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International Council for the Exploration of the Sea

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H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Contents

Executive Summary

Faroe Bank cod

The total reported landings in 2012 2013 were the lowest recorded since 1965 107 (36 tonnes) a three-fold decrease with respect to 2011.

The spring index suggests that since 2013 the stock is increasing but it is however well below levels of those in the 1996-2002 period. The 2013 spring index suggests a slight increase in stock biomass. However this value needs to be taken with caution as only half the total number of stations were surveyed in 2013 due to logistic problems. Nevertheless both the summer and spring index suggest the stock is well below aver-age while there is no indication of strong incoming year classes.

The results of an exploratory production model based on both surveys indicate a good agreement in the stock biomass index in recent years whereas the observed sur-vey-based exploitation rates correlates reasonably well with estimated fishing mortalities. However the model failed to pick up the large increases in stock biomass observed in the 1996-2003 period. Correlation between modelled F's and summer survey based exploitation rates is R2=0.92. The exploitation ratio sharply increased in 2011 as a consequence of the increase in landings and it decreased after-wardsthe following year reflecting the fall of catches observed since 2012in 2012.

Faroe Plateau cod

The input data consisted of the catch-at-age matrix (ages 2-10+ years) for the period 1961-2013 and two age-disaggregated abundance indices obtained from the two Faroese groundfish surveys: the spring survey 1994-2014 (shifted back to the previous year) and the summer survey 1996-2013. The maturities were obtained from the spring survey 1983-2014.

The assessment settings were the same as in the 2013 assessment. An XSA was run and tuned with the two survey indices. The fishing mortality in 2012 (average of ages 3-7 years) was estimated at 0.26, which was lower than the preliminary Fmsy of 0.32. The total stock size (age 2+) in the beginning of 2013 was estimated at 24 600 tonnes and the spawning stock biomass at 22 600 tonnes, which was slightly above the limit biomass of 21 000 tonnes.

The short term prediction until year 2016 showed a slightly increasing total stock biomass to 27 700 and a spawning stock biomass to 24 500 tonnes.

The recruitment seems to be positively correlated with the total stock size of cod. It is, therefore, advised to reduce the fishing mortality so that the stock increases.

Faroe haddock

Being an update assessment, the changes compared to last year are additions of new data from 2013 and 2014 and some minor revisions of recent landings data with corresponding revisions of the catch at age data. The main assessment tool is XSA tuned with 2 research vessel bottom trawl surveys. The results are in line with those from 2013, showing a very low SSB mainly due to poor recruitment but also due to higher than recommended fishing mortalities in recent years. SSB is now estimated well below B_{lim} and is predicted to stay below B_{lim} in 2014-2016 with status quo fishing mortality. Fishing mortality in 2013 is estimated at 0.28 and the average fishing mortality 2011-2013 at 0.27 (F_{MSY} and F_{pa} = 0.25). Landings in 2013 were only 3 100 t, slightly higher than in 2012, which was the lowest in the assessment series back to 1957. This years assessment indicates that the 2013 assessment underestimated the 2012 recruitment by more than 300% (.5 mio. versus 1.9 mio., which still is the lowest on record), overestimated the fishing mortality in 2012 by 9% (0.25 versus 0.23) and underestimated the 2012 total- and spawning stock biomasses by 17% and 15%, respectively (17 and 15 thous. t versus 20 and 17 thous. t).

Faroe saithe

- The most recent benchmark assessment was completed in 2010.
- Nominal landings decreased by more than 25% from 35 kt. in 2012 to 26 kt. in 2013. The corresponding estimate of fishing mortality in 2013 (average of ages 4-8 years) decreased to F=0.45 which is higher than the historical average (F=0.36) and well above Fmsy=0.32(NWWG 2012) and Fmsy=0.28(NWWG2011). The point estimate of the spawning stock biomass in 2013 is around 61 kt., just above Btrigger=55kt. Numbers of the most recent year-class (2010, age 3 in 2013) is estimated at 35 million. Since 2006 recruitment of saithe has remained at low levels compared to the exceptional peaks from 2001 to 2005.
- Predicted landings in the last year assessment were at around 47kt while the actual measurement for 2013 was recorded at 26 kt.. However the estimate of Fbar was reasonably accurate from Fbar=0.48 in last year assessment and Fbar=0.45 in the 2014 assessment. Recruitment strength for 2013 was predicted at 28 million while the estimate for that year in the present assessment reached 35 million. SSB was overestimated by 18%.
- Since 2005 both landings and the spawning stock biomass have declined substantially from historical peaks to levels not observed in nearly 20 years due to increasing harvest rates and relatively poor incoming year-classes.
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Icelandic saithe

- The 2014 reference biomass (B_{4+}) is estimated as 296 kt, above the average in the assessment period (1980 to the present). The spawning biomass is estimated as 150 kt, around the highest level in the assessment period and well above $B_{trigger}$ = 65 kt and B_{lim} = 61 kt.
- According to the assessment model, the reference biomass increased by almost a third between 2009 and 2014, while harvest rate decreased from 27% to 19% (fishing mortality 0.30 to 0.23). Year classes 1999-2000 and 2002 were large, but recruitment since then has been around average.
- Weights of ages 6-9 have increased in recent years towards the average, but other ages are below average weight. Maturity at ages 4-9 has decreased in recent years and is currently around average.
- The assessment model is a separable statistical catch-at-age model implemented in AD Model Builder. Selectivity is age-specific and varies between three periods: 1980-1996, 1997-2003, and 2004 onwards.
- There is some discrepancy between the default separable model and alternative assessment models (ADAPT, TSA, SAM), but the difference is smaller than in recent assessments.

- In spring 2013, the Icelandic government adopted a harvest control rule for managing the Icelandic saithe fishery, evaluated by ICES (Hjorleifsson and Bjornsson 2013). It is similar to the 20% rule used for the Icelandic cod fishery. When the population is above $B_{trigger}$, the TAC set in year t equals the average of 0.2 B_{4+} in year t and last year's TAC.
- According to the adopted harvest control rule, the TAC will be 58 kt in the next fishing year.

Icelandic cod

The spawning stock of Icelandic cod is increasing Fishing mortality has declined significantly in the last decade and is presently at a historical low and below likely candidates for Fpa and Flim.

The spawning stock (SSB2014) is estimated to be about 427 kt and is higher than has been observed over the last five decades. Fishing mortality has declined significantly in recent years and is presently the lowest observed in last 6 decades. Year classes since the mid-1980s are estimated to be relatively stable but with the mean around the lower values observed in the period 1955 to 1985.

The reference biomass (B4+;2014) is estimated to be 1106 kt, the highest observed since the late 1970's. According to the adopted management harvest rule the TAC will be 218 kt in the next fishing season resulting in a reference fishing mortality of 0.XXX. ICES has evaluated the plan and concludes that it is in accordance with the precautionary approach and the ICES MSY framework.

Mean weight at age in the stock and the catches that were record low in 2006-8 have been increasing in recent years and are now around the long term mean.

The input in the analytical assessments are catch at age 1955-2013 and spring groundfish survey (SMB) indices at age from 1985-2014 and fall survey groundfish survey (SMH) indices at age from 1996-2013. The results from the AD-Model builder statistical Catch at Age Model (ADCAM) as was used as the final run, as done in the previous year. No changes were made in the model set-up compared with that applied last year.

The reference stock (B4+) in 2013 is now estimated to be 1161 kt compared to 1173 kt last year. The SSB in 2013 is now estimated to be 437 kt compared to 479 kt estimated last year. Fishing mortality in 2012 is now estimated 0.28 compared to 0.28 estimated last year. Year classes 2010-2012 were estimated to be 119, 183 and 151 million in last years assessment and are now estimated to be 123, 181 and 160 millions.

Icelandic haddock

2013 yearclass estimated to be small, the 6^{th} consecutive small yearclass.

Current assessment shows some upward revision of stock compared to last years assessment, caused by increased numbers in stock. The main features are though the same that recruitment is poor and the stock will decrease in coming years.

Growth in 2013 was around average since 1985 but slower than in 2012 and slower than anticipated.

Mean weight of small, younger cohorts above average and older around average.

Year class 2013 is estimated small so year classes 2008-2013 are now all estimated as small.

Same assessment procedure as last year (SPALY). Adapt type model tuned with both the surveys.

Difference in perception of the state of stock in assessment based on either the spring or autumn survey with autumn survey indicating larger stock. Has been like that since 2009. Different models using the same tuning data show similar results.

Advice given according to the adopted Harvest Control Rule. Advice for the fishing year 2014/2015 (September 1st 2014 – August 31st 2015 is 30 400 tonnes.

Icelandic summer spawning herring

Input data

The total reported landings in 2013/14 fishing season were 72 kt but the TAC was set at 87 kt.

Around 45 kt of the catch was taken in a relatively small area in Breiðafjörður in W Iceland, or 62% of the catch which is less proportion than in the six five preceding fishing seasons.

The fishable stock (age 4+) in the herring acoustic surveys in the winter 2013/14 was estimated at 410 kt, compare to 428 kt in the winter 2012/13. The mass mortality in last winter, where 52 kt died, took place in between the surveys.

Acoustic measurements indicated that the year classes from 2008 and 2009 where numerous off the south coast –but less observed in Breiðafjörður, where older herring was found.

Ichthyophonus infection was observed in the fishable stock (age 4+) the sixth winter in row and amounted to prevalence of 30-35% in the three most infected year classes, which is a comparable level to recent years. It is not considerer to cause significant additional mortality in the stock.

The juvenile herring survey indicates that the 2012 year class (age 1 in 2012) may be just below average size.

Assessment

This is an update assessment where the 2013 data have been added to the input data and no revisions of last year's data, except that the estimated number of fish that diet in the mass mortality in last winter was added to the catch matrix from 2012.

The final analytical assessment model, NFT-Adapt, indicate that the biomass of age 3+ is 560 kt and SSB is 430 kt at the spawning time in 2014.

Predictions

Fishing at $\mathbf{F}_{0.1}$= 0.22 in the fishing season 2014/15 will give a catch of 83 thousands tons. SSB in 2015 is expected to be 420 kt.

Comments

This years researches on the *Ichthyophonus* infection supports the conclusions made last year that it is not causing additional mortality in the stock and increased natural mortality should only be applied for the first two years of the outburst.

General description of the stock's definition, the stock's life-history and the management unit is given in the Stock Annex (Her-Vasu), which was accepted during WKBENCH in Portugal in January 2011 (ICESF 2011a) and updated in May 2014.

Capelin in the Iceland-Greenland-Jan Mayen area

- In March 2013 ICES advised on the basis of precautionary considerations that there should be no fishery until new information on stock size becomes available and it shows a predicted SSB of at least 400 thous. t in March 2014 in addition to a sizeable amount for fishing.
- In October 2013 the Marine Research Institute recommended a TAC of 160 thous. t for the fishing season 2013/2014, based on acoustic survey in September-October 2013.
- The fishery started in January 2014.
- Three acoustic surveys were conducted in January-March 2014. None of them was considered complete regarding coverage of the stock.
- Final TAC for the fishing season 2013/2014 was 160 thous. t. It was set on the basis of the survey in autumn 2013.
- The total landings in the fishing season 2013/2014 amounted 142 thous. t.
- Index for 1 year old capelin from the autumn survey in 2013 is of an average size.
- A predicted TAC for the fishing seasoson 2014/15 is 450 thous. t.
- As the capelin increases its weight rapidly over the summer it is recommended that the fishery doesn't start until late autumn.

Cod-offgr (Greenland offshore cod)

Offshore fishery was conducted as an experimental fishery with TAC of 6,500 tons.

Total landings from the offshore fishery amounted to 5,988 tons. Year classes dominating the catches were 2003-2007 in East Greenland whereas the 2007 YC dominated the catch in West Greenland.

Very large cod (mean length of 85 cm) where caught by trawlers on Dohrn Bank close to the EEZ to Iceland.

Available survey biomass indices show that in the offshore are in West Greenland the biomass has increased due to an appearance of a 2009 YC in considerable numbers. This YC is further south distributed in 2012 and 2013 than in 2011.

Spawning offshore cod are only found in East Greenland in local high densities.

No formal assessment was conducted and there are no biological reference points for the species. Information from survey indices (German Groundfish survey and Greenland Shrimp and Fish survey) are used as basis for advice.

Recent genetic results suggest that the offshore stocks components in East and West Greenland should be considered as separate spawning units.

Cod-ingr (Greenland inshore cod)

- Total landings from the inshore fishery amounted to 13 236 t which is a slight increase compared to 2012. Several year-classes were caught in the inshore fishery and catches were dominated by the 2009 YC.

- Mean length in the fisheries have increases from 44 cm in 2006 to 53 cm in 2013.
- Survey recruitment indices from the inshore area show a relatively strong 2010 and 2011 YC.
- Issues for the upcoming benchmark should include the suggested development of an analytical assessment for this stock.

Greenland halibut

Input data to the assessment: current surveys have continued and sampling intensity and coverage remains also unchanged. Logbooks from the fishery are available as haul by haul data. Since 2001 no age readings of otoliths were available from the main fishing areas which impede age based assessment.

Since 2007 a logistic production model in a Bayesian framework has been used to assess stock status and for making predictions. The model includes an extended catch series going back to the assumed virgin status of the stock at the beginning of the fishery in 1961. Estimated stock biomass showed an overall decline from the mid 1980s to the late 1990s. Since 2004 the stock has increased and is now at 71%Bmsy and fishing mortality exceeds F_{msy} by a factor of 1.1.

This analytical approach was rejected by NWWG and advice is based on data limited approach. The data limited approach is based on catch and survey data in the period 1996-2013. According to this approach biomass has slightly increased and Fproxy slightly decreased in recent years.

Golden redfish (*Sebastes norvegicus*) in Subareas V, VI and XIV

- Total landings in 2013 were about 53,500 t, which is about 8 200 t more than in 2012. About 96% of the catches were taken in Division Va. A substantial increase in landings from XIVb was in 2010-2013 and has not been so high since early 1990s.
- Catch-at-age data from Va show that the catch is dominated by two strong year classes from 1985 and 1990. The 1985 and 1990 year classes are disappearing, but the importance of the 1996-2003 year classes is increasing.
- Survey indices of the fishable stock in Va was more than two times higher than the defined safe biological limits (Upa). The fishable stock situation in Vb remains at low level, but has improved in XIV.
- Recruitment seems to be low in all areas, both according to the Icelandic groundfish surveys, German survey in East Greenland and the Greenland shrimp and fish survey.
- The stock was benchmarked in January 2014 and a management plan evaluated and adopted. The Gadget model was used as basis for advice but the main difference in settings from earlier years was inclusion of the German survey data from East Greenland and changes in growth rate were taken into account.
- The management plan was based on F_{9-19}=0.097 (Fmax in 2012 run) reducing linearly if the spawning stock is estimated below 220 000 t ($B_{trigger}$). B_{lim} was proposed as 160 000 t, lowest SSB in the 2012 run. According to the management plan TAC for 2015 will be 47 300 t.

Icelandic slope *Sebastes mentella* in Va and XIV

- ICES concluded in February 2009 that *S. mentella* is to be divided to three biological stocks and that the *S. mentella* on the continental shelf and slope of Iceland should be treated as separate biological stock and management unit. This chapter therefore deals only with the Icelandic Slope stock.
- Total landings of demersal *S. mentella* in Icelandic waters in 2013 were about 8 761 t, 3 200 less than in 2012.
- No analytical assessment was conducted and there are no biological reference points for the species. Survey indices from the annual autumn survey since 2000 are used as basis for advice.
- Available survey biomass indices show that in Division Va the biomass has gradually decreased from 2006 and is at similar level as in 2003 when it was lowest in the time series.
- The East-Greenland shelf is most likely a nursery area for the stock. No new recruits (>18 cm) are seen in the survey catches of the German survey and the Greenland shrimp and fish shallow water survey conducted in the area and no juveniles are present (<18 cm) recent years.

Shallow Pelagic Sebastes mentella

- ICES concluded in February 2009 that *S. mentella* is to be divided to three biological stocks and that the deep pelagic *S. mentella* in the Irminger Sea and adjacent should be treated as separate biological stock and management unit. This chapter therefore deals only with the shallow pelagic stock.
- Total landings of shallow pelagic *S. mentella* in 2013 were 1527 t, a significant decrease compared to 3173 t in 2012, which was the lowest catch since the fishery started in 1982. The catches were almost entirely taken in NAFO 1F.
- No analytical assessment was conducted and there are no biological reference points for the species. Survey indices from the biennial international acoustic redfish survey conducted in the Irminger Sea and adjacent waters since 1991 are used as basis for advice.
- The last survey was conducted in June/July 2013. Since 1994, the results of the acoustic survey show a drastic decreasing trend within the DSL layer from 2.2 million t to 91,000 t in 2013. With the trawl method within the DSL (350-500 m) the biomass was estimated 200,000 t, significantly below the 361,000 t of 2011. The next international acoustic redfish survey will be conducted in June/July 2015.
- No signs of recruitment have been observed in the latest German survey on the East-Greenland shelf.

Deep Pelagic Sebastes mentella

ICES concluded in February 2009 that *S. mentella* is to be divided to three biological stocks and that the deep pelagic *S. mentella* in the Irminger Sea and adjacent should be treated as separate biological stock and management unit. This chapter therefore deals only with the deep pelagic stock.

Total landings of deep pelagic *S. mentella* s in 2013 were 45,594 t, 12,788 t more than in 2012.

No analytical assessment was conducted and there are no biological reference points for the species. Survey indices from the biennial international trawl-acoustic redfish survey conducted in the Irminger Sea and adjacent waters since 1999 are used as basis for advice.

The survey was conducted in June/July 2013. A total biomass of 280,900 t was estimated, a 41% less than in 2011 (474,000 t). Trawl survey estimates in 2011 and 2013 are lower than the average for 1999–2009 and the estimate for 2013 is the lowest observed. The next international trawl-acoustic redfish survey in the Irminger Sea will be conducted in June/July 2015.

No recruitment has been observed on the East-Greenland shelf during the last year, which is a concern because it is assumed to contribute to the three stocks at unknown shares.

Greenlandic slope *Sebastes mentella* in XIVb

ICES concluded in February 2009 that demersal *S. mentella* is to be divided into three biological stocks and that the *S. mentella* on the continental shelf and slope should be treated as a separate biological stock and management unit. This separation of the stocks did not include the adult *S. mentella* on the Greenlandic slopes. ICES therefore decided that NWWG will conduct a separate assessment of *S. mentella* in subarea XIVb until further information is available to assign stock origin. This chapter therefore deals only with the *S. mentella* on the Greenlandic Slope.

Total landings of demersal *S. mentella* in East Greenland waters in 2013 were about 6600 tons, which is similar to 2010-2012 landings.

In the decade before 2009 *S. mentella* was mainly a valuable by-catch in the fishery for Greenland halibut. However, since 2009 a fishery directed towards demersal redfish has taken place.

No formal assessment was conducted and there are no biological reference points for the species. Information from logbooks and survey indices are used as basis for advice.

Available survey biomass indices show that in Division XIVb the biomass remains at a low level in 2013. This is mainly seen in the fishable part of the stock and mainly in the area of the fishery.

No new recruits (>18 cm) are seen in the survey catches, and no juveniles are present (<18 cm). This suggests that the fishery in coming years will be based on the same cohorts.

Data suggests a local overexploitation by the fishery that has caused a severe local stock decline.

1 Introduction

1.1 Terms of Reference (ToR)

1.1.1 Specific ToR

2013/2/ACOM07 The **North-Western Working Group** (NWWG), chaired by Petur Steingrund, Faroes, will meet at ICES Headquarters, 24 April – 1 May, 2014 to:

a) Address generic ToRs for Regional and Species Working Groups.

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.

For capelin in Iceland-East Greenland-Jan Mayen area, Iceland will provide a WG type report and a draft advice sheet on 18 April. NWWG will agree any changes to the WG type report and the Advice sheet no later than 27 April. An ADG will work by correspondence 29 April. The WEBEX will be 5 May, and the Advice Release date 7 May.

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

NWWG will report by 9 May 2014 for the attention of ACOM. For capelin in Iceland-East Greenland-Jan Mayen area NWWG will report by 1 February 2014 for the attention of ACOM.

Fish Stock	Stock Name	Stock Coord.	Assess. Coord. 1	Assess. Coord. 2	Advice
cod-farp	Cod in Subdivision Vb2 (Faroe Bank)	Faroe Islands	Faroe Islands	Faroe Islands	Update
cod-farb	Cod in Subdivision Vb2 (Faroe Bank)	Faroe Islands	Faroe Islands	Faroe Islands	Multiyear
had-faro	Haddock in Division Vb	Faroe Islands	Faroe Islands	Faroe Islands	Update
sai-faro	Saithe in Division Vb	Faroe Islands	Faroe Islands	Faroe Islands	Update
cod-iceg	Cod in Division Va (Icelandic cod)	Iceland	Iceland	Iceland	Update
had-iceg	Haddock in Division Va (Icelandic haddock)	Iceland	Iceland	Iceland	Update
sai-icel	Saithe in Division Va (Icelandic saithe)	Iceland	Iceland	Iceland	Update
her-vasu	Herring in Division Va (Icelandic summer-spawners)	Iceland	Iceland	Iceland	Update
cap-icel	Capelin in Subareas V, XIV and Division IIa west of 5°W (Iceland-East Greenland-Jan Mayen area	Iceland	Iceland	Iceland	Update

Fish Stock	Stock Name	Stock Coord.	Assess. Coord. 1	Assess. Coord. 2	Advice
cod-ingr	Inshore cod in NAFO Subarea 1 (Greenland cod)	Greenland	Greenland	Germany	Update
cod-offgr	Offshore cod in ICES Subarea XIV and NAFO Subarea 1 (Greenland cod)	Greenland	Greenland	Germany	Update
ghl-grn	Greenland halibut in Subareas V, VI, XII and XIV	Greenland	Greenland	Iceland	Update
smr-5614	Redfish (Sebastes marinus) in Subareas V, VI, XII and XIV	Iceland	Iceland	Faroe Islands	Update
smn-con	Beaked redfish (Sebastes mentella) in Division Va and Subarea XIV (Icelandic slope stock).	Iceland	Iceland	Germany	Multiyear
smn-sp	Beaked Redfish (Sebastes mentella) in Subareas V, XII, XIV and NAFO Subareas 1+2 (Shallow Pelagic stock < 500 m deep)	Iceland	Germany	Spain	Update
smn-dp	Beaked Redfish (Sebastes mentella) in Subareas V, XII, XIV and NAFO Subareas 1+2 (Deep Pelagic stock > 500 m deep)	Iceland	Germany	Spain	Update
smn-grl	Beaked Redfish (Sebastes mentella) in Subarea XIV (East Greenland Slope)	Greenland	Greenland	Germany	Update

1.1.2 Generic ToRs for Regional and Species Working Groups

The working group should focus on:

For the ecoregion:

a) Consider ecosystem overviews where available, and propose and possibly implement incorporation of ecosystem drivers in the basis for advice

b) For the ecoregion or fisheries considered by the working group, produce a brief report summarising for the stocks and fisheries where the item is relevant:

  i) Mixed fisheries overview and considerations;

  ii) Species interaction effects and ecosystem drivers;

  iii) Ecosystem effects of fisheries;

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

For all stocks:

c) If no stock annex is available this should be prepared prior to the meeting, based on the previous year's assessment and forecast method used for the advice, including analytical and data-limited methods

d) Audit the assessments and forecasts carried out for each stock under consideration by the Working Group and write a short report.

e) Propose specific actions to be taken to improve the quality and transmission of the data (including improvements in data collection).

f) Propose indicators of stock size (or of changes in stock size) that could be used to decide when an update assessment is required and suggest threshold % (or absolute) changes that the EG thinks should trigger an update assessment on a stock by stock basis.

g) Prepare planning for benchmarks next year, and put forward proposals for benchmarks of integrated ecosystem, multi or single species for 2016

h) Check the existing static parts of the popular advice and update as required.

i) In the autumn, where appropriate, check for the need to reopen the advice based on the summer survey information and the guidelines in AGCREFA (2008 report). The relevant groups will report on the AGCREFA 2008 procedure on reopening of the advice before 13 October and will report on reopened advice before 29 October.

j) Take into account new guidance on giving catch advice (ACOM, December 2013).

k) Update, quality check and report relevant data for the stock:

1. Load fisheries data on effort and catches (landings, discards, bycatch, including estimates of misreporting when appropriate) in the INTERCATCH database by fisheries/fleets, either directly or, when relevant, through the regional database. 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;
2. Abundance survey results;
3. Environmental drivers.

l) Produce an overview of the sampling activities on a national basis based on the INTERCATCH database or, where relevant, the regional database.

For <u>update</u> advice stocks:

m) 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). If no change in the advice is needed, one page 'same advice as last year' should be drafted.

n) For each stock , when possible prior to the meeting:

i) Update the assessment using the method (analytical, forecast or trends indicators) as described in the stock annex.

ii) Produce a brief report of the work carried out regarding the stock, summarising for the stocks and fisheries where the item is relevant:

1. Input data (including information from the fishing industry and NGO that is pertinent to the assessments and projections);
2. Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
3. Stock status and catch options for next year;
4. Historical performance of the assessment and brief description of quality issues with the assessment;
5. 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.

o) Review the outcomes of WKMSRREF2 for the specific stocks of the EG. Calculate reference points for stocks where the information exists but the calculations have not been done yet and resolve inconsistencies between MSY and precautionary reference points and if possible

For stocks with multiyear advice or biennial (2nd year) advice

p) In principle, there is no reason to update this advice. The advice should be drafted as a one page version referring to earlier advice. If a change in the advice (basis) is considered to be needed, this should be agreed by the working group on the first meeting day and communicated to the ACOM leadership. Agreement by the ACOM leadership will revert the stock to an update procedure.

1.2 NWWG 2012 work in relation to the ToR

The ToRs were not addressed systematically for all the stocks. The following points highlight the WG response to these ToR. The main focus was on the adoption of assessments that were the basis for stock status and the premise for the forecasts. This was done to ensure that the basis for the advice was agreed upon. This year, individual report stock sections were not reviewed in plenary due to time constraints, but relevant issues were discussed in plenary. Also some sections, such as the area overviews, were not sufficiently reviewed at the meeting due to time constraints. The summary sheets were reviewed in plenary during the last four days. All stocks were audited by one other person in the group, where it was assured that the stock annex was followed, and some of the reviewers put these audits into the report. An independent group of students made audits last year.

Regarding the ToRs for the ecoregion:

a) Overviews were available for the Faroe, Iceland and Greenland ecoregions. In the Icelandic ecosystem the increased temperature/salinity since mid 1990s is regarded as a major factor, which has shifted the distribution of many fish species northwards. The biomass of capelin (an important forage fish) is the only ecosystem driver, which has been used directly in the assessment (predicting individual weight of cod). This relationship became less clear in recent years and the weights of cod were therefore estimated in other ways. No new ecosystem driver was proposed this year. It was, however, remarked that the effects of important ecosystem drivers was expected to be expressed in the input data of the stock assessments and therefore taken into account in an indirect way. In the Greenland ecoregion the effect of temperature and wind is outlined since these measures are good indicators of the recruitment of cod. These measures are, however, not used directly in the assessments or the advice. In the Faroe ecoregion there has been shown a positive relationship between primary production and the production of demersal fish (cod, haddock and saithe). Primary production is, however, not used directly in the assessments or advice.

b) In the overview sections there is a description of the fisheries, including mixed fisheries. In the Iceland ecoregion it is pointed out that it may in some cases be possible to fish in a selective way. For the Faroe ecoregion it is pointed out that this is very difficult in the cod/haddock fisheries. For the Greenland ecoregion this is not presented as an issue. The interaction between forage fish and predators (capelin – cod at Iceland, and sandeels – cod, haddock, saithe at the Faroes) is mentioned but not included in the assessments or advice. In the Icelandic ecoregion the ecosystem effect of fisheries is briefly mentioned (corals destroyed by fishing gears). Regulatory changes in the Iceland ecoregion were, among other factors, pinpointed to be of such high importance that the cpue of Greenland halibut was not regarded a reliable biomass index.

e) Although INTERCATCH is not used for any stock, members of the group were encouraged to use it, and a short introduction was made showing how data are loaded into the system.

f) This was not discussed, since many of the stocks are supposed to be assessed every year.

g) Nothing was put on the agenda for benchmarks in 2016.

h) The popular advice was presented at the meeting and supposed to be done for every stock.

k-n) The assessements were done in pretty much the same way as last year, except for Greenland halibut (see later).

o) As a result of WKMSRREF2 the target F for Faroe saithe was changed from 0.28 to 0.30.

1.3 MSY/HCR approaches for individual stocks

See the Introduction in the report from last year.

1.4 Assessment methods applied to NWWG stocks

The methods applied to assess the stock status of the NWWG stocks covers a wide range from descriptive to age based analytical assessments as follows:

Stock	Assessment model	Input*
Faroe Bank cod	Exploratory (production model)	Survey
Faroe Plateau cod	XSA	Survey
Faroe haddock	XSA	Survey
Faroe saithe	XSA	CPUE**
Iceland saithe	ADCAM (statistical catch-at-age)	Survey
Iceland cod	ADCAM (statistical catch-at-age)	Survey
Iceland haddock	Adapt type model	Survey
Iceland herring	NFT-Adapt	Survey
Capelin	Acoustics (absolute biomass)	Survey
Greenland inshore cod	Descriptive	Survey
Greenland offshore cod	Descriptive	Survey
Greenland halibut	Stock production model (Bayesian)***	Survey + CPUE
S. marinus	GADGET (age-length based cohort model)	Survey
S. mentella Iceland slope	Descriptive	Survey
Deep pelagic S. mentella	Descriptive	Survey + CPUE
Shallow pelagic S. mentella	Descriptive	Survey + CPUE
S. mentella Greenland Slope	Descriptive	Survey

*** landings or landings by age are input to all assessments**

**** The CPUE is adjusted by survey information about distribution width.**

*****This model was rejected by NWWG, and a DLS approach was used instead. However, the model run was presented in the report in case the Advice Drafting Group kept the model as a basis for the advice.**

1.5 Benchmarks and workshops

A benchmark of cod and capelin (WKCODCAP) (Barents Sea, Iceland, Greenland) will be held in 2015. Issue lists are found in the respective chapters.

1.5.1 Greenland halibut benchmark in 2013 (WKBUT) and the NWWG assessment in 2014

The benchmark held in November 2013 adopted the stock production model already used since 2007 but noted problems with the CPUE input series (Icelandic trawlers). The NWWG was supposed to take a closer look at the CPUE series. The benchmark also decided that the biomass indices from the East Greenlandic and the Icelandic autumn surveys were combined and used together with the revised CPUE series to tune the production model.

At the NWWG meeting, however, it was decided NOT to use the production model as the assessment tool and basis for the advice. Instead, a data-limited-stock procedure was used as a basis for the advice. The production model and corresponding advice was, nevertheless, presented in case that the Advice Drafting Group, ACOM or benchmark experts should come to a different conclusion and keep the production model.

It is important to note that the NWWG did not reject the production model *per se* as an assessment tool and basis for advice, but rather that the model was considered inappropriate for the North-western Greenland halibut stock. A brief summary of the process, when the stock production model was rejected, is found in the Greenland halibut chapter. A more extensive summary is presented in Working Document 40. The working document is, however, not easy to read because the authors disagreed so much and the fact that counter-arguments sometimes were put right after the arguments. In order to get the complete picture of the process, the reader is referred to the other relevant working documents directly.

In this process, two types of arguments appeared: actual arguments (e.g. the Icelandic trawler CPUE series does not reflect stock development prior to 1995) and formal arguments (e.g. a working group cannot reject the outcome of a recently held benchmark). In the discussion and in the working documents the advocates for the stock production model tended to use formal arguments whereas the advocates for the rejection of the stock production model more often used actual arguments. The use of two types of arguments hampered the discussion and probably prevented a total agreement of rejecting or keeping the stock production model.

At the end of the meeting (the second last day) all working group members, which were present in the room (around eighteen), were specifically asked in a request-round which approach was most sensible to them, the stock production model or the data-limited-stock approach. All members of the group were happy with the data-limited-stock approach and only less than a handful expressed that the stock production model should still be used as the assessment tool and as a basis for the advice. Although such a request-round not necessarily is good science, it, nevertheless, was helpful to get an idea of the support for each of the options.

The fact that the NWWG rejected the outcome of a recently held benchmark meeting is a problem, at least regarding the formal procedure that the benchmark decides upon assessment tools and basis for advice whereas the working groups stick to this until the next benchmark. It can be questioned whether there is any point of having benchmark meetings if the working groups don't follow the adopted procedures. It can also be questioned whether expert groups really are expert groups if they only are supposed to follow procedures adopted at the benchmark. On top of this, advice drafting groups and ACOM sometimes overrule expert group decisions. If these procedures are supposed to work in ICES, a minimum requirement is that all decisions are well documented, including major arguments, and easily available to the working groups.

On the other hand it was not until the final day of the benchmark meeting (the meeting lasted three days, and half of the time was devoted to other stocks) that the problems became evident with the CPUE series (too large changes between years in CPUE for a long-lived species). By that time it was not possible to pursue the problem further. So in a way the benchmark meeting started a process, which was continued at the NWWG meeting. It is not possible to know the result, if the benchmark meeting scrutinized the issue for another 2-3 days.

The benchmark meeting also decided that a GADGET model should be investigated and probably adopted when ready to use. At the NWWG meeting the GADGET model was not ready to use, although exploratory runs were done. Hence, the formal problems created by NWWG this year may be reduced much if the GADGET model becomes adequately worked during the next one or two years.

1.6 Chairman

This is the third and final year for the current chairman, Petur Steingrund (Faroe Islands). Rasmus Hedeholm (Greenland) was by NWWG proposed as the new chairman.

2 Demersal Stocks in the Faroe Area (Division Vb and Subdivision IIa4)

2.1 Overview

2.1.1 Fisheries

The main fisheries in Faroese waters are mixed-species, demersal fisheries and single species pelagic fisheries. The demersal fisheries are mainly conducted by Faroese vessels, whereas the pelagic fisheries are conducted both by Faroese vessels and by foreign vessels licensed through bilateral and multilateral fisheries agreements. The usual picture has changed since 2011, however, since no mutual agreement has been possible between the Faroe Islands and the EU and Norway, respectively, due to the dispute regarding the share of mackerel.

Pelagic Fisheries. Three main species of pelagic fish are fished in Faroese waters: blue whiting, herring and mackerel; several nations participate. The Faroese pelagic fisheries are conducted by purse seiners, larger purse seiners also equipped for pelagic trawling and trawlers otherwise performing demersal fisheries. The pelagic fishery by Russian vessels is conducted by large factory trawlers. Other countries use purse seiners and factory trawlers. Due to the dispute on the mackerel share, only vessels from the Faroes and Iceland have participated in the fishery since 2011.

Demersal Fisheries. Although they are conducted by a variety of vessels, the demersal fisheries can be grouped into fleets of vessels operating in a similar manner. Some vessels change between longlining, jigging and trawling, and they therefore can appear in different fleets. The following describes the Faroese fleets first followed by the fleets of foreign nations. The number of licenses can be found in Table 2.3. In the management scheme, the vessels have been grouped differently, see section 2.1.3.

Open boats. These vessels are below 5 GRT. They use longline and to some extent automatic, jigging engines and operate mainly on a day-to-day basis, targeting cod, haddock and to a lesser degree saithe. A majority of open boats participating in the fisheries are operated by part-time fishermen.

Smaller vessels using hook and line. This category includes all the smaller vessels, between 5 and 110 GRT operating mainly on a day-to-day basis, although the larger vessels behave almost like the larger longliners above 110 GRT with automatic baiting systems and longer trips. The area fished is mainly nearshore, using longline and to some extent automatic jigging engines. The target species are cod and haddock. During summer they also make a few trips to Icelandic waters.

Longliners > 110 GRT. This group refers to vessels with automatic baiting systems. The main species fished are cod, haddock, ling and tusk. The target species at any one time is dependent on season, availability and market price. In general, they fish mainly for cod and haddock from autumn to spring and for ling and tusk during the summer. The spatial distribution is concentrated mainly around the areas closed to trawling (Figure 2.1). On average 92% of their catch is taken within the permanent exclusion zone for trawlers. During summer they also make a few trips to Icelandic waters.

Otter board trawlers < 500 HP. This refers to smaller fishing vessels with engine powers up to 500 Hp. The main areas fished are on the banks outside the areas closed for trawling. They mainly target cod and haddock. Some of the vessels are licensed during the summer to fish within the twelve nautical miles territorial fishing limit, targeting lemon sole and plaice.

Otter board trawlers > 500 HP. Traditionally this group, also called the deep-water trawlers, have targeted several deep-water fish species, especially redfish, blue ling, Greenland halibut, grenadier and black scabbard fish. Saithe is also a target species with by-catches of cod and haddock on the Faroe Plateau. The distribution of hauls by this fleet in 2010-2011 is shown in Figure 2.1. Since 2011 this fleet has been included in the fishing days regulation and most of the vessels have changed to pairtrawling.

Pair trawlers <1000 HP. The few vessels in this group fish mainly for saithe, however, they also have a significant by-catch of cod and haddock. The main areas fished are the deeper parts of the Faroe Plateau and the banks to the southwest of the islands.

Pair trawlers >1000 HP. This category targets mainly saithe, but their by-catch of cod and haddock is important to their profit margin. In addition, some of these vessels during the summers have special licenses to fish in deep water for greater silver smelt. The areas fished by these vessels are the deeper parts of the Faroe Plateau and the banks to the southwest of the islands (Figure 2.1).

Gill netting vessels. This category refers to vessels fishing mainly Greenland halibut and monkfish. They operate in deep waters off the Faroe Plateau, Faroe Bank, Bill Bailey's Bank, Lousy Bank and the Faroe-Iceland Ridge. This fishery is regulated by the number of licensed vessels and technical measures like depth and gear specifications. The areas fished by these vessels can be seen in Figure 2.1.

Jiggers. This category consist of a mixed group of smaller and larger vessels using automatic jigging equipment. The target species are saithe and cod. Depending on availability, weather and season, these vessels operate throughout the entire Faroese region. They can change to longlines.

Foreign longliners. These are mainly Norwegian vessels of the same type as the Faroese longliners larger than 110 GRT. They target mainly ling and tusk with by-catches of cod, haddock and blue ling. Normally Norway has had a bilateral fishery agreement with the Faroes for a total quota of these species while the number of vessels can vary from year to year; as said elsewhere in the report, however, since 2011 no such agreement has been in place.

Foreign trawlers. These are mainly otter board trawlers of the same type as the Faroese otter board trawlers larger than 1 000 HP. Participating nations are normally United Kingdom, France, Germany and Greenland. The smaller vessels, mainly from the United Kingdom and Greenland, target cod, haddock and saithe, whereas the larger vessels, mainly French and German trawlers, target saithe and deep-see species like redfish, blue ling, grenadier and black scabbardfish. As for the foreign longliners, the different nations have in their bilateral fishery agreement with the Faroes, i.e., a total quota of these species while the number of vessels can vary from year to year. Due to the dispute on mackerel, only Greenland is allowed to fish at present.

2.1.2 Fisheries and management measures

The fishery around the Faroe Islands has for centuries been an almost free international fishery involving several countries. Apart from a local fishery with small wooden boats, the Faroese offshore fishery started in the late 19th century. The Faroese fleet had to compete with other fleets, especially from the United Kingdom with the result that a large part of the Faroese fishing fleet became specialised in fishing in other areas. So except for a small local fleet most of the Faroese fleet were fishing around Iceland, at

Rockall, in the North Sea and in more distant waters like the Grand Bank, Flemish Cap, Greenland, the Barents Sea and Svalbard.

Up to 1959, all vessels were allowed to fish around the Faroes outside the 3 nm zone. During the 1960s, the fisheries zone was gradually expanded, and in 1977 an EEZ of 200 nm was introduced in the Faroe area. The demersal fishery by foreign nations has since decreased and Faroese vessels now take most of the catches. The fishery may be considered a multi-fleet and multi-species fishery as described below.

During the 1980s and 1990s the Faroese authorities have regulated the fishery and the investment in fishing vessels. In 1987 a system of fishing licenses was introduced. The demersal fishery at the Faroe Islands has been regulated by technical measures (minimum mesh sizes and closed areas). In order to protect juveniles and young fish, fishing is temporarily prohibited in areas where the number of small cod, haddock and saithe exceeds 30% (in numbers) of the catches; after 1–2 weeks, sometimes longer, the areas are again opened for fishing. A reduction of effort has been attempted through banning of new licenses and buy-back of old licenses.

A quota system, based on individual quotas, was introduced in 1994. The fishing year started on 1 September and ended on 31 August the following year. The aim of the quota system was, through restrictive TACs for the period 1994–1998, to increase the SSBs of Faroe Plateau cod and haddock to 52 000 t and 40 000 t, respectively. The TAC for saithe was set higher than recommended scientifically. It should be noted that especially cod and haddock but also saithe are caught in a mixed fishery and any management measure should account for this. Species under the quota system were Faroe Plateau cod, haddock, saithe, redfish and Faroe Bank cod.

The catch quota management system introduced in the Faroese fisheries in 1994 was met with considerable criticism and resulted in discarding and in misreporting of substantial portions of the catches. Reorganisation of enforcement and control did not solve the problems. As a result of the dissatisfaction with the catch quota management system, the Faroese Parliament discontinued the system as from 31 May 1996. In close cooperation with the fishing industry, the Faroese government has developed a new system based on individual transferable effort quotas in days within fleet categories. The new system entered into force on 1 June 1996. The fishing year from 1 September to 31 August, as introduced under the catch quota system, has been maintained.

The individual transferable effort quotas apply to 1) the longliners less than 110 GRT, the jiggers, and the single trawlers less than 400 HP (Groups 4,5), 2) the pair trawlers (Group 2) and 3) the longliners greater than 110 GRT (Group 3). The single trawlers greater than 400 HP were in 2011 included into the fishing days system and were allocated a number of fishing days (Tables 1 and 2). They are not allowed to fish within the 12 nautical mile limit and the areas closed to them, as well as to the pair trawlers, have increased in area and time. Their catch of cod and haddock was before 2011 limited by maximum by-catch allocation. This fleet has now started to pair-trawl, and since the fiscal year 2011/12, merged with the pair-trawlers group. The single trawlers less than 400 HP are given special licenses to target flatfishes inside 12 nautical miles with a by-catch allocation of 30% cod and 10% haddock. In addition, they are obliged to use sorting devices in their trawls in order to minimize their by-catches. One fishing day by longliners less than 110 GRT is considered equivalent to two fishing days for jiggers in the same gear category. Longliners less than 110 GRT could therefore double their allocation by converting to jigging. Table 2.1 shows the allocated number of fishing days by fleet group since the fiscal year 1996/1997 and in Table 2.2 is a comparison between number of allocated days and number of actually used fishing days. From

Table 1 it can been seen that since 1996/1997, the number of days allocated has been reduced considerable and is now 50% of the originally allocated days. Despite this, there still are many unused days in the system (Table 2.2).

Holders of individual transferable effort quotas who fish outside the thick line on Figure 2.2 can fish for 3 days for each day allocated inside the line. Trawlers are generally not allowed to fish inside the 12 nautical mile limit. Inside the innermost thick line only longliners less than 110 GRT and jiggers less than 110 GRT are allowed to fish. The Faroe Bank shallower than 200 m is closed to trawling. Due to the serious decline of the Faroe Bank cod, the Bank has been closed since 1 January 2009 for all gears except for a minor jigging fishery during summer time.

The fleet segmentation used to regulate the demersal fisheries in the Faroe Islands and the regulations applied are summarized in Table 2.3.

The effort quotas are transferable within gear categories. The allocations of number of fishing days by fleet categories was made such that together with other regulations of the fishery they should result in average fishing mortalities on each of the 3 stocks of 0.45, corresponding to average annual catches of 33% of the exploitable stocks in numbers. Built into the system is also an assumption that the day system is self-regulatory, because the fishery will move between stocks according to the relative availability of each of them and no stock will be overexploited. These target fishing mortalities have been evaluated during the 2005 and 2006 NWWG meetings. The realized fishing mortalities have been substantially higher than the target for cod, appear to have exceeded the target for saithe in recent years, while for haddock, fishing mortality remains below the target.

In addition to the number of days allocated in the law, it is also stated in the law what percentage of total catches of cod, haddock, saithe and redfish, each fleet category on average is expected to fish. These percentages are as follows:

Fleet category	Cod	Haddock	Saithe	Redfish
Longliners < 110GRT,				
jiggers, single trawl. < 400HP	51 %	58 %	17.5 %	1 %
Longliners > 110GRT	23 %	28 %		
Pairtrawlers	21 %	10.25 %	69 %	8.5 %
Single trawlers > 400 HP	4 %	1.75 %	13 %	90.5 %
Others	1 %	2 %	0.5 %	0.5 %

The technical measures as mentioned above are still in effect. An additional measure to reduce the fishing mortality on cod and haddock and to especially reduce the mortality on the youngest age groups has been introduced (See the 2013 NWWG report, Figure 2.3) in July 2011, but was terminated in August 2013.

2.1.3 The marine environment and potential indicators

The waters around the Faroe Islands are in the upper 500 m dominated by the North Atlantic current, which to the north of the islands meets the East Icelandic current. Clockwise current systems create retention areas on the Faroe Plateau (Faroe shelf) and on the Faroe Bank. In deeper waters to the north and east and in the Faroe Bank channel there is deep Norwegian Sea water, and to the south and west is Atlantic water. From the late 1980s the intensity of the North Atlantic current passing the Faroe area decreased, but it has increased again in the most recent years. The productivity of the

Faroese waters was very low in the late 1980s and early 1990s. This applies also to the recruitment of many fish stocks, and the growth of the fish was poor as well. Since then, there have been several periods with high or low productivity, which has been reflected in the fish landings a couple of years afterwards.

There has been observed a clear relationship, from primary production to the higher trophic levels (including fish and seabirds), in the Faroe shelf ecosystem, and all trophic levels seem to respond quickly to variability in primary production in the ecosystem (Gaard, E. et al. 2002). There is a positive relationship between primary production and the cod and haddock individual fish growth and recruitment ½-2 years later. The primary production index has been below average since 2002 except for 2004 and 2008-2010 when it was above average (Figure 2.3). The estimate of primary production in 2014 will not be available until July. The primary production index could therefore be a candidate ecosystem and stock indicator. Another potential indicator candidate is the so-called Sub-polar Gyre Index, which is an index for the primary production in the outer areas (Figure 2.3).

Recent work (Steingrund *et al.*, 2012) shows that there is a moderate positive correlation between primary production on the Faroe Shelf and the subsequent production of cod (Steingrund and Gaard, 2005). There is also a moderate positive correlation for haddock and saithe. However, if all three species are combined, the positive correlation becomes very strong (Figure 2.4). This indicates that a nearly fixed portion of the energy produced by the primary production goes to predatory demersal fish on the Faroe Plateau, but that the portion to each of the fish stocks (to cod, haddock or saithe) may vary much between years. As an example, the last period of high productivity (2008-2010) did not lead to any marked increase in the stock size of cod/haddock, but only in saithe. Sandeels seem to be an important trophic link between the primary production and fish.

2.1.4 Summary of the 2014 assessment of Faroe Plateau cod, haddock and saithe

A summary of selected parameters from the 2014 assessment of Faroe Plateau cod, Faroe haddock and Faroe saithe is shown in Figure 2.5. As mentioned in previous reports of this WG, landings of cod, haddock and saithe on the Faroes appear to be closely linked with the total biomass of the stocks. For cod, the exploitation ratio and fishing mortality have remained relatively stable over time, although they have been more fluctuating in recent years. For haddock, the exploitation rate was decreasing from the 1950s and 1960s, while it have been fluctuating since the mid 1970s. For saithe, there is a suggestion that the exploitation rate was increasing at the beginning of the period, it decreased from the early 1990s to 1998 and has increased close to the highest values observed in 2009. It has since declined again.

Another main feature of the plots of landings, biomasses, mortalities and recruitment is the apparent periodicity during the time series with cod and haddock showing almost the same fluctuations and time-trends.

2.1.5 Reference points for Faroese stocks

As explained elsewhere in this report, MSY reference points have recently been estimated for cod, haddock and saithe in addition to the already existing PA reference points. These reference points are all estimated based on single-species models. Multi-species models may give very different perception of F_{MSY} reference points than single-species models, and for the Faroe area this could be extra true, since there is a close relationship between the environment and the fish stocks and between fish stocks (see section 2.1.3). Therefore, studies have been made recently to construct ecological models for the area. A long-term simulation was performed in the 2011 report to evaluate MSY reference points for cod, haddock and saithe, all in the same ecological model (see working document 22 in the 2011 report). The model settings and the results were presented in the 2011 Overview section for the Faroese stocks.

Recent work (Steingrund *et al*., 2012), however, indicates that another ecological model including fish production and zooplankton may be more appropriate (see section 2.1.3). The results from the ecological modelling are presently, however, to be regarded as very preliminary, but it is hoped that the ecological model work can be included in future NWWG reports.

2.1.6 Management plan

In 2011 the Faroese minister of fisheries established a group of experts to formulate a management plan for cod, haddock and saithe including a harvest control rule and a recovery plan. The group consisted of scientists from the Faroe Marine Research Institute and the Faroese University, of 1 representative from the industry (trawlers) and 1 from the Ministry of Fisheries. The results of this work was delivered to the Minister of Fisheries in the spring 2012 but the outcome has not been approved by the authorities so far and not been implemented. Basically, the plan builds on the MSY framework developed by ICES.

2.1.7 References:

Gaard. E., Hansen, B., Olsen, B and Reinert, J. 2001. Ecological features and recent trends in physical environment, plankton, fish stocks and sea birds in the Faroe plateau ecosystem. In: K-Sherman and H-R Skjoldal (eds). Changing states of the Large Marine Ecosystems of the North Atlantic.

Steingrund, P., and Gaard, E. 2005. Relationship between phytoplankton production and cod production on the Faroe Shelf. ICES Journal of Marine Science, 62: 163-176.

Steingrund, P., and Hátún, H. 2008. Relationship between the North Atlantic subpolar gyre and fluctuations of the saithe stock in Faroese waters. NWWG 2008 Working Document 20.

Steingrund, P., Gaard, E., Reinert, J., Olsen, B., Homrum, E., and Eliassen, K. 2012. Trophic relationships on the Faroe Shelf ecosystem and potential ecosystem states. In: Homrum, E., 2012. The effects of climate and ocean currents on Faroe Saithe. PhD-thesis, 2012.

Table 2.1. Number of allocated days since the fiscal year 1996/97.

Tillutaðir dagar sambært løgtingslógir:													Tøkir	
Bólkur	Smb. Ll.:	Serlig viðm.	1 ytri	1 innaru	2 ytri	2 innari	3	4 A	4 B	4 D	4 T	5	(at ráða yvir)	Dagar tils.
1996/97	(50 20/5-96)	(12/15 mdr!)				8225	3040	4700	3080	1540		22000	1000	43585
1996/97	(84 6/6-97)	(12/15mdr!)				8225	3040	5600	3410	1650		27000	660	49585
1997/98	(133 9/8-97)	12 mdr!				7199	2660	4696	4632			23625	577	43389
1998/99	(69 18/8-98)					6839	2527	4461	4400			22444	548	41219
1999/2000	(80 17/8-99)					6839	2527	4461	4400			22444	548	41219
2000/2001	(104 17/8-00)					6839	2527	4461	4400			22,444	548	41219
2001/2002	(115 15/8-01)					6839	2527	4461	4400			22444	0	40671
2002/2003	(76 13/8-02)					6771	2502	4416	4356			22220	0	40265
2003/2004	(100 8/8-03)					6636	2452	4328	4269			21776	0	39461
2004/2005	(49 18/8-04)					6536	2415	4263	4205			21449	0	38868
2005/2006	(98 19/8-05)					5752	3578	1770	2067		1766	21235	0	36168
2006/2007	(81 17/8-06)					5752	3471	1717	2005		1713	20598	0	35256
2007/2008	(80 20/8-07)					5637	3402	1683	1965		1679	20186	0	34552
2008/2009	(76 15/8-08)					5073	3062	1515	1769		1511	18167	0	31097
2008/2009	(62 25/5-09)					4638	3095	1393	1848		1621	18167	0	30762
2009/2010	(106 17/8-09					4406	2940	1323	1756		1540	17259	0	29224
2010/2011	(87 18/8-10)		1700	900		4274	2852	1323	1756		1540	13259	0	25004
2010/2011	sama -		1700	900		4274	2852	1323	1756		1540	13259	0	27604
2011/12	(105 18/8-11) (112 2/9-11)				1530	4657	2567	1058	1405		1386	10607		23210
2012/13	(89 17/8-12)				1530	4626	2567	1011	1533		1386	10607		23260
2013/14	(109 16/8-13)				1530	4441	2387	1011	1533		1386	9865		22153

Table 2.2. Number of days allocated and the number actually used since the fiscal year 2010/2011

Variabul - JM: Meting 03-06. april 2014 (dagført):										pr. 03-06. apríl 2014 (7 mdr.)		
Fleet segment	Allocated days 2010/11	Used days 2010/11	% used days 2010/11	Allocated days 2011/12	Used days 2011/12	% used days 2011/12	Allocated days 2012/13	Used days 2012/13	% used days 012/13	Allocated days 2013/14	Used days pr. Dato	% used days
Reference:	Ll87 18/8-10(JV)			Ll105 18/8-11 og Ll112 2/9-11(JD)			Ll105 18/8-11 og Ll112 2/9-11(JD)			Ll105 18/8-11 og Ll112 2/9-11(JD)		
Group 1 - innaru leiðir	900	552.39	61%									
Group 1 - ytri leiðir	1700	785.3	46%									
Group 2 - (innaru leiði	4274	3883.23	91%	4657	4758.02	102%	4626	3952.52	85%	4441	2559.15	58%
Group 2 - ytri leiðir				1530	894.94	58%	1530	878.57	57%	1530	624.81	41%
Group 3	2852	2071.16	73%	2567	1985.90	77%	2567	1205.23	47%	2387	750.94	31%
Group 4A	1323	405.36	31%	1058	259.5	25%	1011	270.72	27%	1011	167.41	17%
Group 4B	1756	1015.65	58%	1405	656.61	47%	1533	687.73	45%	1533	167.41	11%
Group 4T	1540	1411.98	92%	1386	1313.14	95%	1386	1165.71	84%	1386	409.06	30%
Group 5A	5304	2856	54%	5060	1834	36%	4730	1410	30%	4311	662	15%
Group 5B	7955	4525	57%	5547	3160	57%	5877	2845	48%	5554	1358	24%
Total	27604	17506.07	63%	23210	14862.11	64%	23260	12415.48	53%	22153	6698.78	30%

Table 2.3. Main regulatory measures by fleet in the Faroese fisheries in Vb. The fleet capacity is fixed, based on among other things no. of licenses. Number of licenses within each group (by May 2006) are as follows: 1: 12; 2:29; 3:25; 4A: 25; 4B: 21; 4T: 19; 5A:140; 5B: 453; 6: 8. These licenses have been fixed in 1997, but in group 5B a large number of additional licenses can be issued upon request.

	Fleet segment	Sub groups		Main regulation tools
1	Single trawlers > 400 HP	non e		Fishing days, have from 2011/12 been merged with the pair trawlers, area closures
2	Pair trawlers > 400 HP	non e		Fishing days, area closures
3	Longliners > 110 GRT	non e		Fishing days, area closures
4	Coastal vessels>15 GRT	4A	Trawlers 15-40 GRT	Fishing days
		4A	Longliners 15-40 GRT	Fishing days
		4B	Longliners>40 GRT	Fishing days
		4T	Trawlers>40 GRT	Fishing days
5	Coastal vessels <15 GRT	5A	Full-time fishers	Fishing days
		5B	Part-time fishers	Fishing days
6	Others		Gillnetters	Bycatch limitations, fishing depth, no. of nets
			Others	Bycatch limitations

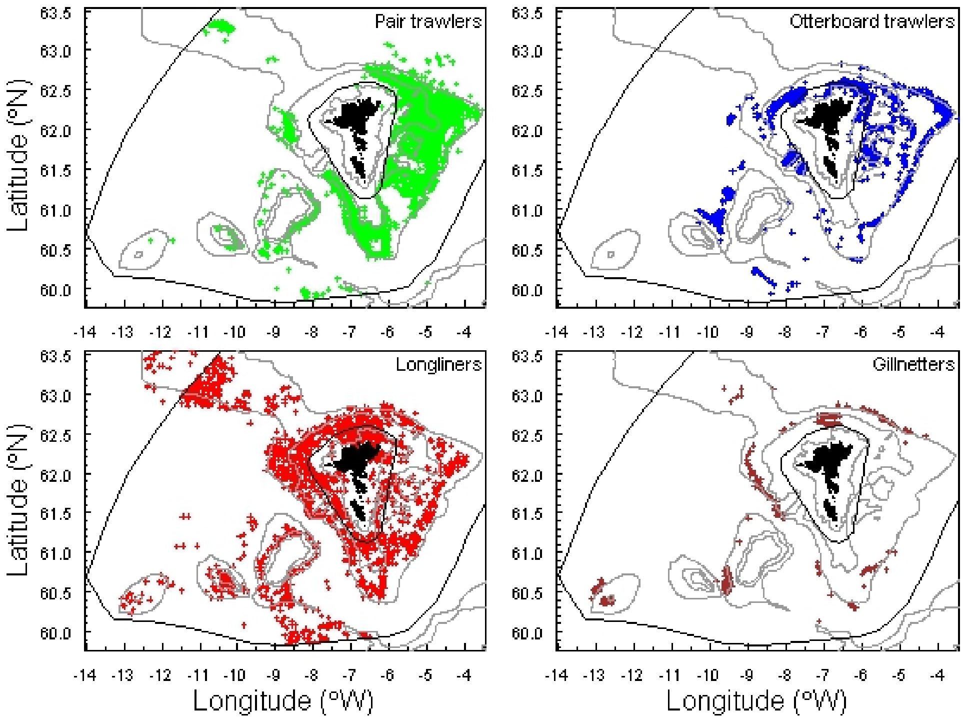
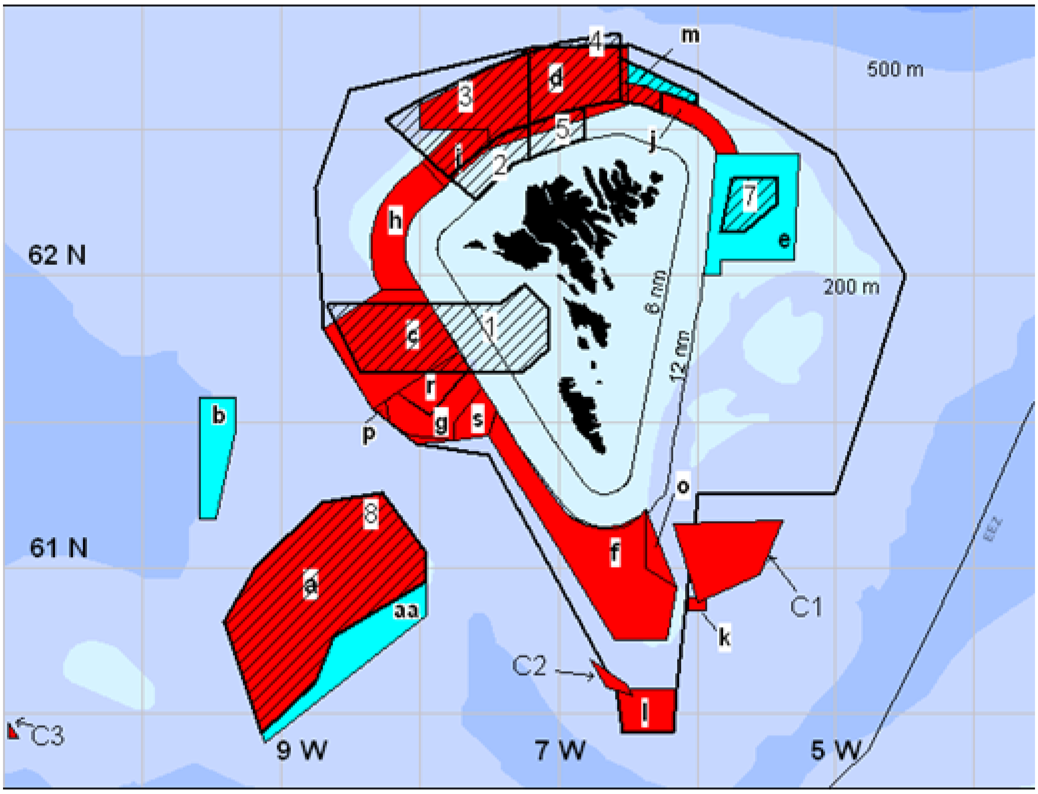


Figure 2.1. The 2012 distribution of fishing activities by some major fleets. The longline fleet below 15 GRT is not shown here since they are not obliged to keep logbooks.



Exclusion zones for trawling

Area	Period
a	1 jan - 31 des
aa	1 jun - 31 aug
b	20 jan - 1 mar
c	1 jan - 31 des
d	1 jan - 31 des
e	1 apr - 31 jan
f	1 jan - 31 des
g	1 jan - 31 des
h	1 jan - 31 des
i	1 jan - 31 des
j	1 jan - 31 des
k	1 jan - 31 des
l	1 jan - 31 des
m	1 feb - 1 jun
n	31 jan - 1 apr
o	1 jan - 31 des
p	1 jan - 31 des
r	1 jan - 31 des
s	1 jan - 31 des
C1	1 jan - 31 des
C2	1 jan - 31 des
C3	1 jan - 31 des

Spawning closures

Area	Period
1	15 feb - 31 mar
2	15 feb - 15 apr
3	15 feb - 15 apr
4	1 feb - 1 apr
5	15 jan - 15 mai
6	15 feb - 15 apr
7	15 feb - 15 apr
8	1 mar - 1 may

Figure 2.2. Fishing area regulations in Division Vb. Allocation of fishing days applies to the area inside the outer thick line on the Faroe Plateau. Holders of effort quotas who fish outside this line can triple their numbers of days. Longliners larger than 110 GRT are not allowed to fish inside the inner thick line on the Faroe Plateau. If longliners change from longline to jigging, they can double their number of days. The Faroe Bank shallower than 200 m depths (a, aa) is regulated separate from the Faroe Plateau. It is closed to trawling and the longline fishery is regulated by individual day quotas.

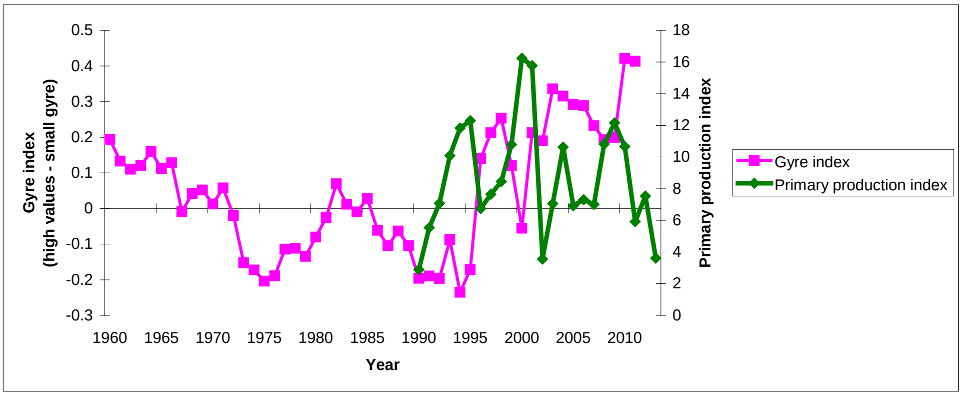


Figure 2.3. Temporal development of the phytoplankton index over the Faroe Shelf area (< 130 m) and the subpolar gyre index which indicates productivity in deeper waters.

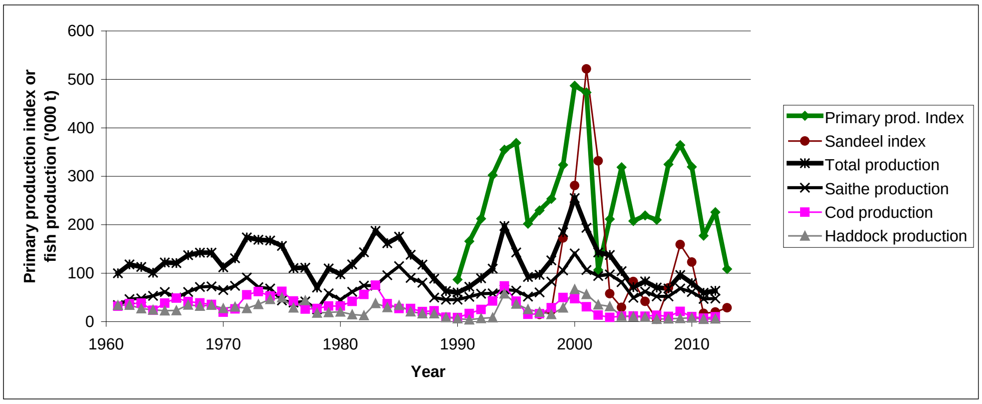


Figure 2.4. Relationship between primary production, a sandeel index (from stomach analyses), and production of cod, haddock and saithe.

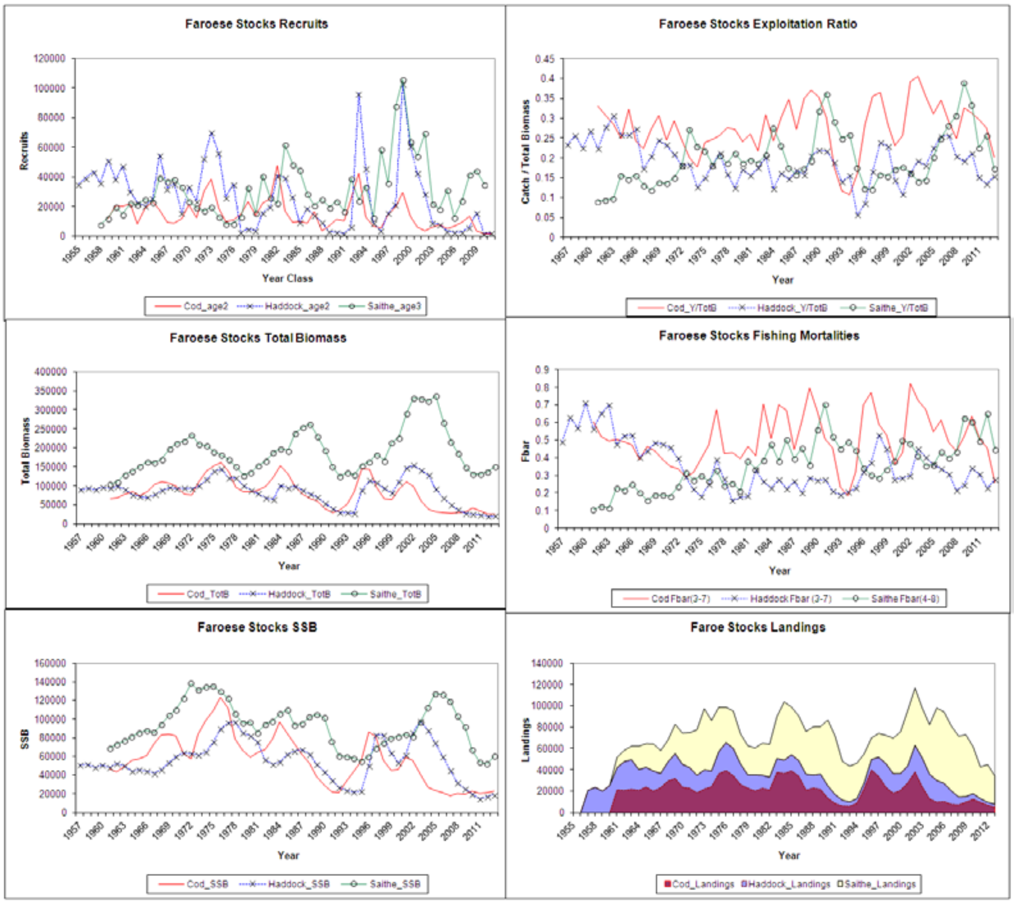


Figure 2.5. Faroe Plateau cod, Faroe haddock and Faroe saithe. 2014 stock summary.

3 Faroe Bank Cod

Summary

The total reported landings in 2013 were the lowest recorded since 1965 (36 tonnes).

The spring index suggests that since 2013 the stock is increasing but it is however well below levels of those in the 1996-2002 period. Nevertheless both the summer and spring index suggest the stock is well below average while there is no indication of strong incoming year classes.

The results of an exploratory production model based on both surveys indicate a good agreement in the stock biomass index in recent years whereas the observed survey-based exploitation rates correlates reasonably well with estimated fishing mortalities. However the model failed to pick up the large increases in stock biomass observed in the 1996-2003 period. Correlation between modelled F's and summer survey based exploitation rates is R=0.90. The exploitation ratio sharply increased in 2011 as a consequence of the increase in landings and it decreased afterwards reflecting the fall of catches observed since 2012.

3.1 State of the stock - historical and compared to what is now.

Total nominal catches of the Faroe Bank cod from 1987 to 2013 as officially reported to ICES are given in Table 3.1 and since 1965 in Figure 3.1. UK catches reported to be taken on the Faroe Bank are all assumed to be taken on the Faroe Plateau and are therefore not used in the assessment. Landings have been highly variable from 1965 to the mid-1980s, reflecting the opportunistic nature of the cod fishery on the Bank, with peak landings slightly exceeding 5 000t in 1973 and 2003. The trend of landings has been smoother since 1987, declining from about 3 500t in 1987 to only 330 t in 1992 before increasing to 3 600t in 1997. In 2013 landings were estimated at 36t which is the lowest ever recorded since 1965 (Figure 3.7.1). Longline fishing effort increased substantially in 2003 and although it decreased in 2004 and 2005 the latter remains the second highest fishing effort observed since 1988 (Figure 3.1). From 2005 to 2007 the effort has been reduced substantially. In the 2010/2011 and 2011/2012 fishing years a total of 61 and 100 fishing-days were allocated to the Bank. No days were allocated in the 2012/2013 fishing year.

The Faroese groundfish surveys (spring and summer) cover the Faroe Bank and cod is mainly taken within the 200 m depth contour. The catches of cod per trawl hour in depths shallower than 200 meter are shown in Figure 3.2.

The spring survey was initiated in 1983 and discontinued in 1996, 2004 and 2005. The summer survey has been carried out since 1996. The CPUE of the spring survey was low during 1988 to 1995 varying between 73 and 95 kg per tow. Although noisy, the survey suggests higher, possibly increasing biomass during 1995 - 2003. The 2013 and the 2014 spring point estimates suggest that the stock is rising but it is however well below the average of that of the period 1996–2002. The 2013 summer index is estimated at 17 kg per tow, which is the lowest value in the series. There are conflicting signals between both indices in recent years. The agreement between the summer and spring index is good during 1996 to 2001 and since 2006, but they diverged in 2002 and 2003 and since 2012. Both indexes have remained well below average since 2004.

The figure of length distributions (figures 3.3 and 3.5) show in general good recruitment of 1 year old in the summer survey from 2000 – 2002 (lengths 26 – 45 cm), corresponding to good recruitment of 2 years old in the spring surveys from 2001 to 2003 (40 – 60 cm). The spring index shows poor recruitment from 2006 to 2014 reflecting the weak year classes observed in the summer survey since 2004. Age-disaggregated indices confirm the pattern observed in the length composition (figure 3.4 and figure 3.6)

A way to estimate recruitment strength is by simply counting the number of fish in length groups in the surveys. In the spring index, recruitment was estimated as total number of fish below 60 cm (2-year old) and in the summer index as number of fish below 45 cm (1-year old). According to the summer index the recruitment of 1 year old was good from 2000 to 2003, while the recruitment has been relatively poor since 2004 (Figure 3.7) The spring recruitment index in 2014 shows no sign of incoming year classes. Correlation between the spring and summer survey recruitment indices is fairly good (r=0.85). Correlation between numbers of 1-year and 2-years old cod in the age-disaggregated summer and spring surveys respectively is estimated at r=0.79.

The group tried the ASPIC (Prager 1992) stock production model for the stock. The model requires catch data and corresponding effort or CPUE data that are reasonable indices of the stock biomass.

ASPIC requires starting guesses for *r*, the intrinsic rate of increase, MSY, B1/Bmsy ratio and *q*, catchability coefficients. No sensitivity analysis was performed to explore the stability of parameter estimation.

The program was run with the time-series from 1983-2013 including spring survey and 1996-2013 summer CPUE's separately. The result of the runs are presented in tables 3.2 and 3.3 For both runs the model seemed to follow reasonably well survey trends in periods of low stock abundances but it failed to pick up the large increases observed in the 1996-2003 period (figures 3.8 and 3.9).

However estimates of *r*=0.072 and Fmsy=0.036 (using the fall survey series) seem spurious given that the Faroe Bank cod is the fastest growing cod stock in the Atlantic.

The ratio of landings to the survey indices provides an exploitation ratio, which can be used as a proxy to relative changes in fishing mortality. For the summer survey, the results suggest that fishing mortality has been reasonably stable during 1996 to 2002, but that it increased steeply in 2003, consistent with the 160% increase in longline fishing days in that year (Figure 3.1). The exploitation ratio has decreased since 2006 but increased in 2011 due to the increase in catches and decreased again afterwards reflecting the fall of catches observed since 2011.

3.2 Comparison with previous assessment and forecast

The status of the stock remains almost unchanged with respect to last year's assessment. Both the spring and the summer indexes suggest the stock is well below average while there are no indications of incoming recruitment. The spring index suggests an increasing stock biomass since 2013 which it is however not picked up by the summer survey. The exploratory production model performed in 2013 and 2014 confirms the poor status of the stock.

3.3 Management plans and evaluations (Could just be a reference to the year when the plan was agreed/evaluated. Include proposed/agreed management plan.)

None

3.4 Management considerations

The landing estimates are uncertain because since 1996 vessels are allowed to fish both on the Plateau and on Faroe Bank during the same trip, rendering landings from both areas uncertain. Given the relative size of the two fisheries, this is a bigger problem for Faroe Bank cod than for Faroe Plateau cod, but the magnitude remains unquantified for both. The ability to provide advice depends on the reliability of input data. If the cod landings from Faroe Bank are not known, it is difficult to provide advice. If the fishery management agency intends to manage the two fisheries to protect the productive capacity of each individual unit, then it is necessary to identify the catch removed from each stock. Simple measures should make it possible to identify if the catch is originating from the Bank or from the Plateau e.g. by storing in different section of the hold and/or by tagging of the different boxes.

Consistent with the advice given in 2013 the WG suggests the closure of the fishery until the recovery of the stock is confirmed. The reopening of the fishery should not be considered until both surveys indicate a biomass at or above the average that of the period 1996-2002.

3.5 Regulations and their effects

In 1990, the decreasing trends in cod landings from Faroe Bank lead ACFM to advise the Faroese authorities to close the bank to all fishing. This advice was followed for depths shallower than 200 meters. In 1992 and 1993 longliners and jiggers were allowed to participate in an experimental fishery inside the 200 meters depth contour. For the quota year 1 September 1995 to 31 August 1996 a fixed quota of 1 050 t was set. The new management regime with fishing days was introduced on 1 June 1996 allowing longliners and jiggers to fish inside the 200 m contour. The trawlers are allowed to fish outside the 200 m contour.

A total fishing ban during the spawning period (1 March to 1 May) has been enforced since 2005. In 2009, fishing was restricted to all fishing gears from 1 January to 31 August. However, in the 2010/2011 and 2011/2012 fishing years a total of 61 and 100 fishing-days were allocated to the Bank to jiggers in the shallow waters of the Bank. No days were allocated in the 2013/2014 fishing year.

3.6 Changes in fishing technology and fishing patterns

None

Changes in the environment

Table 3.1. Faroe Bank (sub-division Vb2) cod. Nominal catches (tonnes) by countries 1986-2012 as officially reported to ICES. From 1992 the catches by Faroe Islands and Norway are used in the assessment.

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Faroe Islands	1836	3409	2966	1270	289	297	122	264	717	561	2051	3459	3092	1001
Norway	6	23	94	128	72	38	32	2	8	40	55	135	147	88
UK (E/W/NI)	-	-	-	-	2 [2]	1 [2]	74 [2]	186 [2]	56 [2]	43 [2]	126 [3]	61 [3]	27 [3]	-
UK (Scotland)	63 [3]	47 [3]	37 [3]	14 [3]	205 [3]	90 [3]	176 [3]	118 [3]	227 [3]	551 [3]	382 [3]	277 [3]	265 [3]	51 [3]
Total	1905	3479	3097	1412	568	426	404	570	1008	1195	2614	3932	3531	210 [3]
Used in assessment					289	297	154	266	725	601	2106	3594	3239 0	1350
														1089

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Faroe Islands		1094	1840	5957	3607	1270	1005	471	231	81	111	393	115	38 [*]
Norway	49	51	25	72	18	37	10	7	1	4	1		0	
Greenland	-	-	-	-	-	-	-	-	-	-	-		1	
UK (E/W/NI) [3]	18 [3]	50 [3]	42 [3]	15 [3]	15 [3]	24 [3]	1 [3]							
UK (Scotland) [3]	245 [3]	288 [3]	218 [3]	254 [3]	244 [3]	1129 [3]	278 [3]	53	32	38	54			
Total	312	1483	2125	6298	3884	2460	1294	531	264	123	166	393	116	38
Correction of Faroese catches in Vb2		-65	-109	-353	-214	-75	-60	-28	-14	-5	-7	-23	-7	-2
Used in assessment	1194	1080	1756	5676	3411	1232	955	450	218	80	105	370	108	36

[*] Preliminary
[2] Included in Vb1.
[3] Reported as Vb.

Table 3.2. Faroe Bank (sub-division Vb2) cod. Surplus production model output using the summer index.

Faroe Bank Cod RV **Page 1**

04 Apr 2014 at 13:17.16

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.82) **FIT Mode**

Author: Michael H. Prager; NOAA/NMFS/S.E. Fisheries Science Center **ASPIC User's Manual**

101 Pivers Island Road; Beaufort, North Carolina 28516 USA **is available gratis**

from the author.

Ref: Prager, M. H. 1994. A suite of extensions to a nonequilibrium

surplus-production model. Fishery Bulletin 92: 374-389.

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed: 49 Number of bootstrap trials: 0

Number of data series: 1 Lower bound on MSY: 5.000E+02

Objective function computed: in effort Upper bound on MSY: 1.000E+09

Relative conv. criterion (simplex): 1.000E-08 Lower bound on r: 7.000E-02

Relative conv. criterion (restart): 3.000E-08 Upper bound on r: 2.500E+00

Relative conv. criterion (effort): 1.000E-04 Random number seed: 2010417

Maximum F allowed in fitting: 8.000 Monte Carlo search mode, trials: 1 10000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) **code 0**

Normal convergence.

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1R > 2	9.283E-05	1	N/A	1.000E-01	N/A	
Loss(1) Survey CPUE Summer	2.393E+00	18	1.496E-01	1.000E+00	1.000E+00	0.766
TOTAL OBJECTIVE FUNCTION:	2.39352046E+00					

NOTE: B1-ratio constraint term contributing to loss. Sensitivity analysis advised.

Number of restarts required for convergence: 8

Est. B-ratio coverage index (0 worst, 2 best): 1.9319 < These two measures are defined in Prager

Est. B-ratio nearness index (0 worst, 1 best): 1.0000 < et al. (1996), Trans. A.F.S. 125:729

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1965	2.062E+00	1.000E+00	1	1
MSY	Maximum sustainable yield	1.002E+03	3.000E+03	1	1
r	Intrinsic rate of increase	7.227E-02	8.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	Survey CPUE Summer	1.661E-02	1.000E-02	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	Related quantity
MSY	Maximum sustainable yield	1.002E+03	Kr/4	
K	Maximum stock biomass	5.543E+04		
Bmsy	Stock biomass at MSY	2.772E+04	K/2	
Fmsy	Fishing mortality at MSY	3.614E-02	r/2	
F(0.1)	Management benchmark	3.252E-02	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	9.916E+02	0.99*MSY	
B-ratio	Ratio of B(2014) to Bmsy	7.264E-02		
F-ratio	Ratio of F(2013) to Fmsy	5.076E-01		
F01-mult	Ratio of F(0.1) to F(2013)	1.773E+00		
Y-ratio	Proportion of MSY avail in 2014	1.400E-01	2*Br-Br^2	Ye(2014) = 1.402E+02
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	Survey CPUE Summer	2.176E+00	r/2q(1)	f(0.1) = 1.958E+00

Faroe Bank Cod RV **Page 2**

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1965	0.042	5.715E+04	5.594E+04	2.341E+03	2.341E+03	-3.729E+01	1.158E+00	2.062E+00
2	1966	0.035	5.477E+04	5.386E+04	1.909E+03	1.909E+03	1.104E+02	9.809E-01	1.976E+00
3	1967	0.030	5.297E+04	5.229E+04	1.569E+03	1.569E+03	2.145E+02	8.304E-01	1.911E+00
4	1968	0.078	5.162E+04	4.983E+04	3.871E+03	3.871E+03	3.630E+02	2.150E+00	1.862E+00
5	1969	0.052	4.811E+04	4.712E+04	2.457E+03	2.457E+03	5.103E+02	1.443E+00	1.736E+00
6	1970	0.067	4.617E+04	4.495E+04	3.002E+03	3.002E+03	6.139E+02	1.848E+00	1.666E+00
7	1971	0.048	4.378E+04	4.307E+04	2.079E+03	2.079E+03	6.939E+02	1.336E+00	1.579E+00
8	1972	0.052	4.239E+04	4.167E+04	2.168E+03	2.168E+03	7.475E+02	1.440E+00	1.529E+00
9	1973	0.132	4.097E+04	3.878E+04	5.101E+03	5.101E+03	8.399E+02	3.640E+00	1.478E+00
10	1974	0.057	3.671E+04	3.612E+04	2.068E+03	2.068E+03	9.093E+02	1.584E+00	1.324E+00
11	1975	0.058	3.555E+04	3.499E+04	2.036E+03	2.036E+03	9.324E+02	1.610E+00	1.283E+00
12	1976	0.067	3.445E+04	3.379E+04	2.258E+03	2.258E+03	9.533E+02	1.849E+00	1.243E+00
13	1977	0.029	3.314E+04	3.315E+04	9.590E+02	9.590E+02	9.631E+02	8.006E-01	1.196E+00
14	1978	0.139	3.315E+04	3.141E+04	4.379E+03	4.379E+03	9.825E+02	3.858E+00	1.196E+00
15	1979	0.044	2.975E+04	2.960E+04	1.306E+03	1.306E+03	9.969E+02	1.221E+00	1.073E+00
16	1980	0.041	2.944E+04	2.934E+04	1.203E+03	1.203E+03	9.981E+02	1.135E+00	1.062E+00
17	1981	0.042	2.924E+04	2.912E+04	1.229E+03	1.229E+03	9.990E+02	1.168E+00	1.055E+00
18	1982	0.077	2.901E+04	2.841E+04	2.184E+03	2.184E+03	1.001E+03	2.127E+00	1.047E+00
19	1983	0.084	2.782E+04	2.717E+04	2.284E+03	2.284E+03	1.001E+03	2.326E+00	1.004E+00
20	1984	0.084	2.654E+04	2.594E+04	2.189E+03	2.189E+03	9.973E+02	2.335E+00	9.576E-01
21	1985	0.120	2.535E+04	2.437E+04	2.913E+03	2.913E+03	9.865E+02	3.308E+00	9.146E-01
22	1986	0.080	2.342E+04	2.299E+04	1.836E+03	1.836E+03	9.723E+02	2.210E+00	8.451E-01
23	1987	0.160	2.256E+04	2.130E+04	3.409E+03	3.409E+03	9.472E+02	4.429E+00	8.139E-01
24	1988	0.156	2.010E+04	1.904E+04	2.966E+03	2.966E+03	9.030E+02	4.310E+00	7.251E-01
25	1989	0.071	1.803E+04	1.784E+04	1.270E+03	1.270E+03	8.742E+02	1.971E+00	6.507E-01
26	1990	0.016	1.764E+04	1.793E+04	2.890E+02	2.890E+02	8.767E+02	4.460E-01	6.364E-01
27	1991	0.016	1.823E+04	1.852E+04	2.970E+02	2.970E+02	8.913E+02	4.437E-01	6.576E-01
28	1992	0.008	1.882E+04	1.920E+04	1.540E+02	1.540E+02	9.068E+02	2.220E-01	6.790E-01
29	1993	0.013	1.957E+04	1.990E+04	2.660E+02	2.660E+02	9.218E+02	3.699E-01	7.062E-01
30	1994	0.036	2.023E+04	2.033E+04	7.250E+02	7.250E+02	9.304E+02	9.867E-01	7.298E-01
31	1995	0.029	2.043E+04	2.060E+04	6.010E+02	6.010E+02	9.355E+02	8.073E-01	7.373E-01
32	1996	0.104	2.077E+04	2.017E+04	2.106E+03	2.106E+03	9.271E+02	2.889E+00	7.493E-01
33	1997	0.198	1.959E+04	1.820E+04	3.594E+03	3.594E+03	8.825E+02	5.466E+00	7.068E-01
34	1998	0.207	1.688E+04	1.563E+04	3.239E+03	3.239E+03	8.104E+02	5.735E+00	6.090E-01
35	1999	0.076	1.445E+04	1.429E+04	1.089E+03	1.089E+03	7.664E+02	2.109E+00	5.213E-01
36	2000	0.086	1.413E+04	1.391E+04	1.194E+03	1.194E+03	7.528E+02	2.376E+00	5.097E-01

37	2001	0.080	1.369E+04	1.351E+04	1.080E+03	1.080E+03	7.385E+02	2.211E+00	4.938E-01
38	2002	0.137	1.334E+04	1.281E+04	1.756E+03	1.756E+03	7.119E+02	3.792E+00	4.815E-01
39	2003	0.597	1.230E+04	9.514E+03	5.676E+03	5.676E+03	5.668E+02	1.651E+01	4.438E-01
40	2004	0.618	7.192E+03	5.524E+03	3.411E+03	3.411E+03	3.583E+02	1.709E+01	2.595E-01
41	2005	0.340	4.139E+03	3.623E+03	1.232E+03	1.232E+03	2.446E+02	9.411E+00	1.493E-01
42	2006	0.347	3.152E+03	2.751E+03	9.550E+02	9.550E+02	1.888E+02	9.608E+00	1.137E-01
43	2007	0.201	2.385E+03	2.235E+03	4.500E+02	4.500E+02	1.550E+02	5.573E+00	8.606E-02
44	2008	0.106	2.090E+03	2.053E+03	2.180E+02	2.180E+02	1.428E+02	2.939E+00	7.542E-02
45	2009	0.039	2.015E+03	2.046E+03	8.000E+01	8.000E+01	1.424E+02	1.082E+00	7.271E-02
46	2010	0.050	2.078E+03	2.098E+03	1.050E+02	1.050E+02	1.459E+02	1.385E+00	7.496E-02
47	2011	0.185	2.119E+03	2.001E+03	3.700E+02	3.700E+02	1.394E+02	5.117E+00	7.643E-02
48	2012	0.057	1.888E+03	1.900E+03	1.080E+02	1.080E+02	1.326E+02	1.573E+00	6.811E-02
49	2013	0.018	1.913E+03	1.963E+03	3.600E+01	3.600E+01	1.368E+02	5.076E-01	6.900E-02
50	2014		2.013E+03				7.264E-02		

Faroe Bank Cod RV **Page 3**

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) **Survey CPUE Summer**

Data type CC: CPUE-catch series **Series weight: 1.000**

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Resid in yield
1	1965	*	9.290E+02	0.0418	2.341E+03	2.341E+03	0.00000	0.000E+00
2	1966	*	8.945E+02	0.0354	1.909E+03	1.909E+03	0.00000	0.000E+00
3	1967	*	8.684E+02	0.0300	1.569E+03	1.569E+03	0.00000	0.000E+00
4	1968	*	8.275E+02	0.0777	3.871E+03	3.871E+03	0.00000	0.000E+00
5	1969	*	7.826E+02	0.0521	2.457E+03	2.457E+03	0.00000	0.000E+00
6	1970	*	7.465E+02	0.0668	3.002E+03	3.002E+03	0.00000	0.000E+00
7	1971	*	7.154E+02	0.0483	2.079E+03	2.079E+03	0.00000	0.000E+00
8	1972	*	6.921E+02	0.0520	2.168E+03	2.168E+03	0.00000	0.000E+00
9	1973	*	6.441E+02	0.1315	5.101E+03	5.101E+03	0.00000	0.000E+00
10	1974	*	5.999E+02	0.0572	2.068E+03	2.068E+03	0.00000	0.000E+00
11	1975	*	5.812E+02	0.0582	2.036E+03	2.036E+03	0.00000	0.000E+00
12	1976	*	5.611E+02	0.0668	2.258E+03	2.258E+03	0.00000	0.000E+00
13	1977	*	5.505E+02	0.0289	9.590E+02	9.590E+02	0.00000	0.000E+00
14	1978	*	5.216E+02	0.1394	4.379E+03	4.379E+03	0.00000	0.000E+00
15	1979	*	4.915E+02	0.0441	1.306E+03	1.306E+03	0.00000	0.000E+00
16	1980	*	4.873E+02	0.0410	1.203E+03	1.203E+03	0.00000	0.000E+00
17	1981	*	4.836E+02	0.0422	1.229E+03	1.229E+03	0.00000	0.000E+00
18	1982	*	4.718E+02	0.0769	2.184E+03	2.184E+03	0.00000	0.000E+00
19	1983	*	4.513E+02	0.0841	2.284E+03	2.284E+03	0.00000	0.000E+00
20	1984	*	4.308E+02	0.0844	2.189E+03	2.189E+03	0.00000	0.000E+00
21	1985	*	4.047E+02	0.1195	2.913E+03	2.913E+03	0.00000	0.000E+00
22	1986	*	3.818E+02	0.0799	1.836E+03	1.836E+03	0.00000	0.000E+00
23	1987	*	3.537E+02	0.1601	3.409E+03	3.409E+03	0.00000	0.000E+00
24	1988	*	3.163E+02	0.1558	2.966E+03	2.966E+03	0.00000	0.000E+00
25	1989	*	2.962E+02	0.0712	1.270E+03	1.270E+03	0.00000	0.000E+00
26	1990	*	2.978E+02	0.0161	2.890E+02	2.890E+02	0.00000	0.000E+00
27	1991	*	3.076E+02	0.0160	2.970E+02	2.970E+02	0.00000	0.000E+00
28	1992	*	3.188E+02	0.0080	1.540E+02	1.540E+02	0.00000	0.000E+00
29	1993	*	3.305E+02	0.0134	2.660E+02	2.660E+02	0.00000	0.000E+00
30	1994	*	3.377E+02	0.0357	7.250E+02	7.250E+02	0.00000	0.000E+00
31	1995	*	3.422E+02	0.0292	6.010E+02	6.010E+02	0.00000	0.000E+00
32	1996	3.105E+02	3.350E+02	0.1044	2.106E+03	2.106E+03	0.07594	0.000E+00
33	1997	4.492E+02	3.022E+02	0.1975	3.594E+03	3.594E+03	-0.39632	0.000E+00
34	1998	3.871E+02	2.596E+02	0.2072	3.239E+03	3.239E+03	-0.39959	0.000E+00
35	1999	1.495E+02	2.373E+02	0.0762	1.089E+03	1.089E+03	0.46170	0.000E+00

36	2000	1.199E+02	2.309E+02	0.0859	1.194E+03	1.194E+03	0.65544	0.000E+00
37	2001	2.626E+02	2.244E+02	0.0799	1.080E+03	1.080E+03	-0.15696	0.000E+00
38	2002	3.472E+02	2.128E+02	0.1370	1.756E+03	1.756E+03	-0.48934	0.000E+00
39	2003	1.618E+02	1.580E+02	0.5966	5.676E+03	5.676E+03	-0.02354	0.000E+00
40	2004	7.304E+01	9.173E+01	0.6175	3.411E+03	3.411E+03	0.22789	0.000E+00
41	2005	6.188E+01	6.016E+01	0.3401	1.232E+03	1.232E+03	-0.02812	0.000E+00
42	2006	2.927E+01	4.568E+01	0.3472	9.550E+02	9.550E+02	0.44501	0.000E+00
43	2007	3.331E+01	3.711E+01	0.2014	4.500E+02	4.500E+02	0.10799	0.000E+00
44	2008	3.117E+01	3.409E+01	0.1062	2.180E+02	2.180E+02	0.08938	0.000E+00
45	2009	4.927E+01	3.398E+01	0.0391	8.000E+01	8.000E+01	-0.37137	0.000E+00
46	2010	4.164E+01	3.484E+01	0.0500	1.050E+02	1.050E+02	-0.17822	0.000E+00
47	2011	5.854E+01	3.323E+01	0.1849	3.700E+02	3.700E+02	-0.56623	0.000E+00
48	2012	3.425E+01	3.156E+01	0.0568	1.080E+02	1.080E+02	-0.08196	0.000E+00
49	2013	1.737E+01	3.259E+01	0.0183	3.600E+01	3.600E+01	0.62935	0.000E+00

*** Asterisk indicates missing value(s).**

Table 3.3. Faroe Bank (sub-division Vb2) cod. Surplus production model output using the spring index.

Faroe Bank Cod RV Page 1

04 Apr 2014 at 13:42.20

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.82) FIT Mode

Author: Michael H. Prager; NOAA/NMFS/S.E. Fisheries Science Center ASPIC User's Manual

101 Pivers Island Road; Beaufort, North Carolina 28516 USA is available gratis

from the author.

Ref: Prager, M. H. 1994. A suite of extensions to a nonequilibrium

surplus-production model. Fishery Bulletin 92: 374-389.

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	49	Number of bootstrap trials:	0
Number of data series:	1	Lower bound on MSY:	5.000E+02
Objective function computed:	in effort	Upper bound on MSY:	1.000E+09
Relative conv. criterion (simplex):	1.000E-08	Lower bound on r:	7.000E-02
Relative conv. criterion (restart):	3.000E-08	Upper bound on r:	2.500E+00
Relative conv. criterion (effort):	1.000E-04	Random number seed:	2010417
Maximum F allowed in fitting:	8.000	Monte Carlo search mode, trials:	1 10000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1R > 2	2.825E-02	1	N/A	1.000E-01	N/A	
Loss(1) Survey CPUE Spring	1.822E+01	28	7.009E-01	1.000E+00	1.000E+00	0.199
TOTAL OBJECTIVE FUNCTION:	1.82514209E+01					

NOTE: B1-ratio constraint term contributing to loss. Sensitivity analysis advised.

Number of restarts required for convergence: 16

Est. B-ratio coverage index (0 worst, 2 best): 1.9118 <These two measures are defined in Prager

Est. B-ratio nearness index (0 worst, 1 best): 1.0000 < et al. (1996), Trans. A.F.S. 125:729

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter	Estimate	Starting guess	Estimated	User guess

B1R	Starting biomass ratio, year 1965	3.403E+00	1.000E+00	1	1
MSY	Maximum sustainable yield	2.164E+03	3.000E+03	1	1
r	Intrinsic rate of increase	6.203E-01	8.000E-01	1	1

.... Catchability coefficients by fishery:

q(1)	Survey CPUE Spring	3.942E-02	1.000E-02	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	Related quantity
MSY	Maximum sustainable yield	2.164E+03	Kr/4	
K	Maximum stock biomass	1.396E+04		
Bmsy	Stock biomass at MSY	6.978E+03	K/2	
Fmsy	Fishing mortality at MSY	3.101E-01	r/2	
F(0.1)	Management benchmark	2.791E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	2.142E+03	0.99*MSY	
B-ratio	Ratio of B(2014) to Bmsy	9.742E-01		
F-ratio	Ratio of F(2013) to Fmsy	2.016E-02		
F01-mult	Ratio of F(0.1) to F(2013)	4.464E+01		
Y-ratio	Proportion of MSY avail in 2014	9.993E-01	2*Br-Br^2	Ye(2014) = 2.163E+03

.... Fishing effort at MSY in units of each fishery:

fmsy(1)	Survey CPUE Spring	7.867E+00	r/2q(1)	f(0.1) = 7.080E+00

Faroe Bank Cod RV Page 2

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1965	0.121	2.375E+04	1.941E+04	2.341E+03	2.341E+03	-4.885E+03	3.890E-01	3.403E+00
2	1966	0.127	1.652E+04	1.502E+04	1.909E+03	1.909E+03	-7.323E+02	4.099E-01	2.367E+00
3	1967	0.119	1.388E+04	1.324E+04	1.569E+03	1.569E+03	4.174E+02	3.822E-01	1.989E+00
4	1968	0.343	1.273E+04	1.129E+04	3.871E+03	3.871E+03	1.313E+03	1.105E+00	1.824E+00
5	1969	0.250	1.017E+04	9.815E+03	2.457E+03	2.457E+03	1.805E+03	8.072E-01	1.457E+00
6	1970	0.335	9.516E+03	8.964E+03	3.002E+03	3.002E+03	1.985E+03	1.080E+00	1.364E+00
7	1971	0.245	8.499E+03	8.490E+03	2.079E+03	2.079E+03	2.062E+03	7.896E-01	1.218E+00
8	1972	0.257	8.482E+03	8.430E+03	2.168E+03	2.168E+03	2.070E+03	8.292E-01	1.216E+00
9	1973	0.759	8.385E+03	6.717E+03	5.101E+03	5.101E+03	2.129E+03	2.449E+00	1.202E+00
10	1974	0.383	5.413E+03	5.406E+03	2.068E+03	2.068E+03	2.054E+03	1.234E+00	7.757E-01
11	1975	0.376	5.399E+03	5.409E+03	2.036E+03	2.036E+03	2.055E+03	1.214E+00	7.737E-01
12	1976	0.426	5.418E+03	5.303E+03	2.258E+03	2.258E+03	2.039E+03	1.373E+00	7.764E-01
13	1977	0.166	5.199E+03	5.772E+03	9.590E+02	9.590E+02	2.095E+03	5.357E-01	7.450E-01
14	1978	0.878	6.335E+03	4.988E+03	4.379E+03	4.379E+03	1.967E+03	2.830E+00	9.078E-01
15	1979	0.312	3.923E+03	4.180E+03	1.306E+03	1.306E+03	1.815E+03	1.007E+00	5.621E-01
16	1980	0.250	4.432E+03	4.810E+03	1.203E+03	1.203E+03	1.953E+03	8.064E-01	6.351E-01
17	1981	0.219	5.182E+03	5.614E+03	1.229E+03	1.229E+03	2.079E+03	7.059E-01	7.426E-01
18	1982	0.364	6.032E+03	5.999E+03	2.184E+03	2.184E+03	2.122E+03	1.174E+00	8.644E-01
19	1983	0.389	5.969E+03	5.878E+03	2.284E+03	2.284E+03	2.110E+03	1.253E+00	8.554E-01
20	1984	0.381	5.795E+03	5.747E+03	2.189E+03	2.189E+03	2.097E+03	1.228E+00	8.305E-01
21	1985	0.557	5.703E+03	5.230E+03	2.913E+03	2.913E+03	2.025E+03	1.796E+00	8.173E-01
22	1986	0.376	4.815E+03	4.884E+03	1.836E+03	1.836E+03	1.969E+03	1.212E+00	6.901E-01
23	1987	0.841	4.949E+03	4.052E+03	3.409E+03	3.409E+03	1.774E+03	2.713E+00	7.092E-01
24	1988	1.296	3.314E+03	2.288E+03	2.966E+03	2.966E+03	1.175E+03	4.180E+00	4.749E-01
25	1989	1.058	1.522E+03	1.200E+03	1.270E+03	1.270E+03	6.790E+02	3.413E+00	2.181E-01
26	1990	0.265	9.312E+02	1.091E+03	2.890E+02	2.890E+02	6.235E+02	8.539E-01	1.334E-01
27	1991	0.195	1.266E+03	1.525E+03	2.970E+02	2.970E+02	8.413E+02	6.281E-01	1.814E-01
28	1992	0.067	1.810E+03	2.296E+03	1.540E+02	1.540E+02	1.186E+03	2.163E-01	2.594E-01
29	1993	0.076	2.842E+03	3.491E+03	2.660E+02	2.660E+02	1.617E+03	2.457E-01	4.073E-01
30	1994	0.151	4.193E+03	4.800E+03	7.250E+02	7.250E+02	1.948E+03	4.870E-01	6.009E-01
31	1995	0.097	5.416E+03	6.182E+03	6.010E+02	6.010E+02	2.127E+03	3.135E-01	7.761E-01
32	1996	0.302	6.942E+03	6.972E+03	2.106E+03	2.106E+03	2.164E+03	9.739E-01	9.949E-01
33	1997	0.579	7.000E+03	6.206E+03	3.594E+03	3.594E+03	2.130E+03	1.867E+00	1.003E+00
34	1998	0.669	5.536E+03	4.843E+03	3.239E+03	3.239E+03	1.956E+03	2.156E+00	7.933E-01
35	1999	0.233	4.252E+03	4.673E+03	1.089E+03	1.089E+03	1.925E+03	7.515E-01	6.094E-01
36	2000	0.216	5.089E+03	5.532E+03	1.194E+03	1.194E+03	2.068E+03	6.959E-01	7.293E-01

37	2001	0.166	5.963E+03	6.509E+03	1.080E+03	1.080E+03	2.150E+03	5.350E-01	8.546E-01
38	2002	0.242	7.033E+03	7.244E+03	1.756E+03	1.756E+03	2.160E+03	7.816E-01	1.008E+00
39	2003	1.068	7.438E+03	5.316E+03	5.676E+03	5.676E+03	1.993E+03	3.443E+00	1.066E+00
40	2004	1.360	3.754E+03	2.508E+03	3.411E+03	3.411E+03	1.259E+03	4.386E+00	5.380E-01
41	2005	0.915	1.602E+03	1.347E+03	1.232E+03	1.232E+03	7.540E+02	2.949E+00	2.296E-01
42	2006	1.081	1.124E+03	8.834E+02	9.550E+02	9.550E+02	5.126E+02	3.486E+00	1.611E-01
43	2007	0.695	6.820E+02	6.479E+02	4.500E+02	4.500E+02	3.832E+02	2.240E+00	9.774E-02
44	2008	0.306	6.152E+02	7.113E+02	2.180E+02	2.180E+02	4.186E+02	9.882E-01	8.816E-02
45	2009	0.076	8.158E+02	1.059E+03	8.000E+01	8.000E+01	6.061E+02	2.436E-01	1.169E-01
46	2010	0.061	1.342E+03	1.730E+03	1.050E+02	1.050E+02	9.375E+02	1.957E-01	1.923E-01
47	2011	0.141	2.174E+03	2.630E+03	3.700E+02	3.700E+02	1.321E+03	4.536E-01	3.116E-01
48	2012	0.028	3.125E+03	3.905E+03	1.080E+02	1.080E+02	1.735E+03	8.917E-02	4.478E-01
49	2013	0.006	4.752E+03	5.757E+03	3.600E+01	3.600E+01	2.082E+03	2.016E-02	6.809E-01
50	2014		6.798E+03				9.742E-01		

Faroe Bank Cod RV Page 3

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Survey CPUE Spring

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Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Resid in yield
1	1965	*	7.650E+02	0.1206	2.341E+03	2.341E+03	0.00000	0.000E+00
2	1966	*	5.919E+02	0.1271	1.909E+03	1.909E+03	0.00000	0.000E+00
3	1967	*	5.219E+02	0.1185	1.569E+03	1.569E+03	0.00000	0.000E+00
4	1968	*	4.452E+02	0.3428	3.871E+03	3.871E+03	0.00000	0.000E+00
5	1969	*	3.869E+02	0.2503	2.457E+03	2.457E+03	0.00000	0.000E+00
6	1970	*	3.534E+02	0.3349	3.002E+03	3.002E+03	0.00000	0.000E+00
7	1971	*	3.347E+02	0.2449	2.079E+03	2.079E+03	0.00000	0.000E+00
8	1972	*	3.323E+02	0.2572	2.168E+03	2.168E+03	0.00000	0.000E+00
9	1973	*	2.648E+02	0.7594	5.101E+03	5.101E+03	0.00000	0.000E+00
10	1974	*	2.131E+02	0.3826	2.068E+03	2.068E+03	0.00000	0.000E+00
11	1975	*	2.132E+02	0.3764	2.036E+03	2.036E+03	0.00000	0.000E+00
12	1976	*	2.091E+02	0.4258	2.258E+03	2.258E+03	0.00000	0.000E+00
13	1977	*	2.276E+02	0.1661	9.590E+02	9.590E+02	0.00000	0.000E+00
14	1978	*	1.967E+02	0.8778	4.379E+03	4.379E+03	0.00000	0.000E+00
15	1979	*	1.648E+02	0.3125	1.306E+03	1.306E+03	0.00000	0.000E+00
16	1980	*	1.896E+02	0.2501	1.203E+03	1.203E+03	0.00000	0.000E+00
17	1981	*	2.213E+02	0.2189	1.229E+03	1.229E+03	0.00000	0.000E+00
18	1982	*	2.365E+02	0.3641	2.184E+03	2.184E+03	0.00000	0.000E+00
19	1983	7.899E+01	2.317E+02	0.3886	2.284E+03	2.284E+03	1.07622	0.000E+00
20	1984	1.752E+02	2.266E+02	0.3809	2.189E+03	2.189E+03	0.25703	0.000E+00
21	1985	1.735E+02	2.062E+02	0.5570	2.913E+03	2.913E+03	0.17264	0.000E+00
22	1986	2.661E+02	1.925E+02	0.3759	1.836E+03	1.836E+03	-0.32352	0.000E+00
23	1987	1.640E+02	1.597E+02	0.8413	3.409E+03	3.409E+03	-0.02653	0.000E+00
24	1988	7.311E+01	9.019E+01	1.2965	2.966E+03	2.966E+03	0.20994	0.000E+00
25	1989	3.655E+01	4.730E+01	1.0584	1.270E+03	1.270E+03	0.25791	0.000E+00
26	1990	2.324E+01	4.302E+01	0.2648	2.890E+02	2.890E+02	0.61577	0.000E+00
27	1991	5.097E+01	6.011E+01	0.1948	2.970E+02	2.970E+02	0.16492	0.000E+00
28	1992	2.843E+01	9.052E+01	0.0671	1.540E+02	1.540E+02	1.15809	0.000E+00
29	1993	2.576E+01	1.376E+02	0.0762	2.660E+02	2.660E+02	1.67576	0.000E+00
30	1994	8.674E+01	1.892E+02	0.1510	7.250E+02	7.250E+02	0.78003	0.000E+00
31	1995	9.017E+01	2.437E+02	0.0972	6.010E+02	6.010E+02	0.99430	0.000E+00
32	1996	*	2.749E+02	0.3020	2.106E+03	2.106E+03	0.00000	0.000E+00
33	1997	5.934E+02	2.446E+02	0.5791	3.594E+03	3.594E+03	-0.88609	0.000E+00
34	1998	6.074E+02	1.909E+02	0.6688	3.239E+03	3.239E+03	-1.15732	0.000E+00
35	1999	4.210E+02	1.842E+02	0.2331	1.089E+03	1.089E+03	-0.82660	0.000E+00
36	2000	3.645E+02	2.181E+02	0.2158	1.194E+03	1.194E+03	-0.51363	0.000E+00

37	2001	1.022E+03	2.566E+02	0.1659	1.080E+03	1.080E+03	-1.38228	0.000E+00
38	2002	4.439E+02	2.856E+02	0.2424	1.756E+03	1.756E+03	-0.44101	0.000E+00
39	2003	8.671E+02	2.096E+02	1.0677	5.676E+03	5.676E+03	-1.42009	0.000E+00
40	2004	*	9.886E+01	1.3602	3.411E+03	3.411E+03	0.00000	0.000E+00
41	2005	*	5.310E+01	0.9146	1.232E+03	1.232E+03	0.00000	0.000E+00
42	2006	6.051E+01	3.483E+01	1.0810	9.550E+02	9.550E+02	-0.55242	0.000E+00
43	2007	5.206E+01	2.554E+01	0.6946	4.500E+02	4.500E+02	-0.71213	0.000E+00
44	2008	6.402E+01	2.804E+01	0.3065	2.180E+02	2.180E+02	-0.82554	0.000E+00
45	2009	5.550E+01	4.175E+01	0.0755	8.000E+01	8.000E+01	-0.28463	0.000E+00
46	2010	5.808E+01	6.820E+01	0.0607	1.050E+02	1.050E+02	0.16063	0.000E+00
47	2011	1.224E+02	1.037E+02	0.1407	3.700E+02	3.700E+02	-0.16591	0.000E+00
48	2012	4.454E+01	1.539E+02	0.0277	1.080E+02	1.080E+02	1.24021	0.000E+00
49	2013	1.390E+02	2.270E+02	0.0063	3.600E+01	3.600E+01	0.49046	0.000E+00

* Asterisk indicates missing value(s).

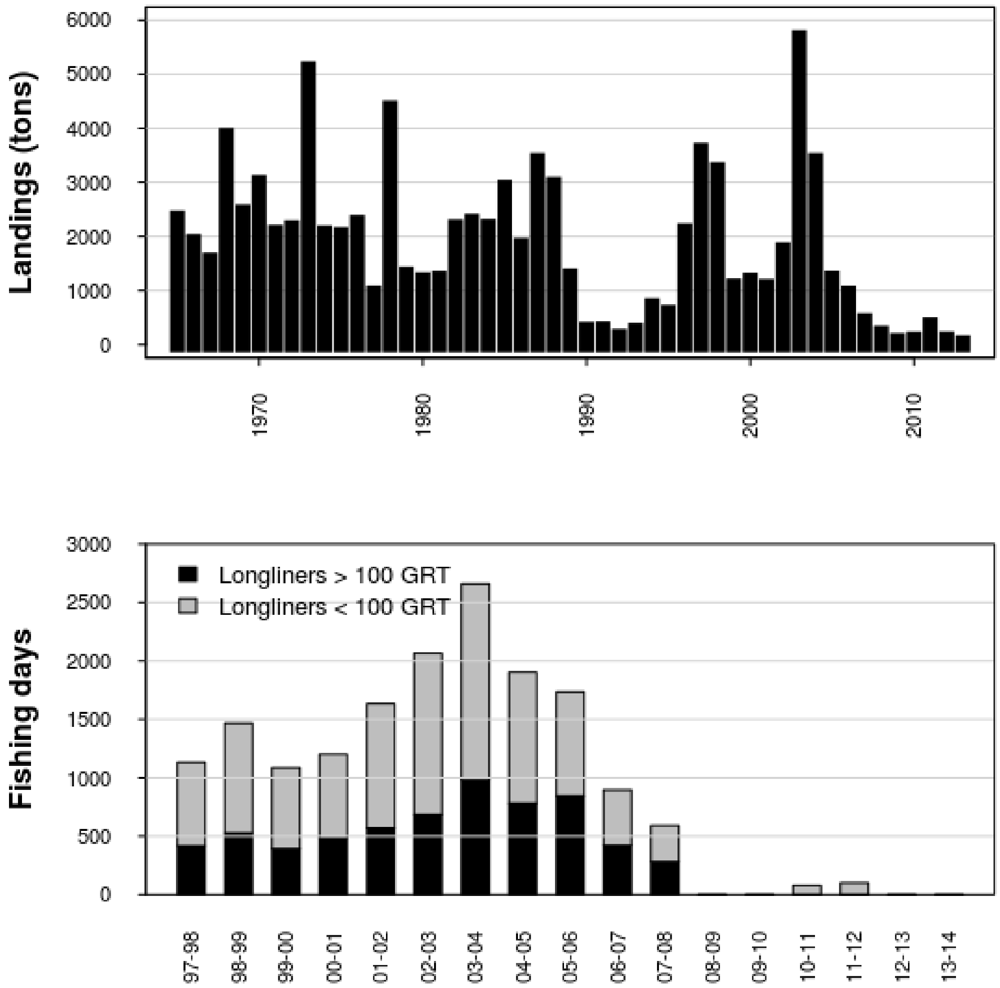

Figure 3.1. Faroe Bank (sub-division Vb2) cod. Reported landings 1965-2013. Since 1992 only catches from Faroese and Norwegian vessels are considered to be taken on Faroe Bank. Lower plot: fishing days (fishing year) 1997-2014 for long line gear type in the Faroe Bank.

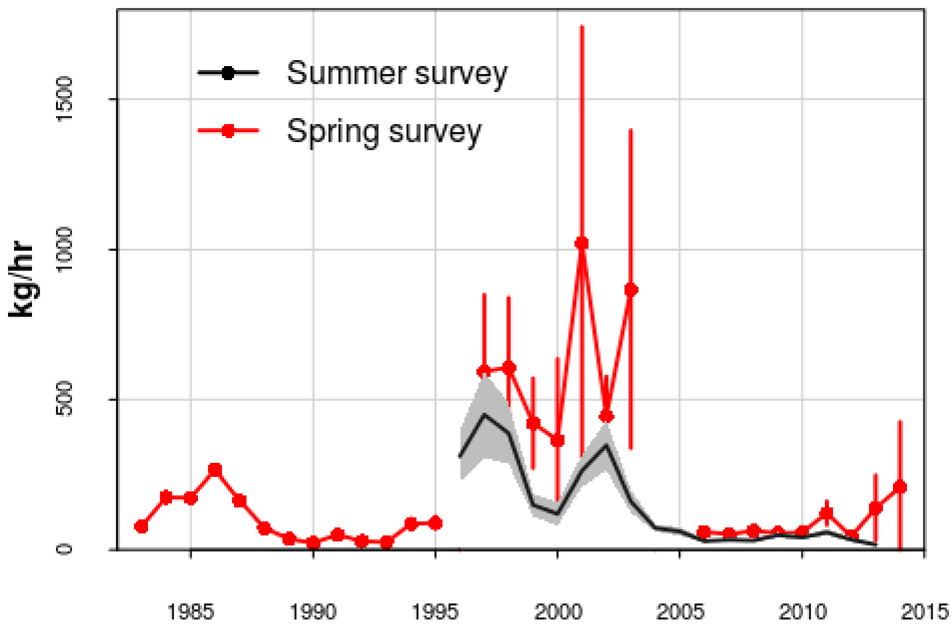

Figure 3.2. Faroe Bank (subdivision Vb2) cod. Catch per unit of effort in the spring groundfish survey (1983-2014) and summer survey (1996-2013). Vertical bars and shaded areas show the standard error in the estimation of indexes.

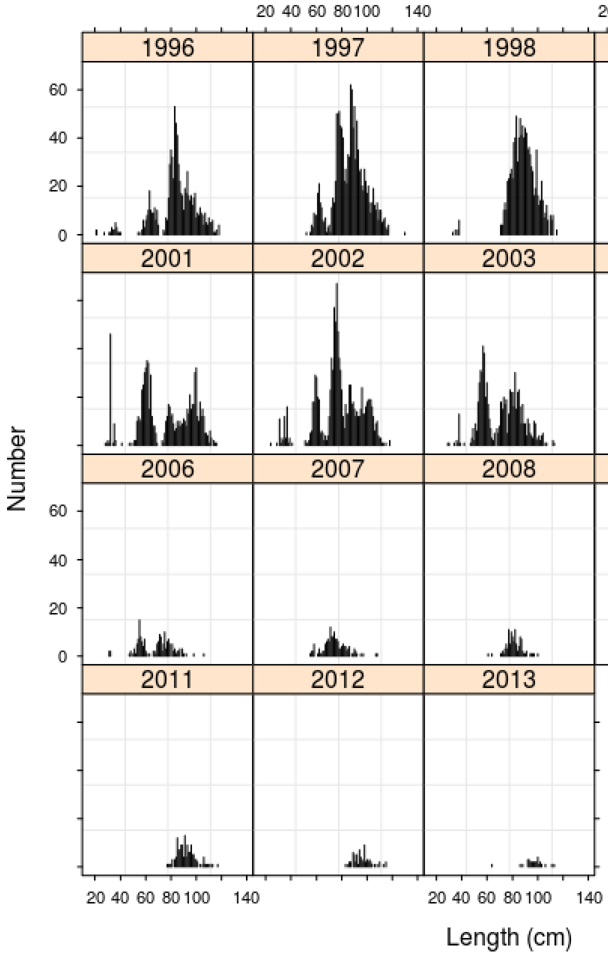

Figure 3.3. Faroe Bank (sub-division Vb2) cod. Length distributions in summer survey (1996-2012)

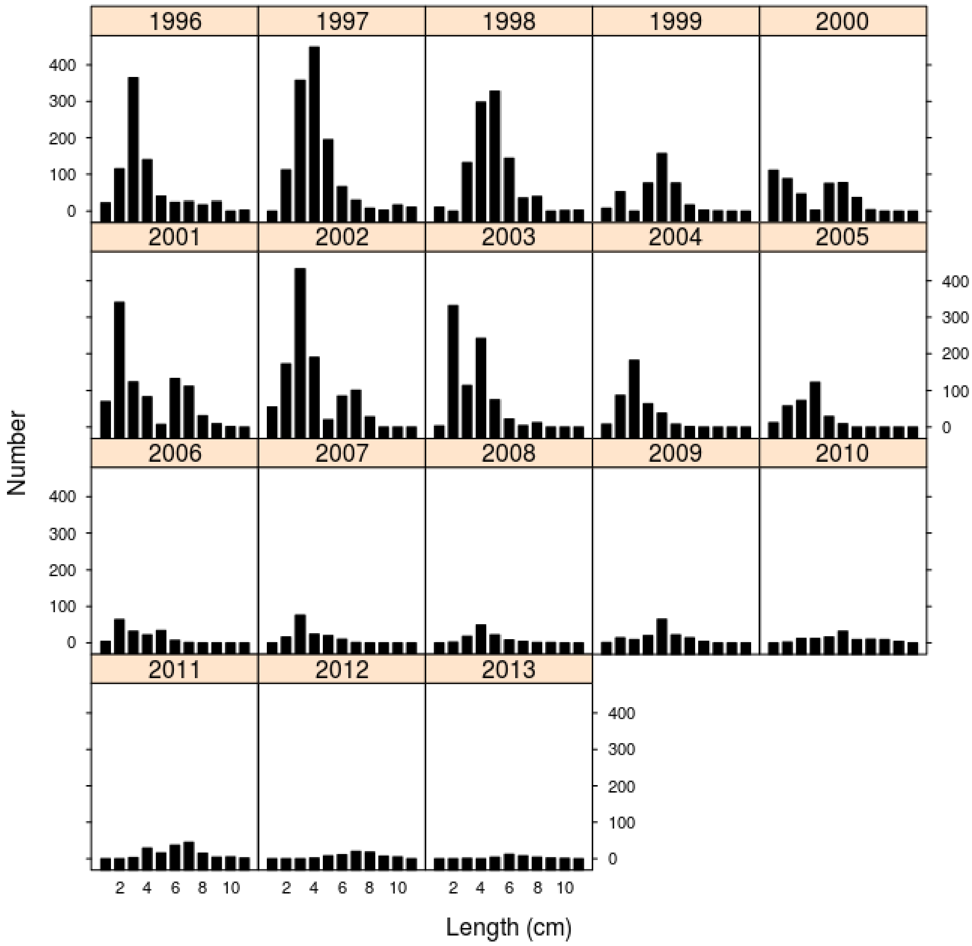

Figure 3.4. Faroe Bank (sub-division Vb2) cod. Age-disaggregated indices in the summer survey (ages 1-11)(1996-2013)

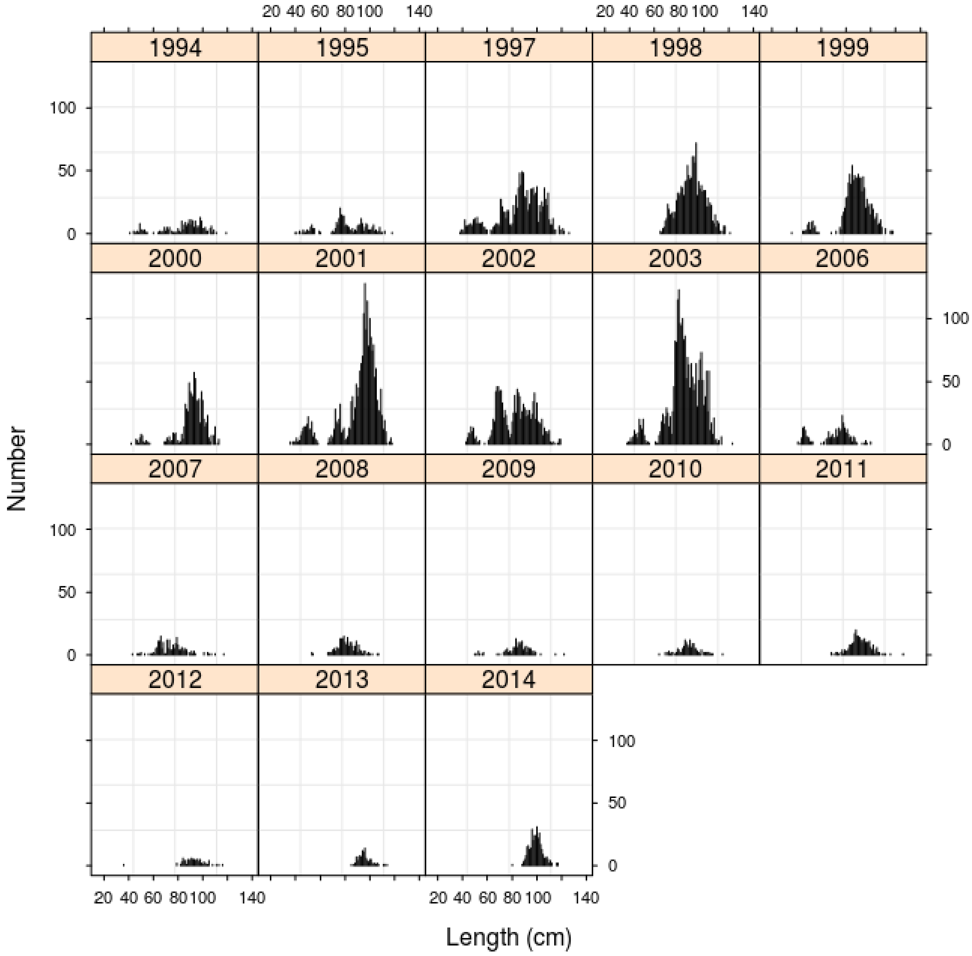

Figure 3.5. Faroe Bank (sub-division Vb2) cod. Length distributions in spring survey (1994-2014). No surveys were conducted in 1996, 2004 and 2005.

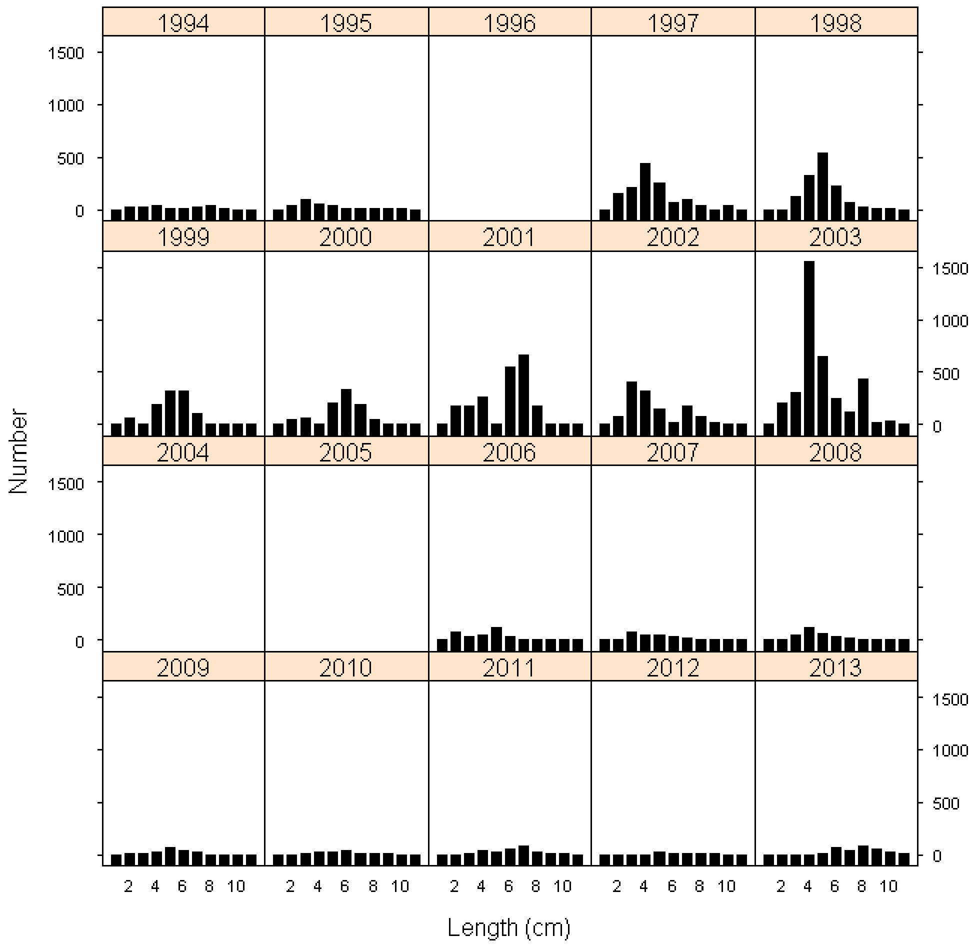

Figure 3.6. Faroe Bank (sub-division Vb2) cod. Age-disaggregated indices in the spring survey (ages 1-11) (1994-2013). No surveys were conducted in 1996, 2004 and 2005.

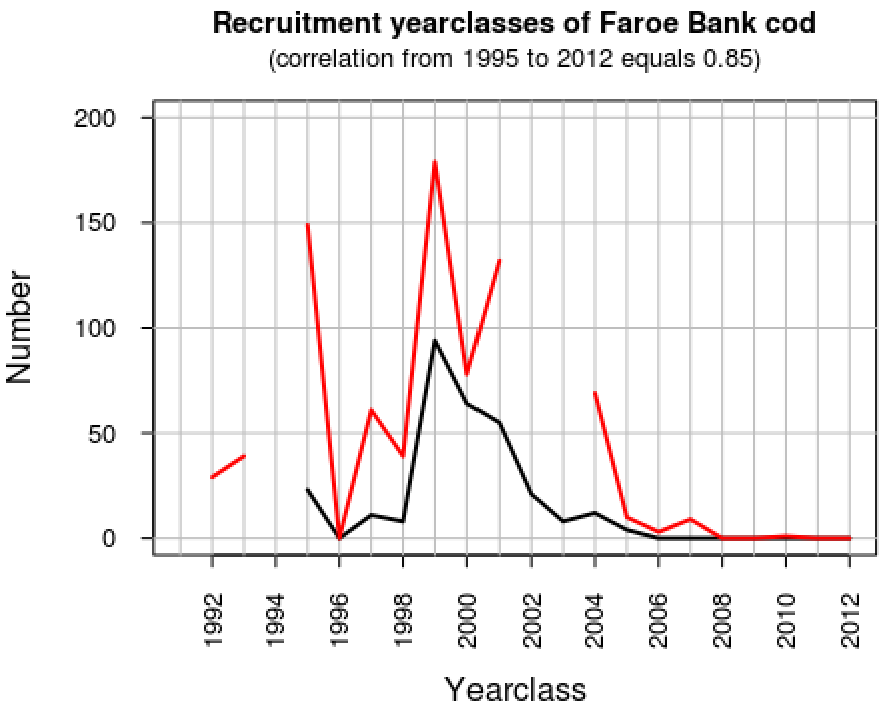

Figure 3.7. Faroe Bank (sub-division Vb2) cod. Correlation between recruitment year classes in both survey indices.

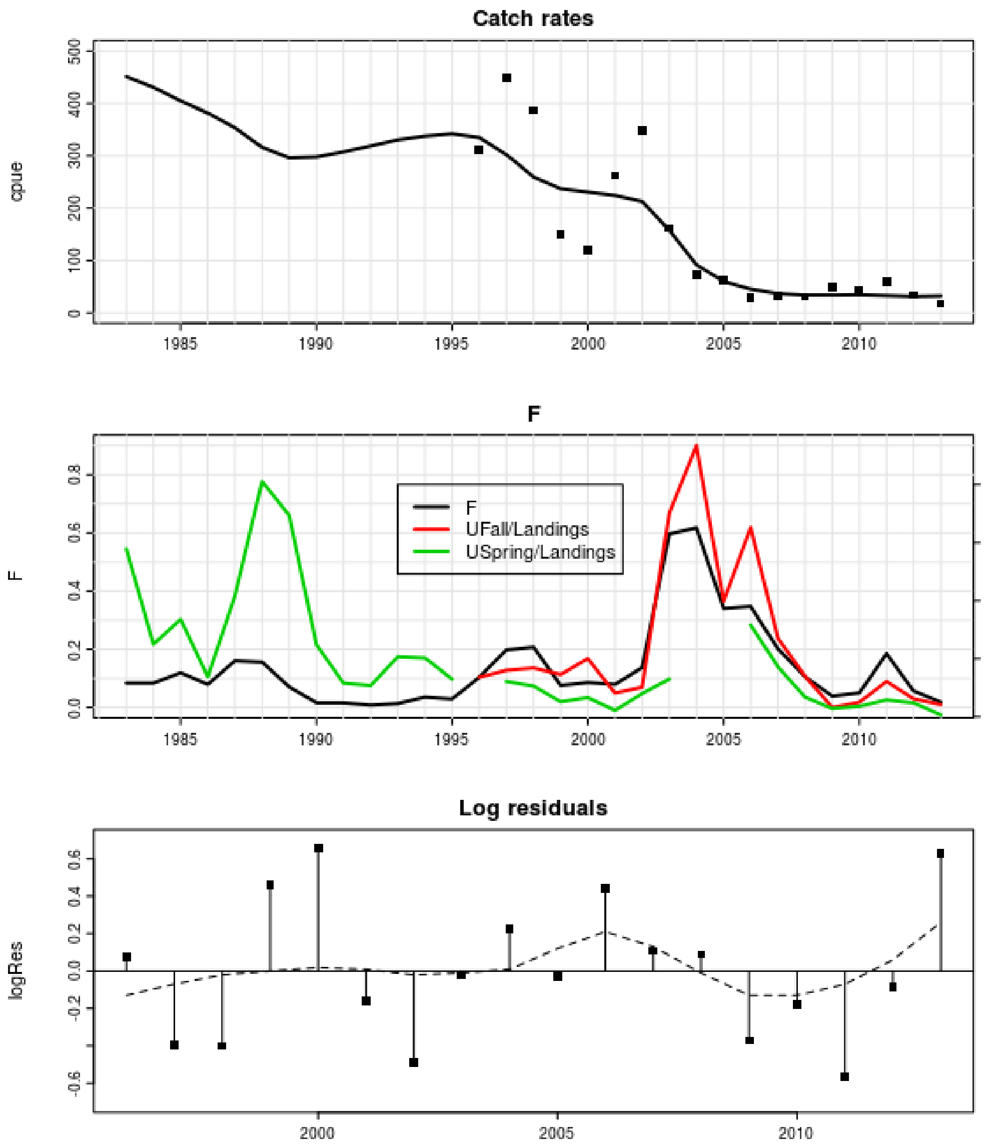

Figure 3.8. Results from the surplus production model using the summer index. Observed (points) and expected catch rates (kg/hour) (top panel). Estimated fishing mortality (black line) and exploitation ratios (ratio of spring index to landings)(green line) (ratio of summer index to landings)(red line)(middle panel). Model residuals in log scale (bottom panel)

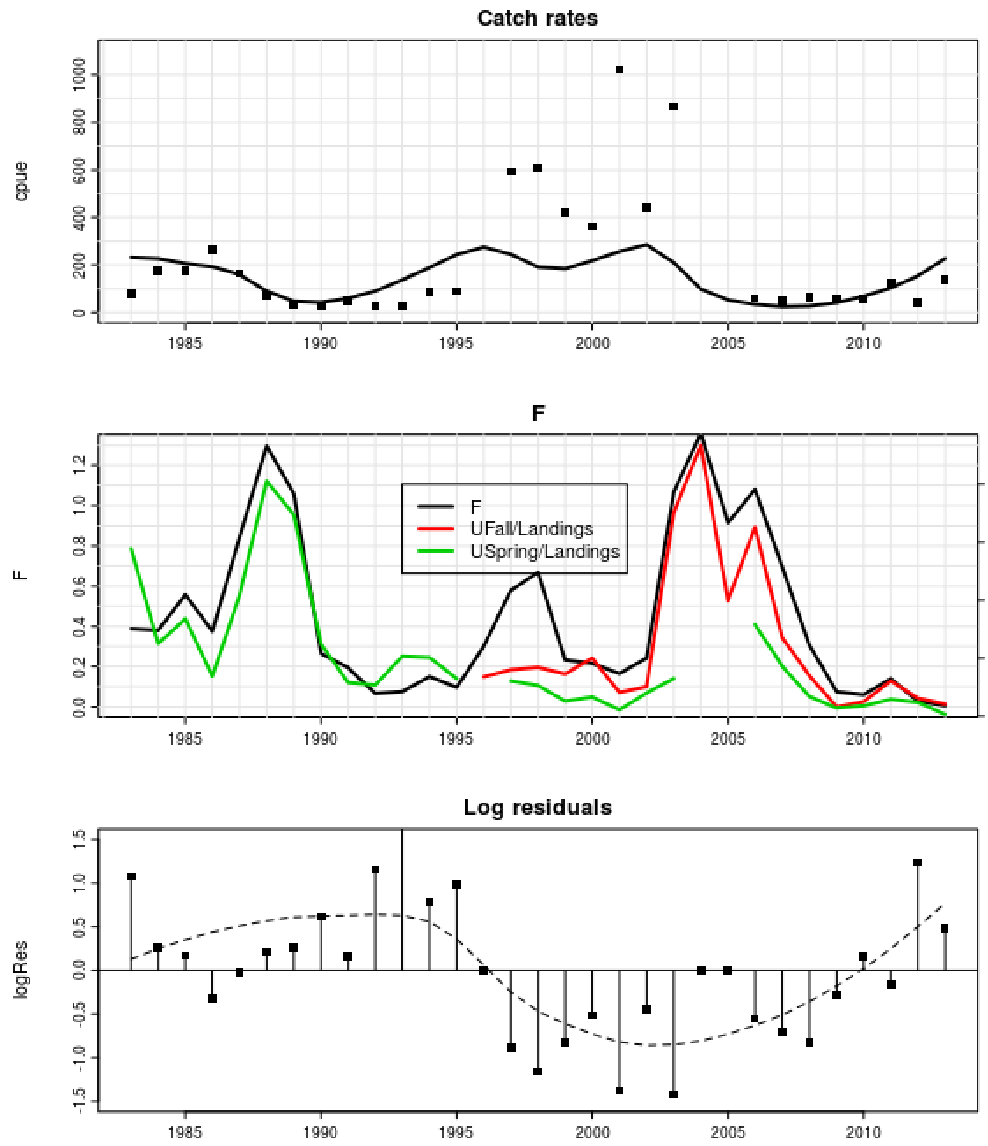

Figure 3.9. Results from the surplus production model using the spring index. Observed (points) and expected catch rates (kg/hour) (top panel). Estimated fishing mortality (black line) and exploitation ratios (ratio of spring index to landings)(green line) (ratio of summer index to landings)(red line)(middle panel). Model residuals in log scale (bottom panel)

4 Faroe Plateau cod

Summary

The input data consisted of the catch-at-age matrix (ages 2-10+ years) for the period 1961-2013 and two age-disaggregated abundance indices obtained from the two Faroese groundfish surveys: the spring survey 1994-2014 (shifted back to the previous year) and the summer survey 1996-2013. The maturities were obtained from the spring survey 1983-2014.

The assessment settings were the same as in the 2013 assessment. An XSA was run and tuned with the two survey indices. The fishing mortality in 2012 (average of ages 3-7 years) was estimated at 0.26, which was lower than the preliminary Fmsy of 0.32. The total stock size (age 2+) in the beginning of 2013 was estimated at 24 600 tonnes and the spawning stock biomass at 22 600 tonnes, which was slightly above the limit biomass of 21 000 tonnes.

The short term prediction until year 2016 showed a slightly increasing total stock biomass to 27 700 and a spawning stock biomass to 24 500 tonnes.

The recruitment seems to be positively correlated with the total stock size of cod. It is, therefore, advised to reduce the fishing mortality so that the stock increases.

4.1 Stock description and management units

Both genetic and tagging data suggest that there are three cod stocks present in Faroese waters: on the Faroe Bank (Division Vb2), on the Faroe Plateau (Division Vb1) and on the Faroe-Iceland Ridge. Cod on the Faroe-Iceland Ridge seem to belong to the cod stock at Iceland, and the WG in 2005 decided to exclude these catches from the catch-at-age calculations. The annex provides more information.

4.2 Scientific data

4.2.1 Trends in landings and fisheries

The landings were obtained from the Fisheries Ministry and Statistics Faroe Islands. The landings are presented in Table 4.2.1 and the working group estimates are presented in Table 4.2.2. The catches on the Faroe-Iceland Ridge, i.e. for the large single trawlers and the large longliners were not included in the catch-at-age calculations. In recent years the longliners have taken the majority of the cod catches (Table 4.2.3).

4.2.2 Catch-at-age

Landings-at-age for 2013 are provided for the Faroese fishery in Table 4.2.4. Faroese landings from most of the fleet categories were sampled (Table 4.2.5). The catch-at-age is shown in Table 4.2.6. Catch curves are shown in Fig. 4.2.1. They show atypical patterns in 1996 and to some extent in 2001-2002 when there appears to be an increase over the previous year for ages where a decrease would normally have been expected. This could be due to catchability for longliners depending on fish growth, causing atypical catch curves for longliners.

4.2.3 Weight-at-age

Mean weight-at-age data are provided for the Faroese fishery in Table 4.2.7. These were calculated using the length/weight relationship based on individual length/weight measurements of samples from the landings. The sum-of-products-check for 2013 showed a discrepancy of 0 %. The weights have increased in recent years (Figure 4.2.2).

4.2.4 Maturity-at-age

The proportion of mature cod by age during the Faroese groundfish surveys carried out during the spawning period (March) are given in Table 4.2.8 and in Figure 4.2.3. Full maturity is generally reached at age 5 or 6, but considerable changes have been observed in the proportion mature for younger ages between years.

4.2.5 Catch, effort and research vessel data

Fisheries independent cpue series

The spring groundfish surveys in Faroese waters with the research vessel *Magnus Heinason* is used as a tuning series. The catch curves showed a normal pattern (Figure 4.2.4), i.e., a decreasing trend after age 5. The stratified mean catch of cod per unit effort (Figure 4.2.5) has been low in the recent years.

The other tuning series used is the Summer Groundfish Survey. The stratified mean catch of cod per unit effort has been low in recent years (Figure 4.2.5). The catch curves (Figure 4.2.6) show that the fish are fully recruited to the survey gear at an age of 4 or 5 years. Both tuning series are presented in Table 4.2.9 and they show that there are few small cod in the stock.

Commercial cpue series

Three commercial cpue series (longliners and pairtrawlers) are also presented (Tables 4.2.10, 4.2.11, and 4.2.12 as well as Figure 4.2.7), although they are not used as tuning series. All these series show that the incoming year classes are small. Note that the small boats (0-25 GRT) operating with longlines and jigging reels close to land have had a relatively higher cpue in recent years compared with the other cpue series and the two tuning series. When that happens, the recruitment of 2-year old cod tends to be low.

4.3 Information from the fishing industry

The sampling of the catches is included in the 'scientific data'. The fishing industry has since 1996 gathered data on the size composition of the landings but this information has not been used in this assessment.

4.4 Methods

This is an update assessment using XSA and the procedure is described in stock annex and the results of the assessment is mostly data-driven implying that there may be limited need to use other assessment methods.

4.5 Reference points

The reference points are dealt with in the general section of Faroese stocks. The PA reference points for Faroe Plateau cod are the following: B_{pa} = 40 kt, B_{lim} = 21 kt, F_{pa} = 0.35 and F_{lim} = 0.68.

The reference points based on the yield-per-recruit curve are the following: F_{max} = 0.25, $F_{0.1}$ = 0.11, F35%SPR = 0.17, F_{med} = 0.41, F_{low} = 0.10, F_{high} = 0.97.

The group adopted in 2011 following preliminary MSY reference points: F_{msy} = 0.32, see section 4.8. The $B_{trigger}$ was set at B_{pa} = 40 kt.

4.6 State of the stock - historical and compared to what is now

Since the current assessment is an update assessment, the same procedure is followed as last year: to use the two surveys for tuning. The commercial series showed a similar overall tendency as the surveys (Figure 4.2.7) but were not used in the tuning. The XSA-run (Table 4.6.1) showed that the fit between the model and the tuning series (logQ residuals, Figure 4.6.1) was rather poor for the young ages and there seemed to be both year class effects and year effects.

The results from the XSA-run shows that fishing mortality (F3-7) has decreased in recent years (down to 0.26 in 2013, Table 4.6.2, Figure 4.6.2), and other measures of fishing mortality have done so as well (Table 4.6.4, Figure 4.6.3). The population numbers, total biomass and spawning stock biomass have been low compared with other years in the series (Table 4.6.3, Table 4.6.4, Figure 4.6.2). The poor state of the stock since 2005 has been due to poor recruitment (not poor individual growth). Prior to that time, extremely weak year classes (< 5 million individuals) were only observed two times, whereas it has happened three times since 2005 (in 2011-2013). There has been a poor relationship between the size of the spawning stock and subsequent recruitment (Figure 4.6.4), since a small spawning stock biomass may be associated with low, as well as high recruitment. The spawning stock biomass in the terminal year was close to Blim and the fishing mortality below Fmsy (Figure 4.6.5).

In order to put the stock status into a wider perspective, we have estimated the stock biomass back to 1906. A cpue series (tonnes per million tonn-hours) for British trawlers 1924-1972 was available from the data presented in Jákupsstovu and Reinert (1994). The cpue series was also used, and explained, in Jones (1966). There was an overlap between the cpue series and the stock assessment for the years 1961-1972. Another cpue series (cwts per day of absence from port, 1 cwt = 50.8 kg) was available for British steam trawlers 1906-1925. The overlap was two years (1924 and 1925) and the 1906-1925 series was scaled to the 1924-1972 series. The results are presented in Figure 4.6.6. There was a decreasing trend in biomass from around 100 thousand tonnes to around 80 tonnes prior to World War II, and since then a decreasing trend from around 100 thousand tonnes to around 50 thousand tonnes. The biomass in 2012-2013 was very low compared with the entire period.

4.7 Short term forecast

4.7.1 Input data

The input data for the short term prediction are given in Table 4.7.1. Note the extremely weak YC2010, YC2011 and YC2012, which were set to the face value from the XSA-run, i.e., according to the Annex. Estimates of stock size (ages 3+) were taken directly from the XSA stock numbers. The exploitation pattern was estimated as the average fishing mortality for 2011-2013 and rescaled to the terminal year (because of the downward trend). The weights at age in the catches in 2014 were estimated from the spring survey (ages 4-6 years). The weights in the catches in 2015 were set to the values in 2014 and the average of 2012-2014 was expected for 2016. The proportion mature in 2013 was set to the 2013 values from the spring groundfish survey, and for 2014-2015 to the average values for 2011-2013.

4.7.2 Results

The landings in 2014 are expected to be 5400 tonnes (Table 4.7.2) (the landings from the Faroe-Icelandic ridge should be added to this figure in order to get the total Faroese landings within the Vb1 area). The spawning stock biomass is expected to be 25 000 tonnes in 2014, 25 000 tonnes in 2015 and eventually 27 000 tonnes in 2016. The current short term prediction is therefore slightly optimistic. The "old" year classes (YC 2008 and YC2009) are still important for the SSB in 2015 and 2016 (Figure 4.7.1).

4.8 Long term forecast

The input to the traditional long term forecast (yield per recruit) is presented in Table 4.8.1 and the result is presented in Table 4.8.2 and Figure 4.8.1.

Single species long term forecasts for Faroe Plateau cod indicated F_{msy} values lower than F_{pa}. An FLR procedure (MSE, Management strategy evaluations using FLR standard packages; a simulation of management and stock response over a 20 yr period) for Faroe Plateau cod indicates that F_{msy} is 0.32. This value (0.32) was adopted by the NWWG 2012 as a preliminary F_{msy}.

4.9 Uncertainties in assessment and forecast

Since there is no incentive to discard fish or misreport catches under the effort management system, the catch figures are considered adequate, as well as the catch-at-age, although the number of otoliths should have been higher.

There was a clear retrospective pattern (Figure 4.9.1), indicating uncertainties in the assessment.

Steingrund et al. (2010) found that the recruitment of Faroe Plateau cod (age 2) could be rather precisely estimated as the ratio between cod biomass (age 3+) and the amount of cannibalistic cod in nearshore waters in June-October the previous year. This approach showed that the YC2010 and YC2011 were extremely weak (Figure 4.9.2).

4.10 Comparison with previous assessment and forecast

The assessment settings were according to the Annex. The 2014 assessment was much in line with the 2013 assessment and forecast (Figure 4.10.1).

4.11 Management plans and evaluations

There is no explicit management plan for this stock. A management system based on number of fishing days, closed areas and other technical measures was introduced in 1996 with the purpose to ensuring sustainable demersal fisheries in Vb. This was before ICES introduced PA and MSY reference values and at the time it was believed that the purpose was achieved, if the total allowable number of fishing days was set such, that on average 33% of the cod exploitable stock in numbers would be harvested annually. This translates into an average F of 0.45, above the F_{pa} of 0.35. ICES considers this to be inconsistent with the PA and MSY approaches. Some work has been done in the Faroes to move away from the Ftarget of 0.45 to be more consistent with the ICES advice.

4.12 Management considerations

The cod stock is assessed to be in a very poor state and is predicted to remain so for the next two years due to poor recruitment. Although the environmental conditions have been rather special since 2007 (lots of mackerel) and may partly be responsible for the poor state of the cod stock, it is certainly necessary to protect the cod stock as much as possible. The reason is not only that it may prevent a total collapse of the stock but also that the stock may recover faster in the future.

Hence, the number of fishing days should be considered and further area closures might be necessary.

4.13 Ecosystem considerations

The effects of the cod-fishery on the ecosystem (e.g. damage on the bottom) are expected to be small since the majority of the cod catch is taken by longlines. Regarding the ecosystem effects on fishing, this issue is partly addressed in the ecological modelling work presented in the overview section for Faroese stocks.

4.14 Regulations and their effects

There seems to be a poor relationship between the number of fishing days and the fishing mortality because of large fluctuations in catchability. Area restrictions may help to reduce fishing mortality, but they cause practical problems for the fishing fleets (e.g. high concentrations of vessels in certain areas). Area restrictions may be best suited to protect certain fish species/sizes in certain areas, whereas the number of fishing days remains the only tool to reduce the overall fishing mortality, given the effort management system.

The area closure (for commercial longliners close to land) introduced in July 2011 and ending in August 2013 to protect young fish has not yet resulted in strong recruitment, since the 2008 year class is below average size, and the 2009-2011 year classes either poor or exceptionally poor.

4.15 Changes in fishing technology and fishing patterns

Fishing effort per fishing day may have increased gradually since the effort management system was introduced in 1996, although little direct quantitative information exists. There also seems to have been substantial increases in fishing power when new vessels are replacing old vessels.

The fishing pattern in recent years has changed in comparison to previous years. The large longliners seem to have exploited the deep areas (> 200 m) to a larger extent (ling and tusk) because the catches in shallower waters of cod and haddock have been so poor – which was also observed in the beginning of the 1990s. This could reduce the fishing mortality on cod and haddock, but the small longliners and jiggers still exploit the shallow areas.

4.16 Changes in the environment

The primary production has been low for a number of years, albeit high in 2008 to 2010, but it is not believed that this has any relationship with a change in the environment. The temperature has been high in recent years, which may have a negative effect on cod recruitment (Planque and Fredou, 1999).

4.17 References

ICES, 2009. Report of the North Western Working Group. ICES CM 2009/ACOM: 4. 655 pp.

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Steingrund, P., Mouritsen, R., Reinert, J., Gaard, E., and Hátún, H. 2010. Total stock size and cannibalism regulate recruitment in cod (Gadus morhua) on the Faroe Plateau. ICES Journal of Marine Science, 67: 111-124.

Table 4.2.1. Faroe Plateau cod (sub-division Vb1). Nominal catch (t) by countries, as officially reported to ICES.

	Denmark	Faroe Islands	France	Germany	Iceland	Norway	Greenland	Portugal	UK (E/W/NI)	UK (Scotland)	United Kingdom	Total
1986	8	34,492	4	8		83	-		-	-	-	34,595
1987	30	21,303	17	12		21	-		8	-	-	21,391
1988	10	22,272	17	5		163	-		-	-	-	22,467
1989	-	20,535	-	7		285	-		-	-	-	20,827
1990	-	12,232	-	24		124	-		-	-	-	12,380
1991	-	8,203	- [1]	16		89	-		1	-	-	8,309
1992	-	5,938	3 [2]	12		39	-		74	-	-	6,066
1993	-	5,744	1 [2]	+		57	-		186	-	-	5,988
1994	-	8,724	-	2		36	-		56	-	-	8,818
1995	-	19,079	2 [2]	2		38	-		43	-	-	19,164
1996	-	39,406	1 [2]	+		507	-		126	-	-	40,040
1997	-	33,556	-	+		410	-		61 [2]	-	-	34,027
1998	-	23,308	- *	-		405	-		27 [2]	-	-	23,740
1999	-	19,156	- *	39	-	450	-		51	-		19,696
2000		0	1	2	-	374	-		18	-		395
2001		29,762	9 [2]	9	-	531 *	-		50	-		30,361
2002		40,602	20	6	5	573			42	-		41,248
2003		30,259	14	7	-	447	-		15	-		30,742
2004		17,540	2	3 [2]		414		1	15	-		17,975
2005		13,556	-			201			24	-		13,781
2006		11,629	7	1 [2]		49	5		1	-		11,692
2007		9,905	1 [2]			71	7		3	358		10,347
2008		9,394	1			40				383		9,818
2009		10,736	1			14	7			300		11,058
2010		13,878	1			10				312		14,201
2011		11,348	-									11,348
2012		8,437	0		28							8,465
2013 *		5,706	0		20		2					5,728

* Preliminary, 1) Included in Vb2, 2) Reported as Vb.

Table 4.2.2. Faroe Plateau cod (sub-division Vb1). Nominal catch (t) used in the assessment.

		Faroese catches:				Catches reported as Vb2:			Foreign catches:				Used in the
	Officially reported	in Vb1	Corrections in Vb1	on Faroe-Iceland ridge	in IIA within Faroe area jurisdiction	UK (E/W/NI)	UK (Scotland)	UK	French [2]	Greenland[2]	Russia[2]	UK[2]	assessment
1986	34595												34595
1987	21391												21391
1988	22467				715								23182
1989	20827				1229				12				22068
1990	12380				1090	-	205		17				13692
1991	8309				351	-	90						8750
1992	6066				154	+	176						6396
1993	5988					1	118						6107
1994	8818					1	227						9046
1995	19164	3330 [3]				-	551						23045
1996	40040					-	382						40422
1997	34027					-	277						34304
1998	23740					-	265						24005
1999	19696			-1600		-	210						18306
2000	395	21793 *		-1400		-	245						21033
2001	30361		-1766	-700		-	288						28183
2002	41248		-2409	-600		-	218	-					38457
2003	30742		-1795	-4700		-	254	-					24501
2004	17975		-1041	-4000		-	244	-					13178
2005	13781		-804	-4200			1129	-					9906
2006	11692		-690	-800			278						10480
2007	10347		-588	-1800			53			6			8018
2008	9818		-557	-1828			32						7465
2009	11058		-637	-487			38			26	4		10002
2010	14201		-823	-680			54			5			12757
2011	11348		-673	-918						3			9760
2012	8465		-500	-760						5			7210
2013	5728 *		-339	-387							0.2		5002

*) Preliminary, 1) In order to be consistent with procedures used previous years, 2) Reported to Faroese Coastal Guard, 3) expected misreporting/discard.

Table 4.2.3. Faroe Plateau cod (sub-division Vb1). The landings of Faroese fleets (in percents) of total catch (t). Note that the catches on the Faroe-Iceland ridge (mainly belonging to single trawlers > 1000 HP) are included in this table, but excluded in the XSA-run.

Year	Open boats	Longliners <100 GRT	Singletrawl <400 HP	Gill net	Jiggers	Singletrawl 400-1000 HP	Singletrawl >1000 HP	Pairtrawl <1000 HP	Pairtrawl >1000 HP	Longliners >100 GRT	Industrial trawlers	Others	Faroe catch Round.weight
1985	16.0	27.2	6.7	0.6	4.3	7.9	11.2	12.3	5.6	7.5	0.2	0.6	39,422
1986	9.5	15.1	5.1	1.3	2.9	6.2	8.5	29.6	14.9	5.1	0.4	1.3	34,492
1987	9.9	14.8	6.2	0.5	2.9	6.7	8.0	26.0	14.5	9.9	0.5	0.1	21,303
1988	2.6	13.8	4.9	2.6	7.5	7.4	6.8	25.3	15.6	12.7	0.6	0.2	22,272
1989	4.4	29.0	5.7	3.2	9.3	5.7	5.5	10.5	8.3	17.7	0.7	0.0	20,535
1990	3.9	35.5	4.8	1.4	8.2	3.7	4.3	7.1	10.5	19.6	0.6	0.2	12,232
1991	4.3	31.6	7.1	2.0	8.0	3.4	4.7	8.3	12.9	17.2	0.6	0.1	8,203
1992	2.6	26.0	6.9	0.0	7.0	2.2	3.6	12.0	20.8	13.4	5.0	0.4	5,938
1993	2.2	16.0	15.4	0.0	9.0	4.1	3.6	14.2	21.7	12.6	0.8	0.4	5,744
1994	3.1	13.4	9.6	0.5	19.2	2.7	5.3	8.3	23.7	13.7	0.5	0.1	8,724
1995	4.2	17.9	6.5	0.3	24.9	4.1	4.7	6.4	12.3	18.5	0.1	0.0	19,079
1996	4.0	19.0	4.0	0.0	20.0	3.0	2.0	8.0	19.0	21.0	0.0	0.0	39,406
1997	3.1	28.4	4.4	0.5	9.8	5.1	2.9	4.8	11.3	29.7	0.0	0.1	33,556
1998	2.4	31.2	6.0	1.3	6.5	6.3	5.5	3.1	8.6	29.1	0.1	0.0	23,308
1999	2.7	24.0	5.4	2.3	5.4	5.2	11.8	6.4	14.5	21.9	0.4	0.1	19,156
2000	2.3	19.3	9.1	0.9	10.5	9.6	12.7	5.7	13.9	15.7	0.1	0.1	21,793
2001	3.7	28.3	7.4	0.2	15.6	6.4	6.4	5.2	9.2	17.8	0.0	0.0	28,838
2002	3.8	32.9	5.8	0.3	9.9	6.7	6.6	2.5	7.2	24.4	0.0	0.0	38,347
2003	4.9	28.7	4.0	1.5	7.4	3.0	14.4	2.2	7.4	26.5	0.0	0.0	29,382
2004	4.4	31.1	2.1	0.5	6.6	1.6	12.9	2.2	11.7	26.8	0.0	0.0	16,772
2005	3.7	27.5	5.1	0.8	5.4	2.4	28.1	1.7	6.4	18.8	0.0	0.0	15,472
2006	6.2	35.0	3.2	0.2	7.1	1.6	12.9	2.5	6.6	24.7	0.0	0.0	8,636
2007	5.1	28.2	2.6	0.3	6.1	1.7	17.5	1.7	4.8	32.0	0.0	0.0	8,866
2008	5.1	32.7	4.7	0.7	6.4	3.2	14.6	1.0	3.1	28.6	0.0	0.0	7,666
2009	6.9	41.6	4.3	0.3	10.1	2.5	1.9	2.8	6.5	23.0	0.0	0.0	7,146
2010	6.2	31.9	2.7	0.0	12.6	1.3	1.4	3.4	9.6	30.8	0.0	0.0	10,258
2011	3.6	26.5	3.4	0.1	6.7	1.3	1.4	3.1	21.9	31.9	0.0	0.0	9,502
2012	2.7	23.5	4.9	0.0	5.3	1.1	2.6	5.3	21.5	32.9	0.0	0.0	6,378
2013	4.6	26.3	6.3	0.2	8.0	2.3	2.0	4.0	15.9	30.2	0.0	0.0	4,749
Average	4.8	26.1	5.7	0.8	9.1	4.1	7.7	7.8	12.4	21.2	0.4	0.1	

Table 4.2.4. Faroe Plateau cod (sub-division Vb1). Catch in numbers at age per fleet in terminal year. Numbers are in thousands and the catch is in tonnes, gutted weight.

Age\Fleet	Open boats	Longliners < 100 GRT	Jiggers	Single trwl 0-399HP	Single trwl 400-1000HP	Single trwl > 1000 HP	Pair trwl 700-999 HP	Pair trwl > 1000 HP	Longliners > 100 GRT	Gillnetters	Others (scaling)	Catch-at-age
2	0	51	7	0	3	0	0	3	1	0	-3	62
3	0	137	25	0	19	2	1	9	16	0	-15	194
4	0	178	44	0	42	16	5	55	61	0	-29	372
5	0	296	77	0	88	29	8	99	109	0	-49	657
6	0	66	19	0	22	12	3	38	52	0	-16	196
7	0	11	4	0	6	2	1	7	17	0	-5	43
8	0	10	2	0	2	1	0	2	12	0	-1	28
9	0	5	2	0	2	0	0	2	6	0	0	17
10+	0	1	0	0	0	0	0	1	4	0	0	6
Sum	0	755	180	0	184	62	18	216	278	0	-118	1575
G.weight	0	1323	345	0	366	201	59	680	678	0	854	4506

Others include gillnetters, industrial bottom trawlers, longlining for halibut, foreign fleets, **and scaling to correct catch.**

Gutted total catch is calculated as round weight divided by 1.11.

Table 4.2.5. Faroe Plateau cod (sub-division Vb1). Number of samples, lengths, otoliths, and individual weights in terminal year.

Fleet	Size	Samples	Lengths	Otoliths	Weights
Open boats		5	696	180	696
Longliners	<100 GRT	2	389	59	389
Longliners	>100 GRT	15	2,995	420	2,995
Jiggers		0	0	0	0
Gillnetters		0	0	0	0
Sing. traw lers	<400 HP	0	0	0	0
Sing. traw lers	400-1000 HP	17	3,604	540	3,604
Sing. traw lers	>1000 HP	0	0	0	0
Pair traw lers	<1000 HP	2	385	60	385
Pair traw lers	>1000 HP	26	4,815	779	4,252
Total		67	12,884	2,038	12,321

Table 4.2.6. Faroe Plateau cod (sub-division Vb1). Catch in numbers at age used in the XSA model.

	Age								
Year	1	2	3	4	5	6	7	8	9	10+
1961	0	3093	2686	1331	1066	232	372	78	29	0
1962	0	4424	2500	1255	855	481	93	94	22	0
1963	0	4110	3958	1280	662	284	204	48	30	0
1964	0	2033	3021	2300	630	350	158	79	41	0
1965	0	852	3230	2564	1416	363	155	48	63	0
1966	0	1337	970	2080	1339	606	197	104	33	0
1967	0	1609	2690	860	1706	847	309	64	27	0
1968	0	1529	3322	2663	945	1226	452	105	11	0
1969	0	878	3106	3300	1538	477	713	203	92	0
1970	0	402	1163	2172	1685	752	244	300	44	0
1971	0	328	757	821	1287	1451	510	114	179	0
1972	0	875	1176	810	596	1021	596	154	25	0
1973	0	723	3124	1590	707	384	312	227	120	97
1974	0	2161	1266	1811	934	563	452	149	141	91
1975	0	2584	5689	2157	2211	813	295	190	118	150
1976	0	1497	4158	3799	1380	1427	617	273	120	186
1977	0	425	3282	6844	3718	788	1160	239	134	9
1978	0	555	1219	2643	3216	1041	268	201	66	56
1979	0	575	1732	1673	1601	1906	493	134	87	38
1980	0	1129	2263	1461	895	807	832	339	42	18
1981	0	646	4137	1981	947	582	487	527	123	55
1982	0	1139	1965	3073	1286	471	314	169	254	122
1983	0	2149	5771	2760	2746	1204	510	157	104	102
1984	0	4396	5234	3487	1461	912	314	82	34	66
1985	0	998	9484	3795	1669	770	872	309	65	80
1986	0	210	3586	8462	2373	907	236	147	47	38
1987	0	257	1362	2611	3083	812	224	68	69	26
1988	0	509	2122	1945	1484	2178	492	168	33	25
1989	0	2237	2151	2187	1121	1026	997	220	61	9
1990	0	247	2892	1504	865	410	298	295	51	26
1991	0	192	451	2152	622	303	142	93	53	24
1992	0	205	455	466	911	293	132	53	30	34
1993	0	120	802	603	222	329	96	33	22	25
1994	0	573	788	1062	532	125	176	39	23	16
1995	0	2615	2716	2008	1012	465	118	175	44	49
1996	0	351	5164	4608	1542	1526	596	147	347	47
1997	0	200	1278	6710	3731	657	639	170	51	120
1998	0	455	745	1558	5140	1529	159	118	28	25
1999	0	1185	993	799	1107	2225	439	59	17	7
2000	0	2091	2637	782	426	674	809	104	7	1
2001	0	3912	3759	2101	367	367	718	437	36	6
2002	0	2079	7283	3372	1671	470	533	413	290	7
2003	0	678	2128	4572	1927	640	177	91	115	20

	Age								
Year	1	2	3	4	5	6	7	8	9	10+
2004	0	100	691	1263	2105	736	240	65	42	37
2005	0	494	592	877	1122	823	204	41	19	30
2006	0	1182	1168	499	706	852	355	81	11	3
2007	0	540	1309	771	337	308	273	91	21	3
2008	0	293	776	799	439	191	160	159	58	20
2009	0	875	2267	863	619	297	85	55	43	17
2010	0	2113	2034	861	468	481	178	58	33	38
2011	0	330	2360	1242	367	189	127	50	19	2
2012	0	49	518	1348	556	201	99	69	25	22
2013	0	62	194	372	657	196	43	28	17	6

Table 4.2.7. Faroe Plateau cod (sub-division Vb1). Mean weight at age (kg) in the catches.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
1961	0	1.080	2.220	3.450	4.690	5.520	7.090	9.910	8.030	10.270
1962	0	1.000	2.270	3.350	4.580	4.930	9.080	6.590	6.660	10.270
1963	0	1.040	1.940	3.510	4.600	5.500	6.780	8.710	11.720	10.820
1964	0	0.970	1.830	3.150	4.330	6.080	7.000	6.250	6.190	14.390
1965	0	0.920	1.450	2.570	3.780	5.690	7.310	7.930	8.090	11.110
1966	0	0.980	1.770	2.750	3.510	4.800	6.320	7.510	10.340	11.650
1967	0	0.960	1.930	3.130	4.040	4.780	6.250	7.000	11.010	10.690
1968	0	0.880	1.720	3.070	4.120	4.650	5.500	7.670	10.950	9.280
1969	0	1.090	1.800	2.850	3.670	4.890	5.050	7.410	8.660	14.390
1970	0	0.960	2.230	2.690	3.940	5.140	6.460	10.310	7.390	9.340
1971	0	0.810	1.800	2.980	3.580	3.940	4.870	6.480	6.370	10.220
1972	0	0.660	1.610	2.580	3.260	4.290	4.950	6.480	6.900	11.550
1973	0	1.110	2.000	3.410	3.890	5.100	5.100	6.120	8.660	7.570
1974	0	1.080	2.220	3.440	4.800	5.180	5.880	6.140	8.630	7.620
1975	0	0.790	1.790	2.980	4.260	5.460	6.250	7.510	7.390	8.170
1976	0	0.940	1.720	2.840	3.700	5.260	6.430	6.390	8.550	13.620
1977	0	0.870	1.790	2.530	3.680	4.650	5.340	6.230	8.380	10.720
1978	0	1.112	1.385	2.140	3.125	4.363	5.927	6.348	8.715	12.229
1979	0	0.897	1.682	2.211	3.052	3.642	4.719	7.272	8.368	13.042
1980	0	0.927	1.432	2.220	3.105	3.539	4.392	6.100	7.603	9.668
1981	0	1.080	1.470	2.180	3.210	3.700	4.240	4.430	6.690	10.000
1982	0	1.230	1.413	2.138	3.107	4.012	5.442	5.563	5.216	6.707
1983	0	1.338	1.950	2.403	3.107	4.110	5.020	5.601	8.013	8.031
1984	0	1.195	1.888	2.980	3.679	4.470	5.488	6.466	6.628	10.981
1985	0	0.905	1.658	2.626	3.400	3.752	4.220	4.739	6.511	10.981
1986	0	1.099	1.459	2.046	2.936	3.786	4.699	5.893	9.700	8.815
1987	0	1.093	1.517	2.160	2.766	3.908	5.461	6.341	8.509	9.811
1988	0	1.061	1.749	2.300	2.914	3.109	3.976	4.896	7.087	8.287
1989	0	1.010	1.597	2.200	2.934	3.468	3.750	4.682	6.140	9.156
1990	0	0.945	1.300	1.959	2.531	3.273	4.652	4.758	6.704	8.689

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
1991	0	0.779	1.271	1.570	2.524	3.185	4.086	5.656	5.973	8.147
1992	0	0.989	1.364	1.779	2.312	3.477	4.545	6.275	7.619	9.725
1993	0	1.155	1.704	2.421	3.132	3.723	4.971	6.159	7.614	9.587
1994	0	1.194	1.843	2.613	3.654	4.584	4.976	7.146	8.564	8.796
1995	0	1.218	1.986	2.622	3.925	5.180	6.079	6.241	7.782	8.627
1996	0	1.016	1.737	2.745	3.800	4.455	4.978	5.270	5.593	7.482
1997	0	0.901	1.341	1.958	3.012	4.158	4.491	5.312	6.172	7.056
1998	0	1.004	1.417	1.802	2.280	3.478	5.433	5.851	7.970	8.802
1999	0	1.050	1.586	2.350	2.774	3.214	5.496	8.276	9.129	10.652
2000	0	1.416	2.170	3.187	3.795	4.048	4.577	8.182	11.895	13.009
2001	0	1.164	2.076	3.053	3.976	4.394	4.871	5.563	7.277	12.394
2002	0	1.017	1.768	2.805	3.529	4.095	4.475	4.650	6.244	7.457
2003	0	0.820	1.362	2.127	3.329	4.092	4.670	6.000	6.727	6.810
2004	0	1.037	1.154	1.693	2.363	3.830	5.191	6.326	7.656	9.573
2005	0	0.986	1.373	1.760	2.293	3.138	5.287	8.285	8.703	9.517
2006	0	0.839	1.304	1.988	2.386	3.330	4.691	7.635	9.524	11.990
2007	0	0.937	1.324	1.970	3.076	3.529	4.710	6.464	9.461	9.509
2008	0	1.209	1.478	2.104	2.714	3.804	4.669	5.915	7.233	9.559
2009	0	0.805	1.431	2.287	2.723	3.435	5.081	6.281	8.312	9.959
2010	0	1.049	1.642	2.400	3.212	3.678	4.774	5.973	7.094	9.800
2011	0	0.815	1.367	2.413	3.493	4.525	5.076	6.631	6.863	10.089
2012	0	1.007	1.315	1.893	3.102	4.279	5.573	5.871	7.482	9.206
2013	0	1.011	1.527	2.528	3.18	4.672	6.776	6.966	9.028	10.324

Table 4.2.8. Faroe Plateau cod (sub-division Vb1). Proportion mature at age. From 1961-1982 the average from 1983-1996 is used (as it was used in the 1990s).

	Age								
Year	1	2	3	4	5	6	7	8	9	10+
1961	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1962	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1963	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1964	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1965	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1966	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1967	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1968	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1969	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1970	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1971	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1972	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1973	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1974	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1975	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1976	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1977	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1978	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1979	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1980	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1981	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1982	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1983	0.00	0.03	0.71	0.93	0.94	1.00	1.00	1.00	1.00	1.00
1984	0.00	0.07	0.96	0.98	0.97	1.00	1.00	1.00	1.00	1.00
1985	0.00	0.00	0.50	0.96	0.96	1.00	1.00	1.00	1.00	1.00
1986	0.00	0.00	0.38	0.93	1.00	1.00	0.96	0.94	1.00	1.00
1987	0.00	0.00	0.67	0.91	1.00	1.00	1.00	1.00	1.00	1.00
1988	0.00	0.06	0.72	0.90	0.97	1.00	1.00	1.00	1.00	1.00
1989	0.00	0.05	0.54	0.98	1.00	1.00	1.00	1.00	1.00	1.00
1990	0.00	0.00	0.68	0.90	0.99	0.96	0.98	1.00	1.00	1.00
1991	0.00	0.00	0.72	0.86	1.00	1.00	1.00	1.00	1.00	1.00
1992	0.00	0.06	0.50	0.82	0.98	1.00	1.00	1.00	1.00	1.00
1993	0.00	0.03	0.73	0.78	0.91	0.99	1.00	1.00	1.00	1.00
1994	0.00	0.05	0.33	0.88	0.96	1.00	0.96	1.00	1.00	1.00
1995	0.00	0.09	0.35	0.33	0.66	0.97	1.00	1.00	1.00	1.00
1996	0.00	0.04	0.43	0.74	0.85	0.94	1.00	1.00	1.00	1.00
1997	0.00	0.00	0.64	0.91	0.97	1.00	1.00	1.00	1.00	1.00
1998	0.00	0.00	0.62	0.90	0.99	0.99	1.00	1.00	1.00	1.00
1999	0.00	0.02	0.43	0.88	0.98	1.00	1.00	1.00	1.00	1.00
2000	0.00	0.02	0.39	0.69	0.92	0.99	1.00	1.00	1.00	1.00
2001	0.00	0.07	0.47	0.86	0.94	1.00	1.00	1.00	1.00	1.00
2002	0.00	0.04	0.37	0.76	0.97	0.93	0.97	1.00	1.00	1.00

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
2003	0.00	0.00	0.29	0.79	0.88	0.98	1.00	1.00	1.00	1.00
2004	0.00	0.00	0.51	0.78	0.92	0.89	0.87	1.00	1.00	1.00
2005	0.00	0.05	0.66	0.90	0.93	0.98	0.92	1.00	1.00	1.00
2006	0.00	0.04	0.59	0.80	0.99	0.99	1.00	1.00	1.00	1.00
2007	0.00	0.00	0.47	0.78	0.91	0.99	0.97	1.00	1.00	1.00
2008	0.00	0.10	0.78	0.91	0.90	0.95	1.00	1.00	1.00	1.00
2009	0.00	0.09	0.61	0.81	0.96	0.94	0.96	1.00	1.00	1.00
2010	0.00	0.08	0.61	0.77	0.94	0.97	1.00	1.00	1.00	1.00
2011	0.00	0.06	0.51	0.69	0.84	0.93	0.98	1.00	1.00	1.00
2012	0.00	0.00	0.63	0.85	0.94	0.97	1.00	1.00	1.00	0.83
2013	0.00	0.24	0.82	0.95	0.98	1.00	1.00	1.00	1.00	1.00

Table 4.2.9. Faroe Plateau cod (sub-division Vb1). Summer survey tuning series (number of individuals per 200 stations) and spring survey tuning series (number of individuals per 100 stations) used as tuning series in the XSA model.

FAROE PLATEAU COD (ICES SUBDIVISION VB1) Surveys_revised.TXT

102

SUMMER SURVEY

1996 2013

1 1 0.6 0.7

2 8

200	707	6576.5	3705.1	1298.1	701.5	233.1	48.5
200	512.7	1500.7	6754.6	1466.6	178.4	137.8	30.1
200	524.9	505.1	979.4	3675.2	902.6	50	37
200	373.3	1256.8	753.1	675.3	1422.5	238	40.4
200	1364.1	1153.3	673.8	309.6	436.9	600.8	35.4
200	3422.1	2458.7	1537.8	415.9	234.8	283	242
200	2326	5562.9	1816.5	810.8	147.7	83.3	69.5
200	354	1038.8	2209.2	565.9	123.4	17.6	11.9
200	437	839.9	1080.2	1550.2	344.2	80.2	25.7
200	616.5	735.1	872.1	1166.3	756	142.5	44.8
200	978.4	684.2	349.3	312	256.6	123	28.2
200	234.1	448.7	314.2	179.7	134.5	75.9	30.9
200	68.8	370.1	328	401.2	160.1	52.4	27.5
200	428.2	1980.6	817.7	551.4	393.1	132.1	47.8
200	1239.3	1543.9	1012	363.4	243.6	148.9	41.5
200	301.7	1373.6	1084.2	380.1	160.6	104.6	37.4
200	22.1	230.8	1081.8	511.7	88.4	35.8	19.5
200	101.7	205.9	209.3	888.4	542.5	104.2	43.9

SPRING SURVEY (shifted back to december)

1993 2013

1 1 0.9 1.0

1 8

100	612.5	336.9	912.8	508.5	129.7	187.2	28.6	0.1
100	623.2	845.7	1528.4	1525.2	1191.4	285.6	350.8	48.9
100	215.5	4043.9	3984.4	1892.1	1372	420.8	82.8	169.7
100	72.5	834.4	5398.3	2359.5	333.9	227	58.8	5.3
100	69.7	425.2	1572.1	4919.3	1136	82.3	40.7	35.2

100	704.7	674.9	991.3	1225.2	2079.2	252.1	25.2	13.4
100	316	1432.4	746.1	441	506.7	836.7	63.8	3.1
100	938.4	2387.8	1993.8	456.2	324.4	578.6	128.6	3.9
100	383	4564.1	2892.1	1579.7	331.9	231.8	178.9	131.9
100	90.2	719	3915	1260.4	528.7	67.4	51.7	39.7
100	609.5	575.8	844.6	1175.1	292.9	66	22.2	11.9
100	383.1	438.2	1151.7	1440.2	844.5	140.6	14	3.8
100	167.5	156.7	177.3	360.1	292	95	15.5	4
100	41.1	270.9	286.6	155.2	170.4	105.1	37.8	14.4
100	176.6	474.5	851.9	479.2	151.5	83.9	39.4	13.3
100	307.8	475.5	977.7	1159.1	427.3	73.7	31.6	24.9
100	697.6	1318.8	745.6	538.1	381	98.9	41	17.2
100	148.4	1319	1240.3	562.4	300.2	237.8	85.2	21.9
100	41.1	273.8	1303.8	326.7	73.6	27	23.7	6.2
100	68	377.6	1699.8	2053.2	295.6	32.6	22.4	17.7
100	130.9	113.4	159.6	419.7	333	74.8	22	13.6

Table 4.2.10. Faroe Plateau cod (sub-division Vb1). Pair trawler abundance index (number of individuals per 1000 fishing hours). This series was not used in the tuning of the XSA. The season is June – December. The otoliths are selected from deep (> 150 m) locations.

	Age							
Year	2	3	4	5	6	7	8	9
1989	1200	1638	1783	1381	928	719	297	194
1990	116	2856	2057	834	465	419	200	0
1991	8	148	1401	869	329	225	65	93
1992	84	487	696	1234	760	353	129	62
1993	51	1081	2192	746	1062	398	67	107
1994	1314	2129	1457	2208	697	1241	461	53
1995	577	3645	5178	4199	2769	543	539	106
1996	242	10608	16683	7985	4410	194	0	723
1997	28	674	6038	9375	2413	944	113	0
1998	80	731	1805	5941	4904	801	286	0
1999	444	2082	1933	3008	5136	2220	218	4
2000	3478	3956	1737	956	1003	1694	382	0
2001	3385	6700	3009	555	415	797	862	25
2002	571	6409	5019	1235	432	400	41	228
2003	63	1341	4450	3630	870	270	152	145
2004	23	0	278	2534	2831	1733	274	184
2005	42	399	655	1766	2171	860	148	70
2006	93	135	699	755	1580	612	787	71
2007	64	916	1767	1392	802	656	206	46
2008	54	295	418	573	387	456	487	182
2009	11	734	801	756	448	247	147	105
2010	1578	2917	1787	543	603	190	0	81
2011	22	1487	4078	1967	622	441	95	25
2012	0	95	1531	1789	950	223	40	107
2013	35	102	761	1583	670	103	57	36

Table 4.2.11. Faroe Plateau cod (sub-division Vb1). Longliner abundance index (number of individuals per 100 000 hooks). This series was not used in the tuning of the XSA. The age composition was obtained from all longliners > 100 GRT. The area was restricted to the area west of Faroe Islands at depths between 100 and 200 m.

	Age							
Year	1	2	3	4	5	6	7	8
1993	405	2610	9306	3330	806	2754	847	258
1994	101	8105	14105	7863	4659	962	1187	71
1995	0	15249	23062	2895	2505	1568	708	1073
1996	0	2269	18658	13265	4153	8435	4513	1147
1997	0	1738	5837	26368	18089	2805	2807	402
1998	1892	4490	2025	2565	11738	2732	131	19
1999	849	10968	3811	985	1891	3759	548	109
2000	2695	10983	6710	998	780	1473	2136	109
2001	287	12999	7409	2660	515	1135	1808	2545
2002	105	6862	20902	10819	7759	1561	1945	1265
2003	16	2099	6057	15910	7778	1830	708	650
2004	59	510	1773	2438	3214	1059	293	71
2005	297	2169	1543	2313	2327	1360	170	13
2006	151	5813	5319	674	2205	2352	1148	56
2007	274	3578	6383	2778	1927	1159	1118	134
2008	1270	2243	4449	4773	2564	1133	816	716
2009	294	2670	15107	6308	3028	2491	683	132
2010	23	20287	16914	8733	2595	4780	1878	864
2011	160	2817	28218	14391	4295	2207	1252	195
2012	0	1833	9562	8309	2364	1296	403	197
2013	0	53	214	2946	5237	2709	1247	366

Table 4.2.12. Longliner abundance index (number of individuals per day) for longliners < 25 GRT operating mainly near shore. This series was not used in the tuning of the XSA. The age composition was obtained from all longliners.

	Age							
Year	1	2	3	4	5	6	7	8
1983	0.9	7.5	4.7	3.8	1.6	0.9	0.5	0.2
1984	0	33.3	32.1	13.2	5.8	6.3	1	0.7
1985	0	3.4	45.8	32.1	23.2	12.9	17.9	5.3
1986	0	5.4	40.4	23.3	14.9	6.6	6	2.1
1987	0	6.2	10.3	15.2	25.2	11.3	4.8	0.8
1988	0	2.5	5.1	10.5	6.9	15.4	5.2	2.1
1989	0	30.9	15.1	14.5	9.8	5.3	11.4	1.6
1990	0	6.4	32.6	7	9.9	5.2	6.3	3.4
1991	0	0	4.5	23.4	7.6	3.4	2.1	0.6
1992	0	5.8	15.9	6.4	3.6	3.4	1.7	1.3
1993	0.4	4.8	20	7.5	1.5	1.4	0.3	1.3
1994	0	13.1	16.2	13.6	5.8	1.8	2.3	0.4
1995	0	44.7	39.9	10.2	7	4.3	1.6	2.6
1996	0	5.8	75	51.2	12.9	28.3	14.1	4.1
1997	0	4.4	15.8	68.3	51.8	7.5	7.3	0.8
1998	4.8	10.1	4.7	6.8	27.6	8.2	0.3	0.3
1999	0.2	23.2	7.9	3.7	5.5	12.6	2	0
2000	5.4	22.5	13.1	0.7	0.7	1.3	2.3	0.3
2001	0.5	82.8	41.7	14.6	2.5	4.9	10.8	11.1
2002	0.1	38.5	78.7	35.2	24.3	5.9	9.3	5.5
2003	0	14.8	31.6	89.8	49.9	10.9	3.4	1.3
2004	0	5.2	16.1	15.7	23.2	6.1	0.2	0
2005	0.4	8.9	12.5	11.2	19.9	9.4	0.9	0
2006	1.4	40.7	32.6	6.3	7.3	9.5	2.8	0.3
2007	0.1	8.8	18.2	7	3.3	3.8	2.8	0.5
2008	0.3	3	14.2	18.4	12.5	2.9	1.3	1.8
2009	1.1	11.4	52.7	19.6	11.6	8	3.3	2
2010	1.4	72.9	79	33.5	14.7	15.3	4.6	1
2011	0	17.9	142.3	59.1	22.9	14.1	7.7	1.8
2012	0.3	4.6	39.3	59.0	15.1	5.2	2.6	1.3
2013	0.1	2.8	4.1	10.8	9.9	1.3	0.5	0.0

Table 4.6.1. Faroe Plateau cod (sub-division Vb1). The XSA-run.

Lowestoft VPA Version 3.1

22/04/2014 7:26

Extended Survivors Analysis

COD FAROE PLATEAU (ICES SUBDIVISION Vb1) COD_ind_Surveys_revised

CPUE data from file Surveys_revised_1replacedvalue.TXT

Catch data for 53 years. 1961 to 2013. Ages 1 to 10.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
SUMMER SURVEY	1996	2013	2	8	.600	.700
SPRING SURVEY (shift	1993	2013	1	8	.900	1.000

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 6

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 = 2.000

Minimum standard error for population

estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 30 iterations

Total absolute residual between iterations

29 and 30 = .00010

Final year F values

Age	1	2	3	4	5	6	7	8	9

Iteration 29 .0000 .0423 .2079 .2742 .2731 .2452 .2920 .3392 .5751

Iteration 30 .0000 .0423 .2079 .2742 .2731 .2452 .2920 .3391 .5752

Regression weights

1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000

Fishing mortalities

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	.031	.093	.188	.124	.051	.112	.193	.106	.038	.042
3	.186	.256	.332	.328	.263	.677	.412	.344	.242	.208
4	.298	.381	.357	.382	.341	.525	.596	.479	.338	.274
5	.755	.472	.609	.438	.390	.486	.611	.551	.409	.273
6	.987	.773	.819	.592	.478	.501	.901	.537	.678	.245
7	1.135	.844	.952	.686	.719	.406	.647	.638	.606	.292
8	1.064	.581	1.030	.689	1.206	.584	.539	.375	.898	.339
9	2.061	1.132	.298	.844	1.481	1.484	.869	.337	.325	.575

XSA population numbers (Thousands)

	AGE								
YEAR	1	2	3	4	5	6	7	8	9
2004	7.49E+03	3.65E+03	4.50E+03	5.42E+03	4.39E+03	1.30E+03	3.91E+02	1.10E+02	5.32E+01
2005	9.32E+03	6.13E+03	2.90E+03	3.06E+03	3.30E+03	1.69E+03	3.96E+02	1.03E+02	3.10E+01
2006	6.26E+03	7.63E+03	4.57E+03	1.83E+03	1.71E+03	1.68E+03	6.39E+02	1.39E+02	4.71E+01
2007	8.00E+03	5.13E+03	5.18E+03	2.69E+03	1.05E+03	7.61E+02	6.08E+02	2.02E+02	4.07E+01
2008	1.11E+04	6.55E+03	3.71E+03	3.05E+03	1.50E+03	5.55E+02	3.45E+02	2.51E+02	8.30E+01
2009	1.62E+04	9.10E+03	5.10E+03	2.34E+03	1.78E+03	8.32E+02	2.82E+02	1.37E+02	6.15E+01
2010	4.42E+03	1.33E+04	6.66E+03	2.12E+03	1.13E+03	8.95E+02	4.13E+02	1.54E+02	6.28E+01
2011	1.77E+03	3.62E+03	8.96E+03	3.61E+03	9.57E+02	5.03E+02	2.98E+02	1.77E+02	7.34E+01

2012 2.02E+03 1.45E+03 2.67E+03 5.20E+03 1.83E+03 4.51E+02 2.41E+02 1.29E+02 9.96E+01

2013 5.98E+03 1.66E+03 1.14E+03 1.71E+03 3.04E+03 9.96E+02 1.88E+02 1.08E+02 4.30E+01

Estimated population abundance at 1st Jan 2014

0.00E+00 4.90E+03 1.30E+03 7.60E+02 1.07E+03 1.89E+03 6.38E+02 1.15E+02 6.28E+01

Taper weighted geometric mean of the VPA populations:

1.42E+04 1.18E+04 9.15E+03 5.83E+03 3.21E+03 1.55E+03 6.95E+02 2.83E+02 1.15E+02

Standard error of the weighted Log(VPA populations) :

.7442 .7343 .6740 .6151 .5962 .6192 .6669 .7137 .8232

Log catchability residuals.

Fleet : SUMMER SURVEY

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	No data for this fleet at this age									
2	99.99	99.99	-.17	.20	.34	-.88	.12	.65	1.09	-.08
3	99.99	99.99	.15	-.20	-.58	.54	-.40	.08	.62	-.34
4	99.99	99.99	.22	.35	-.56	-.09	.10	.14	.13	.14
5	99.99	99.99	.68	-.05	.27	-.67	-.76	-.09	.15	-.31
6	99.99	99.99	.16	-.18	.60	.14	-.63	-.57	-.32	-.70
7	99.99	99.99	.29	-.04	-.37	.54	.06	-.30	-.40	-1.38
8	99.99	99.99	-.15	-.28	.11	.41	-.25	-.03	-.45	-1.06

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	No data for this fleet at this age									
2	.61	.47	.78	-.30	-1.81	-.27	.46	.29	-1.45	-.05
3	.06	.41	-.07	-.62	-.52	1.11	.42	-.03	-.67	.04
4	-.16	.25	-.17	-.64	-.75	.55	.90	.36	-.09	-.67
5	.46	.28	-.29	-.47	-.05	.16	.28	.45	.01	-.04
6	.28	.67	-.38	-.38	.04	.55	.25	.18	-.22	.52
7	.12	.50	-.06	-.67	-.45	.48	.37	.34	-.54	.57
8	.21	.52	.04	-.46	-.46	.29	.01	-.34	-.33	.29

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

Age	2	3	4	5	6	7	8
Mean Log q	-7.8773	-6.7854	-6.4250	-6.1828	-6.1379	-6.1379	-6.1379
S.E(Log q)	.7532	.4884	.4447	.3912	.4399	.5239	.4056

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	.77	1.330	8.11	.67	18	.57	-7.88
3	.92	.564	6.94	.76	18	.46	-6.79
4	.91	.677	6.61	.77	18	.41	-6.42
5	.96	.318	6.26	.77	18	.38	-6.18
6	.96	.234	6.18	.70	18	.44	-6.14
7	1.01	-.068	6.19	.61	18	.54	-6.19
8	1.31	-1.593	6.55	.62	18	.49	-6.24

Fleet : SPRING SURVEY (shift

Age	1993
1	-.09
2	-.94
3	-.66
4	-.56
5	-.52
6	-.66
7	-.30
8	-4.57

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	-.60	-.47	-.87	-.82	.61	-.51	.17	.08	-.62	1.83
2	-.92	.17	-.25	-.23	.36	.24	.46	.73	-.28	.19
3	-.02	.08	-.07	-.19	.07	.03	.17	.28	.34	-.53
4	-.01	.59	-.05	.20	-.21	-.50	-.13	.34	-.01	-.25
5	.81	.44	-.07	.31	.25	-.50	-.28	.14	.33	-.36

6	.92	.56	-.05	.00	.29	.45	.39	.16	-.22	-.41
7	.31	.21	-.11	-.19	-.18	.19	-.67	.09	.18	-.23
8	.77	-.01	-1.45	.93	.09	-1.27	-1.56	.20	.00	-.13

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	.85	-.20	-1.20	.01	.24	.68	.43	.06	.43	.00
2	.36	-1.13	-.71	.19	-.12	.63	.33	-.03	1.14	-.19
3	.36	-1.01	-.91	.05	.46	.26	.25	-.06	1.32	-.23
4	.26	-.48	-.83	-.06	.65	.33	.54	-.65	.69	.15
5	.44	-.60	-.35	-.15	.49	.30	.63	-.67	-.06	-.58
6	.33	-.54	-.39	-.03	.04	-.04	1.14	-.81	-.37	-.75
7	-.64	-.83	-.31	-.48	-.10	.07	.65	-.31	-.19	-.26
8	-.74	-1.09	.32	-.46	.45	.09	.17	-1.39	.48	-.14

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

Age	1	2	3	4	5	6	7	8
Mean Log q	-8.2374	-6.8673	-5.9585	-5.7143	-5.7907	-6.0251	-6.0251	-6.0251
S.E(Log q)	.6896	.5791	.5059	.4437	.4515	.5231	.3842	1.2852

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
1	1.19	-.914	8.05	.54	21	.83	-8.24
2	1.09	-.548	6.67	.65	21	.64	-6.87
3	1.00	.020	5.97	.70	21	.52	-5.96
4	.93	.526	5.91	.73	21	.42	-5.71
5	.89	.834	6.02	.74	21	.40	-5.79
6	.88	.742	6.16	.66	21	.46	-6.03
7	.95	.462	6.18	.80	21	.34	-6.17
8	.64	1.536	6.04	.48	21	.74	-6.47

Terminal year survivor and F summaries :

Age 1 Catchability constant w.r.t. time and dependent on age

Year class = 2012

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SUMMER SURVEY	1.	.000	.000	.00	0	.000	.000
SPRING SURVEY (shift	4898.	.706	.000	.00	1	1.000	.000
F shrinkage mean	0.	2.00				.000	.000

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4898.	.71	.00	1	.000	.000

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

Year class = 2011

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SUMMER SURVEY	1232.	.774	.000	.00	1	.246	.045
SPRING SURVEY (shift	1389.	.454	.305	.67	2	.715	.040
F shrinkage mean	531.	2.00				.038	.100

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1300.	.38	.18	4	.481	.042

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

Year class = 2010

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SUMMER SURVEY	514.	.421	.674	1.60	2	.390	.294
SPRING SURVEY (shift	1011.	.341	.429	1.26	3	.588	.160
F shrinkage mean	368.	2.00				.022	.390

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
760.	.26	.32	6	1.218	.208

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

Year class = 2009

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SUMMER SURVEY	619.	.313	.229	.73	3	.441	.434
SPRING SURVEY (shift	1691.	.276	.305	1.10	4	.543	.182
F shrinkage mean	578.	2.00				.016	.459

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1067.	.21	.25	8	1.230	.274

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

Year class = 2008

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SUMMER SURVEY	1847.	.256	.070	.28	4	.499	.279
SPRING SURVEY (shift	1979.	.248	.277	1.12	5	.488	.263
F shrinkage mean	932.	2.00				.013	.493

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1893.	.18	.14	10	.761	.273

Age 6 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
SUMMER SURVEY	855.	.238	.123	.52	5	.529	.189
SPRING SURVEY (shift	471.	.244	.200	.82	6	.458	.319
F shrinkage mean	204.	2.00				.014	.625

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
638.	.17	.14	12	.846	.245

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 2006

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SUMMER SURVEY	161.	.259	.213	.82	6	.440	.216
SPRING SURVEY (shift	89.	.255	.113	.44	7	.543	.361
F shrinkage mean	46.	2.00				.016	.608

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
115.	.18	.14	14	.745	.292

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 2005

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SUMMER SURVEY	71.	.245	.137	.56	7	.599	.307
SPRING SURVEY (shift	55.	.246	.166	.67	8	.383	.380
F shrinkage mean	24.	2.00				.019	.727

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
63.	.18	.11	16	.605	.339

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 2004

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
SUMMER SURVEY	17.	.260	.138	.53	7	.580	.635
SPRING SURVEY (shift	21.	.259	.199	.77	8	.358	.547
F shrinkage mean	46.	2.00				.062	.286

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
20.	**.22**	**.12**	**16**	**.567**	**.575**

Table 4.6.2. Faroe Plateau cod (sub-division Vb1). Fishing mortality at age from the XSA model.

	Age								
Year	2	3	4	5	6	7	8	9	10+	Fbar 3-7
1961	0.335	0.514	0.499	0.574	0.486	0.957	0.812	0.672	0.672	0.606
1962	0.270	0.498	0.484	0.708	0.557	0.366	0.683	0.564	0.564	0.523
1963	0.253	0.414	0.517	0.512	0.541	0.488	0.327	0.481	0.481	0.494
1964	0.109	0.300	0.452	0.523	0.566	0.668	0.353	0.516	0.516	0.502
1965	0.121	0.252	0.450	0.562	0.660	0.531	0.435	0.532	0.532	0.491
1966	0.083	0.197	0.255	0.450	0.502	0.968	0.852	0.611	0.611	0.474
1967	0.079	0.239	0.269	0.344	0.578	0.520	1.044	0.556	0.556	0.390
1968	0.101	0.232	0.395	0.534	0.447	0.713	0.333	0.488	0.488	0.464
1969	0.110	0.306	0.381	0.418	0.571	0.512	0.846	0.550	0.550	0.438
1970	0.053	0.208	0.365	0.341	0.371	0.656	0.421	0.434	0.434	0.388
1971	0.031	0.134	0.223	0.385	0.557	0.465	0.753	0.480	0.480	0.353
1972	0.046	0.148	0.207	0.250	0.606	0.469	0.246	0.358	0.358	0.336
1973	0.066	0.232	0.305	0.281	0.253	0.372	0.326	0.309	0.309	0.289
1974	0.082	0.157	0.205	0.295	0.380	0.533	0.305	0.346	0.346	0.314
1975	0.077	0.319	0.436	0.413	0.454	0.350	0.449	0.424	0.424	0.395
1976	0.093	0.172	0.367	0.557	0.517	0.762	0.643	0.574	0.574	0.475
1977	0.048	0.304	0.475	0.753	0.733	1.114	0.778	0.778	0.778	0.676
1978	0.059	0.190	0.429	0.429	0.485	0.597	0.567	0.505	0.505	0.426
1979	0.043	0.262	0.431	0.505	0.491	0.448	0.690	0.517	0.517	0.427
1980	0.054	0.239	0.370	0.434	0.518	0.412	0.644	0.479	0.479	0.395
1981	0.052	0.288	0.341	0.437	0.564	0.694	0.502	0.512	0.512	0.465
1982	0.059	0.223	0.360	0.389	0.405	0.693	0.553	0.483	0.483	0.414
1983	0.099	0.467	0.559	0.641	0.784	1.078	0.942	0.809	0.809	0.706
1984	0.107	0.371	0.579	0.661	0.453	0.476	0.479	0.534	0.534	0.508
1985	0.066	0.354	0.508	0.613	0.923	1.108	1.320	0.904	0.904	0.701
1986	0.025	0.354	0.622	0.703	0.826	0.840	0.541	0.713	0.713	0.669
1987	0.029	0.221	0.475	0.485	0.556	0.489	0.622	0.530	0.530	0.445
1988	0.067	0.353	0.564	0.549	0.773	0.798	0.864	0.716	0.716	0.607
1989	0.162	0.440	0.761	0.761	0.961	1.056	1.099	0.938	0.938	0.796
1990	0.078	0.324	0.639	0.801	0.712	0.849	1.132	0.835	0.835	0.665
1991	0.032	0.198	0.428	0.601	0.745	0.578	0.713	0.618	0.618	0.510
1992	0.020	0.100	0.324	0.323	0.642	0.888	0.442	0.528	0.528	0.455
1993	0.013	0.102	0.187	0.252	0.184	0.446	0.574	0.331	0.331	0.234
1994	0.026	0.113	0.191	0.250	0.220	0.142	0.327	1.077	1.077	0.183
1995	0.070	0.162	0.465	0.280	0.361	0.333	0.205	0.762	0.762	0.320
1996	0.031	0.194	0.453	0.810	0.906	1.141	0.919	0.798	0.798	0.701
1997	0.035	0.149	0.414	0.835	1.049	1.404	1.357	1.017	1.017	0.770
1998	0.089	0.176	0.273	0.653	1.059	0.795	1.180	0.868	0.868	0.591
1999	0.096	0.284	0.290	0.318	0.667	1.080	0.800	0.505	0.505	0.528
2000	0.125	0.319	0.380	0.248	0.327	0.547	0.827	0.195	0.195	0.364
2001	0.157	0.345	0.456	0.308	0.350	0.698	0.654	0.786	0.786	0.431
2002	0.190	0.490	0.600	0.823	0.829	1.364	1.236	1.382	1.382	0.821
2003	0.128	0.304	0.664	0.852	0.909	0.900	0.935	1.773	1.773	0.726

	Age								
Year	2	3	4	5	6	7	8	9	10+	Fbar 3–7
2004	0.031	0.186	0.298	0.755	0.987	1.135	1.064	2.061	2.061	0.672
2005	0.093	0.256	0.381	0.472	0.773	0.844	0.581	1.132	1.132	0.545
2006	0.188	0.332	0.358	0.609	0.819	0.952	1.030	0.298	0.298	0.614
2007	0.124	0.328	0.382	0.438	0.592	0.686	0.689	0.844	0.844	0.485
2008	0.051	0.263	0.341	0.390	0.478	0.719	1.206	1.481	1.481	0.438
2009	0.112	0.677	0.525	0.486	0.502	0.406	0.584	1.484	1.484	0.519
2010	0.193	0.412	0.596	0.611	0.901	0.648	0.539	0.869	0.869	0.633
2011	0.106	0.344	0.479	0.551	0.537	0.638	0.375	0.337	0.337	0.510
2012	0.038	0.242	0.338	0.409	0.678	0.606	0.898	0.325	0.325	0.454
2013	0.042	0.208	0.274	0.273	0.245	0.292	0.339	0.575	0.575	0.259

Table 4.6.3. Faroe Plateau cod (sub-division Vb1). Stock number at age from the XSA model.

	Age								
Year	2	3	4	5	6	7	8	9	10+	Total
1961	12019	7385	3747	2699	666	668	155	66	0	52630
1962	20654	7042	3616	1863	1245	335	210	56	0	59804
1963	20290	12907	3503	1825	752	584	190	87	0	66807
1964	21834	12893	6986	1710	895	358	294	112	0	55183
1965	8269	16037	7823	3639	830	416	151	169	0	60009
1966	18566	5999	10207	4085	1698	351	200	80	0	69829
1967	23451	13990	4034	6475	2133	842	109	70	0	72579
1968	17582	17744	9020	2525	3757	980	410	31	0	63439
1969	9325	13012	11522	4976	1212	1967	393	240	0	53161
1970	8608	6840	7843	6447	2682	561	965	138	0	48654
1971	11928	6684	4548	4456	3754	1516	238	519	0	59683
1972	21320	9469	4788	2981	2483	1760	779	92	0	59029
1973	12573	16664	6689	3187	1901	1109	902	499	400	81153
1974	30480	9639	10816	4037	1969	1209	626	533	342	106456
1975	38319	23000	6747	7217	2460	1103	581	378	476	102968
1976	18575	29035	13683	3572	3908	1279	636	304	466	83665
1977	9995	13853	20010	7765	1676	1909	489	274	18	69116
1978	10748	7799	8372	10190	2993	659	513	184	154	59931
1979	14998	8298	5282	4463	5433	1509	297	238	103	69424
1980	23583	11759	5226	2811	2206	2723	789	122	52	66371
1981	14001	18286	7580	2957	1491	1076	1477	339	150	74385
1982	22128	10878	11228	4413	1564	694	440	732	348	83160
1983	25162	17087	7128	6412	2450	854	284	207	200	118131
1984	47770	18656	8768	3339	2765	916	238	91	174	103878
1985	17325	35133	10539	4023	1412	1439	466	121	146	82224
1986	9515	13281	20183	5194	1784	459	389	102	81	63099
1987	9915	7600	7629	8868	2106	640	162	185	69	47825
1988	8720	7885	4990	3884	4471	989	321	71	53	51621
1989	16568	6679	4536	2325	1837	1690	365	111	16	38593
1990	3656	11541	3522	1735	890	575	481	100	50	30692
1991	6666	2770	6832	1523	638	357	202	127	57	33091
1992	11396	5284	1860	3646	684	248	164	81	91	35789
1993	10099	9145	3915	1101	2161	295	84	86	97	57723
1994	25168	8160	6762	2659	701	1472	154	39	26	97069
1995	42516	20087	5968	4575	1696	461	1046	91	100	92249
1996	12862	32443	13988	3069	2830	968	270	698	93	75106
1997	6455	10213	21890	7283	1117	936	253	88	204	55675
1998	5924	5104	7205	11850	2587	320	188	53	47	50788
1999	14335	4438	3505	4489	5051	735	118	47	19	56813
2000	19710	10664	2735	2147	2674	2122	204	44	6	76573
2001	29692	14246	6345	1532	1372	1579	1006	73	12	72053
2002	13260	20770	8262	3294	922	791	643	428	10	56008
2003	6244	8975	10415	3713	1185	330	166	153	26	35661

	Age									
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**
2004	3647	4499	5423	4390	1297	391	110	53	45	27342
2005	6130	2895	3058	3297	1690	396	103	31	48	26966
2006	7629	4572	1835	1710	1684	639	139	47	13	24533
2007	5129	5177	2686	1051	761	608	202	41	6	23657
2008	6547	3711	3054	1502	555	345	251	83	28	27186
2009	9097	5095	2336	1777	832	282	137	61	24	35861
2010	13279	6656	2120	1132	895	413	154	63	71	29206
2011	3622	8960	3609	957	503	298	177	73	8	19977
2012	1449	2667	5200	1831	451	241	129	100	87	14178
2013	1656	1142	1715	3038	996	188	108	43	15	14883

Table 4.6.4. Faroe Plateau cod (sub-division Vb1). Summary table from the XSA model. The results from the short term prediction are shown in bold.

	Recruits	Totalbio	Totspbio	Landings	Yield/SSB	Fbar 3-7
	Age 2					
1961	12019	65428	46439	21598	0.465	0.606
1962	20654	68225	43326	20967	0.484	0.523
1963	20290	77602	49054	22215	0.453	0.494
1964	21834	84666	55362	21078	0.381	0.502
1965	8269	75043	57057	24212	0.424	0.491
1966	18566	83919	60629	20418	0.337	0.474
1967	23451	105289	73934	23562	0.319	0.390
1968	17582	110433	82484	29930	0.363	0.464
1969	9325	105537	83487	32371	0.388	0.438
1970	8608	98398	82035	24183	0.295	0.388
1971	11928	78218	63308	23010	0.364	0.353
1972	21320	76439	57180	18727	0.328	0.336
1973	12573	110713	83547	22228	0.266	0.289
1974	30480	139266	98434	24581	0.250	0.314
1975	38319	153664	109566	36775	0.336	0.395
1976	18575	161260	123077	39799	0.323	0.475
1977	9995	136212	112057	34927	0.312	0.676
1978	10748	96227	78497	26585	0.339	0.426
1979	14998	85112	66723	23112	0.346	0.427
1980	23583	85038	58887	20513	0.348	0.395
1981	14001	88412	63562	22963	0.361	0.465
1982	22128	98964	67033	21489	0.321	0.414
1983	25162	123257	78543	38133	0.486	0.706
1984	47770	152164	96775	36979	0.382	0.508
1985	17325	131249	84791	39484	0.466	0.701
1986	9515	99286	73701	34595	0.469	0.669
1987	9915	78380	62255	21391	0.344	0.445
1988	8720	66188	52143	23182	0.445	0.607
1989	16568	59443	38440	22068	0.574	0.796
1990	3656	38729	29569	13692	0.463	0.665
1991	6666	29136	21456	8750	0.408	0.510
1992	11396	36250	21287	6396	0.301	0.455
1993	10099	51792	33794	6107	0.181	0.234
1994	25168	84675	43250	9046	0.209	0.183
1995	42516	144966	55059	23045	0.419	0.320
1996	12862	142931	85775	40422	0.471	0.701
1997	6455	96488	81226	34304	0.422	0.770
1998	5924	65860	55506	24005	0.433	0.591
1999	14335	64672	44671	18306	0.410	0.528
2000	19710	90723	45793	21033	0.459	0.364
2001	29692	109594	58700	28183	0.480	0.431

	Recruits	Totalbio	Totspbio	Landings	Yield/SSB	Fbar 3-7
	Age 2					
2002	13260	98062	55699	38457	0.690	0.821
2003	6244	60446	40414	24501	0.606	0.726
2004	3647	37059	27073	13178	0.487	0.672
2005	6130	31935	23500	9906	0.422	0.545
2006	7629	30362	20946	10480	0.500	0.614
2007	5129	27479	17473	8018	0.459	0.485
2008	6547	29973	20551	7465	0.363	0.438
2009	9097	30697	19752	10002	0.506	0.519
2010	13279	40907	22342	12757	0.571	0.633
2011	3622	32792	20592	9760	0.474	0.510
2012	1449	26065	21297	7210	0.339	0.454
2013	1656	24632	22635	5002	0.221	0.259
2014	4898	29941	25410	5357	0.211	0.259
2015	2242	29395	25452	5768	0.227	0.259
2016	2242	27678	24490			
Avg. 61-13	18051	81514	56428	21908	0.4011	0.5018

Table 4.7.1. Faroe Plateau cod (sub-division Vb1). Input to management option table.

		Recr.	Source
2013	YC2011	1656	XSA-output
2014	YC2012	4898	XSA-output
2015	YC2013	2242	Average R 2011-13
2016	YC2014	2242	Average R 2011-13

Age	Stock size 2014	Source
2	4898	XSA-output
3	1656	XSA-output
4	1715	XSA-output
5	3038	XSA-output
6	996	XSA-output
7	188	XSA-output
8	108	XSA-output
9	43	XSA-output
10+	15	XSA-output

	Maturity			Exploitation pattern (rescaled to last year)			Weights		
	Observed	Av. 12-14	Av. 12-14	Av. 11-13	Av. 11-13	Av. 11-13		As 2014	Av.12-14
Age	2014	2015	2016	2014	2015	2016	2014	2015	2016
2	0.24	0.16	0.16	0.0394	0.0394	0.0394	1.011	1.011	1.01
3	0.73	0.73	0.73	0.1678	0.1678	0.1678	1.527	1.527	1.456
4	0.98	0.93	0.93	0.2305	0.2305	0.2305	2.807	2.807	2.409
5	1.00	0.97	0.97	0.2608	0.2608	0.2608	3.544	3.544	3.275
6	1.00	0.99	0.99	0.3086	0.3086	0.3086	4.328	4.328	4.426
7	1.00	1.00	1.00	0.3247	0.3247	0.3247	6.776	6.776	6.375
8	1.00	1.00	1.00	0.3407	0.3407	0.3407	6.966	6.966	6.601
9	1.00	1.00	1.00	0.2616	0.2616	0.2616	9.028	9.028	8.513
10+	1.00	0.94	0.94	0.2616	0.2616	0.2616	10.324	10.324	9.951
			Fbar:	0.2585	0.2585	0.2585			

Table 4.7.2. Faroe Plateau cod (sub-division Vb1). Management option table.

2014 Biomass	SSB	FMult	FBar	Landings
29941	25399	1.0000	0.2585	5356

2015 Biomass	SSB	FMult	FBar	Landings	2016 Biomass	SSB
29395	25453	0.0000	0.0000	0	34480	31142
.	25453	0.1000	0.0258	647	33714	30393
.	25453	0.2000	0.0517	1278	32969	29664
.	25453	0.3000	0.0775	1892	32244	28954
.	25453	0.4000	0.1034	2490	31538	28264
.	25453	0.5000	0.1292	3073	30851	27592
.	25453	0.6000	0.1551	3640	30182	26937
.	25453	0.7000	0.1809	4193	29531	26301
.	25453	0.8000	0.2068	4732	28896	25681
.	25453	0.9000	0.2326	5257	28279	25078
.	25453	1.0000	0.2585	5768	27678	24490
.	25453	1.1000	0.2843	6266	27092	23918
.	25453	1.2000	0.3102	6752	26522	23362
.	25453	1.3000	0.3360	7225	25967	22820
.	25453	1.4000	0.3619	7686	25427	22292
.	25453	1.5000	0.3877	8135	24900	21779
.	25453	1.6000	0.4136	8572	24387	21278
.	25453	1.7000	0.4394	8999	23888	20791
.	25453	1.8000	0.4653	9415	23402	20317
.	25453	1.9000	0.4911	9820	22928	19855
.	25453	2.0000	0.5170	10216	22466	19406

Input units are thousands and kg - output in tonnes

Table 4.8.1. Faroe Plateau cod (sub-division Vb1). Input to yield per recruit calculations (long term prediction).

	Expl. pattern	Weight at age	Prop mature
Age	Average 2002-2013 Not rescaled	Average 1978-2013	Average 1983-2014
2	0.108	1.038	0.08
3	0.337	1.557	0.57
4	0.436	2.267	0.84
5	0.556	3.068	0.94
6	0.687	3.873	0.98
7	0.766	4.935	0.99
8	0.790	6.112	1.00
9	1.047	7.660	1.00
10+	1.047	9.569	0.99

Table 4.8.2. Faroe Plateau cod (sub-division Vb1). Output from yield per recruit calculations (long term prediction).

Reference point	F multiplier	Absolute F
Fbar(3-7)	1.0000	0.5563
FMax	0.4433	0.2466
F0.1	0.2024	0.1126
F35%SPR	0.3129	0.1741
Fhigh	2.0025	1.1141
Fmed	0.6177	0.3436
Flow	0.1949	0.1085

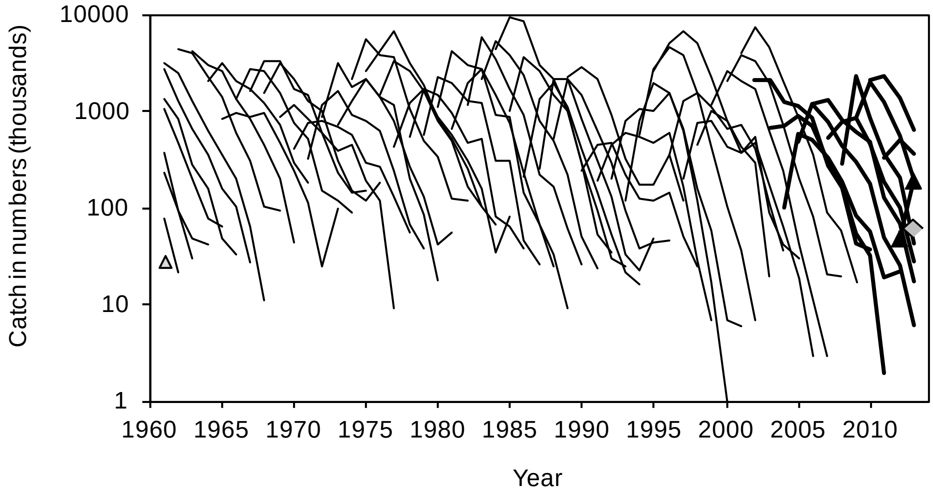


Figure 4.2.1. Faroe Plateau cod (sub-division Vb1). Catch in numbers at age shown as catch curves.

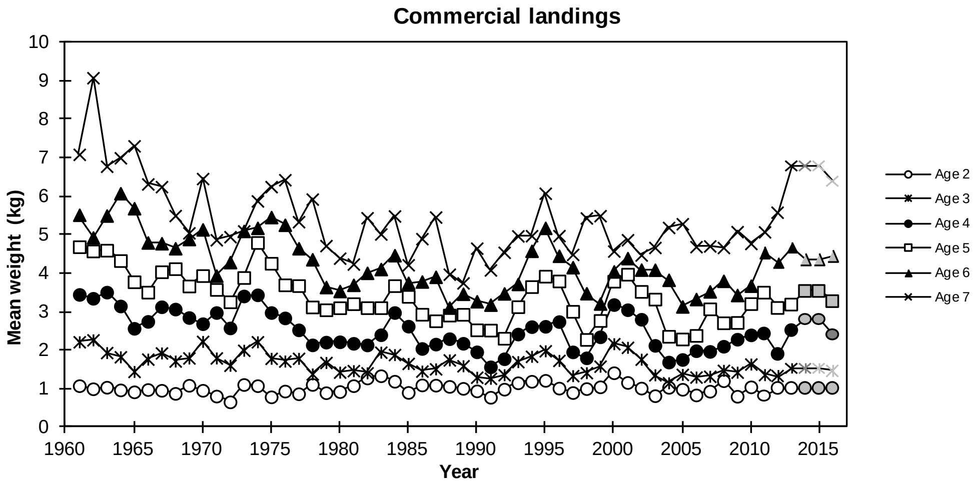


Figure 4.2.2. Faroe Plateau cod (sub-division Vb1). Mean weight at age. The predicted weights are also shown.

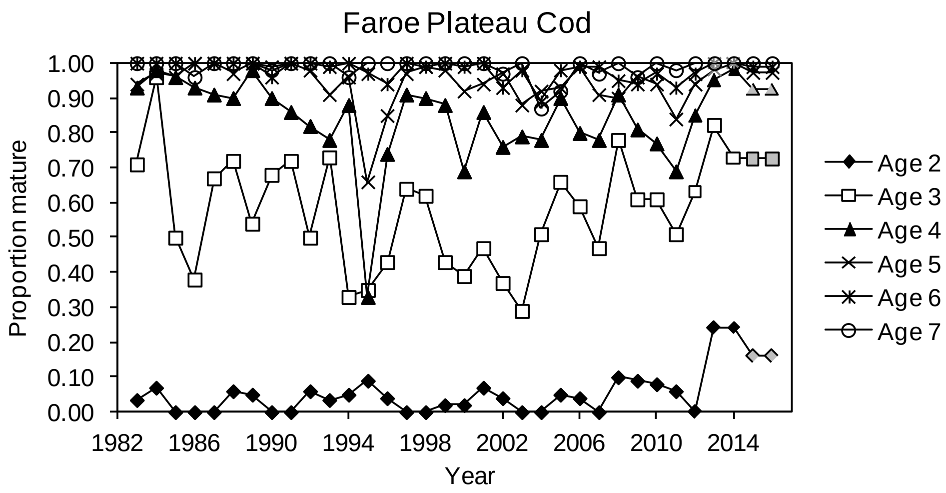


Figure 4.2.3. Faroe Plateau cod (sub-division Vb1). Proportion mature at age as observed in the spring groundfish survey. The predicted values are shown in grey.

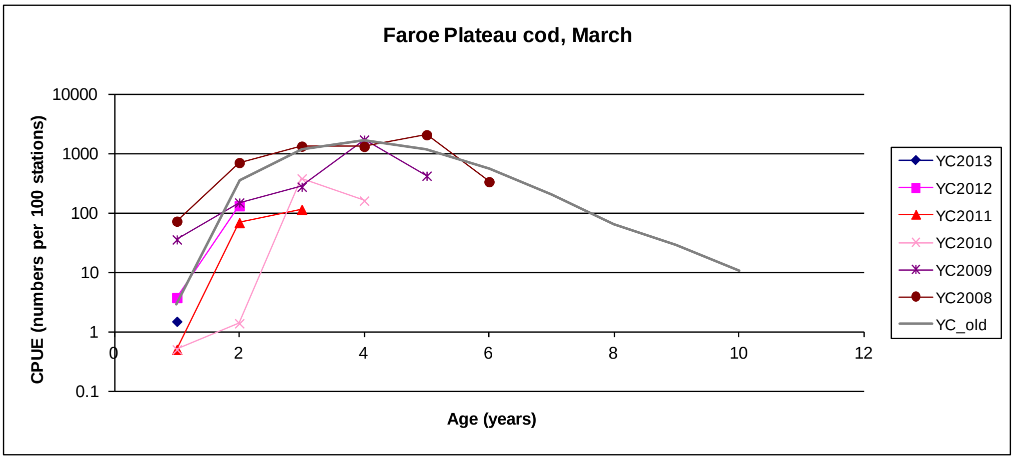


Figure 4.2.4. Faroe Plateau cod (sub-division Vb1). Catch curves from the spring groundfish survey.

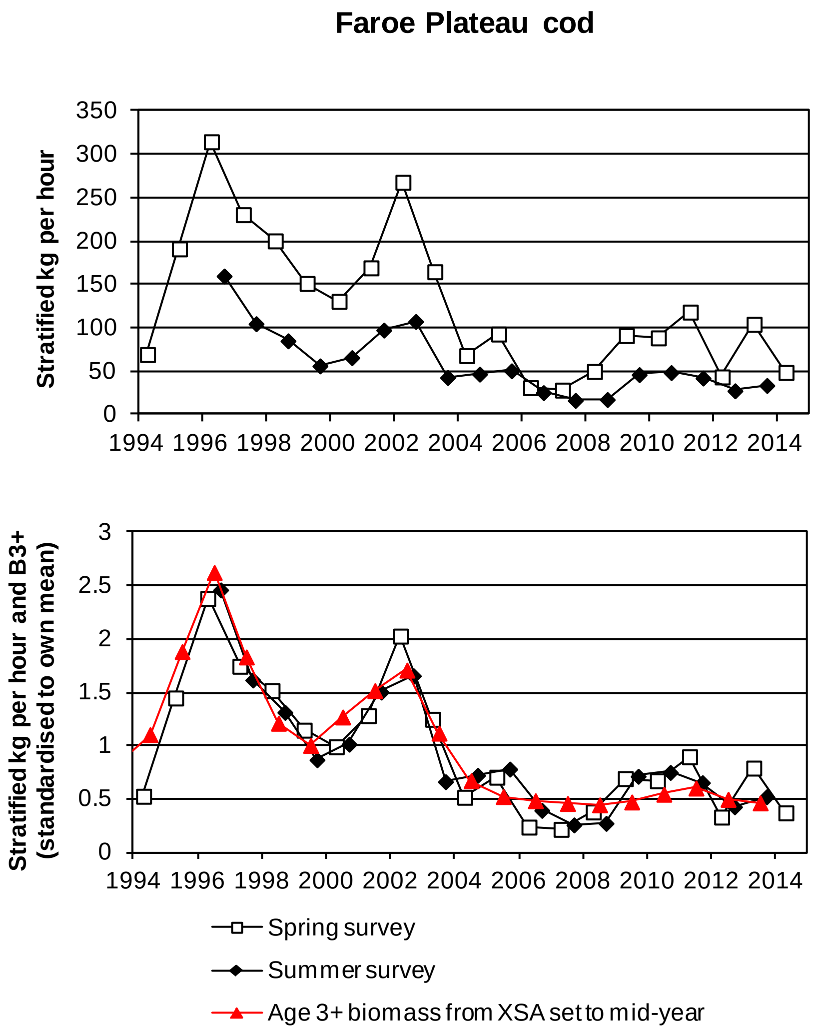


Figure 4.2.5. Faroe Plateau cod (sub-division Vb1). Stratified kg/hour in the spring and summer surveys (upper figure). The age 3+ biomass obtained from the assessment is also included as an index.

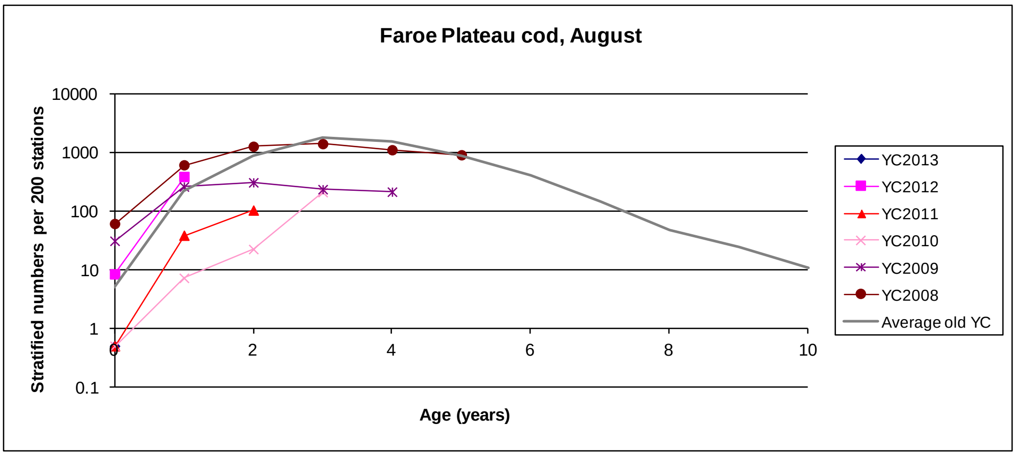


Figure 4.2.6. Faroe Plateau cod (sub-division Vb1). Catch curves from the summer groundfish survey.

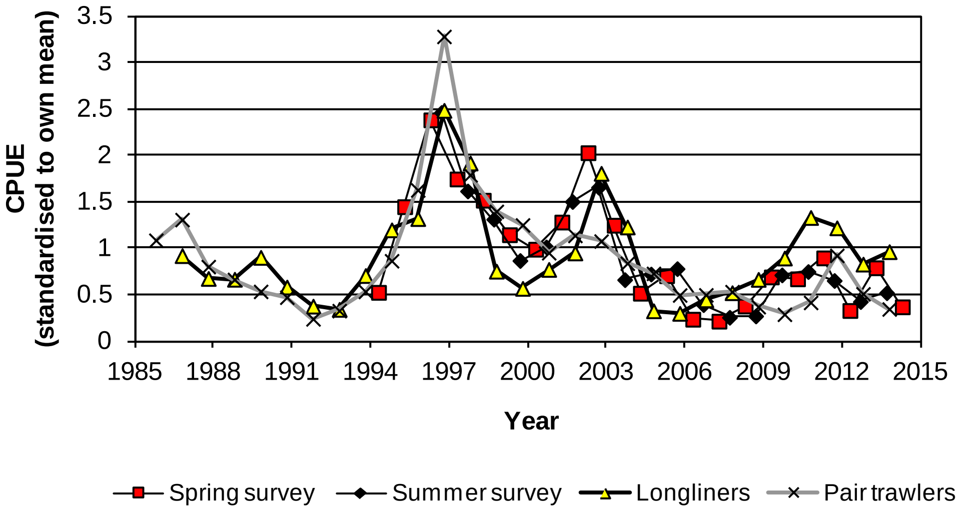


Figure 4.2.7. Faroe Plateau cod (sub-division Vb1). Standardised catch per unit effort for pair trawlers and longliners. The two surveys are shown as well.

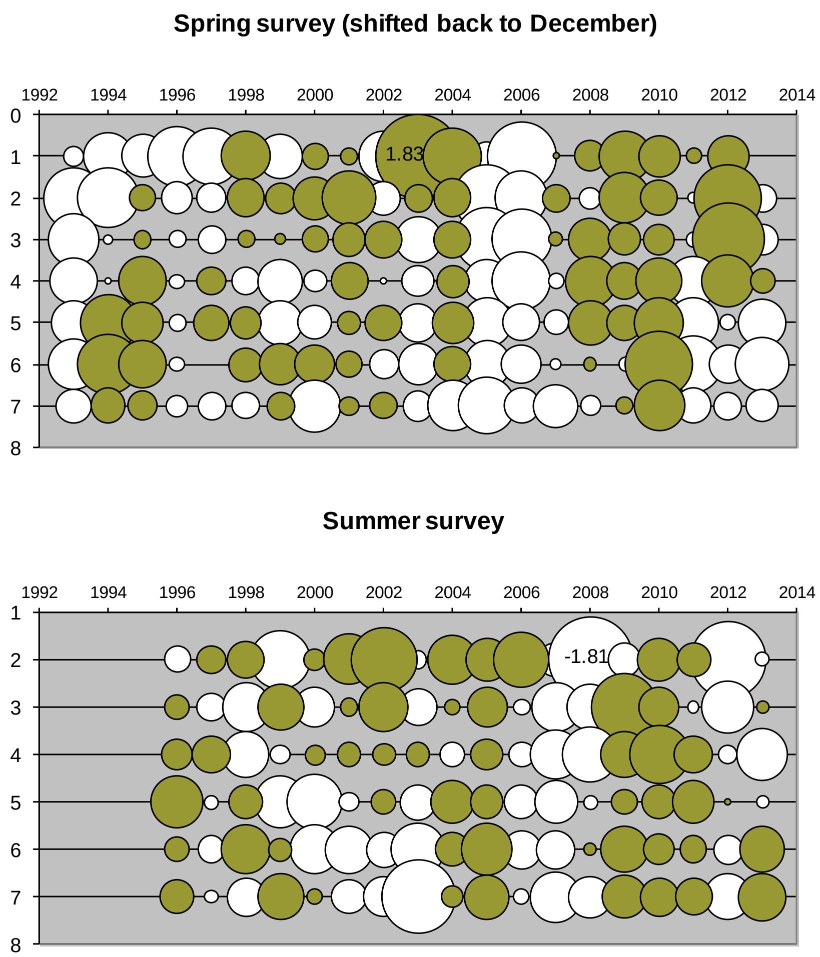
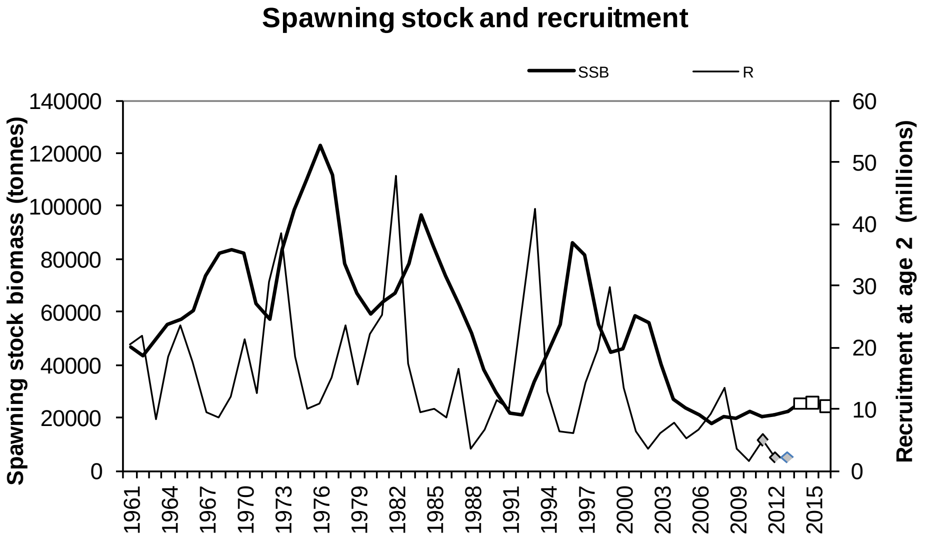


Figure 4.6.1. Faroe Plateau cod (sub-division Vb1). Log catchability residuals for age 2 to 7 for the spring (upper figure) and summer survey. The residuals for age 8 are not presented because some values were off scale. White bubbles indicate negative residuals.



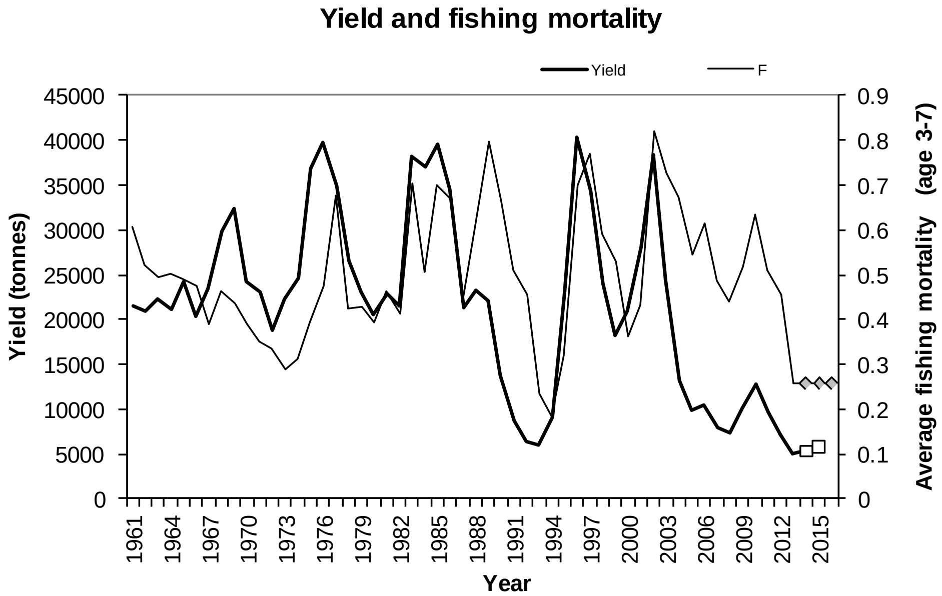


Figure 4.6.2. Faroe Plateau cod (sub-division Vb1). Spawning stock biomass (SSB) and recruitment (year class) versus year (upper figure) and yield and fishing mortality versus year. Points (white and grey) are taken from the short term projections.

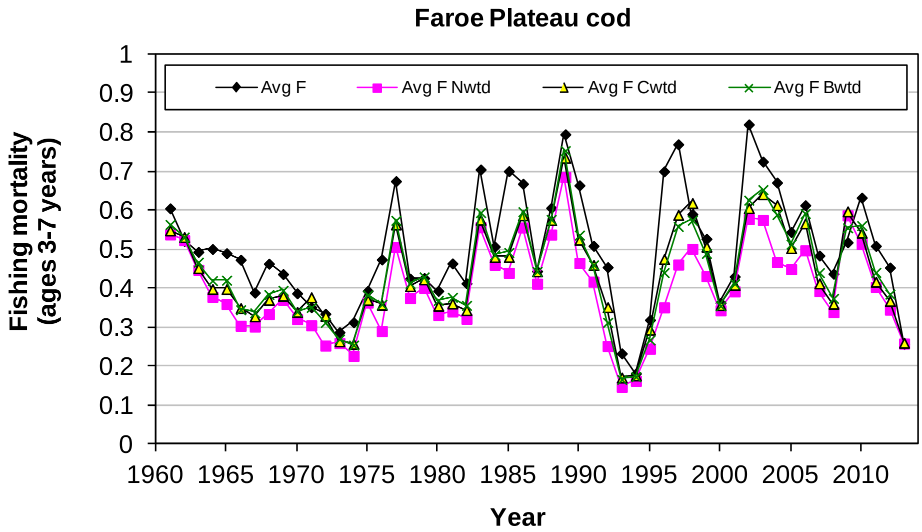


Figure 4.6.3. Faroe Plateau cod (sub-division Vb1). Different measures of fishing mortality: straight arithmetic average (Avg F), weighted by stock numbers (Nwtd), weighted by stock biomass (Bwtd) or weighted by catch (Cwtd).

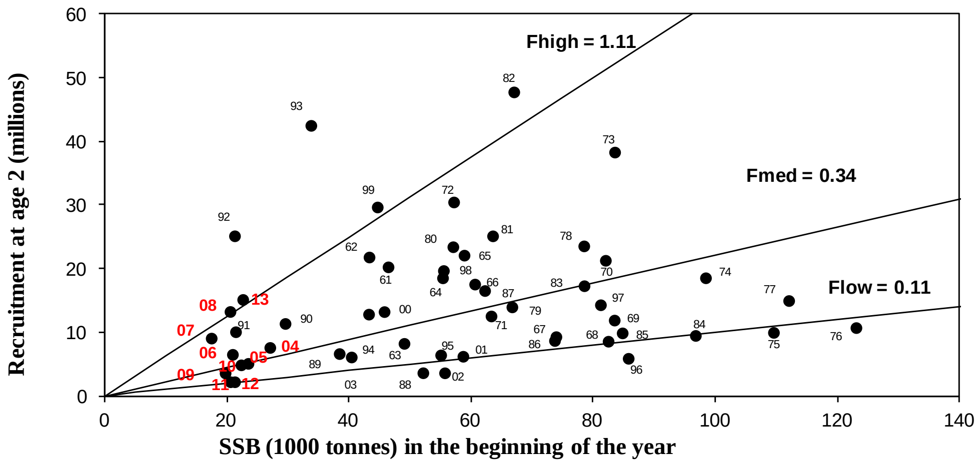


Figure 4.6.4. Faroe Plateau cod (sub-division Vb1). Spawning stock – recruitment relationship. Years are shown at each data point.

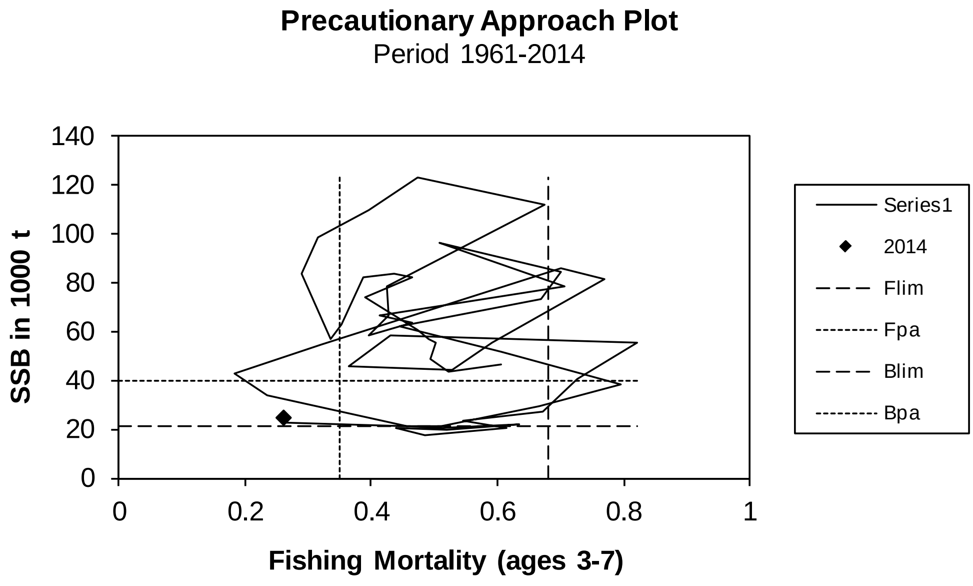


Figure 4.6.5. Faroe Plateau cod (sub-division Vb1). Spawning stock biomass versus fishing mortality.

