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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 1995-2011 as well as catch at age data (including recreational and tourist fisheries).

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

Cod in Sub-areas I and II (Northeast Arctic) was assessed using XSA.

- The fishing mortality (F_{5-10}) has been around 0.25 since 2009. In the time series from 1946 to present, such low values have only been calculated for 1990 and 1946. Estimated SSB for 2011 is 1,857,000 t, which is the highest in the time series which go back to 1946. The total stock biomass is also near the highest value observed in the time series. Compared to last years' assessment, this assessment represents a 40% upward revision of the 2011 SSB and a 20% downward revision of F in 2010.
- The new "hybrid" recruitment model, introduced in 2008, was used, resulting in recruitment at age 3 of between 700-750 million in all the years 2012-2014. This is slightly above the long-term average.
- A catch in 2013 corresponding to the HCR is 940,000 t. This catch corresponds to a fishing mortality of 0.30 in 2013. SSB is estimated to increase from 2,063,000 t in 2012 to 2,225,000 t in 2013. These values are the highest in the time series. Earlier maturation means that a larger proportion of the total stock is spawners now compared to the late 1940s when SSB also was calculated to be above 1,000,000 t.

Haddock in Sub-areas I and II (Northeast Arctic) was assessed using XSA.

- Previously (1950-2000) the fluctuation in the haddock stock has shown a strong cyclic pattern caused by occasionally strong recruitment, where the stock biomass has been dominated by single cohorts. This picture has changed in recent years where three subsequent cohorts (2004-2006) all are very abundant.
- The fishing mortality (F_{4-7}) in the last three years has increased somewhat from 2010 to 2011 and is in 2011 estimated to 0.39. SSB in 2011 and F in 2010 are very close to the estimate from last year. The 2009 and 2010 total stock biomass of 1.2 million is the highest observed in the time series, which goes back to 1950. The SSB peaked in 2011 at 445 000 tonnes, which is also an all-time high.
- In the projection RCT3 was used to estimate recruiting year classes from 2009 and onwards. The results indicate that the year classes 2009 and 2011 are above average, while the 2010 year class is slightly below average. The evaluated and agreed HCR gives a catch in 2013 of 238,000 t, corresponding to F=0.61. A further decrease in stock size and catch level towards a more normal situation is expected in the coming years.

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

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

- In the projections the geometric mean age 3 recruitment of 168 million was used for the 2009 and subsequent year classes.
- A catch in 2013 corresponding to the evaluated and implemented HCR is 164,000 t. This catch corresponds to a fishing mortality of 0.32 in 2013. SSB is estimated to decrease from 315,000 t in 2012 to 302,000 t in 2013.

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

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

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

Beaked redfish (*Sebastes mentella*) in Sub-areas I and II (Northeast Arctic) was for the first time assessed using a statistical catch at age model (SCAA) using fisheries and survey data. The use of this model was approved at the benchmark meeting (WKRED) in February 2012. The results of the new analytical assessment have changed the perception of the stock status. The present advice is based on this new perception and quantitative projections.

The current size of the mature stock, as estimated from the SCAA, Gadget and surveys, is at least ½ million tonnes and more likely above 800 000 tonnes. This is expected to decrease in coming years due to poor year classes born in 1996-2003. The stock of *S. mentella* in subareas I and II may at present sustain a moderate fishery.

If catches are maintained at the level of 2011, it is expected that the SSB will decline by 9% by 2015 but return to current level by 2017. The long term effects of maintaining current catch levels on the demographic structure and reproductive potential of *S. mentella* have not been investigated yet. Given the longevity of the species (70 years) and low productivity of the stock, *S. mentella* has a long recovery time. It is therefore recommended that catches should not increase beyond current levels until the long term effects on demography are better estimated.

Therefore, the advice for 2013 is that a commercial fishery can operate on *S. mentella*, given that the total catch level, including bycatches and discards, does not exceed the current level (2011) of 12 500 tonnes. Measures currently in place to protect juveniles have proven successful and should be maintained.

Golden redfish (*Sebastes marinus*) in Sub-areas I and II (Northeast Arctic) was assessed using the Gadget model. This model was used for the seventh time as an analytical assessment model and the use of this model was approved at the benchmark meeting in February 2012.

- Since 1993, recruitment of *S. marinus* has been extremely low, but there are some signs of improved recruitment in recent years.
- commercial data and surveys show consistent declining trends in the spawning biomass
- the exploratory assessment conducted using the Gadget simulation model covering the period 1986–2011 showed a reduction of the spawning stock to less than 50% of the level in the early 1990s, and a more severe reduction of the recruitment and the immature stock
- present available information confirms last year's evaluation of the very poor status of the stock
- catches have been stable in recent years, and with a declining stock size this indicates that the fishing mortality is increasing
- the stock may become commercially extinct within a decade

Greenland halibut in Subareas I and II (Northeast Arctic) is in the category "same advice as last year" this year and last year's advice (catches should not exceed 15,000 t) was repeated. Stock trends in recent years indicate a slight increase in stock size, but this trend is considerably stronger in Russian surveys than in Norwegian surveys. There is no accepted analytical assessment for the time being. The age reading workshop held in February 2011 (WKARGH) did not lead to agreement on the age reading methodology. Several new age reading methodologies all indicate considerably slower growth after age 4-5 than the old methodology gives.

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

In autumn 2013 there will be a benchmark meeting for Greenland halibut.

1 Introduction

1.1 Participants

Asgeir Aglen	Norway
Matthias Bernreuther	Germany
Bjarte Bogstad (Chair)	Norway
Jose Miguel Casas	Spain
Anatoly Chetyrkin	Russia
Gjert Endre Dingsør	Norway
Anatoly Filin	Russia
Harald Gjøsæter	Norway
Elvar Halldor Hallfredsson	Norway
Daniel Howell	Norway (by correspondence)
Yuri Kovalev	Russia
Sigbjørn Mehl	Norway
Pavel Murashko	Russia
Benjamin Planque	Norway
Dmitry Prozorkevich	Russia
Alexey Russkikh	Russia
Jan Erik Stiansen	Norway (by correspondence)
Oleg Smirnov	Russia (by correspondence)
Ross Tallman	Canada
Tone Vollen	Norway
Natalia Yaragina	Russia

1.2 Terms of reference

The **Arctic Fisheries Working Group** (AFWG), chaired by Bjarte Bogstad, Norway, will meet in ICES Headquarters, Copenhagen 20 April – 26 April 2012 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 03 May 2012 (and 5 October 2012 for Barents Sea capelin) for the attention of ACOM.

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

Generic ToRs for Regional and Species Working Groups

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

The working group should focus on:

ToRs a) to g) for stocks that will have advice (or biennial first year),

ToRs b) to d) and f) for stocks with biennial advice in the second year

a) Produce a first draft of the advice on the fish stocks and fisheries under considerations according to ACOM guidelines and implementing the generic introduction to the ICES advice (Section 1.2).

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). Where relevant suggest improvement for the revision of the DCF.

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

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

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 catch options for next year;
   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) In the autumn, where appropriate, check for the need to reopen the advice based on the summer survey information and the guidelines in AGCREFA2 (2012 report).

Points a-f are dealt with in Chapter 1 and in the chapters covering the respective stocks. Point g) is not relevant for AFWG.

The assessment groups have also been asked to review and revise the categorization proposed by WKLIFE of the data limited stocks within the groups TOR's. This is handled in Section 0.10.

1.3 Unreported landings

In this report, the terms 'landings' and 'catches' are, somewhat incorrectly, used as synonyms, as discards are in no cases used in the assessments. This does not mean, however, that discards are negligible for all stocks, but the WG has no information on the possible extent of discarding.

As last year, a report from the Norwegian-Russian Analysis group dealing with estimation of total catch of cod and haddock in the Barents Sea in 2011 was available to AFWG. The report presents estimated catches made by Norwegian, Russian and third countries separately. According to that report the total catches of both cod and haddock reported to AFWG are very close (within 1%) to the estimates made by the analysis group. Thus it was decided to set the IUU catches for 2011 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. There has been no progress on this issue since it was raised in 2010.

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

1.4 Uncertainties in the data

Catch data

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

During the present AFWG meeting specific concerns were expressed about discarding of small haddock on the nursery grounds in the Russian economic zone, and discarding of cod related to big catches when the skipper hauls the next trawl before the previous catch is processed. The combination of great amounts and fishable concentrations of cod and haddock, reduced minimum legal fish size limits in the Norwegian Economic zone and in the Svalbard area (Spitsbergen archipelago), may due to large amounts of large and better paid fish and a reduced possibility for the enforcement agencies to close small-fish areas (due to more liberal legal catch sizes), lead to a greater risk for discarding.

Discarding has the last year again arisen in the Norwegian management and media debate, and quantification of the problem, whether insignificant or not, should be done routinely. A pilot study of discarding in Norwegian fisheries has been initiated by the Norwegian Directorate of Fisheries and the Norwegian Institute of Marine Research.

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

For *S. mentella*, documentation of the fishing effort involved and the catches taken in the international fishery is very important, and NEAFC is requested to continue to provide timely and consistent information for future stock assessments and advice.

Survey data

While the area coverage of the winter surveys for demersal fish was incomplete in 1997 and 1998, the coverage was normal for these surveys in 1999-2002. In the autumn 2002, 2006 and winter 2003, 2007 however, surveys were again incomplete due to lack of access to both the Norwegian and Russian Economic Zones. This affects the reliability of some of the most important survey time series for cod and haddock and consequently also the quality of the assessments. In some years, the permission to work in the Norwegian and Russian Economic Zones, respectively, has been received so late that the work has been severely hampered, e.g., the Russian survey in autumn 2003 and 2006. There is no acceptable way around this problem except asking the Norwegian and Russian authorities to give each other's research vessels full access to the respective economical zones when assessing the joint resources, as, e.g., was the case for Joint winter surveys (BS-NoRu-Q1 (Btr) and BS-NoRu-Q1 (Aco)) in 2004-2005 and 2008-2011. Due to technical problems with one of the research vessels, the area coverage for this survey was incomplete in 2012. The method applied to adjust for this lack of coverage is described in Section 3.2.2 and WD03.

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

Age reading

In 1992, PINRO, Murmansk and IMR, Bergen began a routine exchange program of cod otoliths in order to validate age readings and ensure consistency in age interpretations (Yaragina *et al*. 2009b, AFWG 2008, WD 20). Later, a similar exchange program has been established for haddock, capelin and *S. mentella* otoliths. Once a year (for capelin every second year, no exchanges of redfish age readers so far) the age readers have come together and evaluated discrepancies, which are seldom more than 1 year, and the results show an improvement over the time period, despite still observing discrepancies for cod in the magnitude of 15-30%. An observation that is supported by the results of a NEA cod otolith exchange between Norway, Russia and Germany (Høie *et al*. 2009, AFWG 2009, WD 6). 100 cod otoliths were read by 3 Norwegian, 2 Russian and 1 German reader, reaching nearly 83% agreement (coefficient of variation 8%). The age reading comparisons of these 100 cod otoliths show that there are no reading biases between readers within each country. However, there is a clear trend of bias between the readers from different countries, Russian age readers assign higher ages than the Norwegian and German age readers. This systematic difference is a source of concern and is also discussed in Yaragina *et al*. (2009b). This seems to be a persistent trend and will be revealed in the following annual otolith and age reader exchanges.

From 2009 onwards it was decided to have meetings between cod and haddock otolith readers only every second year. An otolith reader meeting for cod and haddock was held in 2011 (WD01). The overall precision between the six cod age readers was good with a percent agreement of 87.0% and CV of 4.1%. The individual precision of each age reader compared to modal age was also good and ranged from 80.0 to 96.0%, while individual CV ranged from 2.5 to 8.7%.

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

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

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

A positive development is seen for haddock age readings showing that the frequency of a different reading (usually ±1 year) has decreased from above 25% in 1996-1997 to about 10% at present. The discrepancies are always discussed and a final agreement on the exchanged cod and haddock otoliths is at present achieved for all otoliths except ca. 2-5%.

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

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

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

It was concluded that experts from all laboratories normally interpret capelin otoliths equally. Difficult otoliths are sometimes interpreted differently, but these samples are few, and should not cause large problems for common work on capelin biology and stock assessment. All participants noted the great value of conducting joint work on otolith reading, and it was decided to continue the programme of capelin otolith exchange and to involve the labs at Iceland and Newfoundland in the exchange program. Readers from Norway and Russia will continue to meet at Workshops every second year. Readers from all labs involved will meet less frequently. Details will be discussed and decided by correspondence.

An ICES Workshop on Greenland halibut age reading (WKARGH) was held in February 2011 (ICES CM 2011/ACOM:41). In order to achieve the most accurate age estimates, ICES recommends methods and best practice for age reading of both redfish and Greenland halibut. Still there continue to be differences in opinion between PINRO and IMR regarding age reading methods for these species. It is recommended to start annual or bi-annual exchange of otoliths and age reading experts on these species in order to identify the differences in interpretation and to discuss possibilities for a common approach. The first meeting should be held during autumn 2012 and should include both age reading technicians and scientists involved in the development of the methods.

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

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. It may be difficult to provide annual estimates of CV in this survey for use in the assessment, since the assessment is carried out just after the survey is completed. However, the time series of annual survey CVs given in Tjelmeland (2002) should be updated.

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

Sampling effort - commercial fishery

Table 0.1 and 0.2 show the development of the Norwegian and Russian sampling of commercial catches in the period 2008-2011.

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. A Norwegian port sampling program was restarted in 2011, although with a much lower effort, but this improved the basis for the 2011 catch-at-age estimates and stopped the declining trend in sampling intensity seen after 2008.

The samples and data basis behind each stock assessment are discussed more in detail under each stock chapter (e.g., the coastal cod). The number of aged individuals per 1000 t is now well below the standard set by EU in their Data collection regulations. It is therefore to be expected that the current assessments of these stocks may be less precise than in recent years.

Due to the adopted amendments of the Russian Federal Law "On fisheries and preservation of aquatic biological resources" coming into force, especially concerning the destruction of biological resources caught under scientific research, sampling activities (age sample numbers and mass measurements of fish) onboard Russian fishing vessels are also reduced, especially in ICES Sub-areas IIa and IIb, which may result in greater uncertainty of the stock assessments due to possible biases in the age-length distributions of the commercial catch.

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

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

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

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

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

Table 0.1. Age and length sampling by Norway of commercial catches in 2008-2011. Number of samples and average number of fish per sample. Also number of age samples and aged individuals per 1000t caught. For comparison also the EU DCF requirements are shown.

Stock	Year	No of unique vessels	No of length samples	No of lenght-measured individuals	No of age samples	No of aged individuals	Landings, tonnes	Length-samples pr 1000 t	Age-samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison, per 1000 t
NEA-cod + coastal cod	2008	336	2526	51263	464	16026	196067	12.9	2.4	81.7	125
	2009	272	2669	53350	417	14170	224816	11.9	1.9	63.0	125
	2010	175	2542	39733	338	7671	263816	9.6	1.3	29.1	125
	2011	273	2305	46227	434	10043	331535	7.0	1.3	30.3	125
NEA-haddock	2008	285	2177	45038	281	9474	72553	30.0	3.9	130.6	125
	2009	233	2255	41481	206	6010	104882	21.5	2.0	57.3	125
	2010	154	2155	38045	232	5458	123517	17.4	1.9	44.2	125
	2011	227	2028	39663	312	7225	158293	12.8	2.0	45.6	125
NEA-saithe	2008	252	1327	19419	160	5262	165998	8.0	1.0	31.7	125
	2009	182	1337	13354	113	2981	144570	9.2	0.8	20.6	125
	2010	138	1316	15998	151	3667	173969	7.6	0.9	21.1	125
	2011	152	1210	17412	215	4843	156700	7.7	1.4	30.9	125
S. marinus	2008	104	1093	18305	98	2281	6180	176.9	15.9	369.1	125
	2009	66	1131	17386	96	2302	6215	182.0	15.4	370.4	125
	2010	49	1050	19339	97	2164	6515	161.2	14.9	332.2	125
	2011	75	1064	16347	106	2310	4645	229.1	22.8	497.3	125
*S. mentella **)*	2008	13	178	1038	0	0	2214	80.4	0.0	0.0	125
	2009	12	319	1841	2	40	2567	124.3	0.8	15.6	125
	2010	11	284	3664	11	320	2245	126.5	4.9	142.5	125
	2011	9	255	3210	11	298	2690	94.8	4.1	110.8	125
G. halibut	2008	53	580	9074	0	0	7394	78.4	0.0	0.0	125
	2009	36	922	12853	0	0	8446	109.2	0.0	0.0	125
	2010	26	519	8395	0	0	7685	67.5	0.0	0.0	125
	2011	29	463	8204	0	0	8273	56.0	0.0	0.0	125
Capelin	2008	4	3	150	0	0	5000	0.6	0.0	0.0	125
	2009	18	97	7039	39	1039	233000	0.4	0.2	4.5	125
	2010	75	230	6191	47	1291	246000	0.9	0.2	5.2	125
	2011	115	315	8346	48	1313	273000	1.2	0.2	4.8	125

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

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

Table 0.2. Age and length sampling by Russia of commercial catches, age sampling of surveys in 2008-2011. Also length-measured individuals and aged individuals per 1000 t caught. For comparison also the EU DCF requirements are shown.

Stock	Year	No of lenght-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total No of aged individuals	Landings, tonnes	Lenght-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison, per 1000 t
NEA-cod*	2008	380592	3097	7565	10662	190225	2001	16.3	56.0	125
	2009	178038	1075	7426	8501	229291	776	4.7	37.1	125
	2010	126502	1828	7670	9498	267547	473	6.8	35.5	125
	2011	122623	2376	5783	8159	310326	395	7.7	26.3	125
NEA-haddock	2008	216959	2498	5677	8175	68792	3154	36.3	118.8	125
	2009	43254	489	5421	5910	85514	506	5.7	69.1	125
	2010	85445	834	5060	5894	111372	767	7.5	52.9	125
	2011	61990	1570	3584	5154	139912	443	11.2	36.8	125
NEA-saithe	2008	8865	479	175	654	11577	766	41.4	56.5	125
	2009	5279	7	68	75	11899	444	0.6	6.3	125
	2010	422	112	249	361	14664	29	7.6	24.6	125
	2011	88	9	27	36	10007	9	0.9	3.6	125
S. marinus	2008	1196	45	17	62	749	1597	60.1	82.8	125
	2009	241	2	27	29	698	345	2.9	41.5	125
	2010	486	25	199	224	806	603	31.0	277.9	125
	2011	885	77	62	139	919	963	83.8	151.3	125
S. mentella	2008	21446	471	3379	3850	7117	3013	66.2	541.0	125
	2009	29435	761	1447	2208	3843	7659	198.0	574.6	125
	2010	2776	100	2295	2395	6414	433	15.6	373.4	125
	2011	917	7	640	647	5037	182	1.4	128.4	125
G. halibut	2008	106411	1519	3366	4885	5294	20100	286.9	922.7	125
	2009	77554	819	2282	3101	3335	23255	245.6	929.8	125
	2010	32090	416	2784	3200	6888	4659	60.4	464.6	125
	2011	9892	115	1541	1656	7053	1403	16.3	234.8	125
Capelin	2008**	82625	1644	2341	3985	5000	16525	328.8	797.0	125
	2009	94541	900	2511	3411	73000	1295	12.3	46.7	125
	2010	67265	1072	4043	5115	77000	874	13.9	66.4	125
	2011	63784	1273	2271	3544	86531	737	14.7	41.0	125

*) in addition also used long-term mean age-length keys

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

1.5 Assessment method issues

Issues concerning XSA convergence have been pointed out by the ICES WGMG in 2009 (ICES CM 2009/RMC:12). Both for cod, haddock and saithe, XSA has this year been run to convergence.

1.6 Climate included in advice of NEA cod

For the fifth 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.

1.7 Proposals for status of assessments in 2013–2014

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

FishStock	**Stock Name**	**Advice in 2012***	**Previous benchmark**	**Next benchmark**
cod-arct	Cod in Subareas I and II (Northeast Arctic)	Update	-	2014
cod-coas	Cod in Subareas I and II (Norwegian coastal waters)	Update	-	2014
had-arct	Haddock in Subareas I and II (Northeast Arctic)	Update	WKBENCH 2011	-
sai-arct	Saithe in Subareas I and II (Northeast Arctic)	Update	WKROUND 2010	-
cap-bars	Capelin in Subareas I and II (Barents Sea), excluding Division IIa west of 5°W	Update	WKSHORT 2009	-
ghl-arct	Greenland halibut in Sub-areas I & II	Update	-	2013
smn-arct	Redfish *Sebastes mentella* Subareas I and II	Update	WKRED 2012	-
smr-arct	Redfish *Sebastes marinus* Subareas I and II	Update	WKRED 2012	-

1.8 ICES Quality Handbook

Quality Handbooks for all stocks are presented in this report as annexes (no. 2-9). The stock annexes for the redfish stocks have been updated after the benchmark at WKRED 2012.

1.9 InterCatch

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

1.10 Issues raised by WKLIFE

The 2012 report of WKLIFE (ICES C.M. 2012/ACOM:36) considered development of assessments based on life history traits and exploitation characteristics. All such stocks were classified by WKLIFE. Of the AFWG stocks, Coastal cod, the redfish stocks and Greenland halibut were considered by WKLIFE. The classification made by WKLIFE for the AFWG stocks is given in the table below:

Stock	Category	Comment
Coastal cod	3	
S. mentella	1	WKRED adopted Gadget model
S. marinus	1	WKRED adopted Gadget model
G. halibut	4,6	Catch statistics and survey: awaiting validation of age reading

Where:

category 1 : Data rich stocks (quantitative assessment)

category 3 : Stocks with analytical assessments and forecasts that are only treated qualitatively

category 4: Stocks for which survey-based assessments indicate trends

category 6: Data-limited stocks

The classification of the redfish stocks is OK. For *S. mentella* it is the SCAA model which is adopted, not Gadget. Coastal cod probably belongs both to categories 3 and to 7 – stocks caught in minor amounts as by-catch. Greenland halibut can't be considered a data-limited stock and does not belong in category 6, only in 4.

AFWG has not considered the analysis methods for such stocks proposed by WKLIFE. These methods could be of relevance for the Norwegian Coastal Cod.

1.11 MSY-related reference points and advice

AFWG has followed the guidelines for MSY-based advice outlined by WKFRAME2 (ICES C. M. 2011/ACOM:33). Both for Northeast Arctic cod, haddock and saithe, the F_{MSY} values are based on long-term stochastic simulations with a population dynamics model which also takes density-dependent effects into account. For these as well as most other stocks, the maximum of the yield vs. F curve is not very well determined. For all three stocks, the target fishing mortality in the adopted management plan (F_{MP}) is within the range for which long-term simulations indicate a high long-term yield. There is at present an inconsistency between the advice for the Northeast cod, haddock and saithe stocks, because although similar analyses have been done for all these stocks, the F_{MP} has been adopted as F_{MSY} in the ICES advice for haddock, but not for cod and saithe. AFWG suggests F_{MP} to be adopted as F_{MSY} also for cod. For saithe F_{MSY} is likely to be below F_{MP} but more analyses are needed to investigate this.

1.12 Recommendations

A benchmark meeting for Northeast Arctic cod and Norwegian Coastal cod should be held in 2014.

Sampling effort and coverage should be improved.

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

NEAFC is requested to continue to provide timely and consistent information for future stock assessments and advice of *S. mentella*.

The XSA model sensitivity to parameter "*Catchability dependent on stock size for ages*" needs to be considered by the ICES methods study group (WGMG).

1.13 Time and place of Next Meeting

The Working Group proposes to meet next time at ICES headquarters in the period 19-25 April 2013. Alternative locations can be considered.

1.14 Nomination of new Chair

The Working Group was pleased to unanimously endorse the renomination of Bjarte Bogstad as chairman of the Arctic Fisheries Working Group for the period 2013-2015.

1 Ecosystem considerations (Figures 1.1–1.17, Tables 1.1–1.16)

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

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 by increased impact of warm Atlantic water in the Barents Sea contributing to advection of zooplankton, faster growth rate in fish and emergence of abundant year classes (Dalpadado *et al.* 2002). A cold period is, conversely, characterized by reduced primary biological production in the Barents Sea and emergence of weak year classes of commercial species. 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 the "Joint Norwegian-Russian environmental status 2008, report on the Barents Sea Ecosystem" (Stiansen *et al*., 2009), affiliating more than 100 scientists from 24 institutions in Norway and Russia. It is further based on Stiansen *et al*., (WD18), which describe the current ecosystem situation in the Barents Sea. Additional information is also gathered from other ICES WG's reports and WD's to this AFWG assessment. Text, figures and tables taken from these reports (i.e. Stiansen *et al*., 2009, and Stiansen *et al.* WD18) are in general not further cited in this chapter. In addition, information is also taken from the newly published book "The Barents Sea – ecosystem, resources , management" (Jakobsen and Ozhigin 2011).

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

1.1 General description of the Barents Sea ecosystem (Figure 1.1–1.2, Tables 1.1–1.10)

1.1.1 Geographical description

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

1.1.2 Climate

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

1.1.3 Bacteria and phytoplankton

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

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

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

1.1.4 Zooplankton

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

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

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

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

1.1.5 Benthos and shellfish

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

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

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

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

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

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

There are 8 species of squid inhabiting the Barents Sea (Golikov *et al.*, 2008). The flying squid *Todarodes sagittatus* was a significant fishing resource in Norwegian waters during several periods up about 1988 (Borges, 1990). However, since then this squid has almost been absent from our waters and only sporadic catches have been recorded. *Gonatus fabricii* is another abundant squid species in the off shore waters of the Barents and the Norwegian Sea (Bjørke, 1995). This squid is important food for several bird and cetacean species, but could probably also be seen as a potential fishing resource.

1.1.6 Fish

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

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

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

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

Herring is also a major predator on zooplankton. The herring spawns along the Norwegian western coast and the larvae drifts into the Barents Sea as well as into fjords along the coast. 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 this area has been described to have a profound effect on the survival of capelin larvae, and thereby on the recruitment to the capelin stock. The three collapses during the last three decades were all caused by recruitment failures, and all three were associated with rich herring year classes inhabiting the Barents Sea. However, while the presence of herring is seemingly a necessary factor for total recruitment failures of the capelin stock, it is not a sufficient factor, since in some recent years; the capelin recruitment has been relatively good in spite of moderate to high amounts of young herring in the Barents Sea.

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

Saithe is found mainly along the Norwegian coast, but also occurs in the Norwegian Sea and in the southern Barents Sea. The 0-group saithe drifts from the spawning grounds to inshore waters. The smaller individuals feed on crustaceans, while larger saithe depends more on fish as prey (Jakobsen and Ozhigin 2011). 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 fish predator with the continental slope between the Barents Sea and the Norwegian Sea as its most important area, but it is also found in the deeper parts of the Barents Sea. Investigations in the period 1980-1990 showed that cephalopods (squids, octopuses) dominated in the Greenland halibut stomachs, as well as fish, mainly capelin and herring. Ontogenetic shift in prey preference was clear with decreasing proportion of small prey (shrimps and small capelin) and increasing proportion of larger fish with increasing predator length. The largest Greenland halibut (length more than 65-70 cm) had a rather big portion of cod and haddock in the diet.

The blue whiting has its main distribution area in the Norwegian Sea and Northeast Atlantic, and the marginal northern distribution is at the entrance to the Barents Sea. Usually the blue whiting population in the Barents Sea is small. In some years the blue whiting may enter the Barents Sea in large numbers, and can be a dominant species in the western areas. This situation occurred from 2001 onwards, and blue whiting were found in great numbers for the period 2003-2007. Since then the abundance has decreased strongly again, but shows an increase in 2012 (Table 1.8). These fluctuations are 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 (Jakobsen and Ozhigin 2011).

Long rough dab is a typical ichthyobenthophage, which mainly eats benthos (ophiura, polychaetes etc.) and different fish species (Jakobsen and Ozhigin 2011). 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).

Diet composition of main predatory fish species in the Barents Sea are shown in the Table 1.9.

1.1.7 Mammals

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

Marine mammals may consume up to 1.5 times the amount of fish caught in fisheries. Minke whales and harp seals may each year consume 1.8 million and 3-5 million tons of prey of crustaceans, capelin, herring, polar cod, and gadoid fish respectively (Folkow *et al*., 2000; Nilssen *et al.,* 2000) (Table 1.10). Functional relationships between marine mammals and their prey seem closely related to fluctuations in marine ecosystems. Both minke whales and harp seals are thought to switch between krill, capelin and herring depending on availability of the different prey species (Lindstrøm *et al*., 1998; Haug *et al*., 1995; Nilssen *et al*., 2000).

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

1.1.8 Seabirds

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

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

1.1.9 Parasitic organisms

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

1.1.10 Rare and threatened species

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

1.1.11 Invasive species

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

1.1.12 Human activity

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

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

A reduction in fuel consumption per kg fish caught by the Norwegian fishing fleet has been observed in recent years. Purse seiners and coastal seiners have the lowest fuel consumption per kg fish caught (0.07-0.08 ltr/kg fish), while the longliners, the small coastal vessels and the bottom trawlers have higher fuel consumption (from 0.17-0.34 ltr/kg fish). All fleets have managed to reduce their fuel consumption in recent years (http://www.fiskebat.no/Default.asp?page=5167&item=53485,1&lang=1)

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.

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

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

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

The high biodiversity of the oceans represents a correspondingly rich source of chemical diversity, and there is a growing scientific and commercial interest in the biotechnology potential of Arctic biodiversity. Researchers from several nations are currently engaged in research that could be characterised as bio-prospecting.

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

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

1.2 Current state and expected changes in the ecosystem (Figures 1.3–1.11, Tables 1.1–1.8, 1.10)

1.2.1 Climate

Atmospheric conditions

The winter of 2010/2011 was characterized by relatively small negative value of the North Atlantic Oscillation (NAO) index. The following development of the positive phase, lasting to April, was accompanied by strengthening of westerly in the North Atlantic, minor and short-term reduction in the Arctic ice coverage. Positive air temperature anomalies dominated the Barents Sea during 2011 with maximum anomalies exceeding 5°C in March and December in the eastern Barents Sea.

Water temperature

Variations of sea surface temperature (SST) in 2011 were similar to those of air temperature. The SST anomalies were predominantly positive and gradually increasing during the year. Positive anomalies grew more intensively in the eastern Barents Sea from March to October. In the central part of the sea, steady growth of positive anomalies began in June. In the western areas, from January to August, weak negative SST anomalies (<0.5°C) were registered, and, in September-October, SST was higher-than-normal.

In the bottom layer, positive temperature anomalies continued to be dominating (Figure 1.3). The highest anomalies (>1.5°C) were observed in the eastern and south-eastern parts of the sea, as well as in the Bear Island - Spitsbergen area. Negative anomalies of bottom temperature were registered in the southern Barents Sea, in the area of the coastal branch of the Murman Current. Compared to 2010, there was a temperature reduction in the bottom layer in the central and southern Barents Sea, while in the east, northeast and northwest, an increase in temperature was registered.

The Fugløya-Bear Island Section, which capture all the Atlantic Water entering the Barents Sea from south-west, showed temperatures of only 0.1-0.2 °C above the long-term mean in early 2011 (Figure 1.4). During the year the temperatures increased (compared to the mean), and in August 2011 the temperature in south-west was 0.5 °C above the long-term mean.

According to the data from the Kola Section, the beginning of the year was much colder than 2010 and characterized by small positive anomalies (0.1-0.2 °C) (Figure 1.5). In spring positive anomalies grew in all the branches of the warm currents. In summer and autumn, a reduction in the positive anomalies in the Murman Current branches occurred. Later in the year, the positive anomalies increased in all the branches of the warm currents crossed by the section (Figure 1.5). On the whole, it may be noticed that the mean annual temperature in the 0-200 m layer in the Kola Section in 2011 was at the level of warm years, however it was lower than in 2010.

According to a prediction model (Boitsov and Karsakov, 2005), based on harmonic analysis of the Kola Section temperature time series, the temperature of Atlantic waters is expected to remain at the level of warm years in 2012 and decline to the level of normal years in 2013.

Salinity

The salinity variations are often similar to those in temperature, but but this relation broke down in 2009-2010. In 2011, according to data from the Fugløya-Bear Island Section and the Kola Section, the salinity has increased while the temperature has decreased (Figures 1.3-1.4). During most part of the 2011 year in the 0-200 m layer of the Kola section positive salinity anomalies were registered (Figure 1.5). In October-December the salinity dropped, but on the whole, in 2011 the mean annual salinity was higher than normal and the previous year level.

Inflow of Atlantic water

The volume flux into the Barents Sea varies with periods of several years, and was significantly lower during 1997–2002 than during 2003–2006 (Figure 1.6). After 2006 the inflow has been relatively low. There has been, however, a weak increasing trend since 2009, and the volume flux during the first half of 2011 was close to the 1997-2011 mean. The data series presently stops in summer 2011, thus no information about the fall and early winter 2011/2012 is available. On annual time scales the volume flux and temperature in the inflowing Atlantic Water does not vary in synchrony, and the temperature has shown a declining trend since 2006 which continued into 2011. Thus since 2009 the temperatures have decreased while the volume flux has weakly increased. The temperature is mainly determined by variations upstream in the Norwegian Sea, while the volume flux to a large degree varies with the wind conditions in the western Barents Sea.

Ice conditions

Meteorological situation over the Barents Sea in the winter 2010/2011 favored widening the area covered by sea ice. In January and February, the ice coverage (expressed as a percentage of the sea area) was close to the long-term mean and more than in 2010. In winter and spring, the prevalence of westerlies and higher air temperature over the sea slowed down ice formation process to a great extent. From March to May, the total ice coverage was less than normal and less than that in 2010. The ice melting began already in June and was more intensive than previous year, especially, in the southwestern sea. Ice forming was slow and started in the late October in the northern most part of the sea. In September and October, the total ice coverage of the sea was less than normal and close to the previous year level, and, in November-December, it was lower than in 2010 and less than the long-term mean (Figure 1.7).

Hydrochemical conditions

Based on the observations along the Kola Section, it may be concluded that in 2011, in the bottom layer the oxygen saturation of waters was lower-than-normal and remained close to the previous year level.

1.2.2 Phytoplankton

Not updated this year

1.2.3 Zooplankton

The data obtained during the joint Russian-Norwegian ecosystem survey in the second half of August-early September 2011 showed that the highest biomasses of zooplankton were formed in the northeastern Barents Sea (Figure 1.8). In this region of the Barents Sea, the most abundant copepod species were the Arctic *C. glacialis*, *Pseudocalanus minutus*, *M. longa*, as well as the North Atlantic *C. finmarchicus*. Also in the west at the entrance to the Barents Sea relatively high zooplankton biomass was observed, probably reflecting the influence of the more plankton rich Atlantic water masses. The average mesozooplankton biomass measured in August–September 2011 was somewhat below the long-term mean but has been reasonably stable during the last four years (Figure 1.9).

The macroplankton survey conducted in late autumn and winter 2010 showed that in the west and northwest areas of the Barents Sea the abundance and biomass of krill (euphausiids) were lower than in 2009 but still higher than the long-term means. Arctoboreal *Thysanoessa inermis* has been a dominant species. In the recent years, the area and abundance of *Th. raschii* are reduced, because of the water temperature increase in the Barents Sea.

The abundance of large gelatinous zooplankton was distinctly higher in 2011 compared to 2010. The centre of distribution and highest abundance in 2011 was found in the south-western part of the Barents Sea, while somewhat lower values were found in a wider region surrounding this "hotspot". Overall the distribution and abundance in 2011 was similar to what was observed in 2008.

1.2.4 Northern shrimp

According to the Russian-Norwegian ecosystem survey in August – September 2011 the largest catches of the northern shrimp were recorded in the eastern and northern Barents Sea and north of Spitsbergen. The investigations of 2011 showed that the total stock of the northern shrimp is above the long-term mean, but slightly lower than last year, a conclusion that was confirmed by the assessment done by the NAFO/ICES *Pandalus* Working Group (NIPAG, ICES CM 2011/ACOM:14).

1.2.5 Fish

The current and expected situation of the commercial stocks in the Barents Sea addressed by the AFWG is given in later chapters. Therefore focus in this subchapter is on other main species that interacts with the AFWG stocks, and on the role of the AFWG species in an ecosystem perspective (e.g. as predators). Special attention is given when there are deviations from the general situation. An overview of the development of pelagic and demersal stocks is given in Figures 1.10 and 1.11. The data on recruitment (0-group abundance indices) of the main species are shown in Tables 1.1-1.2.

NEA cod consumption

The food consumption of cod in 1984-2011, 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 2011 were capelin, krill (Euphausiids), polar cod, haddock, cod, shrimp and amphipods. In comparison with 2010 the changes in prey consumption are small. The consumption calculations made by IMR show that the total consumption by age 1 and older cod in 2011 was about 6.4 million tonnes based on cod abundance from the 2011 assessment and 8.8 million tonnes based on cod abundance from 2012 assessment (Table 1.3). Only the results obtained by using the 2012 assessment are shown in Table 1.3. The similar calculations by PINRO based on cod abundance from 2011 assessment gave 4.8 million tons (Table 1.4). The consumption per cod by cod age groups are shown in Tables 1.5-1.6.

Blue whiting and polar cod

In the western part of the Barents Sea blue whiting were observed during the ecosystem survey as in previous years. Since 2004-2005, when more than one million tonnes of blue whiting was found in this area, there has been a steady decrease in biomass and the age distribution has been shifted towards older fish. In autumn 2011, the total biomass of blue whiting in the Barents Sea was estimated to 130,000 tonnes, which is at the same low level as in 2008-2010. However, the abundance of 15-19cm (mainly 1-group) blue whiting during the winter survey 2012 (Table 1.8) was the highest since 2005.

Polar cod was during the ecosystem survey distributed from the western and southern coast of Novaya Zemlja to Spitsbergen. A dense concentration was observed close to the western coast of Novaya Zemlya, while scattered concentrations occurred around Spitsbergen and in the northern parts of the Barents Sea. The total stock, estimated at 0.9 million tonnes, is lower than in 2010, but at about the same level as in 2009. The stock size of polar cod in the Barents Sea has been measured acoustically since 1986 and the stock has fluctuated between 0.1-1.9 million t. In 2011, the stock size was somewhat above the long term mean level. The 2011 year-class of polar cod is slightly above average.

Herring and capelin

Since 2004 no strong year classes of the Norwegian spring-spawning herring have been observed. In 2011 the distribution area of age 1+ herring in the Barents Sea was very small, it was found only north of the coast of Finnmark. 0-group herring were distributed in the central part of the sea. The 2011 year-class of herring is lower than the average level, and can be characterized as poor. The total herring 1+ biomass in the Barents Sea was estimated to be 110,000 t in 2011, which is less than what was found in 2010 and the lowest value in the time series which goes back to 1999. The abundance of herring in the Barents Sea is believed to be at a low level also in 2012.

The capelin stock size is at a level somewhat above average (Figure 1.9). Based on the most recent estimates of SSB and recruitment ICES classifies the stock as having full reproductive capacity. In August-September 2011 age 1 and older capelin was distributed over a wide area - from the Norwegian and Russian coast until 81˚N and from West of Svalbard all the way to the entrances to the Kara Sea. Highest densities of 0-group capelin were observed in the central and south-eastern part of the Barents Sea, between 25-35˚E˚ and 42-48 ˚E. The 2011 year class is higher than the long term average and can be characterized as relatively strong.

The total distribution area of capelin at age 1+ in the Barents Sea in August-September 2011 was wider than in 2010. The total stock is estimated during the ecosystem survey at about 3.7 million tonnes. It is about 6% higher than the stock estimated last year and higher than the long term mean level. About 57 % (2.1 million tonnes) of this stock was above 14 cm and considered to be maturing.

Skates

Thorny skate (*Amblyraja radiata*) is a representative of the boreal zoogeographic group. As in 2009 and 2010, this species was quite widely distributed in the Barents Sea excluding southeastern and northeastern regions. Catches of thorny skate were more common to the north and northeast of Spitsbergen/Svalbard this year than in previous years. Thorny skate preferred to stay in depths from 50 m down to 150 m.

Northern skate (*Amblyraja hyperborea*) is a representative of the arctic zoogeographic group. In 2011 according to the ecosystem survey the northern skate was distributed in the deeper waters of the northeast part of the Barents Sea and in the trench of Saint Anna. The main catches were from range of depths from 200 m down to 350 m.

1.2.6 Marine mammals

Harp Seal

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

In 2011-2012 surveys for pup abundance of harp seals in the White Sea were not performed. The model estimate of the total stock for 2011 is 1.4 million animals of harp seal (ICES C.M. 2011/ACOM: 20).

Minke whale

The last available estimate of the Northeast Atlantic minke whale stock is 81,400 individuals, based on sighting surveys in the period 2002-2007. This estimate was approved by the Scientific Committee of IWC in 2009, and indicates a stable stock situation.

Predation by mammals

Analyses of consumptions by marine mammals in the Barents Sea for 2009-2011 are not available. Last estimates are shown in Table 1.10.

1.2.7 Future long-term trends

Air temperatures have increased almost twice as fast in the Arctic asthe global average over the last 50 years. With an accelerated increase in air temperatures it is predicted that summer sea ice will disappear. This will have a negative impact on ice-dependent species, such as polar bears and harp seals. The disappearance of seasonal sea ice in the Barents Sea would eliminate the ice-edge blooms which would be replaced by blooms resembling those in Atlantic waters. The removal of light limitation in areas presently covered by multi-year sea ice would result in 2-5 fold increase in primary production, assuming adequate nutrient supply (Loeng *et al.*, 2005). The expected northward extension of warm Atlantic water will lead in general to temperate zooplankton being shifted northward while ice fauna, such as the large amphipods would diminish in the Barents Sea (Skjoldal *et al*., 1987; Loeng *et al*., 2005). Ellingsen *et al*. (2008) also projected that the Atlantic zooplankton production, primarily *Calanus finmarchicus*, would increase by about 20% while the Arctic zooplankton biomass would decrease significantly (by 50%) resulting in an overall decrease in zooplankton production in the Barents Sea.

Higher temperatures should lead to improved growth rates of the fish and positive impact on their recruitment (Drinkwater, 2005; Stenevik and Sundby, 2007). A number of fish species, e.g. cod and capelin, will likely have a more northern and/or eastern distribution. Cod is expected to spawn farther north and new spawning sites will likely be established (Sundby and Nakken, 2008; Drinkwater 2005). Boreal species such as blue whiting and mackerel may become common in the Barents Sea. These changes could have ecological implications, as the new species entering the Barents Sea will compete for food with the existing species. Substantial numbers of mackerel could reduce the cod population through predation on their larvae and young juveniles.

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 and changes in predation impact may also occur. Thus, overall effects on fish productivity are hard to predict. So the results of long-term simulations by the STOCOBAR model show that the warming scenarios in the Barents Sea will lead to increase in cod stock production due to faster growth and maturation of cod. On the other hand, cannibalism will also increase caused by increment in cod consumption (Filin, 2011). This will produce a negative impact on survival of young cod. Kjesbu *et al.* (2010) also suggested that under a climate change scenario temperature might increase to a point where the largest cod females spawn too early, missing peak zooplankton production with an overall negative effect on the recruitment potential as a result.

Global warming is expected to affect polar cod and capelin, which are key forage species in the Barents Sea ecosystem, differently. Polar cod will likely become less ice-associated and more pelagic due to reductions in ice extent. The future distribution of capelin is expected to involve an expansion to the north and east. This species may partly replace polar cod in the Arctic marine food web as it moves in sub-Arctic direction due to climate warming (Hop and Gjøsæter, 2011).

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

1.3 Description of the Barents Sea fisheries and its effect on the ecosystem (Tables 1.10–1.12, Figures 1.12–1.16)

Fishing is the largest human impact to the fish stocks in the Barents Sea, and thereby the functioning of the whole ecosystem. Open ocean fisheries in the Barents Sea started in the beginning of the 20th century with the development of trawling technology. At present there is a multinational fishery operating in the Barents Sea using different fishing gears and targeting several species. The largest commercially exploited fish stocks (capelin, Northeast Arctic cod, haddock and saithe) are now harvested within sustainable limits and have full reproductive capacity. However, some of the smaller stocks (golden redfish, beaked redfish and coastal cod) are overfished. Damage to benthic organisms and habitats from trawling as well as unavoidable by-catch of marine mammals and sea birds in the Arctic fisheries 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.

1.3.1 General description of the fisheries

The harvested demersal stocks in the Barents Sea 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 2011, catches of about 1200 thousand tonnes are reported from the stocks of cod, haddock, saithe, redfish, and Greenland halibut.

The harvested pelagic stocks in the Barents Sea are capelin, herring, and polar cod. There was no fishery for capelin in the area in 2004-2008 due to the stock's poor condition, but in 2009-2011 the stock was again sufficiently sound to support a quota between 320 000 and 400 000 tonnes. Russia, as the only nation currently fishing polar cod, fished 19 600 tonnes polar cod in 2011. Norwegian spring spawning herring is the largest stock inhabiting the Northeast Arctic with its spawning stock estimated to 6.9 million tonnes in 2012. About 988 000 tonnes were fished from this stock in 2011. The highly migratory species blue whiting and mackerel extend their feeding migrations into this region, and in 2010 about 277 000 tonnes mackerel and 35 000 tonnes blue whiting were caught in ICES area IIa, 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 1.11.

From 2011 onwards, the minimum mesh size for bottom trawl fisheries for cod and haddock is 130 mm for the entire Barents Sea (previously the minimum mesh size was 135 mm in the Norwegian EEZ and 125 mm in the Russian EEZ). It is still mandatory to use sorting grids. A change/harmonization from 2011 onwards of the minimum legal catch size for cod from 47 cm (Norway) and 42 cm (Russia) to 44 cm for all, and for haddock from 44 cm (Norway) and 39 cm (Russia) to 40 cm for all may lead to more fishing in areas that previously would be closed, and hence more discards when the availability of larger fish are good. The effect of these regulatory changes should therefore be carefully monitored.

1.3.2 Mixed fisheries

The demersal fisheries are highly mixed, usually with a clear target species dominating, and with low linkage to the pelagic fisheries (Table 1.12). 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.

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 1.12-1.15). 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.

1.3.3 Fleet composition

Figure 1.16 shows the main fleets catching bottom and pelagic fishes in the Barents Sea and Svalbard (Spitsbergen archipelago) areas. The pelagic fishery is only conducted by Russia and Norway where both countries target the capelin. Russia has, in addition, fished polar cod with pelagic trawl (Norway has not fished this species since the early 1980s), and Norway has in recent years fished some legal sized herring in a restricted coastal purse seine fishery inside 4 nautical miles off Finnmark. Further in the south western part of the Barents Sea (south-west of a line between Sørøya and Bear Island), extending into the Norwegian Sea, an international herring fishery has been open in some seasons.

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

1.3.4 Impact of fisheries on the ecosystem

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 through fishery-induced changes in food supply, food competitions and predator's pressure. 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 on benthic habitats and biota have been studied to some degree. The challenge for management is to determine levels of fishing that are sustainable and not degradable for benthic habitats in the long run. 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. 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.

Research has been undertaken to explore the possibility of using pelagic trawls when targeting demersal fish. The Russian and Norwegian scientists have collaborated closely on this research since 2008. The purpose is to avoid impact on bottom fauna and to reduce the mixture of other species. It will be mandatory to use sorting grids to avoid catches of undersized fish.

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

In the trawl fisheries in the Barents Sea, harp seals appear and often die in the trawl (Zyryanov *et a*l. 2004). Other seal species occur only occasionally as bycatch in trawls. In addition, harp seal have been caught by thousand during years of low abundance of capelin. In years with low abundance of capelin, the harp seal migrate into coastal waters in search for alternative food resources. This migration into the coastal waters coincides with a winter gillnet fishery for immature cod at the Barents Sea coast of Norway. In the winter 1986-1987 more than 56 000 seals drowned in gillnets (Haug & Nilssen, 1995). The harbour porpoise is also subject to by-catches in gillnet fisheries (Bjørge and Kovacs 2005). Despite the relatively large abundance of dolphins in the Barents Sea, they do not appear to be caught in trawls (Haug et al., 2011). In 2004 Norway initiated a monitoring program on by-catches of marine mammals in fisheries.

Fisheries impact seabird populations in two different ways: 1) Directly through by-catch of seabirds in fishing equipment and 2) Indirectly through competition with fisheries for the same food sources. Documentation of the scale of by-catch of seabirds in the Barents Sea is fragmentary. Special incidents like the by-catch of large numbers of guillemots during spring cod fisheries in Norwegian areas have been documented (Strann *et al*. 1991). Gillnet fishing affects primarily coastal and pelagic diving seabirds, while the surface-feeding species will be most affected by long-line fishing (Furness 2003). The population impact of direct mortality through by-catch will vary with the time of year, the status of the affected population, and the sex and age structure of the birds killed. Even a numerically low by-catch may be a threat to red-listed species such as Common guillemot, White-billed diver and Steller's eider.

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

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

1.4 Ecosystem based management issues and potential assessment improvements (Tables 1.13–1.14)

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

1.4.1 Multispecies and ecosystem models

Development of multispecies models designed to improve fisheries management in the Barents Sea started in the mid-1980s. The first models developed were MULTSPEC, AGGMULT, SYSTMOD and MSVPA (Bogstad and Filin, 2011). These models serve as predecessors to newly developed models, such as Bifrost, Gadget and STOCOBAR that are presently used. Benefits of multispecies models include: improved estimates of natural mortality and recruitment; better understanding of stock-recruit relationships as well as variability in growth and maturation rates; testing of alternative harvesting strategies.

Ecosystem models may be useful for looking at how change in one ecosystem component is affecting the whole or parts of an ecosystem, thereby identifying the most important inter-species/ functional group links and sensitivity of the ecosystem to changes. They are also useful for scenario testing (change in fishery pressure, climate change, and sudden pollution events).

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

Bifrost

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

STOCOBAR

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

GADGET

A multi-species Gadget age-length structured model (www.hafro.is/gadget ; Begley and Howell, 2004, developed during the EU project dst² (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 modeling approach taken has many similarities to the MULTSPEC approach (Bogstad *et al*., 1997). Work is ongoing to enhance the modeling of recruitment processes during the EU projects FACTS and DEFINEIT. An FLR routine has been written that can run Gadget models as FLR Operating Models. This also gives the possibility of using Gadget as an operating model to test the performance of various assessment programs under a range of scenarios (Howell and Bogstad, 2010). In addition the Gadget multi-species model is being developed to assess the likely impact on medium-term population dynamics of oil-spill induced larval mortalities.

ATLANTIS

Atlantis (Fulton *et al*., 2004) 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 IMR started to implement this model for the Barents Sea and the Norwegian Sea. It is expected to be operational in mid-2012.

SYMBIOSES

A new modelling tool, SYMBIOSES, is being developed combining oceanography, ecotoxicology, plankton, larvae and adult fish population models (Carroll *et al*. 2011) involving IMR, SINTEF, Akvaplan-Niva, STATOIL, IMARES and the universities of Nijmegen and Ghent, and others. The combined tool will focus on the impacts on egg- and larval-mortalities of a potential oil spill near the main fish spawning grounds. The model will include cod, capelin and herring, with initial focus on cod mortalities. By focusing on larval mortalities as the only link between the fish and lower levels of the ecosystem, it is hoped that the model will be able to avoid some of uncertainty issues surrounding "whole ecosystem models" and become an operational tool in risk management in the oil industry. The physical oceanography uses the ROMS model, the ecotoxicology section is a development of the OMEGA/DEBtox (De

Leander *et al*. 2008), the chemical fate model is MEMW, phyto- and zoo-plankton are modelled with SINMOD (Slagstad *et al*. 2008, Wassmann *et al*. 2009), the fish larvae and eggs use LARMOD (Vikebø *et al*. 2007), and the fish part of the model is the multi-species Gadget model described above (Howell and Bogstad 2010). The current timetable calls for a first working version to be finished by the end of 2013, with tuning and refinements thereafter.

DSF

The Dynamic Stochastic Food web (DSF) model is under development in Tromsø. The model constraints include mass balance (i.e. the conservation of mass within the system), physiology (i.e. satiation: the maximum amount of food intake of a predator per year per unit biomass) and inertia (i.e. the maximum relative variation in biomass of a tropho-species per year). The first prototype of the model for the Barents Sea includes six tropho-species and the trophic interactions between them (phytoplankton, copepods, euphausiids, capelin, cod and minke whale). The DSF model shows that many of the properties that are observed in real ecosystems could simply result from a very minimal set of constraints. The model is under development to include additional features such as age-structured populations and multiple geographical units.

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

Recruitment

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

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

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

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

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

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

Temp is the Kola annual temperature (0-200m, station 3-7), Age1 is the winter survey bottom trawl index for cod age 1, and MatBio the maturing biomass of capelin. The number in parenthesis is the time lag in years. Two other similar models (JES2, JES3) can be made by substituting the term Age1(-2) with Age2(-1) and Age3(0), respectively (winter survey bottom trawl index for cod age 2 and age 3, respectively), This gives 1 and 0 year predictions, respectively. Using winter survey estimates the same year as the AFWG assessment and with a prediction for the capelin maturing biomass it is possible to extend the prognoses another year.

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

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

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

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

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

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

Titov (Titov, AFWG 2010, WD 22) and Titov *et al*. (AFWG 2005, WD 16) developed models with 1 to 4 year prediction possibility (TITOV1, TITOV2, TITOV3, TITOV4, respectively), based on the oxygen saturation at bottom layers of the Kola section stations 3-7 (OxSat), air temperature at the Murmansk station (Ta), water temperature: 3-7 stations of the Kola section (layer 0-200m) (Tw), ice coverage in the Barents Sea (I), spawning stock biomass (SSB), and the acoustic abundance of cod at age 1 and 2, derived from the joint winter Barents Sea acoustic survey. At the 2010 AFWG assessment it was suggested (Dingsør *et al* 2010, WD 19, and related discussions in the working group) to try to simplify these models. This has been conducted and has improved the statistical performance (details are shown in Titov, WD 23, 2011):

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

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

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

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

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

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

Hjermann *et al*. (2007) developed a model with a one year prognosis, which have been modified by Dingsør *et al* (AFWG 2010 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. The models were not updated this year.

At AFWG 2008, Subbey *et al*. presented a comparative study (AFWG 2008 WD27) on the ability of some of the above models in predicting stock recruitment for NEA cod (Age 3). At the assessment in 2010 a WD by Dingsør *et al*. (AFWG 2010 WD19) was presented, which investigated the performance of some of the mentioned recruitment models. It was strongly recommended by the working group that a Study Group should be appointed to look at criteria's for choosing/rejecting recruitment models suitable for use in stock assessment. The "Study Group on Recruitment Forecasting" (SGRF, ICES CM 2011/ACOM:31) has now been appointed, and their first meeting was in October 2011. They intend to give a "best practice" for choosing recruitment models after their next meeting in autumn 2012, which may be implemented at the next AFWG.

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

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

Both the 2011 and 2012 assessments used the same Hybrid model as in 2010, with the earlier mentioned adjustments of the terms in the Titov models. Table 1.12 show the available estimates from the models, along with last year estimates.

Growth rate

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

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

Maturation and condition factor

The decrease in capelin stock biomass potentially impacts the maturation dynamics of Northeast Arctic cod by delaying the onset of maturation and/or increasing the incidence of skipped spawning. The relationship between weight- and length-at age shows that for a given length, weight-at-length is positively correlated with proportion mature-at-length for the period 1985-2001 (Marshall *et al*., 2004). Estimates of weight-at-length were multiplied by the Russian liver condition index at length (Yaragina and Marshall, 2000) to derive estimates of liver weights in grams for cod at a standard length (see Marshall *et al*. 2004 for details of the calculation). This analysis indicated that for the period 1985-2001 there is a consistently significant, positive relationship between liver weight and proportion mature.

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

Stock Reproductive potential issues

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

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

More complex indices of SRP will result in an improved SSB-R relationship or ability to predict recruitment. Another aspect is reference points and perceptions of stock status relative to these reference points that could be affected by using different indices of RP and related issues in determining whether or not to incorporate more reproductive biology into assessments improves an advice. There are many examples of trends in reproductive biology, particularly as population size decreases under exploitation. Efforts to incorporate this information into our scientific advice are likely to be beneficial in many cases. This can take the form of SSB, Female SB, or TEP, depending on what data are available.

Fisheries Induced Evolution

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

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

Natural mortality

The direct application of results from the trophic investigations in the Barents Sea for management there is inclusion of predator's consumption into fish stock assessment. Predation on cod and haddock by cod has since 1995 been included in the assessment of these two species. Currently AFWG estimates of cod natural mortality caused by cannibalism based on data of the cod proportion in the cod diet is shown in Table 1.7. 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).

Currently AFWG estimates cod natural mortality caused by cannibalism based on data of the cod proportion in the cod diet (Table 1.13). These data are used for estimation of cod consumed by cod and then for estimation of its natural mortality within the XSA (see section 3.4.2). The natural mortality estimated for last year is used as predicted M for next 4 years (section 3.7.1). An alternative approach for prediction of NEA cod cannibalism based on the linear relationship between the natural mortality of cod at ages 3-4 and the biomass of cod spawning stock with minus 3-year lag was proposed by Kovalev (2004). 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 1.14). Because the mechanisms of the cod SSB's influence on the level of own young natural mortality 3-4 years later is unclear and because of this relationship seems to be not in correspondence with observations for last few years the approach will not be used for prediction before it has been further tested. Values for the years 2011 to 2014, predicted by the regression, are given in Table 1.14.

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

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

1.5 Monitoring of the ecosystem (Figure 1.17, Tables 1.15–1.16)

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

1.5.1 Standard sections and fixed stations

Some of the longest ocean time series in the world are along standard sections (Figure 1.17) 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 1.15.

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

1.5.2 Scientific surveys

Scientific surveys are conducted throughout the year. 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 Acronym: BS-NoRu-Q1 (BT*r)

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

Lofoten survey Acronym: Lof-Aco-Q1

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

Norwegian coastal surveys Acronym: NOcoast-Aco-Q4

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

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

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

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

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

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

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

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

Russian young herring survey: RU-HE-Q2

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

1.5.3 Other information sources

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

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

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

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

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

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

1.5.4 Spatial data in the Barents Sea

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

In general most these data are available at the national institutes IMR and PINRO, but some data are also collected by other organisations (such as National fishing authorities, ICES and other national and international data centres). The most relevant data sets are derived from spatial sampling/reporting; from the fishing fleet (catches, effort, etc) and from data from scientific surveys (temperature, salinity, fish catches by length groups and derived parameters, as well as ecosystem parameters such as whales, seabird, pollution, zooplankton). In addition, satellites data are interesting spatial data sets (sea surface temperature, phytoplankton abundance etc).

Spatial data are also generated by re-analyses, numerical models and aggregated datasets. In particular IMR have just launched an aggregated spatial database for ecosystem datasets in the Barents Sea, presently called “the FishExChange database”, with an open service mapping generator (see http://www.imr.no/fishexchange/fishexchangedatabase/nb-no).

1.6 Main conclusions

Current and expected state of the Barents Sea ecosystem (section 1.2)

Climate

- The air temperature was above the long-term mean in 2011 in most areas and periods and slightly warmer than in 2010.
- The sea temperature in the Barents Sea in 2011 was above than the long-term mean, however it was lower than in 2010. In 2012-2013 the temperature is expected to further decrease towards the long-term mean.
- Salinity in 2011 was higher than the long term mean and higher than in 2010.
- Inflow of Atlantic waters at the western entrance in the first half of 2011 was quite similar to the last years, with moderate variability; data for second half of 2011 is not available.
- Oxygen levels in the southern Barents Sea were slightly less than normal in 2011 and remained close to the previous year.

- Ice extent in 2011 was less than normal, and similar to 2010. In early 2012 the amount of ice in the Barents Sea was at a historic low level for that time of the year.

Plankton and northern shrimp

- The mesozooplankton biomass measured in August–September 2011 was similar to 2010, and slightly below the long-term mean.
- The abundance of krill (euphausiids) by early 2011 was above the long-term mean. Arctoboreal *Thysanoessa inermis* has been a dominant species.
- The distribution and abundance of large gelatinous zooplankton, caught by pelagic trawling in 2011, was comparable to 2008, but compared to 2010 the abundance considerably higher.
- The shrimp stock in the Barents Sea and Spitsbergen area in 2011 decreased slightly compared to 2010 but was above than long-term mean.

Fish

- Capelin stock size is at around average level, with a slight increase from last year. The survey estimate at age 1 of the 2010 year class is above the long-term mean. 0-group estimates indicate that the 2011 year class is above average.
- The abundance of young herring in the Barents Sea in 2011 decreased compared to 2010 and was the lowest in the time series going back to 1999.
- Blue whiting abundance in the Barents Sea is at a very low level in autumn 2011, but in winter 2012 the abundance of 1-group blue whiting was the highest since 2005. Thus the blue whiting abundance is expected to increase.
- The polar cod stock decreased in 2011 compared to 2010 but somewhat above the long-term mean and is now at the same level as in 2009.

Marine mammals

- In 2011-2012 surveys for pup abundance of harp seals in the White Sea were not performed. In 2010 the total pup production estimate is slightly higher than in 2009, but still less than observed in 2000-2004. The model estimate of the total stock for 2011 is 1.4 million animals of harp seal.
- The last available estimate of the Northeast Atlantic minke whale stock is 81,400 individuals, based on sighting surveys in the period 2002-2007.

Impact of fisheries on the ecosystem (section 1.3)

- The most widespread gear is trawl.
- The demersal fisheries are mixed, and currently have largest effect on coastal cod and *Sebastes marinus* (Golden redfish) due to the poor condition of these stocks.
- The pelagic fisheries are less mixed, and are weakly linked to the demersal fisheries (however, by-catches of young pelagic stages of demersal species have been reported in some pelagic fisheries)
- Trawling has largest effect on hard bottom habitats; whereas the effects on other habitats are not clear and consistent.

- Work is currently going on exploring the possibility of using pelagic trawls when targeting demersal fish. The purpose is to avoid impact on bottom fauna and to reduce the mixture of other species. It will be mandatory to use sorting grids to avoid catches of undersized fish.
- Fishery induced mortality (lost gillnets, contact with active fishing gears, etc.) on fish is a potential problem but not quantified at present.

Management improvement issues (section 1.4)

- Several methods, which take ecosystem information into account, are presently under development. These methods should in the future be valuable for the improvement of the stock assessment and advice.
- The cod recruitment (age 3) in 2012-2014 is expected to be slightly above the long-term mean.

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

Year	Capelin			Cod			Haddock			Herring			Redfish		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	197278	131674	262883	72	38	105	59	38	81	4	1	8	277873	0	701273
1981	123870	71852	175888	48	33	64	15	7	22	3	0	8	153279	0	363283
1982	168128	35275	300982	651	466	835	649	486	812	202	0	506	106140	63753	148528
1983	100042	56325	143759	3924	1749	6099	1356	904	1809	40557	19526	61589	172392	33352	311432
1984	68051	43308	92794	5284	2889	7679	1295	937	1653	6313	1930	10697	83182	36137	130227
1985	21267	1638	40896	15484	7603	23365	695	397	992	7237	646	13827	412777	40510	785044
1986	11409	98	22721	2054	1509	2599	592	367	817	7	0	15	91621	0	184194
1987	1209	435	1983	167	86	249	126	76	176	2	0	5	23747	12740	34755
1988	19624	3821	35427	507	296	718	387	157	618	8686	3325	14048	107027	23378	190675
1989	251485	201110	301861	717	404	1030	173	117	228	4196	1396	6996	16092	7589	24595
1990	36475	24372	48578	6612	3573	9651	1148	847	1450	9508	0	23943	94790	52658	136922
1991	57390	24772	90007	10874	7860	13888	3857	2907	4807	81175	43230	119121	41499	0	83751
1992	970	105	1835	44583	24730	64437	1617	1150	2083	37183	21675	52690	13782	0	36494
1993	330	125	534	38015	15944	60086	1502	911	2092	61508	2885	120131	5458	0	13543
1994	5386	0	10915	21677	11980	31375	1695	825	2566	14884	0	31270	52258	0	121547
1995	862	0	1812	74930	38459	111401	472	269	675	1308	434	2182	11816	3386	20246
1996	44268	22447	66089	66047	42607	89488	1049	782	1316	57169	28040	86299	28	8	47
1997	54802	22682	86922	67061	49487	84634	600	420	780	45808	21160	70455	132	0	272
1998	33841	21406	46277	7050	4209	9890	5964	3800	8128	79492	44207	114778	755	23	1487
1999	85306	45266	125346	1289	135	2442	1137	368	1906	15931	1632	30229	46	14	79
2000	39813	1069	78556	26177	14287	38068	2907	1851	3962	49614	3246	95982	7530	0	16826
2001	33646	0	85901	908	152	1663	1706	1113	2299	844	177	1511	6	1	10
2002	19426	10648	28205	19157	11015	27300	1843	1276	2410	23354	12144	34564	130	20	241
2003	94902	41128	148676	17304	10225	24383	7910	3757	12063	28579	15504	41653	216	0	495
2004	16701	2541	30862	19157	13987	24328	19144	12649	25638	133350	94873	171826	849	0	1766
2005	41808	12316	71300	21532	14732	28331	33283	24377	42190	26332	1132	51532	12332	631	24034
2006	166400	102749	230050	7860	3658	12061	11421	7553	15289	66819	22759	110880	20864	10057	31671
2007	157913	87370	228456	9707	5887	13527	2826	1787	3866	22481	4556	40405	159159	44882	273436
2008	288799	178860	398738	52975	31839	74111	2742	830	4655	15915	4477	27353	9962	0	20828
2009	189767	113154	266379	54579	37311	71846	13040	7988	18093	18916	8249	29582	66671	29636	103706
2010	91730	57545	125914	40635	20307	60963	7268	4530	10005	20367	4099	36636	66392	3114	129669
2011	175836	3876	347796	119736	66423	173048	7441	5251	9631	13674	7737	19610	7026	0	17885
Mean	81400			23669			4260			27996			62387		

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

Year	Saithe			Gr halibut			Long rough dab			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	3	0	6	111	35	187	1273	883	1664	28958	9784	48132	9650	0	20622
1981	0	0	0	74	46	101	556	300	813	595	226	963	5150	1956	8345
1982	143	0	371	39	11	68	1013	698	1328	1435	144	2725	1187	0	3298
1983	239	83	394	41	22	59	420	264	577	1246	0	2501	9693	0	20851
1984	1339	407	2271	31	18	45	60	43	77	127	0	303	3182	737	5628
1985	12	1	23	48	29	67	265	110	420	19220	4989	33451	809	0	1628
1986	1	0	2	112	60	164	6846	4941	8752	12938	2355	23521	2130	180	4081
1987	1	0	1	35	23	47	804	411	1197	7694	0	17552	74	31	117
1988	17	4	30	8	3	13	205	113	297	383	9	757	4634	0	9889
1989	1	0	3	1	0	3	180	100	260	199	0	423	18056	2182	33931
1990	11	2	20	1	0	2	55	26	84	399	129	669	31939	0	70847
1991	4	2	6	1	0	2	90	49	131	88292	39856	136727	38709	0	110568
1992	159	86	233	9	0	17	121	25	218	7539	0	15873	9978	1591	18365
1993	366	0	913	4	2	7	56	25	87	41207	0	96068	8254	1359	15148
1994	2	0	5	39	0	93	1696	1083	2309	267997	151917	384078	5455	0	12032
1995	148	68	229	15	5	24	229	39	419	1	0	2	25	1	49
1996	131	57	204	6	3	9	41	2	79	70134	43196	97072	4902	0	12235
1997	78	37	120	5	3	7	97	44	150	33580	18788	48371	7593	623	14563
1998	86	39	133	8	3	12	27	13	42	11223	6849	15597	10311	0	23358
1999	136	68	204	14	8	21	105	1	210	129980	82936	177023	2848	407	5288
2000	206	111	301	43	17	69	233	120	346	116121	67589	164652	22740	14924	30556
2001	20	0	46	51	20	83	162	78	246	3697	658	6736	13490	0	28796
2002	553	108	998	51	0	112	731	342	1121	96954	57530	136378	27753	4184	51322
2003	65	0	146	13	0	34	78	45	110	11211	6100	16323	1627	0	3643
2004	1395	860	1930	70	28	113	36	20	52	37156	19040	55271	367	125	610
2005	55	36	73	9	4	14	200	109	292	6540	3196	9884	3216	1269	5162
2006	142	60	224	11	1	20	710	437	983	26016	9996	42036	2078	464	3693
2007	51	6	96	1	1	0	262	45	478	25883	8494	43273	2532	0	5134
2008	45	22	69	6	0	13	956	410	1502	6649	845	12453	91	0	183
2009	22	0	46	7	4	10	115	51	179	23570	9661	37479	21433	5642	37223
2010	402	126	678	14	8	21	128	18	238	31338	13644	49032	1306	0	3580
2011	27	0	59	20	11	29	58	23	93	37431	15083	59780	627	26	1228
Mean	183			28			556			35084			8496		

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

	Capelin			Cod			Haddock			Herring		
Year	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	740289	495187	985391	276	131	421	265	169	361	77	12	142
1981	477260	273493	681026	289	201	377	75	34	117	37	0	86
1982	599596	145299	1053893	3480	2540	4421	2927	2200	3655	2519	0	5992
1983	340200	191122	489278	19299	9538	29061	6217	3978	8456	195446	69415	321477
1984	275233	161408	389057	24326	14489	34164	5512	3981	7043	27354	3425	51284
1985	63771	5893	121648	66630	32914	100346	2457	1520	3393	20081	3933	36228
1986	41814	642	82986	10509	7719	13299	2579	1621	3537	93	27	160
1987	4032	1458	6607	1035	504	1565	708	432	984	49	0	111
1988	65127	12101	118153	2570	1519	3622	1661	630	2693	60782	20877	100687
1989	862394	690983	1033806	2775	1624	3925	650	448	852	17956	8252	27661
1990	115636	77306	153966	23593	13426	33759	3122	2318	3926	15172	0	36389
1991	169455	74078	264832	40631	29843	51419	13713	10530	16897	267644	107990	427299
1992	2337	250	4423	166276	92113	240438	4739	3217	6262	83909	48399	119419
1993	952	289	1616	133046	58312	207779	3785	2335	5236	291468	1429	581506
1994	13898	70	27725	70761	39933	101589	4470	2354	6586	103891	0	212765
1995	2869	0	6032	233885	114258	353512	1203	686	1720	11018	4409	17627
1996	136674	69801	203546	280916	188630	373203	2632	1999	3265	549608	256160	843055
1997	189372	80734	298011	294607	218967	370247	1983	1391	2575	463243	176669	749817
1998	113390	70516	156263	24951	15827	34076	14116	9524	18707	476065	277542	674589
1999	287760	143243	432278	4150	944	7355	2740	1018	4463	35932	13017	58848
2000	140837	6551	275123	108093	58416	157770	10906	6837	14975	469626	22507	916746
2001	90181	0	217345	4150	798	7502	4649	3189	6109	10008	2021	17996
2002	67130	36971	97288	76146	42253	110040	4381	2998	5764	151514	58954	244073
2003	340877	146178	535575	81977	47715	116240	30792	15352	46232	177676	52699	302653
2004	53950	11999	95900	65969	47743	84195	39303	26359	52246	773891	544964	1002819
2005	148466	51669	245263	72137	50662	93611	91606	67869	115343	125927	20407	231447
2006	515770	325776	705764	25061	11469	38653	28505	18754	38256	294649	102788	486511
2007	480069	272313	687825	42628	26652	58605	8401	5587	11214	144002	25099	262905
2008	995101	627202	1362999	234144	131081	337208	9864	1144	18585	201046	68778	333313
2009	673027	423386	922668	185457	123375	247540	33339	19707	46970	104233	31009	177458
2010	318569	201973	435166	135355	68199	202511	23669	14503	32834	117087	32045	202129
2011	594248	58009	1130487	448005	251499	644511	19114	14209	24018	83051	48024	118078
Mean	279332			90167			11988			165961		

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

	Saithe			Polar cod (east)			Polar cod (west)		
Year	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	21	0	47	203226	69898	336554	82871	0	176632
1981	0	0	0	4882	1842	7922	46155	17810	74500
1982	296	0	699	1443	154	2731	10565	0	29314
1983	562	211	912	1246	0	2501	87272	0	190005
1984	2577	725	4430	871	0	2118	26316	6097	46534
1985	30	7	53	143257	39633	246881	6670	0	13613
1986	4	0	9	102869	16336	189403	18644	125	37164
1987	4	0	10	64171	0	144389	631	265	996
1988	32	11	52	2588	59	5117	41133	0	89068
1989	10	0	23	1391	0	2934	164058	15439	312678
1990	29	4	55	2862	879	4846	246819	0	545410
1991	9	4	14	823828	366924	1280732	281434	0	799822
1992	326	156	495	49757	0	104634	80747	12984	148509
1993	1033	0	2512	297397	0	690030	70019	12321	127716
1994	7	1	12	2139223	1230225	3048220	49237	0	109432
1995	415	196	634	6	0	14	195	0	390
1996	430	180	679	588020	368361	807678	46671	0	116324
1997	341	162	521	297828	164107	431550	62084	6037	118131
1998	182	91	272	96874	59118	134630	95609	0	220926
1999	275	139	411	1154149	728616	1579682	24015	3768	44262
2000	851	446	1256	916625	530966	1302284	190661	133249	248072
2001	47	0	106	29087	5648	52526	119023	0	252146
2002	2112	134	4090	829216	496352	1162079	215572	36403	394741
2003	286	0	631	82315	42707	121923	12998	0	30565
2004	4779	2810	6749	290686	147492	433879	2892	989	4796
2005	176	115	237	44663	22890	66436	25970	9987	41953
2006	280	116	443	182713	73645	291781	15965	3414	28517
2007	286	3	568	191111	57403	324819	22803	0	46521
2008	142	68	216	42657	5936	79378	619	25	1212
2009	62	0	132	168990	70509	267471	154687	37022	272351
2010	1066	362	1769	267430	111697	423162	12045	0	33370
2011	96	0	225	249269	100355	398183	4924	218	9629
Mean	525			289709			69358		

Table 1.3. The total NEA cod consumption of various prey species (1000 tonnes), based on Norwegian consumption calculations.

Year	Other	Amphipods	Krill	Shrimp	Capelin	Herring	Polar cod	Cod	Haddock	Redfish	G. halibut	Blue whiting	Long rough dab	Total*
1984	479	27	113	436	722	78	15	22	50	364	0	0	24	2330
1985	1112	170	58	156	1620	183	3	31	47	225	0	1	40	3647
1986	606	1236	111	142	836	133	141	82	110	315	0	0	55	3767
1987	670	1085	67	191	229	32	205	25	4	323	1	0	9	2843
1988	401	1237	318	129	339	8	92	9	3	223	0	4	5	2769
1989	656	800	241	131	572	3	32	8	10	228	0	0	57	2739
1990	1343	137	85	195	1609	7	6	19	15	243	0	87	95	3842
1991	760	65	76	188	2891	8	12	26	20	312	7	10	270	4645
1992	907	102	158	373	2456	331	97	55	106	188	20	2	93	4887
1993	750	253	714	315	3030	163	278	285	71	100	2	2	26	5988
1994	623	562	703	517	1084	147	582	223	48	78	0	1	39	4607
1995	842	980	516	362	628	115	253	367	113	190	1	0	33	4400
1996	599	631	1158	341	538	47	104	536	69	97	0	10	34	4164
1997	443	382	519	316	907	5	113	338	41	36	0	33	14	3146
1998	411	363	455	325	714	86	151	155	33	9	0	13	15	2730
1999	377	145	271	250	1720	128	220	62	26	16	1	31	7	3255
2000	386	167	468	451	1728	53	194	76	51	8	0	38	18	3639
2001	689	173	378	278	1730	71	251	67	49	6	1	151	29	3873
2002	365	97	265	234	1949	87	272	109	124	1	0	226	15	3743
2003	555	285	541	243	2184	217	275	116	169	3	0	75	48	4712
2004	651	572	358	257	1293	216	363	131	208	3	11	57	61	4180
2005	797	591	531	273	1426	134	399	122	325	3	4	119	52	4777
2006	891	228	1090	365	1806	180	108	85	366	13	1	168	122	5424
2007	1348	329	1176	467	2301	301	289	98	400	50	0	46	77	6882
2008	1725	181	1020	424	3154	114	556	213	328	66	12	19	94	7907
2009	1655	269	717	300	4361	135	794	228	295	35	3	6	117	8915
2010	1737	431	1163	323	4336	58	328	292	319	183	14	14	130	9327
2011	1619	243	825	252	4379	78	448	323	327	134	0	24	123	8775

***Calculations are based on the cod abundance from 2012 assessment**

Table 1.4. The North-east arctic cod stock's consumption of various prey species (1000 tonnes), based on Russian consumption calculations (cod abundance are taken from the 2011 assessment)

Year	Euphausiids	Hyperiids	Shrimp	Herring	Capelin	Polar cod	Cod	Haddock	Blue whiting	Norway pout	Redfish	Long rough dab	Greenland halibut	Other fish	Other food	Total
1984	93	31.1	351.1	33.3	591.9	17.1	13.2	49.7	4.7	1.2	194.9	51.5	0	269.4	285.7	1987.7
1985	30	431.6	202.1	24.4	989.3	0	97.7	34.3	17.6	14.8	97.1	22.7	0	518.9	198	2678.7
1986	56.7	859.6	147.7	47	806.7	159.4	28	102.5	3.5	26.9	157.7	24.3	0.7	371.5	169.7	2961.9
1987	69.3	508.1	201	7.5	161.4	104.6	26.5	1.8	10.2	14.6	117.5	5.6	0.4	268.2	188.4	1685.1
1988	209	168.4	117.8	18.5	291.5	0	19.7	92.5	0	0	126.7	20	0	238.4	241.6	1544
1989	166.5	290	103.7	3.8	678.9	33.7	34.1	2.1	0	0	157.4	56	0	201.2	247.7	1975.1
1990	100.7	29.5	270	64.3	1252.9	7.5	21.4	16.4	39.1	14.7	231.7	78.5	0	101.1	166.4	2394.1
1991	54.3	83.4	286.4	28.1	3285.9	43.6	52.1	22.3	6.6	6	143.6	45.5	5.5	132.4	157.6	4353.4
1992	210.5	37.7	261.8	373.8	2019.9	190	82.9	37.6	0	76.7	120.6	43.2	0.8	294.4	415.1	4165.1
1993	176	174.9	219.1	176.7	2772.1	170	146.5	151.8	3.8	25.3	40.7	47.3	4.9	159.4	380.2	4648.7
1994	358.2	293.7	465.3	104.1	1292.7	486.7	384.3	71	1.1	1.5	55.9	40	0.1	98.7	347	4000.3
1995	390.3	458.1	541.9	189.8	678.9	198.6	548.9	128	0.4	0.6	112	53	2.6	164.5	352.3	3819.8
1996	972.8	360.8	200.2	76.4	478.5	78.6	473.2	60.3	8.9	36.5	70.6	47.4	0.1	470.1	174.7	3509
1997	509	132.2	260.1	54.2	522.5	110.3	387.1	35.1	16.7	0.1	31.2	16.8	1.6	96.7	366.3	2540
1998	615.6	204.8	264.6	69.7	851.9	128.8	128.7	22.6	23.3	18.3	15	19.1	0	52.5	225.6	2640.4
1999	450.4	76.8	241.5	73.7	1399.6	164.1	47.4	14.2	24.8	0.8	13	8.4	0.5	57.5	107.4	2680.2
2000	409.3	111	366.1	48.2	1659.9	157	56.6	28.5	26.2	8.3	4.1	20.3	0.1	35.3	180.6	3111.7
2001	412.5	73.7	305.7	87.2	1427.3	139.8	58.7	48.6	136.4	28.5	4	30.3	2.2	144.7	188.5	3088
2002	304.4	44.9	195.6	53.9	2308.9	279.5	98.4	76	101.1	3.5	3.4	16.6	0	43.6	168.9	3698.8
2003	235.1	138.2	209.5	142.6	1139.5	201.4	125.6	318.5	25.4	5	1.5	38	0	86	266.6	2932.8
2004	344	369.8	237.9	120.1	1027	342.4	81.2	148.1	46.8	19.9	6.8	57.4	14.7	174.9	261.6	3252.6
2005	529	130.7	220.1	165.3	937.6	308.3	110.3	266.9	65.9	40.4	6.8	43.8	2.1	159.3	197.9	3184.5
2006	902.5	60	211.3	231.4	1176	106.5	91.3	257.9	101.1	85.5	16.1	92.4	0.5	91.6	334.2	3758.4
2007	912.3	155.1	288.2	264.1	1448.5	242.8	69.9	311.4	31.5	21	22	62.3	0.8	203.3	389.1	4422.4
2008	662.4	38.7	243	102.5	2418.9	520.2	132.6	318.3	16	16.1	43.6	106.8	12.6	312.1	438.5	5382.6
2009	531.9	105.9	197.6	163.2	2344.8	591.9	108.7	306	7.6	80.6	24.3	185.7	0.5	129.6	527.8	5306
2010	1078.4	182.2	198.7	99	2867.3	382.9	143.7	227.6	8.3	53.7	143	120.2	1.2	178.2	436.7	6121.1
2011	345.6	93.1	139.8	41.8	2610.3	244.8	184.3	251.2	24.7	67	94.4	139.2	1.8	106.5	460.1	4804.8
Mean	397.5	201.6	248.1	102.3	1408.6	193.2	134	121.5	26.9	23.8	73.4	53.3	1.9	184.3	281.2	3451.7

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

Year/Age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.247	0.814	1.684	2.513	3.948	5.203	7.973	8.486	9.139	9.867	9.941
1985	0.304	0.761	1.829	3.101	4.671	7.357	11.172	11.892	12.416	13.660	13.773
1986	0.160	0.488	1.347	3.158	5.604	6.834	10.989	11.899	12.701	13.461	13.694
1987	0.219	0.601	1.275	2.055	3.537	5.457	7.044	8.111	8.922	9.343	9.295
1988	0.164	0.703	1.149	2.148	3.744	5.875	10.096	11.218	12.570	13.122	13.345
1989	0.223	0.716	1.606	2.705	3.973	5.601	7.648	8.464	9.559	10.156	10.599
1990	0.363	0.905	1.889	3.027	4.156	5.323	6.249	6.666	6.698	7.039	7.738
1991	0.293	0.969	2.168	3.500	5.281	7.026	9.392	10.154	11.200	12.239	11.886
1992	0.215	0.663	2.095	3.133	4.142	5.093	7.832	8.965	9.352	10.071	10.115
1993	0.112	0.528	1.546	3.044	4.809	6.285	9.421	11.239	11.763	12.253	12.876
1994	0.130	0.408	0.922	2.521	3.504	4.511	6.396	8.846	9.672	9.977	10.176
1995	0.103	0.296	0.921	1.840	3.361	5.252	7.697	10.405	12.333	12.734	13.180
1996	0.108	0.356	0.929	1.847	3.068	4.429	7.381	11.143	14.702	14.876	15.265
1997	0.140	0.319	0.940	1.768	2.710	3.536	5.253	8.149	12.582	13.484	13.091
1998	0.117	0.397	0.983	1.942	2.923	4.186	5.746	8.061	11.339	11.850	11.903
1999	0.163	0.505	1.093	2.717	3.717	5.442	6.965	9.179	11.004	12.007	12.109
2000	0.170	0.499	1.243	2.461	4.252	5.651	7.951	9.364	12.485	13.258	13.298
2001	0.171	0.456	1.309	2.439	3.682	5.294	7.523	11.085	13.422	14.117	14.435
2002	0.199	0.551	1.167	2.441	3.380	4.719	6.357	9.039	10.224	11.538	10.938
2003	0.207	0.653	1.312	2.390	3.995	5.946	8.411	10.405	12.786	13.397	14.352
2004	0.222	0.478	1.306	2.296	3.357	5.569	7.409	11.380	17.307	19.278	18.649
2005	0.203	0.661	1.387	2.743	4.251	6.405	7.662	10.232	13.486	14.433	15.224
2006	0.202	0.626	1.591	2.808	4.251	6.356	7.867	11.612	14.017	15.034	15.970
2007	0.255	0.653	1.747	3.087	4.459	6.213	8.230	10.221	12.547	13.132	13.714
2008	0.204	0.717	1.464	2.874	4.077	7.069	8.376	11.340	15.487	16.023	16.249
2009	0.192	0.617	1.479	2.753	4.440	5.794	8.432	11.485	12.696	13.647	13.685
2010	0.203	0.634	1.408	2.492	3.970	5.692	8.436	12.010	15.278	15.932	16.331
2011	0.219	0.653	1.420	2.650	4.000	5.329	7.263	9.679	15.106	16.255	16.224

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

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	mean
1	0.26	0.30	0.18	0.15	0.18	0.28	0.29	0.24	0.18	0.13	0.18	0.19	0.17	0.12	0.23	0.26	0.19	0.15	0.25	0.23	0.25	0.26	0.35	0.23	0.22	0.22	0.24	0.25	0.22
2	0.89	0.75	0.52	0.43	0.70	0.91	1.01	0.94	0.97	0.48	0.51	0.50	0.50	0.34	0.53	0.43	0.55	0.41	0.68	0.62	0.65	0.69	0.92	0.68	0.72	0.63	0.67	0.75	0.66
3	1.61	1.66	1.46	0.84	1.07	1.47	1.70	2.67	2.47	1.51	1.21	0.96	1.03	0.99	1.08	1.13	1.29	1.16	1.30	1.30	1.41	1.51	1.88	1.87	1.70	1.52	1.42	1.53	1.46
4	2.75	2.68	3.47	1.56	1.63	2.21	2.69	4.47	2.87	2.87	2.40	1.80	1.92	1.91	2.02	2.49	2.55	2.11	2.70	2.03	2.57	2.50	2.81	3.13	2.96	2.58	2.69	2.54	2.53
5	3.85	4.26	4.96	3.08	2.39	3.24	3.28	6.04	3.99	3.94	3.52	3.20	3.06	2.67	2.82	3.68	4.39	3.43	3.85	3.55	3.86	3.90	4.02	4.46	4.19	4.40	4.25	3.99	3.80
6	5.49	6.60	5.91	4.35	4.39	4.80	3.83	7.85	5.14	5.11	5.36	4.85	4.19	3.50	4.09	5.22	6.56	5.57	5.59	4.72	5.66	5.26	5.33	5.89	6.07	5.78	6.12	5.10	5.30
7	6.99	8.24	6.48	7.28	8.21	6.58	5.58	9.59	6.72	7.37	7.56	7.33	6.99	4.95	5.47	6.40	8.83	6.84	7.85	6.68	7.73	7.19	7.45	7.56	7.81	7.93	8.68	7.13	7.27
8	8.56	9.74	8.16	9.68	9.98	8.73	6.87	11.54	7.41	8.94	10.00	9.69	10.21	7.98	7.35	8.22	10.48	10.23	10.80	8.91	11.13	9.39	10.33	9.18	10.46	11.42	11.91	9.46	9.53
9	10.57	10.98	9.77	12.70	10.87	11.13	10.72	14.97	8.75	10.34	11.82	13.83	12.19	12.17	9.59	9.19	11.52	12.46	13.24	13.42	15.91	13.16	13.11	12.03	13.63	13.74	16.30	13.65	12.21
10	13.17	14.45	11.46	14.48	16.54	15.80	11.43	19.29	12.30	11.60	12.90	15.25	13.61	16.76	13.01	13.36	15.13	15.13	18.79	14.49	20.77	15.98	17.76	15.92	17.25	15.71	17.34	17.45	15.25
11	12.44	16.50	12.50	15.01	14.35	15.95	12.66	17.51	13.52	14.07	13.55	16.96	14.58	16.77	14.46	15.33	17.15	17.37	17.90	19.54	21.69	20.70	19.56	20.03	21.66	18.84	19.83	20.85	16.83
12	14.28	16.06	13.58	15.11	15.77	17.91	15.05	20.11	13.74	14.89	15.90	18.23	16.21	18.35	15.58	16.92	19.72	19.32	20.20	19.24	24.85	21.36	22.23	21.56	23.29	21.79	22.94	23.71	18.50
13	15.27	17.34	14.77	16.38	16.51	17.64	16.06	22.11	14.91	15.92	16.81	19.20	16.88	19.15	16.20	17.57	20.51	20.56	21.03	20.04	25.89	24.18	23.13	22.43	24.29	22.69	23.89	24.73	19.50
14	15.27	17.34	14.77	16.38	16.51	17.64	16.06	22.11	14.91	15.92	16.81	19.20	16.88	19.15	16.20	17.57	20.51	20.62	21.03	20.04	25.89	24.18	24.89	22.43	24.29	22.69	23.89	24.73	19.57
15+	15.27	17.34	14.77	16.38	16.51	17.64	16.06	22.11	14.91	15.92	16.81	19.20	16.88	19.15	16.20	17.57	20.51	20.62	21.03	20.04	25.89	24.18	24.89	22.43	24.29	22.69	23.89	24.73	19.57

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

Year/age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.0000	0.0000	0.0032	0.0000	0.0437	0.0263	0.0328	0.0359	0.0367	0.0390	0.0374
1985	0.0015	0.0009	0.0014	0.0017	0.0314	0.0076	0.0827	0.0834	0.0842	0.0847	0.0854
1986	0.0000	0.0022	0.0015	0.0004	0.0130	0.1761	0.1767	0.1766	0.1762	0.1757	0.1751
1987	0.0000	0.0000	0.0007	0.0051	0.0103	0.0246	0.0377	0.0400	0.0418	0.0405	0.0441
1988	0.0000	0.0000	0.0000	0.0002	0.0058	0.0014	0.0038	0.0036	0.0032	0.0038	0.0036
1989	0.0000	0.0006	0.0016	0.0019	0.0027	0.0040	0.0035	0.0035	0.0040	0.0038	0.0042
1990	0.0000	0.0000	0.0000	0.0012	0.0017	0.0019	0.0268	0.0268	0.0268	0.0268	0.0268
1991	0.0000	0.0005	0.0000	0.0003	0.0032	0.0020	0.0224	0.0232	0.0235	0.0239	0.0241
1992	0.0000	0.0021	0.0037	0.0129	0.0250	0.0475	0.0120	0.0159	0.0232	0.0232	0.0230
1993	0.0000	0.0413	0.0368	0.0515	0.0536	0.1156	0.0498	0.0801	0.0801	0.0801	0.0805
1994	0.0000	0.0038	0.0917	0.0347	0.0285	0.0784	0.1247	0.1339	0.2617	0.2634	0.2606
1995	0.0069	0.0811	0.0745	0.0802	0.0925	0.1123	0.1389	0.2533	0.2553	0.2561	0.2581
1996	0.0000	0.1493	0.2549	0.2060	0.1322	0.1267	0.1850	0.2082	0.2459	0.2471	0.2465
1997	0.0000	0.0704	0.0767	0.1140	0.1552	0.1554	0.2329	0.2267	0.2882	0.2815	0.2832
1998	0.0000	0.0135	0.0272	0.0418	0.1041	0.0981	0.1081	0.1492	0.2758	0.2767	0.2778
1999	0.0000	0.0000	0.0049	0.0137	0.0148	0.0338	0.0620	0.1117	0.1937	0.1940	0.1840
2000	0.0000	0.0000	0.0286	0.0147	0.0134	0.0266	0.0499	0.0566	0.2757	0.2726	0.2738
2001	0.0000	0.0158	0.0116	0.0082	0.0131	0.0241	0.0496	0.0381	0.3296	0.3272	0.3307
2002	0.0000	0.0387	0.0591	0.0142	0.0187	0.0285	0.0359	0.0626	0.1604	0.1572	0.1567
2003	0.0000	0.0194	0.0198	0.0199	0.0206	0.0188	0.0457	0.1043	0.2258	0.2277	0.2276
2004	0.0082	0.0235	0.0280	0.0269	0.0299	0.0320	0.0382	0.0666	0.1075	0.1072	0.1074
2005	0.0000	0.0266	0.0229	0.0265	0.0144	0.0277	0.0441	0.0773	0.1525	0.1499	0.1522
2006	0.0000	0.0103	0.0007	0.0128	0.0288	0.0158	0.0393	0.0368	0.0828	0.0831	0.0824
2007	0.0000	0.0000	0.0011	0.0117	0.0119	0.0304	0.0284	0.0905	0.1442	0.1462	0.1428
2008	0.0000	0.0558	0.0253	0.0100	0.0157	0.0098	0.0771	0.0876	0.0972	0.0955	0.0939
2009	0.0122	0.0232	0.0262	0.0251	0.0152	0.0139	0.0219	0.0954	0.1084	0.1087	0.1086
2010	0.0000	0.0339	0.0579	0.0269	0.0243	0.0242	0.0204	0.0387	0.1389	0.1391	0.1342
2011	0.0118	0.0158	0.0483	0.0173	0.0360	0.0299	0.0237	0.0568	0.1285	0.1286	0.1286
Average	0.0015	0.0225	0.0324	0.0279	0.0343	0.0462	0.0634	0.0851	0.1419	0.1415	0.1412

Table 1.8. Swept area estimates of blue whiting (millions) by length groups according to the Joint IMR-PINRO Barents Sea demersal fish survey

21 January – 15 March 2012. (WD03)

Year	Length group (cm)								Total
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	
2001	0.1	306.6	1391.3	616.0	44.6	5.3	1.5	0.1	2365
2002	0.0	0.8	434.7	658.1	80.9	18.3	3.1	0.1	1196
2003	0.0	3.2	192.0	488.8	81.8	29.7	6.3	1.0	803
2004	0.0	7.2	723.0	816.8	274.1	38.4	1.1	0.2	1861
2005	0.0	125.5	715.4	980.1	222.7	31.5	0.1	0.2	2076
2006	0.0	0.0	162.9	1486.8	591.2	68.3	2.0	0.1	2311
2007	0.0	0.0	4.0	594.6	276.1	21.5	1.5	0.3	898
2008	0.0	0.0	0.3	12.0	125.5	19.7	1.3	0.1	159
2009	0.0	0.0	0.02	2.8	49.0	20.4	1.4	0.02	74
2010	0.0	0.0	0.71	1.9	9.4	15.1	0.8	0.0	28
2011	0.0	0.0	0.05	0.2	2.5	4.7	2.1	0.0	9
2012*	0.0	84.3	663.9	1.1	1.5	4.6	1.9	0.3	758

***not scaled for uncovered areas**

Table 1.9. 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 1.10. 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. (Folkow et al., 2000; Nilssen et al.,2000)

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 1.11. 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	As by-catch in fleet(s)	Location	Agreements and regulations
Capelin	PS, TP	seasonal	TR, TS	Northern coastal areas to south of 74°N	Bilateral agreement, Norway and Russia
Coastal cod	GN, LL, HL, DS	all year	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	TS, PS, TP, DS	North of 62°N, Barents Sea, Svalbard	Q, MS, SG, MCS, MBU, MBN, C, RS, RA
Wolffish	LL	all year	TR, (GN), (HL)	North of 62°N, Barents Sea, Svalbard	Q, MB
Haddock	TR, GN, LL, HL	all year	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	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	TR	Deep shelf and at the continental slope	Q, MS, RS, RG, MBH, MBL
Sebastes mentella	No directed fishery	all year	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	TR	Norwegian coast and southwestern Barents Sea	SG, MB MCS, MBU, C
Shrimp	TS	all year		Svalbard, Barents Sea, Coastal north of 62°N	ED, EF, SG, C, MCS

A Provisional figures

Table 1.12. Flexibility in coupling between the fisheries. Fleets and impact on the other species (H, high, M, medium, L, low and 0, nothing). The table below the diagonal indicates what gears couples the species, and the strength of the coupling is given above the diagonal. The gears are abbreviated as: trawl roundfish (TR), trawl shrimp (TS), longline (LL), gillnet (GN), handline (HL), purse seine (PS), Danish seine (DS) and trawl pelagic (TP). The figure is not updated this year.

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

Table 1.13. Overview of available prognoses of NEA cod recruitment (in million individuals of age 3) from different models (section 1.4.2) together with the 2011 assessment estimates (ICES AFWG 2011, Table 1.13). Please note that the H1, H2 and the TB models were not updated at this assessment.

Model	Prognostic years	Updated	2012 Prognoses	2013 Prognoses	2014 Prognoses	2015 prognoses
Titov0	0	At assessment	735			
Titov1	1 (2 [1])	At assessment	**748***	529		
Titov2	2	At assessment	658	**524***		
Titov3	3	At assessment	**694***	**775***	**741***	
Titov4	4	At assessment	1053	1365	1712	1882
TB (1984-2000)	3	Last year assessment	not updated			
TB (1984-2004)	3	Last year assessment	not updated			
JES1	2 (3 [2])	At assessment	812	808*	not calcu-lated	
JES2	1 (2 [2])	At assessment	755	819		
JES3	0 (1 [2])	At assessment	662			
H1	2	At assessment	not up-dated			
H2	2	At assessment	not up-dated			
RCT3 2012	3	At assessment	742	781	899	
Hybrid Model (Assessment 2011)		Last year assessment	433	607	683	
Hybrid model (Assessment 2012)		At assessment	721	702	741	

[1] Based on calculation of data from 2012

[2] Based on prognosis estimate of capelin maturing biomass for October 1 2012, thereby allowing for an additional year.

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

Table 1.14. Cannibalism mortality in cod, approach by Kovalev (2004) compared to the actual assessment.

Year	M2 age 3	M2 age 4
	by regression	
2011	0.47	0.31
2012	0.67	0.40
2013	0.77	0.45
2014	1.01	0.56
	values used in assessment	
2012-2014	0.520	0.405

Table 1.15. 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, zoo**
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.**

**** Not regularly**

Table 1.16. Overview of conducted monitoring surveys by IMR and PINRO in the Barents Sea, with observed parameters and species. Climate and phytoplankton parameters are: T-temperature, S-Salinity, N-nutrients, chla-chlorophyll.

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

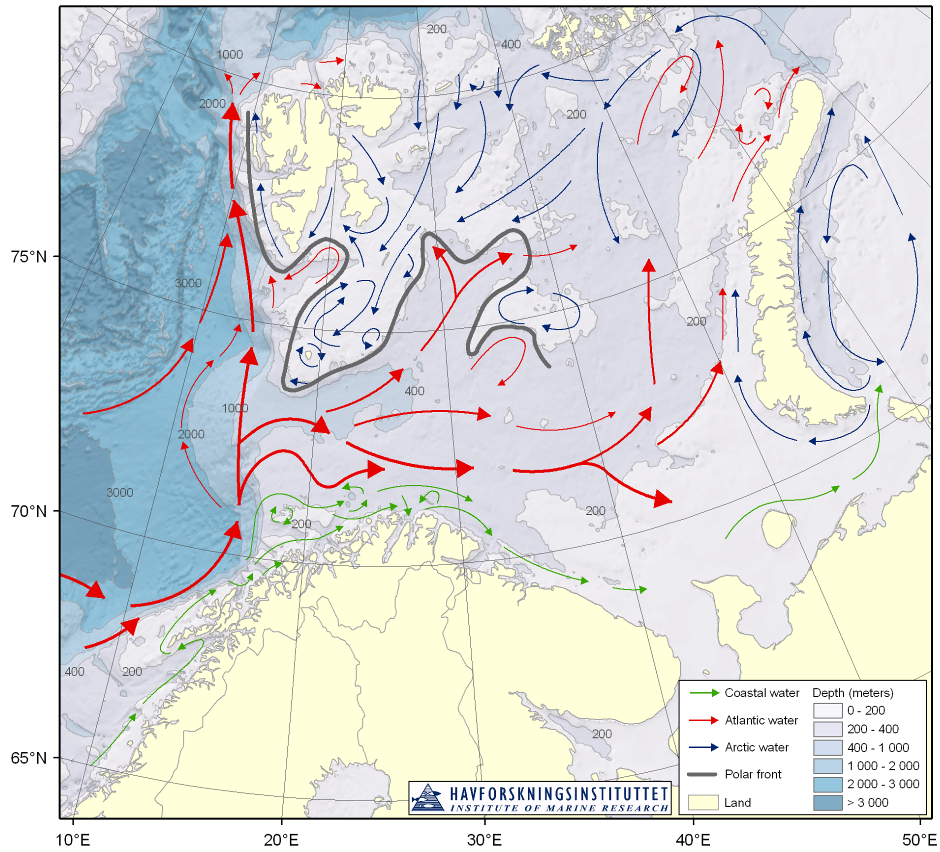

Figure 1.1. The main features of the circulation and bathymetry of the Barents Sea.

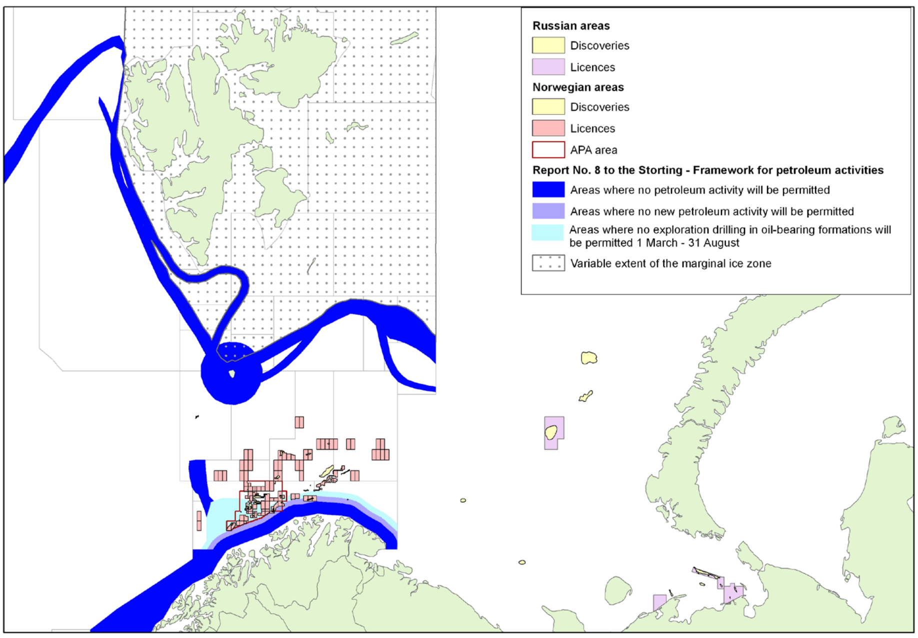

Figure 1.2. Map reflecting current status of petroleum activities in the Barents Sea (source: the Norwegian Petroleum Directorate and Official report Sevmorgeo for Ministry of Natural Resources "Cadastre of the Russian offshore zone", 2007.

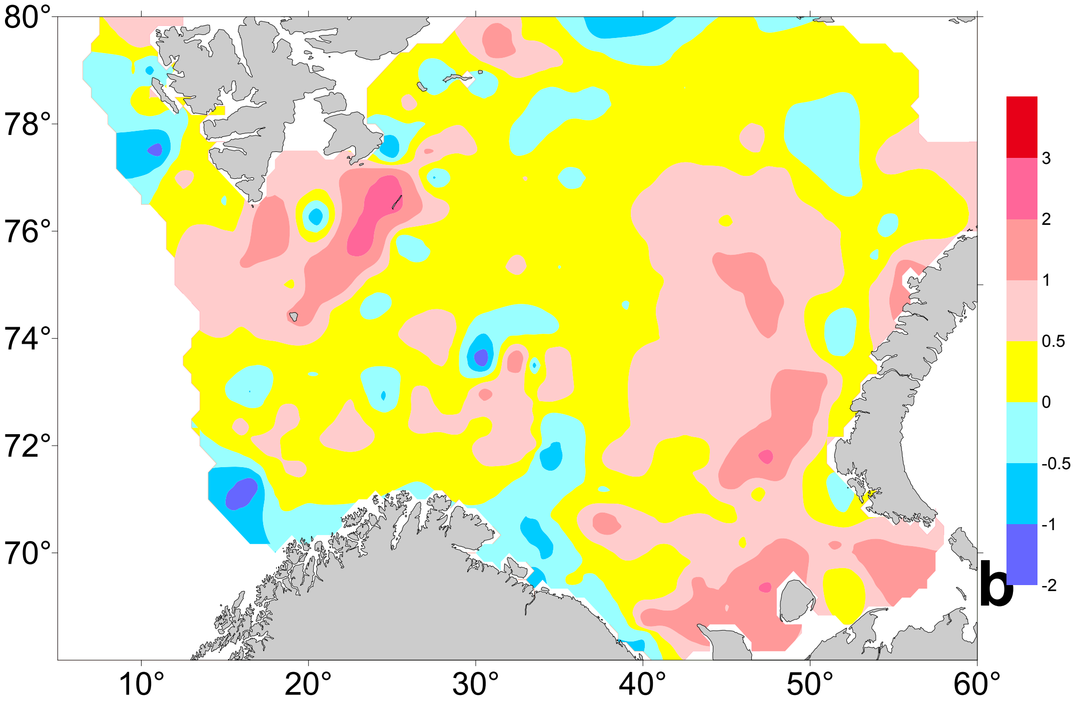

Figure 1.3. Bottom temperature anomalies in the Barents Sea in August-September 2011.

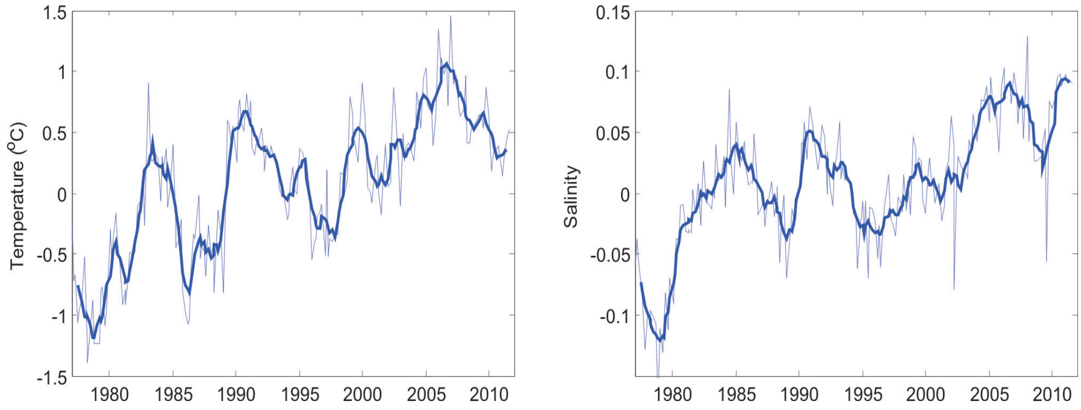

Figure 1.4. Temperature (left) and salinity (right) anomalies in the 50-200 m layer of the Fugløya-Bear Island Section.

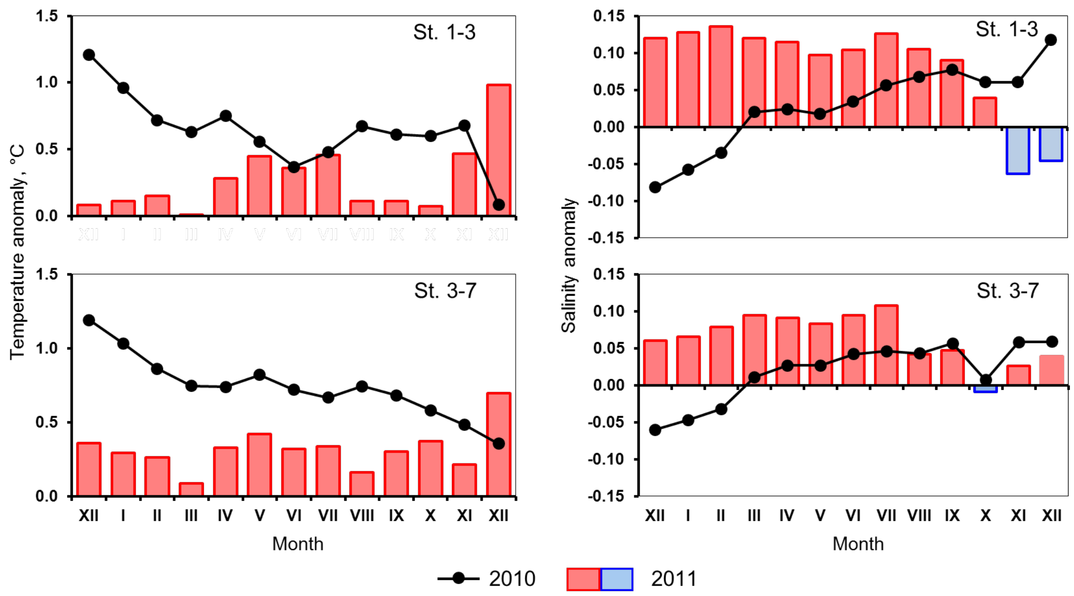

Figure 1.5. Monthly mean temperature (left) and salinity (right) anomalies in the 0-200 m layer of the Kola Section in 2010 and 2011. St. 1-3 – Coastal waters, St. 3-7 – Murman Current.

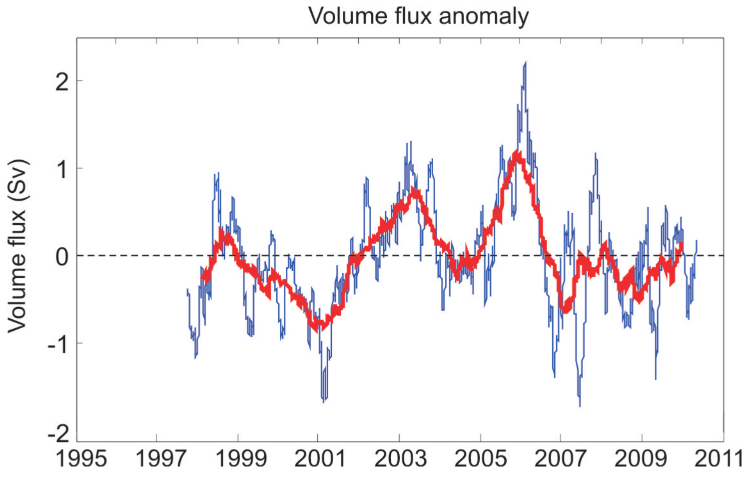

Figure 1.6. Observed Atlantic Water volume flux through the Fugløya-Bear Island Section estimated from current meter moorings. Three months (blue line) and 12-months (red line) running means are shown.

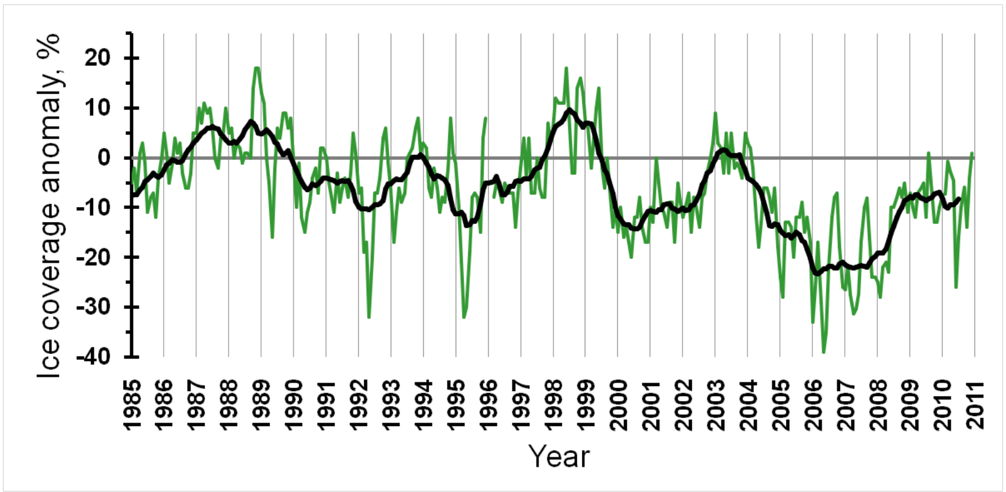

Figure 1.7. Anomalies of mean monthly ice extent in the Barents Sea in 1985-2011. The green line shows monthly values, the black one – 11-month moving average values.

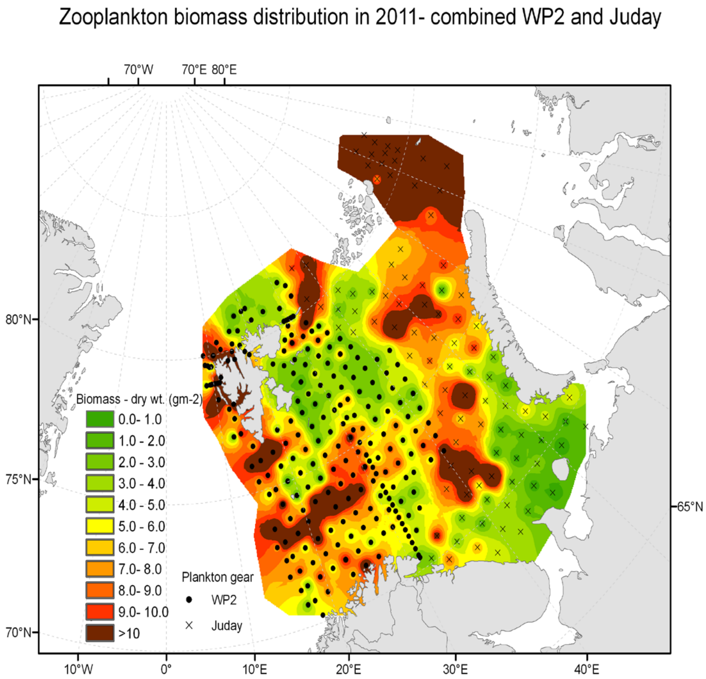

Figure 1.8. Distribution of zooplankton biomass (g/m^{-2} dry weight) in the Barents Sea in August – September 2011 (by the catches by the Juday net and WP2).

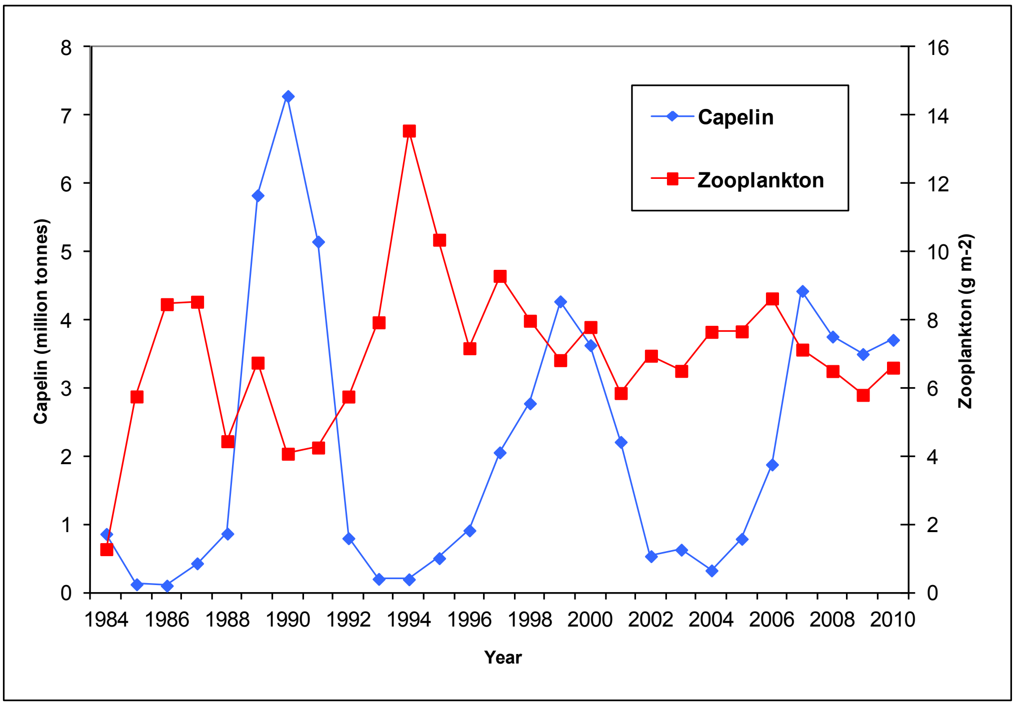

Figure 1.9. Annual variations in zooplankton biomass and the capelin stock in the Barents Sea (From Dalpadado *et al*. 2002, updated with data for 2001-present).

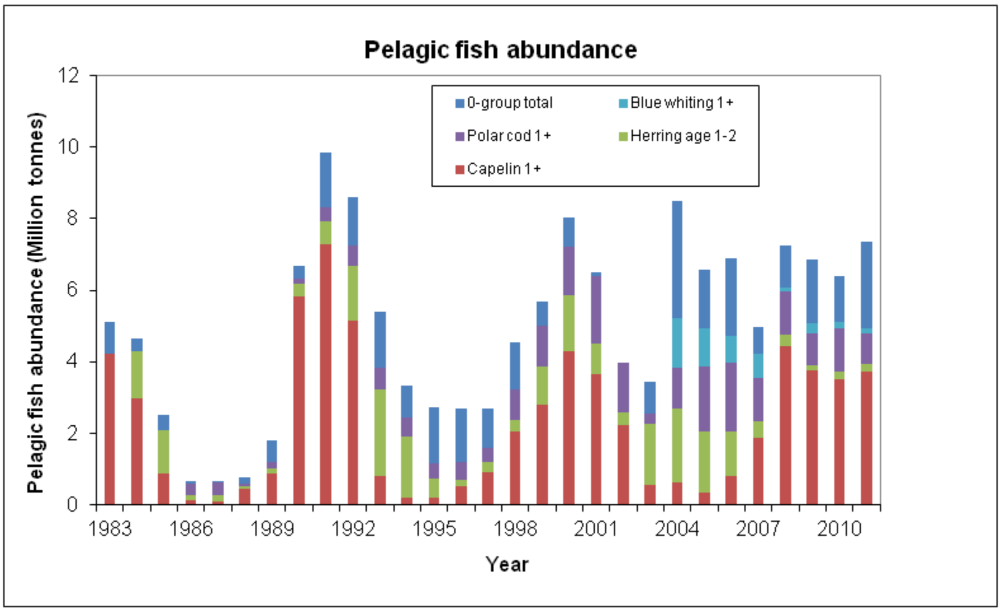

Figure 1.10. Biomass of pelagic fish species in the Barents Sea. Data are taken from; capelin: Acoustic estimates in September, age 1+ (ICES AFWG 2012), herring: VPA estimates of age 1 and 2 herring (ICES C.M. 2011/ACOM:15), using standard weights at age (9 g for age 1 and 20 g for age 2); polar cod and blue whiting: Acoustic estimates in September, age 1+ (Anon. 2011), 0-group: estimates of biomass of cod, haddock, herring and capelin 0-group, corrected for catching efficiency (Eriksen et al. 2011).

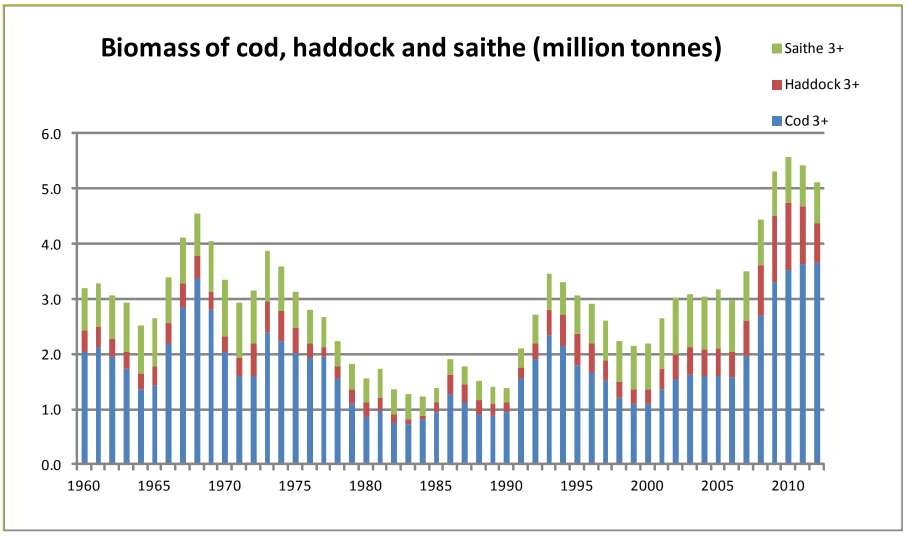

Figure 1.11. Biomass of cod, haddock and saithe, from the 2012 assessments.

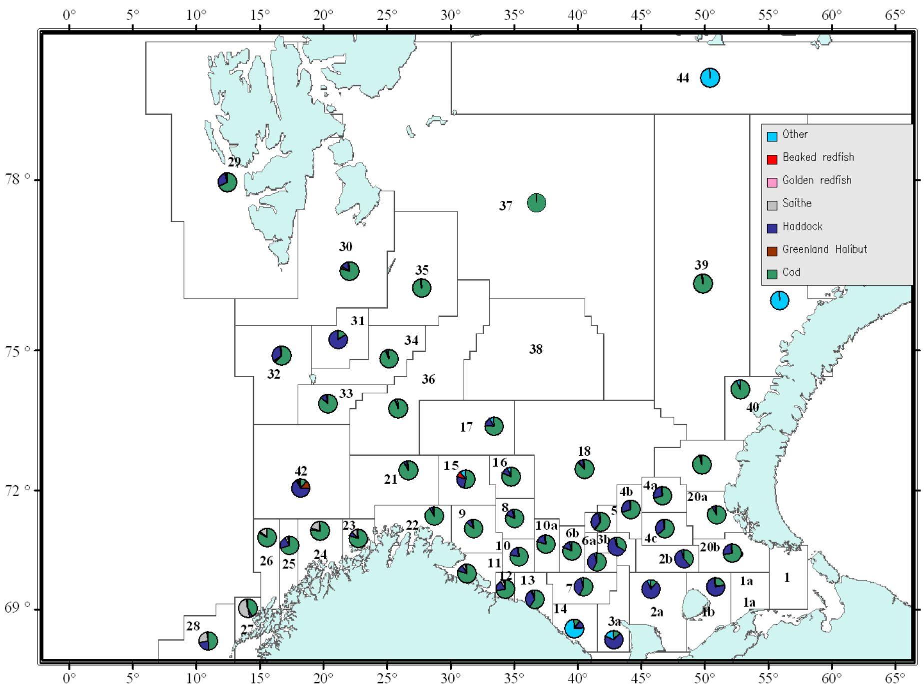

Figure 1.12. Relative distribution by weight of cod, haddock, saithe, Greenland halibut, golden redfish (*Sebastes marinus*), beaked redfish (*Sebastes mentella)* and other species taken by Russian bottom trawl in 2009 per main area for the Russian strata system. ***The Figure was not updated this year.***

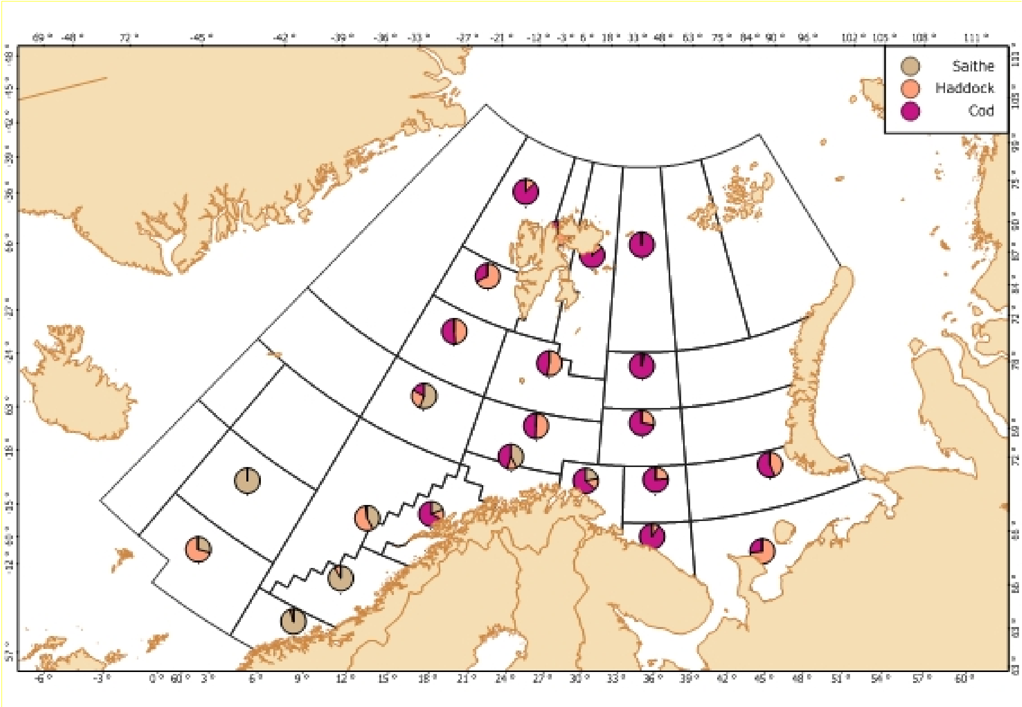

Figure 1.13. Relative distribution by weight of Norwegian catches of cod, haddock, and saithe per main area in 2009 for the Norwegian strata system. ***The Figure was not updated this year.***

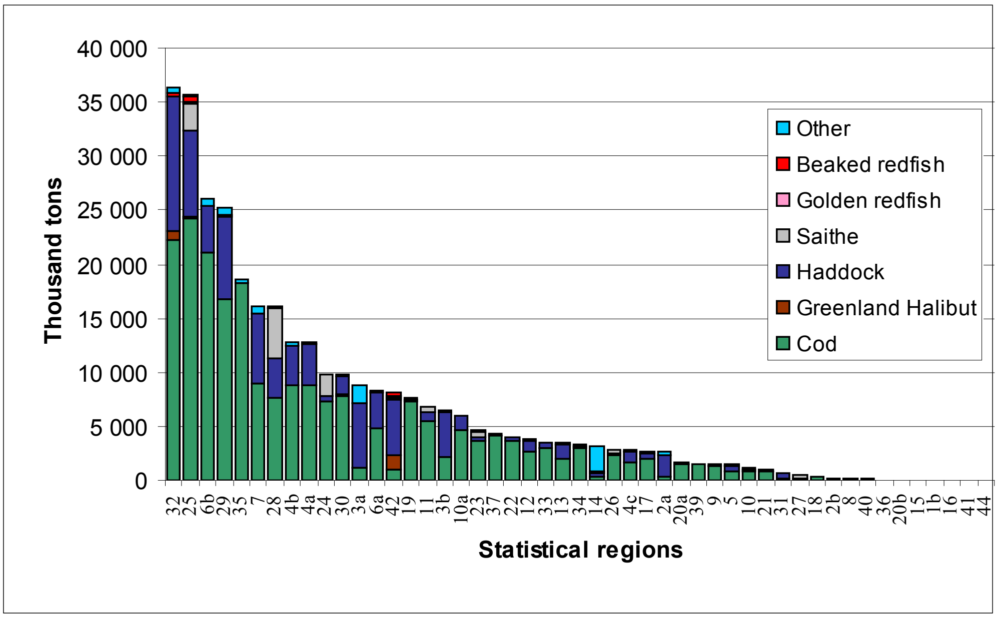

Figure 1.14. The Russian catch of cod, haddock, saithe, Greenland halibut, Sebastes marinus, Sebastes mentella and other species taken by bottom trawl by main statistical areas in 2009, thousand tonnes. The statistical areas correspond to the areas shown in Figure 1.14. The Figure was not updated this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

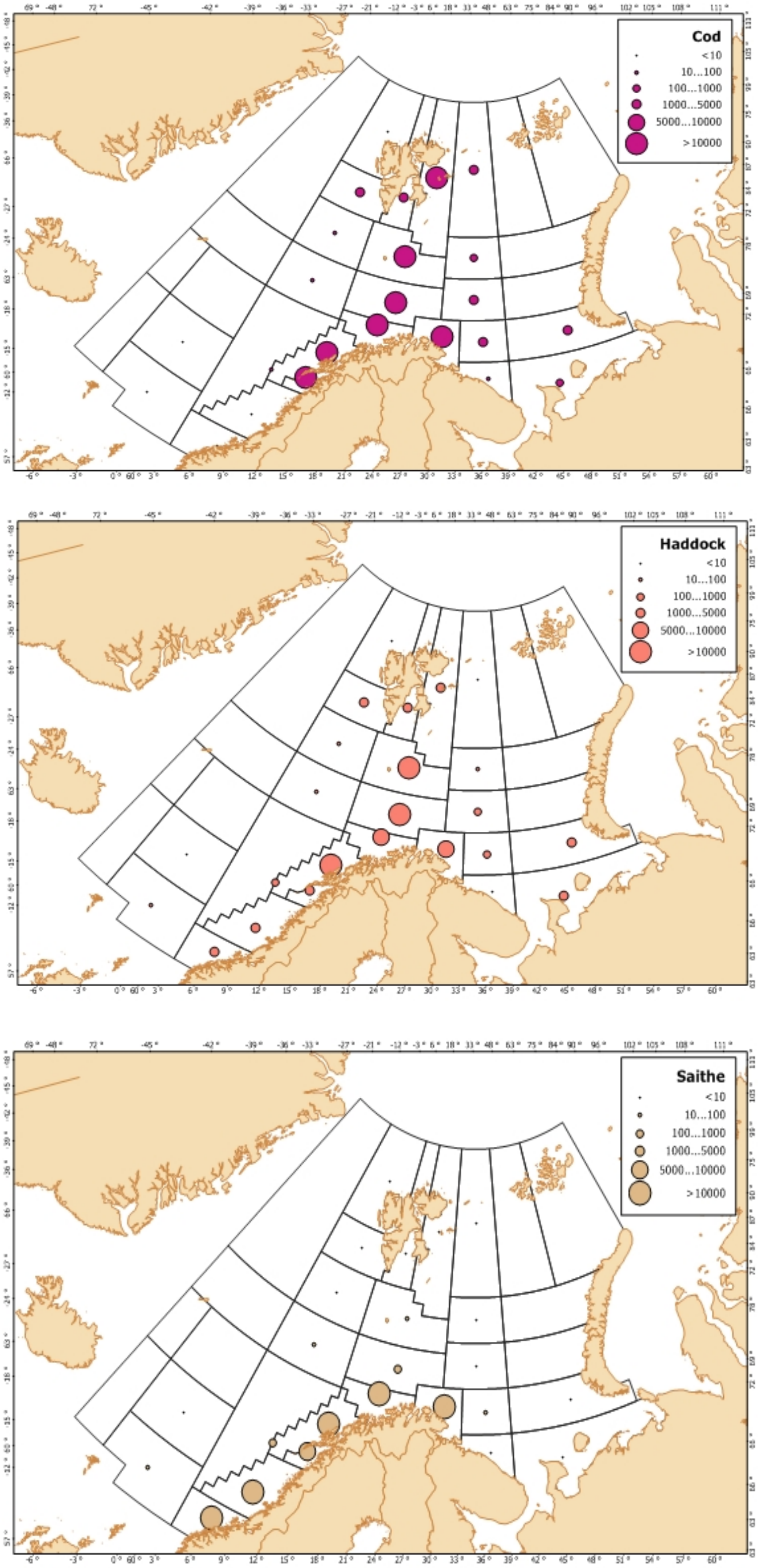

Figure 1.15. The Norwegian catch of cod, haddock and saithe by main statistical areas in 2009, thousand tonnes. The statistical areas correspond to the areas shown in Figure 1.15. ***The Figure was not updated this year.***

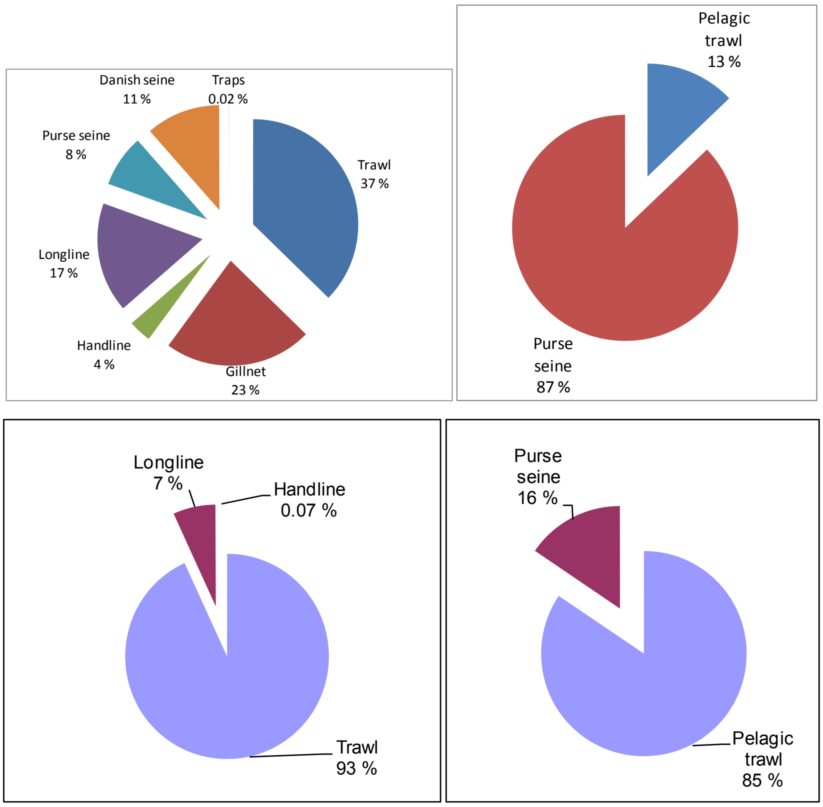

Figure 1.16. Upper panel - gear composition of the Norwegian groundfish (2007; left) and pelagic capelin (2000-2008; right) fisheries in the Northeast Arctic. Note that the purse seine in the groundfish fishery is solely used in a coastal fishery for saithe. Lower panel - gear composition of the Russian groundfish (2007; left) and pelagic capelin (2000-2008; right) fisheries in the Northeast Arctic. The Figure was not updated this year.

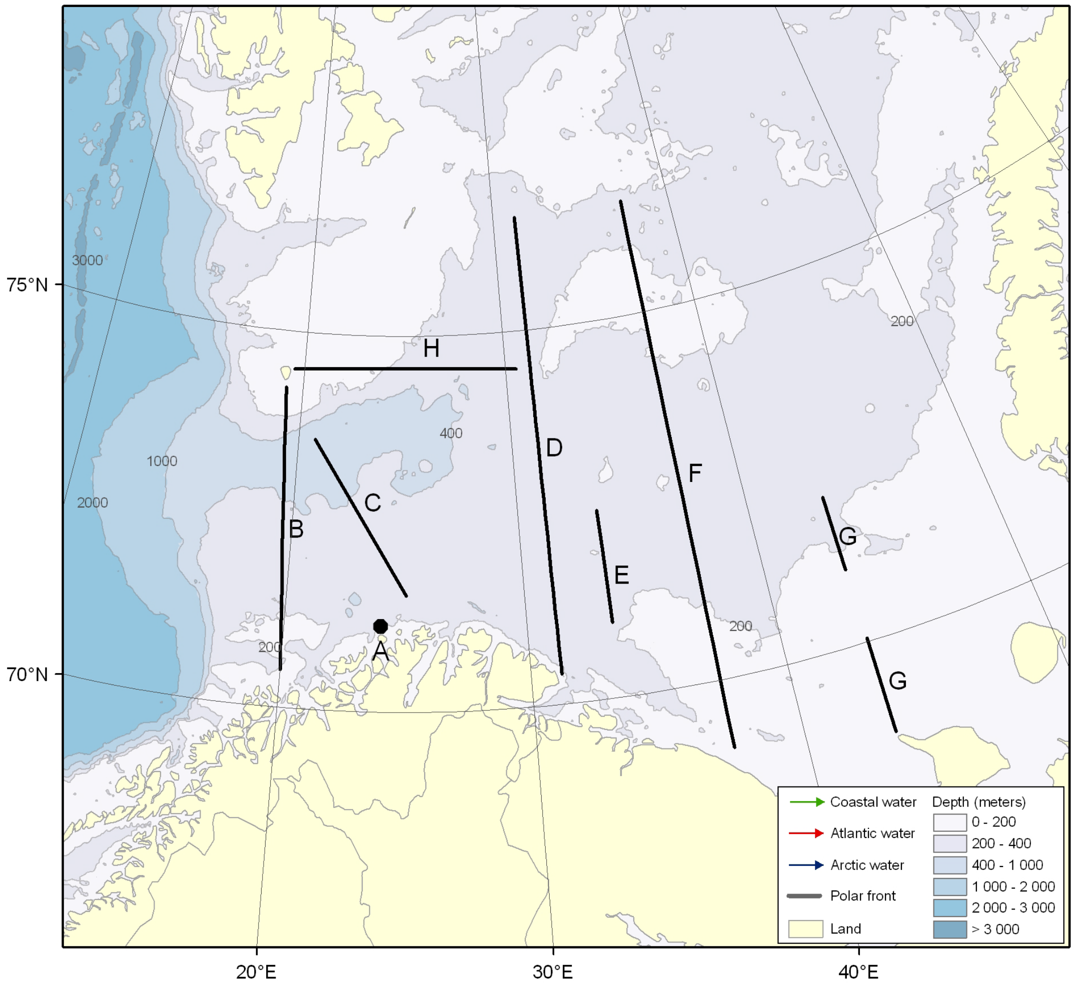

Figure 1.17. Positions of the standard sections monitored in the Barents Sea. A is fixed station Ingøy, B is Fugløya-Bear Island, C is North cape-Bear Island, D is Vardø-North, E is Kola, F is Sem Island-North G is Kanin section and H is Bear Island-East section.

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

Type of assessment: "Update" see stock annex (Annex 02)

2.1 Stock status summary

Both spawning biomass, recruitment and mortality has over the last 8 years been rather stable. Spawning biomass and recruitment is close to the lowest observed.

Current fishing mortality estimates are around 0.3. The survey indicates a weak declining trend in mortality. Both the survey and VPA-analyses indicate marginally improved recruitment since 2006, after a long period of continuous recruitment decline.

2.2 Fisheries

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

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

Recreational fisheries take an important fraction of the catches in some local areas, especially near the coastal cities and in some fjords where commercial fishing activity is low. There is no reporting system for the amount of Norwegian coastal cod (NCC) taken by recreational or tourist fishers in Norway. However, there are a few reports trying to assess the amount in certain years. In 2010 these reports were used to construct a time series (ICES CM 2010/ACOM:05) of recreational/tourist catches. These catch estimates are considered to be rather uncertain. No additional information has been obtained for later years and the recreational/tourist catch in 2010 and 2011 was assumed equal to the one estimated for 2009 (12,700 t). The total catch number at age (Table 2.1c) was upscaled according to the added amount in tonnes. Table 2.1d shows the corresponding catch at age for recreational/tourist fishing.

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

The commercial catches of Norwegian Coastal cod (NCC) have been calculated back to 1984 (Table 2.1a). For this period the estimated landings have been between 22,000 and 75,000 t. The estimated commercial landings of NCC in 2009 are 22,925 t and in 2011 they are estimated to 28,594 t (Table 2.1a, Figure 2.4). Table 2.1b shows the estimated catch by gears, area and quarters in 2011.

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

The basis for estimating coastal cod catches is the total landings of cod inside the 12 n. mile zone in the Norwegian statistical areas 03, 04, 05, 00, 06, 07 (Figures 2.1-2.3), combined with the sampling of these fisheries. Tables 2.2a,b show the sampling of the cod fishery by quarters and areas in 2011 and 2010. Table 2.3 compares the samples by quarters for the period 1985-2011. The total number of age samples in 2011 was 378. 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 8134 fish were aged. 2576 of these otoliths were classified as coastal cod. (Table 2.2a,b). Compared to the sampling in 2010, this is a 46% increase in number of otoliths and 37% increase in number of samples, but it is still somewhat below the sampling level in the years prior to 2010 (Table 2.3). Compared to 2010 the largest relative increase in the 2011 sampling was in areas 00 and 05.

Table 2.4 shows the estimated catches of coastal cod by statistical area and quarter for the years 2008-2011. The corresponding fractions of coastal cod in cod catches are also shown. In the southern areas (06/07) the fractions used to be close to 1.0 in all quarters. In this recent period (2008-2011) some reduced fractions are observed in areas 06/07 , indicating that some NEA cod spawn far to the south in quarter 1 and 2. In all areas the fractions are lower in quarter 1 and 2 due to the spawning migration of NEA cod. In area 03 (eastern Finnmark) a considerable proportion of NEA cod is present also during autumn. Table 2.4 shows lower fractions of coastal cod in all areas in quarter 1 and 2 in 2010 and 2011 compared to previous years. This is due to the increased spawning stock of NEA cod entering the coastal areas during their spawning migration. Compared to 2009 the total cod catches in coastal areas increased by 28% in 2010 and by 44% in 2011. The increase in coastal cod catch in 2011 compared to 2010 is mainly caused by an increase in quarter 1 and 4.

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

In mid-2009 the Institute of Marine Research closed down an important part of the coastal landings sampling programme. This was meant to be compensated by increased sampling by the "reference fleet". This was not fully achieved, and thereby too few cod samples were obtained from the Lofoten area (Area 00) in 2010. The samples from Vesterålen (Area 05) were therefore applied to the 2010 catches in Lofoten. The estimated catches of coastal cod in 2010 were thus even more uncertain than in previous years. In 2011 the sampling problems in this area were mitigated by a new landings sampling program aimed at the areas, seasons and fleet segments that were poorly covered by the reference fleet.

2.2.2 Regulations

The Norwegian cod TAC is a combined TAC for both the NEAC stock and NCC stock.

Landings of cod are counted against the overall cod TAC for Norway, where the expected catch of coastal cod is in the order of 10%. The coastal cod part of this combined quota was set 40,000 t in 2003 and earlier years. In 2004 it was set to 20,000 t, and in the following years to 21,000 t. There are no separate quotas given for the coastal cod for the different groups of the fishing fleet. Catches of coastal cod are thereby not effectively restricted by quotas. Most regulation measures for Northeast Arctic cod also applies to coastal cod; minimum catch size, minimum mesh size, maximum by-catch of undersized fish, closure of areas having high densities of juveniles, and some seasonal and area restrictions.

A number of regulations contribute to some protection of coastal cod: Trawl fishing for cod is not allowed inside the 6-nautical mile line (in the years 2006-2010 about 10 fresh fish trawlers had a dispensation to fish between the 4 and 6-mile line in a few areas in the period 15 April – 15 September). Since the mid-1990s the fjords in Finnmark and northern Troms (areas 03 and 04) have been closed for fishing with Danish seine. Since 2000, the large longliners have been restricted to fish outside the 4-nautical mile line. To achieve a reduction in landings of coastal cod additional technical regulations in coastal areas were introduced in May 2004 (after the main fishing season) and continued with small modifications in 2005 and 2006. In the new regulations "fjord-lines" are drawn along the coast to close the fjords for direct cod fishing with vessels larger than 15 meters. A box closed to all fishing gears except hand-line and fishing rod is defined in the Henningsvær–Svolvær area. This is an area where spawning concentrations of coastal cod are usually observed and where the catches of coastal cod has been high. Since the coastal cod is fished under a merged coastal cod/northeast Arctic cod quota, these regulations are aimed at moving parts of the traditional coastal fishery from the catching of coastal cod in the fjords to a cod fishery outside the fjords, where the proportion of northeast Arctic cod is higher. Further restrictions were introduced in 2007 by not allowing pelagic gillnet fishing for cod and by reducing the allowed bycatch of cod when fishing for other species inside fjord lines from 25% to 5%, and outside fjord lines from 25% to 20%. The regulations were maintained in 2008. Since 2009 the most important spawning area in the southern part of the stock distribution area (Borgundfjorden near Ålesund) has been closed to fishing (except for hand line and fishing rod) during the spawning season.

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

7,000 t of the Norwegian cod quota has since 2010 been set aside to cover the catches taken in the recreational and tourist fisheries and catches taken by young fishers (to motivate young people to become fishers).

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

Additional regulations in 2012: Since the spawning biomass index in the 2011 autumn survey was higher than the 2010 value, the rebuilding plan in operation, implied that the 2011 regulation could be unchanged in 2012. A minimum mesh size (126 mm full mesh) for gill nets in recreational fisheries was activated from 1 January 2012. This had been announced more than a year in advance to allow people to prepare for the change. The regulations for the closed spawning area near Henningsvær-Svolvær were in 2012 relaxed by allowing vessels less than 11m to fish. In the spawning season in 2011 and 2012 large concentrations of NEA cod was observed in this area, and the fraction of coastal cod in the catches was quite low.

2.3 Survey data

A trawl-acoustic survey along the Norwegian coast from the Russian border to 62°N was started in the autumn 1995. In 2003 the survey was somewhat modified by being combined with the former saithe survey at the coastal banks and the survey (ICES acronym: NOcoast-Aco-Q4) was moved from September to October-November. This new survey covers a larger area than the coastal surveys in 1995-2002. However, the survey indices for cod to be used in this report are calculated using the same area coverage and the same method as in the years previous to 2003.

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

The results of the 2011 survey (Mehl *et al.* 2011) are presented in Tables 2.5-2.11 for the area inside the 12 n. miles border in the Norwegian statistical areas 03, 04, 05, 00, 06, and 07 (Figures 2.1 and 2.2). The survey time series of estimated numbers of NCC per age group is given in Table 2.6 and in Figure 2.6. For most age groups the 2011 results are slightly higher than in the period 2008-2010 (Table 2.6), and the estimate of both total biomass (Table 2.9) and spawning biomass (Table 2.11) is the highest since 2007.

The uncertainty is considered to be rather large, and the 2011 result is thus not a clear evidence of an increasing stock trend. The period since 2002 shows considerable variation without any clear 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.

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

A total of 1507 cod otoliths were sampled during the 2011 survey.

As in previous years, NCC was found throughout the survey area. The 2011 survey data on the stock separation are similar to the 2007-2010 data and shows the same pattern as the whole 1995-2010 time series. The sampling showed a higher proportion of NCC in the fjords and to the south compared with the northern and outer areas. The proportion of the NCC increases going from north to south along the Norwegian coast. Table 2.12 shows the proportions of coastal cod in the survey samples by age for 6 previous years. The proportion is rather stable between years, but is consistently higher for young fish compared to old. Nearly all otoliths collected south of 67° N (Norwegian statistical areas 06 and 07) were NCC type. Although the proportions are lower, the total abundance of NCC is higher north of 67° N (Table 2.5).

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

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

Table 2.8 and Figure 2.13a show the time series of mean weights at age for the whole survey. There is a tendency of increased weights over time for ages 3-7. For the older ages mean weights shows large variations, probably caused by few fish sampled.

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

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

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

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

2.4 Data available for the Assessment

2.4.1 Catch at age (Table 2.1 and table 2.14)

The estimated commercial catch at age (2-10+) for the period 1984-2011 is given in Table 2.1a. Table 2.1c shows the total catch numbers at age when recreational and tourist fishing is included.

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

2.4.2 Weights at age (Tables 2.8 and 2.13)

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

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

2.4.3 Natural mortality

A fixed natural mortality of 0.2 has been assumed in the assessment. However, in the Barents Sea cod cannibalism has been documented to be a significant source of mortality that varies in relation to alternative food and in relation to the abundance of large cod. This might also be the case for the coastal cod (Pedersen and Pope, 2003a and b). In the 2005 coastal cod survey 1125 cod stomachs were analysed (Mortensen, 2007). The observed average frequency of occurrence of cod in cod stomachs was around 4%. Other important predators on cod in coastal waters are cormorants, harbour porpoises and otters (Anfinsen, 2002; Pedersen *et al.*, 2007; Mortensen, 2007). Young saithe (ages 2-4) has been observed to consume postlarvae and 0-group cod during summer/autumn (Aas, 2007).

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

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

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

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

In the 2010 WG mortality signals from the survey and from the catch at age data were analysed and an SVPA ("user-defined VPA" in the Lowestoft VPA95-menu) were run using the survey based estimate of F_{2009} (details described in Annex 10 in ICES CM 2010/ACOM:05) as terminal F. The same procedure was used in 2011 and also this year: By using the survey indices for ages 2 to 8 (Table 2.6) a trial XSA (Tables

2.13-2.15) was run to obtain historic values of F(4-7). Calculated survey mortalities (Table 2.17 and Figure 2.15) were regressed with XSA Fs for the years 1996-2006 (Fig. 2.15). This regression was used for converting the 2010 survey mortality to a vpa F(4-7) (Table 2.16). A selection pattern for 2010 was estimated as the average pattern over the years 2008-2010 in the trial XSA, and Fs on oldest true age was taken from the trial XSA. The SVPA, which is considered as the final assessment, was run by using the survey based F(4-7) for 2010 combined with the selection pattern and oldest true Fs described above. The same procedure was repeated for catch at age data including estimates of recreational catches, but the trial XSA for that data set is not shown here.

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

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

2.6 Results of the Assessment

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

The 2011 survey results are for most ages higher than in the 2010 survey, but more similar to the 2007 survey (Table 2.6, Figure 2.6). For the period after 2003 there is no obvious trend in the indices.

The survey based estimate of the F_{2011} relating to commercial catch is 0.33 and F_{2010} relating to total catch data is 0.31. The text table below compares those with corresponding values last year. The table also compares the results of SVPA-runs aimed at those Fs used as terminal Fs.

	F2008	F2009	F2010	F2011	SSB 08	SSB 09	SSB 10	SSB 11
Com.catch 2010 assess	0.32	0.37			48	46		
Com.catch 2011 assess	0.32	0.38	0.38		56	50	44	
Com.catch 2012 assess	0.27	0.28	0.26	0.33	61	59	58	70
Tot.catch 2010 assess	0.27	0.31			85	80		
Tot.catch 2011 assess	0.30	0.37	0.37		82	77	73	
Tot.catch 2012 assess	0.26	0.29	0.26	0.31	88	88	88	106

Some further comparisons are shown in Figures 2.16. The SVPA indicate a rather stable SSB since 2006, while F shows a weak declining trend. Figure 2.17 shows the SSB-series from VPA and survey, both scaled to their average over the years 1995-2010. Figure 2.18 compares the various time series of F.

2.6.2 Recruitment (Table 2.6, Figure 2.16)

The 2010 and 2011 survey value for age 1 is the highest since 2001 (Table 2.6), but the index of age 1 has historically shown poor relation to year-class strength of the same cohort observed in the survey at older ages. The SVPA results (Figure 2.16) indicate that the recruitment decline stopped around 2006.

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

2.6.3 Catches in 2012

No catch predictions have been made. Assuming a stable stock, the availability of coastal cod in 2012 is expected to be similar to 2011.

In the winter/ spring fishery in 2012 the availability of North-east arctic cod in coastal waters was at least as good as in 2010 and 2011. This has most likely lead to low by-catches of coastal cod so far in the year. The experience from 2011 is that reallocations of quotas late in the year lead to some increase in catches of coastal cod. The impact of this could be larger when the total cod quota is larger. The impact of this in 2012 is difficult to predict.

2.7 Comments to the Assessment

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

Reduced sampling of commercial catches in most areas in 2010 has increased the uncertainty. The sampling improved in 2011, but there are still less sampling than in 2009 and earlier.

The new series with recreational and tourist fisheries included may be said to scale the stock size to a more realistic level, but at the same time brings in additional uncertainty. The time series of recreational catch show rather stable catches, and they represent thereby a higher fraction (about 30-35%) after 2004 compared to the period 1984-1988 (15-20%) and 1993-1999 (20-25%).

2.8 Reference points

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

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

2.9 Management considerations

Catches have remained rather stable over the years 2004-2010, while the 2011 catch again increase, partly due to increased coastal fishing towards the end of the year, when the fraction of coastal cod in these areas is high. The regulations seem to have reduced the catches compared to pre-2004 level but have not been sufficient to cause further reduction. Additional regulations should be considered to reduce the autumn fishery in coastal areas.

The implementation of the rebuilding plan requires measures to further reduce the effective fishing effort in all fisheries where coastal cod are caught, including recreational fisheries. There are no evidences that the regulations in 2011 have succeeded in obtaining the 15% reduction in F implied by the rebuilding plan. That catches in 2011 increased compared to 2010. Stronger measures are required to obtain the F-reductions specified in the rebuilding plan.

2.10 Rebuilding plan for coastal cod

The following rebuilding plan was suggested by Norway in 2010, and adopted late in the same year:

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

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

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

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

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

The Evaluation of this plan made at the 2010 WG (Annex 10 in ICES, 2010/ACOM:05) was not reviewed by the review group and advice drafting group dealing with the rest of the AFWG report. ICES selected some experts who during summer 2010 re-

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

[2] Ages 4-7

viewed the evaluation, and an advice group wrote the response to Norwegian Authorities, issued at 1 October 2010. The conclusions are:

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

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

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

2.11 Recent ICES advice

For the years 2004-2011 the advice has been; No catch should be taken from this stock and a recovery plan should be developed and implemented. For 2012 the advice was to follow the rebuilding plan.

2.12 Response to the comments from the review group

The comments below refer to points and headings in the Technical Minutes from the 2011 review group (Annex 11 in ICES CM 2011/ACOM:05)

Under the General comments heading:

A specific table for catch number at age in recreational/tourist fisheries is provided (Table 2.1d)

Under the Technical comments heading:

Annex is updated, describing the procedure followed since 2010

A new paragraph (section 2.1) summarizes the stock status

Plot of stock weights at age is provided (Figure 2.13a)

Total biomass is included in the plots in Figure 2.16

Survey mortality ($Z_{(4-9)}$) is regressed against XSA $F_{(4-7)}$. The correlation between survey Z and XSA F increases when averaging over ages 4-9 instead of 4-7, probably due to reduced "noise" when averaging over a larger number of age groups.

"Larger uncertainty in recent years" refers to the low stock period (since 2001) compared to earlier years with larger cod stock. At low stock density the acoustic contribution from other species (haddock and Norway pout) mixed with cod is relatively higher and the uncertainty of the fraction contributed by cod causes larger relative error in the estimated acoustic values of cod.

For the evaluation of the rebuilding plan at the 2010 WG, a segmented regression (Ockham's racer) was used for fitting stock – recruitment data. This was considered relevant in a precautionary approach context.

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

	Age									Tonnes
	2	3	4	5	6	7	8	9	10+	Landed
1984	829	3478	6954	7278	6004	4964	2161	819	624	74824
1985	396	7848	7367	8699	7085	3066	705	433	264	75451
1986	4095	4095	12662	8906	5750	3868	1270	342	407	68905
1987	170	940	8236	12430	4427	2649	1127	313	149	60972
1988	110	1921	3343	6451	6626	4687	1461	497	333	59294
1989	41	1159	1434	2299	5197	2720	949	236	86	40285
1990	7	349	1233	1330	1129	3456	773	141	73	28127
1991	125	607	1452	3114	1873	1297	873	132	94	24822
1992	40	665	3160	4422	2992	1945	898	837	279	41690
1993	4	369	1706	2343	2684	3072	1871	627	690	52557
1994	332	573	1693	4302	2467	3337	1514	777	798	54562
1995	810	896	2345	5188	5546	3270	1455	557	433	57207
1996	1193	2376	2480	4930	4647	4160	2082	898	543	61776
1997	1326	3438	3150	2258	2490	3935	3312	959	684	63319
1998	554	2819	4786	4023	2272	1546	1826	975	343	51572
1999	252	1322	2346	4263	2773	1602	751	774	320	40732
2000	156	971	3664	3807	2671	1104	326	132	152	36715
2001	44	505	1837	2974	1998	1409	542	187	119	29699
2002	192	893	2331	2822	2742	1538	915	325	377	40994
2003	81	1107	2094	2506	2158	1374	598	258	99	34635
2004	12	306	924	1713	1820	1444	609	226	264	24547
2005	15	474	1299	1828	1436	1115	513	188	143	22432
2006	71	315	1656	1695	1695	1246	671	326	224	26134
2007	88	515	1396	1846	1252	824	391	256	196	23841
2008	92	670	1438	1635	1232	862	440	215	170	25777
2009	3	238	1052	1280	1388	1065	545	172	276	24821
2010	14	710	1617	1895	1040	703	420	198	175	22925
2011	30	632	1907	1777	1526	1133	487	230	315	28594

Table 2.1b. Estimated commercial catch of coastal cod in 2011 by gear and area (tonnes).

Year	2011					
Area	03	04	00	05	06/07	Total
Gillnet	1 445	2 525	2 360	2 753	5 530	**14 614**
L.line/Jig	2 489	1 295	1 566	1 186	808	**7 345**
Danish seine	1 640	1 901	553	1 675	310	**6 078**
Trawl	246	252	30	18	12	**558**
Total	**5 820**	**5 973**	**4 509**	**5 632**	**6 660**	**28 594**

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

	AGE									Tonnes
	2	3	4	5	6	7	8	9	10+	landed
1984	1479	5209	9070	8945	7198	5561	2397	952	624	88124
1985	3558	10438	9733	10444	7732	3291	835	512	264	88851
1986	4722	7128	15330	10565	6889	4303	1521	481	407	82405
1987	278	2912	12244	14611	5076	3080	1236	351	149	74472
1988	744	3328	4910	8159	8714	5237	1590	591	333	72894
1989	459	1984	2917	4057	6610	3238	1057	270	86	53985
1990	408	1843	2485	2012	3838	3906	846	141	73	42627
1991	1308	3305	4448	4456	2681	1880	977	203	94	40122
1992	469	1946	5509	5913	3622	2459	1744	921	279	57790
1993	51	1645	2994	3156	3530	3768	2073	995	690	67357
1994	389	1274	3416	5017	3755	4008	1907	901	798	69262
1995	818	1228	3149	6639	7131	4050	1868	737	433	71907
1996	1214	2967	2989	5547	6144	5533	2543	1125	543	76276
1997	1377	4145	4173	3021	3225	5124	4000	1091	684	77819
1998	803	3956	7113	5339	2857	1956	2155	1230	343	66172
1999	301	1788	3791	6202	3693	1959	949	995	320	54632
2000	219	1525	4817	5322	3715	1448	453	241	152	50315
2001	44	848	2572	4020	2962	2282	740	321	119	43099
2002	248	1191	3161	3877	3681	2134	1250	490	377	54594
2003	166	1449	2758	3422	3076	1824	842	584	99	48535
2004	38	560	1407	2637	2919	2271	967	388	264	37947
2005	36	744	1957	2686	2289	1830	936	364	143	35632
2006	90	551	2672	2562	2678	1858	986	453	224	39134
2007	137	861	2155	2805	1858	1355	718	413	196	36841
2008	107	1065	2181	2473	1882	1262	701	349	170	38577
2009	3	322	1628	2007	2251	1665	825	262	276	37521
2010	21	1103	2512	2945	1616	1092	652	308	272	35625
2011	43	912	2754	2566	2203	1636	704	333	455	41294

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

Quarter	03	04	00	05	06+07	Tot
1	15	23	9	48	38	133
2	21	14	3	22	19	79
3	7	4	0	9	13	33
4	11	2	0	11	6	30
Total samples	54	43	12	90	76	275
Total otoliths	1057	858	267	1774	1598	5554
Coastal cod type otoliths	130	109	100	459	1299	2097

Table 2.2b. Sampling from cod fisheries in 2011 in the statistical areas 00, 03,04,05, 06+07. Number of age samples of cod by quarter, total number of cod otoliths.

Quarter	03	04	00	05	06+07	Tot
1	29	27	11	39	36	142
2	38	10	16	41	21	126
3	9	5	0	10	14	38
4	7	19	3	37	4	70
Total samples	86	65	30	132	75	376
Total otoliths	1984	1330	764	2500	1556	8134
Coastal cod type otoliths	258	371	115	693	1139	2576

Table 2.3 Number of otoliths sampled by quarter from commercial catches in the period 1985-2011. CC=coastal cod, NEAC=Northeast Arctic cod.

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

Table 2.4. Landings in tonnes of Coastal cod by area and quarter 2008-2011 (upper 4 tables) Proportion (of total) coastal cod in landings by area and quarter 2008-2011 (lower 4 tables).

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

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

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

Year		2011				
Qu./Area	03	04	00	05	06-07	Total
1	1231	1888	2328	2762	4236	12445
2	2241	2289	1458	801	1785	8473
3	400	466	293	475	384	2018
4	1949	1330	430	1594	256	5559
Total	5820	5973	4509	5632	6660	28594

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

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

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

Year		2011				
Qu./Area	03	04	00	05	06-07	Total
1	0.13	0.08	0.11	0.07	0.62	0.12
2	0.15	0.17	0.10	0.10	0.77	0.16
3	0.15	0.38	0.92	0.64	0.96	0.38
4	0.45	0.72	0.92	0.87	0.99	0.64
Total	0.19	0.14	0.12	0.11	0.68	0.17

Table 2.5. Coastal cod. Acoustic abundance indices by sub areas and in total in 2011 (in thousands).

	Alder (Årsklasse) / Age (Year class)										
Område	1	2	3	4	5	6	7	8	9	10+	
Area	(10)	(09)	(08)	(07)	(06)	(05)	(04)	(03)	(02)	(01+)	Sum
03	1844	533	669	523	583	276	107	71	66	35	4707
04	2990	1599	819	1066	667	999	249	144	91	226	8850
05	178	289	465	403	29	141	60	55	0	3	1623
00	1761	44	383	712	672	492	0	132	0	40	4236
06	2242	784	1544	1785	1033	231	18	69	10	28	7744
07	0	17	70	82	28	46	14	7	4	7	275
Total	9015	3266	3950	4571	3012	2185	448	478	171	339	27435

Table 2.6. Coastal cod. Acoustic abundance indices by age 1995 – 2011 (in thousands).

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Sum
1995	28707	20191	13633	15636	16219	9550	3174	1158	781	579	109628
1996	1756	17378	22815	12382	12514	6817	3180	754	242	5	77843
1997	30694	18827	28913	17334	12379	10612	3928	1515	26	663	124891
1998	14455	13659	15003	13239	7415	3137	1578	315	169	128	69099
1999	6850	11309	12171	10123	7197	3052	850	242	112	54	51960
2000	9587	11528	11612	8974	7984	5451	1365	488	85	97	57171
2001	8366	6729	7994	7578	4751	2567	1493	487	189	116	40270
2002	1329	2990	4103	4940	3617	2593	1470	408	29	128	21607
2003	2084	2145	3545	3880	2788	2389	1144	589	364	80	19008
2004	3217	3541	3696	4320	2758	1940	783	448	98	110	20914
2005	1443	1843	3525	3198	3217	1700	1120	552	330	78	17006
2006	1929	2525	4049	3783	3472	2509	1811	399	229	13	20719
2007	2202	3300	4080	5518	3259	2447	1444	760	197	34	23241
2008	2128	2181	2475	2863	2101	1219	815	403	319	177	14681
2009	3442	2059	2722	3959	2536	1603	1259	793	443	141	18955
2010	7768	2513	2729	2820	2417	1098	501	426	260	305	20837
2011	9015	3266	3950	4571	3012	2185	448	478	171	339	27435

Table 2.7. Coastal cod. Mean length (cm) at age 1995 – 2011.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
1995	21.5	33.0	43.0	52.0	59.1	64.1	76.0	87.4	89.0	108.3
1996	19.0	30.2	41.7	52.5	59.2	65.2	79.1	84.8	87.0	114.2
1997	16.8	28.7	40.8	51.6	58.1	65.9	73.6	80.8	102.0	110.7
1998	20.3	33.3	43.8	51.4	59.1	66.3	74.1	81.0	93.2	116.9
1999	21.5	32.6	43.8	54.6	59.6	65.8	77.9	90.8	99.4	118.0
2000	21.6	33.3	43.4	53.5	61.0	66.1	75.5	90.8	99.1	105.5
2001	21.1	33.3	44.5	53.6	62.9	64.7	88.7	84.2	85.7	102.1
2002	22.5	34.4	44.6	56.0	61.6	67.7	72.4	66.6	89.0	108.3
2003	18.9	33.8	42.1	51.6	60.0	67.2	72.7	76.9	84.9	94.8
2004	20.7	32.9	43.5	54.5	59.9	68.0	71.9	75.0	74.6	91.8
2005	22.5	32.8	42.2	57.9	60.6	64.0	71.3	69.9	73.5	108.4
2006	22.2	36.1	47.0	55.5	61.4	68.0	69.5	77.8	87.0	100.5
2007	21.6	36.0	48.0	57.9	62.2	66.8	71.8	86.6	100.2	106.3
2008	21.9	36.9	49.2	59.0	66.1	70.9	71.7	74.1	77.6	98.8
2009	20.9	34.5	47.8	57.8	65.8	70.5	77.9	78.4	85.1	73.5
2010	20.3	34.9	46.4	57.5	64.6	71.2	76.9	75.2	78.9	82.7
2011	20.6	32.9	47.2	59.5	66.1	71.5	79.9	82.0	81.1	83.9

Table 2.8. Coastal cod. Mean weight (grams) at age 1995-2011.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
1995	81	390	791	1525	2222	2881	4665	6979	6759	9897
1996	59	252	724	1433	2053	2748	4722	6685	6932	9723
1997	43	240	683	1364	1893	2816	4426	6406	7805	1827
1998	52	372	883	1456	2107	2950	4319	5625	8323	12468
1999	70	323	841	1675	2192	2857	4540	6579	9454	12902
2000	72	365	809	1554	2539	3049	4352	6203	8527	12066
2001	51	396	966	1524	2314	3320	3695	6144	8768	12468
2002	103	428	895	1741	2433	3133	4273	4397	7759	12992
2003	62	385	738	1353	2145	3103	3981	4921	6923	9956
2004	83	352	834	1690	2255	3312	4150	4594	4383	9733
2005	112	359	786	2168	2265	2756	4174	3373	4502	15887
2006	105	474	1080	1746	2430	3336	3684	5125	7028	14650
2007	103	518	1185	2011	2500	3160	4241	6806	11051	14931
2008	96	508	1208	2095	2987	3671	3976	4387	5415	11588
2009	85	434	1116	2003	2894	3632	4875	5400	6125	4719
2010	75	419	1026	1996	2839	3665	4868	4895	5685	6504
2011	77	343	1062	2119	2882	3761	5505	6336	6309	6570

Table 2.9. Coastal cod. Acoustic biomass indices (tonnes) in 1995 – 2011.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Sum
1995	2337	7868	10786	23846	36039	27515	14445	8761	4933	7779	144309
1996	145	4386	16521	17739	25687	18731	15562	4376	3130	46	106323
1997	1319	4518	19748	23644	23435	29884	15060	8860	249	8643	135360
1998	752	5078	13247	19274	15627	9255	6675	1646	1329	2083	74966
1999	477	3650	10233	16960	15774	8720	4723	2097	1220	567	64421
2000	688	4321	9824	14464	20482	17067	5936	4359	926	1232	79299
2001	425	2662	7724	11548	10993	8521	5517	3010	1705	1917	54022
2002	137	1279	3672	8600	8801	8124	6282	1794	225	1663	40577
2003	125	876	2569	5328	5788	6995	4201	2754	2674	1136	32446
2004	329	1269	3087	7394	6089	6901	3009	1779	454	1058	31405
2005	109	675	2947	6521	7167	4807	3648	1942	1315	1205	30336
2006	202	1197	4374	6605	8435	8367	6672	2045	1602	190	39689
2007	227	1709	4835	11097	8148	7733	6124	5173	2177	508	47731
2008	206	1212	3120	6085	6593	4203	3437	2014	1492	2066	30506
2009	294	893	3037	7933	7335	5821	6137	4282	2707	665	39107
2010	583	1053	2800	5629	6862	4024	2439	2085	1478	1984	28936
2011	695	1123	4295	9686	8681	8218	2466	3029	1079	2227	41396

Table 2.10. Coastal cod. Maturity at age as determined from maturity stages observed in the surveys over the period 1995 – 2011.

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

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

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Sum
1995	0	0	96	4925	17424	19614	12573	7648	4933	7779	74992
1996	0	0	468	4467	14320	15130	14365	4311	3130	46	56237
1997	0	0	1185	6857	10546	22712	14608	8860	249	8643	73660
1998	0	92	2026	4870	8252	6804	5774	1461	1329	2083	32691
1999	0	56	315	3544	6778	5716	3478	2097	1220	567	23771
2000	0	0	0	2366	6354	10426	4486	2798	916	1232	28579
2001	0	0	15	508	4102	6662	5398	2978	1650	1917	23230
2002	0	20	87	2240	7702	7551	5650	1747	225	1663	26885
2003	0	0	0	269	1670	3428	3778	2686	2554	1136	15521
2004	0	0	28	679	2252	5253	2853	1736	434	722	13959
2005	0	0	0	447	2844	2670	3247	1898	1315	288	12709
2006	0	0	0	925	4386	6275	6072	1779	1538	571	21546
2007	0	0	0	1554	4400	5877	5879	4294	2177	508	24689
2008	0	0	107	734	3189	3012	3049	1902	1434	2066	15493
2009	0	0	61	476	1907	2037	3621	3169	1624	612	13508
2010	0	0	0	450	2608	2656	2024	1835	1404	1924	12901
2011	0	11	0	581	3646	5999	1997	1605	993	1893	16725

Table 2.12. Proportion coastal cod among sampled cod during the coastal survey by age and statistical areas in the years 2005-2011.

Year	Area/Age	2	3	4	5	6	7	8	9	10+
2005	3	0.63	0.54	0.54	0.45	0.35	0.30	0.20	0.48	0.03
2005	4	0.96	0.91	0.76	0.74	0.71	0.60	0.76	0.81	0.50
2005	5	0.00	0.54	0.65	0.68	0.52	1.00	1.00	0.67	
2005	0	0.11	0.39	0.70	0.61	0.70	0.85	0.50	1.00	
2005	6	1.00	1.00	0.93	0.87	0.81	0.81	0.59	0.96	
2005	7	1.00	1.00	1.00	1.00	1.00	0.86	0.67	0.00	
2006	3	0.79	0.77	0.63	0.59	0.45	0.37	0.30	0.39	0.00
2006	4	1.00	0.88	0.84	0.79	0.68	0.63	0.82	0.40	0.42
2006	5	1.00	0.98	0.81	0.88	0.77	0.63	0.80	0.00	0.50
2006	0	0.99	0.99	0.95	0.87	0.86	0.89	0.85	0.33	
2006	6	1.00	1.00	0.95	0.99	0.80	0.72	1.00	0.67	
2006	7	1.00	0.97	0.95	0.98	0.89	1.00	0.50		
2007	3	0.83	0.38	0.40	0.59	0.27	0.32	0.00	1.00	
2007	4	0.91	0.92	0.92	0.80	0.80	0.90	0.71	0.67	1.00
2007	5	0.97	1.00	0.97	0.94	0.94	0.95	0.86	0.67	0.00
2007	0	1.00	0.88	1.00	1.00	1.00	0.00	1.00	1.00	
2007	6	1.00	1.00	0.95	0.87	0.91	0.81			
2007	7	1.00	1.00	1.00	0.89	0.86	0.86	1.00	1.00	1.00
2008	3	0.98	0.97	0.80	0.83	0.79	0.72	0.53	1.00	0.40
2008	4	1.00	0.99	0.80	0.88	0.84	0.78	0.88	0.88	0.86
2008	5	1.00	1.00	0.93	0.96	1.00	0.80	0.67	1.00	1.00
2008	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
2008	6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2008	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2009	3	0.90	0.72	0.54	0.44	0.48	0.57	0.79	0.67	0.58
2009	4	0.95	0.89	0.78	0.62	0.69	0.92	0.72	0.78	0.79
2009	5	1.00	1.00	0.95	0.84	0.78	0.82	0.88	0.67	1.00
2009	0	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	
2009	6	1.00	1.00	1.00	1.00	0.82	1.00	1.00	1.00	0.50
2009	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00
2010	3	0.86	0.78	0.56	0.47	0.36	0.37	0.81	0.89	0.95
2010	4	0.98	0.96	0.87	0.71	0.49	0.77	0.87	1.00	1.00
2010	5	1.00	0.98	1.00	1.00	0.84	0.88	1.00	0.73	1.00
2010	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2010	6	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
2010	7	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
2011	3	0.83	0.83	0.78	0.67	0.44	0.28	0.70	0.73	0.67
2011	4	0.99	0.99	0.95	0.87	0.79	0.77	0.74	0.93	1.00
2011	5	0.97	1.00	1.00	0.93	0.75	0.71	0.75		0.83
2011	0	1.00	1.00	1.00	1.00	1.00		1.00		
2011	6	1.00	1.00	1.00	1.00	1.00		1.00		1.00
2011	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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

At 20/04/2012 17:06

Table 2 Catch weights at age (kg)

YEAR	1984	1985	1986	1987	1988	1989	1990	1991
AGE								
2	0.248	0.214	0.227	0.331	0.246	0.3	0.345	0.164
3	0.619	0.712	0.525	0.673	0.634	0.661	1.174	0.922
4	1.149	1.415	1.08	1.12	1.17	1.836	1.515	1.608
5	1.734	2.036	1.706	1.693	1.727	2.17	1.678	2.108
6	2.325	2.737	2.256	2.359	2.328	2.448	2.708	2.507
7	3.486	4.012	3.353	3.743	3.256	4.391	3.898	3.469
8	4.845	6.116	4.838	5.326	4.7	4.899	6.515	4.976
9	5.608	6.46	5.838	6.129	5.45	6.661	7.299	5.734
+gp	8.84	10.755	7.053	11.623	8.202	11.608	13.924	11.059
SOPCO	1.0002	1	1.0001	1.0001	1.0001	1	1.0002	1.0003

Table 2 Catch weights at age (kg)

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
2	0.168	0.241	0.254	0.302	0.274	0.277	0.376	0.467	0.515	0.164
3	0.556	0.645	0.805	0.71	0.921	0.97	0.978	1.155	1.305	0.952
4	1.359	1.71	1.476	1.335	1.464	1.554	1.518	1.633	2.272	1.637
5	2.267	2.591	2.097	1.842	1.979	1.97	2.281	2.171	2.555	2.881
6	2.957	3.588	3.287	2.467	2.516	2.897	3.125	3.249	3.283	3.424
7	3.903	4.366	4.095	4.191	3.461	3.716	3.9	4.095	4.504	4.038
8	5.317	5.899	5.592	5.778	4.866	4.829	5.52	5.013	5.4	5.397
9	4.558	6.494	7.217	6.376	5.391	6.349	6.333	6.018	6.379	7.208
+gp	7.032	7.509	8.331	9.903	8.854	9.267	9.337	6.255	6.42	6.881
SOPCO	1.0001	1	1	1.0001	1.0001	1.0003	0.9919	1.0002	0.9999	1.0004

Table 2 Catch weights at age (kg)

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE										
2	0.491	0.944	0.824	0.82	1.274	1.241	0.977	1.219	0.813	0.575
3	1.179	1.552	1.374	1.317	1.599	1.744	1.882	1.47	1.576	1.5
4	1.8	2.146	1.877	2.094	1.894	2.143	2.444	2.348	2.344	2.238
5	2.485	3.082	2.679	2.795	2.687	2.718	3.747	3.331	3.114	3.165
6	3.86	3.594	3.365	3.493	3.562	4.098	4.165	4.251	4	4.05
7	4.76	4.953	4.013	4.087	4.029	4.884	4.989	4.824	5.025	4.878
8	5.195	5.736	4.847	4.836	5.182	5.939	5.992	5.807	4.911	5.533
9	5.507	6.477	5.554	6.264	5.905	6.89	6.143	6.776	5.873	5.898
+gp	9.183	9.686	6.343	5.115	6.213	8.098	8.229	8.571	6.809	6.277
SOPCO	1.0181	1.0001	0.9997	1.0001	0.9999	0.9998	0.9999	1	0.9997	1

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

At 20/04/2012 17:06

Table 3 Stock weights at age (kg)

YEAR	1984	1985	1986	1987	1988	1989	1990	1991
AGE								
2	0.321	0.321	0.321	0.321	0.321	0.321	0.321	0.321
3	0.758	0.758	0.758	0.758	0.758	0.758	0.758	0.758
4	1.479	1.479	1.479	1.479	1.479	1.479	1.479	1.479
5	2.137	2.137	2.137	2.137	2.137	2.137	2.137	2.137
6	2.814	2.814	2.814	2.814	2.814	2.814	2.814	2.814
7	4.722	4.722	4.722	4.722	4.722	4.722	4.722	4.722
8	6.685	6.685	6.685	6.685	6.685	6.685	6.685	6.685
9	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98
+gp	9.723	9.723	9.723	9.723	9.723	9.723	9.723	9.723

Table 3 Stock weights at age (kg)

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
2	0.321	0.321	0.321	0.298	0.27	0.232	0.323	0.318	0.346	0.347
3	0.758	0.758	0.758	0.7	0.717	0.677	0.834	0.804	0.777	0.878
4	1.479	1.479	1.479	1.338	1.435	1.363	1.366	1.559	1.458	1.543
5	2.137	2.137	2.137	1.973	2.044	1.903	2.075	2.042	2.296	2.213
6	2.814	2.814	2.814	2.649	2.694	2.816	3.013	2.798	2.735	2.862
7	4.722	4.722	4.722	4.164	4.817	3.833	4.255	4.678	4.048	3.321
8	6.685	6.685	6.685	7.051	6.28	5.849	5.305	7.151	7.011	4.849
9	6.98	6.98	6.98	6.413	11.365	9.6	8.35	8.959	9.224	7.339
+gp	9.723	9.723	9.723	14.326	15.67	13.037	18.016	18.34	12.277	11.542

Table 3 Stock weights at age (kg)

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE										
2	0.43	0.308	0.339	0.407	0.49	0.518	0.508	0.434	0.419	0.343
3	0.88	0.686	0.834	0.846	1.125	1.185	1.208	1.116	1.026	1.062
4	1.698	1.299	1.614	1.748	1.812	2.011	2.095	2.003	1.996	2.119
5	2.452	2.149	2.269	2.2	2.559	2.5	2.987	2.894	2.839	2.882
6	3.538	3.135	3.29	2.693	3.579	3.16	3.671	3.632	3.665	3.761
7	4.397	4.048	4.124	3.817	3.964	4.241	3.976	4.875	4.868	5.505
8	4.191	5.008	4.718	3.797	4.822	6.806	4.387	5.4	4.895	6.336
9	7.046	5.789	4.976	5.344	7.332	11.051	5.415	6.125	5.685	6.309
+gp	15.619	10.069	6.358	14.829	14.65	14.931	11.558	4.719	6.504	6.57

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

Table 5 Proportion mature at age

YEAR	1984	1985	1986	1987	1988	1989	1990	1991
AGE								
2	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
4	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
6	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
8	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
+gp	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
2	0	0	0	0	0	0	0	0	0	0
3	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
4	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
5	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
6	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
7	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
8	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
9	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
+gp	1	1	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE										
2	0	0	0	0	0	0	0	0	0	0
3	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
4	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
5	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
6	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
7	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
8	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
9	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
+gp	1	1	1	1	1	1	1	1	1	1

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

```
Lowestoft VPA Version 3.1
   20/04/2012  17:03
 Extended Survivors Analysis
 Norwegian     COMBSE                                                       PLUSGROUP
Coastal Cod         X
 CPUE data from file coast-9.txt
 Catch data for  28 years. 1984 to 2011. Ages  2 to  10.
      Fleet              Last   First    Last   Alpha    Beta
                First
                         year     age     age
                 year
 Norw. Coast.    1995    2011       0       8    0.75    0.85
survey

 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  270 iterations
 Total absolute residual between iterations
269 and 270 =     .00190
```

Final year F values

Age	2	3	4	5	6	7	8	9
Iteration **	0.0017	0.0488	0.2253	0.3616	0.4738	0.888	0.5376	0.4572
Iteration **	0.0017	0.0488	0.2252	0.3614	0.4735	0.8874	0.5373	0.4568

Regression weights

	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2	0.012	0.005	0.001	0.001	0.006	0.006	0.007	0	0.001	0.002
3	0.058	0.086	0.024	0.037	0.027	0.051	0.057	0.022	0.06	0.049
4	0.191	0.187	0.096	0.134	0.175	0.162	0.196	0.119	0.204	0.225
5	0.32	0.324	0.23	0.278	0.26	0.301	0.289	0.269	0.325	0.361
6	0.54	0.435	0.415	0.308	0.452	0.312	0.337	0.427	0.366	0.474
7	0.543	0.577	0.59	0.486	0.481	0.414	0.369	0.551	0.4	0.887
8	0.694	0.419	0.548	0.429	0.615	0.27	0.407	0.422	0.437	0.537
9	0.456	0.423	0.275	0.322	0.537	0.505	0.233	0.275	0.265	0.457

XSA population numbers (Thousands)

	AGE							
YEAR	2	3	4	5	6	7	8	9
2002	18400	17600	14800	11400	7260	4060	2020	982
2003	17500	14900	13600	10000	6760	3470	1930	827
2004	17700	14300	11200	9210	5920	3580	1590	1040
2005	15900	14500	11400	8310	5990	3200	1630	754
2006	14100	13000	11400	8170	5150	3610	1610	867
2007	16500	11500	10300	7850	5160	2690	1830	714
2008	14900	13400	8910	7200	4750	3090	1450	1140
2009	16600	12100	10400	5990	4410	2780	1750	792
2010	17900	13500	9700	7560	3750	2360	1310	939
2011	19300	14700	10500	6480	4470	2130	1290	693

Estimated population abundance at 1st Jan 2012

0	15800	11400	6830	3700	2280	718	620

Taper weighted geometric mean of the VPA populations:

18600	15500	12400	8990	5760	3320	1760	931

Standard error of the weighted Log(VPA populations) :

0.2365	0.2614	0.278	0.302	0.3074	0.3418	0.3529	0.3607

Fleet : Norw. Coast. survey

Age	1995	1996	1997	1998	1999	2000	2001
2	0.04	-0.19	0.04	-0.01	0.1	0.21	0.08
3	0.19	0.16	0.11	0.03	-0.04	0.12	0.04
4	0.68	0.7	0.82	0.46	0.32	0.24	0.16
5	0.43	0.95	1.02	0.41	0.3	0.5	-0.02
6	0.06	0.06	1.42	0.2	0.18	0.61	-0.13
7	-0.04	-0.33	0.4	0.43	-0.17	0.11	0.08
8	-0.17	-0.51	0.04	-0.99	-0.26	0.01	-0.14

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2	-0.06	-0.13	0.04	-0.09	0.15	0.09	0.04	-0.09	-0.1	-0.08
3	-0.18	-0.07	-0.03	-0.06	0.11	0.24	-0.13	0	-0.1	-0.02
4	-0.15	-0.31	-0.08	-0.37	-0.17	0.3	-0.18	-0.07	-0.28	0.15
5	-0.22	-0.35	-0.35	-0.06	0.02	0.03	-0.33	0.02	-0.21	0.19
6	0.01	-0.09	-0.18	-0.41	0.25	0.11	-0.49	-0.07	-0.33	0.27
7	0.1	0.03	-0.37	0.01	0.37	0.39	-0.36	0.33	-0.55	-0.17
8	-0.2	-0.01	0.01	0.11	-0.06	0.18	-0.11	0.39	0.07	0.28

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	-0.636	-0.508	-0.446	-0.517	-0.684
S.E(Log q)	0.3012	0.3283	0.371	0.3223	0.2692

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	0.36	4.505	6.8	0.83	17	0.11	-1.47
3	0.44	3.913	5.88	0.83	17	0.12	-1.01

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	0.61	2.203	4.1	0.76	17	0.16	-0.64
5	0.71	1.223	3.02	0.64	17	0.23	-0.51
6	0.74	0.924	2.57	0.56	17	0.28	-0.45
7	0.85	0.566	1.62	0.6	17	0.28	-0.52
8	1.56	-1.635	-3.1	0.46	17	0.39	-0.68

Terminal year survivor and F summaries :

Age 2 Catchability dependent on age and year class strength

Year class = 2009

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	14614	0.3	0	0	1	0.415	0.002
P shrinkage mean	15460	0.26				0.548	0.002
F shrinkage mean	50939	1				0.037	0.001

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
15792	0.19	0.17	3	0.896	0.002

Age 3 Catchability dependent on age and year class strength

Year class = 2008

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	10787	0.212	0.04	0.19	2	0.603	0.052
P shrinkage mean	12412	0.28				0.369	0.045
F shrinkage mean	13696	1				0.029	0.041

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
11437	0.17	0.06	4	0.344	0.049

Age 4 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	6733	0.176	0.08	0.46	3	0.961	0.228
F shrinkage mean	9822	1				0.039	0.162

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
6833	0.17	0.08	4	0.446	0.225

Age 5 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	3661	0.157	0.096	0.61	4	0.96	0.364
F shrinkage mean	4621	1				0.04	0.299

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3695	0.16	0.09	5	0.544	0.361

Age 6 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	2258	0.148	0.086	0.58	5	0.953	0.477
F shrinkage mean	2814	1				0.047	0.399

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2281	0.15	0.08	6	0.523	0.474

Age 7 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	673	0.143	0.086	0.6	6	0.928	0.926
F shrinkage mean	1669	1				0.072	0.479

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
718	0.15	0.12	7	0.826	0.887

Age 8 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	611	0.142	0.132	0.93	7	0.948	0.543
F shrinkage mean	814	1				0.052	0.433

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
620	0.14	0.12	8	0.845	0.537

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

Year class = 2002

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
Norw. Coast. survey	368	0.146	0.087	0.59	7	0.922	0.448
F shrinkage mean	271	1				0.078	0.57

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
360	0.16	0.08	8	0.538	0.457

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

At 20/04/2012 17:06

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1984	1985	1986	1987	1988	1989	1990	1991
AGE								
2	0.0105	0.0059	0.1359	0.0051	0.003	0.001	0.0002	0.0023
3	0.0744	0.1298	0.0776	0.0417	0.0736	0.04	0.0109	0.0193
4	0.2169	0.223	0.3191	0.2208	0.2043	0.0722	0.0544	0.0573
5	0.3337	0.4622	0.4601	0.599	0.2697	0.2112	0.0886	0.1895
6	0.6283	0.6367	0.6431	0.4381	0.7638	0.3634	0.1521	0.1735
7	1.3096	0.7883	0.9004	0.7088	1.2408	0.8553	0.4399	0.262
8	1.0724	0.6333	0.9339	0.7335	1.1871	0.9365	0.6336	0.1869
9	0.8447	0.6358	0.7416	0.6254	0.8746	0.5967	0.3305	0.2039
+gp	0.8447	0.6358	0.7416	0.6254	0.8746	0.5967	0.3305	0.2039
F 4- 7	0.6221	0.5275	0.5807	0.4917	0.6197	0.3755	0.1838	0.1706

Table 8 Fishing mortality (F) at age

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
2	0.0009	0.0001	0.0146	0.0271	0.0336	0.0458	0.0202	0.011	0.0075	0.0023
3	0.015	0.0102	0.026	0.0497	0.1035	0.128	0.1297	0.0614	0.0537	0.0304
4	0.1326	0.0486	0.0589	0.1412	0.189	0.1944	0.2642	0.1517	0.2411	0.1364
5	0.2475	0.1375	0.1665	0.2577	0.4935	0.2631	0.4074	0.3989	0.3927	0.3152
6	0.2808	0.2334	0.2101	0.3357	0.3879	0.5003	0.4619	0.5507	0.4702	0.3686
7	0.2749	0.5219	0.5096	0.4756	0.4549	0.6737	0.6779	0.7045	0.4418	0.489
8	0.2921	0.4647	0.5318	0.4369	0.6418	0.8214	0.7874	0.8565	0.2934	0.4052
9	0.2753	0.3415	0.3568	0.379	0.5327	0.7057	0.6125	0.9676	0.3437	0.2729
+gp	0.2753	0.3415	0.3568	0.379	0.5327	0.7057	0.6125	0.9676	0.3437	0.2729
F 4- 7	0.234	0.2353	0.2363	0.3026	0.3814	0.4079	0.4529	0.4515	0.3865	0.3273

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Table 8 Fishing mortality (F) at age

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE										
2	0.0116	0.0051	0.0008	0.001	0.0056	0.0059	0.0069	0.0002	0.0009	0.0017
3	0.0578	0.0858	0.024	0.0369	0.0272	0.051	0.0567	0.022	0.0597	0.0488
4	0.1913	0.187	0.0958	0.1344	0.1747	0.1617	0.1965	0.1187	0.2037	0.2252
5	0.3204	0.3241	0.23	0.2784	0.2604	0.3011	0.289	0.2692	0.3246	0.3614
6	0.5399	0.4351	0.4148	0.3076	0.4518	0.3125	0.3374	0.4269	0.3661	0.4735
7	0.5431	0.5765	0.5896	0.4856	0.4807	0.4142	0.3688	0.5511	0.3996	0.8874
8	0.6937	0.4195	0.5485	0.4286	0.6153	0.2699	0.4074	0.4223	0.4371	0.5373
9	0.4555	0.4227	0.2752	0.3222	0.5367	0.5045	0.2333	0.2746	0.2655	0.4568
+gp	0.4555	0.4227	0.2752	0.3222	0.5367	0.5045	0.2333	0.2746	0.2655	0.4568
F 4- 7	0.3987	0.3807	0.3326	0.3015	0.3419	0.2973	0.2979	0.3415	0.3235	0.4869

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

At 20/04/2012 17:06

Terminal Fs derived using XSA (With F shrinkage)

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

YEAR	1984	1985	1986	1987	1988	1989	1990	1991
AGE								
2	87929	74490	35618	36744	40047	43525	42776	60343
3	53604	71240	60629	25456	29930	32688	35598	35016
4	39414	40740	51225	45933	19991	22766	25714	28829
5	28351	25977	26689	30483	30155	13343	17342	19937
6	14224	16626	13397	13793	13710	18852	8844	12995
7	7515	6213	7202	5766	7287	5229	10732	6219
8	3631	1661	2312	2396	2324	1725	1820	5659
9	1587	1017	722	744	942	580	554	791
+gp	1191	613	847	350	621	209	285	560
TOTAL	237444	238577	198641	161665	145006	138917	143664	170350

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
2	49327	30130	25318	33504	39948	32744	30592	25347	22928	21496
3	49292	40349	24665	20428	26698	31628	25609	24545	20524	18630
4	28119	39755	32701	19675	15914	19708	22784	18416	18900	15925
5	22290	20163	31005	25242	13987	10786	13286	14323	12955	12158
6	13505	14248	14388	21492	15972	6991	6787	7237	7869	7162
7	8945	8350	9237	9548	12578	8872	3471	3501	3416	4026
8	3918	5563	4057	4543	4858	6534	3703	1443	1417	1798
9	3844	2395	2862	1951	2403	2094	2353	1380	502	865
+gp	1273	2617	2917	1505	1438	1473	818	561	573	547
TOTAL	180513	163571	147149	137889	133797	120830	109402	96752	89084	82608

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
AGE											
2	18380	17533	17683	15861	14066	16503	14888	16553	17927	19318	0
3	17560	14874	14281	14466	12972	11452	13432	12106	13549	14665	15792
4	14796	13569	11177	11416	11415	10336	8910	10391	9696	10451	11437
5	11376	10005	9214	8315	8171	7848	7199	5994	7555	6475	6833
6	7264	6761	5924	5994	5153	5156	4755	4415	3749	4471	3695
7	4056	3466	3582	3203	3608	2685	3089	2778	2359	2129	2281
8	2021	1929	1594	1626	1614	1827	1453	1749	1311	1295	718
9	982	827	1038	754	867	714	1142	792	939	693	620
+gp	1128	315	1205	570	590	541	898	1262	825	941	847
TOTAL	77563	69278	65699	62205	58457	57062	55765	56038	57910	60438	42224

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

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Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 2	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	F 4- 7
1984	87929	310169	140794	74824	0.5314	0.6221
1985	74490	293960	116938	75451	0.6452	0.5275
1986	35618	290626	122015	68905	0.5647	0.5807
1987	36744	254821	114653	60972	0.5318	0.4917
1988	40047	230688	117872	59294	0.503	0.6197
1989	43525	196290	93501	40285	0.4309	0.3755
1990	42776	210167	102482	28127	0.2745	0.1838
1991	60343	245893	122908	24822	0.202	0.1706
1992	49327	288061	154252	41690	0.2703	0.234
1993	30130	301019	167146	52557	0.3144	0.2353
1994	25318	301007	176691	54562	0.3088	0.2363
1995	33504	263209	164003	57207	0.3488	0.3026
1996	39948	265321	176101	61776	0.3508	0.3814
1997	32744	207613	130618	63319	0.4848	0.4079
1998	30592	179174	96519	51572	0.5343	0.4529
1999	25347	155338	78198	40732	0.5209	0.4515
2000	22928	138132	65812	36715	0.5579	0.3865
2001	21496	130549	62758	29699	0.4732	0.3273
2002	18380	152919	82381	40994	0.4976	0.3987
2003	17533	107571	56300	34635	0.6152	0.3807
2004	17683	111467	58511	24547	0.4195	0.3326
2005	15861	103964	51565	22432	0.435	0.3015
2006	14066	118608	60216	26134	0.434	0.3419
2007	16503	118611	60743	23841	0.3925	0.2973
2008	14888	116627	58043	25777	0.4441	0.2979
2009	16553	108678	53630	24821	0.4628	0.3415
2010	17927	104553	49036	22925	0.4675	0.3235
2011	19318	110299	52081	28594	0.549	0.4869
Arith.						
Mean	32197	193405	99492	42757	0.4488	0.3746

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

	av. survey Z ages 4-9	com. Catch F(4-7)	all catch F(4-7)
1996	0.881	0.386	0.362
1997	0.850	0.383	0.360
1998	1.604	0.453	0.415
1999	1.018	0.399	0.372
2000	0.538	0.354	0.337
2001	0.912	0.389	0.364
2002	1.084	0.405	0.377
2003	0.482	0.349	0.333
2004	0.725	0.372	0.350
2005	0.355	0.337	0.323
2006	0.324	0.335	0.321
2007	0.386	0.340	0.325
2008	0.925	0.390	0.365
2009	-0.030	0.302	0.295
2010	0.776	0.377	0.354
2011	0.229	0.326	0.314

Table 2.17. Norwegian Coastal Cod. Stock summary for SVPA based on commercial catch at age and survey derived F in 2011.

At 21/04/2012 10:46

Table 16 Summary (without SOP correction)

Traditional vpa using file input for terminal F

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 4-7
	Age 2					
1984	87047	306263	138836	74824	0.5389	0.6215
1985	74019	290571	115463	75451	0.6535	0.5288
1986	35417	287331	120431	68905	0.5722	0.5818
1987	36511	252051	113151	60972	0.5389	0.4935
1988	39746	228275	116362	59294	0.5096	0.6181
1989	43181	194708	92669	40285	0.4347	0.3746
1990	42406	208640	101775	28127	0.2764	0.1837
1991	59789	244082	122102	24822	0.2033	0.171
1992	48820	285781	153162	41690	0.2722	0.2346
1993	29838	298487	165890	52557	0.3168	0.2357
1994	25123	298373	175277	54562	0.3113	0.2369
1995	33242	260743	162514	57207	0.352	0.3038
1996	39634	262670	174309	61776	0.3544	0.3826
1997	32515	205489	129194	63319	0.4901	0.4089
1998	30348	177500	95559	51572	0.5397	0.4531
1999	25142	153926	77442	40732	0.526	0.4507
2000	22744	137028	65317	36715	0.5621	0.3867
2001	21364	129493	62264	29699	0.477	0.3278
2002	18255	151745	81775	40994	0.5013	0.3986
2003	17421	106707	55828	34635	0.6204	0.3808
2004	18946	111107	58069	24547	0.4227	0.3327
2005	16922	104675	51228	22432	0.4379	0.3018
2006	16551	121797	60086	26134	0.4349	0.338
2007	18896	125097	61535	23841	0.3874	0.2867
2008	18102	127856	60789	25777	0.424	0.2713
2009	22790	125557	59227	24821	0.4191	0.2819
2010	23511	128266	57921	22925	0.3958	0.2558
2011	41391	153253	70291	28594	0.4068	0.3257
Arith.						
Mean	33560	195624	99945	42757	0.4421	0.3631
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 2.18. Norwegian Coastal Cod. Stock summary for SVPA based on total catch at age and survey derived F in 2011.

