0.9434	0.6634	0.4279	0.6355	
0 FBAR 5	0.8584	0.7242	0.6846	0.5428	0.6874	0.7223	0.6081	0.3775	0.3365	0.2763	
1											

Table 3.17. Northeast Arctic cod. Stock number at age

Run title : Arctic Cod (run: XSAASA01/X01)

At 19/04/2010 16:44

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
	AGE						
	1	211683	137580	175810	49274	82193	81870
	2	67035	135551	78615	56342	23818	30065
	3	40282	52874	104753	28778	20660	17463
	4	13543	32331	41043	74178	21020	15883
	5	7852	9800	22329	27180	48326	15149
	6	4763	4727	5507	11163	13367	27319
	7	2465	2082	2113	2227	3583	6023
	8	1304	648	676	670	583	1032
	9	923	318	192	186	199	179
	10	140	214	120	69	70	51
	11	39	44	106	32	15	10
	12	26	11	24	36	9	3
	+gp	12	21	13	16	8	6
0	TOT/	350068	376200	431301	250150	213851	195053

Table 10 Stock number at age (start of year) Numbers*10**-4

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
	1	151924	172884	300927	2421558	936294	2010885	2782456	1923214	667349	301070
	2	53998	112957	127823	153290	147476	137981	254494	309718	127031	107496
	3	24593	41652	72966	90491	79129	62172	44316	72304	85345	55352
	4	13838	19962	33488	57369	68449	52345	31388	22641	42252	47919
	5	11438	10646	15355	24159	42666	45942	32926	18056	13738	24311
	6	9492	8188	7226	10084	13987	24885	26824	17859	8365	6673
	7	14969	6207	4863	3800	5213	6005	11441	12765	7089	3140
	8	2411	9541	3320	2321	1766	1327	2017	4427	4501	2681
	9	347	1358	5532	1493	1045	539	423	698	1056	1300
	10	71	209	760	2871	628	298	169	163	150	269
	11	16	42	133	393	1211	182	88	54	30	36
	12	5	7	30	85	164	311	42	30	10	6
	+gp	4	2	5	19	23	42	162	53	17	11
0	TOT/	283106	383658	572428	2767933	1298051	2342913	3186747	2381983	956935	550264
	1										

Run title : Arctic Cod (run: XSAASA01/X01)

At 19/04/2010 16:44

Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-4

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	GMST 84-**	AMST 84-**
	AGE													
	1	329721	407485	109887	635029	272790	460283	390200	240071	301173	867236	0	343444	635518
	2	82647	67850	129316	48627	127133	86763	124116	125045	83377	87387	108324	96776	113133
	3	61646	52177	45344	70280	30196	58459	57005	90377	83354	58984	59224	51269	56609
	4	39976	46713	40135	33220	54807	22865	39953	45453	64750	56313	42412	34273	37949
	5	31807	28461	34033	29548	25308	40484	16649	28265	32853	45744	41856	22433	25184
	6	11506	17265	17520	20893	18360	16023	22416	10582	17451	22854	29838	12269	13958
	7	2646	5144	8405	8220	10672	8844	7490	11281	6284	11114	14495	5535	6529
	8	1143	1020	2149	3070	3409	4137	3190	3258	6125	3875	7221	1970	2525
	9	761	332	359	717	1246	1152	1528	1194	1650	3144	2412	665	961
	10	266	190	111	131	326	456	374	595	608	853	1768	219	363
	11	54	68	50	43	62	109	161	145	362	336	522	66	130
	12	12	15	25	21	22	24	38	65	73	232	196	23	43
	+gp	4	6	7	14	11	13	40	21	25	27	113		
0	TOT/	562188	626726	387340	849812	544343	699612	663160	556353	598086	1158098	308382		
	1													

Table 3.18. Northeast Arctic cod. Natural mortality used in final VPA.

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

At 22/04/2010 19:53

Table 4 Natural Mortality (M) at age

YEAR	1946	1947	1948	1949
AGE				
3	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2
10	0.2	0.2	0.2	0.2
11	0.2	0.2	0.2	0.2
12	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2

Table 4 Natural Mortality (M) at age

YEAR	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
AGE										
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	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	0.2	0.2
6	0.2	0.2	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	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
1										

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

At 22/04/2010 19:53

Table 4 Natural Mortality (M) at age

YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
AGE										
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	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	0.2	0.2
6	0.2	0.2	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	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	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	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	0.2	0.2
6	0.2	0.2	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	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 3.18 (continued).

Table 4	Natural Mortality (M) at age									
YEAF	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	0.2	0.2	0.2	0.2	0.2006	0.2004	0.3123	0.2587	0.2087	0.2
4	0.2	0.2	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	0.2	0.2
6	0.2	0.2	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	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									
YEAF	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
3	0.2	0.2049	0.2067	0.2664	0.4031	0.6726	0.6477	0.5141	0.5276	0.3095
4	0.2	0.2	0.2	0.2028	0.2929	0.3613	0.4327	0.2935	0.2768	0.2111
5	0.2	0.2	0.2	0.2024	0.2259	0.2111	0.2812	0.2103	0.2164	0.2
6	0.193	0.2	0.2	0.2	0.2047	0.2014	0.206	0.202	0.2096	0.2
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									
YEAF	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
3	0.2686	0.2514	0.3051	0.237	0.2702	0.3686	0.2096	0.3002	0.3799	0.3203
4	0.2417	0.2289	0.2162	0.2	0.2218	0.216	0.2057	0.2113	0.2526	0.2171
5	0.2168	0.2079	0.2032	0.2	0.2054	0.2179	0.2005	0.2001	0.2147	0.2005
6	0.2006	0.2072	0.2002	0.2	0.2003	0.2048	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	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
1										

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	0.2457	0.0356	0.0006	0.0000	0.0000	0.0000
1985	0.3590	0.0562	0.0004	0.0000	0.0000	0.0000
1986	0.9368	0.8010	0.1123	0.0000	0.0000	0.0000
1987	0.5266	0.8017	0.0584	0.0000	0.0000	0.0000
1988	0.8044	0.1094	0.0087	0.0000	0.0000	0.0000
1989	0.2145	0.0000	0.0000	0.0000	0.0000	0.0000
1990	0.0961	0.0590	0.0000	0.0000	0.0000	0.0000
1991	0.1038	0.2373	0.0050	0.0000	0.0000	0.0000
1992	0.4681	0.1450	0.0067	0.0000	0.0000	0.0000
1993	2.5644	0.4482	0.0660	0.0028	0.0024	0.0000
1994	1.7157	0.6312	0.1997	0.0940	0.0259	0.0047
1995*	1.8681	0.9350	0.5392	0.1859	0.0111	0.0014
1996	1.9892	1.0545	0.4450	0.2321	0.0812	0.0060
1997	2.5175	1.0927	0.3145	0.0932	0.0103	0.0020
1998	1.6230	0.6371	0.3360	0.0795	0.0168	0.0098
1999	1.1053	0.3576	0.1022	0.0106	0.0000	0.0000
2000	1.3809	0.2596	0.0686	0.0417	0.0168	0.0006
2001	0.9477	0.2026	0.0514	0.0289	0.0079	0.0072
2002	0.6152	0.4096	0.1051	0.0162	0.0032	0.0002
2003	1.4084	0.2760	0.0370	0.0000	0.0000	0.0000
2004	0.9464	0.5766	0.0702	0.0218	0.0054	0.0003
2005	1.1146	0.2194	0.1686	0.0160	0.0179	0.0048
2006	0.9403	0.1161	0.0097	0.0057	0.0005	0.0000
2007	0.8616	0.2037	0.1001	0.0113	0.0001	0.0000
2008	1.0389	0.1462	0.1806	0.0526	0.0147	0.0000
2009	1.8824	0.1886	0.1209	0.0180	0.0006	0.0000

* corrected data on cod consumption

Table 3.20. Northeast Arctic cod. Fishing mortality, final VPA

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

At 22/04/2010 19:53

Traditional vpa using file input for terminal F

Table 8 Fishing mortality (F) at age

YEAR	1946	1947	1948	1949
AGE				
3	0.0061	0.0018	0.0003	0.0023
4	0.02	0.0249	0.0124	0.0209
5	0.0532	0.1101	0.0751	0.1484
6	0.0973	0.2024	0.1997	0.3662
7	0.1781	0.416	0.5201	0.5101
8	0.1932	0.2545	0.3536	0.3869
9	0.3125	0.4047	0.5286	0.3832
10	0.2798	0.4405	0.3617	0.3766
11	0.3432	0.7827	0.5536	0.6259
12	0.312	0.6182	0.4604	0.5039
+gp	0.312	0.6182	0.4604	0.5039
0 FBAR 5	0.1857	0.3047	0.3398	0.3619

Table 8 Fishing mortality (F) at age

YEAR	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
AGE										
3	0.002	0.0254	0.0225	0.0334	0.0199	0.0159	0.027	0.024	0.0718	0.0535
4	0.0321	0.1612	0.1667	0.1325	0.1457	0.084	0.1291	0.1128	0.2589	0.2564
5	0.1167	0.2637	0.37	0.2299	0.2676	0.2859	0.4568	0.2094	0.3626	0.5093
6	0.2882	0.2787	0.5501	0.3125	0.3333	0.5297	0.69	0.4862	0.5517	0.5121
7	0.4096	0.4122	0.5311	0.3243	0.3969	0.5139	0.6129	0.5494	0.5357	0.5251
8	0.348	0.4046	0.4175	0.3469	0.2494	0.588	0.688	0.6287	0.4593	0.5111
9	0.4741	0.5057	0.579	0.3932	0.4364	0.5805	0.6551	0.5463	0.4535	0.6141
10	0.5031	0.5149	0.7613	0.5364	0.6441	0.7645	0.738	0.6333	0.7388	0.686
11	0.9031	0.4585	1.026	0.698	0.8035	0.7621	0.8756	0.8584	0.8415	0.6511
12	0.7111	0.4879	0.9056	0.6217	0.7304	0.7704	0.8152	0.7529	0.799	0.6734
+gp	0.7111	0.4879	0.9056	0.6217	0.7304	0.7704	0.8152	0.7529	0.799	0.6734
0 FBAR 5	0.3566	0.3966	0.5348	0.3572	0.3879	0.5437	0.6401	0.5089	0.5169	0.5596
1										

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

At 22/04/2010 19:53

Traditional vpa using file input for terminal F

Table 8 Fishing mortality (F) at age

YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
AGE										
3	0.0543	0.0562	0.0663	0.0313	0.0174	0.0226	0.0398	0.0298	0.0251	0.023
4	0.2266	0.2717	0.3063	0.2366	0.1449	0.111	0.1037	0.1525	0.2064	0.2292
5	0.3477	0.4944	0.6498	0.742	0.3537	0.3909	0.2119	0.1814	0.4087	0.4792
6	0.4607	0.5168	0.8279	1.0069	0.4854	0.4494	0.3818	0.2026	0.4683	0.5382
7	0.4363	0.5279	0.6094	0.9764	0.5787	0.4033	0.4713	0.432	0.4019	0.7725
8	0.4855	0.6931	0.6564	0.8798	0.7409	0.5303	0.5797	0.6844	0.5291	0.9302
9	0.4053	0.7389	0.8167	0.9416	1.0674	0.7389	0.7183	0.8781	0.8041	1.1783
10	0.7381	0.8379	0.9855	1.3731	0.8476	0.8074	0.8182	0.885	0.8105	1.0769
11	0.8449	1.0011	0.9522	1.4366	1.2968	0.7617	0.5024	1.2253	0.6772	1.5554
12	0.7981	0.9284	0.9756	1.4264	1.0883	0.7927	0.6634	1.0696	0.7458	1.3377
+gp	0.7981	0.9284	0.9756	1.4264	1.0883	0.7927	0.6634	1.0696	0.7458	1.3377
0 FBAR 5	0.4789	0.6348	0.7576	0.9866	0.6789	0.5533	0.5302	0.5439	0.5704	0.8292

Table 8 Fishing mortality (F) at age

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
3	0.0409	0.0214	0.0394	0.1959	0.2141	0.0837	0.166	0.1338	0.146	0.0489
4	0.1422	0.1028	0.1673	0.1996	0.4959	0.2106	0.3121	0.5671	0.2234	0.209
5	0.4004	0.2285	0.2976	0.3536	0.5375	0.5211	0.48	0.7544	0.6703	0.3475
6	0.568	0.2517	0.3849	0.3917	0.5078	0.7021	0.5715	0.6857	0.8497	0.5478
7	0.6211	0.5144	0.3427	0.421	0.4451	0.705	0.6973	0.6763	0.8581	0.6643
8	0.8479	0.833	0.6583	0.7375	0.4863	0.7032	0.8908	0.9121	0.9296	0.7789
9	0.9682	0.9584	1.1338	0.9698	0.5192	0.6109	0.7746	1.2298	1.3057	1.0352
10	1.09	0.7876	1.3393	0.7386	0.8842	0.7149	0.46	0.7689	1.0301	0.9848
11	0.8533	0.8388	1.2904	0.7222	0.9905	0.9079	0.6132	0.6231	1.8042	1.4314
12	0.9829	0.8179	1.3377	0.7358	0.9492	0.8218	0.5389	0.6958	1.4375	1.2219
+gp	0.9829	0.8179	1.3377	0.7358	0.9492	0.8218	0.5389	0.6958	1.4375	1.2219
0 FBAR 5	0.7493	0.5956	0.6928	0.602	0.5633	0.6595	0.6457	0.8379	0.9406	0.7264

Table 3.20 (continued).

Table 8	Fishing mortality (F) at age									
YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	0.0318	0.0252	0.0672	0.0208	0.0194	0.0533	0.033	0.0558	0.0546	0.033
4	0.1296	0.1003	0.2121	0.205	0.1247	0.1716	0.2133	0.2293	0.1282	0.1292
5	0.3562	0.23	0.3045	0.3308	0.3096	0.3788	0.496	0.5104	0.371	0.2685
6	0.6225	0.5163	0.5518	0.5033	0.6301	0.6078	0.7078	0.9362	0.5974	0.4024
7	0.6766	0.8475	0.7996	0.7821	1.135	0.9264	0.9487	1.1362	1.0411	0.7142
8	0.7123	1.0788	0.9846	1.0295	1.2083	1.0191	1.091	1.0143	0.9788	0.8851
9	0.939	1.2764	1.1588	0.9701	1.2572	0.7818	0.8325	0.7841	1.1546	0.7134
10	1.038	1.2299	0.7507	0.9203	0.9564	0.5088	1.1134	1.3245	1.7027	0.9791
11	1.4798	0.9557	0.9516	0.5853	1.081	0.4237	0.8774	1.0329	1.5282	0.581
12	1.2775	1.1082	0.8607	0.759	1.0345	0.4665	1.0045	1.1899	1.6497	0.7917
+gp	1.2775	1.1082	0.8607	0.759	1.0345	0.4665	1.0045	1.1899	1.6497	0.7917
0 FBAR 5	0.7241	0.8632	0.7583	0.756	0.9161	0.7038	0.8649	0.951	0.9743	0.6604

Table 8	Fishing mortality (F) at age									
YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
3	0.0087	0.0134	0.0341	0.0129	0.0102	0.011	0.024	0.0232	0.0497	0.016
4	0.0627	0.0631	0.1276	0.0942	0.1066	0.103	0.1209	0.2072	0.277	0.1998
5	0.1352	0.1888	0.2226	0.3463	0.3152	0.329	0.3323	0.5608	0.5071	0.549
6	0.2332	0.3228	0.4449	0.4635	0.6433	0.5784	0.5394	0.7235	0.7713	0.7254
7	0.2518	0.4277	0.5417	0.5693	1.1663	0.8921	0.7533	0.8451	0.7748	0.8119
8	0.3755	0.347	0.6013	0.6009	0.9866	0.9447	0.8658	1.2334	1.0443	1.0599
9	0.3067	0.3823	0.4585	0.6697	1.0542	0.9632	0.7576	1.3333	1.1699	1.384
10	0.3242	0.2572	0.4612	0.6668	1.041	1.0203	0.9435	1.5067	1.2346	1.4047
11	0.5377	0.1345	0.2497	0.6797	1.161	1.2493	0.8715	1.4387	1.332	0.9272
12	0.4352	0.1959	0.3556	0.6759	1.1136	1.1498	0.9124	1.4942	1.3016	1.1813
+gp	0.4352	0.1959	0.3556	0.6759	1.1136	1.1498	0.9124	1.4942	1.3016	1.1813
0 FBAR 5	0.2711	0.321	0.455	0.5528	0.8678	0.788	0.6987	1.0338	0.917	0.9892

Table 8	Fishing mortality (F) at age										
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	FBAR **-**
AGE											
3	0.0088	0.0111	0.0061	0.0118	0.008	0.012	0.0169	0.0333	0.0123	0.0097	0.0184
4	0.0987	0.0884	0.0907	0.0725	0.0815	0.1015	0.1406	0.1135	0.095	0.0797	0.0961
5	0.3957	0.2789	0.2861	0.2773	0.2527	0.3735	0.2528	0.282	0.1484	0.2269	0.2191
6	0.6055	0.5144	0.558	0.4734	0.5314	0.5552	0.4861	0.3209	0.2511	0.2556	0.2759
7	0.7537	0.6741	0.8066	0.6815	0.7473	0.818	0.6308	0.4108	0.2835	0.2316	0.3086
8	1.0355	0.8442	0.897	0.7021	0.8844	0.7948	0.7794	0.4793	0.4664	0.2745	0.4067
9	1.1854	0.8928	0.8081	0.5913	0.8054	0.9211	0.7405	0.4737	0.4586	0.3763	0.4362
10	1.1519	1.1235	0.7481	0.5391	0.8983	0.8407	0.7483	0.2974	0.3942	0.2923	0.328
11	1.0771	0.8063	0.6725	0.4567	0.7373	0.8502	0.706	0.4873	0.2474	0.3385	0.3577
12	1.1304	0.9864	0.7553	0.7118	0.9862	0.6022	0.9434	0.6634	0.4279	0.6355	0.5756
+gp	1.1304	0.9864	0.7553	0.7118	0.9862	0.6022	0.9434	0.6634	0.4279	0.6355	
0 FBAR 5	0.8546	0.7213	0.684	0.5441	0.6866	0.7172	0.6063	0.3774	0.3337	0.2762	
1											

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	0.0555	0.2285	0.5097	0.9363
1988	0.0000	0.0009	0.0542	0.1275	0.3704	0.5971
1989	0.0000	0.0009	0.0327	0.1284	0.2674	0.4016
1990	0.0000	0.0004	0.0086	0.0622	0.1342	0.2317
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	0.0933	0.3441	0.4597
1994	0.0000	0.0003	0.0101	0.1058	0.3132	0.6409
1995	0.0000	0.0003	0.0109	0.1023	0.3270	0.5757
1996	0.0000	0.0006	0.0239	0.1203	0.3305	0.5366
1997	0.0000	0.0007	0.0231	0.2061	0.5590	0.7219
1998	0.0000	0.0019	0.0496	0.2759	0.5057	0.7704
1999	0.0000	0.0004	0.0159	0.1987	0.5481	0.7250
2000	0.0000	0.0003	0.0088	0.0980	0.3942	0.6044
2001	0.0000	0.0004	0.0110	0.0878	0.2773	0.5127
2002	0.0001	0.0001	0.0060	0.0900	0.2847	0.5565
2003	0.0000	0.0005	0.0117	0.0720	0.2758	0.4718
2004	0.0000	0.0002	0.0079	0.0811	0.2517	0.5301
2005	0.0000	0.0006	0.0120	0.1012	0.3732	0.5556
2006	0.0000	0.0011	0.0168	0.1404	0.2527	0.4866
2007	0.0010	0.0026	0.0333	0.1133	0.2821	0.3212
2008	0.0000	0.0009	0.0123	0.0949	0.1482	0.2512
2009	0.0000	0.0005	0.0097	0.0797	0.2269	0.2556

Table 3.22. Northeast Arctic cod. Stock number at age. Final VPA

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

At 22/04/2010 19:53

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
	AGE				
	3	728139	425311	442592	468348
	4	577860	592530	347574	362238
	5	402060	463732	473210	281072
	6	197212	312115	340097	359415
	7	93323	146496	208708	228044
	8	96213	63939	79121	101579
	9	244722	64933	40588	45487
	10	101777	146581	35470	19586
	11	38117	62991	77255	20227
	12	39205	22142	23578	36361
	+gp	33324	42765	37377	21337
0	TOT	2551952	2343535	2105569	1943694

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

	YEAR	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
	AGE										
	3	704908	1083753	1193111	1590377	641584	272778	439602	804781	496824	683690
	4	382556	575973	865011	955076	1259285	514924	219807	350332	643259	378598
	5	290427	303320	401364	599477	684912	891184	387619	158175	256234	406511
	6	198391	211595	190765	226975	389987	429102	548181	200984	105033	145989
	7	204032	121764	131099	90099	135956	228785	206850	225110	101196	49529
	8	112107	110900	66016	63110	53333	74845	112048	91748	106395	48488
	9	56484	64808	60583	35603	36525	34028	34036	46105	40060	55027
	10	25387	28785	32000	27799	19673	19329	15591	14474	21860	20840
	11	11003	12568	14083	12237	13311	8459	7368	6103	6291	8550
	12	8856	3651	6506	4133	4985	4880	3232	2513	2118	2220
	+gp	21133	13989	3938	1880	2707	2738	3722	1687	857	1142
0	TOT	2015284	2531108	2964476	3606766	3242259	2481052	1978057	1902013	1780129	1800584
	1										

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

At 22/04/2010 19:53

Traditional vpa using file input for terminal F

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

	YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
	AGE										
	3	789653	916842	728338	472064	338678	776941	1582560	1295416	164955	112039
	4	530599	612324	709603	558039	374580	272501	621906	1245195	1029477	131705
	5	239862	346346	382037	427678	360621	265306	199663	458995	875269	685697
	6	199996	138702	172949	163321	166726	207288	146941	132256	313440	476187
	7	71623	103298	67732	61876	48854	84015	108284	82121	88421	160667
	8	23986	37908	49883	30149	19083	22424	45954	55340	43651	48433
	9	23813	12084	15518	21185	10240	7448	10803	21072	22854	21054
	10	24380	13000	4726	5614	6764	2883	2913	4313	7170	8373
	11	8592	9541	4605	1444	1164	2373	1053	1052	1457	2610
	12	3650	3022	2871	1455	281	261	907	522	253	606
	+gp	1351	2332	1351	1113	1278	670	351	461	498	278
0	TOT	1917505	2195401	2139612	1743938	1328269	1642109	2721334	3296742	2547445	1647648

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

	YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
	AGE										
	3	197105	404774	1015319	1818949	523916	621616	613942	348054	638490	198490
	4	89647	154909	324399	799193	1224278	346265	468089	425778	249276	451722
	5	85743	63671	114439	224670	535936	610486	229669	280485	197708	163230
	6	347649	47037	41482	69576	129164	256342	296843	116349	108004	82807
	7	227600	161288	29940	23112	38504	63643	104000	137232	47987	37806
	8	60756	100131	78947	17401	12421	20199	25746	42398	57130	16658
	9	15642	21306	35642	33463	6815	6253	8186	8650	13943	18463
	10	5306	4863	6690	9391	10388	3320	2779	3089	2070	3093
	11	2335	1461	1811	1435	3673	3513	1330	1436	1172	605
	12	451	815	517	408	571	1117	1160	590	631	158
	+gp	312	421	697	408	525	550	572	583	1198	218
0	TOT	1032545	960676	1649883	2998007	2486189	1933304	1752317	1364643	1317608	973250

Table 3.22 (continued).

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

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	137735	150868	151830	166831	397831	523674	1038825	285293	204644	172782
4	154747	109237	120444	116234	133783	319254	406348	735514	208318	157268
5	300088	111295	80899	79769	77525	96695	220157	268787	478807	150027
6	94414	172067	72401	48848	46916	46570	54207	109763	132093	270501
7	39202	41481	84063	34138	24176	20455	20763	21867	35238	59509
8	15929	16316	14551	30937	12785	6362	6632	6583	5747	10186
9	6259	6397	4542	4451	9048	3127	1880	1824	1954	1768
10	5368	2004	1461	1167	1381	2107	1171	669	682	504
11	946	1557	480	565	381	435	1037	315	146	102
12	118	176	490	152	258	106	233	353	92	26
+gp	87	66	70	170	116	209	130	156	82	56
0 TOT	754893	611465	531231	483261	704200	1018993	1751382	1431123	1067803	822728

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

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
3	242750	411766	721185	894434	781468	613875	438206	715163	844814	547772
4	136871	197021	331007	566869	676449	516912	309891	223856	417894	474298
5	113154	105247	151441	238541	421224	453666	324922	178140	135679	240198
6	93906	80927	71340	99245	137805	245189	264341	175921	82393	65809
7	148105	61322	47980	37433	51114	59020	112414	125445	69725	30896
8	23854	94265	32734	22853	17344	13037	19802	43331	44113	26304
9	3442	13417	54551	14689	10259	5294	4150	6821	10335	12711
10	709	2074	7495	28238	6156	2927	1654	1593	1472	2626
11	155	420	1313	3869	11868	1780	864	527	289	351
12	47	74	301	837	1605	3043	418	296	102	62
+gp	40	25	48	191	232	418	1624	532	174	112
0 TOT	763033	966557	1419394	1907199	2115525	1915161	1478285	1471624	1606989	1401140

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

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	GMST 46-**	AMST 46-**
AGE													
3	610255	516555	449404	697062	300161	581337	566885	899016	830932	588966	0	502228	606393
4	395566	462412	397295	329226	543541	227271	397305	452011	644052	561348	423422	377382	454215
5	314480	281437	336695	292297	250704	401325	165442	281021	326645	454928	417190	260526	311233
6	113571	170453	172973	206415	181363	158566	222165	105146	173527	227181	296705	150016	180068
7	26085	50720	82838	81042	105265	87251	74155	111863	62452	110522	144048	74027	91332
8	11231	10051	21163	30273	33564	40821	31526	32311	60729	38511	71781	32261	42952
9	7462	3265	3538	7066	12282	11349	15096	11839	16381	31187	23961	13396	23262
10	2608	1867	1095	1291	3203	4494	3699	5894	6036	8478	17527	5173	12192
11	528	675	497	424	616	1068	1587	1433	3584	3332	5182	1911	6217
12	114	147	247	208	220	241	374	641	721	2291	1944	694	3155
+gp	42	61	74	139	109	126	402	207	255	272	1111		
0 TOT	1481941	1497643	1465819	1645442	1431027	1513847	1478635	1901382	2125314	2027016	1402871		
1													

Table 3.23. Northeast Arctic cod. Stock biomass at age. Final VPA

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

At 22/04/2010 19:53

Traditional vpa using file input for terminal F

Table 12 Stock biomass at age (start of year) Tonnes

	YEAR	1946	1947	1948	1949
	AGE				
	3	254849	136099	150481	173289
	4	340937	331817	184214	242699
	5	446286	440545	596245	311990
	6	333289	468173	656387	596629
	7	221176	313502	513421	570111
	8	304996	186702	265846	328099
	9	973994	237005	171279	185131
	10	513974	668411	188345	103218
	11	225651	367868	457348	121160
	12	282275	164292	167165	257435
	+gp	271456	378386	315087	175349
0	TOTAL	4168882	3692801	3665819	3065111

Table 12 Stock biomass at age (start of year) Tonnes

	YEAR	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
	AGE										
	3	274914	433501	524969	636151	282297	87289	145069	265578	168920	239291
	4	244836	478058	692009	725857	969649	293507	127488	206696	334495	272591
	5	374651	421615	533814	767331	862989	1007038	414753	161338	243423	597571
	6	337265	397799	366270	438062	768275	742347	1003170	365792	201664	391251
	7	481515	309280	346101	253178	411947	629160	597796	650567	297518	177809
	8	390132	383714	244919	234769	230934	294890	476204	392683	447924	209470
	9	255308	316264	306548	180151	197233	166739	188902	253117	224738	299899
	10	142673	149682	193600	176245	132792	136079	113501	108698	160673	134210
	11	70420	89737	104495	90555	103693	60902	58944	50286	54540	61300
	12	70497	30013	54844	35831	53190	42844	26988	23247	20287	19159
	+gp	187892	131347	40110	19247	26204	27591	37015	17892	9967	13275
0	TOTAL	2830103	3141009	3407679	3557376	4039204	3488383	3189831	2495895	2164149	2415826
	1										

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

At 22/04/2010 19:53

Traditional vpa using file input for terminal F

Table 12 Stock biomass at age (start of year) Tonnes

	YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
	AGE										
	3	268482	284221	233068	151061	111764	295238	696327	375671	54435	49297
	4	270606	336778	390282	340404	206019	185301	460210	1008608	720634	104047
	5	261449	363663	355294	410571	342590	273265	235602	619644	1295399	843407
	6	425991	305145	294013	282545	310111	308859	261555	269803	664492	966659
	7	242086	333654	205229	188104	158775	202475	266378	230760	277642	465934
	8	116810	193710	250910	149537	94841	78931	175545	192584	183771	184531
	9	145737	74320	101645	136428	65640	42675	57905	103040	120443	105690
	10	206985	105953	36390	44408	54588	21740	21174	30662	47678	53839
	11	66934	82819	42684	13894	10875	20098	9087	9500	13129	21742
	12	30297	29013	30314	16454	2856	2911	9669	5524	2444	6492
	+gp	15429	27875	17178	14173	16470	9201	4967	6369	7389	3953
0	TOTAL	2050805	2137149	1957006	1747579	1374529	1440693	2198418	2852164	3387455	2805591

Table 12 Stock biomass at age (start of year) Tonnes

	YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
	AGE										
	3	72929	182148	385821	691201	167653	254863	214880	170547	312860	69471
	4	81578	136320	249787	727266	808024	221610	341705	383200	201913	316206
	5	114895	87866	163647	345992	627045	677639	273307	401093	286676	202406
	6	695298	101599	87943	157241	286743	487049	596655	238515	232208	177208
	7	682799	495154	96707	76038	123596	187748	287041	452865	145879	119088
	8	252138	422555	345787	80219	54527	88269	108649	193334	254800	71461
	9	87437	123791	207793	219854	37616	35894	48132	55876	91184	121484
	10	40323	34676	50977	78601	81651	29113	25849	26656	16521	26635
	11	20948	12590	17245	15127	36074	34848	13669	14264	11898	5579
	12	4958	8822	6248	4742	6512	13192	13760	6427	6843	1720
	+gp	4396	5449	9529	5674	6947	7206	7750	7970	15783	3124
0	TOTAL	2057698	1610969	1621485	2401955	2236387	2037430	1931396	1950748	1576565	1114381

Table 3.23 (continued).

	Table 12	Stock biomass at age (start of year)			Tonnes					
	YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	AGE										
	3	37188	73926	56177	61727	167089	216277	323075	60197	43385	51662
	4	86659	107052	79493	106936	155188	279347	357586	366286	84160	81779
	5	306090	160265	109213	127630	140320	155003	323630	337058	378258	130224
	6	162392	359620	144077	119188	130896	130862	133728	224685	251374	399530
	7	118389	123613	246304	130406	91385	83027	81286	75026	104902	159840
	8	66900	79133	61698	147262	58429	37111	38530	33816	25242	47139
	9	36552	42028	29340	27463	55823	24029	12370	11896	15268	12462
	10	38975	18354	12436	8986	10636	21316	8004	6226	8256	5034
	11	8362	16843	5870	5224	3521	6210	11412	4142	1910	941
	12	1099	1899	5283	1645	2794	1346	2965	4496	1169	330
	+gp	1256	924	979	2209	1514	2984	1863	2226	1181	798
0	TOTAL	863862	983658	750871	738675	817596	957513	1294449	1126053	915105	889738

	Table 12	Stock biomass at age (start of year)			Tonnes					
	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
	3	96614	213295	317321	307685	183645	123389	85450	144463	183325	111198
	4	96494	223815	308167	664370	509366	250702	150917	116629	222737	246635
	5	133748	183445	274411	434145	598138	517179	315499	192213	157523	281992
	6	161424	196490	193760	280169	332522	519311	542957	330380	159760	133658
	7	364043	197088	186881	150892	195513	204798	396484	422624	205340	93738
	8	85040	427776	169433	125624	93936	64375	108968	228050	201772	117420
	9	16210	92306	369528	99374	68029	37907	32232	60888	76714	82395
	10	5534	22227	71933	242026	46970	26692	16807	19359	15260	26970
	11	1389	3966	16313	41966	96272	17977	9217	5908	3393	3816
	12	593	944	3826	10659	20437	38740	5319	3767	1304	795
	+gp	578	354	682	2733	3325	5988	23239	7614	2485	1609
0	TOTAL	961667	1561708	1912257	2359644	2148154	1807057	1687088	1531894	1229614	1100226

	Table 12	Stock biomass at age (start of year)			Tonnes					
	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
	3	118390	147218	112800	160324	75040	134289	145123	235542	237647	153131
	4	183938	241379	240364	176794	296773	141817	239178	315956	472734	359824
	5	379892	336598	400330	382909	272515	448682	198696	376849	447503	610968
	6	223962	381645	369816	414688	369074	306349	446329	223015	410739	536146
	7	79507	168036	276100	262657	307478	265766	230917	354271	205468	415896
	8	46003	51443	100864	150485	147144	161446	139564	149922	292716	196830
	9	42711	20816	24266	47617	76812	65946	91027	76891	107260	204402
	10	19446	17254	10215	11240	27359	37249	29727	53770	51201	77132
	11	5057	7639	5063	6372	6002	14351	15758	16880	31906	31424
	12	1446	1874	3140	2644	2800	3074	4756	8166	9175	29170
	+gp	595	867	1059	1992	1561	1797	5754	2963	3648	3887
0	TOTAL	1100947	1374769	1544017	1617723	1582559	1580766	1546829	1814225	2269997	2618810
	1										

Table 3.24. Northeast Arctic cod. Spawning stock biomass at age

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

At 22/04/2010 19:53

Traditional vpa using file input for terminal F

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR	1946	1947	1948	1949
AGE				
3	0	0	0	0
4	0	0	0	0
5	4463	4405	5962	3120
6	9999	14045	19692	17899
7	13271	18810	35939	51310
8	33550	24271	34560	55777
9	175319	37921	42820	53688
10	226148	280733	88522	55738
11	146673	275901	333864	95716
12	242756	149506	152120	226543
+gp	260598	359467	305634	170088
0 TOTSP	1112776	1165059	1019114	729879

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	3747	4216	5338	7673	8630	10070	4148	1613	2434	5976
6	10118	11934	10988	13142	23048	22270	30095	10974	6050	15650
7	43336	30928	27688	17722	32956	44041	35868	39034	17851	21337
8	89730	92091	53882	44606	36949	38336	57144	35341	44792	71220
9	89358	126506	125685	72060	72976	43352	26446	30374	22474	146950
10	74190	86815	121968	112796	90299	72122	46535	23914	48202	89921
11	55632	64611	85686	76066	90213	50549	39492	30172	27270	51492
12	66972	25511	50457	33681	49467	39416	24559	19063	16635	16668
+gp	182256	126093	38907	18670	25156	26763	35534	17356	9668	13275
0 TOTSP	615339	568705	520599	396417	429694	346919	299823	207840	195377	432489
1										

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

At 22/04/2010 19:53

Traditional vpa using file input for terminal F

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	2706	0	0	3404	0	0	0	0	0	0
5	7843	3637	3553	4106	0	0	2356	0	38862	0
6	25559	18309	14701	8476	9303	3089	5231	8094	33225	19333
7	24209	40038	30784	13167	20641	12149	15983	16153	24988	18637
8	22194	60050	85309	41870	35091	15786	38620	26962	34917	22144
9	65582	48308	62004	57300	43323	23471	20267	39155	46973	35935
10	142819	96417	29476	35970	48583	15870	15669	19624	27653	29611
11	51539	81163	39269	13616	10332	19897	8542	8455	10766	16089
12	25753	28433	29404	16125	2828	2853	9089	4972	2444	6167
+gp	15274	27875	17178	14173	16470	9201	4967	6369	7389	3953
0 TOTSP	383479	404228	311678	208207	186570	102315	120722	129784	227215	151870

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
3	0	0	3858	0	0	0	0	0	0	0
4	816	0	4996	0	0	0	0	0	0	0
5	0	879	3273	0	0	6776	0	8022	0	0
6	6953	5080	879	3145	2867	9741	29833	19081	4644	5316
7	47796	54467	9671	12166	3708	16897	34445	117745	18964	15481
8	57992	126766	117567	42516	11451	18536	31508	104400	112112	27870
9	50714	73036	132988	178082	18808	20100	21659	42466	64741	93543
10	32662	27394	41292	72313	78385	22708	21713	23191	12721	23705
11	18644	10827	16210	14370	36074	27530	11345	13266	9637	4630
12	4512	7763	6248	4647	6251	12532	13760	6041	6090	1342
+gp	4396	5449	9529	5674	6947	7206	6975	7173	12626	2812
0 TOTSP	224482	311662	346511	332913	164491	142028	171238	341385	241536	174699

Table 3.24 (continued).

Table 13	Spawning stock biomass at age (spawning time)				Tonnes					
YEAF	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	0	0	0	617	0	0	0	0	0	413
4	0	0	3975	8555	7759	2793	17879	3663	1683	245
5	0	3205	10921	12763	25258	13950	25890	23594	18913	3776
6	3248	25173	48986	35756	40578	47110	25408	40443	82953	91093
7	15391	24723	160097	95196	51176	45665	43081	16506	55598	87433
8	23415	42732	50592	129590	52586	31544	27356	15555	15650	33233
9	23759	33622	26992	26639	55265	23068	7669	5948	15268	11403
10	31960	17804	12436	8986	10636	19184	7204	4670	8256	5034
11	8362	16843	5870	5224	3521	6210	11412	4142	1910	941
12	989	1899	5283	1645	2794	1346	2965	4496	1169	330
+gp	1130	924	979	2209	1514	2984	1863	2226	1181	798
0 TOTSF	108253	166926	326133	327181	251087	193856	170729	121243	202582	234698

Table 13	Spawning stock biomass at age (spawning time)				Tonnes					
YEAF	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
3	773	213	317	0	551	0	0	0	183	222
4	1254	7162	4314	18602	3566	752	0	0	668	493
5	6821	13758	39790	37771	71178	31548	5994	2307	4096	3948
6	33899	59929	81186	103102	111395	193184	140083	46253	24284	24994
7	190031	139539	149505	106228	115157	127794	250181	256533	96921	50993
8	60804	368315	159775	116956	80973	50277	89354	189281	164243	99454
9	14670	88337	359921	96591	65512	36391	31427	57600	73416	79512
10	5395	22227	71933	240574	46501	26131	16807	19359	14955	26970
11	1389	3966	16313	41966	96272	17977	9217	5908	3393	3816
12	593	944	3826	10659	20437	38740	5319	3767	1304	795
+gp	578	354	682	2733	3325	5988	23239	7614	2485	1609
0 TOTSF	316206	704745	887563	775183	614866	528781	571620	588621	385946	292807

Table 13	Spawning stock biomass at age (spawning time)				Tonnes					
YEAF	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
3	0	442	226	160	75	0	0	0	0	0
4	184	724	3125	177	2968	567	239	1264	1891	0
5	26972	21879	33628	33696	24799	30510	11922	27133	27745	46434
6	55319	137010	143489	135188	163131	121621	164695	76494	115828	199446
7	51123	104855	188576	176505	223229	190288	149404	256138	110542	314001
8	38183	42132	84826	133631	128310	144010	125189	131332	252614	168683
9	41771	19816	23077	45570	74968	63770	87841	75046	99537	199701
10	19446	17254	10215	11240	26730	36914	29727	53770	50894	76900
11	5057	7639	5063	6372	6002	14351	15758	16880	31906	31424
12	1446	1874	3140	2644	2800	3074	4756	8166	9175	29170
+gp	595	867	1059	1992	1561	1797	5754	2963	3648	3887
0 TOTSF	240096	354492	496423	547175	654572	606902	595285	649186	703780	1069646
1										

Table 3.25. Northeast Arctic cod. Summary Table. Final VPA.

Run title : Arctic Cod (run: SVPASA15/V15)						
At 22/04/2010 19:53						
Table 16 Summary (without SOP correction)						
Traditional vpa using file input for terminal F						
	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
	Age 3					
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	1038825	1294449	170729	430113	2.5193	0.8649
1987	285293	1126053	121243	523071	4.3142	0.951
1988	204644	915105	202582	434939	2.147	0.9743
1989	172782	889738	234698	332481	1.4166	0.6604
1990	242750	961667	316206	212000	0.6704	0.2711
1991	411766	1561708	704745	319158	0.4529	0.321
1992	721185	1912257	887563	513234	0.5783	0.455
1993	894434	2359644	775183	581611	0.7503	0.5528
1994	781468	2148154	614866	771086	1.2541	0.8678
1995	613875	1807057	528781	739999	1.3994	0.788
1996	438206	1687088	571620	732228	1.281	0.6987
1997	715163	1531894	588621	762403	1.2952	1.0338
1998	844814	1229614	385946	592624	1.5355	0.917
1999	547772	1100226	292807	484910	1.6561	0.9892
2000	610255	1100947	240096	414868	1.7279	0.8546
2001	516555	1374769	354492	426471	1.203	0.7213
2002	449404	1544017	496423	535045	1.0778	0.684
2003	697062	1617723	547175	551990	1.0088	0.5441
2004	300161	1582559	654572	606445	0.9265	0.6866
2005	581337	1580766	606902	641276	1.0566	0.7172
2006	566885	1546829	595285	537642	0.9032	0.6063
2007	899016	1814225	649186	486883	0.75	0.3774
2008	830932	2269997	703780	464171	0.6595	0.3337
2009	588966	2618810	1069646	523430	0.4893	0.2762
Arith.						
Mean	609629	2007811	412557	651240	2.2527	0.6319
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		
1						

Table 3.26. Northeast Arctic cod. Summary table, run without cannibalism.

Run title : Arctic Cod (run: SVPASA15/V15)						
At 22/04/2010 19:56						
Table 16 Summary (without SOP correction)						
Traditional vpa using file input for terminal F						
	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
	Age 3					
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	397595	817497	251087	277651	1.1058	0.9161
1985	523470	957429	193856	307920	1.5884	0.7038
1986	930301	1260698	170729	430113	2.5193	0.8649
1987	270553	1122943	121243	523071	4.3142	0.951
1988	202921	915093	202589	434939	2.1469	0.9743
1989	172782	890360	234716	332481	1.4165	0.6602
1990	242750	962675	316418	212000	0.67	0.271
1991	408186	1559853	704744	319158	0.4529	0.321
1992	700405	1901909	887537	513234	0.5783	0.455
1993	759326	2295839	774584	581611	0.7509	0.553
1994	516667	2023164	612352	771086	1.2592	0.8687
1995	306766	1689840	528033	739999	1.4014	0.7885
1996	257279	1597385	570574	732228	1.2833	0.7011
1997	491583	1473560	588529	762403	1.2954	1.0348
1998	600510	1159155	385638	592624	1.5367	0.9181
1999	469731	1078374	292763	484910	1.6563	0.9892
2000	553207	1074915	239594	414868	1.7315	0.8554
2001	483301	1353656	353526	426471	1.2063	0.7218
2002	401878	1527198	496236	535045	1.0782	0.6841
2003	649338	1605435	547157	551990	1.0088	0.5441
2004	275602	1564189	654240	606445	0.9269	0.6868
2005	489080	1549531	606000	641276	1.0582	0.7179
2006	549066	1540896	595278	537642	0.9032	0.6063
2007	776167	1774881	649155	486883	0.75	0.3774
2008	689405	2200287	703312	464171	0.66	0.3339
2009	556084	2607202	1069635	523430	0.4894	0.2762
Arith.						
Mean	575237	1994586	412423	651240	2.253	0.632
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		
1						

Table 3.27. Northeast arctic cod. Input for the short-term prediction

MFDP version 1a
Run: out-pa
Time and date: 20:53 26.04.2010
Fbar age range: 5-10

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	384000	0.3335	0	0	0	0.257	0.0155	0.861
4	423422	0.227	0.003	0	0	0.589	0.0806	1.194
5	417190	0.2051	0.045	0	0	1.183	0.1839	1.735
6	296705	0.2	0.323	0	0	2.052	0.2315	2.514
7	144048	0.2	0.573	0	0	3.181	0.259	3.509
8	71781	0.2	0.838	0	0	4.8	0.3414	5.234
9	23961	0.2	0.927	0	0	6.759	0.3661	6.83
10	17527	0.2	0.97	0	0	7.859	0.2753	7.912
11	5182	0.2	0.974	0	0	10.008	0.3002	9.492
12	1944	0.2	0.986	0	0	12.731	0.4831	10.151
13	1111	0.2	1	0	0	14.311	0.4831	10.031

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	465000	0.3335	0	0	0	0.246	0.0155	0.861
4	.	0.227	0.002	0	0	0.643	0.0806	1.307
5	.	0.2051	0.061	0	0	1.196	0.1839	1.756
6	.	0.2	0.326	0	0	2.092	0.2315	2.514
7	.	0.2	0.622	0	0	3.181	0.259	3.604
8	.	0.2	0.852	0	0	4.684	0.3414	4.879
9	.	0.2	0.944	0	0	6.563	0.3661	6.718
10	.	0.2	0.987	0	0	8.707	0.2753	8.315
11	.	0.2	0.985	0	0	8.405	0.3002	9.397
12	.	0.2	0.995	0	0	12.731	0.4831	10.977
13	.	0.2	1	0	0	14.311	0.4831	11.636

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	484000	0.3335	0	0	0	0.262	0.0155	0.861
4	.	0.227	0.002	0	0	0.632	0.0806	1.307
5	.	0.2051	0.061	0	0	1.25	0.1839	1.87
6	.	0.2	0.326	0	0	2.105	0.2315	2.535
7	.	0.2	0.622	0	0	3.22	0.259	3.604
8	.	0.2	0.852	0	0	4.685	0.3414	4.974
9	.	0.2	0.944	0	0	6.448	0.3661	6.363
10	.	0.2	0.987	0	0	8.511	0.2753	8.202
11	.	0.2	0.985	0	0	9.253	0.3002	9.799
12	.	0.2	0.995	0	0	12.731	0.4831	10.881
13	.	0.2	1	0	0	14.311	0.4831	12.461

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	589000	0.3335	0	0	0	0.262	0.0155	0.861
4	.	0.227	0.002	0	0	0.632	0.0806	1.307
5	.	0.2051	0.061	0	0	1.25	0.1839	1.87
6	.	0.2	0.326	0	0	2.105	0.2315	2.535
7	.	0.2	0.622	0	0	3.22	0.259	3.604
8	.	0.2	0.852	0	0	4.685	0.3414	4.974
9	.	0.2	0.944	0	0	6.448	0.3661	6.363
10	.	0.2	0.987	0	0	8.511	0.2753	8.202
11	.	0.2	0.985	0	0	9.253	0.3002	9.799
12	.	0.2	0.995	0	0	12.731	0.4831	10.881
13	.	0.2	1	0	0	14.311	0.4831	12.461

Input units are thousands and kg - output in tonnes

Table 3.28. Northeast arctic cod. Management option table.

MFDP version 1a
Run: out-pa
preMFDP Index file 25.04.2005
Time and date: 09:59 27.04.2010
Fbar age range: 5-10

2010				
Biomass	SSB	FMult	FBar	Landings
2645431	1145460	1	0.2762	592522

2011					2012	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
2838054	1488265	0	0	0	3668732	2294694
.	1488265	0.1	0.0276	73371	3585217	2230437
.	1488265	0.2	0.0552	144828	3503985	2168071
.	1488265	0.3	0.0829	214427	3424970	2107538
.	1488265	0.4	0.1105	282221	3348106	2048782
.	1488265	0.5	0.1381	348260	3273331	1991748
.	1488265	0.6	0.1657	412597	3200583	1936382
.	1488265	0.7	0.1933	475278	3129803	1882635
.	1488265	0.8	0.221	536352	3060935	1830456
.	1488265	0.9	0.2486	595863	2993922	1779797
.	1488265	1	0.2762	653857	2928710	1730613
.	1488265	1.1	0.3038	710375	2865248	1682857
.	1488265	1.2	0.3314	765460	2803485	1636486
.	1488265	1.3	0.3591	819152	2743372	1591460
.	1488265	1.4	0.3867	871491	2684861	1547735
.	1488265	1.5	0.4143	922513	2627906	1505274
.	1488265	1.6	0.4419	972256	2572463	1464038
.	1488265	1.7	0.4695	1020756	2518488	1423989
.	1488265	1.8	0.4972	1068047	2465939	1385092
.	1488265	1.9	0.5248	1114163	2414776	1347313
.	1488265	2	0.5524	1159137	2364959	1310617

Input units are thousands and kg - output in tonnes

Table 3.29a. Northeast arctic cod. Detailed prediction output assuming Fpa in 2011-2013

MFDP version 1a
Run: out-r
Time and date: 19:58 27.04.2010
Fbar age range: 5-10

Year:	2010	F multiplier	1	Fbar:	0.2762				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0155	5024	4326	384000	98688	0	0	0	0
4	0.0806	29378	35078	423422	249396	1270	748	1270	748
5	0.1839	63559	110276	417190	493536	18774	22209	18774	22209
6	0.2315	55788	140251	296705	608839	95836	196655	95836	196655
7	0.259	29919	104985	144048	458217	82540	262558	82540	262558
8	0.3414	18923	99045	71781	344549	60152	288732	60152	288732
9	0.3661	6698	45749	23961	161952	22212	150130	22212	150130
10	0.2753	3840	30386	17527	137745	17001	133612	17001	133612
11	0.3002	1224	11619	5182	51861	5047	50513	5047	50513
12	0.4831	680	6907	1944	24749	1917	24403	1917	24403
13	0.4831	389	3901	1111	15900	1111	15900	1111	15900
Total		215424	592522	1786871	2645431	305860	1145460	305860	1145460

Year:	2011	F multiplier	1.4482	Fbar:	0.4				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0224	8782	7562	465000	114390	0	0	0	0
4	0.1167	26756	34970	270871	174170	542	348	542	348
5	0.2663	66106	116082	311304	372319	18990	22711	18990	22711
6	0.3353	73403	184536	282744	591500	92175	192829	92175	192829
7	0.3751	54972	198121	192720	613042	119872	381312	119872	381312
8	0.4944	32446	158303	91026	426366	77554	363264	77554	363264
9	0.5302	15717	105584	41772	274148	39433	258796	39433	258796
10	0.3987	4081	33932	13604	118446	13427	116906	13427	116906
11	0.4347	3507	32957	10897	91585	10733	90211	10733	90211
12	0.6996	1450	15915	3142	40006	3127	39806	3127	39806
13	0.6996	712	8283	1543	22081	1543	22081	1543	22081
Total		287932	896245	1684622	2838054	377394	1488265	377394	1488265

Year:	2012	F multiplier	1.4482	Fbar:	0.4				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0224	9141	7871	484000	126808	0	0	0	0
4	0.1167	32176	42054	325737	205866	651	412	651	412
5	0.2663	40789	76275	192081	240101	11717	14646	11717	14646
6	0.3353	50439	127864	194289	408978	63338	133327	63338	133327
7	0.3751	47223	170191	165552	533076	102973	331574	102973	331574
8	0.4944	38651	192251	108435	508020	92387	432833	92387	432833
9	0.5302	17103	108824	45455	293096	42910	276683	42910	276683
10	0.3987	6038	49520	20126	171296	19865	169069	19865	169069
11	0.4347	2406	23577	7476	69171	7363	68134	7363	68134
12	0.6996	2665	28997	5776	73533	5747	73165	5747	73165
13	0.6996	879	10956	1906	27271	1906	27271	1906	27271
Total		247510	838380	1550833	2657217	348857	1527114	348857	1527114

Year:	2013	F multiplier	1.4482	Fbar:	0.4				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0224	11332	9757	600000	157200	0	0	0	0
4	0.1167	33490	43772	339047	214278	678	429	678	429
5	0.2663	49051	91725	230988	288735	14090	17613	14090	17613
6	0.3353	31122	78895	119880	252348	39081	82265	39081	82265
7	0.3751	32449	116948	113760	366306	70758	227842	70758	227842
8	0.4944	33202	165149	93149	436403	79363	371815	79363	371815
9	0.5302	20374	129637	54149	349153	51117	329600	51117	329600
10	0.3987	6570	53887	21901	186402	21617	183979	21617	183979
11	0.4347	3560	34883	11060	102339	10894	100804	10894	100804
12	0.6996	1828	19893	3963	50447	3943	50195	3943	50195
13	0.6996	1441	17962	3124	44711	3124	44711	3124	44711
Total		224420	762508	1591021	2448321	294665	1409253	294665	1409253

Input units are thousands and kg - output in tonnes

Table 3.29b. Northeast arctic cod. Detailed prediction output assuming HCR in 2011 and Fpa in 2012-2013

MFDP version 1a
Run: our-r30
Time and date: 20:26 27.04.2010
Fbar age range: 5-10

Year:	2010	F multiplie	1	Fbar:	0.2762				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan	SSB(Jan)	SSNos(ST	SSB(ST)
3	0.0155	5024	4326	384000	98688	0	0	0	0
4	0.0806	29378	35078	423422	249396	1270	748	1270	748
5	0.1839	63559	110276	417190	493536	18774	22209	18774	22209
6	0.2315	55788	140251	296705	608839	95836	196655	95836	196655
7	0.259	29919	104985	144048	458217	82540	262558	82540	262558
8	0.3414	18923	99045	71781	344549	60152	288732	60152	288732
9	0.3661	6698	45749	23961	161952	22212	150130	22212	150130
10	0.2753	3840	30386	17527	137745	17001	133612	17001	133612
11	0.3002	1224	11619	5182	51861	5047	50513	5047	50513
12	0.4831	680	6907	1944	24749	1917	24403	1917	24403
13	0.4831	389	3901	1111	15900	1111	15900	1111	15900
Total		215424	592522	1786871	2645431	305860	1145460	305860	1145460

Year:	2011	F multiplie	1.0862	Fbar:	0.3				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan	SSB(Jan)	SSNos(ST	SSB(ST)
3	0.0168	6604	5686	465000	114390	0	0	0	0
4	0.0875	20347	26593	270871	174170	542	348	542	348
5	0.1998	51136	89795	311304	372319	18990	22711	18990	22711
6	0.2515	57214	143836	282744	591500	92175	192829	92175	192829
7	0.2813	43033	155091	192720	613042	119872	381312	119872	381312
8	0.3708	25720	125486	91026	426366	77554	363264	77554	363264
9	0.3977	12504	84003	41772	274148	39433	258796	39433	258796
10	0.299	3203	26629	13604	118446	13427	116906	13427	116906
11	0.3261	2763	25963	10897	91585	10733	90211	10733	90211
12	0.5247	1173	12876	3142	40006	3127	39806	3127	39806
13	0.5247	576	6702	1543	22081	1543	22081	1543	22081
Total		224273	702662	1684622	2838054	377394	1488265	377394	1488265

Year:	2012	F multiplie	1.4482	Fbar:	0.4				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan	SSB(Jan)	SSNos(ST	SSB(ST)
3	0.0224	9141	7871	484000	126808	0	0	0	0
4	0.1167	32357	42290	327570	207024	655	414	655	414
5	0.2663	41996	78533	197768	247210	12064	15080	12064	15080
6	0.3353	53911	136666	207663	437131	67698	142505	67698	142505
7	0.3751	51351	185068	180023	579675	111975	360558	111975	360558
8	0.4944	42450	211149	119094	557955	101468	475378	101468	475378
9	0.5302	19352	123139	51435	331653	48555	313080	48555	313080
10	0.3987	6893	56538	22979	195571	22680	193028	22680	193028
11	0.4347	2658	26048	8259	76420	8135	75274	8135	75274
12	0.6996	2971	32326	6439	81974	6407	81564	6407	81564
13	0.6996	1047	13050	2270	32483	2270	32483	2270	32483
Total		264129	912677	1607499	2873904	381906	1689364	381906	1689364

Year:	2013	F multiplie	1.4482	Fbar:	0.4				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan	SSB(Jan)	SSNos(ST	SSB(ST)
3	0.0224	11332	9757	600000	157200	0	0	0	0
4	0.1167	33490	43772	339047	214278	678	429	678	429
5	0.2663	49327	92241	232288	290360	14170	17712	14170	17712
6	0.3353	32044	81230	123430	259819	40238	84701	40238	84701
7	0.3751	34683	124998	121590	391521	75629	243526	75629	243526
8	0.4944	36105	179586	101292	474551	86300	404317	86300	404317
9	0.5302	22376	142379	59471	383472	56141	361998	56141	361998
10	0.3987	7434	60976	24782	210923	24460	208181	24460	208181
11	0.4347	4064	39826	12627	116842	12438	115089	12438	115089
12	0.6996	2020	21978	4378	55734	4356	55455	4356	55455
13	0.6996	1634	20364	3542	50690	3542	50690	3542	50690
Total		234510	817108	1622447	2605389	317953	1542098	317953	1542098

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

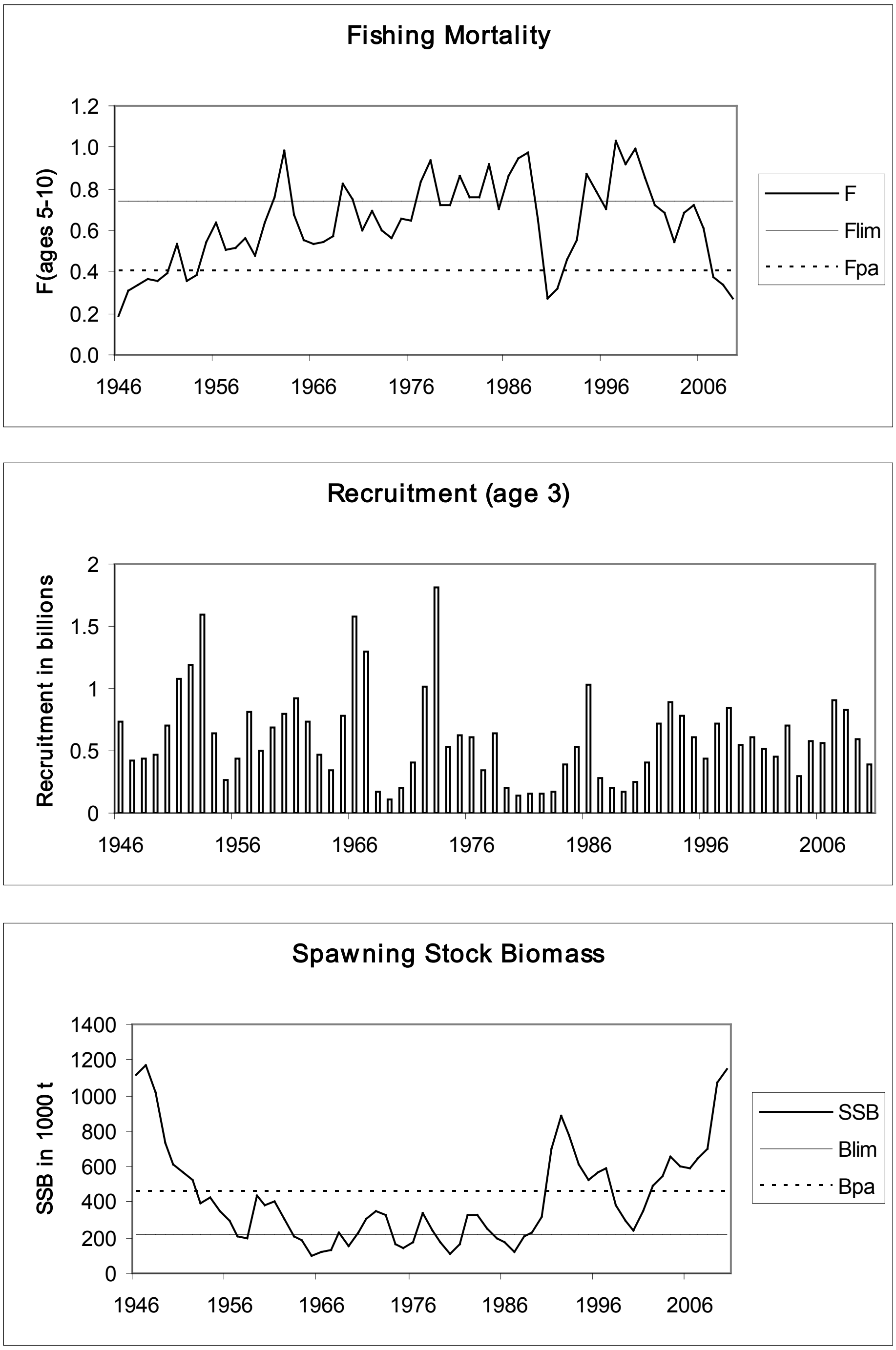
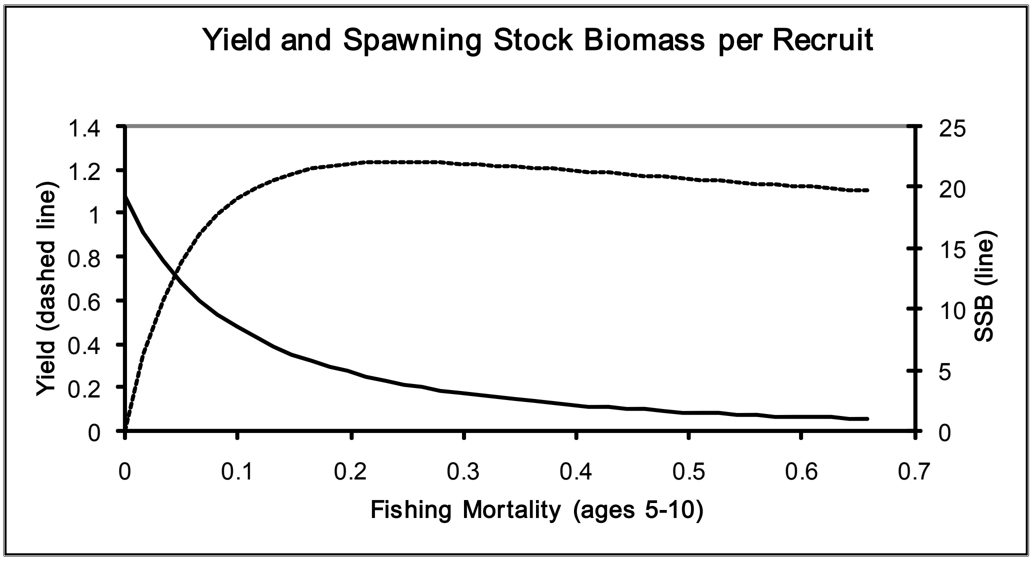


Figure 3.1. ICES Standard plots for Northeast Arctic cod (sub-area I and II)



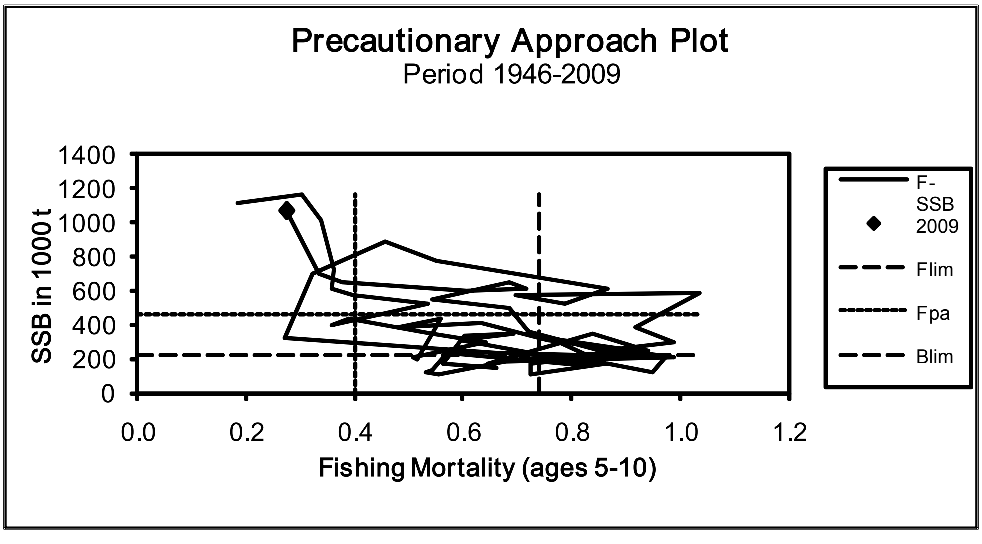


Figure. 3.1. Continued. ICES Standard plots for Northeast Arctic cod (sub-area I and II)

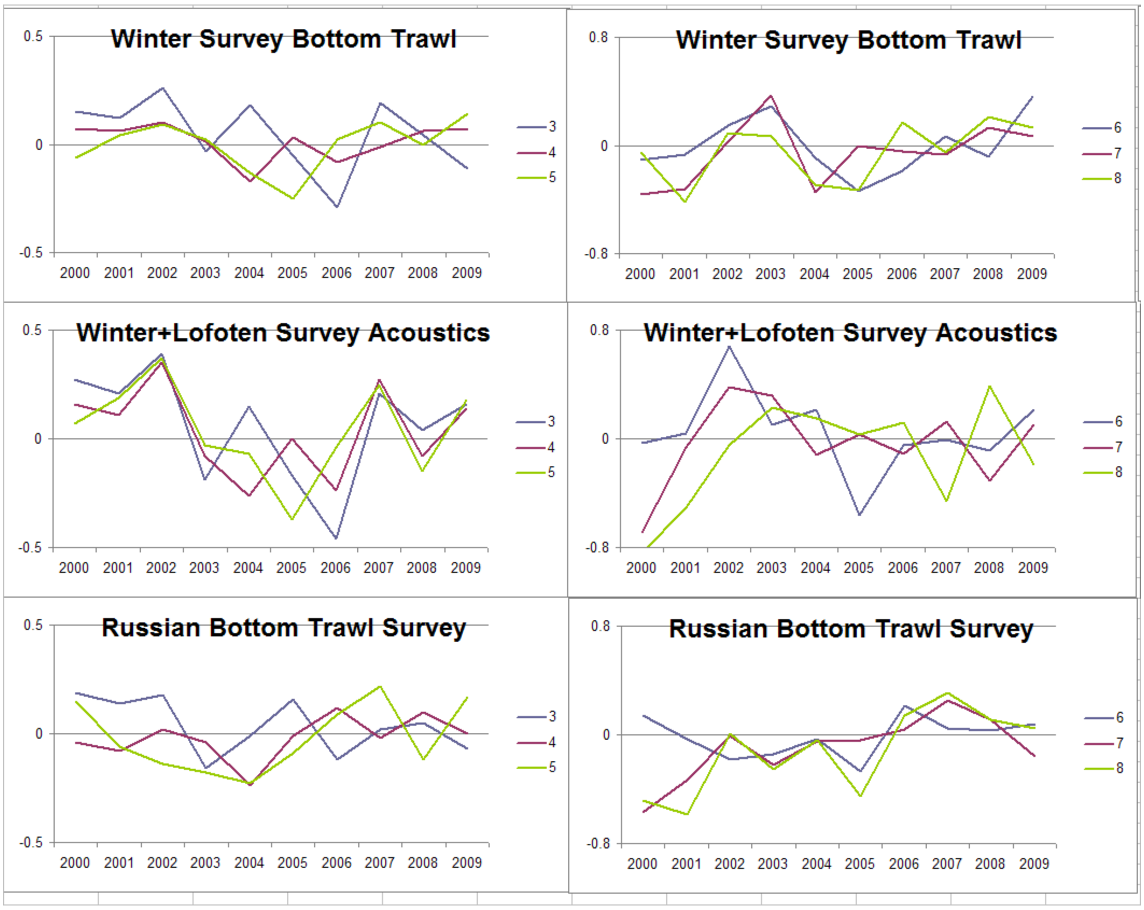


Figure 3.2. Northeast Arctic cod. Log catchability residual (y-axis) by fleets for the tuning data used in xsa. Ages 3-5 in left hand panel and 6-8 in right hand panel.

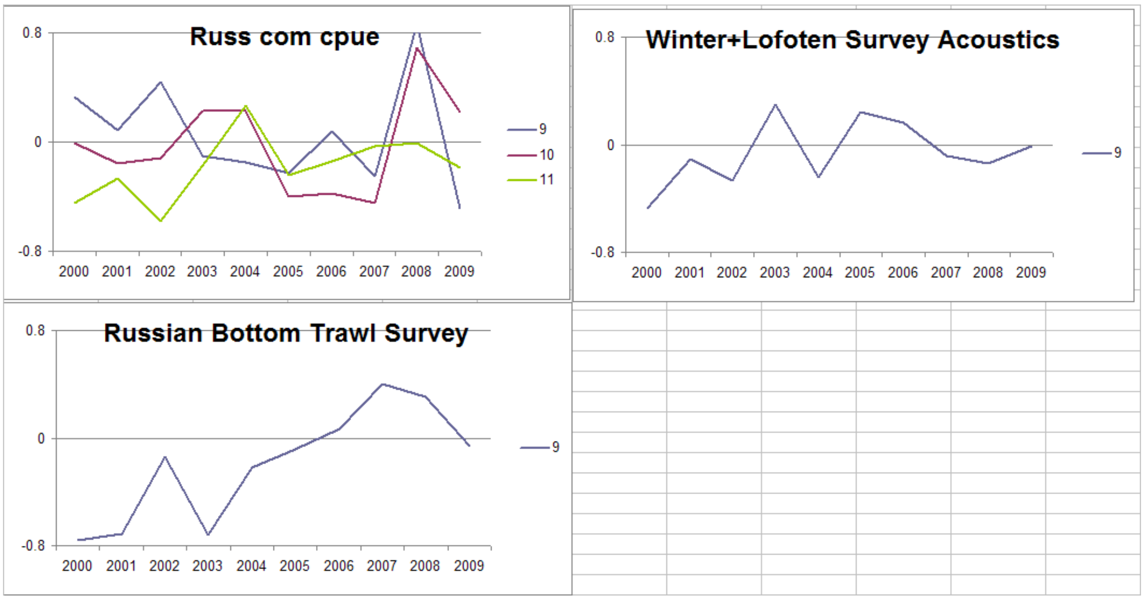


Figure 3.2 continued…. Northeast Arctic cod. Log catchability residual (y-axis) by fleets for the tuning data used in xsa. Ages 9-11.

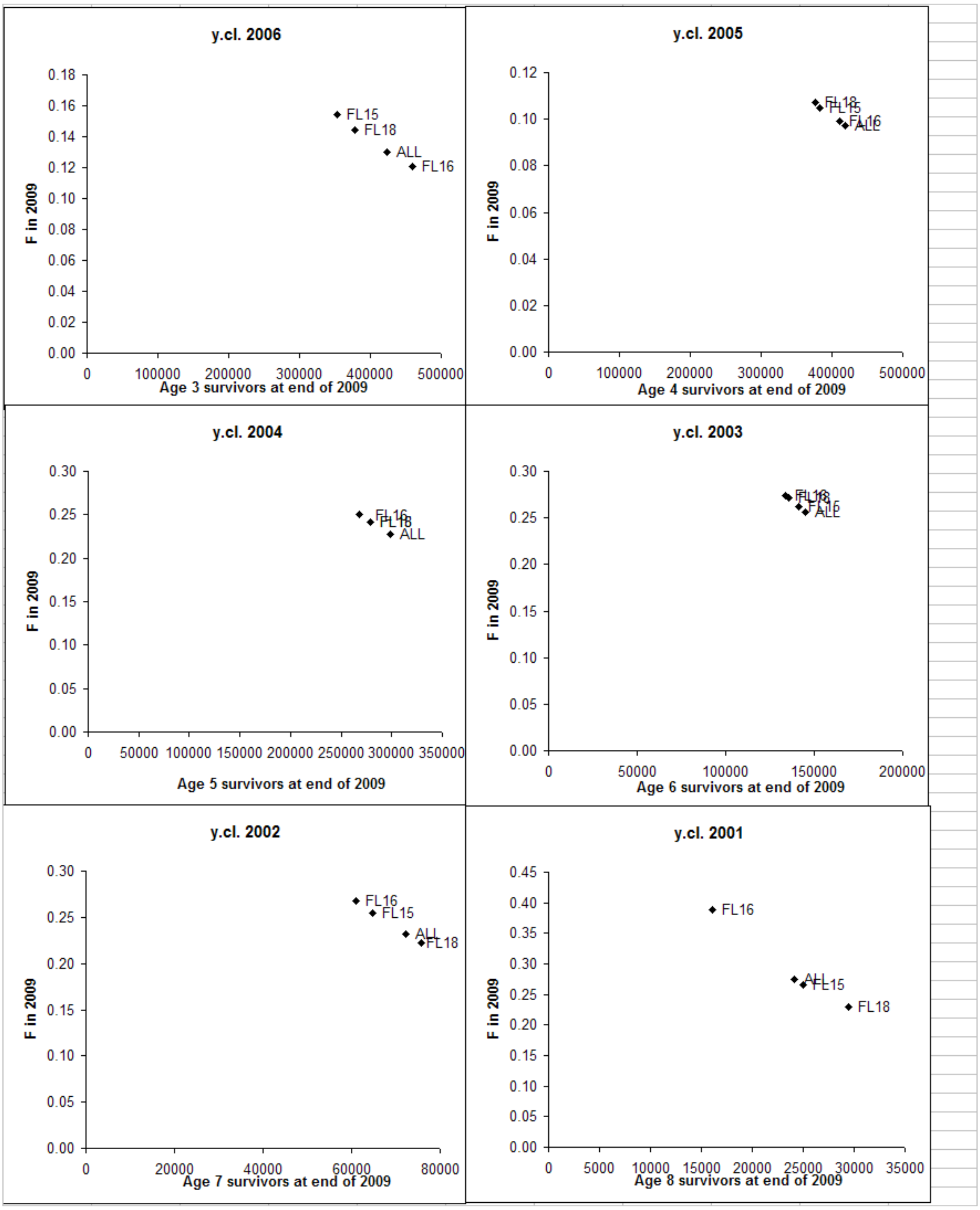


Figure 3.3. Northeast Arctic cod. Single fleet estimates (before shrinkage) of F2009 and survivors at the end of 2009 taken from xsa-diagnostics of single fleet runs. "ALL" is the estimates from the final xsa (with shrinkage, including all fleets). The Fs for ages 3-5 includes cannibalism mortality.

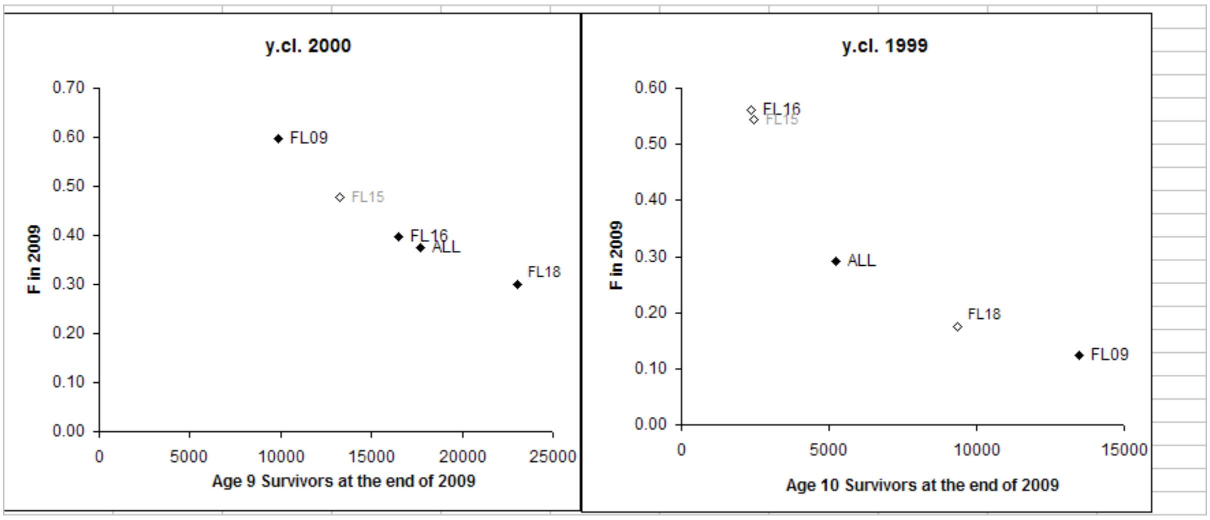


Figure 3.3. continued….Single fleet estimates (before shrinkage) of F2009 and survivors at the end of 2009 taken from xsa-diagnostics of single fleet runs. "ALL" is the estimate from the final xsa (with shrinkage, including all fleets).

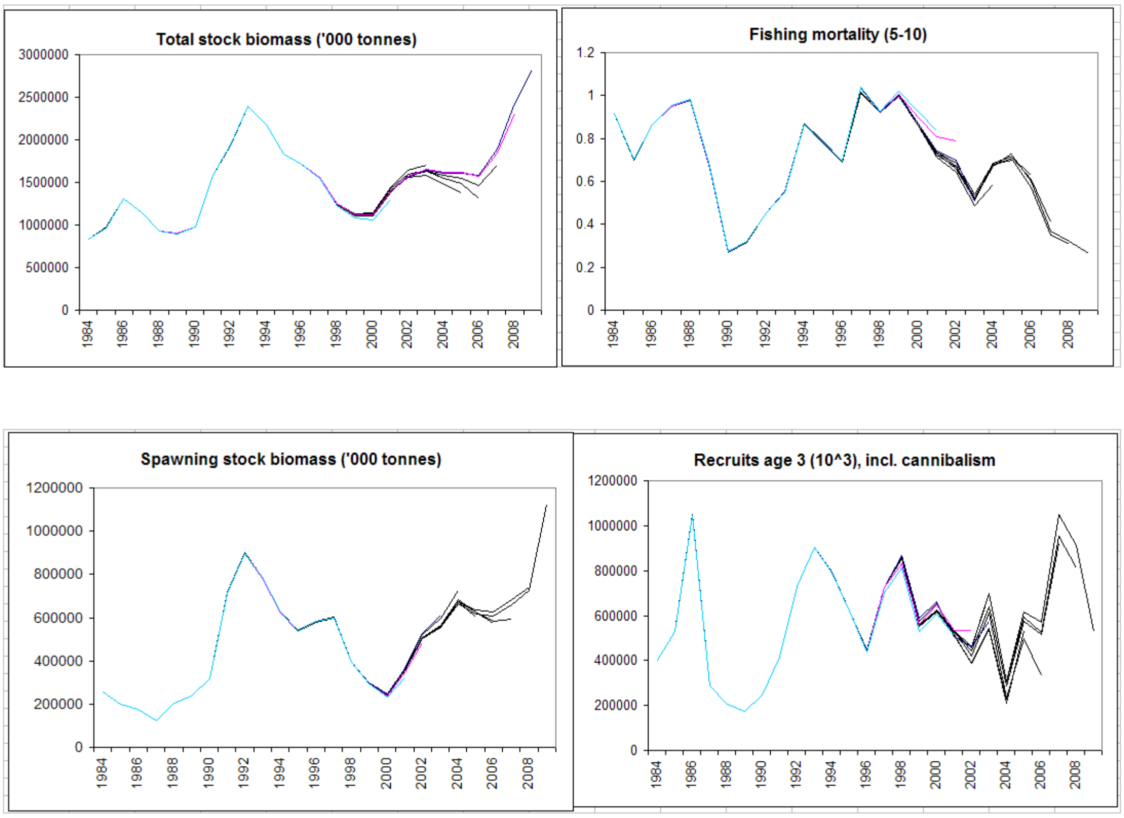


Figure 3.4. Northeast Arctic cod. Retrospective plots with catchability dependent on stock size for ages < 6.

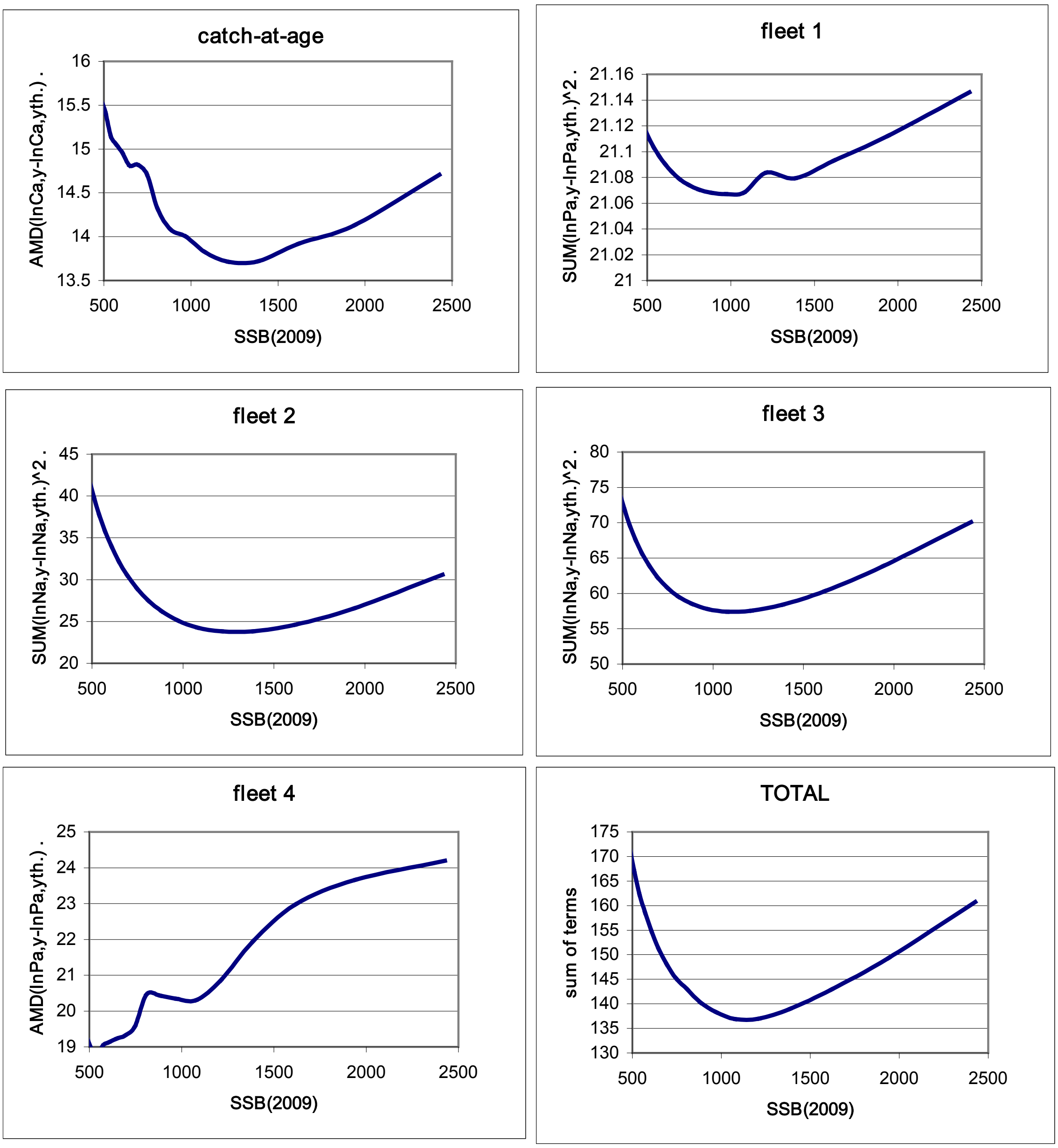
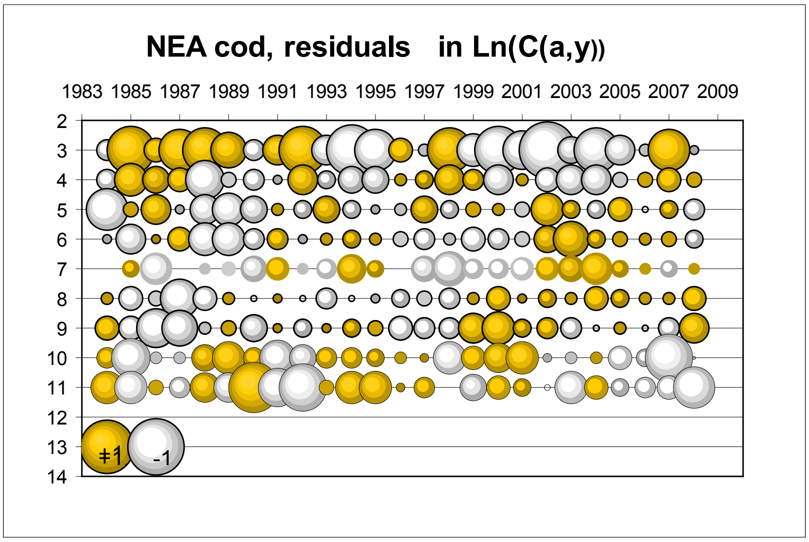
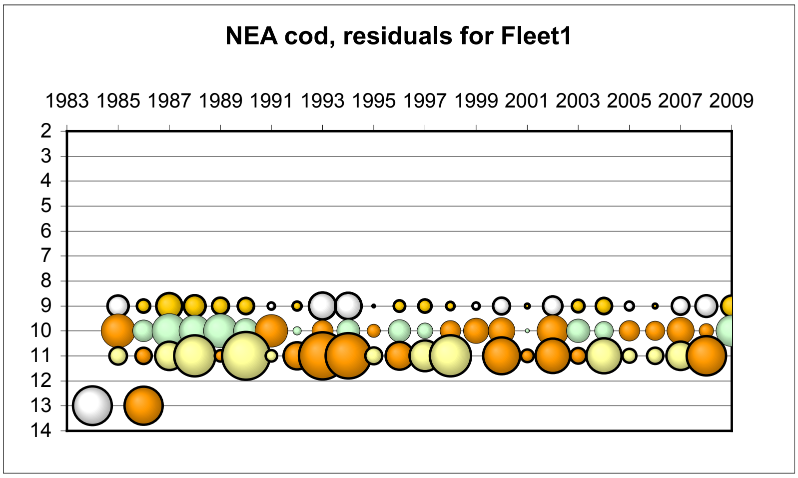


Figure 3.5. Northeast Arctic cod. The profiles of the components of the TISVPA loss function for C(a,y), fleet 1 (FLT09), fleet 2 (FLT15), fleet 3 (FLT16), fleet 4 (FLT18) and Total sum.





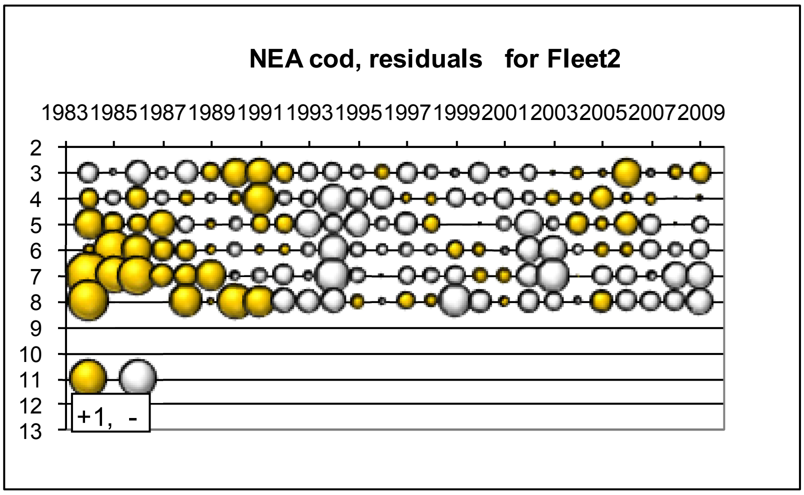
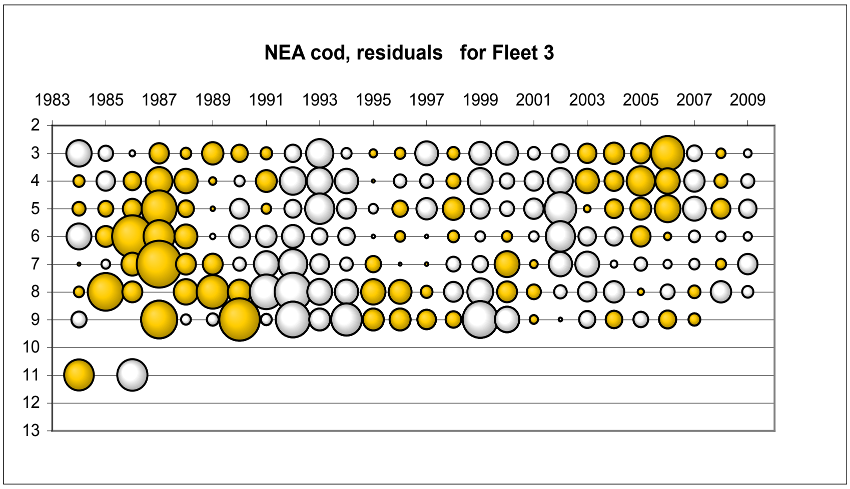


Figure 3.6. Northeast Arctic cod. TISVPA residuals in logarithmic catch-at-age and abundance-at-age for fleets 1 -4. The circles on the low line correspond to +1 (yellow) or -1(grey). (



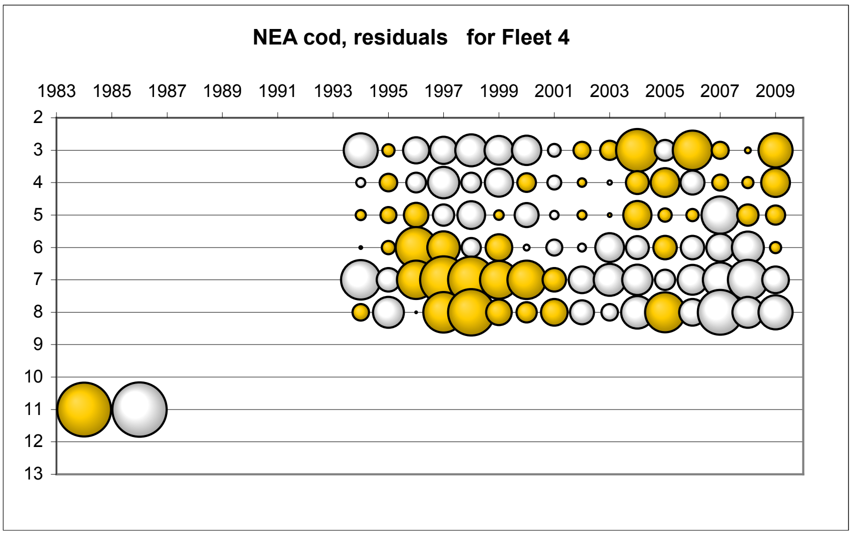


Figure 3.6. Continued.

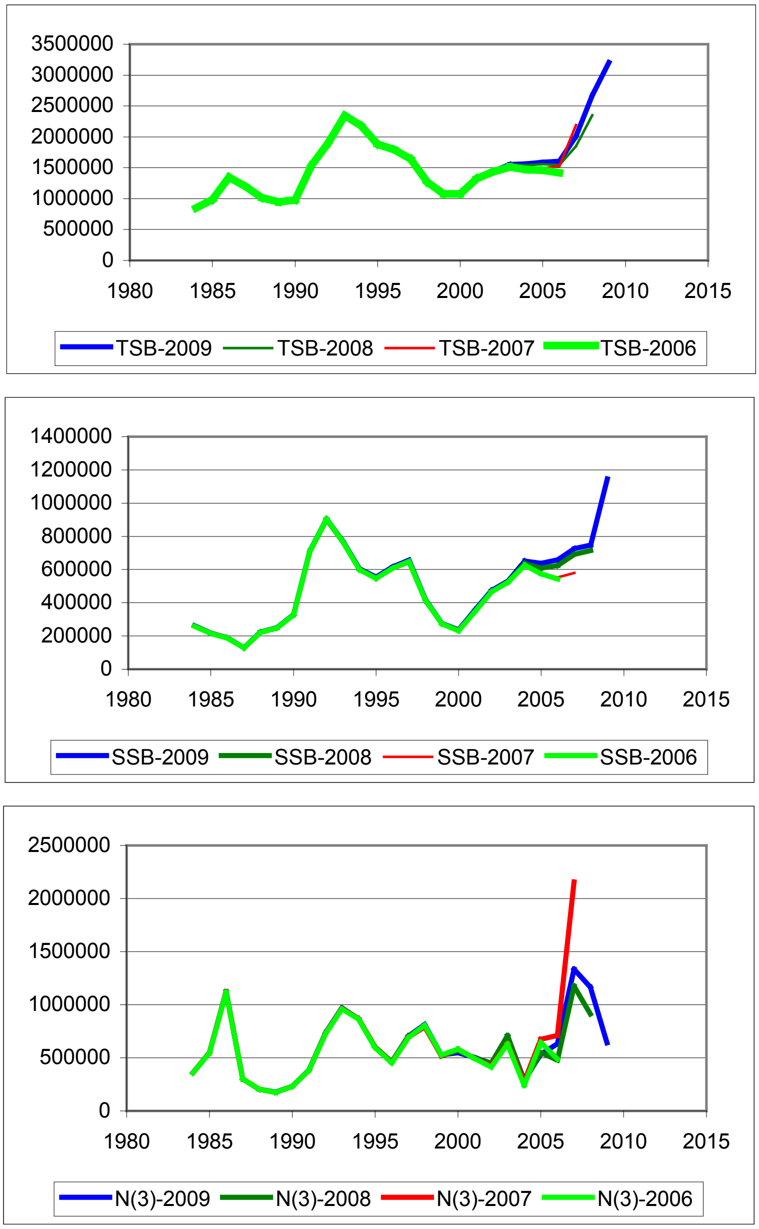
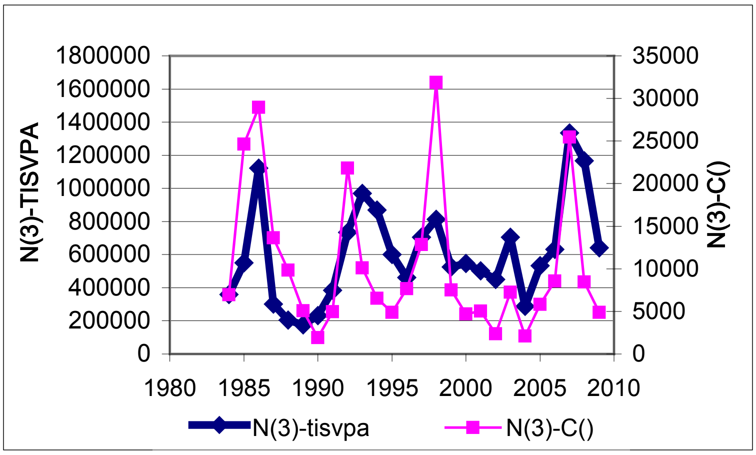


Figure 3.7. Northeast Arctic cod. TISVPA retrospective runs



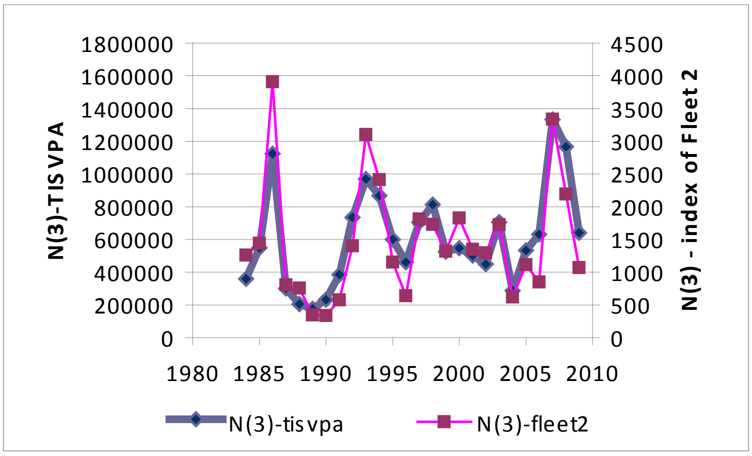
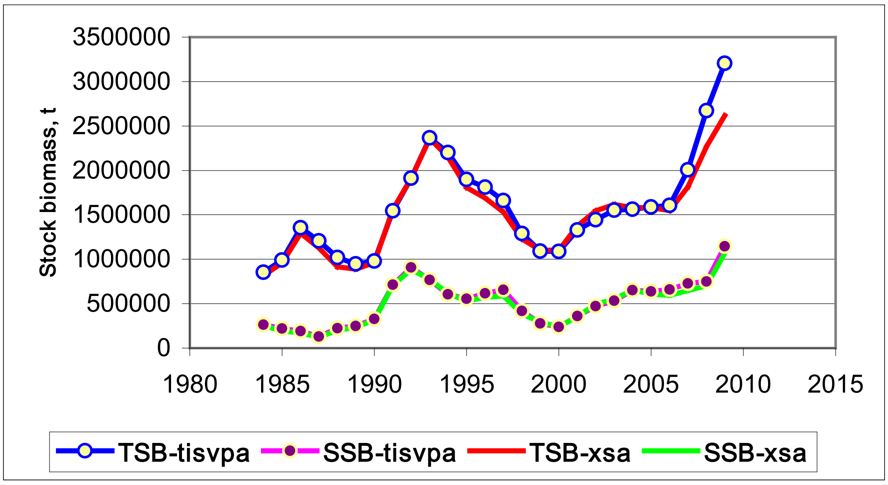


Figure 3.8. Northeast Arctic cod. Comparison of TISVPA-derived estimates of recruitment to catches at age 3 and to index of the same age-group obtained from Fleet 2.