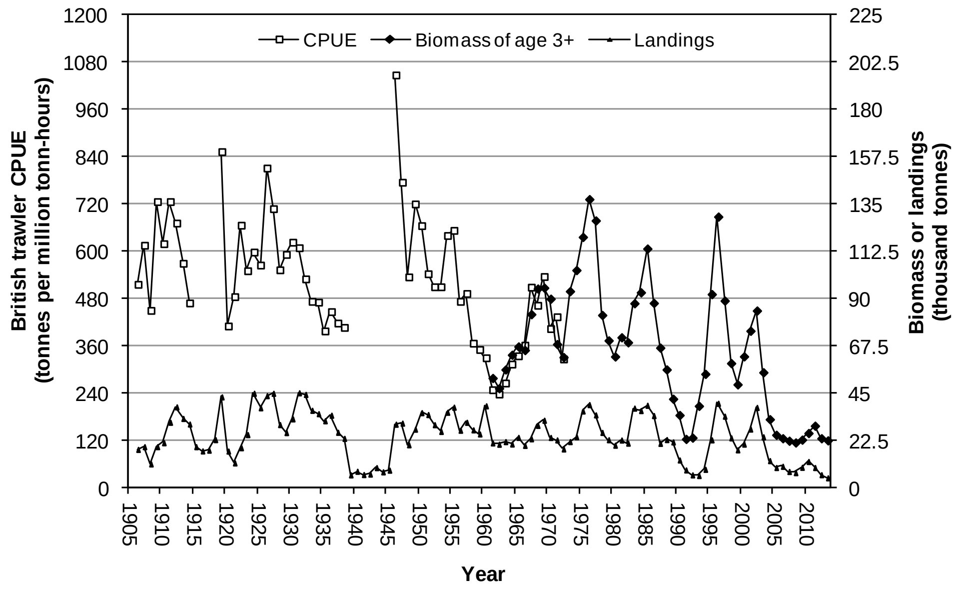


Figure 4.6.6. Faroe Plateau cod (sub-division Vb1). Stock development based on cpues from british steam trawlers (1906-1925: cwts per days of absence from port), cpues from british trawlers (1924-1972: tonnes per million tonn hours) and the XSA-estimates (1961-2010: absolute biomass). The 1906-1925 series was scaled to the 1924-1972 series and the CPUEs refer to the first (left) axis while the XSA-estimates refer to the second axis.

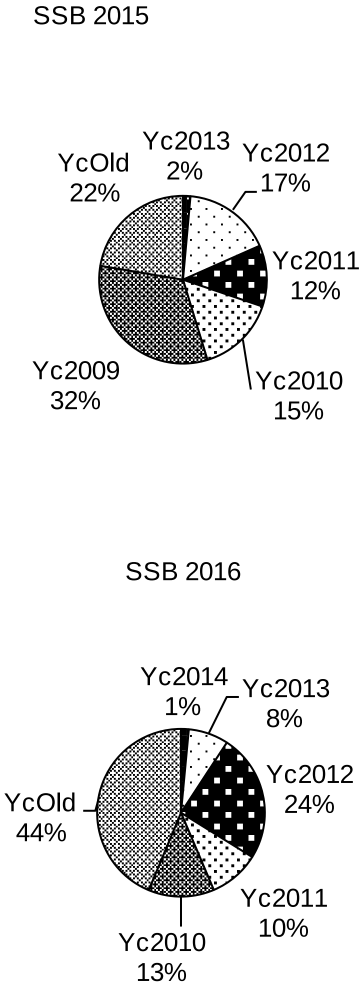


Figure 4.7.1. Faroe Plateau cod (sub-division Vb1). Predictions of the contribution of various year classes to the spawning stock biomass in terminal year +1(upper figure) and terminal year +2 (lower figure).

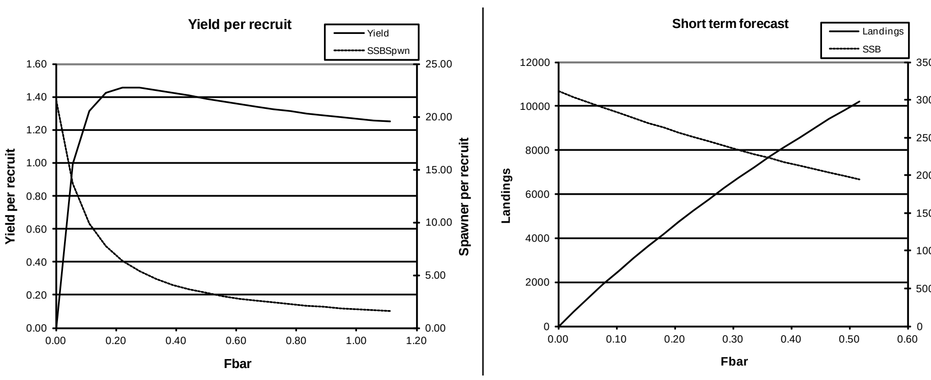


Figure 4.8.1. Faroe Plateau cod (sub-division Vb1). Yield per recruit and spawning stock biomass (SSB) per recruit versus fishing mortality (left figure). Landings and SSB versus Fbar (3-7) (right figure).

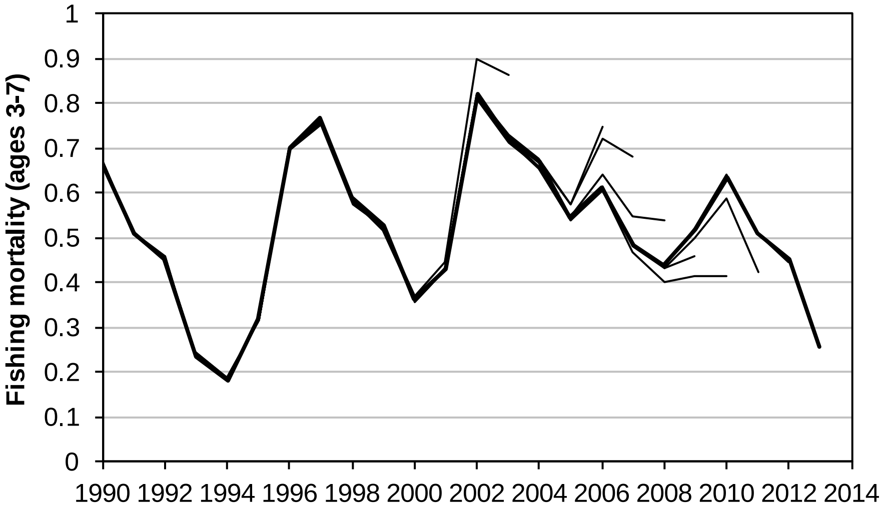
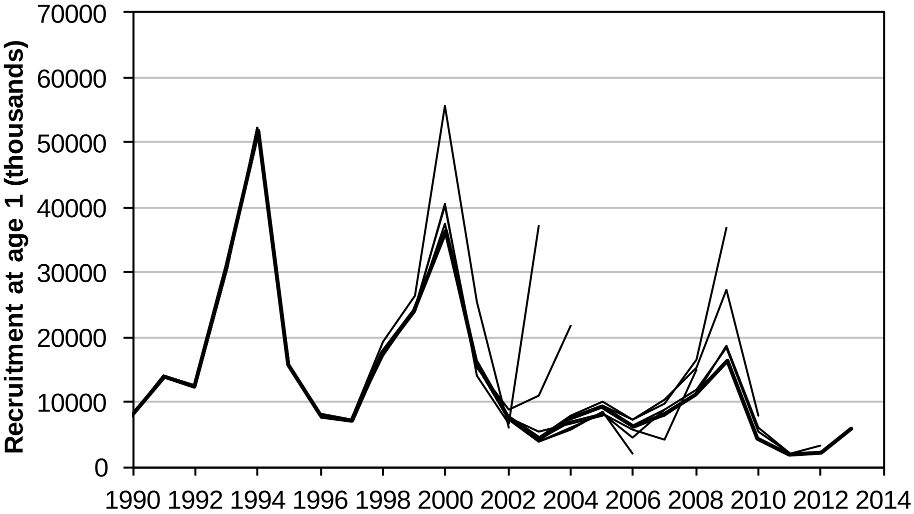


Figure 4.9.1. Faroe Plateau cod (sub-division Vb1). Results from the XSA retrospective analysis of fishing mortality (ages 3-7).



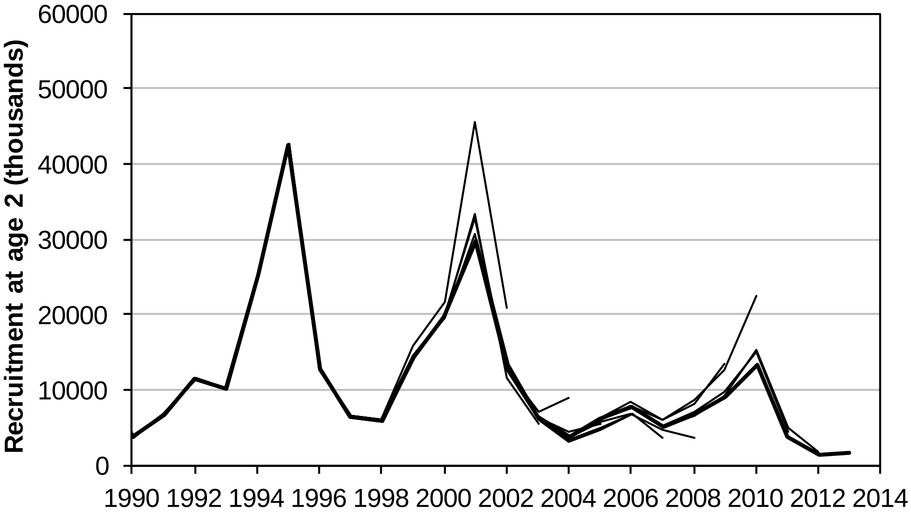


Figure 4.9.1. Faroe Plateau cod (sub-division Vb1). Results from the XSA retrospective analysis (continued). Recruitment at age 1 (upper figure) and at age 2.

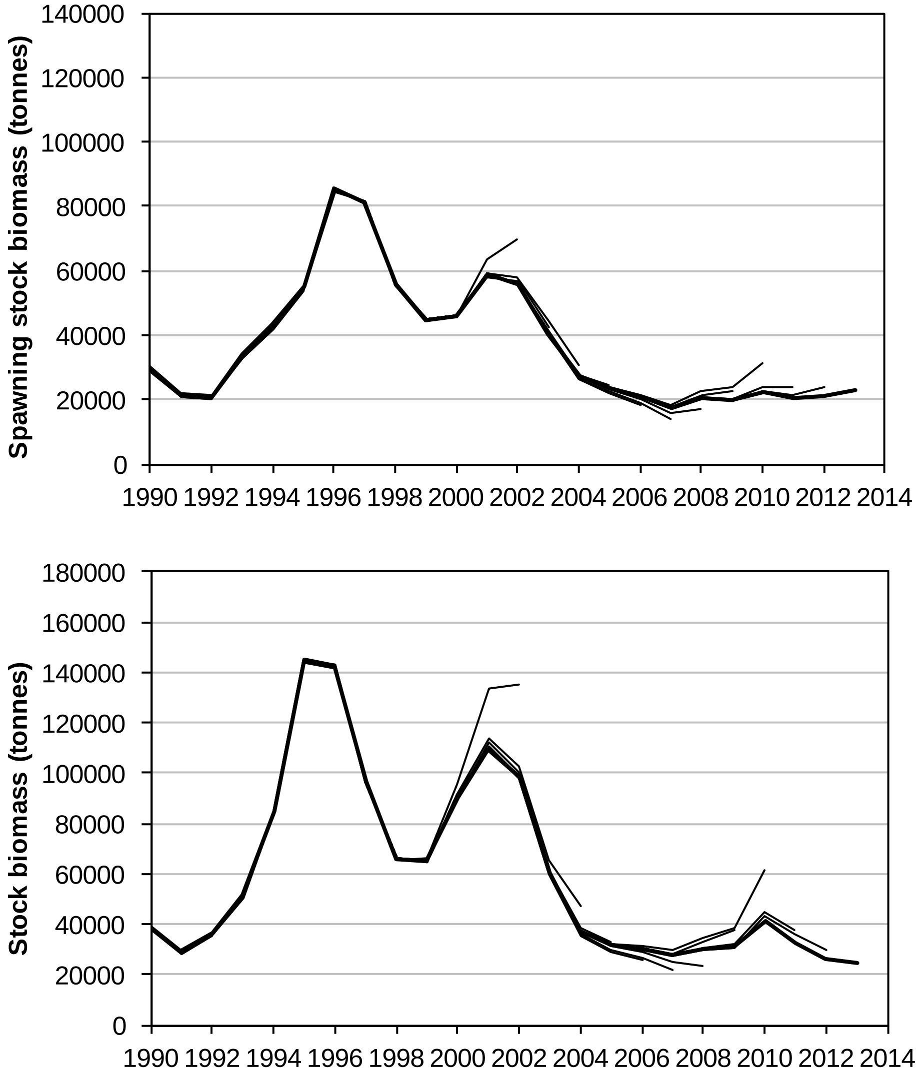


Figure 4.9.1. Faroe Plateau cod (sub-division Vb1). Results from the XSA retrospective analysis (continued). Spawning stock biomass (upper figure) and total stock biomass.

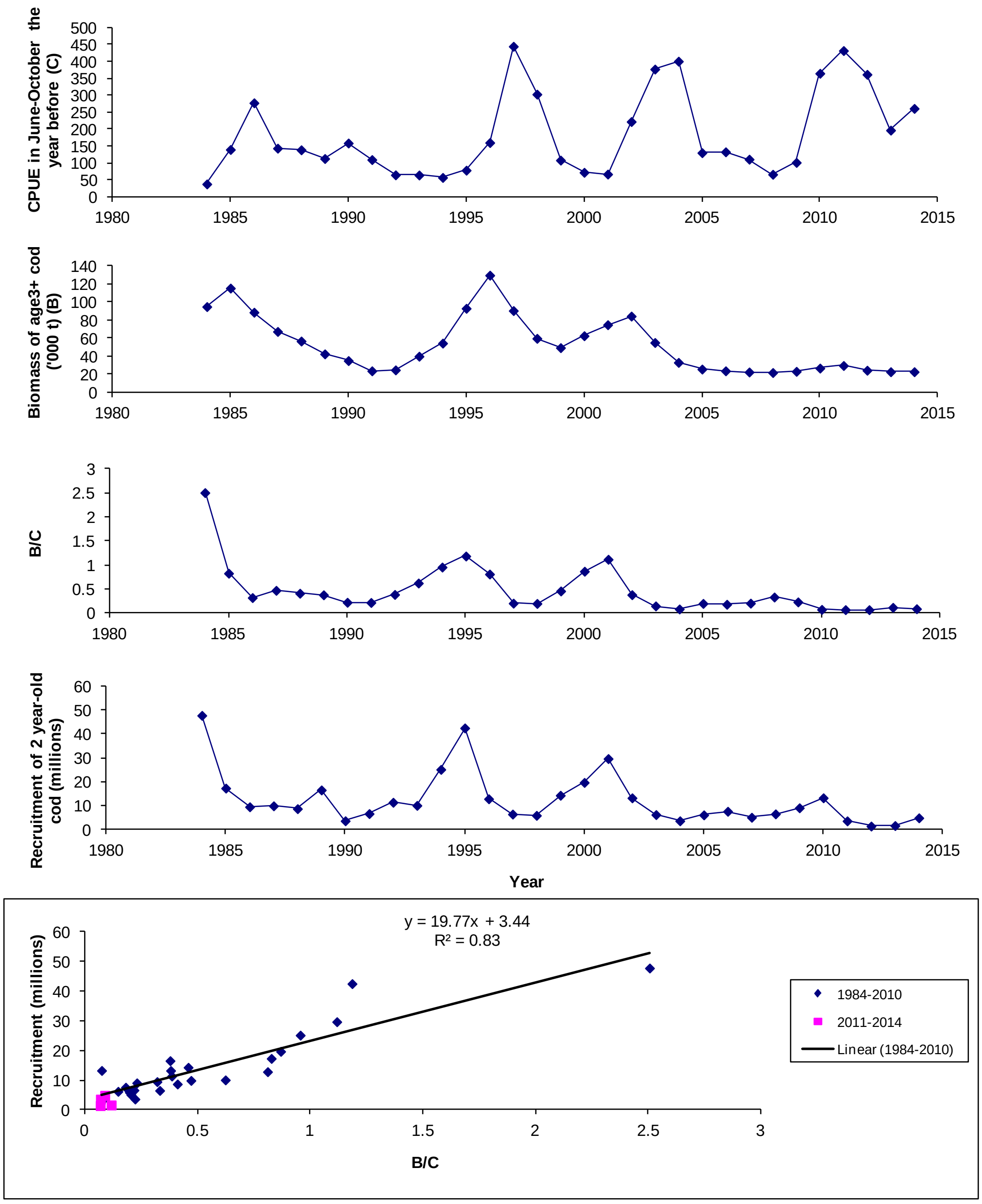


Figure 4.9.2. Faroe Plateau cod (sub-division Vb1). Modelling cod recruitment in three steps. First, the catch-per-unit –effort of cod (C) for small boats operating close to land, as being indicative of the amount of cannibalistic cod. Second, the amount of cod (older than the recruiting cod) (B), as being indicative of e.g. the amount of schools to which recruiting cod can join and hide in. Third, the ratio between B and C, as indicative of recruitment success. Fourth and fifth, a comparison with observed recruitment. Note that the model predicts that the recruitment in 2011-2014 (YC 2009 to 2012) is very poor.

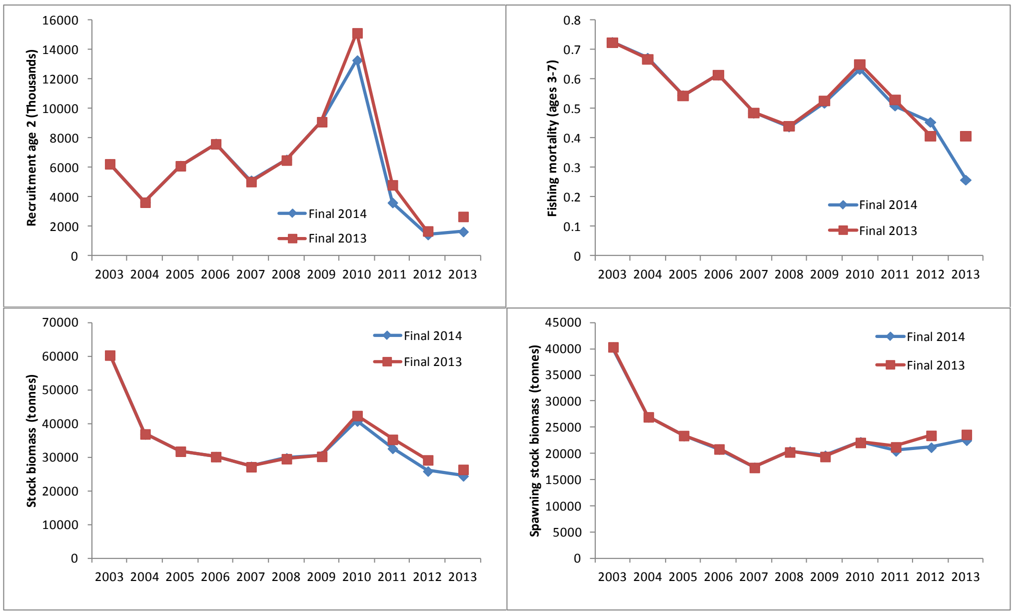


Figure 4.10.1. Faroe Plateau cod (sub-division Vb1). Comparison between the results from the current assessment (Final 2014) and last year final (Final 2013) for recruitment (upper left), fishing mortality (upper right), stock biomass (lower left) and spawning stock biomass (lower right).

5 Faroe haddock

Summary

Being an update assessment, the changes compared to last year are additions of new data from 2013 and 2014 and some minor revisions of recent landings data with corresponding revisions of the catch at age data. The main assessment tool is XSA tuned with 2 research vessel bottom trawl surveys. The results are in line with those from 2013, showing a very low SSB mainly due to poor recruitment but also due to higher than recommended fishing mortalities in recent years. SSB is now estimated well below B_{lim} and is predicted to stay below B_{lim} in 2014-2016 with status quo fishing mortality. Fishing mortality in 2013 is estimated at 0.28 and the average fishing mortality 2011-2013 at 0.27 (F_{MSY} and F_{pa} = 0.25). Landings in 2013 were only 3 100 t, slightly higher than in 2012, which was the lowest in the assessment series back to 1957. This years assessment indicates that the 2013 assessment underestimated the 2012 recruitment by more than 75% (0.5 million versus 1.9 million, which still is the lowest on record), overestimated the fishing mortality in 2012 by 9% (0.25 versus 0.23) and underestimated the 2012 total- and spawning stock biomasses by 17% and 15%, respectively (17 and 15 thous. t versus 20 and 17 thous. t).

5.1 Stock description and management units

Haddock in Faroese Waters, i.e. ICES Sub-Divisions Vb1 and Vb2 and in the southern part of ICES Division IIa, close to the border of Sub-Division Vb1, are generally believed to belong to the same stock and are treated as one management unit named Faroe haddock. Haddock is distributed all over the Faroe Plateau and the Faroe Bank from shallow water down to more than 450 m. A more detailed description of haddock in Farose waters is given in the stock annex. The spatial distribution of the haddock in the summer survey 2013 and in the spring survey 2014 is shown in figure 5.9; the distribuition by year for the whole survey series is in the stock annex. The figures in the stock annex do clearly illustrate the drastic decrease in the stock biomass in recent years.

5.2 Scientific data

5.2.1 Trends in landings and fisheries

Nominal landings of Faroe haddock increased very rapidly from only 4 000 t in 1993 to 27 000 t in 2003, but have declined drastically since and amounted in 2013 to only about 3 100 t. Most of the landings are taken from the Faroe Plateau; the 2013 landings from the Faroe Bank (Sub-Division Vb2), where the area shallower than 200 m depths has been closed to almost all fishing since the fiscal year 2008-2009, amounted to only about 45 t (Tables 5.1 and 5.2). The cumulative landings by month (Figure 5.2) suggest that landings in 2014 may be at the same low level as in 2013.

Faroese vessels have taken almost the entire catch since the late 1970s (Figure 5.1). Due to the dispute on mackerel quota share, there has been no agreement on mutual fishery rights between the Faroe Islands and Norway and EU, respectively, since 2011 and therefore there was no fishery by those parties in Vb in 2012; in 2014 the parties happened to made an agreement again. Table 5.3 shows the proportion of the Faroese landings taken by each fleet category since 1985. The longliners have taken most of the catches in recent years followed by the trawlers. This was also the case in 2013, where the share by longliners was 78% and that by trawlers 22 (Figure 5.3).

5.2.2 Catch-at-age

For the Faroese landings, catch-at-age data were provided for fish taken from the Faroe Plateau (Vb1). The sampling intensity in 2013 is shown in Table 5.4 showing some improvement compared to 2012 . There is, however, a need to increase the sampling level. Reasons for the inadequate sampling level are shortage of resources (people, money) but also that the total catches (and stock) are so small that it is difficult to obtain enough samples. From late 2011, a landing site has been established in Tórshavn close to the Marine Research Institute and it is the intention that technicians from the Institute will regularly be sampling the landings there; this will increase the sampling level in coming years.

The normal procedure has been to disaggregate samples from each fleet category by season (Jan-Apr, May-Aug and Sep-Dec) and then raise them by the corresponding catch proportions to give the annual catch-at-age in numbers for each fleet This year, all longliners were grouped into 2 fleets (larger and smaller than 100 GRT, respectively), and all trawlers were also grouped into 2 fleets (larger and smaller than 1000 Hp, repsectively)The longliner samples had to be treated by using 2 seasons only (Jan-Jun, Jul-Dec. The results are given in Table 5.4. No catch-at-age data were available from the minor catch by trawlers from Iceland and they were assumed to have the same age composition as the Faroese trawlers > 1000 HP. The most recent data were revised according to the final catch figures. The resulting total catch-at-age in numbers is given in Tables 5.4 and 5.5, and in Figure 5.4 the LN(catch-at-age in numbers) is shown since 1990. LN(catch-at-age in numbers) for the whole assessment period from 1957 onwards can be found in the stck annex.

In general the catch-at-age matrix in recent years appears consistent although from time to time a few very small year classes are disturbing this consistency, both in numbers and mean weights at age. The recent very small year classes need to be very carefully inspected when the FBAR is calculated. Also there are some problems with what ages should be included in the plus group; there are some periods where only a few fishes are older than 9 years, and other periods with a quite substantial plus group (10+). These problems have been addressed in former reports of this WG and will not be further dealt with here (See the 2005 NWWG report). No estimates of discards of haddock are available. However, since almost no quotas are used in the management of the fisheries on this stock, the incentive to discard in order to high-grade the catches should be low. The landings statistics is therefore regarded as being adequate for assessment purposes. The ban on discarding as stated in the law on fisheries should also – in theory – keep the discarding at a low level.

5.2.3 Weight-at-age

Mean weight-at-age data are provided for the Faroese fishery (Table 5.6). Figure 5.5 shows the mean weights-at-age in the landings for age groups 2-7 since 1976. During this period, weights have shown cyclical changes. They were at a minimum in 2007-2009, but have increased again since then In the 3 latest years the weights have been fluctuated without a clear trend and a simple average of these years will be used in the short term predictions (figure 5.5). The mean weights at age in the stock are assumed equal to those in the landings.

5.2.4 Maturity-at-age

Maturity-at-age data is available from the Faroese Spring Groundfish Surveys 1982–2014. The survey is carried out in February-March, so the maturity-at-age is determined just prior to the spawning of haddock in Faroese waters and the determinations of the different maturity stages is relatively easy.

In order to reduce year-to-year effects due to possible inadequate sampling and at the same time allow for trends in the series, the routine by the WG has been to use a 3-year running average in the assessment. For the years prior to 1982, average maturity-at-age from the surveys 1982–1995 was adopted (Table 5.7 and Figure 5.6).

5.3 Information from the fishing industry

There exists a considerable amount of data on fish size in the fishing industry. No such information was used directly in the 2014 assessment but catch per unit effort for some selected fleets (logbook data) is used as an additional information on the status of the stock (see section 5.4.1.1).

5.4 Methods

This assessment is an update of the 2013 assessment, with exactly the same settings of the XSA. The only changes are minor revisions of recent landings according to revised data and corresponding revisions of the c@age input. All other input files (VPA) are the same except for the addition of the 2013 data.

5.4.1 Tuning and estimates of fishing mortality

Commercial cpue series. Several commercial catch per unit effort series are updated every year, but as discussed in previous reports of this WG they are not used directly for tuning of the VPA but as additional information on stock trends (for details see the stock annex). The age-aggregated cpue series for longliners and pair trawlers are presented in Figure 5.7. In general the two series show the same trends although in some periods the two series are conflicting; this has been explained by variations in catchability of the longlines due to changes in productivity of the ecosystem (see chapter 2). Both series, however, indicate that the stock is very low. The longliner cpue's do not decrease as much as the trawler cpue's which in addition to the explanation given above may be attributed to the fact that in the management of the demersal Faroese stocks, large areas have been closed to trawling with the effect that when the haddock stock is small, the distribution of it is mainly outside the "trawl areas".

Fisheries independent cpue series. Two annual groundfish surveys are available, one carried out in February-March since 1982 (100 stations per year down to 500 m depth), and the other in August-September since 1996 (200 stations per year down to 500 m depth). The spatial distribution of haddock catches in the surveys in 2013 and 2014 is shown in Figure 5.9 and the spatial distribution in the whole survey series are shown in the stock annex (spring surveys 1994-2014 and summer surveys 1996-2013). Biomass estimates (kg/hour) are available for both series since they were initiated (Figure 5.8). The main trends from the surveys are the same but the summer survey indicates a considerably more depleted stock in recent years than the summer survey. Age disaggregated data are available for the whole summer series, but due to problems with the database (see earlier reports), age disaggregated data for the spring survey are only available since 1994. The calculation of indices at age is based on age-length keys with a smoother applied. This is a useful method but, some artifacts may be introduced because the smoothing can assign wrong ages to some lengths, especially for the youngest and oldest specimen. As in recent years, the length distributions have been used more directly for calculation of indices at age (ages 0-2), since these ages have length distributions almost without overlap. LN(numbers at age) for the surveys are presented in Figures 5.10-5.11. Further analyses of the performances of the two series are shown in the stock annex. In general there is a good relationship between the indices for one year class in two successive years. The same applies when comparing the corresponding indices at age from both surveys .

A SPALY (same procedure as last year) run, with the same settings of the XSA as in 2013 (tuned with the two surveys combined) (Table 5.8), with 2014 data included and some minor revisions of recent catch figures, gave in general similar results as last year (Table 5.9), although this years assessment indicates that the 2013 assessment underestimated the 2012 recruitment by more than 75% (0.5 million versus 1.9 million, which still is the lowest on record), overestimated the fishing mortality in 2012 by 10% (0.25 versus 0.23) and underestimated the 2012 total- and spawning stock biomasses by 15% and 13%, respectively (17 and 15 thous. t versus 20 and 17 thous. t).

The log q residuals for the two surveys are shown in Figure 5.12.

The retrospective analysis of fishing mortality, recruitment and spawning stock biomass of this XSA is shown in Figure 5.13. The retrospective pattern of the fishing mortality is hampered by strange values of some small poorly sampled year classes which in some years are included in the FBAR reference ages and consequently they will create problems for estimation of the stock (see the 2005 NWWG report); this is not a problem for the time being but the development of recent small year classes should be carefully inspected.

It has been questioned if a rather heavy shrinkage of 0.5 is the most appropriate for a stock like Faroe haddock where biological parameters and fishing mortality (catchability) are closely linked to productivity changes in the ecosystem. In order to investigate the possible effect of the shrinkage, the 2010 NWWG carried out an exploratory XSA without shrinkage (Shr. 2.0). Based on that it was concluded to continue with a shrinkage of 0.5 and this shrinkage was also applied this year.

Results. The fishing mortalities from the final XSA run are given in Table 5.10 and in Figure 5.14. The fishing mortality was high (around 0.6) in the 1950s and early 1960s but declined to around 0.2 from 1965-1975.Since then, fishing mortality has usually been low, the exceptions are peaks in 1977, 1982, 1997-1999 and 2003-2006. They occur near the end of relatively high catch periods and some of the highest values (0.32-0.45) are nearly certainly an artefact of the unweighted fishing mortality. Exploitation ratio (Yield/Biomass) is more stable and may be used to indicate the level of fishing mortality.

5.5 Reference points

The yield- and spawning stock biomass per recruit (age 2) based on the long-term data are shown in Table 5.17 and Figure 5.16. From Figure 5.15, showing the recruit/spawning stock relationship, and from Table 5.17, $\mathbf{F}_{med}$, and $\mathbf{F}_{high}$ were calculated at 0.24 and 0.80, respectively. The F_{max} of 0.60 should not be used since it is very poorly determined due to the flat YPR curve. $F_{0.1}$ is estimated at 0.19. The F35%SPR was estimated at 0.23.

The precautionary reference fishing mortalities were set in 1998 by ACFM with F_{pa} as the $\mathbf{F}_{med}$ value of 0.25 and F_{lim} two standard deviations above $\mathbf{F}_{pa}$ equal to 0.40. The precautionary reference spawning stock biomass levels were changed by ACFM in

2007. B_{lim} was set at 22 000 t (B_{loss}) and B_{pa} at 35 000 t based on the formula $B_{pa} = B_{lim}e^{1.645\sigma}$, assuming a σ of about 0.3 to account for the uncertainties in the assessment.

The working group in 2012 investigated possible candidates for F_{MSY}. Based on Medium –term projections, Medium-term projections the NWWG suggested, that FMSY preliminary could be set at 0.25 and the MSY $B_{trigger}$ at 35 thous. t (same as B_{pa}) These values were accepted by ACOM. Some further analyses have indicated that these values are acceptable, but it is anticipated that further work will be untertaken in connection with the next benchmark assessment. See the stock annex for more details.

5.6 State of the stock – historical and compared to what is now.

The stock size in numbers is given in Table 5.11 and a summary of the VPA with the biomass estimates is given in Table 5.12 and in Figure 5.14. According to this assessment, the period up to the mid 1970s was characterized by relative high and stable landings, recruitment and spawning stock biomass and the stock was able to withstand relatively high fishing mortalities. Since then the spawning stock biomass has shown large fluctuations due to cyclical changes in recruitment, growth and maturity (Figures 5.5 and 5.6). The fishing mortality does not seem to be the decisive factor in this development since it most of the period has fluctuated around the F_{MSY} and F_{pa}. It must though be remembered that the characteristics of the stock in recent decades with long periods of poor recruitment make it less resilient to high fishing mortality.

The most recent increase in the spawning stock is due to new strong year classes entering the stock of which the 1999 year class is the highest on record (103 million at age 2). Also the YC’s from 2000 and 2001 are estimated well above average and the 2002 YC above average, but the more recent YC’s are all estimated to be very small except the 2009 YC, which is estimated to be slightly above the half of the average for the whole series back to 1957 and the 2012 and 2013 YC’s, which are estimated somewhat higher than the other small year-classes. Fishing mortality has been relatively high since 2003, highest whent the stock was large leading to large variability in catches. Currently fishing mortality is estimated close to F_{MSY} (0.25).

5.7 Short term forecast

5.7.1 Input data

The input data for the short-term predictions are estimated in accordance with the procedures last year and explained in Tables 5.13-14. The YC 2014 at age 2 in 2016 is estimated as the geometric mean of the 2-year-olds since 2005. This procedure was introduced in 2011. All available information suggests that using the recent short series with poor recruitment is more appropriate than the longer period used in the past. However, the choice of recruitment in 2016 has little effect on the short term prediction.

5.7.2 Results

Although the allocated number of fishing days for the fishing year 2013-2014was reduced for some fleets as compared to the year before (see section 2), it should not be unrealistic to assume fishing mortalities in 2014 as the average of some recent years, here the average of F(2011-2013), since not all allocated days were actually used; however, possible changes in the catchability of the fleets (which seems to be linked to productivity changes in the environment) could undermine this assumption; price differences between cod and haddock may also influence this assumption. The landings in 2014 are then predicted to be about 3400 t, and continuing with this fishing mortality will result in 2015 landings of about 3 800 t Table 5.15). The SSB will decline to 16 000 t in 2014, will be 16 800 t in 2015 and increase to 18 600 t in 2016 i.e. will be below B_{lim} (22 000t) in the next years. The results of the short-term prediction are shown in Table 5.15 and in Figure 5.16. The contribution (%) by year-classes to the age composition of the predicted 2014 and 2015 SSB's is shown in Figure 5.17. It should be noted that the YC 2012 which not have entered the fishery in 2013, will contribute by 40% of the SSB in 2016.

5.8 Medium term forecasts and yield per recruit

No medium term projections were made this year; however, last years projections, which were the basis for suggested MSY reference points, are presented in the stock annex.

The input data for the long-term yield and spawning stock biomass (yield-per-recruit calculations) are listed in Table 5.16. Mean weights-at-age (stock and catch) are averages for the 1977–2013 period. The maturity o-gives are averages for the years 1982-2013. The exploitation pattern is the same as in the short term prediction.

The results are given in Table 5.16, in Figure 5.20 and under Reference points (section 5.5).

5.9 Uncertainties in assessment and forecast

Retrospective analyses indicate periods with tendencies to overestimate spawning stock biomass and underestimate fishing mortality and vice versa. Similar things can be seen with the recruitment. This years assessment indicates that the 2013 assessment underestimated the 2012 recruitment by more than 75% (0.5 million versus 1.9 million, which still is the lowest on record), overestimated the fishing mortality in 2012 by 10% (0.25 versus 0.23) and underestimated the 2012 total- and spawning stock biomasses by 15% and 13%, respectively (17 and 15 thous. t versus 20 and 17 thous. t), see text table below..

Recruitment estimates from surveys are not very consistent for small cohorts..

The sampling of the catches for length measurements, otolith readings and length-weight relationships has improved as compared to 2007-2009, and was considered to be adequate in 2010; the level of sampling decreased again in 2011-2012 and improved marginally in 2013. Although it is regarded to be adequate for the assessment, there is a need to improve it again (see 5.2).

5.10 Comparison with previous assessment and forecast

As explained previously in the report, this assessment is an update of the 2013 assessment. The only changes are minor revisions of recent landings according to revised data and corresponding revisions of the c@age input. All other input files (VPA and tuning fleets) are the same except for the addition of the 2013 data.

Following differences in the 2012 estimates were observed as compared to last year (see text above):

Comparisons between 2013 and 2014 assessment of 2012 data
The year of comparison is 2012

	R at age 2 (thousands	Total B (tonnes)	SSB (tonnes)	Landings (tonnes)	F (3-7)
2013 spaly	453	16725	14641	2613	0.2505
2014 spaly	1854	19581	16886	2634	0.2281
%-change	76	15	13	1	-10

5.11 Management plans and evaluations

There is no explicit management plan for this stock. A management system based on number of fishing days, closed areas and other technical measures was introduced in 1996 with the purpose to ensuring sustainable fisheries. There has been some work with establishing a management plan with a harvest control role for cod, haddock and saithe including a recovery plan, but the proposal has not yet been officially accepted. See overview in section 2 for details.

5.12 Management considerations

Management of fisheries on haddock also needs to take into account measures for cod and saithe.

5.13 Ecosystem considerations

Since on average about 80% of the catches are taken by longlines and the remaining by trawls, effects of the haddock fishery on the bottom is moderate.

5.14 Regulations and their effects

As explained in the overview (section 2), the fishery for haddock in Vb is regulated through a maximum number of allocated fishing days, gear specifications, closed areas during spawning times, closed areas for longlining close to land and large areas closed to trawling. As a consequence, around 80% of the haddock landings derive from long line fisheries. Since the minimum mesh size in the trawls (codend) is 145 mm, the trawl catches consist of fewer small fish than the long line fisheries. Other nations fishing in Faroese waters are regulated by TAC's obtained during bilateral negotiations; their total landings are minimal, however, and in 2011-2013 no agreement could be made between the Faroe Islands and EU and Norway, respectively, due to the dispute on mackerel quota sharing. In 2014, however, the parties managed to get an agreement in place again. Discarding of haddock is considered minimal and there is a ban to discarding.

5.15 Changes in fishing technology and fishing patterns

See section 2.

5.16 Changes in the environment

See section 2.

Table 5.1 Faroe Plateau (Sub-division Vb1) HADDOCK. Nominal catches (tonnes) by countries 2000-2013 and Working Group estimates in Vb.

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013 [2]
Faroe Islands	13,620	13,457	20,776 [6]	21,615	18,995	18,172	15,600	11,689	6,728	4,895	4,932	3,350	2,490	2,846
France[1]	6	8	2	4	1	+	12 [5]	4 [5]	3 [5]	2 [5]	1	3		
Germany	1	2	6	1	6		1							
Greenland	22	0	4 [4]				1	9 [4]		6 [4]	12	+	1 [4]	
Iceland			4										2	26
Norway	355	257	227	265	229	212	57	61	26	8	5			
Russia					16				10					
Spain					49									
UK (Engl. and Wales)	19	4	11 [5]	14	8	1	1							
UK (Scotland)[5]				185	186	126	106	35	60	64				
United Kingdom											73			
Total	14,023	13,728	21,030	22,084	19,490	18,511	15,778	11,798	6,827	4,975	5,023	3,353	2,493	2,872
Used in the assessment	15,821	15,890	24,933	27,072	23,101	20,455	17,154	12,631	7,388	5,197	5,202	3,540	2,634	3,105

1) Including catches from Sub-division Vb2. Quantity unknown 1989-1991, 1993 and 1995-2001.

2) Preliminary data

3)From 1983 to 1996 catches included in Sub-division Vb2.

4) Reported as Division Vb, to the Faroese coastal guard service.

5) Reported as Division Vb.

6) Includes Faroese landings reported to the NWWG by the Faroe Marine Research Institute

Table 5.2 Faroe Bank (Sub-division Vb2) HADDOCK. Nominal catches (tonnes) by countries, 2000-2013.

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013 [2]
Faroe Islands	1,565 [5]	1,948	3,698	4,934	3,594	2,444	1,375	810	556	192	178	194	141	45
France1						+								
Norway	48	66	28	54	17	45	1	8		3	1			
UK (Engl. and Wales)	[1]	[1]	[1]	[1]	[1]	1								
UK (Scotland)3	185	148	177	[4]	[1]	1		15	5	27 [4]	33			
Total	1,798	2,162	3,903	4,988	3,611	1,944	1,376	833	561	222	212	194	141	45

1) Catches included in Sub-division Vb1.

2) Provisional data

3)From 1983 to 1996 includes also catches taken in Sub-division Vb1 (see Table 2.4.1)

4) Reported as Division Vb.

5) Provided by the NWWG

Table 5.3 Total Faroese landings of haddock from Division Vb 1985-2013 by each fleet category (%).

	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	2012	2013
Open boats	7	7	11	2	3	2	3	2	1	1	1	2	2	2	2	1	2	3	4	4	4	6	6	6	4	6	7	6	8
Longliners < 100GRT	39	39	39	49	58	60	56	46	24	18	23	28	31	30	23	24	29	31	34	40	41	47	35	34	27	27	40	41	35
Longliners > 100GRT	13	12	13	19	18	18	18	22	25	25	38	36	38	40	40	36	38	34	42	42	43	36	39	41	30	47	35	34	35
Otter board trawlers < 1000HP	7	5	7	6	4	4	3	3	11	10	12	13	9	8	7	9	7	6	4	3	3	1	4	7	13	4	4	6	10
Otterboard trawlers > 1000HP	8	5	2	2	2	2	2	1	1	3	2	2	3	3	7	5	5	11	3	1	1	2	8	2	2	2	3	5	8
Pairtrawlers < 1000HP	19	20	17	11	7	5	7	11	13	10	8	7	6	5	6	7	6	4	4	2	2	2	3	3	5	3	2	2	2
Pairtrawlers > 1000HP	6	10	9	9	6	8	11	14	22	29	16	13	12	12	14	19	12	10	8	7	4	5	6	7	18	11	9	5	3
Nets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jigging	1	0	0	0	1	1	1	0	0	0	0	1	1	0	0	0	1	2	1	1	1	0	1	0	0	+	1	0	1
Other gears	0	1	1	2	1	1	1	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.4

Catch at age 2013

Age	Vb LLiners < 100GRT	Vb LLiners > 100GRT	Vb Trawl < 1000HP	Vb Trawl > 1000HP	Vb Others	Vb All Faroese fleets	Vb Foreign Trawlers	Vb Total All fleets
1	1	0	0	0	0	0	0	0
2	56	22	1	7	0	86	0	87
3	456	42	10	27	0	535	1	537
4	345	344	178	297	0	1163	14	1177
5	57	82	38	52	0	229	2	231
6	24	38	15	22	0	99	1	100
7	20	30	14	18	0	81	1	82
8	27	34	13	17	0	92	1	93
9	29	25	9	12	0	75	1	75
10	33	33	9	13	0	88	1	89
11	8	12	5	7	0	31	0	31
12	2	0	1	1	0	5	0	5
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
Total no.	1058	661	293	473	0	2485	22	2506
Catch, t.	1150	810	319	495	0	2774	23	2797

Notes: Numbers in 1000'
Catch, gutted weight in tonnes
Others includes netters, jiggers, other small categories and catches not otherwise accounted for
LLiners = Longliners OB.trawl. = Otterboard trawlers Pair Trawl. = Pair trawlers

Comm. Sampling 2013	Vb1 Open Boats	Vb1 LLiners < 100GRT	Vb1 LLiners > 100GRT	Vb1 Trawl <1000HP	Vb1 Trawl <1000HP	Vb1 All Faroese Fleets	Vb2 All Faroese LLiners	Vb2 All Faroese trawlers	Vb2 All Faroese Fleets	Vb Total
No. samples		7	17	11	38	73	0	0	0	73
No. lengths		1630	3995	2512	8805	16942	0	0	0	16942
No. weights		1630	3995	2512	8805	16942	0	0	0	16942
No. ages		240	359	120	660	1379	0	0	0	1379

Tabel 5.5 Faroe haddock. Catch number-at-age

Run title : FAROE HADDOCK (ICES DIVISION Vb) HAD_IND

At 22/04/2014 15:30

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

YEAR,	1957,	1958,	1959,	1960,	1961,	1962,	1963,
AGE							
0,	0,	0,	0,	0,	0,	0,	0,
1,	45,	116,	525,	854,	941,	784,	356,
2,	4133,	6255,	3971,	6061,	7932,	9631,	13552,
3,	7130,	8021,	7663,	10659,	7330,	13977,	8907,
4,	8442,	5679,	4544,	6655,	5134,	5233,	7403,
5,	1615,	3378,	2056,	2482,	1937,	2361,	2242,
6,	894,	1299,	1844,	1559,	1305,	1407,	1539,
7,	585,	817,	721,	1169,	838,	868,	860,
8,	227,	294,	236,	243,	236,	270,	257,
9,	94,	125,	98,	85,	59,	72,	75,
+gp,	58,	105,	47,	28,	13,	22,	23,
TOTALNUM,	23223,	26089,	21705,	29795,	25725,	34625,	35214,
TONSLAND,	20995,	23871,	20239,	25727,	20831,	27151,	27571,
SOPCOF %,	89,	90,	90,	88,	88,	89,	89,

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

YEAR,	1964,	1965,	1966,	1967,	1968,	1969,	1970,	1971,	1972,	1973,
AGE										
0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
1,	46,	39,	90,	70,	49,	95,	57,	55,	43,	665,
2,	2284,	1368,	1081,	1425,	5881,	2384,	1728,	717,	750,	3311,

3,	7457,	4286,	3304,	2405,	4097,	7539,	4855,	4393,	3744,	8416,
4,	3899,	5133,	4804,	2599,	2812,	4567,	6581,	4727,	4179,	1240,
5,	2360,	1443,	2710,	1785,	1524,	1565,	1624,	3267,	2706,	2795,
6,	1120,	1209,	1112,	1426,	1526,	1485,	1383,	1292,	1171,	919,
7,	728,	673,	740,	631,	923,	1224,	1099,	864,	696,	1054,
8,	198,	1345,	180,	197,	230,	378,	326,	222,	180,	150,
9,	49,	43,	54,	52,	68,	114,	68,	147,	113,	68,
+gp,	7,	8,	9,	13,	12,	20,	10,	102,	95,	11,
TOTALNUM,	18148,	15547,	14084,	10603,	17122,	19371,	17731,	15786,	13677,	18629,
TONSLAND,	19490,	18479,	18766,	13381,	17852,	23272,	21361,	19393,	16485,	18035,
SOPCOF %,	101,	94,	109,	101,	102,	108,	102,	97,	96,	97,

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

YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,
AGE										
0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
1,	253,	94,	40,	0,	0,	1,	0,	0,	0,	0,
2,	5633,	7337,	4396,	255,	32,	1,	143,	74,	539,	441,
3,	2899,	7952,	7858,	4039,	1022,	1162,	58,	455,	934,	1969,
4,	3970,	2097,	6798,	5168,	4248,	1755,	3724,	202,	784,	383,
5,	451,	1371,	1251,	4918,	4054,	3343,	2583,	2586,	298,	422,
6,	976,	247,	1189,	2128,	1841,	1851,	2496,	1354,	2182,	93,
7,	466,	352,	298,	946,	717,	772,	1568,	1559,	973,	1444,
8,	535,	237,	720,	443,	635,	212,	660,	608,	1166,	740,
9,	68,	419,	258,	731,	243,	155,	99,	177,	1283,	947,
+gp,	147,	187,	318,	855,	312,	74,	86,	36,	214,	795,
TOTALNUM,	15398,	20293,	23126,	19483,	13104,	9326,	11417,	7051,	8373,	7234,

TONSLAND, 14773, 20715, 26211, 25555, 19200, 12424, 15016, 12233, 11937, 12894,

SOPCOF %, 97, 117, 107, 98, 99, 104, 100, 109, 92, 106,

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

YEAR, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993,

AGE

0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

1, 25, 0, 0, 0, 0, 0, 0, 0, 0, 43,

2, 1195, 985, 230, 283, 655, 63, 105, 77, 40, 113,

3, 1561, 4553, 2549, 1718, 444, 1518, 1275, 1044, 154, 298,

4, 2462, 2196, 4452, 3565, 2463, 658, 1921, 1774, 776, 274,

5, 147, 1242, 1522, 2972, 3036, 2787, 768, 1248, 1120, 554,

6, 234, 169, 738, 1114, 2140, 2554, 1737, 651, 959, 538,

7, 42, 91, 39, 529, 475, 1976, 1909, 1101, 335, 474,

8, 861, 61, 130, 83, 151, 541, 885, 698, 373, 131,

9, 388, 503, 71, 48, 18, 133, 270, 317, 401, 201,

+gp, 968, 973, 712, 334, 128, 81, 108, 32, 162, 185,

TOTALNUM, 7883, 10773, 10443, 10646, 9510, 10311, 8978, 6942, 4320, 2811,

TONSLAND, 12378, 15143, 14477, 14882, 12178, 14325, 11726, 8429, 5476, 4026,

SOPCOF %, 106, 106, 101, 102, 97, 100, 102, 106, 106, 103,

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

YEAR, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003,

AGE

0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

1, 1, 0, 1, 0, 0, 9, 73, 19, 0, 0,

2, 277, 804, 326, 77, 106, 174, 1461, 4380, 1515, 133,

3, 191, 452, 5234, 2913, 1055, 1142, 3061, 3128, 14039, 3436,

4, 307, 235, 1019, 10517, 5269, 942, 210, 2423, 2879, 13551,

5, 153, 226, 179, 710, 9856, 4677, 682, 173, 1200, 2224,

6, 423, 132, 163, 116, 446, 6619, 2685, 451, 133, 949,

7, 427, 295, 161, 123, 99, 226, 2846, 1151, 239, 163,

8, 383, 290, 270, 93, 87, 26, 79, 1375, 843, 334,

9, 125, 262, 234, 220, 95, 20, 1, 17, 1095, 858,

+gp, 301, 295, 394, 516, 502, 192, 71, 18, 33, 924,

TOTALNUM, 2588, 2991, 7981, 15285, 17515, 14027, 11169, 13135, 21976, 22572,

TONSLAND, 4252, 4948, 9642, 17924, 22210, 18482, 15821, 15890, 24933, 27072,

SOPCOF %, 100, 103, 100, 103, 101, 100, 103, 100, 100, 100,

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

YEAR, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013,

AGE

0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

1, 3, 0, 0, 0, 6, 0, 0, 0, 0, 0,

2, 243, 85, 247, 76, 66, 27, 389, 170, 8, 87,

3, 2007, 1671, 446, 982, 204, 329, 445, 773, 960, 537,

4, 4802, 3852, 2566, 547, 918, 402, 426, 324, 513, 1177,

5, 10426, 6753, 3949, 2732, 424, 555, 279, 198, 156, 231,

6, 1163, 6127, 5423, 3309, 1471, 514, 484, 186, 114, 100,

7, 409, 542, 3278, 2758, 1706, 1133, 553, 280, 123, 82,

8, 89, 147, 136, 1117, 1254, 739, 718, 353, 94, 93,

9, 166, 28, 63, 89, 320, 285, 444, 367, 171, 75,

+gp, 811, 154, 70, 9, 39, 48, 159, 187, 114, 125,

TOTALNUM, 20119, 19359, 16178, 11619, 6408, 4032, 3897, 2838, 2253, 2507,

TONSLAND, 23101, 20455, 17154, 12631, 7388, 5197, 5202, 3540, 2634, 3105,

SOPCOF %, 99, 100, 100, 100, 101, 100, 101, 101, 102, 101,

Table 5.6 Faroe haddock. Catch weight-at-age.

Run title : FAROE HADDOCK (ICES DIVISION Vb) HAD_IND

At 22/04/2014 15:30

Table 2 Catch weights at age (kg)

YEAR	1957	1958	1959	1960	1961	1962	1963
AGE							
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.2500	.2500	.2500	.2500	.2500	.2500	.2500
2	.4700	.4700	.4700	.4700	.4700	.4700	.4700
3	.7300	.7300	.7300	.7300	.7300	.7300	.7300
4	1.1300	1.1300	1.1300	1.1300	1.1300	1.1300	1.1300
5	1.5500	1.5500	1.5500	1.5500	1.5500	1.5500	1.5500
6	1.9700	1.9700	1.9700	1.9700	1.9700	1.9700	1.9700
7	2.4100	2.4100	2.4100	2.4100	2.4100	2.4100	2.4100
8	2.7600	2.7600	2.7600	2.7600	2.7600	2.7600	2.7600
9	3.0700	3.0700	3.0700	3.0700	3.0700	3.0700	3.0700
+gp	3.5500	3.5500	3.5500	3.5500	3.5500	3.5500	3.5500
SOPCOFAC	.8937	.8983	.9034	.8832	.8832	.8929	.8915

Table 2 Catch weights at age (kg)

YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
AGE										
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.2500	.2500	.2500	.2500	.2500	.2500	.2500	.2500	.2500	.2500

2, .4700, .4700, .4700, .4700, .4700, .4700, .4700, .4700, .4700, .4700,

3, .7300, .7300, .7300, .7300, .7300, .7300, .7300, .7300, .7300, .7300,

4, 1.1300, 1.1300, 1.1300, 1.1300, 1.1300, 1.1300, 1.1300, 1.1300, 1.1300, 1.1300,

5, 1.5500, 1.5500, 1.5500, 1.5500, 1.5500, 1.5500, 1.5500, 1.5500, 1.5500, 1.5500,

6, 1.9700, 1.9700, 1.9700, 1.9700, 1.9700, 1.9700, 1.9700, 1.9700, 1.9700, 1.9700,

7, 2.4100, 2.4100, 2.4100, 2.4100, 2.4100, 2.4100, 2.4100, 2.4100, 2.4100, 2.4100,

8, 2.7600, 2.7600, 2.7600, 2.7600, 2.7600, 2.7600, 2.7600, 2.7600, 2.7600, 2.7600,

9, 3.0700, 3.0700, 3.0700, 3.0700, 3.0700, 3.0700, 3.0700, 3.0700, 3.0700, 3.0700,

+gp, 3.5500, 3.5500, 3.5500, 3.5500, 3.5500, 3.5500, 3.5500, 3.5500, 3.5500, 3.5500,

SOPCOFAC, 1.0111, .9383, 1.0885, 1.0117, 1.0246, 1.0787, 1.0249, .9688, .9597, .9690,

Table 2 Catch weights at age (kg)

YEAR, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983,

AGE

0, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000,

1, .2500, .2500, .2500, .0000, .0000, .3000, .0000, .0000, .0000, .0000,

2, .4700, .4700, .4700, .3110, .3570, .3570, .6430, .4520, .7000, .4700,

3, .7300, .7300, .7300, .6330, .7900, .6720, .7130, .7250, .8960, .7400,

4, 1.1300, 1.1300, 1.1300, 1.0440, 1.0350, .8940, .9410, .9570, 1.1500, 1.0100,

5, 1.5500, 1.5500, 1.5500, 1.4260, 1.3980, 1.1560, 1.1570, 1.2370, 1.4440, 1.3200,

6, 1.9700, 1.9700, 1.9700, 1.8250, 1.8700, 1.5900, 1.4930, 1.6510, 1.4980, 1.6600,

7, 2.4100, 2.4100, 2.4100, 2.2410, 2.3500, 2.0700, 1.7390, 2.0530, 1.8290, 2.0500,

8, 2.7600, 2.7600, 2.7600, 2.2050, 2.5970, 2.5250, 2.0950, 2.4060, 1.8870, 2.2600,

9, 3.0700, 3.0700, 3.0700, 2.5700, 3.0140, 2.6960, 2.4650, 2.7250, 1.9610, 2.5400,

+gp, 3.5500, 3.5500, 3.5500, 2.5910, 2.9200, 3.5190, 3.3100, 3.2500, 2.8560, 3.0400,

SOPCOFAC, .9678, 1.1696, 1.0741, .9784, .9947, 1.0380, 1.0017, 1.0870, .9238, 1.0554,

Table 2 Catch weights at age (kg)

YEAR, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993,

AGE

0, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000,

1, .3590, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .3600,

2, .6810, .5280, .6080, .6050, .5010, .5800, .4380, .5470, .5250, .7550,

3, 1.0110, .8590, .8870, .8310, .7810, .7790, .6990, .6930, .7240, .9820,

4, 1.2550, 1.3910, 1.1750, 1.1260, .9740, .9230, .9390, .8840, .8170, 1.0270,

5, 1.8120, 1.7770, 1.6310, 1.4620, 1.3630, 1.2070, 1.2040, 1.0860, 1.0380, 1.1920,

6, 2.0610, 2.3260, 1.9840, 1.9410, 1.6800, 1.5640, 1.3840, 1.2760, 1.2490, 1.3780,

7, 2.0590, 2.4400, 2.5190, 2.1730, 1.9750, 1.7460, 1.5640, 1.4770, 1.4300, 1.6430,

8, 2.1370, 2.4010, 2.5830, 2.3470, 2.3440, 2.0860, 1.8180, 1.5740, 1.5640, 1.7960,

9, 2.3680, 2.5320, 2.5700, 3.1180, 2.2480, 2.4240, 2.1680, 1.9300, 1.6330, 1.9710,

+gp, 2.6860, 2.6860, 2.9220, 2.9330, 3.2950, 2.5140, 2.3350, 2.1530, 2.1260, 2.2400,

SOPCOFAC, 1.0593, 1.0559, 1.0141, 1.0197, .9695, 1.0025, 1.0195, 1.0635, 1.0554, 1.0320,

Table 2 Catch weights at age (kg)

YEAR, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003,

AGE

0, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000,

1, .0000, .0000, .3600, .0000, .0000, .2780, .2800, .2800, .0000, .0000,

2, .7540, .6660, .5340, .5190, .6220, .5040, .6610, .6080, .5840, .5710,

3, 1.1030, 1.0540, .8580, .7710, .8460, .6240, .9360, .9400, .8570, .7150,

4, 1.2540, 1.4890, 1.4590, 1.0660, 1.0160, .9740, 1.1660, 1.3740, 1.4050, 1.0080,

5, 1.4650, 1.7790, 1.9930, 1.7990, 1.2830, 1.2200, 1.4830, 1.7790, 1.7990, 1.5370,

6, 1.5930, 1.9400, 2.3300, 2.2700, 2.0800, 1.4900, 1.6160, 1.9710, 1.9740, 1.9110,

7, 1.8040, 2.1820, 2.3510, 2.3400, 2.5560, 2.4560, 1.8930, 2.1190, 2.3010, 2.0910,

8, 2.0490, 2.3570, 2.4690, 2.4750, 2.5720, 2.6580, 2.8210, 2.3730, 2.3700, 2.3010,

9, 2.2250, 2.4900, 2.7770, 2.5010, 2.4520, 2.5980, 3.7490, 2.7500, 2.6260, 2.4060,

+gp, 2.4230, 2.6780, 2.5820, 2.6760, 2.7530, 2.9530, 3.1960, 3.9660, 3.1300, 2.5350,

SOPCOFAC, .9969, 1.0331, 1.0043, 1.0250, 1.0106, .9973, 1.0349, .9960, 1.0010, 1.0049,

Table 2 Catch weights at age (kg)

YEAR, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, AGE

0, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000,

1, .3670, .0000, .0000, .0000, .4910, .0000, .0000, .0000, .0000, .0000,

2, .5740, .5380, .4750, .6280, .6360, .4820, .6920, .5530, .6190, .5760,

3, .7700, .6490, .6010, .6690, .7540, .7340, .8700, .8150, .7860, .8300,

4, .8870, .7970, .7680, .8590, .8600, .9850, 1.1490, 1.0860, 1.0690, 1.1490,

5, 1.1590, 1.0200, .9110, .9690, .9910, 1.1300, 1.3080, 1.3030, 1.4050, 1.4650,

6, 1.6380, 1.2450, 1.1260, 1.0600, 1.0820, 1.2640, 1.3860, 1.3870, 1.6160, 1.7100,

7, 1.8700, 1.8430, 1.3740, 1.2450, 1.1510, 1.3570, 1.4290, 1.4690, 1.6560, 1.8270,

8, 2.4380, 2.0610, 2.1580, 1.4750, 1.3790, 1.5450, 1.5680, 1.5380, 1.6750, 1.8860,

9, 2.3570, 2.2630, 2.2110, 2.2660, 1.7270, 1.7920, 1.7400, 1.7020, 1.7270, 1.8560,

+gp, 2.4170, 2.5790, 2.5690, 2.2560, 2.4350, 2.1540, 1.8410, 1.8620, 1.9050, 2.0850,

SOPCOFAC, .9929, .9988, .9987, .9999, 1.0065, .9955, 1.0076, 1.0060, 1.0190, 1.0073,

Table 5.7 Faroe haddock. Proportion mature-at-age.

Run title : FAROE HADDOCK (ICES DIVISION Vb) HAD_IND

At 22/04/2014 15:30

Table 5 Proportion mature at age

YEAR,	1957,	1958,	1959,	1960,	1961,	1962,	1963,
AGE							
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
2,	.0600,	.0600,	.0600,	.0600,	.0600,	.0600,	.0600,
3,	.4800,	.4800,	.4800,	.4800,	.4800,	.4800,	.4800,
4,	.9100,	.9100,	.9100,	.9100,	.9100,	.9100,	.9100,
5,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
6,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
7,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
8,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
9,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
+gp,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,

Table 5 Proportion mature at age

YEAR,	1964,	1965,	1966,	1967,	1968,	1969,	1970,	1971,	1972,	1973,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,

2, .0600, .0600, .0600, .0600, .0600, .0600, .0600, .0600, .0600, .0600,

3, .4800, .4800, .4800, .4800, .4800, .4800, .4800, .4800, .4800, .4800,

4, .9100, .9100, .9100, .9100, .9100, .9100, .9100, .9100, .9100, .9100,

5, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

6, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

7, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

8, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

9, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

+gp, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

Table 5 Proportion mature at age

YEAR, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983,

AGE

0, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000,

1, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000, .0000,

2, .0600, .0600, .0600, .0600, .0600, .0600, .0600, .0600, .0800, .0800,

3, .4800, .4800, .4800, .4800, .4800, .4800, .4800, .4800, .6200, .6200,

4, .9100, .9100, .9100, .9100, .9100, .9100, .9100, .9100, .8900, .8900,

5, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

6, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

7, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

8, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

9, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

+gp, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

Table 5.7 Faroe haddock. Proportion mature-at-age (cont.).

Table 5 Proportion mature at age

YEAR	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
2,	.0800,	.0300,	.0300,	.0500,	.0500,	.0200,	.0800,	.1600,	.1800,	.1100,
3,	.7600,	.6200,	.4300,	.3200,	.2400,	.2200,	.3700,	.5800,	.6500,	.5000,
4,	.9800,	.9600,	.9500,	.9100,	.8900,	.8700,	.9000,	.9300,	.9100,	.8500,
5,	1.0000,	1.0000,	.9900,	.9800,	.9800,	.9900,	1.0000,	1.0000,	1.0000,	.9700,
6,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	.9900,
7,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
8,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
9,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
+gp,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,

Table 5 Proportion mature at age

YEAR	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,

1,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
2,	.0500,	.0300,	.0300,	.0100,	.0100,	.0100,	.0200,	.0900,	.0800,	.0700,
3,	.4200,	.4700,	.4700,	.4700,	.3600,	.3500,	.3600,	.5400,	.4900,	.4500,
4,	.8600,	.9100,	.9300,	.9100,	.8700,	.8600,	.8700,	.9300,	.9700,	.9700,
5,	.9600,	.9600,	.9800,	1.0000,	.9900,	.9900,	.9900,	1.0000,	1.0000,	.9900,
6,	.9900,	.9900,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
7,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
8,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
9,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
+gp,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,

Table 5 Proportion mature at age

YEAR,	2004,	2005,	2006,	2007,	2008,	2009,	2010,	2011,	2012,	2013,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
2,	.0000,	.0100,	.0100,	.0200,	.0100,	.0100,	.0300,	.0900,	.1700,	.1700,
3,	.3500,	.3400,	.4200,	.5200,	.6400,	.6100,	.6500,	.7400,	.8300,	.8300,
4,	.9400,	.9100,	.9100,	.9100,	.9500,	.9300,	.9600,	.9700,	.9900,	1.0000,
5,	.9900,	.9900,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,

6, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

7, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

8, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

9, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

+gp, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,

Table 5.8 Faroe haddock. 2014 tuning file.

```
FAROE Haddock (ICES SUBDIVISION VB)    COMB-SURVEY-SPALY-14-jr.txt
102
SUMMER SURVEY
1996 2013
1 1 0.6 0.7
1 8
200  42362.00 38050.46 60866.49  1138.05  210.25  286.72 238.48 416.44
200   6851.83 12379.93 24184.20 47016.45  852.22  177.11  81.49 163.30
200  18825.00  2793.18  2545.32 14600.59 18399.09  285.78  89.61  73.64
200  24115.03  9521.26  5553.74  1548.70  8698.75 9829.62 204.06   7.89
200 161583.90 18837.41  7340.20   371.40  1301.41 4638.88 5699.14  85.81
200  98708.03 96675.44 11962.07  4424.74  174.57  629.27 2615.71 3209.95
200  89340.23 52092.34 57922.78  5538.84  1909.63  162.47 395.07 1256.27
200  47450.28 36196.89 22847.00 35941.83  3962.64  621.93 101.63 428.87
200   9049.95 33653.00 15117.67 16561.09 16561.09  885.34 185.66  24.20
200  14574.15  7694.99 12936.61 16513.01 11635.42 11963.56 517.84  36.46
200   3484.57  9591.77  2004.49  8968.12  8908.60 6973.94 3364.52 125.74
200   3908.73  7047.44  1676.69  1520.65  4177.57 5114.12 2491.34 552.65
200   4682.23  1967.06  1153.27  2544.21   995.53 3105.84 3178.90 1379.37
200  10461.67  1394.00   410.40  1336.32  1270.33  933.93 2228.54 1224.04
200  24598.14  3779.02  1315.66  1091.24   571.38  809.59 763.94 1276.77
200    642.08 10501.38  1670.76   406.26   355.99  208.31 223.15 290.88
200   2359.69   405.59  5655.72  1081.33   205.64  135.56 147.14  95.56
200   8886.32   215.98  1379.90  5048.56  1039.73  202.49 101.84 157.04
SPRING SURVEY SHIFTED
1993 2013
1 1 0.95 1.0
0 6
100 16009.60  1958.70   216.70  338.10  172.80 305.30  399.60
100 35395.20 19462.60   702.20  216.60  150.70  48.80  141.10
100  6611.80 33206.50 19338.50  663.10   98.20  73.90   56.00
```

100	371.70	8095.00	15618.00	25478.90	628.10	146.10	37.00
100	3481.60	1545.80	3353.40	10120.10	12687.60	336.20	9.90
100	4459.50	6739.70	112.20	1517.30	4412.30	3139.20	48.70
100	25964.40	8354.40	4858.70	198.10	443.90	1669.60	1940.70
100	25283.30	36311.20	3384.70	1056.60	26.70	106.60	427.70
100	21111.90	17809.30	25760.60	1934.70	684.90	40.60	101.70
100	9391.10	22335.10	13272.70	12734.40	776.10	230.10	19.30
100	1823.10	16068.30	10327.10	7487.70	11212.50	487.50	79.10
100	5798.80	6022.70	7742.00	6165.00	4565.90	4912.80	238.60
100	705.50	6284.80	1574.60	4457.00	3250.40	3267.40	1577.20
100	1191.70	1873.30	4202.40	1008.90	3511.30	3712.50	2875.00
100	667.90	2182.60	820.20	1694.90	599.50	1665.00	1463.80
100	4119.00	2079.00	1125.10	405.90	916.80	371.50	924.90
100	6945.00	4655.30	638.10	418.70	196.20	280.20	265.90
100	101.10	6320.00	1865.90	449.30	260.30	212.60	244.60
100	420.00	367.60	4957.20	908.00	227.80	142.50	293.30
100	3419.90	1232.21	302.60	4022.40	619.60	120.30	103.78
100	3542.60	4099.30	869.80	930.30	2238.40	270.20	90.30

Table 5.9 Faroe haddock 2014 xsa.

Lowestoft VPA Version 3.1

22/04/2014 15:28

Extended Survivors Analysis

FAROE HADDOCK (ICES DIVISION Vb) HAD_IND

CPUE data from file D:\Vpa\vpa2014\input-files\comb-survey-spaly-14-jr.txt

Catch data for 57 years. 1957 to 2013. Ages 0 to 10.

Fleet,	First,	Last,	First,	Last,	Alpha,	Beta
,	year,	year,	age ,	age		
SUMMER SURVEY ,	1996,	2013,	1,	8,	.600,	.700
SPRING SURVEY SHIFTE,	1993,	2013,	0,	6,	.950,	1.000

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 6

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 = .500

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

Prior weighting not applied

Tuning converged after 37 iterations

Regression weights
, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000

Fishing mortalities

Age,	2004,	2005,	2006,	2007,	2008,	2009,	2010,	2011,	2012,	2013
0,	.000,	.000,	.000,	.000,	.000,	.000,	.000,	.000,	.000,	.000
1,	.000,	.000,	.000,	.000,	.002,	.000,	.000,	.000,	.000,	.000
2,	.009,	.011,	.035,	.025,	.027,	.012,	.074,	.012,	.005,	.049
3,	.066,	.082,	.072,	.189,	.086,	.181,	.271,	.205,	.087,	.499
4,	.157,	.173,	.176,	.119,	.272,	.243,	.377,	.324,	.204,	.146
5,	.463,	.346,	.270,	.287,	.128,	.263,	.266,	.301,	.255,	.133
6,	.611,	.549,	.521,	.382,	.247,	.226,	.385,	.285,	.284,	.259
7,	.709,	.653,	.650,	.552,	.346,	.306,	.404,	.404,	.310,	.340
8,	.863,	.604,	.332,	.480,	.526,	.247,	.325,	.492,	.228,	.409
9,	.657,	.749,	.569,	.378,	.243,	.214,	.230,	.274,	.471,	.287

Table 5.9 Faroe haddock 2014 xsa (cont.)

XSA population numbers (Thousands)

AGE

YEAR , 0, 1, 2, 3, 4, 5, 6, 7, 8, 9,

2004 , 1.19E+04, 1.06E+04, 2.88E+04, 3.49E+04, 3.65E+04, 3.11E+04, 2.81E+03, 8.90E+02, 1.70E+02, 3.81E+02,

2005 , 5.11E+03, 9.71E+03, 8.71E+03, 2.33E+04, 2.68E+04, 2.55E+04, 1.60E+04, 1.25E+03, 3.58E+02, 5.87E+01,

2006 , 4.11E+03, 4.19E+03, 7.95E+03, 7.06E+03, 1.76E+04, 1.84E+04, 1.48E+04, 7.58E+03, 5.32E+02, 1.60E+02,

2007 , 3.82E+03, 3.36E+03, 3.43E+03, 6.29E+03, 5.37E+03, 1.21E+04, 1.15E+04, 7.18E+03, 3.24E+03, 3.13E+02,

2008 , 9.03E+03, 3.13E+03, 2.75E+03, 2.74E+03, 4.26E+03, 3.90E+03, 7.42E+03, 6.44E+03, 3.39E+03, 1.64E+03,

2009 , 2.36E+04, 7.39E+03, 2.56E+03, 2.19E+03, 2.06E+03, 2.66E+03, 2.81E+03, 4.75E+03, 3.73E+03, 1.64E+03,

2010 , 2.77E+03, 1.93E+04, 6.05E+03, 2.07E+03, 1.50E+03, 1.32E+03, 1.67E+03, 1.84E+03, 2.86E+03, 2.39E+03,

2011 , 2.97E+03, 2.26E+03, 1.58E+04, 4.60E+03, 1.29E+03, 8.41E+02, 8.28E+02, 9.32E+02, 1.00E+03, 1.69E+03,

2012 , 1.19E+04, 2.43E+03, 1.85E+03, 1.28E+04, 3.07E+03, 7.65E+02, 5.10E+02, 5.10E+02, 5.09E+02, 5.03E+02,

2013 , 1.75E+04, 9.75E+03, 1.99E+03, 1.51E+03, 9.61E+03, 2.05E+03, 4.85E+02, 3.14E+02, 3.06E+02, 3.32E+02,

Estimated population abundance at 1st Jan 2014

, 0.00E+00, 1.43E+04, 7.98E+03, 1.55E+03, 7.51E+02, 6.80E+03, 1.47E+03, 3.07E+02, 1.83E+02, 1.66E+02,

Taper weighted geometric mean of the VPA populations:

, 2.36E+04, 1.98E+04, 1.66E+04, 1.34E+04, 9.28E+03, 5.53E+03, 3.32E+03, 1.89E+03, 9.48E+02, 4.55E+02,

Standard error of the weighted Log(VPA populations) :

, 1.1161, 1.1218, 1.1208, 1.0611, 1.0221, 1.0161, 1.0001, .9913, 1.1124, 1.3690,

Log catchability residuals.

Fleet : SUMMER SURVEY

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	No data for this fleet at this age									
1	99.99	99.99	1.19	.25	-.16	-.24	.09	.13	.38	.14
2	99.99	99.99	.13	.62	.03	-.18	.23	.27	.17	.14
3	99.99	99.99	.34	.17	-.41	1.53	.21	.39	.35	-.16
4	99.99	99.99	-.36	.49	.09	-.45	-.62	.34	.19	.41
5	99.99	99.99	-.05	.09	.15	.19	-.06	-.86	.23	.64
6	99.99	99.99	.26	.48	-.23	.10	.11	-.31	-.46	-.09
7	99.99	99.99	.02	-.30	1.02	.32	.07	.00	-.33	-.23
8	99.99	99.99	-.03	.20	.66	.47	.30	-.07	-.27	.42

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	No data for this fleet at this age									
1	-.32	.25	-.34	-.01	.24	.19	.08	-1.42	-.19	-.25
2	.47	.19	.51	1.04	-.01	-.30	-.12	-.10	-1.21	-1.89
3	-.26	.00	-.67	-.66	-.27	-1.02	.26	-.34	-.22	.77
4	-.11	.21	.02	-.60	.24	.31	.51	-.37	-.33	.03
5	.36	.13	.14	-.19	-.59	.12	.03	.03	-.46	.10
6	-.06	.77	.29	.14	-.01	-.25	.23	-.49	-.44	.00
7	-.41	.24	.31	.00	.22	.14	.09	-.47	-.34	-.20
8	-.69	-1.19	-.53	-.76	.14	-.25	.11	-.22	-.82	.30

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

Age ,	1,	2,	3,	4,	5,	6,	7,	8
Mean Log q,	-5.0092,	-5.4718,	-5.7055,	-5.7486,	-5.8585,	-5.8694,	-5.8694,	-5.8694,
S.E(Log q),	.4991,	.6577,	.5886,	.3730,	.3486,	.3372,	.3573,	.5254,
S.E(Log q),	.3417,	.3333,	.5630,	.3923,	.3611,	.3470,	.3448,	.4918,

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
1,	.88,	1.356,	5.52,	.89,	18,	.43,	-5.01,
2,	.81,	1.939,	6.18,	.87,	18,	.50,	-5.47,
3,	.99,	.114,	5.75,	.83,	18,	.60,	-5.71,
4,	.89,	1.875,	6.11,	.95,	18,	.31,	-5.75,
5,	.90,	2.067,	6.12,	.96,	18,	.29,	-5.86,
6,	.91,	1.727,	6.04,	.96,	18,	.29,	-5.87,
7,	.99,	.174,	5.88,	.94,	18,	.36,	-5.86,
8,	1.08,	-.902,	5.94,	.88,	18,	.56,	-5.99,

Fleet : SPRING SURVEY SHIFTE

Age ,	1993
0 ,	-.60
1 ,	-.48
2 ,	-.60
3 ,	-.17
4 ,	-.35

5 , -.31

6 , .21

7 , No data for this fleet at this age

8 , No data for this fleet at this age

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	.95	.89	-1.11	-.29	-.37	-.18	.32	.49	.08	-.37
1	-.89	.40	.60	-.17	-.12	-.22	-.33	-.51	.06	.13
2	-.71	-.14	.39	.48	-2.02	.31	-.31	.12	-.04	.04
3	-.18	-.40	.47	.31	.11	-.64	-.65	-.37	-.11	-.27
4	-.22	-.16	.40	.49	.21	-.38	-1.95	-.14	-.42	.59
5	-1.10	-.27	1.01	.60	-.22	-.06	-1.19	-.95	-.46	.02
6	-.56	-.47	-.27	-.84	-.41	-.01	-.77	-.65	-1.11	-.54

7 , No data for this fleet at this age

8 , No data for this fleet at this age

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	.88	-.38	.36	-.15	.81	.38	-1.71	-.36	.35	.00
1	.34	.48	.11	.48	.50	.45	-.20	-.91	.23	.05
2	.15	-.24	.85	.05	.59	.08	.35	.31	-.35	.68
3	-.15	-.06	-.35	.39	-.30	.04	.26	.10	.45	1.52
4	-.10	-.12	.38	-.26	.55	-.29	.44	.40	.42	.51
5	.59	.27	.64	.28	-.24	-.01	.42	.50	.38	.09
6	.22	.31	.97	.40	.25	-.04	.55	1.33	.78	.67

7 , No data for this fleet at this age

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	0	1	2	3	4	5	6
Mean Log q	-6.0087	-5.3226	-5.8677	-5.9298	-6.2310	-6.3934	-6.5042
S.E(Log q)	.6731	.4464	.6129	.4793	.5729	.5870	.6528

Table 5.9 Faroe haddock 2014 xsa (cont.)

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
0,	.87,	1.287,	6.50,	.83,	21,	.57,	-6.01,
1,	1.13,	-1.449,	4.79,	.87,	21,	.49,	-5.32,
2,	.94,	.619,	6.08,	.84,	21,	.58,	-5.87,
3,	1.03,	-.403,	5.82,	.87,	21,	.51,	-5.93,
4,	.87,	1.588,	6.55,	.89,	21,	.48,	-6.23,
5,	.96,	.412,	6.47,	.85,	21,	.58,	-6.39,
6,	.92,	.744,	6.60,	.83,	21,	.61,	-6.50,

Terminal year survivor and F summaries :

Age 0 Catchability constant w.r.t. time and dependent on age

Year class = 2013

Fleet,	Estimated, Survivors,	Int, s.e,	Ext, s.e,	Var, Ratio,	N,	Scaled, Weights,	Estimated F
SUMMER SURVEY ,	1.,	.000,	.000,	.00,	0,	.000,	.000
SPRING SURVEY SHIFTE,	14345.,	.689,	.000,	.00,	1,	1.000,	.000
F shrinkage mean ,	0.,	.50,,,,				.000,	.000

Weighted prediction :

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

14345., .69, .00, 1, .000, .000

Age 1 Catchability constant w.r.t. time and dependent on age

Year class = 2012

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
SUMMER SURVEY , 6205., .513, .000, .00, 1, .355, .000
SPRING SURVEY SHIFTE, 9174., .381, .140, .37, 2, .645, .000

F shrinkage mean , 0., .50,,,, .000, .000

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
7984., .31, .15, 3, .505, .000

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

Year class = 2011

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
SUMMER SURVEY , 691., .408, .817, 2.00, 2, .305, .108
SPRING SURVEY SHIFTE, 1934., .326, .256, .79, 3, .481, .040

F shrinkage mean , 3006., .50,,,, .214, .026

Weighted prediction :

Survivors, Int, Ext, N, Var, F

at end of year, s.e, s.e, , Ratio,
1552., .23, .35, 6, 1.547, .049

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

Year class = 2010

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
SUMMER SURVEY , 381., .339, .697, 2.06, 3, .302, .823
SPRING SURVEY SHIFTE, 626., .271, .693, 2.56, 4, .470, .575

F shrinkage mean , 2678., .50,,,, .228, .167

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
751., .20, .48, 8, 2.426, .499

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

Year class = 2009

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
SUMMER SURVEY , 6683., .254, .062, .24, 4, .426, .148
SPRING SURVEY SHIFTE, 8672., .246, .144, .59, 5, .441, .116

F shrinkage mean , 3218., .50,,,, .134, .286

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
6800., .17, .13, 10, .787, .146

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

Year class = 2008

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
SUMMER SURVEY , 1363., .211, .109, .52, 5, .508, .143
SPRING SURVEY SHIFTE, 2030., .232, .100, .43, 6, .369, .098

F shrinkage mean , 757., .50,,,, .123, .244

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
1469., .15, .12, 12, .768, .133

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

Year class = 2007

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
SUMMER SURVEY , 258., .187, .112, .60, 6, .564, .301
SPRING SURVEY SHIFTE, 445., .229, .091, .40, 7, .303, .185

F shrinkage mean , 272., .50,,,, .133, .287

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
307., .14, .09, 14, .650, .259

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 2006

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
SUMMER SURVEY , 156., .173, .134, .77, 7, .622, .389
SPRING SURVEY SHIFTE, 293., .229, .091, .40, 7, .229, .226

F shrinkage mean , 173., .50,,,, .150, .356

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
183., .14, .10, 15, .720, .340

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 2005

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
SUMMER SURVEY , 150., .166, .139, .84, 8, .616, .445
SPRING SURVEY SHIFTE, 201., .221, .234, 1.06, 7, .212, .349

F shrinkage mean , 190., .50,,,, .172, .366

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
166., .14, .11, 16, .755, .409

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 2004

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
SUMMER SURVEY , 169., .173, .165, .95, 8, .600, .337
SPRING SURVEY SHIFTE, 327., .225, .108, .48, 7, .184, .189

F shrinkage mean , 230., .50,,,, .216, .259

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
204., .16, .11, 16, .729, .287

Table 5.10 Faroe haddock. Fishing mortality (F) at age.

Run title : FAROE HADDOCK (ICES DIVISION Vb) HAD_IND

At 22/04/2014 15:30

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR,	1957,	1958,	1959,	1960,	1961,	1962,	1963,
AGE							
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0010,	.0024,	.0132,	.0150,	.0219,	.0149,	.0106,
2,	.1394,	.1939,	.1066,	.2074,	.1875,	.3232,	.3801,
3,	.3707,	.4378,	.3860,	.4599,	.4162,	.5866,	.5639,
4,	.6163,	.5737,	.4782,	.6926,	.4209,	.5980,	.7261,
5,	.3909,	.5386,	.4195,	.5260,	.4387,	.3480,	.5591,
6,	.4380,	.6346,	.6458,	.6591,	.5879,	.6706,	.4026,
7,	.6340,	.9504,	.9184,	1.2130,	.9483,	1.0499,	1.2493,
8,	.5599,	.7839,	.8206,	.9667,	.8742,	.9736,	1.1139,
9,	.5321,	.7028,	.6625,	.8198,	.6600,	.7351,	.8185,
+gp,	.5321,	.7028,	.6625,	.8198,	.6600,	.7351,	.8185,
FBAR 3- 7,	.4900,	.6270,	.5696,	.7101,	.5624,	.6506,	.7002,

Table 8 Fishing mortality (F) at age

YEAR,	1964,	1965,	1966,	1967,	1968,	1969,	1970,	1971,	1972,	1973,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0018,	.0017,	.0032,	.0012,	.0014,	.0024,	.0033,	.0015,	.0016,	.0114,

2,	.0876,	.0691,	.0610,	.0641,	.1261,	.0860,	.0551,	.0526,	.0253,	.1677,
3,	.3723,	.2354,	.2370,	.1873,	.2647,	.2363,	.2528,	.1936,	.4226,	.4320,
4,	.5193,	.4767,	.4515,	.2971,	.3483,	.5320,	.3344,	.4186,	.2853,	.2392,
5,	.5369,	.3678,	.5006,	.2997,	.2847,	.3330,	.3639,	.2754,	.4517,	.3143,
6,	.6107,	.5882,	.5421,	.5406,	.4540,	.4975,	.5561,	.5560,	.1495,	.2703,
7,	.3375,	.9618,	.9128,	.6906,	.8367,	.8277,	.8740,	.8385,	.6720,	.1951,
8,	1.2027,	2.3618,	.7509,	.6634,	.5851,	1.0631,	.5430,	.4224,	.4066,	.2907,
9,	.6472,	.9619,	.6373,	.5022,	.5057,	.6566,	.5386,	.5061,	.3957,	.2633,
+gp,	.6472,	.9619,	.6373,	.5022,	.5057,	.6566,	.5386,	.5061,	.3957,	.2633,
FBAR 3- 7,	.4753,	.5260,	.5288,	.4031,	.4377,	.4853,	.4762,	.4564,	.3962,	.2902,

Table 8 Fishing mortality (F) at age

YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0033,	.0015,	.0014,	.0000,	.0000,	.0002,	.0000,	.0000,	.0000,	.0000,
2,	.1266,	.1230,	.0908,	.0108,	.0010,	.0004,	.0325,	.0237,	.0383,	.0252,
3,	.2172,	.2650,	.1878,	.1128,	.0547,	.0458,	.0285,	.1373,	.4617,	.1916,
4,	.3730,	.2412,	.3810,	.1815,	.1665,	.1255,	.2025,	.1314,	.3708,	.3480,
5,	.1279,	.2116,	.2216,	.5273,	.2115,	.1913,	.2749,	.2112,	.2917,	.3498,

6,	.1714,	.0957,	.2871,	.7246,	.3820,	.1408,	.2135,	.2264,	.2775,	.1382,
7,	.2134,	.0859,	.1601,	.3904,	.5760,	.2721,	.1702,	.2004,	.2523,	.2990,
8,	.1433,	.1599,	.2539,	.3788,	.4968,	.3303,	.3954,	.0920,	.2265,	.3101,
9,	.2068,	.1595,	.2621,	.4437,	.3689,	.2130,	.2526,	.1730,	.2854,	.2906,
+gp,	.2068,	.1595,	.2621,	.4437,	.3689,	.2130,	.2526,	.1730,	.2854,	.2906,
FBAR 3- 7,	.2206,	.1799,	.2475,	.3873,	.2781,	.1551,	.1779,	.1813,	.3308,	.2653,

Table 8 Fishing mortality (F) at age

YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0006,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0060,
2,	.0329,	.0280,	.0096,	.0337,	.0393,	.0049,	.0124,	.0289,	.0167,	.0709,
3,	.1167,	.1694,	.0940,	.0925,	.0679,	.1205,	.1307,	.1646,	.0743,	.1659,
4,	.3895,	.2391,	.2490,	.1844,	.1861,	.1360,	.2206,	.2708,	.1772,	.1834,
5,	.2171,	.3473,	.2596,	.2621,	.2365,	.3322,	.2329,	.2179,	.2743,	.1852,
6,	.3335,	.4161,	.3587,	.3079,	.3058,	.3204,	.3566,	.3167,	.2595,	.2048,
7,	.0853,	.2083,	.1572,	.4744,	.2080,	.5166,	.4228,	.4030,	.2668,	.1971,
8,	.2928,	.1719,	.5176,	.5842,	.2378,	.3880,	.4620,	.2679,	.2299,	.1579,
9,	.2650,	.2781,	.3102,	.3649,	.2360,	.3408,	.3411,	.2970,	.2428,	.1865,

+gp,	.2650,	.2781,	.3102,	.3649,	.2360,	.3408,	.3411,	.2970,	.2428,	.1865,
FBAR 3- 7,	.2284,	.2760,	.2237,	.2642,	.2009,	.2851,	.2727,	.2746,	.2104,	.1872,

Table 8 Fishing mortality (F) at age

YEAR,	1994,	1995,	1996,	1997,	1998,	1999,	2000,	2001,	2002,	2003,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0000,	.0000,	.0001,	.0000,	.0000,	.0004,	.0006,	.0003,	.0000,	.0000,
2,	.0488,	.0093,	.0079,	.0095,	.0319,	.0125,	.0788,	.0482,	.0280,	.0034,
3,	.1644,	.1049,	.0768,	.0909,	.1734,	.5553,	.3149,	.2412,	.2150,	.0818,
4,	.2575,	.3126,	.3632,	.2180,	.2361,	.2312,	.1824,	.4429,	.3662,	.3323,
5,	.1476,	.3066,	.4177,	.4662,	.3268,	.3406,	.2614,	.2249,	.4111,	.5400,
6,	.2104,	.1835,	.3799,	.5284,	.6083,	.3814,	.3348,	.2762,	.2702,	.6755,
7,	.2488,	.2225,	.3567,	.5551,	1.2934,	.7302,	.2795,	.2335,	.2305,	.6244,
8,	.2420,	.2670,	.3265,	.3601,	1.0248,	1.8870,	.6148,	.2111,	.2682,	.5843,
9,	.2223,	.2598,	.3590,	.4850,	.7784,	.6964,	.3053,	.2526,	.2595,	.4819,
+gp,	.2223,	.2598,	.3590,	.4850,	.7784,	.6964,	.3053,	.2526,	.2595,	.4819,
FBAR 3- 7,	.2057,	.2260,	.3189,	.3717,	.5276,	.4477,	.2746,	.2837,	.2986,	.4508,

Table 8 Fishing mortality (F) at age

YEAR,	2004,	2005,	2006,	2007,	2008,	2009,	2010,	2011,	2012,	2013,

AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0003,	.0000,	.0000,	.0000,	.0021,	.0000,	.0000,	.0000,	.0000,	.0000,
2,	.0094,	.0108,	.0349,	.0248,	.0269,	.0117,	.0737,	.0120,	.0048,	.0495,
3,	.0656,	.0824,	.0724,	.1895,	.0860,	.1812,	.2712,	.2053,	.0866,	.4990,
4,	.1573,	.1731,	.1757,	.1194,	.2721,	.2435,	.3772,	.3245,	.2042,	.1455,
5,	.4628,	.3462,	.2701,	.2874,	.1279,	.2625,	.2661,	.3013,	.2554,	.1331,
6,	.6112,	.5489,	.5206,	.3817,	.2471,	.2256,	.3853,	.2854,	.2840,	.2586,
7,	.7093,	.6531,	.6499,	.5521,	.3463,	.3062,	.4043,	.4037,	.3103,	.3405,
8,	.8635,	.6038,	.3319,	.4796,	.5263,	.2471,	.3247,	.4918,	.2281,	.4094,
9,	.6574,	.7486,	.5692,	.3778,	.2425,	.2135,	.2303,	.2738,	.4714,	.2872,
+gp,	.6574,	.7486,	.5692,	.3778,	.2425,	.2135,	.2303,	.2738,	.4714,	.2872,
FBAR 3- 7,	.4012,	.3608,	.3377,	.3060,	.2159,	.2438,	.3408,	.3040,	.2281,	.2753,

Table 5.11 Faroe haddock. Stock number (N) at age.

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

YEAR	1957	1958	1959	1960	1961	1962	1963
AGE							
0	64927	54061	77651	58761	71715	45400	33843
1	47944	53158	44261	63576	48109	58715	37170
2	35106	39212	43417	35763	51279	38537	47362
3	25440	25003	26445	31954	23796	34806	22837
4	20280	14377	13213	14717	16517	12850	15850
5	5517	8965	6632	6706	6028	8877	5786
6	2786	3055	4284	3570	3245	3182	5132
7	1377	1472	1326	1839	1512	1476	1332
8	585	598	466	433	448	480	423
9	252	274	224	168	135	153	148
+gp	154	227	106	54	29	46	45
TOTAL	204367	200401	218024	217540	222811	204522	169929

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

YEAR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
AGE										
0	30192	37948	81924	47768	53237	23136	49622	35418	78971	104854
1	27709	24719	31069	67073	39109	43587	18942	40627	28998	64656
2	30110	22644	20203	25356	54852	31975	35600	15457	33213	23703
3	26515	22585	17302	15563	19470	39587	24022	27583	12006	26514
4	10638	14961	14613	11176	10566	12234	25590	15275	18608	6442

5,	6278,	5182,	7604,	7617,	6798,	6106,	5884,	14996,	8229,	11454,
6,	2708,	3005,	2937,	3774,	4622,	4187,	3583,	3348,	9322,	4289,
7,	2809,	1204,	1366,	1398,	1800,	2403,	2084,	1682,	1572,	6573,
8,	313,	1641,	377,	449,	574,	638,	860,	712,	595,	657,
9,	114,	77,	127,	146,	189,	262,	180,	409,	382,	325,
+gp,	16,	14,	21,	36,	33,	45,	26,	281,	319,	52,
TOTAL,	137402,	133981,	177543,	180356,	191250,	164161,	166394,	155789,	192215,	249517,

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

YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,
AGE										
0,	83631,	39130,	52366,	4154,	7377,	5208,	23625,	29269,	60819,	58866,
1,	85847,	68471,	32037,	42873,	3401,	6040,	4264,	19343,	23963,	49794,
2,	52334,	70057,	55974,	26194,	35102,	2784,	4944,	3491,	15836,	19619,
3,	16410,	37751,	50719,	41850,	21215,	28710,	2279,	3919,	2791,	12478,
4,	14093,	10812,	23712,	34415,	30609,	16445,	22454,	1813,	2797,	1440,
5,	4152,	7946,	6955,	13263,	23500,	21217,	11876,	15014,	1302,	1580,
6,	6849,	2992,	5265,	4562,	6409,	15572,	14346,	7386,	9953,	796,
7,	2680,	4724,	2226,	3235,	1810,	3581,	11075,	9487,	4822,	6174,
8,	4427,	1772,	3549,	1553,	1792,	833,	2234,	7648,	6357,	3067,
9,	402,	3141,	1237,	2254,	870,	893,	490,	1231,	5712,	4150,
+gp,	865,	1396,	1515,	2613,	1109,	424,	423,	249,	947,	3461,

TOTAL,	271690,	248191,	235555,	176966,	133194,	101707,	98010,	98851,	135298,	161427,

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

YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,
AGE										
0,	39519,	14086,	28007,	21061,	14028,	4460,	3992,	2724,	9655,	143943,
1,	48196,	32355,	11532,	22930,	17244,	11485,	3651,	3269,	2230,	7905,
2,	40768,	39437,	26490,	9442,	18773,	14118,	9403,	2990,	2676,	1826,
3,	15664,	32297,	31397,	21480,	7474,	14778,	11502,	7604,	2378,	2155,
4,	8435,	11412,	22323,	23399,	16032,	5718,	10725,	8263,	5281,	1808,
5,	833,	4678,	7356,	14248,	15932,	10897,	4086,	7043,	5160,	3621,
6,	912,	549,	2706,	4646,	8976,	10297,	6400,	2650,	4637,	3211,
7,	568,	535,	296,	1548,	2796,	5413,	6119,	3668,	1581,	2929,
8,	3749,	427,	356,	207,	789,	1859,	2644,	3283,	2007,	991,
9,	1842,	2290,	294,	174,	95,	509,	1033,	1364,	2056,	1306,
+gp,	4567,	4402,	2930,	1198,	669,	308,	410,	137,	826,	1196,
TOTAL,	165051,	142467,	133688,	120333,	102807,	79841,	59966,	42994,	38487,	170891,

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

YEAR,	1994,	1995,	1996,	1997,	1998,	1999,	2000,	2001,	2002,	2003,
AGE										
0,	68039,	13476,	5572,	23106,	31815,	153465,	90575,	63864,	42934,	13000,

1, 117851, 55706, 11034, 4562, 18918, 26048, 125647, 74157, 52287, 35151,

2, 6433, 96487, 45608, 9033, 3735, 15488, 21318, 102805, 60697, 42809,

3, 1393, 5016, 78269, 37046, 7326, 2962, 12523, 16132, 80206, 48324,

4, 1495, 967, 3698, 59346, 27695, 5043, 1392, 7484, 10377, 52964,

5, 1232, 946, 579, 2106, 39072, 17907, 3277, 949, 3935, 5891,

6, 2464, 870, 570, 312, 1082, 23071, 10429, 2066, 621, 2136,

7, 2142, 1634, 593, 319, 151, 482, 12900, 6109, 1283, 388,

8, 1969, 1368, 1071, 340, 150, 34, 190, 7986, 3960, 834,

9, 693, 1266, 857, 633, 194, 44, 4, 84, 5295, 2480,

+gp, 1660, 1416, 1433, 1470, 1011, 417, 296, 89, 159, 2645,

TOTAL, 205370, 179153, 149284, 138271, 131147, 244962, 278551, 281724, 261753, 206621,

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

YEAR, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014,

AGE

0, 11864, 5112, 4106, 3825, 9030, 23592, 2766, 2972, 11910, 17520, 0,

1, 10644, 9713, 4185, 3361, 3131, 7393, 19315, 2264, 2433, 9751, 14345,

2, 28779, 8711, 7953, 3427, 2752, 2558, 6053, 15814, 1854, 1992, 7984,

3, 34929, 23343, 7055, 6288, 2737, 2194, 2070, 4604, 12793, 1511, 1552,

4, 36455, 26781, 17599, 5373, 4259, 2056, 1498, 1292, 3070, 9606, 751,

5, 31102, 25502, 18441, 12087, 3904, 2657, 1320, 841, 765, 2049, 6800,

6, 2811, 16030, 14769, 11525, 7424, 2813, 1673, 828, 510, 485, 1469, 7, 890, 1249, 7581, 7185, 6442, 4747, 1838, 932, 510, 314, 307,

8, 170, 358, 532, 3240, 3387, 3731, 2862, 1004, 509, 306, 183,

9, 381, 59, 160, 313, 1642, 1638, 2386, 1693, 503, 332, 166,

+gp, 1837, 318, 176, 31, 199, 274, 850, 857, 332, 550, 542,

TOTAL, 159861, 117178, 82558, 56655, 44908, 53652, 42629, 33102, 35189, 44416, 34098,

Table 5.12. Faroe haddock. Stock summary of the 2014 VPA.

Run title : FAROE HADDOCK (ICES DIVISION Vb) HAD_IND

At 15/04/2014 20:12

Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 7
	Age 0	Age 2					
1957	64927	35106	90264	51049	20995	0.4113	0.49
1958	54061	39212	92975	51409	23871	0.4643	0.627
1959	77651	43417	89969	48340	20239	0.4187	0.5696
1960	58761	35763	96422	51101	25727	0.5035	0.7101
1961	71715	51279	93296	47901	20831	0.4349	0.5624
1962	45400	38537	98262	52039	27151	0.5217	0.6506
1963	33843	47362	90204	49706	27571	0.5547	0.7002
1964	30192	30110	75561	44185	19490	0.4411	0.4753
1965	37948	22644	71884	45605	18479	0.4052	0.526
1966	81924	20203	68774	44027	18766	0.4262	0.5288
1967	47768	25356	77101	42086	13381	0.3179	0.4031
1968	53237	54852	87971	45495	17852	0.3924	0.4377
1969	23136	31975	94878	53583	23272	0.4343	0.4853
1970	49622	35600	92143	59958	21361	0.3563	0.4762
1971	35418	15457	92930	63921	19393	0.3034	0.4564
1972	78971	33213	91507	63134	16485	0.2611	0.3962
1973	104854	23703	98977	61621	18035	0.2927	0.2902
1974	83631	52334	116876	64631	14773	0.2286	0.2206
1975	39130	70057	138903	75405	20715	0.2747	0.1799
1976	52366	55974	143623	89220	26211	0.2938	0.2475
1977	4154	26194	121043	96376	25555	0.2652	0.3873
1978	7377	35102	120579	97233	19200	0.1975	0.2781
1979	5208	2784	99503	85401	12424	0.1455	0.1551
1980	23625	4944	87640	81905	15016	0.1833	0.1779
1981	29269	3491	78966	75849	12233	0.1613	0.1813
1982	60819	15836	68310	56807	11937	0.2101	0.3308
1983	58866	19619	63968	51815	12894	0.2488	0.2653
1984	39519	40768	100683	53826	12378	0.23	0.2284

1985	14086	39437	93980	62605	15143	0.2419	0.276
1986	28007	26490	98535	65606	14477	0.2207	0.2237
1987	21061	9442	87662	67310	14882	0.2211	0.2642
1988	14028	18773	77440	61917	12178	0.1967	0.2009
1989	4460	14118	69571	51749	14325	0.2768	0.2851
1990	3992	9403	53579	43718	11726	0.2682	0.2727
1991	2724	2990	38751	34653	8429	0.2432	0.2746
1992	9655	2676	29102	26959	5476	0.2031	0.2104
1993	143943	1826	28784	23201	4026	0.1735	0.1872
1994	68039	6433	27453	21580	4252	0.197	0.2057
1995	13476	96487	88093	22744	4948	0.2175	0.226
1996	5572	45608	113479	49890	9642	0.1933	0.3189
1997	23106	9033	108113	82640	17924	0.2169	0.3717
1998	31815	3735	93068	82642	22210	0.2687	0.5276
1999	153465	15488	80651	63575	18482	0.2907	0.4477
2000	90575	21318	110248	53496	15821	0.2957	0.2746
2001	63864	102805	146955	61617	15890	0.2579	0.2837
2002	42934	60697	153806	85701	24933	0.2909	0.2986
2003	13000	42809	140920	97491	27072	0.2777	0.4508
2004	11864	28779	127724	87516	23101	0.264	0.4012
2005	5112	8711	91145	74326	20455	0.2752	0.3608
2006	4106	7953	67336	59920	17154	0.2863	0.3377
2007	3825	3427	49407	44863	12631	0.2815	0.306
2008	9030	2752	36322	32126	7388	0.23	0.2159
2009	23592	2558	27159	25168	5197	0.2065	0.2438
2010	2766	6053	24584	19822	5202	0.2624	0.3408
2011	2972	15814	23537	14561	3540	0.2431	0.304
2012	11910	1854	19581	16886	2634	0.156	0.2281
2013	17520	1992	20183	19017	3105	0.1633	0.2753
Arith.							
Mean	38489	26673	83691	55385	15763	0.2859	0.3518
0 Units	(Thousands)	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 5.13. Management options table - INPUT DATA descriptions.

Stock size

The stock in numbers 2014 is taken directly from the 2014 XSA. The yearclass 2013 at age 2 (in 2015) is estimated from the 2014 XSA age 1 applying a natural mortality of 0.2 in foreward calculation of the number using the standard VPA equation. The yearclass 2014 at age 2 (in 2016) is estimated as the geomean of the numbers at age 2 since 2005.

Age	2014	2015	2016
2	7984	11745	4334
3	1552		
4	751		
5	6800		
6	1469		
7	307		
8	183		
9	166		
10+	542		

Numbers in thousands (predicted values rounded).

Proportion mature at age

The proportion mature at age in 2014 is estimated as the average of the observed data in 2013 and 2014. For 2015 and 2016, the average of 2012 to 2014 is used.

Age	2014	2015	2016
2	0.17	0.16	0.16
3	0.83	0.82	0.82
4	1.00	0.99	0.99
5	1.00	1.00	1.00
6	1.00	1.00	1.00
7	1.00	1.00	1.00
8	1.00	1.00	1.00
9	1.00	1.00	1.00
10+	1.00	1.00	1.00

Table 5.13. Management options table - INPUT DATA descriptions (cont.).

Catch&Stock weights at age

Catch and stock weights at age for all ages and for each of the years 2014-2016 are simply the average of the estimated point-values for 2011-2013 not re-scaled to 2013 since weights have been fluctuating without any trend during the last 3 years (no model was available to predict future mean weights at age).

Age	2014	2015	2016
2	0.583	0.583	0.583
3	0.810	0.810	0.810
4	1.101	1.101	1.101
5	1.391	1.391	1.391
6	1.571	1.571	1.571
7	1.651	1.651	1.651
8	1.700	1.700	1.700
9	1.762	1.762	1.762
10+	1.951	1.951	1.951

Exploitation pattern

The exploitation pattern 2014 is estimated like last year as the average fishing mortality matrix in the 3 preceding years (2011-2013) from the final VPA in 2014, without re-scaling to the terminal year (2013) since fishing mortalities have been fluctuating without any general trend during the last 3 years; the same exploitation pattern was used for all 3 years.

Age	2014	2015	2016
2	0.0221	0.0221	0.0221
3	0.2636	0.2636	0.2636
4	0.2247	0.2247	0.2247
5	0.2299	0.2299	0.2299
6	0.2760	0.2760	0.2760
7	0.3515	0.3515	0.3515
8	0.3764	0.3764	0.3764
9	0.3441	0.3441	0.3441
10+	0.3441	0.3441	0.3441

Table 5.14 Faroe haddock. Management option table - Inp

MFDP version 1
Run: jr1
Time and date: 15:21 19/04/2014
Fbar age range: 3-7

2014

Age	N	M	Mat	PF	PM	SWt
2	7984	0.2	0.17	0	0	0.
3	1552	0.2	0.83	0	0	0.
4	751	0.2	1	0	0	1.
5	6800	0.2	1	0	0	1.
6	1469	0.2	1	0	0	1.
7	307	0.2	1	0	0	1.
8	183	0.2	1	0	0	1.
9	166	0.2	1	0	0	1.
10	542	0.2	1	0	0	1.

2015

Age	N	M	Mat	PF	PM	SWt
2	11745	0.2	0.16	0	0	0.
3	.	0.2	0.82	0	0	0.
4	.	0.2	0.99	0	0	1.
5	.	0.2	1	0	0	1.
6	.	0.2	1	0	0	1.
7	.	0.2	1	0	0	1.
8	.	0.2	1	0	0	1.
9	.	0.2	1	0	0	1.
10	.	0.2	1	0	0	1.

2016

Age	N	M	Mat	PF	PM	SWt
2	4334	0.2	0.16	0	0	0.
3	.	0.2	0.82	0	0	0.
4	.	0.2	0.99	0	0	1.
5	.	0.2	1	0	0	1.
6	.	0.2	1	0	0	1.
7	.	0.2	1	0	0	1.
8	.	0.2	1	0	0	1.
9	.	0.2	1	0	0	1.
10	.	0.2	1	0	0	1.

Input units are thousands and kg - output in tonnes

Table 5.15 Faroe haddock. Management option table - Results

MFDP version 1
Run: jr1
Index file 18/04/2014
Time and date: 15:21 19/04/2014
Fbar age range: 3-7

2014				
Biomass	SSB	FMult	FBar	Landings
20671	16596	1	0.2691	3367

2015					2016	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
23523	16831	0	0	0	26150	22569
.	16831	0.1	0.0269	431	25700	22124
.	16831	0.2	0.0538	850	25262	21690
.	16831	0.3	0.0807	1258	24836	21268
.	16831	0.4	0.1077	1656	24421	20858
.	16831	0.5	0.1346	2043	24017	20458
.	16831	0.6	0.1615	2420	23624	20070
.	16831	0.7	0.1884	2787	23242	19691
.	16831	0.8	0.2153	3145	22869	19323
.	16831	0.9	0.2422	3494	22507	18965
.	16831	1	0.2691	3833	22153	18616
.	16831	1.1	0.2961	4164	21810	18277
.	16831	1.2	0.323	4486	21475	17946
.	16831	1.3	0.3499	4800	21149	17624
.	16831	1.4	0.3768	5105	20832	17311
.	16831	1.5	0.4037	5403	20523	17006
.	16831	1.6	0.4306	5694	20222	16709
.	16831	1.7	0.4575	5977	19929	16420
.	16831	1.8	0.4845	6252	19644	16139
.	16831	1.9	0.5114	6521	19366	15865
.	16831	2	0.5383	6783	19095	15598

Input units are thousands and kg - output in tonnes

Table 5.16 Faroe haddock. Long-term Prediction - Input data

MFYPR version 1
Run: jr2
Index file 18/04/2014
Time and date: 15:48 19/04/2014
Fbar age range: 3-7

Age	M	Mat	PF	PM	SWt	Sel	CWt
2	0.2	0.06	0	0	0.564	0.0223	0.564
3	0.2	0.51	0	0	0.800	0.2637	0.800
4	0.2	0.92	0	0	1.064	0.2250	1.064
5	0.2	0.99	0	0	1.370	0.2297	1.370
6	0.2	1.00	0	0	1.652	0.2760	1.652
7	0.2	1.00	0	0	1.910	0.3517	1.910
8	0.2	1.00	0	0	2.130	0.3763	2.130
9	0.2	1.00	0	0	2.355	0.3440	2.355
10	0.2	1.00	0	0	2.659	0.3440	2.659

Weights in kilograms

Table 5.17 **Faroe haddock. Long-term Prediction - Results**

MFYPR version 1
Run: jak2
Time and date: 15:48 19/04/2014
Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0	0	0	0	5.5167	8.3121	4.1119	7.3944	4.1119	7.3944
0.1	0.0269	0.1051	0.1798	4.9933	7.0806	3.5911	6.1655	3.5911	6.1655
0.2	0.0538	0.1844	0.301	4.5984	6.1789	3.1989	5.2664	3.1989	5.2664
0.3	0.0808	0.2468	0.3855	4.2887	5.4925	2.8917	4.5826	2.8917	4.5826
0.4	0.1077	0.2972	0.446	4.0383	4.9542	2.6437	4.0467	2.6437	4.0467
0.5	0.1346	0.339	0.4901	3.831	4.5216	2.4389	3.6165	2.4389	3.6165
0.6	0.1615	0.3744	0.5228	3.6561	4.1669	2.2664	3.2642	2.2664	3.2642
0.7	0.1884	0.4047	0.5473	3.5062	3.8713	2.1187	2.9708	2.1187	2.9708
0.8	0.2154	0.4311	0.5659	3.3759	3.6213	1.9908	2.7231	1.9908	2.7231
0.9	0.2423	0.4543	0.58	3.2616	3.4074	1.8786	2.5114	1.8786	2.5114
1	0.2692	0.4749	0.5909	3.1601	3.2223	1.7794	2.3285	1.7794	2.3285
1.1	0.2961	0.4934	0.5993	3.0695	3.0607	1.6909	2.169	1.6909	2.169
1.2	0.323	0.51	0.6058	2.9879	2.9185	1.6114	2.0288	1.6114	2.0288
1.3	0.35	0.5251	0.6108	2.914	2.7923	1.5396	1.9046	1.5396	1.9046
1.4	0.3769	0.5389	0.6146	2.8467	2.6797	1.4743	1.794	1.4743	1.794
1.5	0.4038	0.5515	0.6176	2.7851	2.5786	1.4147	1.6948	1.4147	1.6948
1.6	0.4307	0.5632	0.6198	2.7285	2.4873	1.3601	1.6055	1.3601	1.6055
1.7	0.4576	0.5739	0.6214	2.6763	2.4046	1.3098	1.5246	1.3098	1.5246
1.8	0.4846	0.5839	0.6226	2.628	2.3292	1.2634	1.451	1.2634	1.451
1.9	0.5115	0.5932	0.6234	2.5832	2.2603	1.2204	1.3838	1.2204	1.3838
2	0.5384	0.6018	0.6239	2.5414	2.1971	1.1804	1.3223	1.1804	1.3223

Reference point	F multiplier	Absolute F
Fbar(3-7)	1	0.2692
FMax	2.2137	0.5959
F0.1	0.687	0.1849
F35%SPR	0.862	0.2321
Flow	-99	
Fmed	0.8847	0.2382
Fhigh	2.9773	0.8015

Weights in kilograms

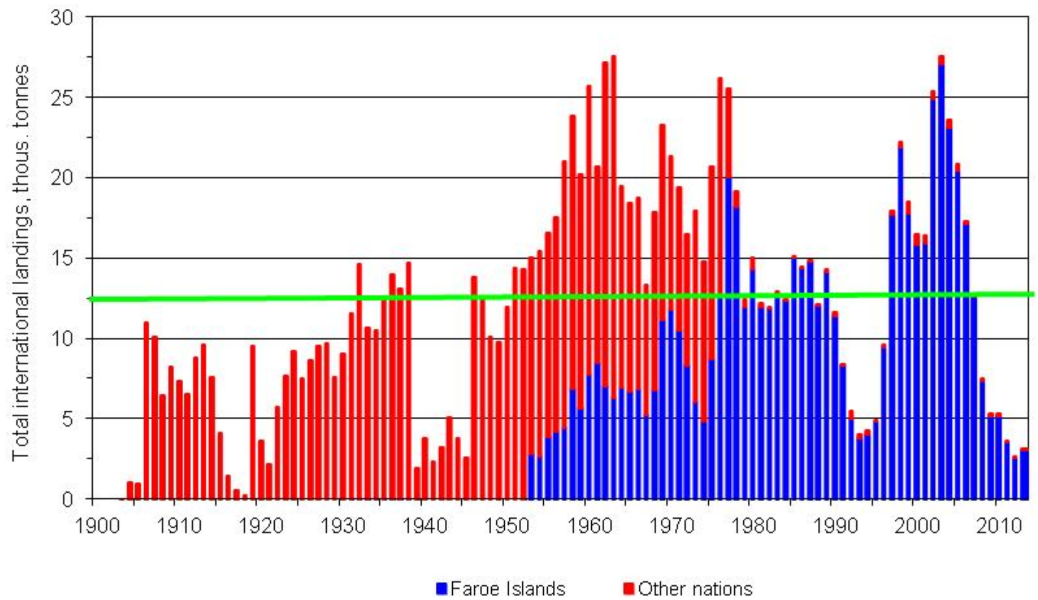


Figure 5.1. Haddock in ICES Division Vb. Landings by all nations 1904-2013. Horisontal line average for the whole period.

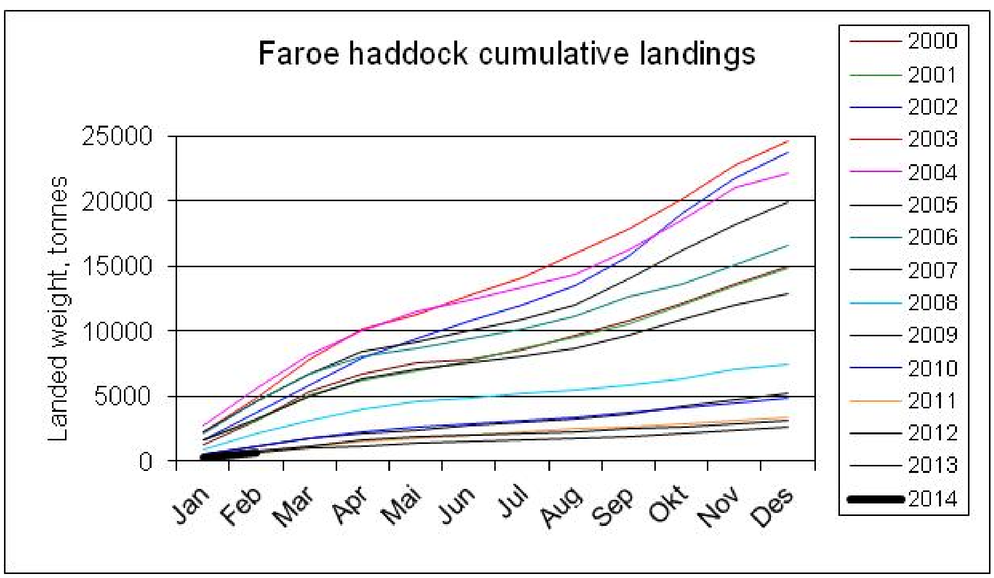


Figure 5.2. Faroe haddock. Cumulative Faroese landings from Vb.

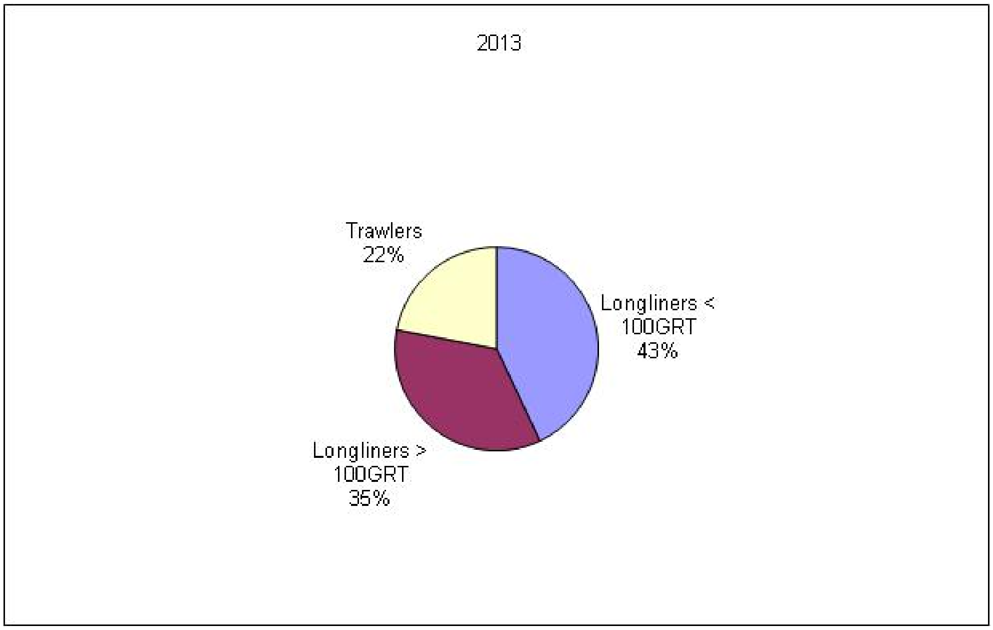


Figure 5.3. Faroe haddock. Contribution (%) by fleet to the total Faroese landings 2013.

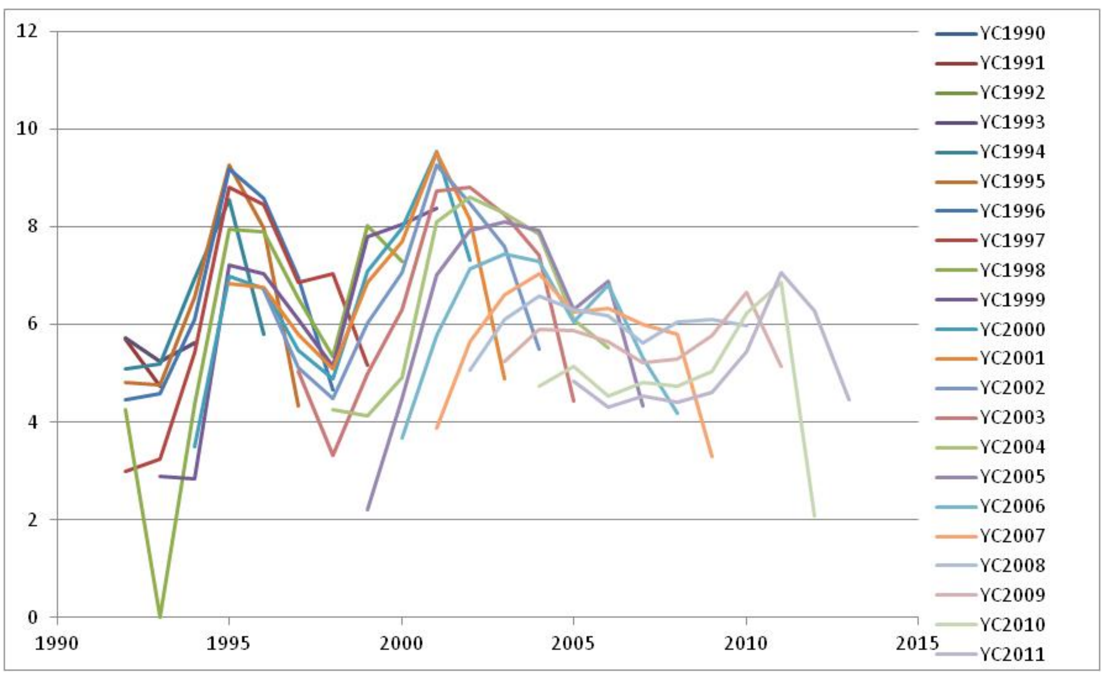


Figure 5.4. Catch curves for YC's 1990 onwards.

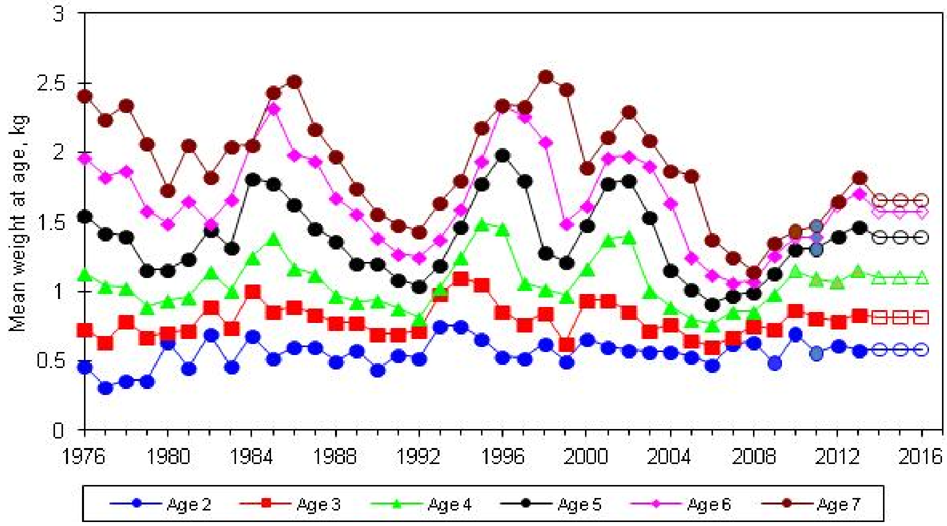


Figure 5.5. Faroe haddock. Mean weight at age (2-7). 2014-2016 are predicted values used in the short term prediction (open symbols).

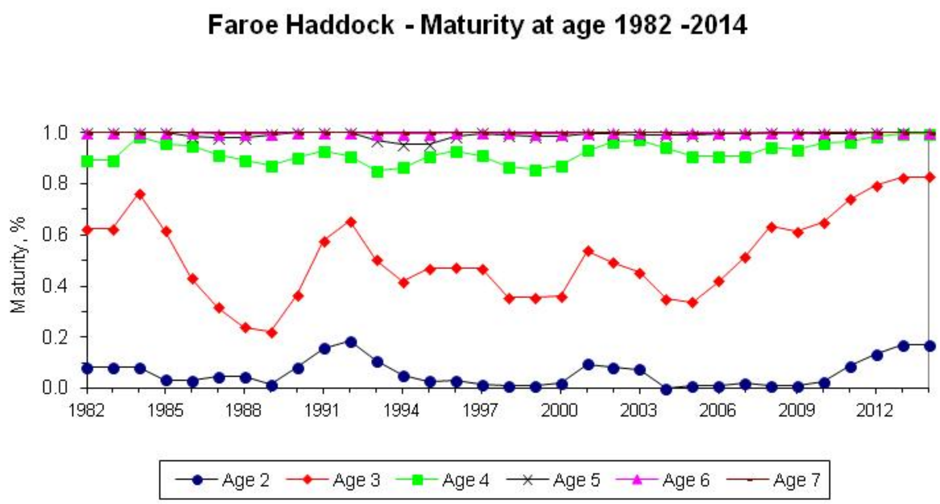


Figure 5.6. Faroe haddock. Maturity at age since 1982. Running 3-years average of survey observations.

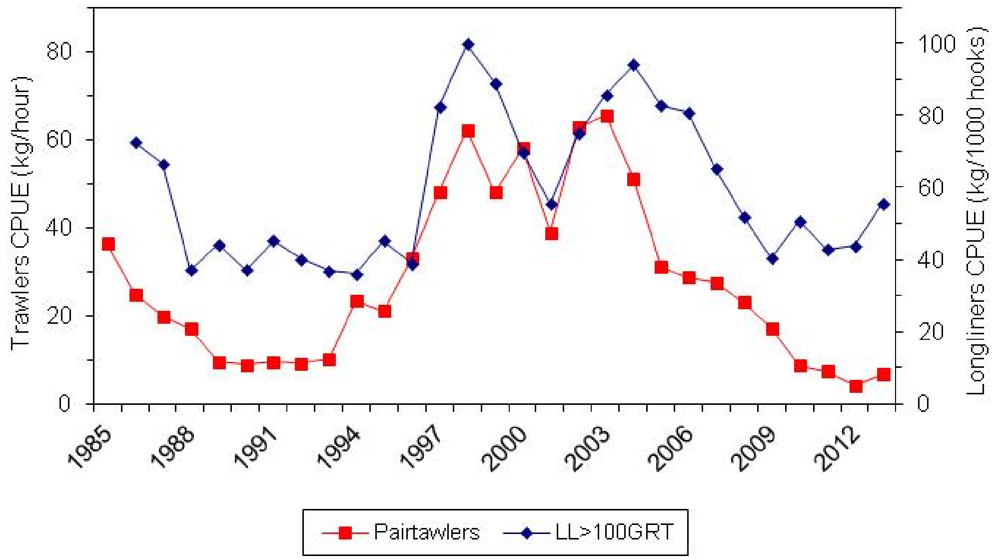


Figure 5.7. Commercial CPUE's for Pairtrawlers > 1000 HP and longliners > 100 HP.

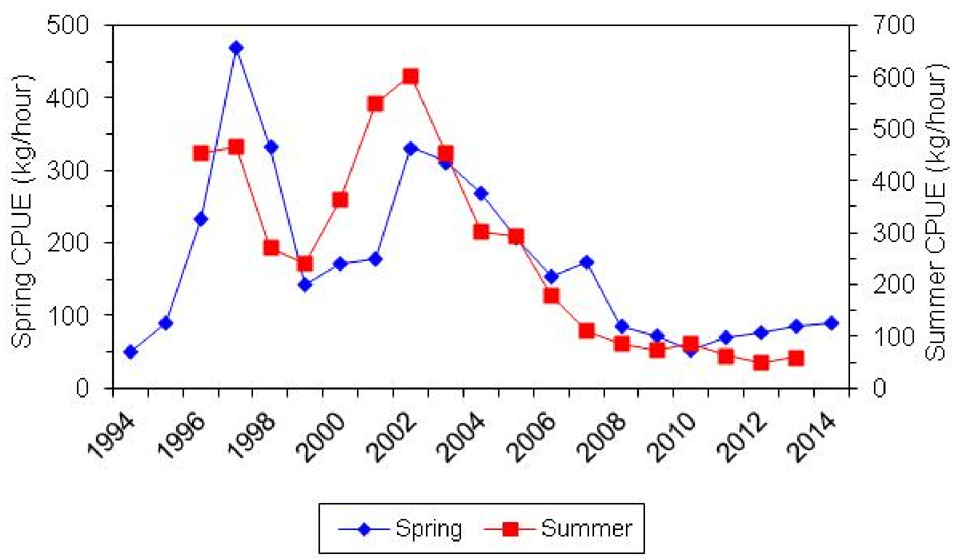


Figure 5.8. Faroe haddock. CPUE (kg/trawlhour) in the spring and summer surveys.

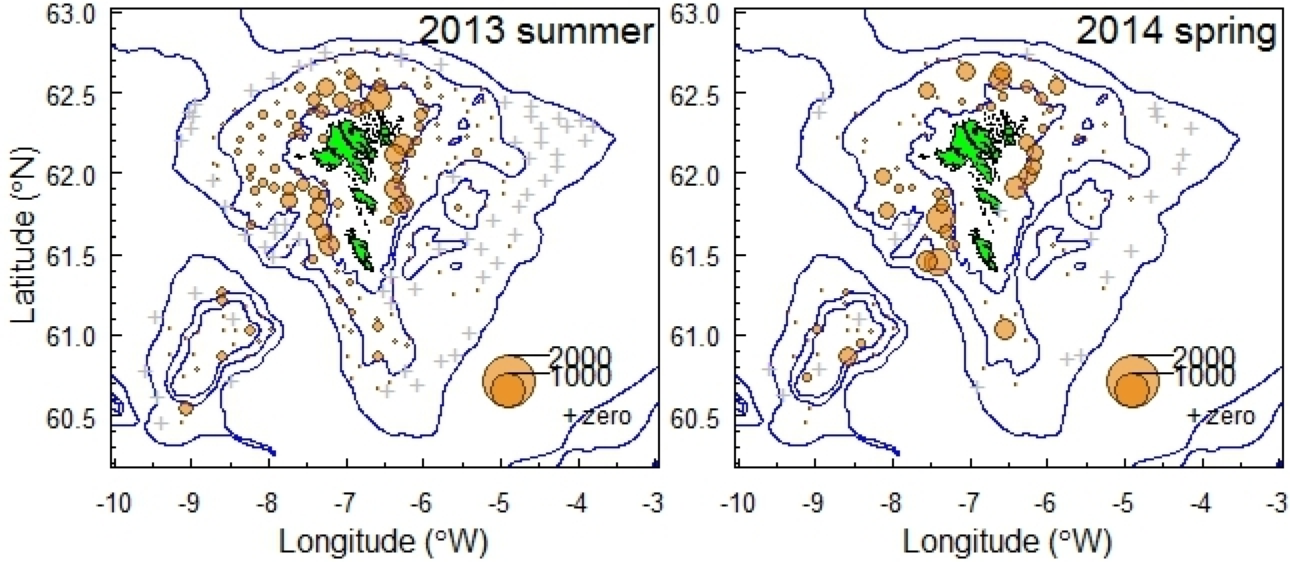


Figure 5.9. Distribution of Faroe haddock catches in the summer survey 2013 and in the spring survey 2014. In the annex, the catch distributions for all years are given.

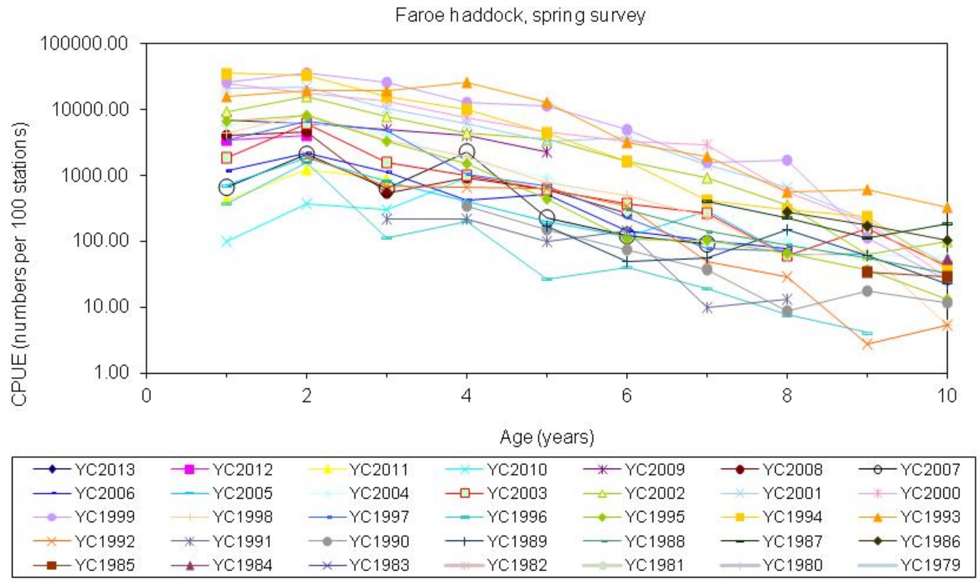


Figure 5.10. Faroe haddock. LN (c@age in numbers) in the spring survey.

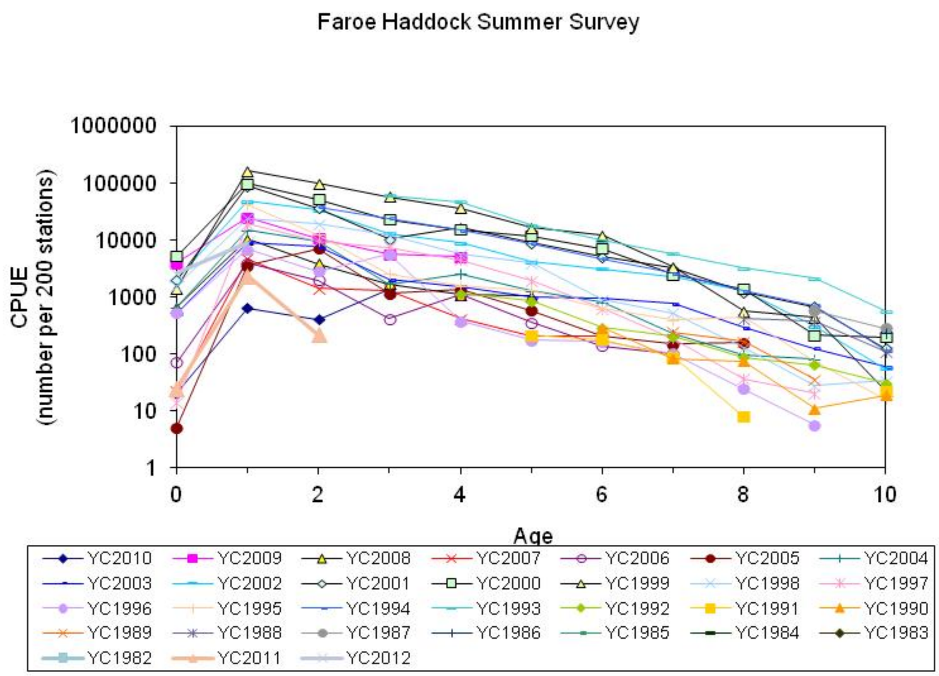
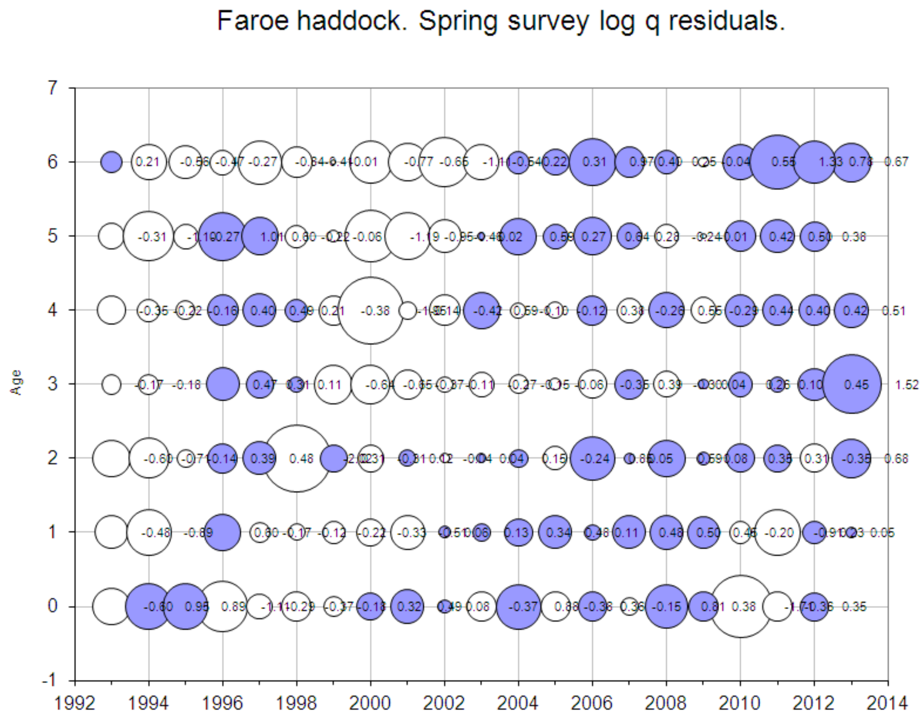


Figure 5.11. Faroe haddock. LN (c@age in numbers) in the summer survey.


Faroe haddock. Spring survey log q residuals.
Age
-1
0
1
2
3
4
5
6
7
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

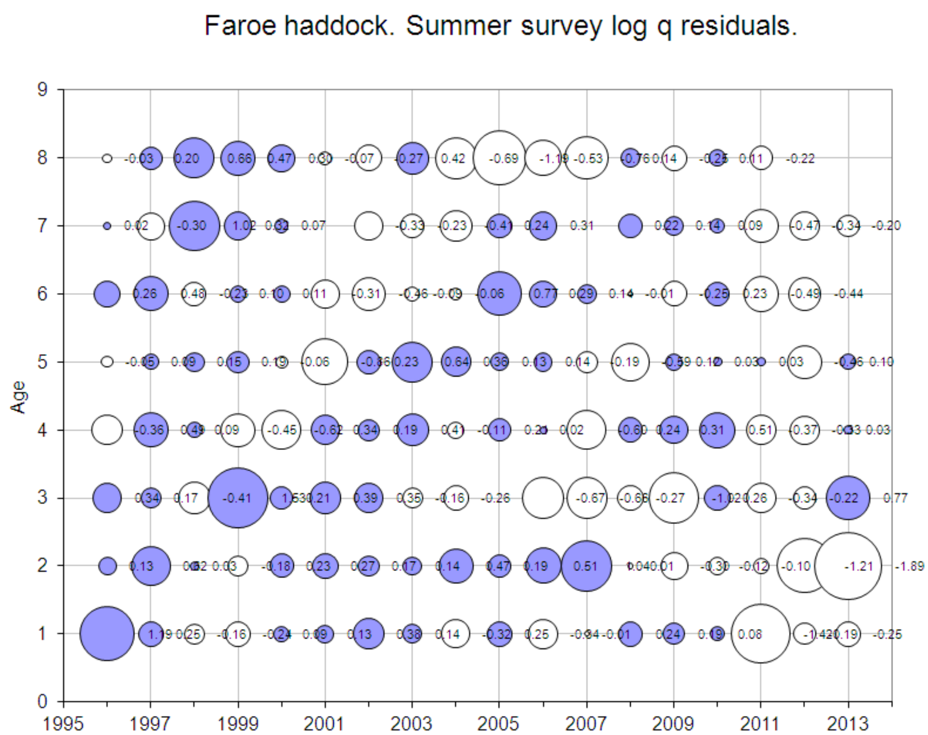

Faroe haddock. Summer survey log q residuals.
Age
0
1
2
3
4
5
6
7
8
9
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013

Figure 5.12.

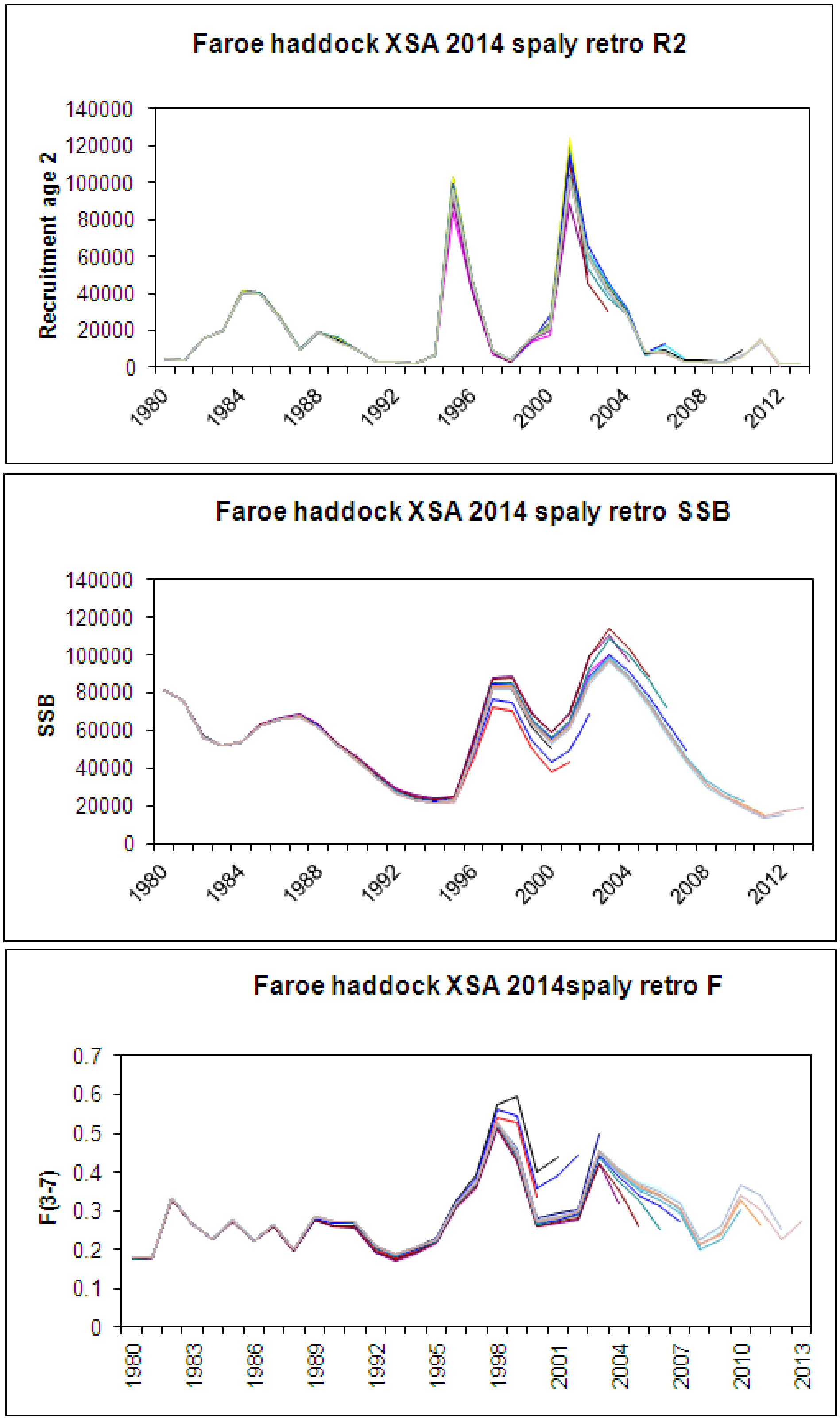


Figure 5.13. Faroe haddock. Retrospective analysis on the 2014 XSA.

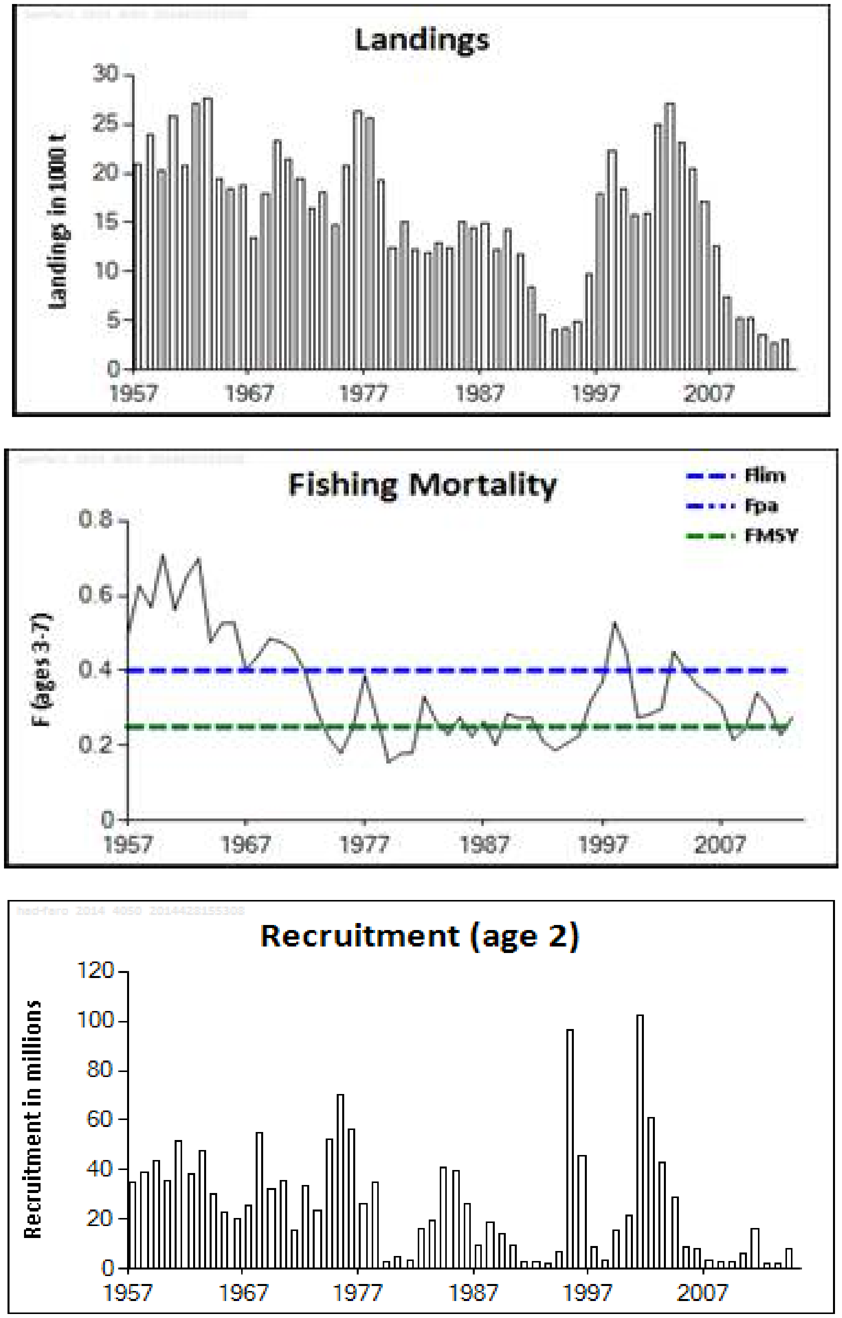


Figure 5.14. Faroe haddock (Division Vb) standard graphs from the 2014 assessment.

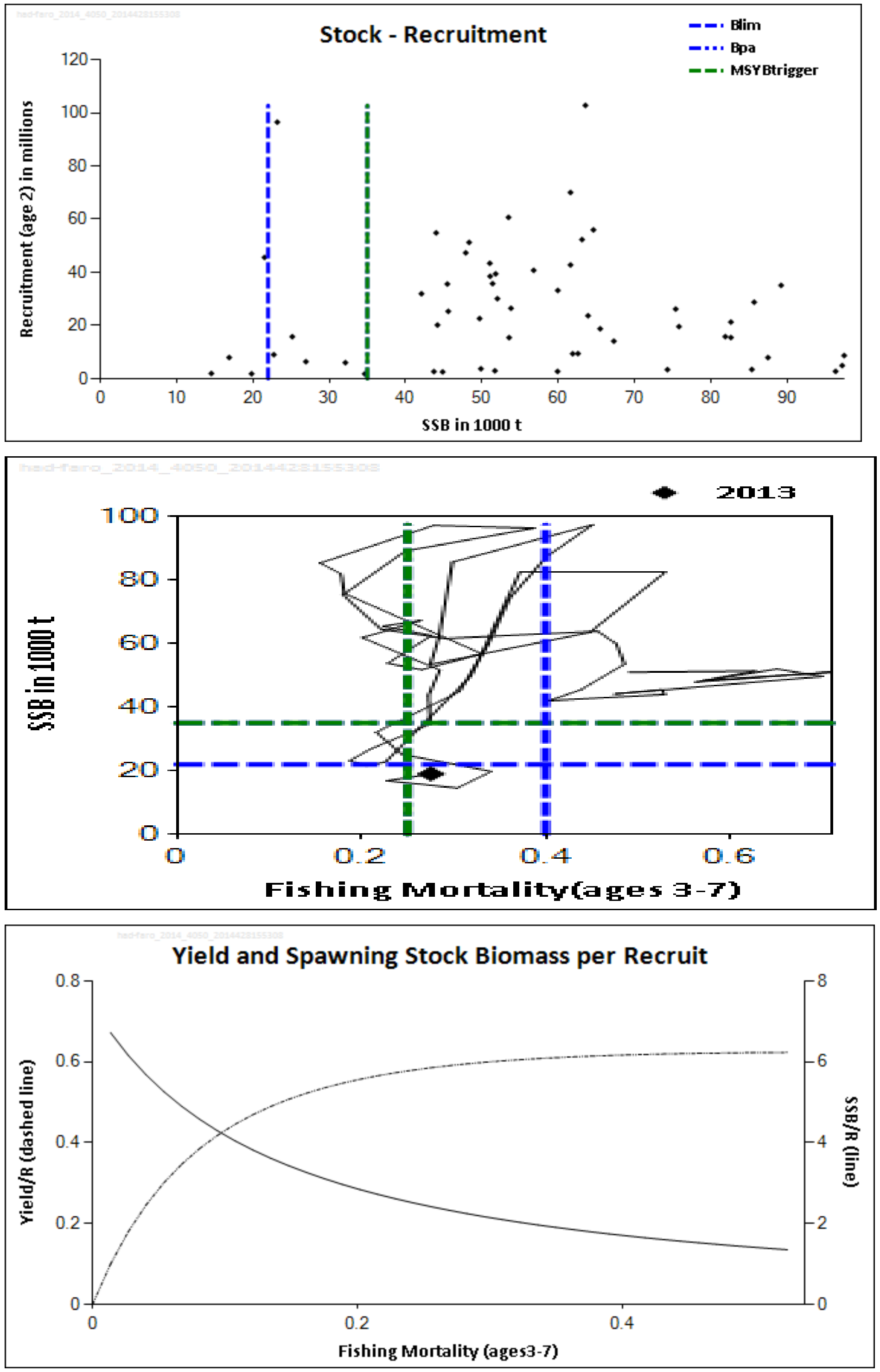


Figure 5.14 (cont.). Faroe haddock (Division Vb) standard graphs from the 2014 assessment.

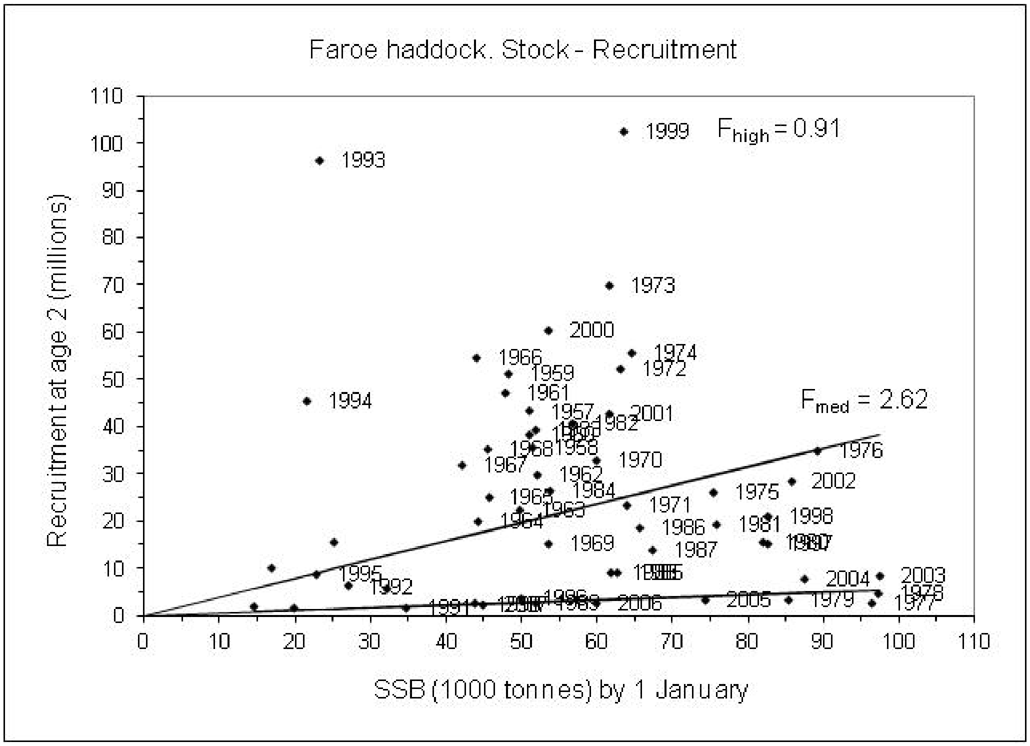
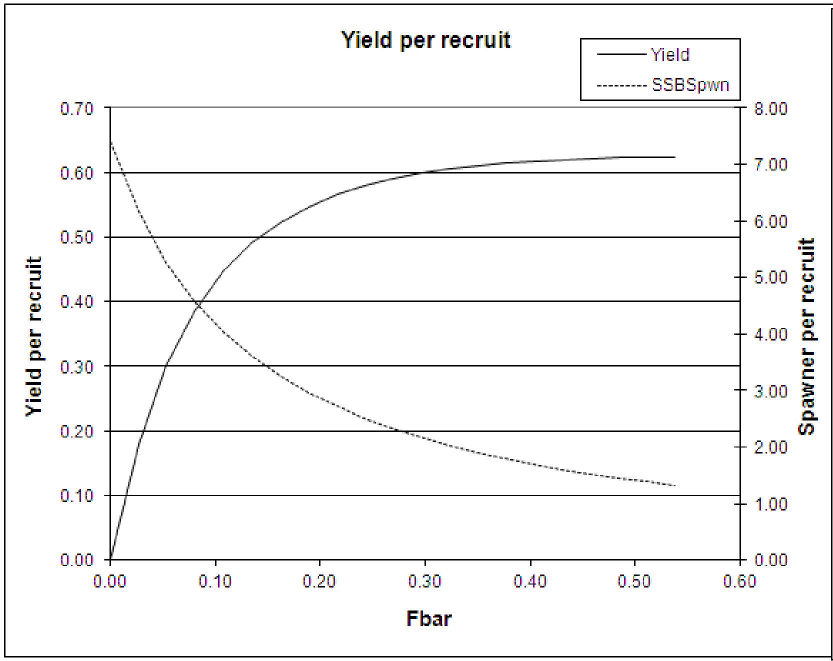
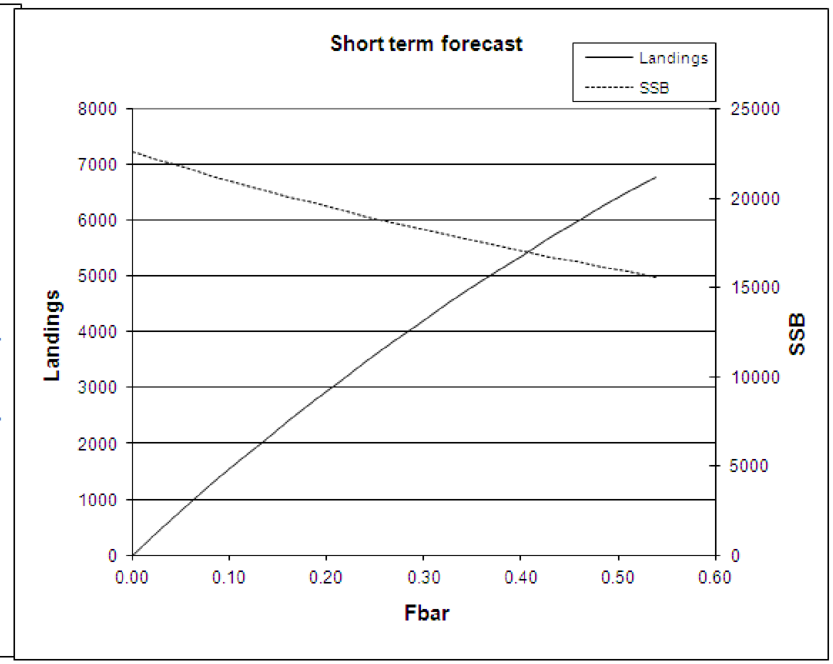


Figure 5.15. Faroe haddock. SSB-R plot.





MFYPR version 1
Run: jr2
Time and date: 15:48 19/04/2014

Reference point	F multiplier	Absolute F
Fbar(3-7)	1	0.2692
FMax	2.2137	0.5959
F0.1	0.687	0.1849
F35%SPR	0.862	0.2321
Fhigh	2.9773	0.8015
Fmed	0.8847	0.2382
Flow	-99	

Weights in kilograms

MFDP version 1
Run: jr1
Index file 18/04/2014
Time and date: 15:21 19/04/2014
Fbar age range: 3-7

Figure 5.16. Faroe haddock. Prediction output.

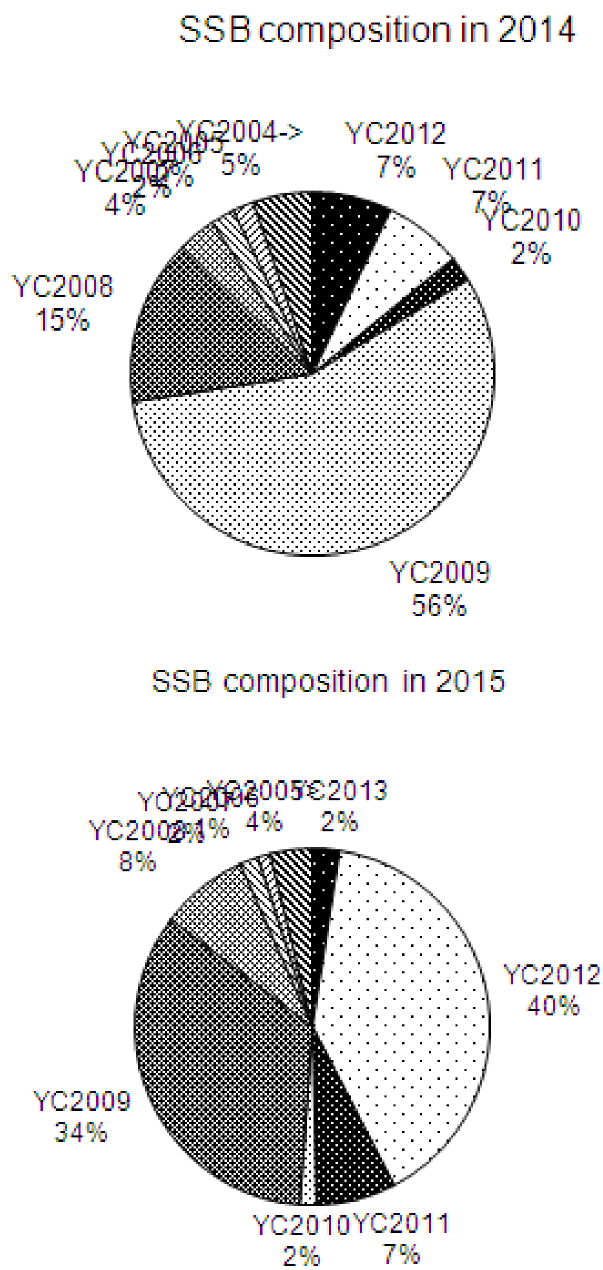


Figure 5.17. Faroe haddock. Projected composition of the number by year-classes in the SSB's in 2014 and 2015.

6 Faroe Saithe

Summary

The most recent benchmark assessment was completed in 2010.

Nominal landings decreased by more than 25% from 35 kt. in 2012 to 26 kt. in 2013. The corresponding estimate of fishing mortality in 2013 (average of ages 4-8 years) decreased to F=0.45 which is higher than the historical average (F=0.36) and well above Fmsy=0.32(NWWG 2012) and Fmsy=0.28(NWWG2011). The point estimate of the spawning stock biomass in 2013 is around 61 kt., just above Btrigger=55kt. Numbers of the most recent year-class (2010, age 3 in 2013) is estimated at 35 million. Since 2006 recruitment of saithe has remained at low levels compared to the exceptional peaks from 2001 to 2005.

Predicted landings in the last year assessment were at around 47kt while the actual measurement for 2013 was recorded at 26 kt.. However the estimate of Fbar was reasonably accurate from Fbar=0.48 in last year assessment and Fbar=0.45 in the 2014 assessment. Recruitment strength for 2013 was predicted at 28 million while the estimate for that year in the present assessment reached 35 million. SSB was overestimated by 18%.

Since 2005 both landings and the spawning stock biomass have declined substantially from historical peaks to levels not observed in nearly 20 years due to increasing harvest rates and relatively poor incoming year-classess.

6.1 Stock description and management units.

See the stock annex.

6.2 Scientific data

6.2.1 Trends in landings and fisheries

Nominal landings of saithe from Faroese grounds (Division Vb) have varied cyclically between 10 000 t and 68 000 t since 1961. After a third high of about 60 000 t in 1990, landings declined steadily to 20 000 t in 1996. Since then landings have increased to 68 000 tonnes in 2005 (Table 6.2.1.1, Figure 6.2.1.1) but has declined to 57 000 tonnes in 2008 and 2009. After a substantial drop in landings in 2011 which was the lowest observed since 1999 (33 000 t) landings increased by 20% in 2012 up to 35 000 t. The total tonnage in 2013 is the lowest observed since 1997. The historical average landings for saithe since 1961 is 37 000 t.

Since the introduction of the 200 miles EEZ in 1977, the saithe fishery has been prosecuted mostly by Faroese vessels. The principal fleet consists of large pair trawlers (>1000 HP), which have a directed fishery for saithe, about 50 - 77% of the reported landings in 1992-2011 (Table 6.2.1.2). The smaller pair trawlers (<1000 HP) and single trawlers (400-1000HP) have a more mixed fishery and they have accounted for about 10-20% of the total landings of saithe in the 1997—2011 period while the percentage of total landings by large single trawlers (>1000 HP) has declined drastically to just 1%. Historically the catch composition by the pair-trawler fleet has accounted for about 75% of the total tonnage for saithe but since 2007 it has increased gradually up to 94% in 2013 due mainly to the gear-shifting of single-trawlers to pair-trawling. The share of catches by the jigger fleet was about 8% in the 1985-1998 period but has decreased to less than .5.% since 2000 and it now accounts for only 3% of the total domestic landings for saithe in 2013. Foreign catches that have been reported to the Faroese Authorities but not officially reported to ICES are also included in the Working Group estimates. Catches in Subdivision IIa, which lies immediately north of the Faroes, have also been included. Little or no discarding is thought to occur in this fishery.

Cumulative landings of saithe for the domestic fleets since 2000 are shown in Figure 6.2.1.2. The last three years are among the the poorest in the time series. The progression of landings in the first three months of 2014 are below monthly averages and suggest a poor fishing year.

6.2.2 Catch at age

Catch at age is based on length, weight and otoliths samples from Faroese landings of small and large single and pair trawlers, and landing statistics by fleet provided by the Faroese Authorities. Catch at age is calculated for each fleet by four-month periods and the total is raised by the foreign catches. Minor adjustments were made to the catch-at-age matrix for previous due to revised final catch statistics (Tables 6.2.2.1 and 6.2.2.2). Most of the age-dissagregated catch matrix is comprised of catches of the pair-trawl fleet. Since 2010 catch numbers is mostly comprised of age-groups 4 to 6 whereas in the period from 2005 to 2009 it is mainly composed of age-groups 4 to 8. Only numbers of 6-years old were higher in 2013 than in 2012.

The sampling program and sampling intensity in 2013 as well as the approach used in compiling catch numbers is the same as in preceding years. Sampling levels in both 2012 and 2013 are identical and went down from 8.5% in 2011 to 4.9% (Table 6.2.2.3.) The average amount sampled per tonnes landed since 2000 is 5.7%.

6.2.3 Weight at age

Mean weights at age have varied by a factor of about 2 during the 1961—2013 period. Mean weights at age were generally high during the early 1980s and they subsequently decreased from the mid 1980s to the early 1990s (Table 6.2.3.1 and Figure 6.2.3.1). Mean weights increased again in the period 1992-96 but have shown a general decrease thereafter. With the exception of 3-years old saithe all age groups were showing signs of increasing size since 2006. By 2011 age-classes 4 to 8 were approaching or at long term average. This trend seemed to continue for older age groups (7 and older) whereas weight of 4 to 6 years old individuals appeared to decrease again in 2012 and 2013. Mean weight of the 2010 year-class (age 3 in 2013) is estimated at 1.21 kg. which is an increase with respect to that in 2012 (1.03 kg.). Since 2001 all age groups have remained below the historical average with the only exception of 7-years old saithe which reached the long-term mean value (3.785 kg.) in 2012 and 3-years old with size above average in 2009. Mean weights at age in the stock are assumed equal to those in the catch.

6.2.4 Maturity at age

Maturity at age data from the spring survey is available from 1983 onward (Steingrund, 2003.) Due to poor sampling in 1988 the proportion mature for that year was calculated as the average of the two adjacent years. At the 2012 working group a model using maturity at age from the Faroese groundfish spring survey was implemented to derive smoothed trends in maturity by age and year. The fitting was done locally and the smoothing level was chosen as a trade-off between retaining the trend in maturities and reducing the data noise. For 1962 to 1982 the average maturity of predicted ogives of the 1983-2011 period was used (Table 6.2.4.1 and Figure 6.2.4.1.) Maturity ogives were low from the early and mid-1990s up to 2001 where they began to rise considerably and are now well above the historical average.

Faroe saithe begins to mature at 3 years old, 20% are mature at age 4, 50% at 5 years old and 100% are mature at age 9 and onwards.

6.2.5 Indices of stock size

6.2.5.1 Surveys

There are two annual groundfish surveys conducted in Faroese waters. The spring survey series (FGFS1) are available since 1994, while the summer survey (FGFS2) was initiated in 1996. The design for both bottom-trawl surveys is depth stratified with randomised stations covering the Faroe Plateau area. The total number of stations in the summer and spring is 100 and 200 respectively. Effort is recorded in terms of minutes towed approximately 60 min. Large proportion of saithe is caught in relatively few hauls and the interannual variability of these hauls seems considerable.

Survey catch rates (kg per hour), length composition and age-disaggreagted indices are presented in figures 6.2.5.1.1 to 6.2.5.1.5. Both surveys suggest low abundances of saithe in mid- and late 1990's and increasing numbers from 2001 to 2006 caused by the strong 1998 and 1999 year classes entering the stock. The most recent estimate in the spring survey suggest a slightly increase in stock biomass in 2014 but given the uncertainty associated with the index the point estimate ought to be taken with caution.

Given the extreme schooling behaviour of saithe the internal consistency in the spring survey measured by the correlation of numbers in the data matrix for the same year class is reasonably good, with R^2 close to 0.85 for the best defined age groups and below $R^2 = 0.3$ for some other age classes (Figure 6.2.5.1.6). Internal consistency in the age-disagregated fall survey is displayed in figure 6.2.5.1.7.

6.2.5.2 Commercial CPUE

The CPUE series that has been used in the assessment since 2000 was introduced in 1998 (ICES C.M. 1998/ACFM:19), and consists of saithe catch at age and effort in hours, referred to as the pair trawler series. A GLM model and a survey spatial scaling factor is used to standardised the CPUE series (Stock Annex B.4., Benchmark report, WKROUND 2010.) The benchmark working group regarded this novel approach to developing the commercial series as reasonable (Benchmark report, WKROUND 2010.) Predicted annual CPUEs derived from this approach indicate a sharp downwards trend since 2006 (Figure 6.2.5.1.1)

The correlation between predicted CPUE and the spring and summer surveys is R^2=0.53 and R^2=0.65 respectively.

The age-disaggregated index suggests that stock abundances were low in the 1990s to increase subsequently in the 2000s. The age composition indicates that the pair-trawl fleet targets mostly age groups 4 to 6. (Figure 6.2.5.2.1) There is a good agreement between age-disaggregated indices in the commercial index and indices of the same year class one year later (Figure 6.2.5.2.2) as measured by R^2 >0.35 for all age-classes.

6.2.5.3 Information from the fishing industry

No additional information beyond the landings from the commercial fleet was presented for incorporation in the assessment.

6.3 Methods

The assessment model adopted at the benchmark assessment in 2010 is described in the Stock annex (Sec. C) and in the benchmark report (WKROUND 2010.) The 2010 XSA was calibrated with the standardized pair trawlers with catchability independent of stock size for all ages, catchability independent of age for ages ≥ 8, the shrinkage of the SE of the mean = 2.0, and no time tapered weighting. The tunings series used are shown in Table 6.3.1. Commercial catch-at age data (ages 3-14+, years 1961-2013) were calibrated in the XSA model using the commercial pair-trawl fleet (ages 3-11, years 1995-2013). XSA model diagnostics of the spaly run is presented in Table 6.3.2... Patterns in log-catchability residuals from the XSA model are relatively random but with large positive blocks in 2006-2010 for 3 to 5 age-classes (Figure 6.3.1.). Residuals from a separable statistical model predicting catch numbers at age and survey data and modelling selectivities over 3 distinct periods are also presented (Figure 6.3.3)

6.4 Reference points

6.4.1 Biological reference points and MSY framework

In the 2011 assessment for Faroe saithe a Management Strategy Evaluation (MSE) was performed using a harvest control rule in the FLR environment. In the 2012 assessment some changes were included in the simulation framework. Maturity by age and year were modified (and therefore SSB) according to the smoothing technique reported in Section 6.2.4. Extra stochasticity was added to weights at age in the form of autocorrelation and the constraint of running XSAs in the simulations was dropped to reduce the simulation running time. All these changes caused a upward revision of the F_{msy} point estimate from F_{msy}=0.28 to F_{msy}=0.32. The simulation framework is explained below.

The MSE approach requires mathematical representations of two systems: a 'true' system and an 'observed' one. The 'true' system is represented by the operating model (OM) that simulates the real world. In contrast, the 'observed' system represents the conventional management procedure (MP), from the data collection through stock assessment to the management implementation. The present MSE evaluation uses the working group stock assessment as the basis for the Operating Model and makes assumptions about the selection pattern of the fishing fleet and its dynamics. The model comprises a single stock that is fished by a single fleet. It implements a harvest control rule through a management procedure that explicitly models the stock assessment process and time lag in implementing the management advice (delay between the gathering of data and making a management decision, i.e. setting the current fishing effort) which explicitly address uncertainty in recent parameter estimates. The stock recruitment relation used is the Hockey-stick or segmented regression with random noise on top of it reflecting the high variability in historical recruitment estimates (CV=0.5). Fishing mortality is estimated from effort, catchability (constant) and the selection pattern. The observed selection pattern since 1996 is used in the simulations which correspond with the implementation of the fishing days quota in the Faroese management system. Maturity-at-age is fixed and taken from the smoothing method implemented in 2012 while stochasticity is included in weights-at-age with a CV=0.18 and autocorrelation of Rho=0.35 applied to all age groups to somehow replicate the observed fluctuations pattern. The data sampling of catches and tuning fleets is carried out by multiplying by random errors. Natural mortality is fixed to M=0.2. Simulations were performed 1000 times on a 40-year forward period with the historical period being replicated in the OM.

Unlike the flat curves obtained from traditional yield-per-recruit calculations simulations curve show a relatively well defined maximum at F_{msy} =0.32. The reason for this difference is that when fishing mortality is above certain level (>0.3) some of the stochastic runs will lead to spawning stock being below the break point in the stock-recruitment function so recruitment and subsequent landing s will be reduced. The breakpoint of 55 kt. in the segmented regression or the revised B_{pa}=60 000 t. (see Section 2. Demersal stocks in the Faroe Area, Subsection 2.1.7 Faroe saithe) could be candidates for $B_{trigger}$ the point at which fishing mortality should be reduced according to the MSY framework. The results of the simulations are shown in Figures 6.4.1.1 and 6.4.1.2.

In 2014 at the WKMSYREF2 workshop the EqSim simulation framework was used to explore candidates to Fmsy. The work was presented at the NWWG meeting in 2014 and the results agree with the previous simulations (see above) in that estimates of Fmsy are in the range of Fmsy=0.30 and Fmsy=0.34 and not as the present level of Fmsy=0.28 . Below it is an excerpt from the WKMSYREF2 report:

The EqSim framework fits three stock-recruit functions (Ricker, Beverton-Holt and Hockey-stick) on the bootstrap samples of the stock and recruit pairs from which approximate joint distributions of the model parameters can be made. The result of this is projected forward for a range of F's values and the last 50 years are retained to calculate summaries. Each simulation is run independently from the distribution of model and parameters. Error is introduced within the simulations by randomly generating process error about the constant stock recruit fit, and by using historical variation in maturity, natural mortality, weight at age, etc.

In the EqSim simulations the Hockey-Stick stock-recruit function were used assuming assessment and autocorrelation errors. Figures 6.4.1.3 and 6.4.1.4 illustrate the results of these simulations which suggest that candidates for FMSY are FMSY =0.34 (median yield) and FMSY =0.30 (F that gives the maximum mean yield in the long term) lie above the current FMSY = Fpa = 0.28 if autocorrelation and assessment errors are included in the simulation framework. If errors are ignored then estimates for FMSY are predicted to FMSY =0.38 (median yield), FMSY =0.35 (maximum mean yield). No Blim is defined for faroe saithe but for the purposes of the analysis a value of Blim=Bpa/1.4 was set for the simulations. A more detailed information of the simulations are available under *http://www.ices.dk/community/groups/Pages/WKMSYREF2.aspx* A summary is given in the table below.

	F	SSB	Catch	option
Flim	0.34	87327.43	36479.8	ass. Error
Flim	0.37	79116.87	35447.45	ass. Error
Flim	0.46	38905.3	22023.28	ass. Error
MSY:median	0.34	88565.78	36665.24	ass. Error
Maxmeanland	0.3	101372.9	37109.88	ass. Error
FCrash5	0.41	63312	31637.31	ass. Error
FCrash50	0.52	855.73	550.19	ass. Error
Flim	0.4	78435.72	38526.07	No ass. Error
Flim	0.42	73052.08	37660.27	No ass. Error
Flim	0.5	38910.57	24279.75	No ass. Error
MSY:median	0.38	82329.53	38694.43	No ass. Error
Maxmeanland	0.35	90688.34	39167.13	No ass. Error
FCrash5	0.43	69750.99	37114.99	No ass. Error
FCrash50	0.54	2847.53	1910.51	No ass. Error

MSY and revised precautionary reference points (Section 2. Demersal stocks in the Faroe Area, Subsection 2.1.7 Faroe saithe) for faroe saithe are listed below:

Biological reference points	NWWG 2012	NWWG 2011	NWWG2014
Btrigger	55 000 t.		55 000 t.
Blim	not defined.		
Bpa	60 000 t.		
Flim	not defined		
Fpa	0.28		
Fmsy	0.32	0.28	0.30

The SSB-R relation with respect to reference fishing mortalities (Fhigh, Fmed and Flow) is presented in Figure 6.5.1.3 or 6.4.1. while the history of the stock/fishery in relation to the existing four reference points can be seen in Figure 6.5.1.4 or 6.4.2.

6.5 State of the stock – historical and compared to what is now

Recruitment in the 1980s was close to the historical average (32 millions). The strongest year class since 1986 was produced in the 1990s and the average for that decade was about 28 millions (Figures 6.5.1 to 6.5.4. and Tables 6.5.1 to 6.5.3) The 1998 (88 millions) and 1999 (106 millions) are the largest observed in the time series. The 2010 year-class (numbers of age-3 saithe in 2013) is estimated at 35 million below the historical average of 31 million. Since 2006 estimated recruitment has remained at low levels in comparison with the exceptionally high recruitment pulses observed from 2001 to 2005.

Relatively low Fs during the 1960s and recruitment above average in early-1970s caused an increase in SSB well above the historical average around the mid-1970s while landings peaked to almost 58 000 t. in 1973. Increasing Fs since 1980 lead to a decrease in the spawning stock biomass of saithe throughout the mid-1980s although recruitment of the 1983 year class rose to 61 000 millions, i.e. double the average from 1961 to 2013. The historically low SSB persisted in 1992-1998 and this along with low Fs caused landings to steeply decline to around 20 000 tonnes in 1996. The SSB increased since 1999 to above 128 000t in 2005 with the maturation of the 1995, 1996, 1997 and 1999 year classes and decreased to 93 000 t in 2009. The 2013 spaly assessment indicates that the point estimator of SSB in 2013 is 60kt.. Since 2005 SSB has been declining sharply and at present is close to Btrigger=55 000 t The cause for concern is perhaps most graphically illustrated in figure 6.5.6 which shows the numbers of mature fish in the stock at each age from 3 yrs to 14+ yrs for the two years 2006 and 2013. It is quite clear that there has been a substantial reduction in the numbers of mature fish over the age groups 4 to 8.

In 2013 average fishing mortality over age groups 4 to 8 (Fbar) is estimated at Fbar=0.45. The assessment model suggests a drop in fishing mortality from 2012 to 2013 reflecting the abrupt decline in landings from 35 kt. to 26 kt. F has been above Fmsy=0.32 (NWWG 2012) and Fmsy=0.28 (NWWG 2011) and Fmsy=0.30 (WKMSYREF2 2014) since 1981.

The relation between stock and recruitment is presented in figure 6.5.7.

PA Precautionary plot is shown in figure 6.5.8

6.6 Short term forecast

6.6.1 Input data

Population numbers at age 3 for the base short term prediction is calculated as the geometric mean of estimated recruitment strength from 2007 to 2011. Natural mortality is set to constant 0.2. Weight-at-age for 3-years old saithe is predicted by the year class strength (number of 3-years old in the stock) with a 3 year time lag (Eq. 1) whereas weight for ages 4 to 8 is estimated by weight-at-age the previous year from the same year class (Eq. 2) Weight for ages 9 to 14+ is an average of the most 3 recent years. Diagnostics and results of the model are shown in Figures 6.6.1.1 and 6.6.1.2. For older age groups (9 to 14+) a 3-year average is used.

$W_{3,y} = \alpha N_{3,y-3} + \beta$ for $a = 3$ (Eq. 1)

$W_{a+1,y+1} = \alpha W_{a,y} + \beta$ for $4 \leq a \leq 8$ (Eq. 2)

$W_{a,y} = (W_{a-3,y}\ W_{a-2,y}\ W_{a-1,y})/3$ for $9 \leq a \leq 14+$ (Eq. 3)

Proportion mature for 2014-2016 is taken as the average of predicted maturity ogives from 2012 and 2014 The exploitation pattern used is a 3 year average rescaled to last year reflecting the trend observed in Fs in recent years..

Spaly short term prognosis (spaly XSA run with calibrated with the commercial pair-trawler fleet)

Input data for the prediction with management options for the spaly scenario are presented in Table 6.6.1.1.

6.6.2 Projection of catch and biomass

Results from predictions with management optionis presented in Table 6.6.2.1.

At status quo F=0.45 landings would increase to 33 kt. in 2014 and 36 kt. in 2015 while spawning stock biomass is expected to around 70kt. in 2014 and increase to 76 kt. tonnes in 2015. Landings in 2014 are predicted to rely on the 2008, 2009 and 2009 year classes (73%) while in the SSB these year-classes will contribute to around 69% of the spawning biomass in 2014 (Figure 6.6.2.1a.)

6.7 Yield per recruit and medium term forecasts

No medium term projections were performed for faroe saithe.

Input data to yield per recruit

The input data to long term prediction are shown in Table 6.7.1.1.

Mean weights-at-age for 1981-2013 were used for the long term projection. Natural mortality is set to constant 0.2. Proportion mature-at-age is taken as the average from 1983-2014.

The exploitation pattern was set equal to the average of the last five years (2005-2013) (as suggested from ACFM, 2004). Results from the yield per recruit analysis are shown in Table 6.7.1.2 and Figure 6.7.1.1.

6.8 Uncertainties in assessment and forecast

In 2012 and 2013 the amount of catch sampled was almost 5% which is regarded as adequate.

The assessment of Faroe saithe is relatively uncertain due to lack of good tuning data although the internal consistency in the commercial fleets used to calibrate the XSA model is reasonable considering the nature of the species that is highly schooling, and widely migrating. The retrospective pattern (Figure 6.8.1) reveals some of the assessment uncertainty. It shows periods of over- and underestimation in average fishing mortality and consequently under- and overestimation in spawning stock biomass. Over- and underestimation seem to occur in periods of poor and high abundances respectively. Various factors could explain this phenomena, e.g., by changes in the vertical distribution of the stock or changes in the selection pattern that have been observed in recent years. With respect to recruitment the retrospective trend suggests an overestimation of incoming year-classes. To avoid large year to year fluctuations in the spawning stock biomass (also dependent on age structure) a locally fitting model was implemented in 2012 to reduce variability in maturities.

6.9 Comparison with previous assessment and forecast

The 2013 assessment predicted recruitment in 2013 to around 28 million while the observed year-class strength was 35 million (Table 6.9.1). Spawning stock biomass and fishing mortality were overestimated from 72 kt. and F=0.48 to 61 kt. and F=0.45 respectively. Landings for 2013 were predicted at 47 k t. while actual observed catches in that year reached 26 kt an overestimation of 45%..

6.10 Management plans and evaluations

No management plan exists for saithe in Division Vb

6.11 Management considerations

Management consideration for saithe is under the general section for Faroese stocks.

Unlike the traditional yield-per-recruit curves the simulations carried out at the 2012 assessment (Sec. 6.4.1) show a relatively well defined maximum at F_{msy} =0.32. Candidates for $B_{trigger}$ might be set to the breakpoint of 55 kt. in the segmented regression or the revised B_{pa}=60 000 t. the point at which fishing mortality should be reduced according to the MSY framework (for more details see Section 6.4.1)

6.12 Ecosystem considerations

No evidence is available to indicate that the fishery is impacting the marine environment. A Ph.D. project was initiated in 2008, with the aim of investigate the role of environmental indicators in the dynamics of Faroe saithe. The results and conclusions of the PhD will be available to the working group in future meetings.

6.13 Regulations and their effects

It seems to be no relationship between number of fishing days and fishing mortality, probably because of large fluctuations in catchability. Area restriction is an alternative to reduce fishing mortality- and this is used to protect small saithe in Faroese area.

6.14 Changes in fishing technology and fishing patterns

See section 6.2.

6.15 Changes in the environment

According to existing literature the productivity of the ecosystem clearly affects both cod and haddock recruitment and growth (Gaard *et al*., 2002), a feature outlined in Steingrund and Gaard (2005). The primary production on the Faroe Shelf (< 130 m depth), over the period May through June, varied interannually by a factor of five, giving rise to low- or high-productive periods of 2-5 years duration (Steingrund and Gaard, 2005). The productivity over the outer areas seems to be negatively correlated with the strength of the Subpolar Gyre (Hátún et al., 2005; Hátún *et al*., 2009; Steingrund *et al*., 2010), which may regulate the abundance of saithe in Faroese waters (Steingrund and Hátún, 2008). When comparing a gyre index (GI) to saithe in Faroese waters there was a marked positive relationship between annual variations in GI and the total biomass of saithe lagged 4 years (Figure 6.15.1.)

There is a negative relationship between mean weight-at-age and the stock size of saithe in Faroese waters. This could be due to simple density-dependence, where there is a competition for limited food resources. Stomach content data show that the food of saithe is dominated by blue whiting, Norway pout, and krill, and the annual variations in the stomach fullness are mainly attributable to variations in the feeding on blue whiting. There seems to be no relationship between stomach fullness and weights-at-age for saithe (í Homrum *et al*. WD 2009).

6.16 References

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Table 6.2.1.1. Faroe saithe (Division Vb). Nominal catches (tonnes round weight) by countries, 1988-2013, as officially reported to ICES.

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Denmark	94	-	2	-	-	-	-	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-	-	-	16	-	-	-	-
Faroe Islands	44402	43,624	59,821	53,321	35,979	32,719	32,406	26,918	19,267	21,721	25,995	32,439		49,676
France 3	313	-	-	-	120	75	19	10	12	9	17	-	273	934
Germany	-	-	-	32	5	2	1	41	3	5	-	100	230	667
German Dem.Rep.	-	9	-	-	-	-	-	-	-	-	-	-	-	-
German Fed. Rep.	74	20	15	-	-	-	-	-	-	-	-	-	-	5
Greenland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	-	-	-	-	0	0	0
Netherlands	-	22	67	65	-	-	-	-	-		-	160	72	60
Norway	52	51	46	103	85	32	156	10	16	67	53	-	-	-
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	20	1
UK (Eng. & W.)	-	-	-	5	74	279	151	21	53	-	19	67	32	80
UK (Scotland)	92	9	33	79	98	425	438	200	580	460	337	441	534	708
USSR/Russia 2	-	-	30	-	12	-	-	-	18	28	-	-	-	-
Total	45027	43,735	60,014	53,605	36,373	33,532	33,171	27,200	19,949	22,306	26,065	33,207	1,161	52,131
Working Group estimate 4,5	45285	44,477	61,628	54,858	36,487	33,543	33,182	27,209	20,029	22,306	26,421	33,207	39,020	51,786

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	20131
Denmark	-	-	-	-	34	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-	-	-	-	-	-
Faroe Islands	55,165	47,933	48,222	71,496	70,696	64,552	61,117	61,889	46,686	32,056	38,175	28,391
France	607	370	147	123	315	108	97	68	46	135	40	31
Germany	422	281	186	1	49	3	3	0				
Greenland	125	-			73	239	0	1			1	
Irland	-	-	-	-	-	-	-	-				
Iceland	-	-	-	-	-	-	-	148	-			
Netherlands	0	0	0	0	0	3	0	0	0			
Norway	77	62	82	82	35	81	38	23	28			
Portugal	-	-	5	-	-	-	-	-				
Russia	10	32	71	210	104	159	38	44	3			1
UK (E/W/NI)	58	89	85	32	88	4	-	-				
UK (Scotland)	540	610	748	4,322	1,011	408	400	685				
United Kingdom	-	-	-	-	-	-	-	-	706	19		1
Total	57,004	49,377	49,546	76,266	72,405	65,557	61,693	62,858	47,469	32,210	38,216	28,424
Working Group estimate 4,5,6,7	53,546	46,555	46,355	67,967	66,902	60,785	57,044	57,949	43,885	29,658	35,314	26,262

Table 6.2.1.2. Faroe saithe (Division Vb). Total Faroese landings (rightmost column) and the contribution (%) by each fleet category (1985-2013). Averages for 1985-2013 are given at the bottom.

year	Open boats	Long– line <100 GRT	Single trawl <400	Gillnet	Jigger	Single trawl 400–	Single trawl	Pair trawl <1000 HP	Pair trawl >1000 HP	Long– line >100 GRT	Industrial	Others	Total round
1985	0.2	0.1	0.1	0.0	2.6	6.6	33.7	28.2	28.2	0.1	0.2	0.2	42598
1986	0.3	0.2	0.1	0.1	3.6	2.8	27.3	27.5	36.5	0.1	0.7	0.9	40107
1987	0.7	0.1	0.3	0.4	5.6	4.1	20.4	22.8	44.2	0.1	1.1	0.0	39627
1988	0.4	0.3	0.1	0.3	6.5	6.8	20.8	19.6	43.6	0.1	1.3	0.1	43940
1989	0.9	0.1	0.3	0.2	9.3	5.4	17.7	23.5	41.1	0.1	1.3	0.0	43624
1990	0.6	0.2	0.2	0.2	7.4	3.9	19.6	24.0	42.8	0.2	0.9	0.0	59821
1991	0.6	0.1	0.1	0.6	9.8	1.3	13.9	26.5	46.2	0.1	0.8	0.0	53321
1992	0.4	0.4	0.0	0.0	10.5	0.5	7.1	24.4	55.6	0.1	1.0	0.0	35979
1993	0.6	0.2	0.1	0.0	9.3	0.6	6.5	21.4	60.6	0.1	0.7	0.0	32719
1994	0.4	0.4	0.1	0.0	12.6	1.1	6.8	18.5	59.1	0.2	0.7	0.0	32406
1995	0.2	0.1	0.4	0.0	9.6	0.9	9.9	17.7	60.9	0.3	0.0	0.0	26918
1996	0.0	0.0	0.1	0.0	9.2	1.2	6.8	23.7	58.6	0.2	0.0	0.0	19267
1997	0.0	0.1	0.1	0.0	8.9	2.5	10.7	17.8	58.9	0.4	0.4	0.0	21721
1998	0.1	0.4	0.1	0.0	8.1	2.8	13.8	16.5	57.6	0.3	0.4	0.0	25995
1999	0.0	0.1	0.1	0.0	5.7	1.2	12.6	18.5	60.0	0.2	1.6	0.0	32439
2000	0.1	0.1	0.2	0.0	3.7	0.3	15.0	17.5	62.3	0.1	0.7	0.0	39020
2001	0.1	0.1	0.1	0.0	2.8	0.3	20.2	16.5	58.8	0.2	0.8	0.1	51786
2002	0.1	0.2	0.1	0.0	1.6	0.1	26.5	10.5	60.8	0.1	0.0	0.0	53546
2003	0.0	0.0	1.9	0.0	0.9	0.4	17.4	14.7	64.7	0.1	0.0	0.0	46555
2004	0.1	0.2	3.7	0.0	1.9	0.4	15.1	14.4	63.8	0.2	0.0	0.0	44605
2005	0.2	0.1	4.4	0.0	2.4	0.2	12.7	20.6	59.2	0.2	0.0	0.0	66394
2006	0.2	0.4	0.3	0.0	3.9	0.1	19.8	20.6	54.1	0.6	0.0	0.0	65394
2007	0.2	0.2	0.2	0.0	2.0	0.1	30.4	16.0	50.6	0.3	0.0	0.0	41341
2008	0.2	0.3	1.5	0.0	3.2	0.2	20.4	16.0	57.7	0.5	0.0	0.0	27475
2009	0.4	0.2	3.3	0.0	4.3	0.1	9.6	15.1	66.8	0.2	0.0	0.0	47122
2010	0.1	0.1	1.2	0.0	3.9	2.4	8.3	15.1	68.3	0.6	0.0	0.0	38293
2011	0.1	0.1	0.5	0.0	3.6	1.3	2.6	14.1	77.1	0.5	0.0	0.0	26854
2012	0.2	0.1	1.9	0.0	2.4	0.1	2.2	18.6	73.5	1.0	0.0	0.0	31633
2013	0.1	0.3	1.0	0.0	3.2	0.2	0.6	24.9	69.0	0.5	0.0	0.1	22339
Avg.	0.3	0.2	0.8	0.1	5.5	1.6	14.8	19.5	56.6	0.3	0.4	0.0	39753

Table 6.2.2.1. Faroe saithe (Division Vb). Catch number at age by fleet categories in 2013 (calculated from gutted weights).

Age	Jiggers	Single trawl>1000 HP	Pair trawl <1000 HP	Pair trawl>1000HP	Others	Total Division Vb
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	9	2	156	424	17	608
4	121	20	1083	3047	91	4362
5	151	21	852	2462	72	3558
6	74	13	471	1295	38	1891
7	18	3	107	293	9	431
8	5	2	44	122	3	176
9	3	1	26	71	2	103
10	2	1	20	56	2	81
11	6	1	30	83	3	123
12	3	1	16	50	2	71
13	1	0	9	22	1	33
14	1	0	7	19	1	28
15	0	0	1	2	0	3
Total No.	393	65	2822	7946	241	11468
Catch t.	746	135	5562	15412	464	22319

Table 6.2.2.2. Faroe saithe (Division Vb). Catch number at age (thousands) from the commercial fleet (1961-2013)

	3	4	5	6	7	8	9	10	11	12	13	14+
1961	183	379	483	403	216	129	116	82	45	27	6	49
1962	562	542	617	495	286	131	129	113	71	29	13	63
1963	614	340	340	415	406	202	174	158	94	169	61	44
1964	684	1908	1506	617	572	424	179	150	100	83	47	44
1965	996	850	1708	965	510	407	306	201	156	120	89	76
1966	488	1540	1201	1686	806	377	294	205	156	94	52	79
1967	595	796	1364	792	1192	473	217	190	97	75	38	27
1968	614	1689	1116	1095	548	655	254	128	89	59	40	88
1969	1191	2086	2294	1414	1118	589	580	239	115	100	36	54

1970	1445	6577	1558	1478	899	730	316	241	86	48	46	38
1971	2857	3316	5585	1005	828	469	326	164	100	54	13	33
1972	2714	1774	2588	2742	1529	1305	1017	743	330	133	28	49
1973	2515	6253	7075	3478	1634	693	550	403	215	103	25	58
1974	3504	4126	4011	2784	1401	640	368	340	197	124	45	96
1975	2062	3361	3801	1939	1045	714	302	192	193	126	64	108
1976	3178	3217	1720	1250	877	641	468	223	141	96	60	131
1977	1609	2937	2034	1288	767	708	498	338	272	129	80	121
1978	611	1743	1736	548	373	479	466	473	407	211	146	178
1979	287	933	1341	1033	584	414	247	473	368	206	136	349
1980	996	877	720	673	726	284	212	171	196	156	261	369
1981	411	1804	769	932	908	734	343	192	92	128	176	717
1982	387	4076	994	1114	380	417	296	105	88	56	49	797
1983	2483	1103	5052	1343	575	339	273	98	98	99	25	416
1984	368	11067	2359	4093	875	273	161	52	65	59	18	176
1985	1224	3990	5583	1182	1898	273	103	38	26	72	41	162
1986	1167	1997	4473	3730	953	1077	245	104	67	33	56	69
1987	1581	5793	3827	2785	990	532	333	81	43	5	11	81
1988	866	2950	9555	2784	1300	621	363	159	27	43	15	2
1989	451	5981	5300	7136	793	546	185	83	55	10	2	27
1990	294	3833	10120	9219	5070	477	123	61	60	18	19	42
1991	1030	5125	7452	5544	3487	1630	405	238	128	77	22	19
1992	521	4067	3667	2679	1373	894	613	123	63	37	52	19
1993	1316	2611	4689	1665	858	492	448	245	54	34	10	8
1994	690	3961	2663	2368	746	500	307	303	150	28	19	2
1995	398	1019	3468	1836	1177	345	241	192	104	73	25	19
1996	297	1087	1146	1449	1156	521	132	77	64	45	29	8
1997	344	832	2440	1767	1335	624	165	71	29	48	29	23
1998	163	1689	1934	3475	1379	683	368	77	32	28	24	21
1999	322	655	3096	2551	4113	915	380	147	24	27	5	37
2000	811	2830	1484	4369	2226	2725	348	186	56	18	2	5
2001	1125	2452	8437	2155	3680	1539	1334	293	90	24	19	13
2002	302	8399	5962	9786	862	1280	465	362	33	36	8	1
2003	330	2432	11152	3994	4287	417	419	304	91	40	3	0

2004	76	2011	8544	8762	2125	1807	265	293	146	100	10	2
2005	454	2948	9486	16606	7099	843	810	32	102	27	3	0
2006	1475	5045	7781	7712	10296	3760	640	282	32	12	12	5
2007	831	3320	11305	6473	3781	4294	1538	406	81	11	9	3
2008	4784	3108	3598	9370	3594	2223	2048	444	159	12	6	0
2009	459	7412	4978	1842	5167	2009	1696	1069	292	41	3	1
2010	2324	2916	5298	1125	1009	2098	1248	832	376	51	22	0
2011	1897	2744	1940	1804	477	530	704	521	439	138	34	4
2012	859	9833	4142	1252	901	304	307	399	229	136	91	21
2013	715	5132	4186	2225	507	207	121	96	145	84	38	36

Table 6.2.2.3. Faroe saithe (Division Vb). Sampling intensity in 2001-2013.

Year		Jiggers	Single trawlers >1000 HP	Pair trawlers <1000 HP	Pair trawlers >1000 HP	Others	Total	Amount sampled pr tons landed (%)
2001	Lengths	1788	4388	5613	30341	0	42130	7.7
	Otoliths	180	450	480	3237	0	4347	
	Weights	180	420	420	3177	0	4197	
2002	Lengths	1197	9235	5049	30761	0	46242	5.8
	Otoliths	120	1291	422	3001	0	4834	
	Weights	120	420	240	2760	0	3540	
2003	Lengths	0	4959	6393	34812	1388	47552	7.0
	Otoliths	0	719	960	3719	180	5578	
	Weights	0	420	239	2999		3658	
2004	Lengths	916	2665	3455	35609	1781	44426	5.9
	Otoliths	180	180	240	3537	240	4377	
	Weights	180	120	120	3357	1364	5141	
2005	Lengths	1048	4266	6183	32046	1564	45107	3.6
	Otoliths	120	413	690	2760	240	4223	
	Weights	340	385	791	3533	1564	6613	
2006	Lengths	1059	7979	8115	23082	1139	41374	3.5
	Otoliths	180	598	1138	2096	60	4072	
	Weights	180	60	1620	5678	812	8350	
2007	Lengths	683	10525	10593	18045	381	40227	4.1
	Otoliths	120	748	960	1977	0	3805	
	Weights	120	697	5603	9884	120	16424	
2008	Lengths	0	6892	3694	13995	234	24815	2.5
	Otoliths	0	690	600	1500	0	2790	

	Weights	0	0	2517	12914	234	15665	
2009	Lengths	511	5273	3695	23352	0	32831	4.1
	Otoliths	97	301	599	2519	0	3516	
	Weights	511	0	3494	19060	0	23065	
2010	Lengths	209	1442	3663	25793	151	31258	6.0
	Otoliths	5	119	480	2459	0	3063	
	Weights	5	0	3060	18749	151	21965	
2011	Lengths	583	18	1874	19990	753	23218	8.5
	Otoliths	60	0	300	2459	60	2879	
	Weights	583	18	1458	14256	753	17068	
2012	Lengths	6	0	1060	24924	211	26201	4.9
	Otoliths	6	0	120	2516	0	2642	
	Weights	6	0	1060	17593	211	18870	
2013	Lengths	0	0	1465	18015	1325	20805	4.9
	Otoliths	0	0	360	1979	120	2459	
	Weights	0	0	1465	13544	1325	16334	

Table 6.2.3.1. Faroe saithe (Division Vb). Catch weights at age (kg)(equal to stock-weights) from the commercial fleet (1961-2013). The value for 2014 is used for short-term projections.

	3	4	5	6	7	8	9	10	11	12	13	14+
1961	1.430	2.302	3.348	4.287	5.128	6.155	7.060	7.265	7.497	8.198	9.154	9.992
1962	1.273	2.045	3.293	4.191	5.146	5.655	6.469	6.706	7.150	7.903	8.449	9.658
1963	1.280	2.197	3.212	4.568	5.056	5.932	6.259	8.000	7.265	8.551	9.020	9.818
1964	1.175	2.055	3.266	4.255	5.038	5.694	6.662	6.837	7.686	8.348	8.123	9.423
1965	1.181	2.125	2.941	4.096	4.878	5.932	6.321	7.288	8.074	7.878	9.479	9.849
1966	1.361	2.026	3.055	3.658	4.585	5.520	6.837	7.265	7.662	8.123	10.210	9.883
1967	1.273	1.780	2.534	3.572	4.368	5.313	5.812	6.554	7.806	7.591	8.551	9.135
1968	1.302	1.737	2.036	3.120	4.049	5.183	6.238	7.520	8.049	8.654	8.298	9.748
1969	1.188	1.667	2.302	2.853	3.673	5.002	5.714	6.405	6.554	7.591	7.951	9.096
1970	1.244	1.445	2.249	2.853	3.515	4.418	5.444	5.733	6.662	7.310	9.047	9.634
1971	1.101	1.316	1.818	2.978	3.702	4.271	5.388	5.972	6.490	7.173	7.380	9.612
1972	1.043	1.485	2.055	2.829	3.791	4.175	4.808	5.294	6.948	6.727	7.591	9.609
1973	1.306	1.754	1.899	2.700	4.426	5.264	6.156	6.334	8.076	8.777	9.782	11.115
1974	1.615	1.723	2.493	2.824	3.524	5.197	6.279	6.454	7.070	7.773	8.763	10.830
1975	1.293	1.924	2.623	3.621	4.128	4.754	5.952	7.073	8.352	9.032	9.984	11.082
1976	1.162	1.790	3.074	3.291	4.579	4.648	5.116	6.314	7.069	7.069	7.808	9.714
1977	1.223	1.641	2.660	3.790	4.239	5.597	5.350	5.912	6.837	6.727	6.948	9.258
1978	1.493	2.324	3.068	3.746	4.913	4.368	5.276	5.832	6.053	6.706	7.686	8.516
1979	1.220	1.880	2.620	3.400	4.180	4.950	5.690	6.380	7.020	7.260	8.150	9.618
1980	1.230	2.120	3.320	4.280	5.160	6.420	6.870	7.090	7.930	8.070	8.590	10.142
1981	1.310	2.130	3.000	3.810	4.750	5.250	5.950	6.430	7.000	7.470	8.140	9.430
1982	1.337	1.851	2.951	3.577	4.927	6.243	7.232	7.239	8.346	8.345	8.956	10.227
1983	1.208	2.029	2.965	4.143	4.724	5.901	6.811	7.051	7.248	8.292	9.478	10.509
1984	1.431	1.953	2.470	3.850	5.177	6.347	7.825	6.746	8.636	8.467	8.556	10.802
1985	1.401	2.032	2.965	3.596	5.336	7.202	6.966	9.862	10.670	10.460	10.202	13.055
1986	1.718	1.986	2.618	3.277	4.186	5.589	6.050	6.150	9.536	9.823	7.303	12.773
1987	1.609	1.835	2.395	3.182	4.067	5.149	5.501	6.626	6.343	10.245	8.491	10.482
1988	1.500	1.975	1.978	2.937	3.798	4.419	5.115	6.712	9.040	9.364	9.142	10.216
1989	1.309	1.735	1.907	2.373	3.810	4.667	5.509	5.972	6.939	8.543	9.514	10.484
1990	1.223	1.633	1.830	2.052	2.866	4.474	5.424	6.469	6.343	8.418	7.383	8.640
1991	1.240	1.568	1.864	2.211	2.648	3.380	4.816	5.516	6.407	7.395	8.079	8.674
1992	1.264	1.602	2.069	2.554	3.057	4.078	5.012	6.768	7.754	8.303	7.786	9.301
1993	1.408	1.860	2.323	3.131	3.730	4.394	5.209	6.540	8.403	7.275	9.414	9.640
1994	1.503	1.951	2.267	2.936	4.214	4.971	5.657	5.950	6.891	8.752	9.752	7.989
1995	1.456	2.177	2.420	2.895	3.651	5.064	5.440	6.167	7.080	7.736	7.295	7.104
1996	1.432	1.875	2.496	3.229	3.744	4.964	6.375	6.745	7.466	7.284	8.470	10.125
1997	1.476	1.783	2.032	2.778	3.598	4.766	5.982	7.658	7.882	8.539	9.488	10.413
1998	1.388	1.711	1.954	2.405	3.300	4.220	4.999	6.391	6.665	8.214	8.485	8.845
1999	1.374	1.712	1.905	2.396	2.845	4.124	5.256	5.526	6.956	8.030	8.349	8.907
2000	1.477	1.606	2.077	2.360	2.977	3.480	4.851	5.268	6.523	4.727	8.807	8.972
2001	1.330	1.590	1.785	2.586	3.059	3.871	4.374	5.565	6.703	5.776	7.745	7.773
2002	1.142	1.460	1.652	1.969	3.130	3.589	4.513	5.138	6.422	8.026	4.759	11.357
2003	1.123	1.304	1.614	1.977	2.532	3.970	4.834	5.499	6.099	6.987	5.961	0.000
2004	1.143	1.333	1.450	1.789	2.560	3.159	4.154	5.167	6.015	6.186	7.056	9.391
2005	1.148	1.325	1.516	1.672	2.087	2.975	3.790	6.087	6.134	6.651	7.424	0.000
2006	1.126	1.218	1.462	1.790	2.035	2.436	3.861	4.222	5.149	6.437	6.905	5.365
2007	1.058	1.391	1.413	1.824	2.361	2.682	3.278	4.104	4.998	6.331	7.844	7.971
2008	1.146	1.312	1.672	1.816	2.395	2.902	3.100	3.728	4.769	6.072	6.451	0.000
2009	0.938	1.485	1.893	2.411	2.601	3.147	3.634	4.024	5.014	5.828	6.308	9.011
2010	1.429	1.706	2.166	2.551	3.172	3.411	3.972	4.352	5.083	4.941	5.305	0.000
2011	1.111	1.693	2.253	2.918	3.609	4.204	4.531	5.087	5.416	6.087	6.763	7.916
2012	1.029	1.334	1.626	2.709	3.785	4.448	4.799	5.207	5.562	6.018	7.143	6.247
2013	1.208	1.466	1.778	2.069	3.553	4.292	5.191	5.742	5.919	6.417	7.941	7.138
2014	1.280	1.296	1.673	2.033	3.370	4.698	4.840	5.345	5.632	6.174	7.282	7.100

Table 6.2.4.1. Faroe saithe (Division Vb). Proportion mature at age (1982-2014). Maturities-at-age from 1961 to 1981 are fixed and equal to those in 1982. The value for 2015 is used for short-term prognosis.

	3	4	5	6	7	8	9	10	11	12	13	14+
1982	0.03	0.22	0.53	0.79	0.92	0.98	1.00	1	1	1	1	1
1983	0.02	0.27	0.61	0.90	1.00	1.00	1.00	1	1	1	1	1
1984	0.04	0.29	0.61	0.88	1.00	1.00	1.00	1	1	1	1	1
1985	0.05	0.29	0.59	0.86	0.97	0.99	1.00	1	1	1	1	1
1986	0.06	0.29	0.58	0.83	0.94	0.98	1.00	1	1	1	1	1
1987	0.06	0.27	0.55	0.80	0.92	0.97	1.00	1	1	1	1	1
1988	0.05	0.25	0.53	0.77	0.90	0.96	1.00	1	1	1	1	1
1989	0.04	0.22	0.50	0.74	0.88	0.96	1.00	1	1	1	1	1
1990	0.03	0.20	0.48	0.73	0.87	0.95	1.00	1	1	1	1	1
1991	0.03	0.18	0.48	0.74	0.88	0.96	0.99	1	1	1	1	1
1992	0.02	0.18	0.49	0.76	0.90	0.98	0.99	1	1	1	1	1
1993	0.01	0.17	0.50	0.79	0.93	1.00	0.99	1	1	1	1	1
1994	0.01	0.17	0.50	0.79	0.93	1.00	0.99	1	1	1	1	1
1995	0.01	0.16	0.48	0.77	0.92	1.00	0.99	1	1	1	1	1
1996	0.01	0.17	0.46	0.73	0.89	0.99	0.99	1	1	1	1	1
1997	0.02	0.17	0.44	0.69	0.86	0.98	0.99	1	1	1	1	1
1998	0.02	0.16	0.41	0.65	0.83	0.96	0.99	1	1	1	1	1
1999	0.02	0.16	0.40	0.62	0.81	0.94	0.99	1	1	1	1	1
2000	0.02	0.17	0.38	0.58	0.78	0.92	0.98	1	1	1	1	1
2001	0.01	0.17	0.37	0.56	0.75	0.90	0.98	1	1	1	1	1
2002	0.01	0.17	0.36	0.55	0.74	0.89	0.98	1	1	1	1	1
2003	0.01	0.18	0.37	0.55	0.74	0.88	0.97	1	1	1	1	1
2004	0.00	0.18	0.38	0.57	0.75	0.88	0.97	1	1	1	1	1
2005	0.00	0.18	0.39	0.59	0.76	0.89	0.97	1	1	1	1	1
2006	0.00	0.18	0.40	0.61	0.78	0.89	0.97	1	1	1	1	1
2007	0.00	0.19	0.41	0.63	0.79	0.90	0.97	1	1	1	1	1
2008	0.00	0.20	0.43	0.66	0.82	0.92	0.97	1	1	1	1	1
2009	0.00	0.21	0.45	0.68	0.84	0.94	0.97	1	1	1	1	1
2010	0.01	0.23	0.47	0.70	0.86	0.95	0.97	1	1	1	1	1
2011	0.03	0.25	0.50	0.72	0.87	0.96	0.98	1	1	1	1	1
2012	0.06	0.29	0.53	0.74	0.89	0.97	0.98	1	1	1	1	1
2013	0.09	0.33	0.57	0.76	0.90	0.97	0.98	1	1	1	1	1
2014	0.12	0.38	0.61	0.79	0.91	0.98	0.98	1	1	1	1	1
2015	0.09	0.33	0.57	0.76	0.90	0.97	0.98	1	1	1	1	1

Table 6.3.1. Faroe saithe (Division Vb). Effort (hours) and catch in number at age for the commercial pair trawlers (1995-2013)

year	effort	3	4	5	6	7	8	9	10	11
1995	11409	47	180	577	236	146	49	24	19	14
1996	49311	310	958	821	1119	503	282	133	127	70
1997	36301	199	533	1488	1013	768	333	73	33	10

1998	35905	107	656	1148	1486	730	325	170	40	13
1999	44854	174	487	1554	2016	2024	817	190	83	12
2000	45593	434	1566	913	2700	1333	1604	192	106	31
2001	43518	611	1438	4946	1165	1855	748	618	127	29
2002	43331	133	3976	3964	6888	520	682	246	177	25
2003	40309	141	1494	6560	2373	2263	197	212	124	35
2004	37239	43	1200	5089	5116	1035	762	113	116	53
2005	34064	188	1189	4039	7266	3130	320	291	7	43
2006	26339	140	1176	2410	2584	3700	1376	268	85	14
2007	25884	204	879	2913	1815	1034	1215	435	110	19
2008	26286	796	762	947	2641	1063	726	611	156	51
2009	70994	154	4082	3377	1283	3612	1402	1153	751	195
2010	59911	459	2019	3586	737	657	1325	814	518	245
2011	62984	397	1936	1367	1257	323	356	488	366	310
2012	71953	366	5652	2332	756	554	187	189	252	143
2013	60018	424	3047	2462	1295	293	122	71	56	83

Table 6.3.2. Faroe saithe (Division Vb). Diagnostics from XSA with commercial pair trawler tuning series (spaly)

FLR XSA Diagnostics 2014-03-31 13:22:44

CPUE data from indices

Catch data for 53 years 1961 to 2013. Ages 3 to 14.

```
              fleet first age last age first year last year alpha beta
1 PairTrawlers_GLM_SD        3       11       1995       2013  <NA> <NA>
 Time series weights :
   Tapered time weighting not applied
 Catchability analysis :
    Catchability independent of 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  3 oldest ages.
   S.E. of the mean to which the estimates are shrunk =   2
   Minimum standard error for population
   estimates derived from each fleet =  0.3
   prior weighting not applied
Regression weights
    year
age   2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
  all    1    1    1    1    1    1    1    1    1    1
```

Fishing mortalities

age \ year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
3	0.002	0.007	0.078	0.051	0.185	0.040	0.114	0.052	0.022	0.023
4	0.043	0.077	0.104	0.252	0.273	0.487	0.384	0.191	0.410	0.174
5	0.148	0.296	0.297	0.355	0.477	0.950	0.793	0.479	0.491	0.306
6	0.370	0.476	0.418	0.433	0.565	0.481	0.575	0.699	0.662	0.538
7	0.479	0.586	0.620	0.372	0.458	0.716	0.534	0.515	0.959	0.623
8	0.731	0.354	0.725	0.576	0.391	0.506	0.731	0.602	0.744	0.601
9	1.021	0.891	0.500	0.758	0.605	0.589	0.691	0.583	0.878	0.769
10	0.747	0.304	0.945	0.699	0.511	0.754	0.656	0.710	0.793	0.770
11	0.864	0.639	0.569	0.802	0.662	0.767	0.661	0.909	0.809	0.769
12	2.551	0.371	0.138	0.388	0.252	0.351	0.282	0.544	0.822	0.817
13	1.339	0.568	0.279	0.145	0.380	0.092	0.322	0.309	0.874	0.571
14	1.339	0.568	0.279	0.145	0.380	0.092	0.322	0.309	0.874	0.571

XSA population number (Thousand)

year \ age	3	4	5	6	7	8	9	10	11	12	13	14
2004	53976	52268	68583	31292	6167	3851	458	615	279	120	15	3
2005	69681	44123	40974	48420	17692	3126	1518	135	239	96	8	0
2006	21755	56640	33458	24963	24617	8061	1797	510	82	103	54	23
2007	18501	16477	41808	20352	13460	10838	3198	892	162	38	74	24
2008	31252	14395	10486	24000	10806	7599	4988	1227	363	60	21	0
2009	12852	21259	8974	5329	11171	5595	4210	2231	603	153	38	13
2010	23875	10107	10698	2843	2697	4471	2763	1912	859	229	88	0
2011	41581	17445	5636	3965	1309	1295	1762	1133	813	363	141	17
2012	44345	32327	11800	2859	1614	640	581	806	456	268	173	39
2013	35084	35529	17570	5913	1208	506	249	198	299	166	97	90

Estimated population abundance at 1st Jan 2014

year \ age	3	4	5	6	7	8	9	10	11	12	13	14
2014	5	28078	24445	10597	2828	530	227	95	75	113	60	45

Fleet: PairTrawlers_GLM_SD

Log catchability residuals.

year

age 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
2010 2011

3 -0.341 0.554 0.096 0.454 -0.815 0.588 0.072 -1.639 -1.006 -1.943 -0.632 0.529 1.072 1.957 0.141
0.818 0.039

4 0.000 -0.687 -0.489 -0.582 -0.132 -0.520 -0.028 0.102 -1.053 -0.684 -0.419 -0.410 0.621 0.607
0.999 1.163 0.436

5 0.463 -0.633 -0.665 -0.414 -0.617 -0.170 0.051 0.417 0.081 -0.460 -0.018 -0.074 -0.064 0.235
0.870 0.859 0.350

6 -0.209 -0.182 -0.096 -0.686 -0.056 0.005 0.331 0.640 0.185 0.029 0.080 -0.060 -0.185 0.068 -
0.180 0.106 0.310

7 0.124 -0.421 0.191 0.023 -0.194 -0.054 0.298 0.187 0.328 -0.043 0.145 0.254 -0.509 -0.239 0.070
-0.122 -0.168

8 0.081 0.147 0.093 -0.036 0.557 0.262 0.104 0.139 -0.015 0.144 -0.592 0.339 -0.127 -0.385 -
0.363 0.072 -0.108

9 -0.054 0.394 -0.019 0.242 -0.030 -0.127 0.392 -0.190 -0.170 0.485 0.268 0.108 0.144 -0.042 -
0.237 0.049 -0.109

10 -0.372 1.058 0.056 0.171 0.208 0.238 0.511 0.282 -0.031 0.102 -1.294 0.407 0.021 -0.045 0.039
-0.050 0.099

11 -0.065 0.150 -0.413 -0.075 -0.569 0.082 0.029 -0.043 -0.359 0.159 0.099 0.279 0.013 0.121
0.006 0.003 0.348

year

age 2012 2013

3 -0.254 0.309

4 0.858 0.218

5 0.018 -0.228

6 -0.020 -0.081

7 0.217 -0.089

8 -0.121 -0.192

9 0.044 0.047

10 -0.031 0.042

11 -0.022 0.022

Mean log catchability and standard error of ages with catchability

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

	3	4	5	6	7	8	9	10	11
Mean_Logq	-15.6178	-13.4959	-12.4970	-12.0935	-11.9461	-11.8593	-11.8593	-11.8593	-11.8593
S.E_Logq	0.4584	0.4584	0.4584	0.4584	0.4584	0.4584	0.4584	0.4584	0.4584

Terminal year survivor and F summaries:

,Age 3 Year class =2010

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.81 38243 2010

fshk 0.19 7494 2010

,Age 4 Year class =2009

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.887 30414 2009

fshk 0.113 11044 2009

,Age 5 Year class =2008

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.93 8433 2008

fshk 0.07 4194 2008

,Age 6 Year class =2007

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.963 2607 2007

fshk 0.037 2441 2007

,Age 7 Year class =2006

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.96 485 2006

fshk 0.04 509 2006

,Age 8 Year class =2005

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.961 187 2005

fshk 0.039 228 2005

,Age 9 Year class =2004

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.954 99 2004

fshk 0.046 113 2004

,Age 10 Year class =2003

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.898 78 2003

fshk 0.102 87 2003

,Age 11 Year class =2002

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.954 116 2002

fshk 0.046 113 2002

,Age 12 Year class =2001

source

scaledWts survivors yrcls

fshk 1 132 2001

,Age 13 Year class =2000

source

scaledWts survivors yrcls

fshk 1 28 2000

Table 6.5.1. Faroe saithe (Division Vb). Fishing mortality at age (1961-2013). The value for 2014 is used for short-term prognosis.

	3	4	5	6	7	8	9	10	11	12	13	14+
1961	0.026	0.058	0.109	0.143	0.120	0.100	0.110	0.106	0.112	0.181	0.134	0.134
1962	0.052	0.101	0.127	0.156	0.143	0.099	0.138	0.149	0.125	0.098	0.124	0.124
1963	0.035	0.040	0.085	0.118	0.185	0.142	0.185	0.250	0.178	0.491	0.308	0.308
1964	0.052	0.144	0.251	0.218	0.236	0.301	0.180	0.241	0.248	0.235	0.243	0.243
1965	0.050	0.085	0.186	0.253	0.283	0.263	0.370	0.316	0.424	0.532	0.427	0.427
1966	0.026	0.103	0.167	0.283	0.348	0.350	0.308	0.456	0.433	0.493	0.464	0.464
1967	0.027	0.053	0.125	0.158	0.332	0.354	0.349	0.335	0.407	0.384	0.378	0.378
1968	0.030	0.099	0.098	0.140	0.156	0.307	0.326	0.358	0.258	0.467	0.363	0.363
1969	0.034	0.136	0.189	0.175	0.207	0.250	0.493	0.586	0.639	0.518	0.586	0.586
1970	0.044	0.262	0.142	0.179	0.160	0.202	0.206	0.390	0.431	0.609	0.480	0.480
1971	0.086	0.135	0.373	0.128	0.144	0.117	0.130	0.157	0.277	0.534	0.325	0.325
1972	0.094	0.070	0.148	0.316	0.293	0.354	0.400	0.490	0.541	0.730	0.592	0.592
1973	0.125	0.325	0.438	0.304	0.315	0.209	0.246	0.272	0.253	0.320	0.283	0.283
1974	0.222	0.311	0.358	0.307	0.192	0.195	0.164	0.237	0.207	0.227	0.225	0.225
1975	0.141	0.345	0.528	0.293	0.180	0.141	0.132	0.120	0.205	0.198	0.175	0.175
1976	0.196	0.340	0.298	0.328	0.208	0.160	0.129	0.137	0.122	0.149	0.136	0.136
1977	0.146	0.281	0.376	0.382	0.344	0.259	0.179	0.130	0.246	0.156	0.178	0.178
1978	0.085	0.233	0.267	0.163	0.180	0.375	0.272	0.259	0.228	0.307	0.266	0.266
1979	0.037	0.180	0.283	0.251	0.261	0.310	0.338	0.490	0.329	0.172	0.333	0.333
1980	0.088	0.153	0.205	0.224	0.281	0.195	0.258	0.415	0.386	0.226	0.344	0.344
1981	0.014	0.227	0.194	0.447	0.533	0.512	0.383	0.394	0.412	0.471	0.429	0.429
1982	0.028	0.184	0.189	0.477	0.329	0.502	0.399	0.191	0.315	0.477	0.330	0.330
1983	0.070	0.103	0.366	0.419	0.486	0.552	0.736	0.221	0.275	0.711	0.405	0.405
1984	0.016	0.498	0.332	0.575	0.535	0.451	0.558	0.292	0.224	0.265	0.262	0.262
1985	0.062	0.236	0.507	0.276	0.579	0.314	0.305	0.243	0.232	0.415	0.298	0.298
1986	0.021	0.138	0.452	0.774	0.375	0.785	0.518	0.578	0.895	0.518	0.670	0.670
1987	0.037	0.138	0.423	0.570	0.476	0.372	0.598	0.320	0.503	0.141	0.323	0.323
1988	0.022	0.089	0.355	0.632	0.576	0.629	0.471	0.650	0.167	1.599	0.814	0.814
1989	0.018	0.203	0.228	0.492	0.366	0.511	0.384	0.184	0.489	0.086	0.254	0.254
1990	0.016	0.203	0.627	0.785	0.801	0.392	0.203	0.209	0.196	0.290	0.233	0.233
1991	0.047	0.415	0.768	0.876	0.800	0.659	0.690	0.757	0.904	0.415	0.699	0.699

	3	4	5	6	7	8	9	10	11	12	13	14+
1992	0.030	0.262	0.596	0.707	0.552	0.484	0.559	0.460	0.455	0.731	0.553	0.553
1993	0.063	0.205	0.547	0.601	0.515	0.389	0.480	0.455	0.375	0.478	0.439	0.439
1994	0.046	0.274	0.334	0.597	0.600	0.652	0.450	0.710	0.564	0.340	0.542	0.542
1995	0.011	0.089	0.411	0.406	0.684	0.624	0.779	0.568	0.568	0.598	0.583	0.583
1996	0.014	0.039	0.137	0.300	0.487	0.757	0.518	0.616	0.373	0.518	0.506	0.506
1997	0.011	0.048	0.115	0.324	0.500	0.534	0.576	0.591	0.498	0.536	0.763	0.763
1998	0.014	0.071	0.150	0.238	0.454	0.520	0.710	0.587	0.586	1.428	0.567	0.567
1999	0.006	0.073	0.181	0.302	0.492	0.628	0.623	0.701	0.362	1.725	1.177	1.177
2000	0.025	0.068	0.235	0.419	0.472	0.722	0.520	0.728	0.640	0.510	0.540	0.540
2001	0.014	0.100	0.294	0.635	0.765	0.712	1.001	1.209	1.001	0.634	1.954	1.954
2002	0.003	0.140	0.373	0.662	0.568	0.670	0.484	0.844	0.391	1.836	0.447	0.447
2003	0.006	0.032	0.279	0.461	0.697	0.601	0.480	0.686	0.523	1.229	0.770	0.770
2004	0.002	0.043	0.148	0.370	0.479	0.731	1.021	0.747	0.864	2.551	1.339	1.339
2005	0.007	0.077	0.296	0.476	0.586	0.354	0.891	0.304	0.639	0.371	0.568	0.568
2006	0.078	0.104	0.297	0.418	0.620	0.725	0.500	0.945	0.569	0.138	0.279	0.279
2007	0.051	0.252	0.355	0.433	0.372	0.576	0.758	0.699	0.802	0.388	0.145	0.145
2008	0.185	0.273	0.477	0.565	0.458	0.391	0.605	0.511	0.662	0.252	0.380	0.380
2009	0.040	0.487	0.950	0.481	0.716	0.506	0.589	0.754	0.767	0.351	0.092	0.092
2010	0.114	0.384	0.793	0.575	0.534	0.731	0.691	0.656	0.661	0.282	0.322	0.322
2011	0.052	0.191	0.479	0.699	0.515	0.602	0.583	0.710	0.909	0.544	0.309	0.309
2012	0.022	0.410	0.491	0.662	0.959	0.744	0.878	0.793	0.809	0.822	0.874	0.874
2013	0.023	0.174	0.306	0.538	0.623	0.601	0.769	0.770	0.769	0.817	0.571	0.571
2014	0.027	0.217	0.358	0.533	0.588	0.546	0.625	0.638	0.698	1.000	1.000	1.000

Table 6.3.2. Faroe saithe (Division Vb). Stock number at age (start of year) (Thousands)(1961-2013). The value for 2014 is used for short-term prognosis.

	3	4	5	6	7	8	9	10	11	12	13	14+
1961	7827	7422	5158	3352	2114	1494	1233	905	468	180	53	431
1962	12256	6243	5734	3786	2379	1535	1107	904	666	343	123	593
1963	19837	9526	4621	4136	2652	1689	1138	789	638	481	254	182
1964	14812	15686	7492	3476	3011	1804	1200	775	503	437	241	224
1965	22363	11508	11116	4771	2287	1947	1093	821	498	322	283	240
1966	21229	17408	8653	7555	3033	1411	1226	618	490	267	155	233
1967	24898	16939	12859	5998	4660	1754	814	738	321	260	134	94
1968	22879	19846	13149	9294	4194	2737	1008	470	432	175	145	317
1969	39799	18176	14720	9755	6618	2938	1648	595	269	273	90	133
1970	37092	31507	12994	9976	6708	4407	1872	825	271	116	133	109
1971	38447	29061	19844	9229	6831	4678	2948	1247	457	144	52	131
1972	33424	28892	20793	11194	6647	4843	3406	2118	873	284	69	120
1973	23622	24910	22050	14682	6684	4058	2784	1868	1062	416	112	258
1974	19421	17064	14737	11651	8873	3993	2696	1782	1165	675	247	525
1975	17327	12730	10238	8436	7020	5997	2691	1874	1151	776	440	740
1976	19709	12320	7381	4943	5152	4802	4264	1930	1361	768	521	1133
1977	13106	13261	7176	4487	2916	3425	3352	3068	1378	986	542	816
1978	8333	9274	8200	4035	2508	1693	2163	2293	2206	882	691	837
1979	8686	6270	6016	5142	2808	1716	953	1350	1450	1438	531	1354
1980	13075	6852	4289	3712	3276	1770	1030	557	677	854	991	1390
1981	33145	9804	4816	2860	2430	2025	1192	652	301	377	558	2253
1982	15675	26765	6394	3248	1498	1168	994	666	360	163	193	3113
1983	40830	12483	18225	4336	1651	883	579	546	450	215	83	1368
1984	26074	31182	9223	10350	2335	831	416	227	358	280	86	840
1985	22330	21015	15516	5416	4771	1120	434	195	139	234	176	690
1986	61853	17175	13595	7651	3365	2188	670	262	125	90	127	154
1987	48610	49585	12254	7083	2889	1893	817	327	120	42	44	322
1988	44846	38368	35355	6570	3279	1470	1068	368	194	60	30	4
1989	28600	35933	28744	20300	2860	1509	642	546	157	134	10	132
1990	20710	23008	24008	18738	10164	1624	741	358	372	79	101	222

	3	4	5	6	7	8	9	10	11	12	13	14+
1991	24971	16690	15369	10499	7000	3734	898	496	238	250	48	41
1992	19563	19512	9028	5840	3579	2576	1582	369	190	79	135	49
1993	23779	15546	12295	4073	2358	1688	1300	741	191	99	31	25
1994	16875	18278	10365	5824	1828	1154	937	659	385	107	50	5
1995	38971	13192	11381	6077	2625	822	492	489	265	179	63	47
1996	24326	31547	9879	6180	3314	1085	361	185	227	123	81	22
1997	33492	19648	24845	7051	3748	1667	417	176	82	128	60	47
1998	12743	27110	15333	18133	4174	1861	800	192	80	41	61	53
1999	58805	10286	20667	10804	11702	2170	906	322	87	36	8	58
2000	35803	47854	7829	14120	6537	5859	948	398	131	50	5	13
2001	87986	28579	36619	5067	7607	3338	2331	462	157	56	24	16
2002	105930	71019	21180	22347	2198	2898	1340	702	113	47	25	3
2003	64205	86455	50546	11946	9442	1020	1215	677	247	62	6	0
2004	53976	52268	68583	31292	6167	3851	458	615	279	120	15	3
2005	69681	44123	40974	48420	17692	3126	1518	135	239	96	8	0
2006	21755	56640	33458	24963	24617	8061	1797	510	82	103	54	23
2007	18501	16477	41808	20352	13460	10838	3198	892	162	38	74	24
2008	31252	14395	10486	24000	10806	7599	4988	1227	363	60	21	0
2009	12852	21259	8974	5329	11171	5595	4210	2231	603	153	38	13
2010	23875	10107	10698	2843	2697	4471	2763	1912	859	229	88	0
2011	41581	17445	5636	3965	1309	1295	1762	1133	813	363	141	17
2012	44345	32327	11800	2859	1614	640	581	806	456	268	173	39
2013	35084	35529	17570	5913	1208	506	249	198	299	166	97	90
2014	28152	28072	24443	10593	2827	530	227	95	75	113	60	86

Table 6.3.3. Faroe saithe (Division Vb). Summary table (1961-2013). Values for 2014-2016 are estimates.

year	Recruits (age 3)	SSB (tonnes)	Yield (tonnes)	Yield/SSB	Fbar(4-8)
1961	7827	68639	9592	0.13	0.106
1962	12256	73051	10454	0.153	0.125
1963	19837	76590	12693	0.173	0.114
1964	14811	81173	21893	0.272	0.23
1965	22362	85017	22181	0.283	0.214
1966	21229	87577	25563	0.299	0.25
1967	24897	85686	21319	0.24	0.204
1968	22879	94206	20387	0.212	0.16
1969	39798	103791	27437	0.274	0.191
1970	37092	109980	29110	0.275	0.189
1971	38446	122330	32706	0.244	0.179
1972	33424	138383	42663	0.307	0.236
1973	23621	131083	57431	0.438	0.318
1974	19420	134334	47188	0.351	0.272
1975	17327	135715	41576	0.306	0.297
1976	19709	129311	33065	0.256	0.267
1977	13106	122418	34835	0.273	0.328
1978	8332	105467	28138	0.265	0.243
1979	8686	96193	27246	0.276	0.257
1980	13074	96358	25230	0.264	0.211
1981	33144	85199	30103	0.369	0.382
1982	15675	94576	30964	0.34	0.336
1983	40829	97964	39176	0.4	0.385
1984	26074	105540	54665	0.518	0.478
1985	22329	110195	44605	0.43	0.382
1986	61852	93587	41716	0.473	0.505
1987	48610	95294	40020	0.437	0.396
1988	44846	102233	45285	0.446	0.456
1989	28600	105133	44477	0.436	0.36
1990	20710	101702	61628	0.618	0.562
1991	24970	76133	54858	0.725	0.703
1992	19563	60736	36487	0.572	0.52
1993	23779	59601	33543	0.553	0.451
1994	16875	57762	33182	0.561	0.491
1995	38971	54632	27209	0.488	0.443
1996	24325	59706	20029	0.325	0.344
1997	33492	68667	22306	0.325	0.304
1998	12743	74420	26421	0.347	0.287
1999	58805	79584	33207	0.41	0.335
2000	35803	81424	39020	0.472	0.383
2001	87985	83758	51786	0.617	0.501
2002	105929	80773	53546	0.663	0.482

2003	64204	96838	46555	0.48	0.414
2004	53976	112362	46355	0.411	0.354
2005	69681	127416	67967	0.534	0.358
2006	21754	126255	66902	0.532	0.433
2007	18500	118881	60785	0.513	0.398
2008	31252	103392	57044	0.547	0.433
2009	12851	92055	57949	0.622	0.628
2010	23875	67055	43885	0.654	0.603
2011	41580	54076	29658	0.548	0.497
2012	44344	51900	35314	0.68	0.653
2013	35084	60727	26262	0.432	0.448
2014	28152	69868	33423		0.448
2015	28152	76304	35864		0.448
2016	28152	78437			
Avg.	31342	92771	37238	0.41	0.36

Table 6.6.1.1a. Faroe saithe (Division Vb). Input data for prediction with management options for the SPALY assessment .

2014								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	28152	0.2	0.09	0	0	1.280	0.027	1.280
4	28072	0.2	0.33	0	0	1.296	0.217	1.296
5	24443	0.2	0.57	0	0	1.673	0.358	1.673
6	10593	0.2	0.76	0	0	2.033	0.533	2.033
7	2827	0.2	0.90	0	0	3.370	0.588	3.370
8	530	0.2	0.97	0	0	4.698	0.546	4.698
9	227	0.2	0.98	0	0	4.840	0.625	4.840
10	95	0.2	1.00	0	0	5.345	0.637	5.345
11	75	0.2	1.00	0	0	5.632	0.698	5.632
12	113	0.2	1.00	0	0	6.174	1.000	6.174
13	60	0.2	1.00	0	0	7.282	1.000	7.282
14	86	0.2	1.00	0	0	7.100	1.000	7.100

2015								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	28152	0.2	0.09	0	0	1.280	0.027	1.280
4	-	0.2	0.33	0	0	1.296	0.217	1.296
5	-	0.2	0.57	0	0	1.673	0.358	1.673
6	-	0.2	0.76	0	0	2.033	0.533	2.033
7	-	0.2	0.90	0	0	3.370	0.588	3.370

8	-	0.2	0.97	0	0	4.698	0.546	4.698
9	-	0.2	0.98	0	0	4.840	0.625	4.840
10	-	0.2	1.00	0	0	5.345	0.637	5.345
11	-	0.2	1.00	0	0	5.632	0.698	5.632
12	-	0.2	1.00	0	0	6.174	1.000	6.174
13	-	0.2	1.00	0	0	7.282	1.000	7.282
14	-	0.2	1.00	0	0	7.100	1.000	7.100

2016								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	28152	0.2	0.09	0	0	1.280	0.027	1.280
4	-	0.2	0.33	0	0	1.296	0.217	1.296
5	-	0.2	0.57	0	0	1.673	0.358	1.673
6	-	0.2	0.76	0	0	2.033	0.533	2.033
7	-	0.2	0.90	0	0	3.370	0.588	3.370
8	-	0.2	0.97	0	0	4.698	0.546	4.698
9	-	0.2	0.98	0	0	4.840	0.625	4.840
10	-	0.2	1.00	0	0	5.345	0.637	5.345
11	-	0.2	1.00	0	0	5.632	0.698	5.632
12	-	0.2	1.00	0	0	6.174	1.000	6.174
13	-	0.2	1.00	0	0	7.282	1.000	7.282
14	-	0.2	1.00	0	0	7.100	1.000	7.100

Input units are thousands and kg - output in tones

Table 6.6.2.1a. Faroe saithe (Division Vb). Prediction with management option for SPALY assessment.

2014						
Biomass	SSB	FMult	FBar	Landings		
150622	69868	1.000	0.448	33423		
2015					2016	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
150399	76304	0.0000	0.0000	0	192929	115255
.	76304	0.1000	0.0448	4320	187559	110715
.	76304	0.2000	0.0897	8452	182434	106392
.	76304	0.3000	0.1345	12406	177542	102276
.	76304	0.4000	0.1794	16189	172873	98356
.	76304	0.5000	0.2242	19811	168414	94623
.	76304	0.6000	0.2690	23279	164156	91067
.	76304	0.7000	0.3139	26601	160088	87678
.	76304	0.8000	0.3587	29783	156201	84449
.	76304	0.9000	0.4036	32833	152486	81371
.	76304	1.0000	0.4484	35756	148936	78437
.	76304	1.1000	0.4932	38559	145540	75640
.	76304	1.2000	0.5381	41247	142293	72972
.	76304	1.3000	0.5829	43826	139188	70427
.	76304	1.4000	0.6278	46301	136216	67999
.	76304	1.5000	0.6726	48676	133372	65682
.	76304	1.6000	0.7174	50957	130649	63471
.	76304	1.7000	0.7623	53148	128043	61361
.	76304	1.8000	0.8071	55252	125546	59346
.	76304	1.9000	0.8520	57274	123155	57422
.	76304	2.0000	0.8968	59218	120864	55584
Input units are thousands and kg - output in tonnes						

Table 6.7.1.1. Faroe saithe (Division Vb). Yield per recruit input data.

Yield per recruit								
Input data								
	Age	M	Mat	PF	PM	SWt	Sel	CWt
	3	0.2	0.027	0	0	1.303	0.073	1.303
	4	0.2	0.214	0	0	1.672	0.320	1.672
	5	0.2	0.472	0	0	2.055	0.583	2.055
	6	0.2	0.705	0	0	2.624	0.587	2.624
	7	0.2	0.858	0	0	3.423	0.634	3.423
	8	0.2	0.950	0	0	4.329	0.596	4.329
	9	0.2	0.985	0	0	5.127	0.686	5.127
	10	0.2	1.000	0	0	5.915	0.699	5.915
	11	0.2	1.000	0	0	6.825	0.763	6.825
	12	0.2	1.000	0	0	7.499	0.511	7.499
	13	0.2	1.000	0	0	7.892	0.425	7.892
	14	0.2	1.000	0	0	9.354	0.425	9.354
Weights in kilograms								

Table 6.7.1.2. Faroe saithe (Division Vb). Yield per recruit, summary table.