At 21/04/2012 18:21

Table 16 Summary (without SOP correction)

Traditional vpa using file input for terminal F

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 4-7
	Age 2					
1984	108559	358570	158827	88124	0.5548	0.6161
1985	98262	344652	132554	88851	0.6703	0.5248
1986	61959	348806	139241	82405	0.5918	0.5887
1987	48405	314607	131985	74472	0.5642	0.5059
1988	53880	292144	138797	72894	0.5252	0.6281
1989	61559	258892	117976	53985	0.4576	0.3778
1990	60240	277739	131473	42627	0.3242	0.2343
1991	79277	321685	157905	40122	0.2541	0.1967
1992	66679	366315	192896	57790	0.2996	0.2531
1993	38806	375634	204243	67357	0.3298	0.2402
1994	33463	370871	212113	69262	0.3265	0.2492
1995	44349	325454	199055	71907	0.3612	0.3116
1996	58894	329582	212718	76276	0.3586	0.3717
1997	47524	263521	157275	77819	0.4948	0.4071
1998	43029	240922	121885	66172	0.5429	0.4159
1999	36848	219155	106567	54632	0.5127	0.4067
2000	34182	202483	96886	50315	0.5193	0.347
2001	32678	193509	93373	43099	0.4616	0.3075
2002	27884	221391	116029	54594	0.4705	0.3559
2003	26467	166359	88224	48535	0.5501	0.3262
2004	29458	171943	89206	37947	0.4254	0.3337
2005	26353	159656	77006	35632	0.4627	0.3028
2006	25288	183466	88066	39134	0.4444	0.3293
2007	28369	190205	92551	36841	0.3981	0.2891
2008	26967	190495	88495	38577	0.4359	0.2641
2009	34052	188152	88129	37521	0.4257	0.2891
2010	35735	193933	88368	35625	0.4031	0.2637
2011	67799	232208	105968	41294	0.3897	0.3139
Arith.						
Mean	47749	260798	129565	56565	0.4484	0.3589
0						
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

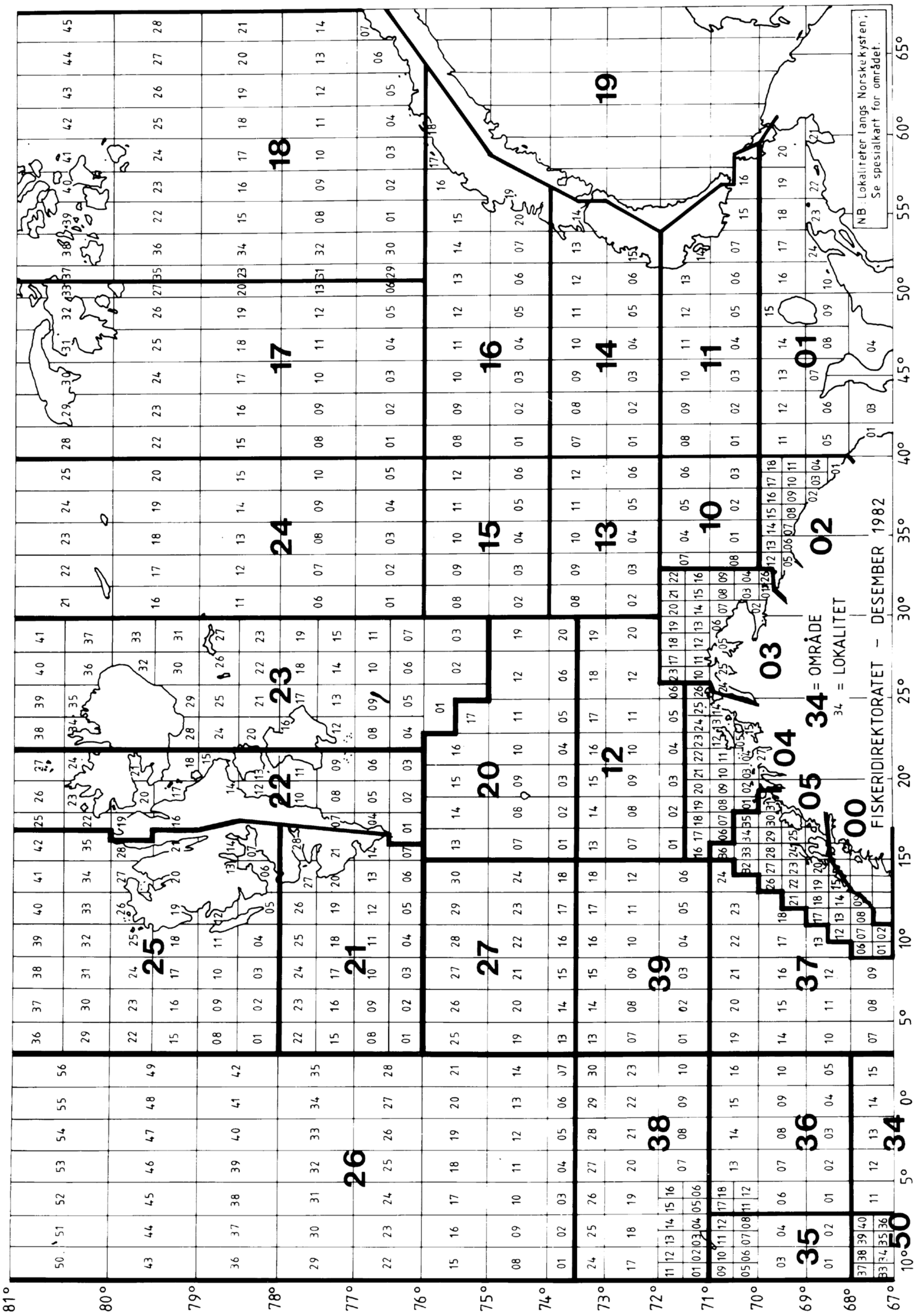


Figure 2.1. Norwegian statistical rectangles in the Barents Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 03 and 04. The same areas are also referred to in the survey results (sec. 2.3).

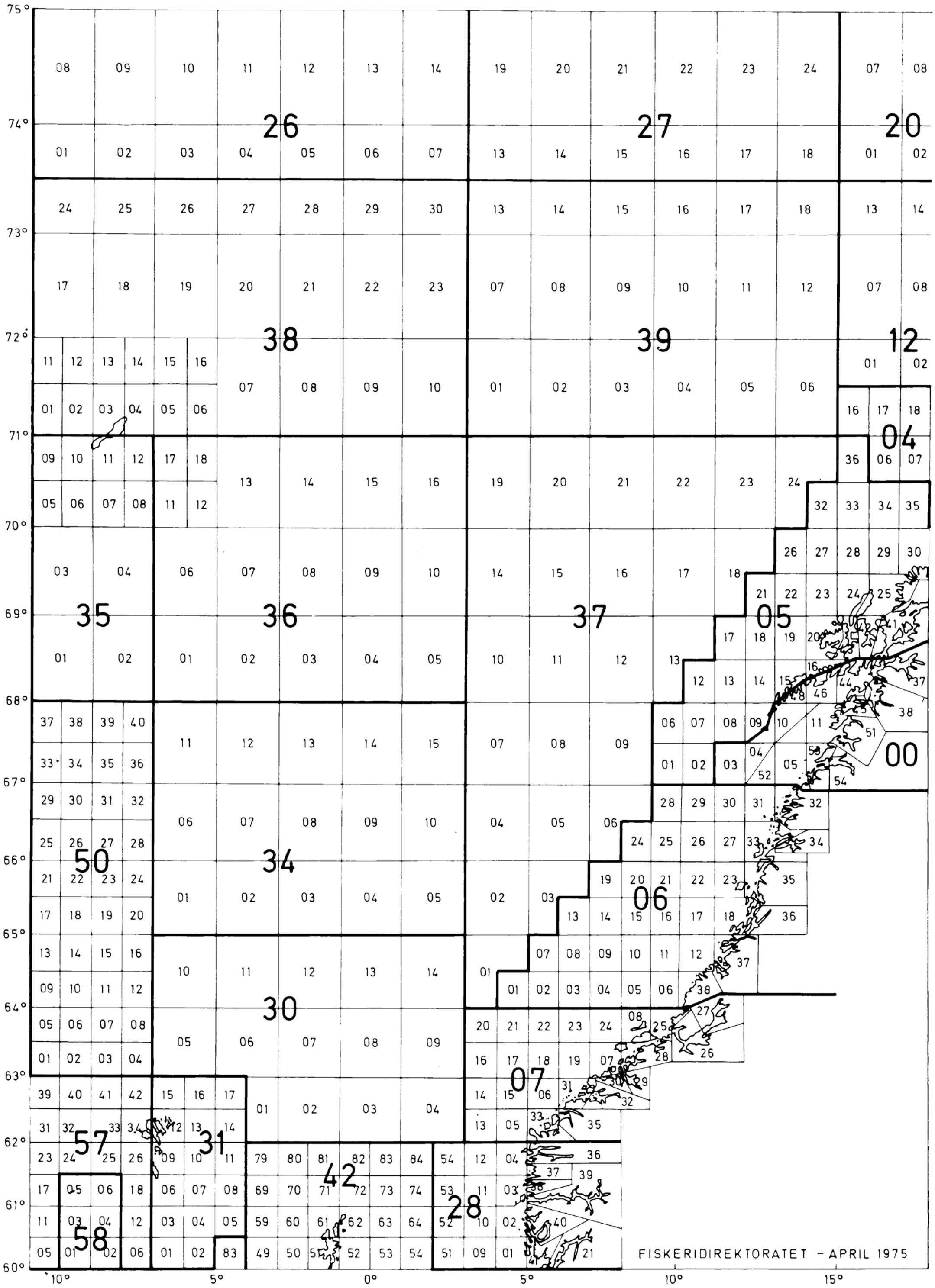


Figure 2.2. Norwegian statistical rectangles in the Norwegian Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 05, 00, 06 and 07. The same areas are also referred to in the survey results (sec. 2.3).

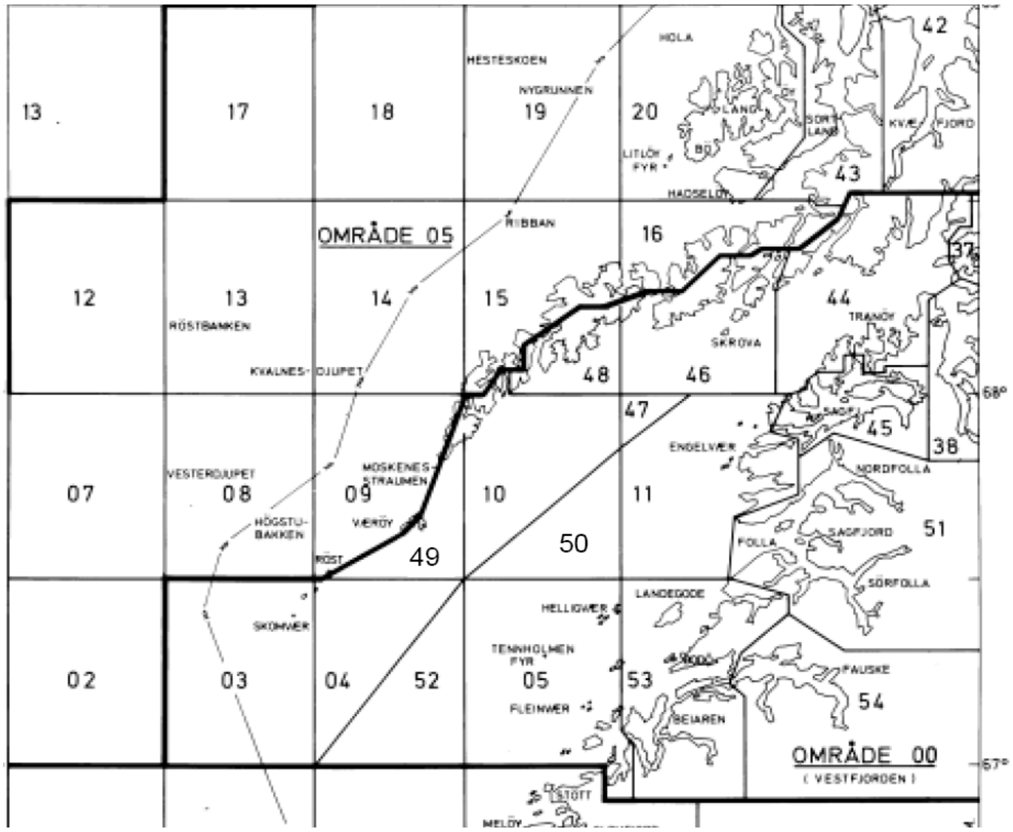


Figure 2.3. Map showing Vestfjorden, the Norwegian statistical area 00 ("OMRÅDE 00") with the south-western location 03 and 04 and the north-eastern locations 46 and 48.

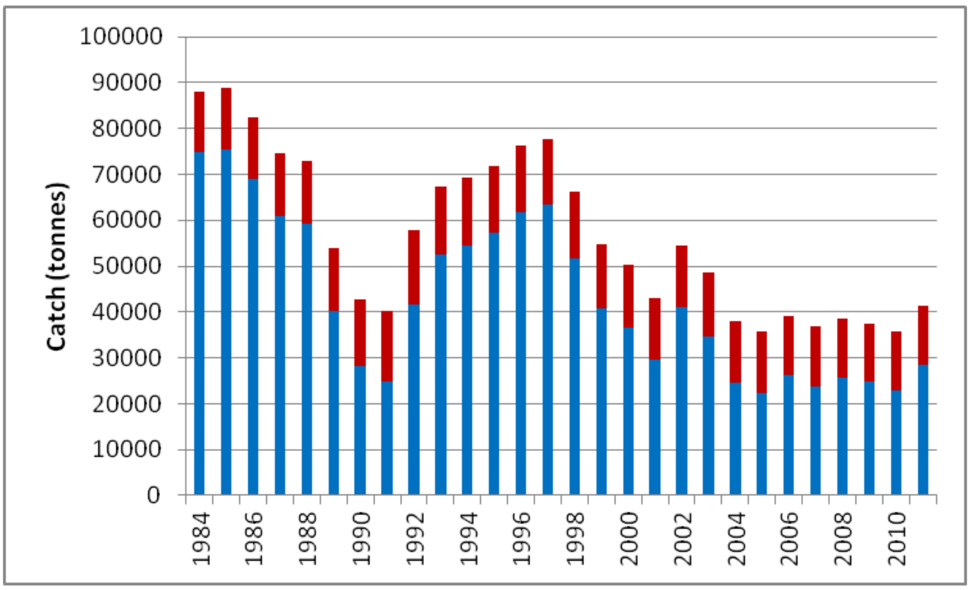


Figure 2.4. Estimated catch of Norwegian coastal cod. Commercial catch in blue and recreational catches in red.

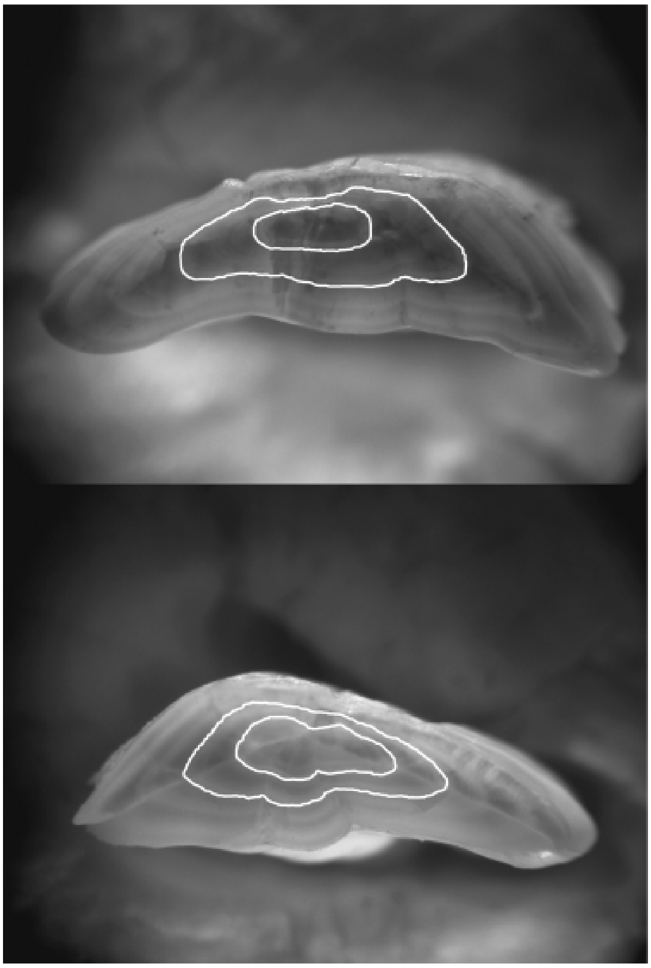


Figure 2.5. An image of a coastal cod otolith (top) and a north-east Arctic cod otolith (bottom). The two first translucent zones are highlighted. (from Berg *et al*. 2005)

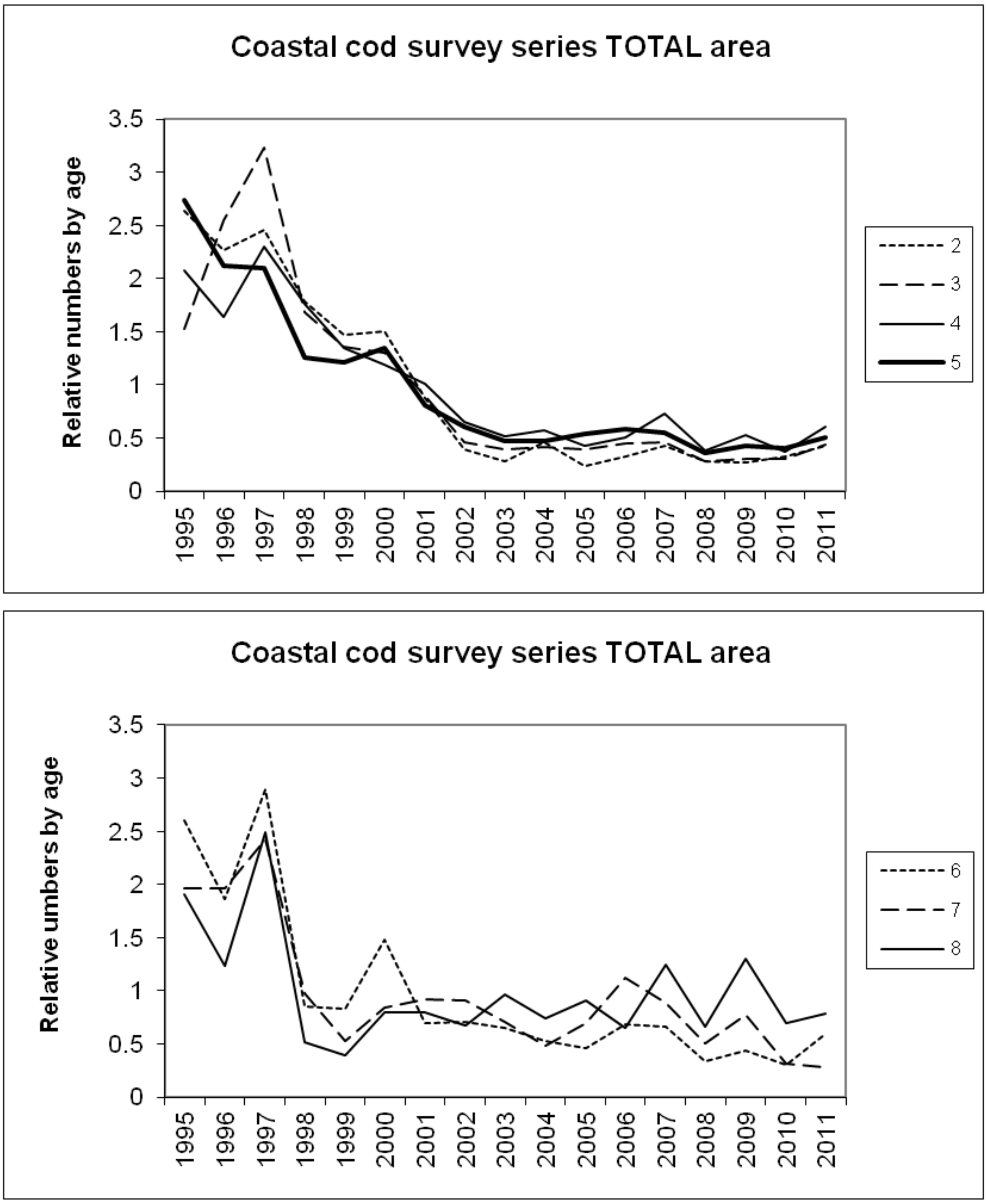
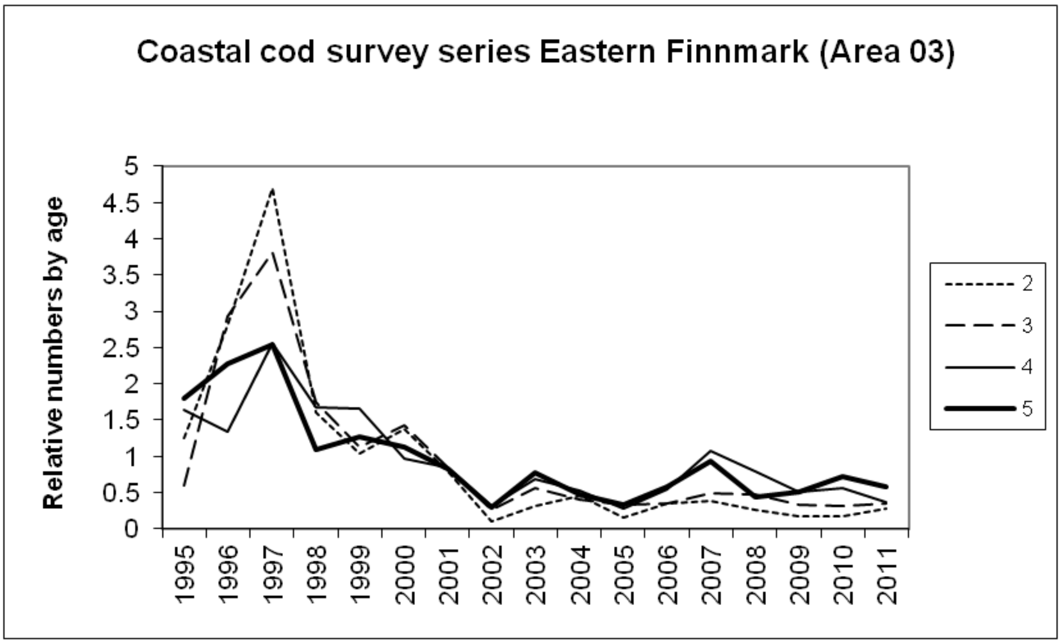


Figure 2.6. Coastal cod survey. Abundance at age relative to time series average in total survey.

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



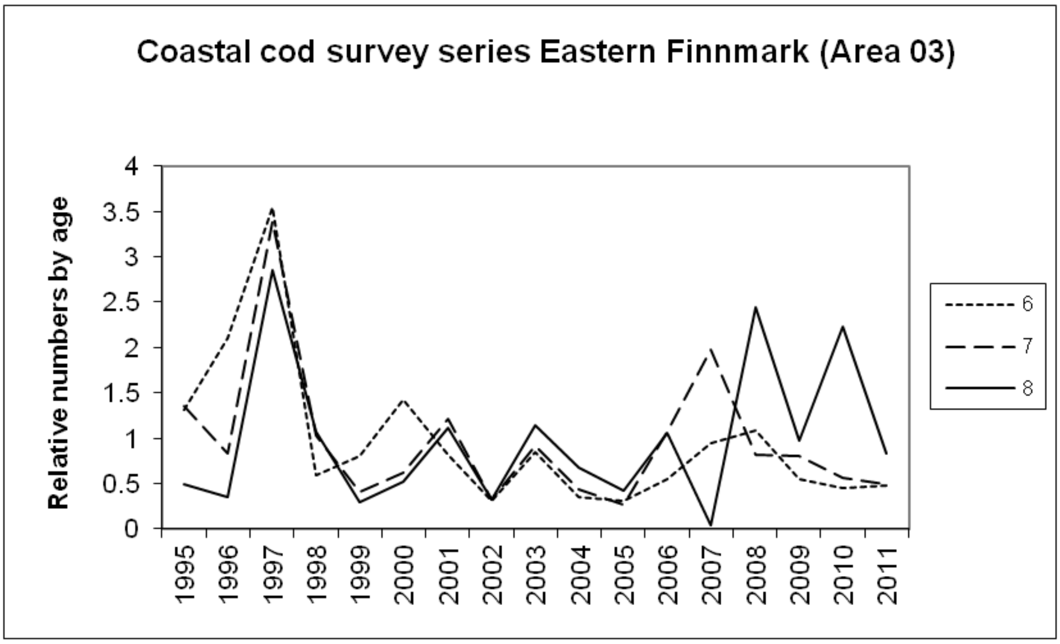
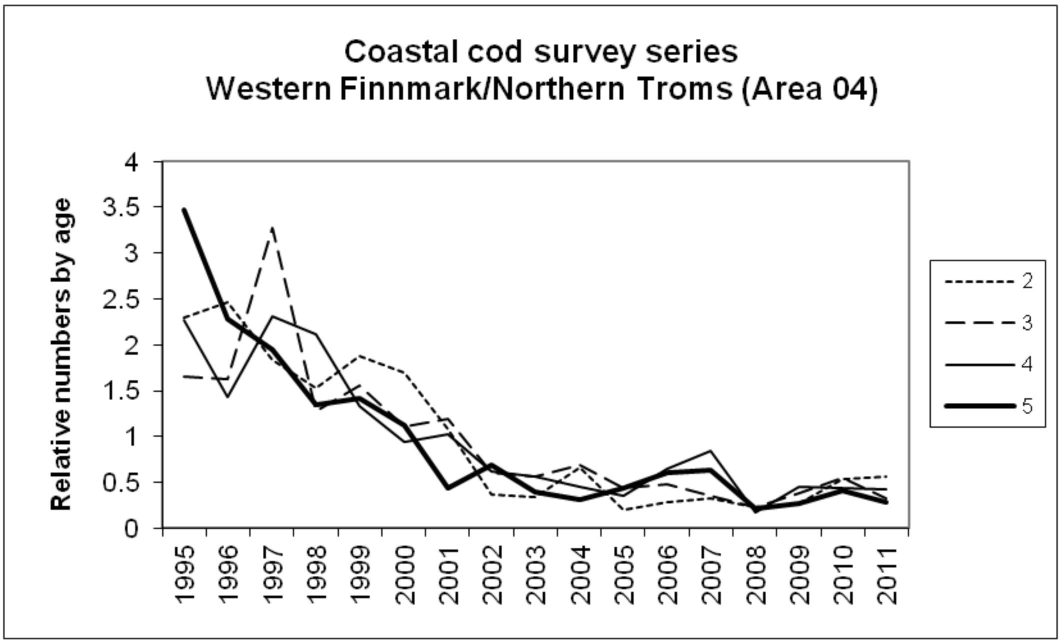


Figure 2.7. Coastal cod survey. Abundance at age relative to time series average in statistical area 03.

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



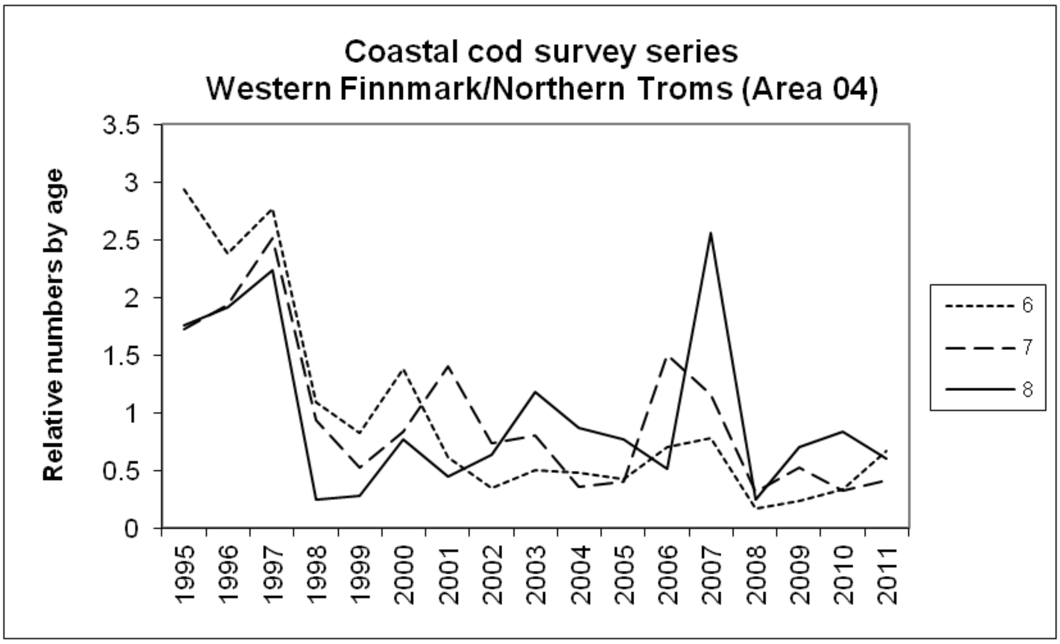
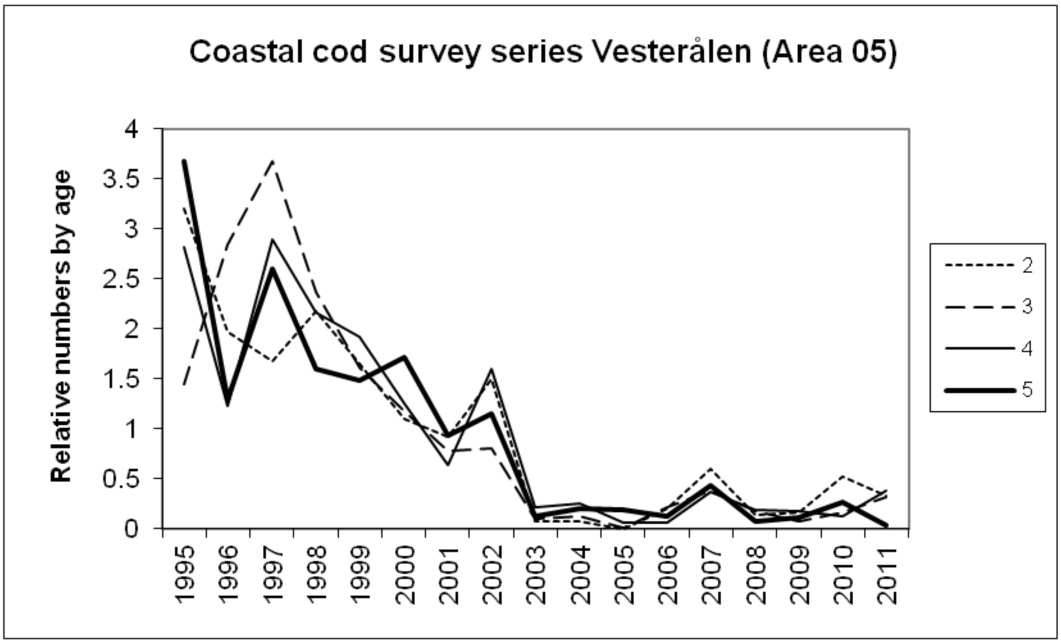


Figure 2.8. Coastal cod survey. Abundance at age relative to time series average in statistical area 04.

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



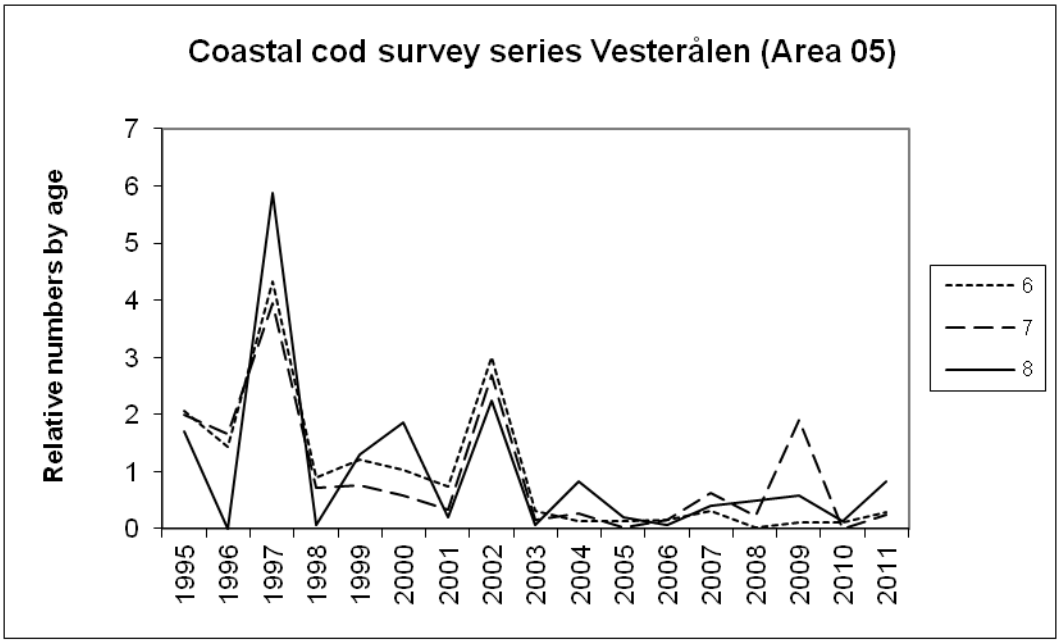
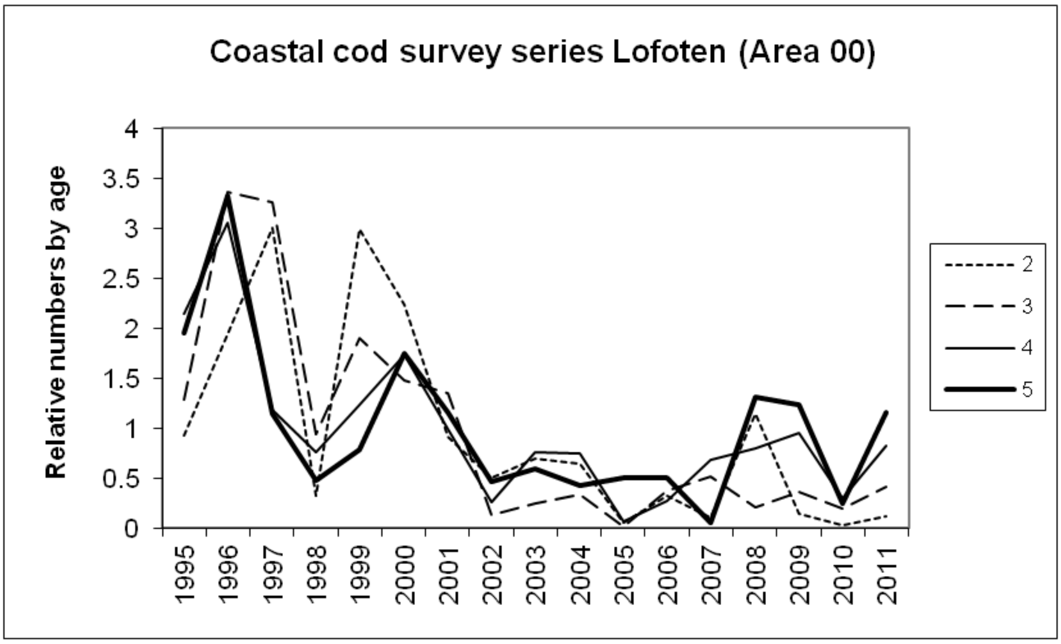


Figure 2.9. Coastal cod survey. Abundance at age relative to time series average in statistical area 05.

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



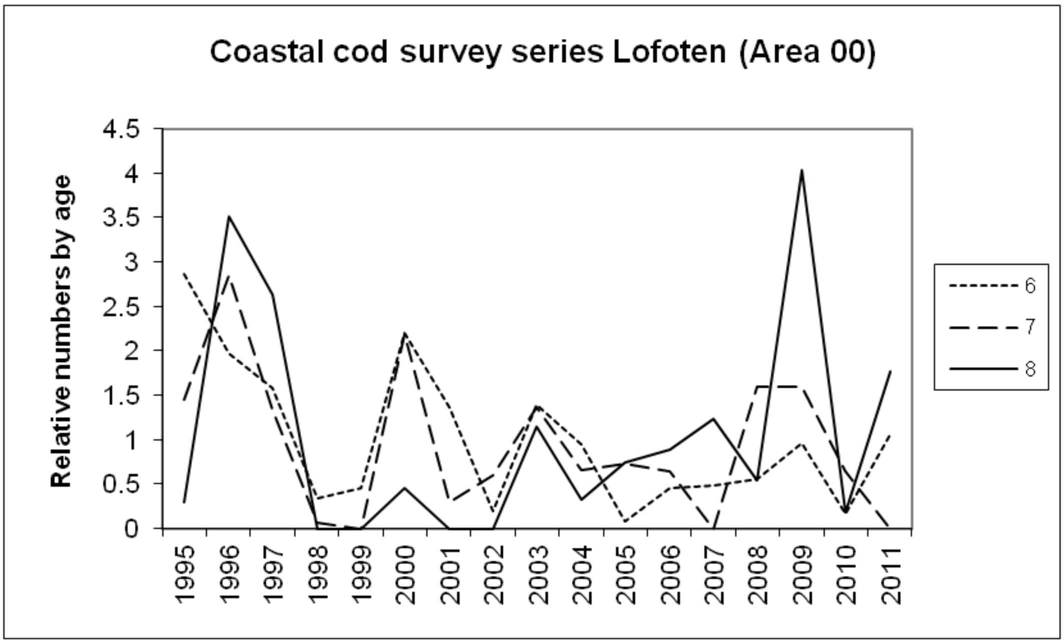
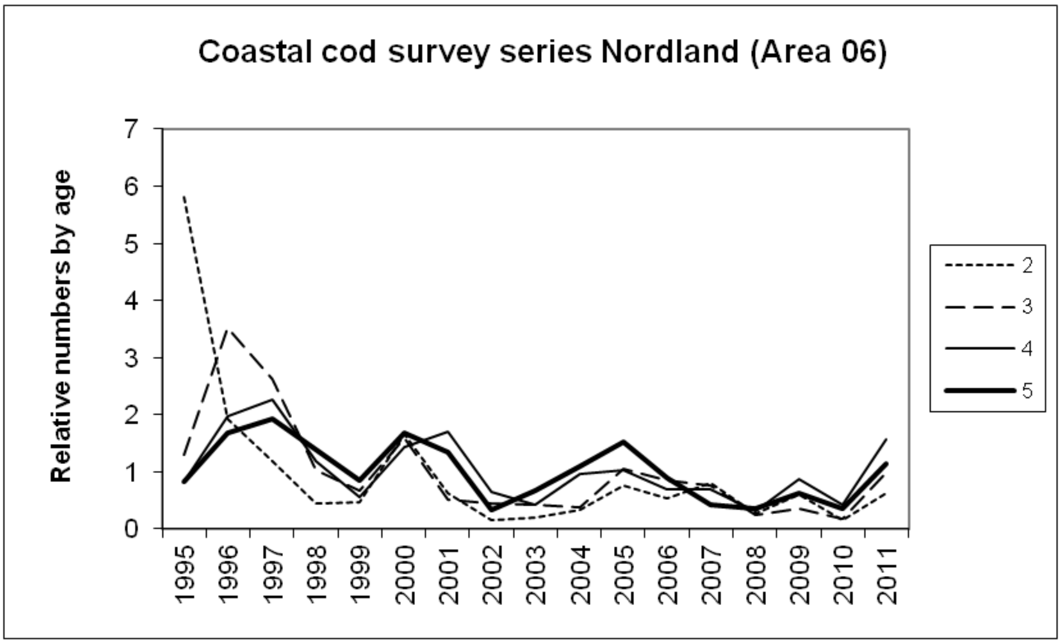


Figure 2.10. Coastal cod survey. Abundance at age relative to time series average in statistical area 00.

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



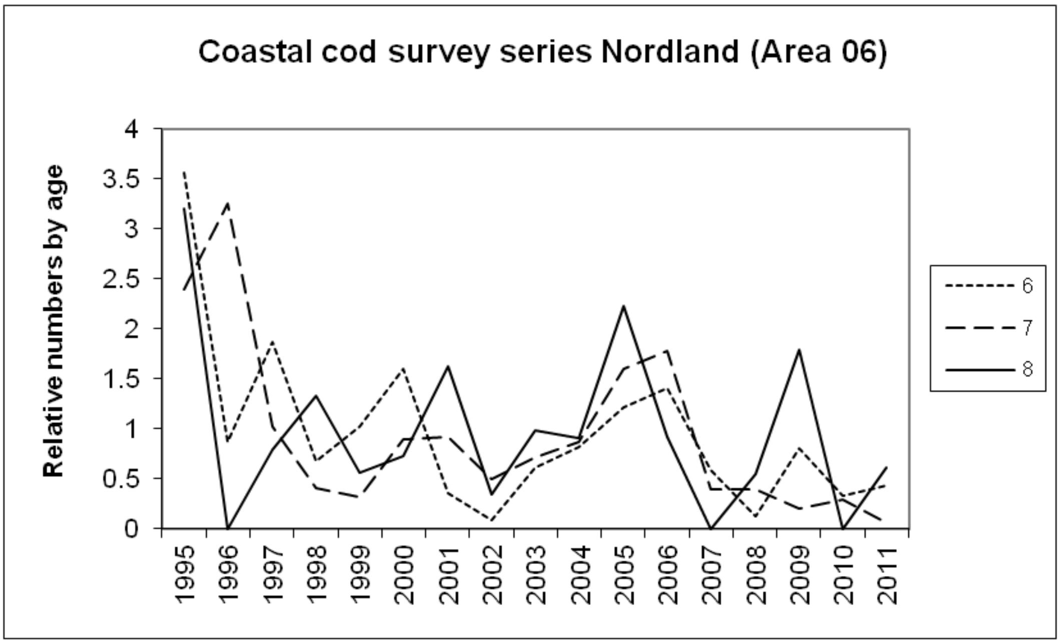
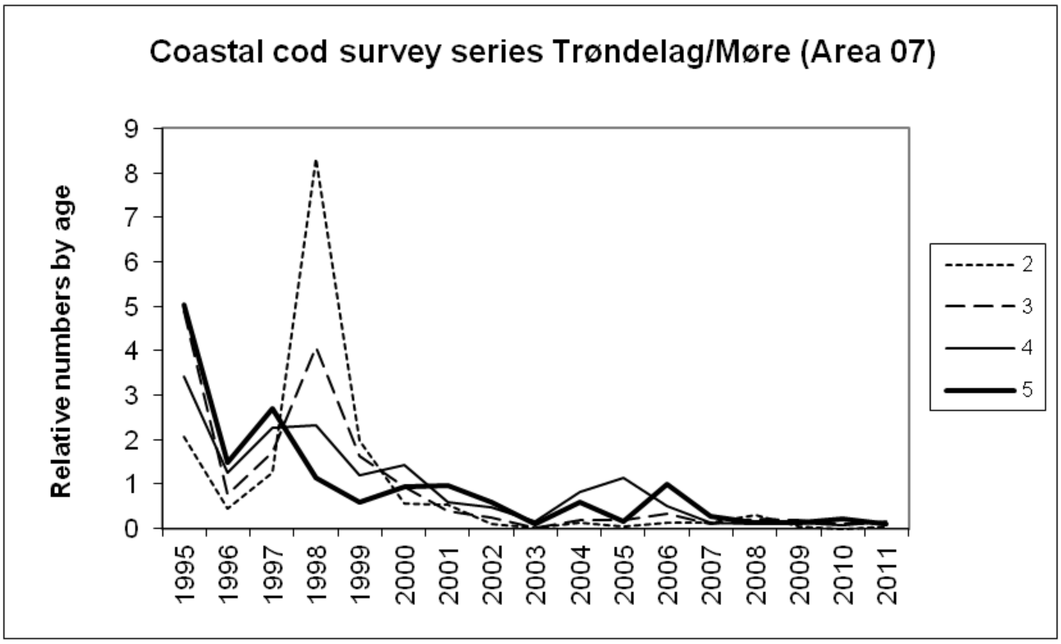


Figure 2.11 Coastal cod survey. Abundance at age relative to time series average in statistical area 06.

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



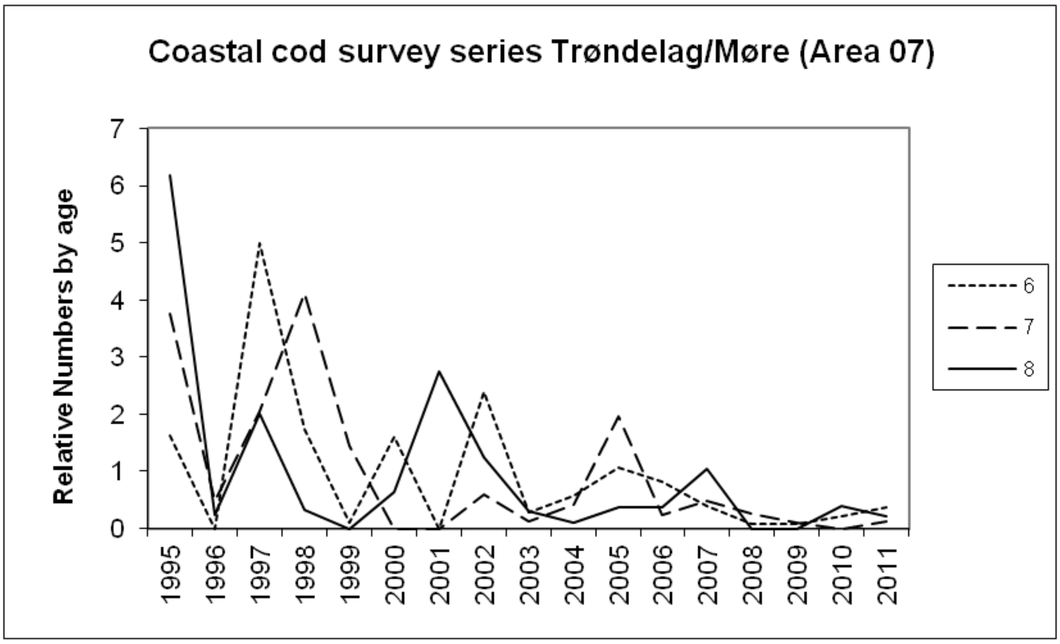


Figure 2.12. Coastal cod survey. Abundance at age relative to time series average in statistical area 07.

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

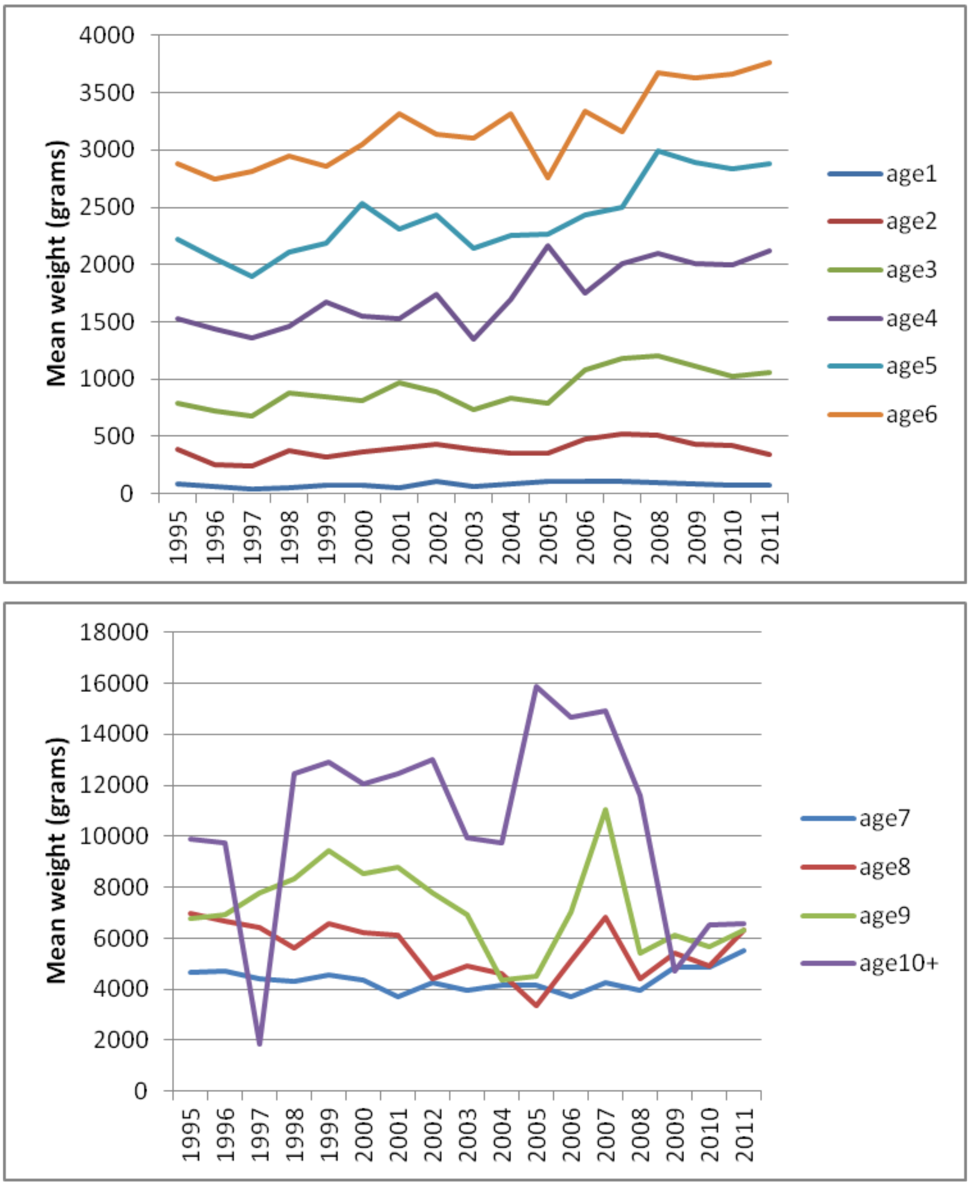


Figure 2.13a. Mean weights at age in the coastal survey

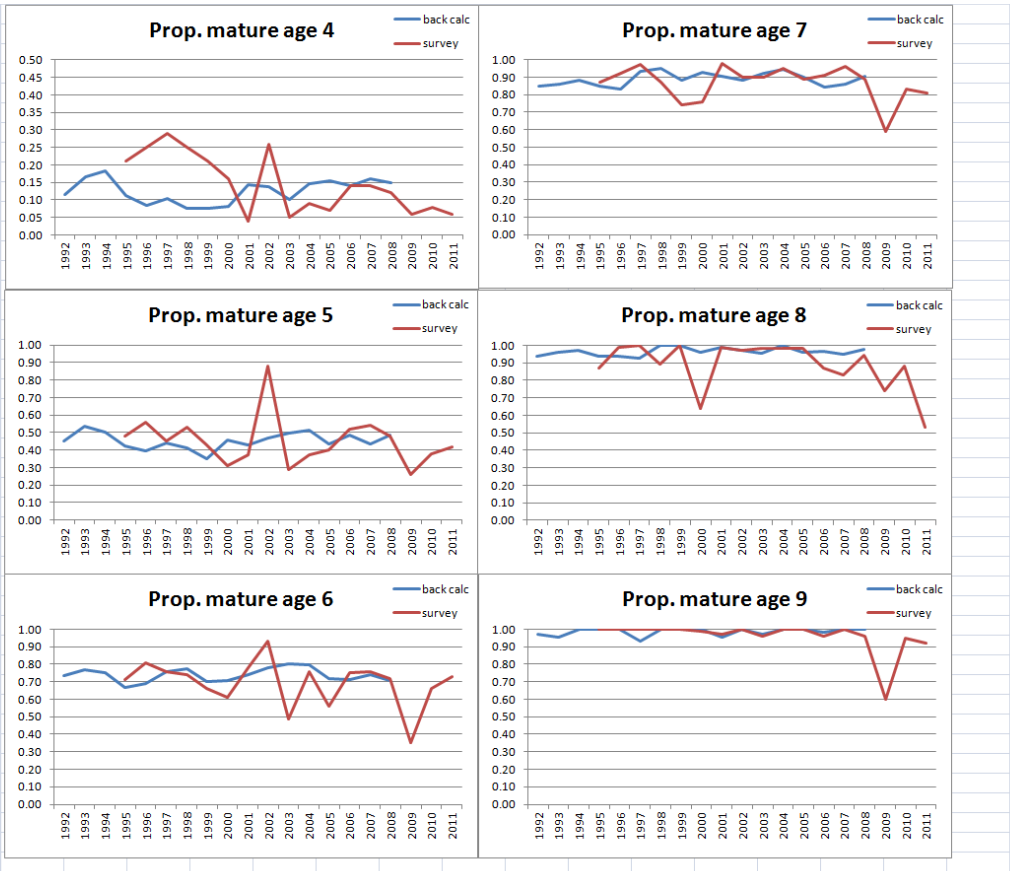


Figure 2.13b. Proportions mature at age as observed in the surveys (red), and as estimated by back-calculation from spawning zones recorded from otoliths (blue).

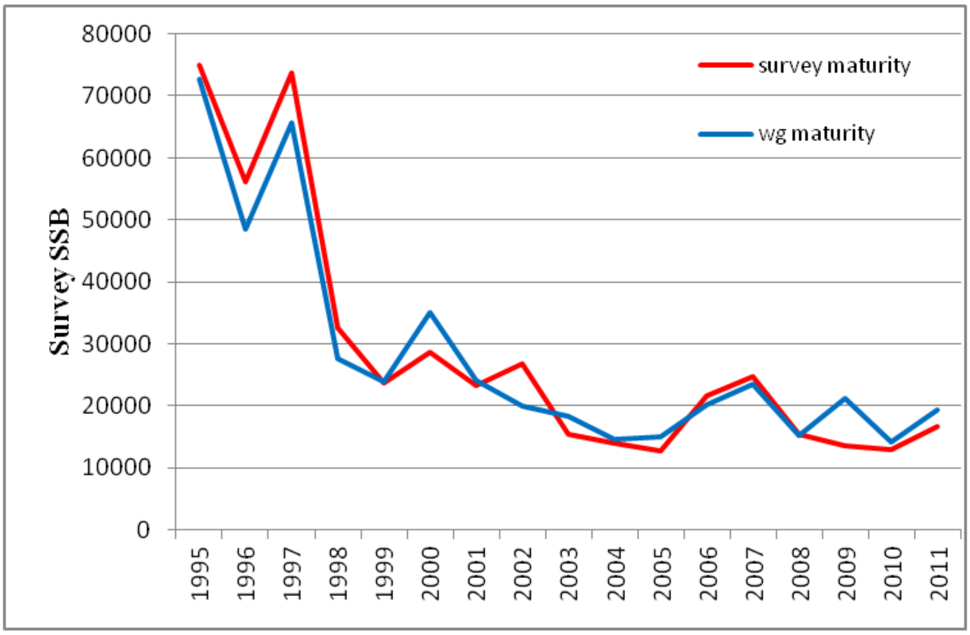


Figure 2.14. Survey SSB calculated by maturity observed in the surveys (red) and by maturity used in the VPA.

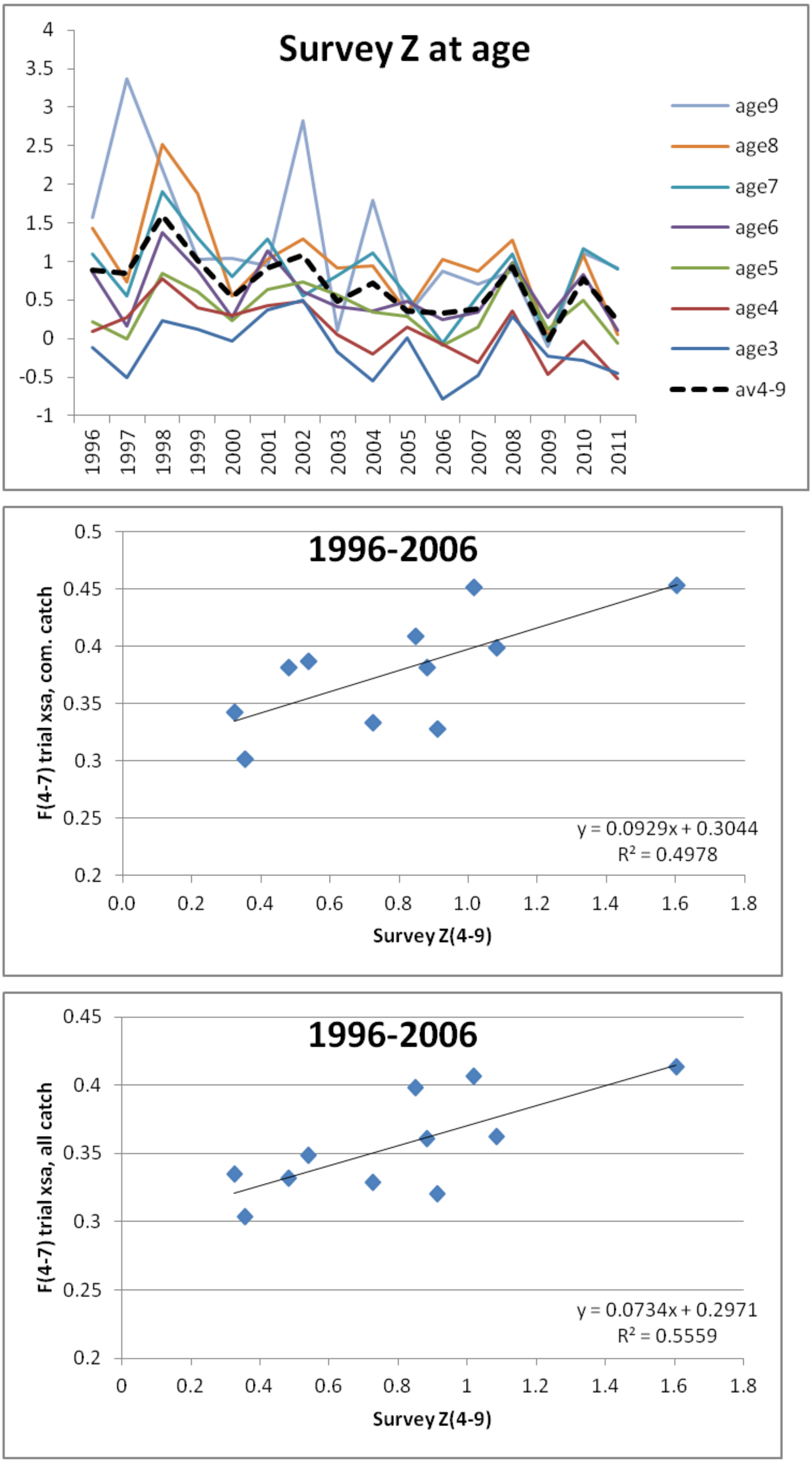


Figure 2.15. Survey mortality Z (upper) and relation to VPA values of F(4-7) over the period 1996-2006 for a trial XSA based on commercial catch (middle) and a trial XSA based on all catch (bottom).

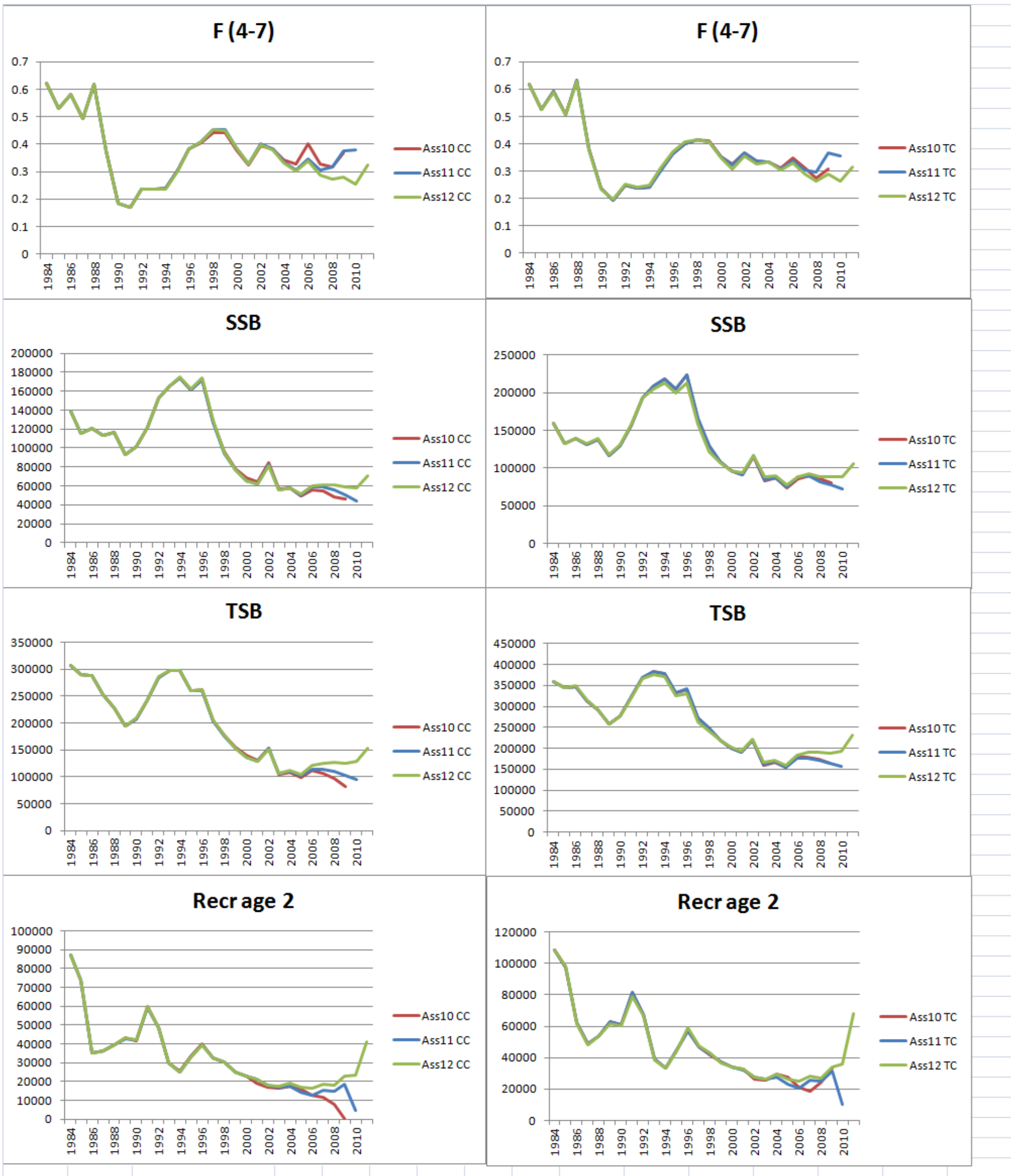


Figure 2.16. Comparisons of SVPA outputs in current assessment (Ass12) with the assessments in 2011 (Ass11) and 2010 (Ass10) for analyses based on commercial catch (left) and total catch (right).

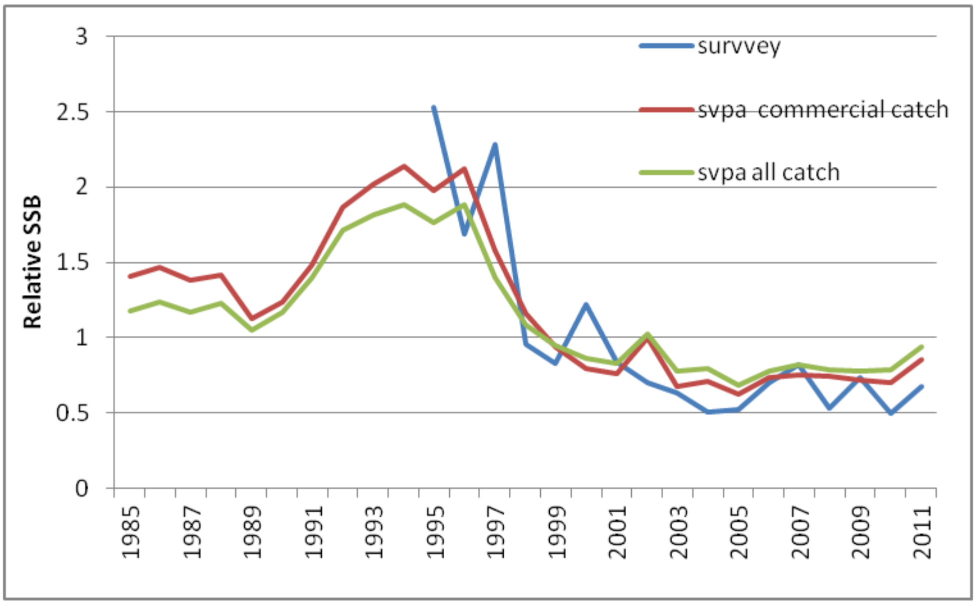


Figure 2.17. Coastal cod. Trends in spawning biomass. Each series are shown relative to its 1995-2010 average. The survey SSB is calculated with the same maturity ogive as in the VPA.

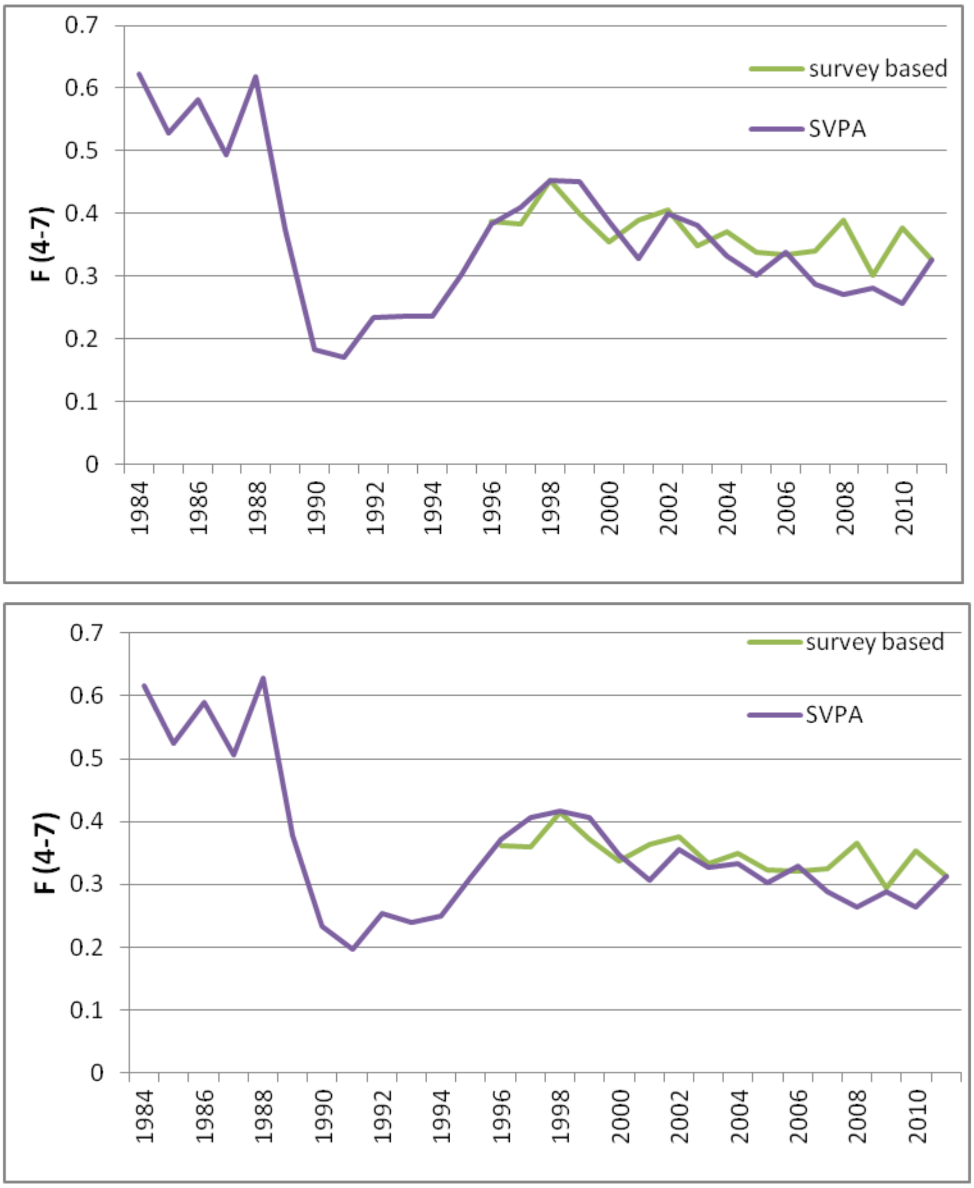


Figure 2.18. Time series of F-estimates corresponding to commercial catch at age (upper) and total catch at age (lower). SVPA is in both cases a traditional vpa using the 2011 estimate of survey F as terminal F.

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

3.1 Status of the fisheries

3.1.1 Historical development of the fisheries (Table 3.1a)

From a level of about 900,000 t in the mid-1970s, total catch declined steadily to around 300,000 t in 1983-1985 (Table 3.1a). Catches increased to above 500,000 t in 1987 before dropping to 212,000 t in 1990, the lowest level recorded in the post-war period. The catches increased rapidly from 1991 onwards, stabilized around 750,000 t in 1994-1997 but decreased to about 414,000 t in 2000. From 2000-2009, the reported catches were between 400,000 and 520,000 t, in addition there were unreported catches (see below). Catches have increased in the last couple of years, reaching 720,000 t in 2011. The fishery is conducted both with an international trawler fleet and with coastal vessels using traditional fishing gears. Quotas were introduced in 1978 for the trawler fleets and in 1989 for the coastal fleets. In addition to quotas, the fishery is regulated by a minimum catch size, a minimum mesh size in trawls and Danish seines, a maximum by-catch of undersized fish, closure of areas having high densities of juveniles and by seasonal and area restrictions.

3.1.2 Reported catches prior to 2012 (Tables 3.1–3.3, Figure 3.1)

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

Final official catch for 2010 amounts to 626,252 t. The provisional catch for 2011 reported to the working group is 726,562 t.

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

The historical practice (considering catches between 62ºN and 67ºN for the whole year and catches between 67ºN and 69ºN for the second half of the year to be Norwegian coastal cod) leads to reported landings of North-East Arctic cod of 609,983 t in 2010 and 719,829 t in 2011 (Table 3.1a). The coastal cod catches calculated this way in 2010 and 2011 were 16,269 t and 6,733 t, respectively (Table 3.1b). The catches of coastal cod calculated this way for the period 1960-2011 are given in Table 3.1b together with the coastal cod catches calculated based on otolith types as described in Section 2.

The catch by area, are shown in Table 3.1a, and further split into trawl and other gears in Table 3.2. The distribution of catches by areas and gears in 2011 was similar to 2010. The nominal landings by country are given in Table 3.3.

There is information on cod discards (see section 0.4) but it was not included in the assessment because this data are fragmented and different estimates are in contradiction with each other. Moreover the level of discards is relatively small in 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 2002–2011 (Tables 3.1a)

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 0.3. The Norwegian and Russian estimates of IUU for this period are given in Table 3.1a. In according to reports from the Norwegian-Russian analytical group on estimation of total catches the total catches of cod in 2011 were very close to officially reported landings. The Working Group decided not to include IUU catches in 2011.

3.1.4 TACs and advised catches for 2011 and 2012

The Joint Norwegian-Russian Fisheries Commission (JNRFC) agreed on a cod TAC of 724,000 t for 2011, including 21,000 t Norwegian coastal cod. The total reported catch of 719,829 + 6,733 t in 2011 was 2,562 t above the agreed TAC.

The advice for 2012 given by ACOM in 2011 was based on the assessment made by AFWG in 2011. The JNRFC used the agreed rule (see section 3.6.3), applying the three years (2012-2014) average catch with F=0.40 when the spawning stock biomass is above B_{pa}. This rule gave a NEA cod TAC for 2012 of 751,000 tonnes, which was the quota set by JNRFC for 2012. In addition, the TAC for Norwegian Coastal Cod was set to the same value for 2012 as for 2011: 21,000 t.

3.2 Status of research

3.2.1 Fishing effort and CPUE (Table A1)

CPUE series of the Norwegian and Russian trawl fisheries are given in Table A1. The data reflect the total trawl effort, both for Norway and Russia. The Norwegian series is given as a total for all areas, and has not been updated since 2007.

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

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

The preliminary swept area estimates and acoustic estimates from the Joint winter survey on demersal fish in the Barents Sea in winter 2012 are given in Tables A2 and A3. More details on this survey are given in Aglen *et al*. (WD 03). Due to engine problems onboard R/V Johan Hjort the eastern area (Main Area D') was not covered. The estimates within the covered area were raised by the average "index ratio by age" observed for the same area in the years 2008-2011. The following ratios were used:

	1	2	3	4	5	6	7	8	9	10+
Acoustics	1.097	1.258	1.099	1.054	1.047	1.046	1.061	1.011	1.006	1.000
Swept area	1.137	1.377	1.217	1.163	1.091	1.088	1.074	1.055	1.048	1.000

Before 2000 this survey was made without participation from Russian vessels, while in 2001-2005 and 2008-2012 Russian vessels have covered important parts of the Russian zone. In 2006-2007 the survey was carried out only by Norwegian vessels. In 2007 the vessels were not allowed to cover the Russian EEZ. The method for adjustment for incomplete area coverage in 2007 is described in the 2007 report. Table 3.4 shows areas covered in the time series and the additional areas implied in the method used to adjust for missing coverage in Russian Economic Zone. In 4 of the 5 adjusted years the adjustments were not based on area ratios, but the "index ratio by age" was used. This means that the index by age for the covered area was scaled by the observed ratio between total index and the index for the same area observed in the years prior to the survey.

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

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

The estimated abundance indices from the Norwegian acoustic survey off Lofoten and Vesterålen (the main spawning area for this stock) in March/April are given in Table A4. A description of the survey, sampling effort and details of the estimation procedure can be found in Korsbrekke (1997). The 2011 survey showed an increase in numbers compared to the 2010 survey approximately by a factor of three, while the biomass increased by a factor of 2.7. The biomass was estimated to 1.08 mill. tonnes. This is the highest in the time series, 40% above the second highest (1992-survey). The 2012 survey was 0.86 mill. tonnes. The concentrations were less dense, but were spread in a wider area compared to the 2011 survey. The fraction of repeat spawners was 50%, compared to 43% in 2011 and 50% in 2010.

Russian autumn survey Acronym: RU-BTr-Q4

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

The Russian autumn 2011 survey was conducted in the standard period and under the standard methods (WD 07). An area of 209 $*10^3$ sq. miles was covered, which is somewhat larger than the standard area. The 2011 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).

Estimates of abundance and biomass made during the survey confirmed the main trends in stocks dynamics i.e. that cod stocks continue to increase. Rather wide distribution of cod was registered, and besides, delaying of return migrations of maturing fish from the eastern feeding grounds was observed.

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

Swept area bottom trawl estimates from the joint Norwegian-Russian ecosystem survey in August-September for the period 2004-2011 are given in Table A14. The new index values were calculated at first in 2010 (AFWG 2010, WD 20). This time series have been tested as a new tuning fleet in XSA (AFWG 2010, section 3.11.3). Using this survey in tuning is postponed until the benchmark meeting.

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

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

Both the Joint winter survey in 2012 and the Russian autumn survey in 2011 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 0.4). The results of fifteen years of annual comparative age readings are described in Yaragina *et al*. (2009b). Zuykova *et al*. (2009) re-read old otoliths and found no significant difference in contemporary and historical age determination and subsequent length at age. However, age at first maturation in the historical material as determined by contemporary readers is younger than that determined by historical readers. Taking this difference into account would thus have effect on the spawning stock-recruitment relationship and thus on the biological reference points.

3.3 Data used in the assessment

3.3.1 Catch at age (Tables 3.5)

For 2011, age compositions from all areas were available from Russia, Germany, Spain and Norway. Poland provided age compositions from Division IIb at 2nd quarter only while catches were taken in quarters 2-4. So, catches from Poland were treated in assessment as unsampled. 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. The 2011 catch at age data was calculated using Intercatch (Table 3.5).

3.3.2 Weight at age (Tables 3.6 –3.8, A2, A4, A6, A8, A12).

Catch weights

For 2011, the mean weight at age in the catch (Table 3.7) was obtained from Intercatch as a weighted average of the weight at age in the catch for Norway, Russia, Germany and Spain (Table 3.6). The weight at age in the catch for all countries is given in Table 3.8.

Stock weights

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

For ages 1-11 stock weights at age at the start of year y ($W_{a,y}$) for 1983-2011 (Table 3.8) 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 3.9 and 3.10)

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 3.9). For the years 1985-2012, Norwegian maturity at age ogives have been obtained by combining the Barents Sea winter survey and the Lofoten survey. Russian maturity ogives from the autumn survey as well as from commercial fishery for November-February are available from 1984 until present. The Norwegian maturity ogives tend to give a higher percent mature at age compared to the Russian ogives, which is consistent with the generally higher growth rates observed in cod sampled by the Norwegian surveys. The approach used is consistent with the approach used to estimate the weight at age in the stock (described in Section 3.3.2). The percent mature at age for the Russian and Norwegian surveys have been arithmetically averaged for all years, except 1982-1983 when only Norwegian observations were used and 1984 when only Russian observations were used.

3.3.5 Cannibalism (Table 3.11)

The method used for calculation of the prey consumption by cod described by Bogstad and Mehl (1997) is used to calculate the consumption of cod by cod (Table 3.11) 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 1984-2011.

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

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

3.4 Assessment using VPA model (Tables 3.12, A13)

The XSA was also this year used as the main assessment method, as an update assessment was carried out. Additional assessment method (survey calibration of VPA) is presented in Section 3.9. Since AFWG-2012 FLR used as assessment tool instead of VPA95 program as it demonstrated better ability to converge (WD 11) and improve convenience of assessment execution.

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

XSA name	Name	Place	Season	Age	Years
Fleet 09	Russian trawl CPUE	Total area	All year	9-11	1985-2011
Fleet 15	Joint bottom trawl survey	Barents Sea	Feb-Mar	3-8	1981-2012
Fleet 16	Joint acoustic survey	Barents Sea+Lofoten	Feb-Mar	3-9	1985-2012
Fleet 18	Russian bottom trawl surv.	Total area	Oct-Dec	3-9	1994-2011

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 2012 could be included in the assessment. The tuning fleet file is shown in Table 3.12. 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 (Figures 3.2a-b, Table 3.14)

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

Survey indices for Fleet 15 and 16 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.

The comprehensive evaluation of XSA settings has been done intersessionally (WD 11). It was demonstrated that the model is quite robust to changes in the currently used values of parameters. The only parameter needs a special attention is "Catchability dependent on stock size for ages".

XSA was run using default settings with the following exceptions:

Tapered time weighting power 3 over 10 years

Catchability dependent of stock size for ages less than 7

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

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

These settings are identical to those used by last years' Working Group.

The WG at 2011 has concluded that the stock size dependent catchability (ssdq) should be extended from ages 3-5 to ages 3-6 (ICES 2011) and also recommended that the development of the high survivorship year classes be monitored, and that the issue is examined in depth at the next benchmark meeting.

In order to follow this recommendation some exploratory runs were done. It was observed that very abundant year classes 2004, 2005, 2006 influence considerably on the VPA-survey relationships during XSA tuning. Similar to last year's assessment (ICES 2011) for such cases it could be that for corresponding ages the power model becomes more preferable. In the XSA diagnostics the *t* – criteria for Fleet 16 shows that age 7 also should be included as age where q is depended on year class strength (see table 3.14). At the same time other surveys do not support such a change and even more tend "to recommend" linear models for younger ages.

As it was also demonstrated by intersessional evaluation of VPA/XSA model behavior (WD11) currently the model becomes rather sensitive to that parameter. It was concluded that increase of 1st age where linear models will be applied to the VPA-survey relationship change VPA estimates and its type of relationship with surveys (WD11). For example when the linear model is applied for younger ages, the results of VPA-diagnostics tend to support the linear relationship between VPA and surveys, and when the nonlinear model is used, the results tend to confirm the nonlinear relationship. The same observation is confirmed for this year's assessment (Figure 3.2a). In such a situation it is necessary to collect more information about yearclass strength (catch-at-age and survey indices for more years) in order to conclude which of the model parameters give more correct estimates (WD11).

However, a further increase number of ages with power relationships in XSA reduced NEA cod VPA model stability. It is seen from the retrospective pattern for SSB that if we increase ages with power relationship until age 7 VPA model become systematically underestimate terminal biomass (Figure 3.2b). Extending the tuning window from 10 to 20 years was exploratory tested with power model until age 7. This gave no significant change in diagnostics and results compared to 10 years window.

So, it was concluded not to change XSA parameter "*Catchability dependent on stock size for ages*" this year and make a final run with the same settings as last year.

The XSA model sensitivity to parameter "*Catchability dependent on stock size for ages*" needs to be considered by the ICES method study group (WGMG).

3.4.2 Including cannibalism in XSA (Tables 3.5, 3.11)

The catch numbers shown in Table 3.5 together with cannibalism numbers (Tables 3.11) 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 realized in FLR script was followed: As a starting point the number of cod consumed by cod was estimated from the stock estimates assessed with zero consumption and the per capita estimates of consumption of cod by cod. Then the number consumed was added to the catches used for tuning. The resulting stock then leads to new estimates of consumption. This procedure was repeated until the consumed numbers for the latest year differed less than 0.001% from the previous iteration. The final numbers of cod eaten by cod are given in Table 3.11.

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 3.13–3.14, Figure 3.2c–3.4)

The tuning diagnostics from XSA with cannibalism are given in Table 3.14. This table got by VPA95 program with final estimates of cod consumed by cod from FLR as VPA95 provides more comprehensive diagnostic compare to FLR.

Figure 3.2c shows the log catchability residuals of the tuning series. There are some contradictory in residuals at last year between surveys. Most of the residuals are negative for the Russian bottom trawl survey (Fleet 18) but positive for the Norwegian bottom trawl survey (Fleet 15) and Russian commercial trawl CPUE (Fleet 9). The residuals in 2011 are relatively low except relatively high (0.44-0.47) positive residual for age 10 in Fleet 9 and have no particular pattern.

Figure 3.3 and Table 3.13 compares the estimated survivors (by end of 2011) 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 most ages are in a fair agreement between fleets. On the other hand differences for ages 6-8 are rather big (up to 50%). Final XSA run including all fleets tends to give lower estimates of survivors at all ages compare to single fleet runs because of decreasing shrinkage weights.

Retrospective plots of F, SSB and recruitment, going back to 2002 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 thought there is an increase in SSB at terminal year compare to previous one.

3.4.4 Results (Table 3.15–3.24, Figure 3.1)

The total fishing mortalities (true fishing mortality plus mortality from cannibalism) and population numbers are given in Tables 3.15 and 3.16.

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 3.17) was used together with the new real Fs (Table 3.19) to run the final VPA on ages 3-13+. M2 and F values for ages 1-6 in 1984-2011 are given in Tables 3.18 and 3.20.

The stock numbers from the final run are given in Tables 3.21, while the corresponding stock biomass at age and the spawning stock biomass at age are given in Tables 3.22-3.23. Summaries of landings, fishing mortality, stock biomass, spawning stock biomass and recruitment since 1946 runs are given in Table 3.24 and Figure 3.1.

3.5 Results of the assessment

3.5.1 Fishing mortalities and VPA

The estimated $F_{5\text{-}10}$ in 2011 from the SVPA is 0.26, which is below F_{pa} and is close to the lowest since 1990. Fishing mortality has gradually declined since 2005. The spawning stock biomass in 2012 is estimated to be 2,063 kt, which is by far the highest in the time series. Total stock biomass in 2012 is estimated to 3,658 kt which is close to the highest level observed in the 1940s. One should bear in mind that in the early part of the time series the fraction mature was lower.

3.5.2 Recruitment (Table 1.12)

Since survey data for the youngest ages are not used in the XSA, these ages are estimated by other models. At the 2008 AFWG meeting it was decided to use a hybrid model, which is an arithmetic mean of different recruitment models (Section 1.4.2). It was agreed to use the same approach this year. The input data for those models are the following time series; survey data for ages 0, 1 and 2 (Russian autumn survey) and ages 1, 2 and 3 (Joint winter survey), 0-group from the ecosystem survey, capelin biomass, ice coverage, temperature and oxygen saturation at the Kola section, air temperature at the Murman coast. Prognosis from all the models, including the hybrid is presented in Table 1.12. Here also the results from the earlier used RCT3 model are shown. The numbers at age 3 calculated by the hybrid method were: 721 million for the 2009 year class, 702 million for the 2010 year class and 741 million for the 2011 year class.

3.6 Reference points and harvest control rules

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

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

TAC advice for 2012 is based on the management rule.

3.6.1 Biomass reference points (Figure 3.1)

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

3.6.2 Fishing mortality reference points

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

3.6.3 Harvest control rule

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

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

conditions for high long-term yield from the stocks

achievement of year-to-year stability in TACs

full utilization of all available information on stock development

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

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

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

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

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

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

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

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

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

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

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

3.6.4 Target reference points

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

According to the same simulations, if the stock is exploited at the F=0.40 level then SSB will be well above B_{pa}, and as B_{pa} already is used in management rule then MSY $B_{trigger}$ could be set at the B_{pa} level.

3.7 Prediction

3.7.1 Prediction input (Tables 3.21, 3.25, 3.26, Figure 3.5a-b, 3.6, 3.6a, 3.7)

The input data to the short-term prediction with management option table (2012-2015) are given in Tables 3.25-3.26. For 2012 stock weights and maturity were taken from surveys as described in Sections 3.3.2 and 3.3.4.

Catch weights in 2012 onwards and stock weights in 2013 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. Since 2005 working group the 3 most recent values of annual increments have been used for predicting stock weights. For catch weights the last 10-year period for averaging the increments is used. Figures 3.5a and 3.5b show how these predictions perform back in history.

The maturity ogive for the years 2013 and 2014 was predicted by using the 2010-2012 average. The exploitation pattern in 2012 and later years was set equal to the 2009-2011 average.

The stock number at age in 2012 was taken from the final VPA (Table 3.21) for ages 4 and older. The recruitment at age 3 in the years 2012-2014 was estimated as described in section 3.5.2. Figure 3.6 shows the development in natural mortality due to cannibalism for cod (prey) age groups 1-3 together with the abundance of capelin in the period 1984-2011. The recent 3 years average M was used previously as input for the prediction. This year it was decided to use only one last year M values to predict natural mortality for years 2012-2014 as this approach gave more reliable results (Figure 3.6a). The recent increasing trend in M is also needed to be taken into account in prediction.

For 2015, the 2014 values were used for all input data, except for recruitment, where the long-term arithmetic mean (624 million at age 3) was used.

The assessment does not show clear pattern in F from 2009 to 2011. Effort also was relatively stable (Figure 3.7). There is practically no difference between last three year average F and last year F, and thus similar to last year's assessment F in terminal year 2011 is considered to be used for F in the intermediate year (2012). Table 3.25 shows input data to the predictions.

3.7.2 Prediction results (Tables 3.26 – 3.28)

The catches corresponding to F_{sq} in 2012 is 857 kt (Table 3.26). This is higher than the TAC for 2012 (751 kt). The resulting SSB in 2013 is 2,225 kt, an all-time high level. Table 3.26 also shows the short-term consequences over a range of F-values in 2013. The detailed outputs corresponding to F_{sq} in 2012, the F corresponding to the HCR in 2013 and F_{pa} in 2014-2015 is given in Table 3.27 and 3.28. Summarised results are shown in the text table below.

Rationale	Landings 1) (2013)	Basis	F (2013)	SSB (2014)	%SSB change 2)	% TAC change 3)
Zero catch	0	$0*F_{sq}$	0	2887	+30	-100
Agreed management Plan4)	940	$1.13*F_{sq}$	0.30	2025	-9	+25
Status quo	844	$1.00*F_{sq}$	0.26	2109	-5	+12
Precautionary Limits	1191	F_{pa}	0.40	1802	-19	+59

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 2014 relative to SSB 2013.

3) TAC 2013 relative to TAC 2012.

4) Forecast based on catch corresponding to 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 overfishing.

3.8 Comparison with last year's assessment

The text table below compares this year's estimates with last year's estimates for the year 2011 numbers at age (millions), total biomass, spawning biomass (thousand tonnes), as well as reference F for the year 2010.

		N(2011)										
Assessment year (specification)	F(2010)	age3	age4	age5	age6	age7	age8	age9	age10	TSB 2011	SSB 2011	F 2011
2011 WG	0.29	433*	251	295	279	167	84	37	17	2507	1311	0.29**
2012 WG	0.23	691	317	391	454	357	97	42	17	3635	1857	0.26
Ratio 2012 WG/ 2011WG	0.80	1.60	1.26	1.33	1.63	2.14	1.16	1.12	1.02	1.45	1.42	0.92

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

The final assessment values for ages 3 to 7 are higher of the 2011 assessment while for ages 8 to 10 they are close to the previous assessment (within 2-16%). The largest revision was for ages 6 and 7. The F in 2010 is 20% less than last year estimate. The total stock biomass and SSB in 2011 are 42-45 % higher than the previous estimates.

3.9 Additional assessment methods

3.9.1 Survey calibration method (Figures 3.8–3.9)

A "calibrated" prediction method of stock numbers from the Joint bottom trawl survey against VPA numbers, using data from the period 1981-1995 to scale the survey series to absolute numbers, was carried out. The method is described in Pennington and Nakken (WD14, 2008). The regression is done for ages 4-6 and 7+ separately. The results, using a regression method with intercept, are shown in Figures 3.8-3.9. The figures show that for ages 4-6 this method gives much lower values than the assessment for the years 2008-2010 in particular, while it compares fairly well with the survey for age 7+. This indicates that for the recent strong year classes, the survey estimates at different ages are not consistent with each other.

3.9.2 Gadget

There were no updates for Gadget model this year.

3.10 Comments to the assessment

The magnitude of IUU catches has decreased considerably from around 30% of official landings to 3% in 2008. No any IUU catches were registered for 2009 and 2011. The uncertainty relating to total catch for the years 2002-2006 could still have significant influence on the assessment of the current stock.

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

The WG realizes that imprecise input data, in particular the catch-at-age matrix, could be a main obstacle to producing precise stock assessments, irrelevant of which model is used. The WG observed a negative tendency in catch sampling both in Russia and Norway (see sec. 0.4) and therefore, recognizes the need for improvement.

Assessment is based on the analysis of surveys and the XSA model with the same settings as last year assessment The WG will monitor the development of the high survivorship year classes, and that issue will be examined in depth at the next benchmark meeting.

3.11 New data sources

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

3.11.1 Catch data (Tables 3.29, 3.30, 3.1b)

Discard and bycatch data series (Table 3.29, 3.30) should be updated and then included in the catch at age matrix. Table 3.30 (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 0.4) into account.

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

3.11.2 Consumption data

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

3.11.3 Survey data (Table A14)

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

3.12 Answering to last year comments from Reviewers:

The minutes of the review of the 2011 AFWG report contained a number of comments to the NEA cod assessment. Below is a summary how AFWG has responded to this:

Small changes in text were done in accordance to recommendations.

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.) For the years 2002-2008, the figures in bold are those used in the assessment

Year		Sub-area I	Division IIa	Division IIb	Unreported catches	Total catch
1961		409 694	153 019	220 508		783 221
1962		548 621	139 848	220 797		909 266
1963		547 469	117 100	111 768		776 337
1964		206 883	104 698	126 114		437 695
1965		241 489	100 011	103 430		444 983
1966		292 253	134 805	56 653		483 711
1967		322 798	128 747	121 060		572 605
1968		642 452	162 472	269 254		1 074 084
1969		679 373	255 599	262 254		1 197 226
1970		603 855	243 835	85 556		933 246
1971		312 505	319 623	56 920		689 048
1972		197 015	335 257	32 982		565 254
1973		492 716	211 762	88 207		792 685
1974		723 489	124 214	254 730		1 102 433
1975		561 701	120 276	147 400		829 377
1976		526 685	237 245	103 533		867 463
1977		538 231	257 073	109 997		905 301
1978		418 265	263 157	17 293		698 715
1979		195 166	235 449	9 923		440 538
1980		168 671	199 313	12 450		380 434
1981		137 033	245 167	16 837		399 037
1982		96 576	236 125	31 029		363 730
1983		64 803	200 279	24 910		289 992
1984		54 317	197 573	25 761		277 651
1985		112 605	173 559	21 756		307 920
1986		157 631	202 688	69 794		430 113
1987		146 106	245 387	131 578		523 071
1988		166 649	209 930	58 360		434 939
1989		164 512	149 360	18 609		332 481
1990		62 272	99 465	25 263	25 000	212 000
1991		70 970	156 966	41 222	50 000	319 158
1992		124 219	172 532	86 483	130 000	513 234
1993		195 771	269 383	66 457	50 000	581 611
1994		353 425	306 417	86 244	25 000	771 086
1995		251 448	317 585	170 966		739 999
1996		278 364	297 237	156 627		732 228
1997		273 376	326 689	162 338		762 403
1998		250 815	257 398	84 411		592 624
1999		159 021	216 898	108 991		484 910
2000		137 197	204 167	73 506		414 870
2001		142 628	185 890	97 953		426 471
2002	2	184 789	189 013	71 242	**90000**/21716	**535045**/466760
2003	2	163 109	222 052	51 829	**115000**/27748	**551990**/464738
2004	2	177 888	219 261	92 296	**117000**/30000	**606445**/519445
2005	2	159 573	194 644	121 059	**166000**/41000	**641276**/516276
2006	2	159 851	204 603	104 743	**67100**/28000	**537642**/497197
2007	2	152 522	195 383	97 891	**41087**/8757	**486883**/454553
2008		144 905	203 244	101 022	**15000**/0	**464171**/449171
2009		161 602	207 205	154 623		523 431
2010		183 988	271 337	154 657		609 983
2011	1	198 333	328 598	192 898		719 829

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, 10^3 tons

Year	As calculated from samples and reported to AFWG	By area and time of capture
1960	-	43
1961	-	32
1962	-	30
1963	-	40
1964	-	46
1965	-	24
1966	-	29
1967	-	33
1968	-	47
1969	-	52
1970	-	49
1971	-	*)
1972	-	*)
1973	-	*)
1974	-	*)
1975	-	*)
1976	-	*)
1977	-	*)
1978	-	*)
1979	-	*)
1980	-	40
1981	-	49
1982	-	42
1983	-	38
1984	74	33
1985	75	28
1986	69	26
1987	61	31
1988	59	22
1989	40	17
1990	28	24
1991	25	25
1992	42	35
1993	53	44
1994	55	48
1995	57	39
1996	62	32
1997	63	36
1998	52	29
1999	41	23
2000	37	19
2001	30	14
2002	41	20
2003	35	19
2004	25	14
2005	22	13
2006	26	15
2007	24	13
2008	26	13
2009	25	15
2010	23	16
2011	29	7
Average 1984-2011	43	25

*) No data

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

	Sub-area I		Division IIa		Division IIb	
Year	Trawl	Others	Trawl	Others	Trawl	Others
1967	238.0	84.8	38.7	90.0	121.1	-
1968	588.1	54.4	44.2	118.3	269.2	-
1969	633.5	45.9	119.7	135.9	262.3	-
1970	524.5	79.4	90.5	153.3	85.6	-
1971	253.1	59.4	74.5	245.1	56.9	-
1972	158.1	38.9	49.9	285.4	33.0	-
1973	459.0	33.7	39.4	172.4	88.2	-
1974	677.0	46.5	41.0	83.2	254.7	-
1975	526.3	35.4	33.7	86.6	147.4	-
1976	466.5	60.2	112.3	124.9	103.5	-
1977	471.5	66.7	100.9	156.2	110.0	-
1978	360.4	57.9	117.0	146.2	17.3	-
1979	161.5	33.7	114.9	120.5	8.1	-
1980	133.3	35.4	83.7	115.6	12.5	-
1981	91.5	45.1	77.2	167.9	17.2	-
1982	44.8	51.8	65.1	171.0	21.0	-
1983	36.6	28.2	56.6	143.7	24.9	-
1984	24.5	29.8	46.9	150.7	25.6	-
1985	72.4	40.2	60.7	112.8	21.5	-
1986	109.5	48.1	116.3	86.4	69.8	-
1987	126.3	19.8	167.9	77.5	129.9	1.7
1988	149.1	17.6	122.0	88.0	58.2	0.2
1989	144.4	19.5	68.9	81.2	19.1	0.1
1990	51.4	10.9	47.4	52.1	24.5	0.8
1991	58.9	12.1	73.0	84.0	40.0	1.2
1992	103.7	20.5	79.7	92.8	85.6	0.9
1993	165.1	30.7	155.5	113.9	66.3	0.2
1994	312.1	41.3	165.8	140.6	84.3	1.9
1995	218.1	33.3	174.3	143.3	160.3	10.7
1996	248.9	32.7	137.1	159.0	147.7	6.8
1997	235.6	37.7	150.5	176.2	154.7	7.6
1998	219.8	31.0	127.0	130.4	82.7	1.7
1999	133.3	25.7	101.9	115.0	107.2	1.8
2000	111.7	25.5	105.4	98.8	72.2	1.3
2001	119.1	23.5	83.1	102.8	95.4	2.5
2002	147.4	37.4	83.4	105.6	69.9	1.3
2003	146.0	17.1	107.8	114.2	50.1	1.8
2004	154.4	23.5	100.3	118.9	88.8	3.5
2005	132.4	27.2	87.0	107.7	115.4	5.6
2006	141.8	18.1	91.2	113.4	100.1	4.6
2007	129.6	22.9	84.8	110.6	91.6	6.3
2008	123.8	21.1	94.8	108.4	95.3	5.7
2009	130.1	31.5	102.0	105.2	142.1	11.4
2010	151.1	32.9	130.0	141.4	149.2	5.4
2011 [1]	158.1	38.4	163.5	167.0	181.0	11.9

[1] Provisional figures.

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

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

[1] Provisional figures.

[2] USSR prior to 1991.

[3] Includes Baltic countries.

[4] Includes unspecified EU catches.

Table 3.4. Barents Sea winter survey. Area covered ('000 square nautical miles) and areas implied in the method used to adjust for missing coverage in Russian Economic Zone. In 4 of the 5 adjusted years the adjustments were not based on area ratios, but the "index ratio by age" was used. This means that the index by age (for the area outside REZ) was scaled by the observed ratio between total index and the index outside REZ observed in the years prior to the survey.

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

Table 3.5. Northeast Arctic cod. Catch numbers at age

FLR, Sat May 05 11:20:04 2012

Year_age	3	4	5	6	7	8	9	10	11	12	+gp	TOTAL NUM	TONS LAND	SOPCOF%
1946	4008	10387	18906	16596	13843	15370	59845	22618	10093	9573	8137	189376	706000	0.9709
1947	710	13192	43890	52017	45501	13075	19718	47678	31392	9348	18055	294576	882017	1.0938
1948	140	3872	31054	55983	77375	21482	15237	9815	30041	7945	12595	265539	774295	1.1217
1949	991	6808	35214	100497	83283	29727	13207	5606	8617	13154	7719	304823	800122	1.008
1950	1281	10954	29045	45233	62579	30037	19481	9172	6019	4133	9862	227796	731982	0.9191
1951	24687	77924	64013	46867	37535	33673	23510	10589	4221	1288	4935	329242	827180	0.8708
1952	24099	120704	113203	73827	49389	20562	24367	15651	8327	3565	2158	455852	876795	1.0697
1953	47413	107659	112040	55500	22742	16863	10559	10553	5637	1752	797	391515	695546	0.9537
1954	11473	155171	146395	100751	40635	10713	11791	8557	6751	2370	1287	495894	826021	1.0759
1955	3902	37652	201834	161336	84031	30451	13713	9481	4140	2406	1350	550296	1147841	0.9404
1956	10614	24172	129803	250472	86784	51091	14987	7465	3952	1655	1906	582901	1343068	0.9565
1957	17321	33931	27182	70702	87033	39213	17747	6219	3232	1220	819	304619	792557	0.9996
1958	31219	133576	71051	40737	38380	35786	13338	10475	3289	1070	433	379354	769313	0.8903
1959	32308	77942	148285	53480	18498	17735	23118	9483	3748	997	513	386107	744607	1.0747
1960	37882	97865	64222	67425	23117	8429	7240	11675	4504	1843	682	324884	622042	0.9601
1961	45478	132655	123458	51167	38740	17376	5791	6778	5560	1682	1298	429983	783221	0.9116
1962	42416	170566	167241	89460	28297	21996	7956	2728	2603	1647	775	535685	909266	0.8093
1963	13196	106984	205549	95498	35518	16221	11894	3884	1021	1025	784	491574	776337	0.9779
1964	5298	45912	97950	58575	19642	9162	6196	3553	783	172	782	248025	437695	0.9731
1965	15725	25999	78299	68511	25444	8438	3569	1467	1161	131	337	229081	444930	0.775
1966	55937	55644	34676	42539	37169	18500	5077	1495	380	403	156	251976	483711	0.8112
1967	34467	160048	69235	22061	26295	25139	11323	2329	687	316	279	352179	572605	0.9165
1968	3709	174585	267961	107051	26701	16399	11597	3657	657	122	240	612679	1074084	0.9272
1969	2307	24545	238511	181239	79363	26989	13463	5092	1913	414	190	574026	1197226	0.9506
1970	7164	10792	25813	137829	96420	31920	8933	3249	1232	260	180	323792	933246	0.8953
1971	7754	13739	11831	9527	59290	52003	12093	2434	762	418	216	170067	689048	0.8061
1972	35536	45431	26832	12089	7918	34885	22315	4572	1215	353	476	191622	565254	0.8459
1973	294262	131493	61000	20569	7248	8328	19130	4499	677	195	195	547596	792685	0.769
1974	91855	437377	203772	47006	12630	4370	2523	5607	2127	322	296	807885	1102433	0.732
1975	45282	59798	226646	118567	29522	9353	2617	1555	1928	575	283	496126	829377	0.868
1976	85337	114341	79993	118236	47872	13962	4051	936	558	442	218	465946	867463	0.7881
1977	39594	168609	136335	52925	61821	23338	5659	1521	610	271	268	490951	905301	0.936
1978	78822	45400	88495	56823	25407	31821	9408	1227	913	446	847	339609	698715	0.9183
1979	8600	77484	43677	31943	16815	8274	10974	1785	427	103	142	200224	440538	0.8238
1980	3911	17086	81986	40061	17664	7442	3508	3196	678	79	58	175669	380434	0.786
1981	3407	9466	20803	63433	21788	9933	4267	1311	882	109	41	135440	399038	0.8468
1982	8948	20933	19345	28084	42496	8395	2878	708	271	260	37	132355	363730	0.7987
1983	3108	19594	20473	17656	17004	18329	2545	646	229	74	83	99741	289992	1.1169
1984	6942	14240	18807	20086	15145	8287	5988	783	232	153	69	90732	277651	1.0545
1985	24634	45769	27806	19418	11369	3747	1557	768	137	36	71	135312	307920	0.9821
1986	28968	70993	78672	25215	11711	4063	976	726	557	136	76	222093	430113	0.9843
1987	13648	137106	98210	61407	13707	3866	910	455	187	227	100	329823	523071	0.9781
1988	9828	22774	135347	54379	21015	3304	1236	519	106	69	62	248639	434939	0.9999
1989	5085	17313	32165	81756	27854	5501	827	290	41	13	28	170873	332481	1.0123
1990	1911	7551	12999	17827	30007	6810	828	179	59	15	13	78199	212000	0.9893
1991	4963	10933	16467	20342	19479	25193	3888	428	48	12	4	101757	319158	1.0503
1992	21835	36015	27494	23392	18351	13541	18321	2529	264	82	13	161837	513234	0.9737
1993	10094	46182	63578	33623	14866	9449	6571	12593	1749	377	86	199168	581611	0.9875
1994	6531	59444	102548	59766	32504	10019	6163	3671	7528	995	144	289313	771086	0.9911
1995	4879	42587	115329	98485	32036	7334	3014	1725	1174	1920	264	308747	739999	0.997
1996	7655	28782	80711	100509	54590	10545	2023	930	462	230	894	287331	732228	0.9855
1997	12827	36491	69633	83017	65768	28392	4651	1151	373	213	383	302899	762403	0.9996
1998	31887	88874	48972	40493	34513	26354	6583	965	197	69	117	279024	592624	0.9929
1999	7501	77714	92816	31139	15778	15851	8828	1837	195	40	72	251771	484910	1.0033
2000	4701	33094	93044	47210	12671	6677	4787	1647	321	71	26	204249	414868	0.9961
2001	5044	35019	62139	62456	22794	5266	1773	1163	343	85	35	196117	426471	1.0006
2002	2348	31033	76175	67656	42122	11527	1801	529	223	120	36	233570	535045	0.9975
2003	7263	20885	64447	71109	36706	14002	2887	492	142	97	65	218095	551990	0.9986
2004	2090	38226	50826	68350	50838	18118	6239	1746	295	127	63	236918	606445	0.9983
2005	5815	19768	113144	61665	44777	20553	6285	2348	562	100	52	275069	641276	1.0007
2006	8548	47207	33625	78150	31770	15667	7245	1788	737	210	226	225173	537642	1.0032
2007	25473	43817	62877	26303	34392	11240	4080	1381	505	285	92	210445	486883	1.0022
2008	8459	51704	40656	35072	14037	20676	5503	1794	715	229	81	178926	464171	0.9989
2009	4866	38711	83998	46639	20789	8417	8920	1957	872	987	117	216273	523430	0.9998
2010	1778	16193	53855	75853	36797	17062	4784	4325	3034	913	273	214867	609983	0.9999
2011	1418	8033	32472	70938	73875	21116	11708	5058	3237	600	446	228901	719830	1

Table 3.6. 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	7.262	9.36	9.52	9.52	10.68	21.66
2004		0.54	1.08	1.41	1.95	2.69	3.46	4.77	6.72	7.90	8.66	12.21	14.02	16.50	11.37
2005		0.58	0.92	1.38	1.86	2.61	3.54	4.57	6.41	8.24	9.89	11.04	14.08	11.81	20.08
2006		0.51	0.97	1.45	2.06	2.71	3.56	4.57	5.53	6.61	7.53	8.55	8.44	9.82	12.31
2007		0.53	1.07	1.70	2.37	3.26	4.36	5.45	6.71	8.08	8.56	9.75	11.72	12.72	15.58
2008		0.65	1.12	1.70	2.44	3.32	4.41	5.61	6.84	8.25	9.31	10.54	12.45	13.59	21.15
2009		0.56	0.98	1.47	2.10	2.83	3.90	5.06	5.76	7.31	7.79	7.81	10.68	11.83	14.76
2010		0.55	0.95	1.46	2.06	2.93	4.02	5.40	6.44	7.19	8.43	9.11	10.46	11.39	15.55
2011		0.53	1.09	1.50	2.06	2.85	3.70	5.01	6.26	7.33	8.34	9.87	13.23		
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	12.42		
2008		0.28	0.64	1.16	1.74	2.65	3.58	4.74	5.73	7.32	8.07	9.52	12.52		
2009		0.31	0.64	1.09	1.58	2.11	3.19	4.80	6.58	7.97	9.84	11.51			
2010		0.25	0.57	1.00	1.64	2.28	3.14	4.53	5.98	8.03	9.71	10.70	13.53		
2011		0.25	0.62	1.05	1.56	2.18	2.95	4.33	6.21	8.04	10.13	12.25	15.18		
Germany (Division IIa and IIb)															
Year				Age											
		2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1994			0.68	1.04	2.24	3.49	4.51	5.79	6.93	8.16	8.46	8.74	9.48	15.25	
1995			0.44	0.84	1.50	2.72	3.81	4.46	4.81	7.37	7.69	8.25	9.47		
1996			0.84	1.15	1.64	2.53	3.58	4.13	3.90	4.68	6.98	6.43	11.32		
1997			0.43	0.92	1.42	2.01	3.15	4.04	5.16	4.82	3.96	7.04	8.80		
1998		0.23	0.73	1.17	1.89	2.72	3.25	4.13	5.63	6.50	8.57	8.42	11.45	8.79	
1999	1		0.85	1.45	2.00	2.65	3.47	4.16	5.45	6.82	5.90		8.01		
2000	2	0.26	0.73	1.36	2.04	2.87	3.67	4.88	5.78	7.05	8.45	8.67	9.33	6.88	
2001		0.38	0.80	1.21	1.90	2.74	3.90	4.99	5.69	7.15	7.32	11.72	9.11	6.60	
2002		0.35	1.00	1.31	1.80	2.53	3.64	4.38	5.07	6.82	9.21	7.59	13.18	19.17	19.20
2003		0.22	0.44	1.04	1.71	2.31	3.27	4.93	6.17	7.773	9.61	9.994	12.29	13.59	
2004	2	0.22	0.73	1.01	1.75	2.58	3.33	4.73	6.32	7.20	8.45	9.20	11.99	10.14	13.11
2005	3	0.57	0.77	1.13	1.66	2.33	3.36	4.38	5.92	6.65	7.26	10.01	11.14		
2006	2	0.71	0.91	1.39	1.88	2.56	3.77	5.33	6.68	9.14	10.89	11.51	16.83	18.77	
2007	3	0.59	1.35	1.79	2.51	3.53	4	4.95	6.55	7.54	9.71	11.40	11.57	23.34	15.61
2008	3	0.23	0.51	1.14	1.76	2.57	3.15	4.4	5.43	7.18	8.39	10.15	10.03	10.99	14.26
2009	3	0.35	0.6	1.19	1.83	2.96	4.08	5.61	6.97	8.55	9.13	10.54	13.34	10.30	17.06
2010	3	0.36	0.67	0.93	1.71	2.46	3.21	4.93	6.75	7.80	8.70	8.53	10.17	12.36	14.11
2011	1			1.75	3.09	3.3	3.28	4.13	4.99	6.61	7.91	9.38	10.79	14.67	14.91
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	15.23	
2003			0.58	1.05	1.70	2.33	3.33	4.92	6.24	9.98	13.07	14.74	14.17		
2004	1	0.31	0.56	0.80	1.28	1.96	2.59	3.72	5.36	5.28	7.41		11.43		
2005	1		0.63	1.14	1.85	2.48	3.43	4.25	5.38	8.41	11.19	15.04	16.93		
2006		0.30	0.61	0.99	1.46	2.04	2.55	3.39	3.50	4.70	6.36				
2007		0.42	0.60	1.20	1.76	2.40	3.18	3.96	5.19	6.61	9.48	7.65	12.65	15.74	19.66
2009	1	0.12	0.45	0.95	1.60	2.18	3.36	4.52	6.04	7.30	9.42	10.35	11.47	12.54	
2010	2	0.18	0.56	1.11	1.73	2.36	3.36	5.14	6.88	8.64	9.65	6.83			
2011	1		0.45	0.90	1.26	1.84	2.55	4.08	5.61	8.17	8.14	7.31	8.91		
1	IIa and IIb combined														
2	I,IIa and IIb combined														
Iceland (Sub-area I)															
1994		0.42	0.85	1.44	2.77	3.54	4.08	5.84	6.37	7.02	7.48	7.37			
1995			1.17	0.91	1.60	2.28	3.61	4.73	6.27			6.26			
1996			0.36	0.99	1.55	2.83	3.79	4.81	5.34	7.25	7.68	9.08	8.98	10.52	
1997		0.42	0.43	0.76	1.60	2.40	3.45	4.40	5.74	6.15		8.28	10.52	9.89	
UK (England & Wales)															
1995	1			1.47	2.11	3.47	5.57	6.43	7.17	8.12	8.05	10.17	10.08		
1996	2			1.55	1.81	2.42	3.61	6.3	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		12.3	8.44			
	1	Division IIa and IIb													
	2	Division IIa													
Poland (Division IIb)															
2006		0.18	0.51	0.89	1.55	2.23	3.6	5.28	6.95	8.478	11	10.82	15.56	18.92	
2008			0.49	0.90	1.45	2.24	2.79	3.82	4.68	5.015	6.45	7.02	7.215	5.99	6.91
2009				1.02	1.72	2.65	3.81	5.23	6.91	8.862	11.1	13.64	16.48		
2010				1.39	1.66	2.29	2.98	3.92	5.18	6.313	6.66	8.715	9.05		
2011				0.99	1.50	2.17	3.15	4.43	7.45	7.28					

Table 3.7. Northeast Arctic COD. Catch weights at age
FLR
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YEAR_AGE	3	4	5	6	7	8	9	10	11	12	+GP	SOPCOF%
1946	0.35	0.59	1.11	1.69	2.37	3.17	3.98	5.05	5.92	7.2	8.15	0.9709
1947	0.32	0.56	0.95	1.5	2.14	2.92	3.65	4.56	5.84	7.42	8.85	1.0938
1948	0.34	0.53	1.26	1.93	2.46	3.36	4.22	5.31	5.92	7.09	8.43	1.1217
1949	0.37	0.67	1.11	1.66	2.5	3.23	4.07	5.27	5.99	7.08	8.22	1.008
1950	0.39	0.64	1.29	1.7	2.36	3.48	4.52	5.62	6.4	7.96	8.89	0.9191
1951	0.4	0.83	1.39	1.88	2.54	3.46	4.88	5.2	7.14	8.22	9.39	0.8708
1952	0.44	0.8	1.33	1.92	2.64	3.71	5.06	6.05	7.42	8.43	10.19	1.0697
1953	0.4	0.76	1.28	1.93	2.81	3.72	5.06	6.34	7.4	8.67	10.24	0.9537
1954	0.44	0.77	1.26	1.97	3.03	4.33	5.4	6.75	7.79	10.67	9.68	1.0759
1955	0.32	0.57	1.13	1.73	2.75	3.94	4.9	7.04	7.2	8.78	10.08	0.9404
1956	0.33	0.58	1.07	1.83	2.89	4.25	5.55	7.28	8	8.35	9.94	0.9565
1957	0.33	0.59	1.02	1.82	2.89	4.28	5.49	7.51	8.24	9.25	10.61	0.9996
1958	0.34	0.52	0.95	1.92	2.94	4.21	5.61	7.35	8.67	9.58	11.63	0.8903
1959	0.35	0.72	1.47	2.68	3.59	4.32	5.45	6.44	7.17	8.63	11.62	1.0747
1960	0.34	0.51	1.09	2.13	3.38	4.87	6.12	8.49	7.79	8.3	11.42	0.9601
1961	0.31	0.55	1.05	2.2	3.23	5.11	6.15	8.15	8.68	9.6	11.95	0.9116
1962	0.32	0.55	0.93	1.7	3.03	5.03	6.55	7.7	9.27	10.56	12.72	0.8093
1963	0.32	0.61	0.96	1.73	3.04	4.96	6.44	7.91	9.62	11.31	12.74	0.9779
1964	0.33	0.55	0.95	1.86	3.25	4.97	6.41	8.07	9.34	10.16	12.89	0.9731
1965	0.38	0.68	1.03	1.49	2.41	3.52	5.73	7.54	8.47	11.17	13.72	0.775
1966	0.44	0.74	1.18	1.78	2.46	3.82	5.36	7.27	8.63	10.66	14.15	0.8112
1967	0.29	0.81	1.35	2.04	2.81	3.48	4.89	7.11	9.03	10.59	13.83	0.9165
1968	0.33	0.7	1.48	2.12	3.14	4.21	5.27	6.65	9.01	9.66	14.85	0.9272
1969	0.44	0.79	1.23	2.03	2.9	3.81	5.02	6.43	8.33	10.71	14.21	0.9506
1970	0.37	0.91	1.34	2	3	4.15	5.59	7.6	8.97	10.99	14.07	0.8953
1971	0.45	0.88	1.38	2.16	3.07	4.22	5.81	7.13	8.62	10.83	12.95	0.8061
1972	0.38	0.77	1.43	2.12	3.23	4.38	5.83	7.62	9.52	12.09	13.67	0.8459
1973	0.38	0.91	1.54	2.26	3.29	4.61	6.57	8.37	10.54	11.62	13.9	0.769
1974	0.32	0.66	1.17	2.22	3.21	4.39	5.52	7.86	9.82	11.41	13.24	0.732
1975	0.41	0.64	1.11	1.9	2.95	4.37	5.74	8.77	9.92	11.81	13.11	0.868
1976	0.35	0.73	1.19	2.01	2.76	4.22	5.88	9.3	10.28	11.86	13.54	0.7881
1977	0.49	0.9	1.43	2.05	3.3	4.56	6.46	8.63	9.93	10.9	13.67	0.936
1978	0.49	0.81	1.45	2.15	3.04	4.46	6.54	7.98	10.15	10.85	13.18	0.9183
1979	0.35	0.7	1.24	2.14	3.15	4.29	6.58	8.61	9.22	10.89	14.34	0.8238
1980	0.27	0.56	1.02	1.72	3.02	4.2	5.84	7.26	8.84	9.28	14.45	0.786
1981	0.49	0.98	1.44	2.09	2.98	4.85	6.57	9.16	10.82	10.77	13.93	0.8468
1982	0.37	0.66	1.35	1.99	2.93	4.24	6.46	8.51	12.24	10.78	14.04	0.7987
1983	0.84	1.37	2.09	2.86	3.99	5.58	7.77	9.29	11.55	16.2	17.03	1.1169
1984	1.42	1.93	2.49	3.14	3.91	4.91	6.02	7.4	8.13	8.57	8.61	1.0545
1985	0.94	1.37	2.02	3.22	4.63	6.04	7.66	9.81	11.8	14.16	14.01	0.9821
1986	0.64	1.27	1.88	2.79	4.49	5.84	6.83	7.69	9.81	10.71	12.05	0.9843
1987	0.49	0.88	1.55	2.33	3.44	5.92	8.6	9.6	12.17	13.72	13.38	0.9781
1988	0.54	0.85	1.32	2.24	3.52	5.35	8.06	9.51	11.36	14.09	16.71	0.9999

1989	0.74	0.96	1.31	1.92	2.93	4.64	7.52	9.12	11.08	11.47	16.48	1.0123
1990	0.81	1.22	1.64	2.22	3.24	4.68	7.3	9.84	13.25	16.88	11.62	0.9893
1991	1.05	1.45	2.15	2.89	3.75	4.71	6.08	8.82	11.8	16.58	16.69	1.0503
1992	1.16	1.57	2.21	3.1	4.27	5.19	6.14	7.77	10.12	11.54	14.33	0.9737
1993	0.81	1.52	2.16	2.79	4.07	5.53	6.47	7.19	7.98	10.11	14.18	0.9875
1994	0.82	1.3	2.06	2.89	3.21	5.2	6.8	7.57	8.01	9.48	11.98	0.9911
1995	0.77	1.2	1.78	2.59	3.81	4.99	6.23	8.05	8.74	9.22	12.32	0.997
1996	0.79	1.11	1.61	2.46	3.82	5.72	6.74	8.04	9.28	10.4	10.97	0.9855
1997	0.67	1.04	1.53	2.22	3.42	5.2	7.19	7.73	8.61	11.07	11.12	0.9996
1998	0.68	1.05	1.62	2.3	3.3	4.86	6.87	9.3	10.3	15.05	14.52	0.9929
1999	0.63	1.01	1.54	2.34	3.21	4.29	6	6.73	10.08	13.88	14.04	1.0033
2000	0.57	1.04	1.61	2.34	3.34	4.48	5.72	7.52	8.02	12.48	17.24	0.9961
2001	0.66	1.05	1.62	2.51	3.51	4.78	6.04	7.54	9	10.48	16.18	1.0006
2002	0.72	1.13	1.56	2.31	3.52	4.78	6.2	7.66	9.14	8.2	10.32	0.9975
2003	0.67	1.12	1.83	2.5	3.58	5.04	6.36	8.2	10.71	11.96	10.66	0.9986
2004	0.72	1.13	1.61	2.43	3.27	4.72	6.71	7.98	9.19	12.02	14.24	0.9983
2005	0.69	1.08	1.57	2.21	3.26	4.44	6.23	8.19	9.72	11.5	14.42	1.0007
2006	0.72	1.16	1.6	2.39	3.32	4.54	5.47	6.78	7.7	8.58	10.15	1.0032
2007	0.74	1.21	1.83	2.51	3.82	5.04	6.58	8.08	8.94	10.17	13.36	1.0022
2008	0.77	1.27	1.87	2.82	3.79	5.12	6.22	7.75	8.4	10.12	13.67	0.9989
2009	0.75	1.17	1.74	2.42	3.86	5.35	6.43	8.01	8.67	8.55	12.02	0.9998
2010	0.78	1.2	1.74	2.44	3.4	5.04	6.25	7.32	8.53	9.15	11.38	0.9999
2011	0.78	1.31	1.72	2.37	3.2	4.62	6.18	7.47	8.57	10.72	13.26	1

Table 3.8. Northeast Arctic COD. Stock weights at age
FLR
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YEAR_AGE	3	4	5	6	7	8	9	10	11	12	+GP
1946	0.35	0.59	1.11	1.69	2.37	3.17	3.98	5.05	5.92	7.2	8.146
1947	0.32	0.56	0.95	1.5	2.14	2.92	3.65	4.56	5.84	7.42	8.848
1948	0.34	0.53	1.26	1.93	2.46	3.36	4.22	5.31	5.92	7.09	8.43
1949	0.37	0.67	1.11	1.66	2.5	3.23	4.07	5.27	5.99	7.08	8.218
1950	0.39	0.64	1.29	1.7	2.36	3.48	4.52	5.62	6.4	7.96	8.891
1951	0.4	0.83	1.39	1.88	2.54	3.46	4.88	5.2	7.14	8.22	9.389
1952	0.44	0.8	1.33	1.92	2.64	3.71	5.06	6.05	7.42	8.43	10.185
1953	0.4	0.76	1.28	1.93	2.81	3.72	5.06	6.34	7.4	8.67	10.238
1954	0.44	0.77	1.26	1.97	3.03	4.33	5.4	6.75	7.79	10.67	9.68
1955	0.32	0.57	1.13	1.73	2.75	3.94	4.9	7.04	7.2	8.78	10.077
1956	0.33	0.58	1.07	1.83	2.89	4.25	5.55	7.28	8	8.35	9.944
1957	0.33	0.59	1.02	1.82	2.89	4.28	5.49	7.51	8.24	9.25	10.605
1958	0.34	0.52	0.95	1.92	2.94	4.21	5.61	7.35	8.67	9.58	11.631
1959	0.35	0.72	1.47	2.68	3.59	4.32	5.45	6.44	7.17	8.63	11.621
1960	0.34	0.51	1.09	2.13	3.38	4.87	6.12	8.49	7.79	8.3	11.422
1961	0.31	0.55	1.05	2.2	3.23	5.11	6.15	8.15	8.68	9.6	11.952
1962	0.32	0.55	0.93	1.7	3.03	5.03	6.55	7.7	9.27	10.56	12.717
1963	0.32	0.61	0.96	1.73	3.04	4.96	6.44	7.91	9.62	11.31	12.737
1964	0.33	0.55	0.95	1.86	3.25	4.97	6.41	8.07	9.34	10.16	12.886
1965	0.38	0.68	1.03	1.49	2.41	3.52	5.73	7.54	8.47	11.17	13.722
1966	0.44	0.74	1.18	1.78	2.46	3.82	5.36	7.27	8.63	10.66	14.148
1967	0.29	0.81	1.35	2.04	2.81	3.48	4.89	7.11	9.03	10.59	13.829
1968	0.33	0.7	1.48	2.12	3.14	4.21	5.27	6.65	9.01	9.66	14.848
1969	0.44	0.79	1.23	2.03	2.9	3.81	5.02	6.43	8.33	10.71	14.211
1970	0.37	0.91	1.34	2	3	4.15	5.59	7.6	8.97	10.99	14.074
1971	0.45	0.88	1.38	2.16	3.07	4.22	5.81	7.13	8.62	10.83	12.945
1972	0.38	0.77	1.43	2.12	3.23	4.38	5.83	7.62	9.52	12.09	13.673
1973	0.38	0.91	1.54	2.26	3.29	4.61	6.57	8.37	10.54	11.62	13.904
1974	0.32	0.66	1.17	2.22	3.21	4.39	5.52	7.86	9.82	11.41	13.242
1975	0.41	0.64	1.11	1.9	2.95	4.37	5.74	8.77	9.92	11.81	13.107
1976	0.35	0.73	1.19	2.01	2.76	4.22	5.88	9.3	10.28	11.86	13.544
1977	0.49	0.9	1.43	2.05	3.3	4.56	6.46	8.63	9.93	10.9	13.668
1978	0.49	0.81	1.45	2.15	3.04	4.46	6.54	7.98	10.15	10.85	13.177
1979	0.35	0.7	1.24	2.14	3.15	4.29	6.58	8.61	9.22	10.89	14.344
1980	0.27	0.56	1.02	1.72	3.02	4.2	5.84	7.26	8.84	9.28	14.448
1981	0.49	0.98	1.44	2.09	2.98	4.85	6.57	9.16	10.82	10.77	13.932
1982	0.37	0.66	1.35	1.99	2.93	4.24	6.46	8.51	12.24	10.78	14.041
1983	0.37	0.92	1.6	2.44	3.82	4.76	6.17	7.7	9.25	10.85	12.988
1984	0.42	1.16	1.81	2.79	3.78	4.57	6.17	7.7	9.25	10.85	13.033
1985	0.413	0.875	1.603	2.81	4.059	5.833	7.685	10.117	14.29	12.731	14.311
1986	0.311	0.88	1.47	2.467	3.915	5.81	6.58	6.833	11.004	12.731	14.311
1987	0.211	0.498	1.254	2.047	3.431	5.137	6.523	9.3	13.15	12.731	14.311
1988	0.212	0.404	0.79	1.903	2.977	4.392	7.812	12.112	13.107	12.731	14.311

1989	0.299	0.52	0.868	1.477	2.686	4.628	7.048	9.98	9.25	12.731	14.311
1990	0.398	0.705	1.182	1.719	2.458	3.565	4.71	7.801	8.956	12.731	14.311
1991	0.518	1.136	1.743	2.428	3.214	4.538	6.88	10.719	9.445	12.731	14.311
1992	0.44	0.931	1.812	2.716	3.895	5.176	6.774	9.598	12.427	12.731	14.311
1993	0.344	1.172	1.82	2.823	4.031	5.497	6.765	8.571	10.847	12.731	14.311
1994	0.235	0.753	1.42	2.413	3.825	5.416	6.631	7.63	8.112	12.731	14.311
1995	0.201	0.485	1.14	2.118	3.47	4.938	7.16	9.119	10.101	12.731	14.311
1996	0.195	0.487	0.971	2.054	3.527	5.503	7.767	10.159	10.669	12.731	14.311
1997	0.202	0.521	1.079	1.878	3.369	5.263	8.927	12.154	11.204	12.731	14.311
1998	0.217	0.533	1.161	1.939	2.945	4.574	7.423	10.367	11.738	12.731	14.311
1999	0.203	0.52	1.174	2.031	3.034	4.464	6.482	10.269	10.882	12.731	14.311
2000	0.194	0.465	1.208	1.972	3.048	4.096	5.724	7.457	9.582	12.731	14.311
2001	0.285	0.522	1.196	2.239	3.313	5.118	6.376	9.241	11.322	12.731	14.311
2002	0.251	0.605	1.189	2.138	3.333	4.766	6.859	9.333	10.186	12.731	14.311
2003	0.23	0.537	1.31	2.009	3.241	4.971	6.739	8.706	15.026	12.731	14.311
2004	0.25	0.546	1.087	2.035	2.921	4.384	6.254	8.543	9.735	12.731	14.311
2005	0.231	0.624	1.118	1.932	3.046	3.955	5.811	8.289	13.44	12.731	14.311
2006	0.256	0.602	1.201	2.009	3.114	4.427	6.03	8.037	9.928	12.731	14.311
2007	0.262	0.699	1.341	2.121	3.167	4.64	6.495	9.123	11.78	12.731	14.311
2008	0.286	0.734	1.37	2.367	3.29	4.82	6.548	8.483	8.902	12.731	14.311
2009	0.26	0.641	1.343	2.36	3.763	5.111	6.554	9.098	9.432	12.731	14.311
2010	0.257	0.589	1.183	2.052	3.181	4.8	6.759	7.859	10.008	12.731	14.311
2011	0.224	0.589	1.088	1.915	2.776	4.319	6.495	8.489	10.016	12.731	14.311

Table 3.9 North-East Arctic COD. Basis for maturity ogives (percent) used in the assessment. Norwegian and Russian data.

Norway

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

Russia

	Percentage mature							
	Age							
Year	3	4	5	6	7	8	9	10
1984	0	5	18	31	56	90	99	100
1985	0	1	10	33	59	85	92	100
1986	0	2	9	19	56	76	89	100
1987	0	1	9	23	27	61	81	80
1988	0	1	3	25	53	79	100	100
1989	0.0	0.0	2.0	15.0	39.0	59.0	83.0	100.0
1990	0.0	2.0	6.0	20.0	47.0	62.0	81.0	95.0
1991	0.0	3.0	1.0	23.0	66.0	82.0	96.0	100.0
1992	0.0	1.0	8.0	31.0	73.0	92.0	95.0	100.0
1993	0.0	3.0	7.0	21.0	56.0	89.0	95.0	99.0
1994	0.0	1.0	8.0	30.0	55.0	84.0	95.0	98.0
1995	0.0	0.0	4.0	23.0	61.0	75.0	94.0	97.0
1996	0.0	0.0	1.0	22.0	56.0	82.0	95.0	100.0
1997	0.0	0.0	1.0	10.0	48.0	73.0	90.0	100.0
1998	0.0	0.0	2.0	15.0	47.0	87.0	97.0	96.0
1999	0.0	0.2	1.3	9.9	38.4	74.9	94.0	100.0
2000	0.0	0.0	6.0	19.2	51.4	84.0	95.5	100.0
2001	0.1	0.1	3.9	27.9	62.3	89.4	96.3	100.0
2002	0.1	1.9	10.9	34.4	68.1	82.8	97.6	100.0
2003	0.2	0.0	11.0	29.2	65.9	89.6	95.1	100.0
2004	0.0	0.7	8.0	33.8	63.3	83.4	96.4	96.4
2005	0.0	0.6	4.6	24.2	61.5	84.9	95.3	98.1
2006	0.0	0.0	6.1	29.6	59.6	89.5	96.4	100.0
2007	0.0	0.4	5.7	20.8	60.4	83.5	96.0	100.0
2008	0.0	0.5	4.0	24.6	48.3	84.4	94.7	98.7
2009	0.0	0.0	6.0	28.0	66.0	85.0	97.0	100.0
2010	0.0	0.2	1.5	22.8	47.0	77.4	90.2	95.5
2011	0.0	0.0	2.2	20.7	50.4	73.7	90.6	95.6
2012	0.2	0	1.5	10.8	43.9	76.1	90.8	96.4

Table 3.9 (continued). 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
1985	0.31	1.36	8.94	38.33	51.27	85.13	100	79.2
1986	2.92	7	7.85	18.85	49.72	66.52	35.59	80.09
1987	0	0.07	4.49	12.42	16.28	31.23	19.32	
1988	0	2.35	6.16	40.54	53.63	45.36	100	100
1989	1.52	0.67	3.88	30.65	70.36	82.02	100.00	100.00
1990	1.52	0.67	4.18	22.00	57.45	80.95	100.00	100.00
1991	0.10	3.40	13.93	38.03	75.52	90.12	95.39	100.00
1992	0.22	1.85	21.04	52.83	86.95	96.52	99.83	100.00
1993	0.00	2.60	10.37	52.60	84.80	97.25	99.30	99.73
1994	0.51	0.33	15.78	36.92	62.84	88.44	97.56	100.00
1995	0.00	0.62	8.19	51.48	63.75	81.11	98.01	99.34
1996	0.03	0.00	2.82	29.56	70.22	82.06	100.00	100.00
1997	0.00	0.00	1.48	17.91	73.31	93.01	99.12	100.00
1998	0.12	0.68	3.17	15.42	47.31	75.73	94.30	100.00
1999	0.42	0.16	1.60	27.46	70.48	94.57	98.99	100.00
2000	0.00	0.11	8.15	30.23	77.30	81.95	100.00	100.00
2001	0.49	0.51	9.03	43.81	62.52	74.36	94.13	100.00
2002	0.27	0.73	5.94	43.22	68.40	85.31	92.52	100.00
2003	0.02	0.18	6.50	35.97	68.56	87.97	96.30	100.00
2004	0.24	1.36	10.23	54.56	81.84	90.94	98.76	98.91
2005	0.00	0.27	9.00	55.16	81.77	93.51	98.03	100.00
2006	0.00	0.22	5.92	44.25	69.85	89.89	96.65	100.00
2007	0.12	0.33	8.70	47.88	84.29	91.68	99.11	100.00
2008	0.00	0.27	9.27	34.13	61.39	88.04	91.17	100.00
2009	0.00	0.00	9.00	46.00	85.00	86.00	98.00	99.00
2010	0.00	0.36	7.50	41.75	67.70	90.10	95.29	98.55
2011	0.00	0.20	5.20	48.00	77.70	89.70	97.30	97.20
2012	0.00	0.00	7.70	32.20	67.50	81.00	90.90	96.30

Table 3.10. Northeast Arctic cod. Proportion mature at age
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YEAR_AGE	3	4	5	6	7	8	9	10	11	12	+GP
1946	0	0	0.01	0.03	0.06	0.11	0.18	0.44	0.65	0.86	0.96
1947	0	0	0.01	0.03	0.06	0.13	0.16	0.42	0.75	0.91	0.95
1948	0	0	0.01	0.03	0.07	0.13	0.25	0.47	0.73	0.91	0.97
1949	0	0	0.01	0.03	0.09	0.17	0.29	0.54	0.79	0.88	0.97
1950	0	0	0.01	0.03	0.09	0.23	0.35	0.52	0.79	0.95	0.97
1951	0	0	0.01	0.03	0.1	0.24	0.4	0.58	0.72	0.85	0.96
1952	0	0	0.01	0.03	0.08	0.22	0.41	0.63	0.82	0.92	0.97
1953	0	0	0.01	0.03	0.07	0.19	0.4	0.64	0.84	0.94	0.97
1954	0	0	0.01	0.03	0.08	0.16	0.37	0.68	0.87	0.93	0.96
1955	0	0	0.01	0.03	0.07	0.13	0.26	0.53	0.83	0.92	0.97
1956	0	0	0.01	0.03	0.06	0.12	0.14	0.41	0.67	0.91	0.96
1957	0	0	0.01	0.03	0.06	0.09	0.12	0.22	0.6	0.82	0.97
1958	0	0	0.01	0.03	0.06	0.1	0.1	0.3	0.5	0.82	0.97
1959	0	0	0.01	0.04	0.12	0.34	0.49	0.67	0.84	0.87	1
1960	0	0.01	0.03	0.06	0.1	0.19	0.45	0.69	0.77	0.85	0.99
1961	0	0	0.01	0.06	0.12	0.31	0.65	0.91	0.98	0.98	1
1962	0	0	0.01	0.05	0.15	0.34	0.61	0.81	0.92	0.97	1
1963	0	0.01	0.01	0.03	0.07	0.28	0.42	0.81	0.98	0.98	1
1964	0	0	0	0.03	0.13	0.37	0.66	0.89	0.95	0.99	1
1965	0	0	0	0.01	0.06	0.2	0.55	0.73	0.99	0.98	1
1966	0	0	0.01	0.02	0.06	0.22	0.35	0.74	0.94	0.94	1
1967	0	0	0	0.03	0.07	0.14	0.38	0.64	0.89	0.9	1
1968	0	0	0.03	0.05	0.09	0.19	0.39	0.58	0.82	1	1
1969	0	0	0	0.02	0.04	0.12	0.34	0.55	0.74	0.95	1
1970	0	0.01	0	0.01	0.07	0.23	0.58	0.81	0.89	0.91	1
1971	0	0	0.01	0.05	0.11	0.3	0.59	0.79	0.86	0.88	1
1972	0.01	0.02	0.02	0.01	0.1	0.34	0.64	0.81	0.94	1	1
1973	0	0	0	0.02	0.16	0.53	0.81	0.92	0.95	0.98	1
1974	0	0	0	0.01	0.03	0.21	0.5	0.96	1	0.96	1
1975	0	0	0.01	0.02	0.09	0.21	0.56	0.78	0.79	0.95	1
1976	0	0	0	0.05	0.12	0.29	0.45	0.84	0.83	1	0.9
1977	0	0	0.02	0.08	0.26	0.54	0.76	0.87	0.93	0.94	0.9
1978	0	0	0	0.02	0.13	0.44	0.71	0.77	0.81	0.89	0.8
1979	0	0	0	0.03	0.13	0.39	0.77	0.89	0.83	0.78	0.9
1980	0	0	0	0.02	0.13	0.35	0.65	0.82	1	0.9	0.9
1981	0	0	0.02	0.07	0.2	0.54	0.8	0.97	1	1	1
1982	0	0.05	0.1	0.34	0.65	0.82	0.92	1	1	1	1
1983	0.01	0.08	0.1	0.3	0.73	0.88	0.97	1	1	1	1
1984	0	0.05	0.18	0.31	0.56	0.9	0.99	1	1	1	1
1985	0	0.01	0.09	0.36	0.55	0.85	0.96	0.9	1	1	1
1986	0	0.05	0.08	0.19	0.53	0.71	0.62	0.9	1	1	1
1987	0	0.01	0.07	0.18	0.22	0.46	0.5	0.75	1	1	1
1988	0	0.02	0.05	0.33	0.53	0.62	1	1	1	1	1
1989	0.008	0.003	0.029	0.228	0.547	0.705	0.915	1	1	1	1

1990	0.008	0.013	0.051	0.21	0.522	0.715	0.905	0.975	1	1	1
1991	0.001	0.032	0.075	0.305	0.708	0.861	0.957	1	1	1	1
1992	0.001	0.014	0.145	0.419	0.8	0.943	0.974	1	1	1	1
1993	0	0.028	0.087	0.368	0.704	0.931	0.972	0.994	1	1	1
1994	0.003	0.007	0.119	0.335	0.589	0.862	0.963	0.99	1	1	1
1995	0	0.003	0.061	0.372	0.624	0.781	0.96	0.979	1	1	1
1996	0	0	0.019	0.258	0.631	0.82	0.975	1	1	1	1
1997	0	0	0.012	0.14	0.607	0.83	0.946	1	1	1	1
1998	0.001	0.003	0.026	0.152	0.472	0.814	0.957	0.98	1	1	1
1999	0.002	0.002	0.014	0.187	0.544	0.847	0.965	1	1	1	1
2000	0	0.001	0.071	0.247	0.643	0.83	0.978	1	1	1	1
2001	0.003	0.003	0.065	0.359	0.624	0.819	0.952	1	1	1	1
2002	0.002	0.013	0.084	0.388	0.683	0.841	0.951	1	1	1	1
2003	0.001	0.001	0.088	0.326	0.672	0.888	0.957	1	1	1	1
2004	0.001	0.01	0.091	0.442	0.726	0.872	0.976	0.977	1	1	1
2005	0	0.004	0.068	0.397	0.716	0.892	0.967	0.991	1	1	1
2006	0	0.001	0.06	0.369	0.647	0.897	0.965	1	1	1	1
2007	0	0.004	0.072	0.343	0.723	0.876	0.976	1	1	1	1
2008	0	0.004	0.062	0.282	0.538	0.863	0.928	0.994	1	1	1
2009	0	0	0.076	0.372	0.755	0.857	0.977	0.997	0.981	1	1
2010	0	0.003	0.045	0.323	0.573	0.838	0.927	0.97	0.974	0.986	1
2011	0	0.001	0.037	0.343	0.64	0.817	0.94	0.964	0.991	0.989	1

Table 3.11. Northeast Arctic COD. Total number of cod (million) consumed by cod, by year and prey age group.
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Year_age	1	2	3	4	5	6
1984	418	21	0	0	0	0
1985	376	67	0	0	0	0
1986	968	392	99	0	0	0
1987	183	281	14	0	0	0
1988	411	22	2	0	0	0
1989	144	0	0	0	0	0
1990	126	28	0	0	0	0
1991	152	215	2	0	0	0
1992	1028	155	4	0	0	0
1993	20244	512	52	1	0	0
1994	6882	641	131	52	8	0
1995	15232	757	211	67	4	0
1996	21842	1509	145	57	21	1
1997	15996	1862	176	17	1	0
1998	4855	536	211	25	2	1
1999	1841	297	52	4	0	0
2000	2240	172	37	14	4	0
2001	2271	113	24	12	2	1
2002	459	395	41	6	1	0
2003	4422	107	23	0	0	0
2004	2348	536	20	11	2	0
2005	3134	140	86	5	6	1
2006	2241	155	6	2	0	0
2007	1268	209	87	4	0	0
2008	789	100	113	37	5	0
2009	8358	157	83	27	7	0
2010	8734	301	62	36	26	3
2011	5177	450	172	53	17	8

Table 3.12. North-East Arctic COD. Tuning data.

FLT09:	Russian	trawl	catch	and	effort	ages	9	-	11	(Catch:	Thousa	(Catch:	Unknown)	(Effort:	Unknown)
1 985	2 011														
1	1	0	1												
9	11														
	0.7	291	77	30											
	1.52	87	59	22											
	2.1	127	95	37											
	2.75	442	215	53											
	2.12	140	47	11											
	1.11	204	49	14											
	1.56	791	71	16											
	2.5	3852	689	62											
	2.64	2019	1778	68											
	2.96	1237	595	167											
	3.88	684	345	146											
	3.73	364	164	34											
	4.92	488	99	34											
	6.77	559	88	34											
	6.39	882	171	0											
	4.25	742	185	25											
	3.5	235	95	35											
	3.15	336	61	18											
	2.34	319	83	19											
	3.47	710	262	56											
	3.54	588	203	57											
	3.64	1182	183	102											
	2.69	554	244	83											
	2	1741	556	175											
	2.05	1075	529	147											
	2.08	1533	627	222											
	1.66	2740	990	526											
FLT15: NorBarTrSur rev99 (Catch: Unknown) (Effort: Unknown)															
1 980	2011														
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								
	1	541	1221	1399	956	168	39								
	1	684	448	873	1241	531	79								

Table 3.12. (continued)

FLT16: NorBarLofAcSur rev99 (Catch: Unknown) (Effort: Unknown)								
1 984	2011							
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
	1	291	824	1587	2843	656	226	61
	1	527	381	828	2244	1547	309	108
FLT18: RusSweptArea rev05 (ages 3-9) (Catch: Unknown) ((Catch: Unknown) (Effort: Unknown)								
1 982	2011							
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	
1	543	1385	3668	2698	1455	603	446	
1	882	508	1432	3065	3300	917	439	

Table 3.13. 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 (done in VPA95).

		FLT 09	FLT 15	FLT 16	FLT 18	Final run
		Rus trawl	Joint BT	Joint+Lof	Rus BT	ALL
		CPUE	survey	Ac survey	survey	Fleets
Ages with fleet data		9 to 11	3 to 8	3 to 9	3 to 9	3 to 11
age3	PshrinkW	**0.91**	**0.31**	**0.30**	**0.43**	0.13
	FshrinkW	0.09	0.07	0.07	0.06	0.03
age4	PshrinkW	**0.89**	0.17	0.18	0.28	0.08
	FshrinkW	0.11	0.05	0.05	0.04	0.02
age5	PshrinkW	**0.88**	0.09	0.09	0.19	0.04
	FshrinkW	0.12	0.03	0.04	0.03	0.01
age6	PshrinkW	**0.84**	0.08	0.07	0.17	0.03
	FshrinkW	0.16	0.03	0.03	0.03	0.01
age7	FshrinkW	**1**	0.03	0.03	0.04	0.01
age8	FshrinkW	**1**	0.03	0.03	0.03	0.01
age9	FshrinkW	0.17	0.05	0.04	0.04	0.01
age10	FshrinkW	0.11	0.06	0.06	0.04	0.02
age11	FshrinkW	0.07	0.15	0.08	0.06	0.03
age12	FshrinkW	0.12	**0.37**	**0.31**	0.09	0.07
2011	F(5-10)	0.315	0.241	0.265	0.272	0.272
TSB2011	incl Age1-2	3339	4288	4293	3705	3883
SSB2011	('000 T)	1649	2059	2044	1952	1879
N2012	yc2009	759890	895870	911300	768450	828080
N*10^-3	yc2008	523930	471630	511090	477060	412990
with	yc2007	344550	262820	274320	243440	206460
shrinkage	yc2006	213920	331730	328110	224550	278410
	yc2005	131400	322640	315820	211380	306090
	yc2004	152550	267420	279170	161690	230490
	yc2003	37300	70390	68100	58100	60940
	yc2002	40000	24830	27710	28820	23920
	yc2001	14550	12330	7300	17610	9380
		No	**shrinkage**			**Shrinkage**
Survivors	yc2008		383979	438483	421527	412988
end of 2011	yc2007		229709	240420	198989	206463
direct	yc2006		346200	342837	221834	278408
predic.	yc2005		353388	344934	233974	306085
by the	yc2004		271744	284571	161024	230495
survey	yc2003		71975	69713	58492	60937
N*10^-3	yc2002	45650	25006	28005	28674	23924
	yc2001	15195	12390	7073	17549	9379
F2011	yc2008		0.298	0.266	0.275	0.280
	yc2007		0.199	0.191	0.226	0.219
direct	yc2006		0.120	0.121	0.182	0.147
predic.	yc2005		0.183	0.187	0.264	0.207
by the	yc2004		0.217	0.208	0.343	0.251
survey	yc2003		0.233	0.239	0.279	0.269
	yc2002	0.207	0.350	0.318	0.312	0.363
	yc2001	0.262	0.312	0.496	0.230	0.395
2011	F(5-10)		0.236	0.262	0.268	0.272

Table 3.14. Northeast Arctic Cod. Diagnostics for final XSA.

Lowestoft VPA Version 3.1

21/04/2012 14:44

Extended Survivors Analysis

Arctic Cod (run: XSAASA01/X01)

CPUE data from file fleet

Catch data for 28 years. 1984 to 2011. Ages 1 to 13.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLT09: Russian trawl	2002	2011	9	11	0	1
FLT15: NorBarTrSur r	2002	2011	3	8	0.99	1
FLT16: NorBarLofAcSu	2002	2011	3	9	0.99	1
FLT18: RusSweptArea	2002	2011	3	9	0.9	1

Time series weights :

Tapered time weighting applied
Power = 3 over 10 years

Catchability analysis :

Catchability dependent on stock size for ages < 7

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

Catchability independent of age for ages >= 10

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 2 oldest ages.

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

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

Prior weighting not applied

Tuning had not converged after 150 iterations

Total absolute residual between iterations
149 and 150 = .00485

Final year F values

Age	1	2	3	4	5	6	7	8	9	10
Iteration **	1.514	0.3391	0.2798	0.2194	0.1471	0.2065	0.2498	0.2694	0.3632	0.3957
Iteration **	1.5148	0.3395	0.2798	0.219	0.1473	0.2073	0.2509	0.2695	0.3632	0.3953

Age	11	12
Iteration **	0.3323	0.3498
Iteration **	0.3322	0.3494

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	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.606	1.403	1.215	0.927	0.786	0.748	0.657	2.008	1.819	1.515
2	0.407	0.27	0.605	0.192	0.1	0.149	0.113	0.256	0.312	0.34
3	0.11	0.048	0.081	0.193	0.027	0.097	0.121	0.134	0.162	0.28
4	0.107	0.071	0.103	0.123	0.148	0.116	0.103	0.087	0.113	0.219
5	0.287	0.274	0.257	0.385	0.245	0.286	0.155	0.144	0.147	0.147
6	0.556	0.469	0.524	0.553	0.472	0.309	0.256	0.234	0.181	0.207
7	0.804	0.678	0.74	0.801	0.611	0.392	0.269	0.237	0.294	0.251
8	0.894	0.696	0.879	0.779	0.745	0.452	0.435	0.257	0.313	0.269
9	0.821	0.583	0.792	0.908	0.708	0.434	0.418	0.339	0.227	0.363
10	0.723	0.552	0.878	0.81	0.722	0.274	0.345	0.256	0.273	0.395
11	0.564	0.427	0.776	0.804	0.652	0.454	0.223	0.28	0.803	0.332
12	0.649	0.515	0.873	0.665	0.829	0.569	0.383	0.546	0.533	0.349

Table 3.14 (continued)

XSA population numbers (Thousands)										
AGE										
YEAR	1	2	3	4	5	6	7	8	9	10
2002	1.12E+06	1.31E+06	4.60E+05	4.04E+05	3.42E+05	1.75E+05	8.43E+04	2.16E+04	3.56E+03	1.14E+03
2003	6.50E+06	5.00E+05	7.14E+05	3.38E+05	2.97E+05	2.10E+05	8.24E+04	3.09E+04	7.22E+03	1.28E+03
2004	3.69E+06	1.31E+06	3.13E+05	5.57E+05	2.58E+05	1.85E+05	1.07E+05	3.42E+04	1.26E+04	3.30E+03
2005	5.69E+06	8.96E+05	5.85E+05	2.36E+05	4.12E+05	1.63E+05	8.98E+04	4.20E+04	1.16E+04	4.67E+03
2006	4.56E+06	1.84E+06	6.05E+05	3.95E+05	1.71E+05	2.29E+05	7.68E+04	3.30E+04	1.58E+04	3.84E+03
2007	2.66E+06	1.70E+06	1.37E+06	4.83E+05	2.79E+05	1.09E+05	1.17E+05	3.41E+04	1.28E+04	6.36E+03
2008	1.67E+06	1.03E+06	1.20E+06	1.02E+06	3.52E+05	1.72E+05	6.57E+04	6.47E+04	1.78E+04	6.80E+03
2009	1.01E+07	7.10E+05	7.54E+05	8.70E+05	7.50E+05	2.47E+05	1.09E+05	4.11E+04	3.43E+04	9.58E+03
2010	1.07E+07	1.11E+06	4.50E+05	5.40E+05	6.53E+05	5.32E+05	1.60E+05	7.02E+04	2.60E+04	2.00E+04
2011	6.80E+06	1.42E+06	6.67E+05	3.14E+05	3.95E+05	4.62E+05	3.63E+05	9.75E+04	4.20E+04	1.70E+04
Estimated population abundance at 1st Jan 2012										
	0.00E+00	1.22E+06	8.28E+05	4.13E+05	2.06E+05	2.78E+05	3.06E+05	2.30E+05	6.09E+04	2.39E+04
Taper weighted geometric mean of the VPA populations:										
	5.12E+06	1.16E+06	7.24E+05	5.19E+05	3.97E+05	2.48E+05	1.24E+05	5.16E+04	2.12E+04	8.33E+03
Standard error of the weighted Log(VPA populations) :										
	0.7116	0.3568	0.445	0.4977	0.4957	0.577	0.5903	0.4318	0.529	0.7123
AGE										
YEAR	11	12								
2002	5.72E+02	2.78E+02								
2003	4.51E+02	2.66E+02								
2004	6.04E+02	2.41E+02								
2005	1.12E+03	2.28E+02								
2006	1.70E+03	4.12E+02								
2007	1.53E+03	7.26E+02								
2008	3.96E+03	7.95E+02								
2009	3.95E+03	2.59E+03								
2010	6.08E+03	2.44E+03								
2011	1.25E+04	2.23E+03								
Estimated population abundance at 1st Jan 2012										
	9.38E+03	7.33E+03								
Taper weighted geometric mean of the VPA populations:										
	3.27E+03	1.04E+03								
Standard error of the weighted Log(VPA populations) :										
	0.9606	0.9569								
1										
Log catchability residuals.										
Fleet : FLT09: Russian trawl										
Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	0.37	-0.19	-0.25	-0.34	-0.05	-0.42	0.69	-0.51	0.05	0.44
10	-0.11	0.3	0.25	-0.4	-0.37	-0.48	0.6	0.14	-0.43	0.47
11	-0.71	-0.18	0.36	-0.25	-0.17	-0.06	-0.07	-0.24	-0.04	0.12
Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time										
Age	9	10	11							
Mean Log q	-3.4112	-3.5382	-3.5382							
S.E(Log q)	0.4594	0.4665	0.1846							

Table 3.14 (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			
9	0.84	0.481	4.49	0.67	10	0.42	-3.41			
10	0.95	0.179	3.83	0.72	10	0.49	-3.54			
11	0.96	0.514	3.79	0.97	10	0.17	-3.61			
1										
Fleet : FLT15: NorBarTrSur r										
Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	0.54	0.27	0.36	0.25	-0.11	0.15	-0.02	-0.08	-0.05	-0.18
4	0.23	-0.01	-0.03	-0.18	-0.02	0.06	-0.06	-0.08	0.19	-0.01
5	0.24	0.08	-0.22	-0.19	-0.18	0.19	0.02	-0.12	0.02	0.18
6	0.1	0.14	-0.09	-0.23	-0.24	0.17	-0.03	0.08	-0.12	0.22
7	-0.04	0.3	-0.43	-0.11	-0.16	-0.19	0	0.03	0.04	0.33
8	0.15	0.12	-0.23	-0.29	0.16	-0.06	0.18	0.12	-0.25	0.09
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	7	8								
Mean Log q	-6.4105	-6.7372								
S.E(Log q)	0.2082	0.1918								
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	0.74	1.41	8.02	0.88	10	0.19	-6.14			
4	0.83	1.544	7.22	0.95	10	0.12	-6.02			
5	0.72	1.843	7.96	0.91	10	0.17	-6.02			
6	0.69	2.124	8.07	0.92	10	0.19	-6.11			
Ages with q independent of year class strength and constant w.r.t. time.										
Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q			
7	0.81	1.925	7.44	0.96	10	0.14	-6.41			
8	0.99	0.028	6.76	0.84	10	0.21	-6.74			
1										
Fleet : FLT16: NorBarLofAcSu										
Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	0.64	0.05	0.33	0.08	-0.3	0.08	-0.07	0.19	-0.07	-0.07
4	0.65	-0.19	-0.17	-0.32	-0.31	0.53	-0.23	0.08	0.03	0.1
5	0.67	0.05	-0.09	-0.32	-0.22	0.45	-0.14	-0.01	-0.01	0.08
6	0.45	0.02	0.13	-0.31	-0.13	0.17	-0.01	-0.03	0.04	0.05
7	0.3	0.25	-0.21	-0.07	-0.23	0.01	-0.45	0.06	0.29	0.28
8	0.01	0.3	0.21	0.07	0.12	-0.46	0.38	-0.2	0.04	-0.02
9	-0.12	0.42	-0.13	0.35	0.23	-0.06	-0.13	0	-0.2	0.03
10	No data for this fleet at this age									
11	No data for this fleet at this age									

Table 3.14 (continued)

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

Age	7	8	9
Mean Log q	-5.2907	-5.2646	-5.4337
S.E(Log q)	0.2774	0.2694	0.1832

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
3	0.55	2.369	9.62	0.87	10	0.19	-6.47
4	0.71	1.032	8.21	0.75	10	0.32	-6.23
5	0.65	1.559	8.38	0.82	10	0.26	-5.94
6	0.62	3.359	8.02	0.95	10	0.15	-5.37

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
7	0.72	2.936	7.08	0.96	10	0.13	-5.29
8	0.84	0.677	6.17	0.8	10	0.24	-5.26
9	1.11	-0.622	4.93	0.88	10	0.22	-5.43
1							

Fleet : FLT18: RusSweptArea

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	0.34	0.04	-0.12	0.44	-0.03	-0.01	0.01	-0.14	-0.05	0.01
4	0.27	0.13	0.01	0.07	0.41	0.19	0.01	-0.1	-0.07	-0.33
5	-0.03	-0.14	-0.3	0.11	-0.03	0.44	-0.08	-0.01	0.13	-0.34
6	-0.22	-0.1	-0.01	-0.42	0.4	-0.16	0.11	0.16	-0.26	0.1
7	0.07	-0.14	0.03	0.02	0.08	0.29	0.14	-0.05	-0.16	-0.21
8	0.17	-0.1	0.12	-0.31	0.23	0.4	0.19	0.14	-0.36	-0.32
9	-0.08	-0.7	-0.21	-0.08	0.03	0.32	0.23	-0.15	0.1	-0.27
10	No data for this fleet at this age									
11	No data for this fleet at this age									

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

Age	7	8	9
Mean Log q	-4.0649	-3.9054	-3.7572
S.E(Log q)	0.1765	0.31	0.2422

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	0.76	1.426	7.89	0.9	10	0.17	-6.17
4	0.9	0.471	6.38	0.83	10	0.25	-5.6
5	1.03	-0.109	4.75	0.8	10	0.28	-4.96
6	1.43	-2.055	1.13	0.84	10	0.28	-4.51

Table 3.14 (continued)

Ages with q independent of year class strength and constant w.r.t. time.							
Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
7	1.26	-1.946	2.09	0.93	10	0.18	-4.06
8	1.99	-1.995	-2.99	0.49	10	0.49	-3.91
9	1.22	-0.898	2.38	0.79	10	0.3	-3.76
1							
Terminal year survivor and F summaries :							
Age 1 Catchability dependent on age and year class strength							
Year class = 2010							
Fleet	Es	Int	Ext	Var	N	Scaled	Estimated
	Su	s.e	s.e	Ratio		Weights	F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	1	0	0	0	0	0	0
FLT16: NorBarLofAcSu	1	0	0	0	0	0	0
FLT18: RusSweptArea	1	0	0	0	0	0	0
P shrinkage mean	1162649	0.36				0.887	1.555
F shrinkage mean	1824489	1				0.113	1.218
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
1223357	0.34	14.02	2	41.708	1.515		
1							
Age 2 Catchability dependent on age and year class strength							
Year class = 2009							
Fleet	Es	Int	Ext	Var	N	Scaled	Estimated
	Su	s.e	s.e	Ratio		Weights	F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	1	0	0	0	0	0	0
FLT16: NorBarLofAcSu	1	0	0	0	0	0	0
FLT18: RusSweptArea	1	0	0	0	0	0	0
P shrinkage mean	723942	0.44				0.835	0.38
F shrinkage mean	1632477	1				0.165	0.187
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
828082	0.41	13.63	2	33.526	0.34		
Age 3 Catchability dependent on age and year class strength							
Year class = 2008							
Fleet	Es	Int	Ext	Var	N	Scaled	Estimated
	Su	s.e	s.e	Ratio		Weights	F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	345302	0.3	0	0	1	0.278	0.327
FLT16: NorBarLofAcSu	385368	0.3	0	0	1	0.278	0.297
FLT18: RusSweptArea	419229	0.3	0	0	1	0.278	0.276
P shrinkage mean	519079	0.5				0.134	0.229
F shrinkage mean	1163405	1				0.033	0.109
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
412988	0.16	0.12	5	0.747	0.28		

Table 3.14 (continued)

Age 4 Catchability dependent on age and year class strength							
Year class = 2007							
Fleet	Es	Int	Ext	Var	N	Scaled	Estimated
	Su	s.e	s.e	Ratio		Weights	F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	200665	0.213	0.019	0.09	2	0.324	0.224
FLT16: NorBarLofAcSu	207746	0.23	0.082	0.36	2	0.274	0.218
FLT18: RusSweptArea	170158	0.22	0.141	0.64	2	0.303	0.26
P shrinkage mean	397252	0.5				0.08	0.12
F shrinkage mean	419107	1				0.02	0.114
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
206463	0.12	0.1	8	0.808	0.219		

Age 5 Catchability dependent on age and year class strength							
Year class = 2006							
Fleet	Es	Int	Ext	Var	N	Scaled	Estimated
	Su	s.e	s.e	Ratio		Weights	F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	311956	0.175	0.085	0.48	3	0.326	0.133
FLT16: NorBarLofAcSu	307956	0.182	0.046	0.25	3	0.301	0.134
FLT18: RusSweptArea	231656	0.176	0.083	0.47	3	0.321	0.175
P shrinkage mean	248086	0.58				0.038	0.164
F shrinkage mean	203888	1				0.013	0.196
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
278408	0.1	0.06	11	0.548	0.147		
1							

Age 6 Catchability dependent on age and year class strength							
Year class = 2005							
Fleet	Es	Int	Ext	Var	N	Scaled	Estimated
	Su	s.e	s.e	Ratio		Weights	F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	322711	0.153	0.066	0.43	4	0.338	0.198
FLT16: NorBarLofAcSu	310740	0.16	0.029	0.18	4	0.311	0.205
FLT18: RusSweptArea	317669	0.16	0.052	0.33	4	0.308	0.201
P shrinkage mean	123896	0.59				0.033	0.452
F shrinkage mean	208398	1				0.011	0.292
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
306085	0.09	0.05	14	0.609	0.207		

Age 7 Catchability constant w.r.t. time and dependent on age							
Year class = 2004							
Fleet	Es	Int	Ext	Var	N	Scaled	Estimated
	Su	s.e	s.e	Ratio		Weights	F
FLT09: Russian trawl	1	0	0	0	0	0	0
FLT15: NorBarTrSur r	243097	0.141	0.097	0.69	5	0.342	0.24
FLT16: NorBarLofAcSu	248624	0.145	0.08	0.55	5	0.323	0.235
FLT18: RusSweptArea	204977	0.145	0.058	0.4	5	0.324	0.279
F shrinkage mean	150722	1				0.011	0.363
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
230495	0.08	0.05	16	0.583	0.251		

Table 3.15. Northeast Arctic COD. Fishing mortality for XSA run down to age 1. Number of cod eaten by cod included in catch matrix.

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Year_age	1	2	3	4	5	6	7	8	9	10	11	12	+gp
1946	0	0	0.006	0.02	0.053	0.097	0.177	0.192	0.312	0.278	0.342	0.312	0.312
1947	0	0	0.002	0.025	0.109	0.201	0.416	0.253	0.404	0.44	0.786	0.618	0.618
1948	0	0	0	0.012	0.075	0.199	0.52	0.353	0.528	0.36	0.554	0.46	0.46
1949	0	0	0.002	0.021	0.148	0.365	0.51	0.386	0.382	0.375	0.625	0.504	0.504
1950	0	0	0.002	0.032	0.116	0.287	0.409	0.347	0.473	0.502	0.907	0.711	0.711
1951	0	0	0.025	0.16	0.263	0.278	0.411	0.403	0.504	0.513	0.456	0.488	0.488
1952	0	0	0.022	0.166	0.369	0.55	0.531	0.416	0.578	0.762	1.03	0.906	0.906
1953	0	0	0.033	0.132	0.229	0.311	0.323	0.345	0.391	0.535	0.698	0.622	0.622
1954	0	0	0.02	0.145	0.266	0.332	0.396	0.248	0.434	0.643	0.804	0.73	0.73
1955	0	0	0.016	0.083	0.284	0.529	0.513	0.587	0.579	0.764	0.762	0.77	0.77
1956	0	0	0.027	0.128	0.456	0.691	0.613	0.688	0.655	0.737	0.877	0.815	0.815
1957	0	0	0.024	0.112	0.208	0.485	0.549	0.628	0.545	0.632	0.859	0.753	0.753
1958	0	0	0.071	0.258	0.361	0.551	0.535	0.458	0.452	0.739	0.843	0.799	0.799
1959	0	0	0.053	0.255	0.509	0.511	0.524	0.509	0.612	0.684	0.65	0.673	0.673
1960	0	0	0.054	0.225	0.346	0.459	0.434	0.483	0.402	0.736	0.844	0.798	0.798
1961	0	0	0.056	0.27	0.492	0.515	0.526	0.69	0.736	0.835	1.001	0.928	0.928
1962	0	0	0.066	0.305	0.648	0.827	0.607	0.655	0.812	0.982	0.948	0.976	0.976
1963	0	0	0.031	0.236	0.743	1.011	0.978	0.879	0.943	1.376	1.441	1.426	1.426
1964	0	0	0.017	0.144	0.353	0.484	0.578	0.74	1.07	0.849	1.303	1.088	1.088
1965	0	0	0.022	0.11	0.39	0.448	0.401	0.528	0.737	0.807	0.763	0.793	0.793
1966	0	0	0.039	0.103	0.21	0.38	0.469	0.577	0.717	0.816	0.499	0.663	0.663
1967	0	0	0.03	0.152	0.18	0.201	0.429	0.683	0.876	0.884	1.231	1.07	1.07
1968	0	0	0.025	0.205	0.407	0.466	0.399	0.525	0.802	0.805	0.672	0.746	0.746
1969	0	0	0.023	0.228	0.478	0.537	0.771	0.93	1.179	1.079	1.562	1.338	1.338
1970	0	0	0.041	0.141	0.4	0.567	0.619	0.846	0.968	1.09	0.854	0.983	0.983
1971	0	0	0.021	0.102	0.228	0.251	0.513	0.831	0.956	0.785	0.834	0.818	0.818
1972	0	0	0.039	0.166	0.296	0.384	0.341	0.656	1.137	1.345	1.297	1.338	1.338
1973	0	0	0.195	0.198	0.352	0.39	0.42	0.738	0.971	0.737	0.72	0.736	0.736
1974	0	0	0.213	0.495	0.536	0.506	0.443	0.485	0.518	0.885	0.992	0.949	0.949
1975	0	0	0.083	0.209	0.52	0.701	0.702	0.701	0.609	0.715	0.911	0.822	0.822
1976	0	0	0.165	0.31	0.478	0.57	0.694	0.888	0.771	0.457	0.613	0.539	0.539
1977	0	0	0.133	0.566	0.754	0.684	0.674	0.909	1.231	0.761	0.617	0.696	0.696
1978	0	0	0.145	0.222	0.67	0.85	0.858	0.929	1.308	1.027	1.811	1.438	1.438
1979	0	0	0.049	0.208	0.345	0.546	0.662	0.777	1.036	0.981	1.433	1.222	1.222
1980	0	0	0.031	0.129	0.354	0.62	0.673	0.709	0.937	1.039	1.484	1.278	1.278
1981	0	0	0.025	0.099	0.228	0.514	0.846	1.079	1.282	1.234	0.957	1.108	1.108
1982	0	0	0.067	0.211	0.302	0.549	0.797	0.985	1.162	0.75	0.953	0.861	0.861
1983	0	0	0.021	0.204	0.329	0.5	0.779	1.029	0.971	0.921	0.582	0.759	0.759
1984	0.246	0.037	0.02	0.124	0.307	0.627	1.136	1.211	1.262	0.958	1.088	1.035	1.035
1985	0.359	0.058	0.053	0.17	0.376	0.605	0.925	1.019	0.779	0.506	0.42	0.467	0.467
1986	0.938	0.802	0.145	0.212	0.493	0.705	0.948	1.091	0.828	1.112	0.875	1.005	1.005
1987	0.527	0.803	0.114	0.229	0.51	0.936	1.14	1.014	0.778	1.324	1.027	1.19	1.19
1988	0.806	0.11	0.063	0.127	0.37	0.597	1.045	0.983	1.159	1.718	1.537	1.65	1.65
1989	0.216	0.001	0.033	0.128	0.266	0.402	0.716	0.889	0.717	0.986	0.582	0.792	0.792
1990	0.096	0.06	0.009	0.062	0.134	0.231	0.25	0.374	0.306	0.324	0.54	0.435	0.435
1991	0.102	0.237	0.018	0.062	0.187	0.321	0.426	0.345	0.38	0.256	0.134	0.196	0.196
1992	0.474	0.145	0.04	0.127	0.221	0.443	0.54	0.599	0.456	0.459	0.248	0.356	0.356
1993	2.6	0.46	0.079	0.096	0.347	0.46	0.566	0.598	0.667	0.663	0.676	0.676	0.676
1994	1.707	0.658	0.213	0.199	0.339	0.646	1.168	0.986	1.054	1.04	1.161	1.114	1.114
1995	1.856	0.932	0.482	0.263	0.338	0.577	0.891	0.943	0.962	1.019	1.253	1.15	1.15
1996	1.997	1.059	0.475	0.357	0.414	0.543	0.749	0.862	0.752	0.939	0.866	0.912	0.912
1997	2.515	1.089	0.339	0.301	0.569	0.723	0.842	1.233	1.334	1.508	1.439	1.493	1.493
1998	1.619	0.629	0.377	0.353	0.523	0.779	0.77	1.039	1.165	1.232	1.33	1.297	1.297
1999	1.099	0.361	0.127	0.21	0.548	0.726	0.809	1.051	1.377	1.396	0.915	1.17	1.17
2000	1.375	0.26	0.078	0.14	0.411	0.604	0.755	1.031	1.158	1.123	1.045	1.097	1.097
2001	0.943	0.201	0.063	0.118	0.285	0.519	0.671	0.85	0.88	1.044	0.75	0.907	0.907
2002	0.605	0.405	0.111	0.106	0.287	0.556	0.804	0.893	0.82	0.723	0.564	0.649	0.649
2003	1.402	0.27	0.048	0.071	0.273	0.469	0.678	0.696	0.583	0.552	0.427	0.514	0.514
2004	1.216	0.604	0.081	0.103	0.256	0.526	0.74	0.879	0.792	0.877	0.775	0.872	0.872
2005	0.937	0.191	0.191	0.123	0.385	0.55	0.801	0.778	0.907	0.81	0.803	0.663	0.663
2006	0.791	0.1	0.028	0.148	0.246	0.472	0.61	0.744	0.708	0.721	0.65	0.827	0.827
2007	0.749	0.15	0.097	0.117	0.287	0.309	0.392	0.452	0.433	0.274	0.453	0.567	0.567
2008	0.678	0.114	0.12	0.103	0.154	0.256	0.269	0.435	0.418	0.344	0.222	0.382	0.382
2009	2.001	0.27	0.137	0.087	0.145	0.236	0.238	0.256	0.338	0.255	0.279	0.544	0.544
2010	1.816	0.33	0.167	0.115	0.147	0.182	0.294	0.313	0.226	0.272	0.8	0.53	0.53
2011	1.552	0.392	0.322	0.237	0.149	0.211	0.258	0.274	0.368	0.397	0.337	0.351	0.351

Table 3.16 Stock numbers at age
FLR, Sat May 05 11:20:04 2012

Year_age	1	2	3	4	5	6	7	8	9	10	11	12	+gp	TOTAL
1946	666180	523805	734497	582966	405783	198974	94185	97114	246943	102870	38521	39479	33328	3764647
1947	705151	545422	428855	597729	467894	315120	147889	64587	65603	148030	63758	22406	42765	3615209
1948	1060541	577329	446554	350475	477442	343366	210932	79910	41048	35870	78056	23796	37374	3762691
1949	1630547	868297	472677	365481	283441	362798	230469	102685	45987	19821	20487	36724	21336	4460748
1950	1796394	1334979	710902	386098	293070	200199	206100	113334	57173	25701	11155	8976	21134	5165215
1951	2395644	1470763	1092988	580878	306199	213665	122980	112117	65612	29182	12743	3687	13989	6420447
1952	966372	1961388	1204159	872525	405074	192773	132527	66725	61325	32445	14311	6614	3938	5920176
1953	410861	791199	1605848	964076	605146	229216	91028	63815	36024	28160	12402	4182	1880	4843839
1954	662245	336385	647779	1271856	691905	394073	137448	53950	36989	19940	13507	5054	2707	4273838
1955	1212185	542200	275409	519975	900903	434020	231477	75765	34477	19615	8583	4950	2738	4262297
1956	748256	992453	443916	221955	391651	554970	209363	113483	34478	15819	7481	3281	3722	3740827
1957	1031597	612620	812552	353844	159849	203206	227735	92886	46683	14667	6197	2549	1687	3566073
1958	1192045	844601	501571	649589	259001	106278	102397	107703	40568	22162	6381	2149	857	3835302
1959	1382467	975964	691500	382403	410974	147762	50153	49108	55799	21145	8667	2249	1142	4179334
1960	1096207	1131868	799052	536919	242561	202303	72587	24324	24159	24766	8732	3705	1351	4168533
1961	710985	897499	926695	619931	351040	140481	104623	38512	12288	13229	9713	3073	2332	3830401
1962	510413	582105	734810	717564	387525	175698	68719	50605	15808	4821	4698	2921	1351	3257037
1963	1171664	417891	476587	563232	433157	165953	62903	30658	21529	5744	1478	1491	1113	3353399
1964	2384761	959277	342140	378256	364332	168651	49461	19362	10423	6864	1188	287	1278	4686281
1965	1951528	1952478	785390	275327	268147	209661	85079	22722	7562	2927	2405	264	670	5564161
1966	248186	1597776	1598553	628794	201894	148692	109665	46634	10968	2962	1069	919	351	4596464
1967	168532	203198	1308148	1258171	464464	133920	83248	56154	21441	4386	1073	532	461	3703728
1968	296784	137982	166364	1039834	885286	317625	89683	44365	23228	7309	1484	256	498	3010699
1969	610179	242986	112970	132851	693373	482350	163185	49266	21485	8524	2675	620	278	2520744
1970	1531620	499572	198940	90405	86560	351872	230923	61794	15915	5408	2372	459	312	3076153
1971	2741171	1253984	409015	156396	64252	47513	163376	101819	21710	4947	1488	827	421	4966921
1972	789484	2244281	1026675	327857	115615	41900	30280	80113	36308	6833	1848	529	697	4702421
1973	938328	646375	1837462	808416	227319	70379	23366	17627	34026	9535	1457	414	408	4615112
1974	926120	768238	529207	1238127	542896	130918	39010	12572	6896	10548	3736	581	525	4209374
1975	524478	758243	628980	350164	617938	260105	64654	20510	6339	3363	3563	1134	550	3240021
1976	961996	429406	620797	473992	232583	300847	105672	26221	8330	2822	1346	1173	572	3165758
1977	299410	787616	351568	431049	284612	118042	139328	43200	8835	3154	1464	597	583	2469460
1978	207985	245137	644845	252013	200350	109660	48756	58134	14252	2113	1206	646	1198	1786296
1979	227604	170283	200701	456634	165251	83959	38366	16929	18804	3156	620	161	218	1382686
1980	228960	186346	139416	156538	303750	95776	39836	16197	6374	5465	969	121	87	1179835
1981	251893	187456	152567	110606	112703	174505	42166	16632	6527	2044	1583	180	66	1058928
1982	600559	206233	153476	121829	81991	73450	85476	14808	4630	1483	487	498	70	1344989
1983	789822	491696	168849	117559	80804	49624	34724	31530	4528	1186	573	154	170	1771221
1984	2117166	670435	402820	135430	78520	47632	24653	13044	9230	1404	387	262	116	3501099
1985	1376706	1355363	528736	323313	97995	47269	20823	6481	3181	2139	441	107	208	3762762
1986	1758025	786907	1047413	410434	223292	55072	21131	6761	1915	1196	1056	237	130	4313570
1987	492749	563417	288869	741776	271798	111631	22274	6704	1859	685	322	361	156	2502601
1988	821942	238183	206603	211087	483256	133665	35832	5834	1991	699	149	94	82	2139417
1989	818712	300648	174635	158833	152216	273190	60232	10322	1787	511	103	26	56	1951269
1990	1519352	539991	245935	138378	114376	95520	149693	24110	3473	714	156	47	40	2831786
1991	1729556	1129662	416534	199626	106462	81881	62075	95407	13578	2095	423	75	25	3837397
1992	3012249	1278804	729710	334891	153547	72264	48632	33197	55317	7599	1328	303	48	5727888
1993	24168247	1535374	905380	573733	241598	100836	37998	23212	14927	28712	3933	848	191	27634989
1994	9291458	1470074	793236	684871	426692	139878	52134	17659	10455	6276	12113	1637	232	12906715
1995	19953707	1380110	623633	525043	459726	248878	60051	13273	5393	2983	1816	3106	418	23278137
1996	27928803	2554140	444985	315398	330538	268495	114427	20178	4231	1688	881	425	1624	31985813
1997	19233505	3102930	725148	226612	180723	178800	127729	44290	6979	1634	540	304	532	23829724
1998	6692005	1273013	854939	422903	137354	83727	71047	45067	10571	1505	296	105	174	9592705
1999	3051355	1085454	555564	479917	243244	66680	31444	26940	13051	2699	359	64	113	5556885
2000	3313296	832707	619707	400613	318629	115164	26418	11467	7714	2698	547	118	42	5649120
2001	4110613	685651	525881	469299	285018	173004	51530	10164	3347	1984	718	158	64	6317431
2002	1119217	1310704	459086	404421	341532	175432	84258	21565	3556	1136	572	278	82	3921840
2003	6482225	500546	715408	336452	297791	209863	82397	30871	7226	1282	452	267	177	8664955
2004	3688711	1305923	312771	557999	256566	185496	107479	34248	12606	3304	605	241	118	6466066
2005	5693587	895459	584252	236130	412079	162647	89784	41996	11646	4676	1125	228	117	8133725
2006	4532312	1825490	605821	395345	170981	229470	76853	32993	15787	3848	1703	412	437	7891451
2007	2662473	1683098	1352839	482547	279143	109495	117161	34175	12836	6369	1533	728	232	6742628
2008	1770611	1030997	1186094	1005706	351570	171500	65847	64804	17810	6817	3965	798	280	5676799
2009	10682000	736096	753251	860995	742886	246657	108678	41210	34349	9602	3958	2600	305	14222585
2010	11528118	1182718	460046	537497	645868	526083	159477	70167	26124	20051	6091	2452	726	15165418
2011	7259810	1535967	696120	318774	392435	456600	358966	97274	42010	17059	12503	2241	1654	11191414

Table 3.17.Northeast Arctic COD. Natural mortality used in final VPA (SVPA run).
FLR, Sat May 05 11:20:04 2012

Year_Age	3	4	5	6	7	8	9	10	11	12	+gp
1946-1983	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1984	0.2006	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1985	0.2004	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1986	0.3122	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.2585	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.2087	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1991	0.2049	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.2067	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.2663	0.2028	0.2024	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.4025	0.2928	0.2259	0.2047	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.6708	0.3608	0.2111	0.2014	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.6509	0.437	0.2848	0.2068	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.5162	0.2946	0.2109	0.2022	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1998	0.5279	0.2774	0.2167	0.2098	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.3111	0.2112	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.2693	0.2426	0.2172	0.2006	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2001	0.2517	0.2304	0.2083	0.2079	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.3048	0.2167	0.2034	0.2002	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2003	0.237	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.2734	0.2235	0.2077	0.2021	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.3785	0.2245	0.2198	0.205	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2006	0.2117	0.2061	0.2005	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2007	0.2747	0.2103	0.2008	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2008	0.312	0.2431	0.2165	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2009	0.3298	0.2356	0.2108	0.2015	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.3622	0.2793	0.2477	0.2079	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.5195	0.4062	0.2507	0.2209	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 3.18. Northeast Arctic COD. Natural mortality of cod (M2) due to cannibalism
FLR, Sat May 05 11:20:04 2012

Year	M2 age 1	M2 age 2	M2 age 3	M2 age 4	M2 age 5	M2 age 6
1984	0.246	0.0358	0.0006	0	0	0
1985	0.3593	0.0562	0.0004	0	0	0
1986	0.9379	0.8004	0.1122	0	0	0
1987	0.5269	0.8021	0.0585	0	0	0
1988	0.8057	0.1095	0.0087	0	0	0
1989	0.2162	0	0	0	0	0
1990	0.0964	0.0592	0	0	0	0
1991	0.1019	0.2363	0.0049	0	0	0
1992	0.4735	0.1442	0.0067	0	0	0
1993	2.5997	0.4598	0.0663	0.0028	0.0024	0
1994	1.7069	0.6572	0.2025	0.0928	0.0259	0.0047
1995	1.8557	0.9316	0.4708	0.1608	0.0111	0.0014
1996	1.9973	1.0585	0.4509	0.237	0.0848	0.0068
1997	2.5153	1.0884	0.3162	0.0946	0.0109	0.0022
1998	1.6189	0.6273	0.3279	0.0774	0.0167	0.0098
1999	1.0987	0.3601	0.1111	0.0112	0	0
2000	1.3753	0.2593	0.0693	0.0426	0.0172	0.0006
2001	0.943	0.2007	0.0517	0.0304	0.0083	0.0079
2002	0.6046	0.4053	0.1048	0.0167	0.0034	0.0002
2003	1.4022	0.2698	0.037	0	0	0
2004	1.2157	0.6041	0.0734	0.0235	0.0077	0.0021
2005	0.9375	0.1901	0.1785	0.0245	0.0198	0.005
2006	0.7906	0.0989	0.0117	0.0061	0.0005	0
2007	0.7479	0.1481	0.0747	0.0103	0.0008	0
2008	0.6777	0.1131	0.112	0.0431	0.0165	0
2009	2.0007	0.2695	0.1298	0.0356	0.0108	0.0015
2010	1.8156	0.3299	0.1622	0.0793	0.0477	0.0079
2011	1.5518	0.3916	0.3195	0.2062	0.0507	0.0209

Table 3.19. Northeast Arctic cod. Fishing mortality, final VPA (SVPA run)
FLR, Sat May 05 11:20:04 2012

Year_Age	3	4	5	6	7	8	9	10	11	12	+gp	FBAR5-10
1946	0.0061	0.02	0.0532	0.0973	0.1781	0.1932	0.3125	0.2798	0.3432	0.312	0.312	0.1857
1947	0.0018	0.0249	0.1101	0.2024	0.416	0.2545	0.4047	0.4405	0.7827	0.6182	0.6182	0.3047
1948	0.0003	0.0124	0.0751	0.1997	0.5201	0.3536	0.5286	0.3617	0.5536	0.4604	0.4604	0.3398
1949	0.0023	0.0209	0.1484	0.3662	0.5101	0.3869	0.3832	0.3766	0.6259	0.5039	0.5039	0.3619
1950	0.002	0.0321	0.1167	0.2882	0.4096	0.348	0.4741	0.5031	0.9031	0.7111	0.7111	0.3566
1951	0.0254	0.1612	0.2637	0.2787	0.4122	0.4046	0.5057	0.5149	0.4585	0.4879	0.4879	0.3966
1952	0.0225	0.1667	0.37	0.5501	0.5311	0.4175	0.579	0.7613	1.026	0.9056	0.9056	0.5348
1953	0.0334	0.1325	0.2299	0.3125	0.3243	0.3469	0.3932	0.5364	0.698	0.6217	0.6217	0.3572
1954	0.0199	0.1457	0.2676	0.3333	0.3969	0.2494	0.4364	0.6441	0.8035	0.7304	0.7304	0.3879
1955	0.0159	0.084	0.2859	0.5297	0.5139	0.588	0.5805	0.7645	0.7621	0.7704	0.7704	0.5437
1956	0.027	0.1291	0.4568	0.69	0.6129	0.688	0.6551	0.738	0.8756	0.8152	0.8152	0.6401
1957	0.024	0.1128	0.2094	0.4862	0.5494	0.6287	0.5463	0.6333	0.8584	0.7529	0.7529	0.5089
1958	0.0718	0.2589	0.3626	0.5517	0.5357	0.4593	0.4535	0.7388	0.8415	0.799	0.799	0.5169
1959	0.0535	0.2564	0.5093	0.5121	0.5251	0.5111	0.6141	0.686	0.6511	0.6734	0.6734	0.5596
1960	0.0543	0.2266	0.3477	0.4607	0.4363	0.4855	0.4053	0.7381	0.8449	0.7981	0.7981	0.4789
1961	0.0562	0.2717	0.4944	0.5168	0.5279	0.6931	0.7389	0.8379	1.0011	0.9284	0.9284	0.6348
1962	0.0663	0.3063	0.6498	0.8279	0.6094	0.6564	0.8167	0.9855	0.9522	0.9756	0.9756	0.7576
1963	0.0313	0.2366	0.742	1.0069	0.9764	0.8798	0.9416	1.3731	1.4366	1.4264	1.4264	0.9866
1964	0.0174	0.1449	0.3537	0.4854	0.5787	0.7409	1.0674	0.8476	1.2969	1.0883	1.0883	0.6789
1965	0.0226	0.111	0.3909	0.4494	0.4033	0.5303	0.7389	0.8074	0.7617	0.7927	0.7927	0.5533
1966	0.0398	0.1037	0.2119	0.3818	0.4713	0.5797	0.7183	0.8182	0.5024	0.6634	0.6634	0.5302
1967	0.0298	0.1525	0.1814	0.2026	0.432	0.6844	0.8781	0.885	1.2253	1.0696	1.0696	0.5439
1968	0.0251	0.2064	0.4087	0.4683	0.4019	0.5291	0.8041	0.8105	0.6771	0.7458	0.7458	0.5704
1969	0.023	0.2292	0.4792	0.5382	0.7725	0.9302	1.1783	1.0769	1.5554	1.3377	1.3377	0.8292
1970	0.0409	0.1422	0.4004	0.568	0.6211	0.8479	0.9682	1.09	0.8533	0.9829	0.9829	0.7493
1971	0.0214	0.1028	0.2285	0.2517	0.5144	0.833	0.9584	0.7876	0.8388	0.8179	0.8179	0.5956
1972	0.0394	0.1673	0.2976	0.3849	0.3427	0.6583	1.1338	1.3393	1.2904	1.3377	1.3377	0.6928
1973	0.1959	0.1996	0.3536	0.3917	0.421	0.7375	0.9698	0.7386	0.7222	0.7358	0.7358	0.602
1974	0.2141	0.4959	0.5375	0.5078	0.4451	0.4863	0.5192	0.8842	0.9905	0.9492	0.9492	0.5633
1975	0.0837	0.2106	0.521	0.7021	0.705	0.7032	0.6109	0.7149	0.9079	0.8218	0.8218	0.6595
1976	0.166	0.3121	0.48	0.5715	0.6973	0.8908	0.7746	0.46	0.6132	0.5389	0.5389	0.6457
1977	0.1338	0.5671	0.7544	0.6857	0.6763	0.9121	1.2298	0.7689	0.6231	0.6958	0.6958	0.8379
1978	0.146	0.2234	0.6703	0.8497	0.8581	0.9296	1.3057	1.0301	1.8042	1.4375	1.4375	0.9406
1979	0.0489	0.209	0.3475	0.5478	0.6643	0.7789	1.0352	0.9848	1.4314	1.2219	1.2219	0.7264
1980	0.0318	0.1296	0.3562	0.6225	0.6766	0.7123	0.939	1.038	1.4798	1.2775	1.2775	0.7241
1981	0.0252	0.1003	0.23	0.5163	0.8475	1.0788	1.2765	1.2299	0.9557	1.1082	1.1082	0.8632
1982	0.0672	0.2121	0.3045	0.5518	0.7996	0.9846	1.1589	0.7507	0.9516	0.8607	0.8607	0.7583
1983	0.0208	0.205	0.3308	0.5033	0.7821	1.0295	0.9701	0.9204	0.5853	0.7589	0.7589	0.756
1984	0.0194	0.1247	0.3096	0.6301	1.135	1.2083	1.2572	0.9564	1.0811	1.0345	1.0345	0.9161
1985	0.0533	0.1716	0.3788	0.6078	0.9264	1.0191	0.7818	0.5088	0.4237	0.4665	0.4665	0.7038
1986	0.033	0.2133	0.496	0.7078	0.9487	1.091	0.8325	1.1134	0.8774	1.0045	1.0045	0.8649
1987	0.0555	0.2293	0.5104	0.9362	1.1362	1.0143	0.7841	1.3245	1.0329	1.1899	1.1899	0.951
1988	0.0546	0.1277	0.371	0.5974	1.0411	0.9788	1.1546	1.7027	1.5282	1.6497	1.6497	0.9743
1989	0.033	0.1292	0.2671	0.4024	0.7142	0.885	0.7134	0.979	0.581	0.7917	0.7917	0.6602
1990	0.0087	0.0627	0.1352	0.2324	0.2518	0.3755	0.3067	0.3243	0.5377	0.4352	0.4352	0.271
1991	0.0134	0.0631	0.1888	0.3228	0.4277	0.347	0.3823	0.2572	0.1345	0.1959	0.1959	0.321
1992	0.0341	0.1276	0.2226	0.4449	0.5417	0.6013	0.4585	0.4612	0.2497	0.3556	0.3556	0.455
1993	0.0129	0.0942	0.3463	0.4635	0.5693	0.6009	0.6697	0.6668	0.6797	0.6759	0.6759	0.5528
1994	0.0102	0.1065	0.3152	0.6432	1.1663	0.9866	1.0542	1.0409	1.161	1.1135	1.1135	0.8677
1995	0.0109	0.1026	0.3287	0.5783	0.892	0.9446	0.9631	1.0202	1.2492	1.1497	1.1497	0.7878
1996	0.0239	0.1206	0.3314	0.5389	0.7531	0.8655	0.7574	0.9432	0.8713	0.9121	0.9121	0.6983
1997	0.0231	0.2072	0.5602	0.7222	0.8443	1.2323	1.3319	1.5055	1.4374	1.493	1.493	1.0327
1998	0.0496	0.2767	0.5074	0.7704	0.7721	1.0415	1.1667	1.2298	1.328	1.2973	1.2973	0.9147
1999	0.016	0.1995	0.5486	0.7263	0.8099	1.0507	1.372	1.391	0.9171	1.1695	1.1695	0.9831
2000	0.0088	0.0985	0.3949	0.6047	0.7556	1.0292	1.1547	1.1187	1.0435	1.0968	1.0968	0.843
2001	0.011	0.088	0.2785	0.5131	0.6723	0.8491	0.879	1.0384	0.7493	0.9066	0.9066	0.7051
2002	0.006	0.09	0.2849	0.5569	0.8034	0.8919	0.8187	0.7227	0.5632	0.649	0.649	0.6798
2003	0.0116	0.0715	0.2748	0.4706	0.6791	0.6962	0.5845	0.553	0.4295	0.5143	0.5143	0.543
2004	0.0077	0.0801	0.2492	0.5248	0.7392	0.8776	0.7912	0.8767	0.774	0.872	0.872	0.6765
2005	0.0121	0.0986	0.3658	0.5446	0.7993	0.7766	0.9042	0.8079	0.8035	0.6629	0.6629	0.6997
2006	0.0159	0.1423	0.2454	0.4716	0.6094	0.7414	0.7054	0.718	0.6498	0.8271	0.8271	0.5819
2007	0.0219	0.1066	0.2865	0.3086	0.392	0.4519	0.4328	0.2748	0.4524	0.567	0.567	0.3578
2008	0.0084	0.0599	0.1382	0.2565	0.2689	0.4342	0.4183	0.3443	0.2233	0.3816	0.3816	0.3101
2009	0.0076	0.052	0.1345	0.2348	0.2379	0.2562	0.3382	0.2565	0.28	0.5441	0.5441	0.243
2010	0.0046	0.0353	0.0992	0.1745	0.2943	0.3132	0.2267	0.2726	0.7957	0.5303	0.5303	0.2301
2011	0.0026	0.0313	0.0984	0.1905	0.2581	0.2743	0.3682	0.397	0.3371	0.3508	0.3508	0.2644
FBAR	0.005	0.04	0.111	0.2	0.263	0.281	0.311	0.309	0.471	0.475		

Table 3.20. Northeast Arctic COD. Fishing mortality of age 1-6 cod
FLR
Sat May 05 11:20:04 2012

YEAR	F AGE 1	F AGE 2	F AGE 3	F AGE 4	F AGE 5	F AGE 6
1984	0	0.0017	0.0194	0.1247	0.3096	0.6301
1985	0.0001	0.0015	0.0533	0.1716	0.3788	0.6078
1986	0	0.0017	0.033	0.2133	0.496	0.7078
1987	0	0.0011	0.0555	0.2293	0.5104	0.9362
1988	0	0.0009	0.0546	0.1277	0.371	0.5974
1989	0	0.0009	0.033	0.1292	0.2671	0.4024
1990	0	0.0004	0.0087	0.0627	0.1352	0.2324
1991	0	0.0007	0.0134	0.0631	0.1888	0.3228
1992	0.0004	0.0011	0.0341	0.1276	0.2226	0.4449
1993	0	0.0006	0.0129	0.0942	0.3463	0.4635
1994	0	0.0003	0.0102	0.1065	0.3152	0.6432
1995	0	0.0003	0.0109	0.1026	0.3287	0.5783
1996	0	0.0006	0.0239	0.1206	0.3314	0.5389
1997	0	0.0007	0.0231	0.2072	0.5602	0.7222
1998	0	0.0019	0.0496	0.2767	0.5074	0.7704
1999	0	0.0004	0.016	0.1995	0.5486	0.7263
2000	0	0.0003	0.0088	0.0985	0.3949	0.6047
2001	0	0.0004	0.011	0.088	0.2785	0.5131
2002	0.0001	0.0001	0.006	0.09	0.2849	0.5569
2003	0	0.0005	0.0116	0.0715	0.2748	0.4706
2004	0	0.0002	0.0077	0.0801	0.2492	0.5248
2005	0	0.0006	0.0121	0.0986	0.3658	0.5446
2006	0	0.0007	0.0159	0.1423	0.2454	0.4716
2007	0.0008	0.0019	0.0219	0.1066	0.2865	0.3086
2008	0	0.0008	0.0084	0.0599	0.1382	0.2565
2009	0	0.0006	0.0076	0.052	0.1345	0.2348
2010	0	0.0001	0.0046	0.0353	0.0992	0.1745
2011	0	0.0004	0.0026	0.0313	0.0984	0.1905

Table 3.21. Northeast Arctic cod. Stock number at age. Final VPA (SVPA run)
FLR, Sat May 05 11:20:04 2012