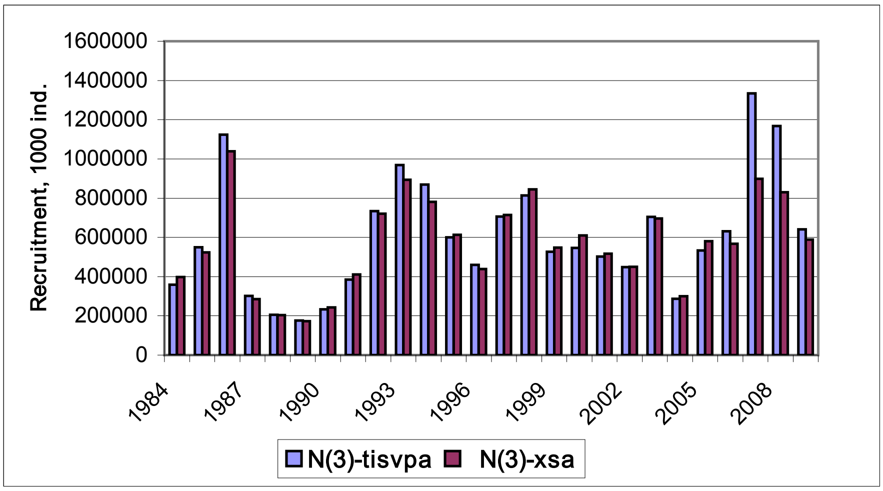


Figure 3.9. Northeast Arctic cod. Comparison of XSA and TISVPA runs

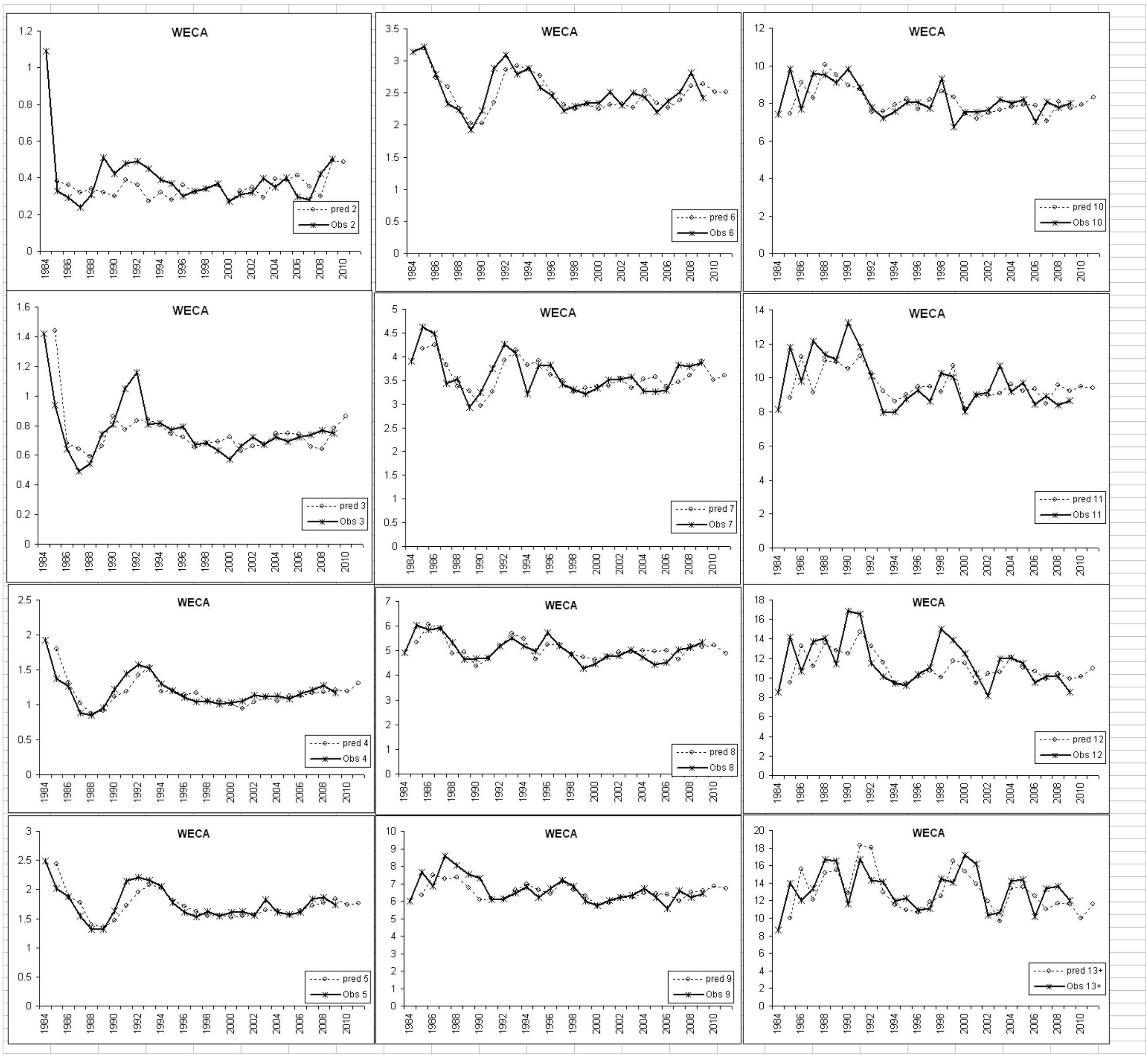


Figure 3.10a. Northeast Arctic cod. Weight in catch predictions.

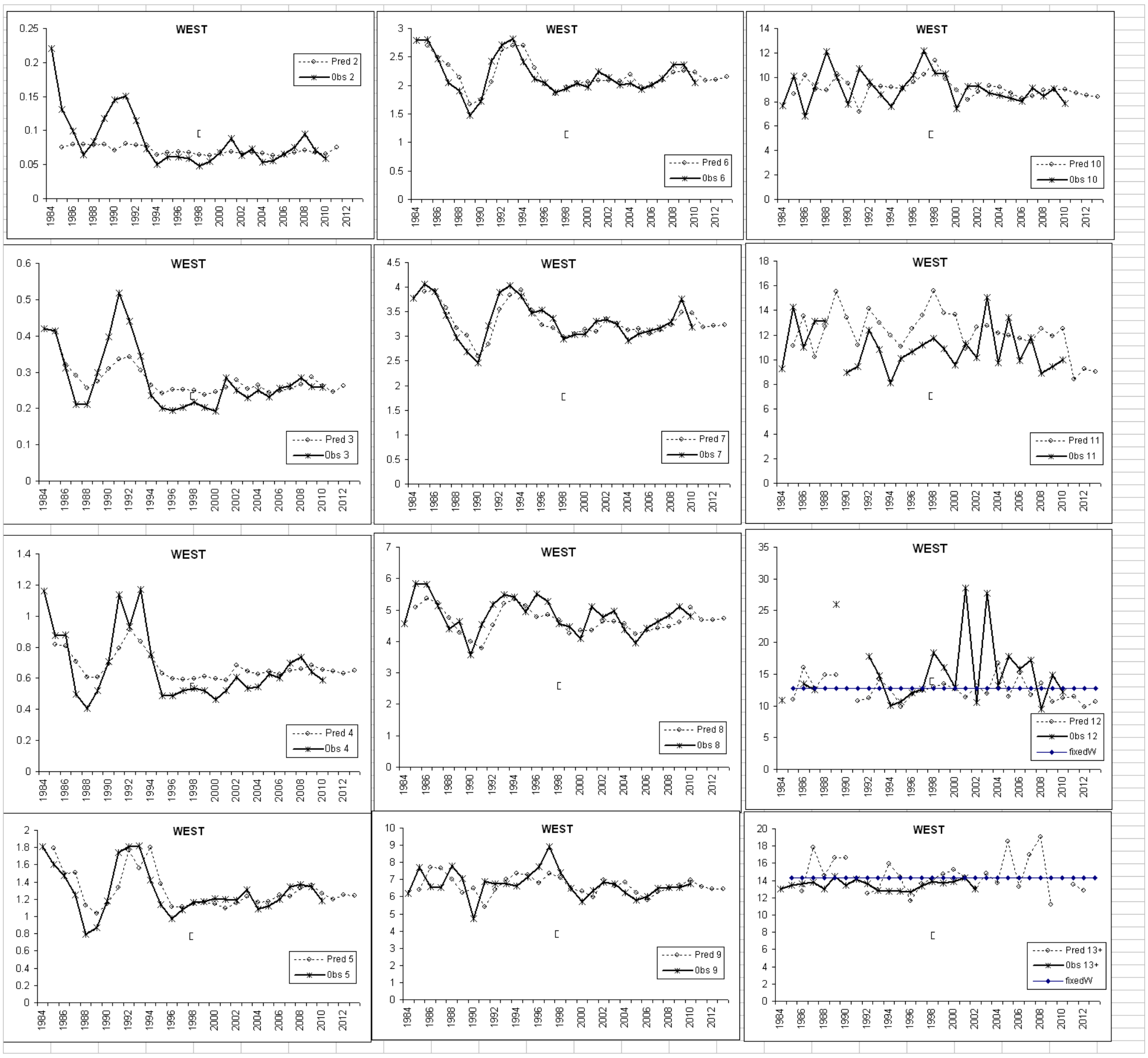


Figure 3.10b. Northeast Arctic cod. Weight in stock projections

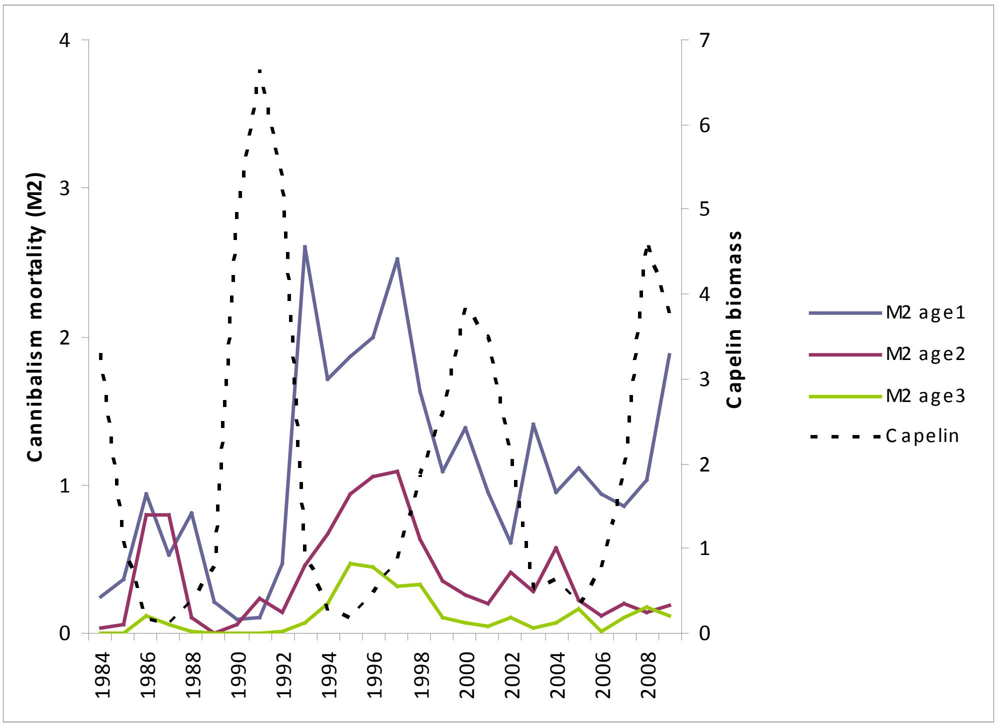


Figure 3.11. Northeast Arctic cod. Capelin biomass and cannibalism mortality on cod age 1, 2 and 3.

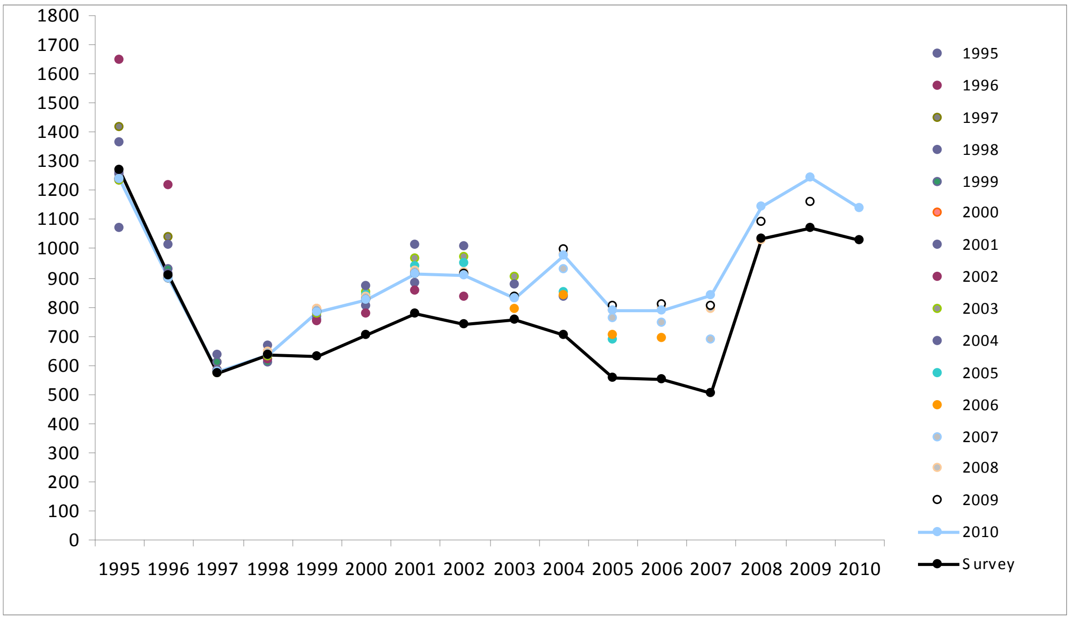


Figure 3.12. Northeast arctic cod. Calibrated (with intercept) bottom trawl survey estimates (connected solid circles), ICES 2010 estimates (connected open diamonds) and the 1995- 2009 ICES annual assessments (unconnected symbols) of the total number of Northeast Arctic cod ages 4 through 6.

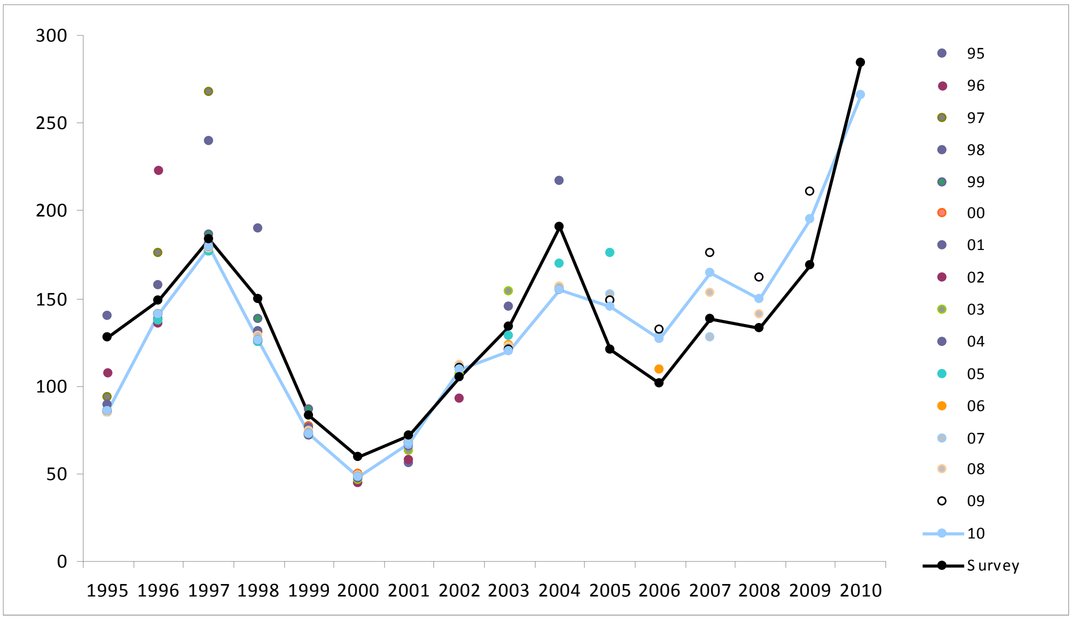


Figure 3.13 Calibrated (with intercept) bottom trawl survey estimates (connected solid diamonds), ICES 2010 estimates (connected open circles) and the 1995- 2009 ICES annual assessments (unconnected symbols) of the total number of Northeast Arctic cod ages 7 and older.

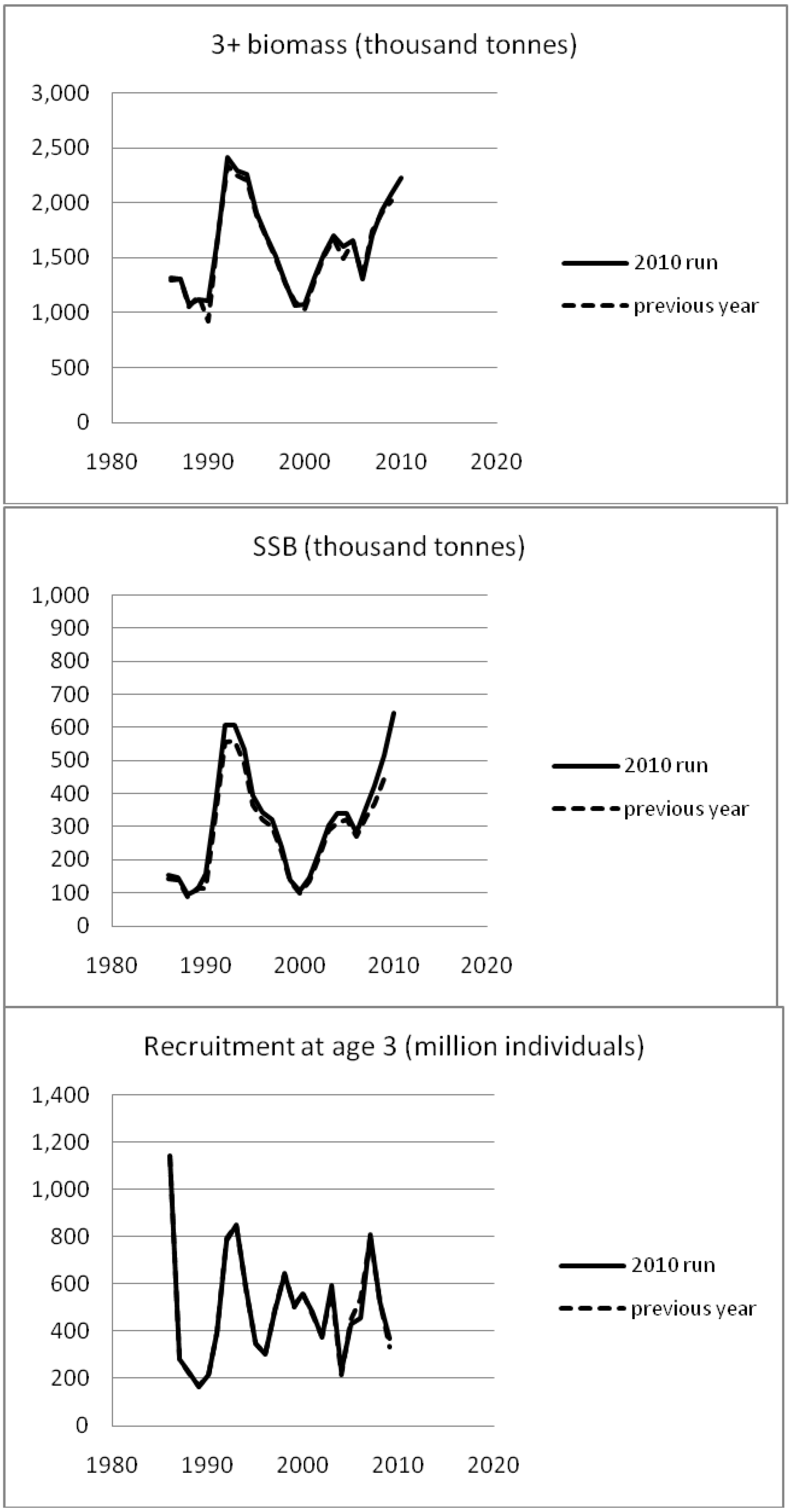


Figure 3.14. Spawning stock biomass, stock biomass (3+) and recruitment from the 2010 Gadget run for Northeast Arctic Cod, compared with the 2009 model run.

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]			1.33			1.16		0.83	

[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

[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.

Year	Age 1	2	3	4	5	6	7	8	9	10+	Total
1981	4.6	34.3	16.4	23.3	40	38.4	4.8	1	0.3	0	163.1
1982	0.8	2.9	28.3	27.7	23.6	15.5	16	1.4	0.2	0	116.4
1983	152.9	13.4	25.0	52.3	43.3	17.0	5.8	3.2	1.0	0.1	313.9
1984	2755.0	379.1	97.5	28.3	21.4	11.7	4.1	0.4	0.1	0.1	3297.7
1985	49.5	660.0	166.8	126.0	19.9	7.7	3.3	0.2	0.1	0.1	1033.6
1986	665.8	399.6	805.0	143.9	64.1	8.3	1.9	0.3	0.0	0.0	2089.1
1987	30.7	445.0	240.4	391.1	54.3	15.7	2.0	0.5	0.0	0.0	1179.8
1988	3.2	72.8	148.0	80.5	173.3	20.5	3.6	0.5	0.0	0.0	502.5
1989	8.2	15.6	46.4	75.9	37.8	90.2	9.8	0.9	0.1	0.1	285.0
1990	207.2	56.7	28.4	34.9	34.6	20.6	27.2	1.6	0.4	0.0	411.5
1991	460.5	220.1	45.9	33.7	25.7	21.5	12.2	12.7	0.6	0.0	832.7
1992	126.6	570.9	158.3	57.7	17.8	12.8	7.7	4.3	2.7	0.2	959.0
1993 [1]	534.5	420.4	273.9	140.1	72.5	15.8	6.2	3.9	2.2	2.4	1471.9
1994 [1]	1035.9	535.8	296.5	310.2	147.4	50.6	9.3	2.4	1.6	1.3	2391.0
1995 [1]	5253.1	541.5	274.6	241.4	255.9	76.7	18.5	2.4	0.8	1.1	6666.2
1996 [1]	5768.5	707.6	170.0	115.4	137.2	106.1	24.0	2.9	0.4	0.5	7032.5
1997 [1,2]	4815.5	1045.1	238.0	64.0	70.4	52.7	28.3	5.7	0.9	0.5	6321.1
1998 [1,2]	2418.5	643.7	396.0	181.3	36.5	25.9	17.8	8.6	1.0	0.5	3729.8
1999 [1]	484.6	340.1	211.8	173.2	58.1	13.4	6.5	5.1	1.2	0.4	1294.4
2000 [1]	128.8	248.3	235.2	132.1	108.3	26.9	4.3	2.0	1.2	0.4	887.5
2001 [1]	657.9	76.6	191.1	182.8	83.4	38.2	8.9	1.1	0.4	0.2	1240.6
2002 [1]	35.3	443.9	88.3	135.0	109.6	42.5	15.1	2.4	0.3	0.2	872.6
2003 [1]	2991.7	79.1	377.0	129.7	91.1	67.3	18.3	4.9	1.0	0.2	3760.3
2004 [1]	328.5	235.4	76.6	172.5	56.9	44.7	27.3	7.6	1.7	0.4	951.6
2005 [1]	824.3	224.6	246.9	62.1	98.1	24.7	15.5	4.5	1.1	0.4	1502.3
2006 [1]	862.7	288.4	118.1	111.5	28.7	43.7	10.2	4.9	1.4	0.6	1470.4
2007 [1,2]	485.9	393.9	367.7	85.0	62.9	14.8	17.9	4.8	1.8	0.7	1435.4
2008 [1]	70.4	95.1	190.2	333.6	91.0	47.2	13.0	8.8	2.0	0.4	851.7
2009 [1]	382.7	39.1	118.3	219.5	193.9	58.7	19.6	6.8	4.8	0.9	1044.3
2010	1020.2	104.4	36.0	106.9	160.8	140.7	40.0	11.9	3.5	2.2	1627.0

[1] Survey covered a larger area

[2] Adjusted indices

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

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

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

[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

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	4.1	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

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

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

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

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

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

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

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

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

Table A14. Northeast Arctic Cod. Swept area estimates (millions) from the Joint Norwegian-Russian ecosystem survey in August-September (taken from WD 20)

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
2004	540.45	332.75	329.74	147.72	421.53	150.21	79.76	40.21	10.09	2.21	0.50	0.13	0.07	0.13
2005	182.17	458.52	143.16	241.68	95.92	159.91	35.54	16.24	5.82	1.01	0.47	0.17	0.00	0.06
2006	274.55	479.02	509.66	186.11	205.71	59.96	70.25	17.93	8.21	2.58	0.65	0.25	0.04	0.00
2007	97.79	334.23	506.27	587.08	159.42	79.26	24.68	27.15	6.05	2.18	0.94	0.15	0.21	0.03
2008	493.55	131.01	372.92	654.33	486.23	133.06	51.79	12.93	17.57	3.30	0.85	0.23	0.20	0.19
2009	922.67	580.99	91.20	202.50	286.83	295.25	103.41	32.45	12.89	7.39	2.64	0.83	0.28	0.22

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 2010 (Tables 4.1–4.3, Figure 4.1A)

The official landings (those reported to ICES and contained in the Statlant statistics) for 2008 amount to 155,604 t, and the provisional official landings for 2009 are 200,512 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). For those years, the Working Group decided to present both estimates but to base the final assessment on the Norwegian IUU estimates. In 2009, however, a joint Norwegian-Russian Analysis Group under the Mixed Norwegian-Russian Fisheries Commission provided joint estimates of IUU catches. Based on these, the AFWG decided to set the IUU estimate for haddock in 2009 to 0 (WD 13). More details on this issue are given in Sections 0.4 and 3.1.3. 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 2006) (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 2009 and 2010

ACFM recommended to set a TAC lower than 194,000 t for 2009 and the agreed TAC for 2009 was 194,000 t, applying the agreed harvest control rule. The provisional reported catch in 2009 is 200,512 t. In 2006 and 2007 the assessment of haddock was rejected by ACFM and the advices was in both years to set a TAC lower than 130,000 t based on the increase of SSB in 2001-2004 being associated with this catch level. In 2008-2009 the assessment of haddock was accepted on the basis of improvement in diagnostics and a clearer explanation of the IUU calculation, and the advice was given according to the agreed 1-year harvest control rule (see Section 4.7.2). For 2010, the mixed Norwegian-Russian Fisheries Commission agreed on a TAC of 243,000 t, which corresponds to the agreed 1-year harvest control rule (see Section 4.7.2) according to the assessment. The assessment shows a decreasing trend in F from 2007 to 2009. The F in 2009 is thus considered to be a better estimate for F in the present year (2010) than using a three year average. In predictions for 2010-2012, a three year average scaled to F-status quo (Fsq) was used for the distribution of fishing mortality at age (fishing pattern). A Fsq predicts the catch for 2010 to be 269,000 t, which is higher than the TAC (243,000 t). The high 2010 catch corresponding to Fsq should not be interpreted as an estimate of a TAC overshoot in 2010.

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. According to the 0-group survey, the 2009 year class seems to be stronger than the two preceding year classes.

Joint Barents Sea winter survey (bottom trawl and acoustics)

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 15).

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, in 2008, 2009, and 2010 permit to enter the Russian zone was again given and the survey was conducted according to the standard area coverage. The survey indices and areas covered are given in Tables B1 and B3.

High indices, caused by the period of good recruitment around 1990, can be tracked from year to year in both series and the 1990 year class appears as the strongest for age groups 3–8 until the 2004-2006 year classes arrive. In the 2010 bottom trawl survey, the 2005 and 2006 year classes show an abundance well above that of the 1990 year class at the same age, while for the 2004 year class (6 years in 2010) the index is somewhat lower than for the 1990 year class. In the acoustic survey, the indices of the 2004-2005 year classes are higher than for the 1990 year class at age groups 5-6, while the 2006 year class (age 4) is a bit smaller.

Russian bottom trawl and acoustic survey

Russia provided indices from the 2009 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.

Also in the Russian bottom trawl and acoustic survey the coverage of REZ in 2006 was reduced compared to previous years, and the survey indices for 2006 were adjusted similar to that of the indices from the joint Barents Sea winter survey. See report from 2007 for details. From 2007 onwards, the survey area covered was again the standard coverage.

International 0-group survey

Estimates of the abundance of 0-group haddock from the International 0-group survey are presented in Tables 1.1 -1.2. The four tables show slightly different pictures, but all indicate that the 2002-2006 year classes are very strong, whereas 2007-2008 year classes are below average. The 2009 year class is again higher, at the level of the 2006 year class.

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 oldest ages compared to last year, 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.

4.3.2 Catch-at-age (Table 4.4)

Age and length compositions of the landings in 2009 were available from Norway and Russia in Subarea I and Subarea II, 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 sampling is believed to be less precise because of the termination of a Norwegian sampling program in Q3 2009 (WD 6). 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 2009 have increased slightly for younger age groups compared to 2008.

Stock weights (Table 4.6) used from 1985 to 2009 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. In 2006 the Working group decided to model the stock weight-at-age data in order to remove some of the sampling variability in the estimates. The weight at age is modelled as follows: Mean length at age is modelled using a von Bertalanffy model with L_∞ and T_0 parameters estimated over the whole time series and a separate K parameter for each year class. Weight at age is estimated from a length-weight relationship using the smoothed (modelled) length at age. Estimates were produced separately for the Russian autumn survey and the joint winter survey and were later combined as plain average.

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 2009 actual data from predation for cod have been used (see table below) while for the previous years (1950-1983) the average natural mortality for 1984-2009 was used (age groups 1-6).

4.3.5 Maturity-at-age (Table 4.8)

In 2006 the Working Group revised the estimates of maturity at age. For the years 1980 onwards the series consists of predicted values using a logistic link function with age and length as explanatory variables from the joint winter survey combined with predicted proportions from the Russian autumn survey:

$$Mat = \frac{1}{1 + e^{(-a*(age-age50\%)}}$$

The new series is based on the data from the Russian autumn survey and the joint winter survey. For the period 1950-1979 an average of both data series is used.

The estimates of maturity-at-age are shown in Table 4.8. The proportions mature at age are presently lower than historic averages.

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. The same approach has been used in consumption of NEA haddock by NEA cod estimates and in maturity at age.

4.3.7 New data sources

The bottom trawl estimates from the joint ecosystem survey in August-September, starting in 2004. This survey covers the entire distribution area of haddock. The new index values (Table 4.9A) for period 2004-2009 become available for AFWG this year as for the cod (WD 20). This time series have been tested as new tuning fleet in XSA (Fleet 007). The single fleet estimates of survivors of all ages, based on this index were slightly lower compare to other single fleet runs (Figure 4.8). The results of XSA run including all fleets (as in Final XSA + Fleet 007) were very close to final XSA ones. Analysis of XSA diagnostic from this run demonstrate that fleet 007 has reasonably good quality comparable to the other time series (fleet 01,02 and 04). This index will be considered on the upcoming benchmark for use as a tuning series.

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	Place	Season	Age	Year	prior weight
Russian bottom trawl	Barents Sea	Autumn	1–7	1983–2009	1
Norwegian bottom trawl	Barents Sea	Winter	1–8	1982–2010	1
Norwegian acoustic	Barents Sea	Winter	1–7	1980–2010	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).

4.4.2 VPA and tuning (Table 4.9)

The Extended Survivors Analysis (XSA) was used to tune the VPA to the available index series (Table 4.9). As last years, FLR was used for the assessment of haddock (see 2008-2009 reports), and thus all results concerning XSA is obtained using FLR. The settings used by the AFWG in 2009 were not changed:

The tuning window is set to 20 years

The F shrinkage was given a weight corresponding to SE=0.5

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 (1984–2009). The consumption of NEA haddock by NEA cod is given below:

	Consumption of Haddock by NEA Cod (millions)					
	1	2	3	4	5	6
1984	980.7	14.7	0.1	0.0	0.0	0.0
1985	1206.2	5.2	0.0	0.0	0.0	0.0
1986	566.4	245.0	168.1	0.0	0.0	0.0
1987	768.4	0.0	0.0	0.0	0.0	0.0
1988	17.2	0.5	9.1	0.0	0.2	0.0
1989	230.7	0.0	0.0	0.0	0.0	0.0
1990	144.0	37.9	3.7	0.0	0.0	0.0
1991	457.8	14.2	0.0	0.0	0.0	0.0
1992	2112.4	151.2	1.1	0.0	0.0	0.0
1993	1376.6	165.7	36.8	3.4	2.9	0.0
1994	1412.8	80.6	25.0	7.7	0.9	0.0
1995	2900.8	163.7	12.0	29.8	29.9	0.3
1996	1594.1	161.4	40.2	5.5	2.6	3.4
1997	906.5	35.5	25.5	1.7	0.8	0.5
1998	1534.8	28.2	2.0	2.9	0.5	0.0
1999	898.2	23.4	0.3	0.0	0.0	0.0
2000	1216.4	65.0	2.1	1.1	0.2	0.1
2001	553.0	52.6	4.9	0.1	0.0	0.0
2002	2377.1	229.1	38.0	2.4	0.4	0.2
2003	3616.1	219.5	38.8	12.3	1.2	0.0
2004	2299.6	299.2	43.4	8.9	2.5	0.0
2005	5856.7	265.4	67.3	11.9	3.5	1.2
2006	8012.5	335.8	3.3	4.4	1.2	0.5
2007	8917.0	561.8	22.0	2.4	2.7	0.3
2008	1118.1	925.7	175.5	23.5	11.6	3.1
2009	1295.6	201.2	191.5	39.1	17.1	1.7

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 RCT3 program has been used to estimate the recruiting year-classes 2006-2008 with survey data for ages 0-3 as input data (Russian autumn survey and joint winter 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
2000	197*	237*	236*	249*	236*	222*
2001	176*	219*	224*	257*	245*	237*
2002	295	313*	339*	367*	365*	371*
2003	156	183	135*	161*	171*	185*
2004	462	755	672	665*	668*	610*
2005		521	731	943	975*	1028*
2006			463	832	1036	811*
2007				202	208	212
2008					149	101
2009						303

4.4.4 Prediction data (Table 4.11, Table 4.19)

Weights at age and proportions mature at age show strong cyclic 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 and maturation processes. The Working Group therefore decided to use similar trends in weight at age, maturity and natural mortality as has been observed in previous periods following good recruitment. The input data for making the prediction are presented in Table 4.19:

- The estimated recruitment from RCT for 2010-2012 is given in Table 4.19.
- The assessment shows a decreasing trend in F from 2007 to 2009 and the F in 2009 is thus considered to be a better estimate for F in the present year (2010) 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 2010-2012.
- Smoothed observed maturity for 2010, smoothed average maturity for the 1982-1985, 1990-1993 and 2000-2006 year classes for 2011-2012.
- Smoothed observed weights at age in the stock for 2010, smoothed average weights for the 1982-1985, 1990-1993 and 2000-2006 year classes for 2011-2012.
- The average weights in the catch for the 1982-1985, 1990-1993 and 2000-2006 year classes for 2010-2012.
- Natural mortality – average for the 3 last years (2007-2009).
- Stock numbers and fishing mortalities from the standard VPA.

4.5 Results of the Assessments

4.5.1 Comparison of assessments

In case the IUU catches estimates equal zero this year, there are no comparisons the differences between assessment with and without IUU estimates as in previous reports.

The current assessment estimated the total stock to be about 5 % lower and SSB 19 % lower in 2008 compared to the previous assessment. F in 2008 is 4% higher than estimated last year.

There is a notable systematic difference between the time series of abundance at age from the XSA and those observed by the surveys, namely that the XSA time series is smoother and generally does not follow the relatively sharp peaks seen in the surveys. Neither the reason for this nor its significance for the assessment is fully understood (See the 2009 report, Figure 4.7). This investigation can be addressed at the benchmark.

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, 4.1B, 4.1C and 4.1D.

The assessments show a stable fishing mortality over the last three years, but 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 but only slightly below Fpa.

The dominating feature of the updated assessments is the rapid increase in biomass in 2009 and further in 2010, which is mainly the effect of a vastly improved recruitment. The increase in spawning stock biomass is still present but the rate of increase appears slightly bigger compared to last year.

4.5.3 Catch options for 2011–2012 (Tables 4.19 – 4.22)

Input to the predictions is given in Table 4.19. The estimated catch in 2009 gives F=0.31 and the corresponding spawning stock biomasses is 285 470 t at the beginning of 2010, which is among the highest recorded.

The average F for the last three years (F status quo) was used last year, but for 2010 it was decided use F status quo equal F_{2009} =0.31. Fishing pattern were calculated the same way as last year and taken as three year average scaled to F status quo.

The deterministic projection shows a further increase in SSB in the beginning of 2011 (Table 4.20).

Fishing at F_{pa} in 2011 corresponds to total landings about 330 000 t, raising the SSB at the beginning of 2012 further to more than 450 000 t (Table 4.21). But the 25 % limitation restricting the TAC (see Section 4.7.2) results in a TAC on 303 000 t for 2011 (+25% compared to TAC for 2010 equal to 243 000 t) predicting F=0.31 in 2011 (Table 4.22).

4.6 Comments to the assessment and forecasts

The problems using XSA on the Northeast Arctic haddock stock was discussed in 2008 (WD 24, AFWG 2008). The main conclusion was, and still is, that the XSA output is rather sensitive to the XSA settings (Figure 4.7), but the reasons for this are not fully understood.

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 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 2002-2008, but for 2009 set as zero.	The estimates were considered quite uncertain, but the uncertainty has decreased in recent years.
Predation on young age groups	The survival due to predation (to a large extent by cod) varies substantially from year to year.	The predictions of young age groups are very uncertain, escpecially for the 3-years HCR.
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.	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 and fishing mortality reference points

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 2006a) and WKHAD report (ICES 2006b) for a detailed description). The reference points have not been updated accordingly. The biomass reference points previously adopted and currently used by ACFM for this stock are $\mathbf{B}_{lim}$=50,000 t and $\mathbf{B}_{pa}$ =80,000 t. The fishing mortality reference points are $\mathbf{F}_{lim}$=0.49 and $\mathbf{F}_{pa}$ =0.35 (Figure 4.4). Due to time constraints there was no work done during the AFWG meeting on revising the reference points of NEA haddock. The WG leave this work to the next benchmark assessment. A plot of SSB versus recruitment is shown in Figure 4.2. Yield and SSB per recruit (YPR and SPR) are presented in Table 4.23 and Figure 4.3.

4.7.2 Harvest control rule

The harvest control rule (HCR) was evaluated by ICES in 2007 (ICES 2007a) 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.*

4.8 Comments to Technical Minutes from ACFM

Our comments to Technical Minutes from ACFM are in *italics* below each comment from ACFM that requires a response.

General comments

The report is well done and the text is an update from last years report with relative changes. The assessment gives the increasing stock as a result of a reduction in fishing mortality and good recruitment last years. The Quality Handbook was revised.

Technical comments

The review was restricted to a check whether the procedures described in the technical annex (handbook) were applied. This was the case. No deviations were spotted.

The procedures used were the same as last year.

The values of stock weights have been changed in 1950-1984 and in 1985-2008 (see Chapter 4.3.3), estimates of consumption of NEA haddock by NEA cod (see chapter 4.4.2) and maturity at age (see chapter 4.3.5) were updated also.

The results of the assessment show that in case of haddock the XSA is rather sensitive to the XSA settings and shows large deviations from last year. The WG discussed it and gives uncertainties in assessment and forecasts in the report. The main uncertainties derive from the biased catch statistics. There are no estimates of discarding. Both Russian (2006) and Norwegian (2007) bottom trawl surveys coverage were reduced compared to previous years.

The assessment indicates that the increasing of the SSB is relative with decreasing F and due to the high level of recruitment.

Decreasing of estimated IUU catches are explained in the Quality handbook. It should be placed in report.

This is now mentioned in the report.

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 PA reference points in a benchmark assessment in 2010.

A benchmark assessment is planned for 2011.

Remarks by the reviewer

In the report not mentioned why in 2006 was decided to include Norwegian landings of haddock from Norwegian statistical areas 06 ad 07. Have to be referred where and when it was.

A reference to WKHAD 2006 is included.

Inspection of historical material raises questions for Norwegian statistical area 06 and 07 in table 4.1. The nominal catch for years 1960-1979 looks something erratically. Have to some explanations below table or in the text.

Due to uncertainties in the reliability of these catch statistics the WG decided to round off these numbers to the nearest thousand tonnes at the time of implementation in 2006. A footnote is added.

No details provided for the sampling data for length and age that are used for estimating catch at age. Is it enough or not?

The biological sampling of NEA haddock catches is considered to be fairly good. However, the present sampling is believed to be less precise because of the termination of a Norwegian sampling program in Q3 2009 (WD 6). A sentence is included in the text.

There are different estimates of unreported catches by Norway and Russian. This assumes to make 3 different assessments and prognoses, based on different assumptions on unreported landings and without it. This year was only 2 assessments with the highest and zero unreported catches estimates were made. Seems to be some explanations why.

This issue was discussed at the working group and it was agreed on using the Norwegian estimates for IUU. This conclusion is strengthened by the decision by ACFM to use the assessment including IUU as basis for the advice.

Retrospective runs for the 2000-2002 and middle 90-th looks strange (figure 4.8). Such a retro needs additional investigation on next benchmark.

This is noted and will be investigated on the benchmark.

Residuals for the ages 7-8 both for all surveys are too high (figure 4.9) and not discussed in the report. Seems that data is not fully correct or incomplete.

This is noted and will be part of the next benchmark.

Have no clear explanation why the CPUE data don't used in the assessment.

Available CPUE data are not considered to be reliable enough to be used in assessment.

Conclusions

The assessment has been performed correctly. There is need for a benchmark in the short time. If a future benchmark the effect of different unreported (both IUU and discards) catches between years should be investigated. Surveys data to be revised again. Suggested to review data on weight at age matrix, seems that some problems with the age reading presented by different nations.

Comparative age readings between Norway and Russia have shown quite large discrepancies (up to 20%) in the past. However, discrepancies have decreased in recent years and were below 10% in 2009 (WD 14).

The present management plan is in accordance with a precautionary approach and the stock is harvested sustainable. However, unreported catches and discards are an important issue for this stock and reduce the effect of management measures and the objectives of the harvest control rule.

The problem of IUU is considered smaller in recent years and negligible in 2009.

The information given by the assessments is sufficient to provide advice.

4.9 Proposals to benchmark 2011.

1. Revising inputs and fleet data.

2. Revising reference points

3 Revise HCR

4 MSY approach addition

Table 4.1 Northeast Arctic haddock. Total nominal catch (t) by fishing areas. (Data provided by Working Group members).

Year	Sub-area I	Division IIa	Division IIb	Unreported[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[1]	58177	66065	76270	0	200512	4498

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, catches prior to 1980 is rounded off due to uncertainties in reliability.

Table 4.2 Northeast 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[1]	49.0	8.8	40.1	25.3	67.1	7.8	0

1 Provisional estimates **2 Figures based on Norwegian/Russian IUU**

Table 4.3 Northeast 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	-	Greenld	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[1]	2953	529	1407	1942	104354	317	1315	85514	2181	0	200512

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)

year										
age	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
3	3189	65643	6012	64528	6563	1154	16437	2074	1727	20318
4	37949	9178	151996	13013	154696	10689	5922	24704	5914	7826
5	35344	18014	13634	70781	5885	176678	14713	7942	31438	7243
6	18849	13551	9850	5431	27590	4993	127879	12535	5820	14040
7	28868	6808	4693	2867	3233	28273	3182	46619	12748	3154
8	9199	6850	3237	1080	1302	1445	8003	1087	17565	2237
9	1979	3322	2434	424	712	271	450	1971	822	5918
10	1093	1182	606	315	319	100	200	356	1072	285
11+	2977	1348	880	1005	543	100	185	176	601	500
TOTNU	139447	125896	193342	159444	200843	223703	176971	97464	77707	61521
TONS	132125	120077	127660	123920	156788	202286	213924	123583	112672	88211
SOPCOF%	61	80	56	68	66	64	77	78	87	104
year										
age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	39910	15429	39503	28466	22363	5936	26345	15907	657	1524
4	70912	56855	30868	72736	49290	46356	22631	41346	67632	1968
5	13647	63351	48903	18969	30672	40201	63176	13496	41267	44634
6	7101	8706	33836	13579	5815	12631	29048	25719	7748	19002
7	6236	3578	3201	9257	3527	1679	5752	8872	15599	3620
8	1579	4407	1341	1239	2716	974	582	1616	5292	4937
9	2340	788	1773	559	833	897	438	218	655	1628
10	2005	527	242	409	104	123	189	175	182	316
11+	606	1434	756	375	633	802	242	271	286	109
TOTNU	144336	155075	160423	145589	115953	109599	148403	107620	139318	77738
TONS	154651	193224	187408	146224	99158	118578	161778	136397	181726	130820
SOPCOF%	94	98	93	85	72	85	84	98	98	111
year										
age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	23444	1978	230942	70679	9685	10037	13994	55967	47311	17540
4	2454	24358	22315	260520	41706	14088	13454	22043	18812	35290
5	1906	1257	42981	24180	88120	33871	6810	7368	4076	10645
6	22417	918	3206	6919	5829	49711	20796	2586	1389	1429
7	8100	9279	1611	422	4138	2135	40057	7781	1626	812
8	2012	3056	6758	426	382	1236	1247	11043	2596	546
9	2016	826	2638	1692	618	92	1350	311	6215	1466
10	740	1043	900	529	2043	131	193	388	162	2310
11+	293	534	1652	584	1870	934	1604	379	400	323
TOTNU	63382	43249	313003	365951	154391	112235	99505	107866	82587	70361
TONS	88257	78905	266153	322226	221157	175758	137264	110158	95422	103623
SOPCOF%	100	128	90	84	109	109	87	90	106	127

Table 4.4 (continued).

year										
age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	627	486	883	1173	1271	29624	23113	5031	1439	2157
4	22878	2561	900	2636	1019	1695	68429	87170	12478	4986
5	21794	22124	3372	1360	1899	564	1565	64556	47890	16071
6	2971	10685	12203	2394	657	1009	783	960	20429	25313
7	250	1034	2625	2506	950	943	896	597	397	3198
8	504	162	344	1799	2619	886	393	376	178	147
9	230	162	75	267	352	1763	702	212	74	1
10	842	72	80	37	87	588	1144	230	88	28
11+	1460	963	649	292	77	281	987	738	446	177
TOTNU	51556	38249	21131	12464	8931	37353	98012	159870	83419	52078
TONS	87889	77153	46955	24600	20945	45052	100563	154916	95255	58518
SOPCOF%	129	136	135	95	95	102	95	101	100	102
year										
age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	1015	4421	11571	13487	3374	2003	1662	2280	1701	16839
4	2580	3564	11567	19457	47821	16109	6818	5633	11304	8039
5	2142	2416	4099	13704	36333	72644	36473	12603	9258	15365
6	4046	3299	2642	4103	13264	19145	73579	32832	8633	6073
7	6221	4633	2894	1747	2057	6417	13426	49478	13801	4466
8	840	3953	3327	1886	903	746	2944	5636	19469	6355
9	134	461	3498	2105	1453	361	573	778	2113	6204
10	42	83	486	1965	2769	770	365	245	330	647
11+	71	54	84	323	2110	1576	1897	748	490	446
TOTNU	17091	22884	40168	58777	110084	119771	137737	110233	67099	64434
TONS	27182	36216	59922	82379	135186	142448	178128	154359	100630	83195
SOPCOF%	98	96	102	100	99	98	98	95	99	98
year										
age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	1520	12971	7132	6803	7993	11452	4539	30707	14536	15379
4	29986	5230	46335	31448	21116	19369	35040	15213	44192	55013
5	6496	32049	11084	56480	41310	22887	27571	45992	15926	52498
6	5149	5279	21985	11736	41226	37067	15033	18516	31173	13679
7	2406	2941	2602	14541	4939	24461	16023	10642	9145	15382
8	1657	1137	1602	1637	4914	2393	8567	7889	4520	3800
9	1570	1161	482	2178	598	2997	1259	2570	2846	1669
10	1744	1169	448	858	1252	990	1298	678	1181	887
11+	437	1204	1029	1219	901	1524	718	988	654	960
TOTNU	50965	63141	92699	126900	124249	123140	110048	133195	124173	159267
TONS	68944	89640	114798	138926	158279	158298	153157	161525	155604	200512
SOPCOF%	97	101	99	98	98	100	101	101	101	100

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

year										
	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
3	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768
4	1.065	1.065	1.065	1.065	1.065	1.065	1.065	1.065	1.065	1.065
5	1.353	1.353	1.353	1.353	1.353	1.353	1.353	1.353	1.353	1.353
6	1.663	1.663	1.663	1.663	1.663	1.663	1.663	1.663	1.663	1.663
7	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921
8	2.183	2.183	2.183	2.183	2.183	2.183	2.183	2.183	2.183	2.183
9	2.463	2.463	2.463	2.463	2.463	2.463	2.463	2.463	2.463	2.463
10	2.752	2.752	2.752	2.752	2.752	2.752	2.752	2.752	2.752	2.752
11+	3.177	3.177	3.177	3.177	3.177	3.177	3.177	3.177	3.177	3.177
SOPCOF%	61	80	56	68	66	64	77	78	87	104
year										
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768
4	1.065	1.065	1.065	1.065	1.065	1.065	1.065	1.065	1.065	1.065
5	1.353	1.353	1.353	1.353	1.353	1.353	1.353	1.353	1.353	1.353
6	1.663	1.663	1.663	1.663	1.663	1.663	1.663	1.663	1.663	1.663
7	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921
8	2.183	2.183	2.183	2.183	2.183	2.183	2.183	2.183	2.183	2.183
9	2.463	2.463	2.463	2.463	2.463	2.463	2.463	2.463	2.463	2.463
10	2.752	2.752	2.752	2.752	2.752	2.752	2.752	2.752	2.752	2.752
11+	3.177	3.177	3.177	3.177	3.177	3.177	3.177	3.177	3.177	3.177
SOPCOF%	94	98	93	85	72	85	84	98	98	111
year										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768
4	1.065	1.065	1.065	1.065	1.065	1.065	1.065	1.065	1.065	1.065
5	1.353	1.353	1.353	1.353	1.353	1.353	1.353	1.353	1.353	1.353
6	1.663	1.663	1.663	1.663	1.663	1.663	1.663	1.663	1.663	1.663
7	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921	1.921
8	2.183	2.183	2.183	2.183	2.183	2.183	2.183	2.183	2.183	2.183
9	2.463	2.463	2.463	2.463	2.463	2.463	2.463	2.463	2.463	2.463
10	2.752	2.752	2.752	2.752	2.752	2.752	2.752	2.752	2.752	2.752
11+	3.177	3.177	3.177	3.177	3.177	3.177	3.177	3.177	3.177	3.177
SOPCOF%	100	128	90	84	109	109	87	90	106	127

Table 4.5 (continued).

year										
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	0.768	0.768	0.768	1.033	1.218	0.835	0.612	0.497	0.55	0.684
4	1.065	1.065	1.065	1.408	1.632	1.29	1.064	0.765	0.908	0.84
5	1.353	1.353	1.353	1.71	2.038	1.816	1.539	1.179	1.097	0.998
6	1.663	1.663	1.663	2.149	2.852	2.174	1.944	1.724	1.357	1.176
7	1.921	1.921	1.921	2.469	2.845	2.301	2.362	2.135	1.537	1.546
8	2.183	2.183	2.183	2.748	3.218	2.835	2.794	2.551	1.704	1.713
9	2.463	2.463	2.463	3.069	3.605	3.253	3.25	3.009	2.403	1.949
10	2.752	2.752	2.752	3.687	4.065	3.721	3.643	3.414	2.403	2.14
11+	3.177	3.177	3.177	4.516	4.667	4.416	5.283	4.213	2.571	2.685
SOPCOF%	129	136	135	95	95	102	95	101	100	102
year										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	0.793	0.941	0.906	0.94	0.614	0.739	0.683	0.682	0.748	0.826
4	1.172	1.281	1.263	1.204	0.906	0.808	0.868	1.028	0.974	1.079
5	1.397	1.556	1.535	1.487	1.287	1.107	1.045	1.151	1.262	1.261
6	1.624	1.797	1.747	1.748	1.602	1.556	1.363	1.369	1.433	1.485
7	1.885	2.044	2.043	1.994	1.968	1.838	1.71	1.637	1.641	1.634
8	2.112	2.079	2.2	2.237	2.059	2.234	1.886	1.856	1.863	1.798
9	2.653	2.311	2.298	2.417	2.39	2.416	2.214	2.073	2.069	2.032
10	3.102	2.788	2.494	2.654	2.545	2.602	2.37	2.5	2.335	2.237
11+	3.338	3.219	2.652	3.026	2.893	3.13	2.675	2.554	2.81	2.712
SOPCOF%	98	96	102	100	99	98	98	95	99	98
year										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	0.853	0.751	0.687	0.594	0.636	0.722	0.745	0.652	0.658	0.706
4	1.186	1.104	1.001	0.875	0.886	0.906	1.041	0.899	0.901	1.023
5	1.395	1.459	1.363	1.113	1.183	1.121	1.287	1.197	1.242	1.279
6	1.588	1.709	1.643	1.364	1.508	1.343	1.504	1.435	1.515	1.536
7	1.808	1.921	1.975	1.361	1.821	1.619	1.72	1.722	1.781	1.807
8	1.989	2.182	2.086	1.972	2.075	2.036	2.082	1.99	2.18	2.11
9	2.264	2.331	2.294	1.636	2.339	2.177	2.377	2.309	2.33	2.406
10	2.415	2.609	2.487	1.877	2.58	2.382	2.738	2.715	2.664	2.532
11+	2.892	2.981	2.778	2.409	2.991	2.768	3.212	3.028	3.328	3.172
SOPCOF%	97	101	99	98	98	100	101	101	101	100

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

year	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
3	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349
4	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648
5	1.015	1.015	1.015	1.015	1.015	1.015	1.015	1.015	1.015	1.015
6	1.431	1.431	1.431	1.431	1.431	1.431	1.431	1.431	1.431	1.431
7	1.883	1.883	1.883	1.883	1.883	1.883	1.883	1.883	1.883	1.883
8	2.357	2.357	2.357	2.357	2.357	2.357	2.357	2.357	2.357	2.357
9	2.832	2.832	2.832	2.832	2.832	2.832	2.832	2.832	2.832	2.832
10	3.299	3.299	3.299	3.299	3.299	3.299	3.299	3.299	3.299	3.299
11+	3.751	3.751	3.751	3.751	3.751	3.751	3.751	3.751	3.751	3.751

year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349
4	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648
5	1.015	1.015	1.015	1.015	1.015	1.015	1.015	1.015	1.015	1.015
6	1.431	1.431	1.431	1.431	1.431	1.431	1.431	1.431	1.431	1.431
7	1.883	1.883	1.883	1.883	1.883	1.883	1.883	1.883	1.883	1.883
8	2.357	2.357	2.357	2.357	2.357	2.357	2.357	2.357	2.357	2.357
9	2.832	2.832	2.832	2.832	2.832	2.832	2.832	2.832	2.832	2.832
10	3.299	3.299	3.299	3.299	3.299	3.299	3.299	3.299	3.299	3.299
11+	3.751	3.751	3.751	3.751	3.751	3.751	3.751	3.751	3.751	3.751

year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349
4	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648	0.648
5	1.015	1.015	1.015	1.015	1.015	1.015	1.015	1.015	1.015	1.015
6	1.431	1.431	1.431	1.431	1.431	1.431	1.431	1.431	1.431	1.431
7	1.883	1.883	1.883	1.883	1.883	1.883	1.883	1.883	1.883	1.883
8	2.357	2.357	2.357	2.357	2.357	2.357	2.357	2.357	2.357	2.357
9	2.832	2.832	2.832	2.832	2.832	2.832	2.832	2.832	2.832	2.832
10	3.299	3.299	3.299	3.299	3.299	3.299	3.299	3.299	3.299	3.299
11+	3.751	3.751	3.751	3.751	3.751	3.751	3.751	3.751	3.751	3.751

Table 4.6 (continued).

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	0.457	0.627	0.633	0.546	0.369	0.358	0.302	0.315	0.351	0.41
4	0.844	0.819	1.101	1.12	0.973	0.672	0.656	0.56	0.584	0.644
5	1.084	1.285	1.251	1.651	1.692	1.48	1.04	1.023	0.885	0.921
6	1.555	1.509	1.769	1.725	2.239	2.311	2.034	1.454	1.441	1.261
7	2.096	2.009	1.958	2.271	2.219	2.833	2.945	2.607	1.894	1.89
8	2.76	2.557	2.469	2.417	2.773	2.713	3.412	3.572	3.176	2.345
9	3.095	3.195	3.01	2.925	2.872	3.261	3.193	3.96	4.173	3.726
10	3.462	3.525	3.612	3.448	3.367	3.316	3.725	3.65	4.468	4.739
11+	3.84	3.877	3.933	4.008	3.864	3.79	3.741	4.161	4.077	4.931

year										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	0.382	0.385	0.335	0.264	0.247	0.276	0.289	0.309	0.33	0.328
4	0.741	0.693	0.7	0.614	0.492	0.461	0.515	0.538	0.571	0.609
5	1.004	1.141	1.072	1.085	0.959	0.779	0.734	0.819	0.851	0.897
6	1.31	1.413	1.588	1.496	1.518	1.351	1.112	1.053	1.172	1.213
7	1.673	1.736	1.854	2.06	1.947	1.978	1.772	1.478	1.405	1.563
8	2.355	2.105	2.182	2.312	2.54	2.407	2.449	2.206	1.863	1.78
9	2.792	2.823	2.547	2.638	2.772	3.016	2.865	2.918	2.641	2.257
10	4.246	3.228	3.283	2.989	3.092	3.226	3.477	3.31	3.375	3.068
11+	5.263	4.73	3.644	3.728	3.422	3.538	3.667	3.916	3.736	3.811

year										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	0.282	0.286	0.268	0.272	0.292	0.31	0.322	0.329	0.291	0.291
4	0.604	0.525	0.53	0.499	0.507	0.542	0.573	0.593	0.606	0.54
5	0.955	0.946	0.83	0.835	0.79	0.803	0.856	0.902	0.931	0.951
6	1.273	1.352	1.336	1.183	1.188	1.128	1.146	1.219	1.279	1.317
7	1.609	1.681	1.782	1.757	1.57	1.572	1.498	1.523	1.615	1.689
8	1.976	2.026	2.108	2.231	2.193	1.976	1.975	1.889	1.921	2.031
9	2.166	2.401	2.453	2.542	2.685	2.633	2.392	2.385	2.289	2.327
10	2.652	2.556	2.828	2.879	2.973	3.135	3.067	2.806	2.793	2.689
11+	3.479	3.04	2.942	3.25	3.297	3.395	3.573	3.486	3.213	3.191

Table 4.7. Northeast Arctic haddock. Natural mortality (M) at age

year	1950-1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
3	0.328	0.2074	0.2	0.6481	0.2	0.4052	0.2	0.3197	0.2	0.2059
4	0.2322	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2238	0.2	0.2	0.2	0.2	0.2027	0.2	0.2	0.2	0.2
6	0.2073	0.2	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	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
year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
3	0.2619	0.2962	0.3451	0.7610	0.4748	0.2382	0.2016	0.2278	0.2151	0.3325
4	0.2256	0.2175	0.3681	0.2983	0.2439	0.2504	0.2000	0.2082	0.2014	0.2103
5	0.2683	0.2115	0.3058	0.2248	0.2234	0.2210	0.2000	0.2080	0.2000	0.2102
6	0.2000	0.2005	0.2083	0.2229	0.2099	0.2000	0.2000	0.2042	0.2000	0.2039
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
year	2003	2004	2005	2006	2007	2008	2009			
3	0.4187	0.4301	0.4276	0.2205	0.2408	0.4019	0.4437			
4	0.2635	0.2798	0.3009	0.2230	0.2202	0.2608	0.2664			
5	0.2081	0.2207	0.2533	0.2178	0.2231	0.3527	0.2674			
6	0.2000	0.2000	0.2204	0.2145	0.2097	0.2546	0.2394			
7	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			
9	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			
11+	0.2	0.2	0.2	0.2	0.2	0.2	0.2			

Table 4.8. Northeast Arctic haddock. Proportion mature at age

year	1950-1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
3	0.034	0.031	0.073	0.071	0.073	0.056	0.028	0.022	0.024	0.029
4	0.109	0.068	0.104	0.199	0.208	0.216	0.167	0.094	0.073	0.077
5	0.298	0.189	0.233	0.298	0.483	0.498	0.506	0.434	0.26	0.215
6	0.579	0.579	0.439	0.478	0.597	0.777	0.772	0.754	0.701	0.526
7	0.806	0.809	0.808	0.688	0.728	0.82	0.916	0.915	0.911	0.886
8	0.926	0.929	0.928	0.927	0.867	0.888	0.934	0.972	0.971	0.971
9	0.975	0.977	0.977	0.977	0.977	0.952	0.961	0.978	0.991	0.991
10	0.992	0.993	0.993	0.993	0.993	0.993	0.984	0.987	0.992	0.997
11+	1	1	1	1	1	1	1	1	1	1
year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
3	0.039	0.058	0.049	0.035	0.018	0.016	0.016	0.022	0.03	0.04
4	0.094	0.129	0.179	0.153	0.112	0.063	0.053	0.059	0.074	0.098
5	0.23	0.28	0.339	0.439	0.383	0.305	0.188	0.174	0.17	0.228
6	0.478	0.516	0.57	0.649	0.721	0.675	0.592	0.426	0.412	0.417
7	0.781	0.747	0.771	0.813	0.85	0.892	0.868	0.824	0.696	0.677
8	0.961	0.918	0.901	0.913	0.932	0.947	0.964	0.955	0.935	0.875
9	0.991	0.988	0.973	0.966	0.971	0.977	0.983	0.989	0.986	0.979
10	0.997	0.997	0.996	0.991	0.989	0.99	0.993	0.995	0.996	0.996
11+	1	1	1	1	1	1	1	1	1	1
year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
3	0.055	0.035	0.035	0.024	0.025	0.029	0.033	0.028	0.013	0.009
4	0.127	0.165	0.109	0.113	0.085	0.08	0.092	0.104	0.088	0.05
5	0.286	0.34	0.403	0.302	0.307	0.233	0.235	0.261	0.296	0.261
6	0.509	0.575	0.637	0.697	0.599	0.594	0.509	0.518	0.549	0.585
7	0.684	0.752	0.817	0.855	0.884	0.821	0.824	0.765	0.776	0.797
8	0.862	0.864	0.905	0.933	0.948	0.961	0.939	0.939	0.912	0.914
9	0.956	0.951	0.953	0.969	0.978	0.983	0.987	0.98	0.979	0.97
10	0.993	0.986	0.984	0.984	0.989	0.993	0.995	0.996	0.994	0.994
11+	1	1	1	1	1	1	1	1	1	1
year	2009									
3	0.005									
4	0.034									
5	0.161									
6	0.528									
7	0.82									
8	0.926									
9	0.972									
10	0.99									
11+	1									

Table 4.9. Northeast Arctic haddock. Survey indices used in tuning XSA

North-East Arctic haddock

103

FLT01: Russian BT survey, total area, Nov-Dec, age 1-7

1983 2009

1 1 0.9 1.00

1 7

1	592	95	5	4	0.1	0	0
1	586	584	15	2	1	0.1	0
1	144	1343	900	4	1	1	0
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	-11	-11	-11	-11	-11	-11	-11
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

Table 4.9 (continued).

FLT02: Norwegian acoustic, age 1-7, shifted
1980 2009
1 1 0.99 1.00
1 7

1	140	50	210	600	180	10	0
1	20	30	40	40	100	60	0
1	50	20	30	10	10	40	20
1	1730	60	20	10	0	0	0
1	7760	2150	50	0	0	0	0
1	2660	4520	1890	0	0	0	0
1	170	490	1710	500	0	0	0
1	40	80	230	460	70	0	0
1	50	60	110	200	210	20	0
1	350	30	30	40	70	110	20
1	2520	450	80	30	30	30	60
1	8680	1340	230	20	0	0	10
1	6260	5630	1300	130	0	0	0
1	1930	2550	6310	1110	120	0	0
1	2850	360	1110	3870	420	20	0
1	2290	440	310	760	1510	80	0
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	0
1	2820	2160	1490	140	120	10	0
1	2790	1450	1980	1690	170	50	0
1	4740	1270	760	760	660	70	20
1	2090	2190	1020	360	400	90	0
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

Table 4.9 (continued).

FLT04: Norwegian BT survey, age 1-8, shifted
1982 2009
1 1 0.99 1.00
1 8

1	48	31	24	9	19	25	7	0
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	0	0	0	0
1	153	253	689	1164	138	1	0	0
1	95	141	216	340	327	34	1	0
1	546	45	34	50	92	118	18	0
1	3003	334	51	42	27	17	42	0
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	0	1
1	2636	525	481	1486	2528	116	9	0
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	0
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

Table 4.9A. Northeast Arctic haddock. Ecosystem survey indices used in tuning XSA

North-East Arctic haddock
101
FLT007: Ecosystem, total area, avg-sep, age 1-8
########
1 1 0.65 0.75
1 8

1	189	269	123	70	69	31	3	2
1	627	114	323	89	29	31	15	0
1	2152	1068	151	143	43	18	16	6
1	995	1827	1287	89	94	19	6	7
1	322	1293	1155	406	43	36	5	3
1	136	143	649	617	306	21	7	1

Table 4.10. Northeast Arctic haddock. Input data for recruitment prediction (RCT3)

NORTHEAST ARCTIC HADDOCK: recruits as 3 year-olds
9 20 2

'Year-class'	'VPA'	'NT1'	'NT2'	'NT3'	'NAK1'	'NAK2'	'NAK3'	'RT1'	'RT2'	'RT3'
1990	687	2006	1375.5	507.7	1890	868	563	-11	42.9	128.6
1991	303	1659.4	599	339.5	1135	626	255	16.7	28.2	35.7
1992	99	727.9	228	53.6	947	193	36	16.4	4.8	5.8
1993	105	603.2	179.3	52.5	562	285	44	3.5	4.9	4.2
1994	119	1463.6	263.6	86.1	1379	229	51	9.1	7.2	5.7
1995	59	309.5	67.9	22.7	249	24	20	6.4	2.3	1.9
1996	231	1268	137.9	59.8	693	122	57	6	4.6	11.5
1997	85	212.9	57.6	27.2	220	46	32	1.8	2.9	6.1
1998	370	1244.9	452.2	296	856	509	210	10.7	28.9	26.2
1999	342	847.2	460.3	314.7	1024	316	216	11.7	20.7	26.1
2000	222	1220.5	534.7	317.4	976	282	145	15.1	14.9	18.9
2001	237	1680.3	513.1	188.1	2062	279	127	20.8	19.3	25.1
2002	371	3332.1	711.2	346.5	2394	474	219	33.2	32.8	20.6
2003	185	715.9	420.4	77.4	752	209	54	19.8	11	13.6
2004	610	4630.2	1313.1	507.7	3364	804	379	50	79.2	122.7
2005	1029	5141.3	1593.8	1522.4	2767	868	723.4	62	79.2	214.2
2006	811	3874.4	2129.4	1270	3197	1835.2	1021.7	53.4	83.9	232.7
2007	-11	860.2	328	102.8	1266.6	246.3	138	6.5	12.7	15.8
2008	-11	564.7	111.2	-11	849	81.8	-11	5.7	2.9	-11
2009	-11	1619.5	-11	-11	2035.8	-11	-11	10	-11	-11

1990 RT was removed from XSA tuning

RT 1 Russian bottom trawl survey age 1

RT 2 Russian bottom trawl survey age 2

RT 3 Russian bottom trawl survey age 3

NT 1 Norwegian bottom trawl survey age 1

NT 2 Norwegian bottom trawl survey age 2

NT 3 Norwegian bottom trawl survey age 3

NA1 Norwegian acoustic survey age 1

NA2 Norwegian acoustic survey age 2

NA3 Norwegian acoustic survey age 3

Table 4.11. Northeast Arctic haddock. Analysis by RCT3 ver.1

Data for 9 surveys over 20 years : 1990 – 2009 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	=	2004	Regression				Prediction		
Survey/	Slope	Inter-	Std	Rsquare	No.	Index	Predicted	Std	WAP
Series		cept	Error		Pts	Value	Value	Error	Weights
NT1	1.11	-2.34	0.56	0.597	14	8.44	7	0.752	0.038
NT2	0.87	0.3	0.42	0.723	14	7.18	6.56	0.541	0.073
NT3	0.7	1.91	0.31	0.826	14	6.23	6.26	0.388	0.143
NAK1	1.23	-3.05	0.64	0.53	14	8.12	6.94	0.842	0.03
NAK2	0.82	0.85	0.45	0.699	14	6.69	6.36	0.556	0.069
NAK3	0.75	1.87	0.23	0.901	14	5.94	6.35	0.285	0.263
RT1	1.38	1.82	0.81	0.388	13	3.93	7.24	1.096	0.018
RT2	0.84	3.18	0.29	0.843	14	4.38	6.85	0.405	0.131
RT3	0.8	3.15	0.24	0.89	14	4.82	6.99	0.341	0.184
VPA	Mean	=					5.28	0.647	0.051
Yearclass	=	2005	Regression				Prediction		
Survey/	Slope	Inter-	Std	Rsquare	No.	Index	Predicted	Std	WAP
Series		cept	Error		Pts	Value	Value	Error	Weights
NT1	0.97	-1.45	0.49	0.688	15	8.55	6.87	0.632	0.051
NT2	0.84	0.46	0.39	0.775	15	7.37	6.67	0.497	0.083
NT3	0.71	1.84	0.31	0.846	15	7.33	7.08	0.425	0.113
NAK1	1.09	-2.14	0.56	0.63	15	7.93	6.51	0.681	0.044
NAK2	0.82	0.86	0.42	0.752	15	6.77	6.44	0.512	0.078
NAK3	0.77	1.83	0.22	0.917	15	6.59	6.87	0.292	0.239
RT1	1.15	2.34	0.66	0.532	14	4.14	7.11	0.877	0.027
RT2	0.77	3.33	0.28	0.873	15	4.38	6.69	0.357	0.161
RT3	0.72	3.31	0.25	0.893	15	5.37	7.2	0.355	0.162
VPA	Mean	=					5.38	0.691	0.043
Yearclass	=	2006	Regression				Prediction		
Survey/	Slope	Inter-	Std	Rsquare	No.	Index	Predicted	Std	WAP
Series		cept	Error		Pts	Value	Value	Error	Weights
NT1	0.97	-1.42	0.47	0.761	16	8.26	6.59	0.561	0.059
NT2	0.89	0.22	0.4	0.813	16	7.66	7.01	0.507	0.072
NT3	0.69	1.95	0.29	0.892	16	7.15	6.89	0.365	0.14
NAK1	1.17	-2.67	0.58	0.671	16	8.07	6.79	0.71	0.037
NAK2	0.91	0.44	0.45	0.775	16	7.52	7.27	0.585	0.054
NAK3	0.78	1.78	0.21	0.939	16	6.93	7.17	0.28	0.238
RT1	1.1	2.47	0.6	0.653	15	4	6.85	0.743	0.034
RT2	0.8	3.25	0.28	0.896	16	4.44	6.81	0.354	0.149
RT3	0.69	3.4	0.24	0.923	16	5.45	7.15	0.315	0.188
VPA	Mean	=					5.53	0.79	0.03

Table 4.11 (continued).

Yearclass	=	2007	Regression				Prediction		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	0.97	-1.4	0.44	0.791	17	6.76	5.15	0.511	0.055
NT2	0.85	0.44	0.37	0.844	17	5.8	5.35	0.425	0.08
NT3	0.67	2.05	0.27	0.91	17	4.64	5.16	0.313	0.147
NAK1	1.14	-2.47	0.54	0.719	17	7.14	5.7	0.614	0.038
NAK2	0.84	0.82	0.4	0.819	17	5.51	5.43	0.463	0.067
NAK3	0.73	1.99	0.22	0.936	17	4.93	5.58	0.256	0.22
RT1	1.06	2.56	0.55	0.71	16	2.01	4.7	0.652	0.034
RT2	0.79	3.28	0.26	0.914	17	2.62	5.34	0.303	0.156
RT3	0.65	3.51	0.25	0.924	17	2.82	5.33	0.283	0.18
VPA	Mean	=					5.65	0.82	0.021
Yearclass	=	2008	Regression				Prediction		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	0.95	-1.28	0.43	0.798	17	6.34	4.76	0.523	0.13
NT2	0.84	0.45	0.37	0.845	17	4.72	4.44	0.461	0.167
NT3									
NAK1	1.13	-2.37	0.53	0.726	17	6.75	5.25	0.616	0.094
NAK2	0.83	0.87	0.39	0.831	17	4.42	4.53	0.481	0.154
NAK3									
RT1	1.05	2.59	0.54	0.72	16	1.9	4.58	0.656	0.083
RT2	0.78	3.29	0.26	0.915	17	1.36	4.35	0.334	0.319
RT3									
VPA	Mean	=					5.69	0.816	0.053
Yearclass	=	2009	Regression				Prediction		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	0.94	-1.16	0.42	0.804	17	7.39	5.76	0.495	0.377
NT2									
NT3									
NAK1	1.12	-2.28	0.52	0.732	17	7.62	6.23	0.615	0.244
NAK2									
NAK3									
RT1	1.04	2.61	0.52	0.73	16	2.4	5.1	0.625	0.237
RT2 RT3									
VPA	Mean	=					5.74	0.808	0.142
Year Class Prediction	Weighted Average	Log WAP	Int Std Error	Ext Std Error	Var	VPA Ratio	Log VPA		
2004	691	6.54	0.15	0.14	0.91	610	6.42		
2005	892	6.79	0.14	0.13	0.77	1029	6.94		
2006	1052	6.96	0.14	0.1	0.58	812	6.7		
2007	212	5.36	0.12	0.07	0.32				
2008	101	4.62	0.19	0.15	0.61				
2009	303	5.71	0.3	0.23	0.56				

Table 4.12. Northeast Arctic haddock. Extended Survivors Analysis

FLR XSA Diagnostics 2010-04-23 18:00:06
CPUE data from indices

Catch data for 59 years. 1950 to 2009. Ages 1 to 11.

fleet	first age	last age	first year	last year
1 FLT01: Russian BT survey, total area, Nov-Dec, age 1-7	1	7	1990	2009
2 FLT02: Norwegian acoustic, age 1-7, shifted	1	7	1990	2009
3 FLT04: Norwegian BT survey, age 1-8, shifted	1	8	1990	2009

Time series weights :
Tapered time weighting applied
Power = 3 over 20 years
Catchability analysis :
Catchability independent of size for ages > 6
Catchability independent of age for ages > 9
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
Minimum standard error for population
estimates derived from each fleet = 0.3
prior weighting not applied

Regression weights

age \ year	2000	2001	2002	2003	2004	2005	2006	2007	2008
all	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1

Fishing mortalities

age \ year	2000	2001	2002	2003	2004	2005	2006	2007	2008
3	0.02	0.04	0.025	0.039	0.043	0.039	0.028	0.058	0.017
4	0.213	0.091	0.198	0.162	0.19	0.165	0.184	0.125	0.118
5	0.279	0.374	0.286	0.398	0.35	0.351	0.402	0.404	0.205
6	0.274	0.386	0.478	0.563	0.575	0.632	0.429	0.53	0.559
7	0.349	0.249	0.334	0.686	0.493	0.828	0.634	0.628	0.55
8	0.357	0.276	0.208	0.363	0.522	0.473	0.802	0.761	0.604
9	0.267	0.457	0.18	0.485	0.217	0.716	0.492	0.599	0.697
10	0.322	0.326	0.319	0.559	0.577	0.676	0.806	0.541	0.617
11	0.322	0.326	0.319	0.559	0.577	0.676	0.806	0.541	0.617

XSA population number (Thousand)

year \ age	3	4	5	6	7	8	9	10	11
2000	84937	173204	29624	23799	9026	6105	7405	6997	1741
2001	370480	66278	113634	18206	14754	5213	3499	4642	4748
2002	342198	287138	49462	64036	10129	9418	3239	1814	4138
2003	221794	239348	190968	30109	32370	5939	6262	2216	3114
2004	237499	140410	156341	104191	14032	13345	3381	3156	2246
2005	370823	148062	87786	88385	48002	7019	6480	2227	3385
2006	185450	232575	92926	47979	37702	17167	3582	2593	1413
2007	609862	144690	154738	50012	25211	16370	6304	1793	2585
2008	1028683	452155	102469	82658	23877	11012	6264	2835	1552
2009	810831	676498	309587	58672	36635	11274	4926	2553	2737

Estimated population abundance at 1st Jan 2009

year \ age	3	4	5	6	7	8	9	10	11
2009	0	508063	470158	191039	34048	16076	5793	2523	1288

Table 4.12 (continued).

Fleet: 1 FLT01: Russian BT survey, total area, Nov-Dec, age 1-7

Log catchability residuals.

year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
age											
3	NA	0.037	0.265	0.201	0.148	-0.143	-0.067	-0.195	0.215	0.002	0.156
4	NA	-0.003	-0.019	0.399	0.066	-0.246	0.114	0.151	0.064	0.29	-0.15
5	NA	-0.249	-0.251	0.147	0.129	-0.204	0.45	-0.413	-0.293	0.198	0.259
6	NA	-0.3	0.279	0.382	-0.013	-0.012	0.161	-0.381	-0.479	-0.004	-0.148
7	NA	0.104	0.305	0.507	-0.793	-0.013	0.973	-1.334	0.001	-0.638	-0.877

age	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	-0.1	0.052	0.131	-0.157	-0.149	-0.085	-0.045	0.096	0.094
4	-0.007	0.132	0.081	-0.056	-0.132	-0.313	-0.239	0.192	0.131
5	-0.193	0.188	0.051	-0.182	-0.144	-0.097	-0.037	0.167	0.132
6	0.098	-0.356	0.408	0.007	-0.056	-0.126	0.088	0.318	0.087
7	-0.77	-0.314	0.245	-0.266	0.392	0.449	0.307	0.481	0.755

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

Mean_Logq	S.E_Logq
-7.016	0.622

Regression statistics

Ages with q dependent on year class strength

		slope	intercept
Age	3	0.6123	8.952543
Age	4	0.6628	8.461045
Age	5	0.6778	8.157107
Age	6	0.7197	7.819472

Table 4.12 (continued).

Fleet: 2 FLT02: Norwegian acoustic, age 1-7, shifted

Log catchability residuals.

year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
age											
3	0.166	-0.11	0.25	0.195	-0.059	0.132	0.004	0.021	0.026	-0.138	0.038
4	0.094	-0.255	-0.197	0.307	0.064	-0.038	-0.09	0.135	-0.043	0.392	-0.439
5	0.036	NA	NA	0.116	0.17	-0.137	0.01	-0.04	0.075	0.229	-0.373
6	-0.275	NA	NA	NA	-0.113	0.059	-0.027	0.133	-0.345	0.207	-0.42
7	0.405	-1.26	NA	NA	NA	NA	-0.152	0.686	-0.472	-0.197	NA

age	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	-0.083	0.157	0.046	0.147	-0.247	-0.094	-0.156	0.077	0.138
4	-0.056	0.123	-0.102	-0.059	-0.177	-0.026	0.072	0.193	0.063
5	-0.292	0.279	-0.013	-0.076	-0.133	0.041	0.155	0.082	0.023
6	-0.184	-0.24	0.479	-0.252	-0.102	0.028	0.297	0.166	0.099
7	NA	NA	-0.287	NA	-0.539	0.425	0.97	-0.341	-0.101

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

Mean_Logq	S.E_Logq
-6.221	0.608

Regression statistics

Ages with q dependent on year class strength

		slope	intercept
Age	3	0.6922	7.4686
Age	4	0.6663	7.5303
Age	5	0.5775	8.0407
Age	6	0.6899	7.5522

Table 4.12 (continued).

Fleet: 3 FLT04: Norwegian BT, age 1-8, shifted

Log catchability residuals.

year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
age											
3	-0.14	-0.171	0.063	-0.067	0.062	0.255	0.155	0.014	-0.094	-0.518	0.065
4	0.19	-0.317	-0.349	-0.07	0.021	0.273	0.094	0.142	-0.236	-0.018	-0.425
5	0.097	0.001	-0.111	-0.2	0.141	0.041	0.074	-0.072	0.049	-0.019	-0.083
6	-0.313	-0.171	0.099	-0.185	0.128	0.211	0.032	-0.059	-0.132	-0.02	-0.219
7	0.842	0.003	-0.772	-0.851	NA	0.615	1.201	0.799	0.159	-0.608	-1.548
8	NA	1.158	-0.478	-0.163	0.308	NA	0.017	1.028	0.238	0.519	-0.676

age	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	-0.066	0.03	0.103	0.188	-0.098	-0.086	0.176	-0.008	-0.022
4	0.009	-0.266	-0.089	0.212	0.018	-0.045	0.258	0.174	0.018
5	-0.323	-0.012	-0.085	0.049	0.083	0.108	0.052	0.185	-0.076
6	-0.066	-0.408	0.384	-0.087	0.109	0.153	0.1	0.011	-0.022
7	-1.04	-0.985	-0.092	-0.054	0.692	0.917	0.926	0.319	-0.373
8	NA	-1.257	0.052	-0.6	-0.7	1.372	0.844	-1.019	0.611

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

	7	8
Mean_Logq	-7.014	-7.487
S.E_Logq	0.808	0.786

Regression statistics

Ages with q dependent on year class strength

		slope	intercept
Age	3	0.6935	7.3331
Age	4	0.6920	7.3349
Age	5	0.5436	8.3400
Age	6	0.5853	8.1385

Table 4.12 (continued).

Terminal year survivor and F summaries:

Age 3 Year class =2006	scaledWts	survivors	yrcls
1 FLT01: Russian BT survey, total area, Nov-Dec, age 1-7	0.285	592494	2006
2 FLT02: Norwegian acoustic, age 1-7, shifted	0.285	619827	2006
3 FLT04: Norwegian BT survey, age 1-8, shifted	0.285	492398	2006
fshk	0.105	323374	2006
nshk	0.04	170846	2006
Age 4 Year class =2005	scaledWts	survivors	yrcls
1 FLT01: Russian BT survey, total area, Nov-Dec, age 1-7	0.281	572721	2005
2 FLT02: Norwegian acoustic, age 1-7, shifted	0.287	516596	2005
3 FLT04: Norwegian BT survey, age 1-8, shifted	0.286	482469	2005
fshk	0.147	282540	2005
Age 5 Year class =2004	scaledWts	survivors	yrcls
1 FLT01: Russian BT survey, total area, Nov-Dec, age 1-7	0.234	232098	2004
2 FLT02: Norwegian acoustic, age 1-7, shifted	0.241	198633	2004
3 FLT04: Norwegian BT survey, age 1-8, shifted	0.363	166256	2004
fshk	0.162	111366	2004
Age 6 Year class =2003	scaledWts	survivors	yrcls
1 FLT01: Russian BT survey, total area, Nov-Dec, age 1-7	0.274	38439	2003
2 FLT02: Norwegian acoustic, age 1-7, shifted	0.223	39304	2003
3 FLT04: Norwegian BT survey, age 1-8, shifted	0.296	32783	2003
fshk	0.207	16535	2003
Age 7 Year class =2002	scaledWts	survivors	yrcls
1 FLT01: Russian BT survey, total area, Nov-Dec, age 1-7	0.171	34216	2002
2 FLT02: Norwegian acoustic, age 1-7, shifted	0.214	14531	2002
3 FLT04: Norwegian BT survey, age 1-8, shifted	0.096	11074	2002
fshk	0.519	15778	2002
Age 8 Year class =2001	scaledWts	survivors	yrcls
3 FLT04: Norwegian BT survey, age 1-8, shifted	0.164	10675	2001
fshk	0.836	3851	2001
Age 9 Year class =2000	scaledWts	survivors	yrcls
fshk	1	2066	2000
Age 10 Year class =1999	scaledWts	survivors	yrcls
fshk	1	1166	1999

Table 4.13. Northeast Arctic haddock. Fishing mortality at age

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
3	0.049	0.126	0.105	0.064	0.055	0.023	0.102	0.040	0.025	0.064	0.182
4	0.576	0.211	0.532	0.379	0.236	0.130	0.168	0.241	0.168	0.168	0.366
5	0.814	0.625	0.577	0.528	0.303	0.482	0.273	0.368	0.570	0.331	0.511
6	0.809	0.911	0.888	0.488	0.410	0.467	0.810	0.403	0.519	0.555	0.649
7	1.158	0.803	0.997	0.714	0.614	1.015	0.625	0.816	0.966	0.601	0.518
8	1.002	1.002	1.256	0.655	0.864	0.622	0.936	0.450	0.870	0.429	0.701
9	0.647	1.428	1.378	0.513	1.366	0.429	0.397	0.628	0.744	0.845	1.150
10	0.946	1.090	1.225	0.633	0.958	0.695	0.659	0.637	0.869	0.630	0.798
11+	0.946	1.090	1.225	0.633	0.958	0.695	0.659	0.637	0.869	0.630	0.798
FBAR4-7	0.839	0.637	0.749	0.527	0.391	0.523	0.469	0.457	0.556	0.414	0.511
	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
3	0.154	0.181	0.109	0.073	0.060	0.117	0.055	0.037	0.090	0.153	0.021
4	0.472	0.579	0.660	0.308	0.231	0.375	0.298	0.384	0.163	0.225	0.259
5	0.686	1.052	0.928	0.684	0.461	0.589	0.416	0.572	0.491	0.243	0.177
6	0.749	1.060	1.027	0.871	0.697	0.743	0.519	0.458	0.581	0.502	0.180
7	0.832	0.698	1.002	0.846	0.677	0.826	0.533	0.704	0.405	0.530	0.402
8	0.880	0.901	0.649	0.961	0.596	0.528	0.581	0.718	0.503	0.413	0.389
9	0.964	1.183	1.362	1.389	1.053	0.593	0.383	0.495	0.502	0.395	0.296
10	0.902	0.937	1.016	1.078	0.783	0.655	0.503	0.645	0.473	0.449	0.365
11+	0.902	0.937	1.016	1.078	0.783	0.655	0.503	0.645	0.473	0.449	0.365
FBAR4-7	0.685	0.847	0.904	0.677	0.516	0.633	0.441	0.530	0.410	0.375	0.255
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
3	0.260	0.308	0.204	0.233	0.295	0.702	0.320	0.132	0.026	0.045	0.066
4	0.378	0.586	0.330	0.572	0.626	1.254	0.602	0.466	0.280	0.153	0.121
5	1.063	0.983	0.413	0.509	0.632	0.912	0.872	0.884	0.617	0.498	0.320
6	0.951	0.476	0.694	0.443	0.704	0.536	0.429	0.929	0.677	0.731	0.582
7	0.551	0.296	0.591	0.597	0.801	0.632	0.791	0.483	0.398	0.533	0.392
8	0.581	0.271	0.480	0.348	0.875	0.533	0.445	0.681	0.637	0.489	0.337
9	0.696	0.275	0.803	0.200	0.811	0.555	0.662	0.488	0.698	0.431	0.441
10	0.615	0.283	0.630	0.384	0.838	0.578	0.638	0.556	0.583	0.488	0.393
11+	0.615	0.283	0.630	0.384	0.838	0.578	0.638	0.556	0.583	0.488	0.393
FBAR4-7	0.736	0.585	0.507	0.530	0.691	0.834	0.673	0.691	0.493	0.479	0.354
	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
3	0.165	0.124	0.118	0.062	0.049	0.032	0.094	0.033	0.048	0.063	0.023
4	0.317	0.226	0.242	0.438	0.462	0.165	0.168	0.156	0.167	0.169	0.146
5	0.280	0.405	0.188	0.370	1.004	0.502	0.330	0.101	0.214	0.294	0.324
6	0.403	0.214	0.392	0.433	0.408	1.103	0.548	0.128	0.222	0.384	0.541
7	0.222	0.276	0.542	0.734	0.703	0.294	0.486	0.247	0.213	0.310	0.476
8	0.514	0.381	0.450	0.456	0.809	0.464	0.168	0.224	0.245	0.233	0.342
9	0.477	0.175	0.480	0.798	0.480	0.356	0.004	0.228	0.184	0.357	0.226
10	0.407	0.279	0.494	0.669	0.670	0.374	0.220	0.234	0.215	0.302	0.349
11+	0.407	0.279	0.494	0.669	0.670	0.374	0.220	0.234	0.215	0.302	0.349
FBAR4-7	0.305	0.280	0.341	0.494	0.644	0.516	0.383	0.158	0.204	0.290	0.372

Table 4.13 (continued).

	1994	1995	1996	1997	1998	1999	2000	2001
3	0.013	0.024	0.024	0.025	0.033	0.084	0.0203	0.0398
4	0.109	0.091	0.123	0.143	0.196	0.220	0.2133	0.0913
5	0.453	0.258	0.344	0.376	0.384	0.460	0.2789	0.3735
6	0.630	0.466	0.491	0.614	0.489	0.476	0.274	0.3864
7	0.580	0.732	0.714	0.747	0.575	0.508	0.3491	0.2489
8	0.486	0.428	0.927	0.764	0.763	0.575	0.3567	0.2759
9	0.483	0.364	0.694	0.679	0.744	0.589	0.2671	0.457
10	0.524	0.514	0.782	0.742	0.700	0.533	0.3224	0.3263
11+	0.524	0.514	0.782	0.742	0.700	0.533	0.3224	0.3263
FBAR4-7	0.443	0.387	0.418	0.470	0.411	0.416	0.2788	0.275
	2005	2006	2007	2008	2009	FBAR2007-2009		
3	0.039	0.0277	0.0585	0.0174	0.024	0.0333		
4	0.165	0.1845	0.1249	0.1181	0.0975	0.1135		
5	0.351	0.4019	0.404	0.2051	0.2155	0.2749		
6	0.6317	0.4292	0.53	0.5595	0.305	0.4648		
7	0.8285	0.6346	0.6289	0.5511	0.6244	0.6014		
8	0.4734	0.8024	0.7613	0.6055	0.467	0.6113		
9	0.716	0.4927	0.5996	0.6987	0.4705	0.5896		
10	0.6765	0.8062	0.5427	0.6182	0.4859	0.5489		
11+	0.6765	0.8062	0.5427	0.6182	0.4859			
FBAR4-7	0.494	0.4125	0.422	0.3584	0.3106			

Table 4.14. Northeast Arctic haddock. Stock numbers at age (start of year). Numbers ´000

year										
age	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
3	78933	651953	71406	1222518	144953	61072	199487	61963	81070	384274
4	97323	54162	414000	46343	826025	98865	43021	129774	42882	56943
5	70978	43365	34766	192868	25153	517100	68858	28833	80884	28730
6	37681	25144	18563	15604	90908	14847	255442	41896	15950	36556
7	46516	13635	8220	6208	7787	49017	7567	92336	22753	7717
8	16065	11963	5003	2484	2488	3450	14550	3316	33416	7094
9	4591	4830	3596	1167	1056	859	1517	4671	1731	11465
10	1975	1968	948	742	572	221	458	835	2041	674
11+	5287	2201	1348	2339	957	218	418	408	1126	1168
TOTAL	359349	809220	557850	1490273	1099899	745649	591318	364031	281852	534619

Table 4.14 (continued).

year										
age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	282781	127726	281125	323637	376654	119919	281063	349446	21122	20770
4	259615	169862	78928	169014	209012	252389	81361	180138	238266	14661
5	38174	142674	84037	35087	69225	121809	158809	44349	105992	128669
6	16493	18317	57421	23461	11090	27919	61440	70478	23389	47841
7	17055	7004	7040	16168	6827	3772	11306	23751	34098	12026
8	3465	8321	2497	2867	4861	2398	1569	4052	11418	13803
9	3784	1408	2825	831	1226	1522	1082	758	1855	4560
10	4032	980	440	709	174	250	435	490	423	926
11+	1201	2624	1350	638	1040	1609	550	751	657	316
TOTAL	626599	478916	515662	572411	680109	531587	597613	674211	437221	243572

year										
age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	194165	112759	1187932	314585	61848	56906	64568	130778	203482	166838
4	13671	119992	79561	659854	166659	36340	32480	34642	46717	106446
5	9870	8653	73437	43204	291144	94986	16265	13770	7836	20286
6	62961	6187	5794	20281	12921	153975	45655	6915	4421	2620
7	21755	30965	4201	1819	10247	5247	80336	18360	3289	2341
8	6571	10482	16956	1982	1107	4645	2364	29528	7991	1221
9	6834	3559	5817	7768	1237	561	2685	807	14184	4194
10	2260	3771	2166	2375	4829	454	376	977	380	5989
11+	887	1916	3930	2606	4367	3209	3078	943	926	828
TOTAL	318973	298283	1379795	1054473	554359	356322	247807	236720	289226	310764

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	28873	12890	16184	9099	12123	293126	529534	116578	55306	26519
4	105315	20270	8874	10911	5560	8706	213186	260254	90894	35702
5	52965	63119	13789	6234	6303	3630	5594	112625	134203	63127
6	6700	22858	30681	8009	3768	3442	2462	3164	33797	66336
7	842	2767	8946	13936	4352	2490	1905	1307	1722	9185
8	1182	463	1330	4949	9143	2703	1186	749	530	1051
9	506	512	232	778	2424	5116	1412	615	273	273
10	2107	206	272	122	395	1666	2593	521	312	156
11+	3613	2730	2191	957	348	789	2209	1649	1568	984
TOTAL	202103	125815	82501	54996	44415	321668	760080	497462	318605	203334

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	36505	105072	210307	686563	302645	99077	104715	118575	59100	230516
4	19760	25652	82025	160733	516523	222149	68476	47787	71956	45063
5	24719	13844	17777	56691	110890	372664	140335	44943	32458	46046
6	37143	18300	9148	10846	31367	57062	212148	79483	24675	17734
7	31407	26749	11998	5099	5167	13669	29082	103935	34874	12391
8	4627	20085	17708	7204	2594	2369	5385	11662	40325	16065
9	727	3028	12867	11488	4192	1307	1265	1745	4448	15399
10	222	474	2062	7370	7501	2117	743	517	725	1730
11+	374	307	354	1202	5657	4290	3808	1557	1062	1180
TOTAL	155485	213511	364247	947195	986537	774705	565957	410204	269624	386124

Table 4.14 (continued).