Yield per recruit results									
FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJ	SSBJan	SpwnNosS	SSBSpwn
0.0	0	0	0	5.499954	20.86934	17.0528	17.0528	17.0528	17.0528
0.1	0.0543833	0.176886	0.673957	4.631463	15.00857	11.32016	11.32016	11.32016	11.32016
0.2	0.1087667	0.290327	0.993563	4.071219	11.57432	8.000213	8.000213	8.000213	8.000213
0.3	0.16315	0.368478	1.149763	3.684888	9.428589	5.956948	5.956948	5.956948	5.956948
0.4	0.2175333	0.425492	1.227171	3.403432	8.008875	4.629516	4.629516	4.629516	4.629516
0.5	0.2719167	0.469025	1.265223	3.18905	7.021078	3.725203	3.725203	3.725203	3.725203
0.6	0.3263	0.503491	1.283106	3.019816	6.303264	3.083239	3.083239	3.083239	3.083239
0.7	0.3806833	0.531579	1.290495	2.882332	5.761931	2.611104	2.611104	2.611104	2.611104
0.8	0.4350667	0.555006	1.292411	2.768024	5.340681	2.253233	2.253233	2.253233	2.253233
0.9	0.48945	0.57492	1.291518	2.671171	5.004104	1.974921	1.974921	1.974921	1.974921
1.0	0.5438333	0.592114	1.289251	2.587817	4.729134	1.753707	1.753707	1.753707	1.753707
1.1	0.5982167	0.607154	1.286391	2.51514	4.500234	1.57457	1.57457	1.57457	1.57457
1.2	0.6526	0.620455	1.283358	2.451066	4.306615	1.427166	1.427166	1.427166	1.427166
1.3	0.7069833	0.63233	1.280379	2.394039	4.140579	1.304178	1.304178	1.304178	1.304178
1.4	0.7613667	0.64302	1.277565	2.342862	3.996495	1.200311	1.200311	1.200311	1.200311
1.5	0.81575	0.652711	1.274968	2.296602	3.870159	1.111648	1.111648	1.111648	1.111648
1.6	0.8701333	0.661553	1.272605	2.254518	3.758369	1.035237	1.035237	1.035237	1.035237
1.7	0.9245167	0.669665	1.270473	2.216013	3.658646	0.968821	0.968821	0.968821	0.968821
1.8	0.9789	0.677146	1.26856	2.180603	3.569041	0.910644	0.910644	0.910644	0.910644
1.9	1.0332833	0.684075	1.266849	2.147888	3.488002	0.859324	0.859324	0.859324	0.859324
2.0	1.0876667	0.690521	1.26532	2.117535	3.41428	0.813762	0.813762	0.813762	0.813762
Reference point	Absolute F	Absolute F							
Fbar(4-8)	0.5438	0.543833							
FMax	0.4895	0.48945							
F0.1	0.1632	0.16315							
Flow	0.1214	0.121412							
Fmed	0.3056	0.305613							
Fhigh	0.7180	0.718							

Table 6.9.1. Faroe saithe (Division Vb). Comparison between the current assessment and predictions from last year.

	NWWG2013 PREDICTION	NWWG2014 OBSERVED
Recruitment	28 mill.	35 mill.
SSB	72 000 t.	61 mill.
Fishing mortality	0.48	0.45
Landings	47 000 t.	26 000 t.

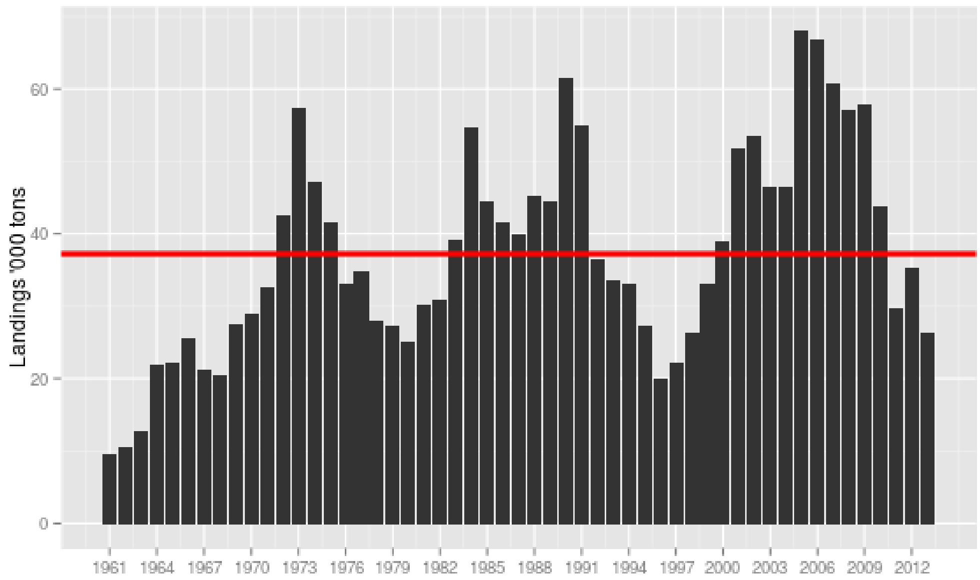


Figure 6.2.1.1. Faroe saithe (Division Vb). Landings in 1000 tonnes (1961-2013). Horizontal line represents historical average landings.

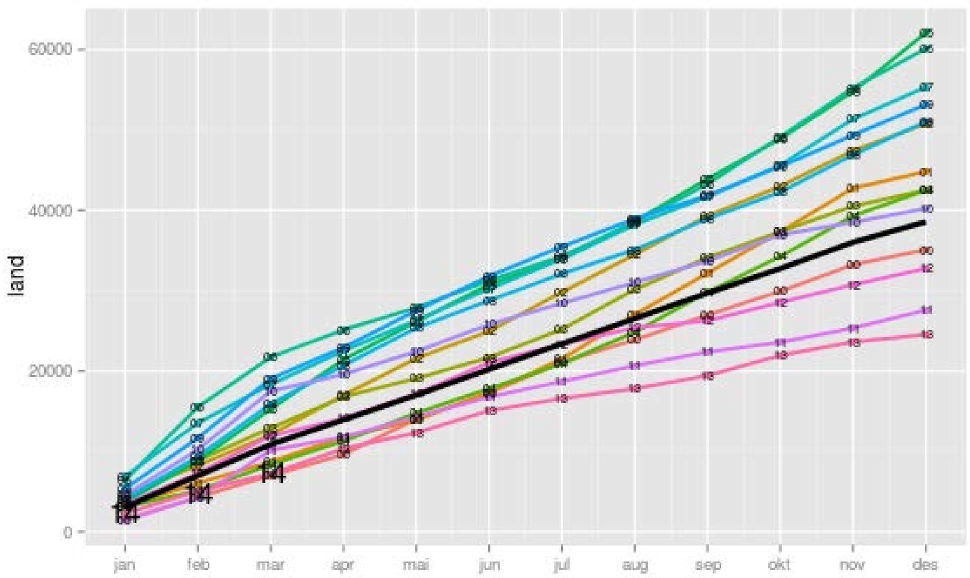


Figure 6.2.1.2. Saithe in the Faroes (Division Vb). Cumulative domestic landings (2000-2014).

Figure 6.2.3.1. Faroe saithe (Division Vb). Mean weight at age (kg) in commercial catches (ages 3-9) (1961-2013). 2014 to 2016 values are estimates. Horizontal lines show historical average.

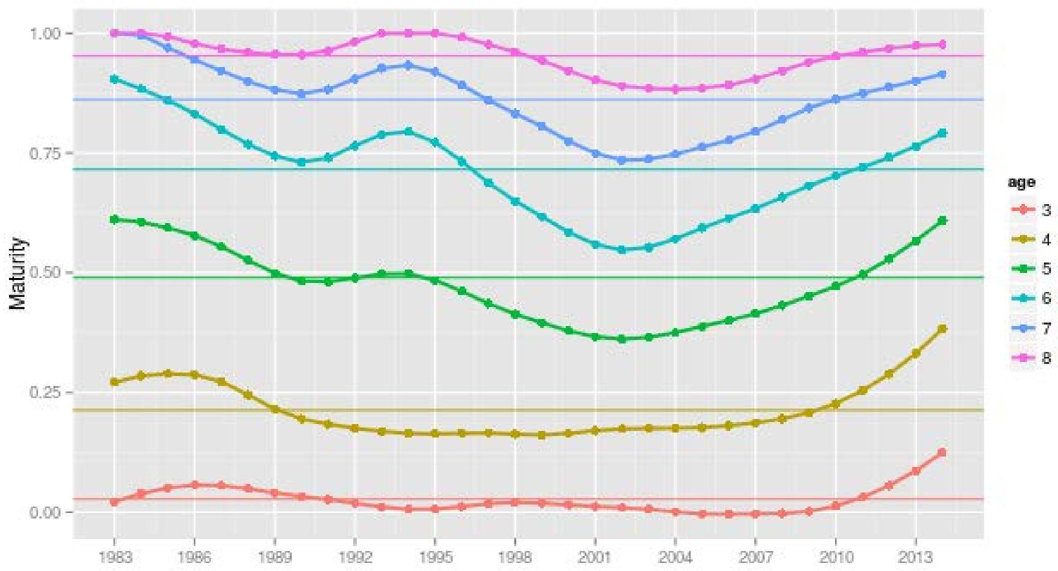


Figure 6.2.4.1. Faroe saithe (Division Vb). Smoothed maturity ogives (ages 3-8)(1983-2014). Horizontal lines show historical average.

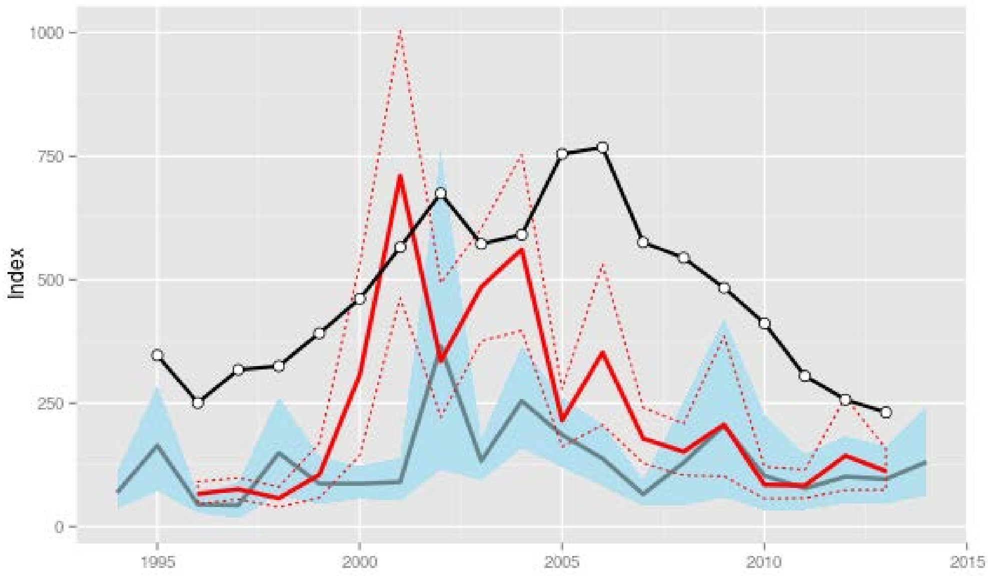


Figure 6.2.5.1.1. Faroe saithe (Division Vb). Predicted catch rates from the commercial fleet (pairtrawlers) used for tunning the assessment (black line). Catch rates (kg/hour) (right-vertical axis) from the Faroese bottom-trawl fall (1996-2013)(red line) and spring survey (1994-2014)(blue line). Dotted lines and shade areas show standard errors in the estimation of indices.

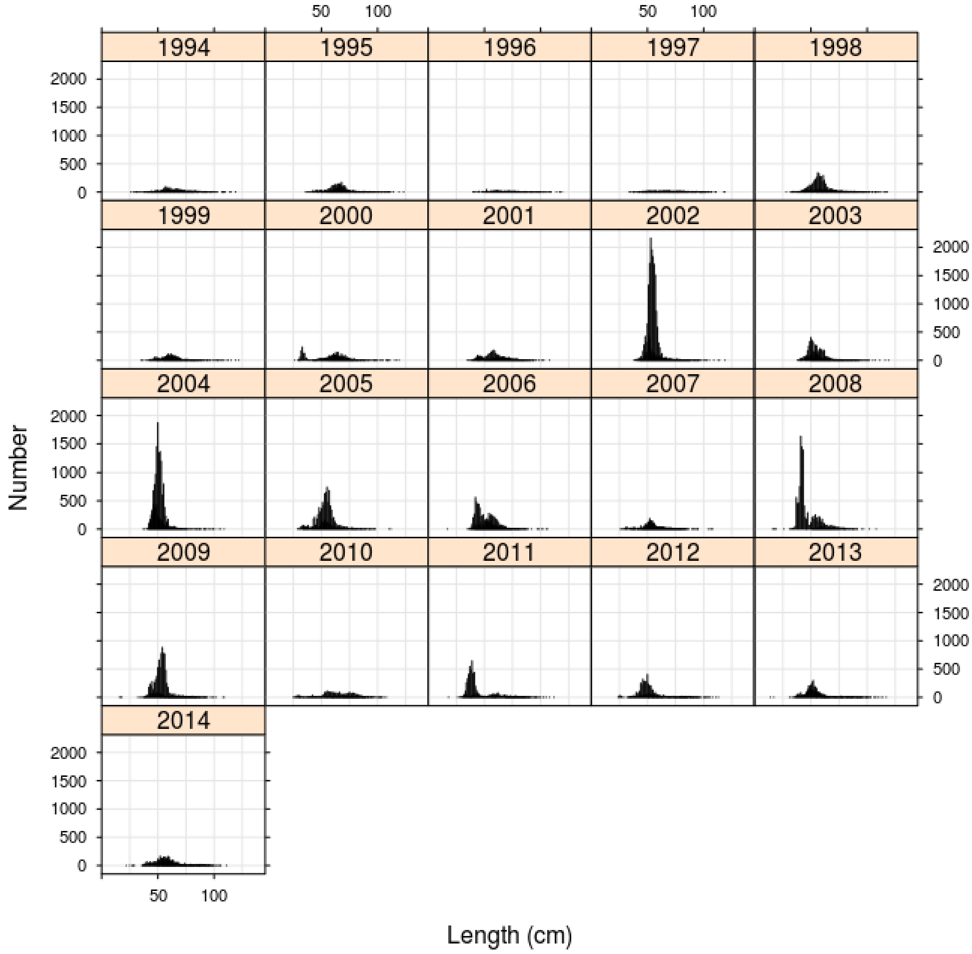


Figure 6.2.5.1.2. Faroe saithe (Division Vb). Length composition from the Faroese bottom-trawl spring survey (1994-2014)

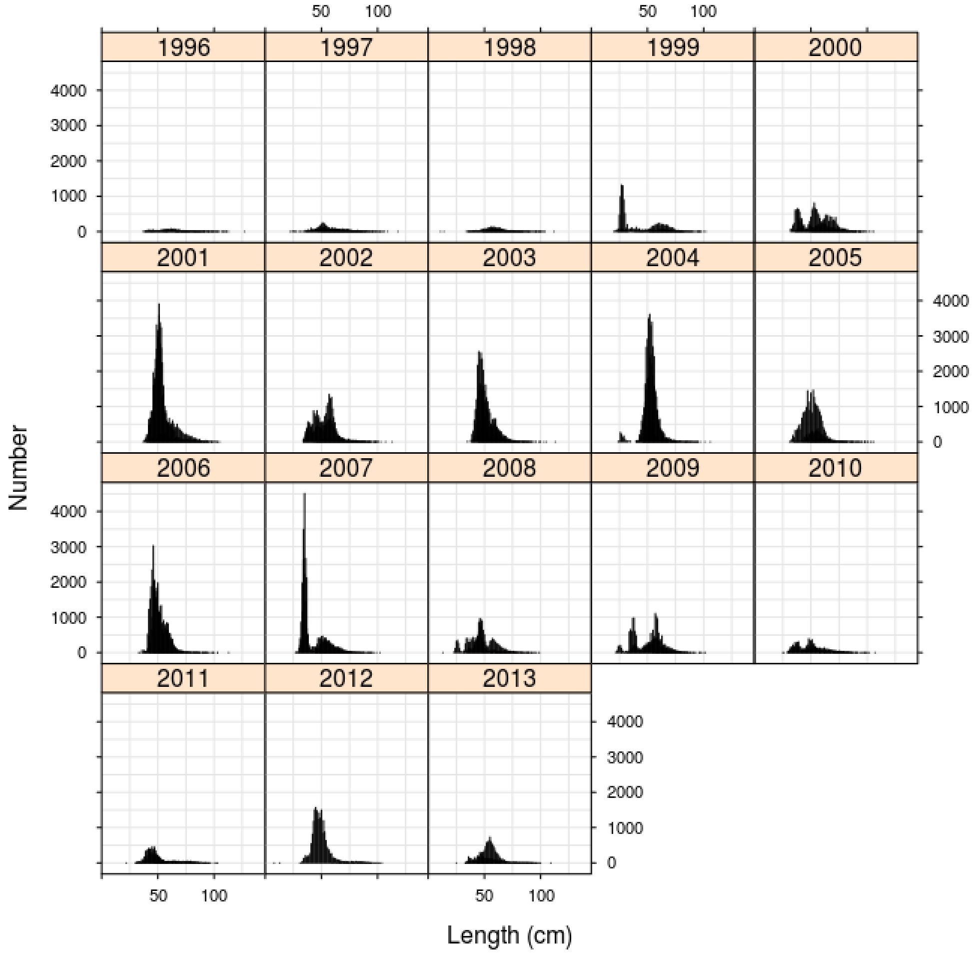


Figure 6.2.5.1.3. Faroe saithe (Division Vb). Length composition from the Faroese bottom-trawl summer survey (1996-2013)

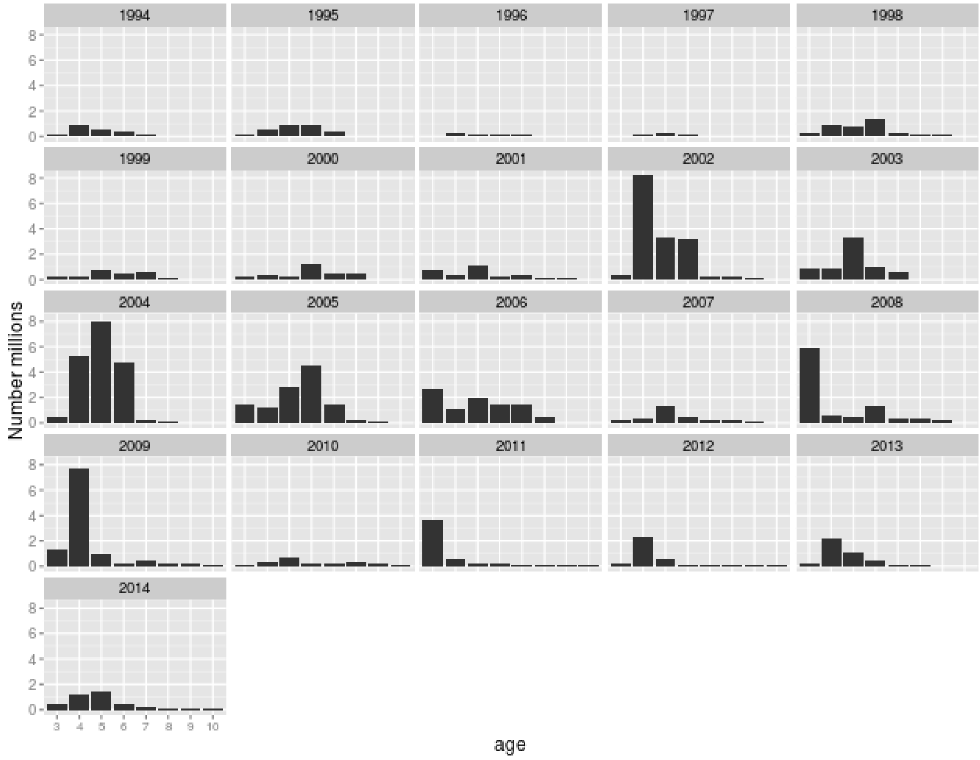


Figure 6.2.5.1.4. Faroe saithe (Division Vb). Age-disaggregated indices in the Faroese bottom-trawl spring survey (ages 3-10, years 1994-2014)

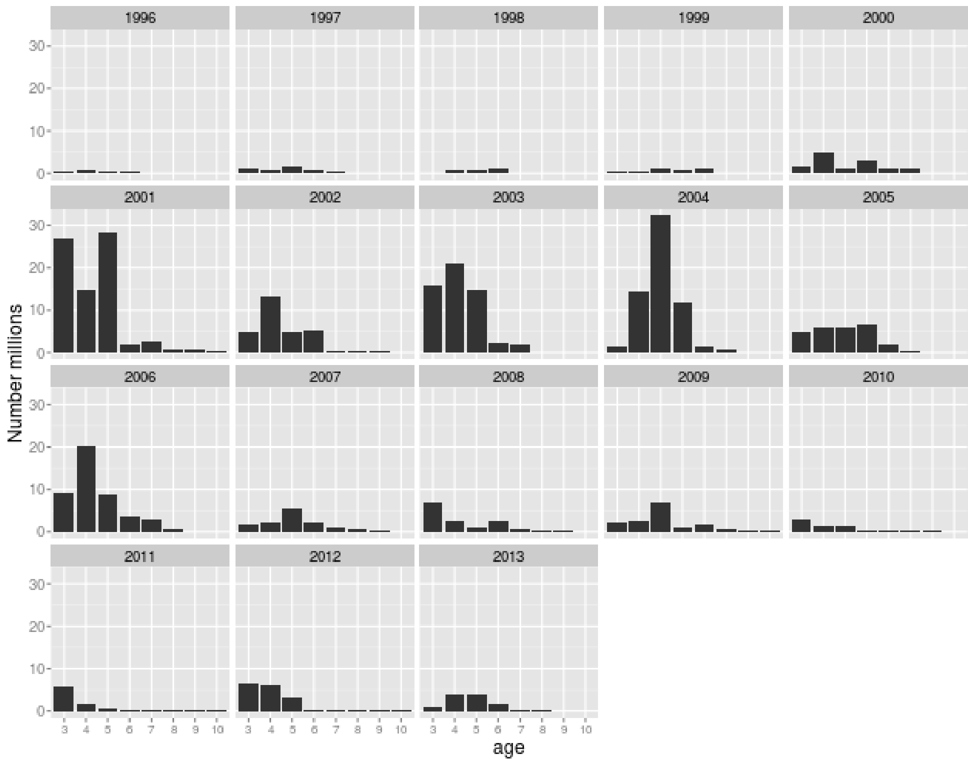


Figure 6.2.5.1.5. Faroe saithe (Division Vb). Age-disaggregated indices in the Faroese bottom-trawl fall survey (ages 3-10, years 1996-2013)

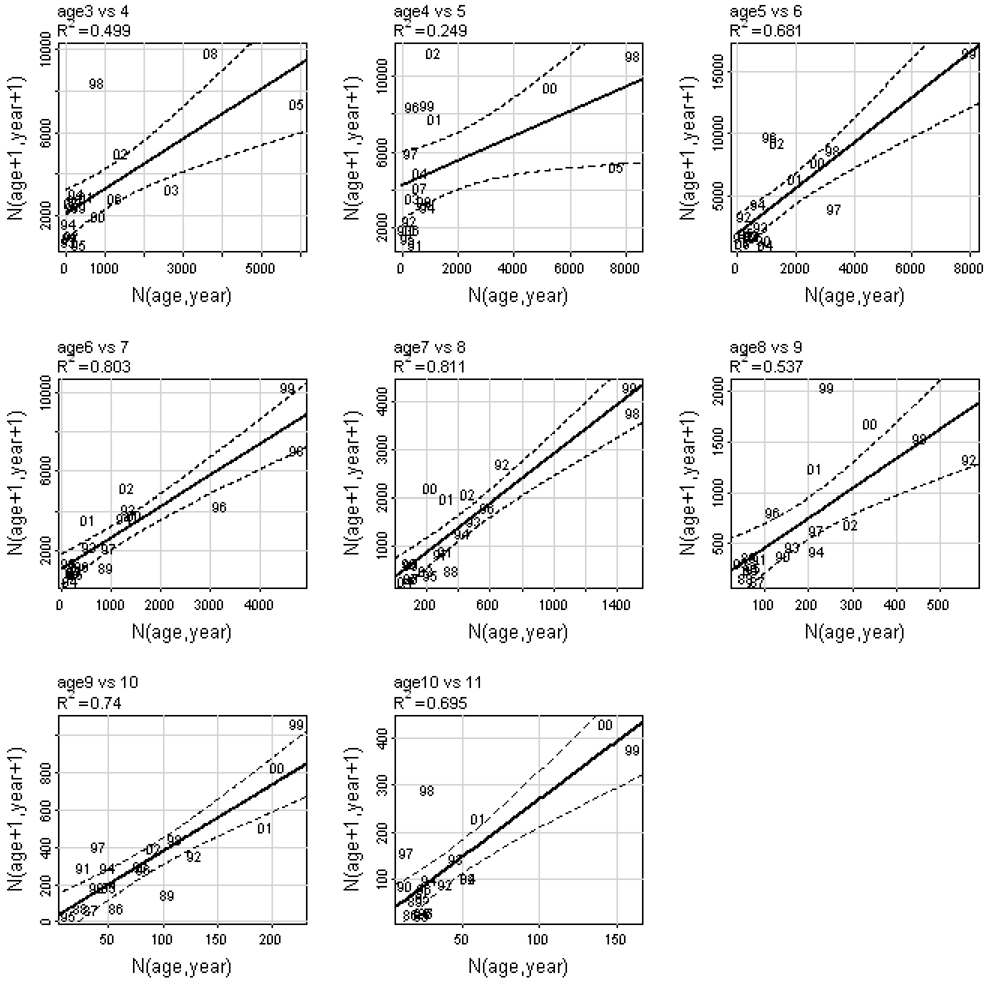


Figure 6.2.5.1.6. Faroe saithe (Division Vb). Indices from spring survey plotted against catch numbers the same year class one year later. The letters in the figure are year classes.

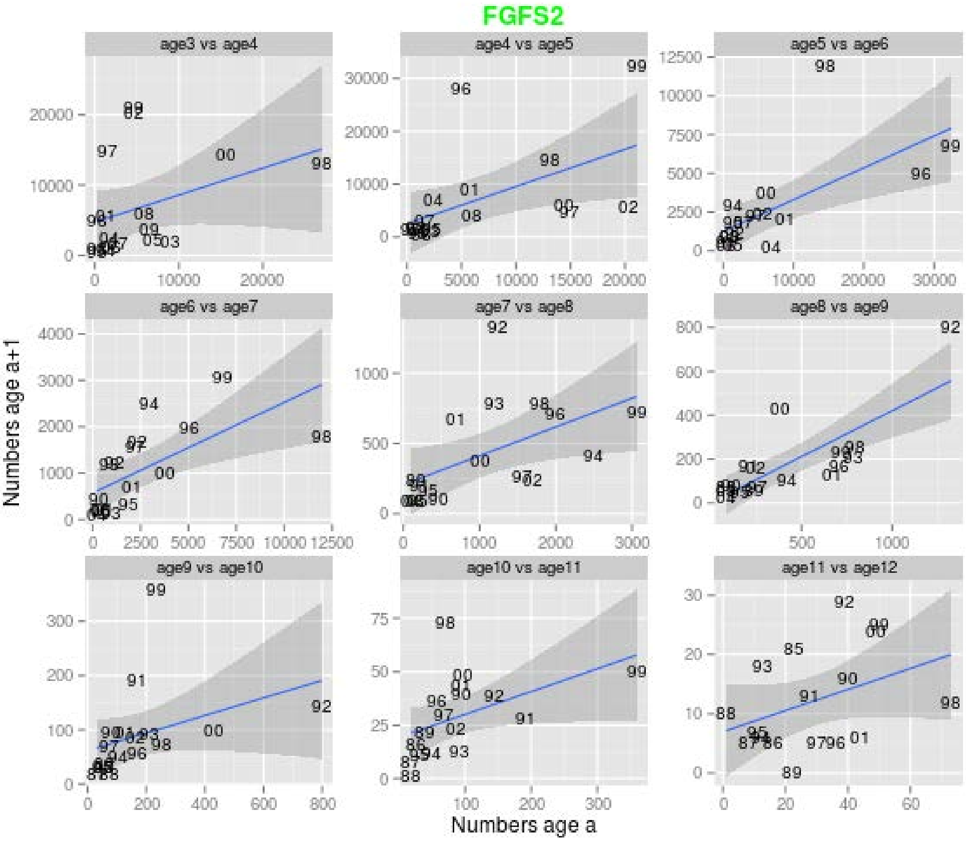


Figure 6.2.5.1.7. Faroe saithe (Division Vb). Indices from summer survey plotted against catch numbers the same year class one year later. The letters in the figure represent year classes.

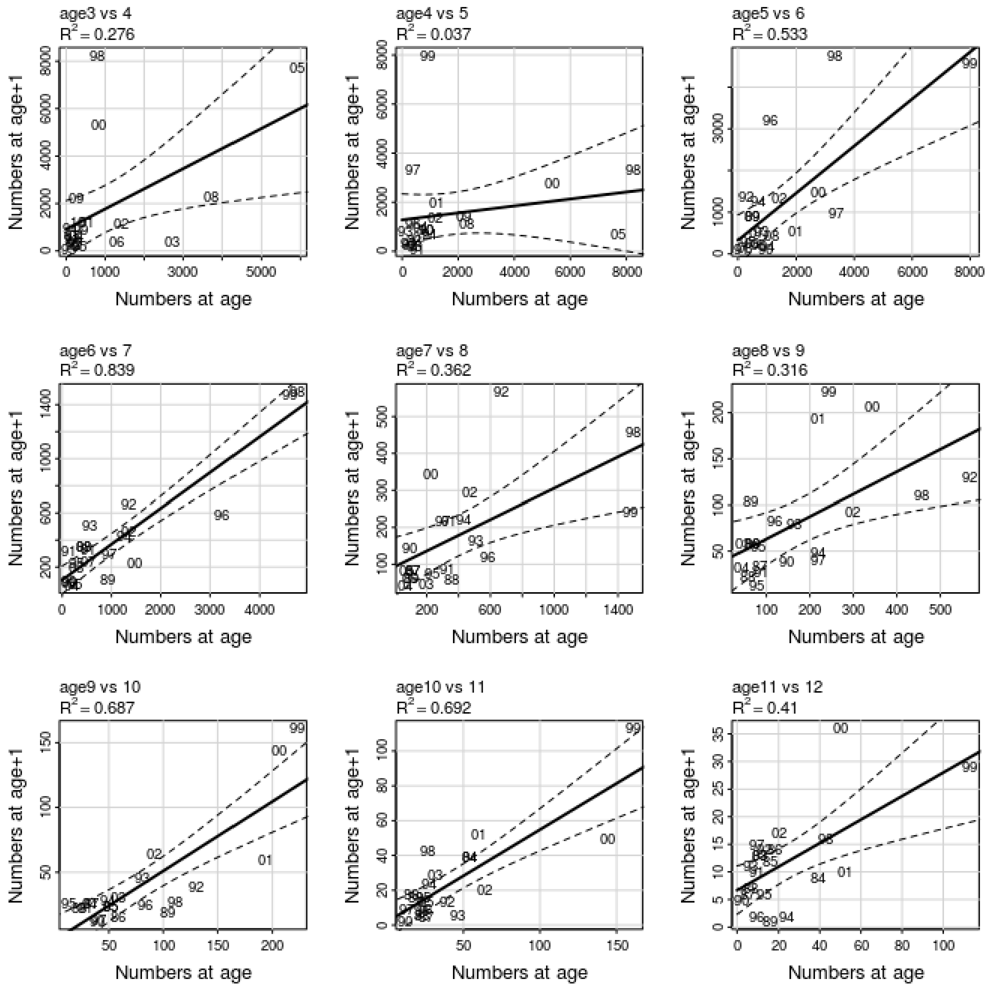


Figure 6.2.5.1.8. Faroe saithe (Division Vb). Indices from spring survey plotted against indices of the same year class one year later. The letters in the figure are year classes.

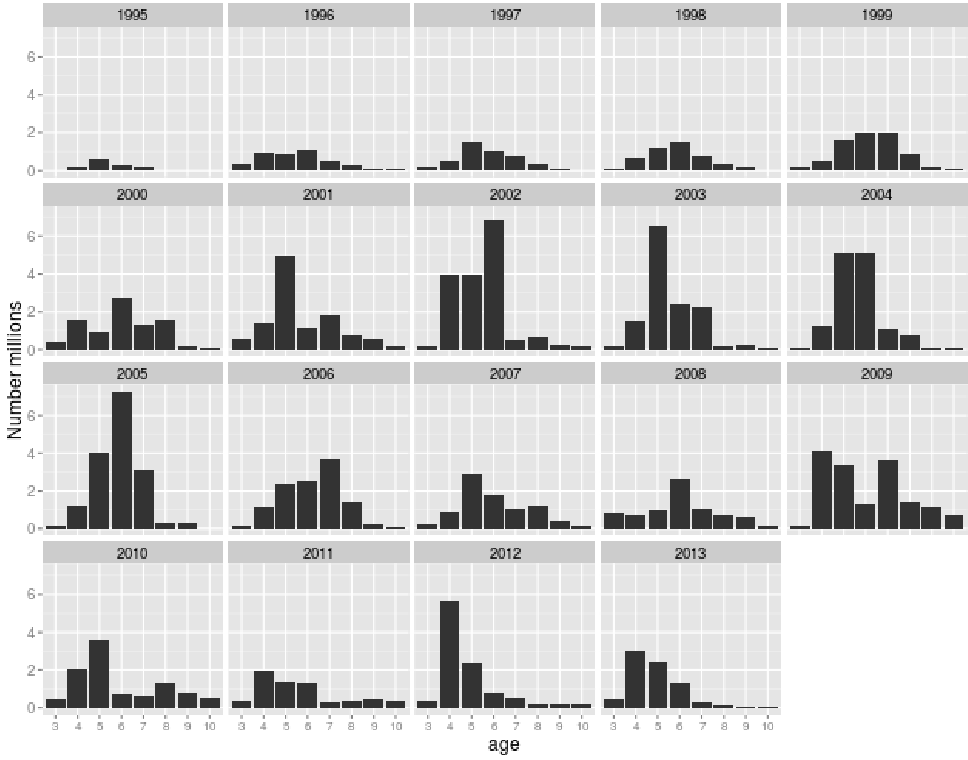


Figure 6.2.5.2.1. Faroe saithe (Division Vb). Age-disaggregated indices in the commercial pair-trawl fleet (ages 3-11, years 1995-2013)

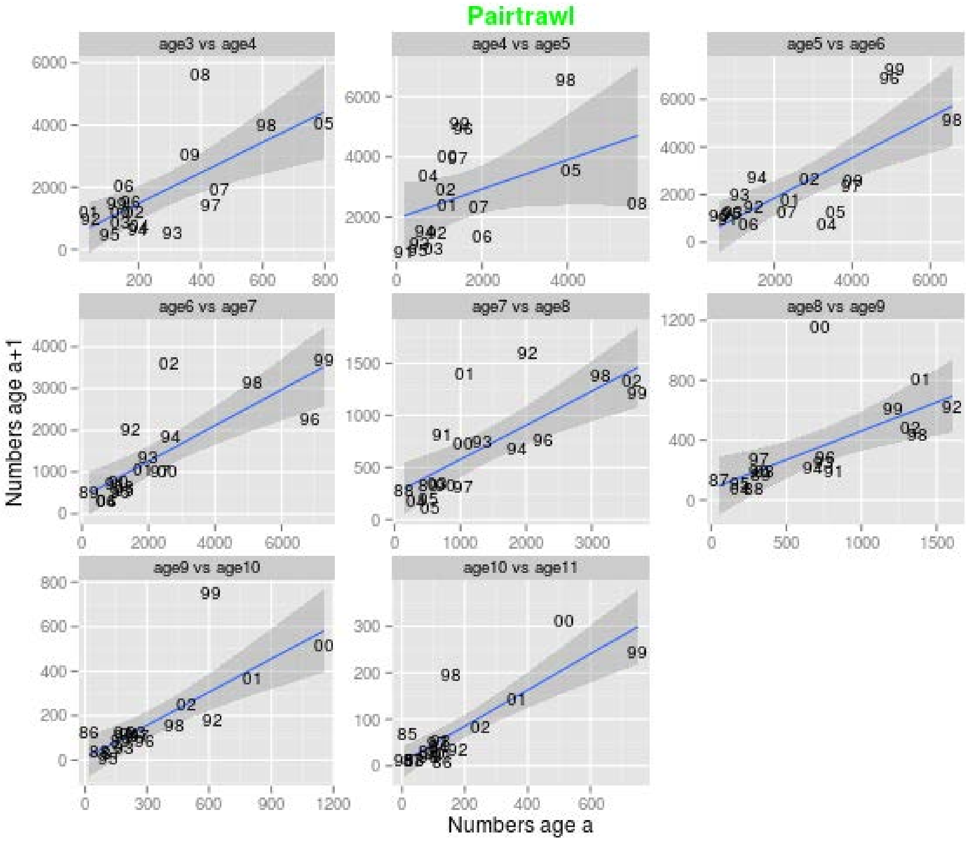


Figure 6.2.5.2.2. Faroe saithe (Division Vb). Indices from spring survey plotted against indices of the same year class one year later in the commercial pair-trawl fleet. The letters in the figure represent year classes.

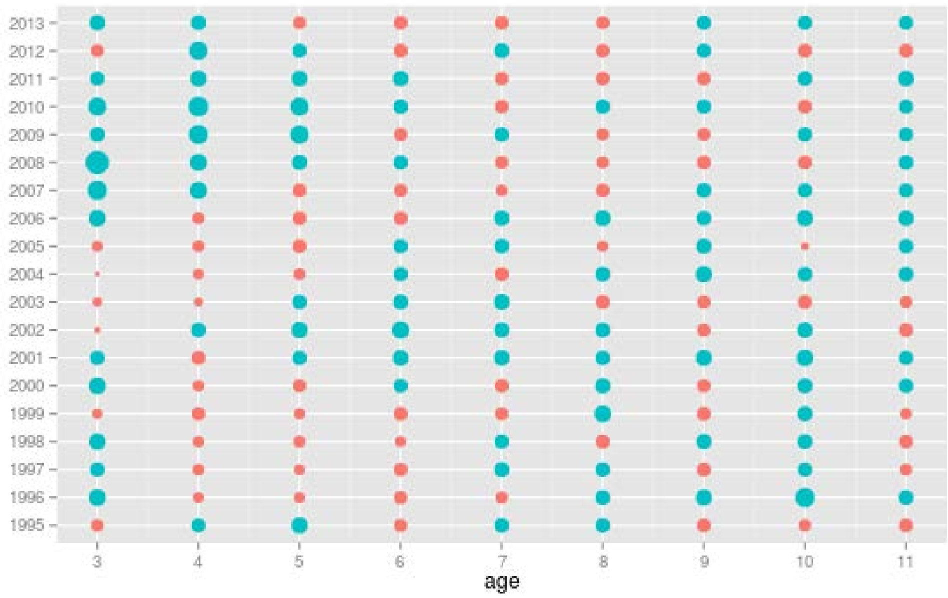
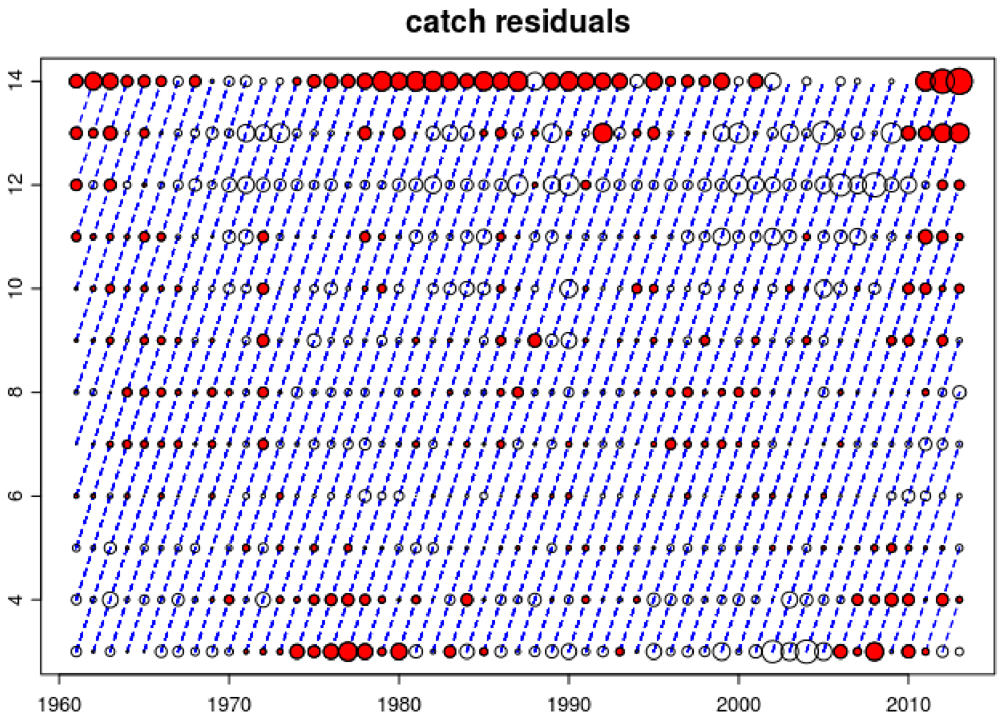


Figure 6.3.1. Faroe saithe (Division Vb). Log-catchability residuals of the XSA calibrated with the commercial series (ages 3-11, years 1995-2013)



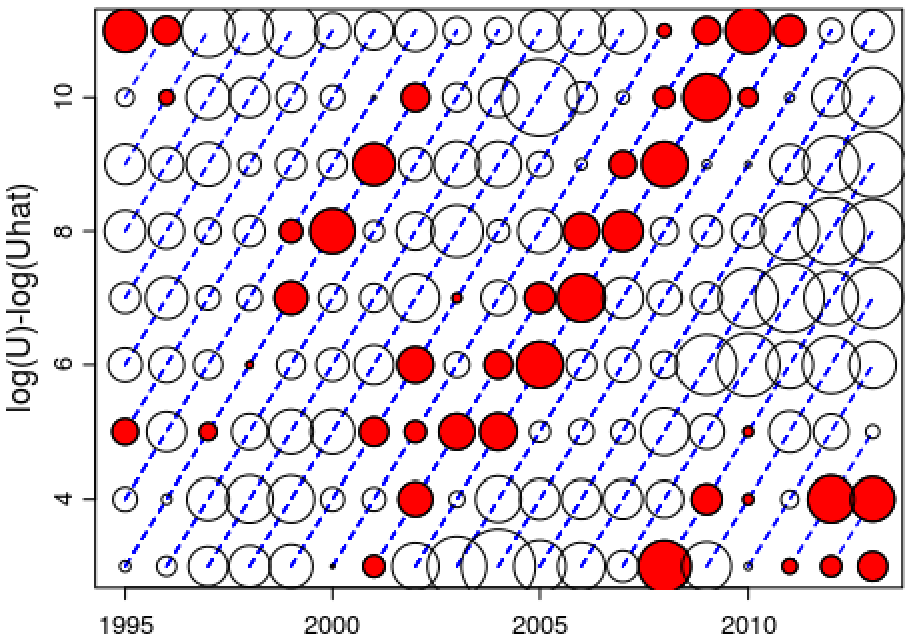


Figure 6.3.3. Faroe saithe (Division Vb). Catch- (ages 3-14+, years 1961-2013) and survey-at-age (ages 3-11, years 1995-2013) residuals from a statistical separable model using three different selection periods.

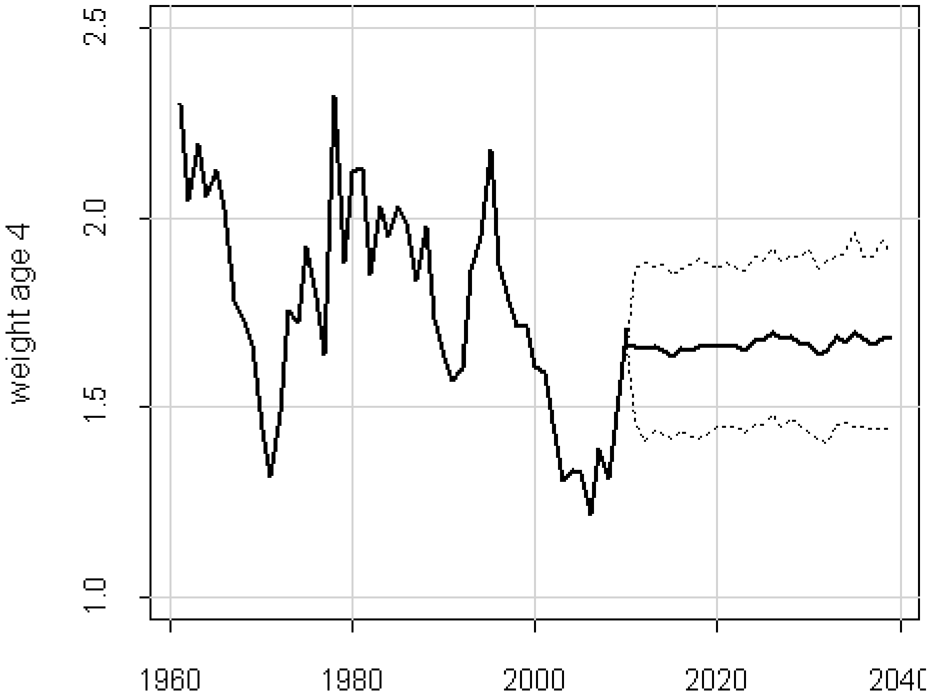


Figure 6.4.1.1. Faroe saithe (Division Vb). Development of weights (age 4) in the MSY simulations. Solid and discontinuous lines represent mean weight and 25% and 75% percentiles respectively.

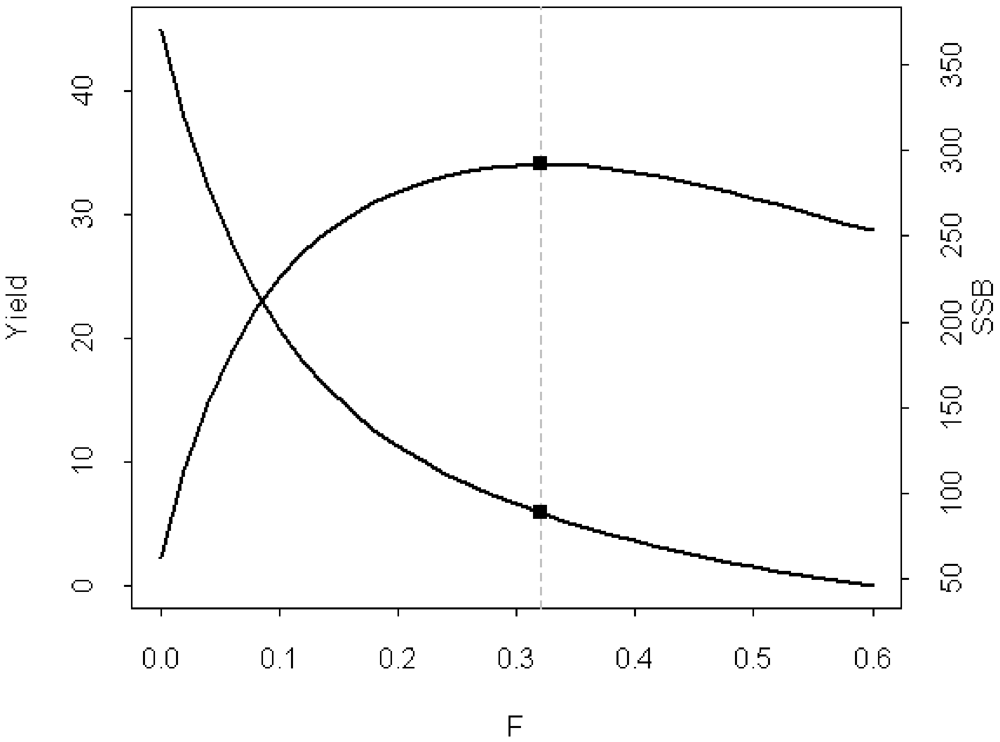


Figure 6.4.1.2. Faroe saithe (Division Vb). Yield and spawning per-recruit from the simulations. Fmsy=0.32, Ymsy=34 kt. and SSBmsy=89 kt.

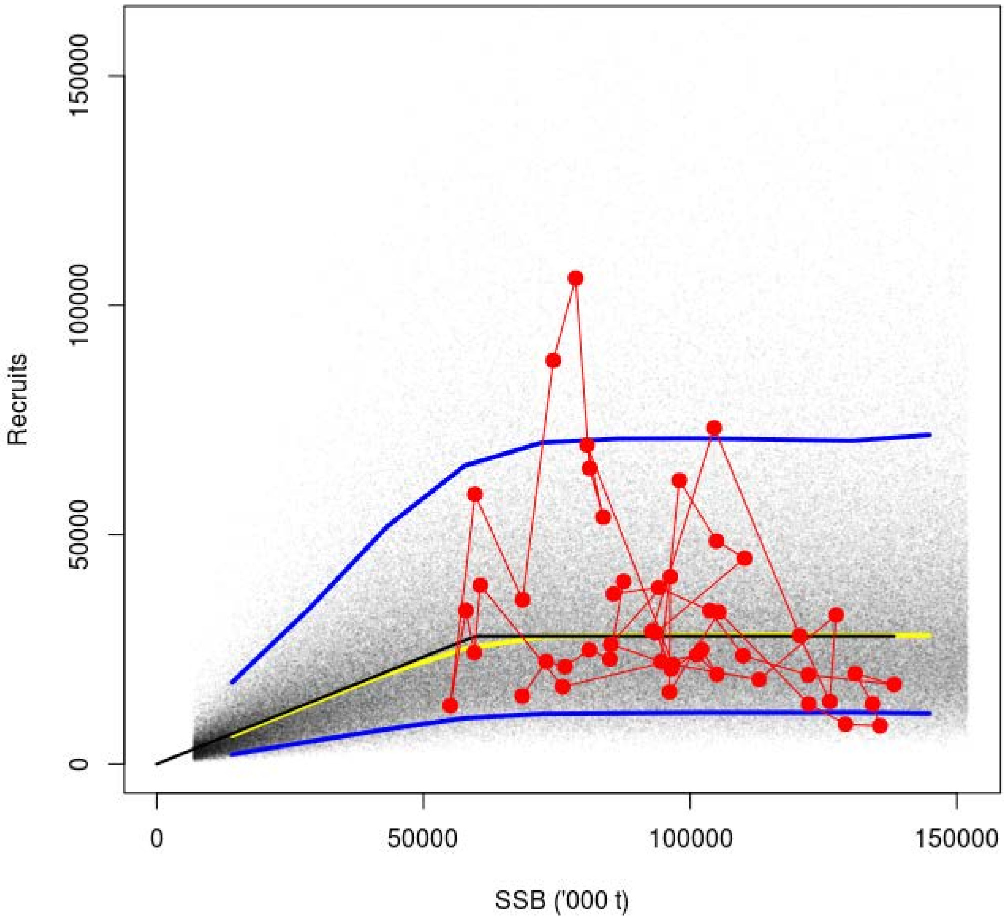


Figure 6.4.1.3. Faroe saithe (Division Vb). EqSim simulation. Stock-recruitment function used in the simulations (Hockey-stick).

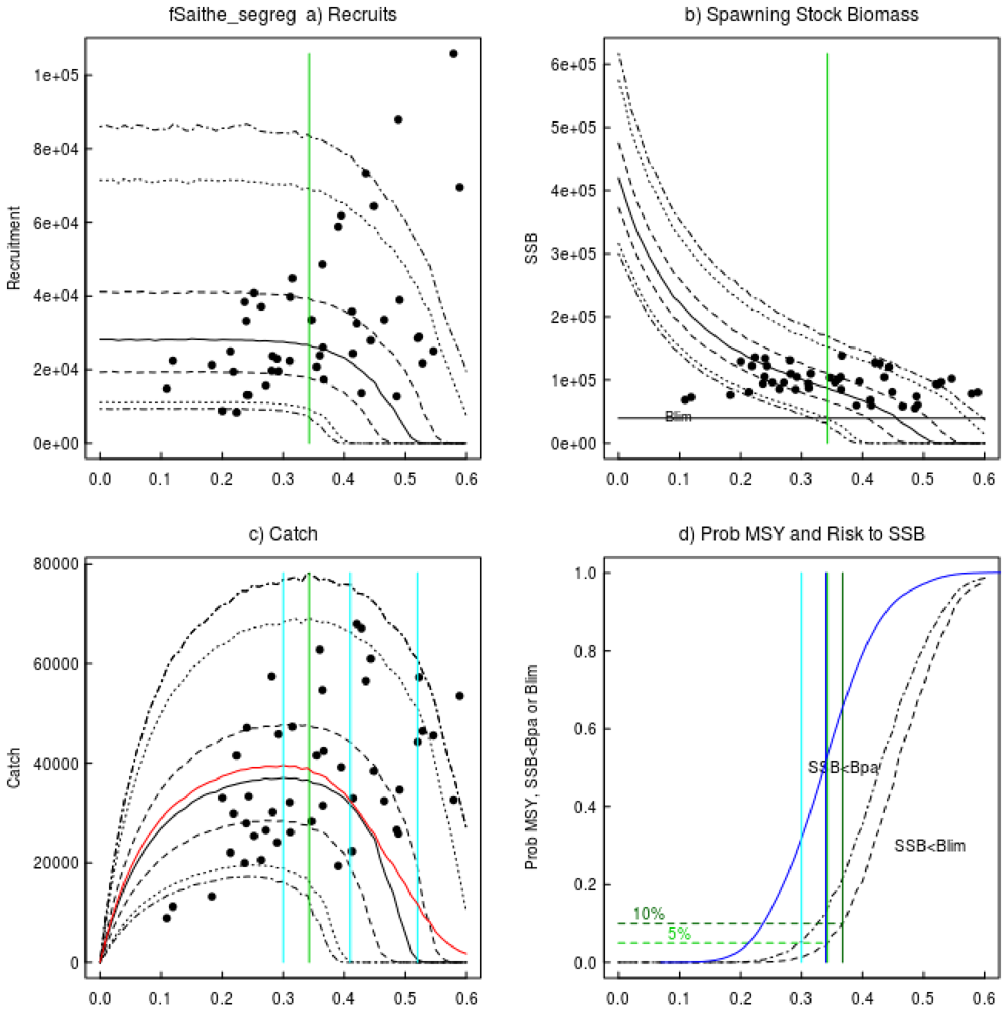


Figure 6.4.1.4. Faroe saithe (Division Vb). EqSim simulation outputs with assessment errors and Hockey-stick function. Blim is undefined but was set as Blim=Bpa/1.4.

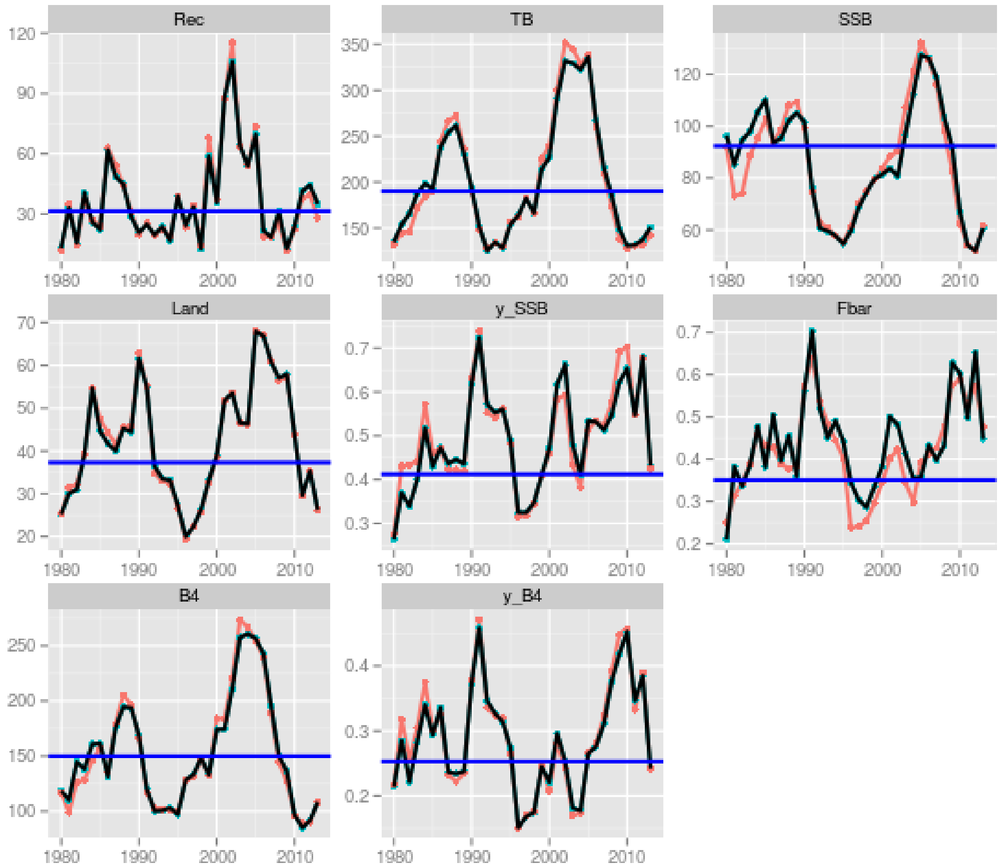


Figure 6.5.1. Faroe saithe (Division Vb). Recruitment (age 3) in millions (top-left), total stock biomass (thousand tonnes)(top-middle), spawning stock biomass (thousand tonnes) (bottom-left), landings (thousand tonnes)(middle-left), landings SSB ratio (middle-middle), Fbar (ages 4 to 8)(middle-right), reference biomass (B4+) (thousand tonnes) (bottom-left) and landings B4+ ratio (bottom-right). Black line represents the spaly run and red lines shows the result from a separable statistical model. Horizontal blue lines represent historical averages.

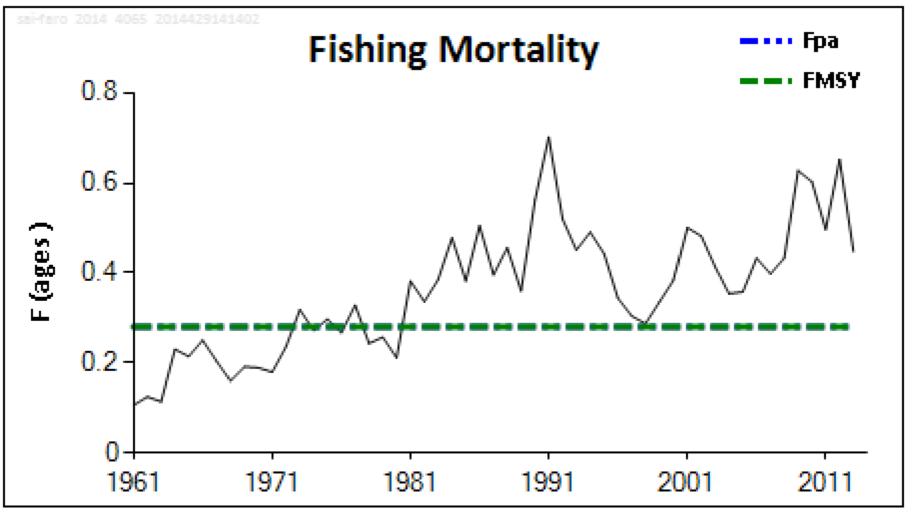


Figure 6.5.2. Faroe saithe (Division Vb). Fishing mortality (average over ages 4-8)(1961-2013)

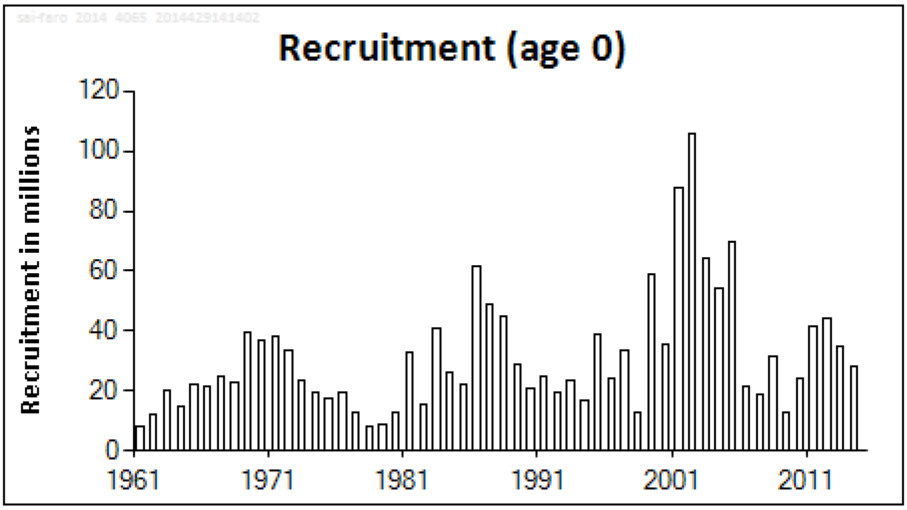


Figure 6.5.3. Faroe saithe (Division Vb). Recruitment at age 3 (tousands)(1961-2012).

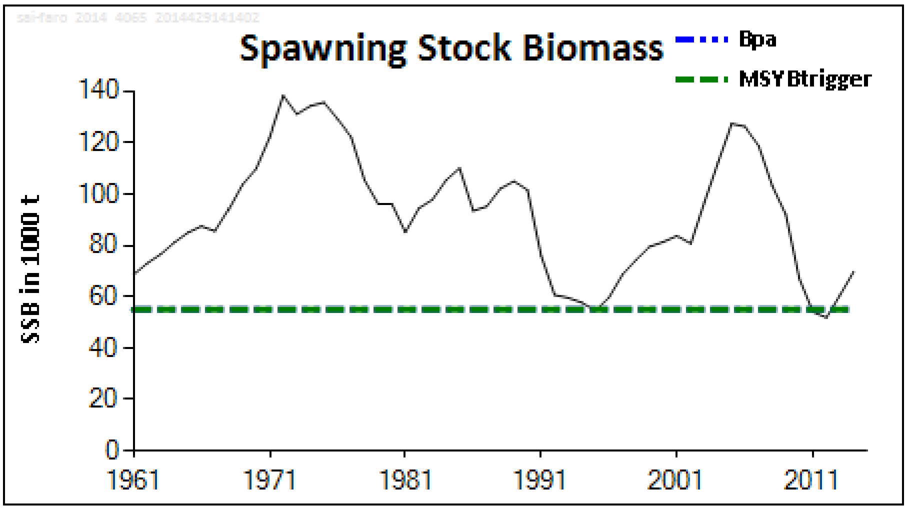


Figure 6.5.4. Faroe saithe (Division Vb). Spawning stock biomass (tonnes)(1961-2013).

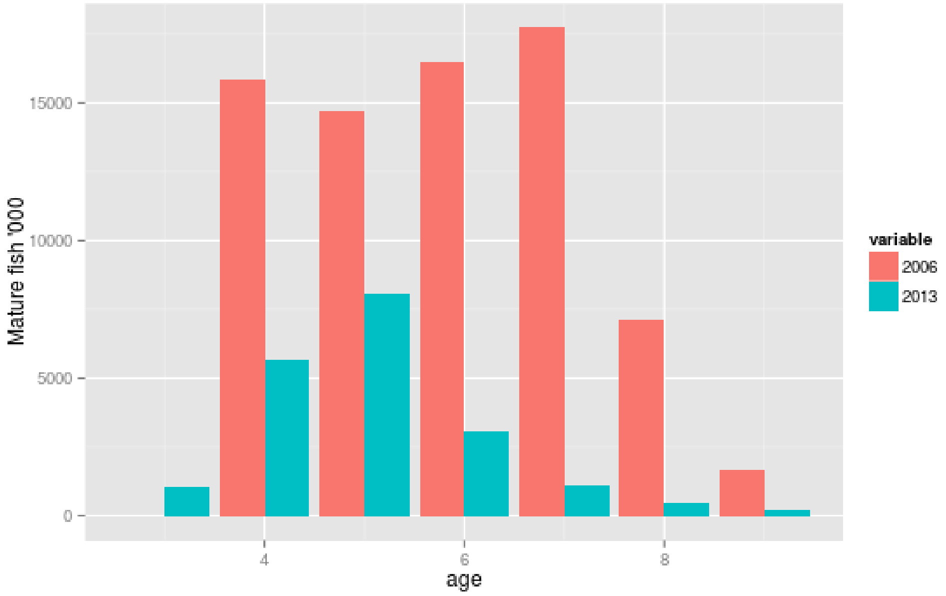


Figure 6.5.6. Faroe saithe (Division Vb). Numbers of mature fish in the stock at each age (3-14+) for 2006 and 2013.

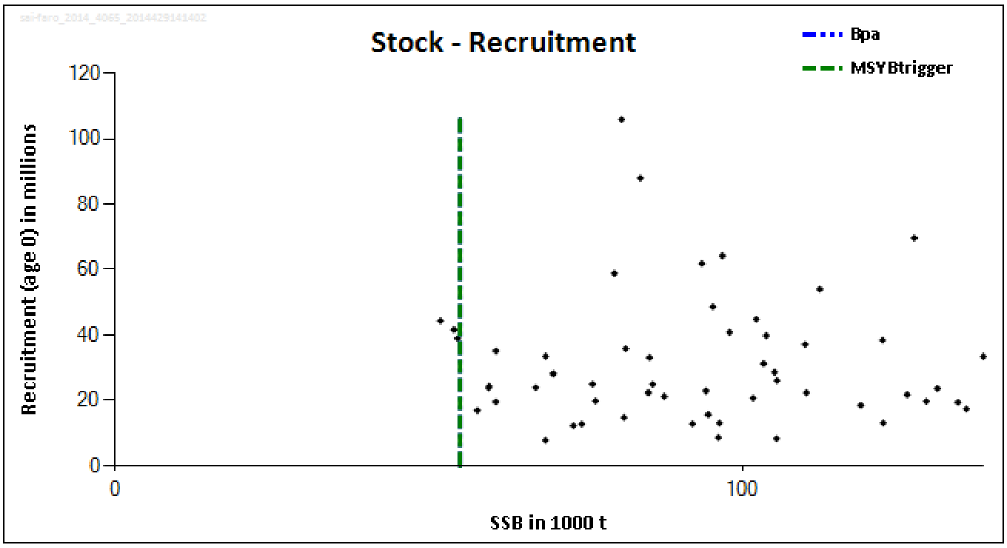


Figure 6.5.7. Faroe saithe (Division Vb). SSB - Recruitment (age 3) plot. Btriger=55 000 t and Blim=45 000 t.

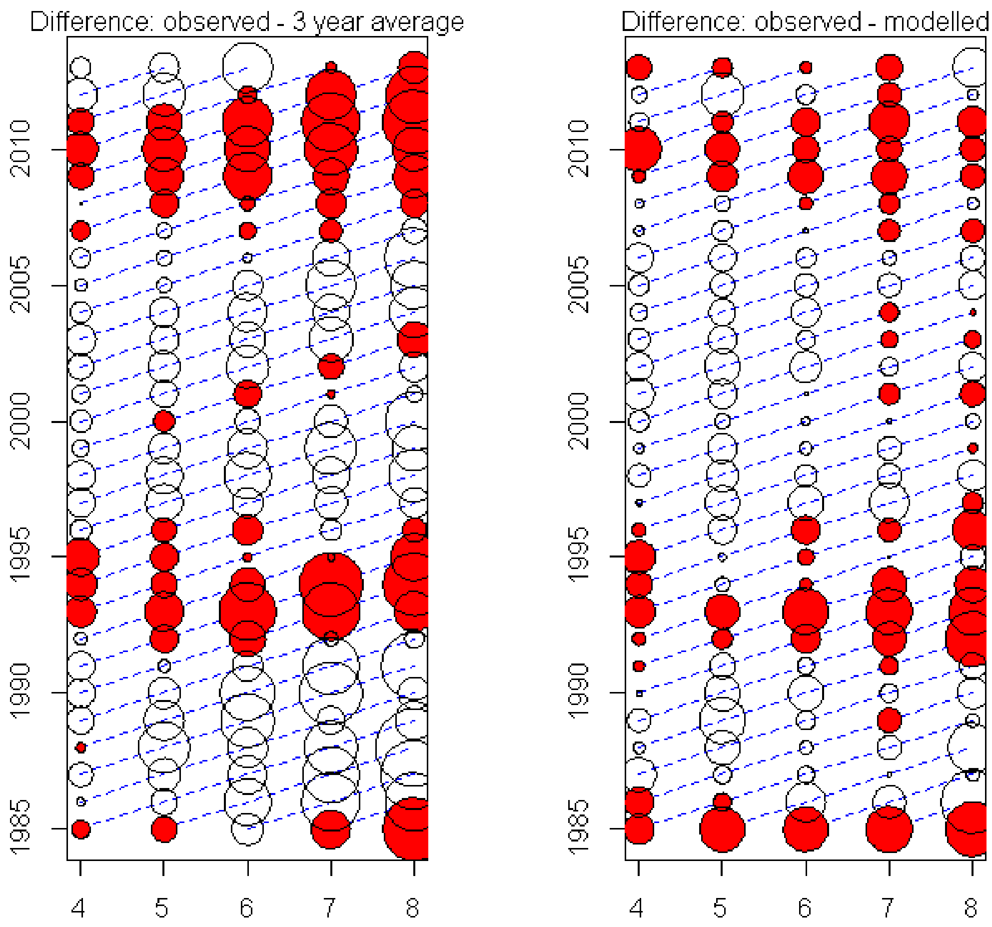


Figure 6.6.1.1. Faroe saithe (Division Vb). Residual plots from a 3-year average weight model and the predicted weight from previous year in the same year class model.

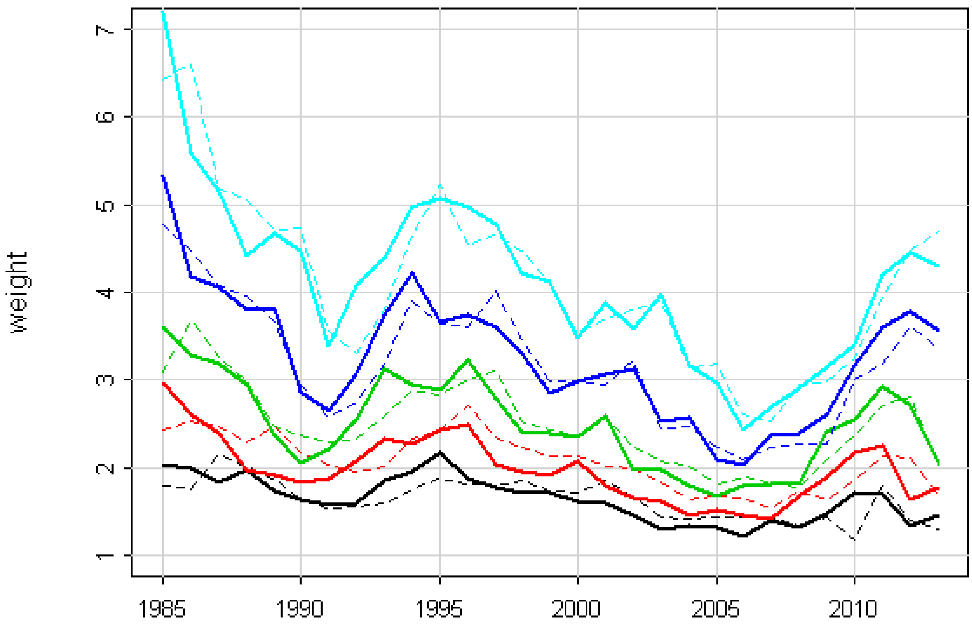


Figure 6.6.1.2. Faroe saithe (Division Vb). Observed (stapled lines) and predicted weights (aes 4-8, years 1985-2013)

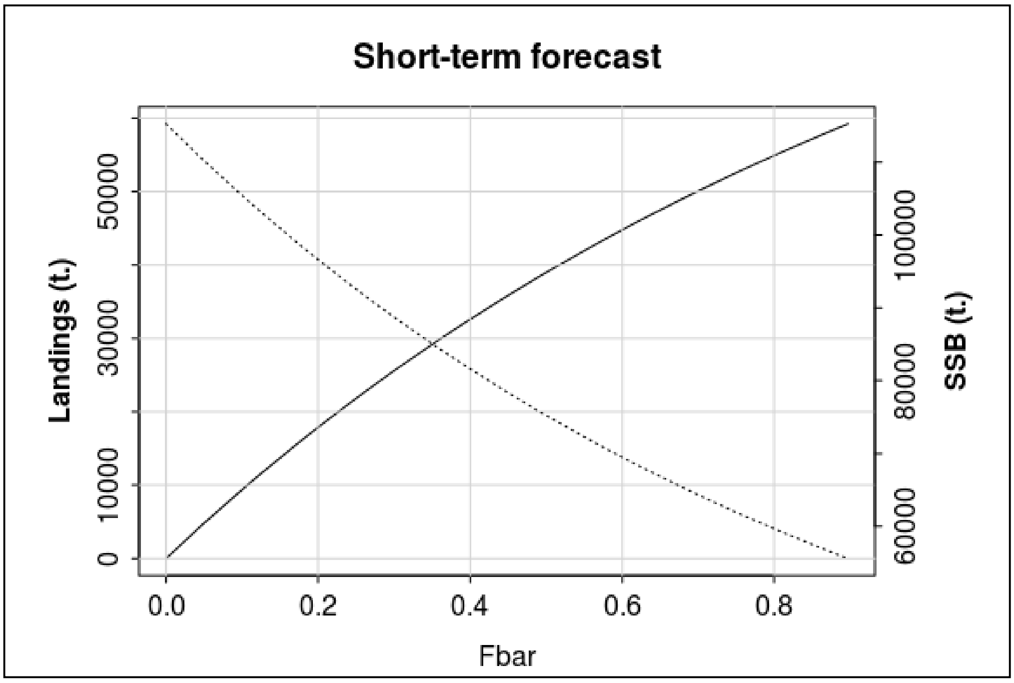


Figure 6.6.2.1a. Faroe saithe (Division Vb). Prediction output from spaly assessment.

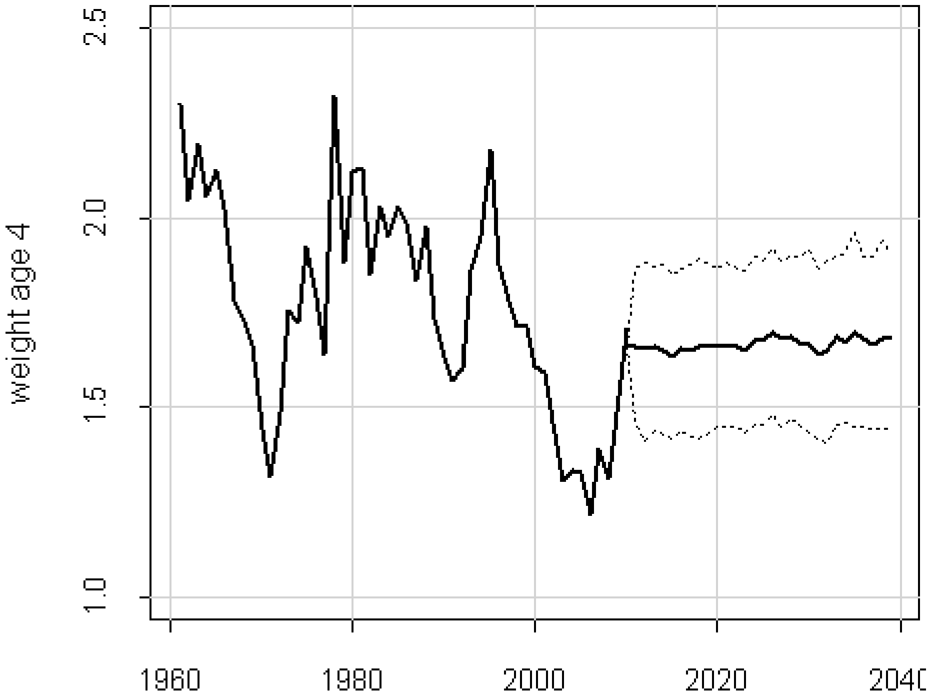


Figure 6.4.2.1. Faroe saithe (Division Vb). Development of weights (age 4) in the MSY simulations. Solid and discontinuous lines represent mean weight and 25% and 75% percentiles respectively.

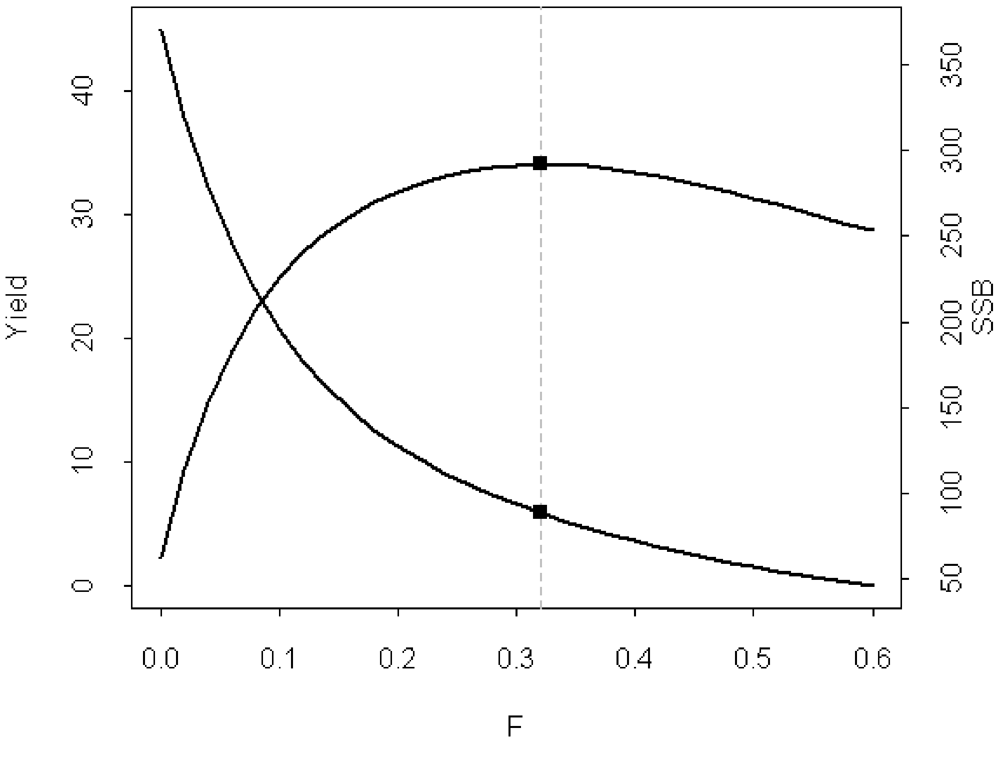


Figure 6.4.1.2. Faroe saithe (Division Vb). Yield and spawning per-recruit from the simulations. Fmsy=0.32, Ymsy=34 kt. and SSBmsy=89 kt.

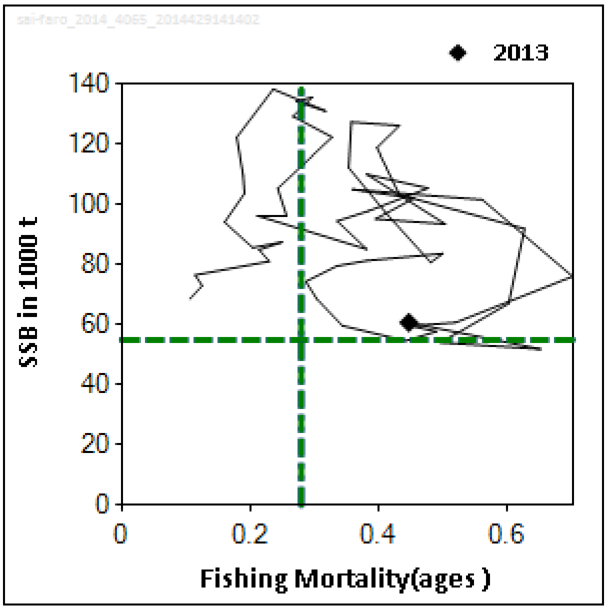


Figure 6.5.8. Faroe saithe (Division Vb). Precautionary approach plot, period 1961-2013. The history of the stock/fishery in relation to the four reference points.

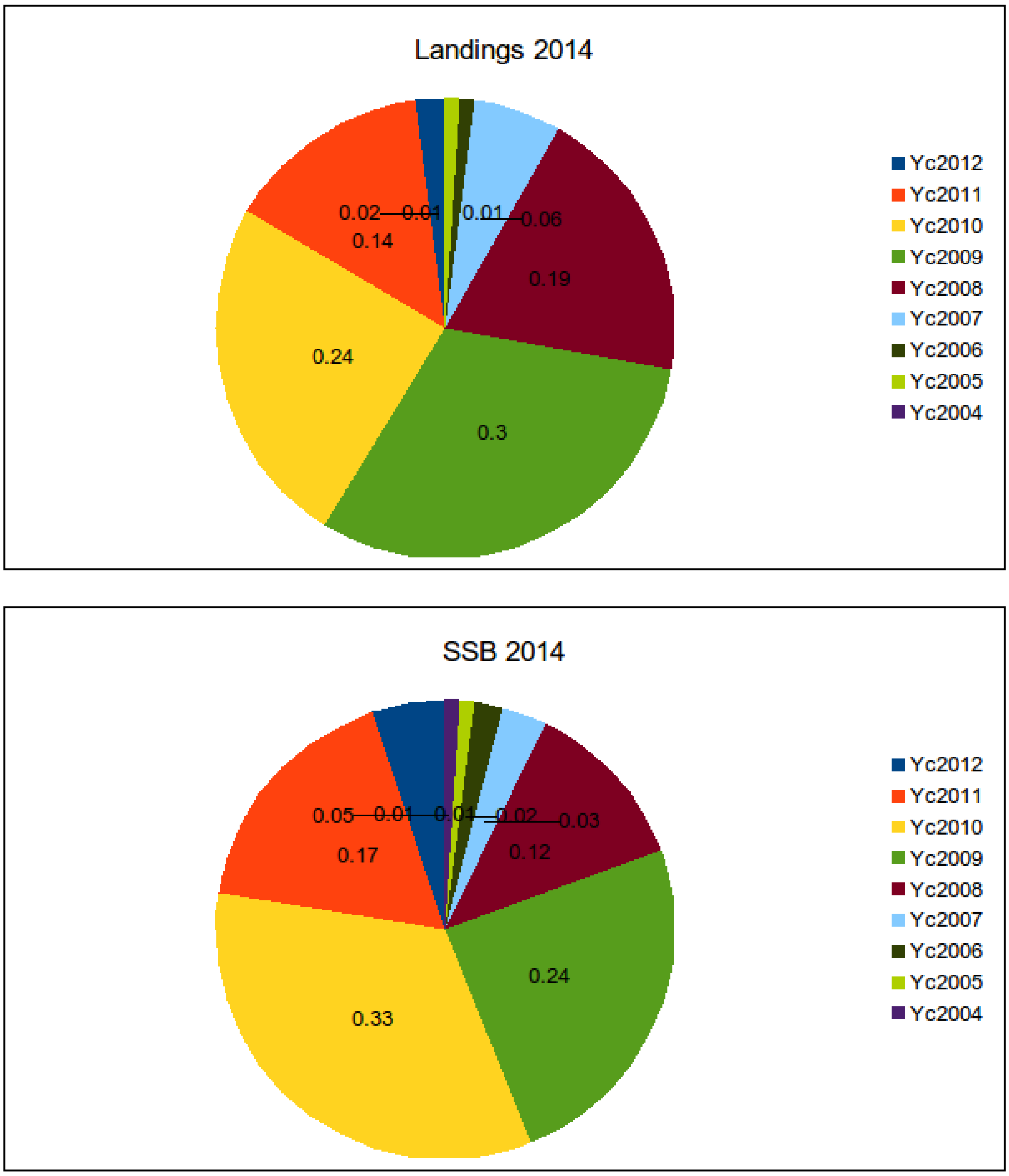


Figure 6.6.2.1a Faroe saithe (Division Vb). Composition in landings (upper figure) and SSB (lower figure) by year classes in 2014.

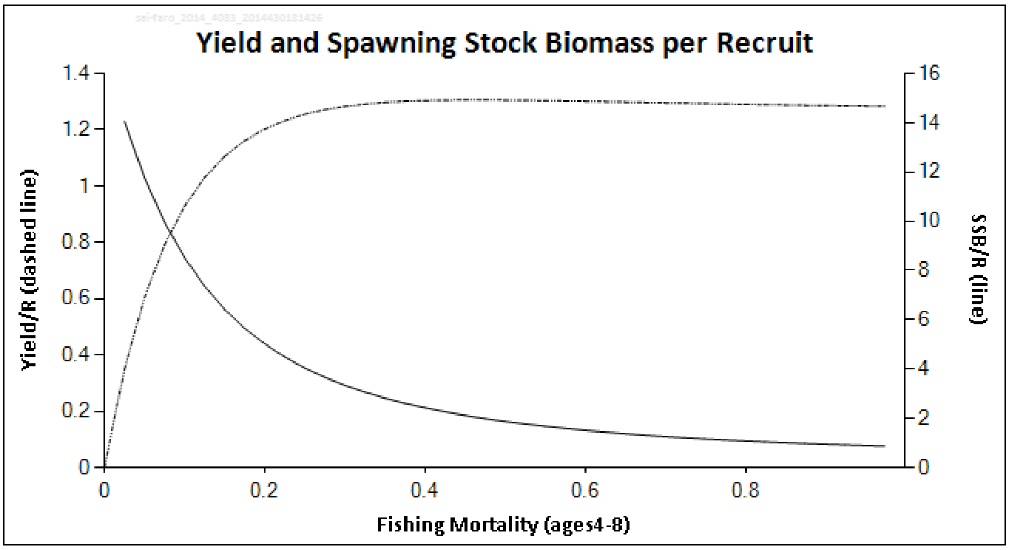


Figure 6.7.1.1. Faroe saithe (Division Vb). Yield and spawning per-recruit calculations.

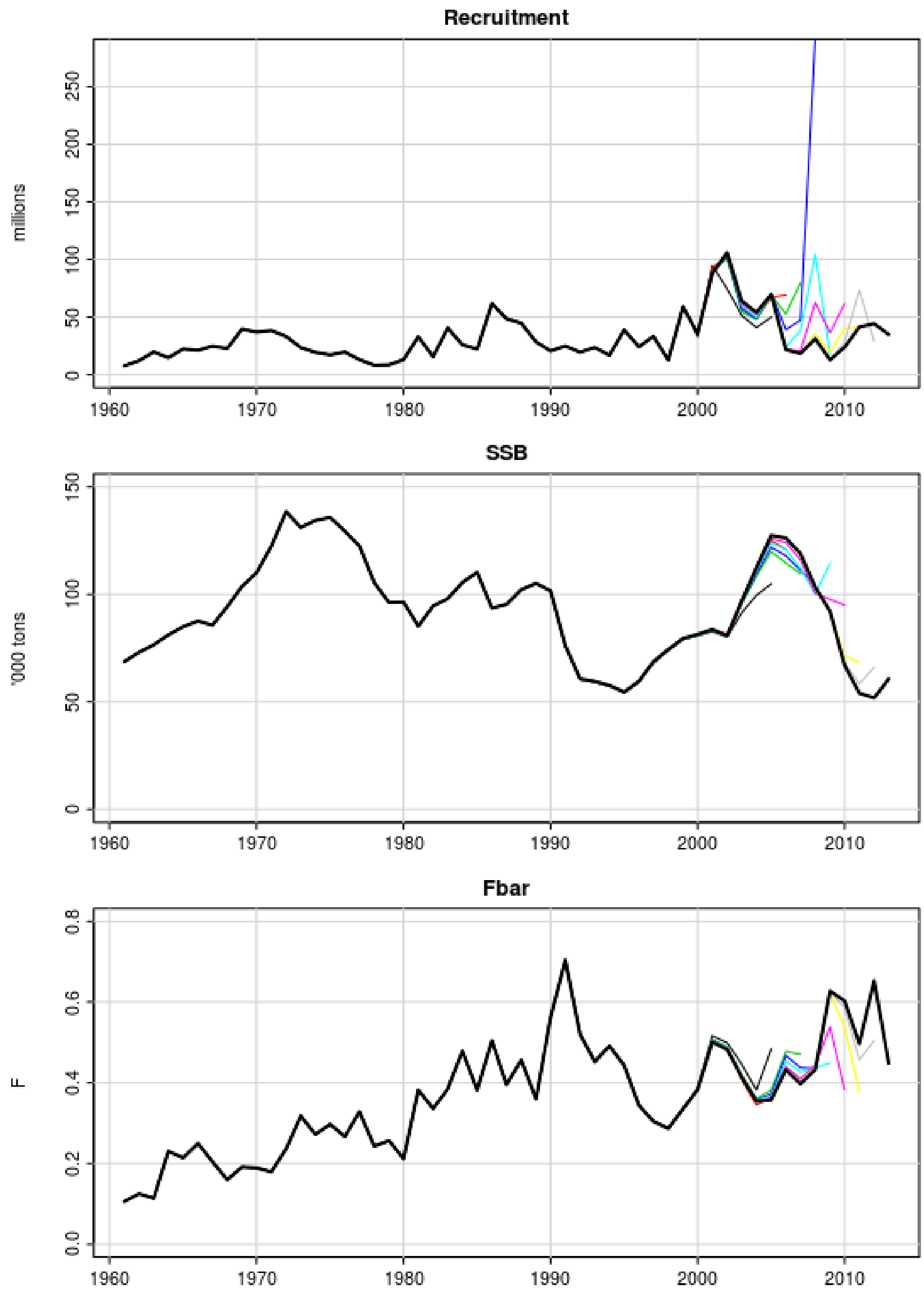


Figure 6.8.1. Faroe saithe (Division Vb). Retrospective analysis of recruitment at age 3, spawning stock biomass and average fishing mortality over age groups 4-8 from the spaly assessment.

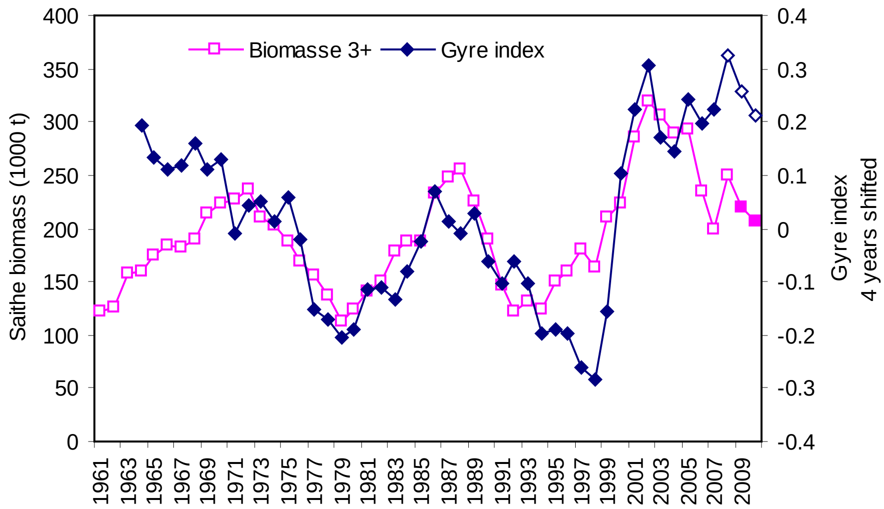


Figure 6.15.1. Faroe saithe (Division Vb). Relationship between the Gyre index (4 years shifted) and saithe biomasse (age 3+) in Faroese waters.

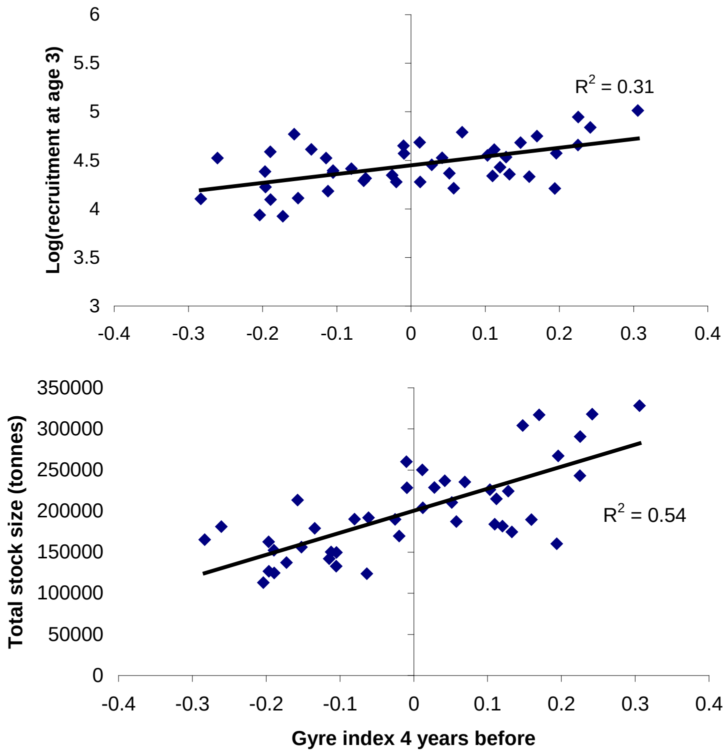


Figure 6.15.2. Relationship between the gyre index and both recruitment (top figure) and total stock biomass estimates (bottom figure.) Note that a large gyre index indicates a small subpolar gyre, and, consequently, a large influx of plankton-rich warmer-than-average water to the outer areas (bottom depth > 150 m) around the Faroes, where saithe typically are found.

7 Overview on ecosystem, fisheries and their management in Icelandic waters

This section gives a very broad and general overview of the marine ecosystem, fishery, fleet, species composition and some bycatch analysis of the commercially landed species as well as management measures in the Icelandic Exclusive Economic Zone. The Icelandic EEZ covers partly the IIa2, Va1, Va2, Vb1b, XIIa4, XIVa and XIVb2 ICES statistical regions. In practice however, the Icelandic landings of different species are generally reported as catches/landings in Va.

The information on the ecosystem of Icelandic waters is brief but a more detailed description is available in the WGRED report (ICES 2008).

7.1 Environmental and ecosystem information

Iceland is located at the junction of the Mid-Atlantic Ridge and the Greenland-Scotland Ridge just south of the Arctic Circle and this is reflected in the topography around the country. Substrate characteristics can be largely influenced by depth. Hard bottom is more often found in shallower waters compared to deep waters. In deeper waters, hard bottom is often confined to abrupt features such as ridges and seamounts. Soft sediments often dominate in the troughs and outside the continental slope. The shelf around Iceland is narrowest off the south coast (Figure 7.3.4) and is cut by submarine canyons around the country (Figure 7.3.4).

The Polar Front lies west and north off Iceland and separates the cold and southward flowing waters of Polar origin from the northward flowing waters of Atlantic origin. South and east off Iceland the North Atlantic Current flows towards the Norwegian Sea. The Irminger Current is a branch of the North Atlantic Current and flows northwards over and along the Reykjanes Ridge and along the western shelf break. In the Denmark Strait it divides into a branch that flows northeastward and eastward to the waters north off Iceland, as the North Icelandic Irminger Current, and another branch that flows south-westward along the East Greenland Current. In the Iceland Sea north off Iceland, a branch originating from the cold East Greenland Current flows over the Kolbeinsey Ridge and continues to the southeast along the northeastern shelf brake as the East Icelandic Current, which is part of a cyclonic gyre in the Iceland Sea. This current subsequently continues into the Norwegian Sea along the Atlantic water flowing eastwards over the Iceland-Faroes Ridge (Stefansson 1962, Valdimarsson and Malmberg 1999).

The Icelandic Shelf is a high (150-300 gC/m2-yr) productivity ecosystem according to SeaWiFS global primary productivity estimates. Productivity is higher in the southwest regions than to the northeast and higher on the shelf areas than in the oceanic regions (Gudmundsson 1998). In terms of abundance, copepods dominate the mesozooplankton within Icelandic waters with *Calanus finmarchicus* being the most abundant species, often comprising between 60-80% of net-caught zooplankton in the uppermost 50 m (Astthorsson and Vilhjalmsson 2002, Astthorsson *et al*. 2007).

The structure of benthic communities in Icelandic waters is likely to be influenced by a large number of factors. Amongst these, water mass characteristics will have profound effects on species composition and spatial distribution patterns at the largest spatial scales (e.g. >50 km) whereas substrate characteristics (e.g. sediment type and rugosity) and topography will have profound effects on smaller scales (e.g. meters to kilometers), (e.g. Weisshappel and Svavarsson 1998). Shrimp biomass in Icelandic waters, both in inshore and offshore waters, has been declining in recent years. Consequently the fishing effort was reduced and is now banned in most inshore areas. The causes for the decline in the inshore shrimp biomass is in part considered to be environmentally driven, both due to increasing water temperature north of Iceland and due to increasing biomass of younger cod, haddock and whiting.

Based on information from fishermen, eleven cold-water coral areas were known to exist close to the shelf break off the northwest towards southeast Iceland around 1970. During the 70s and 80s, more coral areas were found by fishermen as a direct consequence of the bottom trawling fisheries extending into deeper waters. More recently there has been a considerable effort in mapping cold-water coral habitats in Icelandic waters and to investigate their biology using the state of the art technology such as unmanned submersibles. At present, large cold-water coral areas have been located on the Reykjanes Ridge and on the shelf break south and southeast Iceland (Steingrímsson and Einarsson 2004). Many of the cold-water coral areas that have been surveyed have already been destroyed. Currently, 5 areas with relatively undisturbed cold-water corals have received full protection and several other areas are under consideration for further protection.

The database of the BIOICE programme provides information on the spatial distribution of benthic organisms within the Icelandic territorial waters based on samples collected from 579 locations, including horny corals (Gorgonacea) and seapens (Pennatulacea), that are considered sensitive to fishing. Gorgonian corals occur all around Iceland but these are relatively uncommon on the shelf (< 500 m depth) but can be found in relatively high numbers in deep waters (> 500 m) off south, west and north coasts of Iceland, given the right environmental conditions. Similar distribution patterns were observed in the distribution of pennatulaceans, these being common in deeper waters, especially off South Iceland (Guijarro *et al*. 2007).

About 25 species of stocks of fish and marine invertebrates are exploited commercially on a regular basis in Icelandic waters.

Icelandic waters are comparatively rich in species and contain around 30 commercially exploited stocks of fish and marine invertebrates. The most important commercial species are cod, haddock, saithe, redfish, Greenland halibut and various other flatfish, wolffish, tusk *(Brosme brosme)*, ling *(Molva molva)*, herring, capelin and blue whiting. Most fish species spawn in the warm Atlantic water off the south and southwest coasts. Fish larvae and 0-group subsequently drift west and then north from the spawning grounds to nursery areas on the shelf off northwest, north and east Iceland, where they grow in a mixture of Atlantic and Arctic water.

Capelin is important in the diet of cod as well as a number of other fish stocks, marine mammals and seabirds. Unlike other commercial stocks, adult capelin undertake extensive feeding migrations north into the cold waters of the Denmark Strait and Iceland Sea during summer. Capelin abundance has been oscillating on roughly a decadal period since the 1970s, producing a yield of up to 1600 Kt at the most recent peak. In recent years the stock size of capelin has decreased from about 2000 Kt in 1996/97 to about 900 Kt in 2012/13 (Anon. 2013). Herring were very abundant in the early 1960s until the stock collapsed in the nineteen sixties due to overfishing. From 1970 onwards the stock size has increased until attaining historical high levels in the last decade. Abundance of demersal species have been generally trending downward since the 1950s with total catches dropping from over 800 Kt to less than 500 Kt in the early 2000s.

A number of species of sharks and skates are known to be caught as a by-catch in Icelandic waters, but information on amount of the catches is incomplete, and the status of these species is not known. Information on status and trends of non-commercial species are collected in extensive bottom trawl surveys conducted in early spring and autumn.

The seabird community in Icelandic waters is composed of relatively few but mostly abundant species, accounting for roughly ¼ of total number and biomass of seabirds within the whole ICES area (ICES 2002). Auks and petrels are the most important groups, comprising almost 3/5 and 1/4 of the total abundance and biomass in the area, respectively. The estimated annual food consumption is on the order of 1.5 million tonnes.

At least 12 species of cetaceans occur regularly in Icelandic waters, and additional 10 species have been recorded more sporadically. In the continental shelf area, the minke whale (*Balaenoptera acutorostrata*) probably has the largest biomass. Based on the 2001 sightings survey, 67 000 minke whales were estimated in the Central North Atlantic stock region, with 44 000 animals in Icelandic coastal waters (NAMMCO 2004, Borchers *et al.* 2003, Gunnlaugsson 2003). In the 2007 aerial survey the abundance of minke whales was estimated at around 21 000 animals on the Icelandic shelf. The reasons for this decrease are not known. Two species of seals, common seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*) breed in Icelandic waters, while 5 other species are found as vagrants (Sigurjonsson and Hauksson, 1994; Hauksson, 1993, 2004).

7.2 Environmental drivers of productivity

Mean weight at age of Icelandic cod have been shown to correlate well with the size of the capelin stock and therefore the capelin stock was used as a predictor of weights in the landings in 1991-2007. In 1981-1982, cod weights were low following collapse of the capelin stock and were also relatively low in 1990-1991 when the capelin stock was small. In recent years this relationship seems to be much weaker and have not been used for predictions. The reasons for these changes are most likely changes in the spatial distribution of capelin or uncertainties in the estimation of the capelin stock size.

No other ecosystem drivers of productivity that may affect the assessment of the Icelandic stocks assessed in this report were presented to the NWWG in 2013.

7.3 Ecosystem considerations (General)

After 1996 a rise in both temperature and salinity were observed in the Atlantic water south and west of Iceland. Temperature and salinity have remained at similar high levels since and west of Iceland amounts to an increase of temperature of about 1˚C and salinity by one unit on average (Figure 7.3.1.) and these changes can therefore be regarded as conspicuous. Off central N-Iceland, similar trends have been observed although with higher inter-annual variability. This period has been characterized with an increase of temperature and salinity in the winter north of Iceland in the last 12-14 years which is on average above 1˚C and 1 salinity units. (Figure 7.3.2)

It appears that these changes in seawater temperature have had considerable effects on the spatial distribution of fish species in Icelandic waters with many species now found further northwards. The most obvious examples of such changes is the increased abundance of haddock, mackerel, whiting, monkfish, lemon sole and witch in the mixed water area north of Iceland.

On the other hand, coldwater species like Greenland halibut and northern shrimp have become scarcer. Capelin have shifted their larval drift and nursing areas westwards to the colder waters off E-Greenland. Furthermore, the arrival of adult capelin to the over-wintering grounds on the outer shelf off N-Iceland has been delayed and migration routes to the spawning grounds off S- and W-Iceland are currently located farther off N- and E-Iceland and do not reach as far west along the south coast as was the rule in most earlier years (Figure 7.3.3. and 7.3.4.). These changes in the spatial distribution patterns of capelin may have had an effect on the growth rate of various predators, as is reflected in low weight of cod in recent years.

There is one demersal stock, which apparently has not taken advantage, or not been able to take advantage, of the milder marine climate of Icelandic waters. This is the Icelandic cod, which was very abundant during the last warm epoch, which began around 1920 and lasted until 1965. By the early 1980s the cod stock had been fished down to much lower levels as compared to previous decades and has remained relatively low since. During the last 20 years the Icelandic cod stock has not produced a large year class and the average number of age 3 recruits in the last 20 years is about 150 million fish per annum, as compared to 205-210 recruits in almost any period prior to that, even during the ice years of 1965-1971. Immigrants from Greenland are not included in this comparison. It is not possible to pinpoint exactly what has caused this change, but a very small and young spawning stock is the most obvious common denominator for this protracted period of impaired recruitment to the Icelandic cod stock. Regulations, particularly the implementation of the catch rule in 1993 have resulted in lower fishing mortalities in the last ten years when compared with the years prior to 2000. Further, despite the overall low recruitment, this reduction in fishing mortality has almost resulted in almost doubling of the spawning stock biomass. This increase in the SSB biomass has however not resulted in significant increase in recruitment in recent years, although year classes 2008 and 2009 are now estimated around average size.

Associated with the large warming of the 1920s, was a well documented drift of larval and 0-group cod as well as some other fish species, from Iceland across the northern Irminger Sea to East and then West-Greenland. Although many of these fish apparently returned to Iceland to spawn and did not leave again, there is little doubt that the cod, remaining in West-Greenland waters which also had warmed, were instrumental in establishing a self-sustaining Greenlandic cod stock that eventually became very large. It seems that significant numbers of cod of the 2003 year class have drifted across to Greenland in that year. Tag returns, survey estimates in Greenlandic waters as well as anomalies in the catch-at-age matrix in Iceland indicate that a portion of the moderate 2003 year class that has been observed in Greenlandic waters in recent years may have migrated to Icelandic waters in 2009.

7.4 Description of fisheries [Fleets]

Only Icelandic vessels are considered in the following analysis since they constitute the largest operational players in Icelandic waters. Few trawlers and longliners of other nationalities operate in the Icelandic region principally targeting deep-sea redfish, cod, tusk, ling and, with some bycatch of other species. Additionally some limited pelagic fishery of foreign boats on capelin, herring and blue whiting also takes place in Icelandic waters.

The data sources used in this section are landings, boat, log book and discard databases. Landings of species by each boat and gear are effectively available electronically in real time (end of day of landing). Log-book statistics are generally available in a centralized database about 1 month after the day of fishing operation. Since 2009 increasing proportion of vessels are using electronic logbooks. Fisheries scientists have direct access to the logbook database.

The Icelandic fishing fleet can be characterised by the most sophisticated technological equipment available in this field. This applies to navigational techniques and fish-detection instruments as well as the development of more effective fishing gear. The most significant development in recent years is the increasing size of pelagic trawls and with increasing engine power the ability to catch pelagic fishes at greater depths than previously possible. There have also been substantial improvements in recent decades with respect to technological aspects of other gears such as bottom trawl, longline and handline. Each fishery uses a variety of gears and some vessels frequently shift from one gear to another within each year. The most common demersal fishing gear are otter trawls, longlines, seines, gillnets and jiggers while the pelagic fisheries use pelagic trawls and purse seines. The total recorded landings of the Icelandic fleets in 2010 amounted to around 1 million tonnes where pelagic fishes amounted to 0.5 million tonnes. Spatial distributions of the catches are shown in figure 7.4.1. Detailed information of landings by species and gear type are given in Table 7.1. Spatial overviews of the removal of the some important species by different gear are given in Figures 7.4.2. – 7.4.5.

A simple categorization of boats among the different fisheries types is impossible as many change gear depending on fish availability in relation to season, quota status of the individual companies, fish availability both in nature and on the quota exchange market, market price, etc. E.g. larger trawl vessels may operate both on demersal species using bottom trawls as well as using purse seine and pelagic trawls on pelagic species. Total number of vessels within each fleet category in 2010 is thus limited to the broad categories given below:

Type	No. vessels1)	Gear type used
Trawlers	57	Pelagic and bottom trawl
Vessels > 100 t	140	Purse seine, longline, trawl, gillnet
Vessels < 100 t	621	Gillnet, longline, danish seine, trawl, jiggers
Open boats	807	Jiggers, longliners (including recreational fishers)
Total	1625	
1)Source: Statistic Iceland - http://www.statice.is/		

The demersal fisheries take place all around Iceland including variety of gears and boats of all sizes. The most important fleets targeting them are:

Large and small trawlers using demersal trawl. This fleet is the most important one fishing cod, haddock, saithe, redfish as well as a number of other species. This fleet is operating year around; mostly outside 12 nautical miles from the shore.

Boats (< 300 GRT) using gillnet. These boats are mostly targeting cod but haddock and a number of other species are also target. This fleet is mostly operating close to the shore.

Boats using longlines. These boats are both small boats (< 10 GRT) operating in shallow waters as well as much larger vessels operating in deeper waters. Cod and haddock are the main target species of this fleet but a number other species are also caught, some of them in directed fisheries.

Boats using jiggers. These are small boats (<10 GRT). Cod is the most important target species of this fleet with saithe of secondary importance.

Boats using Danish seine. (20-300 GRT) Cod, haddock and variety of flatfishes, e.g. plaice, dab, lemon sole and witch are the target species of this fleet.

Although different fleets may be targeting the main species the spatial distribution of effort may different. In general it can be observed that the bottom trawl fleet is fishing in deeper waters than the long line fleet (Figures 7.4.6. and 7.4.7).

The pelagic fisheries targeting capelin, herring, blue whiting and mackerel is almost exclusively carried out by larger vessels. The fisheries in Icelandic waters for capelin and herring are carried out using both purse seine and pelagic trawl while that of blue whiting and mackerel is exclusively carried out with pelagic trawl. Additionally a significant part of the pelagic fisheries of the Icelandic fleet is caught outside the Icelandic EEZ, both on the Atlanto-Scandian herring and on blue whiting.

7.5 Regulations

The Ministry of Fisheries is responsible for management of the Icelandic fisheries and implementation of the legislation. The Ministry issues regulations for commercial fishing for each fishing year, including an allocation of the TAC for each of the stocks subject to such limitations. Below is a short account of the main feature of the management system.

7.5.1 The ITQ system

A system of transferable boat quotas was introduced in 1984. The agreed quotas were based on the Marine Research Institute's TAC recommendations, taking some socio-economic effects into account. Until 1990, the quota year corresponded to the calendar year but since then the quota, or fishing year, starts on September 1 and ends on August 31 the following year. This was done to meet the needs of the fishing industry. In 1990, an individual transferable quota (ITQ) system was established for the fisheries and they were subject to vessel catch quotas. Since 2006/2007 fishing season, all boats operate under the TAC system.

With some minor exceptions it is required by law to land all catches. Consequently, no minimum landing size is in force. To prevent fishing of small fish various measures such as mesh size regulation and closure of fishing areas are in place (see below).

Within this system individual boat owners have substantial flexibility in exchanging quota, both among vessels within individual company as well as among different companies. The latter can be done via temporary or permanent transfer of quota. In addition, some flexibility is allowed by individual boats with regard to transfer allowable catch of one species to another. These measures, which can be acted on more or less instantaneously, are likely to result in lesser initiative to discards and misreporting than can be expected if individual boats are restricted by strict TAC measures alone. They may however result in fishing pressures of individual species to be different than intended under the single species TAC allocation.

7.5.2 Mesh size regulations

With the extension of the fisheries jurisdiction to 200 miles in 1975, Iceland introduced new measures to protect juvenile fish. The mesh size in trawls was increased from 120 mm to 155 mm in 1977. Mesh size of 135 mm was only allowed in the fisheries for redfish in certain areas. Since 1998 a minimum mesh size of 135 is allowed in the codend in all trawl fisheries not using "Polish cover" and in the Danish seine fisheries. For the gillnet fishery both minimum and maximum mesh-sizes are restricted. Since autumn 2004 the maximum allowed mesh-size in the gillnet fishery is 8 inches. The objective of this measure is to decrease the effort directed towards bigger spawners.

7.5.3 Area closures

Real time area closure: A quick closure system has been in force since 1976 with the objective to protect juvenile fish. Fishing is prohibited for at least two weeks in areas where the number of small fish in the catches has been observed by inspectors to exceed certain percentage (25% or more of <55 cm cod and saithe, 25% or more of <45 cm haddock and 20% or more of <33 cm redfish). If, in a given area, there are several consecutive quick closures the Minister of Fisheries can with regulations close the area for longer time forcing the fleet to operate in other areas. Inspectors from the Directorate of Fisheries supervise these closures in collaboration with the Marine Research Institute. In 2010, 113 such closures took place:

Permanent area closures: In addition to allocating quotas on each species, there are other measures in place to protect fish stocks. Based on knowledge on the biology of various stocks, many areas have been closed temporarily or permanently aiming at protect juveniles. Figure 7.5.1. shows map of such legislation that was in force in 2004. Some of them are temporarily, but others have been closed for fishery for decades.

Temporary area closures: The major spawning grounds of cod, plaice and wolfish are closed during the main spawning period of these species. The general objectives of these measures, which were in part initiated by the fishermen, are to reduce fishing during the spawning activity of these species.

7.5.4 Discards

Discarding measurements have been carried out in Icelandic fisheries since 2001, based on extensive data collection and length based analysis of the data (Pálsson 2003). The data collection is mainly directed towards main fisheries for cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) and towards saithe (*Pollachius virens*) and golden redfish (*Sebastes marinus*) fisheries in demersal trawl and plaice in Danish seine. Sampling for other species is not sufficient to warrant a satisfactory estimation of discarding. The discard rate for cod has been in the range of 0.2-2.2% of the reported landings over the time investigated (Figure 7.5.2.). The discard estimates for haddock are somewhat higher ranging between 0.7-5% annually. Discarding of saithe and golden redfish has been negligible over time period of investigation. Estimates of discards of cod and haddock in 2010 by individual fleets are given in table 7.2. These relatively low discard rates compared to what is generally assumed to be a side effect of a TAC system may be a result of the various measures, including the flexibility within the Icelandic ITQ system (see above). Since the time series of discards is relatively short it is not included in the assessments.

All catch that is brought ashore must by law be weighted by a licensed body. The monitoring and enforcement is under the realm of the Directorate of Fisheries. Under the TAC system there are known incentives for misreporting, both with regards to the actual landings statistics as well as with regards to the species recorded. This results in bias in the landings data but detailed quantitative estimates of how large the bias may be, is not available to the NWWG. Unpublished report from the Directorate of Fisheries, partly based on investigation comparing export from fish processing plants with the amount of fish weighted in the landing process indicate that this bias may be of the order of single digit percentages and not in double digits.

7.6 Mixed fisheries, capacity and effort

A number of species caught in Icelandic waters are caught in fisheries targeting only one species, with very little bycatch. These include the pelagic fisheries on herring, capelin and blue whiting (see however below), the Greenland halibut fishery in the west and southeast of Iceland and the *S. mentella* fishery. Advice given for these stocks should thus not influence the advice of other stocks.

Other fisheries, particularly demersal fisheries may be classified as more mixed, where a target species of e.g. cod, haddock, saithe or *S. marinus* may be caught in a mixture with other species in the same haul/setting (Figure 7.6.1.). Fishermen can however have a relatively good control of the relative catch composition of the different species. E.g. the saithe fishery along the shelf edge is often in the same areas as the redfish fisheries: Fleets are often targeting at redfish during daytime and saithe during nights. Therefore the fishery for one of those species is relatively free of bycatch of the other species even though they take place in the same area. Small differences in the location of setting are also known to affect the catch composition. This has for example been documented in the long line fisheries in Faxabay, where in adjacent areas cod catches and wolfish catches are known to consistently dominate the catches in individual setting. There are however numerous species in Icelandic waters that can be classified as "bycatch species" in some fisheries. E.g. in the bottom trawl fisheries 75 % of the annual plaice yield is caught in hauls where plaice is minority of the catches. In a proper fisheries based advice taking mixed fisheries issues into account, such stocks may have a greater influence on the advice on the main stocks that are currently assessed by ICES than fisheries linkage among the latter.

In the pelagic fisheries catch other than the targeted species is considered rare. In some cases juveniles of other species are caught in significant numbers. When observers are on board or when fishermen themselves provide voluntary information, the fishing areas have in such cases been closed for fishing, temporarily or permanently. By catch of adults of other species in the blue whiting fishery have been estimated (Pálsson 2005).

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Table 7.1 Overview of the 2010 landings of fish and marine invertebrates caught by the Icelandic fleet categorized by gear types. Based on landing statistics from the Directorate of Fisheries. Landings are given in thous. tonnes.

Species/gear	Long line	Gillnets	Jiggers	Danish seine	Bottom trawl	Nephros trawl	Pelagic trawl	Purse seine	Shrimp trawl	Dredge	Other	Total
Herring	0.000	0.000	0.000	0.000	0.112	0.000	213.528	40.836	0.000	0.000	0.000	254.476
Cod	57.493	16.552	3.721	8.285	82.996	1.581	0.923	0.009	1.006	0.000	0.784	173.349
Mackerel	0.000	0.001	0.180	0.000	0.164	0.000	121.680	0.001	0.000	0.000	0.000	122.028
Capelin	0.000	0.000	0.000	0.000	0.000	0.000	3.187	112.328	0.000	0.000	0.000	115.515
Blue whiting	0.000	0.000	0.000	0.000	0.124	0.000	87.784	0.000	0.000	0.000	0.000	87.908
Haddock	23.916	0.380	0.012	10.137	29.481	0.212	0.630	0.000	0.041	0.000	0.028	64.836
Saithe	0.594	4.453	2.383	1.093	42.441	0.404	1.216	0.000	0.007	0.000	0.068	52.660
Golden redfish	1.080	0.194	0.058	0.513	35.777	0.932	0.594	0.000	0.014	0.000	0.014	39.176
Pearlside	0.000	0.000	0.000	0.000	0.000	0.000	17.912	0.000	0.000	0.000	0.000	17.912
Atlantic argentine	0.000	0.000	0.000	0.000	16.321	0.001	0.256	0.000	0.000	0.000	0.000	16.579
Golden redfish	0.000	0.000	0.000	0.000	1.921	0.000	12.872	0.000	0.000	0.000	0.000	14.794
Deepwater redfish	0.052	0.002	0.000	0.000	14.149	0.000	0.181	0.000	0.000	0.000	0.000	14.384
Greenland halibut	0.033	0.000	0.000	0.000	12.147	0.000	0.263	0.000	0.861	0.000	0.001	13.305
Atlantic catfish	6.915	0.020	0.002	1.032	4.490	0.083	0.033	0.000	0.000	0.000	0.027	12.602
Ling	6.529	0.363	0.011	0.404	1.538	0.981	0.011	0.000	0.000	0.000	0.028	9.865
Shrimp	0.000	0.000	0.000	0.000	0.000	0.000	0.155	0.000	7.607	0.000	0.000	7.762
Tusk	6.760	0.052	0.003	0.000	0.093	0.005	0.000	0.000	0.000	0.000	0.001	6.915
Blue Lling	3.978	0.091	0.000	0.092	1.901	0.283	0.013	0.000	0.002	0.000	0.015	6.375
Plaice	0.105	0.118	0.006	3.640	2.020	0.003	0.015	0.000	0.001	0.000	0.077	5.984
Monkfish	0.079	0.176	0.001	0.430	0.452	0.556	0.000	0.000	0.001	0.000	1.586	3.281
Whiting	0.425	0.030	0.002	0.191	2.037	0.155	0.000	0.000	0.001	0.000	0.001	2.842
Redfish	0.001	0.000	0.000	0.000	2.446	0.000	0.154	0.000	0.000	0.000	0.000	2.601
Nephrops	0.000	0.000	0.000	0.000	0.000	2.541	0.000	0.000	0.000	0.000	0.000	2.541
Sea cucumber	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.246	0.000	2.246
Lumpfish roe	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.133	2.135
Lemon sole	0.000	0.002	0.001	0.992	0.886	0.078	0.007	0.000	0.000	0.000	0.001	1.968
Leopardfish	1.045	0.003	0.000	0.004	0.805	0.002	0.022	0.000	0.037	0.000	0.003	1.922
Witch	0.000	0.000	0.000	0.733	0.075	0.514	0.000	0.000	0.000	0.000	0.002	1.325
Starry ray	0.776	0.005	0.000	0.188	0.057	0.001	0.000	0.000	0.001	0.000	0.001	1.029
Common dab	0.007	0.002	0.004	0.574	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.612
Halibut	0.377	0.004	0.000	0.034	0.114	0.014	0.001	0.000	0.000	0.000	0.008	0.552
Lumpfish	0.000	0.017	0.001	0.002	0.002	0.000	0.037	0.000	0.000	0.000	0.333	0.391
Megrim	0.000	0.000	0.000	0.089	0.052	0.111	0.000	0.000	0.000	0.000	0.000	0.252
Long rough dab	0.009	0.004	0.000	0.173	0.031	0.000	0.000	0.000	0.001	0.000	0.000	0.220
Sea-urchins	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.146	0.000	0.146
European whelk	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.142	0.142
Skate	0.042	0.007	0.000	0.026	0.024	0.008	0.000	0.000	0.000	0.000	0.009	0.117
Black scabbard-fish	0.002	0.000	0.000	0.000	0.107	0.000	0.000	0.000	0.000	0.000	0.000	0.109
Boston hake	0.109	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.109
Blue mussel	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.077	0.000	0.077
Dogfish	0.011	0.039	0.000	0.004	0.006	0.000	0.000	0.000	0.000	0.000	0.002	0.062
Rat-tail	0.000	0.000	0.000	0.000	0.058	0.000	0.001	0.000	0.000	0.000	0.000	0.059
Squid	0.000	0.000	0.000	0.000	0.000	0.000	0.051	0.000	0.000	0.000	0.000	0.051
Greenland shark	0.000	0.000	0.000	0.000	0.043	0.000	0.000	0.000	0.000	0.000	0.000	0.043
Norway pout	0.000	0.000	0.000	0.000	0.000	0.000	0.039	0.000	0.000	0.000	0.000	0.039
onioin eye	0.000	0.000	0.000	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.023
Fuller's ray	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019
Arctiv wolffish	0.000	0.000	0.000	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.017
sailray	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012
Deal fish	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.011
Gurnard	0.000	0.000	0.000	0.001	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.010
Black dogfish	0.001	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.010
Total	**110.370**	**22.520**	**6.386**	**28.638**	**252.947**	**8.466**	**461.586**	**153.175**	**9.579**	**2.470**	**5.263**	**1,061.401**

Table 7.2. Estimates of discard of cod and haddock in the Icelandic fisheries in 2008. Source: Ólafur K. Pálsson, Höskuldur Björnsson, Eyþór Björnsson, Guðmundur Jóhannesson og Þórhallur Ottesen 2009. Discards in demersal Icelandic fisheries 2009. Marine Research Institute, 2009, report series no. 154 .

	Gear	*Landings (tonnes)*	*Discards*		
			Numbers (thous.)	*Weight (tonnes)*	% Weight
COD	Longline	61008	509	308	0.51
	Gillnet	21859	0	0	0.00
	Danish Seine	10369	28	18	0.18
	Bottom trawl	77172	690	635	0.82
	Total	**170408**	**1227**	**961**	**0.56**
HADDOCK	Longline	26573	155	79	0.30
	Danish Seine	15126	36	9	0.06
	Bottom trawl	38822	1042	465	1.20
	Total	**808521**	**1233**	**553**	**0.69**

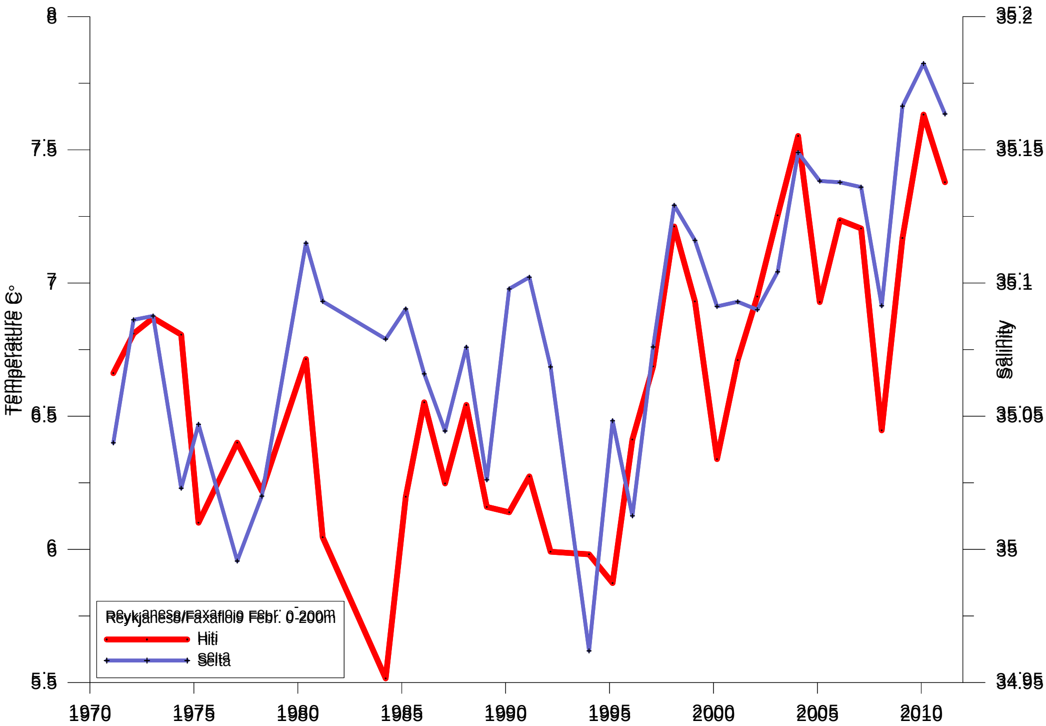

Figure 7.3.1. Temperature and salinity in winter west of Iceland 1971-2011. Mean 0-200m

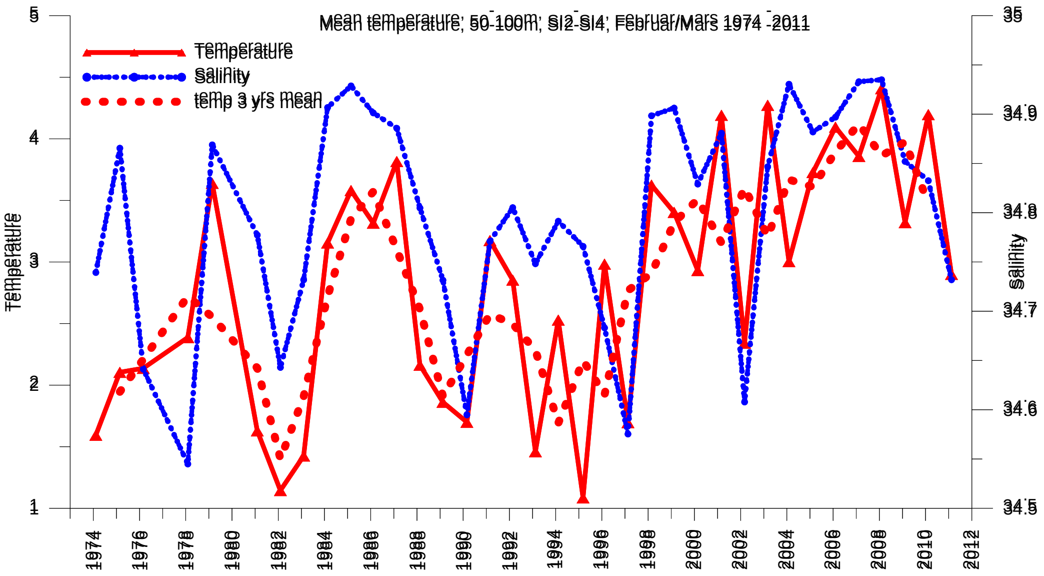

Figure 7.3.2. Temperature and salinity off central North-Iceland 1974-2011.

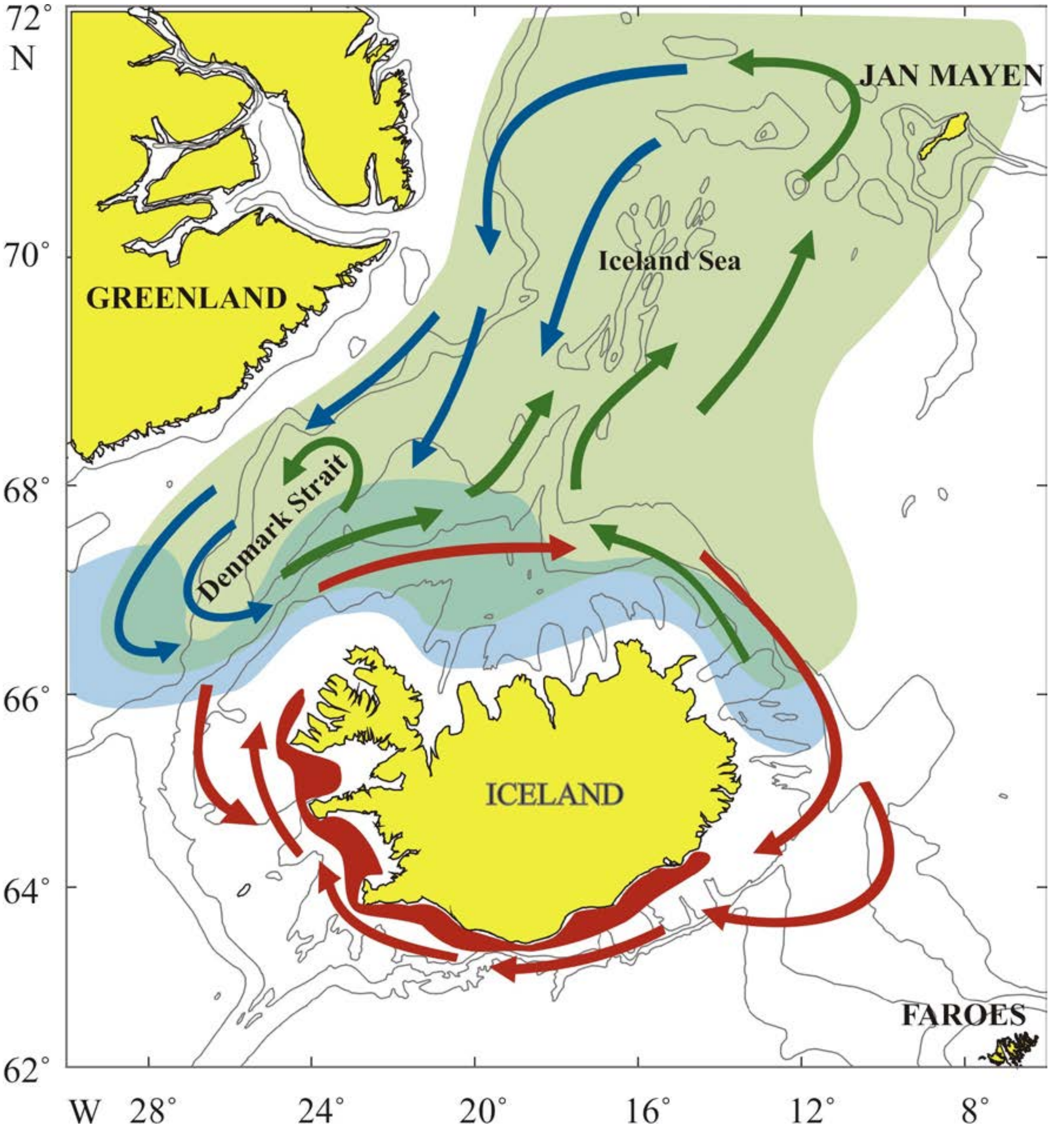
72°
N
70°
68°
66°
64°
62°
W 28°
24°
20°
16°
12°
8°
GREENLAND
JAN MAYEN
Iceland Sea
Denmark Strait
ICELAND
FAROES

Figure 7.3.3. Distribution and migrations of capelin in the Iceland/East-Greenland/Jan Mayen area before 2001. Red: Spawning grounds; Green: Adult feeding area; Blue: Distribution and feeding area of juveniles; Green arrows: Adult feeding migrations; Blue arrows: Return migrations; Red arrows: Spawning migrations; Depth contours are 200, 500 and 1000 m (Vilhjalmsson 2002)

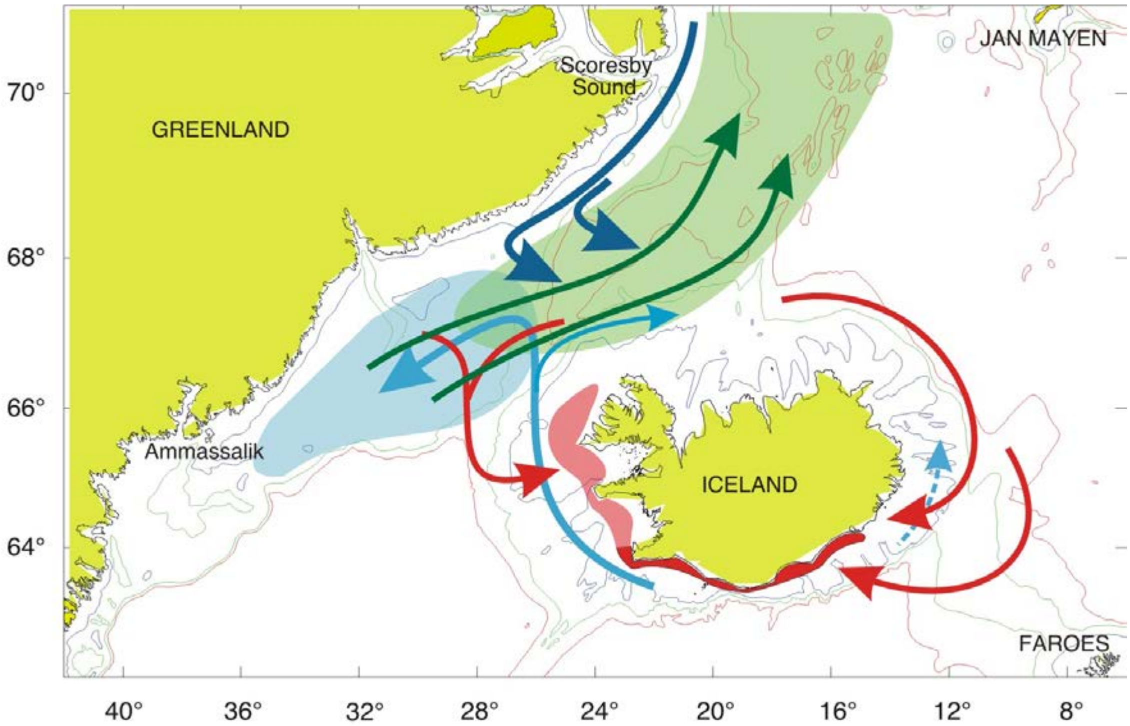

Figure 7.3.4. Likely changes of distribution and migration routes of capelin in the Iceland/Greenland/Jan Mayen area in the last 3-4 years. Green: Feeding area; Light blue: Juvenile area; Red area: Main spawning grounds; Lighter red colour: Lesser importance of W-Iceland spawning areas; Light blue arrows: Larval drift; Dark green arrows: Feeding migrations; Dark blue arrows: Return migrations; Red arrows: Spawning migrations. Depth contours are 200, 500 and 1000 m.

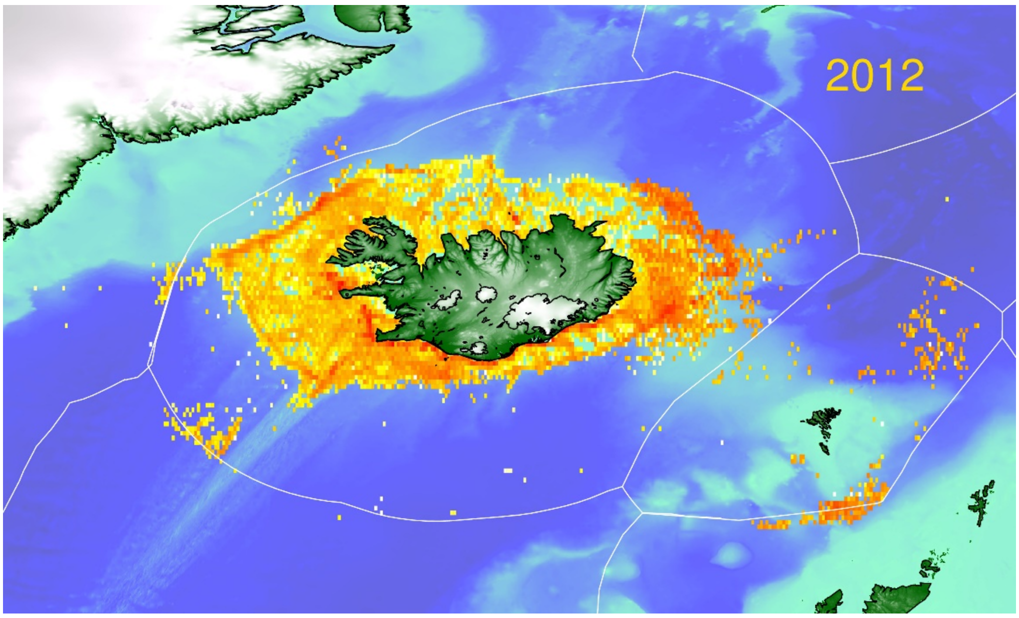

Figure 7.4.1. Distribution of total catch of all species by the Icelandic fishing fleet in Icelandic EEZ and adjacent waters in 2012. The EEZs are shown as white lines.

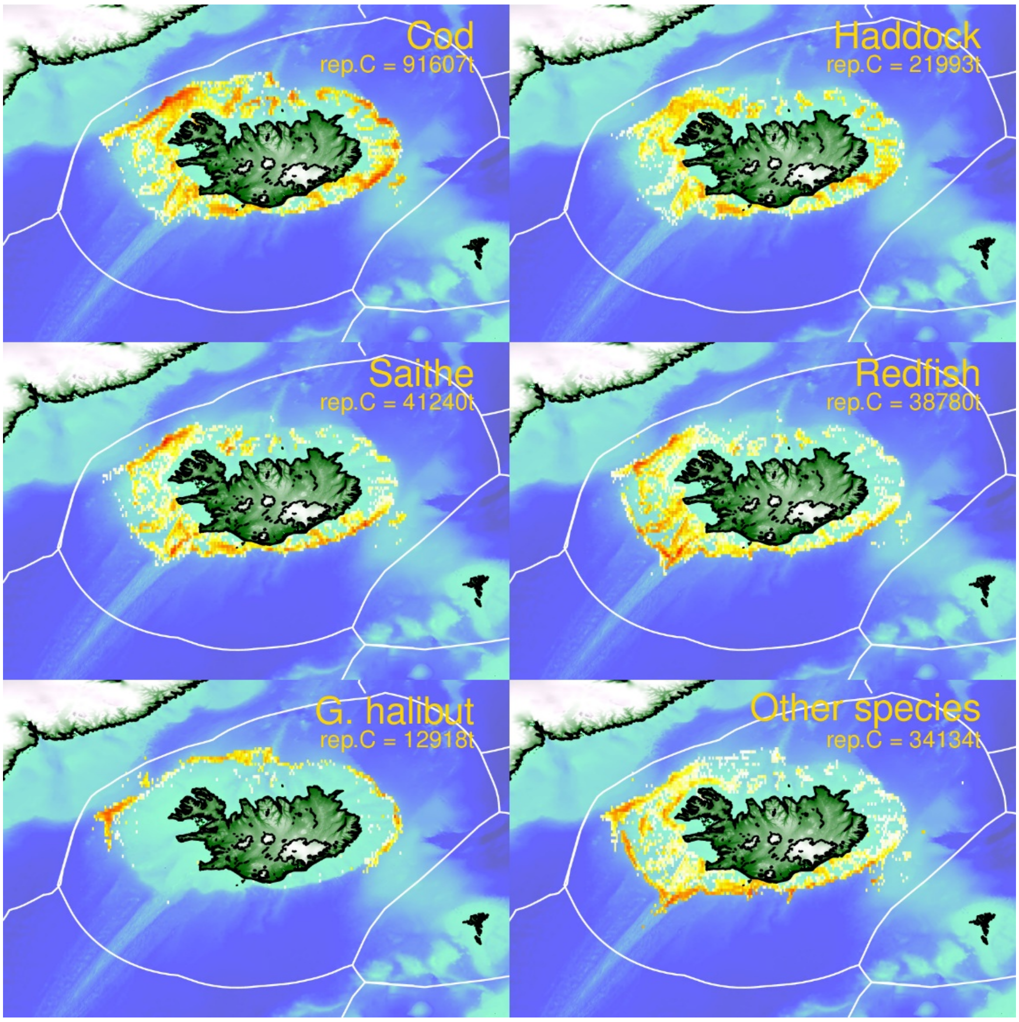

Figure 7.4.2. Location of catches of cod, saithe, haddock, redfish, Greenland halibut and others caught with bottom trawl in 2012.

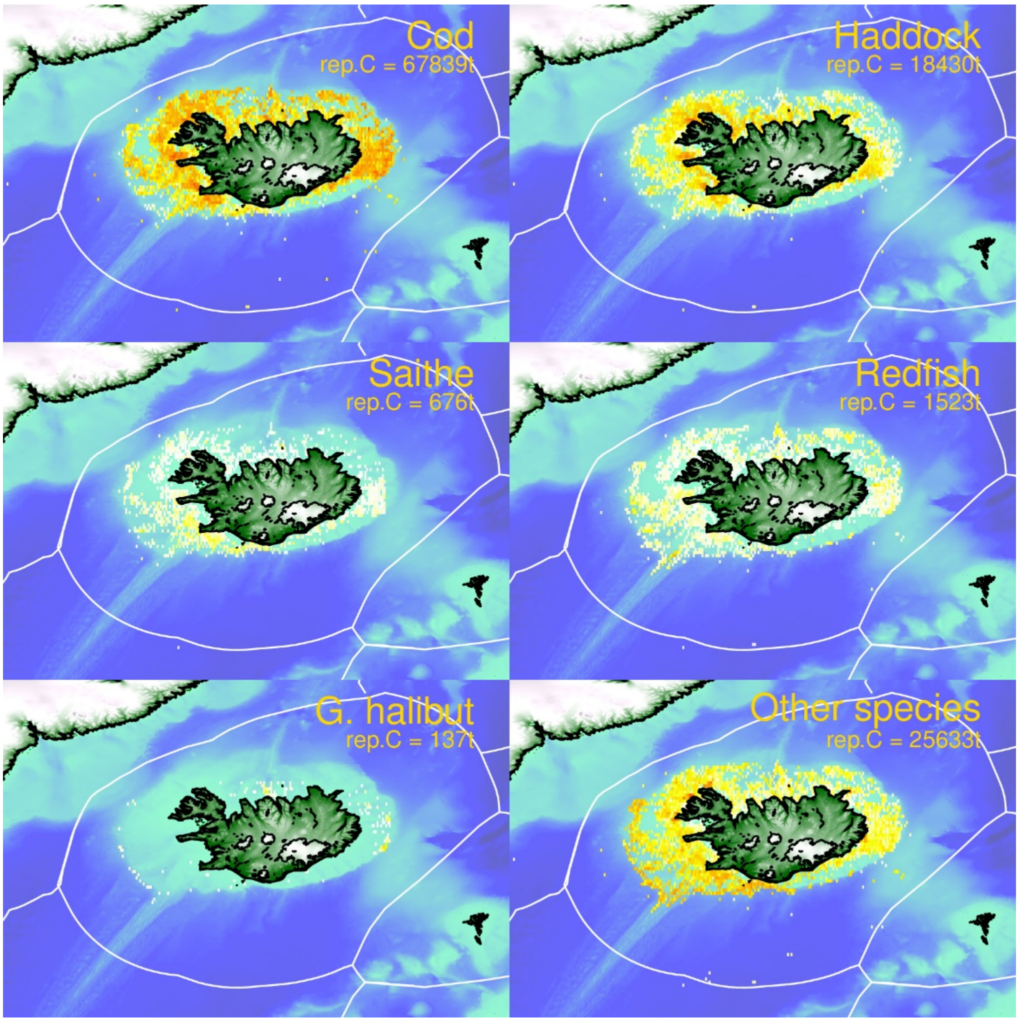

Figure 7.4.3. Location of catches of cod, saithe, haddock, redfish, Greenland halibut and others caught with long-line in 2012.

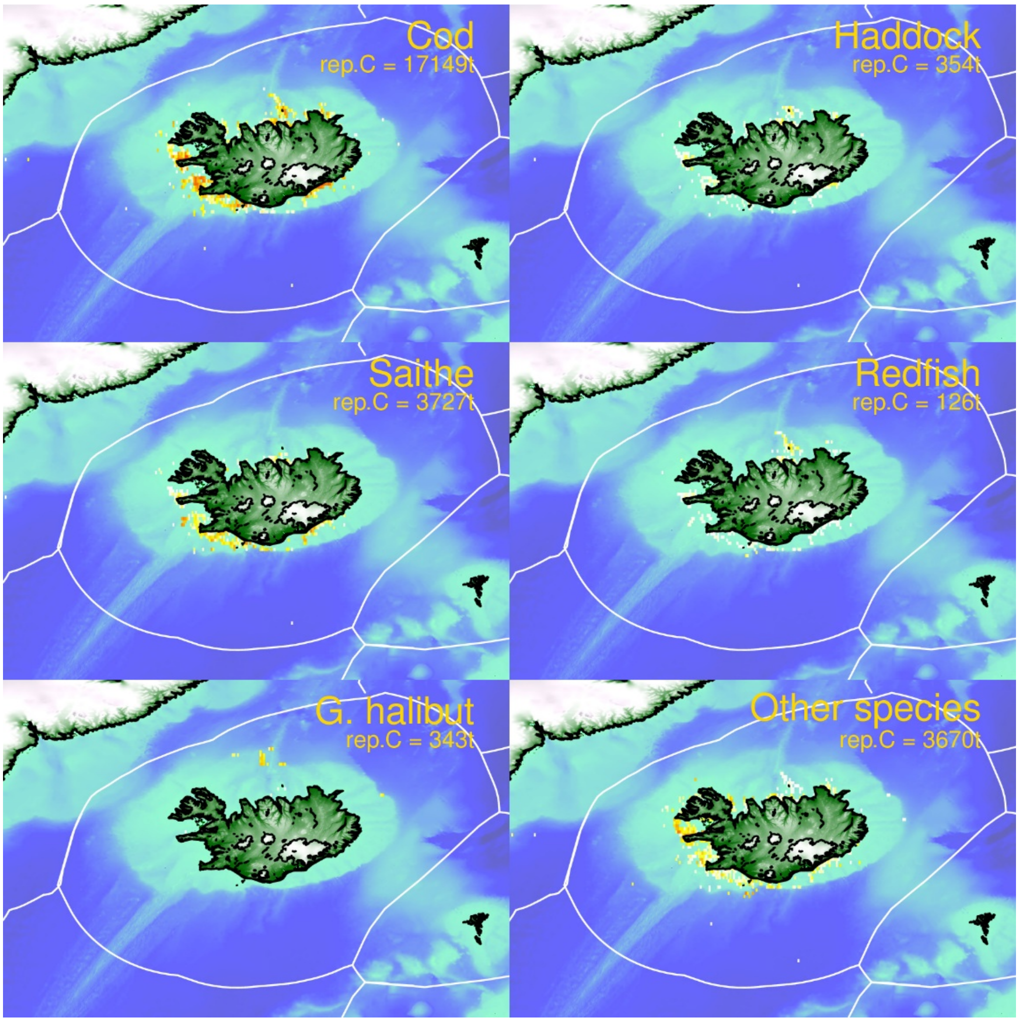

Figure 7.4.4. Location of catches of cod, saithe, haddock, redfish, Greenland halibut and others caught with gillnets in 2012.

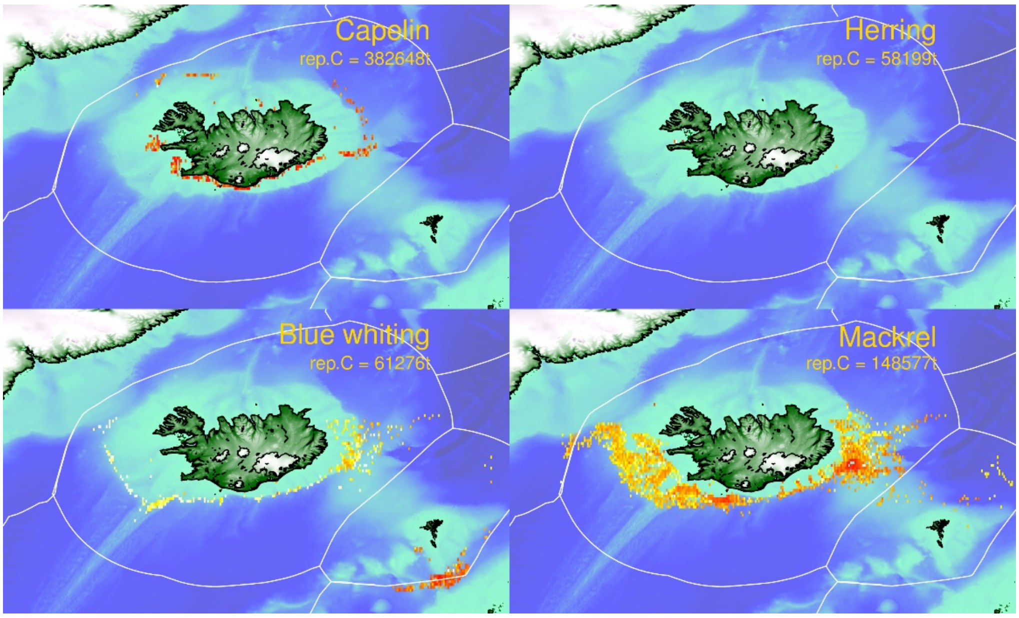

Figure 7.4.5. Location of catches of capelin, Icelandic summer spawning herring, blue whiting and mackerel with purse seine and pelagic trawls in 2012.

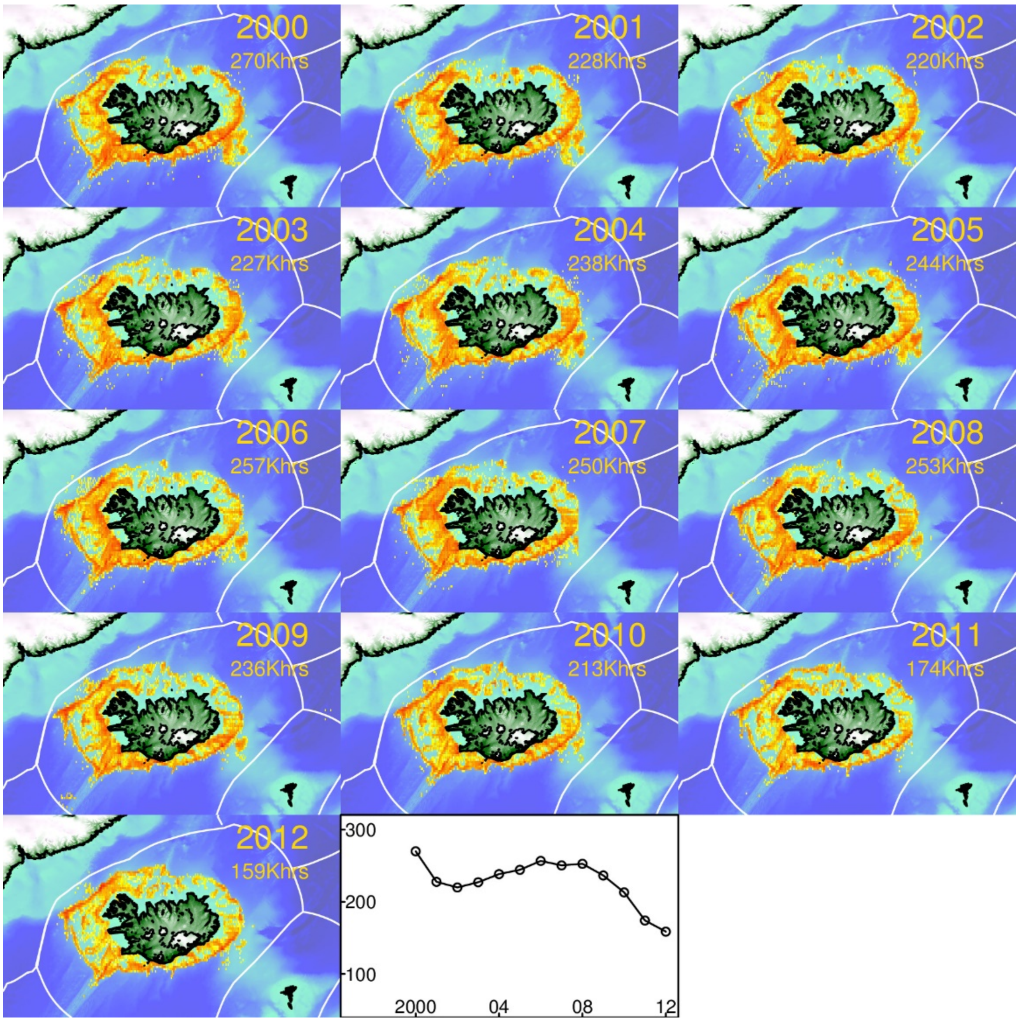

Figure 7.4.6 Spatial distribution of the trawler fleet effort (in hours trawled) in 2000-2012 and as a time-series.

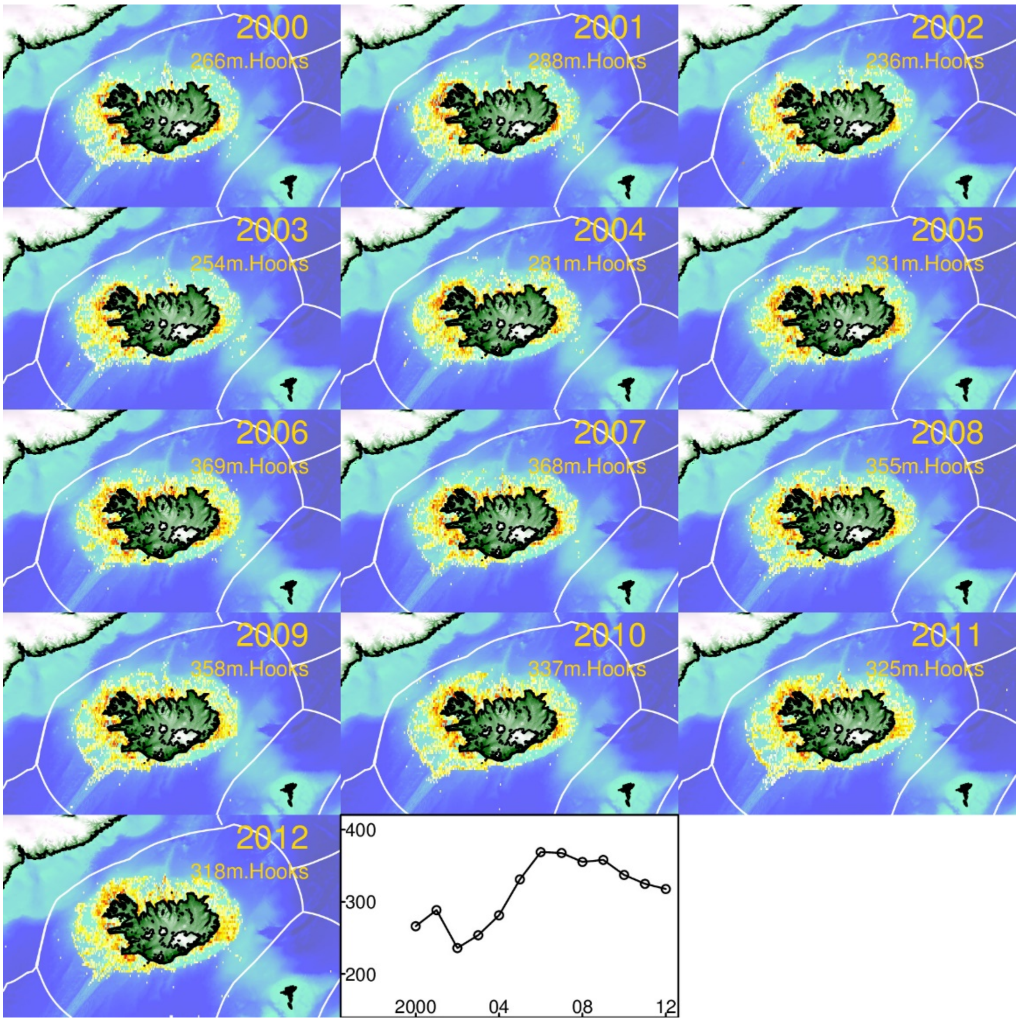

Figure 7.4.7. Spatial distribution of the longlinefleet effort (in number of hooks) in 2000-2012. The main targeted species for longline fishing are cod, haddock, catfish, tusk, ling and blue ling.

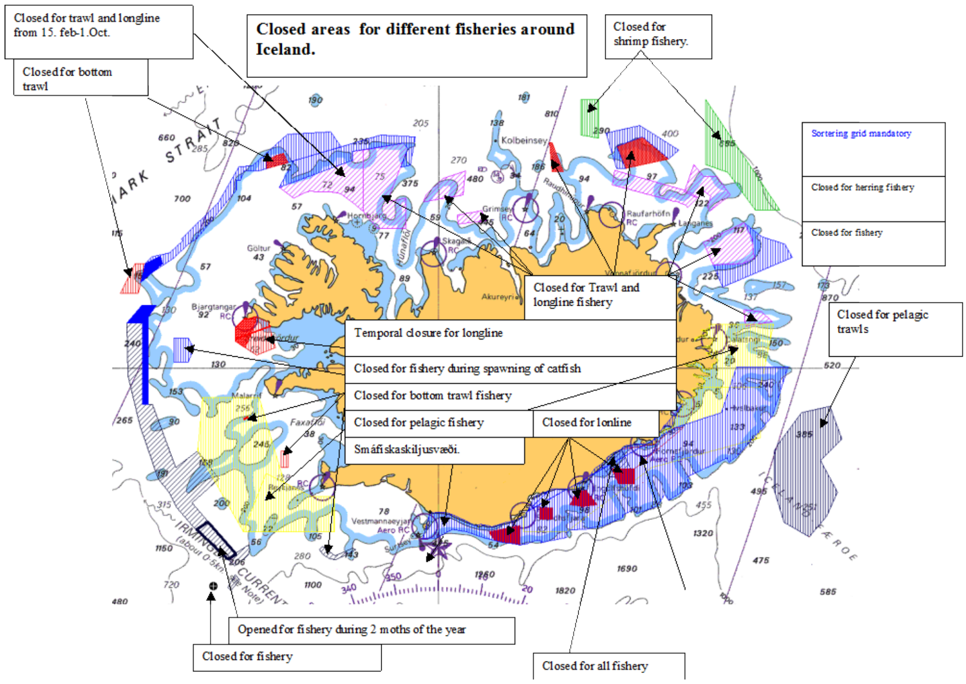

Figure 7.5.1. Overview of closed areas around Iceland in 2006 . The boxes are of different nature and can be closed for different time period and gear type.

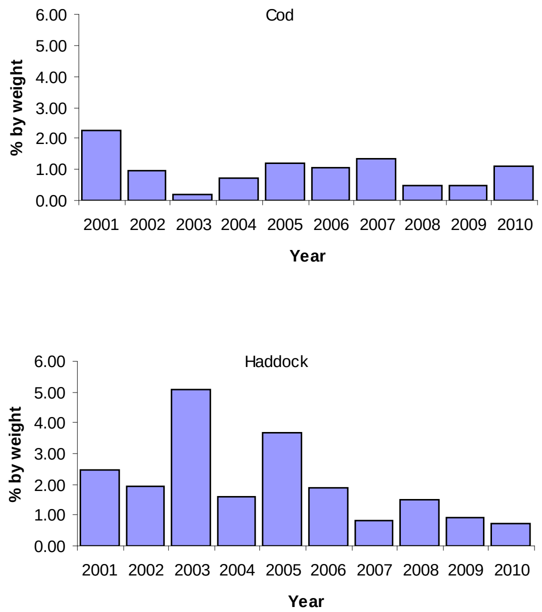

Figure 7.5.2. Estimates of discard percentage by weight for cod and haddock. Source: Ólafur K. Pálsson, Höskuldur Björnsson, Eyþór Björnsson, Guðmundur Jóhannesson , og Þórhallur Ottesen 2009. Discards in demersal Icelandic fisheries 2009. Marine Research Institute, report series Nr. 154. 2010 figures are preliminary .

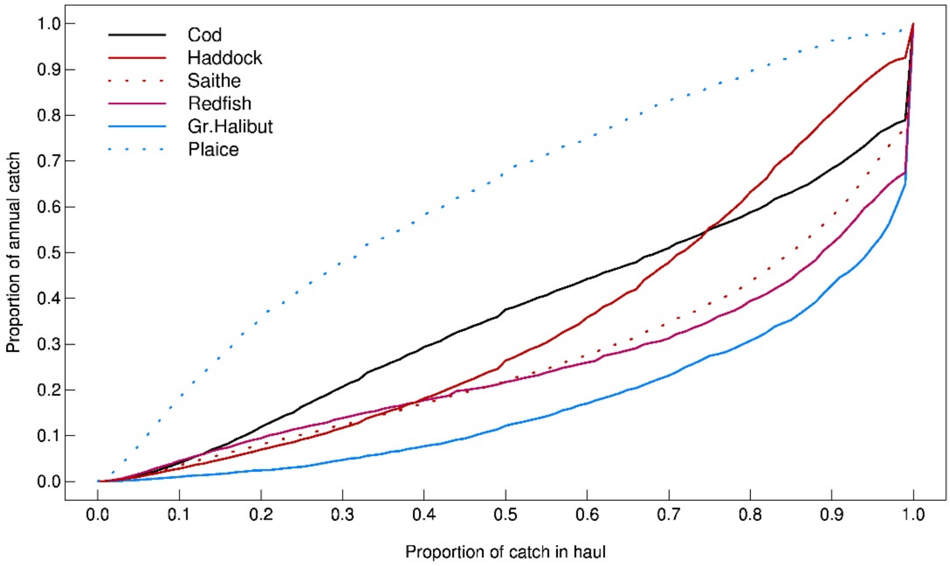

Figure 7.6.1. Cumulative plot for bottom trawl in 2008. An example describes this probably best. Looking at the figure above it can be seen from the dashed lines that 30% of the catch of haddock comes from hauls where haddock is less than 60% of the total catch while only 4% of the catch of greenland halibut comes from hauls where it is less than 50% of the total catch. 75 % of the plaice is on the other hand caught in hauls where plaice is minority of the catches. The figures also shows that 70% of the catch of greenland halibut comes from hauls where nothing else is caught but only 10% of the haddock. Of the species shown in the figure plaice is the one with largest proportion as bycatch while greenland halibut is the one with largest proportion caught in mixed fisheries.

8 Icelandic saithe

8.1 Summary

- The 2014 reference biomass (B_{4+}) is estimated as 296 kt, above the average in the assessment period (1980 to the present). The spawning biomass is estimated as 150 kt, around the highest level in the assessment period and well above $B_{trigger}$ = 65 kt and B_{lim} = 61 kt.
- According to the assessment model, the reference biomass increased by almost a third between 2009 and 2014, while harvest rate decreased from 27% to 19% (fishing mortality 0.30 to 0.23). Year classes 1999-2000 and 2002 were large, but recruitment since then has been around average.
- Weights of ages 6-9 have increased in recent years towards the average, but other ages are below average weight. Maturity at ages 4-9 has decreased in recent years and is currently around average.
- The assessment model is a separable statistical catch-at-age model implemented in AD Model Builder. Selectivity is age-specific and varies between three periods: 1980-1996, 1997-2003, and 2004 onwards.
- here is some discrepancy between the default separable model and alternative assessment models (ADAPT, TSA, SAM), but the difference is smaller than in recent assessments.
- In spring 2013, the Icelandic government adopted a harvest control rule for managing the Icelandic saithe fishery, evaluated by ICES (Hjorleifsson and Bjornsson 2013). It is similar to the 20% rule used for the Icelandic cod fishery. When the population is above $B_{trigger}$, the TAC set in year t equals the average of 0.2 B_{4+} in year t and last year's TAC.
- According to the adopted harvest control rule, the TAC will be 58 kt in the next fishing year.

8.2 Stock description and management units

Description of the stock and management units is provided in the stock annex.

8.3 Fisheries-dependent data

8.3.1 Landings, advice and TAC

Landings of saithe in Icelandic waters in 2013 are estimated to have been 58 002 t (Table 8.1 and Figure 8.1). Of the landings, 48 490 t were caught by trawl, 3 103 t by gillnets, and 6 409 t caught by other fishing gear. The domestic as well as ICES advice for the fishing year 2013/2014 was based on the 20% harvest control rule and was 57 kt. The TAC issued was also 57 kt. The trajectory of the landings in the current fishing year and calendar year is shown in Figure 8.2.

Most of the catch is caught in bottom trawl (79% in 2009-2013), with gillnet and jiggers taking the majority of the rest. The share taken by the gillnet fleet was larger in the past, 25% in 1982-1996 compared to 9% in 1997-2013 (Figure 8.1).

8.3.2 Landings by age

Catch in numbers by age based on landings are listed in Table 8.2. Discarding is not considered to be a problem in the Icelandic saithe fisheries, for which monitoring programmes have been in place (annual reports by Palsson et al. 2003 and later). Comparison of sea and harbour samples indicate that discards have been small in most years since 2000. The sea samples constitute about 60-70% of the length samples used in the calculation of the catch in number. Since the amount of discards is likely to be small, not taking discards into account in the total catches and catch in numbers is not considered to have major effect on the stock assessment.

The sampling program and sampling intensity in 2013, as well as the approach used for calculating catch in numbers, is similar to preceding years. The exception is that factory trawlers are no longer sampled, which reduces the overall the sampling intensity for bottom trawl. This reduction of bottom trawl sampling was the result of analysis of Thordarson (2012). The age and length sampling in 2013 is indicated in the following table:

Gear/nation	Landings (t)	No. of otolith samples	No. of otoliths read	No. of length samples	No. of length measurements
Gillnets	3103	9	449	9	1332
Jiggers	2946	8	400	10	1237
Danish seine	1325	2	100	5	234
Bottom trawl	47565	71	3178	221	33095
Other gear	2138	1	50	139	1662
Foreign landings	925	-	-	-	-
Total	58002	91	4177	384	37560

wo age-length keys are used to calculate catch at age, one key for the gillnet catch and another key for other gears combined. The same length-weight relationship (W = 0.02498 * L^2.75674) is applied to length distributions from both fleets.

8.3.3 Mean weight and maturity at age

Weight at age has declined rather steadily in 1980-2013, but weights of 6 to 9 year-olds have increased rapidly in recent years and are close to the long-term average (Table 8.3 and Figure 8.3). Weight at age in the landings is also used as weight at age in the stock. Weights for the current calendar year are predicted by applying a linear model using survey weights and the weight of a year class in the previous year as predictors (Magnusson 2012).

A model using maturity at age from the Icelandic groundfish spring survey (Table 8.4 and Figure 8.4) is used to derive smoothed trends in maturity by age and year (see stock annex).

8.3.4 Logbook data

Commercial CPUE indices are not used for tuning in this assessment. Although these indices have been explored for inclusion in the past, they were not considered for inclusion in the benchmark (ICES 2010), as the trends in CPUE are considered unreliable as an indicator of changes in abundance.

8.4 Scientific surveys

In the benchmark, spring survey data were considered superior to the autumn survey for calibrating the assessment. Saithe is among the most difficult demersal fishes to get reliable information on from bottom trawl surveys. In the spring survey, which has 500-600 stations, a large proportion of the saithe is caught in relatively few hauls and there seems to be considerable inter-annual variability in the number of these hauls.

The survey biomass indices fluctuated greatly in 1985-1995, but were consistently low in 1995-2001, high in the period around 2005, declining to a relatively low level in 2007-2011. The 2012 and 2013 survey biomass indices were relatively high (Table 8.5 and Figure 8.5).

Internal consistency in the surveys measured by the correlation of the indices for the same year class in 2 adjacent surveys is poor, with R^2 close to 0.3 for the best-defined age groups, and much lower for some other.

Young saithe tend to live very close to shore, so it is not surprising that survey indices for ages 1 and 2 are poor measures of recruitment, and the number of young saithe caught in the survey is very low.

8.5 Assessment method

In accordance with the recommendation from the benchmark (ICES 2010), a separable forward-projecting statistical catch-age model, developed in AD Model Builder, is used to fit commercial catch at age (ages 3-14 from 1980 onwards) and survey catch at age (ages 3-10 from 1985 onwards). (Figure 8.6). The selectivity pattern is constant within each period (Figure 8.6). Natural mortality is set at 0.2 for all ages.

The commercial catch-at-age residuals (Table 8.6 and Figure 8.7) are relatively small in recent years, owing to the model flexibility provided by the two recent selectivity periods 1997-2003 and 2004 onwards. The survey catch-at-age residuals (Table 8.7 and Figure 8.7) have year blocks with all residuals being only negative or only positive in a given year. The survey residuals are modelled as multivariate normal distribution with the correlation estimated (one coefficient).

8.6 Reference points and HCR

In April 2013, the Icelandic government adopted a management plan for managing the Icelandic saithe fishery (Ministry of Industries and Innovation 2013). ICES evaluated this management plan and concluded that it was in accordance with the precautionary approach and the ICES MSY framework. In the harvest control rule (HCR) evaluation (Hjorleifsson and Bjornsson 2013) B_{lim} was defined as 61 kt, based on B_{loss} as estimated in 2010, and B_{trigger} was defined as 65 kt, based on an estimated hockey-stick recruitment function.

The TAC set in year *t* is for the upcoming fishing year, from 1 September in year *t*, to 31 August in year *t*+1. The 20% HCR consists of two equations, as follows.

When $SSB \geq B_{\text{trigger}}$, the TAC set in year *t* equals the average of 0.20 times the current biomass and last year's TAC:

$$TAC_t = 0.5 \times 0.20\, B_{t,4+} + 0.5\, TAC_{t-1} \quad \text{(Eq. 1)}$$

When SSB is below B_{trigger}, the harvest rate is reduced below 0.20:

$$TAC_t = SSB_t/B_{\text{trigger}} \left[(1 - 0.5\, SSB_t/B_{\text{trigger}})\, 0.20\, B_{t,4+}) + 0.5\, TAC_{t-1} \right] \quad \text{(Eq. 2)}$$

Equation 1 is a plain average of two numbers. Equation 2 is continuous over $SSB_t/B_{trigger}$, so the rule does not lead to very different TAC when SSB_t is slightly below or above $B_{trigger}$ (Magnusson 2013).

8.7 State of the stock

The results of the principal stock quantities (Table 8.8 and Figure 8.8) show that the reference biomass declined by a quarter from 2004 to 2009, but has increased since then, and is now above the long-term average. The harvest rate peaked around 30% in the mid 1990s, but has fluctuated around 22% since 1998 (fishing mortalities 0.44 and 0.28). SSB has been stable at a relatively high level during the last ten years, having declined to its historical minimum in the mid 1990s.

Year classes 1999-2000 and 2002 were large, but recruitment since then has been around the long-term average. The details of the fishing mortality and stock in numbers are presented in Tables 8.9 and 8.10.

8.8 Short-term forecast

The input for the short-term forecast is shown in Table 8.11. Future weights, maturity, and selectivity are assumed to be the same as in the assessment year, as described in the stock annex. Recruitment predictions are based on the segmented stock-recruitment function estimated in the assessment model.

he landings for the ongoing calendar year are predicted based on the HCR, with the calendar year landings consisting of 2/3 of the ongoing fishing year's TAC and 1/3 of the next fishing year's TAC. This results in a predicted harvest rate similar to last year (u_{2013}=19% and u_{2014}=19%).

ollowing the HCR, the predicted landings in 2015 are 57 kt, corresponding to F=0.24 in 2015. The resulting SSB in 2016 is predicted to be 157 kt.

8.9 Uncertainties in assessment and forecast

The assessment of Icelandic saithe is relatively uncertain due to fluctuations in the survey data, as well as irregular changes in the fleet selectivity. The internal consistency in the spring bottom trawl survey is very low for saithe. This is not surprising, considering the nature of the species that is partly pelagic, schooling, and relatively widely migrating. There are also indications of time-varying selectivity, so changes in the commercial catch at age may not reflect changes in the age dstribution of the population. The retrospective pattern (Figure 8.9) reveals some of the assessment uncertainty. The harvest control rule evaluation incorporated uncertainties about assessment estimates, among other sources of uncertainty (Hjorleifsson and Bjornsson 2013).

he results from the default separable assessment model are compared to alternative model runs, involving ADAPT, TSA, and SAM, Further comparison with other assessment models was carried outin order to explore the overall uncertainty in the assessment. The comparison involved four models which differ mainly in the way the commercial catch-at-age variability and F-matrix is modelled:

	Model	Family	CA variability	F matrix
1	ADSEP (default)	separable	observation error	multiplicative in 3 periods
2	ADAPT	vpa	process error	no constraints

3	TSA	state-space (kalman filter)	observation & process error	orthogonal polynomials
4	SAM	state-space (random effects)	observation & process error	correlated random walk

The results from the model comparison (Figure 8.10) show that the default model estimates the current stock larger than the other models, which has also been the case for saithe assessments in recent years.

8.10 Comparison with previous assessment and forecast

Compared to last year's assessment the estimated reference biomass B_{4+} in 2013 has decreased from 321 to 298 kt, SSB 2013 has decreased from 158 to 143 kt, the harvest rate u_{2012} has increased from 17% to 18% (fishing mortality 0.19 to 0.21), and the stock numbers at ages 5 to 7 have all decreased as shown below.

	NWWG2013	NWWG2014
B4+(2013)	321	298
SSB(2013)	158	143
u(2012)	17%	18%
F4-9(2012)	0.19	0.21
N5(2013)	34	31
N6(2013)	19	16
N7(2013)	12	10

8.11 Ecosystem considerations

Changes in the distribution of large pelagic stocks (blue whiting, mackerel, Norwegian spring-spawning herring, Icelandic summer-spawning herring) may affect the propensity of saithe to migrate off shelf and between management units. Saithe is a migrating species and makes both vertical and long-distance feeding and spawning migrations (Armannsson et al. 2007, Armannsson and Jonsson 2012, i Homrum et al. 2013). The evidence from tagging experiments (ICES 2008) show some migrations along the Faroe-Iceland Ridge, as well as onto the East Greenland shelf. It is possible that due to migratory behavior, larger saithe become partially out of reach from the fishery. A hypothesis of a descending right limb on the selectivity curve for saithe might have some merit, increasing the saithe resilience to fishing if enough saithe 'escape' from the fishery onto the niche where the large pelagic stocks are available.

8.12 Changes in fishing technology and fishing patterns

According to the stock assessment model fit to the commercial catch-at-age data, the fleet is targeting younger fish since around 2004, compared to earlier periods. This can be partly explained by reduced use of gillnets in the saithe fishery.

8.13 References

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Table 8.1. Saithe in division Va. Nominal catch (t) by countries, as officially reported to ICES.

	Belgium	Faroe Islands	France	Germany	Iceland	Norway	UK (E/W/NI)	UK (Scotland)	UK	Total
1980	980	4 930			52 436	1				58 347
1981	532	3 545			54 921	3				59 001
1982	201	3 582	23		65 124	1				68 931
1983	224	2 138			55 904					58 266
1984	269	2 044			60 406					62 719
1985	158	1 778			55 135	1	29			57 101
1986	218	2 291			63 867					66 376
1987	217	2 139			78 175					80 531
1988	268	2 596			74 383					77 247
1989	369	2 246			79 796					82 411
1990	190	2 905			95 032					98 127
1991	236	2 690			99 811					102 737
1992	195	1 570			77 832					79 597
1993	104	1 562			69 982					71 648
1994	30	975		1	63 333					64 339
1995		1 161		1	47 466	1				48 629
1996		803		1	39 297					40 101
1997		716			36 548					37 264
1998		997		3	30 531					31 531
1999		700		2	30 583	6	1	1		31 293
2000		228		1	32 914	1	2			33 146
2001		128		14	31 854	44	23			32 063
2002		366		6	41 687	3	7	2		42 071
2003		143		56	51 857	164			35	52 255

	Belgium	Faroe Islands	France	Germany	Iceland	Norway	UK (E/W/NI)	UK (Scotland)	UK	Total
2004		214		157	62 614	1	105			63 091
2005		322		224	67 283	2			312	68 143
2006		415		33	75 197	2			16	75 663
2007		392			64 008	3			30	64 433
2008		196			69 992	2				70 190
2009		269			61 391	3				61 663
2010		499			53 772	1				54 272
2011		735			50 386	2				51 123
2012		940			50 843					51 783
2013		925			57 077					58 002

Table 8.2. Saithe in division Va. Commercial catch at age (millions).

	3	4	5	6	7	8	9	10	11	12	13	14
1980	0.275	2.540	5.214	2.596	2.169	1.341	0.387	0.262	0.155	0.112	0.064	0.033
1981	0.203	1.325	3.503	5.404	1.457	1.415	0.578	0.242	0.061	0.154	0.135	0.128
1982	0.508	1.092	2.804	4.845	4.293	1.215	0.975	0.306	0.059	0.035	0.048	0.046
1983	0.107	1.750	1.065	2.455	4.454	2.311	0.501	0.251	0.038	0.012	0.002	0.004
1984	0.053	0.657	0.800	1.825	2.184	3.610	0.844	0.376	0.291	0.135	0.185	0.226
1985	0.376	4.014	3.366	1.958	1.536	1.172	0.747	0.479	0.074	0.023	0.072	0.071
1986	3.108	1.400	4.170	2.665	1.550	1.116	0.628	1.549	0.216	0.051	0.030	0.014
1987	0.956	5.135	4.428	5.409	2.915	1.348	0.661	0.496	0.498	0.058	0.027	0.048
1988	1.318	5.067	6.619	3.678	2.859	1.775	0.845	0.226	0.270	0.107	0.024	0.001
1989	0.315	4.313	8.471	7.309	1.794	1.928	0.848	0.270	0.191	0.135	0.076	0.010
1990	0.143	1.692	5.471	10.112	6.174	1.816	1.087	0.380	0.151	0.055	0.076	0.037
1991	0.198	0.874	3.613	6.844	10.772	3.223	0.858	0.838	0.228	0.040	0.006	0.005
1992	0.242	2.928	3.844	4.355	3.884	4.046	1.290	0.350	0.196	0.056	0.054	0.015
1993	0.657	1.083	2.841	2.252	2.247	2.314	3.671	0.830	0.223	0.188	0.081	0.012
1994	0.702	2.955	1.770	2.603	1.377	1.243	1.263	2.009	0.454	0.158	0.188	0.082
1995	1.573	1.853	2.661	1.807	2.370	0.905	0.574	0.482	0.521	0.106	0.035	0.013
1996	1.102	2.608	1.868	1.649	0.835	1.233	0.385	0.267	0.210	0.232	0.141	0.074
1997	0.603	2.960	2.766	1.651	1.178	0.599	0.454	0.125	0.095	0.114	0.077	0.043
1998	0.183	1.289	1.767	1.545	1.114	0.658	0.351	0.265	0.120	0.081	0.085	0.085
1999	0.989	0.732	1.564	2.176	1.934	0.669	0.324	0.140	0.072	0.025	0.028	0.022
2000	0.850	2.383	0.896	1.511	1.612	1.806	0.335	0.173	0.057	0.033	0.017	0.007
2001	1.223	2.619	2.184	0.591	0.977	0.943	0.819	0.186	0.094	0.028	0.028	0.013
2002	1.187	4.190	3.147	2.970	0.519	0.820	0.570	0.309	0.101	0.027	0.015	0.011
2003	2.262	4.320	5.973	2.448	1.924	0.282	0.434	0.287	0.195	0.027	0.029	0.015
2004	0.952	7.841	7.195	5.363	1.563	1.057	0.211	0.224	0.157	0.074	0.039	0.011
2005	2.607	3.089	7.333	6.876	3.592	0.978	0.642	0.119	0.149	0.089	0.046	0.012
2006	1.380	10.051	2.616	5.840	4.514	1.989	0.667	0.485	0.118	0.112	0.086	0.031
2007	1.244	6.552	8.751	2.124	2.935	1.817	0.964	0.395	0.190	0.043	0.036	0.020
2008	1.432	3.602	5.874	6.706	1.155	1.894	1.248	0.803	0.262	0.176	0.087	0.044
2009	2.820	5.166	2.084	2.734	2.883	0.777	1.101	0.847	0.555	0.203	0.134	0.036
2010	2.146	6.284	3.058	0.997	1.644	1.571	0.514	0.656	0.522	0.231	0.114	0.064
2011	2.004	4.850	4.006	1.502	0.677	1.065	1.145	0.323	0.433	0.244	0.150	0.075
2012	1.183	4.816	3.514	2.417	0.903	0.432	0.883	1.015	0.354	0.277	0.173	0.099
2013	1.163	5.538	6.366	2.963	1.610	0.664	0.375	0.537	0.460	0.124	0.118	0.078

Table 8.3. Saithe in division Va. Mean weight at age (g) in the catches and in the spawning stock, with predictions in gray.

	3	4	5	6	7	8	9	10	11	12	13	14
1980	1428	1983	2667	3689	5409	6321	7213	8565	9147	9617	10066	11041
1981	1585	2037	2696	3525	4541	6247	6991	8202	9537	9089	9351	10225
1982	1547	2194	3015	3183	5114	6202	7256	7922	8924	10134	9447	10535
1983	1530	2221	3171	4270	4107	5984	7565	8673	8801	9039	11138	9818
1984	1653	2432	3330	4681	5466	4973	7407	8179	8770	8831	11010	11127
1985	1609	2172	3169	3922	4697	6411	6492	8346	9401	10335	11027	10644
1986	1450	2190	2959	4402	5488	6406	7570	6487	9616	10462	11747	11902
1987	1516	1715	2670	3839	5081	6185	7330	8025	7974	9615	12246	11656
1988	1261	2017	2513	3476	4719	5932	7523	8439	8748	9559	10824	14099
1989	1403	2021	2194	3047	4505	5889	7172	8852	10170	10392	12522	11923
1990	1647	1983	2566	3021	4077	5744	7038	7564	8854	10645	11674	11431
1991	1224	1939	2432	3160	3634	4967	6629	7704	9061	9117	10922	11342
1992	1269	1909	2578	3288	4150	4865	6168	7926	8349	9029	11574	9466
1993	1381	2143	2742	3636	4398	5421	5319	7006	8070	10048	9106	11591
1994	1444	1836	2649	3512	4906	5539	6818	6374	8341	9770	10528	11257
1995	1370	1977	2769	3722	4621	5854	6416	7356	6815	8312	9119	11910
1996	1229	1755	2670	3802	4902	5681	7182	7734	9256	8322	10501	11894
1997	1325	1936	2409	3906	5032	6171	7202	7883	8856	9649	9621	10877
1998	1347	1972	2943	3419	4850	5962	6933	7781	8695	9564	10164	10379
1999	1279	2106	2752	3497	3831	5819	7072	8078	8865	10550	10823	11300
2000	1367	1929	2751	3274	4171	4447	6790	8216	9369	9817	10932	12204
2001	1280	1882	2599	3697	4420	5538	5639	7985	9059	9942	10632	10988
2002	1308	1946	2569	3266	4872	5365	6830	7067	9240	9659	10088	11632
2003	1310	1908	2545	3336	4069	5792	7156	8131	8051	10186	10948	11780
2004	1467	1847	2181	2918	4017	5135	7125	7732	8420	8927	10420	10622
2005	1287	1888	2307	2619	3516	5080	6060	8052	8292	8342	8567	10256
2006	1164	1722	2369	2808	3235	4361	6007	7166	8459	9324	9902	9636
2007	1140	1578	2122	2719	3495	4114	5402	6995	7792	9331	9970	10738
2008	1306	1805	2295	2749	3515	4530	5132	6394	7694	9170	9594	11258
2009	1412	1862	2561	3023	3676	4596	5651	6074	7356	8608	9812	10639
2010	1287	1787	2579	3469	4135	4850	5558	6289	6750	7997	9429	10481
2011	1175	1801	2526	3680	4613	5367	5685	6466	6851	7039	8268	8958
2012	1160	1668	2369	3347	4430	5486	6161	6448	7220	8054	8147	8901
2013	1056	1675	2219	3244	4529	5628	6397	7055	7378	7955	8400	8870
2014	1130	1525	2319	3042	4163	5568	6913	6656	7150	7683	8272	8910
2015	1130	1525	2319	3042	4163	5568	6913	6656	7150	7683	8272	8910
2016	1130	1525	2319	3042	4163	5568	6913	6656	7150	7683	8272	8910
Avg80-13	1359	1936	2614	3445	4418	5496	6614	7564	8476	9307	10251	10923

Table 8.4. Saithe in division Va. Maturity at age used for calculating the SSB.

	3	4	5	6	7	8	9	10	11	12	13	14
1985	0.000	0.093	0.202	0.385	0.607	0.793	0.904	1.000	1.000	1.000	1.000	1.000
1986	0.000	0.082	0.181	0.354	0.575	0.770	0.892	1.000	1.000	1.000	1.000	1.000
1987	0.000	0.073	0.163	0.325	0.544	0.746	0.879	1.000	1.000	1.000	1.000	1.000
1988	0.000	0.066	0.149	0.302	0.516	0.725	0.867	1.000	1.000	1.000	1.000	1.000
1989	0.000	0.061	0.138	0.283	0.494	0.707	0.856	1.000	1.000	1.000	1.000	1.000
1990	0.000	0.058	0.131	0.271	0.479	0.695	0.849	1.000	1.000	1.000	1.000	1.000
1991	0.000	0.056	0.128	0.267	0.474	0.690	0.846	1.000	1.000	1.000	1.000	1.000
1992	0.000	0.057	0.130	0.270	0.477	0.693	0.848	1.000	1.000	1.000	1.000	1.000
1993	0.000	0.060	0.136	0.280	0.490	0.704	0.854	1.000	1.000	1.000	1.000	1.000
1994	0.000	0.065	0.147	0.298	0.512	0.722	0.865	1.000	1.000	1.000	1.000	1.000
1995	0.000	0.073	0.164	0.326	0.544	0.747	0.879	1.000	1.000	1.000	1.000	1.000
1996	0.000	0.085	0.187	0.362	0.584	0.776	0.895	1.000	1.000	1.000	1.000	1.000
1997	0.000	0.100	0.215	0.404	0.626	0.805	0.911	1.000	1.000	1.000	1.000	1.000
1998	0.000	0.117	0.247	0.447	0.666	0.831	0.924	1.000	1.000	1.000	1.000	1.000
1999	0.000	0.135	0.278	0.487	0.701	0.853	0.935	1.000	1.000	1.000	1.000	1.000
2000	0.000	0.151	0.305	0.520	0.728	0.868	0.942	1.000	1.000	1.000	1.000	1.000
2001	0.000	0.163	0.324	0.542	0.745	0.879	0.947	1.000	1.000	1.000	1.000	1.000
2002	0.000	0.170	0.336	0.556	0.756	0.884	0.950	1.000	1.000	1.000	1.000	1.000
2003	0.000	0.174	0.342	0.562	0.760	0.887	0.951	1.000	1.000	1.000	1.000	1.000
2004	0.000	0.173	0.340	0.560	0.759	0.886	0.950	1.000	1.000	1.000	1.000	1.000
2005	0.000	0.168	0.333	0.552	0.753	0.883	0.949	1.000	1.000	1.000	1.000	1.000
2006	0.000	0.161	0.321	0.539	0.743	0.877	0.946	1.000	1.000	1.000	1.000	1.000
2007	0.000	0.152	0.307	0.523	0.730	0.870	0.943	1.000	1.000	1.000	1.000	1.000
2008	0.000	0.143	0.292	0.505	0.716	0.862	0.939	1.000	1.000	1.000	1.000	1.000
2009	0.000	0.135	0.279	0.488	0.702	0.853	0.935	1.000	1.000	1.000	1.000	1.000
2010	0.000	0.128	0.267	0.473	0.689	0.846	0.931	1.000	1.000	1.000	1.000	1.000
2011	0.000	0.123	0.257	0.461	0.679	0.839	0.928	1.000	1.000	1.000	1.000	1.000
2012	0.000	0.118	0.249	0.450	0.669	0.833	0.925	1.000	1.000	1.000	1.000	1.000
2013	0.000	0.114	0.242	0.441	0.661	0.828	0.922	1.000	1.000	1.000	1.000	1.000
2014	0.000	0.111	0.235	0.432	0.652	0.823	0.920	1.000	1.000	1.000	1.000	1.000
2015	0.000	0.111	0.235	0.432	0.652	0.823	0.920	1.000	1.000	1.000	1.000	1.000
2016	0.000	0.111	0.235	0.432	0.652	0.823	0.920	1.000	1.000	1.000	1.000	1.000

Table 8.5. Saithe in division Va. Survey catch at age.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1985	0.05	0.61	0.58	2.99	5.11	1.74	1.06	0.50	1.37	0.16	0.08	0.08	0.07	0.07
1986	0.02	2.33	2.40	2.06	2.09	1.42	0.62	0.28	0.19	0.32	0.09	0.07	0.03	0.00
1987	0.10	0.39	11.52	12.93	6.42	3.95	3.07	0.79	0.36	0.26	0.33	0.05	0.01	0.03
1988	0.69	0.31	0.49	2.72	2.81	1.71	0.95	0.40	0.07	0.08	0.10	0.05	0.01	0.00
1989	0.20	1.43	3.96	5.05	6.57	2.49	1.77	0.91	0.40	0.00	0.02	0.00	0.03	0.00
1990	0.01	0.35	1.69	4.86	6.37	12.33	3.30	1.21	0.64	0.12	0.06	0.02	0.01	0.03
1991	0.01	0.22	1.40	1.72	2.22	1.13	2.50	0.30	0.02	0.03	0.00	0.01	0.00	0.01
1992	0.01	0.15	0.91	5.73	5.52	2.79	2.68	1.91	0.28	0.06	0.06	0.02	0.00	0.00
1993	0.00	1.27	11.04	2.00	6.80	2.41	2.25	1.02	4.02	0.64	0.05	0.00	0.02	0.00
1994	0.04	0.82	0.73	1.89	1.74	1.95	0.53	0.84	1.00	3.62	0.41	0.18	0.00	0.04
1995	0.06	0.48	1.98	1.12	0.51	0.28	0.34	0.10	0.15	0.15	0.33	0.02	0.00	0.00
1996	0.03	0.13	0.51	3.76	1.12	0.99	0.58	1.00	0.05	0.09	0.10	0.25	0.03	0.00
1997	0.16	0.32	0.90	4.72	3.96	0.94	0.40	0.16	0.10	0.05	0.02	0.02	0.02	0.00
1998	0.01	0.11	1.64	2.33	2.53	1.23	0.71	0.31	0.08	0.07	0.04	0.03	0.05	0.03
1999	0.57	0.75	3.71	0.93	1.25	1.64	0.57	0.17	0.02	0.02	0.02	0.00	0.00	0.02
2000	0.00	0.38	2.02	2.54	0.61	0.84	0.53	0.47	0.07	0.03	0.01	0.00	0.01	0.01
2001	0.00	0.89	1.90	2.64	1.60	0.20	0.23	0.40	0.13	0.07	0.04	0.01	0.00	0.00
2002	0.02	1.05	2.23	2.97	3.08	2.15	0.42	0.49	0.32	0.22	0.02	0.03	0.00	0.00
2003	0.01	0.05	9.62	5.06	2.94	1.34	0.77	0.21	0.05	0.10	0.02	0.03	0.00	0.00
2004	0.01	0.91	1.38	9.39	6.04	4.35	1.48	0.81	0.17	0.16	0.12	0.06	0.02	0.00
2005	0.00	0.26	4.32	2.39	7.42	4.66	2.31	0.86	0.44	0.12	0.05	0.08	0.03	0.00
2006	0.01	0.00	2.18	6.69	1.98	8.91	3.52	1.21	0.29	0.25	0.03	0.04	0.04	0.00
2007	0.00	0.06	0.31	1.73	3.22	0.81	1.62	0.70	0.29	0.16	0.11	0.08	0.02	0.00
2008	0.01	0.08	2.25	1.79	2.85	4.01	0.61	0.78	0.34	0.15	0.09	0.13	0.04	0.02
2009	0.01	0.21	2.43	1.80	0.68	0.91	0.84	0.12	0.26	0.15	0.03	0.04	0.00	0.02
2010	0.00	0.07	1.23	4.99	2.49	0.63	0.60	0.48	0.07	0.13	0.07	0.07	0.07	0.02
2011	0.00	0.15	3.83	4.20	3.06	1.15	0.41	0.39	0.44	0.17	0.10	0.09	0.06	0.05
2012	0.02	0.02	1.75	12.04	6.86	2.75	0.62	0.17	0.38	0.50	0.13	0.12	0.06	0.08
2013	0.01	0.12	4.27	7.43	6.78	4.65	2.57	1.12	0.30	0.44	0.36	0.26	0.13	0.01
2014	0.01	0.03	0.39	3.84	3.78	2.04	0.86	0.42	0.15	0.11	0.18	0.18	0.07	0.09

Table 8.6. Saithe in division Va. Commercial catch-at-age residuals log(obs/fit) from the model.

	3	4	5	6	7	8	9	10	11	12	13	14
1980	-0.78	-0.59	0.25	0.15	-0.08	0.21	-0.04	0.22	-0.30	-0.41	-0.69	-0.04
1981	-0.51	-0.25	-0.55	0.36	-0.16	0.06	0.11	0.28	-0.84	0.92	1.18	1.85
1982	0.82	-0.24	0.12	-0.36	0.23	-0.02	0.36	-0.35	-1.18	-1.13	-0.52	-0.10
1983	-2.44	0.92	-0.66	0.11	0.45	0.20	-0.01	-0.79	-2.39	-2.75	-5.09	-3.77
1984	-4.17	-1.59	-1.27	0.22	0.47	0.78	-0.44	0.42	0.95	1.01	3.42	4.83
1985	-0.28	1.22	0.57	0.08	0.27	-0.19	-1.15	-0.74	-1.38	-3.02	0.64	2.43
1986	2.24	-0.71	0.24	-0.32	-0.08	0.10	-0.40	0.91	-1.08	-1.37	-1.81	-1.73
1987	-0.98	0.15	0.31	0.22	0.09	0.07	0.06	-0.17	-0.08	-2.87	-1.88	-0.24
1988	0.91	-0.31	0.06	0.04	-0.14	0.19	0.78	-0.65	0.47	-1.67	-3.22	-6.78
1989	-0.83	0.60	0.00	0.23	-0.57	0.04	0.27	-0.18	0.70	0.36	-1.11	-3.67
1990	-1.75	-0.53	0.08	0.00	0.34	0.06	0.11	-0.37	0.07	-0.77	0.16	-1.59
1991	-1.93	-1.09	0.06	0.32	0.03	-0.08	0.01	0.70	0.22	-1.36	-3.87	-3.89
1992	-0.21	0.57	1.04	0.42	0.06	-0.81	-0.24	-0.40	-0.28	-1.16	0.47	-0.88
1993	0.96	-0.15	-0.33	-0.14	-0.20	-0.08	0.39	0.04	0.32	0.73	0.63	-1.27
1994	1.07	0.96	-0.12	-0.68	-0.43	-0.46	0.20	0.40	0.50	0.78	1.84	1.76
1995	1.56	0.27	0.10	-0.02	0.04	-0.08	-0.20	-0.19	-0.25	-0.86	-0.67	-1.81
1996	1.43	0.16	-0.12	-0.50	-0.34	0.18	0.27	0.03	0.39	-0.14	1.31	2.37
1997	0.26	0.33	-0.30	0.08	-0.03	0.29	-0.10	-0.40	-0.32	0.34	-1.11	0.18
1998	-0.35	-0.06	-0.46	-0.75	0.18	0.00	0.83	0.68	1.22	1.14	1.54	0.82
1999	0.39	0.04	0.00	0.07	-0.01	-0.19	-0.34	0.33	-0.64	-0.55	0.32	0.18
2000	-0.06	-0.20	0.11	0.07	-0.16	0.47	-0.48	-0.27	-0.21	-0.90	-0.06	-1.08
2001	-0.10	0.23	-0.27	-0.14	-0.03	-0.18	0.38	0.06	0.13	0.06	0.39	1.03
2002	-0.62	-0.09	0.17	0.35	-0.17	0.12	-0.26	-0.34	-0.08	-1.16	-0.05	-0.30
2003	0.38	-0.28	0.41	-0.03	-0.02	-0.60	0.04	-0.18	0.05	-1.24	0.30	1.27
2004	-0.16	-0.42	-0.05	0.28	-0.12	0.22	0.55	0.38	-0.10	-0.50	0.72	-0.25
2005	-0.40	-0.34	-0.25	0.42	0.32	-0.26	-0.16	0.00	0.28	-0.05	-0.27	-0.38
2006	-0.67	-0.19	-0.27	-0.03	0.52	0.04	-0.34	-0.07	0.76	0.98	1.12	0.22
2007	0.79	0.20	0.20	0.25	-0.16	-0.09	-0.41	-0.43	-0.78	0.37	0.35	-0.12
2008	0.06	0.34	0.25	0.22	-0.13	-0.28	-0.27	-0.25	-0.54	0.19	2.81	1.84
2009	0.66	0.43	-0.02	-0.25	-0.18	0.25	-0.36	-0.08	0.14	0.53	1.23	2.70
2010	0.39	0.20	0.16	-0.42	0.03	-0.15	0.46	-0.38	0.10	0.04	0.99	1.38
2011	0.06	-0.11	-0.02	-0.29	-0.02	0.28	0.13	0.42	-0.21	0.08	0.63	1.61
2012	-0.35	-0.44	-0.22	-0.23	-0.26	0.05	0.65	0.58	1.38	0.17	0.65	1.07
2013	-0.34	0.16	0.32	-0.06	-0.27	-0.18	0.26	0.14	-0.38	0.36	-0.47	0.11

Table 8.7. Saithe in division Va. Survey catch-at-age residuals log(obs/fit) from the model.

	2	3	4	5	6	7	8	9	10
1985	-0.45	-1.53	-0.44	0.56	0.20	0.35	-0.15	0.85	-0.97
1986	0.75	-0.61	-0.68	-0.78	-0.49	-0.36	-0.45	-0.65	-0.36
1987	-0.64	0.86	0.74	0.75	0.45	1.12	0.75	0.55	0.28
1988	-0.37	-2.14	-1.46	-0.94	-0.28	-0.46	-0.38	-1.28	-0.55
1989	1.92	0.85	-0.03	-0.32	-0.59	0.49	0.34	0.37	-5.68
1990	-0.14	0.35	0.46	0.34	0.91	0.47	0.89	0.67	-0.43
1991	0.13	-0.28	-0.25	-0.34	-1.16	-0.62	-1.43	-3.06	-2.22
1992	-0.66	0.03	0.75	1.24	0.47	0.65	0.00	-0.67	-1.11
1993	1.98	2.61	0.33	1.08	0.81	1.01	0.46	1.71	1.00
1994	0.85	-0.43	-0.07	0.31	0.19	-0.12	0.85	1.33	2.35
1995	0.40	0.12	-0.54	-1.45	-1.22	-0.96	-1.01	-0.18	-0.05
1996	-0.63	-1.28	0.26	-0.39	-0.07	0.52	1.36	-0.84	0.04
1997	1.20	-0.12	0.71	0.45	-0.05	-0.32	-0.02	-0.44	-0.10
1998	-1.50	1.36	0.38	0.13	-0.40	0.33	0.25	-0.03	-0.13
1999	0.70	0.85	0.09	-0.22	0.10	-0.64	-0.54	-2.19	-0.99
2000	-0.73	0.11	-0.20	-0.27	-0.19	-0.55	-0.04	-0.83	-1.08
2001	0.08	-0.61	-0.19	-0.61	-1.08	-1.03	-0.05	-0.79	-0.16
2002	0.11	-0.61	-0.70	0.11	0.21	0.43	0.63	0.38	0.42
2003	-2.23	0.94	-0.26	-0.58	-0.38	-0.33	0.42	-1.30	-0.34
2004	-0.08	-0.12	0.32	0.09	0.36	0.37	0.49	0.84	0.66
2005	-0.90	-0.01	-0.05	0.28	0.34	0.29	0.44	0.31	0.91
2006	-6.50	-0.16	-0.06	-0.02	1.07	0.70	0.26	-0.27	0.15
2007	-2.15	-1.52	-1.00	-0.66	-0.48	-0.22	-0.45	-0.84	-0.44
2008	-2.34	0.33	-0.04	-0.17	0.17	-0.12	-0.35	-0.73	-1.10
2009	-1.23	-0.10	-0.49	-0.90	-0.91	-0.94	-1.26	-1.05	-1.15
2010	-2.78	-0.92	0.17	0.13	-0.42	-0.71	-0.87	-1.33	-1.36
2011	-1.62	0.14	-0.07	-0.20	-0.25	-0.28	-0.54	-0.47	0.13
2012	-3.84	-0.51	0.89	0.69	0.16	-0.37	-0.67	-0.10	0.08
2013	-0.80	0.63	0.59	0.38	0.71	0.68	0.95	0.45	0.46
2014	-3.10	-1.18	-0.08	-0.02	-0.53	-0.66	-0.80	-0.93	-0.32

Table 8.8. Saithe in division Va. Main population estimates from the fitted model. The recruitment column is aligned so that the 2000 cohort is shown in the year 2000, but that cohort size is the estimated N at age 3 in 2003.

	B4+	SSB	Cohort	Y	F4-9	HR
1980	312	122	32	58	0.29	19%
1981	304	130	42	59	0.26	19%
1982	294	149	35	69	0.30	23%
1983	270	147	67	58	0.24	22%
1984	287	149	92	63	0.23	22%
1985	299	140	50	57	0.25	19%
1986	318	137	32	65	0.28	20%
1987	335	128	21	81	0.35	24%
1988	416	124	29	77	0.32	19%
1989	398	127	15	82	0.31	21%
1990	378	134	20	98	0.35	26%
1991	336	143	18	102	0.37	30%
1992	288	135	30	80	0.37	28%
1993	230	113	25	72	0.40	31%
1994	187	94	17	64	0.45	34%
1995	152	70	9	49	0.46	32%
1996	148	61	30	40	0.41	27%
1997	155	62	31	37	0.37	24%
1998	152	67	53	32	0.30	21%
1999	130	71	62	31	0.32	24%
2000	140	72	72	33	0.33	24%
2001	159	78	26	32	0.28	20%
2002	215	94	73	42	0.31	20%
2003	274	118	42	52	0.30	19%
2004	315	139	19	65	0.27	21%
2005	280	149	28	69	0.29	25%
2006	307	157	44	76	0.31	25%
2007	278	152	45	64	0.28	23%
2008	249	149	57	70	0.32	28%
2009	228	137	45	61	0.30	27%
2010	237	129	42	54	0.26	23%
2011	256	127	18	51	0.22	20%
2012	281	131	32	52	0.21	18%
2013	298	143	33	58	0.22	19%
2014	296	150	33	58	0.23	19%

Table 8.9. Saithe in division Va. Stock in numbers from the fitted model.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1980	32.2	24.6	28.2	46.8	30.9	10.3	8.1	3.7	1.3	0.7	0.7	0.5	0.3	0.1
1981	48.0	26.4	20.2	22.7	35.2	21.2	6.3	4.6	2.0	0.7	0.4	0.4	0.3	0.2
1982	62.4	39.3	21.6	16.3	17.2	24.6	13.3	3.7	2.6	1.1	0.4	0.2	0.2	0.2
1983	52.8	51.1	32.2	17.4	12.2	11.8	14.8	7.5	1.9	1.4	0.6	0.2	0.1	0.1
1984	99.7	43.3	41.9	26.0	13.3	8.6	7.5	9.0	4.3	1.1	0.8	0.4	0.1	0.1
1985	137.0	81.7	35.4	33.8	19.9	9.4	5.6	4.6	5.2	2.5	0.7	0.5	0.2	0.1
1986	75.3	112.2	66.9	28.6	25.8	14.1	6.0	3.4	2.6	3.0	1.4	0.4	0.3	0.1
1987	47.6	61.6	91.8	53.9	21.6	17.8	8.7	3.5	1.8	1.5	1.6	0.8	0.2	0.2
1988	31.0	39.0	50.5	73.7	39.8	14.3	10.3	4.6	1.7	0.9	0.7	0.9	0.4	0.1
1989	44.0	25.4	31.9	40.6	55.0	26.9	8.5	5.6	2.3	0.9	0.5	0.4	0.5	0.2
1990	22.0	36.0	20.8	25.7	30.4	37.4	16.2	4.7	2.9	1.2	0.5	0.3	0.2	0.3
1991	29.5	18.0	29.5	16.7	19.0	20.2	31.4	8.6	2.3	1.5	0.6	0.2	0.1	0.1
1992	26.2	24.1	14.8	23.6	12.3	12.4	11.3	16.2	4.0	1.1	0.7	0.3	0.1	0.1
1993	44.3	21.5	19.8	11.8	17.4	8.0	7.0	5.9	7.7	2.0	0.5	0.4	0.2	0.1
1994	37.9	36.2	17.6	15.8	8.6	11.2	4.4	3.5	2.7	3.6	0.9	0.3	0.2	0.1
1995	24.9	31.0	29.7	14.0	11.4	5.4	5.8	2.1	1.5	1.2	1.5	0.4	0.1	0.1
1996	12.7	20.4	25.4	23.7	10.0	7.0	2.8	2.7	0.8	0.6	0.5	0.7	0.2	0.1
1997	44.6	10.4	16.7	20.3	17.2	6.4	3.8	1.4	1.2	0.4	0.3	0.2	0.3	0.1
1998	45.9	36.5	8.5	13.2	14.4	11.2	3.8	2.1	0.7	0.6	0.2	0.1	0.1	0.2
1999	79.3	37.6	29.9	6.8	9.6	9.8	7.1	2.2	1.1	0.3	0.3	0.1	0.1	0.1
2000	93.0	64.9	30.8	23.7	4.9	6.4	6.1	4.1	1.2	0.5	0.2	0.1	0.0	0.0
2001	107.0	76.2	53.2	24.4	17.0	3.3	4.0	3.4	2.1	0.6	0.3	0.1	0.1	0.0
2002	38.1	87.6	62.4	42.4	17.9	11.7	2.1	2.4	1.9	1.1	0.3	0.1	0.0	0.0
2003	108.8	31.2	71.7	49.6	30.7	12.0	7.3	1.2	1.2	0.9	0.6	0.2	0.1	0.0
2004	62.7	89.1	25.5	57.1	36.1	20.8	7.6	4.3	0.6	0.6	0.5	0.3	0.1	0.0
2005	28.4	51.3	72.9	20.0	37.9	22.9	12.9	4.8	2.7	0.4	0.4	0.3	0.1	0.0
2006	42.4	23.3	42.0	56.8	13.0	23.5	13.8	7.8	2.9	1.5	0.2	0.2	0.1	0.1
2007	66.2	34.7	19.1	32.6	36.5	7.9	13.9	8.2	4.7	1.6	0.8	0.1	0.1	0.1
2008	67.2	54.2	28.4	14.9	21.4	22.8	4.8	8.5	5.0	2.7	0.9	0.4	0.1	0.0
2009	84.7	55.0	44.4	22.0	9.5	12.9	13.3	2.8	5.0	2.8	1.4	0.4	0.2	0.0
2010	67.1	69.4	45.1	34.6	14.3	5.9	7.8	8.1	1.7	2.9	1.5	0.7	0.2	0.1
2011	61.9	54.9	56.8	35.3	23.2	9.2	3.7	4.9	5.1	1.0	1.7	0.8	0.4	0.1
2012	26.6	50.7	44.9	44.8	24.3	15.4	6.0	2.4	3.2	3.2	0.6	0.9	0.4	0.2
2013	48.3	21.8	41.5	35.5	31.2	16.3	10.1	3.9	1.6	2.0	2.0	0.4	0.5	0.3
2014	49.6	39.6	17.8	32.7	24.5	20.7	10.6	6.6	2.6	1.0	1.2	1.1	0.2	0.3

Table 8.10. Saithe in division Va. Fishing mortality from the fitted model.

	3	4	5	6	7	8	9	10	11	12	13	14
1980	0.02	0.09	0.18	0.30	0.36	0.44	0.41	0.44	0.36	0.36	0.36	0.36
1981	0.01	0.08	0.16	0.26	0.32	0.39	0.36	0.39	0.32	0.32	0.32	0.32
1982	0.02	0.09	0.18	0.30	0.37	0.45	0.42	0.45	0.37	0.37	0.37	0.37
1983	0.01	0.07	0.15	0.24	0.30	0.36	0.34	0.36	0.30	0.30	0.30	0.30
1984	0.01	0.07	0.14	0.23	0.29	0.34	0.32	0.34	0.28	0.28	0.28	0.28
1985	0.01	0.07	0.15	0.25	0.30	0.37	0.34	0.37	0.30	0.30	0.30	0.30
1986	0.02	0.08	0.17	0.28	0.35	0.42	0.39	0.42	0.34	0.34	0.34	0.34
1987	0.02	0.10	0.21	0.35	0.43	0.52	0.49	0.52	0.43	0.43	0.43	0.43
1988	0.02	0.09	0.19	0.32	0.40	0.48	0.45	0.48	0.39	0.39	0.39	0.39
1989	0.02	0.09	0.19	0.31	0.38	0.46	0.42	0.46	0.37	0.37	0.37	0.37
1990	0.02	0.10	0.21	0.35	0.43	0.52	0.48	0.52	0.43	0.43	0.43	0.43
1991	0.02	0.11	0.23	0.38	0.46	0.56	0.52	0.56	0.46	0.46	0.46	0.46
1992	0.02	0.11	0.22	0.37	0.45	0.55	0.51	0.55	0.45	0.45	0.45	0.45
1993	0.02	0.12	0.24	0.40	0.49	0.59	0.55	0.59	0.49	0.49	0.49	0.49
1994	0.03	0.13	0.27	0.45	0.56	0.67	0.63	0.67	0.55	0.55	0.55	0.55
1995	0.03	0.13	0.28	0.47	0.57	0.69	0.64	0.69	0.57	0.57	0.57	0.57
1996	0.02	0.12	0.25	0.41	0.50	0.61	0.56	0.61	0.50	0.50	0.50	0.50
1997	0.04	0.14	0.23	0.31	0.42	0.53	0.57	0.56	0.57	0.57	0.57	0.57
1998	0.03	0.12	0.19	0.26	0.34	0.43	0.47	0.46	0.47	0.47	0.47	0.47
1999	0.03	0.12	0.20	0.27	0.36	0.45	0.49	0.48	0.49	0.49	0.49	0.49
2000	0.03	0.13	0.21	0.29	0.38	0.48	0.52	0.51	0.52	0.52	0.52	0.52
2001	0.03	0.11	0.18	0.24	0.32	0.40	0.44	0.43	0.44	0.44	0.44	0.44
2002	0.03	0.12	0.19	0.26	0.35	0.44	0.48	0.47	0.48	0.48	0.48	0.48
2003	0.03	0.12	0.19	0.26	0.34	0.43	0.47	0.46	0.47	0.47	0.47	0.47
2004	0.05	0.21	0.25	0.28	0.27	0.28	0.31	0.38	0.46	0.46	0.46	0.46
2005	0.05	0.23	0.28	0.31	0.30	0.30	0.34	0.41	0.50	0.50	0.50	0.50
2006	0.05	0.24	0.29	0.32	0.32	0.32	0.36	0.44	0.53	0.53	0.53	0.53
2007	0.05	0.22	0.27	0.30	0.29	0.29	0.33	0.40	0.49	0.49	0.49	0.49
2008	0.06	0.25	0.31	0.34	0.33	0.33	0.38	0.46	0.56	0.56	0.56	0.56
2009	0.05	0.23	0.28	0.31	0.30	0.30	0.35	0.42	0.51	0.51	0.51	0.51
2010	0.04	0.20	0.24	0.27	0.26	0.26	0.30	0.36	0.44	0.44	0.44	0.44
2011	0.04	0.17	0.21	0.23	0.23	0.23	0.26	0.32	0.39	0.39	0.39	0.39
2012	0.04	0.16	0.20	0.22	0.21	0.21	0.24	0.30	0.36	0.36	0.36	0.36
2013	0.04	0.17	0.21	0.23	0.23	0.23	0.26	0.31	0.38	0.38	0.38	0.38
2014	0.04	0.18	0.22	0.24	0.24	0.24	0.27	0.33	0.40	0.40	0.40	0.40

Table 8.11. Saithe in division Va. Input values for the short-term projections. Same weights are used for catch weights and stock weights.

2014	3	4	5	6	7	8	9	10	11	12	13	14
N	17.8	32.7	24.5	20.7	10.6	6.6	2.6	1.0	1.2	1.1	0.2	0.3
M	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
mat	0.000	0.111	0.235	0.432	0.652	0.823	0.920	1.000	1.000	1.000	1.000	1.000
w	1.130	1.525	2.319	3.042	4.163	5.568	6.913	6.656	7.150	7.683	8.272	8.910
sel	0.099	0.452	0.551	0.607	0.593	0.599	0.679	0.824	1.000	1.000	1.000	1.000
pF	0	0	0	0	0	0	0	0	0	0	0	0
pM	0	0	0	0	0	0	0	0	0	0	0	0
2015	3	4	5	6	7	8	9	10	11	12	13	14
N	32.4											
M	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
mat	0.000	0.111	0.235	0.432	0.652	0.823	0.920	1.000	1.000	1.000	1.000	1.000
w	1.130	1.525	2.319	3.042	4.163	5.568	6.913	6.656	7.150	7.683	8.272	8.910
sel	0.099	0.452	0.551	0.607	0.593	0.599	0.679	0.824	1.000	1.000	1.000	1.000
pF	0	0	0	0	0	0	0	0	0	0	0	0
pM	0	0	0	0	0	0	0	0	0	0	0	0
2016	3	4	5	6	7	8	9	10	11	12	13	14
N												
M	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
mat	0.000	0.111	0.235	0.432	0.652	0.823	0.920	1.000	1.000	1.000	1.000	1.000
w	1.130	1.525	2.319	3.042	4.163	5.568	6.913	6.656	7.150	7.683	8.272	8.910
sel	0.099	0.452	0.551	0.607	0.593	0.599	0.679	0.824	1.000	1.000	1.000	1.000
pF	0	0	0	0	0	0	0	0	0	0	0	0
pM	0	0	0	0	0	0	0	0	0	0	0	0

Table 8.12. Saithe in division Va. Output from the short-term projections.

F2013 = 0.22

2014			
B4+	SSB	Fbar	Landings
296	150	0.23	58

2015				2016		
B4+	SSB	Fbar	Landings	B4+	SSB	Rationale
272	157	0.24	57	259	157	20% HCR

20% HCR = average between 0.2 B4+ (current year) and last year's TAC

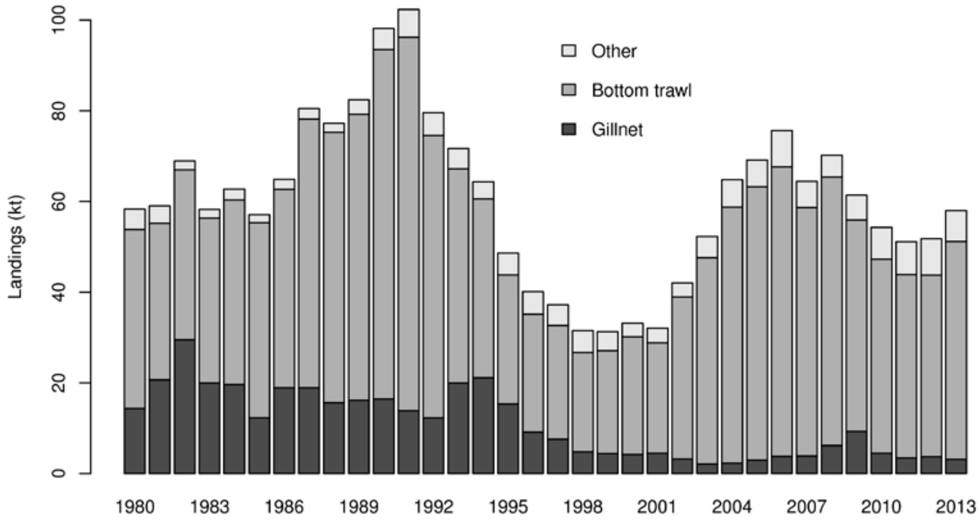


Figure 8.1 Saithe in Division Va. Landings by gear.

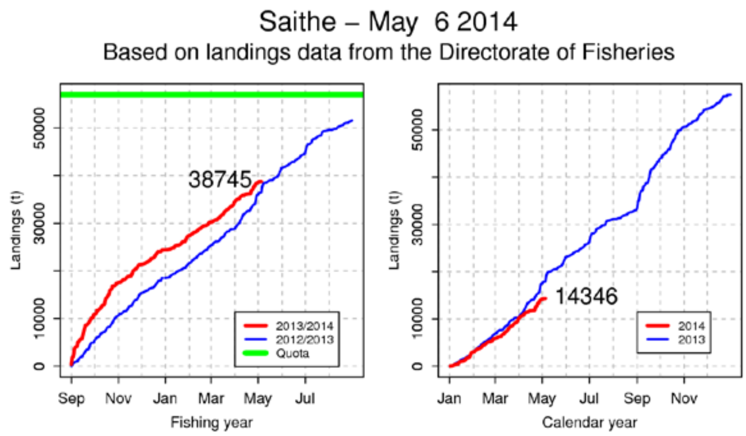


Figure 8.2 Saithe in division Va. Cumulative landings in the current fishing year (left) and calendar year (right). The vertical (green line) in the left figure shows the quota for the current fishing year.

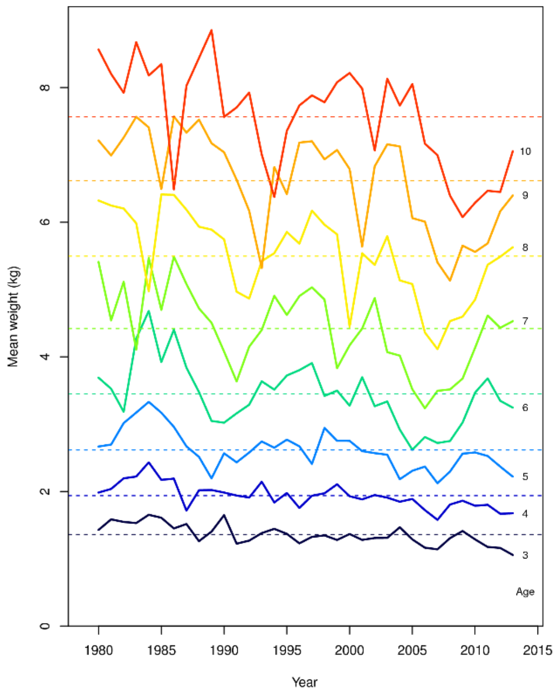


Figure 8.3 Saithe in division Va. Weight at age in the catches. The dotted lines show a linear regression trend on a log-scale.

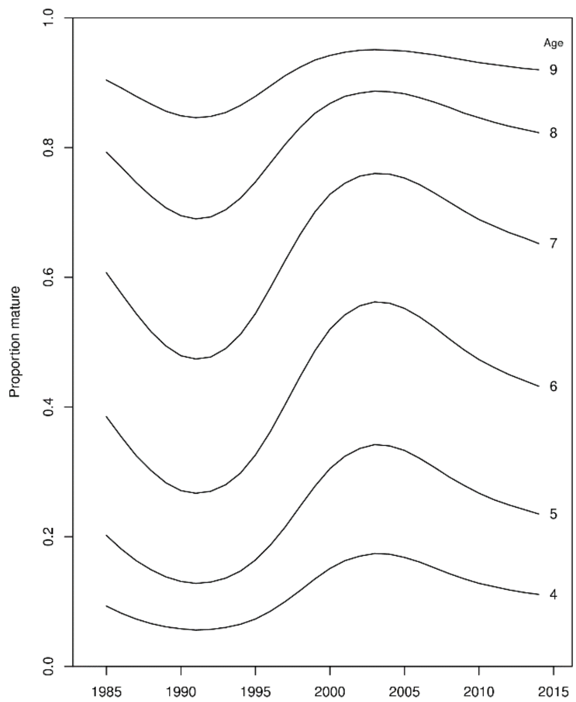


Figure 8.4 Saithe in division Va. Maturity at age used for calculating the SSB.

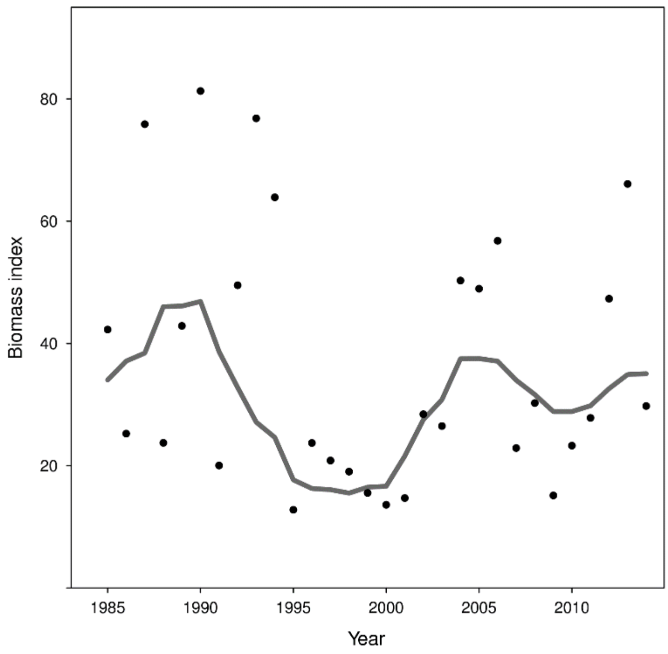


Figure 8.5 Saithe in division Va. Spring survey biomass index and model fit. The vertical lines indicate +/- 1 standard error.

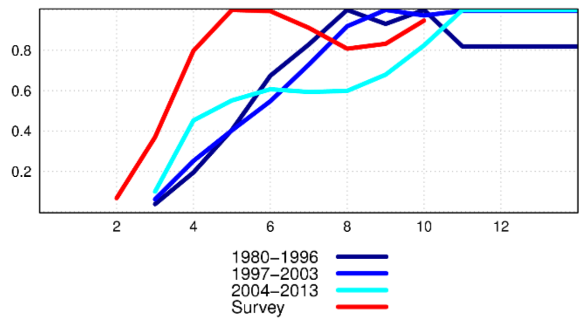


Figure 8.6. Estimated selectivity patterns for the 3 periods.

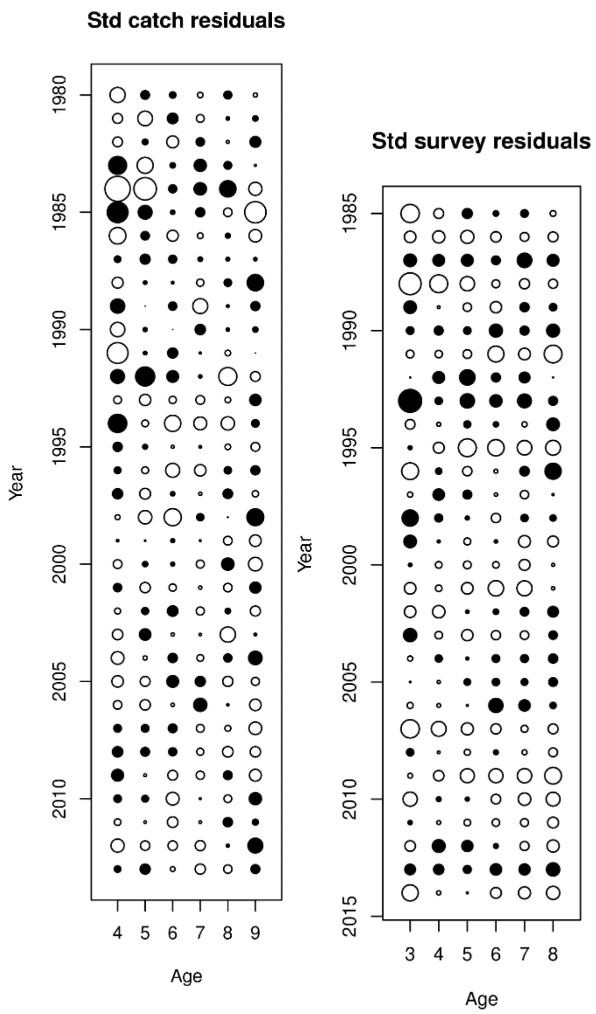


Figure 8.7. Saithe in division Va. Commercial and survey catch-at-age residuals from the fitted model. Filled circles are positive log residuals and hollow circles are negative log residuals.

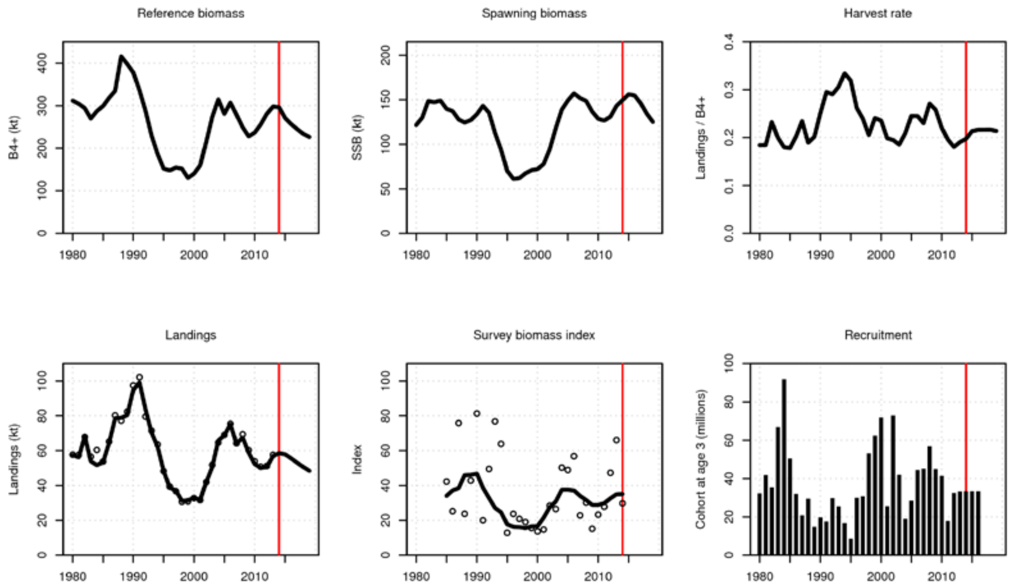


Figure 8.8. Saithe in division Va. Results from the fitted model and short-term forecast. The red line indicates the time of the current assessment.

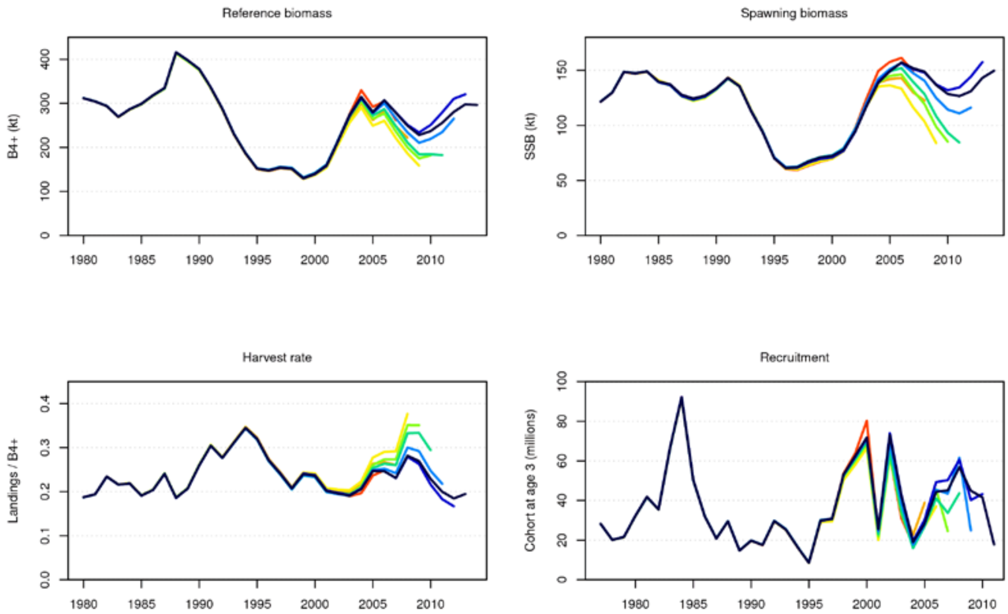


Figure 8.9. Saithe in division Va. Retrospective pattern for the assessment model.

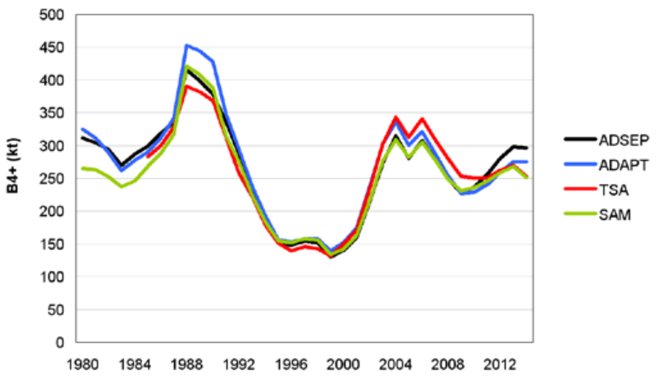


Figure 8.10. Saithe in division Va. Comparison between the default separable model (ADSEP) and alternative assessment models.

9 Icelandic cod

9.1 Summary

The spawning stock (SSB_{2014}) is estimated to be 427 kt and is higher than has been observed over the last five decades. The reference biomass ($B_{4+\,2014}$) is estimated to be 1106 kt, the highest observed since the late 1970's. Fishing mortality, being 0.3 in 2013, has declined significantly in recent years and is presently the lowest observed in last 6 decades. Year classes since the mid-1980s are estimated to be relatively stable but with the mean around the lower values observed in the period 1955 to 1985.

According to the adopted management harvest rule the TAC will be 218 kt in the next fishing season. ICES has evaluated the plan and concludes that it is in accordance with the precautionary approach and the ICES MSY framework.

Mean weight at age in the stock and the catches that were record low in 2006-8 have been increasing in recent years and are now around the long term mean.

The input in the analytical assessments are catch at age 1955-2013 and spring groundfish survey (SMB) indices at age from 1985-2014 and fall survey groundfish survey (SMH) indices at age from 1996-2013. The results from the AD-Model builder statistical Catch at Age Model (ADCAM) as was used as the final run, as done in the previous year. No changes were made in the model set-up compared with that applied last year.

The reference stock (B_{4+}) in 2013 is now estimated to be 1161 kt compared to 1173 kt last year. The SSB in 2013 is now estimated to be 437 kt compared to 479 kt estimated last year. Fishing mortality in 2012 is now estimated 0.28 compared to 0.28 estimated last year. Year classes 2010-2012 were estimated to be 119, 183 and 151 million in last years assessment and are now estimated to be 123, 181 and 160 millions.

9.2 Stock description and management units

The Icelandic cod stock is distributed all around Iceland and in the assessment cod within Icelandic EEZ waters it is assumed to be a single homogeneous unit in the assessment. Spawning takes place in late winter mainly off the south west coast but smaller, variable regional spawning components have also been observed all around Iceland. A slight but significant genetic difference has been observed between the cod spawning in the northern waters vs cod spawning in the southern waters (Pampoulie et al 2007). There are indications that different behavioural type (shallow vs. deep migration) may be found within cod spawning in the same areas (Pampoulie et al 2008). Both these information indicate that management measurements operating on a finer scale may be warranted, although appropriate non-ambiguous management measure in addition to maintaining low fishing mortality have not yet been identified.

The pelagic eggs and larvae from the main spawning grounds off the south west coast drift clockwise around the island to the main nursery grounds off the north coast. A larval drift to Greenland waters has been recorded in some years and substantial immigrations of mature cod from Greenland which are considered to be of Icelandic origin have been observed in some periods. This pattern was quite prevalent prior to 1970, while condition in Greenlandic waters are thought to have been favourable for cod productivity. Periodic immigrations have been estimated in the assessment from anomalies in the catch at age matrix with timing and age of such events being based on expert judgement using external informations. The most recent of such migration was from the 1984 year class in 1990, the number estimated around 30 millions. Recent tagging experiments as well as abnormal decline in survey indices in West Greenlandic waters indicate that part of the 2003 and to some extent the 2002 year classes may have migrated from Greenland to Icelandic waters. In the current assessment the immigration at age 6 in 2009 is estimated around 9.7 millions corresponding an additional biomass of around 31 kt in 2009. The influence of this immigration on the current biomass estimate is minimal.

Extensive tagging experiments spanning with some hiatuses over the last 100 year indicate that significant emigration from Iceland to other areas may be rare. In recent years it has been observed that cod tagged in Iceland has been recaptured inside Faroese waters close to the EEZ line separating Iceland and the Faroes islands. Anecdotal informations from the fishing industry indicate that may be some exchange of cod across the Denmark Strait. These migrations may be of different nature than the hypothesised net "life history" immigration of cod described above.

9.3 Data

The data used for assessing Icelandic cod landings, catch-at-age composition and indices from standardized bottom trawl surveys. The sampling programs i.e log books, surveys, sampling from landings etc. have been described in previous reports.

9.3.1 Catch: Landings, discards and misreporting

9.3.1.1 Landings in 2013

Landings of Icelandic cod in 2013 are estimated to have been 223.274 kt (Table Error: Reference source not found and Figure Error: Reference source not found). Of the total landings 221.569 kt were taken by Icelandic fleet and the remainder by other nations. The landings by month and gear metier are as follows (Gear code - 1: Longline, 2: Gillnet, 3: Hooks, 5: Danish seine, 6: Trawl):

	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	7987	8010	4766	4286	5066	5173	2275	2981	8695	10202	9990	6593	76025
2	2956	5208	6207	3254	776	198	162	34	223	245	243	348	19854
3	33	146	882	1137	2176	2993	3746	2427	820	373	32	19	14784
5	691	1423	2128	1733	603	234	265	220	928	772	931	118	10046
6	8505	7582	7071	8218	9748	5735	5832	3505	10283	12140	12741	11205	102565
	20172	22369	21054	18628	18369	14333	12280	9167	20949	23732	23937	18283	223274

Historically the landings of bottom trawlers constituted a larger portion of the total catches than today, in some years prior to 1990 reaching 60% of the total landings. In the 1990's the landings from bottom trawlers declined significantly within a period of 5 years, and have been just above 40% of the total landings in the last decade. (Figure Error: Reference source not found). The share of long line has tripled over the last 20 years and is now on par with bottom trawl. The share of gill net has over the same time period declined and is now only half of what it was in the 1980's. The percentage split of the landings by gear in 2013 is:

Gear	Landings	Percentage
Longline	76025	34
Gill net	19854	9
Hooks	14784	7
Danish seine	10046	4
Trawl	102565	46

The trend in landings in last two decades is largely a reflection of the set TAC that is set for the fishing year (starting 1. September and ending 31 august).

9.3.1.2 Landings in the 2012/2013 quota years

According to the HCR the TAC for the fishing year 2012/13 was supposed to be capped to 196 kt. Landings of the Icelandic fleet was however 210.636. Including additional landings from the foreign fleet this amounts to an overshoot of some 7.5%.

9.3.1.3 Predicted landings

The best estimate of landings for the fishing year 2013/14 is 227 kt, this being based on data obtained from the Directorate of Fisheries.

The catches in the first four months of the current fishing year (September – December 2013) were 87 kt. The remainder of the estimated catch in the fishing year (227 kt) is 140 kt. Assuming that the same proportion of the allowable catch for the next fishing year is taken in the first four months (September – December 2013) as last year landings (some 0.38), the catch in 2014 is estimated to be 224 kt.