	3	4	5	6	7	8	9	10	11	12	+GP	TOTAL
1946	728153	577856	402057	197211	93323	96214	244717	101774	38117	39210	33328	2551961
1947	425197	592523	463732	312115	146496	63939	64934	146578	62989	22142	42765	2343409
1948	442672	347568	473209	340097	208708	79121	40587	35470	77252	23576	37374	2105632
1949	468394	362237	281072	359415	228044	101579	45487	19586	20227	36359	21336	1943736
1950	704902	382554	290426	198390	204031	112107	56484	25387	11003	8857	21134	2015275
1951	1083765	575972	303320	211595	121763	110900	64808	28785	12568	3651	13989	2531117
1952	1193117	865011	401364	190765	131098	66016	60583	32000	14083	6506	3938	2964481
1953	1590386	955074	599477	226975	90099	63110	35603	27799	12237	4133	1880	3606772
1954	641573	1259288	684912	389987	135956	53333	36524	19673	13311	4985	2707	3242249
1955	272785	514926	891184	429101	228785	74845	34028	19329	8459	4880	2738	2481060
1956	439609	219808	387619	548180	206849	112048	34036	15591	7368	3232	3722	1978062
1957	804793	350331	158175	200984	225109	91748	46105	14474	6103	2513	1687	1902021
1958	496822	643258	256234	105033	101196	106395	40060	21860	6291	2118	857	1780124
1959	683686	378597	406509	145989	49529	48488	55027	20840	8550	2220	1142	1800578
1960	789650	530598	239861	199995	71623	23986	23813	24380	8592	3650	1351	1917500
1961	916839	612323	346345	138702	103298	37908	12084	13000	9541	3022	2332	2195395
1962	728336	709603	382036	172949	67732	49883	15518	4726	4605	2871	1351	2139609
1963	472070	558038	427678	163321	61876	30149	21185	5614	1444	1455	1113	1743941
1964	338682	374578	360621	166726	48854	19083	10240	6764	1164	281	1278	1328272
1965	776925	272502	265305	207288	84015	22424	7448	2883	2373	261	670	1642093
1966	1582567	621906	199663	146941	108284	45954	10803	2912	1053	907	351	2721340
1967	1295405	1245192	458994	132256	82121	55340	21072	4313	1052	522	461	3296726
1968	164952	1029477	875268	313440	88421	43651	22854	7170	1457	253	498	2547441
1969	112038	131705	685696	476186	160667	48433	21054	8373	2610	606	278	1647646
1970	197103	89646	85743	347648	227600	60756	15642	5306	2335	451	312	1032542
1971	404768	154909	63671	47037	161288	100131	21306	4863	1461	815	421	960670
1972	1015331	324398	114439	41482	29940	78947	35642	6690	1811	517	697	1649894
1973	1818945	799194	224670	69576	23112	17401	33463	9391	1435	408	408	2998004
1974	523917	1224276	535935	129163	38503	12421	6815	10388	3673	571	525	2486187
1975	621618	346266	610485	256342	63643	20199	6253	3320	3513	1117	550	1933305
1976	613942	468088	229669	296843	104000	25746	8186	2779	1330	1160	572	1752316
1977	348053	425778	280484	116349	137232	42398	8650	3089	1436	590	583	1364641
1978	638492	249275	197708	108003	47987	57130	13943	2070	1172	631	1198	1317608
1979	198489	451722	163230	82807	37806	16658	18463	3093	605	158	218	973248
1980	137736	154747	300087	94414	39202	15929	6259	5368	946	118	87	754893
1981	150868	109237	111295	172067	41481	16316	6397	2004	1557	176	66	611464
1982	151830	120444	80899	72401	84063	14551	4542	1461	480	490	70	531230
1983	166828	116234	79768	48848	34138	30937	4451	1167	565	152	170	483258
1984	397854	133782	77525	46916	24176	12785	9048	1381	381	258	116	704222
1985	523672	319254	96695	46570	20455	6362	3127	2107	435	106	208	1018991
1986	1038709	406348	220156	54207	20763	6632	1880	1171	1037	233	130	1751266
1987	286365	735514	268786	109763	21867	6583	1824	669	315	353	156	1432195

1988	204645	209194	478807	132093	35238	5747	1954	682	146	92	82	1068680
1989	172780	157268	150744	270501	59509	10186	1768	504	102	26	56	823444
1990	242762	136871	113154	94492	148106	23854	3442	709	155	47	40	763632
1991	411745	197023	105247	80927	61322	94266	13417	2074	420	74	25	966538
1992	721292	331006	151443	71341	47980	32734	54551	7495	1313	301	48	1419503
1993	894864	566932	238541	99246	37433	22853	14690	28238	3869	837	191	1907695
1994	783483	676835	421277	137807	51115	17345	10259	6156	11868	1605	232	2117984
1995	615764	518533	453987	245227	59025	13037	5295	2927	1780	3043	418	1919037
1996	439935	311398	326215	264603	112438	19806	4151	1655	864	418	1624	1483106
1997	717325	224029	178313	176145	125528	43350	6824	1593	527	296	532	1474463
1998	846346	418305	135640	82467	69890	44180	10350	1475	289	103	174	1609218
1999	549795	475041	240341	65752	30946	26438	12765	2639	353	63	113	1404245
2000	613588	396419	315041	113683	26038	11272	7569	2650	538	116	42	1486956
2001	520652	464643	281845	170822	50814	10014	3297	1953	709	155	64	1504967
2002	454916	400367	337945	173215	83062	21239	3507	1121	566	274	82	1476294
2003	709786	333398	294622	207379	81244	30454	7127	1266	446	264	177	1666162
2004	310760	553574	254120	183264	106051	33728	12429	3252	596	237	118	1458131
2005	580528	234620	408657	160931	88598	41459	11481	4613	1108	225	117	1532337
2006	602424	392822	169840	227536	76050	32616	15613	3806	1684	406	437	1523234
2007	1345611	479813	277266	108736	116244	33853	12723	6314	1520	720	232	2383030
2008	1180149	1000266	349497	170328	65387	64306	17638	6758	3927	791	280	2859329
2009	750121	856713	738776	245142	107906	40911	34106	9504	3921	2572	305	2789979
2010	457468	535290	642598	523065	158475	69641	25924	19911	6021	2426	726	2441543
2011	691254	316990	390811	454241	356836	96670	41684	16919	12413	2225	1654	2381697
2012		412982	205826	276799	302614	227059	60536	23802	9391	7308	1292	1527609

Table 3.22. Northeast Arctic cod. Stock biomass at age. Final VPA (SVPA run)
FLR, Sat May 05 11:20:05 2012

YEAR_AGE	3	4	5	6	7	8	9	10	11	12	13	TOTALBIO
1946	254854	340935	446283	333287	221176	304999	973975	513958	225650	282311	271491	4168918
1947	136063	331813	440545	468173	313501	186702	237008	668395	367853	164291	378386	3692730
1948	150508	184211	596243	656387	513421	265845	171279	188347	457332	167151	315060	3665785
1949	173306	242699	311990	596628	570111	328099	185131	103218	121163	257420	175339	3065104
1950	274912	244835	374649	337264	481514	390132	255308	142673	70420	70500	187900	2830106
1951	433506	478057	421615	397798	309279	383713	316264	149682	89736	30012	131347	3141009
1952	524971	692009	533814	366269	346100	244918	306547	193600	104495	54844	40110	3407677
1953	636154	725857	767330	438061	253178	234768	180150	176244	90555	35830	19247	3557375
1954	282292	969652	862988	768274	411945	230933	197232	132791	103693	53191	26204	4039197
1955	87291	293508	1007038	742345	629159	294889	166738	136077	60902	42844	27591	3488381
1956	145071	127489	414752	1003169	597795	476204	188902	113501	58943	26988	37014	3189826
1957	265582	206695	161338	365791	650566	392682	253117	108699	50286	23246	17892	2495893
1958	168920	334494	243422	201664	297517	447922	224738	160673	54541	20287	9967	2164144
1959	239290	272590	597569	391251	177809	209470	299897	134210	61300	19159	13275	2415820
1960	268481	270605	261449	425990	242086	116810	145737	206984	66934	30297	15428	2050801
1961	284220	336778	363662	305144	333653	193710	74320	105952	82818	29013	27874	2137145
1962	233067	390282	355294	294013	205228	250909	101645	36390	42684	30313	17177	1957003
1963	151062	340403	410571	282545	188104	149537	136428	44408	13894	16453	14173	1747578
1964	111765	206018	342590	310110	158775	94841	65640	54588	10875	2856	16470	1374528
1965	295232	185301	273264	308859	202475	78931	42675	21740	20098	2911	9200	1440686
1966	696329	460210	235602	261554	266378	175544	57905	21174	9087	9669	4967	2198419
1967	375667	1008606	619642	269803	230759	192584	103040	30662	9500	5524	6369	2852156
1968	54434	720634	1295397	664492	277642	183771	120443	47678	13129	2443	7388	3387452
1969	49297	104047	843406	966657	465934	184531	105690	53839	21742	6492	3953	2805588
1970	72928	81578	114895	695297	682799	252138	87437	40323	20948	4958	4395	2057696
1971	182146	136320	87865	101599	495154	422555	123791	34677	12590	8822	5449	1610966
1972	385826	249786	163647	87942	96707	345786	207793	50977	17245	6248	9529	1621487
1973	691199	727266	345992	157241	76038	80219	219854	78601	15127	4742	5674	2401954
1974	167653	808022	627044	286743	123596	54527	37616	81651	36074	6512	6947	2236384
1975	254863	221610	677638	487049	187748	88269	35894	29113	34848	13192	7206	2037430
1976	214880	341704	273306	596654	287041	108649	48132	25849	13669	13760	7750	1931394
1977	170546	383200	401093	238516	452865	193334	55876	26656	14264	6427	7970	1950747
1978	312861	201913	286676	232207	145879	254799	91184	16521	11898	6843	15783	1576565
1979	69471	316205	202405	177207	119088	71461	121484	26635	5579	1720	3124	1114380
1980	37189	86658	306089	162392	118389	66900	36552	38975	8362	1099	1256	863861
1981	73926	107052	160265	359619	123613	79133	42028	18354	16843	1899	924	983657
1982	56177	79493	109213	144077	246304	61698	29339	12436	5870	5283	979	750870
1983	61726	106936	127630	119188	130406	147262	27463	8986	5224	1645	2209	738674
1984	167098	155188	140320	130896	91385	58429	55823	10636	3521	2794	1514	817605
1985	216277	279347	155002	130862	83027	37111	24029	21316	6210	1346	2984	957511
1986	323039	357586	323630	133728	81286	38530	12370	8004	11412	2965	1863	1294412
1987	60423	366286	337058	224685	75026	33816	11896	6226	4142	4496	2226	1126279
1988	43385	84514	378257	251373	104902	25242	15268	8256	1910	1169	1181	915459

1989	51661	81780	130846	399530	159840	47139	12462	5034	940	330	798	890360
1990	96619	96494	133749	162432	364043	85040	16210	5533	1389	593	577	962680
1991	213284	223818	183446	196490	197089	427777	92307	22227	3966	945	354	1561702
1992	317368	308167	274414	193762	186882	169434	369530	71934	16313	3826	682	1912312
1993	307833	664444	434144	280172	150894	125625	99375	242028	41967	10659	2733	2359876
1994	184119	509656	598213	332529	195517	93938	68031	46971	96273	20437	3325	2149011
1995	123769	251489	517545	519390	204818	64379	37909	26693	17978	38742	5988	1808700
1996	85787	151651	316755	543494	396567	108994	32238	16810	9218	5320	23243	1690076
1997	144900	116719	192399	330800	422903	228151	60922	19366	5910	3768	7617	1533455
1998	183657	222956	157478	159903	205826	202078	76829	15291	3398	1306	2490	1231213
1999	111608	247022	282160	133542	93890	118017	82744	27096	3842	800	1618	1102340
2000	119036	184335	380569	224183	79365	46170	43326	19764	5151	1471	605	1103976
2001	148386	242543	337086	382471	168346	51250	21024	18049	8027	1973	913	1380069
2002	114184	242222	401817	370334	276845	101225	24057	10462	5766	3493	1178	1551583
2003	163251	179035	385955	416625	263310	151385	48030	11025	6694	3360	2531	1631201
2004	77690	302251	276229	372943	309776	147863	77731	27785	5806	3022	1685	1602782
2005	134102	146403	456878	310919	269868	163970	66716	38237	14893	2867	1676	1606528
2006	154221	236479	203978	457119	236818	144393	94145	30587	16715	5172	6257	1585885
2007	352550	335389	371813	230629	368145	157076	82636	57599	17902	9164	3325	1986229
2008	337523	734195	478811	403167	215123	309957	115496	57324	34961	10076	4006	2700640
2009	195032	549153	992177	578536	406050	209094	223532	86471	36985	32744	4363	3314137
2010	117569	315286	760193	1073329	504108	334275	175219	156483	60260	30890	10383	3537995
2011	154841	186707	425202	869872	990575	417519	270739	143628	124326	28322	23665	3635397

Table 3.23. Northeast Arctic cod. Spawning stock biomass at age (SVPA run)
FLR, Sat May 05 11:20:06 2012

	3	4	5	6	7	8	9	10	11	12	13	TOTSPBIO
1946	0	0	4463	9999	13271	33550	175316	226141	146673	242787	260632	1112830
1947	0	0	4405	14045	18810	24271	37921	280726	275890	149505	359467	1165041
1948	0	0	5962	19692	35939	34560	42820	88523	333852	152107	305609	1019065
1949	0	0	3120	17899	51310	55777	53688	55738	95718	226530	170079	729858
1950	0	0	3746	10118	43336	89730	89358	74190	55632	66975	182263	615348
1951	0	0	4216	11934	30928	92091	126506	86815	64610	25511	126093	568704
1952	0	0	5338	10988	27688	53882	125684	121968	85686	50456	38907	520597
1953	0	0	7673	13142	17722	44606	72060	112796	76066	33681	18670	396417
1954	0	0	8630	23048	32956	36949	72976	90298	90213	49467	25156	429693
1955	0	0	10070	22270	44041	38336	43352	72121	50548	39416	26763	346918
1956	0	0	4148	30095	35868	57144	26446	46535	39492	24559	35533	299820
1957	0	0	1613	10974	39034	35341	30374	23914	30171	19062	17355	207838
1958	0	0	2434	6050	17851	44792	22474	48202	27270	16635	9668	195377
1959	0	0	5976	15650	21337	71220	146950	89921	51492	16668	13275	432488
1960	0	2706	7843	25559	24209	22194	65582	142819	51539	25752	15274	383478
1961	0	0	3637	18309	40038	60050	48308	96417	81162	28432	27874	404227
1962	0	0	3553	14701	30784	85309	62004	29476	39269	29403	17177	311676
1963	0	3404	4106	8476	13167	41870	57300	35970	13616	16124	14173	208207
1964	0	0	0	9303	20641	35091	43323	48583	10332	2828	16470	186570
1965	0	0	0	3089	12148	15786	23471	15870	19897	2853	9200	102315
1966	0	0	2356	5231	15983	38620	20267	15669	8541	9089	4967	120722
1967	0	0	0	8094	16153	26962	39155	19624	8455	4972	6369	129784
1968	0	0	38862	33225	24988	34916	46973	27653	10766	2443	7388	227214
1969	0	0	0	19333	18637	22144	35935	29611	16089	6167	3953	151870
1970	0	816	0	6953	47796	57992	50714	32662	18644	4512	4395	224482
1971	0	0	879	5080	54467	126766	73036	27394	10827	7763	5449	311662
1972	3858	4996	3273	879	9671	117567	132988	41292	16210	6248	9529	346511
1973	0	0	0	3145	12166	42516	178082	72312	14371	4647	5674	332913
1974	0	0	0	2867	3708	11451	18808	78385	36074	6251	6947	164491
1975	0	0	6776	9741	16897	18536	20100	22708	27530	12532	7206	142028
1976	0	0	0	29833	34445	31508	21659	21713	11345	13760	6975	171238
1977	0	0	8022	19081	117745	104400	42466	23191	13266	6042	7173	341385
1978	0	0	0	4644	18964	112112	64741	12721	9637	6090	12626	241536
1979	0	0	0	5316	15481	27870	93543	23705	4630	1342	2811	174698
1980	0	0	0	3248	15391	23415	23759	31959	8362	989	1130	108253
1981	0	0	3205	25173	24723	42732	33622	17804	16843	1899	924	166925
1982	0	3975	10921	48986	160097	50592	26992	12436	5870	5283	979	326132
1983	617	8555	12763	35756	95196	129590	26639	8986	5224	1645	2209	327181
1984	0	7759	25258	40578	51176	52586	55265	10636	3521	2794	1514	251086
1985	0	2793	13950	47110	45665	31544	23068	19184	6210	1346	2984	193855
1986	0	17879	25890	25408	43081	27356	7669	7204	11412	2965	1863	170729
1987	0	3663	23594	40443	16506	15555	5948	4670	4142	4496	2226	121243
1988	0	1690	18913	82953	55598	15650	15268	8256	1910	1169	1181	202589
1989	413	245	3795	91093	87433	33233	11403	5034	940	330	798	234716

1990	773	1254	6821	34111	190031	60804	14670	5395	1389	593	577	316418
1991	213	7162	13758	59930	139539	368316	88338	22227	3966	945	354	704747
1992	317	4314	39790	81186	149506	159776	359922	71934	16313	3826	682	887567
1993	0	18604	37771	103103	106229	116957	96592	240576	41967	10659	2733	775193
1994	552	3568	71187	111397	115159	80975	65513	46502	96273	20437	3325	614890
1995	0	754	31570	193213	127807	50280	36393	26133	17978	38742	5988	528858
1996	0	0	6018	140221	250234	89375	31432	16810	9218	5320	23243	571871
1997	0	0	2309	46312	256702	189366	57632	19366	5910	3768	7617	588981
1998	184	669	4094	24305	97150	164492	73525	14985	3398	1306	2490	386598
1999	223	494	3950	24972	51076	99961	79848	27096	3842	800	1618	293881
2000	0	184	27020	55373	51032	38321	42373	19764	5151	1471	605	241295
2001	445	728	21911	137307	105048	41974	20015	18049	8027	1973	913	356389
2002	228	3149	33753	143690	189085	85130	22878	10462	5766	3493	1178	498812
2003	163	179	33964	135820	176944	134430	45965	11025	6694	3360	2531	551076
2004	78	3023	25137	164841	224897	128936	75866	27146	5806	3022	1685	660437
2005	0	586	31068	123435	193226	146261	64514	37892	14893	2867	1676	616417
2006	0	236	12239	168677	153222	129520	90850	30587	16715	5172	6257	613475
2007	0	1342	26771	79106	266169	137598	80653	57599	17902	9164	3325	679629
2008	0	2937	29686	113693	115736	267493	107180	56980	34961	10076	4006	742749
2009	0	0	75405	215215	306568	179194	218391	86211	36282	32744	4363	1154374
2010	0	946	34209	346685	288854	280123	162428	151788	58694	30458	10383	1364567
2011	0	187	15732	298366	633968	341113	254495	138458	123207	28010	23665	1857201

Table 3.24. Northeast Arctic COD. Summary Table Final VPA (SVPA run)
FLR, Sat May 05 11:20:07 2012

Year	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
1946	728153	4168918	1112830	706000	0.6344	0.1857
1947	425197	3692730	1165041	882017	0.7571	0.3047
1948	442672	3665785	1019065	774295	0.7598	0.3398
1949	468394	3065104	729858	800122	1.0963	0.3619
1950	704902	2830106	615348	731982	1.1895	0.3566
1951	1083765	3141009	568704	827180	1.4545	0.3966
1952	1193117	3407677	520597	876795	1.6842	0.5348
1953	1590386	3557375	396417	695546	1.7546	0.3572
1954	641573	4039197	429693	826021	1.9224	0.3879
1955	272785	3488381	346918	1147841	3.3087	0.5437
1956	439609	3189826	299820	1343068	4.4796	0.6401
1957	804793	2495893	207838	792557	3.8133	0.5089
1958	496822	2164144	195377	769313	3.9376	0.5169
1959	683686	2415820	432488	744607	1.7217	0.5596
1960	789650	2050801	383478	622042	1.6221	0.4789
1961	916839	2137145	404227	783221	1.9376	0.6348
1962	728336	1957003	311676	909266	2.9173	0.7576
1963	472070	1747578	208207	776337	3.7287	0.9866
1964	338682	1374528	186570	437695	2.346	0.6789
1965	776925	1440686	102315	444930	4.3486	0.5533
1966	1582567	2198419	120722	483711	4.0068	0.5302
1967	1295405	2852156	129784	572605	4.412	0.5439
1968	164952	3387452	227214	1074084	4.7272	0.5704
1969	112038	2805588	151870	1197226	7.8832	0.8292
1970	197103	2057696	224482	933246	4.1573	0.7493
1971	404768	1610966	311662	689048	2.2109	0.5956
1972	1015331	1621487	346511	565254	1.6313	0.6928
1973	1818945	2401954	332913	792685	2.3811	0.602
1974	523917	2236384	164491	1102433	6.7021	0.5633
1975	621618	2037430	142028	829377	5.8395	0.6595
1976	613942	1931394	171238	867463	5.0658	0.6457
1977	348053	1950747	341385	905301	2.6518	0.8379
1978	638492	1576565	241536	698715	2.8928	0.9406
1979	198489	1114380	174698	440538	2.5217	0.7264
1980	137736	863861	108253	380434	3.5143	0.7241
1981	150868	983657	166925	399038	2.3905	0.8632
1982	151830	750870	326132	363730	1.1153	0.7583
1983	166828	738674	327181	289992	0.8863	0.756
1984	397854	817605	251086	277651	1.1058	0.9161
1985	523672	957511	193855	307920	1.5884	0.7038
1986	1038709	1294412	170729	430113	2.5193	0.8649
1987	286365	1126279	121243	523071	4.3142	0.951
1988	204645	915459	202589	434939	2.1469	0.9743
1989	172780	890360	234716	332481	1.4165	0.6602
1990	242762	962680	316418	212000	0.67	0.271
1991	411745	1561702	704747	319158	0.4529	0.321
1992	721292	1912312	887567	513234	0.5782	0.455
1993	894864	2359876	775193	581611	0.7503	0.5528
1994	783483	2149011	614890	771086	1.254	0.8677
1995	615764	1808700	528858	739999	1.3992	0.7878
1996	439935	1690076	571871	732228	1.2804	0.6983
1997	717325	1533455	588981	762403	1.2944	1.0327
1998	846346	1231213	386598	592624	1.5329	0.9147
1999	549795	1102340	293881	484910	1.65	0.9831
2000	613588	1103976	241295	414868	1.7193	0.843
2001	520652	1380069	356389	426471	1.1966	0.7051
2002	454916	1551583	498812	535045	1.0726	0.6798
2003	709786	1631201	551076	551990	1.0017	0.543
2004	310760	1602782	660437	606445	0.9182	0.6764
2005	580528	1606528	616417	641276	1.0403	0.6997
2006	602424	1585885	613475	537642	0.8764	0.5819
2007	1345611	1986229	679629	486883	0.7164	0.3578
2008	1180149	2700640	742749	464171	0.6249	0.3101
2009	750121	3314137	1154374	523430	0.4534	0.243
2010	457468	3537995	1364567	609983	0.447	0.2301
2011	691254	3635397	1857201	719830	0.3876	0.2644
Arith. Mean	624331	2077254	451896	651654	2.1941	0.6176
Units	Thousands	Tonnes	Tonnes	Tonnes		

Table 3.25. Northeast Arctic cod. Input for the short-term prediction
FLR, Sat May 05 11:20:07 2012
Fbar age range: 5-10

2012								
Age	N	M	Mat	PF	PM	SWT	Sel	CWT
3	721000	0.5195	0.001	0	0	0.21	0.0054	0.832
4	412982	0.4062	0	0	0	0.561	0.0425	1.24
5	205826	0.2507	0.046	0	0	1.108	0.119	1.863
6	276799	0.2209	0.215	0	0	1.76	0.2151	2.459
7	302614	0.2	0.557	0	0	2.775	0.2834	3.415
8	227059	0.2	0.786	0	0	4.056	0.3025	4.541
9	60536	0.2	0.909	0	0	6.117	0.3346	6.002
10	23802	0.2	0.964	0	0	8.718	0.3317	7.68
11	9391	0.2	0.99	0	0	11.676	0.508	8.681
12	7308	0.2	0.989	0	0	12.731	0.5113	9.662
13	1292	0.2	1	0	0	14.311	0.5113	13
2013								
FLR								
Sat May 05 11:20:07 2012								
Age	N	M	Mat	PF	PM	SWT	Sel	CWT
3	702000	0.5195	0	0	0	0.226	0.0054	0.832
4		0.4062	0.001	0	0	0.543	0.0425	1.288
5		0.2507	0.043	0	0	1.081	0.119	1.792
6		0.2209	0.294	0	0	1.812	0.2151	2.605
7		0.2	0.59	0	0	2.562	0.2834	3.509
8		0.2	0.814	0	0	3.927	0.3025	4.753
9		0.2	0.925	0	0	5.77	0.3346	5.917
10		0.2	0.966	0	0	7.87	0.3317	7.496
11		0.2	0.985	0	0	10.803	0.508	8.887
12		0.2	0.988	0	0	12.731	0.5113	9.777
13		0.2	1	0	0	14.311	0.5113	11.94
2014								
FLR								
Sat May 05 11:20:07 2012								
Age	N	M	Mat	PF	PM	SWT	Sel	CWT
3	741000	0.5195	0	0	0	0.226	0.0054	0.832
4		0.4062	0.001	0	0	0.559	0.0425	1.288
5		0.2507	0.043	0	0	1.063	0.119	1.792

6		0.2209	0.294	0	0	1.785	0.2151	2.605
7		0.2	0.59	0	0	2.614	0.2834	3.509
8		0.2	0.814	0	0	3.713	0.3025	4.753
9		0.2	0.925	0	0	5.64	0.3346	5.917
10		0.2	0.966	0	0	7.522	0.3317	7.496
11		0.2	0.985	0	0	9.954	0.508	8.887
12		0.2	0.988	0	0	12.731	0.5113	9.777
13		0.2	1	0	0	14.311	0.5113	11.94
2015								
FLR								
Sat May 05 11:20:07 2012								
Age	N	M	Mat	PF	PM	SWT	Sel	CWT
3	624000	0.5195	0	0	0	0.226	0.0054	0.832
4		0.4062	0.001	0	0	0.559	0.0425	1.288
5		0.2507	0.043	0	0	1.063	0.119	1.792
6		0.2209	0.294	0	0	1.785	0.2151	2.605
7		0.2	0.59	0	0	2.614	0.2834	3.509
8		0.2	0.814	0	0	3.713	0.3025	4.753
9		0.2	0.925	0	0	5.64	0.3346	5.917
10		0.2	0.966	0	0	7.522	0.3317	7.496
11		0.2	0.985	0	0	9.954	0.508	8.887
12		0.2	0.988	0	0	12.731	0.5113	9.777
13		0.2	1	0	0	14.311	0.5113	11.94

Table 3.26. Northeast Arctic cod. Management option table.
FLR
Sat May 05 11:20:07 2012

Fbar age range: 5-10

2012				
Biomass	SSB	FMult	FBar	Landings
3658006	2062693	1	0.26441	857186

2013				2014	
Biomass	SSB	FBar	Landings	Biomass	SSB
3466507	2225404	0	0	4158015	2886561
		0.05	179344	3966652	2719436
		0.1	348879	3786464	2562530
		0.15	509194	3616749	2415187
		0.2	660846	3456851	2276794
		0.25	804354	3306158	2146781
		0.3	940203	3164101	2024615
		0.35	1068849	3030144	1909799
		0.4	1190717	2903791	1801868
		0.45	1306202	2784574	1700391
		0.5	1415685	2672058	1604962
		0.55	1519509	2565835	1515204
		0.6	1618005	2465524	1430764
		0.65	1711484	2370768	1351311
		0.7	1800230	2281234	1276537
		0.75	1884517	2196607	1206153
		0.8	1964598	2116597	1139890
		0.85	2040715	2040927	1077495
		0.9	2113087	1969342	1018732
		0.95	2181928	1901600	963380
		1	2247435	1837475	911231

Table 3.27. Northeast arctic cod. Detailed prediction output assuming Fpa in 2013-2015
FLR, Sat May 05 11:20:07 2012

Fbar age range: 5-10

Year: 2012 F multiplier: 1 Fbar: 0.2644

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0054	3002	2496	721000	151410	721	151
4	0.0425	14140	17528	412982	231683	0	0
5	0.119	20483	38154	205826	228055	9468	10491
6	0.2151	48253	118660	276799	487166	59512	104741
7	0.2834	68014	232303	302614	839755	168556	467743
8	0.3025	53995	245178	227059	920951	178468	723867
9	0.3346	15691	94172	60536	370301	55028	336604
10	0.3317	6124	47033	23802	207503	22945	200033
11	0.508	3419	29679	9391	109648	9297	108552
12	0.5113	2674	25836	7308	93041	7228	92017
13	0.5113	473	6147	1292	18494	1292	18494
Total	NA	236268	857186	2248609	3658007	512515	2062693

FLR, Sat May 05 11:20:07 2012

Fbar age range: 5-10

Year: 2013 F multiplier: 1.5128 Fbar: 0.4

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0081	4416	3672	702000	158886	234	53
4	0.0643	21874	28175	426576	231489	569	309
5	0.1801	38581	69149	263680	285038	11250	12162
6	0.3254	35652	92866	142213	257737	41763	75689
7	0.4288	56972	199892	178989	458509	105603	270520
8	0.4577	62585	297486	186609	732750	151837	596215
9	0.5062	49874	295122	137370	792576	127113	733397
10	0.5019	12790	95882	35467	279116	34261	269626
11	0.7685	6884	61180	13985	151079	13776	148813
12	0.7736	2287	22364	4626	58897	4571	58190
13	0.7736	2088	24929	4223	60431	4223	60431
Total	NA	294003	1190717	2095738	3466508	495200	2225405

FLR, Sat May 05 11:20:07 2012

Fbar age range: 5-

10							
Year: 2014 F multiplier: 1.5128 Fbar: 0.4							
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0081	4661	3876	741000	167713	247	56
4	0.0643	21239	27358	414197	231536	552	309
5	0.1801	38992	69886	266489	283189	11370	12083
6	0.3254	42968	111924	171397	306001	50334	89862
7	0.4288	26214	91975	82357	215282	48591	127016
8	0.4577	32010	152153	95443	354413	77659	288374
9	0.5062	35099	207693	96674	545274	89456	504560
10	0.5019	24447	183269	67792	509954	65487	492616
11	0.7685	8653	76905	17580	174996	17316	172371
12	0.7736	2625	25667	5310	67597	5246	66786
13	0.7736	1653	19733	3343	47835	3343	47835
Total	NA	238561	970439	1961582	2903790	369601	1801868

FLR, Sat May 05 11:20:07 2012							
Fbar age range: 5-10							
Year: 2015 F multiplier: 1.5128 Fbar: 0.4							
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0081	3925	3264	624000	141232	208	47
4	0.0643	22419	28878	437208	244399	583	326
5	0.1801	37861	67858	258756	274971	11040	11732
6	0.3254	43426	113116	173224	309262	50870	90820
7	0.4288	31594	110850	99258	259461	58562	153082
8	0.4577	14729	70009	43916	163074	35733	132688
9	0.5062	17952	106227	49445	278887	45753	258064
10	0.5019	17205	128976	47709	358881	46087	346679
11	0.7685	16540	146996	33602	334486	33098	329469
12	0.7736	3300	32264	6674	84971	6594	83951
13	0.7736	1616	19294	3268	46772	3268	46772
Total	NA	210567	827732	1777060	2496396	291796	1453630

Table 3.28. Northeast arctic cod. Detailed prediction output assuming HCR in 2013 and Fpa in 2014
FLR, Sat May 05 11:20:07 2012

Fbar age range: 5-10

YEAR: 2012 F MULTIPLIER: 1 FBAR: 0.2644

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0054	3002	2496	721000	151410	721	151
4	0.0425	14140	17528	412982	231683	0	0
5	0.119	20483	38154	205826	228055	9468	10491
6	0.2151	48253	118660	276799	487166	59512	104741
7	0.2834	68014	232303	302614	839755	168556	467743
8	0.3025	53995	245178	227059	920951	178468	723867
9	0.3346	15691	94172	60536	370301	55028	336604
10	0.3317	6124	47033	23802	207503	22945	200033
11	0.508	3419	29679	9391	109648	9297	108552
12	0.5113	2674	25836	7308	93041	7228	92017
13	0.5113	473	6147	1292	18494	1292	18494
Total	NA	236268	857186	2248609	3658007	512515	2062693

FLR, Sat May 05 11:20:07 2012

Fbar age range: 5-10

Year: 2013 F multiplier: 1.1346 Fbar: 0.3

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0061	3315	2756	702000	158886	234	53
4	0.0482	16527	21289	426576	231489	569	309
5	0.1351	29549	52961	263680	285038	11250	12162
6	0.244	27754	72293	142213	257737	41763	75689
7	0.3216	44852	157367	178989	458509	105603	270520
8	0.3433	49420	234910	186609	732750	151837	596215
9	0.3797	39581	234218	137370	792576	127113	733397
10	0.3764	10146	76061	35467	279116	34261	269626
11	0.5764	5606	49820	13985	151079	13776	148813
12	0.5802	1864	18219	4626	58897	4571	58190
13	0.5802	1701	20309	4223	60431	4223	60431
Total	NA	230315	940203	2095738	3466508	495200	2225405

FLR, Sat May 05 11:20:08 2012

Fbar age range: 5-10							
Year: 2014 F multiplier: 1.5128 Fbar: 0.4							
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0081	4661	3876	741000	167713	247	56
4	0.0643	21282	27413	415036	232005	553	309
5	0.1801	39624	71018	270806	287777	11554	12278
6	0.3254	44947	117078	179290	320093	52652	94001
7	0.4288	28436	99770	89336	233525	52708	137780
8	0.4577	35632	169369	106243	394516	86446	321005
9	0.5062	39353	232869	108393	611372	100300	565723
10	0.5019	27745	207994	76938	578754	74322	559077
11	0.7685	9810	87185	19930	198388	19631	195412
12	0.7736	3181	31104	6434	81915	6357	80932
13	0.7736	2005	23943	4056	58041	4056	58041
Total	NA	256676	1071619	2017462	3164099	408826	2024614

FLR, Sat May 05 11:20:08 2012							
Fbar age range: 5-10							
Year: 2015 F multiplier: 1.5128 Fbar: 0.4							
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0081	3925	3264	624000	141232	208	47
4	0.0643	22419	28878	437208	244399	583	326
5	0.1801	37937	67995	259280	275528	11063	11756
6	0.3254	44130	114949	176030	314272	51694	92291
7	0.4288	33049	115955	103829	271410	61259	160132
8	0.4577	15977	75942	47637	176894	38761	143932
9	0.5062	19983	118247	55040	310444	50930	287264
10	0.5019	19290	144610	53492	402385	51673	388704
11	0.7685	18772	166828	38136	379614	37563	373919
12	0.7736	3741	36577	7567	96329	7476	95173
13	0.7736	1959	23393	3962	56707	3962	56707
Total	NA	221182	896638	1806181	2669214	315172	1610251

Table 3.29. 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 3.30. 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

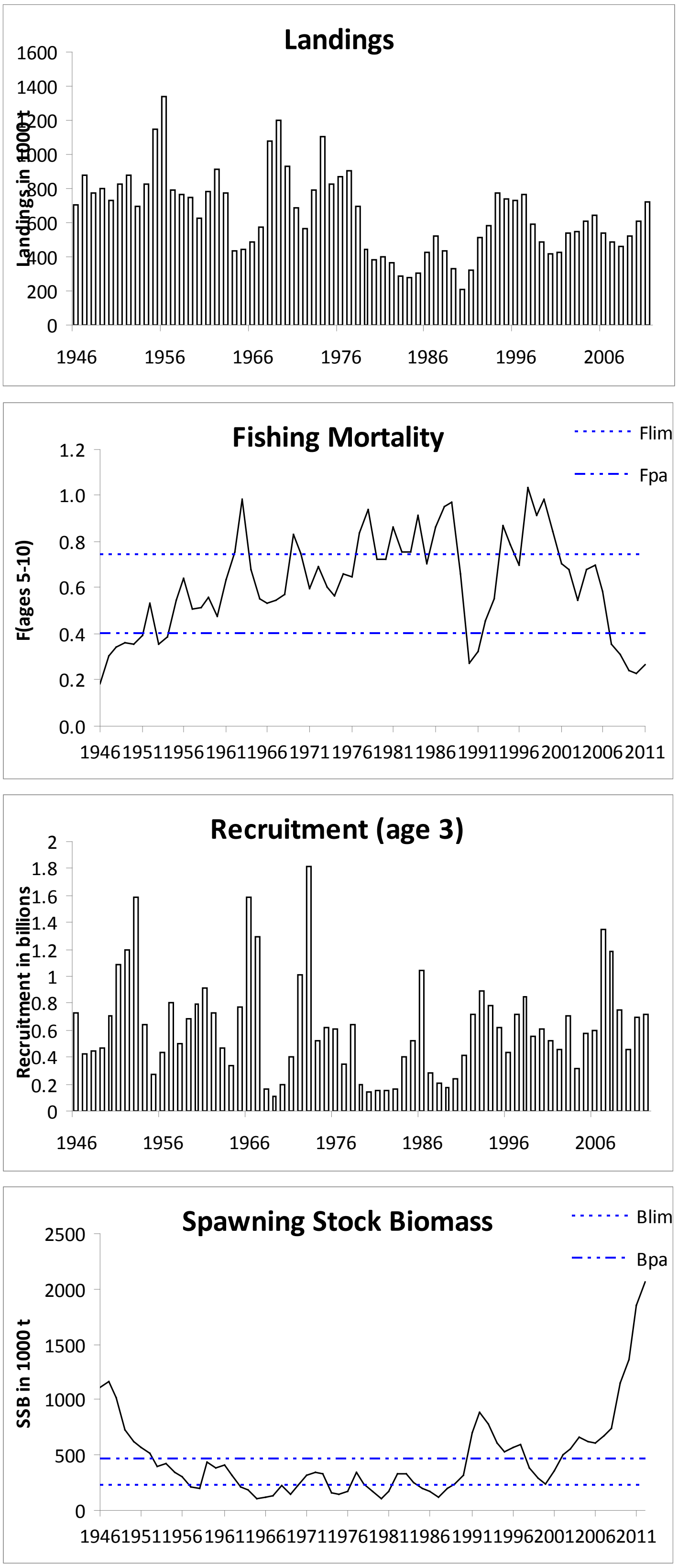
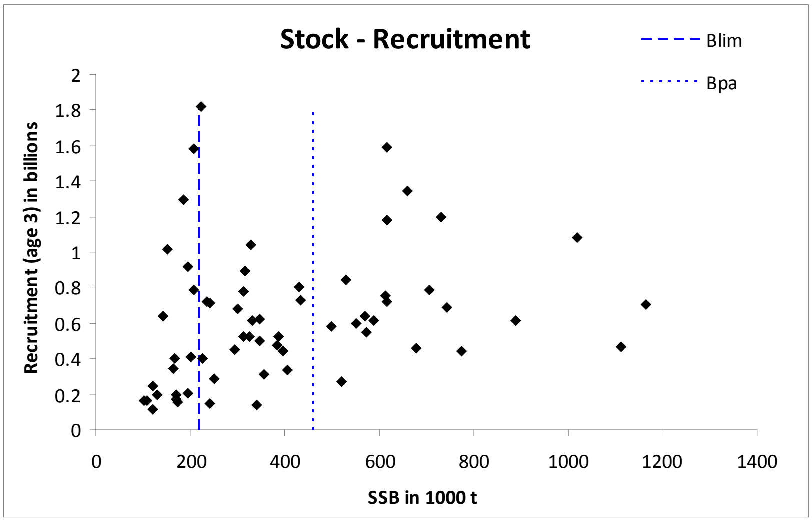


Figure 3.1. ICES Standard plots for Northeast Arctic cod (sub-area I and II)



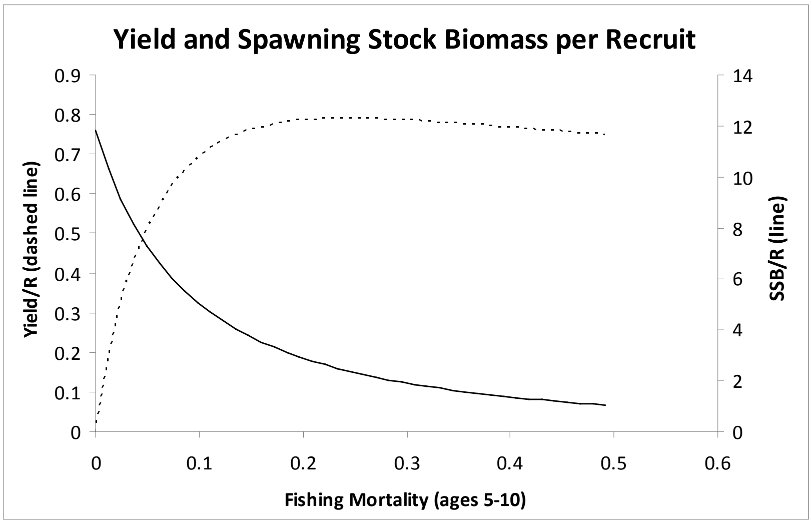


Figure 3.1. Continued. ICES Standard plots for Northeast Arctic cod (sub-area I and II)

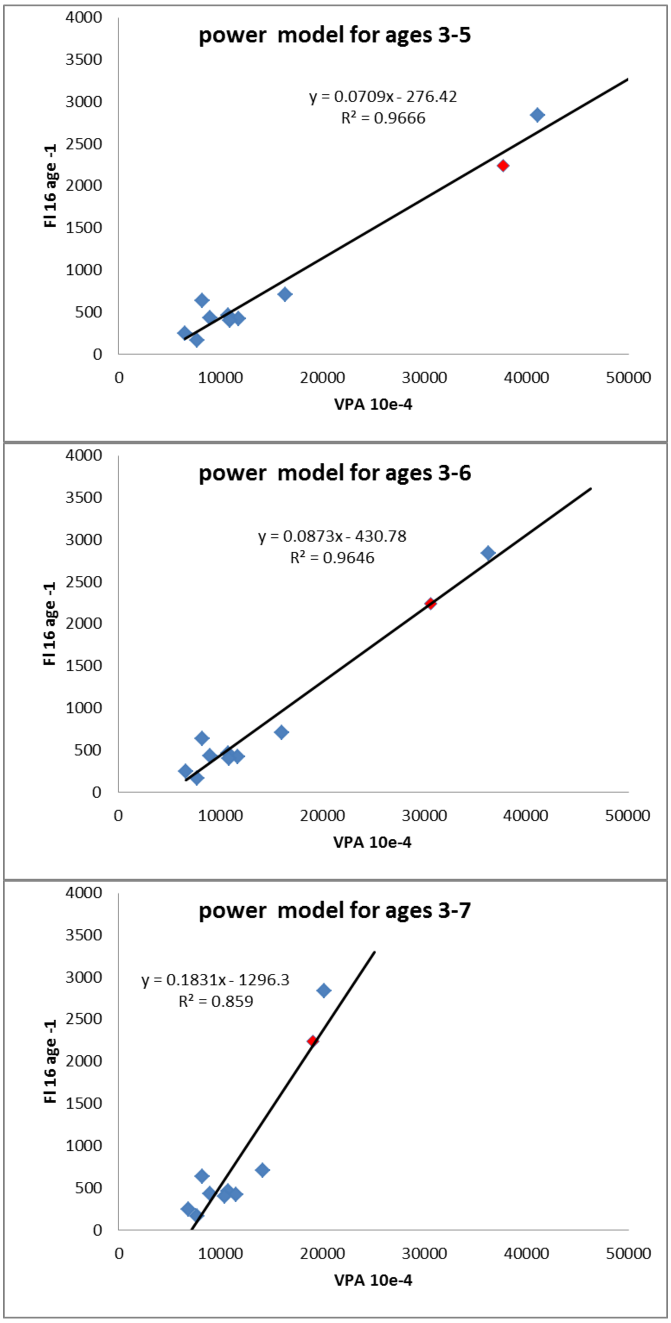


Figure 3.2a. Relationships of NEA cod VPA estimates at age 7 and survey "Fleet16" indexes at age 6 (at the end of year-1) obtained with different value of XSA parameter "*Catchability dependent on stock size for ages*". Terminal year is colored in red.

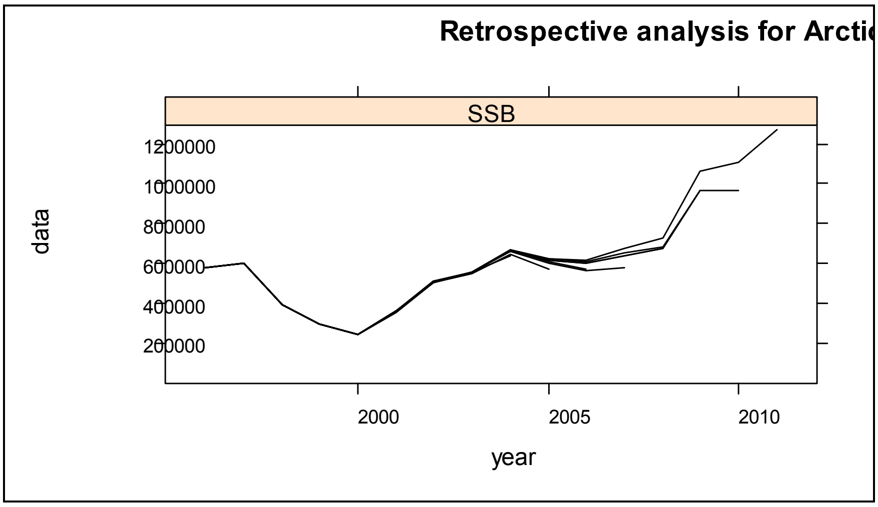


Figure 3.2b. NEA cod SSB retrospective pattern for XSA model with parameter "*Catchability dependent on stock size for ages* < 8" and all other parameters same as last year settings.

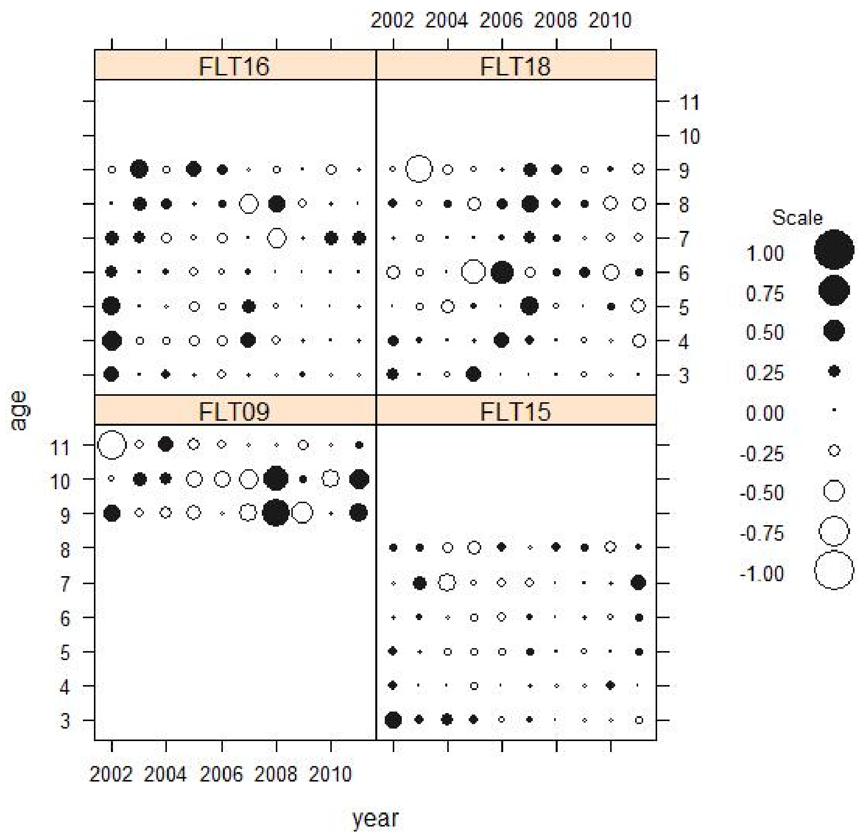


Figure 3.2c. Log catchability residuals by fleets for the tuning data used in XSA.

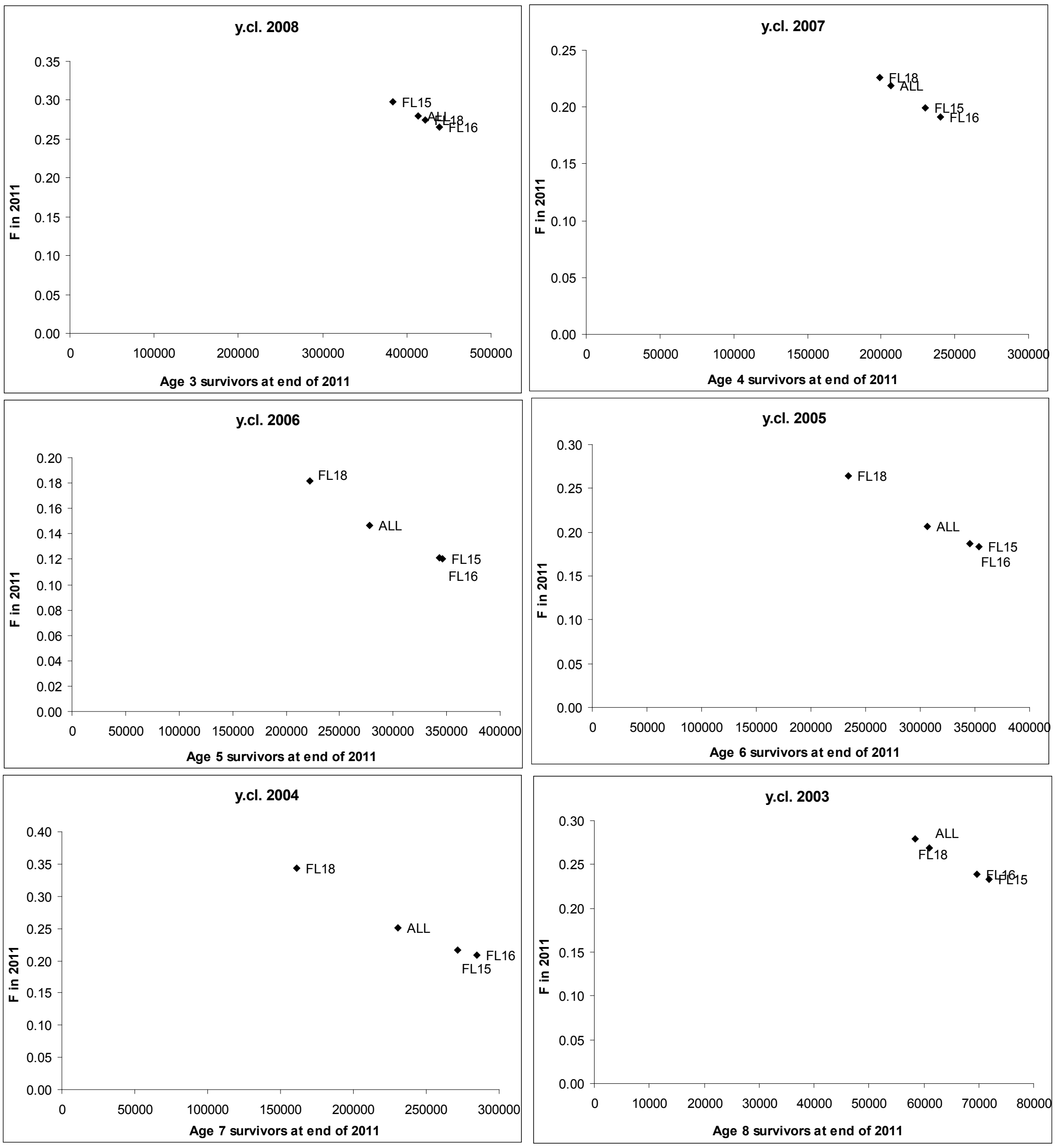


Figure 3.3. Single fleet estimates (before shrinkage) of F2011 and survivors at the end of 2011 taken from xsa-diagnostics of single fleet runs. "ALL" is the estimates from the final xsa (with shrinkage, including all fleets). The Fs for ages 3-5 includes cannibalism mortality.

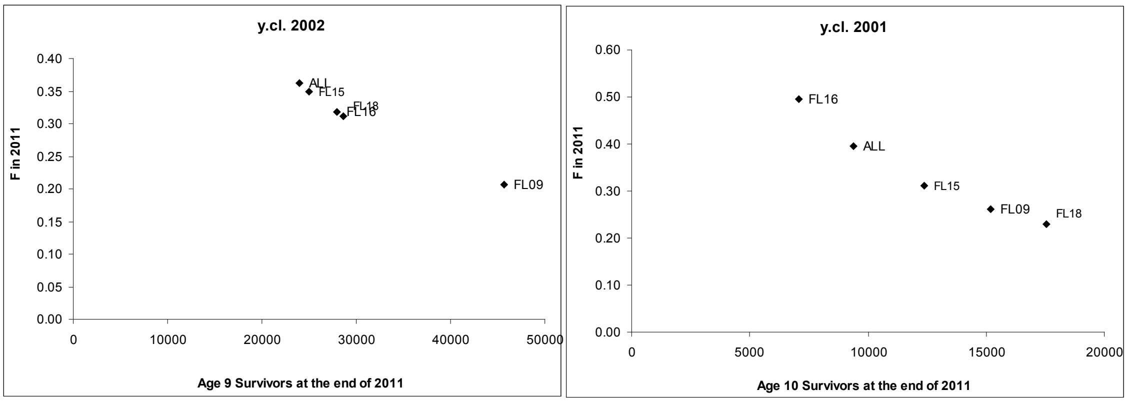


Figure 3.3. (continued). Single fleet estimates (before shrinkage) of F2011 and survivors at the end of 2011 taken from xsa-diagnostics of single fleet runs. "ALL" is the estimate from the final xsa (with shrinkage, including all fleets).

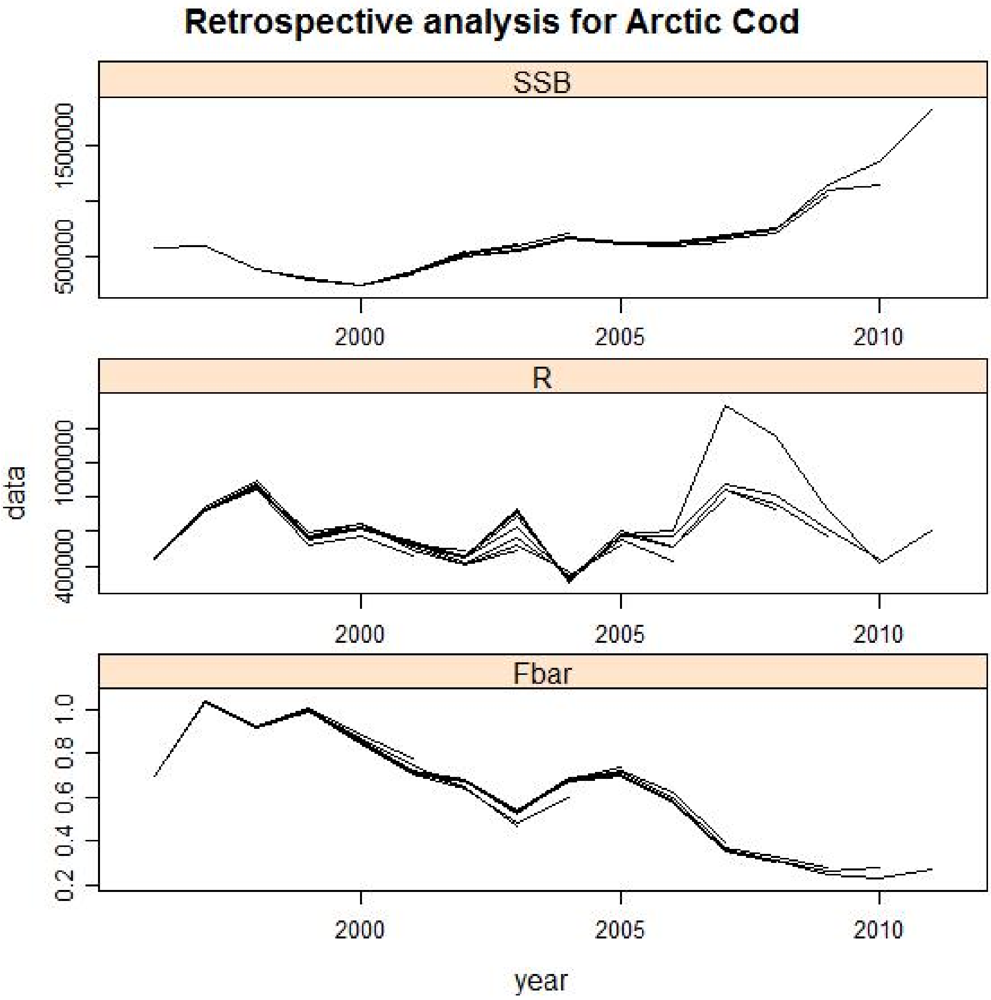


Figure 3.4. Northeast Arctic cod. Retrospective plots with catchability dependent on stock size for ages < 7.

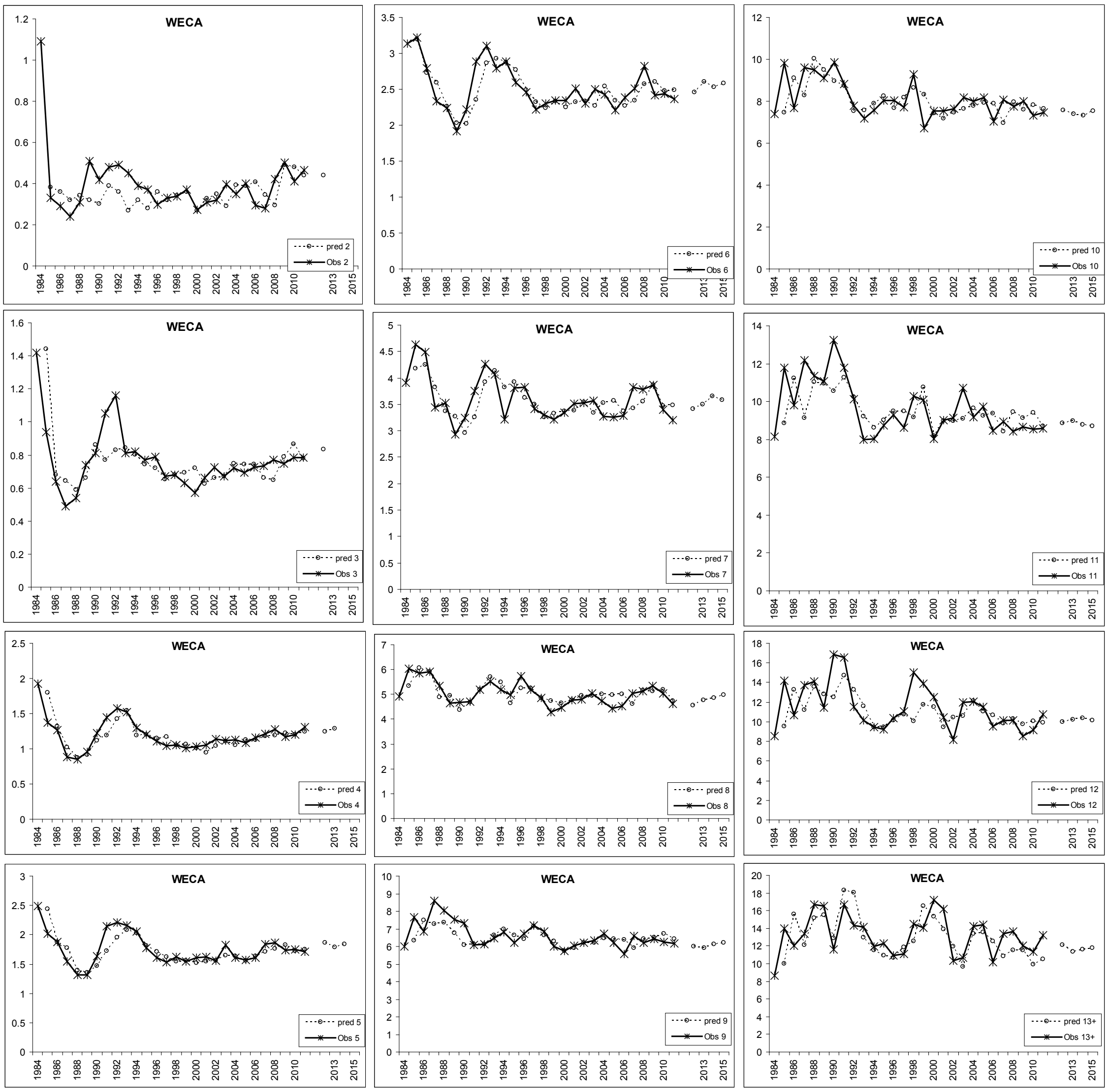


Figure 3.5a. Northeast Arctic cod. Weight in catch predictions.

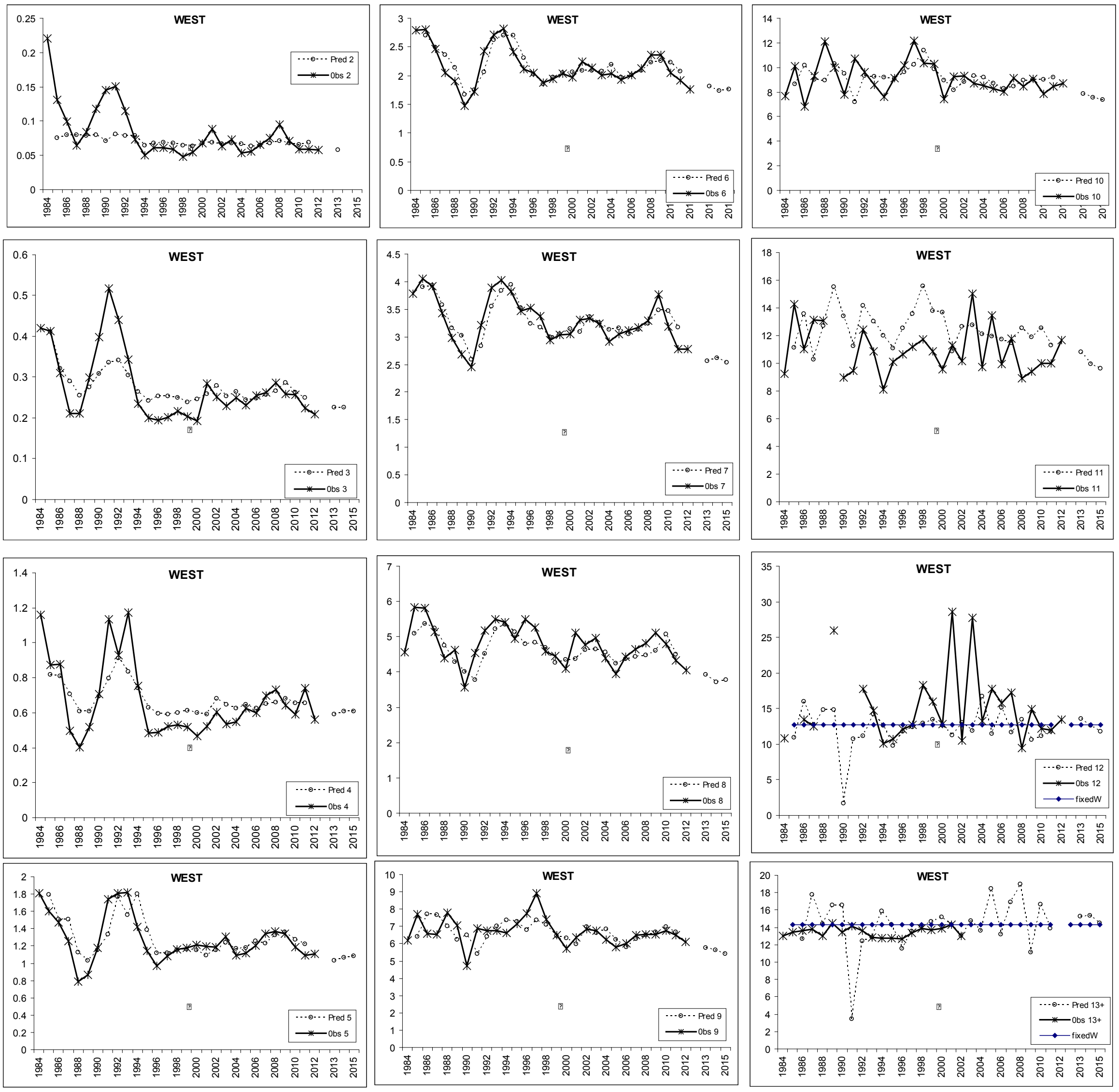


Figure 3.5b. Northeast Arctic cod. Weight in stock projections

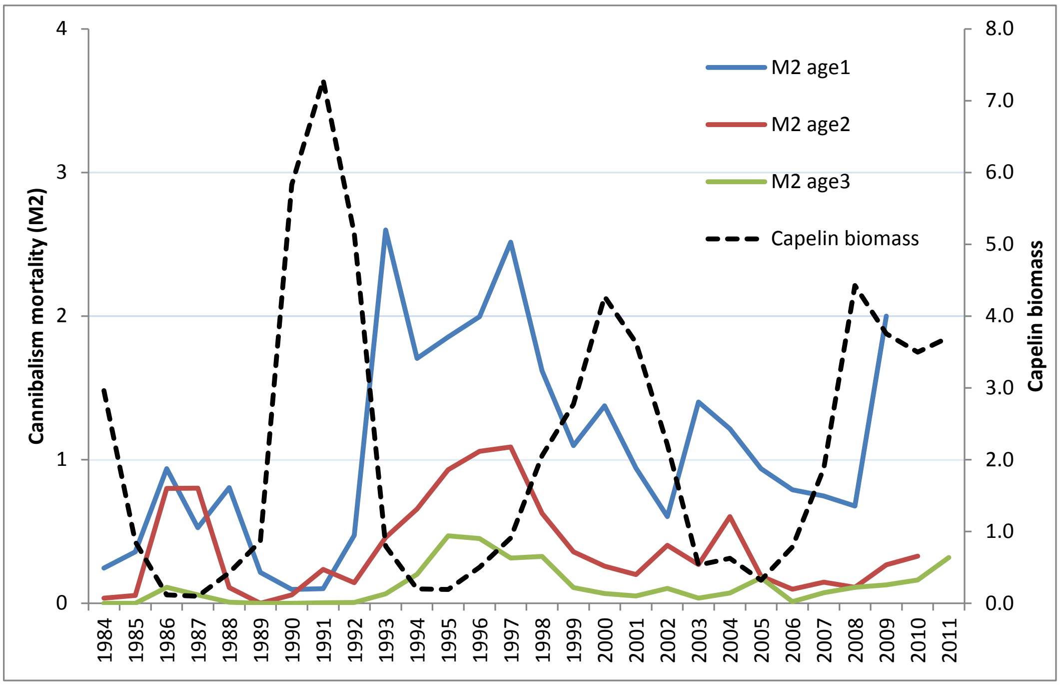


Figure 3.6. Capelin biomass and cannibalism mortality on cod age 1, 2 and 3.

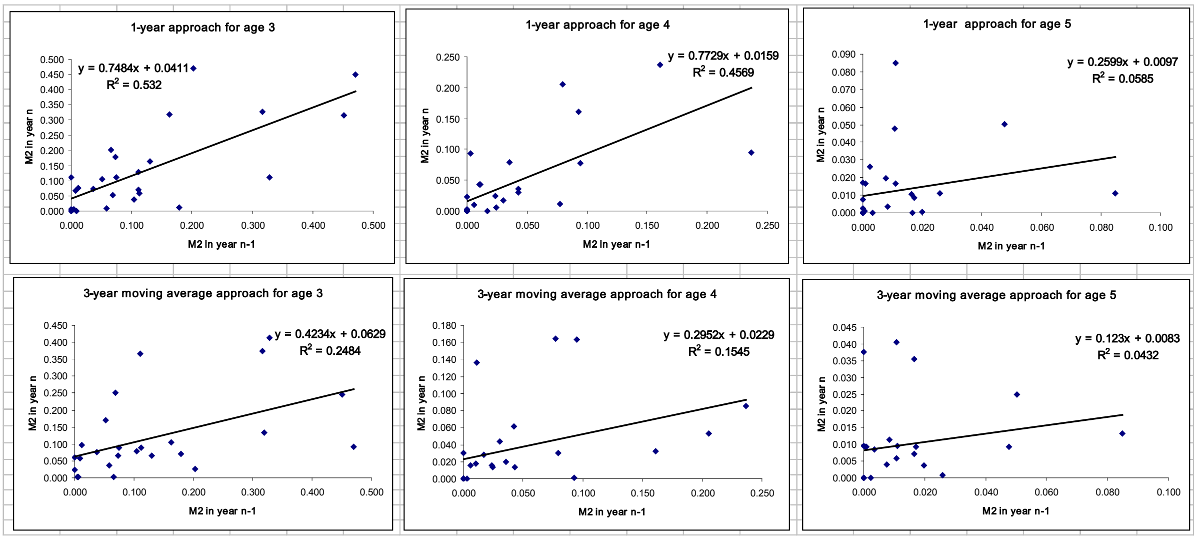
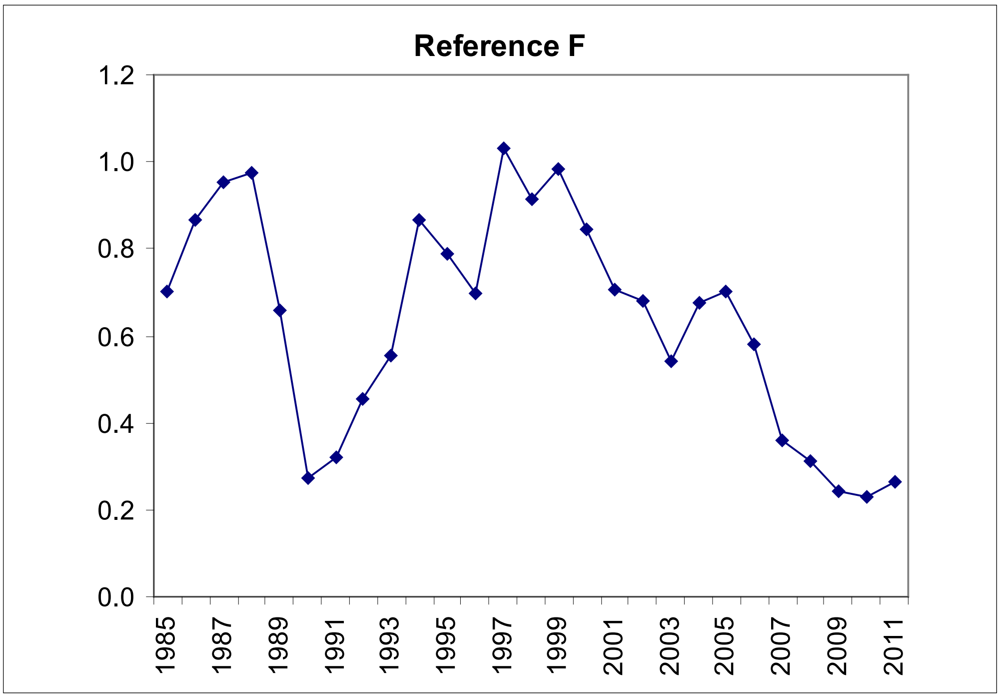


Figure 3.6a. Northeast arctic cod. Comparison of two approaches for predictions of natural mortality of cod (M2) due to cannibalism (1-year approach vs. 3-year moving average approach).



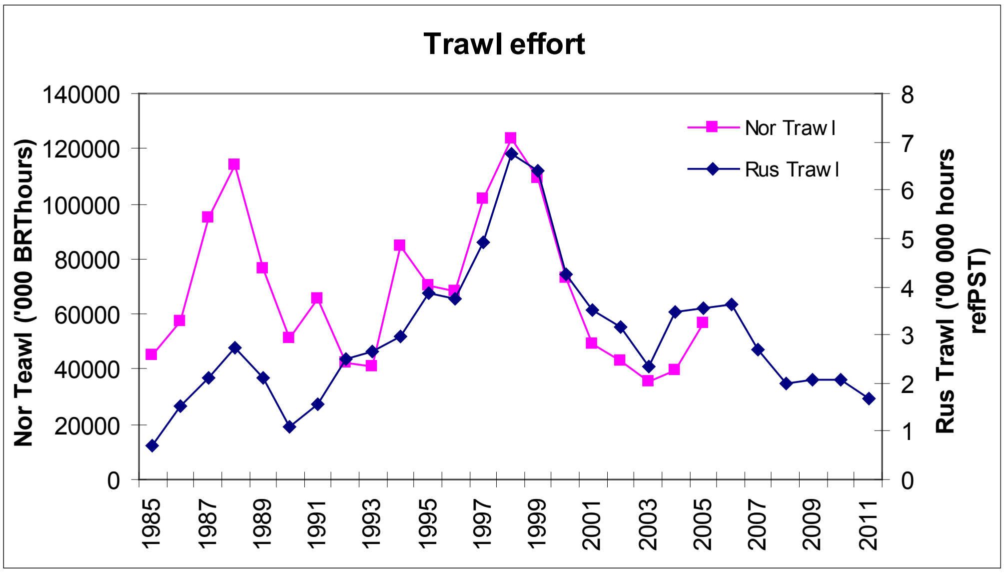


Figure 3.7. Northeast Arctic cod. Fishing mortality ($F_{5\text{-}10}$) (top panel) and trawl efforts in 1985-2011 (bottom panel).

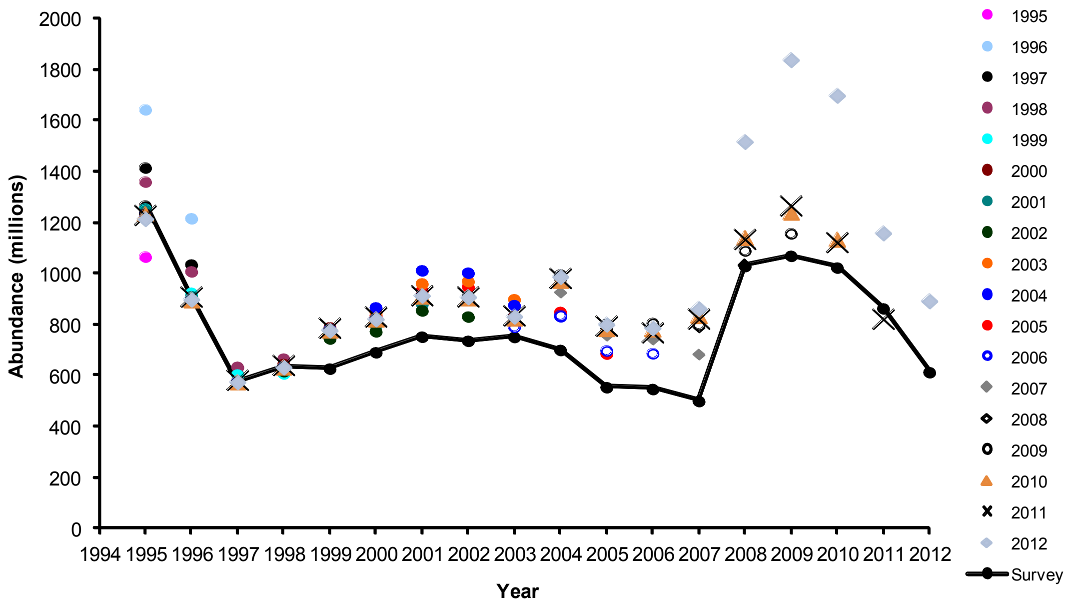


Figure3.8. Calibrated (with intercept) bottom trawl survey estimates (connected solid circles), ICES 2012 estimates (grey diamonds) and the 1995-2011 ICES annual assessments (unconnected symbols) of the total numbers of Northeast Arctic cod ages 4 to 6.

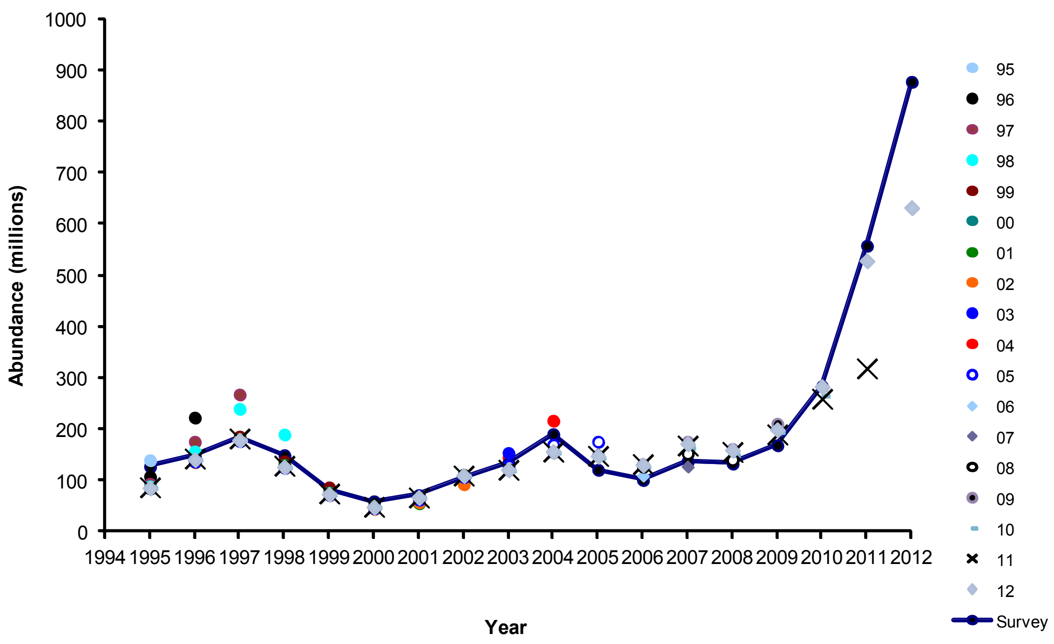


Figure 3.9. Calibrated (with intercept) bottom trawl survey estimates (connected solid circles), ICES 2012 estimates (grey diamonds) and the 1995-2011 ICES annual assessments (unconnected symbols) of the total numbers of Northeast Arctic cod ages 7 and older.

Table A1 North-East Arctic COD. Catch per unit effort.

	Sub-area I			Division IIb			Division IIa		Total
Year	Norway[2]	UK[3]	Russia[4]	Norway[2]	UK[3]	Russia[4]	Norway[2]	UK[3]	Norway
1960	-	0.075	0.42	-	0.105	0.31	-	0.067	
1961	-	0.079	0.38	-	0.129	0.44	-	0.058	
1962	-	0.092	0.59	-	0.133	0.74	-	0.066	
1963	-	0.085	0.60	-	0.098	0.55	-	0.066	
1964	-	0.056	0.37	-	0.092	0.39	-	0.070	
1965	-	0.066	0.39	-	0.109	0.49	-	0.066	
1966	-	0.074	0.42	-	0.078	0.19	-	0.067	
1967	-	0.081	0.53	-	0.106	0.87	-	0.052	
1968	-	0.110	1.09	-	0.173	1.21	-	0.056	
1969	-	0.113	1.00	-	0.135	1.17	-	0.094	
1970	-	0.100	0.80	-	0.100	0.80	-	0.066	
1971	-	0.056	0.43	-	0.071	0.16	-	0.062	
1972	0.90	0.047	0.34	0.59	0.051	0.18	1.08	0.055	
1973	1.05	0.057	0.56	0.43	0.054	0.57	0.71	0.043	
1974	1.75	0.079	0.86	1.94	0.106	0.77	0.19	0.028	
1975	1.82	0.077	0.94	1.67	0.100	0.43	1.36	0.033	
1976	1.69	0.060	0.84	1.20	0.081	0.30	1.69	0.035	
1977	1.54	0.052	0.63	0.91	0.056	0.25	1.16	0.044	1.17
1978	1.37	0.062	0.52	0.56	0.044	0.08	1.12	0.037	0.94
1979	0.85	0.046	0.43	0.62	-	0.06	1.06	0.042	0.85
1980	1.47	-	0.49	0.41	-	0.16	1.27	-	1.23
					Spain[5]			**Russia[4]**	
1981	1.42	-	0.41	(0.96)	-	0.07	1.02	0.35	1.21
1982	1.30	-	0.35	-	0.86	0.26	1.01	0.34	1.09
1983	1.58	-	0.31	(1.31)	0.92	0.36	1.05	0.38	1.11
1984	1.40	-	0.45	1.20	0.78	0.35	0.73	0.27	0.96
1985	1.86	-	1.04	1.51	1.37	0.50	0.90	0.39	1.29
1986	1.97	-	1.00	2.39	1.73	0.84	1.36	1.14	1.70
1987	1.77	-	0.97	2.00	1.82	1.05	1.73	0.67	1.77
1988	1.58	-	0.66	1.61	(1.36)	0.54	0.97	0.55	1.03
1989	1.49	-	0.71	0.41	2.70	0.45	0.78	0.43	0.76
1990	1.35	-	0.70	0.39	2.69	0.80	0.38	0.60	0.49
1991	1.38	-	0.67	0.29	4.96	0.76	0.50	0.90	0.44
1992	2.19	-	0.79	3.06	2.47	0.23	0.98	0.65	1.29
1993	2.33	-	0.85	2.98	3.38	1.00	1.74	1.03	1.87
1994	2.50	-	1.01	2.82	1.44	1.14	1.27	0.86	1.59
1995	1.57	-	0.59	2.73	1.65	1.10	1.00	1.01	1.92
1996			0.74		1.11	0.85		0.99	1.81
1997			0.61			0.57		0.74	1.36
1998			0.37			0.29		0.40	0.83
1999			0.29			0.34		0.39	0.74
2000			0.34			0.37		0.53	0.92
2001			0.46			0.46		0.69	1.21
2002			0.58			0.66		0.57	1.35
2003			0.70			1.22		0.73	1.67
2004			0.48			0.78		0.84	1.67
2005			0.45			0.62		0.81	1.23
2006			0.49			0.54		0.84	0.88
2007			0.71			0.51		0.88	1.16
2008			0.93			0.79		1.21	
2009			1.33			1.16		0.83	
2010			1.47			1.18		1.16	
2011[1]			1.77			1.69		2.46	

[1]Preliminary figures.
[2]Norwegian data - t per 1,000 tonnage*hrs fishing.
[3]United Kingdom data - t per 100 tonnage*hrs fishing.
[4]Russian data - t per hr fishing.
[5]Spanish data - t per hr fishing.

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

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

Table A2. North-east Arctic COD. Abundance indices (millions) from the Norwegian acoustic survey in the Barents Sea in January-March. New TS and rock-hopper gear (1981-1988 back-calculated from bobbins gear). Corrected for length-dependent effective spread of trawl.

Year	Age									
	1	2	3	4	5	6	7	8	9	10+	Total
1981	8.0	82.0	40.0	63.0	106.0	103.0	16.0	3.0	1.0	1.0	423.0
1982	4.0	5.0	49.0	43.0	40.0	26.0	28.0	2.0	+	0.0	197.0
1983	60.5	2.8	5.3	14.3	17.4	11.1	5.6	3.0	0.5	0.1	120.5
1984	745.4	146.1	39.1	13.6	11.3	7.4	2.8	0.2	0.0	0.0	966.0
1985	69.1	446.3	153.0	141.6	19.7	7.6	3.3	0.2	0.1	0.0	840.9
1986	353.6	243.9	499.6	134.3	65.9	8.3	2.2	0.4	0.1	0.0	1308.2
1987	1.6	34.1	62.8	204.9	41.4	10.4	1.2	0.2	0.7	0.0	357.3
1988	2.0	26.3	50.4	35.5	56.2	6.5	1.4	0.2	0.0	0.0	178.4
1989	7.5	8.0	17.0	34.4	21.4	53.8	6.9	1.0	0.1	0.1	150.1
1990	81.1	24.9	14.8	20.6	26.1	24.3	39.8	2.4	0.1	0.0	234.1
1991	181.0	219.5	50.2	34.6	29.3	28.9	16.9	17.3	0.9	0.0	578.7
1992	241.4	562.1	176.5	65.8	18.8	13.2	7.6	4.5	2.8	0.2	1092.9
1993 [1]	1074.0	494.7	357.2	191.1	108.2	20.8	8.1	5.0	2.3	2.5	2264.0
1994 [1]	858.3	577.2	349.8	404.5	193.7	63.6	12.1	3.7	1.7	0.9	2465.4
1995 [1]	2619.2	292.9	166.2	159.8	210.1	68.8	16.7	2.1	0.7	1.0	3537.4
1996 [1]	2396.0	339.8	92.9	70.5	85.8	74.7	20.6	2.8	0.3	0.4	3083.8
1997 [1,2]	1623.5	430.5	188.3	51.7	49.3	37.2	22.3	4.0	0.7	0.1	2407.5
1998 [1,2]	3401.3	632.9	427.7	182.6	42.3	33.5	26.9	13.6	1.7	0.3	4762.8
1999 [1]	358.3	304.3	150.0	96.4	45.1	10.3	6.4	4.1	0.8	0.3	976.1
2000 [1]	154.1	221.4	245.2	158.9	142.1	45.4	9.6	4.7	3.0	1.1	985.5
2001 [1]	629.9	63.9	138.2	171.6	77.3	39.7	11.8	1.4	0.5	0.2	1134.5
2002 [1]	18.2	215.5	69.3	112.2	102.0	47.0	18.0	3.0	0.4	0.3	585.9
2003 [1]	1693.9	61.5	303.4	114.4	129.0	114.9	34.3	7.7	1.9	0.5	2461.5
2004 [1]	157.6	105.2	33.6	92.8	30.7	27.6	17.0	5.9	1.2	0.2	471.8
2005 [1]	465.3	119.6	123.9	33.7	62.8	16.9	14.5	4.2	1.0	0.4	842.4
2006 [1]	544.6	216.6	79.8	59.1	15.5	25.6	8.8	4.5	1.4	0.5	956.5
2007 [1,2]	125.0	61.7	80.3	37.1	30.4	9.1	14.1	5.0	2.1	0.7	365.6
2008 [1]	68.8	97.6	210.2	306.1	140.6	69.4	21.6	12.2	3.1	0.8	930.4
2009 [1]	321.5	30.6	182.6	178.3	137.1	35.0	12.5	5.2	3.7	0.9	907.3
2010 [1]	485.4	59.4	34.7	121.9	174.7	162.3	44.4	13.8	3.5	3.5	1103.6
2011 [1]	389.3	124.8	47.1	29.1	80.4	107.7	105.4	17.1	4.5	3	908.4
2012 [1,2]	950.6	72.7	133.9	52.7	37.7	69.4	126.1	77	10.4	6	1536.4

[1] Survey covered a larger area

[2] Adjusted indices

Table A3. North-East Arctic COD. Abundance indices (millions) from the Norwegian bottom trawl survey in the Barents Sea in January-March. Rock-hopper gear (1981-1988 back-calculated from bobbins gear). Corrected for length-dependent effective spread of trawl.

			Age								
Year	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 [1]	1020.2	104.4	36.0	106.9	160.8	140.7	40.0	11.9	3.5	2.2	1627.0
2011 [1]	618.6	223.0	88.1	54.1	122.1	139.9	95.6	16.8	3.9	2.4	1365.0
2012 [1,2]	1364.0	329.9	98.0	68.4	44.8	87.3	124.1	53.1	7.9	4.8	2182.0

[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
2011	2.02	51.01	178.92	48.47	18.10	4.58	6.98	0.44	310.50
2012	0.37	13.43	98.37	77.69	20.53	7.37	3.18	1.80	222.74

Table A5. North-east Arctic COD. Mean length at age(cm) from Norwegian surveys in January-March 1983-1999 values re-calculated from raw data.									
Year		1	2	3	4	5	6	7	8
1978		14.2	23.1	32.1	45.9	54.2	64.6	67.6	76.9
1979		12.8	22.9	33.1	40.0	52.3	64.4	74.7	83.0
1980		17.6	24.8	34.2	40.5	52.5	63.5	73.6	83.6
1981		17.0	26.1	35.5	44.7	52.0	61.3	69.6	77.9
1982		14.8	25.8	37.6	46.3	54.7	63.1	70.8	82.9
1983		12.8	27.6	34.8	45.9	54.5	62.7	73.1	78.6
1984		14.2	28.4	35.8	48.6	56.6	66.2	74.1	79.7
1985		16.5	23.7	40.3	48.7	61.3	71.1	81.2	85.7
1986		11.9	21.6	34.4	49.9	59.8	69.4	80.3	93.8
1987		13.9	21.0	31.8	41.3	56.3	66.3	77.6	87.9
1988		15.3	23.3	29.7	38.7	47.6	56.8	71.7	79.4
1989		12.5	25.4	34.7	39.9	46.8	56.2	67.0	83.3
1990		14.4	27.9	39.4	47.1	53.8	60.6	68.2	79.2
1991		13.6	27.2	41.6	51.7	59.5	67.1	72.3	77.6
1992		13.2	23.9	41.3	49.9	60.2	68.4	76.1	82.8
1993		11.3	20.3	35.9	50.8	59.0	68.2	76.8	85.8
1994		12.0	18.3	30.5	44.7	55.4	64.3	73.5	82.4
1995		12.7	18.7	29.9	42.0	54.1	64.1	74.8	80.6
1996		12.6	19.6	28.1	41.0	49.3	61.4	72.2	85.3
1997	[1]	11.4	18.8	28.0	40.4	49.9	59.3	69.1	80.6
1998	[1]	10.9	17.4	28.7	40.0	50.5	58.9	67.5	76.3
1999		12.1	18.8	29.0	40.6	50.6	59.9	70.3	78.0
2000		13.0	21.0	28.7	39.7	51.5	61.6	70.5	75.7
2001		12.0	22.5	33.1	41.6	52.2	63.1	71.2	79.2
2002		12.2	19.9	30.1	43.6	52.2	61.7	71.6	79.1
2003		12.0	21.2	29.1	39.2	53.3	61.6	70.3	80.7
2004		11.0	18.9	32.0	40.9	52.0	61.8	69.0	79.0
2005		11.5	18.6	29.3	43.0	51.1	60.3	71.1	78.4
2006		12.2	19.9	31.3	42.1	53.5	60.8	68.9	77.7
2007		13.4	21.3	30.7	42.2	52.8	62.3	70.5	77.9
2008		12.5	22.3	32.5	43.7	52.4	63.6	71.6	80.8
2009		11.7	21.4	32.2	43.2	53.6	63.3	76.0	84.4
2010		11.4	19.1	31.2	42.3	52.0	61.3	70.5	80.6
2011		12.5	19.9	30.3	42.3	51.3	60.8	68.5	78.4
2012	[1]	11.8	18.6	28.2	41.3	51.3	59.0	67.1	75.2

[1)] *Adjusted lengths*

Table A6. North-east Arctic COD. Weight (g) at age from Norwegian surveys in January-March

Year		Age						
		1	2	3	4	5	6	7	8
1983			190	372	923	1597	2442	3821	4758
1984		23	219	421	1155	1806	2793	3777	4566
1985			171	576	1003	2019	3353	5015	6154
1986			119	377	997	1623	2926	3838	7385
1987	[2]	21	65	230	490	1380	2300	3970	
1988		24	114	241	492	892	1635	3040	4373
1989		16	158	374	604	947	1535	2582	4906
1990		26	217	580	1009	1435	1977	2829	4435
1991		18	196	805	1364	2067	2806	3557	4502
1992		20	136	619	1118	1912	2792	3933	5127
1993		9	71	415	1179	1743	2742	3977	5758
1994		13	55	259	788	1468	2233	3355	4908
1995		16	54	248	654	1335	2221	3483	4713
1996		15	62	210	636	1063	1999	3344	5514
1997	[1]	12	54	213	606	1112	1790	2851	4761
1998	[1]	10	47	231	579	1145	1732	2589	3930
1999		13	55	219	604	1161	1865	2981	3991
2000		17	77	210	559	1189	1978	2989	3797
2001		14	103	338	664	1257	2188	3145	4463
2002		15	68	256	747	1234	2024	3190	4511
2003		14	82	228	569	1302	1980	2975	4666
2004		11	58	294	600	1167	1934	2657	4025
2005		13	57	230	705	1135	1817	2948	4081
2006		15	71	288	682	1366	1991	2959	4354
2007		19	78	253	691	1302	2128	3032	4327
2008		16	94	319	798	1393	2412	3413	5067
2009		13	83	291	724	1337	2180	3775	5267
2010		12	63	300	683	1246	2041	3076	4765
2011		15	64	257	684	1175	1930	2735	4055
2012	[1]	13	53	214	635	1168	1706	2560	3667

[1] Adjusted weights

[2] Estimated weights

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

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

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

Year	5	6	7	8	9	10	11	12+
1985	2.00	3.42	4.61	6.67	8.89	10.73	14.29	
1986	2.22	3.22	4.74	6.40	5.80		10.84	13.48
1987	1.44	1.94	3.61	5.40	5.64		13.15	12.55
1988	1.46	2.82	3.39	6.63	7.27	13.64		
1989	1.30	1.77	2.89	4.74	8.28	9.98		26.00
1990	1.54	2.32	2.55	3.78	4.77	8.80		
1991	2.21	2.52	3.51	5.18	7.40	11.36	5.35	
1992	2.56	2.85	3.99	5.43	6.35	8.03	9.50	17.80
1993	1.79	2.58	3.55	5.31	6.21	7.69	9.28	14.71
1994	2.31	3.27	5.06	6.39	6.64	7.92	7.73	10.10
1995	2.20	3.24	4.83	5.98	7.80	10.03	10.39	10.68
1996	2.22	2.75	4.11	5.63	7.92	10.53	10.58	12.08
1997	2.42	2.92	3.86	5.71	9.65	13.41		12.67
1998	1.88	2.09	2.98	4.85	7.92	9.91	11.05	18.34
1999	1.51	2.80	2.96	4.22	5.92	9.33	9.17	16.00
2000	1.71	2.50	3.16	3.85	5.32	7.07	7.62	12.84
2001	1.90	2.72	3.49	6.23	6.82	10.95	10.29	28.58
2002	1.87	2.57	3.52	4.71	6.18	10.56	8.70	10.48
2003	2.30	2.34	3.48	4.59	5.89	8.07	24.50	27.70
2004	1.74	2.30	3.02	4.50	5.77	7.81	9.95	13.25
2005	1.56	2.40	3.20	3.71	5.79	8.52	16.27	18.63
2006	1.54	2.35	3.44	4.19	5.43	6.57	6.19	18.15
2007	2.34	2.67	3.53	5.30	6.70	9.95	11.24	16.62
2008	2.21	2.97	3.63	4.88	6.74	8.18	7.70	9.07
2009	2.04	2.98	4.10	5.19	6.56	9.38	8.58	15.67
2010	1.91	2.28	3.60	4.70	7.03	7.11	9.09	12.50
2011	1.61	2.29	2.89	4.51	6.79	8.30	9.46	10.54
2012	2.34	2.46	2.93	3.93	5.39	8.91	11.68	12.56

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 S

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	427.4	52.4	63.2	92.7	161.3	77.7	180.1	66.2	34.2	16.1	6.8	1178.1
2007	177.5	37.0	148.6	257.9	161.7	190.3	84.6	152.5	55.3	22.6	15.3	1303.3
2008	1468.6	45.2	86.3	220.3	308.8	163.5	147.2	83.0	86.3	29.1	11.5	2638.2
2009	1877.7	287.8	21.9	97.4	231.7	368.7	201.6	117.5	62.0	41.3	31.1	3338.7
2010	2091.2	335.2	35.3	54.3	138.5	366.8	269.8	145.5	60.3	44.6	45.0	3586.7
2011	2296.1	125.9	80.0	88.2	50.8	143.2	306.5	330.0	91.7	43.9	45.7	3602.1

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

Year	Age									
	0	1	2	3	4	5	6	7	8	9
1984	15.7	22.3	30.7	44.3	51.7	63.6	73.4	82.5	88.4	97.0
1985	15.0	21.1	30.6	43.2	53.7	61.2	72.8	83.0	92.8	101.3
1986	15.2	19.7	28.3	39.0	51.8	62.2	70.9	83.0	91.3	104.0
1987	-	19.2	27.9	33.4	41.4	59.1	69.2	80.1	95.7	102.6
1988	11.3	21.3	28.7	36.2	43.9	53.3	65.3	79.5	85.0	-
1989	-	20.8	28.8	34.8	46.0	53.9	61.8	69.8	78.7	88.6
1990	16.0	24.0	30.4	46.5	54.9	62.5	69.7	77.6	87.8	102.0
1991	11.5	22.4	30.6	43.0	55.9	64.6	72.8	78.5	87.9	101.8
1992	11.3	21.3	31.9	50.1	59.8	69.1	78.6	84.0	90.8	97.5
1993	12.1	17.4	29.1	43.4	52.7	64.3	73.9	81.2	89.1	91.8
1994	12.2	20.3	26.3	33.7	47.4	58.7	70.6	80.8	90.1	96.1
1995	11.6	19.8	27.6	33.8	45.2	60.5	71.1	83.5	92.9	99.1
1996	10.2	20.0	28.1	36.7	48.7	58.9	70.5	80.0	93.6	102.7
1997	9.6	18.5	28.8	38.2	50.8	62.0	70.5	80.1	88.9	103.5
1998	11.4	19.0	28.0	36.4	50.5	61.0	70.7	80.3	91.1	102.5
1999	11.7	19.7	27.9	35.3	51.6	60.6	70.6	78.9	86.8	94.3
2000	10.7	20.8	30.1	34.7	49.8	61.1	71.6	82.0	88.3	85.7
2001	10.6	19.4	29.8	37.3	50.4	61.9	71.9	81.4	91.0	98.7
2002	10.7	19.2	29.9	38.2	52.5	60.4	70.6	82.2	91.3	97.2
2003	9.8	18.9	28.3	34.9	49.2	62.2	71.0	81.5	92.3	100.9
2004	9.8	19.6	29.3	38.4	49.1	60.0	70.5	80.0	91.0	98.0
2005	11.2	19.4	29.7	38.5	48.7	59.3	69.3	79.2	87.7	96.1
2006	13.0	21.9	31.6	42.7	53.2	60.1	70.2	79.1	88.3	95.2
2007	10.7	21.5	30.8	42.2	53.6	63.7	71.0	79.6	87.3	95.9
2008	10.2	20.0	30.3	40.2	53.7	64.5	74.6	82.7	89.5	98.2
2009	12.9	19.3	29.5	38.4	50.7	61.5	70.7	81.7	89.9	94.7
2010	11.1	19.3	28.7	38.5	48.9	59.1	68.0	78.4	88.2	97.3
2011	11.2	20.3	29.2	38.5	49.5	58.6	68.7	78.2	90.0	97.9

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

Year	Age										
	0	1	2	3	4	5	6	7	8	9	10
1984	26	90	250	746	1,187	2,234	3,422	5,027	6,479	9,503	-
1985	26	80	245	762	1,296	1,924	3,346	5,094	7,360	6,833	11,167
1986	25	63	191	506	1,117	1,940	2,949	4,942	7,406	9,300	-
1987	-	54	182	316	672	1,691	2,688	3,959	8,353	10,583	13,107
1988	15	78	223	435	789	1,373	2,609	4,465	5,816	-	-
1989	-	73	216	401	928	1,427	2,200	3,133	4,649	6,801	8,956
1990	28	106	230	908	1,418	2,092	2,897	4,131	6,359	10,078	13,540
1991	26	93	260	743	1,629	2,623	3,816	4,975	7,198	11,165	15,353
1992	10	76	273	1,165	1,895	2,971	4,377	5,596	7,319	9,452	12,414
1993	11	46	211	717	1,280	2,293	3,509	4,902	6,621	7,339	8,494
1994	12	69	153	316	919	1,670	2,884	4,505	6,520	8,207	9,812
1995	11	61	180	337	861	1,987	3,298	5,427	7,614	9,787	10,757
1996	7	64	191	436	1,035	1,834	3,329	5,001	8,203	10,898	11,358
1997	6	48	203	487	1,176	2,142	3,220	4,805	6,925	10,823	12,426
1998	11	55	187	435	1,186	2,050	3,096	4,759	7,044	11,207	12,593
1999	10	58	177	371	1,214	1,925	3,064	4,378	6,128	7,843	11,543
2000	8	74	232	379	1,101	2,128	3,341	5,054	6,560	8,497	12,353
2001	9	58	221	459	1,125	2,078	3,329	4,950	7,270	9,541	11,672
2002	8	65	232	505	1,299	1,964	3,271	5,325	7,249	9,195	11,389
2003	6	49	205	492	972	1,993	2,953	4,393	6,638	9,319	11,085
2004	6	55	231	543	1,079	1,798	2,977	4,110	5,822	8,061	12,442
2005	10	59	223	521	1,034	1,910	3,036	4,619	6,580	9,106	12,006
2006	13	72	270	707	1,332	1,953	2,969	4,340	6,410	8,622	12,436
2007	10	96	252	669	1,344	2,277	3,140	4,691	6,178	8,567	10,014
2008	7	58	228	558	1,332	2,305	3,527	5,001	6,519	8,848	10,339
2009	15	54	214	495	1,116	2,024	3,090	4,876	6,592	8,087	10,262
2010	9	54	191	494	989	1,784	2,719	4,246	6,384	8,747	10,499
2011	10	63	206	486	1,037	1,691	2,827	4,312	6,698	8,979	11,557

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	141.6	20.4	15.1	15.7	3.3	1.3	1	0.5	0
1986	353.6	243.9	499.6	134.3	68.4	11.6	7.7	3.1	0.3	0	0.4	0.1
1987	1.6	34.1	62.8	204.9	50.2	17.4	1.4	3	0.7	0	0	0
1988	2	26.3	50.4	35.5	57.8	10.9	4	0.3	0	0.1	0	0
1989	7.5	8	17	34.4	21.4	67	16.6	3.2	0.5	0.2	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
1991	181	219.5	50.2	34.6	29.3	33.9	36.7	50	3.7	0.2	0.2	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	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	2.7
1995	2619.2	292.9	166.2	159.8	216.6	104	29	4.4	4.3	3	2.6	8.1
1996	2396	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	0.8
1998	3401.3	632.9	427.7	182.6	42.4	33.8	34	24.7	4.9	0.7	0.2	0.1
1999	358.3	304.3	150	96.4	45.4	12.2	11.2	18.7	9.2	1	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
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	61.7	80.3	37.1	31.8	13	42.7	13.8	7.5	3.3	0.8	0.4
2008	68.8	97.6	210.2	306.1	141	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	3.7	1.7	0.4
2010	485.4	59.4	34.7	121.9	175.9	194.9	70.9	37.5	11.1	8.8	1.7	1.7
2011	389.3	124.8	47.1	29.1	82.4	158.7	284.3	65.6	22.6	6.1	7.8	1
2012	950.6	72.7	133.9	52.7	38.1	82.8	224.4	154.7	30.9	10.8	4.8	2.7

Table A14. Swept area estimates (millions) of Northeast Arctic Cod from the Joint Norwegian-Russian ecosystem survey in August-September (taken from WD 04)

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
2004	543.0	330.6	329.7	147.7	421.5	150.2	79.8	40.2	10.1	2.2	0.5	0.1	0.1	0.0
2005	182.2	458.5	143.2	241.7	95.9	159.9	35.5	16.2	5.8	1.0	0.5	0.2	0.0	0.1
2006	276.0	479.0	509.7	186.1	205.6	59.9	69.8	17.6	8.1	2.6	0.6	0.2	0.0	0.0
2007	101.0	333.3	505.4	586.2	159.2	79.1	24.6	26.9	6.0	2.2	0.9	0.1	0.2	0.0
2008	494.4	130.9	372.9	654.3	486.2	133.0	51.7	12.9	17.6	3.3	0.9	0.2	0.2	0.1
2009	903.3	569.7	93.5	202.3	280.6	289.6	101.7	31.9	12.7	7.3	2.6	0.8	0.3	0.2
2010	652.6	310.3	84.2	56.8	177.0	397.2	424.9	142.7	38.5	10.5	6.8	1.6	0.3	0.2
2011	2083.0	509.8	160.0	123.6	101.5	240.2	300.4	178.4	32.3	7.7	1.8	1.3	0.6	0.3

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% (25% in 2011) of the catch is with conventional gears, mostly longline, which in the past was used almost exclusively by Norway. Some of the longline catch are from a directed fishery, which is restricted by national quotas. In the Norwegian management the quotas are set separately for trawl and other gears. The fishery is also regulated by a minimum landing size, a minimum mesh size in trawls and Danish seine, a maximum by-catch of undersized fish, closure of areas with high density/catches of juveniles and other seasonal and area restrictions.

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

The exceptionally strong year-classes 2004-2006 have contributed to the strong increase in stock size and SSB that we have seen in later years. These year-classes are estimated to be 91%, 75%, and 50% mature in 2012. The following year-classes are at a much lower level and it is therefore expected that we will experience some years with a decreasing stock size and SSB, which again will result in lower catch advices. However, the WG states that the haddock stock will remain at relatively high stock levels and within acceptable fishing mortalities in the coming years.

4.1.2 Landings prior to 2011 (Tables 4.1–4.3, Figure 4.1A)

The official landings (those reported to ICES and contained in the Statlant statistics) for 2010 amount to 249,200 t, and the provisional official landings for 2011 are 309,875 t. This is the highest landings of haddock since 1973.

In recent years, estimates of unreported catches (IUU catches) of haddock have been added to reported landings for the years 2002 and onwards. In 2007 to 2009 two estimates of IUU catches were available, one Norwegian and one Russian. At the benchmark assessment it was decided to base the final assessment on the Norwegian IUU estimates (ICES CM 2011/ACOM:38). From 2009 and onwards, a joint Norwegian-Russian Analysis Group under the Mixed Norwegian-Russian Fisheries Commission has provided joint estimates of IUU catches. Based on these, the AFWG decided to set the IUU estimate for haddock in 2009 - 2011 to 0. More details on this issue are given in Sections 0.4. Before 2002 the Working Group has no information about IUU catches on haddock, but the WG consider the IUU fisheries prior to 2002 to be low.

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

4.1.3 Catch advice and landings for 2011 and 2012

ACOM recommended to set a TAC lower than 303,000 t for 2011 and the agreed TAC for 2010 was 303,000 t, applying the agreed harvest control rule. The provisional reported catch in 2011 is 309,875 t. For 2012, the mixed Norwegian-Russian Fisheries Commission agreed on a TAC of 318,000 t, which corresponds to the agreed 1-year harvest control rule (see Section 4.7.3) according to the assessment.

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 was 1997 and the following six year classes all appear to be at or above average abundance. These were followed by three year classes 2004-2006, which all rank among the 6-7 most abundant year classes in the VPA time series. The surveys indicate that the 2007, 2008, and 2010 year-classes are slightly below average while the 2009 and 2011 year-classes seems to be a little stronger than average.

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

The preliminary swept area estimates and acoustic estimates from the Joint winter survey on demersal fish in the Barents Sea in winter 2012 are given in Aglen *et al.* (WD 03).

Before 2000 this survey was made without participation from Russian vessels, while in 2001-2005 Russian vessels covered important parts of the Russian zone. In 2006-2007 only Norwegian vessels carried out the survey again and permit to cover the Russian EEZ was not given in 2007, which meant that the 2007 indices had to be adjusted to take into account the incomplete coverage. These adjustments are described in detail in the 2007 report. However, since 2008, Norwegian survey vessels have received permits to enter the Russian zone and the survey was conducted according to the standard area coverage. This year, Norway had to rent a commercial fishing boat because of technical problems with Johan Hjort. This vessel was not allowed into Russian EEZ and the coverage of the eastern survey area was poor. Survey indices were adjusted accordingly (WD 03). The survey indices and areas covered are given in Tables B1 and B3.

Strong year classes, like the 1990 and 2004-2006 year classes, can be tracked from year to year in both series and the 1990 year class was the strongest for age groups 3–8 until the 2004-2006 year classes arrived. The 2012 bottom trawl and acoustic survey indices for the 2004-2006 year-classes (ages 6-8) were still among the highest indices ever recorded for the respective ages.

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

Russia provided indices from the 2011 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. The trawl and acoustic estimates and another information from the survey are given in Sokolov *et al.* (WD 07).

From 1995 onwards there has been a substantial change in the method for calculating acoustic indices. The acoustic survey is therefore presented in 2 tables, Table B4a and B4b, for the old and the new method of calculating indices, respectively.

The survey coverage was reduced in 2006, but from 2007, the survey area covered was again the standard coverage. See report from 2007 for details.

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

Estimates of the abundance of 0-group haddock from the International 0-group survey are presented in Tables 1.1 -1.2. Both indicate that the 2002-2006 year classes are very strong, whereas the 2007-2008 year classes are below average. The 2009 - 2011 year classes are again above the long term average.

The bottom trawl estimates from the joint ecosystem survey in August-September started in 2004. This survey covers a larger proportion of the distribution area of haddock. At the benchmark assessment it was decided to include this survey in the tuning of XSA (ages 3-8, Fleet 007).

4.2.2 Weight-at-age (Tables B5, B6)

Length- and weight-at-age from the surveys are given in Tables B5 and B6, respectively. Neither Norwegian nor Russian surveys show any strong trends in length- or weight-at-age, however the weights at older ages are at a relatively low level,compared to the times series.

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 - 2011.

4.3.2 Catch-at-age (Table 4.4)

Age and length compositions of the landings in 2011 were available from Norway and Russia in Subarea I and from Norway, Russia, and Germany in Division IIa and Division IIb. The biological sampling of NEA haddock catches is considered to be fairly good. However, the termination of a Norwegian port sampling program in Q3 2009 and poor sampling caused problems in estimating Norwegian age-length keys for the oldest ages in 2010. A Norwegian port sampling program was reststarted in 2011, although with a much lower effort, but this improved the basis for 2011 catch-at-age estimates. 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 show a negative trend for ages 6 and older for the last 2-3 years.

Stock weights (Table 4.6) used from 1985 to 2011 are averages of values derived from Russian surveys in autumn (mostly October-December) and Norwegian surveys in January-March the following year (Table B6). These averages are assumed to give representative values for the beginning of the year (see stock annex for details). Stock weights seem to be stable with only small year to year differences for the last years.

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). For the period from 1984 to 2011 actual data from predation for cod have been used (see Table 4.7 and B8) while for the previous years (1950-1983) the average natural mortality for 1984-2010 was used (age groups 3-6). The proportion of F and M before spawning was set to zero.

4.3.5 Maturity-at-age (Table 4.8)

The estimates of maturity-at-age are shown in Table 4.8. The proportions mature at age are presently lower than historic averages (see stock annex for estimation details).

4.3.6 Changes in data from last year (Tables 4.1-4.3)

As stock weights are modelled (See Section 4.3.3) the values of this parameter have changed slightly in 1996-2011. There are also small changes in natural mortality and maturity at age. However, at the benchmark it was decided that these (weight, M, and maturity) historic values (1950-1979) should be kept constant from the 2011 assessment and onwards (ICES CM 2011/ACOM:38).

4.4 Assessment Using VPA

The assessment method was also this year XSA.

4.4.1 Data for tuning (Table 4.9)

The following surveys series are included in the data for tuning:

Name	ICES Acronym	Place	Season	Age	Year	prior weight
FLT01: Russian bottom trawl	RU-BTr-Q4	Barents Sea	October-December	3–7	1991–2011	1
FLT02: Joint Barents Sea survey - acoustic	BS-NoRU-Q1(Aco)	Barents Sea	February-March	3–7	1990–2011	1
FLT04: Joint Barents Sea survey - bottom trawl	BS-NoRu-Q1 (BTr)	Barents Sea	February-March	3–8	1990–2011	1
FLT007: Joined Russian-Norwegian ecosystem autumn survey in the Barents Sea -bottom trawl	Eco-NoRu-Q3 (Btr)	Barents Sea	August - September	3-8	2004-2011	1

The indices for the Russian BT survey in the 1990 were not used for tuning the XSA. Since the 2004 WG meeting the survey data before 1990 have not been used in the XSA run. This decision was based on the analysis of survey residuals and changes in survey methodology (see the 2004 report).

The joint ecosystem survey was first used in last year assessment, after selected for inclusion by the WKBENCH. This index shows reasonably good internal consistency for ages 1–8 and correlated well with catch-at-age data and other surveys.

Like last year, the WG decided to exclude age 1 and 2 in the final XSA run, due to the bad influence on the retrospective patterns (Fig. 4.5 b), see the 2011 report). This year we decided to exclude indices for ages 1 and 2 used in estimation of natural mortality (predation run) because this improved the retrospective pattern and fit the regressions.

4.4.2 VPA and tuning (Table 4.9)

The Extended Survivors Analysis (XSA) was used to tune the VPA by available index series (Table 4.9). As last years, FLR was used for the assessment of haddock (see stock annex), and thus all results concerning XSA are obtained using FLR. The settings used by the AFWG were analyzed during the benchmark (ICES CM 2011/ACOM:38) and some of the settings were changed. Based on the results of evaluation it was concluded to set XSA parameters with following values:

Time series weights :

Tapered time weighting applied

Power = 3 over 20 years

Catchability analysis :

Catchability independent of size for ages > 8

Catchability independent of age for ages > 8

Terminal population estimation :

Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1.5

Minimum standard error for population estimates derived from each fleet = 0.3

Prior weighting not applied

Mortality estimation

The estimated consumption of NEA haddock by NEA cod is incorporated into the XSA analysis by first constructing a catch number-at-age matrix, adding the numbers of haddock eaten by cod to the catches for the years where such data are available (1984–2011). The consumption of NEA haddock by NEA cod is given in table B8.

The fishing mortality estimated by the XSA was split into the mortality caused by the fishing fleet (F) and the mortality caused by the cod's predation (M2) according to the ratio of fleet catch and predation "catch". The new natural mortality data set were then prepared by adding 0.2 (M1) to the predation mortality. This new M matrix (Table 4.7) was used in the final XSA.

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 2008-2011 with survey data for ages 0-2 as input data (Russian autumn survey, joint winter survey and ecosystem survey). Input data and results are shown in Table 4.10 and 4.11, respectively. Similar to XSA tuning, data points from the 1990 Russian BT were removed from recruitment estimation.

The numbers marked with * are XSA estimates, and the rest are RCT3 results (Table 4.11). The recruitment time series is shown in Table 4.18 and Figure 4.1C.

N		Year of assessment						
Year Class	2005	2006	2007	2008	2009	2010	2011	2012
2000	197*	237*	236*	249*	236*	222*	232*	232*
2001	176*	219*	224*	257*	245*	237*	241*	239*
2002	295	313*	339*	367*	365*	371*	352*	359*
2003	156	183	135*	161*	171*	185*	189*	183*
2004	462	755	672	665*	668*	610*	765*	743*
2005		521	731	943	975*	1028*	1193*	1301*
2006			463	832	1036	811*	1057*	1187*
2007				202	208	212	284*	330*
2008					149	101	120	151*
2009						303	315	320
2010							188	146
2011								483

4.4.4 Prediction data (Table 4.11, Table 4.19)

At WKHAD 2006 (ICES CM 2006/ACFM:19) it was decided that weight-at-age and maturity-at-age in stock should be based on smoothed observations. Methods and details are described in the stock annex. At the benchmark in 2011 it was decided to use fitted values of weight at-age and maturity-at-age two years ahead in the short term predictions, using the fitted parameters and last year's lengths as input. The Norwegian and Russian weight-at-age and maturity-at-age are then combined as arithmetic averages.

The Working Group used last year's procedure for estimation of natural mortality. For the selection pattern it was decided to extend the range of averaging to 1984. This was done because using a recent (3-year) average would give a fishing pattern where the selection decreases after age 7. This is not likely, as in the coming years the strong year classes 2004-2006 will move out of the reference age range (4-7) and the fishery is likely to target these year-classes. The input data for making the prediction are presented in Table 4.19:

- The estimated recruitment from RCT3 for 2012-2014 is given in Table 4.19.
- The assessment shows an increase in F from 2010 to 2011 and the F in 2011 is thus considered to be a better estimate for F in the present year (2012) than using a three year average F.
- The average fishing pattern observed in 1984-2011, scaled to F status quo was used for distribution of fishing mortality at age for 2012-2014.
- Smoothed observed average maturity-at-age are used for 2012, predicted maturity estimates, using the fitted parameters and last year lengths as input, are used for 2013-2014.
- Smoothed observed average weight in stock at age used for 2012, predicted stock weights at age, using the fitted parameters and last year lengths as input, are used for 2013-2014.

- The average weights at age in catch for the 1998-2000 year classes are used for 2012-2014.
- Natural mortality – average for the 3 last years (2009-2011).
- Stock numbers and fishing mortalities from the standard VPA.

4.5 Results of the Assessments

4.5.1 Comparison of assessments

The current assessment estimated the total stock to be about 3 % higher and SSB 7 % higher in 2011 compared to the previous assessment. F in 2010 is close to the estimate from last year (6% higher).

Compared to last year's short term projection, total stock estimate is about 24 % lower and SSB 22 % lower in 2012 and mortality in 2011 37% higher than F status quo. The differences in estimates of survivors at the start 2012 of and fishing mortality in 2011 with last year predictions can to a large extent be explained by assumptions about fishing mortality in 2011. According to procedure of short term preditions F status quo was used as F in the intermediate year, but catches corresponding to F status quo was considerably lower than the TAC.

4.5.2 Fishing mortality and VPA (Tables 4.12–4.18 and Figures 4.1A–D, 4.5A,4.7)

The tuning diagnostics of the final XSA (predation included) is given in Table 4.12, the retrospective plot in Figure 4.5a and the log catchability residuals plot is presented in Figure 4.6A.

The proportion of M and F before spawning was set to 0. Fishing mortality are given in Table 4.13, while the stock numbers and spawning stock numbers, stock biomass at age and the spawning biomass at age of the final VPA are given in Tables 4.14-4.17. A summary of landings, fishing mortality, spawning stock biomass, and recruitment since 1950 are given in Table 4.18 and Figures 4.1A-D.

The assessments shows the fishing mortalities for the most recent years have been estimated higher this year than last year. Fishing mortality of main ages (Fbar 4-7) in 2011 start to increase and was estimated slightly above established F_{msy} (0.35) and below the long term mean and F_{pa}. (see Figure 4.1B)

The dominating feature of this assessments is that the stock has started to decrease in 2011. This is mainly the effect of more normal recruitment levels since 2007. The increase in spawning stock biomass is still present mainly from the individual growth of specimens of high abundant year classes 2004-2006, but the rate of increase appears slightly lower compared to last year.

4.5.3 Catch options for 2012 (Tables 4.20 – 4.23)

The deterministic projection shows a decrease in SSB in the beginning of 2012 to 380,000 tonnes (Table 4.20).

The TAC for 2013 is established using one-year HCR (see Section 4.7.3), in accordance of the management plan that will be in force until 2015. Fishing according to the management rule in 2013 corresponds to total landings of about 238,500 t, decreasing the SSB at the beginning of 2014 to 188,000 t (Table 4.21). This corresponds to a 25 % decrease of the TAC and F=0.61.

According to the management plan TAC for 2014 is expected to be equal to 178,800 t (corresponding to future 25 % decreasing of catch in accordance to HCR and F=0.75) (Table 4.23).

4.6 Comments to the assessment and forecasts

The problems using XSA on the Northeast Arctic haddock stock was discussed in 2011 on the benchmark meeting (ICES CM 2011/ACOM:38). The main conclusion was to change XSA settings. During the AFWG 2012 it was decided to keep same procedure and of assessment and same settings as in previous meeting.

The influence of number of iterations on final estimates of SSB in 2011 was explored for both tools used in assessment (FLR and VPA 95).

It was concluded that when using VPA95 standard software XSA estimates depends strongly on number of itearations. "Best" fit with lowest SSQ of log catchability residuals at 30 iterations, but more iterations increase the estimates of SSB and convergence is not reached. At same time the FLR assessment is more stable and XSA converged after 160 iterations. (Figure 4.8)

The assessment shows a strong increase in F from 2010 to 2011. The F in 2011 was thus considered to be a better estimate for F in the present year (2012) than using a three year average. In predictions for 2012-2014, an average fishing pattern for 1984-2011 scaled to F-status quo (F_{sq}) was used for the distribution of fishing mortality at age. A F_{sq} predicts the catch for 2012 to be 246,000 t, which is lower than the TAC (318,000 t). The low 2012 catch corresponding to F_{sq} should not be interpreted as that the TAC will not be reached in 2012.

The table below mainly reflects uncertainties in assessment and forecasts.

Source of uncertainty	Description	Comments
Incomplete survey coverage (1)	Since 1997 all of the surveys used for tuning have been affected by an incomplete coverage for some of the years. (Due to Norwegian vessels not been given access to REZ, Russian vessels not been given access to NEZ).	All indices affected have been corrected using a factor based on geographical distributions observed before and after the incomplete coverage. This procedure is likely to introduce increased uncertainty to the indices (see AFWG 2007 and 4.2).
Incomplete survey coverage (2)	None of the surveys have a complete coverage of the stock. The proportion of a year class being outside the coverage varies between year classes (see also the WG report from 2002).	May appear as year class dependent changes in survey catchability. Catches of haddock in Norwegian statistical areas 06 and 07 (coastal areas) are added to the NEA haddock. These include haddock of older ages compared to the landings of NEA haddock. Since the surveys do not cover the coastal regions the coverage of older ages may be poorer.
Correlated error structures	Year effects in a survey are quite common. The year effect introduces correlated errors between the age groups, but in this case also between survey series.	
Discards	The level of discarding is not known.	Discarding is known to be a (varying) problem in the longline and trawl fisheries related to the abundance of haddock close to, but below the minimum landing size.
Unreported catches	This year, estimates for unreported catches were provided for 2002-2011, 2009-2011 estimates equal to zero.	The estimates were considered quite uncertain, but the uncertainty has decreased in recent years.
Predation on young age groups	The mortality due to predation (to a large extent by cod) varies substantially from year to year.	The predictions of young age groups are very uncertain.
Sampling error	Estimation of catch at age is based on sampling of catches. The error in the estimates caused by sampling can be considerable even if the total catch is known. The estimation of the abundance indices from surveys will also be affected by sampling error. Poorer Norwegian catch-sampling caused problems in estimating age-length keys for 2010.	The effect of not taking sampling error into account when fitting models to data may introduce bias in the resulting estimates. This bias is likely to increase with sampling error.(see chapter 0)

4.7 Reference points and harvest control rules (Tables 4.23 and Figures 4.2-4.3)

4.7.1 Biomass reference points

At last AFWG in 2011 based on the analysis of stock recruitment plot it was proposed to keep $\mathbf{B}_{lim}$=50,000 t and $\mathbf{B}_{pa}$ =80,000 t with the rationale that $\mathbf{B}_{lim}$ is equal to

$\mathbf{B}_{loss}$, and $\mathbf{B}_{pa}$ = $\mathbf{B}_{lim}$*exp(1.645*σ), where σ=0.3. This gives a 95% probability of maintaining SSB above **B**lim taking into account the uncertainty in the assessments and stock dynamics. For BMSY trigger was proposed equal B_{pa}, $B_{trigger}$ was then selected as a biomass that is encountered with low probability if F_{msy} is implemented, as recommended by WKFRAME2 (ICES CM 2011/ACOM:33).

4.7.2 Fishing mortality reference points

Previous values were $\mathbf{F}_{lim}$=0.49 and $\mathbf{F}_{pa}$ =0.35. There is no standard method of estimating $\mathbf{F}_{lim}$ nor $\mathbf{F}_{pa}$, and ACOM accepted to use geometric mean recruitment (146 million) and $\mathbf{B}_{lim}$ as basis for the $\mathbf{F}_{lim}$ estimate. $\mathbf{F}_{lim}$ is then based on the slope of line from origin at SSB=0 to the geometric mean recruitment (146 million) and SSB=$\mathbf{B}_{lim}$. The SPR value of this slope give $\mathbf{F}_{lim}$ value on SPR curve; $\mathbf{F}_{lim}$ =0.77 (found using Pasoft). Using the same approach as for $\mathbf{B}_{pa}$; $\mathbf{F}_{pa}$ = $\mathbf{F}_{lim}$*exp(-1.645*σ)= 0.47.

$\mathbf{F}_{msy}$=0.35 has been estimated by long-term stochastic simulation (WD 16, AFWG 2011).

Yield and SSB per recruit (YPR and SPR) are presented in Table 4.24 and Figure 4.3.

4.7.3 Harvest control rule

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

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

As mentioned above $\mathbf{F}_{lim}$ and $\mathbf{F}_{pa}$ were revised in 2011. The new values of $\mathbf{F}_{lim}$=0.77 and $\mathbf{F}_{pa}$=0.47 are higher than the previous values (0.49 and 0.35, respectively). In last Joint Norwegian Russian Fishery Commission were accepted proposals of ICES and the current HCR management is based on $\mathbf{F}_{msy}$ instead F_{pa}. This corresponds to the goal of the management strategy for this stock and should will provide maximum sustainable yield.

From 2011 a rapid increase of fishing mortality is expected and with catch constraint Fbar for 2014 will be above 0.7 (see Table 4.23). This may cause F to go above F_{lim}.

In accordance with procedure of estimation Fmsy presented in last AFWG (WD 16, AFWG 2011) stochastic long-term simulations using PROST (Åsnes, 2005) with same settings but new density dependent relationships of biological parameters from AFWG 2011 were run. The summary table below shows the probability of SSB falling below Blim (50 000 t) and probability of F being above Flim (0.77).

F	Yield	SSB	TSB	R	% annual change In TAC (absolute value)	No. Years where SSB < Blim	No. Years where SSB <Bpa	No. Years where F >Flim	No. Years where quota is		No. Years where various parts of HCR decide TAC			
									Inreased more than maxthreshold %	Dereased more than minthreshold %	SSB above Bpa			SSB below Bpa
											exactly	%increase	%decrease	
0.00	0	1490	1831	278	NaN	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
0.05	61	998	1329	281	7	0.0	0.0	0.0	4.5	0.0	97.2	2.8	0.0	0.0
0.10	92	706	1025	278	8	0.0	0.0	0.0	7.0	0.0	95.4	4.6	0.0	0.0
0.15	111	530	842	276	9	0.0	0.0	0.0	9.7	0.2	93.0	7.0	0.0	0.0
0.20	125	422	734	279	10	0.0	0.0	0.0	12.9	1.3	90.1	9.8	0.0	0.0
0.25	134	344	653	278	12	0.0	0.0	0.0	16.0	3.4	86.8	12.7	0.4	0.0
0.30	140	287	592	277	13	0.0	0.0	0.0	19.0	6.3	82.9	15.5	1.5	0.0
0.35	147	247	549	278	14	0.0	0.4	0.02	21.8	9.5	78.3	18.0	3.4	0.4
0.40	147	209	500	270	15	0.0	2.1	0.1	23.5	12.5	73.5	18.8	5.6	2.1
0.45	148	179	459	262	17	0.2	5.9	0.3	25.4	15.7	67.3	18.8	8.0	5.9
0.50	142	148	408	245	19	0.6	14.6	0.7	26.2	18.3	60.3	15.9	9.2	14.6
0.55	136	123	363	227	22	1.7	26.2	1.4	26.9	21.2	51.8	12.1	9.9	26.2
0.60	126	103	319	206	26	4.3	40.7	2.5	27.9	24.0	41.4	7.9	10.0	40.7
0.65	116	87	282	186	28	8.2	55.3	4.0	28.9	26.2	31.2	4.5	9.0	55.3

The probabilities are very low, but not zero, and it can concluded that choosen HCR is in accordance with MSY approach. It should be noted that the recruitment function used in those simulations was parameterized without taking the strong 2004-2006 year classes into account, and using a stock-recruitment relationship where also those year classes are taken into account may change the results.

4.8 Comments to Technical Minutes from reviewers

Our comments to Technical Minutes from reviewers are in *italics* below each comment that requires a response

General Comments:

Overall, most of the relevant information is contained in the document, however the presentation of information was not well organized, which made the assessment hard to follow. Further detail on modelling methods and assumptions is needed.

The methods are explained in the stock annex and the recommendation from ICES is not to repeat this in the report text.

WG interpretations of the retrospective analyses and stock status are needed. The WG did not discuss the state the status of the stock or retrospective patterns, only figures were provided.

We included a short discussion of stock status and retrospective pattern.

The benchmark agreed to use ages 1-2 in the XSA tuning, but the WG decided not to include these ages in the final model due to changes in retrospective patterns. The WG did not provide strong supporting evidence for this change in method and retrospective patterns did not appear to be improved by excluding ages 1-2 (see figures below). The results of model runs using multiple values for shrinkage are reported, but it was not clear which value was used in the final model run.

Including ages 1 and 2 in tuning XSA was tested. It was found that changing age range does not improve the assessment. When adding indices of age 1 and 2 in tuning, we get worse retrospective pattern of estimates and using only ages 3-8 in tuning give a better fit of yearclass regressions (lower SSQ of log catchability residuals) as shown in Figure 4.6.

Catch at age shows 11+ is larger than 9 and 10 combined with no explanation of why, perhaps extending the age-structure of the model should be investigated.

This is an artifact of XSA when large catches appear in the + group.

Weights at age show small growth from 8 to 9 and larger growth from 9 to 10 in recent years (see Table 4.5). This point was not discussed by the WG.

The growth estimates of older fish have high uncertainty because of limited age samples and such patterns may occur but will have limited effect on assessment because of low stock numbers and catches of these ages.

Survey data stops at age 8 with no explanation on why older ages are not included or caught.

Older fish are believed to have migrated out of the Barents Sea and thus, out of the survey area.

The proportion of M and F before spawning is set to zero (assumes time of spawning is Jan. 1), although the peak spawning occurs in April.

This has limited effect on assessment.

Technical Comments:

In general, the writing could be improved as there were many typos and unexplained information.

We are sorry about this, but it is difficult to avoid with time limitations and English not being our native language.

Ecosystem considerations were not discussed.

This will be considered, but some ecosystem aspects are discussed in the stock annex.

The WG estimated age 3 for recruitment in another program (RTC3) using ages 0-2 from the surveys, but didn't explain how the program was estimating R. Additionally, WG indicated ages 0-2 were not reliable for inclusion in assessment, so it was unclear why this data was used to estimate recruitment.

RCT3 is a standard ICES program and we do not see the need to describe this. Indices of ages 0-2 do not provide any information for stock assessment of ages 3 and older, but is useful for recruitment prediction used in forward projection of the stock.

Btrigger was defined, but not Bmsy.

MSY Btrigger (Bmsy) is defined in stock annex equal to Bpa=80 000t

No references and some figures and tables were included but not cited or discussed.

All references are given in the report reference section.

The following points are noted and we will try to impove these.

Figure 4.1B and 4.1D x-axis labels are luttered, the same labels should be used for all plots.

Figure 4.6 SSQ are mislabelled for b and d, should be SSQ (ages 1-8).

Table 4.9 is hard to read; there are no labels and no adequate explanation of what is being presented.

Table 4.10 had -11 values and no explanation of what those indicated.

Tables 4.11-4.12 and 4.23 had poor print quality

Table 4.19 didn't define the column labels.

Conclusions:

The assessment has been performed as prescribed in the stock annex (with one exception) and provides a valid basis for management advice. The assessment deviated from the benchmark suggestion to use ages 1-2 in the XSA tuning by using ages 3+. The WG revised Flim and Fpa (at the recent benchmark they revised the time series data, but didn't update the reference points) and estimated Fmsy. The RG agrees with the WG on continuing to use F=0.35 as the HCR target (fishing at Fmsy) as recommended by the benchmark. There appeared to be some problems with maturity and aging data for this stock and additional sampling could improve this, as well as the catch at age and weight at age information.

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

Year	Sub-area I	Division IIa	Division IIb	un-reported[2]	Total[3]	Norw. stat. areas 06 and 07[4]
1960	125026	27781	1844	-	154651	6000
1961	165156	25641	2427	-	193224	4000
1962	160561	25125	1723	-	187409	3000
1963	124332	20956	936	-	146224	4000
1964	79262	18784	1112	-	99158	6000
1965	98921	18719	943	-	118583	6000
1966	125009	35143	1626	-	161778	5000
1967	107996	27962	440	-	136398	3000
1968	140970	40031	725	-	181726	3000
1969	89948	40306	566	-	130820	2000
1970	60631	27120	507	-	88258	-
1971	56989	21453	463	-	78905	-
1972	221880	42111	2162	-	266153	-
1973	285644	23506	13077	-	322227	-
1974	159051	47037	15069	-	221157	10000
1975	121692	44337	9729	-	175758	6000
1976	94054	37562	5648	-	137264	2000
1977	72159	28452	9547	-	110158	2000
1978	63965	30478	979	-	95422	2000
1979	63841	39167	615	-	103623	6000
1980	54205	33616	68	-	87889	5098
1981	36834	39864	455	-	77153	4767
1982	17948	29005	2	-	46955	3335
1983	5837	16859	1904	-	24600	3112
1984	2934	16683	1328	-	20945	3803
1985	27982	14340	2730	-	45052	3583
1986	61729	29771	9063	-	100563	4021
1987	97091	41084	16741	-	154916	3194
1988	45060	49564	631	-	95255	3756
1989	29723	28478	317	-	58518	4701
1990	13306	13275	601	-	27182	2912
1991	17985	17801	430	-	36216	3045
1992	30884	28064	974	-	59922	5634
1993	46918	32433	3028	-	82379	5559
1994	76748	50388	8050	-	135186	6311
1995	75860	53460	13128	-	142448	5444
1996	112749	61722	3657	-	178128	5126
1997	78128	73475	2756	-	154359	5987
1998	45640	53936	1054	-	100630	6338
1999	38291	40819	4085	-	83195	5743
2000	25931	39169	3844	-	68944	4536
2001	35072	47245	7323	-	89640	4542
2002	40721	42774	12567	**18736**/5310	**114798**/101372	6898
2003	53653	43564	8483	**33226**/9417	**138926**/115117	4279
2004	64873	47483	12146	**33777**/8661	**158279**/133163	3743
2005	53518	48081	16416	**40283**/9949	**158298**/127964	5538
2006	51124	47291	33291	**21451**/8949	**153157**/140655	5410
2007	62904	58141	25927	**14553**/3102	**161525**/150074	7110
2008	58379	60178	31219	**5828**/-	**155604**/149776	6629
2009	57723	66045	76293	0	200061	4498
2010	62604	86279	100318	0	249200	3770
2011[1]	86951	99324	123600	0	309875	4578

1) Provisional figures, Norwegian catches on Russian quotas are included 2) Figures based on Norwegian/Russian IUU estimates. From 2009, IUU estimates are made by a Joint Russian-Norwegian analysis group under the Russian-Norwegian Fisheries Commission. 3) Figures based on Norwegian/Russian IUU estimates. During the period 2002-2008, the Norwegian IUU-estimates (bold) were used in the final assessments. 4) Included in total landings and in landings in region IIa

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

	Sub-area I		Division IIa		Division IIb		Unreported[2]
Year	Trawl	Others	Trawl	Others	Trawl	Others	
1967	73.7	34.3	20.5	7.5	0.4	-	-
1968	98.1	42.9	31.4	8.6	0.7	-	-
1969	41.4	47.8	33.2	7.1	1.3	-	-
1970	37.4	23.2	20.6	6.5	0.5	-	-
1971	27.5	29.2	15.1	6.7	0.4	-	-
1972	193.9	27.9	34.5	7.6	2.2	-	-
1973	242.9	42.8	14.0	9.5	13.1	-	-
1974	133.1	25.9	39.9	7.1	15.1	-	-
1975	103.5	18.2	34.6	9.7	9.7	-	-
1976	77.7	16.4	28.1	9.5	5.6	-	-
1977	57.6	14.6	19.9	8.6	9.5	-	-
1978	53.9	10.1	15.7	14.8	1.0	-	-
1979	47.8	16.0	20.3	18.9	0.6	-	-
1980	30.5	23.7	14.8	18.9	0.1	-	-
1981	18.8	17.7	21.6	18.5	0.5	-	-
1982	11.6	11.5	23.9	13.5	-	-	-
1983	3.6	2.2	8.7	8.2	0.2	1.7	-
1984	1.6	1.3	7.6	9.1	0.1	1.2	-
1985	24.4	3.5	6.2	8.1	0.1	2.6	-
1986	51.7	10.1	14.0	15.8	0.8	8.3	-
1987	79.0	18.1	23.0	18.1	3.0	13.8	-
1988	28.7	16.4	34.3	15.3	0.6	0.0	-
1989	20.0	9.7	13.5	15.0	0.3	0.0	-
1990	4.4	8.9	5.1	8.2	0.6	0.0	-
1991	9.0	8.9	8.9	8.9	0.2	0.2	-
1992	21.3	9.6	11.9	16.1	1.0	0.0	-
1993	35.3	11.6	14.5	17.9	3.0	0.0	-
1994	58.6	18.2	26.1	24.3	7.9	0.2	-
1995	63.9	12.0	29.6	23.8	12.1	1.0	-
1996	98.3	14.4	36.5	25.2	3.4	0.3	-
1997	57.4	20.7	44.9	28.6	2.5	0.3	-
1998	26.0	19.6	27.1	26.9	0.7	0.3	-
1999	29.4	8.9	19.1	21.8	4.0	0.1	-
2000	20.1	5.9	18.8	20.4	3.7	0.1	-
2001	28.4	6.7	23.4	23.8	7.0	0.3	-
2002	30.5	10.2	19.5	23.3	12.5	0.1	18.7/5.3
2003	42.7	10.9	21.9	21.7	8.1	0.4	33.2/9.4
2004	52.4	12.5	27.0	20.5	11.5	0.6	33.8/8.7
2005	38.5	15.0	24.9	20.9	13.0	1.6	40.3/9.9
2006	40.1	11	22	25.3	30.1	3.2	21.5/8.9
2007	51.8	11.1	30.5	27.7	20.4	5.5	14.6/3.1
2008	46.8	11.6	30.9	29.3	24.9	6.3	5.8/-
2009	49.0	8.8	40.1	25.3	67.1	7.8	0
2010	43.6	19.0	50.6	35.7	89.9	10.4	0
2011[1]	55.8	31.1	61.3	38.0	109.3	14.3	0

1) Provisional 2) Figures based on Norwegian/Russian IUU estimates

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

Year	Faroe Islands	France	German Dem.Re.	Fed. Re. Germ.	Norway[4]	Poland	United Kingdom	Russia[2]	Others	Unreported catches[3]	Total[3]
1960	172	-	-	5597	46263	-	45469	57025	125	-	154651
1961	285	220	-	6304	60862	-	39650	85345	558	-	193224
1962	83	409	-	2895	54567	-	37486	91910	58	-	187408
1963	17	363	-	2554	59955	-	19809	63526	-	-	146224
1964	-	208	-	1482	38695	-	14653	43870	250	-	99158
1965	-	226	-	1568	60447	-	14345	41750	242	-	118578
1966	-	1072	11	2098	82090	-	27723	48710	74	-	161778
1967	-	1208	3	1705	51954	-	24158	57346	23	-	136397
1968	-	-	-	1867	64076	-	40129	75654	-	-	181726
1969	2	-	309	1490	67549	-	37234	24211	25	-	130820
1970	541	-	656	2119	37716	-	20423	26802	-	-	88257
1971	81	-	16	896	45715	43	16373	15778	3	-	78905
1972	137	-	829	1433	46700	1433	17166	196224	2231	-	266153
1973	1212	3214	22	9534	86767	34	32408	186534	2501	-	322226
1974	925	3601	454	23409	66164	3045	37663	78548	7348	-	221157
1975	299	5191	437	15930	55966	1080	28677	65015	3163	-	175758
1976	536	4459	348	16660	49492	986	16940	42485	5358	-	137264
1977	213	1510	144	4798	40118	-	10878	52210	287	-	110158
1978	466	1411	369	1521	39955	1	5766	45895	38	-	95422
1979	343	1198	10	1948	66849	2	6454	26365	454	-	103623
1980	497	226	15	1365	66501	-	2948	20706	246	-	92504
1981	381	414	22	2402	63435	Spain	1682	13400	-	-	81736
1982	496	53	-	1258	43702	-	827	2900	-	-	49236
1983	428	-	1	729	22364	139	259	680	-	-	24600
1984	297	15	4	400	18813	37	276	1103	-	-	20945
1985	424	21	20	395	21272	77	153	22690	-	-	45052
1986	893	12	75	1079	52313	22	431	45738	-	-	100563

1987	464	7	83	3105	72419	59	563	78211	5	-	154916
1988	1113	116	78	1323	60823	72	435	31293	2	-	95255
1989	1217	-	26	171	36451	1	590	20062	-	-	58518
1990	705	-	5	167	20621	-	494	5190	-	-	27182
1991	1117	-	Greenland	213	22178	-	514	12177	17	-	36216
1992	1093	151	1719	387	36238	38	596	19699	1	-	59922
1993	546	1215	880	1165	40978	76	1802	35071	646	-	82379
1994	2761	678	770	2412	71171	22	4673	51822	877	-	135186
1995	2833	598	1097	2675	76886	14	3111	54516	718	-	142448
1996	3743	6	1510	942	94527	669	2275	74239	217	-	178128
1997	3327	540	1877	972	103407	364	2340	41228	304	-	154359
1998	1903	241	854	385	75108	257	1229	20559	94	-	100630
1999	1913	64	437	641	48182	652	694	30520	92	-	83195
2000	631	178	432	880	42009	502	747	22738	827	-	68944
2001	1210	324	553	554	49067	1497	1068	34307	1060	-	89640
2002	1564	297	858	627	52247	1505	1125	37157	682	18736/5310	114798/101372
2003	1959	382	1363	918	56485	1330	1018	41142	1103	33226/9417	138926/115117
2004	2484	103	1680	823	62192	54	1250	54347	1569	33777/8661	158279/133163
2005	2138	333	15	996	60850	963	1899	50012	1262	40283/9949	158751/128417
2006	2390	883	1830	989	69272	703	1164	53313	1162	21451/8949	153157/140/655
2007	2307	277	1464	1123	71244	125	1351	66569	2511	14553/3102	161525/150074
2008	2687	311	1659	535	72779	283	971	68792	1759	5828/-	155604/149776
2009	2820	529	1410	1957	104354	317	1315	85514	1845	0	200061
2010	3173	764	1970	3539	123384	379	1758	111372	2862	0	249200
2011[1]	1759	8	2110	1724	158293	408	1379	139912	4282	0	309875

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), FLR

	Age										
YEAR	3	4	5	6	7	8	9	10	11+	TOTNU	TONS	SOPCOF%
1950	3189	37949	35344	18849	28868	9199	1979	1093	2977	139447	132125	63
1951	65643	9178	18014	13551	6808	6850	3322	1182	1348	125896	120077	81
1952	6012	151996	13634	9850	4693	3237	2434	606	880	193342	127660	57
1953	64528	13013	70781	5431	2867	1080	424	315	1005	159444	123920	70
1954	6563	154696	5885	27590	3233	1302	712	319	543	200843	156788	68
1955	1154	10689	176678	4993	28273	1445	271	100	100	223703	202286	65
1956	16437	5922	14713	127879	3182	8003	450	200	185	176971	213924	79
1957	2074	24704	7942	12535	46619	1087	1971	356	176	97464	123583	80
1958	1727	5914	31438	5820	12748	17565	822	1072	601	77707	112672	89
1959	20318	7826	7243	14040	3154	2237	5918	285	500	61521	88211	106
1960	39910	70912	13647	7101	6236	1579	2340	2005	606	144336	154651	96
1961	15429	56855	63351	8706	3578	4407	788	527	1434	155075	193224	100
1962	39503	30868	48903	33836	3201	1341	1773	242	756	160423	187408	95
1963	28466	72736	18969	13579	9257	1239	559	409	375	145589	146224	87
1964	22363	49290	30672	5815	3527	2716	833	104	633	115953	99158	74
1965	5936	46356	40201	12631	1679	974	897	123	802	109599	118578	87
1966	26345	22631	63176	29048	5752	582	438	189	242	148403	161778	86
1967	15907	41346	13496	25719	8872	1616	218	175	271	107620	136397	100
1968	657	67632	41267	7748	15599	5292	655	182	286	139318	181726	100
1969	1524	1968	44634	19002	3620	4937	1628	316	109	77738	130820	113
1970	23444	2454	1906	22417	8100	2012	2016	740	293	63382	88257	102
1971	1978	24358	1257	918	9279	3056	826	1043	534	43249	78905	131
1972	230942	22315	42981	3206	1611	6758	2638	900	1652	313003	266153	92
1973	70679	260520	24180	6919	422	426	1692	529	584	365951	322226	86
1974	9685	41706	88120	5829	4138	382	618	2043	1870	154391	221157	112
1975	10037	14088	33871	49711	2135	1236	92	131	934	112235	175758	112
1976	13994	13454	6810	20796	40057	1247	1350	193	1604	99505	137264	89
1977	55967	22043	7368	2586	7781	11043	311	388	379	107866	110158	92
1978	47311	18812	4076	1389	1626	2596	6215	162	400	82587	95422	108
1979	17540	35290	10645	1429	812	546	1466	2310	323	70361	103623	130
1980	627	22878	21794	2971	250	504	230	842	1460	51556	87889	131
1981	486	2561	22124	10685	1034	162	162	72	963	38249	77153	139
1982	883	900	3372	12203	2625	344	75	80	649	21131	46955	138
1983	1173	2636	1360	2394	2506	1799	267	37	292	12464	24600	95
1984	1271	1019	1899	657	950	2619	352	87	77	8931	20945	95
1985	29624	1695	564	1009	943	886	1763	588	281	37353	45052	102
1986	23113	68429	1565	783	896	393	702	1144	987	98012	100563	95
1987	5031	87170	64556	960	597	376	212	230	738	159870	154916	101
1988	1439	12478	47890	20429	397	178	74	88	446	83419	95255	100
1989	2157	4986	16071	25313	3198	147	1	28	177	52078	58518	102
1990	1015	2580	2142	4046	6221	840	134	42	71	17091	27182	98
1991	4421	3564	2416	3299	4633	3953	461	83	54	22884	36216	96
1992	11571	11567	4099	2642	2894	3327	3498	486	84	40168	59922	102
1993	13487	19457	13704	4103	1747	1886	2105	1965	323	58777	82379	100
1994	3374	47821	36333	13264	2057	903	1453	2769	2110	110084	135186	99
1995	2003	16109	72644	19145	6417	746	361	770	1576	119771	142448	98
1996	1662	6818	36473	73579	13426	2944	573	365	1897	137737	178128	98
1997	2280	5633	12603	32832	49478	5636	778	245	748	110233	154359	95
1998	1701	11304	9258	8633	13801	19469	2113	330	490	67099	100630	99
1999	16839	8039	15365	6073	4466	6355	6204	647	446	64434	83195	98
2000	1520	29986	6496	5149	2406	1657	1570	1744	437	50965	68944	97
2001	12971	5230	32049	5279	2941	1137	1161	1169	1204	63141	89640	101
2002	7132	46335	11084	21985	2602	1602	482	448	1029	92699	114798	99
2003	6803	31448	56480	11736	14541	1637	2178	858	1219	126900	138926	98
2004	7993	21116	41310	41226	4939	4914	598	1252	901	124249	158279	98
2005	11452	19369	22887	37067	24461	2393	2997	990	1524	123140	158298	100
2006	4539	35040	27571	15033	16023	8567	1259	1298	718	110048	153157	101
2007	30707	15213	45992	18516	10642	7889	2570	678	988	133195	161525	101
2008	14536	44192	15926	31173	9145	4520	2846	1181	654	124173	155604	101
2009	15313	54795	52371	13693	15409	3789	1643	882	961	158856	200061	100
2010	5521	48048	82801	53253	8989	5710	1189	1457	1936	208904	249200	100
2011	1821	8688	80410	109033	36045	5101	2225	1026	2646	246995	309874	100

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

Year Age	3	4	5	6	7	8	9	10	11+
1950-81	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	3.186
1982	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	3.186
1983	1.033	1.408	1.71	2.149	2.469	2.748	3.069	3.687	4.516
1984	1.218	1.632	2.038	2.852	2.845	3.218	3.605	4.065	4.667
1985	0.835	1.29	1.816	2.174	2.301	2.835	3.253	3.721	4.416
1986	0.612	1.064	1.539	1.944	2.362	2.794	3.25	3.643	5.283
1987	0.497	0.765	1.179	1.724	2.135	2.551	3.009	3.414	4.213
1988	0.55	0.908	1.097	1.357	1.537	1.704	2.403	2.403	2.571
1989	0.684	0.84	0.998	1.176	1.546	1.713	1.949	2.14	2.685
1990	0.793	1.172	1.397	1.624	1.885	2.112	2.653	3.102	3.338
1991	0.941	1.281	1.556	1.797	2.044	2.079	2.311	2.788	3.219
1992	0.906	1.263	1.535	1.747	2.043	2.2	2.298	2.494	2.652
1993	0.94	1.204	1.487	1.748	1.994	2.237	2.417	2.654	3.026
1994	0.614	0.906	1.287	1.602	1.968	2.059	2.39	2.545	2.893
1995	0.739	0.808	1.107	1.556	1.838	2.234	2.416	2.602	3.13
1996	0.683	0.868	1.045	1.363	1.71	1.886	2.214	2.37	2.675
1997	0.682	1.028	1.151	1.369	1.637	1.856	2.073	2.5	2.554
1998	0.748	0.974	1.262	1.433	1.641	1.863	2.069	2.335	2.81
1999	0.826	1.079	1.261	1.485	1.634	1.798	2.032	2.237	2.712
2000	0.853	1.186	1.395	1.588	1.808	1.989	2.264	2.415	2.892
2001	0.751	1.104	1.459	1.709	1.921	2.182	2.331	2.609	2.981
2002	0.687	1.001	1.363	1.643	1.975	2.086	2.294	2.487	2.778
2003	0.594	0.875	1.113	1.364	1.361	1.972	1.636	1.877	2.409
2004	0.636	0.886	1.183	1.508	1.821	2.075	2.339	2.58	2.991
2005	0.722	0.906	1.121	1.343	1.619	2.036	2.177	2.382	2.768
2006	0.745	1.041	1.287	1.504	1.72	2.082	2.377	2.738	3.212
2007	0.652	0.899	1.197	1.435	1.722	1.99	2.309	2.715	3.028
2008	0.658	0.901	1.242	1.515	1.781	2.18	2.33	2.664	3.328
2009	0.707	1.024	1.28	1.538	1.806	2.107	2.398	2.531	3.172
2010	0.596	0.857	1.12	1.381	1.734	1.94	2.222	2.321	2.87
2011	0.840	0.934	1.08	1.258	1.473	1.725	2.023	2.230	2.600

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

Year	3	4	5	6	7	8	9	10	11+
1950-79	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1980	0.454	0.878	1.159	1.675	2.292	3.134	3.31	3.553	3.792
1981	0.603	0.805	1.315	1.582	2.118	2.728	3.51	3.679	3.904
1982	0.631	1.049	1.217	1.782	2.017	2.553	3.14	3.853	4.016
1983	0.524	1.098	1.558	1.663	2.255	2.448	2.97	3.524	4.165
1984	0.391	0.926	1.632	2.093	2.121	2.718	2.865	3.363	3.878
1985	0.379	0.7	1.394	2.195	2.626	2.572	3.158	3.261	3.728
1986	0.311	0.682	1.069	1.898	2.761	3.138	3.005	3.568	3.632
1987	0.331	0.569	1.047	1.473	2.411	3.307	3.616	3.412	3.946
1988	0.383	0.603	0.887	1.452	1.895	2.915	3.822	4.054	3.787
1989	0.445	0.689	0.936	1.248	1.878	2.317	3.395	4.297	4.449
1990	0.413	0.789	1.054	1.312	1.635	2.308	2.728	3.844	4.73
1991	0.402	0.737	1.193	1.458	1.714	2.035	2.732	3.122	4.256
1992	0.34	0.721	1.119	1.63	1.881	2.127	2.437	3.142	3.491
1993	0.279	0.616	1.1	1.537	2.08	2.308	2.54	2.831	3.531
1994	0.262	0.512	0.952	1.518	1.969	2.527	2.729	2.945	3.213
1995	0.282	0.484	0.8	1.327	1.952	2.401	2.959	3.135	3.335
1996	0.312	0.52	0.76	1.128	1.724	2.388	2.82	3.369	3.52
1997	0.34	0.571	0.816	1.076	1.481	2.127	2.814	3.22	3.751
1998	0.36	0.618	0.891	1.155	1.418	1.847	2.526	3.221	3.595
1999	0.366	0.651	0.957	1.255	1.523	1.775	2.215	2.911	3.604
2000	0.298	0.659	1.006	1.339	1.645	1.905	2.137	2.578	3.278
2001	0.289	0.546	1.015	1.403	1.745	2.05	2.292	2.495	2.929
2002	0.274	0.531	0.853	1.412	1.825	2.161	2.456	2.676	2.845
2003	0.295	0.504	0.83	1.203	1.831	2.257	2.576	2.855	3.049
2004	0.302	0.54	0.792	1.173	1.582	2.257	2.687	2.981	3.241
2005	0.304	0.553	0.843	1.122	1.544	1.974	2.678	3.105	3.369
2006	0.308	0.556	0.863	1.188	1.481	1.929	2.37	3.086	3.506
2007	0.288	0.565	0.868	1.215	1.559	1.856	2.317	2.76	3.475
2008	0.268	0.53	0.883	1.222	1.596	1.945	2.236	2.701	3.139
2009	0.274	0.495	0.832	1.245	1.605	1.989	2.334	2.613	3.073
2010	0.265	0.504	0.779	1.178	1.635	2.001	2.385	2.717	2.98
2011	0.222	0.489	0.791	1.106	1.553	2.039	2.399	2.775	3.088

Table 4.7. Northeast Arctic haddock. Natural mortality (M) at age

				Age					
Year	3	4	5	6	7	8	9	10	11+
1950-83	0.3476	0.261	0.2424	0.2189	0.2	0.2	0.2	0.2	0.2
1984	0.2074	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1985	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1986	0.6462	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.4022	0.2	0.2023	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.319	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1991	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.2058	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.263	0.2247	0.2665	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.2963	0.2174	0.2109	0.2005	0.2	0.2	0.2	0.2	0.2
1995	0.3397	0.3593	0.2996	0.2072	0.2	0.2	0.2	0.2	0.2
1996	0.7378	0.2961	0.225	0.2238	0.2	0.2	0.2	0.2	0.2
1997	0.4786	0.2413	0.2227	0.21	0.2	0.2	0.2	0.2	0.2
1998	0.2347	0.2513	0.2193	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.2017	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.2248	0.2082	0.207	0.2044	0.2	0.2	0.2	0.2	0.2
2001	0.2152	0.2012	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.3311	0.2104	0.209	0.2041	0.2	0.2	0.2	0.2	0.2
2003	0.4118	0.2626	0.2081	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.4178	0.2911	0.2219	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.3927	0.2791	0.2335	0.2162	0.2	0.2	0.2	0.2	0.2
2006	0.2347	0.2241	0.2176	0.2136	0.2	0.2	0.2	0.2	0.2
2007	0.324	0.2366	0.222	0.207	0.2	0.2	0.2	0.2	0.2
2008	0.4444	0.335	0.2909	0.275	0.2	0.2	0.2	0.2	0.2
2009	0.5108	0.3552	0.3605	0.2446	0.2	0.2	0.2	0.2	0.2
2010	0.4108	0.3799	0.4264	0.3233	0.2	0.2	0.2	0.2	0.2
2011	0.6823	0.7358	0.5434	0.3996	0.2	0.2	0.2	0.2	0.2

Table 4.8. Northeast Arctic haddock. Proportion mature at age

Year	3	4	5	6	7	8	9	10	11+
1950-79	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994	1
1980	0.026	0.076	0.243	0.649	0.86	0.95	0.984	0.995	1
1981	0.056	0.104	0.303	0.549	0.857	0.948	0.984	0.995	1
1982	0.053	0.161	0.332	0.577	0.77	0.947	0.983	0.995	1
1983	0.057	0.183	0.472	0.665	0.8	0.906	0.983	0.995	1
1984	0.044	0.196	0.51	0.801	0.862	0.921	0.967	0.995	1
1985	0.027	0.149	0.522	0.796	0.928	0.953	0.973	0.989	1
1986	0.021	0.103	0.454	0.758	0.928	0.977	0.984	0.991	1
1987	0.021	0.076	0.294	0.713	0.918	0.976	0.993	0.994	1
1988	0.025	0.074	0.24	0.576	0.898	0.975	0.993	0.998	1
1989	0.032	0.09	0.25	0.534	0.822	0.966	0.993	0.998	1
1990	0.046	0.127	0.305	0.578	0.798	0.937	0.99	0.997	1
1991	0.041	0.164	0.358	0.623	0.82	0.925	0.98	0.997	1
1992	0.03	0.147	0.449	0.704	0.855	0.936	0.976	0.994	1
1993	0.018	0.113	0.396	0.741	0.878	0.95	0.979	0.992	1
1994	0.016	0.073	0.329	0.702	0.903	0.96	0.984	0.993	1
1995	0.016	0.059	0.227	0.633	0.885	0.969	0.987	0.995	1
1996	0.018	0.069	0.213	0.497	0.855	0.964	0.991	0.996	1
1997	0.022	0.062	0.204	0.495	0.76	0.948	0.989	0.997	1
1998	0.03	0.084	0.235	0.502	0.75	0.907	0.984	0.997	1
1999	0.042	0.12	0.307	0.588	0.76	0.898	0.969	0.995	1
2000	0.027	0.15	0.36	0.614	0.789	0.9	0.966	0.99	1
2001	0.029	0.095	0.415	0.673	0.866	0.919	0.967	0.989	1
2002	0.02	0.112	0.318	0.732	0.895	0.949	0.974	0.989	1
2003	0.019	0.074	0.33	0.618	0.895	0.955	0.977	0.992	1
2004	0.023	0.068	0.236	0.613	0.823	0.963	0.985	0.995	1
2005	0.025	0.078	0.221	0.538	0.835	0.939	0.984	0.995	1
2006	0.025	0.093	0.245	0.535	0.778	0.942	0.98	0.997	1
2007	0.02	0.086	0.311	0.559	0.807	0.931	0.977	0.995	1
2008	0.018	0.081	0.238	0.609	0.822	0.926	0.97	0.991	1
2009	0.018	0.063	0.214	0.555	0.825	0.934	0.978	0.991	1
2010	0.016	0.072	0.207	0.516	0.812	0.942	0.978	0.992	1
2011	0.021	0.062	0.216	0.466	0.758	0.949	0.966	0.993	1

Table 4.9. Northeast Arctic haddock. Survey indices used in tuning XSA

FLT01: RU-BTr-Q4
1991 2011
1 1 0.9 1.00
3 7

1	62	9	3	6	18
1	346	50	4	6	9
1	1985	356	48	8	4
1	442	1014	116	15	1
1	31	123	370	40	5
1	28	49	362	334	29
1	32	32	10	27	10
1	38	46	8	5	15
1	196	39	37	8	3
1	60	109	26	11	2
1	334	40	65	11	4
1	399	450	47	24	4
1	221	299	231	34	16
1	113	94	107	87	5
1	240	86	48	57	24
1	113	119	57	26	24
1	838	73	137	38	14
1	2557	1051	124	111	17
1	1647	1704	631	57	32
1	299	1697	1589	466	34
1	47	268	1087	783	165

FLT02: BS-NoRU-Q1(Aco)
1990 2011
1 1 0.99 1.00
3 7

1	**80**	**30**	**30**	**30**	**60**
1	230	20	NA	NA	10
1	1300	130	NA	NA	NA
1	6310	1110	120	NA	NA
1	1110	3870	420	20	NA
1	310	760	1510	80	NA
1	170	120	430	430	20
1	280	120	50	130	160
1	130	140	40	10	20
1	650	190	110	20	10
1	230	220	10	10	NA
1	1490	140	120	10	NA
1	1980	1690	170	50	NA
1	760	760	660	70	20
1	1020	360	400	90	NA
1	860	300	120	90	20
1	540	880	220	60	50
1	2517	573	742	102	58
1	7730	4021	313	149	16
1	5930	5574	1914	103	29
1	681	3130	2626	524	16
1	300	584	2943	1349	316

Table 4.9 (continued).

FLT04: BS-NoRu-Q1 (BTr)
1990 2011
1 1 0.99 1.00
3 8

1	51	42	27	17	42	NA
1	244	21	6	7	16	23
1	1056	105	6	4	3	4
1	4366	497	34	2	1	2
1	1711	3395	345	28	NA	1
1	481	1486	2528	116	9	NA
1	280	194	467	622	35	1
1	332	132	34	80	81	7
1	122	102	28	10	17	11
1	354	84	40	8	3	7
1	293	251	17	9	1	1
1	1853	176	82	8	3	NA
1	1820	736	55	23	2	1
1	1027	804	462	59	11	2
1	1333	668	522	123	6	2
1	1405	482	196	152	31	1
1	660	860	233	75	37	14
1	6009	868	489	62.7	25.1	8.2
1	7732	3654	385	106	14	1
1	5086	4796	1312	70	10	6
1	951	4683	3381	621	16	4
1	461	832	2896	1457	219	24

FLT007: Eco-NoRu-Q3 (Btr)
2004 2011
1 1 0.65 0.75
3 8

1	123	70	69	31	3	2
1	323	89	29	31	15	NA
1	107	125	42	19	17	7
1	1283	88	94	19	6	7
1	1155	406	43	36	5	3
1	651	618	306	21	7	1
1	184	865	666	148	16	3
1	40	74	393	301	37	3

Table 4.10. Northeast Arctic haddock. Input data for recruitment prediction (RCT3)

NORTHEAST ARCTIC HADDOCK: recruits as 3 year-olds
12 22 2

'Year-class'	'VPA'	'NT1'	'NT2'	'NT3'	'NAK1'	'NAK2'	'NAK3'	'RT1'	'RT2'	'RT3'	'ECO1'	'ECO2'	'ECO3'
1990	671	2006	1375.5	507.7	1890	868	563	-11	42.9	128.6	-11	-11	-11
1991	300	1659.4	599	339.5	1135	626	255	16.7	28.2	35.7	-11	-11	-11
1992	100	727.9	228	53.6	947	193	36	16.4	4.8	5.8	-11	-11	-11
1993	108	603.2	179.3	52.5	562	285	44	3.5	4.9	4.2	-11	-11	-11
1994	117	1463.6	263.6	86.1	1379	229	51	9.1	7.2	5.7	-11	-11	-11
1995	65	309.5	67.9	22.7	249	24	20	6.4	2.3	1.9	-11	-11	-11
1996	228	1268	137.9	59.8	693	122	57	6	4.6	11.5	-11	-11	-11
1997	95	212.9	57.6	27.2	220	46	32	1.8	2.9	6.1	-11	-11	-11
1998	373	1244.9	452.2	296	856	509	210	10.7	28.9	26.2	-11	-11	-11
1999	351	847.2	460.3	314.7	1024	316	216	11.7	20.7	26.1	-11	-11	-11
2000	232	1220.5	534.7	317.4	976	282	145	15.1	14.9	18.9	-11	-11	-11
2001	239	1680.3	513.1	188.1	2062	279	127	20.8	19.3	25.1	-11	-11	-11
2002	359	3332.1	711.2	346.5	2394	474	219	33.2	32.8	20.6	-11	-11	268
2003	183	715.9	420.4	77.4	752	209	54	19.8	11	13.6	-11	189	114
2004	743	4630.2	1313.1	507.7	3364	804	379	50	79.2	122.7	104	626	929
2005	1301	5141.3	1593.8	1522.4	2767	868	723.4	62	79.2	214.2	155	2270	1819
2006	1187	3874.4	2129.4	1270	3197	1835.2	1021.7	53.4	83.9	232.7	283	988	1292
2007	330	860.2	328	102.8	1266.6	246.3	138	6.5	12.7	15.8	114	322	144
2008	151	564.7	111.2	64.9	849	81.8	47.6	5.7	2.9	4.3	60	136	65
2009	-11	1619.5	343.5	315.3	2035.8	408	224.3	10	19.7	21.7	169	274	114
2010	-11	685.4	108.4	-11	786.5	176	-11	7.7	3.5	-11	154	105	-11
2011	-11	1921.5	-11	-11	2222.2	-11	-11	14.7	-11	-11	213	-11	-11

1990 RT was removed from XSA tuning

RT1 Russian bottom trawl survey (RU-BTr-Q4) age 1

RT2 Russian bottom trawl survey (RU-BTr-Q4) age 2

RT3 Russian bottom trawl survey (RU-BTr-Q4) age 3

NT1 Norwegian bottom trawl survey BS-NoRu-Q1 (BTr) age 1

NT2 Norwegian bottom trawl survey BS-NoRu-Q1 (BTr)) age 2

NT3 Norwegian bottom trawl survey BS-NoRu-Q1 (BTr) age 3

NA1 Norwegian acoustic survey BS-NoRU-Q1(Aco) age 1

NA2 Norwegian acoustic survey BS-NoRU-Q1(Aco) age 2

NA3 Norwegian acoustic survey BS-NoRU-Q1(Aco) age 3

ECO1 Ecosystem survey Eco-NoRu-Q3 (Btr) age 1

ECO2 Ecosystem survey Eco-NoRu-Q3 (Btr) age 2

ECO3 Ecosystem survey Eco-NoRu-Q3 (Btr) age 3

Table 4.11. Northeast Arctic haddock. Analysis by RCT3 ver.1

Data for 12 surveys over 22 years : 1990 – 2011 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	=	2006	Regression				Prediction		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.03	-1.78	0.51	0.746	16	8.26	6.71	0.613	0.034
NT2	0.94	-0.06	0.45	0.791	16	7.66	7.16	0.569	0.04
NT3	0.73	1.81	0.31	0.885	16	7.15	7.02	0.397	0.081
NAK1	1.25	-3.19	0.64	0.646	16	8.07	6.93	0.787	0.021
NAK2	0.98	0.11	0.52	0.738	16	7.52	7.45	0.68	0.028
NAK3	0.82	1.64	0.23	0.934	16	6.93	7.3	0.306	0.136
RT1	1.16	2.36	0.64	0.651	15	4	6.98	0.785	0.021
RT2	0.84	3.19	0.3	0.894	16	4.44	6.92	0.374	0.092
RT3	0.71	3.38	0.2	0.951	16	5.45	7.26	0.261	0.188
EC01									
ECO2	0.84	0.89	0.39	0.932	3	6.9	6.69	0.789	0.021
ECO3	0.69	1.96	0.07	0.996	4	7.16	6.91	0.12	0.32
VPA	Mean	=					5.58	0.829	0.019
Yearclass	=	2007	Regression				Prediction		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.08	-2.1	0.52	0.768	17	6.76	5.17	0.598	0.029
NT2	0.93	-0.01	0.42	0.834	17	5.8	5.4	0.482	0.044
NT3	0.74	1.78	0.3	0.906	17	4.64	5.19	0.35	0.083
NAK1	1.27	-3.31	0.62	0.695	17	7.14	5.78	0.712	0.02
NAK2	0.92	0.4	0.46	0.806	17	5.51	5.49	0.528	0.037
NAK3	0.79	1.75	0.22	0.948	17	4.93	5.66	0.252	0.161
RT1	1.17	2.33	0.61	0.708	16	2.01	4.68	0.72	0.02
RT2	0.86	3.13	0.3	0.911	17	2.62	5.39	0.338	0.089
RT3	0.69	3.43	0.19	0.961	17	2.82	5.38	0.218	0.215
EC01	0.86	2.58	0.43	0.491	3	4.74	6.64	0.953	0.011
ECO2	0.92	0.45	0.38	0.893	4	5.78	5.78	0.655	0.024
ECO3	0.72	1.8	0.1	0.989	5	4.98	5.39	0.166	0.255
VPA	Mean	=					5.73	0.898	0.013
Yearclass	=	2008	Regression				Prediction		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.07	-1.99	0.52	0.747	18	6.34	4.78	0.622	0.036
NT2	0.94	-0.01	0.42	0.822	18	4.72	4.42	0.516	0.053
NT3	0.74	1.82	0.34	0.873	18	4.19	4.91	0.405	0.085
NAK1	1.27	-3.26	0.59	0.701	18	6.75	5.28	0.677	0.031
NAK2	0.92	0.45	0.43	0.813	18	4.42	4.52	0.527	0.05
NAK3	0.79	1.75	0.21	0.947	18	3.88	4.84	0.255	0.216
RT1	1.16	2.42	0.66	0.648	17	1.9	4.64	0.792	0.022
RT2	0.87	3.15	0.31	0.895	18	1.36	4.33	0.386	0.094
RT3	0.69	3.46	0.22	0.943	18	1.67	4.62	0.27	0.193
EC01	2.21	-4.43	0.94	0.399	4	4.11	4.65	2.17	0.003
ECO2	0.92	0.48	0.31	0.907	5	4.92	5	0.544	0.047
ECO3	0.68	2.15	0.19	0.956	6	4.19	4.98	0.305	0.151
VPA	Mean	=					5.78	0.857	0.019

Table 4.11 (continued).

Yearclass	=	2009	Regression				Prediction		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.03	-1.71	0.49	0.769	19	7.39	5.93	0.554	0.035
NT2	0.89	0.33	0.41	0.824	19	5.84	5.53	0.468	0.049
NT3	0.73	1.88	0.33	0.881	19	5.76	6.07	0.373	0.077
NAK1	1.29	-3.49	0.57	0.708	19	7.62	6.38	0.659	0.025
NAK2	0.88	0.75	0.4	0.833	19	6.01	6.02	0.454	0.052
NAK3	0.78	1.84	0.21	0.949	19	5.42	6.07	0.235	0.195
RT1	1.11	2.6	0.61	0.677	18	2.4	5.27	0.705	0.022
RT2	0.82	3.36	0.33	0.876	19	3.03	5.83	0.381	0.074
RT3	0.67	3.59	0.23	0.935	19	3.12	5.67	0.266	0.152
EC01	1.92	-2.96	0.68	0.709	5	5.14	6.9	0.988	0.011
ECO2	0.91	0.52	0.27	0.939	6	5.62	5.65	0.366	0.08
ECO3	0.67	2.2	0.17	0.97	7	4.74	5.37	0.225	0.212
VPA	Mean	=					5.77	0.846	0.015

Yearclass	=	2010	Regression				Prediction		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.02	-1.61	0.48	0.777	19	6.53	5.06	0.564	0.104
NT2	0.89	0.36	0.41	0.827	19	4.7	4.52	0.508	0.128
NT3									
NAK1	1.3	-3.56	0.56	0.713	19	6.67	5.13	0.663	0.075
NAK2	0.87	0.81	0.38	0.848	19	5.18	5.31	0.439	0.171
NAK3									
RT1	1.1	2.64	0.6	0.683	18	2.16	5.02	0.717	0.064
RT2	0.81	3.38	0.34	0.875	19	1.5	4.6	0.418	0.189
RT3									
EC01	1.92	-2.95	0.68	0.712	5	5.04	6.72	0.978	0.034
ECO2	0.91	0.52	0.27	0.939	6	4.66	4.78	0.419	0.188
NT1	1.02	-1.61	0.48	0.777	19	6.53	5.06	0.564	0.104
VPA	Mean	=					5.81	0.842	0.047

Yearclass	=	2011	Regression				Prediction		
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NT1	1.01	-1.52	0.47	0.784	19	7.56	6.11	0.548	0.336
NT2,NT3									
NAK1	1.32	-3.7	0.56	0.718	19	7.71	6.49	0.665	0.228
NAK2,3									
RT1	1.09	2.67	0.6	0.687	18	2.75	5.67	0.704	0.203
RT2,RT3									
EC01	1.91	-2.94	0.68	0.715	5	5.37	7.33	1.059	0.09
ECO2,3									
VPA	Mean	=					5.86	0.839	0.143

Year Class Prediction	Weighted Average	Log WAP	Int Std Error	Ext Std Error	Var	VPA Ratio	Log VPA
2006	1129	7.03	0.11	0.08	0.55	1188	7.08
2007	229	5.43	0.1	0.06	0.41	330	5.8
2008	117	4.77	0.12	0.08	0.43	151	5.02
2009	320	5.77	0.1	0.09	0.75		
2010	146	4.99	0.18	0.17	0.83		
2011	483	6.18	0.32	0.23	0.52		

Table 4.12. Northeast Arctic haddock. Extended Survivors Analysis

FLR XSA Diagnostics 2011-04-23 18:13:01
CPUE data from indices

Catch data for 62 years. 1950 to 2011. Ages 3 to 11.

fleet	first age	last age	first year	last year
1 FLT01: RU-BTr-Q4	3	7	1990	2011
2 FLT02: BS-NoRU-Q1-(Aco)	3	7	1990	2011
3 FLT04: BS-NoRU-Q1-(Btr)	3	8	1990	2011
4 FLT007:Eco-NoRu-Q3 (Btr)	3	8	1990	2011

Time series weights :
Tapered time weighting applied
Power = 3 over 20 years
Catchability analysis :
Catchability independent of size for ages > 8
Catchability independent of age for ages > 8
Terminal population estimation :
Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.
S.E. of the mean to which the estimates are shrunk = 1.5
Minimum standard error for population
estimates derived from each fleet = 0.3
prior weighting not applied

Regression weights

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
all	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	0.024	0.037	0.042	0.04	0.028	0.05	0.014	0.017	0.021	0.017
4	0.196	0.157	0.18	0.159	0.184	0.13	0.108	0.083	0.087	0.06
5	0.246	0.393	0.336	0.326	0.379	0.402	0.209	0.212	0.215	0.275
6	0.49	0.449	0.564	0.591	0.381	0.483	0.563	0.303	0.412	0.647
7	0.257	0.716	0.345	0.797	0.56	0.516	0.471	0.642	0.342	0.595
8	0.222	0.255	0.565	0.279	0.738	0.601	0.432	0.363	0.524	0.333
9	0.137	0.532	0.139	0.835	0.232	0.511	0.451	0.274	0.183	0.397
10	0.252	0.385	0.679	0.358	1.171	0.188	0.468	0.243	0.418	0.239
11	0.252	0.385	0.679	0.358	1.171	0.188	0.468	0.243	0.418	0.239

XSA population number (Thousand)

year	3	4	5	6	7	8	9	10	11
2002	351091	289382	56463	62898	12694	8897	4159	2224	5078
2003	231920	246099	192765	35831	31433	8039	5835	2969	4185
2004	239247	148101	161684	105648	18717	12578	5100	2807	1994
2005	359434	151053	92445	92533	49195	10855	5852	3635	5553
2006	183233	233291	97420	52830	41275	18144	6722	2079	1127
2007	743256	140860	155123	53639	29158	19295	7103	4365	6330
2008	1300846	511444	97667	83083	26915	14243	8659	3490	1915
2009	1187060	822465	328494	59244	35938	13761	7571	4514	4891
2010	329645	700414	530720	185326	34272	15481	7838	4712	6208
2011	151339	214098	439293	279589	88822	19926	7508	5342	13699

Estimated population abundance at 1st Jan 2012

year	3	4	5	6	7	8	9	10	11
2012	0	75204	96562	193839	98210	40108	11699	4134	3445

Table 4.12 (continued).

Fleet:1 FLT01: RU-BTr-Q4

Log catchability residuals.

year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
age											
3	NA	0.061	0.329	0.329	0.233	-0.147	-0.077	-0.178	0.181	0.06	0.114
4	NA	0.077	0.015	0.344	0.038	-0.214	0.131	0.156	0.111	0.246	-0.116
5	NA	-0.05	-0.049	0.153	0.073	-0.235	0.316	-0.256	-0.167	0.232	0.214
6	NA	-0.043	0.358	0.423	0.051	-0.045	-0.07	-0.267	-0.195	0.082	0.045
7	NA	0	0.258	0.495	0.153	0.127	0.196	-0.695	-0.073	-0.046	-0.086

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	-0.047	0.106	0.165	-0.13	-0.09	-0.036	-0.061	0.076	-0.021	0.057	-0.105
4	-0.039	0.098	0.047	-0.065	-0.123	-0.279	-0.169	0.085	-0.026	0.083	0.228
5	-0.139	0.112	-0.014	-0.189	-0.135	-0.095	-0.058	0.138	0.009	0.067	0.105
6	0.095	-0.213	0.183	-0.095	-0.135	-0.122	0.008	0.129	0.034	0.088	0.104
7	-0.059	-0.003	0.038	-0.123	-0.063	-0.034	-0.015	0.072	0.147	0.107	0.123

Regression statistics

Ages with q dependent on year class strength

		slope	intercept
Age	3	0.645488	8.849941
Age	4	0.620125	8.706159
Age	5	0.585181	8.626654
Age	6	0.543442	8.572332
Age	7	0.539058	8.462786

Fleet:2 FLT02: BS-NoRU-Q1-(Aco), age 3-7, shifted

Log catchability residuals.

year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
age											
3	0.154	-0.107	0.339	0.377	0.026	0.163	-0.002	0.069	-0.047	-0.081	-0.031
4	0.068	-0.271	-0.192	0.339	0.139	0.003	-0.091	0.115	-0.012	0.346	-0.418
5	0.061	NA	NA	0.133	0.166	-0.107	0.031	-0.022	0.066	0.269	-0.401
6	-0.147	NA	NA	NA	-0.02	0.009	-0.136	0.055	-0.158	0.197	-0.153
7	0.15	-0.299	NA	NA	NA	NA	-0.034	-0.01	-0.112	0.18	NA

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	-0.004	0.255	0.084	0.231	-0.182	-0.032	-0.16	0.093	0.052	-0.248	0.025
4	-0.128	0.168	-0.088	-0.066	-0.18	0.011	0.136	0.2	0.026	-0.121	0.059
5	-0.249	0.212	-0.002	-0.077	-0.145	0.031	0.166	0.112	0.028	-0.12	0.08
6	-0.102	-0.152	0.251	-0.237	-0.15	-0.029	0.155	0.075	0.059	-0.014	0.145
7	NA	NA	-0.018	NA	-0.236	0.056	0.274	-0.07	-0.004	-0.238	0.189

Regression statistics

Ages with q dependent on year class strength

		slope	intercept
Age	3	0.745005	7.193064
Age	4	0.683077	7.467988
Age	5	0.565832	8.153543
Age	6	0.55566	8.218438
Age	7	0.53908	8.215312

Table 4.12 (continued).

Fleet: 3 FLT04: BS-NoRU-Q1-(Btr), age 3-8, shifted

Log catchability residuals.

year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
age											
3	-0.264	-0.224	0.098	0.063	0.147	0.276	0.14	0.025	-0.241	-0.57	-0.041
4	0.162	-0.322	-0.356	-0.086	0.041	0.277	0.079	0.103	-0.221	-0.096	-0.415
5	0.111	0.013	-0.077	-0.178	0.129	0.052	0.082	-0.061	0.034	0.02	-0.125
6	-0.195	-0.037	0.189	0	0.135	0.132	-0.052	-0.057	-0.043	0.029	-0.059
7	0.119	-0.001	0.052	0.221	NA	0.273	0.175	-0.14	-0.019	0.058	-0.077
8	NA	0.111	-0.158	0.117	0.408	NA	0.198	0.154	-0.145	0.07	0.039
age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	-0.005	0.089	0.127	0.261	-0.034	-0.056	0.221	-0.011	-0.143	-0.194	0.133
4	-0.079	-0.27	-0.109	0.178	-0.008	-0.046	0.288	0.12	-0.08	0.033	0.183
5	-0.288	-0.071	-0.081	0.035	0.056	0.087	0.057	0.2	-0.078	-0.046	0.06
6	-0.043	-0.277	0.219	-0.108	0.019	0.072	0.044	-0.008	-0.012	0.001	0.081
7	-0.011	-0.041	-0.031	0.011	-0.017	0.048	0.118	0.035	-0.12	-0.068	0.054
8	NA	-0.098	0.076	-0.058	-0.173	0.169	0.021	-0.261	0.066	-0.029	0.154

Regression statistics

Ages with q dependent on year class strength

		slope	intercept
Age	3	0.760567	6.908282
Age	4	0.692186	7.335676
Age	5	0.531303	8.438762
Age	6	0.49305	8.600907
Age	7	0.430771	8.858186
Age	8	0.425446	8.683459

Fleet: 4 FLT007:Eco-NoRu-Q3 (Btr), age 3-8

Log catchability residuals.

year	2004	2005	2006	2007	2008	2009	2010	2011
age								
3	-0.012	0.191	0.036	0.368	-0.062	-0.272	-0.043	-0.182
4	-0.025	0.077	-0.07	0.095	0.002	-0.122	0.188	-0.144
5	-0.09	-0.06	0.045	0.056	0.029	0.01	0.013	-0.015
6	-0.155	-0.072	0.043	0.055	0.04	0	0.007	0.063
7	-0.042	0.023	0.109	-0.035	-0.057	-0.076	0.146	-0.068
8	0.037	NA	0.079	0.046	0.032	-0.099	0.011	-0.096

Regression statistics

Ages with q dependent on year class strength

		slope	intercept
Age	3	0.725265	8.645395
Age	4	0.734705	8.507278
Age	5	0.586827	9.12572
Age	6	0.55306	9.093281
Age	7	0.562272	8.92968
Age	8	0.3539	9.109217

Table 4.12 (continued).

Terminal year survivor and F summaries:

	scaledWts	survivors
Age 3 Year class =2008	scaledWts	survivors
1 FLT01: RU-BTr-Q4	0.26	63866
2 FLT02: BS-NoRU-Q1-(Aco)	0.26	77767
3 FLT04: BS-NoRU-Q1-(Btr)	0.26	89594
4 FLT007:Eco-NoRu-Q3 (Btr)	0.175	58476
fshk	0.011	48260
nshk	0.035	217972
Age 4 Year class =2007	scaledWts	survivors
1 FLT01: RU-BTr-Q4	0.247	139516
2 FLT02: BS-NoRU-Q1-(Aco)	0.247	105245
3 FLT04: BS-NoRU-Q1-(Btr)	0.247	125739
4 FLT007:Eco-NoRu-Q3 (Btr)	0.247	79424
fshk	0.147	282540
Age 5 Year class =2006	scaledWts	survivors
1 FLT01: RU-BTr-Q4	0.261	231950
2 FLT02: BS-NoRU-Q1-(Aco)	0.202	223110
3 FLT04: BS-NoRU-Q1-(Btr)	0.261	217117
4 FLT007:Eco-NoRu-Q3 (Btr)	0.261	188920
fshk	0.162	111366
Age 6 Year class =2005	scaledWts	survivors
1 FLT01: RU-BTr-Q4	0.259	119017
2 FLT02: BS-NoRU-Q1-(Aco)	0.202	127435
3 FLT04: BS-NoRU-Q1-(Btr)	0.26	115773
4 FLT007:Eco-NoRu-Q3 (Btr)	0.26	109998
fshk	0.207	16535
Age 7 Year class =2004	scaledWts	survivors
1 FLT01: RU-BTr-Q4	0.237	50368
2 FLT02: BS-NoRU-Q1-(Aco)	0.136	56926
3 FLT04: BS-NoRU-Q1-(Btr)	0.302	45494
4 FLT007:Eco-NoRu-Q3 (Btr)	0.302	35515
fshk	0.519	15778
Age 8 Year class =2003	scaledWts	survivors
1 FLT04: BS-NoRU-Q1-(Btr)	0.356	16788
2 FLT007:Eco-NoRu-Q3 (Btr)	0.61	8931
fshk	0.836	3851
Age 9 Year class =2002	scaledWts	survivors
fshk	1	5107
Age 10 Year class =2001	scaledWts	survivors
fshk	1	1658

Table 4.13. Northeast Arctic haddock. Fishing mortality at age

	Age								
YEAR	3	4	5	6	7	8	9	10	11+	FBAR(4-7)
1950	0.046	0.562	0.804	0.806	1.158	1.002	0.647	0.946	0.946	0.8325
1951	0.121	0.205	0.617	0.907	0.803	1.002	1.428	1.09	1.09	0.633
1952	0.1	0.517	0.569	0.885	0.997	1.256	1.378	1.225	1.225	0.742
1953	0.061	0.367	0.521	0.486	0.714	0.655	0.513	0.633	0.633	0.522
1954	0.052	0.229	0.298	0.408	0.614	0.864	1.366	0.958	0.958	0.38725
1955	0.021	0.125	0.475	0.465	1.015	0.622	0.429	0.695	0.695	0.52
1956	0.097	0.162	0.269	0.807	0.625	0.936	0.397	0.659	0.659	0.46575
1957	0.038	0.233	0.363	0.401	0.816	0.45	0.628	0.637	0.637	0.45325
1958	0.024	0.163	0.562	0.516	0.966	0.87	0.744	0.869	0.869	0.55175
1959	0.061	0.162	0.326	0.553	0.601	0.429	0.845	0.63	0.63	0.4105
1960	0.175	0.357	0.503	0.646	0.518	0.701	1.15	0.798	0.798	0.506
1961	0.148	0.46	0.678	0.746	0.832	0.88	0.964	0.902	0.902	0.679
1962	0.174	0.565	1.041	1.056	0.698	0.901	1.183	0.937	0.937	0.84
1963	0.104	0.645	0.917	1.023	1.002	0.649	1.362	1.016	1.016	0.89675
1964	0.069	0.299	0.675	0.868	0.846	0.961	1.389	1.078	1.078	0.672
1965	0.057	0.224	0.454	0.694	0.677	0.596	1.053	0.783	0.783	0.51225
1966	0.112	0.363	0.58	0.74	0.826	0.528	0.593	0.655	0.655	0.62725
1967	0.053	0.289	0.41	0.516	0.532	0.581	0.383	0.503	0.503	0.43675
1968	0.035	0.373	0.564	0.456	0.704	0.718	0.495	0.645	0.645	0.52425
1969	0.086	0.158	0.484	0.578	0.404	0.503	0.502	0.473	0.473	0.406
1970	0.147	0.218	0.239	0.5	0.53	0.413	0.395	0.449	0.449	0.37175
1971	0.02	0.252	0.174	0.179	0.402	0.389	0.296	0.365	0.365	0.25175
1972	0.25	0.369	1.051	0.948	0.551	0.581	0.696	0.615	0.615	0.72975
1973	0.295	0.57	0.972	0.473	0.296	0.271	0.275	0.283	0.283	0.57775
1974	0.196	0.32	0.407	0.691	0.591	0.48	0.803	0.63	0.63	0.50225
1975	0.225	0.557	0.502	0.441	0.597	0.348	0.2	0.384	0.384	0.52425
1976	0.286	0.611	0.623	0.701	0.801	0.874	0.811	0.837	0.837	0.684
1977	0.681	1.232	0.901	0.533	0.632	0.533	0.555	0.578	0.578	0.8245
1978	0.308	0.588	0.861	0.426	0.79	0.445	0.662	0.638	0.638	0.66625
1979	0.126	0.453	0.873	0.925	0.483	0.681	0.488	0.555	0.555	0.6835
1980	0.024	0.271	0.608	0.674	0.398	0.637	0.698	0.582	0.582	0.48775
1981	0.043	0.148	0.49	0.727	0.532	0.489	0.43	0.488	0.488	0.47425
1982	0.064	0.117	0.314	0.579	0.392	0.336	0.441	0.392	0.392	0.3505
1983	0.163	0.312	0.277	0.4	0.221	0.513	0.476	0.406	0.406	0.3025
1984	0.123	0.225	0.404	0.213	0.276	0.38	0.174	0.278	0.278	0.2795
1985	0.118	0.241	0.187	0.391	0.54	0.448	0.478	0.492	0.492	0.33975
1986	0.062	0.437	0.366	0.43	0.73	0.453	0.793	0.665	0.665	0.49075
1987	0.048	0.459	1	0.403	0.695	0.802	0.474	0.663	0.663	0.63925
1988	0.032	0.161	0.496	1.092	0.288	0.454	0.35	0.367	0.367	0.50925
1989	0.091	0.164	0.322	0.537	0.476	0.164	0.004	0.216	0.216	0.37475
1990	0.033	0.15	0.098	0.124	0.24	0.218	0.221	0.227	0.227	0.153
1991	0.047	0.165	0.204	0.216	0.205	0.236	0.178	0.207	0.207	0.1975
1992	0.062	0.168	0.291	0.36	0.299	0.222	0.34	0.289	0.289	0.2795
1993	0.023	0.142	0.319	0.533	0.431	0.325	0.214	0.325	0.325	0.35625
1994	0.013	0.112	0.438	0.615	0.564	0.415	0.448	0.482	0.482	0.43225
1995	0.024	0.092	0.265	0.441	0.698	0.409	0.29	0.456	0.456	0.374
1996	0.023	0.12	0.344	0.508	0.646	0.835	0.643	0.536	0.536	0.4045
1997	0.025	0.135	0.365	0.616	0.8	0.627	0.546	0.638	0.638	0.479
1998	0.03	0.2	0.356	0.467	0.578	0.89	0.51	0.472	0.472	0.40025
1999	0.085	0.197	0.472	0.424	0.471	0.58	0.818	0.286	0.286	0.391
2000	0.018	0.216	0.243	0.285	0.295	0.318	0.271	0.571	0.571	0.25975
2001	0.039	0.08	0.379	0.319	0.262	0.221	0.387	0.332	0.332	0.26
2002	0.024	0.196	0.246	0.49	0.257	0.222	0.137	0.252	0.252	0.29725
2003	0.037	0.157	0.393	0.449	0.716	0.255	0.532	0.385	0.385	0.42875
2004	0.042	0.18	0.336	0.564	0.345	0.565	0.139	0.679	0.679	0.35625
2005	0.04	0.159	0.326	0.591	0.797	0.279	0.835	0.358	0.358	0.46825
2006	0.028	0.184	0.379	0.381	0.56	0.738	0.232	1.171	1.171	0.376
2007	0.05	0.13	0.402	0.483	0.516	0.601	0.511	0.188	0.188	0.38275
2008	0.014	0.108	0.209	0.563	0.471	0.432	0.451	0.468	0.468	0.33775
2009	0.017	0.083	0.212	0.303	0.642	0.363	0.274	0.243	0.243	0.31
2010	0.021	0.087	0.215	0.412	0.342	0.524	0.183	0.418	0.418	0.264
2011	0.017	0.06	0.275	0.647	0.595	0.333	0.397	0.239	0.239	0.3943

Table 4.14. Northeast Arctic haddock. Stock numbers at age (start of year). Numbers ´000

YEAR	3	4	5	6	7	8	9	10	11+	TOTAL
1950	83777	100604	72201	38000	46516	16065	4591	1975	5287	369016
1951	685114	56499	44184	25350	13635	11963	4830	1968	2201	845744
1952	75457	428785	35463	18716	8220	5003	3596	948	1348	577536
1953	1296180	48249	196871	15752	6208	2484	1167	742	2339	1569992
1954	154657	861371	25743	91794	7787	2488	1056	572	957	1146425
1955	65108	103732	527698	14989	49017	3450	859	221	218	765292
1956	211035	45021	70518	257602	7567	14550	1517	458	418	608686
1957	66005	135257	29480	42306	92336	3316	4671	835	408	374614
1958	86262	44882	82500	16099	22753	33416	1731	2041	1126	290810
1959	405538	59483	29380	36893	7717	7094	11465	674	1168	559412
1960	296038	269390	38948	16640	17055	3465	3784	4032	1201	650553
1961	133694	175574	145261	18475	7004	8321	1408	980	2624	493341
1962	293925	81472	85337	57874	7040	2497	2825	440	1350	532760
1963	341919	174424	35663	23647	16168	2867	831	709	638	596866
1964	399059	217603	70513	11182	6827	4861	1226	174	1040	712485
1965	126871	263095	124348	28164	3772	2398	1522	250	1609	552029
1966	296726	84631	161963	61970	11306	1569	1082	435	550	620232
1967	369466	187461	45325	71136	23751	4052	758	490	751	703190
1968	22556	247616	108104	23613	34098	11418	1855	423	657	450340
1969	22059	15381	131369	48278	12026	13803	4560	926	316	248718
1970	204309	14301	10120	63553	21755	6571	6834	2260	887	330590
1971	119042	124617	8862	6253	30965	10482	3559	3771	1916	309467
1972	1241920	82428	74608	5841	4201	16956	5817	2166	3930	1437867
1973	329506	683177	43905	20474	1819	1982	7768	2375	2606	1093612
1974	64722	173355	297570	13034	10247	1107	1237	4829	4367	570468
1975	59386	37579	96923	155458	5247	4645	561	454	3209	363462
1976	66851	33513	16581	46056	80338	2364	2685	376	3078	251842
1977	134855	35461	14006	6979	18361	29530	807	977	943	241919
1978	212456	48221	7968	4464	3289	7992	14185	380	926	299881
1979	176240	110313	20632	2642	2341	1222	4195	5990	829	324404
1980	30836	109752	53996	6761	842	1182	506	2108	3614	209597
1981	13702	21255	64457	23067	2769	463	512	206	2731	129162
1982	16901	9270	14124	30984	8955	1331	233	273	2193	84264
1983	9294	11197	6350	8097	13955	4956	779	122	959	55709
1984	12187	5579	6311	3779	4359	9158	2430	396	348	44547
1985	293453	8759	3646	3449	2499	2709	5128	1671	791	322105
1986	531442	213454	5638	2475	1910	1193	1417	2603	2218	762350
1987	118589	261768	112844	3200	1318	753	621	525	1662	501280
1988	56167	92540	135443	33976	1751	539	277	317	1593	322603
1989	27448	36392	64475	67350	9332	1074	280	160	1003	207514
1990	36742	20521	25284	38246	32238	4747	747	228	384	159137
1991	105998	25842	14467	18762	27652	20765	3127	490	317	217420
1992	214813	82783	17933	9658	12376	18447	13424	2143	368	371945
1993	671488	164421	57311	10973	5517	7514	12093	7826	1277	938420
1994	299849	504396	113937	31910	5272	2936	4446	7996	6035	976777
1995	100466	220047	362943	59574	14113	2455	1587	2325	4715	768225
1996	107553	69837	140168	206456	31165	5749	1335	972	5001	568236
1997	117151	50277	46058	79332	99263	13367	2043	574	1732	409797
1998	64811	70800	34504	25589	34746	36500	5845	969	1425	275189
1999	228449	49741	45100	19413	13139	15960	12268	2873	1968	388911
2000	95397	171505	33450	23022	10399	6716	7316	4430	1098	353333
2001	373317	74833	112243	21339	14118	6337	3999	4570	4673	615429
2002	351091	289382	56463	62898	12694	8897	4159	2224	5078	792886
2003	231920	246099	192765	35831	31433	8039	5835	2969	4185	759076
2004	239247	148101	161684	105648	18717	12578	5100	2807	1994	695876
2005	359434	151053	92445	92533	49195	10855	5852	3635	5553	770555
2006	183233	233291	97420	52830	41275	18144	6722	2079	1127	636121
2007	743256	140860	155123	53639	29158	19295	7103	4365	6330	1159129
2008	1300846	511444	97667	83083	26915	14243	8659	3490	1915	2048262
2009	1187060	822465	328494	59244	35938	13761	7571	4514	4891	2463938
2010	329645	700414	530720	185326	34272	15481	7838	4712	6208	1814616
2011	151339	214098	439293	279589	88822	19926	7508	5342	13699	1219616

Table 4.15. Northeast Arctic haddock. Spawning stock numbers at age (spawning time). Num ´000

	Age								
Year	3	4	5	6	7	8	9	10	11+
1950	2262	10161	22455	23636	39306	15166	4508	1963	5287
1951	18498	5706	13741	15768	11521	11293	4743	1956	2201
1952	2037	43307	11029	11641	6946	4723	3532	943	1348
1953	34997	4873	61227	9798	5245	2345	1146	738	2339
1954	4176	86998	8006	57096	6580	2349	1037	568	957
1955	1758	10477	164114	9323	41420	3257	844	219	218
1956	5698	4547	21931	160228	6394	13735	1490	455	418
1957	1782	13661	9168	26314	78024	3130	4587	830	408
1958	2329	4533	25657	10014	19226	31544	1700	2028	1126
1959	10950	6008	9137	22947	6521	6696	11259	670	1168
1960	7993	27208	12113	10350	14412	3271	3715	4008	1201
1961	3610	17733	45176	11492	5918	7855	1382	975	2624
1962	7936	8229	26540	35998	5948	2357	2774	437	1350
1963	9232	17617	11091	14708	13662	2707	816	704	638
1964	10775	21978	21930	6955	5769	4589	1204	173	1040
1965	3426	26573	38672	17518	3187	2264	1495	249	1609
1966	8012	8548	50371	38546	9553	1481	1063	432	550
1967	9976	18934	14096	44247	20069	3825	744	487	751
1968	609	25009	33620	14687	28813	10778	1822	421	657
1969	596	1553	40856	30029	10162	13030	4477	921	316
1970	5516	1444	3147	39530	18383	6203	6711	2246	887
1971	3214	12586	2756	3890	26166	9895	3495	3748	1916
1972	33532	8325	23203	3633	3550	16007	5712	2153	3930
1973	8897	69001	13654	12735	1537	1871	7628	2361	2606
1974	1747	17509	92544	8107	8659	1045	1215	4800	4367
1975	1603	3795	30143	96695	4434	4385	551	451	3209
1976	1805	3385	5157	28647	67885	2232	2637	374	3078
1977	3641	3582	4356	4341	15515	27876	793	971	943
1978	5736	4870	2478	2777	2779	7545	13930	377	926
1979	4758	11142	6417	1643	1978	1153	4119	5954	829
1980	802	8341	13121	4388	724	1123	498	2097	3614
1981	767	2211	19531	12664	2373	439	504	205	2731
1982	896	1493	4689	17878	6895	1261	229	271	2193
1983	530	2049	2997	5384	11164	4490	765	122	959
1984	536	1094	3219	3027	3758	8434	2350	394	348
1985	7923	1305	1903	2745	2319	2582	4990	1653	791
1986	11160	21986	2560	1876	1773	1166	1394	2580	2218
1987	2490	19894	33176	2281	1210	735	617	521	1662
1988	1404	6848	32506	19570	1572	525	275	316	1593
1989	878	3275	16119	35965	7671	1038	278	159	1003
1990	1690	2606	7711	22106	25726	4448	739	228	384
1991	4346	4238	5179	11689	22675	19208	3064	489	317
1992	6444	12169	8052	6799	10582	17267	13102	2130	368
1993	12087	18580	22695	8131	4844	7138	11839	7763	1277
1994	4798	36821	37485	22401	4760	2819	4374	7940	6035
1995	1607	12983	82388	37710	12490	2379	1566	2313	4715
1996	1936	4819	29856	102609	26646	5542	1323	969	5001
1997	2577	3117	9396	39269	75440	12672	2020	573	1732
1998	1944	5947	8108	12846	26059	33106	5751	966	1425
1999	9595	5969	13846	11415	9986	14332	11887	2859	1968
2000	2576	25726	12042	14135	8204	6045	7068	4386	1098
2001	10826	7109	46581	14361	12226	5823	3867	4519	4673
2002	7022	32411	17955	46041	11361	8444	4051	2199	5078
2003	4406	18211	63612	22144	28133	7677	5701	2945	4185
2004	5503	10071	38158	64763	15404	12113	5024	2793	1994
2005	8986	11782	20430	49783	41078	10193	5758	3617	5553
2006	4581	21696	23868	28264	32112	17092	6588	2073	1127
2007	14865	12114	48243	29984	23530	17964	6940	4343	6330
2008	23415	41427	23245	50598	22124	13189	8400	3459	1915
2009	21367	51815	70298	32880	29649	12853	7405	4474	4891
2010	5274	50430	109859	95628	27829	14583	7666	4675	6208
2011	3178	13274	94887	130288	67327	18909	7253	5304	13699

Table 4.16. Northeast Arctic haddock. Stock biomass at age with SOP (start of year). Tonnes

YEAR	3	4	5	6	7	8	9	10	11+	TSBSOP
1950	18660	41335	46156	34119	54643	23522	8004	3970	11966	242375
1951	197517	30046	36559	29461	20731	22672	10899	5120	6448	359453
1952	15341	160806	20693	15339	8814	6686	5724	1740	2784	237927
1953	321331	22064	140075	15741	8116	4048	2265	1661	5893	521194
1954	37152	381695	17749	88889	9866	3929	1986	1240	2335	544841
1955	15005	44097	349032	13924	59577	5227	1550	459	510	489381
1956	59180	23289	56755	291198	11191	26820	3330	1159	1192	474114
1957	18763	70926	24052	48479	138434	6196	10393	2142	1178	320563
1958	27143	26051	74505	20420	37759	69117	4264	5795	3600	268654
1959	152547	41274	31718	55941	15310	17540	33758	2287	4462	354837
1960	100591	168851	37983	22792	30564	7739	10064	12365	4146	395095
1961	47528	115134	148208	26476	13131	19445	3918	3146	9480	386466
1962	98880	50558	82395	78483	12490	5521	7439	1335	4616	341717
1963	105657	99423	31628	29456	26349	5824	2009	1976	2003	304325
1964	104066	104675	52775	11755	9389	8333	2503	410	2757	296663
1965	39047	149363	109837	34942	6122	4851	3667	695	5030	353554
1966	90371	47546	141573	76082	18160	3141	2579	1195	1701	382348
1967	130968	122578	46112	101649	44402	9441	2103	1566	2703	461522
1968	8004	162072	110090	33775	63810	26631	5152	1355	2369	413258
1969	8853	11387	151318	78105	25455	36414	14324	3355	1290	330501
1970	74058	9563	10528	92862	41589	15656	19389	7394	3266	274305
1971	55084	106367	11769	11664	75568	31883	12891	15747	9007	329980
1972	403587	49411	69586	7651	7200	36222	14797	6354	12977	607785
1973	100058	382676	38264	25062	2913	3956	18464	6510	8040	585943
1974	25601	126491	337825	20784	21377	2879	3831	17239	17551	573578
1975	23462	27387	109902	247584	10933	12064	1735	1618	12881	447566
1976	21137	19546	15046	58700	133966	4914	6645	1073	9887	270914
1977	43801	21246	13056	9138	31453	63049	2053	2863	3114	189773
1978	81554	34145	8778	6908	6659	20167	42622	1315	3611	205759
1979	81159	93705	27268	4905	5687	3698	15120	24896	3877	260315
1980	18408	126706	82287	14891	2537	4872	2203	9847	18019	279770
1981	11493	23801	117905	50761	8157	1757	2499	1055	14833	232261
1982	14770	13468	23806	76470	25015	4707	1011	1454	12197	172898
1983	4644	11723	9434	12839	30006	11569	2205	412	3807	86639
1984	4523	4904	9775	7507	8775	23625	6608	1264	1282	68263
1985	113914	6280	5206	7753	6722	7137	16587	5582	3020	172201
1986	157154	138419	5730	4466	5016	3560	4048	8832	7659	334884
1987	39559	150107	119068	4750	3202	2511	2264	1804	6610	329875
1988	21609	56053	120678	49555	3333	1577	1062	1290	6059	261216
1989	12495	25650	61735	85985	17929	2547	972	701	4566	212580
1990	14936	15937	26231	49391	51882	10784	2005	864	1787	173817
1991	41073	18358	16636	26368	45685	40732	8233	1475	1301	199861
1992	74551	60924	20483	16069	23762	40051	33393	6872	1311	277416
1993	186761	100968	62845	16813	11439	17289	30621	22085	4496	453317
1994	78126	256821	107868	48171	10322	7378	12065	23419	19282	563452
1995	27647	103931	283344	77146	26884	5752	4582	7113	15345	551744
1996	32992	35705	104737	228966	52825	13497	3701	3221	17309	492953
1997	37861	27288	35725	81140	139738	27026	5464	1758	6177	362177
1998	23070	43262	30398	29223	48715	66658	14597	3085	5064	264072
1999	81871	31707	42262	23856	19594	27739	26607	8190	6945	268771
2000	27693	110099	32781	30029	16663	12463	15231	11126	3506	259591
2001	108943	41258	115040	30231	24876	13117	9256	11513	13820	368054
2002	95146	151979	47636	87839	22914	19017	10103	5886	14290	454810
2003	67145	121729	157021	42304	56485	17807	14752	8319	12522	498084
2004	70880	78455	125621	121571	29048	27849	13445	8207	6340	481416
2005	108902	83253	77670	103475	75703	21357	15619	11248	18645	515872
2006	56790	130525	84602	63156	61513	35220	16032	6457	3975	458270
2007	215947	80288	135835	65747	45858	36128	16604	12152	22190	630749
2008	351155	273031	86865	102264	43268	27904	19503	9496	6054	919540
2009	325250	407115	273303	73757	57680	27371	17671	11796	15029	1208972
2010	87429	353304	413777	218497	56081	31004	18710	12814	18515	1210131
2011	33669	104918	348224	309887	138236	40715	18051	14855	42392	1050947

Table 4.17. Northeast Arctic haddock. Spawning stock biomass at age with SOP (spawning time). Tonnes.