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	84921	370461	342166	221767	237476	370774	185417	609743	1028578	810740
4	173199	66265	287123	239328	140384	148026	232529	144661	452043	676291
5	29620	113630	49451	190955	156323	87762	92894	154700	102444	309487
6	23796	18203	64033	30100	104181	88371	47958	49985	82625	58646
7	9024	14752	10127	32367	14024	47993	37690	25194	23855	36606
8	6104	5211	9417	5937	13343	7013	17160	16360	10998	11256
9	7403	3498	3238	6260	3379	6478	3577	6298	6256	4914
10	6994	4640	1813	2215	3155	2226	2592	1789	2831	2547
11+	1740	4745	4136	3113	2245	3383	1413	2580	1549	2730
TOTAL	342802	601406	771504	732041	674511	762026	621230	1011310	1711179	1913218

age		GMST 50-**	AMST 50-**
3	0	131922	226065
4	507912	84057	141556
5	469995	49141	82709
6	190963	23778	40309
7	34029	11034	18834
8	16056	4981	8100
9	5780	2274	3650
	2515	1013	1726
	2659		
	1229908		

Table 4.15. Northeast Arctic haddock. Spawning stock numbers at age (spawning time). Numbers ´000

year										
age	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
3	2684	22166	2428	41566	4928	2076	6783	2107	2756	13065
4	10608	5904	45126	5051	90037	10776	4689	14145	4674	6207
5	21152	12923	10360	57475	7495	154096	20520	8592	24103	8561
6	21818	14558	10748	9035	52636	8597	147901	24258	9235	21166
7	37492	10989	6626	5003	6276	39508	6099	74423	18339	6220
8	14877	11078	4633	2300	2304	3195	13473	3070	30943	6569
9	4476	4709	3507	1138	1030	838	1479	4554	1688	11178
10	1959	1952	941	736	567	219	454	828	2024	668
11+	5287	2201	1348	2339	957	218	418	408	1126	1168

year										
age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	9615	4343	9558	11004	12806	4077	9556	11881	718	706
4	28298	18515	8603	18423	22782	27510	8868	19635	25971	1598
5	11376	42517	25043	10456	20629	36299	47325	13216	31586	38343
6	9549	10606	33247	13584	6421	16165	35574	40807	13543	27700
7	13746	5645	5674	13031	5502	3040	9112	19143	27483	9693
8	3208	7705	2312	2655	4501	2221	1453	3752	10573	12781
9	3689	1373	2754	810	1196	1484	1055	739	1809	4446
10	4000	973	436	703	173	248	431	486	420	919
11+	1201	2624	1350	638	1040	1609	550	751	657	316

year										
age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	6602	3834	40390	10696	2103	1935	2195	4446	6918	5672
4	1490	13079	8672	71924	18166	3961	3540	3776	5092	11603
5	2941	2579	21884	12875	86761	28306	4847	4103	2335	6045
6	36454	3582	3355	11743	7481	89152	26434	4004	2560	1517
7	17534	24958	3386	1466	8259	4229	64751	14798	2651	1887
8	6084	9706	15701	1835	1025	4302	2189	27343	7400	1131
9	6663	3470	5671	7573	1206	547	2618	787	13829	4089
10	2242	3741	2149	2356	4790	450	373	969	376	5941
11+	887	1916	3930	2606	4367	3209	3078	943	926	828

Table 4.14 (continued).

year										
age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	895	941	1149	664	679	8208	11650	2798	1604	1034
4	7161	2108	1766	2269	1201	1454	20039	18999	6999	3356
5	10010	14707	4109	3011	3139	1837	2428	29282	28854	14519
6	3879	10035	14666	4782	2928	2657	1856	2218	17777	31708
7	681	2236	6155	10146	3568	2281	1743	1191	1526	7174
8	1098	429	1233	4291	8119	2525	1152	727	515	1010
9	494	500	227	760	2308	4916	1381	610	270	270
10	2092	205	270	121	392	1640	2559	516	311	156
11+	3613	2730	2191	957	348	789	2209	1649	1568	984

year										
age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	2117	5149	7361	12358	4842	1585	2304	3557	2364	12678
4	2549	4592	12550	18002	32541	11774	4040	3536	7052	5723
5	6921	4693	7804	21712	33822	70061	24418	7640	7401	13169
6	19166	10431	5937	7820	21173	33781	90375	32747	10290	9027
7	23461	20623	9754	4334	4609	11864	23964	72339	23610	8475
8	4247	18096	16167	6715	2457	2284	5142	10904	35284	13848
9	718	2946	12430	11155	4096	1285	1251	1720	4355	14722
10	222	472	2043	7289	7426	2103	740	515	722	1718
11+	374	307	354	1202	5657	4290	3808	1557	1062	1180

year										
age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	2972	12966	8212	5544	6887	12236	5192	7927	9257	4054
4	28578	7223	32445	20343	11231	13618	24183	12730	22602	22994
5	10071	45793	14934	58623	36423	20624	24245	45791	26738	49827
6	13683	11595	44631	18030	61883	44981	24842	27442	48336	30965
7	6786	12052	8658	28613	11514	39546	28833	19550	19013	30017
8	5274	4716	8786	5628	12823	6585	16113	14920	10052	10423
9	7040	3334	3138	6122	3322	6394	3505	6166	6069	4777
10	6896	4566	1784	2190	3132	2215	2582	1778	2814	2522
11+	1740	4745	4136	3113	2245	3383	1413	2580	1549	2730

Table 4.16. Northeast Arctic haddock. Stock biomass at age with SOP (start of year). Tonnes

Age\year	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
3	16936	181121	13962	291811	33461	13543	53704	16934	24606	139214
4	38772	27938	150301	20539	354037	40708	21504	65853	24166	38303
5	44292	35037	19770	133890	16886	333509	53912	22917	71398	30270
6	33151	28642	14882	15272	86044	13501	281964	46949	19850	54301
7	53850	20437	8672	7994	9698	58650	10990	136154	37260	15085
8	23280	22446	6606	4004	3879	5167	26453	6120	68496	17356
9	7993	10888	5706	2261	1979	1546	3314	10358	4264	33704
10	4005	5168	1753	1675	1248	463	1166	2157	5855	2307
11+	12193	6572	2832	6002	2374	519	1211	1198	3673	4546
TOTBIO	234472	338248	224485	483448	509606	467606	454218	308640	259568	335084
Age\year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	92457	43715	90954	96160	94527	35506	82305	119046	7210	8022
4	157604	107943	47413	93242	97395	138748	44237	113944	151017	10513
5	36299	142014	79074	30319	50526	104888	135250	43940	105227	144527
6	22110	25705	76174	28582	11412	33894	73771	98447	32738	75762
7	30086	12933	12288	25919	9244	6025	17863	43655	62802	25060
8	7650	19233	5455	5753	8239	4795	3103	9322	26322	36002
9	10038	3910	7417	2003	2497	3657	2571	2095	5139	14290
10	12461	3172	1344	1990	413	701	1203	1576	1366	3381
11+	4220	9654	4695	2037	2806	5119	1730	2748	2410	1314
TOTBIO	372926	368279	324814	286005	277061	333334	362033	434775	394231	318870
Age\year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	67683	50257	371924	91847	23557	21605	19639	40936	75286	73960
4	8848	99300	46250	357704	117861	25617	18343	20134	32093	87616
5	10006	11216	66868	36685	322509	104881	14388	12535	8432	26154
6	89990	11306	7438	24279	20179	239698	56939	8875	6707	4763
7	40915	74464	7097	2865	21058	10748	131839	31008	6565	5599
8	15468	31552	35853	3908	2848	11911	4856	62423	19969	3657
9	19330	12872	14778	18403	3824	1728	6627	2050	42584	15086
10	7447	15886	6412	6556	17385	1628	1081	2890	1327	25097
11+	3322	9177	13224	8177	17876	13093	10061	3174	3681	3947
TOTBIO	263010	316029	569844	550424	547098	430910	263774	184025	196644	245878
Age\year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	16960	10978	13841	4737	4246	107482	152058	37008	19500	11123
4	114250	22550	13201	11652	5135	5992	132975	146878	53321	23521
5	73797	110171	23307	9814	10121	5503	5532	116113	119304	59476
6	13392	46852	73332	13174	8007	8147	4761	4637	48920	85571
7	2267	7552	23667	30179	9165	7226	5334	3434	3276	17759
8	4193	1607	4438	11407	24063	7512	3847	2696	1690	2520
9	2013	2220	945	2169	6609	17086	4286	2455	1144	1040
10	9377	987	1329	402	1263	5660	9184	1915	1399	759
11+	17832	14376	11643	3659	1275	3061	7858	6916	6421	4964
TOTBIO	254081	217294	165702	87193	69883	167669	325835	322051	254976	206733
Age\year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	13726	38993	71913	180687	74340	26685	29754	34828	19284	74035
4	14413	17135	58608	98382	252723	99938	34672	24438	40625	26872
5	24429	15226	19452	61317	105755	283296	101274	34988	27312	40443
6	47894	24925	14829	16175	47351	75230	231941	79556	28594	21063
7	51719	44760	22705	10472	10005	26384	50667	146018	48447	18964
8	10725	40753	39440	16605	6553	5565	12965	24454	74281	28000
9	1999	8240	33452	30210	11556	3847	3563	4839	11616	34032
10	930	1475	6910	21959	23064	6666	2541	1627	2418	5198
11+	1937	1399	1317	4469	19250	14811	13729	5796	3922	4404
TOTBIO	167771	192905	268626	440276	550597	542421	481106	356545	256498	253011
age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	23329	106987	90696	59200	68025	114555	60079	202376	301487	236044
4	101907	35129	150509	117205	69822	79962	134076	86541	275925	365380
5	27556	108545	40595	156484	121149	70237	80017	140771	96067	294469
6	29509	24851	84612	34946	121415	99349	55305	61470	106444	77275
7	14144	25040	17848	55813	21600	75193	56815	38709	38806	61859
8	11749	10661	19633	12998	28705	13812	34104	31177	21280	22873
9	15620	8481	7856	15617	8901	16999	8609	15153	14424	11441
10	18069	11976	5072	6258	9200	6954	7999	5065	7964	6852
11+	5898	14567	12036	9928	7261	11445	5079	9072	5013	8716
TOTBIO	247780	346238	428856	468449	456078	488506	442085	590335	867410	1084910

Table 4.17. Northeast Arctic haddock. Spawning stock biomass at age with SOP (spawning time). Tonnes

Age\year	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
3	576	6158	475	9922	1138	460	1826	576	837	4733
4	4226	3045	16383	2239	38590	4437	2344	7178	2634	4175
5	13199	10441	5891	39899	5032	99386	16066	6829	21276	9020
6	19195	16584	8617	8843	49820	7817	163257	27183	11493	31440
7	43403	16472	6990	6444	7817	47272	8858	109740	30032	12158
8	21557	20785	6118	3708	3592	4785	24495	5667	63428	16071
9	7793	10615	5564	2204	1929	1507	3231	10099	4157	32862
10	3973	5126	1739	1661	1238	459	1156	2140	5808	2288
11+	12193	6572	2832	6002	2374	519	1211	1198	3673	4546
TOTSP	126115	95799	54608	80920	111529	166642	222445	170611	143338	117294
Age\year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	3144	1486	3092	3269	3214	1207	2798	4048	245	273
4	17179	11766	5168	10163	10616	15124	4822	12420	16461	1146
5	10817	42320	23564	9035	15057	31257	40305	13094	31358	43069
6	12802	14883	44105	16549	6608	19625	42713	57001	18955	43866
7	24249	10424	9904	20890	7451	4856	14397	35186	50618	20198
8	7084	17810	5051	5328	7629	4440	2873	8632	24374	33338
9	9787	3812	7231	1953	2435	3566	2507	2043	5010	13932
10	12362	3147	1334	1974	410	695	1194	1564	1355	3354
11+	4220	9654	4695	2037	2806	5119	1730	2748	2410	1314
TOTSP	101643	115302	104145	71199	56226	85889	113339	136736	150787	160490
Age\year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	2301	1709	12645	3123	801	735	668	1392	2560	2515
4	964	10824	5041	38990	12847	2792	1999	2195	3498	9550
5	2982	3342	19927	10932	96108	31255	4288	3736	2513	7794
6	52104	6546	4306	14058	11684	138785	32968	5138	3883	2758
7	32978	60018	5720	2309	16973	8663	106262	24992	5292	4513
8	14324	29217	33200	3619	2638	11030	4497	57804	18491	3386
9	18846	12550	14408	17943	3728	1685	6461	1999	41519	14709
10	7387	15759	6360	6503	17246	1615	1073	2867	1317	24896
11+	3322	9177	13224	8177	17876	13093	10061	3174	3681	3947
TOTSP	135209	149142	114833	105653	179900	209653	168276	103296	82753	74067
Age\year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	526	801	983	346	238	3010	3345	888	565	434
4	7769	2345	2627	2424	1109	1001	12500	10722	4106	2211
5	13948	25670	6946	4740	5040	2784	2401	30189	25650	13680
6	7754	20568	35053	7865	6221	6289	3590	3250	25732	40903
7	1834	6102	16283	21970	7516	6619	4881	3128	2903	13870
8	3895	1492	4114	9889	21368	7016	3739	2618	1641	2422
9	1966	2169	923	2120	6291	16420	4191	2433	1134	1030
10	9311	980	1320	399	1254	5569	9065	1899	1395	756
11+	17832	14376	11643	3659	1275	3061	7858	6916	6421	4964
TOTSP	64835	74504	79890	53412	50312	51769	51570	62044	69547	80270
Age\year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	796	1911	2517	3252	1189	427	655	1045	771	4072
4	1859	3067	8967	11019	15922	5297	2046	1808	3981	3413
5	6840	5162	8540	23485	32255	53260	17622	5948	6227	11567
6	24713	14207	9624	11662	31962	44536	98807	32777	11924	10721
7	38634	34510	18459	8901	8925	22901	41750	101629	32799	12971
8	9846	36718	36008	15476	6206	5365	12382	22865	64996	24136
9	1975	8017	32315	29334	11290	3781	3524	4772	11372	32535
10	927	1469	6848	21718	22833	6619	2529	1621	2408	5161
11+	1937	1399	1317	4469	19250	14811	13729	5796	3922	4404
TOTSP	87527	106460	124594	129315	149832	156997	193041	178260	138400	108980
Age\year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	816	3745	2177	1480	1973	3780	1682	2631	2713	1180
4	16815	3829	17007	9962	5586	7356	13944	7616	13796	12423
5	9369	43744	12260	48041	28228	16506	20884	41668	25074	47410
6	16968	15830	58974	20933	72120	50568	28648	33747	62269	40801
7	10637	20458	15260	49338	17734	61959	43464	30038	30928	50724
8	10151	9649	18317	12323	27586	12969	32024	28433	19450	21181
9	14854	8082	7612	15274	8750	16778	8437	14835	13992	11121
10	17816	11785	4991	6189	9136	6919	7967	5034	7916	6784
11+	5898	14567	12036	9928	7261	11445	5079	9072	5013	8716
TOTSP	103324	131687	148634	173468	178372	188282	162129	173075	181152	200339

Table 4.18. Northeast Arctic haddock. Summary.

YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR4_7
1950	78933	234472	126115	132125	1.0477	0.6148	0.8393
1951	651953	338248	95799	120077	1.2534	0.796	0.6373
1952	71406	224485	54608	127660	2.3378	0.5603	0.7485
1953	1222518	483448	80920	123920	1.5314	0.6839	0.5273
1954	144953	509606	111529	156788	1.4058	0.6614	0.391
1955	61072	467606	166642	202286	1.2139	0.6354	0.5231
1956	199487	454218	222445	213924	0.9617	0.7714	0.4691
1957	61963	308640	170611	123583	0.7244	0.7831	0.4571
1958	81070	259568	143338	112672	0.7861	0.8697	0.5557
1959	384274	335084	117294	88211	0.752	1.038	0.4137
1960	282781	372926	101643	154651	1.5215	0.9368	0.511
1961	127726	368279	115302	193224	1.6758	0.9807	0.6846
1962	281125	324814	104145	187408	1.7995	0.927	0.8473
1963	323637	286005	71199	146224	2.0537	0.8514	0.9043
1964	376654	277061	56226	99158	1.7636	0.7191	0.6774
1965	119919	333334	85889	118578	1.3806	0.8484	0.5164
1966	281063	362033	113339	161778	1.4274	0.8391	0.6331
1967	349446	434775	136736	136397	0.9975	0.9761	0.4414
1968	21122	394231	150787	181726	1.2052	0.9781	0.5295
1969	20770	318870	160490	130820	0.8151	1.1066	0.4099
1970	194165	263010	135209	88257	0.6527	0.9988	0.3753
1971	112759	316029	149142	78905	0.5291	1.2771	0.2545
1972	1187932	569844	114833	266153	2.3177	0.8971	0.736
1973	314585	550424	105653	322226	3.0498	0.8366	0.5852
1974	61848	547098	179900	221157	1.2293	1.0914	0.5071
1975	56906	430910	209653	175758	0.8383	1.0879	0.5303
1976	64568	263774	168276	137264	0.8157	0.8715	0.6905
1977	130778	184025	103296	110158	1.0664	0.8969	0.8335
1978	203482	196644	82753	95422	1.1531	1.0601	0.6732
1979	166838	245878	74067	103623	1.399	1.2702	0.6905
1980	28873	254081	64835	87889	1.3556	1.2854	0.4928
1981	12890	217294	74504	77153	1.0356	1.3583	0.4785
1982	16184	165702	79890	46955	0.5877	1.3511	0.3536
1983	9099	87193	53412	24600	0.4606	0.9535	0.3051
1984	12123	69883	50312	20945	0.4163	0.9491	0.2804
1985	293126	167669	51769	45052	0.8702	1.0242	0.3411
1986	529534	325835	51570	100563	1.95	0.9508	0.4937
1987	116578	322051	62044	154916	2.4969	1.0078	0.6443
1988	55306	254976	69547	95255	1.3696	1.0045	0.5159
1989	26519	206733	80270	58518	0.729	1.023	0.3829
1990	36505	167771	87527	27182	0.3106	0.9843	0.158
1991	105072	192905	106460	36216	0.3402	0.9639	0.2039
1992	210307	268626	124594	59922	0.4809	1.0207	0.2895
1993	686563	440276	129315	82379	0.637	0.9969	0.3716
1994	302645	550597	149832	135186	0.9023	0.9945	0.4429
1995	99077	542421	156997	142448	0.9073	0.9759	0.3865
1996	104715	481106	193041	178128	0.9227	0.9832	0.4177
1997	118575	356545	178260	154359	0.8659	0.9505	0.47
1998	59100	256498	138400	100630	0.7271	0.9888	0.4109
1999	230516	253011	108980	83195	0.7634	0.9792	0.4158
2000	84921	247780	103324	68944	0.6673	0.9741	0.2788
2001	370461	346238	131687	89640	0.6807	1.0098	0.275
2002	342166	428856	148634	114798	0.7724	0.989	0.3241
2003	221767	468449	173468	138926	0.8009	0.9814	0.4525
2004	237476	456078	178372	158279	0.8874	0.981	0.4019
2005	370774	488506	188282	158298	0.8408	0.9967	0.494
2006	185417	442085	162129	153157	0.9447	1.0063	0.4125
2007	609743	590335	173075	161525	0.9333	1.0088	0.422
2008	1028578	867410	181152	155604	0.859	1.0073	0.3584
2009	810740	1084910	200339	200512	1.0009	1.0005	0.3106
Mean	249185	360953	122664	127022	1.1037	0.9594	0.4863

Table 4.19. Northeast Arctic haddock. Prediction with management option table: Input data

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	212000	0.362	0.010	0	0	0.302	0.0284	0.679
4	508063	0.249	0.040	0	0	0.559	0.0969	0.917
5	470158	0.281	0.160	0	0	0.866	0.2347	1.182
6	191039	0.235	0.432	0	0	1.298	0.3968	1.466
7	34048	0.2	0.809	0	0	1.661	0.5131	1.777
8	16076	0.2	0.932	0	0	2.04	0.5213	2.075
9	5793	0.2	0.976	0	0	2.438	0.5026	2.305
10	2523	0.2	0.992	0	0	2.786	0.4675	2.46
11	1288	0.2	1.000	0	0	3.205	0.4675	2.86

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	101000	0.362	0.002	0	0	0.301	0.0284	0.679
4	.	0.249	0.074	0	0	0.558	0.0969	0.917
5	.	0.281	0.228	0	0	0.881	0.2347	1.182
6	.	0.235	0.503	0	0	1.245	0.3968	1.466
7	.	0.2	0.756	0	0	1.640	0.5131	1.777
8	.	0.2	0.901	0	0	2.055	0.5213	2.075
9	.	0.2	0.965	0	0	2.487	0.5026	2.305
10	.	0.2	0.988	0	0	2.938	0.4675	2.46
11	.	0.2	1	0	0	3.361	0.4675	2.86

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	303000	0.362	0.002	0	0	0.301	0.0284	0.679
4	.	0.249	0.074	0	0	0.558	0.0969	0.917
5	.	0.281	0.228	0	0	0.881	0.2347	1.182
6	.	0.235	0.503	0	0	1.245	0.3968	1.466
7	.	0.2	0.756	0	0	1.640	0.5131	1.777
8	.	0.2	0.901	0	0	2.055	0.5213	2.075
9	.	0.2	0.965	0	0	2.487	0.5026	2.305
10	.	0.2	0.988	0	0	2.938	0.4675	2.46
11	.	0.2	1	0	0	3.361	0.4675	2.86

Table 4.20. Northeast Arctic haddock. Prediction with management option table for 2010-2012

Biomass2010	SSB2009	FMult	FBar2009	Landings2009
1117786	285470	1	0.3104	268616

2011					2012	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
1011972	444470	0	0	0	1167816	689292
.	444470	0.1	0.031	35272	1132956	663537
.	444470	0.2	0.0621	69275	1099426	638834
.	444470	0.3	0.0931	102058	1067171	615137
.	444470	0.4	0.1242	133671	1036138	592404
.	444470	0.5	0.1552	164160	1006278	570593
.	444470	0.6	0.1862	193571	977541	549665
.	444470	0.7	0.2173	221946	949882	529581
.	444470	0.8	0.2483	249326	923257	510306
.	444470	0.9	0.2793	275751	897624	491804
.	444470	1	0.3104	301257	872941	474044
.	444470	1.1	0.3414	325882	849171	456993
.	444470	1.2	0.3725	349659	826277	440622
.	444470	1.3	0.4035	372623	804223	424902
.	444470	1.4	0.4345	394803	782974	409804
.	444470	1.5	0.4656	416232	762500	395304
.	444470	1.6	0.4966	436937	742768	381375
.	444470	1.7	0.5276	456948	723749	367993
.	444470	1.8	0.5587	476290	705415	355137
.	444470	1.9	0.5897	494989	687738	342783
.	444470	2	0.6208	513070	670692	330910

Table 4.21. Northeast Arctic haddock. Prediction single option table for 2009-2011

Year	2010	F multiplier:	1	Fbar:	0.3104		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos	SSB
3	0.0284	4985	3385	212000	64024	2120	640
4	0.0969	41619	38165	508063	284007	20323	11360
5	0.2347	86214	101905	470158	407157	75225	65145
6	0.3968	56195	82382	191039	247969	82529	107122
7	0.5131	12491	22197	34048	56554	27545	45752
8	0.5213	5971	12389	16076	32795	14983	30565
9	0.5026	2091	4821	5793	14123	5654	13784
10	0.4675	861	2117	2523	7029	2503	6973
11	0.4675	439	1256	1288	4128	1288	4128
Total		210866	268616	1440988	1117786	232169	285470

Year	2011	F multiplier:	1.1277	Fbar:	0.35		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos	SSB
3	0.032	2673	1815	101000	30401	202	61
4	0.1093	13177	12083	143479	80061	10617	5925
5	0.2647	73328	86674	359497	316717	81965	72211
6	0.4475	91040	133464	280723	349500	141204	175799
7	0.5786	40828	72551	101563	166563	76781	125922
8	0.5878	6788	14086	16688	34293	15036	30898
9	0.5668	3093	7130	7815	19436	7541	18755
10	0.5272	1075	2644	2869	8430	2835	8329
11	0.5272	732	2095	1955	6571	1955	6571
Total		232735	332542	1015588	1011972	338137	444470

Year	2012	F multiplier:	1.1277	Fbar:	0.35		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos	SSB
3	0.032	8020	5446	303000	91203	606	182
4	0.1093	6255	5736	68108	38004	5040	2812
5	0.2647	20454	24176	100275	88342	22863	20142
6	0.4475	67557	99038	208313	259350	104782	130453
7	0.5786	57032	101345	141870	232667	107254	175896
8	0.5878	18965	39352	46622	95808	42007	86323
9	0.5668	3004	6925	7590	18876	7324	18215
10	0.5272	1360	3345	3630	10665	3587	10537
11	0.5272	873	2498	2331	7836	2331	7836
Total		183520	287861	881740	842753	295793	452398

Table 4.22. Northeast Arctic haddock. Prediction using catch constraint for 2011-2012

Year	2010	F multiplier:	1	Fbar:	0.3104		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos	SSB
3	0.0284	4985	3385	212000	64024	2120	640
4	0.0969	41619	38165	508063	284007	20323	11360
5	0.2347	86214	101905	470158	407157	75225	65145
6	0.3968	56195	82382	191039	247969	82529	107122
7	0.5131	12491	22197	34048	56554	27545	45752
8	0.5213	5971	12389	16076	32795	14983	30565
9	0.5026	2091	4821	5793	14123	5654	13784
10	0.4675	861	2117	2523	7029	2503	6973
11	0.4675	439	1256	1288	4128	1288	4128
Total		210866	268616	1440988	1117786	232169	285470

Year: 2011 Fbar=0.3125: Catch constraint 243000*1.25=303000

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos	SSB
3	0.0286	2391	1624	101000	30401	202	61
4	0.0976	11831	10849	143479	80061	10617	5925
5	0.2363	66331	78403	359497	316717	81965	72211
6	0.3996	83049	121749	280723	349500	141204	175799
7	0.5167	37461	66569	101563	166563	76781	125922
8	0.5249	6231	12929	16688	34293	15036	30898
9	0.5061	2837	6539	7815	19436	7541	18755
10	0.4708	984	2421	2869	8430	2835	8329
11	0.4708	671	1918	1955	6571	1955	6571
Total		211785	303000	1015588	1011972	338137	444470

Year: 2012 Fbar=0.35: F multiplier: 1.1277

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos	SSB
3	0.032	8020	5446	303000	91203	606	182
4	0.1093	6276	5755	68342	38135	5057	2822
5	0.2647	20694	24461	101455	89382	23132	20379
6	0.4475	69498	101884	214299	266802	107792	134201
7	0.5786	59829	106317	148830	244081	112516	184526
8	0.5878	20177	41867	49601	101929	44690	91838
9	0.5668	3199	7374	8083	20102	7800	19398
10	0.5272	1445	3555	3857	11332	3811	11196
11	0.5272	924	2643	2467	8291	2467	8291
Total		190063	299301	899933	871257	307871	472834

Table 4.23. Northeast Arctic haddock.Yield per recruit. Input data and results.

MFYPR version 2a

TestProjection index file.

Time and date: 15:32 26.04.2009

Fbar age range: 4-7

Age	M	Mat	PF	PM	SWt	Sel	CWt
3	0.362	0.0031	0	0	0.324	0.0284	0.752
4	0.249	0.107	0	0	0.617	0.0969	1.0486
5	0.281	0.304	0	0	0.994	0.2347	1.3372
6	0.235	0.588	0	0	1.412	0.3968	1.6387
7	0.2	0.811	0	0	1.867	0.5131	1.8935
8	0.2	0.926	0	0	2.331	0.5213	2.17
9	0.2	0.975	0	0	2.802	0.5026	2.4398
10	0.2	0.992	0	0	3.274	0.4675	2.7296
11	0.2	1	0	0	3.737	0.4675	3.2192

Yield per results

FMult	Fbar	Catch Nos	Yield	Stock Nos	Biomass	SpwnNos Jan	SSBJan	SpwnNos Spwn	SSBSpwn
0	0	0	0	4.4371	7.2894	2.184	5.7888	2.184	5.7888
0.1	0.031	0.0921	0.1973	3.9883	5.8098	1.7557	4.3407	1.7557	4.3407
0.2	0.0621	0.1559	0.3167	3.6814	4.8413	1.4681	3.4013	1.4681	3.4013
0.3	0.0931	0.2029	0.3936	3.4575	4.1665	1.2626	2.7538	1.2626	2.7538
0.4	0.1242	0.2393	0.4457	3.2863	3.6744	1.1088	2.2871	1.1088	2.2871
0.5	0.1552	0.2686	0.4823	3.1505	3.3024	0.9897	1.9391	0.9897	1.9391
0.6	0.1862	0.2928	0.5089	3.0398	3.0131	0.8949	1.6722	0.8949	1.6722
0.7	0.2173	0.3132	0.5289	2.9474	2.7826	0.8177	1.4628	0.8177	1.4628
0.8	0.2483	0.3308	0.5443	2.8688	2.5952	0.7537	1.2954	0.7537	1.2954
0.9	0.2793	0.3463	0.5564	2.8008	2.4402	0.6997	1.1592	0.6997	1.1592
1	0.3104	0.36	0.5662	2.7413	2.3099	0.6536	1.0468	0.6536	1.0468
1.1	0.3414	0.3723	0.5742	2.6885	2.1989	0.6137	0.9529	0.6137	0.9529
1.2	0.3725	0.3835	0.581	2.6412	2.1032	0.579	0.8734	0.579	0.8734
1.3	0.4035	0.3937	0.5867	2.5985	2.0198	0.5483	0.8054	0.5483	0.8054
1.4	0.4345	0.403	0.5916	2.5596	1.9464	0.5211	0.7468	0.5211	0.7468
1.5	0.4656	0.4117	0.596	2.5239	1.8812	0.4967	0.6957	0.4967	0.6957
1.6	0.4966	0.4198	0.5998	2.491	1.8229	0.4747	0.651	0.4747	0.651
1.7	0.5276	0.4274	0.6031	2.4606	1.7704	0.4549	0.6114	0.4549	0.6114
1.8	0.5587	0.4345	0.6062	2.4322	1.7228	0.4368	0.5763	0.4368	0.5763
1.9	0.5897	0.4412	0.6089	2.4057	1.6794	0.4202	0.5448	0.4202	0.5448
2	0.6208	0.4475	0.6114	2.3808	1.6396	0.405	0.5165	0.405	0.5165

Reference point	F multiplier	Absolute F
Fbar(4-7)	1	0.3401
FMax	>=1000000	
F0.1	0.5606	0.174
F35%SPR	0.4723	0.1466

Weights in kilograms

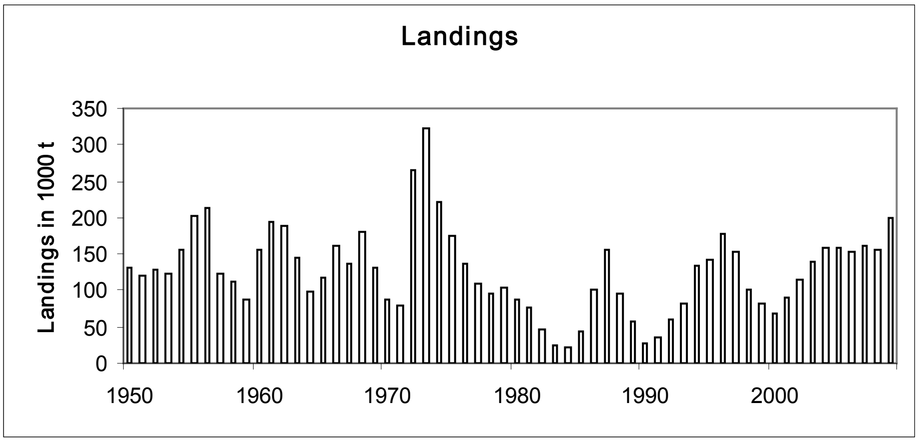


Figure 4.1A Landings of Northeast Arctic haddock 1950-2009

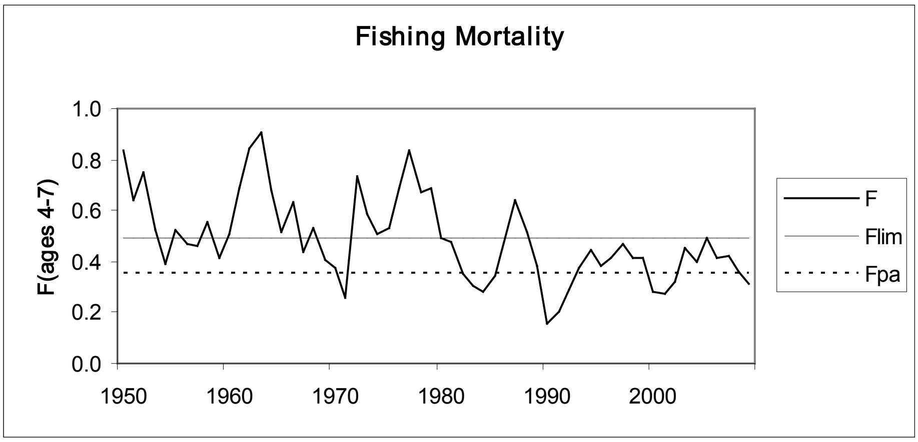


Figure 4.1B Fishing mortality of Northeast Arctic haddock 1950-2009

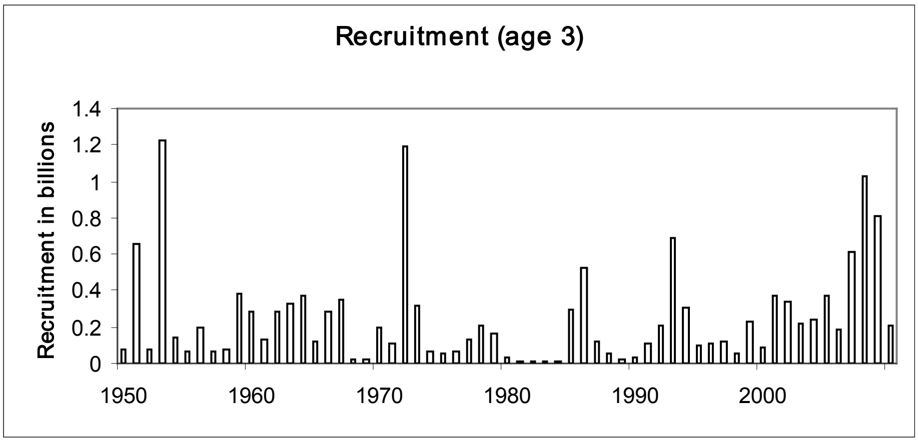


Figure 4.1C Recruitment of Northeast Arctic haddock 1950-2010

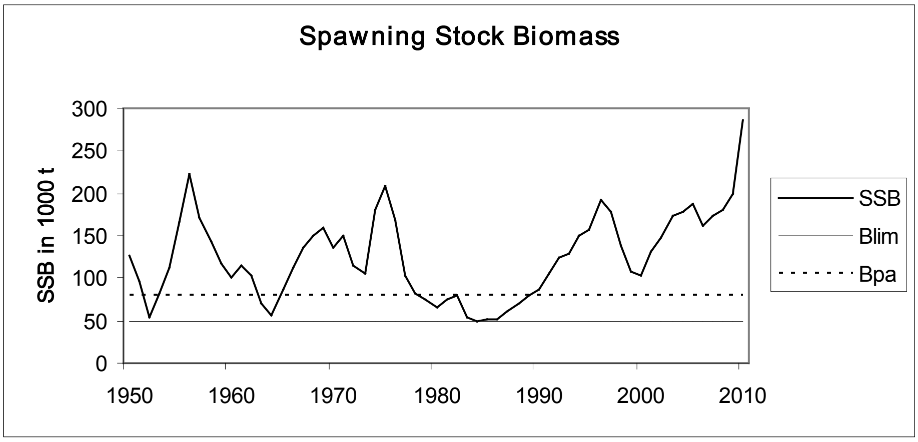


Figure 4.1D Spawning stock biomass of Northeast Arctic haddock 1950-2010

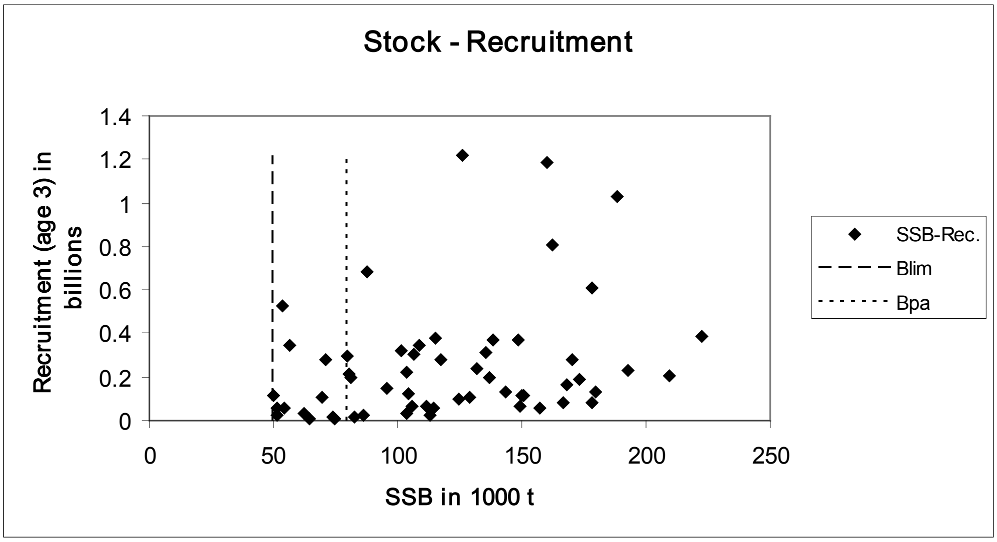


Figure 4.2 Stock-Recruitment relationship of Northeast Arctic haddock 1950-2009

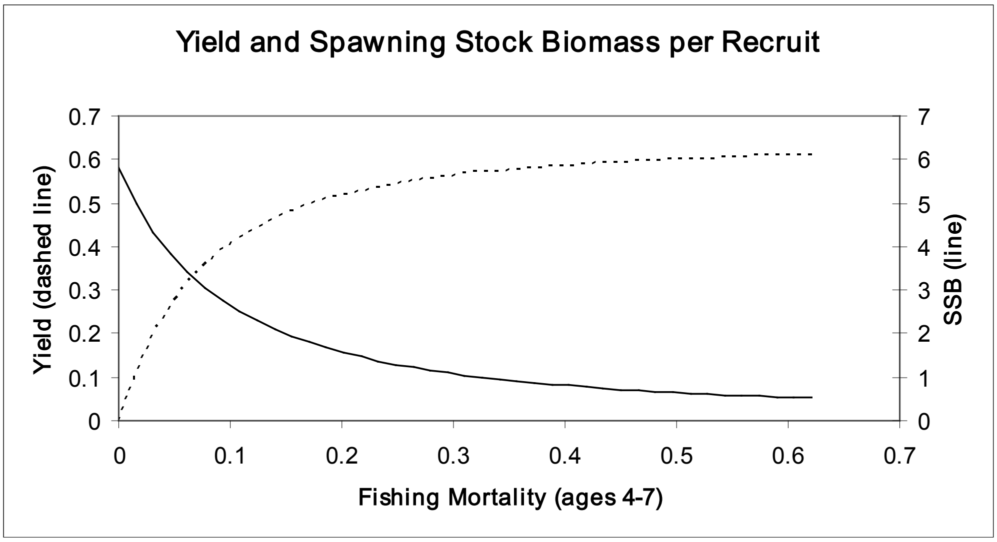


Figure 4.3 Yield and Spawning Stock Biomass per Recruit of Northeast Arctic haddock

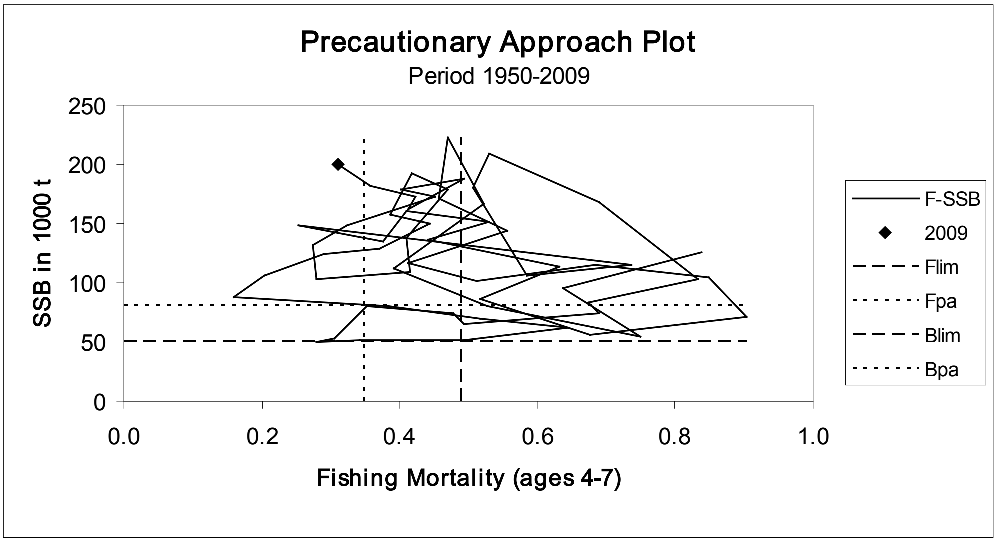
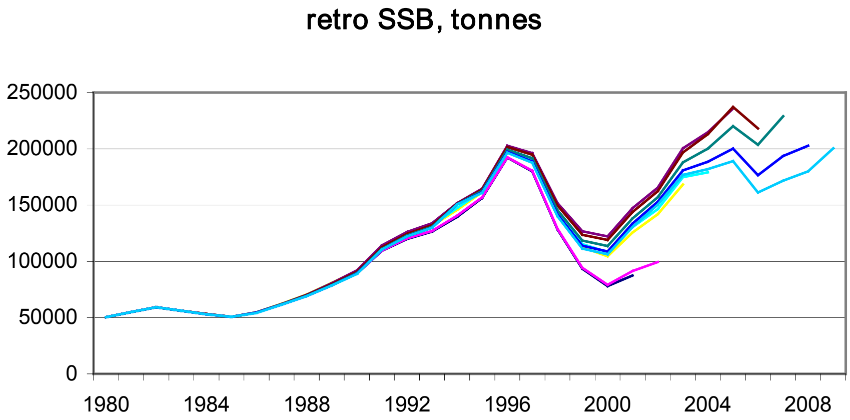
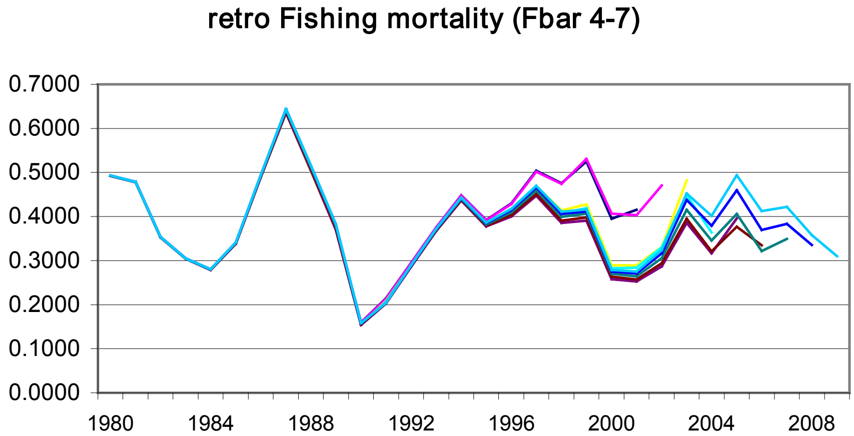


Figure 4.4 Spawning stock biomass – fishing mortality relationship of Northeast Arctic haddock 1950- 2009





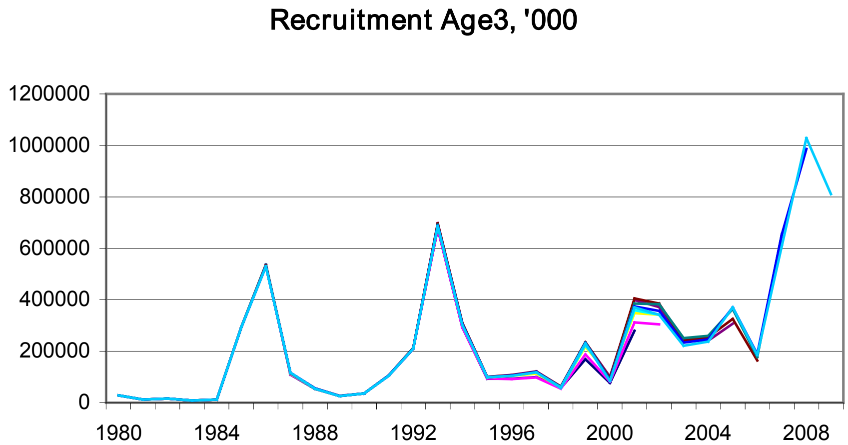
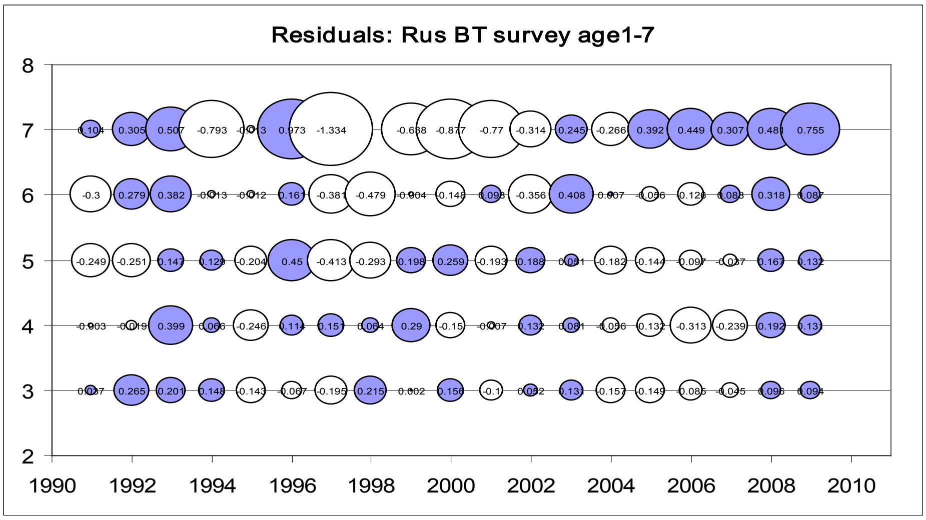


Figure 4.5. Retrospective plots for assessment years 1994-2010 using standard settings in the XSA runs and keeping weight, maturity and natural mortality as estimated in 2010 for all runs.



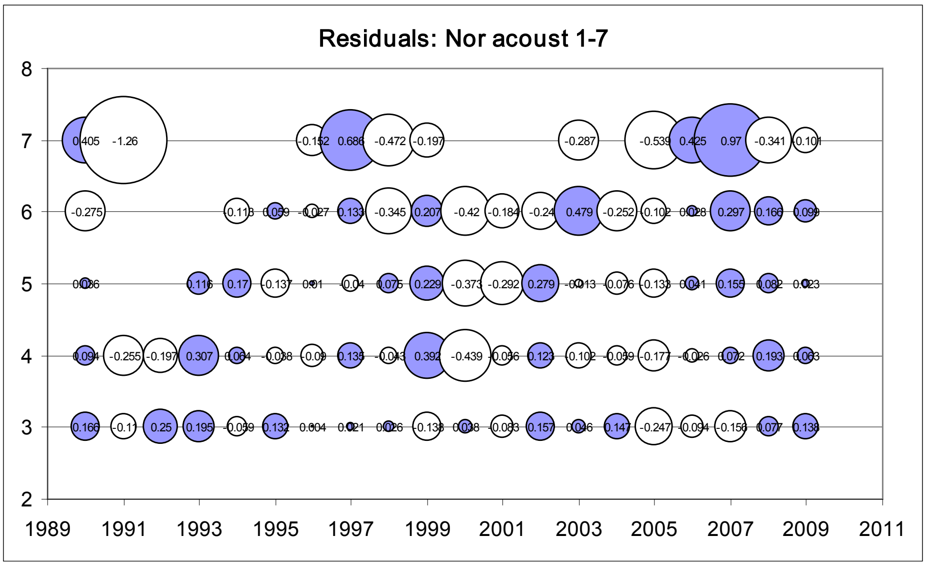


Figure 4.6. Northeast Arctic haddock; log catchability residuals plot, fleets combined, with shrinkage 0.5

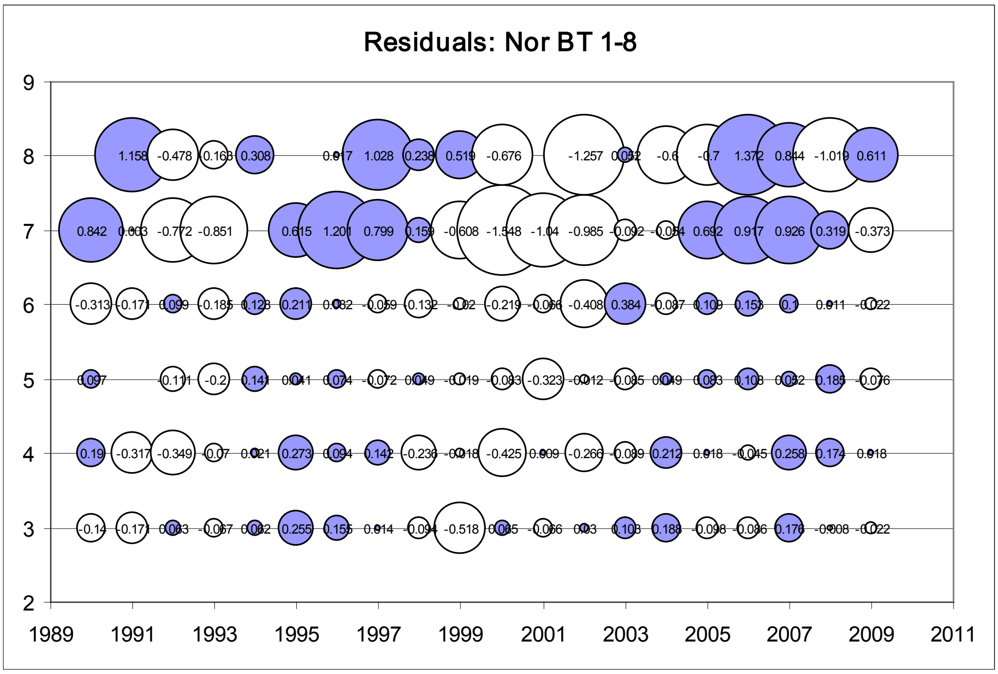


Figure 4.6 (continued).

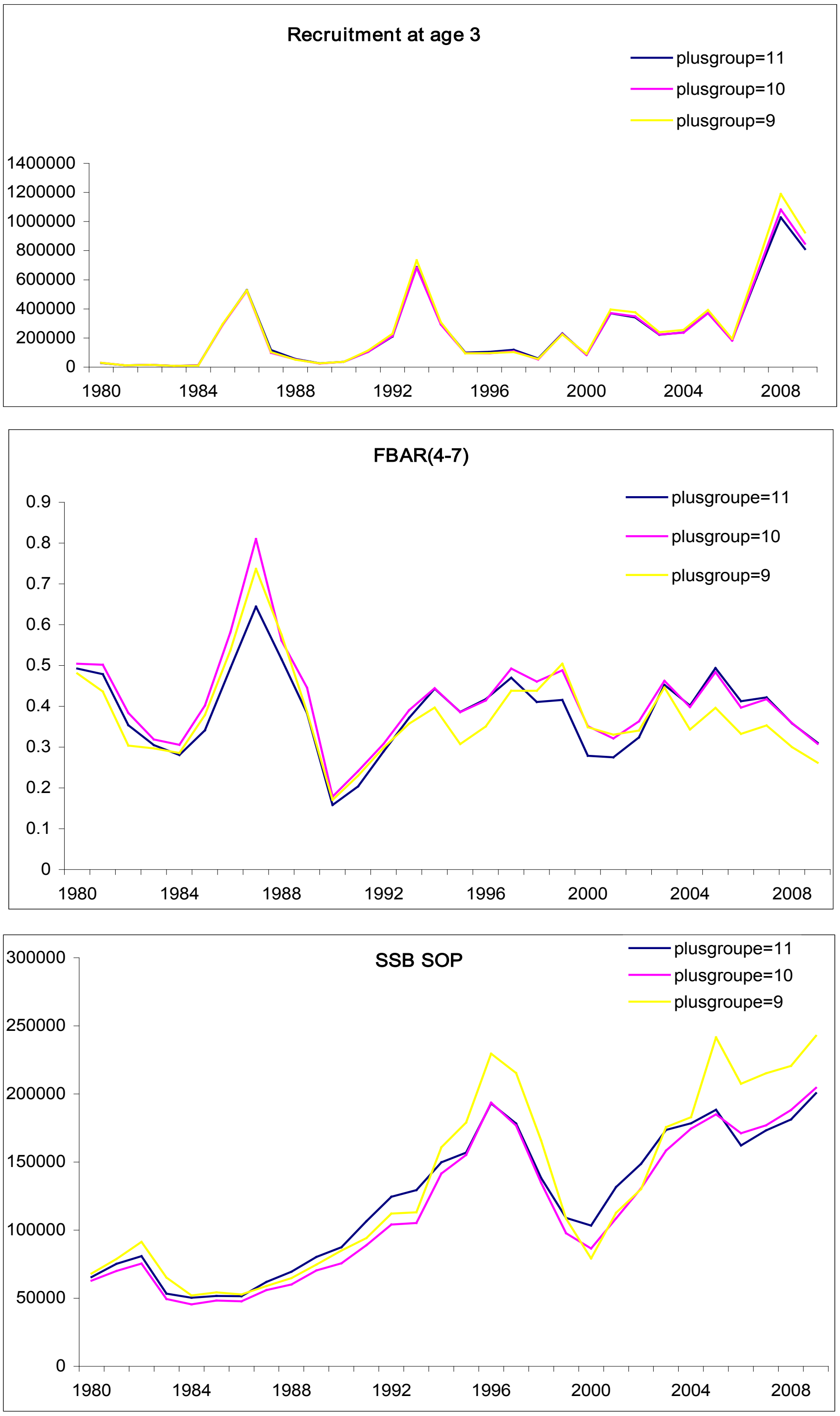


Figure 4.7a Northeast Arctic haddock. Sensitivity analysis of XSA to settings plusgroup=(9,10,11) for Fishing mortality, Spawning stock biomass, and Recruitment at age 3 for the time period 1950 to 2009

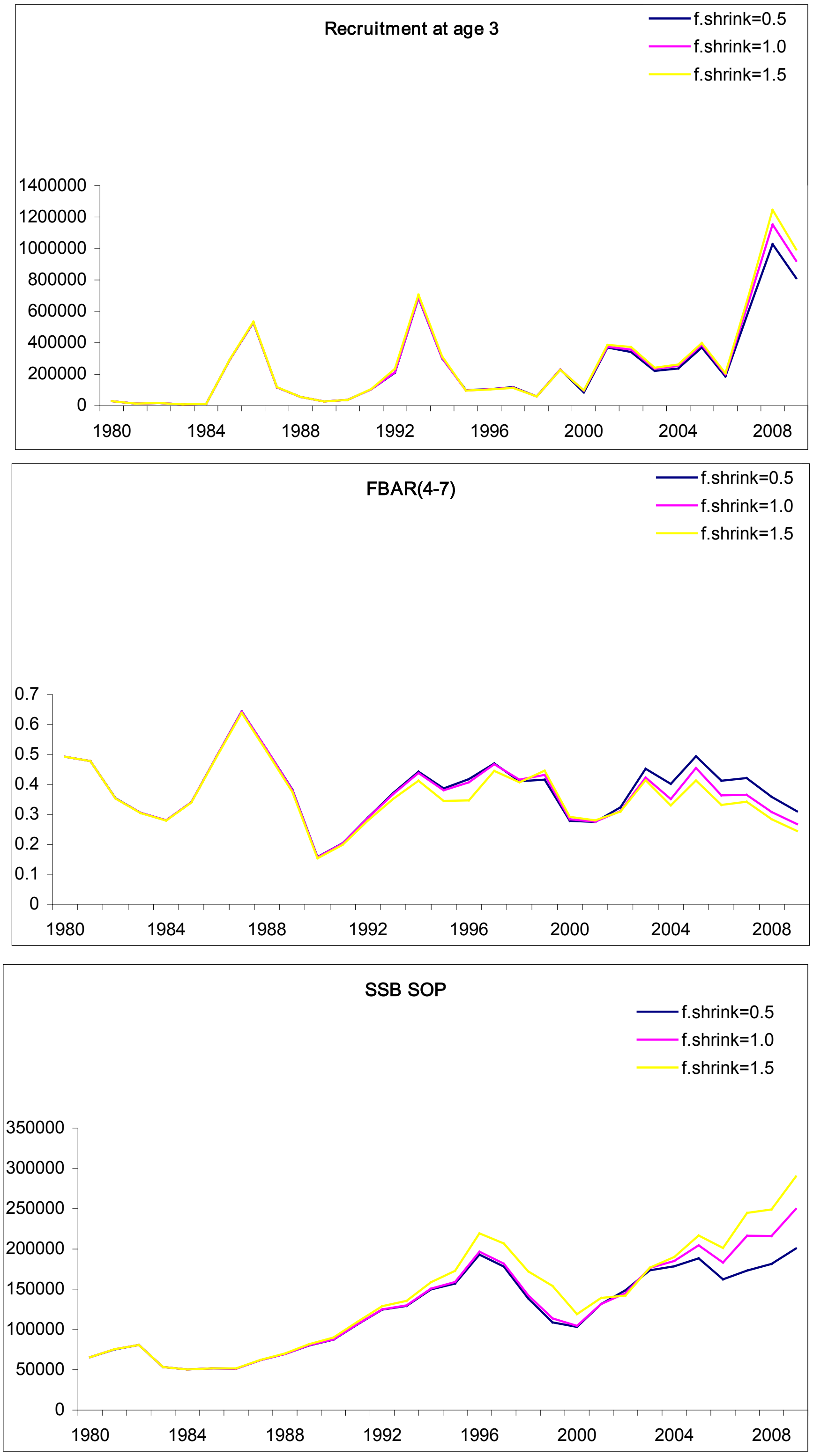


Figure 4.7b Northeast Arctic haddock. Sensitivity analysis of XSA to settings F shr=(0.5,1.0,1.5) for Fishing mortality, Spawning stock biomass, and Recruitment at age 3 for the time period 1950 to 2009

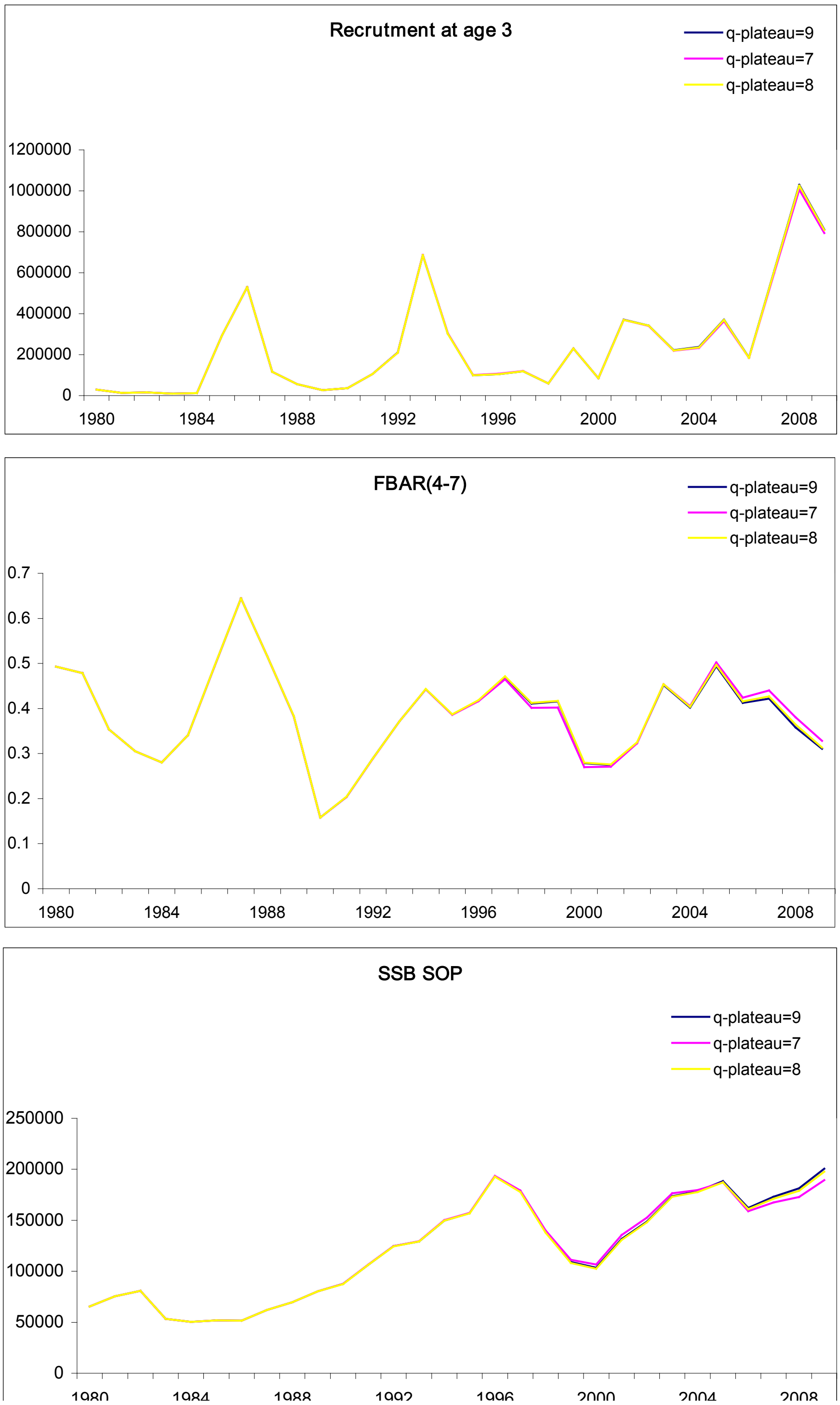


Figure 4.7c Northeast Arctic haddock. Sensitivity analysis of XSA to settings q-plateau=(7,8,9) for Fishing mortality, Spawning stock biomass, and Recruitment at age 3 for the time period 1950 to 2009

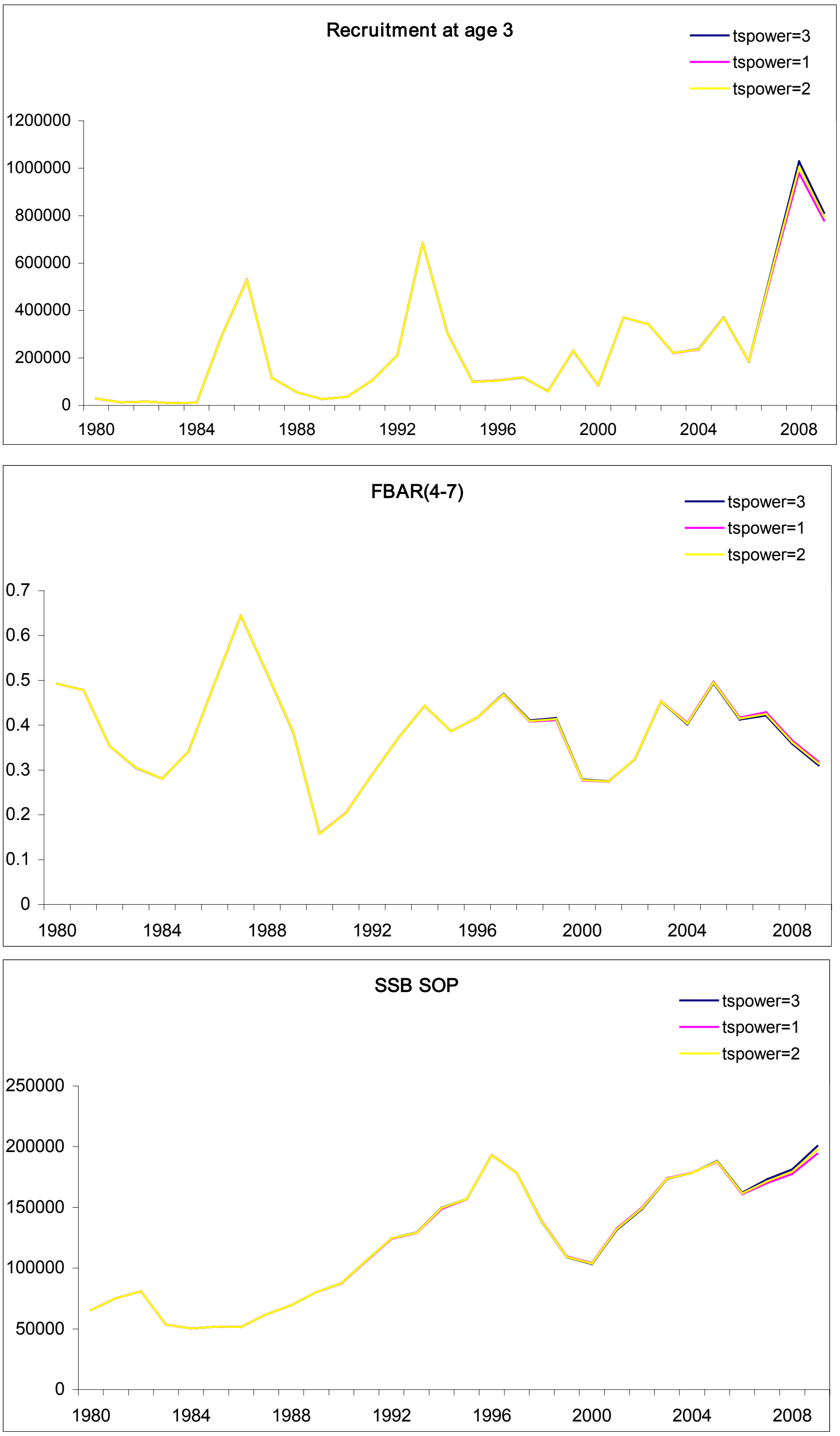


Figure 4.7d Northeast Arctic haddock. Sensitivity analysis of XSA to settings tspower=(1,2,3) for Fishing mortality, Spawning stock biomass, and Recruitment at age 3 for the time period 1950 to 2009

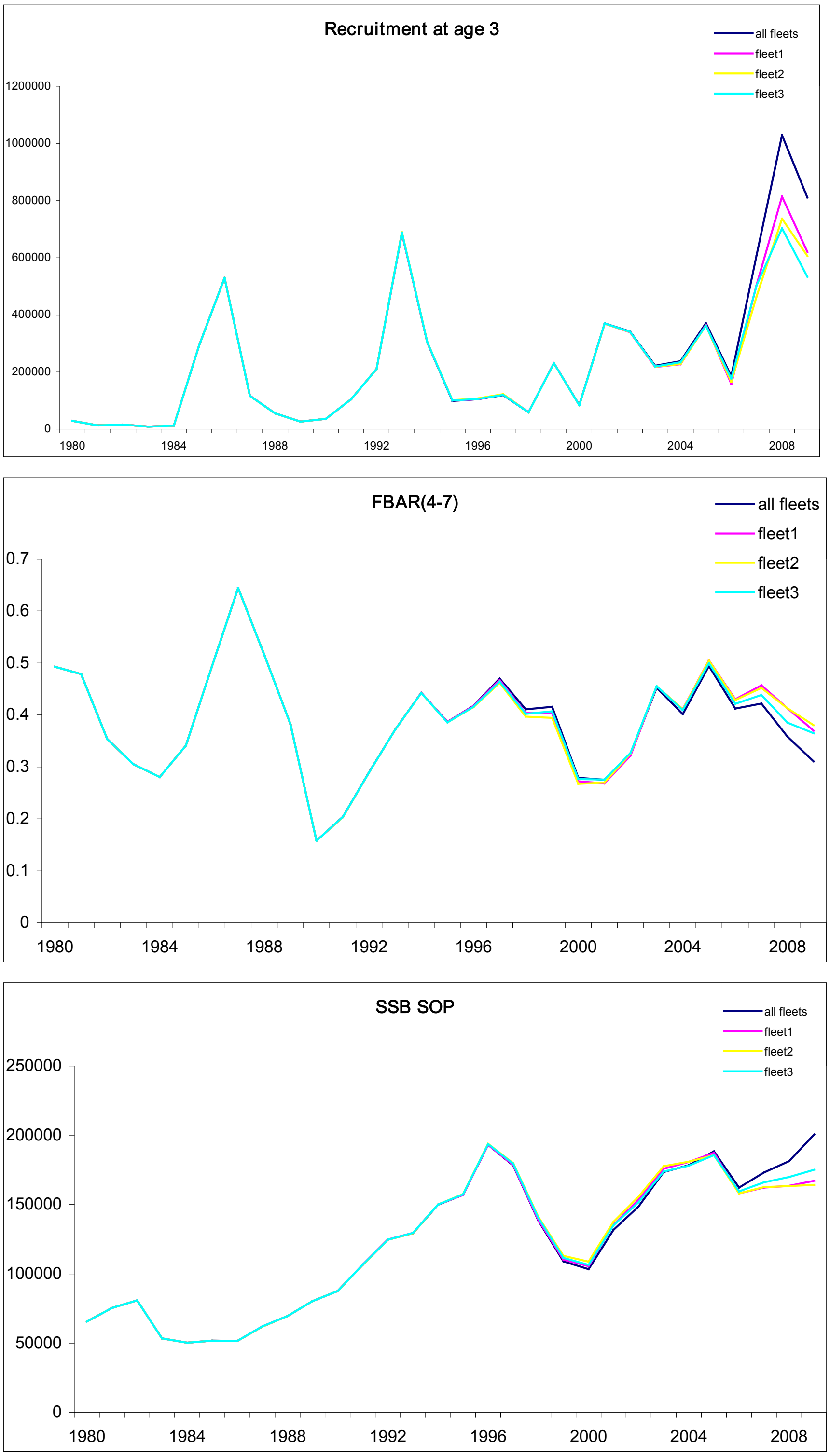
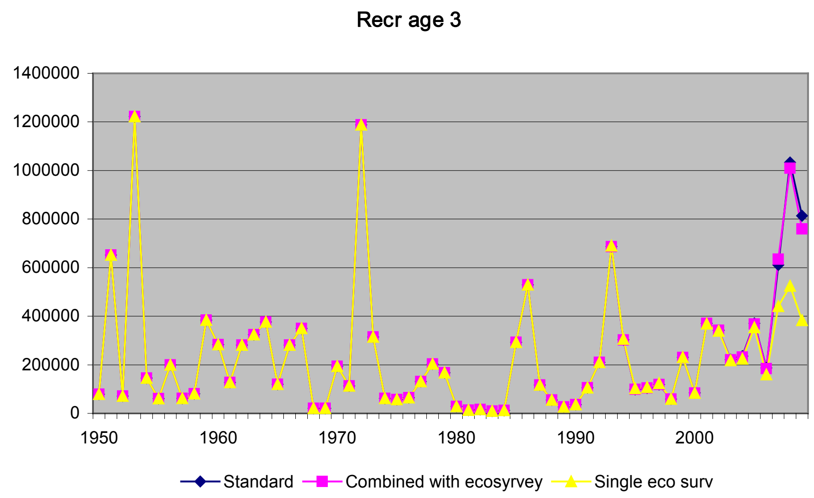
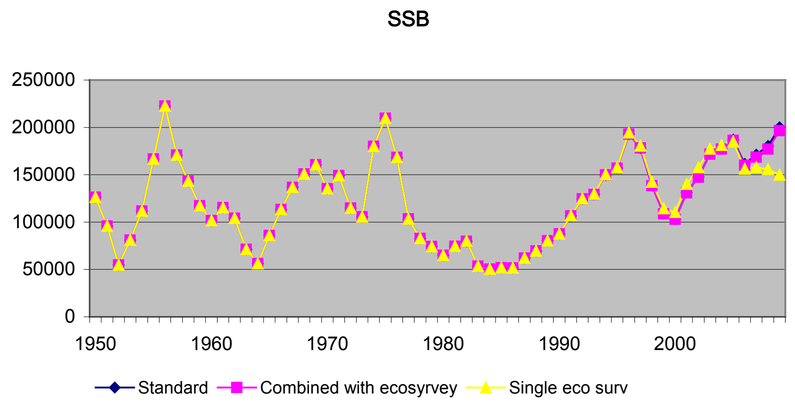


Figure 4.7e Northeast Arctic haddock. Sensitivity analysis of XSA to settings surveys=all for Fishing mortality, Spawning stock biomass, and Recruitment at age 3 for the time period 1950 to 2009





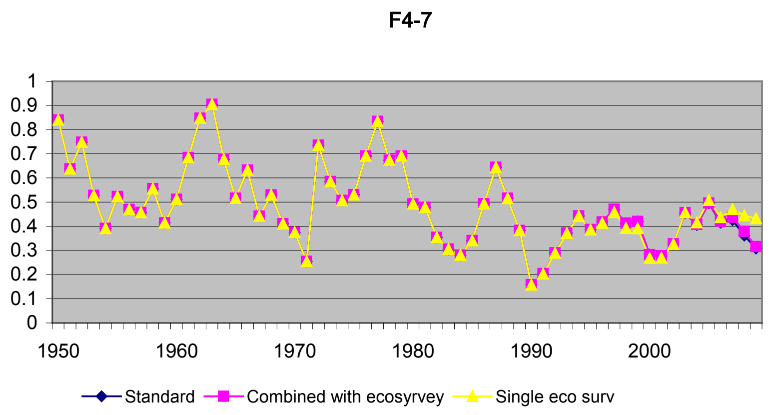


Figure 4.8 Northeast Arctic haddock. Sensitivity analysis of XSA to settings with adding a new surveys, for Fishing mortality, Spawning stock biomass, and Recruitment at age 3 for the time period 1950 to 2009

Table B1 Northeast Arctic haddock. Results from the Norwegian bottom trawl survey in the Barents Sea in January-March. Index of number 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

[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 in the Barents Sea and adjacent waters in late autumn (numbers per hour trawling).

	Age											
Year	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
					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

Table B2 (continued)

	Age											
Year	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
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

[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 Norwegian acoustic survey in the Barents Sea in January-March. Stock numbers in millions. New TS and rock-hopper gear (1981-1988 backcalculated 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

[1]Indices adjusted to account for limited area coverage.

Survey areas extended from 1993 onwards.

Table B4a. Northeast Arctic HADDOCK. Results from the Russian trawl-acoustic survey in the Barents Sea and adjacent waters in late autumn (old 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+	Total
1985[1]	194	434	1468	636	3	1	+	-	-	1	2737
1986[1]	34	37	208	917	910	2	+	+	+	+	2109
1987[2]	6	16	29	62	197	61	+	-	-	12	383
1988[2]	2	1	3	18	83	301	46	-	-	+	454
1989[1]	41	32	94	2	14	35	67	9	1	+	295
1990[1]	594	176	75	28	17	23	43	44	4	1	1004
1991[1]	240	368	143	65	11	4	7	21	17	2	878
1992[1]	199	245	758	218	35	3	4	7	6	+	1475
1993[1]	20	26	199	1076	228	31	5	2	3	5	1595
1994[1]	118	51	39	252	591	76	9	+	1	4	1141
1995[1]	38	40	18	18	77	225	23	3	1	1	443
1996[1,4]	281	44	148	93	69	280	242	19	3	2	1181
1997[1,4]	70	138	41	207	82	48	41	25	20	-	671
1998[3]	107	27	82	22	25	7	3	9	3	+	284
1999[1]	222	330	43	129	25	29	7	3	7	2	798
2000[1]	246	292	238	49	86	23	9	2	1	4	949
2001[1]	256	122	200	229	24	45	7	3	1	2	888
2002[1,5,6]	868	811	581	447	237	329	49	20	12	10	3364
2003[6]	352	310	189	124	161	124	19	9	1	1	1290
2004	3164	472	421	176	143	154	151	10	21	5	4722
2005	7156	2521	271	476	172	114	154	79	5	7	10956
2006	-	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-	-
2008	106	172	1960	1911	783	99	96	15	7	5	5153
2009	302	28	126	943	1050	445	40	20	3	2	2959

Table B4b. Northeast Arctic HADDOCK. Results from the Russian trawl-acoustic survey 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

[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. Length data (cm) from Norwegian surveys in January-March and Russian surveys in November-December.

		Age									
Norway	Year	1	2	3	4	5	6	7			
	1983	16.8	25.2	34.9	44.7	52.5	58.0	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	43.0	54.6	-	-			
	1987	15.4	22.4	29.2	37.3	46.5	-	-			
	1988	13.5	24.0	28.7	34.7	41.5	47.9	54.6			
	1989	16.0	23.2	31.1	36.5	41.7	46.4	52.9			
	1990	15.7	24.7	32.7	43.4	46.1	50.1	52.4			
	1991	16.8	24.0	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	21.0	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	42.0	46.7	55.3			
	1997	16.1	27.7	27.7	35.4	39.7	47.5	50.1			
	1998	14.4	29.2	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	22.2	22.2	32.2	37.8	47.2	51.2	58.7			
	2002	21.1	21.1	29.6	40.2	44.2	50.9	58.4			
	2003	16.5	24.1	28.0	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	30.0	36.6	41.5	47.9	51.9			
	2006	14.7	22.6	31.3	37.8	43.2	48.0	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	50.0			
Russia	Year	0	1	2	3	4	5	6	7	8	9
	1984	-	24.1	35.8	44.4	56.4	62.8	64.8	-	-	-
	1985	16.5	22.4	30.9	44.1	53.8	61.3	64.7	-	-	-
	1986	17.0	20.7	28.1	35.4	46.7	62.0	-	68.0	-	-
	1987	12.1	21.5	27.8	32.3	37.3	48.6	-	-	-	-
	1988	13.7	23.2	29.7	33.7	39.3	46.2	51.2	-	-	-
	1989	14.9	22.2	26.5	38.5	44.5	49.3	53.0	57.7	64.1	-
	1990	17.0	24.5	30.9	40.4	50.6	53.2	55.7	59.7	63.8	67.7
	1991	17.2	24.2	30.5	39.7	53.4	55.4	58.3	60.5	62.7	70.2
	1992	16.0	22.8	31.1	44.6	53.8	63.8	61.2	66.4	69.0	69.6
	1993	15.3	21.7	28.7	38.3	48.3	54.3	60.9	64.2	63.2	65.0
	1994	15.7	22.5	28.1	33.0	44.1	54.9	61.5	67.5	67.7	67.8
	1995	15.5	22.5	28.5	33.3	39.7	49.9	58.2	63.1	66.3	69.5
	1996[1]	15.8	22.8	28.4	33.7	42.0	48.7	54.8	63.4	69.3	72.0
	1997[1]	13.8	23.5	29.3	36.1	45.3	50.0	54.6	58.9	69.4	66.0
	1998	15.0	22.0	29.0	38.3	47.7	52.1	54.5	57.8	63.4	-
	1999	-	22.8	27.4	40.1	47.4	50.9	54.6	55.9	58.0	61.6
	2000	15.0	22.7	30.4	35.2	49.3	55.1	57.8	62.4	63.3	63.6
	2001	15.1	22.4	29.8	37.8	48	55.3	58.8	62.1	63.6	65.4
	2002	14.6	23.8	30.1	35.6	48.2	55.1	60.2	60.5	63.3	66.8
	2003	14.0	22.9	28.9	35.3	44.8	52.2	57.5	63.1	66.3	69.6
	2004	14.4	23.1	30.4	37.7	44.2	49.4	56.4	61.6	66.4	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

[1]Limited area coverage, lengths are not adjusted to account for limited area coverage.

Table B6 Northeast Arctic HADDOCK. Weight data (g) from Norwegian surveys in January-March and Russian surveys 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

Russia

Year /Age	0	1	2	3	4	5	6	7	8	9	10
1984	36	127	438	815	1777	2395	2688	-	-	-	-
1985	37	105	282	817	1530	2262	2263	-	-	-	-
1986	38	88	209	419	919	2240	-	3100	-	-	-
1987	-	95	196	330	497	1055	-	-	-	-	-
1988	35	106	248	398	627	997	1431	-	-	-	-
1989	52	105	181	606	903	1287	1587	2004	2716	-	-
1990	62	143	288	667	1337	1533	1778	2233	2731	3092	-
1991	57	133	292	690	1570	1863	2206	2320	2568	3525	-
1992	40	108	279	850	1542	2199	2363	3045	3391	3400	4200
1993	31	96	217	535	1077	1493	2094	2509	2374	2621	3160
1994	27	106	205	337	841	1602	2256	2913	2934	3033	3163
1995	28	95	196	345	628	1234	1908	2430	2815	3323	3479
1996	30	103	209	347	743	1152	1650	2442	3218	3333	4648
1997	22	115	227	447	911	1216	1583	1966	3155	2815	3423
1998	27	94	230	569	1087	1482	1690	1914	2539	3893	3900
1999	-	104	191	648	1049	1251	1544	1608	1814	2210	2978
2000	29	110	278	427	1249	1681	1966	2488	2625	2648	-
2001	26	102	244	533	1097	1695	2065	2469	2704	2867	3141
2002	25	127	280	457	1166	1690	2293	2484	2784	2962	4655
2003	21	104	220	419	855	1347	1844	2402	2923	2582	-
2004	24	87	253	518	846	1130	1571	1959	2633	3366	-
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	3214	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

[1]Limited area coverage, weights are not adjusted to account for limited area coverage.

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 downweighting

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 1974. 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 again and reached 171,000 t in 1996, followed by a new decline to 136,000 t in 2000 and 2001. 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.

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 2009 and 2010

The advice from ICES for 2009 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 225 000 t in 2009, and a fishing mortality of 0.29.

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 225 000 t in 2009.

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.

5.1.2 Management applicable in 2009 and 2010

Management of Saithe in Sub-areas I and II is by TAC and technical measures. Norwegian authorities set the TACs for 2009 and 2010 to 225,000 t and 204,000 t, respectively. The Institute of Marine Research, Bergen, Norway (IMR), advised a TAC for 2009 of 214,000 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. Following the same principle, IMR advised a TAC of 193 000 t for 2010. 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 2009 and expected landings in 2010

Provisional figures show that the landings in 2009 were approximately 161,000 t, which is about 64,000 t less than the TAC of 225,000 t, which also were expected landings in the forecast last year.

Official landings in 2010 will probably also be less than the TAC of 204,000 t, which is only 9 % less than the 2009 TAC, but 26 % higher than the 2009 landings. However, since the WG does not have any prognosis of total landings in 2010 available, the TAC of 204,000 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 (Tables 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 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 2009 (Mehl *et al*., WD 8) increased by almost 40 % compared to 2008, but is still one of the lowest since 1991. All age groups are all below the 1992-2008 average. In recent years the proportion of saithe in the southern part of the survey area (sub areas C+D) has increased, from about 30% in 1997-2002 to 60 % 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 an 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 is therefore decided to terminate the programme.

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 2008 was updated applying the same method as previously used. The new allocation resulted in a much higher number of 3-year olds in the purse seine catches in 2008. Also for 2007 and 2006 all Norwegian landings data were updated and catch numbers and weights at age were recalculated. For all countries the landings data for 1973-2008 were updated to the official total catch reported to ICES or to Norwegian authorities. The total landings by numbers for the whole time series back to 1960 were expanded to 15+, adjusted to the official total catch reported to ICES (Fotland and Mehl, WD 5). These revisions resulted in only minor changes in catch numbers-at-age and weight-at-age.

Age composition data for 2009 were available from Norway, Russia (Sub-areas I and II) and Germany (Subarea II). These countries accounted for 98% of the landings. 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 2009. The biological sampling of some vessel groups may have become critically low after the termination of the Norwegian port sampling program in 2009. The 2008 and 2009 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 (see Section 0.9).

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 2009.

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.

5.3.5 Tuning data (Table 5.3.5)

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 2002-2009, 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 2002-2009, age groups 3 to 7.

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 Figures 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 somewhat different results compared to the 2009 assessment. F_{4-7} in 2008 is estimated to 0.20 in both runs, while SSB in 2008 decreased from 776,000 t to 751,000 t (Figure 5.4.1). Due to the reallocation of biological samples for 2008, resulting in higher landings of three year olds in the purse seine fishery, the estimated number of recruits at age three in 2008 increased from about 250 millions to 500 millions in the SPALY run.

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, in addition to the 2009 update, also compares estimates of SSB and F_{4-7} in 2009 from the two single fleet XSA -runs and the combined tuning runs. Due to the expansion of the age span from 11+ to 15+ and the changes made to the XSA parameter settings (ICES CM 2010/ACOM:36), the 2009 assessment have much lower F_{4-7} and higher SSB than the new assessment with 2009 as the last data year. The single fleet tuning run based on the CPUE give the lowest F_{4-7} and highest SSB in the last assessment year (2009), while the run based on the acoustic indices gave similar SSB but considerable higher F_{4-7} (0.29 compared to 0.20). The combined run gave the lowest SSB and a slightly higher F_{4-7} than the acoustic single fleet run. This run was used as the final run. Compared to the corresponding run made at the benchmark assessment, F_{4-7} in 2008 is somewhat higher and SSB lower, mainly due to one additional year of data (2009). The run made at WKROUND only had data back to 1989, and the runs are therefore not directly comparable.

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. 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 survey gets the highest weights for age groups 3-6. 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 2008 was 0.25, which is higher than the value of 0.20 from last year's assessment. The main reason for this is the above mentioned changes made to the assessment. The fishing mortality (F_{4-7}) in 2009 was 0.27, i.e. slightly above the corresponding figure for 2008 and below the F_{pa} of 0.35. Fishing mortality and stock size have in the last decade been over- and underestimated, respectively, in the last assessment year. Due to the changes made to the assessment, the retrospective pattern has improved considerably, as is illustrated in Figure 5.5.5.

The XSA-estimates of the 2006-2007 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 of the same strength as the very strong 1989 and 1992-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, while the 2005-year class seems to be slightly above average strength. Little information is available on the strength of recent year classes.

The total biomass (ages 3+) has been above the long-term (1960-2008) 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 twice the B_{pa}.

5.5.2 Recruitment (Table 5.3.1, Figure 5.1.1)

Estimates of the recruiting year classes up to the 2005-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 and decreased again in 2009 (Table 5.3.1). Until the 2005 WG, RCT3-runs were conducted to estimate the corresponding year classes, with 2 and 3 year olds from the acoustic survey as input together with VPA 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 1960-2008 is 169 million 3 year olds, and this value is used for the 2006-year class. The value is lower than the GM recruitment 1995-2008 (181 million), a period where the SSB has been above B_{pa}.

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 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 0.10), it was decided to not change the existing LIM and PA reference points. The estimations done at the present WG are, however, presented below. No attempts were made to set MSY reference points (F_{MSY} and MSY $B_{trigger}$), see Section 0.10.

5.6.1 Biomass reference points

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, the existing values of B_{lim} = 136,000 t and B_{pa} = 220,000 t will still be used.

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 used for 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, the existing values of F_{lim} = 0.58 and F_{pa} = 0.35 will still be used.

Yield and SSB per recruit were based on the parameters in Table 5.7.1 and are presented in Table 5.6.1. and $F_{35\%SPR}$ were estimated to be 0.08, 0.33 and 0.11, respectively. $F_{0.1}$, F_{max} have decreased from last year's estimates of 0.16 and 0.39, respectively. 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 evaluated (see below), the highest long-term yield was obtained for an exploitation level of 0.32.

5.6.3 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. 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 (F_{pa}), and ICES recommended using a lower value in the HCR.

The HCR is expected to rebuild a depleted stock to a level above B_{lim} within three years.

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 2010 was taken from the XSA for age 5 (2005 year class) and older. The recruitment at age 3 in the last assessment year (2009) was calculated as the long-term GM (geometric mean) recruitment 1960-2008 (Section 5.5.2), and the corresponding numbers at age 4 in the intermediate year (2010) 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 169 million was also used for the 2007 and subsequent year classes. The natural mortality of 0.2 is the same as used in the assessment. For exploitation pattern the average of 2007-2009 was used for age groups 3-10, while for age groups 11-15+ the 2007-2009 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 2008-2009 annual determinations was applied.

5.7.2 Catch options for 2011 (short-term predictions) (Tables 5.7.2–5.7.4)

The management option table (Table 5.7.2) shows that the expected catch of 204,000 t in 2010 will increase the fishing mortality compared to 2009 from 0.27 to 0.32, which is below the F_{pa} of 0.35. A catch in 2011 corresponding to the $F_{status\ quo}$ level (3-year average 2007-2009) of 0.25 will be 143,000 t, while a catch in 2011 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 173,000 t. According to the HCR the TAC should not be change by more than 15% compared with the previous year's TAC as long as SSB is above the B_{pa} of 220,000, corresponding to a minimum TAC of 173,400 t in 2011. This catch corresponds to a fishing mortality of 0.31 in 2011.

For a catch in 2010 corresponding to the HCR, i.e. 204,000 t, the SSB is expected to decrease from about 416,000 t at the beginning of 2010 to 357,000 t at the beginning of 2011. At $F_{status\ quo}$ in 2011 SSB is estimated to decrease to 350,000 t at the beginning of 2012 and for a catch corresponding to the HCR it will decrease to about 324,000 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 2011.

5.7.3 Medium term simulations (Figure 5.7.1a–b)

The ACOM review groups have not considered the medium term analyses reliable as the results are mainly driven by the assumption of mean recruitment and ignoring the bias in the assessment. Although the recent assessment indicates a reduction of the bias problem, no improved recruitment estimates are available. However, the WG made medium-term simulations just to illustrate a scenario following the HCR.

The input data were the same as used for the short-term predictions (Table 5.7.1). Following the HCR, the catch will decrease to 150,000 t in 2014, while the SSB will be reduced to 290,000 t. The highest long term yield for GM recruitment and present exploitation pattern and weight at age is about 140,000 t (Table 5.6.1).

5.7.4 Comparison of the present and last year's assessment

The current assessment estimated the total stock in 2009 to be 19 % lower and the SSB 34 % lower, compared to the previous assessment. The F in 2008 is estimated to be higher than in the previous assessment and the realized F in 2009 is comparable to the predicted one based on the TAC.

	Total stock (3+) by 1 January 2009 (tonnes)	SSB by 1 January 2009 (tonnes)	F_{4-7} in 2009	F_{4-7} in 2008
WG 2009 (11+)	1012184	689583	0.28 (TAC constraint)	0.20
WG 2010 (15+)	798292	456509	0.27	0.25

5.8 Comments on the assessment and the forecast (Figures 5.8.1a-b, 5.8.2).

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.

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 last reviews were handled with during the benchmark assessment in February 2010 (ICES CM 2010/ACOM:36).

The 2009 reviewers commented that the level of discarding (by age) might have some impact on the perception of the stock dynamics (recruitment). If saithe age 3 is important component of discarding, than omitting it in the assessment gives an underestimated recruitment level. This potential problem has not been looked into.

Saithe has recently been more distributed southward and such was the biological sampling activity for estimating maturity ogives. Higher maturity rate in the southern area is observed. The 3 -year running average ogive used in the assessment is not weighted by abundance and in consequence it probably results in biased estimate of maturity ogive in the context of the whole stock. This problem has neither been resolved.

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 [1]	1501 [2]	323	697 [2]	2 021	67 [2]	144 338	31	199	11 895	2 [2]	356	32	161 462

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 [1]	35.5	80.9	33.0	12.1	161.5

[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]	1	15.4	199.6	133.0	74.8	205.2	55.4	32.9	70.2	787

[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

Table 5.3.1 Northeast Arctic saithe. Norwegian sampling level in 2009 by ICES area and quarter.

	NeA SAITHE										
2009		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**	4	17	15	216	1	29	12	71	187.2	69.5
	2	2	20	65	830	3	124	47	1935	2340.5	21.4
	3	9	63	80	2051	0	0	6	1189	6739.1	0.9
	4	16	94	34	522	0	0	2	5	2278.3	0.9
	total	31	194	194	3619	4	153	67	3200	11545.1	6.1
IIa	**1**	241	8858	455	15915	16	422	229	15642	55243.1	4.4
	2	89	1836	216	5311	29	816	181	16288	27098.6	7.7
	3	58	827	124	3827	9	142	192	11302	27646.5	7.3
	4	98	1137	148	4778	5	106	59	5995	22736.8	2.8
	total	486	12658	943	29831	59	1486	661	49227	132725.0	5.4
IIb	**1**	0	0	1	1	0	0	0	0	0.3	0
	2	0	0	11	31	0	0	1	1	23.6	42.3
	3	3	5	18	46	0	0	1	1	7.2	138.3
	4	12	23	21	52	0	0	1	1	35.7	28.0
	total	15	28	51	130	0	0	3	3	66.9	44.8

Table 5.3.2 Northeast Arctic saithe. Catch numbers at age
Run title : North-East Arctic saithe
At 22/04/2010 16:49

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

YEAF	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
AGE										
3	13517	25237	45932	51171	10925	42578	25127	28457	29955	76011
4	16828	12929	13720	35199	72344	5737	61199	23826	21856	11745
5	17422	17707	5449	7165	15966	30171	14727	34493	6065	16650
6	6514	5379	10218	5659	3299	11635	14475	3957	9846	4666
7	6281	1886	2991	4699	4214	3282	5220	5388	936	4716
8	3088	1371	1262	1337	3223	2421	1542	2797	2274	1107
9	1691	736	1156	1308	1518	3135	1047	1356	1070	1682
10	956	573	556	848	1482	802	1083	1340	686	663
11	481	538	611	550	1282	1136	530	814	465	199
12	363	275	369	467	965	652	628	603	284	138
13	260	112	282	399	561	509	670	528	168	30
14	185	89	224	166	443	802	497	391	156	47
+gp	673	726	643	580	1069	1023	929	1014	314	88
0 TOTAL	68259	67558	83413	109548	117291	103883	127674	104964	74075	117742
TONSL	133515	105951	120707	148627	197426	185600	203788	181326	110247	140060
SOPC(	100	100	100	100	100	100	100	100	100	100

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

YEAF	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
3	43834	61743	55351	62938	36884	70255	135592	105935	56505	75819
4	63270	47522	44490	20793	44149	13502	33159	36703	31946	28545
5	14081	21614	24752	22199	15714	18901	8618	10845	14396	17280
6	16298	7661	8650	13224	20476	5123	9448	2205	5232	5384
7	5157	7690	4769	5868	12182	9018	3725	4633	1694	3550
8	8004	2326	3012	3246	4815	7841	3483	1557	2132	1178
9	2521	3489	1584	2368	3267	3365	2905	1718	1082	1659
10	3722	1760	1817	2153	2512	2714	1870	1030	1126	536
11	1103	2514	1044	1291	1440	2237	1183	495	756	373
12	762	1045	676	653	1448	1438	924	261	786	344
13	325	284	281	670	433	530	530	226	328	206
14	278	186	222	365	264	300	152	62	267	272
+gp	349	373	452	259	247	276	334	169	345	264
0 TOTAL	159704	158207	147100	136027	143831	135500	201923	165839	116595	135410
TONSL	264924	241272	214334	213859	264121	233453	242486	182817	155464	164680
SOPC(	100	100	100	100	100	100	100	100	100	100

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

YEAF	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	40303	85966	35853	18216	43579	48989	21322	18555	8144	12607
4	36202	22345	67150	25108	34927	11992	12433	51742	35928	19400
5	9100	22044	13481	34543	12679	7200	5845	4506	32901	33343
6	6302	3706	8477	3408	11775	5287	4363	3238	4570	18578
7	3161	2611	1088	3178	1193	3746	2704	3624	2333	1762
8	1322	2056	1291	1243	1862	776	1349	784	1222	352
9	145	378	476	803	589	879	338	644	968	177
10	721	286	271	261	585	134	438	267	321	189
11	406	258	124	215	407	274	123	263	73	1
12	449	91	116	130	158	214	65	164	12	149
13	254	147	78	170	123	55	30	154	2	0
14	236	97	100	99	179	126	54	102	15	36
+gp	265	50	44	188	77	32	3	145	1	20
0 TOTAL	98866	140035	128549	87562	108133	79704	49067	84188	86490	86614
TONSL	144554	175540	168034	156936	158786	107183	67396	92391	114242	122817
SOPC(	100	100	100	100	100	100	100	100	100	105

Table 5.3.2 continue

	Table 1	Catch numbers at age			Numbers*10**-3					
	YEAF	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
	3	23792	68682	44627	22812	7063	17178	10510	11789	3091	9655
	4	16930	13630	33294	61931	32671	52109	54886	11698	16215	12236
	5	9054	5752	5987	31102	49410	40145	18499	35011	11946	22872
	6	10238	4883	5412	3747	19058	30451	18357	13567	31818	10347
	7	7341	3877	4751	1759	2058	4177	17834	13452	8376	18930
	8	1076	2381	3176	1378	724	483	2849	7058	5539	3374
	9	160	383	1462	1027	421	125	485	812	2873	3343
	10	112	61	286	797	278	259	214	55	727	2290
	11	150	90	93	76	528	31	148	48	111	419
	12	37	68	46	35	92	176	68	42	65	103
	13	31	1	163	1	13	2	196	27	19	24
	14	0	12	0	17	15	42	59	21	0	11
	+gp	50	8	141	18	9	43	2	8	198	32
0	TOTAL	68971	99828	99438	124700	112340	145221	124107	93588	80978	83636
	TONSL	95848	107327	127604	154903	146950	168378	171348	143629	153327	150375
	SOPC(	102	101	105	101	100	100	100	100	100	100

	Table 1	Catch numbers at age			Numbers*10**-3					
	YEAF	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
	3	9175	3816	6582	2345	1002	26093	1590	3144	25259	5698
	4	22768	7946	17492	50653	6129	12543	68137	4115	18953	38011
	5	7747	26960	11573	13600	33840	9841	12328	39889	5969	9704
	6	10676	8769	25671	7123	10613	23141	10098	15301	24363	6411
	7	6123	7120	5312	9594	7494	10799	16757	7963	9712	16220
	8	8303	3146	4276	5494	8307	5659	8080	11302	5624	4813
	9	2530	4687	2382	3545	2792	7852	5671	7749	7697	2982
	10	2652	1935	3431	2519	3088	2674	5127	4138	4705	3991
	11	1022	1406	965	2327	2377	713	1815	2157	1606	2343
	12	151	433	1016	1112	2057	387	1013	505	1163	1006
	13	8	60	281	420	338	465	733	254	145	236
	14	25	8	68	170	536	357	506	52	108	93
	+gp	13	27	55	111	141	379	277	38	156	103
0	TOTAL	71193	66313	79104	99013	78714	100903	132132	96607	105460	91611
	TONSL	135928	135853	154870	161592	164636	178568	212822	199008	184740	161462
	SOPC(	101	100	100	100	100	100	100	100	102	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
	AGE										
	3	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
	5	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
	7	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
	9	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
	11	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
	13	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
	+gp	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
0	SOPCOF	1	1	1.0001	1	1	1	1	1	0.9999	1

	Table 2	Catch weights at age (kg)									
	YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
	AGE										
	3	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
	5	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
	7	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
	9	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
	11	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
	13	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
	+gp	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
0	SOPCOF	1	0.9999	1	0.9996	1	1	1	1	1	1

	Table 2	Catch weights at age (kg)									
	YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	AGE										
	3	0.79	0.73	0.77	1.05	0.71	0.75	0.59	0.53	0.62	0.74
	4	1.27	1.4	1.12	1.33	1.26	1.33	1.22	0.84	0.87	0.95
	5	2.03	2.05	2.02	1.86	2.02	2.07	1.97	1.66	1.31	1.4
	6	2.55	2.76	2.61	2.8	2.7	2.63	2.3	2.32	2.43	1.78
	7	3.29	3.3	3.27	4	3.88	3.28	2.87	2.97	3.87	2.96
	8	4.34	4.38	3.91	4.18	4.47	3.96	3.72	4	5.38	3.73
	9	5.15	5.95	4.69	5.33	5.36	4.54	4.3	4.72	5.83	4.62
	10	5.75	6.39	5.63	5.68	6.06	5.55	4.69	5.44	5.36	4.66
	11	6.11	6.61	7.18	7.31	6.28	6.88	5.84	5.79	6.92	8.34
	12	5.94	6.88	7.21	8.68	6.89	8.14	6.39	6.28	8.72	6.77
	13	6.64	6.75	7	8.54	8.2	6.06	8.11	7.02	7.88	10.04
	14	7.73	7.13	8.03	8.57	9.14	9.66	7.55	8.36	8.94	9.13
	+gp	9.47	7.66	9.44	10.37	6.47	13.72	10.08	8.48	10	11.95
0	SOPCOF	1	0.9999	1	1	0.9999	0.9997	1	0.9999	0.9999	1.0469

Table 5.3.3 continue

	Table 2	Catch weights at age (kg)									
	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
	3	0.71	0.68	0.67	0.61	0.52	0.56	0.59	0.62	0.68	0.67
	4	1	1.05	1.01	0.99	0.76	0.79	0.82	0.95	1	1.05
	5	1.45	1.85	1.92	1.65	1.24	1.19	1.33	1.24	1.48	1.45
	6	2.09	2.39	2.28	2.46	2.12	1.71	1.84	1.72	1.87	1.93
	7	2.49	3.08	2.77	2.85	3.22	2.87	2.48	2.35	2.58	2.27
	8	3.75	3.35	3.2	3.03	3.83	3.78	3.73	3.1	3.07	2.97
	9	3.9	4.48	3.73	3.71	4.69	4.06	4.32	4.19	4.13	3.61
	10	6.74	4.66	6.35	4.49	5.31	5.3	5.34	5.79	5.44	4.1
	11	4.94	5.62	6.9	5.56	5.66	6.86	5.98	6.77	6.7	4.93
	12	4.93	6.3	7.18	6.56	6.91	6.59	6.26	6.62	4.97	6.59
	13	8.2	6.73	6.88	10.56	6.3	7.88	7.36	7.3	5.23	7.52
	14	8.2	11.55	7.5	6.73	9.45	9.16	9.61	9.15	6.8	7.88
	+gp	8.59	9.58	9.14	8.41	8.95	10.53	13.64	11.48	10.1	7.46
0	SOPC	1.0235	1.0087	1.0517	1.0107	1	0.999	1.0019	1.0011	1.0015	1.0015

	Table 2	Catch weights at age (kg)									
	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
	3	0.6	0.75	0.69	0.66	0.7	0.59	0.63	0.73	0.63	0.67
	4	1.03	1.12	1.01	0.91	1.03	0.89	0.83	1.08	0.98	1.01
	5	1.63	1.54	1.5	1.42	1.37	1.49	1.43	1.41	1.38	1.69
	6	2.1	2.04	1.97	1.89	1.9	2.09	1.78	1.86	1.92	2.01
	7	2.67	2.6	2.54	2.54	2.41	2.16	2.27	2.43	2.31	2.38
	8	3.14	3.14	3.25	2.58	2.98	2.99	2.73	2.94	2.83	2.68
	9	3.81	3.63	3.77	3.49	3.44	3.24	3.02	3.35	3.16	3.23
	10	4.41	4.54	4.31	3.75	3.73	3.82	3.9	3.66	3.43	3.43
	11	5.76	5.05	4.91	4.12	4.14	3.92	4.06	4.17	3.82	3.47
	12	7.3	5.82	5.69	5.27	5.09	5.14	5.05	5.04	4.09	4.23
	13	9.95	6.4	6.19	5.94	5.96	6.26	5.79	6.07	5.03	4.87
	14	10.56	7.88	7.56	6.49	5.99	6.76	6.01	5.23	5.97	5.59
	+gp	11.08	10.84	11.71	11.21	7.91	6.62	8.35	9.14	8.56	7.31
0	SOPC	1.0051	1.001	1.001	1.0033	1.0031	1.0026	1.0017	1.0009	1.0155	1.0021

Table 5.3.4. Saithe in Subareas I and II (Northeast Arctic). 3-year running average maturity ogive 1985-2009.