9.3.1.4 Discards and misreportings

Estimates of annual cod discards (Ólafur Pálsson et al 2010) since 2001 are in the range of 1.3-4.3% of numbers landed and 0.5-1.8% of weight landed. Mean annual discard of cod over the period 2001-2008 was around 2 kt, or just over 1% of landings. In 2008 estimates of cod discards amounted to 1.1 kt, 0.8% of landings, the third lowest value in the period 2001-2008. The method used for deriving these estimates assumes that discarding only occurs as high grading but larger fish is usually higher priced.

In recent years misreporting has not been regarded as a major problem in the fishery of this stock. No scientific study is though available to support that general perspective. Production figures from processing plants do though seem to be in “good” agreement with landings figures according to the Fisheries Directorate (personal communication).

9.3.1.5 Landings and weight by age

Landings in numbers by age: Sampling protocol for estimating the age composition of the cod has been in effect since 1991 and has been described previous reports. The sampling intensity in 2013 is similar as it has been in previous years. The method for deriving the catch at age are described in the stock annex. The catch at age matrix is reasonably consistent (Table Error: Reference source not found), with CV estimated to be approximately 0.2 for age groups 4-10 based on a Shepherd-Nicholson model.

Mean weight at age in the landings: The mean weight age in the landings (Table Error: Reference source not found and Figure Error: Reference source not found) declined from 2001 to 2007, reaching then a historical low in many age groups. The weight at age have been increasing in recent years and are in 2013 around the average weights observed over the period from 1985 and close to the long term mean (1955-2012). The variation in the pattern of weight at age in the catches is in part a reflection of the variation in the weight in the stock as seen in the measurements from the spring survey (Table Error: Reference source not found and Figure Error: Reference source not found). The latest spring survey weight measurements (in 2014) are below average in younger ages but above average in older ages.

The reference biomass (B_{4+}) upon which the TAC in the fishing year is set (based on the HCR) is derived from population numbers and catch weights in the beginning of the assessment year. In recent years the estimates of mean weights in the landings of age groups 3-9 in the assessment years have been based on a prediction from the spring survey weight measurements in that year using the slope and the intercept from a linear relationship between survey and catch weights in preceding year. The same approach was used this year for predicting weight at age in the catches for 2014. I.e. the *alpha* and *beta* were estimated from :

$$cW_{a\backslash,2013alphabetasWa\backslash,2013}$$

and the catch weights for 2014 then from:

$$cW_{a\backslash,2014alphabetasWa\backslash,2014}$$

Based on this the mean weights at age in the catches in 2014 are predicted to be somewhat below the long term mean for age groups 4 to 7 but at the long term mean for age classes 8 and 9 (Figure Error: Reference source not found).

9.3.1.6 Surveys

Length based indices: The total biomass indices from the spring (SMB) and the fall (SMH) surveys (Figure Error: Reference source not found) indicate that the stock biomass has been increasing substantially in recent years as is in the last 3 years among highest since the start of the spring survey in 1985. The abundance of the fish smaller than 18 cm are a measure of incoming recruits (age 1) indicating that the 2008, 2009 and 2011 year classes are strong while the 2010, 2012 and 2013 year classes are weak to moderate.

Age based indices: Abundance indices by age from the spring and the fall surveys (Tables Error: Reference source not found and Error: Reference source not found) show that the age 1 abundance indices of year classes 2008, 2009 and 2011 are among of the highest observed while the measurement of the 2010, 2012 and 2013 year classes indicate that they are below average. Indices of older fish are all relatively high in recent years despite the indices of these year classes when younger are low or moderate in size (Figure Error: Reference source not found). This is in part attributed to the recent estimated reduction in fishing mortalities.

The variance of age groups 5-9 was abnormally high in the spring 2012 survey but the value for the last two years being normal (Table Error: Reference source not found). This high cv is in part attributed to one haul having extremely high cod catches. In last years NWWG report it was shown that the influence of the large haul did not have a significant effect on the SPALY assessment, this being attributed to survey residuals in a given year being modelled by a multivariate normal distribution (see stock annex).

The variance of age group 2 in 2014 is anomalously high, but the estimates of this age group has no influence on the reference biomass B_{4+} and advise until 2016.

9.3.1.7 Commercial cpue and effort

Unstandardised CPUE and effort indices, based on log book records were not considered during this meeting. In previous reports it has been concluded that changes in these parameters, although to some extent a reflection of the dynamics in the stock they are confounded by other factors.

9.4 Assessment

Last year, the results from a statistical catch at age model (sometimes refer to as ADCAM) tuned with the spring and the fall survey was used as the final point estimator upon which advice was based (referred to as the SPALY model in the text that follows). In this framework the catch at age are modelled and the fishing mortality changes gradually over time, constrained by a random walk (further explanation of the model set-up are provided in the stock annex). In addition to the above model, the data have also been extensively explored in the TSA framework, using a Time Series Analysis developed and run by Guðmundur Guðmundsson (1994, 2004, details of model description are given in WD 29, NWWG 2013). Models where the catch/fishing mortality is not modelled (ADAPT) and where the fishing pattern is not considered to change each year (SEPARABLE) are also routinely run for comparative purpose.

The SPALY framework from last year, i.e. tuning with both the spring and the fall survey using ADCAM show similar diagnostics as that observed last years (see Tables Error: Reference source not found, Error: Reference source not found and Error: Reference source not found and Figure Error: Reference source not found for the residuals). A negative residual block for spring survey indices age groups 2 to 5 in recent years may indicate that there may have been some change in catchability. The detailed result from the SPALY ADCAM run are provided in Tables Error: Reference source not found, Error: Reference source not found and the stock summary in Table Error: Reference source not found and Figure Error: Reference source not found. The reference biomass is estimated to be 1106 kt in 2014 and the fishing mortality 0.3 in 2013.

Assessment based on ADCAM tuning with the spring and the fall survey separately have in recent years shown that the fall survey gives a higher estimate than the spring survey (Figure Error: Reference source not found). Tuning with spring survey only this year resulted in a reference biomass of 998 kt in 2014 and a fishing mortality of 0.34 in 2013. An assessment based on the fall survey only gave reference biomass of 1202 kt in 2014 and fishing mortality of 0.28 in 2013. There are hence conflict with respect to the extent of the increase in the biomass and reduction in fishing mortality in recent years between the two survey input sources. In addition there are conflict in the signals between the surveys on one hand and the catch at age matrix, the year classes declining at a faster rate in the fisheries than in the surveys. To demonstrate this a tuning run where the lamda weight in the likelihood component was set to 0.1 for both surveys gave a reference biomass of 940 and fishing mortality of 0.4.

Further insight into these conflicts between different input sources were provided by Guðmundur Guðmundsson using his TSA analysis (NWWG 2014 WD 38). When M and the catchabilities were kept constant (as done in the ADCAM framework) the principal stock metrics (biomass, fishing mortality) obtained from the TSA runs were similar as in the ADCAM above (Figure Error: Reference source not found). A TSA analysis based on catch at age alone gave a biomass estimate of B_{4+} kt. Additional analysis were done where the catchability was not kept constant. The author concluded that "The residual correlations are satisfactory in the estimations without survey and when the trend [SMH] or random [SMB] walk are included. It is rather high in the estimation with the October [SMH] survey without trend (we don't know the exact distribution under the null hypthesis of no serial correlation) and certainly too high with the March [SMB] survey without random walk in catchability." The analysis were the catchability was not constant resulted in stock trajectory estimates that were similar to that estimated when using catch at age alone. From this analysis the author notes that "Significant estimates of linear trend or random walk in survey catchability are an important warning that results, based on the assumption that no permanent or long-term variations are present in the survey catchability are unreliable. But they are not a strong evidence for the assumption that linear trend or random walk are a good model of the actual process." For further details on the TSA results, including exploration for estimating M and discussion the reader is referred to the NWWG 2014 WD 38 from Guðmundur Guðmundsson.

Although there are indication that there may be violation in the SPALY ADCAM setup it was considered premature to base the advice this year on one of the alternative models setup and assumptions. If the true reference biomass in 2014 is around 900 kt and the TAC is set at 218 kt it is equivalent to the decision being based on a 0.24 harvest rate. If this becomes the realized harvest in 2015 is is still among the lowest observed historical rates.

The issues raised above and the alternative hypothesis that may explain the discrepancy between the survey and catch at age will be further scrutinized prior to the benchmark meeting in early 2015.

9.5 Reference points

In 2010 ACOM set the B_{lim} as 125 kt based on recommendation of the NWWG. The basis for B_{lim} is B_{loss} and/or the SSB_{break} in a segmented regression based on recruitment from year classes 1952-1984 on one hand and recruitment from year classes 1985 onwards on the other hand (Figure Error: Reference source not found). The splitting of the recruitment time series is based on the hypothesis that recruitment productivity as a function of spawning stock biomass, as it is presently measured, is lower in latter period compared with the former period.

An harvest rate limit point derived deterministically from B_{lim} according to the methodology outlined in SGMAS 2006 indicates that it is in the vicinity of 0.35.

B_{pa} and F_{pa} have never been set for this stock. Based on the ICES default methodology for the derivation of B_{pa} and F_{pa} from B_{lim} and F_{lim} these reference points would be somewhere in the vicinity of: B_{pa} = 1.4 B_{lim} = 175 kt HR_{pa} = HR_{lim}/1.4 = 0.25

The $B_{trigger}$ and the HR_{HCR} in the HCR are thus respectively above and below the default candidate PA-reference points. Given the current ICES MSY framework, upon which the HCR for iCod has been evaluated, definition of PA-reference points may be deemed as redundant. The NWWG does not suggest a formal establishment of PA-points for iCod at this point.

F_{msy} point estimate, to be used in stock status classification in the advisory text has not been defined for this stock. The harvest rate in the management control rule upon which the TAC is based (landings being equal to 20% of the reference biomass (B4+) has been deemed by ICES to be in conformity with the ICES MSY approach.

General comments on the use of reference points in the advisory framework were dealt with in NWWG 2011 report.

9.6 State of the stock

The spawning stock reached a historical low in 1993 (120 kt point estimates) but has since then increased and estimated to be 427 kt at present (Figure Error: Reference source not found, Table Error: Reference source not found). A spawning stock biomass above the current estimates has not been observed since the early the 1960's. This increase in biomass of older fish occurs despite productivity in terms of recruitment of the year classes now contributing to the spawning stock having been relatively low. The driving factor is hence attributed to a significant decline in fishing mortality/exploitation rate in recent years, being at present within the same order as observed in the beginning of the time series. The 2008, 2009 and 2011 year classes are estimated to be at or above the long term average, but 2010, 2012 and 2013 year classes are below average.

9.7 Short term deterministic forecast

Input: The stock in numbers in 2014 (Table Error: Reference source not found) for year classes 2013 and older are obtained from the current assessment (Table Error: Reference source not found). Given the current harvest control rule, where the TAC 2014/2015 is determined from the $B_{4+\,2014}$, the only additional prediction needed is the estimates of weights in 2014. These were described in section 9.3.2. Hence there is no need to carry through a short term prediction so what follows is just to keep up with the ICES convention.

Additional assumptions used in the deterministic predictions are as usual: Weights and proportion mature in the spawning stock from 2014 onwards were kept constant. The fishing pattern used is the average of the years 2010-2013. The estimated landings for the calendar year 2014 is 227 kt as discussed in section 9.3.1. Details of the inputs values are provided in Table Error: Reference source not found.

Output: The estimated reference biomass in 2014 is 1106 kt. The TAC in the current fishing year is 215 kt. According to the management harvest control rule, given that the current SSB estimates are above the $SSB_{trigger}$ (220 kt), the TAC in the next fishing year is:

$$TAC_{2014/2015 kt}$$

Fishing mortality, which has been declining significantly in the last decade is not expected to change much in 2014 relative to the current estimate of 0.30 (Table Error: Reference source not found). The deterministic estimates of the reference biomass and the spawning stock are not expected to change much relative to the present.

9.8 Stochastic forecast

Medium term forecasts up to year 2018 was run on the three ADCAM runs, both surveys in the tuning (SPALY), spring survey only and fall survey only. The platform used is the same as used in the assessment. Future harvest rate of 0.20 (for the SPALY assessment), 0.22 (for the SMB tuned assessment) and 0.18 (for the SMH tuned assessment) were used in the future, the latter two to accounting for potential under or overestimation of the stock.

The analysis indicate there is high probability that the spawning stock size is and will remain above $B_{trigger}$ (220 kt) and B_{lim} (125 kt) (Figure Error: Reference source not found).

9.9 Uncertainties in assessment and forecast

Alternative model assumptions indicate that the reference biomass may be around ramge from 900-1200 kt in 2014, compared with the 1100 kt estimated from the SPALY model. The lower alternative state of nature implies that the reference biomass upon which the TAC is set may be 20% lower than used and that the realized harvest rate could materialize to be 24% given a TAC of 218 kt. According to the HCR evaluation (ICES 2009), this is close to the upper bounds of expected harvest rates.

9.10 Comparison with previous assessment, forecast and advise

The reference stock (B_{4+}) in 2013 is now estimated to be 1161 kt compared to 1173 kt last year. The SSB in 2013 is now estimated to be 437 kt compared to 479 kt estimated last year. Fishing mortality in 2012 is now estimated 0.28 compared to 0.28 estimated last year. Year classes 2010-2012 were estimated to be 119, 183 and 151 million in last years assessment and are now estimated to be 123, 181 and 160 millions.

A standard ICES retrospective plots (Figure Error: Reference source not found) show estimates of key metrics in recent years compared with current estimates.

The basis for the assessment has not changed from last year. The basis for the advice this year is the same as last year: the management plan/MSY/precautionary approach.

9.11 Management considerations

Prior to allocating quota to the Icelandic fleet that is under the ITQ control, the managers should ensure subtracting all estimated catches from other sources, including any landings arising from new regulations. The amount is not known precisely in advance but is likely that small fish landings, VS landings and foreign landings will be of similar magnitude as in recent years, or around 12 kt.

Cod and haddock are often caught in the same fishing operation. The TAC constraint on cod has resulted in significant reduction in fishing mortalities. This reduction is not in line with current fishing mortality trends in haddock. Anecdotal information from the fisheries indicates that the restrictions on the landings of cod in recent years changed the behaviour of the fishing fleet, fishermen trying to avoid catching cod but targeting haddock.

9.12 Regulations and their effects

Exploitation rate and fishing mortality have been reduced significantly after the implementation of the catch rule in 1995 compared with the past. I.e. management measure by restricting landings based on the HCR are manifested in lower fishing mortality and higher stock biomass for the iCod.

A quick closure system has been in force since 1976, aimed at protecting juvenile fish. Fishing is prohibited, for at least two weeks, in areas where the number of small cod (< 55 cm) in the catches has been observed by inspectors to exceed 25%. A preliminary evaluation of the effectiveness of the system indicates that the relatively small areas closed for a short time do most likely not contribute much to the protection of juveniles. On the other hand, several consecutive quick closures often lead to closures of larger areas for a longer time and force the fleet to operate in other areas. The effect of these longer closures has not been evaluated analytically.

Since 1995, spawning areas have been closed for 2-3 weeks during the spawning season for all fisheries. The intent of this measure was to protect spawning fish. In 2005, the maximum allowed mesh size in gill nets was decreased to 8 inches in order to protect the largest spawners.

The mesh size in the cod-end in the trawling fishery was increased from 120 mm to 155 mm in 1977. Since 1998 the minimum cod-end mesh size allowed is 135 mm, provided that a so-called Polish cover is not used. Numerous areas are closed temporarily or permanently for all fisheries or specific gears for protecting juveniles and habitat, or for socio-political reasons. The effects of these measures have not been evaluated.

9.13 Changes in fishing technology and fishing patterns

Changes in the importance of the various gears used to catch cod are described in section 9.3. The decline in the gill net fishery are likely to have resulted in overall shift in the fishing pattern away from the largest fish. The increase in the long line fishery in the north was partly the reason for the decline in the observed mean weight at age of oldest fish in the catches.

9.14 Environmental influence on the stock

Environmental influence on the stock are partly integrated in the annual input data for the analytical assessment, both in terms of weight and stock indices. The causation is however poorly understood.

An increased inflow of Atlantic water has been observed in Icelandic waters since 1997, resulting in higher temperature and higher salinity. A northward shift in distribution of immature capelin may be linked to these hydrographical changes, resulting in lower availability of capelin for cod. In the past low weights-at-age of cod have been related to a low biomass of capelin. The increase in mean weight-at-age in cod in recent years may, however, have more to do with reduction in fishing mortality than with changes in availability of capelin.

Table 1: Icelandic cod in division Va. Nominal catches (tonnes) by countries 1973-2013 as reported to ICES and WG best estimates of landings.

Year	Belgium	Faeroe.Islands	France	Germany	Greenland	Iceland	Norway	Poland	UK.Eng.Wales.N.Irl.	UK.England.Wales	UK.Scotland	Total	WG.estimates
1973	1110	14207		6839		235184268				121320	957	379885369205	
1974	1128	12125	203	5554		238066171		1		115395	2144	374787368133	
1975	1269	9440	23	2266		264975144				91000	1897	371014364754	
1976	956	8772		2970		280831514				53534	786	348363346253	
1977	1408	7261		1598		329676108						340051340086	
1978	1314	7069				319648189						328220329602	
1979	1485	6163				360077288						368013366462	
1980	840	4802				429044358						435044432237	
1981	1321	6183				461038559						469101465032	
1982	236	5297				382297557						388387380068	
1983	188	5626				293890109						299813298049	
1984	254	2041				28148190				2		283868282022	
1985	207	2203				32281046				1		325267323428	
1986	226	2554				3658521						368633364797	
1987	597	1848				3898084						392257389915	
1988	365	1966				3757414						378076377554	
1989	309	2012				3539853						356309363125	
1990	260	1782				333348						335390335316	
1991	548	1323				306697						308568307759	
1992	222	883				266662						267767264834	
1993	145	664				251170			0			251979250704	
1994	136	754				177919						178809178138	
1995		739				168685						169424168592	
1996		599		0		1810527						181658180701	
1997		408				202745						203153203112	
1998		1078		9		241545						242632243987	
1999		1247		21	25	25865885			12		4	260052260147	
2000				15		23436260			10		0	234447235092	
2001		1143		11		23387565			15		5	235114234229	
2002		1175		15		20698773			19		13	208282208487	
2003		2118		88		20032756			104		42	202735207543	
2004		2737		113		22002090			310		102	223372226762	
2005		2310		177		20634377			224		220	209351213403	
2006		1665		38		19342578			14		5	195225196077	
2007		1710			15	167159110			11			169005170300	
2008		1608				14380549						145462146104	
2009		1351			2	18132130						182704181151	
2010		1428				16763228						169088168880	
2011		1337			2	16963836						171013171700	
2012		1336				19500264						196402194795	

Year	Belgium	Faeroe.Islands	France	Germany	Greenland	Iceland	Norway	Poland	UK.Eng.Wales.N.Irl.	UK.England.Wales	UK.Scotland	Total	WG.estimates
2013		1294				22157167						222932223548	

Table 2: Icelandic cod in Division Va. Estimateded catch in numbers by year and age in millions of fish in 1955-2013.

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	4.790	25.164	46.566	28.287	10.541	5.224	2.467	25.182	2.101	1.202	1.668	0.665
1956	6.709	17.265	31.030	27.793	14.389	4.261	3.429	2.128	16.820	1.552	1.522	1.545
1957	13.240	21.278	17.515	24.569	17.634	12.296	3.568	2.169	1.171	6.822	0.512	1.089
1958	25.237	30.742	14.298	10.859	15.997	15.822	12.021	2.003	2.125	0.771	3.508	0.723
1959	18.394	37.650	23.901	7.682	5.883	8.791	13.003	7.683	0.914	0.990	0.218	1.287
1960	14.830	28.642	27.968	14.120	8.387	6.089	6.393	11.600	3.526	0.692	0.183	0.510
1961	16.507	21.808	19.488	15.034	7.900	6.925	3.969	3.211	6.756	1.202	0.089	0.425
1962	13.514	28.526	18.924	14.650	12.045	4.276	8.809	2.664	1.883	2.988	0.405	0.324
1963	18.507	28.466	19.664	11.314	15.682	7.704	2.724	6.508	1.657	1.030	1.372	0.246
1964	19.287	28.845	18.712	11.620	7.936	18.032	5.040	1.437	2.670	0.655	0.370	1.025
1965	21.658	29.586	24.783	11.706	9.334	6.394	11.122	1.477	0.823	0.489	0.118	0.489
1966	17.910	30.649	20.006	13.872	5.942	7.586	2.320	5.583	0.407	0.363	0.299	0.311
1967	25.945	27.941	24.322	11.320	8.751	2.595	5.490	1.392	1.998	0.109	0.030	0.106
1968	11.933	47.311	22.344	16.277	15.590	7.059	1.571	2.506	0.512	0.659	0.047	0.098
1969	11.149	23.925	45.445	17.397	12.559	14.811	1.590	0.475	0.340	0.064	0.024	0.021
1970	9.876	47.210	23.607	25.451	15.196	12.261	14.469	0.567	0.207	0.147	0.035	0.050
1971	13.060	35.856	45.577	21.135	17.340	10.924	6.001	4.210	0.237	0.069	0.038	0.020
1972	8.973	29.574	30.918	22.855	11.097	9.784	10.538	3.938	1.242	0.119	0.031	0.001
1973	36.538	25.542	27.391	17.045	12.721	3.685	4.718	5.809	1.134	0.282	0.007	0.001
1974	14.846	61.826	21.824	14.413	8.974	6.216	1.647	2.530	1.765	0.334	0.062	0.028
1975	29.301	29.489	44.138	12.088	9.628	3.691	2.051	0.752	0.891	0.416	0.060	0.046
1976	23.578	39.790	21.092	24.395	5.803	5.343	1.297	0.633	0.205	0.155	0.065	0.029
1977	2.614	42.659	32.465	12.162	13.017	2.809	1.773	0.421	0.086	0.024	0.006	0.002
1978	5.999	16.287	43.931	17.626	8.729	4.119	0.978	0.348	0.119	0.048	0.015	0.027
1979	7.186	28.427	13.772	34.443	14.130	4.426	1.432	0.350	0.168	0.043	0.024	0.004
1980	4.348	28.530	32.500	15.119	27.090	7.847	2.228	0.646	0.246	0.099	0.025	0.004
1981	2.118	13.297	39.195	23.247	12.710	26.455	4.804	1.677	0.582	0.228	0.053	0.068
1982	3.285	20.812	24.462	28.351	14.012	7.666	11.517	1.912	0.327	0.094	0.043	0.011
1983	3.554	10.910	24.305	18.944	17.382	8.381	2.054	2.733	0.514	0.215	0.064	0.037
1984	6.750	31.553	19.420	15.326	8.082	7.336	2.680	0.512	0.538	0.195	0.090	0.036
1985	6.457	24.552	35.392	18.267	8.711	4.201	2.264	1.063	0.217	0.233	0.102	0.038
1986	20.642	20.330	26.644	30.839	11.413	4.441	1.771	0.805	0.392	0.103	0.076	0.044
1987	11.002	62.130	27.192	15.127	15.695	4.159	1.463	0.592	0.253	0.142	0.046	0.058
1988	6.713	39.323	55.895	18.663	6.399	5.877	1.345	0.455	0.305	0.157	0.114	0.025
1989	2.605	27.983	50.059	31.455	6.010	1.915	0.881	0.225	0.107	0.086	0.038	0.005

year	3	4	5	6	7	8	9	10	11	12	13	14
1990	5.785	12.313	27.179	44.534	17.037	2.573	0.609	0.322	0.118	0.050	0.015	0.020
1991	8.554	25.131	15.491	21.514	25.038	6.364	0.903	0.243	0.125	0.063	0.011	0.012
1992	12.217	21.708	26.524	11.413	10.073	8.304	2.006	0.257	0.046	0.032	0.009	0.008
1993	20.500	33.078	15.195	13.281	3.583	2.785	2.707	1.181	0.180	0.034	0.011	0.013
1994	6.160	24.142	19.666	6.968	4.393	1.257	0.599	0.508	0.283	0.049	0.018	0.006
1995	10.770	9.103	16.829	13.066	4.115	1.596	0.313	0.184	0.156	0.141	0.029	0.008
1996	5.356	14.886	7.372	12.307	9.429	2.157	0.837	0.208	0.076	0.065	0.055	0.005
1997	1.722	16.442	17.298	6.711	7.379	5.958	1.147	0.493	0.126	0.028	0.037	0.021
1998	3.458	7.707	25.394	20.167	5.893	3.856	2.951	0.500	0.196	0.055	0.033	0.013
1999	2.525	19.554	15.226	24.622	12.966	2.795	1.489	0.748	0.140	0.046	0.010	0.005
2000	10.493	6.581	29.080	11.227	11.390	5.714	1.104	0.567	0.314	0.074	0.022	0.006
2001	11.338	25.040	9.311	19.471	5.620	3.929	2.017	0.452	0.202	0.118	0.013	0.009
2002	5.934	18.482	24.297	6.874	8.943	2.227	1.353	0.689	0.123	0.040	0.041	0.002
2003	3.950	16.160	21.874	18.145	5.063	4.419	1.124	0.401	0.172	0.034	0.020	0.015
2004	1.778	19.184	25.003	17.384	9.926	2.734	2.023	0.481	0.126	0.062	0.014	0.005
2005	5.102	5.125	26.749	16.980	8.339	4.682	1.292	0.913	0.203	0.089	0.025	0.002
2006	3.258	12.884	8.438	22.041	10.418	4.523	2.194	0.497	0.336	0.067	0.027	0.002
2007	2.074	11.961	15.948	8.280	9.593	5.428	2.205	1.229	0.366	0.198	0.053	0.010
2008	2.616	4.850	12.585	11.973	5.238	4.582	2.040	0.831	0.308	0.053	0.037	0.004
2009	3.660	8.150	9.480	17.330	10.060	3.910	2.290	0.770	0.310	0.090	0.020	0.010
2010	3.174	7.219	9.385	8.692	10.695	5.588	1.599	1.095	0.337	0.197	0.071	0.016
2011	4.780	7.257	9.284	10.735	6.032	6.152	2.361	0.666	0.459	0.151	0.041	0.010
2012	3.839	10.010	10.400	9.435	8.866	4.834	3.206	1.269	0.369	0.218	0.101	0.030
2013	5.206	12.328	14.846	11.194	7.357	5.636	2.694	1.937	0.676	0.290	0.157	0.052

Table 3: Icelandic cod in Division Va. Estimated mean weight at age in the landings (kg) in period the 1955-2013. The weights for age groups 3 to 9 in 2014 are based on predictions from the 2014 spring survey measurements. The weights in the catches are used to calculate the reference biomass (B_{4+}).

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	0.827	1.307	2.157	3.617	4.638	5.657	6.635	6.168	8.746	8.829	10.086	14.584
1956	1.080	1.600	2.190	3.280	4.650	5.630	6.180	6.970	6.830	9.290	10.965	12.954
1957	1.140	1.710	2.520	3.200	4.560	5.960	7.170	7.260	8.300	8.290	10.350	13.174
1958	1.210	1.810	3.120	4.510	5.000	5.940	6.640	8.290	8.510	8.840	9.360	13.097
1959	1.110	1.950	2.930	4.520	5.520	6.170	6.610	7.130	8.510	8.670	9.980	11.276
1960	1.060	1.720	2.920	4.640	5.660	6.550	6.910	7.140	7.970	10.240	10.100	12.871
1961	1.020	1.670	2.700	4.330	5.530	6.310	6.930	7.310	7.500	8.510	9.840	14.550
1962	0.990	1.610	2.610	3.900	5.720	6.660	6.750	7.060	7.540	8.280	10.900	12.826
1963	1.250	1.650	2.640	3.800	5.110	6.920	7.840	7.610	8.230	9.100	9.920	11.553
1964	1.210	1.750	2.640	4.020	5.450	6.460	8.000	9.940	9.210	10.940	12.670	15.900
1965	1.020	1.530	2.570	4.090	5.410	6.400	7.120	8.600	12.310	10.460	10.190	17.220
1966	1.170	1.680	2.590	4.180	5.730	6.900	7.830	8.580	9.090	14.230	14.090	17.924
1967	1.120	1.820	2.660	4.067	5.560	7.790	7.840	8.430	9.090	10.090	14.240	16.412
1968	1.170	1.590	2.680	3.930	5.040	5.910	7.510	8.480	10.750	11.580	14.640	16.011
1969	1.100	1.810	2.480	3.770	5.040	5.860	7.000	8.350	8.720	10.080	11.430	13.144
1970	0.990	1.450	2.440	3.770	4.860	5.590	6.260	8.370	10.490	12.310	14.590	21.777
1971	1.090	1.570	2.310	2.980	4.930	5.150	5.580	6.300	8.530	11.240	14.740	17.130
1972	0.980	1.460	2.210	3.250	4.330	5.610	6.040	6.100	6.870	8.950	11.720	16.000
1973	1.030	1.420	2.470	3.600	4.900	6.110	6.670	6.750	7.430	7.950	10.170	17.000
1974	1.050	1.710	2.430	3.820	5.240	6.660	7.150	7.760	8.190	9.780	12.380	14.700
1975	1.100	1.770	2.780	3.760	5.450	6.690	7.570	8.580	8.810	9.780	10.090	11.000
1976	1.350	1.780	2.650	4.100	5.070	6.730	8.250	9.610	11.540	11.430	14.060	16.180
1977	1.259	1.911	2.856	4.069	5.777	6.636	7.685	9.730	11.703	14.394	17.456	24.116
1978	1.289	1.833	2.929	3.955	5.726	6.806	9.041	10.865	13.068	11.982	19.062	21.284
1979	1.408	1.956	2.642	3.999	5.548	6.754	8.299	9.312	13.130	13.418	13.540	20.072
1980	1.392	1.862	2.733	3.768	5.259	6.981	8.037	10.731	12.301	17.281	14.893	19.069
1981	1.180	1.651	2.260	3.293	4.483	5.821	7.739	9.422	11.374	12.784	12.514	19.069
1982	1.006	1.550	2.246	3.104	4.258	5.386	6.682	9.141	11.963	14.226	17.287	16.590
1983	1.095	1.599	2.275	3.021	4.096	5.481	7.049	8.128	11.009	13.972	15.882	18.498
1984	1.288	1.725	2.596	3.581	4.371	5.798	7.456	9.851	11.052	14.338	15.273	16.660
1985	1.407	1.971	2.576	3.650	4.976	6.372	8.207	10.320	12.197	14.683	16.175	19.050
1986	1.459	1.961	2.844	3.593	4.635	6.155	7.503	9.084	10.356	15.283	14.540	15.017
1987	1.316	1.956	2.686	3.894	4.716	6.257	7.368	9.243	10.697	10.622	15.894	12.592
1988	1.438	1.805	2.576	3.519	4.930	6.001	7.144	8.822	9.977	11.732	14.156	13.042
1989	1.186	1.813	2.590	3.915	5.210	6.892	8.035	9.831	11.986	10.003	12.611	16.045
1990	1.290	1.704	2.383	3.034	4.624	6.521	8.888	10.592	10.993	14.570	15.732	17.290
1991	1.309	1.899	2.475	3.159	3.792	5.680	7.242	9.804	9.754	14.344	14.172	20.200
1992	1.289	1.768	2.469	3.292	4.394	5.582	6.830	8.127	12.679	13.410	15.715	11.267
1993	1.392	1.887	2.772	3.762	4.930	6.054	7.450	8.641	10.901	12.517	14.742	16.874
1994	1.443	2.063	2.562	3.659	5.117	6.262	7.719	8.896	10.847	12.874	14.742	17.470
1995	1.348	1.959	2.920	3.625	5.176	6.416	7.916	10.273	11.022	11.407	13.098	15.182

year	3	4	5	6	7	8	9	10	11	12	13	14
1996	1.457	1.930	3.132	4.141	4.922	6.009	7.406	9.772	10.539	13.503	13.689	16.194
1997	1.484	1.877	2.878	4.028	5.402	6.386	7.344	8.537	10.797	11.533	10.428	12.788
1998	1.230	1.750	2.458	3.559	5.213	7.737	7.837	9.304	10.759	14.903	16.651	18.666
1999	1.241	1.716	2.426	3.443	4.720	6.352	8.730	9.946	11.088	12.535	14.995	15.151
2000	1.308	1.782	2.330	3.252	4.690	5.894	7.809	9.203	10.240	11.172	13.172	17.442
2001	1.499	2.050	2.649	3.413	4.766	6.508	7.520	9.055	8.769	9.526	11.210	13.874
2002	1.294	1.926	2.656	3.680	4.720	6.369	7.808	9.002	10.422	13.402	9.008	16.893
2003	1.265	1.790	2.424	3.505	4.455	5.037	5.980	7.819	8.802	10.712	12.152	13.797
2004	1.257	1.771	2.323	3.312	4.269	5.394	5.872	7.397	10.808	11.569	13.767	12.955
2005	1.194	1.712	2.374	3.435	4.392	5.201	6.200	5.495	7.211	9.909	12.944	18.151
2006	1.070	1.614	2.185	3.052	4.347	5.177	5.382	5.769	6.258	5.688	7.301	15.412
2007	1.083	1.556	2.144	2.754	3.920	5.255	6.272	6.481	7.142	6.530	9.724	10.143
2008	1.162	1.627	2.318	3.120	3.846	5.367	6.771	7.648	8.282	11.181	14.266	17.320
2009	1.109	1.680	2.204	3.206	4.098	4.884	6.744	8.505	10.126	12.108	12.471	15.264
2010	1.131	1.769	2.334	3.161	4.422	5.498	6.552	7.945	8.913	10.090	10.417	13.489
2011	1.163	1.795	2.615	3.471	4.469	5.850	6.742	7.850	8.810	9.797	13.534	13.033
2012	1.256	1.667	2.448	3.728	4.713	5.894	7.616	8.358	9.543	10.916	10.884	11.758
2013	1.248	1.722	2.478	3.559	4.931	6.165	7.522	8.415	9.336	9.926	11.195	12.691
2014	1.226	1.820	2.344	3.108	4.222	5.998	7.558	8.414	9.335	9.925	11.193	12.689

Table 4: Icelandic cod in Division Va. Estimated weight at age in the spawning stock (kg) in period the 1955-2015. These weights are used to calculate the spawning stock biomass (SSB).

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	0.645	1.019	1.833	3.183	4.128	5.657	6.635	6.168	8.746	8.829	10.086	14.584
1956	0.645	1.248	1.862	2.886	4.138	5.630	6.180	6.970	6.830	9.290	10.965	12.954
1957	0.645	1.334	2.142	2.816	4.058	5.960	7.170	7.260	8.300	8.290	10.350	13.174
1958	0.645	1.412	2.652	3.969	4.450	5.940	6.640	8.290	8.510	8.840	9.360	13.097
1959	0.645	1.521	2.490	3.978	4.913	6.170	6.610	7.130	8.510	8.670	9.980	11.276
1960	0.645	1.342	2.482	4.083	5.037	6.550	6.910	7.140	7.970	10.240	10.100	12.871
1961	0.645	1.303	2.295	3.810	4.922	6.310	6.930	7.310	7.500	8.510	9.840	14.550
1962	0.645	1.256	2.218	3.432	5.091	6.660	6.750	7.060	7.540	8.280	10.900	12.826
1963	0.645	1.287	2.244	3.344	4.548	6.920	7.840	7.610	8.230	9.100	9.920	11.553
1964	0.645	1.365	2.244	3.538	4.850	6.460	8.000	9.940	9.210	10.940	12.670	15.900
1965	0.645	1.193	2.184	3.599	4.815	6.400	7.120	8.600	12.310	10.460	10.190	17.220
1966	0.645	1.310	2.202	3.678	5.100	6.900	7.830	8.580	9.090	14.230	14.090	17.924
1967	0.645	1.420	2.261	3.579	4.948	7.790	7.840	8.430	9.090	10.090	14.240	16.412
1968	0.645	1.240	2.278	3.458	4.486	5.910	7.510	8.480	10.750	11.580	14.640	16.011
1969	0.645	1.412	2.108	3.318	4.486	5.860	7.000	8.350	8.720	10.080	11.430	13.144
1970	0.645	1.131	2.074	3.318	4.325	5.590	6.260	8.370	10.490	12.310	14.590	21.777
1971	0.645	1.225	1.964	2.622	4.388	5.150	5.580	6.300	8.530	11.240	14.740	17.130
1972	0.645	1.139	1.878	2.860	3.854	5.610	6.040	6.100	6.870	8.950	11.720	16.000
1973	0.645	1.108	2.100	3.168	4.361	6.110	6.670	6.750	7.430	7.950	10.170	17.000
1974	0.645	1.334	2.066	3.362	4.664	6.660	7.150	7.760	8.190	9.780	12.380	14.700
1975	0.645	1.381	2.363	3.309	4.850	6.690	7.570	8.580	8.810	9.780	10.090	11.000
1976	0.645	1.388	2.252	3.608	4.512	6.730	8.250	9.610	11.540	11.430	14.060	16.180
1977	0.645	1.491	2.428	3.581	5.142	6.636	7.685	9.730	11.703	14.394	17.456	24.116
1978	0.645	1.430	2.490	3.480	5.096	6.806	9.041	10.865	13.068	11.982	19.062	21.284
1979	0.645	1.526	2.246	3.519	4.938	6.754	8.299	9.312	13.130	13.418	13.540	20.072
1980	0.645	1.452	2.323	3.316	4.681	6.981	8.037	10.731	12.301	17.281	14.893	19.069
1981	0.645	1.288	1.921	2.898	3.990	5.821	7.739	9.422	11.374	12.784	12.514	19.069
1982	0.645	1.209	1.909	2.732	3.790	5.386	6.682	9.141	11.963	14.226	17.287	16.590
1983	0.645	1.247	1.934	2.658	3.645	5.481	7.049	8.128	11.009	13.972	15.882	18.498
1984	0.645	1.346	2.207	3.151	3.890	5.798	7.456	9.851	11.052	14.338	15.273	16.660
1985	0.485	1.375	1.750	2.709	3.454	6.372	8.207	10.320	12.197	14.683	16.175	19.050
1986	0.758	1.597	2.882	3.246	4.581	6.155	7.503	9.084	10.356	15.283	14.540	15.017
1987	0.576	1.584	2.423	3.522	4.905	6.257	7.368	9.243	10.697	10.622	15.894	12.592
1988	0.610	1.475	2.261	3.277	4.398	6.001	7.144	8.822	9.977	11.732	14.156	13.042
1989	0.673	1.494	2.338	3.429	4.686	6.892	8.035	9.831	11.986	10.003	12.611	16.045
1990	0.563	1.035	2.170	2.798	4.422	6.521	8.888	10.592	10.993	14.570	15.732	17.290
1991	0.686	1.283	2.039	2.747	3.397	5.680	7.242	9.804	9.754	14.344	14.172	20.200
1992	0.619	1.336	2.094	3.029	3.753	5.582	6.830	8.127	12.679	13.410	15.715	11.267
1993	0.708	1.363	2.309	3.235	4.109	6.054	7.450	8.641	10.901	12.517	14.742	16.874
1994	0.847	1.728	2.254	3.340	4.514	6.262	7.719	8.896	10.847	12.874	14.742	17.470
1995	0.745	1.635	2.345	3.186	4.489	6.416	7.916	10.273	11.022	11.407	13.098	15.182
1996	0.678	1.753	2.490	3.531	4.273	6.009	7.406	9.772	10.539	13.503	13.689	16.194

year	3	4	5	6	7	8	9	10	11	12	13	14
1997	0.670	1.347	2.267	3.746	5.245	6.386	7.344	8.537	10.797	11.533	10.428	12.788
1998	0.599	1.516	2.261	3.263	4.474	7.737	7.837	9.304	10.759	14.903	16.651	18.666
1999	0.711	1.467	1.932	2.996	3.961	6.352	8.730	9.946	11.088	12.535	14.995	15.151
2000	0.600	1.355	1.915	2.881	4.319	5.894	7.809	9.203	10.240	11.172	13.172	17.442
2001	0.661	1.550	2.071	2.694	4.131	6.508	7.520	9.055	8.769	9.526	11.210	13.874
2002	0.630	1.590	2.259	3.120	3.984	6.369	7.808	9.002	10.422	13.402	9.008	16.893
2003	0.900	1.338	2.215	2.988	4.169	5.037	5.980	7.819	8.802	10.712	12.152	13.797
2004	0.900	1.453	2.099	3.057	3.757	5.394	5.872	7.397	10.808	11.569	13.767	12.955
2005	0.900	1.119	1.897	2.963	3.874	5.201	6.200	5.495	7.211	9.909	12.944	18.151
2006	0.900	1.383	1.998	2.905	4.385	5.177	5.382	5.769	6.258	5.688	7.301	15.412
2007	0.900	1.264	2.022	2.580	4.078	5.255	6.272	6.481	7.142	6.530	9.724	10.143
2008	1.017	1.841	2.227	2.924	3.920	5.367	6.771	7.648	8.282	11.181	14.266	17.320
2009	0.644	1.467	2.040	2.884	3.920	4.884	6.744	8.505	10.126	12.108	12.471	15.264
2010	1.017	1.587	2.154	3.151	4.209	5.498	6.552	7.945	8.913	10.090	10.417	13.489
2011	0.794	2.466	2.665	3.215	4.548	5.850	6.742	7.850	8.810	9.797	13.534	13.033
2012	1.017	1.700	2.604	3.713	4.513	5.894	7.616	8.358	9.543	10.916	10.884	11.758
2013	0.944	2.323	2.989	3.833	5.209	6.165	7.522	8.415	9.336	9.926	11.195	12.691
2014	0.944	2.323	2.989	3.832	5.208	6.164	7.521	8.414	9.335	9.925	11.193	12.689

Table 5: Icelandic cod in Division Va. Estimated maturity at age in period the 1955-2014.

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	0.019	0.022	0.033	0.181	0.577	0.782	0.834	0.960	1.000	1.000	1.000	1.000
1956	0.019	0.025	0.033	0.111	0.577	0.782	0.818	0.980	0.980	1.000	1.000	1.000
1957	0.019	0.026	0.043	0.100	0.549	0.801	0.842	0.990	1.000	1.000	1.000	1.000
1958	0.019	0.028	0.086	0.520	0.682	0.801	0.834	1.000	1.000	1.000	1.000	1.000
1959	0.019	0.029	0.070	0.535	0.772	0.818	0.834	0.990	1.000	1.000	1.000	1.000
1960	0.019	0.026	0.066	0.577	0.782	0.826	0.834	0.990	1.000	1.000	1.000	1.000
1961	0.019	0.025	0.053	0.450	0.772	0.818	0.834	0.990	0.990	1.000	1.000	1.000
1962	0.019	0.025	0.048	0.281	0.791	0.834	0.834	0.990	0.990	1.000	1.000	1.000
1963	0.019	0.025	0.048	0.237	0.706	0.834	0.849	1.000	1.000	1.000	1.000	1.000
1964	0.019	0.026	0.048	0.329	0.762	0.826	0.849	1.000	1.000	1.000	1.000	1.000
1965	0.019	0.025	0.045	0.354	0.751	0.826	0.842	1.000	1.000	1.000	1.000	1.000
1966	0.019	0.026	0.045	0.394	0.791	0.849	0.849	1.000	1.000	1.000	1.000	1.000
1967	0.019	0.028	0.051	0.341	0.772	0.842	0.849	1.000	1.000	1.000	1.000	1.000
1968	0.019	0.025	0.051	0.292	0.682	0.801	0.842	1.000	1.000	1.000	1.000	1.000
1969	0.019	0.028	0.043	0.227	0.682	0.801	0.842	1.000	1.000	1.000	1.000	1.000
1970	0.019	0.023	0.041	0.227	0.644	0.772	0.818	1.000	1.000	1.000	1.000	1.000
1971	0.019	0.025	0.037	0.074	0.657	0.706	0.772	0.979	0.994	0.982	0.993	1.000
1972	0.019	0.023	0.035	0.106	0.450	0.772	0.809	0.979	0.994	0.982	0.993	1.000
1973	0.022	0.028	0.163	0.382	0.697	0.801	0.834	0.996	0.996	1.000	1.000	1.000
1974	0.020	0.031	0.085	0.346	0.636	0.790	0.818	0.989	1.000	1.000	1.000	1.000
1975	0.020	0.035	0.118	0.287	0.715	0.809	0.839	1.000	1.000	1.000	1.000	1.000
1976	0.025	0.026	0.086	0.253	0.406	0.797	0.841	1.000	1.000	1.000	1.000	1.000
1977	0.019	0.024	0.060	0.382	0.742	0.817	0.842	1.000	1.000	1.000	1.000	1.000
1978	0.025	0.025	0.052	0.192	0.737	0.820	0.836	1.000	1.000	1.000	1.000	1.000
1979	0.019	0.021	0.053	0.282	0.635	0.790	0.836	0.919	1.000	1.000	1.000	1.000
1980	0.026	0.021	0.047	0.225	0.653	0.777	0.834	0.977	1.000	0.964	1.000	1.000
1981	0.019	0.022	0.030	0.090	0.448	0.751	0.811	0.962	0.988	1.000	1.000	1.000
1982	0.021	0.025	0.038	0.065	0.297	0.705	0.815	0.967	1.000	1.000	1.000	1.000
1983	0.019	0.030	0.047	0.116	0.264	0.530	0.715	0.979	0.985	1.000	1.000	1.000
1984	0.019	0.024	0.053	0.169	0.444	0.620	0.716	0.949	0.969	0.948	1.000	1.000
1985		0.021	0.185	0.412	0.495	0.735	0.572	1.000	1.000	1.000	1.000	1.000
1986	0.001	0.023	0.149	0.395	0.682	0.734	0.941	0.962	0.988	1.000	1.000	1.000
1987	0.002	0.033	0.093	0.360	0.490	0.885	0.782	1.000	0.979	1.000	1.000	1.000
1988	0.006	0.029	0.225	0.511	0.448	0.683	0.937	0.946	0.974	0.821	1.000	1.000
1989	0.008	0.025	0.142	0.372	0.645	0.652	0.634	0.991	1.000	0.903	0.859	1.000
1990	0.006	0.012	0.155	0.437	0.581	0.796	0.814	0.986	1.000	1.000	1.000	1.000
1991		0.055	0.149	0.369	0.637	0.790	0.682	0.842	1.000	1.000	1.000	1.000
1992	0.002	0.062	0.265	0.402	0.813	0.917	0.894	1.000	1.000	1.000	1.000	1.000
1993	0.006	0.085	0.267	0.464	0.693	0.801	0.843	0.968	1.000	1.000	1.000	1.000
1994	0.008	0.110	0.339	0.591	0.702	0.917	0.698	0.852	0.985	1.000	1.000	1.000
1995	0.005	0.109	0.384	0.528	0.752	0.787	0.859	1.000	1.000	1.000	1.000	1.000
1996	0.002	0.031	0.186	0.499	0.650	0.733	0.812	1.000	1.000	0.986	0.971	1.000
1997	0.006	0.037	0.246	0.424	0.685	0.787	0.804	0.932	1.000	0.913	1.000	1.000

year	3	4	5	6	7	8	9	10	11	12	13	14
1998		0.061	0.209	0.491	0.782	0.814	0.810	0.925	0.998	1.000	1.000	1.000
1999	0.012	0.044	0.239	0.516	0.649	0.835	0.687	0.988	1.000	1.000	1.000	1.000
2000	0.001	0.065	0.248	0.512	0.611	0.867	0.998	0.980	1.000	1.000	1.000	1.000
2001	0.004	0.043	0.261	0.589	0.750	0.742	0.862	0.987	1.000	1.000	1.000	1.000
2002	0.008	0.086	0.322	0.656	0.759	0.920	0.550	0.979	1.000	1.000	1.000	1.000
2003	0.005	0.046	0.218	0.524	0.870	0.798	0.860	0.998	1.000	1.000	1.000	1.000
2004		0.038	0.246	0.549	0.626	0.843	0.816	0.990	1.000	1.000	1.000	1.000
2005	0.003	0.109	0.281	0.493	0.792	0.805	0.951	0.908	1.000	1.000	1.000	1.000
2006	0.002	0.023	0.294	0.448	0.752	0.871	0.743	0.747	1.000	1.000	1.000	1.000
2007	0.012	0.032	0.159	0.501	0.693	0.785	0.836	0.924	1.000	1.000	1.000	1.000
2008	0.001	0.041	0.276	0.549	0.727	0.827	0.846	0.954	1.000	1.000	1.000	1.000
2009	0.002	0.015	0.132	0.456	0.688	0.883	0.741	0.631	1.000	1.000	1.000	1.000
2010		0.016	0.058	0.377	0.822	0.869	0.923	0.802	1.000	1.000	1.000	1.000
2011	0.002	0.012	0.135	0.431	0.734	0.926	0.940	0.958	1.000	1.000	1.000	1.000
2012	0.004	0.029	0.126	0.411	0.728	0.882	0.961	0.830	1.000	1.000	1.000	1.000
2013	0.003	0.008	0.061	0.343	0.738	0.923	0.957	1.000	1.000	1.000	1.000	1.000
2014		0.026	0.068	0.236	0.614	0.893	0.967	0.957	1.000	1.000	1.000	1.000

Table 6: Icelandic cod in Division Va. Estimated survey weight at age in the spring survey (SMB).

year	1	2	3	4	5	6	7	8	9	10
1985	14	137	388	1118	1735	2581	3226	4675	5873	7045
1986	15	159	616	1220	2249	2965	4331	5594	7234	8327
1987	14	117	467	1199	1752	2982	4201	6347	6996	10113
1988	11	122	495	1076	1963	3098	3553	4368	8166	9482
1989	22	150	548	1141	1934	3052	4390	6271	7024	12565
1990	19	135	460	1040	1816	2597	3876	6051	8172	9600
1991	18	147	553	1167	1844	2589	3270	5741	7622	14483
1992	24	134	501	1013	1846	2570	3655	5053	7452	13568
1993	12	171	576	1166	1944	2991	3961	5378	5985	9338
1994	13	174	686	1412	2044	3182	4134	6274	8312	9893
1995	10	134	605	1377	2284	2989	4450	5324	8070	9256
1996	11	155	551	1350	2083	3323	4045	5266	7484	9965
1997	18	140	546	1194	2168	3220	4864	5508	6459	6901
1998	15	158	485	1208	2041	3017	4253	5437	6348	8385
1999	14	140	578	1070	1847	2867	3820	4981	5627	8196
2000	16	124	486	1195	1817	2771	4066	5349	8505	8403
2001	17	152	531	1186	1852	2641	3760	5453	6443	8177
2002	11	132	510	1206	1998	2920	3780	5760	6267	6287
2003	16	131	466	1179	1918	2788	4139	4678	6261	9600
2004	20	147	481	1062	1873	2803	3458	4989	5315	7797
2005	11	118	451	1029	1760	2644	3646	4362	7249	6674
2006	13	105	417	982	1689	2600	4050	4750	5624	8384
2007	14	101	410	969	1663	2342	3635	5018	6122	7749
2008	11	121	376	937	1805	2612	3592	4933	6395	8408
2009	12	113	413	845	1602	2633	3659	4684	5770	6289
2010	13	98	391	1008	1697	2570	4021	4912	6101	7754
2011	12	102	395	1126	2114	2986	4225	5876	6645	7905
2012	12	142	477	1143	1929	3180	4249	5718	7826	7610
2013	13	113	495	1054	1785	3022	4772	6381	8054	9538
2014	11	114	359	1079	1710	2632	3987	6168	8069	10118

Table 7: Icelandic cod in Division Va. Survey indices of the spring bottom trawl survey (SMB).

year	1	2	3	4	5	6	7	8	9	10
1985	16.54	110.43	35.40	48.20	64.15	22.57	14.85	4.85	3.21	1.76
1986	15.05	60.24	95.89	22.42	21.21	26.34	6.63	2.48	0.83	0.73
1987	3.65	28.21	103.74	81.99	21.08	12.20	12.01	2.56	0.89	0.38
1988	3.44	6.96	72.09	101.40	66.59	7.81	5.88	6.41	0.58	0.24
1989	4.04	16.38	21.97	77.79	67.59	34.20	4.20	1.45	1.14	0.24
1990	5.56	11.78	26.08	14.07	27.05	32.38	14.21	1.50	0.52	0.41
1991	3.95	16.00	18.20	30.17	15.24	18.09	20.93	4.24	0.79	0.29
1992	0.71	16.80	33.54	18.89	16.34	6.54	5.70	5.12	1.29	0.22
1993	3.57	4.75	30.78	36.48	13.22	9.90	2.13	1.75	1.17	0.36
1994	14.38	14.94	9.01	26.66	21.90	5.77	3.63	0.70	0.48	0.47
1995	1.08	29.13	24.75	8.98	23.88	17.69	3.78	1.80	0.35	0.17
1996	3.72	5.43	42.58	29.44	12.89	14.63	14.02	3.81	1.04	0.18
1997	1.18	22.18	13.55	56.31	29.10	9.50	8.78	6.61	0.56	0.21
1998	8.06	5.36	29.92	16.04	61.73	28.58	6.50	5.24	3.03	0.66
1999	7.39	32.98	7.01	42.25	13.00	23.66	11.12	2.35	1.32	0.70
2000	18.85	27.60	54.99	6.94	30.00	8.28	8.18	4.14	0.51	0.30
2001	12.13	21.74	36.38	38.04	4.95	15.11	3.30	1.96	0.81	0.29
2002	0.91	37.85	41.22	40.13	36.25	7.09	8.32	1.49	0.72	0.30
2003	11.17	4.17	46.36	36.58	28.42	16.89	3.82	4.34	1.03	0.20
2004	6.57	24.43	7.87	61.79	35.00	24.83	14.44	2.82	2.88	0.47
2005	2.56	14.54	38.70	9.68	43.57	22.97	10.84	5.77	0.93	0.92
2006	8.79	6.39	22.67	38.44	10.83	27.74	10.05	3.55	1.38	0.25
2007	5.61	18.21	8.58	21.09	27.60	9.06	9.75	5.08	2.11	0.75
2008	6.40	11.77	22.08	9.31	20.43	20.40	8.10	6.63	2.47	0.60
2009	21.27	11.62	15.80	21.82	14.59	23.45	14.59	4.18	2.73	1.02
2010	18.29	20.00	18.00	17.73	23.75	13.27	16.60	8.93	2.71	1.70
2011	3.57	21.49	26.63	19.90	22.48	25.32	13.51	12.31	4.55	0.91
2012	19.94	9.75	37.59	56.57	41.59	30.22	26.99	9.96	6.30	2.76
2013	10.80	31.40	17.68	43.76	46.47	25.24	16.50	13.81	6.94	3.33
2014	3.31	23.97	38.00	23.48	47.17	37.60	17.31	8.18	4.26	2.22

Table 8: Icelandic cod in Division Va. Survey CV of the spring bottom trawl survey (SMB).

year	1	2	3	4	5	6	7	8	9	10
1985	0.08	0.44	0.19	0.11	0.11	0.10	0.10	0.10	0.14	0.16
1986	0.09	0.10	0.10	0.10	0.09	0.08	0.09	0.07	0.08	0.07
1987	0.13	0.11	0.09	0.10	0.10	0.10	0.09	0.11	0.10	0.13
1988	0.19	0.18	0.10	0.10	0.11	0.10	0.09	0.09	0.12	0.12
1989	0.12	0.10	0.15	0.21	0.16	0.12	0.10	0.10	0.12	0.13
1990	0.14	0.09	0.13	0.13	0.10	0.09	0.09	0.11	0.13	0.17
1991	0.12	0.10	0.07	0.12	0.12	0.10	0.10	0.11	0.16	0.31
1992	0.11	0.08	0.07	0.09	0.10	0.09	0.08	0.09	0.12	0.23
1993	0.20	0.10	0.09	0.11	0.11	0.10	0.10	0.10	0.09	0.10
1994	0.26	0.12	0.09	0.12	0.14	0.14	0.13	0.11	0.14	0.16
1995	0.17	0.08	0.09	0.10	0.10	0.10	0.10	0.12	0.15	0.16
1996	0.12	0.10	0.11	0.15	0.14	0.11	0.10	0.10	0.15	0.22
1997	0.14	0.08	0.08	0.10	0.10	0.09	0.10	0.11	0.15	0.25
1998	0.12	0.15	0.09	0.12	0.17	0.15	0.11	0.11	0.13	0.17
1999	0.11	0.08	0.07	0.10	0.10	0.09	0.09	0.10	0.08	0.10
2000	0.07	0.07	0.08	0.08	0.09	0.09	0.08	0.10	0.10	0.08
2001	0.09	0.10	0.10	0.15	0.17	0.20	0.15	0.12	0.10	0.16
2002	0.18	0.09	0.13	0.16	0.18	0.15	0.15	0.10	0.14	0.11
2003	0.10	0.11	0.07	0.12	0.11	0.10	0.10	0.15	0.19	0.19
2004	0.10	0.08	0.10	0.16	0.15	0.16	0.15	0.13	0.17	0.21
2005	0.12	0.12	0.07	0.09	0.12	0.12	0.12	0.12	0.15	0.19
2006	0.09	0.11	0.08	0.10	0.10	0.11	0.12	0.15	0.13	0.20
2007	0.09	0.12	0.10	0.10	0.11	0.09	0.08	0.09	0.11	0.18
2008	0.11	0.09	0.07	0.09	0.10	0.10	0.10	0.09	0.10	0.09
2009	0.10	0.10	0.09	0.10	0.13	0.13	0.12	0.11	0.09	0.10
2010	0.08	0.10	0.12	0.10	0.11	0.10	0.10	0.09	0.08	0.09
2011	0.11	0.12	0.10	0.12	0.14	0.14	0.12	0.14	0.11	0.09
2012	0.09	0.14	0.08	0.32	0.41	0.34	0.24	0.17	0.11	0.14
2013	0.06	0.13	0.08	0.11	0.13	0.12	0.10	0.11	0.14	0.16
2014	0.13	0.35	0.11	0.13	0.13	0.12	0.11	0.13	0.19	0.30

Table 9: Icelandic cod in Division Va. Survey indices of the fall bottom trawl survey (SMH).

year	1	2	3	4	5	6	7	8	9	10
1996	6.69	3.57	20.00	13.98	5.40	7.44	6.26	1.60	0.31	0.09
1997	0.67	16.89	6.83	29.57	15.76	4.09	3.62	2.36	0.25	0.17
1998	5.92	2.63	15.62	7.36	16.01	16.03	5.20	2.24	1.27	0.20
1999	8.61	14.54	5.68	23.38	7.42	9.94	4.05	0.59	0.34	0.36
2000	4.60	13.17	15.25	3.71	11.15	3.49	2.61	1.11	0.34	0.28
2001	7.11	11.51	19.53	21.13	3.30	6.73	1.60	0.76	0.17	0.03
2002	0.92	13.72	16.11	23.39	15.94	5.41	4.77	1.11	0.61	0.08
2003	5.16	2.68	25.66	16.98	13.22	8.99	1.89	2.55	0.38	0.10
2004	3.67	16.28	6.92	29.86	18.85	11.73	7.38	1.88	1.65	0.23
2005	2.15	9.03	20.37	6.82	25.62	10.88	3.86	1.91	0.29	0.31
2006	4.51	4.52	16.28	23.04	7.67	13.93	6.12	2.05	1.02	0.16
2007	3.73	9.82	4.93	11.73	15.68	6.34	5.91	3.14	0.76	0.50
2008	5.30	11.88	15.19	7.66	17.57	18.51	5.67	5.61	1.50	0.79
2009	7.04	8.30	13.14	18.11	12.39	16.46	10.22	3.15	2.75	0.84
2010	10.78	18.82	16.18	15.52	17.96	9.81	11.21	6.81	2.29	1.20
2012	7.43	9.43	23.38	20.66	12.72	10.82	9.53	5.31	3.33	1.55
2013	6.25	19.28	13.41	27.13	21.99	12.60	7.72	5.94	2.93	1.87

Table : Icelandic cod in Division Va. Survey CV of the fall bottom trawl survey (SMH).

year	1	2	3	4	5	6	7	8	9	10
1996	0.35	0.18	0.11	0.14	0.13	0.13	0.17	0.23	0.27	0.33
1997	0.34	0.54	0.22	0.26	0.21	0.14	0.12	0.12	0.12	0.13
1998	0.16	0.12	0.12	0.11	0.13	0.19	0.32	0.35	0.38	0.34
1999	0.32	0.14	0.24	0.30	0.32	0.23	0.20	0.19	0.19	0.21
2000	0.18	0.26	0.14	0.14	0.15	0.18	0.16	0.18	0.33	0.31
2001	0.17	0.14	0.14	0.11	0.11	0.11	0.17	0.33	0.41	0.79
2002	0.16	0.12	0.12	0.13	0.12	0.11	0.11	0.12	0.15	0.50
2003	0.13	0.14	0.12	0.11	0.11	0.09	0.10	0.14	0.19	0.32
2004	0.14	0.17	0.13	0.14	0.11	0.10	0.09	0.08	0.08	0.09
2005	0.27	0.10	0.11	0.10	0.12	0.11	0.10	0.08	0.09	0.10
2006	0.15	0.14	0.13	0.13	0.11	0.11	0.11	0.10	0.09	0.16
2007	0.21	0.14	0.11	0.14	0.14	0.14	0.13	0.11	0.11	0.12
2008	0.17	0.11	0.10	0.10	0.11	0.11	0.15	0.20	0.24	0.22
2009	0.17	0.11	0.13	0.14	0.13	0.12	0.11	0.11	0.11	0.14
2010	0.17	0.16	0.11	0.13	0.13	0.11	0.15	0.17	0.19	0.20
2012	0.15	0.11	0.12	0.13	0.14	0.14	0.12	0.12	0.14	0.15
2013	0.16	0.14	0.14	0.14	0.12	0.11	0.11	0.12	0.13	0.14

Table 11: Icelandic cod in Division Va. Catch at age residuals from the ADCAM model tuned with the spring (SMB) and the fall (SMH) surveys.

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	-0.122	-0.208	0.077	0.114	0.208	-0.115	-0.164	0.135	-0.099	-0.450	-0.201	0.002
1956	-0.027	-0.048	0.026	-0.007	-0.134	-0.200	-0.006	0.006	0.181	0.095	0.230	0.223
1957	0.092	0.017	-0.016	0.167	-0.133	0.092	0.063	-0.148	-0.097	-0.107	-0.380	0.524
1958	0.154	0.176	-0.265	-0.073	0.059	0.080	0.132	-0.231	0.234	0.003	-0.221	0.399
1959	-0.214	0.211	0.260	-0.243	-0.218	-0.061	-0.070	0.278	-0.262	0.383	-0.228	-0.389
1960	0.101	-0.356	0.141	0.188	0.063	0.074	-0.024	-0.116	-0.039	0.036	-0.637	0.916
1961	0.052	0.041	-0.403	0.119	-0.017	0.272	0.203	-0.141	0.085	-0.190	-0.972	0.840
1962	0.092	-0.007	0.126	-0.243	0.117	-0.296	0.091	0.260	-0.063	0.031	-0.401	0.708
1963	-0.056	0.297	-0.173	0.013	-0.031	-0.070	-0.376	0.208	0.350	0.063	0.069	-0.609
1964	-0.126	-0.015	0.127	-0.251	-0.117	0.377	-0.102	-0.457	-0.013	0.266	-0.159	0.009
1965	-0.032	-0.114	0.085	0.164	-0.128	0.049	0.473	-0.481	-0.056	-0.509	-0.361	0.642
1966	-0.043	-0.043	-0.178	0.096	-0.069	0.124	-0.346	0.591	-0.828	0.278	0.008	1.063
1967	0.189	-0.130	0.023	-0.198	0.025	-0.371	0.492	0.047	0.671	-0.726	-0.837	-0.178
1968	0.033	-0.021	-0.273	-0.120	0.233	0.158	-0.415	0.368	-0.123	0.599	-0.657	0.660
1969	-0.090	-0.028	0.152	-0.011	0.052	-0.149	-0.324	-0.244	-0.040	-0.257	-0.809	-0.138
1970	-0.097	0.135	-0.054	-0.137	0.053	-0.161	0.478	-0.580	-0.117	0.246	0.294	0.456
1971	-0.104	0.070	0.090	0.175	-0.185	0.283	-0.169	0.055	-0.451	-0.020	0.123	0.364
1972	-0.168	-0.127	0.068	-0.034	0.117	-0.052	-0.103	0.293	-0.070	0.171	0.526	-2.759
1973	0.274	-0.022	-0.099	0.027	-0.004	-0.241	0.087	0.172	0.158	-0.196	-1.252	-2.091
1974	-0.160	0.209	-0.022	-0.178	-0.006	-0.003	-0.222	0.289	0.011	0.186	-0.435	0.808
1975	0.188	-0.074	0.040	-0.054	0.030	-0.152	-0.208	-0.005	0.407	-0.016	-0.120	0.093
1976	0.097	0.002	-0.169	0.077	-0.092	0.252	-0.157	-0.154	0.056	0.272	-0.232	0.238
1977	-0.400	-0.063	0.046	-0.093	0.126	0.052	0.308	0.029	-0.702	-0.480	-1.222	-2.495
1978	0.079	-0.014	0.037	-0.096	0.043	-0.206	0.120	-0.188	0.016	-0.052	0.530	1.201
1979	0.157	0.094	-0.217	0.102	-0.047	0.030	-0.312	-0.078	0.045	-0.146	0.411	-0.199
1980	0.210	0.010	0.078	0.060	-0.009	-0.091	0.124	-0.486	0.295	0.096	0.158	-1.084
1981	-0.301	-0.207	0.083	-0.137	0.070	0.089	0.021	0.325	-0.076	0.598	-0.015	1.170
1982	0.009	0.152	0.071	-0.055	-0.222	0.191	0.177	0.136	-0.231	-0.870	0.051	-0.862
1983	-0.321	-0.357	0.111	0.141	0.043	0.008	-0.039	-0.029	0.003	0.370	-0.193	0.583
1984	0.347	0.026	-0.059	-0.046	-0.098	-0.005	0.054	-0.138	-0.353	0.163	0.715	0.099
1985	0.040	0.182	-0.102	0.122	-0.098	-0.023	-0.139	0.133	0.026	-0.347	0.476	0.465
1986	0.149	-0.118	0.015	-0.016	0.179	-0.048	0.116	-0.212	0.075	0.050	-0.591	0.177
1987	-0.147	0.124	0.015	-0.165	0.063	0.035	-0.028	0.111	-0.381	-0.118	0.122	-0.309
1988	-0.086	-0.058	-0.050	0.137	-0.087	0.066	0.156	0.028	0.476	0.013	0.540	0.097
1989	-0.213	0.043	0.149	-0.069	-0.003	-0.155	-0.326	-0.093	-0.026	0.512	-0.023	-1.440
1990	-0.002	-0.139	-0.107	0.003	0.040	0.091	-0.086	-0.231	0.287	0.110	-0.213	0.060
1991	0.071	0.041	-0.131	-0.066	0.093	-0.074	0.115	-0.075	-0.317	0.399	-0.563	0.103
1992	-0.224	0.081	0.045	0.028	0.103	-0.007	-0.043	-0.067	-0.749	-0.774	-0.564	-0.173
1993	0.257	0.047	-0.202	-0.055	-0.074	-0.125	0.066	0.488	0.497	-0.216	-0.983	0.403
1994	0.031	0.247	-0.132	-0.194	-0.040	0.064	-0.194	-0.136	0.426	0.515	0.524	-0.422
1995	0.277	-0.034	0.085	-0.034	-0.041	-0.119	-0.129	-0.291	-0.215	0.730	1.126	0.597
1996	0.004	-0.051	-0.176	0.078	0.042	0.013	0.124	0.174	-0.383	-0.406	0.621	-0.070

year	3	4	5	6	7	8	9	10	11	12	13	14
1997	-0.157	0.026	-0.027	-0.124	-0.095	0.206	0.172	0.258	0.408	-0.735	-0.216	0.161
1998	-0.180	-0.169	0.066	0.075	0.018	-0.168	0.241	0.047	0.085	0.273	0.166	-0.748
1999	-0.102	0.034	0.036	0.029	0.089	-0.046	-0.245	-0.184	-0.268	-0.411	-0.472	-0.936
2000	0.173	-0.240	0.108	-0.039	0.014	0.107	0.034	-0.112	-0.010	0.134	-0.132	-0.118
2001	0.189	0.195	-0.160	-0.004	0.026	-0.182	0.098	0.282	-0.046	0.131	-0.523	-0.065
2002	-0.020	0.085	0.035	-0.077	-0.024	-0.010	-0.152	0.293	0.266	-0.335	0.383	-1.179
2003	-0.229	0.030	-0.009	-0.031	0.175	0.006	0.224	-0.307	0.060	0.138	0.154	0.436
2004	-0.221	0.109	0.101	-0.085	-0.058	0.232	0.027	0.236	-0.494	-0.018	0.245	-0.387
2005	0.195	-0.293	0.146	-0.055	-0.119	-0.089	0.320	0.102	0.327	0.075	0.053	-0.871
2006	-0.064	0.028	-0.136	0.067	0.053	-0.087	-0.081	0.182	-0.009	0.086	-0.184	-1.688
2007	-0.103	0.182	-0.039	-0.010	-0.148	0.052	-0.029	0.186	0.760	0.335	0.779	-0.393
2008	0.018	-0.187	0.078	-0.113	0.082	-0.182	0.016	0.074	0.000	0.043	0.012	-0.582
2009	0.130	-0.063	0.082	0.139	-0.052	0.254	-0.199	-0.233	-0.055	-0.455	0.023	-0.566
2010	0.007	0.007	-0.137	0.080	0.029	-0.070	0.177	-0.108	-0.120	0.278	0.307	0.543
2011	0.121	-0.034	0.009	0.021	-0.020	-0.000	-0.130	0.063	-0.044	-0.178	-0.248	-0.906
2012	-0.131	-0.019	0.019	-0.034	-0.008	0.170	-0.005	-0.186	0.206	-0.307	0.198	-0.140
2013	0.107	0.041	0.012	0.016	-0.097	-0.072	0.179	0.014	-0.173	0.316	0.001	-0.191

Table 12: Icelandic cod in Division Va. Spring survey (SMB) at age residuals from the ADCAM model, assessment tuned with both the spring and the fall survey.

year	1	2	3	4	5	6	7	8	9	10
1985	-0.460	0.032	0.217	0.442	0.126	0.268	0.410	0.197	0.314	0.663
1986	0.439	-0.063	-0.401	-0.231	-0.082	0.007	-0.154	-0.261	-0.251	-0.046
1987	0.636	0.003	0.122	-0.459	-0.028	-0.066	0.050	-0.075	-0.096	-0.008
1988	-0.193	0.029	0.490	0.154	-0.117	-0.333	0.094	0.498	-0.118	-0.102
1989	0.371	0.066	0.524	0.554	0.243	0.198	-0.113	-0.094	0.212	0.106
1990	-0.467	0.124	0.066	0.056	-0.152	-0.143	0.087	-0.139	-0.043	0.155
1991	-0.165	-0.449	0.096	0.157	0.252	0.047	0.140	-0.136	0.222	0.193
1992	-0.246	0.029	-0.196	0.117	-0.087	-0.123	-0.133	-0.129	-0.107	-0.007
1993	-0.502	-0.026	0.181	-0.048	0.052	-0.031	-0.206	-0.144	-0.224	-0.213
1994	0.539	-0.247	0.025	0.113	-0.192	-0.312	-0.155	-0.209	-0.183	-0.052
1995	-0.231	0.139	-0.226	-0.046	0.168	-0.005	-0.212	-0.076	-0.065	-0.203
1996	-0.627	-0.103	0.094	-0.120	0.208	-0.032	0.265	0.408	0.205	0.054
1997	0.179	-0.048	0.134	0.278	-0.029	-0.035	-0.025	0.266	-0.349	-0.293
1998	-0.092	0.132	-0.186	0.129	0.510	0.306	0.101	0.219	0.433	0.496
1999	-0.025	0.179	-0.036	0.050	-0.045	0.093	0.038	-0.007	-0.017	0.136
2000	0.895	0.134	0.275	-0.163	-0.084	-0.198	-0.184	0.010	-0.244	-0.230
2001	0.205	0.024	0.005	-0.095	-0.452	-0.211	-0.363	-0.540	-0.326	0.205
2002	-0.168	0.246	0.140	0.063	0.048	-0.138	-0.166	-0.264	-0.403	-0.138
2003	0.003	-0.121	0.039	-0.043	-0.118	-0.198	-0.187	-0.050	0.171	-0.523
2004	-0.090	0.169	-0.113	0.265	0.107	0.236	0.204	0.153	0.421	0.278
2005	-0.131	0.078	0.188	-0.116	0.087	0.113	0.011	0.056	0.027	0.235
2006	0.174	-0.034	-0.032	0.057	-0.094	0.167	-0.093	-0.305	-0.343	-0.229
2007	0.004	0.147	-0.299	-0.236	-0.173	-0.171	-0.296	-0.041	0.041	-0.086
2008	-0.001	-0.005	-0.091	-0.396	-0.279	-0.101	0.127	-0.034	0.101	-0.186
2009	0.417	-0.099	-0.181	-0.238	-0.157	-0.069	-0.068	0.039	-0.201	-0.120
2010	0.187	-0.167	-0.186	-0.248	-0.212	-0.174	-0.063	-0.037	0.339	0.010
2011	-0.459	-0.166	-0.352	-0.272	-0.120	0.060	0.132	0.115	-0.042	-0.122
2012	0.179	-0.134	-0.085	0.203	0.335	0.300	0.409	0.295	0.121	0.077
2013	-0.101	0.094	-0.148	-0.074	0.053	0.076	0.042	0.233	0.537	-0.004
2014	-0.254	0.036	-0.160	-0.042	0.031	0.189	0.023	-0.163	-0.282	-0.007

Table 13: Icelandic cod in Division Va. Fall survey (SMH) at age residuals from the ADCAM model, assessment tuned with both the spring and the fall survey.

year	1	2	3	4	5	6	7	8	9	10
1996	0.036	-0.079	-0.011	-0.184	-0.008	-0.060	0.175	0.191	-0.160	-0.021
1997	-0.153	0.118	-0.018	0.248	0.053	-0.149	-0.130	-0.034	-0.317	-0.022
1998	-0.206	-0.013	-0.190	0.035	-0.036	0.372	0.515	0.115	0.285	0.077
1999	0.265	-0.092	0.113	0.109	0.082	0.012	-0.096	-0.289	-0.321	0.146
2000	-0.262	-0.071	-0.264	-0.078	-0.225	-0.207	-0.367	-0.308	0.035	0.240
2001	-0.126	-0.144	0.038	-0.014	-0.212	-0.233	-0.227	-0.488	-0.523	-0.306
2002	-0.164	-0.196	-0.126	0.151	-0.001	0.129	0.005	0.019	0.017	-0.349
2003	-0.106	-0.106	0.088	-0.150	-0.114	-0.136	-0.127	0.063	-0.043	-0.403
2004	-0.110	0.152	0.100	0.125	0.166	0.117	0.225	0.319	0.458	0.200
2005	0.107	-0.071	0.094	0.078	0.245	0.012	-0.263	-0.296	-0.230	-0.116
2006	0.086	-0.055	0.098	0.092	0.074	0.061	0.037	-0.216	-0.073	-0.069
2007	0.143	-0.001	-0.317	-0.262	-0.111	-0.015	-0.185	0.021	-0.259	0.083
2008	0.310	0.275	0.048	-0.111	0.089	0.234	0.272	0.233	0.049	0.354
2009	-0.028	-0.056	0.089	0.073	0.156	0.066	0.127	0.214	0.255	0.144
2010	0.301	0.124	0.162	0.115	0.079	0.010	0.108	0.188	0.519	0.079
2011										
2012	-0.139	0.141	0.028	-0.206	-0.203	-0.152	0.034	0.208	-0.089	-0.053
2013	-0.007	0.039	0.081	0.007	-0.022	-0.041	-0.081	-0.035	0.208	-0.076

Table 14: Icelandic cod in Division Va. Estimates of fishing mortality 1955-2013 based on ACAM using catch at age and spring and fall bottom survey indices.

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	0.040	0.170	0.253	0.275	0.303	0.305	0.285	0.329	0.329	0.313	0.329	0.329
1956	0.051	0.182	0.250	0.259	0.291	0.305	0.297	0.347	0.361	0.341	0.340	0.340
1957	0.081	0.215	0.274	0.272	0.301	0.329	0.329	0.367	0.369	0.338	0.306	0.306
1958	0.114	0.248	0.302	0.291	0.324	0.373	0.399	0.443	0.449	0.393	0.333	0.333
1959	0.091	0.233	0.282	0.257	0.299	0.342	0.353	0.402	0.387	0.327	0.236	0.236
1960	0.101	0.233	0.295	0.292	0.338	0.398	0.429	0.479	0.479	0.392	0.277	0.277
1961	0.094	0.225	0.259	0.262	0.334	0.399	0.419	0.461	0.443	0.354	0.232	0.232
1962	0.112	0.248	0.282	0.264	0.347	0.424	0.467	0.514	0.490	0.382	0.244	0.244
1963	0.130	0.283	0.328	0.309	0.383	0.492	0.587	0.647	0.627	0.466	0.290	0.290
1964	0.126	0.290	0.372	0.360	0.435	0.570	0.740	0.811	0.837	0.613	0.394	0.394
1965	0.121	0.284	0.385	0.403	0.471	0.602	0.744	0.849	0.880	0.658	0.430	0.430
1966	0.094	0.254	0.341	0.382	0.491	0.622	0.781	0.916	1.008	0.788	0.537	0.537
1967	0.077	0.229	0.303	0.338	0.484	0.610	0.749	0.879	0.930	0.727	0.464	0.464
1968	0.077	0.247	0.342	0.406	0.576	0.765	1.035	1.200	1.361	1.085	0.744	0.744
1969	0.056	0.232	0.323	0.354	0.505	0.608	0.719	0.837	0.871	0.716	0.447	0.447
1970	0.069	0.270	0.390	0.426	0.551	0.650	0.760	0.892	0.950	0.802	0.518	0.518
1971	0.088	0.309	0.479	0.533	0.620	0.717	0.799	0.957	1.034	0.882	0.582	0.582
1972	0.088	0.302	0.480	0.554	0.650	0.730	0.791	0.959	1.059	0.912	0.602	0.602
1973	0.119	0.321	0.489	0.565	0.668	0.754	0.799	0.953	1.042	0.902	0.591	0.591
1974	0.113	0.325	0.499	0.575	0.699	0.832	0.920	1.055	1.179	1.027	0.695	0.695
1975	0.108	0.310	0.502	0.601	0.722	0.884	1.021	1.126	1.251	1.099	0.768	0.768
1976	0.066	0.258	0.428	0.552	0.695	0.852	0.947	1.007	1.060	0.940	0.649	0.649
1977	0.030	0.195	0.330	0.428	0.609	0.721	0.727	0.737	0.695	0.624	0.403	0.403
1978	0.027	0.174	0.281	0.354	0.525	0.602	0.545	0.547	0.482	0.444	0.277	0.277
1979	0.028	0.171	0.274	0.344	0.502	0.567	0.495	0.489	0.417	0.389	0.243	0.243
1980	0.028	0.175	0.306	0.386	0.538	0.620	0.556	0.544	0.467	0.437	0.287	0.287
1981	0.023	0.176	0.353	0.488	0.648	0.819	0.849	0.816	0.748	0.686	0.510	0.510
1982	0.028	0.192	0.395	0.558	0.699	0.898	0.957	0.866	0.743	0.666	0.500	0.500
1983	0.023	0.179	0.377	0.555	0.705	0.881	0.913	0.849	0.729	0.665	0.512	0.512
1984	0.039	0.200	0.377	0.530	0.674	0.805	0.751	0.699	0.592	0.553	0.421	0.421
1985	0.050	0.230	0.422	0.577	0.714	0.832	0.762	0.696	0.589	0.553	0.425	0.425
1986	0.061	0.262	0.516	0.712	0.823	0.953	0.870	0.763	0.653	0.606	0.471	0.471
1987	0.056	0.272	0.554	0.816	0.904	1.059	0.989	0.843	0.736	0.683	0.549	0.549
1988	0.047	0.258	0.522	0.793	0.920	1.102	1.075	0.934	0.863	0.811	0.687	0.687
1989	0.041	0.242	0.463	0.653	0.793	0.893	0.794	0.712	0.635	0.610	0.486	0.486
1990	0.050	0.251	0.471	0.661	0.787	0.856	0.743	0.679	0.607	0.585	0.463	0.463
1991	0.086	0.302	0.566	0.811	0.882	0.944	0.836	0.759	0.696	0.666	0.543	0.543
1992	0.102	0.320	0.599	0.870	0.923	1.001	0.883	0.789	0.724	0.687	0.568	0.568
1993	0.138	0.313	0.554	0.803	0.887	1.029	1.014	0.916	0.876	0.827	0.716	0.716
1994	0.088	0.241	0.383	0.531	0.676	0.764	0.710	0.684	0.633	0.616	0.509	0.509
1995	0.061	0.196	0.319	0.421	0.568	0.624	0.553	0.559	0.510	0.507	0.409	0.409

year	3	4	5	6	7	8	9	10	11	12	13	14
1996	0.036	0.161	0.282	0.411	0.557	0.622	0.572	0.584	0.536	0.527	0.432	0.432
1997	0.025	0.145	0.275	0.421	0.582	0.667	0.651	0.664	0.623	0.603	0.509	0.509
1998	0.029	0.154	0.331	0.521	0.664	0.779	0.805	0.803	0.782	0.748	0.661	0.661
1999	0.044	0.177	0.394	0.654	0.750	0.870	0.914	0.879	0.859	0.817	0.736	0.736
2000	0.058	0.181	0.393	0.629	0.752	0.890	0.957	0.936	0.931	0.887	0.818	0.818
2001	0.066	0.188	0.380	0.578	0.696	0.854	0.977	0.984	0.997	0.949	0.892	0.892
2002	0.043	0.164	0.337	0.483	0.593	0.702	0.801	0.842	0.836	0.807	0.741	0.741
2003	0.031	0.149	0.331	0.494	0.568	0.642	0.687	0.732	0.713	0.700	0.628	0.628
2004	0.031	0.144	0.331	0.526	0.576	0.648	0.679	0.713	0.692	0.684	0.613	0.613
2005	0.030	0.126	0.291	0.478	0.544	0.621	0.656	0.687	0.674	0.669	0.599	0.599
2006	0.029	0.119	0.263	0.458	0.530	0.622	0.671	0.694	0.686	0.680	0.612	0.612
2007	0.027	0.108	0.228	0.381	0.483	0.589	0.663	0.694	0.703	0.699	0.635	0.635
2008	0.021	0.088	0.177	0.291	0.395	0.469	0.483	0.497	0.463	0.463	0.386	0.386
2009	0.030	0.094	0.183	0.301	0.395	0.465	0.465	0.457	0.406	0.403	0.326	0.326
2010	0.028	0.087	0.161	0.255	0.350	0.407	0.385	0.380	0.325	0.327	0.253	0.253
2011	0.028	0.085	0.153	0.233	0.318	0.361	0.322	0.312	0.251	0.252	0.183	0.183
2012	0.028	0.087	0.158	0.241	0.318	0.360	0.326	0.306	0.242	0.243	0.175	0.175
2013	0.043	0.098	0.173	0.256	0.323	0.370	0.347	0.327	0.262	0.269	0.196	0.196

Table 15: Icelandic cod in Division Va. Estimates of numbers at age in the stock 1955-2014 based on ACAM using catch at age and spring and fall bottom survey indices.

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1955	170.68	152.84	151.98	217.59	211.70	115.20	35.93	24.45	12.86	86.22	9.08	7.69	7.99	2.60
1956	220.63	170.68	152.84	119.55	150.25	134.55	71.62	21.72	14.75	7.91	50.82	5.35	4.60	4.71
1957	289.16	220.63	170.68	118.92	81.57	95.82	85.00	43.84	13.11	8.97	4.58	29.01	3.12	2.68
1958	154.24	289.16	220.63	128.85	78.54	50.78	59.76	51.49	35.06	7.72	5.09	2.59	16.93	1.88
1959	192.69	154.24	289.16	161.13	82.29	47.54	31.08	35.38	51.44	19.25	4.06	2.66	1.43	9.93
1960	128.71	192.69	154.24	216.19	104.48	50.80	30.12	18.87	20.57	37.48	10.54	2.26	1.57	0.93
1961	177.37	128.71	192.69	114.19	140.21	63.71	31.07	17.58	10.38	10.97	19.01	5.35	1.25	0.97
1962	203.85	177.37	128.71	143.63	74.65	88.58	40.16	18.22	23.60	5.59	5.67	10.00	3.07	0.81
1963	216.40	203.85	177.37	94.26	91.76	46.12	55.72	23.25	9.76	12.11	2.74	2.84	5.58	1.97
1964	229.21	216.40	203.85	127.57	58.15	54.12	27.73	31.10	11.63	4.45	5.19	1.20	1.46	3.42
1965	320.36	229.21	216.40	147.18	78.13	32.82	30.90	14.70	14.39	4.55	1.62	1.84	0.53	0.81
1966	172.07	320.36	229.21	157.01	90.70	43.54	17.96	15.79	6.59	5.60	1.59	0.55	0.78	0.28
1967	247.66	172.07	320.36	170.79	99.76	52.79	24.34	9.00	6.94	2.47	1.83	0.48	0.20	0.37
1968	180.62	247.66	172.07	242.92	111.20	60.30	30.82	12.28	4.00	2.69	0.84	0.59	0.19	0.11
1969	188.75	180.62	247.66	130.47	155.40	64.68	32.91	41.21	4.68	1.16	0.66	0.18	0.16	0.07
1970	139.35	188.75	180.62	191.75	84.67	92.15	37.16	32.89	18.36	1.87	0.41	0.23	0.07	0.09
1971	273.17	139.35	188.75	138.06	119.89	46.96	49.27	17.53	14.05	7.03	0.63	0.13	0.08	0.03
1972	179.07	273.17	139.35	141.46	82.99	60.81	22.57	21.69	23.29	5.17	2.21	0.18	0.04	0.04
1973	260.87	179.07	273.17	104.52	85.65	42.05	28.62	9.65	8.56	8.64	1.62	0.63	0.06	0.02
1974	367.68	260.87	179.07	198.62	62.10	43.02	19.58	12.02	3.72	3.15	2.73	0.47	0.21	0.03
1975	143.36	367.68	260.87	130.90	117.54	30.87	19.81	7.96	4.28	1.21	0.90	0.69	0.14	0.09
1976	227.70	143.36	367.68	191.68	78.64	58.24	13.86	7.88	2.69	1.26	0.32	0.21	0.19	0.05
1977	243.30	227.70	143.36	281.72	121.22	41.98	27.46	5.66	2.75	0.86	0.38	0.09	0.07	0.08
1978	140.04	243.30	227.70	113.86	189.74	71.38	22.40	12.23	2.26	1.09	0.34	0.15	0.04	0.04
1979	140.43	140.04	243.30	181.42	78.34	117.28	41.01	10.85	5.48	1.07	0.52	0.17	0.08	0.02
1980	131.67	140.43	140.04	193.65	125.23	48.76	71.82	20.32	5.04	2.74	0.54	0.28	0.09	0.05
1981	232.95	131.67	140.43	111.48	133.11	75.50	27.13	47.12	8.95	2.37	1.30	0.28	0.15	0.06
1982	139.00	232.96	131.67	112.39	76.54	76.57	37.94	11.62	17.01	3.13	0.86	0.50	0.11	0.07
1983	140.19	139.00	232.96	104.86	75.92	42.22	35.89	15.44	3.88	5.35	1.08	0.33	0.21	0.06
1984	329.03	140.19	139.00	186.30	71.81	42.64	19.85	14.52	5.24	1.27	1.87	0.43	0.14	0.10
1985	259.90	329.03	140.19	109.50	124.84	40.31	20.54	8.28	5.31	2.03	0.52	0.85	0.20	0.08
1986	175.48	259.90	329.03	109.17	71.24	67.04	18.53	8.24	2.95	2.03	0.83	0.24	0.40	0.11
1987	89.22	175.48	259.90	253.34	68.81	34.82	26.92	6.67	2.60	1.01	0.77	0.35	0.11	0.20
1988	130.51	89.22	175.48	201.29	158.06	32.37	12.61	8.92	1.89	0.79	0.36	0.30	0.15	0.05
1989	106.86	130.51	89.22	137.07	127.33	76.76	11.99	4.11	2.43	0.53	0.25	0.12	0.11	0.06
1990	174.34	106.86	130.51	70.14	88.11	100.18	32.72	4.44	1.38	0.90	0.21	0.11	0.05	0.06
1991	135.50	174.34	106.86	101.62	44.70	45.03	42.33	12.19	1.55	0.54	0.37	0.09	0.05	0.03
1992	77.75	135.50	174.34	80.30	61.52	20.79	16.38	14.34	3.88	0.55	0.21	0.15	0.04	0.02
1993	150.97	77.75	135.50	128.96	47.75	27.68	7.13	5.33	4.32	1.31	0.20	0.08	0.06	0.02
1994	165.43	150.97	77.75	96.64	77.23	22.45	10.15	2.40	1.56	1.28	0.43	0.07	0.03	0.03
1995	88.25	165.43	150.97	58.27	62.15	43.10	10.81	4.23	0.92	0.63	0.53	0.19	0.03	0.01
1996	161.36	88.25	165.43	116.23	39.23	37.00	23.16	5.02	1.85	0.43	0.29	0.26	0.09	0.02

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1997	70.84	161.36	88.25	130.62	81.04	24.22	20.08	10.87	2.20	0.86	0.20	0.14	0.13	0.05
1998	171.56	70.84	161.36	70.43	92.51	50.38	13.01	9.18	4.57	0.94	0.36	0.09	0.06	0.06
1999	161.47	171.56	70.84	128.37	49.44	54.39	24.49	5.48	3.45	1.67	0.35	0.14	0.03	0.03
2000	158.93	161.47	171.56	55.47	88.07	27.30	23.15	9.47	1.88	1.13	0.57	0.12	0.05	0.01
2001	178.34	158.93	161.47	132.50	37.89	48.69	11.91	8.93	3.19	0.59	0.36	0.18	0.04	0.02
2002	80.29	178.34	158.94	123.73	89.93	21.21	22.37	4.86	3.11	0.98	0.18	0.11	0.06	0.01
2003	154.77	80.29	178.34	124.66	86.01	52.55	10.71	10.12	1.97	1.14	0.35	0.06	0.04	0.02
2004	134.78	154.77	80.29	141.52	87.93	50.59	26.25	4.97	4.36	0.81	0.45	0.14	0.03	0.02
2005	95.99	134.78	154.77	63.74	100.37	51.69	24.48	12.08	2.13	1.81	0.33	0.18	0.06	0.01
2006	133.40	95.99	134.78	122.92	45.99	61.40	26.25	11.63	5.31	0.90	0.74	0.14	0.08	0.03
2007	119.54	133.39	95.99	107.21	89.34	28.96	31.80	12.64	5.11	2.22	0.37	0.31	0.06	0.03
2008	127.99	119.54	133.40	76.52	78.78	58.23	16.20	16.07	5.74	2.16	0.91	0.15	0.13	0.02
2009	169.86	127.99	119.54	106.89	57.37	63.69	35.62	8.93	8.23	2.90	1.08	0.47	0.08	0.07
2010	174.93	169.86	127.99	94.97	79.69	39.11	38.59	19.66	4.60	4.23	1.50	0.59	0.26	0.05
2011	123.00	174.93	169.86	101.94	71.29	55.54	24.80	22.27	10.72	2.56	2.37	0.89	0.35	0.16
2012	181.37	123.00	174.93	135.25	76.69	50.08	36.01	14.78	12.71	6.36	1.53	1.51	0.57	0.24
2013	160.03	181.37	123.00	139.27	101.53	53.60	32.22	21.46	8.44	7.51	3.83	0.99	0.97	0.39
2014	109.45	160.03	181.37	96.48	103.35	69.92	33.98	19.09	12.13	4.89	4.43	2.42	0.62	0.65

Table 16: Icelandic cod in Division Va. Landings (thousand tonnes, average fishing mortality of age groups 5 to 10, recruitment to the fisheries at age 3 (millions), reference fishing biomass (B4+, thousand tonnes), spawning stock biomass (thousand tonnes) at spawning time and harvest ratio.

Year	Yield	F5-10	SSB	Reference biomass	Recruits	Harvest rate
1955	545.250	0.292	929.240	2345.610	151.983	0.224
1956	486.909	0.291	784.523	2071.560	152.843	0.229
1957	455.182	0.312	765.435	1869.680	170.678	0.242
1958	517.359	0.355	866.698	1858.030	220.633	0.272
1959	459.081	0.322	846.183	1821.250	289.163	0.250
1960	470.121	0.372	706.461	1751.370	154.243	0.269
1961	377.291	0.355	563.558	1494.600	192.691	0.253
1962	388.985	0.383	567.393	1490.760	128.705	0.262
1963	408.800	0.458	506.564	1313.920	177.373	0.313
1964	437.012	0.548	449.951	1217.420	203.851	0.352
1965	387.106	0.576	317.131	1021.500	216.397	0.357
1966	353.357	0.589	276.815	1030.550	229.206	0.333
1967	335.721	0.561	256.066	1102.040	320.360	0.300
1968	381.770	0.721	221.301	1222.320	172.068	0.314
1969	403.205	0.558	313.518	1325.590	247.662	0.307
1970	475.077	0.612	330.937	1337.100	180.622	0.345
1971	444.248	0.684	242.406	1098.130	188.751	0.393
1972	395.166	0.694	221.720	997.097	139.351	0.401
1973	369.205	0.705	245.402	844.008	273.170	0.431
1974	368.133	0.764	187.018	918.426	179.072	0.393
1975	364.754	0.809	168.329	895.540	260.874	0.407
1976	346.253	0.747	138.573	955.641	367.679	0.359
1977	340.086	0.592	198.754	1289.930	143.363	0.261
1978	329.602	0.476	212.456	1298.230	227.704	0.258
1979	366.462	0.445	304.328	1397.760	243.297	0.260
1980	432.237	0.492	356.840	1489.750	140.043	0.288
1981	465.032	0.662	264.258	1242.230	140.431	0.363
1982	380.068	0.729	167.467	970.826	131.666	0.384
1983	298.049	0.713	130.362	791.371	232.955	0.367
1984	282.022	0.639	141.377	913.749	139.002	0.316
1985	323.428	0.667	172.745	927.554	140.185	0.349
1986	364.797	0.773	198.193	854.359	329.034	0.421
1987	389.915	0.861	149.764	1029.420	259.904	0.372
1988	377.554	0.891	171.701	1030.480	175.482	0.368
1989	363.125	0.718	171.217	1000.960	89.219	0.357
1990	335.316	0.700	213.699	841.205	130.512	0.406
1991	307.759	0.800	160.661	698.373	106.860	0.443
1992	264.834	0.844	152.811	550.873	174.344	0.472
1993	250.704	0.867	124.522	595.258	135.496	0.423
1994	178.138	0.625	154.228	576.272	77.749	0.313
1995	168.592	0.507	179.242	557.247	150.966	0.297
1996	180.701	0.505	159.681	670.672	165.428	0.269

Year	Yield	F5–10	SSB	Reference biomass	Recruits	Harvest rate
1997	203.112	0.543	190.400	783.058	88.251	0.258
1998	243.987	0.650	211.859	720.766	161.359	0.330
1999	260.147	0.743	184.832	731.141	70.839	0.352
2000	235.092	0.760	167.299	590.388	171.560	0.384
2001	234.229	0.745	162.204	688.013	161.472	0.333
2002	208.487	0.626	197.490	729.016	158.935	0.284
2003	207.543	0.576	186.877	739.773	178.337	0.279
2004	226.762	0.579	202.696	799.959	80.291	0.278
2005	213.403	0.546	230.506	723.544	154.767	0.295
2006	196.077	0.540	221.317	700.792	134.777	0.278
2007	170.300	0.506	203.576	681.227	95.993	0.250
2008	146.104	0.385	269.650	704.125	133.395	0.217
2009	181.151	0.377	255.681	798.614	119.541	0.221
2010	168.880	0.323	300.175	842.711	127.987	0.201
2011	170.425	0.283	364.764	932.087	169.860	0.185
2012	194.795	0.285	405.910	1046.710	174.925	0.186
2013	223.548	0.299	436.995	1161.350	122.997	0.193
2014			426.805	1106.360	181.370	
2015					160.033	
2016					109.447	

Table 17: Icelandic cod in Division Va. Inputs in the deterministic predictions.

Age	Parameter	2014	2015	2016	2017
3	Catch weights	1.226	1.226	1.226	1.226
4	Catch weights	1.820	1.820	1.820	1.820
5	Catch weights	2.344	2.344	2.344	2.344
6	Catch weights	3.108	3.108	3.108	3.108
7	Catch weights	4.222	4.222	4.222	4.222
8	Catch weights	5.998	5.998	5.998	5.998
9	Catch weights	7.558	7.558	7.558	7.558
10	Catch weights	8.414	8.414	8.414	8.414
11	Catch weights	9.335	9.335	9.335	9.335
12	Catch weights	9.925	9.925	9.925	9.925
13	Catch weights	11.193	11.193	11.193	11.193
14	Catch weights	12.689	12.689	12.689	12.689
3	SSB weights	0.944	0.944	0.944	0.944
4	SSB weights	2.323	2.323	2.323	2.323
5	SSB weights	2.989	2.989	2.989	2.989
6	SSB weights	3.832	3.833	3.833	3.833
7	SSB weights	5.208	5.208	5.209	5.209
8	SSB weights	6.164	6.164	6.165	6.165
9	SSB weights	7.521	7.521	7.522	7.522
10	SSB weights	8.414	8.414	8.415	8.415
11	SSB weights	9.335	9.335	9.336	9.336
12	SSB weights	9.925	9.925	9.926	9.926
13	SSB weights	11.193	11.194	11.195	11.195
14	SSB weights	12.689	12.690	12.691	12.691
3	Maturity	0.000	0.000	0.000	0.000
4	Maturity	0.026	0.026	0.026	0.026
5	Maturity	0.068	0.068	0.068	0.068
6	Maturity	0.236	0.236	0.236	0.236
7	Maturity	0.614	0.614	0.614	0.614
8	Maturity	0.893	0.893	0.893	0.893
9	Maturity	0.967	0.967	0.967	0.967
10	Maturity	0.957	0.957	0.957	0.957
11	Maturity	1.000	1.000	1.000	1.000
12	Maturity	1.000	1.000	1.000	1.000
13	Maturity	1.000	1.000	1.000	1.000
14	Maturity	1.000	1.000	1.000	1.000
3	Selection	0.114	0.114	0.114	0.114
4	Selection	0.311	0.311	0.311	0.311
5	Selection	0.558	0.558	0.558	0.558
6	Selection	0.842	0.842	0.842	0.842
7	Selection	1.105	1.105	1.105	1.105
8	Selection	1.258	1.258	1.258	1.258
9	Selection	1.146	1.146	1.146	1.146

Age	Parameter	2014	2015	2016	2017
10	Selection	1.090	1.090	1.090	1.090
11	Selection	0.757	0.757	0.757	0.757
12	Selection	0.757	0.757	0.757	0.757
13	Selection	0.757	0.757	0.757	0.757
14	Selection	0.757	0.757	0.757	0.757
3	Stock numbers	181.370	160.033	109.447	140.298
4	Stock numbers	96.479			
5	Stock numbers	103.353			
6	Stock numbers	69.916			
7	Stock numbers	33.977			
8	Stock numbers	19.093			
9	Stock numbers	12.132			
10	Stock numbers	4.885			
11	Stock numbers	4.431			
12	Stock numbers	2.416			
13	Stock numbers	0.617			
14	Stock numbers	0.653			

Table 18: Icelandic cod in Division Va. Output of the deterministic predictions.

Year	B4.	Fmult	Fbar	SSB	Landings	2016.B4.	2016.SSB	SSB.change	TAC.change
2014	1106		0.31	427	224				
2015	1172	0.00	0.00	522	0	1474	739	42%	-100%
		0.19	0.06	509	51	1415	679	34%	-77%
		0.23	0.07	506	59	1405	670	32%	-74%
		0.26	0.08	504	67	1396	660	31%	-70%
		0.29	0.09	502	75	1387	651	30%	-67%
		0.32	0.10	500	83	1377	642	28%	-63%
		0.36	0.11	498	91	1368	633	27%	-60%
		0.39	0.12	496	98	1359	624	26%	-56%
		0.42	0.13	493	106	1350	616	25%	-53%
		0.45	0.14	491	114	1341	607	24%	-49%
		0.49	0.15	489	121	1332	599	22%	-46%
		0.52	0.16	487	129	1324	590	21%	-42%
		0.55	0.17	485	136	1315	582	20%	-39%
		0.58	0.18	483	144	1306	574	19%	-36%
		0.62	0.19	481	151	1298	566	18%	-32%
		0.65	0.20	479	159	1289	558	17%	-29%
		0.68	0.21	477	166	1281	551	16%	-26%
		0.71	0.22	475	173	1273	543	14%	-23%
		0.74	0.23	473	180	1264	536	13%	-20%
		0.78	0.24	471	187	1256	528	12%	-16%
		0.81	0.25	469	194	1248	521	11%	-13%
		0.84	0.26	467	201	1240	514	10%	-10%
		0.87	0.27	465	208	1232	507	9%	-7%
		0.91	0.28	463	215	1224	500	8%	-4%
		0.94	0.29	461	221	1217	493	7%	-1%
		0.97	0.30	459	228	1209	486	6%	2%
		1.00	0.31	457	235	1201	480	5%	5%
		1.04	0.32	455	241	1194	473	4%	8%
		1.07	0.33	453	248	1186	467	3%	11%
		1.10	0.34	451	254	1179	460	2%	13%
		1.13	0.35	449	261	1171	454	1%	16%
		1.17	0.36	447	267	1164	448	0%	19%
		1.20	0.37	445	273	1157	442	-1%	22%
		1.23	0.38	443	280	1149	436	-2%	25%
		1.26	0.39	441	286	1142	430	-3%	28%
		1.30	0.40	439	292	1135	424	-3%	30%
		1.33	0.41	438	298	1128	418	-4%	33%
		1.36	0.42	436	304	1121	413	-5%	36%
		1.39	0.43	434	310	1114	407	-6%	38%
		1.42	0.44	432	316	1107	402	-7%	41%
		1.46	0.45	430	322	1101	396	-8%	44%
		1.49	0.46	428	328	1094	391	-9%	46%

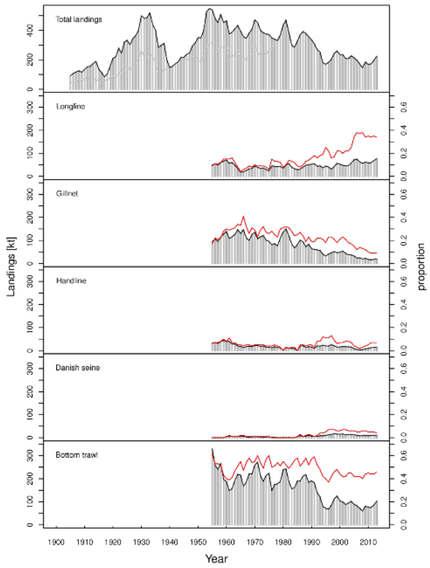


Figure 1: Icelandic cod division Va. Total landings from 1905 to 2013 and landings by principal gear from 1955 to 2013. The proportion of landings by each gear is shown by the red line.

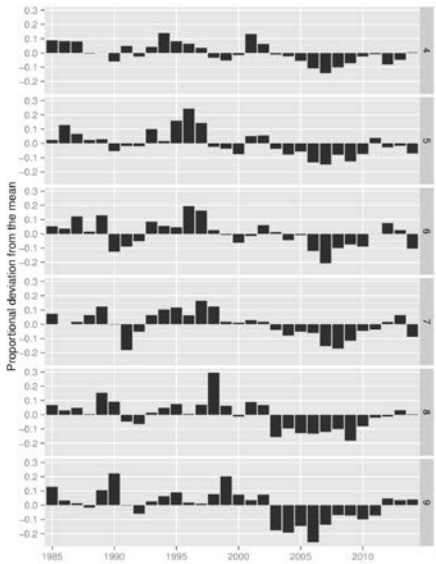


Figure 2: Icelandic cod division Va. Estimated weight at age (numbers in panels indicate age classes) in the catches 1985-2014 expressed as deviation from the mean. Weights at age in 2014 are predicted from 2014 spring survey weights. Note that values that are equal to the mean are not visible in this type of a plot.

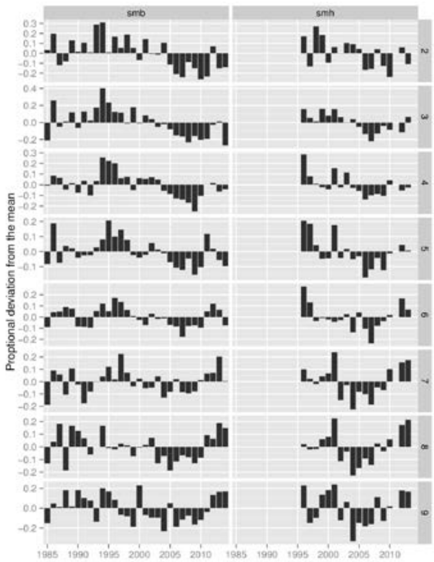


Figure 3: Icelandic cod division Va. Estimated weight at age (numbers in panel indicate age classes) in the spring survey 1985-2014 (SMB) and fall survey 1996-2013 (SMH) expressed as proportional deviations from the mean. No fall survey was conducted in 2011. Note that values that are equal to the mean are not visible in this type of a plot.

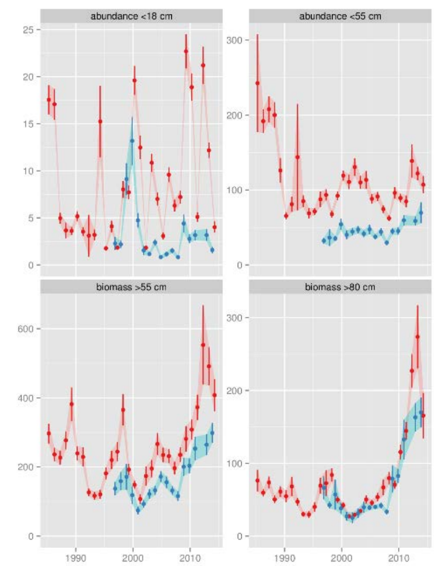


Figure 4: Icelandic cod division Va. Abundance indices of cod in the groundfish survey in spring 1985-2014 (SMB red, longer time series) and fall 1996-2013 (SMH blue, shorter time series). Bottom left) Biomass index of 55 cm and larger, bottom right) Biomass index 80 cm and larger, top right) Abundance index of < 55 cm, top left) Abundance index of < 18 cm fish. The shaded area and the vertical bar show 1 standard error of the estimate.

Figure 5: Icelandic cod division Va. Age based abundance indices of cod in the groundfish survey in spring 1985-2014 (SMB) and fall 1996-2013 (SMH). The indices are standardized within each age group and within each survey.

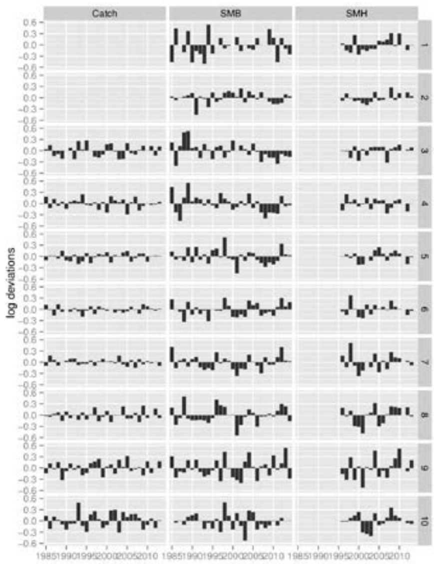


Figure 6: Catch residuals (left), spring survey residuals (SMB, middle) and fall survey residuals (SMH, right) by year and age from the spaly ADCAM run. Note that values that are equal to the mean are not visible in this type of a plot and that no survey was carried out in the fall 2011.

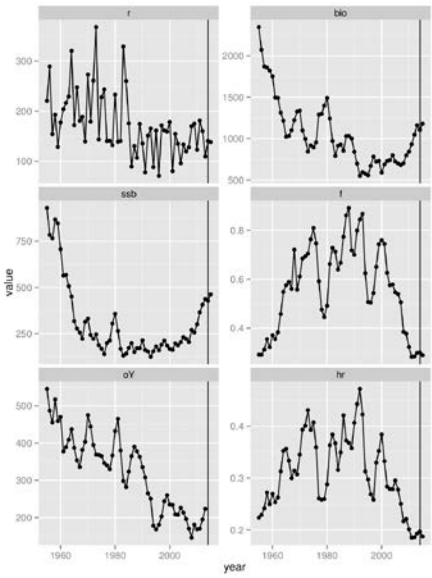


Figure 7: Icelandic cod in division Va. Assessment summary based ADCAM tuned with the spring and the fall survey. Medium term simulations are based recruitment patterns observed since year class 1985 and the application of management harvest control rule. The x-axis in the recruitment panel refers to year class, the vertical green line to the long term average recruitment. Vertical grey line demarks the assessment year (2014). Vertical green lines on the harvest rate and fishing mortality panel refer to expected medium value under the application of the harvest control rule. The different shades of grey refer to 90p, 80p and 50p pseudo-confidence intervals. Note that the x-axis does not cross the y-axis at zero. Two randomly drawn iteration is displayed.

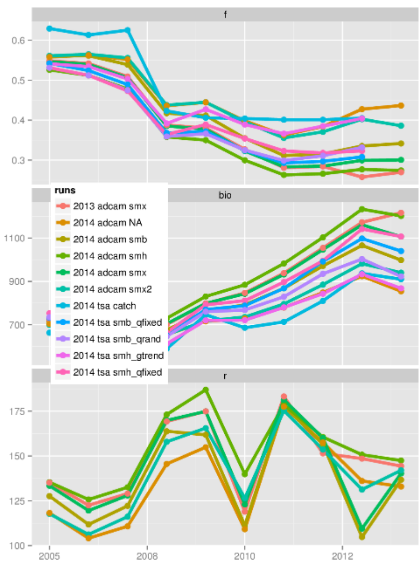


Figure 8: Icelandic cod in division Va. Comparison of different stock trajectories using alternative model frameworks, input and assumptions.

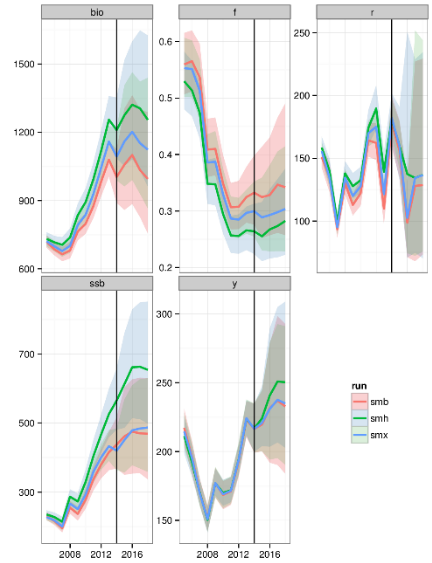


Figure 9: Icelandic cod in division Va. Medium term simulation based on ADCAM.

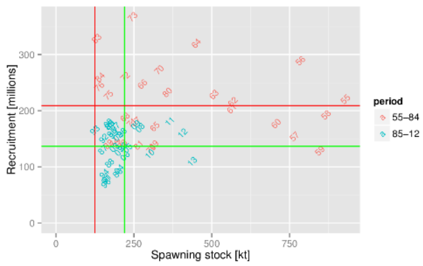


Figure 10: Icelandic cod in division Va. Spawning stock biomass and corresponding recruitment at age 3. The numerical values refer to year class with the horizontal lines referring to mean recruitment for year classes 1954-1984 (red line) and 1985-2013 (green line). Vertical lines refer to B_{lim} (B_{loss}, red) and $B_{trigger}$ (green).

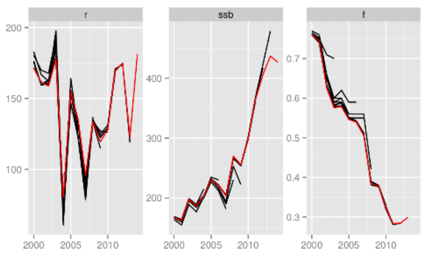


Figure 11: Icelandic cod in division Va. Empirical retrospective patterns from the 2004 to 2014 (this years assessment, marked in red) assessments as summarized in ICES annual advisory sheet.

10 Icelandic haddock

The main points in this section are.

2013 yearclass estimated to be small, the 6th consecutive small yearclass.

Current assessment shows some upward revision of stock compared to last years assessment, caused by increased numbers in stock. The main features are though the same that recruitment is poor and the stock will decrease in coming years.

Growth in 2013 was around average since 1985 but slower than in 2012 and slower than anticipated.

Mean weight of small, younger cohorts above average and older around average.

Year class 2013 is estimated small so year classes 2008-2013 are now all estimated as small.

Same assessment procedure as last year (SPALY). Adapt type model tuned with both the surveys.

Difference in perception of the state of stock in assessment based on either the spring or autumn survey with autumn survey indicating larger stock. Has been like that since 2009. Different models using the same tuning data show similar results.

Advice given according to the adopted Harvest Control Rule. Advice for the fishing year 2014/2015 (September 1st 2014 – August 31st 2015 is 30 400 tonnes.

No environmental drivers or ecosystem effects are known that can help in prediction of the development of the haddock stock. Some effect of the environment on the stock can though not be excluded.

For more detailed description of a number of things, see Björnsson (2013) and Stock annex.

10.1 Data

Landings of Icelandic haddock in 2013 are estimated to have been 44 100 tonnes, see Figure 10.1.1 and Table 10.1.1. Of the landings, 43 500 tonnes are caught by Iceland and 600 tonnes by other nations. The landings have decreased from 100 thous. tonnes between 2005-2008. The share of different gears in the haddock catches does not change much from year to year. Changes on longer time scale have though been seen, with the share of longlines increasing in last 15 years, while the proportion of haddock caught in gillnets is now very small (Figure 10.1.2) . The proportion caught in Danish seine is still relatively high though it has decreased for last 5 years. Spatial distribution of the landings does not change very much from year to year but catches from the area north of Iceland have increased gradually over the last 10-15 years. (Figure 10.1.3).

Catch in numbers at age is shown in Table 10.1.2 and Figure 10.1.4. As expected, age 10 was more abundant than ever before and it contributed 10% by weight. Yearclass 2007 was most important, or 43%. The results for 2013 are close to expectation (Figure 10.1.5) . The most interesting deviation is less than expected of the very large 2003 yearclass (age 10) and more of cohort 2004 (age 9). This "transfer" between cohorts 2003 and 2004 has been seen in other data (autumn survey).

Catch curves show that total mortality of older fish in this stock has usually been high, but decreasing recently (Figure 10.1.6).

Discards are not included in the total catch in tonnes but partly in the samples used for compiling catch in numbers that are a somewhat variable mixture of harbour and sea samples. Discards due to high grading have been small since 2000, due to reduced spatial overlap between fisheries and recuits and in recent years also due to very low number of recruits. Comparison of sea and shore samples indicates that discard due to high grading were small (<1% by numbers) in 2013 (Figure 10.1.7). There is some discrepancy between sea and shore samples with more of young fish caught according to shore samples, indicating negative discards or more likely that sea and shore samples are not completely comparable.

The index of total biomass from the groundfish surveys in March and October is shown in Figure 10.1.8. Both surveys show much increase between 2002 and 2005 but considerable decrease from 2007-2010. The difference in perception of the stock between the surveys is that the autumn survey shows less contrast between periods of large and small stock. The main difference from last years assessment is that survey biomass from the March survey is stable and the autumn survey increasing while the assessment of last two years predicted reduction. As seen in the figure, uncertainty in the indices from the autumn survey 2013 is relatively high.

Age disaggregated indices from the March survey are given in Table 10.1.3 and Figure 10.1.9 and indices from the autumn survey in Table 10.1.4. Abundance of agegroups 6 and younger in the 2014 March survey is low while age 7 is among the highest indices observed (Figure 10.1.9). The index of age 11 (2003 cohort) is much higher than seen before, but that cohort will though not contribute much to the landings.

The survey results indicate that in recent decade higher and higher proportion of the haddock stock has gradually been inhabiting the waters north of Iceland (Figures 10.1.10 and 10.1.11.).

Mean weight at age in the catch is shown in Table 10.1.6 and Figure 10.1.13. Mean weight at age in the stock is given in Table 10.1.5 and Figure 10.1.12. Those data are obtained from the groundfish survey in March and are also used as mean weight at age in the spawning stock.

Both stock and catch weights have been increasing in recent years, after being very low when the stock was large between 2005-2009. Higher mean weight at age is most apparent for the younger haddock from the small cohorts (2008 and later), but mean weight of the old fish is still below average.

Mean weight of the 2007 year class that will be the most important year class in the fisheries in next years (≈35% by weight 2014 and 25% in 2015) is close average since 1985. Mean weight of the youngest, small year classes is now above the average since 1985. Mean weight at age in the March survey 2014 was on the average lower than predicted last year, but growth in 2013 was slower than in 2012 (Figures 10.2.8, and 10.4.1).

Maturity at age data are given in Table 10.1.7 and Figure 10.1.14. Those data are obtained from the groundfish survey in March. Maturity by age of the youngest age groups has been decreasing in recent years while mean weight at age has been increasing so maturity by size has been decreasing. The most likely explanation is high proportion of those agegroups north of Iceland where proportion mature has always been low.

Catch per unit effort data (figure 10.1.15) give somewhat different picture of the development of the stock from the surveys and assessment, much less increase after 2000 but much less decrease in recent years (figures 10.1.8 vs 10.1.15). The interesting thing for the current assessment is the relatively high CPUE, in 2013, confirming fishermen's view that catching haddock in now very easy. The discrepancy observed between CPUE and stock size has not been explained, but a number of plausible reasons mentioned.

- Area inhabited by the stock increased so the density in the traditional fishing area did not increase in relation to the stock size.
- Slower growth lead to higher proportion of the stock below "fishable size" 45cm limiting the areas where large haddock could be caught without too much bycatch of small haddock.
- The opposite is happening in recent years, faster growth and poor recruitment lead to the fisheries not limited by small haddock.
- Bycatch issues, but haddock is often caught as bycatch or one of the species in mixed fisheries where the goal is certain mixture of species.

10.2 Assessment.

From 2007 to 2013 the final assessment was based on an Adapt type model calibrated with indices from both the groundfish surveys in March and October. Before that statistical catch at age model calibrated with indices from the March survey was used.

Assessment in recent years has shown some difference between different models, but more difference between different data sources i.e the March and the October surveys. From 2004 to 2008 models calibrated with the October survey indicated smaller stock . In the last four years things have changed and models calibrated with the October survey indicate a better state of the stock, the difference increased with addition of the most recent data points i.e. October 2013 and March 2014. This behaviour is in line with what is seen in the surveys where the contrast in biomass is higher in the March survey (Figure 10.1.8).

The stock was benchmarked in Febuary 2013, (WKROUND 2013) and the assessment procedure used since 2007 was recommended for few more years, if major problems do not show up (see stock annex).

The results of the assessment indicate that the stock has been deceasing in recent years when large year classes have disappeared from the stock, replaced by smaller year-classes. (Figure 10.2.1) Fishing mortality is now estimated to be low and should continue to be so if the adopted HCR will be followed and the stock size not overestimated. Still the stock is predicted to decrease as incoming year classes are small.

The main features of the current assessment are the same as in the assessments 2011 to 2013. The current assessment shows similar state of the stock as the 2013 assessment (Figures 10.2.7 and 10.2.8). Number in younger agegroups is higher, but growth slower than predicted last years (Figure 10.2.8) leading to the total biomass being similar to last years prediction. Higher than predicted catches in 2013 must of course be taken into account (44 100 tons vs 38 000 tons)

Residuals from the assessment model are positive for the most recent October survey but close to zero for the most recent March survey. (Figures 10.2.2 and 10.2.3). The March surveys 2011-2013 are on the other hand below predictions. Similar thing seem to be happening in the fishery in 2012-2013 (Fig 10.1.15) so there are indication that the stock might be underestimated or availability of haddock is unusually high.

As in recent years there, is some difference between assessment result, depending on which survey is used for calibration. Models tuned with the autumn survey indicate larger stock than models tuned with the March survey, those tuned with both the surveys fit in between (Figure 10.2.6). Different models based on the same data give similar results.

Analysis by the TSA model (WD 38) indicate increased natural mortality after age 6. This increase will not have large effect on the harvest rate in the HCR which is mostly selected based on precautionary criteria, i.e low probability of SSB<B_{loss} in periods of poor recruitment. Higher M of older age groups will reduce the possibility of storing old spawners through periods of poor recruitment. To get maximum yield per recruit increased M would call for higher harvest ratio. Increased M of old fish will be investigated further in coming years, but reduced availability with age leads to similar observations.

Standard error in estimates of SSB in 2014 from the Adapt model are 7 thous. tons for the March survey and 16 thous. for the autumn survey. The difference between the stock biomass is 50 thous. tonnes (103 vs 53 thous. tonnes) that does not fit within the confidence intervals (less than 1% probability of 50 thous tonnes or more difference between autumn survey and March survey results). This is an indication that the estimated confidence intervals are too narrow. The same observation was made last 3 years. The spawning stock according to the model tuned with both the surveys is 67 thous. tonnes.

Plot of observed vs. predicted biomass from the surveys (figure 10.2.3) indicates that historically the autumn survey biomass has been closer to prediction than corresponding values from the March survey where the contrast in observed biomass is more than predicted from the assessment. When the stock was small in 2000 and 2001, the March survey indicated considerably smaller stock while the autumn survey values were reasonably correct and from 2003-2007 the March survey overestimated the stock.

Figure 10.2.5 shows the estimated "catchability" and CV as a function of age for the surveys, showing that estimated CV is lower in the autumn survey for ages 3 to 6 . Therefore, the autumn survey gets more weight for those age groups. The figure also indicates that estimated CV and "catchability" have not changed much for the March survey since 2008, but catchability of the autumn survey increased as has CV of the oldest agegroups.

To summarize there are indications that the stock might be larger than predicted but also that it is smaller. CPUE data, not used directly in the assessment support that the stock might be larger.

10.3 Reference points

In March 2013, ICES evaluated a proposed Harvest Control Rule for Icelandic haddock (Björnsson 2013) and the Icelandic government adopted it in April 2013. The Harvest control rule is

The annual total allowable catch (TAC) will be set by applying the following harvest control rule (HCR):

1. When spawing stock biomass in the year following the assessment year (SSB_{y+1}) is equal to or greater than $SSB_{trigger}$:

$$TAC_{y/y+1} = \alpha\ B_{45+,y+l}$$

2. When SSB_{y+1} is below $SSB_{trigger}$:

$$TAC_{y/y+1} = \alpha\ SSB_{y+1} / SSB_{trigger} \quad B_{45+,y+l}$$

Where:
y the assessment year,
y/y_{+1} the fishing year starting 1 September in year y and ending 31 August in year y+1
y_{-1}/y the fishing year starting 1 September in year y-1 and ending 31 August in year y
$B_{45+,y+1}$ the reference biomass of 45cm and larger haddock in the year following the assessment year
and were α=0.40 and $SSB_{trigger}$ =45000 t.

B_{45+}, is on the average close to the spawning stock, but is not affected by changes in proportion mature by size/age. Large variability in size at age (Figure 10.1.12) is the reason for basing reference biomass on size rather than age. Proportion of a cohort above 45cm (B_{45+}) is calculated from stock weights by the green curve in Figure 10.4.3.

B_{lim} for Icelandic haddock was defined by ICES in 2011 as 45 000 tonnes or B_{loss}. From the simulations done to test the Harvest Control Rule H_{msy} the harvest ratio giving maximum yield was estimated as 0.52 and H_{PA} harvest ratio giving 5% probability of SSB < B_{lim} as 0.46, compared to the target harvest rate of 0.4. These numbers do though not have any meaning when the HCR has been adopted.

10.4 Short term forecast

Prediction of weight at age in the stock, weight at age in the catches, maturity at age and selection has been similar since 2006 (working paper #19 in 2006). The procedure is described in the advice part of the report of ADGISHA (Björnsson 2013) and also in the stock annex.

To summarize, TAC for the fishing year 2014/2015 is a function of the biomass of 45cm and larger haddock and the spawning stock in the beginning of 2015. To be able to predict the stock size in 2015, catch 2014, mean weight at age in the catch 2014, selection at age in the catch 2014, stock weights in 2015 and maturity at age in 2015 must be predicted. The prediction of these values is described in Björnsson (2013) and the stock annex, but to summarize, catch in the assessment year (2014) is the TAC left in the current fishing year in the beginning of the assessment year plus 1/3 of the predicted TAC next fishing year. The TAC for the fishing year 2013/2014 was 38 000 tonnes. The landings in September – December 2013 were 17 000 tonnes or 45% of the TAC. The average contribution of the first 4 month of of the Fishing year is on the other hand around 33%. Landings for the fishing year 2012/2013 are now estimated to be 40 634 tonnes while the TAC issued was 36 thous. tonnes. Looking at the rate of landings (Figure 10.4.1) they slowed down in the winter compared to last fishing year so the quota will likely not be exceeded by as much as last fishing year.

In the Icelandic fishery management system certain relatively small transfer is allowed between species, to increase flexibility in mixed fisheries. Currently netto transfer is towards haddock, probably because haddock is easy to catch, as demonstrated by high CPUE in 2013. The haddock quota does also seem to be limiting in some mixed fisheries. Looking over longer period quota transfer towards/from haddock has on the average been close to zero. In predictions for current fishing year 1000 tons transfer towards haddock is assumed.

On April 12th 2014, 10 thous. tonnes of quota were left and 12 827 tonnes had been caught. To this are added 1/3rd of next years TAC plus the catch taken by foreigners (assumed to be 600 tonnes as in 2013) and 1000 tonnes in transfer from other species . This leads to 35 000 tonnes catch in the calendar year 2014.

In current fishing year 45% of the quota is caught in September-Desember leading to 4 500 tonnes extra catch in 2013 compared to if 1/3rd of the quota was caught in that period. It can be argued that when in the fishing year the TAC is caught is not crucial for development of the stock as long as the total catch is according to the TAC. Therefore the predictions are based on catching 1/3rd of the TAC in September - December.

Mean weight and maturity at age in 2013 are available and are used to predict catch weights and selection at age (Figure 10.4.2). Growth in 2014 is predicted by the equation

$$\log \frac{W_{a+1,t+1}}{W_{a,t}} = \alpha + \beta \log W_{a,t} + \delta_{year}$$

Where the factor δ_{year} for the year 2013 (figure 10.4.2) is used for 2014 and onwards. Maturity, selection, catch weights at age and proportion of the biomass above 45cm are then predicted from stock weights 2014. When those values have been estimated the prediction is done by the same model as used in the assessment.

The model works iteratively as the estimated TAC for the fishing year 2013/2014 has some effect of the biomass in the beginning of 2014, which the TAC is based on.

Results of the short term prediction are shown in figure 10.2.1 assuming that the harvest control rule is followed. TAC for the fishing year 2014/2015 will be 30 400 tons. Short term prognosis based on the traditional ICES approach are shown in table 10.4.1

10.5 References

Gudmundur Gudmunsson. 2014. Fish stock assessment by time series analysis. ICES NWWG WD 38.

Bjornsson, H. 2013. Evaluation of the Icelandic haddock management plan. ICES CM 2013/ACOM:59.

ICES. 2012. Report of the North-Western Working Group, 25 April–02 May 2012. ICES CM 2012

Table 10.1.1 Haddock in Division Va Landings by nation.

Country	1979	1980	1981	1982	1983	1984	1985	1986
Belgium	1010	1144	673	377	268	359	391	257
Faroe Islands	2161	2029	1839	1982	1783	707	987	1289
Iceland	52152	47916	61033	67038	63889	47216	49553	47317
Norway	11	23	15	28	3	3	+	
€UK								
Total	55334	51112	63560	69425	65943	48285	50933	48863

HADDOCK Va

Country	1987	1988	1989	1990	1991	1992	1993	1994
Belgium	238	352	483	595	485	361	458	248
Faroe Islands	1043	797	606	603	773	757	754	911
Iceland	39479	53085	61792	66004	53516	46098	46932	58408
Norway	1	+						1
UK								
Total	40761	54234	62881	67202	53774	47216	48144	59567

HADDOCK Va

Country	1995	1996	1997	1998	1999	2000	2001	2002
Belgium								
Faroe Islands	758	664	340	639	624	968	609	878
Iceland	60061	56223	43245	40795	44557	41199	39038	49591
Norway	+	4						
UK								
Total	60819	56891	43585	41434	45481	42167	39647	50469

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011
Belgium									
Faroe Islands	833	1035	1372	1499	1780	828	625	311	207
Iceland	59970	83791	95859	96115	108175	101651	81418	63868	49231
Norway	30	9			11	11			
UK	51								
Total	60884	84835	97231	97614	109966	102490	82043	64179	49437

Country	2012	2013
Belgium		
Faroe Islands	303	600
Iceland	45888	43500
Norway		

UK	
Total	44100

Table 10.1.2 Haddock in division Va. Catch in number by year and age.

Year/age	2	3	4	5	6	7	8	9	10
1979	149	1908	3762	6057	9022	1743	438	56	0
1980	595	1385	11481	4298	3798	3732	544	91	32
1981	10	514	4911	16900	5999	2825	1803	168	43
1982	107	245	3149	10851	14049	2068	1000	725	169
1983	34	1010	1589	4596	9850	8839	766	207	263
1984	241	1069	4946	1341	4772	3742	4076	238	58
1985	1320	1728	4562	6796	855	1682	1914	1903	212
1986	1012	4223	4068	4686	5139	494	796	897	344
1987	1939	8308	6965	2728	2042	1094	132	165	220
1988	237	9831	15164	5824	1304	1084	609	66	89
1989	188	2474	22560	9571	3196	513	556	144	34
1990	1857	2415	8628	23611	6331	816	150	67	45
1991	8617	2145	5397	7342	14103	2648	338	40	10
1992	5405	10693	5721	4610	3691	5209	999	120	10
1993	769	12333	12815	2968	1722	1425	2239	343	19
1994	3198	3343	28258	10682	1469	726	358	647	93
1995	4015	7323	5744	23927	5769	615	290	187	268
1996	3090	10552	7639	4468	12896	2346	208	79	60
1997	1364	3939	10915	4895	2610	5035	719	64	12
1998	279	8257	5667	7856	2418	1422	1897	261	17
1999	1434	1550	17243	4516	4837	915	620	481	63
2000	2659	6317	2352	13615	1945	1706	324	222	176
2001	2515	11098	6954	1446	6262	675	478	105	42
2002	1082	10434	15998	5099	1131	3149	262	169	42
2003	401	6352	16265	12548	2968	748	1236	91	48
2004	1597	4063	17652	19358	8871	1940	471	489	92
2005	2405	9450	6929	25421	13778	4584	809	251	212
2006	241	10038	21246	6646	18840	7600	2180	323	93
2007	782	3884	42224	22239	3354	9952	2740	519	62
2008	2316	4508	9706	53022	11014	1717	3033	815	167
2009	1066	3185	4886	8892	35011	5733	726	1381	395
2010	121	6032	7061	4806	6766	17503	1874	354	412
2011	253	1584	11797	5080	2853	3983	6220	494	112
2012	196	1322	3421	13107	2223	1231	2480	2662	241
2013	250	1042	2865	4008	9222	1206	668	1248	1367

Table 10.1.3 Icelandic haddock. Age disaggregated survey indices from the groundfish survey in March .

YEAR/ AGE	1	2	3	4	5	6	7	8	9	10	11
1985	28.14	32.68	18.33	23.58	26.39	3.7	10.86	4.8	5.54	0.49	0.11
1986	123.87	108.48	58.97	12.79	16.31	13.13	0.97	2.72	1.23	2.27	0.09
1987	21.82	338.29	147.5	44.15	7.68	7.47	4.72	0.39	0.61	0.44	0.82
1988	15.77	40.73	184.79	88.87	22.86	1.34	2.19	1.77	0.16	0.22	0.01
1989	10.58	23.33	41.16	146.61	45.09	12.91	0.84	0.83	0.41	0.28	0.13
1990	70.48	31.8	26.73	38.84	92.82	30.89	3.44	0.9	0.23	0	0
1991	89.73	145.95	41.43	17.73	20.19	32.85	7.63	0.3	0.1	0.08	0
1992	18.15	211.43	137.77	35.38	16.91	13.77	16.32	2.22	0.18	0.07	0
1993	29.99	37.8	244.96	87.19	11.23	3.85	1.66	4.46	0.88	0	0
1994	58.54	61.34	39.83	142.35	42.18	6.9	2.87	1.42	4.44	0.17	0
1995	35.89	82.47	47.03	19.75	69.52	7.66	1.31	0.11	0.34	0	0
1996	95.32	66.31	119.96	36.81	19.58	40.7	5.84	0.62	0.13	0.12	0
1997	8.6	119.35	50.81	53.33	10.88	7.37	10.9	1.35	0.07	0.03	0.07
1998	23.08	18	107.93	28.23	23.49	4.9	3.54	4.56	0.33	0	0
1999	80.73	85.46	25.53	98.73	12.99	9.85	1.42	1.77	1.03	0.09	0
2000	60.58	90.07	44.63	8.45	25.22	3.14	1.59	0.4	0.15	0.52	0.04
2001	81.27	147.71	115.4	22.15	4.09	10.63	0.93	0.57	0	0.1	0
2002	20.75	298.67	200.74	112.49	23.24	3.51	7.49	0.31	0.3	0.08	0.15
2003	111.64	97.55	282.49	244.86	113.46	18.01	2.57	4.49	0.48	0.85	0.07
2004	325.9	291.65	70.75	208.74	109.33	33.96	6.79	1.24	0.82	0	0.16
2005	57.94	698.32	289.36	44.58	157.19	57.51	15.72	3.35	0.32	0.25	0.02
2006	39.29	88.69	575.93	179.11	19.13	62.94	16.43	6.74	0.7	0.29	0
2007	34	65.6	88.63	436.41	85.68	7.9	21.6	4.74	2.15	0.07	0
2008	88.53	68.05	71.7	75.57	222.79	29.99	3.53	7.47	1.64	0.27	0
2009	10.46	111.21	53.82	41.48	41.91	105.64	12.94	2.23	3.11	0.44	0.23
2010	15.15	27.71	138.2	29.95	18.28	20.59	31.59	2.92	0.46	0.69	0.12
2011	8.79	27.65	24.75	77.43	14.03	5.9	9.4	14.89	1.22	0.31	0.23
2012	12.47	14.9	31.27	27.22	58.3	5.23	2.92	5.3	6.87	0.8	0.26
2013	13.91	23.32	19.72	22.9	22.51	41.93	4.78	2.49	3.86	4.52	0.59
2014	14.01	24.78	30.27	17.74	16.44	14.79	16.44	1.33	1.05	1.68	1.42

Table 10.1.4 Icelandic haddock. Age disaggregated survey indices from the groundfish survey in October

Year/ Age	0	1	2	3	4	5	6	7	8	9	10
1996	16.1	461.3	109.4	85.6	18.5	7.8	18.3	1.6	0	0	0
1997	52.9	32.4	212.9	54.5	38.7	7	5.7	6.1	0.3	0	0
1998	209.1	81.1	32.5	133.4	19.8	15.8	5.3	5.4	1.9	0	0
1999	178.6	397.4	66.9	28.6	97.1	11.9	10.4	0.5	2.1	0.3	0
2000	56.2	161.9	260.1	46.3	8.2	28.7	2	3.2	0.1	0.3	0.6
2001	47	387.5	281.6	170.2	35.7	4.1	13.9	0.7	1	0	0.2
2002	150.6	85.2	237.8	197.5	98.5	19.3	3	2.3	1	0.1	0
2003	316.5	345.5	146.9	251.9	169.1	56.6	9.5	2.4	0.7	0	0
2004	189.4	714.3	347.3	51.2	160.3	70.6	17	4	0.8	0.5	0
2005	91.1	74.2	560.4	182.1	27.3	96.5	26.7	10.4	1.9	0	0.1
2006	85.9	124.1	117.6	510.4	108.5	13.8	40.4	9.8	3.9	1.5	0
2007	203.4	93	78.4	92.8	341.4	58.7	8.5	12.4	3.8	0.6	0.2
2008	95.3	201.8	93.9	68.4	87.9	198.9	16.8	2.9	3.5	0.2	0.1
2009	52.8	47.5	269.5	68.2	31	48.5	96.8	9.5	1.5	2.2	0.1
2010	37.2	43.3	56.6	143.4	30.6	14.4	23.7	37.2	4.8	0.9	1
2012	26.8	53.8	29.1	34.3	37.7	70.5	9.3	3.6	10	10.5	1
2013	27.1	91.9	131.4	37.3	38.6	39.4	45.1	6.3	2.3	5.9	4.3

Table 10.1.5 Haddock in division Va Weight at age in the stock. Predicted values are shaded

Year/age	1	2	3	4	5	6	7	8	9	10
1979	37	185	481	910	1409	1968	2496	3077	3300	4000
1980	37	185	481	910	1409	1968	2496	3077	3300	4615
1981	37	185	481	910	1409	1968	2496	3077	3300	4898
1982	37	185	481	910	1409	1968	2496	3077	3300	3952
1983	37	185	481	910	1409	1968	2496	3077	3300	4463
1984	37	185	481	910	1409	1968	2496	3077	3300	3941
1985	36	244	568	1187	1673	2371	2766	3197	3331	4564
1986	35	239	671	1134	1943	2399	3190	3293	3728	4436
1987	31	162	550	1216	1825	2605	3030	3642	3837	3653
1988	37	176	457	974	1830	2695	3102	3481	3318	4169
1989	26	182	441	887	1510	2380	3009	3499	3195	5039
1990	29	184	457	840	1234	1965	2675	3052	3267	4115
1991	31	176	501	1003	1406	1884	2496	3755	3653	5243
1992	28	157	503	894	1365	1891	2325	2936	3682	4674
1993	41	168	384	878	1492	1785	2562	2573	3266	4047
1994	33	181	392	680	1235	1766	1717	2977	2131	3154
1995	37	167	440	755	1065	1857	2689	5377	1306	3119
1996	41	174	453	813	1076	1477	2171	2426	4847	3686
1997	50	174	424	817	1221	1425	1915	2390	3692	3508
1998	41	203	415	753	1241	1747	1996	2342	3076	3275
1999	33	206	480	715	1189	1956	2366	2782	2922	3534
2000	29	179	552	889	1159	1767	2612	2917	3132	3734
2001	36	190	490	1056	1437	1509	2169	2765	3300	4715
2002	67	172	475	889	1460	1949	2137	1990	3709	4078
2003	40	230	412	801	1268	1873	3139	2343	3301	3289
2004	34	176	556	807	1282	1690	2454	3236	2942	3957
2005	40	153	448	920	1188	1564	2128	2808	2550	2755
2006	33	127	333	736	1145	1512	1944	2232	3272	3617
2007	48	170	350	615	1053	1514	1786	2073	2198	2408
2008	27	179	382	595	868	1295	1828	2201	2340	2568
2009	29	139	442	687	882	1141	1495	1920	2574	3070
2010	32	150	392	773	942	1190	1468	1829	2086	2730
2011	35	175	442	757	1129	1304	1583	1865	2107	3094
2012	28	202	482	801	1145	1480	1909	2072	2353	2350
2013	33	201	589	967	1312	1710	1999	2265	2764	2709
2014	36	222	570	1005	1372	1751	2141	2298	2653	3104
2015	36	193	528	1013	1500	1860	2201	2530	2656	2934
2016	36	190	478	961	1508	1978	2295	2579	2839	2936

Table 10.1.6 Haddock in division Va Weight at age in the catches. Predicted values are shaded.

Year/Age	2	3	4	5	6	7	8	9	10
1979	620	960	1410	2030	2910	3800	4560	4720	4000
1980	837	831	1306	2207	2738	3188	3843	4506	4615
1981	584	693	1081	1656	2283	3214	3409	4046	4898
1982	289	959	1455	1674	2351	3031	3481	3874	3952
1983	320	1006	1496	1921	2371	2873	3678	4265	4463
1984	691	1007	1544	2120	2514	3027	2940	3906	3941
1985	652	1125	1811	2260	2924	3547	3733	4039	4564
1986	336	1227	1780	2431	2771	3689	3820	4258	4436
1987	452	1064	1692	2408	3000	3565	4215	4502	3653
1988	362	780	1474	2217	2931	3529	3781	4467	4169
1989	323	857	1185	1996	2893	4066	3866	4734	5039
1990	269	700	1054	1562	2364	3414	4134	4946	4115
1991	288	699	979	1412	1887	2674	3135	4341	5243
1992	313	806	1167	1524	1950	2357	3075	4053	4674
1993	303	705	1333	1875	2386	2996	3059	3363	4047
1994	337	668	1019	1717	2391	2717	3280	3156	3154
1995	351	746	1096	1318	2044	2893	3049	3675	3119
1996	311	787	1187	1560	1849	2670	3510	3567	3686
1997	379	764	1163	1649	1943	2342	3020	3337	3508
1998	445	724	1147	1683	2250	2475	2834	3333	3275
1999	555	908	1101	1658	2216	2659	2928	3209	3534
2000	495	978	1333	1481	2119	2696	3307	3597	3734
2001	541	945	1456	1731	1832	2243	3020	3328	4715
2002	564	928	1253	1737	2219	2230	2911	3365	4078
2003	498	922	1283	1704	2274	2744	2635	2819	3289
2004	559	1006	1258	1579	2044	2809	3123	2945	3957
2005	339	886	1265	1506	1916	2323	3028	3211	2755
2006	402	749	1093	1495	1758	2163	2555	3054	3617
2007	510	748	988	1346	1840	2062	2350	2525	2408
2008	383	636	857	1125	1575	2149	2417	2802	2568
2009	452	841	960	1131	1352	1757	2364	2497	3070
2010	447	756	1092	1294	1448	1685	2188	2366	2657
2011	588	905	1122	1455	1688	1914	2094	2455	2919
2012	668	978	1222	1492	1903	2164	2366	2704	2765
2013	678	1084	1358	1675	2036	2400	2554	3097	3111
2014	508	966	1420	1755	2072	2376	2493	2749	3059
2015	462	917	1428	1865	2159	2422	2662	2752	2944

Table 10.1.7 Haddock in division Va Sexual maturity at age in the stock. (from the March survey). Predicted values are shaded. The numbers for age 10 do only apply to the spawning stock.

Year/Age	2	3	4	5	6	7	8	9	10
1979	0.08	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1
1980	0.08	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1
1981	0.08	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1
1982	0.08	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1
1983	0.08	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1
1984	0.08	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1
1985	0.016	0.144	0.536	0.577	0.765	0.766	0.961	0.934	1
1986	0.021	0.205	0.413	0.673	0.845	0.884	0.952	0.986	1
1987	0.022	0.137	0.426	0.535	0.778	0.776	1	0.969	1
1988	0.013	0.221	0.394	0.767	0.793	0.928	0.914	1	1
1989	0.041	0.202	0.532	0.727	0.818	0.998	1	1	1
1990	0.114	0.334	0.634	0.814	0.843	0.918	0.882	1	1
1991	0.063	0.224	0.592	0.739	0.817	0.894	0.495	1	1
1992	0.05	0.227	0.419	0.799	0.901	0.901	0.858	1	1
1993	0.124	0.362	0.481	0.67	0.904	0.977	0.908	0.867	1
1994	0.248	0.312	0.573	0.762	0.846	1	0.907	1	1
1995	0.124	0.479	0.382	0.75	0.753	0.606	0.985	1	1
1996	0.191	0.362	0.59	0.648	0.787	0.739	0.949	0.908	1
1997	0.093	0.436	0.587	0.683	0.75	0.783	0.88	1	1
1998	0.026	0.454	0.668	0.77	0.733	0.849	0.899	1	1
1999	0.05	0.397	0.683	0.724	0.749	0.892	0.761	0.92	1
2000	0.107	0.261	0.632	0.808	0.868	0.873	1	0.78	1
2001	0.091	0.377	0.522	0.753	0.895	0.916	0.918	1	1
2002	0.047	0.286	0.633	0.8	0.934	0.928	1	1	1
2003	0.062	0.347	0.685	0.867	0.922	0.946	1	1	1
2004	0.037	0.361	0.57	0.831	0.91	1	1	1	1
2005	0.024	0.23	0.562	0.753	0.927	0.936	0.968	1	1
2006	0.027	0.117	0.462	0.621	0.739	0.918	1	1	1
2007	0.078	0.208	0.418	0.68	0.77	0.875	0.959	1	1
2008	0.027	0.263	0.418	0.621	0.828	0.87	0.904	0.975	1
2009	0.017	0.301	0.47	0.576	0.847	0.891	1	0.968	1
2010	0.029	0.187	0.618	0.778	0.787	0.887	0.934	1	0.958
2011	0.045	0.176	0.426	0.823	0.816	0.838	0.899	0.974	1
2012	0.106	0.167	0.445	0.627	0.819	0.903	0.852	0.911	1
2013	0.046	0.223	0.381	0.714	0.793	0.92	0.986	0.974	0.992
2014	0.107	0.192	0.391	0.567	0.675	0.735	0.925	0.906	0.883
2015	0.072	0.356	0.662	0.807	0.864	0.898	0.92	0.927	1
2016	0.07	0.313	0.638	0.809	0.878	0.905	0.923	0.935	1

Table 10.2.1 Haddock in division Va. Summary table from the SPALY run using the surveys in March and October for tuning.

Year	Recruitment thousand at age 2	Biomass 3+ tons	SSB tons	Landings tons	Yield/SSB	F4-7
1979	80923	162177	96072	55330	0.576	0.521
1980	37390	192244	116521	51110	0.439	0.398
1981	10426	206988	141628	63558	0.449	0.542
1982	42788	180380	136817	69428	0.507	0.444
1983	29306	148112	112589	65942	0.586	0.508
1984	20574	112797	82961	48282	0.582	0.515
1985	42788	102394	66652	51102	0.767	0.537
1986	86501	96480	59837	48859	0.817	0.739
1987	164036	105395	46298	40760	0.88	0.584
1988	48742	153708	69391	54204	0.781	0.675
1989	29778	168184	99537	62885	0.632	0.676
1990	27094	145507	110745	67198	0.607	0.611
1991	92280	122708	89825	54692	0.609	0.664
1992	175094	106310	66379	47121	0.71	0.728
1993	38437	130461	71000	48123	0.678	0.669
1994	46842	127836	83295	59502	0.714	0.641
1995	72857	124042	85054	60884	0.716	0.661
1996	36341	108036	70008	56890	0.813	0.675
1997	102509	87152	58993	43764	0.742	0.624
1998	17976	97121	64203	41192	0.642	0.627
1999	50160	91024	64439	45411	0.705	0.685
2000	117423	90674	63509	42105	0.663	0.636
2001	156535	115046	70366	39654	0.564	0.462
2002	187000	168427	99342	50498	0.508	0.461
2003	49785	219667	147483	60883	0.413	0.404
2004	151630	252404	181124	84828	0.468	0.491
2005	384931	258542	176694	97225	0.55	0.523
2006	89274	298522	143151	97614	0.682	0.581
2007	42306	296738	162179	109966	0.678	0.562
2008	44372	248756	157874	102872	0.652	0.486
2009	119181	191722	141798	82045	0.579	0.501
2010	34603	166939	113030	64168	0.568	0.475
2011	26398	149052	95986	49433	0.515	0.413
2012	18470	136183	91008	46208	0.508	0.349
2013	27105	125196	92144	44097	0.479	0.363
2014	26979	104057	66792			
Mean79-2013	75801	155305	99853	59527	0.619	0.55

Table 10.2.2 Haddock in division Va. Number in stock from the SPALY run using both the surveys. Shaded cells are input to prediction. . Predictions shown are based on HCR.

Year/Age	1	2	3	4	5	6	7	8	9	10
1979	45.7	80.9	117.3	27.7	19.6	20.44	3.41	0.77	0.15	0.05
1980	12.7	37.4	66.1	94.3	19.3	10.54	8.57	1.21	0.23	0.07
1981	52.3	10.4	30.1	52.9	66.8	11.91	5.19	3.64	0.5	0.11
1982	35.8	42.8	8.5	24.2	38.9	39.42	4.33	1.69	1.35	0.26
1983	25.1	29.3	34.9	6.8	16.9	21.99	19.56	1.67	0.48	0.45
1984	52.3	20.6	24	27.7	4.1	9.7	9.09	8.02	0.68	0.21
1985	105.7	42.8	16.6	18.6	18.2	2.14	3.63	4.06	2.88	0.34
1986	200.3	86.5	33.8	12.1	11.1	8.75	0.98	1.45	1.59	0.63
1987	59.5	164	69.9	23.9	6.2	4.88	2.51	0.35	0.46	0.49
1988	36.4	48.7	132.6	49.7	13.2	2.59	2.15	1.07	0.17	0.23
1989	33.1	29.8	39.7	99.6	27	5.58	0.94	0.78	0.32	0.08
1990	112.7	27.1	24.2	30.3	61.1	13.43	1.68	0.31	0.14	0.13
1991	213.9	92.3	20.5	17.6	17	28.7	5.27	0.63	0.12	0.05
1992	47	175.1	67.8	14.8	9.6	7.25	10.74	1.92	0.21	0.06
1993	57.2	38.4	138.5	45.8	7	3.65	2.59	4.08	0.67	0.07
1994	89	46.8	30.8	102.2	25.9	3.03	1.43	0.83	1.31	0.23
1995	44.4	72.9	35.5	22.2	58.1	11.54	1.15	0.52	0.36	0.49
1996	125.2	36.3	56	22.4	12.9	25.93	4.23	0.38	0.16	0.13
1997	22	102.5	27	36.3	11.4	6.56	9.56	1.34	0.13	0.06
1998	61.3	18	82.7	18.5	19.9	4.93	3.01	3.27	0.45	0.05
1999	143.4	50.2	14.5	60.2	10	9.15	1.85	1.18	0.96	0.13
2000	191.2	117.4	39.8	10.4	33.7	4.12	3.11	0.69	0.4	0.35
2001	228.4	156.5	93.7	26.9	6.4	15.28	1.61	1.01	0.27	0.13
2002	60.8	187	125.9	66.7	15.7	3.95	6.85	0.71	0.39	0.12
2003	185.2	49.8	152.1	93.6	40.1	8.23	2.21	2.76	0.34	0.17
2004	470.2	151.6	40.4	118.8	61.9	21.5	4.05	1.13	1.14	0.2
2005	109	384.9	122.7	29.4	81.3	33.19	9.58	1.56	0.5	0.49
2006	51.7	89.3	313	91.9	17.8	43.56	14.71	3.7	0.55	0.18
2007	54.2	42.3	72.9	247.2	56	8.56	18.61	5.17	1.05	0.16
2008	145.6	44.4	33.9	56.1	164.2	25.74	3.97	6.23	1.75	0.39
2009	42.3	119.2	34.2	23.7	37.2	86.42	11.11	1.7	2.36	0.7
2010	32.2	34.6	96.6	25.1	15	22.4	39.08	3.91	0.73	0.68
2011	22.6	26.4	28.2	73.6	14.2	7.92	12.22	16.16	1.51	0.28
2012	33.1	18.5	21.4	21.7	49.6	7.03	3.9	6.4	7.6	0.79
2013	33	27.1	14.9	16.3	14.7	28.76	3.74	2.08	3	3.81
2014	30.9	27	22	11.3	10.8	8.37	15.21	1.97	1.1	1.32
2015	65.2	25.3	21.8	16	7.2	6.2	4.51	7.79	0.99	0.54
2016	65.2	53.4	20.6	16.1	10.2	4.06	3.33	2.32	3.87	0.49

Table 10.2.3 Haddock in division Va. Fishing mortality from the SPALY run using the March and October surveys for tuning. Predictions based on F4-7 = 0.3 are highlighted.

Year/Age	2	3	4	5	6	7	8	9	10
1979	0.002	0.018	0.162	0.419	0.669	0.833	0.99	0.553	0
1980	0.018	0.023	0.144	0.282	0.508	0.657	0.685	0.561	0.724
1981	0.001	0.019	0.108	0.328	0.813	0.92	0.793	0.463	0.569
1982	0.003	0.032	0.156	0.369	0.501	0.751	1.056	0.903	1.288
1983	0.001	0.032	0.301	0.357	0.683	0.692	0.706	0.643	1.051
1984	0.013	0.051	0.22	0.449	0.784	0.607	0.825	0.493	0.369
1985	0.035	0.122	0.315	0.532	0.582	0.719	0.737	1.314	1.184
1986	0.013	0.148	0.467	0.625	1.048	0.816	0.937	0.976	0.918
1987	0.013	0.141	0.389	0.669	0.62	0.657	0.53	0.5	0.685
1988	0.005	0.086	0.411	0.665	0.811	0.815	0.998	0.557	0.557
1989	0.007	0.071	0.288	0.498	1.003	0.917	1.552	0.682	0.632
1990	0.079	0.117	0.379	0.556	0.736	0.772	0.769	0.794	0.467
1991	0.109	0.123	0.413	0.651	0.783	0.811	0.89	0.473	0.25
1992	0.035	0.192	0.555	0.762	0.827	0.768	0.858	0.973	0.204
1993	0.022	0.104	0.37	0.635	0.736	0.934	0.933	0.842	0.383
1994	0.078	0.128	0.365	0.608	0.769	0.821	0.643	0.786	0.575
1995	0.063	0.259	0.337	0.607	0.804	0.895	0.971	0.856	0.926
1996	0.099	0.233	0.473	0.48	0.798	0.95	0.912	0.79	0.756
1997	0.015	0.176	0.404	0.641	0.579	0.873	0.9	0.819	0.253
1998	0.017	0.117	0.413	0.575	0.781	0.738	1.025	1.041	0.53
1999	0.032	0.126	0.38	0.689	0.878	0.792	0.87	0.806	0.776
2000	0.025	0.193	0.286	0.591	0.737	0.93	0.74	0.933	0.807
2001	0.018	0.14	0.337	0.286	0.603	0.62	0.745	0.568	0.44
2002	0.006	0.096	0.308	0.445	0.381	0.71	0.523	0.65	0.468
2003	0.009	0.047	0.213	0.424	0.508	0.469	0.685	0.345	0.383
2004	0.012	0.118	0.179	0.424	0.609	0.753	0.616	0.645	0.71
2005	0.007	0.089	0.302	0.424	0.614	0.753	0.849	0.809	0.653
2006	0.003	0.036	0.295	0.532	0.65	0.846	1.056	1.057	0.829
2007	0.021	0.061	0.209	0.578	0.567	0.894	0.882	0.787	0.58
2008	0.059	0.159	0.212	0.442	0.64	0.649	0.771	0.723	0.636
2009	0.01	0.109	0.259	0.307	0.594	0.844	0.639	1.041	0.987
2010	0.004	0.071	0.372	0.438	0.406	0.683	0.754	0.761	1.1
2011	0.011	0.064	0.195	0.503	0.508	0.447	0.554	0.45	0.581
2012	0.012	0.071	0.192	0.345	0.43	0.429	0.559	0.49	0.414
2013	0.01	0.08	0.216	0.36	0.437	0.44	0.438	0.617	0.505
2014	0.013	0.116	0.255	0.351	0.417	0.469	0.489	0.514	0.514
2015	0.005	0.101	0.251	0.367	0.421	0.464	0.501	0.501	0.501
2016	0.005	0.088	0.239	0.375	0.444	0.484	0.51	0.51	0.51

Table 10.4.1 Output from short term predictions. Numbers here apply to calendar years.

The adopted HCR lead to TAC of 30.4 kt for the fishing year 2014/2015 and landings of 29.0 thous. tonnes in the calendar year 2015.

2014				
Bio 3+	SSB	Fmult	F4-7	Landings
104	67	1.022	0.371	35

		2015			2016	
Fmult	F4-7	Bio 3+	SSB	Landings	Bio 3+	SSB
0.1	0.036	89	71	3	103	83
0.2	0.073	89	71	7	100	80
0.3	0.109	89	71	10	97	78
0.4	0.145	89	71	13	94	75
0.5	0.182	89	71	15	91	73
0.6	0.218	89	71	18	89	70
0.7	0.254	89	71	21	86	68
0.8	0.291	89	71	23	84	66
0.9	0.327	89	71	26	82	64
1	0.363	89	71	28	79	62
1.1	0.4	89	71	31	77	60
1.2	0.436	89	71	33	75	58
1.3	0.472	89	71	35	73	56
1.4	0.509	89	71	37	71	55
1.5	0.545	89	71	39	69	53
1.6	0.582	89	71	41	67	51
1.7	0.618	89	71	43	66	50
1.8	0.654	89	71	44	64	48
1.9	0.691	89	71	46	62	47
2	0.727	89	71	48	61	46

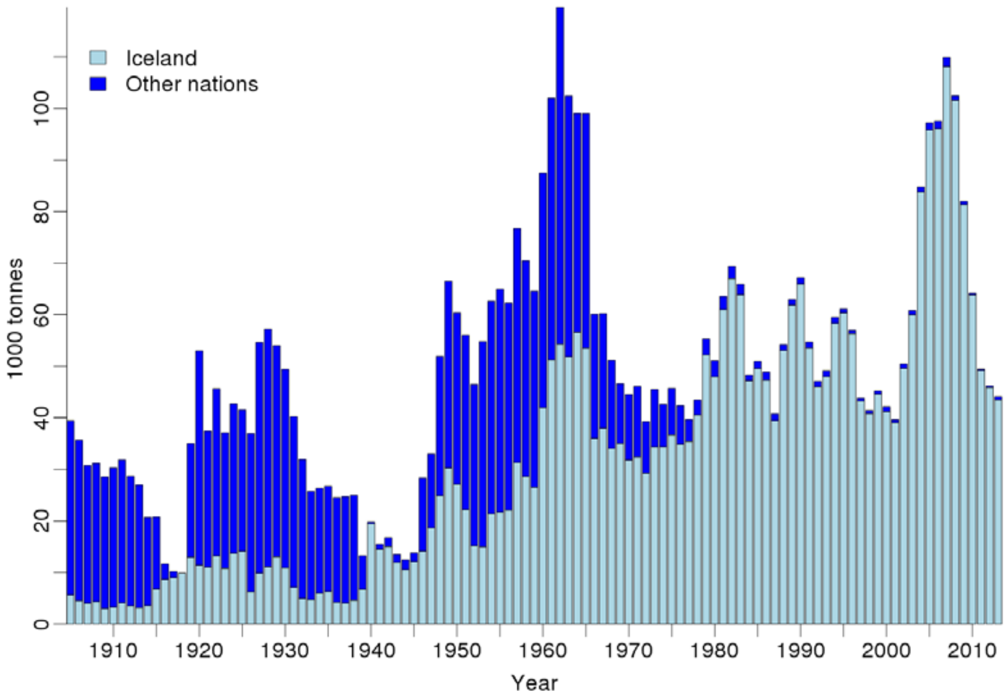


Figure 10.1.1 Haddock in division Va. Landings 1905 – 2013

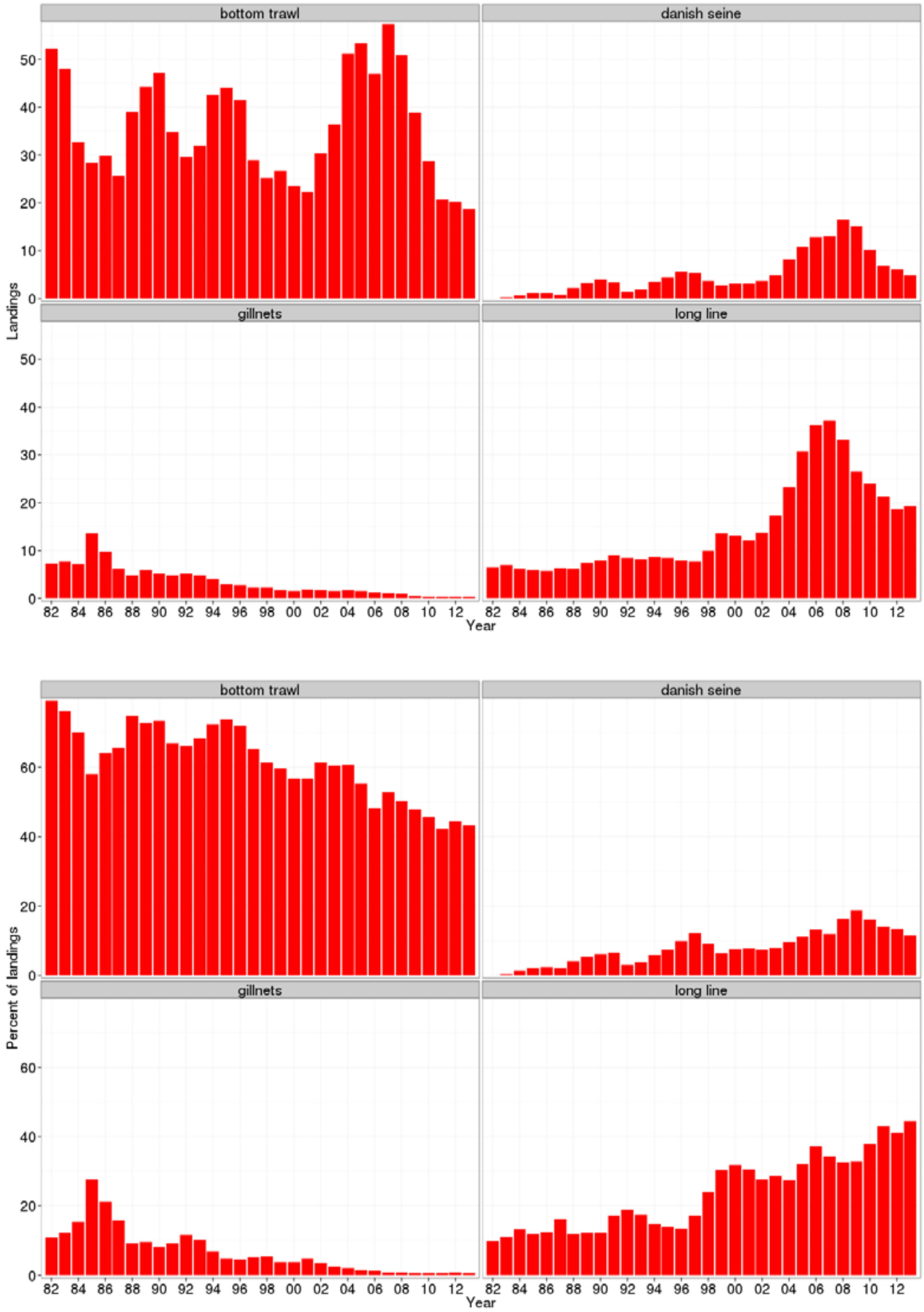


Figure 10.1.2 Haddock Division VA. Landings in tons and percent of total by gear and year.

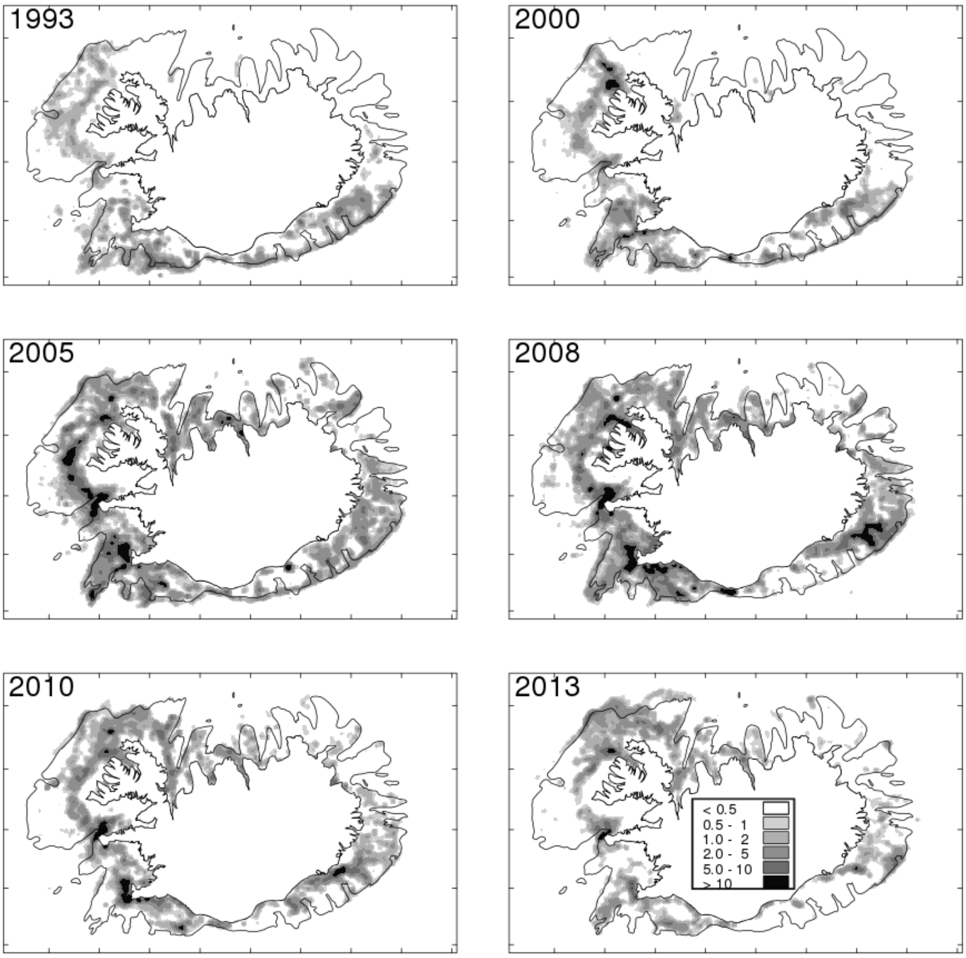


Figure 10.1.3 Haddock Division VA. Spatial distribution af landings. The legend show tonnes per square mile.

Figure 10.1.4 Haddock in division Va. Age disaggregated catch in numbers.

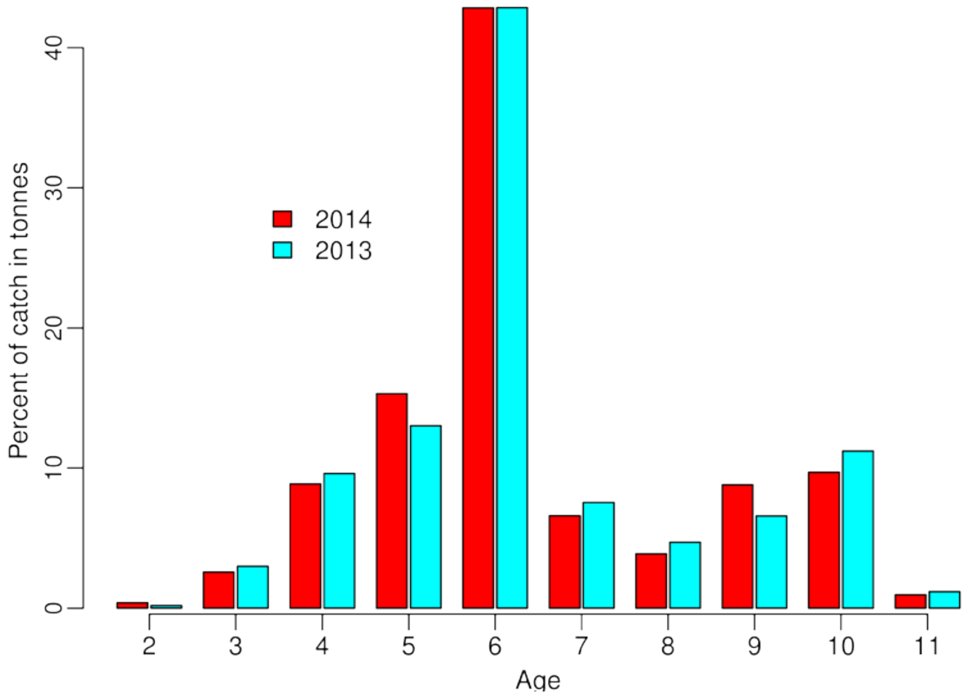


Figure 10.1.5 Haddock in division Va. Percent of catch in tonnes 2013 compared to last years predictions.

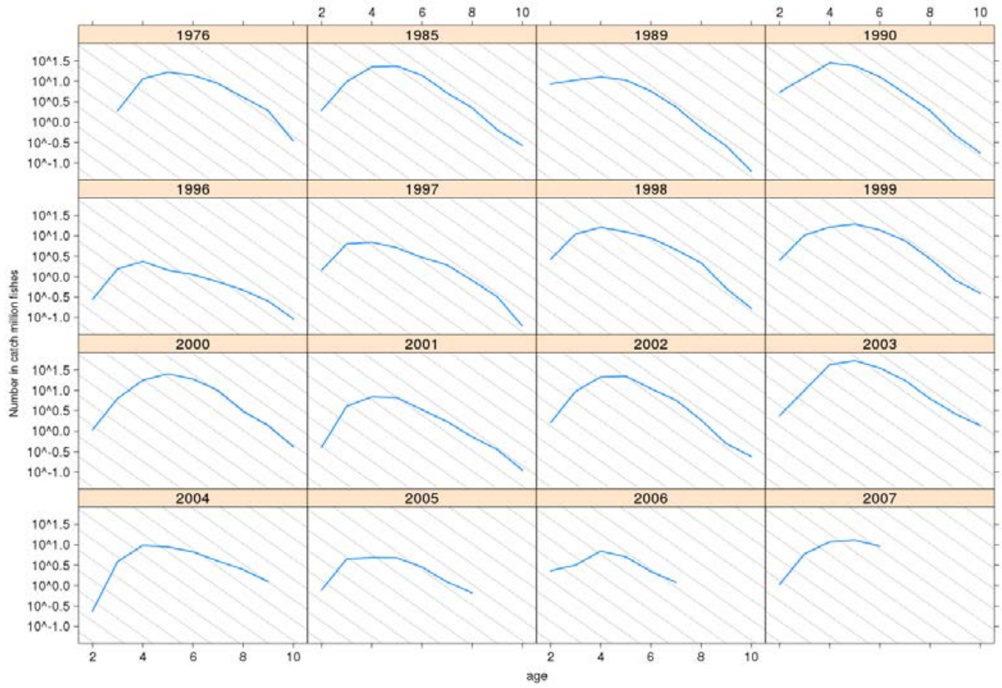


Figure 10.1.6. Haddock in division Va. Age disaggregated catch in numbers plotted on log scale. The grey lines show Z = 1.

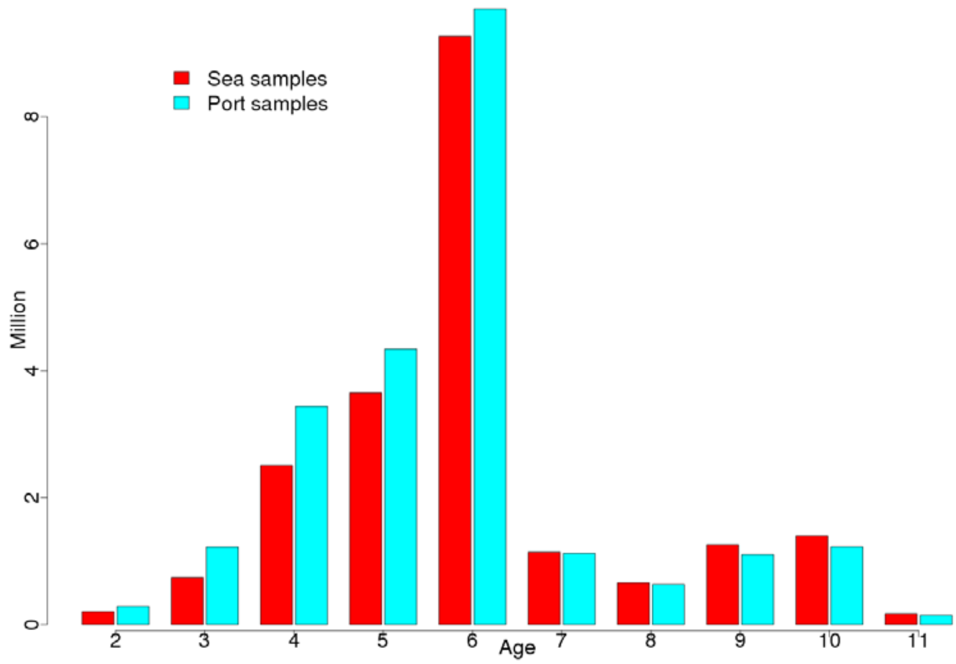


Figure 10.1.7 Comparison of catch in numers in 2013 based on port samples and shore samples.

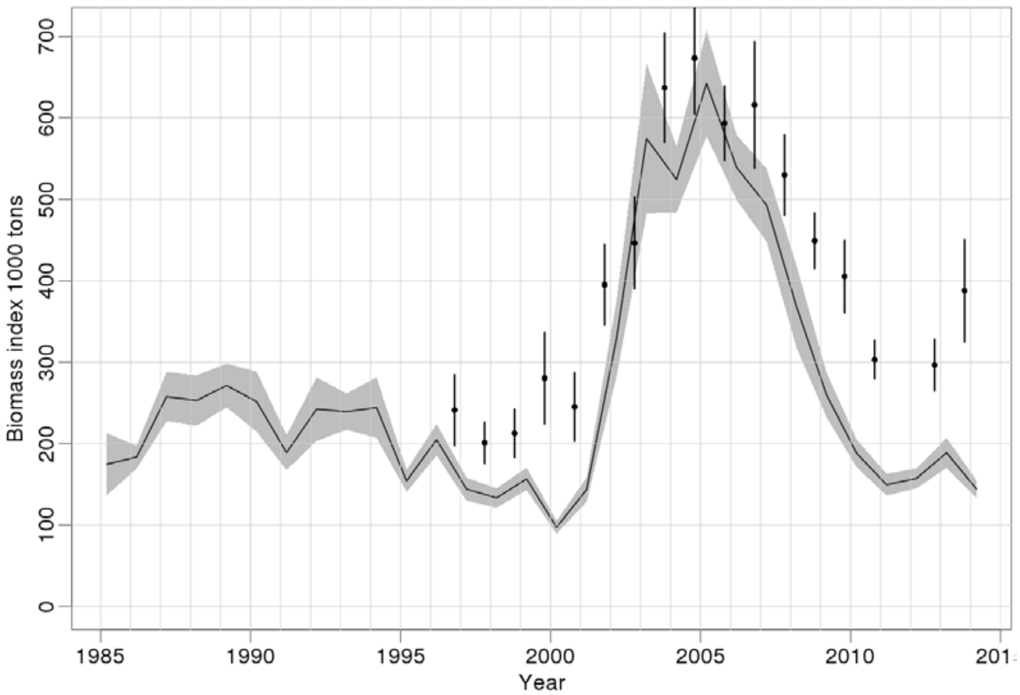


Figure 10.1.8 Icelandic haddock. Total biomass indices from the groundfish surveys in March (lines and shading) and the groundfish survey in October vertical segments. The standard error in the estimate of the indices is shown in the figure. Due to a strike the autumn survey was not conducted in October 2011.

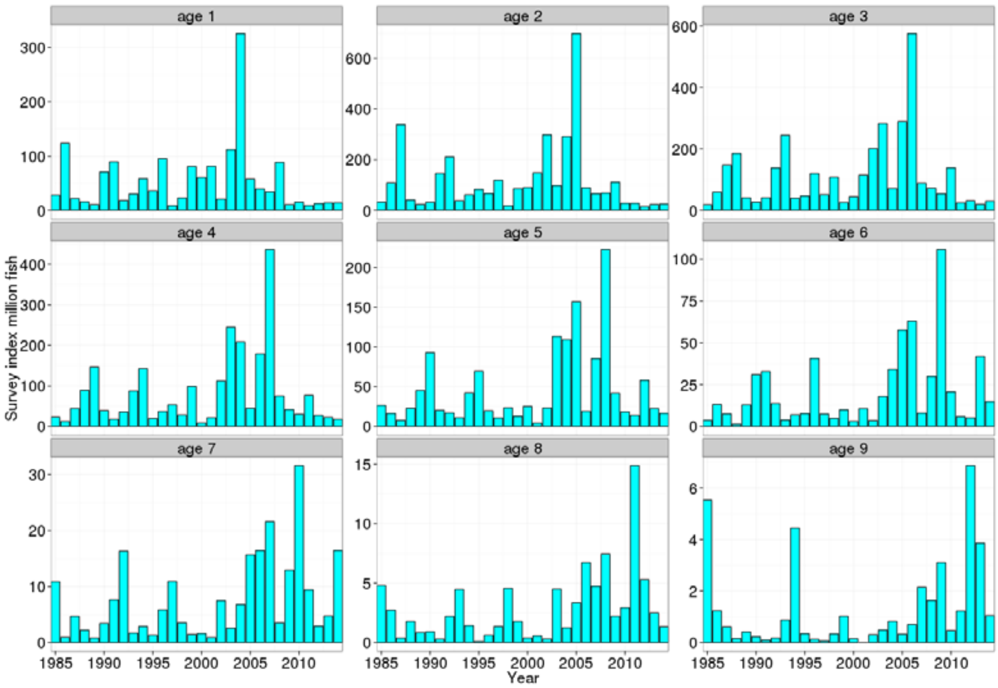


Figure 10.1.9. Age disaggregated indices from the groundfish survey in March.

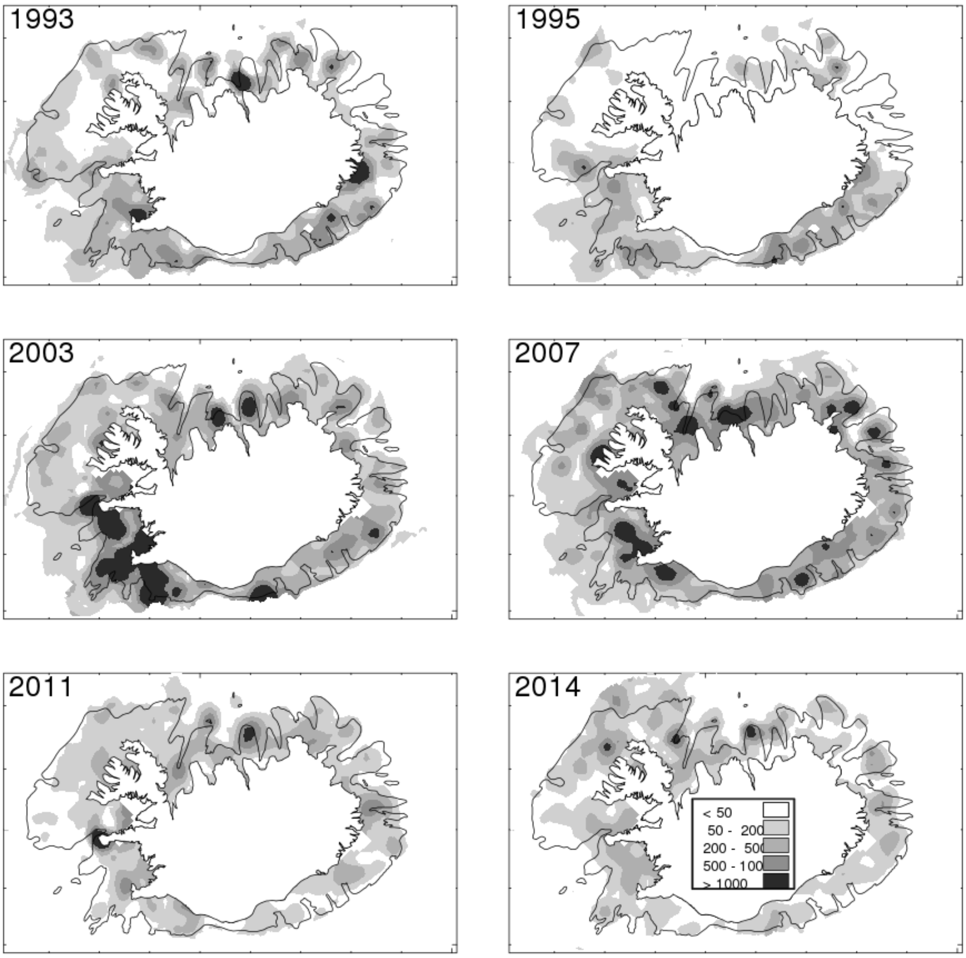


*Figure 10.1.10. Spatial distribution of haddock in the groundfish survey in March. The legend show kg per hour towed.

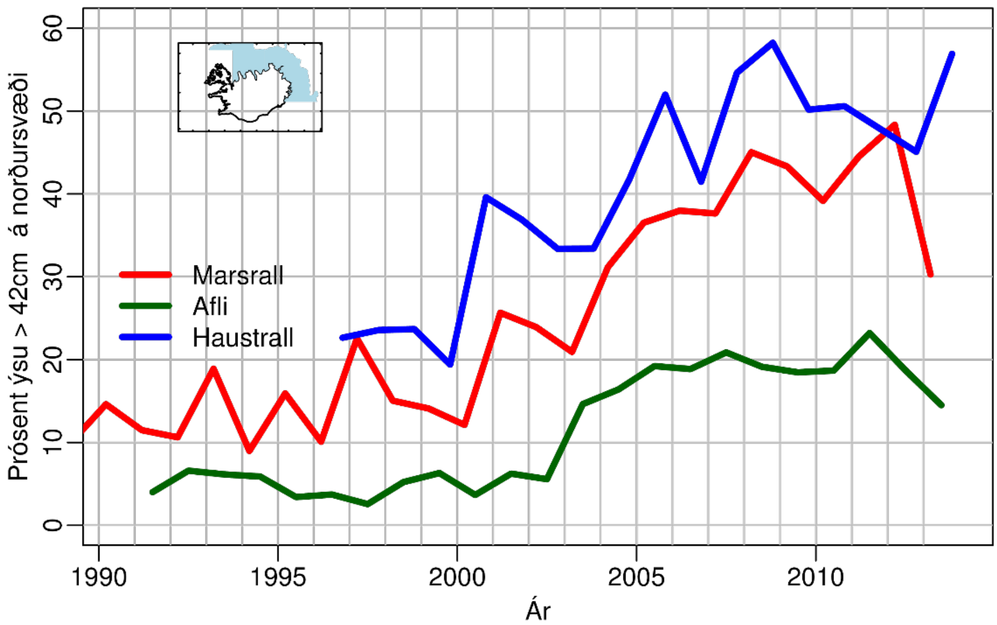


Figure 10.1.11. Proportion of the landings and the biomass of 42cm and larger haddock that is in the north area. The small figure shows the northern area.

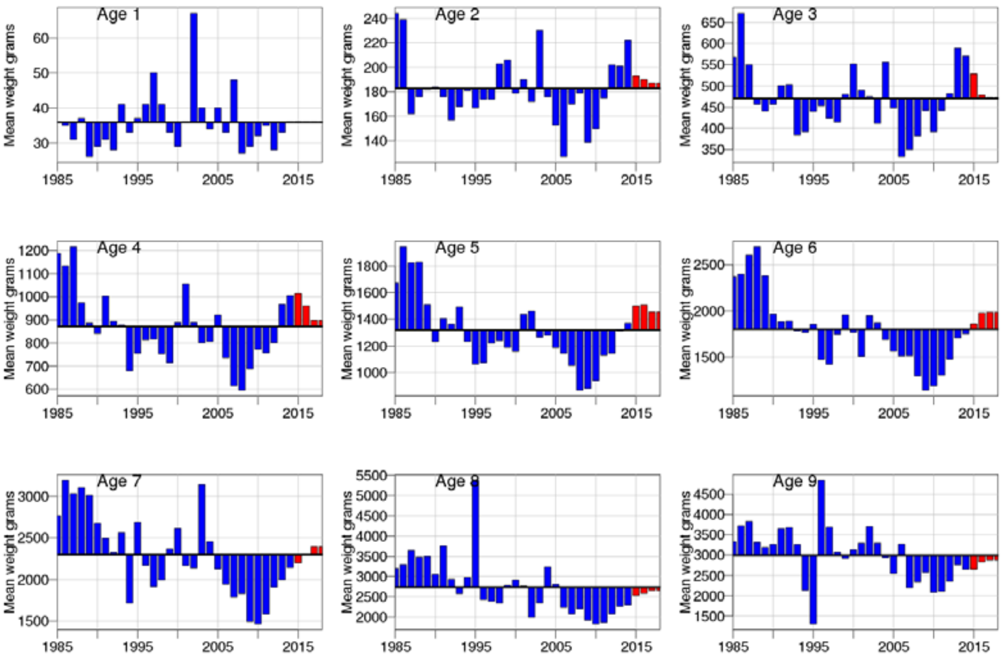


Figure 10.1.12 Haddock in division Va. Mean weight at age in the survey. Predictions are shown as red. The values shown are used as weight at age in the stock and spawning stock.

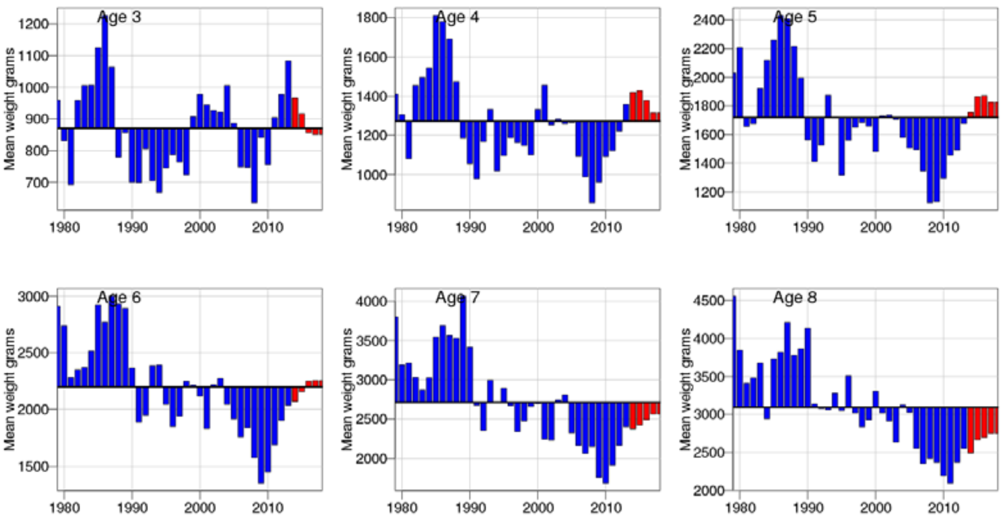


Figure 10.1.13 Haddock in division Va. Mean weight at age in the catches. Perdictions are shown as red.

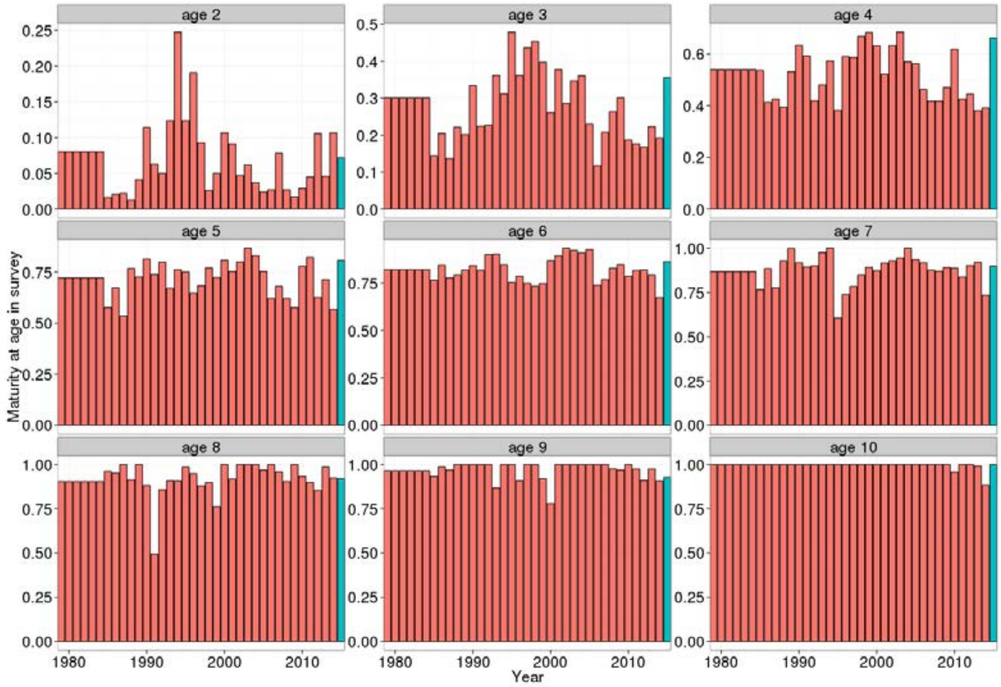


Figure 10.1.14 Haddock in division Va. Maturity at age in the survey. The blue bar indicates predictions. The values are used to calculate the spawning stock.

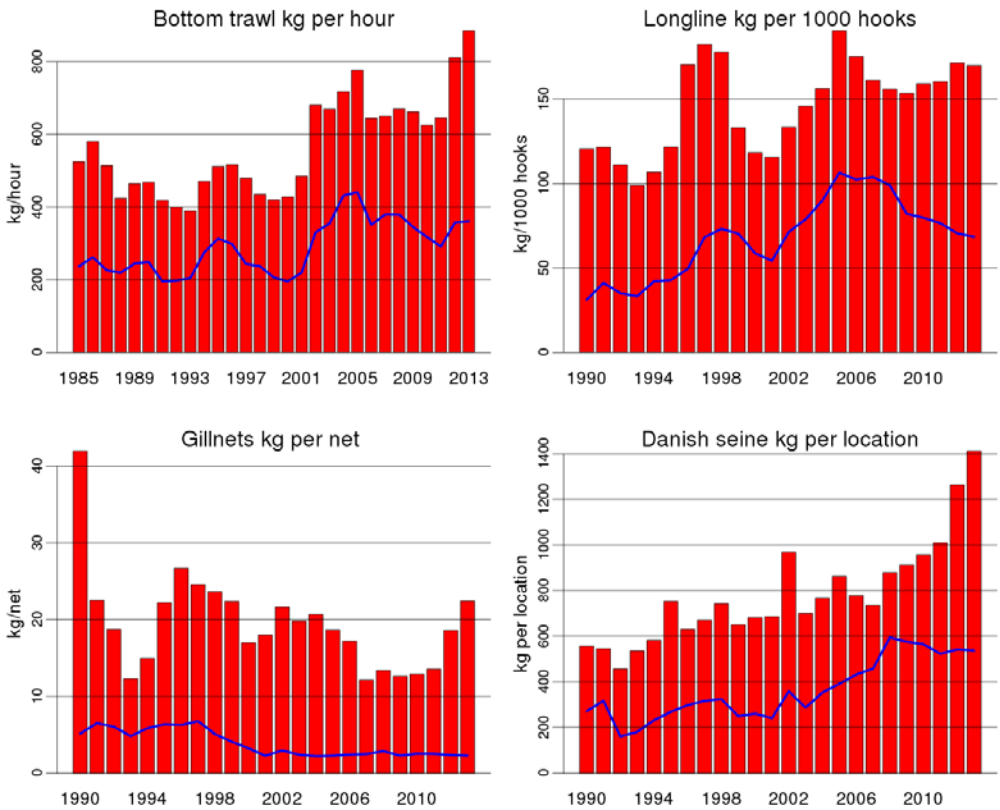


Figure 10.1.15. Catch per unit effort in the most important gear types. The bars are based on locations where more than 50% of the catch is haddock and the lines on all records where haddock is caught. A change occurred in the longline fleet starting September 1999. Earlier only vessels larger than 10 BRT were required to return logbooks but later all vessels were required to return logbooks. Not updated

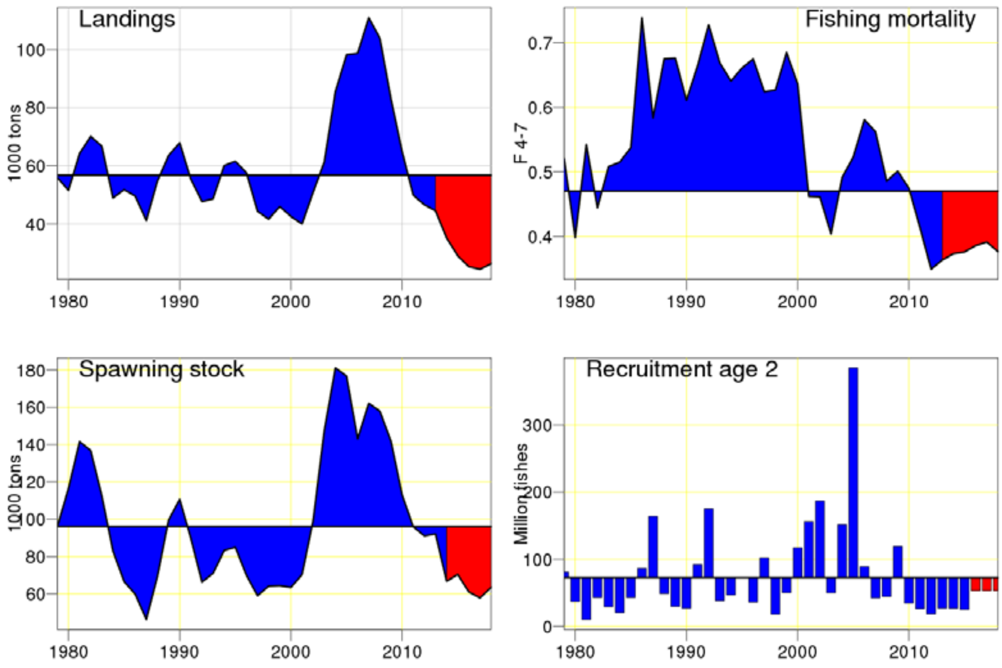


Figure 10.2.1 Haddock in division Va. Summary from assessment. Red colours in lower figure indicates predicted values.

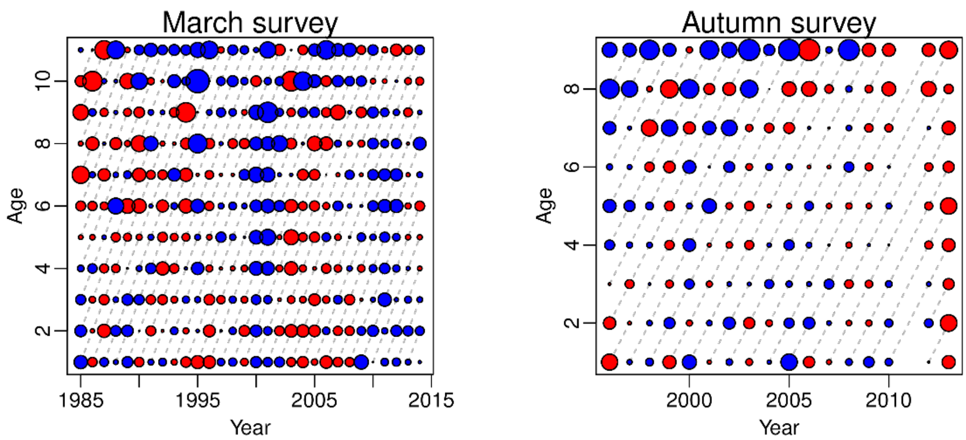


Figure 10.2.2. Haddock in division Va. Residuals from the fit to survey data . from Adapt run based on the both the surveys. Coloured circles indicate positive residuals (observed > modelled). The largest circle corresponds to a value of 0.87. Residuals are proportional to the area of the circles. Lage efri harvest ratio

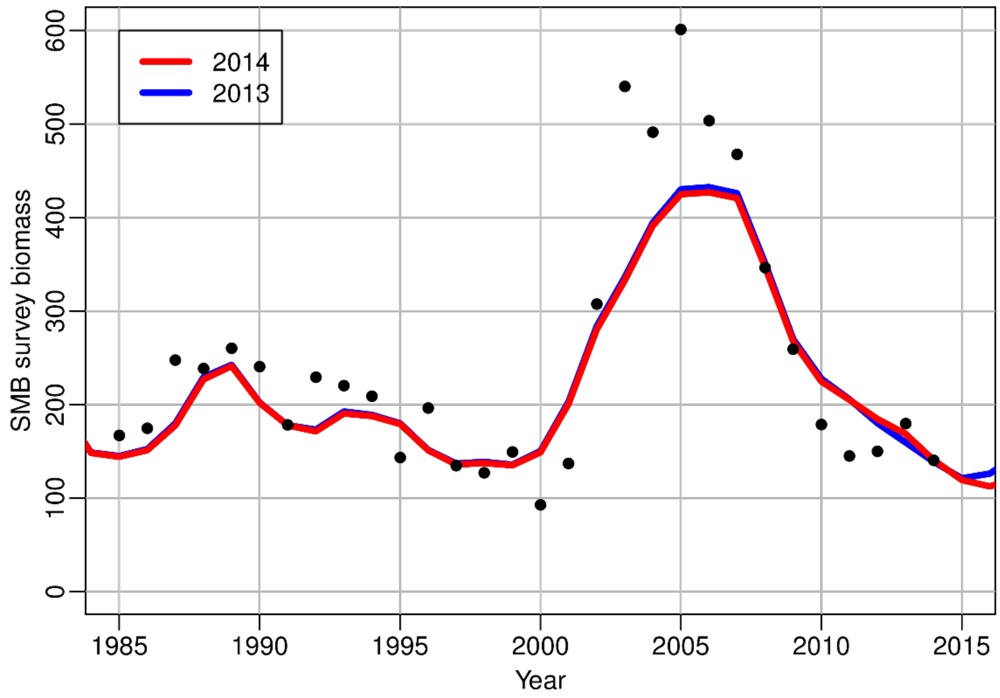


Figure 10.2.3. Haddock in division Va. Observed and predicted biomass from the surveys according to the SPALY run.

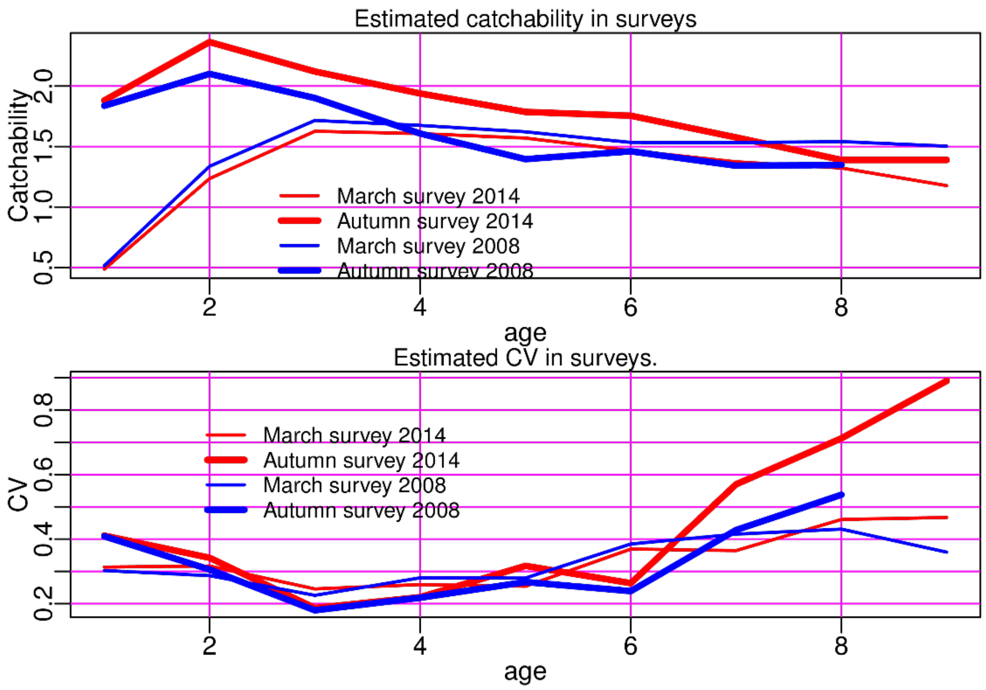


Figure 10.2.4. Haddock in division Va . Results from the spaly run. Catchability and CV from the autumn survey (wide lines) and March survey (thinner lines). Estimates from 2008 shown dashed.

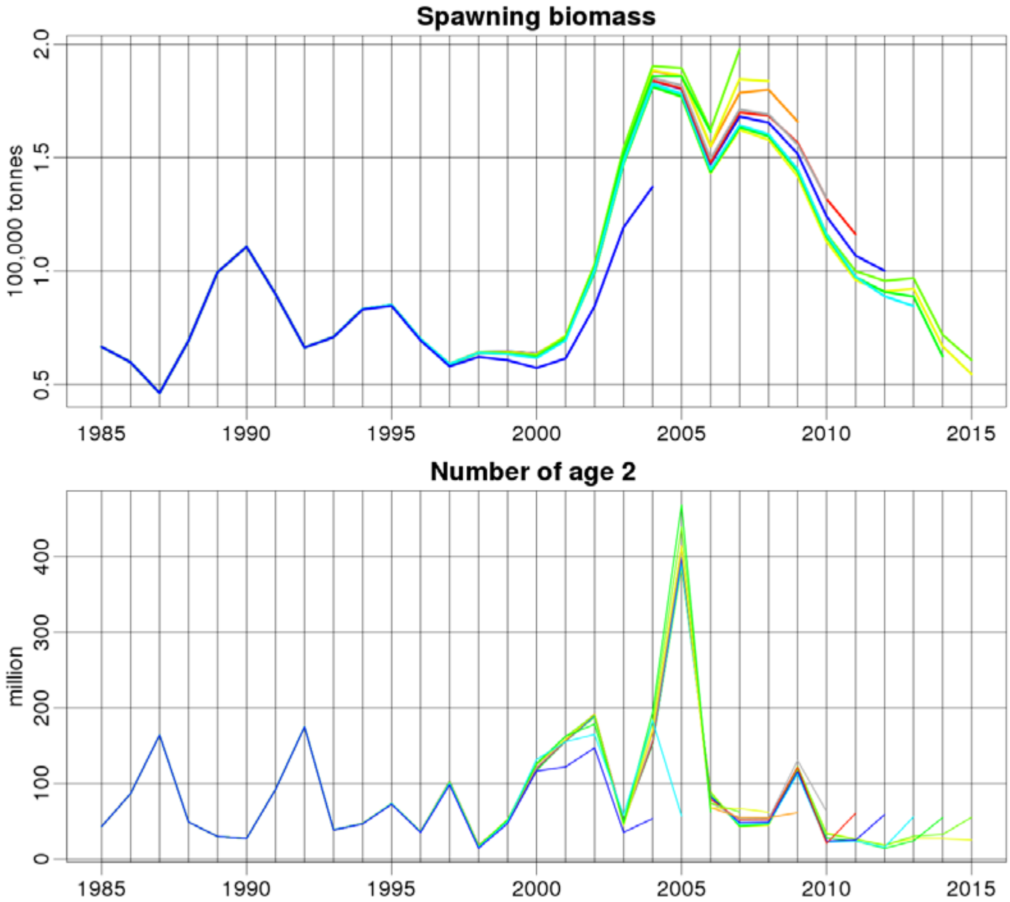
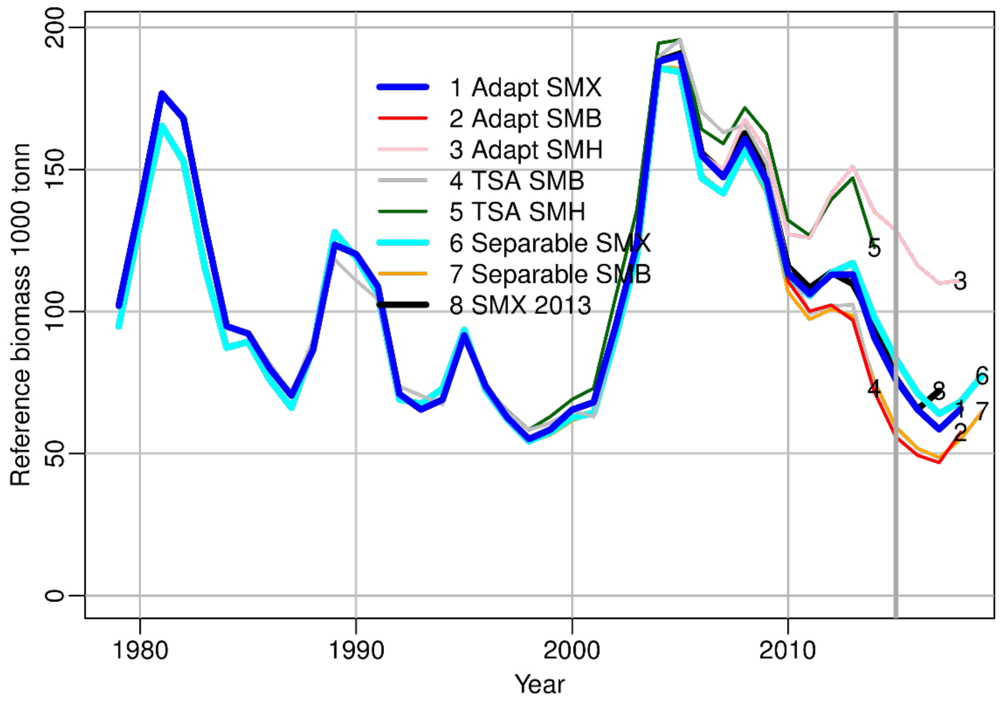
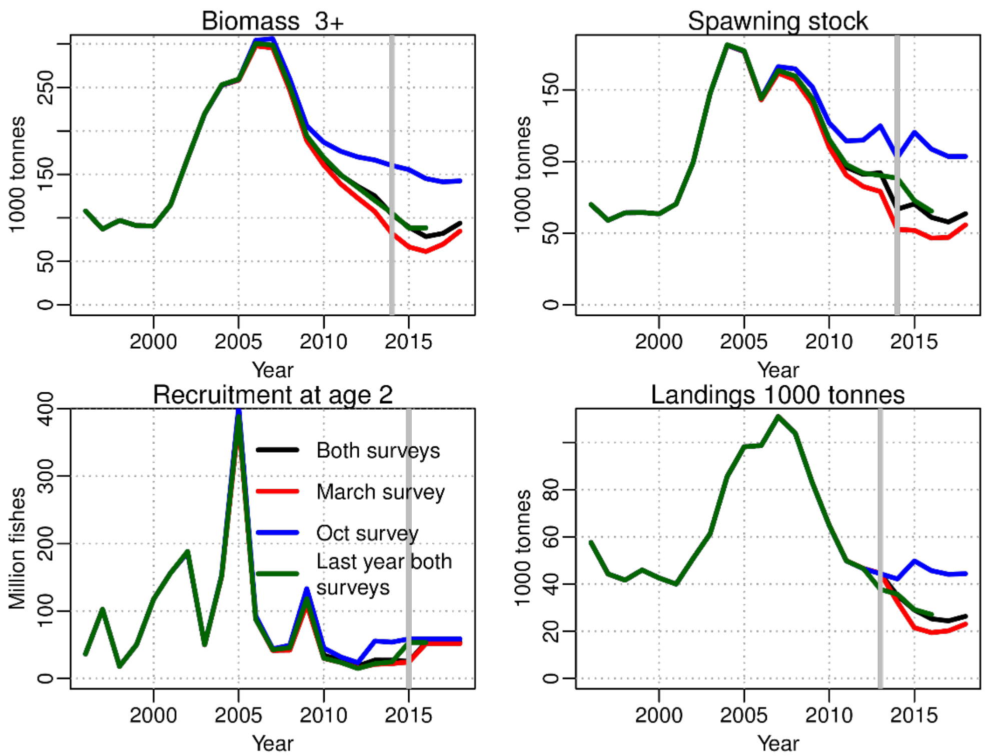


Figure 10.2.5. Haddock in division Va . Retrospective pattern from the SPALY run. The biomass values indicate biomass 1 or 2 years after the assessment year. Errors in prediction of weight and maturity at age are not included.



10.2..6 Haddock in division Va. Estimate of the reference biomass 45cm and larger from some different assessment models and tuning data. (SMB refers to March survey, SMH autumn survey and SMX both.



10.2..7 Haddock in division Va. Comparison of some of the results of 2014 assesement based on different tuning data and 2013 assessment tuned with both the surveys. .

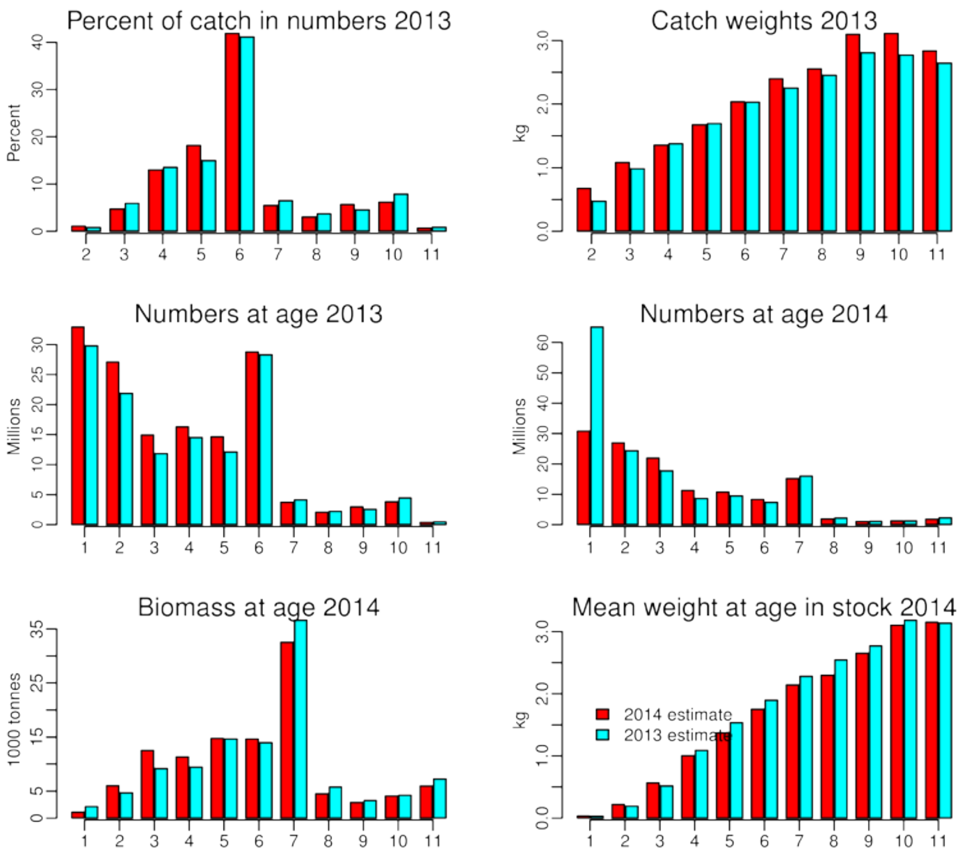


Figure 10.2.8. Comparison of 2013 and 2014 assessment

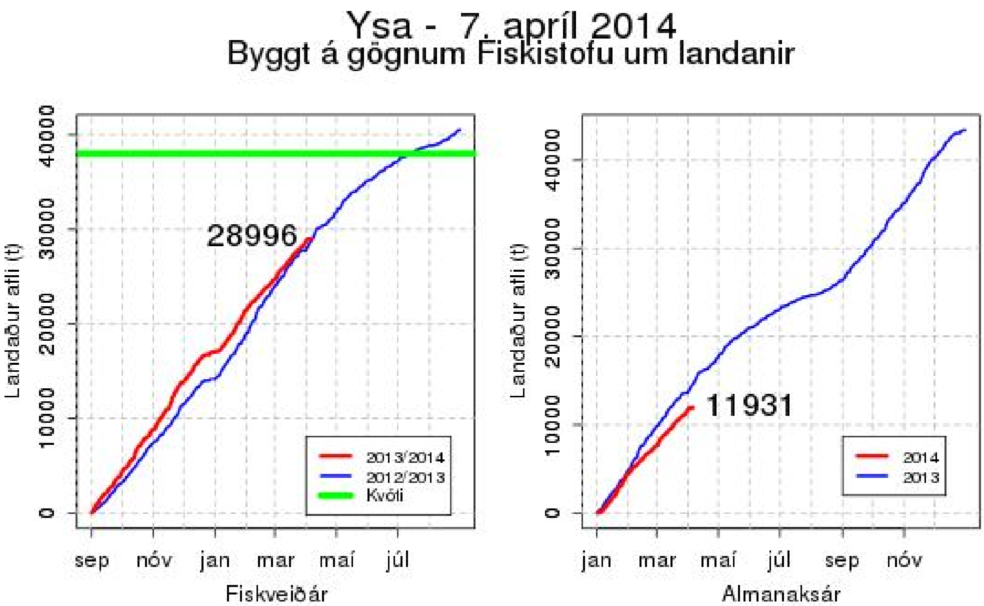


Figure 10.4.1 Haddock in division Va. Development of the landings during the fishing year 2013/2014 (left side) and calendar year (2014) on the left. Fishing year 2012/2013 and calendar year 2013 shown for comparison. Tac (kvóti) for the fishing year shown in the left figure.

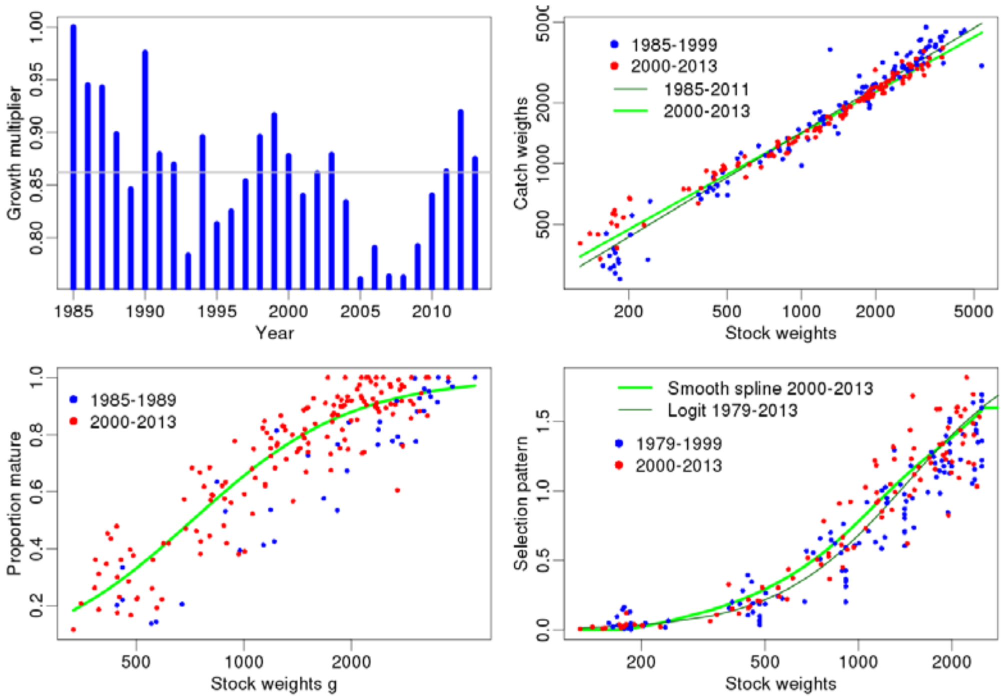


Figure 10.4.2 Haddock in division Va. Input data to prediction. Predictions are based on the period since 2000. . Exponential of the yearfactor (growth multiplier) in the equation

$$\log \frac{W_{a+1,t+1}}{W_{a,t}} = \alpha + \beta \log W_{a,t} + \delta_{year}$$

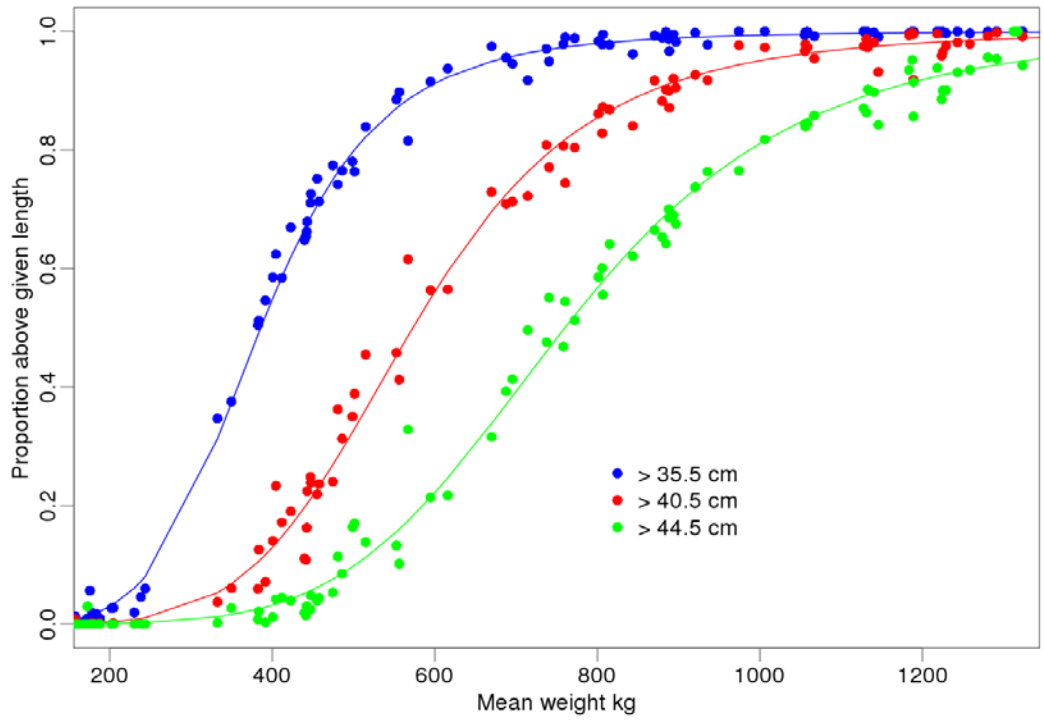


Figure 10.4.3 Haddock in division Va. Proportion of the biomass of a yearclass above certain size. The points show data, compiled from the March survey and the lines a curve fitted to the data and used in simulations.

11 Icelandic summer spawning herring

11.1 Executive summary

Input data

- The total reported landings in 2013/14 fishing season were 72 kt but the TAC was set at 87 kt.
- Around 45 kt of the catch was taken in a relatively small area in Breiðafjörður in W Iceland, or 62% of the catch which is less proportion than in the six five preceding fishing seasons.
- The fishable stock (age 4+) in the herring acoustic surveys in the winter 2013/14 was estimated at 410 kt, compare to 428 kt in the winter 2012/13. The mass mortality in last winter, where 52 kt died, took place in between the surveys.
- Acoustic measurements indicated that the year classes from 2008 and 2009 where numerous off the south coast –but less observed in Breiðafjörður, where older herring was found.
- *Ichthyophonus* infection was observed in the fishable stock (age 4+) the sixth winter in row and amounted to prevalence of 30-35% in the three most infected year classes, which is a comparable level to recent years. It is not considerer to cause significant additional mortality in the stock.
- The juvenile herring survey indicates that the 2012 year class (age 1 in 2012) may be just below average size.

Assessment

- This is an update assessment where the 2013 data have been added to the input data and no revisions of last year's data, except that the estimated number of fish that diet in the mass mortality in last winter was added to the catch matrix from 2012.
- The final analytical assessment model, NFT-Adapt, indicate that the biomass of age 3+ is 560 kt and SSB is 430 kt at the spawning time in 2014.

Predictions

- Fishing at $\mathbf{F}_{0.1}$= 0.22 in the fishing season 2014/15 will give a catch of 83 thousands tons. SSB in 2015 is expected to be 420 kt.

Comments

- This years researches on the *Ichthyophonus* infection supports the conclusions made last year that it is not causing additional mortality in the stock and increased natural mortality should only be applied for the first two years of the outburst.
- General description of the stock's definition, the stock's life-history and the management unit is given in the Stock Annex (Her-Vasu), which was accepted during WKBENCH in Portugal in January 2011 (ICES 2011a) and updated in May 2014.

11.2 Scientific data

11.2.1 Surveys description

The scientific data used for assessment of the Icelandic summer-spawning herring stock are based on annual acoustic surveys (IS-Her-Aco-4Q/1Q)., which have been ongoing since 1974 (Table 11.1.1.1). These surveys have been conducted in October-December or January. The surveyed area each year is decided on basis of available information on the distribution of the stock in previous and the current year, which include information from the fishery. Thus, the survey area varies spatially as the survey is focused on the adult and incoming year classes but is considered to cover the whole stock each year.

The acoustic abundance index for the adult stock in the winter 2013/2014 derives from number of dedicated acoustic surveys in the autumn 2013 and winter 2014 (Table 11.1.1.2). During 29 October to 6 December, RV Bjarni Sæmundsson covered areas south- and southeast off Iceland, and 31 March to 1 April west off Iceland. The acoustic index for Breiðafjörður, which has been the main over wintering areas of the stock in last eight winters, was then derived from total six measurements in four surveys (Óskarsson and Reynisson 2014).

Like last five winters, but different from subsequent years, the nursery grounds of the stock were covered on RV Dröfn in a survey during November 4-18, as well as in January west of Iceland. The objective was to get an acoustic estimate of juveniles and estimate their prevalence of *Ichthyophonus* infection (see Óskarsson and Pálsson 2014).

The instrument and methods in the surveys were the same as in previous years and described in the stock annex.

11.2.2 The surveys results

Herring was observed in three main areas, in Kolgrafafjörður in Breiðafjörður, in Kolluáll west off Iceland and Breiðamerkurdjup off SE Iceland. Since the winter 2006/07, the highest abundance has been observed in the southern part of the bay Breiðafjörður (Fig. 11.1.2.1), however, that changed this winter. The total amount of the adult stock (age 4+) in Breiðafjörður came only to 66 kt, while in Kolluáll on the shelf outside of Breiðafjörður, 200 kt were measured in March. Then, like in recent years, around 200 kt were measured in Breiðamerkurdjúp. The total estimate of the adult stock (age 4+) was therefore 410 kt, compare to 428 kt in the autumn 2012. The total biomass was 473 kt in comparison to 589 kt in the autumn 2012. It must be noted that around 52 kt was estimated to have diet in a moss mortality in Kolgrafafjörður between these two acoustic measurements (in December 2012 and February 2013; Óskarsson et al. 2013).

Figure 11.1.2.2 shows the total estimated biomass of age 3+ in the acoustic survey since 1973, how the eastern part of the stock generally decreased in size and the western part increased during around 1995-2007, and then the opposite from 2007-2013.

The 2008 year class (age 5 in the autumn 2013) was the most numerous in the survey or 20% of the total number of herring and was observed both off the south and west coast of Iceland (Table 11.1.1.1). The 2010 year class was also numerous (18%), and was mostly in off the southeast coast (Breiðamerkudjúp). The 2009 and 2007 year class contributed then to 13% and 9%, respectively.

The number of juvenile herring (i.e. age 1) observed acoustically in the November survey northwest and north of Iceland and in January west off Iceland (Table 11.1.1.2) amounted to 468 million fish. Half of the estimated derived from Hvammsfjörður west of Iceland, while the rest was measured in Ísafjarðardjúp and Eyjafjörður. Applying the linear-regression provided by Gudmundsdottir *et al.* (2007) implied that the 2012 year class will be 526 millions at age 3 in 2015, or just below average year class size (575 millions at age 3). This number is used in the forecast in the 2014 assessment below.

The length composition of the adult part of the stock in the acoustic estimation in 2013/14 was based on total 45 samples, 37 taken in Breiðafjörður and 8 taken in other areas (total 3082 herring; Table 11.1.2.1). The age composition was then derived from length-at-age key from the same samples. The total number of aged scales from these samples was 2552.

11.2.3 Prevalence of *Ichthyophonus* infection in the stock

In a working document to NWWG 2013, Óskarsson and Pálsson (2013) addressed the development and nature of the massive and long-lasting *Ichthyophonus hoferi* outbreak in Icelandic summer-spawning herring since the autumn 2008 to 2013. Their main conclusions were that the infection was only causing significant additional mortality in the first two years, despite a high prevalence of infection for five years. It indicated that the infection to be less lethal for herring than had been assumed in previous assessments. This was followed in the 2013 assessment (ICES 2013a), where additional natural mortality because of the infection, and estimated from catch samples (e.g. Óskarsson et al. 2012a; ICES. 2012), was only be applied for the years 2009 and 2010, but not the following years.

The results of this year's investigations are supporting this main conclusion of not significant infection mortality since 2010.

The prevalence of infection in the Icelandic summer-spawning herring in the winter 2013/2014 in Breiðafjörður and Kolluáll was highest for the 2006, 2005 and 2004 year classes (Figure 11.1.3.1). This is comparable to results in recent years where the prevalence of infection has been in the range of 35-55% (Figure 11.1.3.2). The prevalence of infection of the younger age groups continues to be low, suggesting a low rate, if any, of new infection in the stock. For the yearclasses 2006 and older, the prevalence of infection seems to be going slowly down.

11.3 Information from the fishing industry

The total landings of Icelandic summer-spawning herring in 2013/2014 season were about 72 kt with no discards reported (Table 11.2.1 and in Figure 11.2.1). Note that the total landings include also bycatches in the mackerel fishery in June-August 2013, even if they belong to the official fishing season 2012/2013. This is a traditional method in assessment of the stock. The quality of the herring landing data regarding discards and misreporting is consider to be adequate as implied in a general summary in section 7 and in the Her-Vasu stock annex. The recommended TAC, provided in the spring 2013, was 87 kt and allowable TAC 87 kt.

The direct fishery started in end of October in Breiðafjörður. Most of the catches were taken there in October and November in purse seines, or 62% of the total catch (Fig. 11.2.2). In December, however, the fleet were fishing in Breiðamerkurdjúp because the herring in Breiðafjörður was inaccessible by the fleet as it stayed in the inner part of Kolgrafafjörður where the mass mortality took place in the winter 2012/2013 (Óskarsson et al. 2013). Around 24% of the catch was taken in Breiðamerkurdjúp in December-February. By-catch of Icelandic summer-spawners in the summer fishery for the Norwegian spring-spawning herring, NSSH, and Atlantic mackerel amounted then to 11% of the catch. This winter, drift nets were used in this fishery for the third time since mid 1980s. It was because of allocation of catch quota to small fishing vessels (<200 bt) that were allowed to catch some limited catches. The total catch in drift nets amounted to 767 tons.

Like in the autumn/winter fishing seasons of 2004/05, 2005/06 and 2006/07, NSSH was found to be mixed with the Icelandic summer-spawning herring stock in the catches in the winter 2013/2014 in Breiðamerkurdjúp. Based on maturity stage of the herring in catch samples, 1.8% of the herring there belonged to NSSH. This finding was further supported by collection of two tags there from herring tagged in Norway. This part of the NSSH, maybe around 300 t, was included in the ISSH catch matrix (Table 11.2.2.2). This will be explored further in the coming months.

11.3.1 Fleets and fishing grounds

The herring fishing season has taken minor changes in the last three decades as detailed in the stock annex. All seasonal restricted landings, catches and recommended TACs since 1984 are given in thousands tonnes (kt) in Table 11.2.1.

Around 84% of the catch in 2013/14 was taken with purse-seines, around 15% with pelagic trawls, and around 1% by drift nets (Figure 11.2.1.1). During all fishing seasons since 2007/2008, most of the catches (~90%) have been taken west off Iceland in Breiðafjörður, while prior to that they were mainly taken off the south-, southeast-, and the east coast. In 2013/2014 there were apparently some changes in this pattern where only 60% of the catch was taken in Breiðafjörður.

To protect juveniles herring (27 cm and smaller) in the fishery, area closures are enforced based on a regulation of the herring fishery set by the Icelandic Ministry of Fisheries (no. 376, 8. Oktober 1992). One closure was enforced in this herring fishery in 2013/14 off the south coast in Fjallasjór (Fig. 11.1.2.1). Normally, the age of first recruitment to the fishery is age-3, which is fish at length around 26-29 cm.

11.3.2 Catch in numbers, weight at age and maturity

Catch at age in 2013/2014:

The procedure for the catch at age estimations, as described in the Stock Annex, was followed for the 2013/14 fishing season. It involves calculations from catch data collected at the harbours by the research personnel or at sea by fishermen (Table 11.2.2.1). This year, the calculations were accomplished by dividing the total catch into five cells confined by season and area as detailed in Óskarsson and Pálsson (2014). In the same way, five weight-at-length relationships derived from the length and weight measurements of the catch samples were used and two length-at-age relations (June-September and then October-March). The catches of the Icelandic summer spawners in number-at-age for this fishing season as well as back to 1982 are given in Table 11.2.2.2. The geographical location of the sampling is shown on Figure 11.2.2.1.

Weight at age:

As stated in the stock annex, the mean weight-at-age of the stock is derived from the catch samples (Table 11.2.2.3). The total number of fish weighed from the catch in 2013/14 was 2816 and 2548 of them were aged from their fish scales.

Proportion mature:

The fixed maturity ogives were used in this years assessment, as introduced in the stock annex, where proportion mature-at-age 3 is set 20% and 85% for fish at age 4, while all older fish is considered mature.

Observed versus predictions of catch composition:

The relative contribution of the different year (age) classes was different from what was predicted in the analytical assessment in 2013 (Figure 11.2.2.2). The 2008 and 2009 year classes contributed much less to the catches than predicted. This discrepancy is probably both related to imprecise estimation of the stock composition in the 2013 assessment and characteristic of the fishery where large herring in Breiðafjörður was targeted in October and November but smaller and younger herring in Breiðamerkurdjúp in December to February. The part of the stock that was first found towards the end of the fishing season in March in Kolluáll was obviously not targeted by the fleet, but acoustic measurements indicated that the herring there consisted to large degree of the 2008 year class (Óskarsson and Reynisson 2014). In other words, the 2008 year class was only to a small degree targeted by the fleet in the autumn/winter fishery. The relative contribution of the catches in the summer 2013 (June-September), when the herring was caught as bycatch in the mackerel fishery across the whole continental shelf, was, however, closer to the predicted contribution. Considering how widely distributed the summer fishery was, it is believed to provide the most reliable information about the age composition of the stock. Furthermore, it is also closest to the age composition in the stock as estimated in the acoustic measurements in 2013/2014 (Figure 11.2.2.2). All these information suggest that the relative size of the 2009 year class was probably overestimated in the 2013 assessment.

11.4 Analytical assessment

11.4.1 Analysis of input data

Examination of catch curves for the year classes from 1983 to 2010 (Figure 11.3.1.1) indicates, in general, that the total mortality signal (Z) in the fully recruited age groups is around 0.4. It is under the assumption that the effort has been the same the whole time. In recent years the effort has changed a lot because of the infection and spatial distribution of the stock, and the mass mortality in 2012/2013, which makes any strong deductions from the catch curves for those recent years meaningless.

Catch curves were also plotted using the age disaggregated survey indices for each year class from 1983-2010 (Figure 11.3.1.2). Even if the total mortalities look at bit noisy in general, they seem to be fairly close to 0.4. There is an indication that the fish is fully assessable to the survey at age 3, but apparently a year later occasionally.

Mortality in the stock because of the *Ichthyophonus* outbreak can not be detected clearly from the catch curves of the surveys. There is possibly a small change in level of the curve around 2009 for the big 1999 year classes. However, it should be noted that the highest prevalence of infection has been in the 2004, 2005 and 2006 year classes and they were not fully in the survey prior to the infection outbreak. Further work on this matter is ongoing.

The year class strength was evaluated independently from the analytical assessment, by sum the total catch of each year class (Figure 11.3.1.3). The 1999 year class is apparently the largest in the time series, but according to cumulative fishing of the year classes from 1978-1996 (Figure 11.3.1.4), around 99% can be expected to be already fished of that year class and 97% of the big year class from 2002.

11.4.2 Exploration of different assessment models

In order to explore the data this year, two assessments tools were used, NFT-ADAPT (VPA/ADPAT version 3.0.3 NOAA Fisheries Toolbox) and a new version of TSA (older version see Gudmundsson, G. 1994). However, due to technical problems, the results of the TSA were not available to the group. Anyway, the NFT-Adapt has been used as the basis for the assessments since 2005 and it was considered appropriate as the principal assessment tool for the stock at benchmark assessment in January 2011 (ICES 2011a). The catch data used were from 1987/88-2013/14 (Table 11.2.2.2) and survey data from 1987/88-2013/14 (Table 11.1.1.1). Other input data consisted of: (i) mean weight at age (Table 11.2.2.3); (ii) maturity ogive (Table 11.2.2.4); (iii) natural mortality, M, that was set to 0.1 for all age groups in all years, except for 2009, where it was set 0.49 because of the *Ichthyophonus* infection, and for 2010 where M was for same reasons age dependent (Table 11.3.2.1; Óskarsson and Pálsson 2013); (iv) proportion of M before spawning was set to 0.5; and (v) proportion of F before spawning was set to 0.

NFT-Adapt:

The estimated parameters in NFT Adapt are the stock in numbers at age. The parameters are output by the Levenburg-Marquardt Non-Linear Least Squares minimization algorithm (see VPA/ADAPT Version 2.0, Reference Manual). The estimated parameters were stock numbers for ages 4 to 12 in the end of year 2013, while the stock numbers at age 3 were set to the geometric mean from 1987-2009. Like in last years' assessments, the *input partial recruitment* was set to 1 for ages 4 and older and the *classic* method was used to calculate the value of fully-recruited fishing mortality in the terminal year.

The catchability at age in the survey, as estimated by the NFT Adapt, and the CV is shown in Figure 11.3.2.1. Instead of using age groups 3-9 (i.e. age in autumns) in the final Adapt run for tuning as was done in the assessments in 2006 to 2010, age groups 3-10 were used and with the years 1997 and 2001 in the tuning series also as presented in ICES (2011).

The output and model settings of the NFT-Adapt run (the adopted final assessment model; see below) are shown in Table 11.3.2.2. Stock numbers and fishing mortalities derived from the run are shown in Table 11.3.2.3 and Table 11.3.2.4, respectively, and summarized in Table 11.3.2.5 and Figure 11.3.2.2.

Residuals of the model fit are shown in Figure 11.3.2.3 and Table 11.3.2.6, and shows both cohort and year affects. Positive residuals, where the model estimates it smaller than seen in the survey, can be seen for 1994 and 1999 year classes for almost all age groups and a negative residuals for the 2001 year class. Year blocks of positive residuals are apparent for the years ~2000 to 2006 (i.e. referring to January 1st), indicating that the model estimated the age groups smaller than observed in the surveys. During these years, the stock was overwintering in offshore areas off the east and west coast, compare to mainly easterly distribution before and overwintering in inshore areas there after (from ~2006-2012). These positive blocks could therefore reflect changes in catchability of the survey for these years. Positive residuals, even if relatively weaker, were also observed for 2011 and 2012. A block of negative residuals was however observed for 2009 (survey in the autumn 2008).