Year	3	4	5	6	7	8	9	10	11+	SSBSOP
1950	504	4175	14354	21222	46173	22205	7860	3946	11966	132405
1951	5333	3035	11370	18325	17518	21402	10703	5090	6448	99224
1952	414	16241	6435	9541	7448	6312	5620	1730	2784	56525
1953	8676	2228	43563	9791	6858	3821	2224	1651	5893	84705
1954	1003	38551	5520	55289	8336	3709	1951	1232	2335	117926
1955	405	4454	108549	8661	50343	4934	1522	456	510	179834
1956	1598	2352	17651	181125	9456	25318	3270	1152	1192	243114
1957	507	7163	7480	30154	116977	5849	10206	2129	1178	181643
1958	733	2631	23171	12702	31906	65247	4187	5761	3600	149938
1959	4119	4169	9864	34795	12937	16558	33151	2273	4462	122328
1960	2716	17054	11813	14177	25826	7305	9882	12291	4146	105210
1961	1283	11629	46093	16468	11096	18356	3847	3127	9480	121379
1962	2670	5106	25625	48817	10554	5212	7305	1327	4616	111232
1963	2853	10042	9836	18322	22265	5498	1973	1964	2003	74756
1964	2810	10572	16413	7312	7934	7866	2458	408	2757	58530
1965	1054	15086	34159	21734	5173	4580	3601	691	5030	91108
1966	2440	4802	44029	47323	15345	2965	2533	1188	1701	122326
1967	3536	12380	14341	63226	37520	8913	2065	1557	2703	146241
1968	216	16369	34238	21008	53920	25140	5060	1347	2369	159667
1969	239	1150	47060	48582	21509	34375	14066	3335	1290	171606
1970	2000	966	3274	57760	35143	14779	19040	7349	3266	143577
1971	1487	10743	3660	7255	63855	30098	12659	15653	9007	154417
1972	10897	4991	21641	4759	6084	34193	14530	6316	12977	116388
1973	2702	38650	11900	15588	2462	3734	18131	6471	8040	107678
1974	691	12776	105063	12927	18064	2718	3762	17135	17551	190687
1975	633	2766	34180	153997	9239	11389	1704	1608	12881	228397
1976	571	1974	4679	36512	113201	4639	6525	1067	9887	179055
1977	1183	2146	4060	5684	26578	59518	2016	2846	3114	107145
1978	2202	3449	2730	4296	5626	19038	41855	1307	3611	84114
1979	2191	9464	8480	3051	4805	3491	14848	24746	3877	74953
1980	479	9630	19996	9664	2182	4628	2167	9798	18019	76563
1981	644	2475	35725	27868	6991	1666	2459	1050	14833	93711
1982	783	2168	7904	44123	19262	4458	994	1447	12197	93336
1983	265	2145	4453	8538	24005	10482	2168	410	3807	56273
1984	199	961	4985	6013	7564	21758	6390	1258	1282	50410
1985	3076	936	2717	6171	6238	6802	16139	5520	3020	50619
1986	3300	14257	2602	3385	4654	3478	3983	8752	7659	52070
1987	831	11408	35006	3387	2939	2451	2248	1793	6610	66673
1988	540	4148	28963	28544	2993	1538	1055	1287	6059	75127
1989	400	2309	15434	45916	14738	2460	966	700	4566	87489
1990	687	2024	8000	28548	41402	10105	1985	861	1787	95399
1991	1684	3011	5956	16427	37462	37677	8069	1470	1301	113057
1992	2237	8956	9197	11313	20317	37488	32591	6830	1311	130240
1993	3362	11409	24887	12459	10044	16424	29978	21909	4496	134968
1994	1250	18748	35489	33816	9321	7083	11872	23255	19282	160116
1995	442	6132	64319	48833	23792	5573	4522	7077	15345	176035
1996	594	2464	22309	113796	45165	13011	3668	3208	17309	221524
1997	833	1692	7288	40164	106201	25621	5404	1753	6177	195133
1998	692	3634	7143	14670	36537	60459	14364	3075	5064	145638
1999	3439	3805	12974	14027	14891	24909	25782	8149	6945	114921
2000	748	16515	11801	18438	13147	11217	14713	11015	3506	101100
2001	3159	3920	47742	20346	21543	12055	8951	11386	13820	142922
2002	1903	17022	15148	64298	20508	18047	9840	5821	14290	166877
2003	1276	9008	51817	26144	50554	17005	14412	8253	12522	190991
2004	1630	5335	29646	74523	23906	26819	13243	8166	6340	189608
2005	2723	6494	17165	55669	63212	20054	15369	11192	18645	210523
2006	1420	12139	20727	33789	47857	33177	15711	6437	3975	175232
2007	4319	6905	42245	36753	37008	33635	16222	12092	22190	211369
2008	6321	22116	20674	62279	35566	25839	18918	9410	6054	207177
2009	5854	25648	58487	40935	47586	25564	17282	11690	15029	248075
2010	1399	25438	85652	112744	45538	29206	18299	12711	18515	349502
2011	707	6505	75216	144407	104783	38639	17437	14751	42392	444837

Table 4.18. Northeast Arctic haddock. Summary.

YEAR	RECR_A3	TOTBIO	TOTSPB	LAND	Y/SSB	SOP	FBAR 4-7
1950	83777	242375	132405	132125	0.9979	1.5893	0.8325
1951	685114	359453	99224	120077	1.2102	1.2279	0.633
1952	75457	237927	56525	127660	2.2585	1.7412	0.742
1953	1296180	521194	84705	123920	1.463	1.428	0.522
1954	154657	544841	117926	156788	1.3295	1.4736	0.3872
1955	65108	489381	179834	202286	1.1248	1.5361	0.52
1956	211035	474114	243114	213924	0.8799	1.2624	0.4658
1957	66005	320563	181643	123583	0.6804	1.2453	0.4532
1958	86262	268654	149938	112672	0.7515	1.125	0.5518
1959	405538	354837	122328	88211	0.7211	0.9411	0.4105
1960	296038	395095	105210	154651	1.4699	1.0418	0.506
1961	133694	386466	121379	193224	1.5919	0.9958	0.679
1962	293925	341717	111232	187408	1.6848	1.0523	0.84
1963	341919	304325	74756	146224	1.956	1.1456	0.8968
1964	399059	296663	58530	99158	1.6941	1.3575	0.672
1965	126871	353554	91108	118578	1.3015	1.1502	0.5122
1966	296726	382348	122326	161778	1.3225	1.1623	0.6272
1967	369466	461522	146241	136397	0.9327	0.9986	0.4368
1968	22556	413258	159667	181726	1.1382	0.9977	0.5242
1969	22059	330501	171606	130820	0.7623	0.8821	0.406
1970	204309	274305	143577	88257	0.6147	0.9766	0.3718
1971	119042	329980	154417	78905	0.511	0.765	0.2518
1972	1241920	607785	116388	266153	2.2868	1.0893	0.7298
1973	329506	585943	107678	322226	2.9925	1.1658	0.5778
1974	64722	573578	190687	221157	1.1598	0.8949	0.5022
1975	59386	447566	228397	175758	0.7695	0.896	0.5242
1976	66851	270914	179055	137264	0.7666	1.1196	0.684
1977	134855	189773	107145	110158	1.0281	1.0899	0.8245
1978	212456	205759	84114	95422	1.1344	0.9222	0.6662
1979	176240	260315	74953	103623	1.3825	0.7687	0.6835
1980	30836	279770	76563	87889	1.1479	0.7605	0.4878
1981	13702	232261	93711	77153	0.8233	0.7189	0.4742
1982	16901	172898	93336	46955	0.5031	0.722	0.3505
1983	9294	86639	56273	24600	0.4372	1.0487	0.3025
1984	12187	68263	50410	20945	0.4155	1.0536	0.2795
1985	293453	172201	50619	45052	0.89	0.9763	0.3398
1986	531442	334884	52070	100563	1.9313	1.0517	0.4908
1987	118589	329875	66673	154916	2.3235	0.9923	0.6392
1988	56167	261216	75127	95255	1.2679	0.9955	0.5092
1989	27448	212580	87489	58518	0.6689	0.9775	0.3748
1990	36742	173817	95399	27182	0.2849	1.0159	0.153
1991	105998	199861	113057	36216	0.3203	1.0374	0.1975
1992	214813	277416	130240	59922	0.4601	0.9797	0.2795
1993	671488	453317	134968	82379	0.6104	1.0031	0.3562
1994	299849	563452	160116	135186	0.8443	1.0056	0.4322
1995	100466	551744	176035	142448	0.8092	1.0247	0.374
1996	107553	492953	221524	178128	0.8041	1.0171	0.4045
1997	117151	362177	195133	154359	0.791	1.052	0.479
1998	64811	264072	145638	100630	0.691	1.0114	0.4002
1999	228449	268771	114921	83195	0.7239	1.0213	0.391
2000	95397	259591	101100	68944	0.6819	1.0265	0.2598
2001	373317	368054	142922	89640	0.6272	0.9903	0.26
2002	351091	454810	166877	114798	0.6879	1.0111	0.2972
2003	231920	498084	190991	138926	0.7274	1.0189	0.4288
2004	239247	481416	189608	158279	0.8348	1.0194	0.3562
2005	359434	515872	210523	158298	0.7519	1.0034	0.4682
2006	183233	458270	175232	153157	0.874	0.9938	0.376
2007	743256	630749	211369	161525	0.7642	0.9912	0.3828
2008	1300846	919540	207177	155604	0.7511	0.9928	0.3378
2009	1187060	1208972	248075	200061	0.8065	1	0.31
2010	329645	1210131	349502	249200	0.713	0.9992	0.264
2011	151339	1050947	444837	309874	0.6966	0.9979	0.3942
Units	Thousands	Tonnes	Tonnes	Tonnes			

Table 4.19. Northeast Arctic haddock. Prediction with management option table: Input data

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	317000	0.535	0.030	0	0	0.274	0.046	0.677
4	75204	0.490	0.068	0	0	0.495	0.186	0.921
5	96562	0.443	0.208	0	0	0.832	0.368	1.139
6	193839	0.323	0.497	0	0	1.245	0.494	1.452
7	98210	0.200	0.746	0	0	1.605	0.529	1.687
8	40108	0.200	0.909	0	0	1.989	0.474	2.084
9	11699	0.200	0.967	0	0	2.334	0.417	2.346
10	4134	0.200	0.994	0	0	2.613	0.458	2.505
11	3445	0.200	1.000	0	0	3.073	0.458	2.881

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	146000	0.535	0.029	0	0	0.265	0.046	0.677
4	.	0.490	0.103	0	0	0.504	0.186	0.921
5	.	0.443	0.212	0	0	0.779	0.368	1.139
6	.	0.323	0.476	0	0	1.178	0.494	1.452
7	.	0.200	0.770	0	0	1.635	0.529	1.687
8	.	0.200	0.907	0	0	2.001	0.474	2.084
9	.	0.200	0.972	0	0	2.385	0.417	2.346
10	.	0.200	0.992	0	0	2.717	0.458	2.505
11	.	0.200	1.000	0	0	2.980	0.458	2.881

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	483000	0.535	0.034	0	0	0.222	0.046	0.677
4	.	0.490	0.095	0	0	0.489	0.186	0.921
5	.	0.443	0.300	0	0	0.791	0.368	1.139
6	.	0.323	0.487	0	0	1.106	0.494	1.452
7	.	0.200	0.746	0	0	1.553	0.529	1.687
8	.	0.200	0.914	0	0	2.039	0.474	2.084
9	.	0.200	0.968	0	0	2.399	0.417	2.346
10	.	0.200	0.991	0	0	2.775	0.458	2.505
11	.	0.200	1.000	0	0	3.088	0.458	2.881

Table 4.20. Northeast Arctic haddock. Prediction with management option table for 2012-2014

Biomass 2012	SSB 2012	FMult	FBar		Corresponding	landings 2012
732671	379646	1	0.3942			246043

2013					2014	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
521647	310654	0	0	0	619506	375476
.	310654	0.1	0.0394	20370	599683	358826
.	310654	0.2	0.0788	39898	580746	342955
.	310654	0.3	0.1183	58622	562654	327825
.	310654	0.4	0.1577	76580	545367	313401
.	310654	0.5	0.1971	93805	528847	299649
.	310654	0.6	0.2365	110330	513058	286538
.	310654	0.7	0.276	126187	497968	274037
.	310654	0.8	0.3154	141406	483542	262116
.	310654	0.9	0.3548	156015	469750	250749
.	310654	1	0.3942	170042	456563	239909
.	310654	1.1	0.4336	183512	443953	229571
.	310654	1.2	0.4731	196451	431892	219712
.	310654	1.3	0.5125	208882	420355	210308
.	310654	1.4	0.5519	220827	409319	201338
.	310654	1.5	0.5913	232308	398759	192782
.	310654	1.6	0.6308	243345	388655	184619
.	310654	1.7	0.6702	253958	378984	176833
.	310654	1.8	0.7096	264166	369728	169403
.	310654	1.9	0.749	273986	360867	162315

Table 4.21. Northeast Arctic haddock. Prediction single option table for 2012-2014 based on Fmsy

Year:	2012	F multiplier:	1	Fbar:	0.3942		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0458	11117	7526	320000	87680	9600	2630
4	0.1858	10157	9355	75204	37226	5114	2531
5	0.3678	24332	27715	96562	80340	20085	16711
6	0.4943	65460	95048	193839	241330	96338	119941
7	0.529	36888	62230	98210	157627	73265	117590
8	0.474	13831	28823	40108	79775	36458	72515
9	0.4169	3640	8539	11699	27305	11313	26404
10	0.4581	1388	3476	4134	10802	4109	10737
11	0.4581	1156	3331	3445	10586	3445	10586
Total		167969	246043	843201	732671	259727	379646

Year:	2013	F multiplier:	0.8878	Fbar:	0.35		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0407	4513	3055	146000	38690	4234	1122
4	0.1649	21665	19954	179024	90228	18439	9294
5	0.3265	8714	9925	38260	29805	8111	6319
6	0.4388	13182	19141	42922	50562	20431	24068
7	0.4696	29304	49435	85604	139962	65915	107771
8	0.4208	14852	30951	47376	94799	42970	85982
9	0.3701	5767	13528	20442	48753	19869	47388
10	0.4067	1925	4822	6313	17152	6262	17015
11	0.4067	1197	3447	3925	11696	3925	11696
Total		101118	154259	569865	521647	190156	310654

Year:	2014	F multiplier:	0.8878	Fbar:	0.35		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0407	14931	10108	483000	107226	16422	3646
4	0.1649	9936	9151	82101	40147	7800	3814
5	0.3265	21181	24125	92998	73561	27899	22068
6	0.4388	5443	7904	17723	19602	8631	9546
7	0.4696	6859	11571	20037	31117	14947	23213
8	0.4208	13737	28628	43821	89350	40052	81666
9	0.3701	7184	16853	25465	61091	24650	59136
10	0.4067	3524	8828	11559	32076	11455	31788
11	0.4067	1702	4903	5581	17234	5581	17234
Total		84497	122071	782284	471405	157438	252111

Table 4.22. Northeast Arctic haddock. Prediction single option table for 2012-2014 based on Fpa

Year:	2012	F multiplier:	1	Fbar:	0.3942		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0458	11117	7526	320000	87680	9600	2630
4	0.1858	10157	9355	75204	37226	5114	2531
5	0.3678	24332	27715	96562	80340	20085	16711
6	0.4943	65460	95048	193839	241330	96338	119941
7	0.529	36888	62230	98210	157627	73265	117590
8	0.474	13831	28823	40108	79775	36458	72515
9	0.4169	3640	8539	11699	27305	11313	26404
10	0.4581	1388	3476	4134	10802	4109	10737
11	0.4581	1156	3331	3445	10586	3445	10586
Total		167969	246043	843201	732671	259727	379646

Year:	2013	F multiplier:	1.1921	Fbar:	0.47		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0546	6023	4077	146000	38690	4234	1122
4	0.2215	28373	26132	179024	90228	18439	9294
5	0.4385	11149	12699	38260	29805	8111	6319
6	0.5893	16590	24089	42922	50562	20431	24068
7	0.6306	36671	61863	85604	139962	65915	107771
8	0.5651	18710	38991	47376	94799	42970	85982
9	0.497	7316	17164	20442	48753	19869	47388
10	0.5461	2430	6086	6313	17152	6262	17015
11	0.5461	1510	4352	3925	11696	3925	11696
Total		128772	195452	569865	521647	190156	310654

Year:	2014	F multiplier:	1.1921	Fbar:	0.47		
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0546	19924	13489	483000	107226	16422	3646
4	0.2215	12832	11818	80964	39591	7692	3761
5	0.4385	25610	29170	87884	69517	26365	20855
6	0.5893	6125	8893	15846	17526	7717	8535
7	0.6306	7384	12457	17238	26770	12859	19971
8	0.5651	14732	30701	37304	76062	34095	69521
9	0.497	7890	18509	22044	52883	21338	51191
10	0.5461	3918	9816	10182	28254	10090	27999
11	0.5461	1868	5383	4855	14991	4855	14991
Total		100284	140236	759316	432821	141434	220470

Table 4.23. Northeast Arctic haddock. Prediction using HCR catch constraint for 2013-2014

Year: 2012 F multiplier: 1 Fbar: 0.3942

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0458	11117	7526	320000	87680	9600	2630
4	0.1858	10157	9355	75204	37226	5114	2531
5	0.3678	24332	27715	96562	80340	20085	16711
6	0.4943	65460	95048	193839	241330	96338	119941
7	0.529	36888	62230	98210	157627	73265	117590
8	0.474	13831	28823	40108	79775	36458	72515
9	0.4169	3640	8539	11699	27305	11313	26404
10	0.4581	1388	3476	4134	10802	4109	10737
11	0.4581	1156	3331	3445	10586	3445	10586
Total		167969	246043	843201	732671	259727	379646

Catch corresponding HCR, Changing TAC from 2012 (318000) =-25%

Year: 2013 F multiplier: 1.5542 Fbar: 0.6127

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0712	7793	5276	146000	38690	4234	1122
4	0.2888	35914	33077	179024	90228	18439	9294
5	0.5716	13740	15650	38260	29805	8111	6319
6	0.7682	20070	29142	42922	50562	20431	24068
7	0.8221	44079	74361	85604	139962	65915	107771
8	0.7367	22657	47216	47376	94799	42970	85982
9	0.6479	8930	20950	20442	48753	19869	47388
10	0.712	2949	7386	6313	17152	6262	17015
11	0.712	1833	5281	3925	11696	3925	11696
Total		157965	238339	569865	521647	190156	310654

Catch constraint 238500*0.75=178800 Changing TAC from 2013 (238500) = -25%

Year: 2014 F multiplier: 1.918 Fbar: 0.7561

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.0878	31580	21380	483000	107226	16422	3646
4	0.3564	19146	17634	79633	38940	7565	3699
5	0.7054	34466	39257	82167	64994	24650	19498
6	0.9481	7444	10808	13871	15341	6755	7471
7	1.0146	8466	14283	14414	22384	10752	16699
8	0.9091	16920	35261	30802	62805	28153	57404
9	0.7996	9387	22021	18568	44545	17974	43119
10	0.8786	4707	11790	8755	24296	8676	24077
11	0.8786	2211	6370	4113	12700	4113	12700
Total		134326	178803	735323	393232	125061	188314

Table 4.24. Northeast Arctic haddock.Yield per recruit. Input data and results.

MFYPR	version	2a					
Run:	2012						
Time	and	date:	16:22		24.04.2011		
Age	M	Mat	PF	PM	SWt	Sel	CWt
3	0.535	0.03	0	0	0.274	0.0458	0.677
4	0.49	0.068	0	0	0.495	0.1858	0.921
5	0.443	0.208	0	0	0.832	0.3678	1.139
6	0.323	0.497	0	0	1.245	0.4943	1.452
7	0.2	0.746	0	0	1.605	0.529	1.687
8	0.2	0.909	0	0	1.989	0.474	2.084
9	0.2	0.967	0	0	2.334	0.4169	2.346
10	0.2	0.994	0	0	2.613	0.4581	2.505
11	0.2	1	0	0	3.073	0.4581	2.881

Yield per results							
MFYPR	version	2a					
Run:	2012						
Time	and	date:	16:22		24.04.2012		
Yield	per	results					
FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan
0	0	0	0	3.095	3.4592	1.1201	2.4398
0.1	0.0394	0.0597	0.1018	2.8335	2.778	0.8814	1.7863
0.2	0.0788	0.103	0.1651	2.6524	2.3309	0.7216	1.3647
0.3	0.1183	0.1365	0.207	2.5189	2.0192	0.6082	1.0764
0.4	0.1577	0.1637	0.2365	2.4159	1.7919	0.5242	0.8707
0.5	0.1971	0.1864	0.2581	2.3338	1.6203	0.4598	0.7192
0.6	0.2365	0.2059	0.2747	2.2663	1.487	0.4092	0.6046
0.7	0.276	0.2229	0.2879	2.2097	1.381	0.3687	0.5159
0.8	0.3154	0.2382	0.2986	2.1614	1.295	0.3355	0.4461
0.9	0.3548	0.2519	0.3077	2.1194	1.224	0.308	0.3903
1	0.3942	0.2645	0.3156	2.0825	1.1644	0.2849	0.3449
1.1	0.4336	0.276	0.3225	2.0497	1.1138	0.2653	0.3077
1.2	0.4731	0.2867	0.3286	2.0202	1.0701	0.2484	0.2767
1.3	0.5125	0.2967	0.3342	1.9935	1.0322	0.2338	0.2507
1.4	0.5519	0.306	0.3394	1.9691	0.9989	0.221	0.2286
1.5	0.5913	0.3148	0.3441	1.9467	0.9693	0.2097	0.2098
1.6	0.6308	0.3232	0.3486	1.9261	0.9429	0.1998	0.1935
1.7	0.6702	0.3311	0.3527	1.9068	0.9191	0.1909	0.1794
1.8	0.7096	0.3386	0.3567	1.8889	0.8975	0.1829	0.167
1.9	0.749	0.3458	0.3604	1.8721	0.8779	0.1757	0.1562
2	0.7885	0.3526	0.3639	1.8563	0.8599	0.1691	0.1466

Reference	point	F multiplier		Absolute F
Fbar(4-7)	1	0.3942		
FMax		>=1000000		
F0.1	0.6499	0.2562		
F35%SPR	0.4097	0.1615		

Weights	in	kilograms

Table B1 Northeast Arctic haddock. Results from the Joint Barents Sea bottom trawl survey (BS-NoRu-Q1 (BTr)) in the Barents Sea in January-March. Indices of numbers of fish at age. Indices for 1983-1998 revised August 1999.

	Age											Area covered
Year	1	2	3	4	5	6	7	8	9	10+	Total	(1000 nm²)
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	169.1
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	3353	170.9
2010	1619.5	111.2	102.8	508.6	479.6	131.2	7	1	0.6	0.6	2962	159.9
2011	685.4	343.5	64.9	95.1	468.3	338.1	62.1	1.6	0.4	0.2	2060	173.1
2012[1]	1921.5	108.4	315.3	46.1	83.2	289.6	145.7	21.9	2.4	0.4	2934	150.5

[1]Indices adjusted to account for limited area coverage.

Survey areas extended from 1993 onwards.

Table B2 Northeast Arctic haddock. Results from the Russian trawl survey (RU-BTr-Q4) in the Barents Sea and adjacent waters in late autumn (numbers per hour trawling).

Year \ Age	0	1	2	3	4	5	6	7	8	9	10+	Total
						Sub-area I						
1983	39.9	97.3	16.5	0.8	0.7	+	-	-	-	-	1.1	156.3
1984	9.7	100.2	110.6	2.8	0.4	0.2	+	-	-	-	0.7	224.6
1985	3.9	19.1	213.4	168.8	0.8	0.2	0.1	-	-	-	0.3	406.6
1986	0.2	2.3	16.6	58.1	27.6	0.1	+	+	+	-	-	105
1987	0.4	1.4	2.5	12.5	34.2	8.6	+	+	-	+	-	59.8
1988	1.9	0.4	1.1	2.8	6.2	11.6	1.1	+	+	+	-	25.2
1989	3.3	3	3.6	0.7	2.5	7.1	13.9	1.8	0.1	+	-	36
1990	71.7	22.2	18.6	13.2	7.5	13.2	13.3	10.3	0.6	0.1	-	170.7
1991	15.9	61.5	27.5	10.8	1.6	0.6	1	3.3	2.6	0.3	-	125.1
1992	19.6	44.2	180.6	52.1	8.4	0.7	1	1.6	1.3	0.2	-	309.7
1993	5.5	8.1	69.2	371.5	78.4	10.2	1.4	0.7	0.8	1.8	-	547.7
1994	13.5	6.7	8	65.9	146	15.9	1.7	0.1	0.2	0.7	-	258.8
1995	9.9	12.7	6.5	4	26.8	77.6	7.3	1	0.1	0.5	-	146.3
1996	5	3.1	5.6	3.4	7.7	62.3	56.5	4.8	0.4	0.6	-	149.3
1997[1]	2.7	6.9	3.2	5.3	5.5	1.5	4.5	1.7	1.5	-	-	32.7
1998	10.5	2.9	17.2	6.7	7.8	0.6	0.9	2.1	0.7	+	-	49.4
1999	6.9	34.9	8.8	34	5.3	5.6	1.2	0.3	0.9	0.3	-	98.2
2000	18	25.4	37.5	9.3	13	3.2	1.1	0.2	0.1	0.4	-	108.3
2001	30.5	18.6	42.3	58.9	5.8	6.8	0.8	0.5	0.1	0.1	-	164.5
2002	39.7	29.2	29.4	69.2	74.7	6.7	3.2	0.6	0.1	0.2	-	252.7
2003	28.1	38.9	35.4	28.1	43	28	3.5	0.8	0.1	0.1	-	206
2004	47.9	12	27.9	18.6	12.8	16.1	12.4	0.8	0.3	0.1	-	148.9
2005	62.7	109.6	20.7	34.4	12.4	6.5	7.1	2.5	0.1	0.1	-	256.1
2006[3]	48	168.7	157.9	15.2	25.5	7.3	3.1	2.7	0.8	0.2	-	429.4
2007	4.3	90.2	153.6	98.7	9.1	9	2.3	0.7	0.4	0.1	-	368.5
2008	5.9	14.6	284.4	283.4	153	17.2	11.8	1.5	0.3	0.3	-	772.5
2009	14.7	3.2	25.2	243.8	264.8	102.5	8.8	4.3	0.6	0.4	-	668.4
2010	6.6	25.6	4.7	46.2	223.3	204.5	60.0	2.4	1.2	0.3	-	574.8
2011	16.7	4.8	32.1	6.6	37.9	127.1	96.9	20.9	1.2	0.4	-	344.6
						Division IIa						
1983	5.4	5.5	0.1	0.2	0.3	0.1	-	-	-	-	1	12.6
1984	4.9	14.4	5.6	0.1	0.1	0.1	-	-	-	-	0.2	25.4
1985	3.8	7	11.7	4.1	0.1	-	+	-	-	-	0.1	26.8
1986	0.4	0.3	3.5	10.4	2.9	0.1	+	+	-	-	-	17.6
1987	-	-	-	-	0.3	0.3	-	-	-	-	-	0.6
1988	1	0.1	-	+	0.2	0.5	0.2	-	-	-	-	2.1
1989	0.1	0.7	2.7	+	0.1	0.1	0.1	-	-	-	-	3.8
1990	6.1	0.9	0.9	0.1	0.1	0.1	0.1	0.1	-	-	-	8.4
1991	5.7	3.8	0.6	0.1	+	-	-	-	-	-	-	10.2
1992	1.2	2.3	5.6	2.3	3	0.3	0.3	0.4	0.4	-	-	15.8
1993	1.8	1.1	1.5	4.5	2.5	0.8	0.2	0.1	0.2	0.2	-	12.8
1994	1	0.6	0.5	3.1	15.9	4.4	1.5	+	0.1	0.1	-	27.2
1995	5	8.5	6.3	5.3	6.2	23.9	4.1	0.6	+	0.2	-	60.1
1996	29.2	4.1	25	8.1	4.9	9.1	13.4	1.3	0.4	0.1	-	95.7
1997	1.2	2.8	0.8	1.3	0.7	0.6	0.9	0.5	0.1	-	-	8.9
1998	23.2	7.8	15.5	1.1	2.4	3.2	0.5	2.8	0.8	0.1	-	57.3
1999	34.8	34.1	4.3	16.9	3.9	6.3	1.7	0.9	1.2	0.5	-	104.6
2000	27.9	23.9	13.5	1.8	9.3	2	0.9	0.2	0.2	0.4	-	80.1
2001	39	13.5	7.6	8.4	2.2	7.9	1.4	0.3	0.1	0.4	-	80.8
2002[2]	61.9	16.6	5.3	10.2	29.9	6	3.3	0.3	0.1	0.2	-	133.7
2003	20.6	30.8	9.8	8.3	10.4	16.1	2.4	2.1	0.2	+	-	100.7
2004	100.2	32.8	18.1	4.5	5.5	7.2	8.1	0.7	1.1	0.3	-	178.4
2005	61.6	23.9	4.6	10.9	2.1	2.7	5.3	2.9	0.5	0.2	-	114.6
2006	33.3	36.9	15.2	1.9	8.2	3.4	2.5	1.8	1.8	0.3	-	105.5
2007	28.2	96	33.9	14.1	2.1	5.1	2.2	0.6	0.9	0.4	-	183.4
2008	13.6	23.8	64.3	26.8	9.6	1.8	2.6	0.4	0.3	0.3	-	143.6
2009	8.6	5.7	7.6	34.5	23.2	9.2	1.2	1.7	0.2	0.1	-	91.9
2010	19.9	31.2	9.6	7.4	29.3	22.3	10.8	1.0	1.1	0.2	-	132.8
2011	13.6	2.2	8.2	1.8	1.7	20.0	16.4	4.3	0.2	0.4	-	68.8

Table B2 (continued)

Year \ Age	0	1	2	3	4	5	6	7	8	9	10+	Total
Division IIb												
1983	22.1	9.9	0.2	0.1	+	+	-	-	-	-	0.1	32.4
1984	2.2	14.3	1.8	-	-	-	-	-	-	-	+	18.3
1985	1.4	10.2	61.4	5.1	+	+	+	-	-	-	+	78.1
1986	+	0.2	3.1	7.2	1.4	-	+	-	-	-	-	12
1987	-	-	0.1	0.7	1.4	0.5	+	-	-	-	-	2.8
1988	0.2	-	-	+	0.3	1.1	0.2	-	+	-	-	1.8
1989	0.7	0.1	0.2	+	0.1	0.3	0.6	0.1	+	-	-	2.1
1990	12.9	5.4	0.8	+	+	0.2	0.1	0.1	+	-	-	19.5
1991	20	22.9	6.2	0.4	0.1	0.1	0.1	+	+	-	-	49.8
1992	13.3	9.1	69.8	13.9	0.5	+	+	-	+	+	-	106.6
1993	0.7	0.9	1.9	24.7	1.9	0.2	+	+	+	+	-	30.4
1994	0.4	1.7	1.7	2.3	15.7	2.7	0.8	0.2	+	+	-	25.5
1995	0.1	0.4	0.4	0.8	0.6	1.6	0.4	+	+	+	-	4.3
1996[1]	4.3	0.6	0.5	0.3	0.2	0.4	0.5	0.3	-	-	-	7.1
1997[1]	0.4	1.1	0.1	0.1	0.1	0.1	0.1	0.1	+	+	-	2.1
1998	5.8	1.1	0.2	+	0.1	0.1	+	0.1	+	-	-	7.5
1999	8.6	20.1	1.8	1.2	0.5	0.3	0.1	-	0.2	0.1	-	32.9
2000	7.9	10	13.4	1.3	5.5	2.2	1.2	0.4	0.2	0.3	-	42.4
2001	2.7	13.1	15.9	11.4	0.8	4.7	1.2	0.4	0.1	0.6	-	51
2002[2]	9	4.2	7.7	5.1	2.6	0.7	0.8	0.1	0.1	0.1	-	30.4
2003	3.6	21.5	10.4	15.5	11.3	15.9	3.6	3	0.4	0.3	-	85.7
2004	34.9	5.6	6.4	1.3	2.6	1.8	2.9	0.1	0.2	0.1	-	56
2005	60.9	43.5	4.1	10.3	4.1	2.7	3.6	2.2	0.1	0.3	-	131.7
2006[3]	75.4	110.6	71.6	4.6	6.1	2.4	1.4	2	1.8	0.3	-	276.2
2007	3.3	67.3	396.4	78.7	5.5	26	7.3	2.9	2.6	0.8	-	590.9
2008	1.5	3.8	204.1	304.3	50.7	7.4	13.6	2.9	2	0.7	-	591.9
2009	2.6	1.1	3.5	93.6	81	22	2.4	2.1	0.3	0.5	-	209
2010	4.3	4.5	1.3	11.1	136.5	138.4	38.6	6.3	1.7	0.6	-	343.2
2011	10.8	1.2	4.3	1.7	12.0	100.8	60.5	11.5	0.5	0.3	-	203.7
Total-Sub-area I and Divisions IIa and IIb												
1983	29.8	59.2	9.5	0.5	0.4	+	-	-	-	-	0.8	100.2
1984	6.4	58.6	58.4	1.5	0.2	0.1	+	-	-	-	0.3	125.5
1985	3	14.4	134.3	90	0.4	0.1	0.1	-	-	-	0.2	242.7
1986	0.2	1.4	10.7	36.3	16.4	0.1	+	+	+	-	+	65.1
1987	0.3	0.9	1.7	8.3	22.5	5.7	+	+	-	+	-	39.4
1988	1.3	0.3	0.7	1.7	4	7.6	0.8	+	+	+	-	16.4
1989	2.2	1.8	2.4	0.4	1.4	4.1	8.1	1.1	0.1	+	-	21.6
1990	44.8	14.3	10.6	7.3	4.2	7.3	7.4	5.7	0.3	0.1	-	102
1991	16.7	42.9	17.6	6.2	0.9	0.3	0.6	1.8	1.5	0.2	-	88.7
1992	16.4	28.2	128.6	34.6	5	0.4	0.6	0.9	0.8	0.1	-	215.6
1993	3.5	4.8	35.7	198.5	35.6	4.8	0.8	0.4	0.4	-	-	284.5
1994	9.1	4.9	5.8	44.2	101.4	11.6	1.5	0.1	0.1	0.5	-	179.2
1995	6.4	7.2	4.2	3.1	12.3	37	4	0.5	0.1	0.3	-	75.1
1996[1]	6	2.3	5.7	2.8	4.9	36.2	33.4	2.9	0.3	0.3	-	94.8
1997[1]	1.8	4.6	1.9	3.2	3.2	1	2.7	1	0.8	-	-	20.2
1998	10.7	2.9	11.5	3.8	4.6	0.8	0.5	1.5	0.5	+	-	36.8
1999	11.7	28.9	6.1	19.6	3.9	3.7	0.8	0.3	0.7	0.7	-	76.4
2000	15.1	20.7	26.2	6	10.9	2.6	1.1	0.2	0.1	0.4	-	83.3
2001	20.8	14.9	26.1	33.4	4	6.5	1.1	0.4	0.1	0.3	-	107.5
2002[2]	33.2	19.3	18.9	39.9	45	4.7	2.4	0.4	0.1	0.2	-	164
2003	19.8	32.8	25.1	22.1	29.9	23.1	3.4	1.6	0.2	0.1	-	158.3
2004	50	11	20.6	11.3	9.4	10.7	8.7	0.5	0.4	0.2	-	122.8
2005	62	79.2	13.6	24	8.6	4.8	5.7	2.4	0.1	0.2	-	200.7
2006[3]	53.4	79.2	122.7	11.3	11.9	5.7	2.6	2.4	1.1	0.2	-	290.5
2007	6.5	83.9	214.2	83.8	7.3	13.7	3.8	1.4	1.1	0.4	-	416
2008	5.7	12.7	232.7	255.7	105.1	12.4	11.1	1.7	0.7	0.4	-	638.7
2009	10	2.9	15.8	164.7	170.4	63.1	5.7	3.2	0.5	0.4	-	436.7
2010	7.7	19.7	4.3	29.9	169.7	158.9	46.6	3.4	1.4	0.3	-	441.9
2011	14.7	3.5	21.7	4.7	26.8	108.7	78.3	16.5	0.9	0.4	-	276.3

[1]Adjusted data based on average 1985-1995 distribution. [2]Adjusted based on 2001 distribution.

[3]Adjusted based on 2004-2006 distribution. + means value <0.1; - means 0 value

Table B3 Northeast Arctic HADDOCK. Results from the Joint Barents Sea acoustic survey (BS-NoRu-Q1 (Aco)) **in the Barents Sea in January-March. Stock numbers in millions. New TS and rock-hopper gear (1981-1988 back-calculated from bobbins gear). Corrected for length dependent effective spread of the trawl.**

	Age											Area covered
Year	1	2	3	4	5	6	7	8	9	10	Total	(1000 nm²)
1981	7	14	5	21	60	18	1	0	0	0	126	88.1
1982	9	2	3	4	4	10	6	0	0	0	38	88.1
1983	0	5	2	3	1	1	4	2	0	0	18	88.1
1984	1685	173	6	2	1	0	0	0	0	0	1867	88.1
1985	1530	776	215	5	0	0	0	0	0	0	2526	88.1
1986	556	266	452	189	0	0	0	0	0	0	1463	88.1
1987	85	17	49	171	50	0	0	0	0	0	372	88.1
1988	18	4	8	23	46	7	0	0	0	0	106	88.1
1989	52	5	6	11	20	21	2	0	0	0	117	88.1
1990	270	35	3	3	4	7	11	2	0	0	335	88.1
1991	1890	252	45	8	3	3	3	6	0	0	2210	88.1
1992	1135	868	134	23	2	0	0	1	2	0	2165	88.1
1993	947	626	563	130	13	0	0	0	0	3	2282	137.6
1994	562	193	255	631	111	12	0	0	0	0	1764	143.8
1995	1379	285	36	111	387	42	2	0	0	0	2242	186.6
1996	249	229	44	31	76	151	8	0	0	0	788	165.3
1997[1]	693	24	51	17	12	43	43	2	0	0	885	87.5
1998[1]	220	122	20	28	12	5	13	16	1	0	437	99.2
1999	856	46	57	13	14	4	1	2	2	0	994	118.3
2000	1024	509	32	65	19	11	2	1	2	0	1664	162.4
2001	976	316	210	23	22	1	1	0	0	1	1549	164.1
2002	2062	282	216	149	14	12	1	0	0	1	2737	156.7
2003	2394	279	145	198	169	17	5	0	0	1	3208	146.6
2004	752	474	127	76	76	66	7	2	0	0	1580	164.6
2005	3364	209	219	102	36	40	9	0	0	0	3979	178.9
2006	2767	804	54	86	30	12	9	2	0	0	3764	1691
2007[1]	3197	868	379	54	88	22	6	5	2	0	4621	122.2
2008	1266.6	1835	723	252	57	74	10	6	0	1	4226	164.4
2009	849	246.3	1021.7	773	402.1	31.3	14.9	1.6	0.13	0.53	3341	170.9
2010	2035.8	81.8	138	593	557.4	191.4	10.3	2.9	0.68	0.72	3612	159.9
2011	786.5	408.0	47.6	68.1	313.0	262.6	52.4	1.6	0.45	0.63	1941	173.1
2012[1]	2222.2	176.0	224.3	30.0	58.4	294.3	134.9	31.6	0.83	0.42	3173	150.5

[1]Indices adjusted to account for limited area coverage.

Survey areas extended from 1993 onwards.

Table B4. Northeast Arctic HADDOCK. Results from the Russian trawl-acoustic survey (RU-Aco-Q4) in the Barents Sea and adjacent waters in late autumn (new method). Index of number of fish at age (+ means value <1; - means 0 value).

	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+	Total
1995[5]	163	170	79	71	230	404	41	5	1	1	2	1168
1996[1,3]	992	245	291	91	63	206	187	17	1	+	+	2092
1997[1,3]	185	104	21	121	94	48	47	31	20	+	+	671
1998[2]	257	44	83	20	20	6	2	7	2	+	+	442
1999[1]	632	499	60	123	14	16	4	1	4	1	+	1355
2000[1]	524	395	287	54	57	14	6	1	1	1	1	1340
2001[1]	491	160	227	221	19	35	5	2	1	1	1	1163
2002[1,4,5]	1045	209	139	268	239	27	17	2	1	+	1	1947
2003	1168	473	217	116	134	94	14	6	1	+	+	2223
2004	8529	1141	342	116	54	55	44	3	4	1	1	10289
2005	17782	2903	123	205	62	33	38	16	1	1	+	21165
2006[6]	9396	1286	308	30	31	10	-	5	5	4	1	11075
2007	812	1473	2226	745	53	75	22	8	7	2	1	5423
2008	245	203	2134	1947	728	88	83	13	6	4	2	5455
2009	1650	204	243	1455	1258	485	46	30	4	2	1	5380
2010	1033	643	133	267	1032	923	274	19	9	1	1	4335
2011	1603	137	242	40	166	631	459	96	5	1	1	3383

[1]October-December
[2]September-October
[3]November-January
[4]Adjusted based on average 1985-1995 distribution
[5]Adjusted based on 2001 distribution
[6]Adjusted data in 2004
[7]Not adjusted data to the whole area

Table B5 Northeast Arctic HADDOCK. Results from the joint ecosystem survey (Eco-NoRu-Q3 (Btr)) in August-September in the Subareas I and II . Indices of numbers (in millions) of fish at age (+ means value <1; - means 0 value).

	Age											
Year	0	1	2	3	4	5	6	7	8	9	10+	Total
2004	104	189	268	123	70	69	31	3	2	-	+	861
2005	155	626	114	323	89	29	31	15	+	+	+	1383
2006	283	2270	929	107	125	42	19	17	7	1	+	3802
2007	114	988	1819	1283	88	94	19	6	7	2	1	4421
2008	60	322	1292	1155	406	43	36	5	3	2	+	3323
2009	169	136	144	651	618	306	21	7	1	1	-	2053
2010	154	274	65	184	865	666	148	16	3	-	+	2376
2011	213	105	114	40	74	393	301	37	3	+	+	1281

Table B6 Northeast Arctic HADDOCK. Length data (cm) from Joint Barents Sea surveys (BS-NoRu-Q1 (BTr)) in January-March and Russian surveys (RU-BTr-Q4) in November-December.

		Age									
Norway	Year	1	2	3	4	5	6	7			
	1983	16.8	25.2	34.9	44.7	52.5	58	62.4			
	1984	16.6	27.5	32.7	-	56.6	62.4	61.8			
	1985	15.7	23.9	35.6	41.9	58.5	61.9	63.9			
	1986	15.1	22.4	31.5	43	54.6	-	-			
	1987	15.4	22.4	29.2	37.3	46.5	-	-			
	1988	13.5	24	28.7	34.7	41.5	47.9	54.6			
	1989	16	23.2	31.1	36.5	41.7	46.4	52.9			
	1990	15.7	24.7	32.7	43.4	46.1	50.1	52.4			
	1991	16.8	24	35.7	44.4	52.4	54.8	55.6			
	1992	15.1	23.9	33.9	45.5	53.1	59.2	60.6			
	1993	14.5	21.4	31.8	42.4	50.6	56.1	59.4			
	1994	14.7	21	29.7	38.5	47.8	54.2	56.9			
	1995	15.4	20.1	28.7	34.2	42.8	51.2	55.8			
	1996	15.4	21.6	28.6	37.8	42	46.7	55.3			
	1997	16.1	21.2	27.7	35.4	39.7	47.5	50.1			
	1998	14.4	22.9	29.2	35.8	41.3	48.4	50.9			
	1999	14.7	20.8	32.3	39.4	45.5	52.3	54.6			
	2000	15.8	22.5	30.3	41.6	47.7	50.8	51.1			
	2001	14.5	22.2	32.2	37.8	47.2	51.2	58.7			
	2002	15.4	21.1	29.6	40.2	44.2	50.9	58.4			
	2003	16.5	24.1	28	37.2	46.5	49.6	54.7			
	2004	14.2	22.3	30.6	36.3	43.4	49.8	51.4			
	2005	15.1	20.8	30	36.6	41.5	47.9	51.9			
	2006	14.7	22.6	31.3	37.8	43.2	48	50.8			
	2007[1]	15.7	23.2	28.7	37.4	45.5	48.5	53.5			
	2008	15.9	23.8	30.1	38.1	39.7	48.6	53.4			
	2009	14.5	22.5	29.6	36	41.9	46.9	51.7			
	2010	14.7	20.2	30.4	37.1	41.2	45.9	50			
	2011	13.9	23.4	27.7	37.2	42.8	46.1	48.6			
	2012	15.8	21.1	31.3	34.2	43.7	47.5	50.4			

Russia	Year	0	1	2	3	4	5	6	7	8	9
	1982	14.5	21.3	33.4	37.0	-	-	-	-	-	-
	1983	18.1	26.2	30.9	44.9	53.3	62.0	65.5	67.6	68.0	73.1
	1984	-	24.0	35.8	42.7	53.7	63.1	68.1	68.1	71.0	75.2
	1985	-	21.1	31.7	43.4	53.6	62.2	64.2	-	73.1	74.1
	1986	18.1	21.0	28.7	37.0	46.6	58.8	63.1	68.1	-	73.1
	1987	-	21.7	27.6	33.3	40.9	49.4	-	-	-	-
	1988	-	19.9	29.9	35.1	40.4	46.6	52.0	-	-	-
	1989	-	20.5	25.1	40.2	45.0	48.5	52.2	58.8	63.5	-
	1990	-	20.5	29.8	37.3	48.7	50.8	54.7	58.8	63.3	68.1
	1991	-	23.2	31.7	40.3	52.7	56.7	58.8	60.3	63.2	69.1
	1992	-	22.0	32.2	41.6	52.6	59.7	61.9	65.7	68.3	70.3
	1993	18.1	20.8	28.0	38.6	48.8	55.0	61.2	64.1	63.2	65.0
	1994	15.5	20.8	28.9	36.2	44.6	53.6	60.0	66.2	67.7	67.0
	1995	14.9	21.8	28.6	36.6	42.0	48.3	56.6	62.5	66.1	66.8
	1996[1]	15.7	20.2	28.6	36.8	43.9	49.3	54.7	63.3	67.3	70.8
	1997[1]	13.7	23.3	29.5	36.6	44.6	50.0	54.7	58.7	69.1	68.1
	1998	14.4	19.3	33.1	39.2	45.9	47.9	53.5	56.1	62.0	74.1
	1999	13.5	22.6	28.0	41.9	46.6	49.2	53.1	56.3	59.8	63.5
	2000	14.2	22.3	31.7	37.0	48.6	52.5	54.8	60.8	62.0	60.5
	2001	14.8	21.9	30.7	40.3	45.1	53.0	57.3	60.7	62.2	62.5
	2002	14.7	23.5	29.4	38.2	46.4	50.8	56.2	56.0	64.6	66.9
	2003	13.8	22.7	29.4	37.5	43.9	50.5	55.2	61.1	63.3	63.5
	2004	14.3	22.5	30.0	37.9	43.6	48.4	53.7	58.4	63.5	69.1
	2005	14.9	23.5	30.0	36.9	44.8	49.9	54.7	59.2	65.9	66.6
	2006[1]	15.3	24.1	32.6	39.8	46.7	51.8	54.9	59.0	62.4	65.3
	2007	15.4	23.7	30.6	39.2	46.6	52.0	54.4	58.4	61.3	65.8
	2008	14.5	22.3	30.8	38.1	47.3	52.8	55.8	59.1	62.8	65.0
	2009	15.4	21.8	29.4	36.0	43.9	51.0	55.3	59.2	62.3	63.3
	2010	13.0	23.9	28.3	35.5	42.8	47.8	53.7	60.0	61.8	66.9
	2011	14.7	23.0	31.9	34.3	41.6	47.7	53.0	59.2	64.3	67.8

[1]Limited area coverage, lengths are not adjusted to account for limited area coverage.

Table B7 Northeast Arctic HADDOCK. Weight data (g) from Joint Barents Sea surveys (BS-NoRu-Q1 (BTr)) in January-March and Russian surveys (RU-BTr-Q4) in November-December.

Norway

Year /Age	1	2	3	4	5	6	7
1983	52	133	480	1043	1641	2081	2592
1984	36	196	289	964	1810	2506	2240
1985	35	138	432	731	1970	2517	-
1986	47	100	310	734	-	-	-
1987	24	91	273	542	934	-	-
1988	23	139	232	442	743	1193	1569
1989	43	125	309	484	731	1012	1399
1990	34	148	346	854	986	1295	1526
1991	41	138	457	880	1539	1726	1808
1992	32	136	392	949	1467	2060	2274
1993	26	93	317	766	1318	1805	2166
1994	25	86	250	545	1041	1569	1784
1995	30	71	224	386	765	1286	1644
1996	30	93	220	551	741	1016	1782
1997	35	88	200	429	625	1063	1286
1998	25	112	241	470	746	1169	1341
1999	27	85	333	614	947	1494	1616
2000	32	108	269	720	1068	1341	1430
2001	28	106	337	556	1100	1429	2085
2002	30	84	144	623	848	1341	2032
2003	38	127	202	493	981	1189	1613
2004	23	98	266	459	780	1167	1328
2005	29	84	253	469	699	1054	1378
2006	26	107	303	540	821	1111	1332
2007[1]	32	112	237	539	970	1195	1608
2008	33	115	250	538	692	1259	1609
2009	25	98	230	440	718	1029	1402
2010	28	76	273	473	656	945	1249
2011	21	114	198	491	737	932	1152
2012	34	86	283	384	809	1036	1270

Russia

Year /Age	0	1	2	3	4	5	6	7	8	9	10
1982	32	102	364	500	-	-	-	-	-	-	-
1983	57	170	271	916	1625	2346	2751	3153	3217	4290	5200
1984	-	124	434	722	1410	2296	3071	2942	3224	3747	5408
1985	-	94	302	788	1533	2275	2650	-	3400	4076	3943
1986	40	91	220	470	905	1759	2300	2500	-	3550	4100
1987	-	96	193	353	612	1101	-	-	-	-	-
1988	-	84	250	409	641	1036	1451	-	-	-	-
1989	-	94	160	718	926	1254	1548	2106	2781	-	7160
1990	-	97	264	530	1250	1474	1812	2188	2626	3080	5520
1991	-	122	342	702	1518	1915	2244	2324	2649	3249	3810
1992	-	103	310	726	1505	2101	2386	2977	3315	3773	4800
1993	55	84	197	543	1120	1568	2125	2474	2476	2803	3324
1994	34	91	217	435	850	1498	2167	2875	2880	2963	3742
1995	32	90	210	445	708	1123	1776	2398	2847	3032	3781
1996	37	80	210	468	854	1186	1643	2429	3038	2991	4413
1997	27	113	226	458	882	1191	1579	1963	3155	2815	3565
1998	38	72	340	593	972	1226	1593	1803	2389	3681	4494
1999	27	103	196	730	1003	1182	1522	1748	2148	2547	2807
2000	24	105	313	480	1197	1502	1713	2375	2445	2286	3065
2001	25	98	264	632	930	1534	1935	2383	2589	2631	3210
2002	26	127	302	586	1077	1470	2029	2127	1954	2933	3986
2003	21	103	229	498	797	1241	1649	2308	2617	3061	3390
2004	24	87	253	518	846	1130	1571	1959	2633	3366	3859
2005	27	115	259	511	933	1289	1670	2079	2833	2965	-
2006[1]	26	105	269	444	867	1307	1604	1922	2274	2520	-
2007	30	117	274	600	1012	1436	1647	2018	2314	2885	-
2008	25	94	267	545	1046	1445	1755	2126	2458	2735	3289
2009	28	91	241	448	841	1335	1666	2048	2438	2498	3132
2010	17	123	208	425	764	1071	1546	2116	2317	2827	-
2011	26	107	305	395	737	1102	1546	2177	2779	3055	4069

[1]Limited area coverage, weights are not adjusted to account for limited area coverage.

Table B8 Northeast Arctic HADDOCK. Consumption of Haddock by NEA Cod.

	Consumption of Haddock by NEA Cod						
	millions						1000′ Tonnes
	1	2	3	4	5	6	
1984	980.7	14.7	0.1	0.0	0.0	0.0	50
1985	1206.2	5.2	0.0	0.0	0.0	0.0	47
1986	566.3	244.2	168.1	0.0	0.0	0.0	110
1987	768.4	0.0	0.0	0.0	0.0	0.0	4
1988	17.1	0.5	9.1	0.0	0.2	0.0	3
1989	230.4	0.0	0.0	0.0	0.0	0.0	10
1990	144.0	37.9	3.7	0.0	0.0	0.0	15
1991	457.8	14.2	0.0	0.0	0.0	0.0	20
1992	2111.4	150.8	1.1	0.0	0.0	0.0	106
1993	1376.4	165.3	36.6	3.4	2.9	0.0	71
1994	1412.3	80.0	24.6	7.4	0.9	0.0	48
1995	2899.5	163.0	11.7	27.9	27.4	0.3	113
1996	1594.1	161.4	40.2	5.5	2.6	3.4	69
1997	906.5	35.5	25.5	1.7	0.8	0.5	41
1998	1534.8	28.2	2.0	2.9	0.5	0.0	33
1999	898.2	23.4	0.3	0.0	0.0	0.0	26
2000	1216.4	65.0	2.1	1.1	0.2	0.1	51
2001	554.9	52.8	5.0	0.1	0.0	0.0	49
2002	2395.7	230.2	38.3	2.5	0.4	0.2	124
2003	3654.3	221.8	39.1	12.4	1.2	0.0	169
2004	3083.0	312.8	41.4	10.6	2.7	0.0	208
2005	6664.0	265.2	50.4	9.4	2.3	0.9	325
2006	8060.1	374.0	5.5	4.6	1.3	0.5	366
2007	9154.3	658.6	71.7	4.2	2.5	0.3	400
2008	908.6	880.3	214.8	54.0	6.9	4.3	328
2009	4972.3	502.2	239.8	91.1	35.9	1.8	295
2010	4368.6	149.6	50.1	90.9	79.3	14.4	319
2011	2998.0	448.4	55.0	80.6	100.3	32.3	327

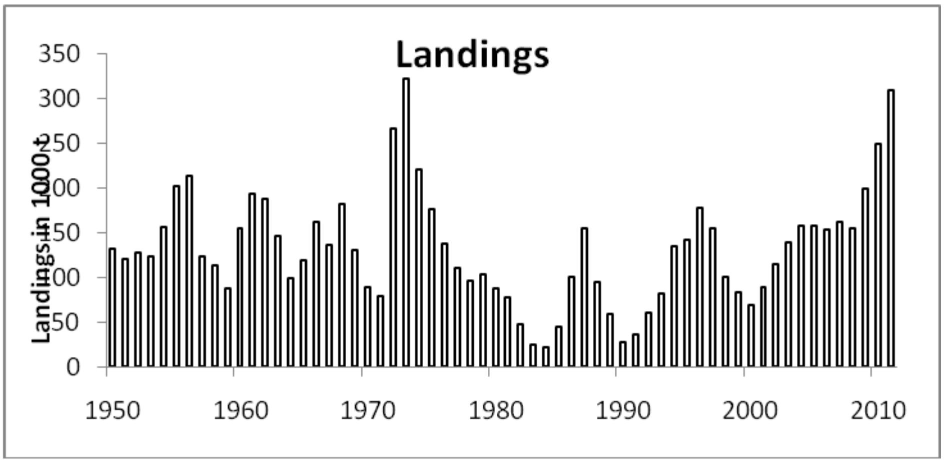


Figure 4.1A Landings of Northeast Arctic haddock 1950-2011

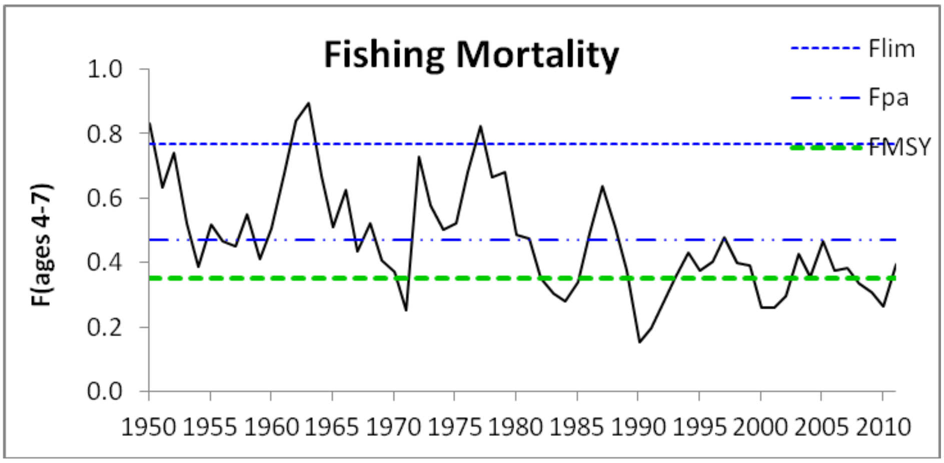


Figure 4.1B Fishing mortality of Northeast Arctic haddock 1950-2011

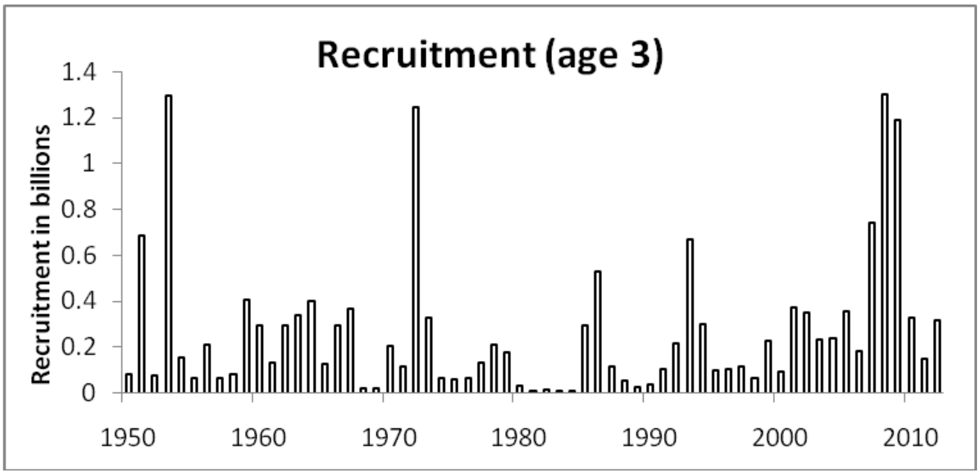


Figure 4.1C Recruitment of Northeast Arctic haddock 1950-2011

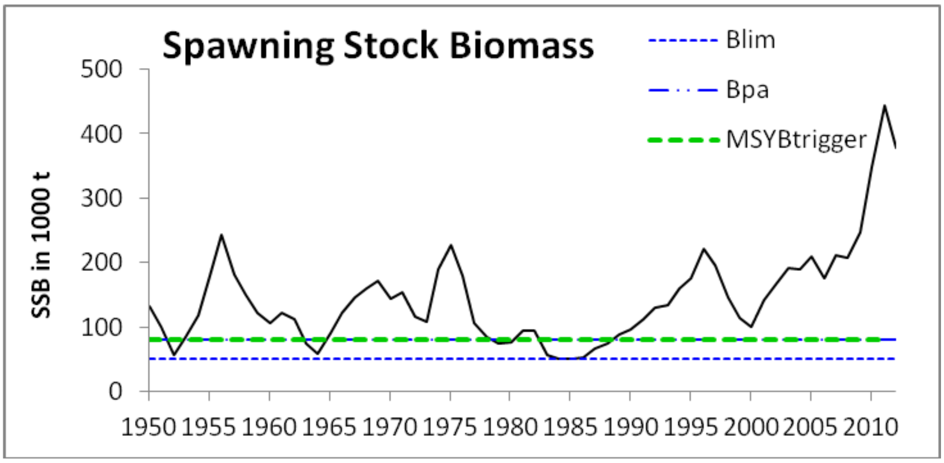


Figure 4.1D Spawning stock biomass of Northeast Arctic haddock 1950-2011

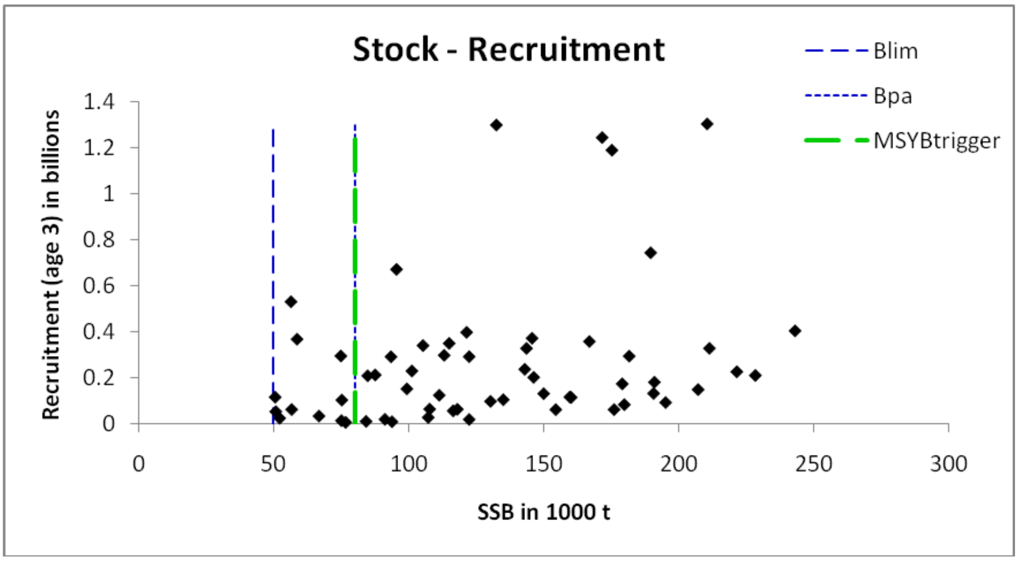


Figure 4.2 Stock-Recruitment relationship of Northeast Arctic haddock 1950-2011

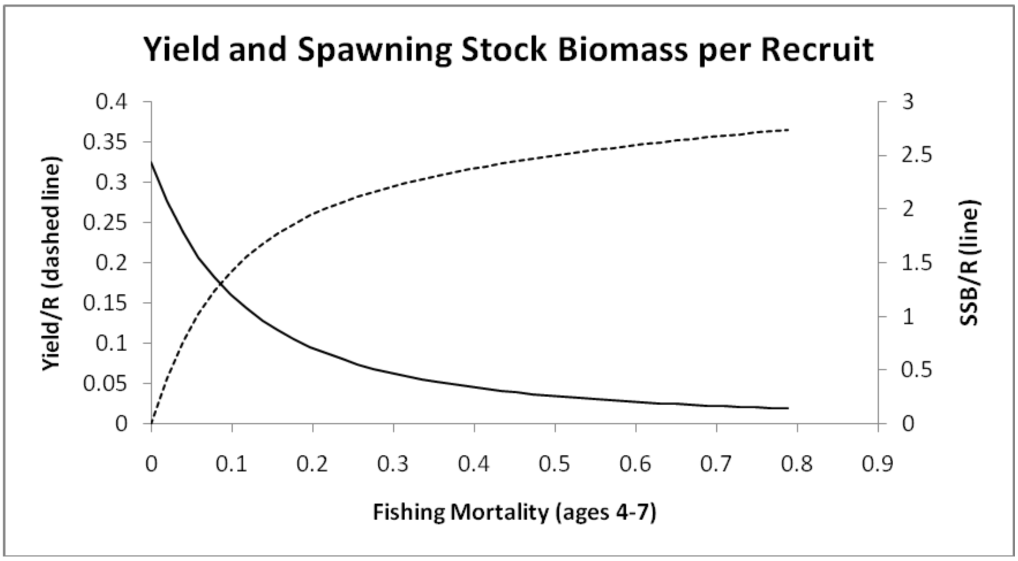


Figure 4.3 Yield and Spawning Stock Biomass per Recruit of Northeast Arctic haddock

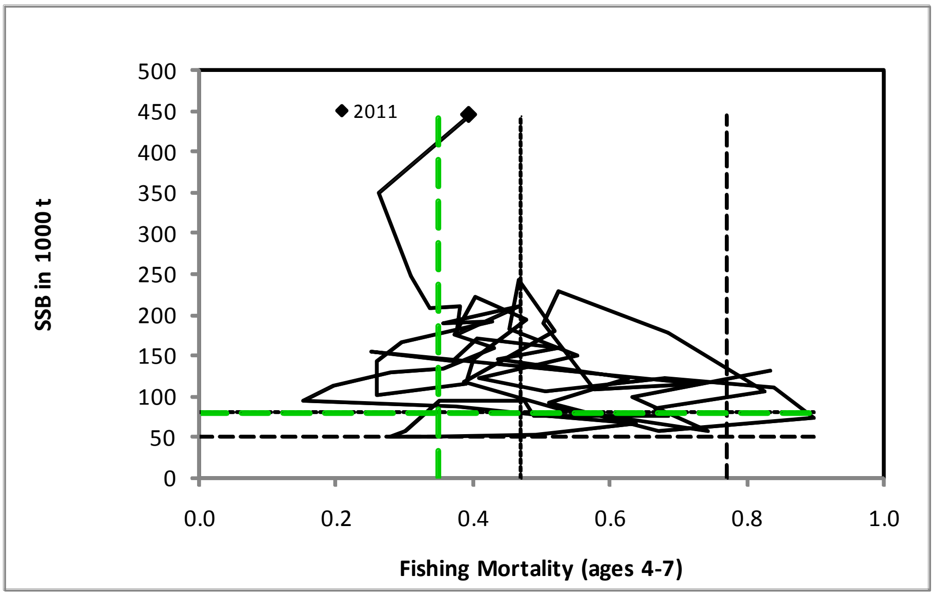


Figure 4.4 Spawning stock biomass – fishing mortality relationship of Northeast Arctic haddock 1950- 2011

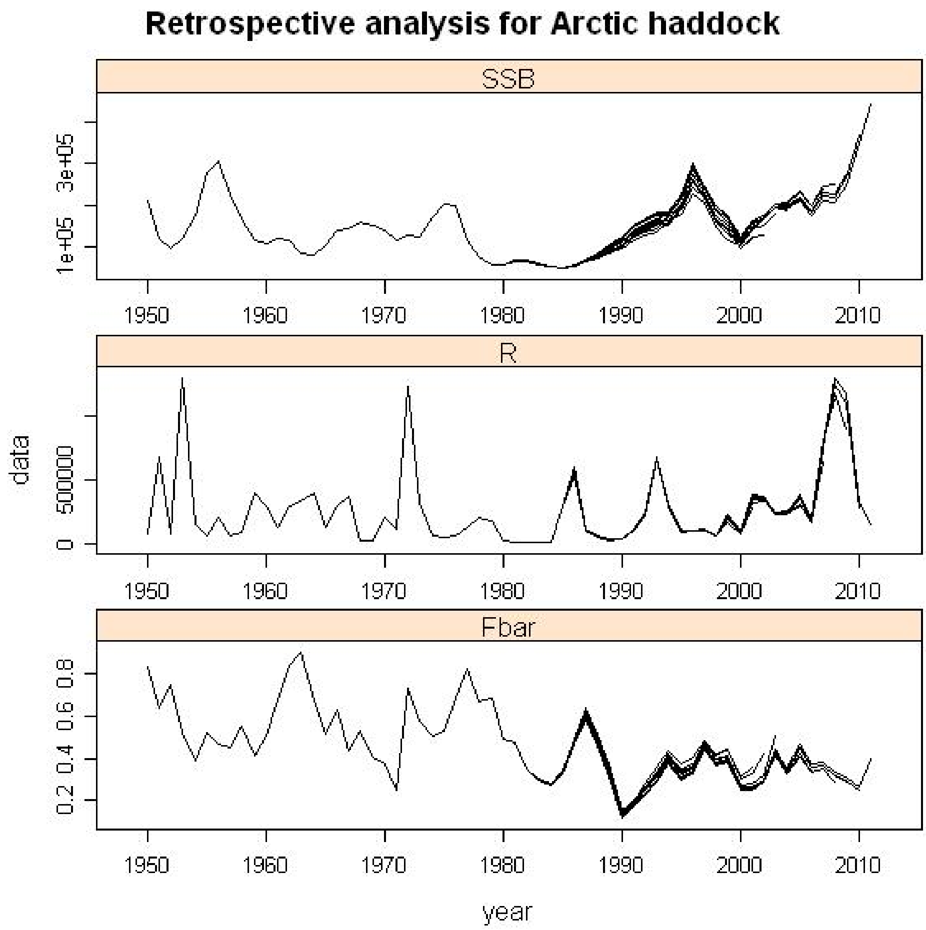


Figure 4.5A. Northeast Arctic haddock. Retrospective plots of SSB, fishing mortality and recruitment for assessment years 2002-2012 using standard settings, but ages 1,2 removed from tuning in the XSA runs.

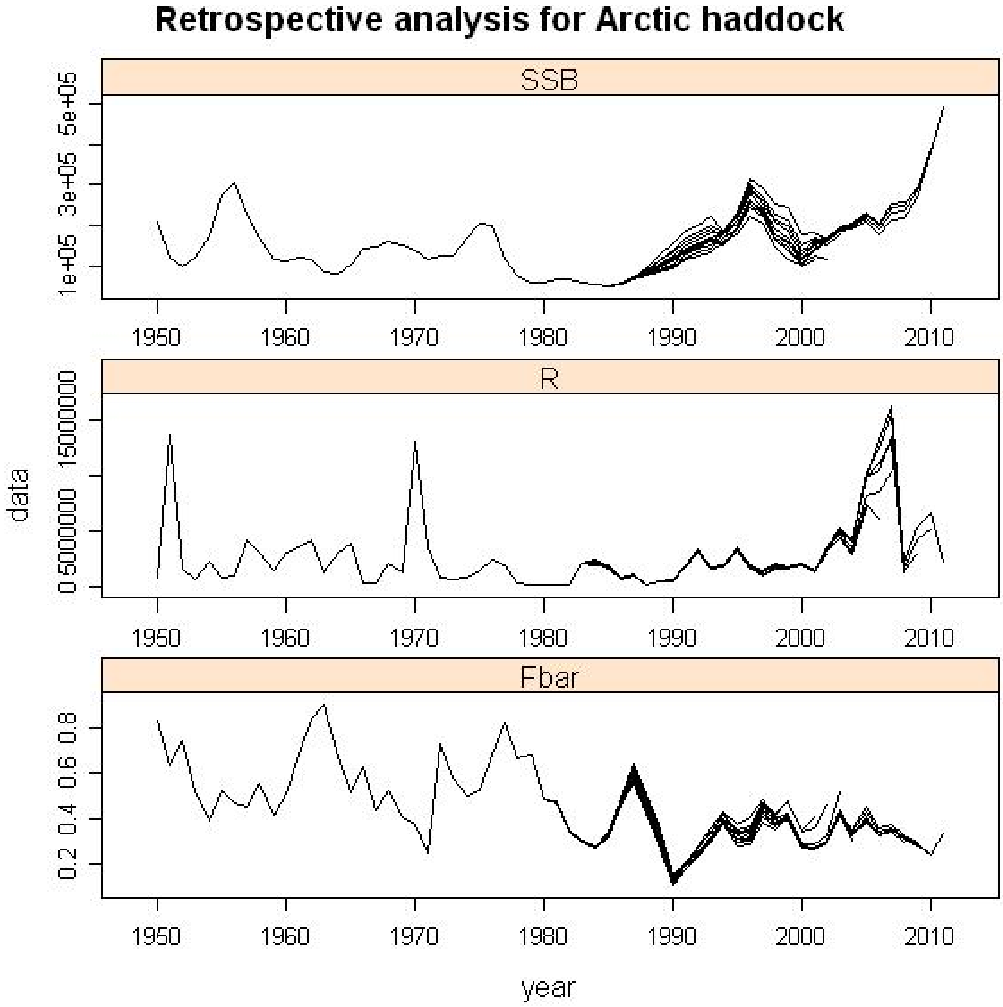
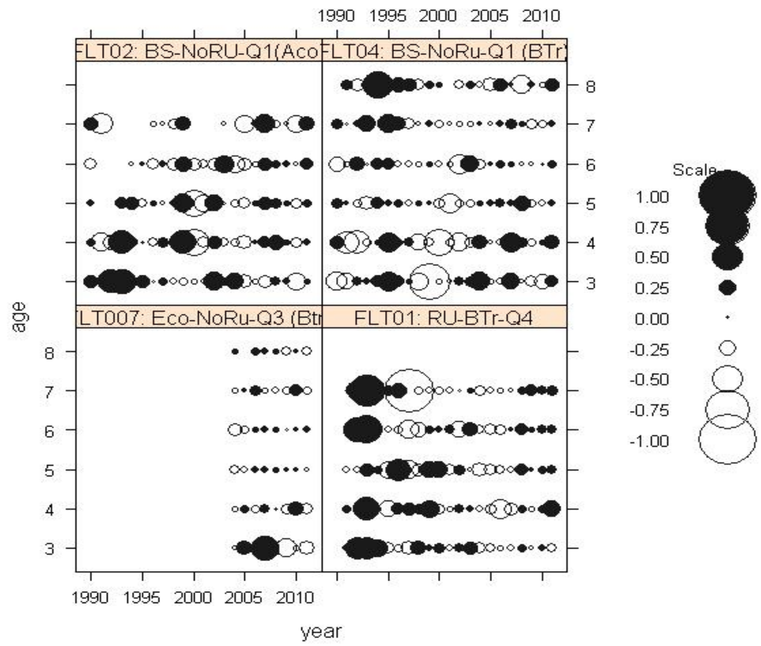


Figure 4.5B. Northeast Arctic haddock. Retrospective plots of SSB, fishing mortality and recruitment for assessment years 2002-2012 using standard settings, but but ages 1,2 included in tuning in the XSA runs, keeping weight, maturity and natural mortality as estimated in 2012 for all runs.

a) SSQ (ages 3-8) = 9.12



b) SSQ (ages 3-8) = 12.31

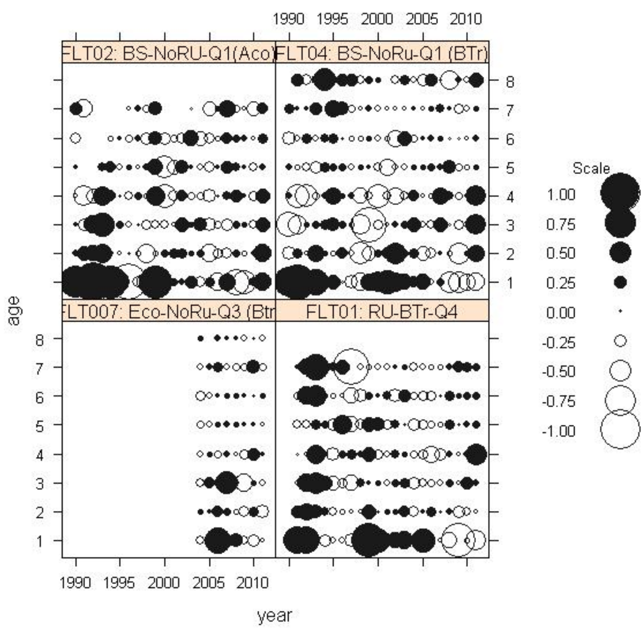
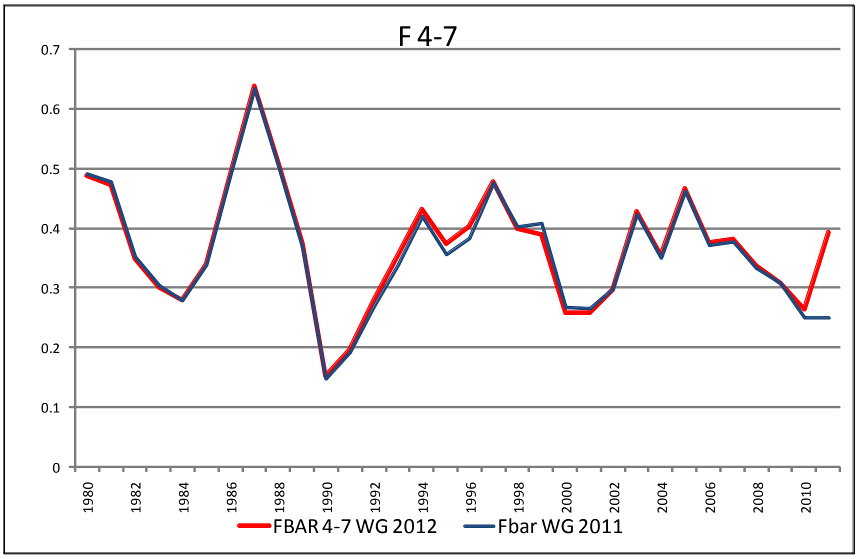
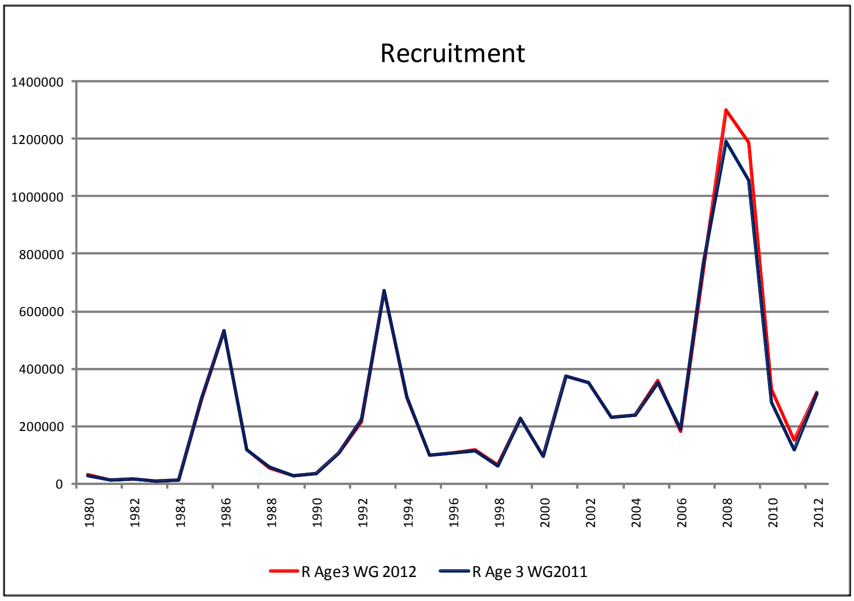


Figure 4.6. Northeast Arctic haddock; log catchability residual plots with values of residual sum of square (SSQ), fleets combined, with different ages for tuning in the XSA runs.

a) run with S.E. of F shrinkage = 1.5, ages 3-8 in tuning

b) run with S.E. of F shrinkage = 1.5, ages 1-8 in tuning





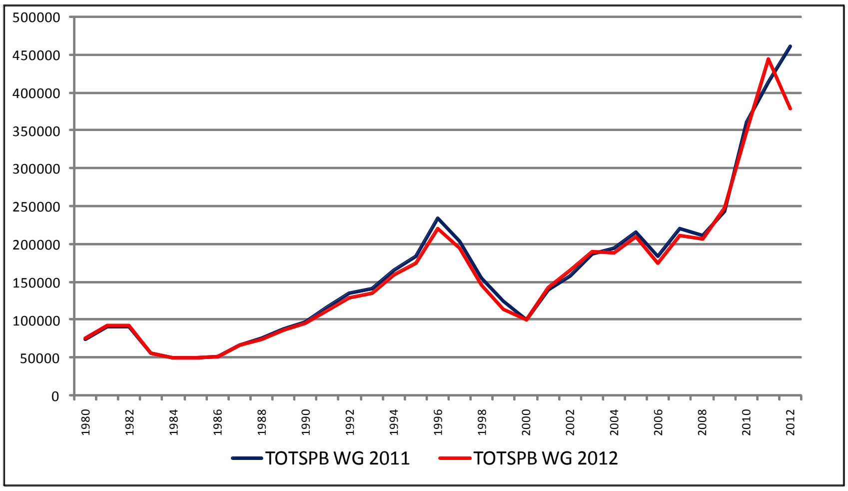


Figure 4.7 Northeast Arctic haddock. Dynamics of fishing mortality, recruitment at age 3 and spawning stock biomass from this year's assessment (F shr.=1.5 ages 3-11), compared with AFWG 2011 estimates for the time period 1980 to 2012 (the WG 2011 values for 2012 are from forecast).

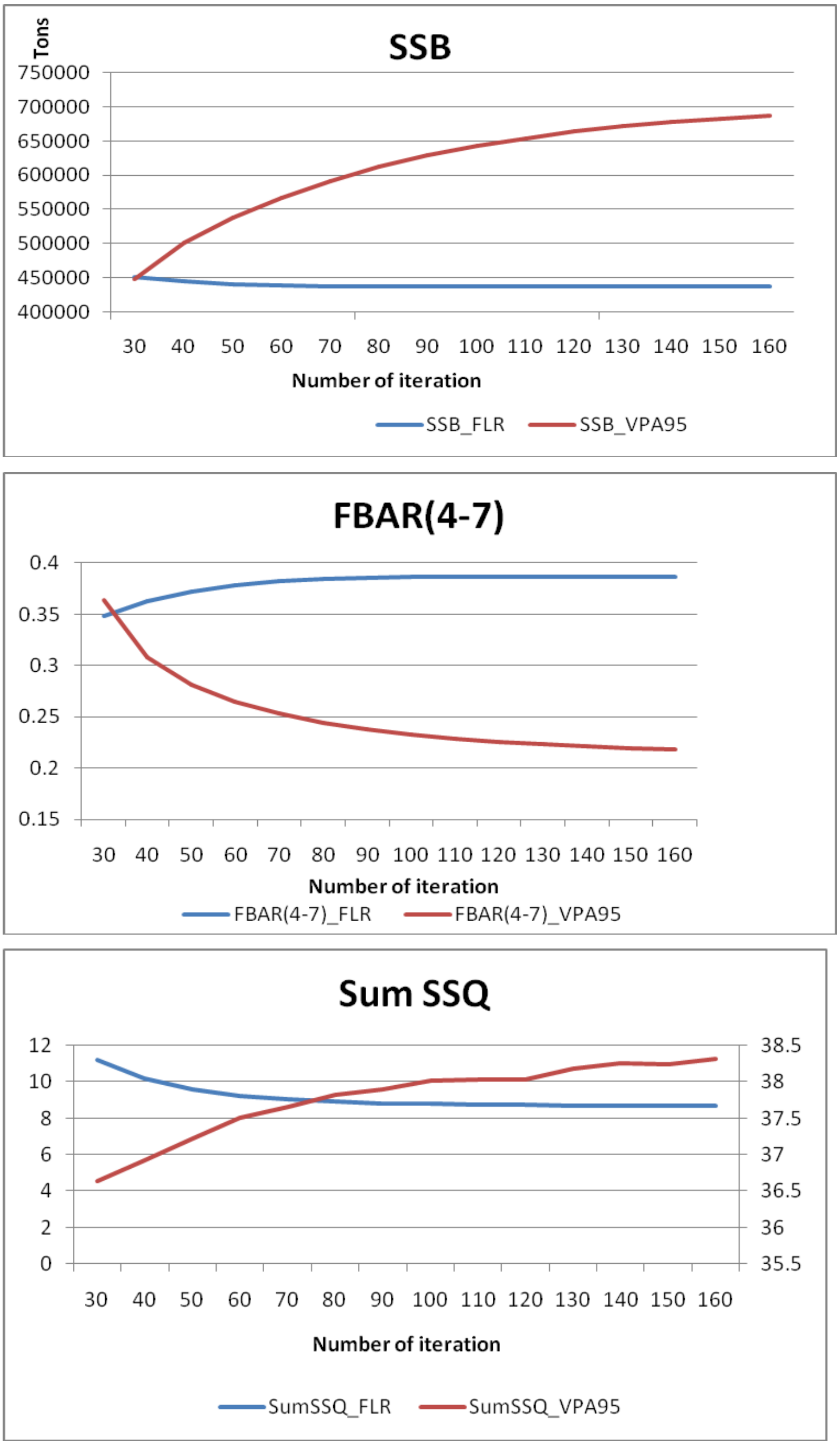


Figure 4.8 Northeast Arctic haddock. Dependence of final estimates of spawning stock, fishing mortality and log catchability residuals on number of iterations. (FLR and VPA 95 used).

5 Saithe in Sub-areas 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 2011 update assessment (ICES CM 2011/ACOM: 05) showed that SSB has been well above B_{pa} since 1995 but has decreased in recent years. Fishing mortality has been well below F_{pa} since 1996, but has increased after 2005 and is approaching F_{pa}.

ICES advised on the basis of the management plan implemented by The Norwegian Ministry of Fisheries and Coastal Affairs that catches in 2012 should be no more than 164,000 t. ICES evaluated the management plan (harvest control rule) in 2007 and again in 2011 due to changes introduced at the 2010 benchmark and concluded that it is consistent with the precautionary approach.

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

5.1 The Fishery (Tables 5.1.1–5.1.2, Figure 5.1.1)

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

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

5.1.1 ICES advice applicable to 2011 and 2012

The advice from ICES for 2011 was as follows:

Following the agreed client management plan implies a TAC of 173,000 t in 2011. The SSB is expected to decrease by 9% in 2011 and to remain above B_{pa} at the beginning of 2012.

The advice from ICES for 2012 was as follows:

Following the agreed management plan implies a TAC of 164,000 t in 2012. The SSB is expected to decrease by 11% in 2012 and to remain above B_{pa} at the beginning of 2013.

5.1.2 Management applicable in 2011 and 2012

Management of Saithe in Sub-areas I and II is by TAC and technical measures. Norwegian authorities set the TACs for 2011 and 2012 to 173,000 t and 164,000 t, respectively.

5.1.3 The fishery in 2011 and expected landings in 2012

Provisional figures show that the landings in 2011 were approximately 157,000 t, about 16,000 t less than the TAC of 173,000 t, which also were expected landings in the forecast last year.

Since the WG does not have any prognosis of total landings in 2012 available, the TAC of 164,000 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 XSA runs with an alternative 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 this tuning series was still too short to perform as well as the one presently used. The estimation of abundance indices is as far as possible done as before the combination of the two surveys. The total index for 2011 (Mehl *et al*. 2011) decreased by almost 40 % compared to 2010, and is the lowest since 1989. The indices for all age groups, especially 2, 3 and 5 year olds (2009, 2008 and 2006-year classes), were well below the 1992-2010 average. The 2006- and 2007 year classes were at or above average level as 3 year olds in 2009 and 2010, respectively, but were considerably reduced to well below average as 4 year olds. This result is supported by the high purse seine catch observed for this age group in 2010. 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 around 50 % in later years (Figure 5.2.1).

5.2.3 Recruitment indices

Owing to the near-shore distribution of juvenile saithe, obtaining early estimates of recruitment is a common problem in saithe stocks. Attempts at establishing year class strength at ages 0-2 for the Northeast Arctic saithe stock have so far failed. The survey recruitment indices are strongly dependent on the extent to which 2-4 year old saithe have migrated from the coastal areas and become available to the acoustic saithe survey on the banks, and this varies between years. An observer programme for establishing a 0-group index series started in 2000 (Borge and Mehl, WD 21 2002). However, these observations do not seem to reflect the dynamics in year class strength very well and are probably not suitable for improving future recruitment estimates for this stock (Mehl, WD 6 2007; Mehl, WD 7 to WKROUND 2010). It was therefore decided to terminate the programme in 2010.

5.3 Data used in the Assessment

5.3.1 Catch numbers at age (Table 5.3.1)

Total Norwegian landings by gear in 2010 were updated. For all countries the landings data for 2010 were updated to the official total catch reported to ICES or to Norwegian authorities. These revisions resulted in only minor changes in catch numbers-at-age and weight-at-age.

Age composition data for 2011 were available from Norway and Germany (Subarea II). Russian length composition data for Subarea IIa and IIb was used in ALK for Norwegian trawl. Other areas and countries were assumed to have the same age composition as Norwegian trawlers. The biological sampling of some vessel groups, periods and areas may have become critically low after the termination of the Norwegian port sampling program in 2009. The revised 2010 and new 2011 catch and sample data were uploaded to the InterCatch database, and there were practically no discrepancies between data allocated and aggregated in InterCatch and data from the spreadsheets presently used.

5.3.2 Weight at age (Table 5.3.2)

Constant weights at age values are used for the period 1960-1979. For subsequent years, annual estimates of weight at age in the catches are used. Weight at age in the stock is assumed to be the same as weight at age in the catch. Compared to the previous years, there were only small differences in weight at age for the most important age groups in 2011.

5.3.3 Natural mortality

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

5.3.4 Maturity at age (Table 5.3.3)

A constant maturity ogive was used until the 2005 WG, when these estimates were evaluated. In later years the maturity at age had decreased somewhat, and the WG decided to use a 3-year running average for the period from 1985 and onwards (2-year average for the first and last year). New analyses were only available back to 1985. Table 5.3.3 presents the 3-year running average maturity ogive. Since 2009 a rather large reduction in maturity at age five has been observed.

5.3.5 Tuning data (Table 5.3.4, Figure 5.3.1)

Until the 2005 WG, the tuning was based on three data series: CPUE from Norwegian purse seine and Norwegian trawl and indices from a Norwegian acoustic survey. The 2005 WG found rather large and variable log q residuals and large S.E. log q for the purse seine fleet, as well as strong year effects, and in the combined tuning the fleet got low-scaled weights. The WG decided not to include the purse seine tuning fleet in the analysis. This was confirmed by new analyses at the 2010 benchmark assessment (ICES CM 2010/ACOM:36).

Analyses of the two remaining tuning series done at the 2010 benchmark assessment indicated that there had been a shift in catchability around year 2002. The survey was redesigned in 2003, and the fishery to a larger degree targeted older ages. Permanent breaks were made in both tuning series in 2002. The following four tuning fleets are used in the present assessment:

Fleet 11: CPUE data from the Norwegian trawl fisheries 1994-2001, age groups 4 to 8, quarter 1-4.

Fleet 12: CPUE data from the Norwegian trawl fisheries 2002-2011, 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 2002-2011, age groups 3 to 7.

Figure 5.3.1a,b presents the tuning data by fleet, year and age for the two periods combined.

5.4 Exploratory runs (Table 5.4.1, Figure 5.4.1)

The settings of the different runs are shown in Table 5.4.1 and the results are given in Figure 5.4.1. The recommendation from the benchmark assessment in 2010 (ICES CM 2010/ACOM: 36) was to run the XSA with a 15+ catch matrix, tuning time series broken in 2002, reduced shrinkage (S.E. of the mean to which the estimate are shrunk increased from 0.5 to 1.5) and no tapered time weighting.

Motivated by some recent discussions in various benchmark groups, about what to do in cases where an XSA does not converge, and also by the considerations made at the WGMG meeting in 2009 (reflected in chapter 5 of that report (ICES CM 2009/RMC: 12)), particular attention was paid to this question this year.

The WGMG in 2009 noted that "It is interesting how earlier advice on the desirability of stopping XSA after 30 iterations in order to check for convergence evolved over time within some Working Groups into a general perception that XSA runs should not be continued at all beyond 30 iterations. This is clearly not what was intended by the original advice, but certainly became the de facto approach for a number of Working Groups using the Lowestoft VPA suite to run XSA." The group further stated that "An unconverged XSA run indicates that something is wrong: either the model is being used incorrectly, or the model is not appropriate to characterizing the available data" (ICES CM 2009/RMC: 12).

In previous years the XSA saithe assessment runs in most cases have failed to converge after 30 iterations, but contrary to the "de facto approach for a number of Working Groups" additional runs with more iterations were made until the XSA converged in such cases. However, in the two last assessments, only 30 iterations were made even though the XSA had not converged. This year, this situation occurred once more, and additional runs were made until convergence occurred. With the settings used in the final run, convergence was reached after 123 and 121 iterations in the Lowestoft VPA suite XSA and the FLXSA respectively. Some exploratory runs were made to determine which settings affected convergence the most. In (ICES CM 2009/RMC: 12) the q-plateau and the plus-group are mentioned as decisive for the convergence behavior. We found that for the NEA saithe assessment, the amount of shrinkage also heavily affected the number of iterations needed; with an FSE = 0.5, 38 iterations (in Lowestoft VPA suite XSA), for FSE = 1.0, 90 iterations and for FSE = 1.5 (final run), 123 iterations were needed to reach convergence.

We followed the recommendation from the WGMG 2009, to run the XSA to convergence, but to check the sensitivity of the assessment for various numbers of iterations. For the 2012 NEA saithe assessment, we concluded that the terminal F and terminal SSB estimates changed very little, and consequently the final assessment was based on the run that converged.

Based on the update of catch statistics for 2010, a SPALY (Same Procedure As Last Year) XSA (run 1) was performed, giving almost the same results as in the 2011 assessment. F_{4-7} in 2010 was estimated to 0.333 in 2011, while the updated run gave a F_{4-7} of 0.336. SSB in 2010 increased from 393,155 t to 393,655 t.

Two single fleet tuning runs were performed with the 2011 data included; one with the Norwegian trawl CPUE (run 2) and one with the Norwegian acoustic survey (run 3). Run 4 was a SPALY analysis with combined fleets, while in the last run (5) the tuning was allowed to converge, which took 123 iterations compared to 30 iterations in runs 1-4.

Figure 5.4.1 compares estimates of SSB and F_{4-7} in 2011 from the two single fleet XSA-runs and the combined tuning runs. The single fleet tuning run based on the CPUE give the lowest F_{4-7} and highest SSB in the last assessment year (2011), while the run based on the acoustic indices gave lower SSB and considerably higher F_{4-7} (0.20 compared to 0.52). The combined runs gave SSB and F_{4-7} values between those from the single fleet runs. Compared to the update of the final run made at the 2011 assessment, F_{4-7} in 2010 is now higher (0.37 compared to 0.33) and SSB lower (383,000 t compared to 393,000 t).

5.5 Final assessment run (Tables 5.5.1–5.5.7, Figures 5.5.1–5.5.4)

Extended Survivors Analysis (XSA) was used for the final assessment with settings shown in Table 5.4.1. The settings are in accordance with the recommendations from the benchmark assessment in February 2010 (ICES CM 2010/ACOM:36), but the tuning was allowed to converge. Full tuning fleet diagnostics are given in Table 5.5.1.

Figure 5.5.1 presents log q residuals for the tuning fleets. In general, there are few year- and age effects and mostly small residuals. The second part of the acoustic survey series seems to perform better then the first part. Figure 5.5.2 presents S.E. log q for the different age groups in the fleets used for tuning. The two tuning series going from 1994 to 2002 have higher S.E. log q, except for age 4 of the trawl CPUE series from 2003 to 2011. The upper panel of Figure 5.5.3 shows estimates of survivors from different fleets, shrinkage and mean survivors, while the bottom panel shows their different weighting in the final XSA-run. The survey series from 2003 to 2011 get the highest weights for age groups 3-7, the CPUE series from 2003 to 2011 get slightly higher weights for the older age groups, while shrinkages only get some weights for ages 12-14. Figure 5.5.4a-b shows plots of the tuning indices versus stock numbers from the XSA.

5.5.1 Fishing mortalities and VPA (Tables 5.5.2–5.5.7, 5.7.1, Figure 5.5.5)

The fishing mortality (F_{4-7}) in 2010 was 0.37, which is above the value of 0.33 from last year's assessment. The fishing mortality (F_{4-7}) in 2011 was 0.35, i.e. a little below the corresponding figure for 2010, and at the F_{pa} of 0.35.

Fishing mortality and stock size have in the last decade been considerably over- and underestimated, respectively, in the last assessment year. Due to the changes made to the assessment following the benchmark assessment workshop in 2010 (ICES CM

2010/ACOM: 36), the retrospective patterns have improved considerably, as is illustrated in Figure 5.5.5, and now shows clear signs of an opposite retrospective trend.

The XSA-estimates of the 2007-2008 year classes are not considered to be reliable and are therefore shaded (Tables 5.5.3 and 5.5.5). In the projections, both were set to the long-term geometrical mean, the value of the 2008-year class at age 4 being obtained by applying Pope's approximation. The figures are given in input data for prediction (Table 5.7.1). The 2002 year class was the most numerous in the landings for several years and is estimated to be the strongest in the time series, above the strong 1989, 1992 and 1999-year classes. The 2003-year class is confirmed to be one of the weakest in the time series, and the 2004-year class is also poor, the 2005-year class is well above average level, the 2006-year class now comes out well below average strength, while the 2007-year class so far is above average, at about the same level as the 2005-year class. Survey indices and purse seine catches in 2011 indicates that the 2008-year class is below average strength and may be weak, while little information is available on the strength of more recent year classes.

The total biomass (ages 3+) has been above the long-term (1960-2011) mean since 1995, reached a maximum in 2005, but 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 above B_{pa}.

5.5.2 Recruitment (Table 5.3.1, Figure 5.1.1)

Estimates of the recruiting year classes up to the 2007-year class (4 year olds) from the XSA were accepted. Catches of age group 3 have varied considerably during the period 2006-2011 (Table 5.3.1). Until the 2005 WG, RCT3-runs were conducted to estimate the corresponding year classes, with 2 and 3 year olds from the acoustic survey as input together with XSA numbers. 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 1960-2010 is 169 million 3 year olds, and this value is used for the 2008-year class.

5.6 Reference points (Figure 5.1.1)

In 2010 the age span was expanded from 11+ to 15+ and important XSA parameter settings were changed (ICES CM 2010/ACOM: 36). 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 reference points were re-estimated at the 2010 WG according to the methodology outlined in ICES CM 2003/ACFM: 15, while the PA reference point estimation was based on the old procedure (ICES CM 1998/ACFM: 10). The results were not very much different from the previous analyses performed in 2005 (ICES CM 2005/ACFM: 20), and since the HCR is based on the PA reference points, it was decided not to change the existing LIM and PA reference points. The re-estimations are presented below.

5.6.1 Biomass reference points

At the 2010 WG, parameter values, including the change-point, were computed using segmented regression on the 1960-2005 time series of SSB-recruitment pairs. The maximum likelihood estimate of the spawning stock biomass at which recruitment is impaired (change point) was 118,542 t. Applying the "magic formula" $B_{pa} = B_{lim}$ exp(1.645*σ), with a value of 0.3 for σ, gave a B_{pa} of 194,176 t. However, as explained above, it was decided to still use the existing values of B_{lim} = 136,000 t and B_{pa} = 220,000 t.

5.6.2 Fishing mortality reference points (Tables 5.6.1, 5.7.1, Figure 5.1.1)

F_{lim} was set on the basis of B_{lim} (ICES CM 2003/ACFM: 15). The functional relationship between spawner-per-recruit and F gave the F associated with the R/SSB slope derived from the B_{lim} estimate obtained from the segmented regression. Arithmetic means of proportion mature 1960-2009, weight in stock and weight in catch 1980-2009 (weights were constant before 1980), natural mortality and fishing pattern 1960-2009 were at the 2010 WG used for re-calculating the spawner-per-recruit function using ICES Secretariat yield-per-recruit software. R/SSB = 1.48 from the B_{lim} estimation gave SSB/R = 0.676 and a F_{lim} = 0.59. Applying the "magic formula" $F_{pa} = F_{lim}$ exp(-1.645*σ), gave a F_{pa} of 0.36, for a σ of 0.3 . As explained above, it was decided to still use the existing values of F_{lim} = 0.58 and F_{pa} = 0.35.

Yield and SSB per recruit were based on the parameters in Table 5.7.1 and are presented in Table 5.6.1. $F_{0.1}$, Fmax and $F_{35\%SPR}$ were estimated to be 0.14, 0.33 and 0.14, respectively, which is slightly higher than last year's estimates of 0.10, 0.32 and 0.12. The plot of SSB versus recruitment is shown in Figure 5.1.1. These points are F_{MSY} candidates, but the estimates, especially of F_{max}, are unstable for this stock. When the HCR was re-evaluated (see below), the highest long-term yield was obtained for an exploitation level of 0.20.

5.6.3 Harvest control rule (Figures 5.6.1–2)

In 2007 ICES evaluate the harvest control rule for setting the annual fishing quota (TAC) for Northeast Arctic saithe. ICES concluded that the HCR was consistent with the precautionary approach for all simulated data and settings, including a rebuilding situation under the condition that the assessment uncertainty and error are not greater than those calculated from historic data. This also held true when an implementation error (difference between TAC and catch) equal to the historic level was included. The HCR was implemented the same year. It contains the following elements:

- Estimate the average TAC level for the coming 3 years based on $\mathbf{F}_{pa}$. TAC for the next year will be set to this level as a starting value for the 3-year period.
- The year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development. However, the TAC should not be changed by more than 15% compared with the previous year's TAC.
- If the spawning stock biomass (SSB) in the beginning of the year for which the quota is set (first year of prediction), is below $\mathbf{B}_{pa}$, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from $\mathbf{F}_{pa}$ at SSB=$\mathbf{B}_{pa}$ to 0 at SSB equal to zero. At SSB levels below $\mathbf{B}_{pa}$ in any of the operational years (current year and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.

In 2011 the evaluation was repeated taking into account the changes made to the assessment after the 2010 benchmark assessment (ICES CM 2010/ACOM: 36). The analyses indicate that the HCR still is in agreement with the precautionary approach (Mehl and Fotland, WD 11).

In the 2007 simulations (ICES CM 2007/ACFM :16) the highest long-term yield was obtained for an exploitation level of 0.32, i.e. a little below the target F used in the HCR (F_{pa}), and ICES recommended using a lower value in the HCR. In the 2011 simulations (ICES CM 2011/ACOM: 05) the highest long-term yield was obtained for F = 0.20 (Figure 5.6.1), but the curve was almost flat between F=0.15 and F=0.25 and the decrease in long-term yield going from F=0.25 to F=0.35 was rather small (about 5%). However, SSB was reduced by a factor of more than 3 between F=0.1 and F=0.4 and approached B_{pa} (Figure 5.6.2).

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 2012 was taken from the XSA for age 5 (2007 year class) and older. The recruitment at age 3 in the last assessment year (2011) was calculated as the long-term GM (geometric mean) recruitment 1960-2010 (Section 5.5.2), and the corresponding numbers at age 4 in the intermediate year (2012) 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 2009 and subsequent year classes. The natural mortality of 0.2 is the same as used in the assessment. For exploitation pattern the average of 2009-2011 was used for age groups 3-10, while for age groups 11-15+ the 2009-2011 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 2010-2011 annual determinations was applied.

5.7.2 Catch options for 2013 (short-term predictions) (Tables 5.7.2–5.7.4)

The management option table (Table 5.7.2) shows that the expected catch of 164,000 t in 2012 will decrease the fishing mortality slightly compared to 2011 from 0.35 to 0.31, which is below the F_{pa} of 0.35. A catch in 2013 corresponding to the $F_{status\ quo}$ level (3-year average 2009-2011) of 0.33 will be 165,000 t, while a catch in 2013 corresponding to the evaluated and implemented HCR (average TAC level for the coming 3 years based on F_{pa}, see Table 5.7.3) is 164,000 t. This catch corresponds to a fishing mortality of 0.32 in 2013.

For a catch in 2012 corresponding to the agreed TAC, i.e. 164,000 t, the SSB is expected to decrease from about 315,000 t at the beginning of 2012 to 302,000 t at the beginning of 2013. At $F_{status\ quo}$ in 2013 SSB is estimated to decrease to 292,000 t at the beginning of 2014 and for a catch corresponding to the HCR it will also decrease to about 292,000 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 2013.

5.7.3 Comparison of the present and last year's assessment

The current assessment estimated the total stock in 2011 to be 5 % higher and the SSB 2 % lower, compared to the previous assessment. The F in 2010 is estimated to be higher than in the previous assessment and the realized F in 2011 is also higher compared to the predicted one based on the TAC.

	Total stock (3+) by 1 January 2011(tonnes)	SSB by 1 January 2011(tonnes)	F_{4-7} in 2011	F_{4-7} in 2010
WG 2011	711210	358114	0.31 (TAC constraint)	0.33
WG 2012	745452	351241	0.35	0.37

5.8 Comments to the assessment and the forecast (Figure 5.5.5).

The retrospective pattern has been a major concern in the assessment, but due to the changes done at the benchmark assessment (ICES CM 2010/ACOM: 36), the assessment has become more stable. The tendency to overestimate F and underestimate SSB in the last assessment year seems to have changed to an opposite situation, but the differences are less than in previous assessments.

The biological sampling may have become critically low after the termination of the Norwegian port sampling program in 2009. This may affect the precision of the catch, weight and maturity at age data.

The assessment is vulnerable since only two tuning series are available. Moreover, in recent years these tuning series have shown increasingly divergent signals, which might influence the perception of the status of the stock. The survey tuning series, showing large reduction in recent years, got the highest weights in the estimation of survivors for the most abundant age groups (Figure 5.3.3), indicating that these follow the trends in the catch-at-age matrix more closely.

Lack of reliable recruitment estimates is still a major problem. Prediction of catches will, to a large extent, be dependent on assumptions of average recruitment, since fish from age four to seven constitute major parts of the catches. Since the saithe HCR is a three-year-rule, the estimation of average F_{pa} catch in the HCR will affect stock numbers up to age seven, and thereby heavily affect the total prognosis of the fishable stock and the quotas derived from it.

5.9 Response to ACOM technical minutes

The major comments made by the five previous reviews were dealt with during the benchmark assessment in February 2010 (ICES CM 2010/ACOM:36).

The 2011 reviewers commented that a section on stock status would be useful, and a few paragraphs have been included in the introduction.

Further it was recommended that as more information is accumulated on the directed fishery for saithe, the directed fishery CPUE should be used, instead of the current basis for CPUE. The WG does not disagree with this, and suggests that the next benchmark assessment could investigate it further.

The reviewers found the information on discards within the assessment to be conflicting: “The assessment stated that discarding, although illegal, occurs in the saithe fishery, but is not considered a major problem in the assessment. Further text on discards indicates that comparisons of scientific samples from non-Norwegian commercial trawlers indicating that discarding may be substantial in certain areas and seasons. Therefore, it is unclear what impact discards may have on the assessment.” The discarding from non-Norwegian commercial trawlers may perhaps be substantial in certain areas and seasons, but this represents a minor part of the saithe landings since Norway accounts for more than 90% of the total landings. Therefore discarding is not considered a major problem in the assessment.

Table 5.1.1 Saithe in Sub-areas I and II (Northeast Arctic).

Nominal catch (t) by countries as officially reported to ICES.

Year	Faroe Islands	France	Germany Dem.Rep	Fed.Rep. Germany	Iceland	Norway	Poland	Portugal	Russia3	Spain	UK	Others 5	Total all countries
1960	23	1 700		25 948		96 050					9 780	14	133 515
1961	61	3 625		19 757		77 875					4 595	18	105 951
1962	2	544		12 651		101 895			912		4 699	4	120 707
1963		1 110		8 108		135 297					4 112		148 627
1964		1 525		4 420		184 700			84		6 511	186	197 426
1965		1 618		11 387		165 531			137		6 741	181	185 600
1966		2 987	813	11 269		175 037			563		13 078	41	203 788
1967		9 472	304	11 822		150 860			441		8 379	48	181 326
1968			70	4 753		96 641					8 781		110 247
1969	20	193	6 744	4 355		115 140					13 585	23	140 060
1970	1 097		29 362	23 466		151 759			43 550		15 469		264 924
1971	215	14 536	16 840	12 204		128 499	6 017		39 397	13 097	10 361		241 272
1972	109	14 519	7 474	24 595		143 775	1 111		1 278	13 125	8 223		214 334
1973	7	11320	12 015	30 338		148 789	23		2 411	2 115	6 841		213 859
1974	46	7119	29 466	33 155		152 699	2521		28 931	7 075	3 104	5	264 121
1975	28	3156	28 517	41 260		122 598	3860	6430	13 389	11 397	2 763	55	233 453
1976	20	5609	10 266	49 056		131 675	3164	7233	9 013	21 661	4 724	65	242 486
1977	270	5658	7 164	19 985		139 705	1	783	989	1 327	6 935		182 817
1978	809	4345	6 484	19 190		121 069	35	203	381	121	2 827		155 464
1979	1117	2601	2 435	15 323		141 346			3	685	1 170		164 680
1980	532	1016		12 511		128 878			43	780	794		144 554
1981	236	218		8 431		166 139			121		395		175 540
1982	339	82		7 224		159 643			14		732		168 034
1983	539	418		4 933		149 556			206	33	1 251		156 936
1984	503	431	6	4 532		152 818			161		335		158 786
1985	490	657	11	1 873		103 899			51		202		107 183
1986	426	308		3 470		63 090			27		75		67 396
1987	712	576		4 909		85 710			426		57	1	92 391
1988	441	411		4 574		108 244			130		442		114 242
1989	388	460 [2]		606		119 625			506	506	726		122 817
1990	1207	340 [2]		1 143		92 397			52		709		95 848
1991	963	77 [2]	**Greenland**	2 003		103 283			504 [4]		492	5	107 327
1992	165	1980	734	3 451		119 763			964	6	541		127 604
1993	31	566	78	3 687	3	140 604		1	9 509	4 [2]	415	5 [2]	154 903
1994	67 [2]	557	15	1 863	4 [2]	141 589		1 [2]	1 640 [2]	655 [2]	557	2	146 950
1995	172 [2]	358	53	935		165 001		5	1 148		688	18	168 378
1996	248 [2]	346	165	2 615		166 045		24	1 159	6	707	33	171 348
1997	193 [2]	560	363 [2]	2 915		136 927		12	1 774	41	799	45	143 629
1998	366	932	437 [2]	2 936		144 103		47	3 836	275	355	40	153 327
1999	181	638 [2]	655 [2]	2 473	146	141 941		17	3 929	24	339	32	150 375
2000	224 [2]	1438	651 [2]	2 573	33	125 932		46	4 452	117	454	8 [2]	135 928
2001	537	1279	701 [2]	2 690	57	124 928		75	4 951	119	514	2	135 853
2002	788	1048	1393	2 642	78	142 941		118	5 402	37	420	3	154 870
2003	2056	1022	929 [2]	2 763	80 [2]	150 400		147	3 894	18	265	18 [2]	161 592
2004	3071	255	891 [2]	2 161	319	147 975		127	9 192	87	544	14	164 636
2005	3152	447	817 [2]	2 048	395	162 338		354	8 362	25	630		178 568
2006	1795	899	786 [2]	2 779	255	195 462	89	339 [2]	9 823	21 [2]	532	42	212 822
2007	2048	966	810 [2]	3 019	219	178 644	99	412	12 168	53 [2]	558	12	199 008
2008	2314	1009	503 [2]	2 263	113	165 998	66	348	11 577	33	506	10	184 740
2009	1611 [2]	326	697	2 021	69	144 570	30	204 [2]	11 899	2 [2]	379	45 [2]	161 853
2010	1632	677	954	1 592	109 [2]	174 544	279	93	14 664	8	283	2 [2]	194 837
2011 [1]	112	357	445	1 371	110	143 252		43	10 007	2 [2]	972	15	156 686

1 Provisional figures.

2 As reported to Norw egian authorities.

3 USSR prior to 1991.

4 Includes Estonia.

5 Includes Denmark,Netherlands, Ireland and Sw eden

6 As reported by Working Group members

Table 5.1.2 Saithe in Sub-areas I and II (Northeast Arctic).
Landings ('000 tonnes) by gear category.

Year	Purse Seine	Trawl	Gill Net	Others	Total
1977	75.2	69.5	19.3	12.7	176.7 [2]
1978	62.9	57.6	21.1	13.9	155.5
1979	74.7	52.5	21.6	15.9	164.7
1980	61.3	46.8	21.1	15.4	144.6
1981	64.3	72.4	24.0	14.8	175.5
1982	76.4	59.4	16.7	15.5	168.0
1983	54.1	68.2	19.6	15.0	156.9
1984	36.4	85.6	23.7	13.1	158.8
1985	31.1	49.9	14.6	11.6	107.2
1986	7.9	36.2	12.3	8.2	64.6 [2]
1987	34.9	27.7	19.0	10.8	92.4
1988	43.5	45.4	15.3	10.0	114.2
1989	49.5	45.0	16.9	11.4	122.8
1990	24.6	44.0	19.3	7.9	95.8
1991	38.9	40.1	18.9	9.4	107.3
1992	27.1	67.0	22.3	11.2	127.6
1993	33.1	84.9	21.2	15.7	154.9
1994	30.2	82.2	21.1	13.5	147.0 [3]
1995	21.8	103.5	26.9	16.1	168.4 [4]
1996	46.9	72.5	31.6	20.3	171.3
1997	44.4	55.9	24.4	19.0	143.6
1998	44.4	57.7	27.6	23.6	153.3
1999	39.2	57.9	29.7	23.6	150.4
2000	28.3	54.5	29.6	23.5	135.9
2001	28.1	58.1	28.2	21.5	135.9
2002	27.4	75.5	30.4	21.5	154.8
2003	43.3	73.8	25.2	19.3	161.6
2004	41.8	74.6	26.9	21.3	164.6
2005	42.1	91.8	25.6	19.1	178.6
2006	73.5	87.1	29.7	22.5	212.8
2007	41.8	100.7	33.3	23.2	199.0
2008	39.4	91.2	37.0	17.1	184.7
2009	35.5	81.1	33.2	12.1	161.9
2010	54.9	89.8	36.9	13.2	194.8
2011 [1]	45.1	67.4	31.8	12.4	156.7

[1] Provisional figures.
[2] Unresolved discrepancy between Norwegian catch by gear figures and the total reported to ICES for these years.
[3] Includes 4,300 tonnes not categorized by gear, proportionally adjusted.
[4] Reduced by 1,200 tonnes not categorized by gear, proportionally adjusted.

Table 5.2.1 Saithe in Sub-areas I and II (Northeast Arctic).
Norwegian trawl CPUE by agegroup (Catch in numbers per trawlhour).
Shaded area shows indices applied in the assessment.

Year	Agegroup									Total CPUE (kg/h)
	effort	3	4	5	6	7	8	9	10	Quarter 1-4
1994	1	3.4	83.2	280.2	174.0	24.0	5.3	1.7	3.3	575
1995	1	28.1	150.0	208.3	226.3	35.9	5.9	0.2	1.5	656
1996	1	17.0	84.7	113.2	164.7	217.1	24.9	5.3	0.5	628
1997	1	10.7	28.5	148.3	151.1	194.4	122.3	12.9	1.3	670
1998	1	2.4	24.5	41.1	181.6	69.2	42.1	12.1	5.7	379
1999	1	11.0	26.6	74.9	56.8	131.6	30.2	22.1	6.3	359
2000	1	5.4	58.8	62.9	117.9	91.3	122.6	46.4	52.4	558
2001	1	5.4	32.2	176.1	126.8	119.8	50.7	72.3	34.7	618
2002	1	6.9	52.2	84.9	264.3	59.6	61.2	28.0	52.1	609
2003	1	4.0	105.9	161.7	107.3	154.7	99.8	82.6	51.1	767
2004	1	2.4	5.8	141.8	105.4	135.3	169.6	54.5	74.8	690
2005	1	13.4	38.6	103.3	305.7	145.9	82.1	145.8	49.0	884
2006	1	0.3	53.5	99.2	86.9	202.3	116.9	103.9	97.7	761
2007	1	3.5	11.2	206.8	161.8	109.1	165.6	110.7	58.0	827
2008	1	15.8	81.1	46.3	266.0	149.1	90.8	135.6	83.9	868
2009	1	51.1	158.6	134.4	79.0	196.5	55.0	34.0	78.9	787
2010	1	45.4	155.5	179.5	89.8	34.0	161.7	33.4	16.7	716
2011 [1]	1	3.2	50.6	100.1	212.3	126.5	50.3	125.1	47.0	715

[1] Provisional figures.

Table 5.2.2 Saithe in Sub-areas I and II (Northeast Arctic).
Acoustic abundance indices from Norwegian surveys in October-November.
In 1985 - 1991 the area coverage was incomplete. Numbers in millions.
Shaded area shows indices applied in the assessment

Year	Age									
	2	3	4	5	6/6+	7	8	9	10+	Total
1985	3.1	4.9	2.4	0.5	0.0					10.9
1986	19.5	40.8	3.6	1.8	1.8					67.5
1987	1.8	22.0	48.4	1.8	1.7					75.7
1988	15.7	22.5	19.0	7.1	0.6					64.9
1989	24.8	28.4	17.0	10.1	12.4					92.7
1990	99.6	31.9	14.7	5.1	7.4					158.7
1991	87.8	104.0	4.6	4.0	7.1					207.5
1992	163.5	273.6	57.5	6.2	8.8					509.6
1993	106.9	227.7	103.9	12.7	3.2					454.4
1994	35.1	87.1	108.9	41.4	8.1	0.7	1.0	0.5	1.0	283.8
1995	38.4	166.1	86.5	46.5	16.5	2.4	0.0	0.0	1.0	357.5
1996	48.8	122.6	207.4	31.7	15.1	4.0	0.5	0.0	0.0	430.0
1997	5.5	38.0	184.8	79.8	50.6	9.6	1.2	0.0	0.3	369.8
1998	44.0	96.7	202.6	69.3	84.3	6.6	3.8	0.7	0.1	508.1
1999	61.1	233.8	72.9	62.2	21.0	19.2	5.9	1.4	0.4	477.8
2000	164.8	142.5	176.3	11.6	11.5	8.0	4.0	1.0	2.0	521.7
2001	104.7	275.9	45.9	53.8	5.6	6.1	3.2	3.4	1.9	500.5
2002	25.5	230.2	92.6	18.9	10.6	2.2	0.9	0.8	1.2	382.9
2003	31.0	87.5	151.7	26.1	6.2	6.4	1.2	0.7	1.3	312.1
2004	152.2	212.4	118.7	49.1	19.2	4.7	3.0	3.1	3.1	565.5
2005	22.2	228.1	67.2	20.3	16.5	7.7	2.2	1.7	0.9	366.7
2006	98.2	42.6	142.9	19.4	4.6	8.5	5.6	2.1	3.5	327.3
2007	45.4	111.0	27.1	61.1	7.9	5.8	4.1	4.3	1.1	267.9
2008	55.6	97.2	29.2	13.8	11.9	4.0	1.0	1.0	1.6	215.3
2009	52.9	139.8	80.2	7.7	5.2	6.8	0.9	0.7	1.7	295.9
2010	7.8	185.7	31.0	22.2	4.0	1.9	3.3	0.3	1.4	257.7
2011	12.8	46.9	77.7	5.2	5.7	1.0	3.3	2.0	0.1	154.7

Table 5.3.1 Catch numbers at age North-East Arctic saithe

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

YEAR	1960	1961
AGE		
3	13517	25237
4	16828	12929
5	17422	17707
6	6514	5379
7	6281	1886
8	3088	1371
9	1691	736
10	956	573
11	481	538
12	363	275
13	260	112
14	185	89
+gp	673	726
0 TOTALNUM	68259	67558
TONSLAND	133515	105951
SOPCOF %	100	100

YEAR	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
AGE										
3	45932	51171	10925	42578	25127	28457	29955	76011	43834	61743
4	13720	35199	72344	5737	61199	23826	21856	11745	63270	47522
5	5449	7165	15966	30171	14727	34493	6065	16650	14081	21614
6	10218	5659	3299	11635	14475	3957	9846	4666	16298	7661
7	2991	4699	4214	3282	5220	5388	936	4716	5157	7690
8	1262	1337	3223	2421	1542	2797	2274	1107	8004	2326
9	1156	1308	1518	3135	1047	1356	1070	1682	2521	3489
10	556	848	1482	802	1083	1340	686	663	3722	1760
11	611	550	1282	1136	530	814	465	199	1103	2514
12	369	467	965	652	628	603	284	138	762	1045
13	282	399	561	509	670	528	168	30	325	284
14	224	166	443	802	497	391	156	47	278	186
+gp	643	580	1069	1023	929	1014	314	88	349	373
0 TOTALNUM	83413	109548	117291	103883	127674	104964	74075	117742	159704	158207
TONSLAND	120707	148627	197426	185600	203788	181326	110247	140060	264924	241272
SOPCOF %	100	100	100	100	100	100	100	100	100	100

YEAR	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
AGE										
3	55351	62938	36884	70255	135592	105935	56505	75819	40303	85966
4	44490	20793	44149	13502	33159	36703	31946	28545	36202	22345
5	24752	22199	15714	18901	8618	10845	14396	17280	9100	22044
6	8650	13224	20476	5123	9448	2205	5232	5384	6302	3706
7	4769	5868	12182	9018	3725	4633	1694	3550	3161	2611
8	3012	3246	4815	7841	3483	1557	2132	1178	1322	2056
9	1584	2368	3267	3365	2905	1718	1082	1659	145	378
10	1817	2153	2512	2714	1870	1030	1126	536	721	286
11	1044	1291	1440	2237	1183	495	756	373	406	258
12	676	653	1448	1438	924	261	786	344	449	91
13	281	670	433	530	530	226	328	206	254	147
14	222	365	264	300	152	62	267	272	236	97
+gp	452	259	247	276	334	169	345	264	265	50
0 TOTALNUM	147100	136027	143831	135500	201923	165839	116595	135410	98866	140035
TONSLAND	214334	213859	264121	233453	242486	182817	155464	164680	144554	175540
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 5.3.1 continue

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

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
AGE										
3	35853	18216	43579	48989	21322	18555	8144	12607	23792	68682
4	67150	25108	34927	11992	12433	51742	35928	19400	16930	13630
5	13481	34543	12679	7200	5845	4506	32901	33343	9054	5752
6	8477	3408	11775	5287	4363	3238	4570	18578	10238	4883
7	1088	3178	1193	3746	2704	3624	2333	1762	7341	3877
8	1291	1243	1862	776	1349	784	1222	352	1076	2381
9	476	803	589	879	338	644	968	177	160	383
10	271	261	585	134	438	267	321	189	112	61
11	124	215	407	274	123	263	73	1	150	90
12	116	130	158	214	65	164	12	149	37	68
13	78	170	123	55	30	154	2	0	31	1
14	100	99	179	126	54	102	15	36	0	12
+gp	44	188	77	32	3	145	1	20	50	8
0 TOTALNUM	128549	87562	108133	79704	49067	84188	86490	86614	68971	99828
TONSLAND	168034	156936	158786	107183	67396	92391	114242	122817	95848	107327
SOPCOF %	100	100	100	100	100	100	100	105	102	101

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
3	44627	22812	7063	17178	10510	11789	3091	9655	9175	3816
4	33294	61931	32671	52109	54886	11698	16215	12236	22768	7946
5	5987	31102	49410	40145	18499	35011	11946	22872	7747	26960
6	5412	3747	19058	30451	18357	13567	31818	10347	10676	8769
7	4751	1759	2058	4177	17834	13452	8376	18930	6123	7120
8	3176	1378	724	483	2849	7058	5539	3374	8303	3146
9	1462	1027	421	125	485	812	2873	3343	2530	4687
10	286	797	278	259	214	55	727	2290	2652	1935
11	93	76	528	31	148	48	111	419	1022	1406
12	46	35	92	176	68	42	65	103	151	433
13	163	1	13	2	196	27	19	24	8	60
14	0	17	15	42	59	21	0	11	25	8
+gp	141	18	9	43	2	8	198	32	13	27
0 TOTALNUM	99438	124700	112340	145221	124107	93588	80978	83636	71193	66313
TONSLAND	127604	154903	146950	168378	171348	143629	153327	150375	135928	135853
SOPCOF %	105	101	100	100	100	100	100	100	101	100

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE										
3	6582	2345	1002	26093	1590	3144	25259	9050	26484	6783
4	17492	50653	6129	12543	68137	4115	18953	34311	43684	42983
5	11573	13600	33840	9841	12328	39889	5969	9954	28723	11361
6	25671	7123	10613	23141	10098	15301	24363	6628	8070	15274
7	5312	9594	7494	10799	16757	7963	9712	15930	3158	7096
8	4276	5494	8307	5659	8080	11302	5624	4766	12551	3012
9	2382	3545	2792	7852	5671	7749	7697	3021	2771	6319
10	3431	2519	3088	2674	5127	4138	4705	4224	1324	1925
11	965	2327	2377	713	1815	2157	1606	2471	1220	901
12	1016	1112	2057	387	1013	505	1163	993	792	649
13	281	420	338	465	733	254	145	234	400	383
14	68	170	536	357	506	52	108	96	120	219
+gp	55	111	141	379	277	38	156	103	131	125
0 TOTALNUM	79104	99013	78714	100903	132132	96607	105460	91781	129428	97030
TONSLAND	154870	161592	164636	178568	212822	199008	184740	161853	194837	156686
SOPCOF %	100	100	100	100	100	100	102	100	100	100

Table 5.3.2 Catch weights at age North-East Arctic saithe

Table 2 Catch weights at age (kg)

	YEAR	1960	1961
	AGE		
	3	0.71	0.71
	4	1.11	1.11
	5	1.63	1.63
	6	2.33	2.33
	7	3.16	3.16
	8	4.03	4.03
	9	4.87	4.87
	10	5.63	5.63
	11	6.44	6.44
	12	7.11	7.11
	13	7.82	7.82
	14	8.92	8.92
	+gp	9.5	9.5
0	SOPCOFAC	1	1

	YEAR	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
	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	SOPCOFAC	1.0001	1	1	1	1	1	0.9999	1	1	0.9999
	1										

	YEAR	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
	AGE										
	3	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.79	0.73
	4	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.27	1.4
	5	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	2.03	2.05
	6	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.55	2.76
	7	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.16	3.29	3.3
	8	4.03	4.03	4.03	4.03	4.03	4.03	4.03	4.03	4.34	4.38
	9	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.87	5.15	5.95
	10	5.63	5.63	5.63	5.63	5.63	5.63	5.63	5.63	5.75	6.39
	11	6.44	6.44	6.44	6.44	6.44	6.44	6.44	6.44	6.11	6.61
	12	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	5.94	6.88
	13	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	6.64	6.75
	14	8.92	8.92	8.92	8.92	8.92	8.92	8.92	8.92	7.73	7.13
	+gp	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.47	7.66
0	SOPCOFAC	1	0.9996	1	1	1	1	1	1	1	0.9999

Table 5.3.2 continue

Table 2 Catch weights at age (kg)

	YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	AGE										
	3	0.77	1.05	0.71	0.75	0.59	0.53	0.62	0.74	0.71	0.68
	4	1.12	1.33	1.26	1.33	1.22	0.84	0.87	0.95	1	1.05
	5	2.02	1.86	2.02	2.07	1.97	1.66	1.31	1.4	1.45	1.85
	6	2.61	2.8	2.7	2.63	2.3	2.32	2.43	1.78	2.09	2.39
	7	3.27	4	3.88	3.28	2.87	2.97	3.87	2.96	2.49	3.08
	8	3.91	4.18	4.47	3.96	3.72	4	5.38	3.73	3.75	3.35
	9	4.69	5.33	5.36	4.54	4.3	4.72	5.83	4.62	3.9	4.48
	10	5.63	5.68	6.06	5.55	4.69	5.44	5.36	4.66	6.74	4.66
	11	7.18	7.31	6.28	6.88	5.84	5.79	6.92	8.34	4.94	5.62
	12	7.21	8.68	6.89	8.14	6.39	6.28	8.72	6.77	4.93	6.3
	13	7	8.54	8.2	6.06	8.11	7.02	7.88	10.04	8.2	6.73
	14	8.03	8.57	9.14	9.66	7.55	8.36	8.94	9.13	8.2	11.55
	+gp	9.44	10.37	6.47	13.72	10.08	8.48	10	11.95	8.59	9.58
0	SOPCOFAC	1	1	0.9999	0.9997	1	0.9999	0.9999	1.0469	1.0235	1.0087

	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	AGE										
	3	0.67	0.61	0.52	0.56	0.59	0.62	0.68	0.67	0.6	0.75
	4	1.01	0.99	0.76	0.79	0.82	0.95	1	1.05	1.03	1.12
	5	1.92	1.65	1.24	1.19	1.33	1.24	1.48	1.45	1.63	1.54
	6	2.28	2.46	2.12	1.71	1.84	1.72	1.87	1.93	2.1	2.04
	7	2.77	2.85	3.22	2.87	2.48	2.35	2.58	2.27	2.67	2.6
	8	3.2	3.03	3.83	3.78	3.73	3.1	3.07	2.97	3.14	3.14
	9	3.73	3.71	4.69	4.06	4.32	4.19	4.13	3.61	3.81	3.63
	10	6.35	4.49	5.31	5.3	5.34	5.79	5.44	4.1	4.41	4.54
	11	6.9	5.56	5.66	6.86	5.98	6.77	6.7	4.93	5.76	5.05
	12	7.18	6.56	6.91	6.59	6.26	6.62	4.97	6.59	7.3	5.82
	13	6.88	10.56	6.3	7.88	7.36	7.3	5.23	7.52	9.95	6.4
	14	7.5	6.73	9.45	9.16	9.61	9.15	6.8	7.88	10.56	7.88
	+gp	9.14	8.41	8.95	10.53	13.64	11.48	10.1	7.46	11.08	10.84
0	SOPCOFAC	1.0517	1.0107	1	0.999	1.0019	1.0011	1.0015	1.0015	1.0051	1.001

	YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	AGE										
	3	0.69	0.66	0.7	0.59	0.63	0.73	0.63	0.73	0.7	0.7
	4	1.01	0.91	1.03	0.89	0.83	1.08	0.98	1.03	0.99	0.8
	5	1.5	1.42	1.37	1.49	1.43	1.41	1.38	1.65	1.45	1.36
	6	1.97	1.89	1.9	2.09	1.78	1.86	1.92	2	2.14	2.03
	7	2.54	2.54	2.41	2.16	2.27	2.43	2.31	2.37	2.5	2.56
	8	3.25	2.58	2.98	2.99	2.73	2.94	2.83	2.69	3.13	3.11
	9	3.77	3.49	3.44	3.24	3.02	3.35	3.16	3.23	3.34	3.56
	10	4.31	3.75	3.73	3.82	3.9	3.66	3.43	3.38	3.81	4.14
	11	4.91	4.12	4.14	3.92	4.06	4.17	3.82	3.46	3.99	4.79
	12	5.69	5.27	5.09	5.14	5.05	5.04	4.09	4.25	4.33	5.91
	13	6.19	5.94	5.96	6.26	5.79	6.07	5.03	4.88	5.38	5.71
	14	7.56	6.49	5.99	6.76	6.01	5.23	5.97	5.65	8.46	6.8
	+gp	11.71	11.21	7.91	6.62	8.35	9.14	8.56	7.33	6.63	5.89
0	SOPCOFAC	1.001	1.0033	1.0031	1.0026	1.0017	1.0009	1.0155	1.0025	1.0016	1.0034

Table 5.3.3. Saithe in Sub-areas I and II (Northeast Arctic).3-year running average maturity ogive 1985-2011.

Year	3	4	5	6	7	8	9	10	11+	12	13	14	15+
1985		0.02	0.50	0.92	0.99	1.00	1	1	1	1	1	1	1
1986		0.02	0.51	0.94	0.99	1.00	1	1	1	1	1	1	1
1987			0.35	0.98	1.00	1.00	1	1	1	1	1	1	1
1988			0.25	0.96	1.00	1	1	1	1	1	1	1	1
1989			0.15	0.92	1.00	1	1	1	1	1	1	1	1
1990			0.20	0.85	0.99	1.00	1	1	1	1	1	1	1
1991		0.02	0.25	0.84	0.98	1.00	1	1	1	1	1	1	1
1992		0.02	0.30	0.83	0.93	0.92	0.90	0.95	1	1	1	1	1
1993		0.02	0.26	0.88	0.92	0.89	0.87	0.89	1	0.98	1	1	1
1994		0.02	0.26	0.84	0.90	0.82	0.87	0.89	1	0.98	1	1	1
1995		0.02	0.22	0.80	0.92	0.90	0.97	0.94	1	0.98	1	1	1
1996		0.03	0.21	0.65	0.91	0.93	1	1	1	1	1	1	1
1997		0.03	0.14	0.45	0.83	0.94	0.93	0.97	1	1	1	1	1
1998		0.04	0.07	0.33	0.74	0.93	0.92	0.96	1	1	1	1	1
1999			0.08	0.32	0.74	0.92	0.92	0.96	0.99	0.97	1	1	1
2000			0.08	0.46	0.82	0.96	0.98	0.99	0.97	0.94	1	1	1
2001			0.11	0.64	0.93	0.97	0.98	0.99	0.97	0.93	1	1	1
2002			0.13	0.78	0.95	0.98	0.98	0.99	0.98	0.96	1	1	1
2003			0.14	0.82	0.96	0.98	0.98	0.99	1.00	0.98	1	1	1
2004			0.21	0.80	0.97	0.99	1	1	1	1	1	1	1
2005		0.03	0.30	0.82	0.97	0.99	1	1	1	1	1	1	1
2006		0.04	0.40	0.86	0.98	0.99	1	1	1	1	1	1	1
2007		0.05	0.42	0.87	0.97	0.98	1	0.97	1	1	1	1	1
2008		0.05	0.34	0.83	0.95	0.99	0.99	0.97	0.98	0.99	1	1	1
2009		0.03	0.27	0.70	0.91	0.97	0.98	0.97	0.98	0.99	1	1	1
2010		0.02	0.20	0.57	0.84	0.94	0.99	1	0.99	1	0.99	1	1
2011		0.02	0.19	0.46	0.80	0.91	0.98	1	0.99	1	0.99	1	1

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

```
North-East Arctic saithe (Sub-areas I and II)
104
FLT11: Nor trawl revised 2010 (Catch: Unknown) (Effort: Un-
known)
1994 2001
1 1 0.00 1.00
4  8
   1     83.2   280.2   174.0    24.0     5.3
   1    150.0   208.3   226.3    35.9     5.9
   1     84.7   113.2   164.7   217.1    24.9
   1     28.5   148.3   151.1   194.4   122.3
   1     24.5    41.1   181.6    69.2    42.1
   1     26.6    74.9    56.8   131.6    30.2
   1     58.8    62.9   117.9    91.3   122.6
   1     32.2   176.1   126.8   119.8    50.7
FLT12: Nor trawl revised 2010 (Catch: Unknown) (Effort: Un-
known)
2002 2011
1 1 0.00 1.00
4  8
   1     52.2    84.9   264.3    59.6    61.2
   1    105.9   161.7   107.3   154.7    99.8
   1      5.8   141.8   105.4   135.3   169.6
   1     38.6   103.3   305.7   145.9    82.1
   1     53.5    99.2    86.9   202.3   116.9
   1     11.2   206.8   161.8   109.1   165.6
   1     81.1    46.3   266.0   149.1    90.8
   1    158.6   134.4    79.0   196.5    55.0
   1    155.5   179.5    89.8    34.0   161.7
   1     50.6   100.1   212.3   126.5    50.3
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 2011
1 1 0.75 0.85
3  7
   1   230.2    92.6    18.9    10.6     2.2
   1    87.5   151.7    26.1     6.2     6.4
   1   212.4   118.7    49.1    19.2     4.7
   1   228.1    67.2    20.3    16.5     7.7
   1    42.6   142.9    19.4     4.6     8.5
   1   111.0    27.1    61.1     7.9     5.8
   1    97.2    29.2    13.8    11.9     4.0
   1   139.8    80.2     7.7     5.2     6.8
   1   185.7    31.0    22.0     4.0     1.9
   1    46.9    77.7     5.2     5.7     1.0
```

Table 5.4.1. Northeast Arctic saithe. Data and parameter settings of exploratory and final XSA-runs.

Run No.	1	2	3	4	5
Ass. type	UPDATE	SFT	SFT	SPALY	FINAL
Catch data	1960-2010	1960-2011	1960-2011	1960-2011	1960-2011
Age range	3-15+	3-15+	3-15+	3-15+	3-15+
F bar	4-7	4-7	4-7	4-7	4-7
Fleet 11 Norw. trawl	1994-2001 age 4-8 Q1-4	1994-2001 age 4-8 Q1-4		1994-2001 age 4-8 Q1-4	1994-2001 age 4-8 Q1-4
Fleet 12 Norw. trawl	2002-2010 age 4-8 Q1-4	2002-2011 age 4-8 Q1-4		2002-2011 age 4-8 Q1-4	2002-2011 age 4-8 Q1-4
Fleet 13 ac. survey	1994-2001 age 3-7		1994-2001 age 3-7	1994-2001 age 3-7	1994-2001 age 3-7
Fleet 14 ac. survey	2002-2010 age 3-7		2002-2011 age 3-7	2002-2011 age 3-7	2002-2011 age 3-7
Time series weights	No	No	No	No	No
Power model	No	No	No	No	No
Catchability (q) plateau	8	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	5 years 5 oldest ages
SE of mean	1.5	1.5	1.5	1.5	1.5
Min. fleet SE for pop. Est.	0.3	0.3	0.3	0.3	0.3
Prior weight.	None	None	None	None	None
Iterations	30	30	30	30	123 (conv.)

Table 5.5.1. NeA saithe, Tuning diagnostics

Lowestoft VPA Version 3.1
18/04/2012 9:21

Extended Survivors Analysis

North-East Arctic saithe

CPUE data from file flt-split.dat

Catch data for 52 years. 1960 to 2011. Ages 3 to 15.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLT11: No	1994	2011	4	8	0	1
FLT12: No	2002	2011	4	8	0	1
FLT13: No	1994	2011	3	7	0.75	0.85
FLT14: No	2002	2011	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 converged after 123 iterations

1

Regression weights

1	1	1	1	1	1	1	1	1	1

Table 5.5.1. Continued

Fishing mortalities

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	0.022	0.02	0.007	0.075	0.025	0.032	0.124	0.077	0.129	0.116
4	0.131	0.23	0.066	0.118	0.288	0.082	0.275	0.246	0.64	0.318
5	0.156	0.142	0.237	0.144	0.163	0.272	0.164	0.227	0.336	0.335
6	0.342	0.136	0.157	0.253	0.215	0.314	0.266	0.277	0.291	0.3
7	0.212	0.206	0.207	0.238	0.294	0.263	0.336	0.279	0.206	0.45
8	0.267	0.353	0.276	0.239	0.281	0.331	0.3	0.274	0.37	0.309
9	0.229	0.371	0.305	0.458	0.401	0.479	0.395	0.261	0.253	0.323
10	0.334	0.403	0.65	0.54	0.623	0.579	0.608	0.393	0.174	0.281
11	0.252	0.397	0.85	0.299	0.902	0.587	0.465	0.77	0.186	0.172
12	0.384	0.518	0.748	0.31	0.925	0.689	0.746	0.592	0.605	0.143
13	0.28	0.27	0.29	0.367	1.831	0.628	0.427	0.318	0.507	0.676
14	0.269	0.273	0.659	0.57	0.891	0.605	0.605	0.564	0.267	0.583

XSA population numbers (Thousands)

YEAR	AGE 3	4	5	6	7	8	9	10	11	12
2002	3.40E+05	1.58E+05	8.84E+04	9.80E+04	3.08E+04	2.02E+04	1.29E+04	1.34E+04	4.78E+03	3.52E+03
2003	1.32E+05	2.72E+05	1.14E+05	6.19E+04	5.70E+04	2.04E+04	1.26E+04	8.39E+03	7.84E+03	3.04E+03
2004	1.53E+05	1.06E+05	1.77E+05	8.06E+04	4.42E+04	3.80E+04	1.17E+04	7.14E+03	4.59E+03	4.32E+03
2005	3.97E+05	1.24E+05	8.13E+04	1.14E+05	5.64E+04	2.94E+04	2.36E+04	7.08E+03	3.05E+03	1.61E+03
2006	7.23E+04	3.01E+05	9.03E+04	5.77E+04	7.26E+04	3.64E+04	1.90E+04	1.22E+04	3.38E+03	1.85E+03
2007	1.10E+05	5.78E+04	1.85E+05	6.28E+04	3.81E+04	4.43E+04	2.25E+04	1.04E+04	5.37E+03	1.12E+03
2008	2.40E+05	8.71E+04	4.36E+04	1.15E+05	3.76E+04	2.40E+04	2.60E+04	1.14E+04	4.77E+03	2.44E+03
2009	1.35E+05	1.74E+05	5.42E+04	3.03E+04	7.23E+04	2.20E+04	1.45E+04	1.44E+04	5.08E+03	2.45E+03
2010	2.42E+05	1.02E+05	1.11E+05	3.53E+04	1.88E+04	4.48E+04	1.37E+04	9.17E+03	7.93E+03	1.93E+03
2011	6.82E+04	1.75E+05	4.41E+04	6.51E+04	2.16E+04	1.25E+04	2.53E+04	8.69E+03	6.31E+03	5.39E+03

Estimated population abundance at 1st Jan 2012

0.00E+00	4.97E+04	1.04E+05	2.58E+04	3.95E+04	1.13E+04	7.53E+03	1.50E+04	5.38E+03	4.35E+03

Taper weighted geometric mean of the VPA populations:

1.66E+05	1.07E+05	5.99E+04	3.37E+04	1.89E+04	1.07E+04	6.25E+03	3.63E+03	2.02E+03	1.12E+03

Standard error of the weighted Log(VPA populations) :

0.4875	0.5527	0.634	0.7174	0.8026	0.925	1.0443	1.1109	1.2247	1.3603

YEAR	AGE 13	14
2002	1.27E+03	3.18E+02
2003	1.96E+03	7.85E+02
2004	1.48E+03	1.23E+03
2005	1.67E+03	9.08E+02
2006	9.65E+02	9.48E+02
2007	6.02E+02	1.27E+02
2008	4.61E+02	2.63E+02
2009	9.49E+02	2.46E+02
2010	1.11E+03	5.65E+02
2011	8.61E+02	5.48E+02

Estimated population abundance at 1st Jan 2012

3.83E+03	3.59E+02

Taper weighted geometric mean of the VPA populations:

6.15E+02	4.15E+02

Table 5.5.1. Continued

Standard error of the weighted Log(VPA populations) :

	1.7804	2.0501
1		

Log catchability residuals.

Fleet : FLT11: Nor trawl rev

Age	1994	1995	1996	1997	1998	1999	2000	2001
3	No data for this fleet at this age							
4	0.21	1.13	-0.05	-0.18	-0.54	-0.17	-0.18	-0.23
5	0.54	0.41	0.21	-0.24	-0.65	-0.18	-0.17	0.09
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	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	No data for this fleet at this age									
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99

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	-7.8314	-6.6295	-5.8033	-5.4422	-5.6363
S.E(Log q)	0.5025	0.387	0.455	0.3958	0.4366

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	0.72	8.93	0.55	8	0.38	-7.83
5	0.65	1.569	8.36	0.77	8	0.23	-6.63
6	1.9	-1.032	1.08	0.18	8	0.86	-5.8
7	1.25	-1.139	4.26	0.78	8	0.48	-5.44
8	1.04	-0.243	5.49	0.86	8	0.49	-5.64

Fleet : FLT12: Nor trawl rev

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	No data for this fleet at this age									
4	-0.11	0.1	-1.94	-0.18	-0.66	-0.67	0.99	0.96	1.65	-0.15
5	-0.35	0.04	-0.49	-0.08	-0.21	-0.14	-0.24	0.63	0.25	0.59
6	0.23	-0.31	-0.58	0.18	-0.41	0.17	0.04	0.16	0.14	0.4
7	-0.42	-0.09	0.04	-0.12	-0.02	0	0.36	-0.05	-0.49	0.79
8	-0.17	0.35	0.22	-0.26	-0.1	0.07	0.07	-0.36	0.05	0.13

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	-7.7447	-6.4259	-5.8829	-5.6285	-5.4054
S.E(Log q)	1.0186	0.382	0.3208	0.3651	0.2206

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	1.05	-0.072	7.53	0.18	10	1.14	-7.74
5	1.64	-1.746	3.24	0.48	10	0.57	-6.43
6	1.04	-0.143	5.69	0.65	10	0.35	-5.88
7	1.08	-0.255	5.25	0.59	10	0.41	-5.63
8	1	-0.007	5.4	0.78	10	0.23	-5.41
1							

Fleet : FLT13: Norway Ac Sur

Age	1994	1995	1996	1997	1998	1999	2000	2001
3	-0.47	-0.36	0.34	-1.04	0.18	0.28	0.35	0.72
4	-0.4	-0.22	-0.02	0.79	0.68	-0.06	0.02	-0.79
5	-0.35	-0.07	-0.09	0.11	0.83	0.63	-0.92	-0.13
6	-0.01	-0.42	-0.47	1.09	0.91	0.3	-0.38	-1.04
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	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	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	-7.115	-6.8254	-7.4578	-7.6628	-8.1102
S.E(Log q)	0.575	0.5242	0.5485	0.7289	0.324

Table 5.5.1. Continued

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	1.47	-0.501	4.77	0.16	8	0.89	-7.12
4	1.51	-0.628	4.24	0.2	8	0.83	-6.83
5	1.16	-0.245	6.78	0.28	8	0.69	-7.46
6	0.69	0.584	8.71	0.37	8	0.53	-7.66
7	0.97	0.23	8.18	0.88	8	0.34	-8.11

Fleet : FLT14: Norway Ac Sur

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	-0.12	-0.14	0.59	-0.24	-0.25	0.29	-0.55	0.35	0.09	-0.03
4	0.08	0.11	0.67	-0.01	-0.01	-0.18	-0.37	-0.07	-0.17	-0.05
5	-0.07	-0.01	0.25	0.07	-0.06	0.46	0.33	-0.42	-0.01	-0.53
6	-0.04	-0.28	0.6	0.18	-0.45	0.09	-0.15	0.37	-0.04	-0.28
7	-0.38	0.07	0.01	0.29	0.18	0.42	0.12	-0.05	-0.04	-0.62
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	-7.003	-7.2554	-8.0923	-8.658	-8.8382
S.E(Log q)	0.3375	0.2738	0.3071	0.3201	0.3067

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	1.15	-0.689	6.25	0.72	10	0.4	-7
4	0.9	0.587	7.71	0.82	10	0.26	-7.26
5	0.74	2.084	8.95	0.89	10	0.19	-8.09
6	1.04	-0.151	8.56	0.65	10	0.35	-8.66
7	0.74	1.761	9.3	0.85	10	0.21	-8.84

Terminal year survivor and F summaries :

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

Year class = 2008

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	1	0	0	0	0	0	0
FLT13: No	1	0	0	0	0	0	0
FLT14: No	48423	0.354	0	0	1	0.941	0.119
F shrinka	76234	1.5				0.059	0.077

Table 5.5.1. Continued

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
49734	0.34	0.11	2	0.32	0.116

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

Year class = 2007

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	89201	1.068	0	0	1	0.045	0.362
FLT13: No	1	0	0	0	0	0	0
FLT14: No	104660	0.229	0.068	0.3	2	0.924	0.316
F shrinka	107854	1.5				0.031	0.308

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
104013	0.22	0.04	4	0.19	0.318

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

Year class = 2006

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	50292	0.38	0.267	0.7	2	0.251	0.186
FLT13: No	1	0	0	0	0	0	0
FLT14: No	20274	0.197	0.237	1.2	3	0.726	0.41
F shrinka	39031	1.5				0.023	0.234

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
25847	0.18	0.23	6	1.294	0.335

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

Year class = 2005

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	57160	0.254	0.093	0.37	3	0.342	0.217
FLT13: No	1	0	0	0	0	0	0
FLT14: No	32318	0.169	0.108	0.64	4	0.643	0.356
F shrinka	43837	1.5				0.015	0.274

Weighted prediction :

Survivors at end of y	Int s.e	Ext s.e	N	Var Ratio	F
39455	0.14	0.12	8	0.853	0.3

Table 5.5.1. Continued

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

Year class = 2004

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	18974	0.215	0.174	0.81	4	0.359	0.291
FLT13: No	1	0	0	0	0	0	0
FLT14: No	8266	0.153	0.151	0.99	5	0.626	0.575
F shrinka	20108	1.5				0.014	0.277

Weighted prediction :

Survivors at end of '	Int s.e	Ext s.e	N	Var Ratio	F
11284	0.12	0.17	10	1.342	0.45

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

Year class = 2003

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	7117	0.177	0.138	0.78	5	0.479	0.324
FLT13: No	1	0	0	0	0	0	0
FLT14: No	7934	0.149	0.122	0.82	5	0.51	0.295
F shrinka	7408	1.5				0.011	0.313

Weighted prediction :

Survivors at end of '	Int s.e	Ext s.e	N	Var Ratio	F
7526	0.12	0.08	11	0.727	0.309

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

Year class = 2002

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	14975	0.18	0.049	0.27	5	0.507	0.323
FLT13: No	1	0	0	0	0	0	0
FLT14: No	15150	0.154	0.112	0.73	5	0.474	0.32
F shrinka	13184	1.5				0.018	0.36

Weighted prediction :

Survivors at end of '	Int s.e	Ext s.e	N	Var Ratio	F
15022	0.12	0.05	11	0.449	0.323

Table 5.5.1. Continued

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 2001

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	4916	0.181	0.149	0.82	5	0.494	0.303
FLT13: No	1	0	0	0	0	0	0
FLT14: No	6049	0.15	0.099	0.66	5	0.485	0.253
F shrinka	2834	1.5				0.021	0.479

Weighted prediction :

Survivors at end of '	Int s.e	Ext s.e	N	Var Ratio	F
5375	0.12	0.09	11	0.761	0.281

Age 11 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 2000

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	3925	0.177	0.153	0.86	5	0.471	0.189
FLT13: No	1	0	0	0	0	0	0
FLT14: No	5069	0.148	0.199	1.35	5	0.508	0.149
F shrinka	1021	1.5				0.02	0.587

Weighted prediction :

Survivors at end of '	Int s.e	Ext s.e	N	Var Ratio	F
4350	0.12	0.14	11	1.17	0.172

Age 12 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 1999

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	3862	0.179	0.096	0.54	5	0.49	0.142
FLT13: No	1	0	0	0	0	0	0
FLT14: No	4425	0.152	0.053	0.35	5	0.472	0.125
F shrinka	559	1.5				0.038	0.718

Weighted prediction :

Survivors at end of '	Int s.e	Ext s.e	N	Var Ratio	F
3827	0.13	0.13	11	1.056	0.143

Table 5.5.1. Continued

Age 13 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 1998

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	1	0	0	0	0	0	0
FLT12: No	295	0.176	0.107	0.61	5	0.4	0.777
FLT13: No	737	0.61	0	0	1	0.02	0.385
FLT14: No	459	0.162	0.132	0.82	4	0.375	0.562
F shrinka	311	1.5				0.205	0.75

Weighted prediction :

Survivors at end of '	Int s.e	Ext s.e	N	Var Ratio	F
359	0.32	0.1	11	0.3	0.676

1

Age 14 Catchability constant w.r.t. time and age (fixed at the value for age) 8

Year class = 1997

Fleet	E S	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT11: No	199	0.533	0	0	1	0.03	0.69
FLT12: No	200	0.177	0.079	0.45	4	0.412	0.689
FLT13: No	187	0.411	0.569	1.38	2	0.05	0.723
FLT14: No	226	0.19	0.089	0.47	3	0.309	0.63
F shrinka	524	1.5				0.199	0.321

Weighted prediction :

Survivors at end of '	Int s.e	Ext s.e	N	Var Ratio	F
251	0.31	0.14	11	0.452	0.583

Table 5.5.2 Northeast Arctic saithe. Fishing mortality

Run title : North-East Arctic saithe

At 18/04/2012 9:24

Table 8 Fishing mortality (F) at age

YEAR	1960	1961
AGE		
3	0.1764	0.3116
4	0.1981	0.2554
5	0.4885	0.3307
6	0.2605	0.2712
7	0.312	0.1112
8	0.2064	0.1027
9	0.1229	0.0691
10	0.1318	0.0556
11	0.127	0.1019
12	0.0948	0.0994
13	0.1557	0.0382
14	0.1269	0.073
+gp	0.1269	0.073
0 FBAR 4-	0.3148	0.2421

Table 8 Fishing mortality (F) at age

YEAR	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
AGE										
3	0.2866	0.2035	0.1355	0.1784	0.2218	0.1719	0.2385	0.34	0.2034	0.3009
4	0.2781	0.3719	0.4937	0.0977	0.4199	0.3391	0.1935	0.1381	0.5305	0.3548
5	0.1622	0.2288	0.2872	0.3933	0.3884	0.4451	0.1341	0.2215	0.2444	0.3453
6	0.3233	0.2528	0.1561	0.3511	0.3318	0.1693	0.2175	0.1448	0.3516	0.2033
7	0.2377	0.2413	0.3033	0.2298	0.262	0.1971	0.0548	0.1533	0.2362	0.2782
8	0.1011	0.1584	0.2595	0.2859	0.1605	0.2182	0.1191	0.0848	0.4207	0.1588
9	0.1181	0.1446	0.2718	0.434	0.1922	0.207	0.121	0.1214	0.2828	0.3264
10	0.0683	0.1192	0.2424	0.2251	0.2604	0.4023	0.1533	0.1024	0.4288	0.3266
11	0.0774	0.0892	0.2661	0.2968	0.2279	0.3189	0.2356	0.0605	0.2473	0.5829
12	0.0941	0.0781	0.2232	0.21	0.2657	0.4395	0.1745	0.1013	0.3448	0.3924
13	0.1402	0.1397	0.127	0.1756	0.3471	0.3748	0.208	0.0249	0.366	0.2075
14	0.0999	0.1145	0.2272	0.2698	0.26	0.3507	0.1792	0.0823	0.336	0.3696
+gp	0.0999	0.1145	0.2272	0.2698	0.26	0.3507	0.1792	0.0823	0.336	0.3696
0 FBAR 4-	0.2503	0.2737	0.3101	0.268	0.3505	0.2876	0.15	0.1644	0.3407	0.2954

Table 8 Fishing mortality (F) at age

YEAR	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
AGE										
3	0.5092	0.3911	0.5762	0.6076	0.88	0.7566	0.6175	0.5215	0.4996	0.4079
4	0.3696	0.3633	0.5277	0.4283	0.6577	0.6282	0.5388	0.7489	0.5096	0.5778
5	0.316	0.3181	0.5182	0.4517	0.5393	0.4646	0.5427	0.6381	0.5692	0.6817
6	0.2252	0.2777	0.5481	0.3152	0.4286	0.2528	0.4284	0.3992	0.5071	0.4804
7	0.188	0.2347	0.4466	0.4987	0.3991	0.3864	0.3145	0.5857	0.4337	0.4068
8	0.1666	0.1887	0.3081	0.5845	0.3639	0.2883	0.308	0.3768	0.4496	0.5644
9	0.1544	0.1912	0.2947	0.3682	0.4452	0.3071	0.3335	0.4198	0.0713	0.221
10	0.2817	0.3247	0.3189	0.4274	0.3598	0.2782	0.3394	0.2738	0.3242	0.196
11	0.3283	0.3318	0.376	0.5251	0.334	0.1508	0.3391	0.1785	0.3444	0.1832
12	0.3009	0.3523	0.7743	0.8135	0.4284	0.113	0.3794	0.254	0.3388	0.1194
13	0.1718	0.5534	0.4186	0.7395	0.8332	0.1741	0.2029	0.1598	0.3022	0.1759
14	0.2487	0.3529	0.4397	0.5797	0.4838	0.2056	0.3207	0.2585	0.2777	0.1798
+gp	0.2487	0.3529	0.4397	0.5797	0.4838	0.2056	0.3207	0.2585	0.2777	0.1798
0 FBAR 4-	0.2747	0.2985	0.5102	0.4235	0.5062	0.433	0.4561	0.593	0.5049	0.5367

Table 5.5.2 continue

Table 8 Fishing mortality (F) at age

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
AGE										
3	0.3942	0.2178	0.7575	0.7822	0.1106	0.1289	0.1193	0.233	0.4508	0.3759
4	0.6549	0.5334	0.8439	0.4793	0.4584	0.4255	0.3937	0.4599	0.5628	0.5085
5	0.8588	0.8703	0.5702	0.4061	0.4558	0.2977	0.5309	0.7915	0.4047	0.3762
6	0.6144	0.5447	0.8622	0.4968	0.4632	0.4955	0.5612	0.6599	0.6026	0.3985
7	0.25	0.4919	0.3705	0.7586	0.514	0.9107	0.8311	0.4378	0.5998	0.4819
8	0.3612	0.5046	0.6064	0.4405	0.6919	0.2718	0.9469	0.2729	0.5271	0.3939
9	0.2414	0.4013	0.4778	0.6555	0.3488	0.8714	0.6367	0.3273	0.1914	0.3591
10	0.2441	0.2019	0.5787	0.1866	0.8292	0.5153	1.8736	0.2386	0.3556	0.1034
11	0.1218	0.3118	0.5554	0.5949	0.2613	2.9415	0.2551	0.0212	0.3028	0.5433
12	0.117	0.1813	0.3981	0.648	0.2685	0.6662	15.8004	1.2885	3.4434	0.2179
13	0.1425	0.2512	0.261	0.2331	0.1697	2.2204	0.0142	0	1.1015	13.5155
14	0.1741	0.271	0.4576	0.4671	0.378	1.4619	3.7668	0.3776	0	2.9899
+gp	0.1741	0.271	0.4576	0.4671	0.378	1.4619	3.7668	0.3776	0	2.9899
0 FBAR 4-	0.5945	0.6101	0.6617	0.5352	0.4729	0.5324	0.5792	0.5873	0.5425	0.4413

Table 8 Fishing mortality (F) at age

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
3	0.1392	0.096	0.0382	0.0545	0.0898	0.0815	0.0292	0.0412	0.0687	0.0216
4	0.315	0.292	0.194	0.432	0.2468	0.1367	0.1539	0.1544	0.1291	0.0782
5	0.4394	0.5489	0.4011	0.3875	0.2669	0.246	0.2018	0.3378	0.1382	0.2222
6	0.7443	0.5478	0.7927	0.4644	0.307	0.3203	0.3704	0.2698	0.2602	0.2293
7	0.8716	0.5773	0.672	0.3912	0.5496	0.3881	0.335	0.3942	0.2535	0.2772
8	0.9664	0.6787	0.4989	0.3211	0.5088	0.4371	0.2724	0.2179	0.2996	0.1997
9	0.4494	1.0305	0.4501	0.1467	0.6245	0.2626	0.3182	0.2624	0.2523	0.2755
10	0.501	0.4745	0.9061	0.5572	0.4009	0.128	0.398	0.4538	0.3435	0.3121
11	0.2267	0.2371	0.6759	0.2242	0.7349	0.1451	0.4103	0.4218	0.3754	0.3085
12	0.5987	0.1244	0.5034	0.4996	1.1191	0.4719	0.2989	0.8555	0.2626	0.2689
13	1.2478	0.022	0.062	0.0175	2.1324	16.8113	0.4053	0.1709	0.1373	0.1575
14	0	0.3802	0.5237	0.2907	1.0138	3.6131	0	0.436	0.2707	0.1982
+gp	0	0.3802	0.5237	0.2907	1.0138	3.6131	0	0.436	0.2707	0.1982
0 FBAR 4-	0.5926	0.4915	0.515	0.4188	0.3426	0.2728	0.2653	0.2891	0.1952	0.2017

Table 8 Fishing mortality (F) at age

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	FBAR *
AGE											
3	0.0216	0.0198	0.0073	0.0755	0.0246	0.0321	0.1236	0.0771	0.1287	0.1164	0.1074
4	0.1305	0.2303	0.066	0.1184	0.2878	0.082	0.2751	0.2462	0.6396	0.3177	0.4012
5	0.1563	0.142	0.2374	0.1436	0.1635	0.2724	0.1642	0.2271	0.336	0.3348	0.2993
6	0.3416	0.136	0.1572	0.2533	0.2151	0.3137	0.266	0.2771	0.2909	0.3003	0.2894
7	0.2116	0.2057	0.2073	0.2377	0.2944	0.2628	0.3364	0.2789	0.2056	0.4504	0.3116
8	0.267	0.3533	0.2764	0.2389	0.2814	0.3312	0.3001	0.274	0.3704	0.309	0.3178
9	0.2287	0.371	0.3052	0.4582	0.4009	0.479	0.3955	0.2609	0.2534	0.3225	0.279
10	0.3335	0.4033	0.6498	0.5405	0.6227	0.5791	0.6083	0.3932	0.1739	0.2807	0.2826
11	0.2525	0.3974	0.8498	0.2985	0.9021	0.5869	0.4649	0.7702	0.1863	0.1718	0.3761
12	0.3841	0.5179	0.7482	0.3097	0.9255	0.6888	0.7461	0.5924	0.6055	0.1428	0.4469
13	0.2804	0.2698	0.2902	0.3673	1.8308	0.6282	0.4271	0.3181	0.5071	0.6762	0.5005
14	0.2694	0.2734	0.6591	0.5698	0.8911	0.6051	0.6051	0.5637	0.2674	0.5827	0.4713
+gp	0.2694	0.2734	0.6591	0.5698	0.8911	0.6051	0.6051	0.5637	0.2674	0.5827	
0 FBAR 4-	0.21	0.1785	0.167	0.1882	0.2402	0.2327	0.2604	0.2573	0.368	0.3508	

Table 5.5.3 Northeast Arctic saithe. Stock number at age

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

	YEAR	1960	1961
	AGE		
	3	92382	104182
	4	103487	63406
	5	49826	69501
	6	31392	25030
	7	25900	19808
	8	18298	15522
	9	16160	12187
	10	8556	11701
	11	4457	6140
	12	4435	3214
	13	1993	3303
	14	1716	1397
	+gp	6218	11360
0	TOTA	364820	346749

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

	YEAR	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
	AGE										
	3	203732	307190	95252	287982	139613	199107	156042	291446	263215	262608
	4	62462	125240	205205	68100	197253	91569	137266	100652	169838	175840
	5	40213	38725	70689	102548	50565	106122	53412	92608	71780	81803
	6	40881	27994	25222	43428	56659	28073	55675	38242	60756	46027
	7	15625	24225	17799	17665	25028	33291	19404	36674	27088	34995
	8	14511	10087	15582	10759	11493	15768	22381	15040	25759	17512
	9	11468	10738	7048	9841	6618	8015	10379	16267	11312	13847
	10	9312	8343	7608	4397	5220	4471	5335	7530	11796	6980
	11	9061	7121	6063	4888	2874	3294	2448	3747	5565	6290
	12	4540	6866	5332	3804	2974	1874	1961	1584	2888	3558
	13	2382	3383	5199	3493	2525	1867	989	1348	1172	1675
	14	2603	1695	2409	3749	2399	1461	1051	657	1077	665
	+gp	7446	5902	5781	4753	4457	3760	2105	1227	1342	1324
0	TOTA	424236	577509	469190	565407	507680	498674	468448	607022	653587	653124

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

	YEAR	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
	AGE										
	3	153304	214898	93077	170518	256069	220593	135546	206194	113271	283643
	4	159138	75431	118995	42831	76039	86963	84753	59848	100214	56271
	5	100966	90035	42944	57477	22850	32252	37989	40484	23170	49291
	6	47417	60267	53628	20941	29956	10910	16593	18077	17510	10736
	7	30752	30995	37377	25379	12509	15977	6937	8851	9928	8633
	8	21694	20862	20067	19579	12619	6871	8889	4147	4034	5268
	9	12233	15036	14144	12073	8935	7180	4217	5348	2329	2107
	10	8180	8582	10168	8624	6840	4687	4324	2473	2878	1776
	11	4122	5053	5078	6052	4605	3908	2905	2521	1540	1704
	12	2875	2431	2969	2855	2931	2700	2751	1695	1727	894
	13	1967	1742	1399	1121	1036	1563	1974	1541	1076	1007
	14	1114	1357	820	754	438	369	1075	1319	1076	651
	+gp	2256	955	760	686	953	1000	1380	1273	1200	334
0	TOTA	546018	527645	401426	368888	435780	394973	309333	353772	279953	422316

Table 5.5.3 continue

	Table 10	Stock number at age (start of year)			Numbers*10**-3						
	YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	AGE										
	3	121615	102847	90673	99780	225093	169531	80036	67032	72454	242239
	4	154442	67129	67721	34805	37366	164998	122011	58159	43474	37792
	5	25852	65686	32242	23842	17645	19343	88271	67385	30063	20274
	6	20410	8968	22524	14925	13005	9158	11760	42500	25000	16421
	7	5437	9040	4258	7786	7435	6700	4568	5493	17986	11205
	8	4706	3467	4526	2407	2985	3641	2206	1629	2903	8083
	9	2453	2685	1714	2020	1269	1224	2272	701	1015	1403
	10	1383	1578	1471	870	859	733	419	984	414	686
	11	1195	887	1056	675	591	307	358	53	635	237
	12	1161	866	532	496	305	373	13	227	42	384
	13	649	846	592	292	212	191	157	0	51	1
	14	692	461	539	373	190	147	17	127	0	14
	+gp	303	870	230	94	10	203	1	70	0	9
0	TOTA	340298	265329	228076	188367	306967	376547	312088	244358	194036	338749

	Table 10	Stock number at age (start of year)			Numbers*10**-3						
	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	AGE										
	3	379449	275340	208334	357793	135206	166453	118881	264486	152720	197163
	4	136183	270286	204788	164179	277393	101188	125613	94535	207807	116735
	5	18609	81371	165254	138105	87268	177447	72261	88171	66327	149536
	6	11395	9818	38479	90591	76746	54710	113602	48353	51493	47294
	7	9026	4432	4648	14259	46616	46224	32517	64220	30226	32499
	8	5665	3091	2037	1943	7895	22029	25673	19044	35450	19206
	9	4463	1765	1284	1013	1154	3886	11650	16008	12539	21511
	10	802	2332	516	670	716	506	2447	6938	10081	7977
	11	507	398	1188	171	314	393	365	1346	3609	5854
	12	113	331	257	495	112	123	278	198	723	2030
	13	253	51	239	127	246	30	63	169	69	455
	14	0	59	41	184	102	24	0	34	117	49
	+gp	0	62	24	187	3	9	0	99	60	165
0	TOTA	566464	649336	627089	769717	633772	573022	503350	603600	571219	600475

	Table 10	Stock number at age (start of year)			Numbers*10**-3									
	YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	GMST 60-**	AMS
	AGE													
	3	339679	132172	152800	396629	72303	109848	240154	134796	242458	68242	0	167935	187107
	4	157971	272150	106091	124195	301123	57758	87091	173766	102173	174544	49734	105729	122551
	5	88384	113508	176985	81314	90333	184885	43565	54155	111222	44125	104013	59539	71867
	6	98036	61891	80627	114283	57670	62804	115278	30267	35331	65071	25847	33279	42268
	7	30787	57037	44227	56409	72628	38079	37574	72337	18783	21625	39455	18805	25170
	8	20166	20399	38017	29429	36412	44301	23971	21975	44811	12521	11284	10362	14600
	9	12878	12641	11730	23609	18974	22501	26044	14537	13680	25331	7526	5985	9048
	10	13371	8388	7142	7078	12225	10403	11410	14358	9169	8693	15022	3504	5531
	11	4780	7843	4589	3053	3375	5370	4773	5085	7934	6309	5375	1925	3169
	12	3521	3040	4315	1606	1855	1121	2444	2455	1927	5392	4350	1076	1925
	13	1270	1963	1483	1672	965	602	461	949	1111	861	3827	406	1156
	14	318	785	1227	908	948	127	263	246	565	548	359	126	757
	+gp	256	510	319	954	511	91	375	261	613	309	392		
0	TOTA	771415	692328	629552	841140	669322	537889	593405	525189	589778	433571	267185		

Table 5.5.4 Northeast Arctic saithe. Spawning stock number at age

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1960	1961
AGE		
3	0	0
4	1035	634
5	27404	38226
6	26684	21275
7	25382	19412
8	18298	15522
9	16160	12187
10	8556	11701
11	4457	6140
12	4435	3214
13	1993	3303
14	1716	1397
+gp	6218	11360

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	625	1252	2052	681	1973	916	1373	1007	1698	1758
5	22117	21299	38879	56401	27811	58367	29377	50934	39479	44991
6	34749	23794	21439	36914	48160	23862	47324	32506	51642	39123
7	15313	23740	17443	17312	24528	32625	19016	35940	26546	34296
8	14511	10087	15582	10759	11493	15768	22381	15040	25759	17512
9	11468	10738	7048	9841	6618	8015	10379	16267	11312	13847
10	9312	8343	7608	4397	5220	4471	5335	7530	11796	6980
11	9061	7121	6063	4888	2874	3294	2448	3747	5565	6290
12	4540	6866	5332	3804	2974	1874	1961	1584	2888	3558
13	2382	3383	5199	3493	2525	1867	989	1348	1172	1675
14	2603	1695	2409	3749	2399	1461	1051	657	1077	665
+gp	7446	5902	5781	4753	4457	3760	2105	1227	1342	1324

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	1591	754	1190	428	760	870	848	598	1002	563
5	55531	49519	23619	31612	12568	17739	20894	22266	12744	27110
6	40305	51227	45583	17800	25463	9274	14104	15365	14883	9126
7	30137	30375	36630	24872	12259	15657	6799	8674	9730	8461
8	21694	20862	20067	19579	12619	6871	8889	4147	4034	5268
9	12233	15036	14144	12073	8935	7180	4217	5348	2329	2107
10	8180	8582	10168	8624	6840	4687	4324	2473	2878	1776
11	4122	5053	5078	6052	4605	3908	2905	2521	1540	1704
12	2875	2431	2969	2855	2931	2700	2751	1695	1727	894
13	1967	1742	1399	1121	1036	1563	1974	1541	1076	1007
14	1114	1357	820	754	438	369	1075	1319	1076	651
+gp	2256	955	760	686	953	1000	1380	1273	1200	334

Table 5.5.4 continue

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	1544	671	677	696	747	0	0	0	0	756
5	14219	36128	17733	11921	8999	6770	22068	10108	6013	5069
6	17348	7623	19145	13731	12225	8975	11289	39100	21250	13793
7	5328	8859	4173	7709	7361	6700	4568	5493	17806	10980
8	4706	3467	4526	2407	2985	3641	2206	1629	2903	8083
9	2453	2685	1714	2020	1269	1224	2272	701	1015	1403
10	1383	1578	1471	870	859	733	419	984	414	686
11	1195	887	1056	675	591	307	358	53	635	237
12	1161	866	532	496	305	373	13	227	42	384
13	649	846	592	292	212	191	157	0	51	1
14	692	461	539	373	190	147	17	127	0	14
+gp	303	870	230	94	10	203	1	70	0	9

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	2724	5406	4096	3284	8322	3036	5025	0	0	0
5	5583	21157	42966	30383	18326	24843	5058	7054	5306	16449
6	9458	8640	32322	72472	49885	24620	37489	15473	23687	30268
7	8394	4078	4183	13119	42421	38366	24063	47523	24785	30224
8	5212	2751	1670	1749	7342	20707	23876	17520	34032	18630
9	4017	1535	1117	982	1154	3614	10718	14727	12288	21081
10	762	2075	459	630	716	491	2349	6661	9980	7897
11	507	398	1188	171	314	393	365	1332	3500	5678
12	113	324	252	485	112	123	278	192	679	1888
13	253	51	239	127	246	30	63	169	69	455
14	0	59	41	184	102	24	0	34	117	49
+gp	0	62	24	187	3	9	0	99	60	165

Table 11 Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE										
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	3726	12045	2888	4355	5213	2043	3491
5	11490	15891	37167	24394	36133	77652	14812	14622	22244	8384
6	76468	50751	64502	93712	49596	54639	95681	21187	20139	29933
7	29247	54755	42900	54716	71176	36937	35696	65827	15778	17300
8	19762	19991	37637	29135	36048	43415	23732	21316	42122	11394
9	12621	12388	11730	23609	18974	22501	25783	14247	13543	24825
10	13237	8305	7142	7078	12225	10091	11068	13928	9169	8693
11	4684	7843	4589	3053	3375	5370	4678	4983	7854	6246
12	3380	2979	4315	1606	1855	1121	2420	2430	1927	5392
13	1270	1963	1483	1672	965	602	461	949	1100	853
14	318	785	1227	908	948	127	263	246	565	548
+gp	256	510	319	954	511	91	375	261	613	309

Table 5.5.5 Northeast Arctic saithe. Stock biomass at age

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

	YEAR	1960	1961
	AGE		
	3	65591	73969
	4	114871	70380
	5	81216	113287
	6	73144	58319
	7	81844	62593
	8	73740	62553
	9	78701	59350
	10	48169	65877
	11	28701	39540
	12	31534	22848
	13	15587	25828
	14	15304	12458
	+gp	59070	107924
0	TOTALI	767473	774927

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

	YEAR	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
	AGE										
	3	144649	218105	67629	204467	99125	141366	110790	206927	186883	186451
	4	69332	139017	227777	75591	218951	101642	152366	111724	188520	195182
	5	65548	63122	115223	167153	82420	172979	87062	150951	117001	133338
	6	95253	65225	58767	101188	132016	65411	129723	89104	141561	107244
	7	49376	76551	56244	55822	79090	105200	61317	115889	85598	110586
	8	58478	40649	62795	43360	46318	63546	90196	60610	103808	70572
	9	55848	52296	34326	47926	32232	39031	50546	79218	55089	67436
	10	52425	46971	42835	24757	29391	25174	30035	42391	66412	39299
	11	58356	45858	39048	31480	18512	21215	15767	24131	35837	40507
	12	32280	48818	37913	27048	21147	13323	13940	11261	20532	25297
	13	18629	26457	40655	27312	19743	14599	7731	10543	9164	13097
	14	23216	15121	21487	33440	21398	13031	9373	5864	9604	5935
	+gp	70741	56068	54923	45150	42344	35722	19999	11657	12748	12577
0	TOTALI	794132	894257	859622	884694	842688	812239	778843	920271	1032756	1007521

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

	YEAR	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
	AGE										
	3	108846	152578	66085	121068	181809	156621	96237	146398	89484	207059
	4	176643	83729	132084	47543	84403	96529	94075	66431	127271	78779
	5	164574	146756	69998	93688	37246	52571	61922	65988	47036	101047
	6	110482	140423	124952	48792	69797	25421	38661	42118	44649	29632
	7	97176	97945	118112	80198	39529	50487	21922	27969	32664	28490
	8	87425	84076	80870	78904	50854	27691	35822	16713	17509	23075
	9	59573	73225	68880	58794	43514	34966	20536	26047	11997	12536
	10	46054	48317	57244	48552	38507	26388	24343	13925	16547	11348
	11	26548	32543	32704	38973	29655	25166	18711	16237	9410	11261
	12	20441	17281	21110	20297	20836	19195	19563	12049	10257	6148
	13	15386	13624	10941	8764	8102	12225	15438	12055	7146	6800
	14	9939	12101	7316	6723	3907	3289	9592	11770	8315	4644
	+gp	21428	9076	7225	6513	9055	9500	13109	12094	11367	2560
0	TOTALI	944517	911672	797521	658808	617215	540047	469932	469793	433652	523380

Table 5.5.5 continue

Table 12	Stock biomass at age (start of year)			Tonnes						
YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
AGE										
3	93643	107989	64378	74835	132805	89851	49622	49604	51442	164723
4	172975	89281	85329	46291	45587	138598	106149	55251	43474	39682
5	52221	122177	65128	49353	34761	32109	115634	94339	43591	37508
6	53270	25110	60814	39252	29913	21246	28576	75650	52250	39246
7	17778	36159	16523	25539	21340	19899	17678	16259	44785	34510
8	18400	14491	20230	9532	11106	14564	11871	6076	10886	27078
9	11505	14309	9185	9173	5455	5776	13243	3238	3959	6285
10	7786	8961	8917	4829	4028	3986	2247	4585	2788	3199
11	8582	6484	6629	4647	3452	1777	2480	440	3135	1334
12	8374	7520	3663	4037	1949	2340	116	1539	208	2418
13	4545	7224	4852	1772	1722	1340	1235	0	421	7
14	5555	3951	4924	3605	1431	1227	152	1155	0	161
+gp	2860	9022	1486	1288	105	1725	11	833	0	85
0 TOTALI	457494	452679	352058	274153	293655	334440	349014	308967	256938	356236

Table 12	Stock biomass at age (start of year)			Tonnes						
YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
3	254231	167958	108334	200364	79772	103201	80839	177206	91632	147873
4	137544	267583	155639	129701	227462	96128	125613	99261	214041	130743
5	35729	134262	204915	164345	116066	220035	106946	127849	108113	230286
6	25980	24153	81575	154910	141212	94102	212436	93321	108136	96480
7	25002	12632	14967	40924	115608	108627	83894	145779	80702	84498
8	18129	9365	7802	7346	29449	68290	78817	56560	111313	60308
9	16649	6547	6021	4112	4985	16283	48113	57787	47773	78086
10	5094	10468	2738	3551	3824	2930	13311	28447	44457	36214
11	3497	2213	6722	1170	1879	2658	2442	6634	20785	29563
12	810	2170	1776	3260	699	817	1382	1305	5274	11813
13	1739	536	1507	1002	1809	218	330	1270	686	2912
14	0	400	384	1686	983	218	0	271	1230	388
+gp	0	525	216	1971	46	99	0	740	667	1790
0 TOTALI	524403	638812	592596	714343	723795	713605	754123	796429	834810	910951

Table 12	Stock biomass at age (start of year)			Tonnes						
YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE										
3	234378	87233	106960	234011	45551	80189	151297	98401	169721	47769
4	159551	247656	109274	110534	249932	62379	85349	178979	101151	139636
5	132577	161182	242469	121158	129176	260688	60120	89355	161271	60010
6	193130	116975	153191	238852	102653	116815	221334	60534	75609	132094
7	78198	144873	106588	121843	164866	92532	86797	171440	46958	55360
8	65538	52630	113290	87994	99405	130244	67839	59114	140258	38940
9	48551	44117	40353	76493	57302	75377	82298	46956	45690	90180
10	57628	31457	26640	27037	47676	38077	39138	48531	34932	35987
11	23469	32312	18997	11969	13704	22391	18234	17593	31655	30218
12	20033	16022	21966	8255	9366	5651	9998	10434	8345	31864
13	7861	11661	8839	10466	5586	3653	2319	4631	5980	4918
14	2405	5098	7351	6140	5698	662	1570	1391	4782	3727
+gp	2995	5714	2522	6313	4264	836	3213	1915	4066	1822
0 TOTALI	1026314	956930	958438	1061065	935178	889494	829505	789274	830419	672524

Table 5.5.6 Northeast Arctic saithe. Spawning stock biomass at age

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

	YEAR	1960	1961
	AGE		
	3	0	0
	4	1149	704
	5	44669	62308
	6	62173	49571
	7	80208	61341
	8	73740	62553
	9	78701	59350
	10	48169	65877
	11	28701	39540
	12	31534	22848
	13	15587	25828
	14	15304	12458
	+gp	59070	107924
0	TOTSPI	539004	570302

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

	YEAR	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	693	1390	2278	756	2190	1016	1524	1117	1885	1952
	5	36051	34717	63372	91934	45331	95139	47884	83023	64351	73336
	6	80965	55441	49952	86010	112214	55599	110264	75739	120326	91157
	7	48389	75020	55119	54705	77508	103096	60090	113571	83886	108374
	8	58478	40649	62795	43360	46318	63546	90196	60610	103808	70572
	9	55848	52296	34326	47926	32232	39031	50546	79218	55089	67436
	10	52425	46971	42835	24757	29391	25174	30035	42391	66412	39299
	11	58356	45858	39048	31480	18512	21215	15767	24131	35837	40507
	12	32280	48818	37913	27048	21147	13323	13940	11261	20532	25297
	13	18629	26457	40655	27312	19743	14599	7731	10543	9164	13097
	14	23216	15121	21487	33440	21398	13031	9373	5864	9604	5935
	+gp	70741	56068	54923	45150	42344	35722	19999	11657	12748	12577
0	TOTSPI	536072	498806	504704	513878	468328	480490	457349	519126	583641	549539

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

	YEAR	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	1766	837	1321	475	844	965	941	664	1273	788
	5	90516	80716	38499	51528	20485	28914	34057	36294	25870	55576
	6	93910	119359	106209	41473	59328	21608	32862	35801	37952	25187
	7	95233	95986	115750	78594	38739	49477	21484	27410	32011	27920
	8	87425	84076	80870	78904	50854	27691	35822	16713	17509	23075
	9	59573	73225	68880	58794	43514	34966	20536	26047	11997	12536
	10	46054	48317	57244	48552	38507	26388	24343	13925	16547	11348
	11	26548	32543	32704	38973	29655	25166	18711	16237	9410	11261
	12	20441	17281	21110	20297	20836	19195	19563	12049	10257	6148
	13	15386	13624	10941	8764	8102	12225	15438	12055	7146	6800
	14	9939	12101	7316	6723	3907	3289	9592	11770	8315	4644
	+gp	21428	9076	7225	6513	9055	9500	13109	12094	11367	2560
0	TOTSPI	568220	587140	548068	439590	323825	259383	246457	221057	189652	187844

Table 5.5.6 continue

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

	YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	1730	893	853	926	912	0	0	0	0	794
	5	28722	67197	35820	24677	17728	11238	28909	14151	8718	9377
	6	45279	21343	51692	36112	28118	20821	27433	69598	44413	32966
	7	17423	35436	16192	25284	21126	19899	17678	16259	44337	33820
	8	18400	14491	20230	9532	11106	14564	11871	6076	10886	27078
	9	11505	14309	9185	9173	5455	5776	13243	3238	3959	6285
	10	7786	8961	8917	4829	4028	3986	2247	4585	2788	3199
	11	8582	6484	6629	4647	3452	1777	2480	440	3135	1334
	12	8374	7520	3663	4037	1949	2340	116	1539	208	2418
	13	4545	7224	4852	1772	1722	1340	1235	0	421	7
	14	5555	3951	4924	3605	1431	1227	152	1155	0	161
	+gp	2860	9022	1486	1288	105	1725	11	833	0	85
0	TOTSPI	160760	196833	164444	125880	97133	84694	105373	117873	118864	117525

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

	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	2751	5352	3113	2594	6824	2884	5025	0	0	0
	5	10719	34908	53278	36156	24374	30805	7486	10228	8649	25331
	6	21563	21254	68523	123928	91788	42346	70104	29863	49742	61747
	7	23252	11621	13470	37651	105203	90160	62082	107876	66176	78583
	8	16679	8335	6398	6611	27387	64193	73300	52035	106861	58498
	9	14984	5696	5238	3988	4985	15143	44264	53164	46818	76524
	10	4839	9317	2437	3338	3824	2842	12779	27309	44013	35852
	11	3497	2213	6722	1170	1879	2658	2442	6567	20162	28676
	12	810	2126	1741	3195	699	817	1382	1266	4958	10986
	13	1739	536	1507	1002	1809	218	330	1270	686	2912
	14	0	400	384	1686	983	218	0	271	1230	388
	+gp	0	525	216	1971	46	99	0	740	667	1790
0	TOTSPI	100832	102283	163026	223290	269802	252383	279192	290589	349961	381287

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

	YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	AGE										
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	3316	9997	3119	4267	5369	2023	2793
	5	17235	22565	50918	36348	51670	109489	20441	24126	32254	11402
	6	150642	95919	122553	195858	88281	101629	183708	42374	43097	60763
	7	74288	139078	103390	118187	161569	89756	82457	156010	39445	44288
	8	64227	51578	112157	87114	98411	127639	67161	57341	131842	35436
	9	47580	43235	40353	76493	57302	75377	81475	46016	45233	88376
	10	57052	31142	26640	27037	47676	36934	37964	47075	34932	35987
	11	23000	32312	18997	11969	13704	22391	17870	17242	31338	29916
	12	19231	15702	21966	8255	9366	5651	9898	10329	8345	31864
	13	7861	11661	8839	10466	5586	3653	2319	4631	5920	4869
	14	2405	5098	7351	6140	5698	662	1570	1391	4782	3727
	+gp	2995	5714	2522	6313	4264	836	3213	1915	4066	1822
0	TOTSPI	466516	454004	515685	587497	553524	577136	512341	413820	383279	351241

Table 5.5.7 Northeast Arctic saithe. XSA summary

Table 16 Summary (without SOP correction)

	REC Age 3	TOTALBI	TOTSPBI	LANDIN(	YIELD/SS	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	187844	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	352058	164444	158786	0.9656	0.6617
1985	99780	274153	125880	107183	0.8515	0.5352
1986	225093	293655	97133	67396	0.6938	0.4729
1987	169531	334440	84694	92391	1.0909	0.5324
1988	80036	349014	105373	114242	1.0842	0.5792
1989	67032	308967	117873	122817	1.0419	0.5873
1990	72454	256938	118864	95848	0.8064	0.5425
1991	242239	356236	117525	107327	0.9132	0.4413
1992	379449	524403	100832	127604	1.2655	0.5926
1993	275340	638812	102283	154903	1.5144	0.4915
1994	208334	592596	163026	146950	0.9014	0.515
1995	357793	714343	223290	168378	0.7541	0.4188
1996	135206	723795	269802	171348	0.6351	0.3426
1997	166453	713605	252383	143629	0.5691	0.2728
1998	118881	754123	279192	153327	0.5492	0.2653
1999	264486	796429	290589	150375	0.5175	0.2891
2000	152720	834810	349961	135928	0.3884	0.1952
2001	197163	910951	381287	135853	0.3563	0.2017
2002	339679	1026314	466516	154870	0.332	0.21
2003	132172	956930	454004	161592	0.3559	0.1785
2004	152800	958438	515685	164636	0.3193	0.167
2005	396629	1061065	587497	178568	0.3039	0.1882
2006	72303	935178	553524	212822	0.3845	0.2402
2007	109848	889494	577136	199008	0.3448	0.2327
2008	240154	829505	512341	184740	0.3606	0.2604
2009	134796	789274	413820	161853	0.3911	0.2573
2010	242458	830419	383279	194837	0.5083	0.368
2011	169149	745452	351241	156686	0.4461	0.3508
Arith. Mean	187826	701769	352107	162954	0.5903	0.3727
0 Units	(Thousar	(Tonnes)	(Tonnes)	(Tonnes)		

Table 5.6.1 Northeast arctic saithe. Yield per recruit

MFYPR version 2a

Run: ypr2

Time and date: 13:04 22.04.2012

Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJa	SSBJan	SpwnNosS	SSBSpwn
0	0	0	0	5.5167	14.1874	2.7426	10.9495	2.7426	10.9495
0.1	0.0325	0.1294	0.345	4.8721	11.1993	2.172	8.0998	2.172	8.0998
0.2	0.0651	0.2242	0.5397	4.4006	9.1937	1.7693	6.2213	1.7693	6.2213
0.3	0.0976	0.2974	0.6546	4.0372	7.7665	1.4701	4.9111	1.4701	4.9111
0.4	0.1302	0.3559	0.7243	3.7468	6.7062	1.2396	3.9588	1.2396	3.9588
0.5	0.1627	0.4041	0.7672	3.5084	5.8919	1.0573	3.2442	1.0573	3.2442
0.6	0.1952	0.4445	0.7934	3.3088	5.2498	0.9102	2.6944	0.9102	2.6944
0.7	0.2278	0.4789	0.8092	3.1389	4.7325	0.7896	2.2627	0.7896	2.2627
0.8	0.2603	0.5086	0.8181	2.9925	4.3083	0.6895	1.918	0.6895	1.918
0.9	0.2928	0.5346	0.8224	2.865	3.9553	0.6054	1.6389	0.6054	1.6389
1	0.3254	0.5574	0.8236	2.753	3.6578	0.5343	1.4101	0.5343	1.4101
1.1	0.3579	0.5777	0.8227	2.6538	3.4043	0.4737	1.2207	0.4737	1.2207
1.2	0.3905	0.5959	0.8204	2.5654	3.1863	0.4217	1.0626	0.4217	1.0626
1.3	0.423	0.6122	0.8172	2.4862	2.9972	0.3767	0.9294	0.3767	0.9294
1.4	0.4555	0.6269	0.8133	2.4147	2.8321	0.3377	0.8166	0.3377	0.8166
1.5	0.4881	0.6403	0.809	2.35	2.6869	0.3038	0.7204	0.3038	0.7204
1.6	0.5206	0.6525	0.8045	2.2911	2.5584	0.274	0.6379	0.274	0.6379
1.7	0.5531	0.6637	0.7998	2.2374	2.4442	0.2479	0.5668	0.2479	0.5668
1.8	0.5857	0.6739	0.7951	2.1882	2.3421	0.2249	0.5052	0.2249	0.5052
1.9	0.6182	0.6834	0.7904	2.1429	2.2505	0.2045	0.4517	0.2045	0.4517
2	0.6508	0.6922	0.7858	2.1011	2.1679	0.1864	0.4051	0.1864	0.4051

Reference	F multiplie	Absolute F
Fbar(4-7)	1	0.3254
FMax	1.0022	0.3261
F0.1	0.433	0.1409
F35%SPR	0.4158	0.1353

Weights in kilograms

Table 5.7.1 Northeast arctic saithe. Prediction input data

MFDP version 1a
Run: F1
Time and date: 11:35 22.04.2012
Fbar age range: 4-7

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	169149	0.2	0	0	0	0.710	0.1074	0.710
4	132350	0.2	0.02	0	0	0.940	0.4012	0.940
5	104013	0.2	0.19	0	0	1.487	0.2993	1.487
6	25847	0.2	0.46	0	0	2.057	0.2894	2.057
7	39455	0.2	0.80	0	0	2.477	0.3116	2.477
8	11284	0.2	0.91	0	0	2.977	0.3178	2.977
9	7526	0.2	0.98	0	0	3.377	0.2789	3.377
10	15022	0.2	1	0	0	3.777	0.2826	3.777
11	5375	0.2	0.99	0	0	4.080	0.4412	4.080
12	4350	0.2	1	0	0	4.830	0.4412	4.830
13	3827	0.2	0.99	0	0	5.323	0.4412	5.323
14	359	0.2	1	0	0	6.970	0.4412	6.970
15	392	0.2	1	0	0	6.617	0.4412	6.617

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	169149	0.2	0	0	0	0.710	0.1074	0.710
4	.	0.2	0.02	0	0	0.940	0.4012	0.940
5	.	0.2	0.19	0	0	1.487	0.2993	1.487
6	.	0.2	0.46	0	0	2.057	0.2894	2.057
7	.	0.2	0.80	0	0	2.477	0.3116	2.477
8	.	0.2	0.91	0	0	2.977	0.3178	2.977
9	.	0.2	0.98	0	0	3.377	0.2789	3.377
10	.	0.2	1	0	0	3.777	0.2826	3.777
11	.	0.2	0.99	0	0	4.080	0.4412	4.080
12	.	0.2	1	0	0	4.830	0.4412	4.830
13	.	0.2	0.99	0	0	5.323	0.4412	5.323
14	.	0.2	1	0	0	6.970	0.4412	6.970
15	.	0.2	1	0	0	6.617	0.4412	6.617

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	169149	0.2	0	0	0	0.710	0.1074	0.710
4	.	0.2	0.02	0	0	0.940	0.4012	0.940
5	.	0.2	0.19	0	0	1.487	0.2993	1.487
6	.	0.2	0.46	0	0	2.057	0.2894	2.057
7	.	0.2	0.80	0	0	2.477	0.3116	2.477
8	.	0.2	0.91	0	0	2.977	0.3178	2.977
9	.	0.2	0.98	0	0	3.377	0.2789	3.377
10	.	0.2	1	0	0	3.777	0.2826	3.777
11	.	0.2	0.99	0	0	4.080	0.4412	4.080
12	.	0.2	1	0	0	4.830	0.4412	4.830
13	.	0.2	0.99	0	0	5.323	0.4412	5.323
14	.	0.2	1	0	0	6.970	0.4412	6.970
15	.	0.2	1	0	0	6.617	0.4412	6.617

Input units are thousands and kg - output in tonnes

Table 5.7.2 Northeast Arctic saithe. Short term prediction

MFDP version 1a
Run: F1
North-East Arctic saithe
Time and date: 11:35 22.04.2012
Fbar age range: 4-7

2012				
Biomass	SSB	FMult	FBar	Landings
734156	314684	0.9587	0.3119	164000

2013					2014	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
712083	301760	0	0	0	874561	405598
.	301760	0.1	0.0325	19030	852249	392370
.	301760	0.2	0.0651	37456	830673	379587
.	301760	0.3	0.0976	55300	809807	367235
.	301760	0.4	0.1302	72581	789625	355298
.	301760	0.5	0.1627	89318	770105	343762
.	301760	0.6	0.1952	105531	751222	332613
.	301760	0.7	0.2278	121236	732956	321838
.	301760	0.8	0.2603	136451	715284	311424
.	301760	0.9	0.2928	151193	698186	301357
.	301760	1	0.3254	165477	681642	291627
.	301760	1.1	0.3579	179319	665634	282221
.	301760	1.2	0.3905	192734	650142	273129
.	301760	1.3	0.423	205736	635148	264339
.	301760	1.4	0.4555	218339	620637	255841
.	301760	1.5	0.4881	230557	606590	247625
.	301760	1.6	0.5206	242401	592993	239682
.	301760	1.7	0.5531	253885	579830	232002
.	301760	1.8	0.5857	265021	567085	224576
.	301760	1.9	0.6182	275820	554745	217396
.	301760	2	0.6508	286294	542797	210452

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: TAC13n
TAC13MFDP Index file 22.04.2012
Time and date: 13:13 24.04.2012
Fbar age range: 4-7

2012

Biomass	SSB	FMult	FBar	Landings
734156	314684	0.9587	0.3119	164000

2013

Biomass	SSB	FMult	FBar	Landings
712083	301760	0.9935	0.3233	164568

	Fpa (0.35) landings	SSB
2013	175989	301760
2014	162960	284482
2015	154755	264304
Average	164568	

2014					2015	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
682695	292246	0	0	0	844515	384002
.	292246	0.1	0.0325	17970	823389	371719
.	292246	0.2	0.0651	35378	802950	359840
.	292246	0.3	0.0976	52243	783175	348353
.	292246	0.4	0.1302	68584	764041	337243
.	292246	0.5	0.1627	84418	745526	326499
.	292246	0.6	0.1952	99762	727609	316108
.	292246	0.7	0.2278	114632	710270	306057
.	292246	0.8	0.2603	129044	693487	296336
.	292246	0.9	0.2928	143015	677243	286932
.	292246	1	0.3254	156557	661519	277836
.	292246	1.1	0.3579	169686	646297	269038
.	292246	1.2	0.3905	182415	631561	260526
.	292246	1.3	0.423	194758	617293	252291
.	292246	1.4	0.4555	206727	603478	244325
.	292246	1.5	0.4881	218335	590100	236618
.	292246	1.6	0.5206	229593	577145	229161
.	292246	1.7	0.5531	240514	564598	221946
.	292246	1.8	0.5857	251107	552445	214965
.	292246	1.9	0.6182	261385	540674	208210
.	292246	2	0.6508	271356	529271	201673

Input units are thousands and kg - output in tonnes

Table 5.7.4. Northeast arctic saithe. Detailed short term projection output HCR landings

MFDP version 1a

Run: TAC13

Time and date: 12:20 22.04.2012

Fbar age range: 4-7

Year:	2012	F multiplie	0.9587	Fbar:	0.3119				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.103	15026	10668	169149	120096	0	0	0	0
4	0.3846	38547	36234	132350	124409	2647	2488	2647	2488
5	0.2869	23628	35127	104013	154633	19762	29380	19762	29380
6	0.2775	5702	11727	25847	53159	11890	24453	11890	24453
7	0.2987	9281	22985	39455	97717	31564	78174	31564	78174
8	0.3047	2700	8036	11284	33589	10268	30566	10268	30566
9	0.2674	1608	5428	7526	25413	7375	24905	7375	24905
10	0.2709	3246	12259	15022	56733	15022	56733	15022	56733
11	0.423	1692	6904	5375	21930	5321	21711	5321	21711
12	0.423	1369	6614	4350	21011	4350	21011	4350	21011
13	0.423	1205	6413	3827	20372	3789	20169	3789	20169
14	0.423	113	788	359	2502	359	2502	359	2502
15	0.423	123	817	392	2594	392	2594	392	2594
Total		104239	164000	518949	734156	112740	314684	112740	314684

Year:	2013	F multiplie	0.9935	Fbar:	0.3233				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.1067	15543	11036	169149	120096	0	0	0	0
4	0.3986	37472	35223	124938	117441	2499	2349	2499	2349
5	0.2974	17281	25691	73760	109656	14014	20835	14014	20835
6	0.2875	14545	29914	63916	131454	29401	60469	29401	60469
7	0.3096	3889	9632	16035	39712	12828	31770	12828	31770
8	0.3157	5911	17594	23961	71324	21804	64905	21804	64905
9	0.2771	1501	5069	6812	23002	6676	22542	6676	22542
10	0.2808	1051	3970	4716	17811	4716	17811	4716	17811
11	0.4383	3039	12400	9380	38271	9286	37888	9286	37888
12	0.4383	934	4511	2883	13924	2883	13924	2883	13924
13	0.4383	756	4024	2333	12420	2310	12296	2310	12296
14	0.4383	665	4635	2053	14306	2053	14306	2053	14306
15	0.4383	131	863	403	2665	403	2665	403	2665
Total		102717	164562	500338	712083	108873	301760	108873	301760

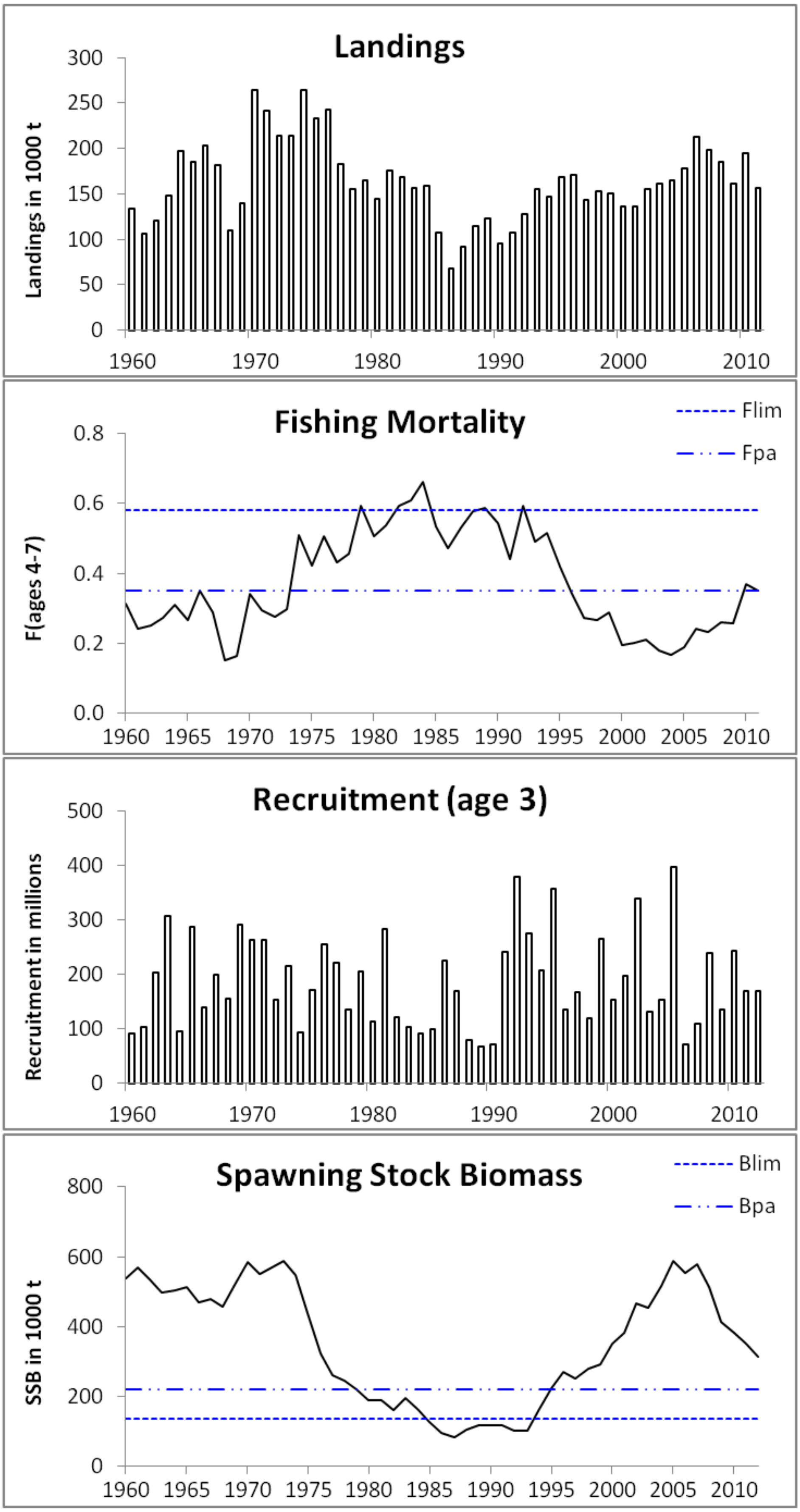
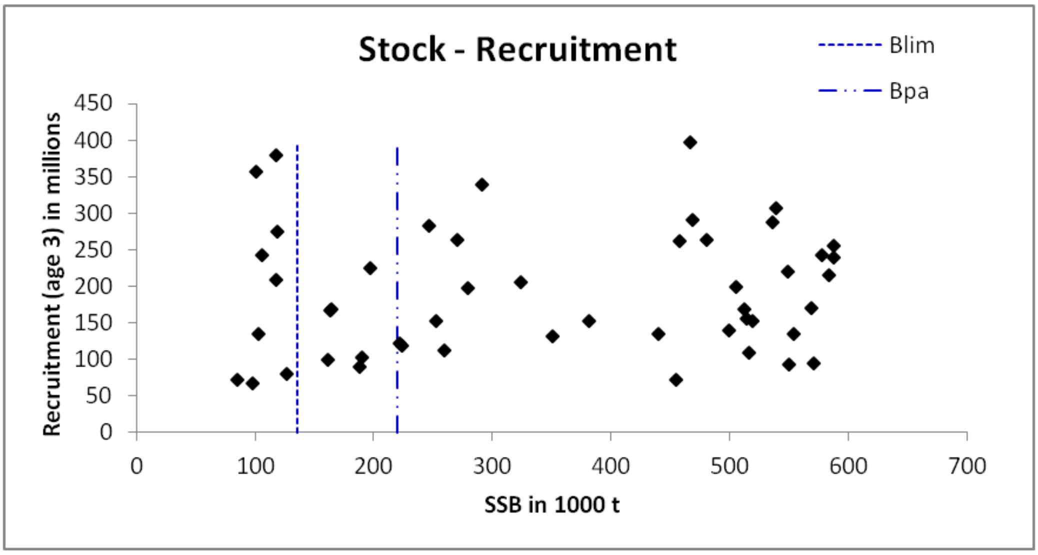
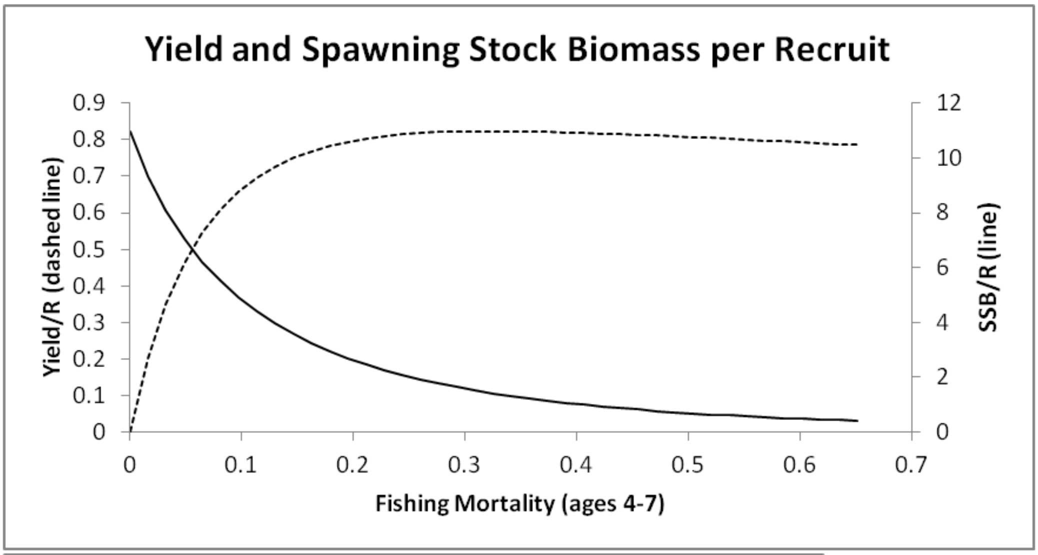


Figure 5.1.1 Northeast Arctic saithe (Subareas I and II)





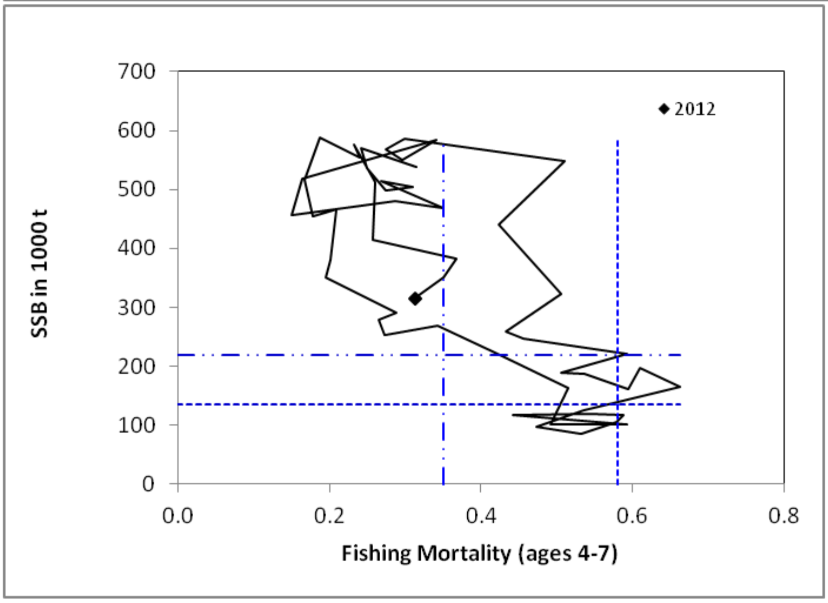


Figure 5.1.1 continued

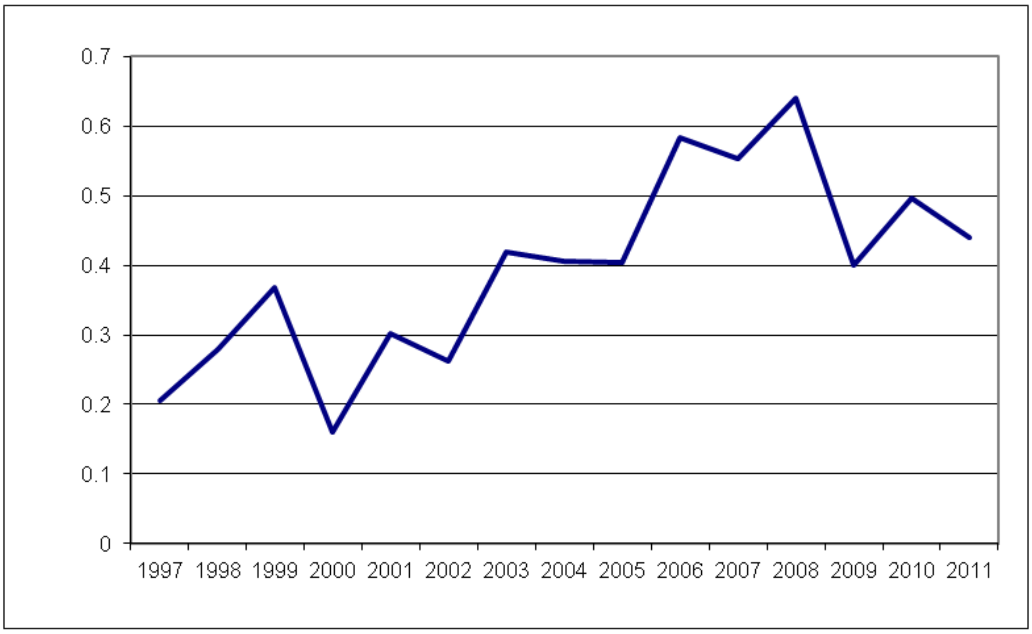


Figure 5.2.1. Northeast Arctic saithe. Proportion of saithe in the southern half of the survey area (sub area C+D).