Year	3	4	5	6	7	8	9	10	11	12	13	14	15+
1985	0.00	0.02	0.50	0.92	0.99	1.00	1	1	1	1	1	1	1
1986	0.00	0.02	0.51	0.94	0.99	1.00	1	1	1	1	1	1	1
1987	0.00	0.00	0.35	0.98	1.00	1.00	1	1	1	1	1	1	1
1988	0.00	0.00	0.25	0.96	1.00	1	1	1	1	1	1	1	1
1989	0.00	0.00	0.15	0.92	1.00	1	1	1	1	1	1	1	1
1990	0.00	0.00	0.20	0.85	0.99	1.00	1	1	1	1	1	1	1
1991	0.00	0.02	0.25	0.84	0.98	1.00	1	1	1	1	1	1	1
1992	0.00	0.02	0.30	0.83	0.93	0.92	0.90	0.95	1	1	1	1	1
1993	0.00	0.02	0.26	0.88	0.92	0.89	0.87	0.89	1	0.98	1	1	1
1994	0.00	0.02	0.26	0.84	0.90	0.82	0.87	0.89	1	0.98	1	1	1
1995	0.00	0.02	0.22	0.80	0.92	0.90	0.97	0.94	1	0.98	1	1	1
1996	0.00	0.03	0.21	0.65	0.91	0.93	1	1	1	1	1	1	1
1997	0.00	0.03	0.14	0.45	0.83	0.94	0.93	0.97	1	1	1	1	1
1998	0.00	0.04	0.07	0.33	0.74	0.93	0.92	0.96	1	1	1	1	1
1999	0.00	0.00	0.08	0.32	0.74	0.92	0.92	0.96	0.99	0.97	1	1	1
2000	0.00	0.00	0.08	0.46	0.82	0.96	0.98	0.99	0.97	0.94	1	1	1
2001	0.00	0.00	0.11	0.64	0.93	0.97	0.98	0.99	0.97	0.93	1	1	1
2002	0.00	0.00	0.13	0.78	0.95	0.98	0.98	0.99	0.98	0.96	1	1	1
2003	0.00	0.00	0.14	0.82	0.96	0.98	0.98	0.99	1.00	0.98	1	1	1
2004	0.00	0.00	0.21	0.80	0.97	0.99	1	1	1	1	1	1	1
2005	0.00	0.03	0.30	0.82	0.97	0.99	1	1	1	1	1	1	1
2006	0.00	0.04	0.40	0.86	0.98	0.99	1	1	1	1	1	1	1
2007	0.00	0.05	0.42	0.87	0.97	0.98	1	0.97	1	1	1	1	1
2008	0.00	0.06	0.33	0.84	0.96	0.99	1	0.97	1	1	1	1	1
2009	0.00	0.07	0.30	0.81	0.95	0.98	1	0.95	1	1	1	1	1

Table 5.3.5 Northeast Arctic saithe. Tuning data sets applied in final XSA run

```
Northeast 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 2009
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
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 2009
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
```

Table 5.4.1. Northeast Arctic saithe. Data and parameter settings of exploratory and final XSA-runs. Changes compared to 2009-assessment in bold.

Run No.	1	2	3	4
Ass. type	SPALY	SFT	SFT	FINAL
Catch data	1960-08	1960-09	1960-09	1960-09
Age range	3-11+	**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**
Fleet 12 Norw. trawl	1994-2006 age 4-8 Q2-4	**2002-2009** age 4-8 **Q1-4**		**2002-2009** age 4-8 **Q1-4**
Fleet 13 ac. survey	1994-07 age 3-7		**1994-2001** age 3-7	**1994-2001** age 3-7
Fleet 14 ac. survey			**2002-2009** age 3-7	**2002-2009** age 3-7
Time series weights	Tricubic over 20y	**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	0.5	**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. Northeast Arctic saithe. Tuning diagnostics

Lowestoft VPA Version 3.1
22/04/2010 16:47

Extended Survivors Analysis

North-East Arctic saithe

CPUE data from file flt-split.dat

Catch data for 50 years. 1960 to 2009. Ages 3 to 15.

Fleet	Fi year	Last year	First age	Last age	Alpha	Beta
FLT11: Nc	1994	2009	4	8	0	1
FLT12: Nc	2002	2009	4	8	0	1
FLT13: Nc	1994	2009	3	7	0.75	0.85
FLT14: Nc	2002	2009	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 = .01747

Final year F values

Age	3	4	5	6	7	8	9	10	11	12
Iteration 2	0.0335	0.3218	0.2156	0.2449	0.279	0.2542	0.2397	0.3023	0.617	1.1183
Iteration 3	0.0334	0.3216	0.2154	0.2446	0.2787	0.2539	0.2393	0.3013	0.6113	1.1151

Age	13	14
Iteration 2	0.63	0.6989
Iteration 3	0.6275	0.6956

1

Regression weights

1	1	1	1	1	1	1	1	1	1

Table 5.5.1. Continued

Fishing mortalities

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	0.071	0.021	0.021	0.019	0.007	0.075	0.023	0.032	0.139	0.033
4	0.131	0.081	0.129	0.222	0.064	0.115	0.285	0.077	0.27	0.322
5	0.139	0.225	0.163	0.14	0.227	0.14	0.157	0.269	0.153	0.215
6	0.261	0.23	0.348	0.143	0.154	0.24	0.208	0.299	0.262	0.245
7	0.254	0.278	0.213	0.211	0.219	0.232	0.274	0.252	0.315	0.279
8	0.301	0.2	0.268	0.356	0.286	0.256	0.272	0.3	0.284	0.254
9	0.253	0.277	0.229	0.373	0.309	0.481	0.443	0.457	0.344	0.239
10	0.345	0.313	0.336	0.404	0.656	0.55	0.677	0.686	0.561	0.301
11	0.379	0.31	0.254	0.401	0.854	0.303	0.936	0.689	0.63	0.611
12	0.265	0.272	0.386	0.522	0.76	0.312	0.953	0.748	1.058	1.115
13	0.139	0.159	0.285	0.272	0.294	0.377	1.888	0.67	0.495	0.628
14	0.273	0.201	0.273	0.279	0.668	0.58	0.94	0.665	0.684	0.696

1

XSA population numbers (Thousands)

	AGE									
YEAR	3	4	5	6	7	8	9	10	11	12
2000	1.48E+05	2.05E+05	6.61E+04	5.14E+04	3.02E+04	3.53E+04	1.25E+04	1.01E+04	3.58E+03	7.17E+02
2001	2.00E+05	1.13E+05	1.48E+05	4.71E+04	3.24E+04	1.92E+04	2.14E+04	7.95E+03	5.83E+03	2.01E+03
2002	3.50E+05	1.60E+05	8.51E+04	9.65E+04	3.06E+04	2.01E+04	1.29E+04	1.33E+04	4.76E+03	3.50E+03
2003	1.35E+05	2.81E+05	1.15E+05	5.92E+04	5.57E+04	2.03E+04	1.26E+04	8.37E+03	7.79E+03	3.02E+03
2004	1.58E+05	1.09E+05	1.84E+05	8.22E+04	4.21E+04	3.70E+04	1.16E+04	7.09E+03	4.57E+03	4.27E+03
2005	4.00E+05	1.28E+05	8.34E+04	1.20E+05	5.77E+04	2.76E+04	2.27E+04	6.99E+03	3.01E+03	1.59E+03
2006	7.66E+04	3.04E+05	9.35E+04	5.94E+04	7.74E+04	3.75E+04	1.75E+04	1.15E+04	3.30E+03	1.82E+03
2007	1.12E+05	6.13E+04	1.87E+05	6.54E+04	3.95E+04	4.82E+04	2.34E+04	9.21E+03	4.79E+03	1.06E+03
2008	2.14E+05	8.85E+04	4.65E+04	1.17E+05	3.97E+04	2.51E+04	2.92E+04	1.21E+04	3.80E+03	1.97E+03
2009	1.92E+05	1.53E+05	5.53E+04	3.26E+04	7.37E+04	2.37E+04	1.55E+04	1.70E+04	5.66E+03	1.65E+03

Estimated population abundance at 1st Jan 2010

0.00E+00	1.52E+05	9.07E+04	3.66E+04	2.10E+04	4.57E+04	1.51E+04	1.00E+04	1.03E+04	2.54E+03

Taper weighted geometric mean of the VPA populations:

1.69E+05	1.06E+05	5.97E+04	3.34E+04	1.88E+04	1.04E+04	5.99E+03	3.50E+03	1.91E+03	1.06E+03

Standard error of the weighted Log(VPA populations) :

0.4741	0.5573	0.6405	0.7281	0.8218	0.9238	1.0421	1.12	1.2188	1.3602

	AGE	
YEAR	13	14
2000	6.81E+01	1.16E+02
2001	4.51E+02	4.86E+01
2002	1.25E+03	3.15E+02
2003	1.95E+03	7.71E+02
2004	1.47E+03	1.22E+03
2005	1.64E+03	8.96E+02
2006	9.55E+02	9.18E+02
2007	5.75E+02	1.18E+02
2008	4.11E+02	2.41E+02
2009	5.60E+02	2.05E+02

Estimated population abundance at 1st Jan 2010

4.46E+02	2.46E+02

Taper weighted geometric mean of the VPA populations:

5.94E+02	4.06E+02

Table 5.5.1. Continued

Standard error of the weighted Log(VPA populations) :

	1.8109	2.0915
1		

Log catchability residuals.

Fleet : FLT11: Nor trawl rev

Age	1994	1995	1996	1997	1998	1999		
3	No data for this fleet at this age							
4	0.21	1.13	-0.05	-0.19	-0.54	-0.18	-0.17	-0.2
5	0.53	0.41	0.2	-0.24	-0.65	-0.19	-0.17	0.1
6	0.86	0.12	-0.1	0.16	-0.36	-0.72	-0.05	0.09
7	0.58	-0.26	0.42	0.25	-0.45	-0.47	-0.14	0.07
8	0.01	0.09	0.21	0.74	-0.55	-0.61	0.21	-0.11

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	No data for this fleet at this age									
4	-0.17	-0.2	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	-0.17	0.1	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	-0.05	0.09	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	-0.14	0.07	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	0.21	-0.11	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	-7.8244	-6.6265	-5.8016	-5.4405	-5.6343
S.E(Log q	0.4995	0.3871	0.4549	0.3955	0.4368

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	0.725	8.92	0.55	8	0.38	-7.82
5	0.65	1.58	8.37	0.77	8	0.23	-6.63
6	1.9	-1.032	1.08	0.18	8	0.86	-5.8
7	1.25	-1.136	4.26	0.78	8	0.48	-5.44
8	1.04	-0.241	5.49	0.86	8	0.49	-5.63
1							

Fleet : FLT12: Nor trawl rev

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	No data for this fleet at this age									
4	99.99	99.99	0.04	0.23	-1.8	-0.05	-0.5	-0.57	1.14	1.52
5	99.99	99.99	-0.18	0.15	-0.41	0.03	-0.12	-0.02	-0.18	0.73
6	99.99	99.99	0.34	-0.17	-0.51	0.22	-0.35	0.22	0.12	0.12
7	99.99	99.99	-0.36	-0.01	0.14	-0.09	-0.04	0	0.34	0.02
8	99.99	99.99	-0.12	0.4	0.3	-0.15	-0.1	0.01	0.06	-0.39

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	-7.907	-6.5574	-5.9819	-5.6781	-5.4471
S.E(Log q	1.0329	0.3371	0.3039	0.1998	0.2543

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	0.87	0.195	8.42	0.27	8	0.97	-7.91
5	1.39	-1.137	4.62	0.58	8	0.46	-6.56
6	0.87	0.515	6.64	0.73	8	0.28	-5.98
7	0.94	0.279	6.01	0.76	8	0.2	-5.68
8	0.95	0.149	5.67	0.63	8	0.26	-5.45
1							

Fleet : FLT13: Norway Ac Sur

Age	1994	1995	1996	1997	1998	1999		
3	-0.48	-0.36	0.34	-1.05	0.18	0.28	0.38	0.7
4	-0.41	-0.22	-0.02	0.78	0.67	-0.06	0.02	-0.76
5	-0.36	-0.07	-0.09	0.11	0.83	0.63	-0.92	-0.12
6	-0.01	-0.42	-0.47	1.09	0.91	0.3	-0.38	-1.03
7	0.01	-0.11	-0.65	0.1	0.04	0.47	0.24	-0.09
8	No data for this fleet at this age							

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	0.38	0.7	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	0.02	-0.76	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	-0.92	-0.12	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	-0.38	-1.03	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	0.24	-0.09	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	-7.1104	-6.8182	-7.4546	-7.6609	-8.1083
S.E(Log q	0.576	0.5166	0.5474	0.7282	0.3241

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	1.48	-0.514	4.7	0.16	8	0.9	-7.11
4	1.46	-0.598	4.48	0.22	8	0.79	-6.82
5	1.15	-0.236	6.81	0.28	8	0.68	-7.45
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	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	99.99	99.99	-0.09	-0.1	0.62	-0.18	-0.25	0.34	-0.36	0.03
4	99.99	99.99	0.04	0.04	0.62	-0.07	-0.04	-0.27	-0.41	0.1
5	99.99	99.99	-0.07	-0.07	0.16	0	-0.14	0.4	0.21	-0.5
6	99.99	99.99	-0.03	-0.25	0.57	0.1	-0.49	0.02	-0.18	0.26
7	99.99	99.99	-0.44	0.03	0.01	0.2	0.04	0.31	-0.02	-0.13
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	-7.0649	-7.2301	-8.0519	-8.6453	-8.7744
S.E(Log q	0.3267	0.3046	0.2698	0.3241	0.2224

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	1.14	-0.521	6.37	0.7	8	0.39	-7.06
4	0.88	0.592	7.77	0.81	8	0.28	-7.23
5	0.78	1.487	8.8	0.89	8	0.19	-8.05
6	1.02	-0.073	8.59	0.63	8	0.36	-8.65
7	0.84	0.693	9.09	0.77	8	0.2	-8.77
1							

Terminal year survivor and F summaries :

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2006

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	156122	0.347	0	0	1	0.948	0.032

Table 5.5.1. Continued

F shrink	90547	1.5				0.052	0.055

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
151736	0.34	0.12	2	0.369	0.033

1

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

Year class = 2005

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	413010	1.096	0	0	1	0.046	0.08
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	81876	0.237	0.227	0.96	2	0.921	0.351
F shrink	194472	1.5				0.034	0.163

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
90744	0.23	0.25	4	1.074	0.322

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

Year class = 2004

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	77942	0.341	0.108	0.32	2	0.252	0.107
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	28109	0.188	0.246	1.31	3	0.732	0.272
F shrink	41935	1.5				0.016	0.19

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
36577	0.16	0.24	6	1.463	0.215

1

Age 6 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	20357	0.235	0.128	0.54	3	0.342	0.251
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	21253	0.164	0.142	0.87	4	0.646	0.241
F shrink	22041	1.5				0.011	0.234

Weighted prediction :

Table 5.5.1. Continued

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
20951	0.13	0.09	8	0.636	0.245

Age 7 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	47338	0.189	0.05	0.26	4	0.42	0.27
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	44477	0.152	0.111	0.73	5	0.569	0.285
F shrinka	49481	1.5				0.011	0.26

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
45709	0.12	0.06	10	0.504	0.279

1

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

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	14584	0.164	0.161	0.98	5	0.524	0.261
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	15724	0.147	0.118	0.8	5	0.465	0.244
F shrinka	13409	1.5				0.011	0.281

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
15091	0.11	0.09	11	0.813	0.254

Age 9 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: Nc	1	0	0	0	0	0	0
FLT12: Nc	9315	0.161	0.129	0.8	5	0.505	0.254
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	10940	0.146	0.181	1.25	5	0.483	0.22
F shrinka	5334	1.5				0.012	0.409

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
9998	0.11	0.1	11	0.954	0.239

Table 5.5.1. Continued

Age 10 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: Nc	1	0	0	0	0	0	0
FLT12: Nc	10146	0.163	0.089	0.54	5	0.524	0.304
FLT13: Nc	1	0	0	0	0	0	0
FLT14: Nc	10939	0.149	0.037	0.25	5	0.456	0.285
F shrinka	4100	1.5				0.02	0.632

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
10308	0.11	0.06	11	0.547	0.301

Age 11 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: Nc	1	0	0	0	0	0	0
FLT12: Nc	2182	0.16	0.102	0.64	5	0.509	0.679
FLT13: Nc	5072	0.611	0	0	1	0.022	0.349
FLT14: Nc	3014	0.16	0.133	0.83	4	0.421	0.533
F shrinka	2138	1.5				0.048	0.689

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
2545	0.13	0.09	11	0.694	0.611

1

Age 12 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	364	0.53	0	0	1	0.029	1.253
FLT12: Nc	412	0.162	0.079	0.49	4	0.461	1.166
FLT13: Nc	338	0.408	0.567	1.39	2	0.047	1.306
FLT14: Nc	408	0.182	0.074	0.41	3	0.314	1.173
F shrinka	779	1.5				0.15	0.774

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
446	0.24	0.1	11	0.396	1.115

Table 5.5.1. Continued

Age 13 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	246	0.325	0.13	0.4	2	0.061	0.625
FLT12: Nc	298	0.181	0.11	0.6	3	0.379	0.54
FLT13: Nc	255	0.335	0.114	0.34	3	0.055	0.608
FLT14: Nc	247	0.229	0.03	0.13	2	0.205	0.623
F shrinka	190	1.5				0.3	0.752

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
246	0.46	0.08	11	0.166	0.628

1

Age 14 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 1995

Fleet		Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: Nc	78	0.271	0.088	0.33	3	0.113	0.735
FLT12: Nc	89	0.213	0.379	1.78	2	0.291	0.667
FLT13: Nc	53	0.309	0.297	0.96	4	0.081	0.947
FLT14: Nc	54	0.3	0	0	1	0.13	0.938
F shrinka	106	1.5				0.385	0.584

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
84	0.58	0.12	11	0.21	0.696

Table 5.5.2 Northeast Arctic saithe. Fishing mortality

Table 8 Fishing mortality (F) at age

YEAF	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
AGE										
3	0.1764	0.3116	0.2866	0.2035	0.1355	0.1784	0.2218	0.1719	0.2385	0.34
4	0.1981	0.2554	0.2781	0.3719	0.4937	0.0977	0.4199	0.3391	0.1935	0.1381
5	0.4885	0.3307	0.1622	0.2288	0.2872	0.3933	0.3884	0.4451	0.1341	0.2215
6	0.2605	0.2712	0.3233	0.2528	0.1561	0.3511	0.3318	0.1693	0.2175	0.1448
7	0.312	0.1112	0.2377	0.2413	0.3033	0.2298	0.262	0.1971	0.0548	0.1533
8	0.2064	0.1027	0.1011	0.1584	0.2595	0.2859	0.1605	0.2182	0.1191	0.0848
9	0.1229	0.0691	0.1181	0.1446	0.2718	0.434	0.1922	0.207	0.121	0.1214
10	0.1318	0.0556	0.0683	0.1192	0.2424	0.2251	0.2604	0.4023	0.1533	0.1024
11	0.127	0.1019	0.0774	0.0892	0.2661	0.2968	0.2279	0.3189	0.2356	0.0605
12	0.0948	0.0994	0.0941	0.0781	0.2232	0.21	0.2657	0.4395	0.1745	0.1013
13	0.1557	0.0382	0.1402	0.1397	0.127	0.1756	0.3471	0.3748	0.208	0.0249
14	0.1269	0.073	0.0999	0.1145	0.2272	0.2698	0.26	0.3507	0.1792	0.0823
+gp	0.1269	0.073	0.0999	0.1145	0.2272	0.2698	0.26	0.3507	0.1792	0.0823
0 FBAR 4	0.3148	0.2421	0.2503	0.2737	0.3101	0.268	0.3505	0.2876	0.15	0.1644

Table 8 Fishing mortality (F) at age

YEAF	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
3	0.2034	0.3009	0.5092	0.3911	0.5762	0.6076	0.88	0.7566	0.6175	0.5215
4	0.5305	0.3548	0.3696	0.3633	0.5277	0.4283	0.6577	0.6282	0.5388	0.7489
5	0.2444	0.3453	0.316	0.3181	0.5182	0.4517	0.5393	0.4646	0.5427	0.6381
6	0.3516	0.2033	0.2252	0.2777	0.5481	0.3152	0.4286	0.2528	0.4284	0.3992
7	0.2362	0.2782	0.188	0.2347	0.4466	0.4987	0.3991	0.3864	0.3145	0.5857
8	0.4207	0.1588	0.1666	0.1887	0.3081	0.5845	0.3639	0.2883	0.308	0.3768
9	0.2828	0.3264	0.1544	0.1912	0.2947	0.3682	0.4452	0.3071	0.3335	0.4198
10	0.4288	0.3266	0.2817	0.3247	0.3189	0.4274	0.3598	0.2782	0.3394	0.2738
11	0.2473	0.5829	0.3283	0.3318	0.376	0.5251	0.334	0.1508	0.3391	0.1785
12	0.3448	0.3924	0.3009	0.3523	0.7743	0.8135	0.4284	0.113	0.3794	0.254
13	0.366	0.2075	0.1718	0.5534	0.4186	0.7395	0.8332	0.1741	0.2029	0.1598
14	0.336	0.3696	0.2487	0.3529	0.4397	0.5797	0.4838	0.2056	0.3207	0.2585
+gp	0.336	0.3696	0.2487	0.3529	0.4397	0.5797	0.4838	0.2056	0.3207	0.2585
0 FBAR 4	0.3407	0.2954	0.2747	0.2985	0.5102	0.4235	0.5062	0.433	0.4561	0.593

Table 8 Fishing mortality (F) at age

YEAF	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	0.4996	0.4079	0.3942	0.2178	0.7575	0.7822	0.1106	0.1289	0.1193	0.233
4	0.5096	0.5778	0.6549	0.5334	0.8439	0.4793	0.4584	0.4255	0.3937	0.4599
5	0.5692	0.6817	0.8588	0.8703	0.5702	0.4061	0.4559	0.2977	0.5309	0.7915
6	0.5071	0.4804	0.6144	0.5447	0.8622	0.4968	0.4632	0.4956	0.5612	0.6599
7	0.4337	0.4068	0.25	0.4919	0.3705	0.7586	0.514	0.9107	0.8312	0.4378
8	0.4496	0.5644	0.3612	0.5046	0.6064	0.4405	0.6919	0.2718	0.9469	0.2729
9	0.0713	0.221	0.2414	0.4013	0.4778	0.6555	0.3488	0.8714	0.6367	0.3273
10	0.3242	0.196	0.2441	0.2019	0.5787	0.1866	0.8292	0.5153	1.8736	0.2386
11	0.3444	0.1832	0.1218	0.3118	0.5554	0.5949	0.2613	2.9415	0.2551	0.0212
12	0.3388	0.1194	0.117	0.1813	0.3981	0.648	0.2685	0.6662	15.8004	1.2885
13	0.3022	0.1759	0.1425	0.2512	0.261	0.2331	0.1697	2.2204	0.0142	0
14	0.2777	0.1798	0.1741	0.271	0.4576	0.4671	0.378	1.4619	3.7668	0.3776
+gp	0.2777	0.1798	0.1741	0.271	0.4576	0.4671	0.378	1.4619	3.7668	0.3776
0 FBAR 4	0.5049	0.5367	0.5945	0.6101	0.6617	0.5352	0.4729	0.5324	0.5793	0.5873

Table 5.5.2 continue

Table 8 Fishing mortality (F) at age

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
3	0.4509	0.376	0.1393	0.0961	0.0382	0.0546	0.0899	0.0816	0.0292	0.0416
4	0.5629	0.5086	0.315	0.2921	0.1941	0.4323	0.247	0.1368	0.1541	0.1549
5	0.4048	0.3763	0.4395	0.5491	0.4014	0.3878	0.2672	0.2463	0.2019	0.3384
6	0.6026	0.3985	0.7446	0.548	0.7932	0.4649	0.3073	0.3207	0.371	0.2701
7	0.5998	0.4819	0.8718	0.5779	0.6726	0.3917	0.5505	0.3885	0.3356	0.3951
8	0.5271	0.3939	0.9664	0.6789	0.4997	0.3215	0.5098	0.4383	0.2729	0.2184
9	0.1914	0.3591	0.4494	1.0305	0.4503	0.147	0.6258	0.2633	0.3195	0.263
10	0.3556	0.1034	0.501	0.4745	0.9061	0.5576	0.4021	0.1284	0.3996	0.4564
11	0.3028	0.5433	0.2267	0.2371	0.6759	0.2242	0.736	0.1457	0.4119	0.4244
12	3.4434	0.2179	0.5988	0.1244	0.5036	0.4996	1.1191	0.4732	0.3004	0.8619
13	1.1015	13.5155	1.2479	0.022	0.062	0.0175	2.1325	16.8113	0.407	0.172
14	0	2.9899	0	0.3802	0.5238	0.2908	1.0146	3.6137	0	0.4388
+gp	0	2.9899	0	0.3802	0.5238	0.2908	1.0146	3.6137	0	0.4388
0 FBAR 4	0.5425	0.4413	0.5927	0.4918	0.5153	0.4191	0.343	0.2731	0.2657	0.2896

Table 8 Fishing mortality (F) at age

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	FBAR
AGE											
3	0.071	0.0213	0.021	0.0193	0.0071	0.0749	0.0232	0.0316	0.1394	0.0334	0.0682
4	0.1306	0.0811	0.1285	0.2224	0.0644	0.1145	0.2851	0.0771	0.2699	0.3216	0.2229
5	0.1388	0.2255	0.1628	0.1395	0.2272	0.1397	0.1575	0.269	0.1531	0.2154	0.2125
6	0.2609	0.2304	0.3483	0.1426	0.154	0.2395	0.2081	0.2991	0.2617	0.2446	0.2685
7	0.2538	0.2781	0.2129	0.211	0.2193	0.2318	0.2736	0.2521	0.3151	0.2787	0.282
8	0.3005	0.2	0.2681	0.3562	0.2856	0.2565	0.2723	0.3001	0.2841	0.2539	0.2794
9	0.2531	0.2767	0.2291	0.3731	0.3087	0.4806	0.4429	0.4566	0.3441	0.2393	0.3467
10	0.3446	0.3134	0.3355	0.4044	0.6561	0.5499	0.6774	0.6864	0.5607	0.3013	0.5161
11	0.3787	0.3098	0.2538	0.4008	0.8542	0.3032	0.936	0.6888	0.6305	0.6113	0.6435
12	0.2648	0.2721	0.3864	0.522	0.76	0.3125	0.9533	0.7479	1.058	1.1151	0.9737
13	0.139	0.1592	0.2849	0.272	0.2936	0.3773	1.8876	0.6698	0.4946	0.6275	0.5973
14	0.2729	0.201	0.2729	0.2791	0.668	0.5803	0.9397	0.6646	0.684	0.6956	0.6814
+gp	0.2729	0.201	0.2729	0.2791	0.668	0.5803	0.9397	0.6646	0.684	0.6956	
0 FBAR 4	0.196	0.2038	0.2131	0.1789	0.1662	0.1814	0.2311	0.2243	0.25	0.2651	

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
AGE										
3	92382	104182	203732	307190	95252	287982	139613	199107	156042	291446
4	103487	63406	62462	125240	205205	68100	197253	91569	137266	100652
5	49826	69501	40213	38725	70689	102548	50565	106122	53412	92608
6	31392	25030	40881	27994	25222	43428	56659	28073	55675	38242
7	25900	19808	15625	24225	17799	17665	25028	33291	19404	36674
8	18298	15522	14511	10087	15582	10759	11493	15768	22381	15040
9	16160	12187	11468	10738	7048	9841	6618	8015	10379	16267
10	8556	11701	9312	8343	7608	4397	5220	4471	5335	7530
11	4457	6140	9061	7121	6063	4888	2874	3294	2448	3747
12	4435	3214	4540	6866	5332	3804	2974	1874	1961	1584
13	1993	3303	2382	3383	5199	3493	2525	1867	989	1348
14	1716	1397	2603	1695	2409	3749	2399	1461	1051	657
+gp	6218	11360	7446	5902	5781	4753	4457	3760	2105	1227
0 TOT/	364820	346749	424236	577509	469190	565407	507680	498674	468448	607022

Table 10	Stock number at age (start of year)				Numbers*10**-3					
YEAF	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
3	263215	262608	153304	214898	93077	170518	256069	220593	135546	206194
4	169838	175840	159138	75431	118995	42831	76039	86963	84753	59848
5	71780	81803	100966	90035	42944	57477	22850	32252	37989	40484
6	60756	46027	47417	60267	53628	20941	29956	10910	16593	18077
7	27088	34995	30752	30995	37377	25379	12509	15977	6937	8851
8	25759	17512	21694	20862	20067	19579	12619	6871	8889	4147
9	11312	13847	12233	15036	14144	12073	8935	7180	4217	5348
10	11796	6980	8180	8582	10168	8624	6840	4687	4324	2473
11	5565	6290	4122	5053	5078	6052	4605	3908	2905	2521
12	2888	3558	2875	2431	2969	2855	2931	2700	2751	1695
13	1172	1675	1967	1742	1399	1121	1036	1563	1974	1541
14	1077	665	1114	1357	820	754	438	369	1075	1319
+gp	1342	1324	2256	955	760	686	953	1000	1380	1273
0 TOT/	653587	653124	546018	527645	401426	368888	435780	394973	309333	353772

Table 10	Stock number at age (start of year)				Numbers*10**-3					
YEAF	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	113271	283643	121615	102847	90673	99780	225093	169531	80034	67025
4	100214	56271	154442	67129	67721	34804	37366	164998	122011	58158
5	23170	49291	25852	65686	32242	23842	17645	19343	88271	67385
6	17510	10736	20410	8968	22524	14925	13005	9157	11759	42500
7	9928	8633	5437	9040	4258	7786	7435	6700	4568	5493
8	4034	5268	4706	3467	4526	2407	2985	3641	2206	1629
9	2329	2107	2453	2685	1714	2020	1269	1224	2272	701
10	2878	1776	1383	1578	1471	870	859	733	419	984
11	1540	1704	1195	887	1056	675	591	307	358	53
12	1727	894	1161	866	532	496	305	373	13	227
13	1076	1007	649	846	592	292	212	191	157	0
14	1076	651	692	461	539	373	190	147	17	127
+gp	1200	334	303	870	230	94	10	203	1	70
0 TOT/	279953	422316	340298	265329	228075	188366	306966	376547	312086	244349

Table 5.5.3 continue

	Table 10	Stock number at age (start of year)			Numbers*10**-3						
	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
	3	72448	242207	379322	275236	208224	357521	135132	166255	118510	261608
	4	43468	37788	136156	270182	204703	164088	277170	101127	125451	94231
	5	30062	20269	18605	81350	165169	138035	87194	177264	72211	88039
	6	25000	16420	11391	9815	38461	90521	76689	54650	113453	48312
	7	17986	11205	9025	4429	4646	14245	46559	46177	32467	64097
	8	2903	8083	5665	3090	2034	1941	7883	21982	25635	19003
	9	1015	1403	4463	1765	1283	1011	1152	3876	11611	15976
	10	414	686	802	2331	516	670	714	505	2439	6907
	11	635	237	507	398	1188	171	314	391	363	1339
	12	42	384	113	331	257	495	112	123	277	197
	13	51	1	253	51	239	127	246	30	63	168
	14	0	14	0	59	41	184	102	24	0	34
	+gp	0	9	0	62	24	187	3	9	0	99
0	TOTAL	194022	338706	566302	649100	626784	769194	633270	572413	502480	600010

	Table 10	Stock number at age (start of year)			Numbers*10**-3									
	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	GMST	AMST
	AGE													
	3	147875	200022	350218	135318	157551	399644	76642	111625	214493	191514	0	167910	187538
	4	205451	112768	160311	280778	108667	128085	303591	61311	88546	152757	151736	105316	122557
	5	66078	147607	85137	115424	184049	83423	93518	186906	46473	55346	90744	60131	73039
	6	51384	47090	96456	59233	82196	120067	59397	65411	116933	32648	36577	32537	41138
	7	30192	32410	30620	55744	42050	57693	77364	39493	39709	73692	20951	18034	23999
	8	35350	19179	20093	20263	36958	27647	37464	48178	25129	23723	45709	10024	14285
	9	12506	21429	12856	12581	11619	22742	17515	23362	29218	15485	15091	5684	8541
	10	10055	7949	13304	8370	7093	6986	11515	9209	12115	16957	9998	3304	5178
	11	3583	5833	4758	7788	4574	3013	3300	4789	3795	5662	10308	1844	3078
	12	717	2009	3503	3022	4270	1594	1822	1060	1969	1654	2545	1037	1899
	13	68	451	1253	1949	1468	1635	955	575	411	560	446	396	1172
	14	116	49	315	771	1216	896	918	118	241	205	246	122	776
	+gp	60	163	253	501	316	941	494	85	344	224	176		
0	TOTAL	563435	596959	779075	701742	642027	854367	684494	552122	579376	570427	384524		

Table 5.5.4 Northeast Arctic saithe. Spawning stock number at age

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAF	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	1035	634	625	1252	2052	681	1973	916	1373	1007
5	27404	38226	22117	21299	38879	56401	27811	58367	29377	50934
6	26684	21275	34749	23794	21439	36914	48160	23862	47324	32506
7	25382	19412	15313	23740	17443	17312	24528	32625	19016	35940
8	18298	15522	14511	10087	15582	10759	11493	15768	22381	15040
9	16160	12187	11468	10738	7048	9841	6618	8015	10379	16267
10	8556	11701	9312	8343	7608	4397	5220	4471	5335	7530
11	4457	6140	9061	7121	6063	4888	2874	3294	2448	3747
12	4435	3214	4540	6866	5332	3804	2974	1874	1961	1584
13	1993	3303	2382	3383	5199	3493	2525	1867	989	1348
14	1716	1397	2603	1695	2409	3749	2399	1461	1051	657
+gp	6218	11360	7446	5902	5781	4753	4457	3760	2105	1227

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAF	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	1698	1758	1591	754	1190	428	760	870	848	598
5	39479	44991	55531	49519	23619	31612	12568	17739	20894	22266
6	51642	39123	40305	51227	45583	17800	25463	9274	14104	15365
7	26546	34296	30137	30375	36630	24872	12259	15657	6799	8674
8	25759	17512	21694	20862	20067	19579	12619	6871	8889	4147
9	11312	13847	12233	15036	14144	12073	8935	7180	4217	5348
10	11796	6980	8180	8582	10168	8624	6840	4687	4324	2473
11	5565	6290	4122	5053	5078	6052	4605	3908	2905	2521
12	2888	3558	2875	2431	2969	2855	2931	2700	2751	1695
13	1172	1675	1967	1742	1399	1121	1036	1563	1974	1541
14	1077	665	1114	1357	820	754	438	369	1075	1319
+gp	1342	1324	2256	955	760	686	953	1000	1380	1273

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAF	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	1002	563	1544	671	677	696	747	0	0	0
5	12744	27110	14219	36128	17733	11921	8999	6770	22068	10108
6	14883	9126	17348	7623	19145	13731	12225	8974	11289	39100
7	9730	8461	5328	8859	4173	7709	7361	6700	4568	5493
8	4034	5268	4706	3467	4526	2407	2985	3641	2206	1629
9	2329	2107	2453	2685	1714	2020	1269	1224	2272	701
10	2878	1776	1383	1578	1471	870	859	733	419	984
11	1540	1704	1195	887	1056	675	591	307	358	53
12	1727	894	1161	866	532	496	305	373	13	227
13	1076	1007	649	846	592	292	212	191	157	0
14	1076	651	692	461	539	373	190	147	17	127
+gp	1200	334	303	870	230	94	10	203	1	70

Table 5.5.4 continue

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	0	756	2723	5404	4094	3282	8315	3034	5018	0
5	6012	5067	5581	21151	42944	30368	18311	24817	5055	7043
6	21250	13793	9454	8637	32307	72417	49848	24592	37439	15460
7	17806	10980	8393	4075	4181	13105	42369	38327	24026	47432
8	2903	8083	5212	2750	1668	1747	7331	20664	23840	17483
9	1015	1403	4017	1535	1116	980	1152	3605	10682	14698
10	414	686	762	2075	459	630	714	489	2341	6631
11	635	237	507	398	1188	171	314	391	363	1326
12	42	384	113	324	252	485	112	123	277	191
13	51	1	253	51	239	127	246	30	63	168
14	0	14	0	59	41	184	102	24	0	34
+gp	0	9	0	62	24	187	3	9	0	99

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	3843	12144	3066	5313	10693
5	5286	16237	11068	16159	38650	25027	37407	78501	15336	16604
6	23637	30138	75236	48571	65756	98455	51081	56908	98224	26445
7	24758	30141	29089	53514	40789	55962	75816	38308	38121	70007
8	33936	18604	19691	19858	36588	27371	37089	47214	24878	23249
9	12255	21000	12599	12330	11502	22515	17515	22894	28634	15175
10	9955	7870	13171	8286	7093	6986	11515	8933	11752	16109
11	3475	5658	4662	7788	4574	3013	3300	4645	3681	5435
12	674	1868	3363	2962	4142	1562	1804	1049	1949	1638
13	68	451	1253	1949	1468	1635	955	575	411	560
14	116	49	315	771	1216	896	918	118	241	205
+gp	60	163	253	501	316	941	494	85	344	224

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
AGE										
3	65591	73969	144649	218105	67629	204467	99125	141366	110790	206927
4	114871	70380	69332	139017	227777	75591	218951	101642	152366	111724
5	81216	113287	65548	63122	115223	167153	82420	172979	87062	150951
6	73144	58319	95253	65225	58767	101188	132016	65411	129723	89104
7	81844	62593	49376	76551	56244	55822	79090	105200	61317	115889
8	73740	62553	58478	40649	62795	43360	46318	63546	90196	60610
9	78701	59350	55848	52296	34326	47926	32232	39031	50546	79218
10	48169	65877	52425	46971	42835	24757	29391	25174	30035	42391
11	28701	39540	58356	45858	39048	31480	18512	21215	15767	24131
12	31534	22848	32280	48818	37913	27048	21147	13323	13940	11261
13	15587	25828	18629	26457	40655	27312	19743	14599	7731	10543
14	15304	12458	23216	15121	21487	33440	21398	13031	9373	5864
+gp	59070	107924	70741	56068	54923	45150	42344	35722	19999	11657
0 TOTAL	767473	774927	794132	894257	859622	884694	842688	812239	778843	920271

Table 12 Stock biomass at age (start of year) Tonnes

YEAF	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
3	186883	186451	108846	152578	66085	121068	181809	156621	96237	146398
4	188520	195182	176643	83729	132084	47543	84403	96529	94075	66431
5	117001	133338	164574	146756	69998	93688	37246	52571	61922	65988
6	141561	107244	110482	140423	124952	48792	69797	25421	38661	42118
7	85598	110586	97176	97945	118112	80198	39529	50487	21922	27969
8	103808	70572	87425	84076	80870	78904	50854	27691	35822	16713
9	55089	67436	59573	73225	68880	58794	43514	34966	20536	26046
10	66412	39299	46054	48317	57244	48552	38507	26388	24343	13925
11	35837	40507	26548	32543	32704	38973	29655	25166	18711	16237
12	20532	25297	20441	17281	21110	20297	20836	19195	19563	12049
13	9164	13097	15386	13624	10941	8764	8102	12225	15438	12055
14	9604	5935	9939	12101	7316	6723	3907	3289	9592	11770
+gp	12748	12577	21428	9076	7225	6513	9055	9500	13109	12094
0 TOTAL	1032756	1007521	944517	911672	797521	658808	617215	540047	469932	469793

Table 12 Stock biomass at age (start of year) Tonnes

YEAF	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
3	89484	207059	93643	107989	64378	74835	132805	89851	49621	49598
4	127271	78779	172975	89281	85329	46290	45586	138598	106149	55250
5	47036	101047	52221	122177	65128	49353	34760	32109	115634	94339
6	44649	29632	53270	25110	60814	39252	29912	21245	28575	75650
7	32664	28490	17778	36159	16523	25539	21340	19899	17677	16258
8	17509	23075	18400	14491	20230	9532	11106	14564	11871	6075
9	11997	12536	11505	14309	9185	9173	5455	5776	13243	3238
10	16547	11348	7786	8961	8917	4829	4028	3986	2247	4585
11	9410	11261	8582	6484	6629	4647	3452	1777	2480	440
12	10257	6148	8374	7520	3663	4037	1949	2340	116	1539
13	7146	6800	4545	7224	4852	1772	1722	1340	1235	0
14	8315	4644	5555	3951	4924	3605	1431	1227	152	1155
+gp	11367	2560	2860	9022	1486	1288	105	1725	11	833
0 TOTAL	433652	523380	457494	452679	352057	274151	293653	334438	349010	308959

Table 5.5.5 continue

Table 12	Stock biomass at age (start of year)				Tonnes					
YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
3	51438	164701	254146	167894	108276	200212	79728	103078	80587	175278
4	43468	39677	137518	267480	155574	129630	227279	96070	125451	98942
5	43589	37499	35721	134227	204810	164262	115968	219808	106872	127656
6	52250	39244	25971	24145	81538	154791	141107	93998	212156	93242
7	44785	34510	25000	12622	14959	40883	115466	108517	83766	145500
8	10885	27078	18129	9364	7792	7338	29405	68146	78699	56440
9	3958	6285	16649	6547	6018	4103	4978	16242	47955	57674
10	2788	3198	5093	10468	2738	3549	3814	2922	13268	28319
11	3135	1334	3496	2212	6722	1170	1877	2648	2435	6602
12	208	2418	810	2169	1776	3260	699	815	1376	1299
13	421	7	1739	536	1506	1002	1809	218	328	1262
14	0	161	0	400	384	1685	983	218	0	270
+gp	0	85	0	525	216	1970	46	99	0	736
0 TOTAL	256924	356196	524271	638590	592309	713854	723160	712779	752893	793219

Table 12	Stock biomass at age (start of year)				Tonnes					
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
3	88725	150016	241650	89310	110286	235790	48285	81486	135130	128314
4	211614	126300	161914	255508	111927	113996	251981	66215	86775	154284
5	107707	227315	127705	163902	252147	124301	133731	263538	64133	93535
6	107907	96064	190019	111950	156172	250940	105726	121665	224511	65623
7	80613	84266	77774	141589	101341	124617	175615	95968	91728	175387
8	110998	60222	65301	52278	110135	82665	102276	141642	71115	63579
9	47646	77787	48466	43909	39968	73685	52895	78261	92329	50017
10	44344	36091	57338	31388	26457	26687	44908	33704	41555	58163
11	20637	29457	23360	32085	18935	11812	13399	19968	14498	19647
12	5236	11690	19935	15926	21736	8192	9200	5341	8052	6997
13	678	2884	7755	11577	8750	10235	5527	3490	2066	2725
14	1222	383	2379	5007	7282	6058	5517	619	1438	1146
+gp	662	1768	2961	5611	2498	6227	4125	781	2941	1639
0 TOTAL	827990	904243	1026557	960039	967634	1075204	953186	912680	836273	821055

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
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	1149	704	693	1390	2278	756	2190	1016	1524	1117
	5	44669	62308	36051	34717	63372	91934	45331	95139	47884	83023
	6	62173	49571	80965	55441	49952	86010	112214	55599	110264	75739
	7	80208	61341	48389	75020	55119	54705	77508	103096	60090	113571
	8	73740	62553	58478	40649	62795	43360	46318	63546	90196	60610
	9	78701	59350	55848	52296	34326	47926	32232	39031	50546	79218
	10	48169	65877	52425	46971	42835	24757	29391	25174	30035	42391
	11	28701	39540	58356	45858	39048	31480	18512	21215	15767	24131
	12	31534	22848	32280	48818	37913	27048	21147	13323	13940	11261
	13	15587	25828	18629	26457	40655	27312	19743	14599	7731	10543
	14	15304	12458	23216	15121	21487	33440	21398	13031	9373	5864
	+gp	59070	107924	70741	56068	54923	45150	42344	35722	19999	11657
0	TOTSF	539004	570302	536072	498806	504704	513878	468328	480490	457349	519126

	Table 13	Spawning stock biomass at age (spawning time)				Tonnes					
	YEAF	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	1885	1952	1766	837	1321	475	844	965	941	664
	5	64351	73336	90516	80716	38499	51528	20485	28914	34057	36294
	6	120326	91157	93910	119359	106209	41473	59328	21608	32862	35801
	7	83886	108374	95233	95986	115750	78594	38739	49477	21484	27410
	8	103808	70572	87425	84076	80870	78904	50854	27691	35822	16713
	9	55089	67436	59573	73225	68880	58794	43514	34966	20536	26046
	10	66412	39299	46054	48317	57244	48552	38507	26388	24343	13925
	11	35837	40507	26548	32543	32704	38973	29655	25166	18711	16237
	12	20532	25297	20441	17281	21110	20297	20836	19195	19563	12049
	13	9164	13097	15386	13624	10941	8764	8102	12225	15438	12055
	14	9604	5935	9939	12101	7316	6723	3907	3289	9592	11770
	+gp	12748	12577	21428	9076	7225	6513	9055	9500	13109	12094
0	TOTSF	583641	549539	568220	587140	548068	439590	323825	259383	246457	221057

	Table 13	Spawning stock biomass at age (spawning time)				Tonnes					
	YEAF	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	1273	788	1730	893	853	926	912	0	0	0
	5	25870	55576	28722	67197	35820	24677	17728	11238	28909	14151
	6	37952	25187	45279	21343	51692	36112	28118	20820	27432	69598
	7	32011	27920	17423	35436	16192	25284	21126	19899	17677	16258
	8	17509	23075	18400	14491	20230	9532	11106	14564	11871	6075
	9	11997	12536	11505	14309	9185	9173	5455	5776	13243	3238
	10	16547	11348	7786	8961	8917	4829	4028	3986	2247	4585
	11	9410	11261	8582	6484	6629	4647	3452	1777	2480	440
	12	10257	6148	8374	7520	3663	4037	1949	2340	116	1539
	13	7146	6800	4545	7224	4852	1772	1722	1340	1235	0
	14	8315	4644	5555	3951	4924	3605	1431	1227	152	1155
	+gp	11367	2560	2860	9022	1486	1288	105	1725	11	833
0	TOTSF	189652	187843	160760	196833	164444	125880	97133	84693	105371	117871

Table 5.5.6 continue

	Table 13	Spawning stock biomass at age (spawning time)				Tonnes				
	YEAF	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	0	794	2750	5350	3111	2593	6818	2882	5018	0
	5	8718	9375	10716	34899	53250	36138	24353	30773	7481	10212
	6	44413	32965	21556	21248	68492	123833	91720	42299	70012	29838
	7	44337	33820	23250	11613	13463	37613	105074	90069	61987	107670
	8	10885	27078	16679	8334	6389	6604	27346	64057	73190	51924
	9	3958	6285	14984	5696	5236	3980	4978	15105	44119	53060
	10	2788	3198	4838	9317	2437	3336	3814	2834	12738	27186
	11	3135	1334	3496	2212	6722	1170	1877	2648	2435	6536
	12	208	2418	810	2126	1740	3195	699	815	1376	1260
	13	421	7	1739	536	1506	1002	1809	218	328	1262
	14	0	161	0	400	384	1685	983	218	0	270
	+gp	0	85	0	525	216	1970	46	99	0	736
0	TOTSF	118862	117519	100818	102254	162947	223117	269519	252018	278683	289954

	Table 13	Spawning stock biomass at age (spawning time)				Tonnes				
	YEAF	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	3420	10079	3311	5207	10800
	5	8617	25005	16602	22946	52951	37290	53492	110686	21164	28060
	6	49637	61481	148215	91799	124937	205771	90925	105849	188590	53155
	7	66103	78367	73885	135925	98301	120878	172103	93089	88059	166618
	8	106558	58415	63995	51232	109034	81838	101253	138809	70404	62307
	9	46693	76231	47497	43031	39568	72948	52895	76696	90482	49016
	10	43901	35730	56765	31074	26457	26687	44908	32693	40309	55255
	11	20018	28573	22893	32085	18935	11812	13399	19369	14063	18861
	12	4922	10872	19137	15608	21084	8028	9108	5288	7972	6927
	13	678	2884	7755	11577	8750	10235	5527	3490	2066	2725
	14	1222	383	2379	5007	7282	6058	5517	619	1438	1146
	+gp	662	1768	2961	5611	2498	6227	4125	781	2941	1639
0	TOTSF	349011	379708	462083	445895	509797	591192	563333	590680	532694	456509

Table 5.5.7 Northeast Arctic saithe. XSA summary

Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RE Age 3	TOTALE	TOTSPE	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	80034	349010	105371	114242	1.0842	0.5793
1989	67025	308959	117871	122817	1.042	0.5873
1990	72448	256924	118862	95848	0.8064	0.5425
1991	242207	356196	117519	107327	0.9133	0.4413
1992	379322	524271	100818	127604	1.2657	0.5927
1993	275236	638590	102254	154903	1.5149	0.4918
1994	208224	592309	162947	146950	0.9018	0.5153
1995	357521	713854	223117	168378	0.7547	0.4191
1996	135132	723160	269519	171348	0.6358	0.343
1997	166255	712779	252018	143629	0.5699	0.2731
1998	118510	752893	278683	153327	0.5502	0.2657
1999	261608	793219	289954	150375	0.5186	0.2896
2000	147875	827990	349011	135928	0.3895	0.196
2001	200022	904243	379708	135853	0.3578	0.2038
2002	350218	1026557	462083	154870	0.3352	0.2131
2003	135318	960039	445895	161592	0.3624	0.1789
2004	157551	967634	509797	164636	0.3229	0.1662
2005	399644	1075204	591192	178568	0.302	0.1814
2006	76642	953186	563333	212822	0.3778	0.2311
2007	111625	912680	590680	199008	0.3369	0.2243
2008	214493	836273	532694	184740	0.3468	0.25
2009	168751	798292	456509	161462	0.3537	0.2651
Arith. Mean	187701	697694	352841	162434	0.5939	0.3728
0 Units	(Thousar	(Tonnes	(Tonnes	(Tonnes)		

Table 5.6.1 Northeast Arctic saithe. Yield per recruit

MFYPR version 2a
Run: y00
Time and date: 10:20 24.04.2010
Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	pwnNosSpw	SSBSpwn
0.0000	0.0000	0.0000	0.0000	5.5167	14.5400	3.1238	12.0072	3.1238	12.0072
0.1000	0.0246	0.1275	0.4268	4.8819	10.9476	2.5199	8.4731	2.5199	8.4731
0.2000	0.0493	0.2104	0.6123	4.4694	8.9537	2.1365	6.5330	2.1365	6.5330
0.3000	0.0739	0.2712	0.7054	4.1675	7.6827	1.8623	5.3118	1.8623	5.3118
0.4000	0.0986	0.3190	0.7576	3.9307	6.7940	1.6518	4.4694	1.6518	4.4694
0.5000	0.1232	0.3582	0.7893	3.7364	6.1303	1.4826	3.8491	1.4826	3.8491
0.6000	0.1479	0.3914	0.8100	3.5721	5.6103	1.3423	3.3698	1.3423	3.3698
0.7000	0.1725	0.4201	0.8239	3.4302	5.1883	1.2234	2.9861	1.2234	2.9861
0.8000	0.1972	0.4453	0.8335	3.3056	4.8365	1.1210	2.6706	1.1210	2.6706
0.9000	0.2218	0.4677	0.8401	3.1949	4.5372	1.0316	2.4057	1.0316	2.4057
1.0000	0.2465	0.4878	0.8445	3.0957	4.2786	0.9528	2.1797	0.9528	2.1797
1.1000	0.2711	0.5061	0.8473	3.0060	4.0523	0.8829	1.9846	0.8829	1.9846
1.2000	0.2958	0.5226	0.8489	2.9244	3.8523	0.8204	1.8143	0.8204	1.8143
1.3000	0.3204	0.5378	0.8494	2.8498	3.6740	0.7642	1.6645	0.7642	1.6645
1.4000	0.3451	0.5518	0.8492	2.7813	3.5141	0.7135	1.5319	0.7135	1.5319
1.5000	0.3697	0.5647	0.8484	2.7180	3.3697	0.6676	1.4137	0.6676	1.4137
1.6000	0.3944	0.5767	0.8472	2.6595	3.2388	0.6258	1.3080	0.6258	1.3080
1.7000	0.4190	0.5878	0.8455	2.6051	3.1195	0.5877	1.2129	0.5877	1.2129
1.8000	0.4437	0.5982	0.8435	2.5544	3.0103	0.5528	1.1272	0.5528	1.1272
1.9000	0.4683	0.6080	0.8413	2.5071	2.9101	0.5208	1.0495	0.5208	1.0495
2.0000	0.4930	0.6171	0.8390	2.4627	2.8179	0.4913	0.9790	0.4913	0.9790

Reference point	multiplie	Absolute F
Fbar(4-7)	1.0000	0.2465
FMax	1.3210	0.3256
F0.1	0.3042	0.075
F35%SPR	0.4396	0.1084

Weights in kilograms

Table 5.7.1 Northeast Arctic saithe. Prediction input data

MFDP version 1a
Run: 00
Time and date: 10:01 24.04.2010
Fbar age range: 3-15

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	168751	0.2	0	0	0	0.677	0.0681	0.677
4	133006	0.2	0.07	0	0	1.023	0.2229	1.023
5	90744	0.2	0.3	0	0	1.493	0.2125	1.493
6	36577	0.2	0.81	0	0	1.930	0.2685	1.930
7	20951	0.2	0.95	0	0	2.373	0.282	2.373
8	45709	0.2	0.98	0	0	2.817	0.2794	2.817
9	15091	0.2	0.98	0	0	3.247	0.3467	3.247
10	9998	0.2	0.95	0	0	3.507	0.5161	3.507
11	10308	0.2	0.96	0	0	3.820	0.7382	3.820
12	2545	0.2	0.99	0	0	4.453	0.7382	4.453
13	446	0.2	1	0	0	5.323	0.7382	5.323
14	246	0.2	1	0	0	5.597	0.7382	5.597
15	176	0.2	1	0	0	8.337	0.7382	8.337

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	168751	0.2	0	0	0	0.677	0.0681	0.677
4	.	0.2	0.07	0	0	1.023	0.2229	1.023
5	.	0.2	0.3	0	0	1.493	0.2125	1.493
6	.	0.2	0.81	0	0	1.930	0.2685	1.930
7	.	0.2	0.95	0	0	2.373	0.282	2.373
8	.	0.2	0.98	0	0	2.817	0.2794	2.817
9	.	0.2	0.98	0	0	3.247	0.3467	3.247
10	.	0.2	0.95	0	0	3.507	0.5161	3.507
11	.	0.2	0.96	0	0	3.820	0.7382	3.820
12	.	0.2	0.99	0	0	4.453	0.7382	4.453
13	.	0.2	1	0	0	5.323	0.7382	5.323
14	.	0.2	1	0	0	5.597	0.7382	5.597
15	.	0.2	1	0	0	8.337	0.7382	8.337

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	168751	0.2	0	0	0	0.677	0.0681	0.677
4	.	0.2	0.07	0	0	1.023	0.2229	1.023
5	.	0.2	0.3	0	0	1.493	0.2125	1.493
6	.	0.2	0.81	0	0	1.930	0.2685	1.930
7	.	0.2	0.95	0	0	2.373	0.282	2.373
8	.	0.2	0.98	0	0	2.817	0.2794	2.817
9	.	0.2	0.98	0	0	3.247	0.3467	3.247
10	.	0.2	0.95	0	0	3.507	0.5161	3.507
11	.	0.2	0.96	0	0	3.820	0.7382	3.820
12	.	0.2	0.99	0	0	4.453	0.7382	4.453
13	.	0.2	1	0	0	5.323	0.7382	5.323
14	.	0.2	1	0	0	5.597	0.7382	5.597
15	.	0.2	1	0	0	8.337	0.7382	8.337

Input units are thousands and kg - output in tonnes

Table 5.7.2 Northeast Arctic saithe. Short term prediction

MFDP version 1a
Run: 00
North-East Arctic saithe
Time and date: 11:30 24.04.2010
Fbar age range: 4-7

2010				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
774856	416334	1.3154	0.3242	204000

2011					2012	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
704195	357284	0.0000	0.0000	0	860913	470829
.	357284	0.1000	0.0246	16483	842519	456599
.	357284	0.2000	0.0493	32429	824724	442886
.	357284	0.3000	0.0739	47861	807504	429668
.	357284	0.4000	0.0986	62800	790834	416922
.	357284	0.5000	0.1232	77267	774692	404627
.	357284	0.6000	0.1479	91282	759057	392764
.	357284	0.7000	0.1725	104861	743908	381315
.	357284	0.8000	0.1972	118023	729225	370260
.	357284	0.9000	0.2218	130784	714992	359585
.	357284	1.0000	0.2465	143160	701189	349272
.	357284	1.1000	0.2711	155166	687800	339307
.	357284	1.2000	0.2958	166815	674810	329675
.	357284	1.3000	0.3204	178122	662204	320363
.	357284	1.4000	0.3451	189100	649966	311358
.	357284	1.5000	0.3697	199760	638085	302648
.	357284	1.6000	0.3944	210114	626545	294220
.	357284	1.7000	0.4190	220174	615336	286064
.	357284	1.8000	0.4437	229951	604445	278170
.	357284	1.9000	0.4683	239453	593861	270527
.	357284	2.0000	0.4930	248692	583572	263125

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
004MFDP Index file 24.04.2010
Time and date: 12:04 24.04.2010
Fbar age range: 4-7

2010					15% change from 2010	
Biomass	SSB	FMult	FBar	Landings		173400
774856	416334	1.3154	0.3242	204000		
						average
2011					2011	191275
Biomass	SSB	FMult	FBar	Landings	2012	171076
704195	357284	1.2579	0.31	173400	2013	156631
						172994

2012					2013	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
667468	324248	0	0	0	828403	440812
.	324248	0.1	0.0246	15280	811206	427712
.	324248	0.2	0.0493	30073	794557	415080
.	324248	0.3	0.0739	44398	778432	402894
.	324248	0.4	0.0986	58275	762812	391135
.	324248	0.5	0.1232	71721	747675	379785
.	324248	0.6	0.1479	84754	733003	368826
.	324248	0.7	0.1725	97389	718777	358242
.	324248	0.8	0.1972	109644	704980	348018
.	324248	0.9	0.2218	121531	691597	338138
.	324248	1	0.2465	133066	678610	328588
.	324248	1.1	0.2711	144262	666005	319355
.	324248	1.2	0.2958	155131	653769	310426
.	324248	1.3	0.3204	165687	641886	301788
.	324248	1.4	0.3451	175939	630345	293431
.	324248	1.5	0.3697	185900	619133	285344
.	324248	1.6	0.3944	195580	608238	277515
.	324248	1.7	0.419	204990	597648	269935
.	324248	1.8	0.4437	214138	587354	262594
.	324248	1.9	0.4683	223033	577345	255484
.	324248	2	0.493	231686	567611	248595

Input units are thousands and kg - output in tonnes

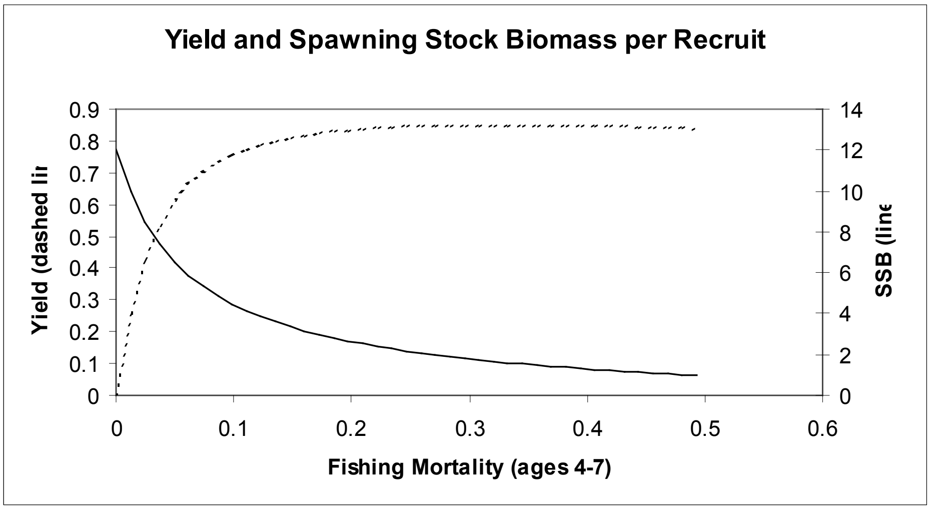
Table 5.7.4. Northeast Arctic saithe. Detailed short term projection output

MFDP version 1a
Run: 004
Time and date: 12:04 24.04.2010
Fbar age range: 4-7

Year:	2010	F multiplie	1.3154	Fbar:	0.3242				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jar	SSB(Jan)	SSNos(ST	SSB(ST)
3	0.0896	13124	8881	168751	114188	0	0	0	0
4	0.2932	30784	31502	133006	136109	9310	9528	9310	9528
5	0.2795	20149	30089	90744	135511	27223	40653	27223	40653
6	0.3532	9922	19150	36577	70594	29627	57181	29627	57181
7	0.3709	5921	14053	20951	49724	19903	47238	19903	47238
8	0.3675	12819	36107	45709	128747	44795	126172	44795	126172
9	0.456	5047	16386	15091	48995	14789	48016	14789	48016
10	0.6789	4516	15836	9998	35060	9498	33307	9498	33307
11	0.971	5897	22528	10308	39377	9896	37801	9896	37801
12	0.971	1456	6484	2545	11334	2520	11220	2520	11220
13	0.971	255	1358	446	2374	446	2374	446	2374
14	0.971	141	788	246	1377	246	1377	246	1377
15	0.971	101	839	176	1467	176	1467	176	1467
Total		110132	204000	534548	774856	168430	416334	168430	416334

Year:	2011	F multiplie	1.2579	Fbar:	0.31				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jar	SSB(Jan)	SSNos(ST	SSB(ST)
3	0.0857	12574	8508	168751	114188	0	0	0	0
4	0.2804	28125	28781	126323	129271	8843	9049	8843	9049
5	0.2673	17344	25900	81223	121293	24367	36388	24367	36388
6	0.3377	14676	28324	56178	108424	45504	87823	45504	87823
7	0.3547	5727	13593	21036	49926	19984	47430	19984	47430
8	0.3514	3198	9007	11837	33342	11601	32675	11601	32675
9	0.4361	8362	27148	25914	84134	25396	82451	25396	82451
10	0.6492	3426	12013	7831	27460	7439	26087	7439	26087
11	0.9286	2311	8828	4152	15860	3986	15225	3986	15225
12	0.9286	1779	7922	3196	14233	3164	14091	3164	14091
13	0.9286	439	2338	789	4201	789	4201	789	4201
14	0.9286	77	431	138	774	138	774	138	774
15	0.9286	73	607	131	1091	131	1091	131	1091
Total		98110	173400	507499	704195	151341	357284	151341	357284

Figure 5.1.1 Northeast Arctic saithe (Subareas I and II)



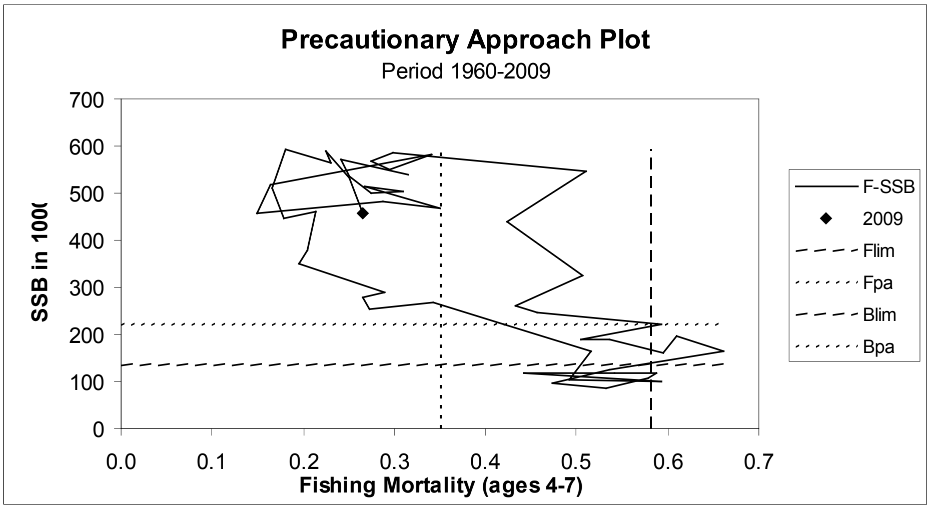


Figure 5.1.1 continued

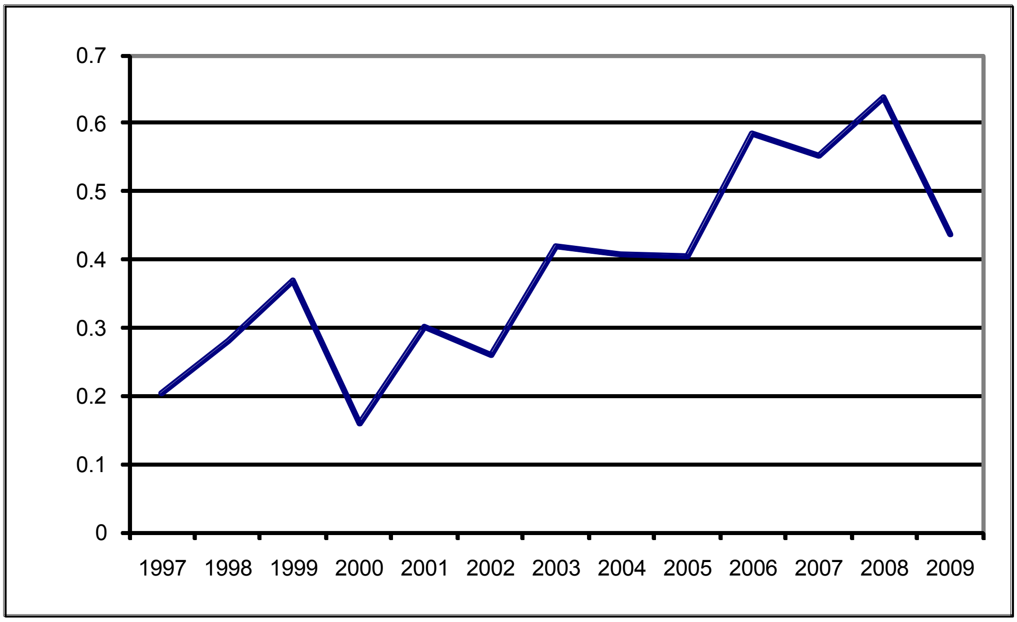


Figure 5.2.1. Northeast Arctic saithe. Proportion of saithe in the southern half of the survey area (sub area C+D).

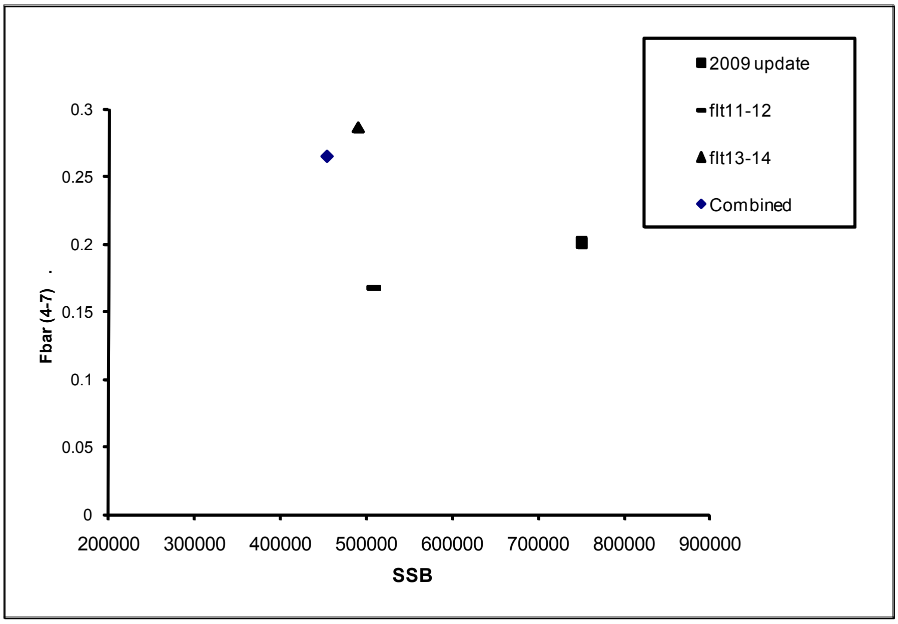
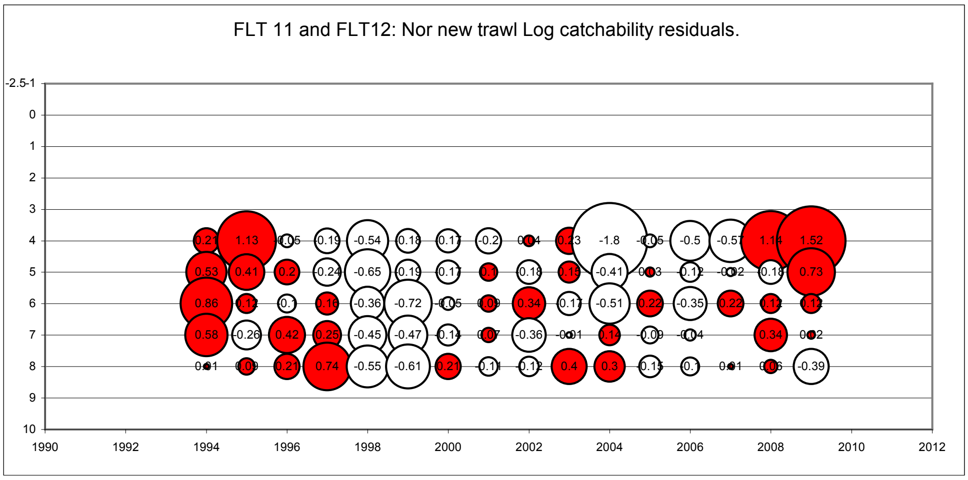


Figure 5.4.1 Northeast Arctic saithe. Comparison of SSB and $F_{4\text{-}7}$ in 2009 from single fleet and combined XSA runs. SSB and $F_{4\text{-}7}$ in 2008 from an updated 2008-data run is also presented.



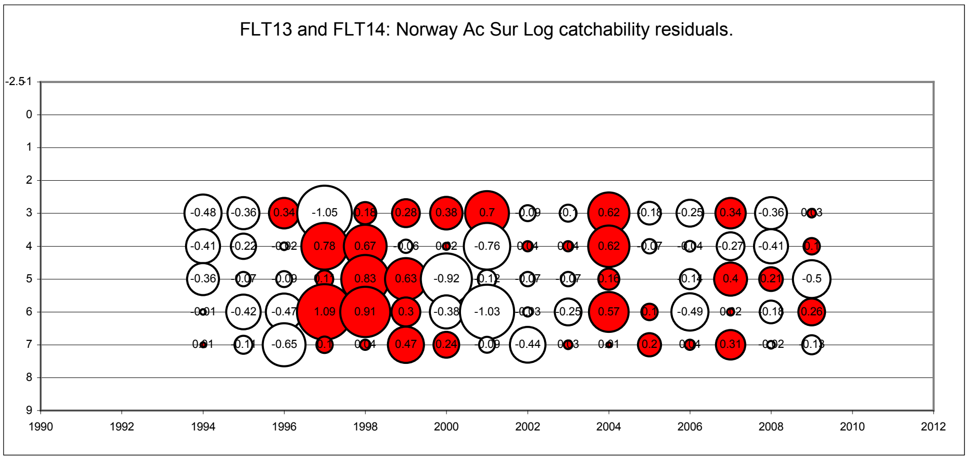


Figure 5.5.1. Northeast Arctic saithe. Final run log Q residuals.

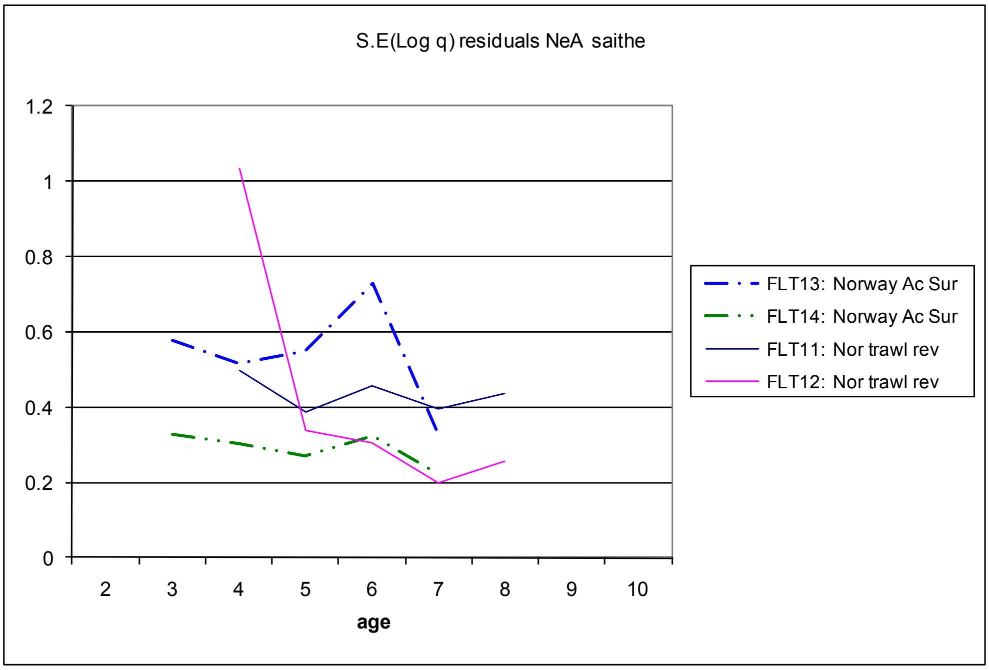


Figure 5.5.2. Northeast arctic saithe. S.E log. Catchability from the four XSA fleet tuning series, final run.

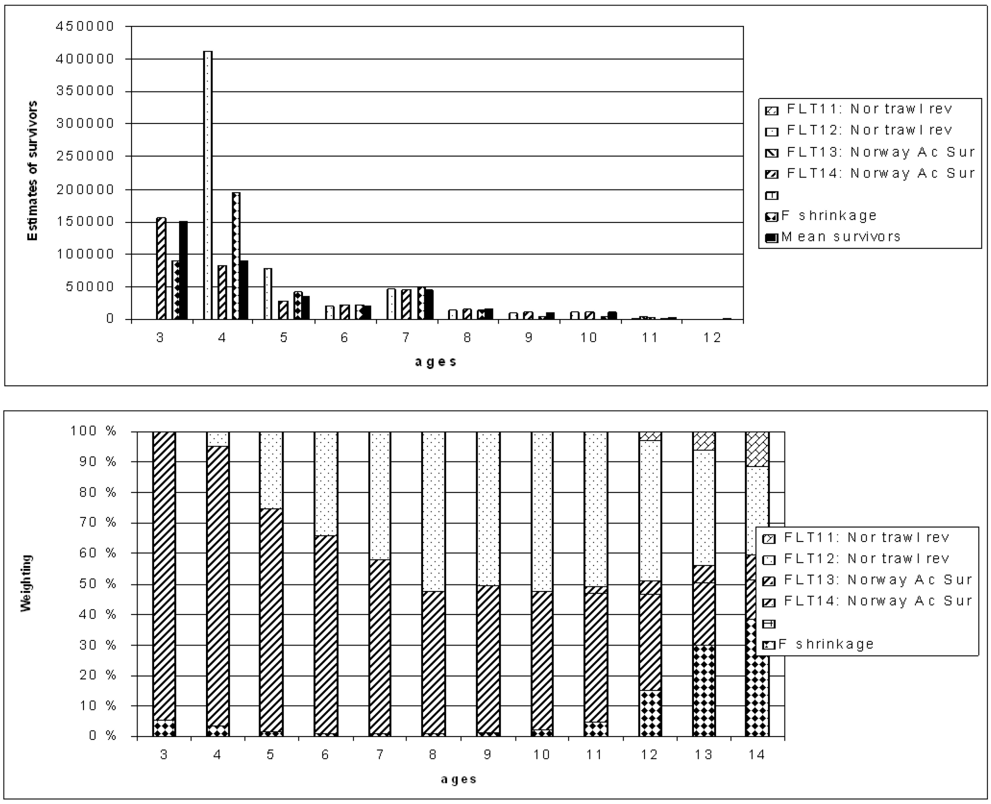


Figure 5.5.3 Northeast Arctic saithe. Estimates of survivors from different fleets and shrinkage and weighting in the final XSA-run.

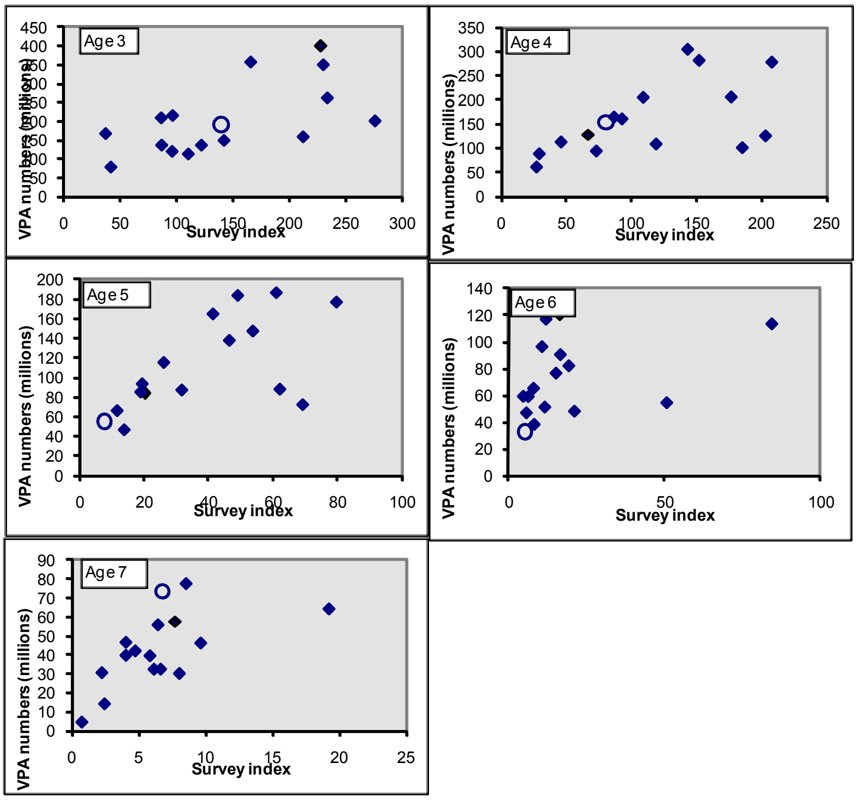


Figure 5.5.4A. NEA Saithe - Acoustic survey vs. VPA, circle shows last data year.

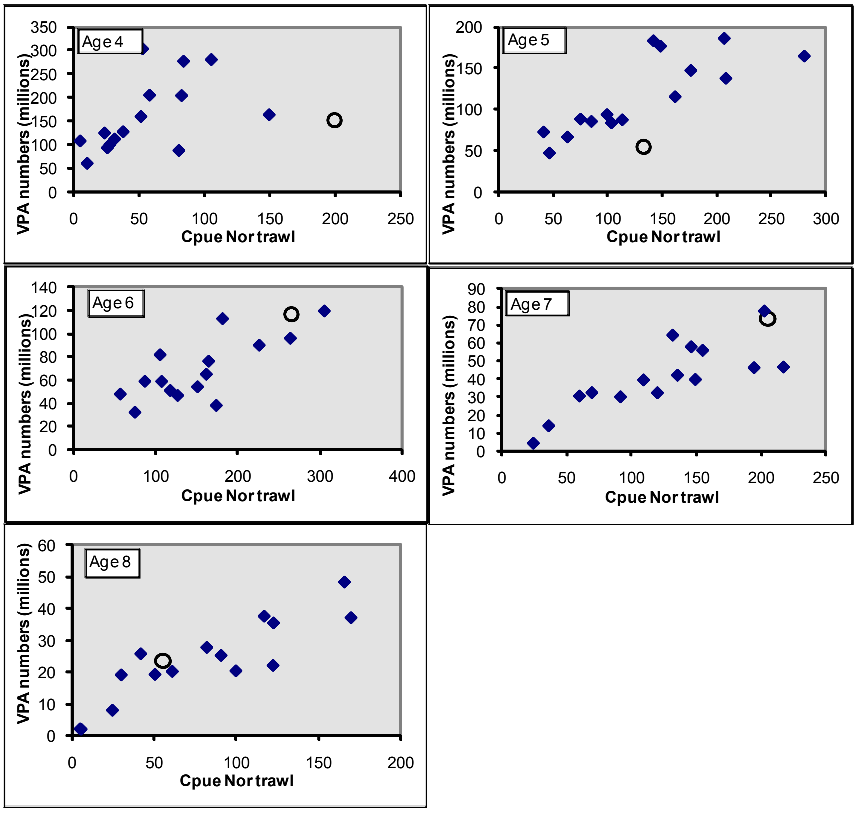


Figure 5.5.4B. NEA Saithe - Acoustic survey vs. VPA, circle shows last data year.

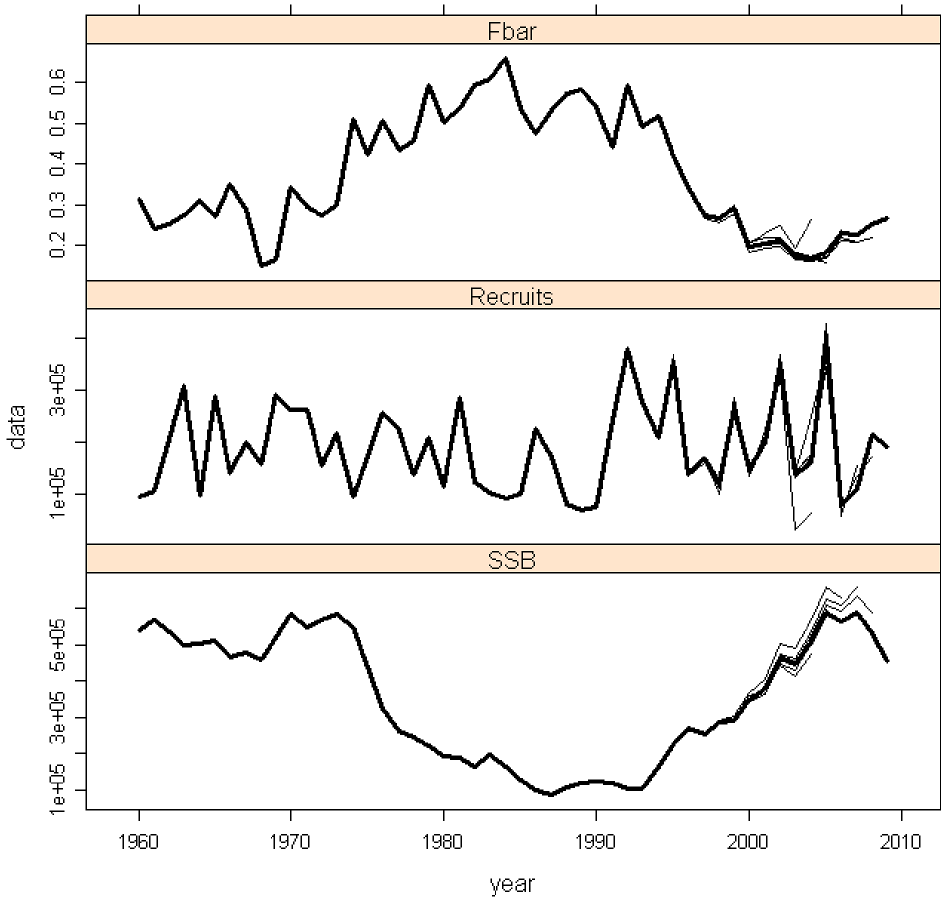


Figure 5.5.5 Saithe in Sub-areas I and II (Northeast Arctic) RETROSPECTIVE XSA F_{4-7}, recruits and SSB for all fleets.

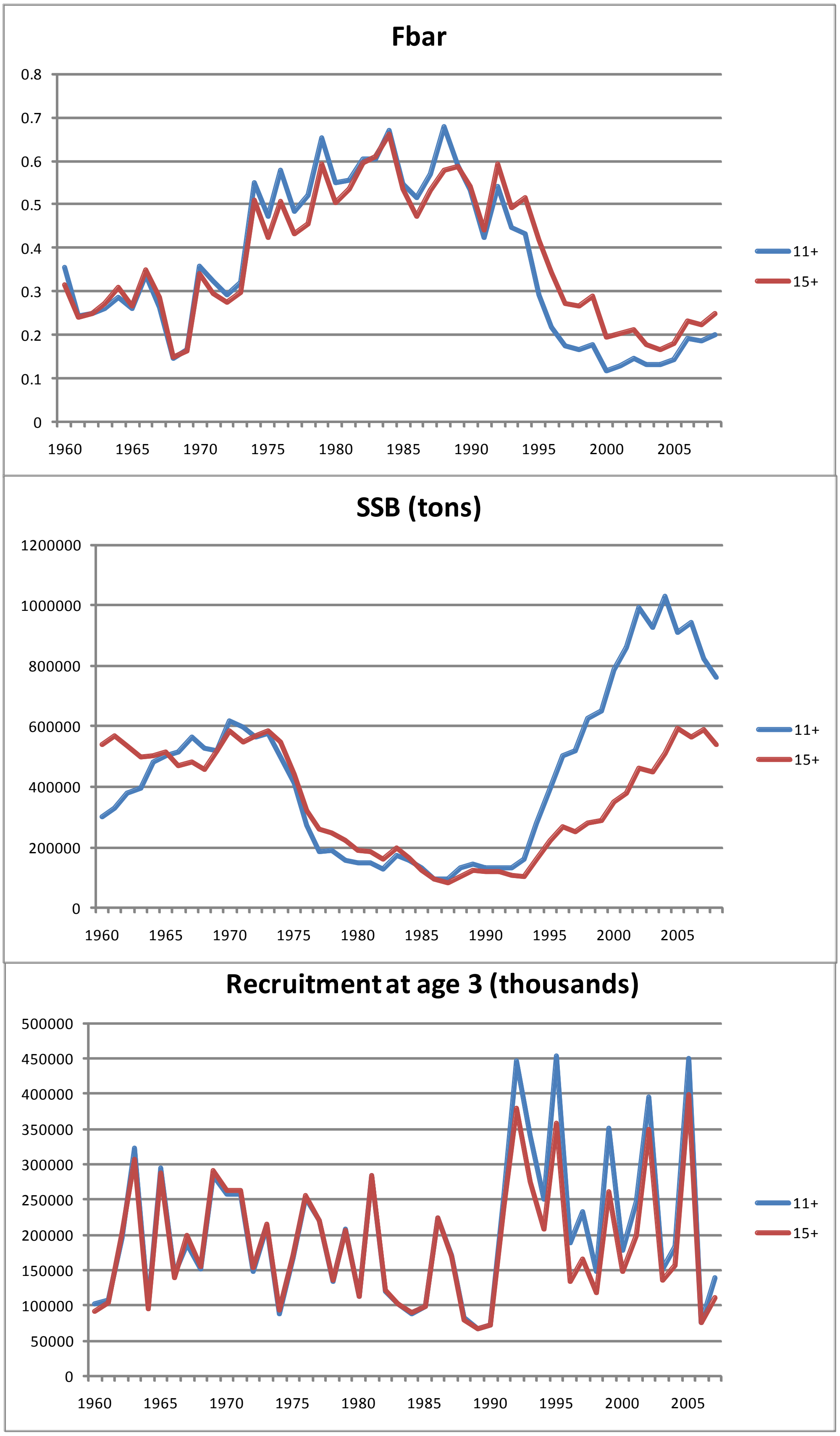


Figure 5.6.1. Northeast Arctic saithe. Fbar, SSB and recruitment for XSA analysis with age span 3-11+ and 3-15+.

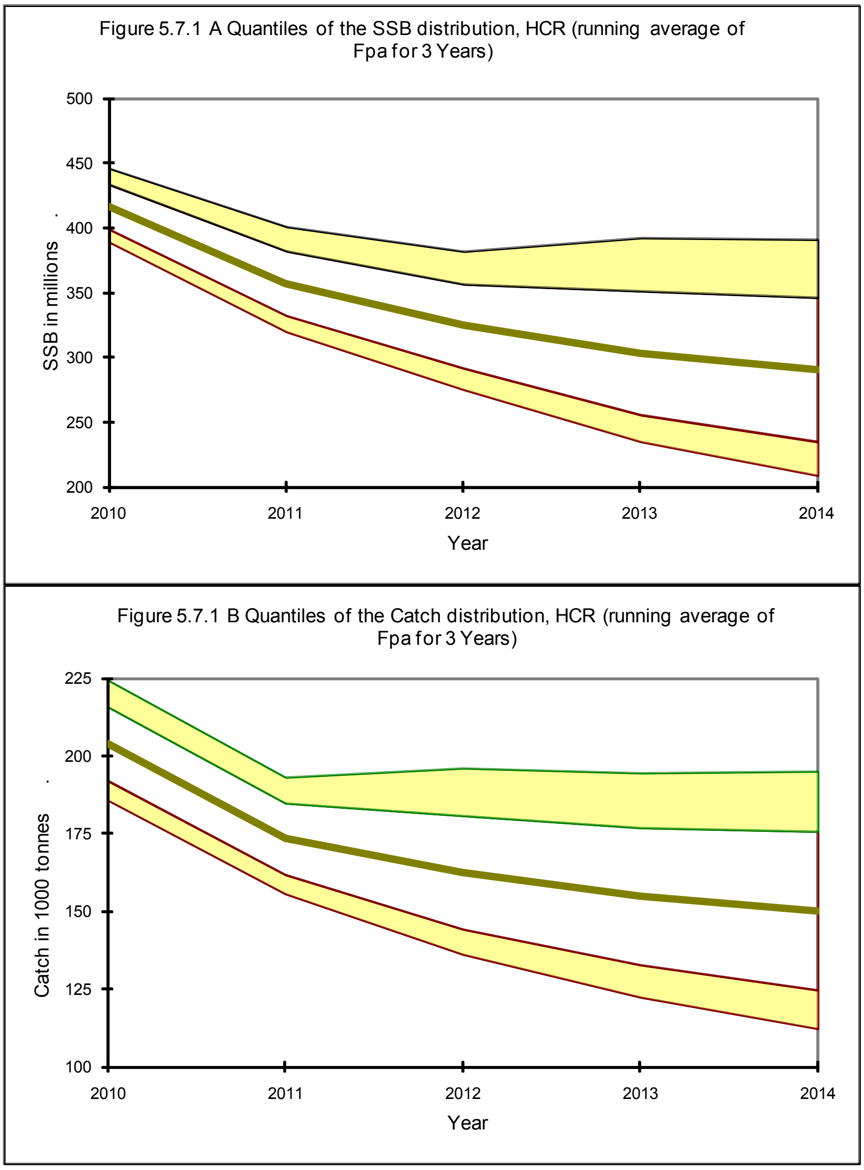


Figure 5.7.1A-B. Northeast arctic saithe. Quantiles of SSB and catch distribution from medium term risk analyses, HCR.

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.

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. The Handbook was updated at this year's AFWG.

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 6.1-6.2). This fishery, which is further described in Quality handbook for this stock, is managed by the North-East Atlantic Fisheries Commission, and during its 28th annual meeting in November 2009 the Commission adopted by consensus a TAC for 2010 of 8,600 t.

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 millions 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.

6.1.3 Landings prior to 2010 (Tables 6.1–6.5, D1–D2, Figure 6.2)

Nominal catches of *S. mentella* by country for Sub-areas 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 Sub-area I and Divisions IIa and IIb are shown in Tables 6.2–6.5. Total international landings in 1965-2009 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 28,429 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 10,500 t (incl. all by-catches) to be taken in the pelagic trawl fisheries in international waters of the Norwegian Sea in 2009. This was, however, a reduction in TAC from 14,500 t in 2008. According to reports to NEAFC and ICES, only 5,291 t were caught due to generally lower and less profitable catch rates. Not all the countries reported the catches to NEAFC and ICES. EU reported catches are not split by individual country, which is problematic. For this reason catches taken by Spain were recalculated according to the preliminary proportions reported to NEAFC during the fishery.

The redfish population in Sub-area 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 Sub-area 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 2010

In 2010 there will be no directed demersal fishery for *S. mentella* , and all the current regulations will be continued in 2010, 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 2010 are expected to be maximum 6,000 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 8,600 t for an olympic fishery in these international waters starting 15 August 2010. In total this may lead to landings in 2010 of up to 14,600 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 2009.

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. The main reason for the difference in size compositions between the Portuguese and the rest of the countries was the season of the fishery.

Length compositions from Russia and Portugal of the commercial pelagic catches of *S. mentella* in the Norwegian Sea outside EEZ in ICES Sub-areas IIa show a different distribution pattern but the same size range (Figure 6.4). This different pattern is difficult to explain, one of the reasons could be the depth or latitude of the fishery.

6.2.2 Catch at age (Tables 6.6 and 6.8)

Catch at age for 2008 was revised according to new catch data. Age data for 2009 for demersal *S. mentella* were available from Norway for all areas, and from Russia in Division IIb. For the pelagic *S.mentella* in 2009, age data based on recommended otolith readings were available from Norway (survey) and Russia. 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 (WKADR, ICES 2006) in 2006 must soon be solved through regular otolith exchanges and comparative age readings between international experienced age readers.

Russian total catch-at-length of the demersal fishery in Sub-area I and Division IIa was converted to catch-at-age using the Norwegian age-length keys from Sub-area I and Division IIa (northern part), respectively. The available length distribution from Portuguese catches in Divisions IIa and IIb were converted to catch-at-age using the Norwegian age-length keys from Division IIa (northern part) and Division IIb. Other countries were assumed to have the same relative age distribution and mean weight as Norway.

Due to uncertainties in the Russian age reading for old fish and potential issues with the length distribution of Portuguese catches in international waters, the catch-at-age figures for 2009 are highly uncertain, in particular for younger (12) and older (18+) age groups. These are presented as preliminary figures.

According to the Norwegian age readings, 77% of all demersal catches of *S. mentella* are composed of fish older than 18 years. A similar age composition is also seen in the pelagic Norwegian Sea fishery during the survey and beginning of the fishing season in 2009 (Figure 6.14).

6.2.3 Weight at age (Tables 6.7 and 6.9)

Catch weight-at-age data for 2009 were available from Norway for all areas, and from Russia from the demersal fishery in Division IIb and the pelagic fishery. 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 indicate an age-at-50% maturity of 11y. The detail of the ogive calculation are provided in the report of the NEAFC working group on zonal attachment of *S. mentella* (Anon., 2009b).

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, 1.4, D3–D7, Figures 6.5–6.10)

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).
2) Russian bottom trawl survey in the Svalbard and Barents Sea areas in October-December from 1978–2009 in fishing depths of 100–900 m (Table D3, Figures 6.6 and D2F).
3) Norwegian Svalbard (Division IIb) bottom trawl survey (August-September) from 1986–2009 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).
4) Norwegian Barents Sea bottom trawl survey (February) from 1986–2010 (joint with Russia since 2000, except 2006 and 2007) in fishing depths of 100–500 m. Data disaggregated by age only for the years 1992–2009 (Tables D5a,b, Figure D2A).

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 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 1996-2009 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.
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 has been observed since 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 have been observed for the 1996-1999 year classes. The 2000 year class was stronger than the preceding four year classes. A promising increase was observed since 2005 with the 2007 and 2009 year classes being the strongest observed since 1990, but survey data indicate low abundance of 0-group fish in 2008 (Figure 6.5).

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. This decrease was also seen in Figure 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. The strong decrease in biomass observed in 2008 from the ecosystem survey was no longer observed in 2009 (Table D6).

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 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 that 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 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 1.5, 1.6; Figure 6.4a). It is important that the estimation of the consumption of redfish by cod is being continued.

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 1000m²/NM², 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 100m²/NM².

Age/length distribution: All fish sampled were older than 11y, the maximum recorded age was 53y and mean age was 22.5y. Males and females have similar age distribution, although females 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 (37.5cm) and mean age (22.5y) are consistent with observations from the open Norwegian Sea in summer (36.6cm, 25y).

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, 2009). Unfortunately, among the five expected participants (EU, Faroes, Iceland, Norway and Russia) only Norway was capable of carrying out the survey. 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 = 36.5cm), age (mean age = 25y) 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 550m (350-550m in 2008). This is shallower than what was observed along the slope in spring 2009 (450-650m, 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 crosses at 72-73°N).

As in 2009, 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, 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. Revision of the target strength equation, which will depend on the result of the ICES workshop on hydroacoustics target strength of redfish (WKTAR, June 2010) may alter this estimate, likely upward. The new survey therefore support the results reported to the AFWG in 2009 which indicated a spawning biomass of 500,000 t, and this is likely an underestimate (ICES 2009).

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 6.4).

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.

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 rapid change in the fisheries dynamics 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.

The WG finds it appropriate and necessary to conduct a benchmark assessment as a follow up of this project and reiterates its recommendation from last year to hold such a benchmark assessment 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.

The fact that only 50% of the allowable NEAFC fish quota of 10 500 tonnes in international waters of the Norwegian Sea in 2009 was caught gave some concerns as to what extent this was only caused by an observed effort reduction or was also caused by lower abundance and/or behavioural changes of the fish. A better documentation of the fishing effort involved in the international fishery is therefore highly recommended, and NEAFC is requested to provide such information for future stock assessments and advice.

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 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 F0.1 and an appropriate Spawning-stock-per-recruit (SPR) level to be useful reference points for management (see ch. 6.7) and recommends to prepare 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 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 apparent weak year-class in 2008. An estimate of the spawning stock biomass in recent years, based on weight-at-age and maturity-at-age data from Anon (2009b) indicates that this might currently follow and increasing trend (78,000t in 2000, 95,000t in 2001, 99,000t in 2002, 127,000t in 2003, 80,000t in 2004, 75,000t in 2005, 134,000t in 2006, 137,000t in 2007, 76,000t in 2008 and 140,000t in 2009). 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 bycatches of redfish. This should be taken into consideration in the management of the stock of *S. mentella*. High and unreported bycatches in the pelagic trawl fisheries for blue whiting, herring, and mackerel in the Norwegian Sea should be avoided.