Retrospective analysis (Figure 11.3.2.4) indicate a more stability in the most recent years than often before, i.e. adding new data to the model does not change the present perception of the stock size. The same applies correspondingly to the fishing mortality. Furthermore, to sustain the high M in the input data for 2009 and 2010 because of the infection, SSB of the most recent three years lifts in comparison to the preceding years. It required also an increase in recruitment estimates as apparent on the retrospective plots of number-at-age 3. The actual size of the incoming year classes (~2010-2012) is also not fully established as reflected on the retros. Note that the high F in 2012 (Figure 11.3.2.4) is due to the mass mortality, which was added to the catches that year in the assessment.

The main difference between observed and predicted survey values from the NFT-Adapt model was for the period 1999-2004, where the observed values were well above the predicted (Figure 11.3.2.5), otherwise they fitted relatively well. Like seen in the residual plot (Figure 11.3.2.3), the observed value for the 2008 survey was lower than predicted and the vice versa for the 2012 survey (referring to the beginning of the year; Figure 11.3.2.5). The low survey value in 2008 is likely underestimate due to distribution of the stock that year in Breiðafjörður (Óskarsson et al. 2010b), while the reason for the positive block during 2000-2004 is less known, but could reflect changes in the catchability of the survey as suggested above. However, an exploratory run in NFT-Adapt done in the 2011 assessment (ICES 2011b) where these years were excluded in the tuning, did not change the point estimate of the stock size in the latest year (January 1st 2011), implying that the terminal point estimates in the final run was not driven by this residual block.

Comparisons of model runs:

As pointed out above, no assessment results were available from TSA this year, thus only the final NFT-Adapt runs in 2013 and 2014 were compared with respect to recruitment, biomass, and N weighed average $F_{5\text{-}10}$ (Figure 11.3.2.2). The final NFT run in 2014 gave higher biomass for the years 2004-2011 than the final NFT run in 2013, which is probably related to the to the mass mortality that was added to the 2012 catches in the 2014 run. The 2014 run gave then lower estimate for the biomass in 2013 and more pessimistic view of the younger age groups than the 2013 run, especially the 2009 and 2010 year classes (Figure 11.3.2.6).

This is an update assessment so the results of the NFT-Adapt were adopted as point estimator for the prediction and thus the basis for the advice as in recent years.

11.4.3 Final assessment

The model settings and outputs of the adopted final model (NFT-Adapt run in 2014) are shown in Table 11.3.2.2 to Table 11.3.2.4 and Figure 11.3.2.2.

The assessment (Table 11.3.2.5 and Figure 11.3.2.2) indicates that the fishing mortality (weighed average for age 5-10) was high during 1987 to 2002 and fluctuated between 0.25 and 0.41, which is well above F_{pa}=0.22. Since then, F has declined and was only 0.07, 0.10 and 0.14 during 2009 to 2011, respectively. The low F then was related to cautious TAC and apparently overestimation of the mortality caused by the *Ichthyophonus* outburst.

As mention above, the estimated number of herring that died in Kolgrafafjörður in the two incidents of the mass mortalities there (Óskarsson et al. 2013) were added to the catches in 2012 in the NFT-Adapt run in 2014. However, the mass mortality is not included in F in Table 11.3.2.5 or Figure 11.3.2.2.

11.5 Reference points

Precautionary reference points:

The Working Group has pointed out that managing this stock at an exploitation rate at or above $\mathbf{F}_{0.1}$ has been successful in the past, despite biased assessments. Thus, as stated in the Stock Annex, the Northern Pelagic and Blue Whiting Fisheries Working Group agreed in 1998 with the SGPAFM on using $\mathbf{F}_{pa}$= $\mathbf{F}_{0.1}$= 0.22, $\mathbf{B}_{pa}$= $\mathbf{B}_{lim}$ * $e^{1.645\sigma}$= 300 000 t where $\mathbf{B}_{lim}$= 200 000 t. The Study Group on Precautionary Reference Points for Advice on Fishery Management met in February 2003 and concluded that it was not considered relevant to change the $\mathbf{B}_{lim}$ from 200 000 t. The WG have not dealt with this issue.

The fishing mortality during 1987 to 2008 was on average 0.31 (weighed F_{5-10}), or approximately 40% higher than the intended target of $F_{0.1}$=0.22. This is despite the fact that the managers have followed the scientific advice and restricted quotas with the aim of fishing at the intended target. During this period the SSB has remained above B_{lim} and reached a record high level around 2008.

MSY based reference points:

The MSY based reference points have not been set for Icelandic summer-spawning herring, but exploratory work was present at the NWWG meeting in 2011 in a form as requested by ICES (ICES 2011b). The HCS program Version 10.3 (Skagen, 2012) was used to evaluate possible points based on the MSY framework that could be a basis for a management plan and Harvest Control Rule later.

Number of different runs was made with varying settings. The results implied that the MSY framework was confirmative with the currently used precautionary reference points. It means that the currently used $F_{0.1}$=0.22 could be a valid candidate for F_{MSY}. This however, needs to be explored more thoroughly later.

11.6 State of the stock

The stock was at high levels until 2008 but since then a substantial reduction took place despite a low fishing mortality. The reduction is considered to be caused by mortality induced by *Ichthyophonus* infection in the stock in 2008 and 2009. However, the observed high prevalence of infection for all the years since then is not considered to be causing further mortality in the stock and the negative trend in the stock size has reversed due to incoming of year classes at near and above average size. Moreover, the stock size is presently well above B_{PA}.

11.7 Short term forecast

11.7.1 The input data

The final adopted model, NFT-Adapt, which gave the number-at-age on January 1st, 2014, was used for the prognosis. All input values for the prognosis are given in Table 11.6.1.1.

The weights were estimated from the last year catch weights (see Stock Annex) and as in the recent years, the weights are expected to continue to be high (Figure 11.6.1.1). The selection pattern used in the prognosis was based on averages over 2011 to 2013 from the final run (Figure 11.6.1.2) (see Stock Annex). As traditionally, M was set 0.1, proportion M before spawning was set 0.5 and proportion F before spawning was set 0. The numbers of recruits in the prognosis were determined as follows:

The 2011 year class: Taken from NFT-Adapt as number-at-age 3 in the beginning of 2014, or 634 millions. The acoustic measurements in the autumn 2013 indicated that it was only 47 millions at age 2, but that age group is normally poorly represented there. According to survey in 2012, it was predicted to be 186 millions at age 3 in 2014 (ICES 2013a).

The 2012 year class: An acoustic survey aimed for getting an abundance index for this year class took place in November 2013, and using a relation obtained by Gudmundsdóttir et al. (2007) provides estimate of 477 millions at age 3 in 2015.

The 2013 year class: No acoustic estimates are available for the year class yet thus the number-at-age 3 in 2016 was set to the geometrical mean for age-3 over 1987-2009, which give 606 millions.

11.7.2 Prognosis results

SSB and biomass of age 3+ are estimated to be 430 kt and 560 kt, respectively, in the beginning of the fishing season 2014/15 (approximately the same as at spawning in July 2014). The results of the short term prediction from the final NFT-Adapt run (Table 11.6.1.2) indicate that fishing at 0.22 (= $F_{0.1}$; the stock is managed at F=0.22~F_{MSY}) would correspond to TAC in 2014/2015 of 83 kt and SSB at the spawning season in 2015 would be 420 kt.

The proposed composition of the catch in the season 2014/15 consists mainly of the 2008 year class with 29%, 2009 year class with 22% and 2007 and 2010 year classes with 10% each (Figure 11.6.2.1). If the distribution of the stock and the fishery in Breiðafjörður will be similar in 2014/2015 as it was the winters before, as well as the age composition there consisting mainly of older part of the stock, it is considered highly unlikely that the composition of the catch becomes like proposed in the prognosis. However, because the herring that has overwintered off the south coast, and has not been targeted by the fishery in recent years, will be at fishable size in the next fishing season it might be targeted also.

11.8 Medium term predictions

Prognosis was made for the stock until the spawning season 2017 (Table 11.6.1.3) and the input data were the same as introduced above in section 11.6.1. The main features are that fishing at target F=0.22 will give relatively constant catches and the SSB will remain at similar size throughout the period.

11.9 Uncertainties in assessment and forecast

11.9.1 Assessment

There are several factors that could lead to uncertainty in the assessment. As introduced above (section 11.1.3), the approach in this year's assessment, and in last year, is different from the previous years in the sense that the mortality caused by the *Ichthyophonus* infection is observed to have taken place in only two years instead of all years since 2009. This new approach is considered to reduce the uncertainty in the assessment.

The 2009 year class was now appearing for the second time in the survey aimed at the adult part of the stock. The results of the 2013 survey implied that it was a smaller year class than the results of the 2012 survey, or 13% of the total number versus 31%, respectively. Thus, there is some uncertainty about it's actual size, also when considered that the 2013 survey was generally conducted under bad weather condition south off Iceland, the spatial coverage therefore minimal and possibly causing underestimation of abundance around Fjallasjór (Óskarsson and Reynisson 2014).

11.9.2 Forecast

The uncertainties mentioned above regarding the assessment apply also for the forecast, both regarding the mortality due to the *Ichthyophonus* infection and the size of the recruiting year classes (2007-2012).

The number-at-age 3 in the beginning of 2014 used in the prognosis was taken from NFT-Adapt run of 634 millions and represent geometric mean, as done in previous years. Acoustic measurements on that year class at age 1 and age 2, indicate however that it is weak, which introduce uncertainties to the forecast. Applying prediction of number at age 3 in 2014 of 186 millions from a survey in 2012 (ICES 2013a), instead of the geometric mean, resulted though only in 5 000 tons less TAC at F0.1=0.22 for the next fishing season (78 kt instead of 83 kt).

11.9.3 Assessment quality

In previous years there has been concerns regarding the assessment because of retrospective patterns of the models. No assessment was provided in the 2005 due to data and model problems and in the two next consecutive years, ACFM rejected the assessment due to the retrospective pattern. In the assessments in 2007-2009 there was observed an improvement in the pattern from NFT-Adapt, while in 2010-2011, a retrospective pattern appeared again which was both related to the high M because of the *Ichthyophonus* infection but also due to new and more optimistic information about incoming year classes to the fishable stock (particularly the 2008 year class) and fishing pattern in recent year. The retrospective pattern in the last and this year's assessment are less than seen for many years for SSB and F. That could be interpreted as an indication for improvements in the assessment quality in comparison to recent years.

11.10 Comparison with previous assessment and forecast

This year's assessment was conducted in the same way as in last year except that the mortality because of the mass mortality was added to the catches in 2012. Overall, this has limited impacts on the current perception of the stock size. In the current assessment, SSB in 2013 is 16% lower (411 kt versus 488 kt, when accounted for the mass mortality), size of the 2008 year class 35% lower (Figure 11.3.2.6), size of the 2009 year class 47% lower, size of the 2010 year class 35% lower, sum of older age groups 4% higher, and $WF_{5\text{-}10}$ in 2012 is the same (0.22 in both cases), compare to the 2013 assessment.

11.11 Management plans and evaluations

The practice has been to manage fisheries on this stock at $F = F_{0.1}$ (= 0.22 = F_{pa}) for more than 20 years. However, no formal management strategy has been adopted.

11.12 Management consideration

For the fishing seasons 2010/2011 and 2011/2012, a regulation was enforced that in practiced prohibited fishery for herring outside of the area of Breiðafjörður in SW Iceland. This was advised by the Marine Research Institute because of small herring mixed with adults in other areas and less prevalence of infection there. Because the herring over-wintering outside of Breiðafjörður will be at age 4+ in the next fishing season, such a regulation will not be advised for 2014/2015 by MRI.

It is unknown how long the current *Ichthyophonus* outbreak in the stock will be observed in the stock. Similar outbreaks in other herring stocks have lasted from 1 to 3 years. Analysis based on all available data show a significant infection mortality in 2009–2010. However, despite a high continuing prevalence of infection after that there are indications that the mortality due to infection was probably insignificant during 2011–2014.

11.13 Ecosystem considerations

The reason for the outbreak of *Ichthyophonus* infection in the herring stock that was first observed in the autumn 2008 is not known but is probably the effect of interaction between environmental factors and distribution of the stock (Óskarsson *et al.* 2009). It includes that outbreak of *Ichthyophonus* spores in the environment, which infect the herring via oral intake (Jones and Dawe 2002), could be linked to the observed increased temperature off the southwest coast. Further researches on the causes of such an outbreak are needed and how the herring get infected, i.e. through intake of free floating spores or through zooplankton that contain spores.

It is unknown how long the current *Ichthyophonus* outbreak in the stock will last and be observed in the stock. Similar outbreaks in other herring stock have lasted from 1-3 years (see Óskarsson and Pálsson 2009). There were some indications in the winter 2010/2011 that the outbreak was vanishing (Óskarsson and Pálsson 2011), and even stronger in the winter 2011/2012 (Óskarsson et al. 2012a). However, as mentioned in above (section 11.1.3) and by Óskarsson and Pálsson (2013) significant additional mortality happened only in the first two years, despite a high prevalence of infection for now six years. Thus, the infection that is still found in the stock (average prevalence of 15% for fish at age 3+; Óskarsson and Pálsson 2014) will decrease and disappear over some years as the fish gets older.

Another factor, which is related to behaviour and geographical distribution of the stock, needs also a consideration. That is the two mass mortalities, which took place in Kolgrafafjörður in the winter 2012/2013 (Óskarsson et al. 2013). These incidents were unexpected and particularly the first one. However, this has been an eye opener and similar incidents in the future there can not be disregarded. If this has something to do with a bridge and road constructions that is crossing the fjord there and makes its opening narrower, can not be concluded for the time being. Researches on the currents in the fjord and the impacts of the bridge are ongoing. This remain to be issue for the stock as long as it overwinter in this area. Environmental conditions were therefore monitored closely the preceding winter where only around 25% of last year's herring biomass overwintered there. No indication of similar mortality was observed in the winter 2013/2014.

The WG does not have any information of direct evidence of environmental effects of the stock but emphasize that increased sea temperature is considered to have generally positive effects on the stock (Jakobsson and Stefansson, 1999; Óskarsson and Taggart 2010). It is manifest in observations of higher number of recruits per SSB during warm years and relatively high mean weight-at-age during recent years. Furthermore, the stock occupies colder water around Iceland than other herring stocks in the N-Atlantic and is therefore on edge of the distribution towards cold water, where warming will generally have a positive impacts on the stock development. The increased temperature in Icelandic waters since 1998 (MRI 2012), has therefore probably positive effects on the stock, possibly apart from the *Ichthyophonus* outbreak.

11.14 Regulations and their effects

The fishery of the Icelandic summer-spawning herring is limited to the period 1 September to 1 May each season, according to regulations set by the Icelandic Fishery Ministry (no. 770, 8. September 2006). Several other regulations are enforced by the Ministry that effect the herring fishery. They involve protections of juveniles herring (27 cm and smaller) in the fishery where area closures are enforced if the proportion of juveniles exceeds 25% in number (no. 376, 8. October 1992). Another regulation deals with the quantity of bycatch allowed. Then there are regulations that prohibit use of pelagic trawls within the 12 nm fishing zone (no. 770, 8. September 2006), which are enforced to limit bycatch of juveniles of other fish species. For the fishing seasons 2011/2012 and 2012/2013, regulations were enforced that prohibited fishery for herring outside of the areas within the bay Faxaflói and the fjord Breiðafjörður off SW Iceland. It was advised by the Marine Research Institute because of small herring mixed with adults in other areas and less prevalence of infection there. Such an advice was not proposed or in effect for 2013/2014 and will not come from MRI for the season 2014/2015.

11.15 Changes in fishing technology and fishing patterns

There are no recent changes in fishing technology which may lead to different catch compositions. The fishing pattern in 2013/2014 was little bit different than in last six seasons' patterns. Instead of fishing near only in a small inshore area off the west coast, some fishery took also place off the south coast where younger age groups where in higher proportion. It is emphasized, however, that the fishing pattern does varies annually as noted in section 11.2 and it is related to variation in distribution and catchability of the different age classes of the stock. This variation in distribution and catchability can have consequences for the catch composition but it is still impossible to provide a forecast about this variation.

11.16 Species interaction effects and ecosystem drivers

The WG have not dealt with this issue in a thoroughly and dedicated manner. However, some work has been done in this field in recent years in one way or another.

Regarding relevant researches on species interaction, the main work relates to the increasing amount of North East Atlantic mackerel (NEAM) feeding in Icelandic waters since 2007 (Astthorsson et al. 2012; ICES. 2013b). The diet composition of NEAM in Icelandic waters showed a clear overlap with those of the two herring stocks, i.e. Icelandic summer-spawning herring and Norwegian spring-spawning herring (Óskarsson et al. 2012b). Even if Copepoda was important diet group for all the three stocks its relative contribution to the total diet was apparently higher for NEAM than the two herring stocks. Considering former studies of herring diet, this finding was unexpected, and particularly how little the Copepoda contributed to the herring diet. This difference in the stomach content of NEAM and the two herring stocks indicated that there could be some difference in feeding ecology between them in Icelandic waters, where NEAM preferred Copepoda, or feed in the water column where they dominate over other prey groups, while the opposite would be for the herring and the prey Euphausiacea. Recent studies in the Nordic Seas have shown similar results (Langøy et al. 2012; Debes et al. 2012). The indication for difference in feeding ecology of the species is further supported by the fact that the body condition of the two herring stocks showed no clear decreasing trend since the invasion of NEAM started into Icelandic waters. It should though be noted that comparison of the diet composition of herring in recent years to earlier studies, mainly on NSS herring, indicate that the herring might have shifted their feeding preference towards Euphausiacea instead of Copepoda. That is possibly a consequence of increased competition for food with NEAM, where the herring is overwhelmed and shifts towards other preys.

The WG is not aware of documentations of strong signals from ecosystem or environmental variables that impact the herring stock and could possibly be a basis for implementing ecosystem drivers in the analytical basis for its advice. For example, recruitment in the stock has been positively, but weakly, linked to sea temperature (Óskarsson and Taggart 2010), while indices representing zooplankton abundance in the spring have not been found to impact the recruitment (Óskarsson and Taggart 2010) or body condition and growth rate of the adult part of the stock (Óskarsson 2008).

11.17 Comments on the PA reference points

The WG have not dealt with this issue recently.

11.18 Comments on the assessment

The assessment implies that the stock size is slowly recovering following a period of depletion related to the *Ichthyophonus* infection. The rise is mainly caused by average size recruiting year classes entering the fishable stock, which are nearly without infection. The assessment follows fairly well the pattern in the tuning series for recent years (Figure 11.3.2.5).

In the NWWG report from 2012 (ICES. 2012) was stated: "*There are indications, and still under explorations, that the mortality because of the infection could be less than the prevalence of infection implies, particularly for the most recent year. That has implications on the assessment* ". This year's research on the *Ichthyophonus* infection in the stock supports the conclusions from last year's report (ICES 2013a; Óskarsson and Pálsson 2013) that the mortality because of the infection in insignificant in recent years and should only be applied for the first two years of the infection. This has mainly impacts on the historical perspective of the stock size.

The decision to add the number of herring that diet in the mass mortality in the winter 2012/2013 to the catches in 2012 in this years assessment was taken and introduced in the 2013 assessment (ICES 2013a).

The cautious allowed TAC in recent years that is based on $F_{0.22}$, has probably facilitated continuous increase in stock size in the last decade. The recent decrease in stock size, both seen in survey indices and analytical assessment, is considered to be mainly related to the *Ichthyophonus* outburst as this decline is despite a low fishing mortality in recent years.

In conclusion of the review group for NWWG 2011 (ICES 2011b), the suggestion was "*to improve the assessment in order to get a better fitting for the years 2000-2005 and to work on the reference points*". In this year's assessment, it was not dealt with these aspects specifically, but they still require attention. The years 2000-2005 fit still poorly to the tuning series and no satisfactory explanation exists for this pattern. The models recently used for the stock (NFT-Adapt, TSA and Coleraine (in Benchmark assessment in 2011; Gudmundsdottir 2011)) are not able to follow this trend in the tuning series. It should be noted that this same pattern was observed in the benchmark assessment in 2011 (Gudmundsdottir 2011) where input data were limited to the period before the infection so assumptions related to the natural mortality-infection are probably only responsible for this pattern to small degree if any. As mention above (section 11.3.2), the discrepancy could be related to the fact that during these years, the stock was over-wintering in offshore areas off the east and west coast, compare to mainly easterly distribution before and overwintering in inshore areas there after (from ~2006-2013). These positive blocks could therefore reflect changes in catchability of the survey for these years.

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Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1973/74	154.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	154
1974/75	5.000	137.000	19.000	21.000	2.000	2.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	186
1975/76	136.000	20.000	133.000	17.000	10.000	3.000	3.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	322
1976/77*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1977/78	212.000	424.000	46.000	19.000	139.000	18.000	18.000	10.000	0.000	0.000	0.000	0.000	0.000	0.000	886
1978/79	158.000	334.000	215.000	49.000	20.000	111.000	30.000	30.000	20.000	0.000	0.000	0.000	0.000	0.000	967
1979/80	19.000	177.000	360.000	253.000	51.000	41.000	93.000	10.000	0.000	0.000	0.000	0.000	0.000	0.000	1004
1980/81	361.000	462.000	85.000	170.000	182.000	33.000	29.000	58.000	10.000	0.000	0.000	0.000	0.000	0.000	1390
1981/82	17.000	75.000	159.000	42.000	123.000	162.000	24.000	8.000	46.000	10.000	0.000	0.000	0.000	0.000	666
1982/83*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1983/84	171.000	310.000	724.000	80.000	39.000	15.000	27.000	26.000	10.000	5.000	12.000	0.000	0.000	0.000	1419
1984/85	28.000	67.000	56.000	360.000	65.000	32.000	16.000	17.000	18.000	9.000	7.000	4.000	5.000	5.000	689
1985/86	652.000	208.000	110.000	86.000	425.000	67.000	41.000	17.000	27.000	26.000	16.000	6.000	6.000	1.000	1688
1986/87*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1987/88	115.544	401.246	858.012	308.065	57.103	32.532	70.426	36.713	23.586	18.401	24.278	10.127	3.926	4.858	1965
1988/89	635.675	201.284	232.808	381.417	188.456	46.448	25.798	32.819	17.439	10.373	9.081	5.419	3.128	5.007	1795
1989/90	138.780	655.361	179.364	278.836	592.982	179.665	22.182	21.768	13.080	9.941	1.989	0.000	0.000	0.000	2094
1990/91	403.661	132.235	258.591	94.373	191.054	514.403	79.353	37.618	9.394	12.636	0.000	0.000	0.000	0.000	1733
1991/92	598.157	1049.990	354.521	319.866	89.825	138.333	256.921	21.290	9.866	0.000	9.327	0.000	0.000	1.494	2850
1992/93	267.862	830.608	729.556	158.778	130.781	54.156	96.330	96.649	24.542	1.130	1.130	3.390	0.000	0.000	2395
1993/94	302.075	505.279	882.868	496.297	66.963	58.295	106.172	48.874	36.201	0.000	4.224	18.080	0.000	0.000	2525
1994/95*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1995/96	216.991	133.810	761.581	277.893	385.027	176.906	98.150	48.503	16.226	29.390	47.945	4.476	0.000	0.000	2197
1996/97	33.363	270.706	133.667	468.678	269.888	325.664	217.421	92.979	55.494	39.048	30.028	53.216	18.838	12.612	2022
1997/98	291.884	601.783	81.055	57.366	287.046	155.998	203.382	105.730	35.469	27.373	14.234	36.500	14.235	11.570	1924
1998/99	100.426	255.937	1081.504	103.344	51.786	135.246	70.514	101.626	53.935	17.414	13.636	2.642	4.209	8.775	2001

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1999/00	516.153	839.491	239.064	605.858	88.214	43.353	165.716	89.916	121.345	77.600	21.542	3.740	11.149	0.000	2823
2000/01	190.281	966.960	1316.413	191.001	482.418	34.377	15.727	37.940	14.320	15.413	14.668	1.705	3.259	0.000	3284
2001/02	1047.643	287.004	217.441	260.497	161.049	345.852	62.451	57.105	38.405	46.044	38.114	21.062	3.663	0.000	2586
2002/03	1731.809	1919.368	553.149	205.656	262.362	153.037	276.199	99.206	47.621	55.126	18.798	24.419	24.112	1.377	5372
2003/04	1115.255	1434.976	2058.222	330.800	109.146	100.785	38.693	45.582	7.039	6.362	7.509	10.894	0.000	2.289	5268
2004/05	2417.128	713.730	1022.326	1046.657	171.326	62.429	44.313	10.947	23.942	12.669	0.000	1.948	11.088	0.000	5539
2005/06	469.532	443.877	344.983	818.738	1220.902	281.448	122.183	129.588	73.339	65.287	10.115	9.205	3.548	12.417	4005
2006/07	109.959	608.205	1059.597	410.145	424.525	693.423	95.997	123.748	48.773	0.955	0.000	0.000	0.000	0.480	3576
2007/08	90.231	456.773	289.260	541.585	309.443	402.889	702.708	221.626	244.772	13.997	22.113	68.105	10.136	2.800	3376
2008/09	149.466	196.127	416.862	288.156	457.659	266.975	225.747	168.960	29.922	26.281	17.790	9.881	0.974	3.195	2258
2009/10	151.066	315.941	490.653	554.818	271.445	327.275	149.143	83.875	156.920	36.666	13.649	8.507	1.458	5.590	2567
2010/11	106.178	280.582	228.857	304.885	296.254	138.686	301.285	60.997	141.323	97.412	37.006	0.000	4.019	0.000	1997
2011/12	704.863	977.323	434.876	313.742	272.140	239.320	154.581	175.088	84.582	92.435	89.376	17.638	6.808	4,989	3676
2012/13	178.500	781.083	631.421	166.627	126.961	142.044	110.084	97.000	74.340	69.473	43.376	38.450	7.458	0.773	2468
2013/14	15.919	314.865	218.715	344.981	151.631	132.767	120.756	118.377	89.555	74.602	48.695	44.637	31.096	11.598	1718

* **No survey**

11.1.1.2. Overview of acoustic surveys conducted in the winter 2013/14 that contributed to the abundance estimates of the fishable stock and juveniles (age-1) of Icelandic summer-spawning herring.

No.	Survey code	Period	Area	The target	Used in 2014 abundance indices
1	B10-2013	29 October – 6 December 2013	South and southeast of Iceland	The fishable stock	Yes
2	D8-2013	28-29 October 2013	Breiðafjörður	The fishable stock	No
3	D9-2013	4-18 November 2013	Breiðafjörður (adults) and then fjords and bays west and north of Iceland (juveniles	The fishable stock and juvenile herring	Yes, the juvenile part
4	Bolli-1-2013	28-29 November 2013	Kolgrafafjörður in Breiðafjörður	The fishable stock	Yes, part of the average
5	D1-2014	8-12 January 2014	Kolgrafafjörður and Hvammsfjörður in Breiðafjörður	The fishable stock and juvenile herring	Yes, part of the average and the juvenile part
6	Bolli-1-2014	12 March 2014	Kolgrafafjörður in Breiðafjörður	The fishable stock	Yes, part of the average
7	B3-2014	31 March – 1 April 2014	Kolluáll and Snæfellsnes west of Iceland	The fishable stock	Yes

Table 11.1.2.1. Icelandic summers-spawning herring. Number of scales by ages and number of samples taken in the annual acoustic surveys in the seasons 1987/88-2013/14 (age refers to the former year, i.e. autumns). In 2000 seven samples were used from the fishery. No survey was conducted in 1994/95.

	Number of scales															Number of samples		
Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Total	West	East
1987/88	11	59	246	156	37	28	58	33	22	16	23	10	5	8	712	8	1	7
1988/89	229	78	181	424	178	69	50	77	42	29	23	13	7	12	1412	18	5	10
1989/90	38	245	96	132	225	35	2	2	3	3	2	0	0	0	783	8		8
1990/91	418	229	303	90	131	257	28	6	3	8	0	0	0	0	1473	15		15
1991/92	414	439	127	127	33	48	84	5	3	0	2	0	0	1	1283	15		15
1992/93	122	513	289	68	73	28	38	34	6	2	2	6	0	0	1181	12		12
1993/94	63	285	343	129	13	15	7	14	11	0	1	3	0	0	884	9		9
1994/95*																		
1995/96	183	90	471	162	209	107	38	18	8	14	18	2	0	0	1320	14	9	5
1996/97	24	150	88	351	141	137	87	32	15	10	7	14	4	2	1062	11	4	7
1997/98	101	249	50	36	159	95	122	62	21	13	8	15	8	5	944	14	7	7
1998/99	130	216	777	72	31	65	59	86	37	22	17	5	6	11	1534	17	10	7
1999/00	116	227	72	144	17	13	26	26	27	10	8	2	1	0	689	7	3	4
2000/01	116	249	332	87	166	10	7	21	8	14	11	3	1	0	1025	14	10	4
2001/02	61	56	130	114	62	136	25	24	17	21	17	10	3	0	676	9	4	5
2002/03	520	705	258	104	130	74	128	46	26	25	13	15	10	1	2055	22	12	10
2003/04	126	301	415	88	35	32	15	17	3	4	4	6	1	1	1048	13	8	5
2004/05	304	159	284	326	70	29	17	5	8	4	0	3	3	0	1212	13	4	9
2005/06	217	312	190	420	501	110	40	38	26	18	5	5	5	7	1894	22	14	8
2006/07	19	77	134	64	71	88	22	4	2	2	0	0	0	1	484	6	4	2

	Number of scales														Number of samples		
Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	Total	West	East
2007/08	58	288	180	264	85	80	104	19	15	2	2	6	1	3	1107	17	13	4
2008/09	274	208	213	136	204	123	125	97	18	13	9	7	4	17	1448	29	19	10
2009/10	104	100	105	116	60	74	34	19	36	8	3	4	2	2	667	17	10	7
2010/11	35	74	102	157	139	61	119	22	52	36	13	0	1	0	811	11	8	3
2011/12	229	330	134	115	100	106	74	87	45	48	51	10	3	3	1335	15	9	6
2012/13 ‡	42	266	554	273	220	252	198	165	126	114	69	61	12	2	2370	60	55‡	5
2013/14	26	472	275	414	199	200	199	208	163	138	90	85	60	23	2552	45	37‡	8

***No survey**

‡Samples in the western part were mainly from the commercial catch as there was impossible to secure a usable research survey samples from Kolgrafafjörður where most of the herring was observed.

Table 11.1.4.1. The age specific abundance estimates from the acoustic measurements in the winter 2012/2013 in Breiðafjörður (Óskarsson and Reynisson 2013), the estimated number of fish that died in the mass mortality in Breiðafjörður ($N_{Breiðafj} \times 175 \times \left(\sum_{Age} N_{Breiðafj} \right)$), where the total number of fish that died was 175 million individuals (ICES, 2013), and the sum of catch-at-age and the fish that diet in the mass mortality to be used in the catch matrix for the year 2012.

Age (years)	Year class	Acoustic estimate of number (10^6)	Proportion (%)	Number of herring that died (10^6)	Catch at age 2012/2013	**Number in catch+mortality 2012/2013**
1	2011	0	0	0		
2	2010	0	0	0	0.4	**0.4**
3	2009	43	4	6.9	10.9	**17.8**
4	2008	225	20.9	36.6	52.8	**89.4**
5	2007	130	12.1	21.1	30.2	**51.3**
6	2006	109	10.2	17.8	25.3	**43.1**
7	2005	132	12.3	21.5	29.7	**51.2**
8	2004	110	10.2	17.9	23.9	**41.8**
9	2003	93	8.7	15.2	19.5	**34.7**
10	2002	74	6.9	12.1	15.1	**27.2**
11	2001	69	6.5	11.3	13.6	**24.9**
12	2000	43	4	7.1	8.4	**15.5**
13	1999	38	3.6	6.3	7.3	**13.6**
14	1998	7	0.7	1.2	1.4	**2.6**
15	1997	1	0.1	0.1	0.1	**0.2**
Total		1076	100	175	238.7	**413.8**

Table 11.2.1. Icelandic summer spawners. Landings, catches, recommended TACs, and set National TACs in thousand tonnes.

Year	Landings	Catches	Recom. TACs	Nat. TACs	Year	Landings	Catches	Recom. TACs	Nat. TACs
1972	0.31	0.31			2007/2008	158.9	158.9	130	150
1973	0.254	0.254			2008/2009	151.8	151.8	130	150
1974	1.275	1.275			2009/2010	46.3	46.3	40	47
1975	13.28	13.28			2010/2011	43.5	43.5	40	40
1976	17.168	17.168			2011/2012‡	49.4	49.4	40	45
1977	28.925	28.925			2012/2013‡	72.0	72.0	67	68.5
1978	37.333	37.333			2013/2014‡	72.0	72.0	87	87
1979	45.072	45.072							
1980	53.268	53.268							
1981	39.544	39.544							
1982	56.528	56.528							
1983	58.867	58.867							
1984	50.304	50.304							
1985	49.368	49.368	50	50					
1986	65.5	65.5	65	65					
1987	75	75	70	73					
1988	92.8	92.8	90	90					
1989	97.3	101	90	90					
1990/1991	101.6	105.1	80	110					
1991/1992	98.5	109.5	80	110					
1992/1993	106.7	108.5	90	110					
1993/1994	101.5	102.7	90	100					
1994/1995	132	134	120	120					
1995/1996	125	125.9	110	110					
1996/1997	95.9	95.9	100	100					
1997/1998	64.7	64.7	100	100					
1998/1999**	87	87	90	70					
1999/2000	92.9	92.9	100	100					
2000/2001	100.3	100.3	110	110					
2001/2002	95.7	95.7	125	125					
2002/2003*	96.1	96.1	105	105					
2003/2004*	130.7	130.7	110	110					
2004/2005	114.2	114.2	110	110					
2005/2006	103	103	110	110					
2006/2007	135	135	130	130					

***Summer fishery in 2002 and 2003 included**

**** TAC was decided 70 thous. tonnes but because of transfers from the previous quota year the national TAC became 90 thous. tonnes.**

‡Landings and catches include bycatch of Icelandic summer-spawning herring in the mackerel and NSS herring fishery during the preceding summer (i.e. from the fishing season before in June-August). In the same way for 2012/2013, the national TAC include preliminary TAC from the summer of 4.5 kt to compensate for the bycatch and TAC given in the autumn of 64 kt.

Table 11.2.2.1. Overview of number of samples and measurements of Icelandic summer-spawning herring catches in June 2013 to March 2014.

	June–September		October–March		Total	
	Number	# per 1000 t	Number	# per 1000 t	Number	# per 1000 t
Number of samples	22	3.1	37	0.6	59	0.8
Length measured	998	139.0	2124	32.7	3122	43.3
Age determined					2548	35.4
Weighed fish					2816	39.1

Table 11.2.2.2. Icelandic summer-spawning herring. Catch in numbers (millions) and total catch in weight (thous. tonnes) (1981 refers to season 1981/1982 etc).

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Catch
1975	1.518	2.049	31.975	6.493	7.905	0.863	0.442	0.345	0.114	0.004	0.001	0.001	0.001	0.001	13.280
1976	0.614	9.848	3.908	34.144	7.009	5.481	1.045	0.438	0.296	0.134	0.092	0.001	0.001	0.001	17.168
1977	0.705	18.853	24.152	10.404	46.357	6.735	5.421	1.395	0.524	0.362	0.027	0.128	0.001	0.001	28.925
1978	2.634	22.551	50.995	13.846	8.738	39.492	7.253	6.354	1.616	0.926	0.4	0.017	0.025	0.051	37.333
1979	0.929	15.098	47.561	69.735	16.451	8.003	26.04	3.05	1.869	0.494	0.439	0.032	0.054	0.006	45.072
1980	3.147	14.347	20.761	60.727	65.328	11.541	9.285	19.442	1.796	1.464	0.698	0.001	0.11	0.079	53.268
1981	2.283	4.629	16.771	12.126	36.871	41.917	7.299	4.863	13.416	1.032	0.884	0.760	0.101	0.062	39.544
1982	0.454	19.187	28.109	38.280	16.623	38.308	43.770	6.813	6.633	10.457	2.354	0.594	0.075	0.211	56.528
1983	1.475	22.499	151.718	30.285	21.599	8.667	14.065	13.713	3.728	2.381	3.436	0.554	0.100	0.003	58.867
1984	0.421	18.015	32.244	141.354	17.043	7.113	3.916	4.113	4.517	1.828	0.202	0.255	0.260	0.003	50.304
1985	0.112	12.872	24.659	21.656	85.210	11.903	5.740	2.336	4.363	4.053	2.773	0.975	0.480	0.581	49.368
1986	0.100	8.172	33.938	23.452	20.681	77.629	18.252	10.986	8.594	9.675	7.183	3.682	2.918	1.788	65.500
1987	0.029	3.144	44.590	60.285	20.622	19.751	46.240	15.232	13.963	10.179	13.216	6.224	4.723	2.280	75.439
1988	0.879	4.757	41.331	99.366	69.331	22.955	20.131	32.201	12.349	10.250	7.378	7.284	4.807	1.957	92.828
1989	3.974	22.628	26.649	77.824	188.654	43.114	8.116	5.897	7.292	4.780	3.449	1.410	0.844	0.348	101.000
1990	12.567	14.884	56.995	35.593	79.757	157.225	30.248	8.187	4.372	3.379	1.786	0.715	0.446	0.565	105.097
1991	37.085	88.683	49.081	86.292	34.793	55.228	110.132	10.079	4.155	2.735	2.003	0.519	0.339	0.416	109.489
1992	16.144	94.86	122.626	38.381	58.605	27.921	38.42	53.114	11.592	1.727	1.757	0.153	0.376	0.001	108.504
1993	2.467	51.153	177.78	92.68	20.791	28.56	13.313	19.617	15.266	4.254	0.797	0.254	0.001	0.001	102.741
1994	5.738	134.616	113.29	142.876	87.207	24.913	20.303	16.301	15.695	14.68	2.936	1.435	0.244	0.195	134.003
1995	4.555	20.991	137.232	86.864	109.14	76.78	21.361	15.225	8.541	9.617	7.034	2.291	0.621	0.235	125.851
1996	0.717	15.969	40.311	86.187	68.927	84.66	39.664	14.746	8.419	5.836	3.152	5.18	1.996	0.574	95.882
1997	2.008	39.24	30.141	26.307	36.738	33.705	31.022	22.277	8.531	3.383	1.141	10.296	0.947	2.524	64.682
1998	23.655	45.39	175.529	22.691	8.613	40.898	25.944	32.046	14.647	2.122	2.754	2.15	1.07	1.011	86.998
1999	5.306	56.315	54.779	140.913	16.093	13.506	31.467	19.845	22.031	12.609	2.673	2.746	1.416	2.514	92.896
2000	17.286	57.282	136.278	49.289	76.614	11.546	8.294	16.367	9.874	11.332	6.744	2.975	1.539	1.104	100.332
2001	27.486	42.304	86.422	93.597	30.336	54.491	10.375	8.762	12.244	9.907	8.259	6.088	1.491	1.259	95.675
2002	11.698	80.863	70.801	45.607	54.202	21.211	42.199	9.888	4.707	6.52	9.108	9.355	3.994	5.697	96.128
2003	24.477	211.495	286.017	58.120	27.979	25.592	14.203	10.944	2.230	3.424	4.225	2.562	1.575	1.370	130.741
2004	23.144	63.355	139.543	182.45	40.489	13.727	9.342	5.769	7.021	3.136	1.861	3.871	0.994	1.855	114.237
2005	6.088	26.091	42.116	117.91	133.437	27.565	12.074	9.203	5.172	5.116	1.045	1.706	2.11	0.757	103.043
2006	52.567	118.526	217.672	54.800	48.312	57.241	13.603	5.994	4.299	0.898	1.626	1.213	0.849	0.933	135.303
2007	10.817	94.250	83.631	163.294	61.207	87.541	92.126	23.238	11.728	7.319	2.593	4.961	2.302	1.420	158.917
2008	10.427	38.830	90.932	79.745	107.644	59.656	62.194	54.345	18.130	8.240	5.157	2.680	2.630	1.178	151.780
2009	5.431	21.856	35.221	31.914	18.826	22.725	10.425	9.213	9.549	2.238	1.033	0.768	0.406	0.298	46.332
2010	1.476	8.843	22.674	29.492	24.293	14.419	17.407	10.045	7.576	8.896	1.764	1.105	0.672	0.555	43.533
2011	0.521	9.357	24.621	20.046	22.869	23.706	13.749	16.967	10.039	7.623	7.745	1.441	0.618	0.785	49.446
2012	0.403	10.927	52.832	30.157	25.279	29.724	23.946	19.453	15.115	13.646	8.373	7.323	1.373	0.127	71.976

2013	6.888	46.848	24.833	35.070	17.250	18.550	19.032	21.821	15.952	15.804	10.081	9.775	6.722	2.486	251.111

Table 11.2.2.3. Icelandic summer-spawning herring. The mean weight (g) at age from the commercial catch (1981 refers to season 1981/1982 etc).

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1975	110	179	241	291	319	339	365	364	407	389	430	416	416	416
1976	103	189	243	281	305	335	351	355	395	363	396	396	396	396
1977	84	157	217	261	285	313	326	347	364	362	358	355	400	420
1978	73	128	196	247	295	314	339	359	360	376	380	425	425	425
1979	75	145	182	231	285	316	334	350	367	368	371	350	350	450
1980	69	115	202	232	269	317	352	360	380	383	393	390	390	390
1981	61	141	190	246	269	298	330	356	368	405	382	400	400	400
1982	65	141	186	217	274	293	323	354	385	389	400	394	390	420
1983	59	132	180	218	260	309	329	356	370	407	437	459	430	472
1984	49	131	189	217	245	277	315	322	351	334	362	446	417	392
1985	53	146	219	266	285	315	335	365	388	400	453	469	433	447
1986	60	140	200	252	282	298	320	334	373	380	394	408	405	439
1987	60	168	200	240	278	304	325	339	356	378	400	404	424	430
1988	75	157	221	239	271	298	319	334	354	352	371	390	408	437
1989	63	130	206	246	261	290	331	338	352	369	389	380	434	409
1990	80	127	197	245	272	285	305	324	336	362	370	382	375	378
1991	74	135	188	232	267	289	304	323	340	352	369	402	406	388
1992	68	148	190	235	273	312	329	339	355	382	405	377	398	398
1993	66	145	211	246	292	324	350	362	376	386	419	389	389	389
1994	66	134	201	247	272	303	333	366	378	389	390	412	418	383
1995	68	130	183	240	277	298	325	358	378	397	409	431	430	467
1996	75	139	168	212	258	289	308	325	353	353	377	404	395	410
1997	63	131	191	233	269	300	324	341	355	362	367	393	398	411
1998	52	134	185	238	264	288	324	340	348	375	406	391	426	456
1999	74	137	204	233	268	294	311	339	353	362	378	385	411	422
2000	62	159	217	268	289	325	342	363	378	393	407	425	436	430
2001	74	139	214	244	286	296	324	347	354	385	403	421	421	433
2002	85	161	211	258	280	319	332	354	405	396	416	433	463	460
2003	72	156	189	229	260	283	309	336	336	369	394	378	412	423
2004	84	149	213	248	280	315	331	349	355	379	388	412	419	425
2005	106	170	224	262	275	298	324	335	335	356	372	394	405	413
2006	107	189	234	263	290	304	339	349	369	416	402	413	413	467
2007	93	158	221	245	261	277	287	311	339	334	346	356	384	390
2008	105	174	232	275	292	307	315	327	345	366	377	372	403	434
2009	113	190	237	274	304	318	326	335	342	360	372	394	409	421
2010	87	204	243	271	297	315	329	335	341	351	367	366	405	416
2011	97	187	245	283	309	328	343	352	356	364	375	386	378	432
2012	65	206	244	282	301	320	333	344	350	359	364	367	373	391

2013	95	182	238	271	300	322	337	349	360	365	362	375	377	394

Table 11.2.2.4. Icelandic summer-spawning herring. Proportion mature at age (1981 refers to season 1981/1982 etc).

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1975	0	0.27	0.97	1	1	1	1	1	1	1	1	1	1	1
1976	0	0.13	0.9	1	1	1	1	1	1	1	1	1	1	1
1977	0	0.02	0.87	1	1	1	1	1	1	1	1	1	1	1
1978	0	0.04	0.78	1	1	1	1	1	1	1	1	1	1	1
1979	0	0.07	0.65	0.98	1	1	1	1	1	1	1	1	1	1
1980	0	0.05	0.92	1	1	1	1	1	1	1	1	1	1	1
1981	0	0.03	0.65	0.99	1	1	1	1	1	1	1	1	1	1
1982	0.02	0.05	0.85	1	1	1	1	1	1	1	1	1	1	1
1983	0	0	0.64	1	1	1	1	1	1	1	1	1	1	1
1984	0	0.01	0.82	1	1	1	1	1	1	1	1	1	1	1
1985	0	0	0.9	1	1	1	1	1	1	1	1	1	1	1
1986	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1987	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1988	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1989	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1990	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1991	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1992	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1993	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1994	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1995	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1996	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1997	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1998	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
1999	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2000	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2001	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2002	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2003	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2004	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2005	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2006	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2007	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2008	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2009	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2010	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2011	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2012	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1
2013	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1

Table 11.3.2.1. Icelandic summer-spawning herring. Natural mortality at age where the deviation from the fixed M=0.1 is due to the *Ichthyophonus* infection (1981 refers to season 1981/1982 etc).

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1987-2008	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
2009	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
2010	0.458	0.74	0.74	0.69	0.63	0.6	0.58	0.57	0.56	0.54	0.53	0.52	0.56	0.58
2011-2013	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Table 11.3.2.2. Model settings and results of model parameters from the NFT-Adapt run in 2014 for Icelandic summer spawning herring.

VPA Version 3.3.0
Model ID: Final in spring 2013 + one more year of data

Input File: C:\USERS\ASTA\NFT\VPA\2014\RUN1\RUN1_2014.DAT
Date of Run: 10-APR-2014 Time of Run: 17:56

Levenburg-Marquardt Algorithm Completed 3 Iterations
Residual Sum of Squares = 49.2560
Number of Residuals = 208
Number of Parameters = 9
Degrees of Freedom = 199
Mean Squared Residual = 0.247518
Standard Deviation = 0.497512
Number of Years = 27
Number of Ages = 11
First Year = 1987
Youngest Age = 3
Oldest True Age = 12
Number of Survey Indices Available = 10
Number of Survey Indices Used in Estimate = 8

VPA Classic Method - Auto Estimated Q's

Stock Numbers Predicted in Terminal Year Plus One (2014)

Age	Stock Predicted	Std. Error	CV
4	291747.181	0.148201E+06	0.507977E+00
5	319291.897	0.118815E+06	0.372119E+00
6	379037.510	0.121245E+06	0.319876E+00
7	122710.393	0.374999E+05	0.305597E+00
8	78389.348	0.240802E+05	0.307187E+00
9	53363.465	0.175288E+05	0.328479E+00
10	48434.362	0.159153E+05	0.328594E+00
11	30507.485	0.755911E+04	0.247779E+00
12	34110.543	0.141551E+05	0.414978E+00

Catchability Values for Each Survey Used in Estimate

INDEX	Catchability	Std. Error	CV
1	0.105799E+01	0.107143E+00	0.101270E+00
2	0.129587E+01	0.127623E+00	0.984844E-01
3	0.130726E+01	0.974058E-01	0.745113E-01
4	0.141131E+01	0.104514E+00	0.740548E-01
5	0.151244E+01	0.124139E+00	0.820786E-01
6	0.172992E+01	0.169182E+00	0.977976E-01
7	0.181065E+01	0.215259E+00	0.118885E+00
8	0.174787E+01	0.225508E+00	0.129019E+00

-- Non-Linear Least Squares Fit --

Maximum Marquadt Iterations = 100
Scaled Gradient Tolerance = 6.055454E-05
Scaled Step Tolerance = 1.000000E-18
Relative Function Tolerance = 1.000000E-18
Absolute Function Tolerance = 4.930381E-32
Reported Machine Precision = 2.220446E-16

VPA Method Options
- Catchability Values Estimated as an Analytic Function of N
- Catch Equation Used in Cohort Solution
- Plus Group Forward Calculation Method Used
- Arithmetic Average Used in F-Oldest Calculation
- F-Oldest Calculation in Years Prior to Terminal Year
  Uses Fishing Mortality in Ages 8 to 11
- Calculation of Population of Age 3 In Year 2014
  = Geometric Mean of First Age Populations
  Year Range Applied = 1990 to 2010
- Survey Weight Factors Were Used

Stock Estimates

Age 4
Age 5
Age 6
Age 7
Age 8
Age 9
Age 10
Age 11
Age 12

Full F in Terminal Year = 0.2608
F in Oldest True Age in Terminal Year = 0.3534

Full F Calculated Using Classic Method

F in Oldest True Age in Terminal Year has been
Calculated in Same Manner as in All Other Years

Age	Input Partial Recruitment	Calc Partial Recruitment	Fishing Mortality	Used In Full F	Comments
3	0.500	0.353	0.1419	NO	Stock Estimate in T+1
4	0.800	0.177	0.0713	NO	Stock Estimate in T+1
5	1.000	0.209	0.0843	YES	Stock Estimate in T+1
6	1.000	0.311	0.1253	YES	Stock Estimate in T+1
7	1.000	0.503	0.2026	YES	Stock Estimate in T+1
8	1.000	0.724	0.2914	YES	Stock Estimate in T+1
9	1.000	0.884	0.3557	YES	Stock Estimate in T+1
10	1.000	1.000	0.4025	YES	Stock Estimate in T+1
11	1.000	0.905	0.3641	YES	Stock Estimate in T+1
12	1.000	0.878	0.3534		F-Oldest

Table 11.3.2.3. Icelandic summer spawners stock estimates (from NFT-Adapt in 2014) in numbers (thousands) by age (years) at January 1st during 1987-2014.

Age	3	4	5	6	7	8	9	10	11	12	13+	Total
Year												
1987	529947	989096	300697	84606	69141	107466	42635	38034	26408	34264	34292	2256586
1988	271102	476527	852591	214873	56995	43837	53489	24151	21192	14258	36997	2066012
1989	447726	240781	391912	677078	128728	29843	20627	18028	10184	9486	26105	2000498
1990	301221	383614	192555	280762	433781	75631	19308	13074	9410	4695	26466	1740517
1991	842382	258410	292992	140449	178431	243596	39801	9723	7687	5314	24864	2043649
1992	1035387	677978	187238	183312	94083	109109	116250	26455	4867	4365	24199	2463243
1993	638221	846737	497067	132999	110332	58664	62334	54955	12971	2768	23679	2440727
1994	694511	528884	597469	361801	100603	72748	40451	37811	35251	7706	22931	2500166
1995	204548	500664	371062	405087	244652	67401	46576	21173	19360	18004	23161	1921688
1996	182985	165142	322902	253351	263050	148607	40744	27717	11073	8429	27601	1451601
1997	778987	150400	111192	210447	163886	157794	96854	22901	17100	4507	22268	1736336
1998	325218	667563	107485	75656	155547	116307	113338	66504	12643	12262	10165	1662688
1999	565226	251168	437584	75726	60276	101962	80625	72171	46279	9426	13676	1714119
2000	408465	457941	175293	262414	53250	41726	62436	54130	44422	29919	12059	1602055
2001	498349	315201	285186	111881	164815	37227	29885	40974	39607	29447	26273	1578845
2002	1576497	410732	203264	169362	72470	97502	23848	18735	25469	26442	34214	2658535
2003	1188978	1349622	304438	140652	101882	45467	48298	12221	12488	16862	28275	3249183
2004	810084	875081	949802	220307	100716	67915	27680	33320	8941	8053	31608	3133507
2005	1189903	672797	659326	686261	160912	78096	52581	19571	23487	5120	27745	3575799
2006	856954	1051865	568750	484663	494319	119433	59201	38841	12805	16398	24405	3727634
2007	945324	662852	745218	462567	392647	392911	95147	47873	31062	10733	32530	3818864
2008	824021	766355	521701	522519	358186	270282	266891	63877	32163	21131	28453	3675579
2009	774086	708700	607062	396341	370650	267468	185561	189923	40610	21288	33819	3595508
2010	594466	457314	406946	347240	228257	209517	155796	106559	108972	23150	31823	2670040
2011	700299	277665	202948	183758	167587	114792	104535	80685	55241	56827	29088	1973425
2012	449344	624761	227850	164592	144552	129129	90810	78479	63472	42745	67682	2083416
2013*	390449	389639	480387	157539	108077	82278	77189	49358	45231	33816	69687	1883650
2014	634306	308798	328961	401349	126162	80183	56393	49156	29545	25956	66099	2106908

*** The mass mortality in Kolgrafafjörður in the winter 2012/13 (Óskarsson et al. 2013) is being accounted for**

Table 11.3.2.4. Estimated fishing mortality at age of Icelandic summer-spawning herring (from NFT-Adapt in 2014) by age (years) during 1987-2013 and weighed average F by numbers for age 5-10.

Year\age	3	4	5	6	7	8	9	10	11	12	13+	WF 5-10
1987	0.006	0.049	0.236	0.295	0.356	0.598	0.468	0.485	0.516	0.517	0.517	0.347
1988	0.019	0.096	0.131	0.412	0.547	0.654	0.988	0.764	0.704	0.777	0.506	0.266
1989	0.055	0.124	0.234	0.345	0.432	0.336	0.356	0.550	0.674	0.479	0.111	0.322
1990	0.053	0.170	0.216	0.353	0.477	0.542	0.586	0.431	0.471	0.508	0.071	0.400
1991	0.117	0.222	0.369	0.301	0.392	0.640	0.309	0.592	0.466	0.502	0.055	0.436
1992	0.101	0.210	0.242	0.408	0.372	0.460	0.649	0.613	0.464	0.547	0.023	0.414
1993	0.088	0.249	0.218	0.179	0.317	0.272	0.400	0.344	0.421	0.359	0.011	0.247
1994	0.227	0.254	0.289	0.291	0.301	0.346	0.547	0.569	0.572	0.509	0.090	0.311
1995	0.114	0.339	0.282	0.332	0.399	0.403	0.419	0.548	0.732	0.526	0.154	0.341
1996	0.096	0.296	0.328	0.336	0.411	0.328	0.476	0.383	0.799	0.497	0.348	0.358
1997	0.054	0.236	0.285	0.202	0.243	0.231	0.276	0.494	0.233	0.308	1.033	0.247
1998	0.158	0.322	0.250	0.127	0.322	0.266	0.351	0.263	0.194	0.269	0.572	0.276
1999	0.111	0.260	0.411	0.252	0.268	0.391	0.298	0.385	0.336	0.353	0.713	0.370
2000	0.159	0.374	0.349	0.365	0.258	0.234	0.321	0.212	0.311	0.270	0.667	0.327
2001	0.093	0.339	0.421	0.334	0.425	0.345	0.367	0.376	0.304	0.348	0.434	0.398
2002	0.055	0.200	0.268	0.408	0.366	0.603	0.569	0.306	0.312	0.447	0.869	0.390
2003	0.207	0.251	0.223	0.234	0.306	0.396	0.271	0.213	0.339	0.305	0.229	0.254
2004	0.086	0.183	0.225	0.214	0.154	0.156	0.247	0.250	0.458	0.277	0.252	0.216
2005	0.023	0.068	0.208	0.228	0.198	0.177	0.203	0.324	0.259	0.241	0.190	0.215
2006	0.157	0.245	0.107	0.111	0.130	0.127	0.112	0.124	0.077	0.110	0.138	0.116
2007	0.110	0.140	0.255	0.156	0.273	0.287	0.299	0.298	0.285	0.292	0.328	0.246
2008	0.051	0.133	0.175	0.243	0.192	0.276	0.240	0.353	0.313	0.296	0.273	0.224
2009	0.036	0.065	0.069	0.062	0.081	0.051	0.065	0.066	0.072	0.063	0.057	0.066
2010	0.021	0.072	0.105	0.099	0.087	0.115	0.088	0.097	0.111	0.103	0.099	0.100
2011	0.014	0.098	0.110	0.140	0.161	0.134	0.187	0.140	0.156	0.154	0.108	0.142
2012	0.043	0.163	0.269	0.321	0.464	0.415	0.510	0.451	0.530	0.476	0.294	0.379
2013	0.135	0.069	0.080	0.122	0.199	0.278	0.351	0.413	0.455	0.374	0.336	0.156

Table 11.3.2.5. Summary table from NFT-Adapt run in 2014 for Icelandic summer spawning herring.

Year	Recruits, age 3 (millions)	Biomass age 3+ (kt)	SSB (kt)	Landings age 3+ (kt)	Yield/SSB	WFage 5-10
1987	530	504	384	75	0.20	0.35
1988	271	495	423	93	0.22	0.27
1989	448	459	386	101	0.26	0.32
1990	301	410	350	104	0.30	0.40
1991	842	424	310	107	0.34	0.44
1992	1035	503	344	107	0.31	0.41
1993	638	547	425	103	0.24	0.25
1994	695	555	442	134	0.30	0.31
1995	205	464	408	125	0.31	0.34
1996	183	350	310	96	0.31	0.36
1997	779	371	272	65	0.24	0.25
1998	325	371	302	86	0.29	0.28
1999	565	379	294	93	0.31	0.37
2000	408	397	314	100	0.32	0.33
2001	498	362	282	94	0.33	0.40
2002	1576	548	316	96	0.30	0.39
2003	1189	633	424	129	0.30	0.25
2004	810	700	547	112	0.21	0.22
2005	1190	833	617	102	0.17	0.22
2006	857	946	742	130	0.17	0.12
2007	945	891	714	158	0.22	0.25
2008	824	953	772	151	0.20	0.22
2009	774	970	648	46	0.07	0.07
2010	594	734	452	43	0.10	0.10
2011	700	526	391	49	0.13	0.14
2012	449	570	450	72	0.16	0.22
2013*	390	504	412	71	0.17	0.16
2014	634	560	430			

*** The mass mortality of 52 000 tons in Kolgrafafjörður in the winter 2012/13 has been accounted for but is not included in the number for catches, yield/SSB or F.**

Table 11.3.2.6. The residuals from survey observations and NFT-Adapt 2014 results for Icelandic summer spawning herring (no surveys in 1987 and 1995) on 1st January.

Year\Age	4	5	6	7	8	9	10	11
1987								
1988	-0.191	-0.216	0.129	-0.308	-0.679	-0.241	-0.148	-0.428
1989	-0.199	-0.743	-0.805	0.071	0.062	-0.003	0.000	0.000
1990	0.516	-0.294	-0.238	0.003	0.484	-0.378	-0.001	-0.002
1991	-0.689	-0.348	-0.629	-0.241	0.367	0.174	0.008	-0.003
1992	0.418	0.416	0.325	-0.356	-0.144	0.277	-0.784	0.002
1993	-0.039	0.161	-0.054	-0.140	-0.461	-0.081	-0.002	0.102
1994	-0.065	0.168	0.085	-0.717	-0.602	0.449	-0.310	-0.509
1995								
1996	-0.230	0.635	-0.139	0.071	-0.207	0.363	-0.007	-0.153
1997	0.568	-0.039	0.569	0.189	0.344	0.292	0.834	0.642
1998	-0.123	-0.505	-0.508	0.303	-0.087	0.068	-0.103	0.496
1999	-0.001	0.682	0.080	-0.462	-0.098	-0.650	-0.225	-0.382
2000	0.587	0.088	0.605	0.195	-0.343	0.460	-0.060	0.469
2001	1.101	1.307	0.303	0.764	-0.460	-1.158	-0.644	-1.553
2002	-0.378	-0.155	0.199	0.489	0.885	0.446	0.547	-0.125
2003	0.333	0.375	0.149	0.636	0.833	1.227	1.527	0.803
2004	0.475	0.551	0.175	-0.229	0.014	-0.181	-0.254	-0.008
2005	0.040	0.216	0.191	-0.247	-0.605	-0.687	-1.148	-0.516
2006	-0.882	-0.723	0.293	0.594	0.476	0.208	0.638	1.210
2007	-0.105	0.129	-0.352	-0.232	0.187	-0.507	0.383	-0.084
2008	-0.537	-0.812	-0.196	-0.456	0.018	0.452	0.677	1.494
2009	-1.304	-0.599	-0.550	-0.099	-0.383	-0.320	-0.684	-0.841
2010	-0.389	-0.036	0.237	-0.137	0.065	-0.560	-0.806	-0.171
2011	-0.009	-0.102	0.275	0.260	-0.192	0.542	-0.847	0.404
2012	0.428	0.424	0.414	0.323	0.236	0.016	0.235	-0.248
2013	0.676	0.051	-0.175	-0.148	0.165	-0.161	0.109	-0.039
2014	0.000	-0.631	-0.383	-0.126	0.123	0.245	0.312	0.573

Table 11.6.1.1. The input data used for prognosis of the Icelandic summer-spawning herring in the 2014 assessment: the predicted weights, the selection pattern, M, proportion of M before spawning, and the number-at-age derived from NFT-Adapt run.

Age (year class)	Mean weights (kg)	M	Maturity ogive	Selection pattern	Mortality prop. before spawning		Number at age
					F	M	Jan. 1st 2014
3 (2011)	0.164	0.10	0.200	0.357	0.000	0.500	634.3
4 (2010)	0.232	0.10	0.850	0.521	0.000	0.500	308.8
5 (2009)	0.275	0.10	1.000	1.000	0.000	0.500	329.0
6 (2008)	0.301	0.10	1.000	1.000	0.000	0.500	401.3
7 (2007)	0.323	0.10	1.000	1.000	0.000	0.500	126.2
8 (2006)	0.340	0.10	1.000	1.000	0.000	0.500	80.2
9 (2005)	0.352	0.10	1.000	1.000	0.000	0.500	56.4
10 (2004)	0.361	0.10	1.000	1.000	0.000	0.500	49.2
11 (2003)	0.370	0.10	1.000	1.000	0.000	0.500	29.5
12 (2002)	0.374	0.10	1.000	1.000	0.000	0.500	26.0
13+ (2001+)	0.372	0.10	1.000	1.000	0.000	0.500	66.1

Table 11.6.1.2. Icelandic summer-spawning herring. Short term prediction where the basis is: SSB(2014): 430 kt; Biomass age 3+ (2014): 560 kt; Catch(2013/14): 72 kt; $WF_{5\text{-}10}$(2013)=0.156. The fishery has been managed on basis of $F_{0.1}$=0.22 for over 20 years. SSB is in the spawning seasons, which is approximately the beginning of the subsequent fishing season. Catches and SSB are in thousands tons.

Rationale	Landings (2013/14)	Basis	F (2013/2014)	SSB 2015	%SSB change 1)	% TAC change 2)
MSY approach	83	Fmsy	0.22	420	-2	13
F0.1	83	F0.1=Fpa=0.22	0.22	420	-2	13
Zero catch	0	F=0	0.00	496	13	
Status quo	83	F(2013)	0.22	420	-2	13
Fmult	8	0.1 × (F0.1)	0.02	489	12	-800
	20	0.25 × (F0.1)	0.05	478	10	-260
	44	0.5 × (F0.1)	0.11	456	6	-64
	62	0.75 × (F0.1)	0.16	439	2	-16
	76	0.9 × (F0.1)	0.20	426	-1	5
	90	1.1 × (F0.1)	0.24	412	-4	20
	100	1.25 × (F0.1)	0.27	404	-6	28
	119	1.5 × (F0.1)	0.33	387	-11	39

[1] SSB 2015 relative to SSB 2014.

[2] Landings 2014/15 relative to TAC 2013/14.

Table 11.6.1.3. Icelandic summer-spawning herring. Medium term prediction where the basis is : SSB(2014): 430 kt; Catch(2013/14): 72 kt; WF_{5-10}(2013)=0.156. The prognosis of the Icelandic summer spawning herring for the next fishing season (2014/2015) and the two subsequent seasons under five different options (F0.1=0.22, constant TAC of 60 kt, 70 kt, 80 kt and 90 kt) from the final NFT-Adapt run in 2014. SSBs are in the spawning seasons, which is approximately the beginning of the subsequent fishing season.

Spawning 2014		2014/2015		Spawning 2015		2015/2016		Spawning 2016		2016/2017		Spawning 2017	
Biomass 3+	SSB (kt)	TAC	F	Biomass 3+	SSB (kt)	TAC	F	Biomass 3+	SSB (kt)	TAC	F	Biomass 3+	SSB (kt)
(kt)		(kt)	(5-10)	(kt)		(kt)	(5-10)	(kt)		(kt)	(5-10)	(kt)	
560	430	83	0.22	521	420	79	0.22	542	428	83	0.22	564	445
		60	0.15	544	441	60	0.15	584	467	60	0.14	627	505
		70	0.18	534	432	70	0.19	564	449	70	0.17	598	478
		80	0.21	524	423	80	0.22	544	430	80	0.21	569	450
		90	0.24	514	413	90	0.26	525	412	90	0.25	540	423

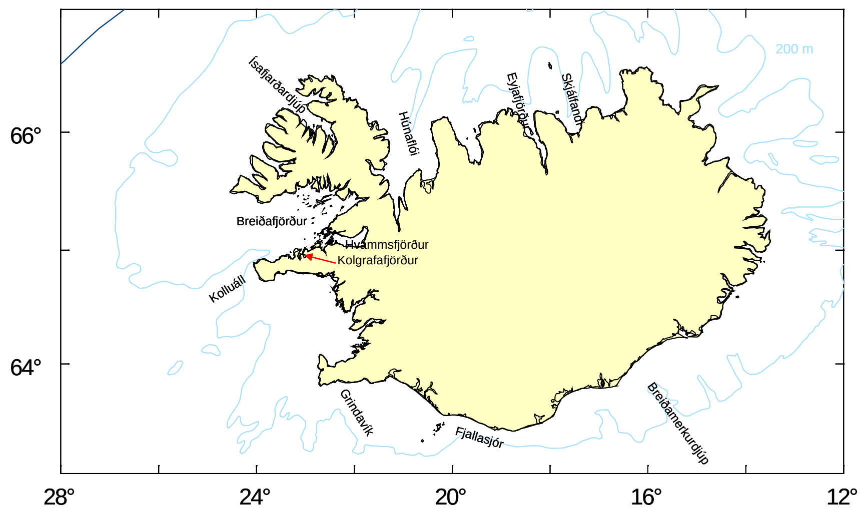


Figure 11.1.2.1. The locations of the areas that are referred to in the text.

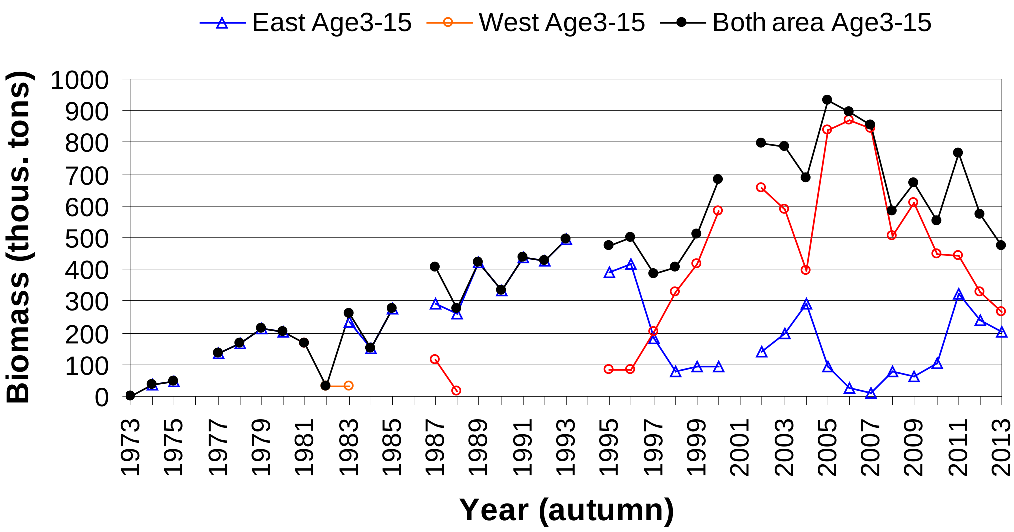


Figure 11.1.2.2 Total biomass index for Icelandic summer-spawning herring from the acoustic surveys for ages 3+ in the areas east and west of 18°W (except in 2011 and 2012 where fish observed outside of Breiðafjörður was set to the eastern part and 2013 which indcludes herring in Breiðafjörður and Kolluáll; Fig. 11.1.2.1), and combined. The years in the plot (1973-2013) refer to the autumn of the fishing seasons.

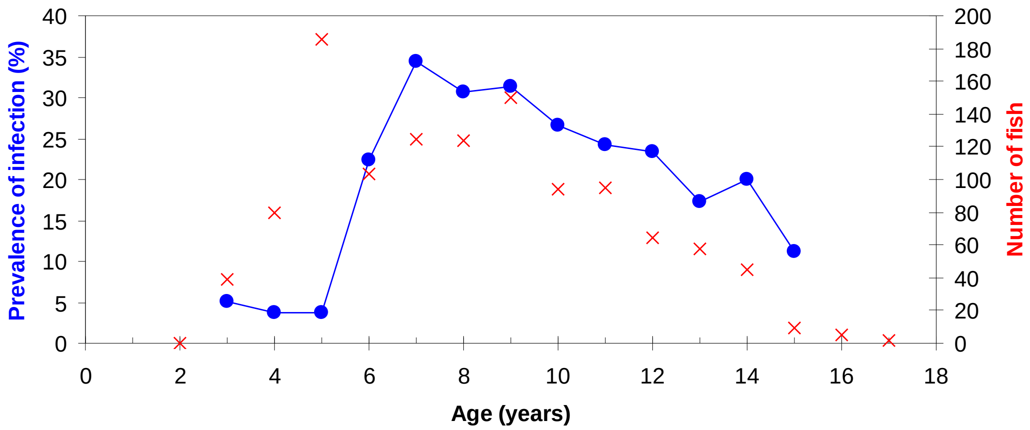


Figure 11.1.3.1. The prevalence of *Ichthyophonus* infection for the different age groups of Icelandic summer-spawning herring in Breiðafjörður and Kolluáll in the winter 2013/2014.

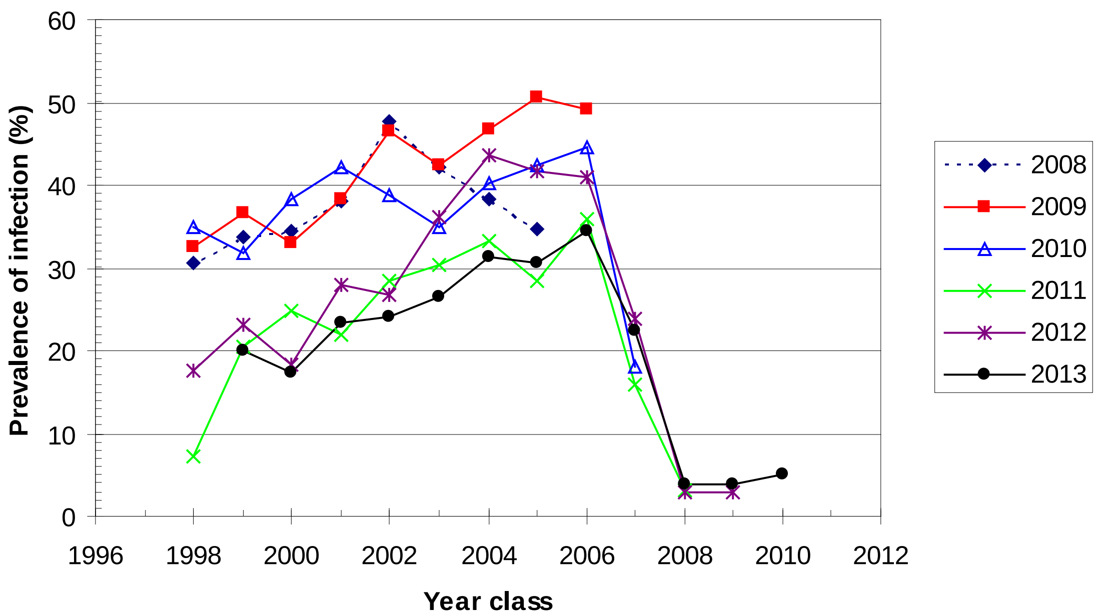


Figure 11.1.3.2. The prevalence of Ichthyophonus infection for the different year classes of Icelandic summer-spawning herring in Breiðafjörður as estimated in the autumns 2008 to 2013.

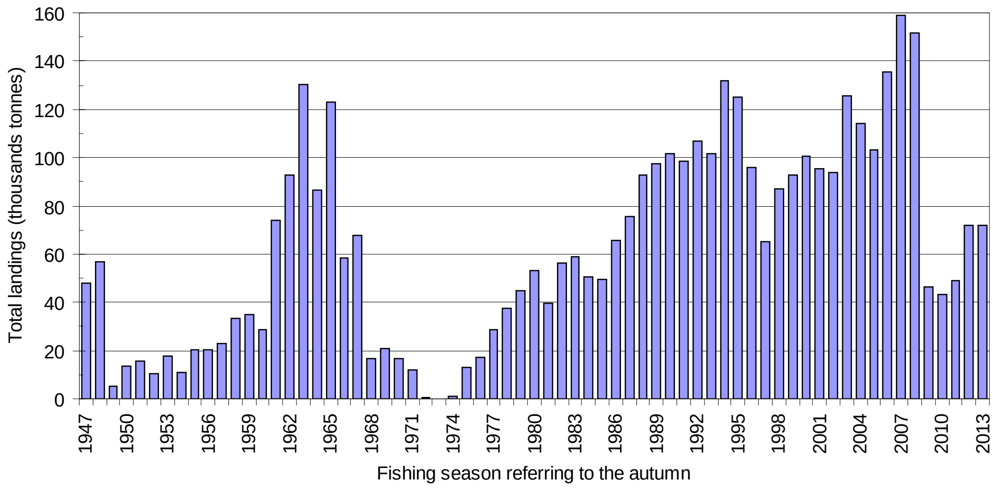


Figure 11.2.1. Icelandic summer spawning herring. Seasonal total landings (in thousand tonnes) during 1947-2013, referring to the autumns.

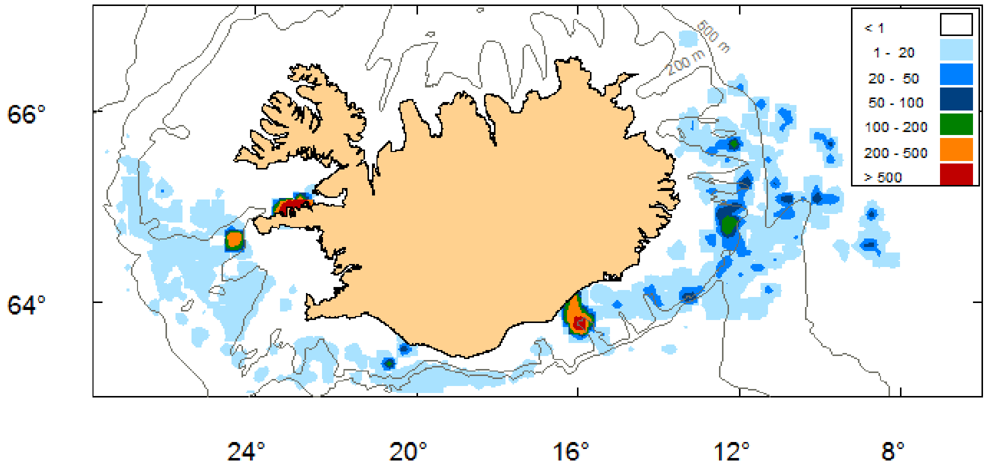


Figure 11.2.2. The distribution of the fishery (in tonnes) of Icelandic summer spawning herring during the fishing season 2013/14, including the bycatch in the mackerel fishery in June-September 2013.

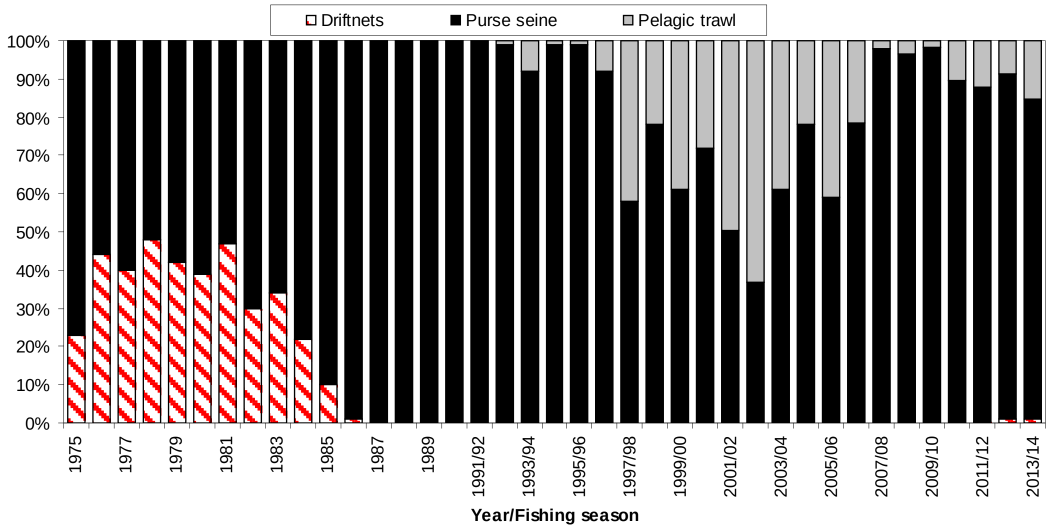


Figure 11.2.1.1. Icelandic summer spawning herring. Proportion of the total catches of the Icelandic summer-spawning herring in 1975/76-2013/14 taken by different gears.

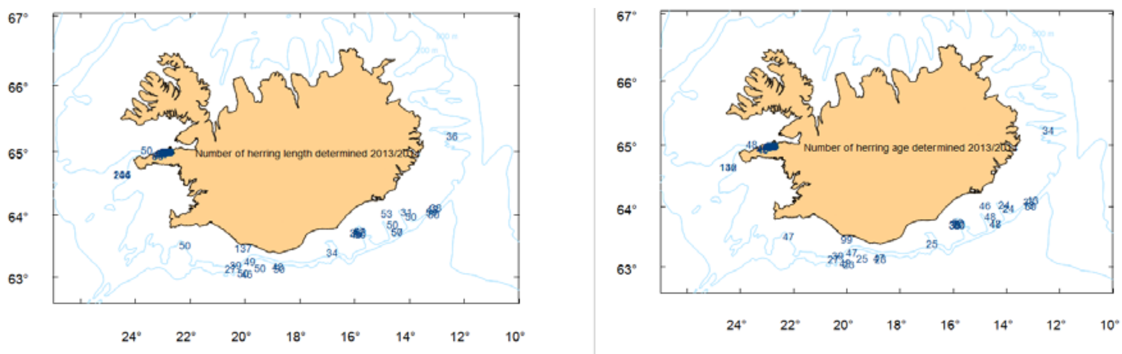


Figure 11.2.2.1. The distribution of samples, and number of fish taken for length measurements (to left) and age determination (to right) as indicated on graphs form the fishery of Icelandic summer-spawning herring in June 2013 to March 2014.

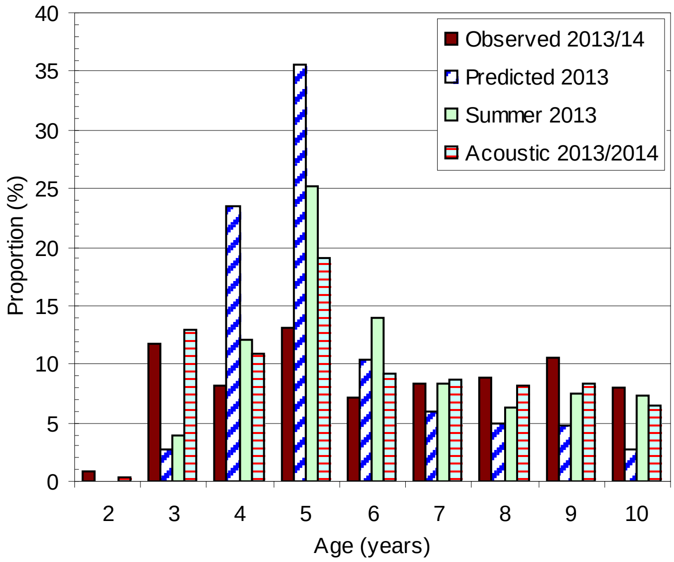


Figure 11.2.2.2. Proportion of the different age groups of Icelandic summer-spawning herring to the total catches (biomass) as observed in 2013/2014 fishing season (June 2013-March 2014), predicted in the 2013 assessment (ICES 2013) for the 2013/2014 fishing season, and the summer catches in June-September 2013 in comparison to the age composition in the stock according to the acoustic measurements in the winter 2013/2014.

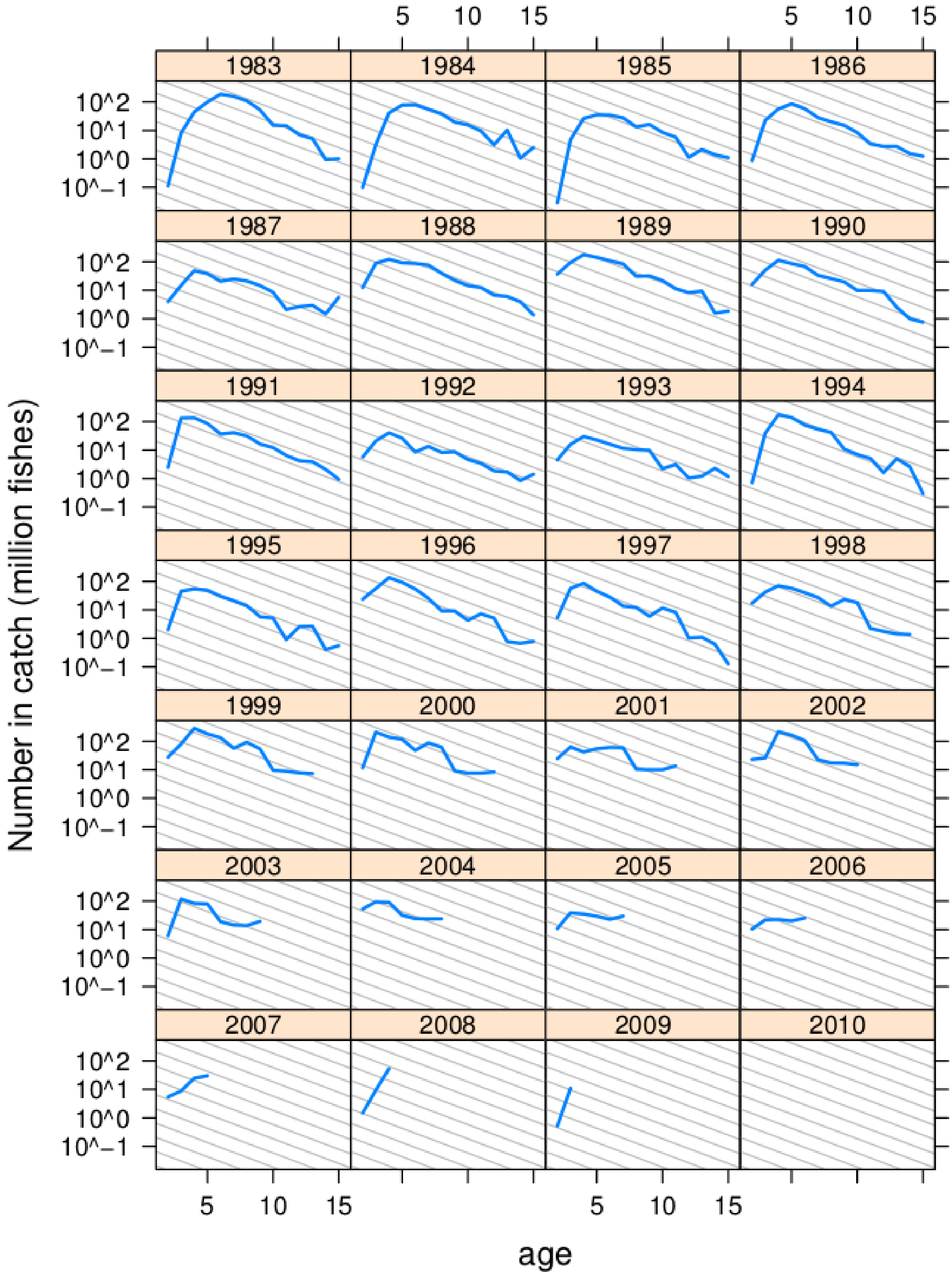


Figure 11.3.1.1. Icelandic summer-spawning herring. Catch curves by year classes 1983-2010. Grey lines correspond to Z=0.4. Note that the mass mortality in Kolgrafafjörður is added to the catches in 2012.

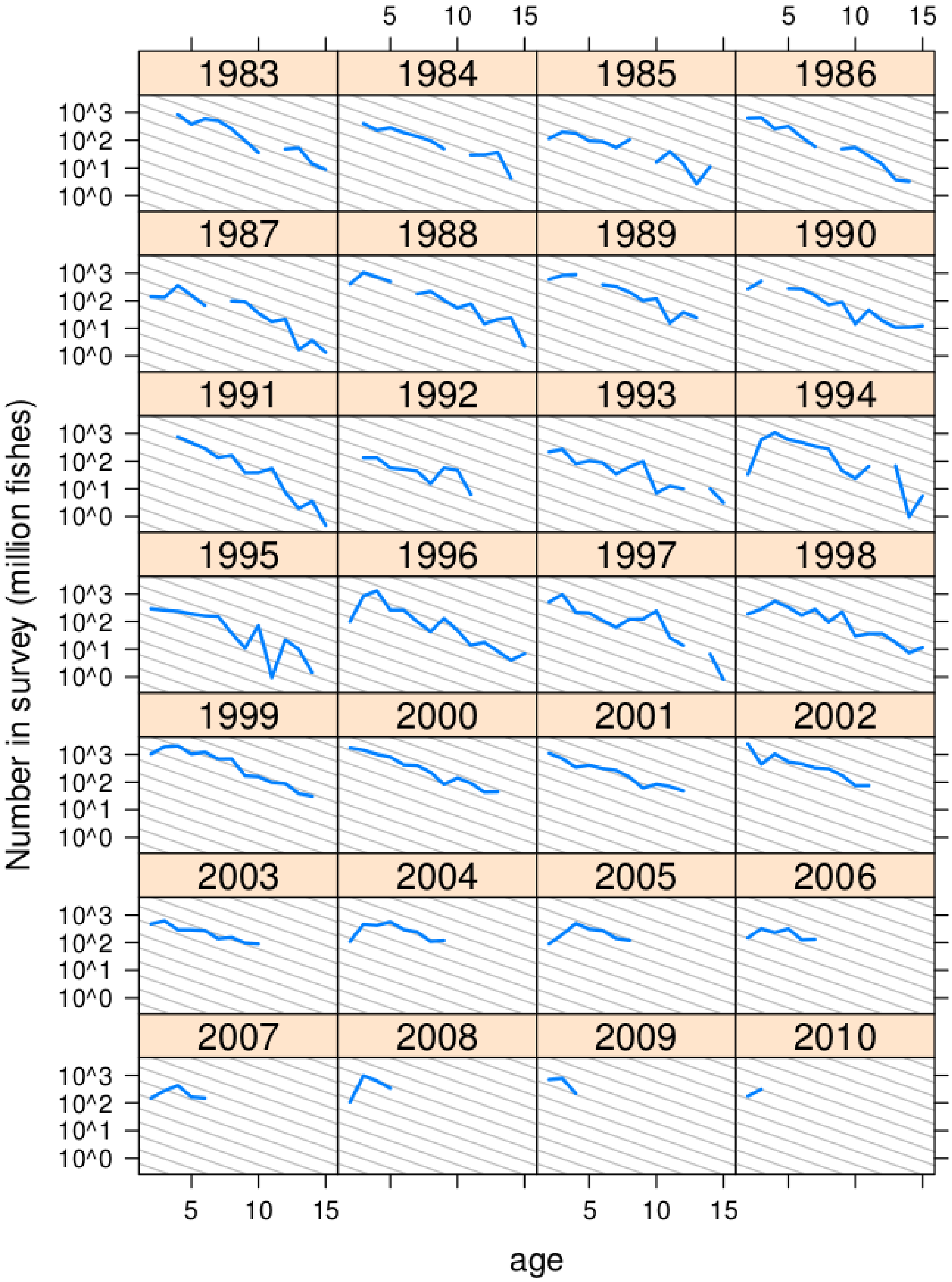


Figure 11.3.1.2. Icelandic summer spawning herring. Catch curves from survey data by year classes 1983-2010. Grey lines correspond to Z=0.4.

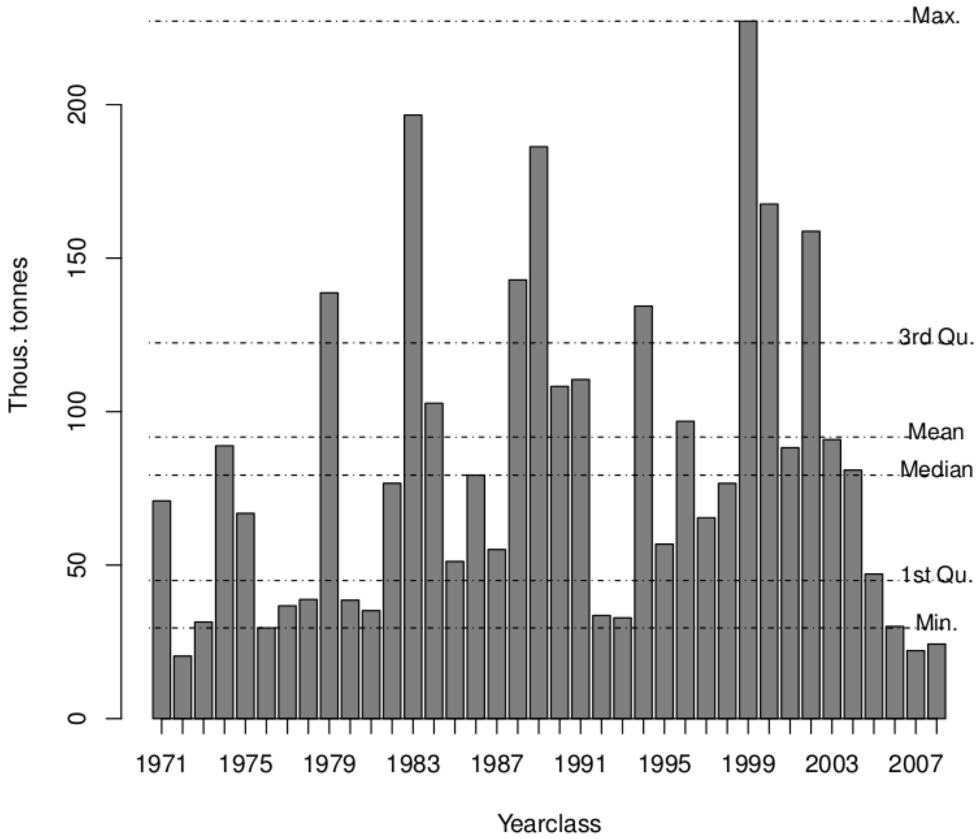


Figure 11.3.1.3. The sum of total catch of each year class of Icelandic summer-spawning herring from 1971 to 2008 based on catch data from 1975-2013. The provided summary statistic is based on year classes from 1973 to 2002.

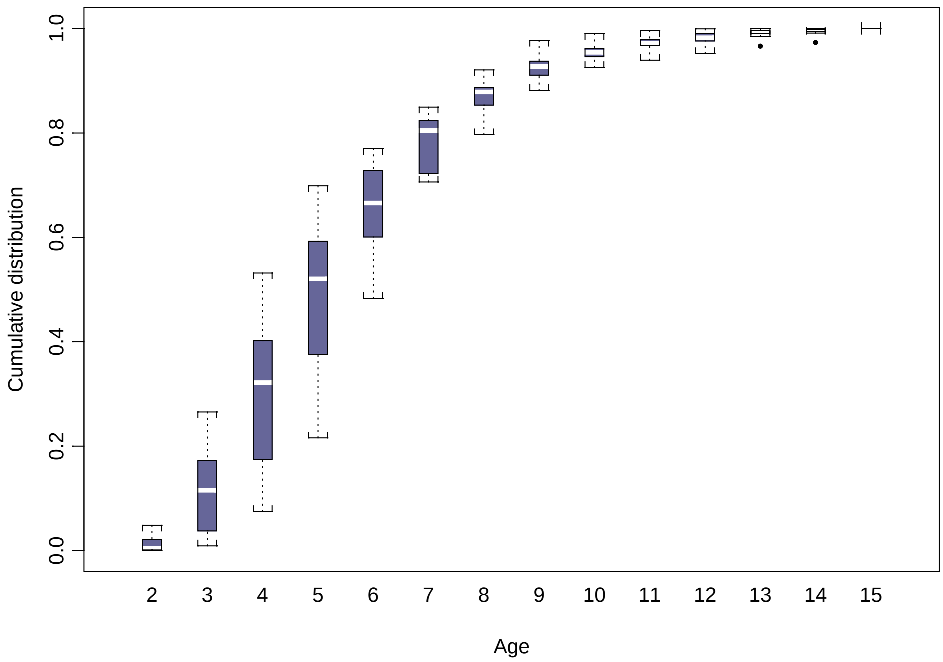


Figure 11.3.1.4. The cumulative total biomass in the catch (in proportion) of Icelandic summer-spawning herring for different age group for the year classes 1978 to 1996.

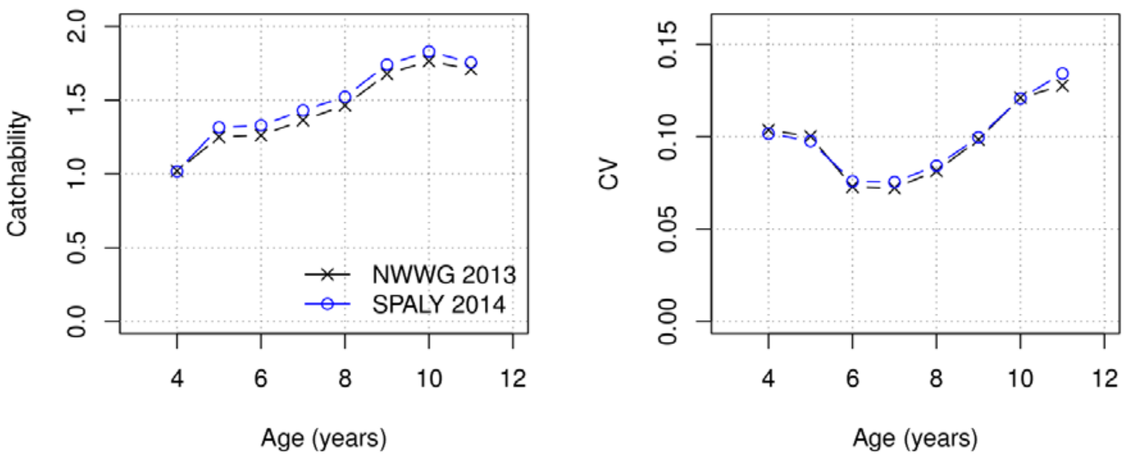


Figure 11.3.2.1. Icelandic summer-spawning herring. The catchability (± 2 SE) and its CV for the acoustic surveys used in the final Adapt run in 2014 (1987-2013) compare to the assessment in 2013.

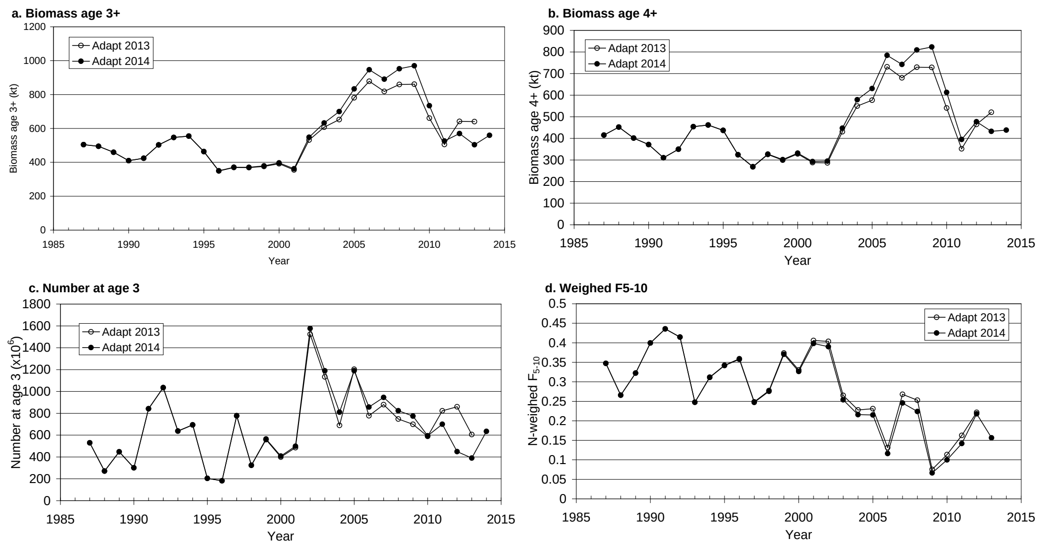


Figure 11.3.2.2. Icelandic summer-spawning herring. Comparisons of NFT-Adapt runs in 2014 and in 2013 concerning (a) biomass of age 3-12, (b) biomass of age 4-12, (c) number at age 3, and N-weighed F for age 5-10. Note that the mass mortality in Kolgrafafjörður in the winter 2012/13 of total 52 kt has been subtracted from the biomass estimate in 2013 from Adapt run in 2013 to be comparable, and the weighed F for 2012 includes only catches for the same reason.

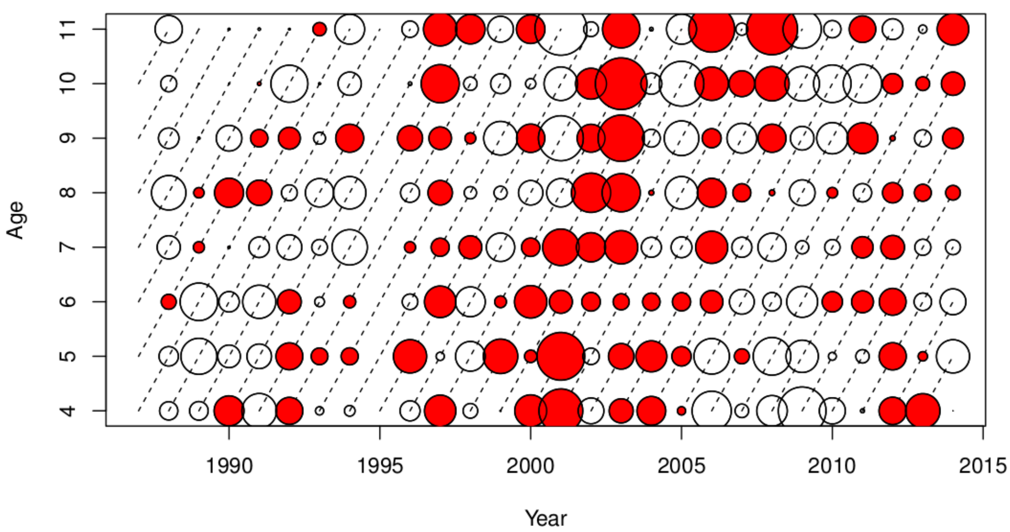


Figure 11.3.2.3. Icelandic summer spawning herring. Residuals of NFT-Adapt run in 2014 from survey observations (moved to 1st January). Filled bubbles are positive and open negative. Max bubble = 1.55.

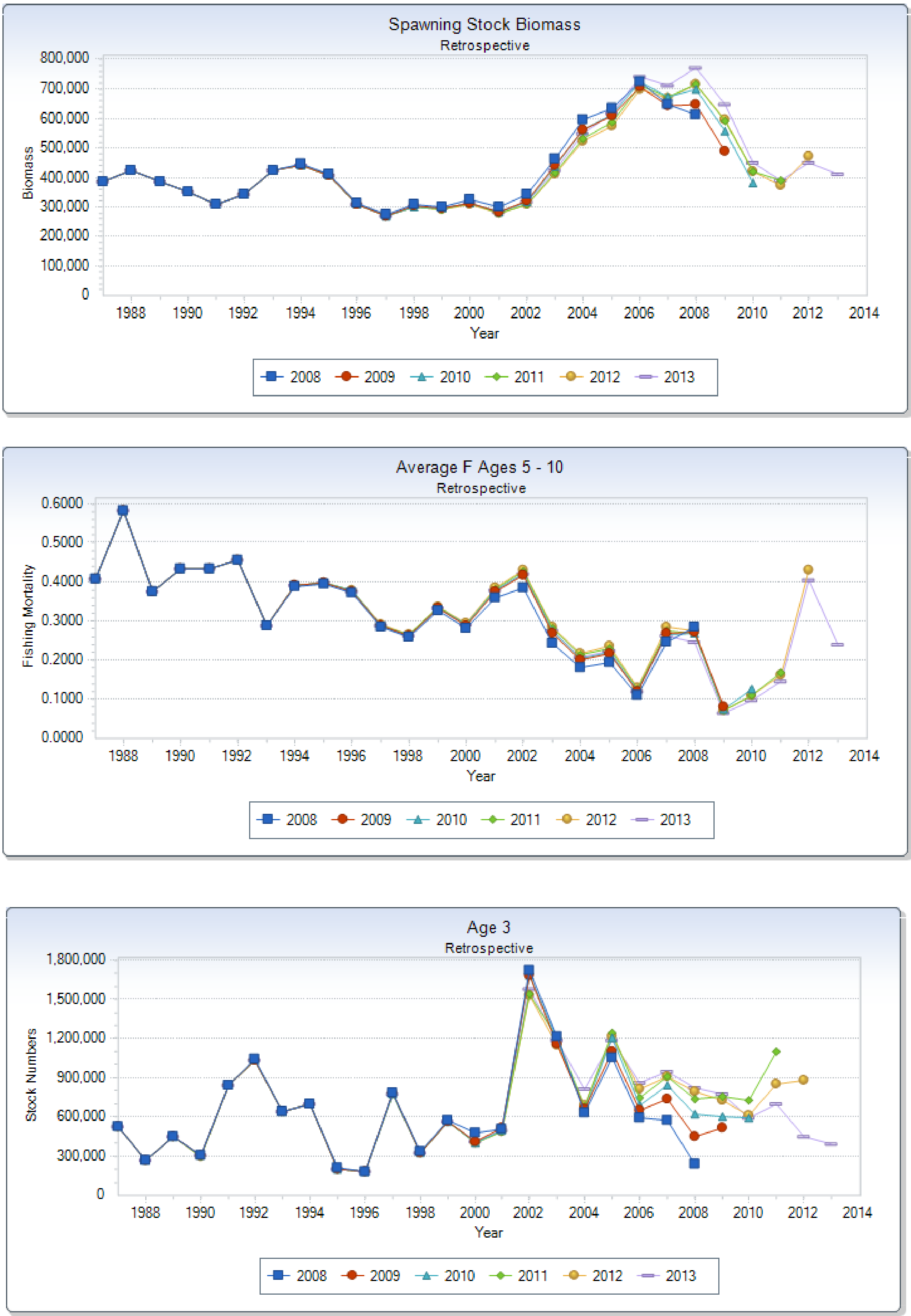


Figure 11.3.2.4. Icelandic summer spawning herring. Retrospective pattern from NFT-Adapt in 2014 in spawning stock biomass (the top panel), N weighted $F_{5\text{-}10}$ (middle panel) and recruitment as number at age 3 (lowest panel).

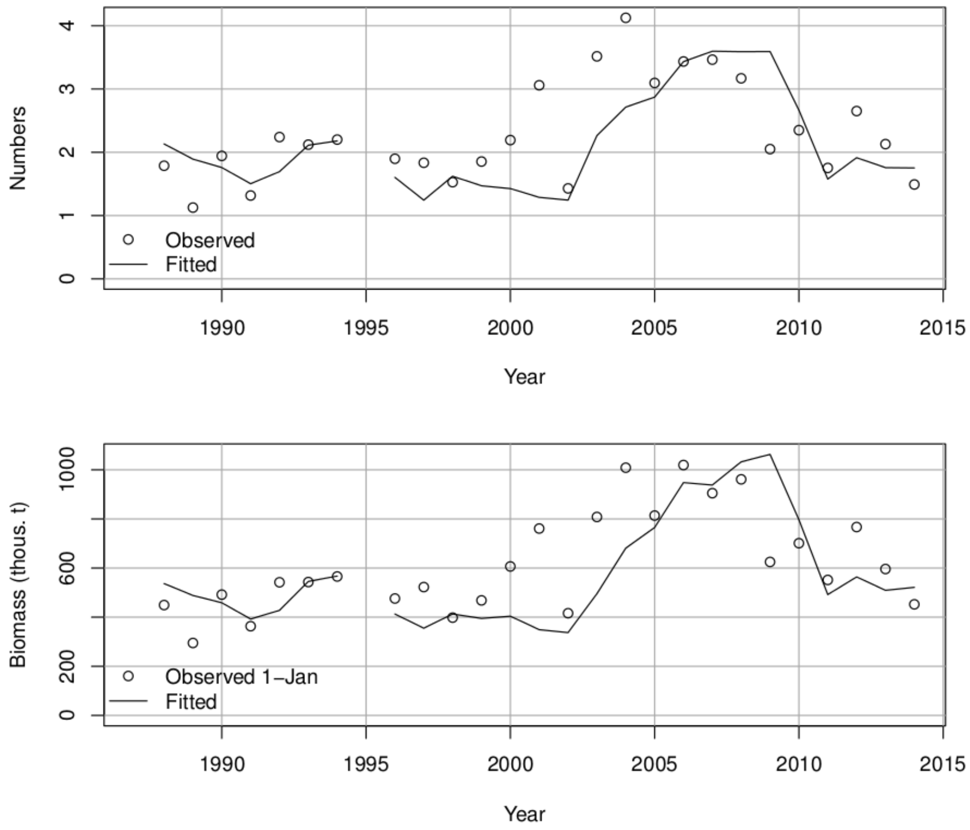


Figure 11.3.2.5. Icelandic summer-spawning herring. Observed versus. predicted survey values for ages 4-11 with respect to numbers (upper) and biomass (lower).

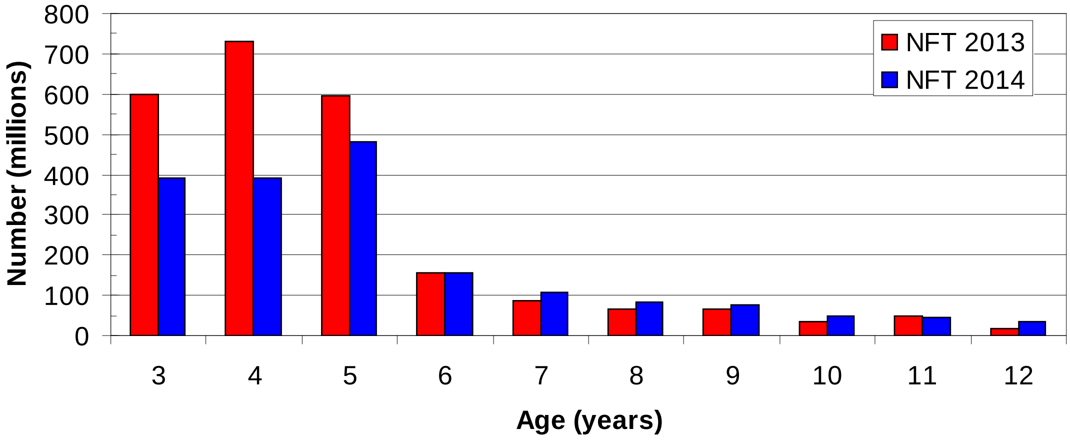


Figure 11.3.2.6. Icelandic summer-spawning herring. Comparison of number-at-age on Jan. 1st. 2013 from the final NFT model runs in 2013 and 2014 assessments (the mass mortality in 2012/2013 has been subtracted from the 2013 values to be comparable).

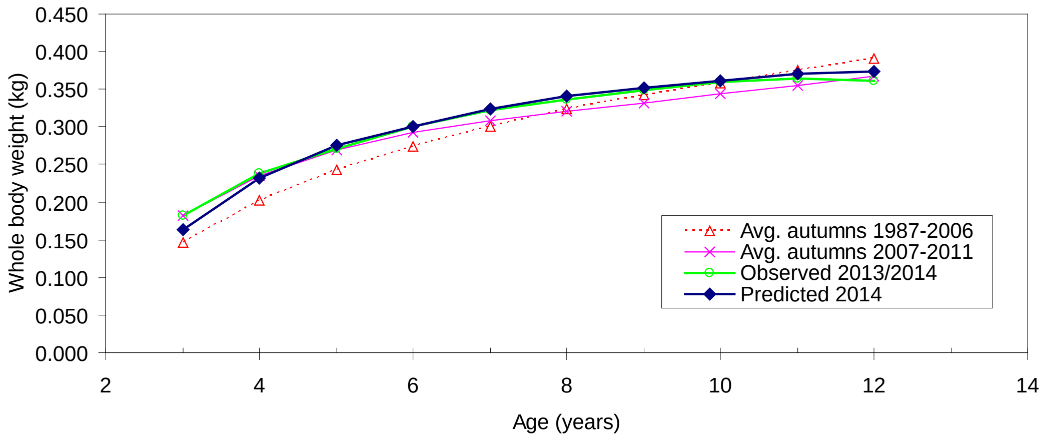


Figure 11.6.1.1. Icelandic summer spawning herring. The mean weight at age for age groups 3 to 12 (+ group) as mean weight across 1986-2006, 2007-2011, observed in the winter 2013/2014, and finally predicted weights for the autumn 2014 from the weights in 2013, which was used in the stock prognosis.

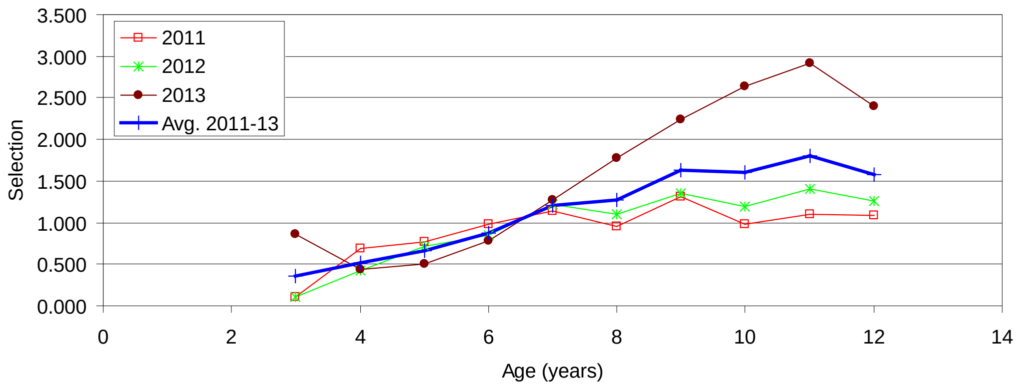


Figure 11.6.1.2. Icelandic summer spawning herring. The selection pattern for age groups 3 to 12 (+ group) for the years 2011 to 2013, and the average selection across these three years.

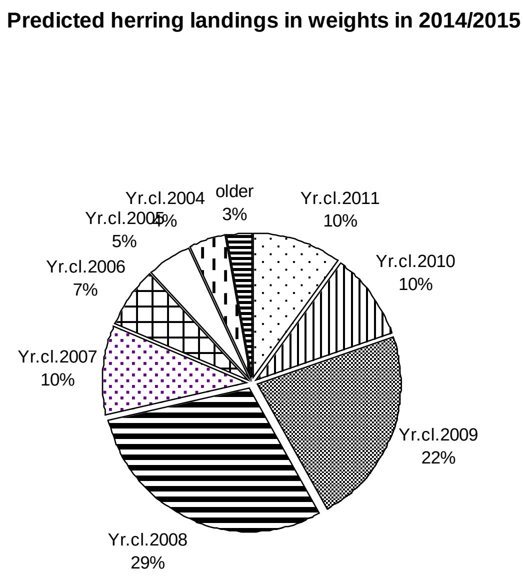


Figure 11.6.2.1. Icelandic summer spawning herring. The predicted biomass contribution of the different year classes to the catches in the fishing season 2014/2015.

12 Capelin in the Iceland-East Greenland-Jan Mayen area

Summary

Fishery

- In March 2013 ICES advised on the basis of precautionary considerations that there should be no fishery until new information on stock size becomes available and it shows a predicted SSB of at least 400 thous. t in March 2014 in addition to a sizeable amount for fishing.
- In October 2013 the Marine Research Institute recommended a TAC of 160 thous. t for the fishing season 2013/2014, based on acoustic survey in September-October 2013.
- The fishery started in January 2014.
- Final TAC for the fishing season 2013/2014 was not changed from what it was first set, as all surveys in winter 2014 were judged invalid for assessment purposes.
- The total landings in the fishing season 2013/2014 amounted 142 thous. t.

Mature stock

- Three acoustic surveys were conducted in January-March 2014. None of them was considered complete.
- The final TAC was set on the basis of the survey in autumn 2013.

Juvenile stock

- The annual autumn survey was conducted in 2013.
    - Index for 1 year old capelin from this survey is of an average size.
    - A predicted TAC in 2014/15 is 450 thous. t.
    - As the capelin increases its weight rapidly over the summer it is recommended that the fishery doesn'tstart until late autumn. .

12.1 Stock description and management units

See stock-annex.

12.2 Scientific data

Surveys

The capelin stock in Iceland-East Greenland-Jan Mayen area has been assessed by acoustics annually since 1978. The surveys have taken place in autumn (September-December) and in winter (January-February).

In autumn the main focus has been on locating and estimating the abundance of young capelin (immature at age 1 and 2), but also, if possible, to estimate the abundance of mature capelin. In some years the whole distribution area of capelin couldn't be covered in autumn because of various reasons, such as bad weather and drift ice. The survey didn't cover the mature part of the stock in late 1990s and in the 2000s. The feeding area of young capelin has been more westerly distributed since early 2000s probably due to warmer climate. Consequently the survey area is much wider since then and spread of ice has been a hindrance when surveying in October-December. Therefore, since 2010 the survey in autumn starts about one month earlier as there is then more chance of surveying the area without ice. The indices on young capelin from these surveys are used to predict a starting quota for the fishing season starting in the year after the surveys are conducted. In years, when no starting quota has been available based on surveys of juveniles, it has been set on the basis of these surveys, provided that the survey succeeded to measure the mature stock.

The surveys in winter, January/February, are aimed at the fishable part of the stock. The purpose of these surveys is to assess the size of the fishable stock and on its basis to set a final TAC for the season based on escapement HCR. The winter surveys have most often been used to set a final TAC. However, in the fishing seasons 1985/86, 1987/88, 1992/93, 1993/94, 1995/96 and 1996/97 the autumn surveys were used to set the final TAC for the corresponding fishing season as well as the survey from autumn 2013 (table 12.2.5).

Surveys on 0-group and 1-group in August discontinued in 2004 (ICES 2009a) and are therefore not mentioned further here.

Oceanography/ecology surveys in summer discontinued in 2009 (see Stock Annex).

12.2.1 Surveys in autumn 2013

In 2013 the survey took place in the period 17 September - 4 October. The survey area extended from the continental shelf of East Greenland in the west, north along the continental shelf edge to 73°N, as well as Denmark Strait and the continental slope north off Iceland (Figure 12.2.1). Weather conditions during the survey were for the most part very favourable and no drift ice was encountered during the survey.

Capelin was found widely, almost up to 73°N (Figure 12.2.1). In 2010 the northern limit was 71°N, in 2012 70°30' N, but in 2011 there was a strike, so no information from that year is available.

Immature capelin dominated south of 67°N, but between 67°N and 70°N a mixture of 1 and 2 year old capelin dominated. North of 70°N mainly 2 and 3 year old maturing capelin was found. The combined index of young capelin (immature at age 1 and 2) in 2013 is slightly above average (Tables 12.2.1-12.2.2 and Figure 12.2.2). The index of young capelin in the autumn surveys has been the basis for the starting quota for many years, see further chapter 12.7.

In this survey around 600 thous. t of mature capelin was measured (Tables 12.2.1-12.2.3). On the basis of this estimate of the mature stock the Marine Research Institute recommended a TAC of 160 thous. t for the fishing season 2013/2014. This recommendation was in accordance with existing HCR and management plan between Iceland, Norway and Greenland.

12.2.2 Surveys in winter 2014

Three surveys were conducted in winter 2014. The first one was conducted in January 17-22. The survey tracks are shown in Figure 12.2.3. On the continental slope east off Iceland only 1 year old capelin was found and close to Kolbeinseyjarridge in the north only very scattered schools were found. They were not acoustically measured. At that time the fishing fleet was at the traditional fishing grounds north-east off Iceland, but only located poor recordings of capelin, so it was decided to stop the survey until further information became available.

The second survey in the winter started 14 February. The cruise lines are shown in figure 12.2.4. Two research vessels scanned the area outside the Westfjords, but there were no sign of a western migration. From 16-18 February the spawning migration was acoustically measured along the south coast (Figures 12.2.4 and 12.2.5). The measurement was done against the spawning migration, so the results is considered to be an underestimate. When trying to measure it again, bad weather became a hindrance. This measurement was done close to the shore, which is not considered favourable for acoustic measurements. During this time there were news of capelin from the fishing grounds all around Iceland and for example almost 6 thous. t were taken by the Norwegian fleet north of Iceland. It was therefore concluded that the survey had failed to cover the whole mature part of the stock. The size of the maturing part was estimated to be around 340 thous. t. At the time of the survey 60 thous. t had been fished. The results from the survey are shown in table 12.2.4.

In the beginning of March capelin were observed on the fishing grounds off Westfjords. An acoustic estimate was done during 5-6 March. Cruise lines are shown in Figure 12.2.6. Around 14 thous. t were estimated to be in the surveyed area. This survey therefore only covers a very little part of the stock distribution.

As the surveys in January-March were not considered valid, regarding coverage of the mature stock, the TAC for the fishing season was not revised on their basis. The total TAC for the 2013/2014 fishing season was therefore set on the basis of the autumn survey in 2013 to 160 thous. t.

It is unfortunate that the survey in winter 2014 was not valid for assessment purposes. Now only 2 pairs are available for comparison since the surveys in autumn started a month earlier, that is the surveys in autumn 2010 and 2012 vs. the surveys in winter 2011 and 2013. In 2011 there was no survey in autumn due to a strike, however a valid winter survey was conducted in 2012.

12.3 Fishery dependent data

No preliminary catch quota was recommended for the 2013/2014 fishing season as the autumn survey in 2012 did not record enough juvenile capelin. However as the autumn survey in 2013 estimated the spawning stock to be around 600 thous. t a recommendation of quota of 160 thous. t was given for the fishing season 2013/2014.

The distribution of the catches, based on logbooks for the Icelandic fleet, is shown in Figure 12.3.1. It represents the distribution for all fleets. The fishery started in the second week of January at the traditional fishing grounds north, north-east of Iceland. In the 2^{nd} and 3^{rd} week about 24 thous. t in total were caught. In week 4 and 5 nothing was caught despite an intensive search of the fleet, but at that time 30 Norwegian vessels were on the fishing grounds. The fishery began again in week 6 at the south coast of Iceland, from where it then followed the spawning migration to the west off Iceland.

The total annual catch of capelin in the Iceland-East Greenland-Jan Mayen area since 1964 is given by weight, season, and fleet in Table 12.3.1 and Figure 12.3.2. The catches of this fishing season, 2013/2014, is the 7th lowest since the beginning of the fishery.

Sampling from commercial catches is not considered to be adequate. From the Icelandic fleet 29 samples (2764 length measured and thereof 2762 age read) were taken, 1 sample was taken by the Norwegian fleet and no samples were taken by either the Faroes or the Greenlandic fleet. Based on the 29 Icelandic samples catches in numbers were calculated for the fishery in winter 2014.

The total catches in numbers by age during the summer/autumn since 1985 are given in Table 12.3.2 and for the winter since 1986 in Table 12.3.3. Similar age distribution was observed in the catches 2014 as in the survey in autumn 2013.

Preliminary and final TAC as well as landings for the fishing seasons since 1992/93 are given in Table 12.3.4.

12.4 Growth

In this section an overview of the growth of capelin in the Iceland-east Greenland-Jan Mayen area in the year before spawning will be given. The capelin spawn in March at age 3 and 4 and the spawning stock is dominated by the younger age group. Analyses of weight increase of capelin, both in relation to length and to age, was done by Vilhjálmsson (1994) for the period 1979-1992, but a comparable study is missing for the years after 1993. This comparable study, for the period 1979-2013, is done by using data from the annual acoustic surveys in autumn in the years 1979-2013. Vilhjálmsson used sex disaggregated data on a biomonthly basis, but in this study the data are not sex disaggregated and the time step is a year.

Figure 12.4.1 shows the relation of the mean weight of a year class as immature at age 1 and as mature 2 years old. The average mean weight over the whole period for age 1 is 4.6 g and for the mature part of age 2 it is 16.6 g. This is almost 4 fold weight increase during one year (from autumn to autumn). There is a time trend in this figure, as it seems that the year classes in the 2000s are heavier at age 1 than those in the 1980s and 1990s. They do however increase the mean weight as the others. Figure 12.4.2 shows the increase in weight from age 1 to age 2 each year and a 3 year running mean. As the one year old are heavier in the last years, then the weight increase is less in the last years than in the years before 2000s, however still between 200% and 300%.

For the older year class this looks different (figure 12.4.3). As for the younger age groups, the weight showed a large increase over the year, as the average mean weight for immature at age 2 is 9.0 g and 22.5 g for mature capelin at age 3. This is a 2.5 fold increase in weight in one year. However, the weight increase was not related to the initial weight as for the younger age groups.

The active feeding season for capelin is considered to start in May (Vilhjálmsson, 1994) and continues until it starts the spawning migration in late autumn. Taking that into account, it is clear that huge weight increase takes place during summer for these two age groups, especially the younger age group (age 2 in the summer) which dominates in the spawning stock in the following year. These findings are in accordance with the results from Vilhjálmsson, namely the weight increase is huge in the year before spawing.

12.5 Methods

See the NWWG report from 2012.

12.6 Reference points

Reference points have not been defined for this stock. 400 000 t has been used as an escapement target.

12.7 State of the stock

The objective of the HCR for the stock is to leave 400 thous. t for spawning. It is estimated that that 424 thous. t were left for spawning in spring 2014 (Table 12.7.1 and

12.7.2 Figure 12.7.1). Since 1979 the spawning stock biomass has been below the target SSB seven times, thereof once in the last 23 years. The SSB has, on the other hand, been slightly above the target SSB since 2006, with the exception of 2009, when it was below.

The acoustic indices of recruits are considered to be close to an average size.

12.8 Short term forecast

In the years 1978-1990 indices from acoustic surveys in August were used to predict quota, but since 1991 indices from acoustic surveys in October/November (Table 12.2.2) have been used. Therefore data for the years 1978-1990 from table 12.2.2 can't be related to advice given in those years. In the years 1978-1982 the preliminary quota was set on arbitrary grounds, resulting in too high quota, SSB below the target of 400 thous. t in 1980-1983 and closure of the fishery in the fishing season 1982/1983. In order to try to do better a model was made to predict the quota. It was used for predicting quotas for the fishing seasons 1983/84-1990/91, but at the end of the period it predicted too high quotas and consequently the SSB fell below the target, so the model was abandoned.

Since 1991 another model has been in use for predicting a quota. It was however rejected by WKSHORT in 2009, but has been used once after that (for the 2011/12 fishing season), but then with more caution. Indices from the autumn surveys from 1991-2001, 2006 and 2010 were used to set an initial quota in the fishing seasons starting a year later. In 2003 and 2004 the fishery was opened after a survey in June and July respectively. In other years the fishery has been opened after an in-season survey. The fishery was closed in 2008/09, but 15 thous. t were assigned to scouting vessels (table 12.2.4).

The survey in autumn 2013 is considered to be valid for assessment purposes. The index of young capelin is close to an average size (Figure 12.2.3, Tables 12.2.1, 12.2.2). It should though be born in mind, that the surveyed area since 2010 is much larger than before 2010 and it is not known if the numbers before and after 2010 are quite comparable. Like last year, three different methods were used to explore the size of the SSB almost one and a half year after the survey takes place, this time then the SSB in spring 2015.

Projection model.

This method was first used in 1992/93, but was rejected by WKSHORT in 2009. The main reasoning was the value of M=0.035 per month, which is considered too low. Another issue identified by the WKSHORT was the intercept. The model is described in Gudmundsdottir and Vilhjálmsson, 2002.

The new data (2013) was added to the time-series. Input data is given in table 12.8.1 and 12.8.2. Data from the acoustic surveys in 2004, 2005, 2007-2009 and 2011 were not used as they are not considered to be valid due to different reasons, but the main reason being lack of coverage due to drift ice in E-Greenland waters. The updated regressions are shown in Figure 12.8.1. By applying this method a zero index for age 1 gives 20.28 millions at age 2 (intercept of 20.28), resulting in a SSB of almost 300 thous. t at spawning time one and a half year after the survey is conducted and using long term average mean weight at age. The residuals from the regression indicate that the regression performs better at medium and high values than at low values, as then the observed values lie all below the fitted line, which makes it questionable if the regression can be used at low values. This year the index of 1 year old is at the lower range of the zone where the regression is considered to behave better. Like last year the predictor in regression 2 lies in the lower range, but opposite to last year it contributes to the SSB, though only just with 30 thous. t.

This method estimates the SSB to be 850 thous. t in spring 2015 if no fishery takes place (Table 12.8.3). The contribution of the older year class is only just 30 thous. t. Based on this model the predicted TAC for the fishing season 2014/2015 is 450 thous. t. According to the management plan 2/3rd of it is allocated as an initial quota, that is 300 thous. t.

Zero intercept regressions.

An alternative procedure to the one above, is to make the regressions go through the origin (figure 12.8.3). For low indices the residuals have similar pattern as in the 'projection model', but in the opposite direction. Bigger changes are observed in the residuals for higher indices. This 'zero intercept regression' causes less problems at low index values. For the older age group the regression gives slightly higher values that in the 'projection model'. This method estimates the SSB in spring 2015 to be 832 thous. t if no fishery takes place (Table 12.8.3).

Simple forward projection.

By using a standard ICES procedure (a simple forward projection) it is assumed that the indices are absolute. A natural mortality pf M=0.035/month is used, but this assumption of M was, among other things, the reasoning for not endorsing the projection model by WKSHORT 2009 as it was considered too low. This method doesn't involve specific issues when index is low. By assuming no fishery on juveniles in 2013/14 and 2014/15 this method gives a SSB of 703 thous. t in spring 2015 (Table 12.8.3).

Summary.

The three methods above estimate the SSB in 2015 to be in the range from 703 thous. – 850 thous. t if no fishery takes place (Table 12.7.1). The highest number is derived with the projection model abandoned by WKSHORT in 2009. This model predicts a TAC of 450 thous. t. Due to uncertainties in the projection model and the approach for calculating the TAC, it has been suggested that the fishery should not be opened until after an acoustic survey (in autumn/winter) if the predicted TAC < 500 thous. t (Gudmundsdottir and Vilhjálmsson, 2002).

12.9 (Medium term forecasts)

12.10 Uncertainties in assessment and forecast

The uncertainty of the acoustic estimates of the stock depends largely on the uncertainty of the echo abundance. The CV of the bootstrapped EA in the survey in autumn 2013 was not evaluated. It was however done for the survey in autumn 2012 and it was in the range of 0.26-0.3 dependent on the sizes of the rectangles used in the grid.

The uncertainty when calculating the stock size by a deterministic method used so far is the value of M. A fixed value of M=0.035/month has been used, but it may be too low according to WKSHORT 2009. The same applies for the short-term prediction.

12.11 Comparison with previous assessment and forecast

For the fishing season 2013/2014 there was no predicted TAC based on survey on young capelin in October 2012. The first quota set for the fishing season was 160 thous. t and it was the final TAC too as all surveys in winter were not deemed valid for assessment purposes. The landings were 142 thous. t.

According to the HCR 400 thous. t shall be left for spawning. It is assumed that around 424 thous. t spawned in spring 2014.

12.12 Management plans and evaluations

In June 1989 Greenland, Iceland and Norway signed a management plan. It has been revised several times since then, most recently in 2003.

The fishery is managed according to a two-step management plan which requires a minimum spawning-stock biomass of 400 thous. t by the end of the fishing season. The first step in this plan is to set a preliminary TAC based on the results of an acoustic survey carried out to evaluate the abundance of immature (age 1 and age 2) part of the capelin stock about a year before it enters the fishable stock. The preliminary TAC is set at 2/3 of the predicted TAC, calculated on the condition that 400 thous. t of the SSB should be left for spawning. The second step is based on the results of another survey conducted during the fishing season for the same year classes. This result is used to revise the TAC and set the final TAC, still based on the condition that 400 thous. t should be left for spawning.

ICES has not evaluated the management plan with respect to its conformity to the precautionary approach.

12.13 Management considerations

The fishing season for capelin has since 1975 started in the period from late June to July/August (when surveys on the juvenile part of the stock the year before has resulted in the setting of a preliminary catch quota). At that time the availability of plankton is at its highest and the fishable stock of capelin is feeding very actively over large areas north of Iceland between Greenland and Jan Mayen, increasing rapidly in size, weight and fatness. By late September/beginning of October this period of rapid growth is over. The growth is fasted the first two years, but the weight increase is most in the year before spawning.

Taken into account the large weight increase in the summer before spawning (section 12.4) it is clear that more catches are gained by the same effort if the fishery starts late autumn instead of summer. This is also supported by information for the Barents Sea capelin, but is has been shown for that stock that fishing during autumn would maximize the yield, but from the ecosystem point of view a winter fishery were preferable (Gjøsæter *et.al.,* 2002). As the biology of these two capelin stocks is similar and their effect on the ecosystem too, this is considered to be valid for the Icelandic capelin too.

Seasonal variation of fat content is also obsered. During the summer period, the fat content rises from approximately 5% to 20% in late autumn before spawning (Figure 12.1.1, Engilbertsson et. al. 2012). In the following fall and winter the fat content slowly declines, until the spawning migration begins in early January where the fat content drops drastically from about 15% to 5% in mid-April. Immature capelin has much lower fat content, usually less than 3-4%.

During the summer and autumn, survey results show often overlap between juveniles and adult capelin. It has been reported by fishermen that while fishing with pelagic trawl in such areas, the catches are often poorer than expected from echo signals than when fishing in areas where there is only adult capelin. That might indicate greater escapement of juveniles through meshes. The effect of such escapement on the fish is unknown.

12.14 Ecosystem considerations

Capelin is an important forage fish and its dynamics are expected to have implications on the productivity of their predators, see further in section 7.3.

12.15 Regulations and their effects

Over the years the fishery has been closed during April - late June and the season has started in July/August or later, depending on the state of the stock.

Areas with high abundances of juvenile age 1 and 2 capelin (on the shelf region off NW-, N- and NE-Iceland) have usually been closed to the summer and autumn fishery.

It is permissible to transfer catches from the purse-seine of one vessel to another vessel, in order to avoid slippage. However, if the catches are beyond the carrying capacity of the vessel and no other vessel is nearby, slippage is allowed. In recent years, reporting of such slippage has not been frequent. Industrial trawlers do not have the permission to slip capelin in order to harmonize catches to the processing.

In Icelandic waters, fishing with pelagic trawl is only allowed in limited area off the NE-coast (fishing in January) to protect capelin juveniles and to reduce the risk of affecting the spawning migration route.

A regulation calling for immediate, temporary area closures when high abundance of juveniles are measured in the catch (more than 20% of the catch composed of fish less than 14 cm) is enforced in Icelandic waters, using on-board observers.

12.16 Changes in fishing technology and fishing patterns

Variable amount of the catches have been taken with pelagic trawl through the fishing seasons. Total landings in 2013/14 amounted 142 kt (80% purse-seine, 20% pelagic trawl). Discards are considered negligible.

12.17 Changes in the environment

Icelandic waters are characterized by highly variable hydrographical conditions, with temperatures and salinities depending on the strength of Atlantic inflow through the Denmark Strait and the variable flow of polar water from the north. Since 1996 the quarterly monitoring of environmental conditions of Icelandic waters shows a rise in sea temperatures north and east of Iceland, which probably also reaches farther north and northwest, as well as on the spawning grounds at South- and Southwest Iceland. It has been put forward in the 2000s that this temperature increase, may have led to displacements of the juvenile part and the spawning areas of the capelin stock (Vilhjálmsson, 2007). The acoustic surveys in autumn 2010, 2012 and 2013 partly confirmed this, but major part of the spawning still takes place on the usual grounds.

More detailed environmental description is in section 7.3.

12.18 Benchmark workshop

The Icelandic capelin was on the agenda list at the benchmark meeting WKSHORT in 2009, but both the assessment model and the forecast model were not endorsed by the group, the main reasoning being the natural mortality M was considered being too low. A benchmark workshop for the Icelandic capelin is scheduled early 2015 together with the capelin stock in the Barents Sea and other stocks.

Icelandic capelin is a short lived species spawning in March at age 3 or 4, with nearly total spawning mortality. The stock is monitored by two acoustic surveys, in the autumn and winter.

The natural mortality, M=0.035, was considered being too low. Capelin is an important forage species for capelin, so it is important to quantify the predation on capelin by cod during the spawning migration. The autumn survey targets both the immature and mature part of the stock while the winter survey is conducted on the mature part of the stock during spawning migration. In the 1980s and early 1990s the autumn surveys often covered the whole stock, but failed in many year to do so in late 1990s and 2000s. In 2010 the area coverage of the autumn survey was increased to try to cover the stock completely. As the 2011 autumn survey was not conducted only few autumn-winter pairs are available to verify the "new" series.

The acoustic survey in winter has usually been the basis of final TAC, but it is treated as absolute measure of stock size. Since 1979 there has been a requirement of leaving 400 000 t for spawning in spring, but spawning takes place around 1.5-2 months after the survey takes place. The stock is projected forward with a fixed natural mortality of 0.035/month. This value of natural mortality was obtained from eight pairs of autumn-winter measurements from 1979 – 1989. Comparison of estimated predation on capelin in autumn from stomach content data and the estimated M indicates that the predation is at least 2 times the amount lost due to natural mortality. Likely explanation is that availability in the autumn survey is lower than in the winter survey.

The topics considered will be:

- Quantify the predation on capelin from the January-February acoustic survey in the spawning. Try to identify temporal pattern and variability in the predation.
- Conduct stochastic predictions, using bootstrap replicas of the acoustic measurements and predation. Fifth percentiles of the spawning stock will be evaluated against Blim, that needs to be defined. This procedure needs to be compared against the current escapement stragety of leaving 400 thous. tonnes for spawning. This procedure is comparable to what is currently done in the Barentssea.
- The forecast model used since 1992 to set preliminary quota based on abundance of juveniles in the autumn was rejected by WKSHORT in 2009. It is based on relationships between indices from autumn surveys and assessments of the same year classes at older ages. As the forecast model is only used to set an initial quota for a fishing season (the final TAC is set during the fishing season itself) a simple model is needed, preferably based only on indices from acoustic assessment surveys. The indices used in the forecast model are treated as relative so the value of natural mortality does not matter if it is fixed. Possible temporal patterns in the relationship that could indicate changes in M will be identified and included if they are considered important.
- Prediction of the mature part of stock from the autumn survey will be analysed as occasionally the autumn survey will have to be used as basis of final TAC. This will be done in similar way as for the January-February survey. Effects of predation are greater as it extends over longer period. Catchability in the survey is most likely less than 1 but negatively correlated with average value of M.

- Changes in the nursery/feeding areas have been observed. Since early 2000s they are more westerly distributed than before probably due to warmer climate. Recent research data in Icelandic Sea and adjacent waters will be analysed.
- Discards is considered negligible in the assessment. However purse-seiners have sometimes had to slip catches exceeding their capacity. An attempt will be made to quantify the reported amount by using logbook data.
- Reference points, B_{lim} and $B_{escapement}$ will have to be defined. Changing M will change the 400 thous. tonnes historically and it needs to be checked what value of B_{lim} is comparable to the current escapement biomass under normal conditions.

12.19 References

Engilbertsson, V., Óskarsson, G.J. and Marteinsdóttir, G. (201). Inter-annual Variation in Fat Content of the Icelandic Capelin. ICES CM 2013/N:26.

Gjøsæter, H., Bogstad, B., and Tjelmeland, S. 2002. Assessment methodology for

Barents Sea capelin, Mallotus villosus (Müller). – ICES Journal of Marine Science, 59:

1086–1095.

Vilhjálmsson, H. (2007). Impact of changes in natural conditions on ocean resources. Law, science and ocean management 11, 225.

Table 12.2.1 Capelin. Acoustic assessment of capelin in the Iceland/Greenland/Jan Mayen area, by r/v Arni Fridriksson 17/9-4/10 2013 (Numbers in millions, biomass in tonnes).

Table 12.2.2. Icelandic Capelin. Abundance of age-classes in numbers (10^9) measured in acoustic surveys in autumn.

Year	Mon	Day	age1	age1	age2	age2mat	age3	age3mat	age4	age5
			imm	mat	imm	mat	imm	mat	mat	mat
1978	10	16				60.0		13.9	0.4	
1979	9	25	22.0			42.0		8.0	0.1	
1979	10	14	10.0			49.7		9.1	0.4	
1980	10	11	23.5			19.5		4.8		
1981	10	14	0.9			7.0		0.2		
1981	11	3	2.7		1.4	16.6		0.3		
1981	11	26	21.0		1.1	11.9		0.6		
1982	10	2	68.0		1.7	15.0		1.6		
1983	10	3	44.1		8.2	58.6		5.6	0.1	
1984	11	1	73.8		4.6	31.9		10.3	0.3	
1985	10	8	33.8		12.6	43.7		14.4	0.4	0.1
1986	10	4	58.6		1.4	19.9		29.8	0.3	
19872)	10	7	21.3		0.7	17.1		4.1	0.1	
1987	11	18	2.6		2.5	52.0		13.5		

Year	Mon	Day	age1	age1	age2	age2mat	age3	age3mat	age4	age5
			imm	mat	imm	mat	imm	mat	mat	mat
1988	10	6	43.9		6.7	53.0		17.0	0.4	
1989	10	26	29.2		1.8	2.9		0.6		
1989	12	5	0.2		0.4	4.5		0.4		
1990	10	1	27.2					0.9		
1990	11	8	24.9		1.3	16.4		2.7	0.1	
1990	12	8	2.4					1.2		
1991	10	5	48.1		5.2	37.7		1.9		
1991	11	15	60.0		5.3	44.7		4.2		
1992	10	13	104.6		2.3	54.5		4.3	0.1	
1993	11	18	100.4		9.8	55.1		4.9		
1994	11	25	119.0		6.9	29.2		4.4		
1995	11	30	165.0		30.1	84.6		7.0		
1996	11	27	111.9		16.4	70.0		15.9		
1997	11	1	66.8		30.8	52.5		8.5		
1998	11	13	121.0		5.9	20.5		3.3		
1999	11	15	89.8		4.4	18.1		0.9		
2000	11	10	103.7		10.9	11.6	0.1	0.6		
2001	11	12	101.8		2.4	22.1	0.0	0.7		
2002	11	12	1.0		0.5					
2003	11	6	4.9		3.1	1.7	0.1	0.2		
2004	11	22	7.9		0.1	7.3		0.8	0.0	
20053)	11									
2006	11	6	44.7		0.3	5.2		0.4		
2007	11	7	5.7		0.1	1.3		0.0		
2008	11	17	7.5	5.1	0.4	12.1		1.8		
2009	11	24	13.0	2.4		5.0		0.7		
2010	10	1	91.6	9.6	6.3	25.8	0.1	0.8	0.02	
20114)	11	29	9.0	0.6	3.6	19.9	0.05	2.1		
2012	10	3	18.5	0.9	2.0	21.2	0.07	11.4	0.1	
2013	9	17	60.1	0.6	6.9	25.0	1.3	6.9	0.1	

The number at age 1 is used from this survey even though used=0 for the whole survey.

Scouting vessels searched for capelin. r/s ÁF measured. No samples taken for age determination. Estimated to be < 50 thous. tonnes.

Only limited coverage of the traditional capelin distribution area.

Table 12.2.3. Icelandic Capelin. Mean weight (g) of age-classes measured in acoustic surveys in autumn. (imm=immature, mat=mature).

Year	Mon.	age1	Age1	age2	age2	age3	age3	age4	age5
		Imm.	Mat.	Imm.	Mat.	Imm.	Mat.	mat	mat
1978	10				19.8		25.4	26.3	
1979	9	6.4			15.2		20.8	36.0	
1979	10	6.2			15.7		23.0	20.8	
1980	10	7.3			19.4		26.7		
1981	10	5.8			19.4		19.0		
1981	11	5.1		12.7	19.1		25.0		
1981	11	3.6		12.3	19.4		22.5		
1982	10	3.8		8.5	16.5		24.1		
1983	10	5.1		9.5	16.8		22.5	23.0	
1984	11	2.9		8.3	15.8		25.7	23.2	
1985	10	3.8		8.5	15.5		23.8	29.5	31.0
1986	10	4.0		6.1	18.1		24.1	28.8	
1987	10	2.8		8.9	17.6		25.4	30.7	
1987	11	4.3		8.7	17.9		25.8		
1988	10	3.0		8.0	15.4		23.4	20.9	
1989	10	3.5		8.0	12.9		24.0		
1989	12	4.7		9.0	17.8		26.0		
1990	10	3.7					24.3		
1990	11	3.9		8.4	18.0		25.5	36.0	
1990	12	5.2					29.1		
1991	10	5.3		8.8	16.1		21.9		
1991	11	4.7		7.9	16.3		25.4		
1992	10	3.7		8.6	16.5		22.6	22.0	
1993	11	3.6		8.9	16.2		23.3		
1994	11	3.3		7.9	15.9		23.6		
1995	11	3.7		7.0	14.0		20.8		
1996	11	3.1		7.4	15.8		20.6		
1997	11	3.3		8.5	14.3		20.1		
1998	11	3.5		9.9	13.7		18.8		
1999	11	3.6		8.0	15.4		19.5		
2000	11	3.9		8.5	13.4	13.0	20.8		
2001	11	3.8		8.8	16.3	15.7	23.9		
2002	11								
2003	11	7.2		14.9	17.0	22.6	23.7		
2004	11	7.4		7.6	16.0		18.0	14.5	
2005									
2006	11	3.7		7.9	15.0		16.7		
2007	11	5.5		8.6	14.9		15.8		
2008	11	6.2	11.0	6.9	18.6		22.4		
2009	11	5.1	9.8		20.0		23.8		
2010	10	5.8	12.9	12.2	19.0	12.9	24.0	21.2	

Year	Mon.	age1	Age1	age2	age2	age3	age3	age4	age5
		Imm.	Mat.	Imm.	Mat.	Imm.	Mat.	mat	mat
2011	11	6.8	11.4	11.1	18.7	15.8	24.4		
2012	10	6.5	16.0	15.3	22.0	22.4	28.0	26.6	
2013	9	5.8	12.6	10.9	18.0	11.2	20.9	23.6	

Table 12.2.4. Icelandic Capelin. Assessment of capelin in the Iceland/EastGreenland/Jan Mayen area, by r/v Arni Fridriksson in February 2014 (Numbers in millions, biomass in tonnes).

Table 12.3.1 Capelin. The international catch since 1964 (thousand tonnes).

	Winter season					Summer and autumn season						
Year	Iceland	Nor-way	Faroes	Green-land	Season total	Iceland	Nor-way	Faroes	Green-land	EU	Season total	Total
1964	8.6	-	-		8.6	-	-	-		-	-	8.6
1965	49.7	-	-		49.7	-	-	-		-	-	49.7
1966	124.5	-	-		124.5	-	-	-		-	-	124.5
1967	97.2	-	-		97.2	-	-	-		-	-	97.2
1968	78.1	-	-		78.1	-	-	-		-	-	78.1
1969	170.6	-	-		170.6	-	-	-		-	-	170.6
1970	190.8	-	-		190.8	-	-	-		-	-	190.8
1971	182.9	-	-		182.9	-	-	-		-	-	182.9
1972	276.5	-	-		276.5		-	-		-	-	276.5
1973	440.9	-	-		440.9	-	-	-		-	-	440.9

	Winter season					Summer and autumn season						
Year	Iceland	Nor-way	Faroes	Green-land	Season total	Iceland	Nor-way	Faroes	Green-land	EU	Season total	Total
1974	461.9	-	-		461.9	-	-	-		-	-	461.9
1975	457.1	-	-		457.1	3.1	-	-		-	3.1	460.2
1976	338.7	-	-		338.7	114.4	-	-		-	114.4	453.1
1977	549.2	-	24.3		573.5	259.7	-	-		-	259.7	833.2
1978	468.4	-	36.2		504.6	497.5	154.1	3.4		-	655.0	1,159.6
1979	521.7	-	18.2		539.9	442.0	124.0	22.0		-	588.0	1,127.9
1980	392.1	-	-		392.1	367.4	118.7	24.2		17.3	527.6	919.7
1981	156.0	-	-		156.0	484.6	91.4	16.2		20.8	613.0	769.0
1982	13.2	-	-		13.2	-	-	-		-	-	13.2
1983	-	-	-		-	133.4	-	-		-	133.4	133.4
1984	439.6	-	-		439.6	425.2	104.6	10.2		8.5	548.5	988.1
1985	348.5	-	-		348.5	644.8	193.0	65.9		16.0	919.7	1,268.2
1986	341.8	50.0	-		391.8	552.5	149.7	65.4		5.3	772.9	1,164.7
1987	500.6	59.9	-		560.5	311.3	82.1	65.2		-	458.6	1,019.1
1988	600.6	56.6	-		657.2	311.4	11.5	48.5		-	371.4	1,028.6
1989	609.1	56.0	-		665.1	53.9	52.7	14.4		-	121.0	786,1
1990	612.0	62.5	12.3		686,8	83.7	21.9	5.6		-	111.2	798.0
1991	202.4	-	-		202.4	56.0	-	-		-	56.0	258.4
1992	573.5	47.6	-		621.1	213.4	65.3	18.9	0.5	-	298.1	919.2
1993	489.1	-	-	0.5	489.6	450.0	127.5	23.9	10.2	-	611.6	1,101.2
1994	550.3	15.0	-	1.8	567.1	210.7	99.0	12.3	2.1	-	324.1	891.2
1995	539.4	-	-	0.4	539.8	175.5	28.0	-	2.2	-	205.7	745.5
1996	707.9	-	10.0	5.7	723.6	474.3	206.0	17.6	15.0	60.9	773.8	1,497.4
1997	774.9	-	16.1	6.1	797.1	536.0	153.6	20.5	6.5	47.1	763.6	1,561.5

	Winter season					Summer and autumn season						
Year	Iceland	Nor-way	Faroes	Green-land	Season total	Iceland	Nor-way	Faroes	Green-land	EU	Season total	Total
1998	457.0	-	14.7	9.6	481.3	290.8	72.9	26.9	8.0	41.9	440.5	921.8
1999	607.8	14.8	13.8	22.5	658.9	83.0	11.4	6.0	2.0	-	102.4	761.3
2000	761.4	14.9	32.0	22.0	830.3	126.5	80.1	30.0	7.5	21.0	265.1	1,095.4
2001	767.2	-	10.0	29.0	806.2	150.0	106.0	12.0	9.0	17.0	294.0	1,061.2
2002	901.0	-	28.0	26.0	955.0	180.0	118.7	-	13.0	28.0	339.7	1,294.7
2003	585.0	-	40.0	23.0	648.0	96.5	78.0	3.5	2.5	18.0	198.5	846.5
2004	478.8	15.8	30.8	17.5	542.9	46.0	34.0	-	12.0		92.0	634.9
2005	594.1	69.0	19.0	10.0	692.0	9.0	-	-	-	-	9.0	701.1
2006	193.0	8.0	30.0	7.0	238.0	-	-	-	-		-	238.0
2007	307.0	38.0	19.0	12.8	376.8	-	-	-	-	-	-	376.8
2008	149.0	37.6	10.1	6.7	203.4	-	-	-	-	-	-	203.4
2009	15.1	-	-	-	15.1	-	-	-	-	-	-	15.1
2010	110.6	28.3	7.7	4.7	150.7	5.4	-	-	-	-	5.4	156.1
2011	321.8	30.8	19.5	13.1	385.2	8.4	58.5	-	5.2	-	72.1	457.3
2012	576.2	46.2	29.7	22.3	674.4	9	-	-	1	-	10.0	684.4
2013	454.0	40.0	30.0	17.0	541.0	-	-	-	-	-	-	541.0
2014*	111.4	6.2	8.0	16.1	141.7							

***preliminary, provided by working group members.**

Table 12.3.2 Icelandic capelin. The total international catch of capelin in the Iceland-East Greenland-Jan Mayen area by age group in numbers (billions) and the total catch by numbers and weight (thousand tonnes) in the autumn season (August-December) since 1985.

Year	age 1	age 2	age 3	age 4	Age 5	Total number	Total weight
1985	0.8	25.6	15.4	0.2		42.0	919.7
1986	+	10.0	23.3	0.5		33.8	772.9
1987	+	27.7	6.7	+		34.4	458.6
1988	0.3	13.6	5.4	+		19.3	371.4
1989	1.7	6.0	1.5	+		9.2	121.0
1990	0.8	5.9	1.0	+		7.7	111.2
1991	0.3	2.7	0.4	+		3.4	56.0
1992	1.7	14.0	2.1	+		17.8	298.1
1993	0.2	24.9	5.4	0.2		30.7	611.6
1994	0.6	15.0	2.8	+		18.4	324.1
1995	1.5	9.7	1.1	+		12.3	205.7
1996	0.2	25.2	12.7	0.2		38.4	773.7
1997	1.8	33.4	10.2	0.4		45.8	763.6
1998	0.9	25.1	2.9	+		28.9	440.5
1999	0.3	4.7	0.7	+		5.7	102.4
2000	0.2	12.9	3.3	0.1		16.5	265.1
2001	+	17.6	1.2	+		18.8	294.0
2002	+	18.3	2.5	+		20.8	339.7
2003	0.3	11.8	1	+		14.3	199.5
2004	+	5.3	0.5	-		5.8	92.0
2005	-	0.4	+	-		0.4	9.0
2006	-	-	-	-		-	-
2007	-	-	-	-		-	-
2008	-	-	-	-		-	-
2009	-	-	-	-		-	-
2010	0.01	0.23	0.02	-		0.25	5.4
2011	-	2.45	1.61	-	0.08	4.13	72.1
2012	-	0.2	0.2	-	-	0.4	10.4
2013	-	-	-	-	-	-	-

Table 12.3.3 Icelandic capelin. The total international catch of capelin in the Iceland-East Greenland-Jan Mayen area by age group in numbers (billions) and the total catch by numbers and weight (thousand tonnes) in the winter season (January-March) since 1986.

Year	Age 1	age 2	age 3	age 4	age 5	Total number	Total weight
1986		0.1	9.8	6.9	0.2	17.0	391.8
1987		+	6.9	15.5	-	22.4	560.5
1988		+	23.4	7.2	0.3	30.9	657.2
1989		0.1	22.9	7.8	+	30.8	665.1
1990		1.4	24.8	9.6	0.1	35.9	686.8
1991		0.5	7.4	1.5	+	9.4	202.4
1992		2.7	29.4	2.8	+	34.9	621.1
1993		0.2	20.1	2.5	+	22.8	489.6
1994		0.6	22.7	3.9	+	27.2	567.1
1995		1.3	17.6	5.9	+	24.8	539.8
1996		0.6	27.4	7.7	+	35.7	723.6
1997		0.9	29.1	11	+	41.0	797.6
1998		0.3	20.4	5.4	+	26.1	481.3
1999		0.5	31.2	7.5	+	39.2	658.9
2000		0.3	36.3	5.4	+	42.0	830.3
2001		0.4	27.9	6.7	+	35.0	787.2
2002		0.1	33.1	4.2	+	37.4	955.0
2003		0.1	32.2	1.9	+	34.4	648.0
2004		0.6	24.6	3	+	28.3	542.9
2005		0.1	31.5	3.1	-	34.7	692.0
2006		0.1	10.4	0.3	-	10.8	230.0
2007		0.3	19.5	0.5	-	20.3	376.8
2008		0.5	10.6	0.4	-	11.5	202.4
2009		0.1	0.6	0.1	-	0.7	15.1
2010		0.7	5.3	0.9	0.01	6.9	150.7
2011		0.1	16.2	0.6	-	17.0	385.2
2012	0.02	0.6	25.0	6.1	0.02	31.8	674.4
2013	-	0.3	12.1	9.7	0.2	22.3	541.0
2014	-	0.1	4.8	1.3	+	6.1	141.8

Table 12.3.4. Initial quota and final TAC by seasons.

Fishing season	Initial quota	Final TAC	Landings
1992/93 1)	500	900	788
1993/941)	900	1250	1179
1994/95	950	850	842
1995/961)	800	1390	930
1996/971)	1100	1600	1571
1997/98	850	1265	1245
1998/99	950	1200	1100
1999/00	866	1000	934
2000/01	650	1090	1065
2001/02	700	1300	1249
2002/03	690	1000	988
2003/04 2)	555	900	741
2004/05 3)	335	985	783
2005/06	No fishery	235	238
2006/07	No fishery	385	377
2007/08	207	207	202
2008/09 4)	No fishery		15
2009/10	No fishery	150	151
2010/11	No fishery	390	391
2011/12	366	765	747
2012/13	No fishery	570	551
2013/141)	No fishery	160	142

1) The final TAC was set on basis of autumn surveys in the season.

2) Indices from April 2003 were projected back to October 2002.

3) The initial quota was set on a basis of an acoustic survey in June/July 2004

4) No fishery was allowed, 15 000 t was assigned to scouting vessels.

Table 12.7.1 Icelandic capelin. The estimated number (billions) of capelin on 1 January since 1979 by age and maturity groups. The total number (billions) and weight (thousand tonnes) of the immature and maturing (fishable) stock components and the remaining spawning stock by number and weight (March) are also given.

	Age 2	Age 3	Age 2	Age 3	Age 4	Age 5	Number		weight			
Year	Juv.	Imm.	Mat.	Mat.	Mat.	Mat.	Imm.	Mat.	Imm.	Mat.	SSN	SSB
1979	137.6	12.8		51.8	14.8	0.3	150.4	66.9	1028	1358	29	600
1980	50.6	13.8		53.4	3.6	0.2	64.4	57.2	502	980	17.5	300
1981	55.3	3.5		16.3	4.9	+	58.8	21.2	527	471	7.7	170
1982	41.2	3		8	0.5	+	44.2	8.5	292	171	6.8	140
1983	123.7	12.6		14.3	2	+	136.3	16.3	685	315	13.5	260
1984	105	35.7		39.8	7.6	0.1	140.7	47.5	984	966	21.6	440
1985	211.6	34.3		25.2	15.6	0.3	245.9	41.1	1467	913	20.7	460
1986	83.2	83.9		34.5	10.5	0.2	167.1	45.2	1414	1059	19.6	460
1987	131.9	25.6		22.1	37	0.2	157.5	59.1	1003	1355	18.3	420
1988	120.5	31.2		34.1	11.7	+	151.3	45.8	1083	993	18.5	400
1989	67.8	20.1		48.8	16	0.3	87.9	64.8	434	1298	22	440
1990	53.9	8.6		31.2	12.1	+	62.5	43.3	291	904	5.5	115
1991	98.9	8.6		22.3	4.5	+	107.5	26.8	501	544	16.3	330
1992	111.6	8.1		54.8	5.3	+	119.7	60.1	487	1106	25.8	475
1993	124.6	13.9		46.5	3.5	+	138.5	50	622	1017	23.6	499
1994	121.3	16.9		50.5	4.6	+	138.2	55.1	573	1063	24.8	460
1995	188.1	29.5		35.1	8.7	+	217.6	43.8	696	914	19.2	420
1996	165.2	37.9		75.5	20.1	+	203.1	95.6	800	1820	42.8	830
1997	160	24.1		72.4	24.8	+	184.1	97.2	672	1881	21.8	430
1998	138.8	29.5		50.1	7.9	+	168.3	58	621	1106	27.6	492
1999	140.9	16.1		53.2	16	+	157	69.3	585	1171	29.5	500
2000	115.8	20.5		68.2	10	+	136.3	78.2	535	1485	34.2	650
2001	122.2	21		46.3	10.5	+	161.2	56.8	655	1197	21.3	450
2002	117.3	7.6		59.3	10.5	+	126.6	69.8	510	1445	22.9	475
2003	109.4	9.4		58.4	2.9		105.1	61.3	487	1214	20.7	410
2004	134.6	11.4		54.2	6.2	+	143.5	60.4	597	1204	28.2	535
2005	48.0	2.9		86.6	7.5	+	50.9	72.5	570	1450	36.3	602
2006	81.7	2.1		29.4	1.9		83.8	31.3	761	639	18.8	400
2007	55.8	1.1		52.5	1.4		56.9	53.9	515	997	19.1	410
2008	32.4	4.0		32.5	0.7		36.3	33.2	339	619	22.2	406
2009	37.3	6.4		14.5	2.6	+	43.7	17.1	413	343	17.3	328
2010	77.0	2.9		21.5	4.2		79.9	25.2	728	548	21.5	410
2011	117.7	13.6		36.2	1.9	-	131.3	38.1	1235	765	22.3	411
2012	49.1	28.8		46.4	7.9	+	77.9	54.4	678	1112	20.7	418
2013	44.1*	9.6*	2.2	22.0	18.8	0.4	53.6*	42.1	457*	983	17.9	417
2014	54.1*	6.2*	0.6	22.5	6.3	0.1	60.3*	29.4	381*	545	21.1	424

*** preliminary**

Table 12.7.2 Icelandic capelin in the Iceland-East Greenland-Jan Mayen area since the fishing season 1978/79. (A fishing season e.g. 1978/79 starts in summer 1978 and ends in March 1979). Recruitment of 1 year old fish (unit 10^9) are given for 1 August in the beginning of the season. Spawning stock biomass ('000 t) is given at the time of spawning at the end of the fishing season. Landings ('000 t) are the sum of the total landings in the season

Season (Summer/winter)	Recruitment	Landings	Spawning stock biomass
1978/79	164	1195	600
1979/80	60	980	300
1980/81	66	684	170
1981/82	49	626	140
1982/83	146	0	260
1983/84	124	573	440
1984/85	251	897	460
1985/86	99	1312	460
1986/87	156	1333	420
1987/88	144	1116	400
1988/89	81	1037	440
1989/90	64	808	115
1990/91	118	314	330
1991/92	133	677	475
1992/93	148	788	499
1993/94	144	1179	460
1994/95	224	864	420
1995/96	197	929	830
1996/97	191	1571	430
1997/98	165	1245	492
1998/99	168	1100	500
1999/00	138	933	650
2000/01	146	1071	450
2001/02	140	1249	475
2002/03	130	988	410
2003/04	160	741	535
2004/05	57	783	602
2005/06	97	238	400
2006/07	67	377	410
2007/08	39	202	406
2008/09	44	15	328
2009/10	92	151	410
2010/11	140	391	411
2011/12	58	747	418
2012/13	52*	551	417
2013/14	64*	142	424

*** preliminary**

Table 12.8.1. Icelandic capelin. Input data for short term predictions. Abundance at age in numbers (billions) measured in acoustic surveys (Age1.ac and Age2.imm.ac) and derived from stock projections (*back*). Numbers in stock projections are back-calculated to 1 August. Numbers estimated by acoustics are from autumn surveys in September-December..

Table 12.8.2. Icelandic capelin. Mean weight at age in autumn, used in the short-term projections.

Table 12.8.3 Icelandic capelin. Outlook for 2014/2015

Basis: The short-term prediction is based on indices on immature age 1 and 2 from an acoustic survey in autumn 2013 and size of the mature 2 year old in August 2013. (biomass in thous. t).

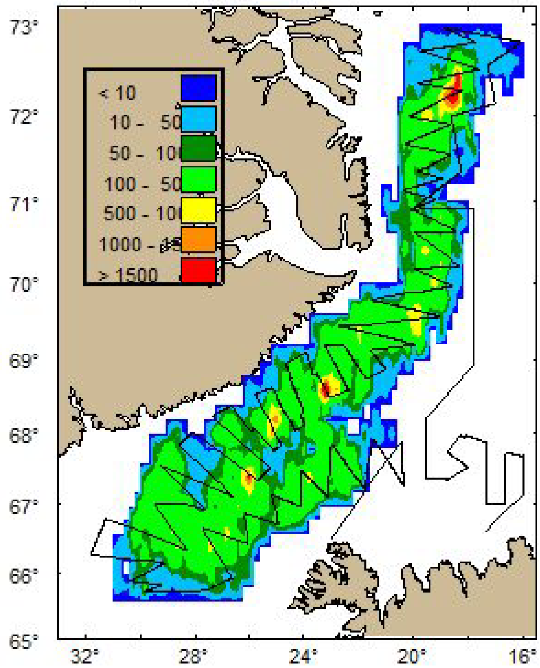


Figure 12.2.1. Icelandic capelin. Cruise tracks, relative density and distribution of capelin during an acoustic survey by r/v Arni Fridriksson during 17 September - 4 October 2013

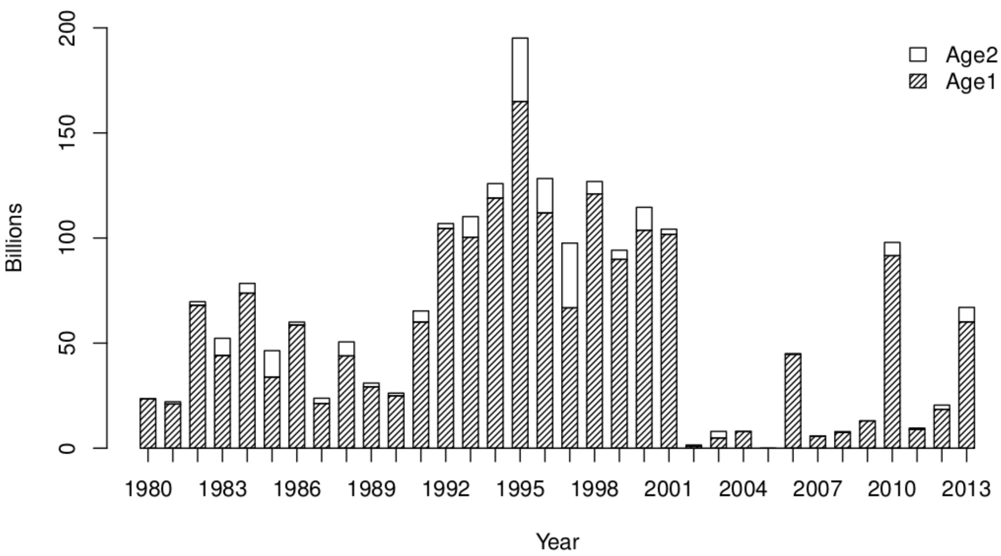


Figure 12.2.2. Icelandic capelin. Indices of immature 1 and immature 2 years old capelin from acoustic surveys in autumn since 1980.

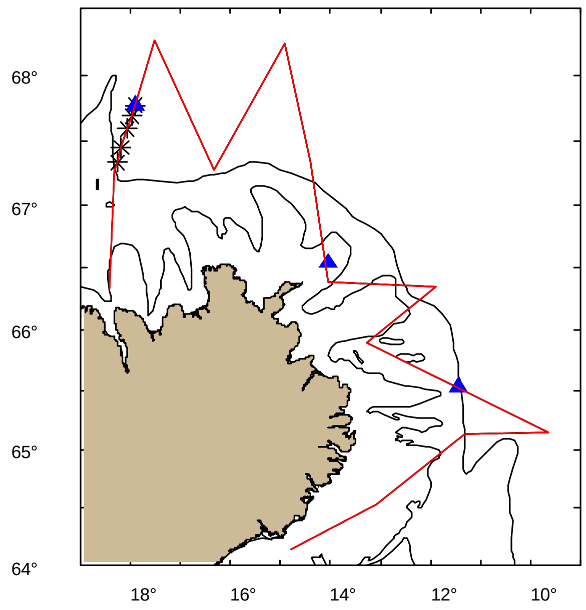


Figure 12.2.3. Icelandic capelin. Survey tracks of r/s Arni Fridriksson during 17 – 21 January 2014. (Blue triangles denote trawl stations and stars scattered schools).

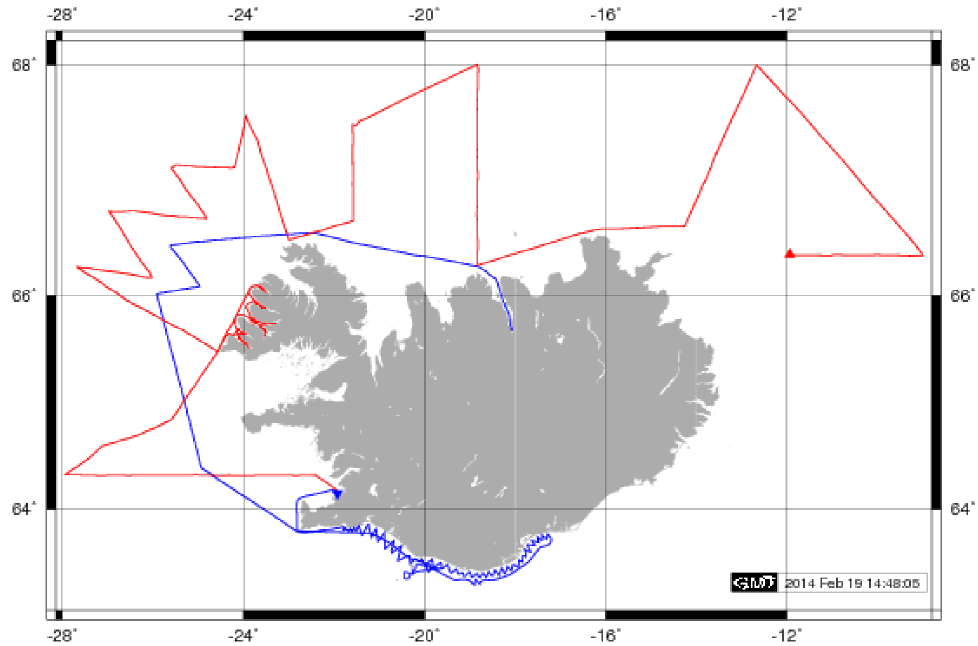


Figure 12.2.4. Icelandi capelin. Survey tracks of r/s Arni Fridriksson during 14 – 19 February 2014 (blue lines) and r/s Bjarni Saemundsson (red lines).

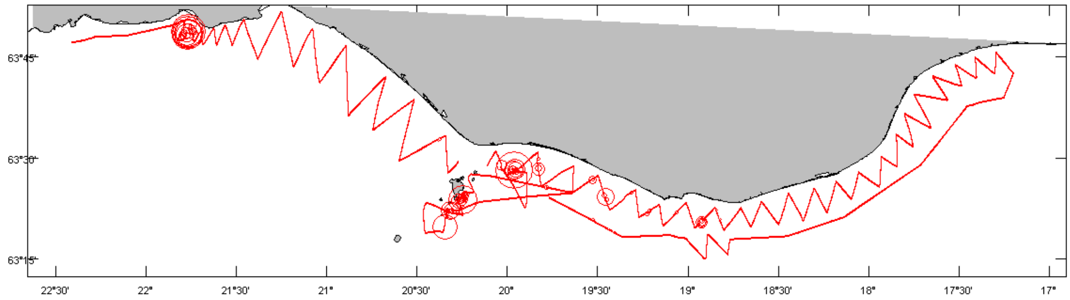


Figure 12.2.5. Icelandic capelin. Cruise tracks of r/s Arni Fridriksson, 16-18 February and relative abundance of capelin.

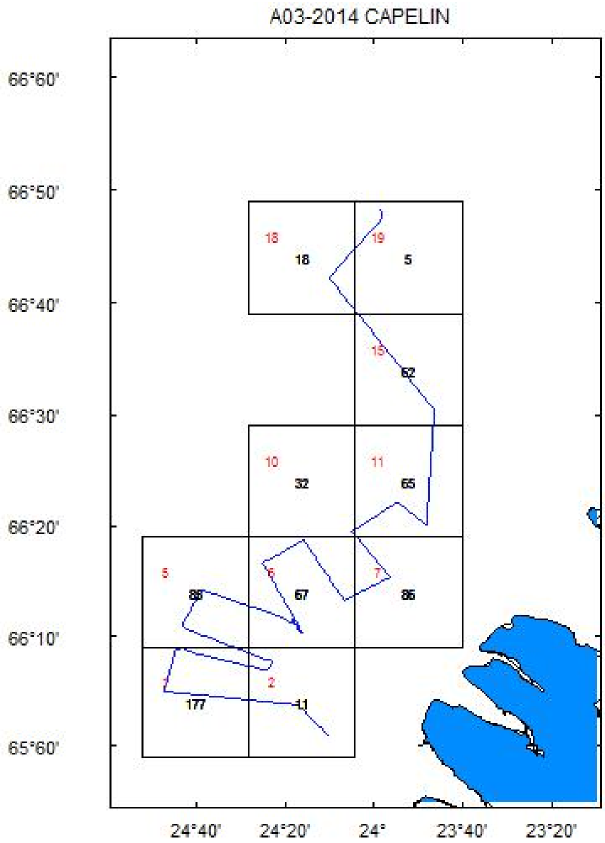


Figure 12.2.6. Icelandic capelin. Cruise tracks of r/s Arni Fridriksson, 5-6 March off the Westfjords and SA-values.

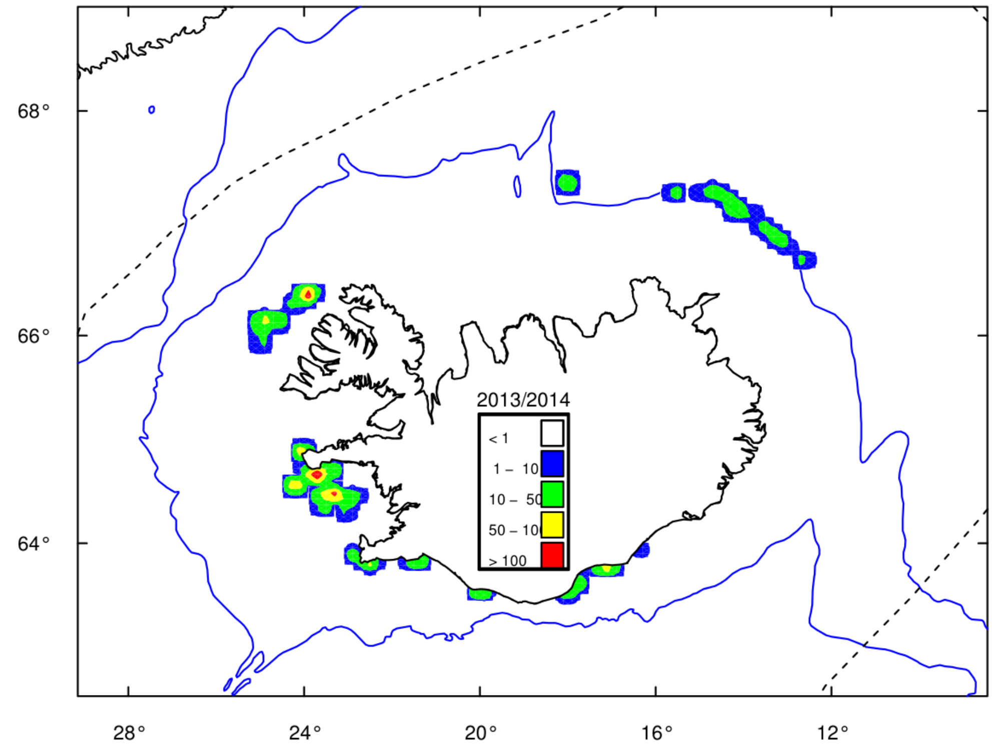


Figure 12.3.1. Icelandic capelin. Distribution of the catches of the Icelandic capelin in the fishing season 2013/14 based on data from logbooks.

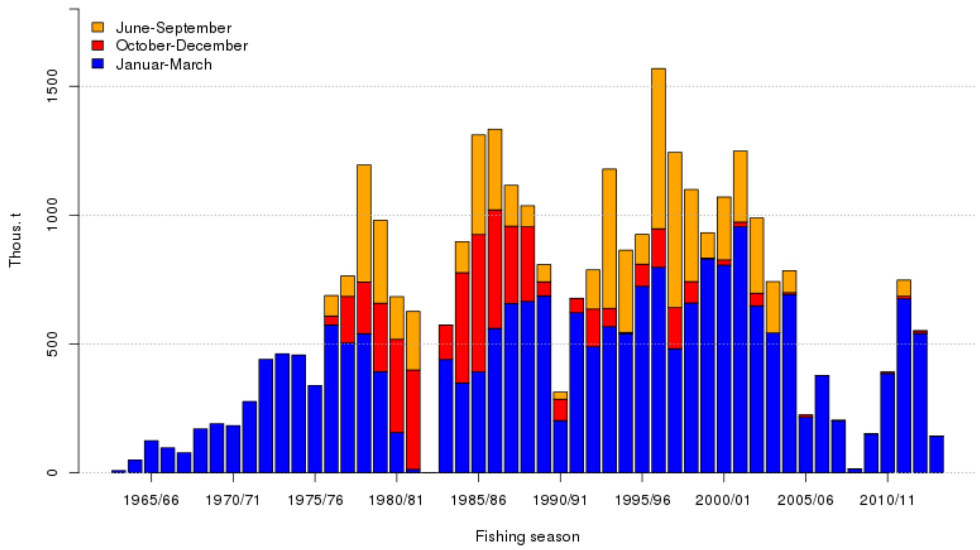


Figure 12.3.2. Icelandic capelin. The total catch (in thousand tonnes) of the Icelandic capelin since 1963/64 by season.

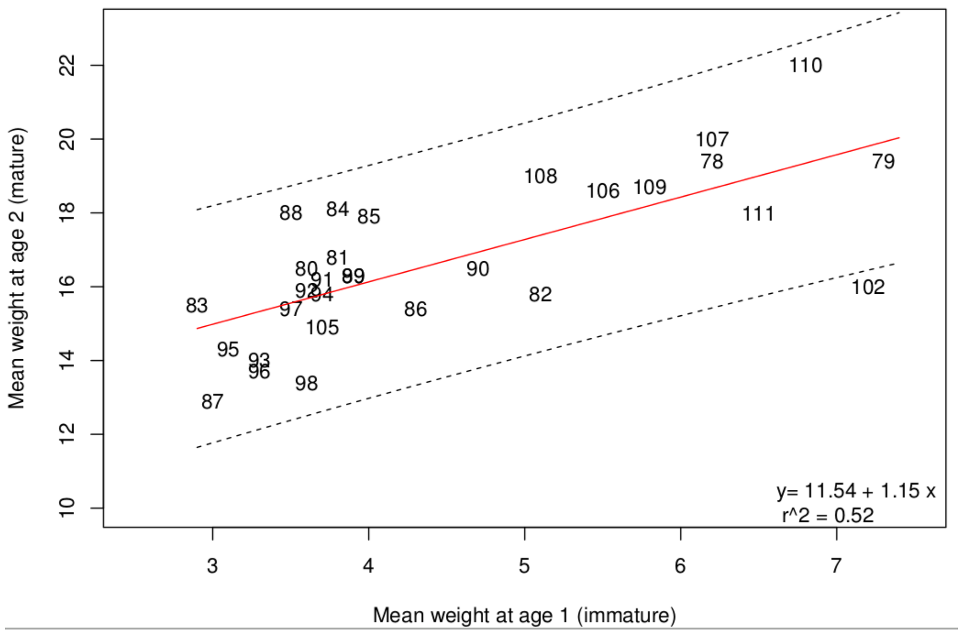


Figure 12.4.1 Icelandic capelin. The mean weight of a year class at age 1 and a year later as mature 2 year old capelin in autumn surveys 1979-2013. Numbers in the plot denote the year classes. Dotted black lines are 95% predictive intervals.

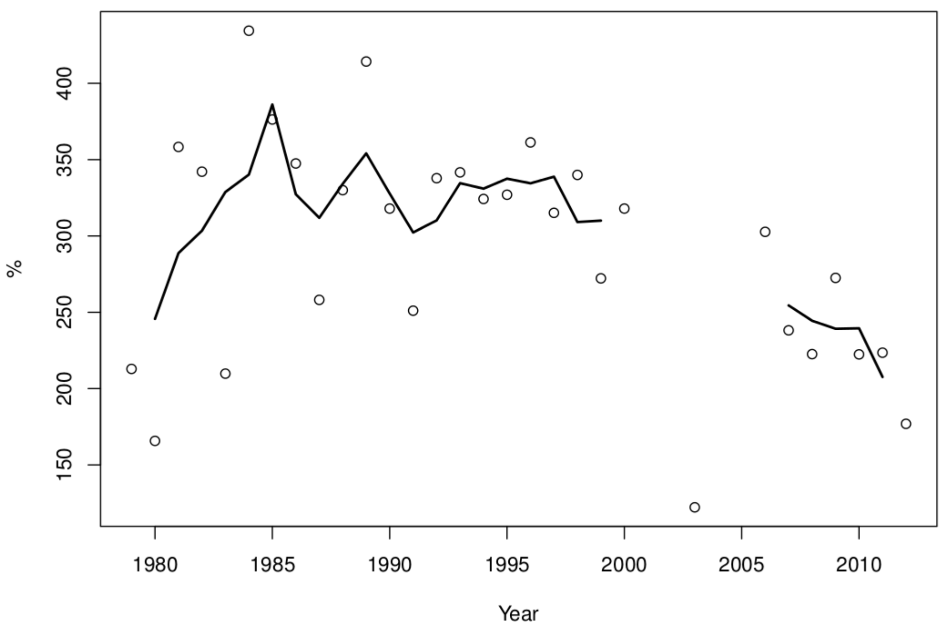


Figure 12.4.2. Icelandic capelin. Percentage increase in weight from age 1 to age 2 (points) and a 3 year running mean (line).

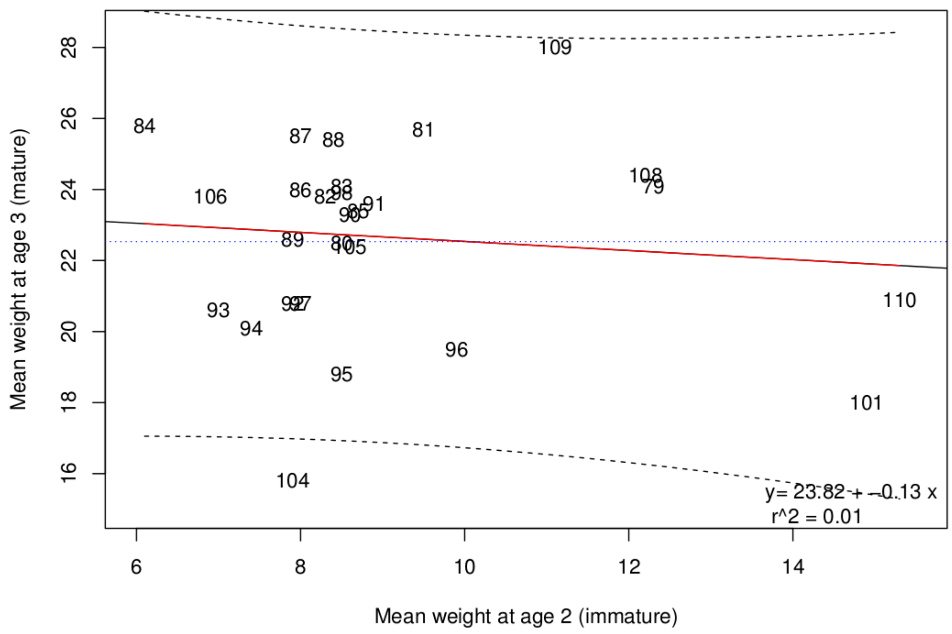
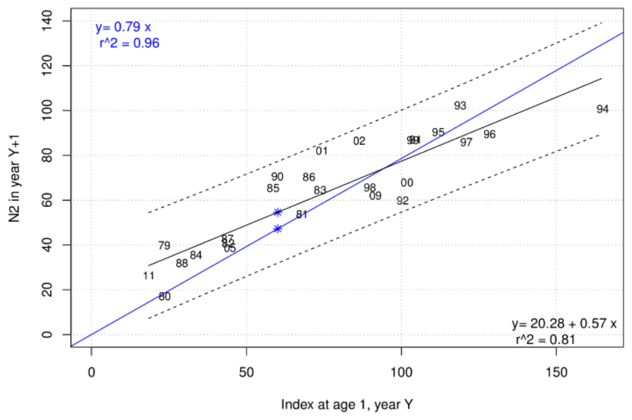
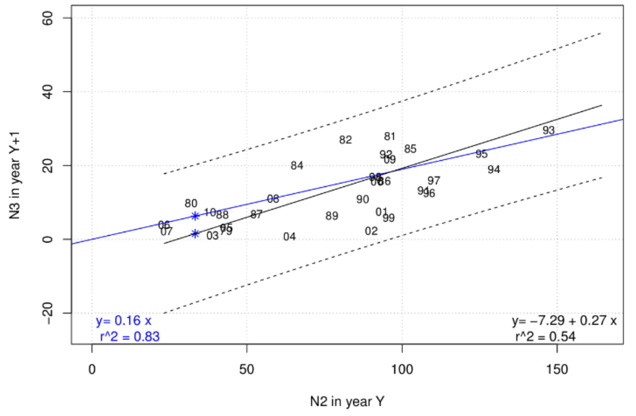


Figure 12.4.3. Icelandic capelin. The mean weight of year classes, immature at age 2 and a year later as mature 3 year old capelin, in autumn surveys 1979-2013. Numbers in the plot denote the year classes. Blue dotted line is the average mean weight.

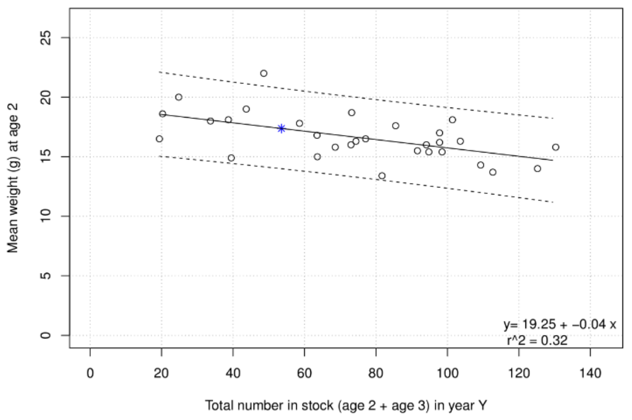
Figure 12.7.1. Icelandic capelin. Spawning stock biomass in March/April (thous. t).



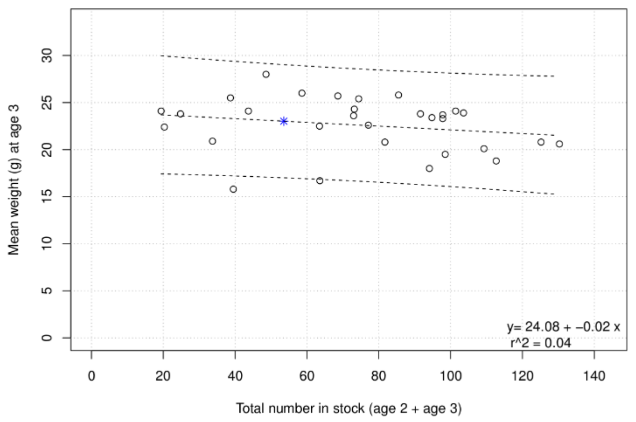
Regression 1 (black line) and prediction interval showing relation between acoustic index at age 1 and mature capelin at age 2 one year later. Blue line is the zero intercept regression.



Regression 2 (black line) and prediction interval showing relation between total number of capelin at age 2 and mature capelin at age 3 one year later. Blue line is the zero intercept regression.



Relation between total number at age 2 and 3 in the stock in year Y and mean weight for capelin at age 2 a year later.



Relation between total number at age 2 and 3 in the stock in year Y and mean weight for capelin at age 3 a year later.

Figure 12.8.1 Regressions used in short-term model.

Figure 12.12.1. Icelandic capelin. Average whole fat content (%) of Capelin between weeks.

13 Overview on ecosystem, fisheries and their management in Greenland waters.

13.1 Ecosystem considerations

The marine ecosystem around Greenland is located from arctic to subarctic regions. The water masses in East Greenland are composed of the polar *East Greenland Current* and the warm and saline *Irminger Current* of Atlantic origin. As the currents round Cape Farewell at Southernmost Greenland the saline, warm Irminger water subducts the colder polar water and forms the relatively warm *West Greenland Current*. This flows along the West Greenland coast mixing extensively as it flows north. This current is of importance in the transport of larval and juvenile fish along the coast for important species such as cod and Greenland halibut. Additionally, cod from Icelandic waters spawning south and west of Iceland occasionally enters Greenland waters via the Irminger current and is distributed along both the Greenland East and West coast (Figure 1).

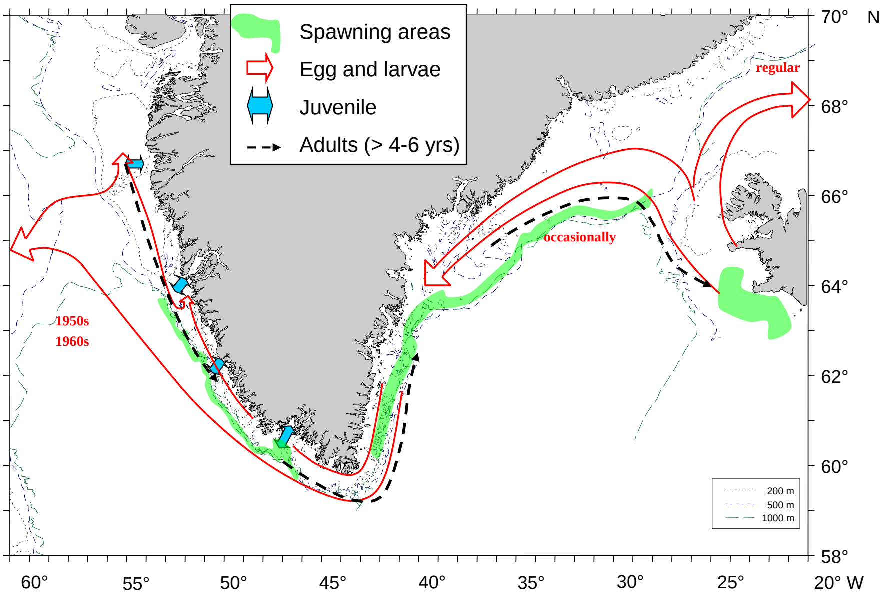


Figure 1: Spawning areas, egg and larval transport of Atlantic cod (*Gadus morhus*) in Greenlandic and Icelandic waters.

Depending of the relative strength of the two East Greenland currents, the Polar Current and the Irminger Current, the marine environment experience extensive variability with respect to the hydrographical properties of the West Greenland Current. The general effects of such changes have been increased production during warm periods as compared to cold ones, and resulted in extensive distribution and productivity changes of many commercial stocks. Historically, cod is the most prominent example of such a change (Holger & Wieland 2008).

In recent year's temperature have increased significantly in Greenland waters. In West Greenland the sea temperature have increased particularly compared to the years in 1970'ies to mid 1990'ies and historical highs was registered in 2005 for the time series 1880-2012 (Figure 2).

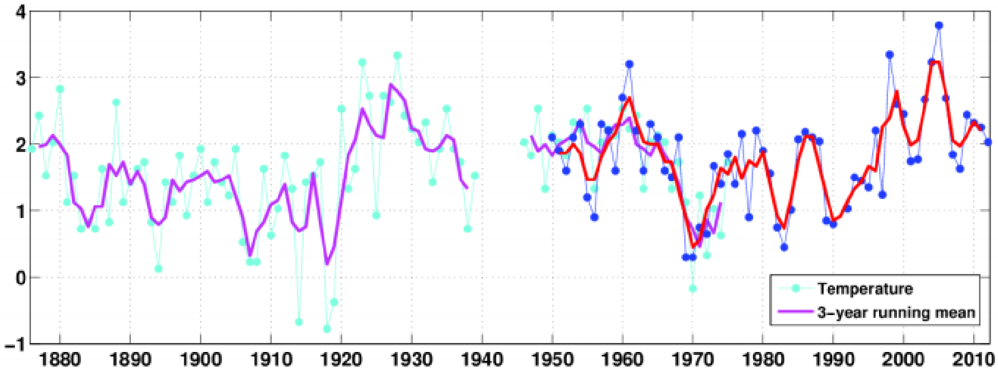


Figure 2. Mean temperature on top of Fylla Bank (located outside Nuuk Fjord, 0–40 m depth) in the middle of June for the period 1950–2012. The curves are 3 year running mean values. The magenta/purple line is extended back to 1876 using Smed-data for area A1. From Ribergaard (2013).

Temperature in the centre of the Irminger Sea, in the depth interval 200–400m, shows no such clear long-term trend (ICES 2013c). However Rudels el al. (2012) finds that between 1998 and 2010, the salinity and temperature of the deep water in the Greenland Sea increased. Furthermore increasing temperatures in salinity the Atlantic Water entering the Arctic in the Fram Strait has increased throughout the period 1996-2012, though with the highest observation in 2006 (ICES 2013c). Such environmental changes might well propagate to different trophic levels. Accordingly, shrimp biomass fluctuations in Greenland waters as a result of environmental changes could affect fish predators such as cod (Hvingel & Kingsley 2006) and the other way around.

The primary production period in Greenland is timely displaced along the coast due to increasing sea ice cover and a shorter summer period moving north (Blicher *et al.* 2007) but the main primary production takes place in May-June (Figure 3). The large latitudinal gradient spanned by Greenland, the ecosystem structure shifts moving north. For instance, the secondary producer assembly (e.g. mainly copepods) shifts from being dominated by smaller Atlantic species (*Calanus finmarchicus* and *Calanus glacialis*) to being increasingly dominated by the (sub)arctic species *Calanus hyperboreus.*

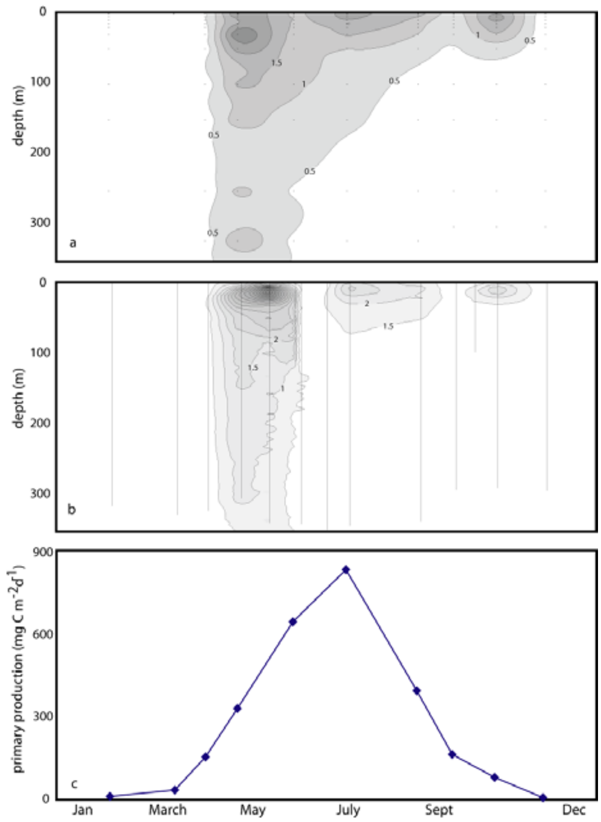


Figure 3. Annual variation in algal biomass and productivity at the inlet of Nuuk Fjord. a: chlorophyll (µg l^{-1}), b: fluorescence, c: primary production (mg C m^{-2} d^{-1}). Dots represent sampling points. From Mikkelsen et al. (2008).

Recently, the distribution of commercial species such as cod and shrimp has shifted considerably north. Such shifts have previously been associated with temperature, and may very well be linked to the observed increase in temperature. Additionally, changes in growth of fishes may also increase as a result of temperature changes as seen for both Greenland halibut (Sünksen et al. 2008) and cod (Hovgård and Wieland, 2008).

In recent years more southerly distributed species not normally seen in Greenland waters such as pearlside (*Maurolicus muelleri*), Whiting (*Merlangius merlangus*), blackbelly rosefish (*Helicolenus dactylopterus*), angler (*Lophius piscatorius*) and snake pipefish (*Entelurus aequoreus*) have been observed in surveys in offshore West and East Greenland and inshore West Greenland and their presence is possibly linked to increases in temperature (Møller et al. 2010).

In 2011 a mackerel (*Scomber scombrus)* fishery was initiated in East Greenland waters. Previous to this, no catches had ever been reported for this area and in 2013 mackerel was for the first time documented along the West Greenland coast. The reason(s) for the increased abundance of mackerel in Greenlandic waters has not been clarified, however factors such as changes in the regime for their usual food resources, a density dependent effect and increased temperatures have been proposed (ICES 2013a). The effects of increased pelagic fishes abundance and their distributional shifts on demersal fishes are unknown.

13.1.1 Atmospheric conditions

Cod and possibly other species recruitment in Greenland waters is significantly influenced by environmental factors such as sea surface temperatures in the important

Dohrn Bank region during spawning and hence by air temperatures together with the meridional wind in the region between Iceland and Greenland (Stein and Borovkov 2004). The effect of the meridional wind component in the region off South Greenland on the first winter of the offspring appears to play a vital role for the cod recruitment process. For instance, during 2003, when the strong 2003 YC was born, negative anomalies were more than -2.0 m/sec, and that particular YC was large in East Greenland waters. In general, it seems that during anomalous east wind conditions during summer months, anomalous numbers of 0-group cod are also found in Greenland waters.

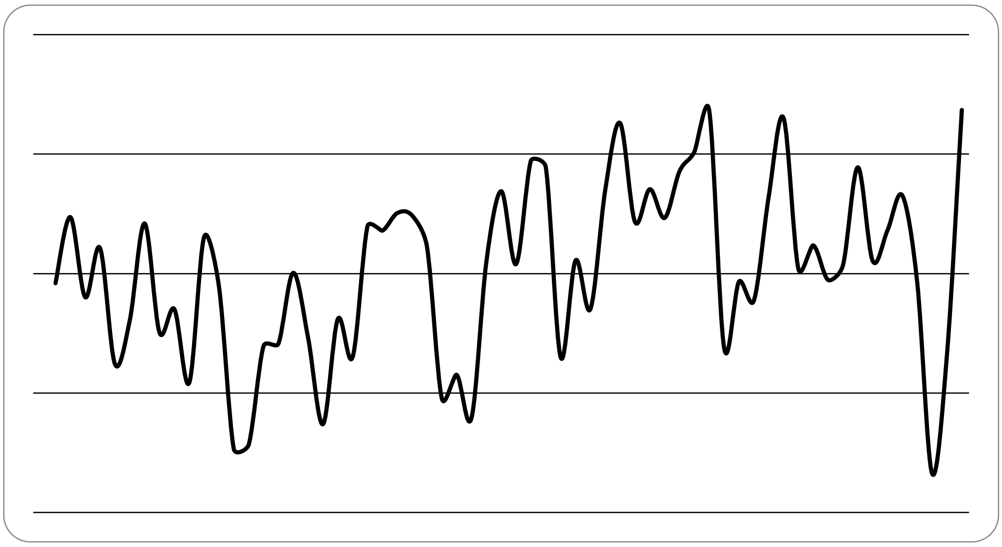


Figure 4. NAO Index (Dec-Feb) 1950-2012.

The NAO index

The NAO index, as given for 1950-2012 (Figure 4), shows negative values for winter (December-February) 2008/2009, 2009/2010 and 2010/2011. The 2009/2010 index is the strongest negative index (-1.64), encountered since 1950.

During the second half of the last century the 1960s were generally "low-index" years while the 1990s were "high-index" years. A major exception to this pattern occurred between the winter preceding 1995 and 1996, when the index flipped from being one of its most positive (1.36) values to a negative value (-0.62). The direct influence of NAO on Nuuk winter mean air temperatures is as follows: A "low-index" year corresponds with warmer-than-normal years. Colder-than-normal temperature conditions at Nuuk are linked to "high-index" years and hence indicate a negative correlation of Nuuk winter air temperatures with the NAO. Correlation between both time series is significant ($r = -0.73$, $p << 0.001$; Stein 2004). This is seen for instance in 2009, 2010 and 2011 where air temperature anomalies at Nuuk (1.0K, 4.8K and 2.9K) where associated with low NAO values (Fig. 5). The 2010 air temperature anomaly (4.0K) was the highest recorded, and was associated with the largest negative NAO anomaly (see Fig. 6).

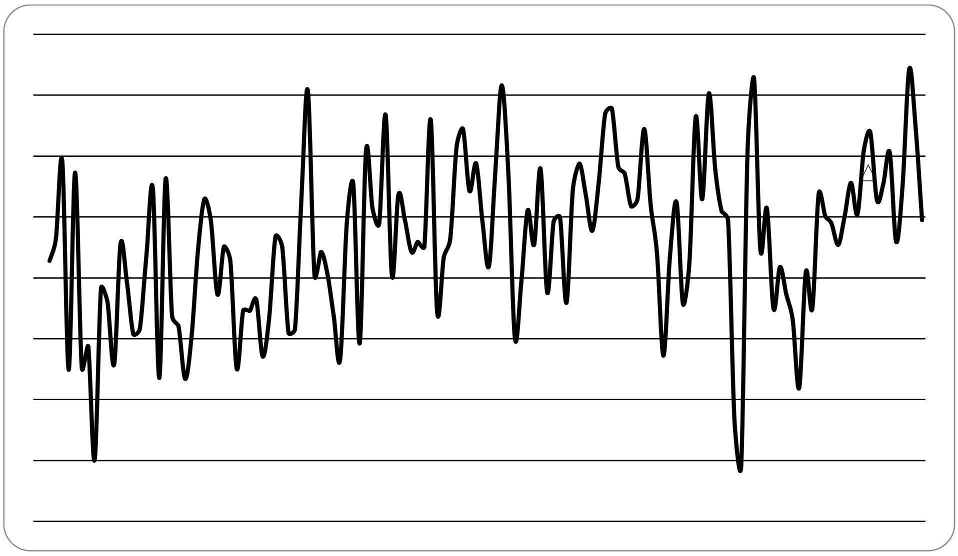


Figure 5 Time series of annual mean winter (DEC-FEB) air temperature anomalies (K) at Nuuk (1876-2012, rel. 1961-1990)

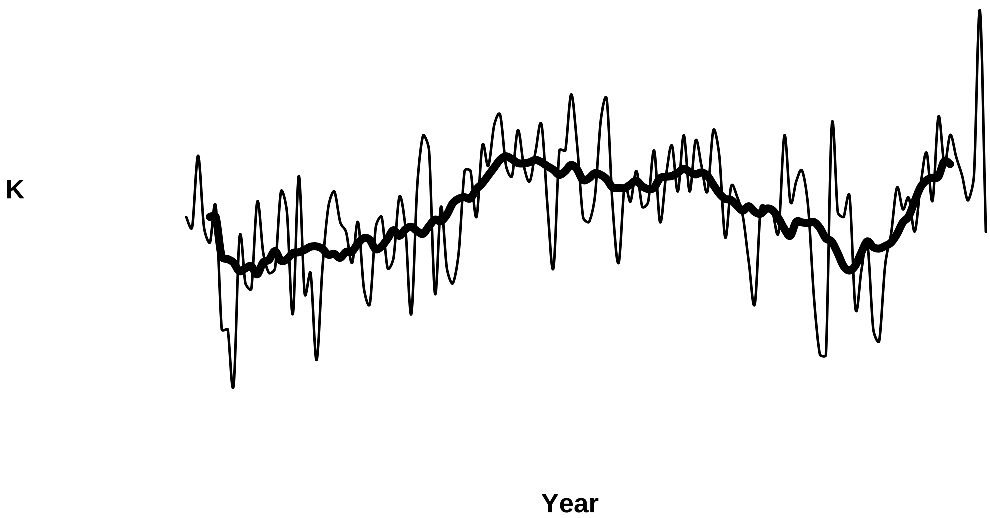


Figure 6. Time series of annual mean air temperature anomalies (K) at Nuuk (1876-2011, rel. 1961-1990), and 13 year running mean.

Zonal wind components

A negative anomaly of zonal wind components for the Northwest Atlantic is associated with atmospheric conditions in the Iceland-Greenland region enclosing strong easterly winds (Figure 7, top left panel in). These winds favour surface water transports from Iceland to East Greenland and was particularly strong in 2009, while it was completely different during the same months in 2010 (Figure 7). During May-August in 2011, the cells of negative anomalies were seen to the east of Newfoundland (anomalies < 3.0 m/sec), and to the east of Iceland.

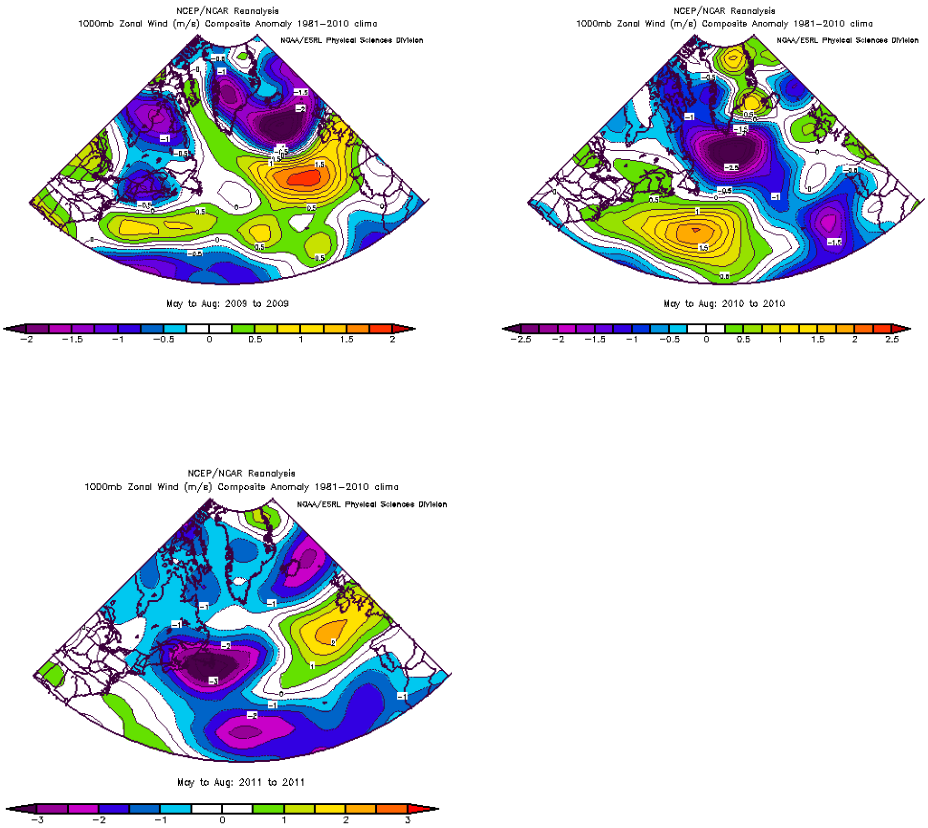


Figure 7. Zonal wind components for the North Atlantic (May-Aug), anomalies from 1981-2010. top left: 2009; top right: 2010; bottom left: 2011.

Meridional wind components

As discussed in Stein and Borovkov (2004), the meridional wind component (Dec-Jan) from the Southwest Greenland region correlated positively with the trend in Greenland cod recruitment time series (first winter of age-0 cod). During winter 2009/2010, positive meridional wind anomalies were observed Southwest Greenland (Figure 8, top left panel). During winter 2010/2011, the center of positive meridional wind anomalies had moved to the Davis Strait region (Figure 5, top right panel), and during winter 2011/2012, positive meridional wind anomalies had moved to the Northeast off Newfoundland (bottom left panel in Fig. 8).

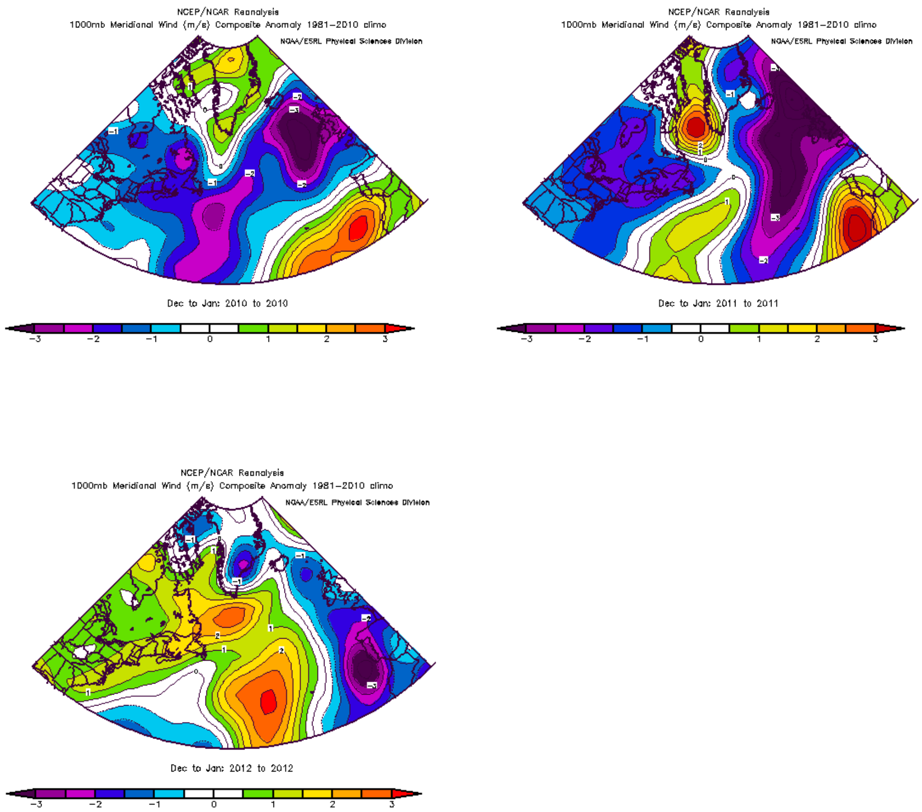


Figure 8. Meridional wind component (Dec-Jan), anomalies from 1981-2010. top left: 2009/2010; top right: 2010/2011;bottom left: 2011/2012;

13.1.2 Description of the fisheries

Fisheries targeting marine resources off Greenland can be divided into inshore and offshore fleets. The majority of the Greenland fleet has been built up through the 60s and is today comprised of approx. 450 larger vessels and a big fleet of small boats. It is estimated that around 1700 small boats are dissipating in some sort of artisanal fishery mainly for private use or in the pound net fishery.

Active fishing fleet reported to Greenland statistic by GRT in 1996 – no later number is available:

All fleet (N)	<5GRT	6-10GRT	11-20GRT	21-80GRT	>80GRT
441	31%	34%	2%	9%	6%

There is a large difference between the fleet in the northern and southern part of Greenland. In south, were the cod fishery has historically been important the average vessel age is 22 years, in north only 9 years as it is mostly comprised of smaller boats targeting Greenland halibut using longlines.

13.1.3 Inshore fleets

The fleet is constituted by a variety of different platforms from dog sledges used for ice fishing, to small multipurpose boats engaged in whaling or deploying passive gears such as gill nets, pound nets, traps, dredges and longlines.

In the northern areas from Disko Bay at 72ºN and north to Upernavik at 74º30N, dog sledge are the platforms in winter and small open vessels the units in summer, both fishing with longlines to target Greenland halibut in the ice fjords. The main by-catch from this fishery is redfish, Greenland shark, roughhead grenadier and in recent years cod in Disko Bay.

The inshore shrimp fisheries are distributed along most of the West coast from 61-72ºN. The main by-catch with the inshore shrimp trawlers is juvenile redfish, cod and Greenland halibut. An inshore shrimp fishery is conducted mainly in Disko Bay.. Most of the small inshore shrimp trawlers have dispensation for using sorting grid, which is mandatory in the shrimp fishery.

Cod is targeted all year, but with a peak in effort in June – July as cod in this period as accessible in shallow waters facilitating the use of the main gear types, pound and gill nets. By-catches are limited and are mainly Greenland cod (*Gadus ogac*) and wolffish.

In the recent years there has been an increasing exploitation rate for lumpfish. The fishing season is short, with the majority of the catch being caught in May-June. Lumpfish is caught along most of the West coast and is caught using gill nets. In smalll areas there is a substantial by catch of birds, especially common eiders (*Somateria mollissima*)

The scallop fishery is conducted with dredges at the West coast from 64-72 ºN, with the main landings at 66ºN. By-catch in this fishery is considered insignificant.

Snow crabs are caught in traps in areas 62-70ºN. Problems with by-catch are at present unknown, but are believed to be insignificant.

Salmon are caught in August-October with drifting nets and gillnets. The fishery is a mix of salmon of European and North American origin.

The inshore fleets fishing for Atlantic cod, snow crab, scallops and shrimp are regulated by licenses, TAC and closed areas. Fishery for salmon and lumpfish are unregulated.

13.1.4 Offshore fleets

Apart from the Greenland fleet, the marine resources in Greenland waters are exploited by several nations, mainly EU, Iceland and Norway using bottom and pelagic trawls as well as longlines

The demersal offshore fishery is compromised of vessels primarily fishing Greenland halibut, shrimp, redfish and cod. Greenland halibut and redfish have been targeted since 1985 using demersal otter board trawls with a minimum mesh size of 140 mm. A cod fishery has previously been conducted since 1920s in West Greenland offshore waters but was absent from 1992 to the 00ies. In 2010 the cod fishery was closed off West Greenland again. The Greenland offshore shrimp fleet consist of 15 freezer trawlers. They exclusively target shrimp stocks off West and East Greenland with landings sligltly below 100 000t. The shrimp fleet is close to or above 80 BT and 75% of the fleet process the shrimp onboard. Shrimp trawls are used with a minimum mesh size of 44 mm and a mandatory sorting grid (22 mm) to avoid by-catch of juvenile fish. The three most economically important fish species in Greenland, Greenland halibut, redfish and cod are found in relatively small proportions in the by-catch. However, when juvenile fish are caught, even small biomasses can correspond to relatively high numbers.

Longliners are operating on both the East and West coast with Greenland halibut and cod as targeted species. By-catches include roundnose grenadier, roughhead grenadier, tusk, Atlantic halibut and Greenland shark (Gordon *et al.* 2003).

The pelagic fishery in Greenland waters is conducted in East Greenland and currently targeted species are mackerel and pelagic redfish. A relatively small fishery after herring is carried out in the border area between Greenland, Iceland and Jan Mayen. A capelin fishery has previously been done but has the Greenland share of the TAC is taken in other waters. Generally, the pelagic fishery in Greenland is very clean, with small amounts of by-catch seen.

The demersal and pelagic offshore fishing, together with longlines are managed by TAC, minimum landing sizes, gear specifications and irregularly closed areas.

13.2 Overview of resources

In the last century the main target species of the various fisheries in Greenland waters have changed. A large international fleet in the 50s and 60s landed large catches of cod reaching historic high in 1962 with about 450 000t. The offshore stock collapsed in the late 60s-early 70s due to heavy exploitation and possible due to environmental conditions. Since then the stock has been low, with occasional larger YC being transported from Iceland (i.e. 1984 and 2003). Since 2010 the cod biomass has been concentrated in the spawning grounds off East Greenland. Following the cod collapse, the offshore shrimp fishery started in 1969 and has been increasing ever since reaching a historic high of close to 150 000 t in 2003. Current catches are slightly lower, but the advised TAC in 2014 is 80 000 t.

13.2.1 Shrimp

The shrimp (*Pandalus borealis)* stock in Greenland waters is considered in moderately good condition, but declining. The stock in East Greenland is considered stable based on available information. The 2003 West Greenland biomass (690 000 tonnes) was the highest in the time series but it has since then decreased.

13.2.2 Snow crab

The biomass of snow crab (*Chionoecetes opilio*) in West Greenland waters has decreased substantially since 2001. Snow crab has been exploited inshore since the mid 90s and offshore since 1999. Total landings have been reported to amount to 3 305t in 2006 down from 15 139t in 2001. After several years of decreasing CPUE it now appears to have stabilized at low levels in the majority of areas.

13.2.3 Scallops

The status of scallops in Greenland is unknown. From the mid 80s to the start 90s landings were between 4-600 t yearly. Since then landings have increased to around 2000 t. The fishery is based on license and is exclusively at the west coast between 20-60m. The growth rate is considered very low reaching the minimum landing size on 65mm in 10 years.

13.2.4 Squids

The status of squids in Greenland water is unknown.

13.2.5 Cod

Current landings are around 10 000t and 6 000t for in-and offshore respectively and are high compared to the last three decades, however they are only a fraction of the landings caught in the 1950's and 1960's. Recruitment has been negligible since the 1984 and 1985 year class, though it has improved in the last decade, especially inshore, where the 2009 YC is the best seen since the 1984 YC. In 2007 and 2009 dense concentrations of unusual large cod were documented to be actively spawning off East Greenland, and management actions have been taken to protect these spawning aggregations. The inshore fishery has been regulated since 2009 and the offshore fishery is managed with license and minimum size (40 cm). As a response to the favourable environmental conditions (large shrimp stock, high temperatures) there is a possibility that the offshore cod will rebuild to historical levels if managed with this objective. A management plan with the objective of achieving this goal has been implemented for the fishing seasons 2014-2016. Several YC are present in the inshore fishery, and with the stable recruitment in recent years and widespread fishery there are several indications that the stock is experiencing favourable conditions and that recruitment is not impaired in spite of an increased fishing effort in later years.

13.2.6 Redfish

Redfish (*Sebastes mentella* and *Sebastes marinus*) are primarily caught of East Greenland. Catches have been small since 1994, but recently large year classes have given rise to a significant fishery with 2010-12 catches being around 8000 t. This includes both redfish species, but the majority (e.g. ~80%) is most likely *S. mentella*. Recent East Greenland survey estimates indicate i decline i *S. mentella* while *S. marinus* is increasing.

13.2.7 Greenland halibut

Greenland halibut in the Greenland area consist of at least two stocks and several components; the status of the inshore component is not known but it has sustained catches of 15-20 000 t annually, taken primarily in the northern area (north of 68°N). The offshore stock component in NAFO SA 0+1 has remained stable in the last decade, sustaining a fishery of about 10 000 t annually. The East Greenland stock is a part of a stock complex extending from Greenland to the Barents Sea. The stock size is currently estimated as being at a historical low. Catches exceeds advice in most years with catches in Greenland waters being around 8 000t.

13.2.8 Lumpfish

The status of the lumpfish is unknown. The landing of lumpfish has increased dramatically in the last decades with catches being close to 13 000 t in 2013. Catches are highest in the southern-mid section of the Greenland west coast. There are no indications of the impact on the stock. A management plan was implemented in 2014 regulating the fishery with TAC and number of fishing days.

13.2.9 Capelin

On the Greenland East coast an offshore pelagic fleet have been conducting a fishery on capelin (106 000t landed in 2003 by EU, Norway and Iceland). The capelin has shifted distribution more west and north in recent years, and are believed to spent a substantial amount of time in Greenland waters. The west Greenland capelin stock is not fished and its size is unknown.

13.2.10 Mackerel

A mackerel fishery in Greenland waters initiated in 2011 with catches of 162 t and increased to more than 54 000t in 2013. There is currently no assessment estimating the stock size within Greenland. Mackerel is known to feed on various species, including fish larvae, and it competes with others pelagic species, such as herring, for resources (Langøy *et al.* 2012). Thus it might/can have a key role on the ecosystem of many commercial important species in Greenland.

13.3 Advice on demersal fisheries

ICES recommends that the offshore cod stock is protected to allow for rebuilding. Inshore cod advice is based on the DLS approach.. For the offshore cod, a recovery plan is recommended to ensure a sustainable increase in SSB and recruitment. Such initiatives must include appropriate measures to avoid any cod by-catch in other fisheries deploying mobile gears capable of catching cod. Observers must monitor functionalism of measures.

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14 Cod in offshore waters of ICES Subarea XIV and NAFO subarea 1

Executive summary

Offshore fishery in 2013 was conducted as an experimental fishery with TAC of 6 500 tons.

Total landings from the offshore fishery amounted to 5 988 tons. Year-classes dominating the catches were 2003-2007 in East Greenland whereas the 2007 YC dominated the catch in West Greenland.

Very large cod (mean length of 85 cm) where caught by trawlers on Dohrn Bank close to the EEZ to Iceland.

Available survey biomass indices show that the biomass in the offshore areas in West Greenland has increased due to an appearance of a 2009 YC in considerable numbers. This YC is distributed further south in 2012 and 2013 than in 2011.

Spawning offshore cod are only found in East Greenland in local high densities.

No formal assessment was conducted and there are no biological reference points for the species. Information from survey indices (German Groundfish survey and Greenland Shrimp and Fish survey) are used as basis for advice.

Recent genetic results suggest that the offshore stocks components in East and West Greenland should be considered as separate spawning units.

14.1 Stock definition

The cod found in Greenland is derived from four separate "stocks" that each is labelled by their spawning areas: I) offshore West Greenland waters; II) West Greenland fiords; III) offshore East Greenland and Icelandic waters and IV) inshore Icelandic waters (Therkildsen *et al*. 2013), (Fig. 14.1).

From 2012 the inshore component (West Greenland, NAFO Subarea 1) was assessed separately from all offshore components. The Stock Annex provides more details on the stock identities including the references to primary works.

14.2 Fishery

14.2.1 The emergence and collapse of the Greenland offshore cod fisheries

The Greenland commercial cod fishery in West Greenland started in the 1920s. The fishery gradually developed culminating with catch levels above 400,000 tons annually in the 1960s. Due to overfishing and deteriorating environmental conditions the stock size declined and the fishery completely collapsed in the early 1990's (Fig 14.2.1). In the 2000s catches have gradually increased with maximum catches in 2008 of 13,000 tons. Between 2008-2010 offshore areal closures were implemented in order to protect the spawning stock in offshore areas. More details on the historical development in the fisheries are provided in the stock annex.

14.2.2 The offshore fishery in 2013

In 2011 a management plan for the offshore fisheries for cod was implemented with the overall objective of rebuilding the stock. The overall strategy to fulfil the objective was that ICES advice must be followed. However a small experimental fishery was allowed in order to collect information on the distribution and composition of the cod stock. The TAC for the experimental fishery was set at 5,000 tons in 2011 and 5,500 tons in 2012.

The TAC for the experimental fishery for offshore cod in Greenland in 2013 was originally set at 5,000 tons. During the season 1,500 tons were transferred from the inshore TAC to the offshore TAC resulting in a total TAC for the offshore fishery for cod of 6,500 tons. Furthemorer a dispensation were given to two small trawlers (< 75BRT/120BRT) to fish offshore on the inshore quota. In 2013 the offshore TAC was divided with 3,550 tons to Greenland, 1,700 tons to EU, 1,250 tons to Norway and 250 tons to the Faroe Islands as part of a mixed quota. EU, Norway and the Faroe Islands fished their quota whereas Greenland fished 2,600 tons. The two small trawlers fishing offshore on the inshore quota caught 200 tons resulting in a total of 6,000 tons cod being fished offshore in Greenland.

On behalf of the Greenland Government, the Greenland Institute of Natural Resources (GINR) outlines conditions for the experimental fishery for cod to be conducted in the offshore areas in Greenland in 2013. The main condition were that fishery with trawl in East Greenland was only allowed from 1st of July to 31st of December whereas fishery with longline was allowed from 1st of April to 31st of December in order to collect information on the spawning stock in East Greenland. A small area in East Greenland (Kleine Bank) was closed for all fisheries. The area was delimited by: 1) 64°40′N 37 °30W′ 2) 64°40′N 36°30W′ 3) 64°15′N 36 °30W′ 4) 64°15′N 37°30W′. In West Greenland fishery was allowed with all gear all year.

Sampling of length frequencies and information on length, weight and age were collected by the crew on the ships who length measured 100 randomly selected cod each day and took individual measurements (length, weight, gutted weight and otoliths) from 20 randomly selected cod each day (40 in spawning season, April-May). In addition whole cod was frozen and delivered to GINR for further analysis at the laboratory.

Offshore catches in the fishery in 2013 amounted to a total of 5,988 tons with 1,884 tons caught in West Greenland and 3,104 tons caught in East Greenland (table 14.2.2.1).

69% of the total catches were taken in East Greenland where the fishery peaked in April and October. Catches in West Greenland peaked in June and November (table 14.2.2.2). The fishery where distributed from Dana Bank (63°N) in West Greenland to Dohrn Bank (66°N) in East Greenland (table 14.2.2.3, figure 14.2.2.2). In West Greenland the majority of the catches where taken in South Greenland in NAFO div. 1F.

54% of the total catch where taken by trawlers. Before 1st of July when the fishery for cod was closed for trawlers in East Greenland, trawlers caught 448 tons of cod in June in SouthWest Greenland (14% of the total trawl catches, table 14.2.2.3), and 65 tons as bycatch in the Redfish fishery in East Greenland. When the fishery opened in East Greenland the trawlers started to fish along the continental shelf south of 65°N and west of 33°V in July, but ended up fishing 67% of the total trawl catches on Dohrn Bank primarily in October. The fishery on Dohrn Bank was concentrated in a small area between 65-66°N and 29-31°W on the edge of the continental shelf. Only 12% of the total trawl catches where taken in the rest of East Greenland (figure 14.2.2.3).

46% of the total catch where taken by longliners primarily in April and May on the spawning grounds in East Greenland (45% of the total longline catches, table 14.2.2.3). The rest of the longline catches were taken in October and November in South West Greenland (20% of the total longline catches). The reason for the enlarged fishery in

Oct-Nov was that a part of the inshore quota (1,500 tons) was transferred to the offshore TAC and the license went primarily to a Greenlandic long-line vessel. Longliners did not fish on Dohrn Bank (figure 14.2.2.3).

The offshore fishery fluctuated during 2013 with peaks in spring and fall. The reason for this was different time restrictions according to gear and hence the longliners took most of their catch in spring in East Greenland when the trawlers where not allowed to fish in East Greenland. The catch taken by the trawlers on the other hand peaked in fall when the trawlers fished very large cod in a small area on the edge of Dohrn bank close to the EEZ to Iceland. No longliner took part in the fishery on Dohrn Bank.

14.2.3 Length, weight and age distributions in the offshore fishery 2013

There is limited landing sample information from the 1990's where the cod fishery was very low in East Greenland and non existing in West Greenland. For that period length frequency information is generally lacking for the offshore fisheries where cod was taken as a by-catch only. Sampling intensities have increased considerably in the later years, and in 2013 the offshore fisheries was very well covered.

Catch-at-age and weight-at-age has been compiled for the offshore area since 2005 (table 14.2.3.1 and 14.2.3.2).

Length frequencies sample information from the offshore fisheries 2013.

Area	Sample number	Number measured
Offshore West Longliner	62	8355
Offshore East Longliner	52	6484
Offshore West Trawler	8	823
Offshore East Trawler	66	7017

The mean length in the fishery in East Greenland was 78 cm and age 6 to 10 (YC 2003-2007) comprised the catches. However mean length of cod caught on Dohrn bank were considerable larger (85 cm) and older (8-9 yrs) than cod caught in the rest of East Greenland (figure 14.2.3.1).

In West Greenland mean length in the fishery was 63 cm and the catches were mainly comprised of 6 year old cod (2007 YC). Length distribution in the long line fishery and trawl fishery was similar.

In 2012 and 2013 the 2007 YC dominated the total catches (Table 14.2.3.1). This YC was especially abundant in the catches in West Greenland and East Greenland south of Dohrn Bank in 2013. Older cod (>6 yrs) where more abundant in East Greenland, especially on Dohrn Bank (figure 14.2.3.1).

Cod older than 5 yrs where previously found in limited numbers in both the survey and the fishery in West Greenland because of an eastward spawning migration when the cod turned 6 yrs. The 2007 YC dominated the catches as 5 yr old in 2012 and as 6 yr old in 2013 both in West and East Greenland. In 2013 this YC should start its eastward spawning migration but where still dominating the catches in 2013 in West Greenland suggesting that either a part of the YC will be spawning at older age or that it has begun to spawn in West Greenland.

14.2.4 CPUE index

Log books on a haul by haul basis from of a portion of the cod fisheries since 1990 where compiled in 2013. The logbook data are however not used in the assessment process due to very low catches in East Greenland and 0 catch in West Greenland. However results of the GLM model are presented here.

As EU (British and German) and Greenland vessels have participated in the fisheries in the entire period, data from these were used in the GLM model. In total 25,179 hauls were available and of these 18,345 originated from EU and Greenland vessels (table 14.2.4.1). It should be noted that in the period with very low catches (1993-2005) catches were mainly taken as bycatch.

From 2008-2010 different regions of the offshore area in Greenland were closed for directed cod fisheries (fig. 14.2.4.1). In 2010 the offshore area was closed except of a small area in South East Greenland. However, cod were caught in the closed areas, especially in 2010, but these hauls were excluded from the analysis as they were considered bycatch.

The CPUE index was relatively high in the first part of the time series (1990-1992, 0.785 ton/hr), then declined from 1993-2005 (0.146 ton/hr) before a large increase in the last part of the time series (2006-2013, 1.854 ton/hr, fig. 14.2.3.2). This trend follows the development in survey index (WD 13), with several YC's being present and a steady increase in biomass since 2006. Sampling however was low in the period of 1994-2005 due to very low catches of about 200-300 tons. There was a drop in CPUE in 2009, which was most likely caused by the east ward migration of the 2003 YearClass out of the allowed fishing areas (table 14.2.3.2). In 2010, were almost all of the offshore area was closed except of a small area in South East Greenland, the index continued to increase, but catches were taken by very few vessels. CPUE trends must be evaluated with regards to the constrained access to fishing areas.

The development in CPUE is consistent with increases in the offshore survey index, also suggesting an increase in biomass in recent years.

14.3 Surveys

At present, two offshore trawl surveys (Greenlandic and German) provide the core information relevant for stock assessment purposes. For details of survey design see stock annex.

The German survey targets mainly cod and has since 1982 covered the main cod grounds off both South East and West Greenland, thus including periods of both high and low cod abundance. The Greenland survey targets shrimp and cod off West Greenland between 60° and 72° N down to 600 m, hereby extending into northern areas where large cod concentrations are not expected. Although most of the effort has previously been allocated towards shrimp the recent addition of additional fish stations implies a fair coverage of the West Greenland cod habitat. In 2008 the Greenland survey was extended to include East Greenland.

14.3.1 Results of the Greenland Shrimp and Fish survey in West and East-Greenland

West Greenland

The numbers valid hauls in West Greenland was 211 in 2013 (table 14.3.1.1).

The 2013 survey abundance of Atlantic cod in West Greenland was estimated at 125 million individuals and the survey biomass at 85,800 tons. Survey abundance and biomass increased with 76 % and 131 % respectively compared to 2012 (table 14.3.1.2 & 14.3.1.3). This large increase was mainly caused by two large hauls accounting for 50%

of the biomass and abundance estimate. Abundance and biomass was primarily found in SouthWest Greenland (NAFO Div. 1E and 1F),(figure 14.3.1.1 and 14.3.1.2).

The stock was dominated by the 2007 YC in 2009 and 2010, but a new 2009 YC appeared in the survey accounting for 79% of the total abundance in 2011 (table 14.3.1.4). In 2012 and 2013 this YC is again the dominating year class accounting for 59% of the total abundance in 2012 and 54 % in 2013. Since the beginning of the time series in 1992 the 2003 YC was the largest observed in the survey, the size of the 2009 YC is estimated to be double the size of the 2003 YC in West Greenland, based on comparing survey abundance at age 4 . However two large hauls, accounting for 50% of the biomass and abundance estimate, were mainly comprised of fish from the 2009 YC (WD 13). Further the size of the 2009 YC compared to the 2003 YC at age 3 in 2012 showed that they were of equal size so comparisons of the size of the 2009 YC versus 2003 YC at age 4 should be precautious.

The 2009 YC was mainly found in the northern part of the survey (NAFO 1B) at age 2 in 2011. In 2012 and 2013 this YC was however mainly found in the southern part of the survey in SouthWest Greenland (NAFO Div. 1E and 1F) (figure 14.3.1.5). Younger yearclasses (2010- and 2011 YC) was mainly found in the northern part of the survey area (NAFO Div. 1A and 1B).

The main cod found offshore in West Greenland are younger than 6 years, and the 2013 survey confirmed that older and larger cod barely exist offshore in West Greenland.

East Greenland

A total number of 92 valid hauls were made in East Greenland in 2013 (table 14.3.1.1).

The 2013 survey abundance of Atlantic cod in East Greenland was estimated at 63 million individuals and the survey biomass at 159,500 tons. Survey abundance and biomass increased with 179% and 148% respectively compared to 2012 (table 14.3.1.2 & 14.3.1.3). Since 2010 biomass and abundance have declined, but increased considerably in 2013. There are three large hauls in the survey which contributed with 60% of the abundance estimate and 40% of the biomass estimate. However even if the three stations are left out of the calculations the abundance and especially biomass is still increasing caused by increasing numbers of especially older cod (> 6 yrs) (WD 13).

The stock was dominated by the 2007 YC in 2011 and 2012 and in 2013 this YC accounted for 30% of the total abundance, followed by the 2009 YC (25%) and the 2008 YC (23%) (table 14.3.1.4). The 2007- and 2008 YC are found in all survey areas, whereas the 2009 YC is mainly found in the southern part of the survey area with 77% of the total abundance of age 4 being concentrated in survey area Q6 (figure 14.3.1.4 & 14.3.1.5).

Overall younger cod (2009 YC) are predominantly found in South East Greenland (Q6), whereas older cod (> 8 yrs) are found in the northern survey area (figure 14.3.1.5).

As the two surveys are carried out in succession and uses the same trawl the Greenland survey now provides an estimate of the total offshore stock distribution. The overall pattern estimated from the Greenland surveys are that a) Old and large cod (>6 yrs)are found in smaller numbers off East Greenland primarily north of 63°N, b) Cod at ages 4-6 yrs are found primarily in South Greenland and c) Young cod (<3 yrs) are primarily found in the northern part of West Greenland. This pattern is reflected in the distribution of the Spawning Stock, where the main part of spawning is occurring in East Greenland, although there appears to be a small increase in the spawning stock in South Greenland (figure 14.3.1.7 & 14.3.1.8).

14.3.2 Results of the German groundfish survey off West and East Greenland

In 2013, 108 valid trawl stations were sampled during autumn in the German Greenland offshore groundfish survey (58 in West and 50 in East Greenland, Table 14.3.2.1, Figure 14.3.2.1).

The survey indices were calculated after re-stratification of the survey to account for within-stratum heterogeneity in East Greenland. The re-stratification was done in 2013 and is described in the Stock Annex.

Overall, abundance decreased from 2012 to 2013, whereas biomass stayed at the same level (Table14.3.2.2, Fig. 14.3.2.2.). The main reason for the reduction in abundance was fewer individuals of the 2009 yearclass being caught in West Greenland (Table 14.3.2.3).

The dominating yearclass both in West and East Greenland is the 2009 YC, and the size of this YC is overall estimated to be half of the 2003 YC compared at age 4 (table 14.3.2.3-14.3.2.5).

The 2013 survey confirmed previous findings. Hence, a strong 2003 year class appears to be the strongest year-class since the 1984 year class. Year-classes since 2003 until the 2009 YC are all above average of the period 1982-2012.

The survey time series (figure 14.3.2.4) shows two abundance peaks in 1987-1989 caused by the 1984 and 1985 YC and from 2005 and onwards caused by the 2003 and younger Yearclasses.

Even though the German survey did not find the same increase in abundance and biomass as the Greenland survey overall findings where the same: a 2009 YC predominantly distributed in South Greenland. The main difference between the surveys where fewer large cod caught especially in the Dohrn Bank area in the northern part of the survey area in East Greenland and fewer individuals caught of the 2009 YC by the German survey.

Catch Curve Analysis resulted in a Z estimate of 0.83 for the YC 2003 compared to 1.72 for the YC 1984, which was heavily exploited and data from the Icelandic cod stock revealed migration of this year class to Iceland (Table 14.3.2.6, Figure 14.3.2.5). The result seems robust and estimates are within the range expected based on the exploitation pattern. The estimates are candidates for use in further development of an improved assessment of this stock.

14.4 Information on spawning

Adequate maturity information has been lacking for the offshore cod stock as the Greelnad and German surveys are conducted well outside the spawning period. The offshore fishery has however shown dense concentrations of large spawning cod off East Greenland at least since 2004. In 2007 GINR carried out an observer program onboard two Greenland trawler in April, May to document East Greenland spawning. Since 2008 East Greenland has been closed for fishing in the spawning season (April-May). However in 2009 an Icelandic survey was carried out in April-May and in 2013 longliners where permitted to fish in April-May in East Greenland in order to collect information on spawning.

Overall the data showed that length at 50% maturity is around 60 cm and age is between 5 and 6 years. Further the area where fishing occurred during spawning season in East Greenland in 2013 was still concentrated between 63 and 64°N as in 2007 indicating that the spatial distribution of spawning cod have not changed greatly over the last 7 years.

14.5 Tagging experiments

A total of 14 827 cod have been tagged in different regions of Greenland in the period of 2003-2013 (table 14.5.1). Cod in the offshore area in West Greenland have been tagged in 2007, 2008, 2012 and 2013. Cod offshore in East Greenland have been tagged in 2007 - 2009, 2011 and 2012.

Offshore recaptures are found both in West-, East Greenland and Iceland (table 14.5.2). Most recaptured tags in both West and East Greenland are recaptured in the same place as they were tagged. Recaptured tags from Iceland are mostly tagged in East Greenland, but also in West Greenland typically in South Greenland. More analysis needs to be performed on the tagging data in order to investigate the relationship between Iceland and East Greenland cod.

14.6 State of the stock

The offshore component has been severely depleted since 1990. However, the surveys indicate an improvement in recruitment with all year classes since 2002 estimated at sizes above the very small year classes seen in the 1990s. These YC's has lead to a stock increase during the 00s, but the levels are far below historical levels, especially in West Greenland.