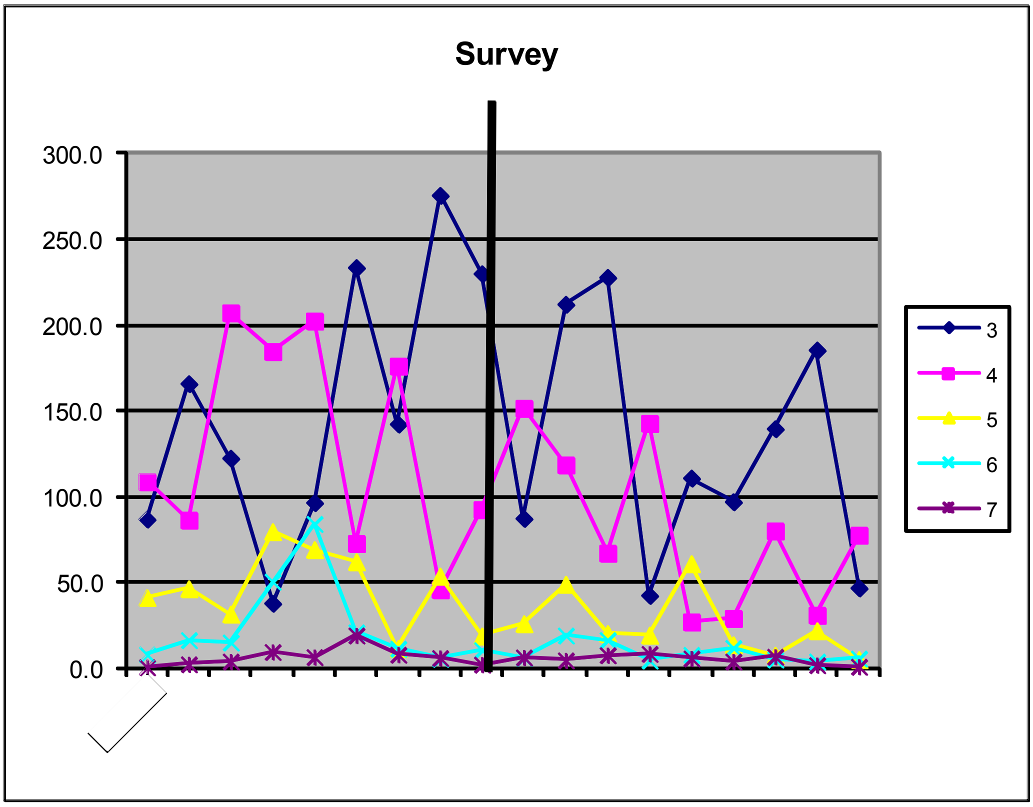


Figure 5.3.1a Northeast Arctic saithe, acoustic survey tuning indices, break in 2002 black line

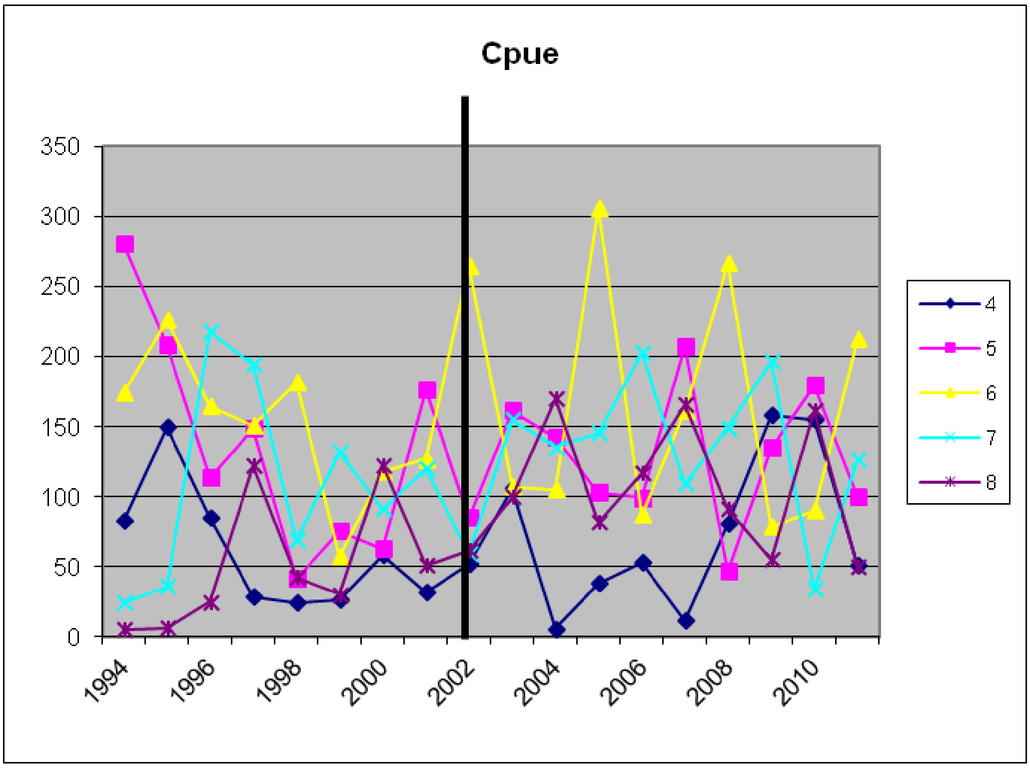


Figure 5.3.1b Northeast Arctic saithe, CPUE tuning indices, break in 2002 black line

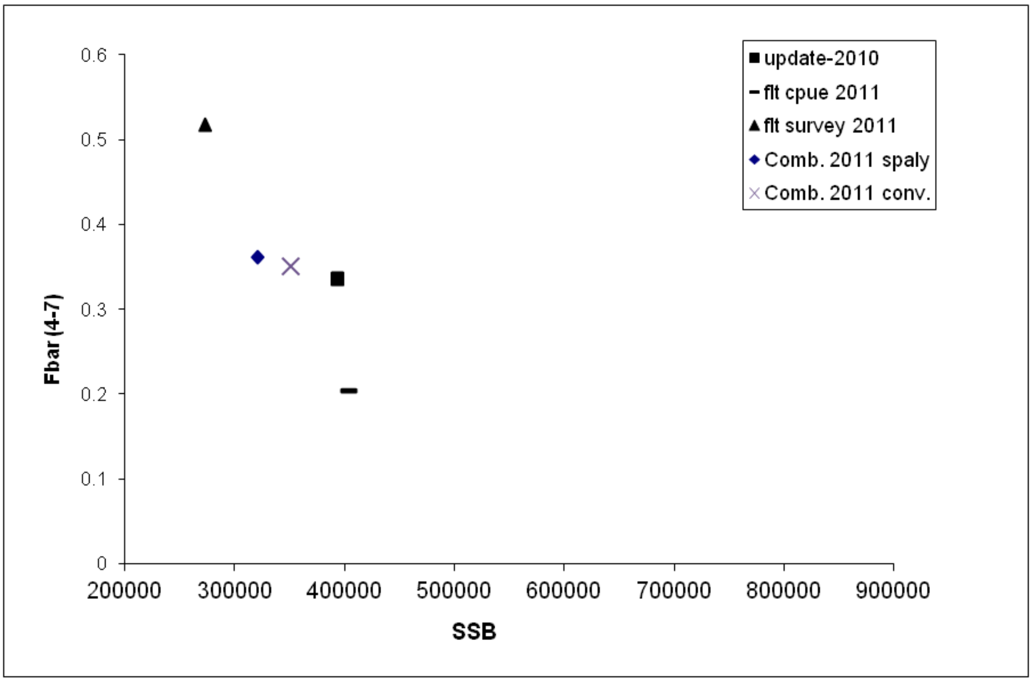


Figure 5.4.1 Northeast Arctic saithe. Comparison of SSB and F_{4-7} in 2011 from single fleet and combined XSA runs. SSB and F_{4-7} in 2010 from an updated 2010 SPALY run is also presented.

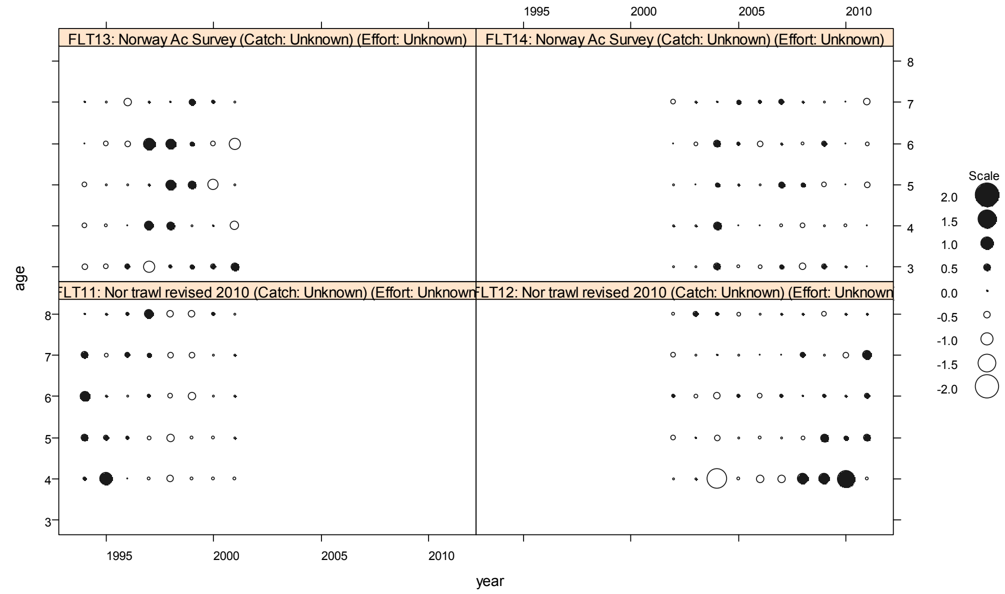


Figure 5.5.1. Northeast Arctic saithe. Final run log Q residuals.

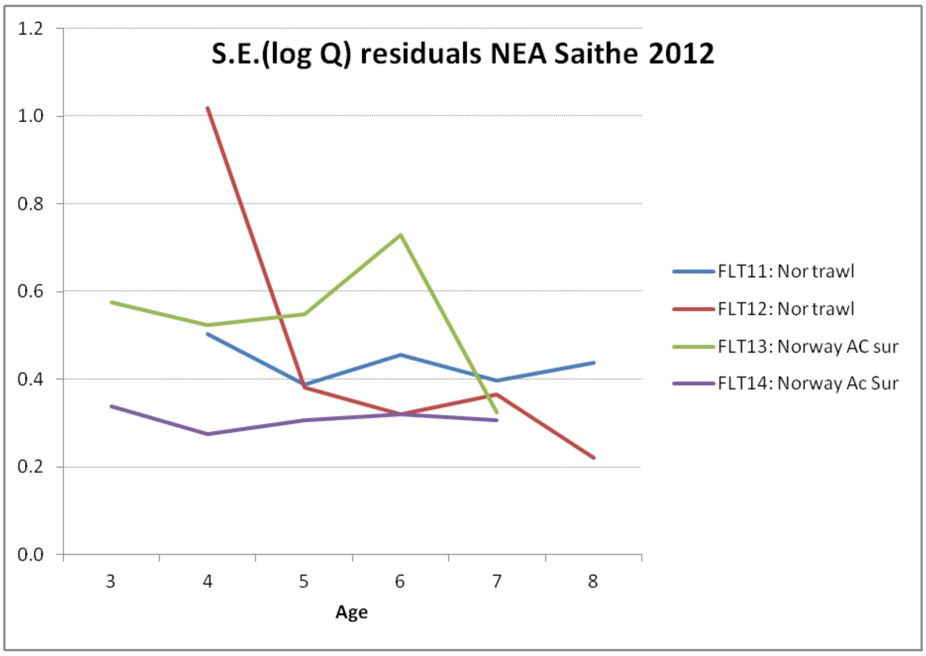


Figure 5.5.2. Northeast arctic saithe. S.E log. Catchability from the four XSA fleet tuning series, final run.

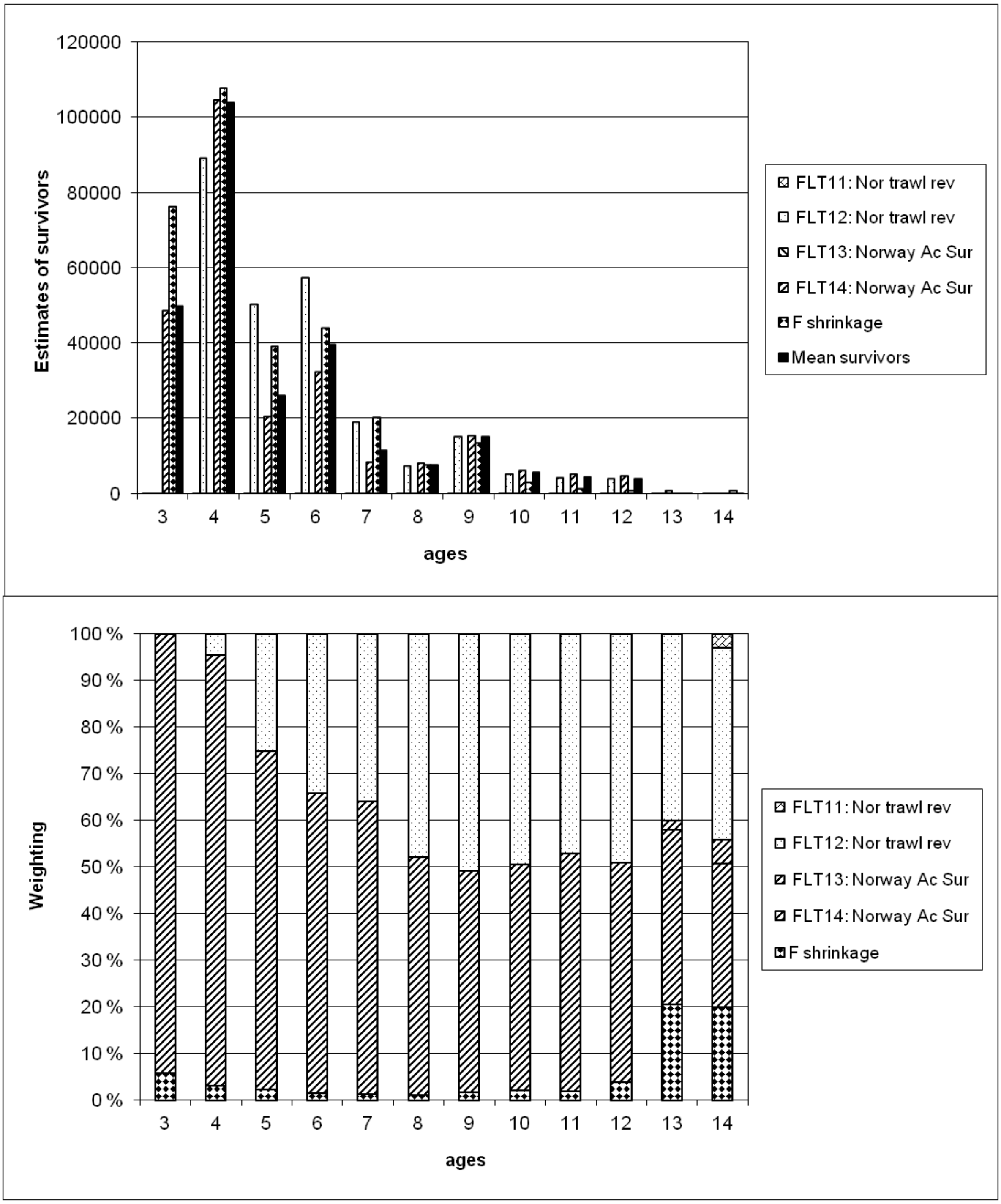


Figure 5.5.3 Northeast Arctic saithe. Estimates of survivors from different fleets and shrinkage and weighting in the final XSA-run.

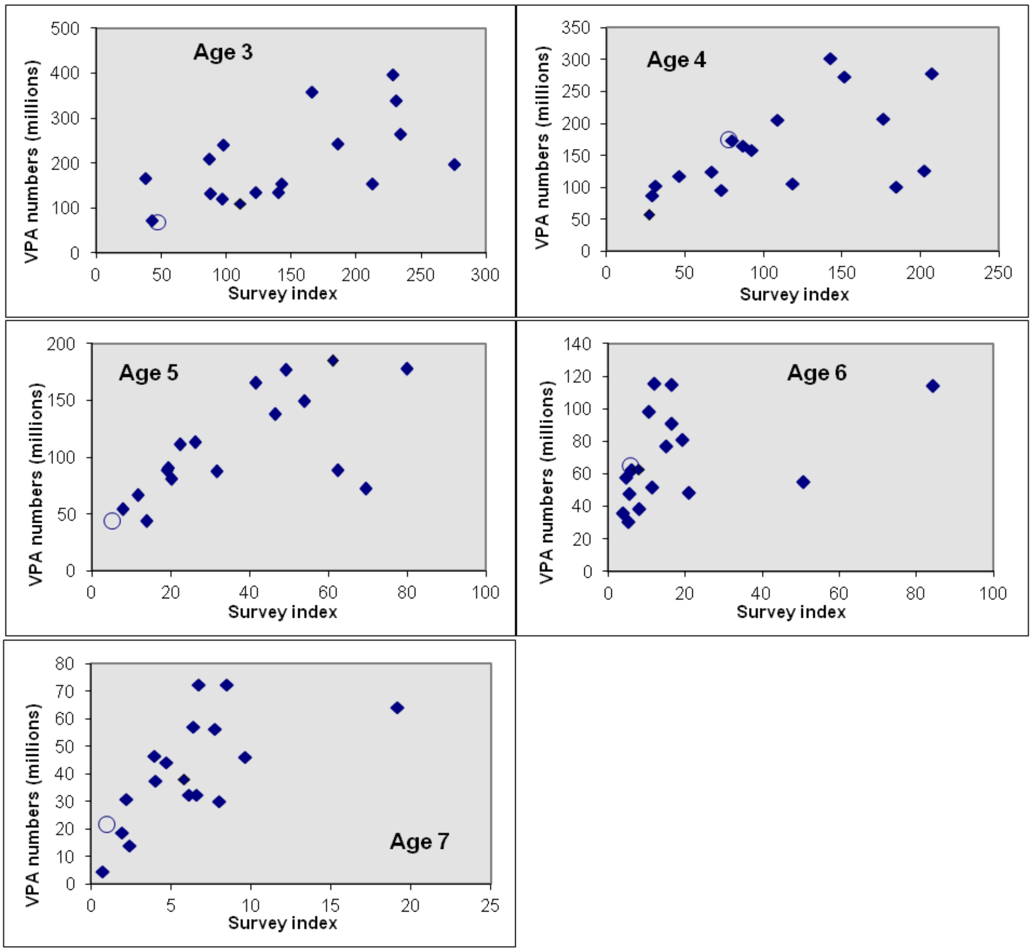


Figure 5.5.4A. NEA Saithe - Acoustic survey vs. VPA, circle shows last data year.

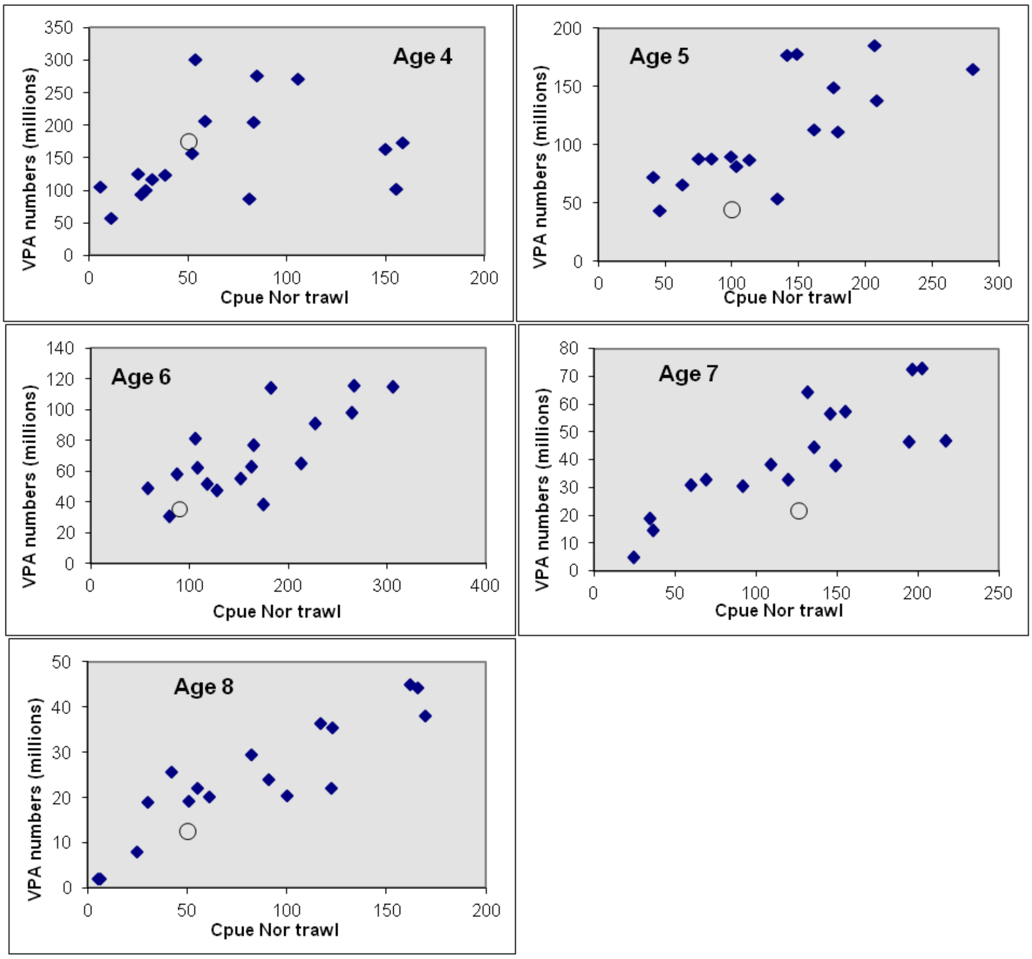


Figure 5.5.4B. NEA Saithe - Acoustic survey vs. VPA, circle shows last data year.

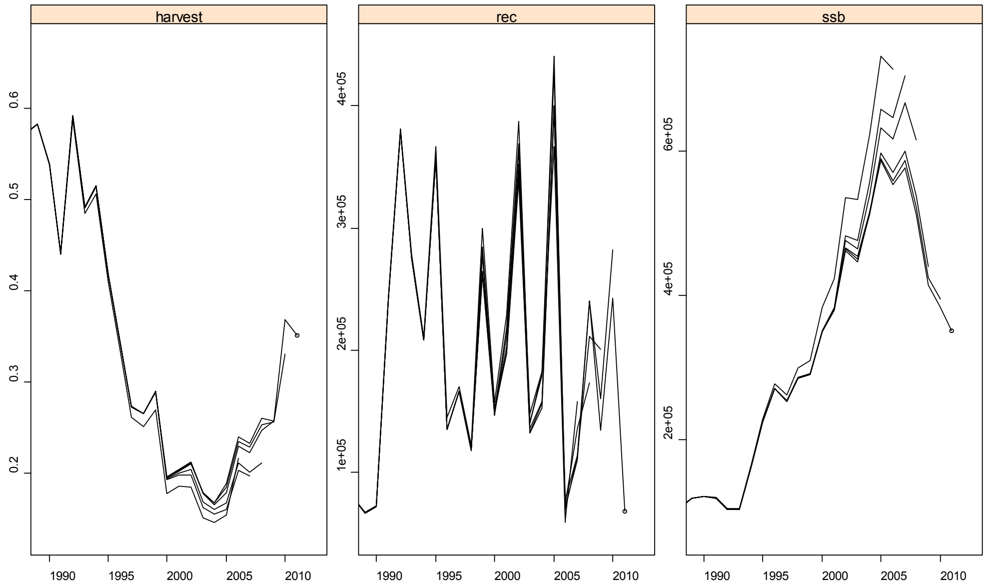


Figure 5.5.5 Saithe in Sub-areas I and II (Northeast Arctic) RETROSPECTIVE XSA F4-7, recruits and SSB for all fleets.

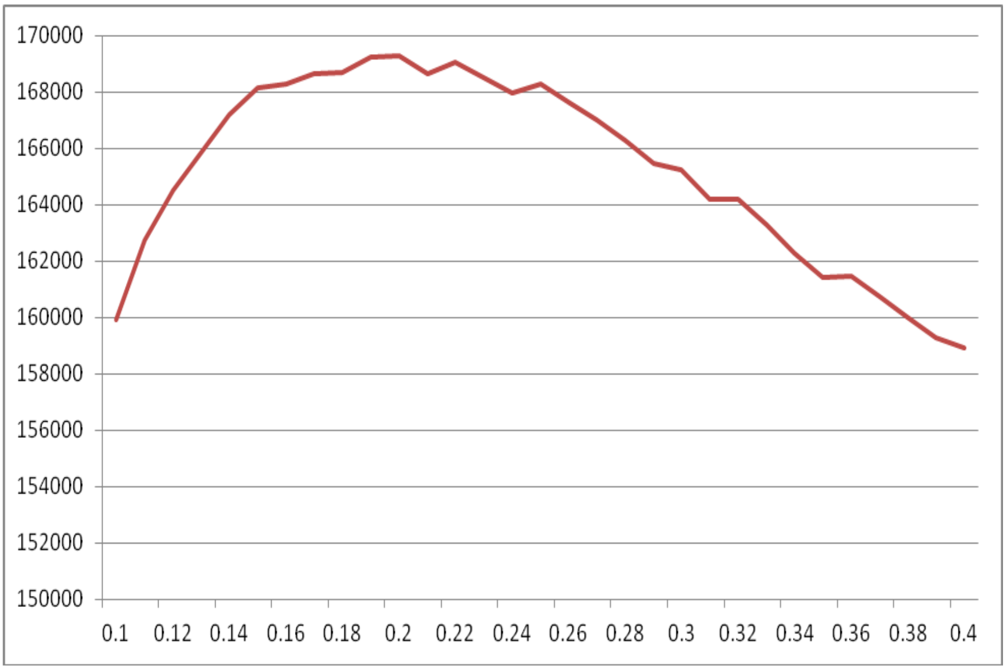


Figure 5.6.1. Long-term yield versus exploitation level in Northeast Arctic saithe simulations

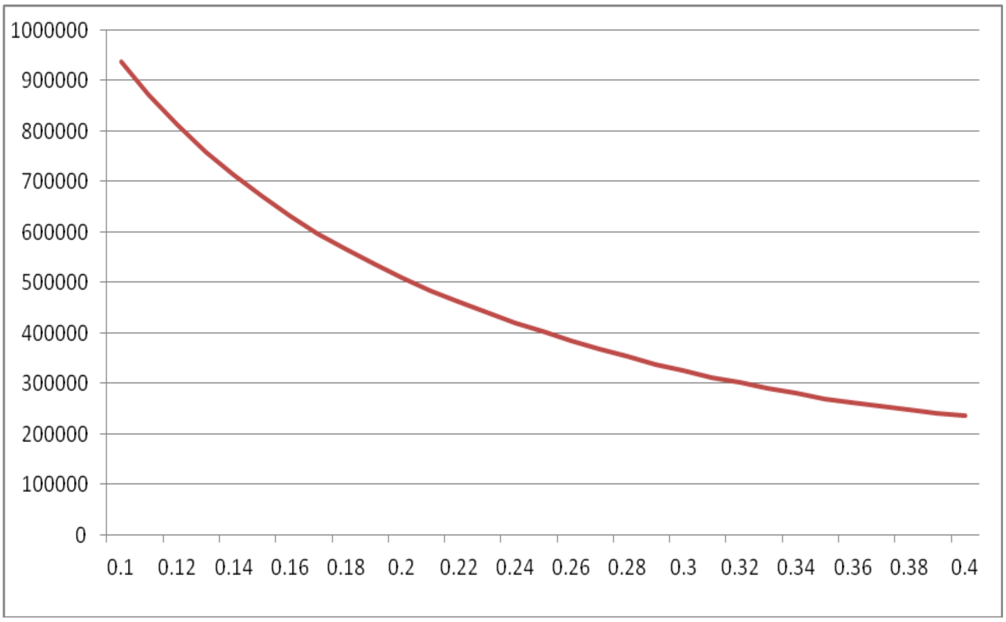


Figure 5.6.2. SSB versus exploitation level in Northeast Arctic saithe simulations

6 Beaked redfish *(Sebastes mentella)* in Subareas I and II

Following the recommendation from the benchmark assessment for redfish stocks in February 2012 (WKRED, ICES CM 2012/ACOM:48) a new analytical assessment is conducted using statistical catch-at-age model (SCAA). Additional Gadget and Schaefer biomass models are presented and used as 'sanity check' for the SCAA output.

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.

A pelagic fishery for *S. mentella* has developed in the Norwegian Sea outside EEZs since 2004 (Figure 6.1). This fishery, which is further described in the Quality handbook for this stock, is managed by the North-East Atlantic Fisheries Commission (NEAFC), and during its 29th annual meeting in November 2011 NEAFC adopted by consensus a TAC for 2012 of 7,500 t. Figure 6.2 shows the location of pelagic *S. mentella* catches by Russian fishing vessels in 2011. This fishing pattern is considered representative for the whole international fleet. 58 vessels took part in the Olympic fishery in 2011, in comparison with 23 vessels in 2010.

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 are taken as by-catches in the blue whiting and herring fisheries.

6.1.3 Landings prior to 2012 (Tables 6.1–6.5, D1–D2, Figure 6.1)

Nominal catches of *S. mentella* by country for Subareas I and II combined are presented in Table 6.1, and for both redfish species (i.e., *S. mentella* and *S. marinus*) in Table D1. The nominal catches by country for Subarea I and Divisions IIa and IIb are shown in Tables 6.2–6.4, while Table 6.5 shows the catches by country for the pelagic fishery in the Norwegian Sea. Total international landings in 1952-2011 are also shown in Figure 6.1.

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 2,520 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 increased considerably. This fishery peaked in 2006 with 33,261 t, but has since declined due to the NEAFC regulations. Nevertheless, contrary to the ICES advice of no directed trawl fishery, NEAFC set a TAC of 7,900 t (incl. all by-catches) to be taken in the pelagic trawl fisheries in international waters of the Norwegian Sea in 2011. This is, however, a reduction in TAC from 8,600 t in 2010.

The total landings of *S. mentella* in Subareas I and II in 2011, demersal and pelagic catches, amount to 12,422 t. This increase compared with the year before (11,751 t) is mainly due to increased by-catches in the demersal fisheries.

The redfish population in Subarea IV (North Sea) is believed to belong to the Northeast Arctic stock. Since this area is outside the traditional areas handled by this Working Group, the catches are not included in the assessment. The total redfish landings from Subarea IV have up to 2003 been 1,000–3,000 t per year. Since 2005 the annual landings from this area have varied between 159 and 335 t (Table D2).

6.1.4 Expected landings in 2012

In 2012 there will be no directed demersal fishery for *S. mentella*, and all the current regulations will be continued in 2012, 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 TAC, the total reported demersal by-catches of *S. mentella* for 2012 are expected to be at the current level, i.e. 4,000 t.

In addition to this come, however, the pelagic catches in the Norwegian Sea outside the EEZs. The Northeast Atlantic Fisheries Commission (NEAFC) has set a TAC of 7,500 t for an Olympic fishery in these international waters starting 15 August 2012. In total this may lead to landings in 2012 of up to 12,000 t.

6.2 Data used in the Assessment

A new analytical assessment was conducted for this stock in 2012, following recommendation from the benchmark assessment working group (WKRED, ICES CM 2012/ACOM:48). All input data sets were updated up to and including 2011. The analytical assessment, based primarily on a statistical catch-at-age model (SCAA) covers the period 1992-2011 and the data used in the SCAA include:

- total catch in tonnes (Table 6.1)
- catch in tonnes in the pelagic fishery (Table 6.5)
- total catch numbers-at-age 6-19+ (Table 6.6)
- catch numbers-at-age 11-19+ in the pelagic fishery (Table 6.8)
- weight-at-age 2-19+ in the population and fishery (Table 6.7)
- maturity-at-age 2-19+ in the population (Figure 6.5)
- Winter survey numbers-at-age 2-15 (Table D5b)
- Ecosystem survey numbers-at-age 2-15 (Table D6)
- Russian autumn survey numbers-at-age 2-11 (Table D3)

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. In 2011, data was only available from the Russian demersal fleet. The age composition is assumed to be representative of all national demersal fleets. The mean length distribution, weighted by sample size, is indicated and is the basis for deriving catch numbers at length and catch numbers at age in the fishery in 2011 (Tables 6.6 and 6.10)

Length compositions of the commercial pelagic catches of *S. mentella* in the Norwegian Sea outside EEZ in ICES Subareas IIa from Germany, Norway, Portugal and Russia are presented in Figure 6.4. Norwegian and Russian length distributions are derived from small samples and considered uncertain. The mean length distribution, weighted by sample size, is indicated and is the basis for deriving catch numbers at length and catch numbers at age in the pelagic fishery in 2011 (Tables 6.8 and 6.11).

6.2.2 Catch at age (Tables 6.6 and 6.8)

Catch at age for 2010 was not revised in 2012 due to lack of time. Age data for 2011 for demersal *S. mentella* were available from Norway for all areas, and from Russia in Division IIb. For the pelagic *S. mentella* fishery in 2010, age data based on recommended otolith readings were available only from Norway. According to Norwegian age readings, 93% of the pelagic catches were of age 19 y and over.

Russian and other countries total catch-at-length of the demersal fishery in Subarea I and Division IIa were assumed to have the same relative age distribution and mean weight as Norway. According to the Norwegian age readings, 72% of all demersal catches of *S. mentella* are composed of fish 19 y and older.

6.2.3 Weight at age (Tables 6.7 and 6.9)

Catch weight-at-age data for 2011 were available from Norway for all areas. 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 D9a,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 D9a). and from Norwegian data collected during 1992-2011 (Table D9b, Figure 6.5). This indicates an age-at-50% maturity of about 11 years with low interannual variations (SD=0.7). The proportion maturity at age was modelled for individual years using a double half Gompertz sigmoid (see legend of Table D9b). The model coefficients are reported in Table D9b. The modelled values of maturity at age for individual years are used in the analytical assessment models.

6.2.5 Scientific surveys

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

6.2.5.1 Surveys in the Barents Sea and Svalbard area (Tables 1.1, 1.3–1.4, D3–D7, Figures 6.6–6.8)

1) The international 0-group survey in the Svalbard and Barents Sea areas in August-September, now part of the Ecosystem survey (Table D8 and Figures D2 and D3). *ICES acronym: Eco-NoRu-Q3*

2) Russian bottom trawl survey in the Svalbard and Barents Sea areas in October-December from 1978–2011 in fishing depths of 100–900 m (Table D3, Figure 6.8). *ICES acronym: RU-BTr-Q4*

3) Norwegian Svalbard (Division IIb) bottom trawl survey (August-September) from 1986–2011 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). *ICES acronym: since 2003 part of Eco-NoRu-Q3 (BTr)*

4) Winter Barents Sea bottom trawl survey (February) from 1986–2012 (joint with Russia since 2000, except 2006 and 2007) in fishing depths of 100–500 m. Data disaggregated by age only for the years 1992–2010 (Table D5a,b). *ICES acronym: BS-NoRu-Q1 (BTr)*

Although the Norwegian Svalbard (August-September) and Barents Sea (February) groundfish surveys are conducted at different times of the year and may overlap in the area south of Bear Island, the two series can be combined to get an approximate total estimate for the whole area by length back to 1986 and by age back to 1992. This has been done in Figures 6.6 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 1996-2011 from less than 100 m to 800 m depth (Table D6, Figures D1 and 6.7). This survey includes survey no. 3 above, and has been a joint survey with Russia since 2003, and since then called the Ecosystem survey. *ICES acronym: Eco-NoRu-Q3 (Btr)*

6) Russian acoustic survey in April-May from 1992–2001 (except 1994 and 1996) on *S. mentella* spawning grounds in the western Barents Sea (Table D7).

Figure D5 shows the cod's predation on juvenile (5-14 cm) redfish during 1986-2011. This time series confirms the presence of redfish juveniles and may be used as an indicator of redfish abundance. A clear difference is seen between the abundance/consumption ratio in the 1980s and at present. A change in survey trawl catchability (smaller meshes) from 1993 onwards (Jakobsen *et al*. 1997) and/or a change in the cod's prey preference may cause this difference. As long as the trawl survey time series has not been corrected for the change in catchability, the abundance index of juvenile redfish less than 15 cm during the 1980s might have been considerably higher, if this change in catchability had been corrected for. The decrease in the abundance of young redfish in the surveys during the 1990s is consistent with the decline in the consumption of redfish by cod. It is important that the estimation of the consumption of redfish by cod is being continued.

6.2.5.2 Surveys along the Norwegian and Barents Seas continental slope (Figure D4)

A slope survey was carried out by IMR from 17th March to 10th April 2012. The survey was dedicated to the joint study of *Sebastes mentella* and greater argentine (*Argentina silus*) and was conducted in a manner consistent with a previous survey conducted in March/April 2009. The survey included trawling and hydroacoustics carried out from the R/V G.O. Sars. The survey track and the spatial distribution of s_A allocated to redfish from the 2009 and 2012 surveys are illustrated in Figure D4. Beaked redfish was predominantly found west of the Lofoten islands and between 70°N and 74°N at bottom depths greater than 400m, in contrast with 2009 when *S. mentella* was also found between 62°N and 63°N, between 65°30'N and 67°N but not west of the Lofoten islands. 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. The detailed biological analyses of the samples collected during the survey were not available at the time of the AFWG meeting.

6.2.5.3 Pelagic surveys in the Norwegian Sea in 2008 and 2009 (Table D12).

Unfortunately, there were no pelagic surveys in the Norwegian Sea in 2010 and 2011, a survey was planned for summer 2012 but this will most likely be postponed until 2013. The observations from the international and Norwegian surveys conducted in 2008 and 2009 are reported in Table D12, as they provide an indication of the current stock size in the open Norwegian Sea, at the time of the pelagic fishery in international waters. Using revised catchability of *S. mentella* by the Gloria trawl 2048 (Bethke et al., 2010) as well as hydroacoustic measurements, the estimated total biomass at this time was estimated to be 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.

6.2.6 Assessment

Following the development, initiated in the AFWG 2011, and the conclusions from the benchmark assessment conducted in February 2012 (WKRED, ICES CM 2012/ACOM:48), the group conducted an analytical assessment. A statistical catch-at-age (SCAA) model was used as the primary model. In addition, results from the Gadget and Schaefer biomass models presented at WKRED were considered as a sanity check.

The SCAA consists of three main entities: an age-structured population dynamics model, a catch numbers-at-age model, and an observation model for survey indices of numbers-at-age in the population. With this structure and providing reasonably accurate data on catches in numbers-at-age and survey indices in numbers-at-age, the model can estimate the parameters necessary to reconstruct population dynamics. The SCAA was developed for the period 1992-2011, with catch-at-age from the pelagic and demersal fisheries and survey numbers-at-age from the winter, ecosystem and Russian surveys. Details of the model input and parameters are provided in the stock annex. The absolute level of the SCAA requires that one of the surveys is used as an absolute index of numbers-at-age. For this purpose, the ecosystem survey level was fixed. Based on hydroacoustic observations conducted during ten surveys in the Barents Sea (ecosystem 2004, winter 2007-2009), it is estimated that the proportion of *S. mentella* in the bottom layer - accessible to bottom trawling - represents between 1/3rd and 1/6th of the fish abundance in the whole water column (measured as sA) (Anonymous, 2009). A ratio of 1/3.5 was used following recommendation from WKRED. Natural mortality was set to 0.05.

The selectivity-at-age in the surveys was originally modelled with a Gompertz sigmoid. WKRED recommended that other survey selectivity-at-age functions be explored. The sigmoid function was replaced by an exponential parabola. This was done to improve the residuals from the winter and ecosystem survey numbers-at-age. An additional likelihood component was added to the SCAA in order to track closely the reported total catches (in biomass).

The SCAA was run in ADMB. There was no prior set on the distribution of parameters. Empirical distributions of parameters were obtained using MCMC sampling, with 10^6 samples. The first 10^5 were discarded and only 1/100th of the remaining samples were retained to draw the empirical distributions. Eighty parameters were estimated in total.

6.2.7 Results of the Assessment (Tables D10 – D11, Figures 6.9 – 6.15)

6.2.7.1 Stock trends

The temporal patterns in recruitment at age 2 (Figures 6.11 and 6.13) confirm the previously reported recruitment failure for the year classes 1996 to 2003, and indicate a return to high levels of recruitment. The estimate for 2011 (year class 2009), although highly uncertain, is the highest on record. Spawning stock biomass (SSB) has steadily increased from 148 000 tonnes in 1992 to 806 000 tonnes in 2005 (Table D11). From 2006 onwards there is no obvious trend in estimated SSB, which has varied between 755 000 and 953 000 tonnes. In recent years, the total stock biomass (TSB) consists of a higher proportion of mature fish than in the 1990s and is fluctuating around one million tonnes (Table D11 and Figure 6.13).

6.2.7.2 Fishing mortality

The trends in fishing mortality (F) for the demersal fleet show a general decline from 0.07 to 0.01 during the period from 1992 to 2011. The fishing mortality of the pelagic fleet is estimated since 2006, when catch numbers-at-age were first reported and has varied between 0.01 and 0.04 (Table D10 and Figure 6.11). The patterns of selectivity at age indicate that most of the fish captured by the demersal fleet are of age 11 years and older, while the pelagic fleet mostly captures fish of age 16 and older (Figure 6.12). This is consistent with the known geographical distribution of different life stages of *S. mentella*.

6.2.7.3 Survey selectivity patterns

The winter and ecosystem surveys selectivity at age are very similar and show reduced selectivity for age 8 y and older (Figure 6.12), which is consistent with the known geographical distribution of different life stages of *S. mentella*. Conversely, the Russian survey shows a reduced selectivity for age 7 y and younger (Figure 6.12). This is believed to result from gear selectivity.

6.2.7.4 Residual patterns

Residual patterns in catch and survey indices are presented in Figure D6a-e. There is generally no trend in the residuals, neither by age nor by year, except for the winter survey, where a temporal trend is noticeable.

6.2.7.5 Retrospective patterns

The retrospective patterns for the years 2007 to 2010 are presented in Figure 6.14. All model parameters were estimated in each individual run. The most recent model run (last year of data 2011) is consistent with previous runs although indicating slightly higher SSBs in recent years.

6.2.7.6 Medium-term projections

Projections of SSB for the period 2012 to 2020 are presented for four catch and 3 recruitment scenarios: catch = 0; catch = ½ of 2011 catches (6 211 t), catch = 2011 catches (12 422 t), catch = twice the 2011 catches (24 844 t); Recruitment = average of recruitment 1998-2005 (39 million), recruitment = ½ average recruitment 2006-2010 (147 million), recruitment = average recruitment 2006-2010 (294 million) (Figure 6.15). The recruitment scenarios did not influence the projected SSB over the considered time period. The future development of the SSB is dependent on the catch scenario and the incoming year classes born prior to 2011. Under the assumption of future catches being constant at the average 2006-2010 level, the SSB is expected to decline to 756 000 tonnes by 2015 and return to the current SSB level by 2018. The short term decrease in SSB results from incoming poor year classes born in 1996-2003.

6.2.7.7 Gadget and Schaefer models

The trends in total biomass and SSB from the Gadget model (Figure 6.10) are similar to those of the SCAA, although smoother. The absolute biomass estimates from the SCAA are slightly greater than those from Gadget: ~ 900/1 000 thousand tonnes for SSB and TSB respectively in SCAA, vs. 700/850 thousand tonnes in Gadget. Since Gadget estimates stock levels directly from the input data, without any ad hoc assumptions about survey catchability, the estimated stock levels have a good lower bound (there must have been a certain population level to sustain the historically reported catches), however the upper bound is much less certain. Consequently the Gadget results may be considered a minimum bound on the actual stock size.

The Schaefer model results show an increasing trend in TSB from 1992 to 2011 from 1.1 to 1.7 million tonnes (Figure 6.9). These absolute biomasses are by far greater than those estimated by Gadget. However, the results from the Schaefer model must be interpreted with great caution because the survey data provided as an input for the recent years (1992 onwards) do not faithfully represent annual variations in the population biomass. The winter and ecosystem survey data predominantly catch immature individuals whilst many of the mature individuals – which constitute the bulk of the adult population and of the fishable stock – are outside the area monitored by these surveys. The ratio of biomass in 2011 over maximum biomass is estimated to be 80%. This can serve as a basis for the setting of reference points.

6.2.7.8 Additional considerations

Historical fluctuations in the recruitment at age 2 (Figures 6.11 and 6.13) are consistent with the 0-group survey index (Table D8 and Figure D3), although the 0-group survey index is not used as an input to the SCAA.

Biomass estimates from the Norwegian Sea pelagic surveys conducted in 2008 and 2009 provide a lower bound for the absolute SSB at around ½ million tonnes. This is consistent with the SSB estimated in recent years, using the SCAA (900 thousand tonnes).

Natural mortality of young *S. mentella* may be considerably higher than the values of 0.05 y^{-1} used in the SCAA. Recruitment of *S. mentella* to the fishery might be influenced by variable and possibly high natural mortality of young *S. mentella* due to predation, mainly by cod. The cod stock is at a high level at present, a situation which is likely to continue (see section 3). Recent recruitment levels estimated with SCAA are highly uncertain and may be revised downwards if cod predation induces high mortality rates (Figure D5).

6.3 Comments to the assessment

The assessment presented in this report is the first analytical assessment conducted for this stock since 2003, when an exploratory XSA was conducted (ICES CM 2003/ACFM:22). The new methodology employed follows the recommendations from the benchmark assessment conducted in February 2012 (WKRED, ICES CM 2012/ACOM:48). The assessment confirms the recruitment failure for the year classes 1996 to 2003, and indicates a subsequent increase in recruitment to high levels. Since 1992 the SSB has increased continuously but this trend has halted in recent years and is expected to reverse in the near future, resulting from the incoming poor year classes 1996-2003. In recent years, the total stock biomass (TSB) consists of a higher proportion of mature fish than in the 1990s and is fluctuating around an estimated one million tonnes.

Current estimated fishing mortalities for the demersal and pelagic fleets are considerably lower (F = 0.003 and 0.013) than the assumed natural mortality of M = 0.05. However, these estimates depend upon the true absolute stock level, which remains uncertain.

The natural mortality level of 0.05 was chosen during the benchmark assessment, based on life-history empirical studies (Hoenig 1983) and Gadget/SCAA fitting performance. However, the cod predation estimates suggest higher mortality rates on young juveniles. This issue needs further investigations.

The weight-at-age of older fish (age 19+) in the catches has steadily declined from 0.85 kg in 1996 to 0.62 kg in 2011 (Table 6.7). The reasons for this decline are still unclear, but it has contributed to a slowing down of the recovery of both TSB and SSB.

Additional data from the 0-group and pelagic Norwegian Sea surveys are consistent with the result of the current assessment.

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. Currently, the survey series used in the SCAA do not appropriately cover the geographical distribution of the adult population. Priority should be given to data collection over the slope (Figure D4) and open Norwegian Sea (Table D12) regions, where the adult population is most abundant, and to including these new surveys in the analytical assessment in the future.

One limitation of the current SCAA model is that the bulk of the biomass is included in the plus group (age 19+). The current SCAA model should be expanded to include separate age groups up to 30 years. Furthermore, it is important that every nation should follow the ICES recommendations for the age reading of mature fish of 20 years or more (WKADR, ICES CM 2006/RMC:09, ICES CM 2009/ACOM:57). The sample size of aged *S. mentella* should be increased to ensure that reliable age-length-keys can be estimated.

Documentation of the fishing effort involved and the catches taken in the international fishery is very important, and NEAFC is requested to continue to provide timely and consistent information for future stock assessments and advice. National reporting of length distributions in the demersal and pelagic commercial catches needs to be increased.

6.4 Biological reference points

In the absence of long time series of surveys on the mature stock and of model runs, it is difficult to establish reference points, although some attempts have been made (ICES CM 2009/ACOM: 49, ICES CM 2010/ACOM:54). However, in the present situation a possible approach is to advice on catch levels which give a low probability of decreasing stock size.

The table below provides expected changes in SSB by 2015 and 2020 assuming four different catch scenarios. The SSB levels are given as proportions of the mean SSB during the period 2006 – 2010. Based on the Schaefer biomass model, the ratio of current TSB over virgin TSB is estimated at 80% in 2011 (Figure 6.9, WKRED, ICES CM 2012/ACOM:48). The projected evolution of this ratio is presented in the table below. The values for 2011 are provided as a reference.

		Catch scenario			
Projection year		zero catch	½ C_{2011}	1 C_{2011}	2 C_{2011}
2011	%$SSB_{2006-2010}$	100%			
	%virgin TSB	80%			
2015	%$SSB_{2006-2010}$	97%	94%	91%	86%
	%virgin TSB	99%	96%	92%	85%
2020	%$SSB_{2006-2010}$	126%	120%	114%	105%
	%virgin TSB	115%	109%	102%	92%

6.5 Management advice

The results of the new analytical assessment have changed the perception of the stock status. The present advice is based on this new perception and quantitative projections.

The current size of the mature stock, as estimated from the SCAA, Gadget and surveys, is at least ½ million tonnes and more likely above 800 000 tonnes. This is expected to decrease in coming years due to poor year classes born in 1996-2003. The stock of *S. mentella* in subareas I and II may at present sustain a moderate fishery.

If catches are maintained at the level of 2011, it is expected that the SSB will decline by 9% by 2015 but return to current level by 2017. The long term effects of maintaining current catch levels on the demographic structure and reproductive potential of *S. mentella* have not been investigated yet. Given the longevity of the species (70 years) and low productivity of the stock, *S. mentella* has a long recovery time. It is therefore recommended that catches should not increase beyond current levels until the long term effects on demography are better estimated.

Therefore, the advice for 2013 is that a commercial fishery can operate on *S. mentella*, given that the total catch level, including bycatches and discards, does not exceed the current level (2011) of 12 500 tonnes. Measures currently in place to protect juveniles have proven successful and should be maintained.

6.6 Implementing the ICES F_{msy} framework

No progress has been made on this matter during the AFWG in 2012. Relevant information can be found in the 2011 AFWG report.

6.7 Response to RGAFNW Technical minutes

Work on the MSY framework has unfortunately not been conducted intersessionally, as originally planned. This was partly due to lack of time and additional work conducted to develop the new analytical assessment models presented at the benchmark assessment and in this report: Gadget and SCAA.

Biological reference points for this stock have not been directly investigated and as an alternative approach, advice has been supported by modelled stock projections based on future catch scenarios and life-history considerations.

Appropriate reference in now given for the catchability of the Gloria trawl 2048. The work is published in the peer reviewed literature (Bethke et al., 2010).

The model options chosen for the SCAA, Gadget and Schaefer models are described in the stock annex. If this option becomes available in the future, the R and ADMB codes used to perform the SCAA can be made available as an electronic supplement to the AFWG report.

Table 6.1. ***Sebastes mentella*** **in Subareas I and II. Nominal catch (t) by countries in Subarea I, Divisions IIa and IIb combined.**

Year	Canada	Denmark	Faroe Islands	France	Germany[2]	Greenland	Ireland	Norway	Poland	Portugal	Russia[3]	Spain	UK (Engl. & Wal.)	UK (Scotl.)[4]	Total
1993	8	4	13	50	35	1	-	5,182	-	963	6,260	5	293	-	12,814
1994	-	28	4	74	18	1	3	6,511	-	895	5,021	30	124	12	12,721
1995	-	-	3	16	176	2	4	2,646	-	927	6,346	67	93	4	10,284
1996	-	-	4	75	119	3	2	6,053	-	467	925	328	76	23	8,075
1997	-	-	4	37	81	16	6	4,657	1	474	2,972	272	71	7	8,598
1998	-	-	20	73	100	14	9	9,733	13	125	3,646	177	93	41	14,045
1999	**Iceland**	-	73	26	202	50	3	7,884	6	65	2,731	29	112	28	11,209
2000	48	**Estonia**	50	12	62	29	1	6,020	2	115	3,519	87		130	10,075
2001	3	-	74	16	198	17	4	13,937	5	179	3,775	90		120	18,418
2002	41	15	75	58	99	18	4	2,152	8	242	3,904	190	**Sweden**	188	6,993
2003	5	-	64	22	32	8	5	1,210	7	44	952	47	-	124	2,520
2004	10	-	588	13	10	4	3	1,375	42	235	2,879	257	1	76	5,493
2005	4	5	1,147	46	33	39	4	1,760	-	140	5,023	163	**Netherl**. -7	95	8,465
2006	2,513	396	3,808	215	2,483	63	4	4,710	2,496	1,804	11,413	710	**Lithu**.- 845 **Latvia**-341 **Ca-da**-433	1,027	33,261
2007	1,587	684	2,197	234	520	29	17	3,209	1,081	1,483	5,660	2,181	**Lithu** -785 **Latvia** -349	202	20,219
2008	9	-	1,849	187	16	25	9	2,214	8	713	7,117	463	**Lithu** -117 **Latvia** -267 **Netherl** -13	83	13,089
2009	33	-	1,343	15	42	-	-	2,567[1]	338	806	3,843	177	**Netherl** -3 **EU**-889	80	10,135
2010[1]	2	-	979	175	21	12	-	2,245	-	293	6,414	831	**Lithu** -457 **Latvia** -243	79	11,751
2011[1]	-	-	755	104	835	-	-	2,690	11	620	5,037	1,267	**Lithu** -512 **Latvia** -536	55	12,422

[1] **Provisional figures.**

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

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

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

Table 6.2. ***Sebastes mentella*** **in Subareas I and II. Nominal catch (t) by countries in Subarea I.**

Year	Faroe Islands	Germany[4]	Greenland	Norway	Russia[5]	UK(Eng.&Wales)	Iceland	Total
1993	2[2]	-	-	16	588	-	-	606
1994	2[2]	2	-	36	308	-	-	348
1995	2[2]	-	-	20	203	-	-	225
1996	-	-	-	5	101	-	-	106
1997	-	-	3[2]	12	174	1[2]	-	190
1998	20[2]	-	-	26	378	-	-	424
1999	69[2]	-	-	69	489	-	-	627
2000	-	-	-	47	406	-	48[2]	501
2001	-	-	-	8	296	-	3[2]	307
2002	-	-	-	4	587	-	-	591
2003	-	-	-	6	292	-	-	298
2004	-	-	-	2	355	-	-	357
2005	-	-	-	3	327	-	-	330
2006	2[3]	-	-	12	460	2	-	476
2007	-	-	-	11	210	20	8	249
2008	-	-	-	5	155	2	-	162
2009	-	-	-	3[1]	80	-	8	91
2010[1]	-	-	-	22	10	-	-	32
2011[1]	-	-	-	42	13	-	-	55

[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 Subareas I and II. Nominal catch (t) by countries in Division IIa (including landings from the pelagic trawl fishery in the international waters).**

Year	Estonia	Faroe Islands	France	Germany[3]	Greenland	Ireland	Norway	Sweden	Portugal	Poland	Russia[5]	Spain	UK (Eng. &Wales)	UK (Scotland)[3]	Total
1993		11[2]	15[2]	35	1[2]	-	5,029		648[2]		5,328	-	2[2]	-	11,069
1994		2[2]	33[2]	16[2]	1[2]	2[2]	6,119		687[2]		4,692	8[2]	4[2]	-	11,564
1995		1[2]	16[2]	176[2]	2[2]	2[2]	2,251		715[2]		5,916	65[2]	41[2]	2[2]	9,187
1996		-	75[2]	119[2]	3[2]	-	5,895		429[2]		677	5[2]	42[2]	19[2]	7,264
1997		-	37[2]	77	12[2]	2[2]	4,422		410[2]		2,341	9[2]	48[2]	7[2]	7,365
1998		-	73[2]	58[2]	14[2]	6[2]	9,186		118[2]		2,626	55[2]	65[2]	41[2]	12,242
1999		-	16[2]	160[2]	50[2]	3[2]	7,358		56[2]		1,340	14[2]	94[2]	26[2]	9,117
2000		50[2]	11[2]	35[2]	29[2]	-	5,892		98[2]		2,167	18[2]	**Iceland**	103[2]	8,403
2001		63[2]	12[2]	161[2]	17[2]	4[2]	13,636		105[2]		2,716	18[2]	-	95[2]	16,827
2002		37[2]	54[2]	59[2]	18[2]	4[2]	1,937		124[2]		2,615	8[2]	41[2]	157[2]	5,055
2003		58[2]	18[2]	17[2]	8[2]	5[2]	1,014		17[2]		448	8[2]	5[2]	102[2]	1,700
2004		555[2]	8[2]	4[2]	4[2]	3[2]	987	1[2]	86[2]		2,081	7[2]	10[2]	18[2]	3,765
2005		1,101[2]	36[2]	17[2]	38[2]	4[2]	1,083[1]	-	71[2]		3,307	20[2]	2[2]	15[2]	5,693
2006	396	3,793	199	2,475	52[2]	3	4,010	**Lithu** -845 **Can** - 433[4]	1,731	2,467	10,110	589	2,513	958[2]	30,915
2007	684	2,157	226	519	29[2]	16	3,043	**Lithu** -785 **Latvia** -349	1,395	1,079	5,061	2,159	1,579[4]	120[2]	19,200
2008	-	1,821	179[2]	9[2]	24[2]	9	1,947	**Lithu** -117 **Latvia** -267 **Nether** -13[2]	666	1	6,442	430	9[2]	62[2]	11,996
2009	-	1,316	7[2]	23[2]	-	-	2,117[1]	**EU**-889[4]	764	338	3,305	137	25	62[2]	8,982
2010[1]	-	961	175[2]	13[2]	12[2]	-	1,854	**Lithu** -457[4] **Latvia**-243[4]	246	-	5,903	825	2[2]	55[2]	10,746
2011[1]	-	740	104	697	-	-	1,736	**Lithu** -507[4] **Latvia** -536[4]	606	-	4,326	1,245		19[2]	10,514

[1] Provisional figures.

[2] Split on species according to reports to Norwegian authorities.

[3] Includes former GDR prior to 1991.

[4]As reported to NEAFC

[5] USSR prior to 1991.

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

Table 6.4. ***Sebastes mentella*** **in Subareas I and II. Nominal catch (t) by countries in Division IIb.**

Year	Canada	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Poland	Portugal	Russia	Spain	UK(Eng. & Wales)	UK (Scot-land)	Total
1993	8[2]	4[2]	-	35[2]	-	-	-	137	-	315[2]	344	57[3]	291[2]	-	1,191
1994	-	28[2]	-	41[2]	-	-	1[2]	356	-	208[2]	21	22[3]	120[2]	12[2]	809
1995	-	-	-	-	-	-	2[2]	375	-	212[2]	227	2[3]	52[2]	2[2]	872
1996	-	-	4[2]	-	-	-	2[2]	153	-	38[2]	147	323[2]	34[2]	4[2]	705
1997	-	-	4[2]	-	3	1[2]	4[2]	223	1[2]	64[2]	457	263[2]	22[2]	-	1,042
1998	-	-	-	-	42[2]	-	3[2]	521	13[2]	7[2]	642	122[2]	28[2]	1[2]	1,379
1999	-	-	4[2]	10[2]	42[2]	-	-	457	6[2]	9[2]	902	15[2]	18[2]	2[2]	1,465
2000	-	-	-	1[2]	27[2]	-	1[2]	82	2[2]	17[2]	946	69[2]	-	27[2,4]	1,172
2001	-	-	11[2]	4[2]	37[2]	-	-	293	5[2]	74[2]	763	72[2]	**Estonia**	25[2,4]	1,284
2002	-	-	38[2]	4[2]	40[2]	-	-	210	8[2]	118[2]	702	182[2]	15	31[2,4]	1,348
2003	-	-	6[2]	4[2]	15[2]	-	-	190	7	27[2]	212	39[2]	-	22[2,4]	522
2004	-	-	33[2]	5[2]	6[2]	-	-	386	42[2]	149[2]	443	250[2]	-	58[2,4]	1,372
2005	**Nether**.-7[2]	**Iceland**- 2[2]	46[2]	10[2]	17[2]	1[2]	-	673	-	69[2]	1,389	143[2]	5	80[2,4]	2,442
2006	-	-	13[2]	16[2]	8[2]	11[2]	1[2]	688	29	73[2]	843	121[2]	-	67[2,4]	1,870
2007	-	-	40	8[2]	1	-	1[2]	155	2	88	389	22[2]	-	62[2,4]	769
2008	-	-	28[2]	8[2]	7[2]	1[2]	-	262	6	47[2]	520	33[2]	-	19[2,4]	931
2009	3[2]	-	27[2]	8[2]	19[2]	-	-	447[1]	1	42	458	41	-	17[2,4]	1,062
2010[1]	-	-	18[2]	-	8[2]	-	-	369	-	47[2]	501	5[2]	-	24[2,4]	973
2011[1]	**Lith**.- 5	-	15	-	139[2]	-	-	912	11	14	698	23	-	36[2,4]	1,852

[1] Provisional figures.

[2] Split on species according to reports to Norwegian authorities.

[3] Split on species according to the 1992 catches.

[4] UK(E&W)+UK(Scot.)

Table 6.5. ***Sebastes mentella*** **in Subareas I and II. Nominal catch (t) by countries of the pelagic fishery in international waters of the Norwegian Sea (see text for further details).**

Year	Canada	Estonia	Faroe Islands	France	Germany	Iceland	Latvia	Lithuania	Norway	Poland	Portu-gal	Russia	Spain	UK	Total
2002	-	-	-	-	9	-	-	-	-	-	-	-	-	-	9
2003	-	-	-	-	40	-	-	-	-	-	-	-	-	-	40
2004	-	-	500	-	2		-	-	-	-	-	1,510		-	2,012
2005	-	-	1,083	-	20	-	-	-	-	-	-	3,299		-	4,402
2006	433	396	3,766	192	2,475	2,510[2]	341	845	2,862	2,447	1,697	9,390	575	841	28,770
2007	-	684	1,968[2]	226	497	1,579[2]	349	785	1,813[2]	1,079	1,377	3,645	2,155	-	16,157
2008	-	-	1,797[2]	-	-	-	267	117	330	-	641	4,901	390[1]	EU[3]	8,443
2009	-	-	1,253	-	-	-	-	-	-	337	701	1,975	135	889	5,290
2010[1]	-	-	912	-	-	-	243	457	450	-	244	5,103	820	-	8,229
2011[1]	-	-	740[2]	104	693[4]	-	536	507	342	-	601	3,621	1,237	-	8,380

[1] Provisional figures.

[2] As reported to NEAFC

[3] EU not split on countries.

[4] As reported in a working document

Table 6.6. *S.mentella* in Subareas I and II. Catch numbers at age 6 to 18 and 19+ (in thousands) and total landings (in tonnes).

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	+gp	Total No.	Tons Land.
1992	1873	2498	1898	1622	1780	1531	2108	2288	2258	2506	2137	1512	677	9258	33946	15590
1993	159	159	174	512	2094	3139	2631	2308	2987	1875	1514	1053	527	6022	25154	12866
1994	738	730	722	992	2561	2734	3060	1535	2253	2182	3336	1284	734	3257	26118	12721
1995	662	941	1279	719	740	1230	2013	4297	3300	2162	1454	757	794	2404	22752	10284
1996	223	634	1699	1554	1236	1078	1146	1413	1865	880	621	498	700	2247	15794	8075
1997	125	533	1287	1247	1297	1244	876	1416	1784	1217	537	1177	342	3568	16650	8597
1998	37	882	2904	4236	3995	2741	1877	1373	1277	1595	1117	784	786	6241	29845	14045
1999	9	83	441	1511	2250	3262	1867	1454	1447	1557	1418	1317	658	3919	21193	11209
2000	1	24	390	1235	2460	2149	1816	1205	1001	993	932	505	596	5705	19012	10075
2001	117	372	542	976	925	1712	2651	2660	1911	1773	1220	714	814	16234	32621	18418
2002	2	40	252	572	709	532	1382	1893	1617	855	629	163	237	4082	12965	6993
2003	6	37	103	93	132	220	384	391	434	466	513	199	231	1193	4400	2520
2004	11	24	108	148	427	624	931	580	1385	1047	937	927	549	2055	9754	5493
2005	5	44	128	347	540	567	432	1607	1332	3174	1041	1216	1024	4266	15725	8466
2006	0	10	8	89	153	256	877	1980	2774	4580	5154	4823	4261	35350	60313	32895
2007	0	1	5	32	52	151	314	1025	2466	2836	3570	4002	2866	17148	34469	19837
2008	0	0	1	10	44	128	186	492	541	1444	1423	923	1730	16389	23311	13089
2009	0	1	16	22	42	48	1507	520	983	1136	1623	1292	2347	7389	16925	10135
2010[1]	10	4	6	19	34	55	61	237	540	532	848	828	792	14659	18625	11751
2011[1]	4	4	4	25	55	114	234	186	177	482	415	445	394	17315	19857	12422

[1] preliminary figures

Table 6.7. *S.mentella* in Subareas I and II. Catch weights at age (kg).

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	+gp
1991	0,13	0,18	0,21	0,27	0,34	0,35	0,42	0,46	0,51	0,58	0,59	0,58	0,59	0,7
1992	0,19	0,22	0,26	0,28	0,31	0,33	0,38	0,46	0,43	0,43	0,45	0,52	0,57	0,67
1993	0,17	0,23	0,25	0,28	0,33	0,38	0,44	0,47	0,5	0,57	0,58	0,62	0,65	0,66
1994	0,16	0,22	0,24	0,3	0,34	0,37	0,4	0,44	0,45	0,49	0,55	0,58	0,67	0,79
1995	0,14	0,16	0,19	0,21	0,28	0,32	0,37	0,41	0,47	0,53	0,58	0,66	0,71	0,81
1996	0,2	0,2	0,25	0,31	0,42	0,44	0,47	0,59	0,67	0,69	0,71	0,74	0,74	0,85
1997	0,18	0,21	0,25	0,29	0,33	0,38	0,46	0,48	0,51	0,55	0,6	0,66	0,65	0,79
1998	0,14	0,19	0,23	0,29	0,33	0,38	0,43	0,48	0,54	0,59	0,61	0,64	0,66	0,75
1999	0,15	0,22	0,22	0,28	0,33	0,37	0,44	0,49	0,53	0,56	0,62	0,66	0,67	0,81
2000	0,1	0,15	0,22	0,26	0,31	0,36	0,42	0,44	0,51	0,56	0,62	0,63	0,67	0,77
2001	0,11	0,15	0,20	0,25	0,30	0,34	0,39	0,44	0,48	0,53	0,59	0,62	0,65	0,70
2002	0,13	0,17	0,22	0,29	0,34	0,38	0,43	0,44	0,52	0,56	0,57	0,60	0,59	0,73
2003	0,09	0,14	0,22	0,28	0,33	0,39	0,43	0,45	0,50	0,54	0,59	0,57	0,62	0,75
2004	0,13	0,17	0,22	0,27	0,33	0,38	0,43	0,43	0,50	0,54	0,58	0,61	0,64	0,72
2005	0,13	0,17	0,21	0,28	0,34	0,38	0,43	0,45	0,50	0,55	0,56	0,59	0,61	0,70
2006	-	0,14	0,23	0,29	0,34	0,42	0,45	0,46	0,49	0,53	0,54	0,55	0,56	0,66
2007	-	0,14	0,25	0,33	0,19	0,33	0,30	0,29	0,48	0,48	0,51	0,61	0,59	0,68
2008	-	0,29	0,30	0,30	0,32	0,36	0,49	0,43	0,63	0,56	0,55	0,64	0,32	0,64
2009	0,21	0,20	0,35	0,43	0,43	0,47	0,52	0,54	0,55	0,62	0,62	0,64	0,65	0,67
2010[1]	0,21	0,14	0,23	0,40	0,49	0,54	0,56	0,61	0,57	0,56	0,60	0,65	0,60	0,64
2011[1]	0,11	0,11	0,31	0,51	0,67	0,63	0,49	0,62	0,62	0,69	0,69	0,63	0,67	0,62

[1] preliminary figures

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

Numbers*10**-3					Age				
YEAR	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19+**
2006	23	93	1083	323	1563	3628	2514	3756	29704
2007	75	440	1331	2909	3347	4138	3692	3437	9114
2008	28	146	115	143	214	594	752	753	13258
2009	9	1314	294	471	889	999	869	1150	2981
2010[1]	0	0	130	336	254	466	467	508	11510
2011[1]	0	223	83	83	168	136	166	136	13182

[1] preliminary figures

Table 6.9 Pelagic *Sebastes mentella* in the Norwegian Sea (outside the EEZ). Catch weights at age (kg).

					Age				
YEAR	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19+**
2006	0,44	0,44	0,52	0,44	0,49	0,55	0,53	0,56	0,61
2007	0,39	0,43	0,41	0,48	0,50	0,52	0,55	0,57	0,64
2008	0,36	0,47	0,56	0,50	0,56	0,54	0,56	0,55	0,64
2009	0,38	0,44	0,45	0,48	0,54	0,59	0,64	0,58	0,69
2010[1]	-	-	0,62	0,56	0,54	0,59	0,59	0,56	0,61
2011[1]	-	0,48	0,54	0,54	0,64	0,59	0,54	0,59	0,59

[1] preliminary figures

[4] **As reported in a working document**

Table 6.10. ***S. mentella*** **in Subareas I and II. Total catch numbers at length, in thousands, for 2011.**

	LENGTH GROUP																
	18	**20**	**22**	**24**	**26**	**28**	**30**	**32**	**34**	**36**	**38**	**40**	**42**	**44**	**46**	**48**	**50**
Year	**20**	**22**	**24**	**26**	**28**	**30**	**32**	**34**	**36**	**38**	**40**	**42**	**44**	**46**	**48**	**50**	**52**
2011	0	11	0	0	1	8	242	2478	6313	6359	3526	808	93	17	1	0	0

Table 6.11. ***S. mentella*** **in Subareas I and II. Catch numbers at length, in thousands, in the pelagic fishery for 2011.**

	LENGTH GROUP																
	18	**20**	**22**	**24**	**26**	**28**	**30**	**32**	**34**	**36**	**38**	**40**	**42**	**44**	**46**	**48**	**50**
Year	**20**	**22**	**24**	**26**	**28**	**30**	**32**	**34**	**36**	**38**	**40**	**42**	**44**	**46**	**48**	**50**	**52**
2011	0	0	0	0	1	8	231	2427	5577	4192	1456	272	13	0	1	0	0

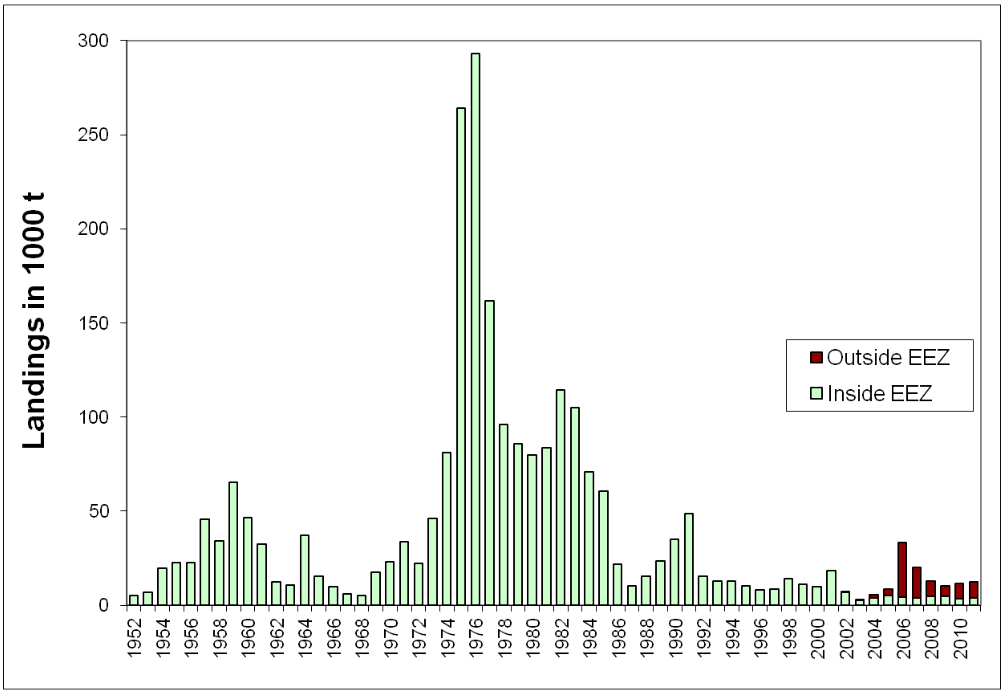


Figure 6.1. ***Sebastes mentella*** **in Subareas I and II. Total international landings 1965-2011 (thousand tonnes).**

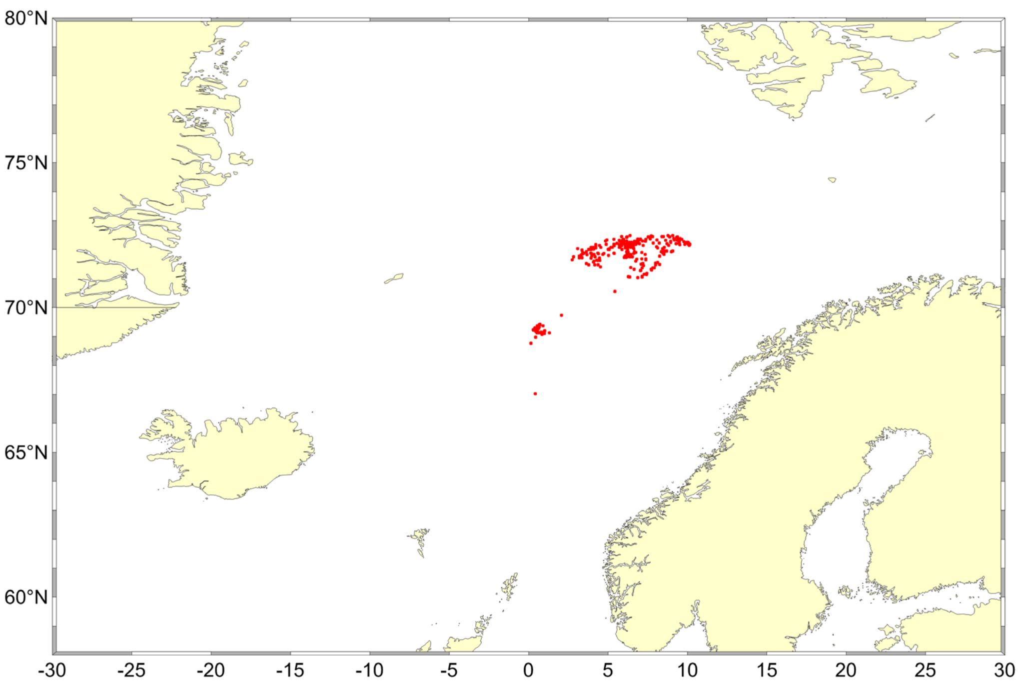


Figure 6.2. ***Sebastes mentella*** **in Subareas I and II. Location of pelagic** ***S. mentella*** **catches by Russian fishing vessels in 2011.**

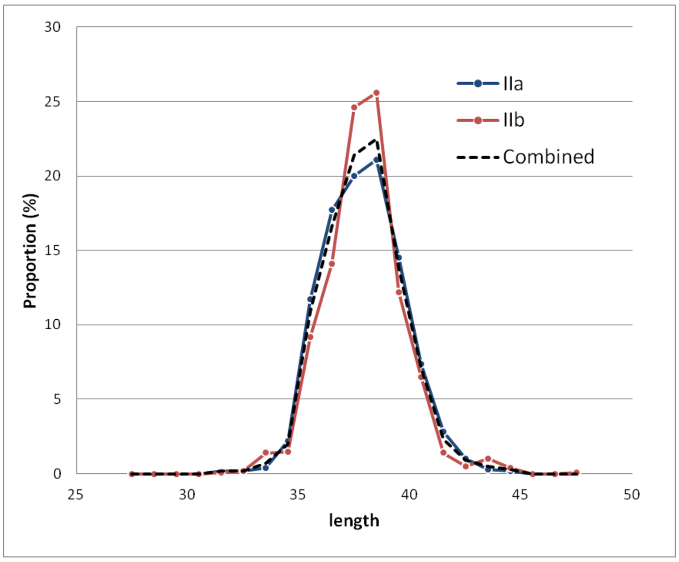


Figure 6.3. ***Sebastes mentella*** **in Subareas IIa and IIb. Length-distributions of the commercial demersal catches inside EEZ in ICES Subareas IIa and IIb by Russia in 2011.**

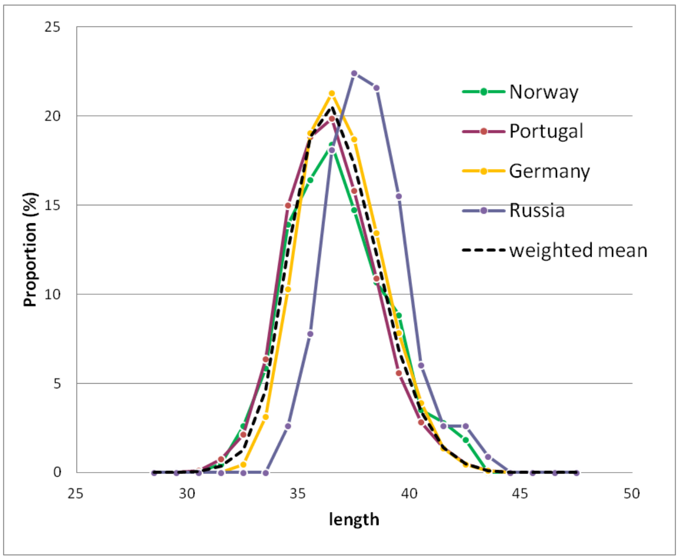


Figure 6.4. ***Sebastes mentella*** **in Subareas I and II. Length-distributions of the commercial pelagic catches in the Norwegian Sea outside EEZ in ICES Subarea IIa by those countries providing length data from their pelagic fisheries in 2011.**

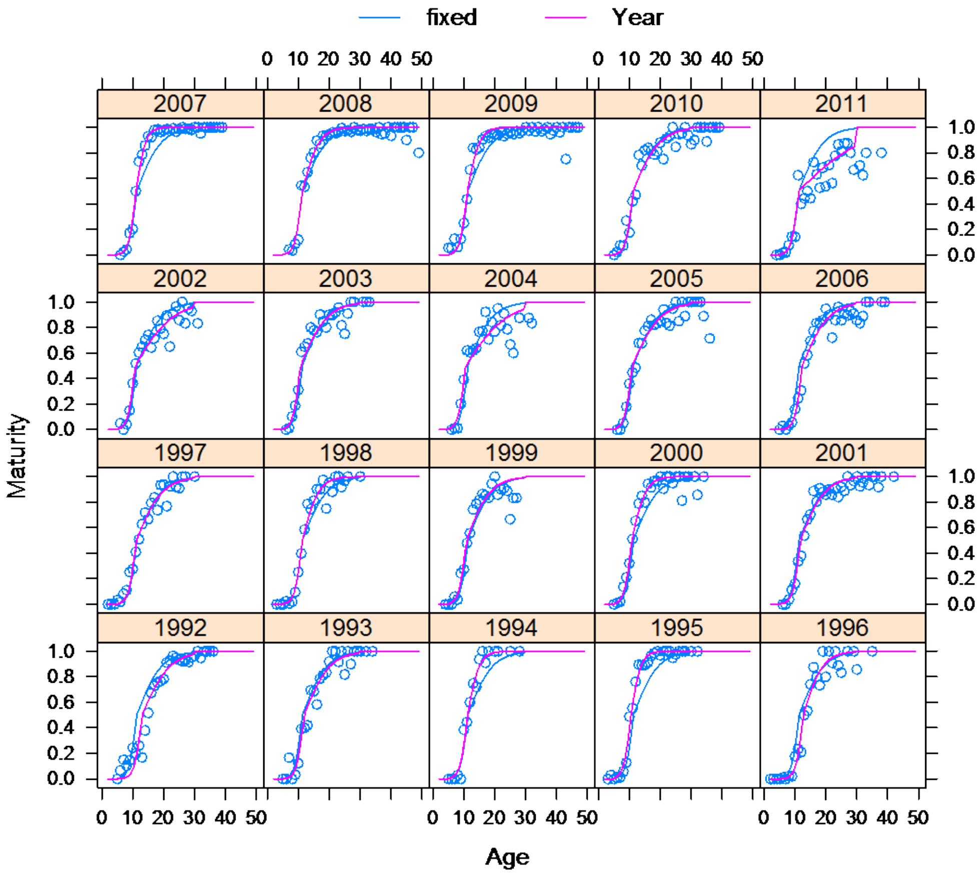


Figure 6.5. Proportion maturity at age of *S. mentella* in subareas I and II derived from Norwegian commercial and survey data (Table D9b). The proportions were derived from samples with at least five individuals. The blue and purple lines show the fitted models. For 2011, the fixed model (blue) was used, for other years the annual models were used (purple).

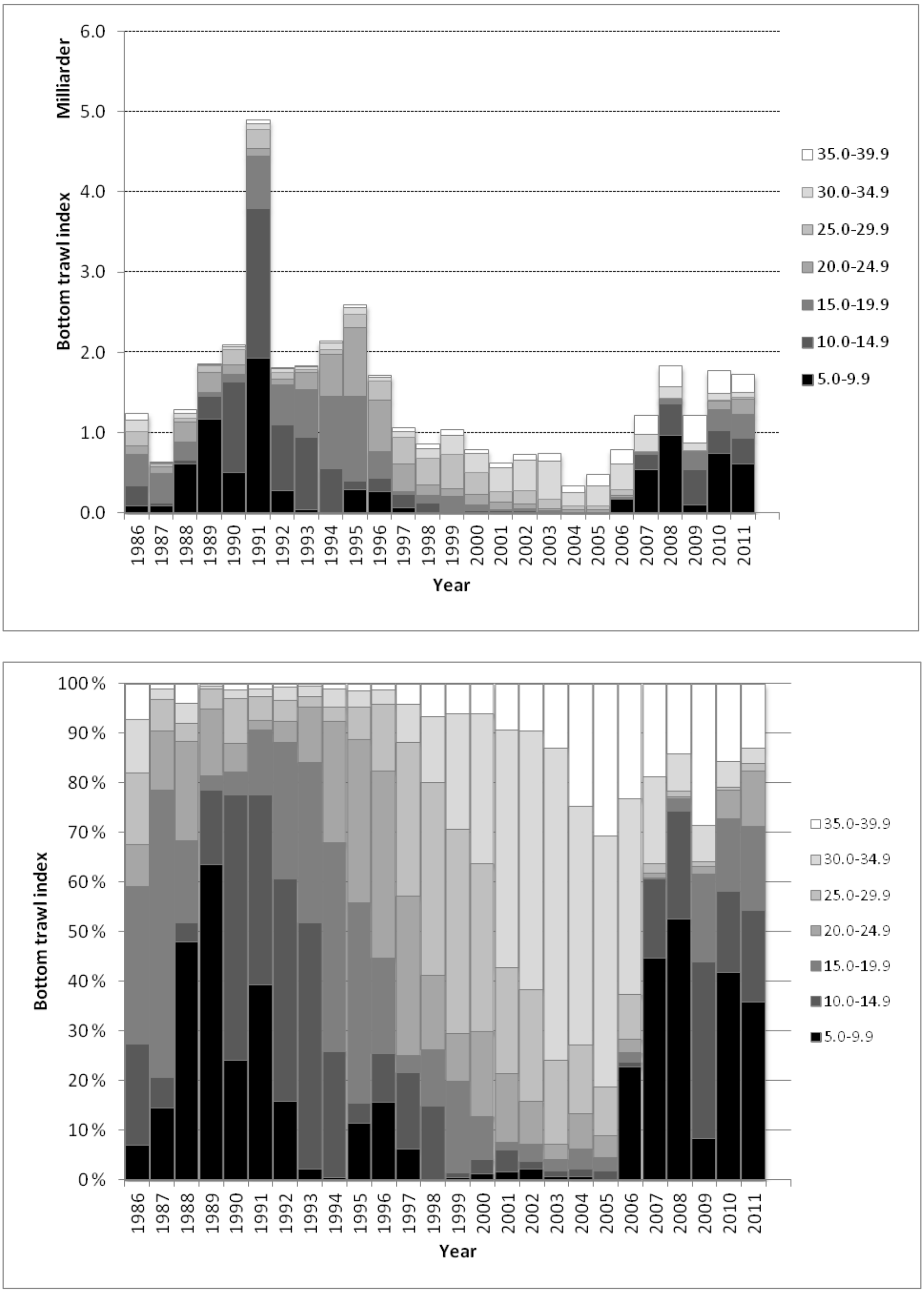
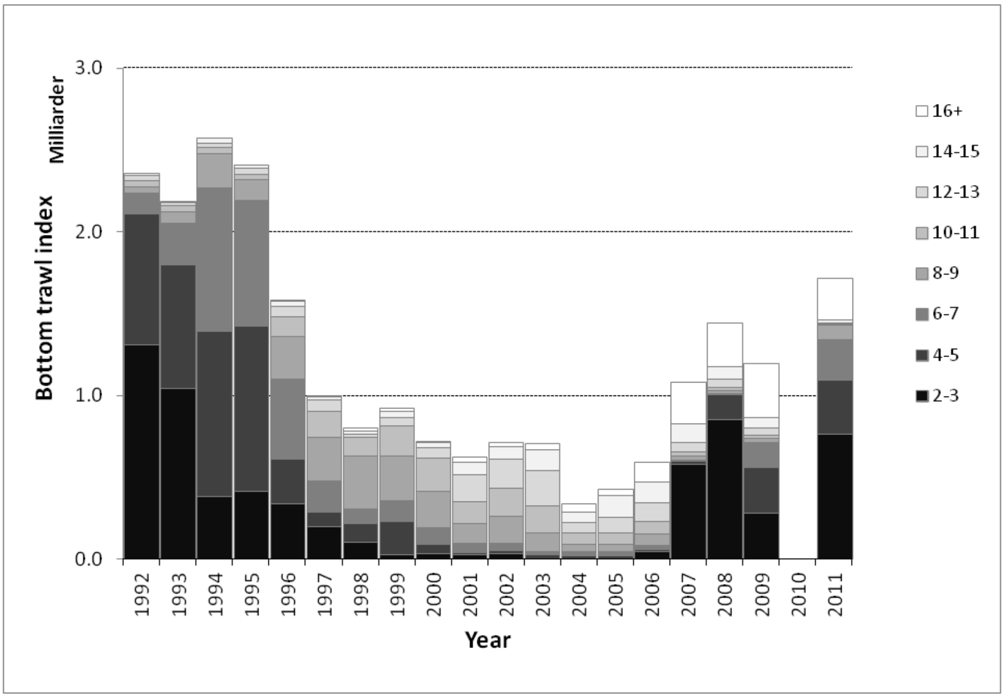


Figure 6.6a. ***Sebastes mentella*** **in Subareas I and II. Abundance indices disaggregated by length when combining the Norwegian bottom trawl surveys 1986-2011 in the Barents Sea (winter) and at Svalbard (summer/fall). Top: absolute index values (in billions). Bottom: relative frequencies.**



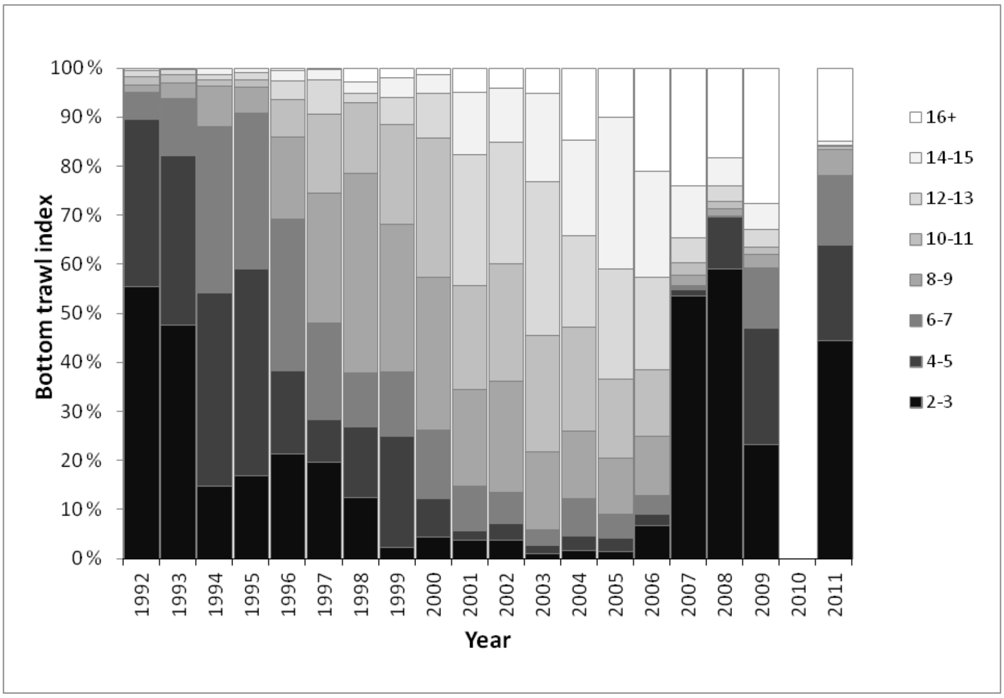
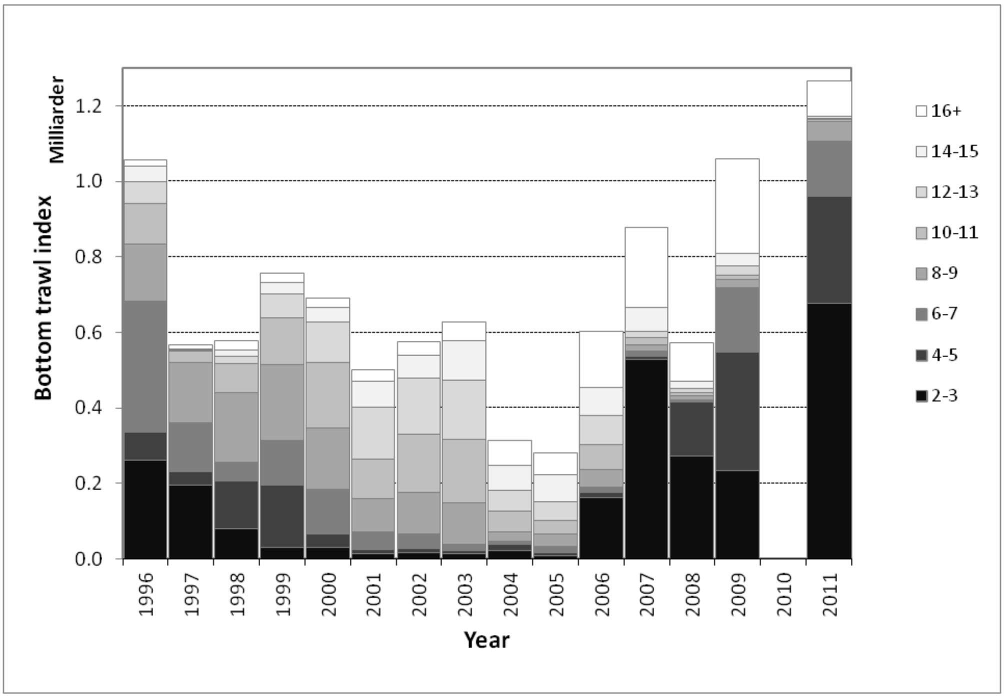


Figure 6.6b. *Sebastes mentella* in Subareas I and II. Age disaggregated abundance indices for combined Norwegian bottom trawl surveys 1992-2011 at Svalbard (summer/fall) and in the Barents Sea (winter). Top: absolute numbers (in billions). Bottom: relative frequencies. The group 16+ is only recorded from 1995 onwards.



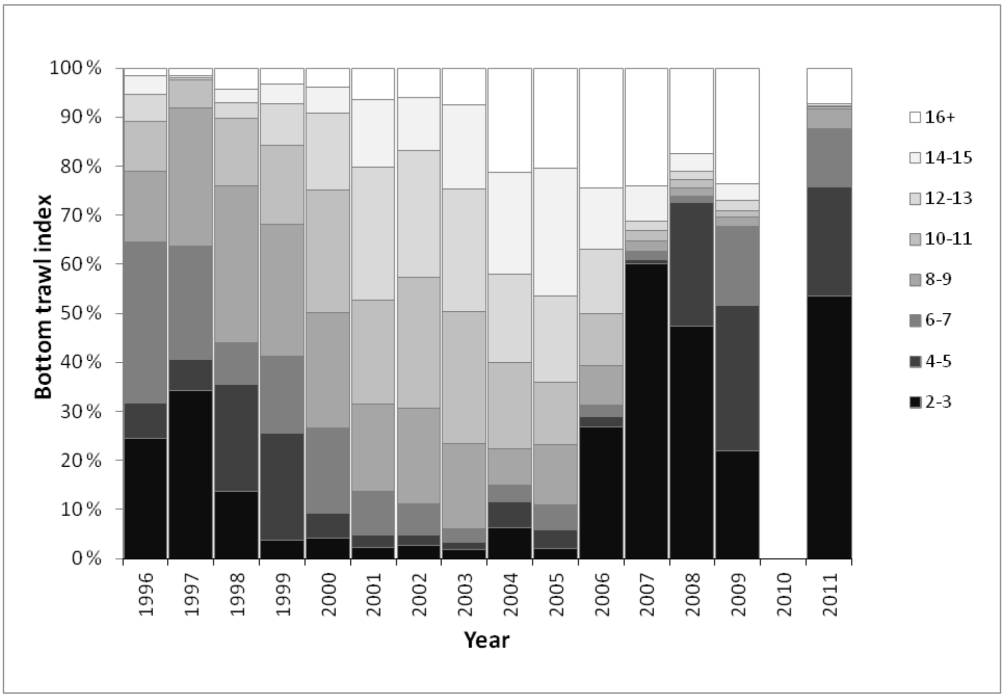
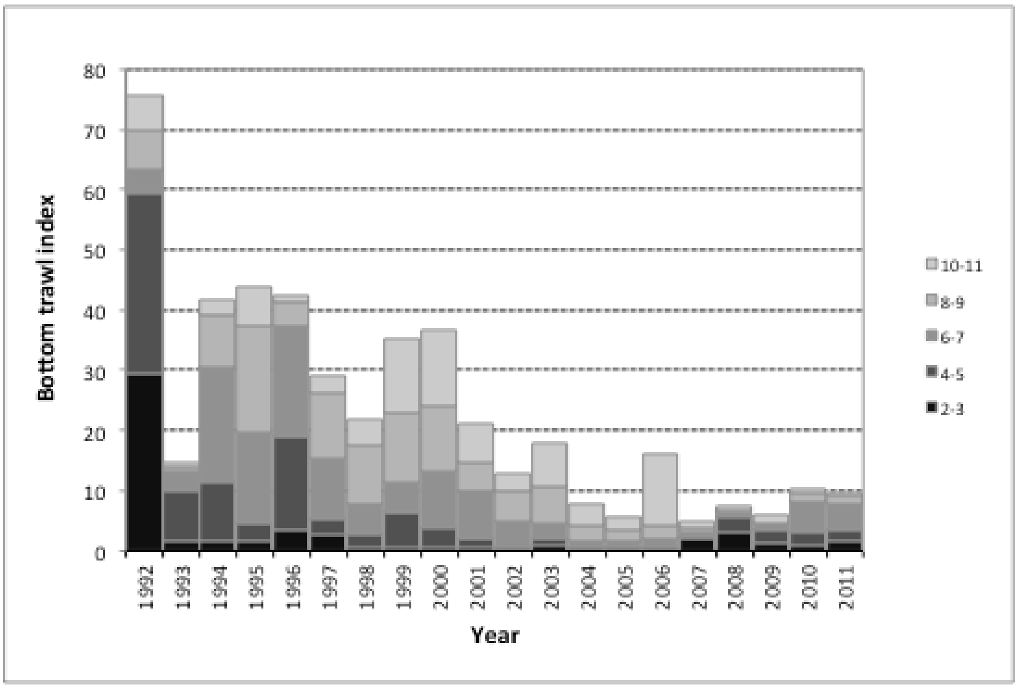


Figure 6.7. ***Sebastes mentella*** **in Subareas I and II. Abundance indices (in billions) disaggregated by age from the Ecosystem survey in August-September 1996-2011 covering the Norwegian Economic Zone (NEZ) and Svalbard including the area north and east of Spitsbergen (ref. Table D6). Top: absolute index values (in billions). Bottom: relative frequencies. The group 16+ is only recorded from 1996 onwards.**



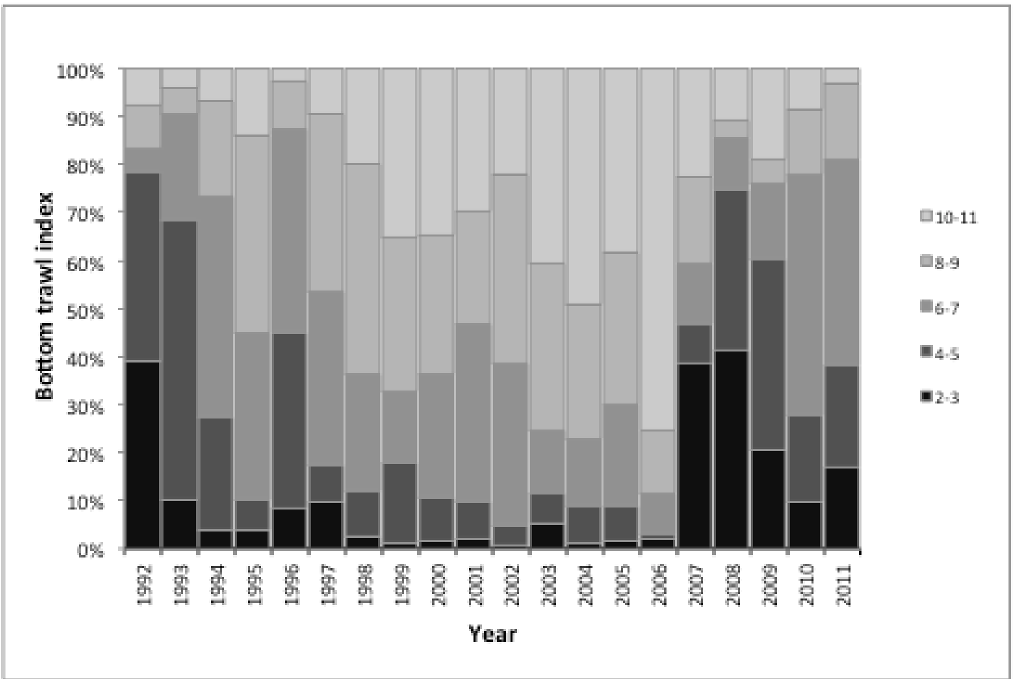


Figure 6.8. ***Sebastes mentella*** **in Subareas I and II. Abundance indices per hour trawling disaggregated by age in the Russian groundfish survey in the Barents Sea and Svalbard areas (ref. Table D3).**

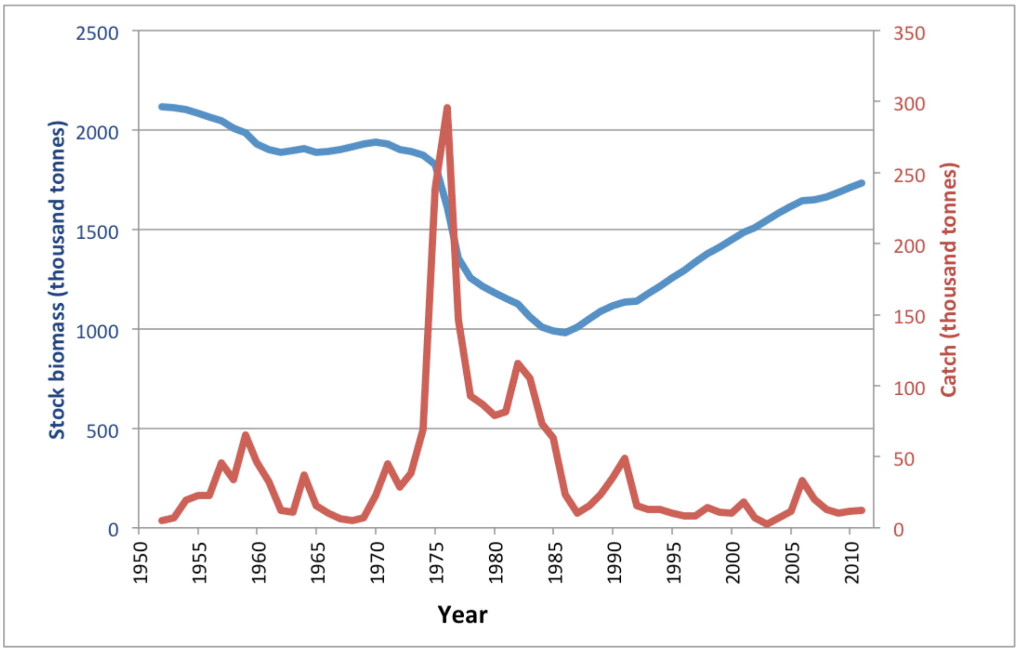


Figure 6.9. Result from the Schaefer biomass model for *S. mentella* in subareas I and II, updated from the benchmark assessment (WKRED, ICES 2012) for the period 1952-2011. The ratio of biomass in 2011 over maximum biomass is 80%.

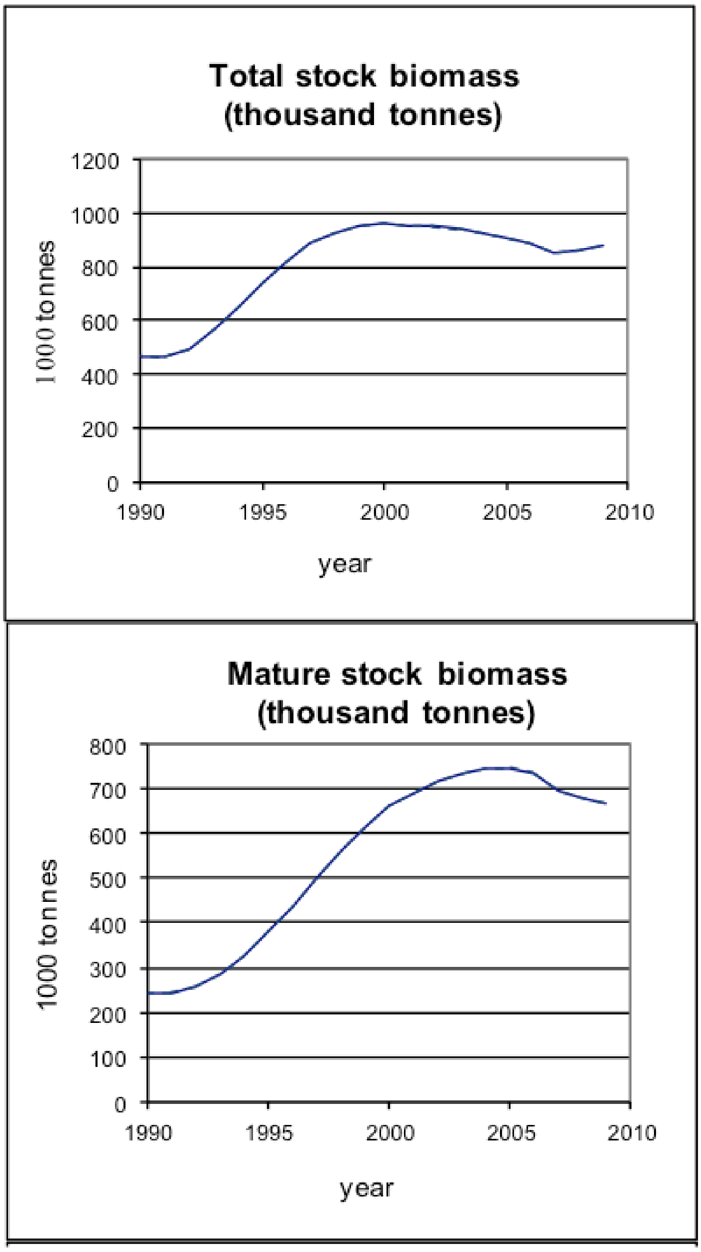
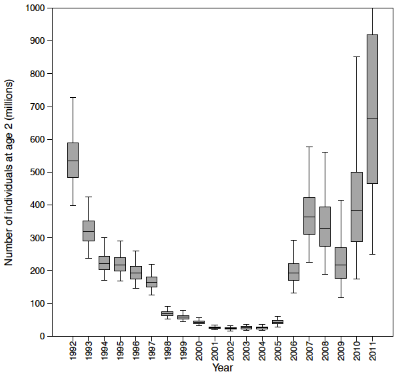
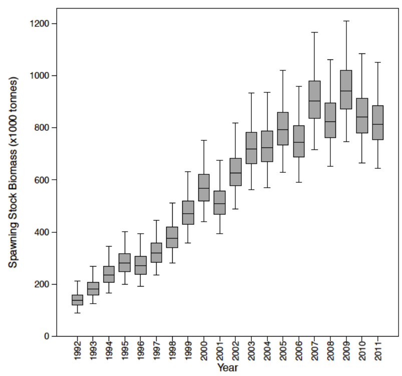


Figure 6.10. Result from the Gadget model for *S. mentella* in subareas I and II, as presented at the benchmark assessment (WKRED, ICES 2012).

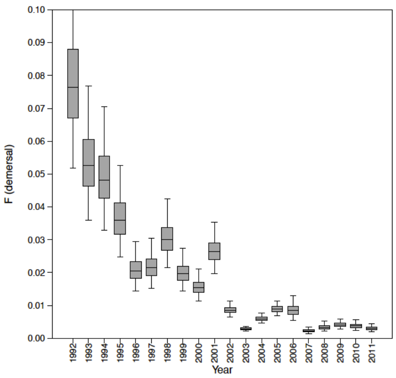
Recruitment at Age 2



Spawning Stock Biomass



Fishing mortality demersal



Fishing mortality pelagic

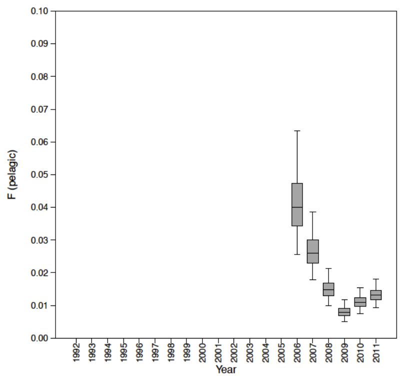


Figure 6.11. Results from the statistical catch-at-age assessment run showing the estimated recruitment at age 2 and spawning stock biomass from 1992 to 2011 and annual fishing mortality coefficients from the demersal and pelagic fleets.

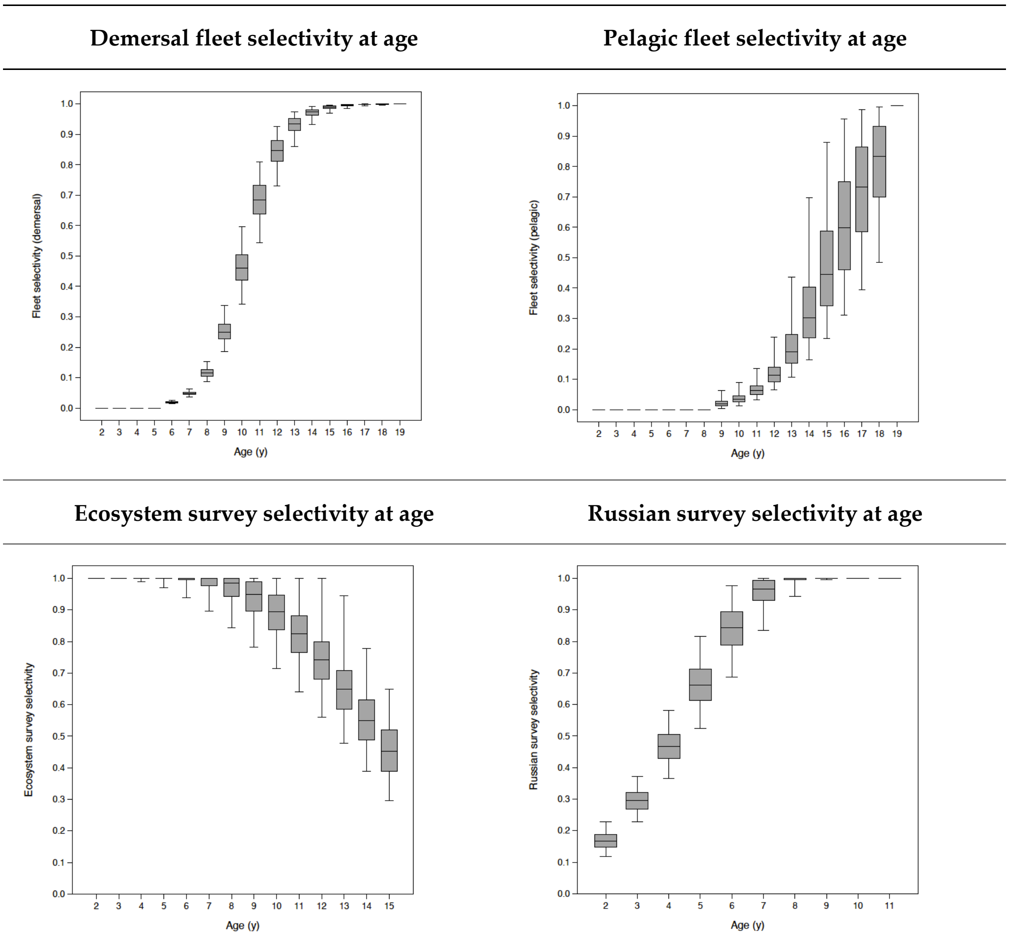


Figure 6.12. Results from the statistical catch-at-age assessment run showing the selectivity-at-age of the fleets (demersal and pelagic) and surveys (ecosystem and Russian). The selectivity of the Winter survey is nearly identical to that of the ecosystem survey and is not presented.

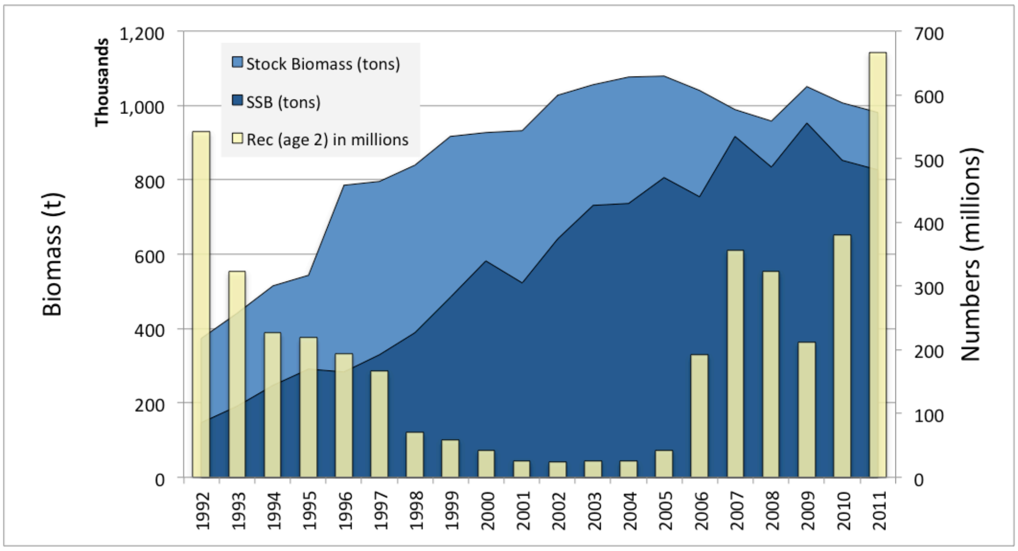


Figure 6.13. Results from the statistical catch-at-age model showing the evolution of total biomass ('000s), spawning stock biomass and recruitment at age 2 for the period 1992-2011, for *S. mentella* in subareas I and II.

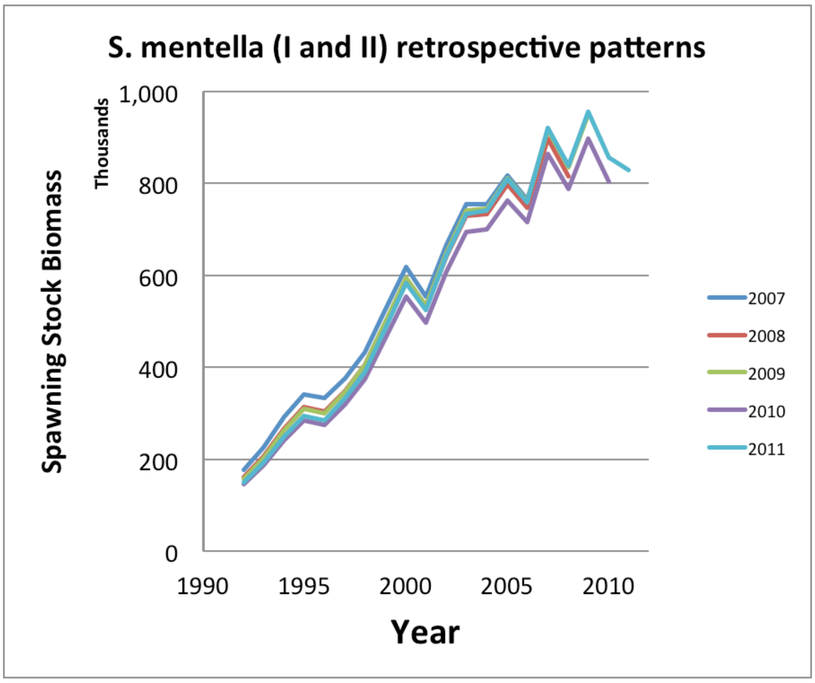


Figure 6.14. Retrospective patterns of the spawning stock biomass of *S. mentella* estimated by the SCAA model for runs carried out up to 2007, 2008, 2009, 2010 and 2011.

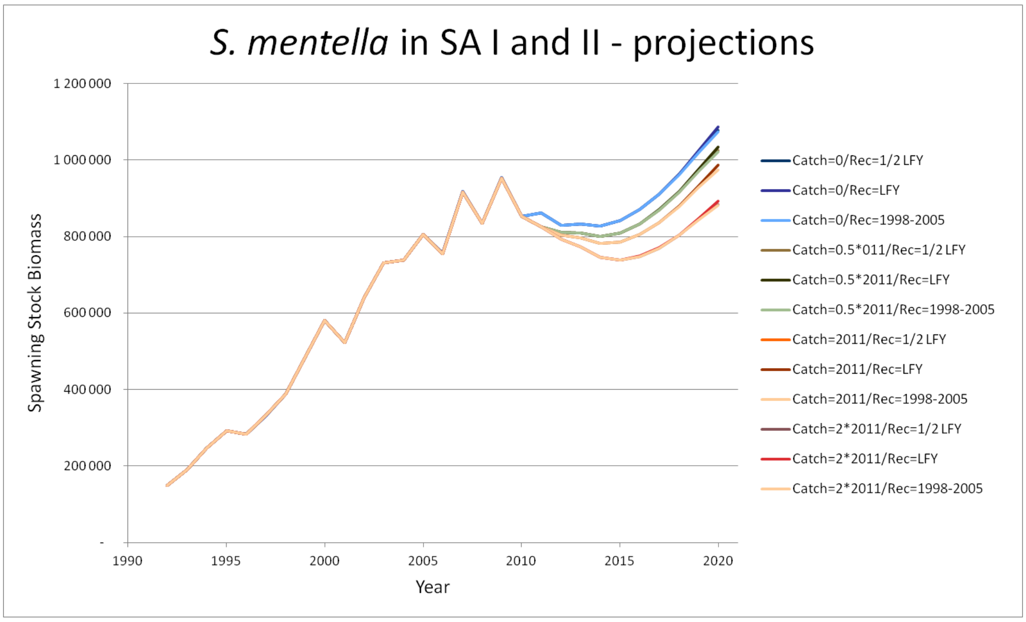


Figure 6.15. Projection of the spawning stock biomass of *S. mentella* estimated by the SCAA model under four catch and 3 recruitment scenarios: catch = 0; catch = ½ of catches in 2011, catch = catches in 2011, catch = twice catches in 2011; Recruitment = average of recruitment 1998-2005, recruitment = average recruitment in LFY, recruitment = ½ average recruitment in LFY. LFY stands for Last Five Years (=2006-2010).

Table D1 REDFISH in Subareas I and II. Nominal catch (t) by countries in Subarea I, Divisions IIa and IIb combined as officially reported to ICES.

Year	Canada	Denmark	Faroe Islands	France	Germany[4]	Greenland	Iceland	Ireland	Nethelands	Norway	Poland	Portugal	Russia[5]	Spain	UK (E&W)	UK (Scot.)	Total
1984	-	-	-	2,970	7,457	-	-	-	-	18,650	-	1,806	69,689	25	716	-	101,313
1985	-	-	-	3,326	6,566	-	-	-	-	20,456	-	2,056	59,943	38	167	-	92,552
1986	-	-	29	2,719	4,884	-	-	-	-	23,255	-	1,591	20,694	-	129	14	53,315
1987	-	+	450[3]	1,611	5,829	-	-	-	-	18,051	-	1,175	7,215	25	230	9	34,595
1988	-	-	973	3,349	2,355	-	-	-	-	24,662	-	500	9,139	26	468	2	41,494
1989	-	-	338	1,849	4,245	-	-	-	-	25,295	-	340	14,344	5[2]	271	1	46,688
1990	-	37[3]	386	1,821	6,741	-	-	-	-	34,090	-	830	18,918	-	333	-	63,156
1991	-	23	639	791	981	-	-	-	-	49,463	-	166	15,354	1	336	13	67,768
1992	-	9	58	1,301	530	614	-	-	-	23,451	-	977	4,335	16	479	3	31,773
1993	8[3]	4	152	921	685	15	-	-	-	18,319	-	1,040	7,573	65	734	1	29,517
1994	-	28	26	771	1026	6	4	3	-	21,466	-	985	6,220	34	259	13	30,841
1995	-	-	30	748	692	7	1	5	1	16,162	-	936	6,985	67	252	13	25,899
1996	-	-	42[3]	746	618	37	-	2	-	21,675	-	523	1,641	408	305	121	26,118
1997	-	-	7	1,011	538	39[2]	-	11	-	18,839	1	535	4,556	308	235	29	26,109
1998	-	-	98	567	231	47[3]	-	28	-	26,273	13	131	5,278	228	211	94	33,199
1999	-	-	108	61[3]	430	97	14	10	-	24,634	6	68	4,422	36	247	62	30,195
2000	-	-	67[3]	25	222	51	65	1	-	19,052	2	131	4,631	87		203[6]	24,537
2001	-	-	111[3]	46	436	34	3	5	-	23,071	5	186	4,738	91	**Estonia**	239[6]	28,965
2002	-	-	135[3]	89	141	49	44	4	-	10,713	8[3]	276	4,736	193[2]	15	234[6]	16,637
2003	**Swed**	-	173[3]	31	154	44[3]	9	5[3]	89	8,063	7	50	1,431	47[2]	-	258[6]	10,361
2004	1	-	607	17[3]	78	24[3]	40	3	33	7,608[1,2]	42	240	3,601[2]	260[2]	-	146[6]	12,699
2005	**Can**	**Lith**	1,194	56	106	75[3]	12[2]	4[3]	55[2]	7,844[1,2]	-	196	5,637	171[3]	5	147[6]	15,501
2006	433	845	3,919	223	2,518	107[3]	2,544[3]	12[3]	21	11,015	2,496[2]	1,873	12,126	719[2]	396	1,066[6]	40,313
2007	**Latv**	785	2,343	249	587	84[3]	1,647[2]	7[3]	20	8,993[2]	1,081[2]	1,708	6,550	2,186[2]	684	257[6]	27,181
2008	267	117	2,123[3]	250	46	74[3]	36[3]	2[3]	15	7,416[1]	8	785	7,866	1,183[2]	**EU[7]**	168[6]	20,356
2009	-	-	1,413	19	100	72	76	-	4	8,149	338	836	4,541	177	889	113	16,727
2010[1]	243[3]	457[3]	1,150	226	52	84[3]	24[3]	-	-	8,760	1[3]	321	7,220	835	-	123	19,495
2011[1]	536	512	476	134	844	51	13	-	1	7,132	58	645	5959	-	-	68	16,430

[1] Provisional figures.

[2] Working Group figure.

[3] As reported to Norwegian authorities or NEAFC.

[4] Includes former GDR prior to 1991.

[5] USSR prior to 1991.

[6] UK(E&W)+UK(Scot.)

[7] EU not split on countries.

Table D2. REDFISH in Subarea IV (North Sea). Nominal catch (t) by countries as officially reported to ICES. Not included in the assessment.

Year	Belgium	Denmark	Faroe Islands	France	Germany	Ireland	Netherlands	Norway	Sweden	UK (E&W)	UK (Scot.)	Total
1986	-	24	-	578	183	-	-	1,048	-	35	1	1,869
1987	-	16	3	833	70	-	-	411	-	16	55	1,404
1988	-	32	90	915	188	-	-	696	-	125	9	2,055
1989	1	23	13	554	111	-	-	500[2]	-	134	6	1,342
1990	+	41	25	554	47	-	-	483[2]	-	369	6	1,525
1991	5	29	144	914	213	-	2	415[2]	-	43	38	1,803
1992	4	22	23	1,960	170	-	1	416	-	65	122	2,783
1993	28	14	4	1,211	33	-	1	373	-	138	71	1,873
1994	4	13	1	863	324	-	8	371	-	38	66	1,688
1995	16	12	65	1,120	80	-	16	297	-	46	241	1,893
1996	20	20	1	932	74	-	41	363	-	37	146	1,634
1997	16	23	-	1,049	45	-	53	595	-	21	528	2,330
1998	2	27	12	570	370	4	21	1,113	-	68	681	2,868
1999	3	52	1	-	58	39	16	862	-	67	465	1,563
2000	5	41	-	224	19	28	19	443	-	132	486	1,397
2001	4	96	-	272	13	19	+	421	-	80	458	1,363
2002	2	40	2	98	11	7	+	241	-		524[3]	925
2003	1	71	2	26	2	-	-	474	-	**Portugal**	463[3]	1,071
2004	+	42	3	26	1	-	-	287	-	-	214[3]	578
2005	2	34	-	10	1	-	-	84	-	-	28[3]	159
2006	1	49	1	12	3	-	-	155	-	33	79[3]	333
2007[1]	+	27	-	8	1	-	-	107	+	-	78[3]	221
2008[1]	+	3	-	35	1	-	-	77	+	-	54[3]	170
2009	-	-	-	-	-	-	-	120	+	-	87[3]	207
2010[1]	-	6	-	112	-	-	-	67	-	-	149[3]	335
2011[1]	-	10	-	167	1	-	-	66	+	-	71	315

[1] Provisional figures.

[2] Working Group figure.

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

+ less than 0.5 ton.

Table D3. *Sebastes mentella*. Average catch (numbers of specimens) per hour trawling of different ages of *Sebastes mentella* in the Russian groundfish survey in the Barents Sea and Svalbard areas (1976-1983 published in "Annales Biologiques").

Year class	0	1	2	3	4	5	6	7	8	9	10	11
1974	-	-	4.8	-	4.9	22.8	4.8	4.8	-	-	-	3
1975	-	7.4	-	1.7	6.4	2.4	3.5	5	-	-	4	-
1976	7	-	8.1	1.2	2.5	6.8	4.9	5	1	13	-	-
1977	-	0.2	0.2	0.2	0.9	5.1	3.7	1	19	2	-	-
1978	0.8	0.02	0.9	1	5	3.8	2	20	6	-	-	-
1979	-	1.9	1.4	3.6	2.3	9	11	16	1	-	-	0.1
1980	0.3	0.4	2	2.5	16	6	11	25	2	-	1.5	2
1981	-	2.2	3.9	20	6	12	47	18	6.3	1.6	0.5	1
1982	19.8	13.2	13	15	34	44	39	32.6	4.3	3.1	4.9	+
1983	12.5	3	5	6	31	34	32.3	13.3	4	4.2	0.6	1.1
1984	-	10	2	-	5	18.3	19	2.2	2.4	0.2	1.7	2.4
1985	107	7	-	1	5.2	16.2	1.7	1.7	0.6	2.8	3.8	0.3
1986	2	-	1	1.8	8.4	3.6	2.1	1.2	5.6	8.2	0.9	0.7
1987	-	3	37.9	1.3	8	4.1	2	10.6	9.6	1.4	2	1.3
1988	4	58.1	4.3	13.3	25.8	3.9	8.6	11.2	2.8	4.2	3	4.7
1989	8.7	9	17	23.4	4.6	5.4	4	6.6	6.6	4.1	7.7	5.3
1990	2.5	6.3	6.1	1	4.3	1.7	11.5	6.5	5.5	6.7	7.4	3.6
1991	0.3	1	0.5	1.5	1.2	11.3	3.9	3.3	4.6	5.8	2.7	1.9
1992	0.6	+	0.2	0.1	4.3	1.3	2	2.3	4.9	2.3	1	4.1
1993[1]	-	+	1.5	1.8	1	1.2	3	4.2	2.6	2	3.2	2.1
1994	0.3	3.5	1.7	1.7	0.9	3.6	5.2	4.3	3.1	3.3	1.8	1.2
1995	2.8	1	1.1	0.4	2.2	2.6	3.5	3.4	2.9	1.2	1	8.5
1996[2]	+	0.1	0.1	0.4	0.7	1.1	1	1.4	1	0.8	3.7	0.6
1997	-	-	+	0.4	0.5	0.3	0.9	0.6	1	1.1	0.5	0.4
1998	-	0.1	0.2	0.3	0.2	1.1	0.5	0.7	1	0.4	0.4	0.7
1999	0.1	-	0.1	+	0.1	0.3	0.5	0.8	0.5	0.2	0.4	0.4
2000	-	0.6	0.1	0.5	0.3	0.3	0.6	0.4	0.1	0.1	0.5	0.2
2001	-	0.1	0.4	-	0.1	0.2	0.2	0.3	0.2	0.5	0.1	
2002[3]	0.1	0.5	0.1	-	-	0.1	0.5	0.4	0.9	0.3		
2003	-	-	0.1	-	0.3	1.0	0.5	2.6	1.2			
2004	-	0.2	0.3	0.5	1.5	0.9	2.6	2				
2005	-	-	1.4	1.9	1.4	1.2	2					
2006[4]	0.1	1.8	1.2	1.1	0.7	1.1						
2007	2.5	0.4	0.1	0.5	0.9							
2008	0.1	0.1	0.5	0.9								
2009	1.6	1.8	0.7									
2010	5.7	0.1										
2011	-											

[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 1986-2011 (numbers in millions).**

					Length group (cm)					
Year	**5.0-9.9**	**10.0-14.9**	**15.0-19.9**	**20.0-24.9**	**25.0-29.9**	**30.0-34.9**	**35.0-39.9**	**40.0-44.9**	**>45.0**	**Total**
1986[2]	6	101	192	17	10	5	2	4	+	338
1987[2]	20	14	140	19	6	2	1	2	+	208
1988[2]	33	23	82	77	7	3	2	2	+	228
1989	566	225	24	72	17	2	2	8	4	921
1990	184	820	59	65	111	23	15	7	3	1,287
1991	1,533	1,426	563	55	138	38	30	7	1	3,791
1992	149	446	268	43	22	15	4	7	4	958
1993	9	320	272	89	16	13	3	1	+	722
1994	4	284	613	242	10	9	2	2	1	1,165
1995	33	33	417	349	77	18	5	1	+	933
1996	56	69	139	310	97	8	4	1	1	685
1997	3	44	13	65	57	9	5	+	+	195
1998	+	37	35	28	132	73	45	2	+	353
1999	4	3	121	62	259	169	42	1	0	661
2000	+	10	31	59	126	143	21	1	0	391
2001	1	5	3	32	57	228	50	3	0	378
2002	1	4	6	21	62	266	47	4	+	410
2003	1	5	7	11	56	271	50	1	0	403
2004	0	2	7	6	14	78	53	2	0	163
2005	1	1	6	11	19	93	63	1	0	196
2006	82	6	5	7	49	211	101	3	0	463
2007	98	68	1	5	11	95	109	3	0	387
2008	119	45	20	3	9	25	79	4	0	303
2009	8	114	83	14	3	23	191	5	0	440
2010	96	19	46	39	2	20	88	7	0	317
2011	124	91	82	46	11	8	67	5	1	436

[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 1992-2011 (numbers in millions).

	Age														
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992	283	419	484	131	58	45	14	8	5	2	7	2	1	3	1,462
1993	2	527	117	202	142	8	23	6	13	1	7	1	1	+	1,050
1994	7	280	290	202	235	42	94	1	1	3	4	1	1	+	1,161
1995	4	50	365	237	132	61	19	17	11	+	1	3	0	0	900
1996	23	47	15	37	105	144	84	17	51	32	34	9	6	2	605
1997	8	43	6	6	40	20	30	25	7	3	1	2	2	1	194
1998	+	26	28	14	10	13	69	66	49	15	1	6	15	5	317
1999	3	16	114	27	36	53	117	78	67	41	45	11	19	13	640
2000	4	6	6	14	35	22	31	54	81	60	24	24	10	8	379
2001	2	4	3	1	9	16	22	30	34	57	57	50	54	6	344
2002	3	2	4	2	5	22	34	23	88	36	62	64	15	21	379
2003	0.3	3	4	3	5	4	29	31	50	59	45	70	38	23	365
2004	1	1	3	3	1	4	2	9	9	18	15	17	19	9	113
2005	1	1	2	3	3	6	9	15	14	16	14	21	22	25	152
2006	33	1	3	3	2	9	17	27	24	35	29	45	25	34	287
2007	23	45	0	0	3	2	5	5	8	5	5	9	29	19	158
2008	6	22	22	12	1	2	2	5	4	4	3	5	10	6	102
2009	14	43	55	41	34	19	7	1	2	2	9	10	26	7	270
2010	No age readings														
2011	112	45	57	43	34	35	22	7	2	0	1	0	0	2	360

[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 1986-2012 (numbers in millions). The area coverage was extended from 1993 onwards.**

	Length group (cm)									
Year	**5.0-9.9**	**10.0-14.9**	**15.0-19.9**	**20.0-24.9**	**25.0-29.9**	**30.0-34.9**	**35.0-39.9**	**40.0-44.9**	**>45.0**	**Total**
1986	81	152	205	88	169	130	88	24	13.8	950
1987	72	25	227	56	35	11	5	1	0.1	433
1988	587	25	133	182	40	50	48	4	0.1	1068
1989	623	55	28	177	58	9	8	2	0.3	961
1990	324	305	36	56	80	13	13	2	0.2	828
1991	395	449	86	39	96	35	24	3	0.2	1127
1992	139	367	227	35	55	34	8	2	0.5	867
1993	31	593	320	116	24	25	6	1	+	1117
1994	7	259	289	284	51	70	20	1	0.1	982
1995	264	71	638	506	91	69	31	4	0.5	1674
1996	213	100	191	338	134	42	17	1	0.3	1037
1997[2]	63	121	25	278	274	72	41	5	0.2	879
1998[2]	1	91	63	101	203	41	13	2	0.2	514
1999	2	7	68	37	167	72	21	3	0.1	377
2000	9	13	39	77	142	97	27	7	1.5	412
2001	9	22	7	55	77	73	9	1	0.1	254
2002	16	7	19	42	104	114	23	1	+	326
2003	4	4	10	13	71	200	47	6	0.3	354
2004	2	3	7	19	33	87	32	2	0.1	184
2005	+	6	7	11	28	153	87	4	0.2	297
2006	99	2	10	15	23	103	82	3	0.7	336
2007	446	125	3	6	12	119	120	7	0.2	838
2008	846	354	26	5	12	114	180	5	0.1	1542
2009	94	322	134	5	9	66	160	6	0	797
2010	647	273	213	64	7	73	190	6	0	1474
2011	496	228	211	148	14	46	157	5	0	1304
2012	127	275	84	123	46	14	151	17	0.2	838

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

[2] - Adjusted indices to account for not covering the Russian EEZ in Subarea I.

Table D5b. ***Sebastes mentella*[1] in Subareas I and II. Preliminary Norwegian bottom trawl indices (on age) from the annual Barents Sea survey in February 1992-2011 (numbers in millions). The area coverage was extended from 1993 onwards.**

	Age													
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Total**
1992	351	252	132	56	14	11	3	9	18	16	12	11	2	5	892
1993	38	473	192	242	62	45	19	22	13	11	10	4	2	3	1,136
1994	7	85	332	189	370	228	73	42	3	30	8	14	25	7	1,413
1995	308	45	146	264	364	211	69	23	7	17	23	9	11	10	1,507
1996	173	119	109	114	128	122	106	64	24	19	12	7	8	4	1,009
1997[2]	43	101	19	54	96	43	44	171	76	74	39	29	10	9	808
1998[2]	1	73	49	27	13	52	107	104	41	18	7	4	3	3	502
1999	1	+	32	43	30	24	30	81	79	28	2	1	6	+	357
2000	9	12	21	17	9	39	77	73	50	41	14	10	7	6	385
2001	1	17	8	1	7	22	39	30	34	23	24	17	9	3	236
2002	18	4	12	7	4	14	49	55	27	19	34	24	28	11	306
2003	0	2	2	4	6	6	14	39	24	34	39	65	46	20	301
2004	0	2	3	1	9	12	15	20	36	8	28	3	25	12	172
2005	0	4	3	3	6	6	11	15	23	14	21	40	35	49	229
2006	4	1	5	5	5	8	15	12	6	15	21	17	32	36	180
2007	428	82	13	1	2	2	5	7	8	8	21	20	31	35	144
2008	648	173	107	11	0	2	5	7	5	10	10	28	27	40	1073
2009	107	112	104	82	63	32	14	9	9	6	16	7	21	11	593
2010	150	239	172	161	103	71	27	13	4	7	13	12	21	33	1027
2011	391	211	106	125	109	67	47	14	5	4	1	3	2	10	1095

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

[2] - Adjusted indices to account for not covering the Russian EEZ in Subarea I.

Table D6. ***Sebastes mentella*** **in Subareas I and II. Abundance indices (on age) from the Ecosystem survey in August-September 1996-2011 covering the Norwegian Economic Zone (NEZ) and Svalbard incl. the area north and east of Spitsbergen (numbers in thousands and total biomass in thousand tonnes) and the continental slope down to 1500 m.**

Year	Age															
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total N	Total B
1996	146198	112742	22353	53507	165531	181980	108738	43328	65310	40546	38254	19843	29446	10931	17414	1 056 120	171
1997	62682	130816	12492	23452	74342	55880	76607	82503	17640	14274	675	2238	1723	633	8765	564 723	73
1998	313	78767	85715	39849	25805	23413	84825	100332	54287	24329	11334	7457	15250	576	25212	577 464	105
1999	5359	23240	117170	47851	41608	76797	128677	73306	58018	64781	49890	13565	18458	12171	24672	755 562	155
2000	5964	23169	14336	19960	52666	68081	83857	77513	100442	72294	71148	36599	17183	20590	26501	690 304	178
2001	5026	6541	10957	1093	19766	25591	36594	51644	44407	61704	50083	86122	53952	15699	31877	501 057	162
2002	9112	6646	7379	3821	8635	28215	47456	63903	103368	49964	76133	71970	25241	36765	34957	573 565	181
2003	3954	7394	6142	3540	8030	9388	48564	59051	98554	69901	83192	73521	69970	37162	47323	625 687	213
2004	9068	10837	9008	7292	2510	7896	8193	15268	25544	29654	35249	21142	39581	25976	66792	314 010	111
2005	1310	4406	5241	5031	5722	8740	13452	20672	16207	19353	17430	32028	37564	34815	57103	279 072	103
2006	156578	5162	6695	5217	3768	10754	18771	29174	25278	38958	31869	46885	30895	44299	147951	602 255	184
2007	302988	224153	290	7686	11346	2031	7903	10770	12182	6578	6367	9998	41425	22090	211178	876 986	172
2008	86880	183796	121430	21430	4178	3009	3334	6991	5120	4441	3581	6008	10352	10172	99808	570 530	89
2009	98726	133218	196908	118322	131668	37586	18194	3679	8633	3494	9736	14091	25949	8384	251370	1 059 960	200
2010								no age reading									
2011	389536	285787	222753	60809	80266	67419	39695	12409	4144	1175	1174	2246	324	3379	93382	1 264 495	

Table D7. *Sebastes mentella* in Subareas I and II. Results of the Russian trawl/acoustic redfish survey in the western Barents Sea in April-May 1992-2001. Abundance indices in millions.

Year	**Period of survey**	**Age**																		**Total**				**Area of survey**
		1-4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21+**	**Numbers 10^6**	**Biomass t 10^3**	**SSN 10^6**	**SSB t 10^3**	**in n.m.^{2}**
1992	April	29	27	27	37	36	50	78	39	34	40	44	43	28	17	13	4	7	3	566	218	191	114	25300
1993	April	31	15	13	6	6	20	56	56	38	28	29	27	19	12	7	3	1	2	396	150	151	90	23500
1994	No Data																							
1995	May	+	32	51	83	90	41	31	31	41	94	73	48	30	10	9	4	1	+	669	202	211	102	23300
1996	No Data																							
1997	Apr-May	86	6	24	102	150	53	48	24	20	26	36	28	11	9	4	2	1	+	630	170	111	58	22400
1998	April	1	+	8	47	77	63	71	46	27	19	23	23	25	6	3	2	1	+	442	153	106	57	22931
1999	Apr-May	11	1	9	14	57	75	63	73	31	25	17	15	11	8	3	1	1	1	415	134	120	55	19333
2000	Apr-May	2	2	14	15	62	100	143	122	54	34	24	29	12	11	7	2	1	1	635	208	114	53	22000
2001	Apr-May	11	1	11	22	24	84	123	134	144	115	78	40	27	19	10	4	+	3	850	316	339	152	23000
2002	No Data																							
…																								
2011	No Data																							

Table D8. *Sebastes mentella* in Subareas I and II. 0-group index from the ecosystem survey. Estimated numbers (in millions) and confidence limits given as 2.5 and 97.5 percentiles.

Year	abundance (millions)	2.50%	97.50%
1980	277873	0	701273
1981	153279	0	363283
1982	106140	63753	148528
1983	172392	33352	311432
1984	83182	36137	130227
1985	412777	40510	785044
1986	91621	0	184194
1987	23747	12740	34755
1988	107027	23378	190675
1989	16092	7589	24595
1990	94790	52658	136922
1991	41499	0	83751
1992	13782	0	36494
1993	5458	0	13543
1994	52258	0	121547
1995	11816	3386	20246
1996	28	8	47
1997	132	0	272
1998	755	23	1487
1999	46	14	79
2000	7530	0	16826
2001	6	1	10
2002	130	20	241
2003	216	0	495
2004	849	0	1766
2005	12332	631	24034
2006	20864	10057	31671
2007	159159	44882	273436
2008	9364	0	19623
2009	66671	29636	103706
2010	66392	3114	129669
2011	7026	0	17885

Table D9a. *Sebastes mentella* in Subareas I and II. Maturity ogives from Russian research vessels. Sexes combined. Data collected during April-June in the Kopytov area (western Barents Sea) and adjacent waters.

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18
1988	0	0	0	0.028	0.125	0.297	0.562	0.76	0.855	1.000	1.000	1.000
1989	0	0	0	0.074	0.178	0.473	0.684	0.716	0.794	1.000	1.000	1.000
1990	0	0	0.012	0.131	0.3	0.688	0.714	0.824	0.848	1.000	1.000	1.000
1991	0	0.046	0.139	0.174	0.138	0.358	0.47	0.637	0.762	1.000	1.000	1.000
1992	0	0	0.013	0.092	0.169	0.396	0.452	0.761	0.939	0.886	1.000	1.000
1993	0	0	0.033	0.133	0.364	0.48	0.696	0.925	0.962	0.953	0.977	1.000
1995	0	0	0	0.055	0.111	0.368	0.587	0.696	0.729	0.789	1.000	1.000
1997	0.018	0	0.027	0.13	0.312	0.281	0.566	0.736	0.831	0.958	0.95	1.000
1998	0.021	0.014	0	0.074	0.171	0.276	0.622	0.714	0.871	0.919	1.000	1.000
1999	0	0.016	0.059	0.11	0.333	0.579	0.689	0.788	0.813	0.903	0.923	1.000
2000	0	0	0.048	0.087	0.202	0.375	0.489	0.742	0.833	0.904	1.000	1.000
2001	0	0	0.082	0.196	0.405	0.442	0.442	0.648	0.775	0.865	0.909	1.000

Table D9b: Proportion of maturity at age 5 - 30 in *Sebastes mentella* in Subareas I and II derived from Norwegian commercial and survey data. The proportions were derived from samples with at least 5 individuals. a50, w1 and w2 are the annual coefficients for modeled maturity ogives using a double half sigmoid of the form 0.5 * ((1+tanh(age- a50)/w1)) for age < a50 and 0.5 * ((1+tanh(age-a50)/w2)) for age > a50. a50 equals the age at 50% maturity.

year	age5	age6	age7	age8	age9	age10	age11	age12	age13	age14	age15	age16	age17	age18	age19
1992	0.00	0.07	0.15	0.10	0.15	0.24	0.20	0.26	0.17	0.38	0.52	0.67	0.73	0.76	0.77
1993	0.00	0.00	0.17	0.00	0.03	0.12	0.39	0.40	0.42	0.69	0.69	0.58	0.79	0.81	0.83
1994	0.00	0.00	0.00	0.03	0.00	0.38	0.44	0.60	0.75	0.72	0.94	1.00	0.91	1.00	-
1995	0.00	0.01	0.01	0.06	0.13	0.49	0.56	0.76	0.90	0.89	0.89	0.91	0.96	0.99	1.00
1996	0.00	0.01	0.00	0.02	0.02	0.18	0.23	0.21	0.50	0.53	0.74	0.88	0.80	0.73	1.00
1997	0.03	0.02	0.08	0.11	0.25	0.28	0.41	0.51	0.63	0.72	0.67	0.79	0.84	0.74	0.93
1998	0.00	0.02	0.01	0.02	0.10	0.25	0.40	0.59	0.79	0.75	0.81	0.90	0.90	0.97	0.75
1999	0.00	0.00	0.06	0.04	0.24	0.27	0.48	0.56	0.74	0.79	0.82	0.86	0.85	0.83	0.94
2000	0.00	0.01	0.02	0.14	0.21	0.32	0.51	0.65	0.79	0.85	0.80	0.94	0.91	0.97	0.97
2001	-	0.00	0.00	0.04	0.11	0.16	0.34	0.38	0.54	0.66	0.70	0.89	0.80	0.91	0.88
2002	-	0.05	0.00	0.04	0.15	0.36	0.52	0.60	0.65	0.70	0.74	0.64	0.71	0.85	0.79
2003	-	0.00	0.01	0.10	0.19	0.31	0.61	0.65	0.68	0.80	0.78	0.76	0.90	0.85	0.80
2004	-	0.00	0.01	0.01	0.20	0.39	0.62	0.60	0.62	0.64	0.77	0.77	0.92	0.71	0.84
2005	-	0.00	0.00	0.05	0.18	0.36	0.45	0.49	0.68	0.68	0.77	0.81	0.86	0.82	0.83
2006	0.00	0.03	0.00	0.03	0.06	0.16	0.25	0.31	0.52	0.58	0.69	0.77	0.84	0.84	0.86
2007	-	0.00	0.03	0.04	0.17	0.20	0.50	0.73	0.79	0.86	0.93	0.92	0.98	0.98	0.96
2008	-	-	0.04	0.03	0.09	0.12	0.54	0.53	0.65	0.76	0.80	0.90	0.87	0.94	0.93
2009	0.06	0.05	0.13	0.06	0.13	0.25	0.44	0.67	0.84	0.83	0.84	0.90	0.93	0.92	0.95
2010	0.00	0.02	0.07	0.07	0.27	0.18	0.42	0.47	0.78	0.70	0.82	0.84	0.82	0.79	0.81
2011	0.00	0.02	0.02	0.08	0.15	0.14	0.63	0.40	0.44	0.50	0.44	0.73	0.63	0.53	0.68

year	age20	age21	age22	age23	age24	age25	age26	age27	age28	age29	age30	a50	w1	w2
1992	0.78	0.91	0.93	0.96	0.95	0.93	0.92	0.93	0.92	0.95	0.96	12.95	2.28	9.11
1993	0.92	1.00	1.00	0.92	1.00	0.82	1.00	0.90	1.00	1.00	1.00	11.87	2.28	8.32
1994	1.00	1.00	-	-	-	1.00	-	-	1.00	-	-	11.17	2.28	3.82
1995	0.97	1.00	1.00	1.00	0.95	0.98	1.00	1.00	1.00	-	1.00	10.50	2.28	3.20
1996	0.80	1.00	0.91	1.00	0.89	0.83	-	1.00	-	1.00	0.86	12.68	2.28	6.35
1997	0.94	0.77	0.92	1.00	0.92	0.91	1.00	1.00	-	-	1.00	11.11	2.28	8.64
1998	0.95	0.88	1.00	1.00	0.92	0.97	1.00	-	-	-	1.00	11.27	2.28	5.37
1999	1.00	0.86	0.90	0.91	0.89	0.67	0.83	0.83	-	-	-	10.78	2.28	7.82
2000	1.00	0.90	1.00	1.00	0.95	1.00	1.00	0.81	1.00	1.00	-	10.72	2.28	4.55
2001	0.86	0.90	0.86	0.91	0.84	0.92	0.89	1.00	0.93	0.97	1.00	11.74	2.28	8.03
2002	0.75	0.89	0.65	0.90	0.96	0.86	1.00	0.83	0.95	0.93	-	10.77	2.28	12.22
2003	0.90	0.90	0.92	0.96	0.82	0.75	0.91	1.00	1.00	-	-	10.65	2.28	8.74
2004	0.77	0.95	0.82	0.91	0.79	0.67	0.60	-	0.88	-	-	10.55	2.28	13.64
2005	0.85	0.94	0.83	0.81	0.95	1.00	0.85	1.00	0.89	1.00	1.00	10.81	2.28	9.36
2006	0.95	0.90	0.72	0.86	0.96	0.86	0.90	0.89	0.93	0.91	0.86	12.35	2.28	8.63
2007	0.98	0.98	0.97	0.99	0.97	0.98	1.00	0.99	0.99	0.98	1.00	11.06	2.28	3.10
2008	0.95	0.96	0.95	0.96	0.99	0.97	0.98	0.96	1.00	0.98	0.97	11.29	2.28	5.46
2009	0.94	0.94	0.97	0.93	0.95	0.96	0.95	0.97	0.95	0.97	1.00	11.09	2.28	4.02
2010	0.88	0.75	0.91	0.93	1.00	0.85	0.94	0.95	1.00	0.94	0.87	11.16	2.28	8.71
2011	0.54	0.70	0.56	0.78	0.86	0.81	0.88	0.88	0.80	0.67	-	11.28[1]	2.27[1]	8.00[1]

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

Table D10: *S. mentella* in subareas I and II. Population matrix with numbers at age and year (in thousands) and separable fishing mortality coefficients for the demersal and pelagic fleet, by year (Fy) and age (Sa). Numbers indicated in italic bold are estimated in the statistical catch-at-age model.

		sa(demersal)	***0.00***	***0.00***	***0.00***	***0.00***	***0.02***	***0.05***	***0.12***	***0.25***	***0.47***	***0.70***	***0.86***	***0.94***	***0.98***	***0.99***	***1.00***	***1.00***	***1.00***	***1.00***
		sa(pelagic)	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.02***	***0.03***	***0.06***	***0.11***	***0.19***	***0.30***	***0.45***	***0.61***	***0.75***	***0.85***	***1.00***
Fy(demersal)	**Fy(pelagic)**	**Year/age**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
0.072	***0.000***	1992	***541380***	***534010***	***455290***	***249540***	***146640***	***93806***	***86028***	***84748***	***101890***	***68271***	***69269***	***49563***	***46126***	***39312***	***26478***	***16713***	***9992***	***123290***
0.050	***0.000***	1993	***322470***	514977	507966	433085	237370	139294	88919	81146	79144	93687	61752	61934	44048	40885	34808	23434	14789	117928
0.046	***0.000***	1994	***226150***	306743	489861	483192	411963	225574	132178	84089	76208	73531	86055	56268	56198	39895	37002	31492	21200	120055
0.035	***0.000***	1995	***218240***	215121	291783	465970	459627	391523	214094	125058	79054	70939	67735	78689	51254	51104	36254	33615	28607	128305
0.020	***0.000***	1996	***193880***	207596	204629	277553	443244	436920	371806	202836	117919	73992	65879	62557	72466	47141	46978	33320	30893	144197
0.021	***0.000***	1997	***166260***	184424	197472	194649	264016	421466	415211	352857	191972	111129	69418	61611	58407	67609	43969	43812	31073	163276
0.029	***0.000***	1998	***70205***	158151	175430	187841	185156	251039	400508	394008	333881	180841	104194	64870	57475	54445	63003	40968	40820	181073
0.019	***0.000***	1999	***58977***	66781	150438	166874	178680	176027	238460	379688	372032	313299	168578	96679	60046	53144	50320	58220	37855	205025
0.015	***0.000***	2000	***42898***	56101	63524	143101	158736	169903	167287	226327	359422	350736	294089	157760	90331	56064	49605	46965	54335	226668
0.026	***0.000***	2001	***26196***	40806	53365	60426	136122	150950	161499	158850	214467	339491	330159	276172	147963	84674	52541	46485	44008	263310
0.008	***0.000***	2002	***23560***	24918	38816	50762	57479	129419	143409	153163	150118	201562	317207	307222	256435	137259	78519	48714	43096	284906
0.003	***0.000***	2003	***25690***	22411	23703	36923	48286	54667	123058	136283	145384	142238	190620	299586	289954	241947	129488	74070	45953	309408
0.006	***0.000***	2004	***25030***	24437	21318	22547	35122	45929	51994	117018	129543	138111	135036	180886	284222	275055	229505	122827	70259	337078
0.009	***0.000***	2005	***42342***	23809	23245	20278	21447	33405	43676	49424	111145	122888	130842	127810	171123	268824	260131	217045	116157	385213
0.008	***0.040***	2006	***193470***	40277	22648	22112	19289	20398	31763	41504	46909	105292	116186	123534	120583	161395	253509	245298	204665	472767
0.002	***0.025***	2007	***359840***	184034	38313	21544	21033	18346	19396	30185	39373	44398	99368	109303	115777	112456	149611	233514	224713	615555
0.003	***0.015***	2008	***323450***	342290	175059	36444	20493	20007	17449	18445	28684	37383	42104	94084	103264	109046	105512	139805	217440	778247
0.004	***0.008***	2009	***211820***	307675	325597	166521	34667	19492	19028	16592	17527	27232	35450	39879	88987	97490	102719	99157	131117	930833
0.004	***0.011***	2010	***380580***	201489	292670	309717	158400	32973	18538	18091	15765	16637	25820	33578	37736	84116	92040	96852	93391	998365
0.003	***0.013***	2011	***667110***	362019	191663	278396	294612	150664	31360	17626	17190	14965	15775	24455	31767	35651	79333	86654	91047	1023657

Table D11. Stock summary for *S. mentella* in sub-areas I and II as estimated by the statistical catch-at-age model.

Year	*Rec (age 2) (millions)*	*Rec (age 6) (millions)*	*Stock Biomass (tons)*	*SSB (tons)*	*Landings (tons)*	*Fy*
1992	541	147	374 533	148 357	15 590	0.072
1993	322	237	441 755	190 504	12 814	0.050
1994	226	412	514 458	247 497	12 721	0.046
1995	218	460	544 666	292 798	10 284	0.035
1996	194	443	786 140	282 960	8 075	0.020
1997	166	264	796 356	331 167	8 598	0.021
1998	70	185	840 447	388 893	14 045	0.029
1999	59	179	917 939	484 349	11 209	0.019
2000	43	159	925 756	581 334	10 075	0.015
2001	26	136	931 479	522 204	18 418	0.026
2002	24	57	1 028 039	640 233	6 993	0.008
2003	26	48	1 054 792	731 643	2 520	0.003
2004	25	35	1 074 727	737 581	5 493	0.006
2005	42	21	1 079 321	805 778	8 465	0.009
2006	193	19	1 040 022	755 390	33 261	0.048
2007	360	21	988 319	916 263	20 219	0.028
2008	323	20	956 599	834 479	13 089	0.018
2009	212	35	1 049 250	952 755	10 135	0.012
2010	381	158	1 007 366	852 473	11 751	0.015
2011	667	295	985 158	824 996	12 422	0.016
sum	4120	3332	17 337 121	11 521 654	246 177	0.494

Table D12. ***Sebastes mentella*****. Comparison of results from the Norwegian Sea pelagic surveys in 2008 and 2009.**

	2009	2008[1]
mean length (cm) All/M/F[2]	36.6 / 36.0 / 37.1	37.0 / 36.4 / 37.5
mean length (cm) S/DSL/D[3]	37.2 / 36.5 / 38.3	37.2 / 36.8 / 39.1
mean weight (cm) All/M/F	625 / 609 / 666	619 / 585 / 648
Mean age (y) All/M/F	25 / 25 / 24	25 / 25 / 25
Sex ratio	45% (M) / 55% (F)	45% (M) / 55% (F)
Occurrence *S. mentella*	100%	96%
Catch rates	3.94 t/NM^2	3.80 t/NM^2
mean s_A	34 m^2/NM^2	33 m^2/NM^2
Total Area	69,520 NM^2	53,720 NM^2
Abundance (Acoustics)[4]	532,000 t	395,000 t
Abundance (Trawl)[5]	548,000 t	406,000 t

[1] **The result for 2008 only concern the northern part of the Norwegian Sea which was surveyed by Norway**

[2] **M = males only, F = females only**

[3] **S = shallower than DSL, DSL = deep scattering layer, D = deeper than DSL**

[4] **The abundance derived from hydroacoustics is calculated assuming a Length-dependent target strength equation of TS=20log(L)-68. The alternative equation 20log(L)-71.3 would result in abundance estimates raised by a factor of 2.**

[5] **The abundance derived from the trawl catches is corrected for the catchability of redfish by Gloria trawl 2048. This is estimated to be 0.5, from Bethke *et al*. (2010).**

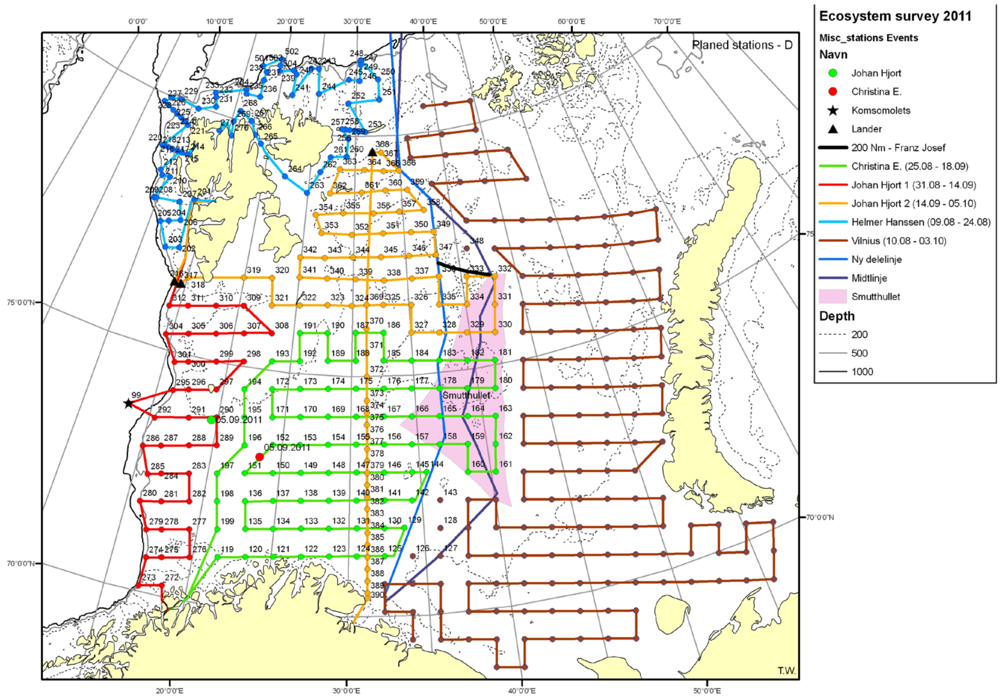


Figure D1. Survey regions and subareas in the ecosystem survey in the Barents Sea and adjacent areas as covered in August-September 2011 by the standard 1800 Campelen research trawl (22 mm codend) shallower than about 500 m, and the Alfredo 5 trawl (60 mm codend) from 500-1500 m along the continental slope from 68-80°N. The Subareas are further depth stratified (ref. Table D6). Stations that are not connected to a line have not been sampled.

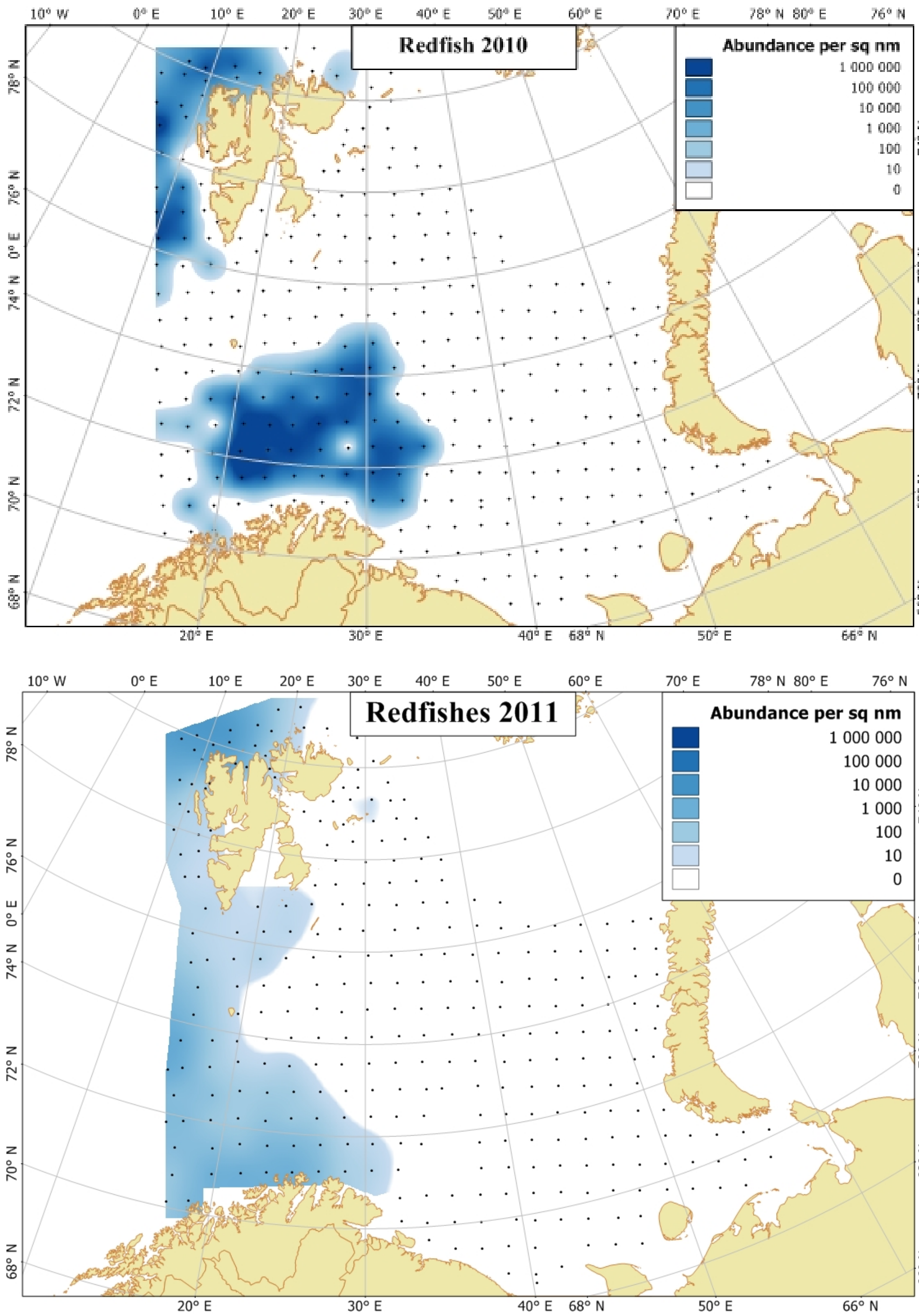


Figure D2. Map showing the specific pelagic 0-group trawl stations and the abundance of 0-group *Sebastes mentella* during the joint Norwegian-Russian Ecosystem survey in the Barents Sea and Svalbard in 2010 (upper panel) and 2011 (lower panel).

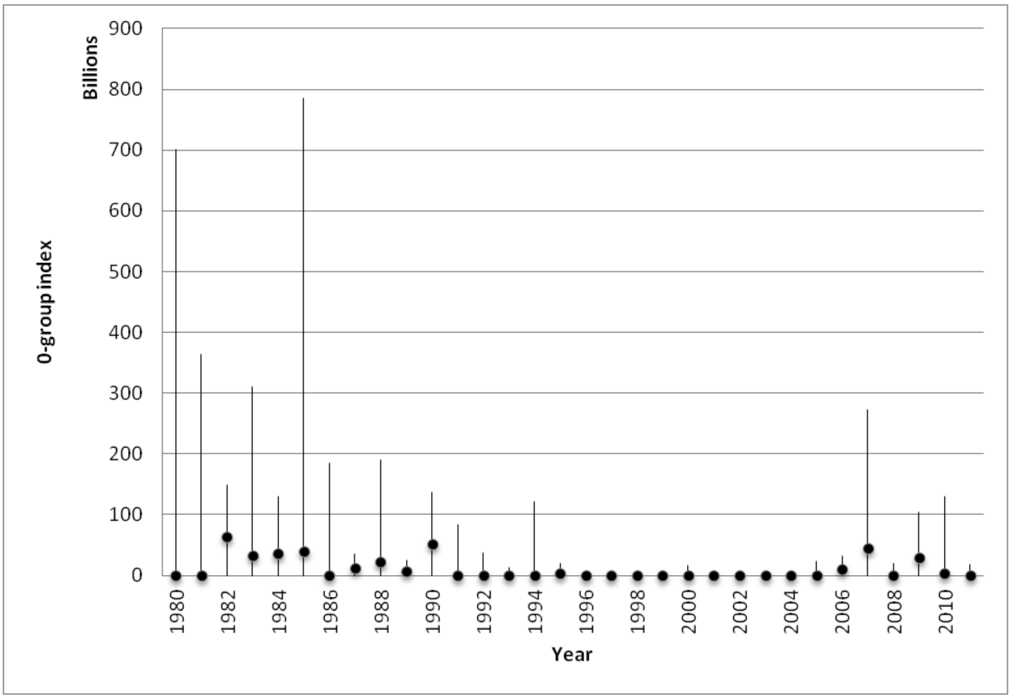


Figure D3. ***Sebastes mentella*** **in Subareas I and II. Abundance indices (in millions) with 95% confidence limits of 0-group redfish (believed to be mostly** ***S. mentella*****) in the international 0-group survey in the Barents Sea and Svalbard areas in August-September 1980-2011. Numbers are given in Table 1.1.**

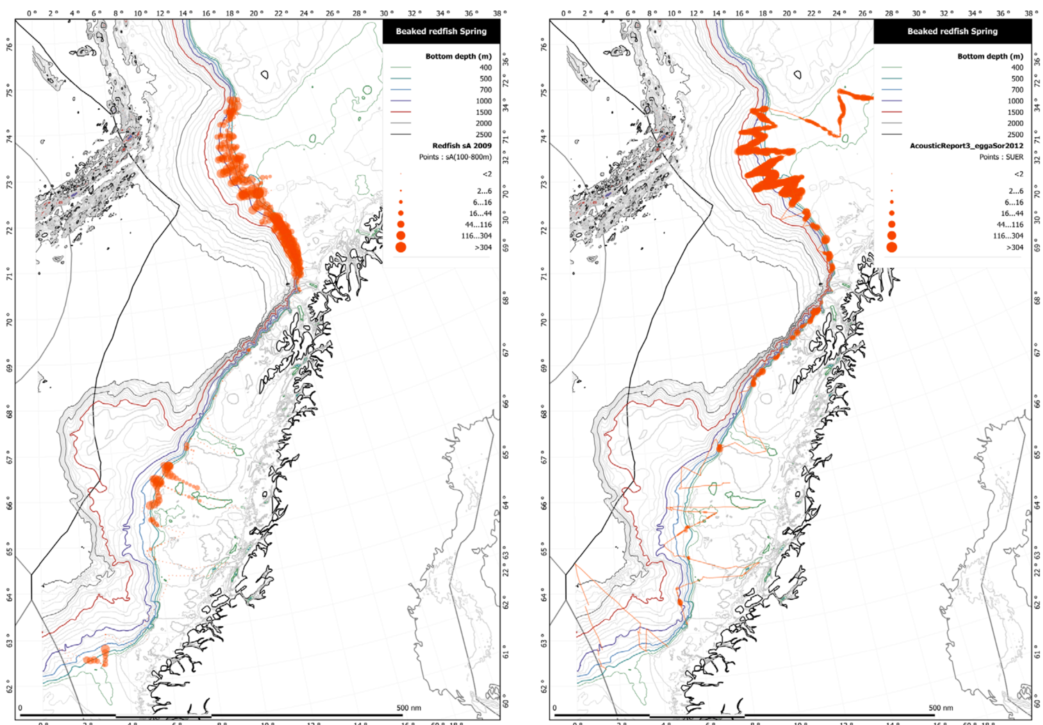


Figure D4. ***Sebastes mentella*** **in Subareas I and II. Horizontal distribution of** ***S.mentella*** **hydroacoustic backscattering (sA) during the Norwegian slope survey in spring 2009 (left panel) and 2012 (right panel). The circles are proportional to the sA assigned to redfish along the vessel track.**

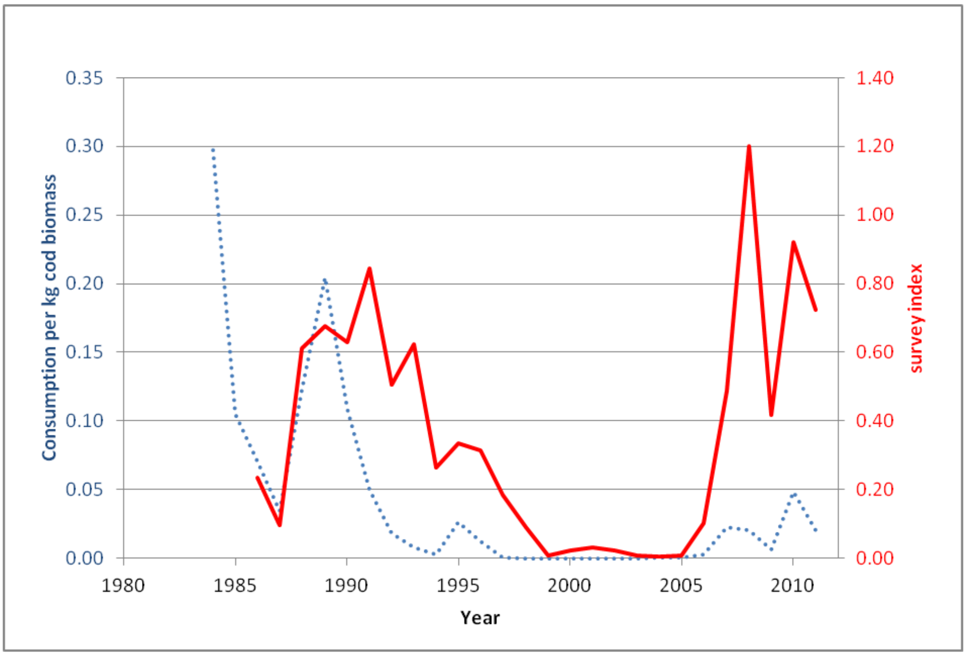


Figure D5. Abundance of *S. mentella* (5-14 cm) during the winter survey (February) in the Barents Sea compared with the consumption of redfish (mainly *S. mentella*) by cod (See Chapter 1, Table 1.3).

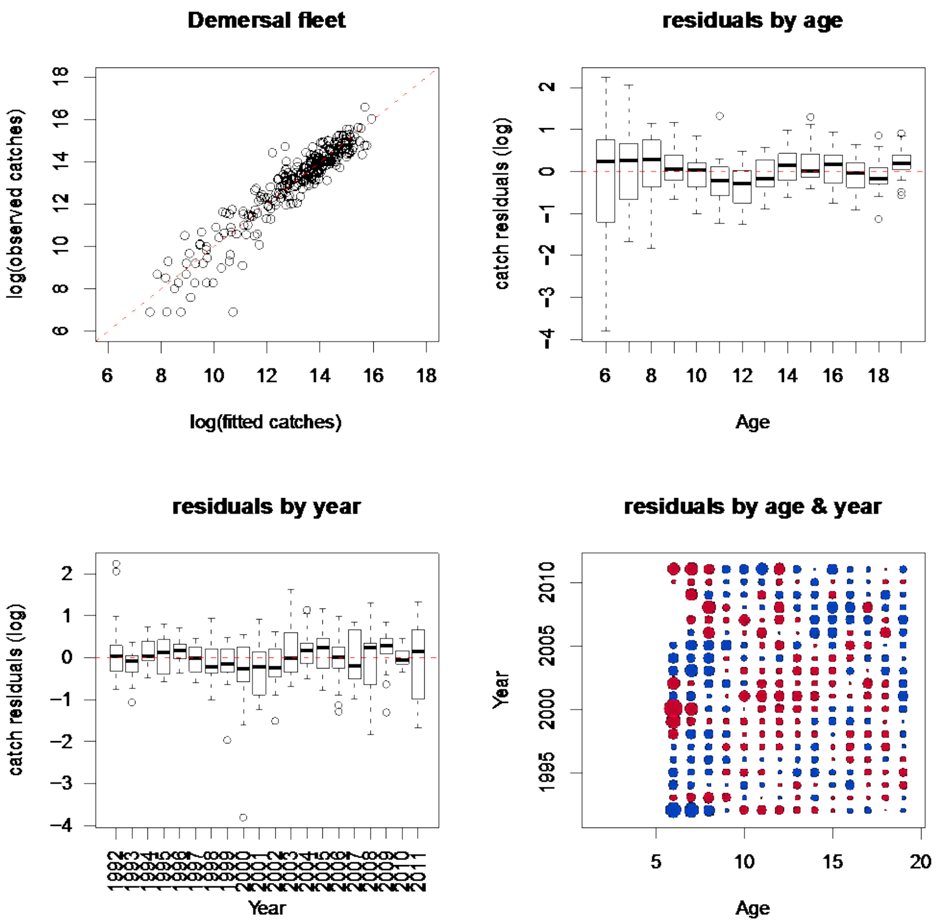


Figure D6a. Diagnostic plots for the demersal fleet catch-at-age data. Top-left: scatter-plot of observed vs. fitted indices, the dotted red line indicates 1:1 relationship. Top right: boxplot of residuals (observed-fitted) for each age. Bottom left: boxplot of residuals for each year. Bottom right: bubble plot of residuals for each age/year combination, bubble size is proportional to mean residuals, blue are positive and red are negative residuals.

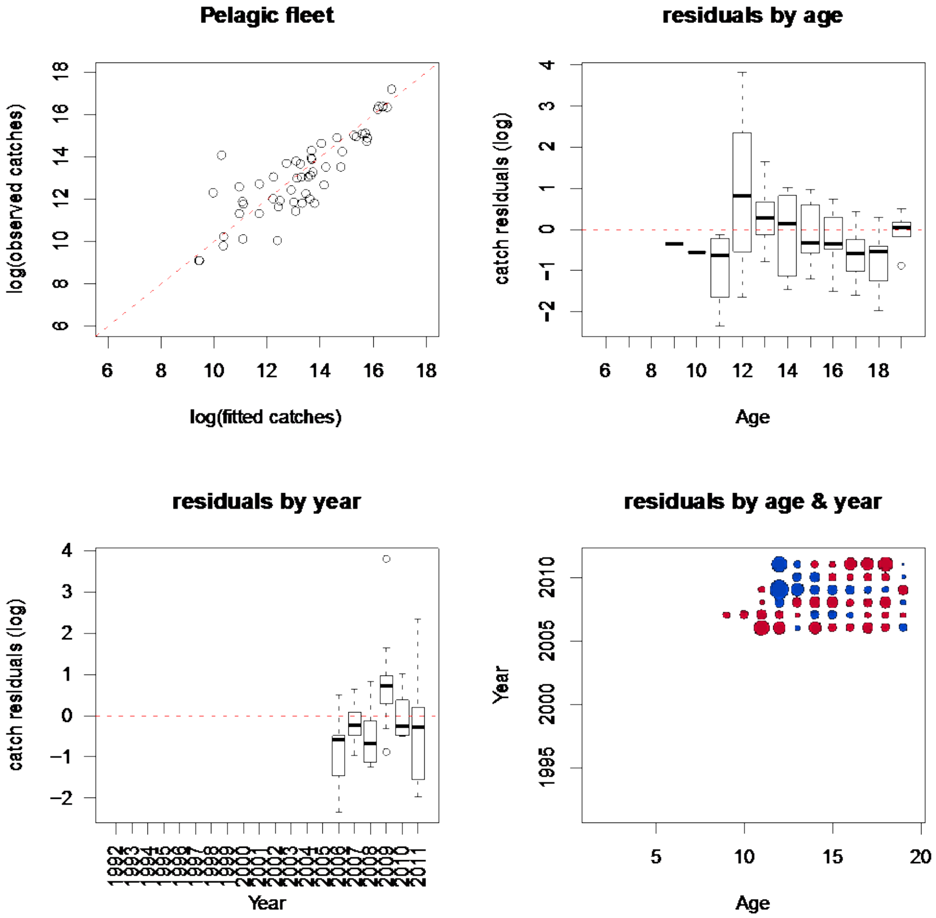


Figure D6b. Diagnostic plots for the pelagic fleet catch-at-age data. See legend from fig. D6a.