The AFWG has earlier estimated the minimum acceptable spawning stock level (MBAL) for *S. mentella* in ICES Sub-areas 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 expected poor new recruitment, and may within some years reach the MBAL level. The poor recruitment in 2008 (after a few years of some promising recruitment) and clear reduction of the biomass in the Barents Sea indicate 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 2011 should be the same as the advice given in 2009 for the 2010 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 Fmsy framework

During the ICES Workshop on Implementing the ICES Fmsy framework (WKFRAME), the *Sebastes mentella* stock in Sub-areas I and II was used as a case study (ICES 2010). WKFRAME recommends that the bounds for FMSY 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 (F01 proxy) and a prescribed percent 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 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, incl. 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 next years' working group and/or the proposed 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 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 recommend a benchmark assessment to be hold for this stock in 2012 together with other *Sebastes* stocks.

Table 6.1*Sebastes mentella* in Sub-areas I and II. Nominal catch (t) by countries in Sub-area I, Divisions IIa and IIb combined.

Year	Canada	Denmark	Estonia	Faroes	France	Germany	Greenland	Iceland	Ireland
1991				487	85		23		
1992				23	12				
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				73	26	202	50		3
2000				50	12	62	29	48	1
2001				74	16	198	17	3	4
2002			15	75	58	99	18	41	4
2003				64	22	32	8	5	5
2004				588	13	10	4	10	3
2005			5	1147	46	33	39	4	4
2006	433		396	3808	215	2483	63	2513	9
2007			684	2197	234	520	29	1579	6
2008				1849	187	16	25	9	2
2009				1343	15	42	45	63	

Year	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	Sweden	UK E& W	Uk Scot	EU not split	Sum
1991				33592		166	14302	1		68	3		50718
1992				10751		972	3577	14		238	3		17582
1993				5182		963	6260	5		293			14807
1994				6511		895	5021	30		124	12		14715
1995				2646		927	6346	67		93	4		12279
1996				6053		467	925	328		76	23		10071
1997				4657	1	474	2972	272		71	7		10595
1998				9733	13	125	3646	177		93	41		16042
1999				7884	6	65	2731	29		112	28		13208
2000				6020	2	115	3519	87			130		12075
2001				13937	5	179	3775	90			120		20419
2002				2152	8	242	3904	190			188		8996
2003				1210	7	44	952	47			124		4523
2004				1375	42	235	2879	257	1		76		7497
2005			7	1760		140	5023	163			95		10471
2006		845		4710	2496	1804	11413	710			1027		34931
2007		785		3209	1081	1483	5660	2181			202		21857
2008	267	117	13	2214	8	713	7117	463			83		15091
2009			3	2766	338	806	3843	177			103	889	12442

* catch not split on countries for EU 2009

Table 6.2 ***Sebastes mentella*** **in Sub-areas I and II. Nominal catch (t) by countries in Sub-area I.**

Year	Faroe Islands	Germany[4]	Greenland	Norway	Russia[5]	UK(Eng.&Wales)	Iceland	Total
1991	-	-	-	8	420	-	-	428
1992	-		-	561	408	-	-	969
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[1]	327	-	-	330
2006	2[3]	-	-	12	460	2	-	476
2007	-	-	-	11	210	20	-	241
2008	-	-	-	5[1]	155	2	-	162
2009[1]	-	-	-	3	80	-	-	83

[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.

Table 6.3 ***Sebastes mentella*** **in Sub-areas I and II. Nominal catch (t) by countries in Division IIa (including landings from the pelagic trawl fishery in the international water).**

Year	Estonia	Faroe Islands	France	Germany[3]	Greenland	Ireland	Norway
1991		487[2]	72[2]	-	-	-	32,810
1992		23[2]	7[2]	-	-	-	9,816
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
2006	396	3,793	199	2,475	52[2]	8[2]	3,985
2007	684	2,157	226	519	29[2]	5[2]	3,043
2008	-	1,821[6]	179[2]	9[2]	24[2]	2[2]	1,947[1]
2009[1]	-	1,316	7	23	45	-	2,300

Table 6.3 (Cont'd)

Year	Sweden	Portugal	Poland	Russia[4]	Spain	UK (Eng.& Wales)	UK (Scotland)	Total
1991		159[2]		7,596	-	23[2]	-	41,147
1992		824[2]		1,096	-	27[2]	-	11,793
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[2,5]	8,403
2001		105[2]		2,716	18[2]	-	95[2,5]	16,827
2002		124[2]		2,615	8[2]	41[2]	157[2,5]	5,055
2003		17[2]		448	8[2]	5[2]	102[2,5]	1,700
2004	1[2]	86[2]		2,081	7[2]	10[2]	18[2,5]	3,765
2005	-	71[2]		3,307	20[2]	2[2]	15[2,5]	5,693
2006	Lithu -845 **Can** - 433	1,731	2,467	10,110	589	2,513[2,6]	958[2,5]	32,895
2007	Lithu -785	1,395	1,079	5,061	2,159	1,579[6]	120[2,5]	18,840
2008	Lithu -117 Latvia - 267 Nether - 13[2]	666	1	6,442	430	9[2]	62[2,5]	11,989
2009[1]	EU[7] – 889	764	338	3,305	137	63	86	9,272

[1] Provisional figures.

[2] Split on species according to reports to Norwegian authorities.

[3] Includes former GDR prior to 1991.

[4] USSR prior to 1991.

[5] UK(E&W)+UK(Scot.)

[6]As reported to NEAFC

[7] EU not split on countries.

Table 6.4 *Sebastes mentella* in Sub-areas I and II. Nominal catch (t) by countries in Division IIb.

Year	Canada	Denmark	Faroe Islands	France	Germany[4]	Greenland	Ireland
1991	-	-	-	13[2]	-	23	-
1992	-	-	-	5[2]	-	-	-
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[1]	3[2]	-	27[2]	8[2]	19[2]	-	-

Table 6.4 (Cont'd)

Year	Norway	Poland	Portugal	Russia[5]	Spain	UK(Eng. & Wales)	UK (Scotland)	Total
1991	774	-	7	6,286	1	45[2]	3[2]	7,152
1992	374	-	148[2]	2,073	14	211[2]	3[2]	2,828
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[2,6]	1,172
2001	293	5[2]	74[2]	763	72[2]	Estonia	25[2,6]	1,284
2002	210	8[2]	118[2]	702	182[2]	15	31[2,6]	1,348
2003	190	7	27[2]	212	39[2]	-	22[2,6]	522
2004	386	42[2]	149[2]	443	250[2]	-	58[2,6]	1,372
2005	673	-	69[2]	1,389	143[2]	5	80[2,6]	2,442
2006	688	29	73[2]	843	121[2]	-	67[2,6]	1,870
2007	155	2	88	389	22[2]	-	62[2,6]	769
2008	262[1]	6	47[2]	520	33[2]	-	19[2,6]	931
2009[1]	463	1	42[2]	458	41[2]	-	17[2,6]	1,079

[1] Provisional figures.

[2] Split on species according to reports to Norwegian authorities.

[3] Split on species according to the 1992 catches.

[4] Includes former GDR prior to 1991

[5] USSR prior to 1991.

[6] UK(E&W)+UK(Scot.)

Table 6.5*Sebastes mentella* in Sub-areas 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	Lithuania
2002					9		
2003					40		
2004			500		2		
2005			1,083		20		
2006	433	396	3,766	192	2,475	2,510[2]	845
2007	Latvia	684	1,968[2]	226	497	1,579[2]	785
2008	267	-	1,797[2]	-	-	-	117
2009[1]	-	-	1,253	-	-	-	-

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	28,429
2007	1,813[2]	1,079	1,377	3,645	2,155	-	15,808
2008	330[2]	-	641	4,901	390[1]	**EU**[3]	8,443
2009[1]	-	338	701	1,975	135	889	5,291

[1] Provisional figures.

[2] As reported to NEAFC

[3] EU not split on countries.

Table 6.6. ***S.mentella*** **in Sub-areas 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[1]
AGE																	
6	159	738	662	223	125	37	9	1	117	2	6	11	5	0	0	0	0
7	159	730	941	634	533	882	83	24	372	40	37	24	44	10	1	0	1
8	174	722	1279	1699	1287	2904	441	390	542	252	103	108	128	8	5	1	16
9	512	992	719	1554	1247	4236	1511	1235	976	572	93	148	347	89	32	10	22
10	2094	2561	740	1236	1297	3995	2250	2460	925	709	132	427	540	153	52	44	42
11	3139	2734	1230	1078	1244	2741	3262	2149	1712	532	220	624	567	256	151	128	48
12	2631	3060	2013	1146	876	1877	1867	1816	2651	1382	384	931	432	877	314	186	1507
13	2308	1535	4297	1413	1416	1373	1454	1205	2660	1893	391	580	1607	1980	1025	492	520
14	2987	2253	3300	1865	1784	1277	1447	1001	1911	1617	434	1385	1332	2774	2466	541	983
15	1875	2182	2162	880	1217	1595	1557	993	1773	855	466	1047	3174	4580	2836	1444	1136
16	1514	3336	1454	621	537	1117	1418	932	1220	629	513	937	1041	5154	3570	1423	1623
17	1053	1284	757	498	1177	784	1317	505	714	163	199	927	1216	4823	4002	923	1292
18	527	734	794	700	342	786	658	596	814	237	231	549	1024	4261	2866	1730	2347
+gp	6022	3257	2404	2247	3568	6241	3919	5705	16234	4082	1193	2055	4266	35350	17148	16389	7389
TOTALNUM	25154	26118	22752	15794	16650	29845	21193	19012	32621	12965	4400	9754	15725	60313	34469	23311	16925
TONSLAND	12866	12721	10284	8075	8597	14045	11209	10075	18418	6993	2520	5493	8466	32895	19837	13860	10434

[1] preliminary figures

Table 6.7. *S.mentella* in Sub-areas 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[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
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
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
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
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
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
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
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
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
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
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
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
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
+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

[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[1]	9	1314	294	471	889	999	869	1150	2981

[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[1]	0,38	0,44	0,45	0,48	0,54	0,59	0,64	0,58	0,69

[1] preliminary figures

Table 6.10: 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).

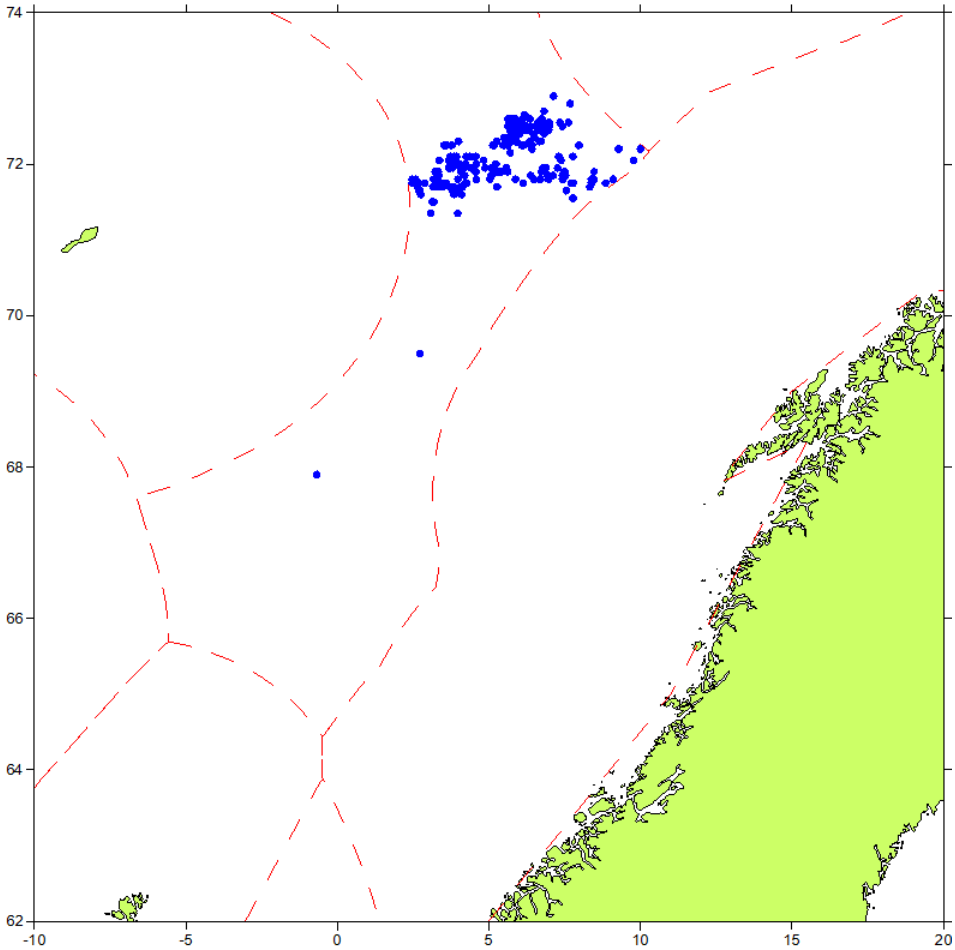


Figure 6.1. ***Sebastes mentella*** **in Sub-areas I and II. Location of pelagic** ***S. mentella*** **catches by Russian fishing vessels in 2009.**

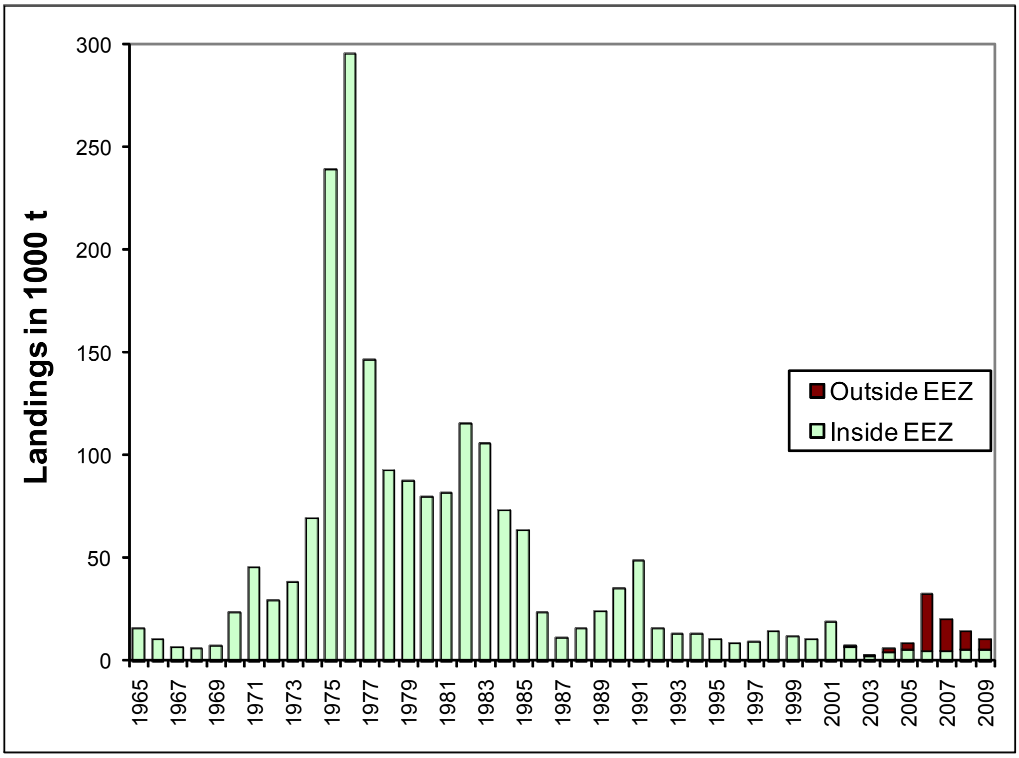


Figure. 6.2. ***Sebastes mentella*** **in Sub-areas I and II. Total international landings 1965-2009 (thousand tonnes).**

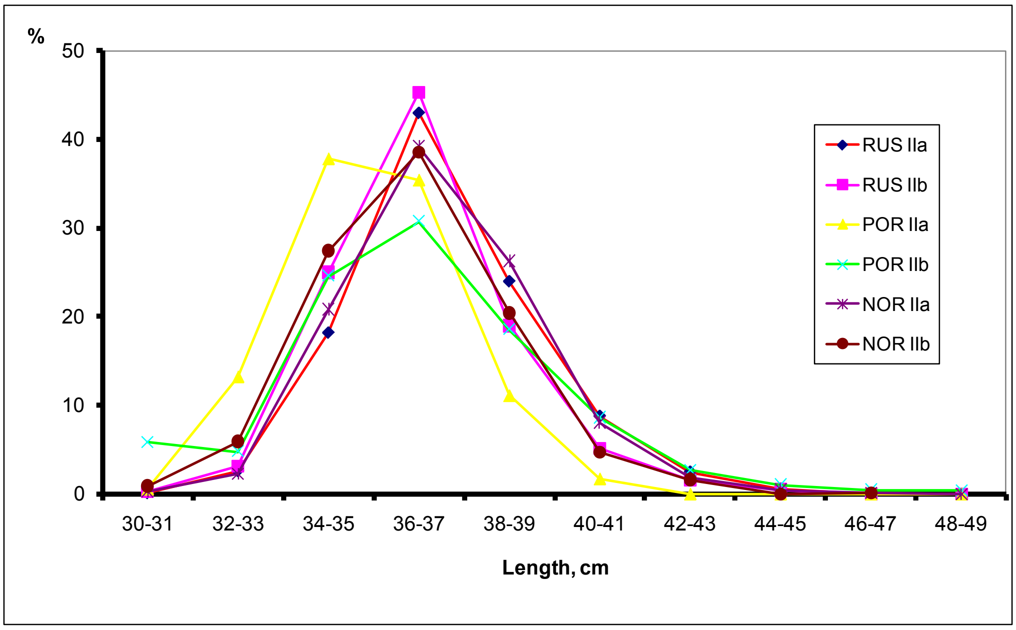


Figure 6.3. ***Sebastes mentella*** **in Sub-areas I and II. Length-distributions of the commercial demersal catches inside EEZ in ICES Sub-areas IIa and IIb by those countries providing length data from their demersal by-catches of** ***S. mentella*** **in 2009.**

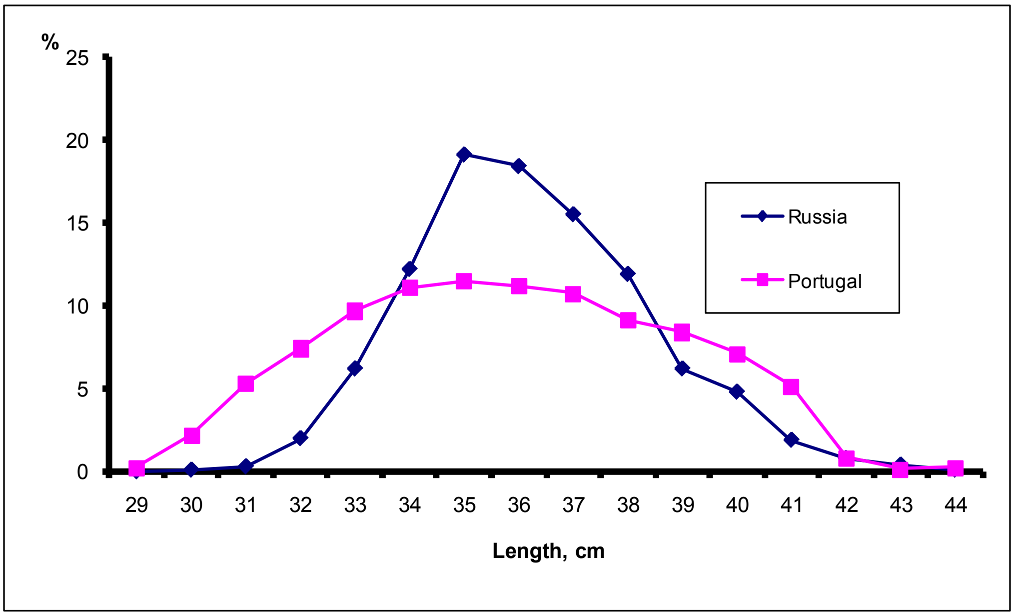


Figure 6.4. ***Sebastes mentella*** **in Sub-areas I and II. Length-distributions of the commercial pelagic catches in the Norwegian Sea outside EEZ in ICES Sub-area IIa by those countries providing length data from their pelagic fisheries in 2009.**

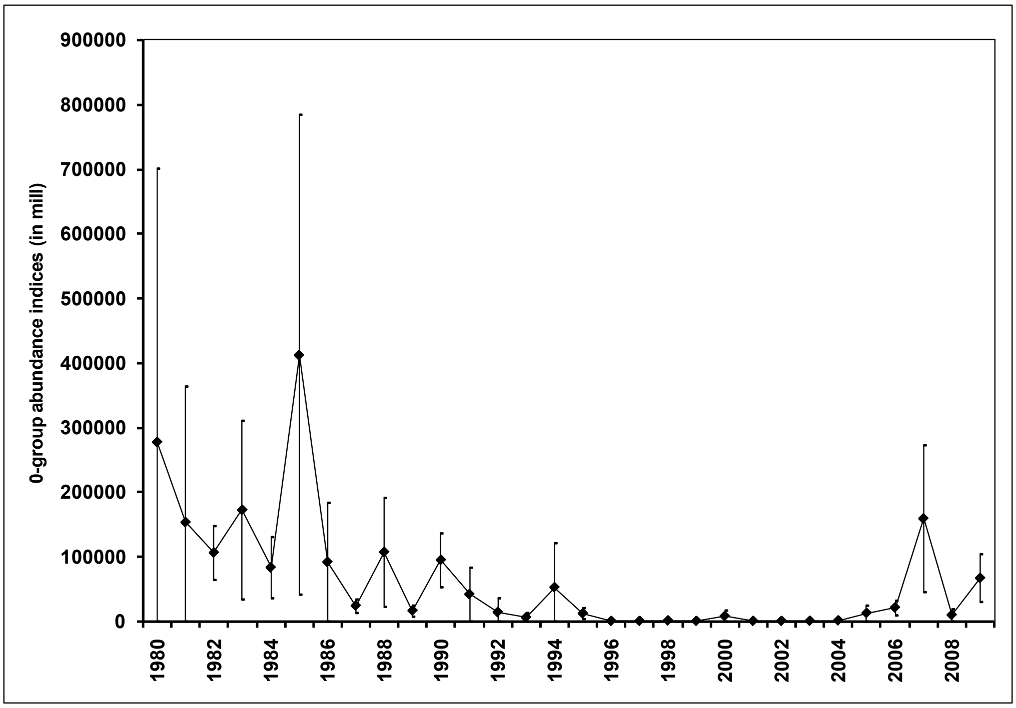


Figure 6.5. ***Sebastes mentella*** **in Sub-areas I and II. Abundance indices (in millions) with 95% confidence limits of 0-group redfish (believed to be mostly** ***S.mentella*****) in the international 0-group survey in the Barents Sea and Svalbard areas in August-September 1980-2009, as calculated by the new method, and not corrected for catching efficiency.**

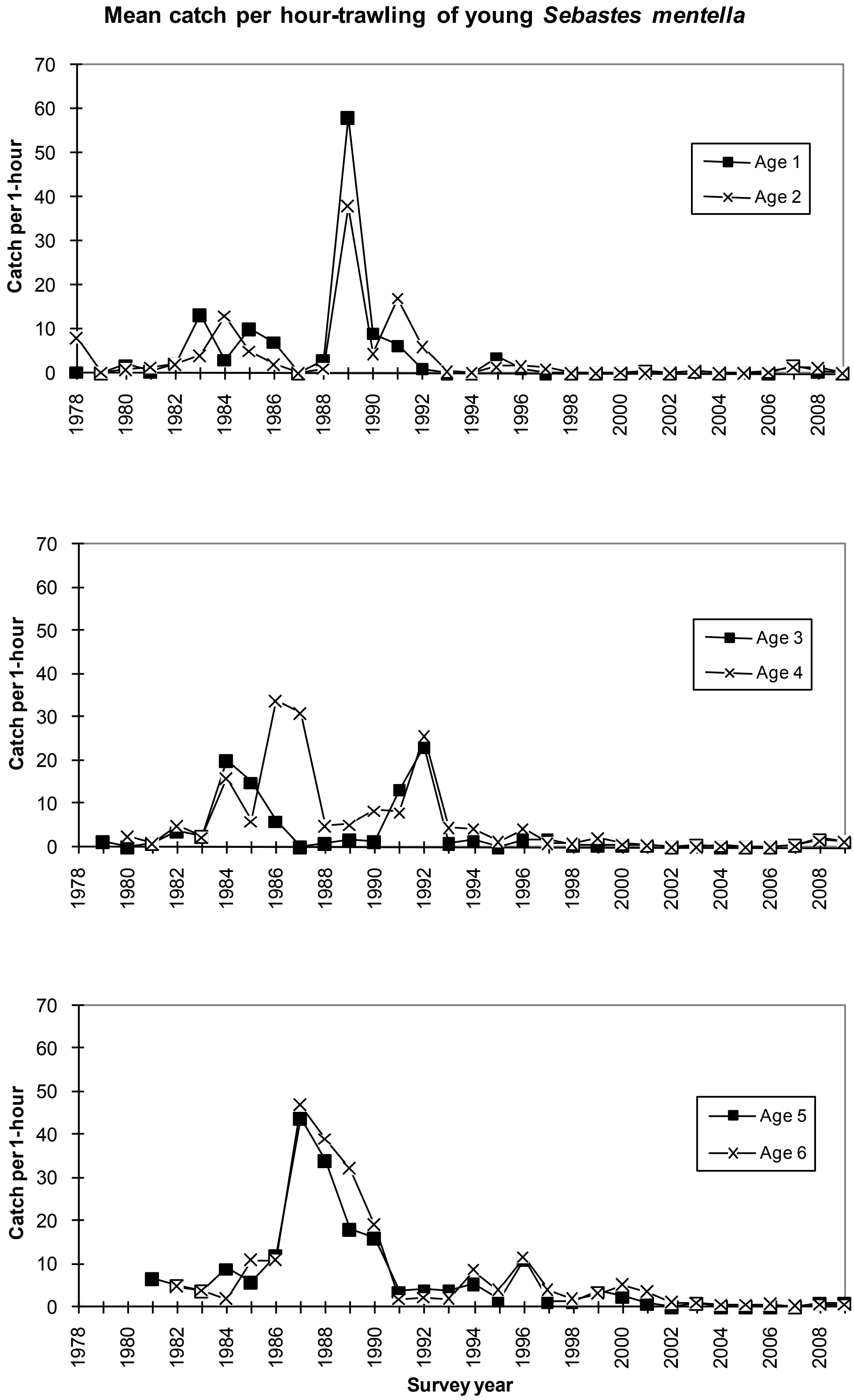
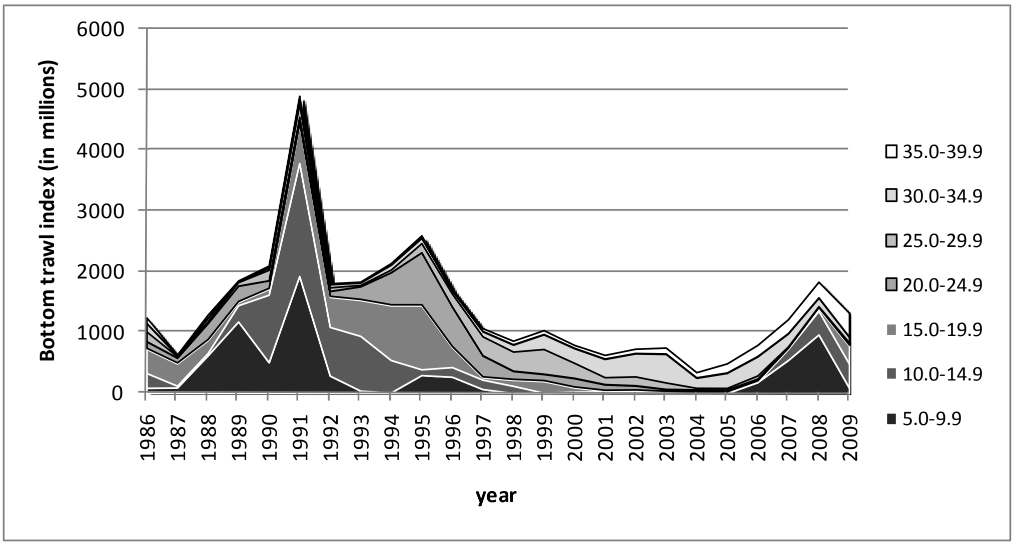


Figure 6.6 *Sebastes mentella* in Sub-areas I and II. Catch (numbers of specimens) per hour trawling of different ages of *S. mentella* in the Russian groundfish survey in the Barents Sea and Svalbard areas (ref. Table D3).



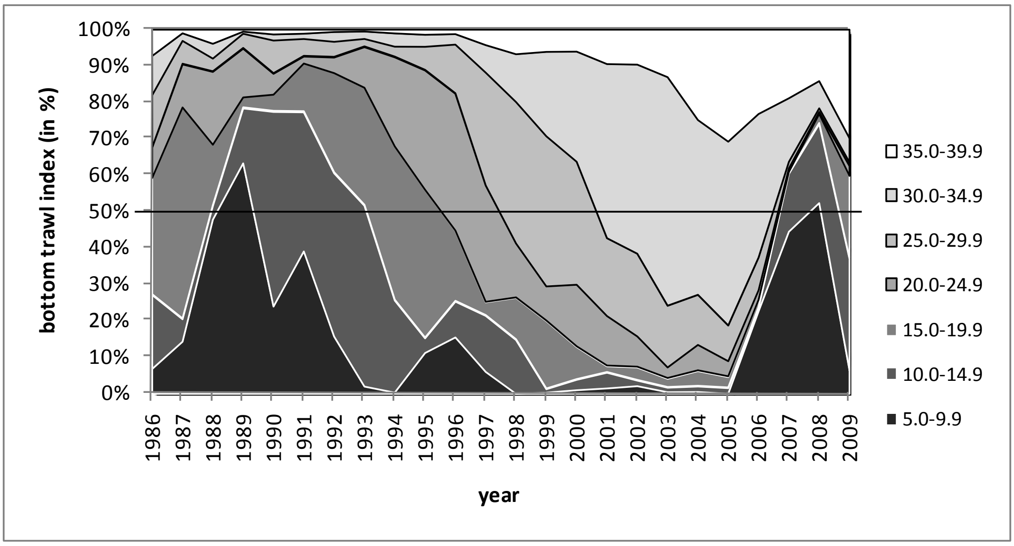


Figure 6.7a. ***Sebastes mentella*** **in Sub-areas I and II. Abundance indices disaggregated by length when combining the Norwegian bottom trawl surveys 1986-2009 in the Barents Sea (winter) and at Svalbard (summer/fall). Top: absolute index values. Bottom: relative frequencies. Horizontal line indicate the median length in the surveyed population.**

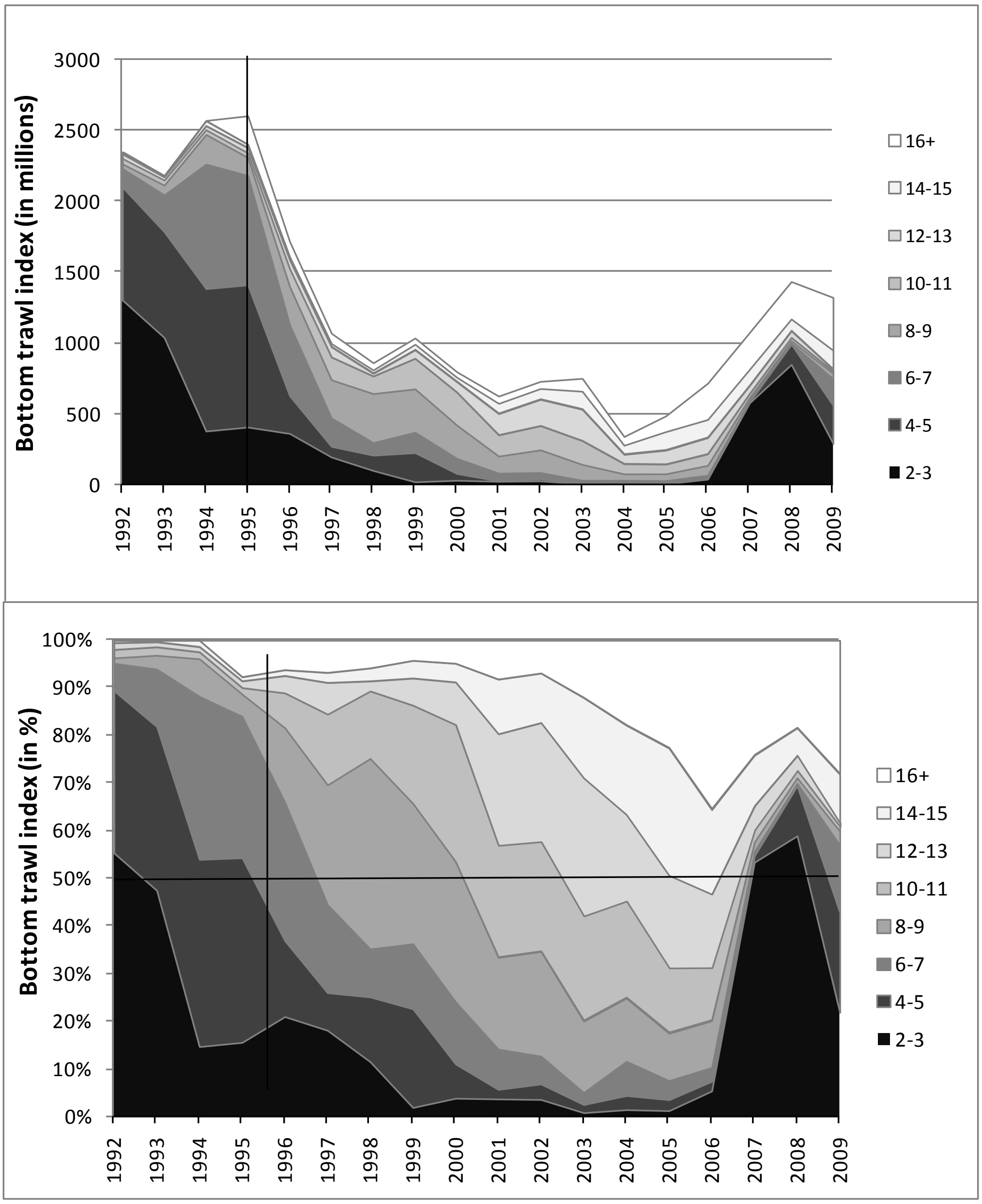


Figure 6.7b. ***Sebastes mentella*** **in Sub-areas I and II. Age disaggregated abundance indices for combined Norwegian bottom trawl surveys 1992-2009 at Svalbard (summer/fall) and in the Barents Sea (winter). Top: absolute numbers. Bottom: relative frequencies. Vertical black line indicate the start of recording for age 16+ group. Horizontal line indicates the median age in the population (50% frequency).**

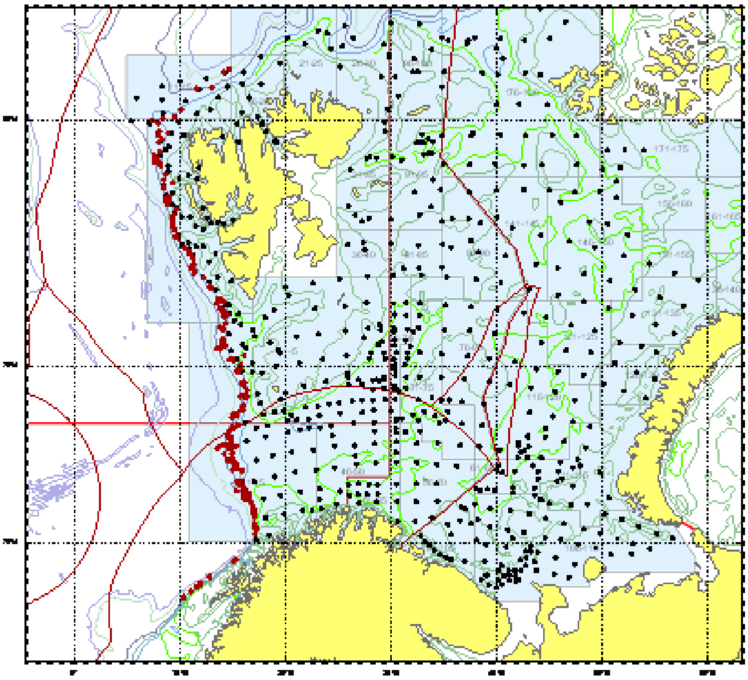


Figure 6.8. Survey regions and subareas in the ecosystem survey in the Barents Sea and adjacent areas as covered in August-September 2007 by the standard 1800 Campelen research trawl (22 mm codend) shallower than about 500 m, and the Alfredo 5 trawl (60 mm codend) from 500-1500 m along the continental slope from 68-80°N. The sub-areas are further depth stratified (ref. Table D6).

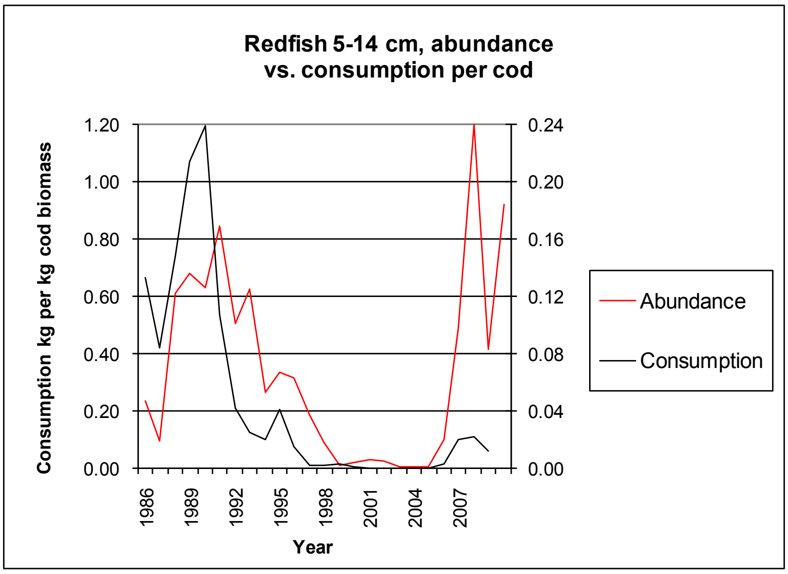


Figure 6.9. Abundance of *S. mentella* during the winter survey (February) in the Barents Sea compared with the consumption of redfish (mainly *S. mentella*) by cod.

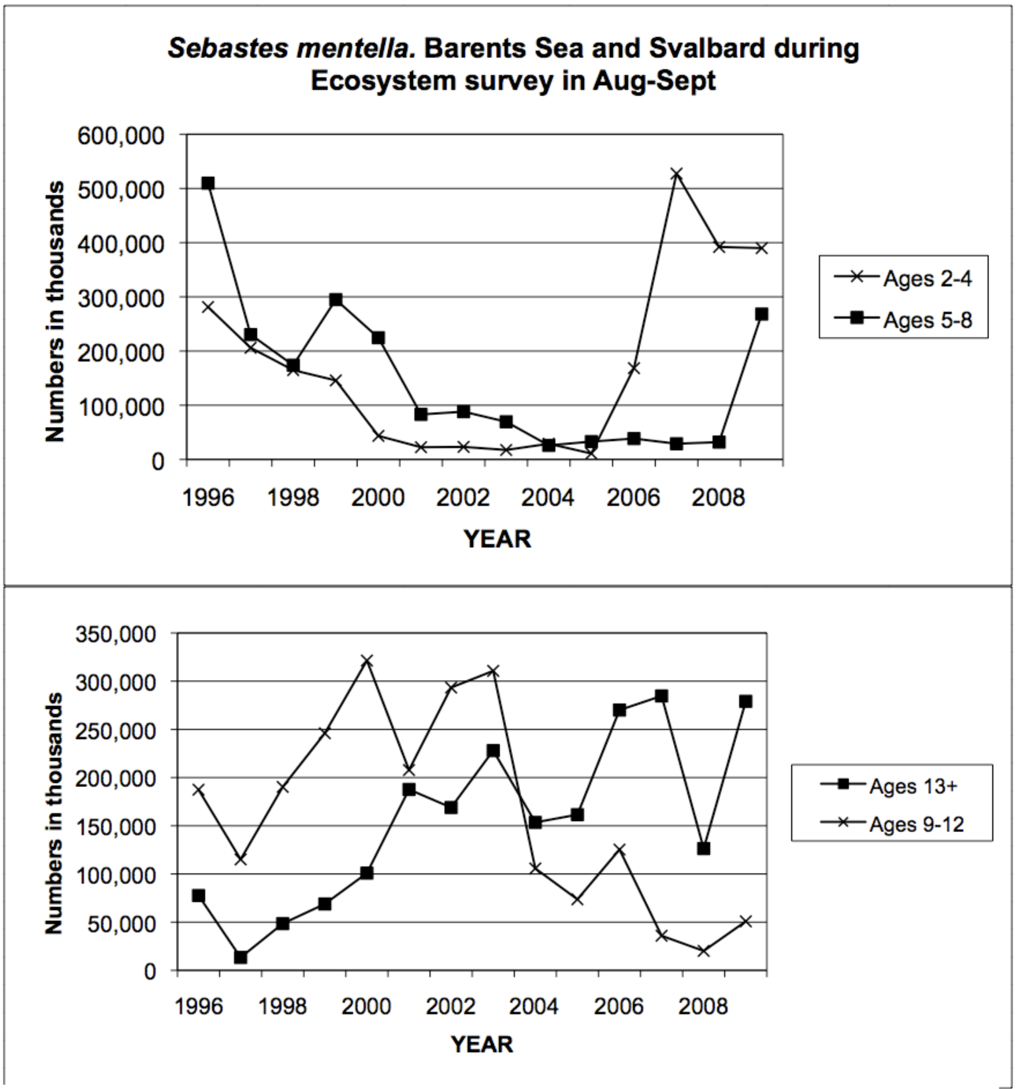


Figure 6.10. *Sebastes mentella* in Sub-areas I and II. Abundance indices (on age) from the Ecosystem survey in August-September 1996-2009 covering the Norwegian Economic Zone (NEZ) and Svalbard incl. the area north and east of Spitsbergen (ref. Table D6). Abundance data in arctic waters are not included for 2009.

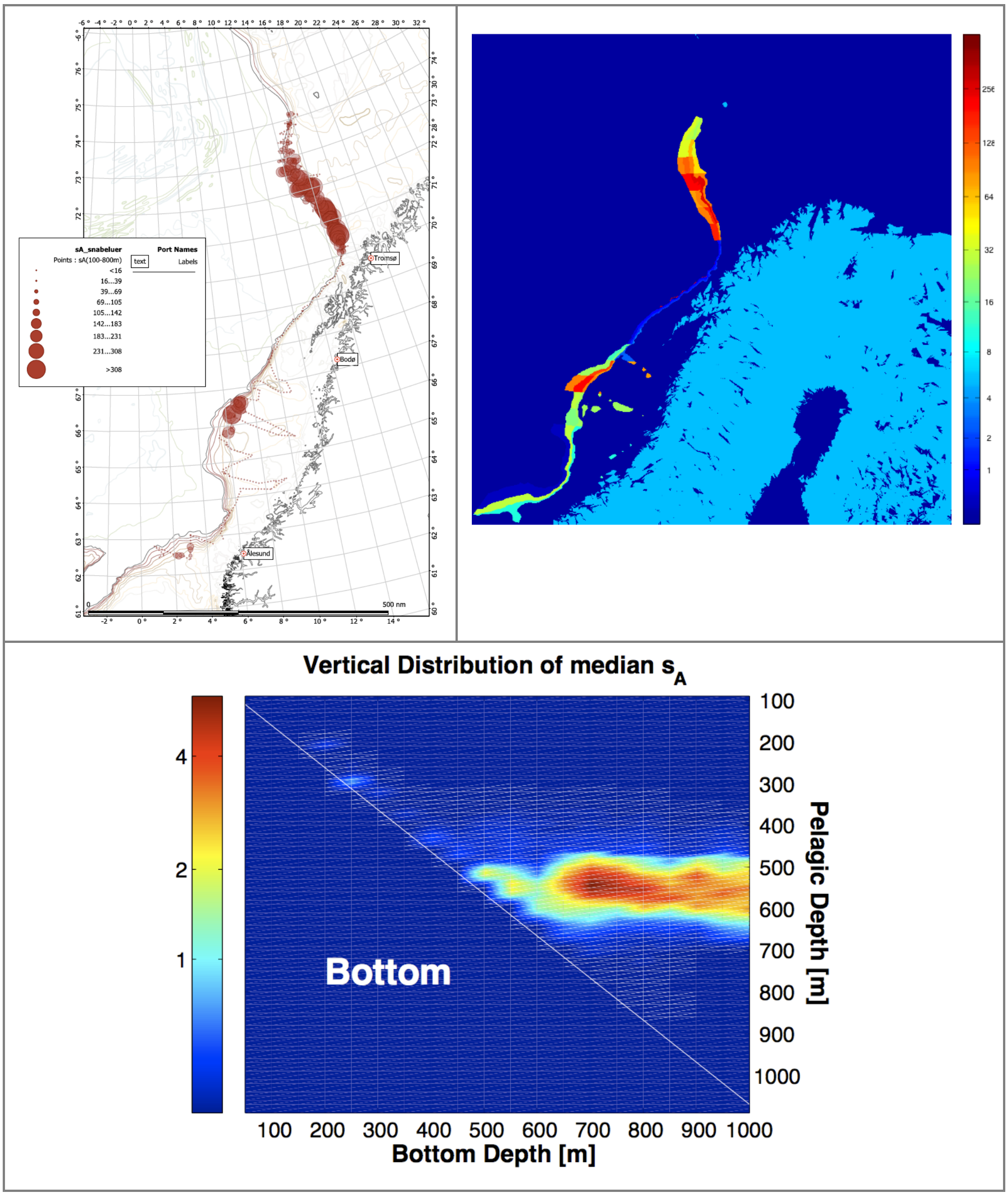


Figure 6.11. *Sebastes mentella* in Sub-areas I and II. Horizontal and vertical distribution of *S.mentella* hydroacoustic backscaterring (s_A) during the Norwegian slope survey in spring 2009. On the top-left panel, circles are proportional to the s_A assigned to redfish along the vessel track. The top-right panel shows the distribution of mean s_A by depth and latitude strata (dark blue = no data). The bottom panel shows the vertical distribution of median s_A as a function of bottom depth, revealing a preferred depth range for *S. mentella* of 450-650m and dominance of pelagic *vs.* demersal distributions.

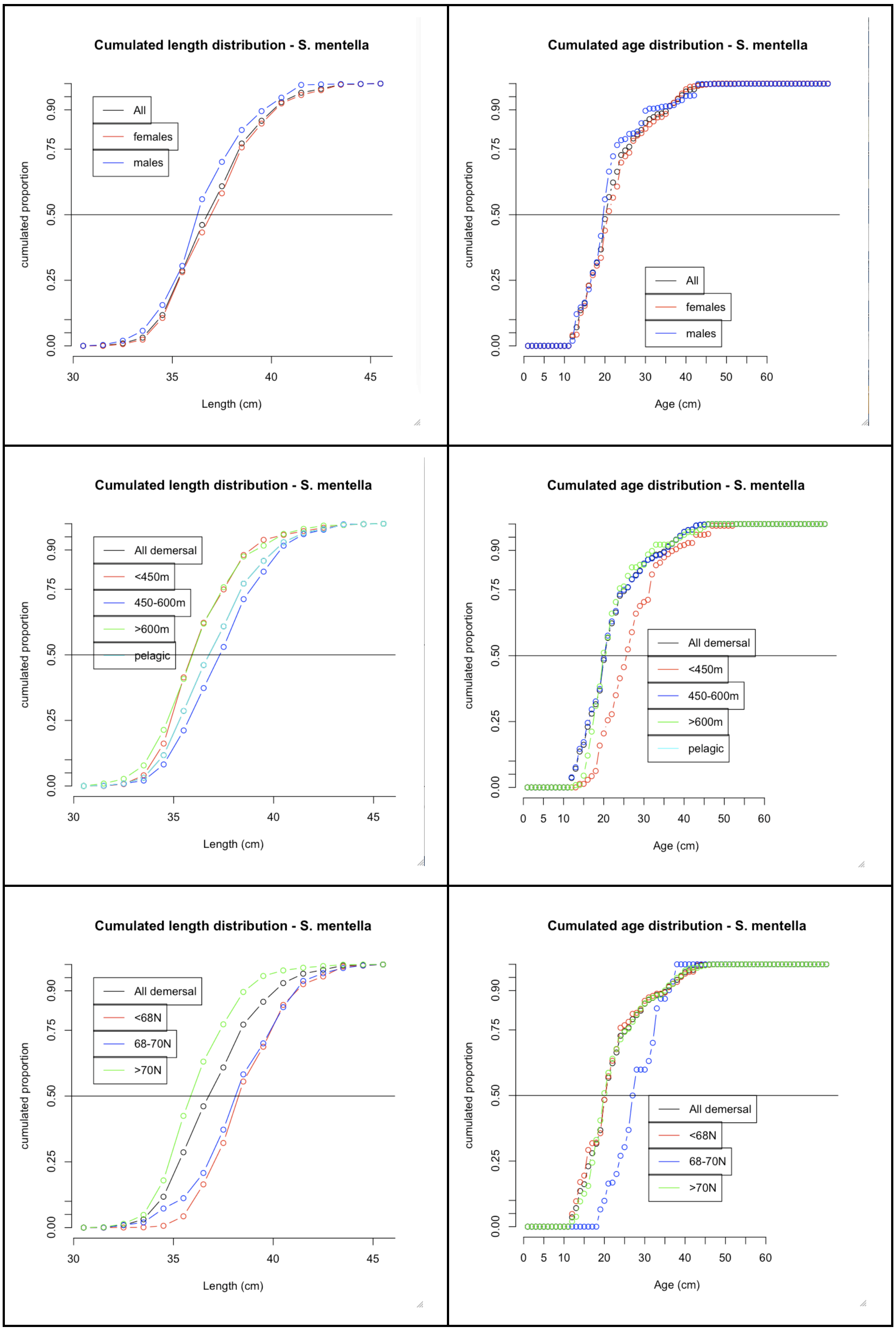


Figure 6.12. ***Sebastes mentella*** **in Sub-areas I and II. Cumulated distribution of length (left) and age (right) of** ***S. mentella*** **as a function of sex (top), depth (middle) and latitude (bottom.)**

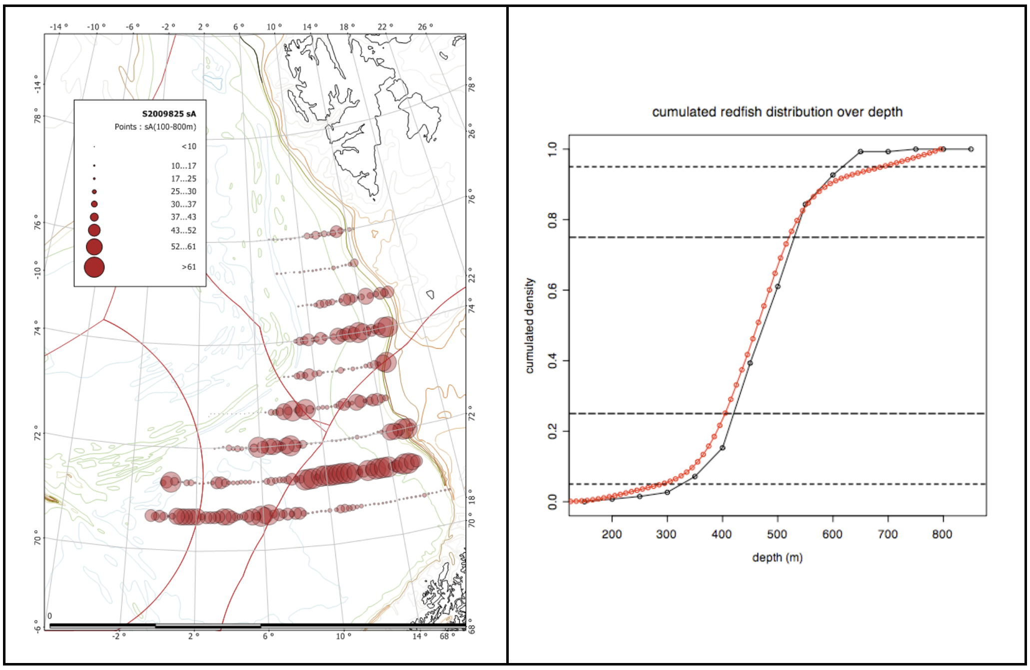


Figure 6.13. *Sebastes mentella* **in Sub-areas I and II. Left: Spatial distribution of area backscattering coefficient (s_A) of *S. mentella* (m^2/NM^2) during the Norwegian Sea pelagic survey in summer 2009. Right: cumulated density distribution of catch rates (black) and area backscattering coefficient (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.**

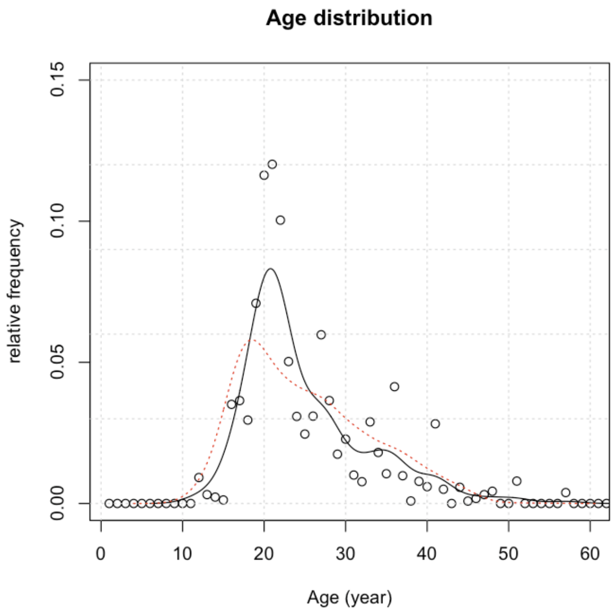


Figure 6.14. *Sebastes mentella* **in Sub-areas I and II. Age distribution of *S. mentella* sampled during the open Norwegian Sea survey in July-August 2009. Dots show the proportion at age for individual age. The black line is a smooth fit, which is believed to be more reliable when precision in age reading is uncertain. The sampled population is dominated by individuals of 16 years and over with 20-22y dominating. Only a fraction (40%) of otoliths collected during the survey were read at the time of reporting. The estimated smoothed age distribution in the same area in 2008 is indicated as a red dotted line.**

Table D1 REDFISH in Sub-areas I and II. Nominal catch (t) by countries in Sub-area 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	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	-	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	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	8	785	7,866	1,183[2]	**EU**[7]	168[6]	20,356
2009[1]	-	-	1,413	19	100	72	76	-	4	8,149	338	836	4,541	177	889	113	16,727

[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 Sub-area IV (North Sea). Nominal catch (t) by countries as officially reported to ICES. Not included in the assessment.

Year	Belgium	Denmark	Faroe Islands	France	Germany	Ireland	Nether-lands	Norway	Sweden	UK (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[1]	-	-	-	-	-	-	-	120	+	-	87	207

[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	10.7	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	
2000	-	0.6	0.1	0.5	0.3	0.3	0.6	0.4	0.1	0.1		
2001	-	0.1	0.4	-	0.1	0.2	0.2	0.3	0.2			
2002[3]	0.1	0.5	0.1	-	-	0.1	0.5	0.4				
2003	-	-	0.1	-	0.3	1.0	0.5					
2004	-	0.2	0.3	0.5	1.5	0.9						
2005	-	-	1.4	1.9	1.4							
2006[4]	0.1	1.8	1.2	1.1								
2007	2.5	0.4	0.1									
2008	0.1	0.1										
2009	1.6											

[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 1986-2009 (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	53	305	228	34	9	63	328	9	0	1029

[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	82	132	146	73	92	50	32	2	5	6	3	2	36	92	752

[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 1986-2010 (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	34	101	70	2	5	26	65	2	0.1	304
2010	647	273	213	64	7	73	190	6	0.4	1474

[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 Sub-areas I and II. Preliminary Norwegian bottom trawl indices (on age) from the annual Barents Sea survey in February 1992-2009 (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	39	37	32	28	30	14	2	4	1	2	3	3	3	3	203

[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 Sub-areas 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	1056120	171
1997	62682	130816	12492	23452	74342	55880	76607	82503	17640	14274	675	2238	1723	633	8765	564723	73
1998	313	78767	85715	39849	25805	23413	84825	100332	54287	24329	11334	7457	15250	576	25212	577464	105
1999	5359	23240	117170	47851	41608	76797	128677	73306	58018	64781	49890	13565	18458	12171	24672	755562	155
2000	5964	23169	14336	19960	52666	68081	83857	77513	100442	72294	71148	36599	17183	20590	26501	690837	178
2001	5026	6541	10957	1093	19766	25591	36594	51644	44407	61704	50083	86122	53952	15699	31877	507131	162
2002	9112	6646	7379	3821	8635	28215	47456	63903	103368	49964	76133	71970	25241	36765	34957	573565	181
2003	3954	7394	6142	3540	8030	9388	48564	59051	98554	69901	83192	73521	69970	37162	47323	625687	213
2004	9068	10837	9008	7292	2510	7896	8193	15268	25544	29654	35249	21142	39581	25976	66792	314030	111
2005	1310	4406	5241	5031	5722	8740	13452	20672	16207	19353	17430	32028	37564	34815	57103	279072	103
2006	156578	5162	6695	5217	3768	10754	18771	29174	25278	38958	31869	46885	30895	44299	147951	602255	184
2007	302988	224153	290	7686	11346	2031	7903	10770	12182	6578	6367	9998	41425	22090	211178	876986	172
2008	86880	183796	121430	21430	4178	3009	3334	6991	5120	4441	3581	6008	10352	10172	99808	570530	89
2009[1]	68775	161824	159311	89730	109995	46726	21792	2560	15734	23819	8737	11244	11739	42990	213123	999245	200

[1] in 2009, data in the arctic waters are not included

Table D7. *Sebastes mentella* in Sub-areas 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																							

Table D8a. *Sebastes mentella* in Sub-areas 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 Sub-areas 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

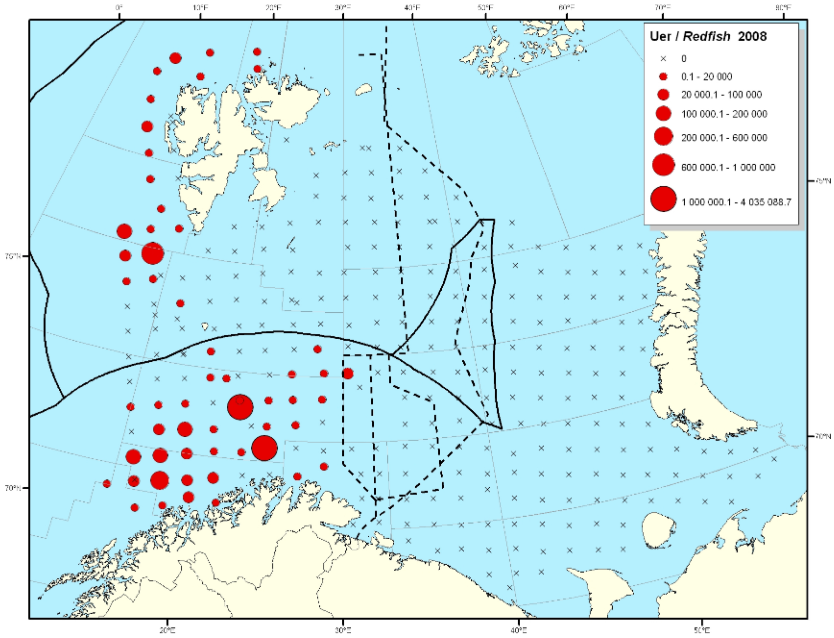


Figure D1. Map showing the strata system, the specific pelagic 0-group trawl stations and the abundance of 0-group *Sebastes mentella* during the joint Norwegian-Russian Ecosystem survey in the Barents Sea and Svalbard. Example from 2008.

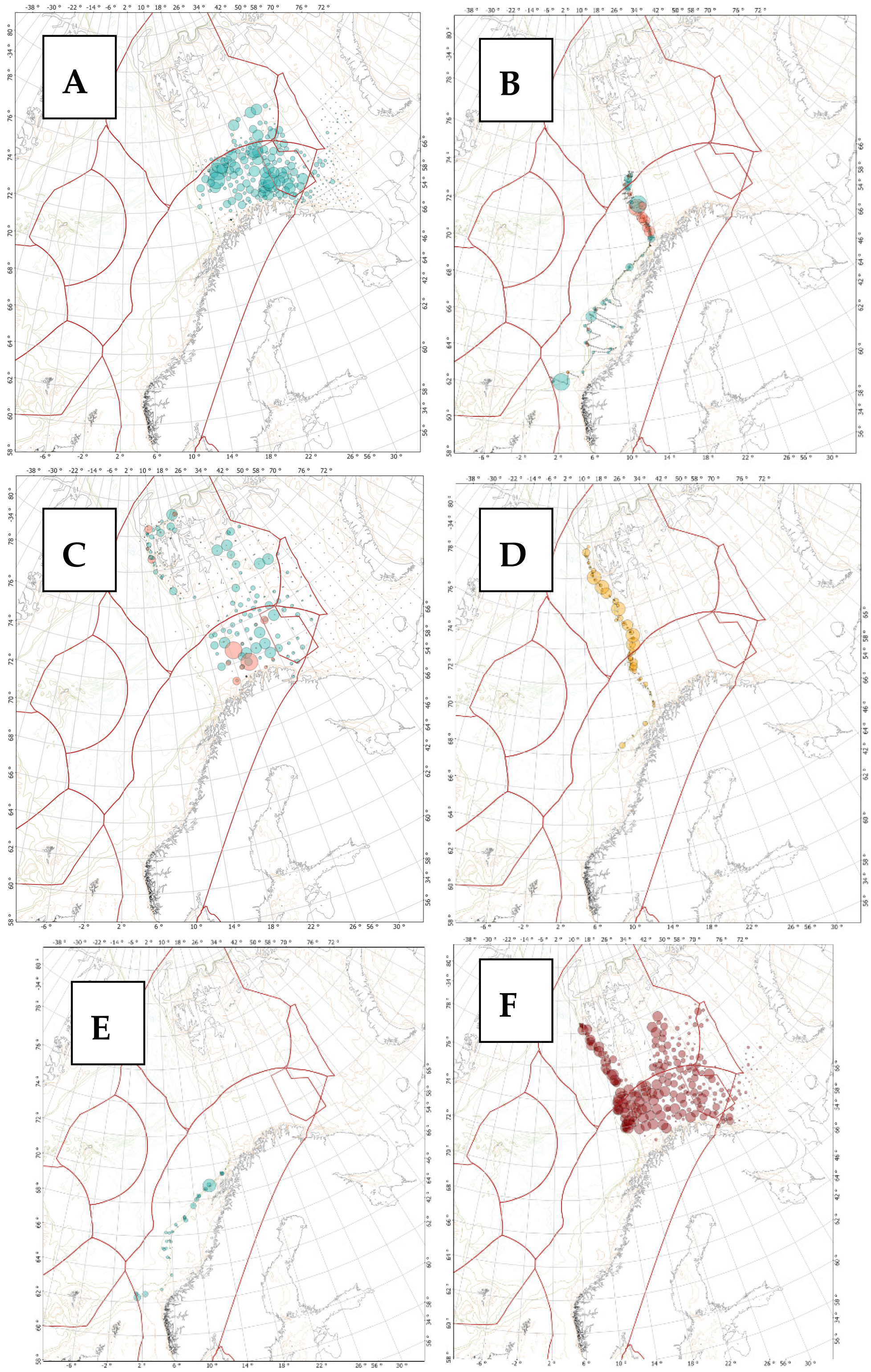


Figure D2. Overview of different scientific surveys contributing with information about the *Sebastes mentella* stock in Sub-area I and II in 2008-2009. A: Norwegian-Russian survey in winter 2008, B: Norwegian slope survey in March/April 2009, C: Norwegian-Russian ecosystem survey in summer 2008, D: Norwegian slope survey in August 2008, E: Norwegian slope survey in November 2008, F: Russian survey in October/December 2008.

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 has been 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 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, a change from April-May and September in 2006, 20 April-19 June in 2005 and 1-31 May in 2004. 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.

7.1.2 Landings prior to 2010 (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 2003-2007 have been low but remarkable stable between 7,000-7,800 t. Provisional figures for 2009 indicate a further decline in landings down to 6,293 t, the lowest since the mid-1940ies. This is mainly attributable to decreasing catches in Division IIa (minus 226 t) and Sub-area I (minus 41 t). No significant changes in landings can be observed in Division IIb. The time series of *S. marinus* landings is given in Figure 7.1 and shows a long-term (1908-2009) mean of 16,734 t.

The Norwegian landings are presented by gear and month in Figures 7.2a,b. Reported landings have diminished in 2009 for trawl and Danish seine and increased in gillnet (for the second year in a row) and longline. Since 2003, the limited moratorium for conventional gears seems to have 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 in 2008 and 2009. Due to the increase in catches by gillnets from 2,649 t in 2008 to 2,841 t in 2009, the total catches, except trawl, have increased to 4,135 t. For fishing gears other than gillnet, bycatches in 2008 and 2009 are the lowest observed for the period 2003-2009.

The reported Russian catches of *S. marinus* were decreasing from 890 t in 2007 and 749 t in 2008 to 698 t in 2009 (Table 7.1)

The bycatch estimates of redfish (*Sebastes* spp.) in the Norwegian Barents Sea shrimp fisheries during 1983-2002 are completely dominated by *S. mentella*, and hence will influence the *S. marinus* to a much lesser extent. However, it 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 authorised 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 2010

In 2009, total Norwegian catch (5,383 t, provisional figure) and total Russian catch (698 t) are close to the values expected in the previous year. Under similar assumptions (reports from the first months of the year, a legal by-catch of 15% in all trawl fisheries, and an assumed effect of the regulations for the other gears) the Norwegian and Russian landings in 2010 are expected to be similar to those reported in 2009.

7.2 Data Used in the Assessment (Figure D1)

An overview of the sampling levels (by season, area and gear) of the data used in the assessment is presented in Figure D1 for 2008. Of technical reasons it became impossible to present the same figure for 2009 before the report had to be printed. The sampling of *S. marinus* commercial catches should be improved. In 2009, only 3 of 11 metiers (area-quarter-gear combinations) responsible for 50% of the Norwegian landings were properly covered with age samples, compared to 8 of 13 metiers the year before

7.2.1 Catch-per-unit-effort (Table D11, 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 D11, 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 D11. Provisional figures for 2006-2009 indicate 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 around 150 days since 2003.

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 are 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 mid 1990ies 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/trawl 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 2006-2008 were revised. Age composition data for 2009 were only provided by Norway, accounting for 86% 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 2009. Variations in the weight-at-age of young individuals (<10y) 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 D12a,b–D13a,b–D14, Figures 7.4a,b–7.5a,b)

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

1) Norwegian Barents Sea (Division IIa) bottom trawl survey (February) from 1986–2010 (joint with Russia some of the years since 2000) in fishing depths of 100–500 m. Length compositions for the years 1986–2010 are shown in Table D12a and Fig 7.4a. Age compositions for the years 1992–2008 are shown in Table D12b and Figure 7.4b. This survey covers important nursery areas for the stock.
2) Norwegian Svalbard (Division IIb) bottom trawl survey (August-September) from 1985–2009 in fishing depths of 100–500 m (depths down to 800 m incl. in the swept area). Length compositions for the years 1985–2009 and age compositions for the years 1992–2008 are shown in Table D13a and D13b, respectively. This survey covers the northernmost part of

the species' distribution. Insufficient number of age readings in 2009 did not allow for updating the age composition in 2009.

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 1995-2009 from Finnmark to Møre (Table D14). The series was updated from last year's assessment for 2009. Observations in 2009 indicate maximum catch rates for the 35-44 cm length group, as before. The estimated catch rates in 2009 were particular high due to one trawl station with an exceptional high catch.

5) 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 2008. 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 D14). 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 2009 should hence be interpreted with great caution (see next chapter).

7.3 Assessment with the GADGET model

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. (2004) and in the latest Quality Handbook for *S. marinus* (2009).

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 2008

Length disaggregated survey indices from the Barents Sea (Division IIa) bottom trawl survey (February) from 1990–2009 (Table D12a),

Age-length keys and aggregated survey indices from the same survey up to 2009 (Table D12b), 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 D14).

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 2008. Commercial catch data have been revised for years 2008 and updated with year 2009. The proportion mature data set has been extended to 2009, and as noted above the period 1986-1992 has been populated using the average of 1993-1995 in order to avoid model artefacts. The data from 1990-1992 had previously been removed (AFWG 2009) as it was inconsistent with later data. This change has not altered the overall biomass in the model.

A difference was discovered between the Gadget input data for the Barents Sea February survey in 1998 and the data given in Tables D12a,b. The reason for this is that the input data to Gadget had not been corrected for a very large catch on a single station. The input data were corrected to be in accordance with the data given in the tables.

In the previous AFWG the coastal survey length distribution series was only included up to 2005, due to an error in data processing. It can be seen (Figure 7.6) that there is a significant residual pattern in the fit between the model and the survey index, with 2008 and 2009 in particular being very much above the modelled trend. In terms of the length distribution within the survey, the recent years (especially 2008 and 2009) of this survey show the presence of significantly more large redfish than previously (table D14). This trend is not seen in the winter survey (table D12a), and the presence of such large numbers of old fish is not consistent with earlier years of the coastal survey. As a consequence it was decided to exclude 2008 and 2009 of the coastal survey from the model. Furthermore the weighting procedure used on the data sets within the model aims to prevent any single data set from dominating the model fit. As a result of the increasing misfit the coastal survey has been downweighted by approximately 1/3 in order to keep its overall contribution to the fit the same as in previous years.

Experimenting with including the 2008 and 2009 coastal survey data resulted in many more mature fish in the model throughout the time period in order to have these available at to be surveyed in 2008 and 2009, and higher residuals to the other data. The model also produced a higher overall biomass as a result, and consequently slightly lower values for F. The alterations in the reasons for the changing signal from the coastal survey in recent years should be investigated inter-sessionally, and should be considered at the forthcoming benchmark workshop for *S.marinus*.

Assessment results using the Gadget model

The text table below compares the results from this year's Gadget model with the four previous years.

	Totalstock (3+) by 1 January 1990 (tons)	Mean weight in stock 1990 (kg)	SSB (15+) by 1 January 1990[1] (tons)	Totalstock (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

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 in 2009, with several minor changes. The improvement of the maturity at age data in the early part of the time series resulted in less mature biomass and more immature biomass (but unchanged total biomass) prior to 1995. It is likely that the new pattern is more realistic. The addition of the most recent data, and especially the extension of the coastal survey to 2007, has resulted in a slight increase in the abundance and biomass estimates throughout the time series. This increase is mostly in the mature biomass, and results from signals in the coastal survey. Furthermore the estimated recruitment is revised slightly upwards in prior to 2001 and downwards in more recent years is revised downwards. However, all of these changes are relatively minor, and the overall picture of the stock development remains unchanged from last year.

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 increasing, although estimated abundance for new year classes are highly uncertain.
- The estimated fishing mortality has declined since 1990 and increased again since 2005. The current mortality is estimated around 0.15 (Figure 7.8).
- 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 45,000 tonnes in 2009 (Figure 7.10, Table 7.8).
- The spawning stock biomass of *S. marinus* has decreased from a maximum of about 70 thousand tonnes in 1996 to approximately 32 thousand tonnes in 2009 (-54%, 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.
- The new treatment of the maturity data has improved the stability of the modelled historical maturity ogives.
- There is increasing uncertainty due to discrepancies in the signals from the different surveys, which needs further investigation

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. Year-classes recruit in 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.

The divergence in the signal in recent years between the two surveys employed here increases the uncertainty in assessing the state of this stock. Further investigation is required to reduce this uncertainty. However it should be noted that this uncertainty does not affect the overall conclusions of a continuing decline in biomass, and poor recent recruitment.

Sebastes marinus is currently on the Norwegian Redlist as a vulnerable (VU) species according to the criteria given by the International Union for Conservation of Nature (IUCN). The Royal Norwegian Ministry of Fisheries and Coastal Affairs asked ICES in 2009 to undertake an evaluation of the IUCN criteria used for redlisting marine fish species.

Redlisting is understood to mean a species (or stock) is at risk of extinction. This advice is relevant to Norway's domestic redlisting process. ICES convened two workshops in 2009. The first Workshop (WKPOOR1 (ICES, 2009a)) addressed methods for evaluating extinction risk, and outlined approaches that could support advice on how to avoid potential extinction. The second Workshop (WKPOOR2 (ICES, 2009b)) 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.

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. ACFM 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 (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 1,600 t, which is well below the current landings and those expected for 2010 of around 6,000 t.

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 measures 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.

7.8 Implementing the ICES Fmsy framework

It should be noted that the current fishery (F=0.15) is well above the suggested F_{pa} of 5% of the stock (Section 7.6). The initial 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 2010) 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 low bound (F_{01} 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 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), but recommends that this should be part of the intersessional work until next year's assessment and the proposed 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. 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). In the case of *S. marinus* preliminary estimations resulted in $F_{SPR50\%} = 0.08$ and $F_{SPR60\%} = 0.06$.

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 2005 and 2008 (ICES CM 2006/RMC:09. ICES 2010/xxx) 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. 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 intercalibrations among national and international readers should be conducted.

There is a lack of data to directly estimate the natural mortality (M) for *S. marinus*. The WG has applied a M=0.1, which has been considered suitable for a long lived species such as *S. marinus*. For *Sebastes marinus* in ICES sub-areas V and XIV the NWWG has set the natural mortality to 0.15 for the youngest age, decreasing gradually to 0.05 for age 5 and older. In the Pacific, e.g., Dorn (2002) presents an overview of the different natural mortalities used for different *Sebastes* species in that area. The WG decided not to change the long term practice of setting this to 0.1 until this has been better investigated, e.g., in connection with a benchmark assessment.

With the exception of a slight increase in the catchability of small individuals (less than 18-20 cm) in the trawl survey since 1993, there is no evidence of changes of catchability. However the WG will continue to monitor the catchability data, and retains the technical ability to implement varying catchability in the model if the evidence suggests it is needed.

The review group shares the view of the AFWG and stated that a benchmark assessment is needed for this stock (expected in 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.

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	55	68	1	20
2008	274	63	30	49	27	-	2
2009[1]	70	4	58	27	13	-	1

Year	Norway	Portugal	Russia[3]	Spain	UK (Eng. & Wales)	UK (Scotl)	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[4]	14,461
2001	9,134	7	963	1		119[4]	10,547
2002	8,561	34	832	3		46[4]	9,643
2003	6,853	6	479	-		134[4]	7,840
2004	6,233	5	722	3		69[4]	7,206
2005	6,085[1]	56	614	8		52[4]	7,037
2006	6,265[1]	69	713	9		39[4]	7,348
2007	5,759[1]	225	890	5		55[4]	7,306
2008	5,202	72	749	4		85	6,557
2009[1]	5,383	30	698	-		9	6,293

[1] Provisional figures.

[2] Includes former GDR prior to 1991.

[3] USSR prior to 1991.

4UK(E&W)+UK(Scot.)

Table 7.2 *Sebastes marinus*. Nominal catch (t) by countries in Sub-area I.

Year	Faroe Islands	Germany[4]	Greenland	Iceland	Norway	Russia[5]	UK(Eng&Wales)	UK(Scotl)	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[6]	2,159
2001	4	11[2]	-	-	1,053	128	France	16[6]	1,212
2002	15	5[2]	-	-	693	220	1[2]	9[2,6]	943
2003	15[2]	-	1	-	815	140	-	4[6]	975
2004	7	-	-	-	1,237	213	-	12[6]	1,469
2005	10	-	-	-	1,002[1]	61	1	4[6]	1,078
2006	46	-	-	-	685	136	-	-	867
2007	15	12	Spain- 2	-	1,029	49	-	20[6]	1,127
2008	45	2	Portug- 3	Ltu-	632	49	7	15	754
2009[1]	-	3[2]	13	-	678	19	-	-	713

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 UK(E&W)+UK(Scot.)

7 Split on species according to reports to Russian authorities.

Table 7.3 ***Sebastes marinus*****. Nominal catch (t) by countries in Division IIa.**

Year	Faroe Islands	France	Germany[4]	Greenland	Ireland	Netherlands	Norway	Portugal	Russia[5]	Spain	UK (Eng. & Wales)	UK (Scotl.)	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]	30[2]	58[2]	5,500
2005	37[2]	9[2]	60[2]	36[2]	-	48	4,855[1]	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]	55[2]	1[2]	20[2]	4,101[1]	70	599	3[2]	68	35[2]	5,142
2008	229[2]	56[2]	28[2]	49[2]	-	2[2]	4,444	68[2]	450	4[2]	27[2]	70[2]	5,426
2009[1]	70[2]	4[2]	55[2]	27[2]	-	1[2]	4,504	17[2]	500	-	13[2]	9[2]	5,200

[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]UK(E&W)+UK(Scot.)

Table 7.4 *Sebastes marinus*. Nominal catch (t) by countries in Division IIb.

Year	Faroe Islands	Germany[5]	Greenland	Norway	Portugal	Russia[6]	Spain	UK(Eng. & Wales)	UK (Scotl.)	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, 7]	549
2003	-	-	-	68	-	75	-	-	-	143
2004	-	-	-	124	-	113	-	-	-	237
2005	-	13[2]	-	228[1]	-	288	-	-	-	529
2006	5[2]	-	-	1,211[1]	10[2]	284	-	-	-	1,510
2007	122	-	-	649	155	242	-	-	-	1,057
2008	-	-	-	126	1[2]	250	-	-	-	377
2009[1]	-	-	-	200	-	179	-	-	-	379

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.
7UK(E&W)+UK(Scot.)

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
7	0	46	60	9	9	28	78	4	23	14	22	19	40	45	15	1	0
8	24	7	85	119	98	51	593	13	23	36	25	47	55	32	21	4	0
9	193	292	230	313	156	206	855	70	44	71	30	46	94	56	31	14	6
10	359	640	672	361	321	470	572	245	199	143	44	65	80	70	68	12	5
11	406	816	908	879	686	721	1006	902	347	414	204	198	165	245	138	49	16
12	1036	1930	1610	1234	1065	968	1230	958	482	686	359	277	173	204	306	139	18
13	1022	2096	2038	1638	1781	1512	1618	1782	1120	1199	705	504	393	201	448	265	110
14	1523	2030	2295	2134	2276	1736	1480	1409	1342	1943	1687	590	779	809	495	366	425
15	2353	1601	1783	1675	2172	1582	1612	2121	1674	1377	1338	677	741	549	523	361	266
16	1410	2725	1406	1614	1848	1045	1239	2203	1653	1274	1071	963	916	779	637	443	230
17	1655	2668	785	1390	1421	1277	1407	1715	1243	1196	937	1059	926	794	892	442	454
18	1678	1409	563	952	851	970	1558	753	568	388	481	787	743	747	616	538	310
19	745	617	670	679	804	1018	1019	483	119	313	367	436	376	496	510	547	591
20	716	733	593	439	608	846	394	458	183	99	146	169	210	332	396	479	549
21	534	514	419	560	511	443	197	132	154	104	84	183	189	310	225	281	386
22	528	256	368	334	205	764	459	230	112	117	51	108	129	188	322	223	229
23	576	177	250	490	334	486	174	224	135	113	18	79	111	165	170	144	236
+gp	3482	1508	3232	3135	2131	3389	2131	895	254	253	69	186	220	397	630	1032	696
TOTALNUM	**18240**	**20065**	**17967**	**17955**	**17277**	**17512**	**17622**	**14597**	**9675**	**9740**	**7637**	**6390**	**6338**	**6419**	**6443**	**5342**	**4526**
TONSLAND	**16651**	**18120**	**15616**	**18043**	**17511**	**19155**	**18986**	**14460**	**10547**	**9643**	**7841**	**7320**	**7037**	**7,348**	**7306**	**6557**	**6292**

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
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	0.28
9	0.31	0.36	0.36	0.28	0.33	0.55	0.33
10	0.39	0.45	0.45	0.41	0.39	0.57	0.57
11	0.49	0.51	0.52	0.51	0.50	0.52	0.57
12	0.58	0.59	0.58	0.58	0.59	0.58	0.59
13	0.69	0.68	0.68	0.66	0.65	0.65	0.76
14	0.84	0.80	0.82	0.74	0.77	0.81	0.86
15	0.96	0.96	0.94	0.83	0.90	0.90	0.95
16	1.05	1.07	1.03	1.00	1.00	1.07	1.07
17	1.29	1.22	1.16	1.14	1.09	1.14	1.20
18	1.36	1.34	1.36	1.27	1.27	1.36	1.34
19	1.65	1.57	1.46	1.39	1.42	1.51	1.43
20	1.74	1.67	1.51	1.46	1.32	1.81	1.61
21	2.09	1.75	1.67	1.37	1.53	1.99	1.67
22	1.85	2.09	1.91	1.47	1.47	2.01	1.93
23	2.30	1.90	2.23	1.64	1.69	2.26	1.91
+gp	2.38	2.04	2.27	2.03	1.81	1.93	1.60

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	0.000	0.001	0.001	0.001	0.001	0.000
7	0.004	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.002
8	0.036	0.010	0.008	0.008	0.008	0.007	0.008	0.007	0.008	0.009	0.007
9	0.067	0.049	0.021	0.020	0.021	0.017	0.020	0.019	0.022	0.022	0.017
10	0.091	0.076	0.067	0.041	0.042	0.035	0.040	0.039	0.044	0.045	0.036
11	0.120	0.096	0.091	0.096	0.071	0.059	0.068	0.066	0.074	0.077	0.061
12	0.154	0.119	0.109	0.120	0.135	0.088	0.100	0.098	0.110	0.114	0.092
13	0.191	0.144	0.128	0.137	0.157	0.139	0.134	0.131	0.147	0.154	0.123
14	0.232	0.170	0.147	0.154	0.173	0.155	0.186	0.161	0.182	0.190	0.153
15	0.276	0.197	0.167	0.171	0.190	0.167	0.200	0.204	0.212	0.223	0.179
16	0.320	0.225	0.186	0.187	0.205	0.179	0.211	0.215	0.250	0.250	0.201
17	0.365	0.252	0.205	0.203	0.220	0.189	0.221	0.224	0.260	0.282	0.218
18	0.387	0.279	0.223	0.218	0.233	0.199	0.231	0.231	0.267	0.289	0.238
19	0.408	0.292	0.240	0.232	0.245	0.208	0.239	0.238	0.274	0.295	0.242
20	0.428	0.304	0.248	0.244	0.257	0.216	0.246	0.244	0.279	0.301	0.246
21	0.447	0.315	0.256	0.250	0.266	0.222	0.253	0.250	0.284	0.305	0.249
22	0.464	0.326	0.263	0.255	0.271	0.228	0.258	0.254	0.288	0.309	0.251
23	0.478	0.335	0.269	0.260	0.275	0.231	0.263	0.258	0.292	0.312	0.253
24	0.491	0.343	0.274	0.264	0.278	0.233	0.265	0.261	0.295	0.314	0.255
25	0.502	0.350	0.279	0.268	0.282	0.235	0.266	0.262	0.297	0.317	0.256
26	0.510	0.356	0.283	0.271	0.284	0.237	0.268	0.263	0.298	0.318	0.257
27	0.517	0.360	0.286	0.274	0.287	0.239	0.269	0.264	0.299	0.319	0.258
28	0.522	0.364	0.289	0.276	0.289	0.240	0.271	0.265	0.300	0.320	0.259
29	0.526	0.366	0.291	0.278	0.290	0.241	0.272	0.266	0.300	0.320	0.259
30	0.530	0.370	0.294	0.281	0.293	0.243	0.274	0.267	0.301	0.321	0.260

	2001	2002	2003	2004	2005	2006	2007	2008	2009
4	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
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002
8	0.005	0.005	0.004	0.004	0.004	0.005	0.006	0.005	0.006
9	0.013	0.012	0.010	0.010	0.011	0.013	0.014	0.014	0.015
10	0.026	0.025	0.021	0.021	0.022	0.026	0.028	0.028	0.030
11	0.045	0.043	0.036	0.035	0.037	0.044	0.048	0.048	0.052
12	0.068	0.064	0.054	0.053	0.055	0.064	0.071	0.071	0.079
13	0.092	0.086	0.072	0.071	0.073	0.085	0.094	0.095	0.106
14	0.114	0.106	0.089	0.087	0.090	0.103	0.115	0.117	0.132
15	0.134	0.123	0.104	0.101	0.103	0.118	0.132	0.136	0.154
16	0.151	0.137	0.116	0.112	0.114	0.130	0.146	0.151	0.171
17	0.164	0.148	0.125	0.120	0.122	0.139	0.156	0.162	0.184
18	0.173	0.157	0.132	0.126	0.128	0.145	0.163	0.170	0.194
19	0.184	0.163	0.137	0.131	0.132	0.150	0.168	0.175	0.200
20	0.186	0.169	0.141	0.134	0.135	0.153	0.172	0.179	0.204
21	0.188	0.170	0.144	0.136	0.137	0.155	0.174	0.181	0.207
22	0.190	0.171	0.145	0.138	0.138	0.156	0.175	0.183	0.209
23	0.191	0.172	0.146	0.139	0.140	0.157	0.176	0.184	0.210
24	0.192	0.173	0.146	0.139	0.140	0.158	0.177	0.185	0.211
25	0.193	0.174	0.147	0.139	0.140	0.159	0.178	0.185	0.212
26	0.194	0.174	0.147	0.140	0.141	0.159	0.178	0.186	0.212
27	0.194	0.175	0.147	0.140	0.141	0.159	0.178	0.186	0.212
28	0.195	0.175	0.147	0.140	0.141	0.159	0.178	0.186	0.213
29	0.195	0.175	0.148	0.140	0.141	0.159	0.178	0.186	0.213
30	0.195	0.176	0.148	0.141	0.141	0.159	0.179	0.186	0.213

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.**

	redfish			mature			immature			recruit
year	Number (millions)	meanweight (kg)	Biomass (1000't)	Number (millions)	meanweight (kg)	Biomass (1000't)	Number (millions)	meanweight (kg)	Biomass (1000't)	Number (1000')
1986	529	0.33	175	114	0.79	90	415	0.20	85	87,615
1987	521	0.32	167	106	0.79	84	414	0.20	83	67,297
1988	499	0.33	163	98	0.77	76	401	0.22	87	51,250
1989	475	0.33	158	90	0.74	67	384	0.24	91	46,525
1990	455	0.33	152	84	0.71	60	371	0.25	93	50,955
1991	443	0.34	152	84	0.70	59	359	0.26	93	50,237
1992	424	0.36	153	86	0.71	61	338	0.27	92	39,665
1993	402	0.38	154	88	0.73	64	314	0.29	90	34,803
1994	372	0.41	152	89	0.75	66	284	0.30	85	26,154
1995	338	0.44	148	89	0.77	68	249	0.32	80	17,587
1996	300	0.48	144	88	0.80	70	213	0.35	74	10,965
1997	265	0.52	137	85	0.83	70	180	0.37	67	10,412
1998	229	0.56	127	81	0.85	68	149	0.40	59	5,977
1999	193	0.59	115	74	0.87	64	119	0.42	51	3,957
2000	163	0.64	104	68	0.90	61	95	0.45	43	2,709
2001	136	0.68	93	62	0.92	57	74	0.48	36	2,361
2002	118	0.74	87	59	0.97	57	59	0.50	30	2,883
2003	102	0.79	80	55	1.01	56	46	0.52	24	2,378
2004	105	0.70	73	51	1.06	54	54	0.36	19	19,477
2005	90	0.75	67	47	1.11	52	43	0.36	15	500
2006	103	0.59	61	42	1.15	48	61	0.21	13	27,185
2007	91	0.59	54	37	1.18	43	55	0.20	11	4,087
2008	78	0.62	48	32	1.20	38	47	0.22	10	500
2009	66	0.64	43	27	1.21	32	39	0.26	10	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

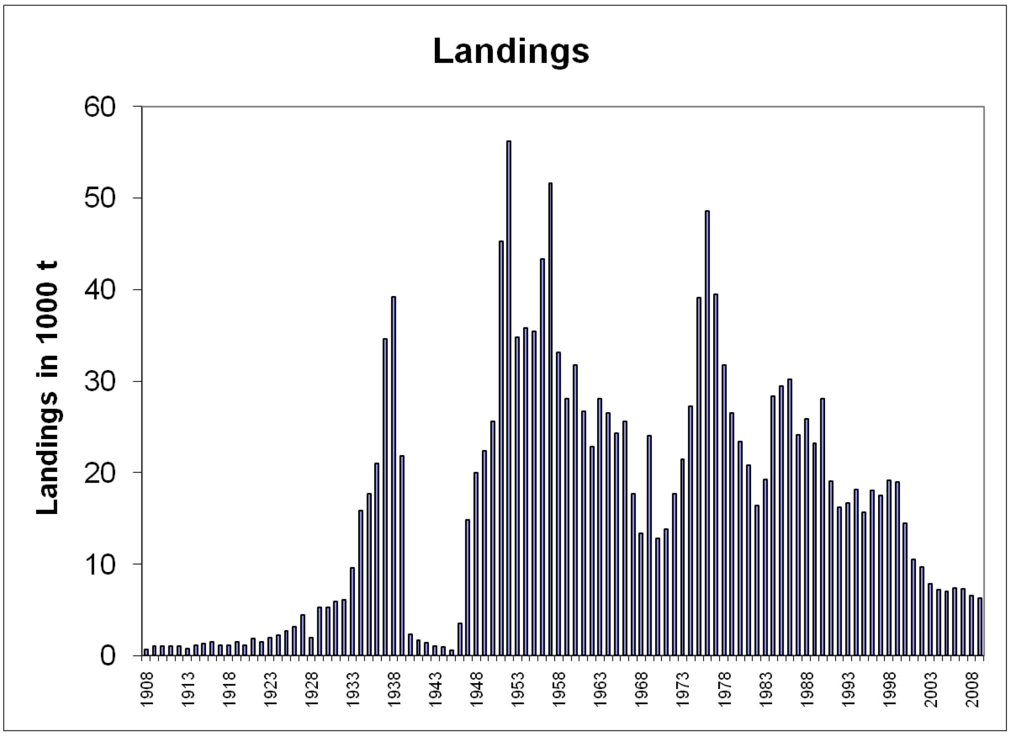


Figure 7.1. ***Sebastes marinus*** **in Sub-areas I and II. Total international landings 1965-2009 (in thousand tonnes)**

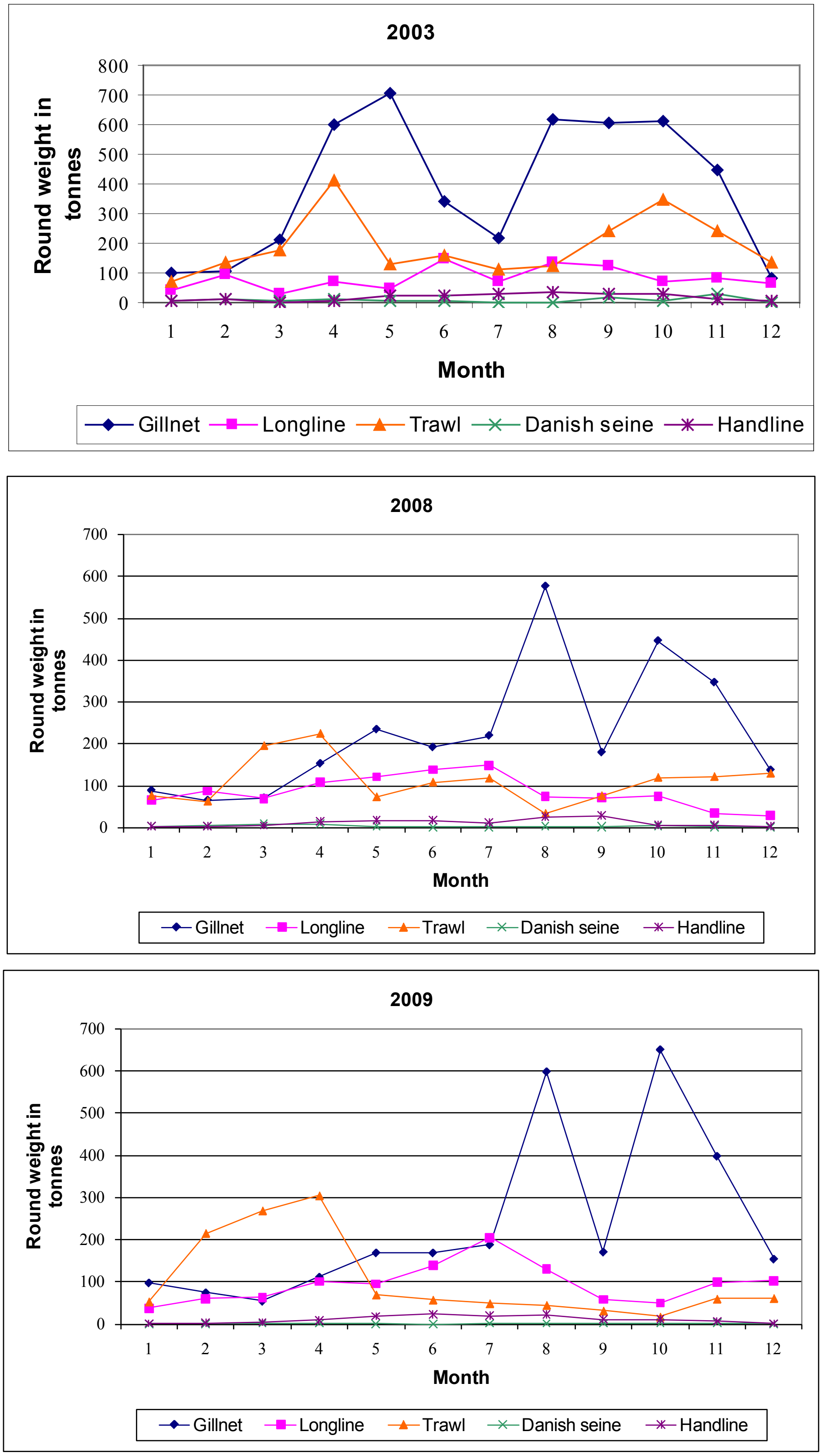


Figure 7.2a. Illustration of the seasonality in the different Norwegian *S. marinus* fisheries in 2003, 2008 and 2009, also illustrating how the current regulations are working.

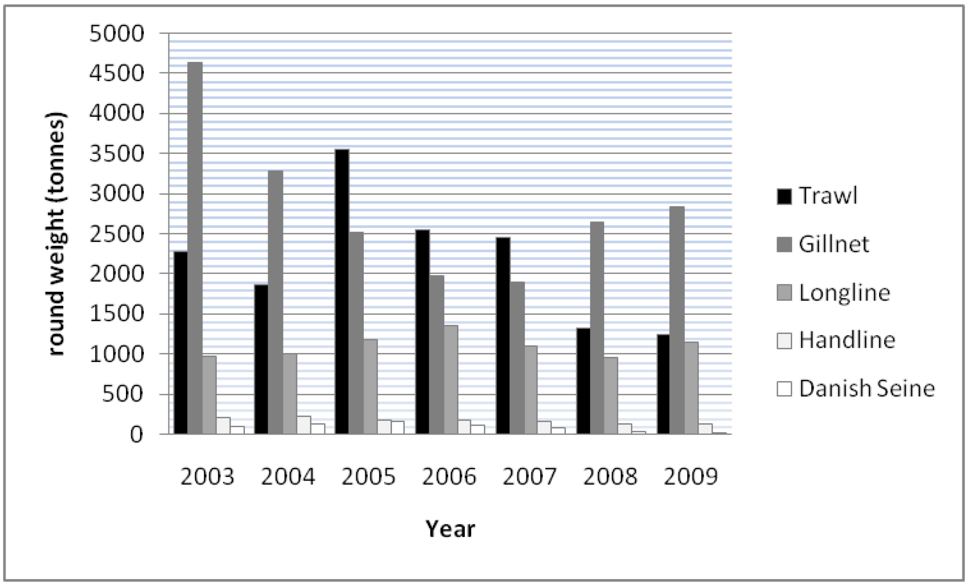


Figure 7.2b. Inter annual changes in the catches reported by different Norwegian *S. marinus* fisheries (2003-2009).