The offshore stock in West Greenland increased in 2013 compared to 2012 (Table 14.3.1.3, Fig. 14.3.2.4). This was mainly caused by the appearance of a 2009 YC in considerable numbers. Cod older than 7 years are almost absent in West Greenland. In East Greenland the trend in overall stock size is not clear as the Greenland survey showed an increase whereas the German survey showed a decline. Older cod belonging to the 2003 YC and older are predominantly found in the northern areas off East Greenland (Dohrn Bank) being scarcer off Cape farewell and absent from West Greenland. Younger cod (2007 - 2009 YC) are predominantly found in South Greenland and juvenile (age 1-3 yrs) are predominantly found in North West Greenland.

The spawning in East Greenland first observed in 2007 by an exploratory fishery was confirmed by an Icelandic survey in 2009. In 2013 longliners where allowed to fish in the spawning season in East Greenland. The area where fishing occurred was still concentrated between 63 and 64°N as in 2007 indicating that the spatial distribution of spawning cod have not changed greatly over the last 7 years. As only cod younger than 6 yrs are found in West Greenland and the spawning aggregations in East Greenland are comprised of cod older than 6 yrs is implying that spawning migration occur from West Greenland to East Greenland. Tag-returns data supports such an eastward migration. This pattern suggests that West Greenland is a nursing area for the East Greenland stock component.

14.7 Implemented management measures for 2014

The offshore quota for the total international fishery is set at 10,000 tons according to a management plan that was implemented in 2014 The conditions of the fishery are as followed:

1) NAFO areas 1A-1E is closed for directed fishery.

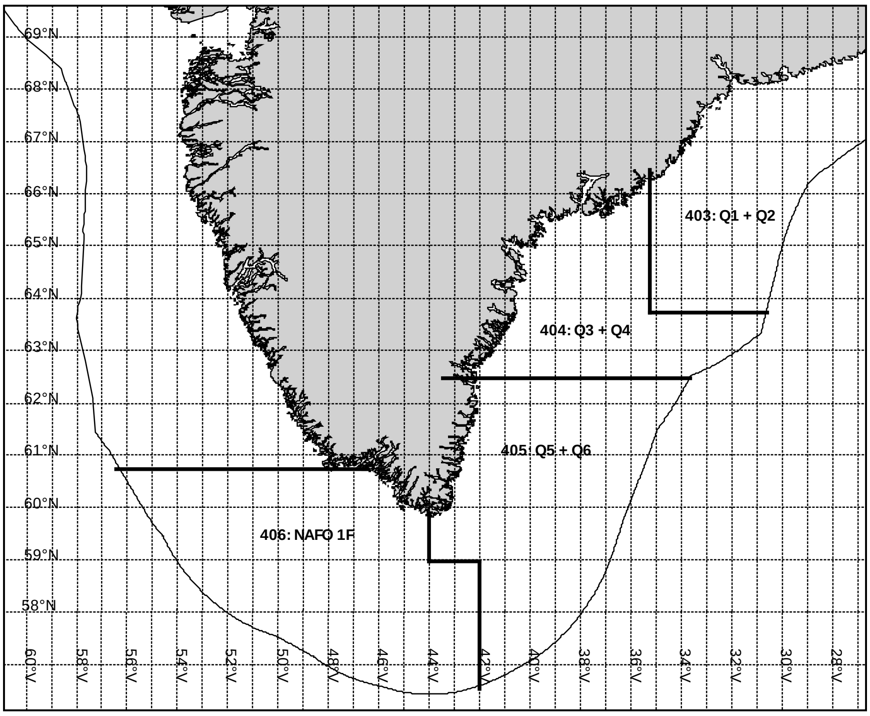
2) To spread the fishery a maximum of 2.500 are allowed to be taken in each of 4 management areas.

3) To protect the spawning stock no fishing is allowed from April 1st to May 31st in all areas.

4) To obtain biological information of the cod stock the vessels must register the catch composition as prescribed in the logbook regulation and conduct samplin of length (length measurements), weight and age (Otoltih).

14.8 Management plan

In 2014 a management plan was implemented for the offshore cod fishery in Greenland (2014-2016). The management plan is build on the distinction between the inshore and offshore stocks (as also recognized by ICES). However, the management plan further divides the offshore stock into a West and an South East component.



Management area West covers NAFO Subarea 1A-E and management area SouthEast covers ICES Subarea XIVb (survey area Q1-6) + NAFO 1F. The reason for choosing this division is based in the genetic studies by Therkildsen et al. (2013) which strongly indicate that Greenland waters are inhabited by at least four distinct Atlantic cod spawning components: 1) west inshore, 2) west offshore, 3) east offshore/Iceland offshore and 4) Iceland inshore.

According to the management plan, management area West TAC should be 0 t for the period 2014-2016 in order to protect the West offshore component. The TAC in management area South East is 10,000 t/year between 2014 and 2016, which is based on the assumption that South East Greenland and Iceland form part of the same stock complex, the South East TAC is set as a proportion of the Icelandic TAC (WD 32).

The TAC in management area South East for every year between 2014 and 2016 is to be taken in equal amounts in four areas: Survey area Q1+Q2, Survey area Q3+Q4, Survey area Q5+Q6 and NAFO area 1F.

The management plan has not been evaluated by ICES.

14.9 Management considerations.

Recent genetic results suggest that stock dynamics for cod in East and West Greenland are different and that the offshore populations in East and West Greenland belong to separate spawning units (Therkildsen *et al*. 2013). Genetic analyses of historic material (otoliths) suggest that the former main fishery in West Greenland was likely based on fish recruited from a West Greenland spawning stock. Further, the genetic studies combined with tagging results suggest that the spawning stock component in East Greenland is associated with the offshore spawning population in Iceland, but the extent and exact dynamics of this association is not possible to quantify. The south-west part of Greenland seem to be a mixture of fish from West Greenland and East Greenland/Iceland. Research is presently undertaken to investigate this mixture for management purposes.

Management of the cod stocks according to the biological entities have been considered in the management plan that manages West and East Greenland cod populations separately. Since the new findings have not yet been fully documented and therefore not approved by ICES, the present advice is still applicable to the combined West and East Greenland populations of cod. However, the new perception of stock entities requires some additional area specific recommendations given this combined advice. In West Greenland there is only weak sign of a recovery of a spawning biomass and older year-classes are relatively few in numbers. Such a status requires full protection of the West Greenland area in order to allow spawning stock recovery. For East Greenland all measures should be taken to protect the documented spawning grounds on the banks between "Skjoldungen" (62°30'N) and "Kleine Banke" (64°30'N).

14.10 Benchmark issues

As the stock is going to be benchmarked before the next NWWG meeting in 2015 the following issues to address at the benchmark where identified:

- Possible split into West Greenland Stock component and South East Greenland stock component (to be addressed by the SIMWG)
- Explore assessment approaches and advice for the South East Greenland stock component
- Exploratory analysis of the possible link between Icelandic cod stock and the Souh-East Greenland stock component.

14.11 References

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Therkildsen, N.O.,Hemmer-Hansen, J., Hedeholm, R.B., Wisz, M.S., Pampoulie, C., Meldrup, D., Bonanomi, S., Retzel, A., Olsen, S.M., Nielsen, E.E. 2013. Spatiotemporal SNP analysis reveal pronounced biocomplexity at the northern renge margin of Atlantic cod *Gadus morhua*. Evoltutionary Applications. DOI 10.1111/eva. 12055

Table 14.1 Nominal catch (t) of Cod in NAFO Sub-area 1 as officially reported to ICES.

year	Faroe islands	Germany	Greenland	Japan	Norway	UK	Togo	Total	WG estimate
1988		6574	52135	10	7	927		59653	626542
1989		12892	92152		2	3780		108826	1115673
1990	51	7515	58816		948	1631		68961	984744
1991	1	96	20335					20335	
1992			5723					5723	
1993			1924					1924	
1994			2115					2115	
1995			1710					1710	
1996			948					948	
1997			904					904	
1998			319					319	
1999			622					622	
2000			764					764	
2001			1680					1680	
20021			3698					3698	
20031			3989		6935		5335	5215	
20041			4948						
2005									6118
2006									7769
2007									13313
2008									21921
2009									10956
2010									9560
2011									11557
2012									12475
2013									1884

[1]) Provisional data reported by Greenland authorities

[2]) Includes 3,000 t reported to be caught in ICES Sub-area XIV

[3]) Includes 2,741 t reported to be caught in ICES Sub-area XIV

[4]) Includes 29,513 t caught inshore

[5]) Transshipment from local inshore fishers

Table 14.2 Nominal catch (t) of cod in ICES Sub-area XIV as officially reported to ICES.

YEAR	FAROE ISLANDS	GERMANY	GREENLAND	ICELAND	NORWAY	PORTUGAL	RUSSIA	UK (E/W/NI)	UNITED KINGDOM	TOTAL	EG ESTIMATE
1988	12	12049	345	9						12415	94571
1989	40	10613	3715					1293		15661	146692
1990		26419	4442		17			2458		33336	335133
1991		8434	6677		828			5861		21800	218284
1992		5893	1283	22	1032		126	2995		11351	
1993		164	241		122			163	46		736
1994	1	24	73		14				296	408	
1995		22	29	1				232		284	
1996		5	5		1			181		192	
1997		39	32					284		355	
1998		128	375			31		149		345	
1999	6	13	5		2			95		116	
2000		3			5			149		152	
2001		92	4	210	43	278	129			756	
20025		5	232		13				34	284	4486
20035		1	78							79	2947
2004	329		23		5					357	
2005	205		1		507			55			8368
2006		775			479						1981
2007	305	772			613				180		3221
2008											2997
2009		5			8			544			1720
2010	214	71	1530					540			2127
2011	221	1793	1175		472			670			4579
2012	208	841		513	260			1063			3941
2013	235		1414		1230			914			4104

[1]) Excluding 3,000t assumed to be from NAFO Division 1F and including 42t taken by Japan

[2]) Excluding 2,74 t assumed to be from NAFO Division 1F and including 1,500t reported from other areas assumed to be from Sub-area XIV and including 94t by Japan and 155t by Greenland (Horsted, 1994)

[3]) Includes 129t by Japan and 48 t additional catches by Greenland (Horsted, 1994)

[4]) Includes 18t by Japan

[5]) Provisional data

[6]) Includes 164t from Faroe Islands

[7]) Includes 215t from Faroe Islands

[8]) Includes 68t from Norway

Table 14.2.2.1. Cod off Greenland, offshore West and East components and Total. Catches (t) as used by the Working Group. Data until 1995 are based on Horsted, 2000.

Cod	Offshore		
Year	East	West	Total offshore
1924		200	200
1925		1871	1871
1926		4452	4452
1927		4427	4427
1928		5871	5871
1929		22304	22304
1930		94722	94722
1931		120858	120858
1932		87273	87273
1933		54351	54351
1934		88122	88122
1935		65846	65846
1936		125972	125972
1937		90296	90296
1938		90042	90042
1939		89807	89807
1940		43122	43122
1941		35000	35000
1942		40814	40814
1943		47400	47400
1944		51627	51627
1945		45800	45800
1946		44395	44395
1947		63458	63458
1948		109058	109058
1949		156015	156015
1950		179398	179398
1951		222340	222340
1952		317545	317545
1953		225017	225017
1954	4321	286120	290441
1955	5135	247931	253066
1956	12887	302617	315504
1957	10453	246042	256495
1958	10915	294119	305034
1959	19178	207665	226843
1960	23914	215737	239651
1961	19690	313626	333316

Cod	Offshore		
Year	East	West	Total offshore
1962	17315	425278	442593
1963	23057	405441	428498
1964	35577	327752	363329
1965	17497	342395	359892
1966	12870	339130	352000
1967	24732	401955	426687
1968	15701	373013	388714
1969	17771	193163	210934
1970	20907	97891	118798
1971	32616	107674	140290
1972	26629	95974	122603
1973	11752	53320	65072
1974	6553	39396	45949
1975	5925	41352	47277
1976	13027	28114	41141
1977	8775	23997	32772
1978	7827	18852	26679
1979	8974	12315	21289
1980	11244	8291	19535
1981	10381	13753	24134
1982	20929	30342	51271
1983	13378	27825	41203
1984	8914	13458	22372
1985	2112	6437	8549
1986	4755	1301	6056
1987	6909	3937	10846
1988	12457	36824	49281
1989	15910	70295	86205
1990	33508	40162	73670
1991	21596	2024	23620
1992	11349	4	11353
1993	1135	0	1135
1994	437	0	437
1995	284	0	284
1996	192	0	192
1997	370	0	370
1998	346	0	346
1999	112	0	112
2000	100	0	100
2001	221	0	221
2002	448	0	448

Cod	Offshore		
Year	East	West	Total offshore
2003	286	7	293
2004	369	27	396
2005	773	75	847
2006	1981	408	2389
2007	3221	1620	4841
2008	2997	9651	12648
2009	1720	3286	5006
2010	2127	290	2417
2011	4579	550	5129
2012	3941	1802	5741
2013	4104	1884	5988

Table 14.2.2.2: 2013 cod catches (t) divided into month and NAFO/ICES areas, caught by the offshore fisheries.

NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
1D					3			71	52	54		29	209	3%
1E						7		45	55	95	41	28	270	5%
1F	94	126	74		0.03	448	98	49	23	111	287	94	1405	23%
ICES XIV			8	1004	295	121	154	734	546	1061	161	20	4104	69%
Total	94	126	83	1004	298	576	252	900	677	1321	488	170	5989	
%	2%	2%	1%	17%	5%	10%	4%	15%	11%	22%	8%	3%		

Table 14.2.2.3: 2013 cod catches (t) divided into gear, month and NAFO/ICES areas, caught by the offshore fisheries.

Gear	NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Longline	1D					3			71	52	54		29	209
	1E						7		45	52	54		28	186
	1F	94	125	74				98	31	2	86	267	94	872
	ICES XIV			0.03	963	290	111	40	1	0.1	108			1512
	Total	94	125	74	963	293	118	138	148	107	302	267	150	2779
Trawl	1D					0.02								0.02
	1E									3	41	41	0.2	84
	1F		1			0.03	448		18	21	25	20		534
	ICES XIV			8	41	6	10	107	21	156	60	18	20	447
	Dohrn Bank (ICES XIV)							8	711	390	893	143		2144

Total	1	8	41	6	458	114	751	570	1019	222	20	3210

Table 14.2.3.1. Cod in Greenland. Catch at age ('000) and Weight at age (kg) for offshore fleets in East and West Greenland combined. 2003 YC, 2005 YC, 2007 YC. *No length measurements in West Greenland.

Catch at age								
Year/age	3	4	5	6	7	8	9	10+
2005	2	21	54	100	86	53	16	7
2006*								
2007	50	1129	543	173	118	124	19	17
2008	78	655	5079	2176	540	39	26	15
2009	276	1177	1101	438	130	22	49	11
2010	12	89	300	168	268	63	9	5
2011	3	68	151	468	368	360	88	27
2012	13	128	610	327	291	258	145	52
2013	0	61	200	690	274	238	167	96
Weight at age								
2005	0.394	0.693	1.244	1.963	2.752	3.717	5.290	7.386
2006*								
2007	0.423	0.923	1.718	3.428	6.203	8.613	11.110	14.446
2008	0.370	0.648	1.279	1.795	2.984	5.109	5.840	6.595
2009	0.464	0.775	1.381	2.927	4.360	6.214	7.154	10.262
2010	0.653	1.024	1.513	2.504	3.662	5.372	7.981	9.638
2011	0.564	1.044	1.565	2.282	3.344	4.688	6.340	10.141
2012	0.534	0.917	1.459	2.353	3.558	5.132	7.072	11.139
2013	0.503	1.105	1.621	2.261	3.359	4.626	6.863	9.042

Table 14.2.3.2. Cod in Greenland. Catch at age ('000) and weight at age (kg) for offshore fleets in East and West Greenland separate. 2003 YC, 2005 YC, 2007 YC. *No length measurements in West Greenland. Only trawlers.**

Catch at age								
Year/age	3	4	5	6	7	8	9	10+
East Greenland								
2005	2	14	44	87	82	51	15	7
2006	28	431	240	136	67	1	0	0
2007	14	239	258	99	100	119	19	16
2008**	26	183	883	452	104	33	26	12
2009	10	129	337	230	46	6	11	2
2010**	7	46	176	94	212	52	7	3
2011	2	26	88	309	337	351	87	27
2012	1	17	181	135	181	225	129	40
2013	0	10	59	229	148	177	156	90
West Greenland								

2005	1	8	9	12	4	2	1	0
2006*								
2007	36	890	285	74	18	4	0	0
2008**	52	458	3630	1487	380	6	0	3
2009	266	1048	764	208	84	16	38	9
2010	2	19	57	33	27	5	1	1
2011	1	42	63	159	31	10	1	0
2012	12	110	429	192	110	33	16	12
2013	0	52	140	461	126	61	11	6
Weight at age								
East Greenland								
2005	0.343	0.663	1.193	1.917	2.717	3.682	5.238	7.328
2006	0.690	1.301	2.251	3.887	4.781	8.216		
2007	0.617	1.052	1.976	3.556	6.232	8.640	11.095	14.472
2008**	0.392	0.627	1.294	1.857	3.540	5.476	5.840	8.291
2009	0.736	1.199	1.725	2.815	4.238	5.969	7.163	9.958
2010**	0.711	1.155	1.696	2.635	3.759	5.545	8.670	9.922
2011	0.577	1.166	1.720	2.490	3.418	4.707	6.342	10.160
2012	0.650	1.112	1.758	2.741	3.874	5.165	7.092	11.380
2013	0.464	1.164	1.887	2.781	3.741	4.949	6.930	9.242
West Greenland								
2005	0.512	0.748	1.480	2.288	3.486	4.919	6.363	12.021
2006*								
2007	0.350	0.889	1.484	3.256	6.043	7.869	11.784	12.678
2008**	0.359	0.650	1.269	1.787	2.889	3.237		0.680
2009	0.454	0.722	1.229	3.050	4.426	6.298	7.152	10.334
2010	0.55	0.88	1.25	2.30	3.16	4.58	6.33	9.09
2011	0.532	0.967	1.348	1.878	2.556	3.981	6.139	6.953
2012	0.522	0.887	1.334	2.080	3.036	4.911	6.908	10.316
2013	0.533	1.093	1.508	2.003	2.910	3.688	5.918	5.928

Table 14.2.4.1: Data used in the Atlantic cod CPUE. N_{before} are number of hauls from all vessels with logbooks data. N_{after} are number of hauls from vessels from EU and Greenland used in the analysis.

year	Nbefore	Nafter	ln CPUE (ton/hr)	SE
1990	10596	6882	0.267191	0.017487
1991	4324	3042	-0.66894	0.028336
1992	2800	2392	-0.61956	0.031921
1993	268	244	-2.44371	0.090681
1994	127	124	-3.91281	0.126438
1995	33	6	-4.50781	0.571354
1996	123	123	-1.94371	0.126945
1997	16	16	-1.21832	0.350061
1998	41	40	-2.16693	0.221669
1999	178	177	-2.36192	0.106112
2000	25	22	-2.03171	0.298624
2001	122	94	-1.89965	0.14497
2002	262	140	-1.90167	0.11909
2003	246	144	-1.2333	0.117448
2004	355	89	-2.29636	0.148949
2005	236	55	-1.19244	0.189147
2006	301	263	0.071322	0.086502
2007	475	422	0.912995	0.068137
2008	1815	1652	0.538342	0.035541
2009	767	710	0.120332	0.052783
2010	532	255	0.978692	0.088752
2011	570	502	0.962411	0.063358
2012	511	498	0.625313	0.063516
2013	456	453	0.2469	0.06632
Total	25179	18345		

Table 14.3.1.1. Number of hauls in the Greenland Shrimp and Fish survey.

West Greenland								
	0A	1A	1B	1C	1D	1E	1F	Total
1992		92	44	18	18	11	15	198
1993		69	49	21	15	12	13	179
1994		76	58	23	8	9	9	183
1995		83	61	29	13	14	11	211
1996		71	57	29	12	9	11	189
1997		84	56	32	12	12	19	215
1998		77	80	27	19	14	14	231
1999		84	81	33	16	14	17	245
2000		56	62	37	23	14	29	221
2001		60	75	36	24	15	26	236
2002		50	80	32	18	20	27	227
2003		51	63	30	18	15	22	199

2004		54	55	24	22	20	34	209
New Survey Gear Introduced								
2005	6	65	56	26	19	23	23	218
2006	5	87	59	26	20	21	31	249
2007	8	73	58	26	27	31	39	262
2008	6	70	60	28	23	25	46	258
2009	8	76	73	28	22	24	48	279
2010	10	95	76	30	23	25	40	299
2011	0	74	63	24	18	12	25	216
2012	0	75	62	21	18	18	26	220
2013	4	73	52	20	13	21	28	211
East Greenland								
Year	Q1	Q2	Q3	Q4	Q5	Q6	Total	
2008	8	6	12	7	7	12	52	
2009	21	12	26	19	6	13	97	
2010	19	14	24	9	6	10	82	
2011	20	11	21	12	7	14	85	
2012	19	16	28	13	7	15	98	
2013	25	12	22	14	5	14	92	

Table 14.3.1.2 Cod abundance indices ('000) from the Greenland Shrimp and Fish survey by year and NAFO/strata divisions. Q1 being the northern strata in East Greenland. The survey gear was changed in 2005. The new gear is estimated as ca. 50% more efficient than the old gear.

West Greenland									
Year	0A	1A	1B	1C	1D	1E	1F	Total	CV
1992		4	53	243	345	0	8	653	49
1993		2	16	54	135	286	18	512	68
1994		10	41	87	0	6	0	144	47
1995		0	51	380	44	62	39	578	55
1996		0	0	46	68	87	107	308	55
1997		0	7	31	0	0	0	38	68
1998		0	4	0	26	26	3	59	54
1999		32	136	16	23	6	0	213	29
2000		585	437	71	58	9	189	1349	23
2001		26	305	110	448	305	313	1508	26
2002		13	203	78	3294	114	457	4158	50
2003		492	1395	351	727	214	211	3391	22
2004		197	152	379	2630	1538	1610	6507	29
New Survey Gear Introduced									
2005	145	205	820	1846	4643	7051	93608	108317	52
2006	454	429	4091	2702	11039	8792	40261	67769	29
2007	737	1267	3179	7424	3798	2857	33256	52517	37
2008	1209	886	4129	4107	9521	11905	21651	53408	23

2009	891	869	4174	3218	2832	1400	1735	15119	11
2010	339	706	2775	2732	8212	2499	6071	23355	24
2011		7169	43610	2137	19550	1032	7352	80850	16
2012		8329	10957	3253	1227	27083	20269	71117	39
2013	4702	8694	12691	6059	7549	29993	55463	125151	36

East Greenland

	Q1	Q2	Q3	Q4	Q5	Q6	Total	CV
2008	5456	1361	13043	1975	1635	8046	31516	22
2009	14304	2191	28539	4374	548	4753	54710	15
2010	5844	732	30042	3975	115	4633	45340	51
2011	7843	1357	5178	7733	1470	19072	42654	25
2012	5414	2164	3658	2453	352	8635	22676	21
2013	11102	1420	5667	17360	537	27145	63230	35

Table 14.3.1.3. Cod biomass indices (tons) from the Greenland Shrimp and Fish survey by year and NAFO/strata divisions. Q1 being the northern strata in East Greenland. The survey gear was changed in 2005. The new gear is estimated as ca. 50% more efficient than the old gear.

West Greenland									
	0A	1A	1B	1C	1D	1E	1F	Total	CV
1992		23	54	75	118	0	2	251	45
1993		2	5	25	39	124	5	200	70
1994		3	9	38	0	1	0	51	46
1995		5	6	120	23	3	4	155	63
1996		0	0	15	23	27	49	113	51
1997		0	2	53	0	0	0	55	76
1998		1	1	0	47	50	3	101	56
1999		29	28	1	17	1	0	53	47
2000		226	130	21	9	2	46	357	23
2001		140	155	56	178	98	100	603	23
2002		67	128	41	1489	42	150	1863	46
2003		444	323	264	453	118	46	1332	26
2004		542	53	176	680	685	305	2394	28
New Survey Gear Introduced									
2005	38	71	349	406	1226	1316	60546	63952	70
2006	114	77	640	481	3148	2855	17197	24514	33
2007	247	386	826	1554	620	899	23957	28488	45
2008	421	372	2012	923	1730	3321	19702	28481	37
2009	212	226	1245	688	453	282	499	3604	13
2010	183	260	965	573	2417	835	2899	8133	31
2011		1264	8962	397	3963	196	3948	18730	16
2012		2097	3314	1226	447	14104	15911	37098	39
2013	2446	2607	3890	1871	4361	19015	51622	85812	37

East Greenland								
	Q1	Q2	Q3	Q4	Q5	Q6	Total	CV
2008	8692	2430	24101	1482	2173	8985	47864	23
2009	10844	8874	27251	7827	252	3094	58141	29
2010	16014	3151	81064	6202	23	4203	110656	53
2011	27064	8128	5561	12486	5235	22665	81138	20
2012	24732	10058	9347	5802	160	14322	64421	21
2013	45018	9639	15017	48519	977	40319	159487	25

Table 14.3.1.4 : Abundance indices ('000) by age from the Greenland Shrimp and Fish survey by year in West and East Greenland. The survey gear was changed in 2005. The new gear is estimated as ca. 50% more efficient than the old gear.

West Greenland

Year/age	0	1	2	3	4	5	6	7	8+
1992		0	221	126	123	63	10	3	1
1993		0	39	170	73	16	7	1	2
1994		0	10	126	22	8	1	0	0
1995		19	345	101	157	40	0	0	0
1996		0	14	203	78	3	0	0	0
1997		0	0	10	3	24	8	1	0
1998		0	17	25	20	0	0	0	0
1999		7	144	66	23	6	1	1	1
2000		90	711	363	92	13	52	0	0
2001		97	540	546	376	0	0	0	0
2002		0	603	2323	1078	245	0	4	0
2003		81	1416	1037	433	135	18	0	0
2004		1215	2812	1205	786	382	71	33	4
New Survey gear Introduced									
2005	3284	1348	38177	44685	10490	5595	4596	113	30
2006	244	6804	5826	42612	9722	1956	532	72	0
2007	224	295	12835	6348	29856	2708	166	69	16
2008	35	3516	2880	20921	8337	16047	1530	150	0
2009	0	308	10203	2295	1928	365	16	5	0
2010	208	3062	2720	13244	2314	1690	48	69	0
2011	18	4617	64111	5767	5346	452	450	64	25
2012	0	203	12621	42195	7046	7673	889	454	35
2013	0	2891	8948	15691	68091	18446	10230	666	190

East Greenland

Year/age	0	1	2	3	4	5	6	7	8	9	10+
2008	4355	333	1147	5785	4440	6429	4508	1946	741	1091	739
2009	14970	8442	6453	3870	5082	5635	6575	2516	227	554	385
2010	150	2084	3262	2492	2584	11302	8106	11037	2958	450	914
2011	315	141	3493	6364	14329	5654	4278	2243	3364	1838	634
2012	0	253	310	2014	3336	7388	3414	1998	1303	1865	795
2013	0	173	1102	748	15911	14505	18866	4652	3274	1800	2199

Table 14.3.2.1 ***German survey*****. Numbers of valid hauls by stratum. In 2012, the survey was re-stratified as described in the stock Annex. Strata 5.1 and 6.1, 5.2 and 6.2 were combined to achieve higher sample coverage.**

year	Str 1.1	Str 1.2	Str 2.1	Str 2.2	Str 3.1	Str 3.2	Str 4.1	Str 4.2	Str 5.1	Str 5.2	Str 7.1	Str 7.2	Str 8.2	Str 9.2	Sum
1981	1	1	13	2	3	1	1	2	2	12	4	12	19	10	83
1982	20	11	16	7	9	6	13	2	.	12	1	9	15	15	136
1983	26	11	25	11	17	5	18	4	1	26	8	14	25	10	201
1984	25	13	26	8	19	6	20	4	4	5	1	5	7	2	145
1985	10	8	26	10	17	5	21	4	5	22	11	26	35	18	218
1986	27	9	21	9	16	7	20	3	2	27	11	14	31	34	231
1987	25	19	21	4	18	4	21	5	16	25	7	21	26	11	223
1988	34	21	28	5	18	5	18	2	20	19	10	13	36	9	238
1989	25	14	30	9	8	3	25	3	37	.	20	.	26	4	204
1990	19	7	23	8	16	3	21	6	15	24	4	6	15	12	179
1991	19	11	23	7	13	6	14	5	9	18	11	7	45	13	201
1992	6	6	6	5	6	6	7	5	.	.	.	.	4	2	53
1993	9	7	9	6	10	8	7	.	9	9	5	5	15	10	109
1994	16	13	13	8	10	6	7	5	.	.	.	.	.	6	84
1995	.	.	3	.	10	7	10	5	8	8	5	4	16	8	84
1996	5	5	8	5	12	5	10	5	7	9	5	3	13	6	98
1997	5	6	5	5	6	5	8	5	5	6	4	1	9	5	75
1998	9	5	10	7	11	6	10	5	5	9	6	2	12	6	103
1999	8	7	14	8	13	6	9	3	5	7	4	4	10	6	104
2000	13	6	15	6	14	5	9	5	6	7	8	4	12	9	119
2001	.	.	15	7	15	5	11	6	5	8	8	2	17	12	111
2002	.	.	7	2	5	6	8	4	6	7	5	2	10	7	69
2003	.	.	7	6	7	7	7	5	5	5	5	1	12	10	77
2004	8	8	11	9	9	5	9	5	7	7	8	3	13	11	113
2005	.	.	9	7	8	6	6	5	6	7	8	4	12	9	87
2006	6	5	7	5	7	7	8	5	3	1	5	4	11	7	81
2007	5	5	7	5	6	5	9	5	4	6	4	3	13	8	85
2008	5	.	7	7	7	9	7	6	6	8	4	3	10	8	87
2009	2	.	5	5	6	6	5	5	2	5	5	4	9	8	67
2010	5	5	10	5	7	9	10	6	1	3	8	3	14	8	94
2011	.	.	5	5	5	5	6	6	5	8	6	4	14	9	78
2012	5	5	10	8	9	7	10	6	6	7	8	3	12	9	105
2013	6	6	8	6	10	7	9	6	5	9	7	5	15	9	108

Table 14.3.2.2 ***German survey*****. Cod off Greenland. Abundance (1000) and biomass indices (t) for West, East Greenland and total by stratum. Confidence intervals (CI) are given in per cent of the stratified mean at 95% level of significance. Spawning stock numbers (SSN, x1000) and biomass indices (SSB, tons) based on survey indices and historical maturity data from Horsted et al, 1984. In 2012, the survey was re-stratified and the survey time series recalculated as described in the stock Annex.**

Year	Abun-dance					Biomass				
	West	East	Total	CI	SSN	West	East	Total	CI	SSB
1982	50273	3205	53478	42	9309	72710	10055	82765	41	26783
1983	27727	2892	30619	31	6655	46648	12605	59253	28	19904
1984	9269	3075	12344	41	3290	14247	9780	24027	40	11192
1985	29266	3911	33177	31	3952	19006	10675	29681	52	11821
1986	65077	8829	73906	29	3904	38915	11385	50300	27	13137
1987	389021	18024	407045	42	11223	316537	23343	339880	44	25171
1988	326110	7479	333589	46	14410	323368	16165	339533	47	22676
1989	211385	13626	225011	50	23155	202297	35186	237483	45	38756
1990	20678	12386	33064	38	8761	21084	29650	50734	33	17675
1991	2899	3379	6278	30	2733	3358	10138	13496	32	7240
1992	1149	595	1744	44	149	363	905	1268	58	445
1993	858	1381	2239	48	217	212	2084	2296	49	849
1994	282	234	516	31	61	70	779	849	86	271
1995	168	3814	3982	90	1093	44	12377	12421	120	5826
1996	435	614	1049	36	123	200	1490	1690	50	473
1997	150	1548	1698	71	309	138	4820	4958	87	1192
1998	899	501	1400	40	137	70	1347	1417	87	511
1999	539	1859	2398	48	297	143	3109	3252	72	1418
2000	1065	1142	2207	54	191	319	1586	1905	48	869
2001	3995	2229	6224	51	305	1302	4268	5570	42	1047
2002	2363	2678	5041	53	590	1224	5095	6319	64	1975
2003	3270	5569	8839	36	1394	1288	12499	13787	71	5300
2004	16717	6393	23110	55	1478	3429	10194	13623	35	5077
2005	33772	31180	64952	34	2535	13596	42105	55701	32	12755
2006	124461	37320	161781	98	4434	81063	44245	125308	71	14690
2007	86548	15833	102381	83	5816	86590	38524	125114	71	18518
2008	47658	22560	70218	36	7036	31812	60681	92493	35	26233
2009	5307	18309	23616	45	7576	2006	63716	65722	54	34954
2010	16125	14892	31017	41	8186	10580	58029	68609	52	43010
2011	10379	11251	21630	29	5479	14334	43134	57468	31	30539
2012	141113	13970	155083	51	7797	100802	57429	158231	37	38365
2013	77444	9505	86949	83	10090	114344	34166	148510	79	39971

Table 14.3.2.3 *German survey*, West Greenland. Age disaggregate abundance indices ('1000). In 2012, the survey was re-stratified and the survey time series recalculated as described in the stock Annex.

Year	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
1982	.	95	575	16467	6340	18553	5619	1512	335	643	56	65	50260
*) 1983	.	.	812	1556	14713	2719	6063	1040	548	175	93	7	27726
1984	103	3	19	1180	849	5367	493	1089	53	93	17	.	9266
1985	414	18748	699	451	3122	1397	3836	211	370	8	12	.	29268
1986	.	4821	51327	1988	428	3399	966	1870	53	198	10	.	65060
1987	.	148	27736	335397	14651	3126	5200	759	1809	.	167	14	389007
1988	.	133	1613	51589	267897	2892	348	591	351	656	15	.	326085
1989	12	163	1378	4458	100890	102716	1586	.	113	19	71	.	211382
1990	69	31	613	1669	796	13213	4247	25	0	0	.	.	20663
1991	.	125	118	244	650	85	1402	250	3	.	.	.	2877
1992	.	98	822	132	27	43	.	27	.	.	.	.	1149
1993	.	8	499	318	12	21	.	.	.	.	.	.	858
1994	.	137	23	98	18	3	.	2	.	.	.	.	281
1995	.	.	137	7	24	.	.	.	.	.	.	.	168
1996	.	76	6	342	7	.	5	.	.	.	.	.	436
1997	.	6	13	7	125	.	.	.	.	.	.	.	151
1998	25	855	.	3	3	13	.	.	.	.	.	.	899
1999	13	244	221	52	3	.	3	.	.	.	.	.	536
2000	.	91	555	347	70	.	.	.	.	.	.	.	1063
2001	.	330	2995	561	70	20	.	.	.	.	.	.	3976
2002	6	6	582	1721	40	.	.	.	.	.	.	.	2355
2003	.	1884	217	632	425	52	15	.	.	.	.	.	3225
2004	412	12238	2875	439	330	328	87	4	.	.	.	.	16713
2005	119	555	28799	3380	232	315	255	21	13	.	.	.	33689
2006	237	2294	9274	103359	6875	330	1242	663	57	.	.	.	124331
2007	184	282	11105	6369	63611	4605	272	83	35	.	.	.	86546
2008	14	1367	2726	27364	6280	9620	232	24	30	0	0	.	47657
2009	64	596	3224	462	672	122	151	14	.	.	.	.	5305
2010	230	1915	1872	9895	792	770	273	340	29	3	.	.	16119
2011	.	288	2404	1570	3560	1341	950	126	143	0	0	0	10382
2012	148	1221	39291	74789	14060	10253	988	274	52	29	.	.	141105
2013	0	156	1597	16720	40211	10482	6955	960	201	46	18	0	77346

***) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (ICES, 1984).**

Table 14.3.2.4 ***German Survey*, East Greenland. Age disaggregate abundance indices (1000),. *). In 2012, the survey was re-stratified and the survey time series recalculated as described in the stock Annex.**

Year/ Age	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
1982	.	5	144	299	615	696	477	189	66	628	36	36	3191
*) 1983	.	.	149	219	365	430	769	466	109	96	255	37	2895
1984	.	8	48	663	262	562	378	781	208	93	13	.	3016
1985	67	596	166	39	807	650	585	245	625	90	18	27	3915
1986	.	2146	3700	826	166	618	289	528	134	349	24	27	8807
1987	.	3	5035	8207	2015	524	771	186	663	80	451	45	17980
1988	6	9	79	2544	3112	644	163	489	50	210	28	132	7466
1989	.	2	26	95	2697	9274	429	44	690	58	235	69	13619
1990	.	22	40	288	278	2555	8844	120	15	74	.	109	12345
1991	.	34	126	120	239	53	1187	1569	30	11	3	.	3372
1992	.	.	46	71	51	35	67	40	51	.	.	.	361
1993	.	4	15	869	152	95	97	31	83	34	.	.	1380
1994	.	32	.	8	80	39	22	38	.	8	.	.	227
1995	.	1	595	346	252	1399	372	120	403	32	192	.	3712
1996	.	.	.	204	128	131	105	23	25	.	.	.	616
1997	.	.	12	17	638	557	191	78	48	.	.	.	1541
1998	26	63	39	4	11	160	138	48	10	.	.	.	499
1999	100	347	334	330	118	257	174	156	.	29	16	.	1861
2000	.	171	212	304	200	40	72	20	46	61	15	.	1141
2001	.	102	326	459	626	362	190	60	50	18	10	.	2203
2002	34	1	122	688	578	477	454	217	61	21	11	.	2664
2003	.	114	41	432	1620	1010	1009	541	220	37	.	.	5024
2004	106	1527	903	316	395	1394	849	616	228	39	10	.	6383
2005	52	1204	17643	5364	1058	2520	2308	706	176	40	.	.	31071
2006	.	94	1062	27887	5102	1043	1213	713	136	30	9	.	37289
2007	83	101	304	435	9352	3788	476	613	611	70	.	.	15833
2008	8	122	104	929	1868	14554	3989	495	192	199	44	.	22504
2009	70	52	346	292	1354	2778	11130	1964	111	134	64	.	18295
2010	.	316	1279	694	630	2376	2296	5415	1336	236	163	140	14881
2011	.	27	414	2290	1682	1129	2032	1079	2205	310	23	.	11191
2012	.	20	205	2251	3855	2440	2066	1580	1122	368	35	5	13947
2013	0	13	0	416	2662	2447	1635	588	402	268	126	68	8625

***) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (ICES, 1984).**

Table 14.3.2.5 ***German survey*****. Greenland (total). Age disaggregate abundance indices (1000). () incomplete sampling. Minor differences between previous tables due to rounding. In 2012, the survey was re-stratified and the survey time series recalculated as described in the stock Annex.**

YEAR/AGE	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
1982	0	100	720	16766	6957	19250	6095	1702	401	1272	94	100	53454
*1983	0	0	940	1710	13814	3074	6547	1585	647	291	436	57	29099
(1984)	103	11	68	1844	1113	5930	871	1871	261	186	27	0	12283
1985	481	19345	866	486	3929	2047	4421	457	992	98	30	27	33176
1986	0	6969	55030	2814	596	4017	1257	2398	188	548	34	27	73875
1987	0	153	32772	343605	16665	3650	5974	945	2472	81	621	59	406996
1988	7	143	1692	54135	271009	3538	512	1081	401	868	45	132	333559
1989	12	166	1408	4553	103586	111991	2017	45	803	76	305	68	225003
1990	69	54	652	1959	1074	15770	13091	144	15	74	0	110	33009
1991	0	160	244	363	888	139	2590	1818	34	11	3	0	6248
(1992)	0	98	869	203	77	78	67	68	51	0	0	0	1508
1993	0	12	516	1186	165	117	97	30	83	33	0	0	2238
(1994)	0	171	23	106	98	41	22	40	0	8	0	0	509
1995	0	1	732	354	278	1399	371	119	404	32	192	0	3880
1996	0	77	6	545	133	131	110	24	25	0	0	0	1049
1997	0	6	24	24	764	557	191	78	49	0	0	0	1690
1998	51	920	40	8	14	172	137	48	11	0	0	0	1400
1999	114	591	557	382	121	258	176	156	0	29	16	0	2398
2000	0	263	767	653	271	39	74	19	47	62	14	0	2207
2001	0	434	3324	1018	696	384	190	59	51	19	10	0	6182
2002	40	8	705	2410	619	480	455	217	61	21	10	0	5023
2003	0	1999	255	1063	2045	1062	1023	542	220	37	0	0	8244
2004	519	13764	3777	755	725	1721	936	622	229	38	11	0	23095
2005	170	1759	46441	8746	1290	2833	2563	727	190	39	0	0	64755
(2006)	239	2388	10337	131246	11977	1372	2455	1375	194	30	10	0	161620
(2007)	267	383	11411	6804	72964	8392	747	696	647	70	0	0	102378
2008	23	1488	2831	28293	8147	24174	4221	521	222	200	46	0	70164
2009	134	647	3570	756	2025	2899	11285	1979	111	133	64	0	23600
2010	230	2232	3151	10590	1422	3145	2570	5757	1365	239	164	140	31003
2011	0	315	2820	3859	5242	2470	2983	1204	2347	310	23	0	21571
2012	149	1242	39497	77041	17915	12693	3055	1855	1171	396	36	5	155053
2013	0	169	1597	17136	42873	12929	8590	1548	603	314	144	68	85971

***) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (ICES, 1984).**

Table 14.3.2.6 *German survey*, **catch curve analysis. Year class mortalities at ages 4-8 estimated from german survey catch at age data. No values for YC 1986-1997 due to many 0 in the catch at age data. Yellow highlights strong Year classes.**

YC	Z (4–8)	R2	Ages in analysis
1982	1.11	0.68	No 7 year old
1983	1.56	0.97	
1984	1.72	0.97	4-7
1985	2.38	0.97	4-7
1986			
1987			
1988			
1989			
1990			
1991			
1992			
1993			
1994			
1995			
1996			
1997			
1998	0.27	0.4	
1999	0.25	0.57	
2000	0.38	0.32	
2001	0.59	0.83	
2002	0.59	0.98	
2003	0.83	0.99	
2004	0.48	0.9	
2005	0.3	0.49	

Table 14.5.1. Number of tagged cod in the period of 2003 to 2013 in different regions.

Tagged			
Year	Fjord	Bank (West)	East Greenland
2003	599		
2004	658		
2005	565		
2006	41		
2007	1140	924	1184
2008	231	491	805
2009	633		525
2010	88		
2011	28		403
2012	86	2805	1117
2013	183	2321	

Table 14.5.2: Number of recaptured cod in the period of 2003 to 2013 in different regions.

Recaptures

	Fjord (West)	Bank (West)	East Greenland
Fjord (West)	430	6	
Bank (West)		64	1
East Greenland		4	40
Fjord (East)			1
Iceland	3	24	60

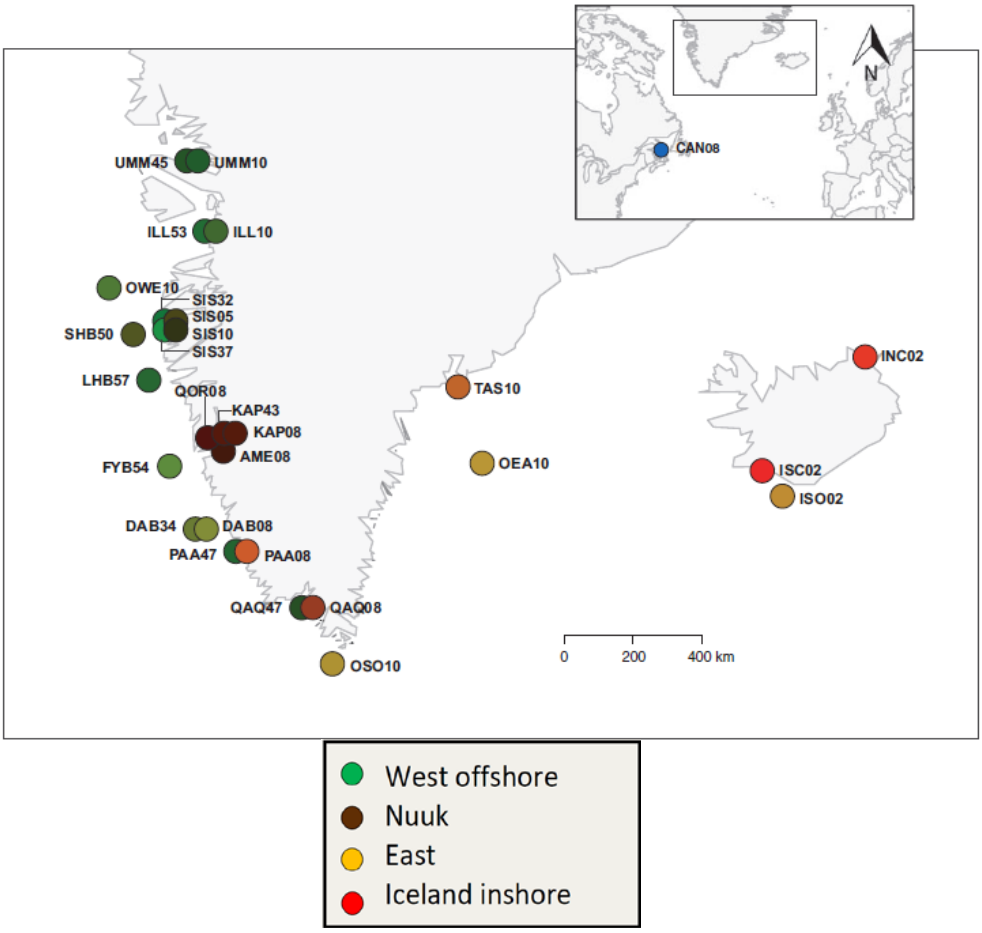


Figure. 14.1. Sampling location of spawning cod in Greenland and Iceland in the genetic project. The colours of the dots represent the blends of sample mean of the different spawning population: West offshore, Nuuk (inshore), East (Greenland and offshore Iceland) and Iceland inshore as signal intensities of green and red respectively. After Therkildsen et al. 2013.

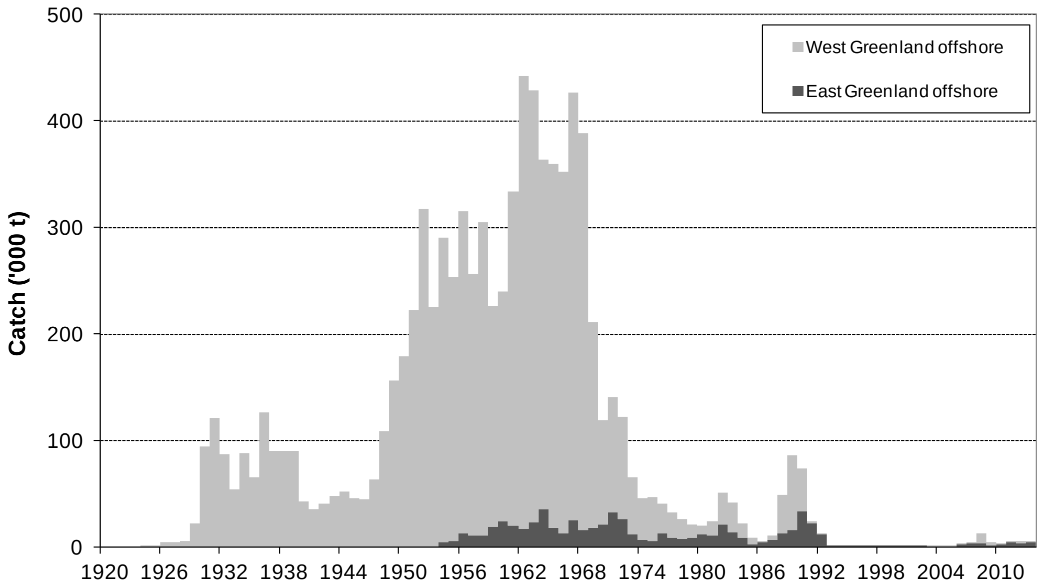


Figure 14.2.1. Cod off Greenland. Catches 1920-2013 as used by the Working Group, offshore by West Greenland and offshore by East Greenland (Horsted 1994,2000). Columns are stacked.

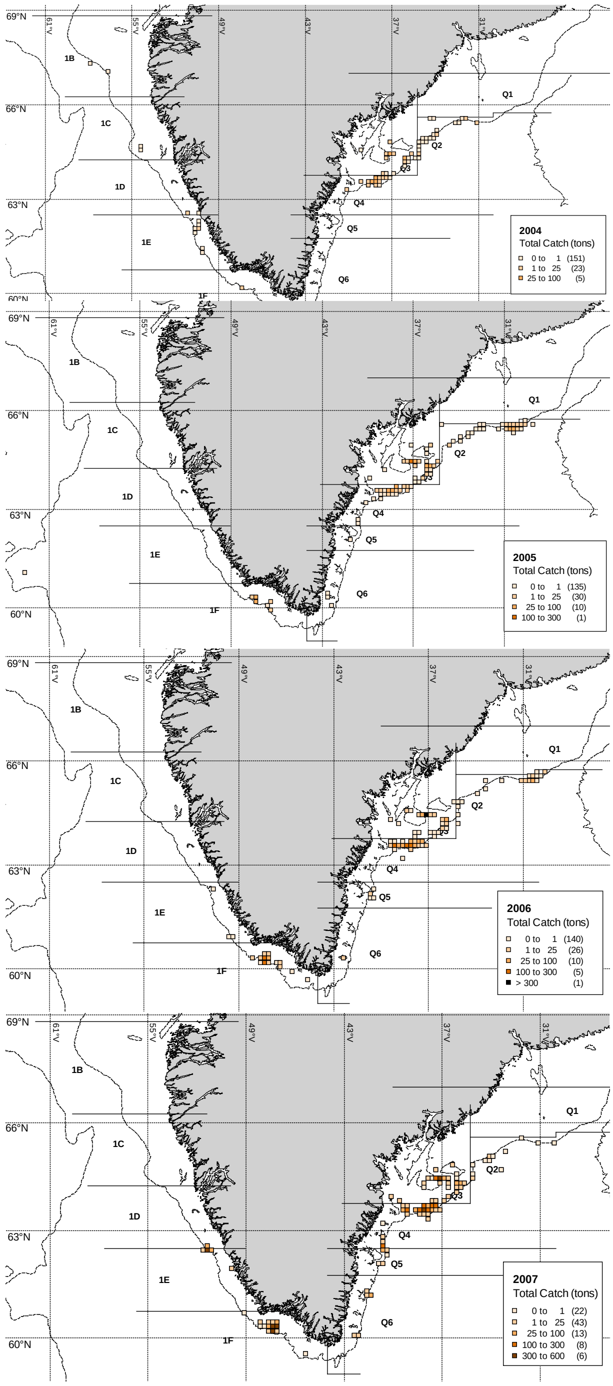
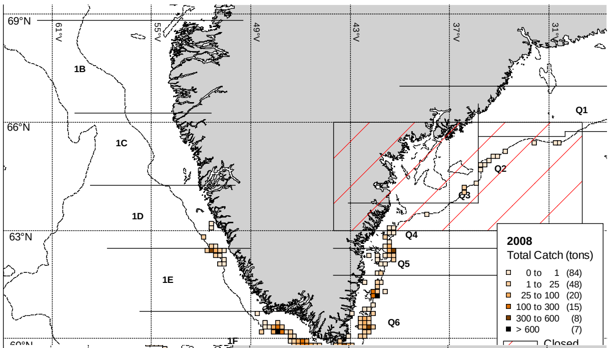
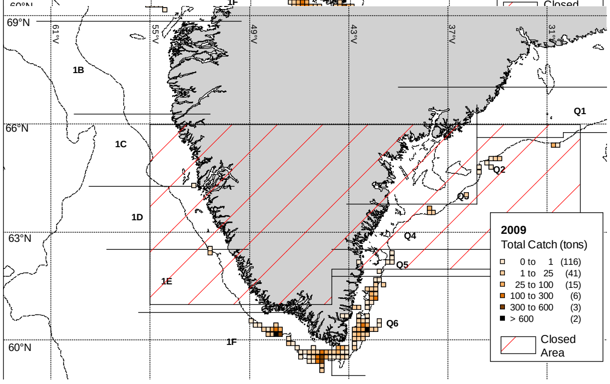


Figure 14.2.2.2: Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.


69°N
66°N
63°N
61°V
55°V
49°V
43°V
37°V
31°V
1B
1C
1D
1E
1F
Q1
Q2
Q3
Q4
Q5
Q6
2008
Total Catch (tons)
0 to 1 (84)
1 to 25 (48)
25 to 100 (20)
100 to 300 (15)
300 to 600 (8)
> 600 (7)
Closed


69°N
66°N
63°N
60°N
61°V
55°V
49°V
43°V
37°V
31°V
1B
1C
1D
1E
1F
Q1
Q2
Q4
Q5
Q6
2009
Total Catch (tons)
0 to 1 (116)
1 to 25 (41)
25 to 100 (15)
100 to 300 (6)
300 to 600 (3)
> 600 (2)
Closed Area

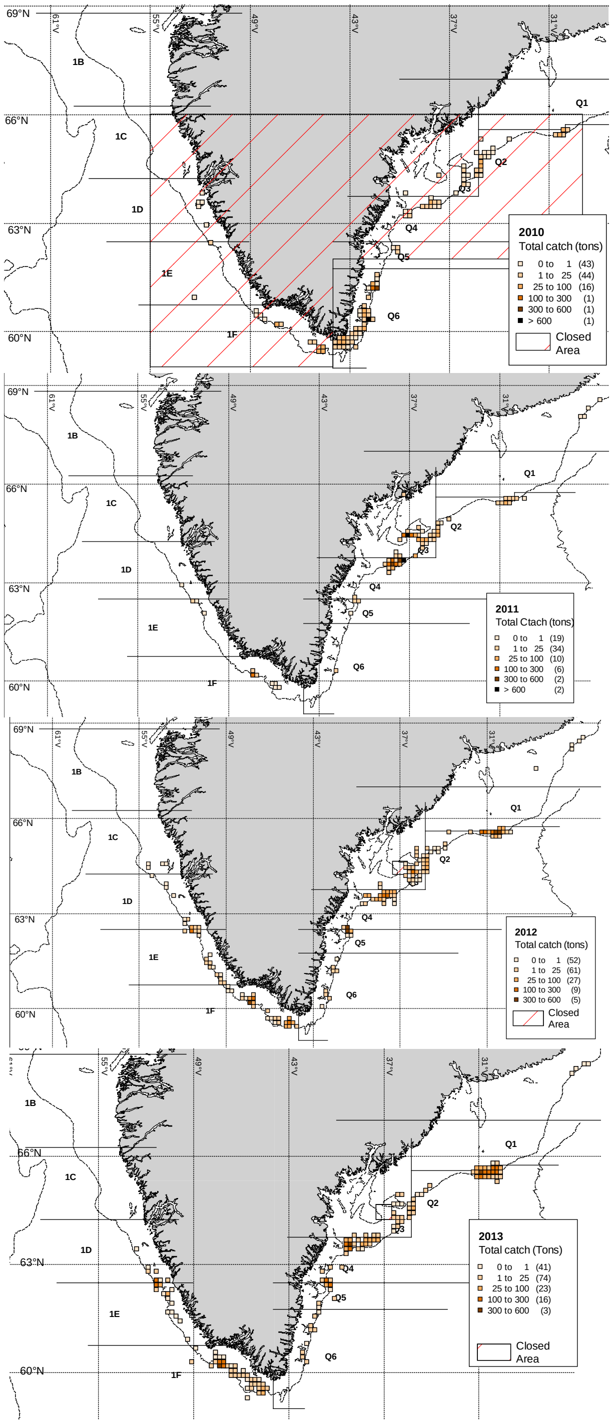


Figure 14.2.2.2: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

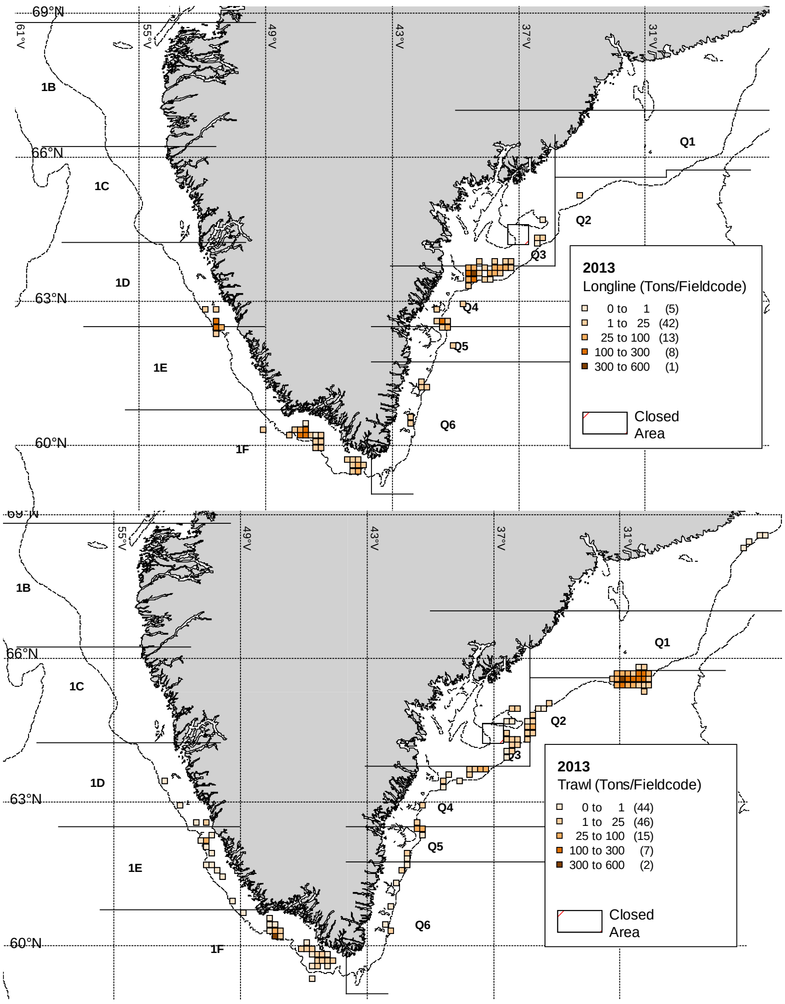


Figure 14.2.2.3: Distribution of Longline and Trawl catches of Atlantic cod in West and East Greenland 2013. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

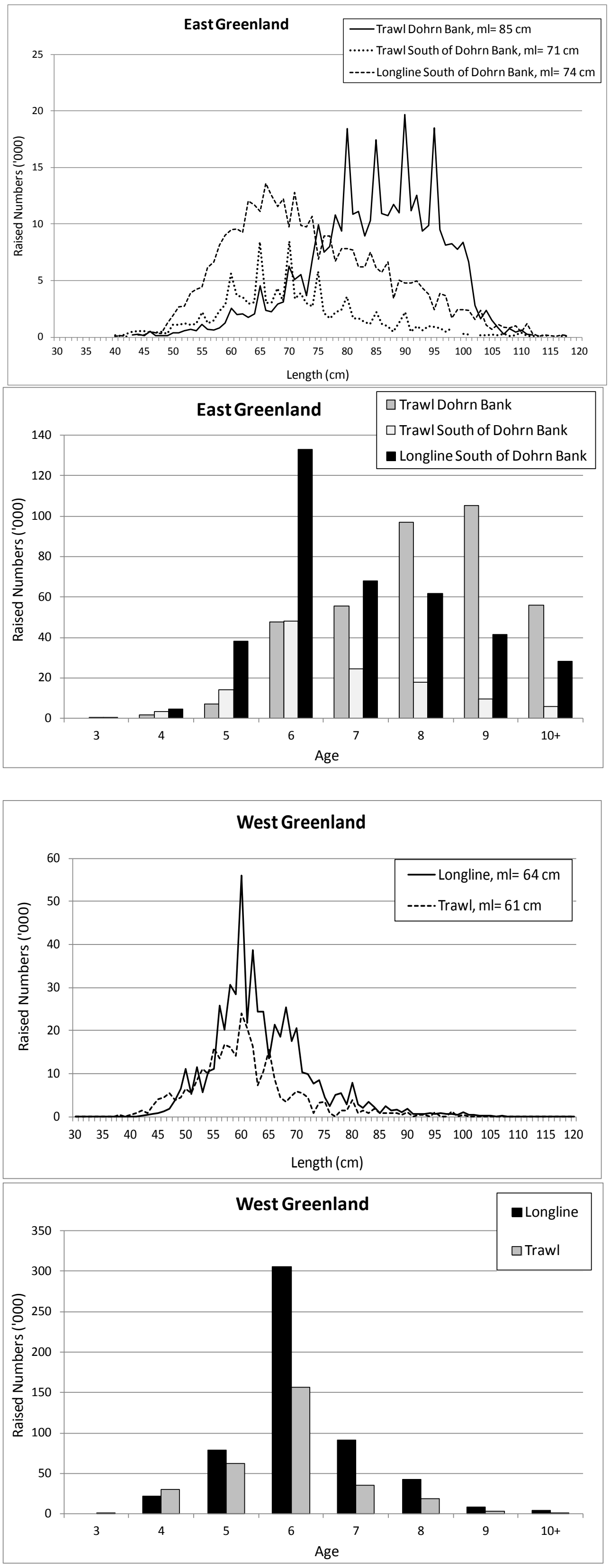


Figure 14.2.3.1: Total length and age distributions of commercial cod catches in the East and West Greenland offshore fishery by gear in 2013.

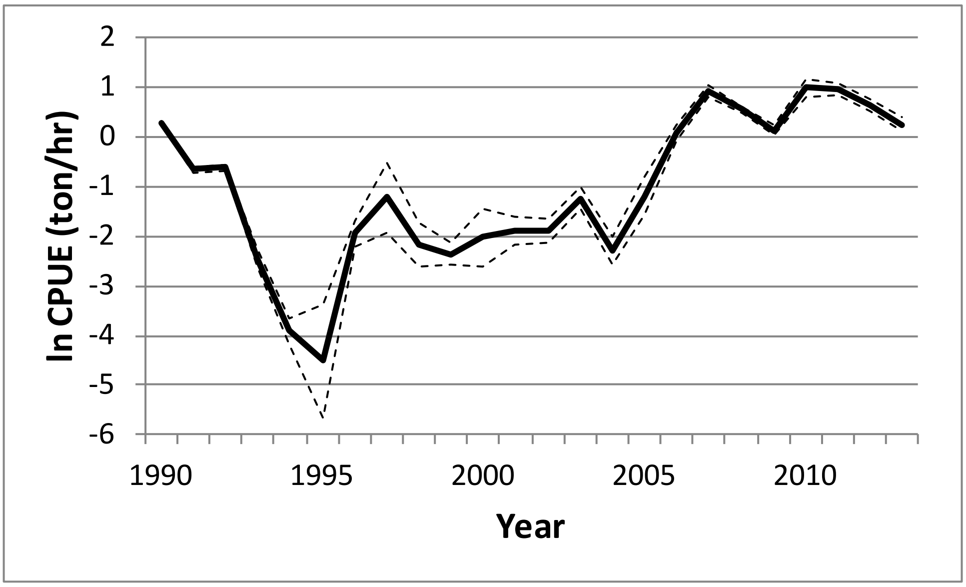
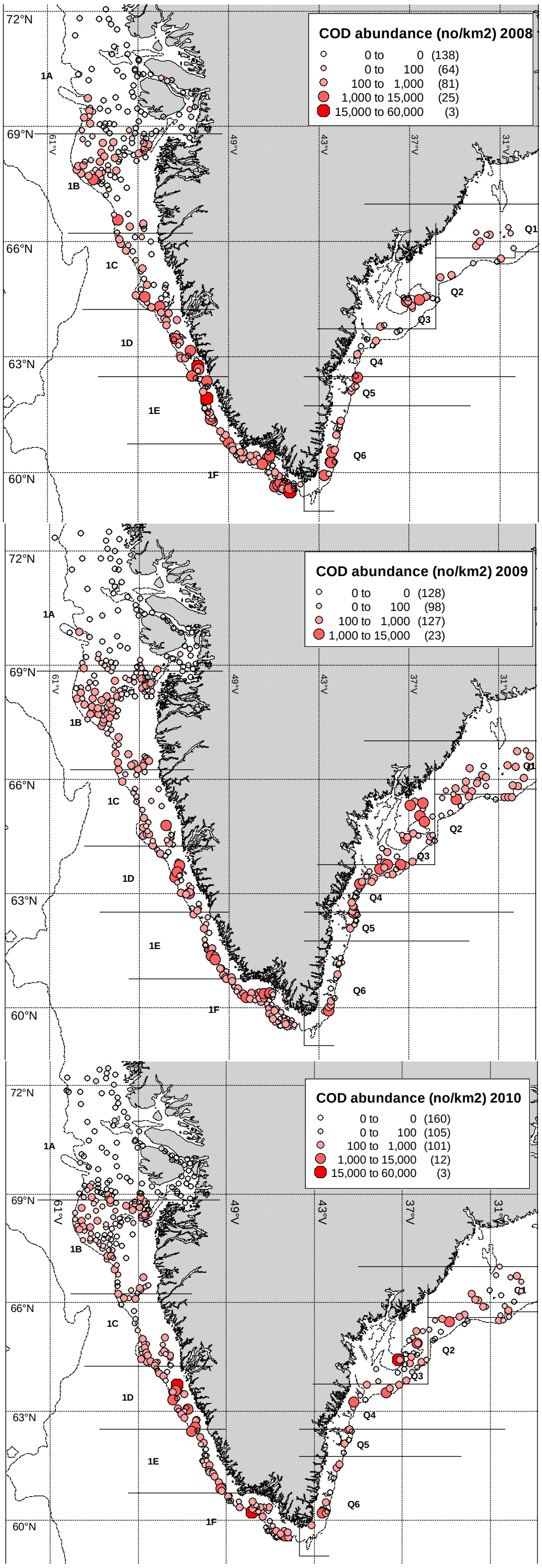


Figure 14.2.4.1: Ln CPUE (ton/hr) for Atlantic Cod caught in the fishery in East (ICES XIVb) and West (NAFO 1DEF) Greenland. Based on model: lncpue = year + area (East and West). Dashed lines are 2*SE.


COD abundance (no/km2) 2008
0 to 0 (138)
0 to 100 (64)
100 to 1,000 (81)
1,000 to 15,000 (25)
15,000 to 60,000 (3)
72°N
69°N
66°N
63°N
60°N
1A
1B
1C
1D
1E
1F
Q1
Q2
Q3
Q4
Q5
Q6
COD abundance (no/km2) 2009
0 to 0 (128)
0 to 100 (98)
100 to 1,000 (127)
1,000 to 15,000 (23)
COD abundance (no/km2) 2010
0 to 0 (160)
0 to 100 (105)
100 to 1,000 (101)
1,000 to 15,000 (12)
15,000 to 60,000 (3)

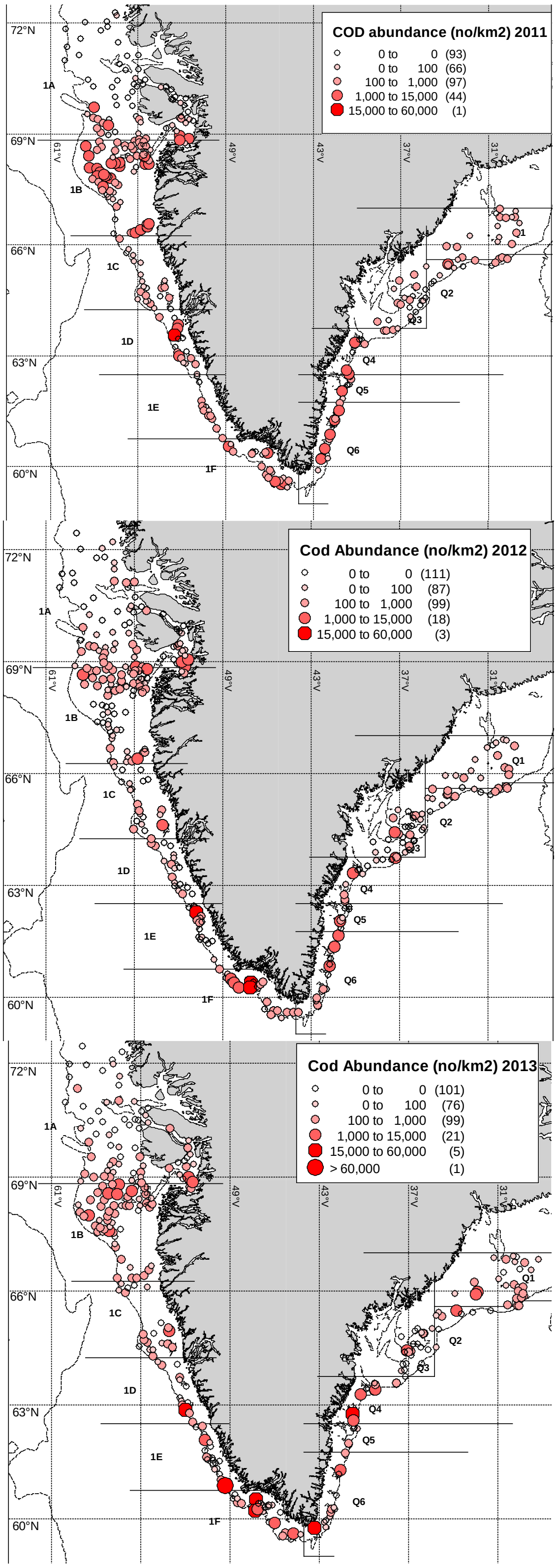
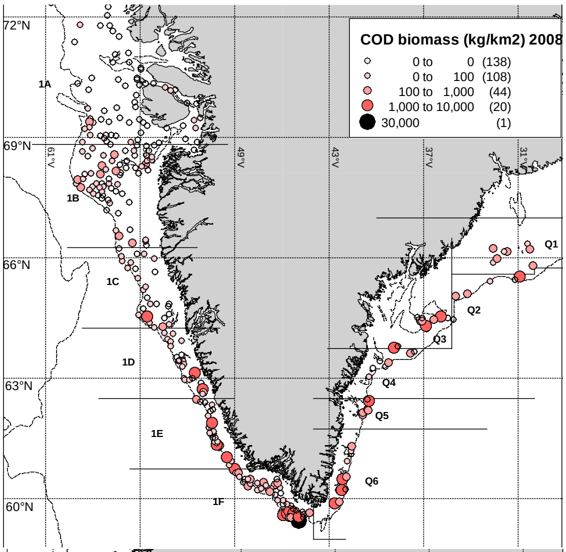
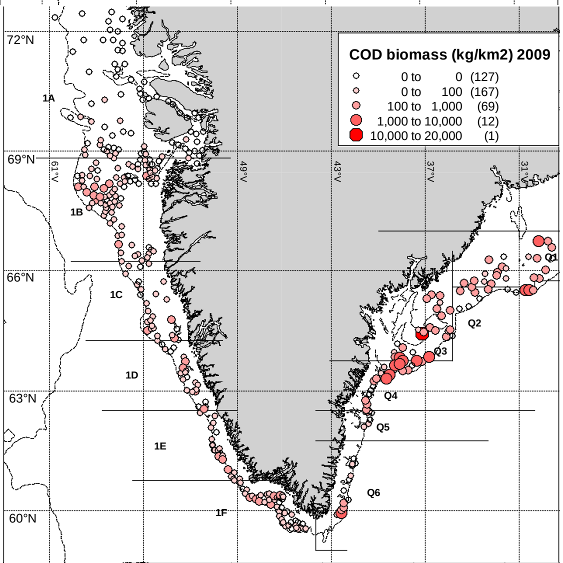
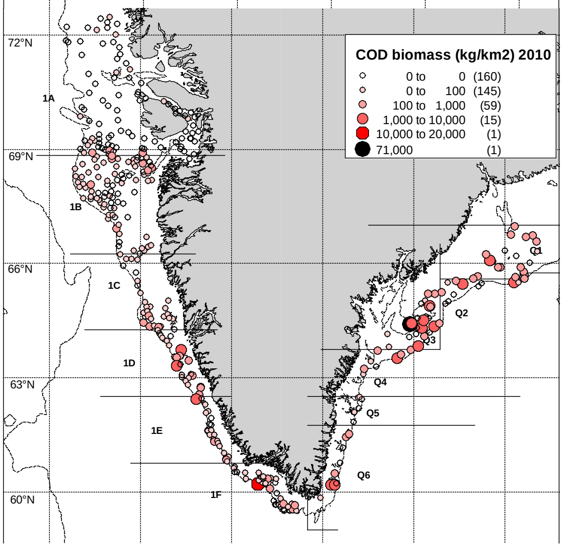


Figure14.3.1.1. Greenland shrimp and fish survey 2008-2013. Abundance per Km²


COD biomass (kg/km2) 2008
0 to 0 (138)
0 to 100 (108)
100 to 1,000 (44)
1,000 to 10,000 (20)
30,000 (1)
72°N
69°N
66°N
63°N
60°N
61°W
49°W
43°W
37°W
31°W
1A
1B
1C
1D
1E
1F
Q1
Q2
Q3
Q4
Q5
Q6


COD biomass (kg/km2) 2009
0 to 0 (127)
0 to 100 (167)
100 to 1,000 (69)
1,000 to 10,000 (12)
10,000 to 20,000 (1)
72°N
69°N
66°N
63°N
60°N
61°W
49°W
43°W
37°W
31°W
1A
1B
1C
1D
1E
1F
Q1
Q2
Q3
Q4
Q5
Q6


COD biomass (kg/km2) 2010
0 to 0 (160)
0 to 100 (145)
100 to 1,000 (59)
1,000 to 10,000 (15)
10,000 to 20,000 (1)
71,000 (1)
72°N
69°N
66°N
63°N
60°N
1A
1B
1C
1D
1E
1F
Q1
Q2
Q3
Q4
Q5
Q6

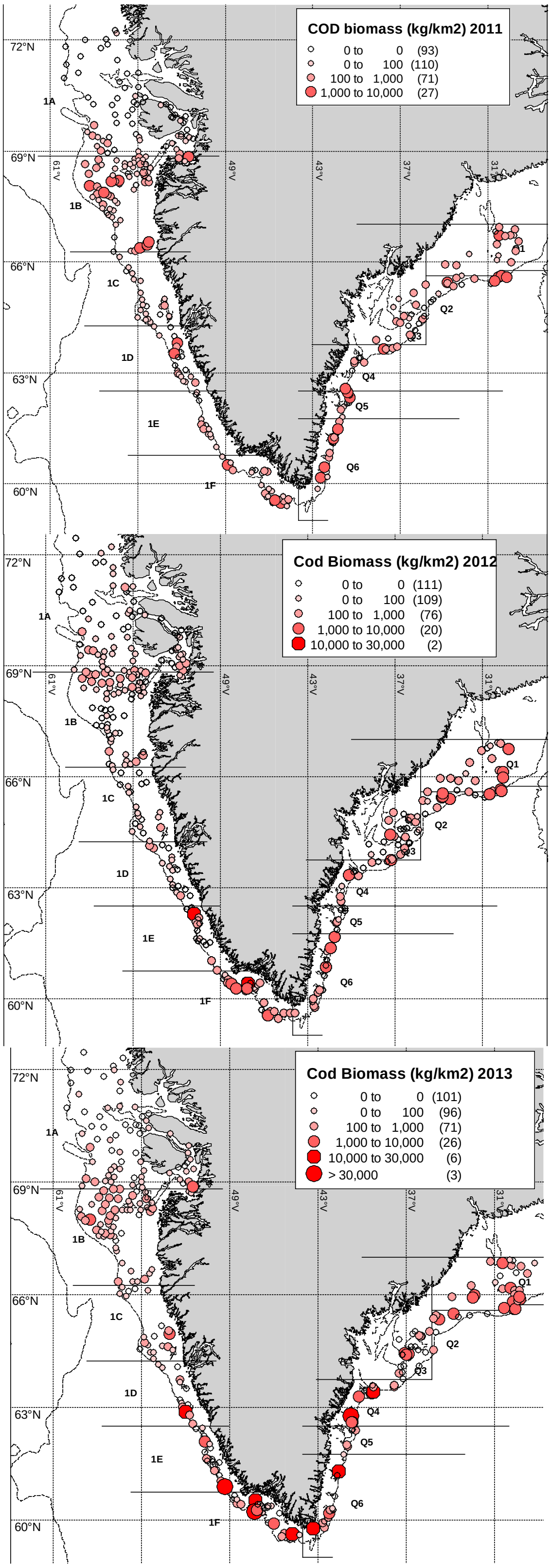


Figure 14.3.1.2. Greenland shrimp and fish survey 2008-2013. Catch weight kg per Km²

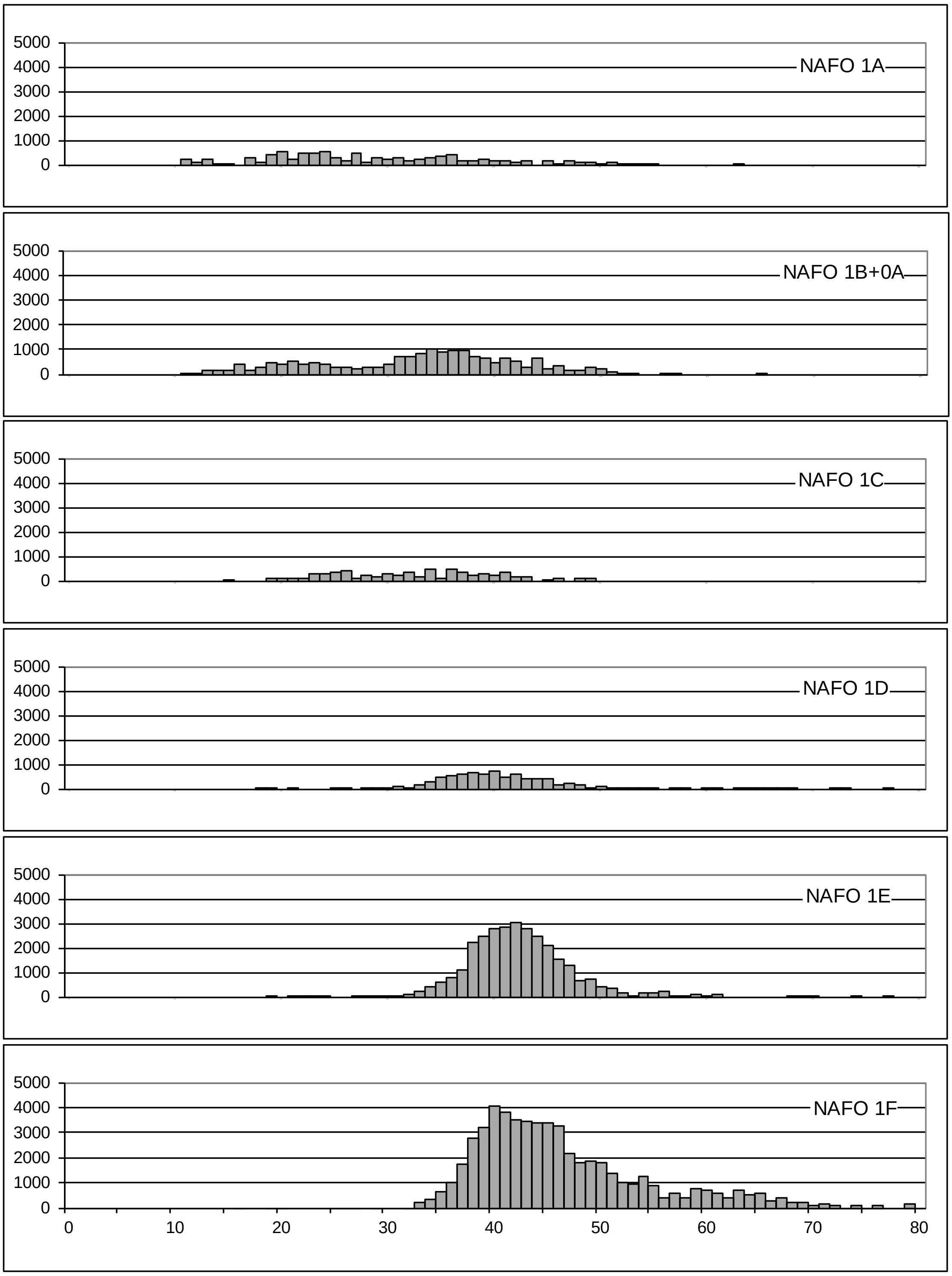


Figure 14.3.1.3: Greenland shrimp and fish survey 2013 in West Greenland. Length distribution from the northern area NAFO Div. 1A (top) to the southern area NAFO Div. 1F (bottom).

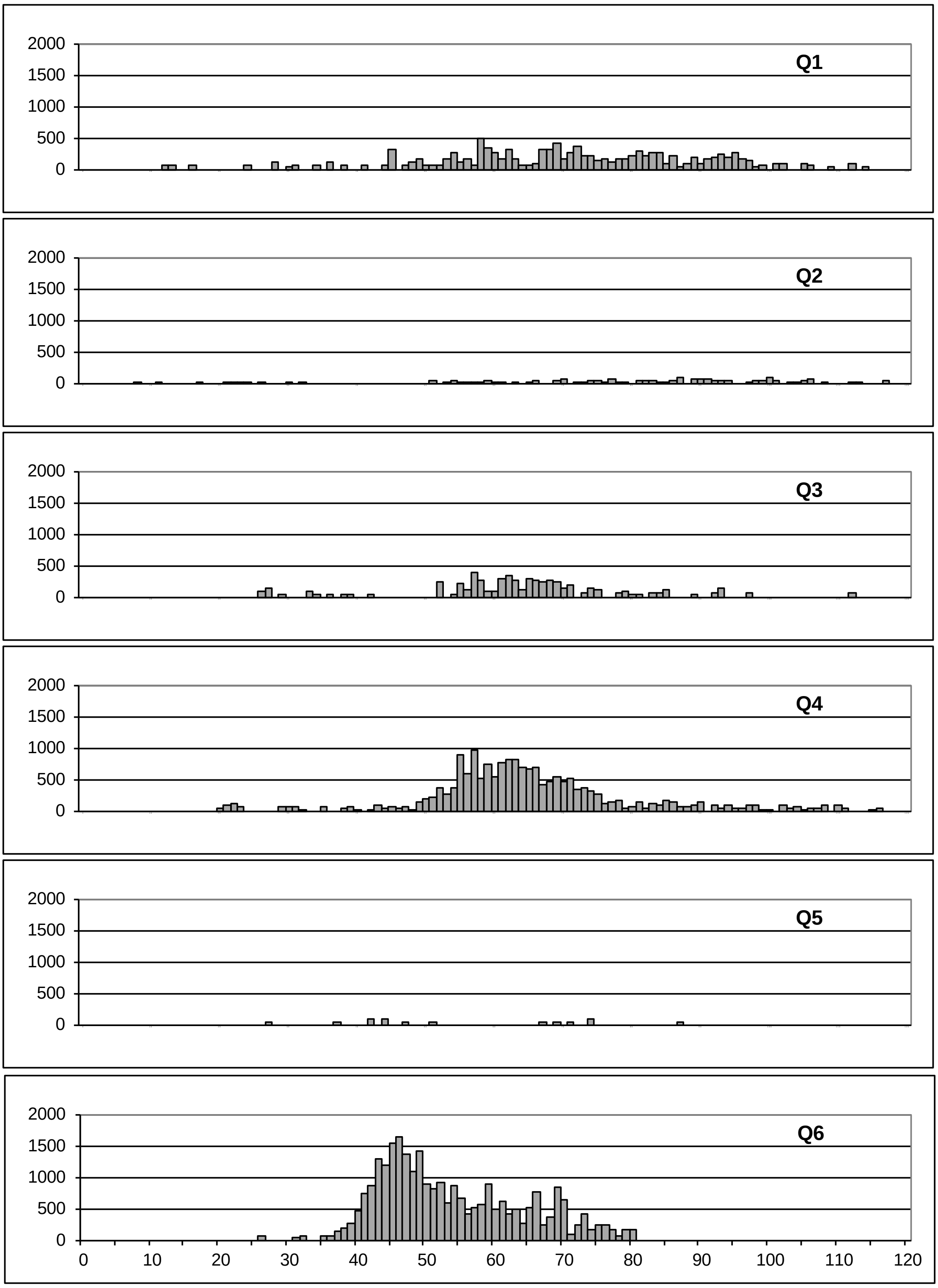


Figure 14.3.1.4 : Greenland shrimp and fish survey 2013 in East Greenland. Length distribution from the northern area Q1 (top) to the southernmost area Q6 (bottom). Areas shown in fig. 14.8.

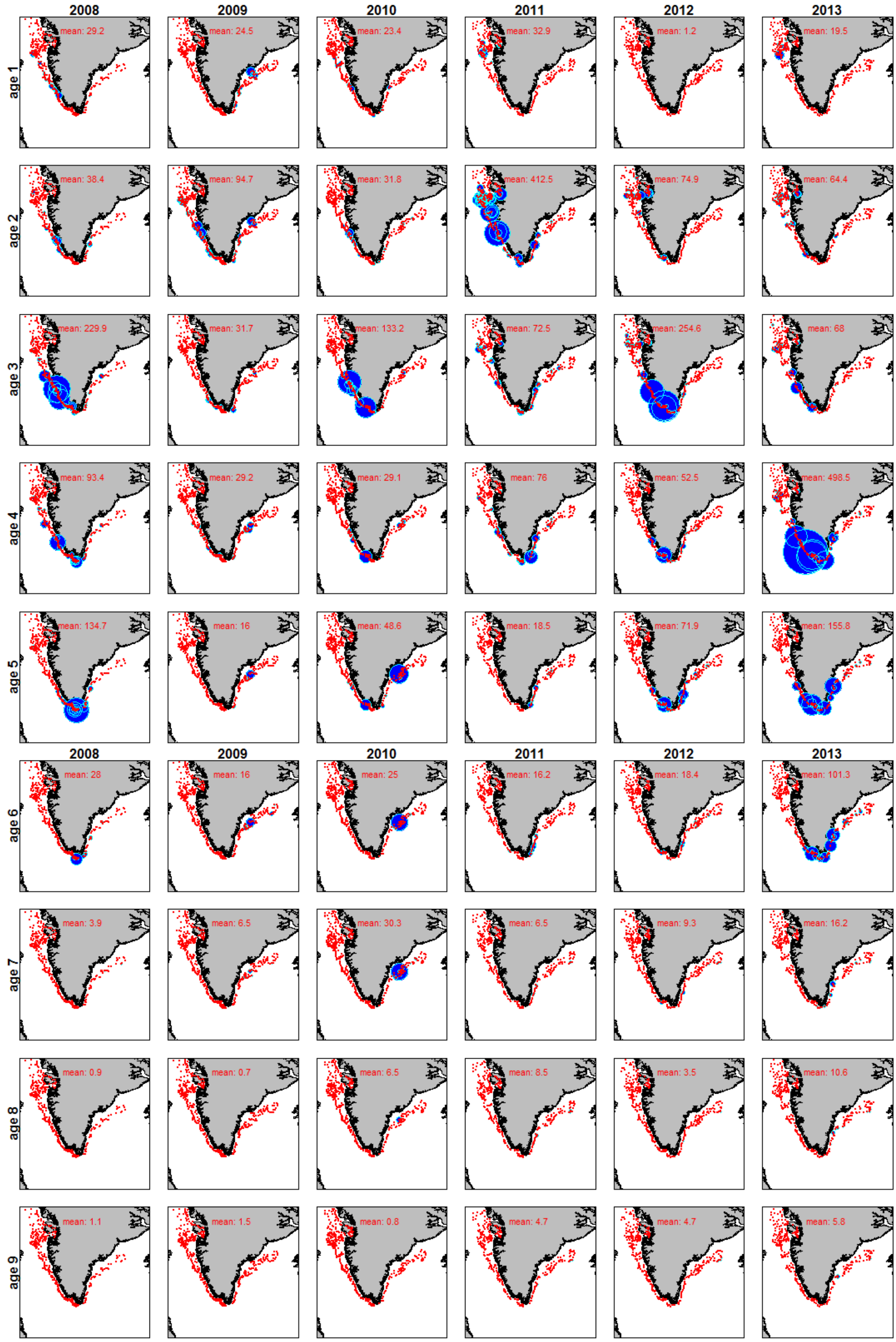


Figure 14.3.1.5. Abundace (no/km²) pr. station of ages 1-9 in the years 2008-2013.

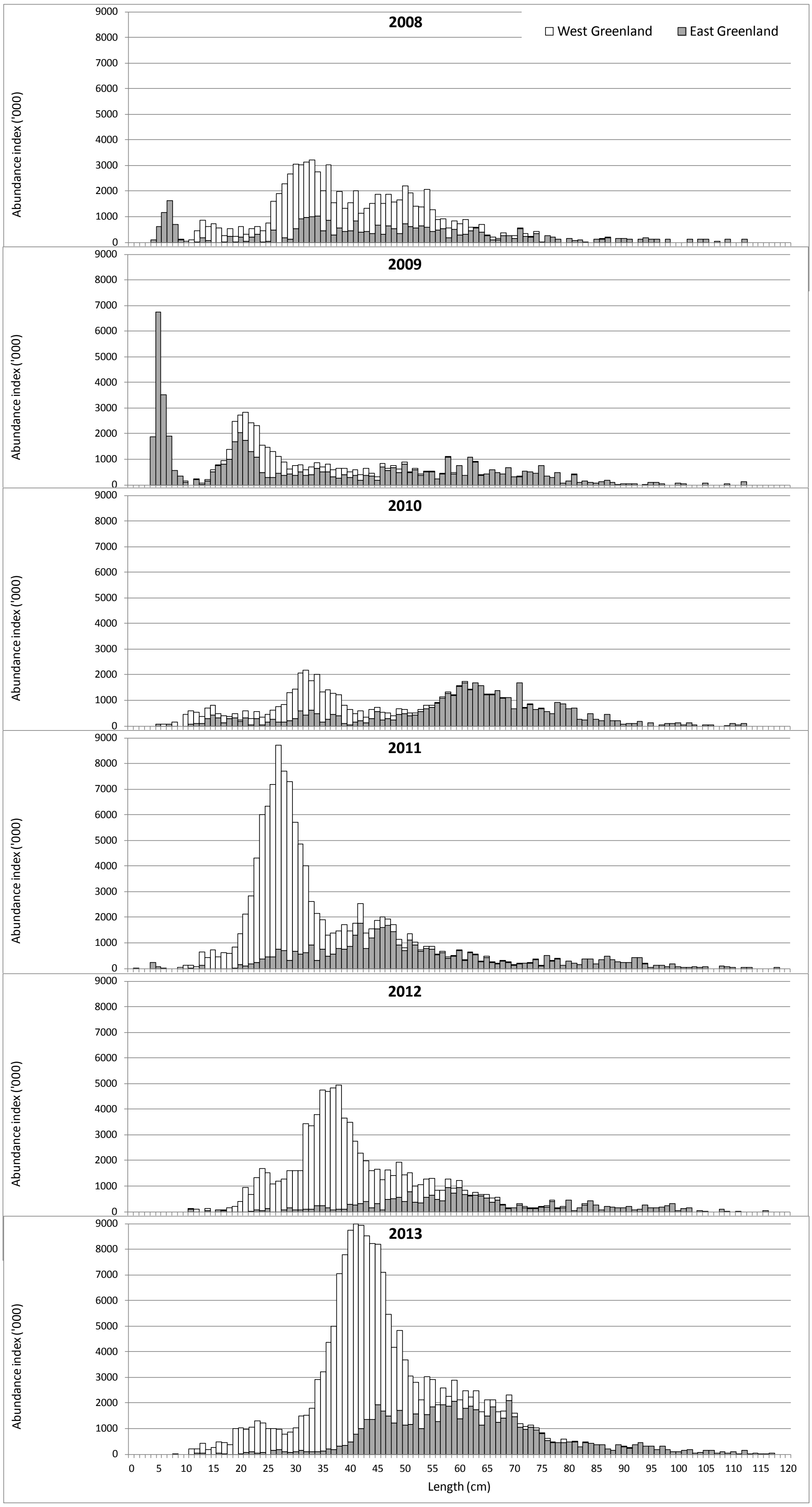

2008
West Greenland
East Greenland
2009
2010
2011
2012
2013
Abundance index ('000)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120
Length (cm)

Figure 14.3.1.6: Total abundance indices by length in West and East Greenland shrimp and fish survey, 2008-2013.

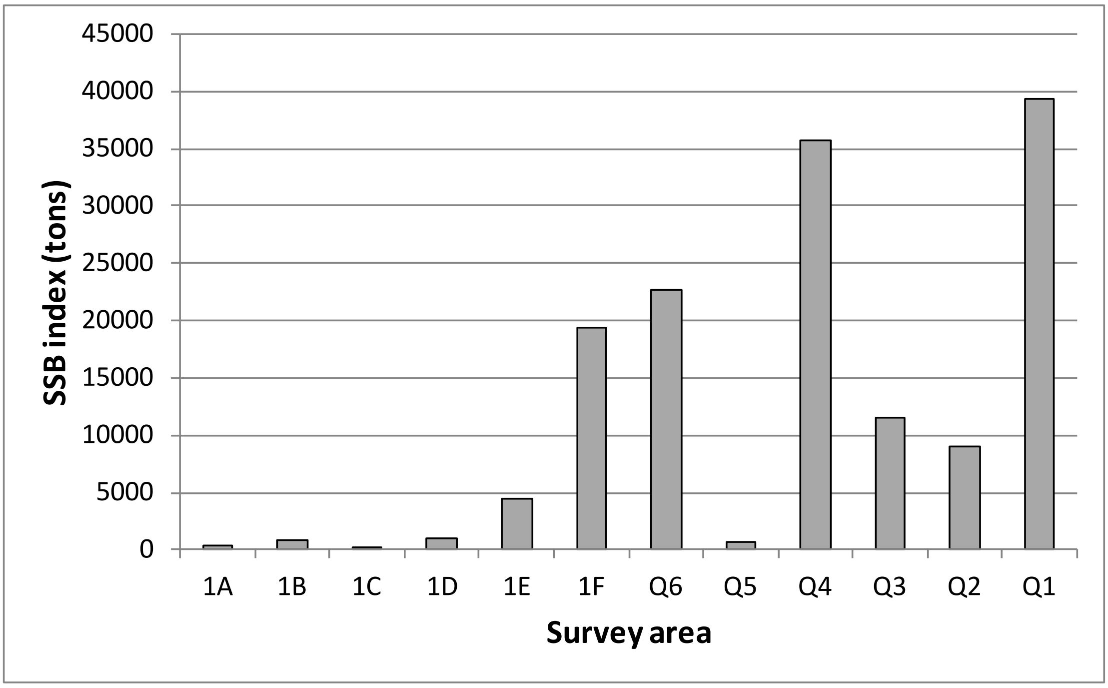


Figure 14.3.1.7: The Spawning stock biomass from the Greenland surveys, 2012. Maturity taken from proportion mature by length as recorded on observer trips off East Greenland in 2007.

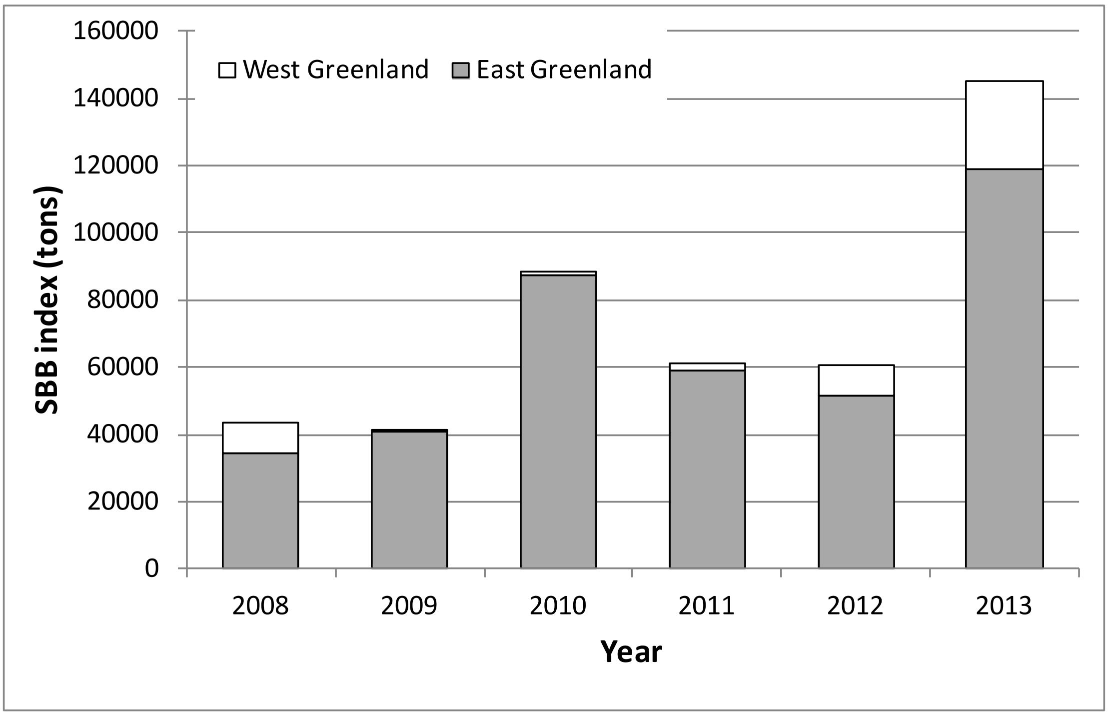


Figure 14.3.1.8: Estimated SSB (tons) by year from the Greenland Shrimp and Fish survey in West and East Greenland.

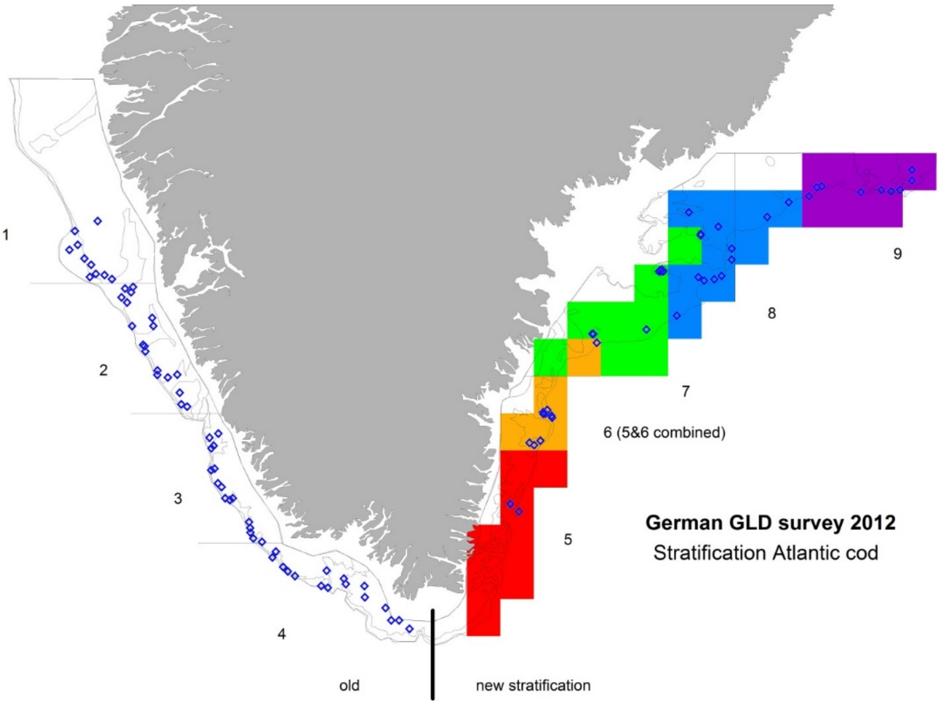


Figure 14.3.2.1 German survey, 2012. Strata and haul positions. At East Greenland, restratification now accounts for habiat heterogeneity such as shelf edge habitats and banks. Stratum 1 not covered in 2011, but 2012

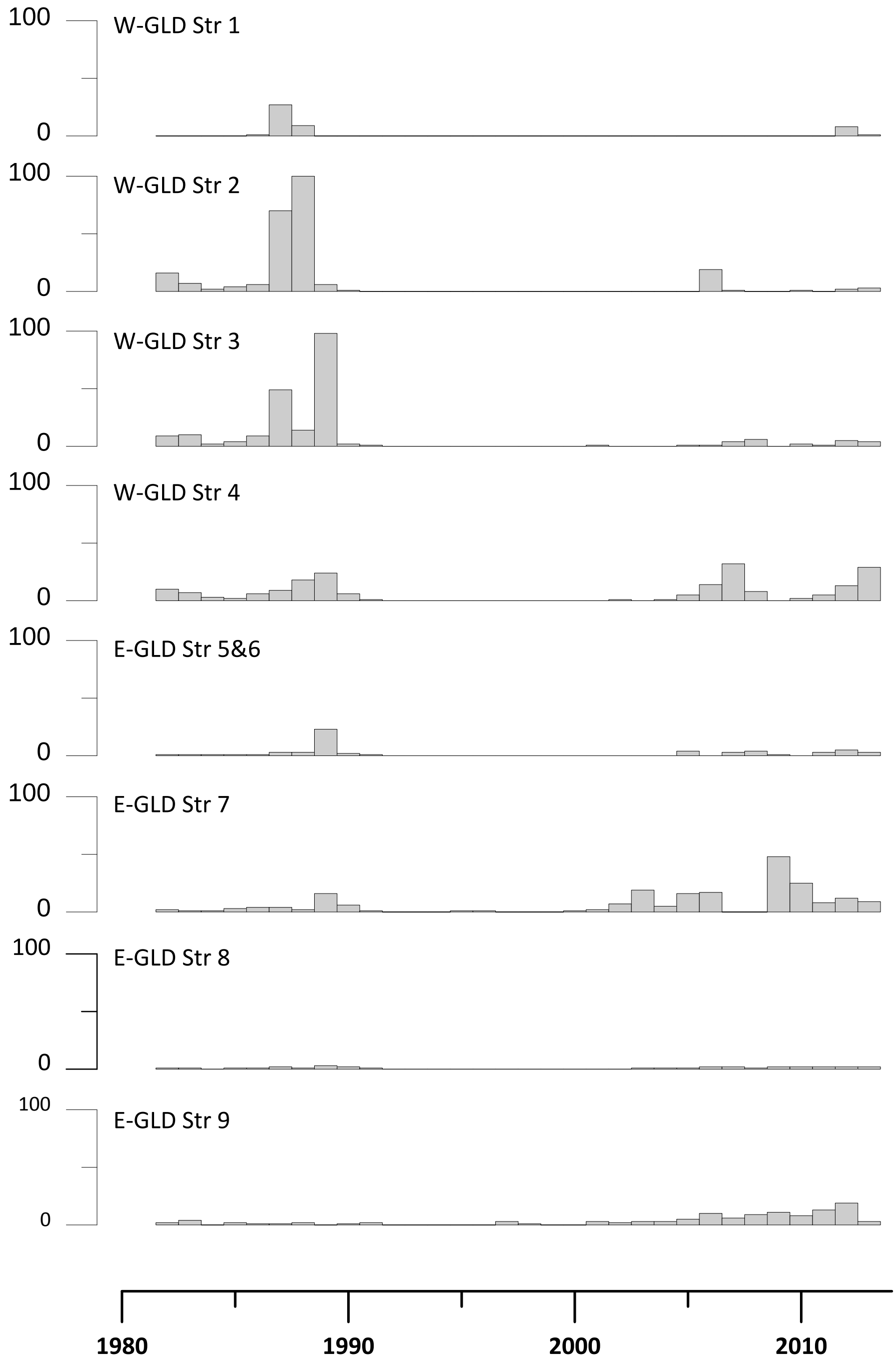


Figure 14.3.2.2 German survey. Mean CPUEs in weight by stratum, depth strata 0-200 and 200-400 combined. CPUEs standardized to maximum=100 in stratum 2, 1988. In 2012, the analysis of CPUEs was adopted to the new stratification of the survey, see Fig. 14.2.7.1

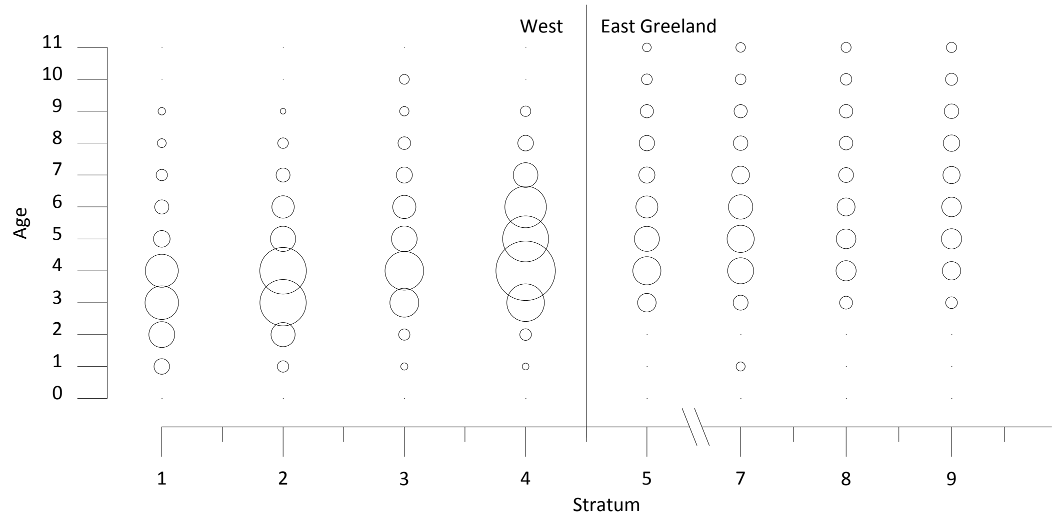


Figure 14.3.2.3 German survey, Cod off Greenland. Abundance per age group and stratum. Strata 1 –4 is West Greenland from north to south; strata 5-9 is East Greenland from south to north.

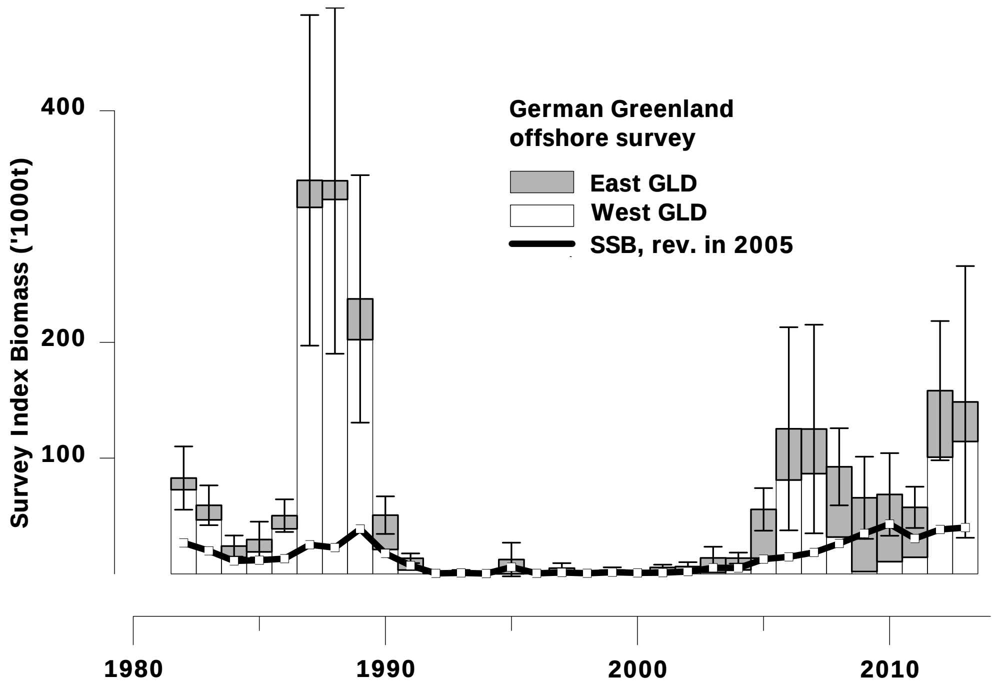


Figure 14.3.2.4 German survey, Cod off Greenland. Aggregated survey biomass indices for West and East Greenland and revised spawning stock biomass, 1982-2012. In 2012, the analysis of indices was based on a re-stratified survey, see Fig. 14.2.7.1

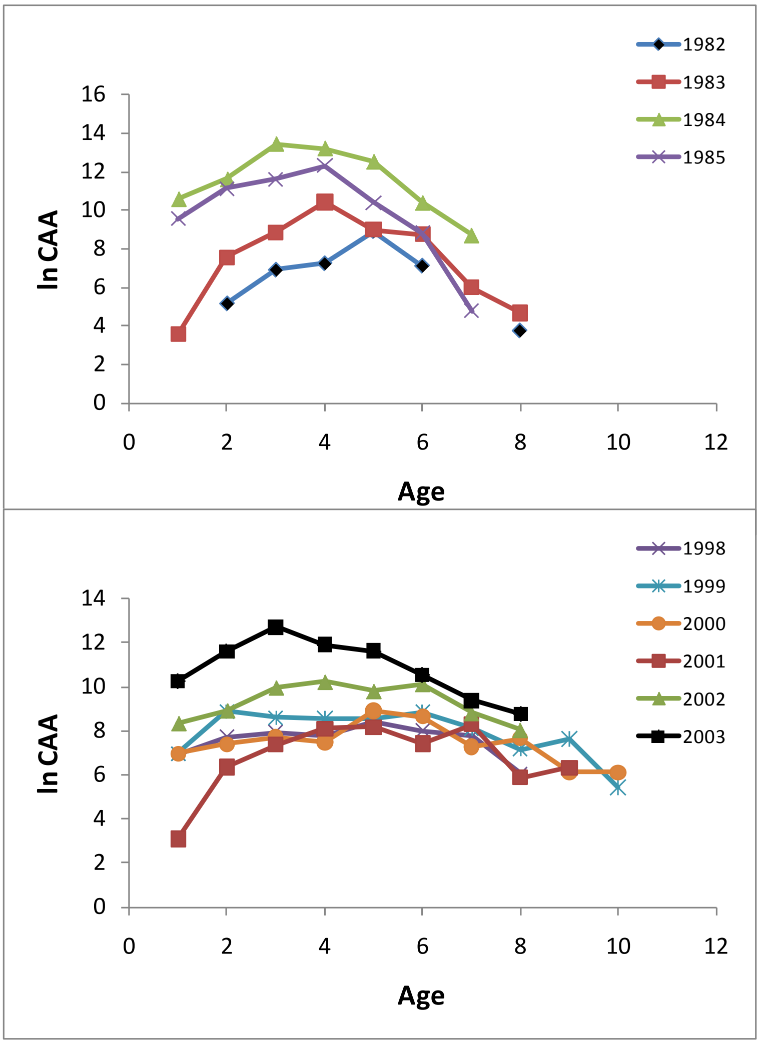


Figure 14.3.2.5 German survey, Catch Curves.

15 Cod in inshore waters of NAFO Subarea 1 (Greenland cod)

Summary

- Total landings from the inshore fishery amounted to 13 236 t which is a slight increase compared to 2012. Several year-classes were caught in the inshore fishery and catches were dominated by the 2009 YC.
- Mean length in the fisheries have increases from 44 cm in 2006 to 53 cm in 2013.
- Survey recruitment indices from the inshore area show a relatively strong 2010 and 2011 YC.
- Issues for the upcoming benchmark should include the suggested development of an analytical assessment for this stock.

15.1 The fishery

Details on the historical development in the fisheries are provided in the stock annex.

15.1.1 The present fishery

2013 landings were 13 236 t (TAC: 13 500 t) which is an increase compared to 2012 (20%) and the highest level since 1991 (Table 14.1.1.1, Figure 14.1.1). The commercial fishery was carried out along the entire coastline of West Greenland from Disko bay to Cap Farewell, with the majority of the catches (92%) being taken in Mid Greenland (NAFO Div. 1B, 1C, 1D and 1E, Table 14.1.1.2, Figure 14.1.1.2). The most important fishery is the pound net fishery (62%) that takes place during summer (Table 14.1.1.2 and 14.1.1.3). The fishery in recent years has expanded north, and catches in this area are to a larger extent caught by jigs and as gill net by-catch (Figure 14.1.1.3). Fish were on average 10 cm larger in NAFO Subarea 1A (65 cm) compared to other areas, but due to the overall catches being higher in the south the mean length was 53 cm (Figure 14.1.1.4).

15.1.2 Length, weight and age distributions

In 2013 the length frequencies were based on 68 inshore samples (N=11 255). Several year-classes were caught in the fishery (Tables 14.1.2.1 and 14.1.2.2). Ages 4-6 (YC 2007-2009) dominated landings with the 2009 YC being the most abundant. The length frequencies were based on 68 inshore samples (N=11 255) and the mean length has gradually increased from 44 cm in 2006 to 53 cm in 2010, and has since been stable around 53 cm (figure 14.1.2.1). Previously, cod caught in South Greenland have generally been smaller than cod caught further north, but in 2013 the mean length were the same as the rest of West Greenland. This was however based on one sample (N=236), and catches in South Greenland were the lowest recorded since 2004 and comprised only 1% of the total inshore catches in 2013 (table 14.1.1.2).

15.1.3 Information on spawning

In 2011 a survey was conducted in spring in order to investigate the extent of spawning in fjords not traditionally surveyed. The results show that spawning occurs in most fjords and is especially pronounced between Sisimiut (NAFO 1B) and Paamiut (NAFO 1E).

15.1.4 Statistical analyses (Catch Curve Analysis and statistical catch-at-age model)

During NWWG 2012 exploratory model runs (statistical catch-at-age) were performed using landings and the inshore gill net survey as well as catch-at-age in both survey and landings. This work was continued in 2013, with improved data and more thorough model scrutiny. Due to data noise the model did not converge to a point that allowed for sensitivity runs, but only produced point estimates (ICES 2013, WD #19). These estimates were used as input to a Yield per recruit analyses that generated F_{max} and $F_{0.1}$ estimates (ICES 2013, WD 20). The harvest rates associated with these estimates were then applied to the estimate from the Statistical catch-at-age model of B_{3+}. Due to high model sensitivity (see ICES 2013, WD#19) a conservative model run was chosen as the basis for further calculations (low SSB, high F). This is in line with a precautionary approach and since the increase in fishery is relatively recent and still based on few cohorts this approach is advisable. Further precaution is taken by using $F_{0.1}$ and not F_{max} when producing catch advice. $F_{0.1}$ = 0.2 and F_{max} = 0.33. These were associated with harvest rates of 0.16 and 0.24. A prerequisite of this MSY approach are defined biological reference points. Based on the statistical catch-at-age output a relatively well defined Spawner-Recruit relationship could be constructed (see stock annex) with a B_{lim} of 3 500 t and a $B_{trigger}$ of 5 000 t. Current indices suggests that the stock is currently well above both these estimates. However, the model was not implemented as the default assessment model, but it will be presented at the upcoming benchmark.

15.1.5 Results of the West Greenland gillnet survey

In NAFO Subarea 1D catches were dominated by 2 year old cod (2011 YC, Table 14.1.5.1). Catch rates of this YC was the third highest in the time series, and the highest since 2006. The same was the case for the catch rates of three year old fish (2010 YC). The 2009 YC has been dominant in the catches in especially 1B, but in 2013 this YC was also observed in high numbers in 1D, having the highest catch rate of 4 year old fish in the time series. Overall, the index for NAFO 1D is the highest in the time series, and a 77% increase compared to 2012 (Figure 14.1.5.1). In NAFO 1B the 2010 and 2011 YC both appear average in size, and are at level similar to the time series mean (figure 14.1.5.1). Overall, the NAFO 1B index declined by 24% compared to 2012. Combining the two NAFO divisions in a joint index shows an overall decline (figure 14.1.5.2). This overall trend is driven by the development in NAFO 1B, where the catch rates and index values are higher. Also, the very large 2009 YC is now 4 years of age, and not represented in the joint 2 and 3 year old index, so the decrease was to be expected. When adding all catches and multiplying weight at age data (Table 14.1.2.2) an index taking all ages into account shows a steady increase in the biomass index since 1996 (Figure 14.1.5.3).

15.1.6 State of the stock

There have been several years of steady and relatively high recruitment and the biomass estimate is increasing and has been doing so for more than ten years. Several year classes are in the catches, and the large 2009 YC has now entered the fishery. Spawning has been documented in most fjords on the west coast, with key areas in NAFO 1B and 1D. Hence the overall state of the stock is considered good and improving.

15.1.7 Implemented management measures for 2014

Until 2009 the inshore fishery was unregulated by a TAC. The TAC in 2009-2013 can be seen in figure 14.1.1.2. The TAC for 2014 is set at 15 000 t. No other management measures have been taken.

15.1.8 Management plan

No management plan currently exists for the inshore cod stock.

15.1.9 Management considerations

When managing this species, it should be taken into consideration that the inshore cod tend to form very dense spawning aggregations in limited areas. It could be considered to limit the fishery in certain areas or certain periods, especially if the stock shows a declining trend. These areas include specifically certain areas in the Nuuk and Sisimiut fjord systems.

Genetic and tagging results indicate limited migration between fjords and management should therefore ensure that not all catches are taken in a limited area. This is especially important in areas that are considered to have maintained the stocks in periods of overall stock decline in Greenland (i.e. Nuuk and Sisimiut fjords).

15.1.10 Basis for advice

The advice is based on the Data Limited Stock approach (DLS) including data from a gill-net survey with biomass indices of 2 and 3 year old fish and recent commercial catches. The advice for 2015 is 12 063 t.

15.1.11 Issues for the upcoming benchmark

The statistical catch-at-age model presented during the NWWG 2013 meeting was accepted by the group and suggested as the basis for advice. Subsequently data quality has improved and has been added to the model input. A further exploration of the model is recommended, and it will be tested as the basis for advice during the benchmark. A prerequisite is data scrutiny of years with a bad model fit to data – in particular concerning the 1984 YC.

15.1.12 References

ICES 2013. Hedeholm, R.B., Retzel, A., Magnusson, A. Stock assessment of West Greenland Inshore cod 2012 – the Coleraine model. North western Working Group (NWWG) WD 19.

ICES 2013. Hedeholm, R.B., Retzel, A., Magnusson, A. Stock assessment of West Greenland Inshore cod 2012 – Yeild per Recruit. North western Working Group (NWWG) WD 20.

Table 14.1.1.1. Landings (t) divided by NAFO Divisions, caught by vessels >50 GRT (Horsted 2000, Statistic Greenland 2007, Greenland Fisheries License Control). XIVb=inshore East Greenland.

	NAFO divisions								
Year	1A	1B	1C	1D	1E	1F	Unknown	Total	XIVb
1976	204	644	1224	904	1367	831		5174	
1977	216	580	2505	2946	3521	4231		13999	
1978	348	1587	3244	2614	4642	7244		19679	
1979	433	1768	2201	6378	9609	15201		35590	
1980	719	2303	2269	7781	10647	14852		38571	
1981	281	2810	3599	6119	7711	11505	7678	39703	
1982	206	2448	3176	7186	4536	3621	5491	26664	
1983	148	2803	3640	7430	5016	2500	7205	28742	
1984	175	3908	1889	5414	1149	1333	6090	19958	
1985	149	2936	957	1976	1178	1245		8441	
1986	76	1038	255	1209	1456	1268		5302	
1987	97	2995	536	8110	4560	1678	510	18486	
1988	333	6294	1342	2992	3346	4484		18791	
1989	634	8491	5671	8212	10845	4676		38529	
1990	476	9857	1482	9826	1917	5241		28799	
1991	876	8641	917	2782	1089	4007		18312	
1992	695	2710	563	1070	239	450		5727	
1993	333	327	168	970	19	109		1926	
1994	209	332	589	914	11	62		2117	
1995	53	521	710	332	4	81		1701	
1996	41	211	471	164	11	46		944	
1997	18	446	198	99	13	130	282	1186	
1998	9	118	79	78	0	38		322	
1999	68	142	55	336	8	4		613	
2000	154	266	0	332	0	12		764	
2001	117	1183	245	54	0	81		1680	
2002	263	1803	505	214	24	813		3622	
2003	1109	1522	334	274	3	479	1494	5215	
2004	535	1316	242	116	47	84	2608	4948	
2005	650	2351	1137	1162	278	382	83	6043	
2006	922	1682	577	943	630	1461	1246	7461	
2007	416	2547	1195	1842	659	4988		11647	42
2008	870	3066	1539	3172	225	3395		12267	6
2009	325	1288	1189	2009	1142	1717		7670	2
2010	559	2990	1607	1795	1458	859		9268	2
2011	567	2364	2850	2905	1274	1047		11007	0
2012	546	1376	2061	4375	1989	325		10673	0.02
2013	788	3271	2784	4711	1450	198		13236	35

Table 14.1.1.2: Landings (t) divided into month and NAFODivisions, caught by the coastal fisheries.

NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1A	23	18	17	19	16	31	51	149	126	184	106	46	788
1B	9	14	20	63	16	193	538	626	520	560	473	239	3271
1C	110	57	18	0	39	669	587	312	295	437	152	107	2784
1D	139	84	81	38	222	987	892	942	667	448	100	111	4711
1E	8	9	11	5	110	296	457	370	152	26	5	0.1	1450
1F	1	1	0	0	64	27	55	22	3	11	13	1	198
ICES XIVb								0.1	10	23	2	0	35
Total	290	184	147	125	466	2204	2581	2422	1774	1689	850	505	13236
%	2%	1%	1%	1%	4%	17%	20%	18%	13%	13%	6%	4%	

Table 14.1.1.3: Landings (%) divided into month and gear and NAFO Divisions and gear.

	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Poundnet	0.03	0.02	0.1	0.4	2	16	17	14	7	4	1	1	62
Gillnet	1	1	0.4	0.2	0.1	0.04	0.1	0.4	1	4	3	2	14
Jig	0.2	0.1	0.3	0.02	0.03	0.4	2	4	4	4	1	0.3	17
Longline	1	1	0.3	0.4	1	1	0.2	0.4	0.3	1	1	1	8
Total	2	1	1	1	4	17	20	18	13	13	6	4	100
	NAFO area												
	1A	1B	1C	1D	1E	1F							Total
Poundnet	0	5	14	33	18	3							73
Gillnet	3	4	3	2	0	0							12
Jig	1	2	2	1	1	0							7
Longline	1	0	1	4	0	0							7
Total	6	12	20	40	19	3							100

Table 14.1.2.1. Estimated commercial landings in numbers ('000) at age, and total landings by year (t). * no sampling.

	Age								Tonnes
Year	2	3	4	5	6	7	8	9	10+	Landed
1976	3	2509	924	556	287	38	31	11	7	5174
1977	13	467	5435	1100	883	179	7	142	46	13999
1978	9	97	1262	9903	132	68	7	3	0	19679
1979	1	323	2297	2380	8280	170	96	4	14	35590
1980	0	4344	4335	1646	806	6493	106	29	37	38571
1981	87	87	15789	5224	725	499	2905	61	17	39703
1982	0	3013	1587	6310	1545	798	152	610	154	26664
1983	5	229	16872	1381	4351	368	139	65	75	28742

1984	15	520	4451	9270	346	634	18	42	12	19958
1985	0	5	2400	1028	2229	196	363	14	78	8441
1986	59	284	177	891	457	717	16	101	38	5302
1987	2	6967	1689	289	899	431	1373	58	335	18486
1988	0	419	15584	150	51	39	90	161	12	18791
1989	0	15	5962	23956	271	46	2	93	176	38529
1990	0	212	2996	15399	6730	33	11	7	16	28799
1991	0	124	6021	4909	5694	330	0	0	0	18312
1992	0	8	2408	2344	452	139	46	13	5	5727
1993	0	28	662	576	206	34	41	10	7	1926
1994	0	22	1469	342	62	45	8	11	1	2117
1995	0	1	832	771	37	5	0	0	0	1701
1996	0	2	164	360	129	25	3	1	0	944
1997	0	0	210	436	237	34	0	0	0	1186
1998*										322
1999	0	87	465	105	1	0	0	0	0	613
2000	0	4	228	336	7	0	0	0	0	764
2001*										1680
2002	0	532	2243	657	29	9	1	0	0	3622
2003	0	152	581	1547	258	51	16	15	11	5215
2004	0	530	1670	1096	228	37	3	0	0	4948
2005	10	1396	2415	947	186	36	10	4	0	6043
2006	15	4295	3394	686	22	0	0	0	0	7461
2007	0	2050	8341	1065	122	40	14	8	4	11647
2008	5	1443	6146	3424	391	44	7	2	0	12267
2009	0	496	3604	2415	197	13	3	0	4	7670
2010	0	301	1091	2475	1524	141	32	21	27	9268
2011	1	129	2931	2569	1481	255	90	12	7	11007
2012	1	735	1724	2680	850	182	21	13	13	10673
2013	1	143	3816	2484	1086	362	115	67	9	13236

Table 14.1.2.2. West Greenland inshore cod. Estimated weight at age (kg).* no sampling.

	Age								
Year	2	3	4	5	6	7	8	9	10+
1976	0.162	0.811	1.114	1.662	2.738	3.226	4.062	5.831	12.747
1977	0.195	0.674	1.382	2.201	2.649	3.322	6.363	3.920	4.616
1978	0.299	0.668	0.965	1.801	2.472	2.845	3.649	4.733	
1979	0.595	0.800	1.309	2.111	3.153	3.696	4.371	6.861	8.007
1980		0.753	1.017	1.884	2.580	3.823	4.107	5.715	7.902
1981	0.179	0.308	1.045	1.576	2.190	2.590	4.029	3.529	7.831
1982		0.844	1.118	1.604	2.605	3.875	5.495	5.425	6.278
1983	0.244	0.552	0.937	1.337	2.039	2.795	3.378	4.218	4.109
1984	0.222	0.624	0.967	1.385	1.869	2.469	3.286	3.985	4.433
1985		0.420	0.754	1.134	1.662	2.065	2.669	3.486	4.337
1986	0.493	0.582	1.248	1.414	2.043	2.689	3.188	3.893	8.401
1987	0.284	0.872	1.187	2.043	2.302	2.963	3.294	4.114	5.107
1988		0.659	1.106	1.251	1.691	2.677	3.046	3.478	5.111
1989		0.558	0.855	1.308	1.821	3.161	4.252	4.397	5.862
1990		0.649	0.889	1.031	1.452	2.614	3.765	5.846	10.868
1991		0.802	0.966	1.088	1.146	1.595	3.964		
1992		0.567	0.869	1.028	1.697	1.849	2.845	3.253	4.402
1993		0.585	0.820	1.239	1.830	1.802	2.873	3.976	8.777
1994		0.430	0.883	1.359	1.706	3.103	3.900	4.976	16.271
1995		0.768	0.930	1.093	1.799	2.493	4.130	6.490	
1996		0.501	0.814	1.201	2.176	2.955	4.151	5.507	6.577
1997		0.545	0.904	1.249	1.647	1.765	3.239		
1998*									
1999		0.739	0.895	1.240	2.254				
2000		0.642	1.121	1.453	2.378	2.621	2.409		
2001*									
2002	0.360	0.708	0.999	1.397	2.318	1.884	2.853	3.560	3.356
2003		1.046	1.391	2.069	2.565	3.300	3.988	5.095	6.958
2004		0.988	1.236	1.584	2.158	3.149	6.132		
2005	0.409	0.811	1.106	1.728	2.415	2.810	6.955		
2006	0.361	0.724	0.944	1.560	3.102				9.922
2007		0.703	0.950	1.543	2.574	4.003	5.136	6.541	10.250
2008	1.168	0.615	0.884	1.406	2.332	3.709	5.463	7.263	
2009	0.272	0.641	0.898	1.461	2.348	4.055	5.132	5.869	14.181
2010	0.505	0.659	0.976	1.517	2.120	3.204	4.872	6.929	9.796
2011	0.369	0.657	0.918	1.466	2.013	3.305	5.396	7.527	10.366
2012	0.366	0.764	1.109	1.810	2.700	3.554	5.964	6.910	14.345
2013	0.245	0.766	1.258	1.623	2.235	3.059	3.636	4.114	7.430

Table 14.1.5.1: Survey effort in the Greenland Inshore Gill-net survey (nos. of valid net settings).

Division	1B	1D	1F	Total
1985	3	38	27	68
1986	26	22	23	71
1987	24	27	26	77
1988	21	24	24	69
1989	28	19	32	79
1990	18	21	18	57
1991	23	24	20	67
1992	27	29	23	79
1993	23	25	19	67
1994	20	29	17	66
1995	24	21	20	65
1996	26	25	-	51
1997	20	23	-	43
1998	24	26	22	72
1999	-	24	-	24
2000	-	27	20	47
2001	-	-	-	-
2002	21	20	-	41
2003	33	27	-	60
2004	27	31	-	58
2005	25	28	-	53
2006	45	51	-	96
2007	52	-	39	91
2008	-	58	60	118
2009	-	58	18	76
2010	66	52	-	118
2011	57	44	-	101
2012	54	52	-	106
2013	58	52	-	110

Table 14.1.5.1 : NAFO Div. 1B. Cod abundance indices (numbers of cod caught per 100 hours net settings) by age in the West Greenland inshore gill-net survey. na= data not available.

Year/Age	1	2	3	4	5	6	7	8+	All
1985	26	23	0	6	0	0	0	0	54
1986	4	245	16	8	2	2	0	0	278
1987	0	122	233	25	1	0	0	0	381
1988	0	33	130	111	2	0	0	0	276
1989	1	110	83	57	32	1	0	0	283
1990	0	109	108	62	53	12	0	0	344
1991	0	3	131	53	11	3	0	0	202
1992	0	43	10	18	3	0	0	0	74
1993	0	22	22	2	1	0	0	0	47
1994	4	8	19	12	0	0	0	0	43
1995	2	115	19	7	1	0	0	0	143
1996	0	28	40	7	1	0	0	0	77
1997	0	14	8	3	1	0	0	0	26
1998	2	7	4	6	3	0	0	0	23
1999	na	na	na	na	na	na	na	na	na
2000	na	na	na	na	na	na	na	na	na
2001	na	na	na	na	na	na	na	na	na
2002	31	207	72	21	9	1	0	0	340
2003	1	68	69	21	3	0	0	0	163
2004	32	28	29	9	5	0		0	102
2005	47	123	35	7	5	1	3	0	221
2006	32	148	60	24	1	1	0	0	170
2007	7	170	82	15	1	0	0	0	275
2008	na	na	na	na	na	na	na	na	na
2009	na	na	na	na	na	na	na	na	na
2010	138	155	120	58	12	1	0	0	484
2011	20	526	106	44	19	1	0	0	717
2012	7	184	304	30	8	3	0	0	536
2013	4	158	105	104	27	8	1	1	408

Table 14.3.7.2, *continued* : NAFO Div. 1D. Cod abundance indices (numbers of cod caught per 100 hours net settings) by age in the West Greenland inshore gill-net survey.

Year/Age	1	2	3	4	5	6	7	8+	All
1985	68	77	0	3	3	3	0	1	155
1986	0	96	15	0	0	1	2	0	114
1987	1	16	68	5	0	0	0	0	90
1988	0	20	48	30	1	0	0	0	99
1989	0	78	47	13	13	0	0	0	152
1990	0	14	35	4	4	3	0	0	60
1991	124	3	17	6	2	1	0	0	154
1992	0	61	22	10	7	1	0	0	100
1993	0	4	57	20	2	0	0	0	83
1994	0	0	6	5	1	0	0	0	12
1995	0	3	2	4	4	0	0	0	12
1996	0	1	1	0	2	0	0	0	4
1997	3	3	1	0	0	1	0	0	8
1998	0	10	17	1	0	0	0	0	28
1999	0	0	1	3	0	0	0	0	5
2000	0	2	2	1	1	0	0	0	6
2001	na	na	na	na	na	na	na	na	na
2002	0	7	4	3	0	0	0	0	14
2003	0	6	4	2	1	0	0	0	13
2004	3	43	6	3	1	1	0	0	57
2005	9	27	7	2	0	0	0	0	45
2006	2	114	37	13	4	0	0	0	170
2007	na	na	na	na	na	na	na	na	na
2008	4	4	47	63	7	0	0	0	124
2009	4	52	14	72	23	1	0	0	166
2010	1	33	107	18	27	3	0	0	189
2011	10	45	3	18	6	4	1	0	88
2012	2	52	46	21	28	2	0	1	151
2013	0	91	61	77	25	8	3	2	267

Table 14.3.7.2, *continued* : NAFO Div. 1F. Cod abundance indices (numbers of cod caught per 100 hours net settings) by age in the West Greenland inshore gill-net survey.

Year/Age	1	2	3	4	5	6	7	8+	All
1985	204	8	1	1	1	1	1	0	217
1986	17	112	5	0	2	0	0	0	136
1987	0	143	147	1	0	0	0	0	291
1988	0	1	83	6	0	0	0	0	89
1989	0	5	2	19	2	0	0	0	29
1990	0	0	3	2	13	1	0	0	18
1991	2	2	0	2	0	1	0	0	7
1992	0	3	1	0	1	0	1	0	6
1993	0	5	2	1	0	0	0	0	8
1994	0	0	1	1	0	0	0	0	3
1995	0	0	0	0	0	0	0	0	0
1996	na	na	na	na	na	na	na	na	na
1997	na	na	na	na	na	na	na	na	na
1998	0	4	12	0	0	0	0	0	17
1999	na	na	na	na	na	na	na	na	na
2000	0	14	8	0	2	0	1	0	24
2001	na	na	na	na	na	na	na	na	na
2002	na	na	na	na	na	na	na	na	na
2003	na	na	na	na	na	na	na	na	na
2004	na	na	na	na	na	na	na	na	na
2005	na	na	na	na	na	na	na	na	na
2006	na	na	na	na	na	na	na	na	na
2007	6	90	9	21	1	0	0	0	108
2008	8	17	30	4	2	0	0	0	62
2009	3	39	14	15	0	0	0	0	71
2010	na	na	na	na	na	na	Na	na	na
2011	na	na	na	na	na	na	Na	na	na
2012	na	na	na	na	na	na	Na	na	na
2013	na	na	na	na	na	na	Na	na	na

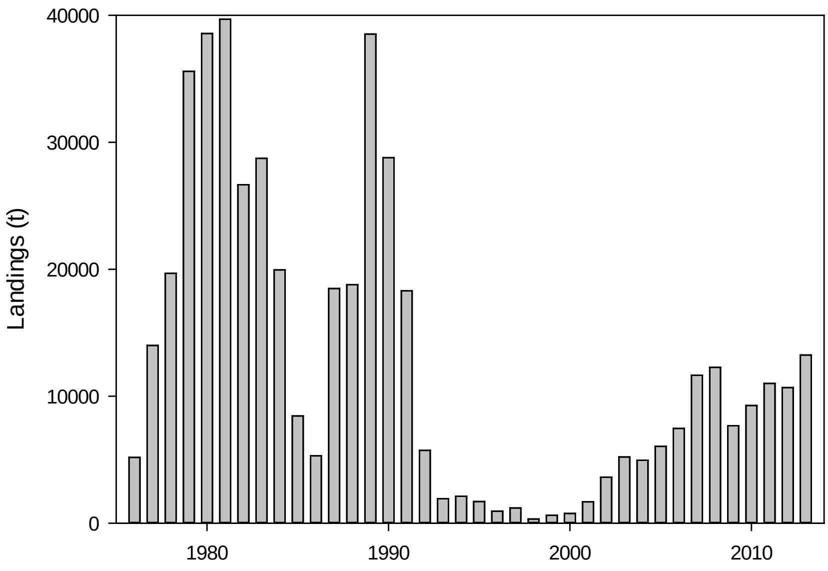


Figure 14.1.1. Inshore landings from West Greenland (Horsted 1994, 2000).

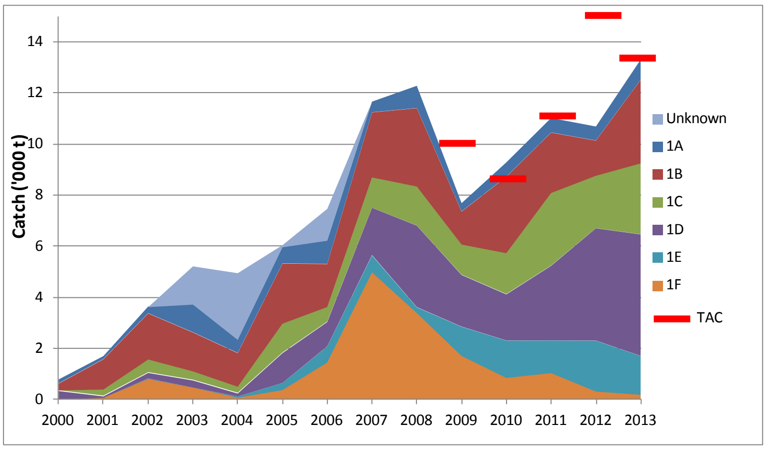


Figure 14.1.1.2. Total catches and TAC in the inshore fishery by NAFO Fivisions from 2000-2013.

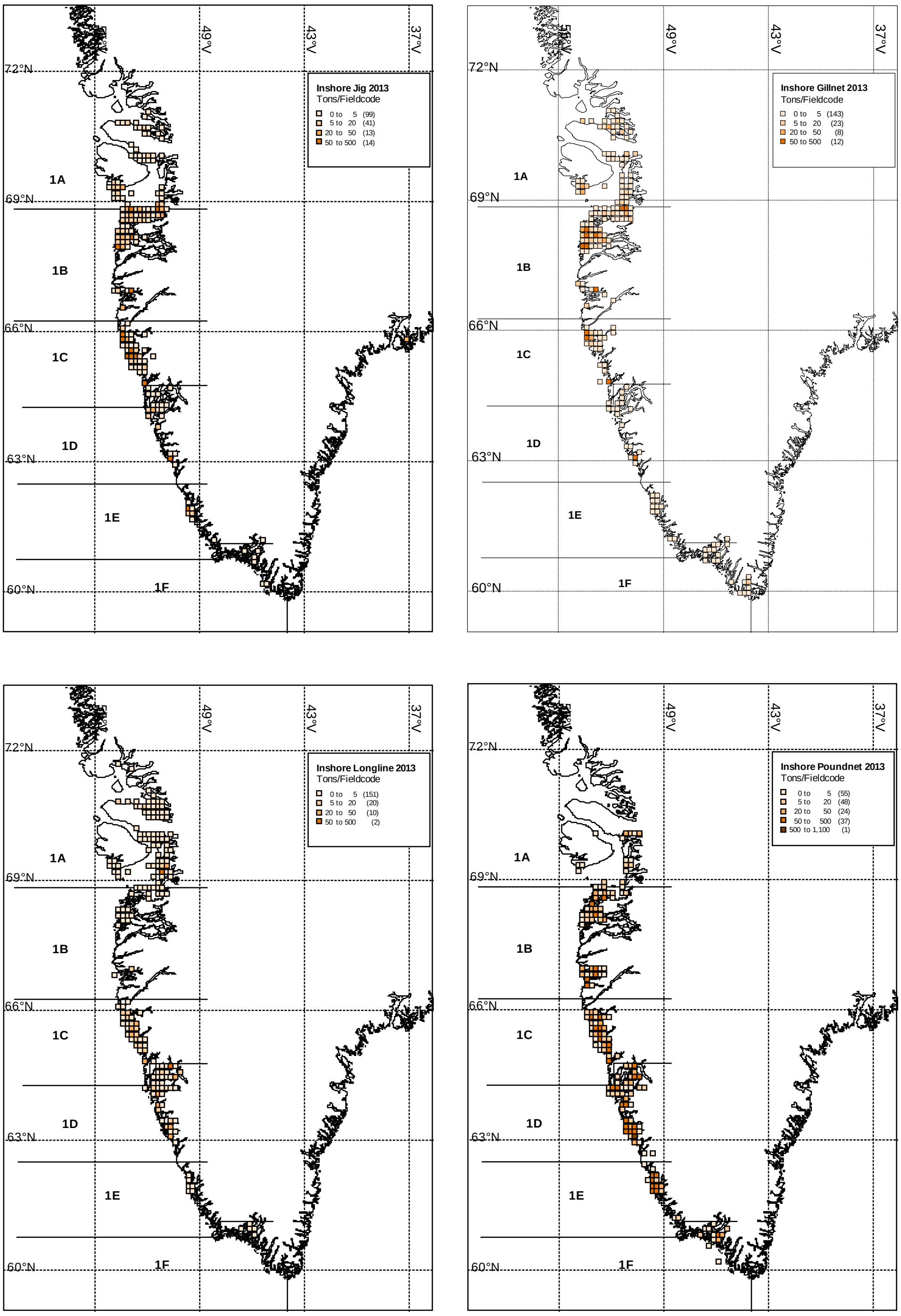
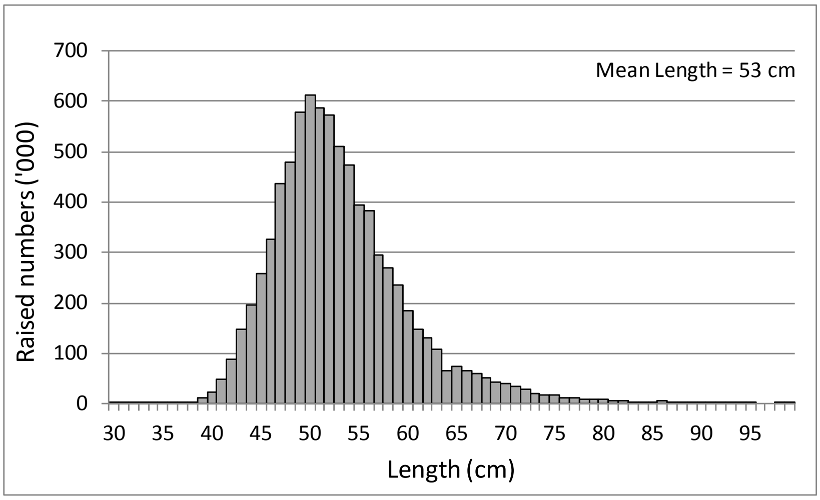


Figure 14.1.1.3. Distribution of inshore commercial fishery along the West Greenland coastline by gear and NAFO Subdivision.



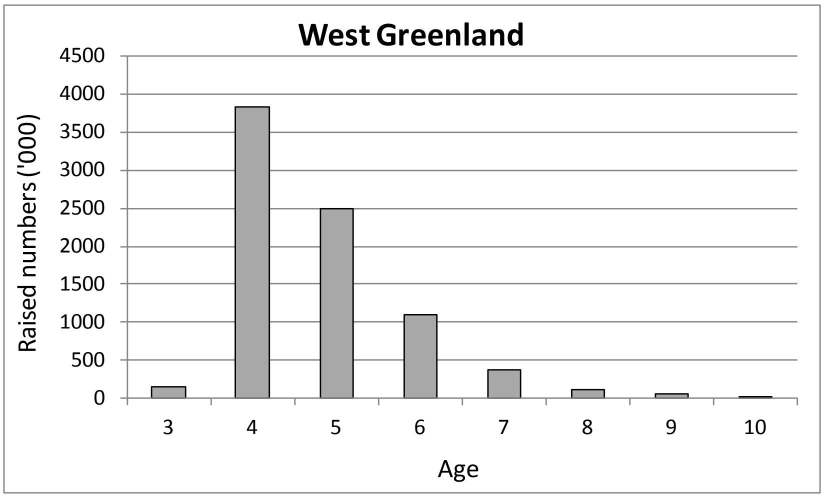


Figure 14.1.1.4. Total length and age distributions of inshore cod catches

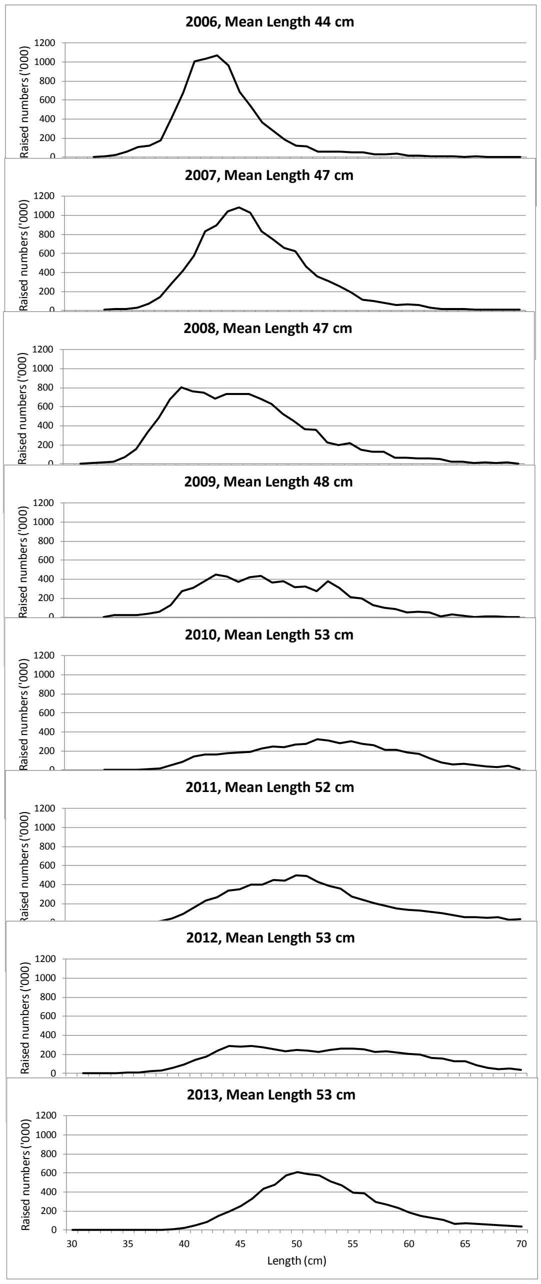


Figure 14.1.2.1. Length distribution in the inshore fishery in the period 2006-2013.

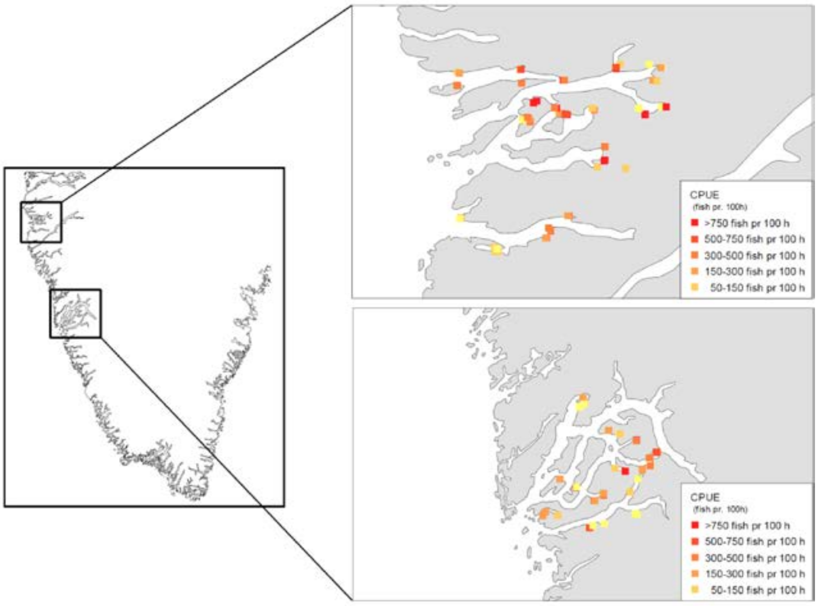


Figure 14.1.5.1 The inshore gill net survey area on the Greenland West coast. Top picture is the Sisimiut fjord system in NAFO 1B and bottom picture is the Nuuk fjord system in NAFO 1D. Survey estimates of catch rates are indicated on both maps as #caught/100h.

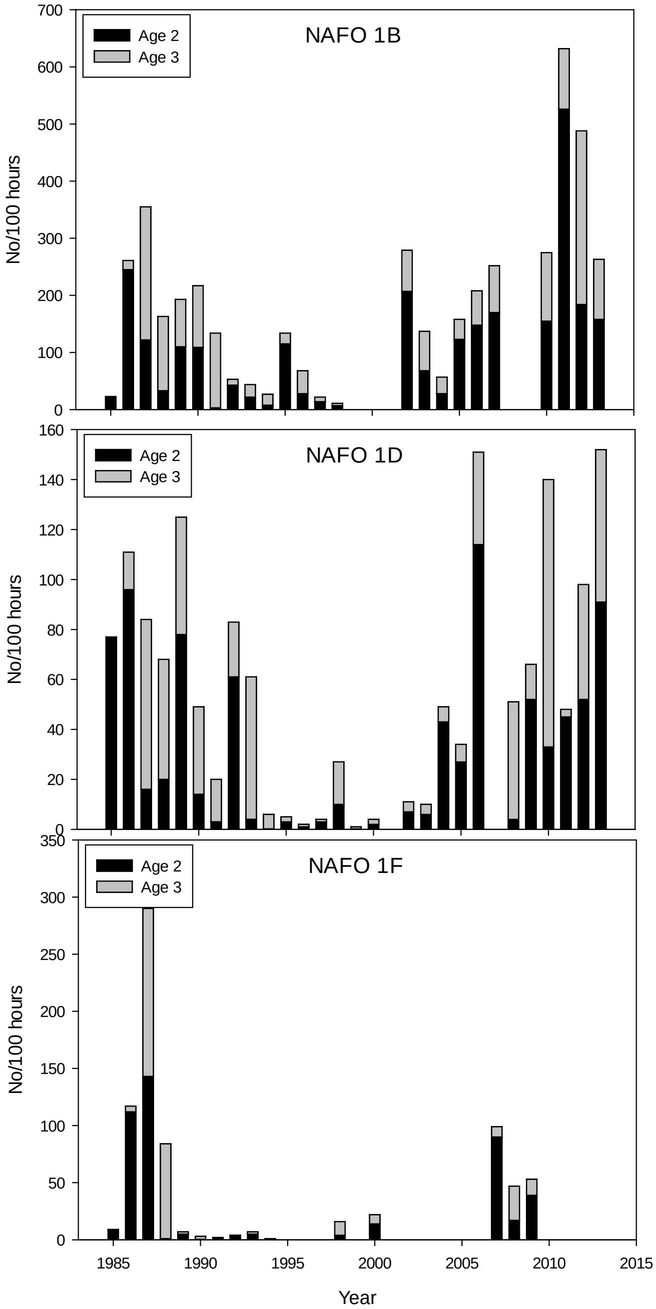


Figure 14.1.5.1. Recruitment index (numbers caught/100 hr. net settings) from the inshore Gillnet survey, by year-class and area. Indices given for age 2 and age 3.

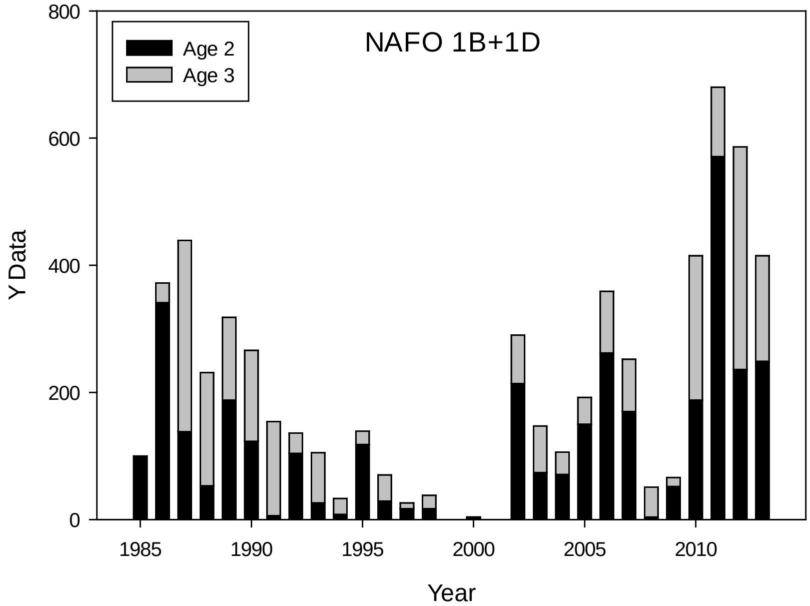


Figure 14.3.7.2. Recruitment indices (numbers caught/100 hr. netsetting) for ages 2 and 3 for the inshore area in the northern (NAFO Div. 1B, Sisimiut) and central (NAFO Div. 1D, Nuuk) part combined. No survey was carried out in both areas in the period 1999-2001 and 2007-2009.

Figure 14.1.2.3 Overall index from the gillnet survey including the estimated biomass of age 1-6.

16 Greenland Halibut in Subareas V, VI, XII, and XIV

Greenland halibut in ICES Subareas V, VI, XII and XIV are assessed as one stock unit although precise stock associations are not known.

The stock was benchmarked in November 2013 (WKBUT) and changes for the stock assessment are given in section 15.6.1. Further, the NWWG rejected the decisions made at the benchmark which resulted in a change of assessment, from analytical to qualitative (data limited approach).

16.1 Executive summary

Input data to the assessment: current surveys have continued and sampling intensity and coverage remains also unchanged. Logbooks from the fishery are available as haul by haul data. Since 2001 no age readings of otoliths were available from the main fishing areas which impede age based assessment.

Since 2007 a logistic production model in a Bayesian framework has been used to assess stock status and for making predictions. The model includes an extended catch series going back to the assumed virgin status of the stock at the beginning of the fishery in 1961. Estimated stock biomass showed an overall decline from the mid 1980s to the late 1990s. Since 2004 the stock has increased and is now at 71%Bmsy and fishing mortality exceeds F_{msy} by a factor of 1.1.

This analytical approach was rejected by NWWG and advice is based on data limited approach.The data limited approach is based on catch and survey data in the period 1996-2013. According to this approach biomass has slightly increased and Fproxy slightly decreased in recent years.

16.2 Catches, Fisheries, Fleet and Stock Perception

16.2.1 Catches

Total annual catches in Divisions Va, Vb, and Subareas VI, XII and XIV are presented for the years 1981–2013 in Tables 15.2.1–15.2.6 and since 1961 in Figure 15.2.1. Catches decreased slightly in 2013 to 27.045 t.

Landings in Icelandic waters (usually allocated to Division Va) have historically predominated the total landings in areas V+XIV, but since the mid 1990s also fisheries in XIV and Vb have developed. Landings have since 2000 been between 20 and 30 kt.

16.2.2 Fisheries and fleets

In 2013 quotas in Greenland EEZ were almost fully utilised by all of the principal fleets. Within the Iceland EEZ, quotas in the fishing year 2012/2013 were fully utilized as in the preceding fishing years. In the Faroe EEZ the fishery is regulated by a fixed numbers of licenses and technical measures like by-catch regulations for the trawlers and depth and gear restrictions for the gillnetters.

Most of the fishery for Greenland halibut in Divisions Va, Vb and XIVb is a directed trawl and gillnet fishery, and only minor catches in Va by Iceland, and in XIVb by Germany and the UK are taken as by-catches in a redfish fishery (see section 21 on Greenland slope redfish). No or insignificant discarding has been observed in this fishery.

Spatial distribution of 2013 fishery and historic effort and catch in the trawl fishery in XIV and V is provided in Figures 15.2.2-5. Fishery in the entire area had previously occurred in a more or less continuous belt on the continental slope from the slope of the Faroe plateau to southeast of Iceland extending north and west of Iceland and further south to southeast Greenland. Fishing depth ranges from 350-500 m southeast, east and north of Iceland to about 1500 m at East Greenland. In 2013 the distribution of the fishery covered all areas but was discontinuous in its distribution. A gillnet fishery developed in 2002 north of Iceland with approx. 10% of the catches in Div. Va.

Since 2000 an increased directed and by-catch fishery by Spain, France, Lithuania, and Norway developed in the Hatton Bank area of Division VIb. However, most fisheries ceased after 2008 and is presently insignificant. Landings in Divisions XII and VIb in Tables 15.2.5-15.2.6 derive from the Hatton Bank area.

16.2.3 By-catch and discard

The Greenland halibut trawl fishery is generally a clean fishery with respect to by-catches. Eventual by-catches are mainly redfish and cod. Southeast of Iceland the cod fishery and a minor Greenland halibut fishery are coinciding spatially. In East Greenland where fishery is on the steep slope, fishing grounds for cod and redfish are close to the Greenland halibut fishing grounds, but nevertheless the catches from single hauls are clean.

The mandatory use of sorting grids in Va and XIVb in the shrimp fishery since November 2002 are observed to have reduced by-catches considerably. Based on sampling from three trips (93 hauls) in 2006 - 2007, scientific staff observed by-catches of Greenland halibut to be less than 1% by weight (2 g or 0.04 specimens per 1 kg shrimp) compared to about 50% by weight (0.48 kg and 0.81 individuals of Greenland halibut were caught per 1 kg shrimp) observed before the implementation of sorting grids (in 2002) (Sünksen 2007, WD # 18). No information has since been available but the fishery in XIVb (logbooks) report discard less than 1% by weight.

16.3 Trends in Effort and CPUE

16.3.1 Division Va

Indices of CPUE for the Icelandic trawl fleet directed at Greenland halibut for the period 1985–2013 is provided in Table 15.3.1 and Figures 15.3.1-3. At the benchmark the CPUE series from this fishery was questioned due to a marked change in season and area, and also because the regulations might have caused a changed behaviour in the fishing fleets (WKBUT 2013). The important fishing grounds west of Iceland, where approximately 70-80% of the landings historically came from, is the area where the season shift mainly has affected the CPUE. A simple standardization procedure was not considered sufficient to account for these changes (Fig. 15.3.2.). Therefore, considering the survey biomass estimates, a rough estimate on stock distribution in Iceland is 25% in each of the areas, west, north, east and south-east (Fig.XX). The overall CPUE index for the Icelandic fishery was therefore compiled as the average of the standardised indices from the four areas (Fig 15.3.1-2.).

Catch rates of Icelandic bottom trawlers decreased for all fishing grounds during 1990–1996 (Figure 15.3.1) but have since peaked in 2001 and has in recent years been stable and slowly increasing. The overall tendency is the same for all fishing grounds in Va (Figure 15.3.2) although the less important fishing grounds in north, east and southeast show a less clear trend since 2006. Both observed and derived effort are about historic average in 2013 (Figure 15.3.3).

16.3.2 Division Vb

Information from logbooks from the Faroese otterboard trawl fleet (>1000 hp) was available for the years 1991-2013 (Table 15.3.1, Figure 15.3.4.-5.). The bulk of the fishery has historically been on the south-east slope of the Faroe plateau . CPUE decreased drastically in the early period by more than 50 % coinciding with a significant increase in effort. In 2011 CPUE increased sharply by more than 60% and remained at that level in 2012 and 2013.

16.3.3 Division XIVb

CPUE and effort from logbooks in XIV are provided in Table 15.3.1 and Figure 15.3.6-7. In 2005-2008 catch rates were high and above the average, but decreased by nearly 20% in 2009 along with a massive increase in effort (85%). CPUE in 2013 decreased slightly (2%), The CPUE series from Divisions Va, Vb and XIVb have different trends over the time series indicating that the populations/areas are inflicted by different dynamics .

16.3.4 Divisions VI and XIIb

Since 2001 a fishery developed in divisions VIb and XIIb in the Hatton Bank area, but in both divisions the recent catches are relatively small. Limited fleet information is available (ICES WGDEEP).

16.4 Catch composition

Length compositions of catches from the commercial trawl fishery in Div. Va are rather stable from year to year. In Figure 15.4.1 length distributions are shown since 1996 from the western area of Iceland, comprising the most important fishing grounds. Distributions are rather stable over the entire period. Little or no information is available of the catch composition in XIV and Vb.

16.5 Survey information

The total surveyed area in 2013 for Greenland halibut in Divisions Va and XIVb is provided in Figure 15.5.1. No survey took place in Div. Va in 2011. Most of the areas where commercial fishing takes place (Figure 15.2.2.) are covered by the annual surveys.

16.5.1 Division Va

The fall survey for Greenland halibut was resumed in 2012-13 after no survey was conducted in 2011. Since 2008 Since 2006 the fishable biomass of Greenland halibut (fish of length equal to or greater than 50 cm) has increased significantly in Icelandic waters (Figures 15.5.2) andthe abundance of fish less 70 cm is historic high in 2013. (Figures 15.5.3. – 15.5.4.).

16.5.2 Division Vb

The catch rates from the available time series of the Faroese survey (1995-2013) shows a declining trend until 2007 and since then an increase to record high levels the last years (Figure 15.5.5).

16.5.3 Division XIVb

Total biomass in the Greenlandic survey (Figure 15.5.6) in 2013 was estimated at 5857 tons (S.E. 793) which is among the lowest value in the time series. A GLM analysis performed on the survey catch rates, taking into account the scattered coverage of area and depth between years did support this development (Figure 15.5.7.). The text table below provides information on the coverage and numbers of stations in 2013.

Survey /Division	No. hauls in 2013 (planned hauls)	Depth range (m)	Coverage (km2)
Va	203 (219)?	32 - 1309?	-130 000
XIVb	80 (70)	400-1500	29 000

The stock annex provides more extensive descriptions of the surveys.

16.6 Stock Assessment

16.6.1 Benchmark decisions for the stock assessment

At the benchmark in November 2013 the following was agreed for the present stock: "The assessment model should remain the stock production model using the new combined survey index and the Icelandic cpue index as it is revised. Reference points as derived from this model are 30% B_{MSY} as B_{lim}, 1.7 x F_{MSY} as F_{lim} and an $MSYB_{trigger}$ defined as 50%B_{MSY}."

The Icelandic CPUE series was considered not to reflect the true stock biomass development due to change in fisheries with respect spatial distribution, seasonality and regulations. The series was suggested to be revised before the NWWG 2014.

The Icelandic and Greenland survey index was combined to one survey index assuming to cover most of the distributional area for the stock.

16.6.2 NWWG decisions post benchmark

At the NWWG the benchmark decision to continue with the stock production model was not followed. The stock production model was rejected due to issues with the input data and the model behaviour. The Icelandic cpue as a biomass indicator was questioned and it was decided to reject the series as input to any assessment.

The argumentation pro and con the rejection is provided in wd 1, 30, 31, 36 and 37, and a brief summary is provided in section 15.7. See also Working Document 40 and the Introduction. In order to have the material ready if other bodies like ADG or ACOM overrule the NWWG decision and stick to the procedures decided in the benchmark, the following sections of the report is therefore provided as of last year. For example with a description of indices and performance of the stock production model, but in addition is given a section on the NWWG agreed data limited approach that was decided to use for catch advice.

16.6.3 Summary of the various observation data

A number of indices from surveys and from the commercial fishery are available as indicators for the biomass development.

The surveys in Va and XIV are considered to cover the adult stock distribution in the two divisions adequately, while the survey/exploratory fishery in Vb is questioned as a biomass indicator due to its design. A detailed description of the survey/fishery design is provided in the stock annex.

The main fishing grounds are covered well by the logbook data in Va and XIV, while in Vb the logbook information does not include the second principal fleet, gill netters, that covers other areas within Vb. The fleet behaviour in the entire area is likely influenced by a number of factors, such as weather conditions and sea ice especially in the north-western areas. Over the years also technological development of the fishing gear has probably caused improved catchability. Therefore CPUE series is considered less qualified as biomass indicators than surveys.

Div. Va: Fishery and survey indices from Va show similar trends although of varying magnitude. The fall groundfish survey in Va (since 1996) indicate a recovery from a low level in 2004-2006 for all sizes of fish and in all surveyed areas . Icelandic trawl CPUE show a similar recovery from a low in 2004 although recovery is slow.

Div. Vb: Both standardised survey/exploratory fishery and commercial cpues show a dramatic increase in 2011-12 and 2013 indices are all high.

Div. XIVb: The Greenland survey in XIV have remained low since 2008 and decreased further in 2013 to a record low. In contradiction to this trend CPUE's from the various trawl fleets in XIVb have been increasing since a low in 2000 although variable.

Subarea VI and XII: No biomass indices are available for these areas. However, the areas are considered negligible with respect to stock distribution.

16.6.4 A model based assessment

An exploratory assessment was derived using a stochastic version of the logistic production model and Bayesian inference (Hvingel et al. 2008 WD #?, Boje et al, 2013 WD 9). A more detailed formulation of the model and its performance is found in the stock Annex.

16.6.4.1 Input data

The model synthesized information from input priors and two independent series of Greenland halibut biomass indices and one series of catches by the fishery (Table 15.6.1) based on the benchmark (WKBUT) decisions. The two series of biomass indices were: a revised and standardised series of annual commercial-vessel catch rates for 1985–2013, $CPUE_t$,; and a combined trawl-survey biomass index for 1996–2013, $Isur_t$,.

Total reported catch or WGs best estimates in ICES Subareas V, VI, XII and XIV 1961-2013 was used as yield data (Table 15.6.1, Figure. 15.2.1). Since the fishery is, being without major discarding problems or misreporting, the reported catches were entered into the model as error-free.

Two additional biomass series were available. However, the Greenland CPUE series showed trends conflicting with those of the other biomass indices – even if restricted to data just opposite the midline next to the Icelandic fishery and were therefore not included. The Faroese indices of stock biomass were not used in the assessment The omission of these indices from the analytical assessment only reflects that the model due to conflicting signals is not able to accommodate them but the indices are though considered to provide true populations trends and should therefore be treated as auxiliary information to the stock assessment. .

16.6.4.2 Model performance

Inference were made from samples from the converged part of the MCMC samples as identified by appropriate statistics (Boje et al. 2011 WD 29). The model was able to produce a reasonable simulation of the observed data. (Figure. 15.6.2). The probabilities of getting more extreme observations than the realised ones given in the data series on stock size were in the range of 0.05 to 0.95 i.e. the observations did not lie in the extreme tails of their posterior distributions (Table 15.6.4). Exceptions are observed for the survey in 1997 (p=0.96). The CPUE series was generally better estimated than the survey series (Figure. 15.6.2). The combination of the Greenland and the Icelandic surveys into one biomass index has improved the residual pattern.

The data could not be expected to carry much information on the parameter P_{1960} – the stock size 25 years prior to when the series of stock biomass series start – and the posterior resembled the prior (Figure.15.6.1). The prior for K was somewhat updated to slightly higher values. However, the posterior still had a wide distribution. If the information in the prior for K was relaxed or restricted to lower values changes in the central parameters MSY and P_{2012} was small. Overall, the model was robust to changes in the priors for the process and observation errors and also evaluated at the benchmark in 2013 (Figure. 15.6.3).

The priors for *MSY* was significantly updated (Figure. 15.6.1). As mentioned above *MSY* was relatively insensitive to changes in prior distributions. The posterior *K* had an inter-quartile range of 712-1071 ktons (Table 15.6.3).

16.6.4.3 Assessment results

The time series of estimated median biomass-ratios starts in 1960 as a virgin stock at K (Figure. 15.6.4 -5). The fishery starts in 1961. Under continuously increasing fishing mortality the stock declined sharply in the mid 1990s to levels below the optimum, B_{msy}. Some rebuilding towards B_{msy} was then seen in 2001 but since then the stock started to increase from its lowest level in 2004-5 of approx. 45% of B_{MSY}. The increase continued in 2013 to about 71%B_{MSY}. The risk of the biomass being below B_{msy} in 2013 is 100% and 0.3% of being below B_{LIM} (Table 15.6.5). The median fishing mortality ratio (F/Fmsy) has exceeded F_{msy} since the 1990s (Figure. 15.6.4 and 15.6.5). This parameter can only be estimated with relatively large uncertainty and the posteriors therefore also include values below F_{msy}. However, the probability that the *F* has exceeded F_{msy} is high for most of the series.

The posterior for *MSY* was positively skewed with upper and lower quartiles at 28 ktons and 43 ktons (Table 15.6.3). As mentioned above MSY was relatively insensitive to changes in prior distributions.

Within a one-year perspective the sensitivity of the stock biomass to alternative catch options seems rather low. This is due to the inertia of the model used (see annex) and the low growth rate of the population. Risk associated with five optional catch levels for 2015 are given in Table 15.6.5.

The risk trajectory associated with ten-year projections of stock development assuming a maintained annual catch in the entire period ranging from 0 to 30 ktons were investigated (Figure. 15.6.6.-7). The calculated risk is a result of the projected development of the stock and the increase in uncertainty as projections are carried forward. It must be noted that a catch scenario of a maintained constant catch over a decade without considering arrival of new biological information and advice is highly unrealistic.

Catches around 20 ktons are likely to led to an increase in stock sizeAnd annual catches of 20 kt or less will result in a 50% probability of reaching B_{MSY} within 10 years.

Scenarios of fixed levels of fishing mortality ratios within the range of 0.3 to 1.7 were conducted and are shown in Fig. 15.6.8. Present biomass is above the MSY Btrigger (50% of B_{MSY}) and a fishery at F_{MSY} is then advised according the ICES MSY approach. A reduced F to F_{MSY} will likely result in catches of 25 kt in 2015 (Figure 15.6.8 panel D) and a stock size of 73% of B_{MSY} in 2016 (Table 15.6.5).

16.6.4.4 Conclusions

Stock status 2013-2014

- Stock size:
  - Stock biomass 0.71B_{msy} (median)
  - 100% probability of being below B_{msy}
  - 0% risk of being below B_{lim}
- Stock production:
  - MSY = 28 – 43 ktons (inter-quartile range)
  - Actual ≈ 0.9MSY (median)
- Exploitation:
  - 27 ktons
  - 1.1F_{msy} (median)
  - 17% risk of exceeding F_{lim}

Predictions

- Risk of exceeding MSY$B_{trigger}$
  - As the stock has improved since 2004-5 and is now further away from B_{LIM} the projected risk of exceeding this reference point is low (between 0 and 1%) at any catch at or below 30 kt.
- Catch option of 25ktons/yr (*F_{MSY} level*)
  - Stock biomass is projected to increase (0.73 of B_{MSY}).
- Moratorium
  - In the order of 4 years or less to rebuild to B_{MSY}

16.6.5 Reference points

At the benchmark in 2013 (WKBUT) it was decided that following reference points be defined for the stock: B_{LIM} is defined as 30%B_{msy} corresponding to production is reduced to 50% of its maximum. This is equivalent to the SSB-level (spawning stock biomass) at 50% R_{max} (maximum recruitment). Greenland halibut is believed to be a slow growing species i.e. with relative low *r* (intrinsic rate of increase). This means that even without fishery it would take some 10 years to rebuild the stock from 30%B_{msy} to B_{msy} (calculated by setting r=0.21, the 75th percentile) – but likely longer.

MSY $B_{trigger}$, the biomass level that triggers a deviation from Fmsy advice, was defined as 50%B_{MSY}. F_{LIM} was defined as 1.7F_{MSY}.

16.6.6 Data limited approach to catch advice

During the NWWG 2014 it was decided that stock production model was not considered reliable to predict catch advice and neither as indicative of stock trends. Therefore the group decided to base the advice on the data limited approach.

In Table 15.6.6. and Fig. 15.6.11 are input data for the data limited approach. Catches are total catches in V,VI, XII and XIV. The index used is combined survey biomass index (I) of Greenland halibut larger than 50 cm and the CV for the index. The estimate of harvest rate (F_{proxy}) is calculated as catches/survey index.

Consideration was given method 3.2 and 3.3 as provided by ICES for the data limited approach.

Method 3.3 will evolve as follows:

Determine catch advice from the survey adjusted status quo catch:

$$\frac{59.4/2 + 57.5/2}{23.5/3 + 37.5/3 + 53.8/3} = 1.53$$

Three years average of the catches is: $\bar{C} = \frac{27.2 + 29.1 + 26.2}{3} = 27.5$

Then the catch in 2015 (without the PA-buffer) is 27.5 * 1.53 = 42.0

Finally applying the PS-buffer of 20% would result in 42.0 * 0:8 = 33.6, resulting in an advice for 2015 of 33.6kt.

Implementing method 3.3 is less obvious due to unclear guidance. A rationale might be that there is no sign of serious depletion of the stock, or more specific that on average fishing mortality may not have been very high. Therefore a target Fproxy might be the overall mean. Then the next step is appliance of a 20% PA-buffer on that average. The long-term average is 0.58 and applying the PA-buffer would lower the target Fproxy to 0.47. Another way to define the target Fproxy would be to define a reference period in the time-series when the stock increased. This approach was used for the advice for blue ling in Va in 2012. Such a period might be 1998 to 2001 (Figure 15.6.11). The mean value in that period is 0.31.

The final step would be to decide if only the terminal index values are to be used in the advice or perhaps a mean over the last three years. The index in figure 15.6.11 does show some variation in the last 4 years therefore it may be valid to use an average value. The terminal value for the index is 59.4 but the average from 2011 to 2013 is 46.8.

In the text table below four different scenarios are presented based on the reference values discussed

above. Scenarios #3 and #4 do not include a 20% PA-buffer but are very precautionary given the trend in the index and the catch history.

Scenario	Target	Reference	Catch 2015
	Fproxy	Index	
#1	0.47	59.4	27.7
#2	0.47	46.8	21.8
#3	0.31	59.4	18.2
#4	0.31	46.8	14.3

Given the data limited approach advice for Greenland halibut should be in the range of 14.3kt to 33.6kt. It is difficult to pick one over the other but scenario #2 or #3 from method 3.3 should maybe be given a bit more consideration than the others. Setting the Fproxy target as 0.47 for the next few years could be chosen to ensure consistency.

16.7 Management Considerations

Available biological information and information on distribution of the fisheries suggest that Greenland halibut in XIV and V belong to the same entity and do mix. Historic information on tag-recapture experiments in Iceland have shown that Greenland halibut migrate around Iceland. Similar information from Greenland suggests some mix, both between West Greenland, East Greenland and Iceland. Therefore, management of the stock needs to be in accordance with the present three distinct management areas, XIV, Va and Vb.

. In 2012 the coastal states have initiated work on a common management plan for Greenland halibut. The plan is aimed to have two steps, a graduals lowering of the total catches until biological reference points have been defined by ICES, and thereafter implementation of a harvest control rule in accordance with ICES MSY approach. The plan will include continuous monitoring of the resource and requirements on information from the fishery. As a first step Greenland and Iceland decided on a TAC for 2013 at 26 000 t and further agreed to reduce catches in 2014 by 15% corresponding to catches of 22 100 t. The aim is to have a management plan to be implemented in 2015 based on the outcome of the recently held benchmark outcome.

16.8 Data consideration and Assessment quality

The Icelandic CPUE series has for many years been used as a biomass indicator in the assessment of the stock. The CPUE of the Greenlandic trawlers and the biomass indices from the Faroese waters have not been used in the assessment, mainly because the stock production model is not able to cope with indices, which do not show the same development over time than the biomass indices (Icelandic CPUE and Greenlandic/Icelandic autumn surveys), which are assumed to reflect stock status in the best way.

This year, concerns were expressed by NWWG members that the first part of the series (1985-1994) could not be used as a biomass indicator, e.g. due to changes in the management system and associated changes in the behaviour of the fleet (see WD01). Local depletion in the 'hot-spot' area west of Iceland was also put forward as a problem. Other members put the argument that decrease in the stock in the early 1990's was consistent in areas of Va but of varying magnitude and this decrease should be considered in the assessment. A weighting by biomass distribution instead of by fishing effort were considered an improvement for a biomass indicator. This version of the CPUE series was used to tune the stock production model. However, many NWWG members were sceptical to this approach, because the CPUE series still showed much more interannual variation than can be expected from a long-lived species, and even the combined survey biomass index showed signs of the same problem (the "bump" around year 2000).

The problem of the large interannual variation in the biomass estimates persisted and became more evident when putting the Icelandic CPUE series (the whole period 1985-2013) and the combined survey biomass index into the stock production model. The stock production model followed very well the data points, with the consequence that the "realised r" (see working documents) became unrealistically negative some years and attained very high positive values other years. The advocates for the stock production model pointed out that biological processes could explain the feature, for example time-varying migration and time-varying natural mortality, and that the model would perform much better if these changes over time could be modelled (which, however, was not possible at the present time). The single most important point in the decision of NWWG to reject the stock production model was the realisation of the extent of the adjustment of the intrinsic growth rate, i.e., these very low or very high realised r values over the years. That is: can such a production model really give a reliable output? The fact that the advocates of the production model did not present alternative runs of the model due to time and expert constraints, where e.g. the process error was gradually restricted, also gave the group no chance to change its mind.

All members of the group agreed that the problems above were conveyed into the terminal years and the advice, i.e., that it resulted in wide confidence intervals in the advice. This problem is evident in the projection of the catches, i.e., they range between 12-45 kt (10-90% of the distribution). The main issue then became whether this is acceptable or not. The vast majority of the NWWG felt that this was not acceptable. The benchmark meeting apparently found it acceptable.

The consequence of the above was to use a data-limited-stock approach.

The assessment relies on a number of indices from surveys and the commercial fishery in absence of material to age-disaggregate the catches. As the stock dynamics and stock structure in the entire distribution area is not fully understood, any stock index are not easily selected to describe the entire stock development. Among many, one possibility to improve the quality of the assessment of the stock, age-disaggregation of catches must therefore be recommenced. This will require that the main labs must continue sampling otoliths from Greenland halibut and put higher priority to age-reading work. Work is ongoing on age interpretation from otoliths. Preliminary results suggests that Greenland halibut grow slower than previously thought (Workshop on Age Reading of Greenland Halibut (WKARGH) 2011).

Table 15.2.1 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Sub-areas V, VI, XII and XIV 1981-2011, as officially reported to ICES and estimated by WG

Country	1981	1982	1983	1985	1986	1987	1988	1989
Denmark	-	-	-	-	-	6	+	-
Faroe Islands	767	1,532	1,146	1,052	853	1,096	1,378	2,319
France	8	27	236	845	52	19	25	-
Germany	3,007	2,581	1,142	863	858	565	637	493
Greenland	+	1	5	81	177	154	37	11
Iceland	15,457	28,300	28,360	29,231	31,044	44,780	49,040	58,330
Norway	-	-	2	3	+	2	1	3
Russia	-	-	-	-	-	-	-	-
UK (Engl. and Wales)	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-	-	-
Total	19,239	32,441	30,891	32,075	32,984	46,622	51,118	61,156
Working Group estimate	-	-	-	-	-	-	-	61,396

Country	1990	1991	1992	1994	1995	1996	1997	1998
Denmark	-	-	-	-	-	1	-	
Faroe Islands	1,803	1,566	2,128	6,241	3,763	6,148	4,971	3,817
France	-	-	3	-	-	29	11	8
Germany	336	303	382	648	811	3,368	3,342	3,056
Greenland	40	66	437	867	533	1,162	1,129	747
Iceland	36,557	34,883	31,955	27,778	27,383	22,055	18,569	10,728
Norway	50	34	221	1,173 [1]	1,810	2,164	1,939	1,367
Russia	-	-	5	-	10	424	37	52
Spain								89
UK (Engl. and Wales)	27	38	109	513	1,436	386	218	190
UK (Scotland)	-	-	19	84	232	25	26	43
United Kingdom								
Total	38,813	36,890	35,259	37,305	36,006	35,762	30,242	20,360
Working Group estimate	39,326	37,950	35,423	36,958	36,300	35,825	30,309	20,382

Country	1999	2000	2001	2003 [1]	2004 [1]	2005 [1]	2006 [1]	2007 [1]
Denmark		-	-	-	-	-	-	-
Estonia		-	-	-	-	5	3	-
Faroe Islands	3,884	-	121	458	338	1,150	855	1,141
France	-	2	32	177	157	-	62	17
Germany	3,082	3,265	2,800	2,948	5,169	5,150	4,299	4,930
Greenland	200	1,740	1,553	1,459	-	-	-	-
Iceland	11,180	14,537	16,590	20,366	15,478	13,023	11,798	-
Ireland		-	56	-	-	-	-	-
Lithuania		-	-	2	1	-	2	3
Norway	1,187	1,750	2,243	1,074	1,233	1,124	1,097	692
Poland		-	2	93	207	-	-	-
Portugal		-	6	-	-	-	1,094	-
Russia	138	183	187	-	262	-	552	501
Spain		779	1,698	3,075	4,721	506	33	-
UK (Engl. and Wales)	261	370	227	40	49	10	1	-
UK (Scotland)	69	121	130	367	367	391	1	-
United Kingdom	-	166	252	841	1,304	220	93	17
Total	20,001	22,913	25,897	30,900	29,286	21,579	19,890	7,301
Working Group estimate	20,371	26,644	27,291	30,891	27,102	24,978	21,466	21,873

Country	2008 [1]	2009 [1]	2010 [1]	2011 [1]	2012 [1]	2013 [1]
Denmark	-	-	-	-	-	-
Estonia	-	-	-	- -	-	-
Faroe Islands	-	270	1,408	1,705	2,811	2,788
France	114	-	-	9	67	133
Germany	4,846	427	5,287	5,782	4,620	3,814
Greenland	-	2,819	-	3,415	5,239	3,251
Iceland	-	-	13,293	13,192	13,749	14,859
Ireland	-	-	-	-	-	-
Lithuania	566		-	-	97	-
Norway	639	124	233	176	856	614
Poland	1,354	988	960	-	786	-
Portugal	-	-	-	-	-	-
Russia	799	762	1,070	1,095	1,168	1,369
Spain	-	-	-	-	-	-
United Kingdom	422	581	577	323 #	12	95
Total	9,744	5,974	22,901	25,618	29,405	26,923
Working Group estimate	24,481	28,197	25,995	26,347 #	29,309 #	29,310

Table 15.2.2 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Division Va 1981-2011, as officially reported to ICES and estimated by WG.

Country	1981	1982	1983	1984	1985	1986	1987	1988	1989
Faroe Islands	325	669	33	46			15	379	719
Germany									
Greenland									
Iceland	15,455	28,300	28,359	30,078	29,195	31,027	44,644	49,000	58,330
Norway			+	+	2				
Total	15,780	28,969	28,392	30,124	29,197	31,027	44,659	49,379	59,049
Working Group estimate									59,272 [2]

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998
Faroe Islands	739	273	23	166	910	13	14	26	6
Germany					1	2	4		9
Greenland					1				
Iceland	36,557	34,883	31,955	33,968	27,696	27,376	22,055	16,766	10,580
Norway									
Total	37,296	35,156	31,978	34,134	28,608	27,391	22,073	16,792	10,595
Working Group estimate	37,308 [2]	35,413 [2]							

Country	1999	2000	2001	2002	2003 [1]	2004 [1]	2005 [1]	2006 [1]	2,007 [1]
Faroe Islands	9		15	7	34	29	77	16	25
Germany	13	22	50	31	23	10	6	1	228
Greenland									
Iceland	11,087	14,507	2,310 [4]	2,277 [4]	20,360	15,478	13,023	11,798	
Norway							100		691
Russia									
UK (E/W/I)	26	73	50	21	16	8	8	1	
UK Scottland	3	5	12	16	5	2	27	1	
UK									1
Total	11,138	14,607	2,437	2,352	20,438	15,527	13,241	11,817	945
Working Group estimate		14,607	16,752	19,714	20,415	15,477	13,172	11,817	10,525

Country	2008 [1]	2009 [1]	2010 [1]	2011 [1]	2012	2013 [1]
Faroe Islands			37	123	585	103
Germany	4	423	797	576	269	386
Greenland				157		92
Iceland			13,293	13,192	6,459	14,859
Norway						
Russia	4					
Poland		270				
UK	179					
Total	187	693	14,128	14,048	7,313	15,440
Working Group estimate	11,859	15,782	14,128	14,048	7,313	15,440

1) Provisional data

2) Includes 223 t catch by Norway.

3) Includes 12 t catch by Norway.

4) fished in Icelandic EEZ, but allocated to XIVb

Table 15.2.3 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Division Vb 1981-2009 as officially reported to ICES and estimated by WG.

Country	1981	1982	1983	1984	1985	1986	1987	1988	1989
Denmark	-	-	-	-	-	-	6	+	-
Faroe Islands	442	863	1,112	2,456	1,052	775	907	901	1,513
France	8	27	236	489	845	52	19	25	...
Germany	114	142	86	118	227	113	109	42	73
Greenland	-	-	-	-	-	-	-	-	-
Norway	2	+	2	2	2	+	2	1	3
UK (Engl. and Wales)	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-	-	-	-
Total	566	1,032	1,436	3,065	2,126	940	1,043	969	1,589
Working Group estimate	-	-	-	-	-	-	-	-	1,606 [2]

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998
Denmark	-	-	-	-	-	-	-	-	
Faroe Islands	1,064	1,293	2,105	4,058	5,163	3,603	6,004	4750	3660
France 6	...	...	3 [1]	2	1	28	29	11	8 [1]
Germany	43	24	71	24	8	1	21	41	
Greenland	-	-	-	-	-	-	-	-	
Norway	42	16	25	335	53	142	281	42 [1]	114 [1]
UK (Engl. and Wales)	-	-	1	15	-	31	122		
UK (Scotland)	-	-	1	-	-	27	12	26	43
United Kingdom	-	-	-	-	-				
Total	1,149	1,333	2,206	4,434	5,225	3,832	6,469	4,870	3825
Working Group estimate	1,282 [2]	1,662 [2]	2,269 [2]	-	-		-	-	-

Country	1999	2000 [1]	2001 [1]	2002 [1]	2003 [1]	2004 [1]	2005 [1]	2006 [1]	2007 [1]
Denmark									
Faroe Islands	3873		106	13	58	35	887	817	1116
France		1	32	4	8	17		40	9
Germany	22								
Iceland									
Ireland									
Norway	87	1	2	1	1		1		1
UK (Engl. and Wales)	9	35	77	50	24	41	2		
UK (Scotland)	66	116	118	141	174	87	204		
United Kingdom								19	1
Total	4057	153	335	209	265	180	1,094	876	1,127
Working Group estimate	2694 [2]	5079	3,951	2,694	2,459	1,771	892	873	1060

Country	2008	2009	2010	2011	2012	2013
Denmark						
Faroe Islands			1,037	1,476	2,149	2,560
France	36		35	1	13	20
Germany						
Iceland						
Ireland						
Norway	1	1	5			
UK (Engl. and Wales)						
UK (Scotland)						
United Kingdom	32	117	336	11		2
Total	69	118	1,413	1,489	2,162	2,582
Working Group estimate	1,759	1,739	1,413	1,489	2,162	2,582

1) Provisional data
2) WG estimate includes additional catches as described in Working Group reports for each year and in the report from 2001.

Table 15.2.4 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Sub-area XIV 1981-2009, as officially reported to ICES and estimated by WG.

Country	1981	1982	1983	1984	1985	1986	1987	1988	1989
Faroe Islands	-	-	-	-	-	78	74	98	87
Germany	2,893	2,439	1,054	818	636	745	456	595	420
Greenland	+	1	5	15	81	177	154	37	11
Iceland	-	-	1	2	36	17	136	40	+
Norway	-	-	-	+	-	-	-	-	-
Russia	-	-	-	-	-	-	-	-	+
UK (Engl. and Wales)	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-	-	-	-
Total	2,893	2,440	1,060	835	753	1,017	820	770	518
Working Group estimate	-	-	-	-	-	-	-	-	-

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998
Denmark	-	-	-	-	-	-	1	+	+
Faroe Islands	-	-	-	181	168	147	130	148	151
Germany	293	279	311	391	639	808	3,343	3,301	3,399
Greenland	40	66	437	288	866	533	1,162	1,129	747 [1,7]
Iceland	-	-	-	19	82	7	-	1,803	148
Norway	8	18	196	511	1,120	1,668	1,881	1,897 [1]	1,253 [1]
Russia	-	-	5	-	-	10	424	37	52
UK (Engl. and Wales)	27	38	108	796	513	1405	264	218	190
UK (Scotland)	-	-	18	26	84	205	13		
United Kingdom	-	-	-	-	-	-	-		
Total	368	401	1,075	2,212	3,472	4,783	7,218	8,533	5940
Working Group estimate	736 [2]	875 [3]	1,176 [4]	2,249 [5]	3,125 [6]	5,077 [7]	7,283 [8]	8,558 [9]	

Country	1999	2000	2001 [1]	2002 [1]	2003 [1]	2004 [1]	2005 [1]	2006 [1]	2007 [1]
Denmark									
Faroe Islands	2			274	366	274	186	22	
Germany	3047	3243	2,750	2,019	2,925	5,159	5,144	4,298	4,702
Greenland	200 [1,4]	1740	1,553	1,887	1,459				
Iceland	93	30	14,280	16,947	6				
Ireland			7						
Norway	1100	1161	1,424	1,660	846	1,114	1,023	1,094	
Poland						205			
Portugal			6	130				1,094	
Russia	138	183	186	44		261		505	500
Spain		8	10		2,131	3,406	2		
UK (Engl. and Wales)	226	262	100						
UK (Scotland)				24	188	278	160		
United Kingdom				178	799	1,294			
Total	4806	6627	20,316 0	22,889	8,720	11,991	6,515	7,013	5,202
Working Group estimate	5376 [11]	6958	6,588 [6]	6,750 [6]	8,017	9,854	10,185	8,589	10,261

Country	2008 [1]	2009 [1]	2010 [1]	2011 [1]	2012 [1]	2013 [1]
Denmark						
Faroe Islands		270	333		77	125
Germany	4,842	4	4,490	5,206	4,351	3,428
Greenland		2,819		3,258	5,239	3,159
Iceland					7,290	
Ireland						
Norway	637	29	226	164	853	613
Poland	1,354	718	960		786	
Portugal						
Russia	763		1,070	1,095	1,168	1,369
Spain						
United Kingdom	131	452	229	309	1	1
Total	7,727	4,292	7,308	10,032	19,765	8,694
Working Group estimate	9,102	9,805	10,402	10,761		

1) Provisional data

2)WG estimate includes additional catches as described in working Group reports for each year and in the report from 2001.

3) Includes 125 t by Faroe Islands and 206 t by Greenland.

4) Excluding 4732 t reported as area unknown.

5) Includes 1523 t by Norway, 102 t by Faroe Islands, 3343 t by Germany, 1910 t by Greenland, 180 t by Russia, as reported to Greenland authorities.

6) Does not include most of the Icelandic catch as those are included in WG estimate of Va.

7) Excluding 138 t reported as area unknown.

Table 15.2.5 GREENLAND HALIBUT. Nominal landings (tonnes) by countries in Sub-area XII, as officially reported to the ICES and estimated by WG

Country	1996	1997	1998	1999	2000	2001	2002	2003 [1]	2004 [1]
Faroe Islands		47					40		
France					1			4	30
Ireland						49			
Lithuania								2	1
Poland						2		2	1
Spain [2]	2	42	67	137	751	1338	28	730	1145
UK					7	5			
Russia									
Norway	2				553	500	316	201	119
Estonia									
Total	4	89	67	137	1,312	1,894	384	939	1,296
WG estimate									

Country	2005 [1]	2006 [1]	2007 [1]	2008 [1]	2009 [1]	2010 [1]	2011 [1]	2012 [1]	2013 [1]
Faroe Islands							106		
France									
Ireland									
Lithuania		2	3	566				97	
Poland									
Spain [2]	501								
UK	3								
Russia		46	1		762				
Norway					94				
Estonia		2							
Total	504	50	4	566	856	0	106	97	0
WG estimate	504	50	4	566	856	0	106	97	0

[1] Provisional data

[2] Based on estimates by observers onboard vessels

Table 15.2.6 GREENLAND HALIBUT. Nominal landings (tonnes) by countries in Sub-area VI, as officially reported to the ICES and estimated by WG.

Country	1996	1997	1998	1999	2000	2001	2002	2003 [1]	2004 [1]
Estonia							8		
Faroe Islands									
France							286	165	110
Poland							16	91	1
Spain [2]			22	88	20	350	1367	214	170
UK					159	247	77	42	10
Russia						1			1
Norway					35	317	21	26	
Total	0	0	22	88	214	915	1775	538	292
WG estimate									

Country	2005 [1]	2006 [1]	2007 [1]	2008 [1]	2009 [1]	2010 [1]	2011 [1]	2012 [1]	2013 [1]
Estonia	5	1							
Faroe Islands						1			0
France		22	8	114		38	8	54	113
Poland									
Spain [2]	3	33							
UK	217	74	15	80	12	11	3	11	93
Russia		1		32					
Norway		3		1	3	2	7	3	1
Lithuania				968				2	
Total	225	134	23	1195	15	52	18	70	207
WG estimate	225	134	23	1195	15	52	18	70	207

[1] Provisional data

[2] Based on estimates by observers onboard vessels

Table 15.3.1. CPUE indices of trawl fleets in Div Va, Vb and XIVb as derived from GLM multiplicative models.

area	year	cpue	% change in CPUE between years	landings	relative derived effort	relative derived effort	% change in effort between years
Iceland Va	1985	1.00		29,197	29	100	
	1986	1.02	2	31,027	31	105	5
	1987	1.13	11	44,659	40	130	24
	1988	1.20	6	49,379	41	104	-19
	1989	1.12	-6	59,049	53	127	22
	1990	0.76	-33	37,308	49	94	-26
	1991	0.73	-4	35,413	49	99	6
	1992	0.61	-16	31,978	53	108	9
	1993	0.47	-23	34,134	73	138	29
	1994	0.39	-17	28,608	74	101	-27
	1995	0.31	-21	27,391	90	122	21
	1996	0.26	-16	22,073	86	96	-21
	1997	0.28	9	16,792	60	70	-27
	1998	0.42	50	10,595	25	42	-40
	1999	0.48	14	11,138	23	92	119
	2000	0.54	13	14,607	27	116	25
	2001	0.57	6	16,755	29	108	-7
	2002	0.48	-16	19,714	41	139	29
	2003	0.33	-32	20,415	62	152	9
	2004	0.23	-29	15,477	66	107	-30
	2005	0.26	9	13,015	51	77	-28
	2006	0.26	2	11,817	45	89	16
	2007	0.30	15	10,525	35	77	-13
	2008	0.29	-5	9,580	33	96	24
	2009	0.27	-7	15,782	59	177	85
	2010	0.32	21	14,128	44	74	-58
	2011	0.36	12	14,048	39	89	21
	2012	0.35	-2	13,749	39	99	12
Greenland, XIVb	1991	1.00		875	1	100	0
	1992	0.91	-9	1,176	1	147	47
	1993	2.49	173	2,249	1	70	-52
	1994	3.20	29	3,125	1	108	54
	1995	3.33	4	5,077	2	156	45
	1996	3.37	1	7,283	2	142	-9
	1997	3.50	4	8,558	2	113	-20
	1998	3.41	-3	5,940	2	71	-37
	1999	2.60	-24	5,376	2	119	66
	2000	2.16	-17	6,958	3	156	31
	2001	2.21	2	7,216	3	102	-35
	2002	2.38	8	6,621	3	85	-16
	2003	2.42	1	8,017	3	119	40
	2004	2.27	-6	9,854	4	131	9
	2005	3.16	39	10,185	3	74	-43
	2006	3.25	3	8590	3	82	11
	2007	3.08	-5	10261	3	126	53
	2008	3.10	1	8,952	3	86	-31
	2009	2.58	-17	10,567	4	142	64
	2010	2.73	6	10,402	4	93	-35
	2011	2.68	-2	10,761	4	106	14
	2012	3.16	18	12,475	4	98	-7
Faroe Islands, Vb	1991	1.00		1,662	2	100	35
	1992	0.34	-21	2,269	7	397	297
	1993	0.24	-11	4,434	19	282	-29
	1994	0.23	-2	5,225	23	121	-57
	1995	0.16	-28	3,832	23	103	-15
	1996	0.17	4	6,469	37	160	55
	1997	0.19	12	4,870	25	67	-58
	1998	0.14	-34	3,825	28	112	67
	1999	0.16	12	4,265	27	96	-15
	2000	0.17	11	5,079	29	109	14
	2001	0.20	19	3,245	16	55	-50
	2002	0.16	-24	2,694	17	104	91
	2003	0.10	-29	2,426	24	141	35
	2004	0.08	-12	1,771	21	89	-37
	2005	0.09	4	892	10	48	-46
	2006	0.10	19	873	8	83	72
	2007	0.12	16	1,060	9	107	28
	2008	0.18	60	1735	9	100	-6
	2009	0.21	26	1760	10	107	7
	2010	0.17	-21	1,413	8	87	-19
	2011	0.31	65	1,489	8	98	13
	2012	0.30	-4	2163	5	59	-40

Table 15.6.1. Model input data series: Catch by the fishery; three indices of stock biomass – a standardized catch rate index based on fishery data (CPUE) from the Iceland EEZ, a Icelandic (Ice) and a Greenlandic (Green) research survey index.

Year	Catch (ktons)	CPUE (index)	Survey (ktons)
1960	0	-	-
1961	0.029	-	-
1962	3.071	-	-
1963	4.275	-	-
1964	4.748	-	-
1965	7.421	-	-
1966	8.030	-	-
1967	9.597	-	-
1968	8.337	-	-
1969	26.200	-	-
1970	33.823	-	-
1971	28.973	-	-
1972	26.473	-	-
1973	20.463	-	-
1974	36.280	-	-
1975	23.494	-	-
1976	6.045	-	-
1977	16.578	-	-
1978	14.349	-	-
1979	23.622	-	-
1980	31.157	-	-
1981	19.239	-	-
1982	32.441	-	-
1983	30.891	-	-
1984	34.024	-	-
1985	32.075	1.92	-
1986	32.984	1.87	-
1987	46.622	1.82	-
1988	51.118	1.66	-
1989	61.396	2.02	-
1990	39.326	1.37	-
1991	37.950	1.37	-
1992	35.487	1.20	-
1993	41.247	0.95	-
1994	37.190	0.79	-
1995	36.288	0.61	-
1996	35.932	0.52	66.00
1997	30.309	0.58	90.00
1998	20.382	0.90	91.00
1999	20.371	0.99	90.00
2000	26.644	1.10	101.00
2001	27.291	1.15	110.00
2002	29.158	0.89	84.00
2003	30.891	0.63	52.00
2004	27.102	0.53	37.00
2005	24.249	0.45	56.00
2006	21.432	0.60	39.00
2007	20.957	0.82	50.00
2008	22.169	0.69	58.00
2009	27.349	0.72	80.00
2010	25.995	0.72	59.00
2011	26.424	0.76	71.00
2012	29.309	0.78	82.00
2013	27.045	0.82	84.00
2014*	25.000		

*estimated

Table 15.6.2. Priors used in the assessment model. ~ means "distributed as..", dunif = uniform-, dlnorm = lognormal-, dnorm= normal- and dgamma = gammadistributed. Symbols as in text.

Parameter		Prior	
Name	Symbol	Type	Distribution
Maximal Suatainable Yield	MSY	reference	dunif(1,300)
Carrying capacity	K	low informative	dnorm(750,300)
Catchability Iceland survey	q_{Ice}	reference	$\ln(q_{Ice})$~dunif(-3,1)
Catchability Greenland survey	q_{Green}	reference	$\ln(q_{Green})$~dunif(-3,1)
Catchability Iceland CPUE	q_{cpue}	reference	$\ln(q_{cpue})$~dunif(-10,1)
Initial biomass ratio	P_1	informative	dnorm(2,0.071)
Precision Iceland survey	$1/\sigma_{Ice}^2$	low informative	dgamma(2.5,0.03)
Precision Greenland survey	$1/\sigma_{Green}^2$	low informative	dgamma(2.5,0.03)
Precision Iceland CPUE	$1/\sigma_{cpue}^2$	low informative	dgamma(2.5,0.03)
Precision model	$1/\sigma_P^2$	reference	dgamma(0.01,0.01)

Table 15.6.3. Summary of parameter estimates: mean, standard deviation (sd) and 25, 50, and 75 percentiles of the posterior distribution of selected parameters (symbols as in the text).

	Mean	sd	25%	Median	75%
MSY (ktons)	36.00	12.94	27.93	35.14	42.86
K (ktons)	898	260	712	887	1071
r	0.18	0.08	0.12	0.17	0.22
q_{cpue}	0.003	0.001	0.002	0.003	0.003
q_{Survey}	0.28	0.10	0.20	0.25	0.32
P_{1985}	1.59	0.13	1.50	1.59	1.67
P_{2013}	0.71	0.11	0.64	0.71	0.78
σ_{cpue}	0.11	0.03	0.09	0.10	0.12
σ_{Survey}	0.17	0.04	0.15	0.17	0.20
σ_P	0.18	0.03	0.16	0.18	0.20

Table 15.6.4. Model diagnostics: residuals (% of observed value), probability of getting a more extreme observation (p.extreame; see text for explanation).

	CPUE		Survey	
Year	resid (%)	Pr	resid (%)	Pr
1986	-2.53	0.57	-	-
1987	-0.51	0.51	-	-
1988	-0.23	0.51	-	-
1989	3.74	0.39	-	-
1990	-9.53	0.75	-	-
1991	4.12	0.38	-	-
1992	-2.27	0.57	-	-
1993	-2.46	0.57	-	-
1994	0.69	0.48	-	-
1995	-0.09	0.51	-	-
1996	5.87	0.34	-15.49	0.78
1997	14.92	0.14	-33.50	0.96
1998	17.13	0.11	-9.33	0.69
1999	-1.99	0.56	1.81	0.46
2000	-1.32	0.54	-0.19	0.50
2001	-2.35	0.57	-7.27	0.65
2002	-5.29	0.65	-2.91	0.56
2003	-2.28	0.57	12.46	0.26
2004	-0.48	0.51	26.14	0.08
2005	-3.60	0.60	-17.36	0.82
2006	10.76	0.21	28.66	0.07
2007	-8.06	0.72	25.31	0.10
2008	-17.97	0.91	9.94	0.30
2009	-1.01	0.53	-14.92	0.79
2010	2.19	0.44	12.12	0.26
2011	-1.50	0.54	0.18	0.49
2012	-0.22	0.51	-8.52	0.67
2013	2.90	0.41	-7.08	0.64

Table 15.6.5. Upper: stock status for 2013 and predicted to the end of 2014. Lower: predictions for 2015 with catch options from 0 to 30 ktons.

Status	2013	2014 *
Risk of falling below B_{lim}	0%	0%
Risk of falling below B_{MSY}		92%
Risk of exceeding F_{MSY}	60%	51%
Risk of exceeding F_{lim} (1.7F_{MSY})	17%	15%
Stock size (B/Bmsy), median	0.71	0.72
Fishing mortality (F/Fmsy),	1.10	1.00
Productivity (% of MSY)	91%	92%

*Predicted catch in 2014 = 25ktons

Catch option 2015 (ktons)	0	5	10	15	20	30
Risk of falling below *30%*B_{MSY}	0%	0%	0%	0%	0%	1%
Risk of falling below B_{MSY}	79%	80%	81%	82%	83%	87%
Risk of exceeding F_{MSY}	-	1%	5%	15%	31%	67%
Risk of exceeding F_{lim} (1.7F_{MSY})	-	0%	2%	4%	9%	28%
Stock size (B/Bmsy), median	0.79	0.78	0.77	0.77	0.75	0.71
Fishing mortality (F/Fmsy),	0.00	0.18	0.37	0.57	0.77	1.24
Productivity (% of MSY)	96%	95%	95%	95%	94%	92%

Table 15.6.6 Input to the data limited approach for catch advice.

Year	Catches	Survey index	CV for index	FProxy
1996	35.83	40.9919	0.133	0.874
1997	30.22	58.1181	0.136	0.52
1998	19.8	75.0765	0.14	0.264
1999	18.64	71.5398	0.117	0.261
2000	26.64	78.2717	0.128	0.34
2001	27.29	75.9566	0.163	0.359
2002	29.16	56.8469	0.128	0.513
2003	30.89	40.9913	0.107	0.754
2004	27.1	29.5616	0.105	0.917
2005	24.25	43.3441	0.17	0.559
2006	21.28	29.1645	0.102	0.73
2007	21.85	36.3292	0.178	0.601
2008	22.56	40.6955	0.089	0.554
2009	27.01	53.7591	0.274	0.502
2010	25.13	37.5362	0.122	0.669
2011	26.22	23.4909	0.135	1.116
2012	29.11	57.5007	0.122	0.506
2013	27.18	59.3573	0.138	0.458

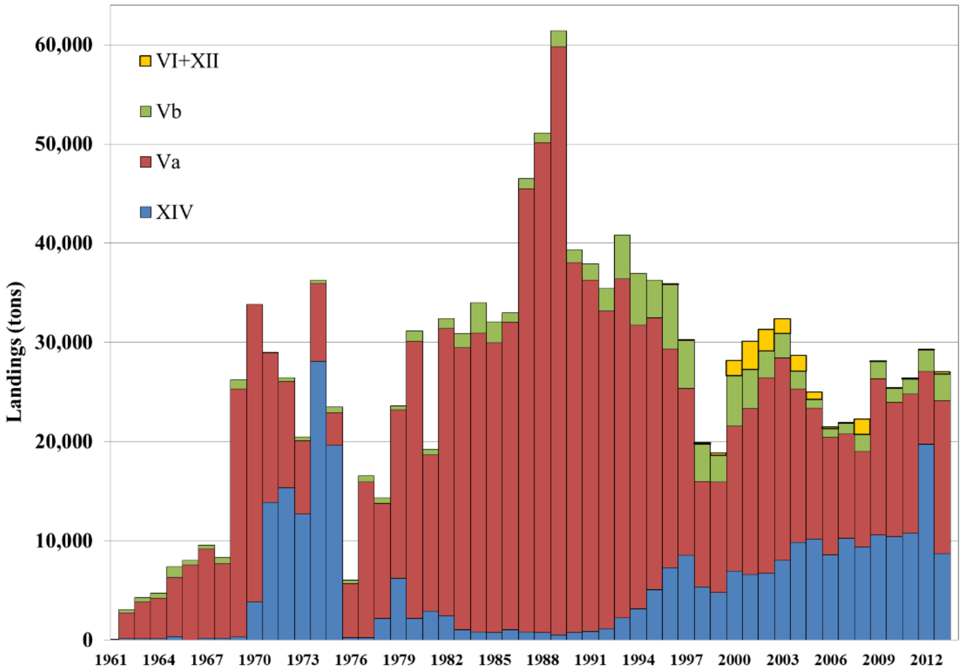


Fig. 15.2.1. Landings of Greenland halibut in Divisions V, XI and XIV. As the landings within Icelandic waters, since 1976, have not officially been separated and reported according to the defined ICES statistical areas, they are set under area Va by the North Western Working Group. In 2012 Icelandic landings in XIV were recorded in XIV, while for remaining years all landings are recorded in Va.

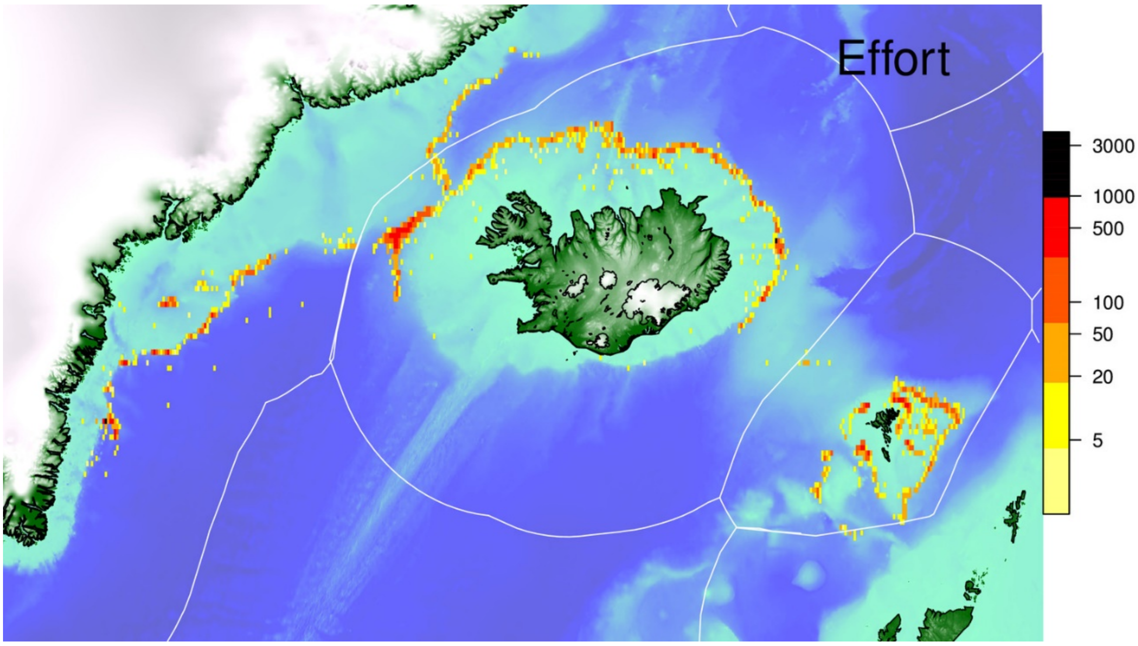


Fig. 15.2.2 Greenland halibut V+XIV. Distribution of fishing effort in 2013.

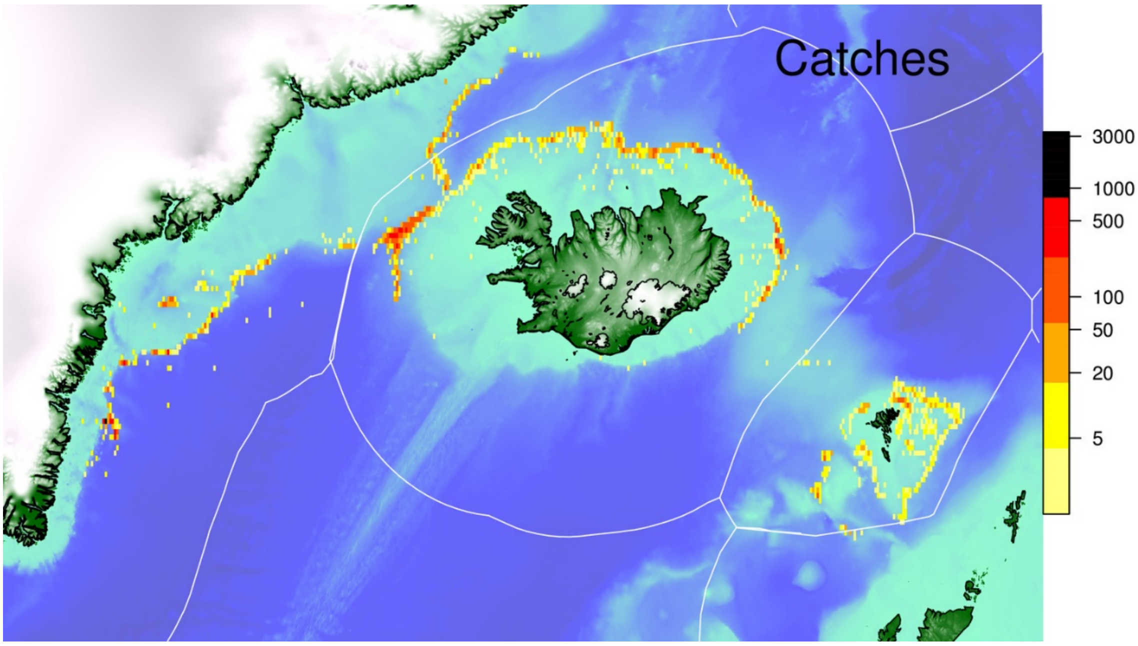


Fig. 15.2.3. Greenland halibut V+XIV. Distribution of catches in the fishery in 2013.

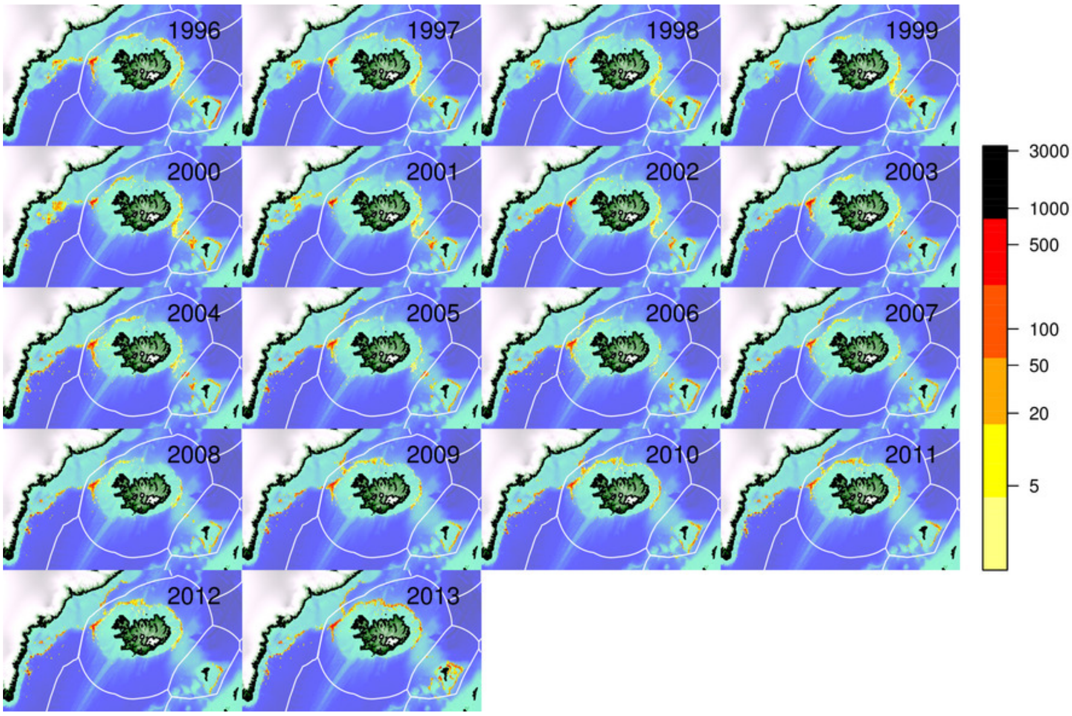


Fig. 15.2.4. Greenland halibut V+XIV. Distribution of total fishing effort 1991-2013.

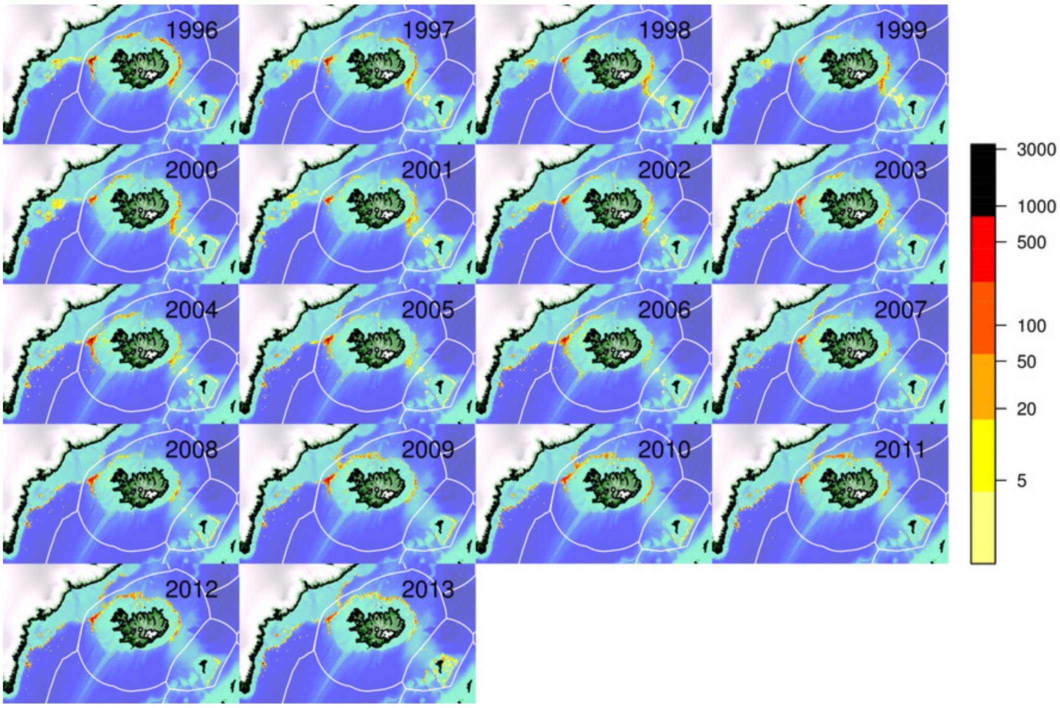


Fig. 15.2.5. Greenland halibut V+XIV. Distribution of total catches in the fishery 1991-2013.

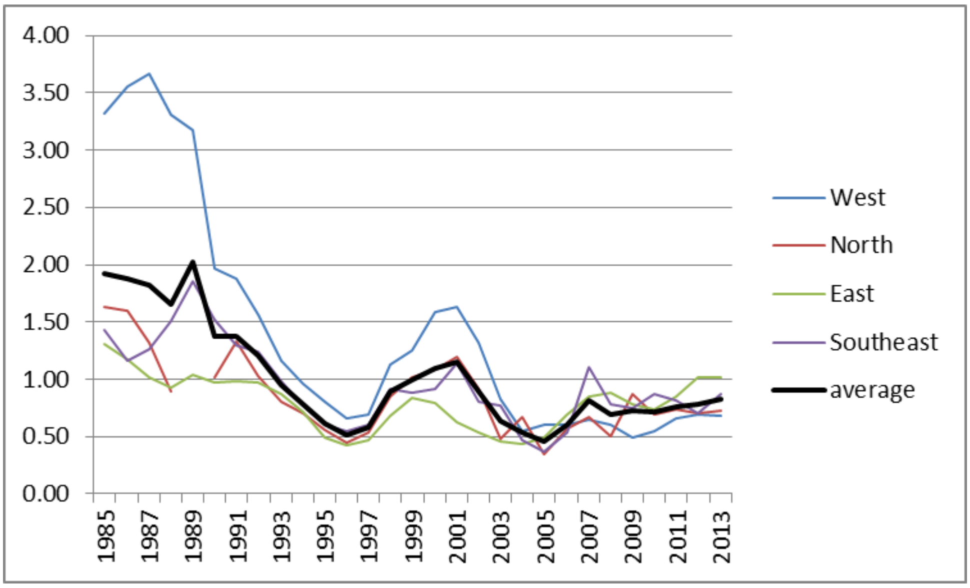


Fig. 15.3.1. Standardised CPUEs from the Icelandic trawler fleet in Va. The average index (equal weighing) of the four areas are used as biomass indicator input to the stock production model.

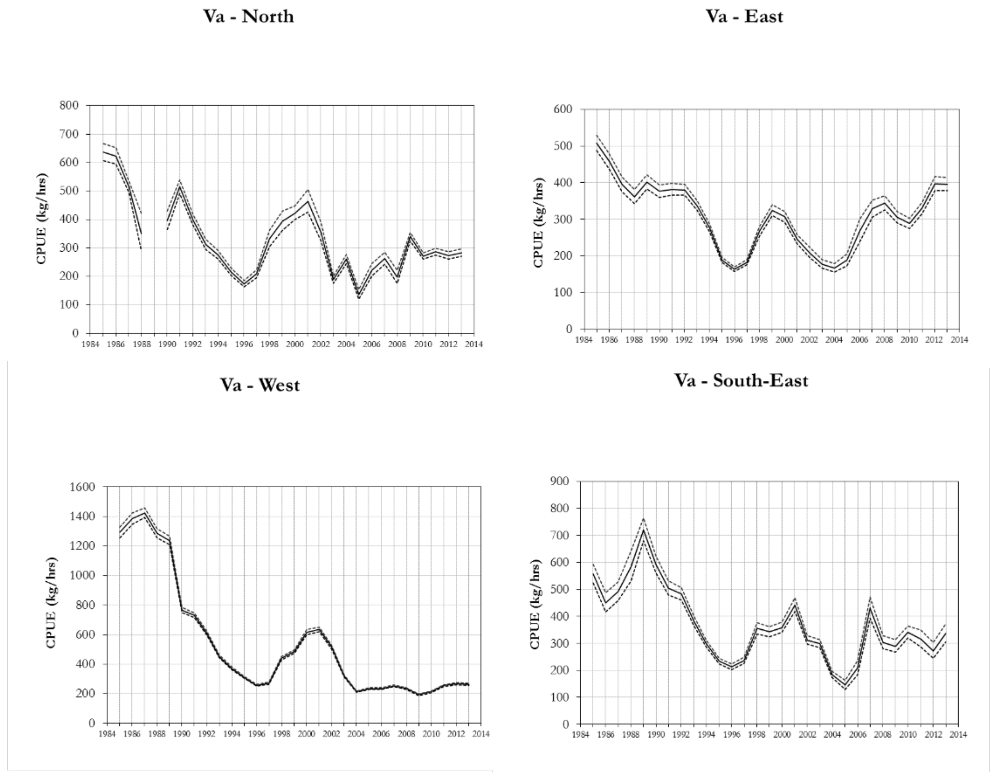


Fig. 15.3.2 Standardised CPUE from the Icelandic trawler fleet in Va by four main fishing areas in Va. 95% CI indicated.

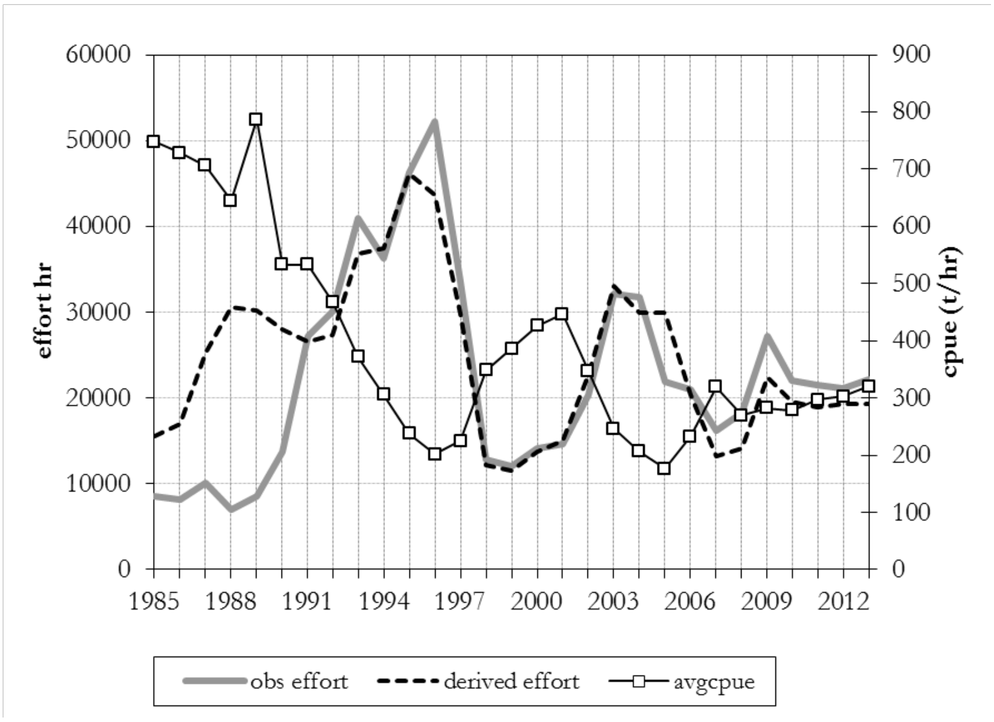


Fig. 15.3.3. Standardised CPUE,observed and derived effort from Icelandic trawl fishery.

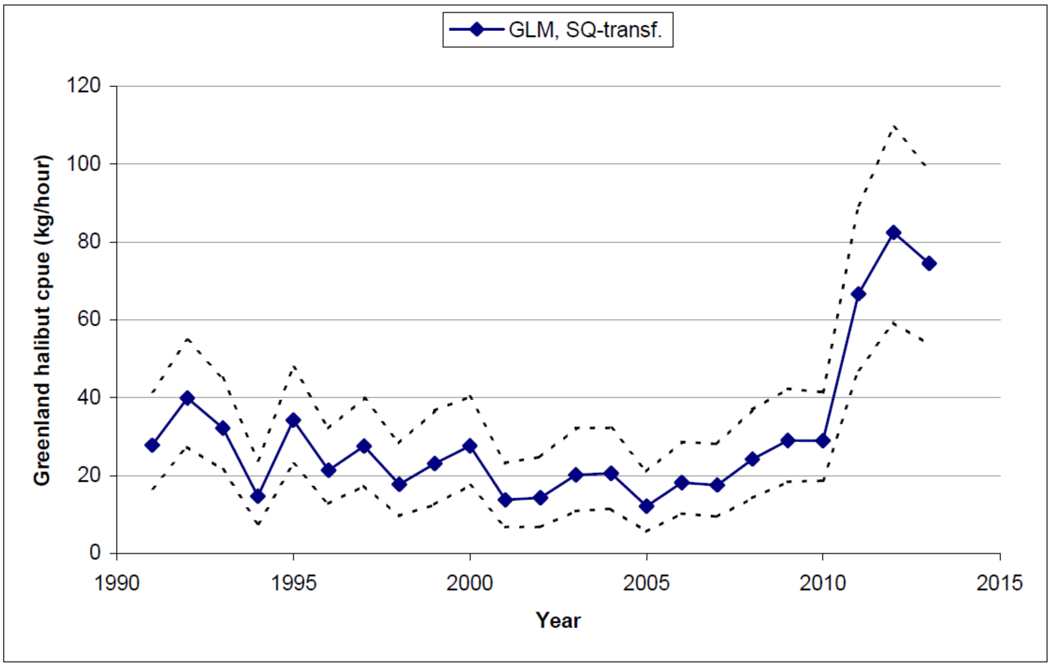


Figure 15. 3.4. Standardised CPUE from the Faroese trawler fleet. 95% CI indicated.

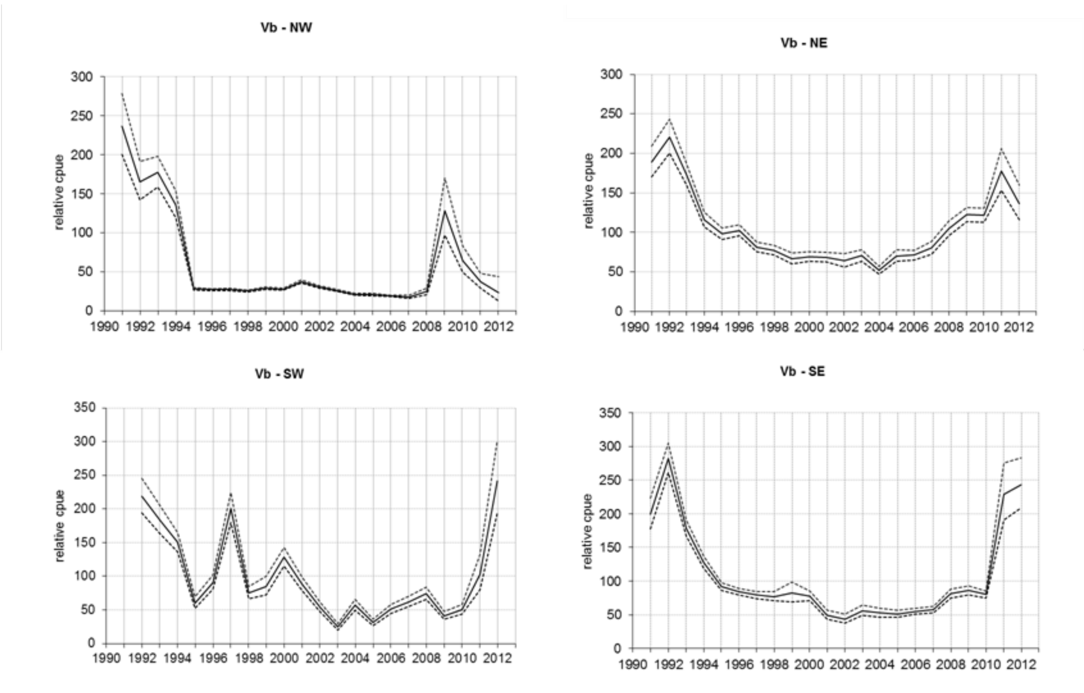


Figure 15.3.5. Standardised CPUE from the Faroese trawler fleet by four fishing areas as indicated on map. 95% CI indicated.[

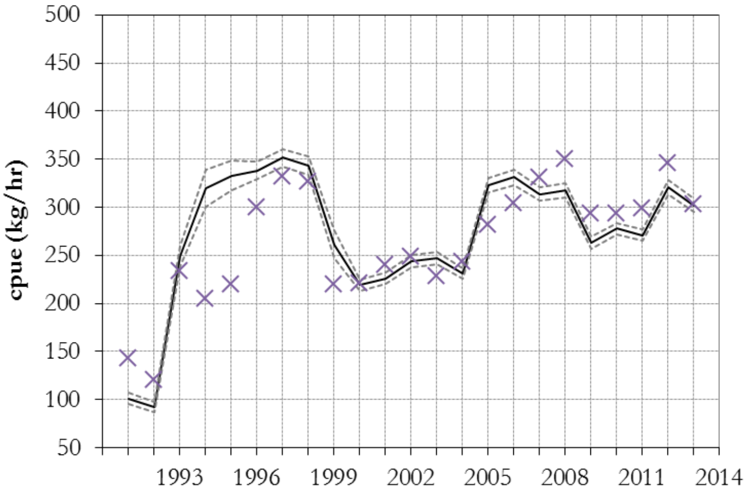


Fig. 15.3.6. Standardised CPUE from trawler fleets in XIVb. 95% CI indicated. Points (x) are raw observations.

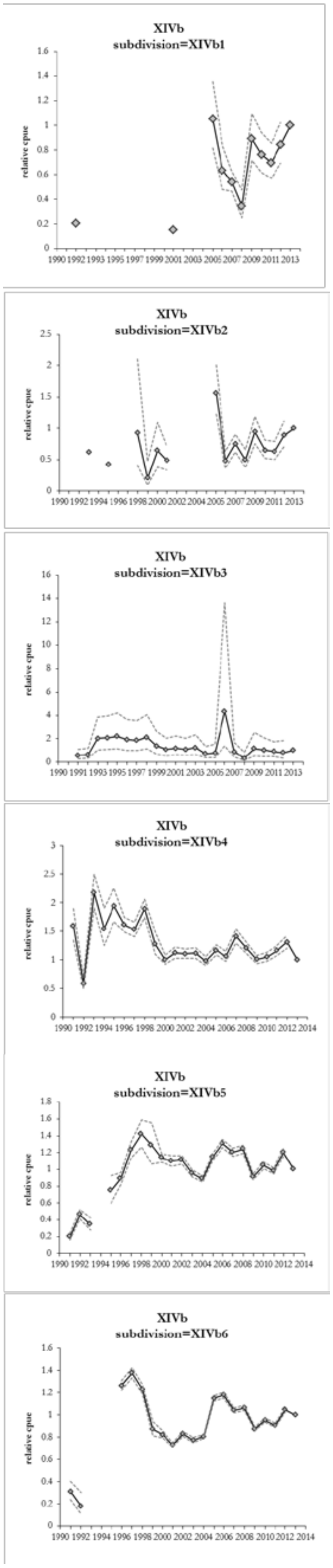


Fig. 15.3.7. Standardised CPUE from trawler fleets in XIVb shown by subdivisions in XIVb in a north-south orientation. 95% CI indicated.

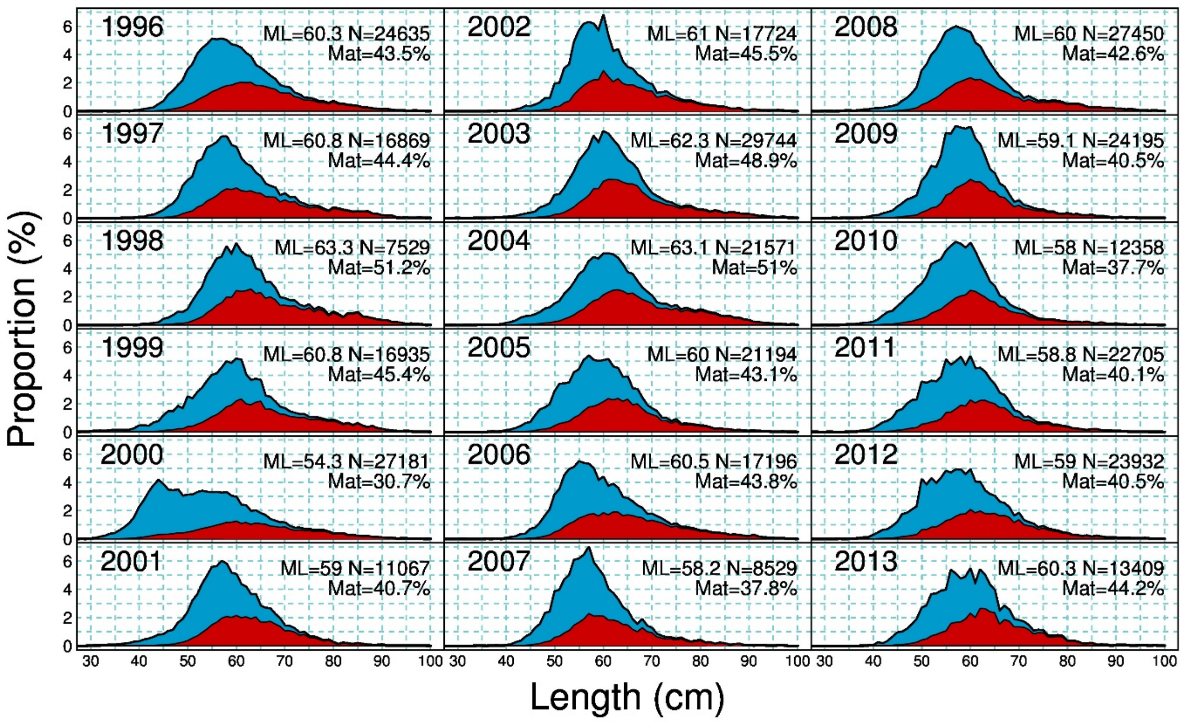


Fig. 15.4.1. Length distributions from the commercial trawl fishery in the western fishing grounds of Iceland (Va) in the years 1996-2013. Blue indicate males and red indicates females.