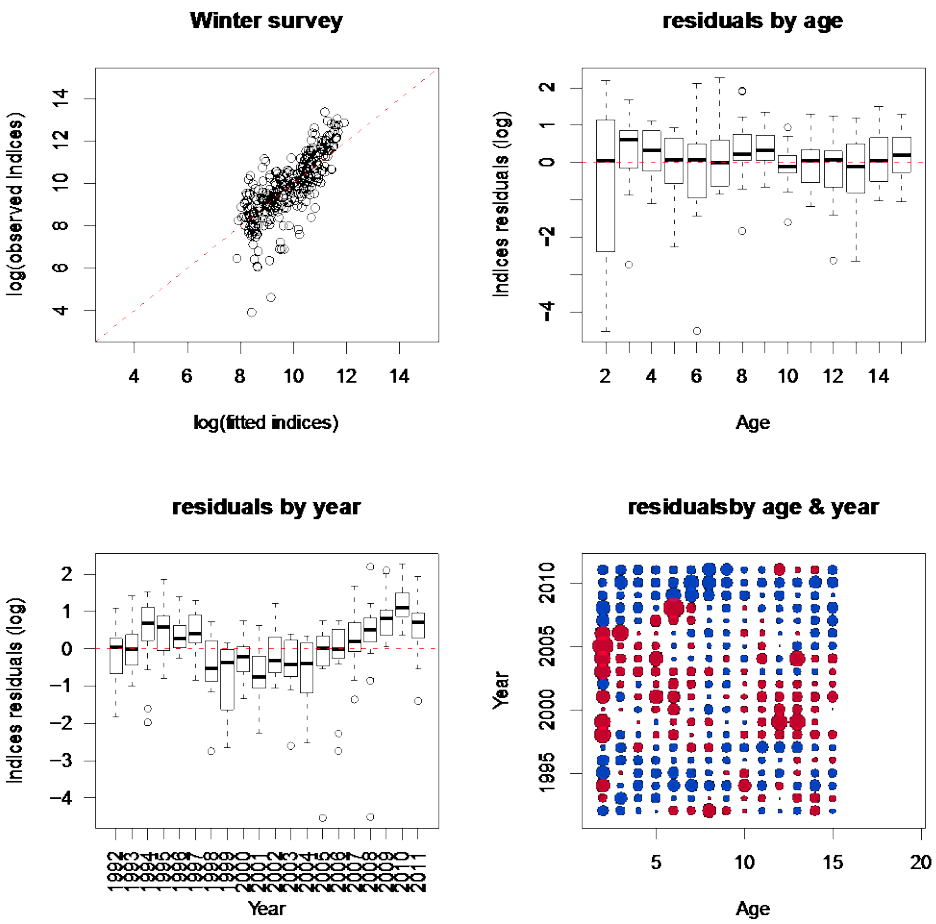


Figure D6c. Diagnostic plots for the Winter survey data. See legend from fig. D6a.

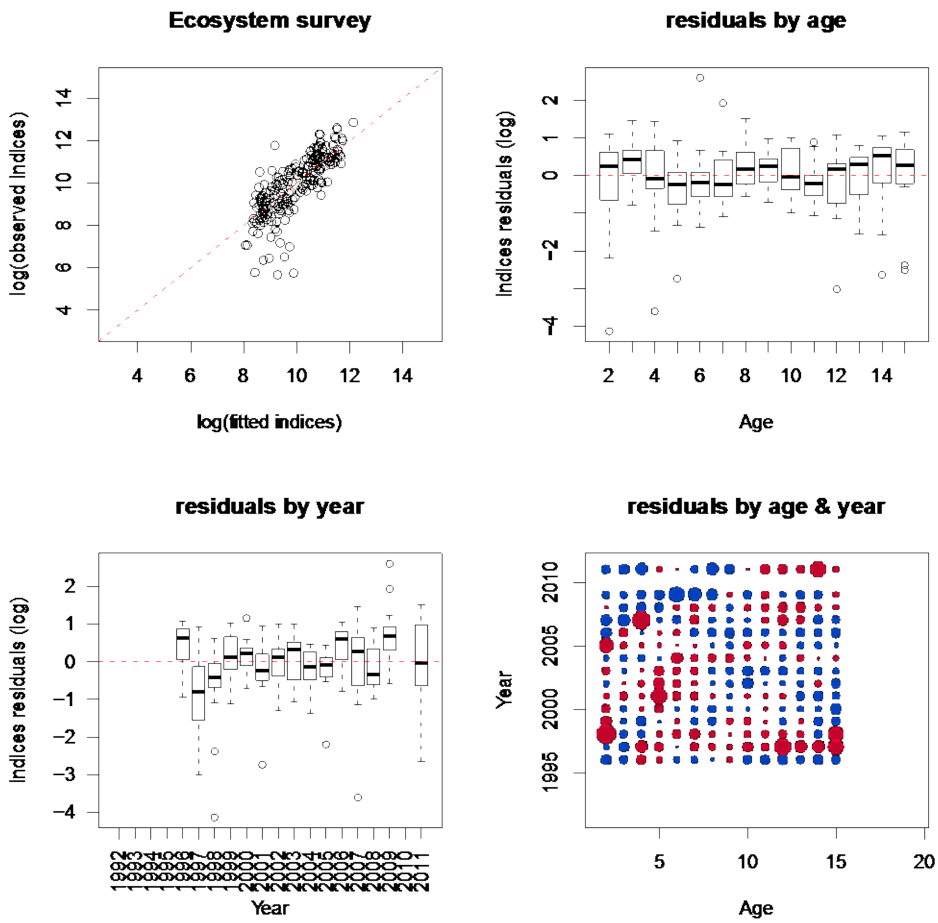


Figure D6d. Diagnostic plots for Ecosystem survey data. See legend from fig. D6a.

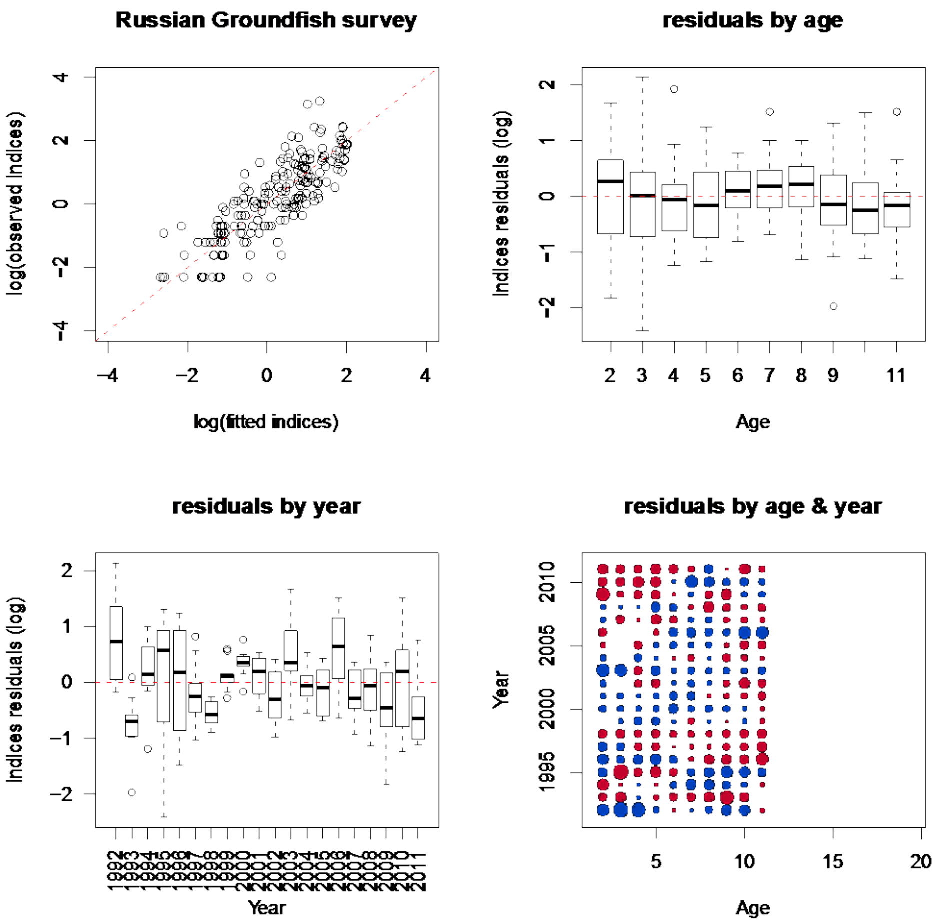


Figure D6e. Diagnostic plots for the Russian groundfish survey data. See legend from fig. D6a.

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 Quality handbook was last updated in February 2012 (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* had only marginal effects on the *S. marinus* stock. After this date, all directed trawl fishery for redfish (both *S. marinus* and *S. mentella*) outside the permanently closed areas have been forbidden in the Norwegian Economic Zone north of 62°N and in the Svalbard area. When fishing for other species it is currently legal to have up to 15% redfish (both species together) in round weight as bycatch per haul and on board at any time. Until 14 April 2004 there were no regulations of the other gears/fleets fishing for *S. marinus*. After this date, a minimum legal catch size of 32 cm has been set for all fisheries, with the allowance to have up to 10% undersized (i.e., less than 32 cm) specimens of *S. marinus* (in numbers) per haul. In addition, a time-limited moratorium has been enforced in the conventional fisheries (gillnet, longline, handline, Danish seine) except for handline vessels less than 11 meters. Since 2007 this moratorium has been during 5 months, i.e., March-June and September. When fishing for other species (also during the moratorium) it is allowed to have up to 15% bycatch of redfish (in round weight) summarized during a week fishery from Monday to Sunday. No new regulations were imposed on the fishery since 2009.

7.1.2 Landings prior to 2012 (Tables 7.1–7.4, D1 & D2, Figures 7.1–7.2)

Nominal catches of *S. marinus* by country for Sub-areas I and II combined, and for each Sub-area and Division are presented in Tables 7.1 - 7.4. The total landings for both *S. marinus* and *S. mentella* are presented in Tables D1 and D2. Landings of *S. marinus* showed a decrease from a level of 23,000–30,000 t in 1984–1990 to a stable level of about 16,000-19,000 t in the years 1991–1999. Since then the landings have decreased further, and the total landings figures for *S. marinus* in 2003-2010 have been low but remarkably stable between 6,000-8,000 t. The 2009 level of 6,293 t was the lowest since the 1940s. The figures for 2010 showed an increase to 7,744 t but in 2011 landings have returned to lower values: 5,829 t. The time series of *S. marinus* landings is given in Figure 7.1.

The Norwegian landings are presented by gear and month/year in Figures 7.2a,b. Reported landings in 2011 have returned to values similar to 2009 after an increase in 2010 for all gears except Danish seine. Since 2003, the limited moratorium for conventional gears reduced the catches taken by these gears from about 5,900 t to about 3,200 t in 2007, but this trend has halted due to the increase in gillnet catches since 2008. The return to lower landings in 2011 confirms that the increase observed in 2010 was due to increased effort/greater catchability and not new year classes contributing to the landings (ref. Table 7.5).

The reported Russian catches of *S. marinus* have been around 600 - 900 t since 2001, while ten other countries together usually report catches of less than 300 t per year (Table 7.1).

The bycatch of redfish (*Sebastes* spp.) in the Norwegian Barents Sea shrimp fisheries during 1983-2002 were completely dominated by *S. mentella*, and hence influenced the *S. marinus* to a much lesser extent. However, these by-catches probably inflicted an extra mortality on *S. marinus* in the coastal areas before the sorting grid was enforced in 1990. From 1 January 2006, the maximum legal bycatch of redfish juveniles in the international shrimp fisheries in the northeast Arctic has been reduced from ten to three redfish per 10 kg shrimp.

Information describing the splitting of the redfish landings by species and area is given in the Stock Annex.

7.1.3 Expected landings in 2012

Under similar assumptions as before (i.e., reports from the first months of the year, a legal by-catch of 15% in all trawl fisheries, and a continuation of the regulations for the other gears, i.e., free fishing during seven months of the year) the Norwegian and Russian landings in 2012 are expected to be similar to those reported in 2011, circa 6,000 t.

7.2 Data Used in the Assessment (Figure E2)

An overview of the sampling levels (by season, area and gear) of the data used in the assessment is presented in Figure E2 for 2010. This figure could not be updated for 2011. In 2010, only 36% of the metiers (area-quarter-gear combinations) responsible for more than 50% of the Norwegian landings were properly covered with age samples.

7.2.1 Catch-per-unit-effort (Figure 7.3)

The CPUE-series for *S. marinus* from Norwegian 32-50 meter freezer trawlers and Factory trawlers (>53m) is presented from 1992 to 2010 (Table E1, Figure 7.3). Only data from days with more than 10% *S. marinus* in the catches (in weight) are included in the annual averages. Mean CPUEs with standard errors together with number of vessel days meeting the 10% criterion are presented in Table E1. This indicates an important reduction in the effort of freezer trawlers since 2006 in comparison with the previous decade. The effort of factory trawlers has remained stable between 100 and 180 vessel fishing days (with >10% *S. marinus* in haul) per year since 2003. The 2010 CPUE value for the 41 freezer vessel days is very high, 760 kg/hour, and with 2 st. errors equal 740 kg/hours it was decided to omit this point from Figure 7.3.

Although the trawl fishery until 2003 was almost unregulated, the trawlers experienced fewer and fewer fishing days with more than 10% of their catches composed of *S. marinus* (Figure 7.3). During 2001-2005 both the catch-rates and the number of vessel-days were rapidly decreasing, and this is worrying since the criterion for defining it to be a *S. marinus* vessel-day have not been more than 20% (since 2003) or 10% (since 2004) *S. marinus* in each trawl haul. Since 2005 a slight improvement of the catch-rates is seen for both trawler fleets, but it is worrying that the number of vessel days containing a minimum of 10% redfish still is decreasing in one of the fleets. With some variation, the average annual catch-rates for the freezer trawlers have decreased from an average level of 350 kg/trawl hour during the mid-1990s to about 150 kg/h since 2003, i.e., less than 40% of the former recent level. Corresponding values for the factory trawlers are 600 kg/h until 2001 and about 200-300 kg/h since 2002. The decrease seems though to have halted for both fleets. There was no update for this data for 2011.

7.2.2 Catch at length and age (Table 7.5)

Age composition data for 2011 were only provided by Norway, accounting for 84% of the total landings. Other countries were assumed to have the same relative age distribution and mean weight as Norway. The updated catch-in-numbers at age matrix is shown in Table 7.5. Catch at length data were available from Norway and Portugal (WD14, Figure 7.4). Length data for 2011 were however not available in time for use at this year's AFWG meeting.

7.2.3 Catch weight at Age (Table 7.6)

Weight-at-age data for ages 7–24+ were available from the Norwegian landings in 2011. Variations in the weight-at-age of young individuals (<10 years) must be considered with caution as these numbers are derived from only a small number of aged individuals.

7.2.4 Maturity at age (Figure 7.8)

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. Maturity-at-age and length is available from Norwegian surveys and landings, as reported in Table E5 and presented in Figure 7.8a. The maturity ogive modelled by Gadget is presented (Figure 7.8b). 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 7.8b. Testing showed that this did not otherwise alter the model dynamics (note that no SSB-recruitment relationship is used in the model), and has therefore been adopted from the 2009 WG onwards.

7.2.5 Survey results (Tables E2a,b–E3a,b–E4, Figures 7.5a,b–7.6a,b)

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

1) Winter Norwegian Barents Sea (Division IIa) bottom trawl survey (BS-NoRu-Q1 (BTr)) from 1986 to 2012 (joint with Russia some of the years since 2000) in fishing depths of 100–500 m. Length compositions for the years 1986–2012 are shown in Table E2a and Figure 7.5a. Age compositions for the years 1992–2010 are shown in Table E2b and Figure 7.5b. This survey covers important nursery areas for the stock.
2) Norwegian Svalbard (Division IIb) bottom trawl survey (August-September) from 1985–2011 in fishing depths of 100–500 m (depths down to 800 m incl. in the swept area). Since 2005 this is part of the Ecosystem survey (Eco-NoRu-Q3 (BTr)). Length compositions for the years 1985–2011 and age compositions for the years 1992–2008 are shown in Table E3a and E3b, respectively. This survey covers the northernmost part of the species' distribution. Insufficient number of age readings in 2009 and 2011, and no

age samples collected in 2010 did not allow for updating the age composition after 2008.

3) Data on length and age from both these surveys have been combined and are shown in Figures 7.6a,b.

4) Age disaggregated catch rates (numbers/nm^2 averaged for all stations within subareas and finally averaged, weighted by subarea, for the total surveyed area) of *Sebastes marinus* from the Norwegian Coastal and Fjord survey in 1995-2010 from Finnmark to Møre (NOcoast-Aco-Q4) (Table E4). The estimated catch rates in 2008 and 2009 were particularly high due to one trawl station with an exceptional high catch. Updating of table E4 is discontinued. The data is no longer used as an input to the Gadget analytical assessment as described in the stock annex.

The bottom trawl surveys covering the Barents Sea and the Svalbard areas show that the abundance indices over the commercial size range (> 25 cm) were relatively stable up to 1998 but declined to lower levels afterwards. Abundance of pre-recruits (<25cm) has steadily decreased since 1991 and has dropped to very low levels after 2000 (Figure 7.5a). An increase in the number of pre-recruits is visible from 2008 onwards. Although this could originally partly result from taxonomic misidentification, the confirmation of increased numbers for individuals of size 15cm and greater confirms that increasing numbers are *S. marinus*.

7.3 Assessment with the GADGET model

7.3.1 Description of the model

Since AFWG2005, experimental analytical assessments have been conducted on this stock using GADGET, and results presented for the years 1990 – last year. This model was evaluated by the WKRED (2012) benchmark meeting (ICES CM 2012/ACOM:48), and its continued use for analysing this stock was recommended.

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 Quality Handbook for *S. marinus*. In brief, the model is a single species forward simulation age-length structured model, split into mature and immature components. There are two commercial fleets (a gillnet fleet and a combined trawl and other gears fleet), and one survey used in the model. Growth and fishing selectivity are assumed constant over time, and recruitment is estimated on annual basis (no SSB-recruit relationship).

The weighting scheme for combining the different datasets into a single likelihood score is an ad hoc method where weights are selected so that the catch and survey data have approximately equal contribution to the overall likelihood score in the optimised model, and that each dataset within each group gives approximately equal contributions to each other. The parameters in the model are estimated using a combination of Simulated Annealing (wide area search) and Hooke and Jeeves (local search) repeated in sequence until a converged solution is found.

7.3.2 Data used for tuning

- Quarterly catch in tonnes from two commercial fishing fleets, i.e., Norwegian gillnet and 'all others', to 2011.
- Quarterly length distribution of total international commercial landings from two commercial fishing fleets, i.e., Norwegian gillnet and 'all others' to 2010 (not 2011). Due to late data submissions, there is one year time lag in the inclusion of length distributions from other countries than Norway.
- Quarterly age-length keys from the same fishing fleets, up to 2010 (not 2011)
- Length disaggregated survey indices from the Barents Sea (Division IIa) bottom trawl survey (February) from 1990–2011 (Table E2a)
- Age-length keys and aggregated survey indices from the same survey up to 2011 (Table E2b)

Note that biological samples (age and length distributions) from the commercial catch for 2011 were not available in time for this assessment. As a result the estimated populations for the final year should be treated with caution, especially for mature fish. There is no direct data on the older fish, as the winter survey data employed here only covers younger fish. It is likely that the overall downward trend in the mature population seen in recent years has continued, but the exact estimates for 2011 should be treated as highly uncertain at this point. Equally any revisions to the estimate of recruitment since 2000 should also be treated with caution.

7.3.3 Changes made to the model and in input data compared with last year's Working Group

Several revisions have been made to the model following the WKRED benchmark meeting. It has been decided to exclude the Coastal and Fjord survey (which was previously included in the model up to 2007), and the value of natural mortality has been reduced from M=0.1 to M=0.05. The principle effect of these changes has been to revise the overall stock size down from the previous model. The average age and mean weight in the stock have also been increased by this reduced mortality. The trends in stock number and biomass have not been affected. For a full evaluation of the changes consult the WKRED (2012) report (ICES CM 2012/ACOM:48).

Commercial catch data have only been included as catch in tonnes for 2011. Biological samples for 2011 (length and age&length based) were not available in time for this assessment, and have therefore not been included. The proportion mature has been extended to 2010. The winter survey has been extended to 2011, with minor revisions to the 2010 data.

7.3.4 Assessment results using the Gadget model

The text table below compares the results from this year's Gadget model with the four previous years. Note that the natural mortality in the model has been changed in 2012, meaning that results are not directly comparable with earlier years.

	Total stock (3+) by 1 January 1990 (tons)	Mean weight in stock 1990 (kg)	SSB (15+) by 1 January 1990[1] (tons)	Total stock (3+) by 1 January 2003 (tons)	Mean weight in stock 2003 (kg)	SSB (15+) by 1 January 2003[1] (tons)
WG 2006	179 313	0.39	64 019	71 013	0.71	38 927
WG 2007	163 536	0.35	66 712	64 240	0.64	43 096
WG 2008	158 851	0.35	64 838	74 717	0.78	47 693
WG 2009	149 763	0.34	66 153	73 673	0.77	51 683
WG 2010	152 419	0.34	58 774	80 073	0.79	55 995
WG 2011	148 727	0.33	56 271	80 808	0.78	55 810
WG [2] 2012	109 021	0.43	48 308	55 229	0.80	40 030

1) Since WG2007 based on modeled maturation and not 15+, data series used for estimation of maturity modified in 2010

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

The general patterns in the stock dynamics of *S. marinus* are similar to those modelled for the past several years (Figure 7.11). The overall stock numbers and biomass continue to show a decline, with possible sporadic moderate year classes recruited in recent years. Mature biomass and numbers are in steady decline, while modelled immature numbers and biomass show signs of flattening out.

It should be noted that it is possible that the improved recruitment signal may be due to misidentification of small *S.mentella* (which is a larger stock and has had good recent recruitment) as *S.marinus*. If this were the case then one would expect to see the recruitment numbers progressively revised downwards as the fish grow larger and become easier to identify and begin to enter the fishery. The number of recruits around the 2005 was revised downwards in the 2010 and 2011 reports. No commercial data was available to inform such a revision this year. This will be monitored in the coming years. The model is estimating that 2011 was another year with reasonably good recruitment. This may also be subject to revisions in future years.

The overall trend of the model fits well to the overall Barents Sea winter survey index (Figure 7.7), especially in recent years. The fit to coastal survey is presented, although this data is no longer used in tuning. Note that the 2009 point presented in the figure for the coastal survey has had several outlying data points from large hauls removed, revising this down from the raw data. As can be seen the recent trends in the coastal survey do not match those in the model, nor those in the Svalbard winter survey. Also note that the recent upwards trend in the coastal survey have been reversed in 2010, and it is difficult to see how the survey pattern could represent the actual trajectory of a long lived species such as *S. marinus.*

The model fits (by length) to the winter survey, the trawl fleet and the gillnet fleet are presented in figures 7.12, 7.13 and 7.14 respectively. In the case of 7.13 and 7.14 the fits are summarized over the entire year. In the case of the survey the fit is reasonable, except that the model has been unable to match the erratic signal of recent recruitment since 2007 (this is discussed further in section 7.6). The fits to the commercial fisheries are also generally good, although the catch is somewhat smoother and more constant between years than the actual data. The gillnet catch in 2009 stands out as a year the model was unable to replicate, owing to a rather different length distribution in the catches in that year compared to the other years. It should also be noted that in recent years the model has begun to overpredict the catches of the larger fish. This may be an indication that the mature portion of the stock is in a rather worse state than the model is indicating.

Figure 7.15 presents the retrospective pattern for the current model for the last 7 years of data. Note that a forward simulation model, such as GADGET exhibits different retrospective behaviour than a VPA, and there is not always a tendency to have complete convergence between runs in the early part of the model. The immature stock is rather consistent over this time period, both in numbers and biomass. There has been a trend to revise the mature stock biomass upwards, but with a steeper decline at the end of the time series. These revisions are most marked from 2005-2009, and the estimate has been much more stable since 2009. It should be noted here that since the coastal survey has been excluded the only data on fish older than 15 comes from the commercial catches. One might therefore speculate that the retrospective pattern is could have arisen if the assumption of constant selectivity over time is not correct. However without survey data on abundance of such older fish it is difficult to confirm or refute this speculation.

The most important conclusions to be drawn from the current assessment using the Gadget model are:

- The recruitment to the stock has been very poor over the last decade (Figure 7.10) but may possibly be increasing, although estimated abundance for new year classes are uncertain.
- The estimated fishing mortality has declined between 1990 and 2005 and steadily increased since 2005. The current mortality is estimated to 0.35 (Figure 7.9). This upwards trend in F has been continuing for five years, and is a major source of concern.
- According to the model the total stock biomass (3+) of *S. marinus* has decreased from about 151,000 tonnes in 1992-1993 to around 40,000 tonnes in 2011 (Figure 7.11, Table 7.8).
- The spawning stock biomass of *S. marinus* has decreased from a maximum of about 55 thousand tonnes in 1996 to be below 20 thousand tonnes in 2011 (Figure 7.11, Table 7.8). This reduction is primarily the result of low recruitment in the last 10-15 years, combined with excessively high fishing pressure. It should be noted that in the absence of biological samples from the commercial fleet the estimate for SSB in 2011 is highly uncertain (there is no tuning data constraining this estimate).

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 continue for several years irrespective of current management actions. However indications are that the stock is continuing to fall while the total catch has remained relatively constant. This has led to an upwards trend in F, which may place an increasing burden on an already poorly performing stock. Year-classes recruit to the SSB at old age (~12 years) and surveys indicate failure of recruitment over a long period. There are indications that new recruits (<15cm) may have entered the population in recent years as noted in previous AFWG reports. However it is not clear if this trend genuinely reflects increased *S. marinus* recruitment, or if it results from species misidentification (with *S. mentella*). Even if the recruits are assumed to be entirely *S. marinus*, the current fishing is well above the level that these year classes could sustain.

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.

Figure 7.16 presents an analysis of the reported landings from the fishery (from table 7.5). It can be seen that between the earlier part of the time series (1995-2003) and the later part (2004-2011) there has been a marked shift in the fishery. The catch was previously dominated by fish in the 10-18 year old range, with a smaller number from age 18-23, and then a significant catch in the 24-plus group. Since 2004 the overall catches have fallen, however this has not occurred evenly across all age groups. The oldest fish (24+) have declined steeply, as have the 10-18 year olds. This is likely because there are fewer fish in these age categories left in the stock. In contrast the catches of 18-23 year old fish have remained constant. Since there is no evidence that the abundance in this age range is increasing, this implies increased mortality on the fish of reproductive age. There is as yet no sign of improved year classes entering the fishery. This is consistent with results from the Gadget and Scheafer models indicating a stock in the process of collapsing.

Clearly the stock has at present a reduced reproductive potential and the model suggests that the declining trend in biomass is still going on. In order to reverse this negative development, no directed fishery should be conducted on this stock until a clear increase in the number of juveniles has been detected in surveys, and an improved situation of the mature stock is confirmed by the assessment. Furthermore it is imperative that actions be taken to prevent F increasing further, and reduce F to at least the levels seen in 2005.

Sebastes marinus is currently on the Norwegian Redlist as a threatened (EN) species according to the criteria given by the International Union for Conservation of Nature (IUCN).

Redlisting is understood to mean that a species (or stock) is at risk of extinction. ICES convened two workshops in 2009. The first Workshop WKPOOR1 (ICES CM 2009/ACOM:29) addressed methods for evaluating extinction risk, and outlined approaches that could support advice on how to avoid potential extinction. The second Workshop WKPOOR2 (ICES CM 2009/ACOM:49) applied the results of the first workshop to four stocks selected as being of interest to Norway and ICES.

There are three general methods for evaluating extinction risk: (1) screening methods, such as the IUCN redlisting criteria; (2) simple population viability analysis (PVA) based on time trends; and (3) age structured population viability analysis. None of the methods are considered reliable for accurately estimating the absolute probability of extinction, but they may be useful to evaluate the relative probability of extinction between species or between management options.

Simulations were performed on the *Sebastes marinus* stock using the Gadget model at WKRED. An assumption was made that the recruitment observed over the last 10 years would apply in the future, with recruitment independent of the spawning biomass. This indicated that the population could sustain an annual catch of around

1,500 tonnes, and finding which was in line with the Schaefer model estimates conducted during WKRED. Separate simulations done by WKPOOR2 indicate that a constant catch above about 6,500 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.

7.5 Projections

The current level of catches is likely well above the sustainable catch, and will probably lead to a stock collapse without a substantial increase in recruitment. Based on the Gadget and Schafer modelling results, the stock cannot currently sustain any catch in excess of 1,500 tonnes per year, around a quarter of the actual catch.

The group evaluated the consequences of keeping the current management unchanged by projecting the stock trajectory in future years under the assumption of constant catch at the level of 2011 (Figure 7.17), and recruitment at the average of the past 10 years in the Gadget model. Although there is uncertainty about the exact biomass in 2011 (due to limited data) and the current recruitment, the overall downward trend in the stock is clear and well established. It should be noted that although there has been a retrospective pattern to increase the estimated mature population over time, the retrospective pattern has also been for a steeper decline at the end of the time series as more data is added (Figure 7.15). The net effect of these two trends is that the overall likely date of the collapse of the stock is largely unaffected by the retrospective pattern. The model projections are unambiguous, projecting a collapse of the stock within the next ten years.

7.6 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. The model also ignores variable predation mortality on the youngest fish, which may lead to errors in estimating recruitment.

Two difficulties have arisen with regard to the recruitment signal in the winter survey. The first is that some or all of this signal may be due to young *S. mentella* being misidentified as *S. marinus* (discussed above). A second problem is that the signal in the winter survey has been erratic in recent years, and the model is not able to follow the survey signal (Figure 7.12). Note that the survey indicates large numbers of young fish in 2008, 2010 and 2011, but not in 2007 or 2009. As a result of this inconsistent signal the model has produced a population which does not well match the signal in any of the years. It is likely that further years of survey will help identify the actual population trend.

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.

7.7 Biological reference points

The ability to set biological reference points was examined at WKRED (2012). It was not possible to accurately define a SSB-recruitment relationship, or the productivity level of the stock. In addition there was considerable uncertainty over recent levels of recruitment (due to possible species misidentification and inconsistent signals in the winter survey). As a result, it was not considered possible to set target reference points for this stock.

A maximum exploitation rate of 5% has been suggested sustainable for long lived species like *Sebastes* spp. when the stocks show no sign of reduced reproductive potential (corresponding to keeping SPR at 60% of the level when no fishing occurs; see chapter 7.8 and Dorn 2002). Based on the selection curves for the fleets, a reasonable classification of the fishable biomass would be the mature biomass. A corresponding 5% harvest of this would yield not more than 1,600 t, which is well below the current landings. This is consistent with the modeling at WKRED, where both Gadget and Schaefer modeling suggested around 1,500 t as the sustainable yield at current recruitment levels.

7.8 Management advice

AFWG considers that the area closures and low bycatch limits should be maintained, but stronger regulations than those recently enforced are needed given the continued decline in SSB and low recruitment. Despite the extended ban on the directed fishery by conventional gears from 3 months in 2006 to 5 months in 2007, the current measures are considered insufficient to stop the stock from declining to such low levels that any *S. marinus* fisheries in future will be difficult to conduct. More stringent protective measures should thus be implemented. No directed fishery should be conducted on this stock at the moment, and the percent legal bycatch should be set as low as possible for other fisheries to continue. Several different lines of evidence suggest that continuing fishing pressure at the current level would drive the stock towards actual or commercial extinction within few years. This is confirmed by quantitative projections which indicate stock collapse by 2017 if current catch levels are maintained (5,829 t/year). Significant efforts should be made to rapidly reduce the total catch, at least down to a level no higher than the 1,500 t per year, and preferably less.

7.9 Implementing the ICES F_{msy} framework

As a long lived species, *S. marinus* has many year classes contributing to the population, and consequently a relatively stable stock level from year to year. This makes it relatively simple to manage to some proxy of MSY (e.g. $F_{0.1}$) provided adequate measures can be implemented to reduce fishing pressure to an appropriate level. It should be noted that the current fishery (F = 0.35) is well above the suggested F_{pa} of 5% of the stock (Section 7.6). The main focus should therefore be on reducing total F to no higher than $F_{pa.}$ The current priority is to stabilize the stock and prevent further decline, only then could a recovery strategy and eventually an MSY fishery be implemented.

During the ICES Workshop on Implementing the ICES F_{msy} framework (WKFRAME), the closely related beaked redfish *Sebastes mentella* stock in Sub-areas I and II was used as a case study (ICES CM 2010/ACOM:54) for a data limited situation. The results of this Workshop refer also to *Sebastes marinus* in the Barents Sea, where the AFWG is faced with a data limited situation. WKFRAME recommends that the bounds for F_{msy} proxies should be evaluated in function of the YPR and SPR curves, and that the reproductive capacity of the *S. mentella* (in this case *S. marinus*) stock be at least above 30% of the SPR at F=0. The YPR curve left of the plateau can be used as lower bound ($F_{0.1}$ proxy) and a prescribed per-cent SPR as upper bound. The WKFRAME also illustrates by examples why it is informative and important to carry out sensitivity analyses, particularly assumptions regarding natural mortality, selection pattern, growth (density dependence) and maturity. The WG did some preliminary analyses of the sensitivity of $F_{0.1}$ for different natural mortalities. In comparison with *S. mentella*, $F_{0.1}$ for *S. marinus* is much less sensitive towards changes in natural mortality

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

For $F_{max} = 0.15$ the sustainable yield at current recruitment is 1,500 tonnes per year

For $F_{0.1} = 0.08$ the sustainable yield at current recruitment is 1,400 tonnes per year

7.10 Response to RGAFNW Technical Minutes

It should be emphasized that at the 2012 AFWG, the redfish manpower was particularly reduced since the group lacked participation from the historical redfish participants, Kjell Nedreaas and Konstantin Drevetnyak as well as Daniel Howell who operated Gadget remotely from Bergen. Benjamin Planque was stock coordinator for the 2 redfish stocks which assessment methodology had been revised during February 2012 (WKRED). The meeting was also shortened in comparison with previous years. There was therefore limited time to undertake all the tasks planned in the working group and as a result, a low priority had to be given to the RGAFNW technical minutes.

Figures and tables of model fit: As requested figures of the fit between the model and the survey and fleet data are included (Figures 7.12, 7.13 and 7.14). Note that these are fits at length rather than age (since this is a length-based model). As such the corresponding tables would be rather large, and are not included here.

The reviewing panel asked for the provision of detailed account of S. marinus life history. Information on spawning patterns, maturity rates, life expectancy, growth and spatial distribution (including 'spawning' grounds) is now provided in the stock annex.

It was also advised to provide a detailed map explaining the fishing and spawning grounds for redfish in the Arctic/Barents Sea to help reviewers better understand the dynamics and interplay of the redfish's life history, fishing fleet, and surveys and to present spatial closures on the map and a map of fishing effort by the various fleets. This information could not be prepared in the requested form at the meeting.

The requested graph of the weight at age was not prepared due to lack of time.

Basic formulas/modelling framework within the annex: -> It is not possible to briefly describe the entire GADGET model within a short space. However the fuller GADGET model description given when the model was first introduced has been included in the stock annex.

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	Germany2	Greenland	Iceland	Ireland	Netherlands	Norway	Portugal	Russia3	Spain	UK(Eng. & Wales)	UK (Scotl)4	Poland	Total
1989	3	796	412	-	-	-	-	20,662	-	1,264	-	97	-	-	23,234
1990	278	1,679	387	1	-	-	-	23,917	-	1,549	-	261	-	-	28,072
1991	152	706	981	-	-	-	-	15,872	-	1.052	-	268	10	-	19,041
1992	35	1,289	530	623	-	-	-	12,700	5	758	2	241	2	-	16,185
1993	139	871	650	14	-	-	-	13,137	77	1,313	8	441	1	-	16,651
1994	22	697	1,008	5	4	-	-	14,955	90	1,199	4	135	1	-	18,120
1995	27	732	517	5	1	1	1	13,516	9	639	-	159	9	-	15,616
1996	38	671	499	34	-	-	-	15,622	55	716	81	229	98	-	18,043
1997	3	974	457	23	-	5	-	14,182	61	1,584	36	164	22	-	17,511
1998	78	494	131	33	-	19	-	16,540	6	1,632	51	118	53	-	19,155
1999	35	35	228	47	14	7	-	16,750	3	1,691	7	135	34	-	18,986
2000	17	13	160	22	16	-	-	13,032	16	1,112	-	-	73	-	14,461
2001	37	30	238	17	-	1	-	9,134	7	963	1		119	-	10,547
2002	60	31	42	31	3	-	-	8,561	34	832	3		46	-	9,643
2003	109	8	122	36	4	-	89	6,853	6	479	-		134	-	7,840
2004	19	4	68	20	30	-	33	6,233	5	722	3		69	-	7,206
2005	47	10	72	36	8	-	48	6,085	56	614	8		52	-	7,037
2006	111	8	35	44	31	3	21	6,305	69	713	9		39	-	7,388
2007	146	15	67	84	68	13	20	5,784	225	890	5		55	-	7,372
2008	274	63	30	71	27	6	2	5,202	72	749	4		85	-	6,585
2009	70	1	58	81	66	-	1	5,225[1]	30	698	-		31	-	6,261
2010[1]	171	51	31	72	22	-	-	6,515	28	806	4		44	1	7,744
2011[1]	68	30	9	51	13	-	1	4,645	25	919	6		13	48	5,829

[1] **Provisional figures.**

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

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

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

Table 7.2 ***Sebastes marinus*** **in Sub-areas I and II. Nominal catch (t) by countries in Sub-area I.**

Year	Faroe Islands	France	Germany3	Greenland	Iceland	Norway	Portugal	Russia4	Spain	UK(Eng. & Wales)	UK (Scotl)5	Total
1989	-	-	-	-	-	1,763	-	110	-	4[2]	-	1,877
1990	5	-	-	-	-	1,263	-	14	-	-	-	1,282
1991	-	-	-	-	-	1,993	-	92	-	-	-	2,085
1992	-	-	-	-	-	2,162	-	174	-	-	-	2,336
1993	24[2]	-	-	-	-	1,178	-	330	-	-	-	1,532
1994	12[2]	-	72	-	4	1,607	-	109	-		-	1,804
1995	19[2]	-	1[2]	-	1[2]	1,947	-	201	-	1[2]	-	2,170
1996	7[2]	-	-	-	-	2,245	-	131	-	3[2]	-	2,386
1997	3[2]	-	-	5[2]	-	2,431	-	160	-	2[2]	-	2,601
1998	78[2]	-	5[2]	-	-	2,109	-	308	-	30[2]	-	2,530
1999	35[2]	-	18[2]	9[2]	14[2]	2,114	-	360	-	11[2]	-	2,561
2000	-	-	1[2]	-	16[2]	1,983	-	146	-		12	2,159
2001	4	-	11[2]	-	-	1,053	-	128	-		16	1,212
2002	15	1[2]	5[2]	-	-	693	-	220	-		9[2]	943
2003	15[2]	-	-	1	-	815	-	140	-		4	975
2004	7	-	-	-	-	1,237	-	213	-		12	1,469
2005	10	1	-	-	-	1,002	-	61	-		4	1,078
2006	46	-	-	-	-	690	-	136	-		-	872
2007	15	-	12	15	-	1,034	-	49	2		20	1,147
2008	45	7	2	-		632	3	49	-		15	754
2009	-	-	3[2]	2	6	672	13	19	-		24	739
2010[1]	58[2]	-	-	-	-	541	-	19	1		6	625
2011[1]	68[2]	-	-	2	-	517	-	7	-		-	594

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

Table 7.3 ***Sebastes marinus*** **in Sub-areas I and II. Nominal catch (t) by countries in Division IIa.**

Year	Faroe Islands	France	Germany3	Greenland	Iceland	Ireland	Netherland	Norway	Portugal	Russia4	Spain	UK(Eng. & Wales)	UK(Scotl)5	Poland	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]		103[2]	-	9,031
2002	45[2]	30[2]	37[2]	31[2]	3[2]	-	-	7,761	18[2]	192	2[2]		32[2]	-	8,151
2003	94[2]	9[2]	122[2]	35[2]	4[2]	-	89[2]	5,970	6[2]	264			130[2]	-	6,722
2004	12[2]	4[2]	68[2]	20[2]	30[2]	-	33[2]	4,872	5[2]	396	3[2]		58[2]	-	5,500
2005	37[2]	9[2]	60[2]	36[2]	8[2]	-	48	4,855	56[2]	265	8[2]		48[2]	-	5,430
2006	60[2]	8[2]	35[2]	44[2]	31[2]	3[2]	21[2]	4,404	59[2]	293	9[2]		39[2]	-	5,006
2007	119[2]	15[2]	55[2]	69	68	13	20[2]	4,101	70	599	3[2]		35[2]	-	5,168
2008	229[2]	56[2]	28[2]	71	27	6	2[2]	4,444	68[2]	450	4[2]		70[2]	-	5,454
2009	70[2]	1	55[2]	79	60	-	1[2]	4,355[1]	17[2]	500	-		7[2]	-	5,145
2010[1]	113[2]	51[2]	31[2]	72[2]	22[2]	-	-	5,885	26[2]	287	2[2]		38[2]	1	6,527
2011[1]	-	30[2]	9	49	13	-	1	4,059	-	695	2[2]		13[2]	-	4,871

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

Table 7.4 ***Sebastes marinus*** **in Sub-areas I and II. Nominal catch (t) by countries in Division IIb.**

Year	Faroe Islands	Germany[2]	Greenland	Norway	Portugal	Russia[5]	Spain	UK(Eng. & Wales)	UK(Scotl)[6]	Polans	Total
1989	-	-	-	66	-	242	-	-	-	-	308
1990	-	-	1[2]	210	-	1157	-	-	-	-	1,368
1991	-	303	-	44	-	426	-	-	-	-	773
1992	-	319	9[2]	2	5[2]	180	2	35[2]	-	-	552
1993	-	177	-	-	-	43	8[3]	10[2]	-	-	238
1994	-	282	-	18	-	60	4[3]	6[2]	1[2]	-	371
1995	-	187	-	103	7	33	-	-	-	-	330
1996	4	51[2]	-	27	5	136	76[2]	3[2]	-	-	302
1997	-	20	-	43	-	225	-	-	-	-	288
1998	-	10[2]	-	105	-	246	-	3[2]	-	-	364
1999	-	-	-	38	-	355	-	2[2]	-	-	395
2000	-	-	-	10	-	308	-	-	-	-	318
2001	-	-	-	79	1[2]	223	-	-	-	-	303
2002	-	-	-	107	16[2]	420	1[2]		5[2]	-	549
2003	-	-	-	68	-	75	-		-	-	143
2004	-	-	-	124	-	113	-		-	-	237
2005	-	13[2]	-	228[1]	-	288	-		-	-	529
2006	5[2]	-	-	1,211	10[2]	284	-		-	-	1,510
2007	12	-	-	649	155	242	-		-	-	1,057
2008	-	-	-	126	1[2]	250	-		-	-	377
2009	-	-	-	199		179	-		-	-	378
2010[1]	-	-	-	90	2[2]	500	1[2]		-	-	593
2011[1]	-	-	-	70	25	217	4[2]		-	48	364

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

Table 7.5. *Sebastes marinus* in Sub-areas I and II. Catch numbers at age (in thousands).

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp	Total Num.	Tons Land.
1992	5	22	78	114	394	549	783	1718	3102	2495	2104	1837	998	858	688	547	268	3110	19670	16185
1993	0	24	193	359	406	1036	1022	1523	2353	1410	1655	1678	745	716	534	528	576	3482	18240	16651
1994	46	7	292	640	816	1930	2096	2030	1601	2725	2668	1409	617	733	514	256	177	1508	20065	18120
1995	60	85	230	672	908	1610	2038	2295	1783	1406	785	563	670	593	419	368	250	3232	17967	15616
1996	9	119	313	361	879	1234	1638	2134	1675	1614	1390	952	679	439	560	334	490	3135	17955	18043
1997	9	98	156	321	686	1065	1781	2276	2172	1848	1421	851	804	608	511	205	334	2131	17277	17511
1998	28	51	206	470	721	968	1512	1736	1582	1045	1277	970	1018	846	443	764	486	3389	17512	19155
1999	78	593	855	572	1006	1230	1618	1480	1612	1239	1407	1558	1019	394	197	459	174	2131	17622	18986
2000	4	13	70	245	902	958	1782	1409	2121	2203	1715	753	483	458	132	230	224	895	14597	14460
2001	23	23	44	199	347	482	1120	1342	1674	1653	1243	568	119	183	154	112	135	254	9675	10547
2002	14	36	71	143	414	686	1199	1943	1377	1274	1196	388	313	99	104	117	113	253	9740	9643
2003	22	25	30	44	204	359	705	1687	1338	1071	937	481	367	146	84	51	18	69	7637	7841
2004	19	47	46	65	198	277	504	590	677	963	1059	787	436	169	183	108	79	186	6390	7320
2005	40	55	94	80	165	173	393	779	741	916	926	743	376	210	189	129	111	220	6338	7037
2006	45	32	56	70	245	204	201	809	549	779	794	747	496	332	310	188	165	397	6419	7348
2007	15	21	31	68	138	306	448	495	523	637	892	616	510	396	225	322	170	630	6443	7306
2008	1	4	14	12	49	139	265	366	361	443	442	538	547	479	281	223	144	1032	5342	6557
2009	0	0	1	3	9	31	144	245	272	270	416	391	536	431	332	332	266	954	4633	6261
2010	0	0	0	9	8	36	92	336	437	489	420	336	610	537	498	319	317	884	5328	7744
2011[1]	3	3	9	0	1	24	30	130	220	238	220	237	292	332	483	396	348	1353	4331	5829

[1] **Provisional figures.**

Table 7.6. ***Sebastes marinus*** **in Sub-areas I and II. Catch weights at age (kg).**

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp
1992	0.18	0.29	0.48	0.42	0.50	0.59	0.58	0.65	0.65	0.71	0.82	0.84	0.94	1.02	1.03	1.15	1.27	1.27
1993	0.2	0.33	0.36	0.43	0.51	0.51	0.64	0.64	0.76	0.86	0.89	0.98	1	1.03	1.21	1.03	1.2	1.14
1994	0.25	0.37	0.38	0.49	0.51	0.64	0.74	0.76	0.86	0.95	1.03	1.07	1.11	1.16	1.15	1.13	1.02	1.36
1995	0.33	0.43	0.64	0.61	0.59	0.65	0.74	0.79	0.84	0.92	1.12	1.01	1.01	1.21	1.14	1.09	1.3	1.01
1996	0.22	0.49	0.56	0.65	0.71	0.81	0.84	0.88	0.96	1	1.02	1.01	1	1.03	1.04	1.14	1.09	1.16
1997	0.23	0.51	0.53	0.74	0.72	0.78	0.8	0.86	0.91	0.99	1.16	1.18	1.21	1.34	1.28	1.54	1.19	1.29
1998	0.37	0.21	0.47	0.62	0.67	0.77	0.77	0.85	1.05	0.96	1.25	1.28	1.3	1.23	1.87	1.46	1.73	1.29
1999	0.14	0.26	0.44	0.57	0.69	0.78	0.86	1.04	1.07	1.12	1.18	1.71	1.09	1.18	1.04	1.34	1.18	1.34
2000	0.19	0.24	0.32	0.44	0.53	0.64	0.73	0.84	0.96	1.11	1.25	1.32	1.53	1.06	1.29	1.32	1.12	1.2
2001	0.15	0.26	0.45	0.55	0.58	0.67	0.8	0.89	1.01	1.14	1.33	1.43	1.62	1.6	1.47	2	2.7	2.31
2002	0.17	0.25	0.33	0.42	0.54	0.67	0.72	0.84	0.98	1.09	1.2	1.3	1.44	1.78	1.68	1.88	2.12	1.84
2003	0.19	0.22	0.31	0.39	0.49	0.58	0.69	0.84	0.96	1.05	1.29	1.36	1.65	1.74	2.09	1.85	2.3	2.38
2004	0.21	0.26	0.36	0.45	0.51	0.59	0.68	0.8	0.96	1.07	1.22	1.34	1.57	1.67	1.75	2.09	1.9	2.04
2005	0.16	0.21	0.36	0.45	0.52	0.58	0.68	0.82	0.94	1.03	1.16	1.36	1.46	1.51	1.67	1.91	2.23	2.27
2006	0.13	0.15	0.28	0.41	0.51	0.58	0.66	0.74	0.83	1	1.14	1.27	1.39	1.46	1.37	1.47	1.64	2.03
2007	0.15	0.21	0.33	0.39	0.5	0.59	0.65	0.77	0.9	1	1.09	1.27	1.42	1.32	1.53	1.47	1.69	1.81
2008	0.41	0.55	0.55	0.57	0.52	0.58	0.65	0.81	0.9	1.07	1.14	1.36	1.51	1.81	1.99	2.01	2.26	1.93
2009	-	-	0.62	0.55	0.54	0.51	0.77	0.88	0.9	1.06	1.16	1.25	1.36	1.53	1.59	1.66	1.72	1.55
2010	-	-	-	0.33	0.46	0.79	0.71	0.85	0.95	1.11	1.24	1.38	1.45	1.6	1.71	2	1.78	1.86
2011[1]	0.23	0.21	0.22	-	0.47	0.54	0.73	0.94	1.10	1.15	1.18	1.37	1.36	1.41	1.58	1.80	1.57	1.28

[1] **Provisional figures.**

Table 7.7. ***Sebastes marinus*** **in Sub-areas I and II. Fishing mortalities as estimated by Gadget.**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
7	0.005	0.004	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.003	0.002
8	0.036	0.011	0.009	0.009	0.009	0.007	0.008	0.008	0.009	0.009	0.007
9	0.066	0.048	0.021	0.021	0.021	0.018	0.020	0.019	0.022	0.023	0.018
10	0.090	0.075	0.065	0.040	0.042	0.035	0.040	0.038	0.043	0.044	0.035
11	0.119	0.095	0.089	0.092	0.069	0.058	0.066	0.064	0.072	0.074	0.059
12	0.152	0.117	0.107	0.116	0.130	0.085	0.097	0.094	0.106	0.110	0.087
13	0.191	0.142	0.126	0.134	0.153	0.136	0.129	0.126	0.142	0.148	0.118
14	0.233	0.170	0.146	0.152	0.171	0.153	0.183	0.157	0.177	0.185	0.148
15	0.280	0.199	0.167	0.170	0.189	0.167	0.200	0.204	0.209	0.219	0.175
16	0.328	0.229	0.188	0.189	0.207	0.180	0.214	0.218	0.254	0.249	0.200
17	0.379	0.260	0.210	0.207	0.224	0.193	0.226	0.229	0.267	0.290	0.220
18	0.404	0.291	0.231	0.224	0.240	0.205	0.238	0.240	0.277	0.300	0.246
19	0.429	0.306	0.251	0.241	0.255	0.216	0.249	0.249	0.286	0.309	0.253
20	0.453	0.321	0.261	0.257	0.269	0.226	0.259	0.258	0.295	0.317	0.258
21	0.476	0.335	0.271	0.264	0.283	0.236	0.268	0.265	0.302	0.324	0.263
22	0.498	0.349	0.280	0.272	0.289	0.244	0.276	0.272	0.309	0.330	0.267
23	0.518	0.362	0.289	0.278	0.295	0.248	0.283	0.278	0.314	0.336	0.271
24	0.535	0.373	0.296	0.285	0.300	0.252	0.286	0.283	0.319	0.340	0.274
25	0.550	0.383	0.303	0.290	0.305	0.255	0.289	0.285	0.324	0.344	0.277
26	0.562	0.392	0.310	0.295	0.310	0.258	0.292	0.287	0.325	0.347	0.279
27	0.572	0.399	0.315	0.300	0.313	0.261	0.295	0.289	0.327	0.349	0.281
28	0.580	0.404	0.319	0.303	0.317	0.263	0.297	0.291	0.329	0.350	0.282
29	0.585	0.409	0.322	0.306	0.320	0.265	0.299	0.293	0.330	0.351	0.282
30	0.593	0.415	0.328	0.309	0.322	0.267	0.301	0.294	0.332	0.353	0.284
model 2011											
12 - 19	0.299	0.214	0.178	0.179	0.196	0.167	0.192	0.190	0.215	0.226	0.181
model previous year											
12 - 19	0.291	0.209	0.175	0.177	0.194	0.165	0.190	0.187	0.212	0.224	0.180

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
7	0.002	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.003
8	0.005	0.005	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.009
9	0.013	0.012	0.010	0.010	0.010	0.012	0.013	0.012	0.013	0.021
10	0.026	0.024	0.020	0.019	0.020	0.024	0.025	0.025	0.026	0.042
11	0.043	0.041	0.033	0.033	0.034	0.039	0.042	0.041	0.045	0.070
12	0.065	0.060	0.050	0.049	0.050	0.057	0.062	0.062	0.067	0.104
13	0.087	0.081	0.067	0.065	0.067	0.076	0.083	0.083	0.091	0.139
14	0.110	0.101	0.084	0.081	0.082	0.094	0.103	0.103	0.113	0.174
15	0.130	0.119	0.099	0.095	0.096	0.109	0.120	0.122	0.134	0.205
16	0.148	0.134	0.112	0.107	0.108	0.122	0.134	0.137	0.152	0.232
17	0.164	0.147	0.123	0.117	0.117	0.132	0.146	0.149	0.166	0.254
18	0.176	0.157	0.131	0.124	0.124	0.140	0.154	0.158	0.176	0.271
19	0.191	0.166	0.138	0.130	0.130	0.145	0.161	0.165	0.184	0.283
20	0.195	0.175	0.143	0.135	0.134	0.150	0.165	0.170	0.190	0.292
21	0.198	0.177	0.149	0.138	0.137	0.153	0.169	0.173	0.194	0.298
22	0.201	0.179	0.150	0.142	0.139	0.155	0.171	0.176	0.196	0.302
23	0.203	0.181	0.151	0.142	0.142	0.157	0.173	0.177	0.198	0.305
24	0.205	0.183	0.152	0.143	0.142	0.158	0.174	0.179	0.200	0.307
25	0.207	0.184	0.153	0.144	0.143	0.159	0.175	0.180	0.200	0.308
26	0.208	0.185	0.154	0.144	0.143	0.159	0.176	0.181	0.201	0.309
27	0.209	0.186	0.154	0.145	0.143	0.159	0.176	0.181	0.202	0.310
28	0.210	0.186	0.155	0.145	0.144	0.160	0.176	0.181	0.202	0.311
29	0.211	0.187	0.155	0.145	0.144	0.160	0.176	0.181	0.202	0.311
30	0.212	0.188	0.156	0.146	0.144	0.160	0.177	0.181	0.202	0.311
model 2011										
	0.134	0.121	0.101	0.096	0.097	0.109	0.120	0.122	0.135	0.208
model previous year										
	0.135	0.123	0.103	0.100	0.102	0.117	0.130	0.135	0.152	

Table 7.8. Sebastes marinus in Sub-areas I and II. Stock numbers, biomass, mean weight and maturity ogives as estimated by GADGET using two survey series as input.

	total stock			mature			immature			recruit (age 3)
	number	mean wei	biomass	number	mean wei	biomass	number	mean wei	biomass	number
year	(millions)	(kg)	('1000 t)	(millions)	(kg)	('1000 t)	(millions)	(kg)	('1000 t)	(1000')
1986	519	0.33	172	108	0.81	88	411	0.20	84	76,810
1987	512	0.32	165	101	0.80	81	410	0.20	83	66,074
1988	492	0.32	160	93	0.77	72	399	0.22	88	52,032
1989	471	0.33	155	86	0.73	63	385	0.24	92	48,359
1990	453	0.33	149	81	0.69	56	372	0.25	92	52,062
1991	441	0.34	148	82	0.68	56	360	0.26	92	50,475
1992	425	0.35	149	85	0.69	58	340	0.27	91	42,012
1993	406	0.37	150	87	0.71	62	319	0.28	88	37,465
1994	377	0.39	148	88	0.73	64	289	0.29	84	27,290
1995	342	0.42	145	88	0.75	66	254	0.31	79	17,910
1996	305	0.46	141	88	0.78	68	218	0.34	73	11,379
1997	271	0.49	134	85	0.80	68	186	0.36	66	11,837
1998	236	0.53	125	81	0.82	66	155	0.38	59	7,154
1999	201	0.57	114	74	0.84	62	126	0.41	51	4,961
2000	169	0.61	103	69	0.86	59	100	0.44	44	2,342
2001	141	0.66	93	63	0.89	56	78	0.47	37	1,654
2002	121	0.72	87	60	0.93	56	61	0.51	31	1,602
2003	104	0.78	81	57	0.98	56	47	0.53	25	1,544
2004	102	0.73	74	53	1.03	54	49	0.41	20	14,380
2005	87	0.79	68	49	1.08	53	38	0.41	16	514
2006	101	0.62	62	44	1.13	49	57	0.22	13	27,737
2007	90	0.62	55	38	1.17	45	51	0.21	11	4,496
2008	77	0.64	49	33	1.20	40	43	0.22	10	300
2009	66	0.66	44	28	1.21	34	38	0.24	9	1,719
2010	56	0.69	39	24	1.21	29	32	0.29	9	300

	Proportion mature					
age	1991-1993	1994-1996	1997-1999	2000-2002	2003-2005	2006-2009
4	0.03	0.03	0.03	0.03	0.03	0.03
5	0.05	0.05	0.05	0.05	0.05	0.05
6	0.08	0.08	0.08	0.08	0.08	0.08
7	0.12	0.12	0.12	0.12	0.12	0.12
8	0.17	0.17	0.17	0.17	0.17	0.17
9	0.23	0.24	0.24	0.24	0.24	0.24
10	0.30	0.32	0.32	0.32	0.32	0.32
11	0.39	0.42	0.42	0.42	0.42	0.42
12	0.51	0.52	0.53	0.53	0.53	0.53
13	0.64	0.63	0.64	0.64	0.64	0.64
14	0.76	0.74	0.75	0.75	0.75	0.75
15	0.86	0.84	0.84	0.85	0.85	0.85
16	0.93	0.92	0.91	0.92	0.92	0.92
17	0.97	0.96	0.96	0.96	0.96	0.96
18	0.99	0.99	0.99	0.99	0.99	0.99
19	1.00	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00	1.00
21	1.00	1.00	1.00	1.00	1.00	1.00
22	1.00	1.00	1.00	1.00	1.00	1.00
23	1.00	1.00	1.00	1.00	1.00	1.00
24	1.00	1.00	1.00	1.00	1.00	1.00
25	1.00	1.00	1.00	1.00	1.00	1.00
26	1.00	1.00	1.00	1.00	1.00	1.00
27	1.00	1.00	1.00	1.00	1.00	1.00
28	1.00	1.00	1.00	1.00	1.00	1.00
29	1.00	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00	1.00

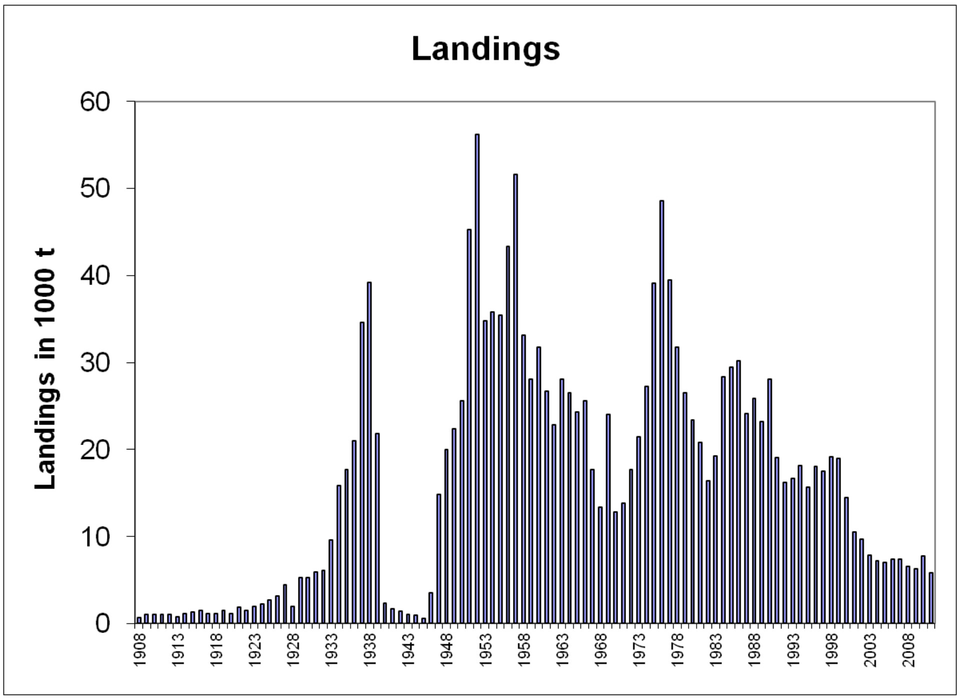


Figure 7.1. ***Sebastes marinus*** **in Sub-areas I and II. Total international landings 1965-2011 (in thousand tonnes).**

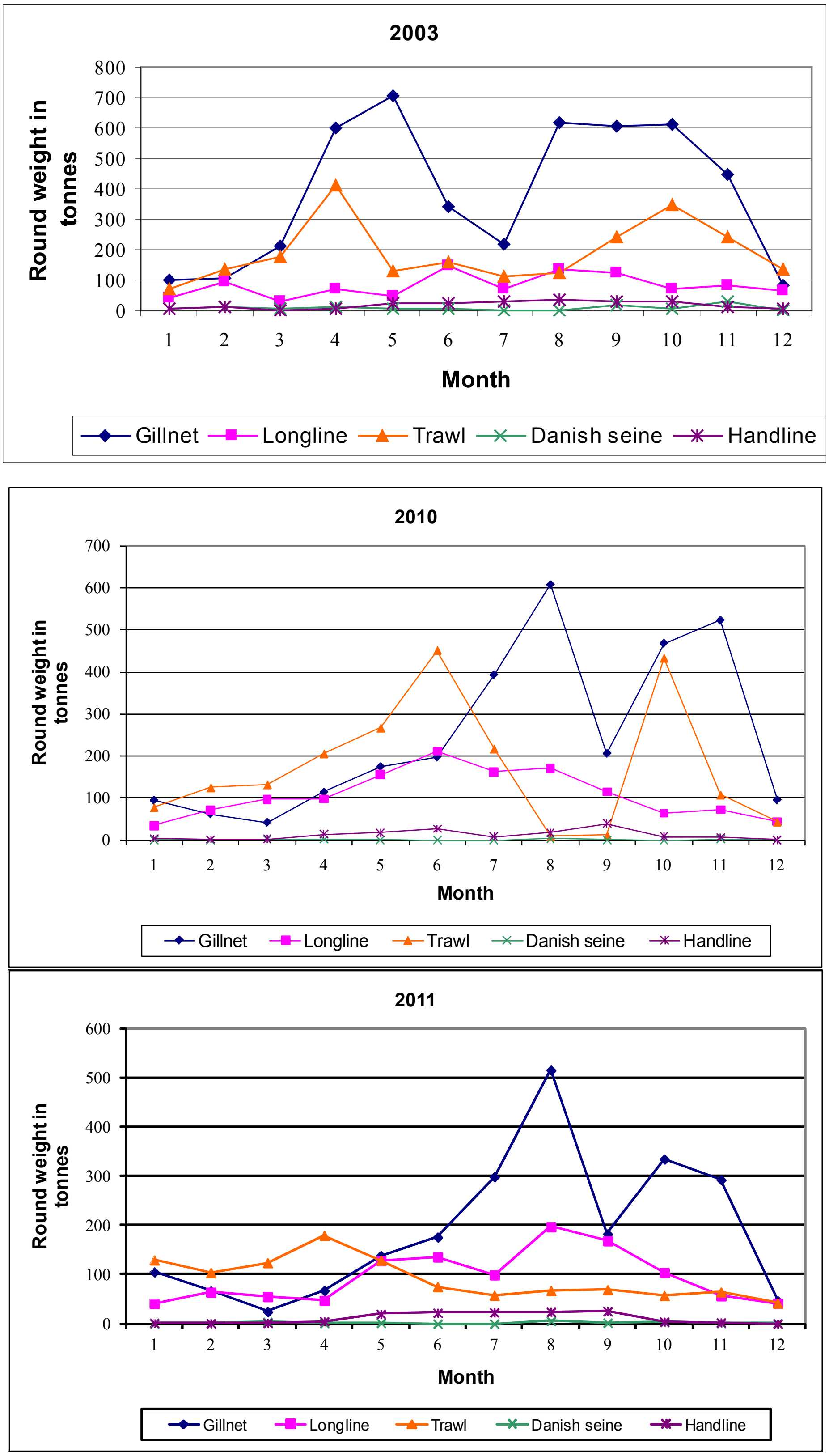


Figure 7.2a. Illustration of the seasonality in the different Norwegian *S. marinus* fisheries in 2003, 2010 and 2011, also illustrating how the current regulations are working.

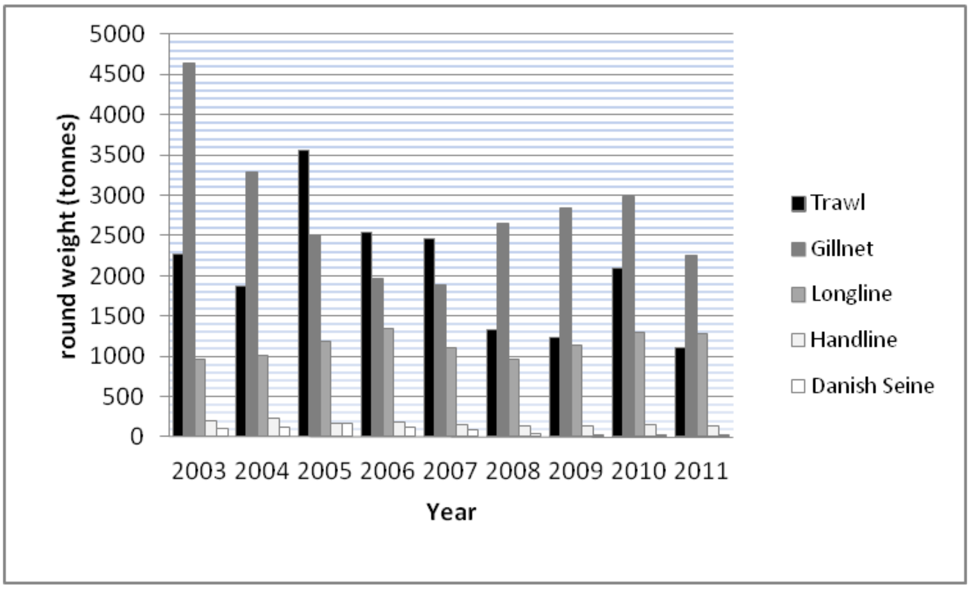


Figure 7.2b. Inter annual changes in the catches reported by different Norwegian *S. marinus* fisheries (2003-2011).

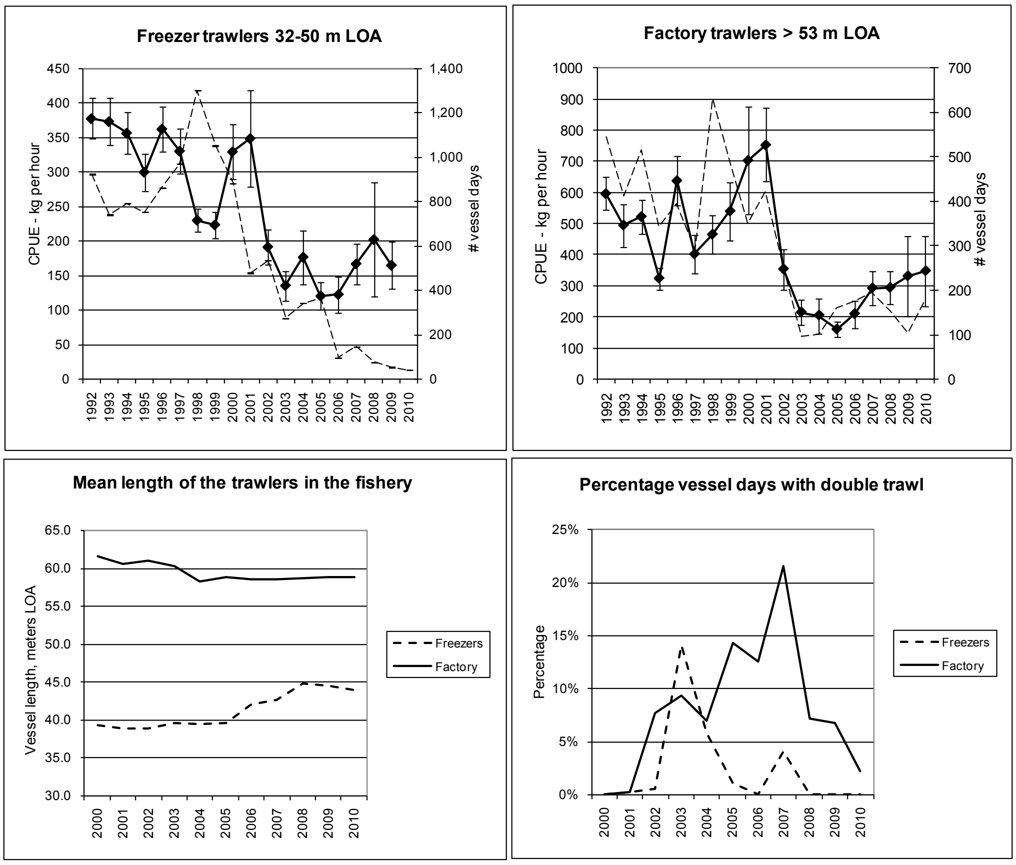


Figure 7.3. ***Sebastes marinus*****. Plot of simple mean CPUEs with 2 st. errors from the Norwegian trawl fishery, and numbers of vessel days (stippled curve) meeting the criterion of minimum 10% *S. marinus* in the catch per day. Upper panel shows data from the logbooks of freezer trawlers (left) and factory trawlers (right). The lower panel shows how the vessel length and use of double trawl have developed through the time series. The figure is an illustration of the data given in Table E1.**

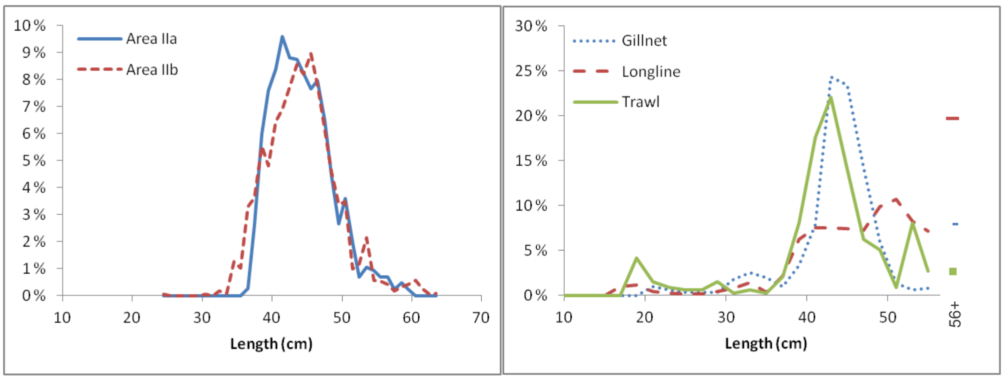


Figure 7.4. ***Sebastes marinus*****. Length frequency of *S. marinus* from Portugese catches in area IIa and IIb, all gears combined (left). Length frequency distribution of *S. marinus* from Norwegian gillnet, longline and trawl catches, all areas combined (right).**

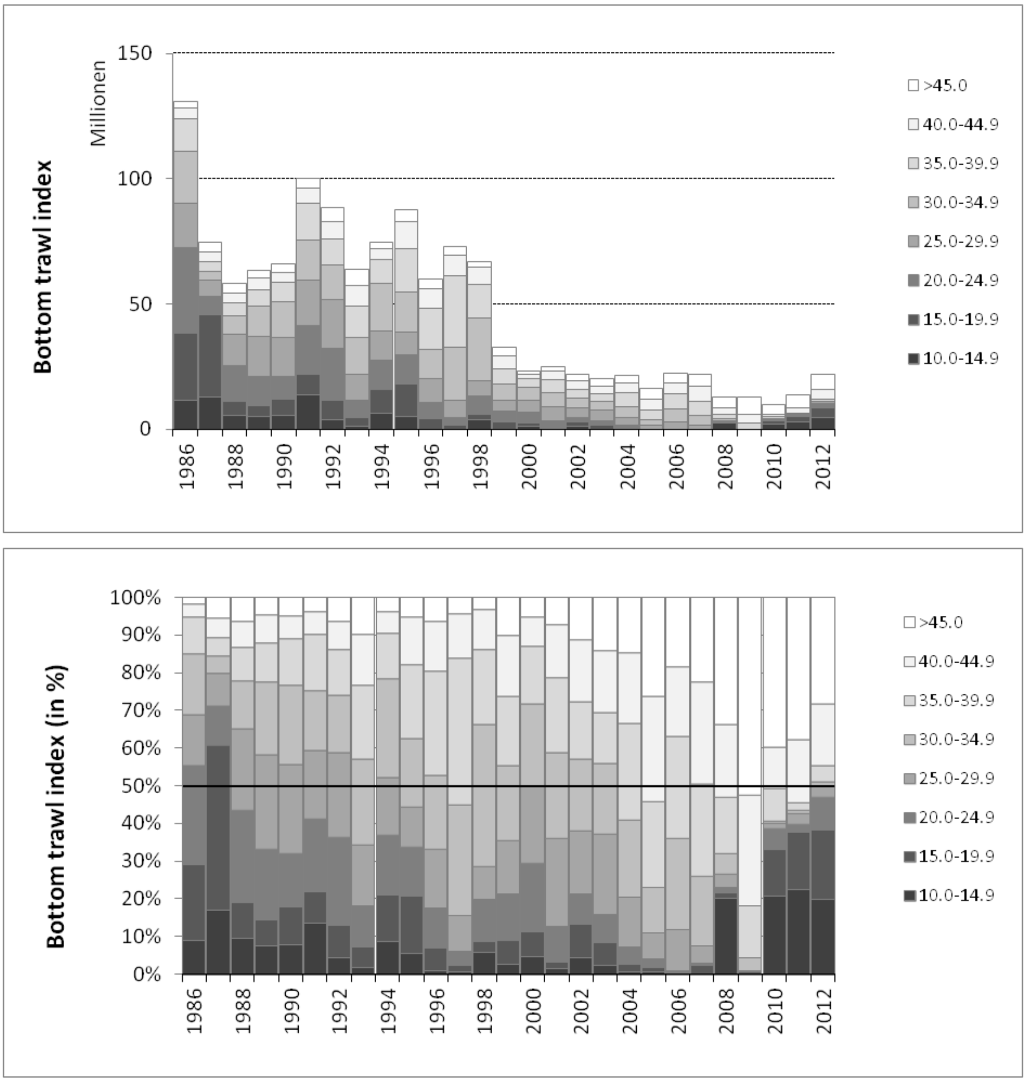
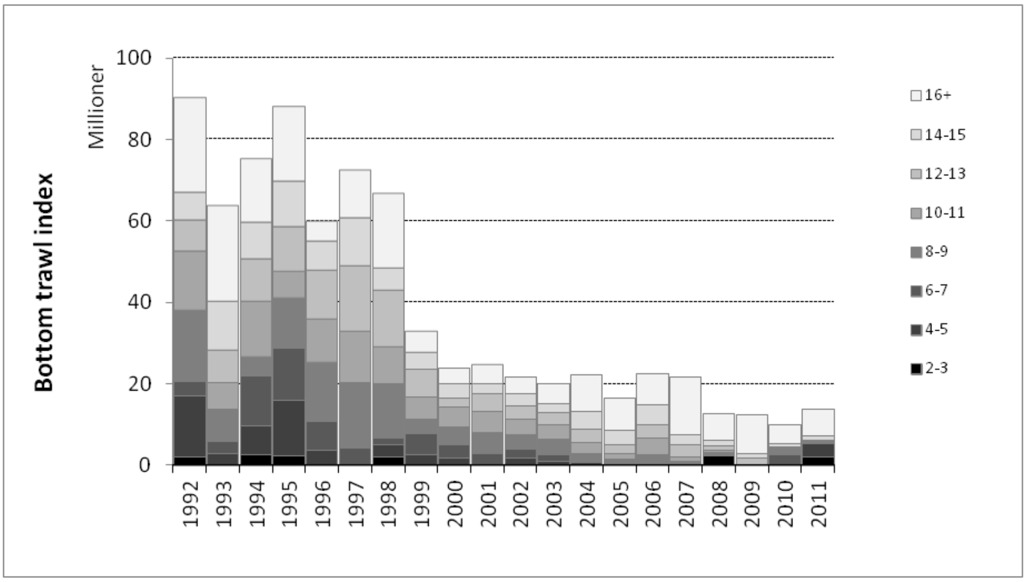


Figure 7.5a. *Sebastes marinus*. Abundance indices disaggregated by length for the Norwegian bottom trawl survey in the Barents Sea in winter 1986-2012 (ref. Table E2a). Top: absolute index values, bottom: relative frequencies. Horizontal line in lower panel indicates the median length in the surveyed population.



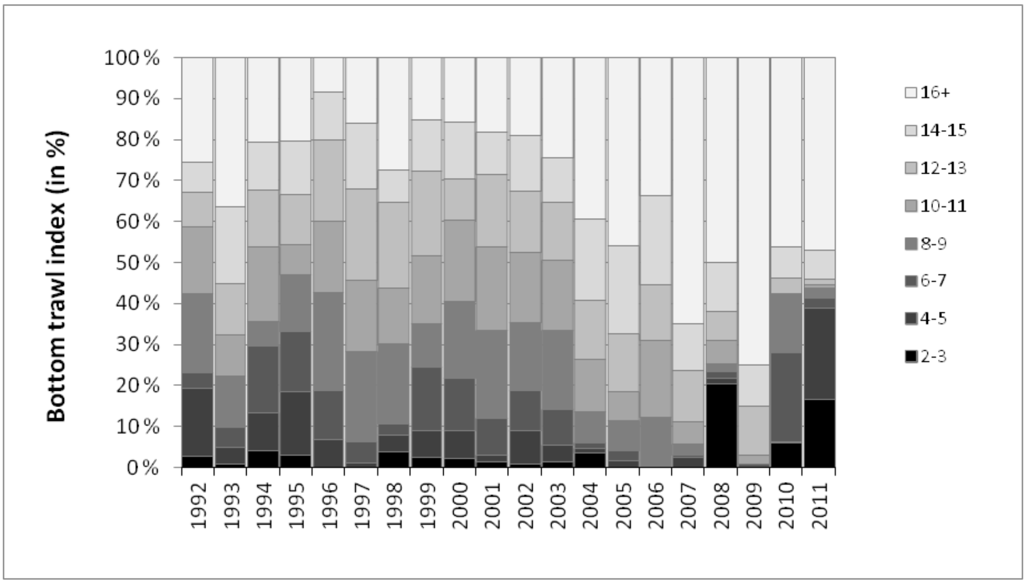
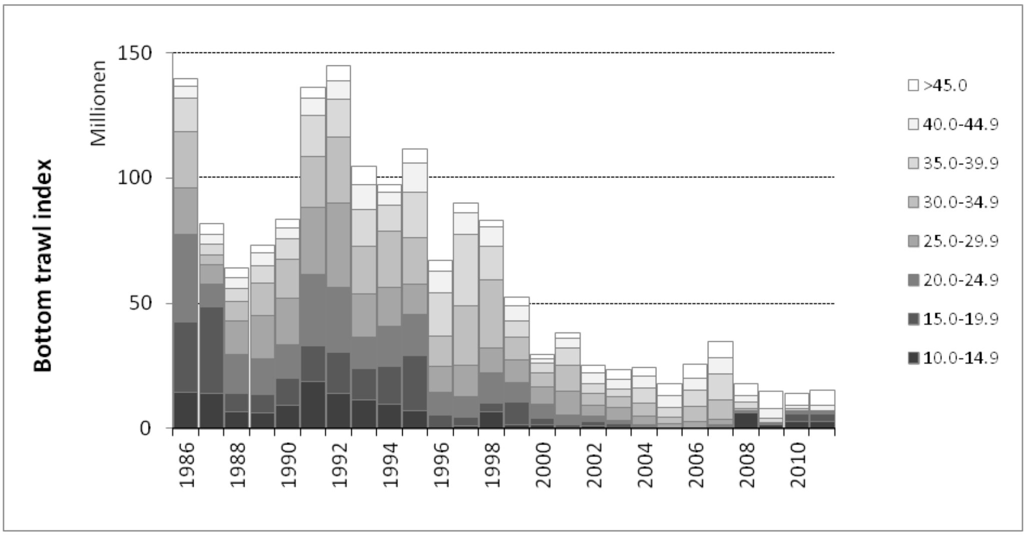


Figure 7.5b. ***Sebastes marinus.*** **Abundance indices (by age) from the Norwegian bottom trawl surveys 1992-2011 in the Barents Sea (ref. Table E2b). Top: absolute index, bottom: relative frequencies. Horizontal line indicates the median age of the surveyed population.**



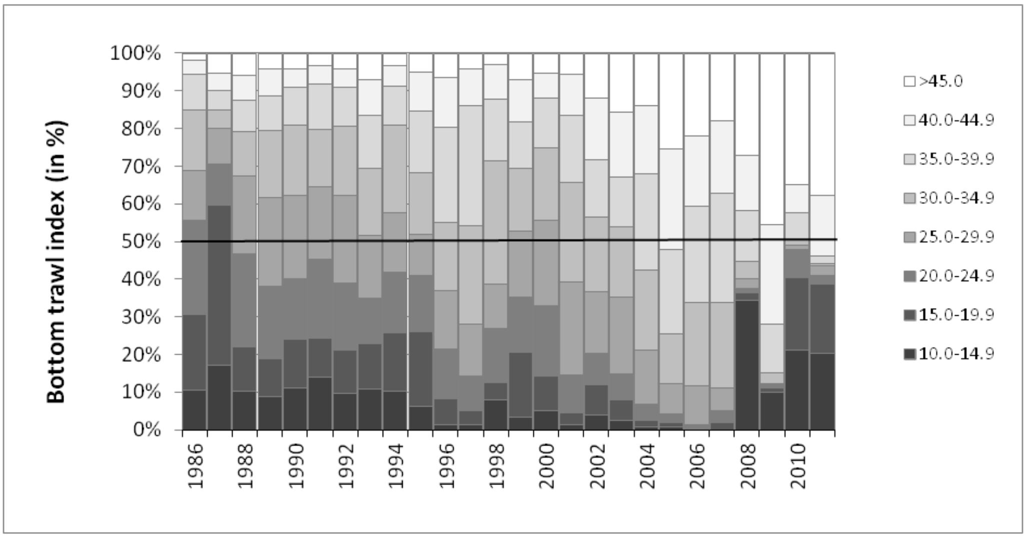


Figure 7.6a. ***Sebastes marinus.*** **Abundance indices disaggregated by length when combining the Norwegian bottom trawl surveys 1986-2011 in the Barents Sea (winter) and at Svalbard (summer/fall). Top: absolute index values. Bottom: relative frequencies. Horizontal line indicates the median length in the surveyed population.**

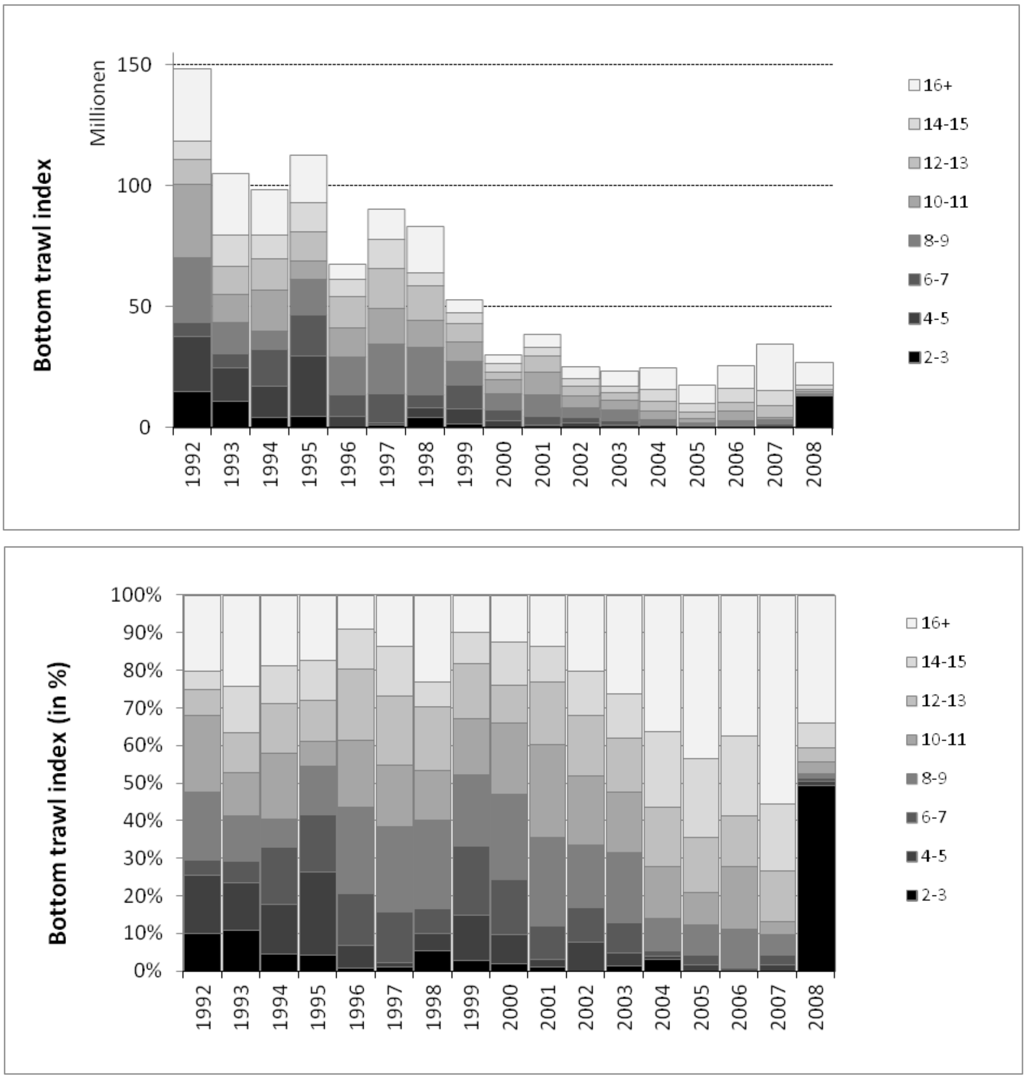


Figure 7.6b. ***Sebastes marinus*. Abundance indices disaggregated by age. Combined Norwegian bottom trawl surveys 1992-2008 in the Barents Sea (winter) and Svalbard survey (summer/fall). Top: absolute index values, bottom: relative frequencies. Horizontal line indicates median age of the surveyed population.** ***No age readings have been conducted for the Svalbard part of the survey after 2008.***

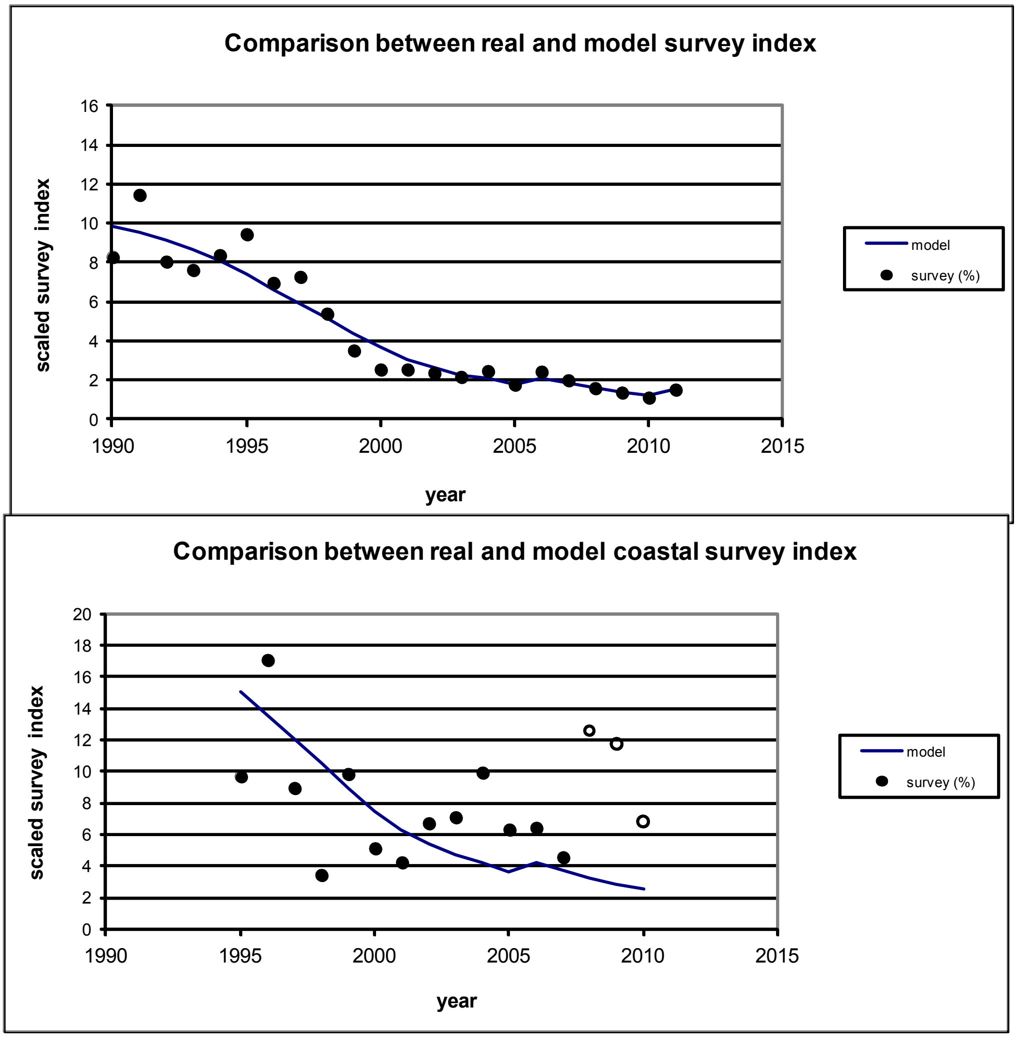


Figure 7.7. ***Sebastes marinus*** **in Sub-areas I and II. Results from the Gadget assessment using two scientific surveys as input. The Figure shows comparison of observed and modelled survey indices (total number scaled to sum=100 during the time period) – the traditional Barents Sea February survey (top), and the coastal and fjord survey (bottom). Dots: survey indices. Plain lines: survey indices estimated by the model. Note that the 2008-2010 years in the coastal survey (hollow circles) have been excluded from the model tuning and the scaling.**

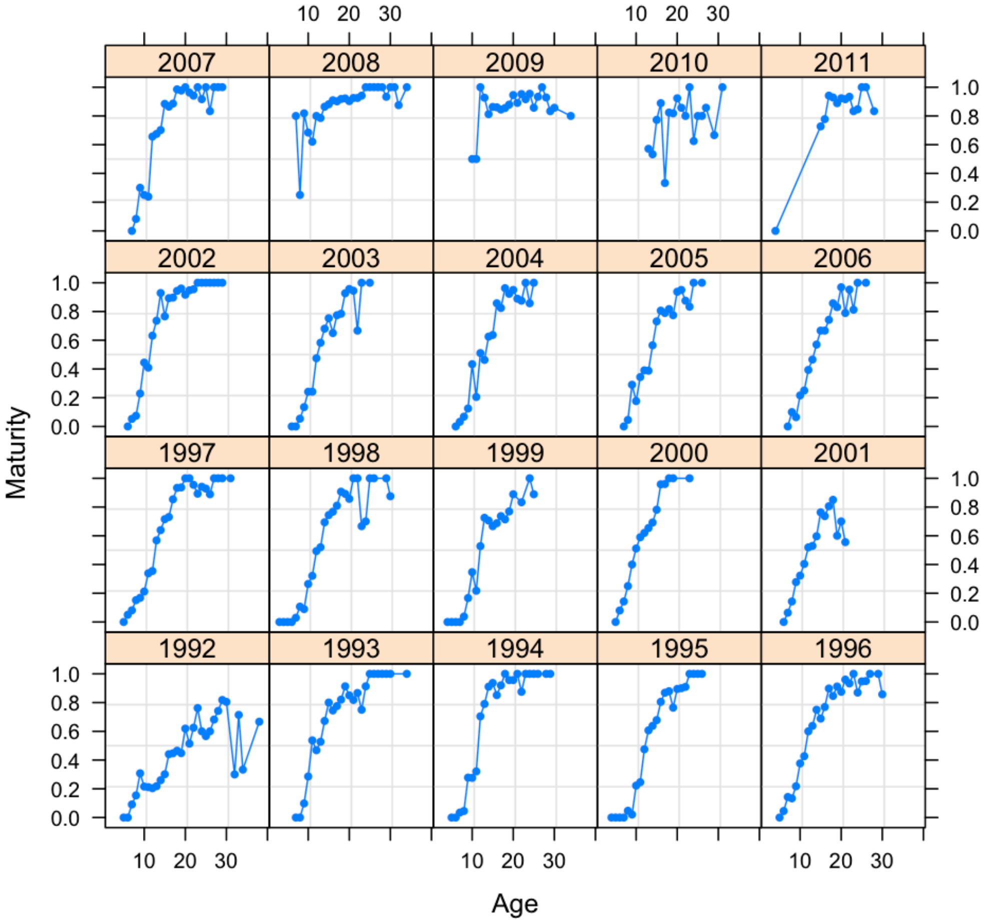


Figure 7.8a. Proportion maturity at age of *S. marinus* in subareas I and II derived from Norwegian commercial and survey data (Table E5). The proportions were derived from samples with at least five individuals.

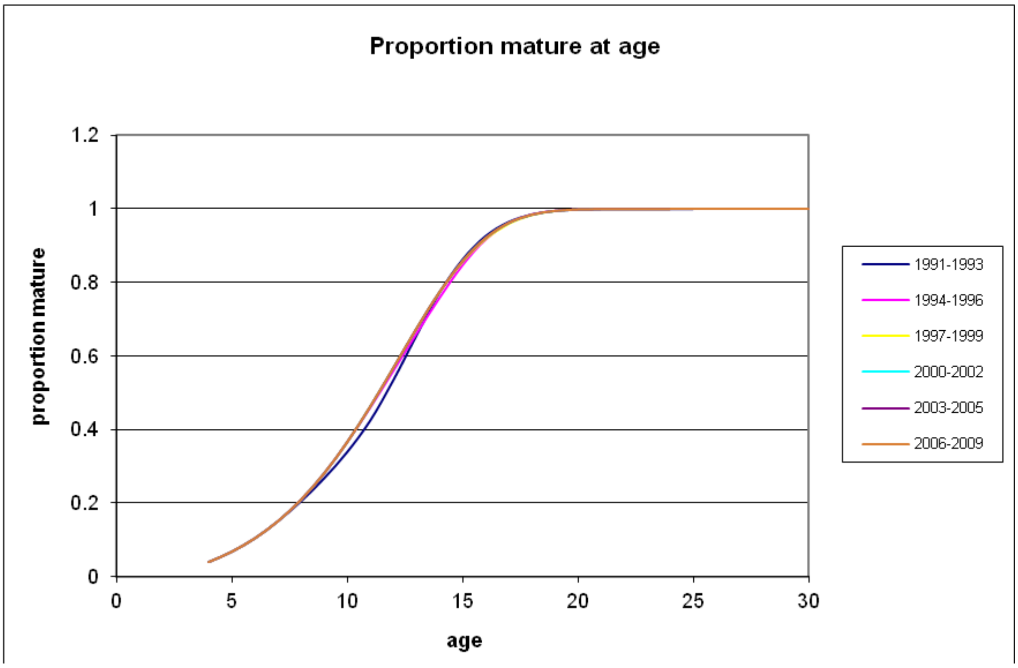


Figure 7.8b. ***Sebastes marinus*** **in Sub-areas I and II. Estimates of maturity at age by Gadget. Input data have been proportions of** ***S. marinus*** **mature both at age and length as collected and classified from Norwegian commercial landings and surveys.**

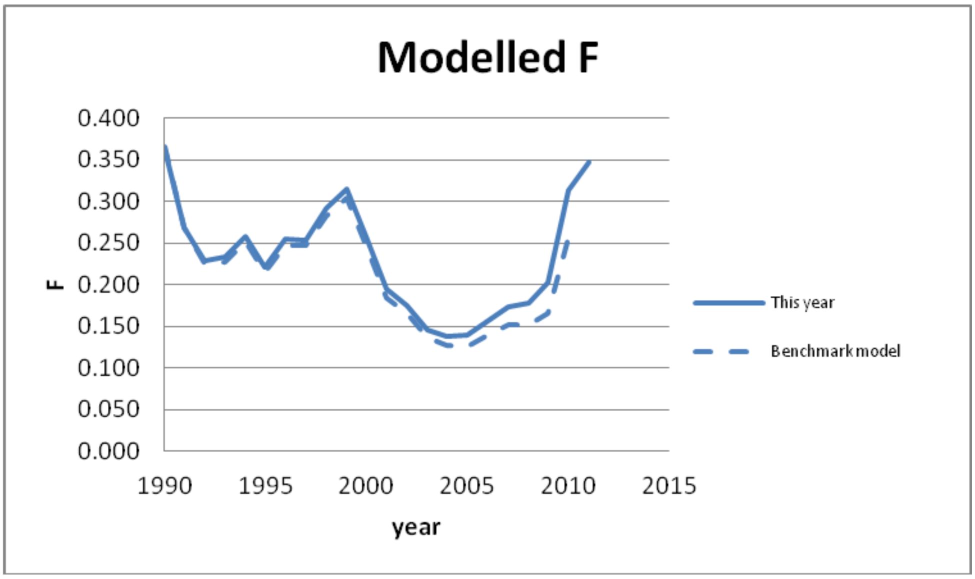


Figure 7.9. ***Sebastes marinus*** **in sub-areas I & II. Unweighted average fishing mortality of ages 12-19 as estimated by Gadget in 2012 (solid line) and at the 2012 benchmark (dashed line).**

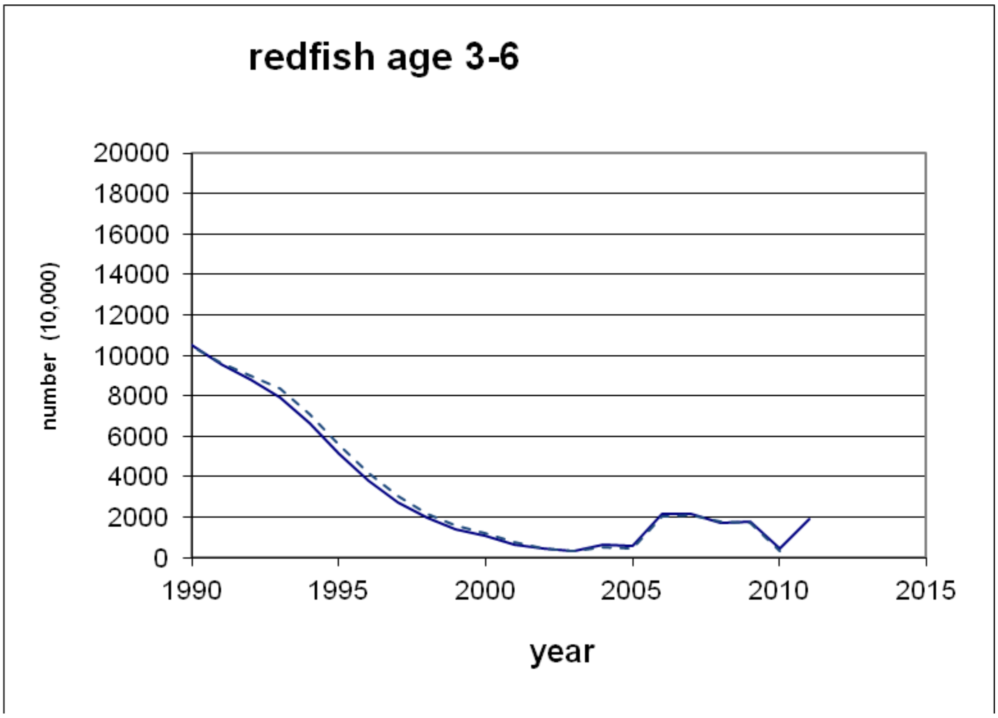


Figure 7.10. ***Sebastes marinus*** **in Sub-areas I and II. Estimates of abundance at age 3-6 by Gadget using two surveys as input. Gadget outputs provided at the benchmark are shown as dotted line. Current results are shown as plain lines.**

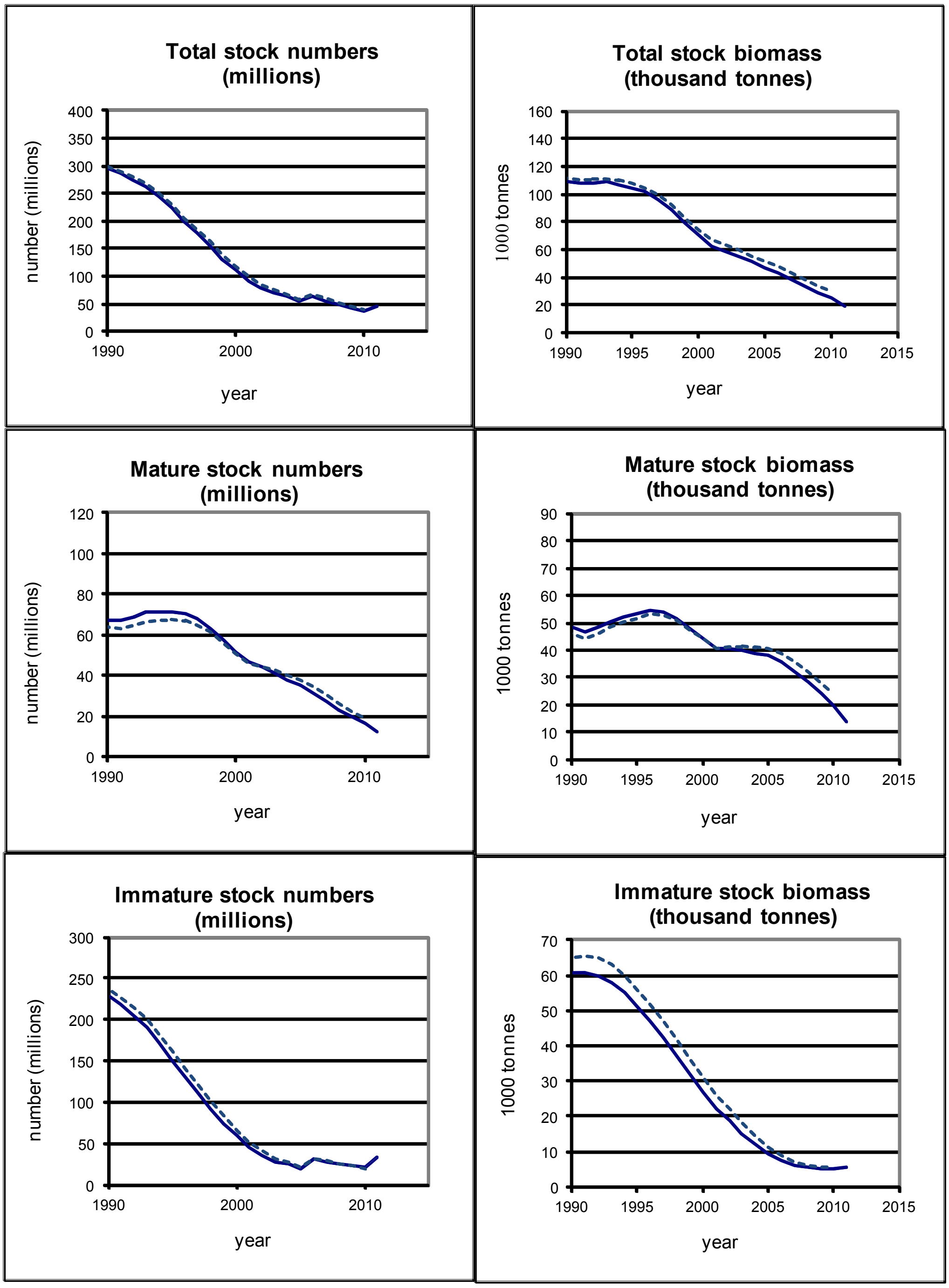


Figure 7.11. ***Sebastes marinus*** **in Sub-areas I and II. Stock numbers (in thousands) and biomass (in tonnes) for the total stock (3+) (upper panel), and the fishable and mature stock (middle panel), and the immature stock (lower panel), as estimated by Gadget using two surveys as input. Gadget outputs provided at the benchmark are shown as dotted lines. Current results are shown as plain lines.**

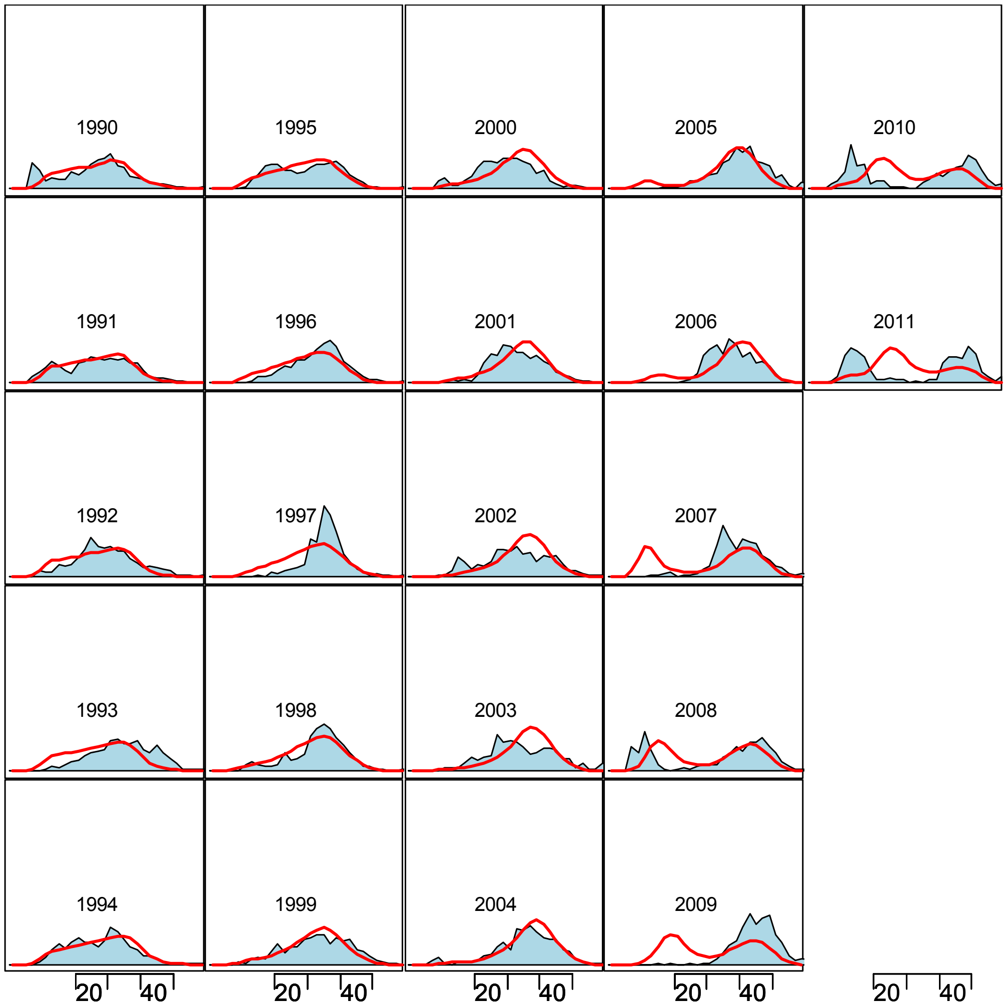


Figure 7.12. ***Sebastes marinus*** **in Sub-areas I and II. Annual fit of modelled length distributions (red line) to the winter survey (blue shaded area). Horizontal scale in cm.**

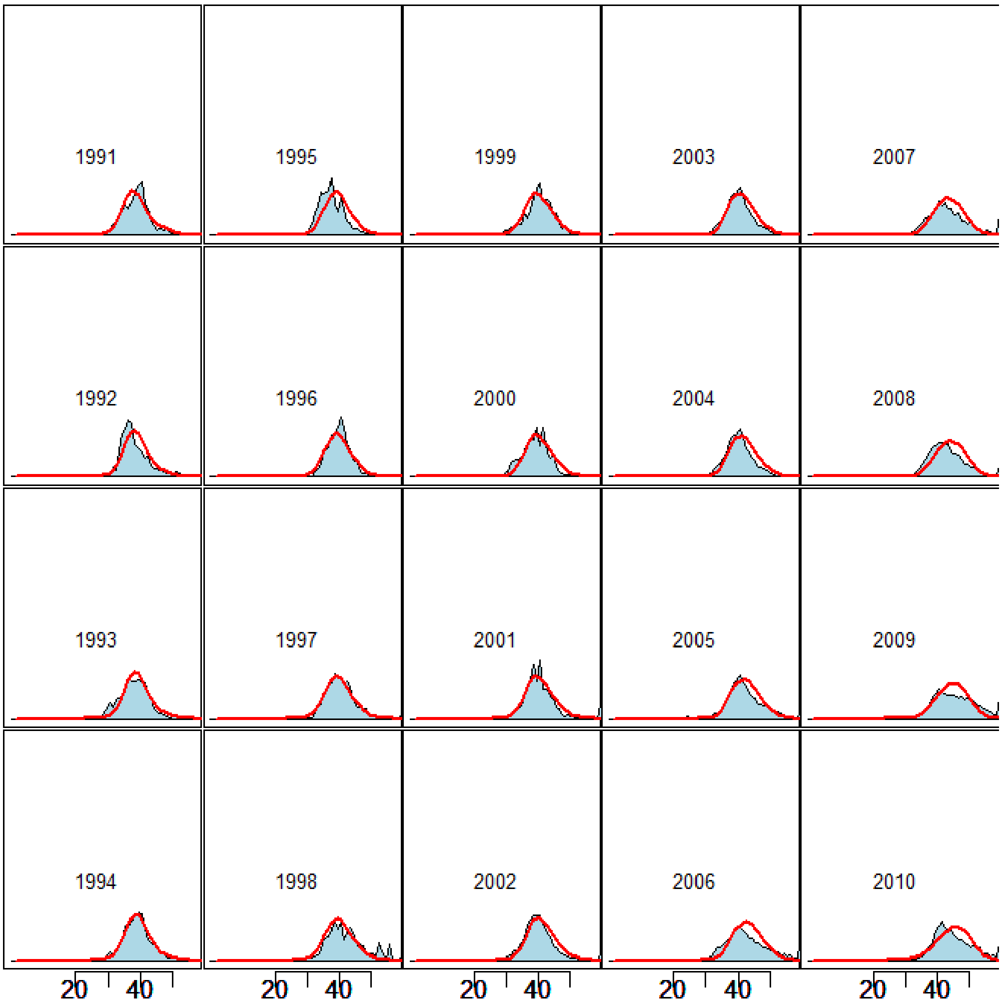


Figure 7.13. *Sebastes marinus* in Sub-areas I and II. Annual fit of modelled length distributions (red line) to the commercial trawl catch (blue shaded area). Horizontal scale in cm. Note that 2011 was not available for running this model.

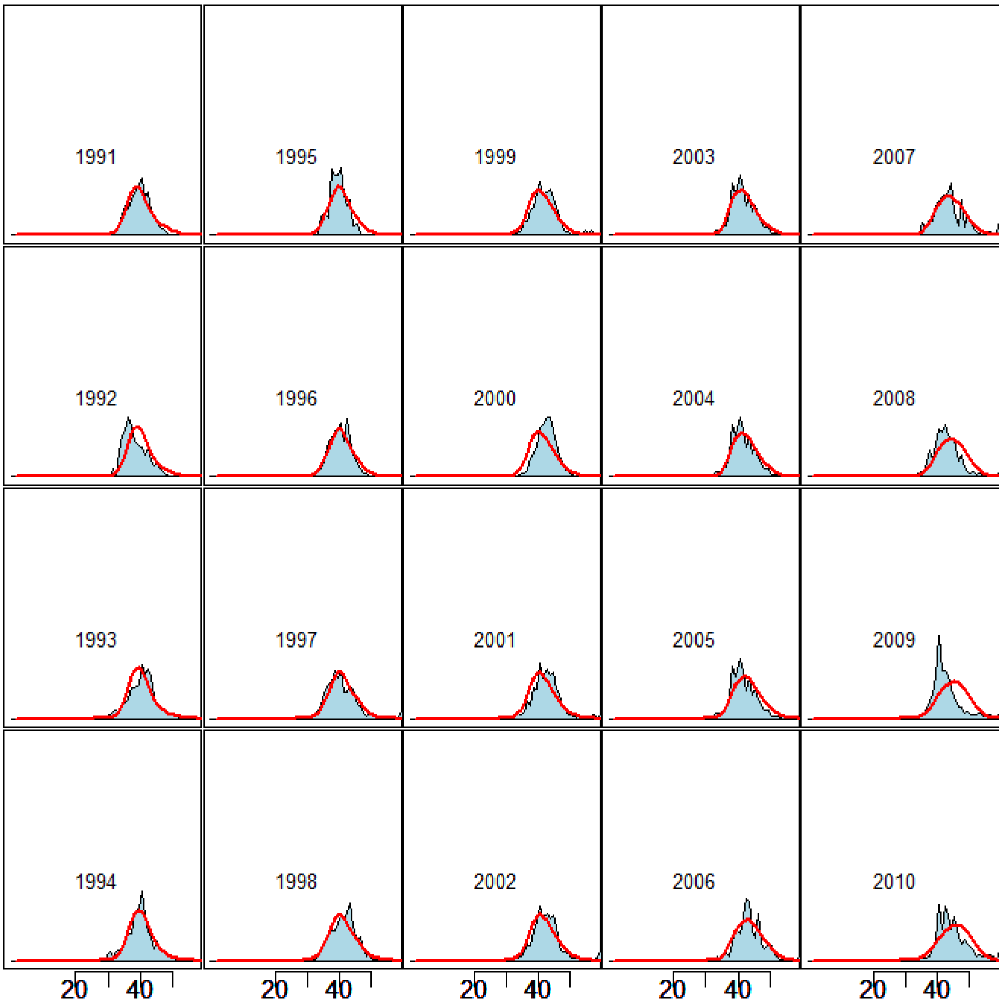


Figure 7.14. *Sebastes marinus* in Sub-areas I and II. Annual fit of modelled length distributions (red line) to the commercial gill fleet catch (blue shaded area). Horizontal scale in cm. Note that 2011 was not available for running this model.

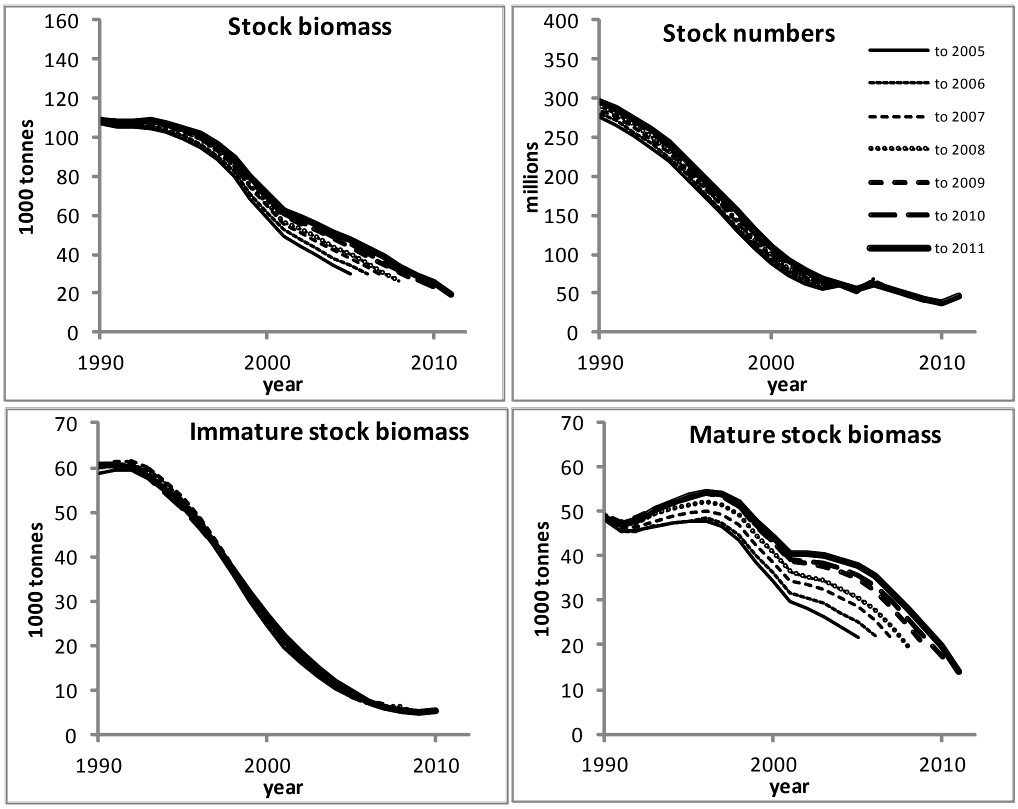


Figure 7.15. *Sebastes marinus* in Sub-areas I and II. Retrospective plot from the gadget model. Top left: total stock biomass in thousand tonnes, top right: total stock numbers in millions, bottom left: immature biomass and bottom right: mature biomass, both in thousand tonnes.

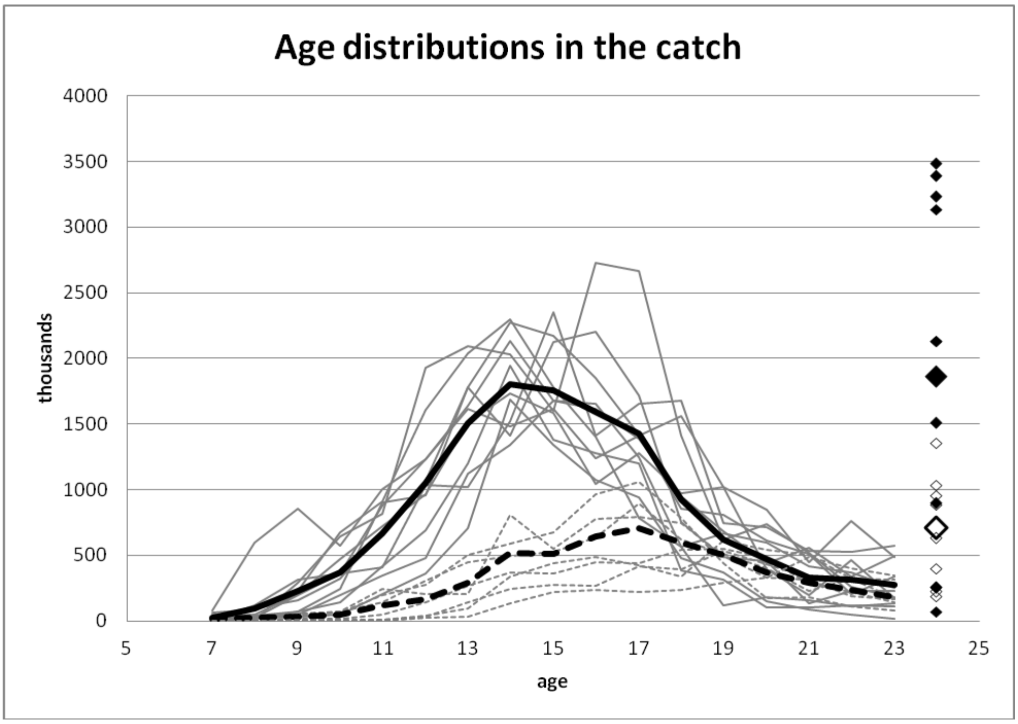


Figure 7.16. Age distributions in the *S. marinus* commercial catch (from table 7.5). The heavy solid line is the average from 1995-2003. Light solid lines are the individual years 1995-2003 (see table 7.5 for details). Heavy dotted line is the average from 2004-2011. Light dotted lines are the individual years 2004-2011 (see table 7.5 for details). Note that the four lines with lowest catches in the 13-18 year old range are 2008, 2009, 2010 and 2011. The diamonds are the plus group in the catch (age 24+). Large filled diamond is the average 1995-2003, small filled diamonds are the individual years 1995-2003. Large hollow diamond is the average for 2004-2011, small hollow diamonds are the individual years 2004-2011.

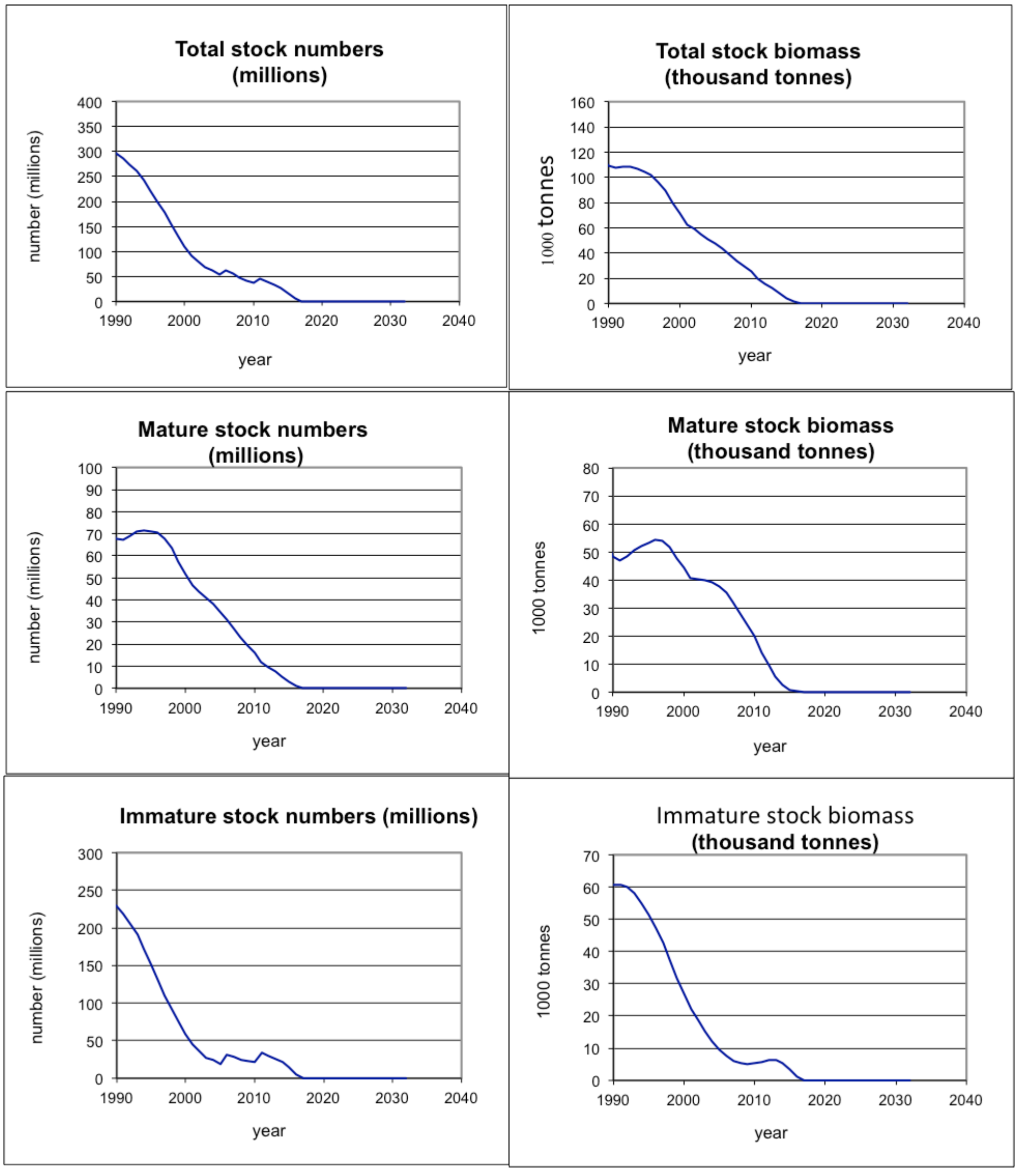


Figure 7.17. *Sebastes marinus* in Sub-areas I and II. Projection of abundance (left) and biomass (right) of the total (top), mature (middle) and immature (bottom) components of the stock under the assumption of constant catch to the level of 2011.

Table E1. *Sebastes marinus*. Effort (vessel days) and catch per unit effort (kg per trawl hour) with 2 x st.error for Norwegian trawlers.1

	Freezer trawlers (32-50m)			Factory trawlers (>53m)		
Year	Number of vessel days meeting the 10% requirement	Mean CPUE per year (kg/hour)	2 x standard error of the mean	Number of vessel days meeting the 10% requirement	Mean CPUE per year (kg/hour)	2 x standard error of the mean
1992	926	378	29.4	545	596	53.1
1993	743	374	34.4	411	495	68.9
1994	793	357	30.1	516	522	53.9
1995	754	300	26.7	343	323	35.9
1996	864	363	32.1	395	638	78.4
1997	972	331	31.9	291	402	60.3
1998	1 303	230	17.2	631	465	62.1
1999	1 054	224	18.8	486	540	93.1
2000	884	330	39.9	349	703	172.6
2001	481	349	70.5	421	753	118.4
2002	536	192	26.0	246	353	65.8
2003	276	136	21.4	96	214	40.7
2004	344	177	38.5	101	204	56.2
2005	368	120	20.2	160	160	24.2
2006	98	123	26.0	175	209	43.9
2007	147	167	29.4	195	292	53.5
2008	78	202	82.5	153	294	53.2
2009	55	165	34.4	104	331	129.2
2010[2]	41	*776*	*740.5*	180	347	112.9

[1] Only including days with more than 10% *S. marinus* in the catches. Only including areas with low mixing of *S. mentella.*

[2] Provisional figures.

Table E2a. *Sebastes marinus* in Sub-areas I and II. Abundance indices - on length - from the bottom trawl surveys in the Barents Sea (Division IIa) in the winter 1986-2012 (numbers in millions). The area coverage was extended from 1993.

Year	Length group (cm)									
	5.0-9.9	10.0-14.9	15.0-19.9	20.0-24.9	25.0-29.9	30.0-34.9	35.0-39.9	40.0-44.9	>45.0	Total
1986	3.0	11.7	26.4	34.3	17.7	21.0	12.8	4.4	2.6	133.9
1987	7.7	12.7	32.8	7.7	6.4	3.4	3.8	3.8	4.2	82.5
1988	1.0	5.6	5.5	14.2	12.6	7.3	5.2	4.1	3.7	59.2
1989	48.7	4.9	4.3	11.8	15.9	12.2	6.6	4.8	3.0	112.2
1990	9.2	5.3	6.5	9.4	15.5	14.0	8.0	4.0	3.4	75.3
1991	4.2	13.6	8.4	19.4	18.0	16.1	14.8	6.0	4.0	104.5
1992	1.8	3.9	7.7	20.6	19.7	13.7	10.5	6.6	5.8	90.3
1993	0.1	1.2	3.5	6.9	10.3	14.5	12.5	8.6	6.3	63.9
1994	0.7	6.5	9.3	11.7	11.5	19.4	9.1	4.4	2.8	75.4
1995	0.6	5.0	13.1	11.5	9.1	15.9	17.2	10.9	4.7	88.0
1996	+	0.7	3.5	6.4	9.4	11.7	16.6	7.9	3.9	60.1
1997[1]	-	0.5	1.3	2.7	6.9	21.4	28.2	8.5	3.3	72.7
1998[1]	0.1	3.9	2.0	7.4	5.8	25.3	13.2	7.0	2.3	67.0
1999	0.2	0.9	2.1	4.0	4.6	6.4	6.0	5.3	3.5	33.0
2000	0.5	1.1	1.5	4.2	4.7	5.0	3.5	1.8	1.2	24.0
2001	0.1	0.4	0.4	2.4	5.8	5.6	5.0	3.5	1.8	25.0
2002	0.1	1.0	1.9	1.7	3.7	4.1	3.3	3.6	2.5	22.0
2003	0.0	0.5	1.2	1.5	4.3	3.8	2.7	3.3	2.9	20.2
2004	0.7	0.2	0.4	1.0	2.9	4.4	5.5	4.0	3.2	22.3
2005	+	0.1	0.2	0.4	1.1	2.0	3.7	4.6	4.3	16.4
2006	0.0	0.0	0.0	0.2	2.5	5.4	6.1	4.1	4.2	22.5
2007	0.0	0.1	0.5	0.1	1.0	4.0	5.4	5.9	4.9	21.9
2008	1.8	2.6	0.2	0.2	0.4	0.7	1.9	2.5	4.4	14.8
2009	0.0	0.0	0.1	0.0	0.0	0.4	1.7	3.7	6.6	12.7
2010	0.4	2.0	1.2	0.6	0.1	0.1	0.8	1.1	3.9	10.3
2011	0.3	3.1	2.1	0.3	0.4	0.1	0.3	2.3	5.2	14.1
2012	0.8	4.4	4.0	1.9	0.6	0.3	0.9	3.6	6.2	22.7

1 - Adjusted indices to account for not covering the Russian EEZ in Subarea I

Table E2b. *Sebastes marinus* in Sub-areas I and II. Norwegian bottom trawl indices - on age - from the annual Barents Sea survey in February 1992-2011 (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	2,637	0	0	0	203	72	175	272	476	369	553	850	700	**6,306**	6,543
2009	0	0	0	0	85	0	14	77	192	358	1,146	532	737	**3,141**	9,539
2010	0	0	16	1,966	267	0	1,450	35	0	117	268	285	494	**5,510**	4,779
2011	1,832	1,621	1,529	163	148	0	343	0	122	0	204	107	903	**7,458**	6,624

16+ group is considered in the calculation since 2005. Values prior to this date were derived by subtracting the sum of abundance in groups 1-15 to the total abundance, available in Table E2a.

Table E3a. ***Sebastes marinus*** **in Subarea I and II. Abundance indices - on length - from the bottom trawl survey in the Svalbard area (Division IIb) in summer/fall 1985-2011 (numbers in thousands).**

	Length group (cm)									
Year	**5.0-9.9**	**10.0-14.9**	**15.0-19.9**	**20.0-24.9**	**25.0-29.9**	**30.0-34.9**	**35.0-39.9**	**40.0-44.9**	**>45.0**	**Total**
1985[1]	-	1,307	795	1,728	2,273	1,417	311	142	194	8,325
1986[1]	200	2,961	1,768	547	643	1,520	639	467	196	8,941
1987[1]	100	1,343	1,964	1,185	1,367	652	352	29	44	7,060
1988[1]	500	1,001	1,953	1,609	684	358	158	68	95	6,450
1989	200	1,629	2,963	2,374	1,320	846	337	323	104	10,100
1990	1,700	3,886	4,478	4,047	2,972	1,509	365	140	122	19,185
1991	100	5,371	5,821	9,171	8,523	4,499	1,531	982	395	36,420
1992	1,700	10,228	8,858	5,330	13,960	12,720	4,547	494	346	58,172
1993	200	10,160	9,078	5,855	7,071	4,327	2,088	1,552	948	41,284
1994	100	3,340	5,883	4,185	3,922	3,315	1,021	845	423	22,985
1995	470	2,000	9,100	5,070	3,060	2,400	1,040	920	780	24,840
1996	80	130	1,260	2,480	1,030	480	550	990	400	7,400
1997	0	810	1,980	5,470	5,560	2,340	590	190	450	17,430
1998	180	2,698	1,741	4,620	4,053	1,761	535	545	241	16,403
1999	0	794	7,057	3,698	4,563	2,449	467	619	369	20,017
2000	40	360	1,240	1,390	2,010	760	400	160	390	6,750
2001	10	110	790	1,470	3,710	4,600	1,880	680	370	13,660
2002	0	0	64	415	459	880	620	565	519	3,522
2003	90	90	108	83	525	565	447	760	769	3,437
2004	0	0	10	50	650	740	670	430	190	2,740
2005	0	45	0	30	315	384	307	159	274	1,513
2006	0	0	70	64	167	376	473	735	1,514	3,398
2007	0	32	58	1,003	1,049	3,875	4,656	811	1,267	12,751
2008	7,009	3,573	175	21	42	142	475	162	529	12,130
2009	227	1,476	114	114	0	0	185	213	193	2,522
2010	666	917	1,506	522	0	117	172	0	985	4,885
2011	0	0	681	33	0	0	0	131	568	1,413

1 - Old trawl equipment (bobbins gear and 80 meter sweep length)

Table E3b. ***Sebastes marinus*** **in Sub-areas I and II. Norwegian bottom trawl survey indices - on age - in the Svalbard area (Division IIb) in summer/fall 1992-2008 (numbers in thousands).** *No age readings have been conducted after 2008.*

	Age													
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992	284	12,378	5,576	2,279	371	2,064	3,687	5,704	9,215	6,413	1,454	1,387	696	22	51,530
1993	32	10,704	5,710	5,142	1,855	1,052	1,314	3,520	2,847	2,757	2,074	1,245	844	119	39,215
1994	429	1,150	3,418	2,393	1,723	1,106	1,714	1,256	1,938	1,596	2,039	484	550	319	20,155
1995	600	1,600	6,400	5,100	1,800	2,200	1,800	700	700	400	700	500	400	500	23,400
1996	40	110	+	560	1,050	940	930	400	1,050	280	320	590	160	70	6,500
1997	320	490	+	480	1,500	6,950	2,720	1,680	800	1,310	550	30	+	120	16,950
1998	210	1,817	881	202	1,555	2,187	4,551	1,913	1,010	797	49	264	73	187	15,696
1999	0	760	2,893	1,339	3,534	1,037	3,905	2,603	762	1,663	481	361	258	152	19,748
2000	40	20	400	350	840	480	730	1,670	620	340	510	100	80	70	6,250
2001	0	40	50	450	330	790	1,760	1,970	3,300	1,200	1,810	150	660	430	12,940
2002	0	0	+	+	65	160	204	326	364	614	442	328	15	0	2,518
2003	30	30	30	+	108	+	219	263	126	259	306	199	248	411	2,229
2004	0	0	0	+	+	20	360	120	430	160	410	360	370	200	2,430
2005	0	45	0	0	0	30	48	228	138	187	194	93	105	109	1,177
2006	0	0	23	23	23	21	22	21	84	0	84	279	194	376	1,148
2007	0	33	19	19	19	764	764	525	0	0	21	1,927	1,927	1,683	7,702
2008	10583	44	88	44	11	11	0	42	88	13	13	118	63	174	11,292

Table E4. ***Sebastes marinus*** **in Sub-area I and II. Mean catch rates (N/nm2) of** ***Sebastes marinus*** **from Norwegian Coastal Surveys (Division IIa) in 1995-2010 within 100-350 m depth. Catch rates for the total area.**

Length range (cm)	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	# Hauls	Total.Distance (nm)	# Fish Caught	# Fish Sampled	Area (nm^2)
1995	0	41	118	59	54	38	69	214	157	21	2	1	0					
1996	0	34	87	124	151	67	210	415	209	64	0	0	0					
1997	0	4	9	12	64	112	96	178	190	45	2	1	0					
1998	0	0	0	4	12	16	17	110	96	18	3	0	0					
1999	0	0	19	242	160	34	43	151	117	15	4	2	0					
2000	0	0	2	13	7	10	30	160	155	30	4	0	0					
2001	0	0	2	11	14	22	15	83	160	30	2	0	0					
2002	0	0	0	0	2	6	29	259	213	26	4	1	0					
2003	0	0	6	10	43	66	49	219	225	55	6	1	2	123	160	1367	1053	43574
2004	0	1	3	6	21	66	35	351	552	42	3	1	0	104	130	1290	950	43574
2005	0	1	5	5	30	46	48	190	171	37	1	0	0	99	132	833	780	43574
2006	0	0	3	0	2	3	30	145	256	66	9	0	0	112	112	771	680	43574
2007	0	0	0	0	4	7	17	129	177	29	1	0	0	131	140	637	637	43574
2008	0	4	5	1	4	5	17	363	490	99	12	2	0	110	140	1156	850	43574
2009	**0**	0	8	3	10	19	45	808	945	109	14	1	0	109	127	2945	581	43574
2010	**0**	40	78	20	9	1	3	67	214	99	7	2	0	117	136	833	690	43574

Table E5. Proportion of maturity at age 5 – 30 in *S. marinus* in subareas I and II derived from Norwegian commercial and survey data. The proportions were derived from samples with at least five individuals.

year	age5	age6	age7	age8	age9	age10	age11	age12	age13	age14	age15	age16	age17	age18
1992	0.00	0.00	0.09	0.15	0.31	0.22	0.21	0.20	0.22	0.26	0.30	0.44	0.45	0.47
1993	-	-	0.00	0.00	0.10	0.29	0.54	0.47	0.53	0.67	0.80	0.75	0.78	0.82
1994	0.00	0.00	0.03	0.05	0.28	0.28	0.32	0.70	0.79	0.91	0.94	0.85	0.92	1.00
1995	0.00	0.00	0.00	0.05	0.02	0.22	0.25	0.48	0.61	0.64	0.68	0.80	0.87	0.88
1996	0.00	0.05	0.14	0.13	0.22	0.38	0.43	0.60	0.64	0.75	0.69	0.77	0.90	0.85
1997	0.00	0.05	0.08	0.15	0.17	0.21	0.34	0.35	0.57	0.64	0.72	0.73	0.85	0.93
1998	0.00	0.00	0.03	0.11	0.09	0.26	0.32	0.49	0.52	0.69	0.74	0.77	0.81	0.91
1999	0.00	0.00	0.00	0.04	0.17	0.35	0.22	0.53	0.73	0.71	0.67	0.69	0.74	0.71
2000	0.00	0.08	0.14	0.25	0.40	0.51	0.59	0.62	0.65	0.69	0.78	0.96	0.96	1.00
2001	-	0.00	0.06	0.14	0.28	0.32	0.40	0.52	0.53	0.60	0.76	0.74	0.81	0.85
2002	-	0.00	0.05	0.07	0.23	0.44	0.41	0.63	0.74	0.93	0.77	0.89	0.90	0.94
2003	-	0.00	0.00	0.05	0.13	0.24	0.24	0.47	0.58	0.68	0.75	0.65	0.77	0.78
2004	-	0.00	0.03	0.07	0.13	0.43	0.21	0.51	0.46	0.63	0.64	0.86	0.82	0.96
2005	-	-	0.00	0.05	0.29	0.18	0.34	0.39	0.39	0.56	0.73	0.81	0.79	0.82
2006	-	-	0.00	0.10	0.06	0.22	0.25	0.39	0.47	0.57	0.67	0.67	0.74	0.86
2007	-	-	0.00	0.08	0.30	0.25	0.24	0.66	0.68	0.70	0.88	0.86	0.89	0.99
2008	-	-	0.80	0.25	0.82	0.68	0.62	0.80	0.79	0.86	0.88	0.91	0.90	0.92
2009	-	-	-	-	-	0.50	0.50	1.00	0.93	0.81	0.86	0.86	0.84	0.86
2010	-	-	-	-	-	-	-	-	0.57	0.53	0.77	0.89	0.33	0.82
2011	-	-	-	-	-	-	-	-	-	-	0.73	0.78	0.94	0.93

year	age19	age20	age21	age22	age23	age24	age25	age26	age27	age28	age29	age30
1992	0.45	0.62	0.51	0.63	0.76	0.60	0.57	0.60	0.68	0.74	0.82	0.80
1993	0.91	0.85	0.82	0.87	0.75	0.91	1.00	1.00	1.00	1.00	1.00	1.00
1994	0.96	0.96	1.00	0.88	1.00	1.00	1.00	1.00	-	1.00	1.00	-
1995	0.76	0.89	0.90	0.91	1.00	1.00	1.00	1.00	-	-	-	-
1996	0.91	0.88	0.96	0.93	1.00	0.87	0.95	0.95	1.00	-	1.00	0.86
1997	0.94	1.00	1.00	0.95	0.89	0.94	0.93	0.89	1.00	1.00	1.00	-
1998	0.89	0.86	1.00	1.00	0.67	0.70	1.00	1.00	-	-	1.00	0.88
1999	0.77	0.89	-	0.83	-	1.00	0.89	-	-	-	-	-
2000	1.00	-	-	-	1.00	-	-	-	-	-	-	-
2001	0.60	0.70	0.56	-	-	-	-	-	-	-	-	-
2002	0.96	0.92	0.95	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-
2003	0.93	0.96	0.94	0.67	1.00	-	1.00	-	-	-	-	-
2004	0.92	0.95	0.89	0.88	1.00	0.86	1.00	-	-	-	-	-
2005	0.77	0.94	0.95	0.88	0.83	1.00	-	1.00	-	-	-	-
2006	0.83	0.97	0.79	0.95	0.81	1.00	-	1.00	-	-	-	-
2007	0.98	1.00	0.96	0.94	1.00	0.92	1.00	0.83	1.00	1.00	1.00	-
2008	0.92	0.90	0.93	0.93	0.94	1.00	1.00	1.00	1.00	1.00	0.93	1.00
2009	0.88	0.95	0.89	0.95	0.92	0.95	0.86	0.93	1.00	0.93	0.83	0.86
2010	0.82	0.92	0.86	0.80	1.00	0.63	0.80	0.80	0.86	-	0.67	-
2011	0.89	0.92	0.92	0.93	0.83	0.85	1.00	1.00	-	0.83	-	-

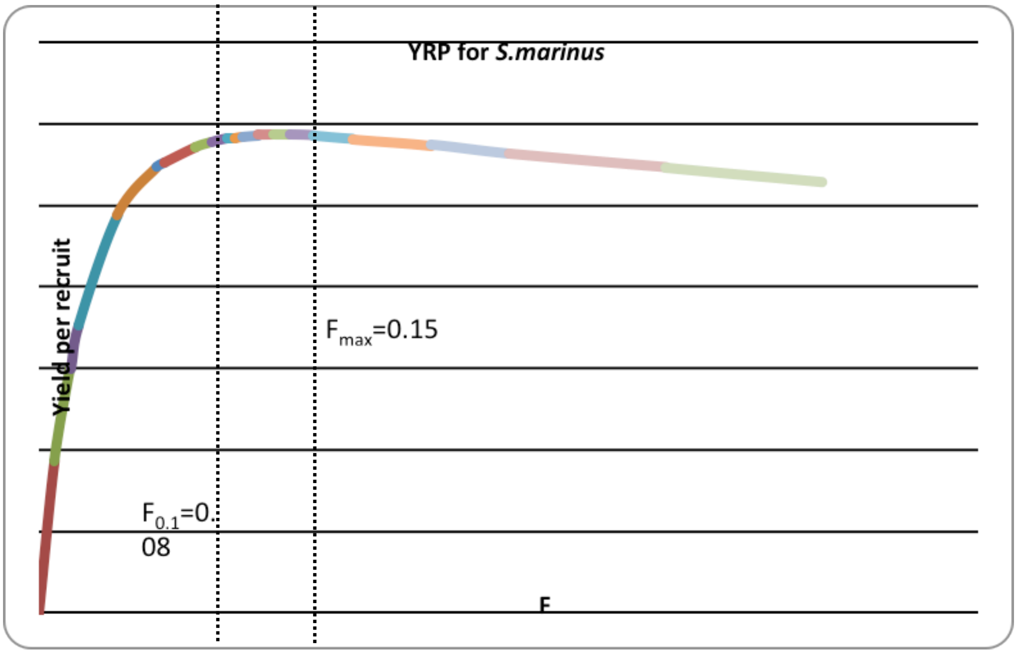


Figure E1. ***Sebastes marinus*** **in Sub-areas I and II. Yield per recruit for** ***S. marinus*****, computed from the base case GADGET model presented at the benchmark assessment in February 2012 (WKRED).**

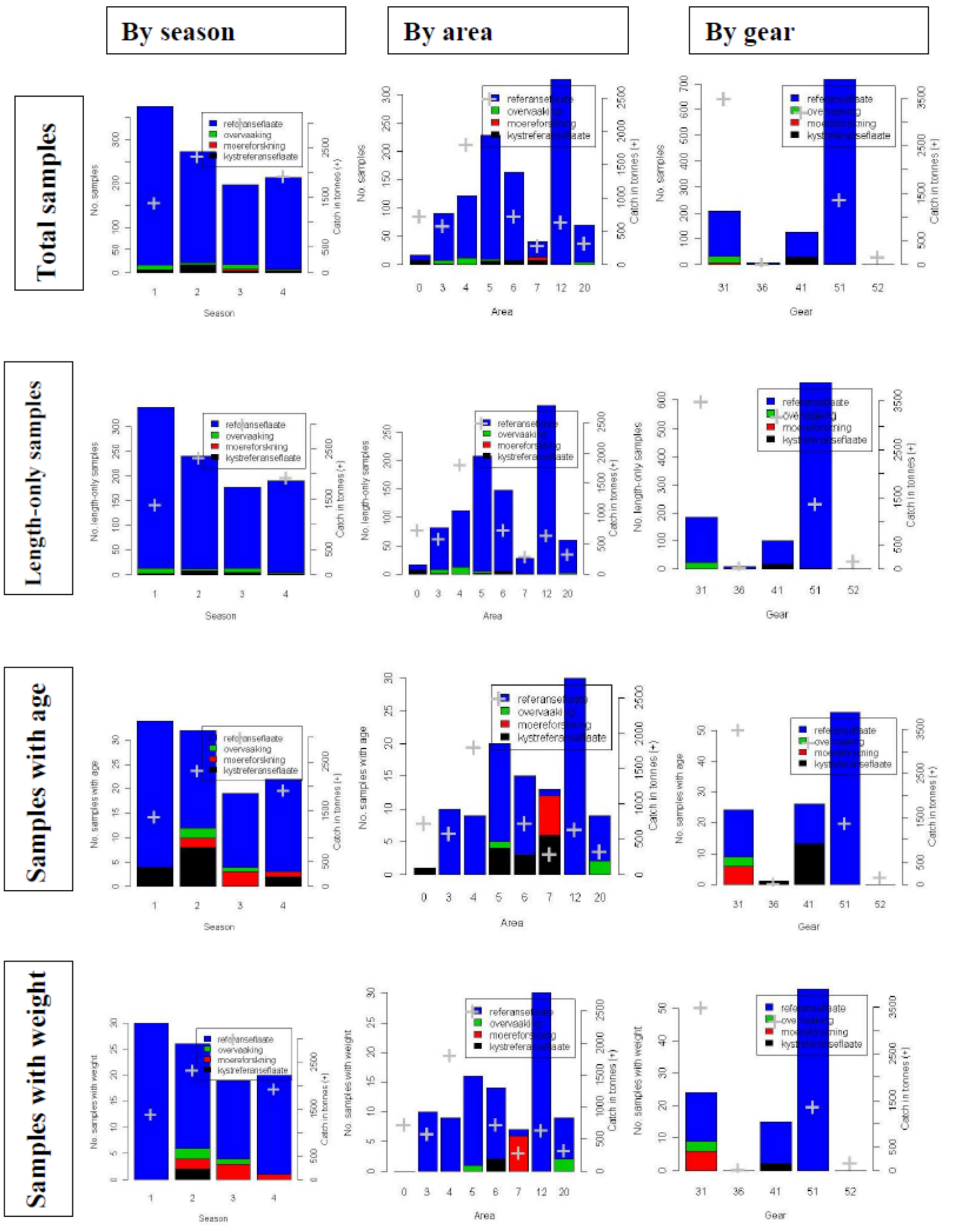


Figure E2. Overview of the Norwegian biological samples from the commercial fisheries for *S. marinus* in 2010 representing 84% of the catches and which the input data to the Gadget model are based upon. The colors denote which sampling platform has been used: port sampling (red), High Seas Reference fleet (blue), Coastal Reference Fleet (black), inspectors/observers at sea (green). The crosses show the catch in tonnes for the different seasons, areas and gear.

8 Greenland halibut in subareas I and II

The stock is assessed by trends in surveys. 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 age reading problems was addressed at the ICES WKARGH workshop in February 2011 (ICES CM 2011/ACOM:41). Scientists still need time before a thorough benchmark assessment can be carried out. During the annual PINRO and IMR scientists meeting in March 2012 it was decided that a workshop of Russian and Norwegian experts on Greenland halibut age reading will take place in autumn 2012. General information about this stock is located in the Quality Handbook.

8.1 Status of the fisheries

8.1.1 Landings prior to 2012 (Tables 8.1 – 8.5, F10)

Nominal landings by country for Subareas I and II combined are presented in Table 8.1. Tables 8.2–8.4 give the landings 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 landings listed in the tables are similar to those officially reported to ICES. Some of the values in the tables vary slightly from the official statistics, and represents those presented to the Working Group by the members.

The preliminary estimate of the total landings for 2011 is 16,474 t. This is 1,253 t more than landings in 2010 and about 27% more than the ICES advised maximum catch for 2011 (13,000 t). Combined Norwegian, Russian as well as third countries landings exceeded the national quotas set by the joint Russian-Norwegian Fisheries Commission (total TAC 15,000 t). Some fishing for Greenland halibut has taken place in the northern part of Division IVa during the past 20-30 years, varying between a few tonnes and up to 2,500 t in 1999. Since 2005 this catch has been mostly below 100 t, and in 2011 it was 190 t taken mostly by Norway, France and UK (Table F10). This fishery is in another management area, and is not restricted by any TAC regulations. Although there is a continuous distribution of this species from the southern part of Division IIa along the continental slope towards the Shetland area, little is known about the stock structure and the landings taken from this area have therefore not been added to the total from Subareas I and II.

Around Jan Mayen, small catches of Greenland halibut have been taken in some years. 21 t were landed from this area in 2006, whereas in 2007-2011 no landings 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 landings given for Subarea II.

8.1.2 ICES advice applicable to 2011 and 2012

The advice from ICES for 2011 was as follows:

Advice summary for 2011

The 2009 data (landings, survey and CPUE) available for this stock do not change the perception of the stock and give no reason to change the advice from that given in 2009.

The advice for the fishery in 2011 was the same as the advice given in 2009 for the 2010 fishery: "The stock has remained at a relatively low size in the last 25 years at catch levels of 15 000–25 000 t. In order to increase the SSB, catches should be kept well below that range. Catches should be below 13 000 t as advised since 2003; this is the level below which SSB has increased in the past".

Additionally, ICES noted that the evaluation of this stock is uncertain due to age-reading problems and lack of contrast in the data. The age-reading issue is being addressed and should be resolved in the not too distant future. Corrections to the whole time-series are required.

The 38th Session of the Joint Norwegian-Russian Fisheries Commission in 2009 decided to cancel the ban against targeted Greenland halibut fishery and established a TAC at 15 000 t for next three years (2010-2012). The TAC was allocated between Norway, Russia and other countries with shares of 51, 45 and 4% respectively.

Reference points

No reference points are defined for this stock.

The advice from ICES for 2012 was as follows:

ICES advises on the basis of precautionary considerations that catches should not be allowed to increase.

Stock status

Only landings and survey trends of biomass are available for this stock. The total stock has shown a positive trend since catches were reduced in 1992, especially in most recent years. For this long-lived species this is a positive sign regarding recruitment into the fisheries. Increase in mature female biomass is not as marked. There is no information on the exploitation rate of the stock.

Management plans

No specific management objectives are known to ICES.

Outlook for 2012

No analytical assessment can be presented for this stock. Therefore, fishing possibilities cannot be projected.

Precautionary considerations

There are signs that the rebuilding strategy for this stock of the last two decades is improving the status of the stock, and measures should be taken to maintain the positive trends. ICES advises on the basis of precautionary considerations that catches should not be allowed to increase above 15 000 t, the average catch for the last 10 years.

8.1.3 Management applicable in 2010 and 2011

The 38th JRNFC's Session in 2009 decided to cancel the ban against targeted Greenland halibut fishery and established the TAC at 15,000 t for next three years (2010-2012). The 40th JRNFC's Session in 2011 decided to increase the TAC for 2012 up to 18,000 t.

Minimum size regulation for Greenland halibut is 45 cm. Bycatch of undersized Greenland halibut shall not exceed 15% by number in each haul. A joint PINRO/IMR project examined this minimum legal size (MLS) and concluded:

"Given the substantial sexual dimorphism for Greenland halibut the current MLS of 45 cm might be a suitable to utilise juvenile growth potential and minimise fishing pressure on the smallest immature females, and still avoid allocating too much fishing pressure on the largest females in the trawl fisheries.

Results from selection experiments on the RV "Vilnius" April-May 2011 survey may indicate that none of the examined selection gear alternatives were suitable to satisfactorily give selection according to the current MLS for Greenland halibut in the Barents Sea. However, the experiments were too limited to give a clear conclusion. It is necessary to continue this research in order to get more statistically significant results. Future studies might involve experiments with modifications for instance on the lifting panel and should also be conducted in the most appropriate time and areas." (Hallfredsson et al. 2011). Starting in 2012 it became mandatory to use sorting grids during target Greenland halibut trawl fishery.

Further information on regulations are found in the stock annex.

8.1.4 Expected landings in 2012

Due to new regulation measures established in 2009 for 2010-2012, and change in TAC at the JRNFC 2011 meeting, the total Greenland halibut landings in the Barents Sea and adjacent waters (ICES Subarea I and Divisions IIa and IIb) in 2012 are expected to be about 18,000 t. Discards at present is not regarded as a problem, but it is believed that there may be additional landings that are not reported. The landings from Division IVa are expected to be maintained at a low level (below 200 t).

8.2 Status of research

8.2.1 Survey results (Tables 1.1, F1–F8)

Norwegian combined index has been used as one of the biomass indices for this stock. It is made by combining results from the Norwegian autumn slope survey with surveys in the Barents Sea. Further information on this index is found in Pennington 2003 (WD ICES AFWG 2003). This index is not updated in 2011. The Working Group has in earlier meetings advised that further work should be done to improve the combined index with regards to pooling different surveys using different gears.

Also in the Russian bottom trawl surveys in October-December (ICES acronym: *RU-BTr-Q4*) (Table F6) it has been difficult to identify year classes that appear consistently either strong or weak across ages. In previous Working Group reports this survey series was the one with the clearest and strongest trends in catchability with age in the XSA calibrations. These surveys are important since they usually cover large parts of the total known distribution area of the Greenland halibut within 100–900 m depth. However, it has been considered imprudent to use the 2002 and 2003 data from this survey series. During the 2002 survey, no observations were available from the Exclusive Economic Zone of Norway (NEEZ). In 2003, observations on the main spawning grounds were conducted three weeks later than usual because access to NEEZ was obtained too late. The number of trawl stations was also insufficient due to the same reason. Length distributions by year for this survey are given in table F11 and figure 8.8.

The Norwegian CPUE survey (Table F9) was stopped from 2005. This was one of the tuning fleets, but an evaluation of this survey revealed a lot of inconsistencies in the series. Since 2006, none of the age structured tables of the Norwegian surveys have been updated due to changes in the age reading procedure.

During the last ten years before the Norwegian CPUE survey ended in 2006 there was a slowly increasing trend in biomass estimates in this series. Total biomass index from the Russian autumn survey showed a slowly increasing trend from 1992 to 2005 but has shown a sharply increasing trend since then (Figure 8.4). The biomass indices of mature females from different surveys showed a slight upward trend in the last years (Figure 8.5).

Total biomass indices from the Norwegian autumn slope survey (ICES acronym: *NO-GH-Btr-Q3*) has shown an upward trend in biomass estimates between 1994 and 2003, then a downward trend until 2008 until it increased again in 2009 but levels out again in 2011 (Figure 8.6). The length distributions from this survey show modes that can be followed through the years with marked change between 2006 and 2007 (figure 8.7, table F12 and F13). This survey was conducted every year 1994-2009 but is now run biennially starting in 2011.

The Spanish bottom trawl survey from 1997 to 2005 (Table F7), ICES acronym: *SP-Svalbard-Q4,* showed an increase of Greenland halibut abundance and biomass in the Svalbard-Bear Island area from 2002 after three years with a declining trend. From 2008 the Spanish autumn survey is carried out on a new hired commercial trawler vessel and some changes have been done in the initial standard protocol. One of the most important changes is the increasing of the bridle's length now being 300 m instead of 175 m before 2008. This new features increased the swept area in the trawl stations making the comparison of the biomass and abundance index before and after 2008 difficult. The biomass index in 2010 has increased compared to the 2008 index. Effort should be made to see if it is possible to recalculate the index for 1997 to 2005 to be comparable to 2008 and 2010 values. The Spanish survey is now alternately run every other year in spring and autumn (WD#20). Update of the Spanish survey index is shown in table F7.

Polish bottom trawl surveys on Greenland halibut were carried out in the Svalbard-Bear Island area (ICES IIb) in October 2006, April 2007, April 2008, June 2009 and March 2011. The main objectives of the survey are to determine the biological structure, distribution, density and standing biomass of Greenland halibut in the survey area (WD#6). In the future this new survey probably can be treated as an additional tuning series.

Based on the decision of the 34th session of the Joint Russian-Norwegian Fisheries Commission (JRNFC), a joint research program aimed at improvement of Greenland halibut stock assessment methods and elaboration of optimal management strategy was developed at the meeting of PINRO and IMR scientists (21-27 March 2006). The final report (Albert et al. 2010) gives a brief description of the main findings from the three-year program and summarizes the present level of knowledge within each of the six sub-projects. Results from this program should be included in evaluation of the NEA Greenland halibut stock assessment.

8.2.2 Commercial catch-per-unit-effort (Table 8.6 and F9)

The CPUE from the experimental fishery was found to be considerably higher than in the traditional fishery and exhibited an increasing trend from 1992–1996. After 1996 the Norwegian CPUE series varied between 1200 and 1800 kg/h with the highest value in 2005 (Table F9). The Norwegian CPUE survey was terminated in 2006. The Russian experimental CPUE series shows an increasing trend since 1997, and this series shows the highest value in 2003. A significant decline was observed in 2004-2008 (Table 8.6) and in 2009 the indices jump up again. Results of the Russian commercial trawl fishery in 2010 and 2011 showed high level of CPUE in comparison with 1975-1990, but comparisons of commercial CPUE between periods several decades apart may probably not be valid because of the 'technology creep' in fisheries (Table 8.6).

When comparing the CPUE between years the effort level should also be taken into account.

8.2.3 Age readings

Based on scientific presentiment that the species is more slow growing and vulnerable than the previous age readings suggest, the Norwegian age reading methods were changed in 2006. The new Norwegian age readings are not comparable with older data or the Russian age readings.

The report from Workshop on Age Reading of Greenland Halibut (WKARGH) 14-17 February 2011 ((ICES CM 2011/ACOM:41) described and evaluated several age reading methods for Greenland Halibut.

The different methods can be classified into two groups: A) Those that produce age-length relationships that broadly compare with the traditional methods described by the joint NAFO-ICES workshop in 1996 (ICES CM 1997/G:1); and B) Several recently developed techniques that show much higher longevity and approximately half the growth rate from 40-50 cm onwards compared to the traditional method.

Information concerning validation and corroboration techniques was reviewed by WKARGH. There is still work to be done to determine the best methods, although considerable progress has been made.

AFWG plans to follow the recommendations of WKARGH and study the influence of different age reading methods on stock assessment results.

The annual meeting between Russian and Norwegian scientists in March 2011 concluded:

" 4.5 Harmonization of PINRO and IMR age reading of beaked redfish and Greenland halibut using the ICES protocol - annual exchange of otoliths and age readers

In order to achieve the most accurate age estimates, ICES recommends methods and best practice for age reading of both redfish and Greenland halibut. Still there continue to be differences in opinion between PINRO and IMR regarding age reading methods for these species. It is recommended to start annual or bi-annual exchange of otoliths and age reading experts on these species in order to identify the differences in interpretation and to discuss possibilities for a common approach. The first meeting should be held during autumn 2012 and should include both age reading technicians and scientists involved in the development of the methods. " (PROTOCOL of the Annual Meeting between Norwegian and Russian Scientists Hamn i Senja, 12-16 March 2012).

8.3 Data used in the assessment

Data on total biomass, mature female biomass and length distributions in the surveys described in section 8.2.1 form the basis for trend-based assessment.

Based on the arguments in Section 8.2.1 the survey indices for ages below age 5 were not considered appropriate for inclusion in the tuning data also this year. Consequently, a standard XSA was run for age 5 and above.

Following sections (8.3.1-8.3.5) describe data in the exploratory XSA run.

NB. Due to late arrival of data, catch of 136 t in division IIb from the Spanish ground gear survey in 2011 was not included in the assessment.

8.3.1 Catch-at-age (Table 8.7)

The catch-at-age data for 2010 were updated using revised catch figures. Catch-at-age data for 2006-2011 were available only from the Russian fisheries. The Russian age-length keys were used to allocate catches from the other countries by age groups. Also Norwegian catches were allocated using Russian ALKs along with Norwegian length distributions. Total international catch-at-age is given in Table 8.7. Greenland halibut are usually caught in the range of 3–16 years old, but the catch is mainly dominated by ages 6–10. Generally, fish older than age 10 comprise a low proportion of the catches.

8.3.2 Weight-at-age (Table 8.8)

For the years 1964-1969 separate weight-at-age data were used for the Norwegian and the Russian catches. Both data sets were mean values for the period and were combined as a weighted average for each year. A constant set of weight-at-age data was used for the total catches in the years 1970–1978. For subsequent years annual estimates were used. The Russian weight-at-age data was used in the catch in 2006-2011 (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 1984-2011, 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 2004-2010 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. The ogive for 2011 was constructed as mean for 2009-2011.

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 1992-2011 for ages 5-14. The 2002 and 2003 data was not included in this series due to the problems mentioned in section 8.2.1.

Fleet 8: Norwegian Combined Survey from 1996-2005 for ages 5-15.

The software XXSA.exe was used.

8.4 Recruitment indices (Tables A14, F1–F9)

In addition to the indices mentioned in Section 8.3.5, all surveys in Section 8.2.1 may provide information on recruitment. However, because the dynamics of migration and distribution patterns are not well understood for this stock, it is not known which age should be used for a reliable recruitment estimate. 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

Trends in total biomass, mature female biomass and length distributions in the surveys described in section 8.2.1 form the basis for the advice.

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 year's 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

Results of the trend based assessment

Trends in total biomass indexes from the Russian and Norwegian autumn surveys show in general a gradual increase in biomass until 2006 (figure 8.4 and 8.6). After 2006 there is a considerable discrepancy in the trends, where indices from the Russian autumn survey show steep increase while results from the Norwegian autumn survey show slow increase or status quo. Trends in mature female biomass indices show the same discrepancy between the surveys as is seen for the total biomass.

Exploratory XSA

The diagnostics of the XSA assessment indicate that the analysis is increasingly governed by the Russian autumn survey tuning series (figure 8.1, 8.2 and 8.5), being the only tuning series that is updated since 2006. This further emphasises the need for revision of the analytical assessment including revision of data for this stock, in line with what is intended for the upcoming benchmark in 2013 (see section 8.9).

The survivor estimates for 2011 for most of the important year classes are determined primarily from the tuning fleet data and in most instances each tuning fleet contributes significantly to the determinations with little effect from inclusion of F shrinkage means in the tuning process. Nevertheless, the assessment diagnostics also indicated substantial uncertainties in absolute values of the survivor estimates determined by the analysis shown by instances of very high residuals, large S.E. (log q)'s and low R^2's in the regression statistics for certain fleets and ages.

8.6.1 Results of the VPA (Figure 8.2, Tables 8.11–8.15)

The fishing mortality (F) matrix indicates that historically Greenland halibut were fully recruited to the fishery at approximately age 6–7 with F>0.2 for older ages, and F>0.5 in many cases. Since 1991 the age of full recruitment appears closer to age 10 (Table 8.11). This is likely due to a substantial proportional reduction in trawler effort since 1991 combined with reduced catchability of some year classes in the fishing areas. Trawlers catch more young fish compared to gillnetters and longliners. Nevertheless, F on ages 6–10 continues to represent the average fishing mortality on the major age groups prosecuted by the fishery. In 2010 F<=0.2 for all ages included in the analysis (5-15 years).

Until 1976 the female spawning stock estimates varied between 60,000 and 140,000 t, then it was relatively stable at around 40,000 t until the mid 1980s 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 2003, which was the highest value estimated since 1976 and higher than the long-term average for the whole period 1964-2009. It then stayed in the 60,000-70,000 t range until 2009, followed by a rapid increase to 92,000 t in 2011. The total stock decreased from 312,000 t in 1970 to the historical minimum at 46,000 t in 1992 and then shows an increasing trend with the highest estimates of 309,000 t in 2011. The maturity ogives used have shown a very variable maturity by age in the recent years and this affects the SSB.

Prior to the reduction in the early 1990’s the fishing mortality had increased continuously for more than a decade and peaked in 1991 at 0.65. The high catch in 1999 resulted in an increase in fishing mortality to 0.31 but has since then declined to 0.14-0.15 by 2002 and 2003. For 2011 F was estimated at 0.05 which is the lowest level estimated for all years in the analysis. Recruitment-at-age 5 in this year assessment shows a marked increase from 2007 to 2009. The 2009-2010 level of 70-75 million specimens is more than twice the long-term average (Table 8.15). In 2011 the recruitment-at-age 5 is 58 millions.

8.6.2 Biological reference points

Given the continuing levels of uncertainty in the current assessment no further attempts were made to develop reference points for this stock.

8.6.3 Catch options for 2013

Given the uncertainty around the absolute values of population size at age no catch options are provided.

8.7 Comparison of this year’s assessment with last year’s assessment

Compared to last year assessment stock size and SSB for 2011 has increased, while fishing mortality remained at nearly the same level.

	Total stock (5+) by 1 January 2011	SSB by 1 January 2011	F6-10 in 2011	F6-10 in 2010
WG 2011	234073*	80326*	0.06*	0.06
WG 2012	308870	92344	0.05	0.05

*Prediction

8.8 Comments to the assessment (Figures 8.3 – 8.7)

The assessment is still considered to be uncertain due to the age-reading and input data quality problems. Nevertheless the assessment may be accepted as indicative for stock trends. Although many aspects of the assessment remain uncertain, fishery independent indices of stock size indicate positive trends in recent years. The biomass indices from the Norwegian autumn survey series seem to level out in later years (Figure 8.5 and 8.6).

The main result from the XSA assessment is that the total stock has an increasing trend since 1992 and this is also seen in the SSB from 1995 to 2004. In 2004-2009 the SSB show a decreasing signal, whereas it has a significant increase in 2011. The estimate of the SSB is based on maturity ogives from the Russian survey.

Other sources for stock trends beside the exploratory XSA analyses are abundance indices from surveys. Biomass indices of mature females from the Norwegian survey in the slope area (main adult area) shows upward trend in 1994-2003 and then a downward trend until 2008, but showed increase in 2009 and 2010 (Figure 8.5). SSB estimates from the Russian October-December survey show a general increase in mature female biomass between 1996 and 2011. Total biomass index from Russian autumn survey showed slowly increasing trend from 1992 to 2005 but has shown sharply increasing trend since then (Figure 8.4). It should be mentioned that this survey is the only tuning series with data after 2005, when Norway stopped to update age data, and the XSA results are thus not independent on the results from this survey (Figure 8.2 and 8.4). Total biomass indices from the Norwegian autumn slope survey has showed an upward trend in biomass estimates between 1994 and 2003, then a downward trend until 2008 until it increased again in 2009. Results for the 2011 survey are again down to around 2008 levels (Figure 8.6). Noticeably, the abundance in numbers in this survey has showed a marked increase since 2006, reflecting increased proportion of smaller fish in the survey length distributions for those years. In 2011 the proportion of small fish is reduced again, as is the estimated total numbers (Figure 8.6 and 8.7). The length distributions also show modes that can be followed through the years in this survey with marked change towards smaller fish between 2006 and 2007.

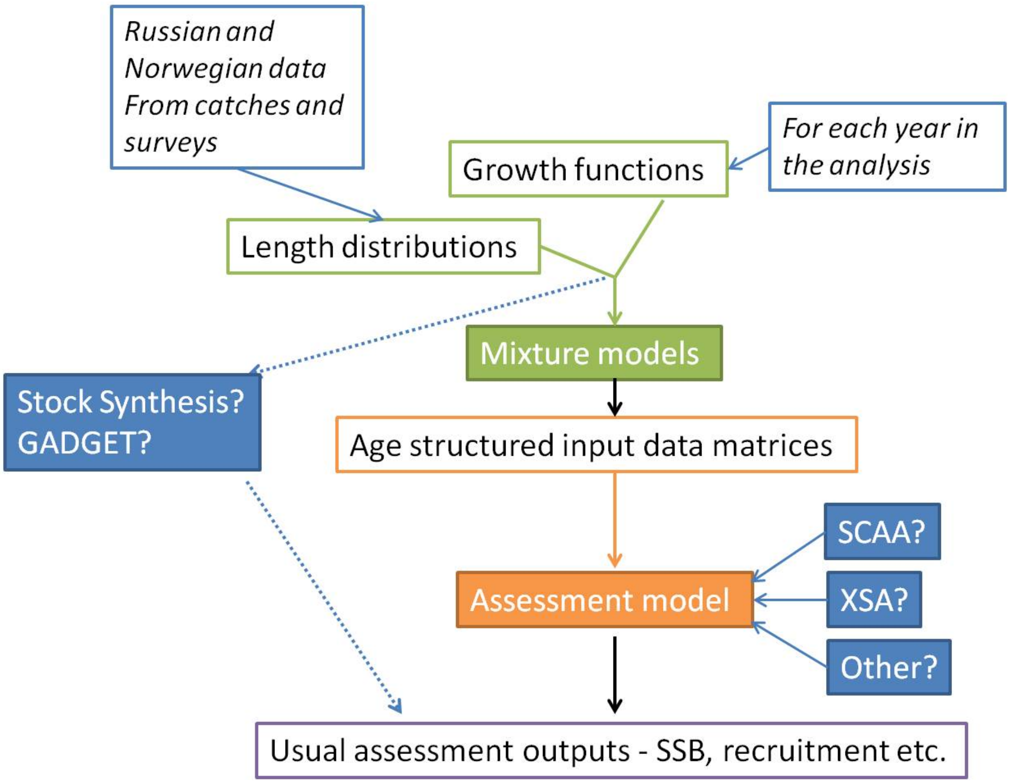
The Working Group has stated in several previous reports that catches above the mean in the period 1992-2003 (ca. 13,000 t) reduces the stocks ability to rebuild. Ever since catches were reduced by regulations in 1992 the available stock indices have in general shown increasing trend, and some indexes show strong increase in most recent years. For this long lived species this increase in recent years is a positive sign regarding recruitment into the fisheries.

Average catch during the period 2002-2011 was approximately 15,600 t. At the same time most of the monitored population parameters in general showed positive trends. This supports that this catch level is at least not harmful for the NEA stock.

8.9 Further work on assessment methods

The evaluation of the NEA Greenland halibut stock is uncertain due to age-reading problems and lack of contrast in the data, as also reflected in recent AFWG reports. This is the background for the suggested ICES benchmark in 2013.

The 2011 working group outlined a possible approach that conceptually can be presented as follows:



Also less data demanding supporting approaches as surplus biomass models can be examined. They can potentially give rough idea on MSY and be useful to compare with results from other models.

To revise accepted analytical age structured assessment requires recalculations of catch and survey data back in time that incorporates changes in growth functions.

All points mentioned above in this subchapter need to be carefully explored and discussed by experts in order to investigate the possibility of using any new approaches as helpful tools but not as sources of additional uncertainties.

The respective national institutes (IMR, PINRO) need to focus effort to address this challenge before next year's AFWG meeting, in particular by making all relevant survey and catch data available by length and sex. Additionally analysis and programming resources need to be made available.

The annual meeting between Russian and Norwegian scientists in March 2011 concluded:

"4.6 Data requirements for revision of Greenland halibut assessment

A PINRO/IMR working group should be established to make preparation work for ICES benchmark meeting for Greenland halibut that is planned in 2013. The assessment of the NEA Greenland halibut stock is uncertain due to age-reading problems and lack of contrast in the data, as also reflected in resent ICES arctic fisheries working group (AFWG) reports. AFWG 2011 recognized the need to facilitate work toward accepted analytical assessment for this stock. In the preparation for the benchmark meeting there is a need for a joint effort by Russia and Norway to prepare and make available necessary data in good time in advance. This way it is possible to do exploratory analysis with a variety of methods using models which can be structured in various ways (by biomass/age/length/sex), and allow for exploration of the consequences of various assumptions about growth patterns. The data needed are:

Catch in tons (by quarter)

Length distribution in the catch (preferably for each quarter, but one each year would do)

Length distribution in the survey(s)

Survey index from the survey(s)

Length-weight relationships

Data should be prepared in adequate spatial and temporal resolution. It would be highly preferable if the data are available as soon as possible." (PROTOCOL of the Annual Meeting between Norwegian and Russian Scientists Hamn i Senja, 12-16 March 2012).

A fixed quota for this stock was agreed by JRNFC for the period 2010-2012. It is urgent with new assessment methods to provide as good assessments and advice as possible.

To facilitate thorough scrutiny of data and analytical assessment alternatives the meeting recommends the benchmark to be held in autumn 2013.

8.10 Response to ACOM technical minutes

Comments from reviewers will be kept in mind in the upcoming benchmark process.

Table 8.1. GREENLAND HALIBUT in Sub-areas I and II.

Nominal catch (t) by countries (Sub-area I, Divisions IIa and IIb combined) as officially reported to ICES.

Year	Denmark	Estonia	Faroe Isl.	France	Fed. Rep. Germany	Gre enland	Iceland	Ireland	Lithuania	Norway	Poland	Portugal	Russia[3]	Spain	UK (England & Wales)	UK (Scotland)	Total
1984	0	0	0	138	2,165	0	0	0	0	4,376	0	0	15,181	0	23	0	21,883
1985	0	0	0	239	4,000	0	0	0	0	5,464	0	0	10,237	0	5	0	19,945
1986	0	0	42	13	2,718	0	0	0	0	7,890	0	0	12,200	0	10	2	22,875
1987	0	0	0	13	2,024	0	0	0	0	7,261	0	0	9,733	0	61	20	19,112
1988	0	0	186	67	744	0	0	0	0	9,076	0	0	9,430	0	82	2	19,587
1989	0	0	67	31	600	0	0	0	0	10,622	0	0	8,812	0	6	0	20,138
1990	0	0	163	49	954	0	0	0	0	17,243	0	0	4,764[2]	0	10	0	23,183
1991	11	2,564	314	119	101	0	0	0	0	27,587	0	0	2,490[2]	132	0	2	33,320
1992	0	0	16	111	13	13	0	0	0	7,667	0	31	718	23	10	0	8,602
1993	2	0	61	80	22	8	56	0	30	10,380	0	43	1,235	0	16	0	11,933
1994	4	0	18	55	296	3	15	5	4	8,428	0	36	283	1	76	2	9,226
1995	0	0	12	174	35	12	25	2	0	9,368	0	84	794	1 106	115	7	11,734
1996	0	0	2	219	81	123	70	0	0	11,623	0	79	1,576	200	317	57	14,347
1997	0	0	27	253	56	0	62	2	0	7,661	12	50	1,038	157[2]	67	25	9,410
1998	0	0	57	67	34	0	23	2	0	8,435	31	99	2,659	259[2]	182	45	11,893
1999	0	0	94	0	34	38	7	2	0	15,004	8	49	3,823	319[2]	94	45	19,517
2000	0	0	0	45	15	0	16	1	0	9,083	3	37	4,568	375[2]	111	43	14,297
2001	0	0	0	122	58	0	9	1	0	10,896[2]	2	35	4,694	418[2]	100	30	16,365
2002	0	219	0	7	42	22	4	6	0	7,011[2]	5	14	5,584	178[2]	41	28	13,161
2003	0	0	459	2	18	14	0	1	0	8,347[2]	5	19	4,384	230[2]	41	58	13,578
2004	0	0	0	0	9	0	9	0	0	13,840[2]	1[2]	50	4,662	186[2]	43	0	18,800
2005	0	170	0	32	8	0	0	0	0	13,011[2]	0[2]	23	4,883	660[2]	29	18	18,834
2006	0	0	204	46	8	0	8	0	196	11,119[2]	201[2]	26[2]	6,055	27[2]	6	0	17,897
2007	0	0	203	40	8	0	15	+	0	8,229[2]	200[2]	47[2]	6,484	11[2]	0	0	15,237
2008	0	0	640	42	5	0	28	0	0	7,394[2]	201[2]	46[2]	5,294	112	16	0	13,778
2009[1]	0	0	422	16	19	20	15	2	0	8,446[2]	204[2]	239	3,335	210[2]	69	0	12,996
2010[1]	0	0	272	102	14	15	16	0	0	7,685[2]	3[2]	11	6,888	190[2]	26	0	15,221
2011[1]	0	0	404	32	81	4	3	0	250	8,273[2]	169	21.5	7,053	145[2]	40	0	16,474

[1] **Provisional figures.**

[2] **Working Group figures.**

[3] **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	Lithuania	Greenland	Iceland	Ireland	Norway	Poland	Portugal	Russia[3]	Spain	UK (E & W)	UK (Scot.)	Total
1984	-	-	-	-	-	-	-	-	593	-	-	81	-	17	-	691
1985	-	-	-	-	-	-	-	-	602	-	-	122	-	1	-	725
1986	-	-	1	-	-	-	-	-	557	-	-	615	-	5	1	1,179
1987	-	-	2	-	-	-	-	-	984	-	-	259	-	10	+	1,255
1988	-	9	4	-	-	-	-	-	978	-	-	420	-	7	-	1,418
1989	-	-	-	-	-	-	-	-	2,039	-	-	482	-	+	-	2,521
1990	-	7	-	-	-	-	-	-	1,304	-	-	321[2]	-	-	-	1,632
1991	164	-	-	-	-	-	-	-	2,029	-	-	522[2]	-	-	-	2,715
1992	-	-	+	-	-	-	-	-	2,349	-	-	467	-	-	-	2,816
1993	-	32	-	-	-	-	56	-	1,754	-	-	867	-	-	-	2,709
1994	-	17	217	-	-	-	15	-	1,165	-	-	175	-	+	-	1,589
1995	-	12	-	-	-	-	25	-	1,352	-	-	270	84	-	-	1,743
1996	-	2	+	-	-	-	70	-	911	-	-	198	-	+	-	1,181
1997	-	15	-	-	-	-	62	-	610	-	-	170	-[2]	+	-	857
1998	-	47	+	-	-	-	23	-	859	-	-	491	-[2]	2	-	1,422
1999	-	91	-	-	-	13	7	-	1,101	-	-	1,203	-[2]	+	-	2,415
2000	-	-	+	-	-	-	16	-	1,021	+	-	1,169	-[2]	1	-	2,206
2001	-	-	-	-	-	-	9	-	925[2]	+	-	951	-[2]	2	-	1,887
2002	-	-	3	-	-	-	+	-	791[2]	-	-	1,167	-[2]	+	-	1,961
2003	-	48	+	+	-	2	+	1	949[2]	1	-	735	+[2]	+	+	1,736
2004	-	-	-	-	-	-	+	-	812[2]	-	-	633	-[2]	3	-	1,449
2005	-	-	-	1	-	-	-	-	572[2]	-	-	595	-[2]	3	-	1,171
2006	-	17	1	-	-	-	1	-	575[2]	-	-	626	-[2]	2	-	1,222
2007	-	18	+	+	-	+	3	-	514[2]	-	-	438	+	+	-	973
2008	-	12	-	1	-	-	5	-	599[2]	-	-	390	-	-	-	1,007
2009[1]	-	33	-	-	-	16	5	-	734[2]	-	2	483	-	1	-	1,272
2010[1]	-	15	-	-	-	-	16	-	733[2]	-	-	708	2[2]	-	-	1,473
2011[1]	-	10	-	-	+	-	-	-	894[2]	-	-	782	-	-	-	1,686

[1] **Provisional figures.**

[2] **Working Group figures.**

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

Table 8.3. GREENLAND HALIBUT in Sub areas I and II. Nominal catch (t) by countries in Division IIa as officially reported to ICES.

Year	Estonia	Faroe Islands	Fed. Rep. Germ.	France	Greenland	Iceland	Ireland	Norway	Poland	Portugal	Russia[5]	Spain	UK (E & W)	UK (Scot.)	Total
1984	-	-	265	138	-		-	3,703	-	-	5,459	-	1	-	9,566
1985	-	-	254	239	-		-	4,791	-	-	6,894	-	2	-	12,180
1986	-	6	97	13	-		-	6,389	-	-	5,553	-	5	1	12,064
1987	-	-	75	13	-		-	5,705	-	-	4,739	-	44	10	10,586
1988	-	177	150	67	-		-	7,859	-	-	4,002	-	56	2	12,313
1989	-	67	104	31	-		-	8,050	-	-	4,964	-	6	-	13,222
1990	-	133	12	49	-		-	8,233	-	-	1,246[2]	-	1	-	9,674
1991	1,400	314	21	119	-		-	11,189	-	-	305[2]	-	+	1	13,349
1992	-	16	1	108	13[4]		-	3,586	-	15[3]	58	-	1	-	3,798
1993	-	29	14	78	8[4]		-	7,977	-	17	210	-	2	-	8,335
1994	-	-	33	47	3[4]		4	6,382	-	26	67	+	14	-	6,576
1995	-	-	30	174	12[4]		2	6,354	-	60	227	-	83	2	6,944
1996	-	-	34	219	123[4]		-	9,508	-	55	466	4	278	57	10,744
1997	-	-	23	253	-[4]		-	5,702	-	41	334	1[2]	21	25	6,400
1998	-	-	16	67	-[4]		1	6,661	-	80	530	5[2]	74	41	7,475
1999	-	-	20	-	25[4]		2	13,064	-	33	734	1[2]	63	45	13,987
2000	-	-	10	43	-[4]		+	7,536	-	18	690	1[2]	65	43	8,406
2001	-	-	49	122	-[4]	9	1	8,740	-	13	726	5[2]	56	30	9,751
2002	-	-	9	7	22[4]	4	-	5,780[2]	-	3	849	-[2]	12	28	6,714
2003	-	390	5	2	12[4]	+	+	6,778[2]	+	10	1,762	14[2]	5	58	9,036
2004	-	-	4	-	-[4]	9	-	11,633[2]	-	24	810	4[2]	1	-	12,485
2005	-	-	3	31	-[4]	-	-	11,216[3]	-	11	1,406	+	5	18	12,690
2006	-	175	-	38	-	7	-	8,897[3]	-[2]	6	950	+	2	-	10,075
2007	-	162	2	37	+	12	-	6,760[3]	-[2]	2	489[2]	-	+	+	7,463
2008	-	626	4	38	-	23	-	5,566[3]	1	1	1,170	3	16	-	7,448
2009[1]	-	379	+	14	4	10	-	6,456[3]	-	9	1,531	-	60	-	8,464
2010[1]	-	255	-	102	15	-		6,040[3]	-	+	4,757	+	22	-	11,199
2011[1]	-	387	-	32	4	3	-	6,500[3]	-	0	3,643	2	4	-	10,575

[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	-	-	12	8	7	-	196	1,647[3]	201[2]	20	4,479	27[2]	2	-	6,600
2007	-	-	23	3	6	+	-	955[3]	200[2]	45	5,557	11[2]	+	+	6,800
2008	-	-	2	3	1	-	-	1,229[3]	200	45	3,734	109	0	-	5,323
2009[1]	-	-	10	2	19	2	-	1,256[3]	204	228	1,321	210[2]	8	-	3,259
2010[1]	-	-	2	-	14	-	-	904[3]	3	11	1,423	188	4	-	2,546
2011[1]	-	-	6	-	81	-	250	879[3]	169	21	2,628	143[2]	36	-	4,213

[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	Other	Total
1980	1 189	336	11 759			13 284
1981	730	459	13 829			15 018
1982	748	679	15 362			16 789
1983	1 648	1 388	19 111			22 147
1984	1 200	1 453	19 230			21 883
1985	1 668	750	17 527			19 945
1986	1 677	497	20 701			22 875
1987	2 239	588	16 285			19 112
1988	2 815	838	15 934			19 587
1989	1 342	197	18 599			20 138
1990	1 372	1 491	20 325			23 188
1991	1 904	4 552	26 864			33 320
1992	1 679	1 787	5 787			9 253
1993	1 497	2 493	7 889			11 879
1994	1 403	2 392	5 353			9 148
1995	1 500	4 034	5 494			11 028
1996	1 480	4 616	7 977			14 073
1997	998	3 378	5 198			9 574
1998	1 327	3 891	6 664			11 882
1999	2 565	6 804	10 177			19 546
2000	1 707	5 029	7 700			14 437
2001	2 041	6 303	7 968			16 312
2002	1 737	5 309	6 115			13 161
2003	2 046	5 483	6 049			13 578
2004	2 290	7 135	8 778	599		18 801
2005	1 842	7 539	9 420	447		19 248
2006	1 503	6 146	10 042	205		17 896
2007	997	4503	9 618	119		15 237
2008	901	3575	9 285	9	8	13 778
2009	1 409	4 952	6 583	34	18	12 996
2010	1 449	5 427	8 165	170	10	15 221
2011	1 583	5 039	9 597	239	15	16 473

Table 8.6. GREENLAND HALIBUT in Sub-areas I and II. Catch per unit effort and total effort.

Year	USSR catch/hour trawling (t)		Norway[10] catch/hour trawling (t)		Average CPUE		Total effort (in '000 hrs trawling)[5]	CPUE 7+[6]	GDR[7] (catch/day tonnage (kg)
	RT[1]	PST[2, 12]	A[8]	B[9]	A[3]	B[4]			
1965	0.80	-	-	-	0.80	-	-	-	-
1966	0.77	-	-	-	0.77	-	-	-	-
1967	0.70	-	-	-	0.70	-	-	-	-
1968	0.65	-	-	-	0.65	-	-	-	-
1969	0.53	-	-	-	0.53	-	-	-	-
1970	0.53	-	-	-	0.53	-	169	0.50	-
1971	0.46	-	-	-	0.46	-	172	0.43	-
1972	0.37	-	-	-	0.37	-	116	0.33	-
1973	0.37	-	0.34	-	0.36	-	83	0.36	-
1974	0.40	-	0.36	-	0.38	-	100	0.36	-
1975	0.39	0.51	0.38	-	0.39	0.45	99	0.37	-
1976	0.40	0.56	0.33	-	0.37	0.45	100	0.34	-
1977	0.27	0.41	0.33	-	0.30	0.37	96	0.26	-
1978	0.21	0.32	0.21	-	0.21	0.27	123	0.17	-
1979	0.23	0.35	0.28	-	0.26	0.32	67	0.19	-
1980	0.24	0.33	0.32	-	0.28	0.33	47	0.25	-
1981	0.30	0.36	0.36	-	0.33	0.36	42	0.28	-
1982	0.26	0.45	0.41	-	0.34	0.43	39	0.37	-
1983	0.26	0.40	0.35	-	0.31	0.38	58	0.32	-
1984	0.27	0.41	0.32	-	0.30	0.37	59	0.30	-
1985	0.28	0.52	0.37	-	0.33	0.45	44	0.37	-
1986	0.23	0.42	0.37	-	0.30	0.40	57	0.32	-
1987	0.25	0.50	0.35	-	0.30	0.43	44	0.35	-
1988	0.20	0.30	0.31	-	0.26	0.31	63	0.26	4.26
1989	0.20	0.30	0.26	-	0.23	0.28	73	0.19	2.95
1990	-	0.20	0.27	-	-	0.24	95	0.16	1.66
1991	-	-	0.24	-	-	-	134	0.18	-
1992	-	-	0.46	0.72	-	-	20	0.29	-
1993	-	-	0.79	1.22	-	-	15	0.65	-
1994	-	-	0.77	1.27	-	-	11	0.70	-
1995	-	-	1.03	1.48	-	-	-	-	-
1996	-	-	1.45	1.82	-	-	-	-	-
1997	0.71	-	1.23	1.60	-	-	-	-	-
1998	0.71	-	0.98	1.35	-	-	-	-	-
1999	0.84	-	0.82	1.77	-	-	-	-	-
2000	0.94	-	1.38	1.92	-	-	-	-	-
2001	0.82 [11]	-	1.18	1.57	-	-	-	-	-
2002	0.85	-	1.07	1.82	-	-	-	-	-
2003	0.97 [12]	-	0.86	2.45	-	-	-	-	-
2004	0.63 [13]	-	1.16	1.79	-	-	-	-	-
2005	0.61 [12]	-	1.30	2.29	-	-	-	-	-
2006	0.57 [12]	-	0.96	2.09	-	-	-	-	-
2007	0.64 [12]	-	-	-	-	-	-	-	-
2008	0.48 [12]	-	-	-	-	-	-	-	-
2009	0.77 [13]	-	-	-	-	-	-	-	-
2010	-	1.57[12]	-	-	-	-	-	-	-
2011	-	2.32[12]	-	-	-	-	-	-	-

[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: 2012/1)

At 19/04/2012 18:49

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

AGE	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
5	372	253	170	156	114	1064	526	80	1109	212	917	840
6	1480	853	563	332	283	2420	2792	4486	3521	1117	2519	2337
7	2808	1735	1106	623	452	3208	10464	12712	9605	3923	6204	6520
8	5674	3868	2715	2006	1976	6288	18562	12283	6438	3515	3838	4118
9	4951	4203	4054	3237	3923	4921	10034	6130	2775	2551	1834	2265
10	3981	3799	2499	2409	2950	4431	6671	4339	1734	1919	1942	1654
11	1853	1799	1284	1718	2234	2381	2517	2703	1368	1536	1622	1857
12	1018	1002	783	871	792	812	1250	1660	1234	1127	1338	1536
13	364	372	246	315	146	229	616	1044	675	716	734	1122
14	251	282	261	155	43	100	1104	300	200	251	531	600
+gp	76	50	28	19	7	30	281	143	80	126	216	368
0 TOTALNUM	22828	18216	13709	11841	12920	25884	54817	45880	28739	16993	21695	23217
TONSLAND	40391	34751	26321	24267	26168	43789	89484	79034	43055	29938	37763	38172
SOPCOF %	100	100	101	100	100	103	94	104	98	92	98	88

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

AGE	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
5	830	2037	1897	2218	731	1896	1304	1543	915	1219	1672	1212
6	2982	3255	3589	3155	1138	1917	1494	1864	3698	2874	3335	2972
7	5824	4200	4118	2727	1665	1919	1276	1851	3350	2561	2712	3572
8	5002	2524	2365	1234	1341	933	1208	2287	1938	1548	1531	1746
9	3000	1610	1509	495	944	484	1493	1491	1064	972	1128	752
10	1350	1104	946	319	473	448	1258	1228	1191	1037	997	828
11	915	1062	934	296	511	482	838	713	602	614	530	362
12	1212	858	438	243	275	380	502	488	340	363	434	202
13	698	595	349	103	242	384	324	247	171	161	314	186
14	526	384	147	45	145	150	108	201	132	120	305	63
+gp	358	180	112	51	78	62	46	64	71	63	239	7
0 TOTALNUM	22697	17809	16404	10886	7543	9055	9851	11977	13472	11532	13197	11902
TONSLAND	36074	28827	24617	17312	13284	15018	16789	22147	21883	19945	22875	19112
SOPCOF %	93	101	105	104	109	107	100	98	100	99	98	101

Table 8.7 (Continued)

Run title : NEA Greenland halibut (run: 2012/1)

At 19/04/2012 18:49

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

AGE	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
5	907	2080	2139	3312	1098	1140	631	846	1034	330	359	433
6	2540	4453	5163	3889	1195	1088	708	992	2083	921	1116	1905
7	3141	3655	4642	4716	1069	1608	1252	1719	3795	1822	2466	3955
8	2096	1657	1932	2355	778	1118	817	990	1426	953	1464	1810
9	1182	801	1221	1031	360	140	310	405	262	342	527	914
10	860	318	499	1284	600	976	642	726	655	822	924	1905
11	481	228	264	774	188	444	416	461	270	231	237	380
12	313	126	314	673	150	144	330	371	132	150	122	237
13	133	120	42	177	79	36	88	154	29	18	15	67
14	140	140	96	266	89	20	39	56	22	41	29	42
+gp	47	28	44	517	56	4	3	8	1	1	15	7
0												
TOTALNUM	11840	13606	16356	18994	5662	6718	5236	6728	9709	5631	7274	11655
TONSLAND	19587	20138	23183	33320	8602	11933	9226	11734	14347	9410	11893	19517
SOPCOF %	100	103	102	105	95	102	99	101	101	99	100	102

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

AGE	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
5	380	441	277	397	290	429	566	987	449	982	206	424
6	735	1347	921	1025	1016	1072	1432	1598	751	1180	612	828
7	1926	2338	1475	1827	2316	1962	2345	2202	1231	1448	906	1414
8	1464	1325	983	928	1392	1766	1898	1134	1277	1834	1428	1918
9	743	788	631	632	1087	936	1138	629	790	761	949	1303
10	1318	1140	1097	1045	778	991	677	436	314	268	471	698
11	457	519	563	520	675	616	471	426	365	540	440	630
12	330	372	301	311	607	622	490	464	412	341	681	563
13	49	115	132	77	199	376	377	246	341	316	524	322
14	37	54	59	107	155	244	167	169	207	101	173	200
+gp	14	12	42	26	105	328	184	224	247	121	290	244
0												
TOTALNUM	7453	8451	6481	6895	8620	9342	9745	8515	6384	7892	6680	8544
TONSLAND	14437	16307	13161	13578	18800	18834	17897	15237	13778	12996	15221	16337
SOPCOF %	101	100	100	100	99	97	101	96	101	102	99	100

Table 8.8. Catch weights at age (kg)

Run title : NEA Greenland halibut (run: 2012/1)

At 19/04/2012 18:49

Table 2 Catch weights at age (kg)

AGE	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
5	0.42	0.42	0.42	0.42	0.42	0.42	0.567	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	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	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	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	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	2.281
11	3.11	3	2.94	2.84	2.79	2.99	2.887	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	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	4.303
14	5.01	4.91	4.84	4.88	5	5.38	4.931	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	5.91
0 SOPCOFAC	0.9986	1.0046	1.0054	1.0024	0.9994	1.0262	0.9436	1.0434	0.9752	0.9231	0.9825	0.8805

Table 2 Catch weights at age (kg)

AGE	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
5	0.567	0.567	0.567	0.9	0.702	0.66	0.69	0.75	0.63	0.6	0.62	0.709
6	0.737	0.737	0.737	1.2	0.872	0.84	0.84	1.04	0.96	0.89	0.92	1.003
7	1.079	1.079	1.079	1.5	1.141	1.15	1.03	1.34	1.18	1.2	1.28	1.266
8	1.421	1.421	1.421	1.8	1.468	1.56	1.31	1.57	1.53	1.85	1.9	1.683
9	1.848	1.848	1.848	2.2	1.778	2.04	1.74	1.97	2.31	2.59	2.48	2.482
10	2.281	2.281	2.281	2.6	2.302	2.57	2.24	2.73	2.87	3.18	3.11	2.982
11	2.887	2.887	2.887	3	2.664	2.98	2.77	3.29	3.46	3.62	3.35	3.547
12	3.247	3.247	3.247	3.5	3.046	3.43	3.37	4.22	3.77	3.95	3.72	3.8
13	4.303	4.303	4.303	4.1	3.368	4.13	4.32	4.71	3.99	4.48	4	4.56
14	4.931	4.931	4.931	4.8	4.285	4.68	5.35	6.08	4.35	4.25	4.18	5.002
+gp	5.923	6.027	5.906	6.176	5.346	5.999	5.833	6.122	4.525	4.825	4.526	5.953
0 SOPCOFAC	0.9255	1.0095	1.0485	1.0364	1.0894	1.068	1.0038	0.9783	1.0009	0.9858	0.9782	1.0116

Table 2 Catch weights at age (kg)

AGE	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
5	0.74	0.76	0.71	0.77	0.68	0.79	0.72	0.73	0.77	0.77	0.73	0.7	0.76
6	0.962	1.03	1.06	1.05	0.97	1.02	0.94	0.94	0.97	0.94	0.93	0.95	0.97
7	1.249	1.32	1.29	1.38	1.27	1.35	1.27	1.25	1.31	1.28	1.3	1.27	1.33
8	1.626	1.8	1.7	1.75	1.76	1.88	1.72	1.74	1.74	1.64	1.61	1.55	1.63
9	2.164	2.42	2.1	2.2	2.21	2.46	2.19	2.09	2.24	2.07	2.12	2	2.11
10	2.897	3.13	2.61	2.6	2.56	2.67	2.52	2.51	2.59	2.59	2.57	2.46	2.61
11	3.406	3.37	2.87	2.79	3.11	3.43	2.97	2.95	3.29	3.3	3.25	3.22	3.35
12	3.661	4.05	3.45	3.28	3.59	4.29	3.29	3.34	4.02	4.01	3.91	3.85	3.97
13	4.247	4.29	3.72	3.89	3.83	5.08	3.84	3.83	4.75	4.83	4.9	4.61	4.97
14	4.187	4.5	4.09	4.38	4.25	6.33	4.95	4.98	6.24	5.95	5.66	5.84	5.82
+gp	4.463	4.72	4.52	5.29	4.8	8.91	6.68	8.15	6.09	6.26	4.91	5.98	7.22
0 SOPCOFAC	0.9973	1.0346	1.0204	1.047	0.9519	1.0183	0.9937	1.0095	1.0066	0.9851	0.9983	1.0172	1.0055

Table 2 Catch weights at age (kg)

AGE	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
5	0.74	0.69	0.715	0.77	0.669	0.637	0.626	0.695	0.567	0.532	0.502
6	1.03	0.94	1.05	1.095	0.952	0.86	0.903	0.919	0.802	0.796	0.742
7	1.39	1.36	1.428	1.498	1.306	1.149	1.313	1.359	1.071	1.117	1.018
8	1.75	1.68	1.748	1.903	1.653	1.53	1.686	1.756	1.471	1.492	1.415
9	2.29	2.18	2.318	2.463	2.131	2.122	2.321	2.231	1.928	2.045	1.935
10	2.68	2.68	2.615	2.775	2.544	2.622	2.553	2.378	2.216	2.437	2.374
11	3.33	3.19	3.043	3.128	2.848	2.699	2.925	2.855	2.63	2.876	2.773
12	3.92	3.89	3.694	3.809	3.334	3.315	3.189	3.23	3.082	3.39	3.195
13	4.81	4.46	4.566	4.291	3.734	3.998	3.747	3.546	3.791	3.897	3.905
14	5.81	5.25	5.568	5.453	4.384	4.641	4.539	3.915	4.528	5.222	4.109
+gp	7.41	6.32	6.365	6.355	5.791	6.743	9.078	7.453	7.069	6.798	6.092
0											
SOPCOFAC	1.0014	1	0.996	0.9853	0.9655	1.0055	0.9592	1.0086	1.0157	0.9936	1.0041

Table 8.9. Proportion mature at age

Run title : NEA Greenland halibut (run: 2012/1)

At 19/04/2012 18:49

Table 5 Proportion mature at age

AGE	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
5	0	0	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	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	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	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	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	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	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	0.98	0.98
13	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1
+gp	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
5	0	0	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	0.04	0.04	0.03	0.01	0.01	0.01
7	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.02	0.01	0.02
8	0.21	0.21	0.21	0.21	0.21	0.21	0.18	0.18	0.19	0.24	0.22	0.21	0.18
9	0.67	0.67	0.67	0.67	0.67	0.67	0.6	0.61	0.65	0.74	0.66	0.53	0.49
10	0.86	0.86	0.86	0.86	0.86	0.86	0.82	0.83	0.85	0.91	0.9	0.87	0.8
11	0.98	0.98	0.98	0.98	0.98	0.98	0.96	0.97	0.97	0.99	0.95	0.89	0.89
12	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.99	0.98	0.98	0.98	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1
+gp	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 8.9 (Continued)

Table 5 Proportion mature at age

AGE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
5	0	0	0	0.01	0.01	0.01	0	0	0	0	0	0.01	0.01
6	0.01	0.01	0.01	0.01	0.01	0.01	0	0	0	0	0.01	0.03	0.03
7	0.02	0.04	0.06	0.08	0.07	0.08	0.07	0.07	0.04	0.02	0.03	0.06	0.1
8	0.17	0.15	0.28	0.32	0.34	0.29	0.25	0.21	0.1	0.07	0.1	0.19	0.31
9	0.51	0.54	0.66	0.68	0.69	0.58	0.58	0.53	0.45	0.33	0.37	0.49	0.66
10	0.77	0.77	0.86	0.83	0.81	0.79	0.88	0.85	0.82	0.66	0.63	0.65	0.79
11	0.91	0.89	0.87	0.88	0.95	0.96	0.97	0.94	0.92	0.86	0.87	0.84	0.91
12	1	1	1	0.94	0.94	0.89	0.94	0.94	1	0.99	0.96	0.96	0.96
13	1	1	1	1	1	1	1	1	1	1	1	1	0.99
14	1	1	1	1	1	1	1	1	1	1	1	1	1
+gp	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 5 Proportion mature at age

AGE	2003	2004	2005	2006	2007	2008	2009	2010	2011
5	0.01	0	0	0	0	0	0	0	0
6	0.02	0.01	0.01	0.01	0.01	0.01	0	0	0
7	0.11	0.08	0.05	0.05	0.04	0.03	0.02	0.04	0.04
8	0.34	0.28	0.22	0.18	0.13	0.07	0.04	0.09	0.11
9	0.72	0.66	0.57	0.5	0.34	0.24	0.19	0.26	0.3
10	0.88	0.91	0.88	0.74	0.53	0.36	0.34	0.36	0.39
11	0.92	0.94	0.91	0.85	0.66	0.58	0.54	0.61	0.61
12	0.97	0.96	0.95	0.93	0.8	0.73	0.73	0.77	0.78
13	0.98	0.98	0.99	0.98	0.86	0.82	0.83	0.88	0.88
14	0.98	0.98	0.98	0.99	0.96	0.96	0.97	1	1
+gp	1	1	1	1	0.99	0.99	0.99	1	1

Table 8.10. Extended Survivors Analysis

Lowestoft VPA Version 3.1

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Extended Survivors Analysis

NEA Greenland halibut (run: 2012/1)

CPUE data from file fleet

Catch data for 48 years. 1964 to 2011. Ages 5 to 15.