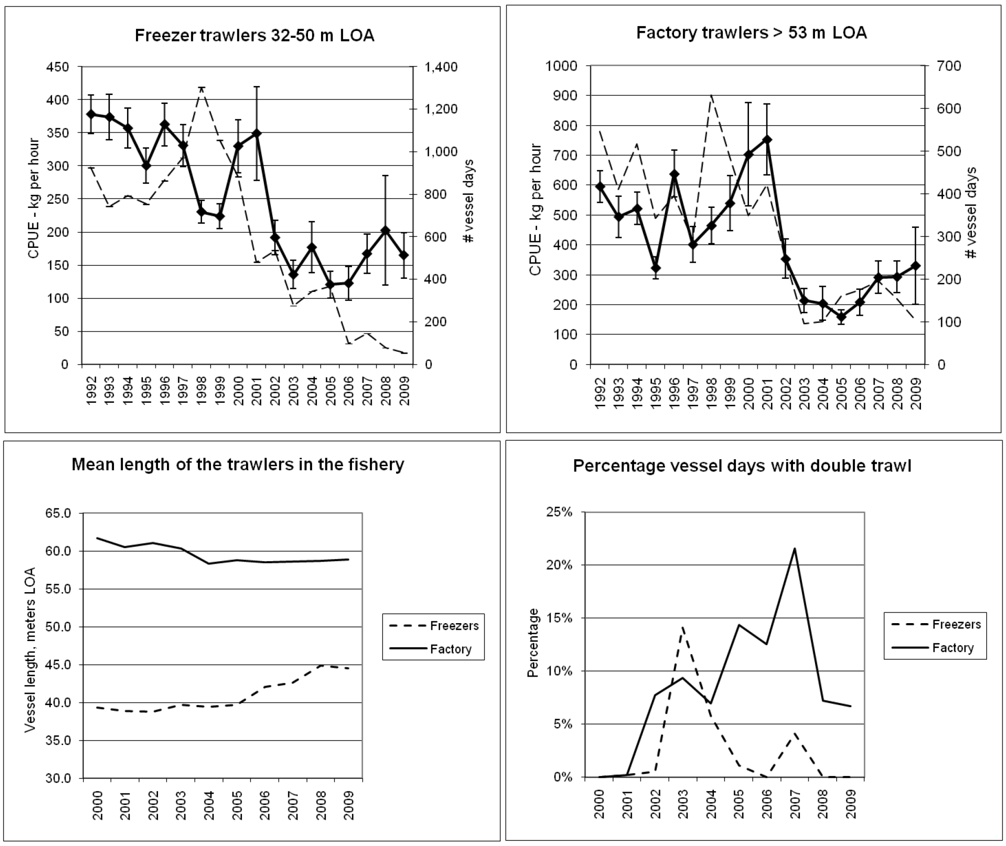
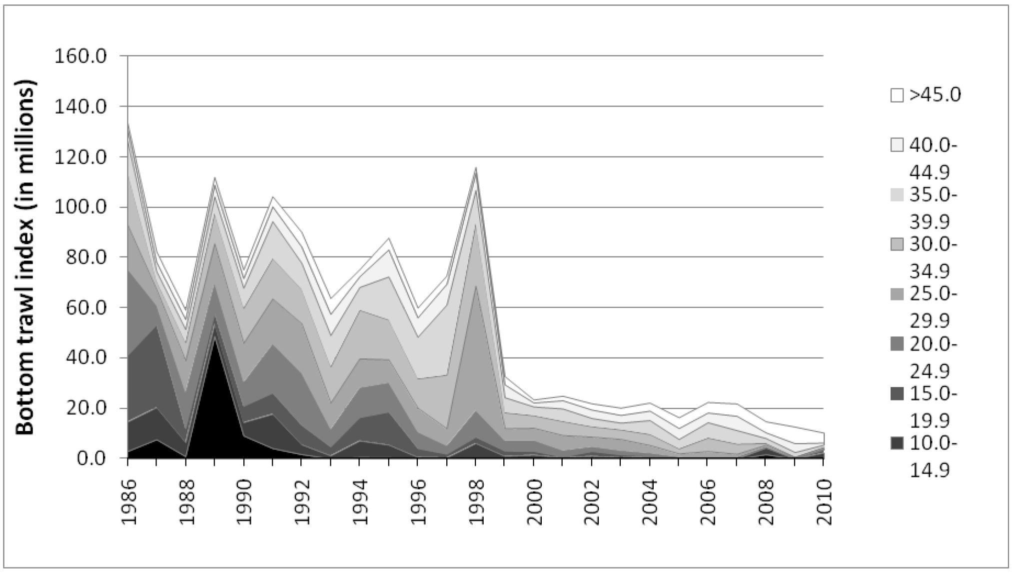


Figure 7.3. ***Sebastes marinus*****. Plot of simple mean CPUEs with 2 st. errors from the Norwegian trawl fishery, and numbers of vessel days (stippled curve) meeting the criterium of minimum 10%** ***S. marinus*** **in the catch per day. Upper panel shows data from the logbooks of freezer trawlers (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 D11.**



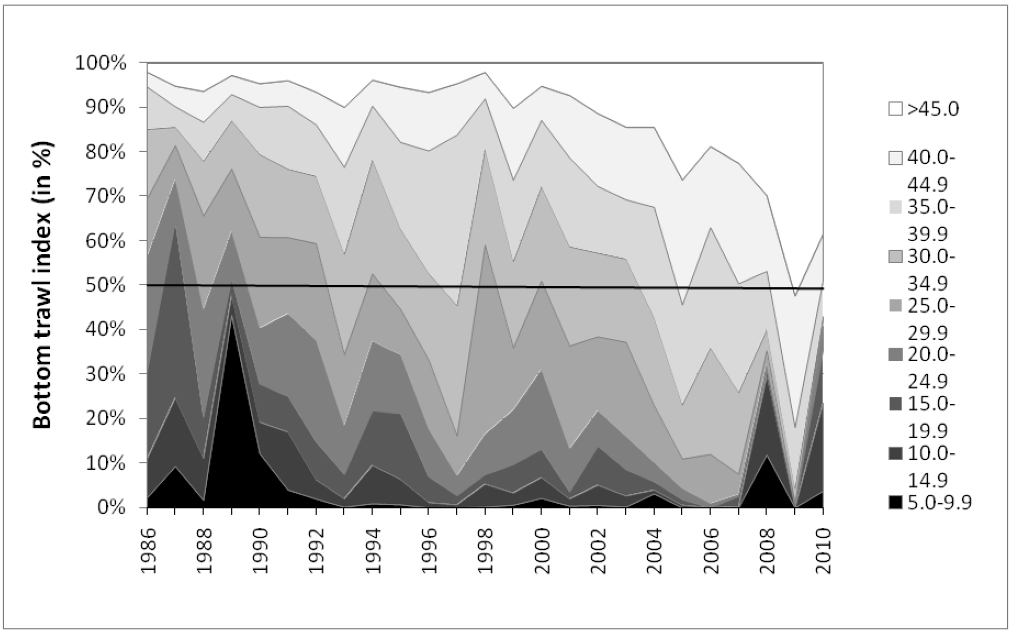
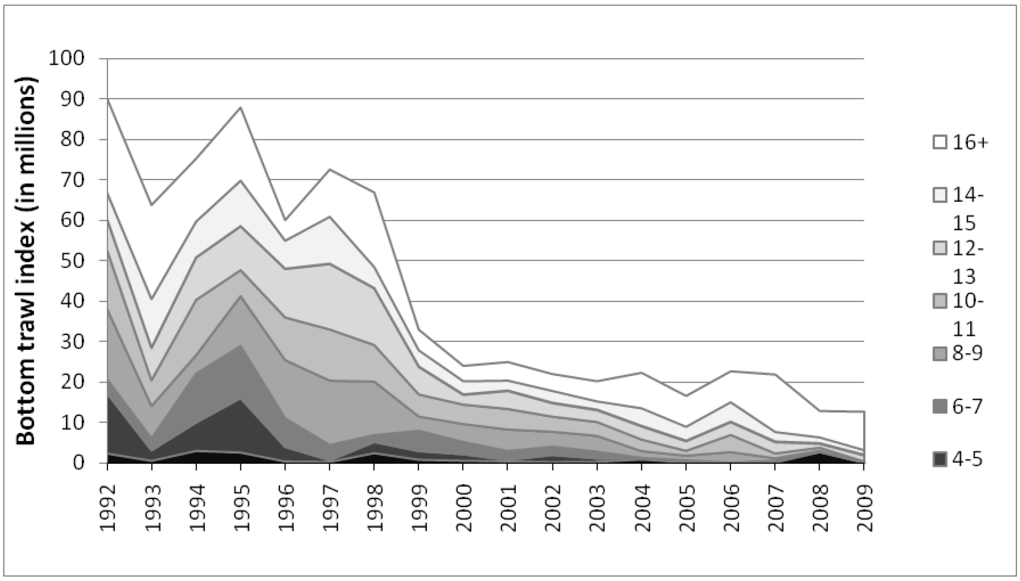


Figure 7.4a. ***Sebastes marinus*. Abundance indices disaggregated by length for the Norwegian bottom trawl survey in the Barents Sea in winter 1986-2010 (ref. Table D12a). Top: absolute index values, bottom: relative frequencies. Horizontal lines indicates the median length in the surveyed population.**



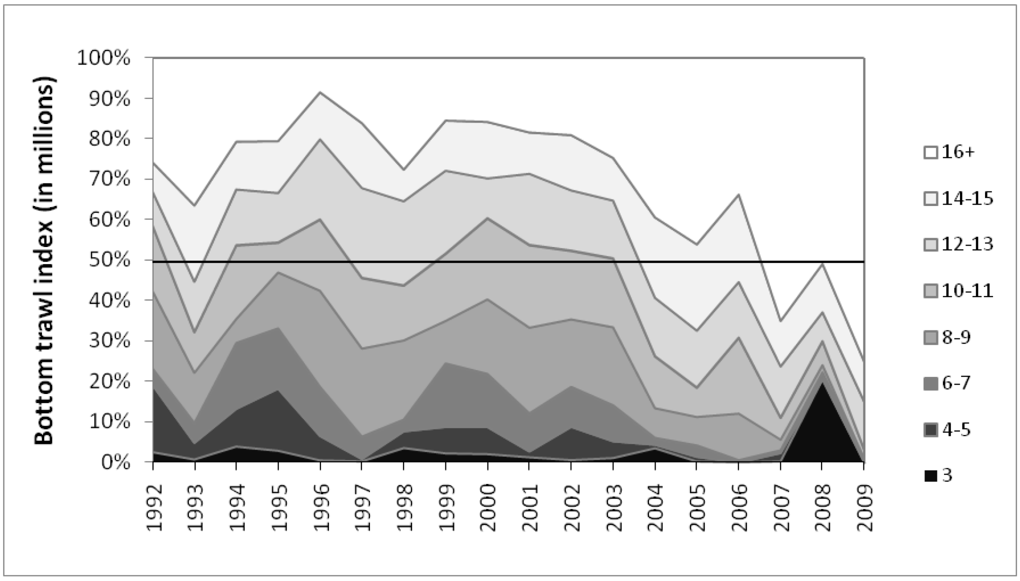
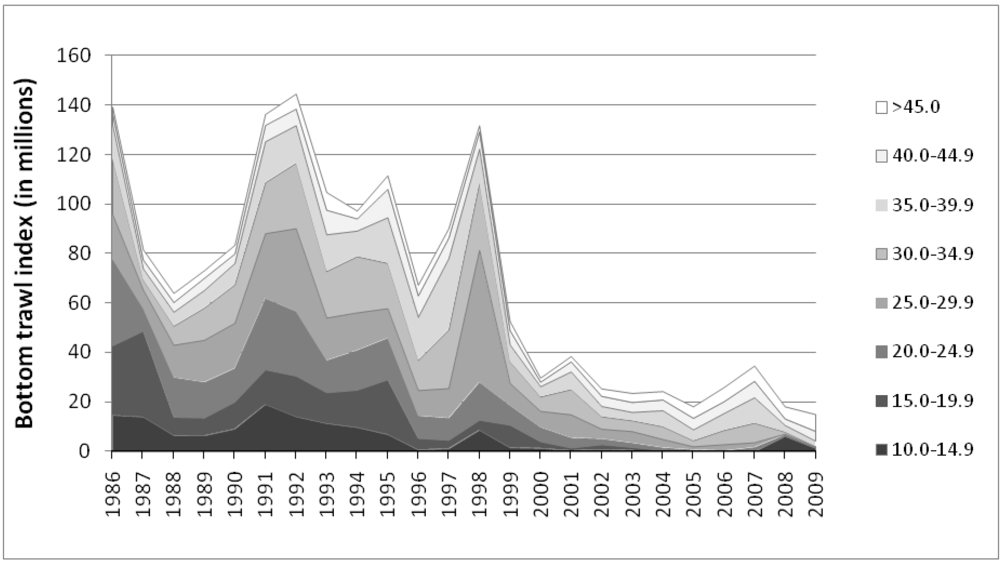


Figure 7.4b. ***Sebastes marinus*****. Abundance indices (by age) from the Norwegian bottom trawl surveys 1992-2009 in the Barents Sea (ref. Table D12b). Top: absolute index, bottom: relative frequencies. Horizontal line indicates the median age of the surveyed population.**



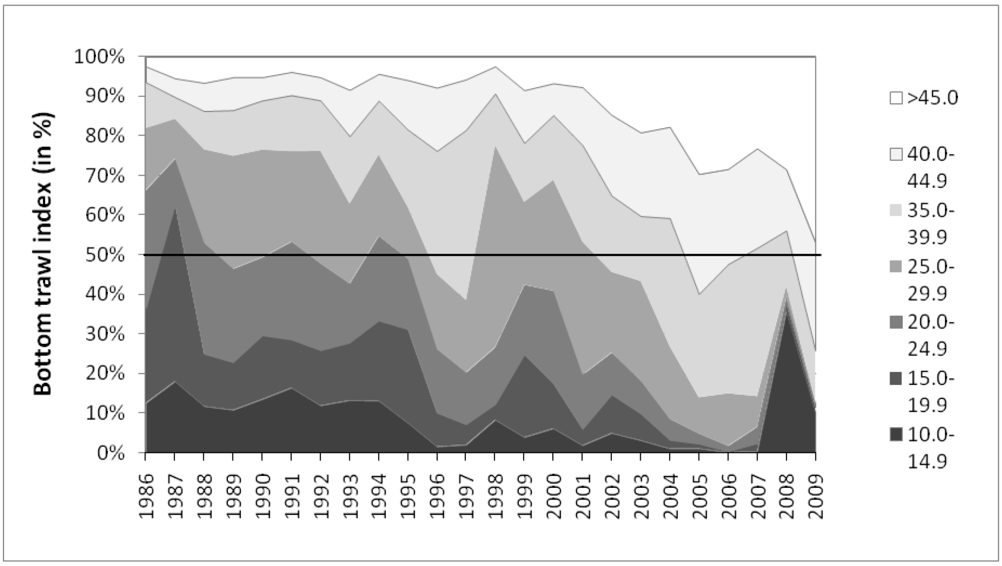


Figure 7.5a. ***Sebastes marinus*. Abundance indices disaggregated by length when combining the Norwegian bottom trawl surveys 1986-2008 in the Barents Sea (winter) and at Svalbard (summer/fall). Top: absolute index values. Bottom: relative frequencies. Horizontal line indicates the median length in the surveyed population.**

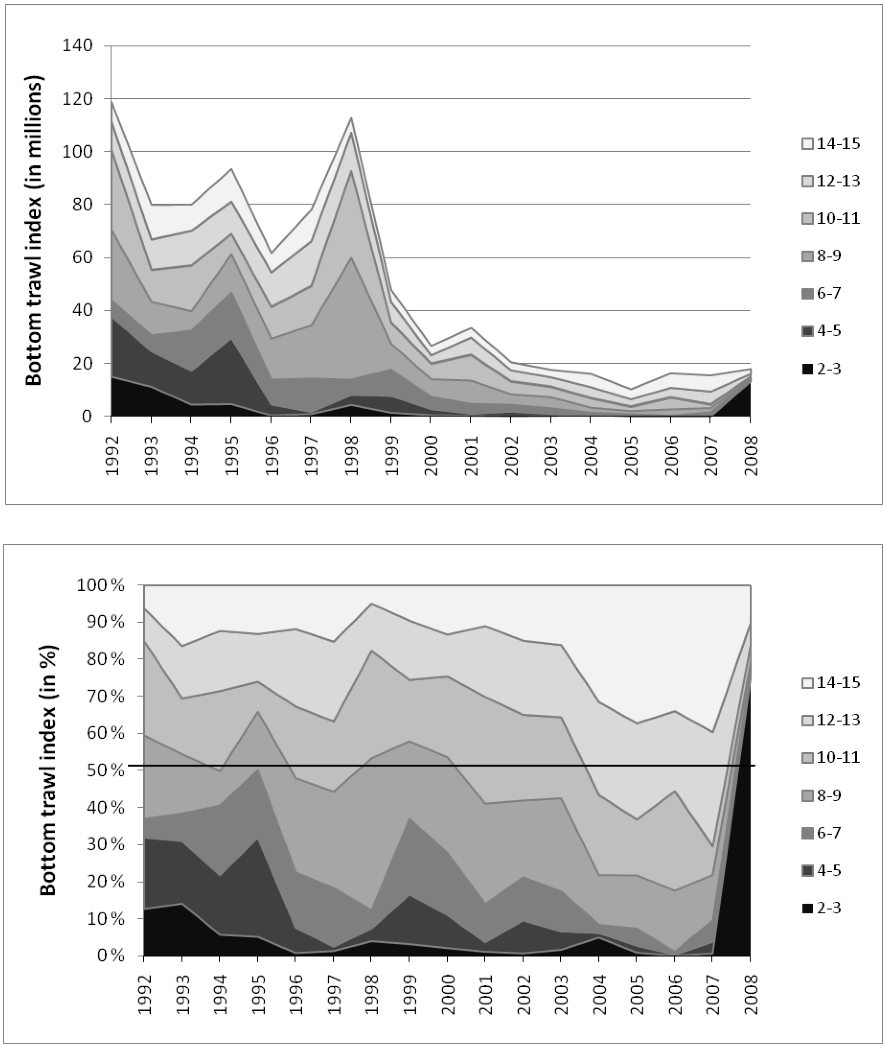


Figure 7.5b. ***Sebastes marinus*****. Abundance indices disaggregated by age. Combined Norwegian bottom trawl surveys 1992-2008 in the Barents Sea (winter) and Svalbard survey (summer/fall). Top: absolute index values, bottom: relative frequencies. Horizontal line indicates median age of the surveyed population.**

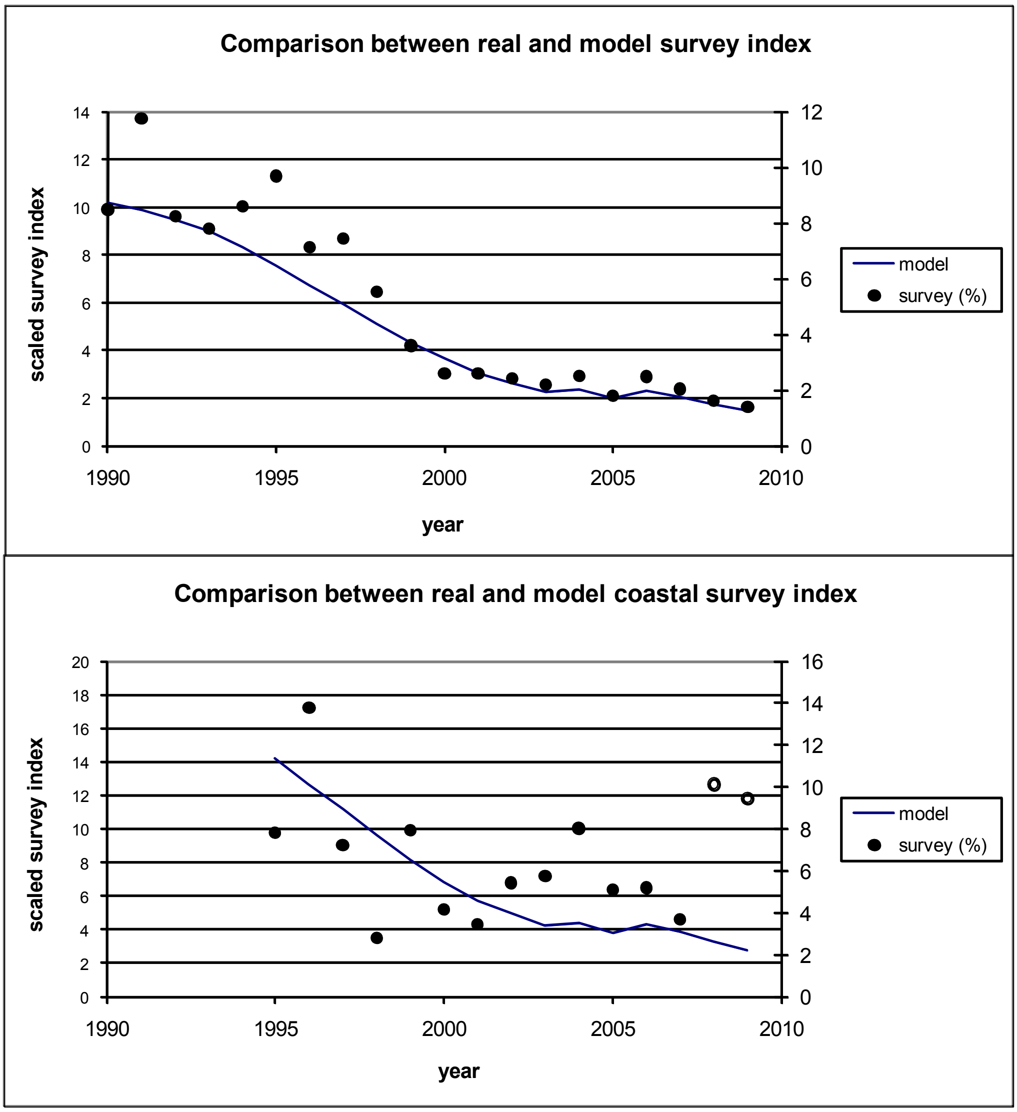


Figure 7.6. Sebastes marinus in Sub-areas I and II. Results from the Gadget assessment using two scientific surveys as input. The Figure shows comparison of observed and modelled survey indices (total number scaled to sum=100 during the time period) – the traditional Barents Sea February survey (top), and the coastal and fjord survey (bottom). Dots: survey indices. Plain lines: survey indices estimated by the model. Note that the 2008 and 2009 years in the coastal survey (hollow circles) have been excluded from the model tuning and the scaling.

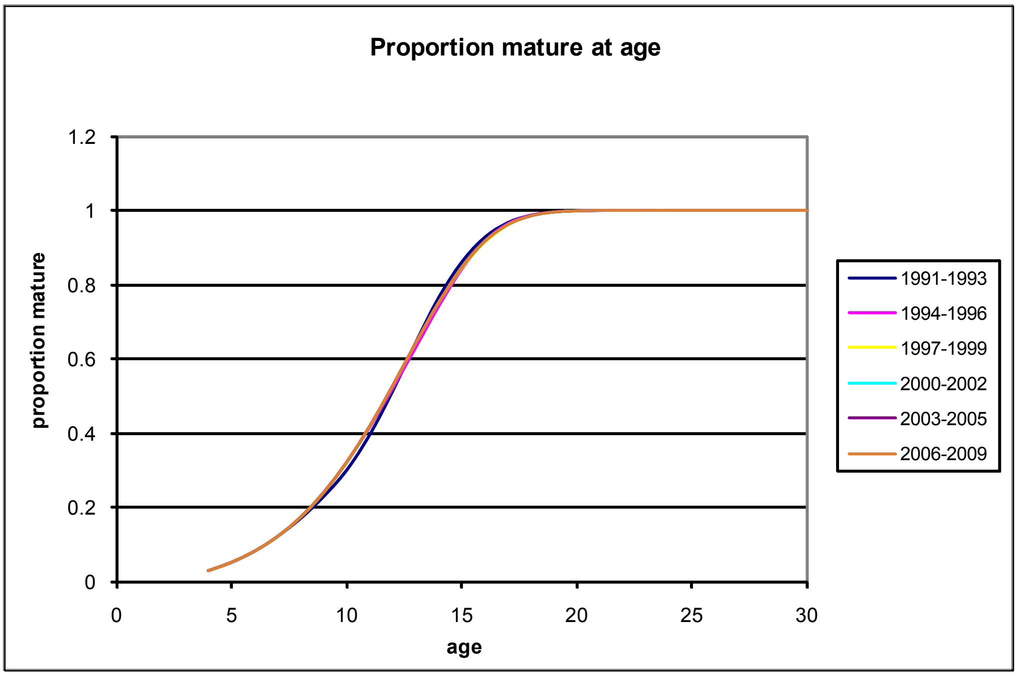


Figure 7.7. *Sebastes marinus* in Sub-areas I and II. Estimates of maturity at age by Gadget. Input data have been proportions of *S. marinus* mature both at age and length as collected and classified from Norwegian commercial landings and surveys.

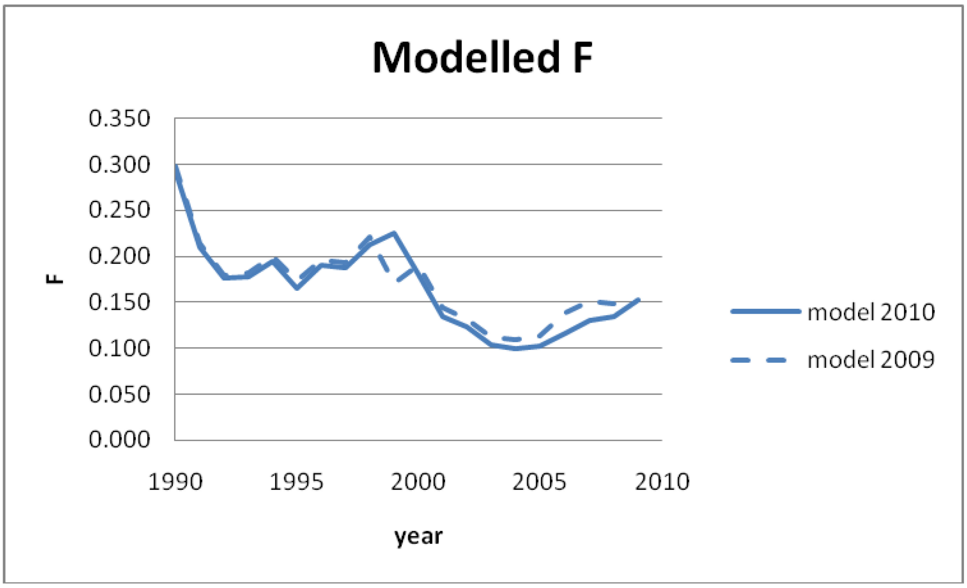


Figure 7.8. *Sebastes marinus* in sub-areas I & II. Unweighted average fishing mortality of ages 12-19 as estimated by Gadget in 2010 (solid line) and in 2009 (dashed line).

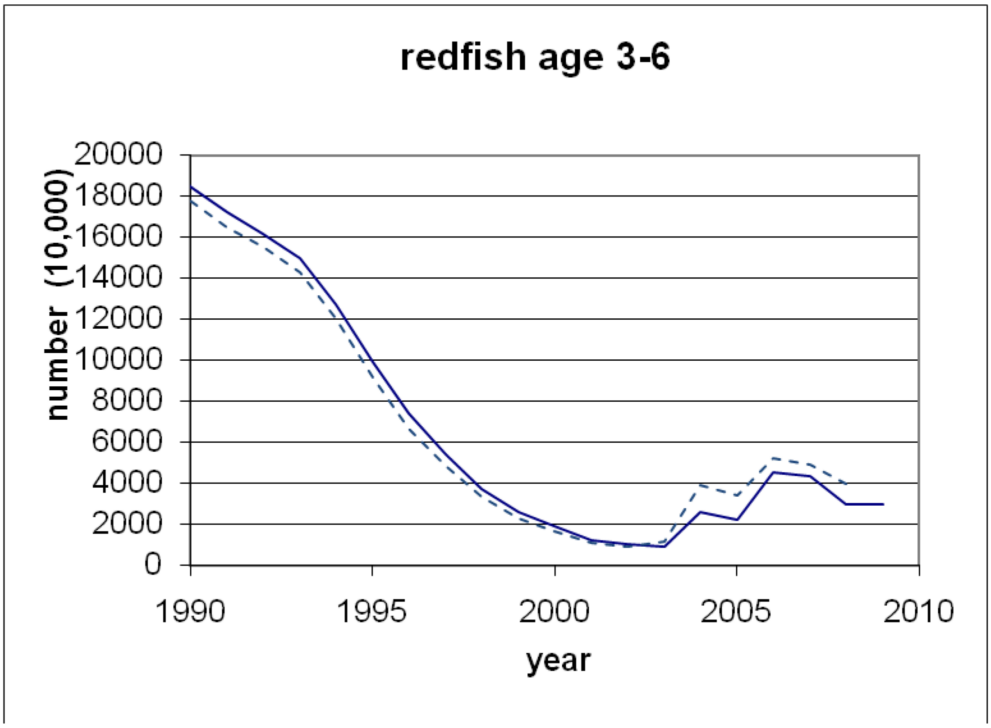


Figure 7.9. ***Sebastes marinus*** **in Sub-areas I and II. Estimates of abundance at age 3-6 by Gadget using two surveys as input. Gadget output provide at the 2009 AFWG are shown as dotted line. Current results are shown as plain lines.**

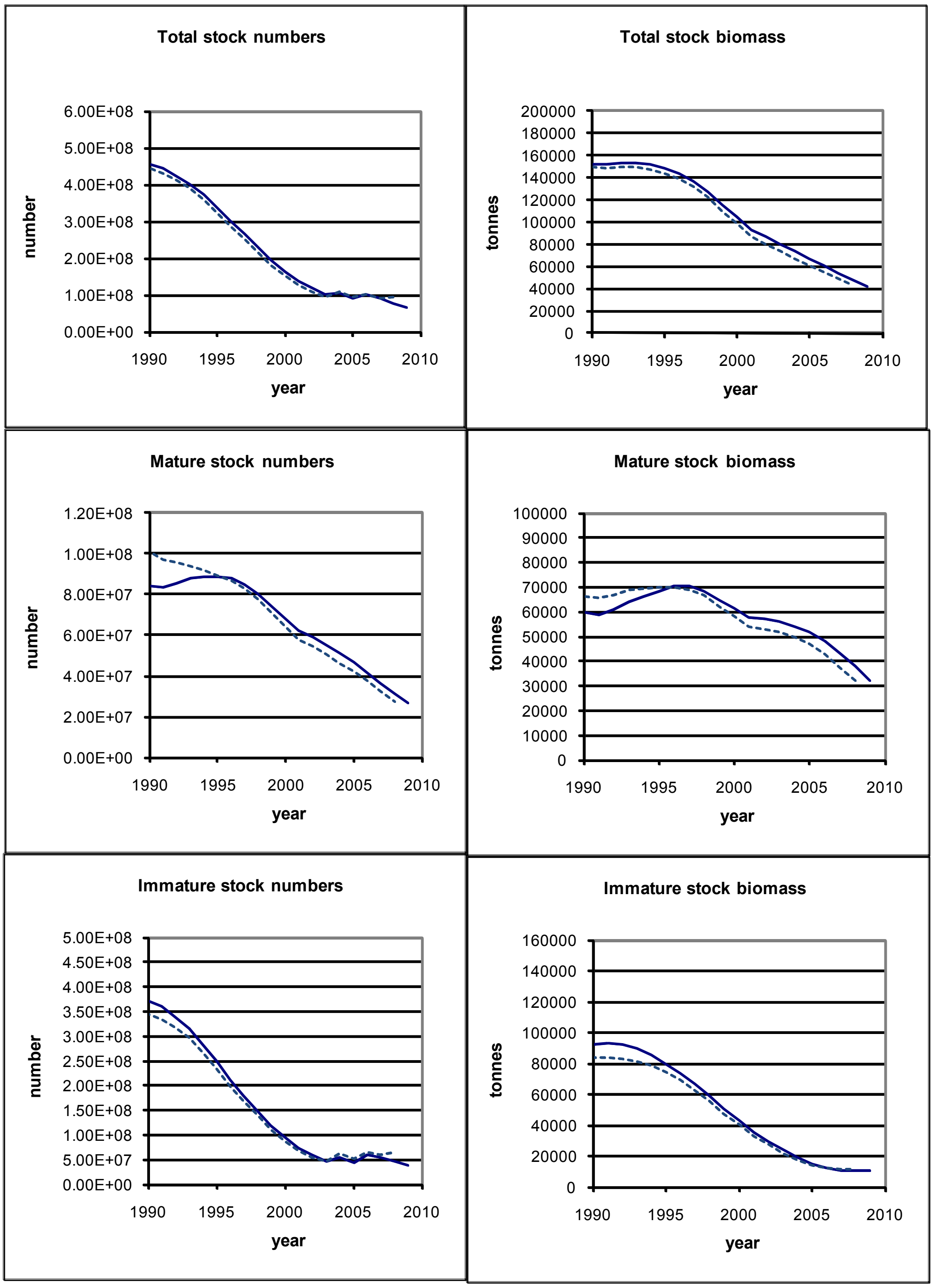


Figure 7.10. *Sebastes marinus* in Sub-areas I and II. Stock numbers (in thousands) and biomass (in tonnes) for the total stock (3+) (upper panel), and the fishable and mature stock (middle panel), and the immature stock (lower panel), as estimated by Gadget using two surveys as input. Gadget output provided at the 2009 AFWG are shown as dotted line. Current results are shown as plain lines.

Table D11. *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[2]	55	165	34.4	104	331	129.2

[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 D12a. 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 1986-2009 (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

1 - Adjusted indices to account for not covering the Russian EEZ in Subarea I

Table D12b. ***Sebastes marinus*** **in Sub-areas I and II. Norwegian bottom trawl indices - on age - from the annual Barents Sea survey in February 1992-2008 (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

[1] 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 D12a.

Table D13a. ***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 1985-2008 (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

1 - Old trawl equipment (bobbins gear and 80 meter sweep length)

Table D13b. ***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).**

	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 D14. ***Sebastes marinus*** **in Sub-area I and II. Mean catch rates (N/nm2) of** ***Sebastes marinus*** **from Norwegian Coastal Surveys (Division IIa) in 1995-2009 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	To-tal.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

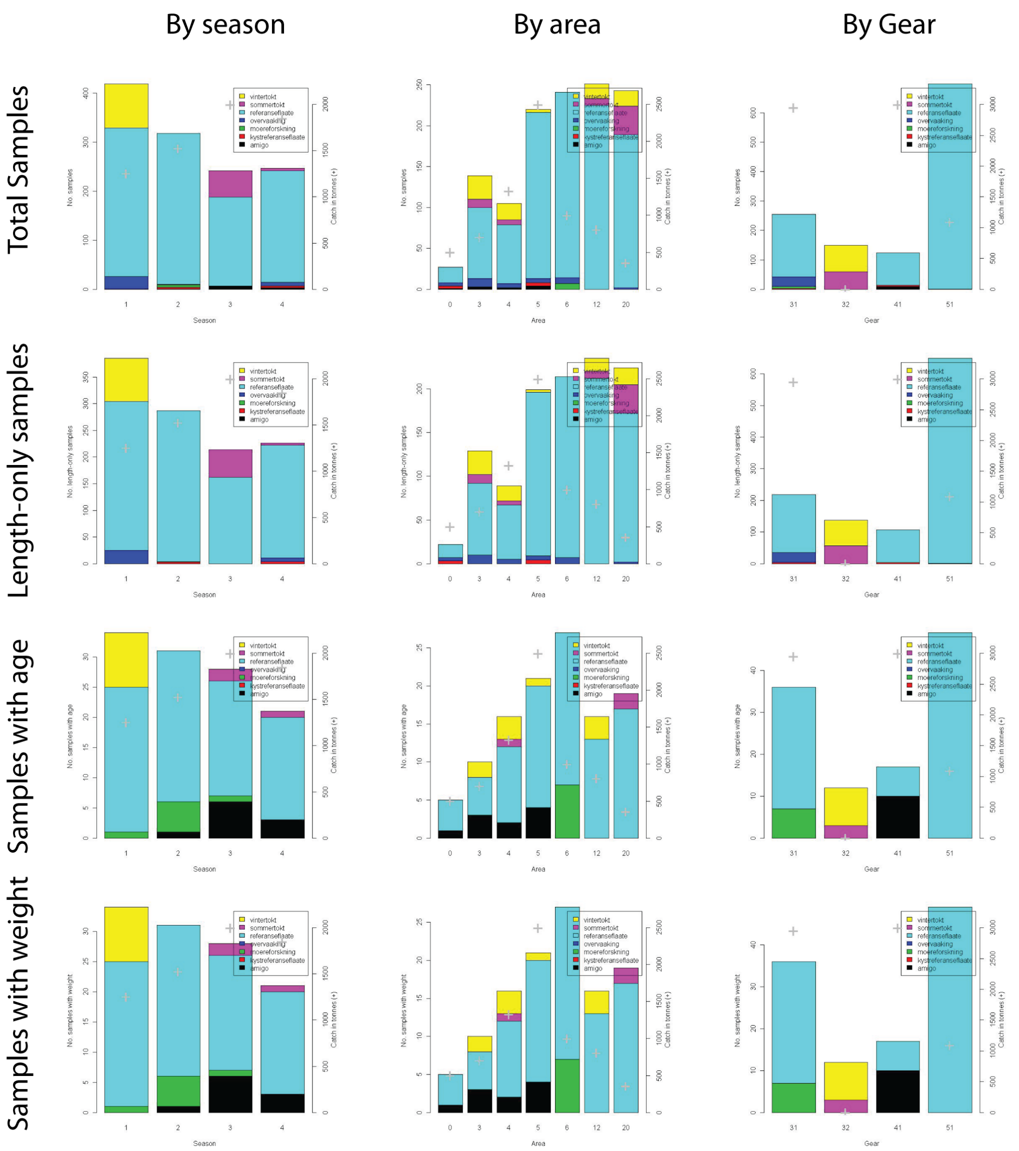


Figure D 1. Overview of the Norwegian biological samples from the commercial fisheries for *S. marinus* in 2008 representing more than 80% of the catches and which the input data to the Gadget model are based upon. The colours denote which sampling platform has been used: port sampling (black), Reference fleet (light blue), inspectors/observers (dark blue, green), winter (yellow) and summer (pink) scientific surveys. 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 are continued, but we 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 2010 (Tables 8.1 – 8.5, E10)

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 2009 is 12,207 t. This is about 6% less than the projected catch for 2009 estimated by the Working Group during its 2009 meeting (13,000 t). It is also the lowest catch since 1999. The difference between projected catch and preliminary estimate of total catch for 2009 is mainly due to Russian landings being lower than projected.

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 2009 it was 134 t taken mostly by UK (Table E10). 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 2007-2009 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 2009 and 2010

The advice from ICES for 2009 was as follows:

Exploitation boundaries in relation to precautionary limits: 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 for 2008 should be below 13 000 t as advised since 2003; this is the level below which SSB has increased in the past.

Exploitation boundaries in relation to high long-term yield, low risk of depletion of production potential and considering ecosystem effects: *There is no estimate of high-yield reference points.*

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Exploitation boundaries in relation to high long-term yield, low risk of depletion of production potential and considering ecosystem effects: *There is no estimate of high-yield reference points.*

8.1.3 Management applicable in 2009 and 2010

Target Greenland halibut fishery was forbidden since 1992 until 2009. Management of Greenland halibut is by bycatch regulations and a limited coastal Norwegian fishery using longline and gillnet. From 2001 the bycatch regulations in each haul was not to exceed 12% in each haul and 7% of the landed catch. From early 2004 the Norwegian Department of Fisheries 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 limited 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. This fishery is supposed to keep the total catch at a level which these vessels landed historically (ca. 2,500 t).

The 30th Session of the joint Russian-Norwegian Fisheries Commission (JRNFC) in 2001 stated that both the Russian and the Norwegian party could catch up to 1,500 t of Greenland halibut for research and surveillance purposes in 2002. This research quota was increased in the commission meeting the year after to 3,000 t for each party, and stayed at this level until 2005. The JRNFC then increased the quota to 4,500 t for each party in 2006, and 4,900 t for each party in 2007. During the 36th Session of the JRNFC it was decided to decrease quotas for 2008 to 4,000 t for each party. The 37th JRNFC's Session kept the research quotas for 2009 at the same level.

The 38th JRNFC's Session in 2009 decided to cancel the ban against target Greenland halibut fishery and established the TAC at 15,000 t within next three years (2010-2012). The TAC was allocated between Norway, Russia and other countries with shares 51, 45 and 4% respectively.

8.1.4 Expected landings in 2010

Due to new regulation measures established in 2009 for 2010-1012, the total Greenland halibut catch in the Barents Sea and adjacent waters (ICES Subarea I and Divisions IIa and IIb) in 2010 is expected to be about 15,000 t. Discards 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 A14, E1–E8)

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 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 lower 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 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). 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 (Table E6) 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 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 E9) 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 change in age reading procedure.

The joint Russian-Norwegian research program on Greenland halibut had finished in 2009 and will eventually contribute by increasing the understanding of the occuring processes. One of the main objectives of the program was to clarify the migration dynamics of the stock, including vertical distribution and relations with Greenland halibut in other areas. The results may improve both biological sampling and the subsequent assessments. The project has developed a new age reading procedure which has been used in Norway since 2006. This will eventually end up in total revision of the input data to the assessment.

During the last ten years there was a slowly increasing trend in biomass estimates both from the Norwegian CPUE survey (ended in 2006), the Norwegian Combined Index and the Russian Index (Figure 8.4). However, the biomass indices of mature females from different surveys showed opposite trends in last years (Figure 8.5).

The Spanish bottom trawl survey from 1997 to 2008 (Table E7) showed an increase of Greenland halibut abundance and biomass in the Svalbard-Bear Island area from 2002 after three years with a declining trend.

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 2007-2009 indices were very low. It should be noted that the Ecosystem survey is not optimal for surveying 0-group Greenland halibut.

8.2.2 Commercial catch-per-unit-effort (Table 8.6 and E9)

The CPUE from the experimental fishery was found 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 1800 kg/h with the highest value in 2005 (Table E9). 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 indices jump up again. The Norwegian CPUE survey was terminated in 2006.

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. Age reading problems are addressed in the joint research program, and this will lead to revised age structure in the input data in the future. There are some uncertainties to when these revised age readings can be used in the assessment. It is of outmost importance that scientists that are engaged in age reading on Greenland halibut from all involved member states will participate in the ICES ageing workshop on Greenland halibut (WKARGH) in Vigo 14-17 February 2011. The workshop will be a milestone towards age reading method for this species that is accepted and agreed on.

In 2007-2010, Russian age-length keys were used on the total catch matrix and the Russian survey was the only tuning fleet being updated. The two Norwegian surveys were used as before as tuning series until 2005.

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 2008 were updated using revised catch figures. Catch-at-age data for 2006-2009 were available only from the Russian fisheries. The Russian age-lenght keys were used to allocate catches from the other countries by age groups. 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 5–10. Generally, fish older than age 10 comprise a very 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 2006-2009 (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 1984–2008, 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.

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 1992-2009 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 were used.

8.4 Recruitment indices (Tables A14, E1–E9)

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 2008 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. 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.

Until 1976 the female spawning stock 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 2005-2007 and increased again in 2009. 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 167,000 t in 2009. 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. After the reduction the fishing mortality has averaged around 0.25. 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, the lowest value estimated for the last 20 years. Due to the increased catch in 2004-2006 the fishing mortality again slightly raised (0.17-0.18) but remained lower than average. For the 2009 Fbar was estimated at 0.08 – the same as in 2008 which is lowest level in history. It was conditioned by stock growth and significant reducing of total catch.

Recruitment-at-age 5 in this year assessment shows the huge increase from 2007 to 2009. The 2009 level at 52 millions specimens occured twice higher than long-term average (table 8.15).

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 2011

Given the uncertainty around the absolute values of population size at age no catch options are provided.

8.7 Comparison of this years assessment with last years assessment

Compared to last year assessment stock size for 2008 has sharply increased while SSB has been little bit reduced, fishing mortality remained at nearly the same level.

	TOTAL STOCK (5+) BY 1 JANUARY 2009	SSB BY 1 JANUARY 2009	F6-10 IN 2009	F6-10 IN 2008
WG 2009	127097	42255	0.13*	0.09
WG 2010	160481	41526	0.08	0.08

*prediction

8.8 Comments to the assessment (Figures 8.3 – 8.6)

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 2008 and new data for 2009. 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.

The assessment is considered to be still uncertain due to the age-reading and survey 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 2004-2008 the SSB show a decreasing signal, whereas it has a significant increase in 2009. The estimate of the SSB is based on maturity ogives from the Russian survey. Other sources indicates no decreasing trend in the maturity of Greenland halibut in recent years. Biomass indices of mature females from the Norwegian survey in the slope area (main adult area) had opposite trends untill 2008, but showes increase in 2009 (Figure 8.5). However, estimates from the Russian December survey show decrease in mature female biomass between 2008 and 2009.

A WD was presented to the meeting where the XSA diagnostics were scrutinized (Hallfredsson WD 18). Based on this scrutiny XSA runs were conducted where canges were made in defination of plus group and the age from where catchability is considered constand in the analysis. The results showd that the current XSA is senistive to these changes regarding especially SSB estimates and to some extend the trends in SSB (figure 8.6). The sensitivity to these relatively minor modifications in model assumptions one more time confirms the nessesity of carefulness in settings selection and possible shortcomings in input data.

Also the presentation was distributed on a GIS based assessment for Greenland halibut (Bulatov and Moiseenko). According to them in 1998-2009 the average value of fishable biomass of Greenland halibut exceeded 347 thou. t. This method has been presented to AFWG previously for other stocks, e.g. NEA cod (AFWG report 2007) and some problems were identified:

- First, the use of catch rates from commercial fishing vessels to obtain swept area estimates representative for larger areas violates the condition that such measures of density have to be based on random samples. Obviously, fishing vessels do not fish at random, but use former experience and various fish-finding tools to seek up the densest concentrations before setting the trawls. Consequently, the catch rates obtained are only representative for the area covered by the trawl during the haul.
- Second, the method uses a constant trawl catchability factor for all length groups, trawl types, seasons etc., which is highly questionable.
- Third, a width of trawling equal to the wingspread of the trawl is used, not taking into consideration the herding effect of trawl wires, trawl doors, and sweeps.

The same problems are identified for the present analysis on Greenland halibut. The first point is a fundamental problem, which does not allow for this method to be used for absolute abundance estimation. Additionally one can question if data from the fisheries on trawl geometry and trawling distance, as required for the analysis, are sufficiently reliable for absolute abundance estimates. Consequently, this method has potential for use as an index of relative abundance that can be used as an additional tuning series for a VPA, but cannot be used as absolute abundance estimates.

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. The quite low catch in 2008 and 2009 will most likely lead to further growth of the both total and spawning stock size.

Average catch during the period 2004-2009 have consisted ca. 16,000 t.

8.9 Response to ACOM technical minutes

ACOM technical minutes are not commented on because the 2010 advice should be “same as previous year” and the report will not be reviewed. There were few technical comments and most of them relate to ageing, and cannot be solved until there is a consensus on age reading methods. A workshop on age reading of Greenland halibut will be held in February 2011.

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	Greenland	Iceland	Ireland	Lithuania	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[1]	0	170	0	32	8	0	0	0	0	13,011[3]	0[2]	23	4,883	660[2]	29	18	18,834
2006[1]	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	0	0	22	0	0	0	0	8,542[3]	204	27	3,335[2]	210	68	0	12,407

[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[1]	-	-	-	-	-	+	-	812[2]	-	-	633	-[2]	3	-	1,449
2005[1]	-	-	-	1	-	-	-	572[3]	-	-	595	-[2]	3	-	1,171
2006[1]	-	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]	-	-	-	-	-	-	-	739[3]	-	2	483[2]	-	-	-	1,224

[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[1]	-	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]	-	-	+	-	-	-	-	6,146[3]	-	9	1,531[2]	-	60	-	7,746

[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	Den-mark	Esto-nia	Faroe Isl.	France	Fed. Rep. Germ.	Ire-land	Lithua-nia	Norway	Po-land	Portu-gal	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[1]	-	-	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]	-	-	-	-	22[2]	-	-	1,657[3]	204	16	1,321[2]	210	8	-	3,437

[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	9618	119		15237
2008	901	3575	9285	9	8	13778
2009	1 409	4 952	5 994	34	18	12407

Table 8.6. GREENLAND HALIBUT in Sub-areas I and II. Catch per unit effort and total effort.

Year	USSR catch/hour trawling (t)		Norway[10] catch/hour trawling (t)		Average CPUE		Total effort (in '000 hrs trawling)[5]	CPUE 7+[6]	GDR[7] (catch/day tonnage (kg)
	RT[1]	PST[2]	A[8]	B[9]	A[3]	B[4]			
1965	0.80	-	-	-	0.80	-	-	-	-
1966	0.77	-	-	-	0.77	-	-	-	-
1967	0.70	-	-	-	0.70	-	-	-	-
1968	0.65	-	-	-	0.65	-	-	-	-
1969	0.53	-	-	-	0.53	-	-	-	-
1970	0.53	-	-	-	0.53	-	169	0.50	-
1971	0.46	-	-	-	0.46	-	172	0.43	-
1972	0.37	-	-	-	0.37	-	116	0.33	-
1973	0.37	-	0.34	-	0.36	-	83	0.36	-
1974	0.40	-	0.36	-	0.38	-	100	0.36	-
1975	0.39	0.51	0.38	-	0.39	0.45	99	0.37	-
1976	0.40	0.56	0.33	-	0.37	0.45	100	0.34	-
1977	0.27	0.41	0.33	-	0.30	0.37	96	0.26	-
1978	0.21	0.32	0.21	-	0.21	0.27	123	0.17	-
1979	0.23	0.35	0.28	-	0.26	0.32	67	0.19	-
1980	0.24	0.33	0.32	-	0.28	0.33	47	0.25	-
1981	0.30	0.36	0.36	-	0.33	0.36	42	0.28	-
1982	0.26	0.45	0.41	-	0.34	0.43	39	0.37	-
1983	0.26	0.40	0.35	-	0.31	0.38	58	0.32	-
1984	0.27	0.41	0.32	-	0.30	0.37	59	0.30	-
1985	0.28	0.52	0.37	-	0.33	0.45	44	0.37	-
1986	0.23	0.42	0.37	-	0.30	0.40	57	0.32	-
1987	0.25	0.50	0.35	-	0.30	0.43	44	0.35	-
1988	0.20	0.30	0.31	-	0.26	0.31	63	0.26	4.26
1989	0.20	0.30	0.26	-	0.23	0.28	73	0.19	2.95
1990	-	0.20	0.27	-	-	0.24	95	0.16	1.66
1991	-	-	0.24	-	-	-	134	0.18	-
1992	-	-	0.46	0.72	-	-	20	0.29	-
1993	-	-	0.79	1.22	-	-	15	0.65	-
1994	-	-	0.77	1.27	-	-	11	0.70	-
1995	-	-	1.03	1.48	-	-	-	-	-
1996	-	-	1.45	1.82	-	-	-	-	-
1997	0.71	-	1.23	1.60	-	-	-	-	-
1998	0.71	-	0.98	1.35	-	-	-	-	-
1999	0.84	-	0.82	1.77	-	-	-	-	-
2000	0.94	-	1.38	1.92	-	-	-	-	-
2001	0.82 [11]	-	1.18	1.57	-	-	-	-	-
2002	0.85	-	1.07	1.82	-	-	-	-	-
2003	0.97 [12]	-	0.86	2.45	-	-	-	-	-
2004	0.63 [13]	-	1.16	1.79	-	-	-	-	-
2005	0.61 [12]	-	1.30	2.29	-	-	-	-	-
2006	0.57 [12]	-	0.96	2.09	-	-	-	-	-
2007	0.64 [12]	-	-	-	-	-	-	-	-
2008	0.48 [12]	-	-	-	-	-	-	-	-
2009	0.77 [13]	-	-	-	-	-	-	-	-

[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: 2010/1)

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

YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE											
5	372	253	170	156	114	1064	526	80	1109	212	917
6	1480	853	563	332	283	2420	2792	4486	3521	1117	2519
7	2808	1735	1106	623	452	3208	10464	12712	9605	3923	6204
8	5674	3868	2715	2006	1976	6288	18562	12283	6438	3515	3838
9	4951	4203	4054	3237	3923	4921	10034	6130	2775	2551	1834
10	3981	3799	2499	2409	2950	4431	6671	4339	1734	1919	1942
11	1853	1799	1284	1718	2234	2381	2517	2703	1368	1536	1622
12	1018	1002	783	871	792	812	1250	1660	1234	1127	1338
13	364	372	246	315	146	229	616	1044	675	716	734
14	251	282	261	155	43	100	1104	300	200	251	531
+gp	76	50	28	19	7	30	281	143	80	126	216
0 TOTALNUM	22828	18216	13709	11841	12920	25884	54817	45880	28739	16993	21695
TONSLAND	40391	34751	26321	24267	26168	43789	89484	79034	43055	29938	37763
SOPCOF %	100	100	101	100	100	103	94	104	98	92	98

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

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
AGE											
5	840	830	2037	1897	2218	731	1896	1304	1543	915	1219
6	2337	2982	3255	3589	3155	1138	1917	1494	1864	3698	2874
7	6520	5824	4200	4118	2727	1665	1919	1276	1851	3350	2561
8	4118	5002	2524	2365	1234	1341	933	1208	2287	1938	1548
9	2265	3000	1610	1509	495	944	484	1493	1491	1064	972
10	1654	1350	1104	946	319	473	448	1258	1228	1191	1037
11	1857	915	1062	934	296	511	482	838	713	602	614
12	1536	1212	858	438	243	275	380	502	488	340	363
13	1122	698	595	349	103	242	384	324	247	171	161
14	600	526	384	147	45	145	150	108	201	132	120
+gp	368	358	180	112	51	78	62	46	64	71	63
0 TOTALNUM	23217	22697	17809	16404	10886	7543	9055	9851	11977	13472	11532
TONSLAND	38172	36074	28827	24617	17312	13284	15018	16789	22147	21883	19945
SOPCOF %	88	93	101	105	104	109	107	100	98	100	99

Table 8.7 (Continued)

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

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
AGE												
5	1672	1212	907	2080	2139	3312	1098	1140	631	846	1034	330
6	3335	2972	2540	4453	5163	3889	1195	1088	708	992	2083	921
7	2712	3572	3141	3655	4642	4716	1069	1608	1252	1719	3795	1822
8	1531	1746	2096	1657	1932	2355	778	1118	817	990	1426	953
9	1128	752	1182	801	1221	1031	360	140	310	405	262	342
10	997	828	860	318	499	1284	600	976	642	726	655	822
11	530	362	481	228	264	774	188	444	416	461	270	231
12	434	202	313	126	314	673	150	144	330	371	132	150
13	314	186	133	120	42	177	79	36	88	154	29	18
14	305	63	140	140	96	266	89	20	39	56	22	41
+gp	239	7	47	28	44	517	56	4	3	8	1	1
0 TOTALNUM	13197	11902	11840	13606	16356	18994	5662	6718	5236	6728	9709	5631
TONSLAND	22875	19112	19587	20138	23183	33320	8602	11933	9226	11734	14347	9410
SOPCOF %	98	101	100	103	102	105	95	102	99	101	101	99

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

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE												
5	359	433	380	441	277	397	290	429	548	987	449	959
6	1116	1905	735	1347	921	1025	1016	1072	1347	1598	751	1137
7	2466	3955	1926	2338	1475	1827	2316	1962	2067	2202	1231	1384
8	1464	1810	1464	1325	983	928	1392	1766	1584	1134	1277	1746
9	527	914	743	788	631	632	1087	936	1034	629	790	723
10	924	1905	1318	1140	1097	1045	778	991	691	436	314	255
11	237	380	457	519	563	520	675	616	485	426	365	514
12	122	237	330	372	301	311	607	622	548	464	412	325
13	15	67	49	115	132	77	199	376	466	246	341	300
14	29	42	37	54	59	107	155	244	209	169	207	96
+gp	15	7	14	12	42	26	105	328	230	224	247	115
0 TOTALNUM	7274	11655	7453	8451	6481	6895	8620	9342	9209	8515	6384	7554
TONSLAND	11893	19517	14437	16307	13161	13578	18800	18834	17897	15237	13778	12407
SOPCOF %	100	102	101	100	100	100	99	97	100	96	101	102

Table 8.8. Catch weights at age (kg)

Run title : NEA Greenland halibut (run: 2010/1)

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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
AGE		
5	0.695	0.567
6	0.919	0.802
7	1.359	1.071
8	1.756	1.471
9	2.231	1.928
10	2.378	2.216
11	2.855	2.63
12	3.23	3.082
13	3.546	3.791
14	3.915	4.528
+gp	7.453	7.069
0 SOPCOFAC	1.0086	1.0165

Table 8.9. Proportion mature at age

Run title : NEA Greenland halibut (run: 2010/1)

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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
AGE		
5	0	0
6	0.01	0.02
7	0.03	0.03
8	0.07	0.12
9	0.24	0.42
10	0.36	0.59
11	0.58	0.79
12	0.73	0.86
13	0.82	0.95
14	0.96	1
+gp	0.99	1

Table 8.10. Extended Survivors Analysis

Lowestoft VPA Version 3.1

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Extended Survivors Analysis

Arctic Green.halibut (run: 2010/1)

CPUE data from file fleet

Catch data for 46 years. 1964 to 2009. Ages 5 to 15.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLT04: Norw. Exp. CP	1992	2009	5	14	0.38	0.44
FLT07: Russ.Surv. ne	1992	2009	5	14	0.75	0.92
FLT08: Norw.Comb.Sur	1996	2009	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 2009
shrunk towards 1.000 * 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 56 iterations

Regression weights

	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
5	0.022	0.026	0.015	0.023	0.016	0.017	0.02	0.041	0.015	0.02
6	0.054	0.098	0.067	0.067	0.07	0.071	0.065	0.072	0.038	0.047
7	0.174	0.232	0.14	0.174	0.2	0.178	0.18	0.137	0.069	0.086
8	0.195	0.165	0.136	0.116	0.184	0.219	0.202	0.134	0.104	0.125
9	0.154	0.145	0.104	0.115	0.184	0.172	0.182	0.109	0.124	0.075
10	0.48	0.353	0.29	0.237	0.192	0.24	0.175	0.103	0.069	0.051
11	0.346	0.332	0.278	0.205	0.224	0.217	0.168	0.148	0.111	0.146
12	0.58	0.496	0.308	0.231	0.369	0.314	0.288	0.227	0.197	0.13
13	0.235	0.383	0.307	0.113	0.214	0.388	0.387	0.191	0.245	0.204
14	0.417	0.415	0.326	0.414	0.329	0.417	0.365	0.222	0.231	0.095

Table 8.10 (Continued)

XSA population numbers (Thousands)

	AGE									
YEAR	5	6	7	8	9	10	11	12	13	14
2000	1.85E+04	1.50E+04	1.30E+04	8.90E+03	5.60E+03	3.72E+03	1.68E+03	8.08E+02	2.52E+02	1.17E+02
2001	1.83E+04	1.56E+04	1.22E+04	9.41E+03	6.30E+03	4.13E+03	1.98E+03	1.03E+03	3.90E+02	1.71E+02
2002	2.02E+04	1.53E+04	1.22E+04	8.33E+03	6.87E+03	4.70E+03	2.50E+03	1.22E+03	5.38E+02	2.29E+02
2003	1.92E+04	1.71E+04	1.23E+04	9.12E+03	6.25E+03	5.33E+03	3.02E+03	1.63E+03	7.75E+02	3.40E+02
2004	1.99E+04	1.62E+04	1.38E+04	8.92E+03	6.98E+03	4.80E+03	3.62E+03	2.12E+03	1.11E+03	5.96E+02
2005	2.72E+04	1.69E+04	1.30E+04	9.69E+03	6.39E+03	5.00E+03	3.41E+03	2.49E+03	1.26E+03	7.72E+02
2006	2.94E+04	2.30E+04	1.35E+04	9.35E+03	6.71E+03	4.63E+03	3.39E+03	2.36E+03	1.56E+03	7.37E+02
2007	2.63E+04	2.48E+04	1.86E+04	9.73E+03	6.58E+03	4.81E+03	3.35E+03	2.47E+03	1.52E+03	9.15E+02
2008	3.17E+04	2.17E+04	1.99E+04	1.40E+04	7.32E+03	5.08E+03	3.74E+03	2.48E+03	1.69E+03	1.08E+03
2009	5.27E+04	2.69E+04	1.80E+04	1.60E+04	1.08E+04	5.57E+03	4.08E+03	2.88E+03	1.76E+03	1.14E+03
Estimated population abundance at 1st Jan 2010										
	0.00E+00	4.44E+04	2.21E+04	1.42E+04	1.21E+04	8.65E+03	4.55E+03	3.04E+03	2.18E+03	1.23E+03
Taper weighted geometric mean of the VPA populations:										
	2.37E+04	1.81E+04	1.36E+04	9.11E+03	5.96E+03	4.05E+03	2.32E+03	1.34E+03	6.61E+02	3.57E+02
Standard error of the weighted Log(VPA populations) :										
	0.3242	0.2405	0.2551	0.3276	0.3757	0.3779	0.5869	0.7462	0.9246	0.9718

Log catchability residuals.

Fleet : FLT04: Norw. Exp. CP

Age	1992	1993	1994	1995	1996	1997	1998	1999
5	0.45	1.02	0.76	0.88	1.11	1.02	-0.55	-0.21
6	-0.1	0.16	0.28	0	0.82	0.22	-0.12	-0.1
7	-0.39	0.19	0.21	0.21	0.43	0.11	0.09	-0.11
8	-0.07	0.3	0.38	0.39	0.28	-0.11	-0.03	-0.13
9	-1.49	-1.47	-0.97	0.23	-0.27	-0.07	-0.26	-1.22
10	-0.28	0.24	0.44	0.9	0.14	0.61	-0.93	0.32
11	-0.06	0.02	-0.07	0.32	-0.54	0.62	-0.88	-1.03
12	0.22	-0.05	-0.69	0.27	-0.67	0.55	-0.82	0.61
13	-0.26	0.03	-0.64	-0.09	99.99	0.15	99.99	-0.64
14	-1.4	-0.2	-0.51	0.18	-0.17	-0.12	99.99	-0.08

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
5	0.35	-0.37	-0.22	-0.07	-0.04	-0.67	99.99	99.99	99.99	99.99
6	-0.03	-0.08	-0.21	-0.06	-0.12	0.1	99.99	99.99	99.99	99.99
7	0.29	-0.23	0.18	-0.14	-0.2	-0.17	99.99	99.99	99.99	99.99
8	-0.11	0.31	-0.21	-0.56	-0.06	0.43	99.99	99.99	99.99	99.99
9	0	0.23	0.09	0.32	0.41	0.54	99.99	99.99	99.99	99.99
10	0.45	-0.06	0.01	0.1	-0.64	-0.16	99.99	99.99	99.99	99.99
11	-1.06	-0.74	-0.75	-0.34	-0.51	-0.53	99.99	99.99	99.99	99.99
12	-0.06	-0.07	-0.67	-0.01	-0.04	0.09	99.99	99.99	99.99	99.99
13	0.34	-0.88	-1.64	-0.29	-0.33	0.14	99.99	99.99	99.99	99.99
14	99.99	-0.45	-0.09	-0.22	-0.12	-0.09	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	-5.2259	-4.1666	-3.3703	-3.8336	-4.5028	-3.7661	-3.7661	-3.7661	-3.7661	-3.7661
S.E(Log q)	0.5741	0.2333	0.2211	0.3219	0.5629	0.4777	0.7437	0.458	0.7743	0.2778

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	-1.63	-1.169	17.5	0.03	14	0.91	-5.23
6	1.67	-0.628	0.49	0.13	14	0.41	-4.17
7	1.42	-0.696	0.86	0.32	14	0.33	-3.37
8	1.44	-0.68	1.55	0.28	14	0.48	-3.83
9	0.59	1.314	6.17	0.63	14	0.32	-4.5
10	1.6	-0.876	1.11	0.26	14	0.78	-3.77
11	1.24	-0.646	3.55	0.55	14	0.59	-4.31
12	0.96	0.152	3.97	0.74	14	0.46	-3.86
13	1	-0.009	4.16	0.59	12	0.7	-4.17
14	0.97	0.286	3.99	0.95	12	0.21	-3.94
1							

Fleet : FLT07: RussSurv. ne

Age	1992	1993	1994	1995	1996	1997	1998	1999
5	1.92	0.77	0.07	-0.44	-0.33	-0.98	-0.27	-0.4
6	1.06	0.75	0.34	-0.04	0.09	-0.45	-0.36	-0.49
7	0.61	0.63	0.13	0.11	0.17	-0.2	-0.24	-0.47
8	0.48	0.47	0.2	0.45	0.31	0.1	0.15	-0.01
9	-0.51	0.04	0.12	0.42	0.85	-0.05	0.25	0.11
10	-0.27	0.15	0.42	0.36	-0.71	0.13	0.31	0.22
11	0.53	0.02	-0.32	0.07	-0.52	0.42	0.86	-0.12
12	0.39	0.54	0.11	0.16	-0.79	-0.31	0.63	0.33
13	-0.35	-0.23	-0.28	-0.19	-0.35	0.49	0.48	0.65
14	-5.09	0.75	0.54	-1.69	-0.32	-0.35	-0.26	-0.19

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
5	0.15	0.65	99.99	99.99	-0.05	-0.16	0.25	0.21	-0.24	0.29
6	-0.17	0.7	99.99	99.99	0.09	-0.14	0.2	-0.09	-0.26	0.26
7	-0.23	0.28	99.99	99.99	-0.06	-0.13	0.43	0.05	-0.18	0.15
8	0.16	-0.33	99.99	99.99	-0.25	-0.31	0.08	-0.09	0.1	0.11
9	0.16	-0.3	99.99	99.99	-0.13	-0.64	-0.18	-0.02	0.62	-0.18
10	0.27	0.17	99.99	99.99	-0.17	-0.32	-0.2	0.22	0.18	-0.38
11	0.62	0.13	99.99	99.99	-0.26	-0.52	-0.26	0.48	0.67	0.62
12	0.62	0.84	99.99	99.99	0.02	-0.28	0.14	0.84	1.11	0.47
13	-0.74	1.1	99.99	99.99	0.01	-0.24	0.29	0.48	1.29	0.94
14	0.39	0.49	99.99	99.99	0.49	-0.08	0.19	0.52	1.2	0.09

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	-0.551	0.3891	0.8607	0.9962	0.5897	0.2167	0.2167	0.2167	0.2167	0.2167
S.E(Log q)	0.4193	0.3497	0.2658	0.2224	0.3827	0.3007	0.5124	0.6357	0.7301	0.7258

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	0.91	0.248	1.45	0.46	16	0.4	-0.55
6	1.19	-0.344	-2.35	0.28	16	0.44	0.39
7	1.28	-0.673	-3.79	0.41	16	0.35	0.86
8	1.24	-0.95	-3.44	0.65	16	0.28	1
9	1.5	-1.091	-5.21	0.37	16	0.57	0.59
10	1.16	-0.532	-1.56	0.58	16	0.36	0.22
11	1.04	-0.131	-0.67	0.62	16	0.53	0.39
12	0.87	0.69	0.41	0.78	16	0.46	0.58
13	0.84	0.94	0.55	0.81	16	0.52	0.59
14	0.8	1.201	0.88	0.81	16	0.54	0.4
1							

Fleet : FLT08: Norw.Comb.Sur

Age	1992	1993	1994	1995	1996	1997	1998	1999
5	99.99	99.99	99.99	99.99	0.26	-0.11	-0.31	-0.34
6	99.99	99.99	99.99	99.99	0.37	0.2	-0.3	-0.03
7	99.99	99.99	99.99	99.99	0.41	0.13	0.22	-0.01
8	99.99	99.99	99.99	99.99	0.57	-0.28	-0.11	0.32
9	99.99	99.99	99.99	99.99	0.06	-0.4	-0.63	-0.37
10	99.99	99.99	99.99	99.99	0.89	0.45	0.41	0.47
11	99.99	99.99	99.99	99.99	0.19	0.12	0.15	-0.3
12	99.99	99.99	99.99	99.99	0.31	0.48	0.8	0.84
13	99.99	99.99	99.99	99.99	-0.36	-1.06	-2.9	0.06
14	99.99	99.99	99.99	99.99	0.22	0.08	0.33	0.23

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
5	0.06	-0.19	0.01	0.19	-0.01	0.3	99.99	99.99	99.99	99.99
6	-0.15	0.05	-0.11	0.1	-0.07	0.1	99.99	99.99	99.99	99.99
7	-0.16	0.11	0.16	0.07	-0.01	-0.53	99.99	99.99	99.99	99.99
8	-0.06	-0.01	0.02	-0.05	-0.06	-0.1	99.99	99.99	99.99	99.99
9	0.41	-0.23	0.33	0.22	-0.02	0.2	99.99	99.99	99.99	99.99
10	-0.23	0.16	-0.22	-0.07	-0.5	-0.35	99.99	99.99	99.99	99.99
11	-0.89	-0.69	-0.15	-0.77	-0.95	-0.58	99.99	99.99	99.99	99.99
12	-0.27	-0.06	0.15	-0.15	0.11	-0.32	99.99	99.99	99.99	99.99
13	-0.55	-0.62	-0.15	-0.31	-0.07	-0.25	99.99	99.99	99.99	99.99
14	-0.66	-0.17	-0.16	-0.52	0.1	-0.58	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	-0.2967	0.2253	0.8256	0.3604	-0.1927	0.5791	0.5791	0.5791	0.5791	0.5791
S.E(Log q)	0.2241	0.1662	0.2595	0.2003	0.3412	0.4155	0.6655	0.4338	0.982	0.4103

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	0.51	1.614	4.97	0.67	10	0.1	-0.3
6	2.32	-0.521	-13.34	0.03	10	0.41	0.23
7	-3.98	-0.881	50.32	0.01	10	1.05	0.83
8	3.28	-1.332	-21.79	0.06	10	0.62	0.36
9	0.71	0.808	2.61	0.6	10	0.25	-0.19
10	7.26	-2.952	-55.97	0.04	10	2.03	0.58
11	2.15	-2.702	-8.98	0.5	10	0.65	0.1
12	1.69	-2.435	-5.96	0.7	10	0.53	0.7
13	0.66	1.444	2.05	0.77	10	0.49	0.05
14	1.21	-0.96	-1.66	0.79	10	0.45	0.41
1							

Terminal year survivor and F summaries :

Age 5 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	59116	0.439	0	0	1	0.56	0.015
FLT08: Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	30939	0.5				0.44	0.028

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
44447	0.33	0.43	2	1.302	0.02

Table 8.10 (Continued)

Age 6 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	23354	0.281	0.248	0.88	2	0.75	0.044
FLT08: Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	18652	0.5				0.25	0.055

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
22076	0.25	0.17	3	0.699	0.047

Age 7 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	14732	0.205	0.141	0.69	3	0.841	0.084
FLT08: Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	11828	0.5				0.159	0.103

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
14226	0.19	0.12	4	0.615	0.086

Age 8 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	12038	0.17	0.091	0.54	4	0.877	0.126
FLT08: Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	12779	0.5				0.123	0.119

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
12127	0.16	0.07	5	0.464	0.125

Table 8.10 (Continued)

Age 9 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	4427	0.616	0	0	1	0.04	0.141
FLT07: Russ.Surv. ne	8879	0.158	0.068	0.43	5	0.707	0.073
FLT08: Norw.Comb.Sur	11721	0.304	0	0	1	0.163	0.056
F shrinkage mean	5430	0.5				0.09	0.116

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
8649	0.13	0.1	8	0.745	0.075

Age 10 Catchability constant w.r.t. time and dependent on age

Year class = 1999

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	4885	0.273	0.054	0.2	2	0.127	0.047
FLT07: Russ.Surv. ne	4688	0.143	0.162	1.13	6	0.606	0.049
FLT08: Norw.Comb.Sur	4786	0.216	0.055	0.26	2	0.201	0.048
F shrinkage mean	2634	0.5				0.066	0.086

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4555	0.11	0.1	11	0.94	0.051

Age 11 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	2638	0.205	0.025	0.12	3	0.187	0.166
FLT07: Russ.Surv. ne	3393	0.147	0.089	0.6	6	0.504	0.132
FLT08: Norw.Comb.Sur	2599	0.178	0.211	1.19	3	0.244	0.168
F shrinkage mean	3442	0.5				0.066	0.13

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3036	0.1	0.07	13	0.703	0.146

Table 8.10 (Continued)

Age 12 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	2266	0.179	0.157	0.88	4	0.219	0.125
FLT07: Russ.Surv. ne	2339	0.157	0.142	0.9	6	0.427	0.121
FLT08: Norw.Comb.Sur	2154	0.156	0.042	0.27	4	0.285	0.131
F shrinkage mean	1273	0.5				0.069	0.213

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2176	0.1	0.08	15	0.81	0.13

Age 13 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	1145	0.176	0.115	0.66	5	0.22	0.218
FLT07: Russ.Surv. ne	1322	0.169	0.23	1.36	7	0.373	0.191
FLT08: Norw.Comb.Sur	1224	0.148	0.067	0.46	5	0.319	0.205
F shrinkage mean	1138	0.5				0.088	0.219

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1233	0.1	0.09	18	0.922	0.204

Age 14 Catchability constant w.r.t. time and age (fixed at the value for age) 10

Year class = 1995

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04: Norw. Exp. CP	827	0.171	0.144	0.84	6	0.233	0.102
FLT07: Russ.Surv. ne	1033	0.186	0.202	1.09	8	0.337	0.083
FLT08: Norw.Comb.Sur	874	0.144	0.067	0.47	6	0.33	0.097
F shrinkage mean	691	0.5				0.1	0.121

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
892	0.1	0.08	21	0.836	0.095

Table 8.11. Fishing mortality (F) at age

Run title : NEA Greenland halibut (run: 2010/1)

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Terminal Fs derived using XSA with final year & oldest age shrinkage.

Table 8 Fishing mortality (F) at age

YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE											
5	0.0094	0.0053	0.0032	0.0024	0.0019	0.0207	0.0139	0.0027	0.0363	0.0074	0.0378
6	0.0484	0.0255	0.0138	0.0072	0.0051	0.0484	0.0659	0.1491	0.151	0.0442	0.1079
7	0.1146	0.0699	0.0397	0.018	0.0116	0.0691	0.2864	0.4473	0.511	0.2369	0.3446
8	0.2531	0.216	0.1411	0.0891	0.0694	0.2081	0.6556	0.6021	0.4033	0.3335	0.3623
9	0.4566	0.2848	0.3476	0.2356	0.2381	0.2332	0.5603	0.4391	0.2444	0.2596	0.2744
10	0.7003	0.7254	0.2583	0.3382	0.3302	0.435	0.5339	0.4738	0.1999	0.2516	0.3041
11	0.6375	0.7606	0.5421	0.2684	0.5684	0.4571	0.4457	0.4037	0.2511	0.2585	0.3297
12	0.5666	0.8214	0.8585	0.8372	0.1802	0.3905	0.4362	0.5627	0.3063	0.3191	0.3545
13	0.4065	0.391	0.4515	1.0092	0.2945	0.0686	0.5465	0.7562	0.4414	0.2765	0.3346
14	0.5568	0.6004	0.4943	0.5409	0.3237	0.3182	0.5074	0.5302	0.2897	0.2741	0.3208
+gp	0.5568	0.6004	0.4943	0.5409	0.3237	0.3182	0.5074	0.5302	0.2897	0.2741	0.3208
0 FBAR 6-10	0.3146	0.2643	0.1601	0.1376	0.1309	0.1988	0.4204	0.4223	0.3019	0.2252	0.2787

Table 8 Fishing mortality (F) at age

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
AGE											
5	0.041	0.0413	0.0972	0.1045	0.1292	0.0432	0.1211	0.077	0.0909	0.0569	0.0681
6	0.1211	0.1894	0.2134	0.2343	0.2394	0.0858	0.1443	0.1254	0.1426	0.3077	0.2402
7	0.4196	0.4664	0.4174	0.4302	0.2654	0.1813	0.1929	0.1279	0.2136	0.3858	0.3424
8	0.3817	0.625	0.3556	0.4139	0.2072	0.1908	0.1386	0.1692	0.3342	0.3421	0.2913
9	0.3557	0.4999	0.3926	0.3518	0.1331	0.229	0.0923	0.3235	0.307	0.2414	0.2714
10	0.4017	0.3508	0.3248	0.3979	0.1093	0.1721	0.153	0.3451	0.4542	0.4057	0.3698
11	0.5023	0.3823	0.4845	0.4735	0.1956	0.2421	0.2515	0.4452	0.3166	0.3966	0.3562
12	0.5617	0.6828	0.708	0.3548	0.2022	0.2655	0.27	0.4246	0.4772	0.2311	0.4171
13	0.5354	0.5073	0.8178	0.6669	0.1237	0.3001	0.6798	0.3669	0.3601	0.2863	0.1544
14	0.4739	0.4873	0.5488	0.4513	0.1532	0.2426	0.2905	0.3829	0.3848	0.3135	0.3151
+gp	0.4739	0.4873	0.5488	0.4513	0.1532	0.2426	0.2905	0.3829	0.3848	0.3135	0.3151
0 FBAR 6-10	0.336	0.4263	0.3408	0.3656	0.1909	0.1718	0.1442	0.2182	0.2903	0.3365	0.303

Table 8.11 (Continued)

Terminal Fs derived using XSA with final year & oldest age shrinkage.

Table 8 Fishing mortality (F) at age

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE											
5	0.095	0.0695	0.0433	0.114	0.1721	0.3283	0.1181	0.0983	0.0373	0.051	0.0601
6	0.2536	0.2303	0.1926	0.2912	0.4281	0.5053	0.1778	0.1558	0.0775	0.0719	0.1623
7	0.3534	0.445	0.3827	0.4387	0.5267	0.8372	0.2357	0.3628	0.2555	0.2577	0.4027
8	0.3335	0.3813	0.4815	0.3366	0.4127	0.5254	0.2891	0.39	0.2986	0.3112	0.3331
9	0.3374	0.256	0.4543	0.321	0.4194	0.3809	0.131	0.0727	0.1668	0.2237	0.119
10	0.4645	0.4189	0.4905	0.1982	0.3202	1.0123	0.3761	0.5811	0.5134	0.6811	0.6367
11	0.3089	0.2869	0.4325	0.2169	0.2375	1.1399	0.3538	0.4986	0.4946	0.8203	0.5478
12	0.4329	0.1747	0.4062	0.1799	0.4904	1.5795	0.6517	0.4745	0.8168	1.0875	0.5497
13	0.7343	0.3144	0.1578	0.2525	0.0794	0.5353	0.7454	0.296	0.564	1.155	0.1968
14	0.458	0.2913	0.3901	0.2345	0.3107	0.9371	0.5338	0.394	0.568	0.8213	0.4476
+gp	0.458	0.2913	0.3901	0.2345	0.3107	0.9371	0.5338	0.394	0.568	0.8213	0.4476
0 FBAR 6-10	0.3485	0.3463	0.4003	0.3171	0.4214	0.6522	0.2419	0.3125	0.2623	0.3091	0.3308

Table 8 Fishing mortality (F) at age

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
AGE											
5	0.0167	0.0192	0.0265	0.0223	0.0263	0.0149	0.0225	0.0158	0.0171	0.0203	0.0412
6	0.0662	0.0685	0.1273	0.0544	0.0977	0.067	0.0668	0.0701	0.0709	0.0651	0.0719
7	0.1973	0.2395	0.3451	0.1738	0.2315	0.1399	0.1739	0.2002	0.1778	0.18	0.1366
8	0.1563	0.2277	0.2623	0.1951	0.1645	0.1361	0.1162	0.1841	0.2186	0.2016	0.1343
9	0.1167	0.115	0.2051	0.1544	0.1447	0.1042	0.1153	0.1836	0.1718	0.1818	0.1087
10	0.6177	0.492	0.7176	0.4804	0.3532	0.2901	0.2374	0.1922	0.2402	0.1753	0.1028
11	0.4538	0.3373	0.3619	0.346	0.3315	0.2785	0.205	0.2245	0.2168	0.1677	0.1476
12	0.6364	0.4345	0.6274	0.5798	0.4959	0.3077	0.2308	0.3691	0.3139	0.288	0.2268
13	0.1234	0.1091	0.4265	0.2353	0.3828	0.3074	0.1133	0.2144	0.3876	0.3871	0.1912
14	0.4419	0.2822	0.47	0.4174	0.415	0.3258	0.414	0.3292	0.4166	0.3649	0.2221
+gp	0.4419	0.2822	0.47	0.4174	0.415	0.3258	0.414	0.3292	0.4166	0.3649	0.2221
0 FBAR 6-10	0.2308	0.2285	0.3315	0.2116	0.1983	0.1475	0.1419	0.166	0.1759	0.1607	0.1109

Table 8 Fishing mortality (F) at age

YEAR	2008	2009	FBAR **-**
AGE			
5	0.0154	0.0198	0.0255
6	0.0379	0.0467	0.0522
7	0.0691	0.0864	0.0974
8	0.1038	0.1254	0.1212
9	0.1237	0.0747	0.1024
10	0.0689	0.0506	0.0741
11	0.1112	0.1459	0.1349
12	0.1969	0.1298	0.1845
13	0.245	0.2035	0.2133
14	0.2307	0.0952	0.1827
+gp	0.2307	0.0952	
0 FBAR 6-10	0.0807	0.0768	

Table 8.12. Stock number at age (start of year) Numbers*10-3**

Run title : NEA Greenland halibut (run: 2010/1)

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	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		42840	51686	57829	70444	64281	55933	41113	31553	33558	31064	26648
6		33792	36528	44252	49616	60487	55222	47154	34898	27083	27855	26540
7		27961	27712	30649	37566	42397	51799	45285	37996	25876	20044	22939
8		27353	21461	22243	25353	31755	36072	41608	29269	20910	13360	13613
9		14559	18279	14883	16626	19961	25499	25214	18591	13796	12025	8238
10		8521	7938	11834	9049	11307	13541	17381	12393	10314	9300	7983
11		4237	3641	3307	7867	5554	6995	7544	8771	6641	7269	6224
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	2085
	+gp	190	118	77	49	27	118	756	372	341	564	844
0	TOTAL	163799	171203	187989	219159	241730	252002	234434	180908	146458	130252	122729

	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		22548	22108	23711	20604	19729	18655	17916	18968	19148	17841	19960
6		22086	18628	18258	18518	15974	14923	15378	13661	15116	15049	14507
7		20506	16841	13266	12695	12609	10822	11788	11458	10372	11281	9522
8		13988	11601	9092	7522	7106	8323	7770	8366	8678	7210	6602
9		8156	8219	5345	5484	4280	4972	5919	5822	6080	5347	4408
10		5389	4919	4291	3106	3320	3225	3403	4646	3626	3850	3616
11		5069	3104	2981	2669	1796	2562	2337	2514	2832	1982	2209
12		3853	2640	1823	1580	1431	1271	1731	1564	1386	1776	1147
13		2917	1891	1148	773	954	1006	839	1137	880	740	1213
14		1713	1470	980	436	341	726	641	366	678	529	479
	+gp	1044	993	456	330	386	389	264	155	215	283	250
0	TOTAL	107269	92414	81351	73719	67927	66873	67988	68657	69011	65888	63912

	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		19896	19464	23050	20808	14584	12756	10626	13125	18579	18325	19117
6		16049	15573	15628	18998	15980	10568	7907	8127	10239	15406	14988
7		9820	10719	10647	11095	12220	8964	5488	5697	5986	8156	12340
8		5820	5936	5912	6250	6158	6212	3340	3732	3411	3991	5425
9		4246	3589	3489	3144	3842	3508	3162	2153	2175	2178	2516
10		2892	2608	2391	1907	1963	2174	2063	2387	1723	1584	1499
11		2150	1565	1477	1260	1346	1227	680	1219	1149	888	690
12		1331	1359	1011	825	873	914	338	411	637	603	336
13		651	743	982	580	593	460	162	152	220	242	175
14		895	269	467	722	388	471	232	66	97	108	66
	+gp	696	30	156	144	177	905	145	13	7	15	3
0	TOTAL	64446	61854	65210	65732	58124	48159	34142	37082	44225	51497	57155

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		21470	20340	17846	18538	18284	20155	19224	19915	27240	29430	26328
6		15495	18173	17173	14958	15603	15328	17091	16178	16872	23048	24823
7		10968	12482	14606	13014	12193	12180	12338	13759	12982	13528	18588
8		7100	7750	8455	8903	9414	8326	9115	8925	9694	9353	9726
9		3347	5227	5312	5598	6304	6874	6254	6984	6390	6705	6581
10		1923	2563	4010	3724	4129	4695	5331	4796	5003	4632	4812
11		683	892	1349	1684	1983	2496	3023	3619	3407	3387	3345
12		343	373	548	808	1026	1225	1626	2120	2489	2361	2465
13		167	156	208	252	390	538	775	1111	1261	1565	1523
14		124	127	121	117	171	229	340	596	772	737	915
	+gp	3	65	20	44	38	162	82	401	1031	806	1208
0	TOTAL	61621	68149	69649	67640	69535	72207	75200	78405	87141	95551	100313

	Table 10	Stock number at age (start of year)			Numbers*10**-3	
	YEAR	2008	2009	2010	GMST 64-**	AMST 64-**
	AGE					
5		31706	52671	0	23733	26301
6		21745	26873	44447	19519	22039
7		19882	18019	22076	14745	17254
8		13956	15971	14226	9747	12096
9		7319	10827	12127	6360	7984
10		5081	5566	8649	4289	5267
11		3737	4082	4555	2480	3128
12		2484	2878	3036	1439	1863
13		1691	1756	2176	752	1049
14		1083	1139	1233	428	619
	+gp	1287	1362	1957		
0	TOTAL	109972	141146	114483		

Table 8.13. Stock biomass at age (start of year) Tonnes

Run title : NEA Greenland halibut (run: 2010/1)

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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	29586	26998	23492	23311	17890	19028	17613	15110
6	21627	23378	28321	32251	39921	35342	34753	25720	19960	20529	19560
7	25165	24941	27890	34936	40701	47137	48862	40998	27920	21628	24751
8	32824	26182	27581	32199	41599	45090	59124	41591	29713	18985	19344
9	23731	30343	25301	28430	34732	41818	46595	34356	25496	22221	15224
10	19258	17701	26270	19908	24762	30467	39647	28268	23527	21214	18209
11	13178	10923	9724	22342	15494	20915	21779	25323	19173	20986	17970
12	9488	6728	4965	5463	16515	9828	12376	13501	16371	14439	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	172936	171360	181481	209629	244357	274338	312358	242821	196247	180315	173145

Table 12 Stock biomass at age (start of year) Tonnes

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
AGE											
5	12784	12535	13444	11683	17756	13096	11825	13088	14361	11240	11976
6	16277	13729	13456	13648	19169	13013	12918	11476	15721	14447	12911
7	22126	18172	14314	13698	18914	12348	13557	11802	13899	13312	11426
8	19877	16485	12920	10689	12792	12218	12121	10959	13624	11032	12213
9	15072	15189	9877	10135	9416	8840	12076	10131	11978	12353	11417
10	12293	11219	9788	7086	8633	7423	8747	10407	9899	11049	11497
11	14635	8962	8606	7706	5388	6825	6963	6963	9316	6857	7995
12	12510	8573	5919	5132	5008	3872	5937	5271	5850	6695	4532
13	12553	8137	4941	3326	3911	3388	3465	4913	4147	2954	5434
14	8449	7248	4833	2151	1639	3109	3002	1958	4124	2300	2034
+gp	6169	5884	2747	1950	2383	2078	1583	904	1315	1280	1206
0 TOTALBIO	152745	126133	100845	87203	105009	86210	92194	87871	104233	93518	92643

Table 12 Stock biomass at age (start of year) Tonnes

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
AGE											
5	12335	13800	17057	15814	10355	9822	7226	10369	13377	13378	14720
6	14765	15620	15034	19568	16939	11096	7669	8290	9625	14482	14538
7	12570	13570	13298	14645	15764	12371	6970	7690	7602	10195	16165
8	11058	9990	9613	11250	10469	10870	5879	7016	5867	6944	9440
9	10530	8907	7551	7609	8068	7718	6987	5297	4763	4552	5637
10	8995	7777	6927	5968	5123	5653	5281	6374	4343	3976	3882
11	7202	5549	5030	4247	3863	3422	2115	4181	3413	2619	2270
12	4953	5163	3700	3340	3013	2997	1212	1763	2097	2015	1353
13	2603	3389	4171	2486	2206	1790	621	770	845	928	831
14	3740	1344	1956	3248	1585	2065	986	418	480	537	410
+gp	3152	177	696	679	799	4787	695	117	49	124	18
0 TOTALBIO	91902	85288	85033	88855	78185	72592	45641	52285	52462	59750	69264

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	2008	2009
	AGE													
5		16532	14848	12492	14089	13530	13907	13745	15335	18224	18747	16481	22036	29865
6		14565	16901	16315	14510	16071	14408	17945	17715	16062	19821	22415	19984	21552
7		14039	16226	18550	17308	16948	16565	17619	20611	16954	15543	24406	27020	19299
8		11644	12477	13106	14511	16475	13987	15933	16984	16024	14310	16397	24506	23493
9		6927	11081	10624	11813	14437	14985	14496	17203	13617	14229	15274	16328	20875
10		4980	6587	9865	9720	11066	12583	13940	13310	12728	12144	12285	12082	12335
11		2252	2900	4343	5642	6602	7964	9200	11320	9702	9141	9785	10670	10735
12		1377	1459	2110	3210	4020	4765	6008	8074	8297	7825	7861	8024	8870
13		807	767	959	1252	1874	2398	3539	4769	4710	6256	5708	5997	6657
14		736	720	705	680	996	1201	1894	3248	3384	3420	4151	4240	5159
	+gp	19	321	120	317	280	1024	523	2551	5972	5438	10963	9594	9627
0	TOTALBIO	73879	84287	89189	93051	102300	103785	114843	131119	125675	126875	145727	160481	168467

Table 8.14. Spawning stock biomass at age (spawning time) Tonnes

Run title : NEA Greenland halibut (run: 2010/1)

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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	17082	14888	10200
10		16562	15223	22593	17121	21295	26202	34096	24311	20233	18244	15660
11		12914	10704	9529	21895	15185	20496	21344	24816	18789	20566	17611
12		9298	6594	4866	5354	16185	9631	12129	13231	16044	14150	15374
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	139622	111285	94884	95800	91525

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	409	575	390	388	344	472	578	516
7		664	545	429	411	567	370	407	354	417	399	457
8		4174	3462	2713	2245	2686	2566	2546	2301	2452	1986	2321
9		10098	10177	6617	6790	6309	5923	8091	6788	7187	7535	7421
10		10572	9648	8418	6094	7424	6384	7522	8950	8117	9171	9773
11		14342	8782	8434	7552	5281	6688	6824	6824	8944	6651	7755
12		12259	8402	5800	5029	4908	3795	5818	5165	5733	6561	4486
13		12553	8137	4941	3326	3911	3388	3465	4913	4147	2954	5434
14		8449	7248	4833	2151	1639	3109	3002	1958	4124	2300	2034
	+gp	6169	5884	2747	1950	2383	2078	1583	904	1315	1280	1206
0	TOTSPBIO	79769	62698	45336	35957	35684	34692	39645	38501	42906	39415	41404

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	104	134	134	0
6		443	156	150	196	169	111	77	83	96	145	0
7		377	271	133	293	315	495	418	615	532	816	1132
8		2654	2198	2019	2025	1780	1631	1646	2245	1995	2014	2360
9		7792	5879	4002	3728	4115	4168	4612	3602	3286	2640	3269
10		8186	7000	6027	4775	3945	4352	4542	5290	3518	3141	3417
11		7130	5272	4476	3780	3516	3046	1840	3679	3243	2514	2202
12		4854	5060	3626	3340	3012	2997	1212	1657	1971	1793	1271
13		2603	3389	4171	2486	2206	1790	621	770	845	928	831
14		3740	1344	1956	3248	1585	2065	986	418	480	537	410
	+gp	3152	177	696	679	799	4787	695	117	49	124	18
0	TOTSPBIO	40930	30746	27256	24550	21442	25442	16648	18581	16149	14786	14910

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	135	139	137	0	0	0	0
6		0	0	0	145	482	432	359	177	161	198	224
7		983	649	371	519	1017	1656	1938	1649	848	777	976
8		2445	1248	917	1451	3130	4336	5417	4755	3525	2576	2132
9		3672	4987	3506	4371	7074	9890	10437	11354	7762	7114	5193
10		4233	5402	6511	6124	7193	9940	12267	12112	11200	8987	6511
11		2117	2668	3735	4908	5546	7247	8464	10641	8829	7770	6458
12		1295	1459	2089	3081	3859	4574	5828	7751	7882	7277	6289
13		807	767	959	1252	1874	2374	3468	4673	4663	6131	4909
14		736	720	705	680	996	1201	1856	3183	3316	3386	3985
	+gp	19	321	120	317	280	1024	523	2551	5972	5438	10854
0	TOTSPBIO	16306	18220	18913	22849	31587	42814	50696	58847	54158	49654	47531

Table 13 Spawning stock biomass at age (spawning time) Tonnes

	YEAR	2008	2009
	AGE		
5		0	0
6		200	431
7		811	579
8		1715	2819
9		3919	8767
10		4349	7278
11		6188	8480
12		5858	7628
13		4918	6324
14		4070	5159
	+gp	9498	9627
0	TOTSPBIO	41526	57093

Table 8.15. Summary (without SOP correction)

Run title : NEA Greenland halibut (run: 2010/1)

At 26/04/2010 18:36

	RECRUITS Age 5	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 6-10
1964	42840	172936	72644	40391	0.556	0.3146
1965	51686	171360	69254	34751	0.5018	0.2643
1966	57829	181481	68558	26321	0.3839	0.1601
1967	70444	209629	76710	24267	0.3163	0.1376
1968	64281	244357	90724	26168	0.2884	0.1309
1969	55933	274338	116541	43789	0.3757	0.1988
1970	41113	312358	139622	89484	0.6409	0.4204
1971	31553	242821	111285	79034	0.7102	0.4223
1972	33558	196247	94884	43055	0.4538	0.3019
1973	31064	180315	95800	29938	0.3125	0.2252
1974	26648	173145	91525	37763	0.4126	0.2787
1975	22548	152745	79769	38172	0.4785	0.336
1976	22108	126133	62698	36074	0.5754	0.4263
1977	23711	100845	45336	28827	0.6359	0.3408
1978	20604	87203	35957	24617	0.6846	0.3656
1979	19729	105009	35684	17312	0.4852	0.1909
1980	18655	86210	34692	13284	0.3829	0.1718
1981	17916	92194	39645	15018	0.3788	0.1442
1982	18968	87871	38501	16789	0.4361	0.2182
1983	19148	104233	42906	22147	0.5162	0.2903
1984	17841	93518	39415	21883	0.5552	0.3365
1985	19960	92643	41404	19945	0.4817	0.303
1986	19896	91902	40930	22875	0.5589	0.3485
1987	19464	85288	30746	19112	0.6216	0.3463
1988	23050	85033	27256	19587	0.7186	0.4003
1989	20808	88855	24550	20138	0.8203	0.3171
1990	14584	78185	21442	23183	1.0812	0.4214
1991	12756	72592	25442	33320	1.3097	0.6522
1992	10626	45641	16648	8602	0.5167	0.2419
1993	13125	52285	18581	11933	0.6422	0.3125
1994	18579	52462	16149	9226	0.5713	0.2623
1995	18325	59750	14786	11734	0.7936	0.3091
1996	19117	69264	14910	14347	0.9622	0.3308
1997	21470	73879	16306	9410	0.5771	0.2308
1998	20340	84287	18220	11893	0.6528	0.2285
1999	17846	89189	18913	19517	1.0319	0.3315
2000	18538	93051	22849	14437	0.6319	0.2116
2001	18284	102300	31587	16307	0.5163	0.1983
2002	20155	103785	42814	13161	0.3074	0.1475
2003	19224	114843	50696	13578	0.2678	0.1419
2004	19915	131119	58847	18800	0.3195	0.166
2005	27240	125675	54158	18834	0.3478	0.1759
2006	29430	126875	49654	17897	0.3604	0.1607
2007	26328	145727	47531	15237	0.3206	0.1109
2008	31706	160481	41526	13778	0.3318	0.0807
2009	52671	168467	57093	12407	0.2173	0.0768
Arith. Mean	26992	125838	49678	24312	0.5444	0.2648
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table E1. 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 E2. 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													
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	Total
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													
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	Total
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 E3. 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 E4. 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 Year	Age						Total
	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 Year	Age						Total
	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 updated from 2006 due to new age reading method

Table E5. 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 E6. 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

[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 E7. 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	379 456 / 129 221**	424 822 / 144 561**

***No survey in 2006-2007**

**** New swept area estimation method**

Table E8. 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													Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	
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													Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	
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 E9 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 E9 (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 E10. 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	Greenland	Ireland	Norway	Russia	UK England & Wales	UK Scotland	Total
1973	-	-	-	4	-	-	9	8	28	-	49
1974	-	-	-	2	-	-	2	-	30	-	34
1975	-	-	-	1	-	-	4	-	12	-	17
1976	-	-	-	1	-	-	2	-	18	-	21
1977	-	-	-	2	-	-	2	-	8	-	12
1978	-	-	2	30	-	-	-	-	1	-	33
1979	-	-	2	16	-	-	2	-	1	-	21
1980	-	177	-	34	-	-	5	-	-	-	216
1981	-	-	-	-	-	-	7	-	-	-	7
1982	-	-	2	26	-	-	17	-	-	-	45
1983	-	-	1	64	-	-	89	-	-	-	154
1984	-	-	3	50	-	-	32	-	-	-	85
1985	-	1	2	49	-	-	12	-	-	-	64
1986	-	-	30	2	-	-	34	-	-	-	66
1987	-	28	16	1	-	-	35	-	-	-	80
1988	-	71	62	3	-	-	19	-	1	-	156
1989	-	21	14[1]	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 [1]	-	+	+	-	-	-	129	-	+	+	129
2008 [1]	-	-	-	-	-	-	14	-	22	-	36
2009 [1]	-	-	-	-	-	-	5	-	129	-	134

[1] **Provisional figures**

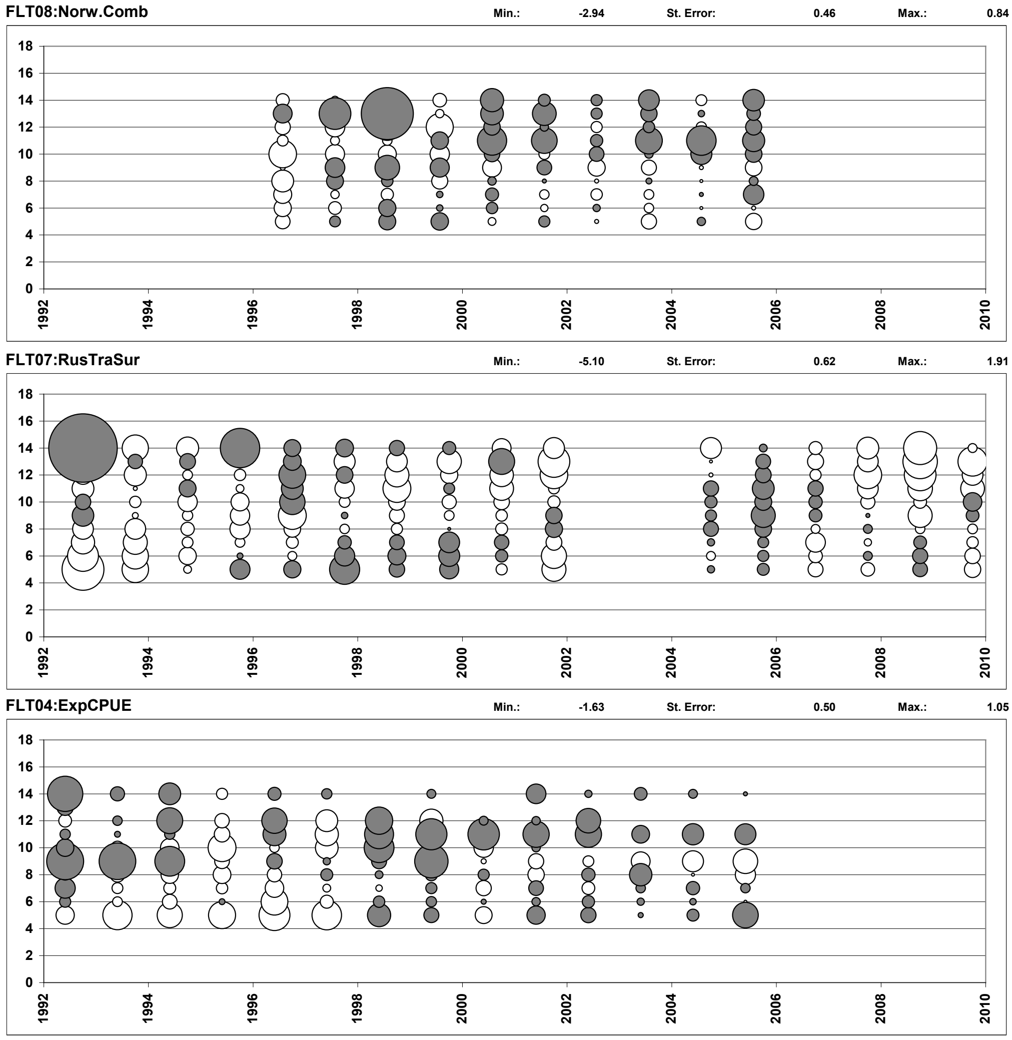

Figure 8.1. <u>NEA Greenland halibut</u>. Log catchability residuals by age and year for the tuning fleets included in the assessments. For each graph all bubbles are normalized to the same maximum bubble-size. Open bubbles represent positive values; filled bubbles represent negative values.