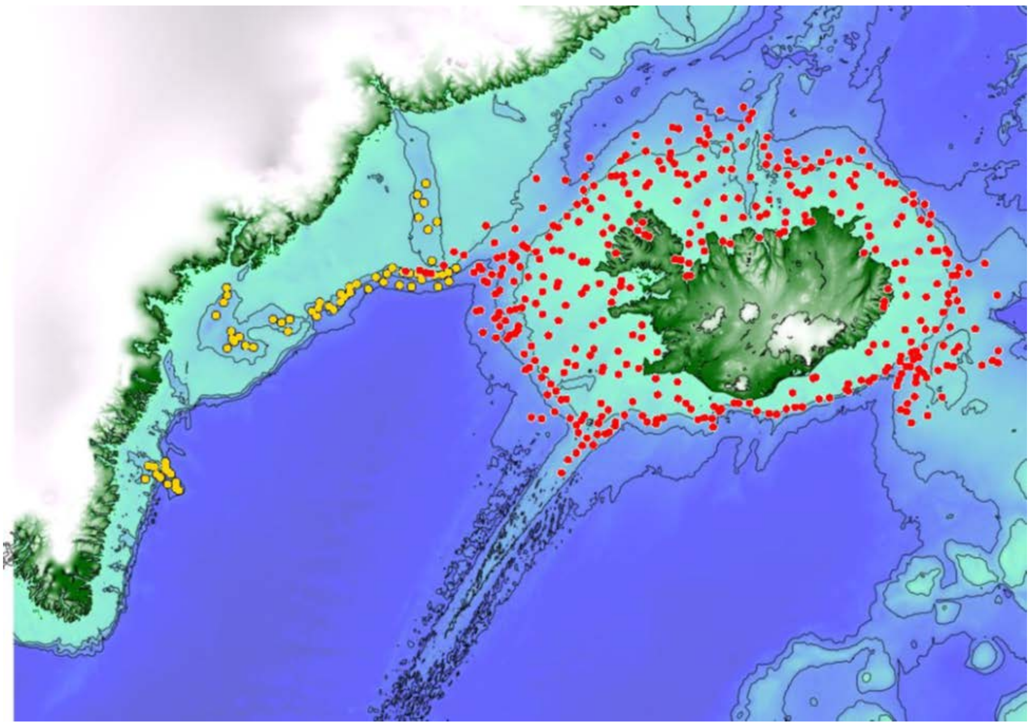


Fig. 15.5.1. Stations covered by scientific surveys in XIV+V indicated as station positions in 2013 by the Greenland (n=80) and Iceland (n=203).

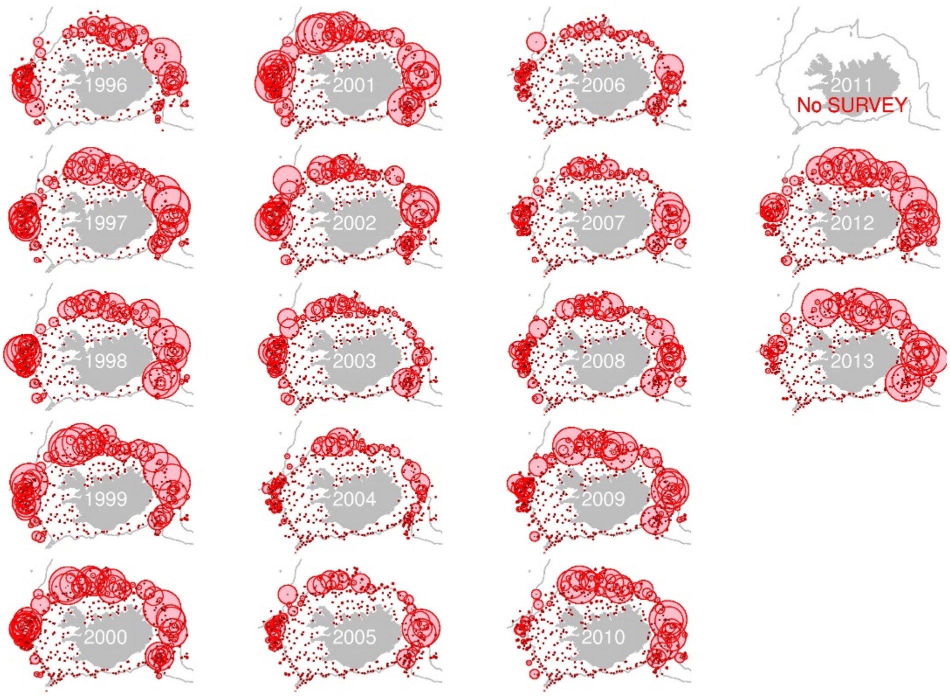


Fig. 15.5.2. Distribution of Greenland halibut catches from the Icelandic fall survey 1996-2013.

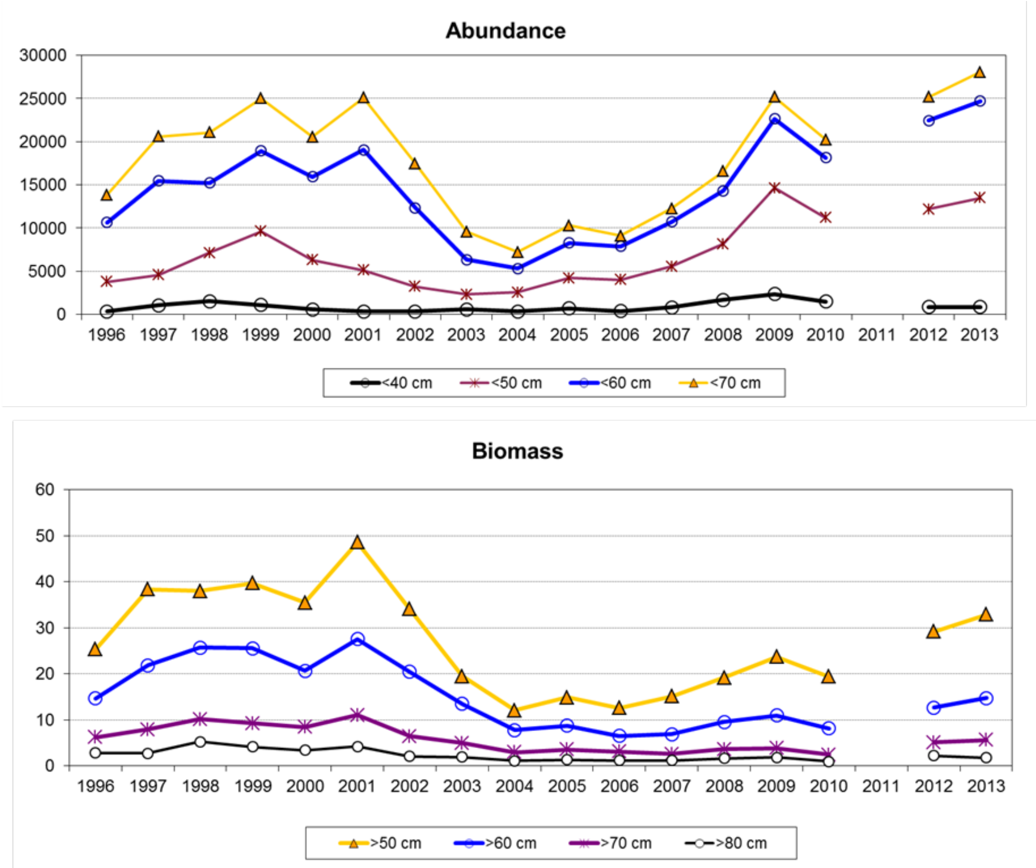


Fig. 15.5.3. Greenland halibut in Icelandic fall groundfish survey. No survey was conducted in 2011.

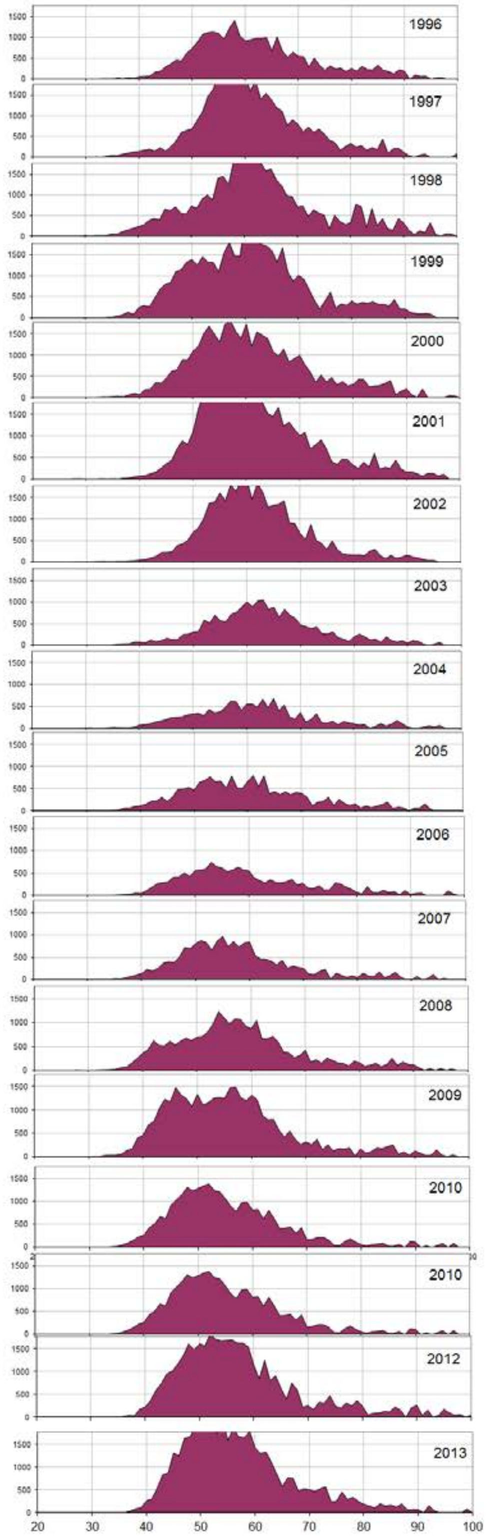


Fig. 15.5.4. Abundance indices by length for the Icelandic fall survey 1996-2013. No survey was conducted in 2011.

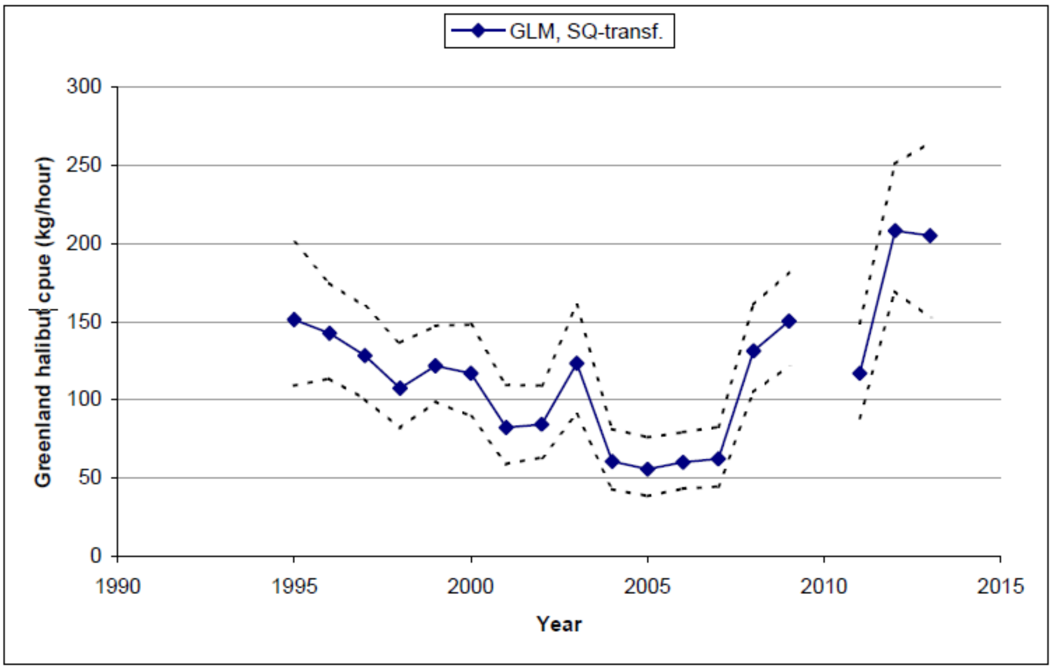


Figure 15.5.5. Catch rates from a combined survey/fisherman's survey in Vb. Estimates are from a GLM model.

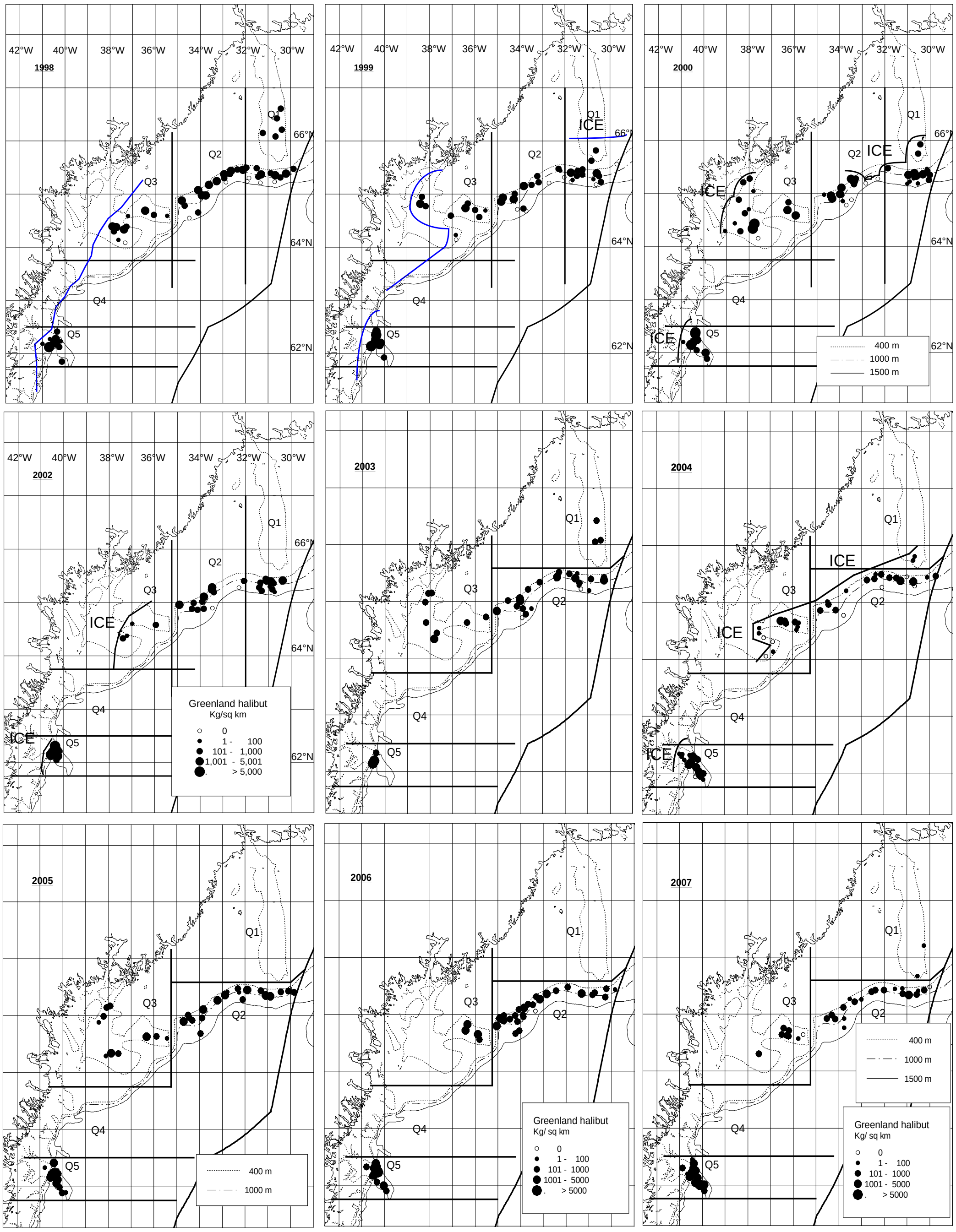


Fig. 15.5.6. Distribution of catches of Greenland halibut at East Greenland in 1998 – 2012 in the Greenland deep-water survey.

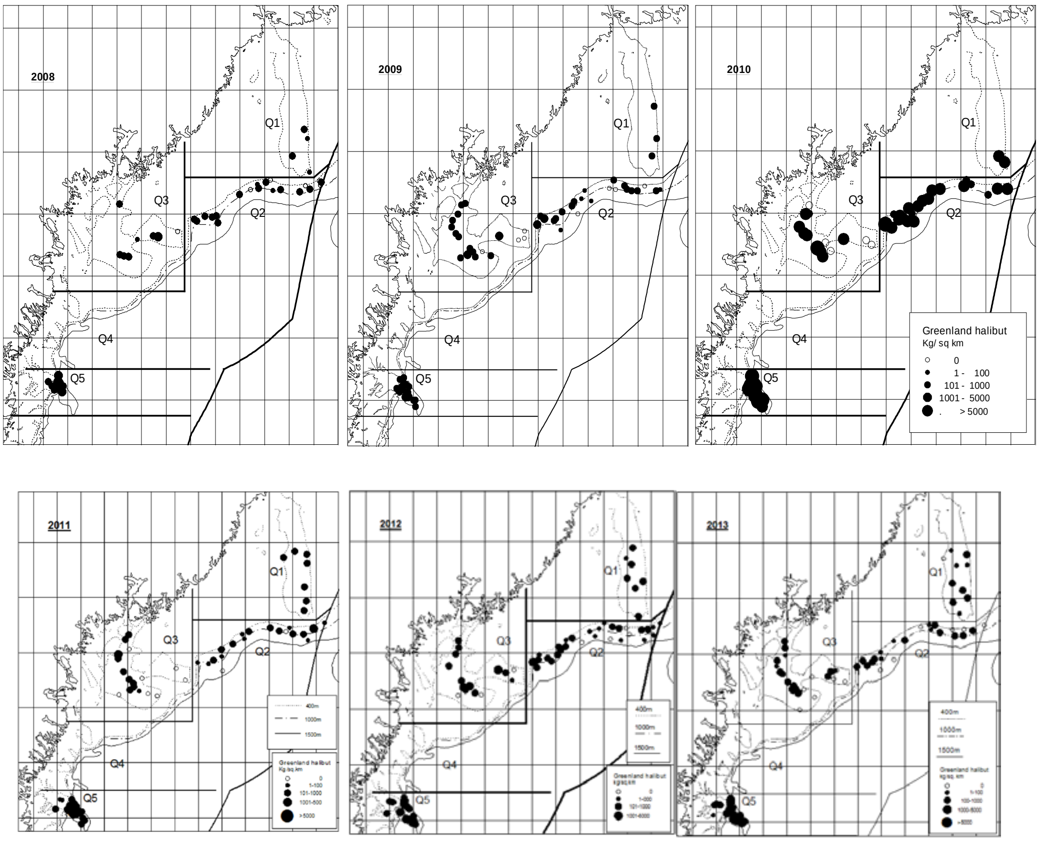


Fig. 15.5.6 continued. Distribution of catches of Greenland halibut at East Greenland in 1998 – 2013 in the Greenland deep-water survey.

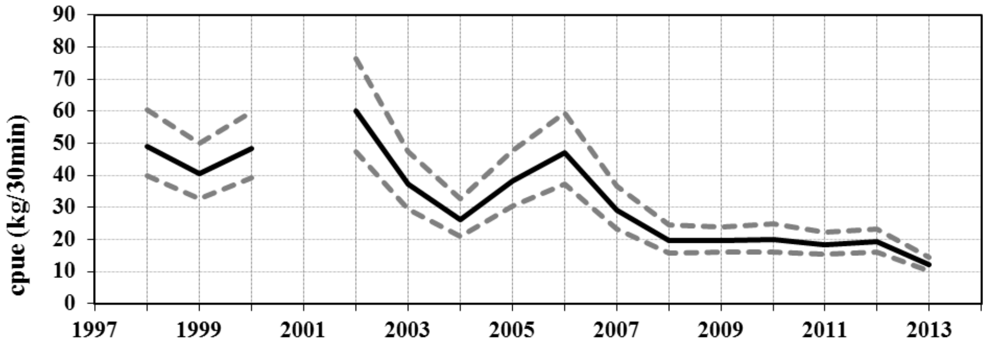


Fig. 15.5.7. Standardised catch rates from the Greenland survey.(95% CI indicated.)

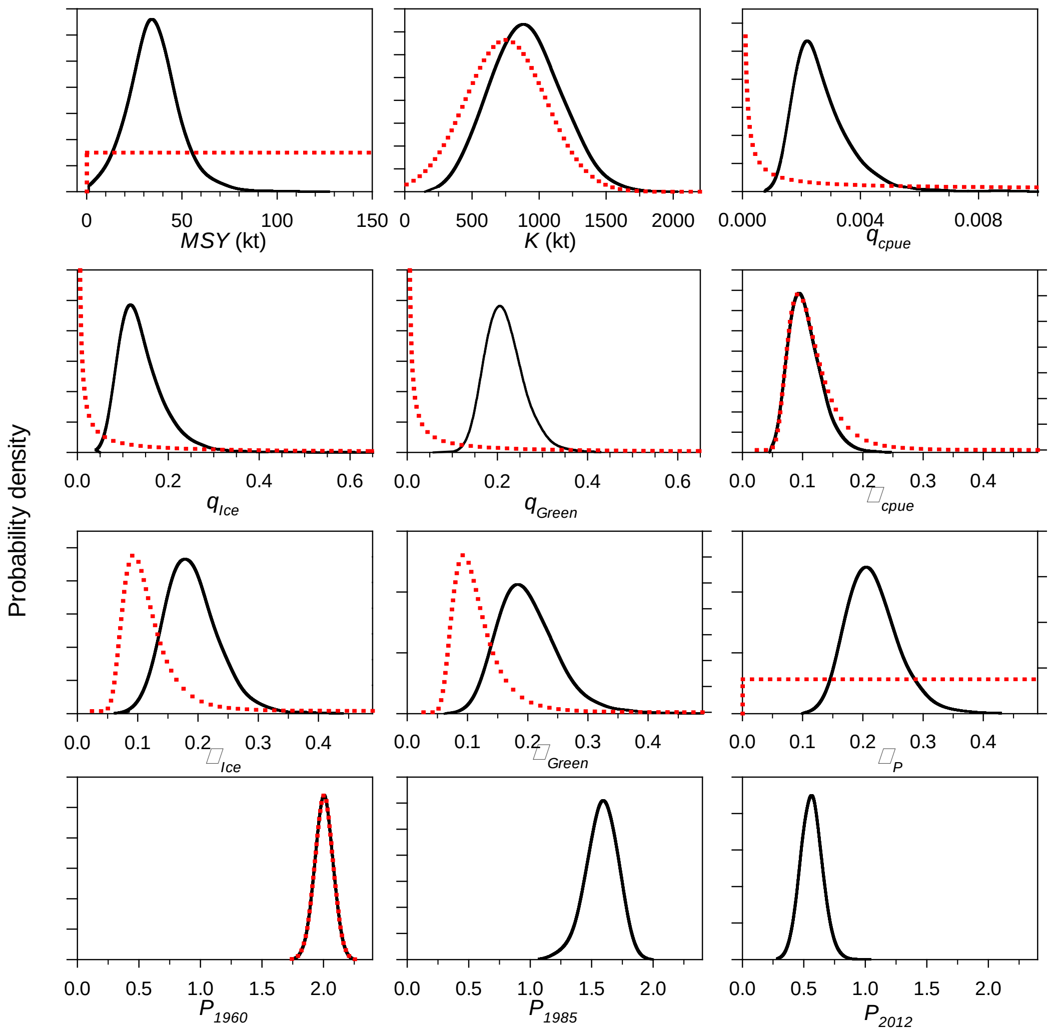


Figure 15.6.1. Probability density distributions of model parameters: estimated posterior (solid line) and prior (broken line) distributions.

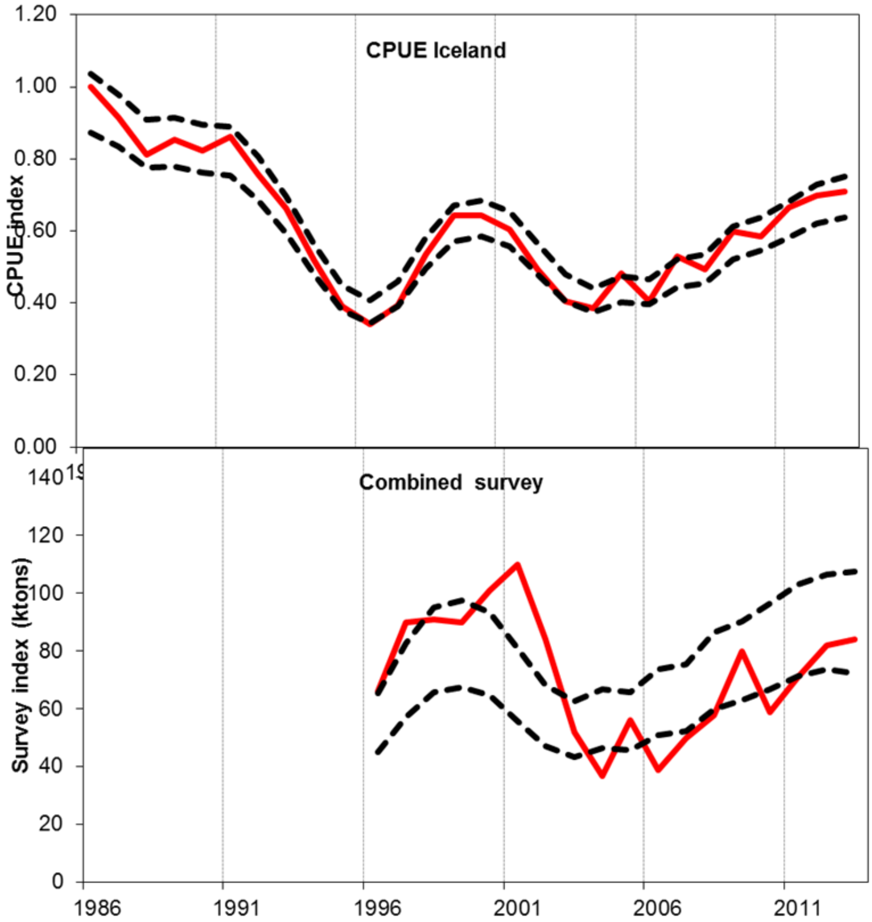


Figure 15.6.2. Observed (red curve) and predicted (dashed lines) series of the two biomass indices input to the model. Dashed lines are inter-quartile range of the posteriors.

Figure 15.6.3. Retrospective plot of median relative biomass (*B/B$_{msy}$*). Relative biomass series are estimated by consecutively leaving out from 0 to 9 years of data. [NEED UPDATE]

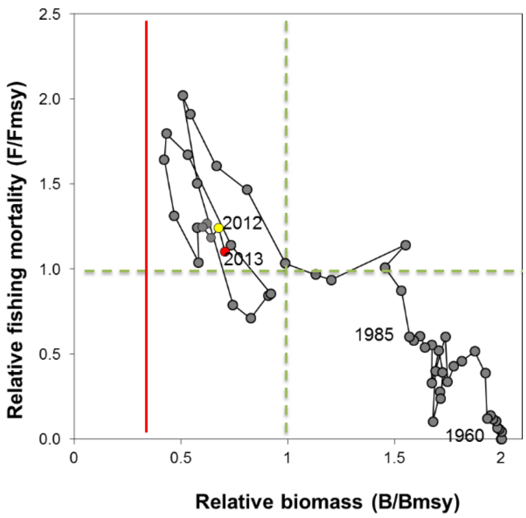


Figure 15.6.4. Estimated annual median biomass-ratio (B/BMSY) and fishing mortality-ratio (F/FMSY) 1985-2012. Candidate for lower range of MSY Btrigger is indicated by 30%Bmsy.(2012 and 2013 point indicated yellow and red, respectively)

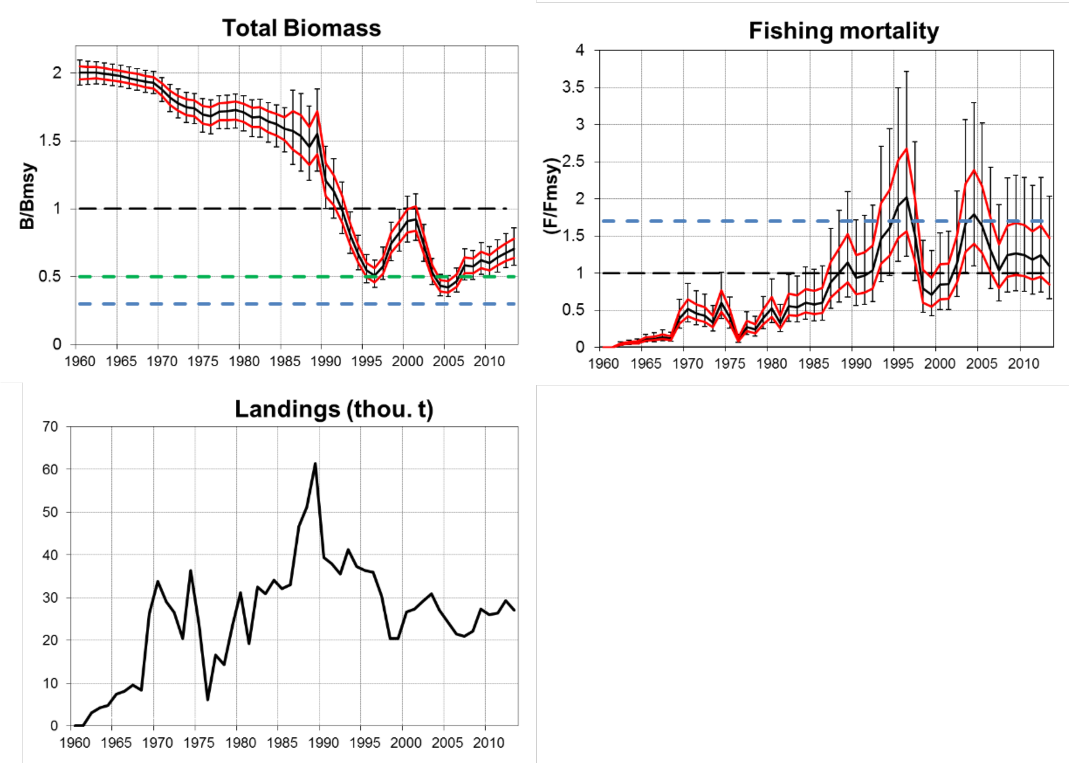


Figure 15.6.5. Stock summary, upper panel: right is fishing mortality (F/Fmsy), left is total biomass (B/Bmsy) and lower panel is landings since start of the fishery.

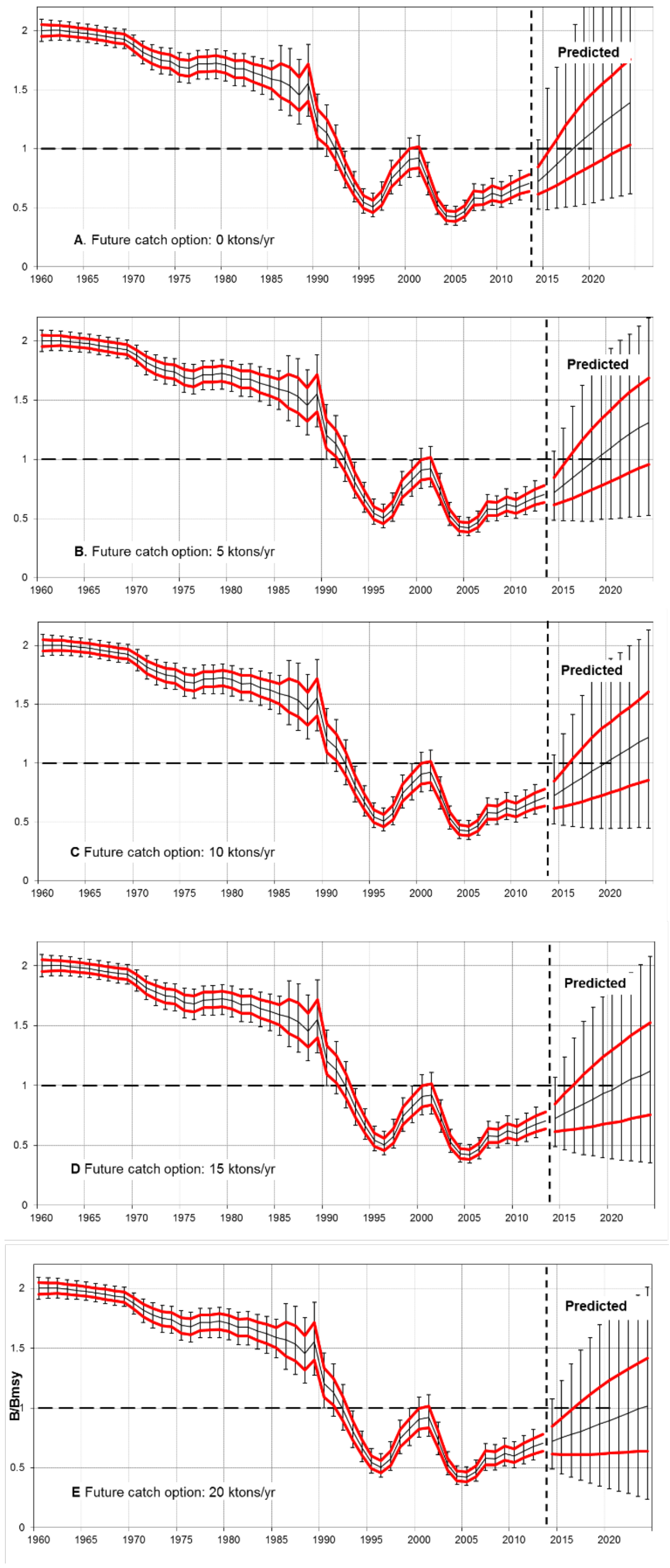


Fig. 15.6.6 Estimated time series of relative biomass (B_t/B_{msy}) under different catch option scenarios: 0, 5, 10, 15 and 20 kt from upper to lower.. Bold red lines are inter-quartile ranges and the solid black line is the median; the error bars extend to cover the central 90 per cent of the distribution.

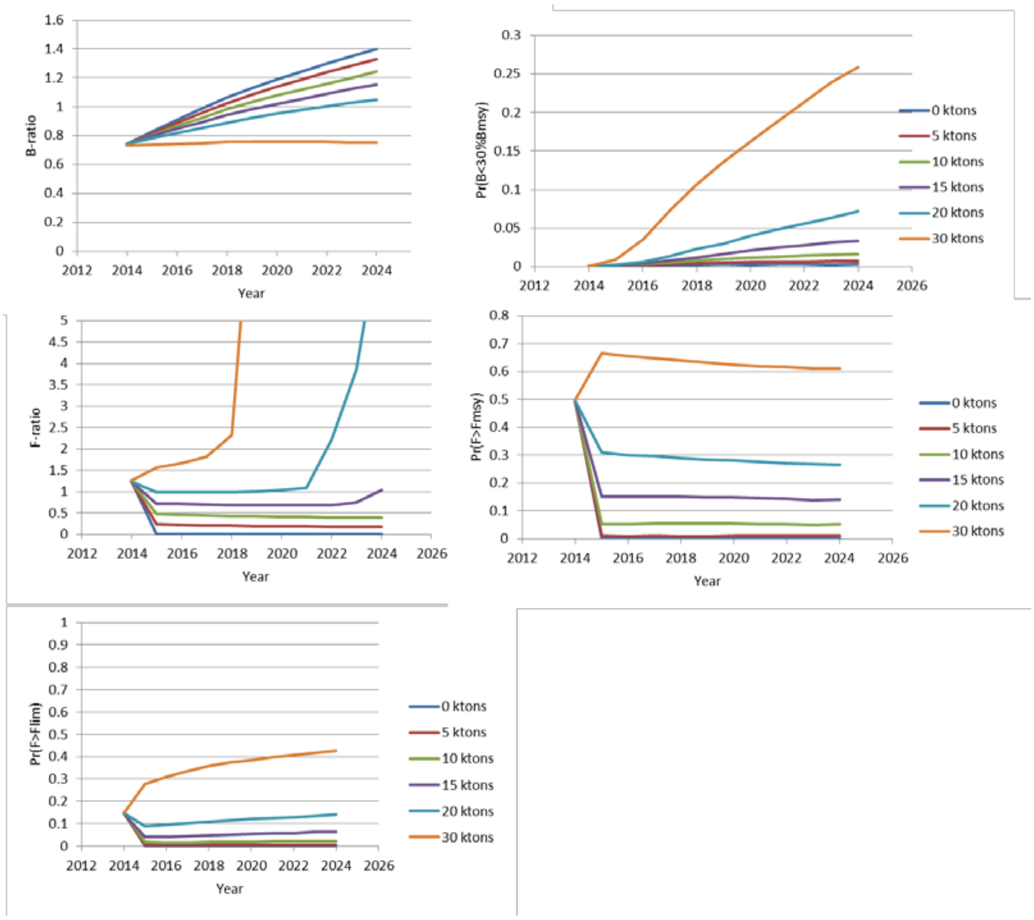


Figure 15.6.7. Projections: Medians of estimated posterior biomass- and fishing mortality ratios; estimated risk of exceeding F_{msy} or going below and $B_{MSYtrigger}$ given catches at 0, 5,10, 15, 20 and 30 ktons.

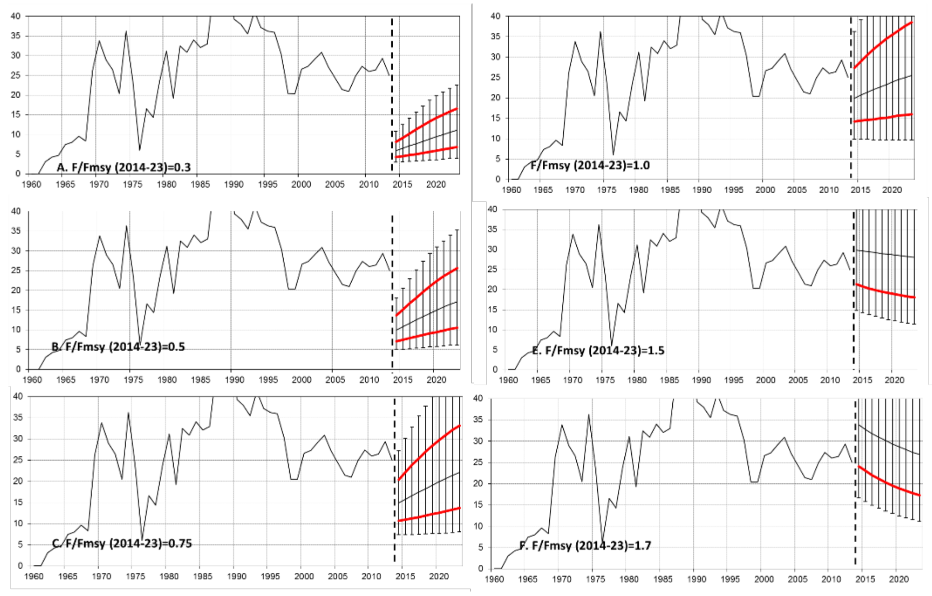


Figure 15.6.8. Historic landings and projected landings 2014-2023 under various F ratio options from 0.3-1.7 F/Fmsy Solid line is median, red bold lines are quartiles and bars indicate 90% conf limit.

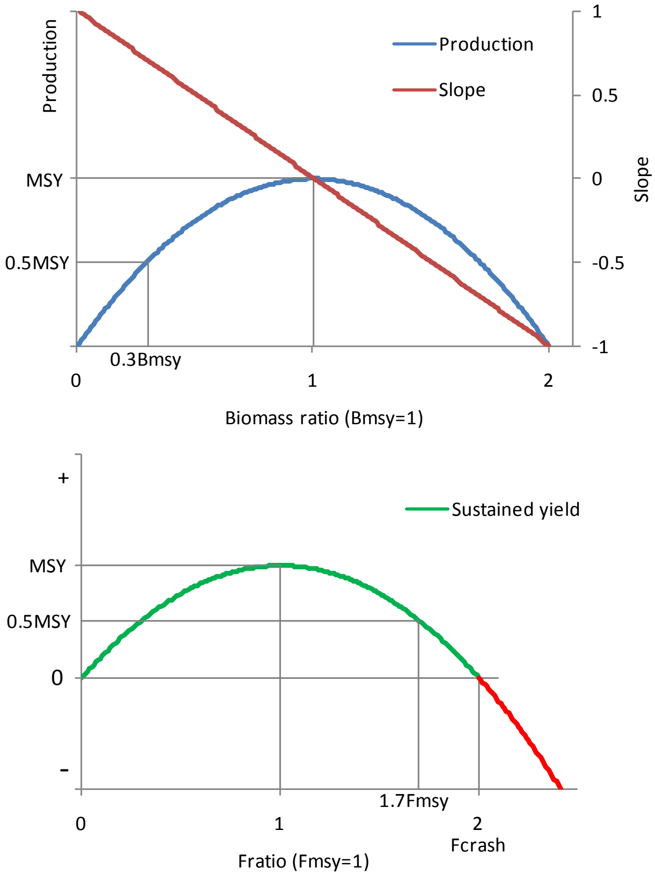


Figure 15.6.9. The logistic production curve in relation to stock biomass (B/Bmsy) (*upper*) and fishing mortality (F/Fmsy) (*lower*). *Upper*: points of maximum sustainable yield (MSY) and corresponding stock size are shown as well as the slope (red line) of the production curve (blue line); *lower*: points of MSY and corresponding fishing mortality and Fcrash (F≥Fcrash do not have stable equilibriums and will drive the stock to zero).

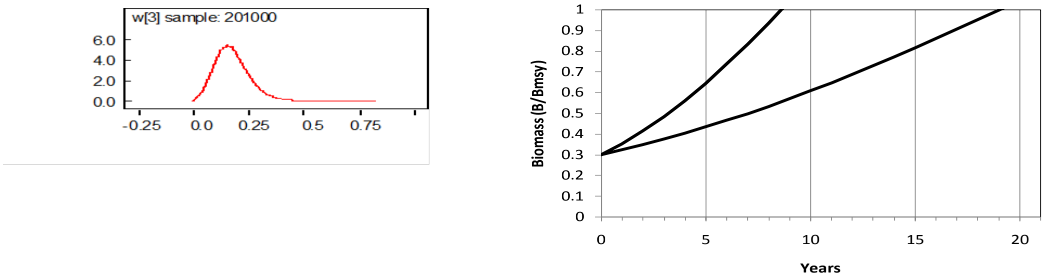


Figure 15.6.10 ***Left*****: The posterior probability density distribution of *r*, the intrinsic rate of growth. Right: estimated recovery time from Blim (0.3Bmsy) to Bmsy (relative biomass = 1) given *r*-values ranging within the 95% conf. lim. of the posterior (left figure) and no fishing mortality.**

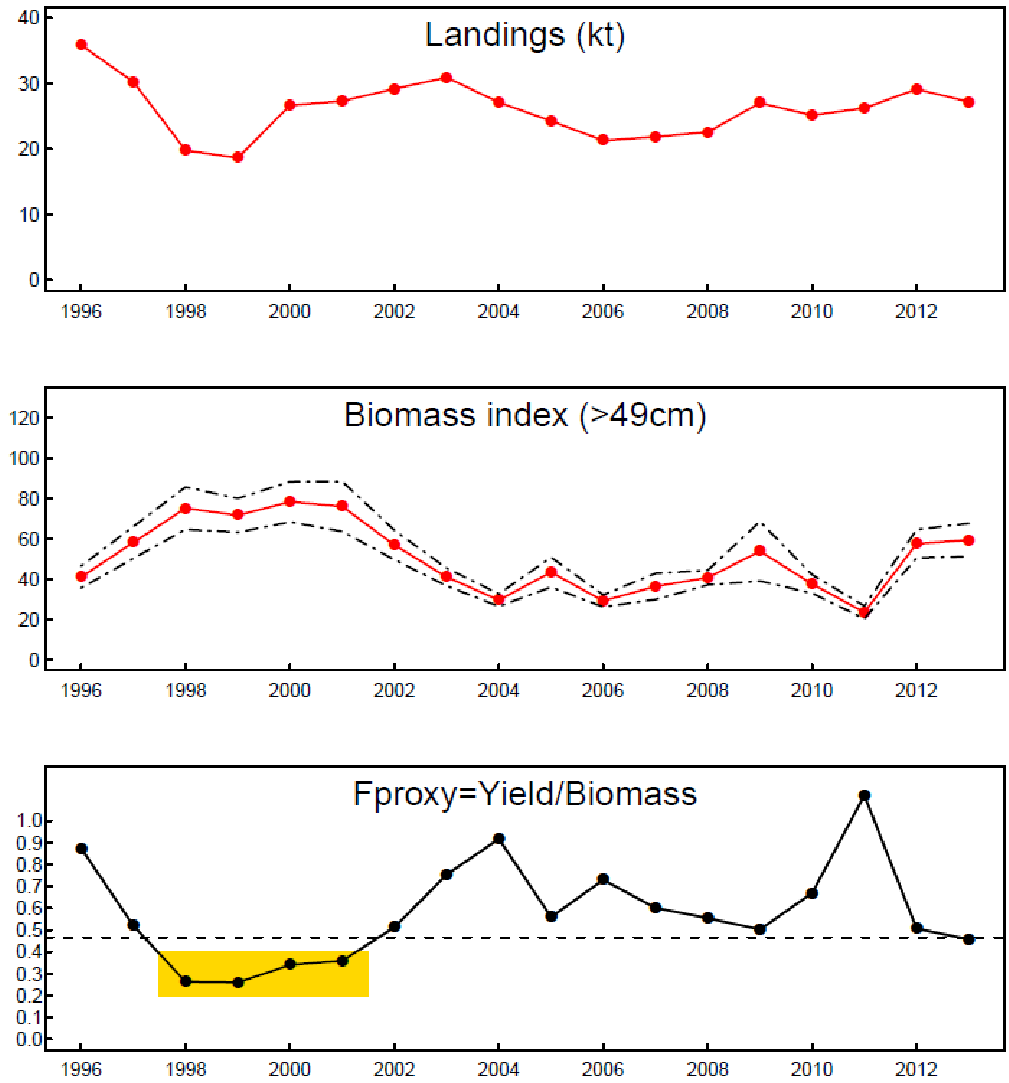


Figure 15.6.11. Input data 1996-2013 for the data limited approach. Upper panel: Landings, middle panel: survey biomass index and lower panel: Landings/survey biomass as Fproxy. Dashed line is average Fproxy and yellow indicates period of low Fproxy and stable survey biomass index.

17 Redfish in Subareas V, VI, XII and XIV

This chapter deals with fisheries directed to *Sebastes* species in Subareas V, VI, XII and XIV (chapters 17.4 and 17.7), and the abundance and distribution of juveniles (chapter 17.2.1), among other issues.

The "Workshop on Redfish Stock Structure" (WKREDS, 22-23 January 2009, Copenhagen, Denmark; ICES 2009) reviewed the stock structure of *Sebastes mentella* in the Irminger Sea and adjacent waters. ACOM concluded, based on the outcome of the WKREDS meeting, that there are three biological stocks of *S. mentella* in the Irminger Sea and adjacent waters:

- a 'Deep Pelagic' stock (NAFO 1–2, ICES V, XII, XIV >500 m) – primarily pelagic habitats, and including demersal habitats west of the Faeroe Islands;
- a 'Shallow Pelagic' stock (NAFO 1–2, ICES V, XII, XIV <500 m) – extends to ICES I and II, but primarily pelagic habitats, and includes demersal habitats east of the Faeroe Islands;
- an 'Icelandic Slope' stock (ICES Va, XIV) – primarily demersal habitats.

This conclusion is primarily based on genetic information, i.e. microsatellite information, and supported by analysis of allozymes, fatty acids and other biological information on stock structure, such as some parasite patterns. The Russian Federation maintains the point of view that there is only one stock of *S. mentella* in the pelagic waters of the Irminger Sea. Accordingly, the Russian Federation presented alternative approaches to stock assessment as well as environmental influence on stock dynamics. Briefly, it is claimed that the current survey based assessment does not adequately reflect stock status and that environmental factors – temperature causes major distributional changes of redfish – affect stock status more than fisheries and also undermines the use of the current management areas (see WD28, WD33 and Annex XX). The other NWWG members did not agree with the Russian Federation's view on stock structure and did not consider the presented assessment approach sufficiently documented.

The adult redfish on the Greenland shelf has traditionally been attributed to several stocks, and there remains the need to investigate the affinity of adult *S. mentella* in this region. The East-Greenland shelf is most likely a common nursery area for the three biological stocks.

ICES past advice for *S. mentella* fisheries was provided for two distinct management units, i.e. a demersal unit on the continental shelves and slopes and pelagic unit in the Irminger Sea and adjacent waters. However, based on the new stock identification information, ICES recommends three potential management units that are geographic proxies for biological stocks that were partly defined by depth and whose boundaries are based on the spatial distribution pattern of the fishery to minimize mixed stock catches (see Figure 17.1.1):

Management Unit in the northeast Irminger Sea: ICES Areas Va, XII, and XIV.

Management Unit in the southwest Irminger Sea: NAFO Areas 1 and 2, ICES areas Vb, XII and XIV.

Management Unit on the Icelandic slope: ICES Areas Va and XIV, and to the north and east of the boundary proposed in the MU in the northeast Irminger Sea.

The pelagic fishery in the Irminger Sea and adjacent waters shows a clear distinction between two widely separated grounds fished at different seasons and depths. Spatial analysis of the pelagic fishery catch and effort by depth, inside and outside the boundaries proposed for the management units in the northeast Irminger Sea, indicate that the boundaries effectively delineate the pelagic fishery in the northeast Irminger Sea from the pelagic fishery in the southwest Irminger Sea, with a small portion of mixed-stock catches. In the last decade the majority (more than 95%) of the catches have been taken in the northeast Irminger Sea. The northeastern fisheries on the pelagic *S. mentella* occur at the start of the fishing season at depths below 500 m and overlap to some extent with demersal fisheries on the continental slopes of Iceland (Sigurdsson *et al*., 2006).

A schematic illustration of the relationship between the management units and biological stocks is given in Figure 17.1.2.

For the abovementioned reasons, the Group now provides advice for the following *Sebastes* units:

- the *S. marinus* on the continental shelves of ICES Divisions Va, Vb and Subarea VI and XIV (chapter 18),
- the demersal *S. mentella* on the Icelandic slope (chapter 19),
- the shallow and deep pelagic *S. mentella* units in the Irminger Sea and adjacent waters (chapters 20and 21, respectively),
- the Greenland shelf *S. mentella* (chapter 22).

17.1 Environmental and ecosystem information

Species of the genus *Sebastes* are common and widely distributed in the North Atlantic. They are found off the coast of Great Britain, along Norway and Spitzbergen, in the Barents Sea, off the Faroe Islands, Iceland, East and West Greenland, and along the east coast of North America from Baffin Island to Cape Cod. All *Sebastes* species are viviparous. Larvae extrusion takes place in late winter–late spring/early summer, but copulation occurs in autumn–early winter. Little is known about the copulation areas.

The increase of water temperature in the Irminger Sea may have an effect on spatial and vertical distribution of *S. mentella* in the feeding area (Pedchenko, 2005). The abundance and distribution of pelagic *S. mentella* in relation to oceanographic conditions were analyzed in a special multistage workshop (ICES 2012). Based on 20 years of survey data, the results reveal the average relation of pelagic redfish to their physical habitat in shallow and intermediate waters: The most preferred latitude, longitude, depth, salinity and temperature for *S. mentella* are approximately 58ºN, 40ºW, 300 m, 34.89 and 4.4ºC, respectively. The spatial distribution of *S. mentella* in the Irminger Sea mainly in waters < 500 m (and thus mainly relating to the “shallow” stock) appears strongly influenced by the Irminger Current Water (ICW) temperature changes, linked to the Subpolar Gyre (SPG) circulation and the North Atlantic Oscillation (NAO). The fish avoid waters mainly associated with the ICW (>4.5ºC and >34.94) in the northeastern Irminger Sea, which may cause displacement of the fish towards the southwest, where fresher and colder water occurs.

Results based on international redfish survey data suggest that the interannual distribution of fish above 500 m will shift in a southwest/northeast direction depending on integrated oceanographic conditions (ICES 2012).

17.2 Environmental drivers of productivity

17.2.1 Abundance and distribution of 0-group and juvenile redfish

Available data on the distribution of juvenile *S. marinus* indicate that the nursery grounds are located in Icelandic and Greenland waters. No nursery grounds have been found in Faroese waters. Studies indicate that considerable amounts of juvenile *S. marinus* off East Greenland are mixed with juvenile *S. mentella* (Magnússon *et al.* 1988; 1990, ICES CM 1998/G:3). The 1983 Redfish Study Group report (ICES CM 1983/G:3) and Magnússon and Jóhannesson (1997) describe the distribution of 0-group *S. marinus* off East Greenland. The nursery areas for *S. marinus* in Icelandic waters are found all around Iceland, but are mainly located west and north of the island at depths between 50 and 350 m (ICES CM 1983/G:3; Einarsson, 1960; Magnússon and Magnússon 1975; Pálsson *et al.* 1997). As they grow, the juveniles migrate along the north coast towards the most important fishing areas off the west coast.

Indices for 0-group redfish in the Irminger Sea and at East Greenland areas were available from the Icelandic 0-group surveys from 1970–1995. Thereafter, the survey was discontinued. Above average year class strengths were observed in 1972, 1973–74, 1985–91, and in 1995.

There are very few juvenile demersal *S. mentella* in Icelandic waters (see chapter 19), and the main nursery area for this species is located off East Greenland (Magnússon *et al*. 1988, Saborido-Rey *et al*. 2004). Abundance and biomass indices of redfish smaller than 17 cm from the German annual groundfish survey, conducted on the continental shelf and slope of West and East Greenland down to 400 m, show that juveniles were abundant in 1993 and 1995-1998 (Figure 17.2.1). Since 2008, the survey index has been very low and was in 2013the lowest value recorded since 1982.Juvenile redfish were only classified to the genus *Sebastes* spp., as species identification of small specimens is difficult due to very similar morphological features. The 1999-2013survey results indicate low abundance and are similar to those observed in the late 1980s. Observations on length distributions of *S. mentella* fished deeper than 400 m indicate that a part of the juvenile *S. mentella* on the East Greenland shelf migrates into deeper shelf areas and into the pelagic zone in the Irminger Sea and adjacent waters (Stransky 2000), with unknown shares.

17.3 Ecosystem considerations

Information on the ecosystems around the Faroe Islands, Iceland and Greenland is given in chapters 2, 7 and 13.

Analysis of the oceanographic situation in the Irminger Sea during the 2013 international survey and long-term data including 2003, allows the following conclusions:

Strong positive anomalies of temperature observed in the upper layer of the Irminger Sea with a maximum in 1998 are related to an overall warming of water in the Irminger Sea and adjacent areas in 1994-2013. These changes were also observed in the Irminger Current above the Reykjanes Ridge (Pedchenko, 2000), off Iceland (Malmberg *et al*., 2001) and in the Labrador Sea water (Mortensen and Valdimarsson, 1999). Thus, temperature and salinity in the Irminger Current have increased since 1997 to the highest values seen for decades (ICES, 2001).

The 2003 survey detected high temperature anomalies within the 0-200 m layer in the Irminger Sea and adjacent waters. At 200-500 m depth and deeper waters, positive anomalies were observed in most of the surveyed area. However, increasing temperature as compared to the survey in June-July 2001 was detected only north of 60° N in the flow of the Irminger Current above the Reykjanes Ridge and the northwestern part of the Irminger Sea. These changes in oceanographic conditions might have an effect on the seasonal distribution of redfish and its aggregations in the layer shallower than 500 m in the survey area (ICES, 2003).

In June/July 2005 and 2007, water temperature in the shallower layer (0-500 m) of the Irminger Sea was higher than normal (ICES, 2005). As in the surveys 1999-2003, the redfish were aggregating in the southwestern part of the survey area, partly influenced by these hydrographic conditions. Favorable conditions for aggregation of redfish in an acoustic layer have been marked only in the southwestern part of the survey area with temperatures between 3.6-4.5°C, as confirmed by the survey results obtained in 2009.

The hydrography in the survey of June/July 2013 shows that temperature in the survey area is above average but it was lower than in 2011 in most of the surveyed area, except for the Irminger Current (ICES, 2013).

17.4 Description of fisheries

There are three species of commercially exploited redfish in ICES Subarea V, VI, XII, and XIV: *S. norvegicus* (in publication both names *S. norvegicus* and *S. marinus* can be found, but according to Fernholm and Wheeler (1983) the first name is the correct name), *S. mentella* and *S. viviparus*. *S. viviparus* has only been of a minor commercial value in Icelandic waters and it is exploited in two small areas south of Iceland at depths of 150-250 m. The landings of *S. viviparus* decreased from 1160 t in 1997 to 2-9 t in 2003-2006 (Table 17.4.1) due to decreased commercial interest in this species. The landings in 2009 amounted to 37 t, more than a twofold increase in comparison with 2008. After a directed fishery developed in 2010, with a total catch of 2,600 t, the MRI advised on a 1,500 t TAC for the 2012-2013 fishing year. Annual catches in 2012 and 2013were 535 t.

The Group has in the past included the fraction of *S. mentella* that are caught with pelagic trawls above the western, south-western and southern continental slope of Iceland as part of the landing statistics of the demersal *S. mentella*. This practice has been in accordance with Icelandic legislation, where captains are obligated to report their *S. mentella* catch as either "pelagic redfish" or as "demersal redfish" depending in which fishing area they fish. According to this legislation, all catch outside the Icelandic EEZ and west of the ‘redfish line’ (red line shown in Figure 17.1.1, which is drawn approximately over the 1000-m isoclines within the Icelandic EEZ) shall be reported as pelagic *S. mentella*. All fish caught east of the ‘redfish line’ shall be reported as demersal *S. mentella*. Most of the catches since 1991 have been taken by bottom trawlers along the shelf west, southwest, and southeast of Iceland at depths between 500 and 800 m. The Group accepts this praxis as pragmatic management measure, but notes that there is no biological information that could support this catch allocation.

As the Review Group in 2005 noted that this issue needed more elaboration, detailed portrayals of the geographical, vertical and seasonal distribution of the demersal *S. mentella* fisheries with different gears are presented here, as done previously (see below). Quantitative information on the fractions of the pelagic catches of demersal *S. mentella* is given in chapter 18. The proportion of the total demersal *S. mentella* catches taken by pelagic trawls has ranged since 1991 between 0% and 44% (Table 18.3.2), and is on average 15%. With exception of 2007, no demersal *S. mentella* has been by pelagic trawls since 2004. The geographic distribution of the Icelandic fishery for *S. mentella* since 1991 was in general close to the redfish line, off South Iceland, and has expanded into the NAFO Convention Area since 2003 (Figure 17.4.1). The pelagic catches of demersal *S. mentella* were taken in similar areas and depths as the bottom trawl catches (Figure 17.4.2). The vertical and horizontal distribution of the pelagic catches focused, however, on smaller areas and shallower depth layers than the bottom trawl catches. The seasonal distribution by depth (Figure 17.4.3) shows that the pelagic catches of demersal *S. mentella* were in general taken in autumn, and overlapped in June with the traditional pelagic fishery only in 2003 and 2007. The bottom trawl catches of the demersal *S. mentella* were mainly taken in the first quarter of the year and during autumn/winter. The length distributions of the demersal *S. mentella* catches in Iceland by gear and area are given in Figure 17.4.4. During 1994-1999 and in 2003, the fish taken with pelagic trawls were considerably larger than the fish caught with bottom trawls, but they were of similar length during 2000-2002. The fish caught in the north-eastern area were on average about 5 cm larger than those caught in the south-western area.

17.5 Russian pelagic *S. mentella* fishery

Russia's position regarding the structure of redfish stock in the Irminger Sea remains unchanged and it has been expressed in previous reports (ICES, 2009, Annex 4; ICES, 2013; Makhrov *et al*. 2011; Zelenina *et al*. 2011.) The Russian Federation still maintains its point of view that there is only one stock of beaked redfish *S. mentella* in the pelagic waters of the Irminger Sea and that is why no split catches information about the fisheries is presented to the NWWG. Russia reiterates its standpoint that studies of the redfish stock structure should be continued (Artamonova *et. al* 2013) with the aim of developing agreed recommendations using all available scientific and fisheries data as a basis.

In 2013 the fishery was conducted from April to September in ICES Subareas XII and XIV and NAFO Divisions 1F and 2J (Tables 20.2.1, 20.2.2, 21.2.1 and 21.2.2) with average CPUE 3.6 t /day and 34.2 t/ day in ICES Subareas XII and XIV, respectively; and 1.03 t/hour in NAFO. It should be noted that these are the highest Russian CPUE indices since 1996 (WD 16).

17.6 Biological sampling

Biological samples are taken both in national and international surveys and from the commercial catches. They consist of length measurements, otolith collection, stomach contents, sex and maturity stages. The following samples were taken by several nations during 2013:

Country	Area	No. of samples	No. of fish measured
Germany	XIV		
Russia	XIV	350	29 918
Russia	NAFO 1F		9 171
Russia	NAFO 2J		842
Iceland	XIV (deep)		2 948
Greenland	XIVb	14	1 019
Spain	XIVb (deep)	41	9 131

17.7 Demersal *S. mentella* in Vb and VI

17.7.1 Demersal *S. mentella* in Vb

17.7.1.1 Surveys

The Faroese spring and summer surveys in Division Vb are mainly designed for species inhabiting depths down to 500 m and do not cover the vertical distribution of demersal *S. mentella* fully. Therefore, the surveys are not used to evaluate the stock status.

17.7.1.2 Fisheries

In Division Vb, landings gradually decreased from 15,000 t in 1986 to about 5,000 t in 2001 (Table 17.6.1). Between 2002 and 2011 annual landings varied between 1,100 and 4,000 t. In 2012 and 2013 the landings decreased drastically and were 260 t and 400 t respectively.

Length distributions from the landings in 2001-2013 indicate that the fish caught in Vb are slightly larger than 40 cm (Figure 17.6.1).

Non-standardized CPUE indices in Division Vb were obtained from the Faroese otter board (OB) trawlers (> 1000 HP) towing deeper than 450 m and where demersal *S. mentella* composed at least 70% of the total catch in each tow. The OB trawlers have in recent years landed about 50% of the total demersal *S. mentella* landings from Vb. CPUE decreased from 500 kg/hour in 1991 to 300 kg/hour in 1993 and remained at that level until 2012 (Figure 17.6.2). In 2013, the CPUE decreased to the lowest level in the time series (Figure 17.6.2).

Fishing effort has decreased since the beginning of the time series and has been the lowest in the time series since 2008.

17.7.2 Demersal *S. mentella* in VI

17.7.2.1 Fisheries

In Subarea VI, the annual landings varied between 200 t and 1 100 t in 1978-2000 (Table 17.6.1). The landings from VI in 2004 were negligible (6 t), the lowest recorded since 1978. They increased again to 111 t in 2005 and 179 t in 2006. The reported landings in 2008 were 50 t and no catches were taken since 2009.

17.8 Regulations (TAC, effort control, area closure, mesh size etc.)

Management of redfish differs between stock units and is described in sections 17.14 for *S. norvegicus*, section 18.7 for demersal *S. mentella*, section 19.10 for shallow pelagic *S. mentella* and section 20.10 for deep pelagic *S. mentella*.

The allocation of Icelandic *S. mentella* catches to the pelagic and demersal management unit has been based on the "redfish line" (see section 17.4).

17.9 Mixed fisheries, capacity and effort

The official statistics reported to ICES do not divide catch by species/stocks, and since the Review Group in 2005 recommended that "multispecies catch tables are not relevant to management of redfish resources", these data are not given here and the best estimates on the landings by species/stock unit are given in the relevant chapters. Preliminary official landings data were provided by the ICES Secretariat, NEAFC and NAFO, and various national data were reported to the Group. The Group, however, repeatedly faced problems in obtaining catch data, especially with respect to pelagic *S. mentella* (see chapter 19.11). Detailed descriptions of the fisheries are given in the respective chapters: *S. norvegicus* in chapter 17.3, demersal *S. mentella* in chapter 18.3, shallow pelagic *S. mentella* in chapter 19.2, deep pelagic *S. mentella* in chapter 20.2 and Greenland slope redfish in chapter 21.3.

Information from various sources is used to split demersal landings into two redfish species, *S. norvegicus* and *S. mentella* (see stock annexes for Icelandic slope *S. mentella* and *S. norvegicus*). In Division Va, if no direct information is available on the catches for a given vessel, the landings are allocated based on logbooks and samples from the fishery. According to the proportion of biological samples from each cell (one fourth of ICES statistical square), the unknown catches within that cell are split accordingly and raised to the landings of a given vessel. For other areas, samples from the landings are used as basis for dividing the demersal redfish catches between *S. marinus* and *S. mentella*.

17.10 References

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Table 17.4.1. Landings of *S. viviparus* in Division Va 1996-2013.

Year	Landings (t)
1996	22
1997	1,159
1998	994
1999	498
2000	227
2001	21
2002	20
2003	3
2004	2
2005	4
2006	9
2007	24
2008	15
2009	37
2010	2,602
2011	1,427
2012	535
2013	532

Table 17.6.1. Nominal landings (tonnes) of demersal *S. mentella* 1978-2013 in ICES Division Vb and VI.

Year	Vb	VI
1978	7 767	18
1979	7 869	819
1980	5 119	1 109
1981	4 607	1 008
1982	7 631	626
1983	5 990	396
1984	7 704	609
1985	10 560	247
1986	15 176	242
1987	11 395	478
1988	10 488	590
1989	10 928	424
1990	9 330	348
1991	12 897	273
1992	12 533	134
1993	7 801	346
1994	6 899	642
1995	5 670	536
1996	5 337	1 048
1997	4 558	419
1998	4 089	298
1999	5 294	243
2000	4 841	885
2001	4 696	36
2002	2 552	20
2003	2 114	197
2004	3 931	6
2005	1 593	111
2006	3 421	179
2007	1 376	1
2008	750	50
2009	1,077	0
2010	1,202	0
2011	1,126	0
2012	263	0
20131	398	

[1)] **Provisional**

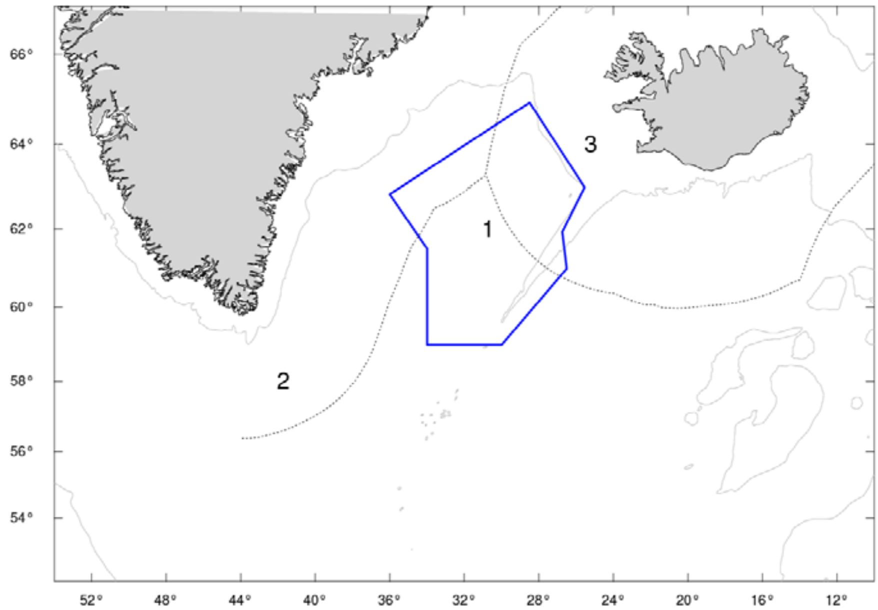


Figure 17.1.1 Potential management unit boundaries. The polygon bounded by blue lines, i.e. 1, indicates the region for the 'deep pelagic' management unit in the northwest Irminger Sea, 2 is the "shallow pelagic" management unit in the southwest Irminger Sea, and 3 is the Icelandic slope management unit.

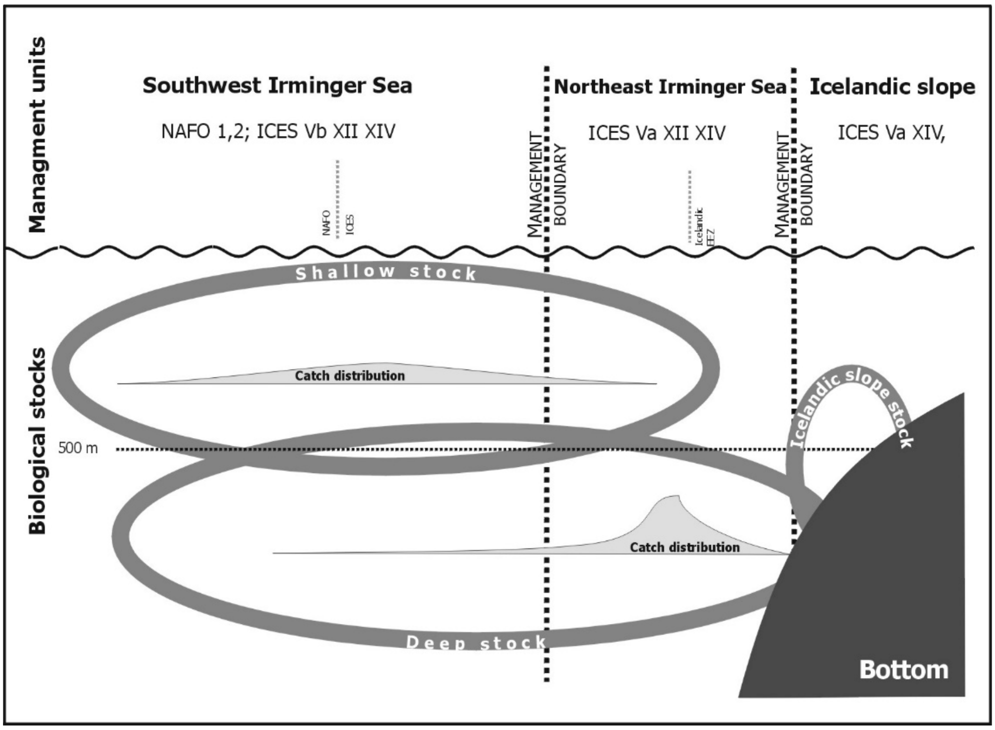


Figure 17.1.2 Schematic representation of biological stocks and potential management units of *S. mentella* in the Irminger Sea and adjacent waters. The management units are shown in Figure 17.1.1. Included is a schematic representation of the geographical catch distribution in recent years. Note that the shallow pelagic stock includes demersal *S. mentella* east of the Faroe Islands and the deep pelagic stock includes demersal *S. mentella* west of the Faroe Islands.

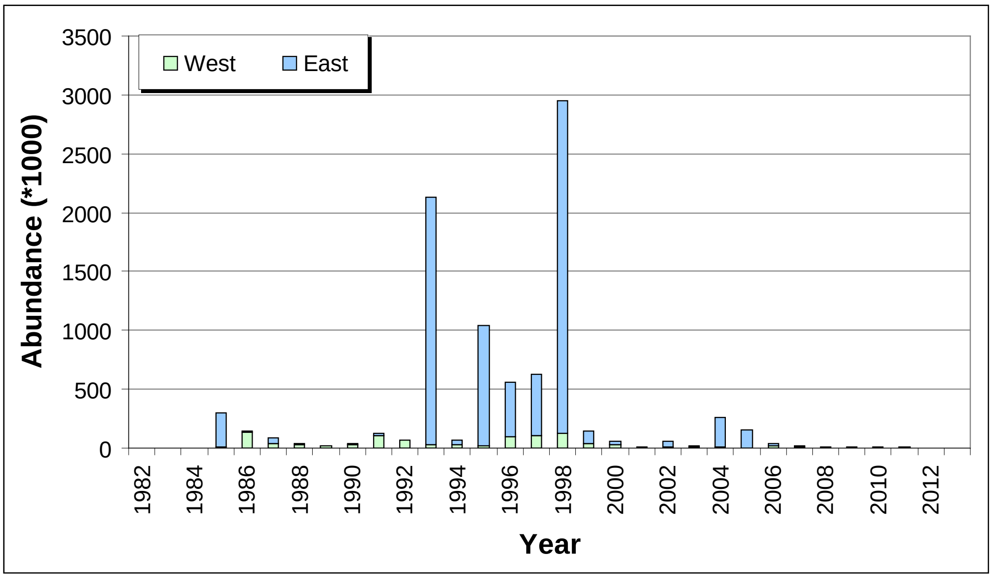


Figure 17.2.1 Survey abundance indices of *Sebastes spp.* (<17 cm) for East and West Greenland from the German groundfish survey 1982-2013.

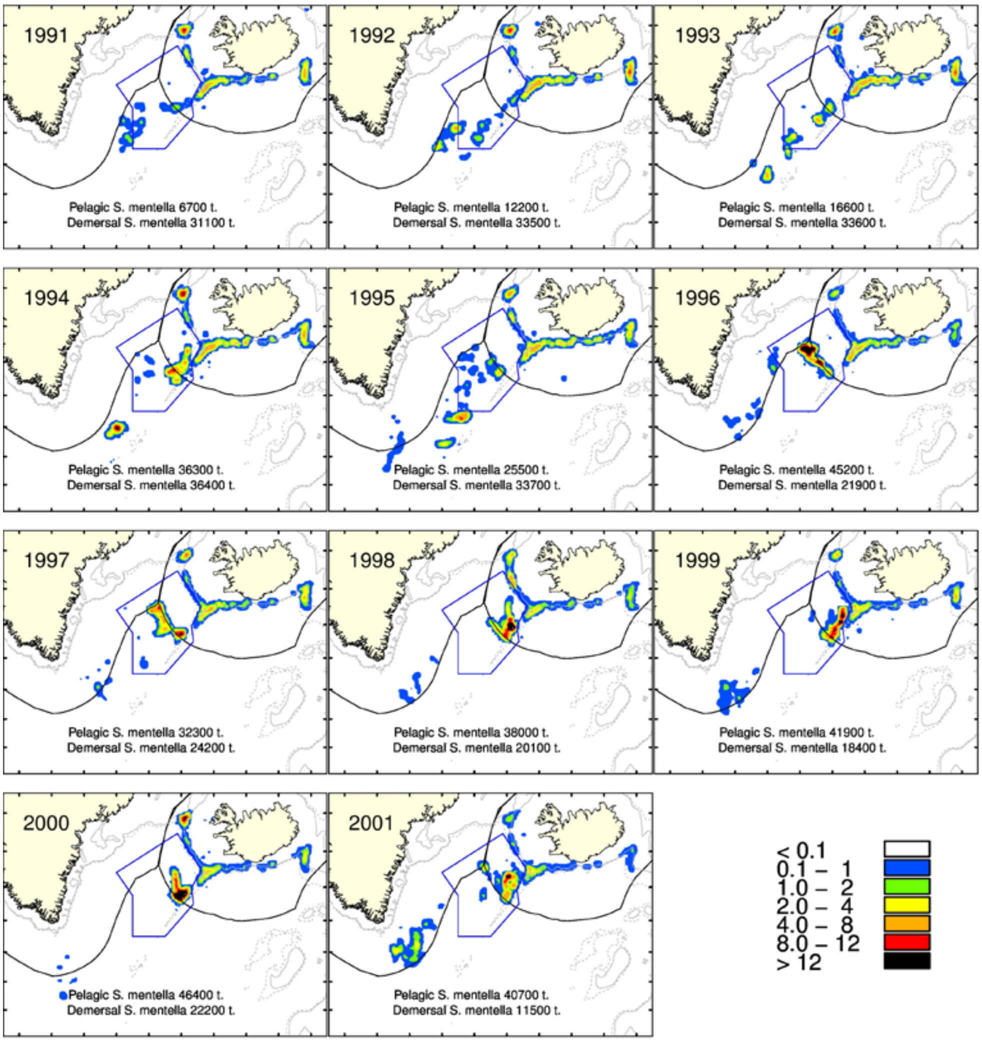


Figure 17.4.1 Geographical distribution of the Icelandic catches of *S. mentella* 1991-2001. The color scale indicates catches (tonnes per NM²).

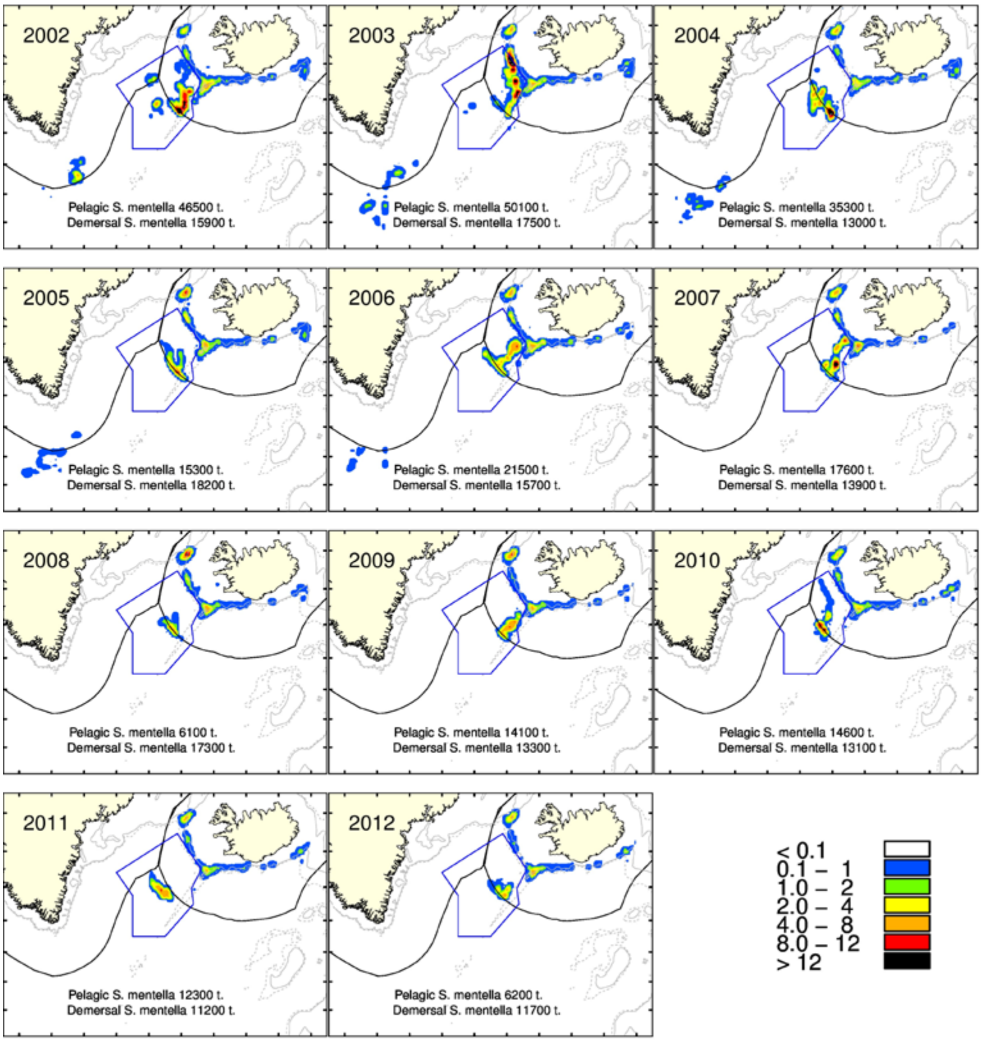


Figure 17.4.1 Geographical distribution of the Icelandic catches of *S. mentella* 2002-212 The color scale indicates catches (tonnes per NM²).

Figure 17.4.2 Distance-depth plot for Icelandic *S. mentella* catches, where distance (in NM) from a fixed position (52°N 50°W) is given. The contour lines indicate catches in a given area and distance. The coloured contours represent the fishery on pelagic *S. mentella*, the black contours indicate bottom trawl catches of demersall *S. mentella*, and the red contours represent catches of demersal *S. mentella* taken with pelagic trawls.

Figure 17.4.3 Depth-time plot for Icelandic *S. mentella* catches 1991-2012 where the y-axis is depth, the x-axis is day of the year and the colour indicates the catches. The coloured contours represent the fishery on pelagic *S. mentella*, the black contours indicate bottom trawl catches of demersal *S. mentella*, and the red contours represent catches of demersal *S. mentella* taken with pelagic trawls.

Figure 17.4.4 Length distributions from different Icelandic *S. mentella* fisheries, 1991-2012 The blue lines represent the fishery on pelagic *S. mentella* in the northeastern area, the red lines the pelagic fishery in the southwestern area, the black lines indicate bottom trawl catches of demersal *S. mentella*, and the green lines represent catches of demersal *S. mentella* taken with pelagic trawls.

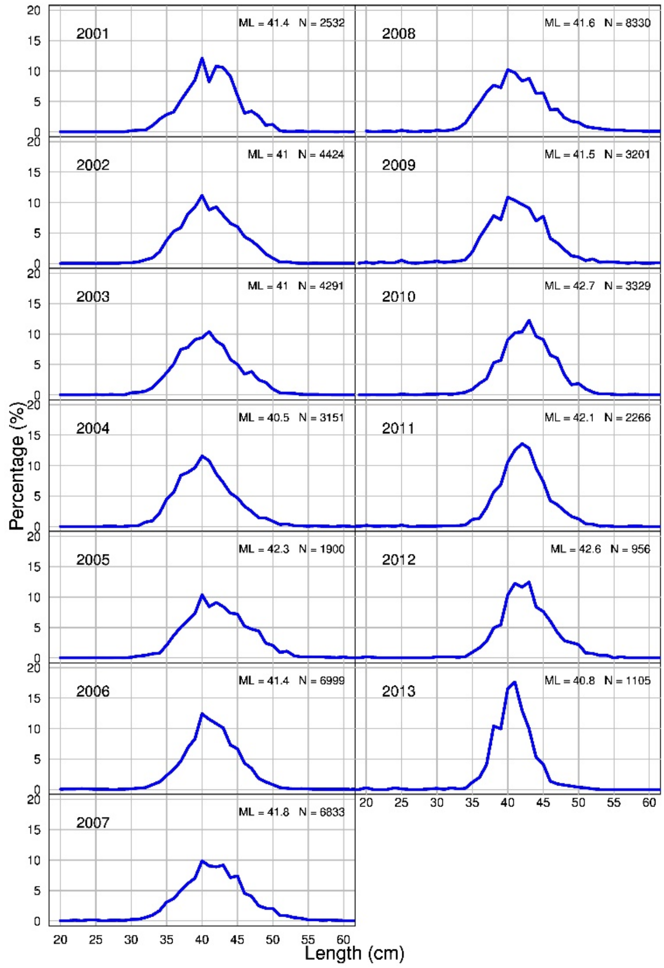


Figure 17.6.1 Length distribution of demersal *S. mentella* from landings of the Faeroese fleet in Division Vb 2001-2013.

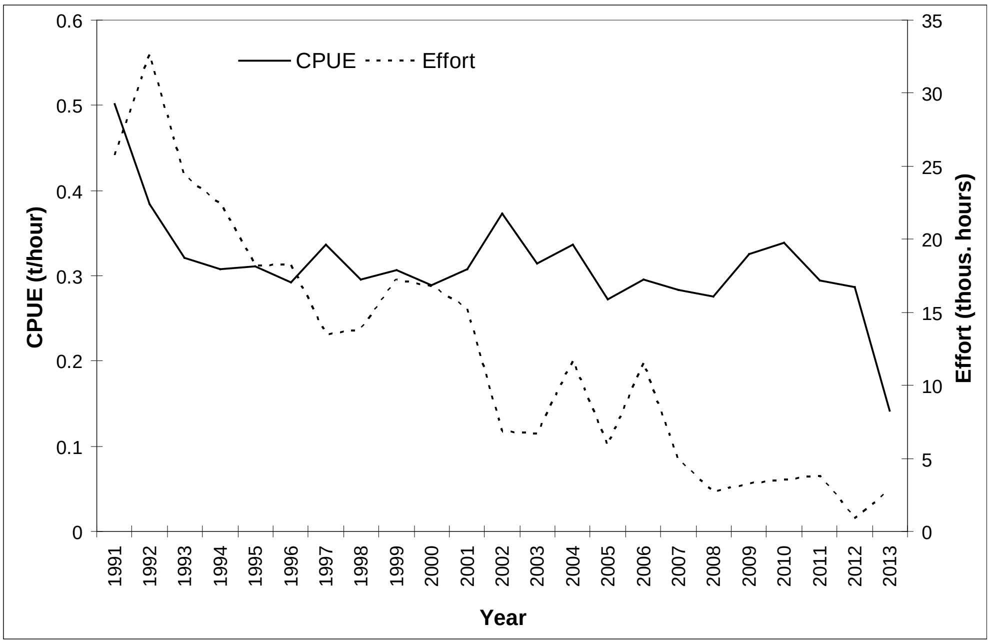


Figure 17.6.2 Demersal *S. mentella*, CPUE (t/hour) and fishing effort (in thousands hours) from the Faeroese CUBA fleet 1991-2013 and where 70% of the total catch was demersal *S. mentella*.

18 Golden redfish (*Sebastes norvegicus*) in Subareas V, VI and XIV

Executive summary

- Total landings in 2013 were about 53 500 t, which is about 8 200 t more than in 2012. About 96% of the catches were taken in Division Va. A substantial increase in landings from XIVb was in 2010-2013 and has not been so high since early 1990s.
- Catch-at-age data from Va show that the catch was dominated by two strong year classes from 1985 and 1990. The 1985 and 1990 year classes have disappeared, but the 1996-2003 year classes are now most important .
- Survey indices of the fishable stock in Va was more than two times higher than the defined safe biological limits (Upa). The fishable stock situation in Vb remains at low level, but has been high since 2007 in XIV.
- Recruitment seems to be low in all areas, both according to the Icelandic groundfish surveys, German survey in East Greenland and the Greenland shrimp and fish survey.
- The stock was benchmarked in January 2014 and a management plan evaluated and adopted. The Gadget model was used as basis for advice but the main difference in settings from earlier years was inclusion of the German survey data from East Greenland and changes in growth rate were taken into account.
- The management plan was based on F_{9-19}=0.097 (F_{max} in 2012 run) reducing linearly if the spawning stock is estimated below 220 000 t ($B_{trigger}$). B_{lim} was proposed as 160 000 t, lowest SSB in the 2012 run. According to the management plan TAC for 2015 will be 47 300 t.

18.1 Stock description and management units

Golden redfish (*Sebastes norvegicus*) in ICES Subareas V and XIV have been considered as one management unit.

Catches in ICES Subarea VI have traditionally been included in this report and the Group continues to do so.

18.2 Scientific data

This chapter describes results from various surveys conducted annually on the continental shelves and slopes of Subareas V and XIV.

18.2.1 Division Va

Two bottom trawl surveys are conducted in Icelandic waters: the Spring Survey in March 1985-2014 and the Autumn Survey in October 1996-2013. The autumn survey was not conducted in 2011. Two survey indices are calculated from these surveys and used in the assessment of golden redfish in Va. Length disaggregated indices from the Spring survey are used in the Gadget model and the length based TSA model (WD #29 in 2013 NWWG). Age disaggregated indices from the autumn survey are used in TSA model but the age data as age-length keys in 2 cm length groups in the Gadget model. The sum of those abundance indices multiplied by mean weight at length or age are the total indices shown in Figure 18.2.1. Another index that is calculated is the index of fishable biomass from the Spring Survey (U), but the relative state of the stock has been assessed through this index (see description below).

The survey stratification and subsequent survey indices for golden redfish were recalculated for the Autumn Survey in 2008 and for the Spring Survey in 2011. The method is described in the Stock Annex for the species. Further changes were made in the calculation of the survey indices in 2012 by taking into account length dependent diurnal vertical migration of the species. Golden redfish is known for its diurnal vertical migration showing semi-pelagic behaviour. Usually the species is in the pelagic area during the night time and close to the bottom during the day time. However, there is also a size or age difference in this pelagic behaviour where smaller fish shows opposite vertical migration pattern compared to larger fish. The method is described in more details in the Stock Annex.

This scaled diurnal variation by length was used for calculating Cochran index for redfish.

Figure 18.2.1*a* shows the total biomass index from the Icelandic spring and autumn groundfish surveys with ±1 standard deviation in the estimate (68% confidence interval). The total biomass of golden redfish as observed in the spring survey decreased from 1988 to a record low in 1995. Between 1996 and 2002 the stock showed signs of improvement but was low compared to the beginning of the series. In 2003 the biomass increased significantly and has since then been high. The 2012 and 2013 estimates were the highest in the time series, but decreased again in 2014. The index although remains high and is 25% higher than in the beginning of the time series. The CV of the measurement error has been considerably higher since 2003 than before that.

The total biomass index from the autumn survey gradually increased from 2000 to 2012 and were in 2012 and 2013 the highest in the time series. The autumn survey is more difficult to interpret partly because the time series is shorter (Figure 18.2.1*a*).

In 1998 an index was compiled from the spring survey based on a selection curve rising sharply from 34-36 cm (L_{50} = 35 cm) and for the depth range of 0-400 m. This was done because before the changes in the survey calculations taking diurnal variations into account, the indices were much more noisy and difficult to use when advice is based directly on indices. The survey extends down to 500 m depth but the stations between 400 and 500 m are few and show the largest variability. This index (Figure 18.2.2 and Table 18.2.1) and defined reference points (U_{pa}=60% and U_{lim}=20% of the 1987 value) have since then been used to classify the state of the stock. The index has been above U_{pa} since 2009 after having been below it for 18 years. The 2013 and 2014 values of the index are the highest in the time series, two times higher than the U_{pa} level but with relatively high measurement error compared to previous years.

Length distribution from the spring survey shows that the peaks, which can be seen first in 1987 and then in 1991-1992, reached the fishable stock approximately 10 years later (Figure 18.2.3). The increase in the survey index between 1995 and 2005 reflects the recruitment of a relatively strong year classes (1985-year class and then the 1990-year class). Abundance of small redfish has since then been much smaller, highest in 1998-2000, but in recent five years very little has been observed of small redfish (Figure 18.2.1*d*). This has been confirmed by age readings (Figure 18.2.5). In recent 3-4 years the modes of the length distribution in both surveys has shifted to the right and much less is now observed of golden redfish less than 30 cm compared to other years (Figures 18.2.3 and 18.2.4).

Age disaggregated abundance indices from the autumn survey indicate that indices of the year-classes 1998-2003 are now similar to the indices of year-class 1990 at same age (Figure 18.2.5 and Table 18.2.2). The sharp increase in the survey indices since 2005 reflects the recruitment of these year-classes. In 2013, the abundance of fish 7 years' old and younger was at the lowest level in the time series for all age groups (Table 18.2.2).

18.2.2 Division Vb

In Division Vb, CPUE of *S. norvegicus* were available from the Faeroes spring groundfish survey from 1994-2014 and the summer survey 1996-2013. Both surveys show similar trends in the indices from 1998 onwards with sharp declines between 1998 and 1999 (Figure 18.2.6). After an increase in the mid 1990s, CPUE decreased drastically. CPUE in the spring survey was between 2000 and 2008 stable at low level. In the period 2009-2014 it has been at the lowest level since the beginning of the series. The CPUE index in the summer survey has gradually decreased and is also at the lowest level recorded.

18.2.3 Subarea XIV

Relative abundance and biomass indices from the German groundfish survey from 1982 to 2013 for *S. norvegicus* (fish >17 cm) are illustrated in Figures 18.2.7. In 2013, the survey was re-stratified, with 4 strata in West Greenland resembling NAFO sub-area structure, and 5 strata in East Greenland. Depth zones considered are 0-200 m and 200-400 m. The time series was recalculated accordingly. In general, the survey indices are much lower with the new stratification scheme but show similar trend (WD 30 of the 2013 NWWG report).

After a severe depletion of the *S. norvegicus* stock on the traditional fishing grounds around East Greenland in the early 1990's, the survey estimates showed a significant increase in both abundance and biomass with the highest value observed in 2007 (Figure 17.2.7). The survey indices have since then fluctuated and were in 2013 similar as it was in 2007 (Figure 17.2.7*a* and Figure 17.2.7*b*). It should be noted that the CV for the indices are high and the increase is driven by few very large hauls. During the recent period of increase, both the fishable biomass (> 30 cm) and the biomass of pre-fishery recruits (17-30 cm) have increased considerably (Figures 18.2.7*c* and 18.2.8). In 2010-2013 the biomass of 17-30 cm fish has decreased compared to previous five years whereas the fishable biomass has remained high since 2007.

Abundance indices of redfish smaller than 18 cm from the German annual groundfish survey show that juveniles were abundant in 1993 and 1995-1998 (Figure 17.2.1). Since 2008, the survey index has been very low and was in 2013 the lowest value recorded since 1982. Juvenile redfish were only classified to the genus *Sebastes* spp., as species identification of small specimens is difficult due to very similar morphological features. The 1999-2013 survey results indicate low abundance and are similar to those observed in the late 1980s. The Greenland shrimp and fish shallow water survey also shows no juvenile redfish (<18 cm, not classified to species) were present.

18.3 Information from the fishing industry

18.3.1 Landings

Total landings gradually decreased by more than 70% from about 130,000 t in 1982 to about 43,000 t in 1994 (Table 18.3.1 and Figure 18.3.1). Since then, the total annual landings have varied between 33,500 and 51,000 t. The total landings in 2013 were 53,500 t, which is about 8,300 t more than in 2012 and the highest landings since 1992. The increase is because of increased landings in Va. The majority of the golden redfish catch is taken in ICES Division Va and contributes to about 94-98% of the total landings.

Landings of golden redfish in Division Va declined from about 98,000 t in 1982 to 39,000 t in 1994 (Table 18.3.1). Since then, landings have varied between 32,000 and 49,000 t. The landings in 2013 were about 51,300 t, about 8,200 t more than in 2012. Between 90-95% of the golden redfish catch is taken by bottom trawlers targeting redfish (both fresh fish and factory trawlers; vessel length 48-65 m). The remaining catches are partly caught as by-catch in gillnet, long-line, and lobster fishery. In 2013, as in previous years, most of the catches were taken along the shelf southwest, west and northwest of Iceland (Figure 18.3.2). A notable change is that higher proportion of the catches is now taken along the shelf northwest of Iceland and much less south and southwest.

In Division Vb, landings dropped gradually from 1985 to 1999 from 9,000 t to 1,500 t and varied between 1,500 and 2,500 t from 1999-2005 (Table 18.3.1). In 2006-2013 annual landings were less than 1,000 t which has not been observed before in the time series. The landings in 2013 were 372 t which is 100 less than in 2012 and the lowest landings in the time series. The majority of the golden redfish caught in Division Vb is taken by pair and single trawlers (vessels larger than 1000 HP).

Annual landings from Subarea XIV have been more variable than in the other areas (Table 18.3.1). After the landings reached a record high of 31,000 t in 1982, the golden redfish fishery drastically reduced within the next three years (the landings from XIV were about 2,000 t in 1985). During the period 1985-1994, the annual landings from Subarea XIV varied between 600 and 4,200 t, but from 1995 to 2009 there was little or no direct fishery for golden redfish and landings were 200 t or less mainly taken as by-catch in the shrimp fishery. In 2010, landings of golden redfish increased considerable and were 1,650 t, similar to it was in early 1990s. This increase is mainly due to increased *S. mentella* fishery in the area. Annual landings 2010-2013 have been about 1,650 t.

Annual landings from Subarea VI increased from 1978 to 1987 followed by a gradual decrease to 1992 (Table 18.3.1). From 1995 to 2004, annual landings have ranged between 400 and 800 t, but decreased to 137 t in 2005. Little or no landings of golden redfish were reported from Subarea VI in 2006-2013 and were 92 t in 2013.

18.3.2 Discard

Comparison of sea and port samples from the Icelandic discard sampling program does not indicate significant discarding due to high grading in recent years (Palsson *et al* 2010), possibly due to area closures of important nursery grounds west off Iceland. Substantial discard of small redfish took place in the deepwater shrimp fishery from 1986 to 1992 when sorting grids became mandatory. Since then the discard has been insignificant both due to the sorting grid and much less abundance of small redfish in the region.

Discard of redfish species in the shrimp fishery in Subarea XIVb is currently considered insignificant (see Chapter 17).

18.3.3 Biological data from the commercial fishery

The table below shows the fishery related sampling by gear type and Divisions in 2013. No sampling of the commercial catch from subdivision VI was carried out.

Area	Nation	Gear	Landings	Samples	No. length measured	No. Age read
Va	Iceland	Bottom trawl	51,33024136,0341,757			
Vb	Faroe Islands	Bottom trawl	3728362			
XIV	Greenland	Bottom trawl	1,663			

18.3.4 Landings by length and age

The length distributions from the Icelandic commercial trawler fleet in 1975-2013 show that the majority of the fish caught is between 30 and 45 cm (Figure 18.3.3). The modes of the length distributions range between 35 and 37 cm. The length distributions in 2012 and 2013 are unusually narrow, less than average of both small and large fish.

Catch-at-age data from the Icelandic fishery in Division Va show that the 1985-year class dominated the catches from 1995-2002 (Figure 18.3.4 and Table 18.3.2) and in 2002 this year class still contributed to about 25% of the total catch in weight. The strong 1990-year class dominated the catch in 2003-2007 contributing between 25-30% of the total catch in weight. This year class contributed about 6% of the total catch in weight in 2013 and the 1985-year class about 1.5%, but their share has gradually been decreasing in recent years. The 1996-2003 year classes contributed in total about 78% of the total catch in 2013, whereof the 2000-2002 year classes contributed 44 % of the total catch.

The average total mortality (Z), estimated from the 16-year series of catch-at-age data (Figure 18.3.5) is about 0.20 for age groups 15 and older.

Length distribution from the Faroese commercial catches for 2001-2013 indicates that the fish caught are on average larger than 40 cm with modes between 45 cm and 50 cm (Figure 18.3.6).

No length data from the catches have been available for several years in Subareas XIV and VI.

18.3.5 CPUE

CPUE in Va was calculated as non-standardized CPUE and standardised using GLM multiplicative model. Description is given in the stock annex. The outcome of the GLM model run is given in Table 18.3.3 and Figure 18.3.7 and the model residuals in Figure 18.3.8. CPUE derived from logbooks is not considered indicative of stock trends however the information contained in the logbooks on effort, spatial and temporal distribution the fishery is of value.

The CPUE index derived from the GLM model increased considerably in 2001 after being at low level 1993-1999 and was until 2006 high but stable (Figure 18.3.7). In 2006, the CPUE index decreased by 12% compared to the previous year but has since then increased. Both the un-standardized CPUE index and the one derived from the GLM model was in 2013 the highest in the time series with sharp increase in recent 5 years. Effort towards golden redfish has since 1986 gradually decreased and is at the lowest level recorded (Figure 18.3.7).

Un-standardized CPUE of the Faroese otter-board (OB) trawlers has been presented in previous reports. They are however considered unreliable and un-representative about the stock in Division Vb. This is because no separation of S. *norvegicus*/*S. mentella* is made in the catches.

18.4 Methods

18.4.1 Changes to the assessment model in January 2014.

The stock was benchmarked in January 2014 and a management plan evaluated and adopted (WKREDMP, ICES 2014). The benchmark group agreed to base the advice for next 5 years on the Gadget model. The settings are described in the Stock Annex. Compared to the 2012 and 2013 runs following changes were done to the model:

- Abundance indices from the German survey in East Greenland were included in the tuning. The indices were added to the Icelandic spring survey.
- Tuning data were limited to 19-54 cm instead of 25-54 cm as larger part of the stock area is included. 19 cm is around the length at which redfish in the German survey is classified to species. Earlier, smaller fish had gradually been removed from the tuning fleet as the nursery area for year classes 1996 – 2003 seemed to be outside Icelandic waters.
- Length at recruitment was estimated separately for year classes 1996-2000 and 2001 and onwards. The reason was higher mean weight at age in landings and autumn survey.

Of the changes mentioned above, the first one has the largest effect on the estimated stock size but the third one does also have considerable effect as when growth increases fishes recruit to the fisheries at younger age if selection is size dependent.

The German survey did get half weight compared to the results in Figure 18.2.7. This was done to avoid extrapolation to areas not surveyed, and hence reduce noise, but the indices are calculated as numbers per square km^2 multiplied by an area drawn around the stations (Figure 18.4.1). By using the stratification used to calculate indices shown in Figure 18.2.7 each station in the German survey would get 2.5 times more weight compared to the Icelandic survey. Several things are not comparable between the two surveys, for example different gears are used and the German survey is not conducted during night while the Icelandic survey is conducted both day and night. Therefore the “correct” weight of each survey in the sum can not be found.

The German survey has in recent decade provided increased proportion of the total biomass, but is still only 10% of the total biomass (Figure 18.4.2). The contribution for each length group (Figure 18.4.3) does though show that large redfish is abundant in East Greenland and large part of the largest redfish (45+ cm) found there. This affects the model results as the relatively large abundance of middle size redfish in the Icelandic spring survey (Figure 18.2.1a) has not lead to subsequent increase in large fish (Figure 18.2.1c). Including the large fish from East Greenland does therefore affect model results and estimated SSB is 25-30% higher when the German survey is included, even though the German survey does only account for 10% of the total biomass as it is weighted. The recruitment signal from the German survey (Figure 18.4.3) is on the other hand not explaining much of the “missing recruitment” from Icelandic waters in recent years.

The weighing of individual data sets in the GADGET model using an iterative reweighing algorithm is now a routine part of each assessment run. This process essentially assigns weights to each input data set on the basis of the inverse variance of the fitted residuals. This is done to reduce the effect of low quality input data. It can also help to identify data discrepancy as shown in Figure 18.4.4 (taken from the WKREDMP report; ICES 2014) which shows that information from the commercial catches indicate *status quo* state of the stock while the increase is caused by the survey data.

18.4.2 Revised Gadget model

18.4.2.1 Data and model settings

Below is a brief description of the data used in the model and model settings is given. A more detailed description is given in the Stock annex.

Data used in the GADGET model are:

Length disaggregated survey indices 19-54 cm in 2 cm length increments from the Icelandic groundfish survey in March 1985-2014 and the German survey in East Greenland 1984-2013. Indices are added together and the German survey gets half the weight compared to what is presented in Figure 18.2.7.

Length distributions from the Icelandic, Faroe Islands and East Greenland commercial catches since 1970.

Landings by 6 month period from Iceland, Faroe Islands and East Greenland.

Age-length keys and mean length at age from the Icelandic groundfish survey in October 1996-2013.

Age-length keys and mean length at age from the Icelandic commercial catch 1995-2013.

The simulation period is from 1970 to 2018 using data until the first half of 2014 for estimation. Two time steps are used each year. The ages used were 5 to 30 years, where the oldest age is treated as a plus group (fish 30 years and older). Recruitment was set at age 5.

Estimated parameters are:

- Number of fishes when the simulation starts (8 parameters).
- Recruitment at age 5 each year (43 parameters).
- Length at recruitment (2 parameters).
- Parameters in the growth equation; (2 parameters).
- Parameter β of the beta-binomial distribution controlling the spread of the length distribution.
- Selection pattern of the three commercial fleets assuming logistic selection (S-shape) (3x2 parameters).
- Selection pattern of the survey fleet assuming an Andersen selection curve (bell-shape) (3 parameters).

It needs to be mentioned that the length disaggregated indices are from the spring survey but the age data are from the autumn survey conducted six months later. The surveys could have different catchability but the age data are used as proportions within each 2 cm length group so it should not matter. Growth in between March and October is taken care of by the model.

Projections were run using the Gadget model based fishing mortality of equal to 0.097 for ages 9 to 19 according to agreed management plan.

Assumptions done in the predictions:

- Recruitment in 2012 and onwards was set as the average of the recruitment in 1970-2011.
- Catches in the first time step in 2014 (first 6 months) were set at the same as in the first time step of 2013 for all the fleets. In step 2 in 2014 and onwards the model was run at fixed effort corresponding to F_{9-19}=0.097
- The estimated selection pattern from the Icelandic fleet was used for projections.

18.4.2.2 Results of the assessment model and predictions

Summary of the assessment is shown in Figure 18.4.5 and Table 18.4.1. The spawning stock has increased in recent years and fishing mortality decreased but annual landings have been relatively stable. The last year class estimated is the 2006 year class but the following year classes are assumed to be the average. Based on experience from recent years the estimated size of the 2006 year class will most likely be higher next year than this year. Later year classes are likely to be smaller than assumed here based on information from the surveys in East Greenland and Iceland that do all indicate low abundance of small redfish. Assumptions about those year classes will not have much effect on the advice given this year but later advice will be affected as will the development of the spawning stock in short term.

The results of the assessment presented here are similar to what was presented at WKREDMP (ICES 2014) (Figure 18.4.6). This similarity is expected as only one year of data has been added and the model is a is a low pass filter that does usually not respond rapidly to new data except they are very far from predicted values.

Estimated selection patterns of different fleets are shown in Figure 18.4.7. The Greenlandic and Faeroese fleet catch much larger fish than the Icelandic fleet. This is in line with the results from the German survey in East Greenland that show most of the large fish in East Greenland (Figure 18.4.3)

18.4.2.3 Fit to data

An aggregated fit to the survey index (converted to biomass) is presented in Figure 18.4.8. It shows a greater level of agreement than most runs based only on the Icelandic data but does mostly show negative residuals for the last 10 years. Residuals by length group show positive residuals in size groups 33-38 cm in recent years but negative for most other size groups, indicating narrower length distributions in the survey than predicted.

This lack of fit between observed and predicted survey biomass was one of the main critics of WKRED 2012 (ICES 2012). As can be seen in Figure 18.4.7 the fit is still not good. That lack of fit is caused by too narrow length distribution, with both small and fish missing but they weight much more in the tuning data than in the total biomass. When looking at the number of years with observed > predicted biomass it must be born in mind that the assessment converges very slowly and 10 years are in some sense comparable to less than 5 years in other species. Discussions about the problem in WKRED 2014 are still valid.

The correlation between observed and predicted survey indices is good for 33-50 cm fish (Figure 18.4.10). The model does though converge slowly so predicted indices could change a number of years back when more data are added. However, it is not the magnitude of the residuals but rather the temporal pattern that is worrying (Figure 18.4.9).

Length distributions from the Icelandic commercial catch does usually show good fit except in the most recent period when the large fish is missing and the length distribution narrower than ever. One explanation could be that selection in recent years is dome shaped as the large fish is in East Greenland where the fisheries are not conducted.

The discrepancy between predicted and observed age distributions is not as apparent as for the length distributions (Figure 18.4.12). The model uses the data as age-length keys in 2 cm intervals for tuning. Presenting the residuals on that scale is difficult so here the age distributions are shown as aggregates over all length groups. This is not a problem for the catches where the otolith sampling is random which, is not the case for the survey as there is a maximum limit on the number of otoliths sampled in each tow and therefore lower proportion sampled in hauls with many fish.

18.5 Reference points

Yield-per-recruit analysis show that when average size at age 5 was allowed to change after year class 1996 $F_{9-19,MAX}$ changed from 0.097 to 0.114 (Figure 15). F_{MAX} of fully recruited fish or size based F_{MAX} does not change. This is a known phenomenon, for example taken into account in the management of Icelandic haddock and George bank haddock. The proposed fishing mortality of 0.097 is therefore around 85% of F_{MAX} with current settings. Stochastic simulations indicate that it leads to very low probability of spawning stock going below $B_{trigger}$ and B_{lim}, even with relatively large auto-correlated assessment error.

Yield-per-recruit reference points from the Gadget model (length-based) are not comparable to age based reference points. The proposed harvest ratio, 0.097, is well above $F_{0.1}$ and F_{SSB35} estimate from the Gadget model. These reference points have previously been proposed for this stock, but these points are also lower than from age based models.

The recruitment pattern observed from year classes 1975–2003 (Figure 18.4.6) does not show long periods of poor recruitment often seen in redfish stocks. From a management perspective this is beneficial since overly cautious rules (i.e. low harvest rates) may not be needed to see the stock through sustained periods of very low recruitment. A spawning stock generated by poor recruitment and low fishing mortality has much broader, and hence resilient, age distribution than the same size spawning stock generated under higher fishing mortality and a few large recruitment events. Therefore, if poor recruitment lead to the stock declining towards B_{loss} after adoption of the HCR, 19+ biomass (or another measure of old fish) would still be relatively high, potentially benefitting the stock due the disproportionate reproductive output of older fish.

$B_{trigger}$ was defined as 220 kt by adding a precautionary buffer to the proposed B_{lim} of 160 kt: 160*exp(0.2*1.645). The probability of current SSB $<B_{trigger}$ is estimated 2.7%. For simplicity, the action of $B_{trigger}$ is not included in the simulations since Gadget is not keeping track of "perceived spawning stock". Analysis of the stochastic prediction in R shows that if SSB is below $B_{trigger}$ it will only be noted in <15% of the cases. The reason is that the spawning stock is only likely to go below $B_{trigger}$ in periods of severe overestimation of the stock that occur due to the assumed high autocorrelation in assessment error. This situation differs from that of the stock going below $B_{trigger}$ due to poor recruitment (worse than observed in recent decades). In this case the spawning stock should still have a resilient age structure (as discussed above) and this could reduce the need to take further action below $B_{trigger}$.

Data on recruitment are still poor and data from other surveys at East Greenland than the German survey need to be investigated. The Icelandic surveys indicate that recruitment has been very poor for at least the last five years (Figure 18.2.1). The applicability of the Icelandic surveys as measure of recruitment of redfish has been questioned but this is at least a negative signal and in long periods of poor recruitment a low harvest ratio is preferable.

Finally, it must be remembered that the F_{target} suggested implies a substantial reduction from the fishing mortality of last three decades. The stock is not at present considered to be in a very unhealthy state despite this three decade period of relatively high fishing pressure in relation to that proposed for the HCR. Still, the adoption of the HCR should not lead to major changes in the advice from recent years, which has partly been based on similar considerations.

The deliberations above offer some justification that the proposed harvest rate ($F_{9\text{–}19}$ = 0.097) is a sensible target for this stock. This of course depends also on the assumption that assessment is based on natural mortality M=0.05.

18.6 State of the stock

The results from GADGET indicate that fishing mortality has reduced in recent years and is now close to F_{MSY} (Figure 18.4.5). Spawning stock and fishable stock have been increasing in recent years and are now the highest since 1986 (Figure 18.4.5). Fishing at F_{MSY} will lead most likely lead to some increase in stock size and catches (figure 18.5.2) but the average long term catch shown is around 55 thousand tonnes with considerable variability.

In Vb, survey indices are stable at low level and do not indicate an improved situation in the area. In Subarea XIV, the biomass of the fishable stock has been relatively high since 2007. No information is available on exploitation rates in Divisions Vb and XIV.

Results from surveys in Iceland and East Greenland indicate that most recent year classes are poor. The reliability of the surveys as and indicator of recruitment is not known.

18.7 Short term forecast

The Gadget model is length based where growth is modelled, based on estimated parameters. The only parameters needed for short term forecast are assumptions about size of those cohorts that have not been seen in the surveys. These year classes were assumed to be the average of year classes 1975-2003 (Figure 18.4.5).

The results from the short term simulations based on F9-19 is shown in Figure 18.4.5 and from short term prognosis with varying fishing mortality in 2015 in Table 18.4.2.

18.8 Medium term forecast

No medium term forecast was carried out.

18.9 Uncertainties in assessment and forecast

Various factors regarding the uncertainty and modelling challenges are listed in the WKRED-2012 and WKREDMP-2014 reports. The main things relate to the lack of explanation of the GADGET model (or any model for that matter) to account for the increase of abundance in intermediate length groups in the Icelandic March survey. The reasons put forward as explanation are:

- Immigration of intermediate sized redfish in to Va, most likely from Greenland.
- Increased aggregation of redfish in areas closed to fishing. These areas on the western part of the Icelandic shelf make up most but not all of the increase in intermediate sized golden redfish in the Icelandic surveys. However eliminating the hauls from these areas in calculation of indices does to some extend reduce this increase.
- There are indications that growth of golden redfish has changed over time. This can be seen for example in the 2001 year class which is on average larger than fish of the same age in the earlier year classes (for example, the 1985-1990 year classes). Size at maturity has also decreased that could lead to growth ceasing earlier than before explaining lack of large fish in recent years.

18.10 Comparison with previous assessment and forecast

The current assessment gives more optimistic state of the stock than last years assessment. The estimated trends are by and large the same as in 2012.

Last years advice was based on the DLS method (Category 1).

18.11 Management plans and evaluation

See chapter 18.5

18.12 Basis for advice

Harvest control rule accepted at WKREDMP 2014 (ICES 2014).

18.13 Management consideration

In 2009 a fishery targeting redfish was initiated in ICES XIV with annual catches of more than 8,000 tonnes in 2010-2012. The fishery does not distinguish between species, but based on survey information, golden redfish is estimated to account for 20% of catches, i.e. annual catch of about 1,650 t in 2010-2013.

Redfish and cod in XIV are found in the same areas and depths and historically these species have been taken in the same fisheries. An increased redfish fishery may therefore affect cod. ICES presently advise that no fishery should take place on offshore cod in Greenland waters. ICES therefore recommend measures that will keep effort on cod low in the redfish fishery.

Greenland opened an offshore cod fishery in 2008. To protect spawning aggregations of cod present management measures in Greenland EEZ prohibits trawl fishery for cod north of 63°N latitude. Restrictions on cod bycatch in fisheries directed towards other demersal fish (i.e. redfish and Greenland halibut) provide some protection of cod, but additional measures such as a closure of potential redfish fisheries north of 63°N could be considered.

Subarea XIV is an important nursery area for the entire resource. Measures to protect juvenile in Subarea XIV should be continued (sorting grids in the shrimp fishery).

No formal agreement on the management of *S. norvegicus* exists among the three coastal states, Greenland, Iceland and the Faeroe Islands. In Greenland and Iceland the fishery is regulated by a TAC and in the Faeroe Islands by effort limitation. The regulation schemes of those states have previously resulted in catches well in excess of TACs advised by ICES.

18.14 Ecosystem consideration

Not evaluated for this stock.

18.15 Regulation and their effects

The separation of golden redfish and Icelandic slope *S. mentella* quota was implemented in the 2010/2011 fishing season.

In the late 1980's, Iceland introduced a sorting grid with a bar spacing of 22 mm in the shrimp fishery to reduce the by-catch of juveniles in the shrimp fishery north of Iceland. This was partly done to avoid redfish juveniles as a by-catch in the fishery, but also juveniles of other species. Since the large year classes of golden redfish disappeared out of the shrimp fishing area, there in the early 1990's, observers report small redfish as being negligible in the Icelandic shrimp fishery. If the sorting grids work where the abundance of redfish is high is a question but not a relevant problem at the moment in Vb as abundance of small redfish is low and shrimp fisheries limited.

There is no minimum landing size of golden redfish in Va. However, if more than 20% of a catch observed onboard is below 33 cm a small area can be closed temporarily. A large area west and southwest of Iceland is closed for fishing in order to protect young golden redfish.

There is no regulation of the golden redfish in Vb.

Since 2002 it has been mandatory in the shrimp fishery in Subarea XIV to use sorting grids in order to reduce by-catches of juvenile redfish in the shrimp fishery.

18.16 Changes in fishing technology and fishing patterns

There have been no changes in the fishing technology and the fishing pattern of golden redfish in Subareas V and XIV.

18.17 Changes in the environment

No information available.

18.18 References

ICES 2012. Report of the Benchmark Workshop on Redfish (WKRED 2012). ICES CM 2012/ACOM:48, 291 pp.

ICES 2014. Report of the Workshop on Redfish Management Plan Evaluation (WKREDMP). ICES CM 2014/ACOM:52, 269 pp.

Pálsson, Ó., Björnsson, H., Björnsson, E., Jóhannesson, G. and Ottesen Þ. 2010. Discards in demersal Icelandic fisheries 2009. Marine Research in Iceland 154.

Table 18.2.1 Index on fishable stock of golden redfish in the Icelandic spring groundfish survey 1985-2014, divided by depth intervals.

	Depth Intervals					
Year	< 100m	100-200m	200-400m	400-500m	0 - 400m	Total
1985	7.0	91.1	145.2	23.6	243.2	266.8
1986	2.0	86.1	179.9	12.1	268.0	280.1
1987	2.0	123.8	150.2	10.0	276.0	286.0
1988	1.1	94.6	110.1	4.0	205.8	209.7
1989	1.1	101.4	117.8	10.9	220.2	231.1
1990	2.3	67.9	81.0	22.2	151.2	173.4
1991	1.7	75.9	52.6	8.3	130.3	138.6
1992	1.2	62.2	58.5	9.4	121.9	131.3
1993	0.7	47.5	50.2	16.6	98.4	115.0
1994	0.5	57.7	51.4	1.3	109.6	110.9
1995	0.3	36.0	44.6	11.2	81.0	92.1
1996	0.8	44.3	76.5	21.1	121.5	142.6
1997	1.0	60.3	71.5	33.6	132.7	166.4
1998	1.6	56.9	71.2	2.7	129.7	132.4
1999	0.7	55.5	107.3	44.4	163.6	207.9
2000	2.0	46.7	68.5	8.1	117.2	125.4
2001	1.6	33.1	66.6	5.8	101.2	107.0
2002	1.8	64.0	74.2	11.4	140.1	151.4
2003	8.7	60.2	107.5	28.8	176.4	205.2
2004	7.9	48.8	91.6	102.3	148.4	250.6
2005	9.4	42.3	112.3	37.6	164.1	201.7
2006	6.0	52.6	95.7	17.0	154.4	171.4
2007	4.9	51.1	76.5	77.4	132.6	209.9
2008	5.5	38.5	85.1	33.1	129.1	162.2
2009	4.3	41.8	100.7	272.4	146.8	419.2
2010	4.5	54.4	108.7	62.1	167.6	233.6
2011	4.0	50.6	172.6	106.6	227.1	338.8
2012	5.6	59.0	189.2	161.1	253.8	421.9
2013	4.3	84.9	232.5	56.1	321.7	381.7
2014	5.9	65.6	219.3	57.3	290.8	353.3

Table 18.2.2 Golden redfish in Va. Age disaggregated indices (in numbers) from the autumn groundfish survey 1996-2013. The survey was not conducted in 2011.

Year/ Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.3	1.0	3.7	3.3	0.8	0.4	0.1	0.0	0.0	0.1	0.2	0.1	0.0	0.1	0.0		0.0	0.0
2	2.4	0.3	1.5	3.3	1.7	1.0	1.0	0.6	0.2	0.1	0.6	1.3	0.3	0.3	0.0		0.0	0.0
3	0.7	2.2	0.9	3.3	1.4	2.0	1.5	1.1	1.0	0.2	0.7	1.2	2.5	0.4	1.7		0.1	0.0
4	1.6	1.6	2.3	1.5	1.6	2.4	6.1	1.1	1.9	1.0	0.5	1.1	2.7	4.6	0.3		1.1	0.2
5	8.4	2.2	0.9	4.7	1.2	5.2	5.8	12.2	3.2	4.2	5.0	2.1	4.1	12.2	4.3		3.9	1.1
6	40.4	6.9	3.5	2.8	7.8	2.2	11.7	17.4	28.1	4.8	6.8	10.2	7.7	11.6	14.3		3.1	4.0
7	11.4	22.4	16.7	10.5	6.6	10.6	3.2	37.5	35.9	39.0	15.2	25.6	38.3	13.7	15.0		23.1	3.0
8	19.0	14.2	58.5	47.2	6.1	10.7	25.5	9.6	63.8	43.9	79.8	35.0	73.1	72.4	23.0		68.6	40.8
9	14.7	12.8	22.4	100.0	25.5	6.8	10.9	47.4	20.3	61.2	79.1	74.8	65.7	94.0	53.4		58.9	82.3
10	28.6	10.8	26.0	43.4	92.8	16.6	15.9	12.2	44.2	24.1	83.2	36.3	103.3	56.9	67.8		61.0	54.0
11	103.4	17.3	18.7	20.3	11.0	109.3	30.8	16.5	18.6	43.1	25.4	35.2	61.2	98.2	31.8		100.9	39.3
12	15.7	67.4	19.0	16.5	13.8	23.0	114.6	39.0	12.9	19.0	36.4	18.5	53.5	44.6	56.6		71.8	65.2
13	9.7	5.9	105.4	20.6	7.6	22.7	19.5	109.6	25.9	15.0	17.5	23.2	13.1	41.7	28.2		42.1	45.2
14	16.6	5.1	10.0	148.1	7.8	7.6	11.0	12.1	101.5	26.3	14.6	7.9	17.7	9.8	19.3		38.1	25.1
15	34.0	7.0	7.6	5.8	50.6	8.7	9.5	10.6	13.3	80.8	17.9	6.6	8.8	17.7	8.9		19.1	30.1
16	15.9	9.8	7.7	9.6	5.1	57.4	10.3	6.0	9.4	9.3	74.0	16.6	7.6	6.7	10.8		16.2	17.8
17	1.7	6.8	14.2	10.8	2.5	4.1	45.1	7.5	5.8	6.5	8.5	48.8	12.8	6.2	4.6		5.9	12.2
18	1.6	3.9	7.6	11.1	2.5	4.9	4.5	32.5	5.9	3.7	4.2	10.2	36.0	7.1	3.0		5.8	6.8
19	4.2	2.0	0.5	8.4	4.5	3.5	2.7	4.5	21.2	5.0	2.7	4.4	6.0	27.7	6.6		3.8	4.9
20	6.5	1.4	3.2	3.9	6.5	4.1	3.2	1.6	3.0	21.8	3.1	1.5	5.6	4.6	22.0		3.8	4.3
21	1.0	0.8	2.4	2.8	1.0	3.6	3.9	1.1	1.8	2.5	17.6	3.9	2.0	2.1	3.1		3.4	4.6
22	4.9	1.5	0.8	1.0	1.6	2.2	3.1	2.7	1.7	2.0	1.9	13.6	2.3	1.3	1.2		17.9	2.3
23	3.9	2.4	2.2	2.0	0.4	0.3	0.8	1.0	2.4	2.3	1.7	1.3	10.8	1.9	1.6		2.8	17.3
24	4.5	0.8	0.4	0.5	1.0	0.5	0.4	0.3	0.0	0.9	1.0	1.2	1.4	10.0	0.7		2.0	2.4
25	3.8	2.7	1.4	2.8	0.7	0.2	0.5	0.3	1.2	1.2	1.7	0.2	0.8	0.7	5.7		1.2	1.2
26	0.8	1.1	0.2	1.1	0.6	0.5	0.5	0.2	0.4	0.3	0.9	0.6	0.8	0.9	0.6		1.6	1.1
27	0.8	0.2	0.9	2.9	0.5	0.7	0.3	0.3	0.0	0.1	0.9	0.3	1.2	1.3	0.4		7.4	0.8
28	0.8	0.4	0.5	1.5	0.6	0.5	0.2	0.0	0.2	0.2	0.2	0.0	0.5	0.2	0.7		0.4	8.3
29	0.1	0.0	0.4	1.2	0.5	0.2	0.7	0.1	0.2	0.0	0.4	0.4	0.8	1.5	0.4		0.4	0.4
30+	0.8	1.3	3.1	1.1	1.3	2.1	1.4	1.5	1.5	2.1	1.0	0.9	1.4	1.6	2.0		2.0	3.3
Total	358.0	211.8	342.3	492.0	265.5	313.9	344.4	386.4	425.4	420.5	502.6	382.9	542.3	551.9	387.9		566.4	477.9

Table 18.3.1 Official landings (in tonnes) of golden redfish, by area, 1978-2013 as officially reported to ICES. Landings statistics for 2012 are provisional.

	Area				
Year	Va	Vb	VI	XIV	Total
1978	31,300	2,039	313	15,477	49,129
1979	56,616	4,805	6	15,787	77,214
1980	62,052	4,920	2	22,203	89,177
1981	75,828	2,538	3	23,608	101,977
1982	97,899	1,810	28	30,692	130,429
1983	87,412	3,394	60	15,636	106,502
1984	84,766	6,228	86	5,040	96,120
1985	67,312	9,194	245	2,117	78,868
1986	67,772	6,300	288	2,988	77,348
1987	69,212	6,143	576	1,196	77,127
1988	80,472	5,020	533	3,964	89,989
1989	51,852	4,140	373	685	57,050
1990	63,156	2,407	382	687	66,632
1991	49,677	2,140	292	4,255	56,364
1992	51,464	3,460	40	746	55,710
1993	45,890	2,621	101	1,738	50,350
1994	38,669	2,274	129	1,443	42,515
1995	41,516	2,581	606	62	44,765
1996	33,558	2,316	664	59	36,597
1997	36,342	2,839	542	37	39,761
1998	36,771	2,565	379	109	39,825
1999	39,824	1,436	773	7	42,040
2000	41,187	1,498	776	89	43,550
2001	35,067	1,631	535	93	37,326
2002	48,570	1,941	392	189	51,092
2003	36,577	1,459	968	215	39,220
2004	31,686	1,139	519	107	33,451
2005	42,593	2,484	137	115	45,329
2006	41,521	656	0	34	42,211
2007	38,364	689	0	83	39,134
2008	45,538	569	64	80	46,251
2009	38,442	462	50	224	39,177
2010	36,155	620	220	1,653	38,648
2011	43,773	493	83	1,676	46,025
2012	43,103	491	41	1,643	45,278
20131)	51,330	372	92	1,663	53,457

1) Provisional

Table 18.3.2 Golden redfish in Va. Observed catch in weight (tonnes) by age and years in 1995-2012. It should be noted that the catch-at-age results for 1996 are only based on three samples, which explains that there are no specimens older than 23 years. NOT UPDATED

Year/ Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
7	62	0	33	24	7	40	122	129	201	226	235	187	136	464	109	60	143	71	56
8	374	360	230	284	350	65	138	900	211	845	779	1063	453	1279	979	356	559	585	625
9	1596	825	481	595	1623	849	394	759	1366	497	1917	2217	1760	2244	1756	2204	1561	1603	2395
10	9436	3701	1039	1208	1259	4290	1620	833	1120	2098	1519	3721	2480	5173	3153	2710	4519	3271	3991
11	2719	9127	2701	1129	1855	1888	7746	3155	1194	789	3120	2143	3356	4053	5069	2770	5453	6532	6015
12	1319	2102	11572	3245	2523	2268	1802	10939	3945	975	1908	2837	1923	4721	4503	4893	4869	7322	9500
13	3518	1317	2822	12501	2441	1686	1977	3046	9749	2020	1371	1640	3070	2285	3426	3873	6248	4034	6876
14	5671	1477	1365	2077	15504	2346	1246	2580	2349	8594	3007	1300	1048	2758	1827	2727	3811	4948	4003
15	5971	4347	3108	2026	1238	14677	835	1820	1958	2131	11771	2827	953	1491	1974	1371	2462	2896	4424
16	1730	5456	3599	2392	1246	1744	11486	2938	1204	1675	2056	10097	2150	1056	1229	1192	1381	1310	3010
17	852	934	2981	3376	1791	1167	512	11695	2223	804	1433	2063	9261	1800	664	814	915	781	1711
18	368	379	877	2025	2606	1574	766	2038	6330	1366	1231	1154	1308	8032	1482	643	639	696	1190
19	1134	259	620	1002	2183	2359	1021	1119	748	5129	1229	666	733	1464	6023	1081	802	389	757
20	1128	340	910	714	1236	2099	1683	626	402	1104	6331	946	713	876	938	4972	845	899	474
21	503	1157	444	512	452	528	914	1360	593	331	386	5433	861	516	635	897	5156	709	516
22	644	988	511	389	210	435	400	983	773	482	457	597	4708	802	561	757	1162	3557	705
23	1427	791	651	416	325	266	400	703	737	605	765	221	718	4062	330	569	754	499	3171
24	647	0	564	652	214	62	156	357	375	556	598	365	111	363	2495	661	220	368	204
25	745	0	711	510	821	384	119	281	292	250	410	452	595	241	96	2147	66	257	197
26	365	0	267	391	264	330	109	176	73	102	97	71	323	407	96	264	1589	217	170
27	350	0	134	420	597	192	264	79	80	178	264	248	341	329	189	383	86	1408	99
28	725	0	192	352	226	508	182	288	26	136	162	194	195	163	91	131	177	208	803
29	0	0	136	52	104	357	142	479	102	134	28	161	35	163	381	176	47	83	36
30+	232	0	394	480	747	1076	1033	1287	524	660	1520	916	1131	795	438	506	309	447	406
Total	41516	33560	36342	36772	39822	41190	35067	48570	36575	31687	42594	41519	38362	45537	38444	36157	43773	43090	51334

Table 18.3.3 Results of the GLM model to calculate standardized CPUE for Icelandic golden redfish fishery in Va. Note that the residuals are shown in Fig. 8.2.2.

```
Call: glm(formula = lafli ~ ltogtimi + factor(ar) + as.factor(veman) +
    factor(skipnr) + factor(reitur), family = gaussian(), data = tmp)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-6.4143  -0.4711   0.0302   0.5005   7.8391

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)      4.9159810  0.8746529   5.620 1.91e-08 ***
ltogtimi         1.1248700  0.0036231 310.468  < 2e-16 ***
factor(ar)1979   0.0415870  0.0470791   0.883 0.377054
factor(ar)1980   0.1422627  0.0443975   3.204 0.001355 **
factor(ar)1981   0.1923573  0.0437248   4.399 1.09e-05 ***
factor(ar)1982   0.1389745  0.0434691   3.197 0.001389 **
factor(ar)1983   0.0014170  0.0422681   0.034 0.973257
factor(ar)1984  -0.0066725  0.0436094  -0.153 0.878394
factor(ar)1985   0.0484283  0.0440143   1.100 0.271212
factor(ar)1986   0.0119174  0.0437752   0.272 0.785437
factor(ar)1987   0.0955042  0.0448442   2.130 0.033202 *
factor(ar)1988   0.0436673  0.0452598   0.965 0.334642
factor(ar)1989   0.0645111  0.0452917   1.424 0.154352
factor(ar)1990   0.0575212  0.0451487   1.274 0.202654
factor(ar)1991   0.0556060  0.0400421   1.389 0.164933
factor(ar)1992  -0.1399276  0.0402709  -3.475 0.000512 ***
factor(ar)1993  -0.2582378  0.0399726  -6.460 1.05e-10 ***
factor(ar)1994  -0.2701709  0.0408054  -6.621 3.60e-11 ***
factor(ar)1995  -0.2400185  0.0410579  -5.846 5.07e-09 ***
factor(ar)1996  -0.2315390  0.0414415  -5.587 2.32e-08 ***
factor(ar)1997  -0.2298930  0.0415804  -5.529 3.24e-08 ***
factor(ar)1998  -0.1550128  0.0418119  -3.707 0.000210 ***
factor(ar)1999  -0.2000966  0.0413353  -4.841 1.30e-06 ***
factor(ar)2000  -0.0536851  0.0414113  -1.296 0.194847
factor(ar)2001   0.0968330  0.0424483   2.281 0.022540 *
factor(ar)2002   0.1240441  0.0419874   2.954 0.003135 **
factor(ar)2003   0.1275115  0.0431054   2.958 0.003096 **
```

```
factor(ar)2004      0.1773123  0.0437644   4.052 5.09e-05 ***
factor(ar)2005      0.1092999  0.0423780   2.579 0.009906 **
factor(ar)2006     -0.0264077  0.0417807  -0.632 0.527353
factor(ar)2007      0.0202091  0.0426838   0.473 0.635886
factor(ar)2008      0.0181087  0.0420686   0.430 0.666864
factor(ar)2009      0.0498447  0.0423259   1.178 0.238944
factor(ar)2010      0.0853818  0.0424904   2.009 0.044495 *
factor(ar)2011      0.3204041  0.0427980   7.486 7.17e-14 ***
factor(ar)2012      0.4798235  0.0433718  11.063  < 2e-16 ***
factor(ar)2013      0.5715094  0.0433210  13.192  < 2e-16 ***
as.factor(veman)2   0.1476698  0.0179822   8.212  < 2e-16 ***
as.factor(veman)3   0.3375887  0.0172465  19.574  < 2e-16 ***
as.factor(veman)4   0.3175148  0.0178112  17.827  < 2e-16 ***
as.factor(veman)5   0.1566315  0.0202914   7.719 1.19e-14 ***
as.factor(veman)6   0.3585409  0.0185878  19.289  < 2e-16 ***
as.factor(veman)7   0.3233893  0.0178901  18.076  < 2e-16 ***
as.factor(veman)8   0.2340433  0.0179345  13.050  < 2e-16 ***
as.factor(veman)9   0.1563196  0.0174416   8.962  < 2e-16 ***
as.factor(veman)10  0.0988800  0.0175188   5.644 1.67e-08 ***
as.factor(veman)11  0.0410802  0.0183438   2.239 0.025130 *
as.factor(veman)12 -0.0791970  0.0202306  -3.915 9.06e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
(Dispersion parameter for gaussian family taken to be 0.7340511)
    Null deviance: 155370  on 61153  degrees of freedom
Residual deviance:  44594  on 60751  degrees of freedom
AIC: 155044
Number of Fisher Scoring iterations: 2
----------------------------------------------------------------
Analysis of Deviance Table
Model: gaussian, link: identity
Response: lafli
Terms added sequentially (first to last)

            Df Deviance Resid. Df Resid. Dev          F    Pr(>F)
NULL                        61153     155370
ltogtimi     1    94225     61152      61145 128362.547 < 2.2e-16 ***
factor(ar)  35     3517     61117      57628    136.902 < 2.2e-16 ***
```

```
as.factor(veman)  11     1121     61106      56507    138.819 < 2.2e-16 ***
factor(skipnr)   205     8851     60901      47656     58.816 < 2.2e-16 ***
factor(reitur)   150     3062     60751      44594     27.810 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table 18.4.1 Results from the Gadget model of total biomass, spawning stock biomass, recruitment at age 5, catch and fishing mortality, projections are in italic.

Year	Biomass	SSB	R(age5)	Catches	F9-19
1971	574.5	349.9	192.9	67.9	0.108
1972	578.4	347.9	184.6	50.9	0.082
1973	624.8	357.0	457.5	43.7	0.070
1974	659.0	371.7	207.5	50.6	0.077
1975	678.2	382.3	123.7	61.9	0.091
1976	683.0	379.2	194.5	94.4	0.138
1977	692.4	384.1	187.7	53.8	0.082
1978	720.0	412.9	129.4	48.7	0.068
1979	737.7	435.4	157.6	77.2	0.102
1980	728.3	441.6	104.5	89.1	0.117
1981	699.8	435.5	75.9	102	0.138
1982	645.1	407.7	77.0	130.3	0.189
1983	581.7	371.4	72.2	106.0	0.167
1984	531.4	343.1	77.1	95.3	0.159
1985	497.4	320.6	139.1	78.5	0.136
1986	470.4	301.2	128.1	76.9	0.144
1987	436.5	278.5	63.5	76.6	0.156
1988	390.4	246.4	36.1	89.8	0.209
1989	351.3	219.2	44.1	56.6	0.148
1990	351.6	201.0	330.7	66.3	0.195
1991	330.5	182.0	59.9	56.0	0.181
1992	311.4	166.9	39.8	55.8	0.197
1993	294.6	154.5	54.2	50.2	0.194
1994	283.9	148.3	63.9	42.5	0.173
1995	301.7	146.0	317.0	44.3	0.183
1996	306.6	147.3	93.0	35.6	0.146
1997	305.1	148.5	42.8	39.0	0.156
1998	306.3	153.5	45.4	39.7	0.157
1999	304.1	154.5	91.2	42.5	0.168
2000	299.4	157.4	55.0	42.6	0.165
2001	306.6	162.0	113.3	36.7	0.137
2002	311.2	162.7	127.4	50.7	0.187
2003	329.0	165.2	194.0	38.2	0.141
2004	348.8	177.1	119.5	32.8	0.115
2005	372.6	185.9	185.7	46.6	0.160
2006	402.2	196.3	196.4	42.1	0.144
2007	420.1	210.7	106.6	39.2	0.128
2008	442.8	232.5	108.3	46.2	0.140
2009	463.2	252.3	133.3	39.3	0.111
2010	486.2	281.1	91.9	38.5	0.098
2011	496.0	307.4	40.1	45.8	0.108
2012	505.0	323.4	120.0	44.9	0.100

Year	Biomass	SSB	R(age5)	Catches	F9–19
2013	516.5	339.6	120.0	53.3	0.114
2014	520.4	347.2	120.0	48.5	0.102
2015	530.6	357.9	120.0	47.3	0.097
2016	539.3	366.1	120	48.2	0.097

Table 18.4.2 Output from short term prognosis. Multiplier is based on reference to the adopted HCR $F_{9\text{-}19}$=0.097. Biomasses are in the beginning of the year to apply to ICES standard in short term prognosis in other places in the report they are in the middle of the year.

F(2013)=0.113 C(2013)=53.250 tons.

2014				
Bio 5+	SSB	Fmult	F9-19	Landings
507	342	1.043	0.101	48.5

		2015			2016	
Fmult	F9-19	Bio 5+	SSB	Landings	Bio 5+	SSB
0	0	516	352	0	574	404
0.1	0.01	516	352	4.9	569	399
0.2	0.019	516	352	9.7	564	395
0.3	0.029	516	352	14.5	559	391
0.4	0.038	516	352	19.3	554	387
0.5	0.048	516	352	24	549	382
0.6	0.058	516	352	28.7	544	378
0.7	0.067	516	352	33.4	539	374
0.8	0.077	516	352	38	535	370
0.9	0.087	516	352	42.7	530	366
1	0.097	516	352	47.3	525	362
1.1	0.107	516	352	51.8	520	358
1.2	0.117	516	352	56.4	516	354
1.3	0.127	516	352	60.9	511	350
1.4	0.137	516	352	65.4	506	346
1.5	0.147	516	352	69.8	502	342
1.6	0.158	516	352	74.3	497	338
1.7	0.168	516	352	78.7	493	334
1.8	0.178	516	352	83	488	330
1.9	0.189	516	352	87.4	484	326
2	0.199	516	352	91.7	479	322

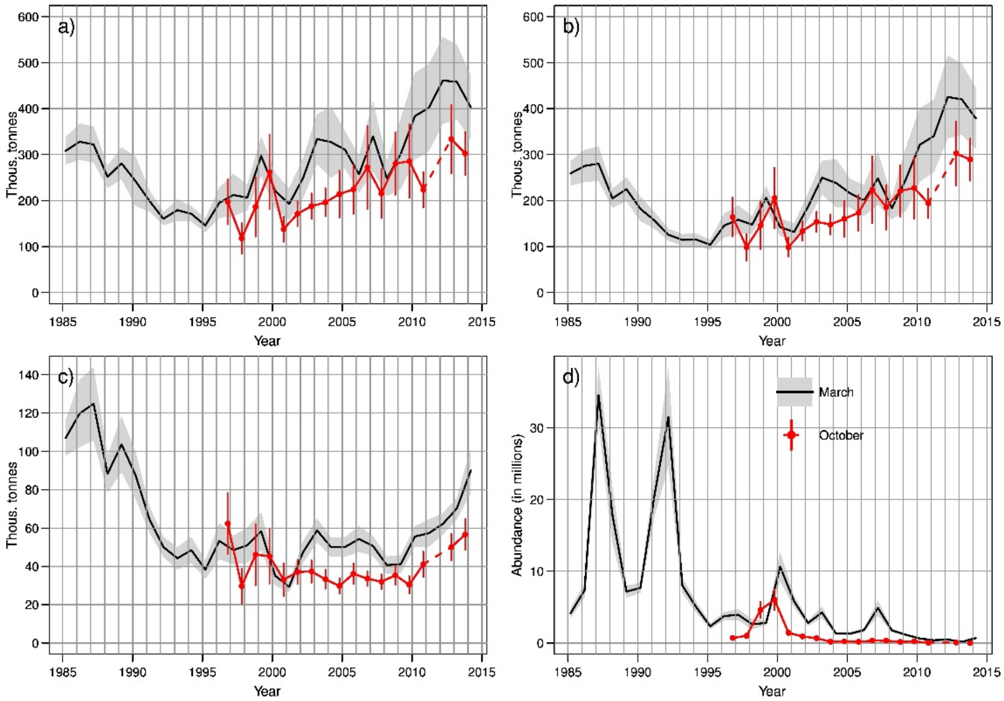


Figure 18.2.1 Indices of golden redfish from the groundfish surveys in March 1985-2014 (line, shaded area) and October 1996-2013 (red and vertical lines). a) Total biomass; b) biomass of fish larger than 32 cm; c) biomass of fish larger than 40 cm; d) indices of juvenile golden redfish (4-11) cm in millions. The shaded area and the vertical bar show □1 standard error of the est

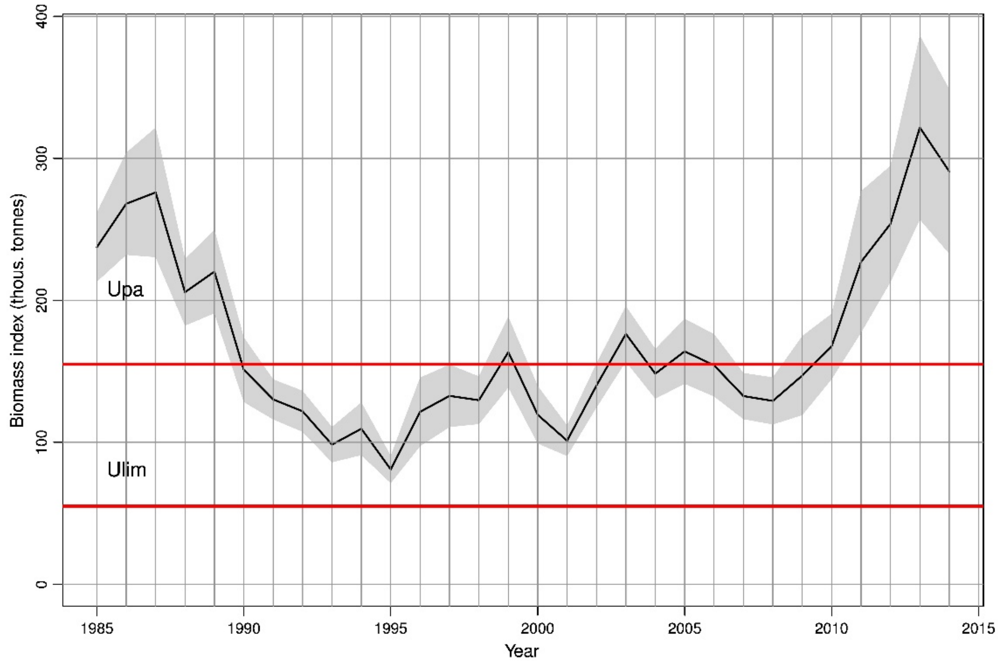


Figure 18.2.2 Index on fishable stock of golden redfish from Icelandic groundfish survey in March 1985-2014. The shaded area and the vertical bar show □1 standard error of the estimate

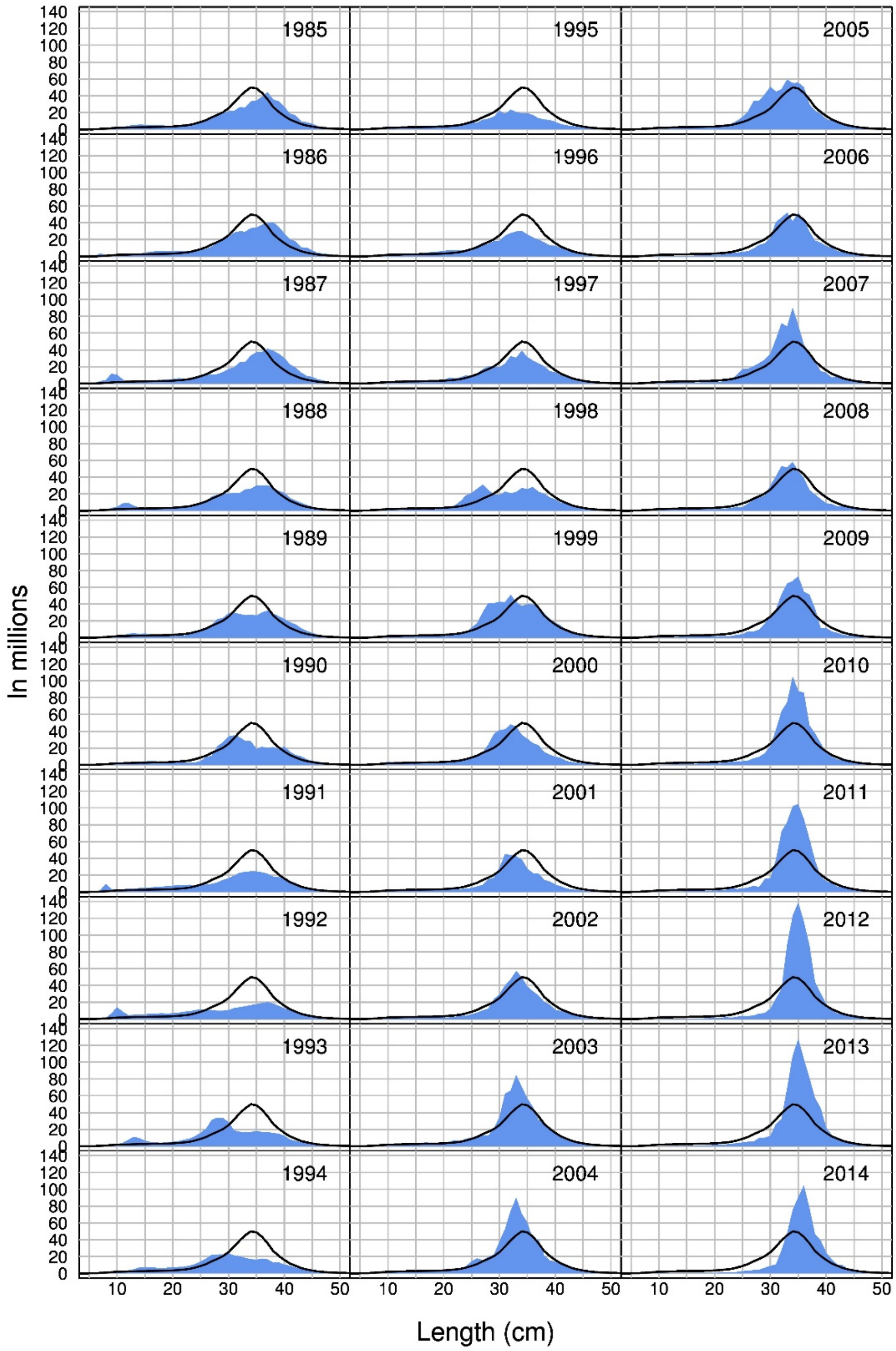


Figure 18.2.3. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in March 1985-2014 conducted in Icelandic waters. The black line is the mean of total indices 1985-2014.

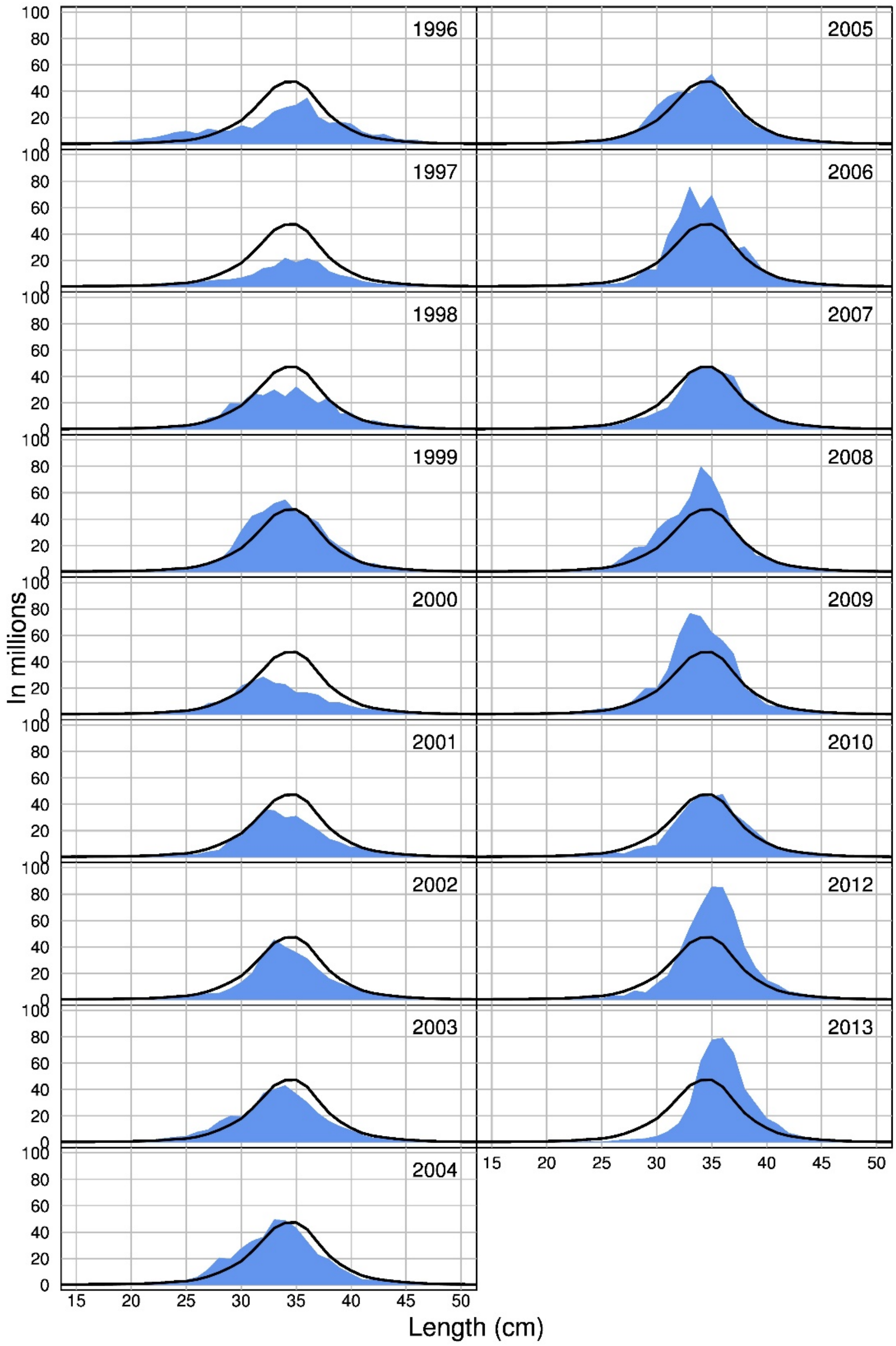


Figure 18.2.4. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in October 1996-2013 conducted in Icelandic waters. The black line is the mean of total indices 1996-2013. The survey was not conducted in 2011.

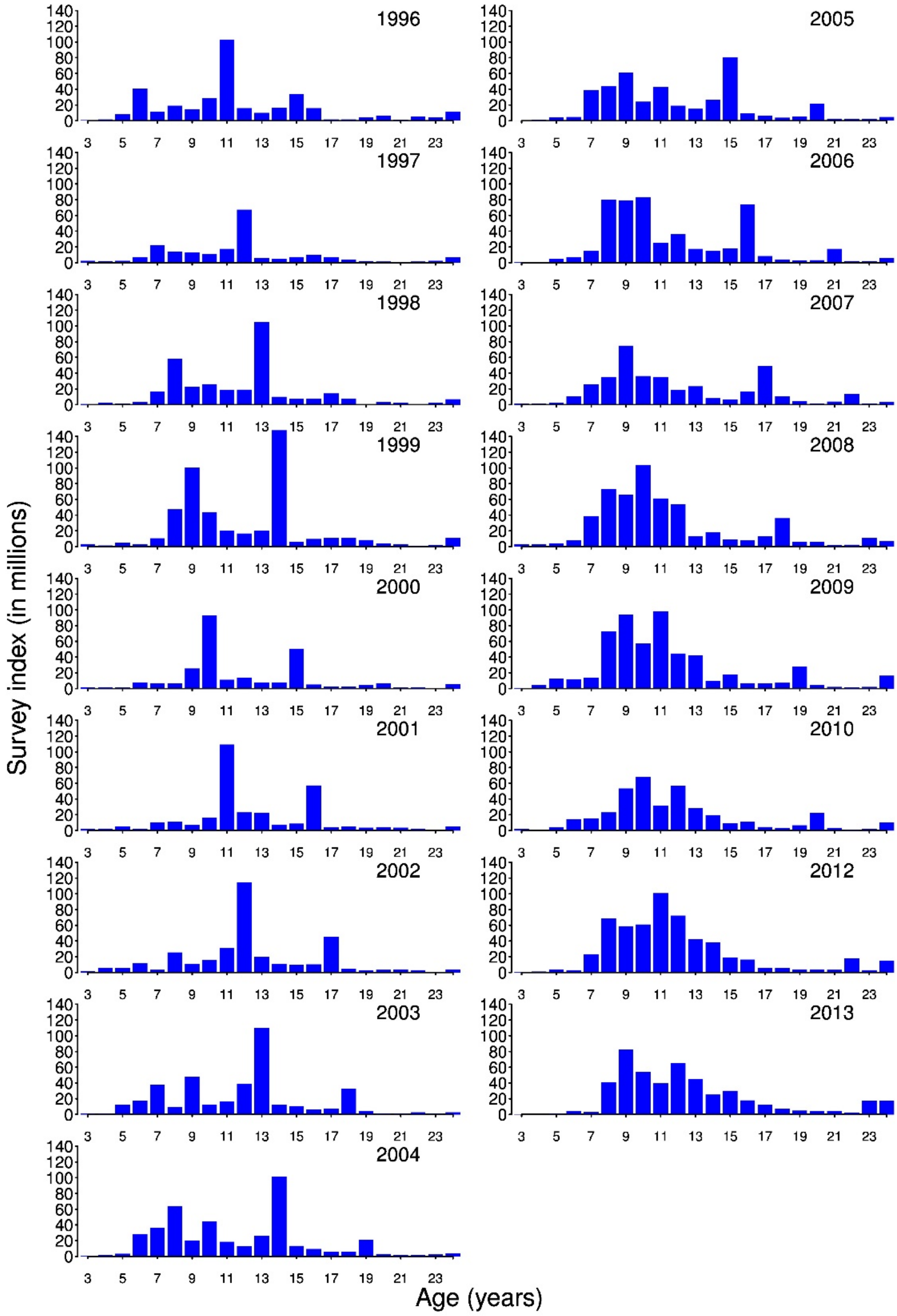


Figure 18.2.5 Age disaggregated abundance indices of golden redfish in the bottom trawl survey in October conducted in Icelandic waters 1996-2013. The survey was not conducted in 2011.

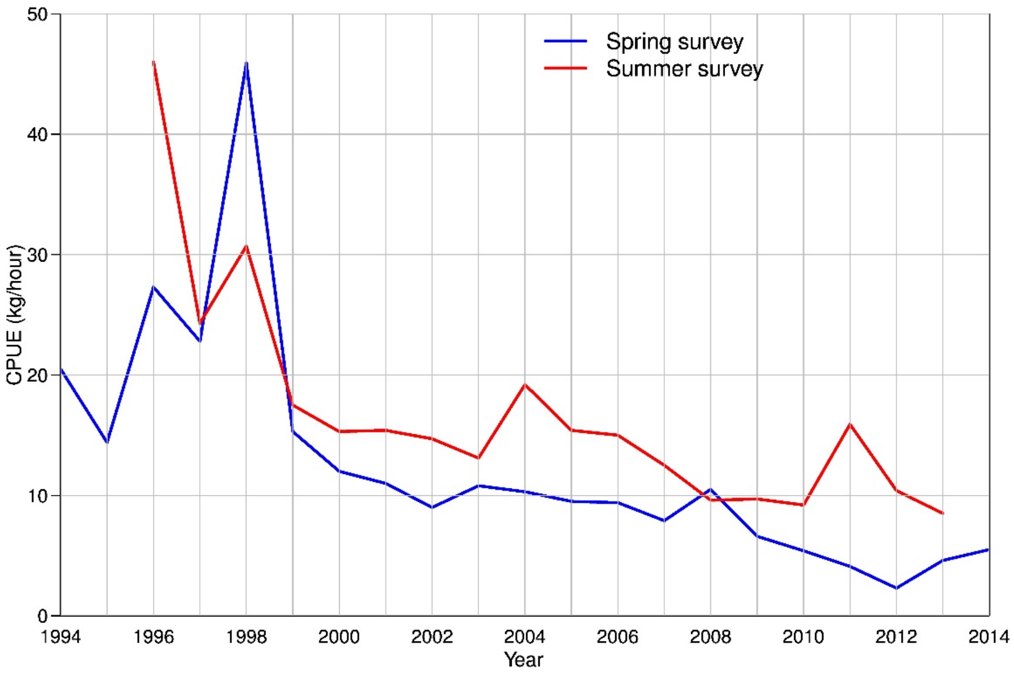


Figure 18.2.6 CPUE of golden redfish in the Faeroes spring groundfish survey 1994-2014 and the summer groundfish survey 1996-2013 in ICES Division Vb.

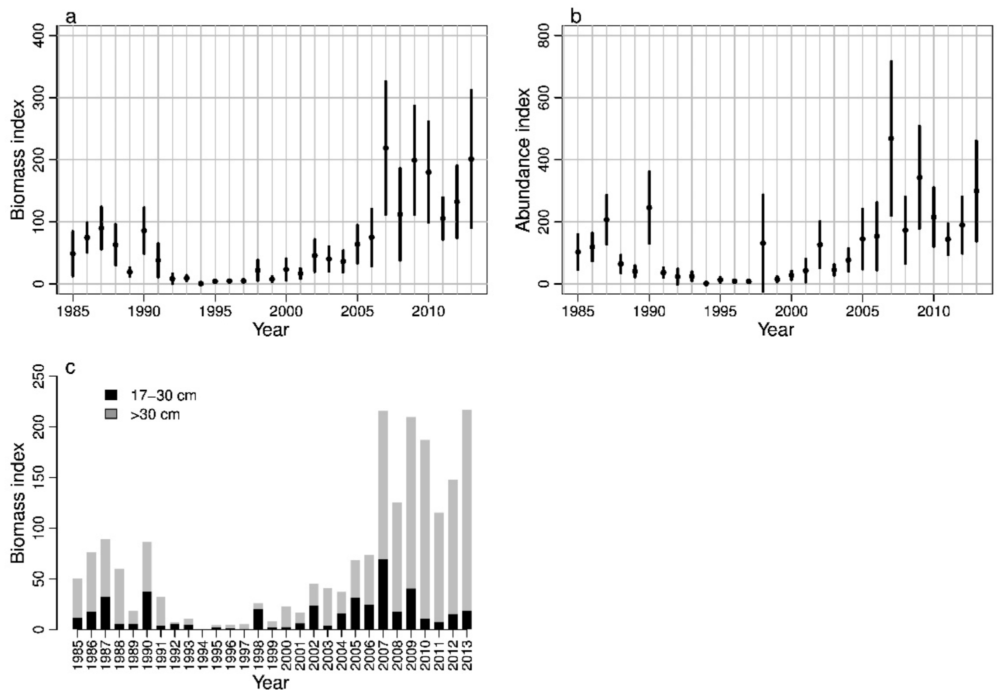


Figure 18.2.7 Golden redfish (□17 cm). Survey abun
from the German groundfish survey 1985-2013. a) Total biomass index, b) total abundance index, c) biomass index divided by size classes (17-30 cm and > 30 cm).

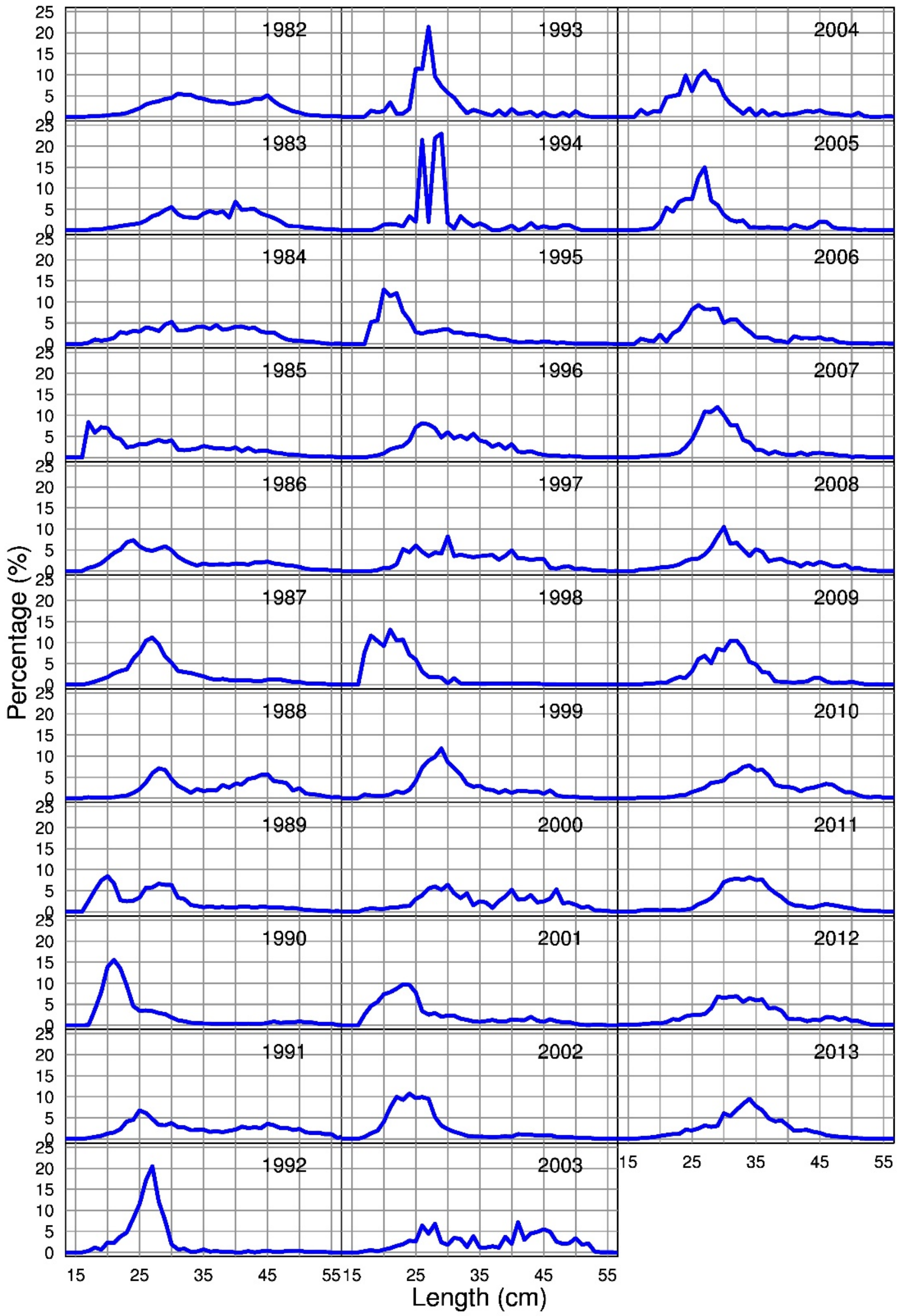


Figure 18.2.8 Golden redfish (>17 cm). Length frequencies for East and West Greenland 1982-2013.

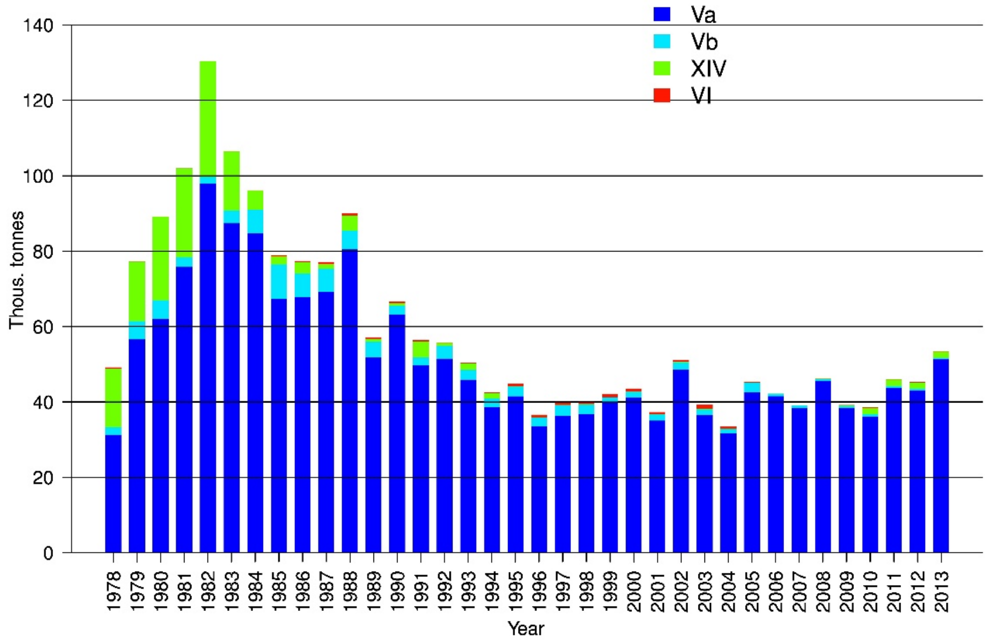


Figure 18.3.1 Nominal landings of golden redfish in tonnes by ICES Divisions 1978-2013. Landings statistics for 2013 are provisional.

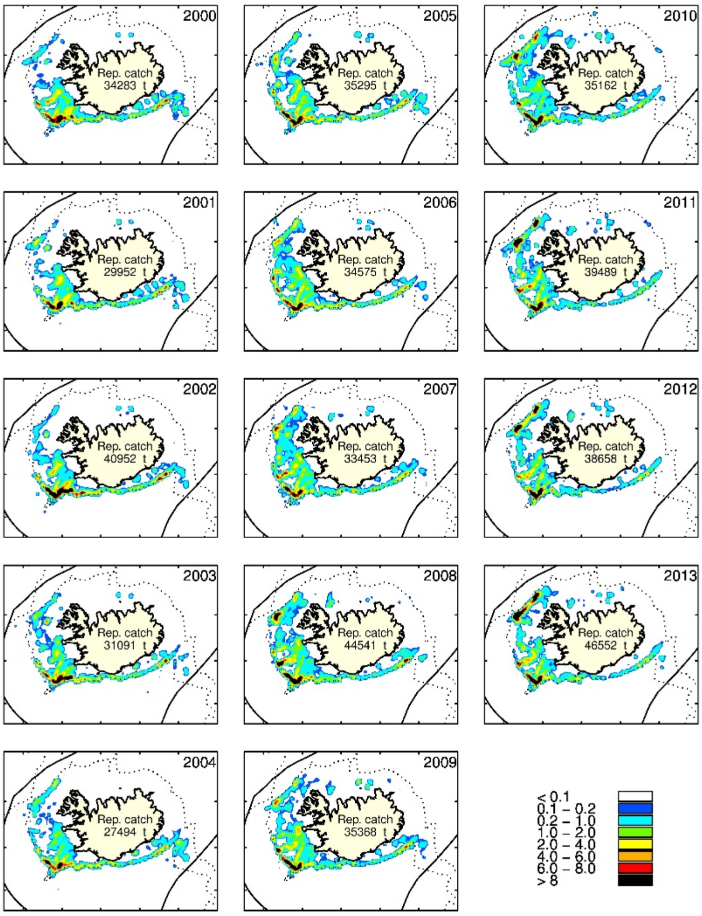


Figure 18.3.2 Geographical distribution of golden redfish bottom trawl catches in Division Va 2000-2013.

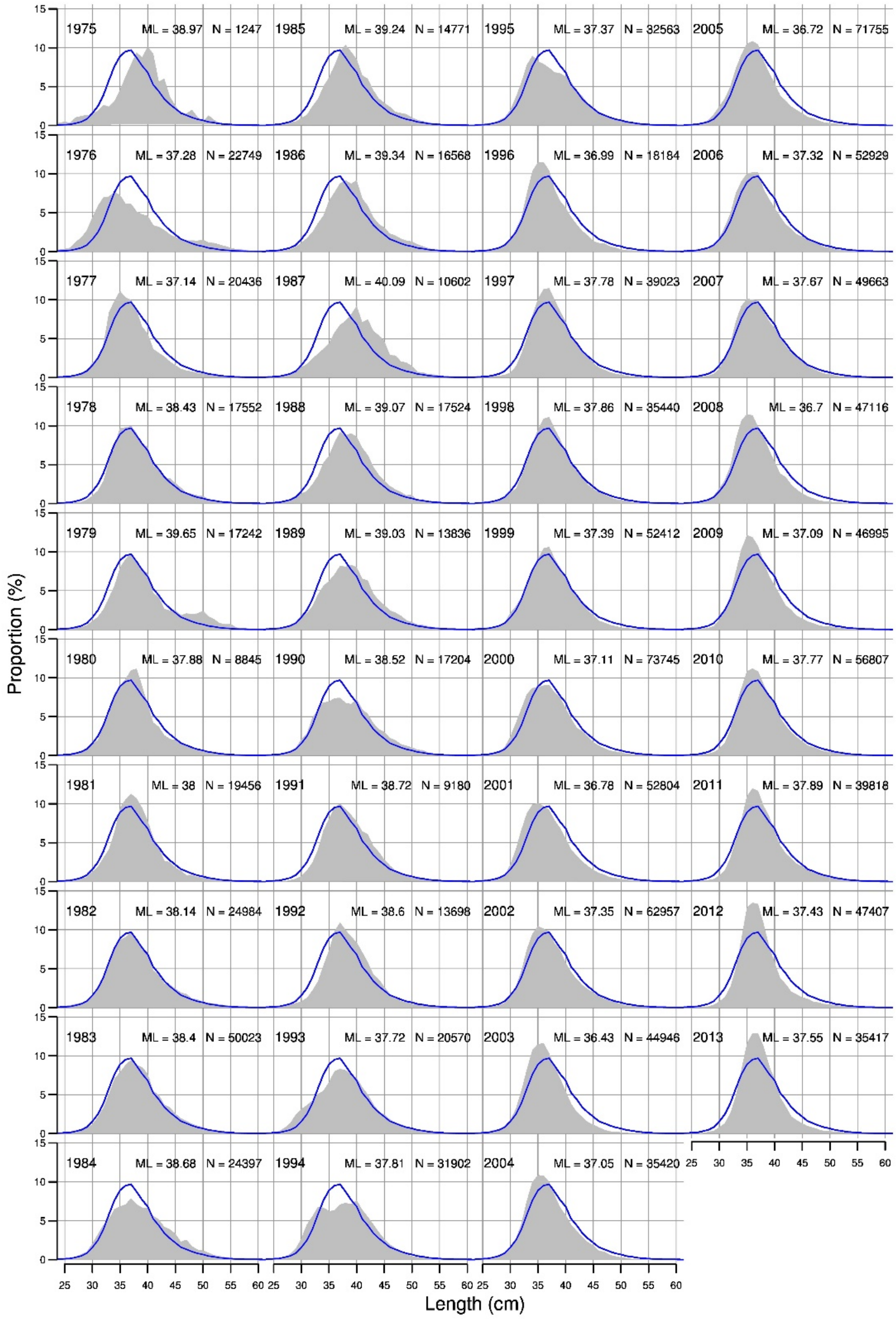


Figure 18.3.3 Length distribution (gray shaded area) of golden redfish in the commercial landings of the Icelandic bottom trawl fleet 1975-2013. The blue line is the mean of the years 1975-2013.

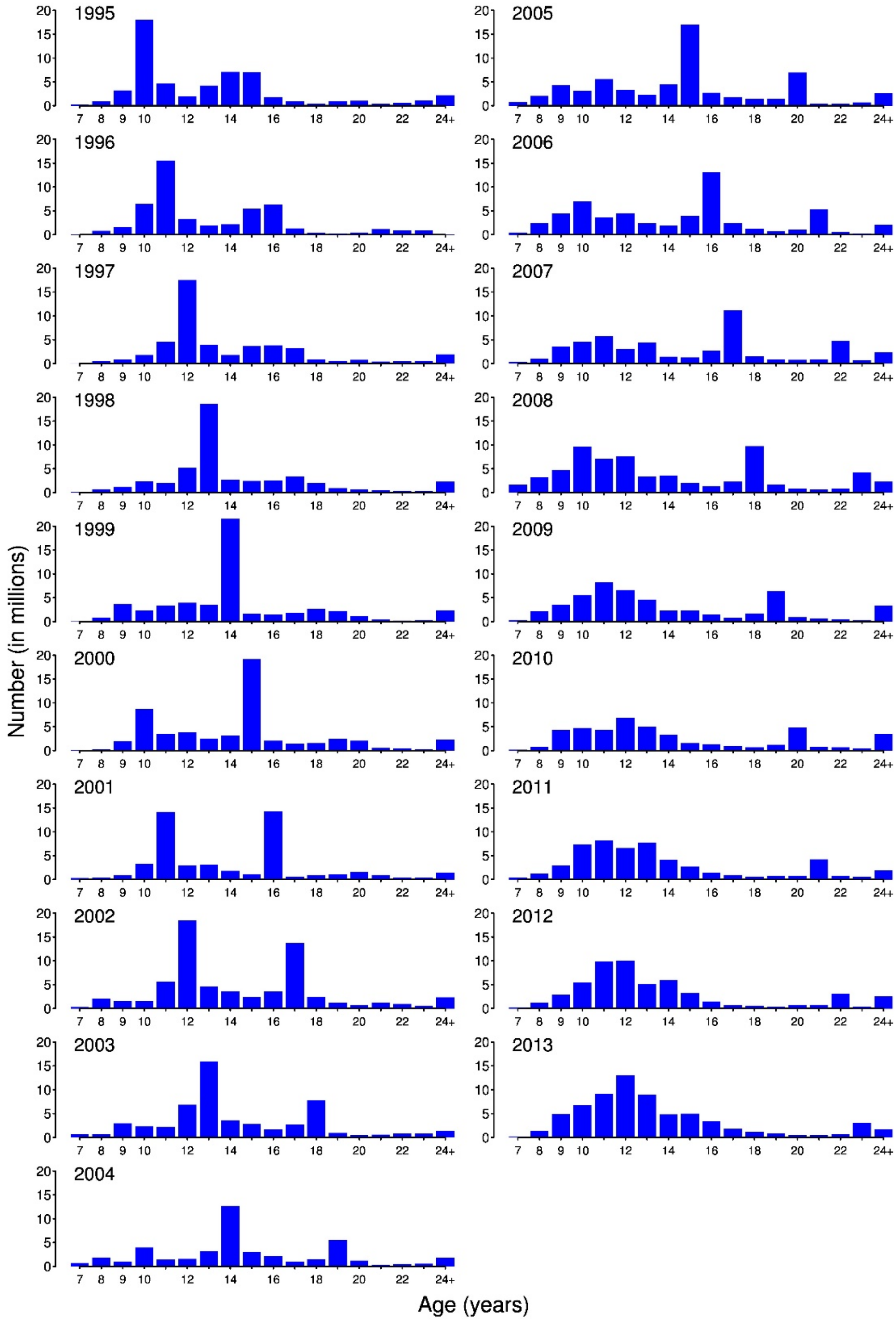


Figure 18.3.4 Catch-at-age of golden redfish in numbers in ICES Subdivision Va 1995-2013.

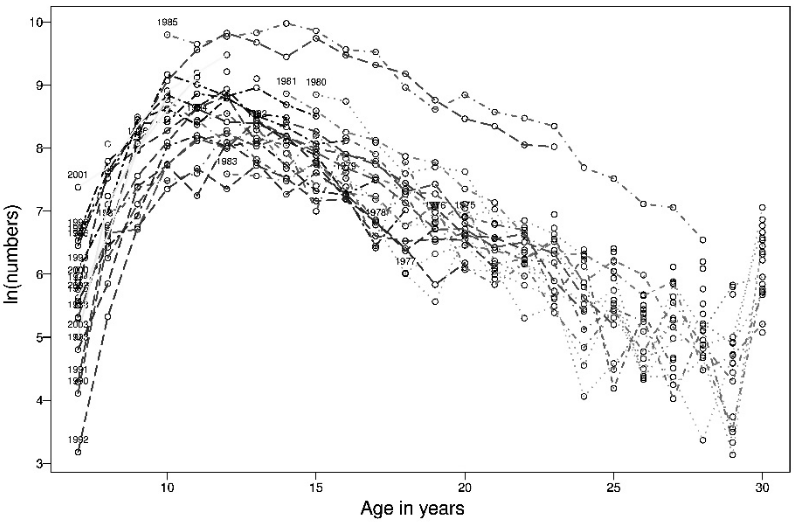


Figure 18.3.5 Catch curve of golden redfish based on the catch-at-age data in ICES Division Va 1995-2013.

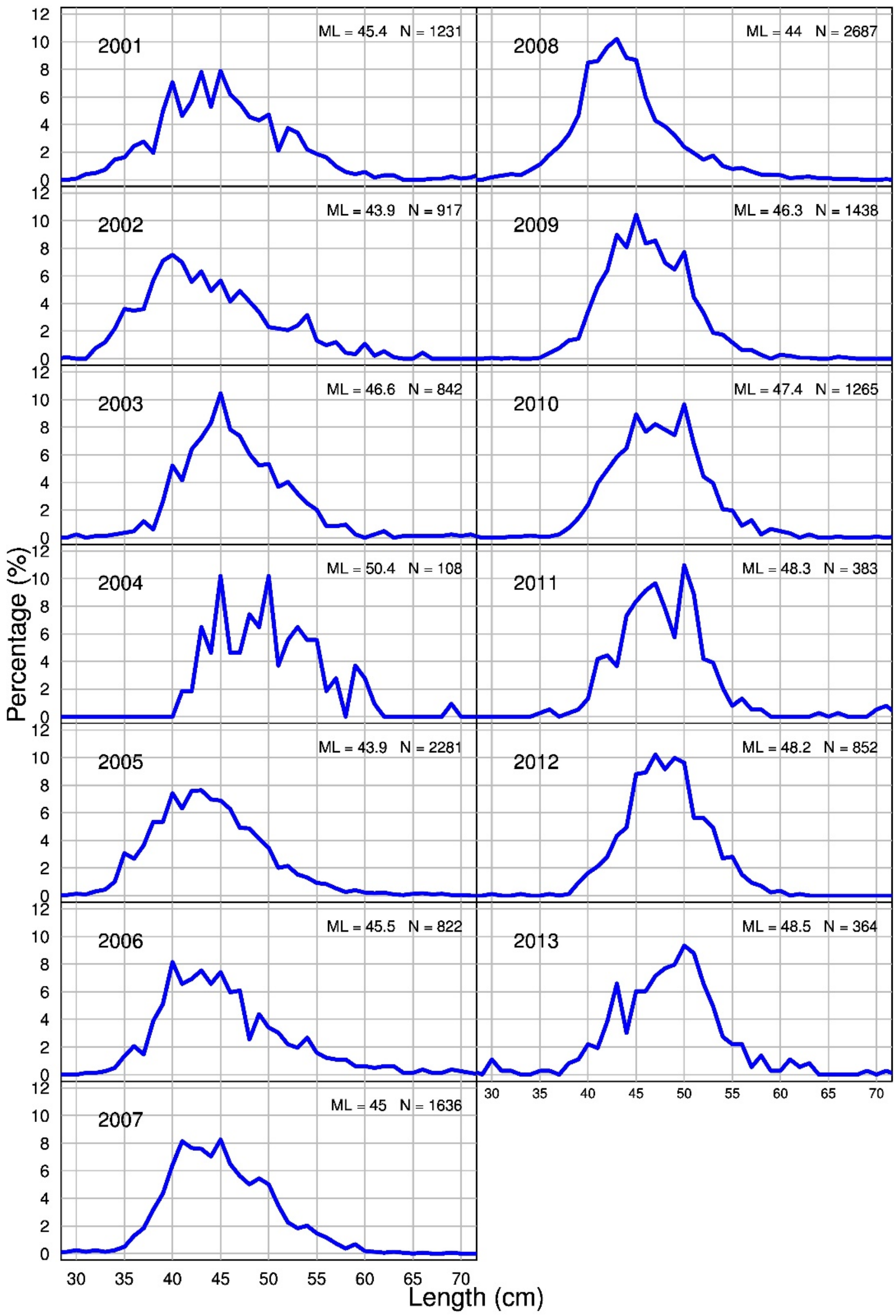


Figure 18.3.6 Length distribution of golden redfish from Faroese catches in 2001-2013.

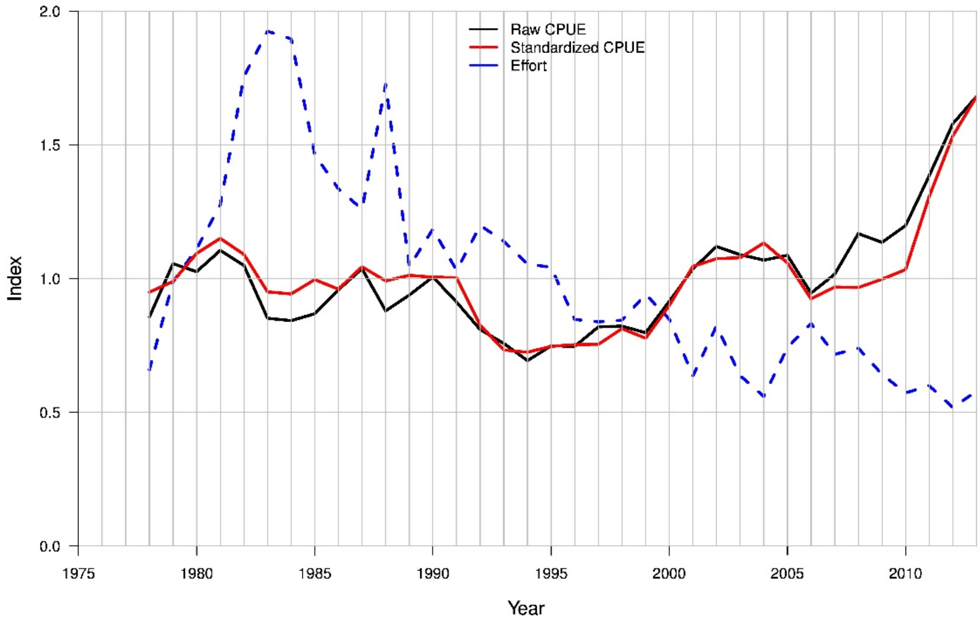


Figure 18.3.7 CPUE of golden redfish from Icelandic trawlers based on results from the GLM model 1978-2013 where golden redfish catch composed at least 50% of the total catch in each haul. The figure shows the raw CPUE index (sum(yield)/sum(effort)), standardized CPUE index estimated using a generalized linear model, and effort (blue dotted line).

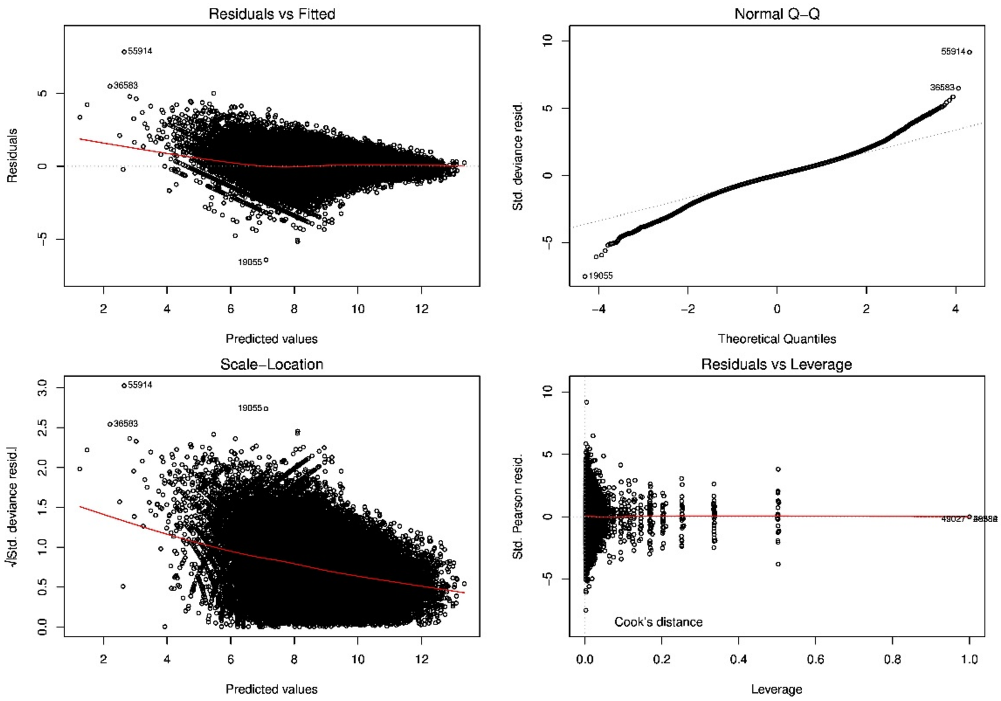


Figure 18.3.8 Results from the GLM modle (section 8.2.1) for the CPUE series of golden redfish in Va. From left to right, top to bottom: Residuals against fitted values; square root of the absolute value of residuals against predicted values; response against fitted values; normal QQplot of standardized residuals.

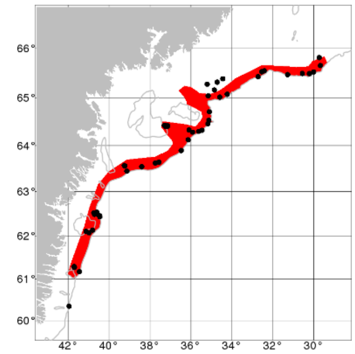


Figure 18.4.1 Stations in the German survey in East Greenland with an area used to compile the indices for Gadget shown. This area corresponds to giving a weight of 0.5 to the results in figure 17.2.7.

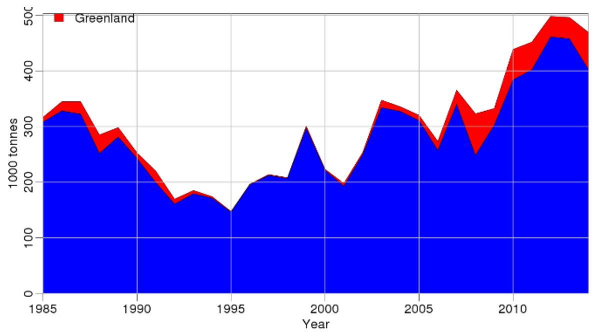


Figure 18.4.2 Biomass index from Iceland (blue) and Greenland black, based on weighting the German survey data in Figure 18.2.7 by 0.5.

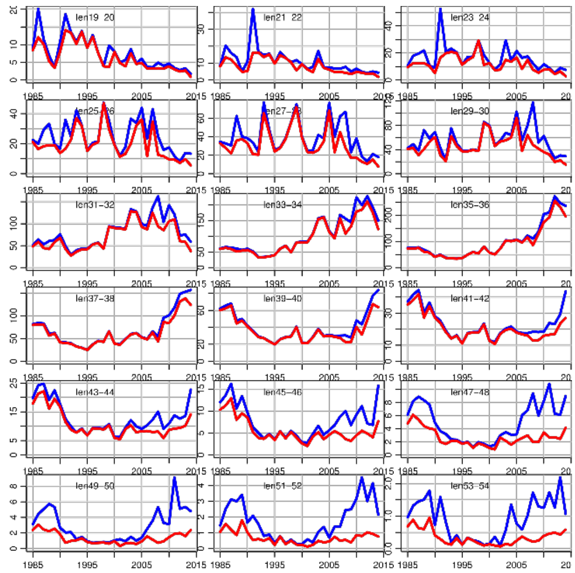


Figure 18.4.3. Indices from the Icelandic March survey (red) and Icelandic March survey plus German survey in Greenland (blue) by length group.

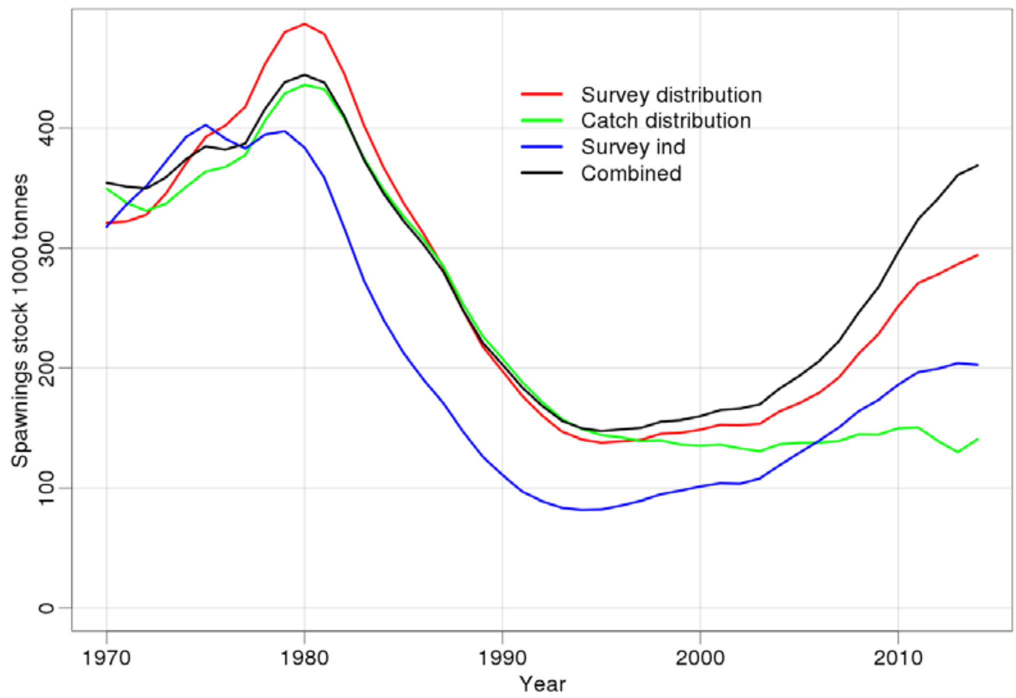


Figure 18.4.4. Development of SSB from run where certain compontents of the likelihood function weighted much more than the other components.

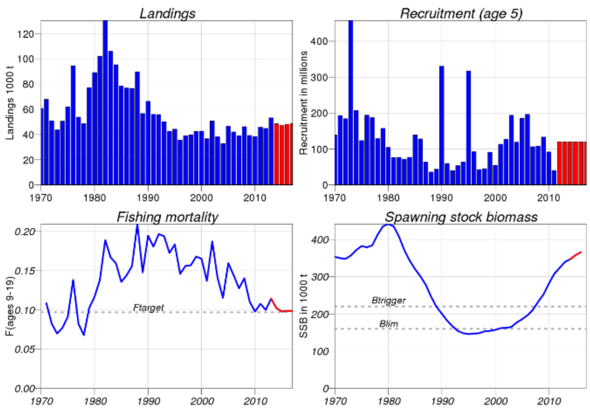


Figure 18.4.5. Summary from the assessment. Red values are predictions. Spawning stock is compiled using a fixed maturity ogive with L50=33cm.

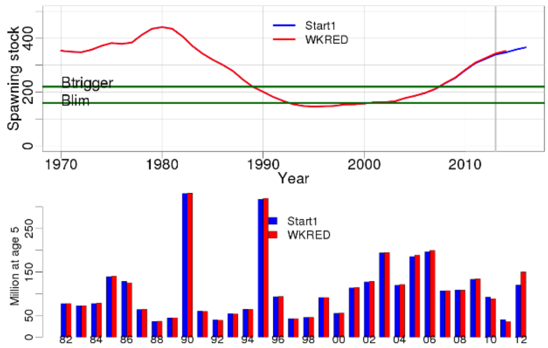


Figure 18.4.6. Comparison of the current assessment and the same assessment done at WKREDMP in January 2014.

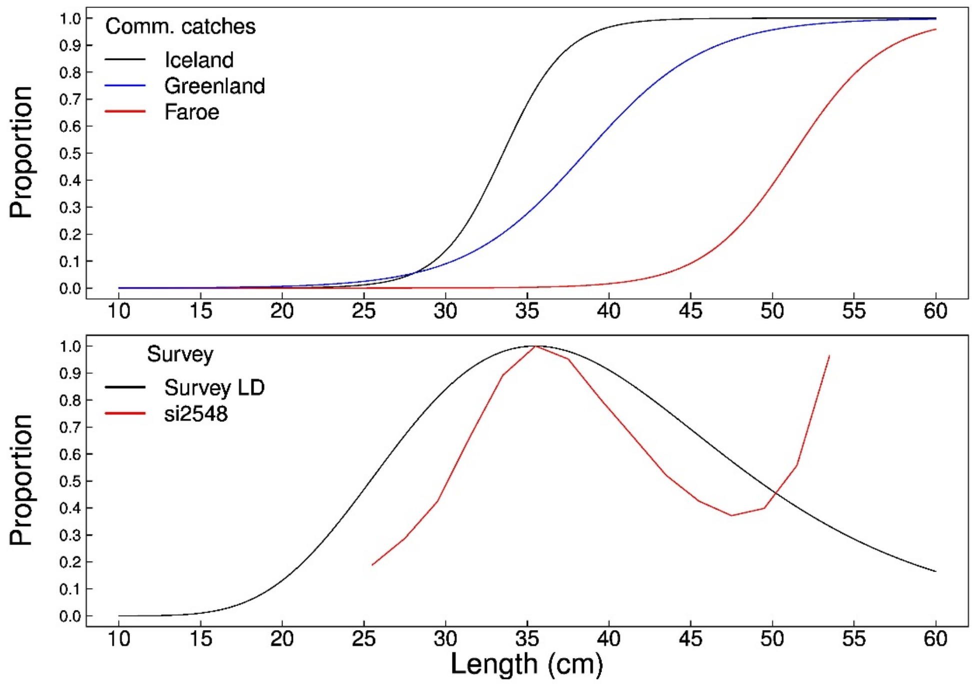


Figure 18.4.7. Estimates of selection curves from commercial catches (upper panel) and from the Icelandic March survey. The black line is the estimated selection curve fitted to the length distributional data (Figure 18.4.14) and the red line is the estimated q from the disaggregated tuning indices, scaled to one.

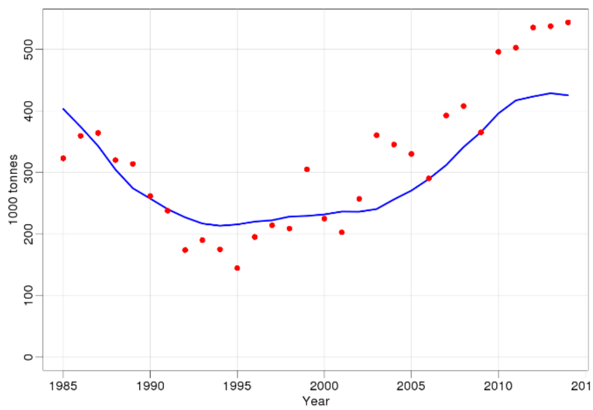


Figure 18.4.8. Comparison of observed and predicted survey biomass.

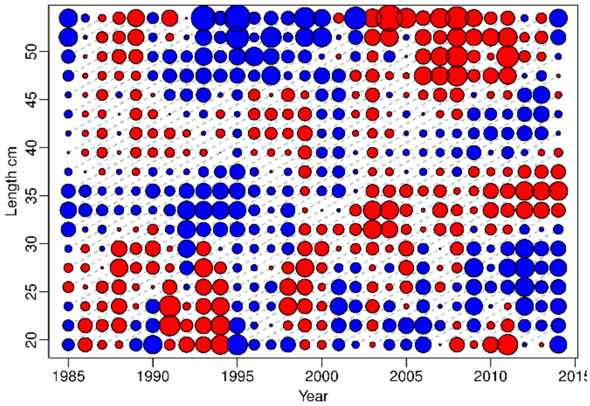


Figure 18.4.9. Residuals from the fit between model (run 1) and survey indices. The red circles indicate positive residuals (survey results exceed model prediction). Largest residuals correspond to log(obs/mod) = 1

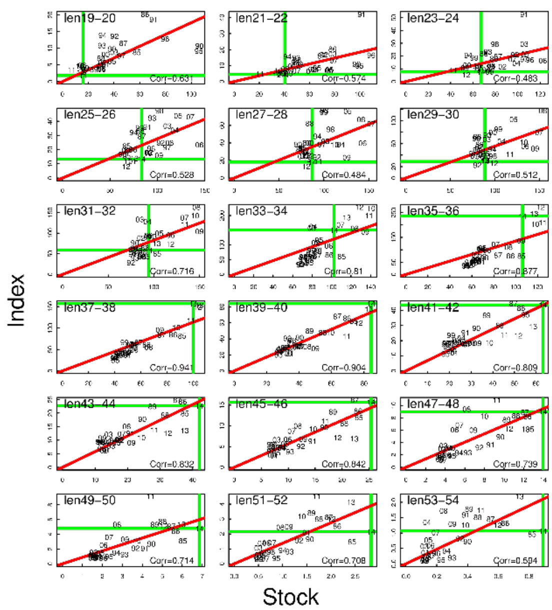


Figure 18.4.10. Fit to length disaggregated survey indices from Gadget run 1 as XY-scatter. The red line is fitted going through the 0-point, the green cross goes over the terminal year.

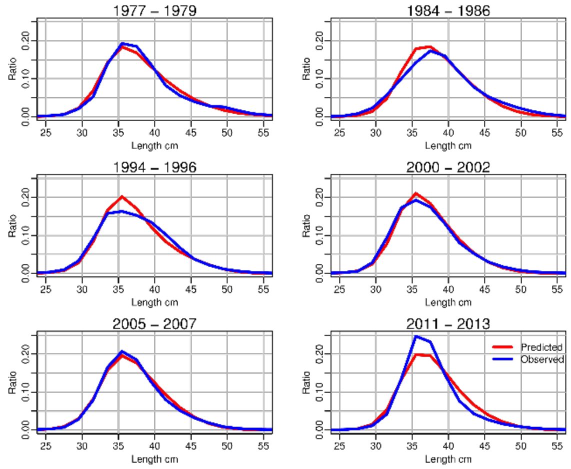


Figure 18.4.11. Fit (red line) to Icelandic commercial length distributions aggregated by 3 years.

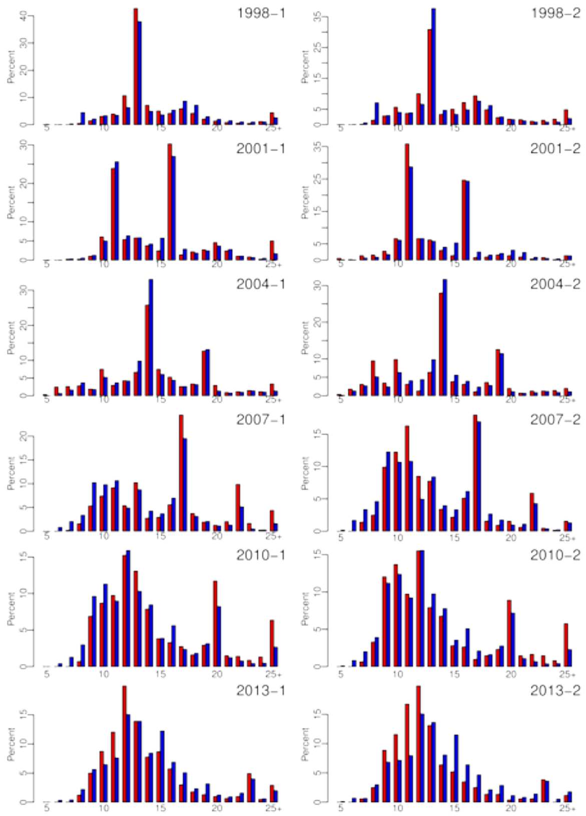


Figure 18.4.12. Predicted (red) and observed (blue) age distributions from Icelandic commerical fishery.

19 Icelandic slope *Sebastes mentella* in Va and XIV

Executive summary

- ICES concluded in February 2009 that *S. mentella* is to be divided to three biological stocks and that the *S. mentella* on the continental shelf and slope of Iceland should be treated as separate biological stock and management unit. This chapter therefore deals only with the Icelandic Slope stock.
- Total landings of demersal *S. mentella* in Icelandic waters in 2013 were about 8 761 t, 3 200 less than in 2012.
- No analytical assessment was conducted and there are no biological reference points for the species. Survey indices from the annual autumn survey since 2000 are used as basis for advice.
- Available survey biomass indices show that in Division Va the biomass has gradually decreased from 2006 and is at similar level as in 2003 when it was lowest in the time series.
- The East-Greenland shelf is most likely a nursery area for the stock. No new recruits (>18 cm) are seen in the survey catches of the German survey and the Greenland shrimp and fish shallow water survey conducted in the area and no juveniles are present (<18 cm) recent years.

19.1 Stock description and management units

The stock structure of *S. mentella* in the Irminger Sea and adjacent water is described in Chapter 16 and Stock Annex. The *S. mentella* on the continental shelf and slope of Iceland is treated as separate biological stock and management unit. Only the fishable stock of Icelandic slope *S. mentella* is found in Icelandic waters, i.e. mainly fish larger than 30 cm. The East-Greenland shelf is most likely a common nursery area for the three biological stocks described in Stock Annex, including the Icelandic slope one.

19.2 Scientific data

Only the fishable stock of Icelandic slope *S. mentella* is found in Icelandic waters. The Icelandic autumn survey on the continental shelf and slope in Division Va, covering depths down to 1,500 m, does, therefore, not cover the whole distribution of the stock. Data for Icelandic slope *S. mentella* from the Autumn Survey is available from 2000-2013. No survey was conducted in 2011. A description of the autumn survey is given in Stock Annex for the species.

The survey area was re-stratified in 2008 (detailed description is found in the Stock Annex B.3 for the species). In general, the number of strata was reduced and subsequently number of station per stratum increased. The aim of this revision was to reduce the weight of certain tows (the few but large tows that account for the bulk of the total catch of some species such as Icelandic slope *S. mentella*) and to reduce area weight. At the edge of the survey area some strata were reduced in size. The total biomass indices showed similar trend for Icelandic slope *S. mentella*, but the measurement errors (CV) based on the new stratification are in some years lower than the ones based on the old one.

The total biomass index and the abundance indices from the autumn survey were highest in 2001. After a decrease in 2003 the index increased again in 2006 but has since then gradually decreased and was in 2013 at similar level as in 2003 when it was lowest in the time series (Table 8.2.1 and Figure 19.2.1*a* and *b*). The biomass index of fish larger than 45 cm was at lowest level in 2007 but increased again and was in 2010 similar to the 2001 value and has been at that level since then (Figure 19.2.1*c*). The abundance index of fish smaller than 30 cm has in 2007-2013 been at lowest level (Figure 19.2.2*d*). The length of the Icelandic slope *S. mentella* in the autumn survey is between 25 and more than 50 cm. Since 2000, the mode has shifted to the right, that is, from 36-39 cm in 2000 to about 42-43 cm in 2013 (Figure 19.2.2). Very little Icelandic slope *S. mentella* smaller than 35 cm was observed in the 2013 survey.

Otoliths have been sampled since 2000 and otoliths from the 2000, 2009 and 2010 surveys have been age read. Figure 19.2.3 shows that the 1985 and the 1990 year classes are the most abundant ones in this samples.

19.3 Information from the fishing industry

19.3.1 Landings

Total annual landings of Icelandic slope *S. mentella* from ICES Division Va 1978-2013 are presented in Table 19.3.1 and from 1950-2013 in Figure 19.3.1. Annual landings gradually decreased from a record high of 57 000 t in 1994 to 17 000 t in 2001 t. Landings in 2001-2010 fluctuated between 17 000 t and 20 500 except in 2003 and 2008 when annual landings were 28 500 t and 24 000 respectively. The landings in 2013 were about 8 761 t, 3 200 t less than 2012. The decrease is related to lower TAC for the species.

19.3.2 Fisheries and fleets

Most of the fishery for Icelandic slope *S. mentella* in Va is a directed bottom trawl fishery taken by bottom trawlers along the shelf and slope west, southwest, and southeast of Iceland at depths between 500 and 800 m (Figure 19.3.2). The proportion of Icelandic slope *S. mentella* catches taken by pelagic trawls 1991-2000 varied between 10 and 44% of the total landings (Table 19.3.2). In 2001-2013, no pelagic fishery occurred or it was negligible except in 2003 and 2007 (see Stock Annex). In general, the pelagic fishery was mainly in the same areas as the bottom trawl fishery (Figure 19.3.3), but usually in later months of the year (Figure 19.3.4). The bottom trawl catches in the third and fourth quarter of the year decreased considerable in 2001-2007 compared with earlier years but increased again in 2008-2013 (Figure 19.3.4).

A notable change in the catch pattern is that catches taken in the southeast fishing area has been gradually decreasing since 2000 and in recent years very little Icelandic slope *S. mentella* was taken on these fishing grounds (Figure 19.3.2). This area has historically been an important fishing area for Icelandic slope *S. mentella*.

19.3.3 Sampling from the commercial fishery

The table below shows the 2013 biological sampling from the catch and landings of Icelandic slope *S. mentella* in ICES Division Va. This is considered to be adequate sampling from the fishery. Otoliths from the commercial catch have been collected, but no systematic age reading is done.

Year	Nation	Gear	Landings (t)	No. samples	No. length measured
Va	Iceland	Bottom trawl	8 761	56	9 013

19.3.4 Length distribution from the commercial catch

Length distributions of Icelandic slope *S. mentella* in Va from the bottom trawl fishery show an increase in the number of small fish in the catch in 1994 compared to previous years (Figure 19.3.5). The peak of about 32 cm in 1994 can be followed by approximately 1 cm annual growth in 1996-2002. The fish caught in 2004-2013 peaked around 39-42 cm. The length distribution of Icelandic slope *S. mentella* from the pelagic fishery, where available, showed that in most years the fish was on average bigger than taken in the bottom trawl fishery (Figure 19.3.5).

19.3.5 Catch per unit effort

Trends in both standardized (glm) and raw CPUE and effort are shown in Figure 19.3.6. CPUE gradually decreased from 1978 to a record low in 1994, but has since then slightly increased annually to 2000. The CPUE estimate in 2013 was at similar level as in late 1980s and about 40% higher than it was in 1994. CPUE in 2013 was similar as in 2012. From 1991 to 1994, when CPUE decreased, the fishing effort increased drastically. Since then, effort decreased and is now at similar level as in the early 1980s. Output of the model is given in Table 19.3.3 and the model residuals in Figure 19.3.7.

19.3.6 Discard

Although no direct measurements are available on discards, it is believed that there are no significant discards of Icelandic slope *S. mentella* in the Icelandic redfish fishery.

19.4 Methods

No analytical assessment was conducted on this stock.

19.5 Reference points

There are no biological reference points for the species. Previous reference points established were based upon commercial CPUE indices, but are now considered to be unreliable indicators of stock size. ICES has withdrawn these reference points.

Icelandic slope beaked redfish in ICES Division Va has previously been assessed based on trends in survey biomass indices from the Icelandic Autumn survey or in ICES “trends based assessment”. Supplementary data used in the assessment includes information from the fishery and length distributions from the commercial catch and the Autumn Survey. ICES advised in 2013, based on DLS approach (Method 3.2), that catches are set no higher than 9 875 t. The TAC set by the Icelandic government was 10 000 t.

19.6 State of the stock

The Group concludes that the state of the stock is on a low level. With the information at hand, current exploitation rates cannot be evaluated for the Icelandic slope *S. mentella* in Division Va.

The fishable biomass index of Icelandic slope *S. mentella* from the Icelandic autumn survey shows that the biomass index for 2004-2013 has decreased and was in 2013 at similar level as in 2003 when it was at lowest level. The survey was not conducted in 2011. Standardised CPUE indices show a reduction from highs in the late 1980s, but there is an indication that the stock has started a slow recovery since the middle of 1990s, when CPUE was close to 50% of the maximum. The CPUE index has been stable since 2000.

In 2000-2008, good recruitment was been observed in the German survey on the East Greenland shelf (growth of about 2cm/yr) which is assumed to contribute to both the Icelandic slope and pelagic stock at unknown shares. The German survey and the Greenland shrimp and fish shallow water survey both show no new recruits (>18 cm) and no juveniles are present (<18 cm). This suggests that the fishery in coming years will be based on the same cohorts.

19.7 Management considerations

S. mentella is a slow growing, late maturing deep-sea species and is therefore considered vulnerable to overexploitation and advice has to be conservative.

The CPUE has slightly increased annually since a record low in 1994, especially in recent 3-4 years and is now 40% higher than in 1994. It is, however, not known to what extent CPUE series reflect change in stock status of Icelandic slope *S. mentella*. The nature of the redfish fishery is targeting schools of fish using advancing technology. The effect of technological advances is to increase CPUE, but is unlikely to reflect biomass increase.

The advice for 2008-2012 was that a management plan to be developed and implemented which takes into account the uncertainties in science and the properties of the fisheries. ICES suggested that catches of *S. mentella* are set no higher than 10 000 t as a starting point for the adaptive part of the management plan. The advice for 2014 was 9 875 t based on the DLS approach (Category 3.2).

The Icelandic slope *S. mentella* fishery southeast of Iceland has gradually ceased since 2000 and very little fishing is conducted in this area. This fishing area was prior to 2000 very important fishing area for Icelandic slope *S. mentella*.

The landings increased in Division Va between 2002 and 2003 by about 10 000 t when the fishery of pelagic *S. mentella* merged with the Icelandic slope fishery at the redfish line. Those two fisheries merged again in 2007.

There are no explicit management for Icelandic slope *S. mentella* but the species is within the TAC system described in Chapter 7.5. Icelandic authorities gave until the 2010/2011 a joint quota for golden redfish and Icelandic slope *S. mentella* in Icelandic waters, but now give separate quotas for the species. The quota for the 2013/2014 fishing year for Icelandic slope *S. mentella* was set to 10 000 t, similar as the ICES advice.

19.8 Basis for advice

Icelandic slope *S. mentella* is considered a data limited stock (DLS) and should follow the ICES framework for such (Category 3.2). The advice for 2015 is the same as last year. Below is the description of the formulation of the advice for 2014.

Based on the North Western Working Group recommendation, the stock is treated as a stock with survey data, but no proxies for MSY $B_{trigger}$ or F values, are known. This means that the catch advice for 2014 is based on the survey adjusted status quo catch equation:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where *I* is the survey index, *x* is the number of years in the survey average, z=5 and C_{y-1} is the average catch of the last three years. The biomass is estimated to have decreased by 10.4% between 2007-2009 (average of the three years) and 2010 and 2012 (average of the two years, no survey conducted in 2011). This implies a decrease of catches of at most 10.4% in relation to the last three years average catch, corresponding to catch of no more than 12 343 t. However, a precautionary buffer of 20% consistent with the ICES approach is subtracted from this, resulting in catch advice of 9 875 t in 2014.

19.9 Regulation and their effects

There are no explicit management for Icelandic slope *S. mentella*. The species is managed under the ITQ system (see Chapter 7.5.1). Icelandic authorities gave until the 2010/2011 fishing year a joint quota for golden redfish (*S. marinus*) and Icelandic slope *S. mentella*. The separation of quotas was implemented in the fishing year that started September 1, 2010.

A general description of management and regulation of fish populations in Icelandic waters is given in Chapter 7.5 and in Stock Annex A.2 with emphasis on Icelandic slope *S. mentella* where applicable.

19.10 Benchmark meeting in 2012

The WKRED 2012 Benchmark workshop met from 1-8 February 2012 at ICES headquarters in Copenhagen, Denmark. The objective of the workshop were for Icelandic beaked redfish was among other things to agree upon and document the preferred method for evaluating stock status.

Icelandic slope *S. mentella* in ICES Division Va has previously been assessed based on trends in survey biomass indices from the Icelandic Autumn survey. Supplementary data used includes relevant information from the fishery and length distributions from the commercial catch and the Autumn Survey.

For Icelandic slope *S. mentella*, the WKRED-2012 external review panel recommended an alternative assessment method or the Schaefer biomass dynamic model. There was, however, disagreement regarding the biomass dynamic model as a step forward from the current trends based methods. The experts on beaked redfish present at the WKRED-2012 did not support the use of biomass dynamics models because of lack of contrast in the survey data and unrealistic estimates of production from the model given the biology of redfish. NWWG-2012 supports this view.

Table 18.2.1 Total biomass index of Icelandic slope *S. mentella* in the Icelandic Autumn Groundfish survey 2000-2013. No survey was conducted in 2011.

Year	Iceland	cv
2000	138 924	0.145
2001	164 030	0.172
2002	96 923	0.137
2003	64 621	0.127
2004	98 373	0.164
2005	114 953	0.249
2006	124 509	0.172
2007	85 469	0.183
2008	82 703	0.139
2009	99 767	0.183
2010	81 963	0.149
2011		
2012	78 016	0.144
2013	70 250	0.139

Table 18.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* 1978-2013 ICES Division Va.

Year	Iceland	Others	Total
1978	3 693	209	3 902
1979	7 448	246	7 694
1980	9 849	348	10 197
1981	19 242	447	19 689
1982	18 279	213	18 492
1983	36 585	530	37 115
1984	24 271	222	24 493
1985	24 580	188	24 768
1986	18 750	148	18 898
1987	19 132	161	19 293
1988	14 177	113	14 290
1989	40 013	256	40 269
1990	28 214	215	28 429
1991	47 378	273	47 651
1992	43 414	0	43 414
1993	51 221	0	51 221
1994	56 674	46	56 720
1995	48 479	229	48 708
1996	34 508	233	34 741
1997	37 876	0	37 876
1998	32 841	284	33 125
1999	27 475	1 115	28 590
2000	30 185	1 208	31 393
2001	15 415	1 815	17 230
2002	17 870	1 175	19 045
2003	26 295	2 183	28 478
2004	16 226	1 338	17 564
2005	19 109	1 454	20 563
2006	16 339	869	17 208
2007	17 091	282	17 373
2008	24 123	0	24 123
2009	19 430	0	19 430
2010	17 642	0	17 642
2011	11 738	0	11 738
2012	11 965	0	11 965
20131)	8 761	0	8 761

1) Provisional

Table 18.3.2 Proportion of the landings of Icelandic slope *S. mentella* taken in ICES Division Va by pelagic and bottom trawls 1991-2013.

Year	Pelagic trawl	Bottom trawl
1991	22%	78%
1992	27%	73%
1993	32%	68%
1994	44%	56%
1995	36%	64%
1996	31%	69%
1997	11%	89%
1998	37%	63%
1999	10%	90%
2000	24%	76%
2001	3%	97%
2002	3%	97%
2003	28%	72%
2004	0%	100%
2005	0%	100%
2006	0%	100%
2007	17%	83%
2008	0%	100%
2009	0%	100%
2010	0%	100%
2011	0%	100%
2012	0%	100%
2013	0%	100%

Table 18.3.3 Results of the GLM model to calculate standardized CPUE for Icelandic slope redfish fishery in Va. Note that the residuals are shown in Figure 18.3.8.