FLEET			FIRST	LAST	FIRST	LAST	ALPHA	BETA
year	year	age	age					
FLT04:Norw.Exp.CP	1992	2011	5	14	0.38	0.44		
FLT07:Russ.Surv.	ne	1992	2011	5	14	0.75	0.92	
FLT08:Norw.Comb.Sur	1996	2011	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 2011
shrunk towards1.000 * the mean F of ages 9 - 13
S.E. of the mean to which the estimates are shrunk = .500
Minimum standard error for population estimates from each cohort age = .300
Individual fleet weighting not applied
Tuning converged after 88 iterations
Regression weights

	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1
Fishing mortalities										
Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
5	0.012	0.019	0.013	0.015	0.017	0.028	0.011	0.015	0.003	0.008
6	0.059	0.055	0.059	0.057	0.06	0.058	0.026	0.033	0.011	0.014
7	0.123	0.152	0.16	0.146	0.163	0.118	0.055	0.06	0.03	0.03
8	0.115	0.101	0.157	0.167	0.194	0.104	0.088	0.103	0.074	0.079
9	0.092	0.096	0.156	0.143	0.146	0.086	0.093	0.066	0.067	0.085
10	0.264	0.205	0.155	0.197	0.138	0.073	0.054	0.039	0.05	0.061
11	0.238	0.182	0.187	0.167	0.128	0.114	0.076	0.116	0.08	0.083
12	0.251	0.189	0.315	0.249	0.184	0.17	0.147	0.09	0.199	0.131
13	0.239	0.089	0.168	0.31	0.222	0.126	0.172	0.152	0.184	0.129
14	0.249	0.293	0.245	0.303	0.208	0.139	0.14	0.067	0.11	0.094

Table 8.10 (Continued)

XSA population numbers (Thousands)

	AGE									
YEAR	5	6	7	8	9	10	11	12	13	14
2002	2.44E+04	1.72E+04	1.37E+04	9.74E+03	7.74E+03	5.10E+03	2.86E+03	1.46E+03	6.70E+02	2.89E+02
2003	2.27E+04	2.07E+04	1.40E+04	1.04E+04	7.47E+03	6.07E+03	3.37E+03	1.94E+03	9.77E+02	4.54E+02
2004	2.44E+04	1.92E+04	1.69E+04	1.03E+04	8.13E+03	5.84E+03	4.26E+03	2.42E+03	1.38E+03	7.70E+02
2005	3.11E+04	2.07E+04	1.56E+04	1.24E+04	7.59E+03	5.99E+03	4.31E+03	3.04E+03	1.52E+03	1.01E+03
2006	3.62E+04	2.64E+04	1.68E+04	1.16E+04	9.01E+03	5.66E+03	4.23E+03	3.14E+03	2.04E+03	9.60E+02
2007	3.81E+04	3.06E+04	2.14E+04	1.23E+04	8.22E+03	6.70E+03	4.25E+03	3.21E+03	2.25E+03	1.41E+03
2008	4.59E+04	3.19E+04	2.49E+04	1.63E+04	9.56E+03	6.50E+03	5.36E+03	3.26E+03	2.33E+03	1.70E+03
2009	7.07E+04	3.91E+04	2.67E+04	2.02E+04	1.29E+04	7.49E+03	5.30E+03	4.28E+03	2.42E+03	1.69E+03
2010	7.42E+04	5.99E+04	3.26E+04	2.17E+04	1.57E+04	1.04E+04	6.20E+03	4.06E+03	3.36E+03	1.79E+03
2011	5.85E+04	6.37E+04	5.10E+04	2.72E+04	1.73E+04	1.27E+04	8.50E+03	4.93E+03	2.86E+03	2.41E+03

Estimated population abundance at 1st Jan 2012

0.00E+00	5.00E+04	5.41E+04	4.26E+04	2.16E+04	1.37E+04	1.02E+04	6.73E+03	3.72E+03	2.17E+03

Taper weighted geometric mean of the VPA populations:

3.45E+04	2.68E+04	1.95E+04	1.29E+04	8.58E+03	5.90E+03	3.58E+03	2.17E+03	1.20E+03	7.00E+02

Standard error of the weighted Log(VPA populations) :

0.4819	0.48	0.4416	0.422	0.4457	0.4644	0.6358	0.77	0.9605	1.0558

Log catchability residuals.

Fleet : FLT04:Norw.Exp.CP

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
5	0.65	1.22	0.96	1.07	1.29	1.2	-0.4	-0.11	0.47	-0.26
6	0.04	0.29	0.42	0.13	0.94	0.33	0	-0.03	0.01	-0.04
7	-0.24	0.32	0.34	0.34	0.56	0.22	0.19	0	0.35	-0.22
8	0.07	0.43	0.5	0.5	0.4	0	0.06	-0.06	-0.02	0.35
9	-1.47	-1.45	-0.95	0.22	-0.29	-0.07	-0.27	-1.26	-0.05	0.19
10	-0.12	0.39	0.59	1.04	0.25	0.71	-0.81	0.42	0.51	-0.01
11	0.1	0.18	0.07	0.46	-0.41	0.69	-0.82	-0.94	-1.01	-0.72
12	0.34	0.11	-0.54	0.38	-0.55	0.64	-0.8	0.61	-0.02	-0.07
13	-0.12	0.12	-0.49	0.02	99.99	0.24	99.99	-0.69	0.26	-0.91
14	-1.4	-0.08	-0.46	0.32	-0.12	-0.09	99.99	-0.05	99.99	-0.61

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
5	-0.19	-0.01	-0.02	-0.58	99.99	99.99	99.99	99.99	99.99	99.99
6	-0.17	-0.1	-0.14	0.04	99.99	99.99	99.99	99.99	99.99	99.99
7	0.21	-0.12	-0.26	-0.22	99.99	99.99	99.99	99.99	99.99	99.99
8	-0.22	-0.55	-0.06	0.32	99.99	99.99	99.99	99.99	99.99	99.99
9	0	0.17	0.29	0.39	99.99	99.99	99.99	99.99	99.99	99.99
10	0.09	0.12	-0.68	-0.19	99.99	99.99	99.99	99.99	99.99	99.99
11	-0.73	-0.29	-0.52	-0.61	99.99	99.99	99.99	99.99	99.99	99.99
12	-0.7	-0.03	-0.03	0.03	99.99	99.99	99.99	99.99	99.99	99.99
13	-1.72	-0.37	-0.39	0.09	99.99	99.99	99.99	99.99	99.99	99.99
14	-0.18	-0.39	-0.25	-0.23	99.99	99.99	99.99	99.99	99.99	99.99

Table 8.10 (Continued)
Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	5	6	7	8	9	10	11	12	13	14
Mean Log q	-5.4531	-4.3254	-3.5253	-3.9829	-4.5381	-3.9358	-3.9358	-3.9358	-3.9358	-3.9358
S.E(Log q)	0.543	0.2262	0.2646	0.3262	0.4776	0.4937	0.7459	0.4424	0.8515	0.3585

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	-1.06	-1.428	14.93	0.1	14	0.53	-5.45
6	4.31	-0.964	-13.84	0.02	14	0.98	-4.33
7	9.15	-1.413	-45.62	0.01	14	2.22	-3.53
8	1.33	-0.398	2.27	0.26	14	0.47	-3.98
9	0.63	0.973	6.11	0.62	14	0.3	-4.54
10	1.88	-0.884	0.03	0.2	14	0.95	-3.94
11	1.18	-0.473	3.91	0.62	14	0.54	-4.5
12	1.01	-0.052	3.97	0.74	14	0.49	-4.02
13	0.98	0.054	4.45	0.58	12	0.75	-4.4
14	1.05	-0.349	4.12	0.94	12	0.25	-4.2

Fleet : FLT07:Russ.Surv.ne

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
5	2.04	0.89	0.19	-0.34	-0.23	-0.88	-0.21	-0.38	0.18	0.67
6	1.24	0.93	0.52	0.14	0.25	-0.3	-0.2	-0.37	-0.09	0.79
7	0.8	0.81	0.3	0.28	0.33	-0.05	-0.1	-0.33	-0.13	0.33
8	0.63	0.62	0.32	0.57	0.43	0.22	0.24	0.07	0.25	-0.28
9	-0.33	0.22	0.29	0.57	0.99	0.1	0.39	0.22	0.25	-0.2
10	-0.02	0.39	0.66	0.59	-0.52	0.3	0.51	0.39	0.41	0.3
11	0.78	0.27	-0.09	0.29	-0.32	0.56	1	0.04	0.75	0.22
12	0.59	0.79	0.34	0.33	-0.6	-0.15	0.71	0.38	0.72	0.89
13	-0.13	-0.06	-0.04	-0.01	-0.2	0.67	0.63	0.65	-0.76	1.13
14	-5.04	0.95	0.66	-1.47	-0.2	-0.26	-0.11	-0.1	0.28	0.37

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
5	99.99	99.99	-0.12	-0.15	0.18	-0.03	-0.48	0.13	0.38	0.08
6	99.99	99.99	0.12	-0.16	0.27	-0.11	-0.45	0.08	0.11	-0.11
7	99.99	99.99	-0.1	-0.14	0.4	0.1	-0.22	-0.07	-0.03	-0.02
8	99.99	99.99	-0.26	-0.44	0.02	-0.2	0.09	0.01	0.06	0.31
9	99.99	99.99	-0.12	-0.65	-0.32	-0.07	0.52	-0.17	-0.27	0.44
10	99.99	99.99	-0.14	-0.27	-0.17	0.12	0.18	-0.43	-0.48	0.22
11	99.99	99.99	-0.19	-0.54	-0.26	0.47	0.54	0.6	-0.15	0.47
12	99.99	99.99	0.1	-0.27	0.02	0.79	1.05	0.3	0.71	0.85
13	99.99	99.99	0.01	-0.23	0.15	0.3	1.17	0.83	0.56	0.85
14	99.99	99.99	0.42	-0.18	0.05	0.28	0.93	-0.07	-0.09	0.51

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	-0.6916	0.1855	0.66	0.836	0.4026	-0.0432	-0.0432	-0.0432	-0.0432	-0.0432
S.E(Log q)	0.3458	0.3123	0.2126	0.2511	0.389	0.3392	0.4945	0.6734	0.7191	0.4502

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	0.88	0.575	1.86	0.73	18	0.32	-0.69
6	1.11	-0.46	-1.32	0.68	18	0.36	0.19
7	1.12	-0.671	-1.91	0.79	18	0.24	0.66
8	0.96	0.236	-0.38	0.77	18	0.25	0.84
9	1.16	-0.494	-1.89	0.54	18	0.47	0.4
10	1.36	-1.227	-3.05	0.58	18	0.45	-0.04
11	1.11	-0.44	-1.06	0.66	18	0.52	0.16
12	0.92	0.489	0.26	0.8	18	0.44	0.43
13	0.89	0.689	0.43	0.82	18	0.5	0.4
14	0.9	0.962	0.57	0.91	18	0.37	0.14

Fleet : FLT08: Norw.Comb.Sur

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
5	99.99	99.99	99.99	99.99	0.34	-0.02	-0.26	-0.34	0.08	-0.18
6	99.99	99.99	99.99	99.99	0.47	0.3	-0.2	0.03	-0.13	0.08
7	99.99	99.99	99.99	99.99	0.54	0.24	0.32	0.1	-0.1	0.13
8	99.99	99.99	99.99	99.99	0.69	-0.17	-0.02	0.39	0.03	0.03
9	99.99	99.99	99.99	99.99	0.11	-0.34	-0.58	-0.35	0.41	-0.2
10	99.99	99.99	99.99	99.99	1.01	0.57	0.54	0.58	-0.15	0.23
11	99.99	99.99	99.99	99.99	0.33	0.2	0.22	-0.19	-0.82	-0.66
12	99.99	99.99	99.99	99.99	0.43	0.58	0.83	0.84	-0.21	-0.06
13	99.99	99.99	99.99	99.99	-0.27	-0.95	-2.82	0.01	-0.62	-0.63
14	99.99	99.99	99.99	99.99	0.29	0.12	0.43	0.26	-0.82	-0.34

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
5	-0.05	0.14	-0.09	0.3	99.99	99.99	99.99	99.99	99.99	99.99
6	-0.08	0.04	-0.1	0.03	99.99	99.99	99.99	99.99	99.99	99.99
7	0.19	0.1	-0.08	-0.57	99.99	99.99	99.99	99.99	99.99	99.99
8	0	-0.04	-0.07	-0.23	99.99	99.99	99.99	99.99	99.99	99.99
9	0.3	0.13	-0.09	0.11	99.99	99.99	99.99	99.99	99.99	99.99
10	-0.12	-0.03	-0.53	-0.36	99.99	99.99	99.99	99.99	99.99	99.99
11	-0.12	-0.7	-0.95	-0.65	99.99	99.99	99.99	99.99	99.99	99.99
12	0.13	-0.17	0.14	-0.37	99.99	99.99	99.99	99.99	99.99	99.99
13	-0.22	-0.36	-0.13	-0.3	99.99	99.99	99.99	99.99	99.99	99.99
14	-0.25	-0.69	-0.02	-0.72	99.99	99.99	99.99	99.99	99.99	99.99

Table 8.10 (Continued)
Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	5	6	7	8	9	10	11	12	13	14
Mean Log q	-0.4229	0.0813	0.6652	0.2083	-0.2939	0.3866	0.3866	0.3866	0.3866	0.3866
S.E(Log q)	0.2172	0.1516	0.3092	0.2156	0.3008	0.447	0.6877	0.437	0.9026	0.5508

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	0.54	1.535	4.89	0.74	10	0.1	-0.42
6	1.53	-0.449	-5.37	0.15	10	0.25	0.08
7	-1.13	-1.642	21.18	0.13	10	0.3	0.67
8	5.41	-1.829	-41.63	0.04	10	0.96	0.21
9	0.75	0.666	2.44	0.64	10	0.24	-0.29
10	17.28	-2.719	******	0.01	10	5.1	0.39
11	2.19	-2.383	-9.03	0.51	10	0.68	-0.1
12	1.76	-2.298	-6.26	0.7	10	0.55	0.48
13	0.69	1.25	2.07	0.8	10	0.46	-0.12
14	1.31	-1.003	-1.9	0.73	10	0.58	0.09

Terminal year survivor and F summaries :

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

Year class = 2006

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
FLT04:Norw.Exp.CP	1	0	0	0	0	0	0
FLT07:Russ.Surv.ne	53959	0.362	0	0	1	0.654	0.007
FLT08:Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	43275	0.5				0.346	0.009

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
49998	0.29	0.13	2	0.442	0.008

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

Year class = 2005

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
FLT04:Norw.Exp.CP	1	0	0	0	0	0	0
FLT07:Russ.Surv.ne	60230	0.243	0.241	0.99	2	0.807	0.013
FLT08:Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	34386	0.5				0.193	0.022

Table 8.10 (Continued)

Weighted prediction :

Survivors	Int	Ext	N	Var	F
atendofyear	s.e	s.e		Ratio	
54056	0.22	0.23	3	1.062	0.014

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

Year class = 2004

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
FLT04:Norw.Exp.CP	1	0	0	0	0	0	0
FLT07:Russ.Surv.ne	45295	0.189	0.049	0.26	3	0.871	0.029
FLT08:Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	28253	0.5				0.129	0.045

Weighted prediction :

Survivors	Int	Ext	N	Var	F
atendofyear	s.e	s.e		Ratio	
42615	0.18	0.1	4	0.594	0.03

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

Year class = 2003

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
FLT04:Norw.Exp.CP	1	0	0	0	0	0	0
FLT07:Russ.Surv.ne	21909	0.16	0.156	0.97	4	0.897	0.078
FLT08:Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	19252	0.5				0.103	0.088

Weighted prediction :

Survivors	Int	Ext	N	Var	F
atendofyear	s.e	s.e		Ratio	
21619	0.15	0.13	5	0.849	0.079

Age 9 Catchability constant w.r.t. time and dependent on age

Year class = 2002

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
FLT04:Norw.Exp.CP	1	0	0	0	0	0	0
FLT07:Russ.Surv.ne	13333	0.149	0.132	0.88	5	0.902	0.087
FLT08:Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	17540	0.5				0.098	0.067

Weighted prediction :

Survivors	Int	Ext	N	Var	F
atendofyear	s.e	s.e		Ratio	
13695	0.14	0.12	6	0.827	0.085

Table 8.10 (Continued)

Age 10 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	9932	0.139	0.08	0.58	6	0.912	0.063
FLT08:Norw.Comb.Sur	1	0	0	0	0	0	0
F shrinkage mean	14134	0.5				0.088	0.045

Weighted prediction :

Survivors atendofyear	Int s.e	Ext s.e	N	Var Ratio	F
10246	0.13	0.08	7	0.612	0.061

Age 11 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	3785	0.61	0	0	1	0.032	0.144
FLT07:Russ.Surv.ne	6691	0.136	0.113	0.83	7	0.773	0.084
FLT08:Norw.Comb.Sur	9054	0.313	0	0	1	0.12	0.063
F shrinkage mean	5667	0.5				0.076	0.098

Weighted prediction :

Survivors atendofyear	Int s.e	Ext s.e	N	Var Ratio	F
6729	0.12	0.1	10	0.804	0.083

Age 12 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	3837	0.28	0.024	0.09	2	0.116	0.128
FLT07:Russ.Surv.ne	3770	0.135	0.141	1.04	8	0.633	0.13
FLT08:Norw.Comb.Sur	3631	0.224	0.059	0.27	2	0.18	0.134
F shrinkage mean	3347	0.5				0.071	0.145

Weighted prediction :

Survivors atendofyear	Int s.e	Ext s.e	N	Var Ratio	F
3721	0.11	0.09	13	0.813	0.131

Table 8.10 (Continued)

Age 13 Catchability constant w.r.t. time and dependent on age

Year class = 1998

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04:Norw.Exp.CP	1842	0.212	0.044	0.21	3	0.178	0.15
FLT07:Russ.Surv.ne	2565	0.145	0.113	0.78	8	0.527	0.11
FLT08:Norw.Comb.Sur	1821	0.192	0.206	1.07	3	0.213	0.152
F shrinkage mean	1632	0.5				0.083	0.168

Weighted prediction :

Survivors atendofyear	Int s.e	Ext s.e	N	Var Ratio	F
2166	0.1	0.08	15	0.814	0.129

Age 14 Catchability constant w.r.t. time and dependent on age

Year class = 1997

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT04:Norw.Exp.CP	1827	0.188	0.138	0.73	4	0.204	0.097
FLT07:Russ.Surv.ne	2032	0.155	0.14	0.9	8	0.468	0.087
FLT08:Norw.Comb.Sur	1720	0.169	0.06	0.35	4	0.254	0.102
F shrinkage mean	1799	0.5				0.075	0.098

Weighted prediction :

Survivors atendofyear	Int s.e	Ext s.e	N	Var Ratio	F
1889	0.1	0.07	17	0.725	0.094

Table 8.11. Fishing mortality (F) at age

Run title : NEA Greenland halibut (run: 2012/1)

At 19/04/2012 18:49

Table 8 Fishing mortality (F) at age

AGE	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
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	0.4472	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	0.3622
9	0.4566	0.2848	0.3476	0.2355	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	0.2515	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	0.2786

Table 8 Fishing mortality (F) at age

AGE	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
5	0.041	0.0413	0.0971	0.1045	0.129	0.0431	0.1209	0.0769	0.0902	0.0568	0.068
6	0.1211	0.1894	0.2133	0.2341	0.2392	0.0857	0.1439	0.1252	0.1424	0.305	0.24
7	0.4196	0.4663	0.4172	0.43	0.2651	0.1812	0.1926	0.1275	0.2131	0.385	0.3382
8	0.3817	0.6249	0.3554	0.4136	0.2071	0.1905	0.1385	0.1689	0.333	0.341	0.2906
9	0.3557	0.4998	0.3925	0.3516	0.133	0.2288	0.0921	0.3232	0.3063	0.2402	0.2702
10	0.4016	0.3507	0.3247	0.3977	0.1092	0.1719	0.1528	0.3444	0.4534	0.4043	0.3674
11	0.5023	0.3823	0.4843	0.4733	0.1955	0.2419	0.2512	0.4445	0.3157	0.3957	0.3545
12	0.5616	0.6827	0.7078	0.3546	0.2021	0.2653	0.2697	0.4239	0.476	0.2302	0.4156
13	0.5354	0.5072	0.8175	0.6666	0.1236	0.2999	0.6791	0.3663	0.3592	0.2853	0.1536
14	0.4739	0.4872	0.5486	0.4511	0.1531	0.2424	0.2901	0.3822	0.3839	0.3124	0.3136
+gp	0.4739	0.4872	0.5486	0.4511	0.1531	0.2424	0.2901	0.3822	0.3839	0.3124	0.3136
0 FBAR 6-10	0.3359	0.4262	0.3406	0.3654	0.1907	0.1716	0.144	0.2178	0.2896	0.3351	0.3013

Table 8 Fishing mortality (F) at age

AGE	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
5	0.0949	0.0694	0.0432	0.1138	0.1713	0.3241	0.1156	0.0965	0.0364	0.0492	0.0573
6	0.253	0.2302	0.1923	0.2903	0.4269	0.5022	0.1749	0.1521	0.0759	0.0701	0.1558
7	0.353	0.4437	0.3824	0.4377	0.5242	0.8325	0.2336	0.3549	0.2479	0.2517	0.3901
8	0.3278	0.3808	0.4791	0.3362	0.4114	0.5212	0.2863	0.3853	0.2897	0.2991	0.3227
9	0.3361	0.2503	0.4533	0.3187	0.4188	0.3791	0.1295	0.0718	0.1642	0.2151	0.1134
10	0.4615	0.4166	0.4745	0.1976	0.317	1.0091	0.3735	0.5721	0.5055	0.6646	0.5994
11	0.3061	0.2842	0.4289	0.2071	0.2366	1.1155	0.3517	0.4932	0.4817	0.7959	0.5239
12	0.4298	0.1726	0.4008	0.1779	0.4591	1.5632	0.6196	0.4701	0.7998	1.025	0.5187
13	0.7294	0.3111	0.1556	0.248	0.0784	0.4806	0.723	0.2735	0.5554	1.0913	0.1771
14	0.455	0.2881	0.3845	0.2306	0.3032	0.9168	0.4471	0.3739	0.5041	0.7964	0.398
+gp	0.455	0.2881	0.3845	0.2306	0.3032	0.9168	0.4471	0.3739	0.5041	0.7964	0.398
0 FBAR 6-10	0.3463	0.3443	0.3963	0.3161	0.4197	0.6488	0.2396	0.3072	0.2567	0.3001	0.3163

Table 8.11 (Continued)

Table 8 Fishing mortality (F) at age

AGE	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
5	0.0161	0.0178	0.0235	0.0201	0.0235	0.0123	0.019	0.0129	0.015	0.017	0.0283
6	0.0629	0.0657	0.1175	0.0481	0.0872	0.0594	0.0548	0.0587	0.0573	0.0603	0.0579
7	0.1879	0.2258	0.328	0.1583	0.201	0.1232	0.1521	0.1601	0.1457	0.1625	0.1178
8	0.1499	0.2144	0.2433	0.1827	0.1474	0.1152	0.1007	0.1572	0.1671	0.194	0.1044
9	0.1122	0.1097	0.1905	0.1409	0.1339	0.092	0.0956	0.1557	0.1427	0.1463	0.086
10	0.5756	0.4663	0.6673	0.4332	0.3142	0.2637	0.2051	0.1549	0.1966	0.138	0.0727
11	0.4101	0.3021	0.3338	0.3072	0.285	0.2381	0.1817	0.1873	0.1673	0.1278	0.1145
12	0.5879	0.3726	0.5271	0.5106	0.4157	0.2513	0.1893	0.315	0.2492	0.1843	0.1696
13	0.114	0.0976	0.3398	0.1824	0.3144	0.2389	0.0888	0.1684	0.3099	0.2223	0.1257
14	0.3831	0.2561	0.4056	0.3007	0.296	0.2488	0.2932	0.2447	0.3028	0.2076	0.1388
+gp	0.3831	0.2561	0.4056	0.3007	0.296	0.2488	0.2932	0.2447	0.3028	0.2076	0.1388
0 FBAR 6-10	0.2177	0.2164	0.3093	0.1926	0.1768	0.1307	0.1217	0.1373	0.1419	0.1402	0.0878

Table 8 Fishing mortality (F) at age

AGE	2008	2009	2010	2011	FBAR **-**
5	0.0106	0.0151	0.003	0.0078	0.0086
6	0.0257	0.0331	0.0111	0.0141	0.0194
7	0.0549	0.0602	0.0305	0.0303	0.0403
8	0.088	0.1027	0.0737	0.0791	0.0852
9	0.0933	0.0658	0.0673	0.0846	0.0726
10	0.0535	0.0393	0.0502	0.0613	0.0503
11	0.0762	0.1164	0.0796	0.0833	0.0931
12	0.1465	0.0899	0.1994	0.1314	0.1402
13	0.1718	0.1515	0.1838	0.1292	0.1548
14	0.1403	0.0667	0.1099	0.0937	0.0901
+gp	0.1403	0.0667	0.1099	0.0937	
0 FBAR 6-10	0.0631	0.0602	0.0465	0.0539	

Table 8.12. Stock number at age (start of year) Numbers*10-3**

Run title : NEA Greenland halibut (run: 2012/1)

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

AGE	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
5	42841	51686	57830	70444	64282	55933	41114	31555	33561	31066
6	33793	36528	44252	49617	60487	55222	47155	34899	27085	27857
7	27961	27712	30649	37566	42397	51799	45285	37996	25876	20046
8	27353	21461	22243	25353	31755	36072	41608	29269	20910	13361
9	14559	18279	14883	16626	19961	25499	25214	18592	13797	12025
10	8521	7938	11834	9049	11307	13541	17382	12393	10315	9301
11	4237	3641	3307	7867	5554	6995	7544	8772	6641	7269
12	2537	1928	1465	1656	5177	2707	3812	4158	5042	4447
13	1175	1239	730	534	617	3721	1577	2121	2039	3195
14	634	673	721	400	168	395	2990	786	857	1129
+gp	190	118	77	49	27	118	756	372	341	564
0 TOTAL	163800	171204	187990	219160	241732	252004	234437	180912	146465	130259

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

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
5	26653	22554	22115	23729	20614	19750	18697	17947	18992	19280	17852
6	26542	22090	18633	18265	18534	15983	14941	15414	13688	15137	15163
7	22941	20508	16845	13271	12701	12623	10830	11804	11489	10396	11299
8	13614	13989	11602	9095	7526	7111	8335	7777	8380	8705	7230
9	8239	8157	8220	5346	5487	4283	4976	5930	5828	6092	5370
10	7983	5390	4920	4292	3107	3323	3228	3407	4655	3631	3860
11	6225	5070	3104	2982	2670	1797	2564	2339	2517	2839	1986
12	4832	3853	2641	1823	1581	1432	1272	1733	1566	1389	1782
13	2782	2917	1891	1148	773	955	1007	840	1139	882	743
14	2086	1714	1470	980	436	342	726	642	366	680	530
+gp	844	1044	994	456	330	386	389	264	155	215	284
0 TOTAL	122740	107285	92436	81388	73761	67984	66964	68097	68775	69244	66099

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

AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
5	19995	19904	19489	23109	20851	14642	12898	10842	13357	19018	18997
6	14517	16079	15581	15650	19048	16017	10618	8028	8313	10439	15783
7	9620	9828	10745	10653	11113	12264	8996	5531	5802	6146	8328
8	6617	5904	5943	5935	6255	6174	6249	3368	3769	3502	4128
9	4425	4259	3661	3496	3163	3847	3522	3194	2177	2207	2256
10	3635	2907	2620	2453	1912	1980	2178	2075	2415	1744	1612
11	2217	2167	1577	1487	1314	1351	1241	683	1229	1173	905
12	1151	1339	1373	1022	833	919	918	350	414	646	624
13	1218	654	750	995	589	600	500	165	162	223	250
14	481	899	271	473	733	396	478	266	69	106	110
+gp	251	700	30	158	146	180	917	166	14	8	16
0 TOTAL	64128	64641	62040	65428	65958	58370	48514	34669	37720	45210	53008

Table 8.12 (Continued)

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

AGE	1996	1997	1998	1999	2000	2001	2002	2003	2004
5	20022	22331	21914	20065	20617	20464	24356	22749	24399
6	15566	16274	18914	18528	16869	17393	17205	20706	19212
7	12665	11465	13153	15244	14180	13837	13720	13954	16871
8	5573	7380	8178	9033	9452	10418	9741	10441	10315
9	2635	3474	5468	5680	6095	6777	7738	7472	8126
10	1566	2024	2673	4217	4041	4557	5102	6074	5845
11	714	740	980	1443	1862	2256	2865	3373	4259
12	352	364	423	624	890	1179	1460	1943	2421
13	193	180	174	251	317	459	670	977	1384
14	72	139	138	136	154	227	289	454	770
+gp	3	3	71	22	58	50	205	110	519
0 TOTAL	59359	64374	72085	75244	74534	77618	83349	88254	94121

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

AGE	2005	2006	2007	2008	2009	2010	2011	2012	GMST 64-**	AMST 64-**
5	31085	36158	38075	45912	70710	74221	58542	0	25693	28706
6	20732	26357	30597	31856	39100	59949	63692	49998	20725	23275
7	15593	16849	21357	24852	26722	32559	51031	54056	15599	18076
8	12372	11601	12327	16340	20248	21656	27183	42615	10370	12696
9	7587	9011	8224	9558	12879	15726	17315	21619	6748	8354
10	5985	5662	6700	6495	7494	10379	12655	13695	4535	5507
11	4309	4232	4245	5362	5299	6201	8496	10246	2664	3330
12	3039	3137	3206	3259	4277	4060	4929	6729	1567	2022
13	1521	2039	2246	2329	2422	3364	2863	3721	837	1159
14	1007	960	1405	1705	1688	1792	2410	2166	486	699
+gp	1347	1054	1858	2029	2019	2997	2934	4188		
0 TOTAL	104578	117061	130239	149694	192857	232905	252050	209033		

Table 8.13. Stock biomass at age (start of year) Tonnes
Run title : NEA Greenland halibut (run: 2012/1)
At 19/04/2012 18:49

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

AGE	1964	1965	1966	1967	1968	1969	1970	1971
5	17993	21708	24288	29587	26998	23492	23312	17892
6	21627	23378	28321	32251	39922	35342	34753	25721
7	25165	24941	27890	34936	40702	47137	48863	40998
8	32824	26182	27581	32199	41599	45091	59125	41592
9	23731	30343	25301	28430	34732	41818	46596	34357
10	19258	17701	26271	19908	24762	30467	39647	28269
11	13178	10923	9724	22342	15494	20915	21779	25323
12	9488	6729	4965	5463	16515	9828	12376	13501
13	5368	5452	3196	2281	2634	17416	6786	9127
14	3175	3306	3491	1952	838	2128	14746	3875
+gp	1131	697	452	282	163	707	4378	2172
0 TOTALBIO	172937	171360	181482	209630	244359	274341	312362	242826

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

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
5	19029	17614	15112	12788	12539	13454	11688	17775	13125	11845
6	19962	20531	19561	16280	13732	13461	13660	19180	13029	12948
7	27920	21629	24753	22128	18176	14319	13704	18934	12357	13575
8	29714	18986	19346	19879	16487	12925	10694	12801	12235	12131
9	25497	22222	15225	15074	15191	9879	10140	9424	8847	12096
10	23528	21215	18210	12294	11221	9790	7088	8639	7430	8756
11	19174	20987	17971	14636	8963	8608	7708	5391	6830	6971
12	16371	14440	15689	12510	8574	5920	5134	5011	3874	5943
13	8773	13748	11971	12554	8138	4941	3327	3914	3391	3468
14	4226	5565	10284	8450	7249	4834	2152	1640	3111	3005
+gp	2060	3388	5035	6169	5885	2748	1951	2385	2080	1585
0 TOTALBIO	196254	180324	173157	152762	126156	100880	87247	105092	86309	92323

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

AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
5	13105	14460	11247	11997	12341	13817	17100	15847	10396	9931
6	11498	15742	14556	12920	14793	15627	15055	19620	16978	11149
7	11833	13930	13333	11544	12580	13604	13306	14669	15820	12415
8	10978	13666	11063	12242	11217	10002	9650	11259	10496	10936
9	10140	12001	12406	11462	10563	9087	7564	7656	8078	7748
10	10426	9912	11078	11560	9041	7812	7108	5985	5167	5663
11	6972	9341	6871	8027	7259	5594	5063	4428	3876	3462
12	5278	5861	6719	4545	4981	5218	3740	3375	3172	3010
13	4919	4156	2963	5459	2615	3419	4224	2527	2233	1945
14	1961	4132	2307	2042	3759	1357	1980	3297	1618	2092
+gp	905	1317	1284	1211	3169	179	704	689	816	4852
0 TOTALBIO	88015	104518	93826	93009	92318	85717	85494	89351	78651	73203

Table 8.13 (Continued)

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

AGE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
5	7372	10552	13693	13868	15417	17195	15997	14046	15669	15144
6	7788	8479	9812	14836	15099	15298	17590	17602	16363	17915
7	7024	7832	7805	10410	16591	14675	17098	19360	18859	19234
8	5928	7085	6023	7183	9697	12103	13166	14001	15406	18232
9	7058	5356	4833	4715	5901	7191	11591	11361	12861	15519
10	5312	6448	4395	4045	4056	5243	6869	10374	10548	12213
11	2125	4216	3484	2671	2348	2442	3185	4647	6239	7511
12	1257	1775	2125	2083	1413	1459	1653	2401	3531	4622
13	634	824	855	957	915	870	852	1156	1574	2210
14	1131	437	526	547	451	826	783	793	894	1320
+gp	798	122	54	127	20	21	350	135	418	372
0 TOTALBIO	46427	53126	53604	61442	71907	77323	89134	95874	102362	114290

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

AGE	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
5	16806	16266	18788	20796	23033	23835	31909	40092	39486	29388
6	16172	21742	21037	19737	22667	27629	29275	31358	47720	47259
7	18660	19926	25273	20365	19360	28042	33774	28619	36368	51950
8	16364	18251	19630	20452	17750	20783	28692	29785	32311	38464
9	16868	17320	20013	16168	19121	19089	21323	24831	32161	33504
10	13673	15885	16219	15227	14845	17105	15446	16606	25294	30044
11	9138	10265	13322	12272	11423	12417	15309	13937	17834	23560
12	5679	7179	9222	10133	10400	10223	10525	13180	13764	15749
13	2987	4462	5939	5678	8152	8414	8258	9183	13111	11179
14	1516	2527	4197	4413	4456	6378	6673	7643	9357	9901
+gp	1294	699	3300	7800	7108	16863	15119	14270	20372	17872
0 TOTALBIO	119157	134521	156940	153040	158313	190777	216303	229505	287777	308870

Table 8.14. Spawning stock biomass at age (spawning time) Tonnes
Run title : NEA Greenland halibut (run: 2012/1)
At 19/04/2012 18:49

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

	AGE	1964	1965	1966	1967	1968	1969	1970	1971
	5	0	0	0	0	0	0	0	0
	6	649	701	850	968	1198	1060	1043	772
	7	755	748	837	1048	1221	1414	1466	1230
	8	6893	5498	5792	6762	8736	9469	12416	8734
	9	15900	20330	16952	19048	23270	28018	31219	23019
	10	16562	15223	22593	17121	21295	26202	34097	24311
	11	12914	10704	9529	21895	15185	20497	21344	24817
	12	9298	6594	4866	5354	16185	9631	12129	13231
	13	5368	5452	3196	2281	2634	17416	6786	9127
	14	3175	3306	3491	1952	838	2128	14746	3875
	+gp	1131	697	452	282	163	707	4378	2172
0	TOTSPBIO	72644	69254	68558	76710	90724	116542	139624	111287

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

	AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
	5	0	0	0	0	0	0	0	0	0	0
	6	599	616	587	488	412	404	410	575	391	388
	7	838	649	743	664	545	430	411	568	371	407
	8	6240	3987	4063	4175	3462	2714	2246	2688	2569	2548
	9	17083	14889	10201	10100	10178	6619	6794	6314	5928	8104
	10	20234	18245	15660	10573	9650	8420	6096	7429	6390	7530
	11	18790	20567	17612	14343	8783	8436	7554	5283	6694	6831
	12	16044	14151	15375	12260	8403	5801	5031	4910	3797	5824
	13	8773	13748	11971	12554	8138	4941	3327	3914	3391	3468
	14	4226	5565	10284	8450	7249	4834	2152	1640	3111	3005
	+gp	2060	3388	5035	6169	5885	2748	1951	2385	2080	1585
0	TOTSPBIO	94886	95803	91530	79775	62706	45347	35971	35707	34721	39691

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

	AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	5	0	0	0	0	0	0	0	0	0	0
	6	345	472	582	517	444	156	151	196	170	111
	7	355	418	400	462	377	272	133	293	316	497
	8	2305	2460	1991	2326	2692	2201	2026	2027	1784	1640
	9	6794	7201	7567	7450	7817	5997	4009	3751	4120	4184
	10	8967	8128	9195	9826	8227	7031	6184	4788	3979	4360
	11	6832	8967	6665	7786	7186	5315	4506	3941	3528	3082
	12	5172	5744	6584	4500	4881	5114	3666	3375	3172	3010
	13	4919	4156	2963	5459	2615	3419	4224	2527	2233	1945
	14	1961	4132	2307	2042	3759	1357	1980	3297	1618	2092
	+gp	905	1317	1284	1211	3169	179	704	689	816	4852
0	TOTSPBIO	38556	42994	39539	41579	41168	31040	27583	24883	21735	25774

Table 8.14 (Continued)

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

	AGE	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	5	0	106	137	139	0	0	0	0	0	151
	6	78	85	98	148	0	0	0	0	164	537
	7	421	627	546	833	1161	1027	684	387	566	1154
	8	1660	2267	2048	2083	2424	2542	1317	980	1541	3464
	9	4658	3642	3334	2735	3423	3811	5216	3749	4759	7604
	10	4568	5352	3560	3196	3569	4457	5632	6847	6645	7938
	11	1849	3710	3310	2564	2277	2296	2930	3996	5428	6309
	12	1257	1669	1998	1854	1329	1371	1653	2377	3390	4437
	13	634	824	855	957	915	870	852	1156	1574	2210
	14	1131	437	526	547	451	826	783	793	894	1320
	+gp	798	122	54	127	20	21	350	135	418	372
0	TOTSPBIO	17054	18839	16465	15182	15569	17221	19417	20419	25378	35498

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

	AGE	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	5	168	163	0	0	0	0	0	0	0	0
	6	485	435	210	197	227	276	293	0	0	0
	7	1866	2192	2022	1018	968	1122	1013	572	1455	2078
	8	5073	6205	5496	4499	3195	2702	2008	1191	2908	4231
	9	11133	12470	13209	9216	9560	6490	5118	4718	8362	10051
	10	10802	13978	14760	13399	10985	9065	5560	5646	9106	11717
	11	8316	9444	12522	11167	9709	8195	8879	7526	10879	14372
	12	5452	6963	8853	9627	9672	8178	7683	9622	10598	12284
	13	2957	4373	5820	5622	7989	7236	6771	7622	11538	9838
	14	1516	2477	4113	4325	4411	6123	6407	7414	9357	9901
	+gp	1294	699	3300	7800	7108	16694	14967	14127	20372	17872
0	TOTSPBIO	49061	59399	70306	66870	63824	66082	58700	58438	84574	92344

Table 8.15. Summary (without SOP correction)
Run title : NEA Greenland halibut (run: 2012/1)
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	RECRUITS Age 5	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 6-10
1964	42841	172937	72644	40391	0.556	0.3146
1965	51686	171360	69254	34751	0.5018	0.2643
1966	57830	181482	68558	26321	0.3839	0.1601
1967	70444	209630	76710	24267	0.3163	0.1376
1968	64282	244359	90724	26168	0.2884	0.1309
1969	55933	274341	116542	43789	0.3757	0.1988
1970	41114	312362	139624	89484	0.6409	0.4204
1971	31555	242826	111287	79034	0.7102	0.4223
1972	33561	196254	94886	43055	0.4538	0.3019
1973	31066	180324	95803	29938	0.3125	0.2252
1974	26653	173157	91530	37763	0.4126	0.2786
1975	22554	152762	79775	38172	0.4785	0.3359
1976	22115	126156	62706	36074	0.5753	0.4262
1977	23729	100880	45347	28827	0.6357	0.3406
1978	20614	87247	35971	24617	0.6843	0.3654
1979	19750	105092	35707	17312	0.4848	0.1907
1980	18697	86309	34721	13284	0.3826	0.1716
1981	17947	92323	39691	15018	0.3784	0.144
1982	18992	88015	38556	16789	0.4354	0.2178
1983	19280	104518	42994	22147	0.5151	0.2896
1984	17852	93826	39539	21883	0.5535	0.3351
1985	19995	93009	41579	19945	0.4797	0.3013
1986	19904	92318	41168	22875	0.5557	0.3463
1987	19489	85717	31040	19112	0.6157	0.3443
1988	23109	85494	27583	19587	0.7101	0.3963
1989	20851	89351	24883	20138	0.8093	0.3161
1990	14642	78651	21735	23183	1.0666	0.4197
1991	12898	73203	25774	33320	1.2928	0.6488
1992	10842	46427	17054	8602	0.5044	0.2396
1993	13357	53126	18839	11933	0.6334	0.3072
1994	19018	53604	16465	9226	0.5603	0.2567
1995	18997	61442	15182	11734	0.7729	0.3001
1996	20022	71907	15569	14347	0.9215	0.3163
1997	22331	77323	17221	9410	0.5464	0.2177
1998	21914	89134	19417	11893	0.6125	0.2164
1999	20065	95874	20419	19517	0.9558	0.3093
2000	20617	102362	25378	14437	0.5689	0.1926
2001	20464	114290	35498	16307	0.4594	0.1768
2002	24356	119157	49061	13161	0.2683	0.1307
2003	22749	134521	59399	13578	0.2286	0.1217
2004	24399	156940	70306	18800	0.2674	0.1373
2005	31085	153040	66870	18834	0.2817	0.1419
2006	36158	158313	63824	17897	0.2804	0.1402
2007	38075	190777	66082	15237	0.2306	0.0878
2008	45912	216303	58700	13778	0.2347	0.0631
2009	70710	229505	58438	12996	0.2224	0.0602
2010	74221	287777	84574	15221	0.18	0.0465
2011	58542	308870	92344	16337	0.1769	0.0539
Arith. Mean	30275	139887	53479	23969	0.5107	0.2492
0 Units	(Thousands)	(Tonnes)	(Tonnes)		(Tonnes)	

Table F1. GREENLAND HALIBUT in Sub-area I and II. Norwegian bottom trawl survey indices (numbers in thousands) in the Svalbard area (Division IIb).

Year	Fish<20 cm[2]	Age									Total
		1	2	3	4	5	6	7	8	9+	
1981	2.1										20 100
1982	0.7					No age data					2 600
1983	5.9										26 690
1984	3.2	550	3 042	2 924	8 573	6 847	5 657	4 345	2 796	1 896	36 630
1985	1.6	884	3 921	4 294	6 674	8 793	8 622	3 920	1 817	525	39 450
1986	0.1	49	1 005	1 967	7 314	4 671	1 754	2 301	372	37	19 470
1987	1	630	1 014	3 076	4 409	4 786	3 141	964	364	116	18 500
1988	2.5	818	4 298	6 191	6 696	12 289	2 396	6 015	338	1 277	40 318
1989 [1]	1.4	712	3 232	8 158	7 493	7 069	2 374	1 753	353	744	31 888
1990 [1]	0.4	115	336	5 050	7 130	7 730	4 490	2 330	918	544	28 643
1991 [1]	0.1	71	877	3 080	6 720	9 270	5 450	2 800	1 660	524	30 452
1992 [1]	+	33	30	338	1 190	3 520	4 420	2 280	1 280	474	13 565
1993 [1]	+	25	60	51	1 049	2 369	2 056	2 772	1 114	665	10 161
1994 [1]	+	4	238	296	652	2 775	2 371	2 593	531	844	10 304
1995 [1]	0.1	76	+	+	322	886	1 200	1 950	487	497	5 418
1996 [1]	0.4	410	61	104	171	881	2 052	2 587	862	976	8 104
1997 [1]	0.4	268	484	21	65	284	2 089	2 143	379	295	6 028
1998 [1]	2.5	1 999	2 351	2 715	493	609	2 192	2 814	1 252	822	15 247
1999 [1]	1.3	126	+	995	1 789	415	709	2 501	507	674	7 716
2000 [1]	2	2 009	540	323	1 347	2 135	2 634	1 784	1 197	530	12 499
2001 [1]	4.3	4 258	1 235	873	1 506	2 456	1 718	1 504	558	1 079	15 187
2002 [1]	2.3	1 435	2 019	1 176	2 437	3 413	2 685	3 304	847	2 229	19 545
2003 [1]	0.8	410	638	901	2 937	2 630	3 146	2 602	452	684	14 400

[1]New standard trawl equipment (rockhopper gear and 40 meter sweep length).

[2]In millions.

Not updated from 2004, new ecosystem survey

Table F2. GREENLAND HALIBUT in Sub-area I and II. Abundance indices from bottom trawl surveys in the Barents Sea and Svalbard area in August (in thousands).

A: The Barents Sea area; **B**: The expanded Svalbard area.

A	Age												Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	
1995	42	-	-	596	989	1 239	1 673	1 020	-	195	-	-	-	5 754
1996	12 028	900	-	-	-	415	829	861	85	261	118	82	-	15 579
1997 [1]	143	1 162	53	331	589	1 579	2 736	1 120	550	44	-	-	-	8 307
1998 [1]	46	446	328	416	481	323	1 828	924	432	234	-	-	-	5 458
1999	11 637	5 910	384	280	201	1 508	1 729	215	134	661	255	218	-	23 132
2000	-	619	302	417	816	620	1 163	844	605	270	54	221	-	5 931
2001	-	-	259	203	743	1 120	293	697	-	215	107	-	-	3 637
2002	-	-	-	85	773	2 509	3 047	165	290	839	-	255	-	7 963
2003	-	-	-	420	450	1 630	1 070	840	250	410	-	-	-	5 070

B	Age													Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	
1995	77	-	-	429	1 255	1 720	2 535	665	135	281	136	95	-	7 328
1996	1 760	360	105	291	1 144	2 717	3 525	1 290	309	603	30	92	45	12 271
1997	593	2 357	311	116	593	3 053	3 019	478	312	20	-	-	-	10 852
1998	2 295	2 836	2 918	540	770	2 477	3 248	1 472	340	346	130	-	65	17 437
1999	387	263	1 516	3 095	809	836	2 773	486	333	360	-	87	140	11 085
2000	1 976	818	1 280	2 836	3 946	3 216	2 112	1 560	460	199	-	95	-	18 498
2001	4 659	1 690	1 789	2 517	3 536	2 474	1 889	690	383	773	134	27	50	20 611
2002	2 174	2 475	1 718	2 962	4 291	3 620	4 205	1 031	293	1 267	453	304	212	25 005
2003	1 390	600	1 170	3 510	3 350	4 310	3 470	640	520	150	90	140	-	19 340

[1] Only Norwegian and international zones covered. Adjusted (according to the mean distribution in the period 1991-1999) to include the Russian EEZ.

Not updated from 2004, new ecosystem survey

Table F3. GREENLAND HALIBUT in Sub-area I and II. Abundance indices on age from the Norwegian stratified bottom trawl survey in August using a hired commercial vessel (numbers in thousands). Trawls were made at 400-1500 m depth along the continental slope from 68-80°N.

Year	Age															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	
1994	0	0	1	2 001	16 980	11 008	15 552	6 173	1 241	3 628	1 460	443	129	81	11	58 708
1995	0	0	0	1 432	16 945	12 946	20 925	6 737	1 975	4 393	1 385	648	152	103	21	67 662
1996	0	0	10	704	13 623	18 538	24 908	8 114	1 473	3 223	820	396	131	100	2	72 042
1997	0	0	16	1 446	11 738	17 005	18 927	5 383	1 107	3 261	936	600	87	165	16	60 687
1998	0	0	66	1 726	7 868	12 399	23 487	6 243	1 458	4 317	1 238	969	13	183	14	59 981
1999	0	0	27	1 300	5 901	15 383	20 209	12 019	1 872	5 913	1 167	1 198	273	183	15	65 460
2000	0	0	383	1 920	6 901	10 352	17 885	7 795	5 038	3 284	867	458	204	75	16	55 178
2001	0	10	95	986	6 107	15 068	22 584	10 086	3 130	5 442	1 146	1 147	267	180	67	66 315
2002	0	3	427	2 492	7 730	10 913	21 660	9 847	6 327	4 248	2 468	1 642	619	208	183	68 767
2003	6	18	662	3 972	10 293	14 552	20 438	9 191	4 507	6 388	1 902	1 795	861	253	125	74 963
2004	0	5	328	3 637	6 962	12 909	20 674	8 692	3 771	3 908	1 663	2 886	1 276	865	641	68 217
2005	3	24	2 036	9 170	10 195	13 477	8 785	7 683	4 611	4 388	2 500	2 250	995	401	693	67 210

Not updated from 2006 due to new age reading method

Table F4. GREENLAND HALIBUT in Sub-area I and II. Abundance indices on age from the Norwegian bottom trawl survey north and east of Spitsbergen in September (numbers in thousands).

A: Survey area, Russian EEZ excluded **B**: Including Russian EEZ

A 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 upda~~F~~ted from 2006 due to new age reading method

Table F5. GREENLAND HALIBUT in Sub-area I and II. Abundance indices from three Norwegian bottom trawl surveys in the Barents Sea in August - September (from 2004 two of them are part of the joint ecosystem survey covering the whole Barents Sea) combined to one index (in thousands).

A: Old strata system used B: Ecosystem survey combined with Norw. GrHal survey

A	Age															Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	
1996	17 926	14 906	10 134	4 486	16 194	22 217	30 014	10 163	1 857	3 954	957	523	175	100	2	133 608
1997	4 050	18 107	14 547	4 481	12 917	20 753	22 984	6 362	1 563	3 312	936	600	87	165	16	110 880
1998	10 704	21 705	12 521	7 603	9 915	14 680	27 784	7 800	1 937	4 586	1 353	1 027	13	241	14	121 883
1999	5 895	9 451	5 200	7 116	8 412	17 437	24 175	12 857	2 407	6 595	1 294	1 387	273	183	144	102 826
2000	11 474	17 755	9 870	11 359	13 093	14 139	20 608	9 704	5 707	3 548	901	695	204	75	16	119 148
2001	30 631	17 452	6 521	5 115	10 077	17 548	24 465	10 973	3 440	6 280	1 302	1 147	267	180	67	135 464
2002	42 348	36 537	17 472	9 105	13 649	15 040	27 076	10 130	6 679	5 104	2 909	1 893	619	257	183	188 999
2003	50 512	37 972	8 298	11 410	15 428	20 553	24 664	10 521	5 437	6 958	1 992	1 955	861	253	125	196 939
2004	17 233	29 072	50 471	17 112	13 233	16 459	24 970	9 753	4 568	4 170	1 963	3 042	1 460	865	726	195 096
2005	153 834	29 173	32 072	46 345	24 680	20 381	14 189	9 919	5 261	4 929	2 709	2 392	1 242	540	776	348 443

B	Age															Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	
2004	16 513	37 564	56 050	12 858	11 967	18 047	25 933	10 060	4 974	4 413	2 151	3 600	1 276	865	641	206 912
2005	182 754	40 350	40 139	40 760	25 334	21 739	15 320	10 504	5 594	5 131	2 967	2 494	1 249	686	758	395 780

Not updated from 2006 due to new age reading method

Table F6. GREENLAND HALIBUT in Sub-area I and II. Russian autumn bottom trawl surveys: Abundance indices at different age (numbers in thousands).

Year	Age-group													Total
	≤ 3	4	5	6	7	8	9	10	11	12	13	14	15+	
1984	4 124	5 359	7 788	24 951	19 863	11 499	6 750	5 416	2 420	1 196	247	146	143	89 902
1985	3 331	4 371	17 076	35 648	27 826	11 717	5 722	4 090	1 937	895	311	31	131	113 086
1986	2 687	6 600	15 853	25 696	16 468	5 436	3 811	2 660	974	539	184	72	6	80 986
1987	289	6 761	9 724	12 703	7 633	3 867	1 903	1 627	721	416	110	0	38	45 792
1988	2 591	4 409	7 891	14 181	11 311	4 308	2 253	1 756	820	307	125	163	54	50 169
1989	1 429	11 310	13 124	25 881	12 782	5 989	2 381	1 285	334	271	98	102	118	75 104
1990	2 820	8 360	16 252	15 621	11 393	4 120	1 911	1 158	307	198	58	36	0	62 234
1991	[1] 1 422	8 455	25 408	21 843	15 235	9 419	2 369	1 211	655	142	95	16	26	86 296
1992	685	7 461	33 341	25 498	17 272	10 178	2 720	1 262	938	318	67	0	0	99 740
1993	114	2 166	13 317	19 752	16 528	10 305	3 370	1 868	903	519	103	111	111	69 167
1994	49	1 604	9 868	17 549	11 533	7 746	3 401	1 876	605	394	114	114	57	54 910
1995	19	467	5 759	18 222	15 296	11 539	4 393	1 413	529	312	84	11	32	58 076
1996	[2] 0	1 670	6 680	18 722	21 714	13 354	8 512	476	284	106	115	36	20	71 689
1997	235	1 575	4 023	12 165	15 919	16 452	4 591	1 432	779	162	271	66	88	57 758
1998	3 917	5 542	7 768	15 589	16 842	17 727	9 676	2 548	1 752	535	254	85	72	82 307
1999	4 057	4 961	5 951	12 350	14 255	16 078	7 952	3 009	965	494	307	74	-	70 453
2000	2 841	5 327	10 718	15 719	18 694	21 235	9 155	3 593	2 580	1 011	108	133	120	91 234
2001	1 592	6 884	17 365	37 881	27 661	14 163	6 576	3 988	1 875	1 713	929	217	180	121 024
2002	[3] 2 145	7 127	10 771	44 220	33 675	18 747	5 947	5 477	1 216	1 877	1 973	60	120	133 355
2003	1 735	6 479	10 029	19 751	14 160	7 592	3 519	2 555	2 200	1 664	831	141	470	71 126
2004	3 305	8 342	9 461	21 834	22 876	14 187	8 331	3 776	2 544	1 745	1031	811	966	99 209
2005	2 096	7 668	11 657	17 933	20 555	14 140	4 658	3 264	1 844	1 585	789	554	420	87 164
2006	3 099	13 954	18 873	34 869	37 481	20 542	7 631	3 586	2 489	2 329	1 663	720	785	148 021
2007	995	5 713	15 982	27 722	36 544	18 917	9 382	6 033	5 221	5 171	2 297	1 399	1 134	136 510
2008	1 483	11 642	12 475	21 157	32 551	33 844	19 618	6 297	7 262	6 994	5 474	3 240	4 092	166 129
2009	713	13 726	35 041	43 719	40 611	38 274	13 509	4 006	7 371	4 522	4 152	1 257	1 398	208 300
2010	198	11 153	47 621	70 442	52 675	44 081	15 045	5 227	4 217	5 927	4 271	1 263	2 561	264 692
2011	321	2 400	27 736	59 948	82 923	70 786	32 987	12 646	10 675	8 729	5 063	3 124	2 687	320 025

[1] Age composition based on combined age-length-keys for 1990 and 1992.

[2] Only half of standard area investigated.

[3] Adjusted assuming area distibution as in 2001.

Table F7. GREENLAND HALIBUT catch in weight, numbers, and biomass (in tonnes) and abundance (in thousands) estimated from Spanish autumn and Spring surveys 1997-2011. NB. Absolute biomass and abundance values must not be compared between spring and autumn surveys due to different gears. The trawl used during the spring surveys is considered less efficient on benthic species as Greenland halibut and skates, and better to catch species less associated with bottom.

Autumn survey

Year	Catch (Kg)	Catch (numbers)	Biomass™	Abundance ('000)
1997	195056	211533	344014	379444
1998	180974	187259	351466	373149
1999	198781	172687	436956	377792
2000	169389	140355	340619	291265
2001	152681	129289	283511	249219
2002	144335	115213	256460	207466
2003	151952	132117	283644	256327
2004	153859	135631	320485	283965
2005	144573	134566	317320	313459
2006*				
2007*				
2008	91573	101578	129221**	144561**
2009*				
2010	167862	182464	191510**	216731**
2011*				

***No survey in 2006, 2007, 2009 and 2011**

**** New swept area estimation method**

Spring survey

Year	Catch (Kg)	Catch (numbers)	Biomass™	Abundance ('000)
2008	96797	109515	38406	38951
2009	200299	222018	58273	65464
2010*				
2011	136610	160566	98142	117666

***No survey in 2010**

Table F8. GREENLAND HALIBUT in Sub-area I and II. Abundance indices from bottom trawl surveys in the Barents Sea in winter (in thousands).

A: Restricted area surveyed every year; **B**: Enlarged area (includes the restricted one) surveyed since 1993

A	Age													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 F9 GREENLAND HALIBUT in Sub-areas I and II. Results from a research program using trawlers in a limited commercial fishery 1992-2005. All areas combined. Spring and autumn combined in 1992-1993, otherwise only spring-data.

	Catch in numbers on age (%)													
Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1														
2														
3	0.1			0.1		0.0	0.0	0.0					0.1	0.2
4	4.6	4.2	3.2	0.7	0.5	0.9	0.2	0.7	1.2	1.3	0.7	1.8	1.4	1.8
5	19.1	25.0	24.7	22.5	19.5	24.8	6.6	7.7	10.8	6.3	7.7	8.5	8.9	5.4
6	23.0	18.4	23.8	22.6	31.6	22.9	25.5	23.0	17.1	20.2	16.8	21.7	18.9	20.4
7	25.9	27.1	26.8	30.2	35.6	30.5	44.5	39.6	43.0	28.5	42.5	30.5	31.3	25.4
8	13.3	12.4	11.2	11.0	8.7	10.1	15.5	14.5	12.3	24.5	12.4	9.6	14.8	21.5
9	1.7	0.7	1.0	2.7	1.3	2.6	4.5	1.6	4.5	7.8	7.1	8.1	9.5	8.2
10	6.8	7.4	5.9	6.6	2.0	5.0	2.0	9.7	8.5	7.3	8.8	11.0	4.7	6.5
11	2.9	3.1	2.4	2.0	0.5	1.9	0.8	1.0	0.9	1.9	2.2	4.1	4.0	3.1
12	1.7	1.0	0.6	1.1	0.2	0.8	0.3	1.8	1.1	1.7	1.2	3.1	3.5	4.0
13	0.5	0.4	0.2	0.3	0.0	0.3		0.2	0.6	0.3	0.2	1.2	1.5	2.1
14	0.2	0.2	0.1	0.2	0.1	0.2		0.2	0.0	0.2	0.4	0.5	0.9	1.0
15	0.1					0.0		0.0	0.0	0.2	0.1	0.0	0.4	0.5

	Mean individual weight (kg)													
Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1														
2														
3	0.26			0.40		0.39							0.27	0.24
4	0.50	0.53	0.52	0.47	0.48	0.45	0.41	0.51	0.50	0.60	0.44	0.48	0.44	0.48
5	0.71	0.76	0.73	0.70	0.74	0.69	0.76	0.74	0.69	0.66	0.69	0.68	0.65	0.64
6	0.96	0.98	0.95	0.94	0.94	0.88	0.96	0.92	0.98	0.94	0.93	1.00	0.88	0.84
7	1.29	1.33	1.28	1.24	1.23	1.15	1.19	1.25	1.23	1.12	1.22	1.28	1.17	1.14
8	1.77	1.85	1.79	1.71	1.66	1.55	1.79	1.64	1.57	1.48	1.39	1.67	1.43	1.40
9	2.00	2.28	2.23	2.03	2.00	1.87	2.26	2.18	1.90	1.84	1.69	1.97	1.73	1.67
10	2.46	2.65	2.55	2.50	2.50	2.34	2.54	2.38	2.40	2.30	2.31	2.37	2.14	2.26
11	3.10	3.43	3.37	3.28	3.16	2.95	3.47	3.17	3.13	2.92	3.19	3.20	2.34	2.62
12	3.86	4.32	4.22	3.71	3.70	3.46	4.16	3.79	4.04	3.82	3.91	3.48	2.77	2.87
13	4.44	5.18	5.01	4.62		4.52		5.07	4.47	3.68	5.20	4.28	2.92	2.98
14	6.00	6.44	6.29	5.59		5.47		5.60	6.00	5.74	5.59	4.74	3.89	3.30
15	5.22								8.79	5.52	7.03	9.17	4.65	3.32

Not updated from 2006 due to new age reading method

Table F9 (Continued) GREENLAND HALIBUT in Sub-areas I and II. Results from a research program using trawlers in a limited commercial fishery 1992-2005. All areas combined. Spring and autumn combined in 1992-1993, otherwise only spring-data.

	CPUE (N) on age													
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1														
2														
3	0			1	0	0	0	0	0	0	0	0	1	2
4	19	30	26	7	7	11	2	7	14	12	7	19	15	24
5	80	176	198	219	286	298	59	72	132	63	81	90	96	70
6	97	130	191	220	463	275	229	214	208	201	176	229	203	263
7	109	191	215	294	521	366	400	369	524	284	447	322	337	328
8	56	87	90	107	127	121	139	135	150	244	130	101	159	278
9	7	5	8	26	19	31	40	15	55	78	75	86	102	106
10	29	52	47	64	29	60	18	90	104	73	92	116	51	84
11	12	22	19	19	7	23	7	9	11	18	23	43	43	40
12	7	7	5	11	3	10	3	17	13	17	12	32	38	52
13	2	3	2	3	0	4	0	2	7	3	2	12	16	27
14	1	1	1	2	1	2	0	2	0	2	4	5	10	13
15	0			0	0	0	0	0	0	2	1	0	4	6

	CPUE (kg) on age													
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1														
2														
3	0			0	0	0	0	0	0	0	0	0	0	1
4	10	16	13	3	4	5	1	3	7	7	3	9	6	11
5	57	134	145	153	211	207	45	53	91	41	56	61	63	44
6	93	127	182	207	435	243	220	197	204	189	164	229	179	220
7	140	254	276	364	641	423	476	461	645	318	543	411	396	373
8	99	162	161	183	211	189	249	221	236	361	181	169	228	389
9	14	11	18	53	38	59	91	32	105	143	127	169	177	176
10	70	138	121	161	73	141	46	215	250	167	213	275	109	189
11	38	75	65	64	23	68	25	30	33	54	74	138	101	104
12	28	30	20	40	11	33	11	64	53	66	48	113	105	150
13	9	15	8	13	0	16	0	9	32	11	9	52	48	79
14	5	9	5	11	0	13		10	2	10	24	23	38	43
15	2			0	0	0		0	3	11	4	4	20	20

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Overall mean individual weight (kg)	1.35	1.38	1.27	1.29	1.12	1.16	1.30	1.39	1.35	1.38	1.38	1.57	1.37	1.39
CPUE (kg round weight per trawlhour)**	567	973	1020	1255	1640	1393	1169	1294	1647	1377	1449	1657	1475	1795
CPUE (Number fish per trawlhour)**	420	705	803	973	1464	1201	899	931	1220	998	1050	1055	1077	1291
Catch (in tonnes)	695	862	811	368	436	274	272	269	295	297	288	298	304	292

***) Preliminary**

*** *) Average for freezer- and factorytrawler**

Not updated from 2006 due to new age reading method

Table F10. GREENLAND HALIBUT in ICES Sub-area IV (North Sea. Nominal catch (t) by countries as officially reported to ICES. Not included in the assessment .

Year	Denmark	Faroe Islands	France	Germany	Green-land	Ire-land	Norway	Russia	UK England & Wales	UK Scotland	Total
1973	-	-	-	4	-	-	9	8	28	-	49
1974	-	-	-	2	-	-	2	-	30	-	34
1975	-	-	-	1	-	-	4	-	12	-	17
1976	-	-	-	1	-	-	2	-	18	-	21
1977	-	-	-	2	-	-	2	-	8	-	12
1978	-	-	2	30	-	-	-	-	1	-	33
1979	-	-	2	16	-	-	2	-	1	-	21
1980	-	177	-	34	-	-	5	-	-	-	216
1981	-	-	-	-	-	-	7	-	-	-	7
1982	-	-	2	26	-	-	17	-	-	-	45
1983	-	-	1	64	-	-	89	-	-	-	154
1984	-	-	3	50	-	-	32	-	-	-	85
1985	-	1	2	49	-	-	12	-	-	-	64
1986	-	-	30	2	-	-	34	-	-	-	66
1987	-	28	16	1	-	-	35	-	-	-	80
1988	-	71	62	3	-	-	19	-	1	-	156
1989	-	21	14[1]	1	-	-	197	-	5	-	238
1990	-	10	30[1]	3	-	-	29	-	4	-	76
1991	-	48	291[1]	1	-	-	216	-	2	-	558
1992	1	15	416[1]	3	-	-	626	-	+	1	1 062
1993	1	-	78[1]	1	-	-	858	-	10	+	948
1994	+	103	84[1]	4	-	-	724	-	6	-	921
1995	+	706	165	2	-	-	460	-	52	283	1 668
1996	+	-	249	1	-	-	1 496	-	105	159	2 010
1997	+	-	316	3	-	-	873	-	1	162	1 355
1998	+	-	71[1]	10	-	10	804	-	35	435	1 365
1999	+	-		1	-	18	2 157	-	43	358	2 577
2000	+		41	10	-	19	498[1]	-	67	192	827
2001	+		43	-	-	10	470	-	122	202	847
2002	+		8	+	-	2	200	-	10	246	466
2003	-	-	1	+	+	+	453	-	+	122	576
2004	-	-	-	-	-	-	413	-	90	-	503
2005	-	-	2	-	-	-	58	-	4	-	64
2006	-	-	3	-	-	-	89	-	7	-	99
2007	-	+	+	-	-	-	129	-	+	+	129
2008	-	-	-	-	-	-	14	-	22	-	36
2009[1]	-	-	-	-	-	-	5	-	129	-	134
2010[1]	+	1	38	-	-	-	39	-	49	-	126
2011[1]	-	1	50	-	-	-	95	-	44	-	190

[1] **Provisional figures**

Table F11. Abundance indices of different length groups in 1984-2011 (in thousands), Russian autumn survey (Smirnov O, WD-AFWG 2011).

Year	Length, cm												Total
	<=30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	>80	
1984	4837	5078	11690	21171	15167	10886	7370	6549	3751	1786	1128	483	89896
1985	4003	6748	16858	24897	23244	15702	8376	5704	3776	2054	1028	698	113088
1986	3482	6062	13765	18945	15997	10369	4839	3022	2534	1325	440	205	80985
1987	2010	4828	7228	10490	8831	5513	2123	1784	1437	645	481	421	45791
1988	3374	5111	9022	10147	10128	5828	2265	1862	1218	511	361	341	50168
1989	2030	7055	13962	17252	16790	10028	3789	1916	1279	415	200	388	75104
1990	2762	6056	12802	13061	9527	9829	4967	2094	589	312	115	119	62233
1991	1036	5012	16237	20998	17418	11728	8012	4562	814	181	122	174	86294
1992	184	2153	17185	32399	22481	12977	6229	3473	1869	502	182	106	99740
1993	-	290	3593	14782	21080	16013	6743	3341	2031	859	269	164	69165
1994	49	17	1651	12582	16203	12566	5391	3320	2019	819	188	106	54911
1995	-	38	1245	13193	20571	12445	5432	2717	1587	579	187	82	58076
1996*	-	11	786	13012	30573	18294	5730	1795	773	534	169	12	71689
1997	140	152	1318	7744	18504	17221	6932	3079	1952	465	195	142	57844
1998	2449	2238	2949	10847	24266	19640	11112	5946	2158	440	172	90	82307
1999	1070	2815	4632	7886	17734	18489	10158	4827	2043	529	196	74	70453
2000	1274	1698	5184	14996	24170	20721	12805	5675	3100	1228	240	143	91234
2001	1399	2887	7496	18136	34752	29886	13463	6759	3772	1511	593	369	121024
2002**	662	2033	6395	13329	19810	13135	7180	3406	1311	381	129	58	67828
2003***	955	2396	7420	13006	17160	11630	7978	5332	3541	985	485	238	71126
2004	1431	2705	11945	16937	20155	18274	12594	6948	4783	2087	813	536	99209
2005	830	3970	10726	17850	17547	15164	9726	5859	3343	1150	453	545	87163
2006****	293	1981	18471	35224	36563	26335	14138	7248	4943	1669	668	488	148021
2007	376	1431	6937	24330	26780	26086	22157	15586	7480	3786	932	628	136510
2008	463	4626	19991	28799	30062	32159	23175	11326	8368	4198	1872	1089	166129
2009	152	4919	29389	48321	45833	33915	24484	10227	6568	3032	881	616	208338
2010	146	5097	37901	66086	57863	46321	25428	10058	8612	3983	1587	1610	264692
2011	456	1285	22470	61115	78247	64186	49620	19412	11607	7226	3529	874	320025

*** Only half of the standard area was investigated**

**** No observations in NEEZ**

***** Observations in the NEEZ on the main spawning grounds were conducted considerably later than usual**

****** Survey was conducted by one vessel with a reduced number of trawls at depths less than 500 m**

Table F12. Abundance indices of different length groups in 1994-2011 (in thousands), Norwegian autumn survey.

Year	Length, cm												Total
	<=30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	>80	
1994	0	15	1228	11572	17070	12095	6642	3049	1900	709	240	104	54624
1995	0	26	968	11321	21752	15813	7763	3629	2055	794	339	106	64566
1996	0	14	620	10301	27005	19473	7255	2730	1541	608	192	73	69812
1997	7	81	1194	9801	24890	16683	6172	2885	1681	758	306	183	64641
1998	8	65	891	5671	16538	18475	8942	3890	2376	1200	393	205	58654
1999	10	99	627	4651	16792	22922	12163	4939	3547	1436	632	282	68100
2000	2	129	1060	5030	11869	17886	10337	4423	2469	1093	405	223	54926
2001	21	315	2167	6865	15650	18784	11523	5074	3137	1202	485	300	65523
2002	97	751	3028	7146	14968	18806	12679	6012	3033	1263	467	247	68497
2003	35	734	3963	7709	13948	17207	15192	8120	4469	2815	681	318	75191
2004	25	768	4301	6722	12476	18463	11452	6526	3817	1873	637	429	67489
2005	70	1987	7187	12129	13500	12000	8812	5495	3533	1507	571	422	67213
2006	12	1001	6471	9516	11681	11063	8487	5287	3383	1640	633	495	59669
2007	160	2813	21106	24410	15982	11181	7015	3868	2239	892	315	281	90262
2008	383	6021	16581	19557	14151	10863	6197	3015	2300	915	348	504	80835
2009	30	1924	15211	24599	18037	14023	9533	4411	3121	1587	603	402	93481
2010*	-	-	-	-	-	-	-	-	-	-	-	-	-
2011	0	252	4426	15531	17296	13711	8428	3524	2231	1342	746	502	67989

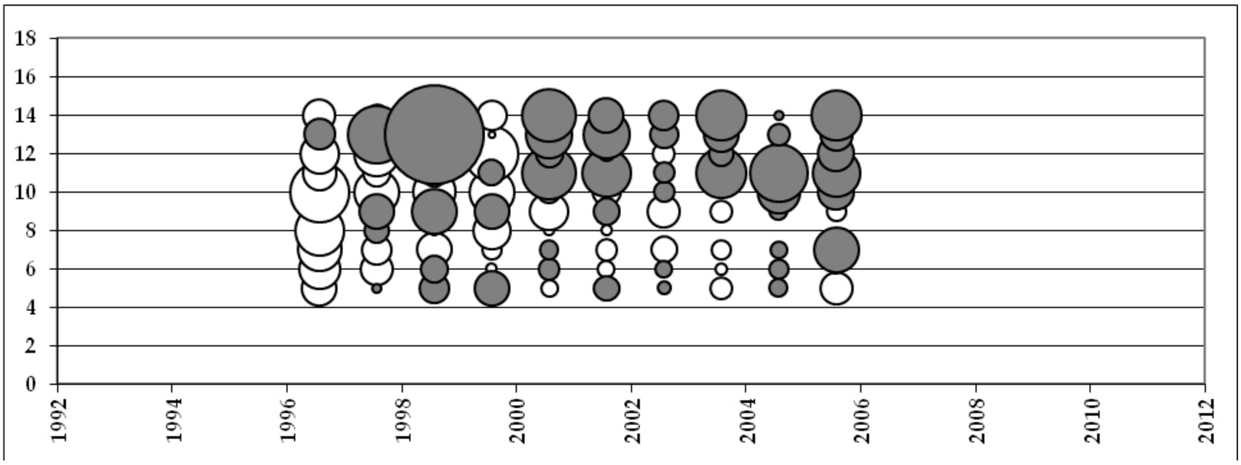
* No survey in 2010

Table F13. Abundance indices of females of different length groups in 1996-2011 (in thousands), Norwegian autumn survey.

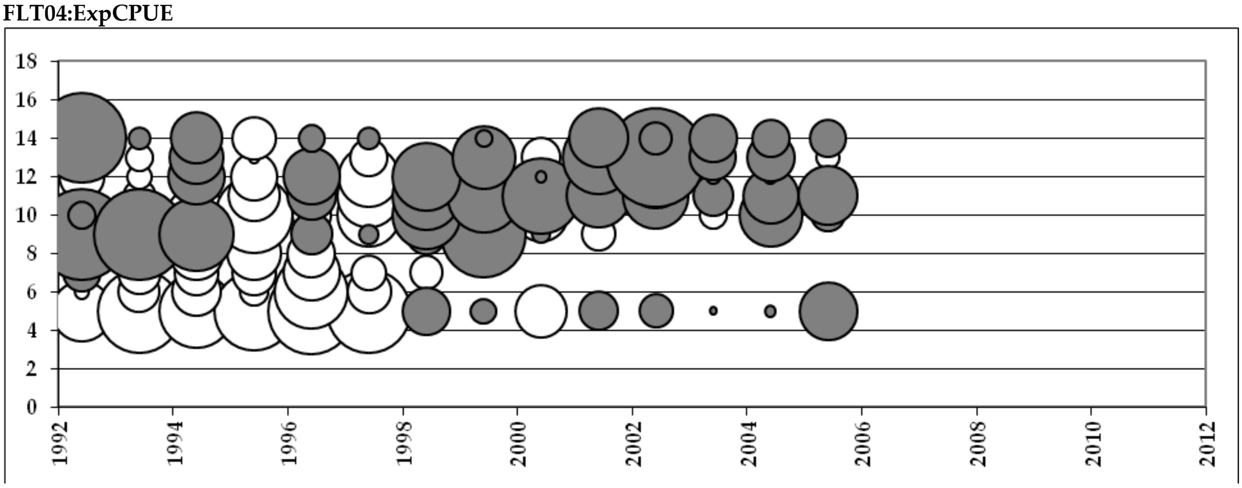
Year	Length, cm												Total
	<=30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	>80	
1996	0	2	255	2095	5390	5002	2829	2303	1502	602	192	73	20245
1997	8	62	691	2365	4809	4530	2725	2504	1661	790	296	187	20628
1998	5	24	372	1287	2961	5044	3948	3398	2393	1205	399	209	21245
1999	2	29	248	1166	2430	5152	5262	4443	3562	1468	637	282	24681
2000	1	57	433	1234	1810	2978	3629	3488	2407	1107	420	230	17794
2001	13	136	890	2038	2457	3179	3940	4139	3093	1205	485	301	21876
2002	51	360	1242	1898	2294	2946	3886	4283	2958	1268	471	250	21907
2003	13	358	1831	2505	2431	2919	5036	5935	4342	2197	700	287	28554
2004	15	320	1811	2063	1877	2802	4349	5688	3777	1814	638	430	25584
2005	32	676	2645	3122	2600	2023	3567	4677	3457	1469	566	428	25262
2006	4	485	2768	3050	2624	2271	3131	4339	3314	1630	642	499	24757
2007	89	1458	10321	9839	4347	2521	2754	3234	2201	882	317	276	38239
2008	229	3175	7537	6454	4270	2696	2484	2635	2315	936	365	539	33635
2009	14	759	5956	8623	5246	3644	3810	3408	3057	1623	614	391	37145
2010	-	-	-	-	-	-	-	-	-	-	-	-	-
2011	0	88	1301	3205	3362	2288	1968	2097	2139	1334	746	502	19030

* No survey in 2010

FLT08:Norw.Comb



FLT04:ExpCPUE



FLT07:RusTraSur

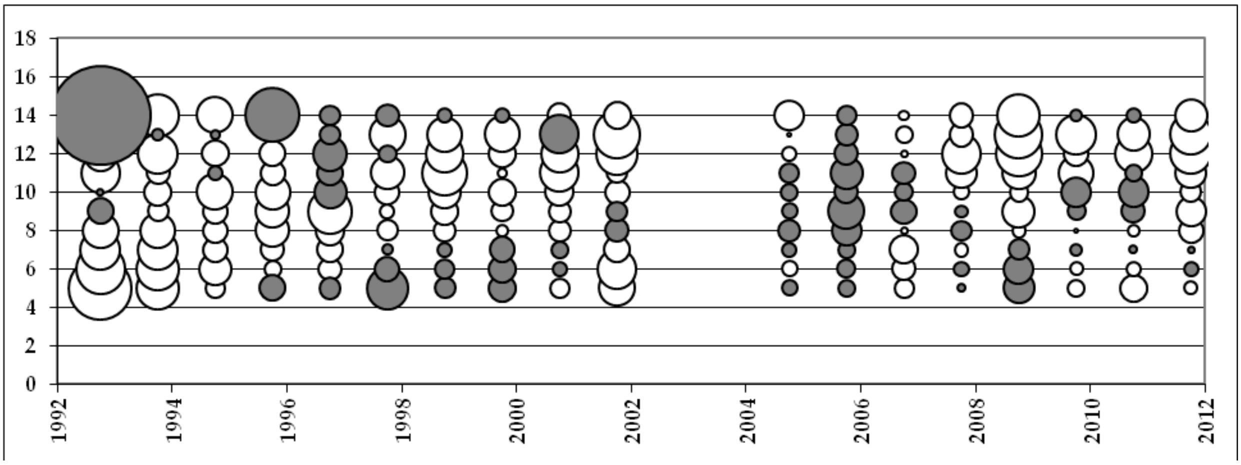


Figure 8.1. <u>NEA Greenland halibut</u>. Log catchability residuals by age and year for the tuning fleets included in the assessments. For each graph all bubbles are normalized to the same maximum bubble-size. Open bubbles represent positive values; filled bubbles represent negative values. Upper panel is for Norwegian combined survey index, middle panel shows Norwegian CPUE series and lower panel is Russian autumn survey.

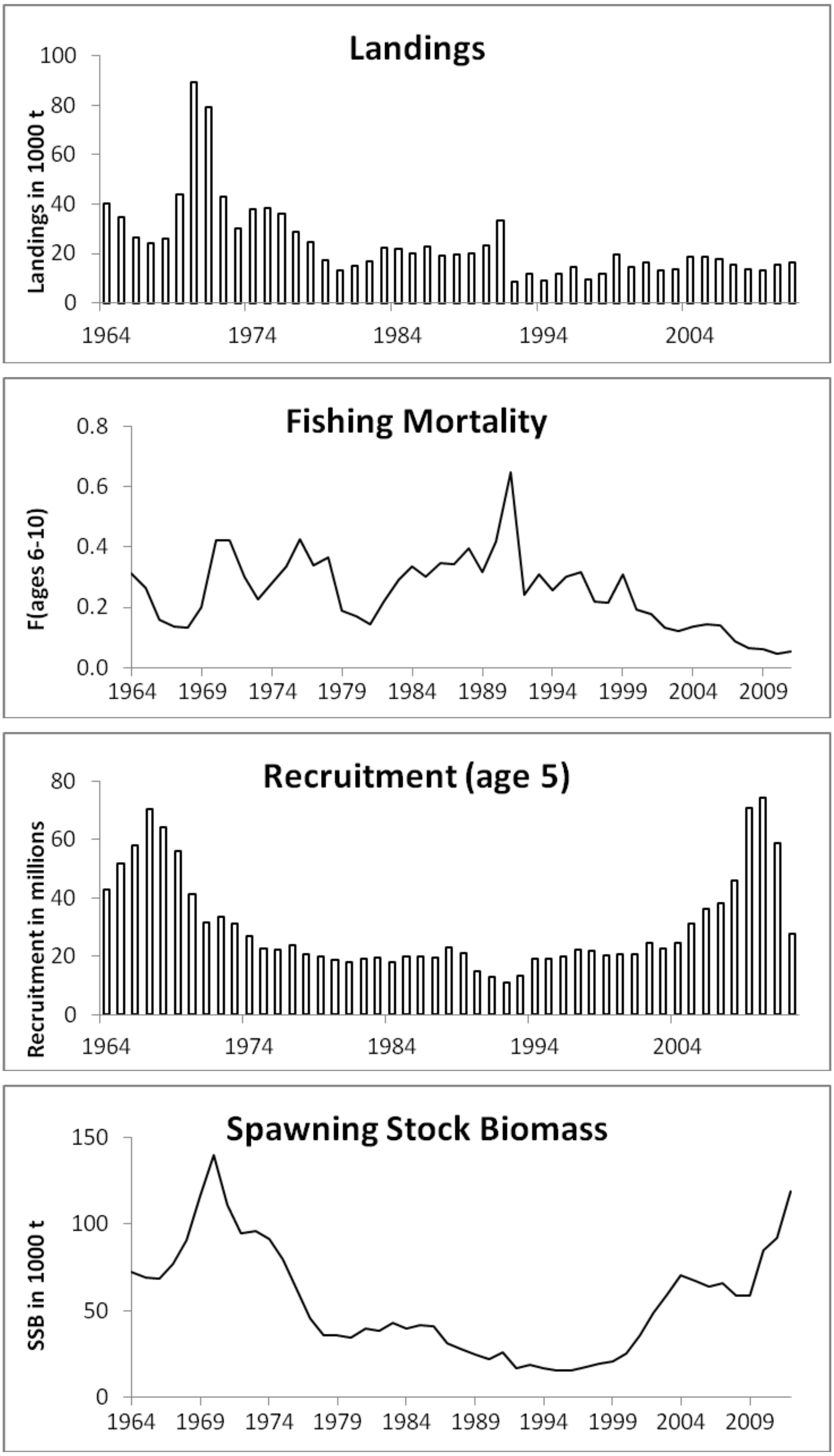


Figure 8.2. NEA Greenland halibut. Historical landings, fishing mortality, recruitment and spawning stock biomass.

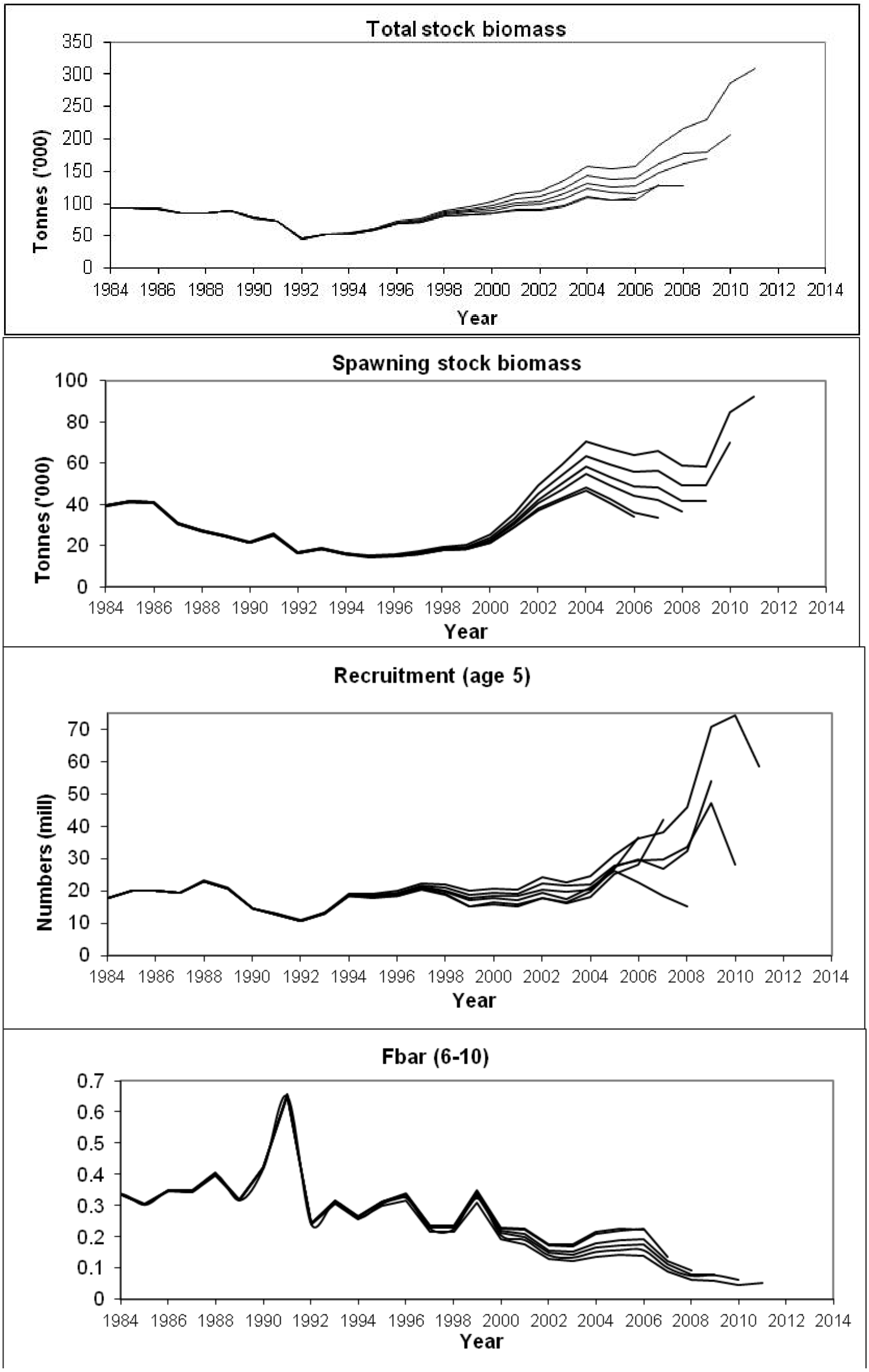


Figure 8.3. NEA Greenland halibut. Retrospective plots.

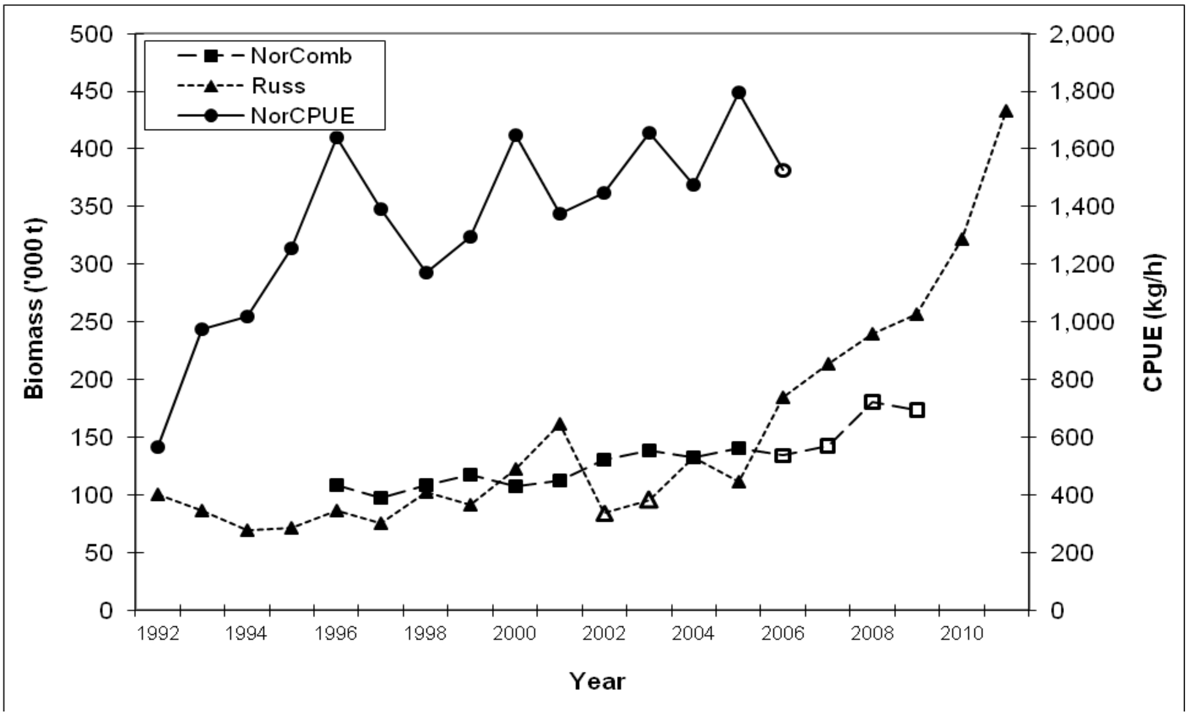


Figure 8.4. NEA Greenland halibut. Biomass estimates from different tuning series used in the trial XSA. Years with open symbols indicate years excluded from the tuning. (Russian survey in 2002 and 2003 excluded due to nonstandard survey coverage/time. Norwegian Combined Survey in 2006-2009 and Norwegian CPUE in 2006 – excluded due to lack of age readings).

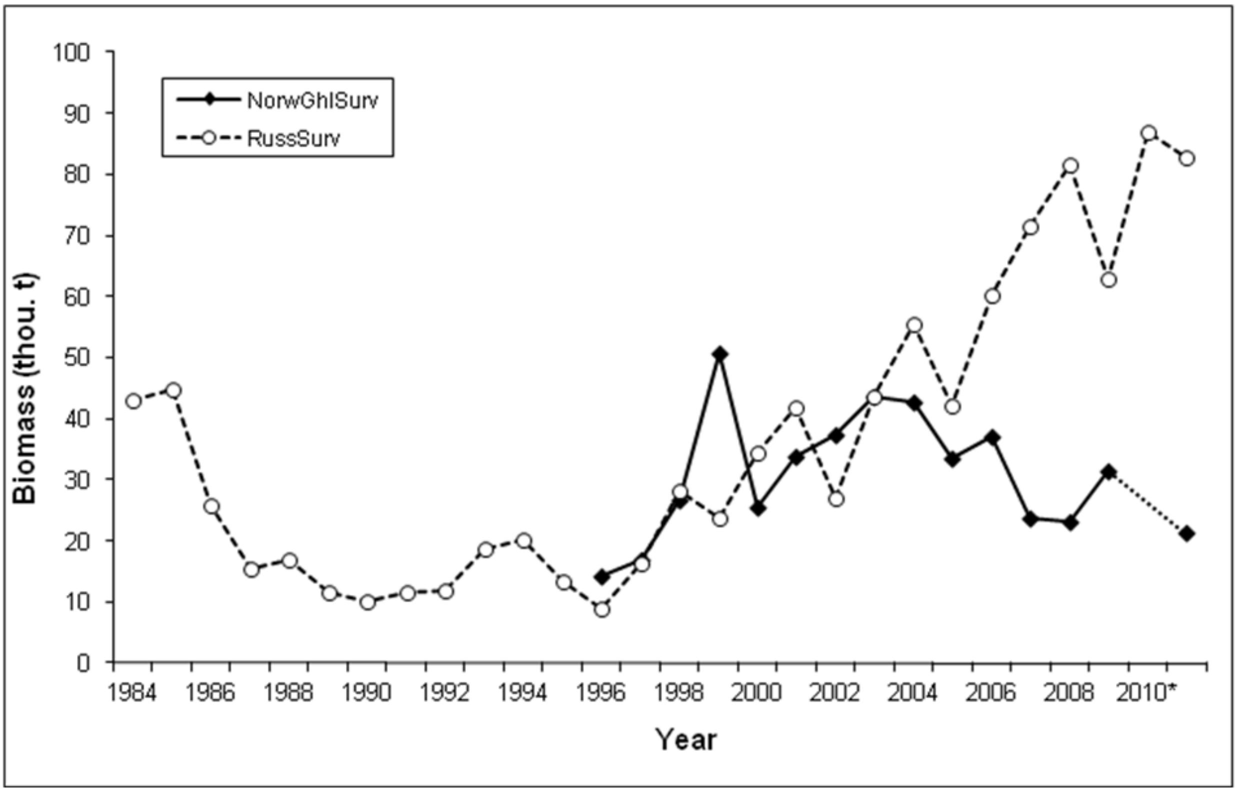


Figure 8.5. <u>NEA Greenland halibut</u>. Swept area estimate of the mature female biomass based on the data from the Norwegian Greenland halibut survey along the continental slope in August (*not executed in 2010) and Russian trawl survey in October-December (compared to previous reports, 2007-2008 recalculated using complete data for these years).

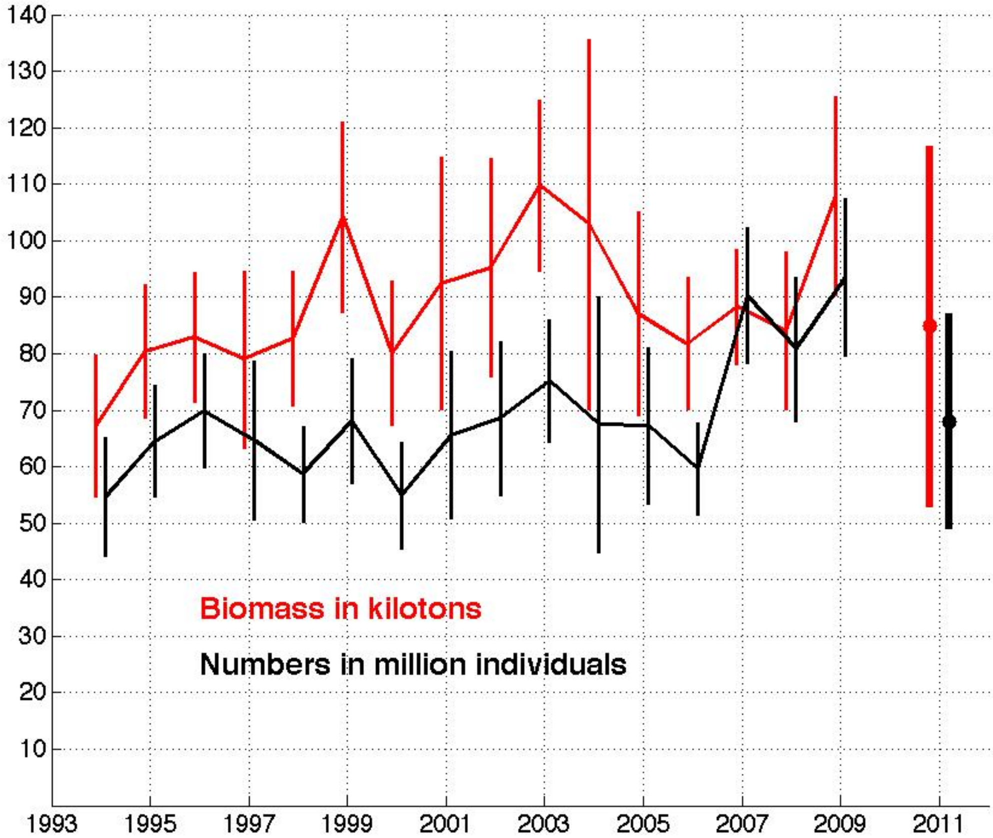


Figure 8.6 Estimated Greenland halibut total abundance in biomass and by number of individuals from the Norwegian slope surveys 1994-2011. The vertical bars show 95% confidence intervals.

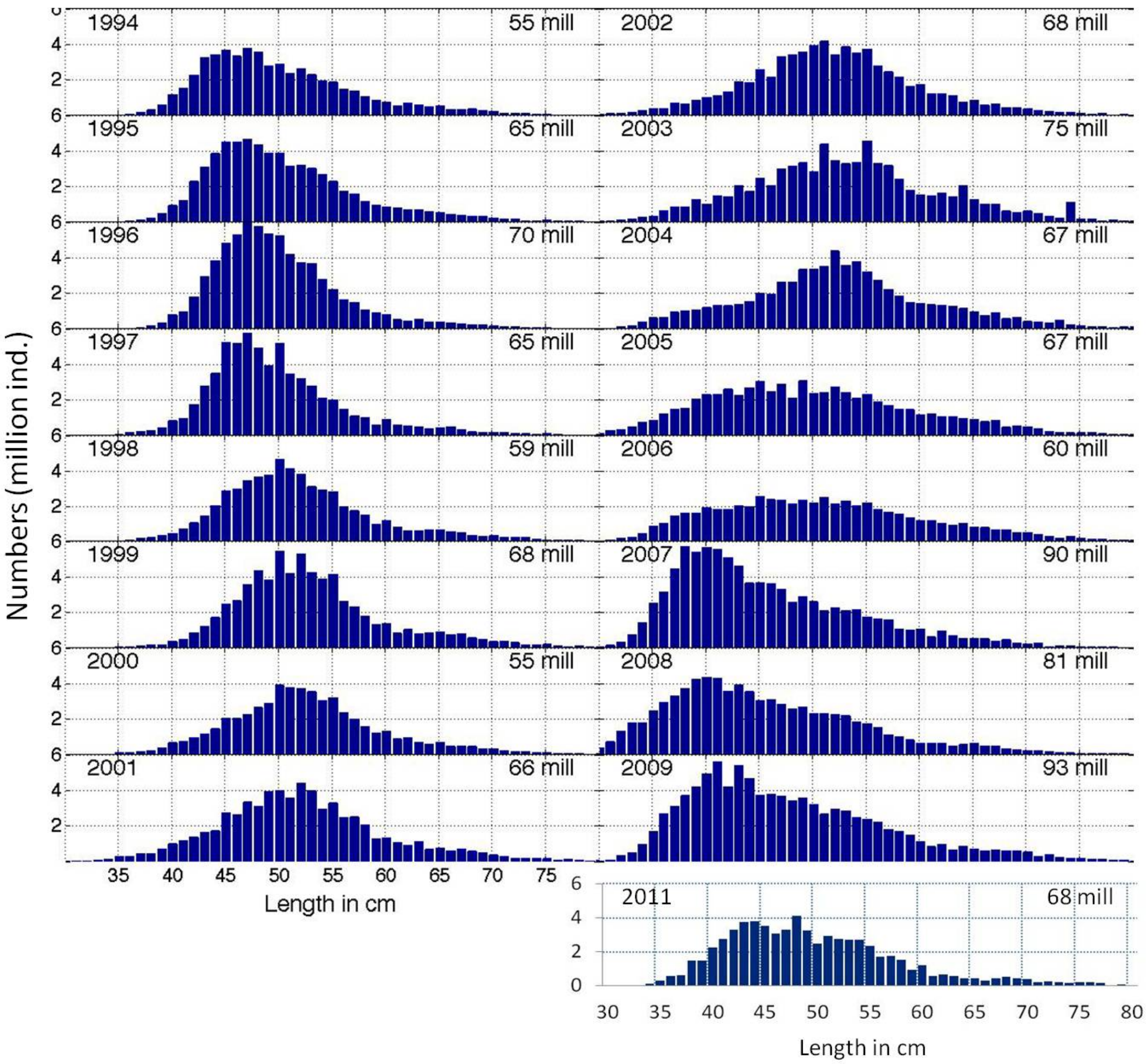


Figure 8.7. Length frequency distributions for Greenland halibut from the Norwegian autumn surveys 1994-2011. Note the abrupt shift in 2007.

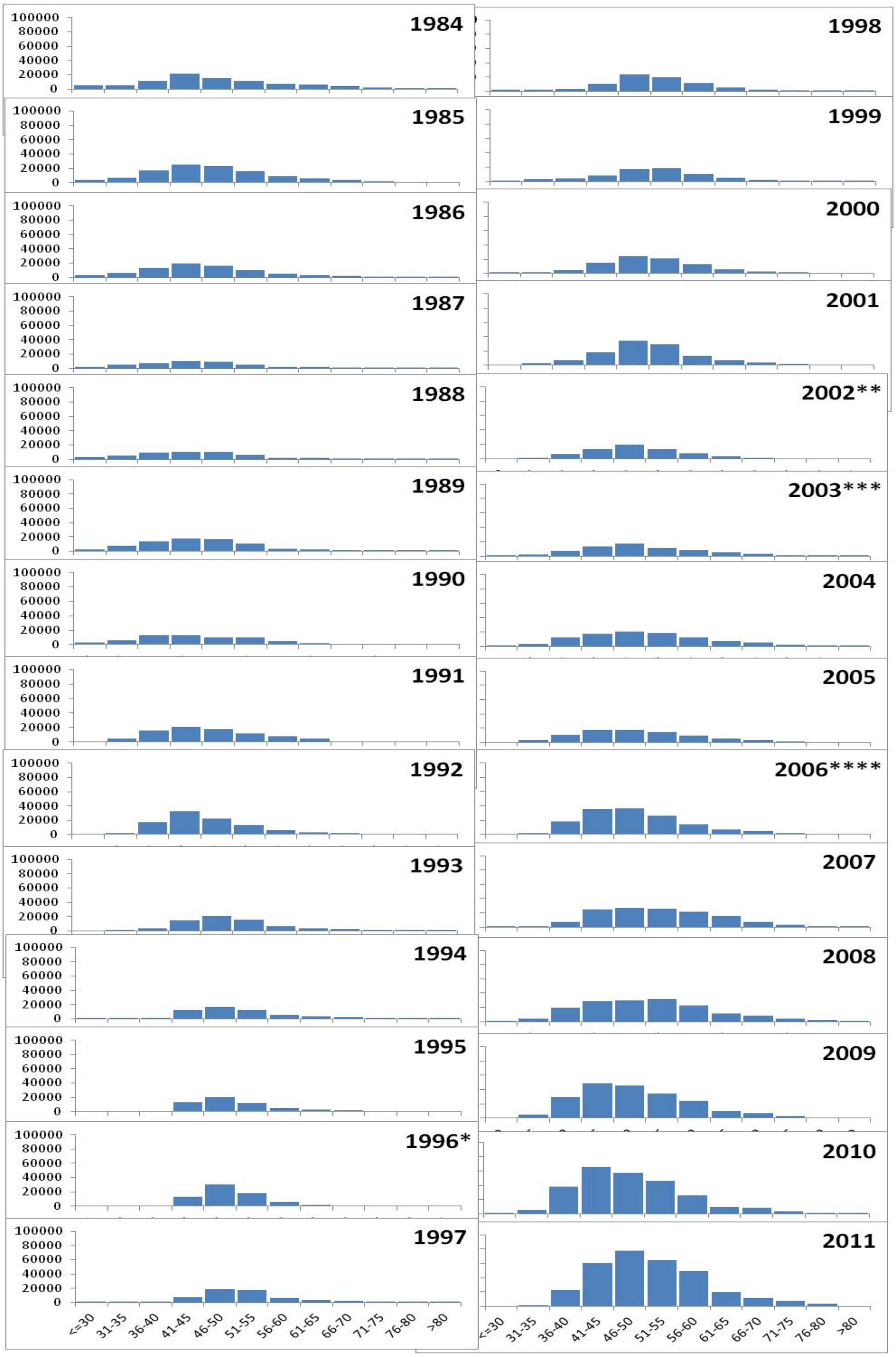


Figure 8.8. Length distribution for Greenland halibut in the Russian autumn survey 1984-2011
*** Only half of the standard area was investigated**
**** No observations in NEEZ**
***** Observations in the NEEZ on the main spawning grounds were conducted considerably later than usual**
****** Survey was conducted by one vessel with a reduced number of trawls at depths less than 500 m**

9 Barents Sea Capelin

9.1 Regulation of the Barents Sea Capelin Fishery

Since 1979, the Barents Sea capelin fishery has been regulated by a bilateral fishery management agreement between Russia (former USSR) and Norway. A TAC has been set separately for the winter fishery and for the autumn fishery. In recent years (from 1999) no autumn fishery has taken place, except for a small Russian experimental fishery. The fishery was closed from 1 May to 15 August until 1984. After 1984, the fishery was closed from 1 May to 1 September. A minimum landing size of 11 cm has been in force since 1979. From the autumn of 1986 to the winter of 1991, from the autumn 1993 to the winter 1999, and in 2004-2008, no commercial fishery took place. A commercial fishery in the wintering-spring period started again in 2009. AFWG strongly recommends capelin fishery only on mature fish during the period from January to April.

9.2 Catch Statistics (Table 9.1, 9.2)

The total catches that were taken during spring 2012 amounted to 218 541 tonnes by Norway and 68 167 tonnes by Russia, giving a total of 286 708 tonnes. This is 33 292 tonnes below the agreed TAC. The trawlers had difficulty catching their part of the TAC, and in the Norwegian fishery this caused a transfer of quota to the purse seiners at the end of the fishing season. Thus the Norwegian TAC was caught, but as the Russian fishery is conducted only by trawlers, a part of the Russian TAC was not taken. The amount of capelin killed by fishing operation (including discards) is uncertain, but by expert assessment it lower than in 2011, because there were not many high density schools observed during the fishing season.

The age-length composition from Norwegian catches in 2012 will be presented later (in autumn assessment report, Table 9.1a) while the composition of the Russian fishery is shown in Table 9.1b. The international historical catch by country and seasons in the years 1972-2012 is given in Table 9.2. The detailed catch statistics by months for 2012 are given in WD16.

9.3 Sampling

The sampling from scientific surveys, exploratory fishing and observers of capelin from September 2011 to April 2012 is summarised below:

Investigation	No. of samples	Length measurements	Aged individuals
Ecosystem survey in autumn 2011 (Norway)	300	17043	3508
Ecosystem survey in autumn 2011(Russia)	221	18099	905
Capelin winter investigations 2012 (Russia)	20	5364	250
Observer on fishing vessels in winter-spring 2012(Russia)	58	18298	880
Sampling from fishing vessels in winter-spring 2012 (Norway)	29	2697	349
Bottom survey winter 2012 (Norway)	177	5714	1058
Bottom survey winter 2012 (Russia)	64	5517	200

9.4 Stock Size Estimates

9.4.1 Acoustic stock size estimates in 2011 (Table 9.3)

One Russian and three Norwegian vessels jointly carried out the 2011 acoustic survey as part of an ecosystem survey during autumn (Anon., 2011). The geographical coverage of the total stock was considered complete. It was also synoptic as in the previous years and the results of estimation are representative. The geographical distribution of capelin is shown in Figure 9.1.

The results from the survey are given in Table 9.3. The total capelin stock was estimated at 3.7 million tonnes. It is about 5% higher than the stock estimated last year and higher than the long term mean. Almost 57% (2.1 million tonnes) of the stock biomass consisted of maturing fish (>14.0 cm). The estimated amount of maturing fish is almost at the same level as in 2010. The weight at age in the 2011 survey is below that in 2010.

9.4.2 Recruitment estimation in 2011 (Table 9.4)

The historical estimated total number of larvae is shown in Table 9.4. These larval abundance estimates should reflect the amount of larvae produced each year (Gundersen and Gjøsæter, 1998). There were some problems with this survey in 1986, 1995 and since 1997 when permission has not been granted to enter the Russian EEZ. The larval surveys based on Gulf III plankton samples, which have been carried out in June each year since 1981, were discontinued in 2007.

A swept volume index (Dingsør, 2005; Eriksen *et al.*, 2009) of abundance of 0-group capelin in August-September is given in Table 9.4. This index is calculated both without correction and with correction for catching efficiency. The 0-group index in 2011 a higher them the long-term average. Table 9.4 also shows the number of fish in the various year classes, and their "survey mortality" from age one to age two. As there usually has been no fishing on these age groups, the figures for total mortality constitute natural mortality only, and probably reflect quite well the variation in predation on capelin.

There is negative "survey mortality" from age zero to one for several cohorts and also from age one to two for a couple of cohorts with low abundance. The reason for this is that it is very difficult to assess the younger age groups, particularly in the mixed concentrations.

9.5 Other surveys and information from 2012

Russian capelin spring investigation

Russian capelin spring investigations were performed on board Norwegian purse-seiner "M/S Birkeland" in the period from 04 to 28 March 2012. The area of distribution of capelin was only partly covered during the survey, and the main aim was to study purse-seining of capelin, bycatches of cod, and migration of capelin schools. Estimation of the spawning stock biomass was not carried out.

The water temperatures in the surface layer inside the surveyed area were characterized as very warm.

To the south of 71°N and west of 24°E single capelin schools (100-500 tonnes) 25-30 nautical miles apart were observed. Capelin gathered in schools of higher densities

(500-1000 tonnes) 5-10 miles apart in some areas. The smallest schools (30-50 tonnes) were recorded in the coastal zone of the northern part of Porsanger Fjord.

The maximum biomass of capelin was observed in the central part of the Norwegian Deep and the northern part of Fugløy bank, where it reached 750 tonnes/sq. nautical mile (Figure 9.2). The largest capelin migrating schools were observed in that area. The biomass of schools was more than 1 000 tonnes, but the schools were few.

The density of capelin in March was relatively low, indicating a significant spreading of spawning approaches in time and space. The capelin in the catches were from 12 to 19.5 cm and fish from 15.5-17.5 cm dominated. The average length was 16.4 cm, 0.5 cm less than in 2011 and close to the average value.

Abnormally high temperatures in the southern part of Barents Sea (about +1°C above long-term mean by survey observation) caused the longest capelin migration along the coast of Northern Norway, up to the eastern borders of Andøy bank (16°E). As a rule, prespawning capelin are moving far to the west along the coast in case of unsuitable conditions at spawning grounds in the eastern and central coastal areas. These conditions could be related to the temperature. The type of capelin migration seen in 2012 is relatively rare and during historically period was observed only 6 times, in 1972, 1983-1985, 2000 and 2003.

A distinctive feature of 2012 was also a complete lack of capelin approach into internal coastal waters east of 28°E.

About 70% of the capelin were three-year-olds from the abundant year class 2009. In contrast to 2011, the proportion of fish at age 4 did not exceed 6.4%. (In 2011 it amounted to 80%).

The average age was estimated at 3.8 years. There was not more than 0.4% young capelin (one-year-olds) in catch.

During the survey the bycatches of cod occurred in the all capelin catches. All cod was mature and fed actively on capelin.

Norwegian capelin winter-spring investigation

No special capelin investigation was conducted by Norway in winter-spring 2012. Capelin observations were made during the winter groundfish survey, but no attempt was made to quantify the amount of maturing capelin approaching the coast to spawn.

9.6 Stock assessment

As decided by the Arctic Fisheries Working Group at its 2011 meeting (ICES C.M. 2011/ACOM:05), the assessment of Barents Sea capelin was left to the parties responsible for the autumn survey, i.e. IMR in Bergen and PINRO in Murmansk. In accordance with this, the assessment was made during a meeting in Murmansk after the survey. The assessment was an update assessment, without significant changes in the methodology.

Estimates of stock in number by age group and total biomass for the historical period are shown in Table 9.5. Other data which describe the stock development are shown in Table 9.6.

A probabilistic projection of the spawning stock to the time of spawning at 1 April 2012 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 2011 Arctic Fisheries Working Group. The methodology is described in the 2009 WKSHORT report (ICES C.M. 2009/ACOM:34). Some changes were made in the models and parameters of capelin mortality. A detailed explanation of the changes is given in ICES 2011/ACOM:05 Annex 12. Probabilistic prognoses for the maturing stock from October 1 2011 until April 1 2012 were made for four runs (Fig. 9.3). The assessment was based on run 4. The natural mortality M to use in the months October to December is drawn among the replicates of M-values estimated from historic data. In 2009, it was decided to draw from the period 1995 to 2001 (the period between the two last capelin stock collapses), based on an assessment of which period should best reflect the situation encountered from 2009 when a more complete overlap between capelin and cod during autumn. The same period was chosen in 2011. In previous years it has been assumed that the catches are distributed on months in the following way: January: 20%, February: 30% and March: 50%. Based on the monthly distribution of catches in 2009-2011, the distribution was changed to 0% in January, 30% in February and 70% in March. The actual catch in 2012 by months was 3% in January, 43 % in February, 48% in March and 6% in April.

Two underlying model assumptions were identified as questionable:

1. Only immature cod eats mature capelin during the period January-March
2. The M for maturing capelin during the period October-December can be modeled from the mean monthly M on immature capelin estimated from the annual surveys

Work is now being done to address these assumptions and if possible amend the assessment model at these points. Initial work to study the first of these assumptions from cod stomach content data is described in WD15.

Probabilistic prognoses for the maturing stock from October 1 2011 until April 1 2012 were made, with a CV of 0.20 on the abundance estimate. A CV of 0.20 is slightly higher than the value calculated for most years (see Stock Annex). With no catch, the estimated median spawning stock size in 2012 is 776 000 tonnes. With a catch of 320 000 tonnes, the probability for the spawning stock in 2012 to be below 200 000 t, the B_{lim} value used by ACFM in recent years, is 5 % (Fig. 9.4). The median spawning stock size in 2012 will then be 504 000 tonnes. Figure 9.4 shows the probabilistic forecast from 1 October 2011 to 1 April 2012 conditional on a quota of 320 000 tonnes, while Fig 9.5 shows the probability of SSB < B_{lim} as a function of the catch. The advised catch for 2012 is slightly lower than for 2011 (320 000 tonnes vs. 380 000 tonnes).

The 0-group index for herring in 2011 is low, and the ecosystem survey in 2011 also showed that the abundance of age 1-2 herring in the Barents Sea is very low (Anon., 2011) which is consistent with the most recent stock assessment for herring (ICES C.M. 2011/ACOM:15). The total abundance of 1 year and older herring in the Barents Sea in 2012 will thus be low and the recruitment conditions for capelin can thus be expected to be average to good in 2012. High abundance of herring has been suggested to be a necessary but not sufficient factor for recruitment failure in the capelin stock (Hjermann *et al*. 2010).

The 2011 year class was found to be higher than average at the 0-group stage. If we insert the 2011 value (176.0) in the 1-group vs. 0-group regression shown in Fig. 9.6 we get 406.9 billion as the predicted value of 1-group abundance in 2012. However, it is unknown whether the extremely western capelin spawning could affect the recruitment negatively.

Being a forage fish in an ecosystem where two of its predators cod and haddock are presently at 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 and 1.4) and haddock (ICES AFWG 2010 WD#04) has been on high levels. At the same time, capelin have for the last years been at levels at which the current harvest control rule allowed a capelin fishery to take place (Table 9.5). Consequently, the stock is under "double pressure" and should be monitored carefully to look for signs of overexploitation that could, eventually, lead to recruitment failure and a reduced stock size. The fishing operations should also be monitored carefully to check whether additional mortality caused by slipping, sorting through the meshes etc. could be a potential problem.

9.7 Reference points

A B_{lim} (SSB_{lim}) management approach has been suggested for this stock (Gjøsæter *et al*. 2002). In 2002, the Mixed Russian-Norwegian Fishery Commission agreed to adopt a management strategy based on the rule that, with 95% probability, at least 200 000 t of capelin should be allowed to spawn. Consequently, 200 000 t was used as a B_{lim}.

A multispecies model including cod, herring and possible other species is needed for calculation of a target reference point for capelin B_{target}. It is necessary to take into account the strong species interactions. Such studies have been made by Tjelmeland (2005), and still in progress.

9.8 Regulation of the fishery for 2012

During its autumn 2011 meeting, the Joint Russian-Norwegian Fishery Commission set the quota for 2012 to 320 000 tonnes, in accordance with the harvest control rule. Of this, 10 000 tonnes (5 000 tonnes to Norway and 5 000 tonnes to Russia) is a research quota.

9.9 The Barents Sea capelin Stock Annex

According to recommendation from WKSHORT (August 2009, Bergen, Norway) the data and methodology used for the Barents Sea capelin assessment was described in detail in a new Stock Annex and included in the AFWG report in 2011. (ICES C.M. 2011/ACOM:05). No changes were made to the Stock Annex in 2012.

***Table 9.1a Barents Sea Capelin. Age- and length distribution (percentages) of Norwegian catches January-April 2012.**

*The catch statistic data are in processing and will be presented later.

Table 9.1b Barents Sea Capelin. Age- and length distribution (million) of Russian catches January-March 2012.

Length,cm	Age1	Age 2	Age 3	Age 4	Age 5	Sum %
6.0	0.1					0.00
6.5	0.2					0.01
7.0	0.1					
12.5			0.5			0.01
13.0			7.1			0.21
13.5			38.5	8.3		1.42
14.0			72.8	37.4		3.34
14.5			131.7	99.5		7.01
15.0			145.5	203.8	3.7	10.70
15.5			125.5	314.1	8.3	13.57
16.0			98.2	375.0	21.4	14.99
16.5		3.9	112.0	349.4	13.7	14.52
17.0			43.8	339.8	61.0	13.47
17.5			33.9	228.5	59.7	9.76
18.0			20.4	181.3	47.2	7.54
18.5				61.4	23.0	2.56
19.0				19.5	5.1	0.75
19.5				3.3	1.0	0.13
20.0				0.2	0.1	0.01
Sum	0.4	3.9	829.7	2221.4	244.4	100.0
%	0.01	0.12	25.14	67.32	7.41	

Table 9.2 Barents Sea CAPELIN. International catch ('000 t) as used by the Working Group.

Year	Winter				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
1965	217	7	0	**224**	0	0	**0**	**224**
1966	380	9	0	**389**	0	0	**0**	**389**
1967	403	6	0	**409**	0	0	**0**	**409**
1968	460	15	0	**475**	62	0	**62**	**537**
1969	436	1	0	**437**	243	0	**243**	**680**
1970	955	8	0	**963**	346	5	**351**	**1314**
1971	1300	14	0	**1314**	71	7	**78**	**1392**
1972	1208	24	0	**1232**	347	13	**360**	**1591**
1973	1078	34	0	**1112**	213	12	**225**	**1337**
1974	749	63	0	**812**	237	99	**336**	**1148**
1975	559	301	43	**903**	407	131	**538**	**1441**
1976	1252	228	0	**1480**	739	368	**1107**	**2587**
1977	1441	317	2	**1760**	722	504	**1226**	**2986**
1978	784	429	25	**1238**	360	318	**678**	**1916**
1979	539	342	5	**886**	570	326	**896**	**1782**
1980	539	253	9	**801**	459	388	**847**	**1648**
1981	784	429	28	**1241**	454	292	**746**	**1986**
1982	568	260	5	**833**	591	336	**927**	**1760**
1983	751	373	36	**1160**	758	439	**1197**	**2357**
1984	330	257	42	**629**	481	368	**849**	**1477**
1985	340	234	17	**591**	113	164	**277**	**868**
1986	72	51	0	**123**	0	0	**0**	**123**
1987	0	0	0	**0**	0	0	**0**	**0**
1988	0	0	0	**0**	0	0	**0**	**0**
1989	0	0	0	**0**	0	0	**0**	**0**
1990	0	0	0	**0**	0	0	**0**	**0**
1991	528	159	20	**707**	31	195	**226**	**933**
1992	620	247	24	**891**	73	159	**232**	**1123**
1993	402	170	14	**586**	0	0	**0**	**586**
1994	0	0	0	**0**	0	0	**0**	**0**
1995	0	0	0	**0**	0	0	**0**	**0**
1996	0	0	0	**0**	0	0	**0**	**0**
1997	0	0	0	**0**	0	1	**1**	**1**
1998	0	2	0	**2**	0	1	**1**	**3**
1999	50	33	0	**83**	0	22	**22**	**105**
2000	279	94	8	**381**	0	29	**29**	**410**
2001	376	180	8	**564**	0	14	**14**	**578**
2002	398	228	17	**643**	0	16	**16**	**659**
2003	180	93	9	**282**	0	0	**0**	**282**
2004	0	0	0	**0**	0	0	**0**	**0**
2005	1	0	0	**1**	0	0	**0**	**1**
2006	0	0	0	**0**	0	0	**0**	**0**
2007	2	2	0	**4**	0	0	**0**	**4**
2008	5	5	0	**10**	0	2	**0**	**12**
2009	233	73	0	**306**	0	1	**1**	**307**
2010	246	77	0	**323**	0	0	**0**	**323**
2011	273	87	0	**360**	0	0	**0**	**360**
2012	219	68	0	**287**				

Table 9.3. Barents Sea CAPELIN. Stock size estimation table. Estimated stock size from the acoustic survey in August-September 2011.

Length (cm)	1 2010	2 2009	3 2008	4 2007	Sum (10^9)	Biomass (10^3 t)	Mean weight (g)
6.0 - 6.5	6.328				6.328	6.328	1.0
6.5 - 7.0	20.507				20.507	20.507	1.0
7.0 - 7.5	21.124				21.124	23.236	1.1
7.5 - 8.0	22.874				22.874	32.024	1.4
8.0 - 8.5	22.217	0.001			22.218	39.992	1.8
8.5 - 9.0	25.953	0.402			26.355	52.710	2.0
9.0 - 9.5	27.848	0.284			28.132	70.330	2.5
9.5 - 10.0	21.955	1.704			23.659	75.709	3.2
10.0 - 10.5	17.792	4.497			22.289	86.927	3.9
10.5 - 11.0	14.803	9.553			24.356	109.602	4.5
11.0 - 11.5	6.226	16.851			23.077	124.616	5.4
11.5 - 12.0	1.534	18.455			19.989	123.932	6.2
12.0 - 12.5	0.393	25.937	0.078		26.408	192.778	7.3
12.5 - 13.0	0.002	25.690	0.604		26.296	228.775	8.7
13.0 - 13.5	0.001	21.897	0.189		22.087	225.287	10.2
13.5 - 14.0	0.003	13.833	1.961		15.797	180.086	11.4
14.0 - 14.5	0.001	15.513	2.009		17.523	234.808	13.4
14.5 - 15.0		11.197	6.834		18.031	288.496	16.0
15.0 - 15.5		6.765	6.421	0.496	13.682	246.276	18.0
15.5 - 16.0		4.764	8.138	1.713	14.615	293.762	20.1
16.0 - 16.5		2.850	9.800	0.469	13.119	301.737	23.0
16.5 - 17.0		0.268	7.583	0.264	8.115	201.252	24.8
17.0 - 17.5		0.678	6.921	0.752	8.351	239.674	28.7
17.5 - 18.0		0.034	3.253	1.421	4.708	144.065	30.6
18.0 - 18.5			1.327	2.449	3.776	139.712	37.0
18.5 - 19.0				0.412	0.628	22.294	35.5
19.0 - 19.5				0.011	0.011	0.407	37.0
19.5 - 20.0				0.060	0.060	2.340	39.0
TSN (10^9)	209.561	181.173	55.334	8.047	454.115		
TSB (10^3 t)	495.9	1764.0	1213.9	233.7		3707.7	
Mean length (cm)	8.71	12.87	16.00	17.22			11.41
Mean weight (g)	2.37	9.74	21.94	29.05			8.2
SSN (10^9)	0.001	42.069	52.502	8.047	102.619		
SSB (10^3 t)	0.2	697.2	1183.8	233.7		2114.8	

Table 9.4 Barents Sea CAPELIN. Recruitment and natural mortality table. Larval abundance estimate in June, 0-group indices and acoustic estimate in August-September, total mortality from age 1+ to age 2+.

Year class	Larval abundance	0-group Index (10^9 ind.)		Acoustic estimate (10^9ind.)		Z survey(1-2)
	(10^{12})	Without Keff	With Keff	1+ (Y+1)	2+ (Y+2)	%
1980	-	197.3	740	402.6	147.6	63
1981	9.7	123.9	477	528.3	200.2	62
1982	9.9	168.1	600	514.9	186.5	64
1983	9.9	100.0	340	154.8	48.3	69
1984	8.2	68.1	275	38.7	4.7	88
1985	8.6	21.3	64	6.0	1.7	72
1986	0.0	11.4	42	37.6	28.7	24
1987	0.3	1.2	4	21.0	17.7	16
1988	0.3	19.6	65	189.2	177.6	6
1989	7.3	251.5	862	700.4	580.2	17
1990	13.0	36.5	116	402.1	196.3	51
1991	3.0	57.4	169	351.3	53.4	85
1992	7.3	1.0	2	2.2	3.4	--
1993	3.3	0.3	1	19.8	8.1	59
1994	0.1	5.4	14	7.1	11.5	--
1995	0.0	0.9	3	81.9	39.1	52
1996	2.4	44.3	137	98.9	72.6	27
1997	6.9	54.8	189	179.0	101.5	43
1998	14.1	33.8	113	156.0	110.6	29
1999	36.5	85.3	288	449.2	218.7	51
2000	19.1	39.8	141	113.6	90.8	20
2001	10.7	33.6	90	59.7	9.6	84
2002	22.4	19.4	67	82.4	24.8	70
2003	11.9	94.9	341	51.2	13.0	75
2004	2.5	16.7	54	26.9	21.7	19
2005	8.8	41.8	148	60.1	54.7	9
2006	17.1	166.4	516	221.7	231.4	--
2007	-	157.9	480	313.0	166.4	46
2008	-	288.8	995	124.0	127.6	--
2009	-	189.8	673	248.2	181.1	27
2010	-	91.7	319	209.6		
2011	-	176.0	594			
Average	9.0	81	279	189	104	

Table 9.5 Barents Sea CAPELIN. Stock size in numbers by age, total stock biomass, biomass of the maturing component at 1. October.

Year	Stock in numbers (10^9)						Stock in weight	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	Maturing
1973	528	375	40	17	0	961	5144	1350
1974	305	547	173	3	0	1029	5733	907
1975	190	348	296	86	0	921	7806	2916
1976	211	233	163	77	12	696	6417	3200
1977	360	175	99	40	7	681	4796	2676
1978	84	392	76	9	1	561	4247	1402
1979	12	333	114	5	0	464	4162	1227
1980	270	196	155	33	0	654	6715	3913
1981	403	195	48	14	0	660	3895	1551
1982	528	148	57	2	0	735	3779	1591
1983	515	200	38	0	0	754	4230	1329
1984	155	187	48	3	0	393	2964	1208
1985	39	48	21	1	0	109	860	285
1986	6	5	3	0	0	14	120	65
1987	38	2	0	0	0	39	101	17
1988	21	29	0	0	0	50	428	200
1989	189	18	3	0	0	209	864	175
1990	700	178	16	0	0	894	5831	2617
1991	402	580	33	1	0	1016	7287	2248
1992	351	196	129	1	0	678	5150	2228
1993	2	53	17	2	2	75	796	330
1994	20	3	4	0	0	28	200	94
1995	7	8	2	0	0	17	193	118
1996	82	12	2	0	0	96	503	248
1997	99	39	2	0	0	140	911	312
1998	179	73	11	1	0	263	2056	931
1999	156	101	27	1	0	285	2776	1718
2000	449	111	34	1	0	595	4273	2099
2001	114	219	31	1	0	364	3630	2019
2002	60	91	50	1	0	201	2210	1290
2003	82	10	11	1	0	104	533	280
2004	51	25	6	1	0	82	628	294
2005	27	13	2	0	0	42	324	174
2006	60	22	6	0	0	88	787	437
2007	222	55	4	0	0	280	1882	844
2008	313	231	25	2	0	571	4427	2468
2009	124	166	61	0	0	352	3756	2323
2010	248	128	61	1	0	438	3500	2051
2011	209	181	55	8	0	454	3707	2115

Table 9.6 Barents Sea CAPELIN. Summary stock and data for prognoses table.

Year	Estimated stock by autumn acoustic survey (10^3 t) 1 October		Spawning stock biomass, assessment model, April 1 (10^3 t)	Spawning stock biomass, by winter acoustic survey (10^3 t)	Recruitment Age 1+, survey assessment 1 October 10^9 sp.	Young herring biomass age 1 and 2 in the Barents Sea. (10^3 t)	Landing (10^3 t)	Rate of the TSB change
	TSB	SSB						
1972	6600	2727					1591	
1973	5144	1350	33		528	2	1337	0.8
1974	5733	907	*		305	48	1148	**1.1**
1975	7806	2916	*		190	74	1441	**1.4**
1976	6417	3200	253		211	39	2587	0.8
1977	4796	2676	22		360	46	2986	0.7
1978	4247	1402	*		84	52	1916	0.9
1979	4162	1227	*		12	39	1782	1.0
1980	6715	3913	*		270	66	1648	**1.6**
1981	3895	1551	316		403	47	1986	0.6
1982	3779	1591	106		528	9	1760	1.0
1983	4230	1329	100		515	12	2357	**1.1**
1984	2964	1208	109		155	1313	1477	0.7
1985	860	285	*		39	1220	868	0.3
1986	120	65	*		6	155	123	0.1
1987	101	17	34	4	38	81	0	0.8
1988	428	200	*	10	21	134	0	**4.2**
1989	864	175	84	378	189	356	0	**2.0**
1990	5831	2617	92	94	700	641	0	**6.7**
1991	7287	2248	643	1769	402	1518	933	**1.2**
1992	5150	2228	302	1735	351	2429	1123	0.7
1993	796	330	293	1498	2	1684	586	0.2
1994	200	94	139	187	20	541	0	0.3
1995	193	118	60	29	7	198	0	1.0
1996	503	248	60		82	271	0	**2.6**
1997	909	312	85		99	327	1	**1.8**
1998	2056	932	94	414	179	1094	3	**2.3**
1999	2775	1718	382		156	1590	105	**1.3**
2000	4273	2098	599	700	449	880	410	**1.5**
2001	3630	2019	626		114	366	578	0.8
2002	2210	1291	496	1417	60	1738	659	0.6
2003	533	280	427		82	2071	282	0.2
2004	628	294	94	105	51	1721	0	**1.2**
2005	324	174	122		27	1242	1	0.5
2006	787	437	72		60	438	0	**2.4**
2007	2119	844	189		277	319	4	**2.7**
2008	4428	2468	330	469	313	158	12	**2.1**
2009	3765	2323	517	180	124	231	307	0.9
2010	3500	2051	504	452	248	214	315	0.9
2011	3707	2115	487	160	209	81	360	**1.1**
2012			504				287	

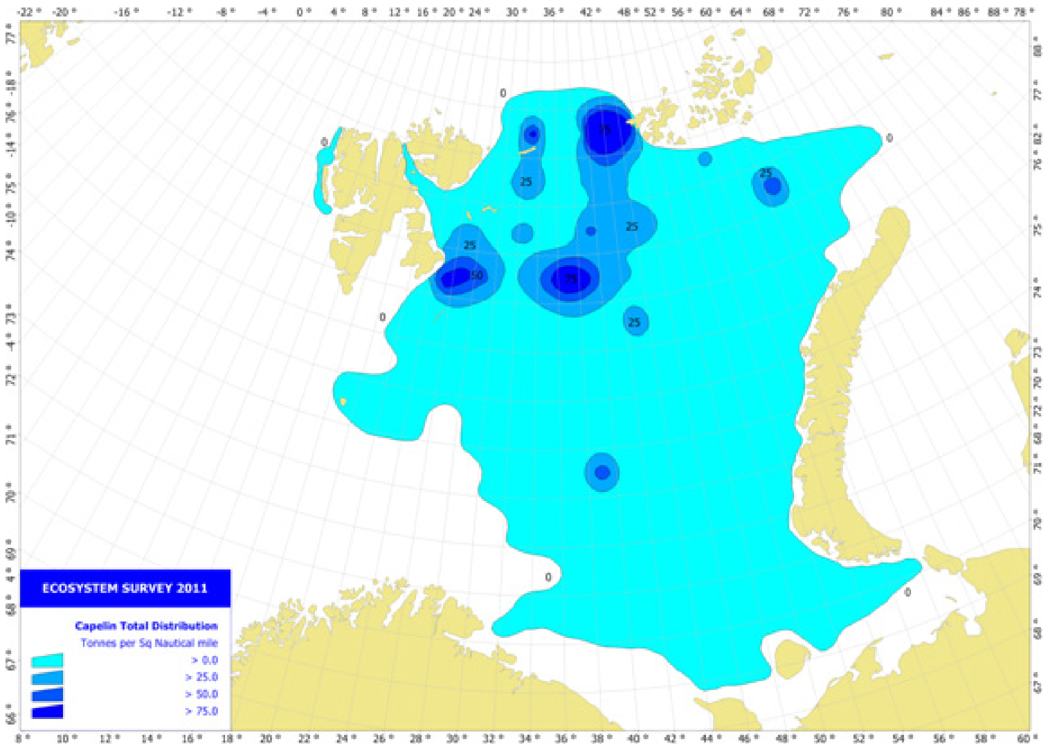


Figure 9.1. Geographical distribution of capelin in autumn 2011 (t/nm²).

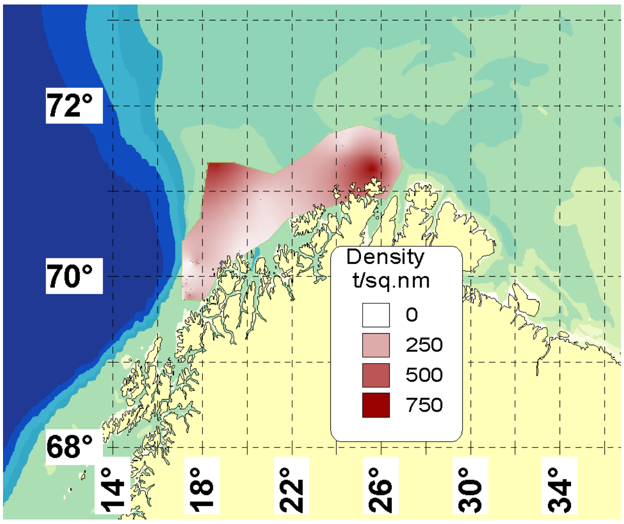


Figure 9.2 Survey area and density of capelin distribution in March 2012. "M/S Birkeland".

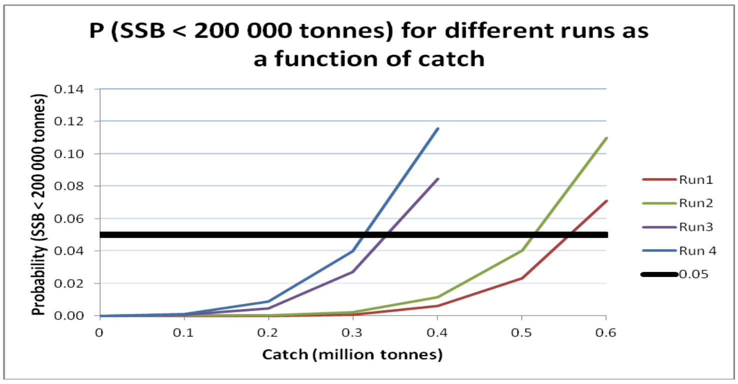


Figure 9.3. Probability of spawning biomass of capelin (1 April 2012) being below B_{lim} (200 000 tonnes), as a function of catch, for different model settings.

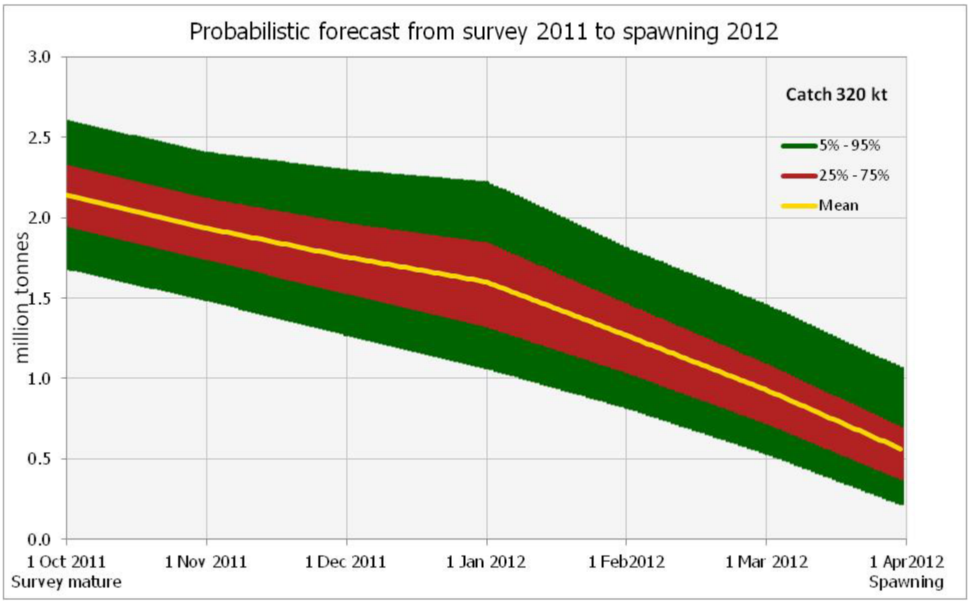


Figure 9.4. Probabilistic prognosis 1 October 2011-1 April 2012 for Barents Sea capelin (maturing stock, catch of 320 000 tonnes).

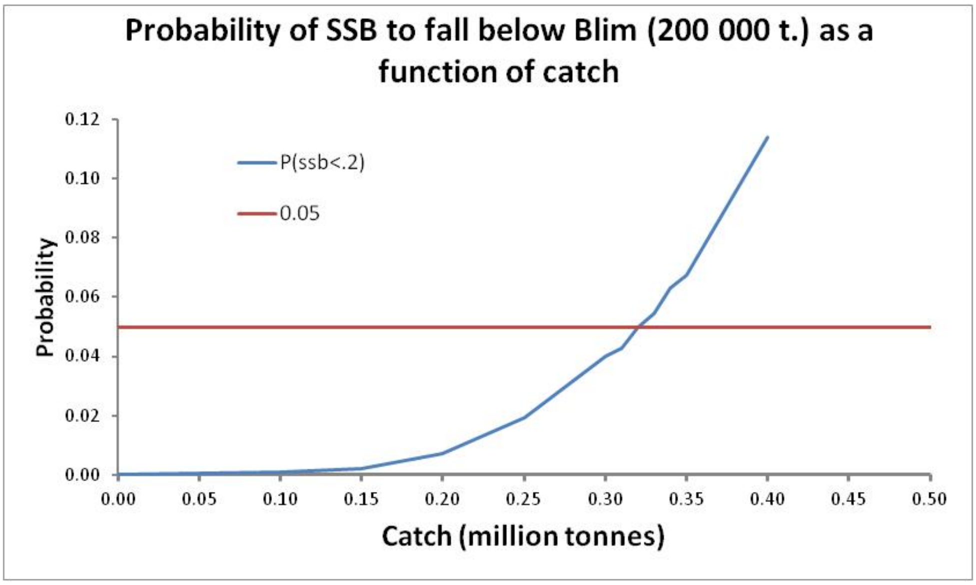


Figure 9.5. Probability of spawning biomass of capelin (1 April 2012) being below B_{lim} (200 000 tonnes), as a function of catch.

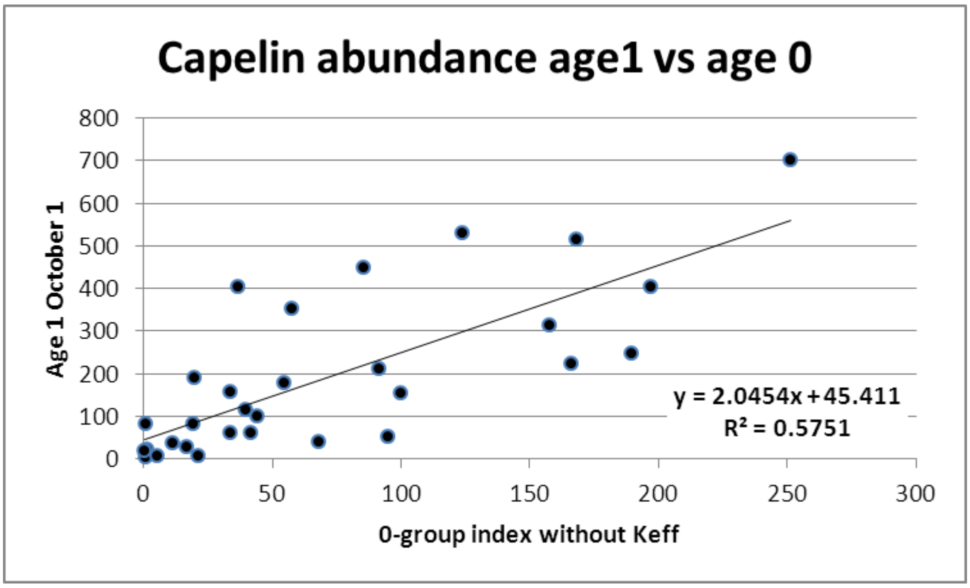


Figure 9.6. Regression of abundance of capelin at age 0 (0-group index without K_{eff}) and age 1 (acoustic estimate) of year classes 1981-2010. The 2008 year class was excluded due to extremely "noisy " data.

10 Working Documents

No	Author	Title
1	Mjanger et al.	Report of the 2011 meeting between the Norwegian and Russian cod and haddock age reading specialists
2	Bernreuther et al.	German commercial fishery on beaked redfish (*Sebastes mentella*) in ICES Divisions IIa and IIb in 2011
3	Aglen et al.	Barents Sea winter survey 2012
4	Prozorkevitch	Cod ecosystem survey index 2004-2011
5	Prozorkevitch	Haddock ecosystem survey index 2004-2011
6	Trella and Janusz	Polish Greenland halibut survey
7	Sokolov et al	Results of the Russian trawl-acoustic survey on cod and haddock in the Barents Sea and adjacent waters in November-December 2011
8	Casas	The Spanish NE Arctic Cod Fishery in 2011
9	Kovalev and Chetyrkin	Possible reductions in Barents Sea surveys – a test of its influence on NEA cod assessment quality
10	Dolgov	Consumption by cod
11	Kovalev and Chetyrkin	Evaluation of the NEA cod assessment quality
12	Smirnov	Greenland halibut Russian survey 1984-2011
13	Prozorkevitch	Capelin IMR_PINRO Age reading.
14	Alpoim et al.	Report of the Portuguese fishery in 2011: ICES Div. I, IIa and IIb.
15	Johannesen et al	Predation on capelin by cod
16	Prozorkevitch	Capelin catch statistic 2012
17	Hallfredsson	Norwegian slope survey autumn 2011
18	Stiansen et al	Barents Sea ecosystem status 2011
19	Prozorkevitch	Greenland halibut ecosystem survey index 2004-2011
20	Ruiz & Mugerza	Spanish G. halibut survey report

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Annex 1 – List of Participants

ARCTIC FISHERIES WORKING GROUP

ICES Headquarters, Copenhagen

20 April - 26 April 2012

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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

Chapters A-I is the stock Annex dated 24. April 2009.

Approach used by the 2010 WG and later

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.

Further details on the procedure followed since 2010.

1. Run a trial xsa (IFAP / Lowestoft VPA suite) with updated catch at age and survey data with the following model options chosen:
    a. Tapered time weighting applied, power = 3 over 20 years
    b. Catchability independent of stock size for all ages
    c. Catchability independent of age for ages >= 8
    d. Survivor estimates shrunk towards the mean F of the final 2 years or the 4 oldest ages

e. S.E. of the mean to which the estimate are shrunk = 1.0

f. Minimum standard error for population estimates derived from each fleet = 0.300

g. Prior weighting not applied

h. 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+	No-fixed at the average survey observation in the yrs 1995-2009
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	

2. Estimate annual F(4-7) from survey Z at age

a. Survey Z at age a in year y is calculated as $Z_{a,y} = -Log(U_{a+1,y+1} / U_{a,y})$ where U is the survey index (observed late in the year). If both catchability and natural mortality is stable between years, those factors will only influence the scaling of the "survey mortality" while the trends observed would be driven by F. Within years the Z-values have been averaged over various age group, and the 4-9 average have shown the highest correlation with the F(4-7) in the converged years of the trial xsa (1995-2005 in the 2010 assessment. 1995-2006 in the 2011 and 2012 assessment). The annual values of Z(4-9) is then fitted by a linear regression to the F(4-7) in the converged part of the vpa, and the regression parameters are used to convert Z(4-9) to F(4-7) for the terminal year.

b. Average F at age for the 3 latest years in the trial xsa is then scaled to this survey based F(4-7) and further used as terminal F at age in a standard VPA ("user-defined VPA" in the Lowestoft sweet). The historical Fs for the oldest true age group are also taken from the trial xsa.

3. The procedure is repeated for total catch including recreational fisheries

Data series on recreational and tourist fisheries for Norwegian Coastal Cod

(WD 17 to the AFWG, April 2010, by Knut Sunnanå, Institute of Marine Research, Norway)

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 asses the amount at certain years and these reports has been used to construct time series based on assumptions made in the reports of temporal trends.

Raising these figures to numbers caught at age is done by assuming that most of these catches are taken by hook and that the distribution of numbers at age for hook and lonkgline is the most relevant data set to be used to split the data series.

Recreational fisheries

A survey for mapping recreational fisheries was conducted in 2003 (Hallenstveit and Wulf, 2004) and the results from this report gives reason to assume that there were fished app 13000t 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 are all north east atlantic cod. This is probably not the case – since the winter fishery is small and is probably conducted close to the home.

The effort used in recreational fisheries is monitored through surveys of questionnaires mapping the amount of the population thet has conducted recreationa fisheries durin the last year and to what exctent it has been in salt water or in lakes and rivers. Based on tintepolating these surveys onto the development of the populatoni Norway, it is possible to give an indeks of effort in recreational fisheries in the sea. It is assumes that recreational fisheries are conducte 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 13000 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 duing recreational sea fisheries. It is assumed the the amount of cod is 50% throughout all the years.

Tourist fisheries

There is one report available to indicate the level of tourist fisheries in Norway. The report is by a consultant company Essens management (Anon, 2005) and is based partly on Hallenstvedt and Wulf, 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 1100 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 1800 t cod. It also gives a time series back to the beginning of the 90's 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 investigation 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 com Nedreaas, 2009).

Numbers caught at age

From Hallenstevit and Wulf (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 in the present working document.

For the early part of the time series 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. 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.

Results

In table 1 is given a catch matrix to be added to the catches from the commercial fisheries for Norwegian coastal cod (NCC). The construvcted time series may not be as accurate as desired, however, the level of catch to be added to the commercial cathes 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.

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.

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Table 1. Yield in tonnes from recreational and tourist fishery in Norway (catonrt), together with catch in numbers at age (canumrt).

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

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:	8 May 2012.

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 67°30′ and 70° N. 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 44 cm, and the maximum proportion of undersize fish allowed is 15% by number for cod, haddock and saithe combined. 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 Table 1.9 AFWG Report 2012).

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 Kingdom	x 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).

Natural mortality (M) is assumed to be equal to 0.2 + cannibalism mortality for ages 1-6.

The method used for calculation of the prey consumption by cod described by Bogstad and Mehl (1997) is used to calculate the consumption of cod by cod (Table 3.11) 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 1984-2011.

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. All occurrences of intra-cohort predation were removed from the data set as these could possibly cause problems with convergence. The following procedure realized in FLR script was followed: As a starting point the number of cod consumed by cod was estimated from the stock estimates assessed with zero consumption and the per capita estimates of consumption of cod by cod. Then the number consumed was added to the catches used for tuning. The resulting stock then leads to new estimates of consumption. This procedure was repeated until the consumed numbers for the latest year differed less than 0.001% from the previous iteration.

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).

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: FLR / Lowestoft VPA suite

Model Options chosen:

Tapered time weighting applied, power = 3 over 10 years

Catchability independent of stock size for ages >7

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 < 7 Regression type = C Min. 5 points used Survivor estimates shrunk to the population mean for ages < 6 Catchability independent of age for ages >= 10	The same
Terminal population estimation	Survivor estimates shrunk towards the mean F of the final 5 years or the 2 oldest ages. S.E. of the mean to which the estimate are shrunk = 1.0. Minimum standard error for population estimates derived from each fleet = 0.300.	The same
Prior fleet weighting	Prior weighting not applied	The same

D. Short-term projection

Model used: Age structured

Software used: MFDP (version 1a) prediction with management option table

Initial stock size: Taken from the XSA for age 4 and older. The recruitment at age 3 for the initial stock and the following 2 years are estimated from survey data and environmental data using the “hybrid model” described in section 1.4.5 in ICES CM 2008/ACOM:01

Natural mortality: average of the three last years or set equal to the values estimated for the terminal year.

Maturity: average of the three last years

F and M before spawning: Set to 0 for all ages in all years

Weight at age in the stock: Predicted by applying (10yr average) annual increments by cohort on last year’s observation.

Weight at age in the catch: Predicted by applying (10yr average) annual increments by cohort on last year’s observation.

Exploitation pattern: Average of the three last years, scaled by the Fbar (5-10) to the level of the last year, or to the average of the latest 3 years, if there is no clear trend in F and effort.

Intermediate year assumptions: F constraint

Stock recruitment model used: None

Procedures used for splitting projected catches: Not relevant

E. Medium-term projections

F. Long-term projections

SPR and YPR calculations

G. Biological reference points

Introduced 1998: Blim=112000t, Bpa=500000t, Flim=0.7, Fpa=0.42

Adopted in 2003: Blim=220000t, Bpa=460000t, Flim=0.74, Fpa=0.40

H. Other issues

Since the 1999 AFWG a new assessment model (Fleksibest-now Gadget) has been used to provide alternative assessments and to describe characteristics of the data for this stock.

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Annex4 – Quality Handbook ANNEX:NEA Haddock

Stock Annex **Haddock in Subareas I and II**

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Haddock in Subareas I and II (Northeast Arctic)
Working Group:	Arctic Fisheries Working Group
Date:	31.01.2011
Revised by:	WKBENCH 2011 / AFWG 2011, Alexey Russkikh (stock coordinator), Gjert En dre Dingsør

A. General

A.1. Stock definition

The North-East Arctic Haddock (*Melanogrammus aeglefinus*) is distributed in the Barents Sea and adjacent waters, mainly in waters above 2° Celsius. Tagging carried out in 1953-1964 showed the contemporary area of the Northeast Arctic haddock inhabits the continental shelf of the Barents Sea, adjacent waters and polar front. The main spawning grounds are located along the Norwegian coast and area between 70°30′ and 73° N along the continental slope, but spawning also occurs as far south as 62°N. Larvae are dispersed in the central and southern Barents Sea by warm currents. The 0-group haddock drifts from the spawning grounds eastwards and northwards and during the international 0-group survey in august it is observed over wide areas in the Barents Sea. Until maturity, haddock are mostly distributed in the southern Barents Sea being their nursery area. Having matured, haddock migrate to the Norwegian Sea.

A.2. Fishery

Haddock are harvested throughout the year; in years when the commercial stock is low, they are mostly caught as bycatch in cod trawl fishery; when the commercial stock abundance and biomass are high, haddock are harvested during their target fishery. On average approximately 25% of the catch is with conventional gears, mostly longline, which are used almost exclusively by Norway. Part of the longline catches are from a directed fishery.

The fishery is restricted by national quotas. In the Norwegian fishery the quotas are set separately for trawl and other gears. The fishery is also regulated by a minimum landing size, a minimum mesh size in trawls and Danish seine, a maximum by-catch of undersized fish, closure of areas with high density/catches of juveniles and other seasonal and areal restrictions.

In recent years Norway and Russia have accounted for more than 90% of the landings. Before the introduction of national economic zones in 1977, UK (mainly England) landings made up 10–30% of the total. Each country fishing for haddock and engaged in the stock assessment provide catch statistic annually. Summary sheets in the AFWG Report indicate total yield of haddock by Subareas I, IIa and IIb, as well as catch by each country by years. Catch information by fishing gear used by Norway in the haddock fishery is used internally when making estimations at AFWG meeting. Catch quotas were introduced in the trawl fishery in 1978 and for the fisheries with conventional gears in 1989. Since January 1997 sorting grids have been mandatory for the trawl fisheries in most of the Barents Sea and Svalbard area. Discarding is prohibited.

From 01.01.2011, the minimum catching size of haddock is 40 cm in the Russian Economic zone, the Norwegian Economic zone, and the Svalbard area. It is allowed that up to 15% (by number) of the fish is below the minimum catching size of (this is counted for cod, haddock and saithe combined), larger proportions of undersized fish leads to closure of areas. The minimum mesh size in trawl cod ends is 130 mm. The fisheries are controlled by inspections at sea, requirement of reporting to catch control points when entering and leaving the EEZs and by inspections when landing the fish for all fishing vessels. Keeping a detailed fishing logbook on board is mandatory for most vessels, and large parts of the fleet report to the authorities on a daily basis. There is some evidence that the present catch control and reporting systems are insufficient to prevent discarding and under-reporting of catches. Although since 2005 Port State Control (PSC) has been implemented, these should prevent IUU catches at Barents Sea.

The historical high catch level of 320,000 t in 1973 divides the time-series into two periods. In the first period, highs were close to 200,000 t around 1956, 1961 and 1968, and lows were between 75,000 and 100,000 t in 1959, 1964 and 1971. The second period showed a steady decline from the peak in 1973 down to the historically low level of 17,300 t in 1984. Afterwards, landings increased to 151,000 t before declining to 26,000 t in 1990. A new increase peaked in 1996 at 174,000 t. Three strong year-classes (2004-2006) are causing peak catches at the present time. The exploitation rate of haddock has been variable (F between 0.2 and 0.5 in the last 20 years).

The highest fishing mortalities for haddock have occurred at intermediate stock levels and show little relationship with the exploitation rate of cod, in spite of haddock being primarily a by-catch in the cod fishery. The exception is the 1990s when more restrictive quota regulations resulted in a similar pattern in the exploitation rate for both species. It might be expected that good year classes of haddock would attract more directed trawl fishing, but this is not reflected in the fishing mortalities.

Since 2007, estimates of unreported catches (IUU catches) of haddock have been added to reported landings for the years 2002 and onwards. In 2007-2008, two assessments were presented, based on Norwegian and Russian estimates of IUU catches, respectively. The basis for the Norwegian IUU estimates (N ‐ IUU) is the annual ratio between cod and haddock in the international reported landings from Sub ‐ area I and Division II b in 2002 ‐ 2008. These ratios are assumed to be representative of the ratios in the IUU catches. The ratio is applied to the estimated IUU catches of cod in order to get the estimate for haddock. The estimates are similar to those made by the Norwegian Directorate of Fisheries for 2005-2008. The Russian estimates of IUU haddock are obtained by applying the same ratio, but using the Russian estimate of IUU catches of cod in 2002-2007. Both approaches show an increase from 2002 to 2005 followed by a decline. In 2010 the Working Group decided to set the IUU estimate for haddock in 2009 to 0. During the benchmark meeting in 2011, as in recent AFWG, it was decided to use Norwegian estimates for the period 2002-2008, because now IUU catches equal Zero and only small differences exist in final estimates using both values of IUU.

A.3. Ecosystem aspects

The composition and distribution of species in the Barents Sea depend considerably on the position of the polar front which separates warm and salty Atlantic waters from colder and fresher waters of arctic origin. Variation in the recruitment of haddock has been associated with the changes in the influx of Atlantic waters to the large areas of the Barents Sea shelf.

Independently from age and season, haddock vary their diet and will prey on plankton or benthic organisms. During spawning migration of capelin (*Mallotus villosus*) haddock prey on capelin and their eggs on the spawning grounds. When the capelin abundance is low or when their areas do not overlap, haddock can compensate by eating other fish species (e.g., young herring) or euphausiids and benthic organisms. Haddock growth rate depends on the population abundance, stock status of main prey species and water temperature.

Water temperature at the first and second years of the haddock life cycle is a fairly reliable indicator of year-class strength. If mean annual water temperature in the bottom layer during the first two years of haddock life does not exceed 3.75 C (Kola-section), the probability that strong year-classes will appear is very low even under favorable effects of other factors. A steep rise or fall of the water temperature shows a marked effect on abundance of year-classes.

Nevertheless, water temperature is not always a decisive factor in the formation of year-class abundance. Strength of year-classes is also determined to a great extent by size and structure of the spawning stock. Under favorable environmental conditions, strong year classes are mainly observed in years when the spawning stock is dominated by individuals from older age groups with abundance at a fairly high level.

Annual consumption of haddock by marine mammals, mostly seals and whales, depends on stock status of capelin as their main prey. In years when the capelin stock is large the importance of haddock in the diet of marine mammals is minimal, while under the capelin stock reduction a considerable increase in consumption by marine mammals of all the rest abundant gadoid species including haddock is observed (Korzhev and Dolgov, 1999; Bogstad et al, 2000).

The appearance of strong haddock year classes usually leads to a substantial increase in natural mortality of juveniles as a result of cod predation.

B. Data

B.1. Commercial catch

Norway

Norwegian commercial catch in tonnes by quarter, area and gear are derived from the sales notes statistics of The Directorate of Fisheries. Data from about 20 sub-areas are aggregated on 6 main areas for the gears gill net, long line, hand line, purse seine, Danish seine, bottom trawl, shrimp trawl and trap. For the bottom trawl, the quarterly area distribution of the catches is adjusted by logbook data from The Directorate of Fisheries and the total bottom trawl catch by quarter and area is adjusted so that the total annual catch for all gears is the same as the official total catch reported to ICES. No discards are reported or accounted for.

The sampling strategy is to have age and length samples from all major gears in each main area and quarter. The main sampling program is sampling the landings. Additional samples from catches are obtained from the coast guard, from observers and from crew members reporting, according to an agreed sampling procedure (reference fleet).

The age distribution and weight at age for the Norwegian catches were estimated using the software based on the method of Hirst *et al*. (2005). In this method, the three different types of available samples (age and weight samples, age and weight stratified by length groups, and length samples) are modelled simultaneously using a previously developed Bayesian hierarchical model (Hirst *et al*., 2004). This method replaced the traditional method in 2006, and the time series of Norwegian catch at age (early 80's and onward) was updated based on the modelling approach. The old method involved allocating unsampled catches to sampled catches based on judgements on "distance criteria's" (in area, time and sometimes gear) and the use of ALK's to fill holes in the sampling frame.

Russia

Russian commercial catch in tonnes by season and area are derived from the Russian Federal Research Institute of Marine Fisheries and Oceanography (VNIRO, Moscow) statistics department. Data from each fishing vessel are aggregated on three ICES sub-Division (I, IIa and IIb). Russian fishery by passive gears was almost stopped by the end of the 1940s. Until late 1990’s, relative weight (percentage) of haddock taken by bottom trawls in the total Russian yield exceeded 99%. Only in recent years an upward trend in a proportion of Russian long-line fishery for haddock was observed to be up to 5% on the average and long-line catches were taken into account for estimation catch-at-age matrix.

The sampling strategy was to conduct mass measurements and collect age samples directly at sea, onboard both research and commercial vessels to have age and length distributions from each area and season. Data on length distribution of haddock in catches are collected in areas of cod and haddock fishery all the year round by a "standard" fishery trawl and summarized by three ICES sub-areas (I, IIa and IIb).

Age sampling was carried out in two ways: without any selection (otoliths were taken from any fish caught in one trawl, usually from 100-300 sp.) or using a stratified by length sampling method (i.e. approximately 10-15 sp. per each 10-cm length group). The last method has been used since 1988.

All fish taken for age-reading were measured and weighted individually.

Data on length distribution of haddock catches, as well as age-length keys, are formed for each ICES Subarea, each fishing gear (trawl and longline) for the whole year. Catch at age are reported to ICES AFWG by sub-Division (I, IIa and IIb) for the whole year. In the lack of data by ICES Subareas, information on size-age composition of catches from other areas is used.

Germany

Catch at age were reported to the WG by ICES sub-Division (I, IIa and IIb) according to national sampling. Missing sub-Divisions were filled in by use of Russian or Norwegian sampling data.

Other nations

Total annual catch in tonnes is reported by ICES sub-Divisions or by Russian and Norwegian authorities directly to WG. All catches by other nations are taken by trawl. The age composition from the sampled trawl fleets is therefore applied to the catches by other nations.

Table below shows which country supplied which kind of data:

	Kind of data				
Country	Caton (catch in weight)	Canum (catch at age in numbers)	Weca (weight at age in the catch)	Matprop (proportion mature by age)	Length composition in catch
Norway	X	X	X	X	X
Russia	X	X	X	X	X
Germany	X	X	X		X
United Kingdom	X				
France	X				
Spain	X				
Portugal	X				
Ireland	X				
Greenland	X				
Faroe Islands	X				
Iceland	X				
Poland	X				
Belarus	X				

The combined catch data were previously estimated by the SALLOC program (Patterson, 1998). The national data from 2009 and onwards are available in Intercatch (ICES database); earlier data should be found in the national laboratories and with the stock coordinator.

For 1983 and later years mean weight at age in the catch is calculated as the weighted average for the sampled catches. For the earlier period (1946-1982) mean weight at age in catches is set equal to mean weight at age in the catch for period 1983-2009.

The result files can be found at ICES (sharepoint) and with the stock co-ordinator as ASCII files on the Lowestoft format.

B.2. Biological

Weights and length at age in stock and proportion of mature fish to ages 1–11 derived from Russian surveys in autumn (mostly October-December) and Norwegian surveys in January-March for the period from 1983 and onwards. In 2006 the AFWG, based on WKHAD06 investigations, decided to smooth raw data of stock weight-at-age and maturity-at-age using models in order to remove some of the sampling variability in the estimates.

Mean length-at-age is calculated from the bottom trawl surveys. A von Bertalanffy function is fitted to the data:

$$L = L_\infty - L_\infty \cdot e^{(-K_Y(A-A_0))}$$

with L and A being the length and age variables. L_∞ and A_0 are constants, estimated on the entire time series, while K_Y is dependent on year-class. Weight-at-age is then fitted with:

$$W = \alpha \cdot L^\beta$$

where α and β are constants and L are smoothed lengths.

Norwegian maturity data is smoothed by fitting a logistic function using both age, A, and length, L, as explanatory variables:

$$\log\left(\frac{m}{1-m}\right) = I + \alpha A + \beta L$$

Russian maturity data is smoothed by fitting a logistic function using age, A, and year-class dependent age at 50% maturity, $A_{50\%}$, as explanatory variables:

$$Mat = \frac{1}{1 + e^{(-\alpha\cdot(A - A_{50\%}))}}$$

Estimates were produced separately for the Russian autumn survey and the joint winter survey and were later combined using an arithmetic average. These averages are assumed to give representative values for the beginning of the year.

Norwegian lengths-at-age are used to estimate mean weights-at-age and maturity-at-age for the period 1980-1982.

The combined data on weight-at-age in stock and proportion of mature fish by age group for the period (1950-1979) are set equal to mean values for period 1980-2010.

Natural mortality used in the assessment is estimated as 0.2 + mortality from predation by cod. The estimated consumption of NEA haddock by NEA cod is incorporated into the XSA analysis on first step by constructing catch-at-age matrix, adding estimated numbers of haddock eaten by cod to the catches for the ages 1-6, for years where such data are available (1984–present). The fishing mortality estimated by the XSA is split into the mortality caused by the fishing fleet (F) and the mortality caused by the cod's predation (M2) according to the ratio of fleet catch and predation "catch". The new natural mortality data set were then prepared by adding 0.2 (M1) to the predation mortality. This new M matrix is used in the final XSA. Natural mortality for period without observations (1950-1983) is replaced by mean values for period 1984-2010.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0. The peak spawning occurs most years in the middle of April.

B.3. Surveys

Russian surveys of cod and haddock in the southern Barents Sea started in the late 1940s as trawl surveys of young demersal fishes. Since 1957 such surveys have been conducted over the whole feeding area including the Bear Island - Spitsbergen area (Baranenkova, 1964; Trambachev, 1981); both young and adult haddock have been surveyed simultaneously. Duration of the survey has declined from 5-6 months (September-February) in 1946-1981 to 2-2.5 months (October-December) since 1982. The aim of the survey is to investigate both the commercial size haddock as well as the young haddock. The survey covers the main areas where juveniles settle to the bottom, as well as the area where the commercial fishery takes place. A total number of more than 400 trawl hauls are conducted during the survey (mainly bottom trawl, a few pelagic trawls). In 1984, acoustic methods started to be implemented during surveys of fish stocks (Zaferman and Serebrov, 1984; Lepesevich and Shevelev, 1997; Lepesevich *et al.*, 1999). From 1995 onwards there has been a substantial change in the method for calculating acoustic indices, which allowed the differentiation and registration of echo intensities from fish of different length (Shevelev *et al.*, 1998).

There are two survey abundance indices at age: 1) absolute numbers (in thousands) computed from the acoustics estimated by the new method (RU-Aco-Q4) for the period 1995-2009 (ages 0-10); 2) trawl index, calculated as relative numbers per hour trawling (RU-BTr-Q4) for the period 1983-2009 (ages 0-9).

The indices (RU-Aco-Q4) were not used for tuning the XSA due to a strong "year effect" observed in years with incomplete area coverage. This index needs further adjusting before it can be used for tuning. Based on internal consistency test the RU-BTr-Q4 index is used in tuning for ages 1-7.

Norwegian winter (February) survey (from 2000 - Joint Barents Sea survey, NoRu-BTr-Q1 and NoRu-Aco-Q1)

The survey started in 1981 and covers the ice-free part of the Barents Sea. Both swept area estimates from bottom trawl and acoustic estimates are produced. The swept area estimates are used in the tuning for ages 1-8. The survey is described in Jakobsen *et al*. (1997) and Aglen *et al*. (2002).

Before 2000 this survey was made without participation from Russian vessels, while in the three latest surveys Russian vessels have covered important parts of the Russian zone. The indices for 1997 and 1998, when the Russian EEZ was not covered, have been adjusted as reported previously (Mehl, 1999). The number of fish (age group by age group) in the Russian EEZ in 1997 and 1998 was interpolated assuming a linear development in the proportion found in the Russian EEZ from 1996 to 1999. These estimates were then added to the numbers of fish found in the Norwegian EEZ and the Svalbard area in 1997 and 1998.

It should be noted that the survey conducted in 1993 and later years covered a larger area compared to previous years (Jakobsen *et al*. 1997). Other changes in the survey methodology through time are described by Jakobsen *et al*. (1997). Note that the change from 35 to 22 mm mesh size in the cod-end in 1994 has not been corrected for in the time series. This mainly affects the age 1 indices. There are two abundance indices at age from that survey used in stock assessment:

1) swept area estimates from bottom trawl NoRu-BTr-Q1 for the period 1981-2010 (ages 1-10);

2) swept area estimates from acoustic NoRu-Aco-Q1 for the period 1981-2010 (ages 1-10).

For tuning XSA used: NoRu-BTr-Q1 for (ages 1-8) and NoRu-Aco-Q1 for ages 1-7.

Joint Norwegian-Russian Ecosystem survey (Eco-NoRu-Btr-Q3)

The bottom trawl estimates from the joint ecosystem survey in August-September, starting in 2004. This survey covers a larger portion of the distribution area of haddock. The new index Eco-NoRu-Btr-Q3 for period 2004-2009 ages 1-8 became available for AFWG 2010. This time series have been tested as new tuning fleet in XSA and it was found that the index was acceptable for use in the NEA haddock assessment.

Based on the test made during WKBENCH 2011 and previous AFWG work it is decided to use only tuning indices for the period 1990 and onwards.

B.4. Commercial CPUE

Russia

No Russian data are used in the stock assessment.

Norway

Historical time series of observations onboard Norwegian trawlers were earlier used for tuning of older age groups in VPA. The basis was catch per unit effort (CPUE) in Norwegian statistical areas 03, 04 and 05 embracing coastal banks north of Lofoten, on which approximately 70% of Norwegian haddock catch was taken. However, the proportion of haddock taken as by-catch is pretty high and thus it is difficult to estimate their actual catch per unit effort. Since 2002, CPUE indices have not been used in XSA tuning.

B.5. Other relevant data

Not used.

C. Assessment: data and method

Model used: XSA

Software used: FLR suite (and VPA95 suite)

Model Options chosen:

Tapered time weighting applied, power = 3 over 20 years

Catchability independent of stock size for ages > 8

Catchability independent of age for ages > 8

Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages

S.E. of the mean to which the estimate are shrunk = 1.500[1]

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

[1] During the benchmark in 2011 (ICES 2011) it was decided that the AFWG 2011should evaluate different options for this value and make the final decision on the appropriate value. The AFWG 2011 decided to change this setting from 0.5 to 1.5.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1950 – last data year	3 – 11+	Yes
Canum	Catch at age in numbers	1950 – last data year	3 – 11+	Yes
Weca	Weight at age in the commercial catch	1983 – last data year	3 – 11+	Yes, set equal to west for 1950-1982
West	Weight at age of the stock at start of year.	1950 – last data year	3 – 11+	Yes
Mprop	Proportion of natural mortality before spawning	1950 – last data year	3 – 11+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1950 – last data year	3 – 11+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1950 – last data year	3 – 11+	Yes, set equal to average for 1950-1980
Natmor	Natural mortality	1950 – last data year	3 – 11+	Includes annual est. of predation by cod from 1984, otherwise set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1 (RU-BTr-Q4)	Russian bottom trawl survey, October-December	1991 – last data year	3-7 (1-7 in predation run)
Tuning fleet 2 (BS-NoRu-BTr-Q1)	Joint Norwegian-Russian trawl survey, February	1990 – last data year	3 – 8 (1-8 in predation run)
Tuning fleet 3 (BS-NoRu-Aco-Q1)	Joint Norwegian-Russian Acoustic survey, February	1990 – last data year	3 – 7 (1-7 in predation run)
Tuning fleet 4 (Eco-NoRu-Btr-Q3)	Joint Norwegian-Russian Ecosystem survey	2004 – last data year	3 – 8 (1-8 in predation run)

D. Short-Term Projection

Model used: Age structured

Software used: R and FLR suite, MFDP with management option table and yield per recruit routines

Initial stock size: Estimated in XSA as abundance of individuals that survive the terminal year for age 3 and older.

Recruitment at age 3 for the start year and the 2 consecutive years is estimated from survey data in RCT3 using the tuning series as input.

F and M before spawning: assumed equal to 0 for all ages in all years

Maturity: for current year smoothed actual data combined by Russian and Norwegian surveys are used; for subsequent years – using the fitted parameters and last year maturity as input.

Weight at age in the stock: for current year smoothed actual data combined by Russian and Norwegian surveys are used, for two years ahead, using the fitted parameters and last year lengths as input.

The Norwegian and Russian weight-at-age and maturity-at-age are then combined as arithmetic averages.

Weight at age in the catch and natural mortality: show strong patterns related to periods of good recruitment. The Working Group believes that the estimated recruitment in the most recent years is so high that it will affect growth. The Working Group therefore decided to use similar trends in weight at age, and natural mortality as has been observed in previous periods following good recruitment.

Exploitation pattern: For current year it is taken to be at the level of previous year ($F_{Status\ quo}$) or to be equal to average for the recent 3 years; for subsequent years method used to determine this parameter and its substantiation are given in the AFWG Reports. In 2010 the average fishing pattern observed in the 3 last years, scaled to F status quo was used for distribution of fishing mortality at age for 2010-2012.

Intermediate year assumptions:

Stock recruitment model used: None

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

Not used in assessment.

F. Long-Term Projections

Not used in assessment.

G. Biological Reference Points

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	80 000 t	$B_{trigger}$=B_{pa}
	F_{MSY}	0.35	Stochastic long-term simulations
Precautionary Approach	B_{lim}	50 000 t	B_{loss}
	B_{pa}	80 000 t	B_{lim}*exp(1.645*σ), where σ=0.3
	F_{lim}	0.77	SSB=B_{lim}, SPR value of slope of line from origin at SSB=0 to geometric mean recruitment
	F_{pa}	0.47	F_{lim}*exp(-1.645*σ), where σ=0.3

H. Other Issues

H.1. Historical overview of previous assessment methods (this subsection is optional. See example below.)

Summary of data ranges used in recent assessments:

Data	2006 assessment	2007 assessment	2008 assessment	2009 assessment	2010 assessment
Catch data	Years:1950–2005 Ages: 1–11+	Years: 1950–2006 Ages: 1–11+	Years: 1950–2007 Ages: 1–11+	Years: 1950–2008 Ages: 1–11+	Years: 1950–2009 Ages: 1–11+
Cod consumption data	Available: Years 1984–2005 Ages: 0–6 Used ages: 1-6	Available: Years1984–2006 Ages: 0–6 Used ages: 1-6	Available: Years1984–2007 Ages: 0–6 Used ages: 1-6	Available: Years1984–2008 Ages: 0–6 Used ages: 1-6	Available: Years1984–2009 Ages: 0–6 Used ages: 1-6
Fleet 01 Survey: RU-BTr-Q4	Available: Years1983-2005 Ages 0+ 9 Used 1991-2005 ages: 1–7	Available: Years1983-2006 Ages 0+ 9 Used 1991-2006 ages: 1–7	Available: Years1983-2007 Ages 0+ 9 Used 1991-2007 ages: 1–7	Available: Years1983-2008 Ages 0+ 9 Used 1991-2008 ages: 1–7	Available: Years1983-2009 Ages 0+ 9 Used 1991-2009 ages: 1–7
Fleet 02 Survey: NoRu-Aco-Q1	Available: Years1980-2006 Ages 1 10+ Used: shifted 1990-2005 ages: 1–7	Available: Years1980-2007 Ages 1 10+ Used: shifted 1990-2006 ages: 1–7	Available: Years1980-2008 Ages 1 10+ Used: shifted 1990-2007 ages: 1–7	Available: Years1980-2009 Ages 1 10+ Used: shifted 1990-2008 ages: 1–7	Available: Years1980-2010 Ages 1 10+ Used: shifted 1990-2009 ages: 1–7
Fleet 04 Survey: NoRu-BTr-Q1	Available: Years1982-2006 Ages 1 10+ Used: shifted 1990-2005 ages: 1–8	Available: Years1982-2007 Ages 1 10+ Used: shifted 1990-2006 ages: 1–8	Available: Years1982-2008 Ages 1 10+ Used: shifted 1990-2007 ages: 1–8	Available: Years1982-2009 Ages 1 10+ Used: shifted 1990-2008 ages: 1–8	Available: Years1982-2010 Ages 1 10+ Used: shifted 1990-2009 ages: 1–8

(The historic perspective, as well as all the other section on the stock annex, should only update in a benchmark workshop. If there is any reason to deviate from the stocks annex, this should be explain in the Working Group report and only update this deviation in the historic perspective after consultation with ICES Secretariat and WG Chair).

Harvest control rule

The harvest control rule (HCR) was evaluated by ICES in 2007 (AFWG 2007) and found to be in agreement with the precautionary approach. The agreed HCR for haddock is as follows (Protocol of the 36th Session of The Joint Norwegian Russian Fishery Commission, 10 October 2007):

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

At the 39th Session of The Joint Norwegian Russian Fishery Commission in 2010 it was agreed that this HCR should be left unchanged for 5 years and then re-evaluated.

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Annex 5 – Stock Annex Northeast Arctic Saithe

Quality Handbook **Annex: Saithe in Subareas I and II**

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Saithe in Subareas I and II (Northeast Arctic)
Working Group:	Arctic Fisheries Working Group
Date:	28.04.2010
Revised by:	Sigbjørn Mehl / Åge Fotland

A. General

A.1. Stock definition

The Northeast Arctic saithe is mainly distributed along the coast of Norway from the Kola Peninsula in northeast and south to Stad at 62º N (Figure 1). The 0-group saithe drifts from the spawning grounds to inshore waters. 2-4 years old the saithe gradually moves to deeper waters, and at age 3-6 it is found at typical saithe grounds. It starts to mature at age 5-7 and in early winter a migration towards the spawning grounds further out and south starts.

The stock boundary 62º N is more for management purposes than a biological basis for stock separation. Tagging experiments show a regular annual migration of mature fish from the North-Norwegian coast to the spawning areas off the west coast of Norway and also to a lesser extent to the northern North Sea (ICES 1965). There is also a substantial migration of immature saithe to the North Sea from the Norwegian coast between 62º and 66º N (Jakobsen 1981). In some years there are also examples of mass migration from northern Norway to Iceland and to a lesser extent to the Faroe Islands (Jakobsen 1987). 0-group saithe, on the other side, drifts from the northern North Sea to the coast of Norway north of 62º N.

A.2. Fishery

Norway accounts for more than 90% of the landings. Over the last ten years about 40% of the Norwegian catch originates from bottom trawl, 25% from purse seine, 20% from gill net and 15% from other conventional gears (long line, Danish sine and hand line). The gill net fishery is most intense during winter, purse seine in the summer months while the trawl fishery takes place more evenly all year around. Landings of saithe were highest in 1970-1976 with an average of 239,000 t and a maximum of 265,000 t in 1974 (Figure 2). Catches declined sharply after 1976 to about 160,000 t in the years 1978-1984. This was partly caused by the introduction of national economic zones in 1977. The stock was accepted as exclusively Norwegian and quota restrictions were put on fishing by other countries while the Norwegian fishery for some years remained unrestricted. Another decline followed and from 1985 to 1991 the landings ranged from 67,000 to 123,000 t. An increasing trend was seen after 1990 to 171,000 t in 1996, followed by a new decline to 136,000 t in 2000. Since then the annual landings have increased gradually to 212,000 t in 2006, followed by a decline to

199 000 t in 2007, 183 000 t in 2008 and 161 000 t in 2009. Quotas can be transferred between gears if the quota allocated to one of the gears will not be taken. The target set for the total landings has generally been consistent with the scientific recommendations.

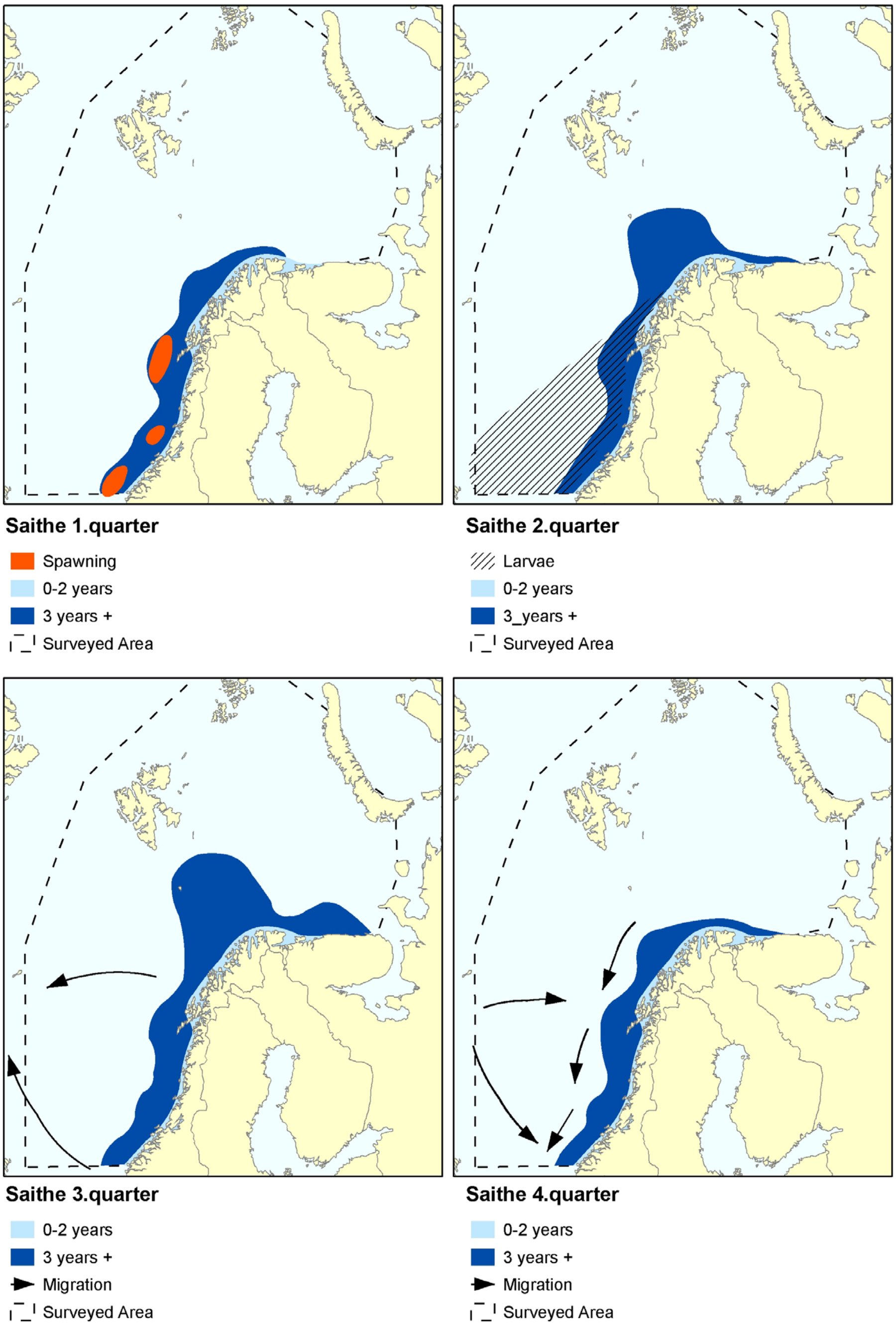

Figure 1. NEA saithe. Distribution of larvae, juveniles, adult spawning areas and the main migration patterns by (a) first quarter, (b) second quarter, (c) third quarter, and (d) fourth quarter.

The number of vessels taking part in the purse seine fishery has varied between 110 and 429 since 1977, with the highest participation in the first part of the period. There have been some variations from year to year, and many of the vessels that have taken part in the fishery the last decade have accounted for only a small fraction of the purse seine catches. The annual effort in the Norwegian trawl fishery has varied between 12 000 and 77 000 hours, with the highest effort from 1989 to 1995. Like in the purse seine fishery there have been rather large changes from year to year.

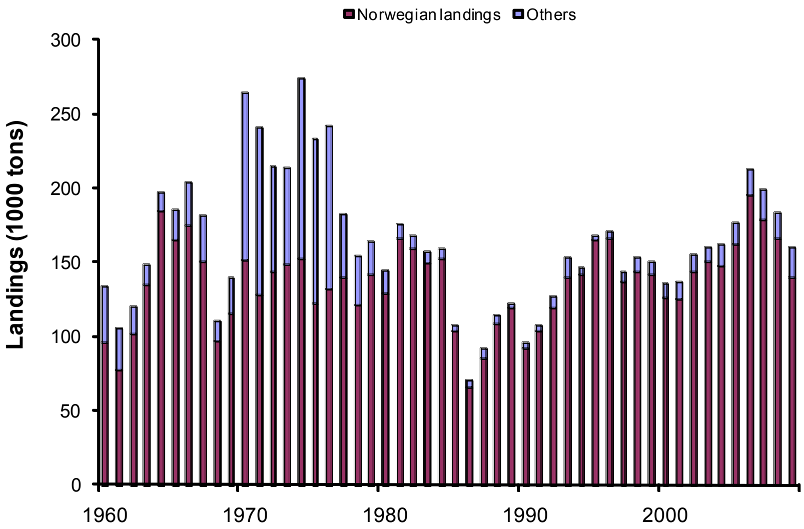

Figure 2. NEA saithe landings 1960-2009. Red part of bars shows the Norwegian landings.

1 March 1999 the minimum landing size was increased from 35-40 cm to 45 cm for trawl and conventional gears, and to 42 cm (north of Lofoten) and 40 cm (between 62° N and Lofoten) for purse seine, with an exception for the first 3000 t purse seine catch between 62° N and 66°33′ 30 N, where the minimum landing size still is 35 cm.

A.3. Ecosystem aspects

The recruitment of saithe may suffer in years with reduced inflow of Atlantic water (Jakobsen 1986).

B. Data

B.1. Commercial catch

Norwegian commercial catch in tonnes by quarter, area and gear are derived from the sales notes statistics of The Directorate of Fisheries. Data from about 20 sub areas are aggregated on 6 main areas for the gears gill net, long line, hand line, purse seine, Danish seine, bottom trawl, shrimp trawl and trap. For bottom trawl the quarterly area distribution of the catches is adjusted by logbook data from The Directorate of Fisheries and the total bottom trawl catch by quarter and area is adjusted so that the total annual catch for all gears is the same as the official total catch reported to ICES. No discards are reported or accounted for, but there are several reports of discards. In later years there are also reports of misreporting, saithe is landed as cod in a period with decreasing quotas and availability of cod and good availability of saithe.

The sampling strategy is to have age-length samples from all major gears in each area and quarter. There are at present no defined criteria on how to allocate samples of catch numbers, mean length and mean weight at age to unsampled catches, but the following general process has been applied: First look for samples from a neighbouring area if the fishery extends to this area in the same quarter. If there are no samples available in neighbouring areas, search for samples from other gears with the most similar selectivity in the same area or in neighbouring areas. The last option is to search in neighbouring quarters, first from the same gear in the same area, and then from neighbouring areas and similar gears. For some gears, areas and quarters length samples taken by the coast guard are applied and combined with an ALK from a neighbouring area, gear or quarter. ALKs from research surveys (shrimp trawl) are also used to fill holes. The alternative method applied for cod and haddock (ECA, Hirst *et al.* 2004, 2005) produce unrealistic high weights at age compared to the method presently applied for NEA saithe (ICES 2007/ACFM:16).

Constant weight at age values is used for the period 1960 – 1979. For subsequent years, Norwegian weights at age in the catch are estimated from length at age by the formula:

$$\text{Weight (kg)} = (l^3 *5.0+l^2 *37.5+l*123.75+153.125)*0.0000017,$$

Where

l = length in cm.

Norway has on average accounted for about 95% of the saithe landings. Data on catch in tonnes from other countries are either taken from ICES official statistics (by ICES area) or from reports to Norwegian authorities. A few countries also supply some additional data. The text table below shows which countries supply which kind of data:

	Kind of data				
Country	Caton (catch in weight)	Canum (catch at age in numbers)	Weca (weight at age in the catch)	Matprop (proportion mature by age)	Length composition in catch
Norway	x	x	x	x	x
Russia	x	x	x		x
Germany	x	x	x		
United kingdom	x				
France	x				
Spain[1]	x				
Portugal	x				
Poland	x				
Greenland[1]	x				
Faroe Islands[1]	x				
Iceland[1]	x				

[1] **As reported to Norwegian authorities**

The Norwegian, Russian and German input files are Excel spreadsheet files. Russian input data earlier than 2002 are supplied on paper and later punched into Excel spreadsheet files before aggregation to international data. The data should be found in the national laboratories and with the Norwegian stock co-ordinator.

The national data have been aggregated to international data on Excel spreadsheet files. Age composition data are normally available from Norway, Russia (some areas) and Germany (Division IIA). In some areas Russian length composition has been applied on the Russian landings together with an age-length-key (ALK) and weight at age data from the Norwegian trawl landings. Catches from the other countries were assumed to have the same age composition and weight at age as the Norwegian trawl landings. In some years the final German and Russian numbers at age have been adjusted to remove SOP discrepancies before aggregation to international data. The Excel spreadsheet files used for age distribution, adjustments and aggregations can be found with the Norwegian stock co-ordinator. Since 2007 the national data have also been uploaded to the ICES InterCatch database.

The result files (FAD data) can be found with the stock co-ordinator and at ICES as ASCII files on the Lowestoft format under **w:\acom\afwg\year\Stock\sai_arct**.

B.2. Biological

Weight at age in the stock is assumed to be the same as weight at age in the catch.