Figure 8.2. NEA Greenland halibut. Historical landings, recruitment, fishing mortality and spawning stock biomass.

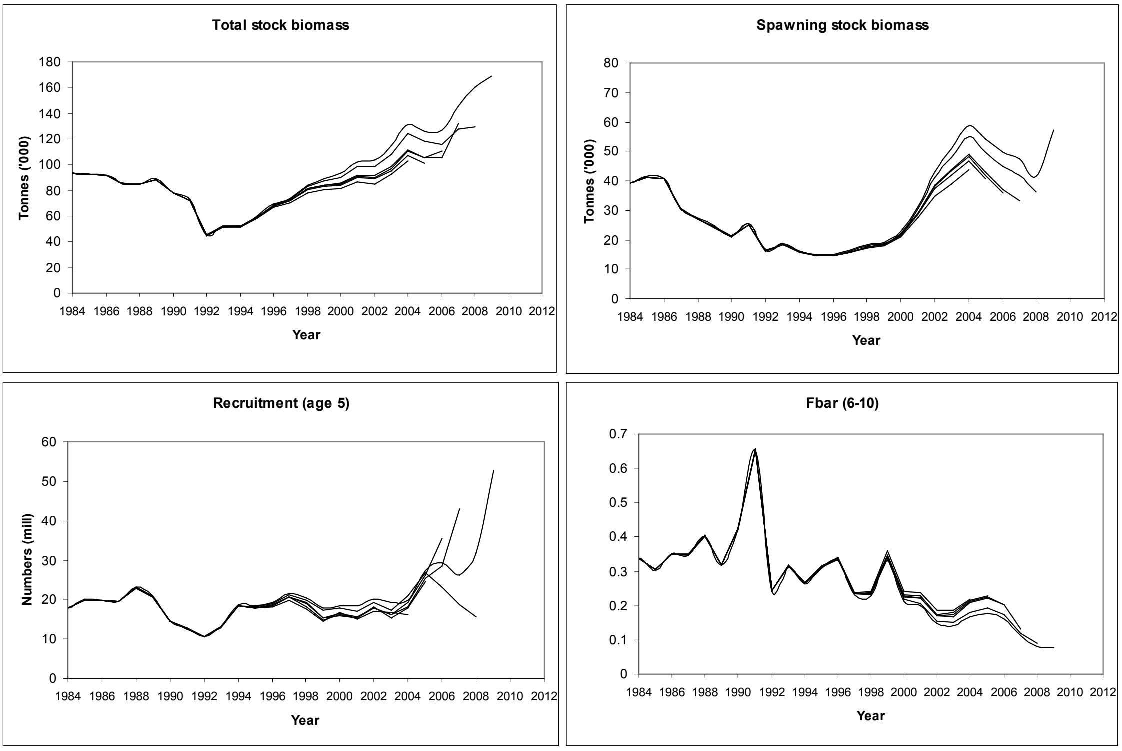

Figure 8.3. NEA Greenland halibut. Retrospective plots.

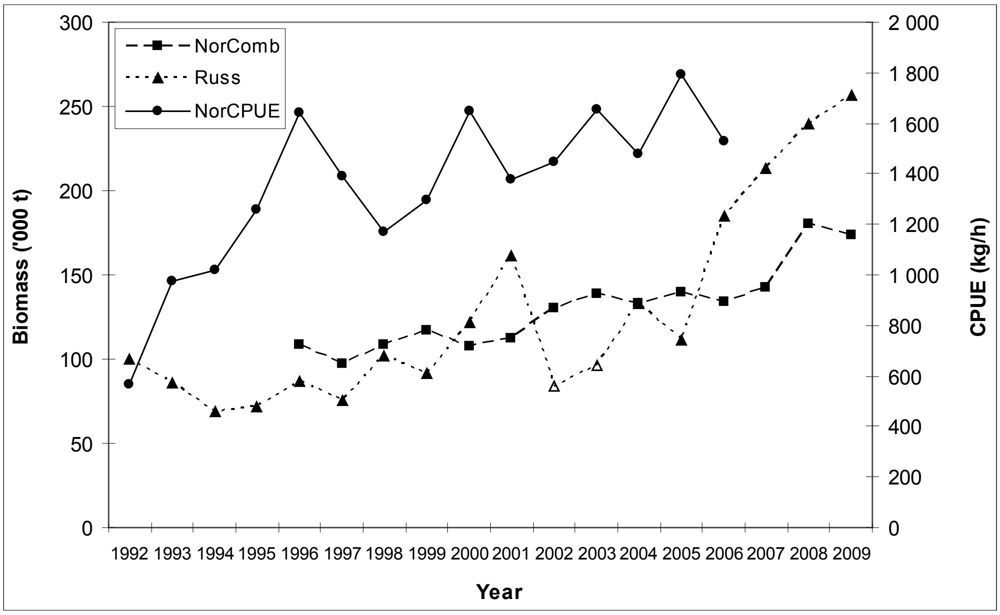

Figure 8.4. NEA Greenland halibut. Biomass estimates from the tuning series used in the assessment. Years with open symbols in the Russian series excluded from the tuning. The Norwegian CPUE Survey was ended in 2006.

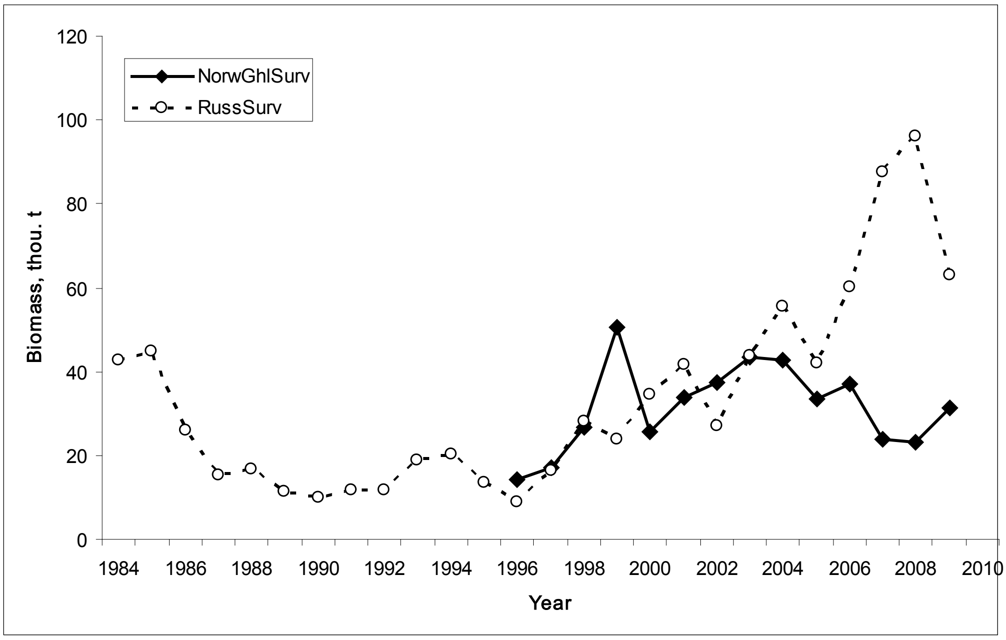

Figure 8.5. <u>NEA Greenland halibut</u>. Swept area estimate of the mature female biomass based on the data from the Norwegian Greenland halibut survey along the continental slope (August) and Russian trawl survey (October-December).

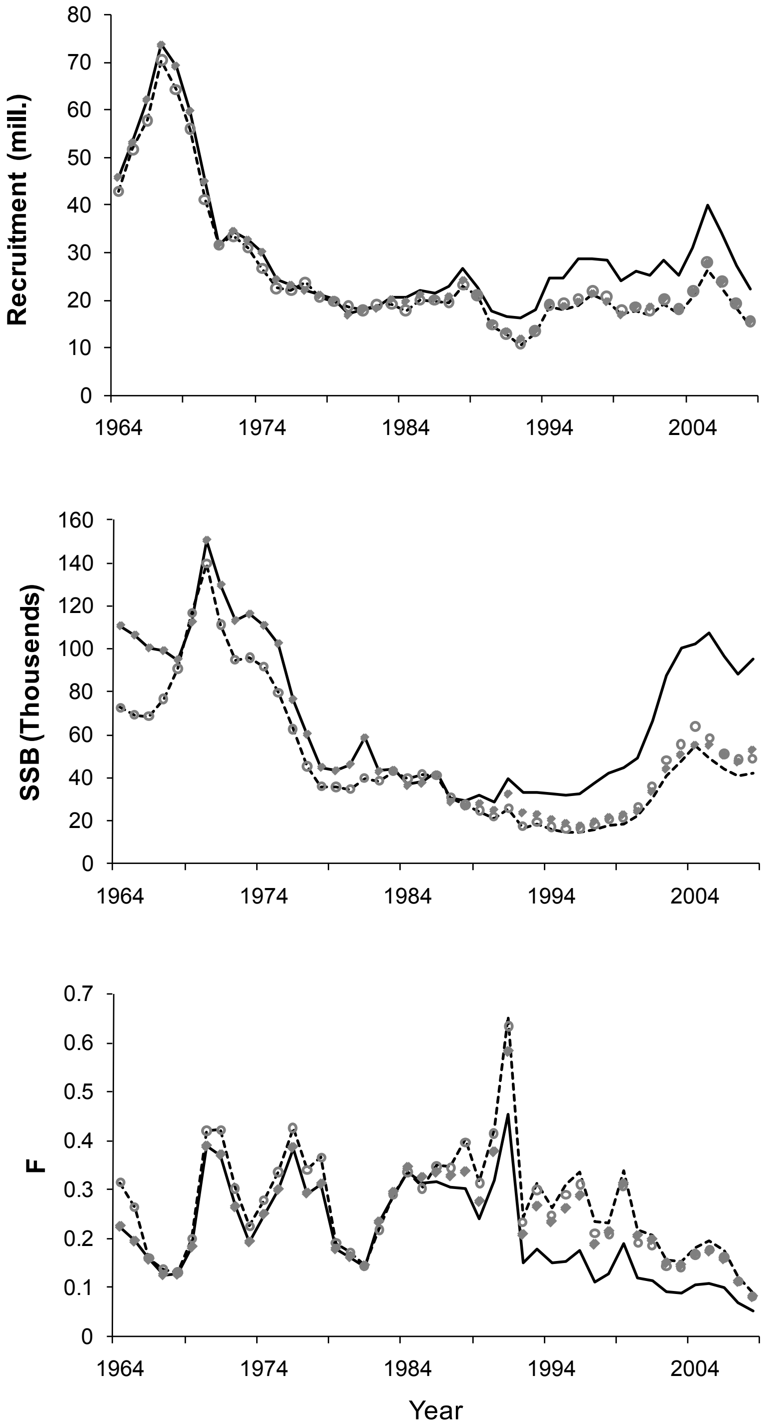

Figure 8.6 XSA estimates for recruitment, spawning stock biomass (SSB) and fisheries mortality (F) for NEA-Greenland halibut as found in the latest ICES assessment (stippled black line) (ICES 2009 AFWG report), with plus group changed from age 15 to 13 (grey diamonds), catchability constant in the analysis from age 11 in stead of 10 (grey open circles), and a run with both 13 as plus group and catbchability constant in the analysis from age 11 (black solid line) (see Hallfredsson 2010).

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 for years of regulating fishery. 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 and during the period from January to April only.

9.2 Catch Statistics (Table 9.1, 9.2)

The total catches that were taken during spring 2010 amounted to 246 209 tonnes to Norway and 77 367 tonnes to Russia. Russian catch statistics are shown in Tables 9.1. The age-length composition showed some variation in time and place of fishery. Because of this, five regions for length-age calculation of catch statistic for Russian fleet were used.

Data of age-length composition is presented in table 9.1. The international historical catch by country and seasons in the years 1972-2009 is given in Table 9.2.

9.3 Sampling

The sampling from scientific surveys, exploratory fishing and observers of capelin from January 2009 – April 2010 is summarised below:

Investigation	No. of samples	Length measurements	Aged individuals
Capelin investigations winter 2009 (Norway)	103	26805	3137
Capelin investigations winter 2009 (Russia)	46	5529	710
Exploratory fishing winter 2009 (Russia)	101	28958	700
Bottom survey winter 2009 (Russia)	26	1511	-
Bottom survey winter 2009 (Norway)	193	6125	2625
Young herring surv. In the Barents Sea, May 2009 (Russia)	14	2414	484
Ecosystem survey autumn 2009 (Norway)	308	16953	3546
Ecosystem survey autumn 2009 (Russia)	458	13868	1142
Bottom fish survey, November 2009 (Russia)	144	10799	275
Exploratory polar cod fishing autumn 2009 (Russia)	27	3974	200
Capelin winter investigations 2010 (Russia)	27	9598	1100
Observer on fishing vessels in winter-spring 2010(Russia)	90	11878	1000
Bottom survey winter 2010 (Norway)	133	8950	3810
Bottom survey winter 2010 (Russia)	46	3151	50
Sampling from fishing vessels in winter-spring 2010 (Norway)	in processing	in processing	in processing
Total 2009- 2010	1716	150513	18779

9.4 Stock Size Estimates

9.4.1 Acoustic stock size estimates in 2009 (Table 9.3)

One Russian and three Norwegian vessels jointly carried out the 2009 acoustic survey as part of an ecosystem survey during autumn (Anon., 2009). 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 total capelin stock was estimated at 3.76 million tonnes. It is about 15% lower than the stock estimated last year but higher than the long term mean level. Almost 62% (2.3 million tonnes) of the stock biomass consisted of maturing fish (>14.0 cm). The estimated maturing stock is some smaller then in 2008. The results from the survey are given in Table 9.3.

9.4.2 Recruitment estimation in 2009 (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 . During the last three years the larval surveys based on Gulf III plankton samples, which have been carried out in June each year since 1981, were not conducted.

A swept volume index (Dingsør, 2005; Eriksen *et al*., 2007) 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 (Anon. 2007). The four successive and abundant years classes of capelin were last years and 2009 year class is rich.

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 predation on capelin.

9.5 Other surveys and information from 2009–2010

9.5.1 Russian capelin spring investigation

Data on capelin prespawning concentrations in the wintering grounds, the pattern of prespawning migrations, periods and areas of fish approaches to the coasts for spawning were obtained using the results of fishing vessel activity as well as the data from the cruise by R/V "Vilnyus" (02.02-03.03) and from the scientific observers onboard fishing vessels "Admiral Shabalin" (26.01-17.03), "Capitan Morgun" (04-24.02) and "Demjansk" (27.03-06.04 and 08-10.04).

More details and information about fishery and spring investigation is possible to find in WD02.

9.5.2 Norwegian capelin spring investigation.

No special capelin investigation was conducted by Norway in winter-spring 2010. The three-year program to investigate the possibilities for implementing stock size estimates obtained during winter in the management of capelin, was ended in 2009, and was reported on in 2010. The conclusion was that it is not advisable to base the quotas on stock size estimates from the winter period, since such estimates are much more uncertain than those obtained during autumn.

The biological samples used for calculating the Norwegian catch in numbers by age are collected by 6 purse seiners taking part in the commercial catch. These vessels belong to the Norwegian Reference Fleet.

9.6 Stock development assessment

As decided by the Arctic Fisheries Working Group at its 2009 meeting (ICES 2009), 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 were used for stock development assessment are shown in table 9.6.

A probabilistic projection of the spawning stock to the time of spawning at 1 April 2010 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 2009 Arctic Fisheries Working Group. The methodology is described in "Stock assessment methodology for the Barents Sea capelin", WD22, AFWG 2008. The predation model for the period January-March was based on data from the period 1983-2002. It was decided to draw the natural mortality during October-December randomly from estimates for the period 1995-2001. Also, drawing from the entire period 1983-2002 would include some years with very high estimated natural mortality based on low stock sizes. The models for maturation, predation and mortality are unchanged since 2003.

Probabilistic prognoses for the maturing stock from October 1 2009 until April 1 2010 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 in Tjelmeland (WD1, 2008). With no catch, the estimated median spawning stock size in 2010 is 750 000 tonnes. With a catch of 360 000 tonnes, the probability for the spawning stock in 2009 to be below 200 000 t, the $\mathbf{B}_{\text{lim}}$ value used by ACFM in recent years, is 5 % (Fig. 9.2). The median spawning stock size in 2010 will then be 504 000 tonnes. Fig 9.2 shows the 95 % percentile of the spawning stock biomass 1 April 2010 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 assumed to be 20 % in January, 30 % in February and 50 % in March. A 1.5-year prognosis has been made for this stock in 2008. Such a prognosis was not carried out this year. Instead, we will give a qualitative view on how the stock will develop in the coming years. This view is to a large extent based on the observation that the three capelin stock collapses observed during the last 30 years have all been preceded by a period of high herring abundance in the Barents Sea. However, some years with good capelin recruitment despite high young herring abundance have also been observed (Fig. 9.5).

The 0-group index for herring in 2009 is low, and the ecosystem survey in 2009 also showed that the abundance of age 1-2 herring in the Barents Sea is low (Anon.2009). The total abundance of 1 year and older herring in the Barents Sea in 2009 will thus be low, and the recruitment conditions for capelin can then be expected to be good in 2010.

The 2009 year class was found to be strong at the 0-group stage; more than twice the average index. However, the 2008 year class, that had an 0-group index more than three times the average value, was reduced to about 75% of average numbers at age 1 (Table. 9.4). Uncertainties in the survey estimates might partly explain this large reduction, but if this large reduction represents a real increased mortality, this may cause a reduction in the total stock in the years to come.

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, WD#04) has increased and is at historic high levels. At the same time, capelin during the two last years reached levels where, 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}. 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 2010

During its autumn 2009 meeting, the Joint Russian-Norwegian Fishery Commission decided that the quota according to the harvest control rule in 2010 will be 360 000 tonnes, of which 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 shortlived species (WKSHORT) was arranged in Bergen, Norway, and the Barents Sea capelin stock was among the stocks dealt with during that workshop (ICES 2009a). 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.

Work is now going on to finalize the Stock Annex, and it will be added to the assessment report made during autumn 2010. It will also be included in the 2011 AFWG report.

Table 9.1 Barents Sea Capelin. Russian catch statistic table. Catch in number (10^6 sp.) and biomass (tonnes) by age and length during the fishery in January-April 2010.

Length, cm	Age/year class													
	1(2009)		2(2008)		3(2007)		4(2006)		5(2005)		Total(2009-2005)			
	N	B	N	B	N	B	N	B	N	B	N	B	N(%)	B (%)
5.0	2.34	0.68									2.34	0.68	0.07	+
5.5	6.46	2.63									6.46	2.63	0.18	+
6.0	9.01	4.94									9.01	4.94	0.25	0.01
6.5	17.19	12.85									17.19	12.85	0.48	0.02
7.0	5.21	4.92	2.10	1.98							7.31	6.90	0.21	0.01
7.5	2.41	2.88	2.41	2.88							4.83	5.76	0.14	0.01
8.0			3.89	5.75							3.89	5.75	0.11	0.01
8.5			4.06	7.45							4.06	7.45	0.11	0.01
9.0			3.07	6.97							3.07	6.97	0.09	0.01
9.5			1.64	4.55							1.64	4.55	0.05	0.01
10.0			2.35	7.91							2.35	7.91	0.07	0.01
10.5			1.19	4.79							1.19	4.79	0.03	0.01
11.0			1.09	5.36							1.09	5.36	0.03	0.01
11.5			1.31	7.52							1.31	7.52	0.04	0.01
12.0			1.08	7.24	1.35	9.07					2.43	16.31	0.07	0.02
12.5			0.94	7.23	4.16	32.12					5.09	39.35	0.14	0.05
13.0			0.66	5.96	14.32	129.09	1.55	14.01			16.53	149.06	0.46	0.19
13.5			0.00	0.00	52.57	547.71	0.67	6.96			53.24	554.67	1.50	0.72
14.0			0.00	0.00	117.50	1406.87	17.15	205.34			134.65	1612.22	3.79	2.08
14.5			0.00	0.00	195.36	2669.81	54.79	748.76			250.16	3418.58	7.04	4.42
15.0			0.00	0.00	284.52	4417.62	62.27	966.77			346.79	5384.39	9.75	6.96
15.5			0.00	0.00	225.96	3958.87	173.90	3046.67			399.86	7005.55	11.25	9.05
16.0			0.00	0.00	127.08	2510.07	314.72	6216.44	6.46	127.57	448.25	8854.08	12.61	11.44
16.5			0.00	0.00	102.76	2277.40	378.36	8385.60	0.94	20.90	482.06	10683.90	13.56	13.81
17.0			0.00	0.00	58.31	1444.71	353.35	8754.66	0.80	19.90	412.47	10219.27	11.60	13.21
17.5			0.00	0.00	27.36	755.79	324.02	8950.81	0.87	24.17	352.25	9730.77	9.91	12.58
18.0			0.00	0.00	10.01	307.42	269.08	8259.78	7.07	217.15	286.17	8784.35	8.05	11.35
18.5			0.00	0.00	15.63	531.77	155.58	5291.87	6.37	216.70	177.59	6040.33	5.00	7.81
19.0			0.00	0.00	0.00	0.00	79.86	3001.75	1.22	45.94	81.08	3047.70	2.28	3.94
19.5			0.00	0.00	0.00	0.00	26.65	1102.46	3.78	156.56	30.43	1259.02	0.86	1.63
20.0			0.00	0.00	0.00	0.00	8.41	382.18	0.00	0.00	8.41	382.18	0.24	0.49
20.5			0.00	0.00	0.00	0.00	2.00	99.06	0.08	3.72	2.07	102.78	0.06	0.13
Sum	42.61	28.89	25.79	75.61	1236.90	20998.33	2222.34	55433.14	27.61	832.61	3555.24	77368.58		
%	1.20	0.04	0.73	0.10	34.79	27.14	62.51	71.65	0.78	1.08			100.00	100.00

Table 9.2 Barents Sea CAPELIN. Catch statistic table. Catch 1972-2010. Thousand tonnes.

Year	TAC	Catch				
		spring		autumn		total
		Russia	Norway	Russia	Norway	
1972		24	1208	13	347	1592
1973		34	1078	12	213	1336
1974		63	749	99	237	1149
1975		301	559	131	407	1440*
1976		228	1252	368	739	2587
1977		317	1441	504	722	2987*
1978		429	784	318	360	1915*
1979	1800	342	539	326	570	1783*
1980	1600	253	539	388	459	1648*
1981	1900	429	784	292	454	1986*
1982	1700	260	568	336	591	1760*
1983	2300	373	751	439	758	2358*
1984	1400	257	330	368	481	1478*
1985	1100	234	340	164	113	868*
1986	120**	51	72			123
1987						
1988						
1989						
1990						
1991	1100	159	528	195	31	933*
1992	1099	247	620	159	73	1123*
1993	600**	170	402			586*
1994						
1995						
1996						
1997				(1)		(0,5)
1998		(2)		(1)		(3,02)
1999	80**	33	50	(22)		104
2000	435**	94	279	(29)		410*
2001	630**	180	376	(14)		578*
2002	650**	228	398	(18)		660*
2003	310**	93	180	(+)		282
2004						
2005	(2)		(1)	(+)		(1)
2006						
2007	(4)	(2)	(2)			(4)
2008	(10+4)	(5)	(5)	(2)		(12)
2009	380+(10)	73	228+(5)	1***		307
2010	350+(10)	77	246			

In brackets – reseach quota and catch.

*Include catch by other countries.

**Recommended for spring season only.

*** Expert assesment catch during Russian polar cod fishery in Autumn 2009.

Table 9.3. Barents Sea CAPELIN. Stock size estimation table. Estimated stock size from the acoustic survey in August-October 2010.

Length (cm)	Age/Year class, number 10^9				Sum	Biomass	Mean
	1(2008)	2(2007)	3(2006)	4(2005)	(10^9)	(10^3 t)	weight (g)
6.0	0.022				0.022	0.0	1.0
6.5	0.211				0.211	0.2	1.0
7.0	0.695				0.695	0.8	1.2
7.5	1.932				1.932	3.3	1.7
8.0	9.910	0.068			9.979	19.8	2.0
8.5	19.592				19.592	46.9	2.4
9.0	22.901	0.808			23.709	67.1	2.8
9.5	24.444	0.360			24.804	82.3	3.3
10.0	25.150	1.673			26.824	106.1	4.0
10.5	11.826	3.286			15.112	72.4	4.8
11.0	4.929	5.089			10.018	54.7	5.5
11.5	1.400	16.871			18.271	117.7	6.4
12.0	0.437	16.257			16.694	122.5	7.3
12.5	0.420	26.085	0.009		26.513	224.1	8.5
13.0	0.062	24.569	0.140		24.770	242.4	9.8
13.5	0.024	24.103	0.325		24.452	272.3	11.1
14.0	0.015	13.755	1.494		15.263	192.9	12.6
14.5	0.051	9.958	1.581		11.590	164.5	14.2
15.0		6.002	3.677		9.679	159.1	16.4
15.5		5.313	6.720		12.033	222.8	18.5
16.0		5.065	8.415		13.479	282.5	21.0
16.5		3.255	12.818	0.029	16.101	377.3	23.4
17.0		1.151	9.490	0.061	10.702	287.2	26.8
17.5		1.996	7.073	0.161	9.230	278.6	30.2
18.0		0.650	6.439		7.089	234.5	33.1
18.5		0.068	1.952		2.020	72.2	35.7
19.0			1.206		1.206	46.9	38.9
19.5			0.127		0.127	5.5	43.4
TSN (109)	124.021	166.382	61.465	0.251	352.118		
TSB (103 t)	417.4	1821.8	1510.2	7.1		3756.5	
Mean length (cm)	9.6	13.4	16.8	17.5	12.7		
Mean weight (g)	3.4	10.9	24.6	28.4			10.7
SSN (106)	0.066	47.213	60.992	0.251	108.522		
SSB (103 t)	0.9	809.0	1505.7	7.2		2322.9	

Based on TS value: 19.1 log L - 74.0, corresponding to σ = 5.0 · 10 · L1.9

Table 9.4 Barents Sea CAPELIN. Recruitment and natural mortality table. Larval abundance estimate in June, 0-group indices and acoustic assessment 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	Survey assesment (10^9 ind.) 1+ (Y+1)	2+ (Y+2)	Z 1-2 % (by survey)
1980	-	197.3	740.3			
1981	9.7	123.9	477.3			
1982	9.9	168.1	599.6	514.9	186.5	64
1983	9.9	100.0	340.2	154.8	48.3	69
1984	8.2	68.1	275.2	38.7	4.7	88
1985	8.6	21.3	63.8	6.0	1.7	72
1986	0.0	11.4	41.8	37.6	28.7	24
1987	0.3	1.2	4.0	21.0	17.7	16
1988	0.3	19.6	65.1	189.2	177.6	6
1989	7.3	251.5	862.4	700.4	580.2	17
1990	13.0	36.5	115.6	402.1	196.3	51
1991	3.0	57.4	169.5	351.3	53.4	85
1992	7.3	1.0	2.3	2.2	3.4	–
1993	3.3	0.3	1.0	19.8	8.1	59
1994	0.1	5.4	13.9	7.1	11.5	–
1995	0.0	0.9	2.9	81.9	39.1	52
1996	2.4	44.3	136.7	98.9	72.6	27
1997	6.9	54.8	189.4	179.0	101.5	43
1998	14.1	33.8	113.4	156.0	110.6	29
1999	36.5	85.3	287.8	449.2	218.7	51
2000	19.1	39.8	140.8	113.6	90.8	20
2001	10.7	33.6	90.2	59.7	9.6	84
2002	22.4	19.4	67.1	82.4	24.8	70
2003	11.9	94.9	340.9	51.2	13.03	75
2004	2.5	16.7	53.9	26.94	21.7	19.3
2005	8.8	41.8	148.5	60.1	54.7	9.0
2006	17.1	166.4	515.8	277.2	231.4	17
2007	-	157.9	480.1	313.0	166.4	46
2008	-	288.8	995.1	124.0		
2009		189.8	673.0			
Average	9.0	77.71	266.9	167.3	95.1	45.6

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

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 increase
	TSB	SSB						
1972	6600	2727					1592	
1973	5144	1350	*33*		528	2	1336	0.8
1974	5733	907	*		305	48	1149	**1.1**
1975	7806	2916	*		190	74	1440	**1.4**
1976	6417	3200	*253*		211	39	2587	0.8
1977	4796	2676	*22*		360	46	2987	0.7
1978	4247	1402	*		84	52	1915	0.9
1979	4162	1227	*		12	39	1783	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*		514,9	12	2358	**1.1**
1984	2964	1208	*109*		154,8	1313	1478	0.7
1985	860	285	*		38,7	1220	868	0.3
1986	120	65	*		6,0	155	123	0.1
1987	101	17	*34*	3,63	37,6	145	0	0.8
1988	428	200	*	10,3	21,0	70	0	**4.2**
1989	864	175	*84*	378,09	189,2	126	0	**2.0**
1990	5831	2617	*92*	94,2	700,4	356	0	**6.7**
1991	7287	2248	*643*	1769,7	402,1	646	933	**1.2**
1992	5150	2228	*302*	1734,8	351,3	1537	1123	0.7
1993	796	330	*293*	1498,39	2,2	2466	586	0.2
1994	200	94	*139*	187,4	19,8	1715	0	0.3
1995	193	118	*60*	29,83	7,1	558	0	1.0
1996	503	248	*60*		81,9	208	0	**2.6**
1997	909	312	*85*		98,9	273	0,5	**1.8**
1998	2056	932	*94*	413,59	179,0	376	3,02	**2.3**
1999	2775	1718	*382*		156,0	1201	104	**1.3**
2000	4273	2098	*599*	699,9	449,2	1766	410	**1.5**
2001	3630	2019	*626*		113,6	949	577,6	0.8
2002	2210	1291	*496*	1416,88	59,7	309	660,3	0.6
2003	533	280	*427*		82,4	2197	281,54	0.2
2004	628	294	*94*	104,94	51,2	2556	0	**1.2**
2005	324	174	*122*		26,94	1878	1,21	0.5
2006	787	437	*72*		60,1	1335	0	**2.4**
2007	2119	844	*189*		277,2	408	4,0	**2.7**
2008	4428	2468	-	468,9	313,0	232	12,0	**2.1**
2009	3765	2323	*517*	180,03	124.02	60	306,14	0.9
2010			*504*	451.9				

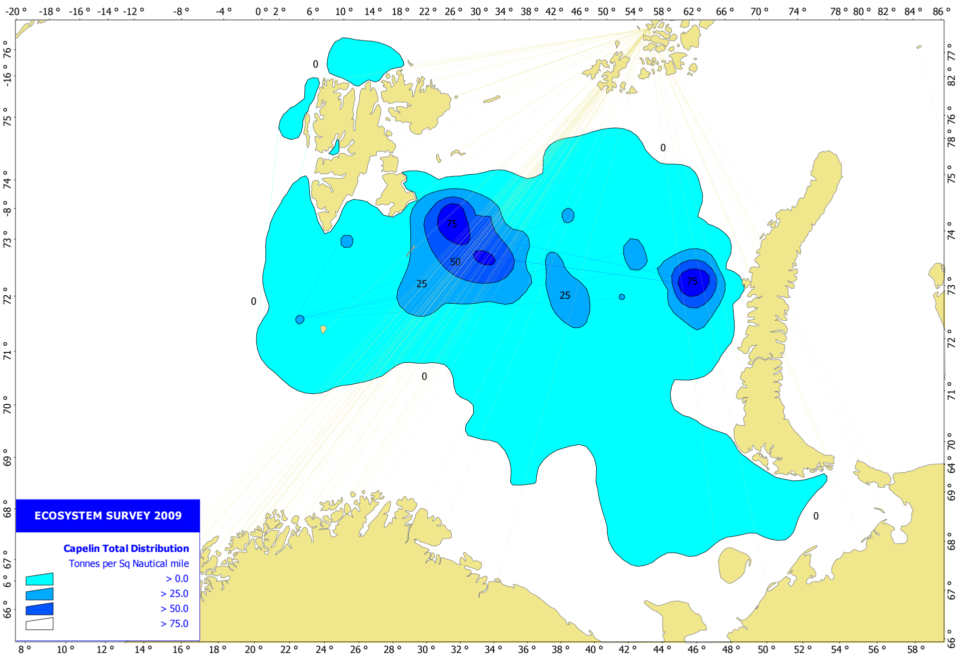

Figure 9.1. Geographical distribution of capelin during the acoustic survey in autumn 2009 (1:0-25, 2: 25-50, 3: 50-75, 4: >75 t/nm²)

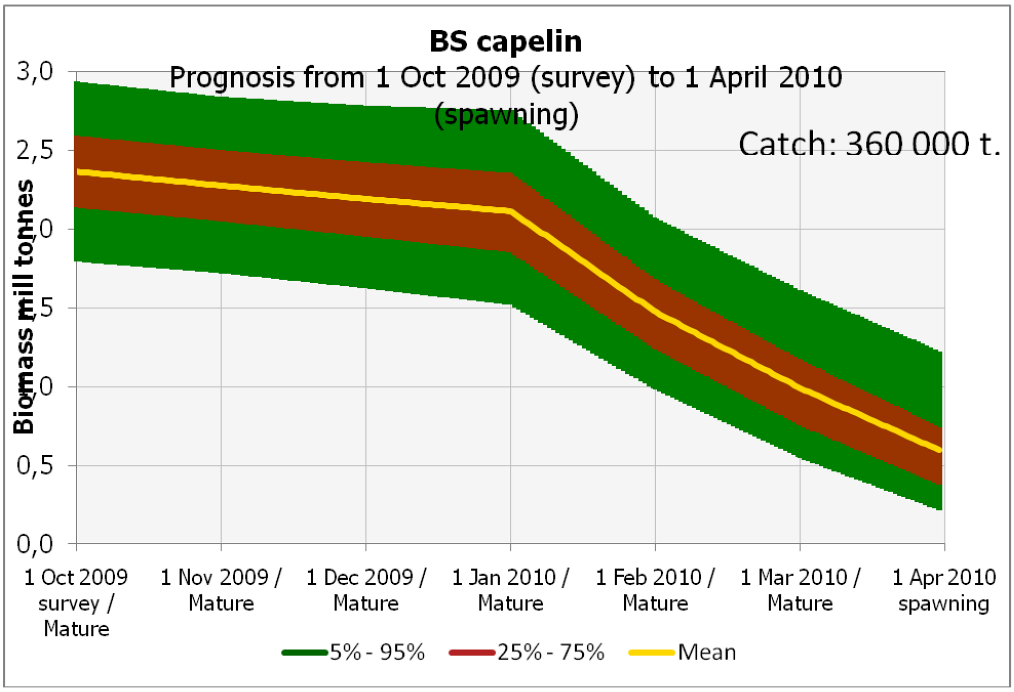

Figure 9.2. Probabilistic prognosis 1 October 2009-1 April 2010 for Barents Sea capelin (maturing stock, catch of 360 000 tonnes).

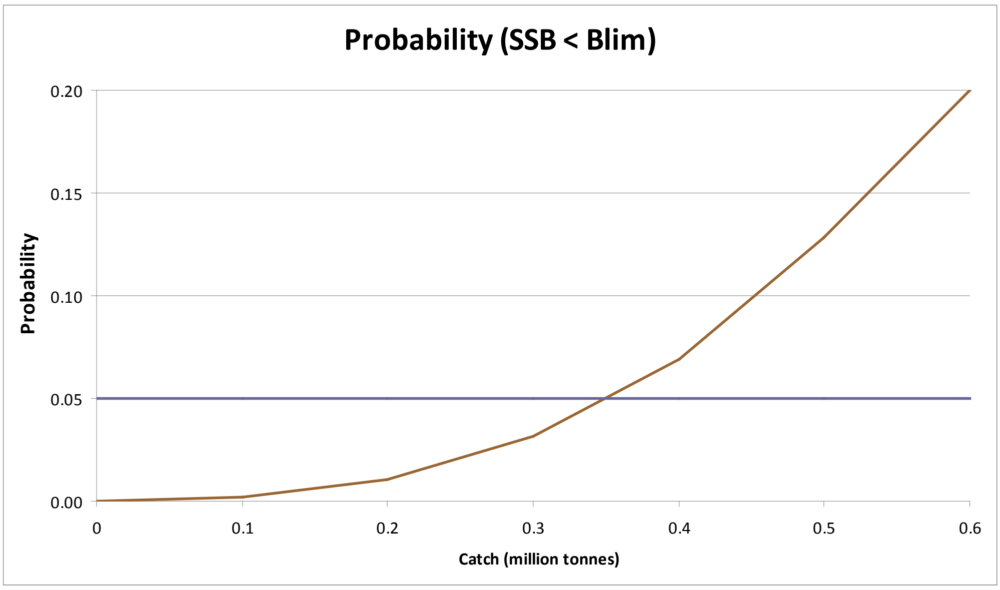

Figure 9.3. Probability of spawning biomass of capelin (1 April 2010) being below B_{lim} (200 000 tonnes), as a function of catch.

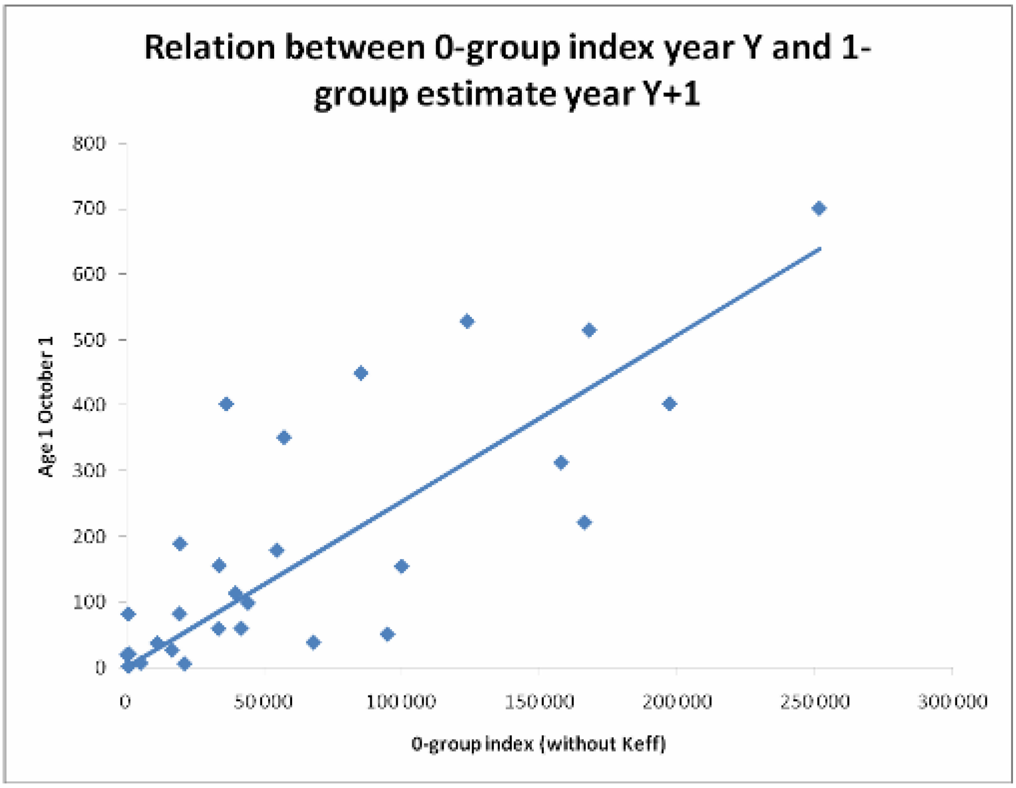

Figure 9.4. Regression of abundance of capelin at age 0 (0-group index without K_{eff}) and age 1 (acoustic estimate) of year classes 1981-2008. The regression line is forced through the origin, to avoid systematic overestimation of weak year classes.

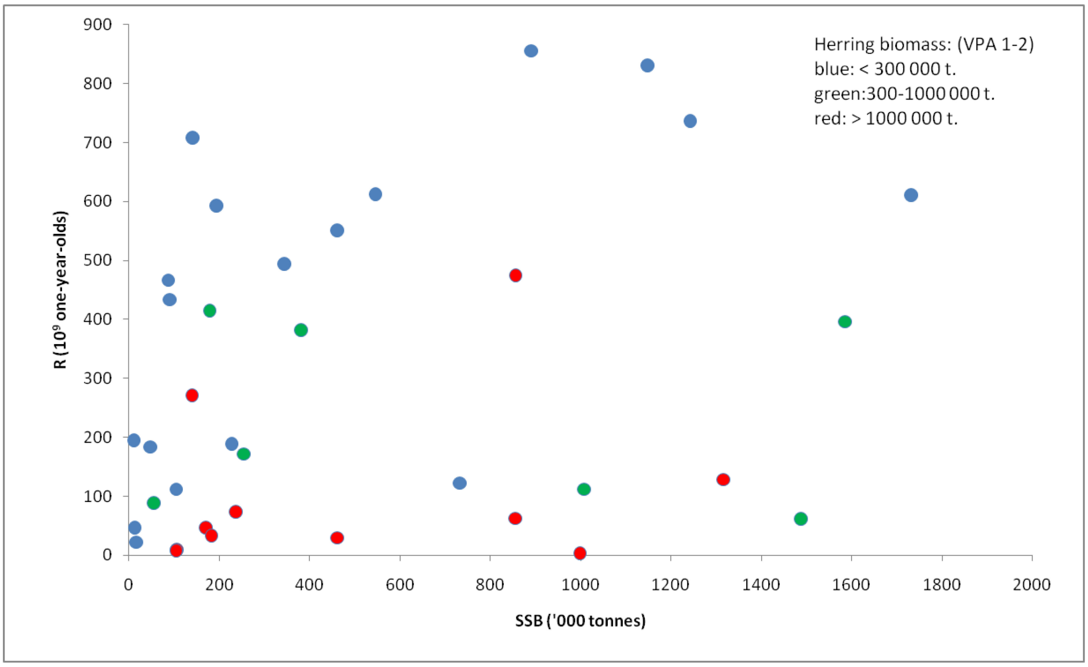

Figure 9.5. Spawning stock-recruitment plot for capelin, with colours of points indicating different levels of young herring abundance.

10 Working documents

WD#	Title	Authors
1	Protocol of an international workshop on capelin otolith reading	Anon.
2	Capelin spawning stock, prespawning migrations and Russian fishery in winter-spring 2010	Ushakov and Prozorkevitch
3	The Spanish NE Arctic Cod Fishery in 2009	Casas
4	Consumption of various prey species by cod in 1984-2009	Dolgov
5	Retrieving the times series of input data for assessment of NEA saithe	Fotland and Mehl
6	Data availability and critical gaps in knowledge in estimation of Catch at age for 3 stocks in the Norwegian Northeast Arctic fishery.	Fotland
7	Report on the Portuguese fishery 2009:ICES Div. I, IIa, IIb	Alpoim, Vargas and Santos
8	Acoustic abundance of saithe, coastal cod and haddock Finnmark – Møre, autumn 2009	Mehl, Berg and Aglen
9	Results of the Russian survey of Greenland halibut in the Barents Sea and adjacent waters in 2009	Smirnov
10	Methods for estimating F for coastal cod	Aglen
11	Spatial resolution of German CPUE for North-east Arctic saithe (Pollachius virens L.) in ICES Division IIa from 1995 to 2009	Bernreuther, Fock and Stransky
12	Evaluation of haddock predation on the Barents Sea capelin stock	Dolgov
13	Estimation of total catches of cod and haddock in the Barents Sea in 2009 incl. Comparison of vessel information	Norwegian-Russian Analysis Group
14	Report of the 2009 meeting between the Norwegian and Russian age reading specialists	Mjanger et al.
15	Results from the Joint IMR-PINRO Barents Sea demersal fish survey 1 February – 17 March 2010	Aglen et al.
16	Spanish bottom trawl May survey fletan artico 2009 in sthe slope of Svalbard area, ICES division IIb.	Ruiz Gondra and Mugerza
17	Data series on recreational and tourist fisheries for Norwegian Coastal Cod	Sunnanå
18	Current XSA analysis on Greenland halibut is sensitive to changes in some model assumptions	Hallfredsson
19	How can we assess recruitment models for (age-3) NEA cod?	Dingsør et al.
20	Indices of abundance from the Joint Norwegian-Russian Ecosystem Survey in autumn	Prozorkevitch
21	Stochastic Approach for Evaluating of Capelin Impact on NEA Cod Stock Dynamics	Filin
22	Assessment of population recruitment abundance of Northeast Arctic cod considering the environment data	Titov
23	The current situation of climate, phytoplankton, zooplankton, shrimp, harp seal and fish in the Barents Sea 2009 and beginning of 2010	Stiansen et al.
24	An assessment of the future assessment site	Stiansen et al.
25	To problem on methodology of Greenland halibut age reading by different registering structures	Kuznetsova

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Annex 1 - List of Participants

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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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Annex 4 – Stock Annex – Haddock in Subareas I and II

Quality Handbook **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:	26.04.2009
Revised by:	Alexey Russkikh / Sondre Aaanes

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 to embrace 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. Larvae extruded are widely drifted over the 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 a 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 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. The minimum catching size of haddock is 39 cm in the Russian Economic zone, 44 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.

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. The exploitation rate of haddock has been variable.

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 Iib 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 2009, the Working Group decided to follow the same procedure used as basis for advice in last year's, and only use the Norwegian 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.

In dependence on age and season haddock can vary their diet and act as both predator and plankton-eater or benthos-eater. 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 for lacking capelin with other fish species, i.e. young herring (*Clupea harengus*) or euphausiids and benthos, which are predominant in the haddock diet throughout a year. Haddock growth rate depends on the population abundance, stock status of main preys 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 favourable effect of other factors. Besides, 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 favourable environmental conditions strong year classes are mainly observed in years when the spawning stock is dominated by individuals from older age groups which abundance is 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, 2000).

The appearance of haddock strong 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 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.

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 seasons 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.

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 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 (mesh size is 125/135 mm in the Russian Economic zone and Svalbard area and 135 mm in the Norwegian Economic zone) and summarized by three ICES sub-areas (I, IIa and IIb).

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.

Data on length distribution of haddock in 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 reported to the WG by ICES sub-Division (I, IIa and IIb) according to national sampling. Missing 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 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.

The text 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				

The combined catch data were estimated by the SALLOC program (Patterson, 1998). The national data will soon be available in Intercatch, until then the 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 catch.

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

Stock weights used from 1985 and onwards are averages of values derived from Russian surveys in autumn (mostly October-December) and Norwegian surveys in January-March the following year. These averages are assumed to give representative values for the beginning of the year. In 2006 the Working group decided to model the stock weight-at-age data in order to remove some of the sampling variability in the estimates. The weight at age is modelled as follows: Mean length at age is modelled using a von Bertalanffy model with L_∞ and T_0 parameters estimated over the whole time series and a separate K parameter for each year class. Weight at age is estimated from a length-weight relationship using the smoothed (modelled) length at age. Estimates were produced separately for the Russian autumn survey and the joint winter survey and were later combined as plain average. For the earlier period (1950-1984) mean weight at age in stock is set equal to mean weight at age in the stock for 1985 and onwards.

In 2006 the Working Group revised the estimates of maturity at age. For the years 1980 onwards the series consists of predicted values using a logistic link function with age and length as explanatory variables from the joint winter survey combined with predicted proportions from the Russian autumn survey:

$$Mat = \frac{1}{1+e^{(-a*(age-age50\%)}}$$

The new series is based on the data from the Russian autumn survey and the joint winter survey. For the period 1950-1979 an average of both data series is used.

For both estimations and predictions the fixed natural mortality of 0.2 is used, and for age 3-6 mortality from predation is applied in addition.

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

Russia

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 - Spitbergen area (Baranenkova, 1964; Trambachev, 1981), both young and adult haddock 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).

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 haddock as well as the young haddock. The survey covers the main areas where fries settle down as well as 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 trawl).

There are two survey abundance indices at age: 1). absolute numbers (in thousands) computed from the acoustics and 2). trawl indices, calculated as relative numbers per hour trawling. 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 old and new method of calculating indices.

Ages 1-7 are used in the XSA-tuning.

Norwegian (from 2000 - Joint Norwegian-Russian) winter (February) survey

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). In 1991 and 1992, the number of young cod (particularly 1- and 2-year old fish) was probably underestimated, as cod of these ages were distributed at the edge of the old survey area. 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 codend in 1994 is not corrected for in the time series. This mainly affects the age 1 indices.

B.4. Commercial CPUE

Russia

No Russian data are used in the stock estimations.

Norway

Historical time series of observations from 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 the Lofoten, on which approximately 70% of Norwegian haddock catch fell. However, 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.

Other data

Not used.

C. Historical Stock Development

Model used: XSA

Software used: FLR suite and IFAP / Lowestoft VPA suite,

Model Options chosen:

Tapered time weighting applied, power = 3 over 20 years

Catchability independent of stock size for ages >6

Catchability independent of age for ages >= 9

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 = 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	1950 – last data year	1 – 11+	Yes
Canum	Catch at age in numbers	1950 – last data year	1 – 11+	Yes
Weca	Weight at age in the commercial catch	1983 – last data year	1 – 11+	Yes, set equal to west for 1950-1982
West	Weight at age of the spawning stock at spawning time.	1950 – last data year	1 – 11+	Yes
Mprop	Proportion of natural mortality before spawning	1950 – last data year	1 – 11+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1950 – last data year	1 – 11+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1950 – last data year	1 – 11+	Yes, set equal to average for 1950-1980
Natmor	Natural mortality	1950 – last data year	1 – 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	Russian bottom trawl survey, October-December	1983 – last data year	1-7
Tuning fleet 2	Joint Barents Sea trawl survey, February	1982– last data year	1 -8
Tuning fleet 3	Joint Barents Sea Acoustic survey, February	1980 – last data year	1 -7

D. Short-Term Projection

Model used: Age structured

Software used: R and FLR suite, IFAP prediction with management option table and yield per recruit routines

Initial stock status: is estimated in XSA as abundance of individuals survived in 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.

Natural mortality is mainly assumed equal to the level estimated for terminal year or to the average for the recent 3 years in dependence on expected cod predation. Method used to determine this parameter and its substantiation are given in the AFWG Reports.

Proportion mature: for current year preliminary actual data presented by Russia are used; for subsequent years – expert estimates by AFWG members. Method used to determine this parameter and its substantiation are given in the AFWG Reports.

F and M prior to spawning are assumed equal to 0 for all ages in all years.

Weight at age in the stock: Method used to determine this parameter and its substantiation are given in the AFWG Reports.

Weight at age in catch: Method used to determine this parameter and its substantiation are given in the AFWG Reports.

Distribution of fishing mortality at age (fishing 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.

F and M before spawning: Set to 0 for all ages in all years

Stock recruitment model used: None

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

Time lag: 4 years

Software used: R and FLR.

Initial stock status, natural mortality, proportion mature, proportion of F and M prior to spawning, mean weight at age in stock and in catch, exploitation pattern, predicted F in intermediate year: the same as in the short-term prediction.

Stock recruitment model is not used.

Uncertainty models used: See AFWG 2007.

F. Long-Term Projections

Spawning stock biomass per recruit (SPR) and yield per recruit (YPR) are estimated annually.

G. Biological Reference Points

Introduced 1998: Blim=50000t, Bpa=80000t, Flim=0.49, Fpa=0.35

H. Other Issues

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.*

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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.

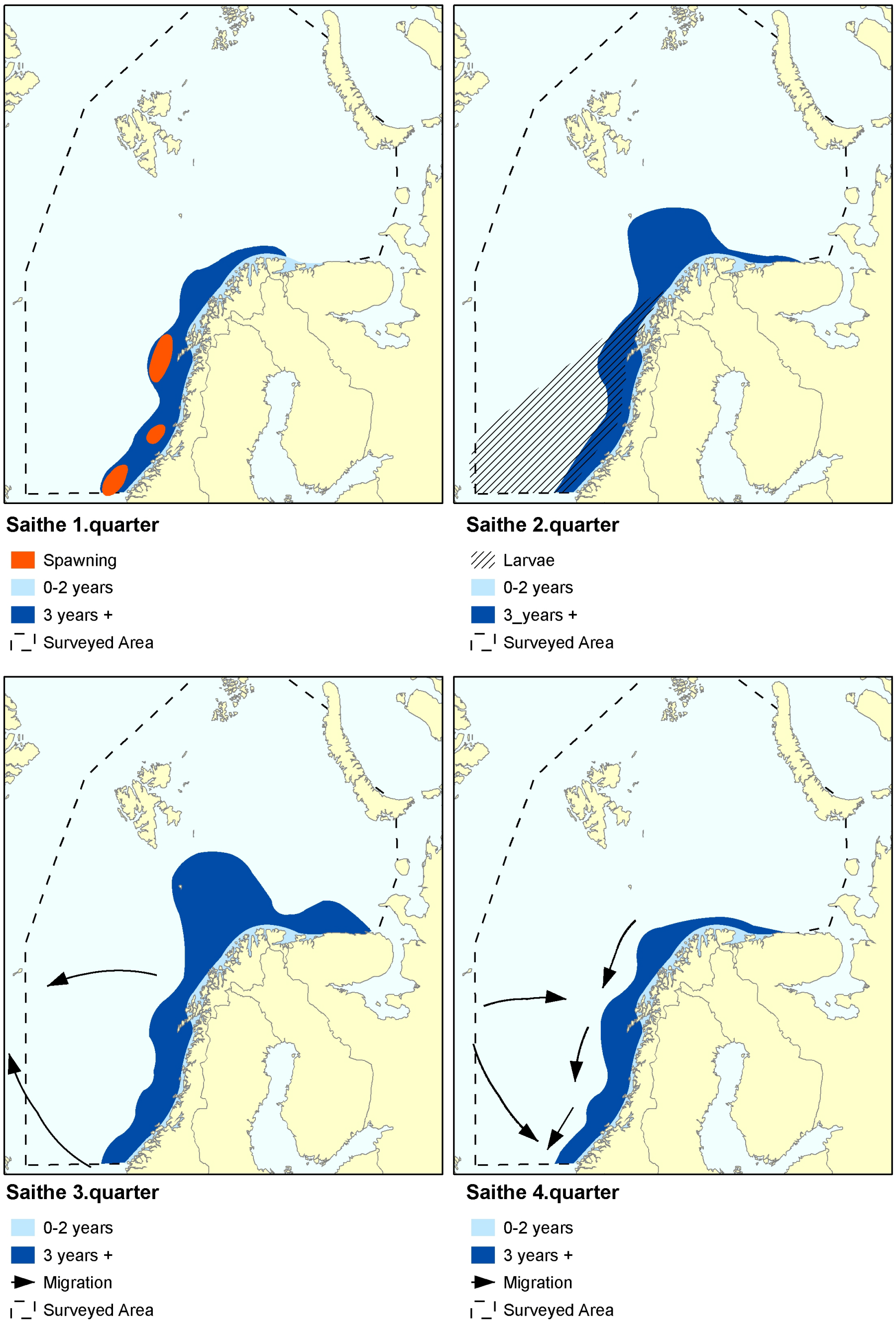

Figure 1. NEA saithe. Distribution of larvae, juveniles, adult spawning areas and the main migration patterns by (a) first quarter, (b) second quarter, (c) third quarter, and (d) fourth quarter.

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.

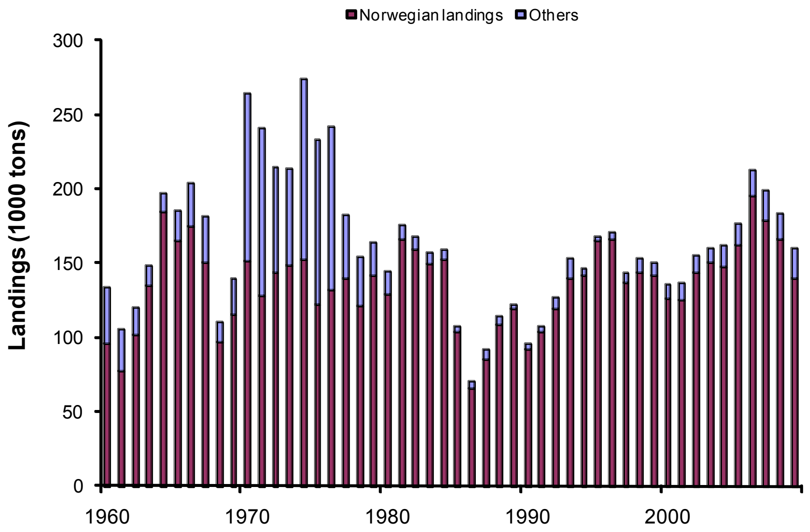

Figure 2. NEA saithe landings 1960-2009. Red part of bars shows the Norwegian landings.

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.

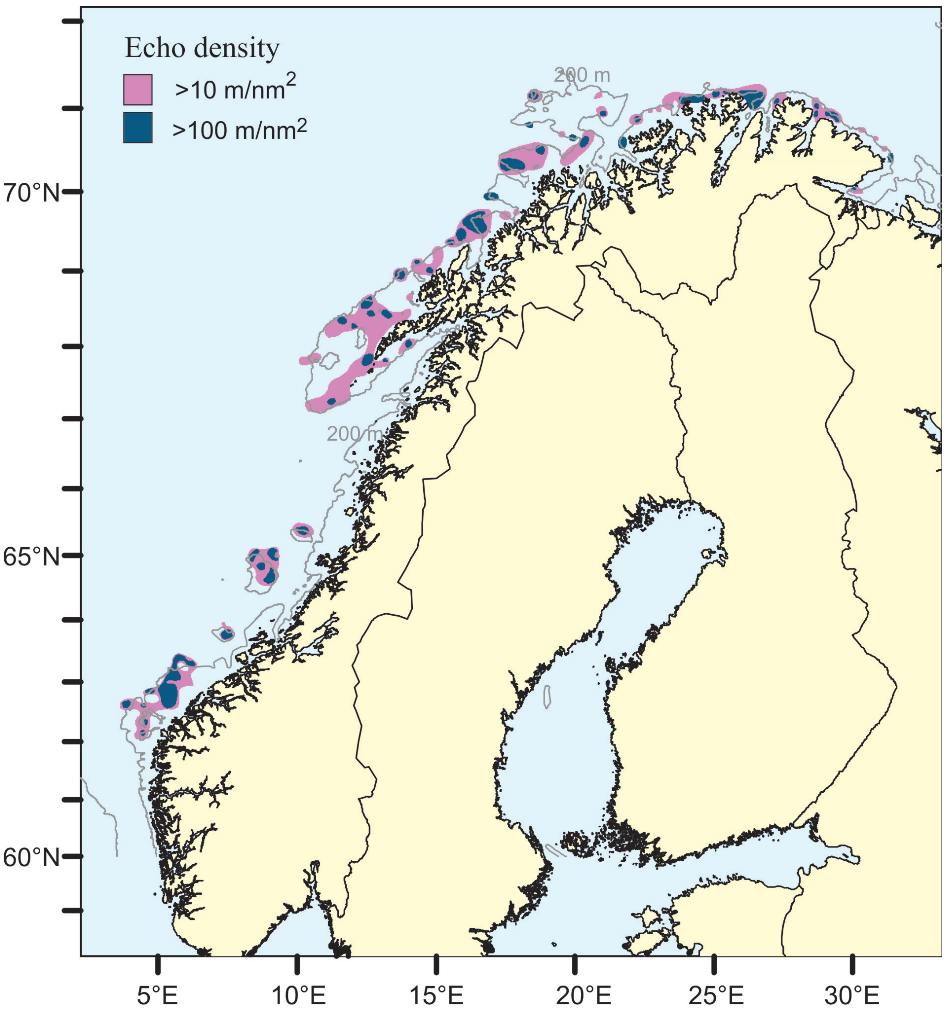

Figure 3. NEA saithe. Distribution of total saithe echo density in the acoustic survey autumn 1998.

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.

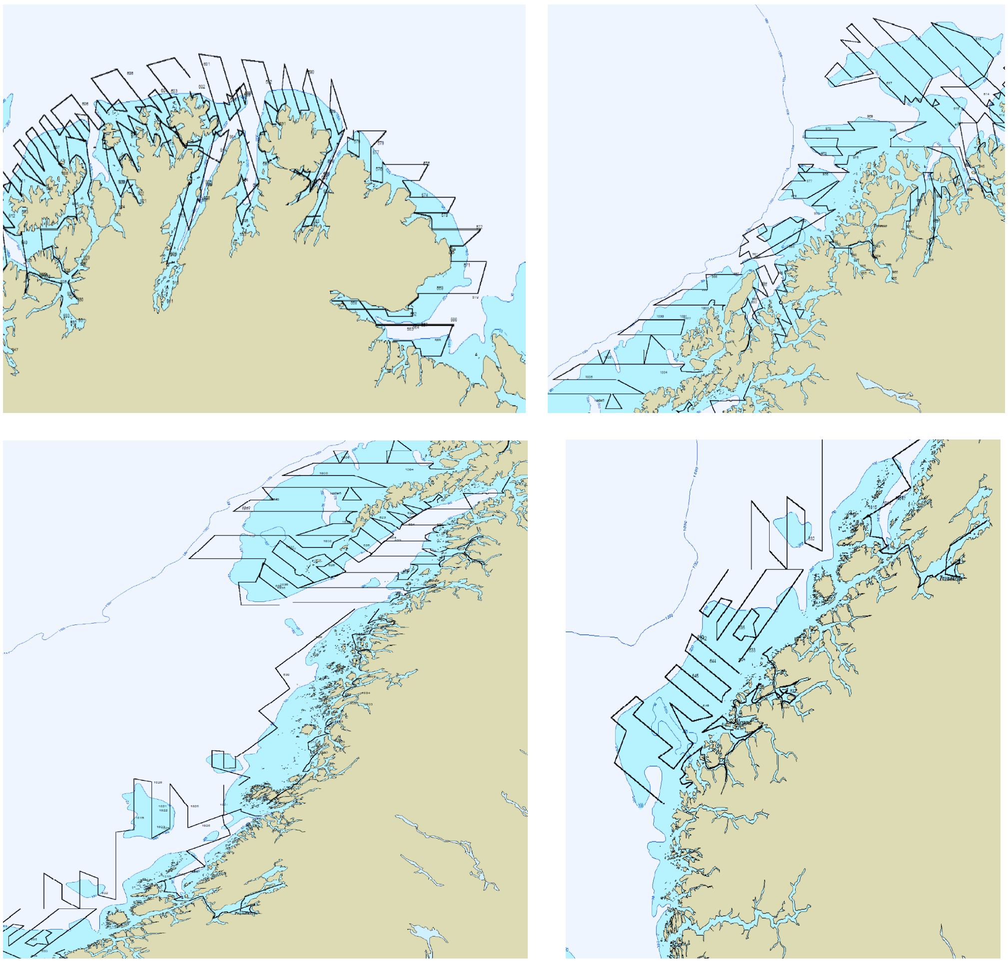

Figure 4. Standard transects in new combined saithe and coastal survey.

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 by-catch 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.

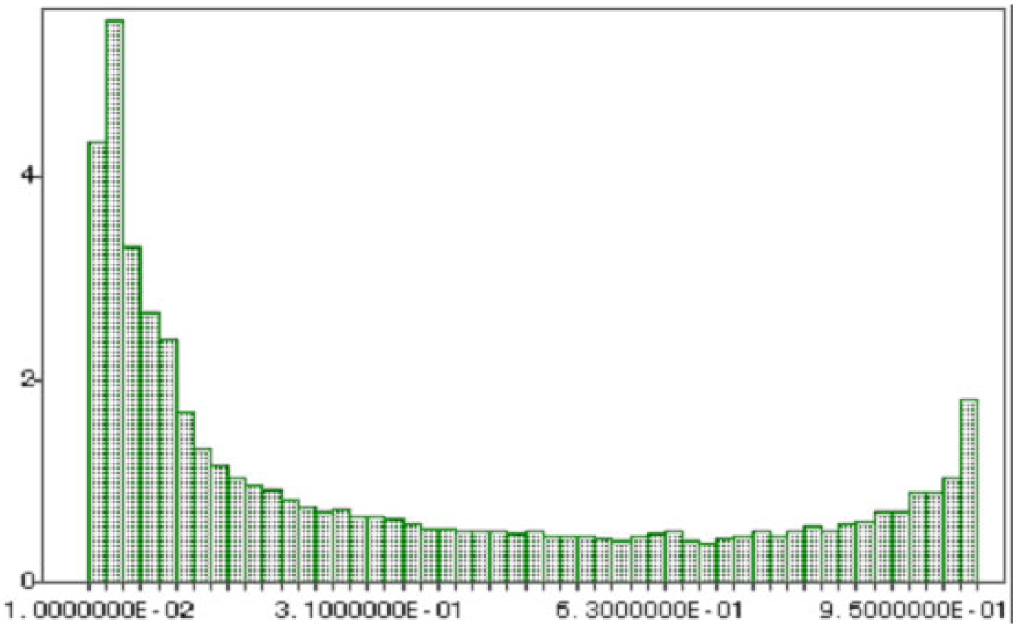

Figure 5a Distribution of small and large trawl catches of NEA saithe (in percent) 1994-1999.

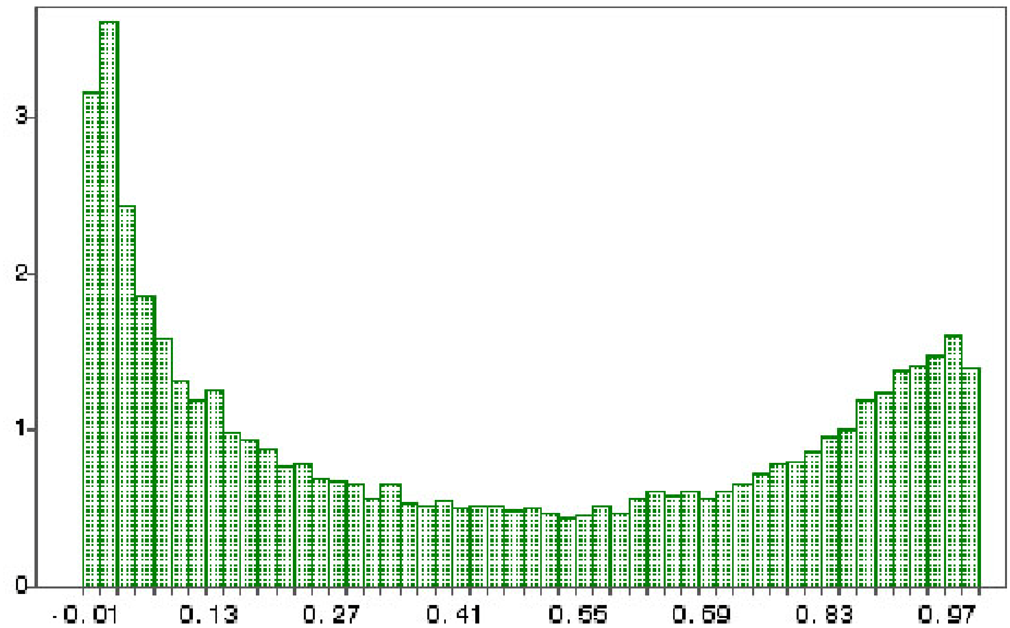

Figure 5a Distribution of small and large trawl catches of NEA saithe (in percent) 2000-2008.

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.

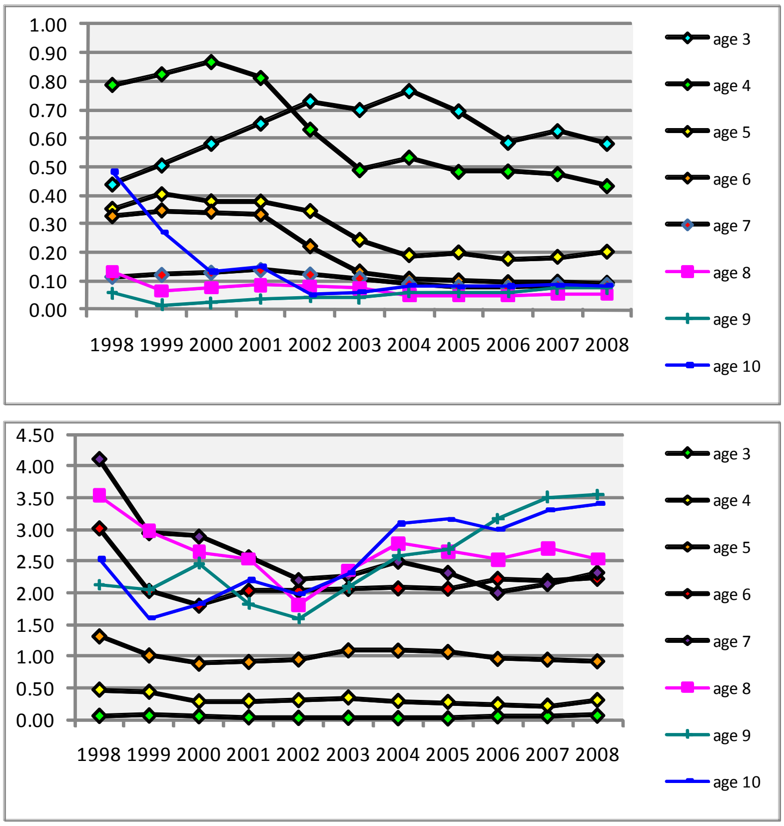

Figure 6 Catchability (index/N) at age in the Norwegian acoustic survey (upper panel) and in the Norwegian trawl CPUE series (lower panel).

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" $\mathbf{B}_{pa} = \mathbf{B}_{lim}\ \exp(1.645*\sigma)$ and $\mathbf{F}_{pa}=\mathbf{F}_{lim}*\exp(-1.645*\sigma)$, 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 ($\mathbf{S^*} = \mathbf{B}_{lim}$), 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" $\mathbf{B}_{pa} = \mathbf{B}_{lim}\ \exp(1.645*\sigma)$, 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" $\mathbf{B}_{pa} = \mathbf{B}_{lim} \exp(1.645^*\sigma)$, 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 PA-Soft 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*σ), 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*σ), 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 Sub-area 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 Kingdom	x	1)				
France	x	1)				
Spain	x	1)				
Portugal	x	1)				
Ireland	x	1)				
Greenland	x	1)				
Faroe Islands 1)						
Iceland	x	1)				

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 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. 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.

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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 Kingdom	*x*				
	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 – Stock Data Problems

Issues related to catch data collection and methodological improvements:– AFWG

Stock	Data Problem	How to be addressed	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.***
NeA saithe	Reduction in samples north of 67N from Q3 2009 for gillnet, Danish seine and line	The sampling should be improved from 2011 onwards	Norway
NEA saithe	Lack of purse seine samples between 62-67N	The sampling should be improved from 2011 onwards	Norway
NEA saithe	Lack of useful recruitment indices of 1 year olds		
NEA cod	Recruitment indices	Study group for recruitement	PGCCDBS
NeA saithe	In FLR "0" values in Canum file is not handled properly	Observed in WKROUND 2010 for NeA saithe where age span was expanded from 11+ to 15+ and for some years there are "0" values in canum file for som age groups. Bug reported to FLR web site http://bugs.flr-project.org/	FLR development team
Afwg stocks	Aiming at changing the basis for its advice from F_{pa} - B_{pa} to F_{MSY}, combined with a trigger spawning biomass ($B_{trigger}$). How should MSY be analysed and evaluated and be selected compared to excisting values in use.Which Year span and other settings is representative for long term Yield considerations for each stock? Is it a new targetpoint or range?	Work shop of MSY-related studies, in between afwg meetings?	ACOM

Stock	Data Problem	How to be addressed	By who
NEA haddock	Systematic differences in weight at age when comparing Russian surveys in late autumn and Norwegian surveys in winter. Possibly an age-reading problem.	First, the actual differences should be investigated further, e.g. by region, to exclude other possible sources of error Second, age reading comparisons should be intensified to investigate and possibly remedy between-reader bias	IMR, PINRO
Sebastes mentella	Norwegian and Russian age readings are not properly harmonized for mature fish, especially above age 15	The ICES Workshop on Age Determination of Redfish (WKADR) has reported this problem to be related to not including the proximal zone of the otolith sections when reading and determining the age.	Frequent exchanges of otoliths between Norway, Russia and others for comparative age readings. Should be reported to PGCCDBS and AFWG.
Sebastes mentella	Not all countries fishing S. mentella in international waters of the Norwegian Sea report their catches to NEAFC and ICES. EU reported catches are not split by individual country, which is problematic for the assessment. Lack of consistency between daily reports from the sea to NEAFC and later official reports by delegates to NEAFC.	NEAFC should provide ICES and AFWG with both the daily reports from the sea and the official reports to NEAFC by delegates.	PGCCDBS, ACOM, RCM NSEA
Sebastes spp.	Reduction in samples from the commercial fisheries for S. mentella and S. marinus	The sampling should be improved from 2010 onwards	RCM NSEA, Russia, Norway, ACOM

Annex 10 Evaluation of Rebuilding plan for coastal cod

Request from the Royal Norwegian Ministry of Fisheries and Coastal Affairs

Rebuilding plan for Norwegian coastal cod

The Norwegian coastal cod north of 62° N is recognized as a stock complex. Genetic studies indicate that some of the spawning components along the coast could be local stocks - more or less isolated from coastal cod in adjacent areas. Subsequently, the coastal cod management faces two major challenges – those being, first, to keep the total stock complex at a productive level and second, to give protection to potentially vulnerable local stock components. Both of these challenges are addressed in this draft rebuilding plan for coastal cod. Moreover, the knowledge regarding local stocks should be more specified, due to the fact that the scientific advice provided has become increasingly more specific on these matters.

The catch at age analysis (xsa) prepared for this stock has been considered uncertain. This is mainly due to the shortage of information from the recreational and tourist fisheries respectively. Similarly, the division of Northeast Arctic cod and coastal cod in the catches in northern areas has also been deemed uncertain. As a result of this uncertainty, the analyses of annual updates of spawning stock and fish mortality has not been particularly useful when seeking to define reference values for a rebuilding plan. Nevertheless, the coastal survey time series from 1995 onwards could be applied to define a sufficient rebuilding target. Similarly, mortality signals from sampling data could be used to monitor changes in fishing mortality.

Rebuilding plan

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.

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

[2] Ages 4-7

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.

ICES is asked to evaluate whether the above rebuilding plan is consistent with the precautionary approach. If this is not the case, or if the basis for evaluation is unsatisfactory, further advice for modifications or alternative plans is requested.

Comments on regulatory measures

At present, there are several regulatory measures employed. Importantly, the commercial catches of coastal cod are currently taken by vessels that have quotas of Northeast Arctic cod, whereby a small quantity has been added to their quota in addition to the expected "by-catch" of coastal cod. Second, the core regulation strategy used to reduce catches of coastal cod has been to restrict parts of the fleet to areas and seasons were they are most likely to catch Northeast Arctic cod. Third, since 2004 only vessels less than 15 meters have been allowed to fish within the fjords, as defined by fjord-lines. Moreover, only vessels less than 21 meters have been allowed to fish between the base lines and the fjord lines. Fourth, long-liners fishing with automatic baiting have to fish outside 4 nautical miles (nm), whereas trawlers have to fish outside 12 nm.[3] , Similarly, vessels fishing with Danish seine have to fish outside the fjord lines. Fifth, two coastal cod spawning areas have - in the spawning season - been closed for fishing, except for fishing with hand lines. Finally, some restrictions to the recreational fishery have also been introduced.

All the aforementioned regulation measures can potentially be employed to further restrict catches of coastal cod. In addition to these measures, a principle of increased mesh size can be introduced in coastal areas. This will improve the likeliness of survival to age of spawning, and further, the survival of second time spawning.

Due to the complexity of these fisheries and the variable mixing between Northeast Arctic cod and coastal cod, the exact annual effect of gradually increased regulations has proved difficult to predict. The accumulated effects over several years should, however, be expected to be in line with the above rebuilding plan.

Approach for the evaluation

The essence of the Rebuilding plan:

> ***-Reduce F annually by 15% relative to F2009.***
>
> ***-If the latest survey shows an increase, or if latest F is estimated to be <0.10, the regulations shall remain unchanged.***
>
> ***Rebuilding target = average survey SSB in the period 1995-1998.***

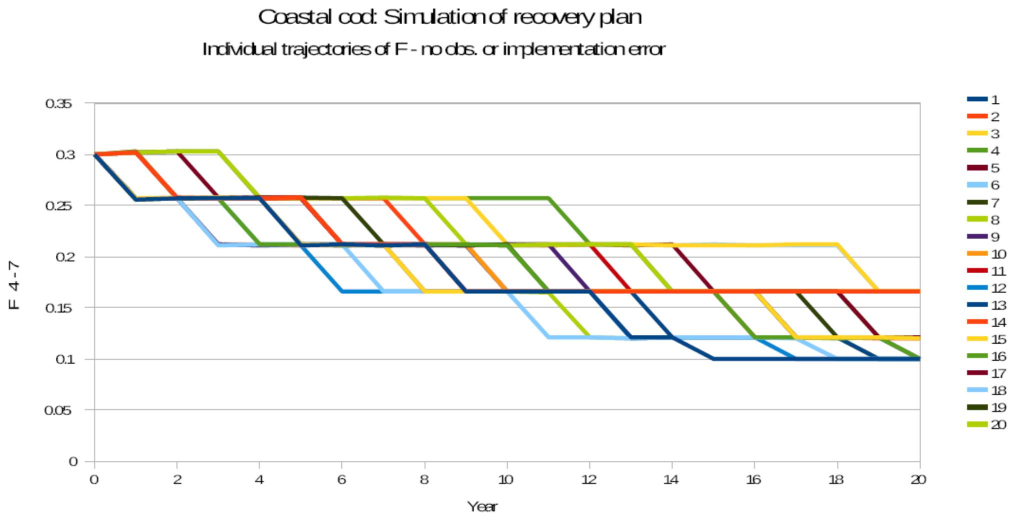
Assessment in spring in year Y, using survey and catches up to year Y-1

On this basis give management advice for year Y+1 (conditional to the survey result in fall in year y)

This reduction rule means that, conditional to the survey results, the following year will either require further action, or status quo. The starting value of F2009 will determine the number of action years required to reach the lower limit. As an example:

[3] 6 nm in some areas

F2009=0.3 will represent action steps of 0.045, which means 5 steps for theoretically getting below the lower limit. The total time span for reaching the lower F-limit will then be 5 plus the number of years with increased survey estimates. This is illustrated in the scheme below, where no errors are assumed for F, the starting point is 0.3 and the last step is adjusted to hit 0.1. In reality there will also be some additional action years in cases when the real F is below threshold, while estimated above, and at the same time the survey does not increase.



[The reduction rule is here taken as fixed steps. The wording "15% annually" could possibly be interpreted as 15% relative to the latest reduction. This means gradually decreasing steps, which prolongs the whole process and, after some years, causes "micro steps" that would be unrealistic compared to the precision both for the regulation measures and the stock assessment.]

The request is rather open both in terms of the basis for rebuilding target ("full reproduction potential", reference to historic survey results, or reference to historic SSB from analytical assessment). There is thus a need for considering candidates for "full reproductive potential" (analogous to B_{lim}), and considering improvements of the assessment. The HCS software (see details under "simulation model" p621) was considered useful both for examining candidate reference points and for simulating the plan.

The Norway-Russia annual quota agreements specify an expected catch of Norwegian coastal cod (NCC). This is a part of the total quota balance for cod. In the Norwegian regulations there is no specific quota for fishing coastal cod, but a total quota for cod, which typically is about 10 times larger than the expected "by-catch" of coastal cod. Thus the fishery for coastal cod is not directly regulated by quotas. Regulations introduced for reducing catches of NCC are closures of areas and seasons, and restrictions on vessel size and gear types/mesh size. These regulations shift the effort from fishing NCC to fishing NEAC or other species. For NCC this is thereby a type of effort regulation, which is an appropriate approach for regulating F. Originally the HCS simulation soft ware was designed to evaluate TAC-regulations where the intended F were translated to TAC, and the realized F was the result of the realized catch under the given TAC. Several simulations were done with this version, in case more direct TAC-regulations are part of the future plan. The main simulations were made with a modified, pure F-based version of HCS to better reflect the purpose of gradual F-reductions.

The complexity of these fisheries leads to a rather complex relation between the regulation and the effective effort "hitting" NCC. The implementation of the planned F-reductions will therefore be rather uncertain, and the simulations need to assume a rather large implementation error.

The F-reduction is conditional to the survey result. The consequence is that the uncertainty of the survey will contribute to slowing down the F-reduction rate, at least when the true stock is stable or declining. The simulations are therefore set up to examine different assumed survey uncertainties.

The xsa-assessment for NCC has shown rather serious retrospective problems and recent stock assessments have mainly been based on inspections of survey trends and signals in the catch data. In such a situation it is, therefore, convenient to consider a rebuilding target relating to future survey results. Since the plan is expressed in terms of F-reductions it is essential to be able to estimate recent Fs with a reasonable accuracy, thereby monitoring the results of future regulations following this plan. The retrospective XSA-analysis (made according to the existing Stock Annex) shows a quite biased F for the unconverged period (Figure 1). Trends of Z and F from "Surba" analysis has been tried at recent AFWGs, but currently warnings are given that the program should not be trusted. The next chapter describes how alternative methods can give reasonable estimates for the current F. Such estimates can be used further to estimate current stock size from the catch at age (defining terminal F in a traditional vpa), thereby giving an SSB that can be compared to a historic estimate of SSB. AFWG has this year used this approach to obtain an improved analytical assessment. This may be further improved before next benchmark assessment, and hopefully provide the basis for an alternative reference for the rebuilding target, in case the survey would be unsuccessful or cancelled.

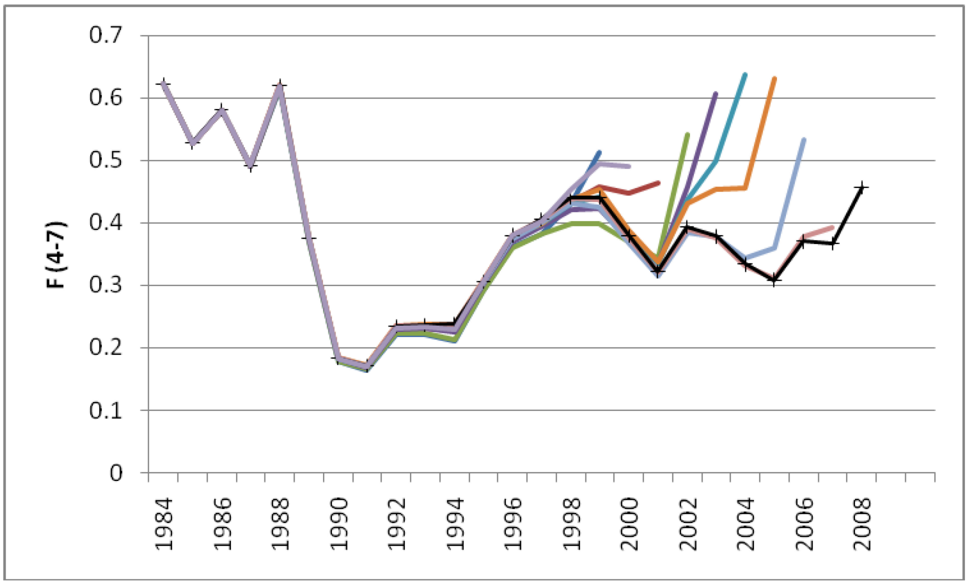


Figure 1. Retrospective F in xsa with the input and settings used by AFWG09.

Alternative methods for estimation of F

Survey based mortality estimates

A simple approach is to use the survey data, taking the decline in survey index (U) of each cohort from one year ($U_{a,y}$) to the next ($U_{a+1,y+1}$). This would contain all mortality, and in addition it will contain the age dependence in catchability. If both catchability and natural mortality is considered stable between years, those factors will only influence the scaling of the "survey mortality" while the trends observed would be driven by F. The coastal cod survey takes place late in the year, and it is reasonable to define the survey mortality for age a in year y as:

$Z_{a,y} = -Log(U_{a+1,y+1} / U_{a,y})$.

These age specific values can be further averaged within years for those ages where the survey is considered to be best. The resulting survey Zs by age and average across ages are shown in Table 1 and Figure2.

Table 1. Survey Z at age and averaged for ages 4-9, xsa values and F predicted from the survey Z. R is the correlation with vpa Fs for the corresponding age groups over the period 96-05.

	2	3	4	5	6	7	8	9	av4-9	F(4-7)vpa	survey pred F
1995										0.306	
1996	0.502	-0.122	0.096	0.223	0.867	1.100	1.437	1.566	0.881	0.380	0.381
1997	-2.372	-0.509	0.275	0.000	0.165	0.551	0.741	3.367	0.850	0.405	0.379
1998	0.810	0.227	0.781	0.849	1.373	1.906	2.523	2.193	1.604	0.441	0.443
1999	0.245	0.115	0.393	0.610	0.888	1.306	1.875	1.034	1.018	0.441	0.393
2000	-0.521	-0.026	0.305	0.237	0.278	0.805	0.555	1.046	0.538	0.379	0.352
2001	0.354	0.366	0.427	0.636	1.135	1.295	1.031	0.949	0.912	0.322	0.384
2002	1.029	0.495	0.481	0.740	0.606	0.557	1.297	2.821	1.084	0.393	0.398
2003	-0.479	-0.170	0.056	0.572	0.415	0.818	0.915	0.114	0.482	0.378	0.347
2004	-0.530	-0.544	-0.198	0.341	0.363	1.115	0.937	1.793	0.725	0.334	0.368
2005	0.557	0.005	0.145	0.295	0.484	0.549	0.350	0.306	0.355	0.309	0.336
2006	-0.560	-0.787	-0.071	-0.082	0.249	-0.063	1.032	0.880	0.324	0.370	0.334
2007	-0.537	-0.480	-0.310	0.149	0.350	0.552	0.868	0.706	0.386	0.367	0.339
2008	0.010	0.288	0.354	0.966	0.983	1.099	1.276	0.868	0.925	0.457	0.385
2009	0.033	-0.222	-0.470	0.121	0.271	-0.032	0.027	-0.095	-0.030		0.304
R	-0.453	-0.181	0.641	0.188	-0.087	0.278	0.666	0.327	0.665		

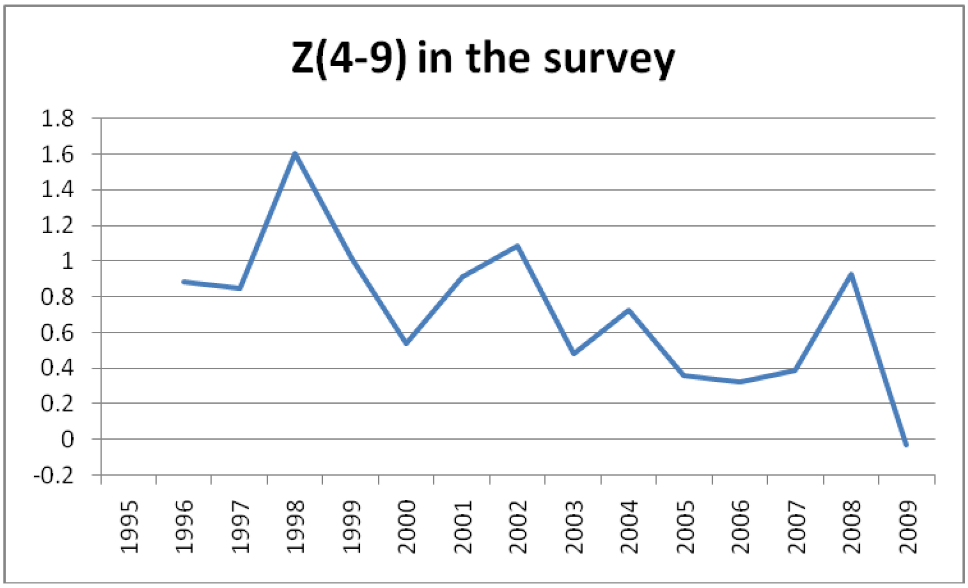


Figure 2. Survey Z averaged over ages 4-9.

When using such mortalities to monitor the effect of new regulations it would be a great advantage to normalize the level of the values so that they can be compared to F values used in the analytical assessment and in the model used for simulating the rebuilding plan. The survey mortalities are therefore regressed against the Fs in the converged part of the xsa. Figure 3 shows the relationship. This relationship is further used to convert the survey mortalities to "predicted xsa-Fs". The time trend of such predictions is shown in Figure 6. A weakness of this data series is the small range of Fs experienced over the observation period.

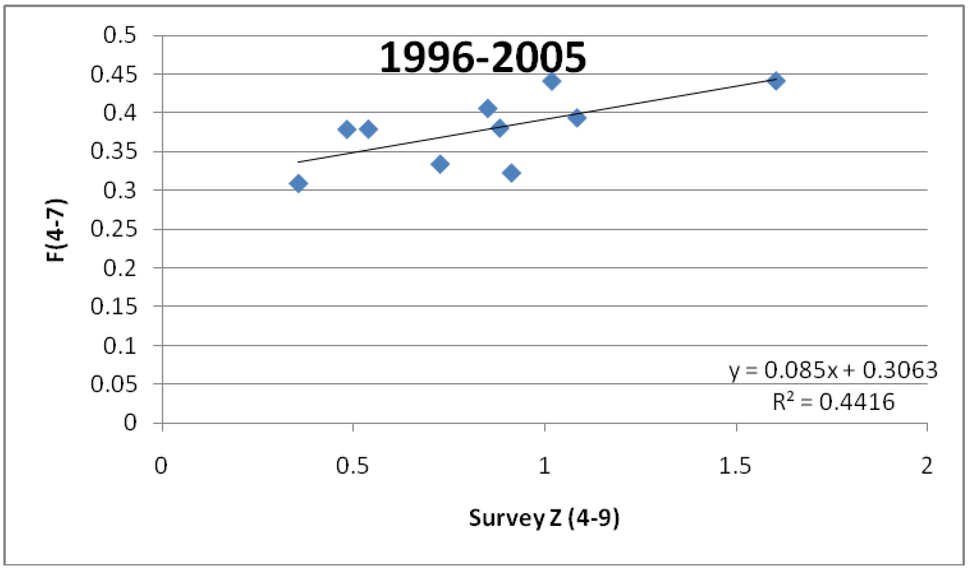


Figure 3. The relation between survey Z and xsa F for the overlapping part of the converged period (1996-2005).

Catch based mortality estimates

Similar calculation of Z can be made from the catch matrix. In this case log($C_{a,y}$/ $C_{a+1,y+1}$) is functionally related to F_y and F_{y+1}, but somewhat more related to F_y than to F_{y+1} . It is therefore reasonable to define

$Z_{a,y}$=Log ($C_{a,y}$/ $C_{a+1,y+1}$).

As for the survey mortalities, these catch based year to year mortalities can be used for predicting "vpa-Fs". Results for the coastal cod commercial catch data are shown in Table 2 and Figures 4, 5 and 6. Figure 7 and Table 3 show the results of similar analysis with the new data on recreational catches added.

Both the survey mortality and the catch based mortality show a fairly good ability to follow the historic variations in F seen in the vpa. It is not surprising that the catch based one follow the variation in vpa, but it is interesting to note that this simple mortality estimate appears more precise than the Fs that have been estimated in the unconverged part of the vpa. One disadvantage of the catch method is that it only gives values up to the second last catch year. A value for the latest year could be obtained by scaling the second last year by fishing effort or simply scaling by catch in tonnes.

Table 2. Age specific mortalities estimated from commercial catch at age data. R is the correlation with vpa Fs for the corresponding age groups over the period 96-05.

	3	4	5	6	7	8	9	av4-7	F(4-7) xsa	Catch pred F
1984	-0.751	-0.224	0.027	0.672	1.952	1.608	1.132	0.607	0.622	0.499
1985	-0.478	-0.190	0.414	0.605	0.881	0.723	0.062	0.428	0.528	0.430
1986	-0.699	0.018	0.699	0.775	1.233	1.401	0.831	0.681	0.581	0.528
1987	-1.269	0.244	0.629	-0.057	0.595	0.819	-0.062	0.353	0.492	0.401
1988	0.292	0.374	0.216	0.890	1.597	1.823	1.754	0.770	0.620	0.562
1989	-0.062	0.075	0.711	0.408	1.258	1.907	1.173	0.613	0.376	0.501
1990	-1.426	-0.926	-0.342	-0.139	1.376	1.767	0.405	-0.008	0.184	0.261
1991	-1.650	-1.114	0.040	-0.038	0.368	0.042	-0.748	-0.186	0.171	0.192
1992	-0.942	0.299	0.499	-0.026	0.039	0.359	0.193	0.203	0.235	0.343
1993	-1.523	-0.925	-0.052	-0.218	0.708	0.879	-0.241	-0.122	0.236	0.217
1994	-1.409	-1.120	-0.254	-0.282	0.830	1.000	0.585	-0.206	0.237	0.184
1995	-1.018	-0.743	0.110	0.288	0.451	0.483	0.025	0.027	0.306	0.274
1996	-0.282	0.094	0.683	0.166	0.228	0.775	0.272	0.293	0.380	0.377
1997	-0.331	-0.245	-0.006	0.477	0.768	1.223	1.028	0.248	0.405	0.360
1998	0.184	0.116	0.372	0.349	0.722	0.858	1.114	0.390	0.441	0.415
1999	-1.019	-0.484	0.468	0.921	1.592	1.739	1.628	0.624	0.441	0.506
2000	-0.638	0.209	0.645	0.640	0.711	0.556	0.104	0.551	0.379	0.477
2001	-1.529	-0.429	0.081	0.262	0.432	0.511	-0.701	0.086	0.322	0.298
2002	-0.852	-0.072	0.268	0.691	0.945	1.266	1.189	0.458	0.393	0.441
2003	0.181	0.201	0.320	0.402	0.814	0.973	-0.023	0.434	0.378	0.432
2004	-1.446	-0.682	0.176	0.490	1.035	1.175	0.458	0.255	0.334	0.363
2005	-1.251	-0.266	0.076	0.142	0.508	0.453	-0.175	0.115	0.309	0.309
2006	-1.489	-0.109	0.303	0.721	1.159	0.964	0.509	0.519	0.370	0.465
2007	-1.027	-0.158	0.404	0.373	0.627	0.598	0.409	0.312	0.367	0.385
2008									0.457	
R	0.732	0.740	0.717	0.729	0.879	0.786	0.810	0.846		

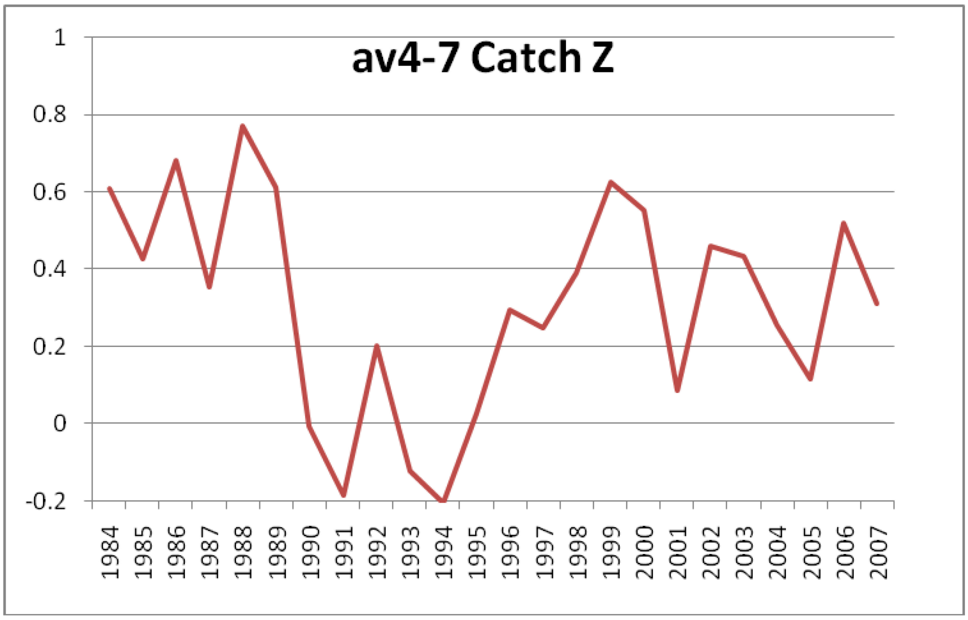


Figure 4. Catch based Z averaged over ages 4-7.

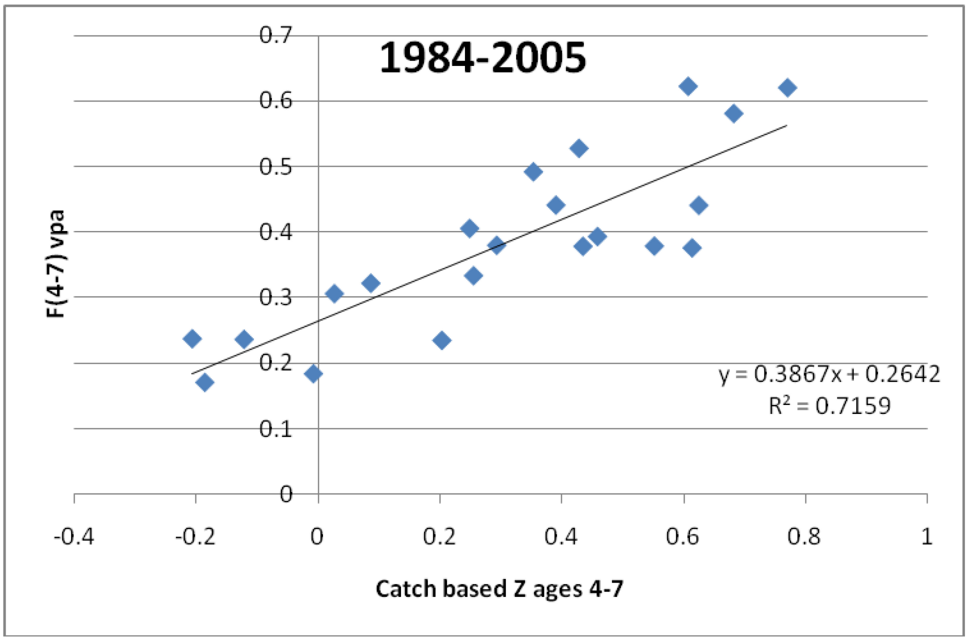


Figure 5. The relation between catch based Z and xsa F for the overlapping part of the converged period (1984-2005).

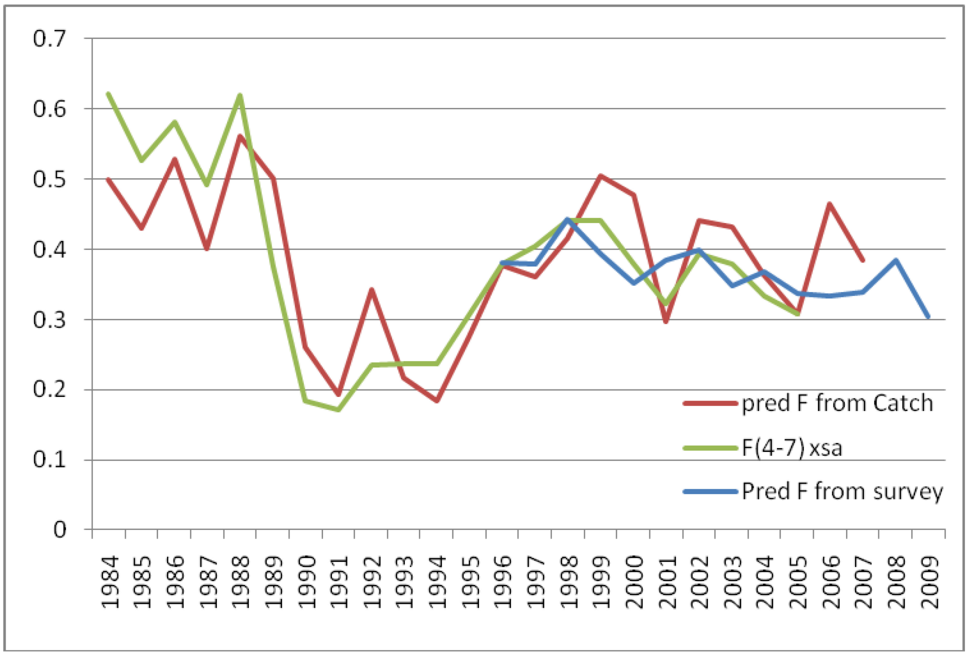


Figure 6. Comparison of F-estimates from survey, F-estimates from commercial catches and the converged part of the xsa based on commercial catch . 2009 data are included for the survey, but not for the catches.

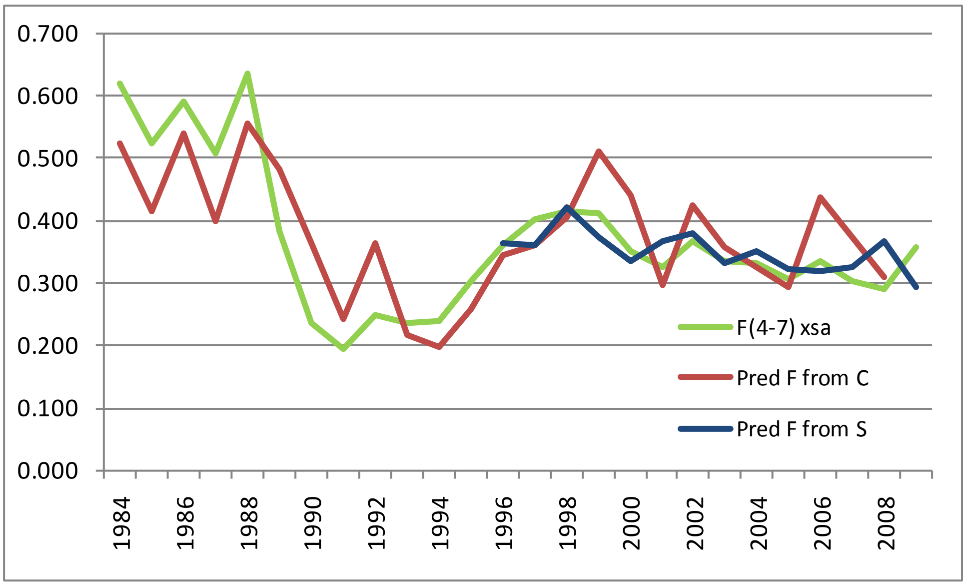


Figure 7. Comparison of F-estimates from survey, F-estimates from total catches and the converged part of the xsa based on total catches. 2009 data are included for the survey, and for the catches.

Table 3. Age specific mortalities estimated from catch at age including recreational catches. R is the correlation with vpa Fs for the corresponding age groups over the period 96-05.

	3	4	5	6	7	8	9	av4-7	F(4-7) xsa	Catch pred F
1984	-0.625	-0.141	0.146	0.783	1.896	1.544	1.283	0.671	0.618	0.523
1985	-0.384	-0.082	0.416	0.586	0.772	0.552	0.230	0.423	0.524	0.416
1986	-0.541	0.048	0.733	0.805	1.247	1.466	1.172	0.708	0.590	0.539
1987	-0.522	0.406	0.517	-0.031	0.661	0.738	0.053	0.388	0.507	0.401
1988	0.132	0.191	0.211	0.990	1.600	1.773	1.927	0.748	0.634	0.556
1989	-0.225	0.371	0.055	0.526	1.342	2.014	1.308	0.574	0.383	0.481
1990	-0.881	-0.584	-0.287	0.714	1.386	1.427	0.405	0.307	0.237	0.365
1991	-0.511	-0.285	0.207	0.086	0.075	0.059	-0.318	0.021	0.194	0.242
1992	-0.431	0.557	0.516	-0.040	0.171	0.561	0.289	0.301	0.249	0.363
1993	-0.731	-0.516	-0.174	-0.127	0.681	0.833	0.221	-0.034	0.236	0.218
1994	-0.905	-0.664	-0.352	-0.076	0.763	0.951	0.733	-0.082	0.240	0.197
1995	-0.890	-0.566	0.077	0.254	0.465	0.507	0.305	0.058	0.302	0.257
1996	-0.341	-0.011	0.542	0.182	0.324	0.846	0.498	0.259	0.362	0.345
1997	-0.540	-0.246	0.056	0.500	0.866	1.179	1.157	0.294	0.401	0.360
1998	0.043	0.137	0.369	0.377	0.723	0.773	1.346	0.402	0.413	0.406
1999	-0.991	-0.339	0.512	0.936	1.464	1.371	1.879	0.643	0.411	0.511
2000	-0.523	0.181	0.586	0.487	0.671	0.344	0.706	0.481	0.352	0.441
2001	-1.316	-0.410	0.088	0.328	0.602	0.412	-0.161	0.152	0.325	0.298
2002	-0.840	-0.079	0.231	0.702	0.930	0.761	1.599	0.446	0.367	0.426
2003	0.029	0.045	0.159	0.303	0.635	0.775	0.794	0.285	0.336	0.356
2004	-1.251	-0.647	0.142	0.467	0.886	0.977	0.998	0.212	0.333	0.324
2005	-1.279	-0.269	0.003	0.209	0.618	0.726	0.486	0.140	0.305	0.293
2006	-1.364	-0.049	0.321	0.681	0.951	0.870	0.838	0.476	0.336	0.439
2007	-0.929	-0.138	0.399	0.387	0.659	0.721	0.888	0.327	0.302	0.374
2008	-0.424	0.083	0.094	0.123	0.425	0.984	0.235	0.181	0.292	0.311
R	0.635	0.583	0.832	0.778	0.791	0.858	0.683	0.819		

Estimates of F2009 and future F-reductions

The current stock assessment has used these alternative estimates. For the time series based on only the commercial catch F2009 is estimated to 0.37. For the time series including recreational fisheries F2009=0.31. The corresponding Fs to aim at in future "Action years" will then be as follows:

Assessment basis	F2009	Action yr 1	Action yr 2	Action yr 3	Action yr 4	Action yr 5
commercial	0.37	0.31	0.26	0.20	0.15	0.10
Total catch	0.31	0.26	0.22	0.17	0.12	0.10

Simulations

Simulation model

Simulations were done with a modification of the HCS10 software. The simulation program HCS has been used to explore and evaluate several harvest rules in the past (e.g. mackerel and Blue whiting). It has developed gradually; the most recent update from 2010 is termed HCS10. This program was used recently to explore candidate FMSY values for a range of stocks (Skagen, WD to WKFRAME) and by HAWG for the same purpose for most herring stock covered by that group (ICES 2010 a and b).

The program has not been formally published but a full description of the program, as well as the source code, are available from the author (dankert.skagen@imr.no).

The program was modified to simulate a harvest rule that is only guided by a noisy survey estimate of SSB (instead of an assessment result). The program is a stochastic medium term simulation, with 1000 replicas run over 20 years for each set of management options. It has an age structured true population that is projected forwards with randomly drawn recruitments, and true catches emerging from implementing (with noise) a TAC set according to a harvest rule. The harvest rule sets a TAC based on noisy observations of the true stock. In the present version, the observations are SSBs derived by adding noise to the true stock numbers. The rule specifies an F-value that is reduced if the observed SSB is reduced from one year to the next, but with a lower bound of 0.1. An alternatively option available for simulation is that the F is reduced irrespective of the observed SSB until it reaches 0.1. The reduction is by a fixed step size, which is a given percentage of the F in the intermediate year at the start of the simulation. The implementation of the rule is by deriving the catch corresponding to the decided F applied to the true stock, adding random noise to the catch numbers at age. This realized catch at age is normalized so that the total catch in tonnes is unchanged. On top of that, the numbers are expanded with a random year multiplier. These implemented catches are removed from the true population.

In the present study, recruitments were drawn according to a hockey stick stock-recruit function with lognormal noise. Weights and maturities at age had fixed values. The assumed selection at age also had fixed values; the realized selection is influenced by the age factor in the implementation error. The F for year Y was reduced if the observed (survey) SSB in year Y-1 was lower than in year Y-2. Simulations started at 1. January 2009, with initial numbers taken from the assessment and an assumed catch for that year. The initial numbers were made noisy using the same model as for observations elsewhere. F was modified for the first time in 2011, while the decided F in 2010 was equal to the realized F in 2009.

The model was set up to with the following parameter values:

-F reduction: 15, 20 and 25% relative to F2009

-CVmod; CV of the survey estimate of SSB: 0 and 0.3

-CVi; CV of "the random year multiplier" reflecting the implementation error in a given year: 0 and 0.3

-CVage; CV of the implementation error by age, reflecting the variability in selection at age, was set to 0.2 for all ages in all years. This value is also used for the uncertainty of the initial stock numbers.

F-based simulations

Choice of biological input

A time series of estimated recreational catch at age was presented to the 2010 AFWG. These catches show rather low variation (13-16 kt) over the years 1984-2009, while commercial catch has varied between 22 and 75 kt. The recreational catches thus represent a considerable fraction of total catch, particular in recent years (about 35%) when commercial catch has been low. The new catch data including recreational catches is expected to better reflect the stock dynamics, but the uncertainty of these additional catches are considered to be large. It is, therefore, useful to explore whether the simulation results are sensitive to the differences in the two sets of input data.

In addition, there is large uncertainty relating to the current and future recruitment regime. The long term decline in recruitment, also in periods with high SSB, could indicate that the high recruitments experienced in the early history may not reoccur even with a rebuilt stock. Therefore, two versions of hockey-stick S-R relationships were assumed for each of the time series; one utilizing the full time series, thereby allowing for high R at high SSB, and one based on the most recent years when only low R has been observed.

The input data based on the new catch data, combined with the assumption of low future recruitment was considered to be the most realistic basis for simulations. Simulations with other inputs were run to examine the robustness of the conclusions against these differences of input.

Equilibrium estimates as function of F for yield, SSB and R is estimated as a part of the HCS simulation. Thereby, also F0.1, Fmax, F35%SPR and Fcrash are estimated. The results of these 4 break point analysis are shown below. The Fmax was at Fcrash (beyond Fcrash if estimated by classical Yield per Recruit analyses) in all cases, except the one with added catch and high recruitment, where it was just below Fcrash.

"Reported catch"

A break point analysis of the full series (red line in Figure 8) gives a plaeau of 33.3 million recruits above an ssb of 114 kt. Assuming changed recruitment conditions since 2000 (Figure 8; the green line based on the lower 6 points) gives a plateau at 17.6 mill recruits above an ssb of 71 kt.

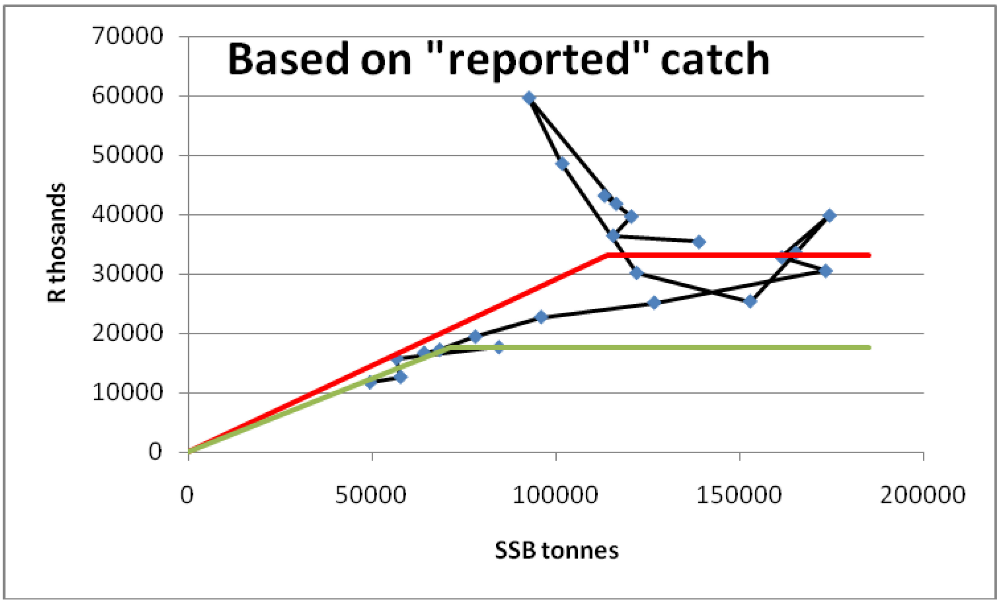


Figure 8.Stock-Recruit plot for the year-classes 1984-2005. Red line fitted to full time series, green line fitted to the 6 lowest points (year-classes 2000-2005). From an assessment based on commercial catch.

Simulations with hockey-stick recruitment functions with these breakpoints were run, setting recruitment variation according to a cv=0.33 for the log residuals. This give the following results

R-plateau	bp SSB	Fcrash	F0.1	Y at F_{crash}	Y at F_{max}	Y at $F_{0.1}$	SSB at F_{crash}	SSB at F_{max}	SSB at $F_{0.1}$
17.6	71	0.30	0.17	27	27*	25	72	72*	125
33.3	114	0.35	0.17	52	52*	48	114	114*	237

The F at 35%SPR = 0.16, which is very close to F0.1. This shows slightly higher Fcrash values and slightly lower F0.1 than those calculated at WKPOOR2 (ICES 2009). The changes in Fcrash seem to be mainly caused by the changed maturity input for the historic SSB time series. The change in F0.1 is related to updated values for exploitation pattern and weights at age.

Recreational fisheries added

The SSB and R time series from an assessment based on the added catch data gives the S-R relationship shown in Figure 9. A break point analysis of the full series (red line) gives a plaeau of 46.7 million recruits above an ssb of 139 kt. Assuming changed recruitment conditions since 2000 (the green line based on the lower 6 points) gives a plateau at 28.6 mill recruits above an ssb of 103 kt.

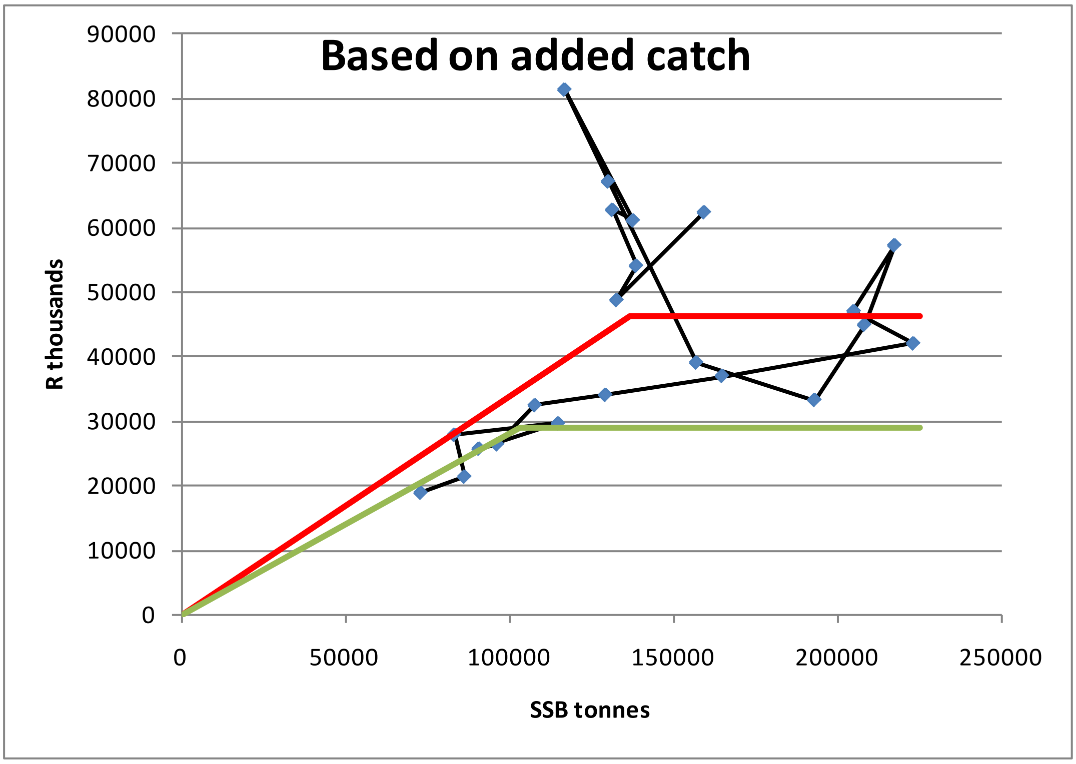


Figure 9. Stock-Recruit plot for the year classes 1984-2005. Red line fitted to full time series, green line fitted to the 7 lowest points (year classes 2000-2005). From an assessment based where recreational catches are added.

HCS analysis with hockey-stick recruitment functions with these breakpoints were run, setting recruitment variation according to a CV=0.33 for the log residuals. This give the following results

R-plateau	bp SSB	Fcrash	F0.1	Y at F_{crash}	Y at F_{max}	Y at $F_{0.1}$	SSB at F_{crash}	SSB at F_{max}	SSB at $F_{0.1}$
28.6	103	0.32	0.16	45	45*	41	104	104*	209
46.7	139	0.38	0.16	73	74	67	139	158	341

The F at 35%SPR = 0.15, which is very close to F0.1. The values of F0.1 are similar to those calculated including only "reported" catch. A minor increase for Fcrash seem to be mainly a result of the added catches being larger relative to total catch in recent years, thereby causing a larger relative increase for the recent R and SSB values compared to the older. These new Fcrash values are still close to the current F, and there is still very important to reduce the F well below the current level. Thus, the main conclusions with these new data are similar to those given by WKPOOR2 (ICES 2009).

Precautionary Approach Reference points have not been established for this stock. Taking this "added catch and low break point" data set as the best description of the stock dynamic, the break-point SSB=103 kt would be a good candidate for Blim, and Fcrash=0.32 a good candidate for Flim.

Bpa would then be the estimated SSB which has high probability of being above the break-point SSB (103 kt) and Fpa the estimated F that has high probability of being below Fcrash (0.32). The simulations based on this break point (Figures 10 and 11) shows that the 90 percentile of F falls below Fcrash when average F falls below about 0.16. This reflects, however, the frequency distribution of realized Fs corresponding to the rebuilding conditions and the assumed errors. This can thus not be taken as a candidate Fpa. The simulation setup applied is not well designed for giving estimates of PA values.

Simulations based on alternative stock dynamics and regulations

The simulations based on added catch and low recruitment are presented in some detail in the section below. The three other sets of biological input data described above were also tested out and some results are summarized in Tables 4-9. The main patterns are similar to those described in the section below. Those based on commercial catches were generally a bit more pessimistic than those based on added catch. Those with high recruitment were a bit more optimistic than those with low, not only in terms of biomass and catches, but also in terms of rebuilding time (Table 9).

Simulations with the TAC versions of the software are also shown in Tables 8 and 9. These are indicating slightly slower rebuilding. The main reason is probably that the CVobs used here results in some cases where the stock is strongly overestimated and the corresponding quota results in a realized F much higher than intended. This might illustrate that when uncertainty is high, pure TAC-regulation could be more risky than a F control regime.

Simulations based on the added catch data and low recruitment

The current F (in 2008 and 2009) was in the assessment estimated to be near 0.30 which is close to the average of the previous 5 yrs. The selection and weights at age was set as the recent 5yr average in the vpa. In the forward simulations the total catch in 2009 was set equal to 2008 (37 kt), and the recovery plan started from 2010 with an intended F equal to the realized F in 2009. Three reduction rates; 15%, 20% and 25% was simulated. The rebuilding target (a survey value of 60 kt spawners = 95-98 average) was in the model replaced by the 95-98 average of ssb in the historic assessment =180 kt. This corresponds to scaling the survey to the historic vpa, while keeping the assumed CV. Various assumptions were explored. The CV of the implementation error (CVi) and the CV of the survey (CVmod) were both run for the values 0 and 0.3. The auto correlation for the observation model (survey) was kept at 0. The survey is recognized as uncertain, and it is rather obvious that it will be very difficult to design regulations that will give the desired F-reduction by a high accuracy. CVs at 0.3 could be considered realistic. Some results with these CVs set to zero are shown for comparison. An additional "CV at age" (uncertainty in age distribution) was set to 0.2 for all ages in all simulations, also those where other CVs were zero.

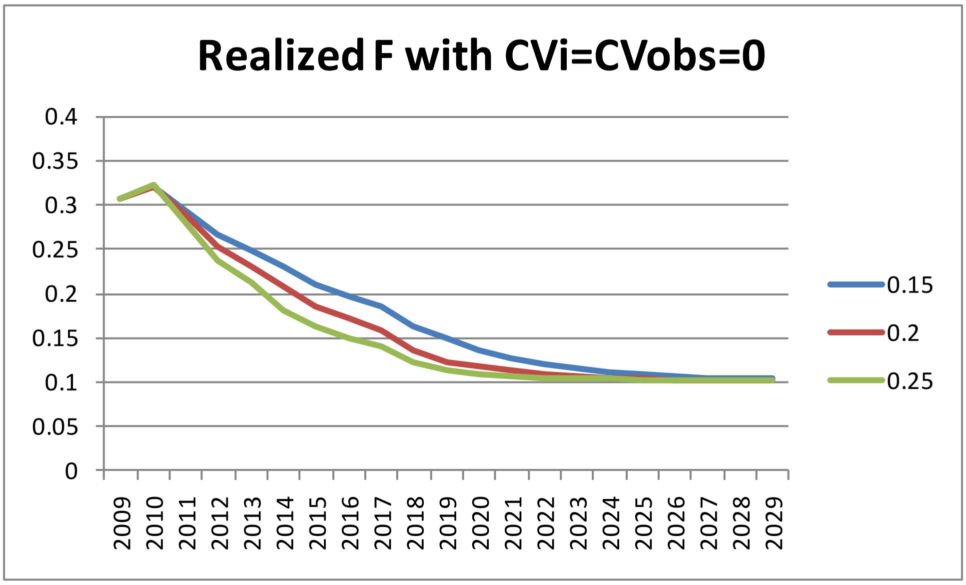
No attempts have been made to split the simulation on the commercial and the recreational fleet. If the additional regulations in coming years work equally on the two fleets, it should be expected that about 35% of catches will be taken in the recreational fishery.

Figures 10-13 show the time development for the average of 1000 simulations. Figures 14 and 15 show the development of 20 individual trajectories for F and SSB. This illustrates the larger variability caused higher CVs. Tables 4-6 summarize some of the key findings, and compare these simulations with those based on other input and assumptions. In the further description the terms 0.15, 0.20 and 0.25 are used for 15, 20 and 25 % F-reduction steps. This is done to avoid confusion with percentiles in the observed frequency distributions.

The average F in 2010 comes out higher when errors in observation and implementation are assumed (Figure 10). The further propagation of average F is rather similar with and without those errors. With errors assumed the average F levels off at 0.11, just above the minimum threshold. The 90 percentile of F is below the Fcrash already in 2013 when CVs are zero, while for the 0.15 curve with CVs of 0.3 this does not occur before 2017 (Figure 11).

For all F-reduction rates the average catches decrease to a minimum of 23 kt, and increases from there (Figure 12). Both the decrease and the increase are slowest for the 0.15 case.

Average SSB increases very slowly the first 4 years (Figure 13a). The 0.15 curve shows an average SSB hitting the rebuilding target (180 kt) in 2025. The 10 percentile of the SSB distribution (Figure 13b) does not reach the rebuilding target within the period considered, but it crosses Blim in 2026 in the 0.15 case, while for the 0.25 case it occurs 3 years earlier. The lower panel of Figure 13b shows the probability of SSB<Blim. In the 0.15 case the curve falls below the 10%-line in 2026 as also illustrated by the upper panel in Figure 13b.



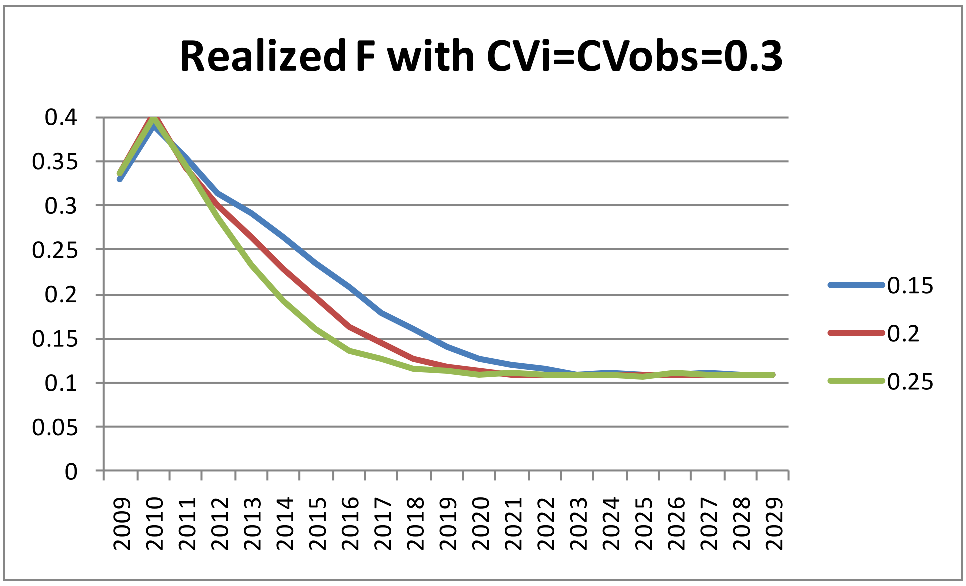
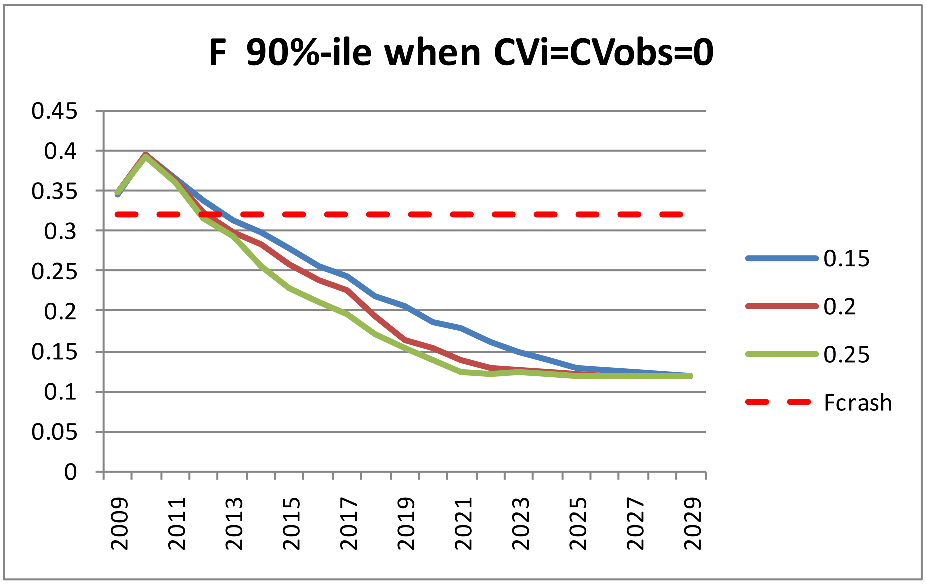


Figure 10. Average realized F when the reduction steps in "action years" are 15% (blue), 20% (red) and 25% (green)



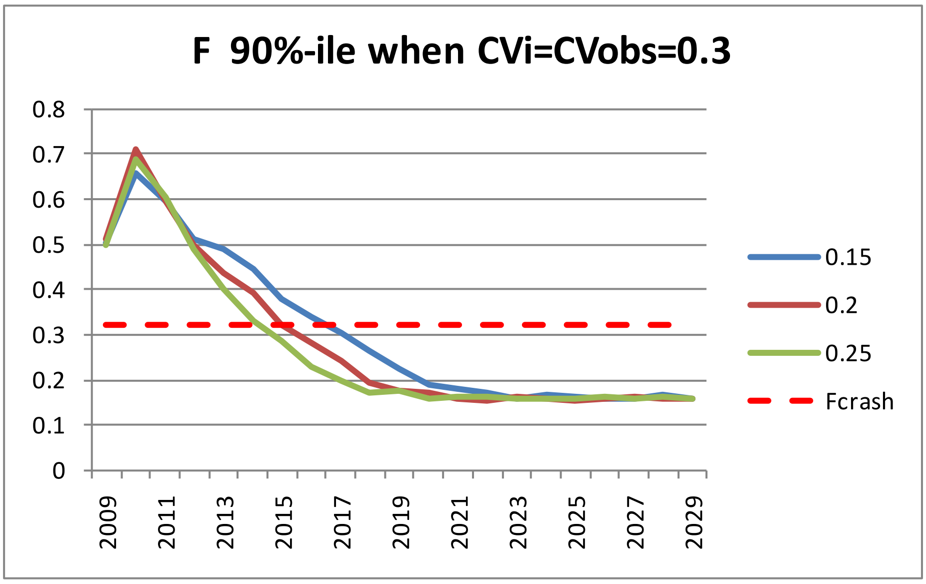


Figure 11. The 90 percentile for the distribution of realized Fs when the reduction steps in "action years" are 15% (blue), 20% (red) and 25% (green). Dotted red line is the Fcrash.

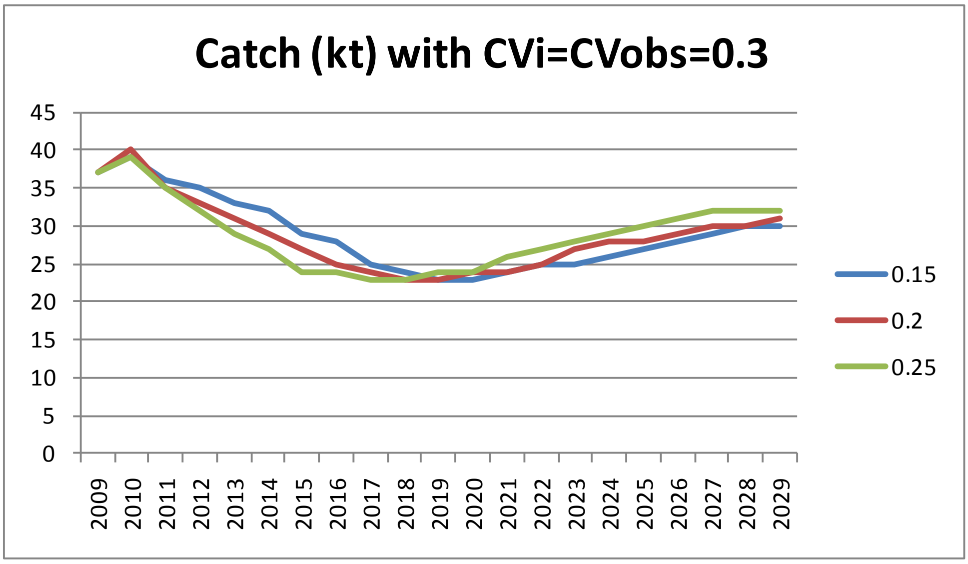


Figure 12. Average realized catch when the reduction steps in "action years" are 15% (blue), 20% (red) and 25% (green).

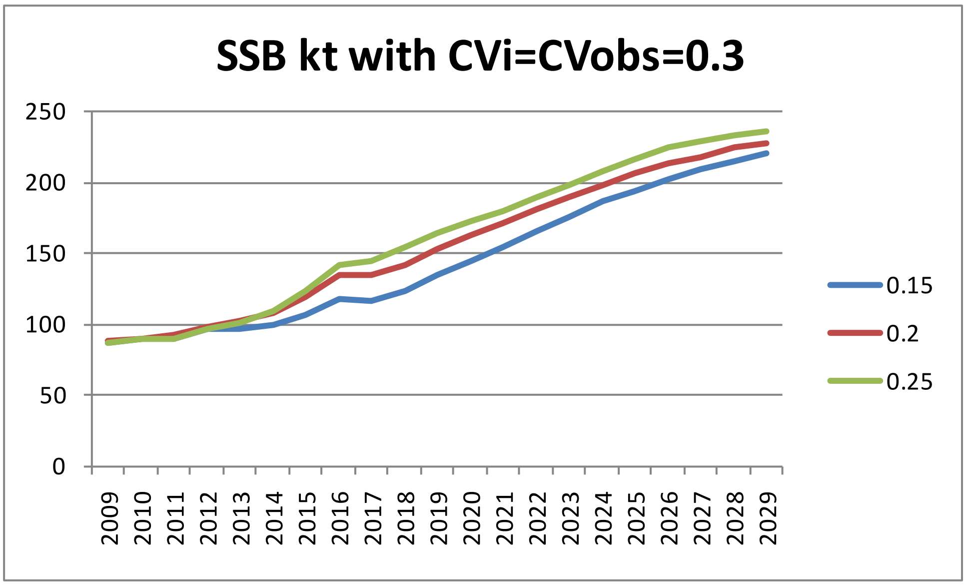


Figure 13a. Average SSB when the reduction steps in "action years" are 15% (blue), 20% (red) and 25% (green).

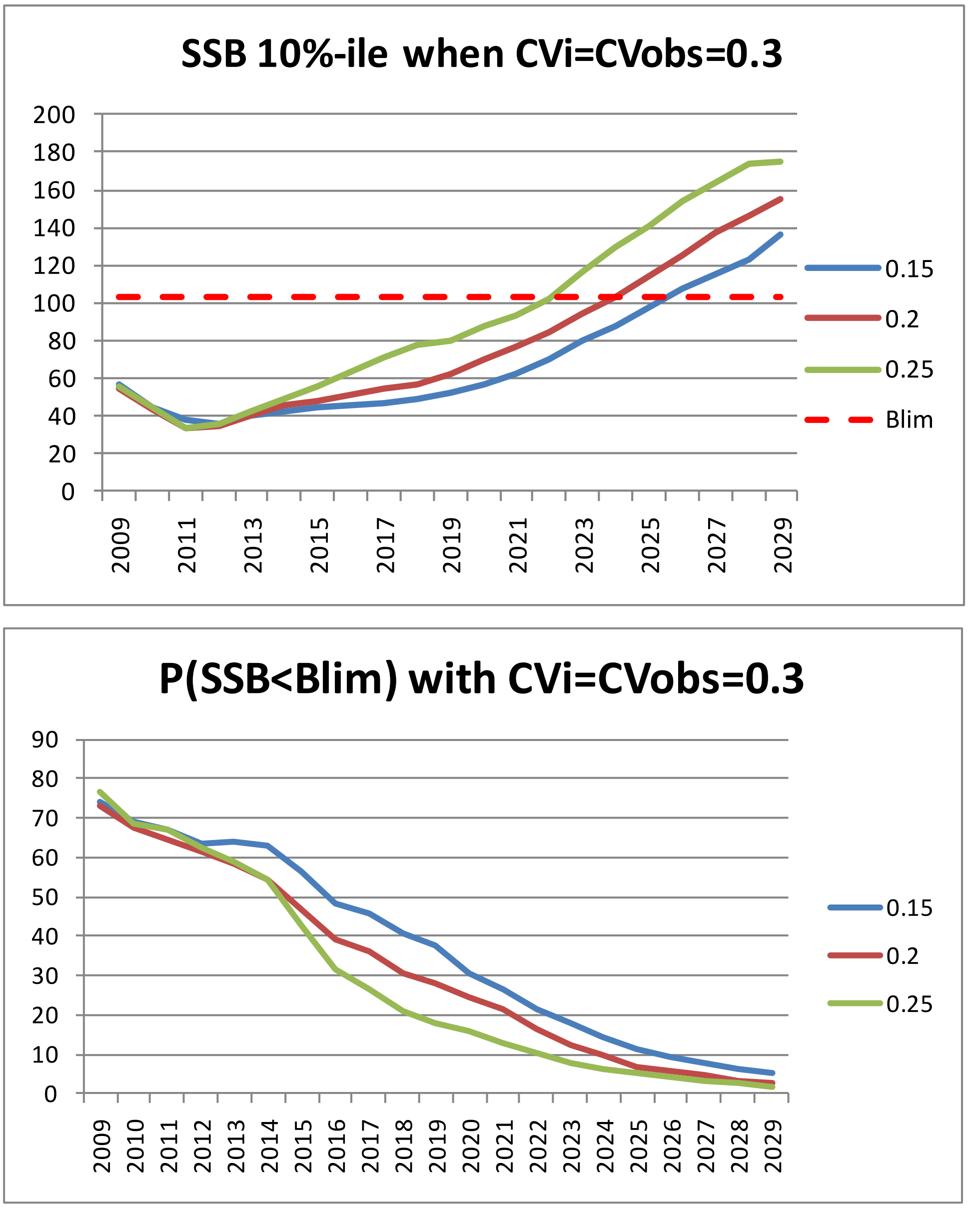


Figure 13b. Upper panel; The 10 percentile for the distribution of SSBs when the reduction steps in "action years" are 15% (blue), 20% (red) and 25% (green). Dotted red line is the Blim. Lower panel: The probability that SSB<Blim, when the reduction steps in "action years" are 15% (blue), 20% (red) and 25% (green).

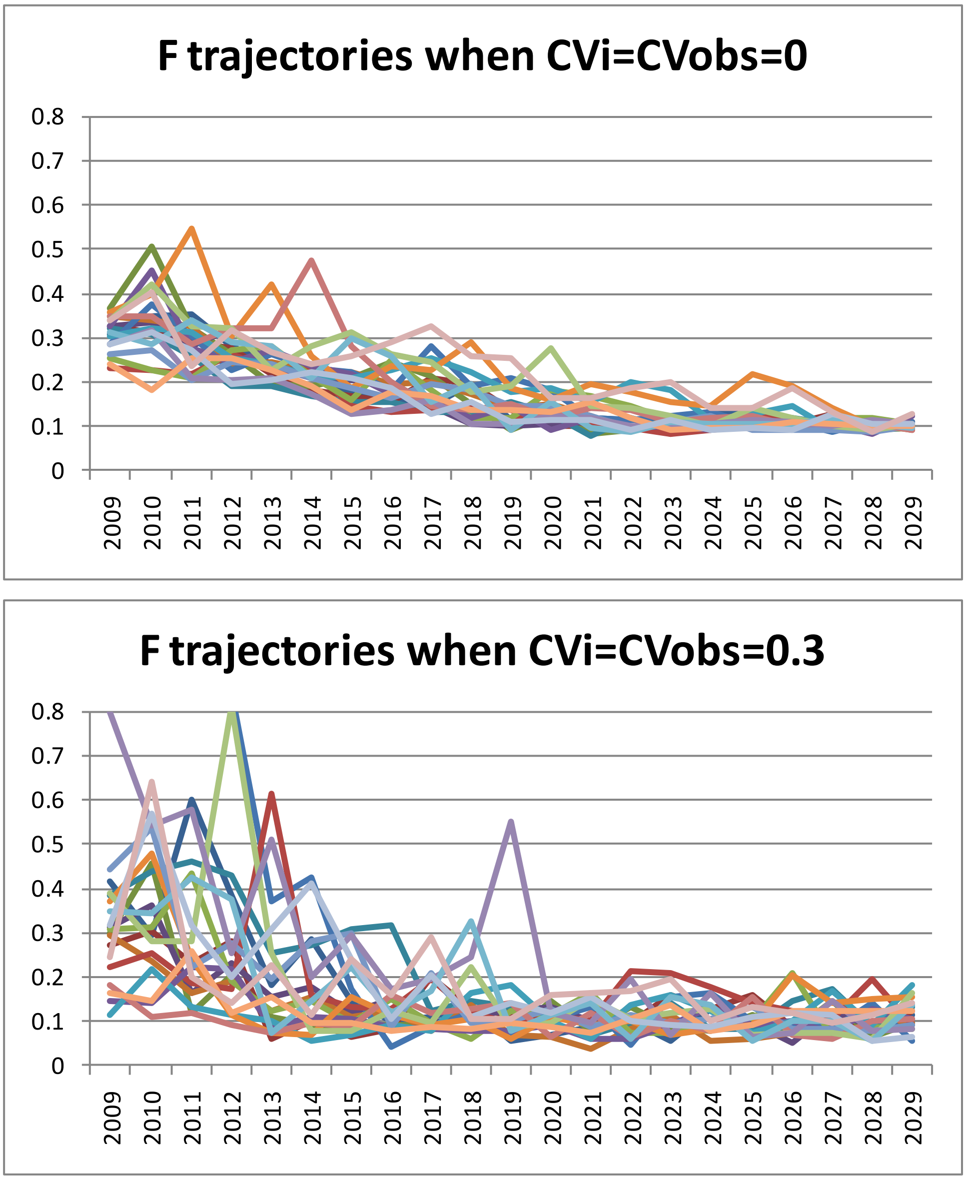


Figure 14. Trajectories of F for 20 individual simulations with 15% F steps in "action years".

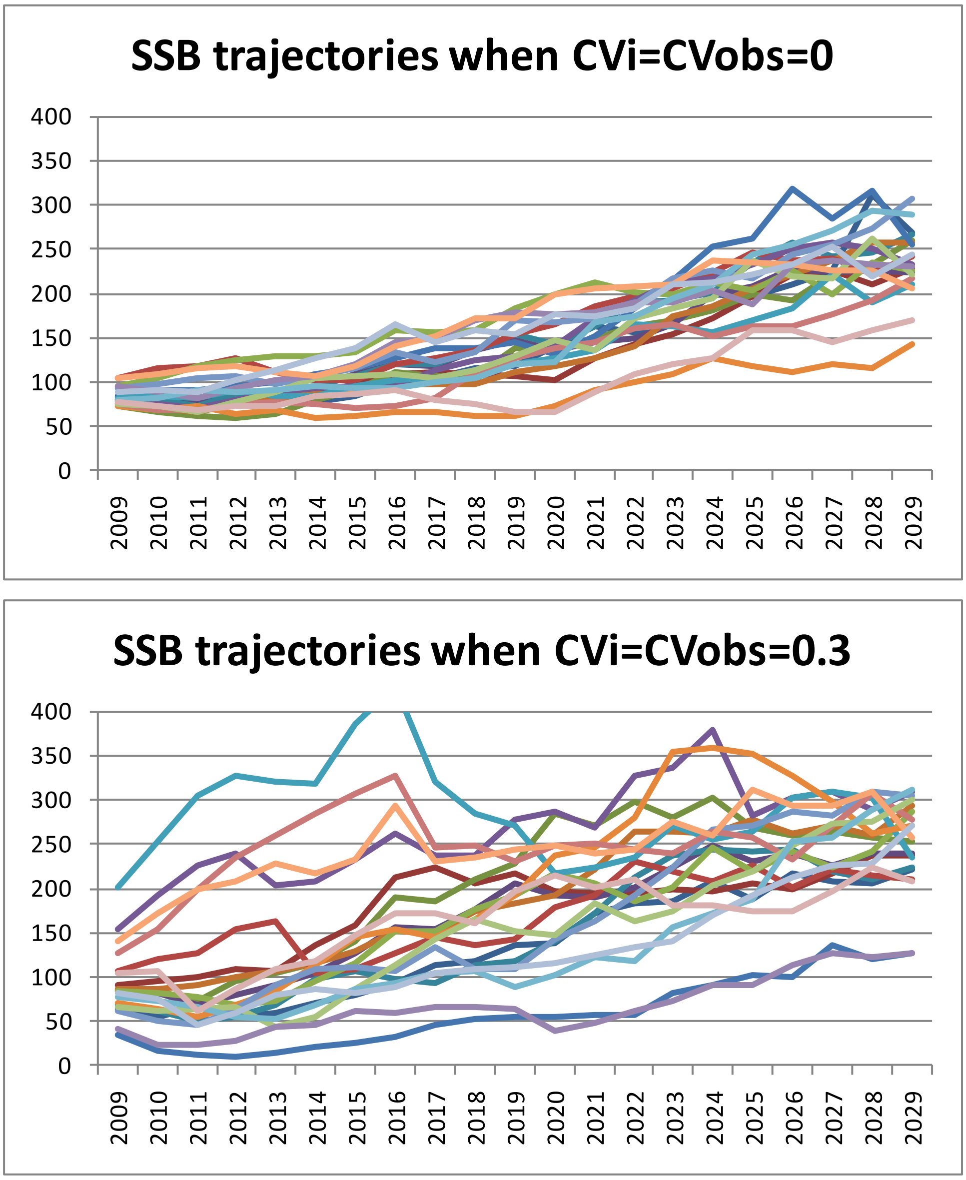


Figure 15. Trajectories of SSB for 20 individual simulations with 15% F steps in "action years"

Summary of the simulations

For the proposed 0.15 version of the plan the average SSB reaches the rebuilding target in 2024, which corresponds to about 50% probability for the true stock to be above in that year. High probability towards Blim is obtained 2 years later. True F safely below F crash (Flim) is obtained in 2017. This is an important milestone in the sense that the management then has reached a safe ground, and further reductions of F will gradually increase the SSB until equilibrium is reached for Fs close to 0.1. The equilibrium SSB for F=0.11 is (without density dependant effects) estimated at 280 kt.

A faster route to safe ground is obtained by having larger F steps. F safely below Fcrash occurs in 2016 in the 0.2 version, and in 2015 in the 0.25 version (Table 9). Another approach could be to have the F reduction unconditional to the survey, at least for the first few years. Simulations applying reductions every year until the lower limit is reached are summarized in Table 7 (3rd column). Then F safely below Fcrash occurs in 2014 in the 0.15 version, and in 2013 in the 0.2 and 0.25 versions.

Conclusion

If the plan is fully implemented it will lead to a safe rebuilding. Under presumed realistic errors a rather long rebuilding period is required, but the fishing mortality comes down to fairly safe levels within few years. On this basis the proposed rule is considered to be in accordance with the Precationary Approch. Increasing the F step, or aiming for annual reductions unconditional to survey results during the first 3-5 years, will both contribute to a faster and safer rebuilding. If future observations show recruitment declines stronger than assumed in the current stock-recruit model, the plan may need revisions. The new data on recreational fisheries also highlights the need to consider further regulations on these activities to obtain the F-reductions specified in the plan.

The current regulations aiming for protection of local stock components should be maintained. This should be improved when the scientific basis is improved.

Other relevant issues raised by the request

In these quantitative simulations and analyses no direct attempts have been made to take account of the stock complexity. Genetic studies indicate that the cod in some fjords could be separate stocks isolated from neighboring stocks. An assessment of the merged stock is not likely to detect fluctuations of the smaller components, and thereby the current assessment approach involves some risk to local stocks. The stock complex is still not fully mapped, but the existence of local stocks also calls for special attention for protecting genetic diversity. Full monitoring and research on small local stocks requires large efforts and may not be realistic. A possible approach could be to obtain information from local fisheries and look for data that could be appropriate indicators for at least detecting sharp declines of local stocks. The established strategy of more strict regulations inside the fjords than outside should be continued.

A fixed natural mortality of 0.2 is used both in the assessment and the simulations. Some fjord studies (Pedersen and Pope, 2003a and b, Mortensen 2007, Pedersen *et al*., 2007, Aas, 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. Thus, the development of the cod predators, mentioned in the request, is not taken into account. Reduced predator stocks may enhance the rebuilding of cod, while an increase of predators may inhibit the process and require prolonged strong regulations of the fishery for obtaining the rebuilding target.

Table 4. F-based simulations. 15% reduction, conditional to survey results. The shaded part specifies the input and reference values. The unshaded part refers to the year when the criterion specified in the left column is reached. The bold heading indicates the input considered to be most realistic. The bold rows relate to PA-criteria.

15% F-red CVi=CVobs=0.3	Commercial catch, low bp	Commercial catch, high bp	**Added catch, low bp**	Added catch, high bp
Breakp. SSB	71	114	103	139
Target SSB	139	139	180	180
R-plateau	17.6	33.3	29.1	46.7
Fcrash	0.30	0.35	0.32	0.38
F0.1	0.17	0.17	0.16	0.16
avF<Fcrash	2015	2014	2012	2011
P(F>Fcrash)<0.1	**2019**	**2018**	**2017**	**2016**
avF<F0.1	2019	2019	2019	2019
avSSB>bp	2021	2024	2015	2017
avSSB>Btarget	>2029	2029	2020	2020
P(SSB<bp)<0.1	**>2029**	**>2029**	**2026**	**2026**

Table 5. F-based simulations. 20% reduction, conditional to survey results. The shaded part specifies the input and reference values. The unshaded part refers to the year when the criteria specified in the left column is reached. The bold heading indicates the input considered to be most realistic. The bold rows relate to PA-criteria.

20% F-red CVi=CVobs=0.3	Commercial catch, low bp	Commercial catch, high bp	**Added catch, low bp**	Added catch, high bp
Breakp. SSB	71	114	103	139
Target SSB	139	139	180	180
R-plateau	17.6	33.3	29.1	46.7
Fcrash	0.30	0.35	0.32	0.38
F0.1	0.17	0.17	0.16	0.16
avF<Fcrash	2014	2013	2012	2016
P(F>Fcrash)<0.1	**2017**	**2016**	**2016**	**2015**
avF<F0.1	2016	2017	2017	2017
avSSB>bp	2019	2022	2014	2016
avSSB>Btarget	>2029	2024	2022	2019
P(SSB<bp)<0.1	**>2029**	**>2029**	**2024**	**2024**

Table 6. F-based simulations. 25% reduction, conditional to survey results. The shaded part specifies the input and reference values. The unshaded part refers to the year when the criterion specified in the left column is reached. The bold heading indicates the input considered to be most realistic. The bold rows relate to PA-criteria.

25% F-red CVi=CVobs=0.3	Commercial catch, low bp	Commercial catch, high bp	**Added catch, low bp**	Added catch, high bp
Breakp. SSB	71	114	103	139
Target SSB	139	139	180	180
R-plateau	17.6	33.3	29.1	46.7
Fcrash	0.30	0.35	0.32	0.38
F0.1	0.17	0.17	0.16	0.16
av F<Fcrash	2016	2013	2012	2012
P(F>Fcrash)<0.1	**2020**	**2016**	**2015**	**2014**
av F<F0.1	2016	2016	2016	2016
avSSB>bp	2018	2021	2014	2016
avSSB>Btarget	>2029	2026	2021	2018
P(SSB<bp)<0.1	**2029**	**>2029**	**2023**	**2023**

Table 7. F-based simulations. 15% reduction, unconditional to survey results. The shaded part specifies the input and reference values. The unshaded part refers to the year when the criterion specified in the left column is reached. The bold heading indicates the input considered to be most realistic. The bold rows relate to PA-criteria.

15% F-red CVi=CVobs=0.3	Commercial catch, low bp	Commercial catch, high bp	**Added catch, low bp**	Added catch, high bp
Breakp. SSB	71	114	103	139
Target SSB	139	139	180	180
R-plateau	17.6	33.3	29.1	46.7
Fcrash	0.30	0.35	0.32	0.38
F0.1	0.17	0.17	0.16	0.16
av F<Fcrash	2013	2013	2012	2011
P(F>Fcrash)<0.1	**2015**	**2014**	**2014**	**2013**
av F<F0.1	2015	2015	2014	2014
avSSB>bp	2017	2016	2013	2015
avSSB>Btarget	2029	2026	2020	**2017**
P(SSB<bp)<0.1	**2027**	**2024**	**2021**	**2022**

Table 8. TAC-based simulations (Intended F translated to TAC, realized catch lead to the realized F). 15% reduction, conditional to survey results. The shaded part specifies the input and reference values. The unshaded part refers to the year when the criterion specified in the left column is reached. The bold heading indicates the input considered to be most realistic. The bold rows relate to PA-criteria.

15% F-red CVi=CVobs=0.3	Commercial catch, low bp	Commercial catch, high bp	**Added catch, low bp**	Added catch, high bp
Breakp. SSB	71	114	103	139
Target SSB	139	139	180	180
R-plateau	17.6	33.3	29.1	46.7
Fcrash	0.30	0.35	0.32	0.38
F0.1	0.17	0.17	0.16	0.16
av F<Fcrash	2018	2017	2015	2014
P(F>Fcrash)<0.1	**2022**	**2022**	**2021**	**2020**
av F<F0.1	2022	2023	2022	2023
avSSB>Btarget	2024	2029	2015	2018
SSB>Btrig	**>2029***	**>2029**	**2028**	**2022**
P(SSB<bp)<0.1	**2028**	**>2029**	**>2029**	**>2029**

*Hardly obtainable: Btarget close to equlibr SSB at F=0.1

Table 9. Overview of all simulation runs. Combinations of model versions, assumptions, input data and CVs. "Low" break point is based on year-classes 2000-2005. "High" is based on full time series. The 4 columns to the right show the year (20xx) when P (F above Fcrash)<0.10.

			CV survey		0	0	0.3	0.3
			CV implementation		0	0.3	0	0.3
Model version	Conditional to survey	Data basis	S/R breakP. L=Low H=high	Steps F-red	year	year	year	year
F-based	yes	Tot catch	L103/29	0.15	13	17	16	17
F-based	yes	Tot catch	L103/29	0.2	12	15	15	16
F-based	yes	Tot catch	L103/29	0.25	12	14	14	15
F-based	yes	Tot catch	H139/47	0.15	11	15	15	16
F-based	yes	Tot catch	H139/47	0.2	11	14	13	15
F-based	yes	Tot catch	H139/47	0.25	11	13	13	14
F-based	no	Tot catch	L103/29	0.15	12	13	13	14
F-based	no	Tot catch	L103/29	0.2	12	12	13	13
F-based	no	Tot catch	L103/29	0.25	11	12	12	13
F-based	no	Tot catch	H139/47	0.15	11	12	12	13
F-based	no	Tot catch	H139/47	0.2	11	12	12	13
F-based	no	Tot catch	H139/47	0.25	11	12	12	12
F-based	yes	Com catch	L71/18	0.15	16	19	18	19
F-based	yes	Com catch	L71/18	0.2	15	17	17	17
F-based	yes	Com catch	L71/18	0.25	14	15	15	16
F-based	yes	Com catch	H114/33	0.15	15	18	17	18
F-based	yes	Com catch	H114/33	0.2	13	16	16	16
F-based	yes	Com catch	H114/33	0.25	13	15	14	16
F-based	no	Com catch	L71/18	0.15	13	14	14	15
F-based	no	Com catch	L71/18	0.2	12	13	13	14
F-based	no	Com catch	L71/18	0.25	12	13	13	13
F-based	no	Com catch	H114/33	0.15	13	13	14	14
F-based	no	Com catch	H114/33	0.2	12	13	13	13
F-based	no	Com catch	H114/33	0.25	12	12	12	13
TAC-related	yes	Tot catch	L103/29	0.15	15	20	20	21
TAC-related	yes	Tot catch	L103/29	0.2	14	17	17	19
TAC-related	yes	Tot catch	L103/29	0.25	13	17	16	17
TAC-related	yes	Tot catch	H139/47	0.15	12	20	19	20
TAC-related	yes	Tot catch	H139/47	0.2	11	17	16	17
TAC-related	yes	Tot catch	H139/47	0.25	9	15	15	16
TAC-related	yes	Com catch	L71/18	0.15	16	20	19	21
TAC-related	yes	Com catch	L71/18	0.2	15	17	17	18
TAC-related	yes	Com catch	L71/18	0.25	14	17	16	17
TAC-related	yes	Com catch	H114/33	0.15	16	20	20	22
TAC-related	yes	Com catch	H114/33	0.2	15	18	17	19
TAC-related	yes	Com catch	H114/33	0.25	14	17	16	18

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Annex 11 – Technical Minutes of a review of the ICES Arctic Fisheries Working Group (AFWG)

Report 2010 (by correspondence)

6-20 May 2010

Reviewers:	Noel Cadigan (chair)
	Rasmus Nielsen
	Jean-Claude Mahe
	Fernando González
Chair WG:	Bjarte Bogstad
Secretariat:	Mette Bertelsen

Audience to write for: advice drafting group, ACOM, benchmark groups and next years EG.

General

Use bullet points and subheadings (Recommendations, General remarks for WGs, etc.) if needed

The Review Group ToR's (from Guidelines for Review Groups):

1. Thoroughly check to ensure that the assessment is carried out according to the descriptions in the stock annex.
2. Check the content of figures and tables, and review whether the texts are supported by the scientific results.
3. Check consistency with the previous years reporting.

Reviewers also provided comments additional to the ToR's, and these are included as well.

The Review Group considered the following stocks:

- Cod in Subareas I and II (Northeast Arctic cod)
- Cod in Subareas I and II (Norwegian coastal cod)
- Greenland halibut in Subareas I and II
- Haddock in Subareas I and II (Northeast Arctic)
- Saithe in Subareas I and II (Northeast Arctic)
- Beaked Redfish (*Sebastes mentella*) in Subareas I and II
- Golden Redfish (*Sebastes marinus*) in Subareas I and II
- Capelin in Subareas I and II (Barents Sea), excluding Division IIa west of 5°W

And the following special requests:

- none

The RG acknowledges the intense effort expended by the working group to produce the report. The report was well structured and information was usually easy to find.

The stocks listed above were all updates, except Greenland halibut in Subareas I and II (SALY), and were reviewed by the group. In most cases (except Barents Sea capelin) a quality handbook was available with instructions on the procedure to carry out the assessment.

The reviewers met by correspondence and had contact through e-mail and sharepoint. For the purpose of evaluation the chair of the review group split the stocks between the reviewers. The chair read all stock reports. It was checked by the reviewers whether the procedures followed were according the procedures established in a previous bench mark assessment. In most cases the present assessments were also compared with those of last year. There was insufficient time to review other chapters of the report. Also no draft stock summaries were considered by the review group.

Stock	Name	Assessment Type	Reviewers (1st)
cod-arct	Cod in Subareas I and II (Northeast Arctic)	Update	Rasmus Nielsen
cod-coas	Cod in Subareas I and II (Norwegian coastal waters)	Update	Rasmus Nielsen
had-arct	Haddock in Subareas I and II (Northeast Arctic)	Update	Rasmus Nielsen
sai-arct	Saithe in Subareas I and II (Northeast Arctic	Update	Rasmus Nielsen
cap-bars	Capelin in Subareas I and II (Barents Sea), excluding Division IIa west of 5°W	Update	Noel Cadigan
ghl-arct	Greenland halibut in Sub-areas I & II	Same advice as last year	Rasmus Nielsen
smn-arct	Red fish *Sebastes mentella* Subareas I and II	Update	Jean-Claude Mahe
smr-arct	Red fish *Sebastes marinus* Subareas I and II	Same advice as last year	Jean-Claude Mahe

Stock: Cod in subareas I and II (Norwegian coastal waters) (report section 2)

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type:** Schedule says update, but the assessment was in many ways new.
2) **Assessment**: Analytical.
3) **Forecast**: Type: MFDP Program.
    a. Catch options for 2011 and 2012. Reducing F4-7 by 15% each year over two years will result in an increase in SSB.
    b. With 15% reduction steps for F, it will take 7 years to have high probability that F < Fcrash (see below), 10 years for having average SSB > the stock rebuilding plan target, and about 15 years to have high probability for SSB>Blim.
4) **Assessment model**:
    a. XSA– including commercial and recreational catches and tuning by one acoustic survey, and standard VPA (SVPA).
    b. Retrospective analyses showed a tendency for XSA to overestimate F4-7 in the last year. XSA F's were combined with F's based on an external analysis presented in an annex to generate F's to use in the final SVPA. This procedure was not described clearly.
5) **Consistency**:
    a. The assessment gives the same perception of SSB, R and F as last years assessment.
    b. In the two last years a SURBA assessment was used while an XSA assessment is used this year. In earlier years the working group has not considered the XSA to give reliable results. This year the working group did not consider SURBA to give reliable results.
6) **Stock status**:
    a. The assessment proposed candidates for B_{lim} and F_{lim}: B_{lim} = 103Kt SSB; F_{lim} = 0.32 (Fcrash). B2009 (80Kt) < B_{lim}; F2009 (0.31) < F_{lim}.
    b. F decreased in 1999-2000 and has since been relatively stable. F2009 = 0.31.
    c. F0.1 is estimated to be 0.16, and a safe long term Fmsy-target is, according to the working group, close to 0.16. The corresponding MSY Btrigger will be in the range of 150-200 kt.
    d. SSB is estimated to be stable but at low level, and well below long term average.
    e. Survey estimates of age group 1-3 in 2009 are among the lowest in time series and indicate low recruitment.
7) **Man. Plan.**:
    a. There is no management plan.

b. Fishery is managed with annual TAC and technical measures. Since 2001 the TAC has been 21 Kt.

c. For 2010, an additional TAC of 10 kt was set for the recreational and tourist fishery and added to the commercial fishery TAC of 21 kt.

d. Since 2004, the ICES advice has been no catch and a recovery plan should be implemented.

e. A rebuilding plan has been proposed by Norwegian authorities and has been evaluated by the working group.

General comments

This is a well ordered section. Some parts of the text in the report are updated from last year's assessment based on updated analyses; however, major revisions are presented. Last year a SURBA assessment was used. This year an XSA assessment is used with additional inclusion of new catch at age time series as well as introduction of fixed maturity ogive in the assessment. The working group reasoning for the revisions have been to have some additional basis for evaluating the proposed rebuilding plan for the stock. Last years assessment was considered tentative and used as a basis for advice last year.

A new catch series for recreational and tourist fisheries is added to the commercial catch. This time series contributes around 1/3 of the catch. Major assumptions are made in relation to estimating catch in this new time series (see below). The combined data series is by the working group found to fit better with the survey, using stock dependent catchability for ages 2 and 3 in a XSA. The XSA is otherwise set to standard values given in the Quality Handbook Stock Annex (also from last year). General information regarding the stock and earlier assessments are given in an updated Quality Handbook Stock Annex. As such the update cannot be considered as an actual SPALY.

There was little discussion of the quality of the catch at age data. Sources for large errors include unreported catch (i.e. recreational+tourism) and catches mixed with the NEA stock. An accurate resolution to these problems may not be possible; however, it would be useful for the working to assess, perhaps using only expert opinion, the accuracy of the catch. If the plausible catch times series have substantial pointwise range then this uncertainty should be accounted for in the assessment.

Furthermore, from the retrospective plots of the XSA it is stated that there is a tendency for the F4-7 in the last year to be overestimated, and this is dealt with in the final SVPA by setting a terminal F based on external analysis presented in an Annex. Also, this is a change compared to last year.

The maturity in the surveys are variable, but show overall a declining tendency. Maturity data originates from surveys. The ogives are variable which according to the working group is influenced by time of surveying more than real between year variation. On this basis, the working group conclude that it might be better to use a fixed (average) maturity ogive over years. This variability has not been analysed in detail. A fixed maturity ogive has been implemented in this years final XSA assessment compared to previous years (survey based) assessment using SURBA. Further benchmark investigations of this is needed.

Results and full comparative plots of exploratory runs testing each of these changes in the assessment individually has not been performed, i.e. with inclusion/exclusion of the new data time series, different maturity ogives, and different assessment models. On this basis, the reviewer found it difficult to evaluate the impact of each of the individual changes made in the assessment, as well as difficult to evaluate the impact of changing the assessment model. Thorough benchmark analysis should have been (and needs to be) done to evaluate the changes in the assessment.

Several exploratory runs with different methods and input data were carried out this year, and the most "appropriate" was selected by the working group. The basis for appropriateness has not been benchmark analysed. The assessment should have presented comparative plots for SSB, Fbar and Recruitment for each of the assessment runs compared to last years assessment. This would have eased the evaluation of the impact of each of the assessments with variable input data, settings and model use.

The outcome of the tentative assessments gives the same perception of the development of stock and fishery as last year's assessments.

Technical comments

1) The review was restricted to a check whether the procedures described in the technical annex (handbook) were applied, and a comparison with last years assessment was performed. The technical annex (quality handbook) has been revised this year and the procedures of the new assessment this year has been included. The present assessment must be characterized as a new assessment which needs to follow standard benchmarking procedures.

2) Also a comparison with last year's report was made. This is commented in detail above and below.

3) No checks on the calculation of the international age structure have been carried out by the reviewer.

4) The assessment with SURBA is based on an acoustic survey. Because cod contributes only a relatively low fraction of the observed acoustic values, the estimates of the survey are more sensitive to allocation error. The WG is aware of this. This contributes to uncertainty in the point estimates of the analyses but not to the perception of the present stock size.

5) It would be an advantage to show survey trends in CPUE normalized to unit mean in Figures 2.7-2.13.

6) There should in section 2.3.1 be made reference to both Table 2.1.13 and 2.1.14.

7) There is no indication in the text or table for which time of the SSB is calculated. Biomass and landings input in the prediction is similar to 2009 biomass and landings.

8) It would have been a benefit for the review if the assessment had presented standard stock overview plots with Landings, Fishing Mortality, Recruitment and SSB, as well as a standard Stock-Recruitment plot, a Y/R plot and a precautionary approach plot (which traditionally are associated to the advisory sheets).

9) The methods used to infer recreational and tourist catch are based on little actual data and must be considered tenuous. The WG estimates of these components comprise approximately 30% of the total catch which is a substantial amount. Error in the catch at age should be accounted for in the assessment model.

10) Age distribution from the commercial fishery long line and hand line fishery is applied to these recreational fishery catch time series. This assumption has not been evaluated.

11) All recreational fishery cod catches are assumed to be coastal cod (i.e. no fraction of NEA cod).

12) Last year an old version of SURBA (version 2.1) was used. The catchabilities calculated by this version of SURBA are not correct.

13) XSA's are not converged. This was considered in the 2009 report of WGMG.

Conclusions

The assessment has been performed correctly. There is need for a benchmark in the short time. The information given by the assessments is sufficient to provide advice.

The final stock assessment gives the same perception of SSB, R and F development as last years assessment.

Stock: North-East Arctic Cod (Subareas I and II) (report section 3)

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type:** update/SPALY
2) **Assessment**: Analytical.
3) **Forecast**: Type: MFDP Program. Fbar (5-10) in 2010 equal to same Fbar in 2009. Exploitation pattern: Average of 2007-2009.
4) **Assessment model**:
   a. XSA using 4 tuning fleets (3 surveys and 1 commercial cpue) as an up-date assessment with identical settings to last years assessment;
   b. maturity data and weight at age in the stock data are from surveys;
   c. M is set as the value M1 of 0.2 (by age and year) but added a matrix of natural mortality caused by cannibalism (M2);
   d. Unreported catches are considered low by the WG in the most recent years, and in 2009 IUU catches was not included.
   e. Additional models presented were TISVPA, Gadget, and survey calibrated VPA.
   f. There is general consistency in trends and perception of the stock dynamics between the models.
5) **Consistency**: Last years assessment was accepted and used as a basis for advice. This year's assessment is consistent with the assessment for the two last years.
6) **Stock status**:
   a. The stock is within safe biological limits. Fsq<Fpa (and well below Flim, lowest F(5-10) since 1990) and SSB>Bpa (and well above Blim, SSB at 1145 kt is the highest since 1947).
   b. Also, recruitment in recent years (589 millions in 2009) is around long term average (610 millions).
   c. Reference points have not been revised since 2003. Target reference points according to MSY has been evaluated including cannibalism and a segmented regression SSB-recruitment relationship. The results indicated that a long term yield is fairly stable for a range of fishing mortalities between 0.25 and 0.6. Density dependent effects in cannibalism and growth are by the WG considered as the main reason for this rather wide F-range with stable high yield
7) **Man. Plan.**
   a. There is an agreed management plan. An amended HCR from 2009 was evaluated and was considered by the WG to be in accordance with the precautionary approach.
   b. The fishery is regulated through TAC quota with max. 10% change. Other technical measures are described in the stock annex.
   c. The 2009 TAC was not taken in 2009, as catches were slightly below.

d. The fishery is mixed with Norwegian coastal cod fishery, and there are by-catches of NEA cod in the shrimp fishery.

General comments

This was a well documented, well ordered and well considered section. The text in the report is an update from last year's report. The various analytic assessments give the perception of a significant increasing stock as a result of a reduction in fishing mortality.

Technical comments

1) The review was restricted to a check of whether the procedures described in the technical annex (handbook) were applied. This was the case. No deviations were spotted. Little or no attention has been given to the additional models by the reviewer. These additional models are not described in the annex.

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 results of the XSA assessment were robust to assumptions made on q (stock size dependent catchability) for age groups 3-7 as well as on sensitivity to the length of the tuning period. This was tested by the WG. The final XSA run was compared with single tuning fleet runs with standard shrinkage settings. The swept area bottom trawl estimates from the joint Norwegian-Russian ecosystem survey have been tested as a new survey tuning time series in these single fleet runs.

4) There was no description of the methods used to account for cannibalism in the Annex. There was insufficient details presented in the report, and insufficient time available, to review this aspect to evaluate technical correctness.

5) Some of the survey indices have been multiplied by a factor 10. According to the working group, this has been done in order to keep survey dynamics even for very low indices because XSA adds 1.0 to the indices before the logarithm is taken.

6) There seems to be a tendency to a general higher level in the log catchability residuals for later years in the Russian bottom trawl survey, as well as a positive trend in the later years for the winter bottom trawl survey (Fig. 3.2).

7) There seems to be a small tendency to overestimate F and underestimate SSB when all fleets are included compared to single fleet runs which probably is due to higher influence of shrinkage in single fleet runs. Because it is low, it should not be considered to be problematic. Also, a test run without stock dependent catchability for age groups 3-5 gave slightly lower F and higher SSB for 2009.

8) There seems to be goods consistency between the different surveys. Survivors estimates from single fleet runs for all ages are in relatively good agreement between fleets. However, it would be an advantage to have a concluding paragraph on the degree of consistency between fleets and temporal development herein under sections 3.2.1 and 3.2.2.

9) Although the XSA is the standard method accepted in the benchmark, the TISVPA is run as an alternative. The same settings as last year was used in

the TISVPA. The two models give same perception of development in the stock, and the TISVPA output is consistent with last years results using the method. As such the results of XSA and TISVPA are very similar. However, in the most recent years TISVPA gives higher SB and SSB compared to XSA, and a slightly lower estimate of F(5-10). This was also the case for the two last years assessments. Last year, a different loss function was chosen to find a minimum compared to year before. The reviewer evaluated last year that such an approach would be difficult to accept in a benchmark procedure since this may lead to great differences in the results of the assessment between years. Also, the reviewer noted that i) the TISVPA is useful to demonstrate inconsistencies in the catch at age matrix, and ii) the reason for considering a TISVPA would be: suspecting an effect of cohort(size) on the exploitation.

10) The text in section 3.1 mentions a total landing in relation to Table 3.1a, while the table text to Table 3.1a mentions total catch. Table texts for 3.2-3.3 also indicates catch rather than landings of 523 431 t, while the text sections writes landings. It is important to be precise here with respect to what is catch and landings, especially when discard is mentioned in the text and partly considered in the assessment.

11) Sequence in Table numbering is not consistent with the sequence of reference in the text. For example, in relation to Tables 3.4-3.11.

12) Weight at age in catch is variable between years, periods and countries. Plots of this should be shown in order to be able to follow trends and tendencies (besides Table 3.4). For example, it seems that Norwegian landings weight at age has increased by about 1 kg in the latest period for age groups 6-10, but not in other nation's landings. This should be looked at more closely.

13) Maturity at age in catch is variable between years, periods and countries. There should be shown plots of this to be able to follow trends and tendencies (besides Table 3.5). There seems to be a quite drastic decrease in the percentage mature at age in 2010 for the Russian data. This should be looked at more closely.

14) There is no reference to Table 3.8 in the text describing cannibalism (section 3.3.5) even though cannibalism is included in the XSA.

15) The last part of Table 3.9 is missing – only catch at age numbers up to year 1969 is given here. The full table needs to be included.

16) With respect to stock weights at age, the text (section 3.3.2) refers to Table 3.12, while stock weights at age is given in Table 3.11.

17) There are different estimates of unreported catches by Norway and Russia for 2008 in last years assessment. Norway estimated 15 kt in 2008. Russia comes with underutilization of 425 tonnes. In 2008, there were 2 different assessments and prognoses, based on different assumptions on unreported landings. In the 2009 assessment, the (higher) Norwegian estimate was accepted – both for the assessment and prediction. The Norwegian estimates were also used in the past for the final advice. In the 2010 assessment the working group decided not to include unreported catches (IUU). The unreported catches have declined considerable in recent years from over 100 kt in the early 2000's.

18) This years assessment present considerations of inclusion of data time series for discards in a coming benchmark assessment to meet the reviewer comments from last year.

19) The catch forecast covers all catches. This means that if any over-fishing takes place the forecasted TAC should be reduced.

20) The assessment noted 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. This would indicate a decrease in survey catchability.

21) 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.

22) Different vessels have been used in the Joint Barents Sea winter survey, but the report provided no information on whether the survey index has been standardized to account for these vessel changes.

23) XSA is not converged (i.e. Table 3.15). This was considered in the 2009 report of WGMG.

24) This years assessment includes a discussion of a data time series for discards and a new tuning time series from the swept area bottom trawl joint Norwegian-Russian ecosystem survey, to be considered in an up-coming benchmark assessment.

25) A benchmark assessment should also consider the apparent increased catchability in the surveys and contradiction in trends of WAAC in landings by different nations.

26) Last year the reviewer noted: Inspection of historical material indicate a different interpretation of age of 1st maturity by contemporary age readers. The WG notes (2009) this may affect the SR relationship and biological reference points. This point should also get attention in the next benchmark assessment.

Conclusions

The assessment has been performed correctly. The information given by the XSA assessment is sufficient to provide advice. The present management has lead to a reduction in F, a substantial increase in SSB and a reduction in unreported landing. There is not an urgent need for a benchmark assessment.

Stock: North Northeast Arctic Haddock (Subareas I and II) (report section 4)

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type:** update/SPALY
2) **Assessment**: Analytical.
3) **Forecast**: Type: MFDP Program. Analytical forecast is presented.
    a. Recruitment is estimated by RCT3 based on age 0-3 from surveys using same procedure as in previous years.
    b. F2010=F2009 because F shows a decreasing tendency from 2007-2009; fishing pattern for 2010-2012 Fsq=F(2007-2009) scaled.
    c. The 25% limitation HCR in restricting TAC results in a TAC of 303 kt for 2011 (+25% compared to 2010 TAC of 243 kt) corresponding to F=0.31.
    d. The assessment has a retrospective pattern (see below), and one can anticipate a similar pattern in the advice such that in 2-4 years the assessment will say that F in 2010 was somewhat above Fpa, and that the forecasted changes in SSB were not achieved
    e. Weight at age and proportion mature is dependent of year class strength, and the WG decided to use smoothed averages for weight at age in stock and catch, maturity, and natural mortality as has been observed in previous years following good recruitment (see section 4.4.4 in WG report).
4) **Assessment model**:
    a. XSA (FLR) using 3 tuning fleets (3 surveys);
    b. maturity data are from surveys;
    c. M is estimated including predation by cod (0.2+predation mortality by year and age);
    d. Unreported catches are considered low by the WG in the most recent years, and in 2009 IUU catches was not included
    e. The settings are the same as used in 2009.
5) **Consistency**: Last years assessment was accepted and used as a basis for advice. This year's assessment is consistent with the assessment for the two last years. There is a tendency to overestimate F and under-estimate SSB in the terminal assessment year.
6) **Stock status**: The stock is within safe biological limits.
    a. Fsq just below F_{pa} (and well below F_{lim}) and SSB>B_{pa} (and well above B_{lim}); SSB is the highest since 1950.
    b. Recruitment in recent years is well above long term average – especially the 2006 year class is strong. Surveys indicate a relatively strong 2009 year class as well.

c. Reference points have not been revised since 2000 (B_{lim}=50 kt, B_{pa}=80 kt, F^{lim}=0.49 and F_{pa}=0.35. No work was done this year to revise the reference points for the stock due to time constraints by the WG

7) **Man. Plan.** There is an agreed management plan.

a. The fishery is regulated through a TAC with max 25% change and based on a 1-year HCR. Other technical measures are described in the stock annex.

b. In 2007 ICES evaluated the management plan (that was agreed in 2004), and it was found in accordance with the precautionary approach.

c. The HCR is set to a level corresponding to Fpa and a TAC with max 25% change, and the HCR regulates F if SSB falls below B_{pa}.

d. The TAC in 2009 of 194 kt was taken with a minor overshoot (landings 200 kt). TAC in 2010 is 243 kt.

e. Haddock is fished in mixed fisheries and is mainly taken as by-catch in trawl fishery targeting cod. Also, directed haddock fishery with longline and trawl is conducted, and there are set national quotas divided by gear type.

General comments

The report is well structured and the text is an update from last years report with relative few changes. The assessment show an increasing stock as a result of a reduction in fishing mortality and good recruitment in the last years (especially 2006).

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.

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 years assessment procedures. These procedures should be clarified in the annex.

5) The annex should describe why 0-group survey indices are not used as a tuning index.

6) The year-classes mentioned in the first line of section 4.4.3 should be 2007-2009.

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 indicate a 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.

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).

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.

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).

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.

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.

17)Reference points were not revised due to time constraints by the WG, and this should be done at the next benchmark assessment.

18)Retrospective runs for 2000-2002 show strong trends and look strange. Such a retro needs additional investigation in the next benchmark.

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.

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.

21)Why are years not specified in Table 4.9A?

22)The titles of Tables B1 and B3 should be changed to Joint Surveys.

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?

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.

25)The annex does not specify the inputs to the RCT3 analyses. The procedures used were the same as last year.

26)There are substantial differences in biomass and SSB in Table 4.18 of the this years report and Table 4.18 of last years report.

27)Table 4.12 does not indicate if the XSA has converged.

Conclusions

The assessment has been performed correctly as specified in the annex. There is need for a benchmark in the near future. The present management plan is in accordance with a precautionary approach and the stock is currently harvested sustainably. However, unreported catches and discards is an important issue for this stock and reduce the effect of management measures and the objectives of the harvest control rule. The information given by the assessments is sufficient to provide advice.

Stock: Saithe in Subareas I and II (Northeast Arctic) (report section 5)

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type:** update/SPALY from the February 2010 benchmark assessment (ICES CM 2010/ACOM:36).

2) **Assessment**: analytical

3) **Forecast**: analytical forecast presented

a) recruitment age 3 calculated as long term geometric mean (1960-2008);

b) stock numbers from XSA (age 5+);

c) Pope's approximation used;

d) exploitation pattern is average of 2007-2009 (age 3-10) while average 2007-2009 for age 11-13 was used for age 11-15+;

e) three last years averages of weight at age in the catch and stock used;

f) maturity average of 2008-2009.

g) $F_{status\ qou\ (2007\text{-}2009)}$=0.25 and $F_{TAC\ 204\ kt}$=0.32 are both below Fpa at 0.35.

4) **Assessment model**: XSA is applied for the final assessment, using 4 tuning time series (2 acoustic survey cpue series (age 3-7) for the time span 1994-2001 and 2002-2009, and 2 trawl commercial cpue series (age 4-8, quarter 1-4) for the time span 1994-2001 and 2002-2009 according to benchmark recommendations - among other due to catchability shift in 2002);

a) maturity ogive – 3-year running average (1985-present);

b) M fixed at 0.2 for all age groups;

c) annual estimates of weight at age in catch, and assumed catch at age in the stock to be equal to weight at age in catch.

d) SSB is calculated at Jan 1st.

e) The settings of the XSA has been changed according to the February 2010 benchmark recommendations (see under Consistency below).

f) Discard is not included in the assessment.

g) Exploratory single fleet runs were performed among other with the new tuning time series from the combined survey but they did not perform as well as the "old" ones presently used mainly because of their short time span.

5) **Consistency**: Update assessment from the February 2010 benchmark assessment. Last year's assessment was accepted and used as a basis for advice in 2009.

a) Last years assessment estimated total stock (TSB (11+)) in 2008 to 4% higher and the SSB (11+) in 2008 4% lower than the previous assessment, while the present assessment estimates TSB (15+) 19% lower, the SSB (15+) 34% lower, and the terminal year F(4-7) 25% higher in 2009 compared to previous years assessment (for TSB (11+), SSB (11+)).

6) **Stock status**: Stock is within safe biological limits. Fbar<Fpa and well below Flim; SSB>Bpa (since 1995) and well above Blim.

a) Recruitment is around average strength, the 2005 year class being slightly above long term mean, while the 2003 and 2004 year classes were poor.

b) New Fpa estimated in 2005 was accepted by ACFM.

c) The same biomass and fishing mortality reference points are used in this years assessment (Fpa=0.35, Flim=0.58, Bpa=220 kt, and Blim=136 kt).

d) In the 2010 assessment, the age span was expanded from 11+ to 15+ and important XSA parameters were changed due to benchmarking. Accordingly, reference points was re-estimated in 2010 using segmented regression. The results were a Bpa at 194 kt and a Fpa at 0.35.

e) The HCR is based on PA reference points, and if new ones are introduced, the HCR will have to be evaluated again. The WG explains that due to lack of time and transition to MSY based reference points the existing reference points was not changed. No attempts were made to set MSY reference points (F_{MSY} and MSY $B_{trigger}$).

f) F_{max} is estimated to 0.33, F0.1 to 0.08 and $F_{35\%SPR}$ to 0.11, and these points are F_{MSY} candidates, but the estimates (especially F_{max}) are unstable for this stock. Highest long-term yield was obtained for an exploitation level of 0.32.

g) The current F (0.27) is lower than the F associated with high long-term yield when applied within the agreed HCR.

7) **Man. Plan.**: There is a management plan for this stock, and a harvest control rule (HCR) is used for setting the annual TAC (target F_{pa}) which was in 2007 evaluated by ICES to be consistent with the precautionary approach. The implemented management plan implies a TAC based on the average catches for the coming 3 years based on F_{pa} resulting in a TAC of 225 kt in 2009 and 204 kt in 2010 corresponding to F=0.29 in 2009 and F=0.30 in 2010. The fishery is regulated through TAC quota with max. 15% yearly change (when SSB is above B_{pa}). Landings in 2009 was 64 kt below the TAC. There are indications that the TAC will not be taken in 2010 according to the WG. In addition to TAC, the fishery is regulated through technical measures. Discarding, although illegal, occurs in the saithe fishery. There are no quantitative estimates of discard. Discard of young fish is by the WG not considered a major problem for the stock because they are inaccessible to commercial fishery due to their near shore distribution.

General comments

This is a well documented, well ordered and well considered section. The assessment is due to the new benchmarking changes not fully consistent with last year's assessment, however, it is consistent with the benchmark assessment in February 2010. SSB is well above B_{pa} and F is below F_{pa}, and the reference points are considered in accordance with the precautionary approach. The current F (0.27) is lower than the F associated with high long-term yield when applied within the agreed HCR.

Technical comments

- The Stock Annex (Quality Handbook) has been revised. The review was restricted to a check whether the procedures described in the technical annex (handbook) were applied. This was evaluated to be the case. The benchmark assessment report (ICES CM 2010/ACOM:36) was not reviewed.

- The main conclusions from the recent benchmark assessment in February 2010 were: i) expand the catch matrix from 3-11+ to 3-15+, ii) base the Norwegian trawl CPUE on data from all quarters from days with > 20% but <80% saithe in catches, iii) split the two tuning series to before and after 2002, iv) reduce the shrinkage in the XSA (S.E. of the mean to which the estimate is shrunk increased from 0.5-1.5) and remove time tapered down weighting. (ICES CM 2010/ACOM:36; this report was not reviewed).
- The Total Stock Biomass (TSB) for 2009 is not fully consistent between Table 5.5.5 (821055) compared to Table 5.5.7 (798292).
- The report refers to the retrospective patterns in Figures 5.8.1-2 which are illustrated in Fig. 5.5.5.
- Comparison with the last year report indicates better retrospective pattern obtained this year (more stable assessment) with the new benchmark settings than the one observed last year. The tendency to overestimate F and underestimate SSB in the terminal year seems to have changed to the opposite situation (see above). Despite these changes, the assessment is still evaluated to be in line with last year's assessment.
- 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.
- 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.
- 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.
- Medium term projections were made even though not considered reliable because the results are mainly driven by the assumption of mean recruitment and ignoring bias in the assessment. No improved recruitment estimates are available.
- Graphs of the tuning indices should be provided.
- Table 5.5.1 XSA run had not converged. This was considered in the 2009 report of WGMG.

Remarks by the reviewer

- • There is an indication in the sub-section "5.1 The Fishery" on saithe temporal substantial discarding occurring from non-Norwegian commercial trawlers. Although AFWG specifies that discarding is a minor problem, it could however be of some importance to investigate the level of discarding (by age) as this might have some impact on the perception of the stock dynamics (especially recruitment).
- • Saithe has recently been more distributed southward and such was the biological sampling activity for estimating maturity ogives. Higher maturity rate in the southern area is observed. The 3-year running average ogive used in the assessment is not weighted by abundance, and in consequence

it probably results in biased estimate of maturity ogive in the context of the whole stock.

Conclusions

The assessment has been performed correctly. There has been performed benchmark assessment in 2010 which has improved the previous years problematic retrospective patterns. There are still trends in the residuals by age and year. The present assessment is consistent with the benchmark assessment. The information given by the assessments is sufficient to provide advice.

Stock: Beaked redfish (Sebastes mentella) in Subareas I and II (report section 6)

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type:** update/SPALY
2) **Assessment**: no analytical assessment, survey trends.
3) **Forecast**: not presented.
4) **Assessment model**: not relevant.
5) **Consistency**: Survey data are still consistent and perception of stock status is unchanged.
6) **Stock status**: There are no reference points defined for this stock. All signals show that the stock has gradually declined and is at present near a low. Recruitment has failed since 1991, but the 2007 YC seems strong.
7) **Man. Plan.** There is no management plan. The fishery is managed with annual TAC and technical measures such as closed areas for certain gears. A description of the technical measures and history is given in section 2.1.2: Regulations.

General comments

This was a well documented, well ordered and considered section. Most of the text was an update of last year's report but some new information on length composition of the demersal fishery (Sec. 6.2.1) and results from a new survey (Sec. 6.2.5.2) have been added. The description of the pelagic fishery has been moved to the stock annex.

Technical comments

1) The review was restricted to a check whether the procedures described in the technical annex (handbook) were applied. The handbook was updated again this year.
2) Also, a comparison with last year's report was made.
3) No assessment was carried out and the WG restricted the work to updating tables. There were also changes in the text but most was revised from last year.
4) Why is Iceland in the Canada catch column of Table 6.1, and Estonia in the Denmark column?
5) Is there a real need to have a second different set of tables and figures labeled starting with a D. These could be included with the other tables and figures, this would make reading easier.
6) In section 6.1.1 the reference to fig 6-2 should be deleted, same for figure 6-9 in 6.2.5.1 , it doesn't deal with the ecosystem survey in August but with cod predation.
7) In section 6.1.3 the 2001 and 2006 landings figures don't match the values in the table 6.1.
8) Paragraph on cod's predation in section 6.2.5.1 should mention the data source.

9) What is the status of the new surveys described in 6.2.5.2 and 6.2.5.3? One time event or start of a series?

10) Paragraph 6.3 reference to figure 6.4 is wrong, it is now figure 6.7 and although stated that there is an increase in fish>30cm in pelagic surveys, there is no data (table or figure) illustrating this.

Remarks by the reviewer

- The unchanged perception of the stock compared to last year gives no reason to change previous advice.
- The report contains several chapters with information relevant to the advice
- The continued poor recruitment (decades), slow growth and late maturation gives no expectation that the stock will recover within the next 12-15 years. The only year classes that can contribute to the spawning stock in near future are those prior to 1991 as the following fifteen year classes are very poor. There are signs of increased recruitment at least in some areas (see figure 6.7 and 6.10) but the 2008 YC estimates are back to low value..
- Results from the pelagic surveys conducted in 2008 and 2009 indicate possible trawlable biomasses of about 400 - 500 kt but such estimates are highly imprecise. The section management advice in the report mention estimates of SSB from Anon (2009b) that are not discussed in the report and there not easily accessible (NEAFC WG report).
- There are no biological reference points defined for this stock. During the WKFRAME meeting, recommendations were made for this stock as it was used as a case study. The WG find it premature to adopt the values estimated by WKFRAME but will work on this prior to the benchmark assessment proposed for 2012

Conclusions

There are no indications that there are changes in the stock status. The development of a fishery in international waters may be a source of concern, since the fishable stock consists of year classes before 1991 and there was poor recruitment thereafter. Traditional PA reference points may be not appropriate, but a more general approach on management advice could be adopted towards stocks with similar characteristics unless a gadget or other assessment method can be evaluated and adopted during the next benchmark assessment.

Stock: Golden redfish (Sebastes marinus) in Subareas I and II (report section 7)

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type:** SALY
2) **Assessment**: assessed on the basis of available trends in the fisheries and surveys and an experimental analytical assessment.

   The Gadget model was used for the sixth time as an experimental analytical assessment model.
3) **Forecast**: none.
4) **Assessment model**: model – tuning by 2 commercial fleets + 2 surveys (experimental)
5) **Consistency**: In this year's update the Gadget model configuration and settings were identical to that of 2009. Commercial catch data have been revised for 2008 and updated with year 2009. The general patterns in the stock dynamics are very similar to those modelled in 2008 but there is an increased discrepancy between the two surveys used in numbers at older ages and the years 2008 and 2009 have been excluded from the coastal survey.

   At ADGANW,
6) **Stock status**: The stock is currently in a very poor situation as confirmed by survey observations and Gadget assessment update. Reference points have not been defined.
7) **Man. Plan.** No Management Plan agreed.

General comments

This was a well documented, well ordered and considered section. The text in the report is an update from last years´ report. The tables and figures were unambiguous but the ordering in two sets (labeled 7… and D…) is questionable and makes the reading harder than necessary.

Note that in the state of the stock, there are a few paragraphs on the positioning of the species in the Norwegian Redlist as a vulnerable species and that following results from 2 workshops convened by ICES conclude that under current harvesting level and low recruitment there is a risk of stock collapse.

Technical comments

1) The review was restricted to a check whether the procedures described in the technical annex (handbook) were applied. The handbook was updated again this year.
2) Also, a comparison with last year's report was made.
3) Tables numbering should be updated, there are no tables D1 etc but D11…
4) In 7.1.2. year range mentions 1983, while tables starts in 1989.
5) The total index in Figure 7.5a is somewhat different than the total index in Figure 7.5b, and there are discrepancies with Tables 12a,b. Indices in Fig 7.4a,b are somewhat different as well. A description of the reasons for these differences would be helpful.
6) The data was used as specified in the stock annex.

7) The assessment experimental model been applied as specified in the stock annex but some changes have been made to the parameterisation of the Gadget model (revision of the 1998 data of the Barents sea survey, exclusion of the two most recent years from the Coastal survey and down-weighting of the series in the fit).
8) The updated assessment gives a valid basis for advice as trends are overall similar.
9) However, there are some issues:
    a) There is little information on the parameterization of the Gadget model and model fit except aggregated surveys residuals. The text table comparing the successive Gadget model's results shows a strong retrospective pattern (SSB in 2003 has been successively revised upward from 2006 to 2010 by a total of 44%).
    b) The fit is poor for the coastal survey but it has been down-weighted in the fit. The overall fit seemed better in the 2009 formulation. There seems to be bias in the fits shown in Figure 7.6. Most points are above the lines. This could be an issue with convergence.
    c) A constant selectivity through time was assumed in the model; the possibility of an extension with varying selectivity was mentioned by the group; this should be included in the next assessment.
    d) We had to go back to the 2007 report to find more on parameters estimated and likelihood components employed. And from this report: "The weighting of different components in a likelihood function is a clear problem in any model combining multiple data sources, and needs to be addressed in a wider fisheries assessment context in order for researchers to make best use of all the available data." The weightings of various data components should be described.
    e) Although the assessment based on the Gadget model is experimental, it is a strong component of the advice on the state of the stock. There is a need to address better parameterization of the model used, including tuning indices selection now that there are increased discrepancies in the 2 surveys and a strong retrospective pattern. Why was the Inshore survey chosen and not the Norwegian Svalbard? There may be good reasons but it is not stated even in the Stock annex.
    f) Retrospective plots (i.e. Fig. 7.8-7.10) should include assessments for several years.
    g) the general problems of age reading in redfish should be addressed
    h) Recruitment estimates may be biased due to species misidentification.

Conclusions

The assessment has been performed correctly and gives a valid basis for advice as long as it is based on trends that are overall similar. A benchmark assessment is needed for this stock (expected in 2012) to address issues mentioned earlier. Until then, due to the expected low recruitment, the advice for this stock can be based on the assessment of the working group.

Stock: Greenland halibut in subareas I and II (report section 8)

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type:** update/SPALY (update assessment in form of exploratory run used to view trends in the stock)

2) **Assessment**: analytical

3) **Forecast**: not presented

4) **Assessment model**: XSA (ages 5 and above) using same settings as last year and using 3 tuning fleets (2 surveys and 1 experimental commercial CPUE); estimates shrunk towards the mean of the final 2 years and 5 ages; S.E. of the mean to which the estimates were shrunk was set at 0.5; catch at age data and mean weigth at age in catch data for 2006-2009 are only available from Russian fisheries due to age determination problems; the mean weight at age in the stock is assumed equal to mean weight at age in catch; natural mortality set to 0.15 for all ages and years; a three year running average maturity ogive is used.

5) **Consistency**: The current assessment used the same catch matrix, survey series and settings as last year with updated data for 2008 and new data for 2009. Fishing mortalities tend to be overestimated while SSB tends to be underestimated, and recruitment tends to be overestimated in some recent years. The assessment is considered to be uncertain due to age-reading and survey data quality problems (e.g. uncertain recruitment and maturity indices as well as uncertain catch number and mean weight at age numbers). SSB is sensitive to the maturity ogive which is uncertain, and different survey indices shows opposite tendencies in proportion mature.

6) **Stock status**: The stock is currently stable at a relatively low level with a slightly increasing tendency. Fishing mortality in 2009 was at the same low level as in 2008. There are indications of low recruitment in the most recent year, while recruitment was high in the previous year. There are no reference points defined for this stock, and there is no estimate of high yield reference points. The catch in 2009 was 12 kt which is 6% less than the TAC and projected catch. The advice is that the catch in 2009 and 2010 should be below 13 kt, which is the level below which SSB has increased in the past. A TAC of 15 kt has been set for 2010 (see below) which is also the projected catch for this year by the WG. Discard and non-reported catches are not included in the assessment. Discard is not regarded to be significant and a problem by the WG, while it is believed that there may be some additional non-reported landings. The magnitude of the latter is not known.

7) **Man. Plan.**: No Management Plan agreed and no HCR set. There is no estimate of high yield reference points. The advice has not changed since 2003, yearly catches should be below 13 000t. This is the level below which SSB has increased in the past. The stock is regulated through by-catch regulations (max 12% GHL in each haul and max 7% GHL in each landing, and annual catch of GHL should not exceed 4% of the sum of vessel quotas on cod, haddock and saithe and in total not exceed 40 t per vessel per year). Targeted Greenland halibut fishery has been forbidden in the period 1992 to 2009 except for a limited coastal Norwegian fishery where vessel specific TACs of 10-14 t dependent on vessel size has been set. In 2009, it was decided to cancel the ban against directed Greenland halibut fishery, and a yearly TAC of 15 kt has been established for 2010-2012 shared between Norway (51%), Russia (45%) and other countries (4%). There is allowed 4 kt catch by Norway and Russia each for research and surveillance purposes.

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

- In section 8.1.2 the years should be up-dated to 2009 and 2010.
- 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.
- Exploratory runs of XSA have shown that there is high sensitivity in the assessment in relation the XSA parameter settings.
- 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 NEA and another stock in the Faeroe Islands-Iceland area and Greenland.
- 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.
- 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.
- 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.
- 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.
- 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 2010 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.

Stock: Barents Sea Capelin (report section 9)

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type:** update (but no annex)
2) **Assessment**: Absolute survey estimates
3) **Forecast**: Probabilistic projection of the spawning stock to the time of spawning at 1 April 2010 was made using the spreadsheet model CapTool (implemented in the @RISK software).
4) **Assessment model**: none
5) **Consistency**: The assessment methodology appeared consistent with last years report.
6) **Stock status**: Blim=200 kt. Acoustic estimates of SSB for October in 2008 and 2009 are well above the Blim.
7) **Man. Plan.** 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. With a catch of 360 000 tonnes, the probability for the spawning stock in 2009 is below B_{lim} is 5%. The median spawning stock size in 2010 will then be 504 000 tonnes. During its autumn 2009 meeting, the Joint Russian - Norwegian Fishery Commission decided that the quota according to the harvest control rule in 2010 will be 360 000 tonnes

General comments

There is no stock annex yet, and it was not possible to provide a technical review of this stock.

The acoustic survey estimates are treated as absolute. This requires defense. There is no assessment of the impact of past fishing on stock dynamics.

Technical comments

None

Conclusions

In October of 2008 and 2009 the stock was estimated to be well above the B_{lim}.