A fixed natural mortality of 0.2 is used both in the assessment and the forecast.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

Regarding the proportion mature at age, until AFWG 1995 knife-edge maturity at age 6 was used for this stock. In the 1996-2004 assessments, an ogive based on analyses of spawning rings in otholiths for the period 1973-1994 was applied for all years. The analysis showed a lower maturation in the last part of the period, and some extra weight was given to this part when an average ogive was calculated. In 2005 a large number of otholiths with missing information on spawning rings were re-read, and new analyses were done for the period 1985-2004. The maturity at age had decreased somewhat in the last part of that period, and the 2005 WG decided to use a 3-year running average, reference year being the middle of the 3-year period, for the years from 1985 and onwards (2-year average for the first and last year) (ICES 2005). The ogives used until AFWG 1995 and in 1996-2004 assessments are presented in the text table below.

Age group	2	3	4	5	6	7	8	9	10	11+
Until 1995	0	0	0	0	1	1	1	1	1	1
1996 - 2004	0	0	0.01	0.55	0.85	0.98	1	1	1	1

B.3. Surveys

In 1985-2002 a Norwegian acoustic survey specially designed for saithe was been conducted annually in October-November (Nedreaas 1997). The survey covers the near coastal banks from the Varangerfjord close to the Russian border and southwards to Stad at 62° N (Figure 3). The whole area has been covered since 1992, and the major parts since 1988. The aim of conducting an acoustic survey targeting Northeast Arctic saithe has been to support the stock assessment with fishery-independent data of the abundance of the youngest saithe. The survey mainly covers the grounds where the trawl fishery takes place, normally dominated by 3 - 5(6) year old fish. 2-year-old saithe, mainly inhabiting the fjords and more coastal areas, are also represented in the survey, although highly variably from year to year. In 1997 and 1998 there was a large increase in the abundance of age 5 and older saithe, confirming reports from the fishery. In 1999 the abundance of these age groups decreased somewhat, but was still at a high level compared to the years before 1997 (Mehl 2000). Abundance indices for ages 2-5 were used for tuning from 1988 onwards, but including older ages as a 6+ group in the tuning series improved the scaled weights a little and at the 2000 WG meeting it was decided to apply the extended series in the assessment. The results from the survey in autumn 2000 showed a further decrease in the abundance of age 5 and older saithe (Korsbrekke and Mehl 2000). It is not known how well the survey covers the oldest age groups from year to year, but at least for precautionary reasons the 6+ group was kept in the tuning series. Before the 2005 WG the 6+ group from the Norwegian acoustic survey was split into individual age groups 6 – 9 by rerunning the original acoustic abundance estimates. However, this was only possible to do for the years back to 1994. Based on further analysis during the 2005 benchmark assessment, indices for ages 3-7 was used for tuning in the 2005 and later assessments.

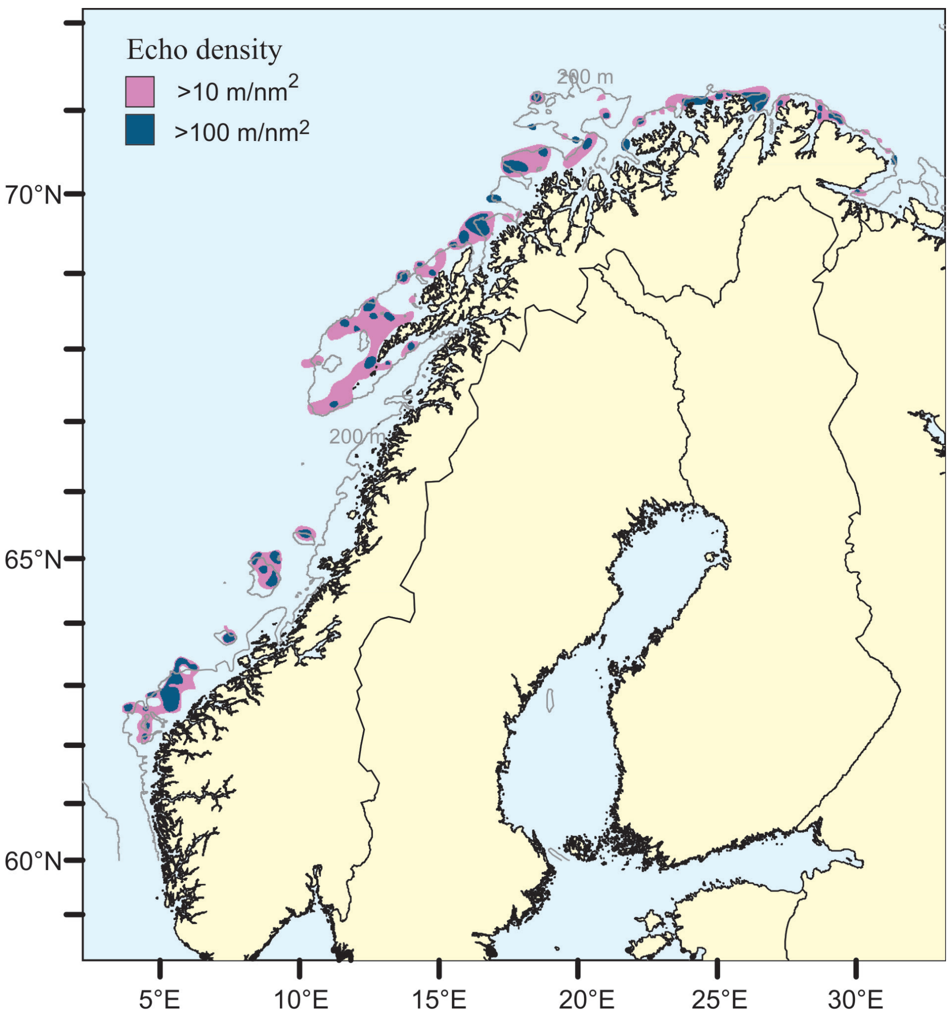

Figure 3. NEA saithe. Distribution of total saithe echo density in the acoustic survey autumn 1998.

In 1995-2002 a Norwegian acoustic survey for coastal cod was conducted along the coast and in the fjords from Varanger to Stad in September, just prior to the saithe survey described above. This survey covers coastal areas not included in the regular saithe survey. Because saithe is also acoustically registered, this survey provides supplementary information, especially about 2- and 3-year-old saithe that have not yet migrated out to the banks. At the WG meeting in 2000 analyses were done on combining these indices with indices from the regular saithe survey in the tuning series, but it did not influence the assessment much. The WG therefore decided, for the time being, to apply only indices from the longer time series of the regular saithe survey in the assessment.

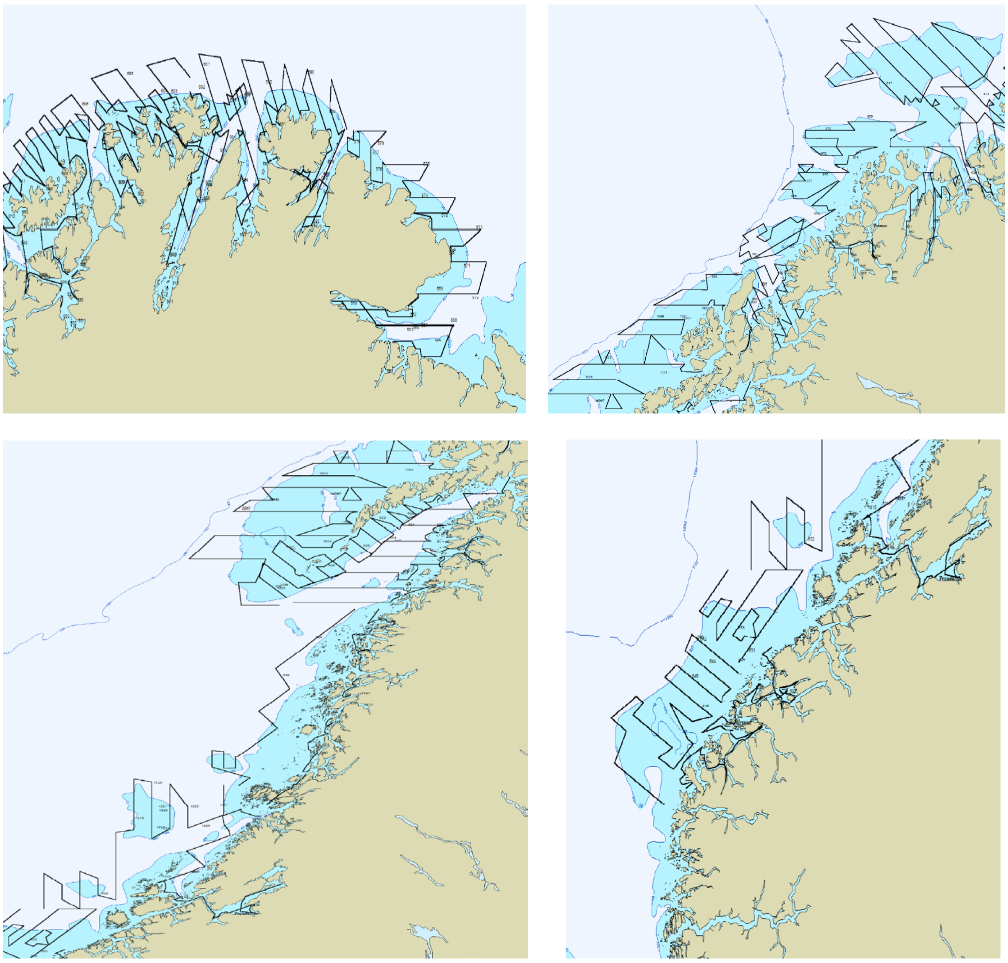

Figure 4. Standard transects in new combined saithe and coastal survey.

In autumn 2003 the saithe- and coastal cod surveys were combined. A new survey was designed, with new stratification and smaller strata based on depth and fish distribution in recent years, and with new and more regular transects (Figure 4). The new course lines had already been partly introduced in the saithe survey in 2001 and 2002. At the 2010 benchmark assessment two alternative survey index series was tested, one for 2001-2008 representing the traditional saithe survey area with new course lines and stratification, and one for 2003-2008 representing the combined saithe and coastal cod survey areas. The new tuning series gave lower and more stable S. E. Log q residuals than the tuning series presently used. However, the retrospective trend was still poor and the estimates of F and SSB in the last assessment year were far away from any other analysis. The new series are probably still too short to be used for tuning of the NEA saithe XSA. Until a longer time series based on the new survey design is established, indices from the whole survey time series, representing the traditional saithe survey area only, will be applied for tuning. The estimation of these abundance indices is done very much in the same way for the whole time series and the results for later years should be comparable with earlier years.

B.4. Commercial CPUE

Two CPUE data series have been used, one from the Norwegian purse seine fishery and one from the Norwegian trawl fishery.

Until 1999 indices of fishing effort in the purse seine fishery were based on the number of vessels of 20-24.9 m length and the effort (number of vessels) of this length category was raised by the catches to represent the total purse seine effort. However, the number of vessels taking part in the fishery almost doubled from 1997 to 1998, but due to regulations the catches were almost the same as in 1997. In such a situation the total number of vessels participating in a fishery is clearly not a good measure of effort. Examination of the data showed that many of the vessels that have taken part in the fishery the last decade have accounted for only a small fraction of the purse seine catches, and these also included most of the vessels that tend not to be involved on a regular basis. Roughly half of the vessels have caught less than 100 tonnes per year, and the sum of these catches represents only about 5 – 10% of the total purse seine catch. Therefore the number of vessels catching more than 100 tonnes annually seems to be a more representative and more consistent measure of effort in the purse seine fishery. These numbers are raised to the total purse seine catch. The new effort series showed a smaller decrease in later years than the old one and in the XSA runs it gets higher scaled weights. The 2000 WG meeting therefore decided to use the new CPUE data series in the assessment.

The quality and performance of the purse seine tuning fleet has been discussed several times in the WG. The effort, measured as number of vessels participating, has been highly variable from year to year. This was partly taken care of by only including vessels with total catch > 100 tonnes. However, with a restricting and changing TAC and transfer of quota, the CPUE may change much from year to year without really reflecting trends in the saithe abundance. This is also reflected in the tuning diagnostics of exploratory runs. There are rather large and variable log q residuals and large S.E. log q for all age groups except age 4, which often is the dominant age group in the purse seine landings. But even for age 4 the S.E. log q is higher than in the Norwegian trawl CPUE and acoustic survey indices single fleet tunings. There are strong year effects, and in the combined tuning the purse seine series get low scaled weights. Mainly based on this the 2005 WG decided to not include the purse seine tuning fleet in the analysis (ICES 2005). In later years with lower availability of young saithe the TAC has been less restricting, and at the 2010 benchmark assessment exploratory runs were done with updated purse seine tuning series. The purse seine tuning series showed the higher S.E_Log q residuals and lower scaled weights than the other tuning series and did not perform any better than in previous analysis, and were not reintroduce as a tuning series in the assessment.

Catch and effort data for Norwegian trawlers were until 2000 taken from hauls where the effort almost certainly had been directed towards saithe, i.e., days with more than 50% saithe and only on trips with more than 50% saithe in the catch. The effort estimated for the directed fishery was raised by the catches to give the total effort of Norwegian trawlers. From 1997 to 1998 the effort increased by more than 50%, but due to regulations the catches were slightly lower in 1998 and the CPUE decreased by almost 40% from 1997 to 1998 and stayed low in 1999. This may at least partly be explained by change in fishing strategies in a period with increasing problems with bycatch of saithe in the declining cod fishery due to good availability of saithe. In 2001 new CPUE indices by age were estimated based on the logbook database of the Directorate of Fisheries, which has a daily resolution (Salthaug and Godø 2000). After some initial analyses it was decided to only include data from vessels larger than the median length since they showed the least noisy trends. One single CPUE observation from a given vessel is the total catch per day divided by the duration of all the trawl hauls that day. To increase the number of observations during a time period with decreasing directed saithe fishery, all days with 20% or more saithe were included. The effort (hours trawling) for each CPUE observation was standardised or calibrated to a standard vessel. Until 2002, first averaging all CPUE observations for each month, and then averaging over the year a yearly index was calculated. The CPUE indices were divided on age groups by quarterly weight, length and age data from the trawl fishery. From 2003, first averaging all CPUE observations for each quarter, and then averaging over the year a yearly index was calculated. The CPUE indices were finally divided on age groups by yearly catch in numbers and weight at age data from the trawl fishery. The new approach was less influenced by short periods with poor data, while it still evens out seasonal variations.

There was an increase in the total CPUE from 1999 to 2003, when it reached the highest level in the time series going back to 1980. In 2004 the total CPUE was almost exactly the same as in 2003, while there was about a 30 % increase from 2004 to 2005. This was caused by an increase in the quarter one CPUE. This increase started already in 2003, but was most pronounced in 2005. The increase may be explained by increased availability and catchability of saithe in spawning areas of Norwegian spring spawning herring, where the saithe feeds on herring during quarter one. A similar increase was not seen in the other areas and quarters. AT the 2005 benchmark assessment an annual CPUE series was calculated without quarter one data. This CPUE series showed much less variations over the last four years, and the WG decided to use a CPUE time series averaged over quarters 2-4 for tuning (ICES 2005). Due to rather large negative log q residuals in the first part of the new time series, it was shortened to only cover the period after 1993. Based on exploratory runs done at the 2005 benchmark assessment the age span was set to 4-8.

The estimates of total CPUE increased considerably both in 2007 and 2008. The survey (Aglen *et al*. 2009) shows a higher proportion of saithe in the southern half of the distribution area in the last years, and logbook data show that the trawl catches included in the CPUE calculations also have become gradually more southerly distributed, i.e. the trawlers follow saithe aggregations that may have become extra available in 2007 and 2008. The biological samples used for dividing total CPUE on age groups are, however, from the whole saithe fishery and therefore include age groups that are not numerous in these aggregations. Based on this and the decline in survey indices in the same years and additional analysis, the WG decided to exclude the 2007 and 2008 CPUE data in the final assessment (ICES 2008, ICES 2009a).

Further analysis and exploratory runs were presents at the 2010 benchmark assessment. Six different options were tested, included a proposal from the industry. The CPUE index based upon 7 vessels proposed by the industry could implement new bias or noise due to lack of quarterly indices and index values out of range. To take account of a time period (2000-2008) with increasing directed saithe fishery (Figure 2b), all days with 80% or more saithe are excluded in some runs. Of the two options A) leaving out quarter 1 in the averaging and use all catches with > 20% saithe for the rest of year (as in the current index) or B) leaving out days with > 20% but < 80% saithe and including quarter 1 in the averaging, option B was chosen because it gave somewhat better diagnostics in the XSA runs and is more consistent regarding how data is selected and direct fishery is treated in the rest of the year. The increase in CPUE at the end of the time period was much less for this option and all data years were included in the analysis.

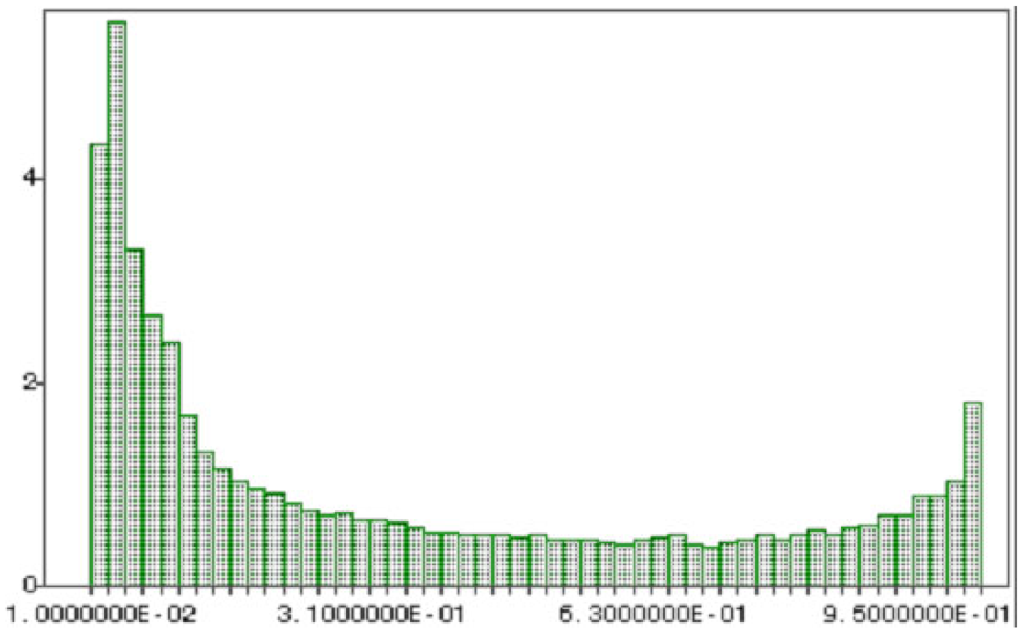

Figure 5a Distribution of small and large trawl catches of NEA saithe (in percent) 1994-1999.

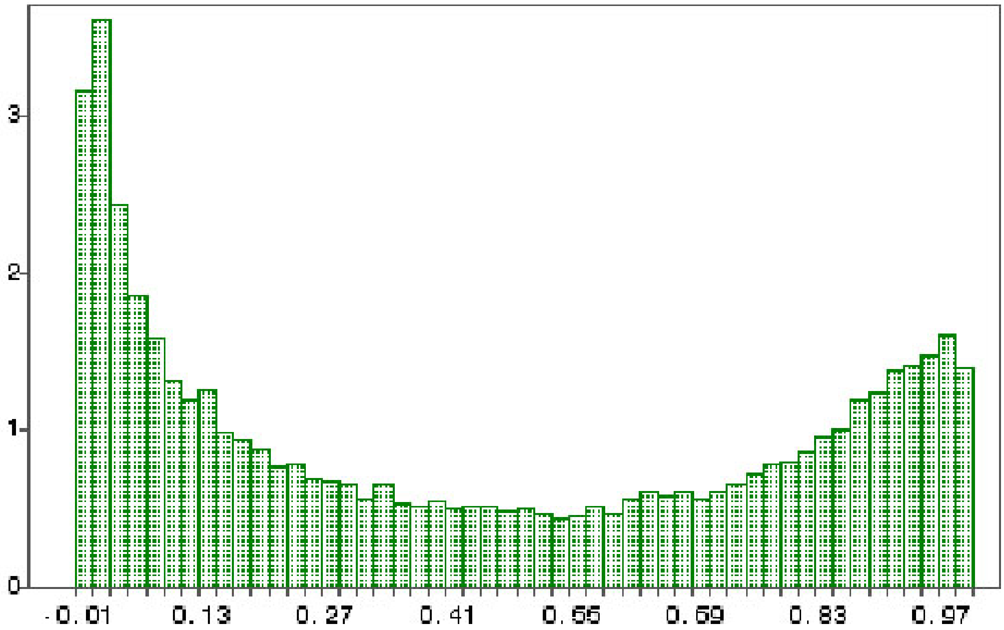

Figure 5a Distribution of small and large trawl catches of NEA saithe (in percent) 2000-2008.

B.5. Other relevant data

None.

C. Historical Stock Development

Until the 2005 assessment age 2 was applied as recruitment age in the XSA runs, projections and calculations of reference points. Since the mid 1990's there has been almost no catch of 2 year olds and this age group should in theory be fully protected by the new minimum landing size. 2-year-old saithe, mainly inhabiting the fjords and more coastal areas, are represented in the survey, but highly variable from year to year. The saithe is normally not fully recruited to the survey before at age 3 and in some years at age 4. It is therefore difficult to estimate good recruitment indices, even at age 2. This especially effects the projections. Retrospective XSA analyses showed that applying age 3 as recruitment age implies that one may include more years in the last part of the recruitment time series. The 2005 WG therefore decided to apply age 3 as recruitment age.

Since about year 2000 the number of old (11+) fish in the catch matrix has been gradually increasing until 2004 and then decreased somewhat, but is still on a high level compared to the years before 2000. VPA based assessment models fitted to data sets with significant numbers in the oldest age and plus group, are extremely sensitive to the method by which fishing mortality at the oldest age is estimated, due to relatively poor VPA convergence at the oldest ages (see ICES 2002, Annex 7). At the 2010 benchmark assessment (WKROUND 2010) the catch matrix was extended to 15+ to avoid some of the potentially plus group problems. At WKROUND this was only possible to do back to 1989. Exploratory XSA runs showed much better retrospective patterns and lower SSB levels and higher F levels at the end of the time period. Prior to AFWG 2010 the whole time series of both catch, weight and maturity at age was extended.

Analysis of the tuning series indicated that there had been a shift in catchability around year 2002 (Figure 6). The survey was redesigned in 2003, and the fishery to a larger degree targeted older ages. Permanent breaks were made in both tuning series in 2002. This allows the XSA freedom to estimate different qs. Exploratory XSA runs showed improvement of retrospective patterns and diagnostics, and some year effects were no more apparent. Additional exploratory runs with reduced shrinkage were done to better allow the model to fit population number to the tuning series. Detailed XSA diagnostics indicated that both tuning indices were relative good in estimating year class strength at different ages. Therefore lowering the shrinkage, allowing the commercial CPUE and survey to determine more of the year classes seemed appropriate (ICES 2009b). The proposed shrinkage of 1.5 lowered the weight of the shrinkage to less than 4 % for all ages. The use of a 20 year tricubic taper against a no-taper was also investigated. Although diagnostics did not substantially improve, it was decided that there were no benefits in keeping the tricubic taper as the splitting up of the tuning series already had a similar impact on the assessment as the 20 year taper and improved substantially the assessment.

The recommendation from WKROUND 2010 therefore was to run the XSA with a 15+ catch matrix, tuning time series broken in 2002, reduced shrinkage (S.E. of the mean to which the estimate are shrunk increased from 0.5 to 1.5) and no tapered time weighting. The new model options are shown below.

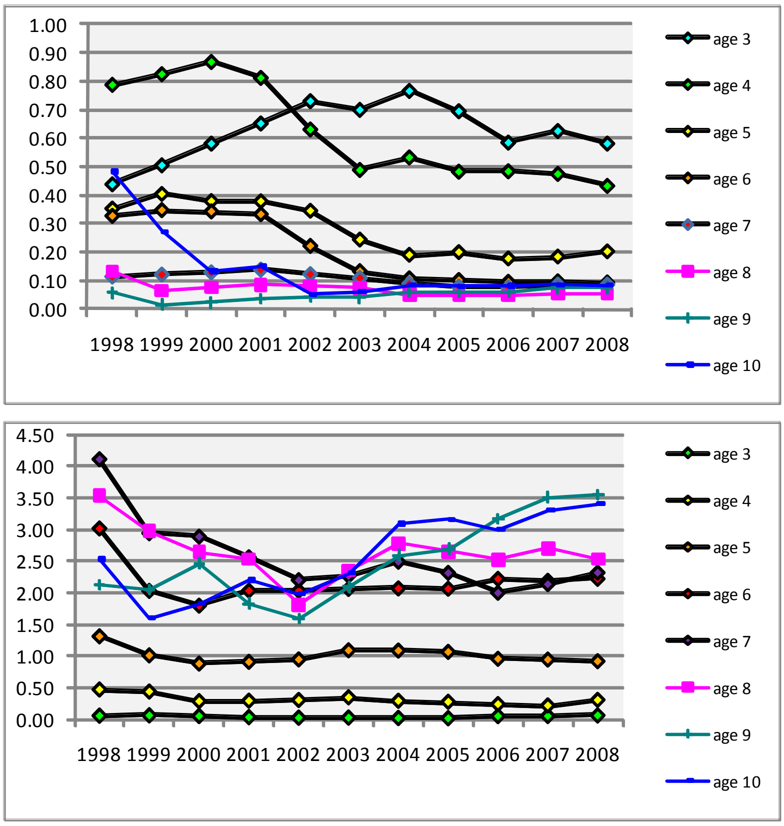

Figure 6 Catchability (index/N) at age in the Norwegian acoustic survey (upper panel) and in the Norwegian trawl CPUE series (lower panel).

Until the 2005 assessment age group 3-6 was the reference age group for Fbar and has been applied in the projections and calculations of fishing mortality reference points. Before the mid 1990's 3 year old fish made up a significant part of the landings, and age group 3-6 contributed about 80 %. Since the mid 1990's there has been a marked reduction in the landings of 3 year olds, and age group 4-7 contributes more than age group 3-6. This is partly related to transference of quota from purse seine to conventional gears and partly to better price for larger saithe. In 1999 the minimum landing size was increased, and most of the 3-year-old fish will be below this size the whole year. The 2005 WG therefore decided to apply age group 4-7 as reference age group for Fbar. The fishing mortality PA-reference points therefore were re-calculated.

Due to the increased number of old fish in the catch matrix the 2010 benchmark assessment also investigated the age span for Fbar. Age groups 4-7 still make up most of the landings, and there are more noisy data in older age groups. Therefore it was decided keep Fbar as current.

Model used: XSA

Software used: Lowestoft VPA suite. In AFWG 2009 exploratory assessment runs were conducted in FLR version 2.8.1.

Model Options chosen:

No tapered time weighting applied

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 8

Survivor estimates shrunk towards the mean F of the final 5 years or the 5 oldest ages

S.E. of the mean to which the estimate are shrunk = 1.500

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1960 – last data year	3 – 15+	Yes
Canum	Catch at age in numbers	1960 – last data year	3 – 15+	Yes
Weca	Weight at age in the commercial catch	1960 – last data year	3 – 15+	Yes/No - constant at age from 1960 - 1979
West	Weight at age of the spawning stock at spawning time.	1960 – last data year	3 – 15+	Yes/No - assumed to be the same as weight at age in the catch
Mprop	Proportion of natural mortality before spawning	1960 – last data year	3 – 15+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1960 – last data year	3 – 15+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1960 – last data year	3 – 15+	Yes/No – constant ogive 1960-1984, three year running average since 1985
Natmor	Natural mortality	1960 – last data year	3 – 15+	No – set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 11	Nor trawl quarter 1-4	1994 – 2001	4 - 8
Tuning fleet 12	Nor trawl quarter 1-4	2002 – last data year	4 - 8
Tuning fleet 13	Norway ac survey	1994 – 2001	3 - 7
Tuning fleet 14	Norway ac survey	2002 – last data year	3 - 7

For analysis of alternative procedures see WG reports from AFWG 1997-2009.

D. Short-Term Projection

Model used: Age structured

Software used: MFDP prediction with management option table and yield per recruit routines, MFYPR.

Initial stock size. Taken from the XSA for age 5 and older. The recruitment at age 3 in the last data year is estimated using the long-term geometric mean, and numbers at age 4 in the intermediate year is calculated applying a natural mortality of 0.2 and the F value estimated by XSA, (advised by RG in 2004).

From AFWG 2009 the numbers at age 4 in the intermediate year is calculated applying a natural mortality of 0.2 and the F value estimated by standard Pope's equation for calculation of this y-c at age 4, i.e. N(4)=[N(3)*exp(-M/2)-C(3)] *exp(-M/2), (advised by RG in 2009).

Natural mortality: Set to 0.2 for all ages in all years

Maturity: Constant ogive 1960-1984, three year running average since 1985, reference year being the middle

F and M before spawning: Set to 0 for all ages in all years

Weight at age in the stock: Assumed to be the same as weight at age in the catch

Weight at age in the catch: For weight at age in stock and catch the average of the last three years in the VPA is normally used.

Exploitation pattern: The average of the last three years for ages 3-10, and a constant value for age 11 to 15+ calculated as the average of ages 11-13 over the last three years.

Selection pattern for yield per recruit: The average selection pattern from the last three years (2006–2008) of the assessment was used.

Intermediate year assumptions: TAC constraint, scaled to a TAC value. If using Sq F for the intermediate year, exploitation patterns described above should be used if there is no trend in F. If a trend in F is observed, the exploitation pattern should be scaled by the Fbar (4-7) to the level of the last year.

Stock recruitment model used: None, the long-term geometric mean recruitment at age 3 is used

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

The issue was not addressed during the 2010 benchmark and no projections were made. Settings previously used are listed below.

Model used: Age structured

Software used: MFDP single option prediction

Initial stock size: Same as in the short-term projections.

Natural mortality: Set to 0.2 for all ages in all years

Maturity: Same as in the short-term projections.

F and M before spawning: Set to 0 for all ages in all years

Weight at age in the stock: Assumed to be the same as weight at age in the catch

Weight at age in the catch: Same as in the short-term projections.

Exploitation pattern: Same as in the short-term projections.

Intermediate year assumptions: F-factor from the management option table corresponding to the TAC

Stock recruitment model used: None, the long-term geometric mean recruitment at age 3 is used

Uncertainty models used: @RISK for Excel, Latin Hyper cubed, 5000 replications, fixed random number generator

- Initial stock size: Lognormal distribution, LOGNORM (mean, standard deviation), with mean as in the short-term projections and standard deviation calculated by multiplying the mean by the external standard error from the XSA diagnostics (except for age 3, see recruitment below)
- Natural mortality: Set to 0.2 for all ages in all years
- Maturity: Constant ogive 1960-1984, three year running average since 1985
- F and M before spawning: Set to 0 for all ages in all years
- Weight at age in the stock: Assumed to be the same as weight at age in the catch
- Weight at age in the catch: Average weight of the three last years
- Exploitation pattern: Average of the three last years, scaled by the Fbar (4-7) to the level of the last year if there is a trend
- Intermediate year assumptions: F-factor from the management option table corresponding to the TAC
- Stock recruitment model used: specified as a PERT distribution (as special form of the beta distribution) with a *minimum* and *maximum* value as specified. The shape parameter is calculated from the defined *most likely* value.

  RiskPertAlt(*arg1type, arg1value, arg2type,arg2value, arg3type,arg3value*). Specifies a PERT distribution with three arguments of the type *arg1type to arg3type*. These arguments can be either a *percentile* between 0 and 1 or *"min", "m. likely"* or *"max"*.

  Examples: *RiskPertAlt(2%; min; 50%; geomean; 98%; max) specifies a PERT distribution with a* minimum *of min and a most likely value of geomean and a 98th percentile of max.*

F. Long-Term Projections

The issue was not addressed during the 2010 benchmark and no projections were made.

G. Biological Reference Points

Due to the change of Fbar from 3-6 to 4-7 and age at recruitment from 2 to 3, the **lim** and **pa** reference points were re-estimated at the 2005 WG. The **lim** reference points were estimated according to the new methodology outlined in ICES CM 2003/ACFM:15. Saithe retrospective XSA-analyses show that in later years there have been an overestimation of F and underestimation of SSB in the assessment year. The trend may have been the opposite in earlier years, but the length of the tuning series do not allow for long enough retrospective analysis to verify this. The new methodology (ICES CM 2003/ACFM:15) does not give any advice on how to deal with such situations. The **pa** reference point estimation was therefore based on the old procedure, applying the "magic formula" $\mathbf{B}_{pa} = \mathbf{B}_{lim}$ exp(1.645*σ) and $\mathbf{F}_{pa}$=$\mathbf{F}_{lim}$*exp(-1.645*σ), where σ is a measure of the uncertainty of F estimates (ICES CM 1998/ACFM:10). For NEA saithe a value of 0.3 was applied in both estimates.

In 2010 the age span was expanded from 11+ to 15+ and important XSA parameter settings were changed (ICES CM 2010/ACOM:36). This resulted in changes in estimated fishing mortality, spawning stock biomass and recruitment, especially in the last part of the time series. Therefore the **lim** and **pa** reference points were re-estimated at the 2010 WG. The results of the segmented regression were not very much different from the previous analyses. The HCR is based on the PA reference points, and if new ones are introduced, the HCR would have to be evaluated again. Due to lack of time to do this during the WG and the transition to MSY based reference points (see Section 0), it was decided to not change the existing LIM and PA reference points. The estimations done at the present WG are, however, presented below.

Biomass reference points

In 1994 the WG proposed a MBAL of 150,000 t, based on the frequent occurrence of poor year classes below this level of SSB. The new maturity ogive introduced in 1995 gave somewhat higher historical SSB estimates. 150,000 t was considered to represent a less restrictive MBAL and 170,000 t was found to correspond better with the arguments used in 1994 (ICES 1996/Assess: 4). The Study Group on the Precautionary Approach to Fisheries Management (SGPAFM, ICES 1998/ACFM: 10) also found this to be a suitable level for B_{pa}. However, based on a visual examination of the stock-recruitment plot ACFM later reduced the B_{pa} to 150,000 t (ICES 1998b).

At the 2005 WG parameter values, including the change-point (**S* =** $\mathbf{B}_{lim}$), slope in the origin ($\hat{\alpha}$) and recruitment plateau (**R***), were computed using segmented regression on the 1960-2000 time series of SSB-recruitment pairs. The values are presented in the text table below.

From algorithm in Julious (2001)		
S*	$\hat{\alpha}$	R*
136378	1.27	173200

Applying the "magic formula" $\mathbf{B}_{pa} = \mathbf{B}_{lim}$ exp(1.645*σ), gives a $\mathbf{B}_{pa}$ of 223,392 t, rounded to 220,000 t.

At the 2010 WG this procedure was repeated based on the results of the new assessment settings, using segmented regression on the 1960-2005 time series of the new SSB-recruitment pairs. The new values were:

From algorithm in Julious (2001)		
S*	$\hat{\alpha}$	R*
118542	1.48	175485

Applying the "magic formula" $\mathbf{B}_{pa} = \mathbf{B}_{lim}$ exp(1.645*σ), gives a $\mathbf{B}_{pa}$ of 194,176 t. However, as explained above, the existing values of B_{lim} = 136,000 t and B_{pa} = 220,000 t will still be used.

Fishing mortality reference points

$F_{0.1}$ and F_{max} are estimated by the MFDP yield per recruit routine, and increased from 0.08 to 0.15 and from 0.14 to 0.30 for $F_{0.1}$ and F_{max}, respectively, in the 1999 - 2005 assessments. In the 2010 assessment $F_{0.1}$ and F_{max} were estimated to 0.08 and 0.33, respectively.

The values of F_{low}, F_{med} and F_{high} obtained by the 2002 WG were 0.11, 0.34 and 0.69, respectively.

The SGPAFM (ICES 1998/ACFM: 10) suggested the limit reference point $F_{lim} = F_{med}$ for Northeast Arctic cod, haddock and saithe. A precautionary fishing mortality (F_{pa}) was defined as $F_{pa} = F_{lim} \cdot e^{-1.645\sigma}$ (σ = 0.2-0.3). The 1998 WG, however, found that setting $F_{lim} = F_{med}$ did not correspond very well with the exploitation history for those fish stocks. It was therefore decided to estimate F_{pa} and other reference points by the PASoft program package (MRAG 1997). The estimates for $F_{0.1}$, F_{max}, and F_{med} were exactly the same as the values already estimated by other routines. The median value for F_{loss} was estimated at 0.43. F_{lim} can be set at F_{loss} (ICES 1998/ACFM:10). The probability of exceeding F_{lim} should be no more than 5 % (ICES 1997/Assess: 7). The 5th percentile of the F_{loss} estimated here was 0.30 and the 1998 WG recommended using this value for F_{pa}. ACFM considered the 5th percentile calculated from the PASoft program package to be too unstable for long term use and re-estimated F_{pa} using the formula $F_{pa} = F_{lim} \cdot e^{-1.645\sigma}$ with $\sigma = 0.3$ giving a $F_{pa} = 0.26$, based on an estimated $F_{lim} = 0.45$ (ICES 1998c). An updated version of the PASoft program package (CEFAS 1999) was available at the 1999 WG and F_{pa} was re-estimated to 0.26. The WG therefore agreed to use this value for a precautionary fishing mortality for saithe ($F_{pa} = 0.26$).

ICES CM 2003/ACFM:15 proposed that $\mathbf{F}_{lim}$ should be set on the basis of $\mathbf{B}_{lim}$, and $\mathbf{F}_{lim}$ should be derived deterministically as the fishing mortality that will on average (i.e. with a 50% probability) drive the stock to the biomass limit. The functional relationship between spawner-per-recruit and F will then give the F associated with the R/SSB slope derived from the $\mathbf{B}_{lim}$ estimate obtained from the segmented regression. At the 2005 WG arithmetic means of proportion mature 1960-2004, weight in stock and weight in catch 1980-2004 (weights were constant before 1980), natural mortality and fishing pattern 1960-2004 were used for calculating the spawner-per-recruit function using ICES Secretariat yield-per-recruit software. R/SSB = 1.27 from the $\mathbf{B}_{lim}$ estimation gives SSB/R = 0.7874 and a $\mathbf{F}_{lim} = 0.58$. Applying the "magic formula" $F_{pa} = F_{lim} \exp(-1.645*\sigma)$, gives a F_{pa} of 0.35.

At the 2010 WG the latter procedure was repeated. Arithmetic means of proportion mature 1960-2009, weight in stock and weight in catch 1980-2009 (weights were constant before 1980), natural mortality and fishing pattern 1960-2009 were used for calculating the spawner-per-recruit function using ICES Secretariat yield-per-recruit software. R/SSB = 1.48 from the $\mathbf{B}_{lim}$ estimation gives SSB/R = 0.676 and a $\mathbf{F}_{lim} = 0.59$. Applying the "magic formula" $F_{pa} = F_{lim} \exp(-1.645*\sigma)$, gives a F_{pa} of 0.36. As explained above, the existing values of $F_{lim} = 0.58$ and $F_{pa} = 0.35$ will still be used.

H. Other Issues

Harvest control rule

In 2007 Norway asked ICES to evaluate whether a proposal for a harvest control rule for setting the annual fishing quota (TAC) for Northeast Arctic saithe was consistent with the precautionary approach. The harvest control rule contains the following elements:

- estimate the average TAC level for the coming 3 years based on $\mathbf{F}_{pa}$. TAC for the next year will be set to this level as a starting value for the 3-year period.
- the year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development. However, the TAC should not be changed by more than +/- 15% compared with the previous year's TAC.
- if the spawning stock biomass (SSB) in the beginning of the year for which the quota is set (first year of prediction), is below $\mathbf{B}_{pa}$, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from $\mathbf{F}_{pa}$ at SSB=$\mathbf{B}_{pa}$ to 0 at SSB equal to zero. At SSB levels below $\mathbf{B}_{pa}$ in any of the operational years (current year and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.

ICES concluded that the HCR is consistent with the precautionary approach for all simulated data and settings, including a rebuilding situation under the condition that the assessment uncertainty and error are not greater than those calculated from historic data (ICES 2007). This also holds true when an implementation error (difference between TAC and catch) equal to the historic level of 3% is included.

The highest long-term yield was obtained for an exploitation level of 0.32, i.e. a little below the target F used in the HCR (Fpa), and ICES recommended using a lower value in the HCR.

The HCR is expected to rebuild a depleted stock to a level above $\mathbf{B}_{lim}$ within three years.

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Annex 6: Quality Handbook ANNEX:_*Smentella*

Stock specific documentation of standard assessment procedures used by ICES. 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. New analytical assessment since 2012.

Stock:	Arctic *Sebastes mentella* (beaked Redfish) in Su bareas I and II
Working Group:	Arctic Fisheries Working Group (AFWG)
Date:	01.03.12

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 (Figure 1). 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.

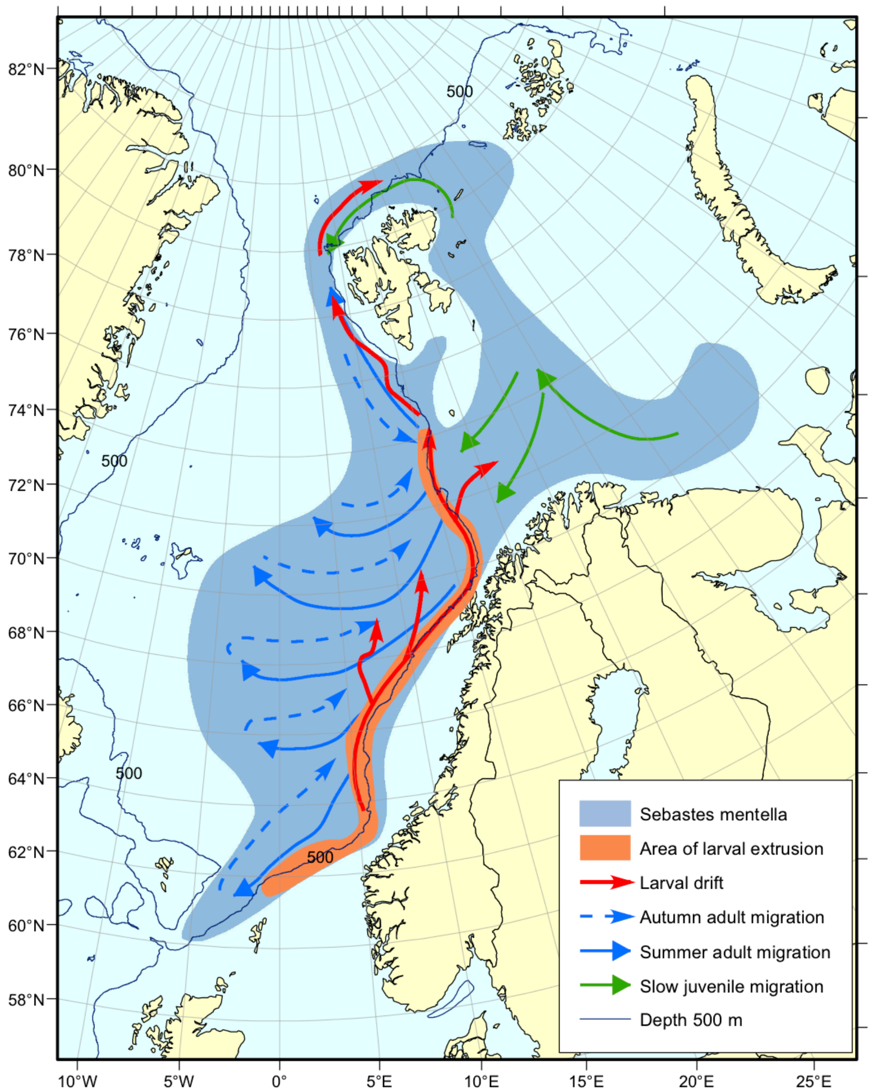

Figure 1. Beaked redfish distribution, area of larval extrusion larval drift and migration routes. Reproduced from Drevetnyak et al. (2011).

A.2. Fishery

The only directed fisheries for *Sebastes mentella* (deep-sea redfish) are trawl fisheries. By-catches are taken in the cod fishery, occasionally also by longline, 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 293,000 t in 1976. This was followed by a rapid decline to about 80,000 t in 1979–1981, and a second peak of 114,000 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.

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. Faroes and Russian vessels were the first to report large catches in 2004. Since 2007 NEAFC has decided on a TAC to be fished in an olympic fishery starting in August each year. In 2008, seven countries and 31 trawlers were involved in this fishery. Although single specimens of *S. marinus* occasionally may be observed and caught, 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.

From the first years with a free pelagic fishery, i.e., 2005-2006, it is possible to observe the seasonality and migration pattern of this pelagic behavior of the *S. mentella*. During summer small quantities of redfish were present regularly in catches from the blue whiting and herring fisheries in the international waters of the Norwegian Sea and the Bear Island-Spitsbergen area. Targeted redfish fishery began south of the Mohn Ridge (i.e., the ridge separating the Norwegian Sea into two main basins) in August. The fishery was conducted with gigantic "Gloria" trawls. The fishery finished in the beginning of November after the redfish dispersed and migrated eastwards into the Norwegian EEZ and the Svalbard fishery protection zone.

Some countries have only reported catches taken in Subarea IIa, without information whether the fish were caught pelagic or demersal. For these countries, the WG has considered all catches not reported to Norwegian authorities as being caught in international waters outside the EEZ.

Bycatch of herring could be a problem during day-time trawling in these waters at the time of the olympic fishery (August-September). 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 occur. Even if some of the herring escape 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 achieved during day-time. According to the skippers they observed and obtained 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.

The redfish population in Subarea IV (North Sea) is believed to belong to the Northeast Arctic stock. Since this area is outside the traditional areas handled by this Working Group, the catches are tabulated but 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 in Subarea IV are considered to be *S. mentella*.

A.3. Ecosystem aspect

As 0-group and juvenile fish, this stock is an important plankton eater in the Barents Sea, and when this stock was sound, 0-group fish have been 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 reports to ICES do not exist, reports 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. Because of uncertainties in the geographical allocation of reported catches, the quarterly areal distributions of bottom trawl catches are area adjusted on the basis of logbook data available from The Directorate of Fisheries. No discards are reported or taken into account. 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 from the length proportions-at-age in the catch combined with a length-weight equation of the for Weight = a*(Length)^b. The equation coefficients a and b are estimated annually from biological samples.

The text table below shows data types supplied by individual countries:

	KIND OF DATA					
Country	Caton (catch in weight) of unidentified redfish	Caton (catch in weight) of *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	x
Russia		x	x[2)]	x[2)]	x (86-01)	x
Germany	x	x[3)]				x[3)]
UK	x	[1)]				
France	x	[1)]				
Spain	x	[1)]				
Portugal	x	[1)]				x
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 also held by 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 compositions have been assumed to apply to the Russian and German landings, respectively, using an annual 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. 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 analytical assessments, the weight at age in the stock is assumed to be the same as the weight at age in the catch.

A fixed natural mortality of $0.05y^{-1}$ is used both in the assessment and the forecast.

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 and from 1992-present from Norwegian samples (surveys and commercial samples combined). In some years the maturity ogives are unprecise or unrealistic, mainly due to low sampling intensity. The approach taken is to model maturity at age with a double half Gompertz sigmoid[1], using mixed-effect models. In years of poor sampling intensity, the fixed ogive is used, while in years when more data is available, the random (i.e. annual) effects are incorporated.

B.3. Surveys

The results from the following research vessel survey series have annually been presented to 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) The 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) The 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) The Winter Norwegian Barents Sea bottom trawl survey (February) since 1986 (incl.) in fishing depths of 100–500 m. Data disaggregated on age only since 1992.
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 including 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, which since then has been called the Ecosystem survey.
6) The 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 which provide estimates of the commercially sized / 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 for a limited part of its areal distribution only.

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[1] the double half sigmoid equation is of the form 0.5 * ((1+tanh(age- a50)/w1)) for age < a50 and 0.5 * ((1+tanh(age- a50)/w2)) for age > a50. a50 equals the age at 50% maturity.

In order to investigate the distribution and abundance of pelagic *Sebastes mentella* in the Norwegian Sea the following surveys are/have been conducted:

i. The Norwegian part of the international ecosystem survey in the Nordic Seas in spring 2007-2009 (PGNAPES).

ii. The Norwegian trawl and acoustic survey in September 2007 and August 2009 and ICES coordinated international trawl and acoustic survey conducted by Norway, Russia and the Faroes in August 2008.

A schematic illustration of these survey series is given below in Figure 2.

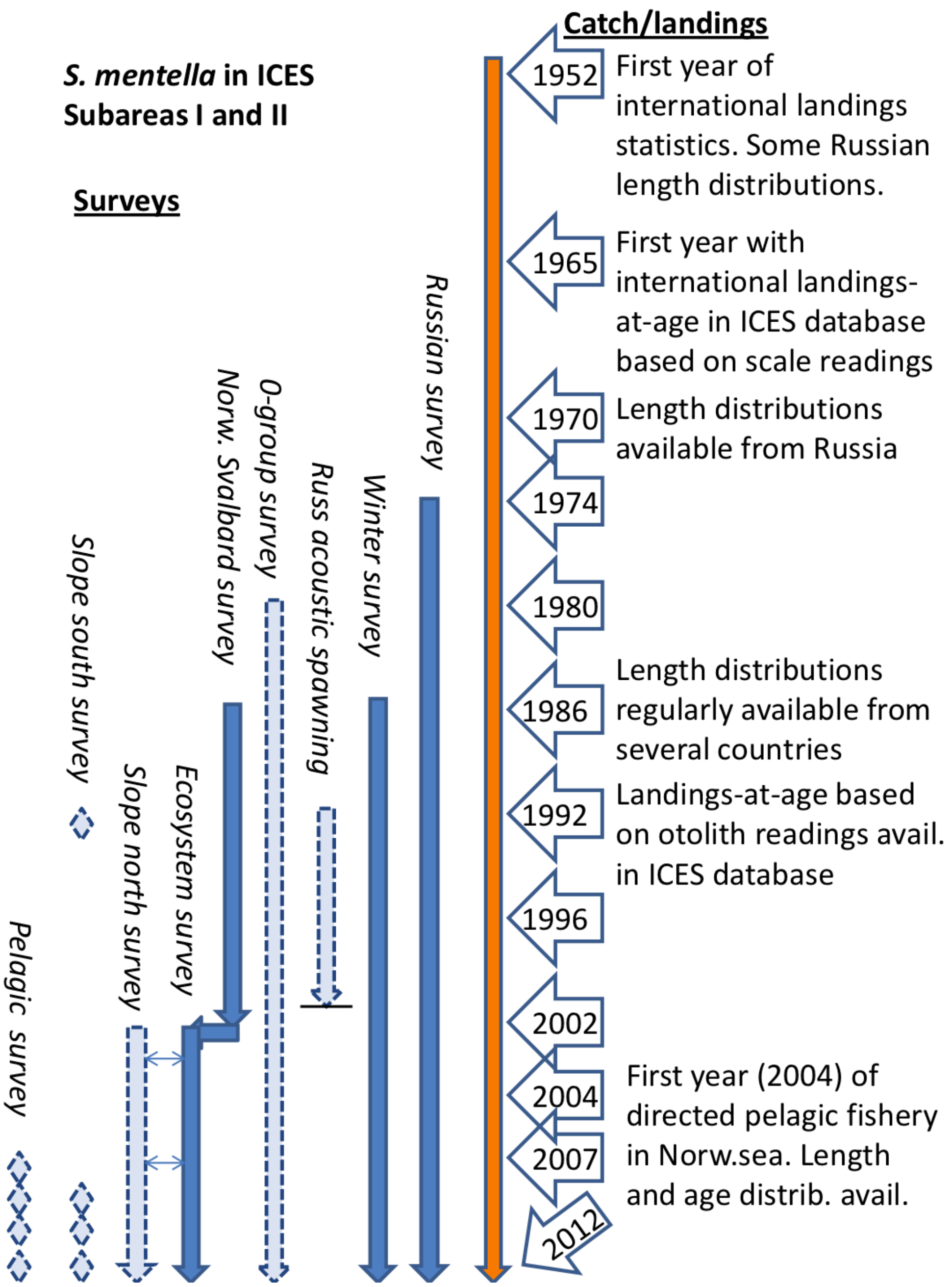

Figure 2. Illustration of the available time series of surveys and catch/landings data. Solid blue arrows show the scientific surveys currently used in both the SCAA and Gadget models, while the dotted light blue arrows show available surveys for which data are available, but are currently not used as inputs to the assessment models.

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; these are representative of the directed Russian fishery which accounts for 60-80% of the total Russian catch. The Arctic Fisheries Working Group concluded that the Russian trawl CPUE series do not reflect the trend in stock size but is more an indication of stock density in a localised area. This is because the fishery from which these data have been forthcoming since 1996 was carried out by one or two vessels only and on localised concentrations in the Kopytov area southwest of Bear Island. This is also reflected by the relative low fishing effort at present. Due to this change in fishing behaviour/effort, CPUEs have been presented for the period after 1991 only.

B.5. Other relevant data

Estimates of predation by cod on redfish juveniles in the Barents Sea, derived from the ecosystem survey, are provided to the assessment working group. The series covers the period 1984 to present.

C. Analytical assessment model

Model used: Statistical Catch-at-Age (SCAA).

Additional models: Gadget and Schaefer models used for validation.

Software used: R ,ADMB and Gadget.

C.1. Statistical catch-at-age model structure

Statistical catch-at-age (SCAA) is used to estimate abundance, recruitment and fishing mortality for many exploited fish stocks. In contrast to virtual population analysis (VPA), in SCAA fishery catch-at-age data are assumed to be measured with error. Under many conditions, SCAA provides more accurate estimates of stock size and other important management quantities than other stock assessment techniques (Wilberg and Bence, 2006). An introduction to SCAA can be found for in Chapter 11.3 in Haddon (2001).

The basic equation SCAA relates numbers N in the population in year y and age a to numbers in the previous year (y-1) for the previous age (a-1):

$$N_{y,a} = N_{y-1,a-1} e^{-Z_{y-1,a-1}}$$

In the specific case of a +group, the contribution of the +group in the previous year should be added:

$$N_{y,a+} = N_{y-1,a-1} e^{-Z_{y-1,a-1}} + N_{y-1,a+} e^{-Z_{y-1,a+}}$$

where Z is the total mortality for year y and age a. $Z_{y,a}$ can be decomposed into 2 components: the natural mortality $M_{y,a}$ and the fishing mortality $F_{y,a}$. In SCA the fishing mortality is derived from two quantities: the fishing mortality in year y, F_y, and the fleet selectivity at age, σ_a. The resulting fishing mortality at age a in year y is given as $F_{y,a} = \sigma_a F_y$. The resulting equation becomes:

$$N_{y,a} = N_{y-1,a-1} e^{-(M_{y-1,a-1} + \sigma_{a-1} F_{y-1})}$$

Fitting the model requires estimating σ_a's, F_y's, the number of fish in year 1, for all ages ($N_{1,\cdot}$) and the number of fish of age 1 for all years ($N_{\cdot,1}$). The natural mortality cannot be estimated for each year and age, since such estimates would be confounded with the fishing mortalities. However, it is possible to estimate a fixed mortality term $M_{\cdot,\cdot}$ identical for all years and all ages.

The model is fitted to catch-at-age data, where predicted catch-at-age is given as:

$$\hat{C}_{y,a,f} = \frac{F_{y,a,f}}{M_{y,a} + F_{y,a,\cdot}} N_{y,a} \left(1 - e^{-(M_{y,a,\cdot} + F_{y,a,\cdot})}\right)$$

with *f* the fleet index. Two commercial fleets are considered. The by-catch fleet mostly operating in national waters are using bottom trawl, and the pelagic fleet operating in international waters and using very large pelagic trawls. The selectivity-at-age of the two fleets are different (due to differences in gear and in the geographical distribution of age groups of redfish). The fishing mortality for each year is also different, and the pelagic fleet only started to operate in 2006. Typically, the model is fitted on the log of the catch-at-age, $logC_{y,a,f}$, assuming normal error distribution.

In addition, the model can be fitted to auxiliary data such as survey indices, with:

$$\hat{I}_{y,a} = q\theta_a N_{y,a}$$

Where *I* is the survey index and *q* a survey scaling coefficient and θ_a is the survey selectivity at age. The above equation is valid if the survey is conducted at the beginning of the year, when this is not the case the equation must account for mortality prior to the survey:

$$\hat{I}_{y,a} = q\theta_a N_{y,a} e^{-\tau(M_{y,a} + F_{y,a})}$$

with τ the fraction of the year before the time of the survey.

Typically, the model is fitted on the log of the survey indices, $logI_{y,a}$, assuming normal error distribution.

Optimisation is carried out by minimizing the negative log-likelihood on observations (log-catches and log-survey indices):

$$nll = \sum \left(\frac{1}{2} \log(2\pi\sigma_s) + \left(\frac{\widehat{\mathrm{LogO}}_i - \mathrm{LogO}_i}{\sigma_s} \right)^2 \right)$$

Where $LogO_i$ are the log-observations (catches and survey indices), *i* is the observation index (from 1 to the total number of observations) and *s* is the index which relate to fleets or surveys from which an individual observation is originating. An additional log-likelihood component is calculated for the total catch in tonnes in each year (following the same equation as above, where C_y – catch in year *y* – are substituting O_i's).

The selectivity of fleets (σ_a) can be estimated for each individual age or can alternatively be approximated by a sigmoid function. The second option was chosen, and the sigmoid was modeled following the Gompertz sigmoid equation:

$$\sigma_a = \frac{1}{2} + tanh\left(\frac{(a - a50)}{w}\right)$$

The use of selectivity functions significantly reduces the number of parameters to estimate. Here there only two parameters need to be estimated: *a50* (the age of 50% selectivity) and *w* (the slope of the sigmoid).

For the survey selectivity, several functions should be tested, including the sigmoid equation above, exponential declines or dome-shaped functions (e.g. exponential parabola). The shape selected for the assessment will depend on the results of these investigations.

C.2. Gadget and Schaefer models

These models are used for quality check and the detailed structured is not presented in the stock annex, although the model configurations are provided in the section below.

C.2. Model Options chosen:

	SCAA	Gadget	Schaefer
Year-span	1992-2010	(1986) 1990-2009	1965-2010
Population characteristics			
Maximum age	19+	30+	-
Genders	1	1	-
Number of maturity stages	2	2	-
Population lengths (cm)	N/A	1-60+	-
Summary biomass (mt)	Immature/SSB/Total	Immature/SSB/Total	Total
Data characteristics			
Data lengths	N/A	1-60+	-
Data ages	2-19+	2-19+	-
First mature age	From fitted annual ogives	Estimated age-based maturation	-
Starting year of estimated recruitment	1992	1986	-
Fishery characteristics			
Fishery timing	Annual	Quarterly	Annual
Fishery ages	6-19+	6-30+	-
Winter survey timing (year fraction or quarter)	0.12	Q1	Annual
Winter survey ages	2-15	3-15	-
Ecosystem survey timing	0.75	Q3	Annual
Ecosystem survey ages	2-15	3-15	-
Russian survey timing	0.90	Q4	Not included
Russian survey ages	2-11	3-11	-
Fishing mortality	Separable, age x year	Match reported catches (no selectivity)	Total catches
Fishery selectivity	Gompertz sigmoid	exponential	-
Winter & ecosystem survey selectivities	Exponential decline	exponential	-
Russian groundfish survey selectivity	Gompertz sigmoid	exponential	-

For the SCAA, the catchability coefficient for the Ecosystem survey needs to be fixed. After comparisons with the output from the Gadget model, it was agreed to set the value $q = 1/3.5$, so that the absolute biomass levels in SCAA are consistent with those in Gadget.

C.3 Data sources

Fisheries data sources

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Total catch in tonnes	1992-2010	NA	yes
Canum1	Catch at age in numbers for the demersal fleet	1992-2010	6-19+	yes
Canum2	Catch at age in numbers for the pelagic fleet	2006-2010	6-19+	yes
Weca	Weight at age in the commercial catch	1992-2010	6-19+	yes
Matprop	Proportion mature at age	1992-2010	6-19+	yes
Natmor	Natural mortality	1965-2008	6-19+	Constant=0.05

numbers-at-age from surveys

Type	Name	Year range	Age range
Tuning fleet 1	Winter survey	1992-2010	2-15
Tuning fleet 2	Ecosystem survey	1996-2009	2-15
Tuning fleet 3	Russian survey	1992-2010	2-11

D. Short-Term Projection (<5y)

Model used: projection with SCAA model output

Software used: Excel / ADMB

Initial stock size: 1,150 thousand tonnes (SSB) in 2010

Natural mortality: 0.05

Maturity: as in 2010

F and M before spawning: $M = 0.05$, F varies with age

Weight at age in the stock: as in 2010

Weight at age in the catch: as in 2010

Exploitation pattern: as in 2010, i.e. sigmoid with 50% selectivity at 11y (demersal) and 14y (pelagic)

Intermediate year assumptions: constant recruitment, weight-at-age, maturity-at-age, exploitation patterns

Stock recruitment model used: N/A. Recruits do not contribute to the fishery before age 6.

Procedures used for splitting projected catches: Projected catches are allocated to fleets according to the proportions in the last year of assessment (2010).

E. Medium & Long-Term Projections(>5y)

Model used: projection with SCAA model output and different scenarios for recruitment.

Software used: Excel / ADMB

Initial stock size: as of last year of assessment

Natural mortality: 0.05

Maturity: as in 2010, sigmoid with 50% maturity at age 11

F and M before spawning: $M = 0.05$. F varies with age, as in last year of assessment (2010)

Weight at age in the stock: as in last year of assessment

Weight at age in the catch: as in last year of assessment

Exploitation pattern: as in 2010, i.e. sigmoid with 50% selectivity at 11y (demersal) and 14y (pelagic)

Intermediate year assumptions: constant recruitment, weight-at-age, maturity-at-age, exploitation patterns

Stock recruitment model used: Recruitment (age 2) scenarios with different levels: average of the last five years and average of the recruitment failure period (1998-2005).

Catch scenario: Future catches were set equal to zero (as a bound), half, the same and double the average catch for the last five years

Uncertainty models used:

1. Initial stock size: Distribution from ADMB MCMC
2. Natural mortality: fixed
3. Maturity: fixed
4. F and M before spawning: M fixed, F distribution from ADMB MCMC
5. Weight at age in the stock: fixed
6. Weight at age in the catch: fixed
7. Exploitation pattern: Distribution from ADMB MCMC
8. Intermediate year assumptions:
9. Stock recruitment model used: scenarios

G. Biological Reference Points

Biological reference points could be defined based upon SCAA and Gadget model results but this has yet to be done.

The Schaefer model (see WKRED report - Appendix ??) the estimates of MSY for $r = 0.05$ and 0.10 are respectively 27 (SE 9) and 30 (SE 12) thousand tonnes respectively.

The Schaefer model indicates the abundance of this resource to be appreciably above 50% (MSY level in terms of this model) over a wide range of r values (see WKRED report - Appendix ??). It should be noted that this model does not take explicit account of recent low recruitments.

H. Other Issues

The bulk of the population biomass of arctic *S. mentella* is constituted by individual of age 19 and older. The assessment of the status of Arctic *S. mentella* stock should therefore explicitly consider the demographic structure of the adult stock, beyond 19y, but this is not the case in the current assessment models used (SCAA and Gadget). It must be emphasised that even if these models can be configured to include more age groups, the survey series currently used in these models do not provide adequate data on the older age groups. The winter, ecosystem and Russian groundfish surveys are restricted to the Barents Sea where juveniles and young adults predominate, but a large fraction of older mature individuals migrate into the Norwegian Sea. Therefore, these surveys do not appropriately cover the demographic distribution of the adult population and are only considered for individuals up to age 11y (Russian survey) and 15 y (Winter and Ecosystem surveys). Priority should be given to data collection over the slope and open Norwegian Sea regions, were the adult population is most abundant, and to including these new surveys in the analytical assessment in the future.

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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:	15.05.2012

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. Directed trawl fishery is not allowed. From 2012, the moratorium was extended to 20 December-31 July 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 reports to ICES do not exist, reports 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.

A schematic illustration of these survey series is given below in Figure 1.

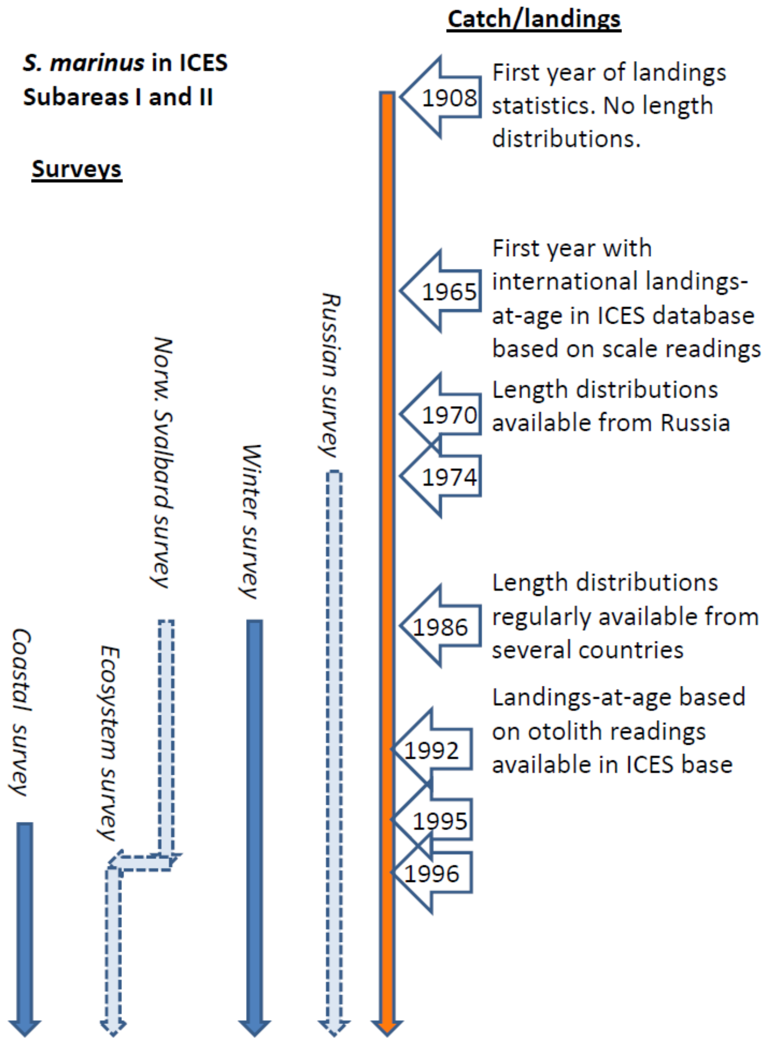

Figure 1. Illustration of the available time series of surveys and catch/landings data. Solid blue arrows show the scientific surveys currently used in the Gadget model, while the dotted light blue arrows show available surveys currently not used.

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. Analytical Assessment model

Since WG2005, experimental analytical assessments have been conducted on this stock using GADGET, and results presented for the years 1990 – last year. This model has been evaluated at the WKRED benchmark (2012), and it is recommended that this remain the basis for advice, with results from a Schaefer model being used to "sanity check" the results.

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). As a GADGET model is rather complex the full model is not described here. Rather, the functioning of a Gadget model, including parameter estimation, is described in Bogstad et al. (2004), and full details of the model are available at http://www.hafro.is/gadget. Only the specific settings and data sources used for this stock are described below.

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. Following the WKRED benchmark meeting 2012, natural mortality within the model has been altered to 0.05. 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 with an age based logistic function for the probability of becoming mature in a given year, allowing for a direct estimate of the spawning stock.

The fishing was handled as two main 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, and are thus combined into the "trawl fleet" within the model. In addition to catch-in-tons, quarterly catch-in-numbers-at-length and age-length keys have been used. The format of the selectivity (a logistic function) was selected and assumed to remain constant over time for each fleet.

Estimated parameters were: an a50 and slope for the maturation, two growth parameters, annual recruitment parameters, 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).
- Estimated maturity ogives for the population for 1993-2007

The Barents Sea survey data were used as both age-length keys, and as a purely length based survey index. This allows for estimation of growth without having the model totally dependent on accurate age readings. 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. As a result of uncertainties surrounding the recruitment signal,no full analytical short-term projection has been made for this stock. However, Gadget model runs can be conducted to estimate the optimum yield-per-recruit, and the optimum catch from the stock if recent average recruitment were to continue.

E. Medium-Term Projections

Model used: Visual inspection/analysis of survey results together with information from the fishery and Gadget model outputs. As a result of uncertainties surrounding the recruitment signal, and the lack of a good SSB-recruitment relationship, no full analytical medium-term projection has been made for this stock. However, Gadget model runs can be conducted to estimate the optimum yield-per-recruit, and the optimum catch from the stock if recent average recruitment were to continue.

Uncertainty models used: None

F. Long-Term Projections

Not done

G. Biological Reference Points

Analysis at WKRED (2012) using a Schaefer model suggested that the stock is heavily depleted. Uncertainties over recent recruitment (from erratic signals in the survey data and concerns over species identification for young fish) and the absence of knowledge on productivity or SSB-recruitment relationships precludes medium-long term projections of the stock.

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 1.500 tonnes. Work conducted at WKRED (2012) using GADGET suggested that a catch of around 1,500 tonnes represented the optimum given current stock size and recruitment levels. This figure was similar to that obtained by a Schaefer model at the same meeting.

H. Other issues

A major source of uncertainty in the *S.marinus* stock is the level of recent recruitment. This is uncertain for two different reasons. Firstly, the recruitment signal in the winter survey has been erratic, with the small fish being observed intermittently between years. Secondly, the good yearclasses in the survey correspond with the years of known good recruitment in the much larger *S. mentella* stock in the region. Species indentification is difficult for young fish of these species, and a species misindentification rate of less than 5% of *S. mentella* as *S.marinus* would completely account for the recent apparent recruitment of *S. marinus*. Until these fish enter the fishery caution is needed in evaluating the estimates of recent recruitment.

I. References

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WKRED 2012, Benchmarch Workshop on Redfish ACOM:49

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.

The 38th JRNFC's Session in 2009 decided to cancel the ban against targeted Greenland halibut fishery and established the TAC at 15,000 t for next three years (2010-2012). The TAC was allocated between Norway, Russia and other countries with shares of 51, 45 and 4% respectively. The 40th JRNFC's Session in 2011 decided to increase TAC for 2012 up to 18,000 t.

During fishing for other species, it is permitted to have an intermixture of Greenland halibut of up to 7% by weight on board at the end of fishing operations and in the catch landed. Nevertheless, a bycatch of up to 12% by weight of Greenland halibut is permitted in individual catches.

From early 2004 the Norwegian Ministry of Fisheries and Coastal affairs decided that for Norwegian vessels in the NEEZ allowable bycatch at any time on board and by landing should not exceed 7 %. In addition, the annual catch for each trawler are not allowed to exceed 4 % of the sum of the vessels quota on cod, haddock and saithe, and limited by a maximum annual catch of 40 t pr. vessel.

The Norwegian conventional fleet, vessels smaller than 28 m, are allowed to conduct a target fishery with longlines and gillnets in a limited area in approximately one month each year. For these vessels the TAC is set to 10, 12 and 14 t, dependent of size of the vessel.

Minimum size regulation for Greenland halibut is 45 cm, and starting in 2012 it became mandatory to use sorting grids during target Greenland halibut trawl fishery.

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 F1 and F2).

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 F3).

3) Norwegian bottom trawl surveys east and north of Svalbard in autumn from 1996 (Table F4).

4) The Norwegian Combined Survey index Table E5, combination of the results from Tables F1-F4.

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 F6).

6) Spanish bottom trawl survey in the slope of Svalbard area in October, ICES Division IIb: from 1997 (Table F7).

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 F4). 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 F1 and F2), the Norwegian Greenland halibut survey in August along the continental slope (Table F3), and the Norwegian bottom trawl survey in August-September north and east of Svalbard (Table F4). 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 F5) 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 EF) 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 F4). (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 F9). 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 F9). 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 Annex - Barents Sea capelin Stock

Introduction

The present (2009) methodology for Barents Sea capelin, which has remained the same since 2003 was evaluated during the ICES benchmark workshop WKSHORT in Bergen 31 August - 4 September 2009 (ICES, 2009b). Although the method was endorsed, the written documentation provided by the Stock Annex made at the meeting was not accepted, as it was found incomplete. The present document is a rewrite of the WKSHORT Stock Annex, where the essential elements in the methodology are made clearer, and model assumptions are motivated.

The 2003 methodology was established in an era with less demand for rigid documentation at the level where people com- pletely unfamiliar with either the ecosystem or the essential methodological elements shall be able to understand and repeat the analyses. After 2003, modelling work has concentrated on bringing the management of capelin more firmly into an ecosystem context, and developing methodology for long-term simulations needed to test harvest control rules, with little or no emphasis on documenting the 2003 methodology.

A comprehensive Stock Annex is needed not only for a full ICES endorsement and for meeting the demands on transparency of ICES methodology, but is also needed for facilitating technology transfer in PINRO and IMR. The present version of the underlying model Bifrost provides for consumption of capelin by cod the year around. However, in the context of the present Stock Annex, only consumption during January-March is modelled, in compliance with the management methodology applied since 2003.

Models used

Unlike most other stocks, the management of capelin is founded on one survey, which is considered giving an absolute measurement of the stock, no model to reconstruct history is needed. Also, the precautionary approach is implemented by carrying out simulations with uncertainty, so a precautionary reference point is not needed, only a limit reference point.The Barents Sea capelin assessment is based on the use of two different models. CapTool is an Excel spreadsheet from which the catch quota corresponding to the harvest control rule is calculated using stochastic prognostic simulation from the time of measurement (October 1) to the time of spawning (April 1 the following year). Bifrost is a model which is used to estimate parameters in the two main biological processes behind the simulations: maturation and predation by cod. The relation between the two models is shown in Figure 1.

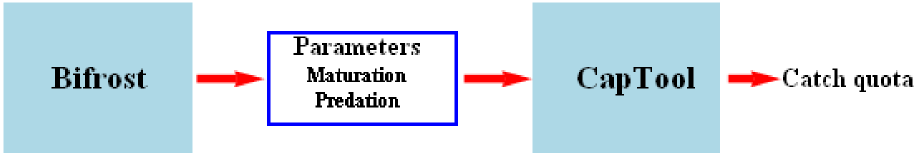

Figure 1. Relation between the models Bifrost and CapTool.

Unlike most other stocks, for which the entire population dynamics is represented by one subjectively chosen parameter (M), the assessment of the Barents Sea capelin rests on a quantitative description of the essential parts of the population dynamics of the stock. Therefore, the Stock Annex gets somewhat more involved in the model description part than most other stocks. Even though the management of Barents Sea capelin is a strictly single species management, it rests on a multispecies model and as such is a small step into an ecosystem based approach to management of the Barents Sea species.

A. General

A.1. Stock definition

Capelin in the Barents Sea spawn in March-April in shallow water off the northern coasts of Norway and Russia (Gjøsæter 1998). The juveniles are transported to the central and eastern parts of the Barents Sea where they grow. The capelin matures and spawns at age 3-5. In recent years, the number spawning at age 5 has been negligible, but during the 1970s spawning capelin of age 5 or even age 6 was not uncommon. The capelin die after spawning (Christiansen et al. 2008). The capelin undertakes extensive feeding migration during the summer into the northern and eastern parts of the Barents Sea.

A.2. Fishery

Some fishing for Barents Sea capelin has taken place for centuries. The fishery intensified during the early 1960s, when a Norwegian purse seine fishery started (Gjøsæter 1998). It soon became a large-scale fishery, and was followed by a Russian fishery conducted mainly with pelagic trawl. The fishery took place from January to March on schools of prespawning capelin on or close to the spawning grounds. In the 1970s and early 1980s a fishery also took place on the feeding grounds in the central and northern Barents Sea during August to October. In recent years, this summer and autumn fishery has been banned (ICES, 2009a). The winter fishery has also been banned during periods when the capelin stock was at a low level. This has happened three times, in the mid 1980s, in the mid 1990s and in the early 2000s. During each of these periods the fishery was stopped for 5 years.

In recent years, the fishery has changed from being mostly an industrial fishery to being mostly for human consumption. This is partly because of low TACs, but also because new markets for frozen capelin for human consumption have developed. In the present fishing period a substantial part of the catch has been delivered for meal and oil production, driven by demands from the aquaculture industry. In the future, the part of the capelin catch delivered for meal and oil production will be associated to the international market for fish meal and fish oil. The Russian part of the catch is delivered exclusively to human consumption.

A.3. Ecosystem aspects

A.3.1. Predators

The capelin plays a key role in the marine ecosystem and is by far the most important pelagic fish stock in the Barents Sea. They are the main diet of Northeast arctic cod (Mehl and Yaragina, 1992, Gjøsæter et al 2009). Juvenile herring may feed intensively on capelin larvae (Hallfredsson and Pedersen, 2009). They are prey to several species of marine mammals, e.g. harp seals, humpback whales, minke whales, and seabirds, kittiwakes and guillemots. They are also important food for several other commercial species (Dolgov, 2002).

The main impact on capelin from predators is the consumption by cod, which has expanded its area northwards the latest year, thereby increasing the predation also on immature capelin. Harp seals may also have a significant impact on capelin. There are less data, however, to evaluate the impact of harp seals on capelin.

B. Data

B.1. Commercial catch

B.1.1 Landings

B.1.1.1 Norwegian landings

Most of the Norwegian catch is taken by purse seiners, constituting about half of the vessels in numbers and taking about 75% of the catch. The rest of the catch is taken by smaller coastal vessels, about half of which operating by trawl and half by purse seie. The Norwegian catch in numbers by age and length (larger and smaller than 14 cm) and by ICES areas is calcu- lated by the program FangstFisk using an Excel file of catch in tonnes by month and geographical location from the Directorate of Fisheries and a file of biological samples from the fishery in the format SPD. The result is stored on Excel files lo<4-digit year>.xls, from which the catch in numbers and biomass by age and maturation group (divided at 14 cm) are transferred to the Excel file CapCatch, which is used by Bifrost.

B.1.1.2 Russian landings

The Russian catch is taken by trawl.The Russian catch in number and age by length and the division in tonnes on months are reported to the WG. From these data the catch in numbers and biomass by age and maturation group are transferred to CapCatch.

B.1.1.3 Use of catch data in the assessment

The catch data influence the population dynamics parameters transferred from Bifrost to CapTool, but not the current assessment.

Formally, the historic simulation during January-March is made for an age-disaggregated stock. However, the predation mortality is assumed equal for all age groups and the food abundance for cod is expressed as biomass of capelin. Thus, the age distribution of the catch does not influence the estimated predation parameters. Uncertainty in catch is not taken into account.

The uncertainty in catch in tonnes by month connected to registration of catch and biological sampling is not known, but considered to be small and the uncertainty in the catch will then have a small influence on the uncertainty in the estimated predation parameters.

In the fishery some capelin may be killed in the catch operation. The magnitude of this is not known, but considered to be larger in the trawl fishery than in the purse seine fishery.

B.1.2 Discards

Discarding is considered negligible for this stock

B.2. Biological data

No biological data are used other than those used for converting commercial catch in tonnes to catch in numbers by age and length and the data used in the September survey to calculate the number of capelin by age and length.

B.3. Surveys

One survey is used in the assessment of the Barents Sea capelin stock: a joint Russian-Norwegian trawl-acoustic survey in September, which started in 1972 and is conducted annually. The abundance estimate from this survey is considered an absolute estimate of the stock. Figure B.1 shows the tracks of the 2007 and 2010 surveys. Each nautical mile of Sa data (for the Russian vessel in the east, each 5 nmi) is represented by a filled circle, the radius of which being proportional to the Sa value, with a maximum of 500. The colour denotes the time referred to the start of the survey, with violet at the start and red at the end.

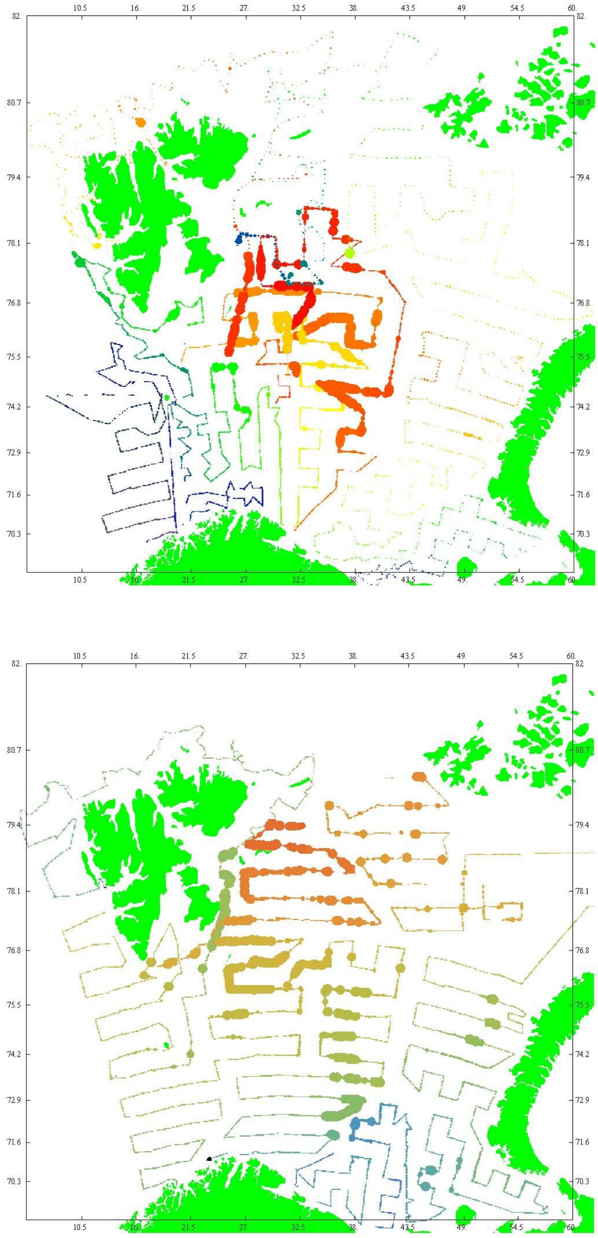

Figure B.1. Survey tracks in 2007 (upper panel) and 2010 (lower panel). Explanations in the text.

Synopticity can be an issue at this survey, where a large area is covered by several vessels that for practical reasons not always can work simultaneously. This is evidently a problem in the 2007 survey, and much less of a problem in the 2010 survey. Migration during the survey will introduce an uncertainty in the estimate that cannot be accounted for. This seems to have been a problem in 2007, as vessels recording nearby registrations at different time encountered different densities of capelin.

In designing the surveys, the 2010 survey might be the model survey, and designs as that of 2007 should be avoided. How- ever, this may be difficult to achieve in practice, as the survey from 2003 has been a multipurpose survey also covering 0-group fish, demersal fish and benthos.

Figure B.2 shows the Sa values by depth for one Norwegian vessel in 2001 and one Norwegian vessel in 2008. Sa values are coloured white and the position of trawl stations are coloured yellow. 0-group stations where the trawling is in different depths during one trawl haul are marked with two yellow dots, one at the surface and one at 40 m. In 2008 the capelin survey was a part of a multipurpose survey also covering 0-group fish and demersal fish. Trawl stations directed at capelin registrations are substantially fewer in 2008 than in 2001. Even if the identification of capelin may not have been seriously hampered, the representativity of trawl stations for the most abundant parts of the capelin distribution certainly has.

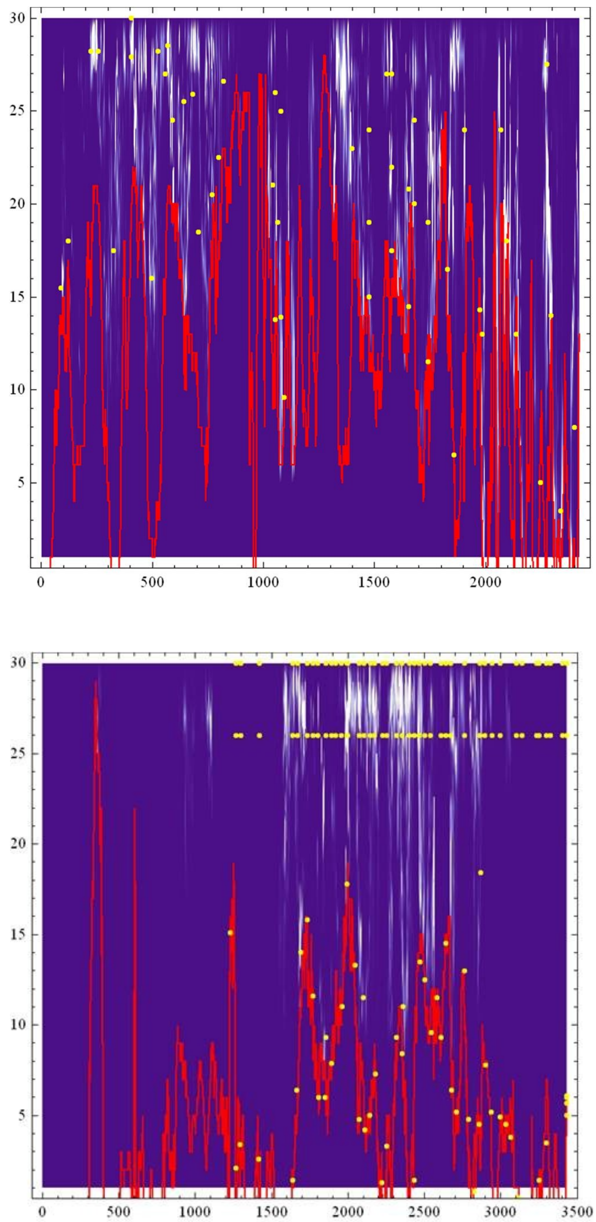

Figure B.2. Sa values (white) by depth and trawl stations (yellow) in 2001 and 2008. Further explanatioms in the text.

Figure B.2 serves is a demonstration of how trawling for obtaining biological samples representative for the main acoustic densities of the capelin can be sacrificed when the survey shall deliver data for many purposes. Care must be exercised by the cruise leader that enough directed trawl samples for capelin are obtained.

Survey uncertainty

The survey uncertainty is a part of the input to CapTool. It would be natural to base the survey uncertainty on the actual survey that has been conducted, so that a poor survey with bad coverage and inadequate sampling resulting in a large uncertainty yielded a more cautious capelin quota. This has not been implemented yet. Instead, a fixed survey CV of 0.2 is used based on the historic replicates for all years, as shown in figure B.3

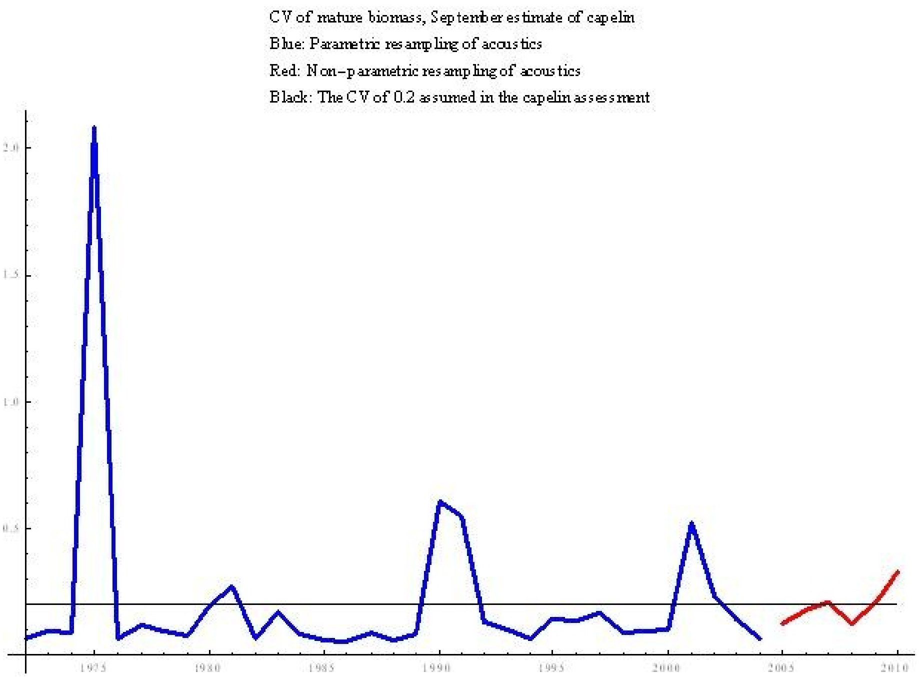

Figure B.3. CV from resampling historic September surveys. The value 0.2 is shown as a horizontal black line. The CV is in most years somewhat below 0.2. The reason for the large spikes is not known.

Area coverage may be an issue, especially during the 1970s where the surveys were primarily directed towards the adult capelin. Figure B.4 shows the development of the year classes 1971-2009, starting from age 1. Most of the year classes prior to 1980 show an increase in abundance from age 1 to age 2. There is an increase in abundance from age 1 to age 2 also for the 2007 year class, which is worrying since the area coverage in later years is considered adequate. However, the observed increase is not highly unlikely in view of the assumed CV on the estimates (0.2).

When recruitment relations are estimated in Bifrost, the number of 1 year old capelin is adjusted so that the cohort matches the observed number of 2 year old capelin when natural mortality on immature capelin is accounted for. This is done in order to avoid the problems of underestimation of the 1-group encountered in earlier years.

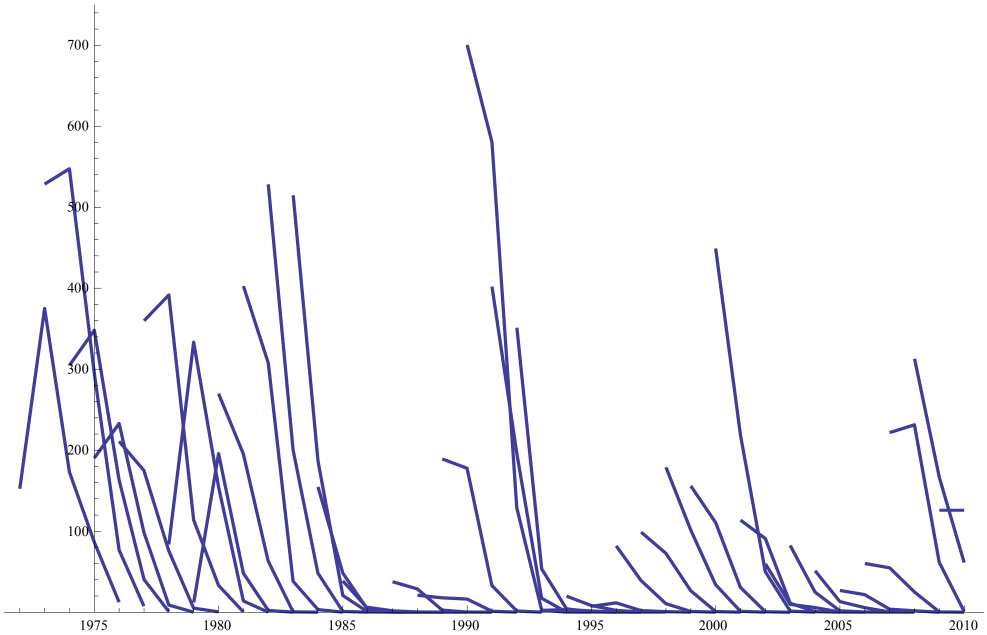

Figure B.4. Development of year classes 1971-2009.

B.3.1. Calculation of capelin abundance from survey data

Based on past experience the available vessels are allocated to areas in such a way that the whole area in which capelin is expected to occur is covered with a spacing between survey tracks of preferrably no less than 30 nmi. The mean Sa value in each WMO (1 by 2 degrees) square is calculated and a length distribution representative for the square is calculated by manually selecting trawl stations within or close to the square that are considered representative for the capelin in the square.

The total number of fish in one WMO square is calculated as

$$\frac{\text{Sa areaSize } 10^7}{5.0\ \frac{\sum_i n(i)\, l^{1.91}}{\sum_i n(i)}}$$

where:

Sa	Mean Sa values from all transects through the square
n (i)	Number of fish in each length group i from biological samples in the square or in the vicinity of the square. Care must be taken that the biological samples are representative for the capelin that contributed most to the Sa value.
areaSize	The size of the area in nautical miles squared

The total number of fish is multiplied with the relative length distribution to yield the total length distribution within the square. It is worth noting that the length dependence of the backscattering ability is used only to calculate the total number of fish. It does not affect the calculated length distribution, which only depends on the observed relative length distribution from the samples.

It has usually been taken for granted that it will be possible to find trawl stations in or in the vicinity of a square that are representative of the fish in the square, since trawling as a rule was conducted to identify the registrations. After the multipurpose survey started in 2003 this is no longer as obvious, as the large number of stations in predefined locations have led to a severe decrease in trawl stations on acoustic registrations.

B.3.1.1. Checklist for capelin abundance estimation

Task	Comment
Plot integratorvalues Determine if necessary to reduce size of some squares	Applies near border of distribution
Verify that representative samples are used in each square	If insufficent directed trawls, apply the following rule : Use 0 - group stations if more than 50 kg capelin. Use bottom trawl stations if more than 10 kg capelin

B.4. Commercial CPUE

Commercial CPUE data are not relevant for this stock

B.5. Other data used in the assessment

In addition to capelin data, the modelling of consumption of capelin by cod requires data for the cod stock, abundance data, maturation data, weight data and stomach content data. Parameters in the function for capelin consumption by cod are estimated by constructing a likelihood with modelled consumption as expectation values and consumption calculated exogeneously directly from the stomach content data using laboratory data of the evacuation rate as observation values. Since the evacuation rate depends on the temperature, data in the vicinity of trawl stations where stomachs are samples are needed. Finally, the consumption per cod is scaled with cod abundance data taken from the February bottom trawl survey, in order to correct for a possibly geographically skewed sampling of cod stomachs with respect to the geographical distribution of the cod stock.

Cod weight at age and maturation at age are taken from the Arctic Fisheries WG assessment. When Bifrost is run, number of cod at age have been calculated exogeneously using the catch at age data and terminal F-values from the Arctic Fisheries WG assessment. In these calculations, Pope's approximation is used. When CapTool is run, the number at age of cod is taken directly from the latest Arctic Fisheries WG assessment.

• B.6. Summary of data

Table B.1 shows a summary of the data used in the Barents Sea capelin assessment.

Table B.1. Summary of data used in the Barents Sea capelin assessment.

Type	Origin	Name of file	Year range	Biological division	Used by
Catch at age in numbers	Commercial catch Biological samples	CapCatch.xls	1972 - present	Age 1 - 5 Season Maturation, divided at 14 cm	Bifrost
Stock size * October 1	Survey	CapTab.xls	1972 - present	Age 1 - 5 Length Weight by length	Bifrost CapTool
Stock size replicates October 1	Survey	bootstrapSexAgeLength - AcousticBiology < year >	1972 - present	Age 1 - 5 Length Weight by length	Bifrost
Cod abundance Assessment year + 1	Arctic Fisheries WG assessment	CapTool.xls	Assessment year + 1	· Age 1 - 13	CapTool
Cod abundance Historic	Calculation in MakeVPA.nb		1946 - present	Age 1 - 13	Bifrost
Consumption of capelin per cod	Calculations in StomachData . nb	consumptionPerCod < year > < length group >	1984 - present	Age 1 - 10	Bifrost

***Considered an absolute estimate of the stock**

Summary of data used to calculate consumption of capelin per cod

The consumption per cod data used in Bifrost to estimate parameters in the predation function are calculated exogeneously using stomach content data from the field, stomach content data from an evacuation rate experiment (dos Santos and Jobling 1992), temperature data from stations in the vicinity of trawl stations where stomachs are sampled and cod distribution data from the demersal survey in February. Replicates of the evacuation rate parameters are calculated exogeneously using a model without the stomach content immediately after a meal as a variable, since this quantity is not known in the field (Temming and Andersen 1994). Table B.2 shows an overview of the data used for calculating consumption per cod replicates.

Table B.2. Summary of data used to calculate consumption per cod replicates.

Type	Origin	Name of file	Year range	Biological division	Used by
Stomach content data from the laboratory experiment	Laboratory data University of Tromsø	Evacjsmj.csv			StomachData .nb
Stomach content data from the field	Biological samples from research vessels	nydump	1984 - present	Prey in individual cod stomachs	StomachData .nb
Temperature data	CTD stations from research vessels taken from the IMR tindor data base	tindorCTD < year >	1986 - present	Depth	StomachData .nb
Geographical distribution of cod	February demersal survey	allEstimateArea·DemersalWinter	1984 - 1987 *	Area, age, maturation	StomachData .nb

*** Remains to be updated**

C. Assessment methodology

The models used and the basic assumptions are listed in Table C.1

Table C.1. Models and assumptions used in the Barents Sea capelin assessment

Model	Usage	Assumptions	
FangstFisk	Calculation of catch statistics for use in Bifrost		
BEAM	Calculation of abundance, September survey		
Bifrost	Estimation of maturation and predation parameters	Maturation	Sigmoidal function of length Estimated
		Predation by cod	Type II relationship to capelin biomass by cod Estimated maximum consumption and prey biomass at half maximum consumption Only immature cod preys on capelin during January - March Max predation is a power function of weight, exponent from literature
CapTool	Calculation of limit catch according to HCR	Maturation	Identical to Bifrost Parameters from Bifrost
		Predation by cod	Identical to Bifrost Parameters from Bifrost

C.1 Model formulations

The mathematical formulations are essentially the same in Bifrost and CapTool.

C.1.1. Maturation

The proportion maturing (as of October 1) of capelin is modelled as a function of length using the logistic function:

$$m(l \mid P_1, P_2) = \frac{1}{1 + e^{4 P_1 (P_2 - l)}}$$

where P_2 is the length at 50% maturation and P_1 is the increase in maturation by length at P_2. l is the length in cm.

Figure C .1 shows the estimated replicate values of the parameters in the maturation function. In 24 % of the replicates P_1 have been estimated to values larger than 2, i.e. approximate cut – off maturation. The mean of the P_2 is 13.816.

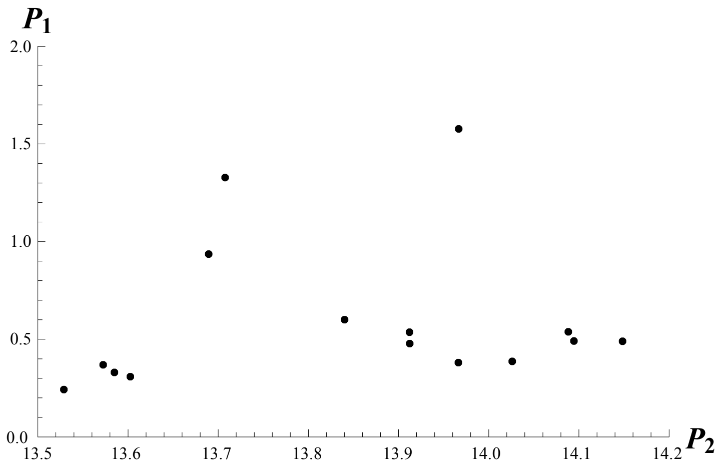

Figure C.1. Estimated replicates of the parameters in the maturation function.

C.1.2. Consumption by cod during January-March

The consumption of capelin by cod is given by:

$$\text{consumption} = P_{17} \frac{\text{capelinBiomass}^{P_{13}}}{P_{10}^{P_{13}} + \text{capelinBiomass}^{P_{13}}} \text{predationAbility}$$

$$\text{predationAbility} = \text{Suit}(i)\, N(i)\, W(i)^{0.801}$$

consumption is the consumption of capelin by cod in million tonnes per month and capelinBiomass is the capelin biomass in million tonnes. The suitability of capelin as food for cod is assumed not to be dependent on capelin age. This assumption would be violated of the spatial and temporal migration pattern of young mature capelin differed from that of older mature capelin. Suit(i) is the suitability of capelin as food for cod of age i. N(i) is the number of immature cod at age i in billions and W(i) is the weigth at age i of cod in kg. The exponent 0.801 is taken from the literature (Jobling 1988).

The number of immature cod by age residing in the Svalbard area thus not preying on capelin during January-March is subtracted before the calculations are carried out. The fraction of cod in the Svalbard area is inferred from autumn demersal surveys. It has not been updated since 2004, however. Data on cod area distribution from the autumn (ecosystem) survey are now available and will be used for updating the area distribution before the 2011 capelin assessment. P_{10} and P_{17} are parameters to be estimated from the data.

Figure C.2 shows consumption as function of capelinBiomass for unit predationAbility for the estimated paremeter replicates.

The suitability of capelin as food for cod is dependent on cod age. The stomach content data show that the youngest cod do not eat much capelin, and the oldest cod tend to have a lesser portion of capelin in their diet than cod of intermediate ages. Figure C.3 show the assumed suitability by age.

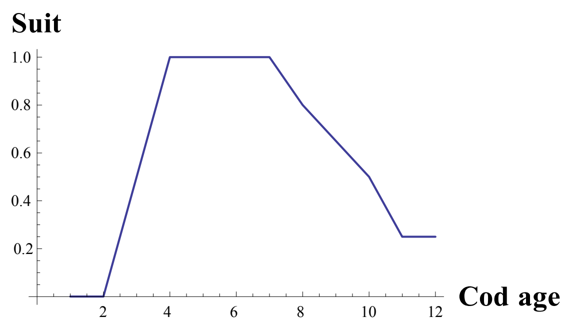

Figure C.3. Suitability of capelin as food for cod by cod age used in Bifrost.

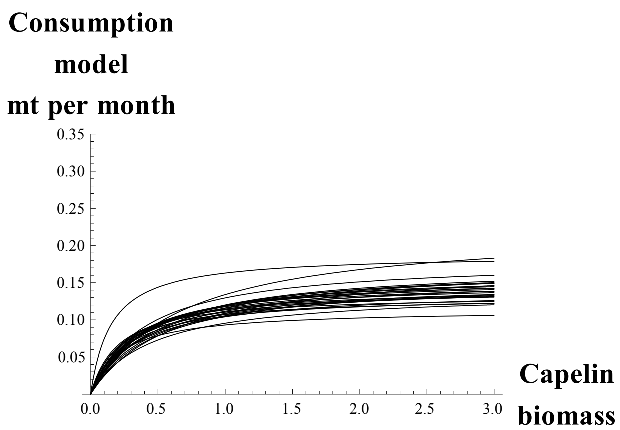

Figure C.2. Replicates of consumption per month as function of unit predation ability.

C.1.3. Simulation

The simulation of capelin in Bifrost is shown in figure C.5. Events are shown in blue boxes and processes in light blue boxes. The model results from each event or process are shown in yellow letters. The yearly simulation period starts October 1, when the stock is initialized as number by age and length from the measurement obtained by the September survey. On these data the maturation model is applied to split the stock into an immature and a mature component on the basis of the length distribution, and both components are summed over length, i.e. the length distribution is not kept during the subsequent simulation - it is used only for the maturation model.

Then the mature component is projected to spawning at 1 April and the immature component to the time of next measurement at 1 October.

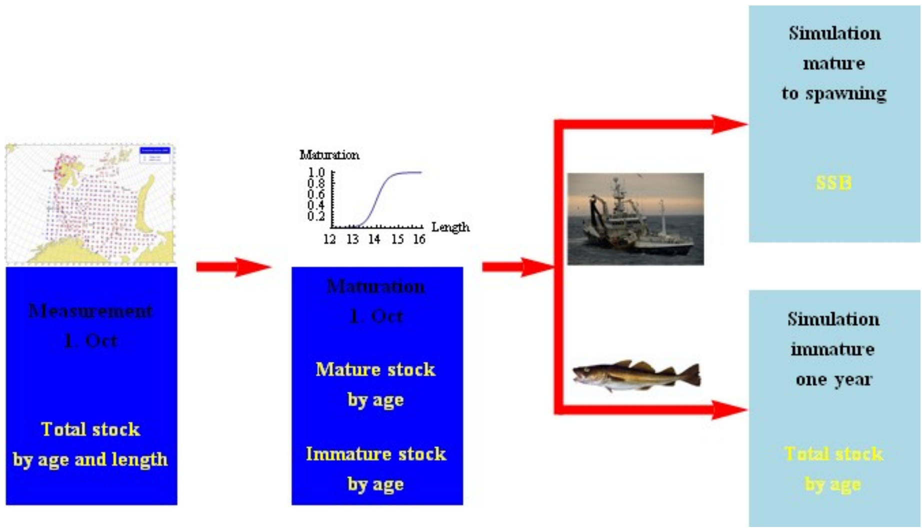

Figure C.5. Overview of Bifrost simulation.

The simulation of both mature and immature capelin from time of measurement 1 October is performed using Pope ' s model for the catch and a natural mortality by month, which is constant during the 12 month simulation period :

$$Cap = (Cap\ e^{-0.5\,P_3} - C_i)\ e^{-0.5\,P_3}$$

During the period January – February the consumption of capelin by cod is particularly intense, as is the fishery. The catch statistics used by Bifrost is given on season only (e.g. January – March), and a constant subdivision of the season is applied to give the catch by month.

The natural mortality for immature capelin P_3 is a constant parameter that is estimated along with the parameters in the maturation function.

C 2. The Bifrost model framework and estimation of parameters

Bifrost is written in Mathematica. Accompanying the Bifrost notebook are several notebooks that are used for data handling and other tasks outside of the Bifrost simulations. Table C.2 gives an overview of the notebooks used. The overview is limited to tasks relevant for the estimation of parameters to be used in CapTool.

Table C.2 Overview of Mathematica notebooks used in Bifrost simulation and estimation

Bifrost	Main notebook
StomachData	Stomach content data handling, calculation of consumption per cod
Temperature	Handling of temperature data
STUVData	Handling of biological data of cod
EstablishingDat-aForMigration	Calculation of cod distribution
MakeVPA	VPA for cod, based on terminal Fs from the WG
SeaStar	Prognostic simulation of herring
BootstrapCapelin	Calculation of September data replicates

C 2.1 Estimation of parameters

C 2.1.1 Historic replicates of estimated parameters – uncertainty in input data

How the uncertainty in the input data affect the uncertainty in the estimated parameters is evaluated by repeated estimation of parameters, each time drawing input data at random from a distribution constructed from the actual measured values. The collection of these replicates of parameters is then transferred to CapTool. Table C.3 shows how the uncertainties in the individual input data sources are treated.

Table C.3. Overview of Mathematica notebooks used in Bifrost simulation and estimation

September data	Data are drawn according to the uncertainty used in CapTool (CV of 0.2)	
Consumption per cod	Stomach content data	No uncertainty for the measured data or for the division of unidentified food
	Evacuation rate parameters	Estimated repeatedly by resampling laboratory data
	Temperature	Drawn from a normal distribution with uncertainty taken from an analysis of using temperature stations not in the immediate vicinity of the trawl stations
	Cod distribution	No uncertainty applied
Cod assessment entities	No uncertainty applied	

C 2.1.2 Estimation of maturation parameters

Figure C.6 gives an overview of the estimation of the maturation parameters.

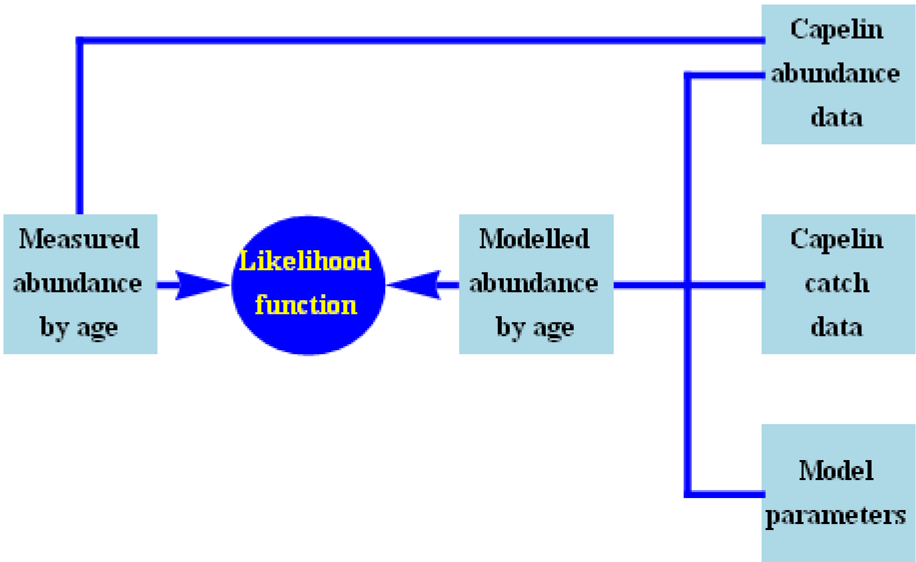

Figure C.6. The estimation of maturation parameters in Bifrost.

The estimation of the maturation parameters relies on projecting the immature part of the population one year, from after the estimate in September until the new estimate in September the following year. The basis for the likelihood function is the projected immature stock, which is the total stock next year since the mature capelin dies after spawning, which is compared to the measured total stock.

The projected immature stock depends not only on the maturation parameters, but also on the monthly natural mortality of immature capelin, which is a parameter in the model.

The trawl-acoustic estimation of Barents Sea capelin started in 1972. Past modelling experience has shown that during the first decade the population dynamics of the capelin remained fairly stable, i.e. the variation in natural mortality from year to year was fairly small. All thre parameters P_1, P_2 and P_3 are estimated simultaneously. Only the 9 first periods are used, i.e.1972-1973, ------, 1980-1981. It is assumed that length at maturity is constant across age groups.The age groups 2-3 and 3-4 years are used in the likelihood.

It is assumed that the measurement of number at age given that the simulated values are the expectation values follow the gamma distribution, and the CV of the distribution is estimated along with the other parameters.

C 2.1.3 Estimation of predation parameters

The maturation parameters must have been estimated before the predation parameters are being estimated.

The main idea behind estimating parameters in the model for consumption is to calculate the consumption by year during January-March outside of the modelled (referred to here as "empirical consumption") and adjust parameters so that the consumption calculated by the model is as close to the empirical consumption as possible. The estimation is done with standard minimizing software that is part of Mathematica.

Figure C.8 gives an overview of the estimation of the predation parameters.

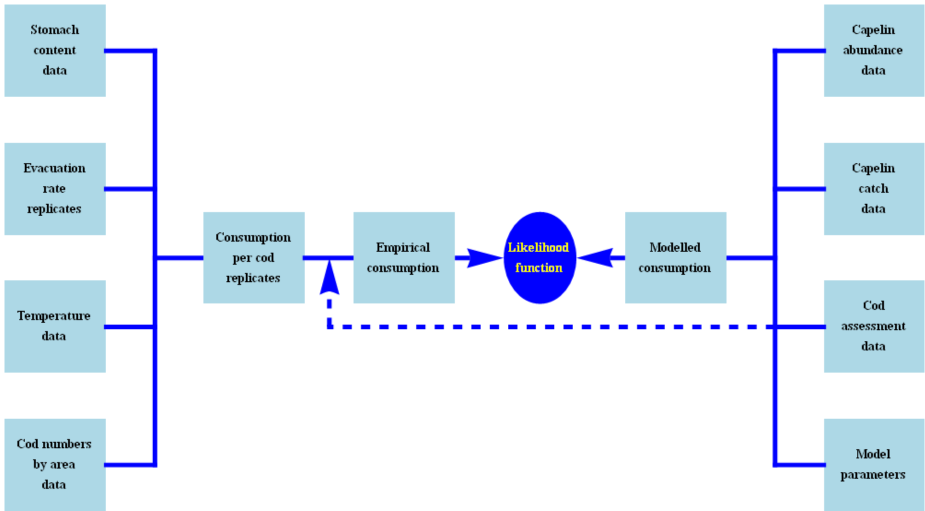

Figure C.8. The estimation of predation parameters in Bifrost.

C 2.1.1.1 Calculation of empirical consumption

The calculation of the empirical consumption is based on an assumption of equilibrium: during the period of calculation (which in this case is January-March) the food eaten equals the food evacuated from the cod stomachs. The total amount of food evacuated is calculated as the average of the food evacuated per time unit for each each stomach times the duration of the period. The evacuation rate is given by Bogstad and Mehl (1997):

$$R = \frac{\ln(2)\, e^{\Gamma T}\, W^{\Delta}\, S^{\Xi}}{A\, S_0{}^{B}}$$

where:

A: evacuation rate halftime
B: dependence on initial meal size
Γ: dependence on ambient temperature
Δ: dependence on predator body weight in grams
Ξ: shape parameter
S: stomach content of prey
S_0: initial meal size in grams

T: ambient temperature
R: consumption in grams per hour

The initial stomach content S0 is not known in the field, so B is set to zero. The other parameters are estimated repeatedly by resampling the laboratory data from an experiment at the University in Tromsø (dos Santos and Jobling 1992). This approach is the same as the approach recommended by Temming and Andersen (1994).The file of estimated evacuation rate parameters is kept on a separate input file, see figure C.8

The consumption per cod in grams per hour is then calculated as:

$$C_a = \frac{\sum_i N_{i,a} \bar{R}_{i,a}}{\sum_i N_{i,a}}$$

where

C_a: consumption of capelin per hour by preying cod of age a

$N_{i,a}$: the number of preying cod of age a in area i

$\bar{R}_{i,a}$: the mean consumption of capelin by preying cod in area i, calculated as $\frac{1}{n}\sum_{j=1}^{n} R_{i,a,j}$

where the summation extends over stomachs of cod of age a in area i and n is the number of sampled stomachs of preying cod of age a in the area.

Weighting with geographical distribution from survey

The empirical consumption is the consumption per cod times the number of cod preying on capelin. It is possible that the geographical distribution of stomach content samples does not equal the geographical distribution of cod preying on capelin. For that reason, the consumption per cod calculated from stomach samples is weighted by the number of cod preying on capelin in sub-areas of the Barents Sea. The area division chosen is the Multspec areas, which were used in connection with the Multspec model (Tjelmeland and Bogstad, 1998), which was used with management of capelin before Bifrost.

Figure C.9 shows the Multspec areas.

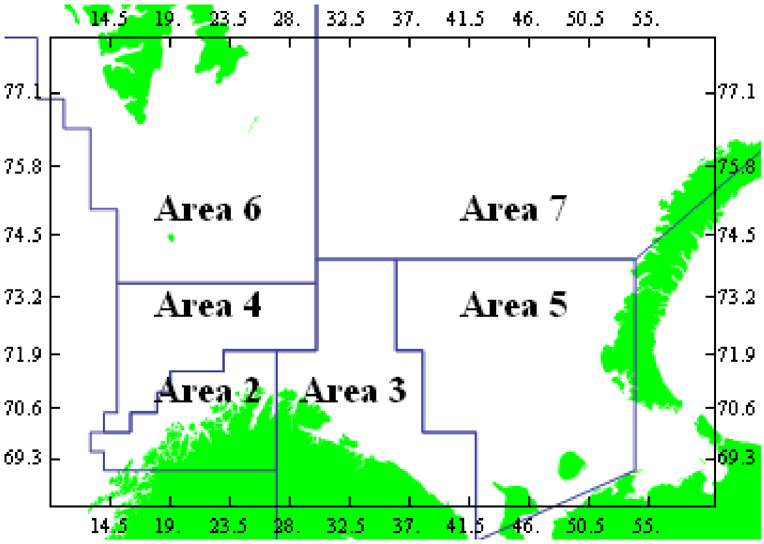

Figure C.9. Multspec areas.

Handling of temperature

A temperature must be connected to each cod stomach, preferrably being indicative of the ambient temperature since time of last ingestion. There are gradients in temperature - the depth gradient ususally being especially strong - which would lead to possibly large inaccuracies using one temperature for a large spatio-temporal area. Unfortunately, the temperature during trawling has not been collected and stored with the stomach content data. As a rule, a CTD station is taken a short time after each trawl station.

In order to find the most appropriate temperature for a given trawl station, first a CTD station in the close spatio-temporal vicinity is sought. If none is found, the search box is increased. If still no CTD station is found, a neighbouring year is tried and the temperature from the CTD station is scaled with the changes in the temperature in the Kola section. The uncertainty connected to not finding a CTD station at the first attempt is evaluated by investigating all CTD data using the same algo- rithm around all CTD stations in the material. The procedure is described more fully in the separate document "Temperature in Bifrost.pdf".

C 2.1.1.2 The likelihood function

The file of consumption per cod replicates is an input file to Bifrost (see figure C.8) and read during initialisation. The total consumption is calculated during the estimation process by multiplying consumption per cod with the number of preying cod from the cod assessment (Arctic Fisheries WG) and the duration of the preying period January-March. The modelled consumption is also summed over January-March before the log-likelihood is evaluated.

It is assumed that the exogeneously calculated consumption follows a gamma distribution when the expectation values are represented by the simulated consumption. The CV of the distribution is estimated along with the parameters in the consumption function.

C 2.1.3 Likelihood estimation and parsimonious models

The estimation of parameters in Bifrost is based on maximum likelihood throughout. The parameters do then have a justification in that they represent a model for which the likelihood of the observed data is the highest possible. Also, using a likeli hood is a powerful tool in seeking models that give the best balance between simplicity and overfitting. The models should be as simple as possible, yet capture the essentials of the population dynamics. The small-sample Akaike Information Criterion (AIC, Burnham and Anderson 2002) is used, defined as:

$$AIC_c = -2\log(L(\hat{\theta})) + K\left(\frac{n}{n-K-1}\right)$$

where L is the likelihood, evaluated at the estimated values of the parameters –

$\hat{\theta}$ – and n is the number of data points and K the number of parameters.

The model with the lowest AIC is the most parsimonious model and to be preferred. This is a model where the parameters represent a biological reality, avoiding superfluous model fit due to overparameterization. Two alternatives to the chosen models were tested: a cut-off maturation function as opposed to the chosen sigmoid maturation, and a three-parameter consumption model enabling a type III feeding relationship. The sigmoid maturation was in itself not an improvement. It had a better fit in terms of a lower log-likelihood, but a higher AIC value. However the fit to the consumption data was signifi- cantly (in terms of AIC) worse using a cutoff maturation than using the sigmoid maturation. Using a three-parameter con- sumption model gave a modest better fit, but an increased AIC.

C3. The CapTool spreadsheet for short term probabilistic projections

C 3.1 The harvesting rule

The harvesting rule adopted by the Norwegian-Russian Fishery Commission is that there shall be a maximum probability of 5% for the SSB at April 1 to be smaller than 200 000 tonnes. This rule was originally devised by the then ACFM.

C 3.1 CapTool

The total Bifrost methodology is quite involved and a simpler tool is needed with the yearly assessment of capelin following the September survey, when only probabilitisc projections from October 1 to April 1 the following year are needed. This is done in an Excel spreadsheet - CapTool - with the @RISK simulation module implemented. The Bifrost model formulations are programmed into CapTool and the replicates of the estimated parameters are copied to a separate page in CapTool. The CapTool spreadsheet, which is self-explanatory, carries out a large number of trajectories and calculates the number of trajectories that leads to a SSB at April 1 of less than 200 000 tonnes.

D. Short term projection

CapTool is used for short term projections. The current September estimate and latest cod assessment are entered manually into CapTool on separate pages. By trial and error a total catch rounded to the nearest 10 000 t for January-March is set so that the harvest rule is satisfied. Figure D.1 shows the simulation output from the assessment the autumn 2010.

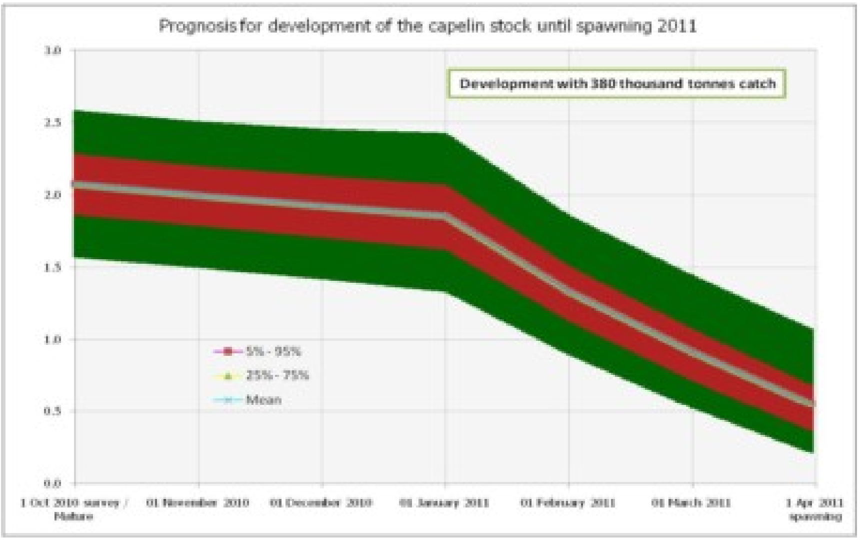

Figure D.1. Simulation output from CapTool, from the assessment of the autumn 2010.

E. Medium term projections

Not relevant.

F. Long term projections

Not relevant.

G. Biological reference points

Blim for Barents Sea capelin is set to 200 000 tonnes by ICES.

H. Other issues

None.

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Annex 10 Stock Data Problems Relevant to Data Collection –AFWG

Stock	Data Problem	How to be addressed in	By who
Stock name	***Data problem identification***	***Description of data problem and recommend solution***	***Who should take care of the recommended solution and who should be notified on this data issue.***
NeA saithe	Biological sampling of commercial catches	In 2011 there were not available enough biological samples from Norwegian catches, especially ALKs from purse seine in Q3, to apply the new standard program (ECA) for producing the catch matrix. Manual allocations had to be done as in previous years, using sample information from other areas, quarters and gear types. This largely contribute to the uncertainty in the assessment.	IMR
Norwegian coastal cod	Biological sampling of commercial catches	Commercial catches of cod are separated to types of cod by the structure of the otoliths in commercial samples. This requires a relatively high sampling intensity and port sampling is the most cost effective sampling programme. The uncertainty in stock separation increased in 2009 when the Norwegian port sampling programme was terminated. The new port sampling programme has improved this situation slightly in 2011, however there is still a need for increased port sampling effort.	IMR
NeA cod	Biological sampling of commercial catches	Certain gears, areas and season groups have a low sampling intensity and well below the EU CDF requirements of 125 sampled individuals per 1000t. (Table 0.1) The WG recommends that this will be improved by an intensified port sampling programme. The WG does also raise concern about the decrease in Russian catch samples (Table 0.2).	IMR PINRO

Stock	Data Problem	How to be addressed in	By who
NeA haddock	Biological sampling of commercial catches	Certain gears, areas and season groups have a low sampling intensity and well below the EU CDF requirements of 125 sampled individuals per 1000t. (Table 0.1) The WG recommends that this will be improved by an intensified port sampling programme. The WG does also raise concern about the decrease in Russian catch samples (Table 0.2).	IMR PINRO

Annex 11 Technical Minutes of the Arctic / North-Western Review Group (RGANW)

Review of ICES Arctic Fisheries Working Group (AFWG) Report 2012

Dates of AFWG: 20 – 26 April 2012.

Reviewers:	Mike Armstrong (chair), Frans van Beek, Patrick Sullivan, Valerio Bartolino
Chair WG:	Bjarte Bogstad
Secretariat:	Mette Bertelsen, Michala Ovens

General

Process

The ICES advisory service quality assurance program requested a team of three independent reviewers and a review group chair to review the AFWG stock assessments and WG results given in the ACOM advice sheets, as specified in the ICES Guidelines for Review Groups. The RGANW initially met along with the ICES secretariat by webex on 2 May to identify the responsibilities of the group, plan the review activities and assign several WG report sections to each reviewer. A second webex conference was held on 8 May and included the AFWG and NWWG chairs to clarify when assessment report sections would be completed and to identify any major issues that RGANW should be aware of. The review group then proceeded with the independent reviews, and had a third webex conference on 16 May to discuss reviewers' draft technical minutes and form RG conclusions.

The Review Group was required to review 24 often complex stock assessment reports within a very short time, and in some cases with missing or out-dated stock annexes. A final RG report could not be compiled prior to the Advice Drafting Group, but many issues became clearer at the ADG in discussion with the WG chairs and are reflected in the final report completed at the ADG by the RG Chair.

General remarks

Stock assessment reports for seven stocks were reviewed (Table 1). Four of the stocks had previously been benchmarked, including two redfish stocks covered by WKRED in 2012. The Review Group concludes that the reports are technically correct, and with a few exceptions agrees with WG recommendations. Any errors or inconsistencies were detected in report sections and advice sheets were passed to the WG chair and ICES secretariat for correction.

The stock annexes and WG report sections varied widely in the amount and quality of information describing the input data, model formulations and model settings. In some cases important material supporting specific assessment choices were contained in Working Documents from the current or previous WGs. The Review Group strongly recommends that all information needed to understand the basis for the assessments and decisions made must be adequately described in the stock annex.

The Arctic ecosystems have undergone changes in line with climatic trends, affecting distribution and productivity of stocks. The WG has provided detailed information on the ecosystems and in some cases has incorporated environmental variables or cannibalism processes into assessments or forecasts. The Review Group supports any further initiatives by the WG to better understand how changes in the environment affect co-occurring and neighbouring stocks and the interactions between them, where this can lead to better decisions for managing the fisheries.

Although the generic ToRs for AFWG ask for a mixed fishery overview and considerations where relevant, the WG has in general given only a description of the fisheries in a region, and then focuses on individual stock assessments, largely in isolation from other species taken in the same fisheries. This is not a criticism of the WG as they are not asked to develop or use a mixed fisheries modelling framework.

Table 1. AFWG stocks reviewed

code	name	assessment type	Last Benchmark	Next planned benchmark	AFWG report section
cod-coas	Cod in Subareas I and II (Norwegian coastal cod)	Trends survey	No	2014	2
cod-arct	Cod in Subareas I and II (Northeast Arctic cod)	Analytic	No	2014	3
had-arct	Haddock in Subareas I and II (Northeast Arctic)	Analytic	2011	-	4
sai-arct	Saithe in Subareas I and II (Northeast Arctic)	Analytic	2010	-	5
smn-arct	Beaked Redfish (Sebastes mentella) in Subareas I and II	Analytic	2012	-	6
smr-arct	Golden Redfish (Sebastes marinus) in Subareas I and II	Analytic	2012	-	7
ghl-arct	Greenland halibut in Subareas I and II	Trends survey	No	2013	8

Cod in Subareas I and II (Norwegian coastal waters cod; cod-coast) (Report section 2)

Stock code: cod-coast

1) **Assessment type:** update

2) **Assessment**: Analytical for trends only

3) **Forecast**: not presented

4) **Assessment model**: XSA

5) **Consistency**: The assessment and stock trends are consistent with last year's assessment

6) **Stock status**: Unknown in the absence of reference points. Survey indices and tentative assessments indicate that the stock is stable near the historical low over the last 10 years while fishing mortality (F4-7) in this period varied around 0.3-0.4.

7) **Man. Plan.**: A rebuilding plan as agreed by the Norwegian authorities (Annex 3.4.2) was evaluated by ICES in 2010 (ICES, 2010). ICES considers the proposed plan to be provisionally consistent with the precautionary approach.

General aspects

- The WG addressed its Tors in providing an update assessment, which is suitable for developing management advice.
- All graphs/tables are the same as last year updated with 1 year of data, and changes to text are minor.
- The perception of the stock and fishery is unchanged compared to last year. Survey indices and XSA indicate no changes in abundance of the stock which remains stable near the historical low over the last 10 years while fishing mortality (F4-7) in this period varied around 0.3-0.4.
- The stock annex must be updated. It provides no information on recreational fishery estimates used in the assessment and the XSA settings don't match those used by the WG this year and last year.

Technical comments

- The exploratory XSA uses a power model at ages 2 -3. Diagnostics suggest non-linear relationship between survey indices and XSA at some ages above 3 as well. However XSA convergence is already poor.
- The WG adopts a procedure of estimating annual Z from survey log catch ratios, regressing against historical XSA estimates of Z (tuned using the same survey) then predicting a "VPA" equivalent Z for the terminal year to start an SVPA. This method will be influenced by the very large variations in survey Z's (AFWG Table 2.16), often with clear year effects. The WG has more belief in the estimate of Z from the last two survey years than in the XSA terminal Z estimate. The XSA is already tuned by the sur-

vey, noting that the retrospective adjustments that can be large (WG Fig. 2.16). A more statistical catch at age model might be better, allowing more flexibility in dealing with the different forms of error and data quality.

- Some measure of precision in the survey would be useful, including the variance due to stock splitting. Also, an indicator of data quality for the estimated landings after splitting with the offshore stock would be valuable.
- Strong year effects are observed in survey nos at age in earlier years, especially 1997, and to a lesser extent in some recent years e.g. 2007-2009. This is reflected in survey Zs as well (WG Fig. 2.15). A more detailed analysis is warranted – use of a survey only model is recommended so that residual error patterns can be explored. (WG stopped using SURBA because of error messages). The method of estimating survey Zs needs to be described in the Annex.
- Table 2.1d is missing
- Make sure that the name of the stock is included in captions of all tables and figures
- From the text it is not clear which assessment summary table is the final one. If the other assessment summaries are meant to demonstrate something this would be better presented graphically.

Benchmarking

This stock has not previously been benchmarked but one is planned for 2014.

Advice sheet

Information from the WG report is accurately reflected in the advice sheet.

Conclusions and recommendations

The Review Group considers that the assessment is consistent with last year's assessment and is a valid basis for advice. As highlighted by the WG, there is a high degree of uncertainty in the catch data as well as in the surveys in later years. The RG provides the following recommendations:

- A move to a more statistical model would allow more objective treatment of errors in data such as surveys and commercial and recreational catch estimates.

Cod in Subareas I and II (report section 3)

Stock code: cod-arct

1) **Assessment type:**	Update
2) **Assessment**:	Analytical
3) **Forecast**:	Analytical short-term forecast. WG has changed the input M in the forecast from a 3-year-mean to the last year's estimate which is very large.
4) **Assessment model**:	XSA – tuning by 3 surveys + 1 commercial. One additional assessment methods (Survey Calibration method) was performed for comparison to XSA
5) **Consistency**:	The assessment method is the same as last year, but fishing mortality in 2010 is now estimated to be 20% lower and SSB in 2011 40% higher. Recruitment (at age 3) in 2007, 2008 and 2009 is much higher than estimated/assumed in previous assessments.
6) **Stock status**:	In spite of the uncertainties in the assessment the SSB is well above agreed reference point Bpa and F is estimated well below Fpa.
7) **Man. Plan.**:	A management plan has been adopted and harvest control rules have been set. The harvest control rules were evaluated by the 2010-AFWG, and were considered to be in accordance with the PA. TAC in 2013 based on F = 0.30 (minimum F in the management plan) corresponding to 940 kt.

General aspects

- The assessment WG addressed its TORs and the review Group considers that the assessment is suitable for providing advice. The assessment has not been included yet in the current ICES benchmark process, and the procedure applied in AFWG 2012 is the same as in AFWG 2011.
- The assessment model is the standard XSA with a procedure to estimate cannibalism mortality (M2) in an iterative process using stomach data. Most cannibalism is at ages 1 and 2 which are excluded from the assessment. Cannibalism at age group 3 can be significant in some years. The estimated M values up to 2010 are consistent with last years assessment but the estimates for 2011 are much higher than in most other years at ages 3 and 4. It is not clear if this could be a real increase or just estimation error. Given the variability of M between years, the use of the high point values of 2011 in all the years of the prediction rather than a recent average is questionable. The sensitivity of forecasts to choice of M should be investigated.
- The SSB of this stock has increased rapidly since 2000 and is now at a series high whilst the F estimates are near the lowest observed and well below Fpa. The addition of one more year of data (with all previous data un-

changed) resulted in a 40% upward adjustment to SSB in 2011 with corresponding lower estimates of F and higher estimates of recruitment in recent years. WG Figure 3.3 suggests that signals pointing to a low F and high N are strongest in tuning fleets 15 (table A3) and 16 (table A2 +A4). The Barents Sea component of these indices is from the same survey which provides acoustic estimates and trawl estimates. These are treated as independent in the assessment, whereas they must have some correlation due to common survey design and use of trawl data in the acoustic analysis. The pattern of the indices in both survey are quite similar. Tuning fleet 16 does include additional information (for older age groups) from an acoustic survey in the Lofoten area (table A4). The WG should consider procedures to ensure these surveys are weighted appropriately in the assessment taking into account the lack of independence.

- The WG should provide a more detailed evaluation of the sensitivity of the assessment to model settings and assumptions, including uncertainties in M estimates. For example, the assessment is very sensitive to the choice of the ages for which catchability is dependent on stock size.
- Inconsistent naming of the surveys and splitting of information between the WG report and annex hindered the review – this should be corrected.

Technical comments

- There is uncertainty in the catch data. In particular in the years 2002-2008 there are different estimates of unreported landings. The WG has used the highest estimates in the assessment. However, there is no mention of this in the report and sensitivity to plausible catch series should be investigated.
- Deductions of catches of coastal cod are based on an arbitrary procedure. Errors in this will be of greatest concern for the quality of catch data for the much smaller coastal population, but the accuracy of the split data should be quantified.
- CPUE data, certainly those used in the assessment, should be better documented how they were derived (show effort and catches in table).
- For each survey, a short description should be given in the Annex, at least including: a standard name used all over in the report; survey type; survey period; year range; indicate use or no use in assessment (and why);table with results.
- In the report refer to the result and use of the survey in the recent year
- Tables of weight at age and maturity at age by country or survey are not relevant in the report if they are not referred to, and should be move to the annex. Full details for procedures for calculating weights at age should be described in the annex.
- The report says that "*the approach used to calculate maturity at age 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*". This is confusing. Stock weights are a weighted average between both surveys whereas an arithmetic mean has been used for maturity.
- Recruitment for use in forecasts is derived from a "hybrid" approach that includes some environment-recruitment relationships described in a dif-

ferent section of the WG report but not described in the Annex. The WG should provide a detailed description in the Annex of the models and how they are combined, and provide diagnostics of the various model fits and predictions of recruitment, with relative standard errors.

- The values of M assumed in the forecast for all years are the point values estimated for 2011. They are exceptionally high compared to previous year and also compared to F. The assumption has significant impact on the forecast – sensitivity of predictions to M assumptions should be shown.
- The comparative "survey calibration method (section 3.9.1) scaling survey numbers at age to VPA-equivalents shows that for ages 4-6 this method gives much lower values than the XSA assessment for the years 2008-2010 in particular, while it compares fairly well with the survey for age 7+. This indicates that for the recent strong year classes, the survey estimates at different ages are not consistent with each other.
- An MSY and FMSY is included in the advice sheet. However, there is no analysis presented in the AFWG report. A reference is made to a 'first step' analyses by Kovalev and Bogstad, 2005, which comes to the conclusion that the proposed values are acceptable. These simulations are now 7 years old and the WG should conduct new analyses using contemporary approaches agreed by ICES.

Benchmarking

A benchmark is planned for 2014. The benchmarking including data-compilation/evaluation and assessment modelling for the two Arctic cod stocks should be planned to consider data quality, new data and possible alternative modelling frameworks that can more explicitly deal with the nature and forms of error in the data, and calculation of reference points. This is important given the very large growth in the offshore stock and poor state of the inshore stock.

Advice sheet

Information from the WG report is reflected accurately in the ACOM advice sheets.

Conclusions and recommendations

The Review Group accepts the assessment as a basis for providing advice although has reservations about choices made, for example the handling of M values in forecasts and weightings of surveys. Recommendations are included under "benchmarking".

Haddock in Subareas I and II (Northeast Artic) (Report section 4)

Stock code: had-arct

1)	**Assessment type**	Update
2)	**Assessment**:	Analytical
3)	**Forecast**:	Analytical short-term forecast
4)	**Assessment model**:	XSA
5)	**Consistency**:	Assessment method and stock trends are consistent with last year's assessment
6)	**Stock status**:	The SSB has been above $MSY_{btrigger}$ since 1990, it has increased since 2000 and was at the series maximum in 2011. Fishing mortality has been around F_{MSY} since the mid-1990s.
7)	**Man. Plan.**:	A management plan has been agreed by the Joint Russian–Norwegian Fisheries Commission in 2004 and was modified in 2007 from a three-year rule to a one-year rule on the basis of the HCR evaluation conducted by ICES. ICES has evaluated the modified management plan and concluded that it is in accordance with the precautionary approach and not in contradiction with the MSY framework.

General aspects

- The assessment WG addressed its TORs and the review Group considers that the assessment is suitable for providing advice. Strong recruitment in the late 2000s in combination with fishing around Fmsy has resulted in a rapid growth in SSB to around double any previous highest SSB values since the 1950s. Retrospective analysis shows only minor differences in stock perception in successive years.
- The WG provided a response to last year's RG comment on excluding ages 1 and 2 from tuning which deviates from a previous benchmark decision. Retrospective analysis shows good consistency in SSB and F but a tendency to revise the strong recruitments upwards when ages 1 & 2 are included in tuning. Removing ages 1 & 2 from tuning appeared to correct this bias. This year's RG agrees with this approach.
- The occurrence of several very large year classes in succession in the mid 2000s has some major consequences for the assessment and management: i) the stock will become dominated by age classes lying beyond the Fbar range; ii) the catch stabiliser rule in the MP will eventually result in F rising above Fmsy as the more recent weaker year classes feed through and cause a reduction in biomass faster than catch can be reduced (25% limit per year while SSB is >Bpa). Future work on HCRs should ensure such recruitment patterns are possible in the simulations, and that the HCR has provisions to deal with such eventualities if required.

Technical comments

- The Review Group appreciates the table provided by the WG listing uncertainties in the data and assessment. Although this is an update, the WG should however provide information on the sensitivity of the final assessment to particular assumptions, model settings and data sets, including the predation estimates of M.

Benchmarking

The assessment was benchmarked in 2011.

Advice sheet

Information from the report section is accurately reflected in the advice sheet (the historical performance plot is not in the WG report section and appears to be inconsistent with last year's advice sheet).

The biology section focuses on aspects of limited use for managers. More useful information would cover spawning, migration, nursery areas, age at maturity, changes in growth etc.

Conclusions and recommendations

The Review Group accepts the assessment for provision of advice but considers that the assessment should be better documented in the report and annex. The main recommendation for the WG is to better characterize and present the uncertainties in the assessment including sensitivity to model choices, assumptions and data sets.

Saithe in Division I and II (Northeast Artic) (Report section 5)

Stock code: sai-arct

1) **Assessment type:**	Update
2) **Assessment**:	Analytical
3) **Forecast**:	Analytical short term prediction
4) **Assessment model**:	XSA tuned with one commercial CPUE fleet and an acoustic survey, each with a separate 2002-2011 series.
5) **Consistency**:	The current assessment model and results are very consistent with last year's
6) **Stock status**:	Since 1995, SSB has been well above B_{pa} and has decreased in recent years. Fishing mortality was well below F_{pa} for a number of years after 1996, but has increased since 2005 to F_{pa} in 2010 and 2011.
7) **Man. Plan.**:	The Norwegian Ministry of Fisheries and Coastal Affairs implemented a harvest control rule (HCR) in autumn 2007. ICES evaluated the Harvest Control Rule in 2007 and concluded that it is consistent with the precautionary approach.

General aspects

- The assessment WG addressed its TORs and the review Group considers that the assessment, which follows the procedures adopted since the 2010 WKROUND benchmark, is suitable for providing advice.
- The perception of SSB altered substantially after the benchmark due to changes in the specification of plus group to 15+, plus breaking the two tuning series at 2002, but has been consistent since then.
- The signals in the two tuning series are diverging in recent years, with the research survey receiving most weight.
- In common with most saithe stocks the lack of robust indices of recruitment is a deficiency for projecting future stock sizes and catches.

Technical comments

- The Review Group appreciates the presentation of some sensitivity analyses for the assessment (terminal Fbar vs SSB plots) but considers that more detailed information on the sensitivity of the results and advice to particular model settings, assumptions and input data should be provided.

Benchmarking

The stock was benchmarked at WKROUND 2010.

Advice sheet

Information from the report section is accurately reflected in the advice sheet

Conclusions and recommendations

The Review Group accepts the assessment for provision of advice, and has the following recommendations:

- WG should develop more detailed quantitative diagnostics of the quality of the assessment and forecasts including sensitivity to model settings, assumptions and data.
- In the longer term, development of better methods to develop recruitment inputs for forecasts will help management of this stock (and other saithe stocks),although experiences so far are that survey approaches are difficult.

Beaked Redfish (Sebastes mentella) in Subareas I and II (Report Section 6)

Stock code: smn-arct

1) **Assessment type:** Update
2) **Assessment**: Analytical
3) **Forecast**: Short term and longer term projections based on SCAA output.
4) **Assessment model**: Statistical catch-at-age model (SCAA) fit to catch-at-age and three survey series .
5) **Consistency**: This is a new assessment.
6) **Stock status**: No biological reference points are calculated from the SCAA model results or yield-per-recruit. The biomass has been increasing due to stronger year classes in the early 1990s, and model estimates of F are extremely low for recent years (~0.01 compared with assumed M of 0.05.)
7) **Man. Plan.**: There is no specific management plan

General aspects

- The Review Group considers that the assessment is acceptable for informing management advice although the period of the analytical assessment (1992 – 2011) is very short considering the longevity of the fish. Historical landings data show periods of elevated catches in the 1950s/60s and particularly 1970s/80s, presumably following periods of increased recruitment.
- The assessment indicates a ten-fold reduction in F in the demersal fishery from 0.05-0.07 in the early 1990s to below 0.005 in the 2000s, and a similar reduction in the pelagic fishery from 0.04 in 2006 (first year of data) to below 0.01 by 2009. Model diagnostics look reasonable although residuals over ages and years are non-random. The ability to understand stock dynamics from a catch-based model when F has fallen so far below M is questionable. The absolute level of biomass (and F) is very dependent on the assumed M.
- The internal consistency of the surveys (year class tracking) should be demonstrated analytically, and an evaluation made of the ability of the bottom trawl surveys to accurately track abundance given the pelagic behaviour of the stock.
- Currently the bulk of the biomass is in the 19+ plus group which is a further issue for the assessment.
- The assessment indicates that recruitment at age 2 was very low during 1998 – 2005, which will start to impact the fishery and SSB from now onwards given age at first recruitment and maturity around 10 – 15 years. Projections were calculated for the years 2012-2020 under zero catch and at

catches equal to half of and double the 2011 catches. A decline in SSB is noted up to around 2015 due to the poor year classes from the 1990s, followed by an increase due to the more recent improvement in recruitment.

Technical comments

- The WG will have to consider how to conduct the assessment with most of the stock now in the plus group.
- Trends in F, SSB etc. are given with error bars but the WG needs to present more information on the sensitivity of the model to assumptions, model settings and data inputs.

Benchmarking

The new analytical approach was developed at the WKRED 2012 benchmark.

Advice sheet

Information from the report section is accurately reflected in the advice sheet

Conclusions and recommendations

The Review Group accepts the assessment as giving a basis for general advice on stock trends and possible future stock trajectories in relation to apparent recruitment patterns, but has concerns about the ability of the model to represent stock dynamics when F is (apparently) so far below the assumed M which is fixed across ages and years. The RG makes the following recommendations:

- Efforts should be made to identify biological reference points that are based on the SCAA and associated projections.
- Further work is needed to evaluate the ability of the surveys to track stock abundance.
- The WG should consider how to extend stock perception further back in time as there is a long catch history.

Golden Redfish (Sebastes marinus) in Subareas I and II (report section 07)

Stock code: smr-arct

1) **Assessment type** :	Update
2) **Assessment**:	Analytical
3) **Forecast**:	Projections based on Gadget model.
4) **Assessment model**:	Gadget, age-length structured model – 2 commercial fleet + 1 survey as tuning
5) **Consistency**:	Model inputs have been altered following WKRED 2012. Revision of M from 0.1 to 0.05 revised the overall stock size down compared to previous models. The methods are consistent with the description in the stock annex.
6) **Stock status**:	The status of the golden redfish stock is extremely poor and continues to decline; F=0.35 is well above the suggested F_{pa} of 5% of the stock and $F_{0.1}$=0.08; R poor in the last decade, abundance of the new year class very uncertain; no target reference points have been identified.
7) **Man. Plan.**:	No official management plan has been evaluated or adopted, and before 2003 no regulation existed for this stock.

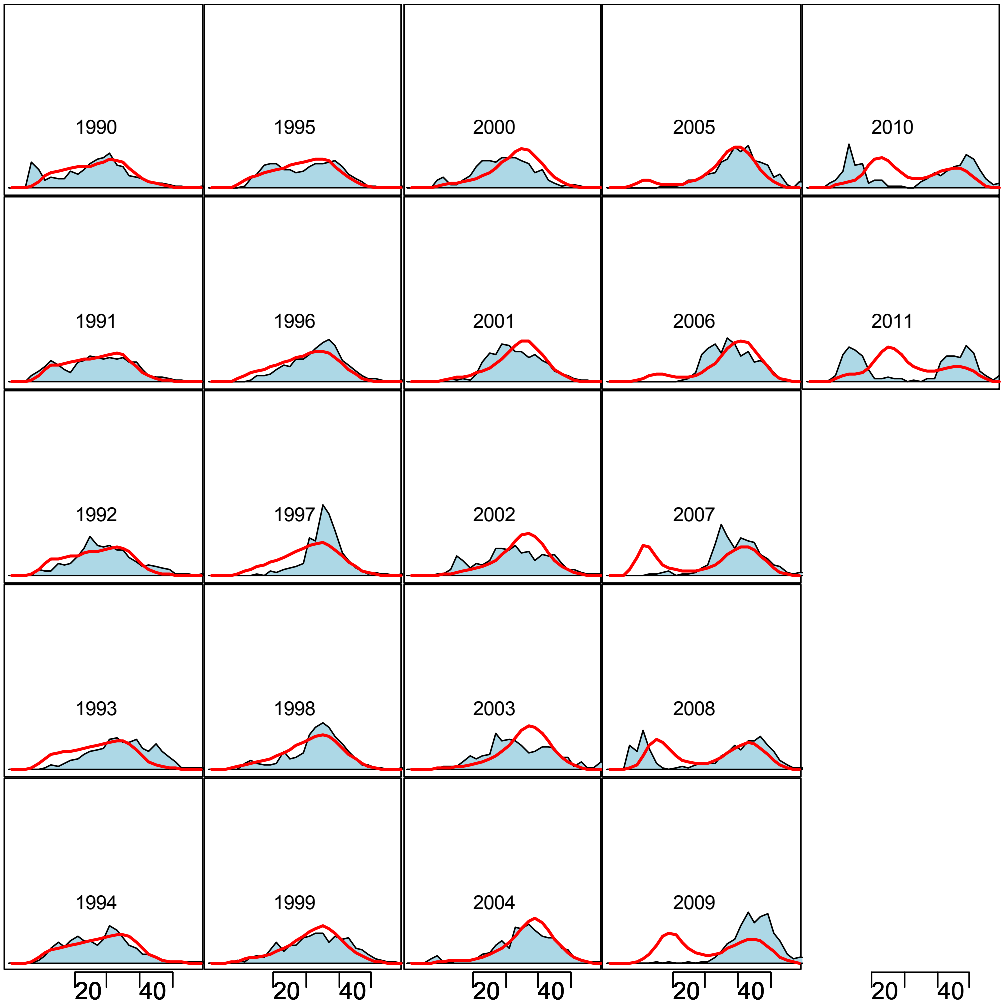
General aspects

- The Review Group considers that the assessment has been carried out according to the procedure agreed during the recent benchmark (WKRED 2012), and provides a suitable basis for management advice.
- All the data sources and the assessment describe a steady decline of the stock to an extremely low biomass. Although there are uncertainties in the assessment (lack of a clear recruitment signal for recent years; non-availability of biological sampling data for 2011 catches; species misidentification with *S mentella*), these do not alter the perception of the very poor state of the stock.
- One of the main issues facing the assessment for this stock is the coverage of biological sampling of catches (e.g. biological data only available from the Norwegian fishery) affecting the quality of data for the assessment. The small sample size on the weight-at-age of juveniles (<10 years old fish) represents an important source of uncertainty.
- Misidentification between *S. marinus* and *S. mentella* can affect particularly the perception and estimation of new recruiting year classes. Increased sampling of all fleets operating in the international waters would help in reporting catches disaggregated by redfish species. At the moment the WG splits these aggregated catches using information communicated by each fleet to the Norwegian authorities.

- Recruitment has been particularly poor during the last decade, but with erratic signals of larger year-classes from the winter survey (i.e., 2008, 2010, 2011). These contrasting signals are not well understood yet, and negatively affect the model fitting.
- Discards are not reported or accounted. Considering the limit on percent bycatch allowed in non-direct fisheries, and the very poor status of the stock, the amount of discards and underreporting may become a concern for this stock.

Technical comments

- Not all the available survey data are used in the assessment. The RG could not find explanation for this, but within an appropriate weighting procedure most of the data sources could be probably used unless there are specific issues on their quality. There is not an exact correspondence between the data presented in Fig.1 in the annex and the data used within the GADGET model (i.e., length composition of the catch is provided by Norway, Russia and Germany, but only length data from the former is used in the assessment model).
- The annex document is rather scarce for this stock and it does not provide all the information needed for a complete evaluation of the assessment. The main assumptions used in the GADGET framework are presented, but they are not sufficient. Without being excessively long, the annex should contain all those technical details needed to understand how the assessment model works, without the need to go into the GADGET technical document.
- Weighting of the data components is crucial in complex models where multiple data sources are employed, and in the case of assessment models it may have a large impact on the estimated dynamics for the stock. The weighting scheme is mentioned in the stock document, but not details or justification of the applied scheme is given in the annex.
- In recent years the model has begun to overestimate the catches of the larger fish. This may be an indication that the mature portion of the stock is actually smaller than what predicted by the model.
- Model fitting to the survey data is problematic in the last years.



WG Figure 7.12. *Sebastes marinus* in Sub-areas I and II. Annual fit of modelled length distributions (red line) to the winter survey (blue shaded area). Horizontal scale in cm.

- Diagnostics on the model fit to the observed length-structure are very useful, however, additional model diagnostics, in particular on how the model fit the age-structure, and on the temporal pattern of the residuals would be helpful for a more complete evaluation.
- In table E2 there is mention that the area coverage for the bottom trawl surveys in the Barents Sea (Division IIa) was extended from 1993. It is unclear if and how it can have affected the input data for the assessment.

Advice sheet

Information from the report section is accurately reflected in the advice sheet

Conclusions and recommendations

The RG accepts the assessments as forming the basis for advice. The following additional recommendations are made:

- Further work is recommended to confirm and explain the contrasting signals on the incoming year classes in recent years. When confirmed, such pattern should be reflected in the model fitting to the survey data.

- A number of data issues remain, in particular concerning species misidentification, uncertainty on juvenile weight-at-age due to small sampling size, lack of biological data from fisheries other than from Norway, occurrence of discarding. The RG recommends improved effort and coordination to moderate these issues.
- The expansion of ALK from the Norwegian samples to the unsampled fleets and areas appears rational, but evaluation of criteria, methodologies and standards is recommended.
- The amount of discards and underreporting may become a concern for this stock, and should be carefully evaluated.

Greenland halibut in Subareas I and II (report section 8)

Stock code: ghl-arct

1) **Assessment type:**	update
2) **Assessment**:	Survey trends. (Supporting exploratory XSA assessment is not usable for advice).
3) **Forecast**:	No forecast possible
4) **Assessment model**:	None
5) **Consistency**:	Survey trends are consistent with those presented previously.
6) **Stock status**:	Stable or increasing biomass is indicated by most surveys. The level of fishing mortality is poorly understood. There are no biomass or F reference points.
7) **Man. Plan.**	There is no specific management plan

General aspects

- The WG fully addressed its ToRs in providing an update assessment using the same procedure as last year, however the XSA assessment is considered inappropriate for supporting advice due to issues with ageing and advice can be based only on survey trends.
- Difficulties in assessing this stock are due to i) issues with accuracy of age readings; ii) inconsistent trends in survey and CPUE series that cover varying periods and parts of the population. On balance there seems to be more evidence in favour of stable or increasing rather than decreasing abundance but little more than this can be concluded until issues regarding age determination and ability of surveys to track abundance are resolved.
- The Review Group appreciates the WG's exploration of work required for a future benchmark – considerable development work is clearly needed before 2013.

Technical comments

- The catch, age compositions and survey data used this year are the same as for last year's assessments, with addition of 2011 catch data and 2012 Russian survey data and some minor adjustments to preliminary catch data.
- Survey problems are highlighted in a paper by Daniel Howell (IMR) drafted following the AFWG meeting in 2012 examined the Russian trawl survey data, which is presently the only tuning data after 2005 and concluded that all length classes appear to rise of fall synchronously. He suggests that the increasing trend in the indices are reflective of increasing availability of the whole population to the survey (e.g. due to shifts in distribution) rather than actual changes in abundance.

- The trial XSA run, carried out with the same settings as last year, shows strong retrospective bias in biomass estimates, and for some age groups in Flt04 (Norwegian CPUE) and most age groups in Flt 08 (Norwegian combined survey) the log catchability slopes estimates vary wildly indicating there is no temporal signal compatible with the VPA cohort reconstruction.
- The Workshop on Age Reading of Greenland Halibut (WKARGH – 2011) reported that the different age methods can be classified into two groups: A) Those that produce age-length relationships that broadly compare with the traditional methods described by the joint NAFO-ICES workshop in 1996, typically indicating age around 10-12 years for 70 cm fish; and B) Several recently developed techniques that provide much higher longevity and approximately half the growth rate from 40-50 cm onwards compared to the traditional method. These typically produce age estimates around 20 years or more for 70 cm fish. All available validation and corroboration results were in favour of group B methods. There is still validation needed to be done in order to fully appreciate the full range of variability in the formation of annuli in otoliths from different stocks within different environmental regimes. There is also a need for improved precision, especially for the group B methods. WKARGH advised the relevant assessment working groups to seriously consider how to proceed with age reading of their stocks.

Benchmarking

The stock has not been benchmarked, but one is planned for 2013.

Advice sheet

Relevant estimates and plots been carried over correctly to the advice sheet.

Conclusions and recommendations

The Review Group does not accept the exploratory XSA assessment as giving a valid basis for advice, and recommends that advice can only be given on the basis of the general trends apparent over a range of surveys, acknowledging that (some) individual series may be biased by trends in catchability.

The Review Group makes the following additional recommendations:

- Given the issues around age determination, any future modelling development may be better targeted towards stock synthesis type approaches using mixed length and age data as appropriate, and allowing more flexibility to explore the envelope of uncertainty around growth patterns and age error, building on results of WKARGH and any subsequent studies.
- Further investigations should be carried out on robust methods for combining different series of survey data taking into account spatial patterns and relative catchability in regions of survey overlap. This may require spatial modelling approaches. The goal should be to ensure that shifts in distribution do not cause trends in catchability according to changes in the relative coverage of the stock by different surveys with different catchability characteristics.
- A lengthy process of development is needed for this stock to be ready for the planned benchmark in 2013.

Annex 12: Barents Sea Capelin

As decided by the Arctic Fisheries Working Group at its 2012 meeting (ICES C.M. 2012/ACOM:05), the assessment of Barents Sea capelin was left to the parties responsible for the autumn survey, i.e. IMR in Bergen and PINRO in Murmansk. In accordance with this, the assessment was made during a meeting in Svanhovd, Norway 30 September-2 October 2012. The assessment was an update assessment, without changes in the methodology.

Therefore the information in this annex overrides section 9 of the AFWG 2012 report.

Participants:

Jaime Alvarez	Norway
Bjarte Bogstad (AFWG Chairman)	Norway
Anatoly Chetyrkin	Russia
Harald Gjøsæter	Norway
Pavel Krivosheya	Russia
Tatyana Prokhorova	Russia
Dmitry Prozorkevich	Russia
Bente Røttingen	Norway
Sam Subbey	Norway
Sigurd Tjelmeland	Norway

Regulation of the Barents Sea Capelin Fishery

Since 1979, the Barents Sea capelin fishery has been regulated by a bilateral fishery management agreement between Russia (former USSR) and Norway. A TAC has been set separately for the winter fishery and for the autumn fishery. In recent years (from 1999) no autumn fishery has taken place, except for a small Russian experimental fishery. The fishery was closed from 1 May to 15 August until 1984. After 1984, the fishery was closed from 1 May to 1 September. A minimum landing size of 11 cm has been in force since 1979. From the autumn of 1986 to the winter of 1991, from the autumn 1993 to the winter 1999, and in 2004-2008, no commercial fishery took place. A commercial fishery in the wintering-spring period started again in 2009. AFWG strongly recommends capelin fishery only on mature fish during the period from January to April.

Catch Statistics (Table 9.1, 9.2)

The total catches that were taken during spring 2012 amounted to 228 011 tonnes by Norway and 68 167 tonnes by Russia, giving a total of 296 178 tonnes. This is 23 822 tonnes below the agreed TAC. The trawlers had difficulty catching their part of the quota, and in the Norwegian fishery this caused a transfer of quota to the purse seiners at the end of the fishing season. Thus the Norwegian quota was caught, but as the Russian fishery is conducted only by trawlers, a part of the Russian quota was not taken. The amount of capelin killed by fishing operation (including discards) is uncertain, but by expert assessment it was lower than in 2011, because there were not many high density schools observed during the fishing season.

The age-length composition from Norwegian catches in 2012 is given in Table 9.1a while the composition of the Russian fishery is shown in Table 9.1b. The international historical catch by country and seasons in the years 1972-2012 is given in Table 9.2.

Sampling

The sampling from scientific surveys, exploratory fishing and observers of capelin in 2012 is summarised below:

Investigation	No. of samples	Length measurements	Aged individuals
Ecosystem survey in autumn 2012 (Norway)	296	20053	3310
Ecosystem survey in autumn 2012 (Russia)	244	14170	954
Capelin winter investigations 2012 (Russia)	20	5364	250
Observer on fishing vessels in winter-spring 2012 (Russia)	58	18298	880
Sampling from fishing vessels in winter-spring 2012 (Norway)	29	2697	349
Bottom fish survey winter 2012 (Norway)	177	5714	1058
Bottom fish survey winter 2012 (Russia)	64	5517	200

Stock Size Estimates

Acoustic stock size estimates in 2012 (Table 9.3)

One Russian and three Norwegian vessels jointly carried out the 2012 acoustic survey as part of an ecosystem survey during autumn (Anon., 2012). The geographical coverage of the total stock was considered complete. It was also synoptic as in the previous years and the results of estimation are representative. The geographical distribution of capelin is shown in Figure 9.1.

The results from the survey are given in Table 9.3. The total capelin stock was estimated at 3.6 million tonnes. It is about 3% lower than the stock estimated last year and higher than the long term mean. About 56% (2.0 million tonnes) of the stock biomass consisted of maturing fish (>14.0 cm). The estimated amount of maturing fish is 5% lower than in 2011. The weight at age in the 2012 survey is below that in 2011 for age 2 and older fish, while weight at age 1 was higher in 2012 than in 2011.

Recruitment estimation in 2012 (Table 9.4)

A swept volume index (Dingsør, 2005; Eriksen *et al*., 2009) of abundance of 0-group capelin in August-September is given in Table 9.4. This index is calculated both without correction and with correction for catching efficiency. The 0-group index in 2012 is at a record high level. 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 usually has been no fishing on these age groups, the figures for total mortality constitute natural mortality only, and probably reflect quite well the variation in predation on capelin.

There is negative "survey mortality" from age zero to one for several cohorts and also from age one to two for a couple of cohorts with low abundance. The reason for this is that it is very difficult to assess the younger age groups, particularly in the mixed concentrations.

Other surveys and information from 2012

Russian capelin spring investigation

Russian capelin spring investigations were performed on board Norwegian purse-seiner "M/S Birkeland" in the period from 04 to 28 March 2012. The area of distribution of capelin was only partly covered during the survey, and the main aim was to study purse-seining of capelin, bycatches of cod, and migration of capelin schools. Estimation of the spawning stock biomass was not carried out.

The water temperatures in the surface layer inside the surveyed area were characterized as very warm.

To the south of 71°N and west of 24°E single capelin schools (100-500 tonnes) 25-30 nautical miles apart were observed. Capelin gathered in schools of higher densities (500-1000 tonnes) 5-10 miles apart in some areas. The smallest schools (30-50 tonnes) were recorded in the coastal zone of the northern part of Porsanger Fjord.

The maximum biomass of capelin was observed in the central part of the Norwegian Deep and the northern part of Fugløy bank, where it reached 750 tonnes/sq. nautical mile (Figure 9.2). The largest capelin migrating schools were observed in that area. The biomass of schools was more than 1 000 tonnes, but the schools were few.

The density of capelin in March was relatively low, indicating a significant spreading of spawning approaches in time and space. The capelin in the catches were from 12 to 19.5 cm and fish from 15.5-17.5 cm dominated. The average length was 16.4 cm, 0.5 cm less than in 2011 and close to the average value.

Unusually high temperatures in the southern part of Barents Sea (about +1°C above long-term mean by survey observation) caused the longest capelin migration along the coast of Northern Norway, up to the eastern borders of Andøy bank (16°E). As a rule, prespawning capelin are moving far to the west along the coast in case of unsuitable conditions at spawning grounds in the eastern and central coastal areas. These conditions could be related to the temperature. The type of capelin migration seen in 2012 is relatively rare and during historically period was observed only 6 times, in 1972, 1983-1985, 2000 and 2003.

A distinctive feature of 2012 was also a complete lack of capelin approach into internal coastal waters east of 28°E.

About 70% of the capelin were three-year-olds from the abundant year class 2009. In contrast to 2011, the proportion of fish at age 4 did not exceed 6.4%. (In 2011 it amounted to 80%).

The average age was estimated at 3.8 years. There was not more than 0.4% young capelin (one-year-olds) in catch.

During the survey bycatches of cod occurred in the all capelin catches. All cod was mature and fed actively on capelin.

Norwegian capelin winter-spring investigation

No special capelin investigation was conducted by Norway in winter-spring 2012. Capelin observations were made during the winter groundfish survey, but no attempt was made to quantify the amount of maturing capelin approaching the coast to spawn.

Stock assessment

Estimates of stock in number by age group and total biomass for the historical period are shown in Table 9.5. Other data which describe the stock development are shown in Table 9.6.

A probabilistic projection of the spawning stock to the time of spawning at 1 April 2013 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 2012 Arctic Fisheries Working Group. The methodology is described in the 2009 WKSHORT report (ICES C.M. 2009/ACOM:34). The natural mortality M to use in the months October to December is drawn among the replicates of M-values estimated from historic data. The same years for drawing M as was chosen in 2011 was used also in 2012 (ICES 2011/ACOM:05, Annex 12). Based on the monthly distribution of catches in 2009-2011, the monthly distribution used in the prediction was set to 0% in January, 30% in February and 70% in March. These values were used in the predictions both in 2013 and 2012. The actual catch distribution in 2012 by months was 3% in January, 39 % in February, 50% in March and 8% in April.

Probabilistic prognoses for the maturing stock from October 1 2012 until April 1 2013 were made, with a CV of 0.20 on the abundance estimate. A CV of 0.20 is slightly higher than the value calculated for most years (see Stock Annex). With no catch, the estimated median spawning stock size in 2013 is 641 000 tonnes. With a catch of 200 000 tonnes, the probability for the spawning stock in 2013 to be below 200 000 t, the B_{lim} value used by ACOM in recent years, is 5 % (Fig. 9.4). The median spawning stock size in 2013 will then be 479 000 tonnes. Figure 9.4 shows the probabilistic forecast from 1 October 2012 to 1 April 2013 conditional on a quota of 200 000 tonnes, while Fig 9.5 shows the probability of SSB < B_{lim} as a function of the catch. The advised catch for 2013 is lower than for 2012 (200 000 tonnes vs. 320 000 tonnes).

Two underlying model assumptions were identified as questionable:

- Only immature cod eats mature capelin during the period January-March
- The M for maturing capelin during the period October-December can be modelled from the mean monthly M on immature capelin estimated from the annual surveys

A modified model incorporating predation of capelin (immature and mature) in October-December, predation of capelin by mature cod in January-March and predation of immature capelin by cod in January-March (WD 1) was run. With this model, a catch of 140 000 tonnes gives a 5% probability for the spawning stock in 2013 to be below 200 000 t. This is a lower catch than the established model gives.

With the modified model, the problem with understocking of the capelin has increased, as SSBs in the 1970s vanish and simulated capelin by October 1 (12-month simulations) fall below the measured values on several occasions in the 1990s and 2000s. The latter could partly be due to large relative uncertainties at small stock size, but the problem of reconciling data from different origins (cod stock assessment, stomach evacuation rates, capelin stock measurement) appears important. It should be noted that if the capelin measurement is scaled up the reference point of 200 000 tonnes should be modified.

In 2010, the JNRFC decided that the management strategy should not be changed for the following 5 years. It would thus be suitable with a new benchmark at latest in 2015. Such a benchmark could be held together with the planned benchmark for capelin in the Iceland-East Greenland-Jan Mayen area.

The 0-group index for herring in 2012 is average, and the ecosystem survey in 2012 also showed that the abundance of age 1-2 herring in the Barents Sea is very low

(Anon., 2012) which is consistent with the most recent stock assessment for herring (ICES C.M. 2012/ACOM:15). The total abundance of 1 year and older herring in the Barents Sea in 2013 will thus be low and the recruitment conditions for capelin can thus be expected to be average to good in 2013. High abundance of herring has been suggested to be a necessary but not sufficient factor for recruitment failure in the capelin stock (Hjermann *et al*. 2010).

The 2012 year class was found to be at a record high level at the 0-group stage. If we insert the 2012 value (313.4) in the 1-group vs. 0-group regression shown in Fig. 9.6 we get 582.9 billion as the predicted value of 1-group abundance in 2013.

Being a forage fish in an ecosystem where two of its predators cod and haddock are presently at 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 and 1.4) and haddock (ICES AFWG 2010 WD#04) has been on high levels. At the same time, capelin have for the last years been at levels at which the current harvest control rule allowed a capelin fishery to take place (Table 9.5). Consequently, the stock is under "double pressure" and should be monitored carefully to look for signs of overexploitation that could, eventually, lead to recruitment failure and a reduced stock size. The fishing operations should also be monitored carefully to check whether additional mortality caused by slipping, sorting through the meshes etc. could be a potential problem.

Reference points

A B_{lim} (SSB_{lim}) management approach has been suggested for this stock (Gjøsæter *et al*. 2002). In 2002, the Mixed Russian-Norwegian Fishery Commission agreed to adopt a management strategy based on the rule that, with 95% probability, at least 200 000 t of capelin should be allowed to spawn. Consequently, 200 000 t was used as a B_{lim}.

A multispecies model including cod, herring and possible other species is needed for calculation of a target reference point for capelin B_{target}. It is necessary to take into account the strong species interactions. Such studies have been made by Tjelmeland (2005), and still in progress.

Regulation of the fishery for 2012

During its autumn 2011 meeting, the Joint Russian-Norwegian Fishery Commission set the quota for 2012 to 320 000 tonnes, in accordance with the harvest control rule. Of this, 10 000 tonnes (5 000 tonnes to Norway and 5 000 tonnes to Russia) was a research quota.

The Barents Sea capelin Stock Annex

According to recommendation from WKSHORT (August 2009, Bergen, Norway) the data and methodology used for the Barents Sea capelin assessment was described in detail in a new Stock Annex and included in the AFWG report in 2011 (ICES C.M. 2011/ACOM:05). No changes were made to the Stock Annex in 2012.

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Table 9.1a Barents Sea Capelin. Age- and length distribution (million) of Norwegian catches January-April 2012.

Length, cm	Age1	Age 2	Age 3	Age 4	Age 5	Sum %
12.0			4.5	0.0	0.0	0.04
12.5			6.4	0.0	0.0	0.06
13.0			76.1	0.0	0.0	0.66
13.5			242.5	59.7	0.0	2.62
14.0			552.1	75.7	0.0	5.43
14.5		34.3	578.3	584.8	76.7	11.03
15.0			368.8	889.6	85.6	11.63
15.5		17.6	461.6	1402.0	31.1	16.55
16.0			307.8	1526.9	170.7	17.36
16.5			288.9	1128.7	219.5	14.17
17.0			89.8	682.2	172.7	8.18
17.5			79.0	810.8	62.4	8.24
18.0			23.5	246.8	41.3	2.70
18.5			0.0	92.8	35.9	1.11
19.0			0.0	13.4	10.1	0.20
19.5			0.0	1.5	1.5	0.03
20.0			0.0	0.6	0.6	0.01
Sum	0.0	51.9	3079.4	7515.6	908.1	100.00
%	0.00	0.45	26.65	65.04	7.86	

Table 9.1b Barents Sea Capelin. Age- and length distribution (million) of Russian catches January-March 2012.

Length, cm	Age1	Age 2	Age 3	Age 4	Age 5	Sum %
6.0	0.1					0.00
6.5	0.2					0.01
7.0	0.1					0.00
12.5			0.5			0.01
13.0			7.1			0.21
13.5			38.5	8.3		1.42
14.0			72.8	37.4		3.34
14.5			131.7	99.5		7.01
15.0			145.5	203.8	3.7	10.70
15.5			125.5	314.1	8.3	13.57
16.0			98.2	375.0	21.4	14.99
16.5		3.9	112.0	349.4	13.7	14.52
17.0			43.8	339.8	61.0	13.47
17.5			33.9	228.5	59.7	9.76
18.0			20.4	181.3	47.2	7.54
18.5				61.4	23.0	2.56
19.0				19.5	5.1	0.75
19.5				3.3	1.0	0.13
20.0				0.2	0.1	0.01
Sum	0.4	3.9	829.7	2221.4	244.4	100.00
%	0.01	0.12	25.14	67.32	7.41	

Table 9.2 Barents Sea CAPELIN. International catch ('000 t) as used by the Working Group.

Year	Winter				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
1965	217	7	0	**224**	0	0	**0**	**224**
1966	380	9	0	**389**	0	0	**0**	**389**
1967	403	6	0	**409**	0	0	**0**	**409**
1968	460	15	0	**475**	62	0	**62**	**537**
1969	436	1	0	**437**	243	0	**243**	**680**
1970	955	8	0	**963**	346	5	**351**	**1314**
1971	1300	14	0	**1314**	71	7	**78**	**1392**
1972	1208	24	0	**1232**	347	13	**360**	**1591**
1973	1078	34	0	**1112**	213	12	**225**	**1337**
1974	749	63	0	**812**	237	99	**336**	**1148**
1975	559	301	43	**903**	407	131	**538**	**1441**
1976	1252	228	0	**1480**	739	368	**1107**	**2587**
1977	1441	317	2	**1760**	722	504	**1226**	**2986**
1978	784	429	25	**1238**	360	318	**678**	**1916**
1979	539	342	5	**886**	570	326	**896**	**1782**
1980	539	253	9	**801**	459	388	**847**	**1648**
1981	784	429	28	**1241**	454	292	**746**	**1986**
1982	568	260	5	**833**	591	336	**927**	**1760**
1983	751	373	36	**1160**	758	439	**1197**	**2357**
1984	330	257	42	**629**	481	368	**849**	**1477**
1985	340	234	17	**591**	113	164	**277**	**868**
1986	72	51	0	**123**	0	0	**0**	**123**
1987	0	0	0	**0**	0	0	**0**	**0**
1988	0	0	0	**0**	0	0	**0**	**0**
1989	0	0	0	**0**	0	0	**0**	**0**
1990	0	0	0	**0**	0	0	**0**	**0**
1991	528	159	20	**707**	31	195	**226**	**933**
1992	620	247	24	**891**	73	159	**232**	**1123**
1993	402	170	14	**586**	0	0	**0**	**586**
1994	0	0	0	**0**	0	0	**0**	**0**
1995	0	0	0	**0**	0	0	**0**	**0**
1996	0	0	0	**0**	0	0	**0**	**0**
1997	0	0	0	**0**	0	1	**1**	**1**
1998	0	2	0	**2**	0	1	**1**	**3**
1999	50	33	0	**83**	0	22	**22**	**105**
2000	279	94	8	**381**	0	29	**29**	**410**
2001	376	180	8	**564**	0	14	**14**	**578**
2002	398	228	17	**643**	0	16	**16**	**659**
2003	180	93	9	**282**	0	0	**0**	**282**
2004	0	0	0	**0**	0	0	**0**	**0**
2005	1	0	0	**1**	0	0	**0**	**1**
2006	0	0	0	**0**	0	0	**0**	**0**
2007	2	2	0	**4**	0	0	**0**	**4**
2008	5	5	0	**10**	0	2	**0**	**12**
2009	233	73	0	**306**	0	1	**1**	**307**
2010	246	77	0	**323**	0	0	**0**	**323**
2011	273	87	0	**360**	0	0	**0**	**360**
2012	228	68	0	**296**				

Table 9.3. Barents Sea CAPELIN. Stock size estimation table. Estimated stock size from the acoustic survey in August-September 2012.

Length (cm)	Age/Year class				Sum	Biomass	Mean weight
	1	2	3	4			
	2011	2010	2009	2008	(10^9)	(10^3 t)	(g)
6.5 - 7.0	2.540				2.540	3.048	1.2
7.0 - 7.5	5.482				5.482	6.578	1.2
7.5 - 8.0	8.817				8.817	14.107	1.6
8.0 - 8.5	11.736				11.736	23.472	2.0
8.5 - 9.0	13.283	0.054			13.337	33.343	2.5
9.0 - 9.5	17.982	0.000			17.982	53.946	3.0
9.5 - 10.0	15.782	0.096			15.878	52.397	3.3
10.0 - 10.5	21.092	0.951			22.043	83.763	3.8
10.5 - 11.0	18.077	4.841			22.918	103.131	4.5
11.0 - 11.5	14.363	10.298			24.661	128.237	5.2
11.5 - 12.0	7.909	16.599			24.508	149.499	6.1
12.0 - 12.5	6.977	28.824	0.160		35.961	251.727	7.0
12.5 - 13.0	1.283	24.929	0.755		26.967	210.343	7.8
13.0 - 13.5	0.303	24.508	3.017		27.828	244.886	8.8
13.5 - 14.0	0.042	17.968	4.423		22.433	228.817	10.2
14.0 - 14.5	0.071	10.954	6.780		17.805	204.758	11.5
14.5 - 15.0	0.079	6.359	9.968		16.406	221.481	13.5
15.0 - 15.5	0.075	3.457	10.149	0.011	13.692	212.226	15.5
15.5 - 16.0	0.012	2.474	12.695	0.396	15.577	277.271	17.8
16.0 - 16.5	0.002	2.208	13.234	0.224	15.668	310.226	19.8
16.5 - 17.0		0.979	10.101	0.086	11.166	255.701	22.9
17.0 - 17.5		0.759	7.440	0.742	8.941	224.419	25.1
17.5 - 18.0		0.099	4.968	0.458	5.525	156.910	28.4
18.0 - 18.5			3.110	0.119	3.229	102.036	31.6
18.5 - 19.0			0.707	0.234	0.941	31.053	33.0
19.0 - 19.5			0.051		0.051	1.811	35.5
19.5 - 20.0					0.000	0.000	31.8
20.0 - 20.5			0.013		0.013	0.533	41.0
TSN (10^9)	145.907	156.357	87.571	2.270	392.105		
TSB (10^3 t)	536.1	1373.3	1619.6	56.7		3585.7	
Mean length (cm)	9.82	12.95	15.79	17.17	12.45		
Mean weight (g)	3.67	8.78	18.49	24.99			9.1
SSN (10^9)	0.239	27.289	79.216	2.270	109.014		
SSB (10^3 t)	3.3	397.4	1541.0	56.7		1998.4	

Table 9.4 Barents Sea CAPELIN. Recruitment and natural mortality table. Larval abundance estimate in June, 0-group indices and acoustic estimate in August-September, total mortality from age 1+ to age 2+.

Year class	Larval abundance	0-group Index (10^9 ind.)		Acoustic estimate (10^9ind.)		Z survey(1-2)
	(10^{12})	Without Keff	With Keff	1+ (Y+1)	2+ (Y+2)	%
1980	-	197.3	740	402.6	147.6	63
1981	9.7	123.9	477	528.3	200.2	62
1982	9.9	168.1	600	514.9	186.5	64
1983	9.9	100.0	340	154.8	48.3	69
1984	8.2	68.1	275	38.7	4.7	88
1985	8.6	21.3	64	6.0	1.7	72
1986	0.0	11.4	42	37.6	28.7	24
1987	0.3	1.2	4	21.0	17.7	16
1988	0.3	19.6	65	189.2	177.6	6
1989	7.3	251.5	862	700.4	580.2	17
1990	13.0	36.5	116	402.1	196.3	51
1991	3.0	57.4	169	351.3	53.4	85
1992	7.3	1.0	2	2.2	3.4	--
1993	3.3	0.3	1	19.8	8.1	59
1994	0.1	5.4	14	7.1	11.5	--
1995	0.0	0.9	3	81.9	39.1	52
1996	2.4	44.3	137	98.9	72.6	27
1997	6.9	54.8	189	179.0	101.5	43
1998	14.1	33.8	113	156.0	110.6	29
1999	36.5	85.3	288	449.2	218.7	51
2000	19.1	39.8	141	113.6	90.8	20
2001	10.7	33.6	90	59.7	9.6	84
2002	22.4	19.4	67	82.4	24.8	70
2003	11.9	94.9	341	51.2	13.0	75
2004	2.5	16.7	54	26.9	21.7	19
2005	8.8	41.8	148	60.1	54.7	9
2006	17.1	166.4	516	221.7	231.4	--
2007	-	157.9	480	313.0	166.4	46
2008	-	288.8	995	124.0	127.6	--
2009	-	189.8	673	248.2	181.1	27
2010	-	91.7	319	209.6	156.4	25
2011	-	175.8	594	145.9		
2012	-	313.4	989			
Average	9.0	88	300	187	106	

Table 9.5 Barents Sea CAPELIN. Stock size in numbers by age, total stock biomass, biomass of the maturing component at 1. October.

Year	Stock in numbers (10^9)						Stock in weight	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	Maturing
1973	528	375	40	17	0	961	5144	1350
1974	305	547	173	3	0	1029	5733	907
1975	190	348	296	86	0	921	7806	2916
1976	211	233	163	77	12	696	6417	3200
1977	360	175	99	40	7	681	4796	2676
1978	84	392	76	9	1	561	4247	1402
1979	12	333	114	5	0	464	4162	1227
1980	270	196	155	33	0	654	6715	3913
1981	403	195	48	14	0	660	3895	1551
1982	528	148	57	2	0	735	3779	1591
1983	515	200	38	0	0	754	4230	1329
1984	155	187	48	3	0	393	2964	1208
1985	39	48	21	1	0	109	860	285
1986	6	5	3	0	0	14	120	65
1987	38	2	0	0	0	39	101	17
1988	21	29	0	0	0	50	428	200
1989	189	18	3	0	0	209	864	175
1990	700	178	16	0	0	894	5831	2617
1991	402	580	33	1	0	1016	7287	2248
1992	351	196	129	1	0	678	5150	2228
1993	2	53	17	2	2	75	796	330
1994	20	3	4	0	0	28	200	94
1995	7	8	2	0	0	17	193	118
1996	82	12	2	0	0	96	503	248
1997	99	39	2	0	0	140	911	312
1998	179	73	11	1	0	263	2056	931
1999	156	101	27	1	0	285	2776	1718
2000	449	111	34	1	0	595	4273	2099
2001	114	219	31	1	0	364	3630	2019
2002	60	91	50	1	0	201	2210	1290
2003	82	10	11	1	0	104	533	280
2004	51	25	6	1	0	82	628	294
2005	27	13	2	0	0	42	324	174
2006	60	22	6	0	0	88	787	437
2007	222	55	4	0	0	280	1882	844
2008	313	231	25	2	0	571	4427	2468
2009	124	166	61	0	0	352	3756	2323
2010	248	128	61	1	0	438	3500	2051
2011	209	181	55	8	0	454	3707	2115
2012	146	156	88	20	0	392	3586	1997

Table 9.6 Barents Sea CAPELIN. Summary stock and data for prognoses table.

Year	Estimated stock by autumn acoustic survey (10^3 t) 1 October		Spawning stock biomass, assessment model, April 1 (10^3 t)	Spawning stock biomass, by winter acoustic survey (10^3 t)	Recruitment Age 1+, survey assessment 1 October 10^9 sp.	Young herring biomass age 1 and 2 in the Barents Sea. (10^3 t)	Landing (10^3 t)	Rate of the TSB change
	TSB	SSB						
1972	6600	2727					1591	
1973	5144	1350	33		528	2	1337	0.8
1974	5733	907	*		305	48	1148	**1.1**
1975	7806	2916	*		190	74	1441	**1.4**
1976	6417	3200	253		211	39	2587	0.8
1977	4796	2676	22		360	46	2986	0.7
1978	4247	1402	*		84	52	1916	0.9
1979	4162	1227	*		12	39	1782	1.0
1980	6715	3913	*		270	66	1648	**1.6**
1981	3895	1551	316		403	47	1986	0.6
1982	3779	1591	106		528	9	1760	1.0
1983	4230	1329	100		515	12	2357	**1.1**
1984	2964	1208	109		155	1313	1477	0.7
1985	860	285	*		39	1220	868	0.3
1986	120	65	*		6	155	123	0.1
1987	101	17	34	4	38	145	0	0.8
1988	428	200	*	10	21	68	0	**4.2**
1989	864	175	84	378	189	128	0	**2.0**
1990	5831	2617	92	94	700	352	0	**6.7**
1991	7287	2248	643	1769	402	640	933	**1.2**
1992	5150	2228	302	1735	351	1507	1123	0.7
1993	796	330	293	1498	2	2395	586	0.2
1994	200	94	139	187	20	1650	0	0.3
1995	193	118	60	29	7	525	0	1.0
1996	503	248	60		82	202	0	**2.6**
1997	909	312	85		99	279	1	**1.8**
1998	2056	932	94	414	179	321	3	**2.3**
1999	2775	1718	382		156	1063	105	**1.3**
2000	4273	2098	599	700	449	1518	410	**1.5**
2001	3630	2019	626		114	837	578	0.8
2002	2210	1291	496	1417	60	364	659	0.6
2003	533	280	427		82	1595	282	0.2
2004	628	294	94	105	51	1912	0	**1.2**
2005	324	174	122		27	1609	1	0.5
2006	787	437	72		60	1177	0	**2.4**
2007	2119	844	189		277	433	4	**2.7**
2008	4428	2468	330	469	313	305	12	**2.1**
2009	3765	2323	517	180	124	143	307	0.9
2010	3500	2051	504	452	248	217	315	0.9
2011	3707	2115	487	160	209	158	360	**1.1**
2012	3586	1997	504		146	60	296	1.0

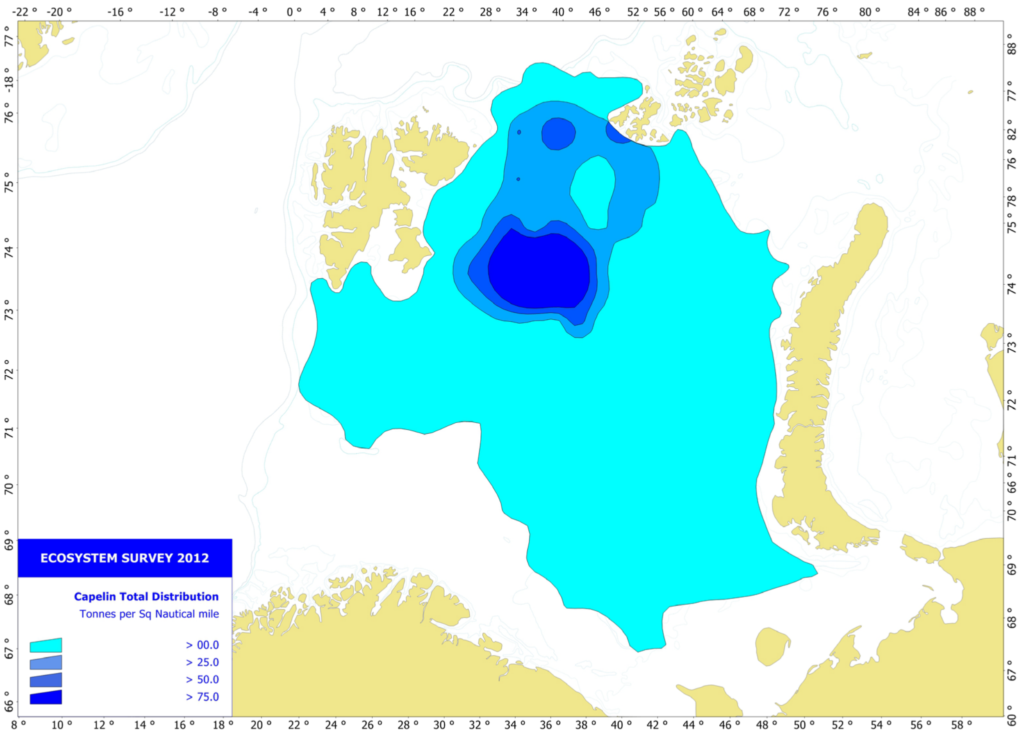

Figure 9.1. Geographical distribution of capelin in autumn 2012 (t/nm²).

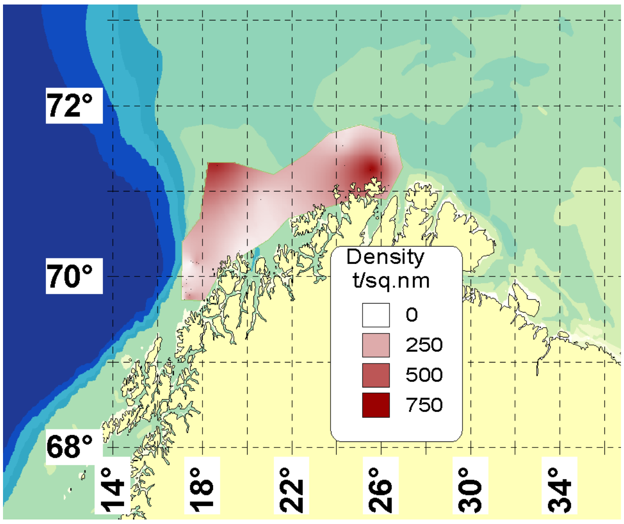

Figure 9.2 Survey area and density of capelin distribution in March 2012. "M/S Birkeland".

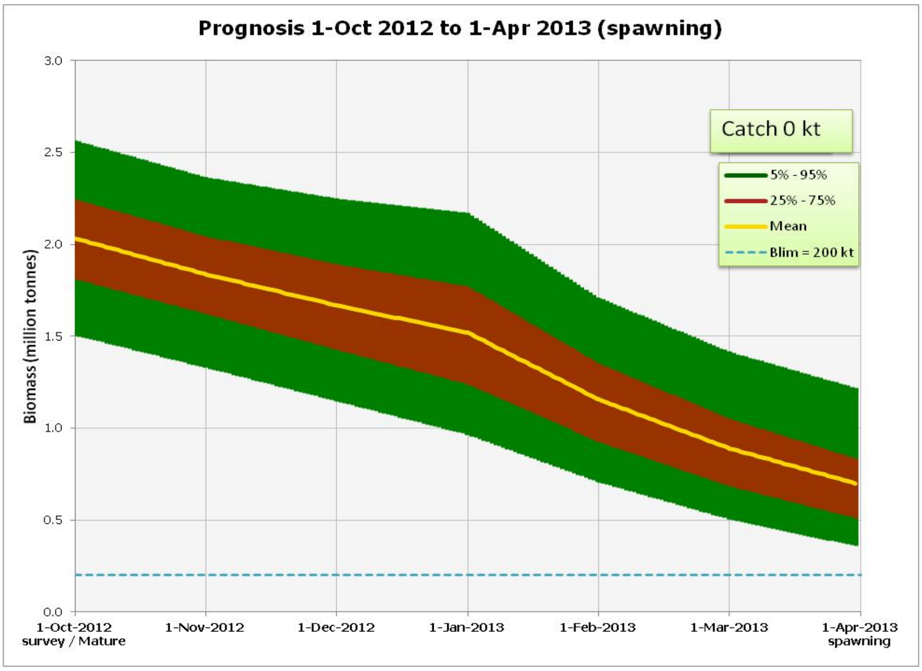

Figure 9.3. Probabilistic prognosis 1 October 2012-1 April 2013 for Barents Sea capelin (maturing stock, no catch).

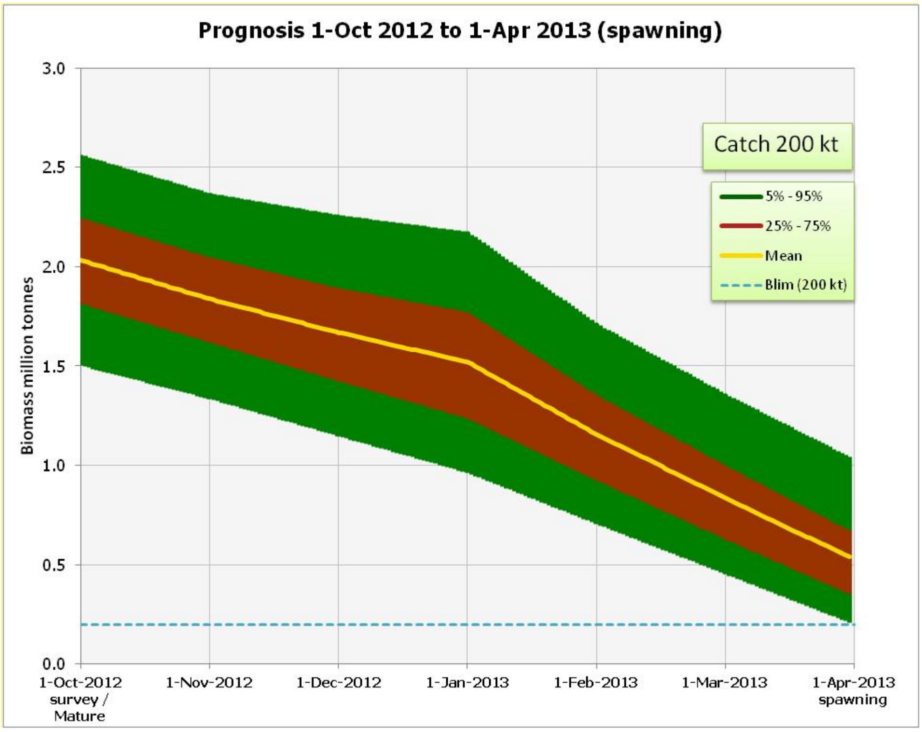

Figure 9.4. Probabilistic prognosis 1 October 2012-1 April 2013 for Barents Sea capelin (maturing stock, catch of 200 000 tonnes).

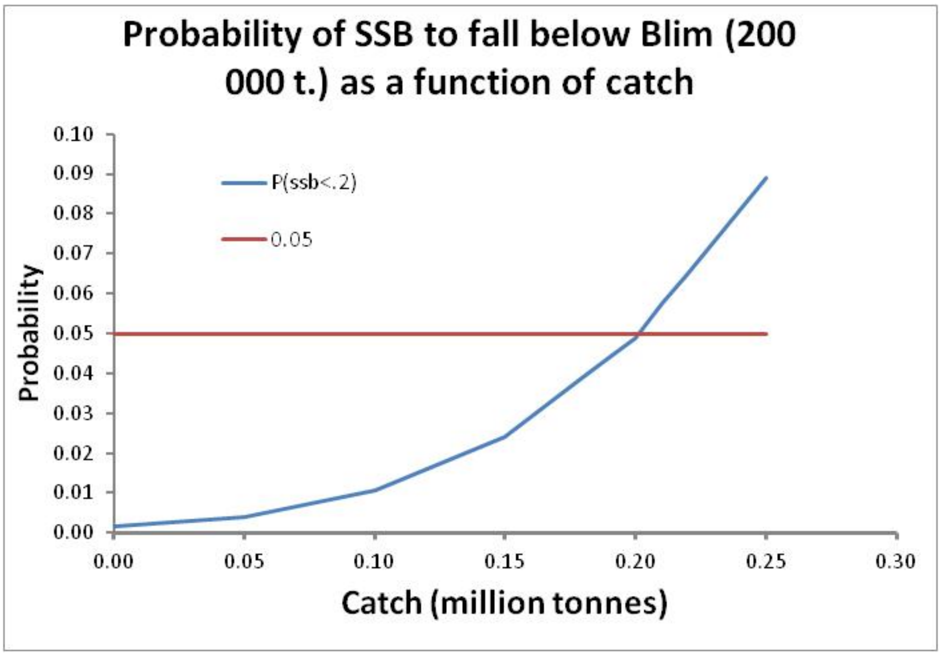

Figure 9.5. Probability of spawning biomass of capelin (1 April 2013) being below B_{lim} (200 000 tonnes), as a function of catch.

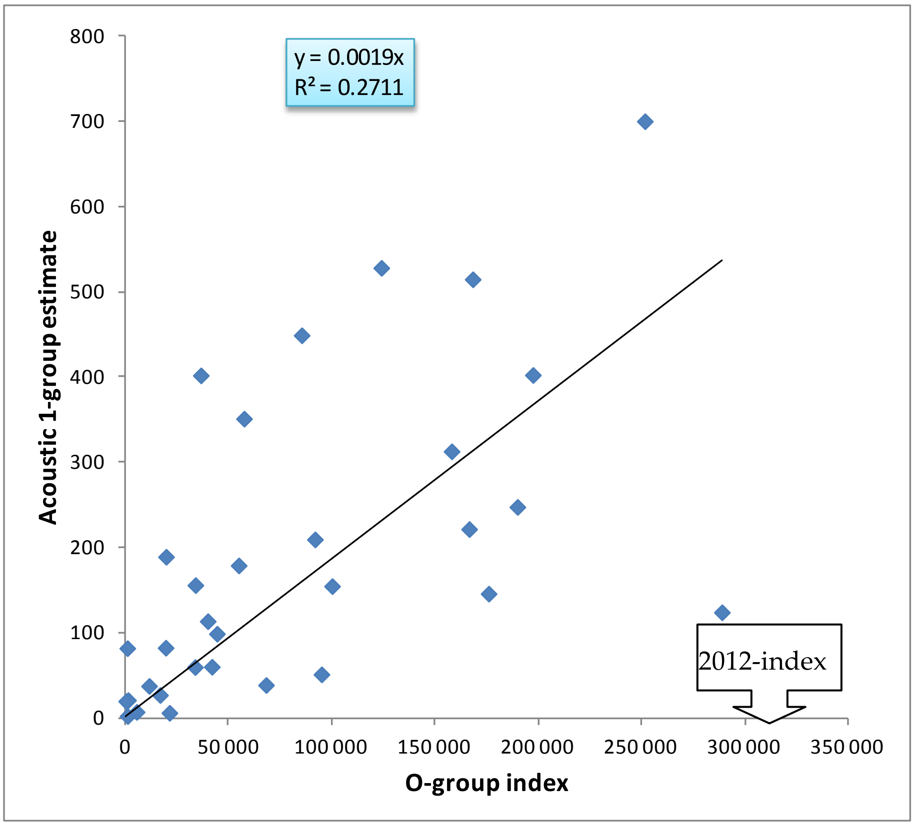

Figure 9.6. Regression of abundance of capelin at age 0 (0-group index without K_{eff}) and age 1 (acoustic estimate) of year classes 1981-2011.