```
Call: glm(formula = lafli ~ ltogtimi + factor(ar) + as.factor(veman) +
    factor(skipnr) + factor(reitur), family = gaussian(), data = tmp)
Deviance Residuals:
    Min      1Q   Median     3Q     Max
-5.0471  -0.3326   0.0151   0.3495   4.7143
Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)      7.8127956  0.6351737  12.300  < 2e-16 ***
ltogtimi         1.1289743  0.0036478 309.491  < 2e-16 ***
factor(ar)1979   0.0481676  0.0759452   0.634 0.525928
factor(ar)1980   0.1615737  0.0708185   2.282 0.022524 *
factor(ar)1981   0.0531324  0.0714473   0.744 0.457088
factor(ar)1982   0.1141574  0.0677332   1.685 0.091922 .
factor(ar)1983  -0.0201749  0.0658018  -0.307 0.759149
factor(ar)1984  -0.0006674  0.0663865  -0.010 0.991979
factor(ar)1985  -0.0402650  0.0664529  -0.606 0.544574
factor(ar)1986  -0.0133107  0.0669547  -0.199 0.842419
factor(ar)1987   0.0662477  0.0678393   0.977 0.328805
factor(ar)1988  -0.0074033  0.0670420  -0.110 0.912070
factor(ar)1989  -0.0530598  0.0664987  -0.798 0.424930
factor(ar)1990  -0.1050808  0.0649183  -1.619 0.105530
factor(ar)1991  -0.0742978  0.0625743  -1.187 0.235097
factor(ar)1992  -0.3278540  0.0623069  -5.262 1.43e-07 ***
factor(ar)1993  -0.4197133  0.0622775  -6.739 1.62e-11 ***
factor(ar)1994  -0.5349749  0.0623199  -8.584  < 2e-16 ***
factor(ar)1995  -0.4999593  0.0624763  -8.002 1.26e-15 ***
factor(ar)1996  -0.4825627  0.0628669  -7.676 1.69e-14 ***
factor(ar)1997  -0.4211458  0.0627374  -6.713 1.94e-11 ***
factor(ar)1998  -0.4266753  0.0638911  -6.678 2.46e-11 ***
factor(ar)1999  -0.3735611  0.0633751  -5.894 3.80e-09 ***
factor(ar)2000  -0.3190459  0.0637808  -5.002 5.70e-07 ***
factor(ar)2001  -0.3186263  0.0648443  -4.914 8.98e-07 ***
factor(ar)2002  -0.3572821  0.0640375  -5.579 2.43e-08 ***
factor(ar)2003  -0.2826736  0.0640620  -4.412 1.03e-05 ***
```

```
factor(ar)2004     -0.3540496  0.0644457  -5.494 3.96e-08 ***
factor(ar)2005     -0.3565041  0.0637665  -5.591 2.28e-08 ***
factor(ar)2006     -0.3646533  0.0642721  -5.674 1.41e-08 ***
factor(ar)2007     -0.3615773  0.0659392  -5.483 4.20e-08 ***
factor(ar)2008     -0.2850310  0.0649483  -4.389 1.14e-05 ***
factor(ar)2009     -0.3287797  0.0655624  -5.015 5.34e-07 ***
factor(ar)2010     -0.3012304  0.0659162  -4.570 4.90e-06 ***
factor(ar)2011     -0.1889722  0.0661157  -2.858 0.004263 **
factor(ar)2012     -0.2935987  0.0664127  -4.421 9.86e-06 ***
factor(ar)2013     -0.2670277  0.0679110  -3.932 8.44e-05 ***
as.factor(veman)2   0.1250368  0.0147128   8.499  < 2e-16 ***
as.factor(veman)3   0.1374460  0.0154991   8.868  < 2e-16 ***
as.factor(veman)4   0.1183179  0.0154998   7.633 2.35e-14 ***
as.factor(veman)5   0.0295244  0.0168979   1.747 0.080607 .
as.factor(veman)6  -0.0038583  0.0193320  -0.200 0.841810
as.factor(veman)7  -0.1070731  0.0199098  -5.378 7.59e-08 ***
as.factor(veman)8  -0.0980051  0.0191263  -5.124 3.01e-07 ***
as.factor(veman)9  -0.0523508  0.0165151  -3.170 0.001526 **
as.factor(veman)10 -0.0433386  0.0154207  -2.810 0.004951 **
as.factor(veman)11 -0.0775967  0.0157373  -4.931 8.23e-07 ***
as.factor(veman)12 -0.1293661  0.0164904  -7.845 4.46e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
(Dispersion parameter for gaussian family taken to be 0.3894023)
    Null deviance: 60228  on 32728  degrees of freedom
Residual deviance: 12614  on 32394  degrees of freedom
AIC: 62348
Number of Fisher Scoring iterations: 2
---------------------------------------------------------------
Analysis of Deviance Table
Model: gaussian, link: identity
Response: lafli
Terms added sequentially (first to last)

                Df Deviance Resid. Df Resid. Dev       F    Pr(>F)
NULL                            32728      60228
```

```
ltogtimi           1    43109     32727      17119 110704.574 < 2.2e-16 ***
factor(ar)        35     1377     32692      15742    101.034 < 2.2e-16 ***
as.factor(veman)  11      274     32681      15468     63.880 < 2.2e-16 ***
factor(skipnr)   157     1875     32524      13594     30.663 < 2.2e-16 ***
factor(reitur)   130      980     32394      12614     19.350 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
```

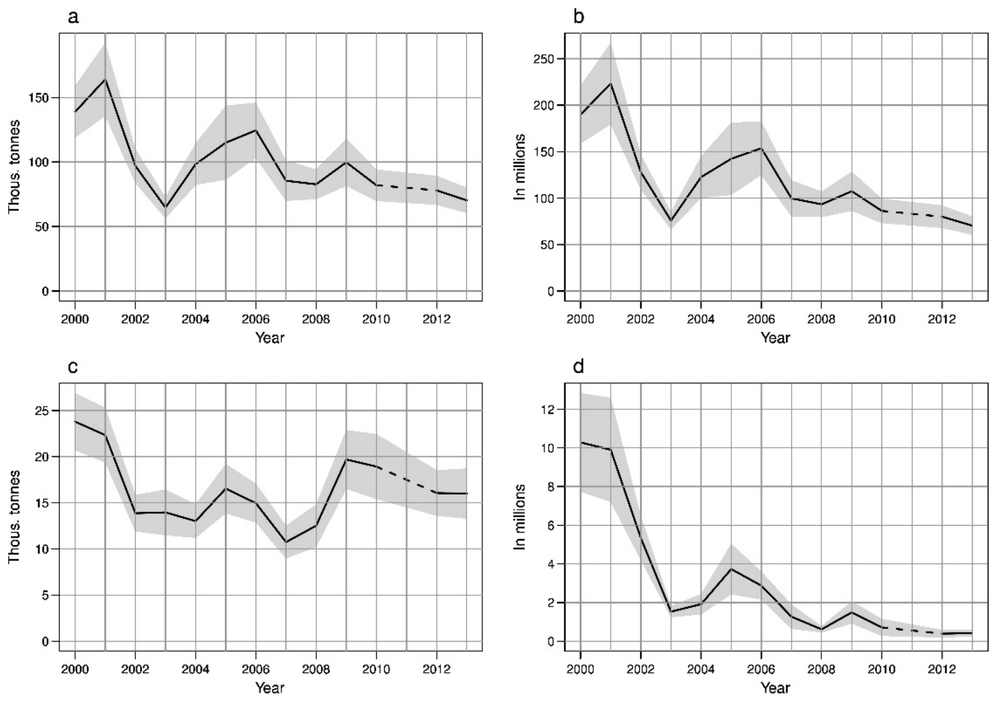


Figure 18.2.1 Survey indices of the Icelandic slope *S. mentella* in the autumn survey in ICES Division Va 2000-2013. No survey was conducted in 2011. a) Total biomass index. b) Total abundance index in millions of fish. c) Biomass index of fish larger than 45 cm. d) Abundance index of fish smaller than 30 cm.

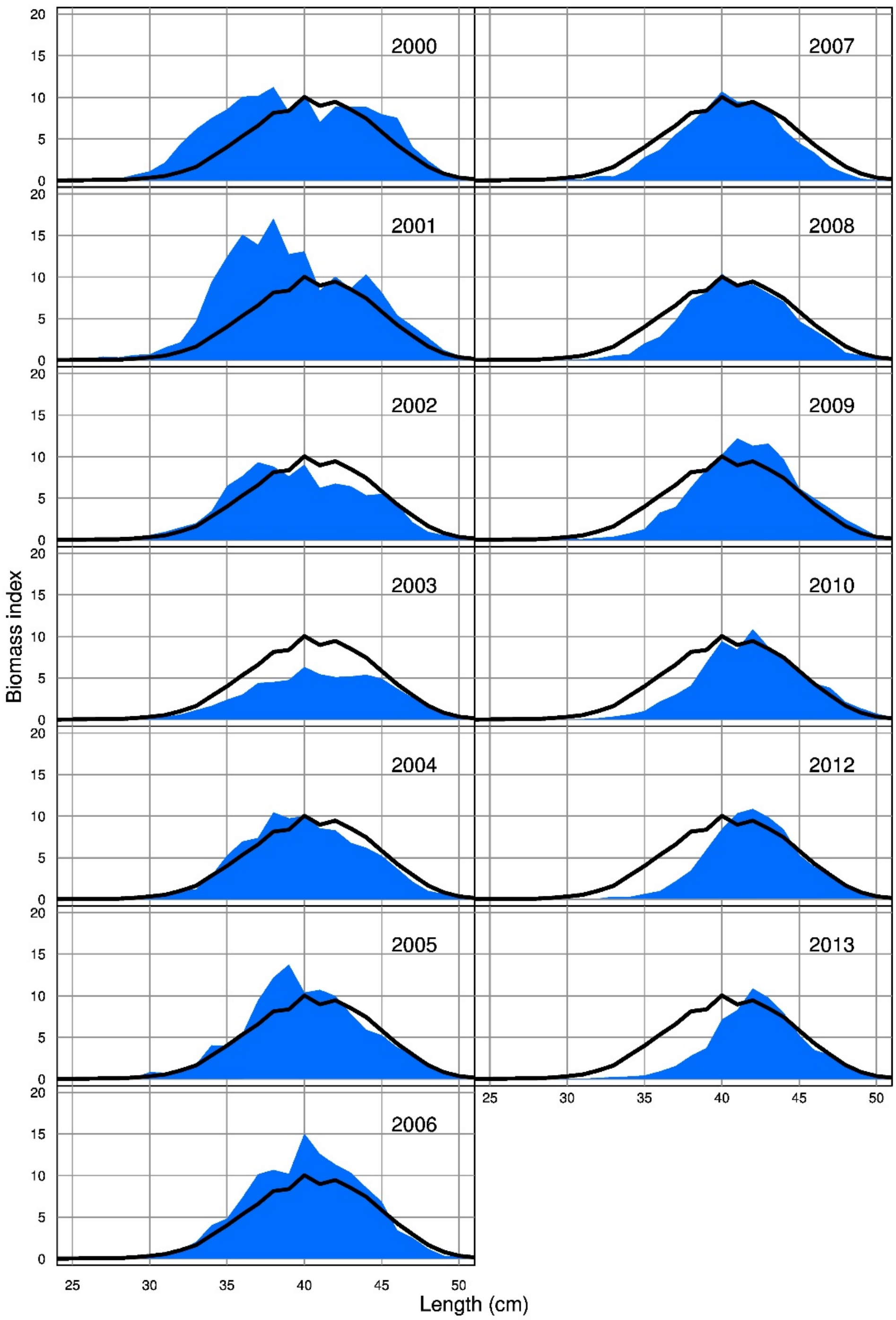


Figure 18.2.2 Length distribution of Icelandic slope *S. mentella* in the Autumn Groundfish Survey in October 2000-2013 in ICES Division Va. No survey was conducted in 2011. The black line is the mean of 2000-2013.

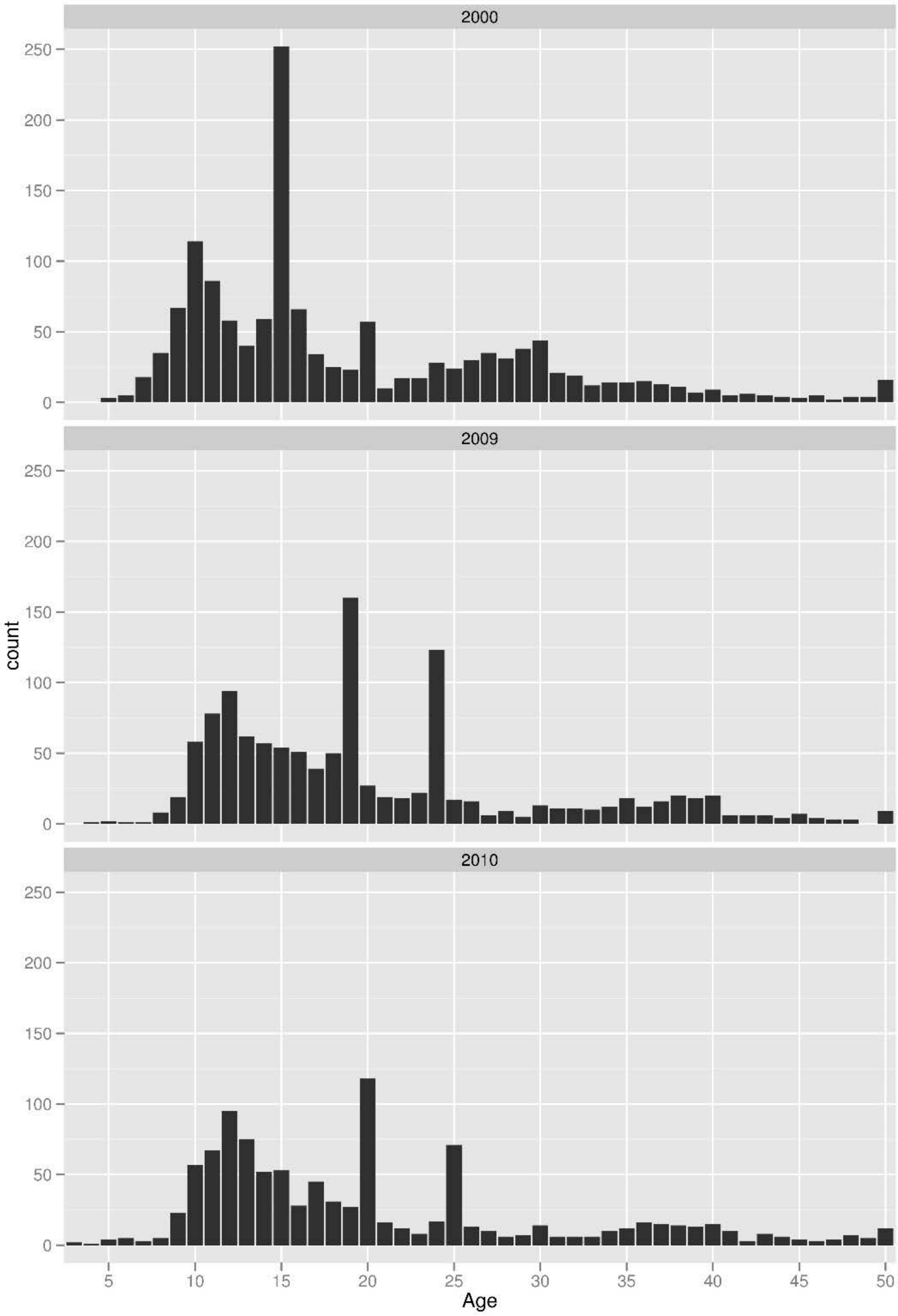


Figure 18.2.3 Age distribution of Icelandic slope *S. mentella* from the Autumn Survey in 2000 (n = 1 405), 2009 (n = 1 101), and 2010 (n = 1 206). The age class 50 are the combined age-classes of 50 years and older.

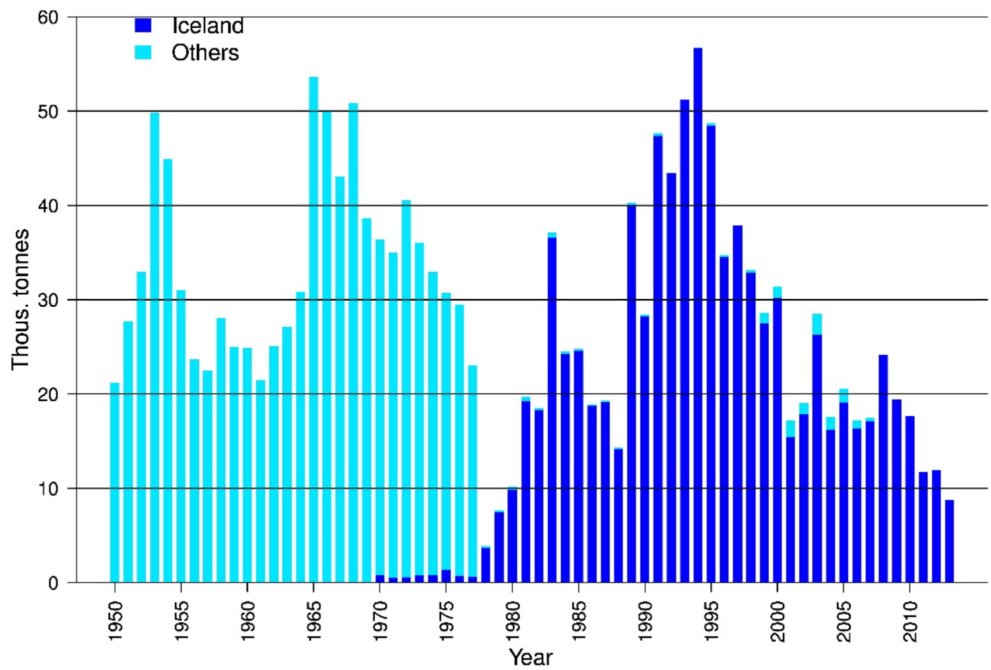


Figure 18.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* from ICES Divisions Va 1950-2013.

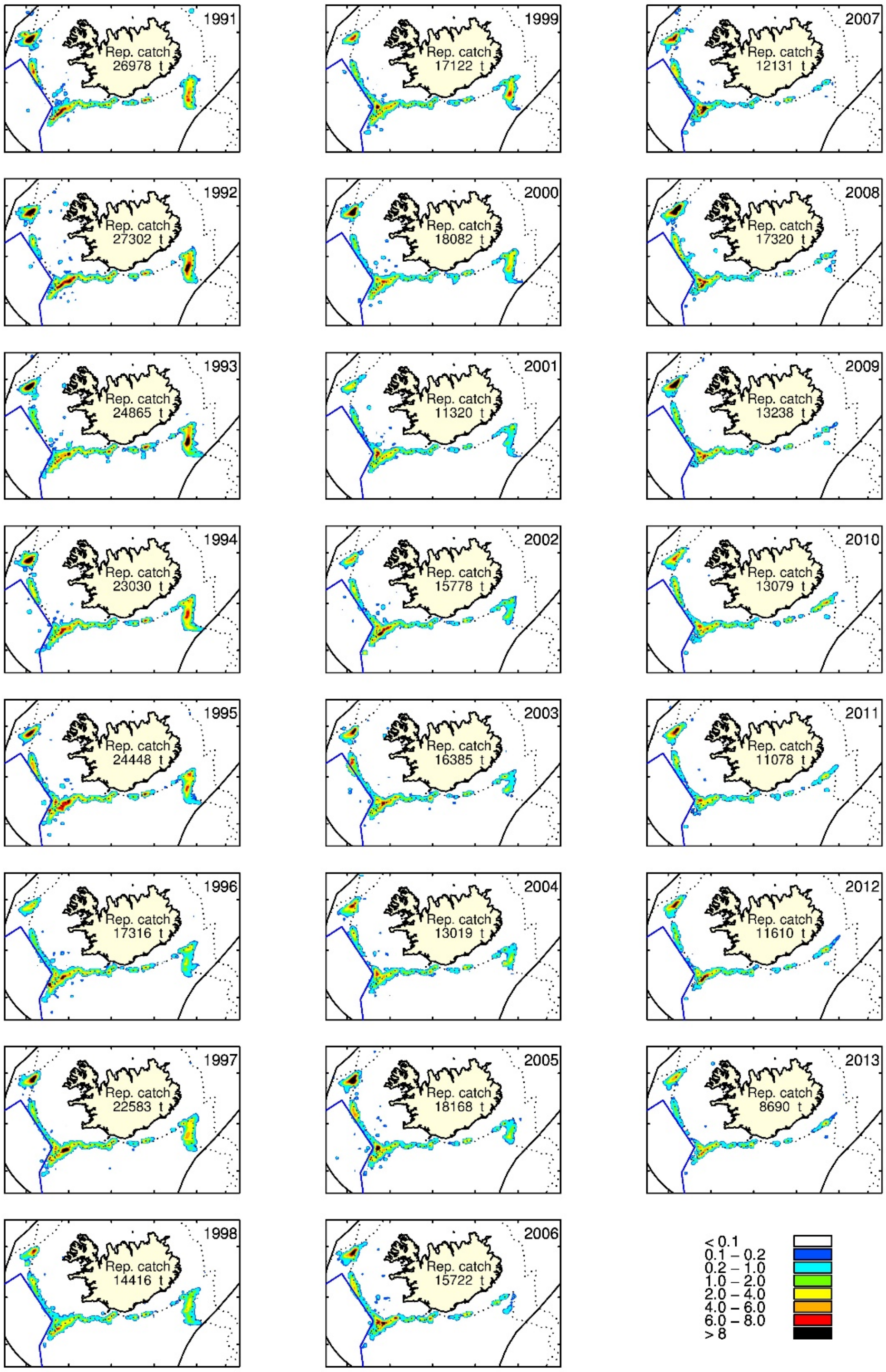


Figure 18.3.2 Geographical location of the Icelandic slope *S. mentella* catches in Icelandic waters (ICES Division Va and XIV) 1991-2013 as reported in log-books of the Icelandic fleet using bottom trawl. The blue line indicates part of the proposed management unit for the deep-pelagic redfish stock. The dotted line represents the 500 m isobaths.

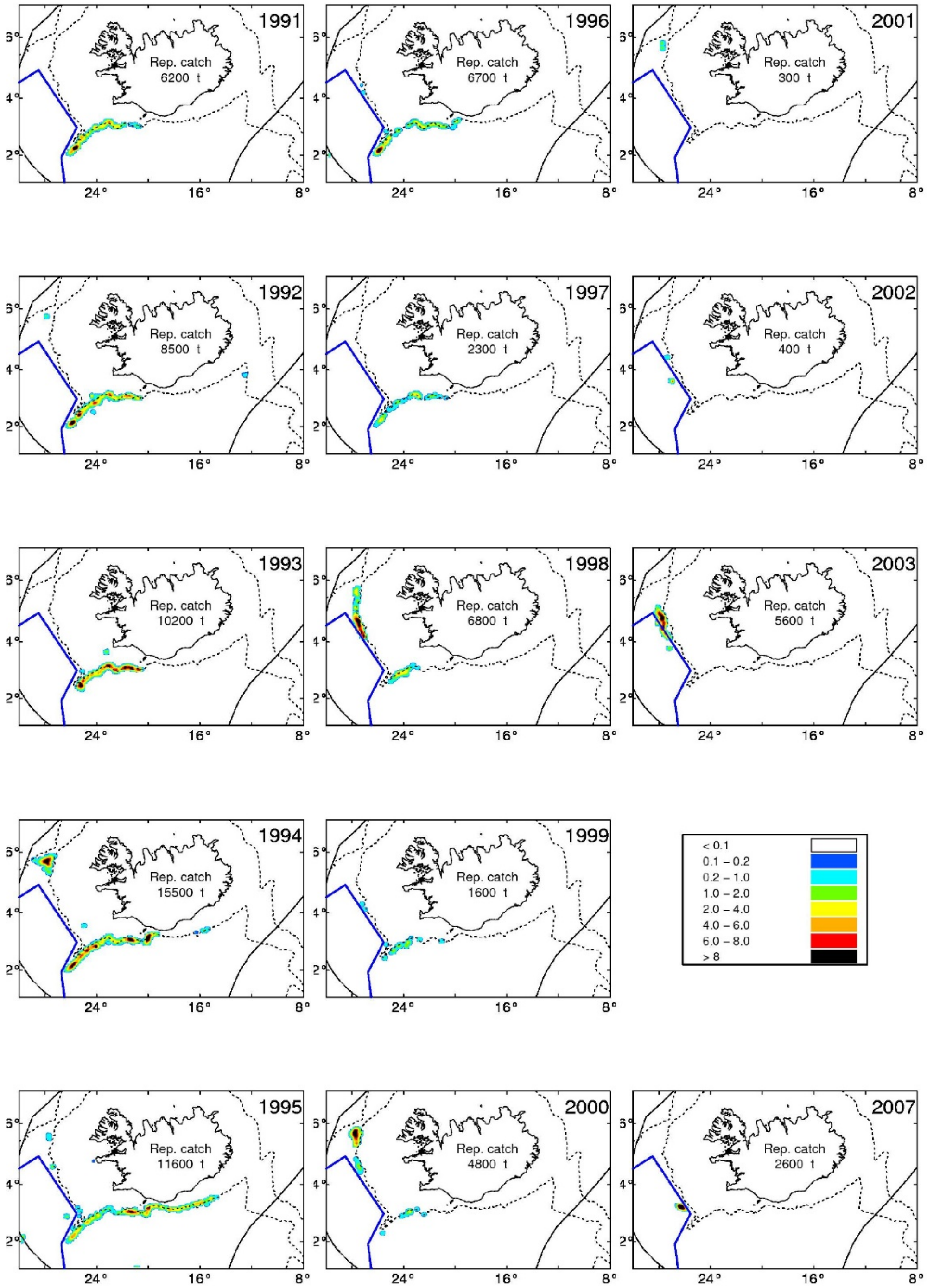


Figure 18.3.3 Geographical location of the Icelandic slope *S. mentella* catches in Icelandic waters (ICES Division Va and XIV) 1991-2003 and 2007 as reported in log-books of the Icelandic fleet using pelagic trawl. The blue line indicates part of the proposed management unit for the deep-pelagic redfish stock. The dotted line represents the 500 m isobaths.

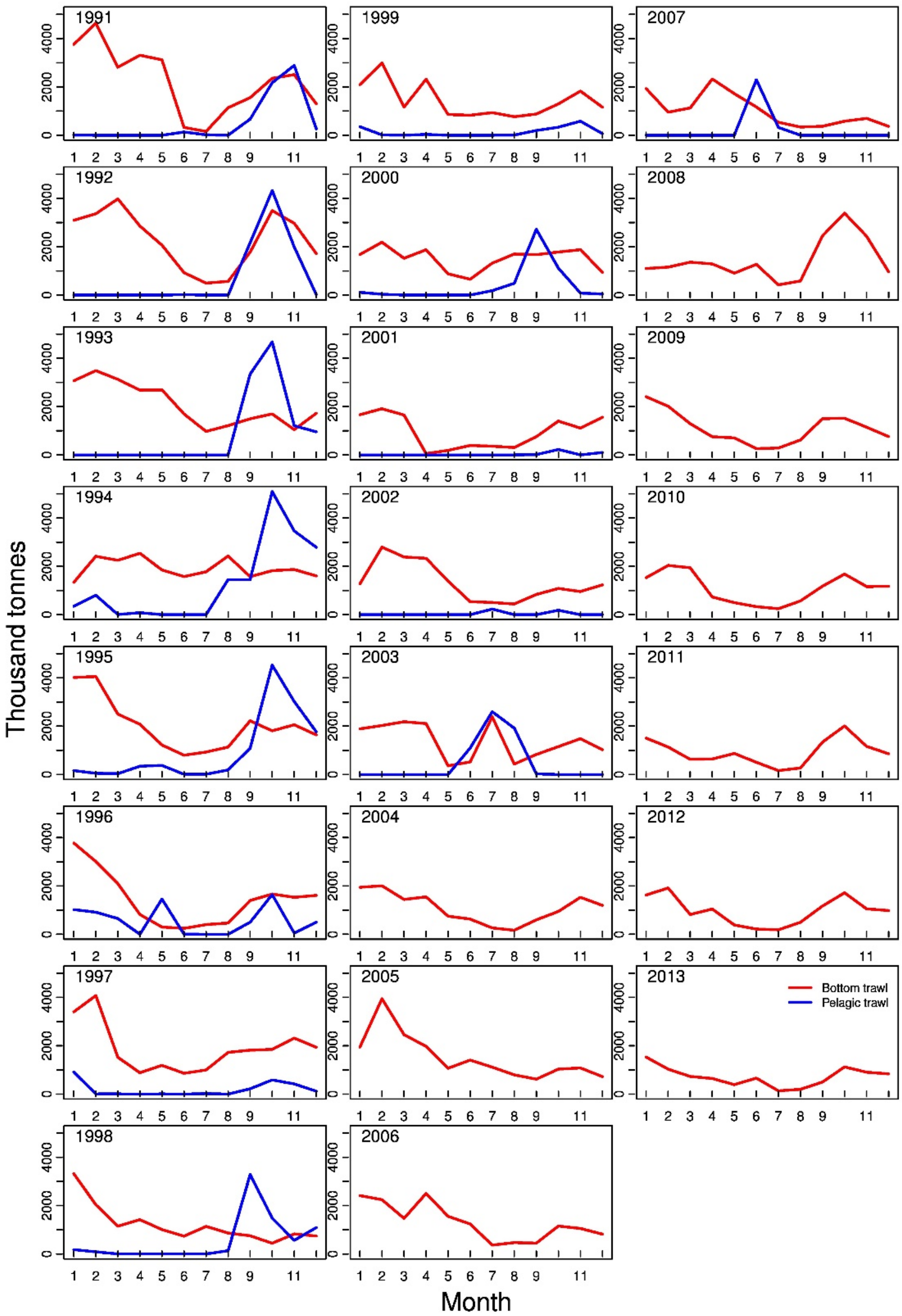


Figure 18.3.4 Nominal landings (in tonnes) of Icelandic slope *S. mentella* in Icelandic waters (ICES Division Va and XIV) of the Icelandic fleet using either bottom trawl (red line) or pelagic trawl (blue line) 1991-2013 divided by month.

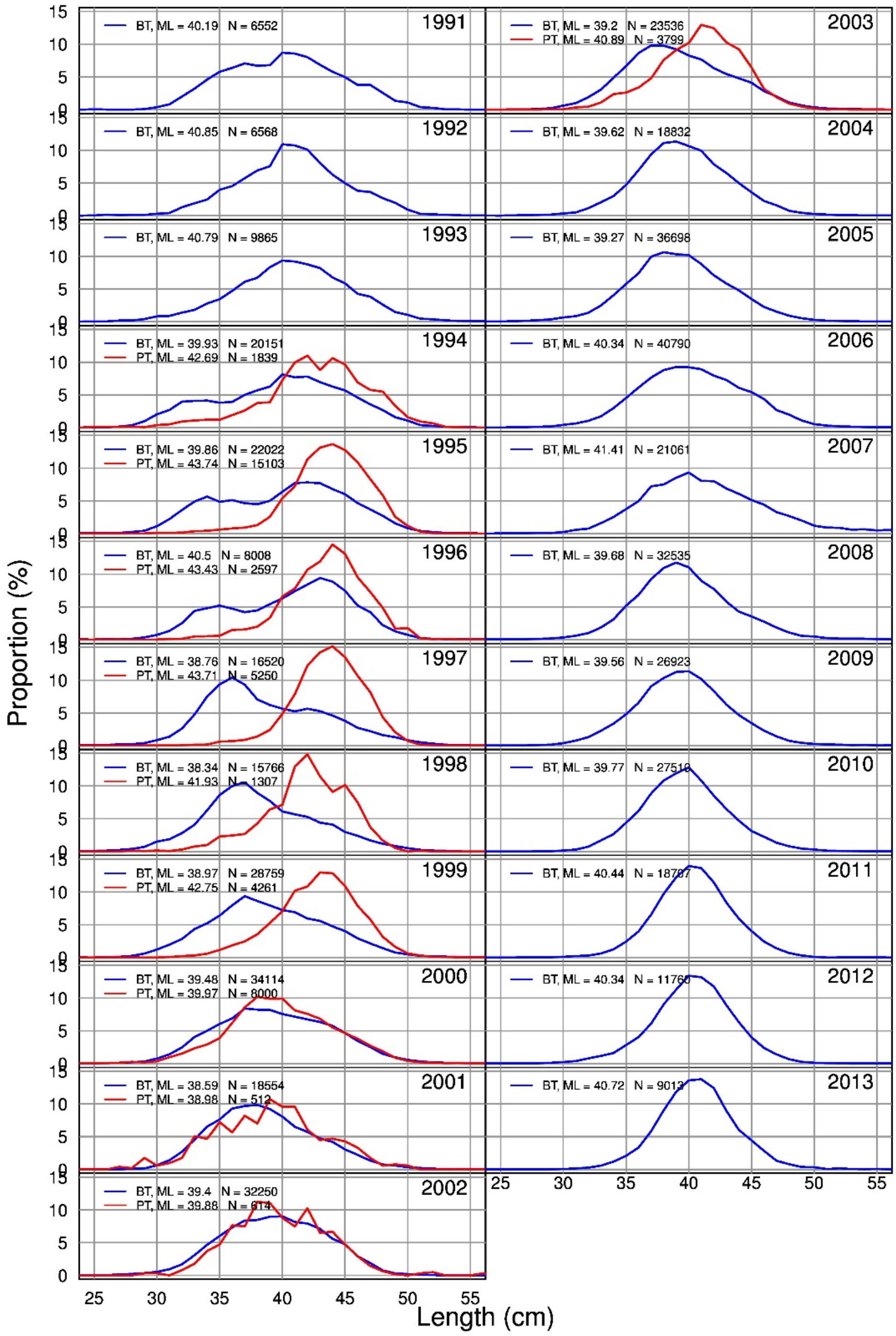


Figure 18.3.5 Length distributions of Icelandic slope *S. mentella* from the Icelandic landings taken with bottom trawl (blue line) and pelagic trawl (red line) in ICES Division Va 1991-2013.

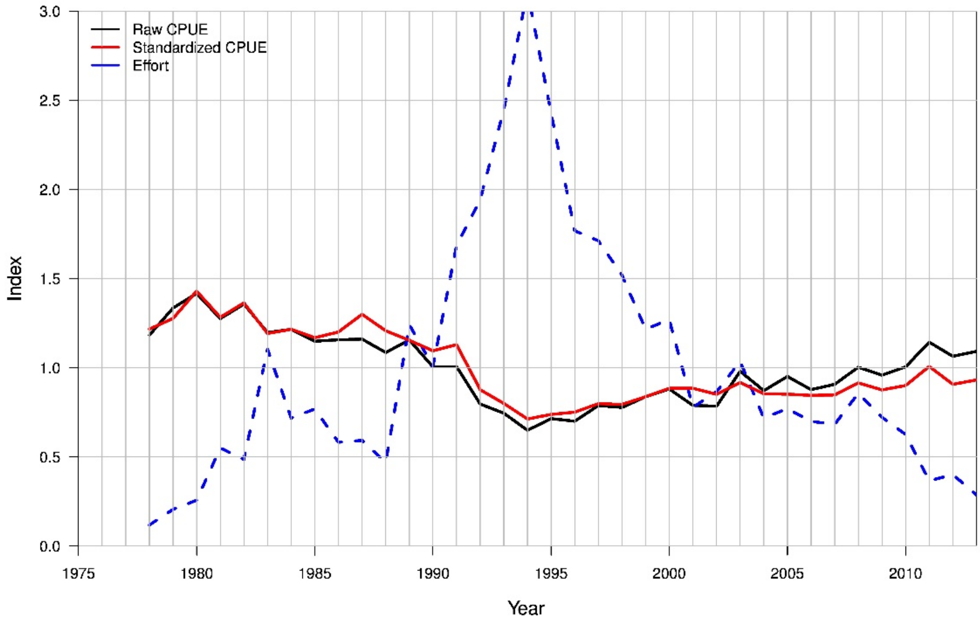


Figure 18.3.6 CPUE relative to 1978 of Icelandic slope *S. mentella* from the Icelandic bottom trawl fishery in Division Va. CPUE based on a GLM model based on data from log-books and where at least 50% of the total catch in each tow was Icelandic slope *S. mentella*. Also shown is fishing effort (hours fished in thousands).

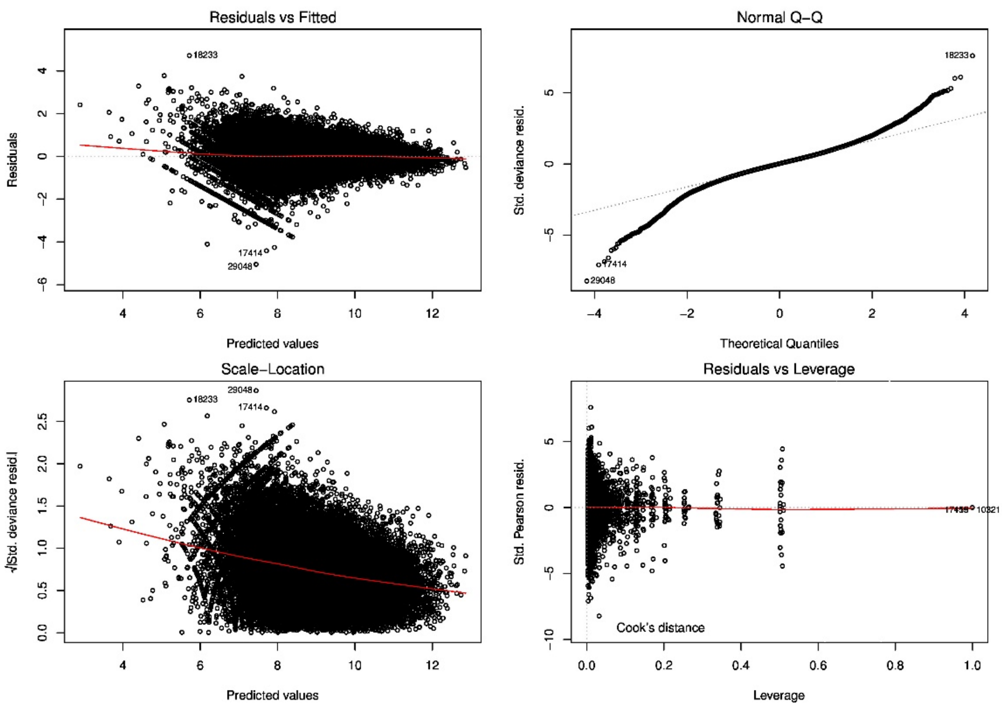
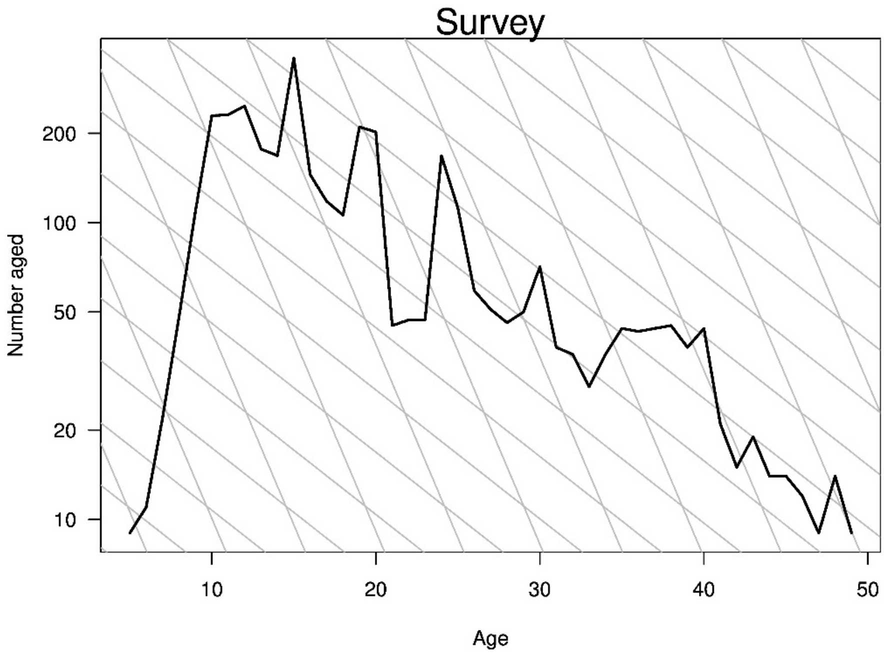


Figure 18.3.7 Residual of the GLM model (section 18.3.5) for the CPUE series of Icelandic slope *S. mentella*.



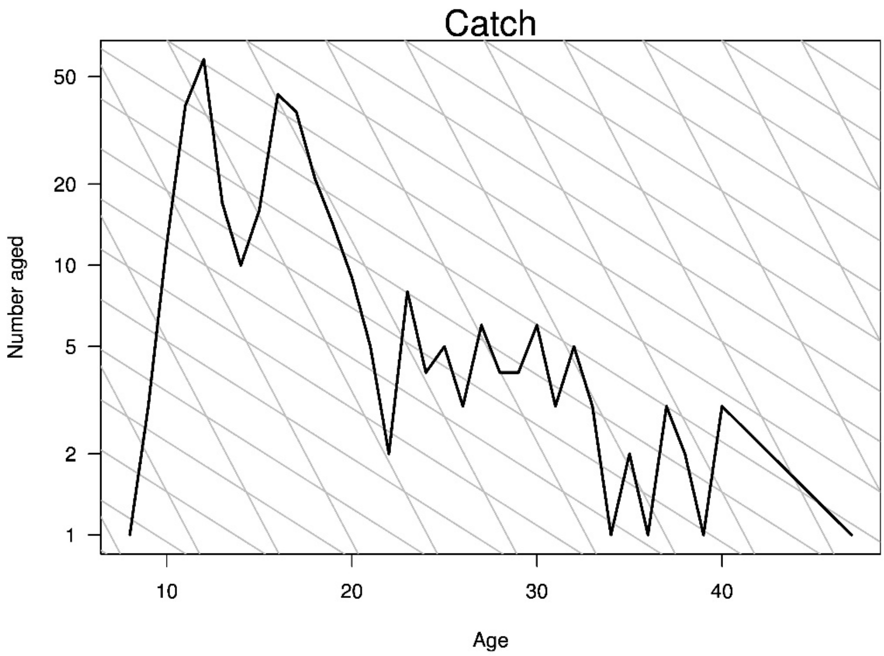


Figure 18.5.1. Icelandic slope *S. mentella*. Number aged plotted on log-scale. Grey lines correspond to *Z*=0.1 and *Z*=0.3.

20 Shallow Pelagic Sebastes mentella

Executive summary

- ICES concluded in February 2009 that *S. mentella* is to be divided to three biological stocks and that the deep pelagic *S. mentella* in the Irminger Sea and adjacent should be treated as separate biological stock and management unit. This chapter therefore deals only with the shallow pelagic stock.
- Total landings of shallow pelagic *S. mentella* in 2013 were 1 527 t, a significant decrease compared to 3 173 t in 2012. The catches were almost entirely taken in NAFO 1F.
- No analytical assessment was conducted and there are no biological reference points for the species. Survey indices from the biennial international acoustic redfish survey conducted in the Irminger Sea and adjacent waters since 1991 are used as basis for advice.
- The last survey was conducted in June/July 2013. Since 1994, the results of the acoustic survey show a drastic decreasing trend within the deep scattering layer (DSL) from 2.2 million t to 91,000 t in 2013. With the trawl method within the DSL (350-500 m) the biomass was estimated 200,000 t, significantly below the 361,000 t of 2011. The next international acoustic redfish survey will be conducted in June/July 2015.
- No signs of recruitment have been observed in the latest German survey on the East-Greenland shelf.

20.1 Stock description and management unit

This section addresses the fishery for shallow pelagic *S. mentella* in the Irminger Sea and adjacent areas (parts of Division Va, Subareas XII and XIV; eastern parts of NAFO Divisions 1F, 2H and 2J) at depths shallower than 500 m.

The following text table summarizes the available information from fishing fleets in the Irminger Sea and adjacent waters fishing for the shallow pelagic redfish in 2013. Only Russia conducted directed fishery on the stock. It should be noted that they also fished the deep pelagic stock:

Russia	18 factory trawlers

20.2 Summary of the development of the fishery

The historic development of the fishery can be found in the Stock Annex. The clear changes in the spatial pattern of the fishery can be seen in Figure 20.2.1, based on logbook data from the Faroe Islands, Greenland, Iceland and Norway. A summary of the catches by ICES Divisions/NAFO regulatory area as estimated by the Working Group is given in Table 20.2.1 and Figure 20.2.2. The estimated catch for 2013 is 1,527 t is a significant idecrease from the 3,173 t caught in 2012. The catches were almost entirely produced by Russia with 1,443 t from NAFO 1F (Tables 20.2.1 and 20.2.2).

There are no new CPUE data for 2013. The standardized CPUE index trend for the period 1994-2006 is shown in Figure 20.2.3. This standardized CPUE series includes data from Faroe Islands, Iceland, Germany, Greenland, and Norway, and it is estimated with a GLM model including the factors year, ship, month and towing time. The model output is shown in Table 20.2.3 and the residuals are in Figure 20.2.4.

20.3 Biological information

There are no new data. The length distributions for the period 1989-2006 of biological stocks based on Icelandic data are shown in Figure 20.3.1. The length of the largest proportion of caught fish oscillates around 35 cm for the whole period.

20.4 Discards

Redfish form aggregations composed of individuals with a narrow size range, which results in very clean catches. Thus, discards are negligible according to available data from various institutes.

20.5 Illegal Unregulated and Unreported Fishing (IUU)

The Group had again difficulties in obtaining catch estimates from several fleets. Furthermore, there are problems with misreported catches from some nations. The Group requests NEAFC and NAFO to provide ICES in time with all the necessary information.

20.6 Surveys

The last international trawl-acoustic survey was carried out in 2013 and it is described in detail in ICES WGRS Report 2013 (ICES, 2013). The next survey will be carried out in June/July 2015 (ICES, 2013).

20.6.1 Survey acoustic data

Since 1994, the results of the acoustic survey show a drastic decreasing trend from 2.2 kt to 0.6 kt in 1999 and have fluctuated between 0.7 kt - 0.09 kt in 2001-2013 (Table 20.6.1). The 2003 estimate, however, was considered to be inconsistent with the time series due to a shift in the timing of the survey.

The most recent trawl-acoustic survey on pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters was carried out by Iceland, Germany and Russia in June/July 2013. Approximately 341 000 NM^2 were covered. Figures 20.6.1 and 20.6.2 show the biomass estimates for depth shallower than the DSL (Depth Scattering Layer). A total biomass of 91 000 t was estimated acoustically in the layer shallower than the DSL (Table 20.6.1 and Figure 20.6.4). The results showed a substantial biomass decline in subarea B compared to 2011 but in other areas the biomass was similar as in 2011 (Table 20.6.2 and Figure 20.6.5 for area definition). Biological samples from the acoustic estimate within the DSL and shallower than 500 m showed a mean length of 36.0 cm (Figure 20.6.6).

20.6.2 Survey trawl estimates

In addition to the acoustic measurements, redfish biomass was estimated by correlating catches and acoustic values at depths shallower than 500 m at 200,000 t, a 45% decrease respect the estimation of 360,000 for 2011 (Table 20.6.1 and Figure 20.6.4). Figure 20.6.3 shows the distribution of the redfish catches within the DSL and shallower than 500 m. It should be noted that the estimate for 2013 was recalculated due to technical error made in 2013 (ICES 2014).

The obtained correlation was used to convert the trawl data at greater depths to acoustic values and from there to abundance. For that purpose, standardized trawl hauls were carried out at depth 350-500 m, evenly distributed over the survey area (Figure 20.6.3). For the time being, the correlation between the catch and acoustic values is based on few data points only and it is highly variable. It is also assumed that the catchability of the trawl is the same, regardless of the trawling depth, thus the abundance estimate obtained is questionable and must only be considered as a rough attempt to measure the abundance within the DSL. Evaluation on the consistency of the method has to wait until more data points are available.

Biological samples from the trawls taken at depth <500 m showed a mean length of 35.5 cm. Figure 20.6.3 shows the spatial distribution of samples used in the survey and Figure 20.6.6 shows the corresponding length distribution.

20.6.3 Methods

The assessment of pelagic redfish in the Irminger Sea and adjacent waters is based on survey indices, catches, CPUE and biological data. See Stock Annex and Section 20.6 for details.

20.6.4 Reference points

For pelagic redfish in the Irminger Sea and adjacent waters, no analytical assessment is being carried out due to data uncertainties and the lack of reliable age data. Thus, no reference points can be derived.

20.7 State of the stock

20.7.1 Short term forecast

For pelagic redfish in the Irminger Sea and adjacent waters, no analytical assessment is being carried out due to data uncertainties and the lack of reliable age data. Thus, no short-term forecasts can be derived.

20.7.2 Uncertainties in assessment and forecast

20.7.2.1 Data considerations

Preliminary official landings data were provided by the ICES Secretariat, NEAFC and NAFO, and various national data were reported to the Group. The Group, however, repeatedly faces problems to obtain reliable catch data due to unreported catches of pelagic redfish and lack of catch data disaggregated by depth from some countries. There are indications that reported effort (and consequently landings) could represent only around 80% of the real effort in certain years (see Chapter 20.3.3 in the 2008 NWWG report, ICES, 2008). No new data in IUU have been available since 2008.

As in previous years, detailed descriptions on the horizontal, vertical and seasonal distribution of the fisheries were given.

The need and importance of having catch and biological data disaggregated by depth from all nations taking part in the fishery cannot be stressed strongly enough, and the Group urges all nations involved on supplying better data. With this need in mind, ICES sent a data call to all EU countries participating in the redfish fishery, encouraging stockholders to deliver detailed catch data before the WG would meet, but the response was very limited.

20.7.2.2 Assessment quality

The results of the international trawl-acoustic survey are given in section 20.6. Given the high variability in the correlation between trawl and acoustic estimates as well as the assumptions that need to be made about constant catchability across depth and areas, the uncertainty of these estimates is very high.

The reduction in biomass observed in the surveys within the hydroacoustic layer (about 2 million t in the last decade) cannot be explained by the reported removal by the fisheries (about 500,000 t in the entire depth range in 1995-2011) alone. A decreasing trend in the relative biomass indices in the acoustic layer, however, is visible since 1991.

It is not known to what extent CPUE reflects changes in the stock status of pelagic *S. mentella*, since the fishery focuses on aggregations. Therefore, stable or increasing CPUE series might not indicate or reflect actual trends in stock size, although decreasing CPUE indices are likely to reflect a decreasing stock. The new data available to the NWWG were insufficient to estimate the CPUE for 2013.

NEAFC set for 2013 a 0 TAC for Shallow Pelagic *S. mentella*. However, the Russian Federation decided on an unilateral quota of 27 300 t. This quota was taken from both Shallow and Deep pelagic stocks, since the Russian Federation does not agree on the division of the *S. mentella* management units.

20.7.3 Comparison with previous assessment and forecast

The data available for evaluating the stock status are similar to last year.

20.7.4 Management considerations

The Group needs more and better data and requests that NEAFC and NAFO provide ICES with all information leading to more reliable catch statistics.

The main feature of the fishery since 1998 is a clear distinction between two widely separated fishing grounds with pelagic redfish fished at different seasons and different depths. Since 2000, the southwestern fishing grounds extended also into the NAFO Convention Area. Biological data, however, suggest that the aggregations in the NAFO Convention Area do not constitute a separate stock. The NAFO Scientific Council agreed with this conclusion (NAFO, 2005). The Group concludes that at this time there are not enough scientific bases available to propose an appropriate split of the total TAC among the two fisheries/areas.

20.7.5 Ecosystem considerations

The fisheries on pelagic redfish in the Irminger Sea and adjacent waters are generally regarded as having negligible impact on the habitat and other fish or invertebrate species due to very low bycatch and discard rates, characteristic of fisheries using pelagic gear.

20.7.6 Changes in the environment

The hydrography in the June/July 2013 survey show that temperature in the survey area is above average but it was lower than in 2011 in most of the surveyed area, except for the Irminger Current (ICES, 2013).

The increase of water temperature in the Irminger Sea may have an effect on spatial and vertical distribution of S. mentella in the feeding area (Pedchenko, 2005). The abundance and distribution of *S. mentella* in relation to oceanographic conditions were analysed in a special multistage workshop (WKREDOCE1-3). Based on 20 years of survey data, the results reveal the average relation of redfish to their physical habitat in shallow and intermediate waters: The most preferred latitude, longitude, depth, salinity and temperature for *S. mentella* are approximately 58ºN, 40ºW, 300 m, 34.89 and 4.4ºC, respectively. The spatial distribution of S. mentella in the Irminger Sea mainly in waters < 500 m (and thus mainly relating to the "shallow" stock) appears strongly influenced by the Irminger Current Water (ICW) temperature changes, linked to the Subpolar Gyre (SPG) circulation and the North Atlantic Oscillation (NAO). The fish avoid waters mainly associated with the ICW (>4.5ºC and >34.94) in the north-eastern Irminger Sea, which may cause displacing towards the southwest, where fresher and colder water occurs (ICES 2012).

Results based on international redfish survey data suggest that the interannual distribution of fish above 500 m will shift in a southwest/northeast direction depending on integrated oceanographic conditions (ICES 2012).

20.8 Benchmark meeting 2012

The WKRED 2012 Benchmark workshop met from 1-8 February 2012 at ICES headquarters in Copenhagen, Denmark. The objective of the workshop for beaked redfish was among other things to agree upon and document the preferred method for evaluating stock status.

Shallow pelagic beaked redfish has previously been assessed based on trends in survey biomass indices from international redfish survey since 1991. Supplementary data used includes relevant information from the fishery and length distributions from the commercial catch and the survey.

For shallow pelagic beaked redfish, the WKRED-2012 external review panel recommended an alternative assessment method or the Schaefer biomass dynamic model. There was, however, disagreement regarding the biomass dynamic model as a step forward from the current trends based methods. The experts on beaked redfish present at the WKRED-2012 did not support the use of biomass dynamics models because of lack of contrast in the survey data and unrealistic estimates of production from the model given the biology of redfish. NWWG-2012 supports this view.

20.9 References

ICES. 2009a. Report of the Workshop on Redfish Stock Structure (WKREDS). ICES CM 2009/ACOM:37.

ICES. 2009b. Report of the Planning Group on Redfish Surveys (PGRS). ICES CM 2009/RMC:01.

ICES. 2012a. Report of the Benchmark Workshop on Redfish (WKRED 2012), 1–8 February 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:48. 291 pp.

ICES. 2012b. Report of the Third Workshop on Redfish and Oceanographic Conditions (WKREDOCE3), 16-17 August 2012, Johann Heinrich von Thunen Institute, Hamburg, Germany. ICES CM 2012/ACOM:25. 70 pp.

ICES. 2013. Report of the Working Group on Redfish Surveys (WGRS), 6-8 August 2013, Hamburg, Germany. ICES CM 2013/SSGESST:14. 56 pp.

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NAFO 2005. Scientific Council Reports 2004, 306 ppPedchenko, A. P. 2000. Specification of oceanographic conditions of the Irminger Sea and their influence on the distribution of feeding redfish in 1999. ICES North-Western Working Group 2000, Working Document 22, 13 pp.

Pedchenko, A. P. 2005. The role of interannual environmental variations in the geographic range of spawning and feeding concentrations of redfish *Sebastes mentella* in the Irminger Sea. ICES Journal of Marine Science 62: 1501-1510.

Table 20.2.1 Shallow Pelagic *S. mentella* (stock unit < 500 m). Catches (in tonnes) by area as used by the Working Group.

Year	Va	XII	XIV	NAFO 1F	NAFO 2J	NAFO 2H	Total
1982	0	39,783	20,798	0	0	0	60,581
1983	0	60,079	155	0	0	0	60,234
1984	0	60,643	4,189	0	0	0	64,832
1985	0	17,300	54,371	0	0	0	71,671
1986	0	24,131	80,976	0	0	0	105,107
1987	0	2,948	88,221	0	0	0	91,169
1988	0	9,772	81,647	0	0	0	91,419
1989	0	17,233	21,551	0	0	0	38,784
1990	0	7,039	24,477	385	0	0	31,901
1991	0	9,689	17,048	458	0	0	27,195
1992	106	22,976	38,709	0	0	0	62,564
1993	0	66,458	32,500	0	0	0	100,771
1994	665	77,174	18,679	0	0	0	96,869
1995	77	78,895	17,895	0	0	0	100,136
1996	16	22,474	18,566	0	0	0	41,770
1997	321	18,212	8,245	0	0	0	27,746
1998	284	21,976	1,598	0	0	0	24,150
1999	165	23,659	827	534	0	0	25,512
2000	3,375	17,491	687	11,052	0	0	33,216
2001	228	32,164	1,151	5,290	8	1,751	41,825
2002	10	24,004	222	15,702	0	3,143	43,216
2003	49	24,211	134	26,594	325	5,377	56,688
2004	10	7,669	1,051	20,336	0	4,778	33,951
2005	0	6,784	281	16,260	5	4,899	28,229
2006	0	2,094	94	12,692	260	593	15,734
2007	71	378	98	2,843	175	2,561	6,126
2008	32	25	422	1,580	0	0	2,059
2009	0	210	2,170	0	0	0	2,380
2010	15	686	423	1,074	0	0	2,198
2011	0	0	234	0	0	0	234
2012	28	0	0	3,113	32	0	3,173
2013	32	11	40	1,443	1	0	1,527

1982-1991	All pelagic catches assumed to be of the shallow pelagic stock
1992-1996	Guesstimates based on different sources (see text)
1997-2013	Catches from calculations based on jointed catch database and total landings

Table 20.2.2 Shallow pelagic *S. mentella* catches (in tonnes) in ICES Div. Va, Subareas XII, XIV and NAFO Div. 1F, 2H and 2J by countries used by the Working Group. * Prior to 1991, the figures for Russia included Estonian, Latvian and Lithuanian catches.

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Russia*	Spain	UK	Ukraine	Total
1982														581		60,000				60,581
1983						155										60,079				60,234
1984	2,961					989								239		60,643				64,832
1985	5,825					5,438								135		60,273				71,671
1986	11,385			5		8,574								149		84,994				105,107
1987	12,270			382		7,023								25		71,469				91,169
1988	8,455			1,090		16,848										65,026				91,419
1989	4,546			226		6,797	567	3,816						112		22,720				38,784
1990	2,690					7,957		4,537					7,085			9,632				31,901
1991			2,195	115		201		8,724					6,197			9,747				27,179
1992	628		1,810	3,765	2	6,447	9	12,080		780	6,656		14,654			15,733				62,564
1993	3,216		6,365	6,812		16,677	710	10,167		6,803	7,899		14,112			25,229			2,782	100,771
1994	3,600		17,875	2,896	606	15,133		5,897		13,205	7,404		6,834		1,510	16,349			5,561	96,869
1995	2,660	421	11,798	3,667	158	10,714	277	8,733	841	3,502	16,025	9	4,288		2,170	28,314	1,934		2,230	100,136
1996	1,846	343	3,741	2,523		5,696	1,866	5,760	219	572	5,618		1,681		476	9,348	1,671	137	273	41,770
1997		102	3,405	3,510		9,276		4,446	28				330	776	367	3,693	1,812			27,746
1998			3,892	2,990		9,679	1,161	1,983	30		1,734		701	12	60	89	1,819			24,150
1999			2,055	1,190		8,271	998	3,662					2,098	6	62	6,538	447	183		25,512
2000			4,218	486		5,672	956	3,766			430		2,124		37	14,373	1,154			33,216
2001			9	4,364		4,755	1,083	14,745			8,269		947		256	5,964	1,433			41,825
2002				719		5,354	657	5,229		1,841	12,052		1,094	428	878	13,958	1,005			43,216
2003				1,955		3,579	1,047	4,274		1,269	21,629		3,214	917	1,926	15,418	1,461			56,688
2004				777		1,126	750	5,728		1,114	3,698		2,721	1,018	2,133	13,208	1,679			33,951
2005				210		1,152		3,086		919	1,169		624	1,170	2,780	15,562	1,557			28,229
2006				334		994		1,293		1,803	466		280	663	1,372	4,953	3,576			15,734
2007			209	98		0		71		186	467			189	529	4,037	339			6,126

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Russia*	Spain	UK	Ukraine	Total
2008				319				63			8					1,597	73			2,059
2009				87				5			138					649	1,438			2,380
2010				653				22			551		12		377	567	16			2,198
2011				162				72												234
2012				0		0		28		0	0		0		0	3,145	0			3,173
2013				0		0		72		0	0		0			1455	0			1527

Table 20.2.3 Output from the GLM model used to standardize CPUE

Call:

glm(formula = lafli ~ ltogtimi + factor(land) + factor(yy) + factor(mm) + factor(skip),
family = gaussian(), data = south)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-2.67560	-0.27475	0.01545	0.28216	1.70226

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	7.288330600	0.62153190	11.72639829	4.487183e-27
ltogtimi	1.031189089	0.02865434	35.98719217	1.185172e-120
factor(land)46	0.307108007	0.19677419	1.56071282	1.194800e-01
factor(land)58	-0.609222384	0.59427534	-1.02515171	3.059877e-01
factor(yy)1995	-0.014544145	0.17246972	-0.08432869	9.328425e-01
factor(yy)1996	-0.539967092	0.20301506	-2.65973905	8.173648e-03
factor(yy)1997	-0.781097375	0.19187694	-4.07082472	5.775636e-05
factor(yy)1998	-0.598205682	0.20022972	-2.98759682	3.006814e-03
factor(yy)1999	-1.032123656	0.19849297	-5.19979958	3.371986e-07
factor(yy)2000	-0.449067015	0.18062595	-2.48617105	1.337053e-02
factor(yy)2001	-0.294095749	0.18731402	-1.57006796	1.172876e-01
factor(yy)2002	-0.553422698	0.20779476	-2.66331403	8.089018e-03
factor(yy)2003	-0.448530462	0.20695582	-2.16727635	3.087629e-02
factor(yy)2004	-0.940467562	0.19921557	-4.72085375	3.382253e-06
factor(yy)2005	-0.874228087	0.21534893	-4.05958874	6.047701e-05
factor(yy)2006	-0.792513622	0.23511568	-3.37073907	8.318962e-04
factor(mm)3	0.403539915	0.62653390	0.64408313	5.199363e-01
factor(mm)4	0.080886336	0.59965529	0.13488805	8.927766e-01
factor(mm)5	0.697289482	0.59729418	1.16741383	2.438246e-01
factor(mm)6	0.106581504	0.59582112	0.17888172	8.581323e-01
factor(mm)7	0.156006539	0.59913389	0.26038677	7.947160e-01
factor(mm)8	0.288687902	0.60200469	0.47954427	6.318459e-01
factor(mm)9	0.147372745	0.60350755	0.24419370	8.072215e-01
factor(mm)10	-0.073137396	0.61289180	-0.11933166	9.050799e-01

factor(mm)11	-0.111429636	0.62872288	-0.17723172	8.594272e-01
factor(mm)12	-0.687207654	0.84232729	-0.81584399	4.151349e-01
factor(skip)118	-0.309179778	0.22143007	-1.39628629	1.634983e-01
factor(skip)1270	0.037603149	0.44828091	0.08388300	9.331966e-01
factor(skip)1273	-0.628141253	0.22041607	-2.84979787	4.629299e-03
factor(skip)1279	-1.173362444	0.44513557	-2.63596647	8.756942e-03
factor(skip)1308	-0.266919265	0.22303502	-1.19675943	2.321967e-01
factor(skip)1328	-0.271654251	0.21750992	-1.24892811	2.125120e-01
factor(skip)1345	-0.389432255	0.27300563	-1.42646238	1.546113e-01
factor(skip)1351	-0.210922567	0.30230014	-0.69772567	4.858042e-01
factor(skip)1360	-0.160337035	0.37131520	-0.43180843	6.661421e-01
factor(skip)1365	-0.037778373	0.28528994	-0.13242098	8.947261e-01
factor(skip)1369	0.008221878	0.23222821	0.03540430	9.717772e-01
factor(skip)1376	-0.079339629	0.21104413	-0.37593857	7.071865e-01
factor(skip)1408	-0.360954071	0.46295849	-0.77966833	4.361041e-01
factor(skip)1412	-0.186735060	0.60272438	-0.30981833	7.568804e-01
factor(skip)1459	-0.659207386	0.22905256	-2.87797434	4.243932e-03
factor(skip)1471	-0.067779436	0.39810737	-0.17025416	8.649070e-01
factor(skip)1472	-0.243213212	0.33706786	-0.72155563	4.710413e-01
factor(skip)1473	-0.831933012	0.45025953	-1.84767443	6.547885e-02
factor(skip)1552	-1.308585894	0.61116338	-2.14113925	3.294138e-02
factor(skip)1578	-1.486687432	0.38045634	-3.90764269	1.115534e-04
factor(skip)1579	-0.474709749	0.30501933	-1.55632678	1.205189e-01
factor(skip)1585	-0.553949127	0.61783175	-0.89660191	3.705373e-01
factor(skip)1628	0.048861984	0.45291686	0.10788290	9.141494e-01
factor(skip)180	-0.532613734	0.18564922	-2.86892530	4.364387e-03
factor(skip)1833	-0.296067754	0.22785023	-1.29939633	1.946488e-01
factor(skip)1868	-0.104954736	0.22921245	-0.45789282	6.473088e-01
factor(skip)1880	0.004153055	0.25826361	0.01608068	9.871790e-01
factor(skip)1902	0.204043987	0.28417282	0.71802782	4.732111e-01
factor(skip)1976	-0.380940434	0.61538320	-0.61902963	5.362928e-01
factor(skip)1977	-0.774106835	0.33815309	-2.28922009	2.265145e-02
factor(skip)2165	0.105047590	0.20580896	0.51041311	6.100784e-01
factor(skip)2170	-0.122213348	0.20408250	-0.59884286	5.496585e-01
factor(skip)2182	-0.454140930	0.23283220	-1.95050737	5.190006e-02
factor(skip)2184	-0.295249414	0.25222782	-1.17056639	2.425561e-01

```
factor(skip)2203 -0.136558045 0.20059787 -0.68075523  4.964689e-01
factor(skip)2212  0.183302143 0.30496276  0.60106402  5.481798e-01
factor(skip)2236 -0.581565095 0.26502996 -2.19433717  2.885678e-02
factor(skip)2265  0.239718865 0.43951519  0.54541657  5.858086e-01
factor(skip)2592 -0.282434578 0.59801605 -0.47228595  6.370121e-01
factor(skip)3033 -0.283499142 0.72458991 -0.39125461  6.958431e-01
factor(skip)3135 -0.016478186 0.66105345 -0.02492716  9.801270e-01
factor(skip)3156 -0.260805362 0.61679034 -0.42284281  6.726652e-01
factor(skip)3382 -0.423424919 0.62159313 -0.68119305  4.961922e-01
factor(skip)3523 -0.395258535 0.72563919 -0.54470396  5.862982e-01
factor(skip)3542  0.018355745 0.61994189  0.02960882  9.763956e-01
factor(skip)3709 -0.609676578 0.64465767 -0.94573695  3.449242e-01
factor(skip)934  -1.054646713 0.17107235 -6.16491621  1.912436e-09---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 0.3450127)

    Null deviance: 989.53  on 458  degrees of freedom
Residual deviance: 131.45  on 381  degrees of freedom
AIC: 886.64

---------------------

Number of Fisher Scoring iterations: 2
Analysis of Deviance Table
Model: gaussian, link: identity
Response: lafli
Terms added sequentially (first to last)


             Df Deviance Resid. Df Resid. Dev         F    Pr(>F)
NULL                           428     934.30
ltogtimi      1   682.16       427     252.14 2126.3228 < 2.2e-16 ***
factor(land)  2    38.99       425     213.15   60.7682 < 2.2e-16 ***
factor(yy)   12    43.18       413     169.96   11.2167 < 2.2e-16 ***
factor(mm)   10    17.04       403     152.92    5.3122 2.600e-07 ***
```

```
factor(skip) 47    38.71       356     114.21    2.5673 5.376e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table 20.6.1 Shallow Pelagic *S. mentella*. Results for the acoustic survey indices from shallower than the scattering layer, trawl estimates within the deep scattering layer and shallower than 500 m, and area coverage of the survey in the Irminger Sea and adjacent waters.

Year	Area covered (1000 NM2)	Acoustic estimates 1000 t	Trawl estimates 1000 t
1991	105	2235	
1992	190	2165	
1993	121	2556	
1994	190	2190	
1995	168	2481	
1996	253	1576	
1997	158	1225	
1999	296	614	
2001	420	716	565
2003*	405	89*	92*
2005	386	550	392
2007	349	372	283
2009	360	108	331
2011	343	123	361
2013	340	91	200

*** The 2003 biomass estimate is considered as inconsistent as the survey was carried out about one month earlier than usual, and a marked seasonal effect was observed.**

Table 20.6.2. Results (biomass in ´000 t) for the international surveys conducted since 1994, for redfish shallower than the DSL for each subarea (see Figure 20.6.5 for area definition) and total.

	Sub-area						
Year	A	B	C	D	E	F	Total
1994	673	1228	-	63	226		2190
1996	639	749	-	33	155		1576
1999	72	317	16	42	167		614
2001	88	220	30	267	103	7	716
2003	32	46	1	2	10	0	89
2005	121	123	0	87	204	17	551
2007	80	95	0	53	142	3	372
2009	39	48	4	1	15	1	108
2011	5	74	0	3	40	1	123
2013	9	33	2	5	42	0	91

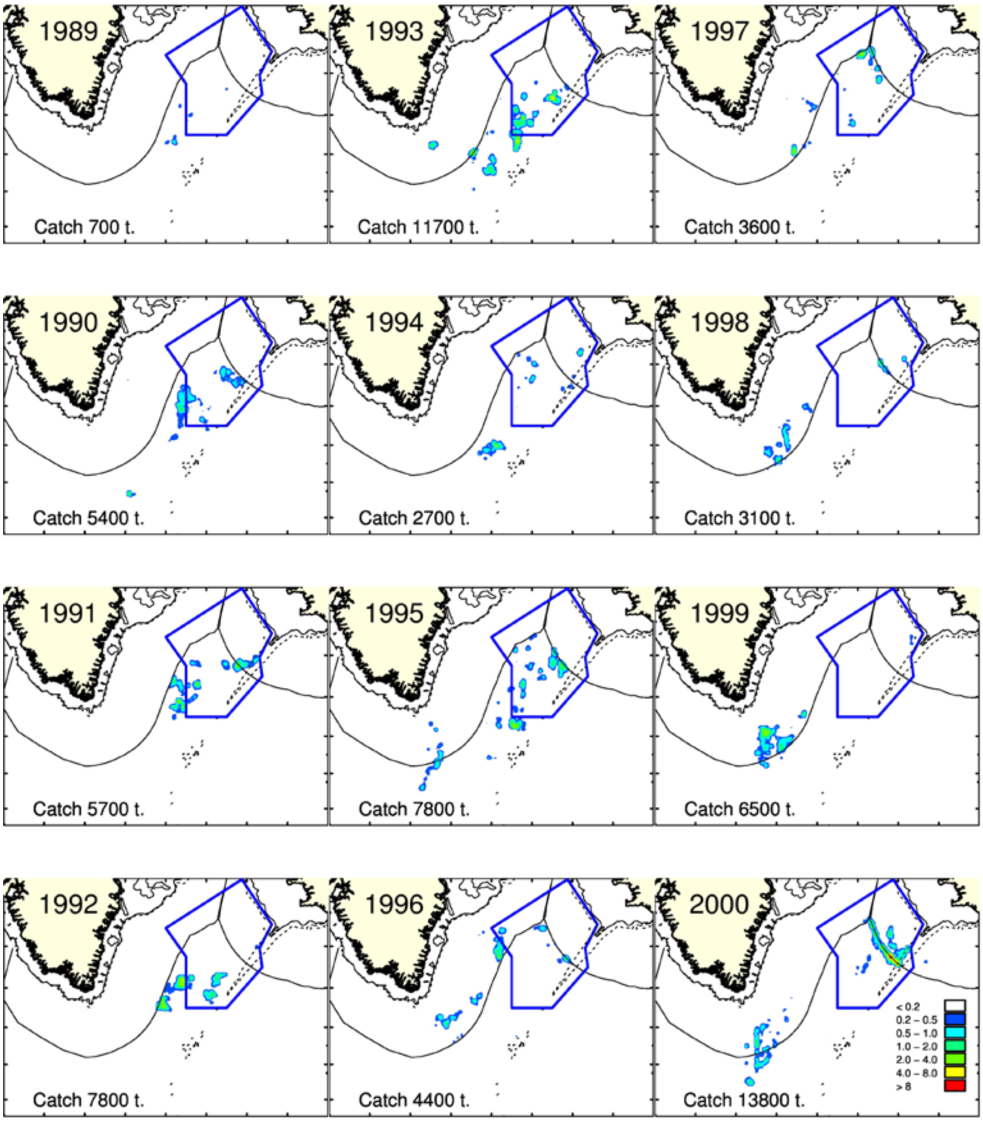

Figure 20.2.1 Fishing areas and total catch of pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1989-2012. Data are from the Faroe Islands (1995-2012), Iceland (1989-2012) and Norway (1992-2003). The catches in the legend are given as tonnes per square nautical mile. The blue box represents the management unit for the northern fishing area.

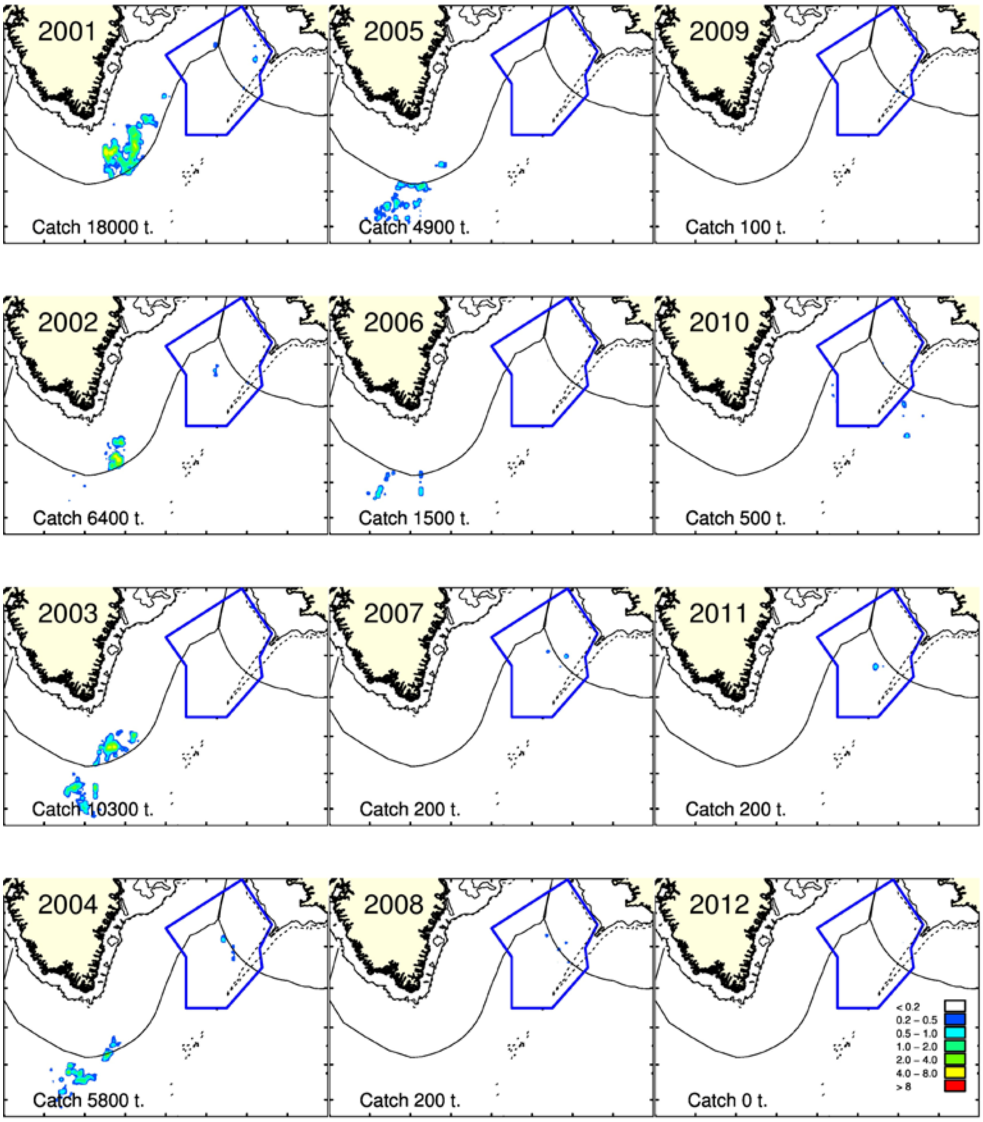

Figure 20.2.1 (Cont.) Fishing areas and total catch of pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1989-2012. Data are from the Faroe Islands (1995-2012), Iceland (1989-2012) and Norway (1992-2003). The catches in the legend are given as tonnes per square nautical mile. The blue box represents the management unit for the northern fishing area. – NOT UPDATED

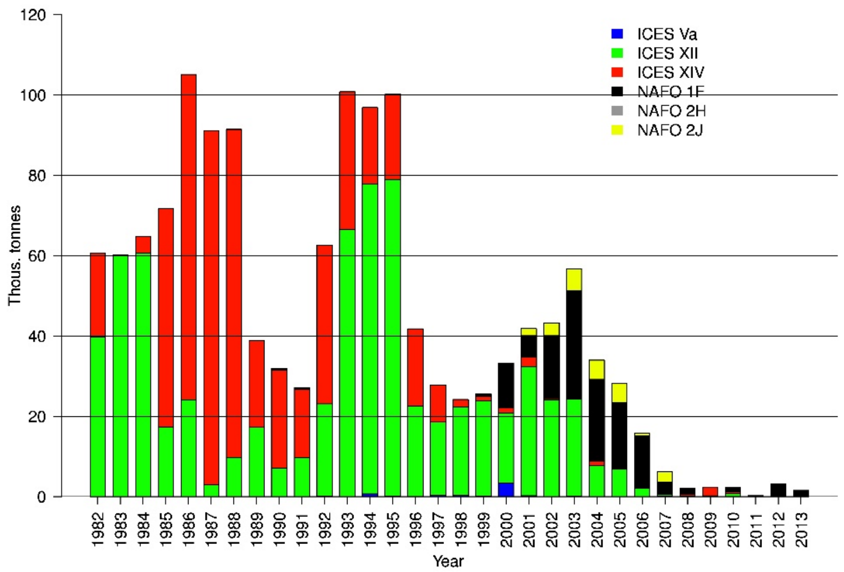

Figure 20.2.2 Landings of shallow pelagic *S. mentella* (Working Group estimates, see Table 20.2.1).

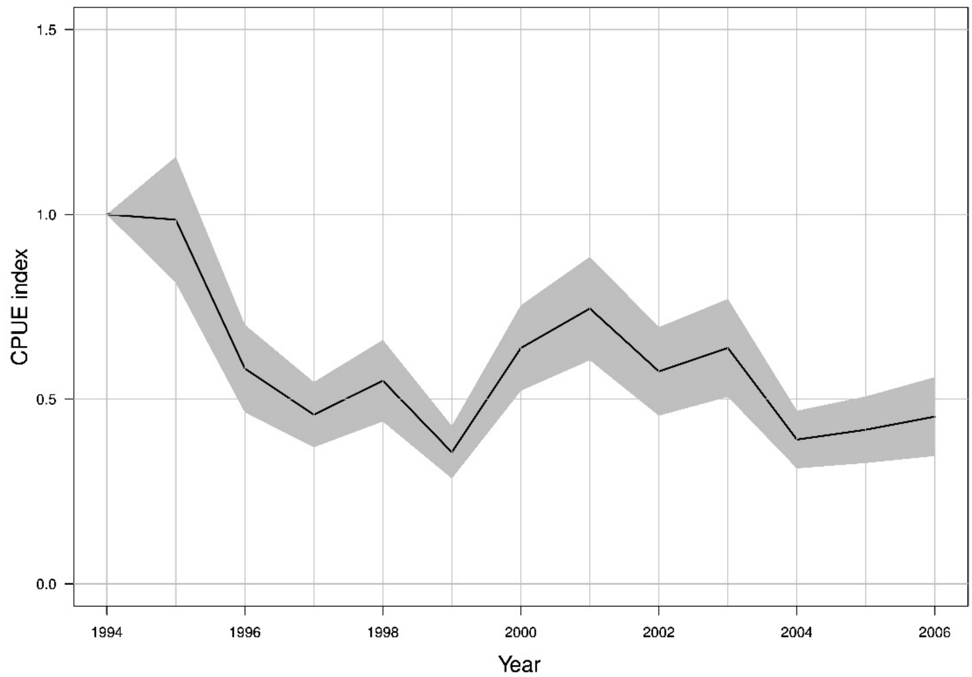

Figure 20.2.3 Trends in standardised CPUE of the shallow pelagic *S. mentella* fishery in the Irminger Sea and adjacent waters, based on log-book data from Faroes, Iceland, Norway, and Greenland.

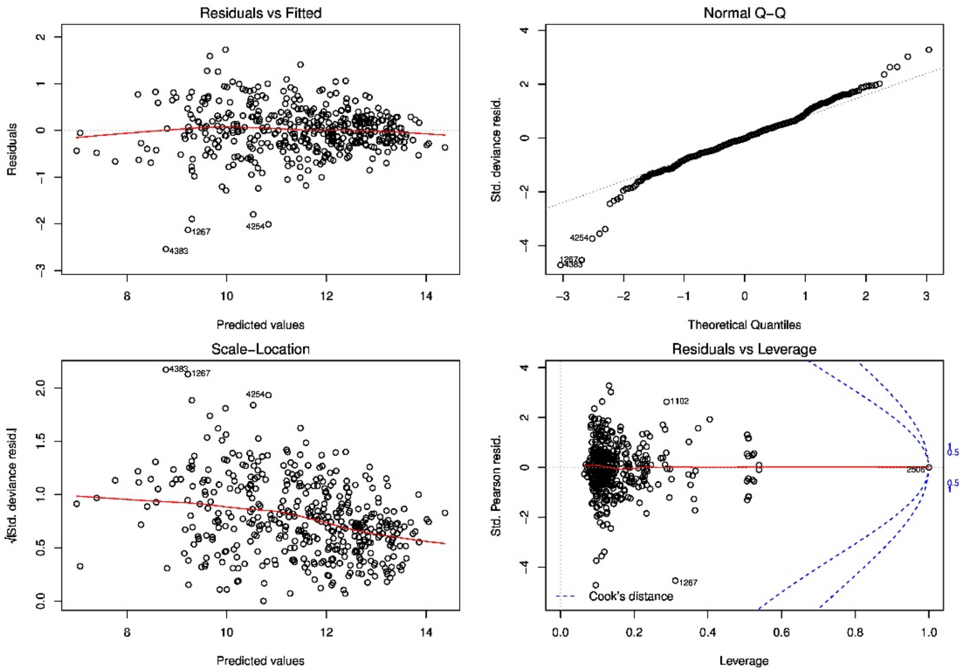

Figure 20.2.4 Residuals from the GLM model used to standardize CPUE, based on log-book data from Faroe Islands, Iceland, Greenland and Norway.

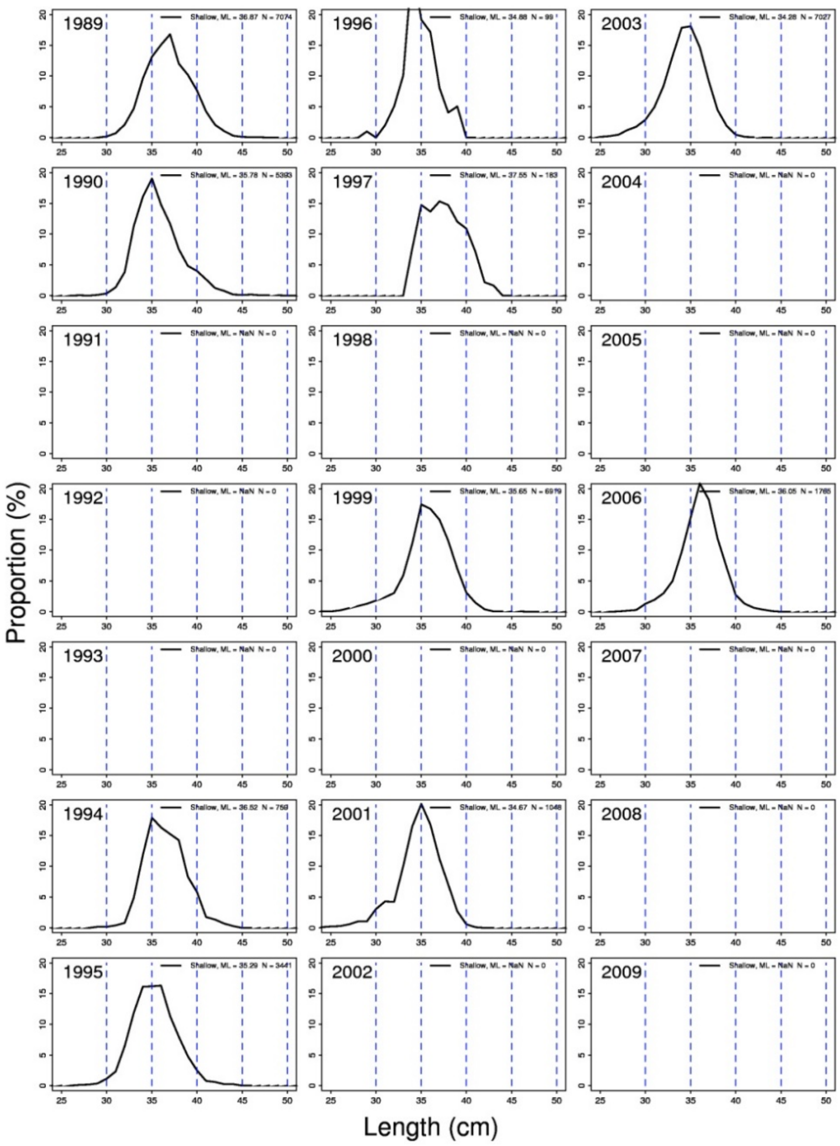

Figure 20.3.1 Length distribution from Icelandic landings of shallow pelagic *S. mentella*.

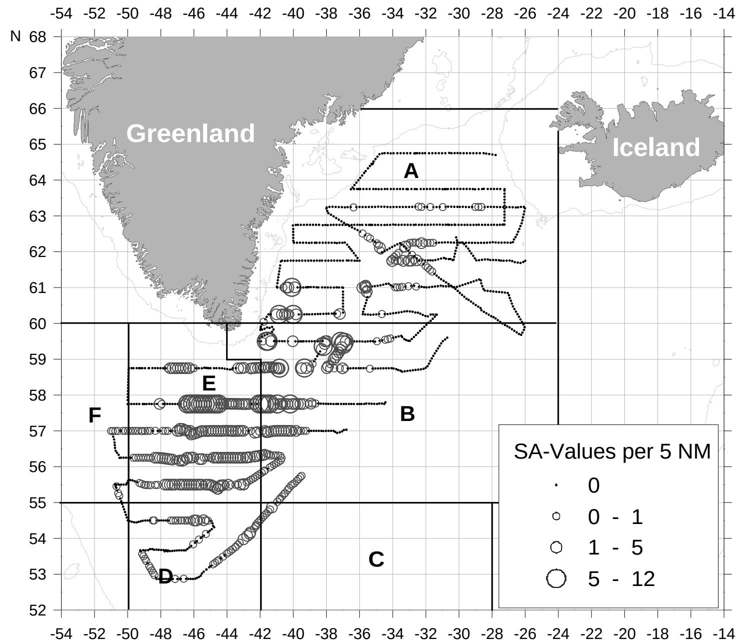

Figure 20.6.1 Pelagic *S. mentella*. Acoustic estimates (average s_A values by 5 NM sailed) shallower than the deep-scattering layer (DSL) from the joint trawl-acoustic survey in June/July 2013.

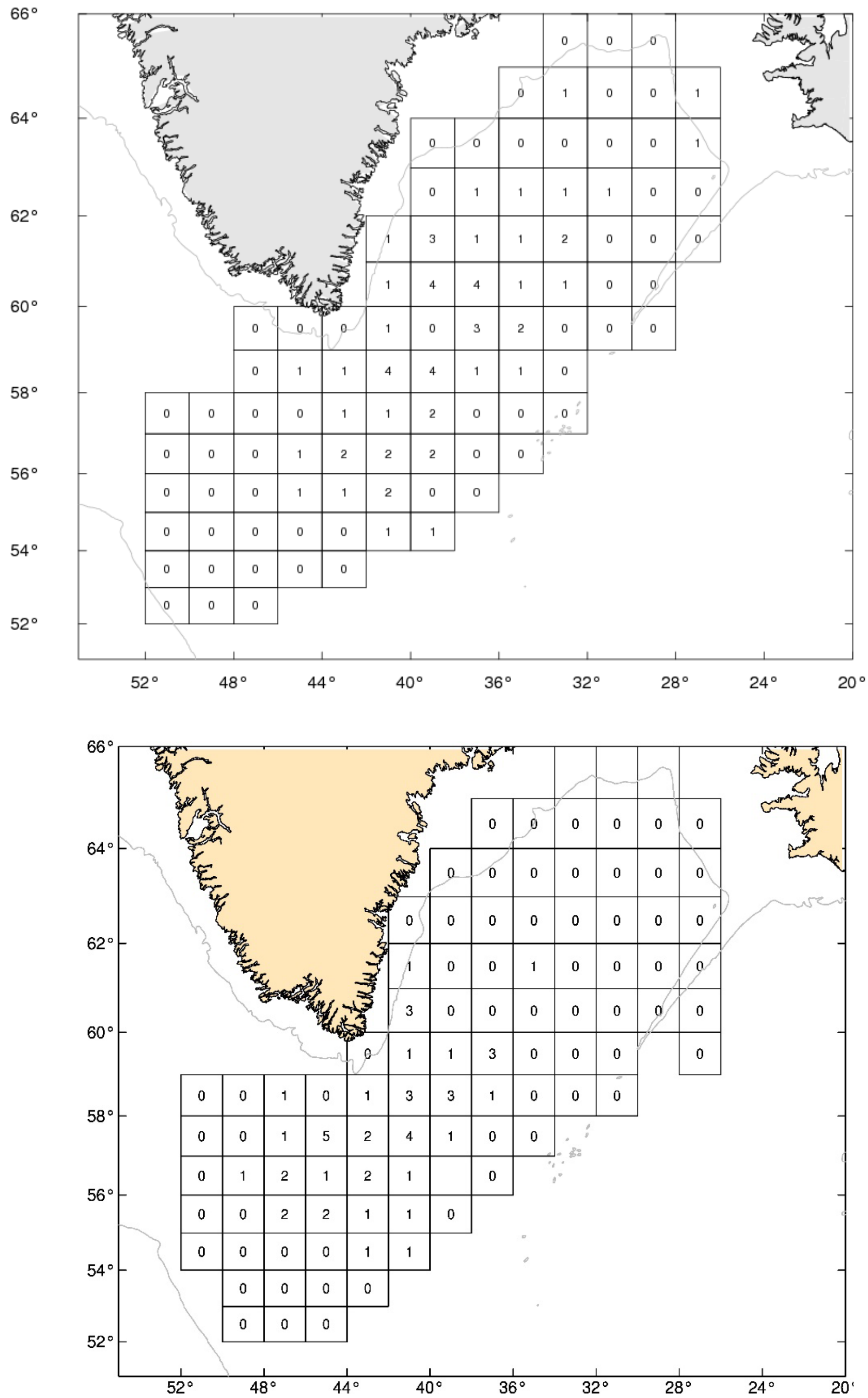

Figure 20.6.2. Redfish acoustic estimates shallower than the DSL. Average sA values within statistical rectangles during the joint international redfish survey in June/July 2013.

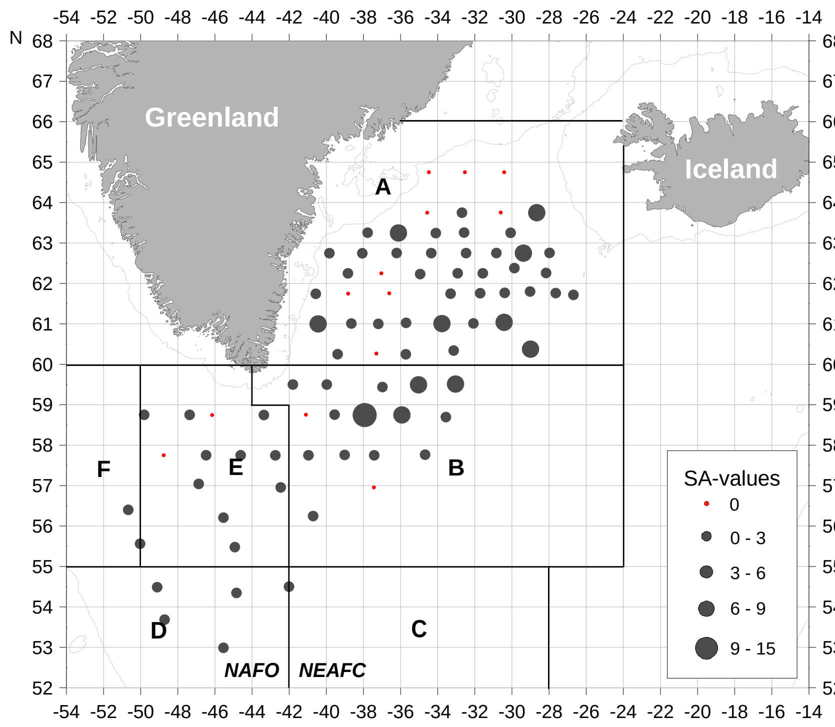

Figure 20.6.3 Redfish trawl estimates within the DSL shallower than 500 m (type 2 trawls). sA values calculated by the trawl method (chapter 2.2.3) during the joint international redfish survey in June/July 2013.

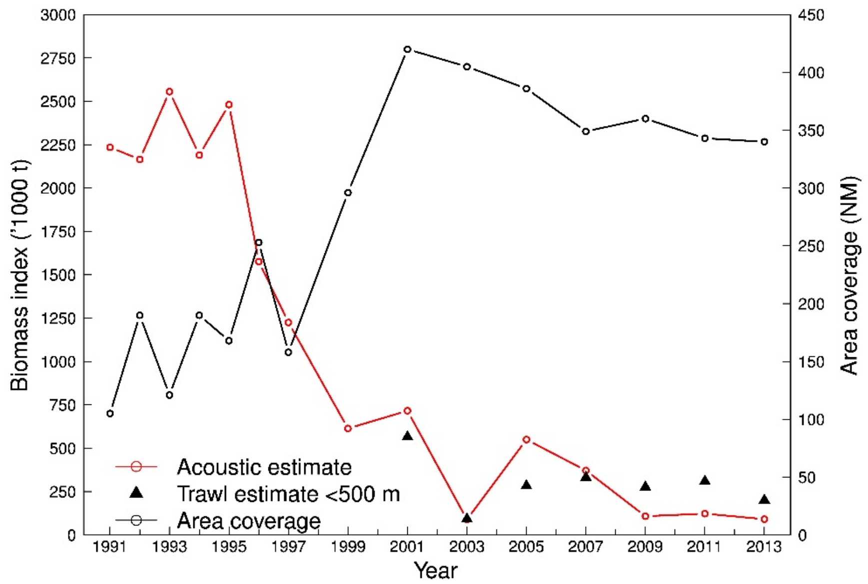

Figure 20.6.4. Overview of acoustic survey indices (thousand tonnes) from above the scattering layer (red filled circle), trawl estimates within the scattering layer and shallower than 500 m (black triangle), and aerial coverage (NM2) of the survey (black open circle) in the Irminger Sea and adjacent waters.

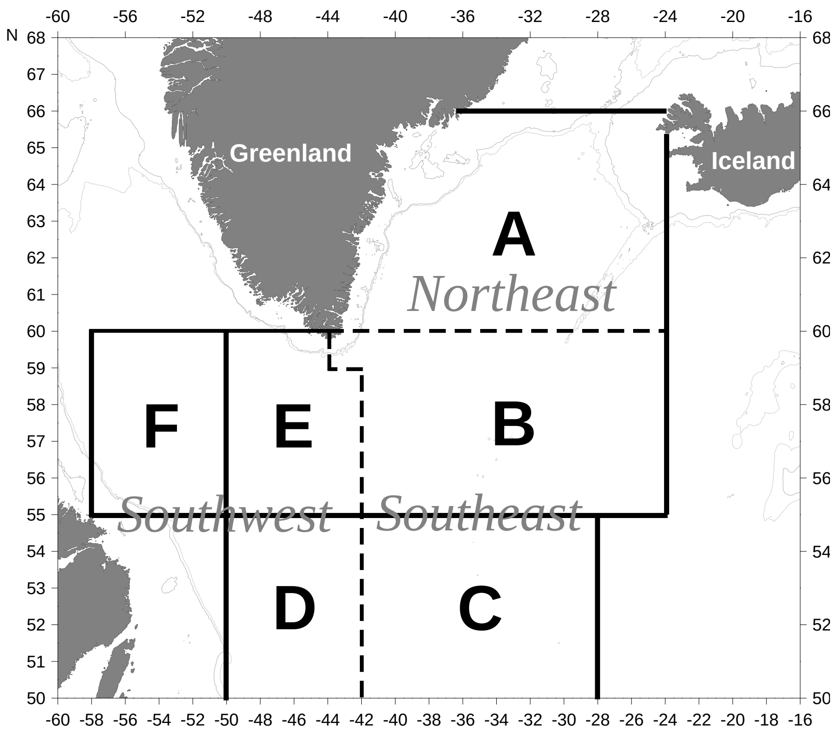

Figure 20.6.5 Sub-areas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines).

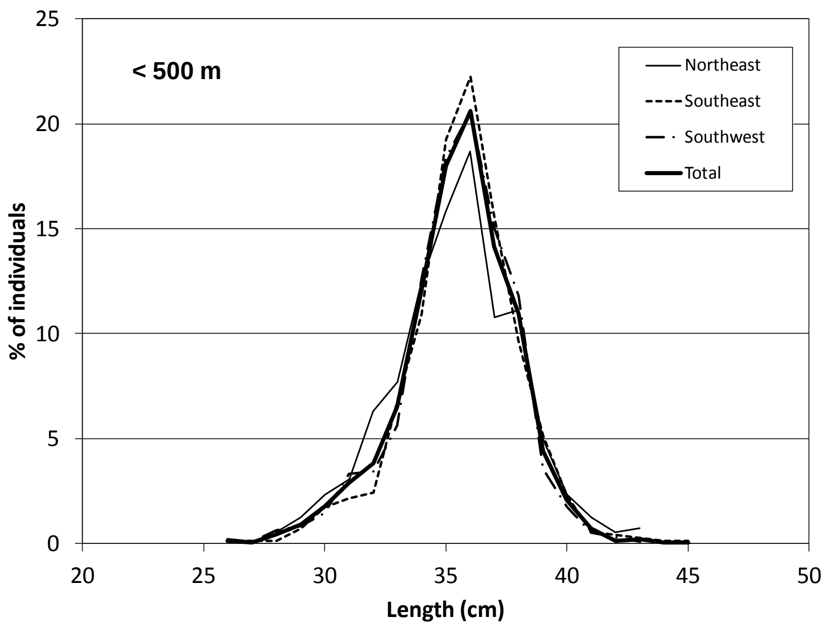

Figure 20.6.6 Length distribution of redfish in the trawls, by geographical areas and total, from fish caught shallower than 500 m (in 2013).

21 Deep Pelagic Sebastes mentella

Executive summary

ICES concluded in February 2009 that *S. mentella* is to be divided to three biological stocks and that the deep pelagic *S. mentella* in the Irminger Sea and adjacent should be treated as separate biological stock and management unit. This chapter therefore deals only with the deep pelagic stock.

Total landings of deep pelagic *S. mentella* s in 2013 were 45,594 t, 12,788 t more than in 2012.

No analytical assessment was conducted and there are no biological reference points for the species. Survey indices from the biennial international trawl-acoustic redfish survey conducted in the Irminger Sea and adjacent waters since 1999 are used as basis for advice.

The survey was conducted in June/July 2013. A total biomass of 280,900 t was estimated, a 41% less than in 2011 (474,000 t). Trawl survey estimates in 2011 and 2013 are lower than the average for 1999–2009 and the estimate for 2013 is the lowest observed. The next international trawl-acoustic redfish survey in the Irminger Sea will be conducted in June/July 2015.

No recruitment has been observed on the East-Greenland shelf during the last year, which is a concern because it is assumed to contribute to the three stocks at unknown shares.

21.1 Stock description and management unit

This section addresses the fishery for the biological stock deep pelagic *S. mentella* in the Irminger Sea and adjacent areas: NAFO 1-2, ICES V, XII, and XIV at depths > 500 m, including demersal habitats west of the Faeroe Islands. This stock corresponds to the management unit in the northeast Irminger Sea (ICES areas Va, XII and XIV).

The following text table summarizes the available information from fishing fleets in the Irminger Sea and adjacent waters in 2013. It should be noted that some these fleets are also fishing the Shallow Pelagic stock:

Country	Number of trawlers
Faroes	3 factory trawlers
Iceland	13 factory trawlers
Germany	1 factory trawlers
Latvia	1 factory trawlers
Lithuania	1 factory trawlers
Norway	2 factory trawlers
Russia	18 factory trawlers
Spain	5 factory trawlers

21.2 The fishery

The historic development of the fishery can be found in the Stock Annex. Tables 21.2.1 and 21.2.2 show annual catches, as estimated by the Working Group, disaggregated by ICES and NAFO regulatory areas and by country, respectively.

The changes in the spatial pattern of the fishery for the period 1992-2013 are shown in Figure 21.2.1, and annual catches are presented in Figure 21.2.2. Catches increased by approx. 41% compared to 2012, from 32,806 t in 2012 to 45,594 t (Table 21.2.2).

Standardized CPUE series for Faroe Islands, Iceland, Greenland, and Norway 1994-2013 are estimated with a GLM model including the factors year, ship, month and towing time. The results from the model show that the CPUE oscillates without trend since 1995 (Figure 21.2.3). The model output is shown in Table 21.2.3 and the residuals are in Figure 21.2.4. The CPUE index increased from about 0.3 in 2012 to >1.0 in 2013

21.3 Biological information

The length distribution from Icelandic landings for the period 1991-2013 is shown in Figure 21.3.1. Peak length between 1994 and 1997 was about 37 cm, but increased to roughly 42 from 1998 to 2005, although in 2002 the distribution showed two peaks, at 37 and 42 cm, and in 2003 the peak declined to 40 cm. Mean length has decreased further over the past years, but an increase was observed with 38.3 cm in 2012 compared with 37.8 cm in 2011. The length distribution in 2013 was similar as observed in 2012 (Figure 21.3.1).

21.4 Discards

Discards are not considered to be significant for the time being, according to available data from various institutes.

21.5 Illegal, Unregulated and Unreported Fishing (IUU)

The Group had again difficulties in obtaining catch estimates from several fleets. Furthermore, there are problems caused by misreported catches. The Group requests NEAFC and NAFO to provide ICES in time with all the necessary information.

21.6 Surveys

The last international trawl-acoustic survey took place in 2013 and it is described in detail in ICES CM WGRS REPORT 2013 (ICES, 2013). The next survey will be carried out in June/July 2015. It should be noted that the 2013 estimate was recalculated during the WKREDMP meeting in January 2014 (ICES 2014) as it was wrong because of technical error. The 1999 estimate was also recalculated.

21.6.1 Survey trawl estimates

Considering the conclusion of WKREDS (ICES, 2009a) and the recommendation of ICES on stock structure of redfish in the Irminger Sea and adjacent waters, the Group decided in the planning meeting (ICES, 2009b) to sample redfish separately above and below 500 m, i.e. to sample redfish as was done in the 1999, 2001 and 2003 surveys . The deep identification hauls covered the depth layers (headline) 550 m, 700 m, and 850 m.

The most recent trawl-acoustic survey on pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters was carried out by Iceland, Germany and Russia in June/ July 2013. Approximately 341,000 NM^2 were covered. A total biomass of 280,000 t was estimated, significantly below the 474,000 t of 2011 (Table 21.6.2). The results showed large biomass declines in subareas A, B and E (see Figure 21.6.1 for area definition) (Table 21.6.2). Biological samples from the trawls taken at depth >500 m showed a mean length of 38.5 cm, which is 0.5 cm larger than the mean length in 2011. Figure 21.6.2

shows the spatial distribution of samples used in the survey and Figure 21.6.3 shows the corresponding length distribution.

21.7 Methods

The assessment of pelagic redfish in the Irminger Sea and adjacent waters is based on survey indices, catches, CPUE and biological data.

21.8 Reference points

For pelagic redfish in the Irminger Sea and adjacent waters, no analytical assessment is carried out due to data uncertainties and the lack of reliable age data. Thus, no reference points can be derived.

21.9 State of the stock

21.9.1 Short term forecast

For pelagic redfish in the Irminger Sea and adjacent waters, no analytical assessment is being carried out due to data uncertainties and the lack of reliable age data. Thus, no short-term forecasts can be derived.

21.9.2 Uncertainties in assessment and forecast

21.9.2.1 Data considerations

Preliminary official landings data were provided by the ICES Secretariat, NEAFC and NAFO, and various national data were reported to the Group. The Group, however, repeatedly faces problems to obtain reliable catch data due to unreported catches of pelagic redfish and lack of catch data disaggregated by depth from some countries.

As in previous years, detailed descriptions on the horizontal, vertical and seasonal distribution of the fisheries are given.

The need and importance of having catch and biological data disaggregated by depth from all nations taking part in the fishery cannot be stressed strongly enough, and the Group urges all nations involved on supplying better data. With this need in mind, ICES sent a data call to all EU countries participating in the redfish fishery, encouraging stockholders to deliver detailed catch data before the WG would meet, but the response was very limited.

21.9.2.2 Assessment quality

The results of the international trawl-acoustic survey are given in section 21.6. Given the high variability in the correlation between trawl and acoustic estimates as well as the assumptions that need to be made about constant catchability across depth and areas, the uncertainty of these estimates is very high.

It is not known to what extent CPUE reflect changes in the stock status of pelagic *S. mentella*, since the fishery focuses on aggregations. Therefore, stable or increasing CPUE series might not indicate or reflect actual trends in stock size, although decreasing CPUE indexes are likely to reflect a decreasing stock.

21.9.3 Comparison with previous assessment and forecast

The data available for evaluating the stock status are similar to last year.

21.9.4 Management considerations

The Group needs more and better data and requests that NEAFC and NAFO provide ICES with all information leading to more reliable catch statistics.

The main feature of the fishery since 1998 is a clear distinction between two widely separated fishing grounds with pelagic redfish fished at different seasons and different depths. Since 2000, the southwestern fishing grounds extended also into the NAFO Convention Area. Biological data, however, suggest that the aggregations in the NAFO Convention Area do not constitute a separate stock. The NAFO Scientific Council agreed with this conclusion (NAFO, 2005). The Group concludes that at this time there is not enough scientific basis available to propose an appropriate split of the total TAC among the two fisheries/areas.

The 26,000 t TAC set by NEAFC for 2013 was overshot by 80%, mostly due to the unilateral decision of the Russian Federation to self-allocate a TAC of roughly 27,500 t. This quota was taken from both Shallow and Deep pelagic stocks, since the Russian Federation does not agree on the division of the *S. mentella* management units..

21.9.5 Ecosystem considerations

The fisheries on pelagic redfish in the Irminger Sea and adjacent waters are generally regarded as having negligible impact on the habitat and other fish or invertebrate species due to very low bycatch and discard rates, characteristic of fisheries using pelagic gear.

21.9.6 Changes in the environment

The hydrography in the survey of June/July 2013 show that temperature in the survey area is above average but it was lower than in 2011 in most of the surveyed area, except for the Irminger Current (ICES, 2013).

The increase of water temperature in the Irminger Sea may have an effect on spatial and vertical distribution of S. mentella in the feeding area (Pedchenko, 2005). The abundance and distribution of *S. mentella* in relation to oceanographic conditions were analysed in a special multistage workshop (WKREDOCE1-3, see ICES 2012b). Based on 20 years of survey data, the results reveal the average relation of redfish to their physical habitat in shallow and intermediate waters: The most preferred latitude, longitude, depth, salinity and temperature for *S. mentella* are approximately 58ºN, 40ºW, 300 m, 34.89 and 4.4ºC, respectively. The spatial distribution of *S. mentella* in the Irminger Sea mainly in waters < 500 m (and thus mainly relating to the "shallow" stock) appears strongly influenced by the Irminger Current Water (ICW) temperature changes, linked to the Subpolar Gyre (SPG) circulation and the North Atlantic Oscillation (NAO). The fish avoid waters mainly associated with the ICW (>4.5ºC and >34.94) in the north-eastern Irminger Sea, which may cause displacing towards the southwest, where fresher and colder water occurs (ICES 2012b).

Results based on international redfish survey data suggest that the inter-annual distribution of fish above 500 m will shift in a southwest/northeast direction depending on integrated oceanographic conditions (ICES 2012). Whether the results of the study mentioned are applicable to the conditions for the deep pelagic stock needs further investigation.

21.10 Benchmark meeting in 2012

The WKRED 2012 Benchmark workshop met from 1-8 February 2012 at ICES headquarters in Copenhagen, Denmark (ICES 2012a). The objectives of the workshop were for beaked redfish, among other things to agree upon and document the preferred method for evaluating stock status.

Deep pelagic beaked redfish has previously been assessed based on trends in survey biomass indices from international redfish survey since 1991. Supplementary data used includes relevant information from the fishery and length distributions from the commercial catch and the survey.

For deep pelagic beaked redfish, the WKRED-2012 external review panel recommended an alternative assessment method or the Schaefer biomass dynamic model. There was, however, disagreement regarding the biomass dynamic model as a step forward from the current trends based methods. The experts on beaked redfish present at the WKRED-2012 did not support the use of biomass dynamics models because of lack of contrast in the survey data and unrealistic estimates of production from the model given the biology of redfish. NWWG-2013 supported this view.

21.11 Various calculations related to DLS

This chapter provides for convenience information on DLS calculations (Category 3.2) for deep pelagic *S. mentella* and does not necessarily reflect the basis for the advice by the NWWG.

Deep pelagic *S. mentella* is considered a data limited stock (DLS) and should follow the ICES framework for such (Category 3.2).

For data-limited stocks (DLS) for which a biomass/abundance index is available, ICES uses as harvest control rule an index-adjusted status quo catch. The advice is based on a comparison of the two most recent index values (2011 and 2013 as the survey is conducted biennially) with the three preceding values (2001, 2003 and 2009, no surveys conducted in 2005 and 2007), combined with recent catch or landings data. Knowledge about the exploitation status also influences the advised catch. This means that the catch advice is based on the survey adjusted status quo catch equation:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where *I* is the survey index, *x* is the number of years in the survey average, z=5 and C_{y-1} is the average catch of the last three years.

For this stock the biomass is estimated to have decreased by 47.1% of the years 2001, 2003 and 2009 (average of three indices) and 2011 and 2013 (average of two indices). This implies a decrease in catches of at most 47.1% in relation to the average catch of the last three years, corresponding to a catch of no more than 22 181 t. Additionally, considering that exploitation is unknown, the DLS approach implies that catch should decrease by a further 20% as a precautionary buffer. This results in catch/landings of no more than 17 745 t.

Another option for advice could be following: Since the advice is more than 20% less than the three years average catches (47.1%) then a 20% uncertainty cap is applied. This means that the catch can not be reduced by more than 20% of recent average catches. This gives advice of 33 529 t. Applying the 20% precautionary buffer will give final advice of 26 823 t.

21.12 WKREDMP 2014

At WKREMP 2014 ICES was requested by Faroe Islands, Iceland and Greenland to evaluate proposed harvest control rules for deep pelagic redfish in the Irminger Sea and adjacent waters (ICES 2014). ICES reanalysed the survey time-series, which is the main source of information for the assessment. This changed the perception of stock status and productivity: The stock appears to be at a historical low. ICES also evaluated the proposed harvest control rules, and none of them are expected to lead to an increase in stock size by 2025. Therefore, ICES considers none of these options as being in accordance with the precautionary approach. It is suggested that managers discuss other options with ICES that might be more suitable, including a starting phase to reverse the decline of the stock.

21.13 References

ICES. 2009a. Report of the Workshop on Redfish Stock Structure (WKREDS). ICES CM 2009/ACOM:37.

ICES. 2009b. Report of the Planning Group on Redfish Surveys (PGRS). ICES CM 2009/RMC:01.

ICES. 2012a. Report of the Benchmark Workshop on Redfish (WKRED 2012), 1–8 February 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:48. 291 pp.

ICES. 2012b. Report of the Third Workshop on Redfish and Oceanographic Conditions (WKREDOCE3), 16-17 August 2012, Johann Heinrich von Thunen Institute, Hamburg, Germany. ICES CM 2012/ACOM:25. 70 pp.

ICES. 2013. Report of the Working Group on Redfish Surveys (WGRS), 6-8 August 2013, Hamburg, Germany. ICES CM 2013/SSGESST:14. 56 pp.

ICES. 2014. Report of the Workshop on Redfish Management Plan Evaluation (WKREDMP) ICES CM 2014/ACOM: 52.

NAFO 2005. Scientific Council Reports 2004, 306 pp

Pedchenko, A. P. 2000. Specification of oceanographic conditions of the Irminger Sea and their influence on the distribution of feeding redfish in 1999. ICES North-Western Working Group 2000, Working Document 22, 13 pp.

Pedchenko, A. P. 2005. The role of interannual environmental variations in the geographic range of spawning and feeding concentrations of redfish *Sebastes mentella* in the Irminger Sea. ICES Journal of Marine Science 62: 1501-1510.

Table 21.2.1 Deep Pelagic *S. mentella* (stock unit > 500 m). Catches (in tonnes) by area as used by the Working Group.

Year	Va	XII	XIV	NAFO 1F	Total
1991	0	7	52	0	59
1992	1 862	280	1 257	0	3 398
1993	2 603	6 068	6 393	0	15 064
1994	14 807	16 977	20 036	0	51 820
1995	1 466	53 141	21 100	0	75 707
1996	4 728	20 060	113 765	0	138 552
1997	14 980	1 615	78 485	0	95 079
1998	40 328	444	52 046	0	92 818
1999	36 359	373	47 421	0	84 153
2000	41 302	0	51 811	0	93 113
2001	27 920	0	59 073	0	86 993
2002	37 269	2	65 858	0	103 128
2003	46 627	21	57 648	0	104 296
2004	14 446	0	77 508	0	91 954
2005	11 726	0	33 759	0	45 485
2006	16 452	51	50 531	254	67 288
2007	17 769	0	40 748	0	58 516
2008	4 602	0	25 443	0	30 045
2009	16 828	4 658	32 920	0	54 406
2010	8 552	0	50 736	0	59 288
2011	0	7	47 326	0	47 333
2012	5 530	608	26 668	0	32 806
2013	5 274	0	40 320	0	45 594

Table 21.2.2 Deep pelagic *S. mentella* catches (in tonnes) in ICES Div. Va, Subareas XII, XIV and NAFO Div. 1F, 2H and 2J by countries used by the Working Group.

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Nederland	Norway	Poland	Portugal	Russia	Spain	UK	Ukraine	Total
1991								59												59
1992								3,398												3,398
1993				310		1,135		12,741					878							15,064
1994						2,019		47,435					523		377	1,465				51,820
1995	1,140	181	5,056	1,572	68	8,271	1,579	25,898	396	1,501	6,868	4	3,169		2,955	15,868	227		956	75,707
1996	1,654	307	3,351	3,748		15,549	1,671	57,143	196	512	5,031		5,161		1,903	36,400	5,558	123	245	138,552
1997		9	315	435		11,200		36,830	3				2,849		3,307	33,237	6,895			95,079
1998			76	4,484		8,368	302	46,537	1		34		438		4,073	25,748	2,758			92,818
1999			53	3,466		8,218	3,271	40,261					3,337		4,240	11,419	9,885	5		84,153
2000			7,733	2,367		6,827	3,327	41,466			0		3,108		3,694	14,851	9,740			93,113
2001			878	3,377		5,914	2,360	27,727			7,515		4,275		2,488	23,810	8,649			86,993
2002			15	3,664		7,858	3,442	39,263			9,771		4,197		2,208	25,309	7,402			103,128
2003				3,938		7,028	3,403	44,620			0		5,185		2,109	28,638	9,374			104,296
2004				4,670		2,251	2,419	31,098			0		6,277	1,889	2,286	31,067	9,996			91,954
2005				1,800		1,836	1,431	12,919			1,027		3,950	1,240	1,088	16,323	3,871			45,485
2006				3,498		1,830	744	20,942			1,294		5,968	1,356	1,313	23,670	6,673			67,288
2007				2,902		1,110	1,961	18,097		575	1,394		4,628	636	2,067	21,337	3,810			58,516
2008				2,632			1,170	6,723			749		571	219	1,733	15,106	1,142			30,045
2009				3,206			1,519	15,125		1,355	2,613			178	1,596	25,309	2,907			54,006
2010				3,195			1,932	14,772		1,963	2,228		2,388	3	2,203	22,803	7,801			59,288
2011				2,028		1,787		11,994		845	1,348		1,066		1,540	22,364	4,361			47,333
2012				1,438		1,523		5,912		724	558		3,362		250	18,377	632			32,806

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Nederland	Norway	Poland	Portugal	Russia	Spain	UK	Ukraine	Total
2013				1,719		1176		8,545		1,197	1,163		2,680			26,452	2,662			45,594

Table 21.2.3 Output from the GLM model used to standardize CPUE – NOT UPDATED

```
Call:
glm(formula = lafli ~ ltogtimi + factor(land) + factor(yy) +
    factor(mm) + factor(skip), family = gaussian(), data = north)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.5126  -0.2410   0.0168   0.2924   1.4568

Coefficients: (3 not defined because of singularities)
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       7.871595279 0.39094194  20.134946938 2.522077e-78
ltogtimi          1.051438993 0.01695572  62.010886787 0.000000e+00
factor(land)6    -0.198774546 0.35054379  -0.567046256 5.707845e-01
factor(land)46    0.356416371 0.13062029   2.728644788 6.448602e-03
factor(land)58    0.385905663 0.35297372   1.093298568 2.744732e-01
factor(land)69    0.131427216 0.21480114   0.611855295 5.407447e-01
factor(yy)1995   -0.544478224 0.09104861  -5.980082924 2.906186e-09
factor(yy)1996   -0.591350758 0.08559433  -6.908761003 7.764598e-12
factor(yy)1997   -1.074579737 0.08522551 -12.608663463 2.120951e-34
factor(yy)1998   -0.695638042 0.08486144  -8.197339811 6.028342e-16
factor(yy)1999   -0.797915967 0.08474619  -9.415361145 2.186144e-20
factor(yy)2000   -0.431790078 0.08594177  -5.024216475 5.788362e-07
factor(yy)2001   -0.955769159 0.08486379 -11.262391106 4.296930e-28
factor(yy)2002   -0.575545027 0.08596398  -6.695188372 3.244414e-11
factor(yy)2003   -0.316293204 0.08682628  -3.642828098 2.806914e-04
factor(yy)2004   -1.016098316 0.08870892 -11.454296393 5.867807e-29
factor(yy)2005   -1.325075546 0.09344673 -14.180009215 1.955001e-42
factor(yy)2006   -0.919905830 0.09688906  -9.494424199 1.079864e-20
factor(yy)2007   -0.681404991 0.10068657  -6.767585940 2.007085e-11
factor(yy)2008   -1.039292973 0.11665575  -8.909059427 1.776186e-18
factor(yy)2009   -0.575811515 0.10378067  -5.548350380 3.516366e-08
factor(yy)2010   -0.337330572 0.10886481  -3.098618992 1.987589e-03
factor(yy)2011   -0.715714357 0.10794155  -6.630573586 4.961323e-11
factor(yy)2012   -1.309676579 0.11568546 -11.321012872 2.345629e-28
```

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factor(mm)4	-0.378550109	0.37671843	-1.004862201	3.151575e-01
factor(mm)5	-0.180482597	0.37822841	-0.477178853	6.333181e-01
factor(mm)6	-0.333063915	0.37796344	-0.881206692	3.783752e-01
factor(mm)7	-0.503871648	0.37798537	-1.333045363	1.827596e-01
factor(mm)8	-0.608838137	0.38197175	-1.593934978	1.112032e-01
factor(mm)9	-0.459326697	0.39365610	-1.166822263	2.435045e-01
factor(mm)10	-0.758170930	0.43452708	-1.744818582	8.126201e-02
factor(mm)11	-0.746833434	0.50556889	-1.477213994	1.398700e-01
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factor(skip)1265	-0.305357861	0.22335074	-1.367167461	1.718184e-01
factor(skip)1268	-0.266852354	0.48481836	-0.550417180	5.821315e-01
factor(skip)1270	-0.152220760	0.13168835	-1.155916653	2.479360e-01
factor(skip)1273	-0.419400828	0.13225616	-3.171125008	1.555377e-03
factor(skip)1279	-0.447449821	0.22139223	-2.021072797	4.348488e-02
factor(skip)1308	-0.038459005	0.12407714	-0.309960450	7.566427e-01
factor(skip)1328	-0.144677028	0.13096482	-1.104701450	2.695014e-01
factor(skip)1345	-0.458372216	0.12962963	-3.536014115	4.210561e-04
factor(skip)1351	-0.357088024	0.13798946	-2.587792070	9.771199e-03
factor(skip)1360	-0.115260878	0.13128164	-0.877966489	3.801305e-01
factor(skip)1365	-0.295965760	0.14818615	-1.997256610	4.601360e-02
factor(skip)1369	-0.011320574	0.14158965	-0.079953400	9.362871e-01
factor(skip)1376	-0.169473795	0.12691871	-1.335294073	1.820230e-01
factor(skip)1395	-0.409995924	0.26206284	-1.564494724	1.179543e-01
factor(skip)1408	-1.101773815	0.48734615	-2.260762308	2.394521e-02
factor(skip)1412	-0.111357948	0.29537612	-0.377003899	7.062346e-01
factor(skip)1459	-0.583761981	0.13242885	-4.408117879	1.132118e-05
factor(skip)1471	-0.613726934	0.17679359	-3.471432056	5.353333e-04
factor(skip)1472	-0.511423665	0.16493944	-3.100675325	1.973945e-03
factor(skip)1473	-0.952361655	0.21265005	-4.478539431	8.201613e-06
factor(skip)1484	-1.433135836	0.48533948	-2.952852375	3.207303e-03
factor(skip)1497	-1.418776803	0.35333866	-4.015345477	6.288939e-05
factor(skip)1530	-0.740040738	0.48506624	-1.525648831	1.273501e-01
factor(skip)1536	-1.814090714	0.48651089	-3.728777180	2.010160e-04
factor(skip)1552	-1.430344940	0.29607192	-4.831072584	1.525962e-06

factor(skip)1553	-0.003402939	0.35390074	-0.009615518	9.923296e-01
factor(skip)1578	-0.354319033	0.15025452	-2.358125591	1.852067e-02
factor(skip)1579	-0.071762545	0.12696644	-0.565208749	5.720331e-01
factor(skip)1585	-0.417372263	0.17163124	-2.431796521	1.516373e-02
factor(skip)1628	-1.097387934	0.29532540	-3.715860332	2.114507e-04
factor(skip)180	-0.522664061	0.11197449	-4.667706574	3.373762e-06
factor(skip)1833	-0.025339243	0.12377825	-0.204714826	8.378282e-01
factor(skip)1868	-0.141108499	0.12362729	-1.141402470	2.539209e-01
factor(skip)1880	-0.300538211	0.13797726	-2.178172089	2.957946e-02
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factor(skip)1903	-0.503244254	0.29824691	-1.687341029	9.178708e-02
factor(skip)1976	-0.628200177	0.20114205	-3.123166888	1.830228e-03
factor(skip)1977	-0.169902957	0.14830443	-1.145636427	2.521647e-01
factor(skip)2107	-0.796278905	0.35043313	-2.272270619	2.323928e-02
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factor(skip)2203	-0.195064716	0.12387778	-1.574654639	1.155890e-01
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factor(skip)2220	0.170552846	0.48621844	0.350774122	7.258169e-01
factor(skip)2236	-0.240310005	0.20254007	-1.186481294	2.356576e-01
factor(skip)2248	-0.468803577	0.35307606	-1.327769382	1.844965e-01
factor(skip)2265	-0.081118608	0.13404819	-0.605145127	5.451923e-01
factor(skip)2410	-0.192166371	0.21987506	-0.873979834	3.822970e-01
factor(skip)2549	-0.144974322	0.14686104	-0.987153031	3.237585e-01
factor(skip)2550	0.027568334	0.48384311	0.056977837	9.545719e-01
factor(skip)2592	0.229114661	0.35461605	0.646092198	5.183381e-01
factor(skip)3033	-1.789786537	0.44139343	-4.054855382	5.326475e-05
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factor(skip)3382	-1.174260049	0.37396205	-3.140051352	1.728735e-03
factor(skip)3523	-1.415480845	0.45907228	-3.083350696	2.091640e-03
factor(skip)3542	-0.818668375	0.38925897	-2.103145841	3.565233e-02
factor(skip)3709	-1.212729719	0.37572436	-3.227711221	1.280216e-03
factor(skip)934	-0.560484938	0.10397540	-5.390553316	8.388350e-08

```
factor(skip)A     0.478887900 0.44197157   1.083526488 2.787836e-01
factor(skip)B     0.747484733 0.39901053   1.873345878 6.125365e-02
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 0.2216236)

    Null deviance: 1901.61  on 1335  degrees of freedom
Residual deviance:  274.59  on 1239  degrees of freedom
AIC: 1873.7

Number of Fisher Scoring iterations: 2

Analysis of Deviance Table

Model: gaussian, link: identity

Response: lafli

Terms added sequentially (first to last)


              Df Deviance Resid. Df Resid. Dev         F    Pr(>F)
ltogtimi       1  1353.66      1347     559.66 6153.6477 < 2.2e-16 ***
factor(land)   4    68.12      1343     491.55   77.4139 < 2.2e-16 ***
factor(yy)    19   132.78      1324     358.76   31.7700 < 2.2e-16 ***
factor(mm)     9    17.82      1315     340.94    9.0021 2.899e-13 ***
factor(skip)  64    65.75      1251     275.19    4.6701 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table 21.6.1 Deep pelagic *S. mentella*. Survey estimates for depth >500 m from trawl samples taken in 2013.

	A	B	C	D	E	F	Total
Area (NM2)	123,531	83,385	4,181	51,185	62,730	15,683	340,695
Mean length	(cm)	38.8	37.5	36.1	36.3	38.2	37.7
Mean weight	(g)	717	653	615	595	482	654
Biomass (t)	193,000	75,000	0	2,000	10,000	0	280,000

Table 21.6.2. Results (biomass in ´000 t) for the international redfish surveys conducted since 1999 for deep pelagic *S. mentella* for each subarea (see Figure 21.6.2) and total.

	Sub-area						
Year	A	B	C	D	E	F	Total
1999	277	568	12	27	52	0	935
2001	497	316	28	79	64	18	1001
2003	476	142	20	13	27	0	678
2005	221	95	0	8	65	3	392
2007	276	166	1	5	62	11	522
2009	291	121	0	8	37	1	458
2011	342	112	0	1	18	0	474
2013	193	75	0	2	10	0	280

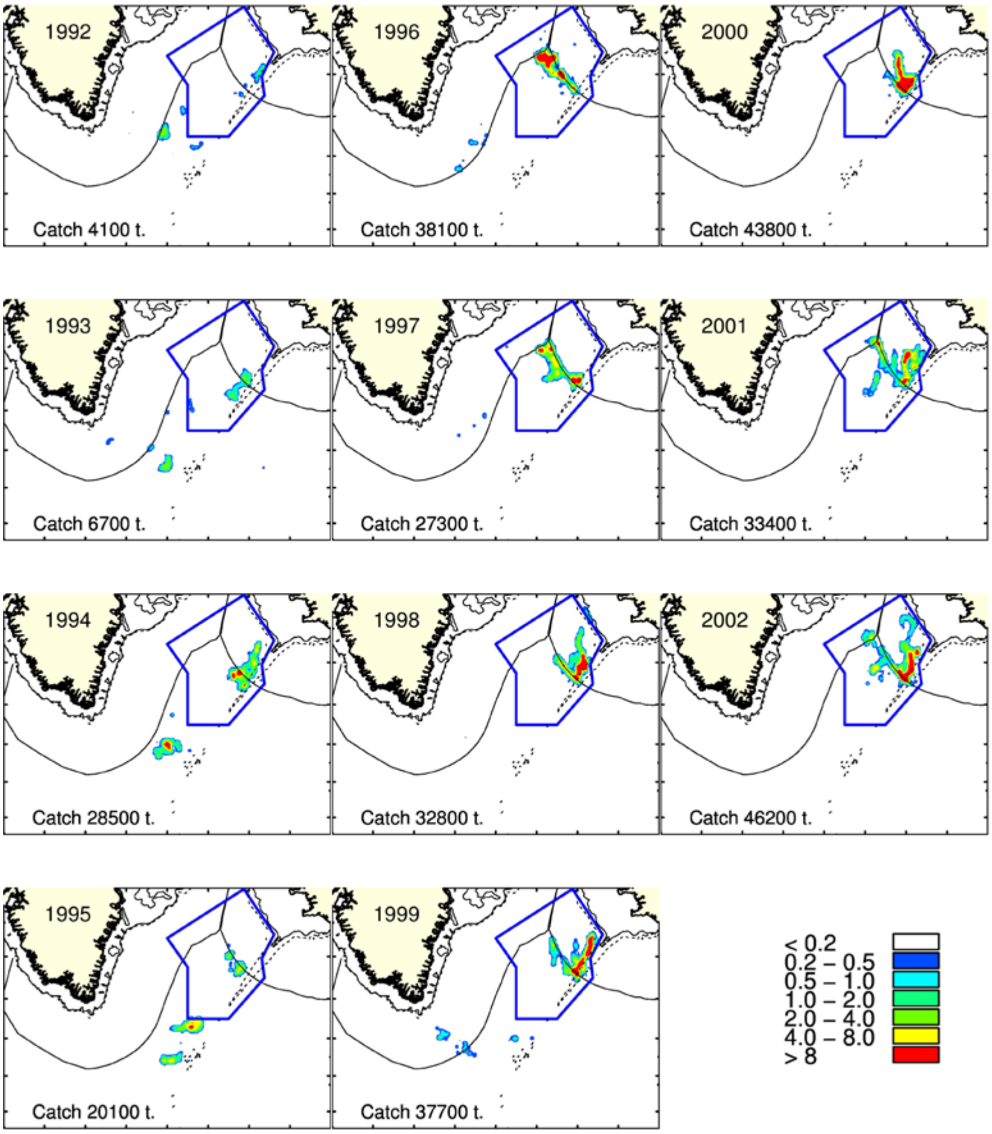

Figure 21.2.1 Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992-2013. Data are from the Faroe Islands (1995-2013), Germany (2011-2013) Greenland (1999-2003 and 2009-2010), Iceland (1995-2013), and Norway (1995-2003 and 2010-2013). The catches in the legend are given as tones per square nautical mile. The blue box represents the proposed management unit.

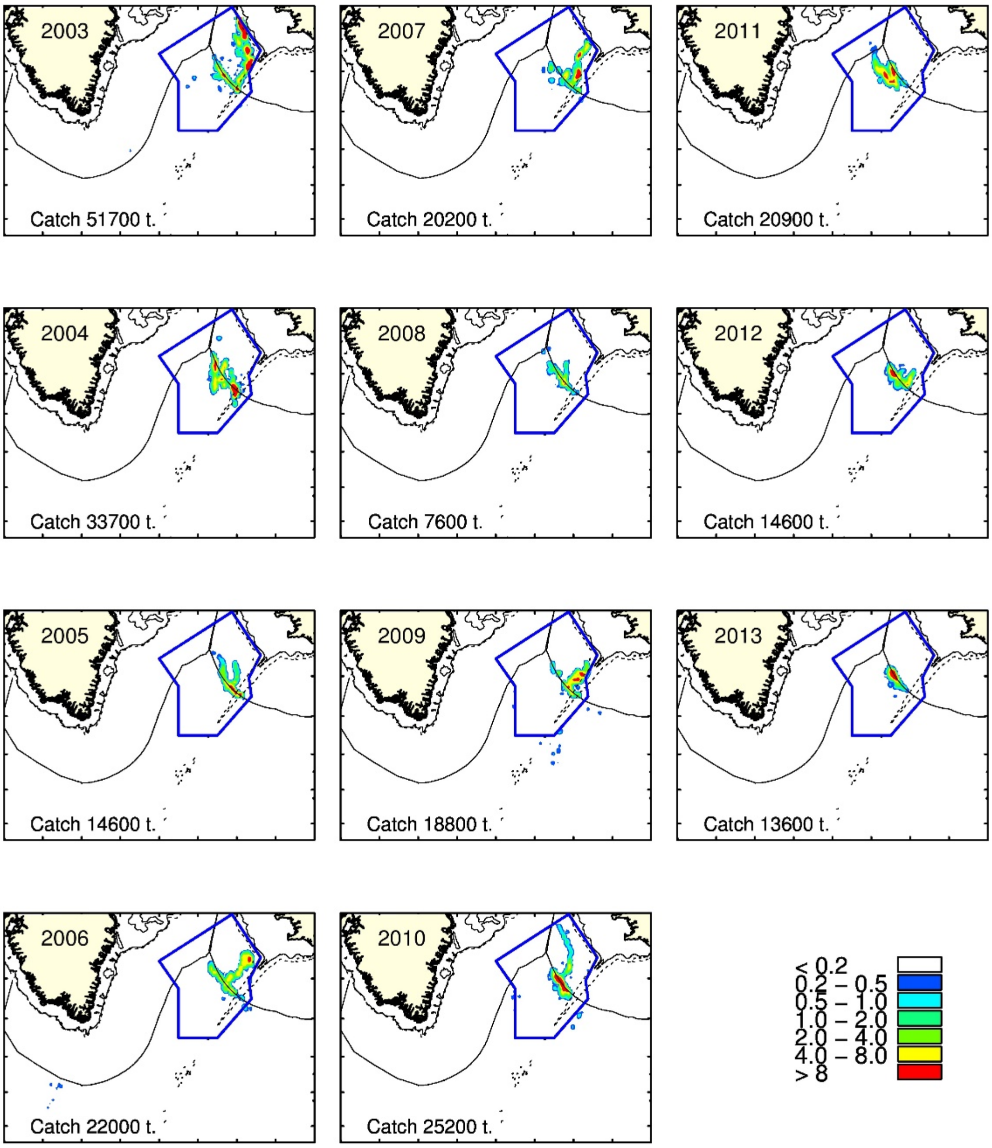

Figure 21.2.1 (Cont.) Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992-2013. Data are from the Faroe Islands (1995-2013), Germany (2011-2013) Greenland (1999-2003 and 2009-2010), Iceland (1995-2013), and Norway (1995-2003 and 2010-2012). The catches in the legend are given as tones per square nautical mile. The blue box represents the proposed management unit.

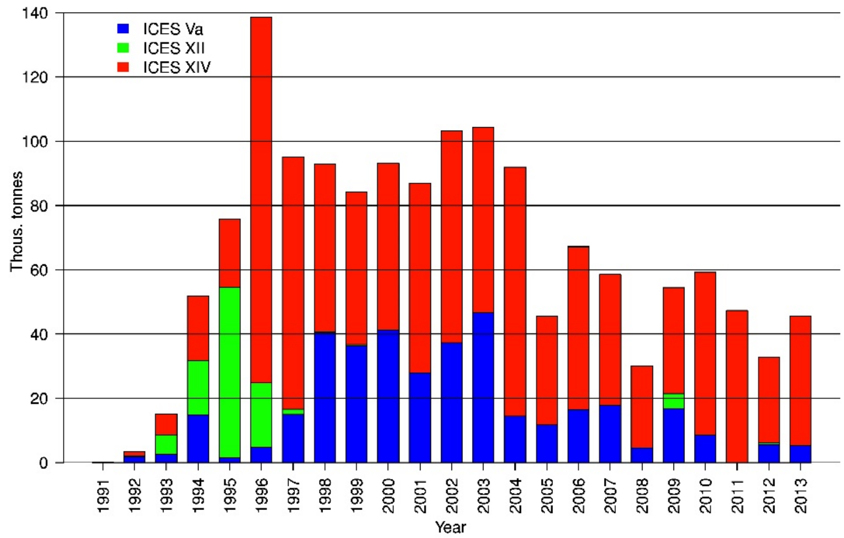

Figure 21.2.2 Landings of deep pelagic *S. mentella* (Working Group estimates, see Table 21.2.1).

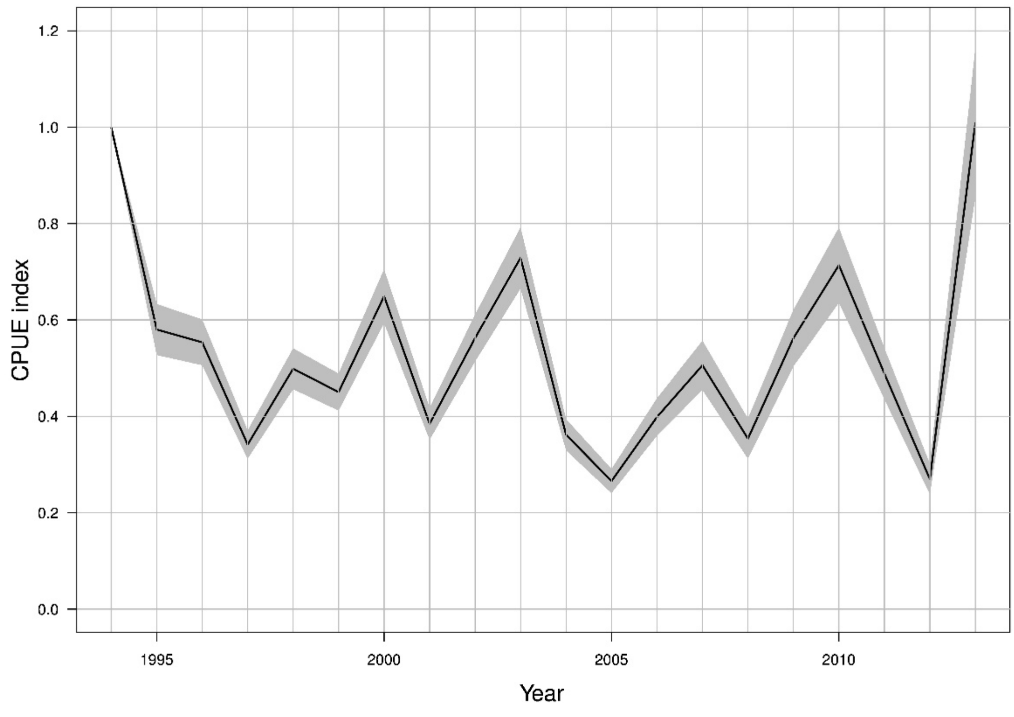

Figure 21.2.3 Trends in standardised CPUE of the deep pelagic *S. mentella* fishery in the Irminger Sea and adjacent waters, based on log-book data from Faroe Islands, Iceland, Germany, Greenland and Norway.

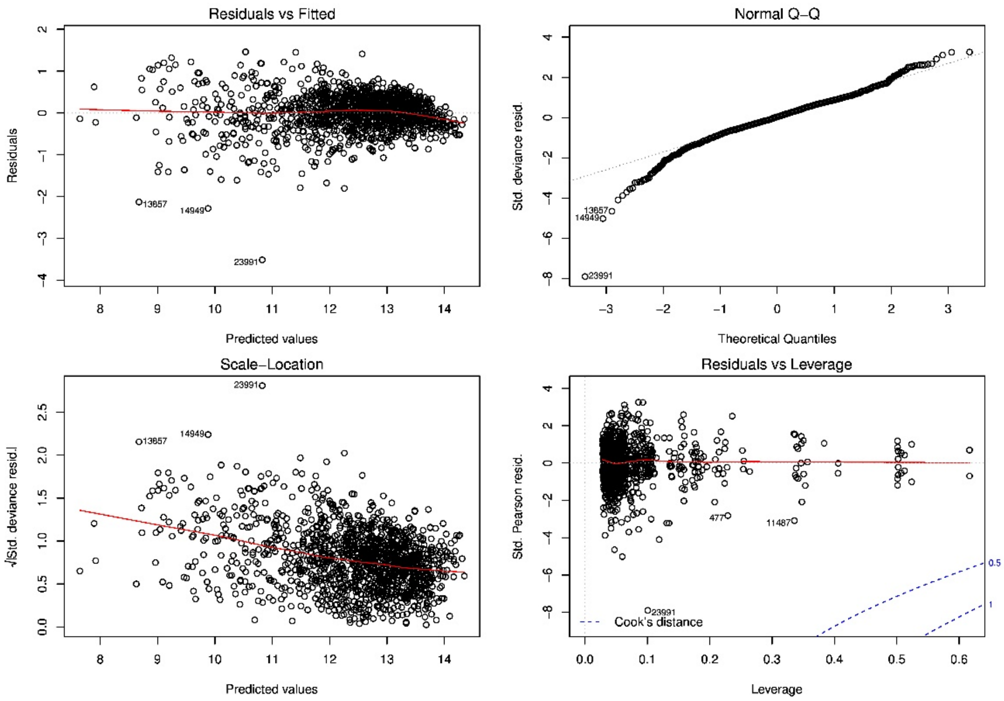

Figure 21.2.4 Residuals from the GLM model used to standardize CPUE, based on log-book data from Faroe Islands, Iceland, Greenland and Norway.

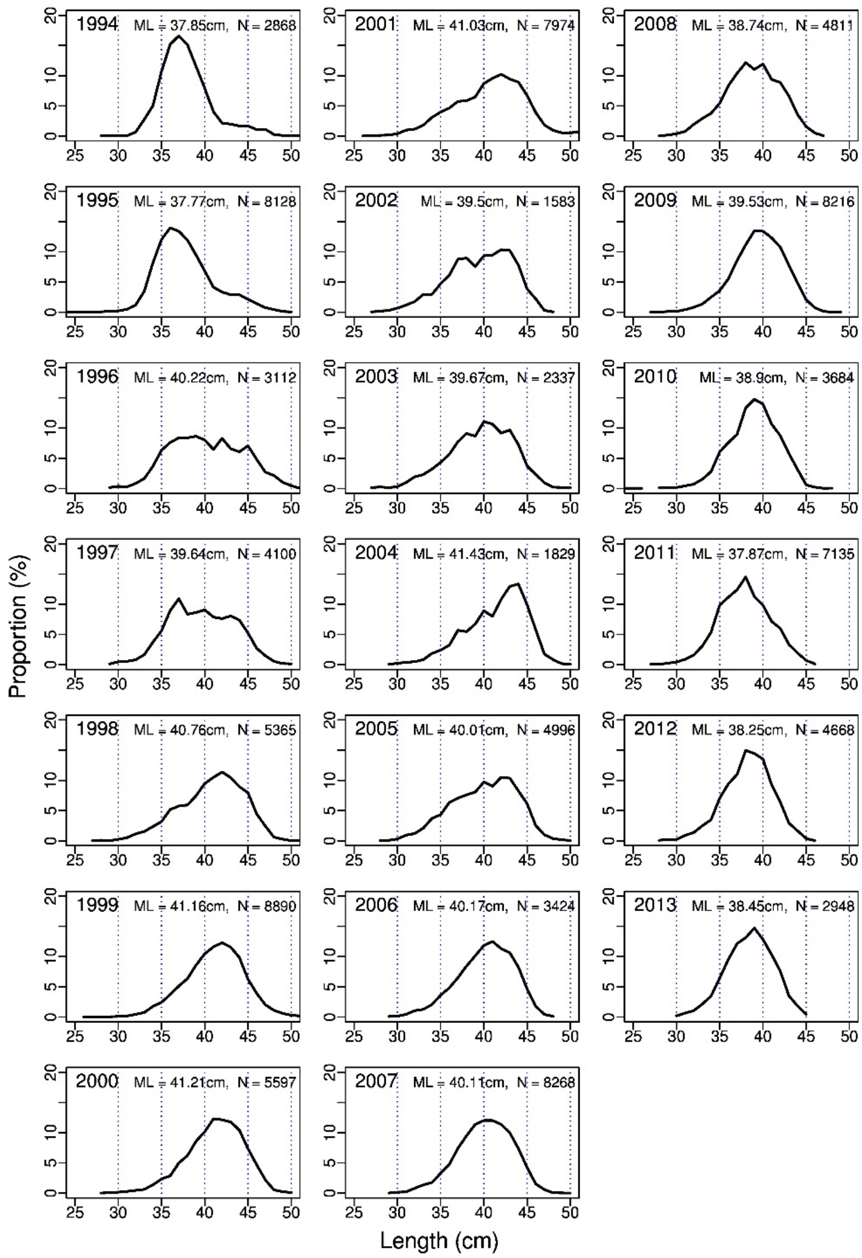

Figure 21.3.1 Length distribution from Icelandic landings of deep pelagic *S. mentella*.

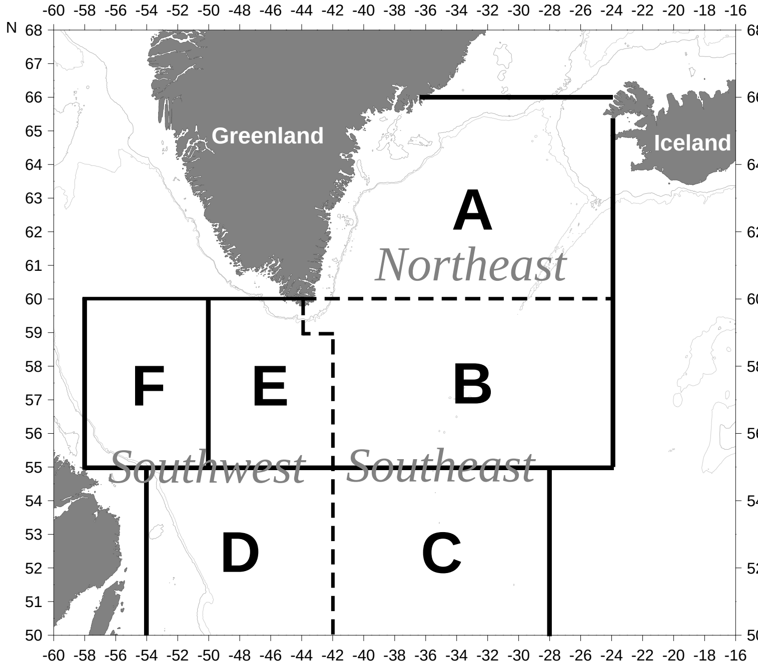

Figure 21.6.1 Sub-areas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines).

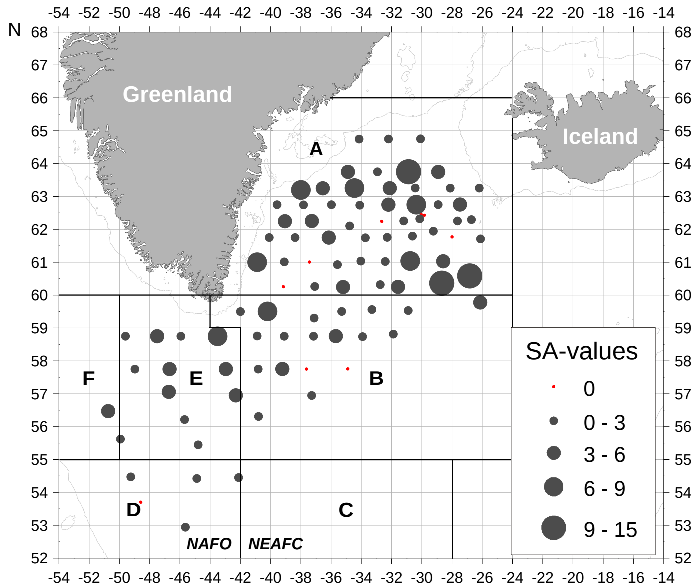

Figure 21.6.2. Redfish trawl estimates deeper than 500 m (type 3 trawls). sA values calculated by the trawl method (see WGRS Report, 2013) during the joint international redfish survey in June/July 2013.

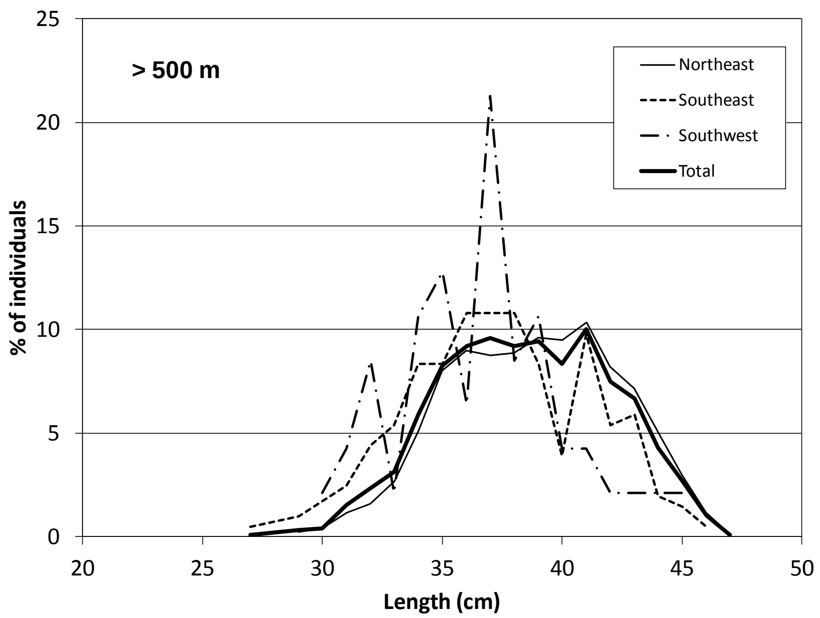

Figure 21.6.3 Length distribution of redfish in the trawls, by geographical areas (see Fig. 21.6.1) and total, from fish caught deeper than 500 m.

22 Greenlandic slope *Sebastes mentella* in XIVb

Summary

- ICES concluded in February 2009 that demersal *S. mentella* is to be divided into three biological stocks and that the *S. mentella* on the continental shelf and slope should be treated as a separate biological stock and management unit. This separation of the stocks did not include the adult *S. mentella* on the Greenlandic slopes. ICES therefore decided that NWWG will conduct a separate assessment of *S. mentella* in subarea XIVb until further information is available to assign stock origin. This chapter therefore deals only with the *S. mentella* on the Greenlandic Slope.
- Total landings of demersal *S. mentella* in East Greenland waters in 2013 were about 6600 tons, which is similar to 2010-2012 landings.
- In the decade before 2009 *S. mentella* was mainly a valuable by-catch in the fishery for Greenland halibut. However, since 2009 a fishery directed towards demersal redfish has taken place.
- No formal assessment was conducted and there are no biological reference points for the species. Information from logbooks and survey indices are used as basis for advice.
- Available survey biomass indices show that in Division XIVb the biomass remains at a low level in 2013. This is mainly seen in the fishable part of the stock and mainly in the area of the fishery.
- No new recruits (>18 cm) are seen in the survey catches, and no juveniles are present (<18 cm). This suggests that the fishery in coming years will be based on the same cohorts.
- Data suggests a local overexploitation by the fishery that has caused a severe local stock decline.

22.1 Stock description and management units

See chapter 16 for description of the stock structure of *S. mentella* in the Irminger Sea and adjacent waters. ICES has advised separately for *S. mentella* found demersal in ICES XIVb since 2011, and will do so until all available information on stock origin in this area is analysed and a new procedure is agreed upon. New genetic data presented at the 2014 NWWG meeting suggests that the stock is not easily grouped with existing stocks treated by ICES and that there are distinct area related differences in stock affiliation along the slope. This information should be presented in a forum where a decision on future proceedings can be made.

Genetic data from the fishery were collected spring in a very limited area and the survey samples were collected in all subareas (Q1-Q6, Figure 22.1.1). Reference samples from the Iceland shelf, deep pelagic and shallow pelagic stocks (all *S. mentella)* and *S. marinus* were also included for comparison. The presented results should be considered preliminary, but certain overall patterns were evident. Four clusters were detected with high probability in the samples: shallow pelagic (oceanic in figure), deep pelagic (deep sea in figure), *S. marinus* and a slope stock. All components were found in both commercial and survey samples, but in very different proportion and with a clear latitudinal effect. Generally, the commercial samples consisted of slope stock fish. Some of the Iceland slope samples were also in this cluster, suggesting a continental slope stock that spans both the Icelandic and Greenlandic shelf. The survey samples also include the slope stock, but these are restricted to the southern part of the area (Q4-Q6) with some between year variability in the northern limit. The discrepancy between survey and commercial samples (commercial samples were collected further north then where the survey indicates the limit of the slope stock) indicates some seasonal variation or that the survey does not have sufficient resolution to detect cluster delineation. The northern survey area (Q1+Q2) mainly contained fish from the deep pelagic cluster, similar to the Iceland shelf samples and the deep pelagic samples.

22.2 Scientific data

Indices were available from three surveys in XIVb. A German survey directed towards cod in Greenlandic waters (0-400 meters, Fock *et al*. 2014), the Greenland deep water survey (400-1500 meters) targeting Greenland halibut (Hedeholm and Boje 2014a) and the Greenland shrimp and fish survey in shallow water (0-600 meters) which has been conducted since 2008 (Hedeholm and Boje 2014b). In 2012, a redfish by-catch CPUE based on the Greenland halibut directed fishery in East Greenland was introduced (Hedeholm and Boje 2013b). This covers the period from 1999-2012. In 2014 a CPUE index from the redfish directed fishery was introduced (Hedeholm et al. 2014b), covering the period from 1999-2013, but the index is only useable for between 2009 and 2013 as there was no directed fishery in the earlier years in the time series.

The German survey on the slope in XIVb has since 1982 been covering the slopes in East Greenland waters. Cod is the target species in this survey and it operates at depths of 400 meters and shallower. The survey was re-stratified in 2009 (see Stock Annex). From 1993-1998 a large number of *Sebastes* sp. smaller than 17 cm. was found in the survey (Figure 22.2.1). This coincided with a large increase in the amount of 17-30 cm large *S. mentella* from 1995-1998. From 1998 to 2003 the total biomass increased as a result of many small fish (<17 cm) in the survey, followed by a few years of high biomass estimates for *S. mentella* from 2003-2009. This increase occurred in one particular stratum only, i.e. stratum 8.2. From 2009 onward, a declining trend was observed, with the low biomass estimates resembling the conditions before (Figure 22.2.1). In the same period, the amount of small fish (17-30 cm) has steadily declined causing an increase in the amount of larger fish (Figure 22.2.1c) until the overall biomass declines in 2010 and 2011. The depletion of the small size group has led to a progressive decline in the juvenile biomass index to a current low level, and no new recruits have been seen in the survey. This pattern is also reflected in the abundance estimates (Figure 22.2.1). The modal size of the adult fish has increased from 25 cm in 2001 to around 37 cm in 2010, but declined slightly in 2011 and the distribution has becomes flat with clearly defined mode in 2013 (Figure 22.2.2).

The Greenland deep water survey has since 1998, except in 2001, surveyed the slopes of east Greenland from 400 to 1500 meters with the majority of stations deeper than 600 meters targeting Greenland halibut (Figure 22.2.3). There was a small decrease in the 2013 biomass estimate, but this follows a time series high in 2012, and the estimate is still above the time series average (Figure 22.2.4). The overall length distribution from the entire area in 2013 shows a mode around 31 cm. which is a 1-2 cm increase compared to 2011 and 2012 values (Figure 22.2.5).

The Greenland shrimp and fish survey in shallow water in East Greenland started in 2007, and surveys the East Greenland shelf and shelf edge at depths between 0-600 m. However, 2007 was mostly exploratory and is not reported. In general, survey estimates of schooling fish are associated with large uncertainties due to their patchy distribution. This, in conjunction with the relatively short time series, makes overall conclusions regarding stock trends based solely on this survey tentative although it is probably the survey with the best coverage of redfish distribution. The 2013 biomass estimate is an increase of 61% compared to 2012 (Figure. 22.2.6). This was however the result of a single large haul in Q5 and excluding this reduced the biomass estimate by 49% making the increase small. The German survey shows very similar trends both with regards to adult fish and juveniles. The juveniles are at the lowest level in the 30 year time series, and the adult biomass index has declined for the past five years and is at the lowest level since 2005. Both survey length distributions showed no clear mode, but a rather flat distribution (Figure 22.2.7).

22.3 Information from the fishing industry

22.3.1 Landings

From the Greenland and German surveys we know that the demersal redfish found on the Greenland slope is a mixture of *S. marinus* and *S. mentella*. Based on the surveys and fourteen samples from the commercial fishery (see section 22.3.6) the amount of *S. mentella* caught in XIVb in 2013 was estimated as 82 % of the reported catch of demersal redfish derived from logbooks.

Prior to 2008, the splitting factor has varied. Prior to 1974 all catches were reported as *S. marinus* and the split was determined by working groups on a yearly bases.

Total annual landings of demersal *S. mentella* from Divisions XIVb since 1974 are presented in Table 22.3.1.1. From 1976 to 1994 annual landings were at a relatively high level with landings ranging between 2 000 tons to 20 000 tons with a very high peak at nearly 60 000 t in 1976. However, this fishery was ended abruptly in 1995 due to large amounts of very small redfish in the catches. From 1998 to 2002 the landings ranged from 1 000 to 2 000 tons and from 2003 to 2008 landings remained at lower levels (<500 tons). In 2009 an exploratory fishery landed 895 tons of *S. mentella*. This was a large increase compared to 2008 and for the first time in ten years the fishery was limited by a TAC. In 2010, a quota on 5,000 tons demersal redfish was initially given and of these, 400 t were allocated to the Norwegian fleet. After this amount was fished, an extraordinary research quota of 1,000 tons was given to a Greenlandic vessel. Since 2010 the catches have been around 8,300 t (*S. mentella* and *S. marinus* combined) and 2013 catches were 8,246 t (Figure 22.3.3). The TAC for 2014 is 8,500. In 2010 there was no jurisdiction that clearly delimited the pelagic stocks from the redfish found on the shelf. A few vessels benefitted from this by fishing their pelagic quota on the shelf (2,179 tons) making catches on the shelf exceed the TAC. This led to the introduction of a "redfish line" that separates the demersal slope stock from the pelagic stocks (see stock annex).

22.3.2 CPUE and by-catch CPUE

A redfish by-catch CPUE was introduced at the redfish 2012 benchmark (WKRED). This is based on catches from the Greenland halibut directed fishery (Hedeholm and Boje 2014a) which covers redfish distribution better than data from the redfish directed fishery and covers a longer period (1999-2012). The CPUE has very low values in the initial two years of the time series, but following an increase in 2001, values have remained at the same level until 2006 after which a decline followed. From 2010 to 2012 the CPUE increased, followed by a small decline in 2013 (Figure 22.3.2.1).

The index does not show the decline in biomass index seen in the shallow water surveys (German and Greenland). This could be associated with the nature of the decline, which appears to be confined to the commercial area. The Greenland halibut fishery is not as spatially restricted as the redfish fishery, so it will not be as sensitive to local changes. Based on the CPUE there does not appear to be any large decline in stock size.

The CPUE from the redfish directed fishery showed a drastic decline from 2010 (3.7 t/h) to 2013 (1.3 t/h, Figure 22.3.2.2). This fishery takes place in a geographically limited area between 63.5°N and 65°N, where approximately 90% of the catches are taken. Accordingly, the CPUE series can only be used as an index on local stock development. Both the Greenland shallow water survey (0-600m) and German survey (0-400m) show that the main fishing area coincides with the area of highest overall abundance. Hence, the CPUE decline indicates a severe local stock depletion that is also reflected in the overall stock trend.

22.3.3 Fisheries and fleets

The fishery for *S. mentella* on the slopes in XIVb is mainly conducted with bottom trawl. From 1998-2012 only 1% were caught with longlines. The area where *S. mentella* is caught is closely related to the area where fishery for Greenland halibut and cod takes place. The majority of the catches are taken at depths from 300 m to 400 m. (Figure 22.3.3.1)

The directed fishery was stopped in 1995, but in 1998 Germany restarted a directed fishery for redfish with annual landings of approximately 1 000 t in 1998-2001 increasing to 2 100 t in 2002 (Bernreuther et al. 2013). Samples taken from the German fleet indicated that substantial quantities of the redfish caught, especially in 2002, were juveniles, i.e. fish less than 30 cm. There was very little demersal redfish fishery in XIVb in 2003-2004 (less than 500 t). This continued in 2005-2008 and most *S. mentella* were caught as by-catch in the Greenland halibut fishery.

In 2009 three Greenland vessels started a fishery targeting demersal redfish. Each was given an explorative quota of 250 t. This fishery was very successful and led to an increased fishery in 2010 (seven boats), 2011 (15 boats) and 2012 (21 boats). However, in 2012 95% of the catch was taken by six vessels and 97% by five vessels in 2013.

On the steep slopes very little horizontal distance separates the distribution of cod, redfish and Greenland halibut (Figure 22.3.3.2). The part of the fleet with both quotas for redfish and Greenland halibut takes advantage of this by shifting between very short hauls targeting redfish and long hauls directed to Greenland halibut. Thereby avoiding time where the vessel is not fishing due to processing of the catch.

After the German fleet stopped fishing in 2002 the majority of the catches have been taken by the British, Faroese, Norwegian and Greenland fleet. The British fishery took place from 2001 to 2005 and since 2006 only Greenland, Faroese Islands,Norway and Germany have had any significant catches (Table 22.3.3.1).

22.3.4 By-catch/discard in the shrimp fishery

To minimize by-catch of fish species in the fishery for shrimp the trawls have since 2002 been equipped with grid separators (G.H. 2001). However, the 22 mm spacing between the bars in the separator allows small fish to enter the codend. In a study of the amount of by-catch in the shrimp fishery the mean length of the redfish that entered the cod end was 13-14 cm. The same study also documented that redfish by weight accounted for less than 1% of the amount of shrimp that were caught (Sünksen 2007).

Coincident with the introduction of these separator grids the amount of juvenile redfish caught by the shrimp fishery dropped from annual 100-200 tons to a lower level near 100 tons. Since 2006 not much shrimp fishery has taken place in ICES XIVb and the current level of by-catch must be considered negligible (Table 22.3.4.1). Since 1999 the fishery has started in April-May due to poor winter conditions such as ice and wind that prevents fishing. Only in 2000 and 2002 the fishery started already in February (Table 22.3.4.2). Since 2010, the fishery has been starting already in January. The depth distribution of cod and redfish overlaps (Figure 22.3.3.2) and therefore the fishery for redfish led to a by-catch of cod on 96 tons in 2013. The vessels are allowed a 10% by-catch of cod.

22.3.5 Sampling from the commercial fishery

In 2013 the catch length distribution was estimated from 14 samples (N=1 019, Figure 22.3.6.1). It showed a clear mode around 34 cm. which is a decrease of 4 cm compared to the last three years. All samples were analyzed by the Greenland Institute of Natural Resources, and it was found that *S. mentella* constituted 76% of the total sample weight (Figure 22.3.6.2). In both species a mode was seen between 34-36cm. and for *S. marinus* an additional increase in frequency was seen at 45-50cm.

22.4 Methods

No analytical assessment was conducted.

22.5 Reference points (Benchmark, WKRED)

There are no biological reference points defined for this stock. However, part of the benchmark in 2012 (WKRED) was to evaluate the possible use of a stock production model in generating a quantitative advice for this stock. Under certain assumptions and for various intrinsic growth rates (r), current sustainable yields (and MSY) were calculated using the German survey and landings as input data. Across the range of r's, results seemed robust (CV range: 0.03-0.17), and the current sustainable yield was estimated at approximately 3.5 Kt. However, this procedure was criticized at the benchmark due to lack of coverage of redfish distribution in the survey and questionable landings, and it is stated in the benchmark report that: "*The panel does not suggest that the Schaefer model approach used here is to be final; to the contrary it is offered as a first step (from which interim management advice might be formulated)*". As there are doubts on stock structure, species determination (and hence catch data accuracy), migration and the quality of the surveys used as basis for the model approach, the applicability of the proposed reference points from WKRED is questionable. Indeed, the use of a stock production model on an aggregation of fish that is not clearly defined as a stock is questionable.

22.6 State of the stock

The German survey and the Greenland shrimp and fish shallow water survey both show overall declines in the *S. mentella* biomass since 2010, and both show a complete absence of small fish (<18 cm). The adult stock decline is caused by a large decline in a small area which coincides with the main fishing area (see figure 22.3.3.1). The CPUE for this area has declined from 3.7 t/h (2010)to 1.3 t/h suggesting a large local decline. Changes in length distributions in both surveys also suggests that no new cohorts are present on the slope and that the adult biomass decline is caused by the gradual decline of a single/few cohorts. Especially the complete absence of juveniles is cause for concern.

The biomass estimate declines and the concentrated fishery could point to a fishery induced decline. However, the declines are of a magnitude that seems beyond what a limited number of years catches can cause. Hence, surveys may either overestimate the biomass in especially Q3, not survey the entire area of distribution or *S. mentella* is disappearing due to migration. Survey overestimation may result from the large aggregations of redfish in Q3, which may cause two different survey scenarios, a low-density and high-density situation. If large redfish aggregations changes the catchability, the assumptions of linearity between catch and abundance are rendered invalid – high fish concentration may simply reduce the trawl escape potential. Such a situation would produce disproportionally high catches and subsequently biomass estimates in high density areas such as Q3. Hence, the decline may be a synergetic effect of a reduced biomass caused by the local fishery, and the reduced catchability inferred from the less dense fish aggregations following some years of intense fishing. This is further complicated by the lack of knowledge on the stocks connection to the pelagic (deep and shallow) and Icelandic slope stocks and the degree of migration. Based on this, care must be taken when evaluating stock status, but nevertheless, the consistency in both the German and shallow Greenlandic surveys suggests that the biomass has decreased, especially in area Q3, but the magnitude of the decline is probably not attributable to the fishery alone. Also, the apparent lack of juveniles in all the East Greenland area means that no new fish will grow into the fishable part of the stock for at least 6-8 years, and there is reason for caution.

22.7 Management considerations

S. mentella is a slow growing, late maturing deep-sea species and is therefore considered vulnerable to overexploitation and advice has to be conservative. The fact that the fishery is targeting a very localized aggregation of fish is cause for concern as is the absence of juveniles in the area. Given the biology of the species and the uncertainty in the biomass trend, any advice should consider this a hotspot fishery as it is potentially detrimental to this local and potentially important aggregation of larger fish. The fishery should still be at a low level involving few vessels. This should be maintained until the effect of the fishery can be clarified, especially with the recent declines in biomass estimates (Figures 22.2.1 and 22.2.6) and the fishery should preferably cover a larger area.

In order to obtain knowledge and better understanding of the proportions of which the redfish in XIVb contributes to the established stocks, a research study was initiated in 2011. Material from both industry and surveys were collected in 2011 and 2012 in order to conduct a genetic study. Preliminary results from these studies were presented at the 2014 NWWG meeting (see figure 22.1.2). They indicated the presence of several stock components on the East Greenland shelf (see section 22.1). Accordingly, managers should consider treating the southern and northern part of ICES XIVb as separate management units. The southern area (Q3-Q6) appears to be a (local) slope stock whereas the northern area (Q1-Q2) appears to be more related to the deep pelagic *S. mentella* stock dynamics. The industry fished almost exclusively on the slope stock in 2011 and 2012, although with some fish from the shallow pelagic stock in 2012. This was however based on samples collected in the spring. More thorough analyses will be presented at the 2015 NWWG following a meeting ultimo 2014.

Since none of the surveys in the area are targeting *S. mentella* it should be ensured that information from the fishery is available to ICES. This has improved since 2011 and should be maintained at this level. A sampling program was initiated in 2011 where information crucial to the assessment was being collected from the fishery. Some of these points were also implemented in the 2013 licenses:

- Official logbooks with additional notes on the target species.
- Information on which species is actually fished. This can be ensured only by sending samples of frozen fish from each trip to relevant scientific institutions in either Iceland or Greenland.

22.8 Basis for advice

This is a trend based assessment. Both surveys covering the area that is fished show declining trends of both adult and juvenile biomass and the CPUE. Also, mean length has declined in the catches. Hence, trends indicate a decreasing biomass driven by a overexploitation in a local hotspot area and that no new cohorts will enter the fishery in coming years. Since the fishery is relatively new following almost two decades of very low catches, the precautionary approach is considered appropriate as basis for the advice. Consequently, the advice is maintained at 3 500 t.

22.9 References

Bernreuther, M., Stransky, C. & Fock, H. 2013. German commercial catches of demersal redfish (*Sebastes mentella* and *Sebastes marinus*) on the East Greenland shelf (ICES Division XIVb) up to 2012.ICES NWWG WD#11, 10 pp.

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Hedeholm R. and Boje J. 2014a. Survey for Greenland halibut in ICES Division 14B, August – September 2013. ICES NWWG WD#04.

Hedeholm R. and Boje J. 2014b. Greenland Shrimp and Fish Survey Results for Redfish in East Greenland Offshore Waters in 2012. ICES NWWG WD#02

G.H. 2001. Hjemmestyrets bekendtgørelse nr. 39 af 6. december 2001 om regulering af fiskeri ved tekniske bevaringsforanstaltninger. Http://www.nanoq.gl/gh.gllove/dk/2001/bkg/bkg_nr_39-2001_dk.htm

Sünksen, K. 2007. Discarded by-catch in shrimp fisheries in Greenlandic offshore waters 2006-2007. NAFO SCR doc. 07/88

Hedeholm, R. and Boje J. 2012. Exploratory analysis on survey and commercial catch data from the Greenland slope Sebastes mentella and Sebastes marinus stocks. ICES WKRED WD#17

Table 22.3.1.1 Nominal landings (tonnes) of demersal *S. mentella* 1974-2013 ICES division XIVb.

Demersal redfish	
1974	0
1975	4 400
1976	59 700
1977	0
1978	5 403
1979	5 131
1980	10 406
1981	19 391
1982	12 140
1983	15 207
1984	9 126
1985	9 376
1986	12 138
1987	6 407
1988	6 065
1989	2 284
1990	6 097
1991	7 057
1992	7 022
1993	14 828
1994	19 305
1995	819
1996	730
1997	199
1998	1 376
1999	853
2000	982
2001	901
2002	2109
2003	446
2004	482
2005	267
2006	202
2007	226
2008	92
2009	895
2010	6 613
2011	6 705
2012	6 572
2013	6 597

Table 22.3.3.1 Landings (tons) of demersal redfish caught in ICES XIVb by nation. By far the largest proportion were probably *S. mentella* but none of these amounts were converted by the *mentella/marinus* ratio (80% *S. mentella*) found by the two surveys covering the area.

Year	DEU	ESP	EU	FRO	GBR	GRL	ISL	NOR	POL	RUS	UNK	Sum
1999											853	853
2000	884		11			19		65			3	982
2001	782				11	9		99				901
2002	1703			48	16	246	29	32		36		2109
2003	3	2	2	20	155	232		32				446
2004	5	1	79	12	221	93		68	3			482
2005	2		4	38	96	72		56				267
2006	1					152		48				202
2007	7		15	138		35		30				226
2008	1		8	50	5	5		23				92
2009				203		822		93				1118
2010	10		12	381		5672		2190		1		8266
2011	1262		26	2		6757		334		1		8381
2012	1810		5	32		5964	1	403		1		8216
2013	1957			32	30	5863		356		8		8246
Sum	8427	3	162	956	534	25941	30	3829	3	47	856	40787

Table 22.3.4.1 Discarded by-catch (tons) of Sebastes sp. from the shrimp fishery in ICES XIVb

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
1999	6	16	17	5	1	13	2	48	22	30	40	33	234
2000	10	3	31	17	15	4	21	78	28	18	9	6	239
2001	7	9	10	16	9	11	4	5	3	3	28	6	111
2002	3	11	9	6	1	0	0	5	4	8	3	5	55
2003	5	6	8	5	5	8	8	15	2	10	12	4	88
2004	7	10	17	13	4	2	27	20	7	2	9	0	118
2005	7	14	16	8	7	5	6	21	14	4	5	20	126
2006	6	2	4	1	3	5	2	4	4	0	0	4	35
2007	7	3	2	1	0	0	0	0	0	0	0	0	14
2008	0	2	2	0	0	1	0	0	0	0	0	1	7
2009	1	2	11	1	0	0	0	0	0	0	0	0	16
2010	1	2	2	1	1	0	1	0	0	0	0	2	10
2011	0	0	0	0	1	0	0	0	0	0	0	0	3
2012	0	0	1	1	1	0	0	0	0	0	0	0	4
2013	0	1	1	0	0	0	0	0	0	0	0	0	2
Sum	60	81	131	75	48	49	71	196	84	75	106	81	1056

Table 22.3.4.2 Landings (tons) of demersal redfish caught in ICES XIVb by month. By far the largest proportion were probably *S. mentella* but none of these amounts were converted by the *mentella/marinus* ratio (80% *S. mentella*) found by the two surveys covering the area

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
1999		10		108		4	42	10	15	34	481	149	853
2000	18	238	286	260	10	4	79	72	13	0	3		982
2001			1				108	2		184	369	236	901
2002		183	445	354	390	50	472	35	44	59	77		2109
2003			9	4	26	27	135	195	20	16	12		446
2004				35	41	63	75	48	64	96	25	35	482
2005			1	15	66	24	80	29	13	18	19		267
2006		3	7	50	14	39	20	61	2	1	1	2	202
2007	6	13	8	8	14	42	4	106	16	7	1	1	226
2008	4	3	1	6	12	11	31	12	10	2			92
2009				1	84	346	148	105	128		288	17	1118
2010	799	786	708	1058	2149	2100	108	134	88	301	36		8266
2011	419	1396	1661	1017	268	250	236	598	255	583	1223	475	8381
2012	899	2197	628	852	577	699	966	143	44	23	474	712	8215
2013			709	1290	925	1423	1218	1086	723	227	119	527	8246
Sum	2145	4829	4464	5058	4576	5082	3722	2636	1435	1551	3128	2154	40786

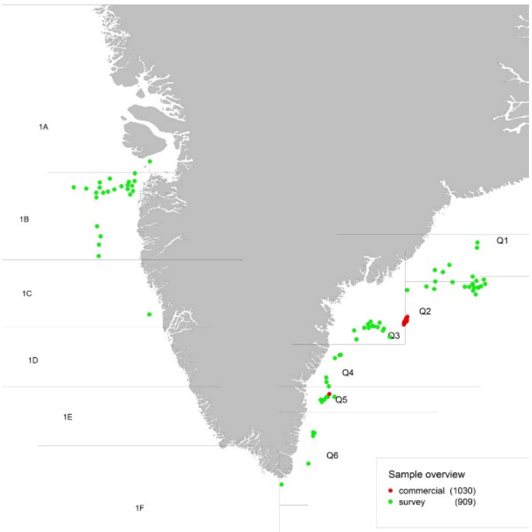

Figure 22.1.1 Sample locations of redfish for genetic analyses. Green dots are survey samples, red are commercial samples. The samples were collected in 2011 and 2012. The west coast samples are not presented in this report.

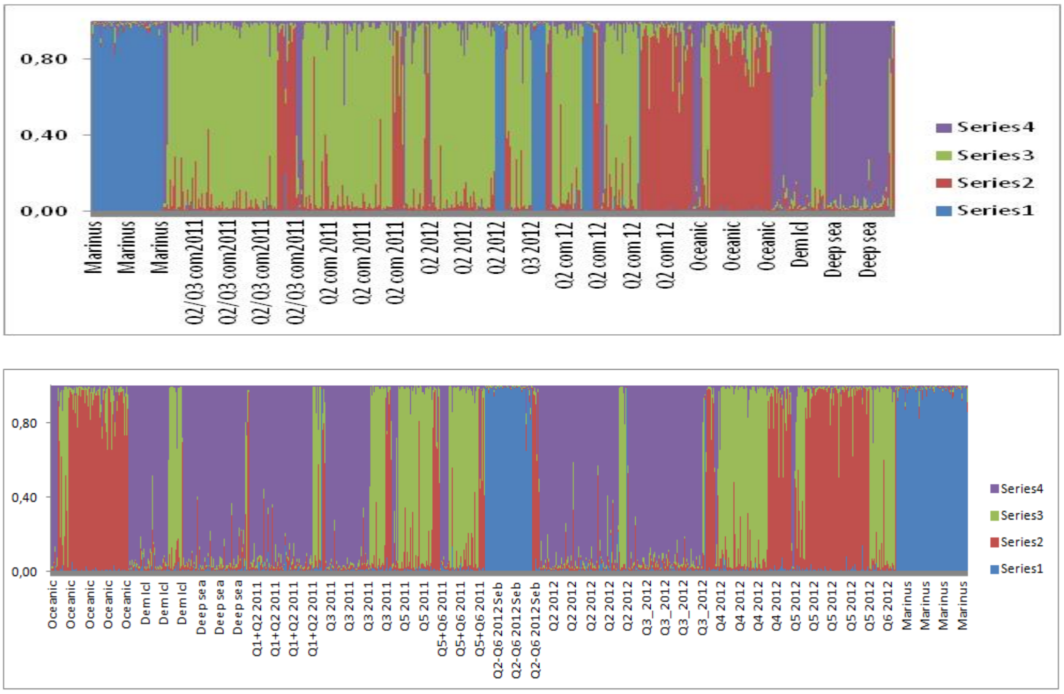

Figure 22.1.2 STRUCTURE analyses of *S. mentella* and *S. marinus* samples collected in ICES XIVb in 2011 and 2012 from both commercial (top panel) and survey (bottom panel) catches.

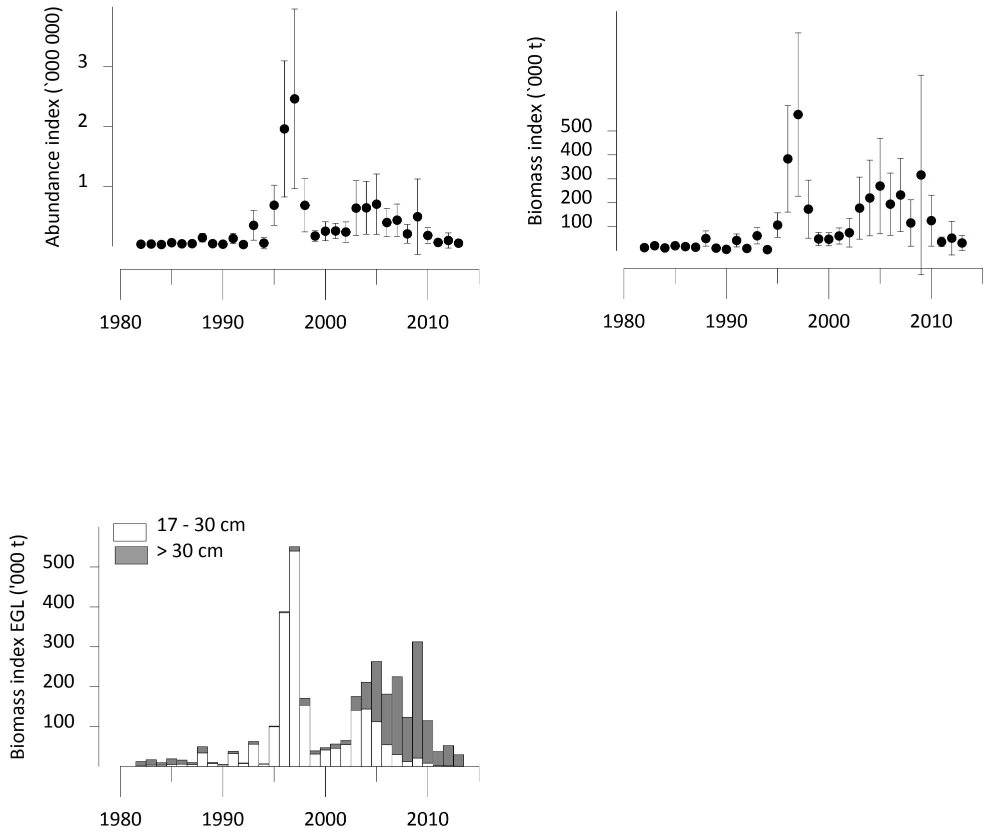

Figure 22.2.1. Indices from the German East Greenland survey of *S. mentella* larger than 17 cm. Abundance (a), biomass (b), and biomass split on length (c). On figure (c) the grey bars represent the biomass of *S. mentella* larger than 30 cm and the light bars biomass in fish from 17-30 cm.

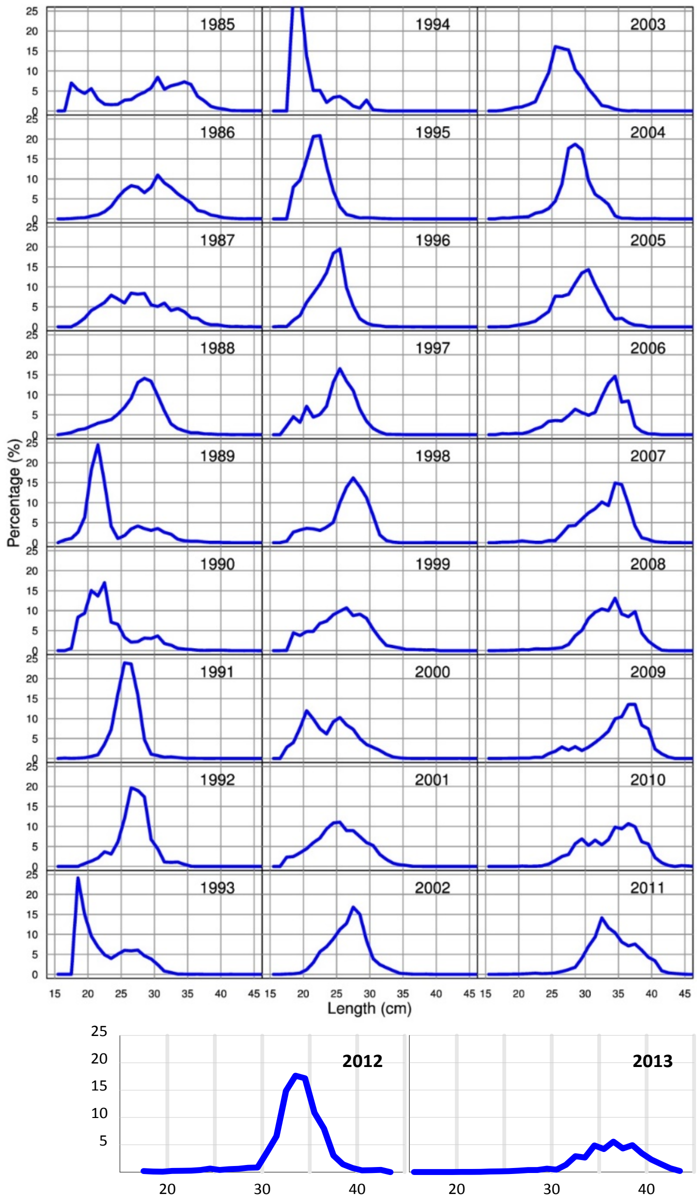

Figure 22.2.2. Length distributions from the German East Greenland survey 1985-2013

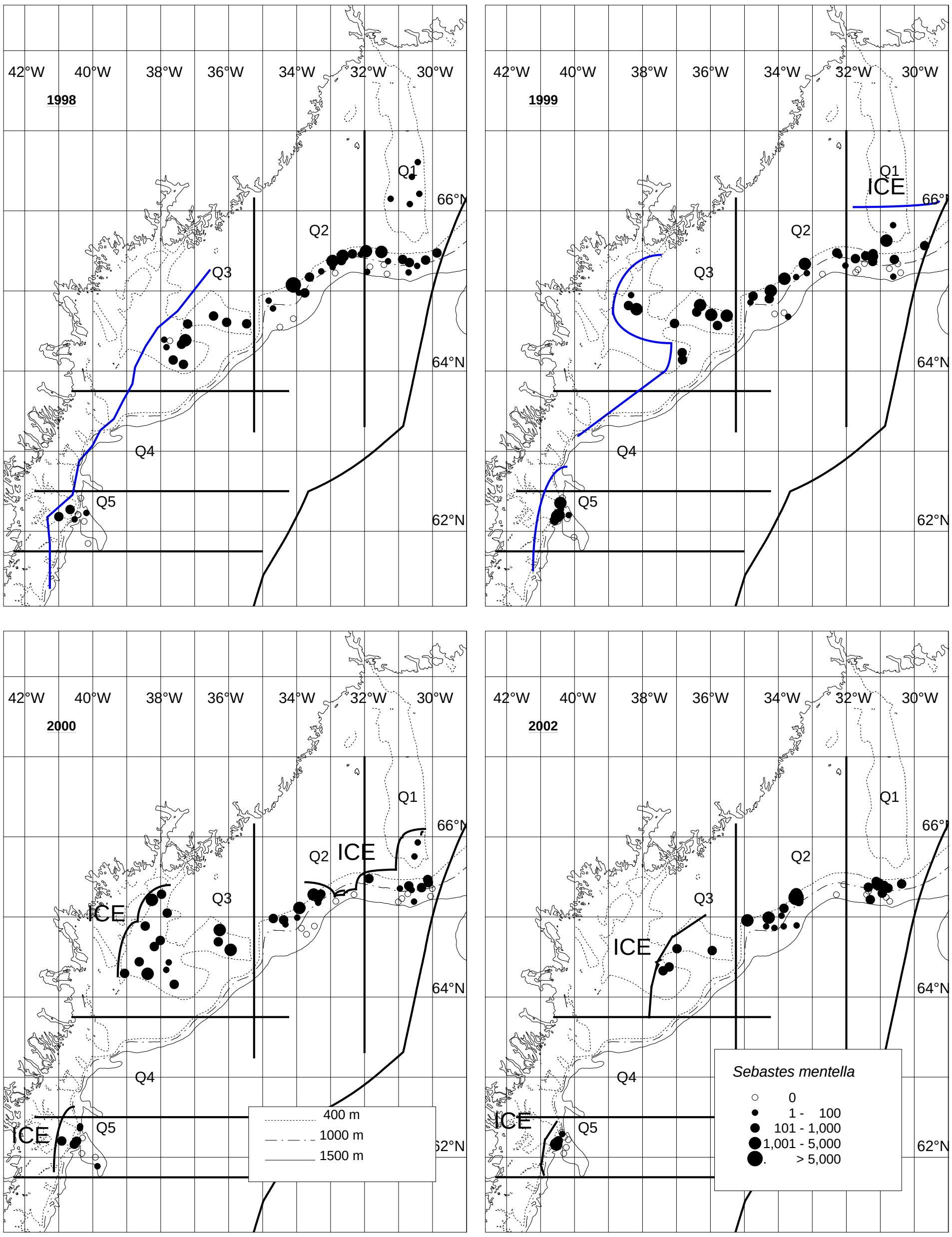

Figure 22.2.3. Distribution of catches of *Sebastes mentella* including *Sebastes Sp* at East Greenland from the deep Greenland survey.

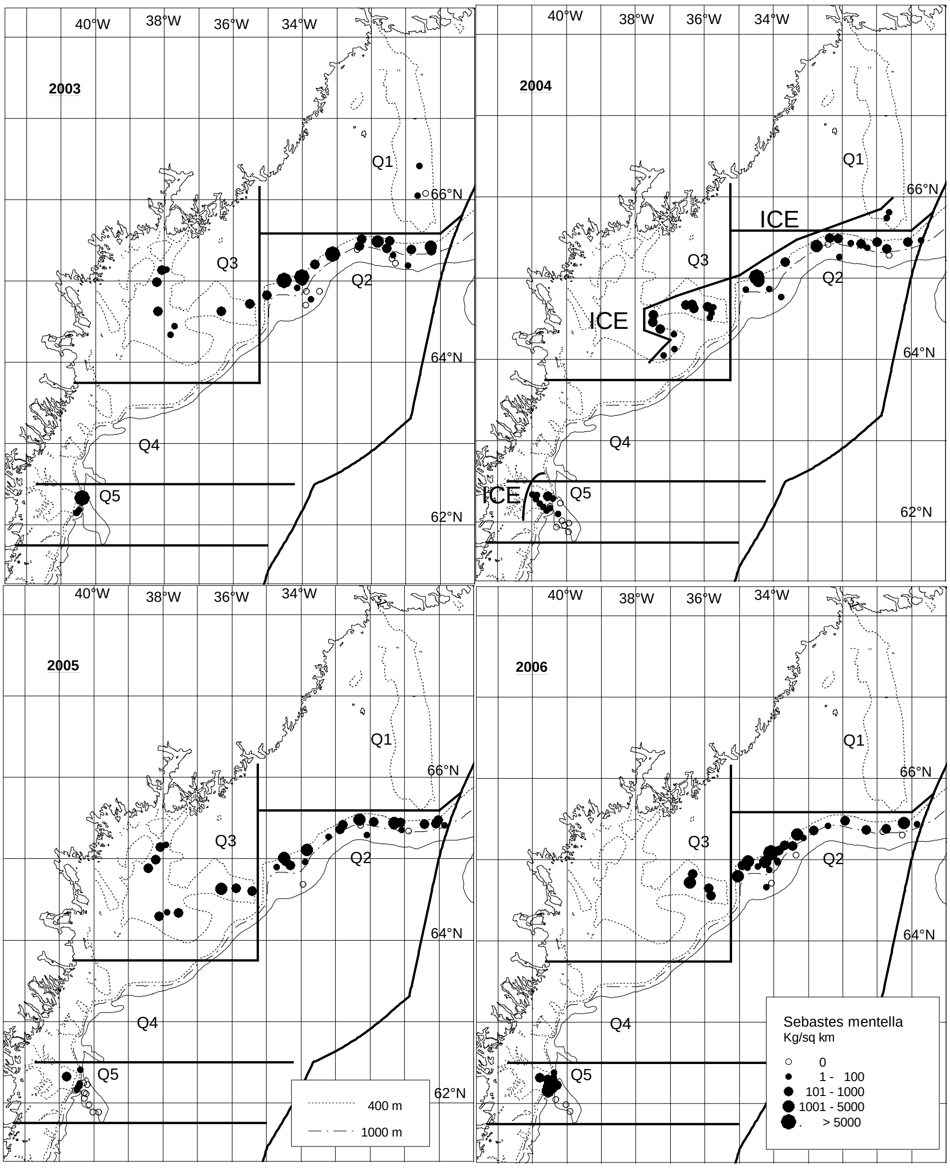

Figure 22.2.3 continued. Distribution of catches of *Sebastes mentella* including *Sebastes Sp* at East Greenland from the deep Greenlandic survey.

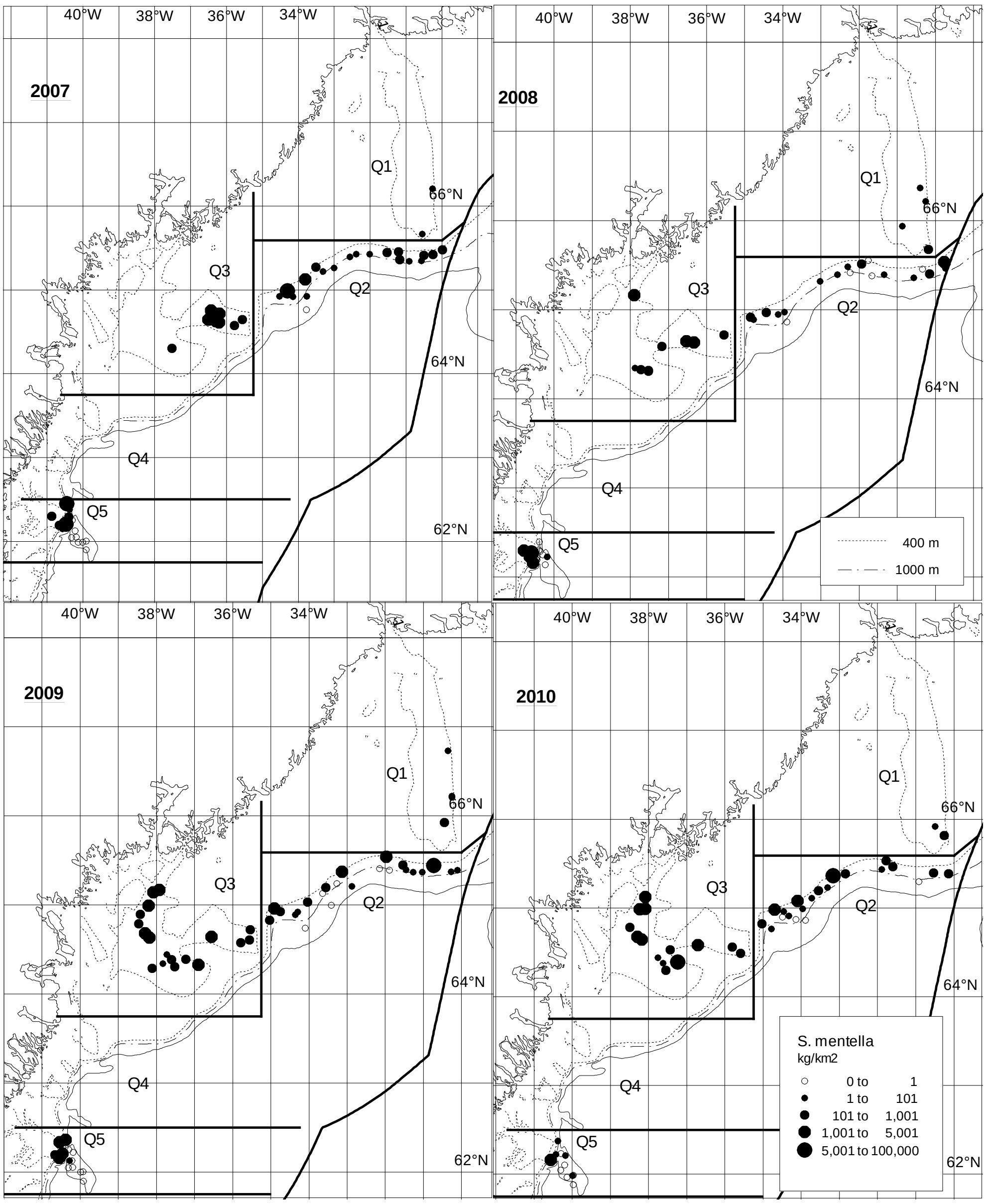

Figure 22.2.3. Distribution of catches of *Sebastes mentella* including *Sebastes Sp* at East Greenland from the deep Greenlandic survey.

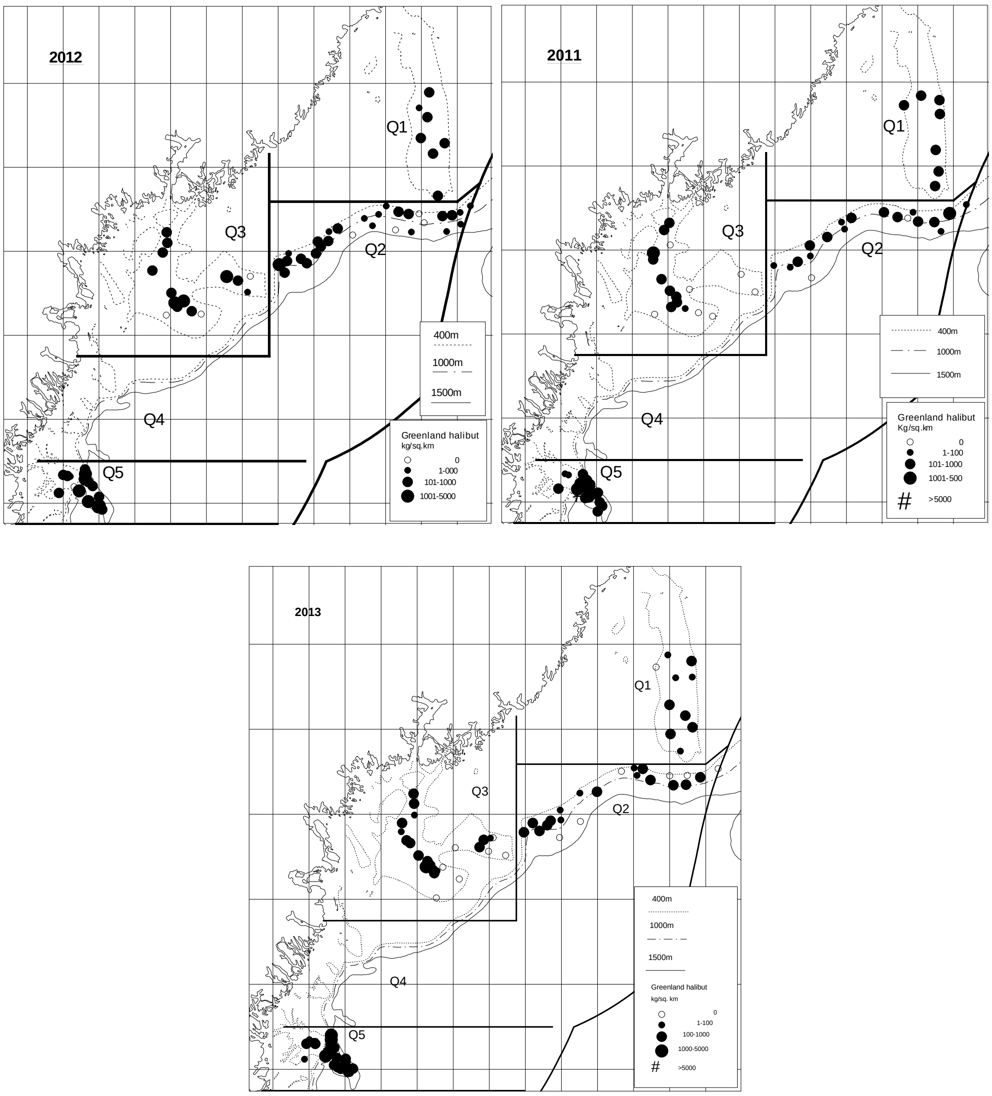

Figure 22.2.3 continued. Distribution of catches of *Sebastes mentella* including *Sebastes Sp* at East Greenland from the deep Greenlandic survey.

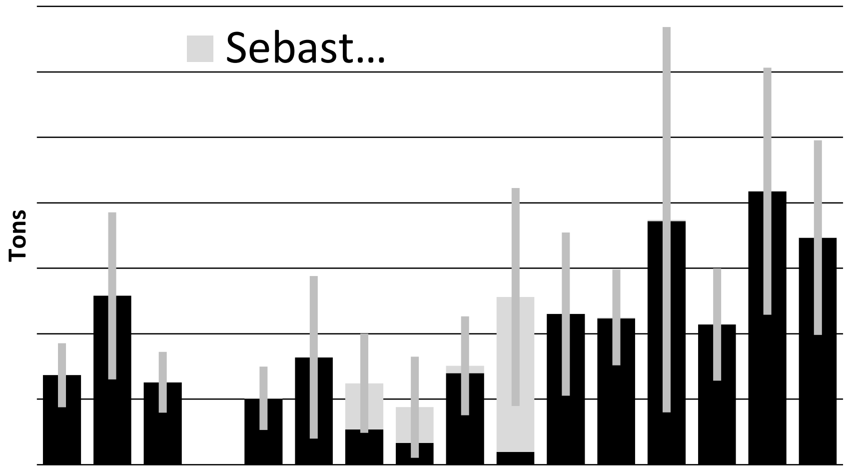

Figure 22.2.4. Biomass of *S .mentella* and *Sebastes* sp derived from the deep Greenland survey. Bars indicate 2SE of the biomass of *S. mentella* including *Sebastes* sp.. No survey in 2001. In 2004, 2005 and 2007 a large proportion of the redfish were not determined to species and only reported as "*Sebastes* sp". It is most likely that the majority of these fish were *S. mentella*.

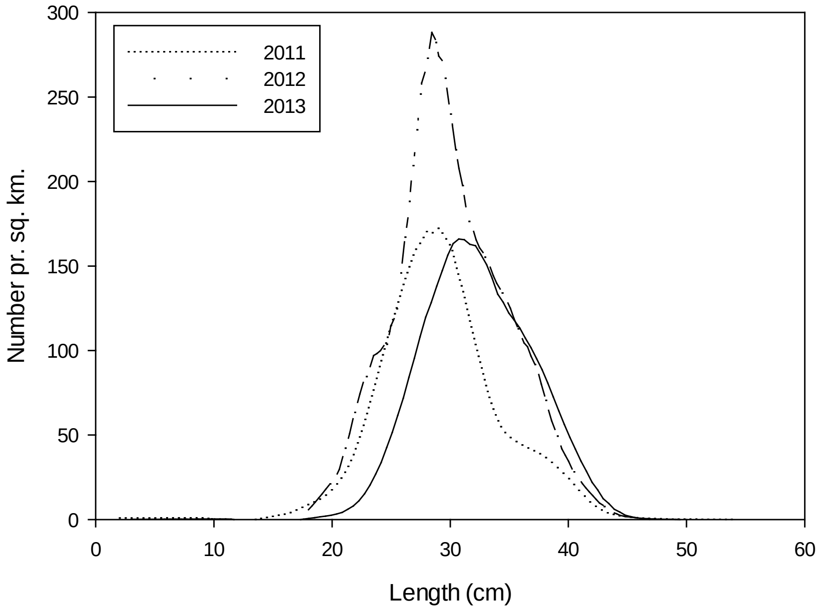

Figure 22.2.5. Overall length distribution of *Sebastes mentella* (number per km^2) from the deep Greenland survey.

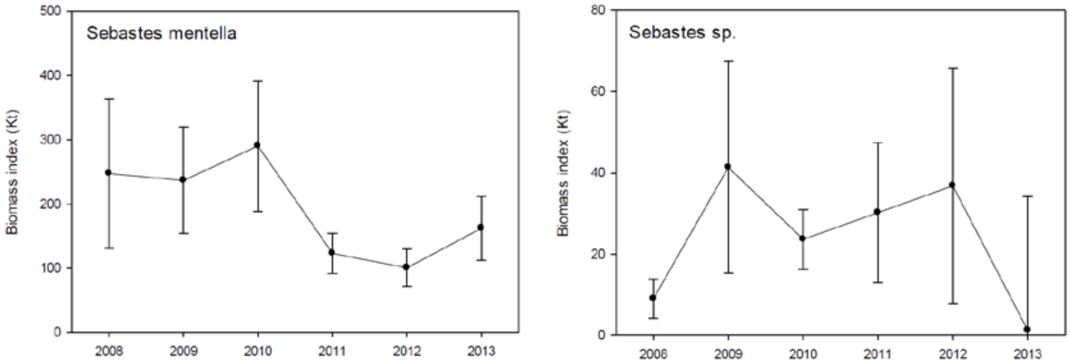

Figure 22.2.6: Biomass (kg*10⁶, Kt, left) indices for *S. mentella* (left) and *Sebastes* sp. (<18cm) off East Greenland in 2008-2013 from the Greenlandic shallow water survey. All surveyed areas (Q1-Q6) are combined.

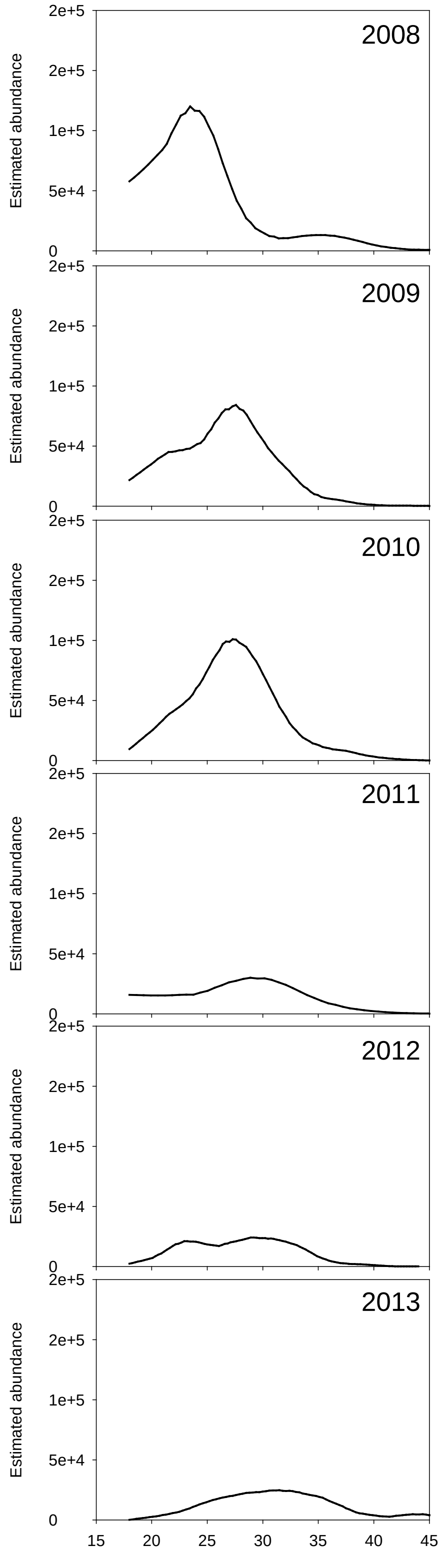

Figure 22.2.7. Overall length distributions for *S. mentella* from the Greenlandic shallow water survey. All surveyed areas combined (Q1-Q6).

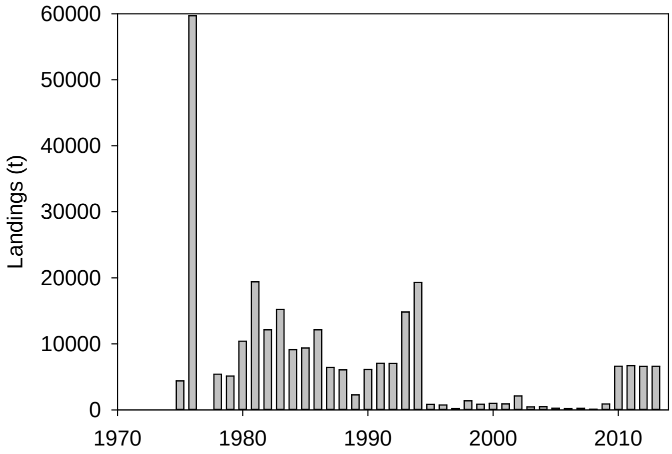

Figure 22.3.1.1 Landings of *S. mentella*. in subarea XIVb. Landings of "redfish" have been split based on estimates from survey and commercial catches

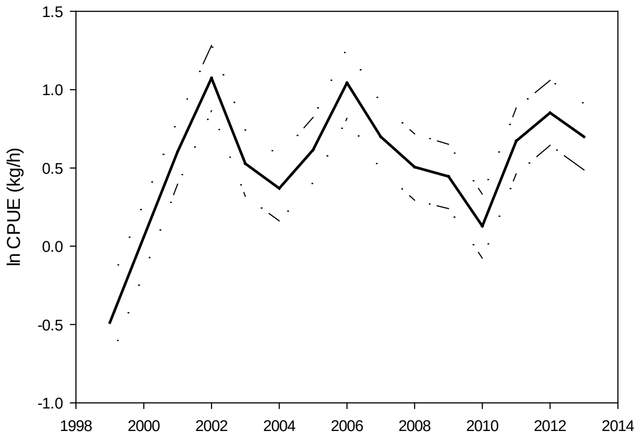

Figure 22.3.2.1 Standardized redfish by-catch CPUE in the directed fishery for Greenland halibut in ICES XIVb as a function of year. CPUE was estimated from the GLM model: lnCPUE=year+ICES subdivision+depth. Bars represent standard error. Only hauls made below 1000m were used in the analyses.

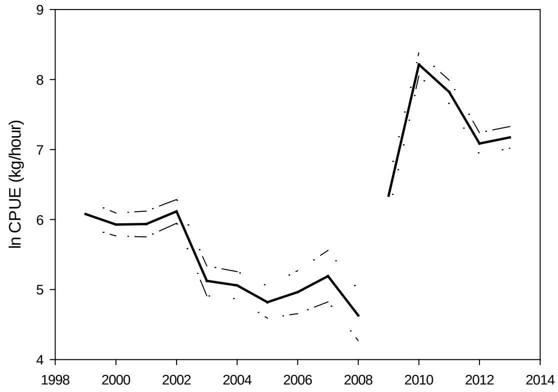

Figure 22.3.2.2 Standardized redfish CPUE in the redfish directed fishery ICES XIVb as a function of year. CPUE was estimated from the GLM model: lnCPUE=year+ICES subdivision+depth. Dashed lines represent standard error.

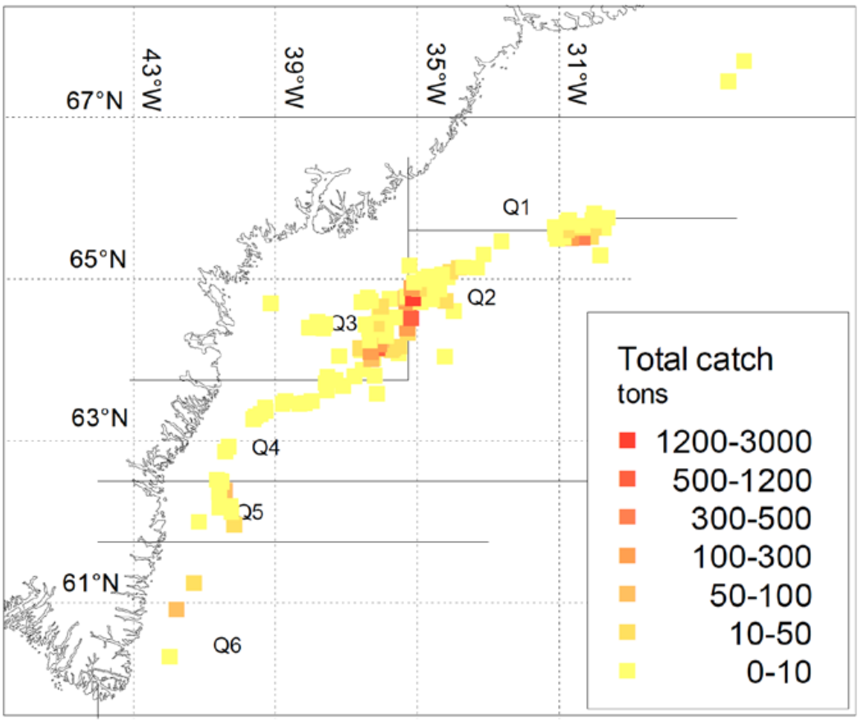

Figure 22.3.3. Distribution of catches of demersal redfish in 2013

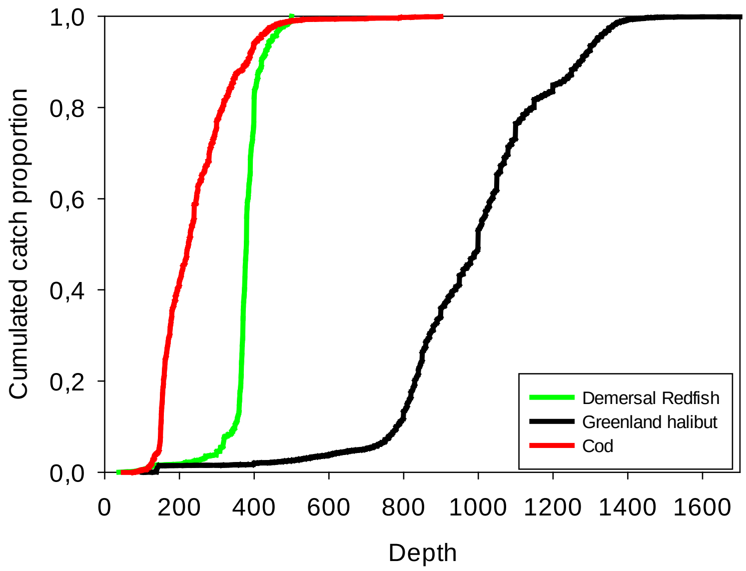

Figure 22.3.3.2. Lines represent the share of the total commercial catch caught at a given depth from 1999-2011 in *G. morhua*, demersal redfish (mixed *S. mentella* and *S. marinus)* and *R. hippoglossoides*.

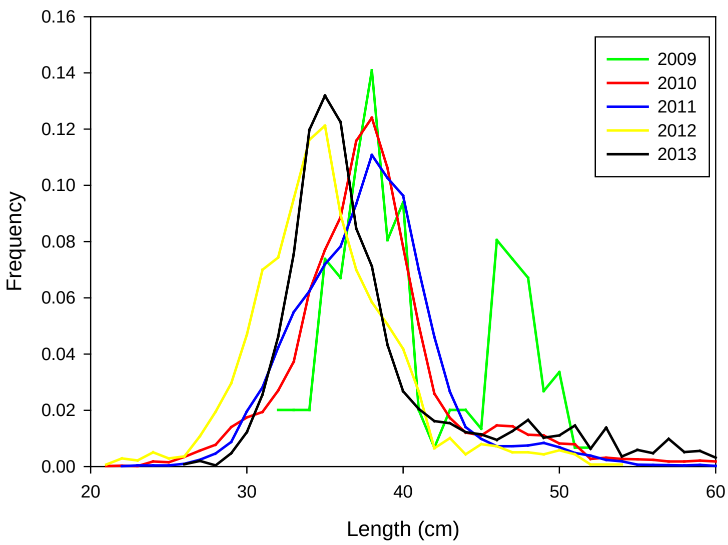

Figure 22.3.6.1: Length distribution of *Sebastes* sp. in the commercial catches from 2009-2013. In 2013, 1019 fish were measured in 14 samples. In 2009-2011 the measurements were conducted onboard the trawlers by inspectors that were unable to separate *S. mentella* from *S. marinus*.

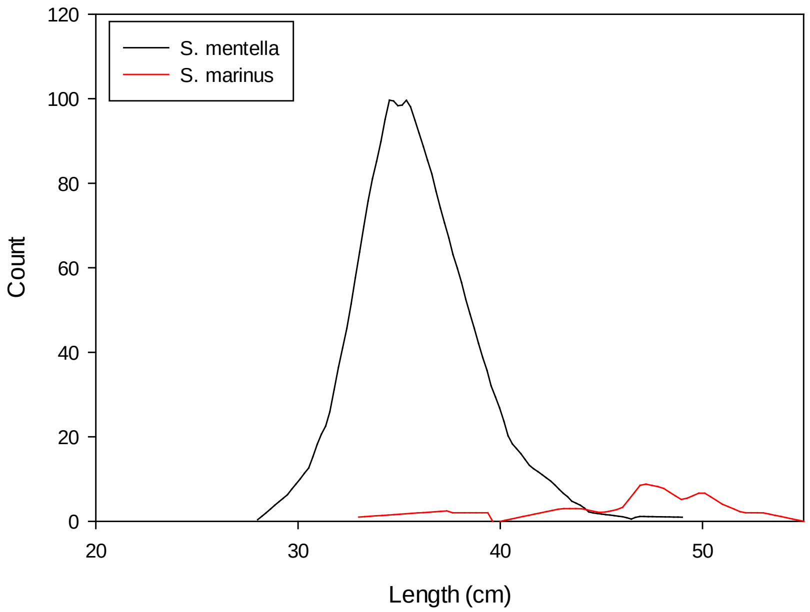

Figure 22.3.6.2: Length distribution of 712 redfish from 14 commercial samples analysed by the Greenland Institute of Natural Resources separated into *S.mentella* (N=654) and *S.marinus* (N=58).

Annex 1 – List of Participants

North-Western Working Group

24 April – 01 May 2014

Name	Address	Phone/Fax	Email
Petur Steingrund (Chair)	Faroe Marine Research Institute	Phone +298 35 3900	peturs@hav.fo
	P.O. Box 3051	Fax +298 353901	
	FO-110 Tórshavn		
	Faroe Islands		
Sergey Melinkov	Russian Federal Research Institute of Fisheries & Oceanography (VNIRO)	Phone +7 (495) 2644583	melnikov@vniro.ru
	17 Verkhne Krasnoselskaya	Fax +7 (499) 264 31 87	
	107140 Moscow		
	Russian Federation		
Ilya Antonov	Russian Federal Research Institute of Fisheries & Oceanography (VNIRO)	Phone +7 (499) 2649078	AntonovI.VNIRO@yandex.ru
	17 Verkhne Krasnoselskaya	Fax +7 (499) 264 31 87	
	107140 Moscow		
	Russian Federation		
Søren Post	Greenland Institute for Natural Resources	Phone +299 361200	sopo@natur.gl
	P.O. Box 570	Fax +299 361212	
	GL-3900 Nuuk		
	Greenland		
Höskuldur Björnsson	Marine Research Institute	Phone +354 575 2000	hoski@hafro.is
	PO Box 1390	Fax +354 575 2001	
	121 Reykjavík		
	Iceland		
Jesper Boje	The National Institute of Aquatic Resources Section for Fisheries Advice	Phone +45 339 634 64	jbo@aqua.dtu.dk
	Charlottenlund Slot, Jægersborg Alle 1	Fax +45 339 63333	
	DK-2920 Charlottenlund		
	Denmark		

Name	Address	Phone/Fax	Email
Luis Ridao Cruz	Faroe Marine Research Institute	Phone +298 35 3900	Luisr@hav.fo
	P.O. Box 3051	Fax +298 353901	
	FO-110 Tórshavn		
	Faroe Islands		
Heino Fock	Johann Heinrich von Thünen-Institute, Institute for Sea Fisheries	Phone +49 40 38905 169	heino.fock@vti.bund.de
	Palmaille 9	Fax +49 40 389 05 263	
	D-22767 Hamburg		
	Germany		
Rasmus Hedeholm	Greenland Institute for Natural Resources	Phone +299 361200	rahe@natur.gl
	P.O. Box 570	Fax +299 361212	
	GL-3900 Nuuk		
	Greenland		
Einar Hjörleifsson	Marine Research Institute	Phone +354 552 0240	einarhj@hafro.is
	Skúlagata 4	Fax +354 562 3790	
	IS-121 Reykjavík		
	Iceland		
Kristjan Kristinsson	Marine Research Institute	Phone +354 575 2000	krik@hafro.is
	Skúlagata 4	Fax +354 575 2091	
	IS-121 Reykjavík		
	Iceland		
Arni Magnusson	Marine Research Institute	Phone +354 575 2000	arnima@hafro.is
	PO Box 1390	Fax +354 575 2001	
	IS-121 Reykjavík		
	Iceland		
Lise Helen Ofstad	Faroe Marine Research Institute	Phone +298 35 3900	liseo@hav.fo
	P.O. Box 3051	Fax +298 353901	
	FO-110 Tórshavn		
	Faroe Islands		
Gudmundur J. Oskarsson	Marine Research Institute	Phone +354 575 2000	gjos@hafro.is
	Skúlagata 4	Fax +354 575 2001	
	IS-121 Reykjavík		
	Iceland		
Jákup Reinert	Faroe Marine Research Institute	Phone +298 35 3900	jakupr@hav.fo
	P.O. Box 3051	Fax +298 353901	
	FO-110 Tórshavn		
	Faroe Islands		

Name	Address	Phone/Fax	Email
Anja Retzel	Greenland Institute for Natural Resources	Phone +299 361200	AnRe@natur.gl
	P.O. Box 570	Fax +299 361212	
	GL-3900 Nuuk		
	Greenland		
Alexey Rolskiy	Knipovich Polar Research Institute of Marine Fisheries and Oceanography	Phone +7 8152 45 05 68	rolskiy@pinro.ru
	6 Knipovitch Street	Fax +7 8152 47 33 31	
	RU-183763 Murmansk		
	Russian Federation		
Gudmundur Thordarson	Marine Research Institute	Phone +354 5752000	gudthor@hafro.is
	PO Box 1390	Fax +354 5752001	
	121 Reykjavík		
	Iceland		
Elena Guijarro Garcia	Instituto Español de Oceanografía	Phone +34 986 462 201	elena.guijarro@vi.ieo.es
	Centro Oceanográfico de Vigo	Fax +34 986 498626	
	P.O. Box 1552		
	E-36200 Vigo		
	Spain		
Ages Gundersen	Møreforsking Marin,	+47 70 11 16 21 (00) / +47 926 11 524	agnes@mfaa.no
	PO Box 5075, 6021 Ålesund,		
	Norway		
Asta Gudmundsdóttir	Marine Research Institute	Phone +354-5752001	asta@hafro.is
	PO Box 1390	Fax +354-5752000	
	IS-121 Reykjavík		
	Iceland		

Annex 2: Stock Annexes

Stock Annex: Faroe Haddock

Stock specific documentation of standard assessment procedures used by ICES.

Stock	**Faroe Haddock**
Working Group:	**North-Western Working Group**
Date:	**30 April 2014**
Revised by	**Jákup Reinert**

A. General

A.1. Stock definition

Haddock in Faroese Waters, i.e. ICES Subdivisions Vb1 and Vb2 and in the southern part of ICES Division IIa, close to the border of Sub-Division Vb1, are generally believed to belong to the same stock and are treated as one management unit named Faroe haddock. Haddock is distributed all over the Faroe Plateau and the Faroe Bank from shallow water down to more than 450 m. Spawning takes place from late March to the beginning of May with a peak in the middle of April and occurs in several areas on the Faroe Plateau and on the Faroe Bank. Haddock does not form as dense spawning aggregations as cod and saithe, nor does it perform ordinary spawning migrations. After spawning, eggs and fry are pelagic for about 4 months over the Plateau and Bank and settling starts in August. This is a prolonged process and pelagic juveniles can be found at least until September. Also during the first years of life they can be pelagic and this vertical distribution seems to be connected to year class strength, with some individuals from large year classes staying pelagic for a longer time period. No special nursery areas can be found, because young haddock are distributed all over the Plateau and Bank. The haddock is considered very stationary as seen in tagging experiments.

A.2. Fishery

Landings statistics are available since 1903. During the first half of this century, foreign nations dominated the landings, especially England and Scotland, but since the early 1950s, the Faroese landings have increased considerably. After the introduction of the 200 nm EEZ in 1977, almost all landings have been by Faroese vessels. Due to the recent dispute on mackerel quota share, there has been no agreement on mutual fishery rights between the Faroe Islands and Norway and EU, respectively, since 2011, and therefore there was no fishery by those parties in Vb in 2012 and 2013; in 2014 the parties happened to made an agreement again.

Nominal landings of Faroe haddock have in recent years increased very rapidly from only 4 000 t in 1993 to 27 000 t in 2003; they have declined drastically since and amounted in 2013 to only about 3 100 t. Most of the landings are taken from the Faroe

Plateau; the 2013 landings from the Faroe Bank (Sub-Division Vb2), where the area shallower than 200 m depths has been closed to almost all fishing since the fiscal year 2008-2009, amounted to only about 45 t (Tables 5.1 and 5.2 in the NWWG 2014 report). Faroese vessels have taken almost the entire catch since the late 1970s. The longliners have taken most of the catches in recent years followed by the trawlers; the proportions in 2013 were: longliners 78% and trawlers 22%.

A.3. Ecosystem aspects

The waters around the Faroe Islands are in the upper 500 m dominated by the North Atlantic current, which to the north of the islands meets the East Icelandic current. Clockwise current systems create retention areas on the Faroe Plateau (Faroe shelf) and on the Faroe Bank. In deeper waters to the north and east and in the Faroe Bank channel is deep Norwegian Sea water, and to the south and west is Atlantic water. From the late 1980s the intensity of the North Atlantic current passing the Faroe area decreased, but it has increased again in the most recent years. The productivity of the Faroese waters was very low in the late 1980s and early 1990s. This applies also to the recruitment of many fish stocks, and the growth of the fish was poor as well. From 1992 onwards the conditions have returned to more normal values which also is reflected in the fish landings. There has been observed a very clear relationship, from primary production to the higher trophic levels (including fish and seabirds), in the Faroe shelf ecosystem, and all trophic levels seem to respond quickly to variability in primary production in the ecosystem (Gaard, E. et al. 2002). A positive relationship has been demonstrated between primary production and the cod and haddock individual fish growth and recruitment 1-2 years later. The primary production indices was above average in 2008-2010 but this has, however, only marginally resulted in improved recruitment of haddock; the indices in 2011-2012 were below average. There seems to be a link between the primary production and growth of haddock. The primary production seems to be negatively correlated with the catchability of longlines, suggesting that haddock attack longline baits more when natural food abundance is low. Since longliners usually take the majority of the haddock catch, the total fishing mortality fluctuates in the same way as the long line catchability and thus there is a negative relationship between primary production and fishing mortality. It is, however, important to note that the relationship between the productivity of the ecosystem and the catchability of long lines depends on the age of the fish. For young haddock there apparently is no such relationship between productivity and catchability and overall this relationship has not been very clear in recent years.

B. Data

B.1. Commercial catch

For the Faroese landings, catch-at-age data were provided for fish taken from the Faroe Plateau (Vb1). The sampling intensity in 2013 is shown in Table 5.4 and it was improved somewhat as compared to 2012. There is, however, a need to improve the sampling level. Reasons for the inadequate sampling level are shortage of resources (people, money) but also that the total catches (and stock) are so small that it is difficult to obtain enough samples. From late 2011, a landing site has been established in Tórshavn close to the Marine Research Institute and it is the intention that technicians from the Institute will be sampling these landings regularily; this will improve the sampling level in coming years.

The normal procedure has been to disaggregate samples from each fleet category by season (Jan-Apr, May-Aug and Sep-Dec) and then raise them by the corresponding catch proportions to give the annual catch-at-age in numbers for each fleet This year, all longliners were grouped into 2 fleets (over and below 100 GRT), and all trawlers were also grouped into 2 fleets (over and below 1000 Hp), and the longliner samples had to be treated by using 2 seasons only (Jan-Jun, Jul-Dec. The results are given in Table 5.4. No catch-at-age data were available from the minor catch by trawlers from Iceland and they were assumed to have the same age composition as the Faroese trawlers > 1000 HP. The most recent data were revised according to the final catch figures. The resulting total catch-at-age in numbers is given in Tables 5.4 and 5.5 of the 2014 NWWG report, and in Figure 5.4 of the report the LN(catch-at-age in numbers) is shown since 1990. LN(catch-at-age in numbers) for the whole assessment period from 1957 onwards can be found in the stck annex.

In general the catch-at-age matrix in recent years appears consistent although from time to time a few very small year classes are disturbing this consistency, both in numbers and mean weights at age. The recent very small year classes need to be very carefully inspected when the FBAR is calculated. Also there are some problems with what ages should be included in the plus group; there are some periods where only a few fishes are older than 9 years, and other periods with a quite substantial plus group (10+). These problems have been addressed in former reports of this WG and will not be further dealt with here (See the 2005 NWWG report). No estimates of discards of haddock are available. However, since almost no quotas are used in the management of the fisheries on this stock, the incentive to discard in order to high-grade the catches should be low. The landings statistics is therefore regarded as being adequate for assessment purposes. The ban on discarding as stated in the law on fisheries should also – in theory – keep the discarding at a low level.

B.2. Biological

Mean weight-at-age data are provided for the Faroese fishery. In the period 1957-1976, constant weights have been applied, but from 1977 onwards they have been estimated each year. During the period, weights have shown cyclical changes, and have decreased during the most recent years to very low values in 2006; since 2007 mean weights at age have increased again but during the recent 3 years they have been fluctuating without any trend. The mean weights at age in the stock are assumed equal to those in the landings.

Maturity-at-age data is available from the Faroese Spring Groundfish Surveys 1982–2014. The survey is carried out in February-March, so the maturity-at-age is determined just prior to the spawning of haddock in Faroese waters and the determinations of the different maturity stages is relatively easy. In order to reduce eventual year-to-year effects due to possible inadequate sampling and at the same time allow for trends in the series, the routine by the NWWG has been to use a 3-year running average in the assessment. For the years prior to 1982, average maturity-at-age from the surveys 1982–1995 was adopted

B.3. Surveys

Two annual groundfish surveys are available on the Faroe Plateau, one carried out in February-March since 1982 (100 stations per year down to 500 m depth), and the other in August-September since 1996 (200 stations per year down to 500 m depth). Up to 1991 three cruises per year were conducted between February and the end of March, with 50 stations per cruise selected each year based on random stratified sampling (by depth) and on general knowledge of the distribution of fish in the area. In 1992 the period was shortened by dropping the first cruise and one third of the 1991-stations were used as fixed stations. Since 1993 all stations are fixed stations. The surveyed area is divided into 15 strata defined by depth and environmental conditions. The distribution of haddock catches in the surveys in in the whole survey series are shown in Figures 1 and 2 (spring surveys 1994-2012 and summer surveys 1996-2011).

The standard abundance estimates is the stratified mean catch per hour in numbers at age calculated using smoothed age/length keys. This is a useful method but some artifacts may be introduced because he smoothing can assign wrong ages to some lengths, especially for the youngest and oldest specimen. As in recent years, the length distributions have been used more directly for calculation of indices at age (ages 0-2) since these ages have discrete length distribution without overlap. LN(numbers at age) for the surveys are presented in Figures 5.10-5.11 of the 2014 NWWG report and show consistent patterns.

Age disaggregated data are available for the whole summer series, but due to problems with the database (see earlier North-Western Working Group reports), age disaggregated data for the spring survey are only available since 1994.

In general both surveys show a good relationship between the indices for one year class in two successive years. The same applies when comparing the corresponding indices at age from the two surveys (Figures 3-5).

B.4. Commercial CPUE

Several commercial catch per unit effort series are updated every year, but as discussed in previous reports of the NWWG they are not used directly for tuning of the VPA due to changes in catchability caused by e.g. productivity variations in the area (see Ecosystem aspects), a different behaviour of the fleets after the introduction of the effort management system with large areas closed for trawlers, and in years when haddock prices are low as compared to cod the fleets apparently try to avoid grounds with high abundances of haddock, especially the younger age groups areas. The opposite may also happen if prices of haddock become high as compared to other species. The data are based on logbooks. These are mixed fisheries and not directly targeting haddock.

B.5. Other relevant data

C. Historical Stock Development

Model used: Several different models have been applied to this stock but the basic method has for many years been the Extended Survivors Analysis.

Software used: Virtual Population Analysis, version 3.2, beta: Windows 95. Copyright: MAFF Directorate of Fisheries Research. License number: DFRVPA31M.DFR.

Model Options chosen: The assessment for this stock has been an update for several years. Consequently the same options have been used in 2014 as in the recent years:

Lowestoft VPA Version 3.1

19/04/2013 13:51

Extended Survivors Analysis

FAROE HADDOCK (ICES DIVISION Vb) HAD_IND

CPUE data from file D:\Vpa\vpa2013\input-files\comb-survey-spaly-13-jr.txt

Catch data for 56 years. 1957 to 2012. Ages 0 to 10.

Fleet,	First,	Last,	First,	Last,	Alpha,	Beta
,	year,	year,	age ,	age		
SUMMER SURVEY ,	1996,	2012,	1,	8,	.600,	.700
SPRING SURVEY SHIFTE,	1993,	2012,	0,	6,	.950,	1.000

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 6

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 = .500

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

Prior weighting not applied

Tuning converged after 40 iterations

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1957-2013		Yes
Canum	Catch at age in numbers	1957-2013	0-10+	Yes
Weca	Weight at age in the commercial catch	1957-2013	0-10+	Yes
West	Weight at age of the spawning stock at spawning time.	1957-2013	0-10+	Yes
Mprop	Proportion of natural mortality before spawning	1957-2013	0-10+	No
Fprop	Proportion of fishing mortality before spawning	1957-2013	0-10+	No
Matprop	Proportion mature at age	1957-2014	0-10+	Yes
Natmor	Natural mortality	1957-2013	0-10+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Summer survey	1996-2013	1-8
Tuning fleet 2	Spring survey	1994-2014	0-6
Tuning fleet 3			
….			

D. Short-Term Projection

Since this is an update assessment, the same procedure as last year has been used in 2014 and the input and assumptions are exemplified with the 2013 ones.

Model used: Multi Fleet Deterministic Projection

Software used*:* MFDP version 1

The input data for the short-term predictions are estimated in accordance with the procedures last year and given in Tables 5.13-14 of the 2013 NWWG report. All year classes up to 2011 are taken directly from the 2013 final XSA, the 2014 year class at age 2 is estimated from the 2013 XSA age 1 applying a natural mortality of 0.2 in a forward calculation of the numbers using basic VPA equations. The YC 2013 at age 2 in 2015 is estimated as the geometric mean of the 2-year-olds since 2005. This procedure was introduces in 2011. All available information suggests that using the recent short series with poor recruitment is more appropriate than the longer period used in the past. However, the choice of recruitment in 2015 has little effect on the short term prediction. The normal procedure in estimating the exploitation pattern has been to calculate the average fishing mortality at age for the 3 most recent years and if there is a trend, then the average is re-scaled to the most recent year. If no trend is obvious, the simple average is used. This year, the exploitation pattern used in the prediction was derived from averaging the 2010–2012 fishing mortality matrices from the final VPA without re-scaling to 2012 since the fishing mortalities fluctuate without a trend. The same exploitation pattern was used for all three years.

The mean weight@age have been declining in recent years to low values but from inspection of Figure 5.5 and Table 5.6 in the 2013 NWWG report, most ages have increased again since 2007. However, the average weights since 2009 seem to fluctuate without a trend and like for the estimation of the exploitation pattern (see above), the mean weights at age for the prediction are simply the average of the weights in 2010-2012 without re-scaling to 2012.The maturity ogive for 2013 is estimated as the average of the observed maturities in the Faroese Groundfish Spring Survey 2012-2013, and the ogives in 2014-2015 are estimated as the average of the 2011-2013 values.

Intermediate year assumptions: Status quo fishing mortality.

E. Medium-Term Projections

Medium term projections presented here was carried out in 2012 in order to be able to estimate MSY reference values. No new projections were made this year. In the projections, the weight at age, maturity at age and selection at age are the same used in the long term (yield per recruit) deterministic analysis.

Starting condition (2011):

- Na,2011 are based on point values from the final stock esimates in the assessment. Error in the stock in numbers in the first year are ignored. The fishing mortality in the assment and advisory year set to 0.30 equivalent to the F_{sq} in the short term deterministic predictions.

Simulation:

- No stochasicity is modelled for catch weights, stock weights, maturity nor selection pattern.
- Recruitment: Year classes 2010 and later. Deviations series from the mean recruitment from 1961-2010 year classes (17.5 millions) is applied to a hockey stick model with SSB_{break}=B_{loss}=22 kt and R_{break}=R_{mean}=17.5 millions. No error is assumed in the breakpoints. The time series of the recruitment deviation sinces 1961 is kept, with randomly drawn starting year in each iteration, looped continuously by repeating the time series. Effectively this means that when SSB is above 22 kt the historical time series of recruitment in absoluted values is repeated, while SSB being below 22 kt results in proportional reduction in the absolute recruitment values while the historical deviation is maintained. This formulation is largely set up so as to test the robustness of fishing mortality applied againts a series of years with very poor recruitment.
- Assessment error: Assessment error is modeled on the fishing mortality in the advisory year upon which the annual removal is taken: cv=0.20, rho=0.15. When setting up the starting value in the simulation (2011), the first 100 values in the error series are ignored in order to apply a potential assessment bias (as manifested in the rho) already in the starting year.
- Other parameters, such as natural mortality are kept the same as in the assessment with no stochastic errors applied in the simulations.

The analysis indicate that F_{msy} is in the range of 0.2-0.4 with a maximum close to 0.3 (Figure 6). A target fishing mortality of F=0.3 would result in a low probability of the stock going below B_{lim} but around 30% probability in going below B_{pa} (Figure 5.7). At target fishing mortality of F=0.25 there is only a slight loss in yield (Figure 5.6) but the probability of going below B_{pa} is only around 10% (Figure 5.7). The stock development when applying a target of F=0.25 (Figure 5.8) indicate that variability in catch and spawnings stock is within the range of historical observations. The realized fishing mortality when applying a target of F=0.25 is in the range of 0.17-0.32.

The evaluation are done without taking default action when SSB is below B_{pa}, a default canditate for $B_{trigger}$. Such action would result in lower probability of the SSB going below B_{lim}. The default ICES MSY rule dictates that action dictating a lower fishing mortality than F_{msy} is when the SSB in the assessment year is below $B_{trigger}$. However, given the nature of the recruitment in haddock, where very low recruitment can be observed for a number of years a the trigger action could potentially be applied to estimates of spawning stock biomass 1-3 years into the future, based on available recruitment estimates from survey measurements. I.e. instead of:

$$F_{\text{target},y+1} = f(F_{MSY}, SSB_y, SSB_{TRIGGER})$$

where y refers to the assessment year the action would be based on:

$$F_{\text{target},y+1} = f(F_{MSY}, SSB_{y+3}, SSB_{TRIGGER})$$

Here the SSB in year y+3 (or y+2) would be largely a function of the recruitments already estimated from available survey indices. In cases where the indices were low, action in term of lower target would thus be taken “ahead of time”. If the recruitment indices are however averages or above average size no action in the form of reducing F in the advisory years is requied.

Further evaluation of a suitable F_{msy} harvest rate mechanims is pending and will be presented in the next NWWG report. The WG proposes, based on the preliminary analysis presented here that the F_{msy} target be set provisionally at 0.25 and that this value be used as the basis for deriving an MSY advice for upcoming fishing year.

F. Long-Term Projections

Model used: Multi Fleet Yield Per Recruit.

Software used*:* MFYPR version 1.

Maturity: Average for the whole time series: 1982-2013

F and M before spawning: Zero

Weight at age in the stock: Average for the whole time series: 1977-2013

Weight at age in the catch: Average for the whole time series: 1977-2013

Exploitation pattern: The same as in the short term projection: The exploitation pattern is estimated as the average fishing mortality matrix in 2011-2013 from the final VPA in 2014 without re-scaling since the fishing mortalities fluctuate without trends, and kept constant for all 3 years (the same as in the short term projection).

G. Biological Reference Points

The yield- and spawning stock biomass per recruit (age 2) based on the long-term data are shown in Table 5.17 and Figure 5.16 of the NWWG 2014 report. From Figure 5.19 in the report, showing the recruit/spawning stock relationship, and from Table 5.17, $\mathbf{F}_{med}$, and $\mathbf{F}_{high}$ were calculated at 0.24 and 0.80, respectively. The F_{max} of 0.60 should not be used since it is very poorly determined due to the flat YPR curve. $F_{0.1}$ is estimated at 0.19. The F35%SPR was estimated at 0.23.

The precautionary reference fishing mortalities were set in 1998 by ACFM with F_{pa} as the $\mathbf{F}_{med}$ value of 0.25 and F_{lim} two standard deviations above $\mathbf{F}_{pa}$ equal to 0.40. The precautionary reference spawning stock biomass levels were changed by ACFM in 2007. B_{lim} was set at 22 000 t (B_{loss}) and B_{pa} at 35 000 t based on the formula $B_{pa} = B_{lim}e^{1.645\sigma}$, assuming a σ of about 0.3 to account for the uncertainties in the assessment.

The medium term projections made in 2012 (see above) was used to come up with likely MSY reference candidates. Based on this the 2012 WG proposed to preliminary set F_{MSY} at 0.25 and the MSY $B_{trigger}$ at 35 000 t (the same as B_{pa}). These values were accepted by ACOM.

H. Other Issues

I. References

Gaard, E., Hansen, B., Olsen, B., and Reinert, J. 2002. Ecological features and recent trends in physical environment, plankton, fish and sea birds in the Faroe plateau ecosystem. *In* Large Marine Ecosystem of the North Atlantic (eds K. Sherman, and H.-R. Skjoldal), pp. 245-265. Elsevier. 449 pp.

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ICES C.M. 2014/ACOM:07. Report of the North-Western Working Group.

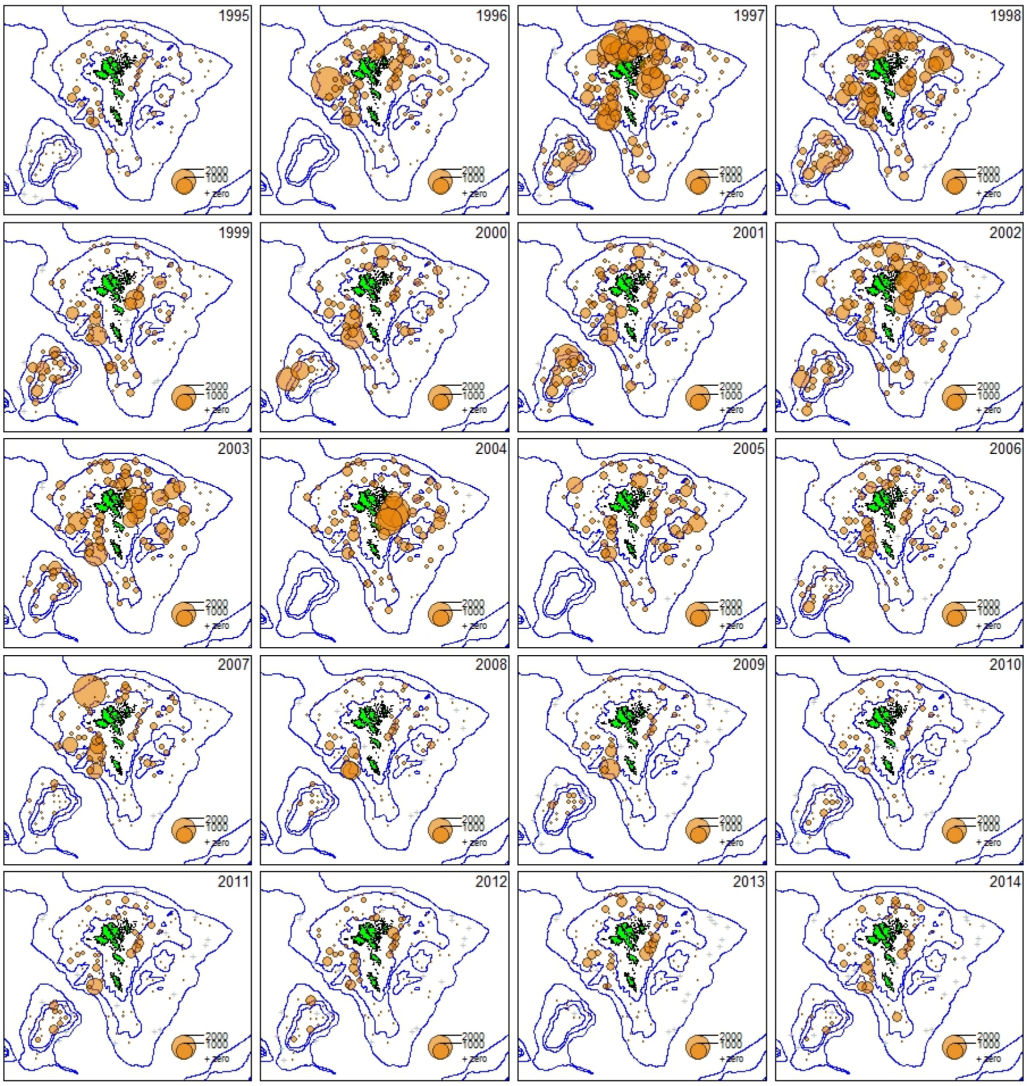


Figure 1. Distribution of haddock in the spring survey.

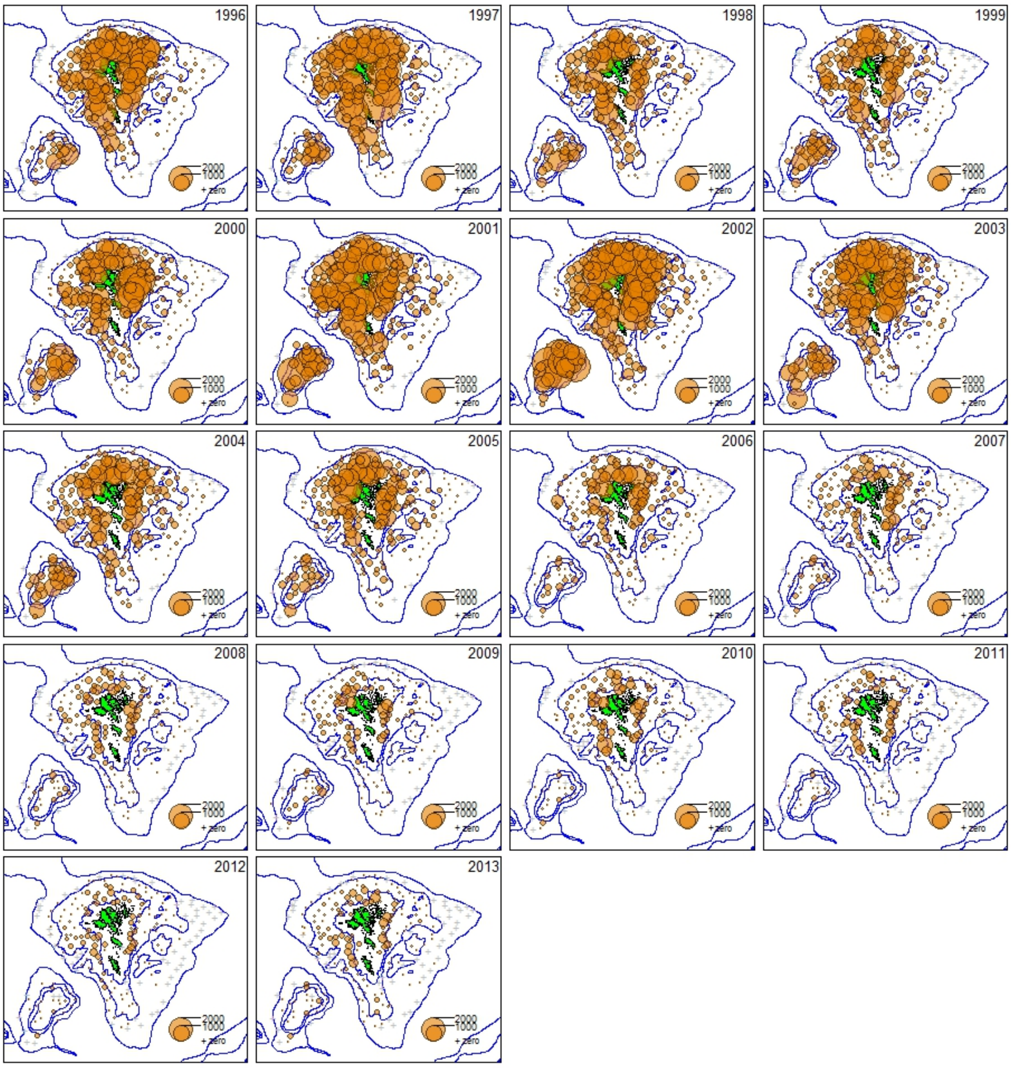


Figure 2. Distribution of haddock in the summer survey.

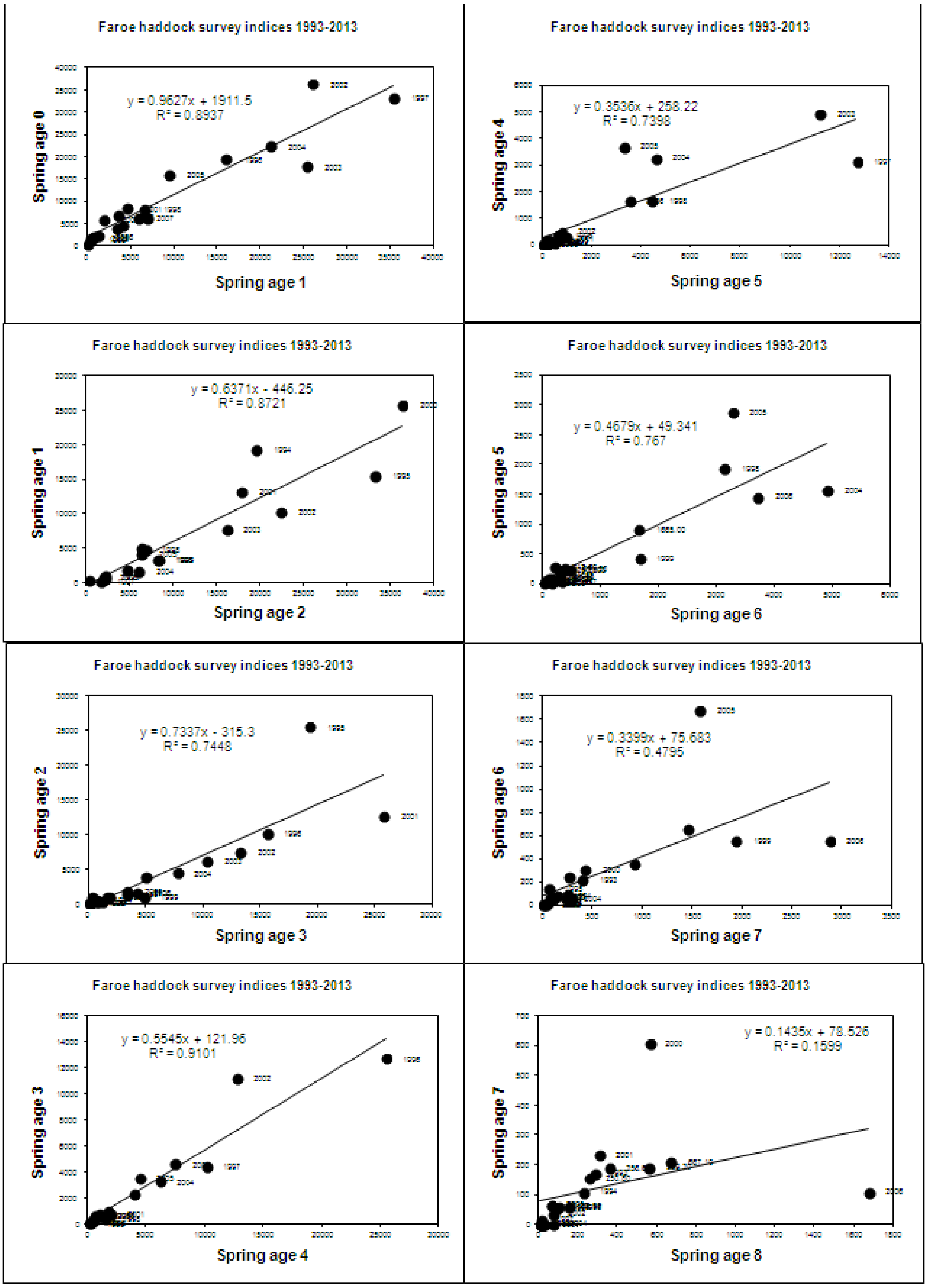


Figure 5.13. Faroe haddock. Comparison between spring survey indices (shifted) at age and the indices of the same YC one year later.

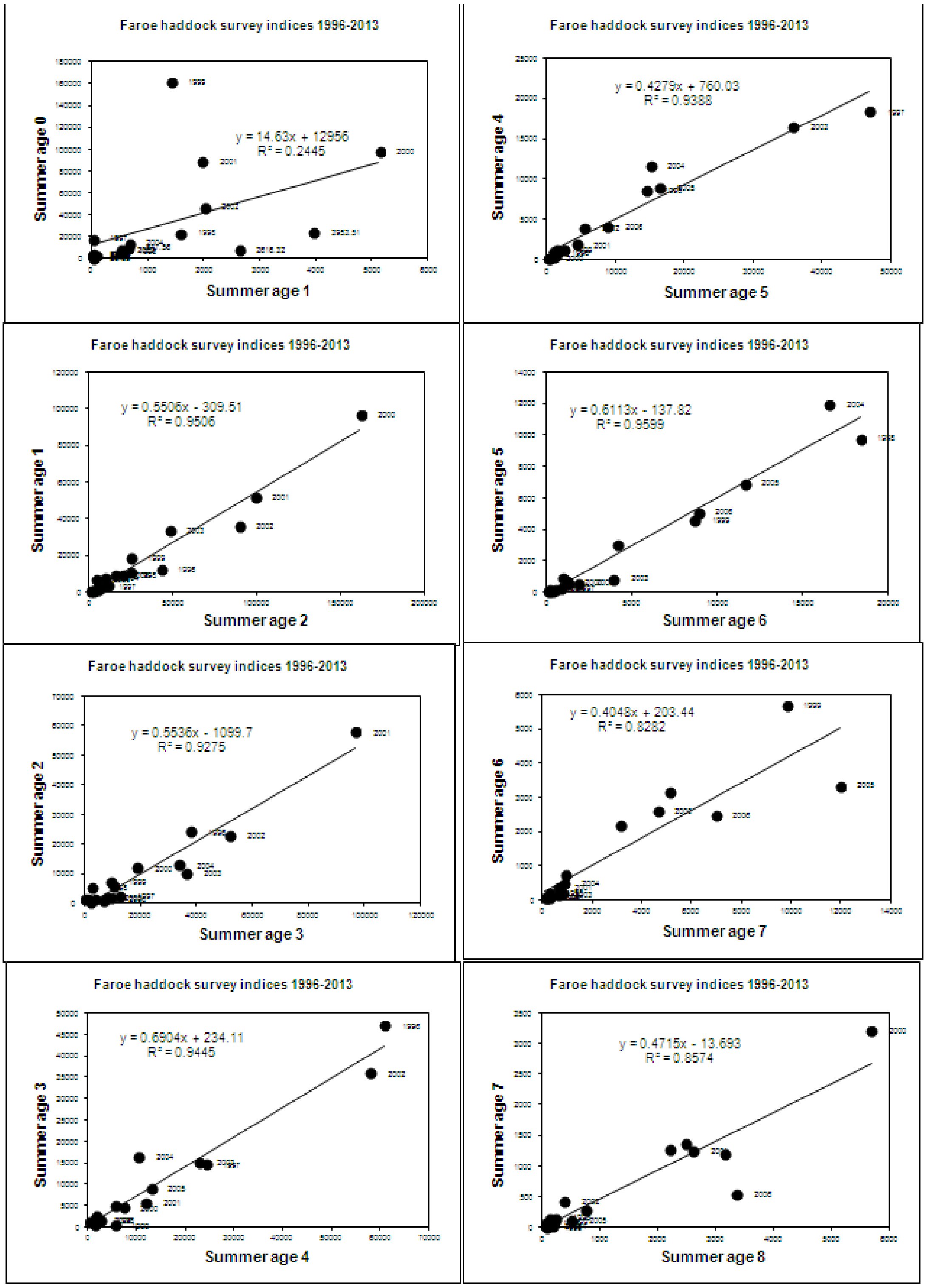


Figure 5.14. Faroe haddock. Comparison between summer survey indices at age and the indices of the same YC one year later.

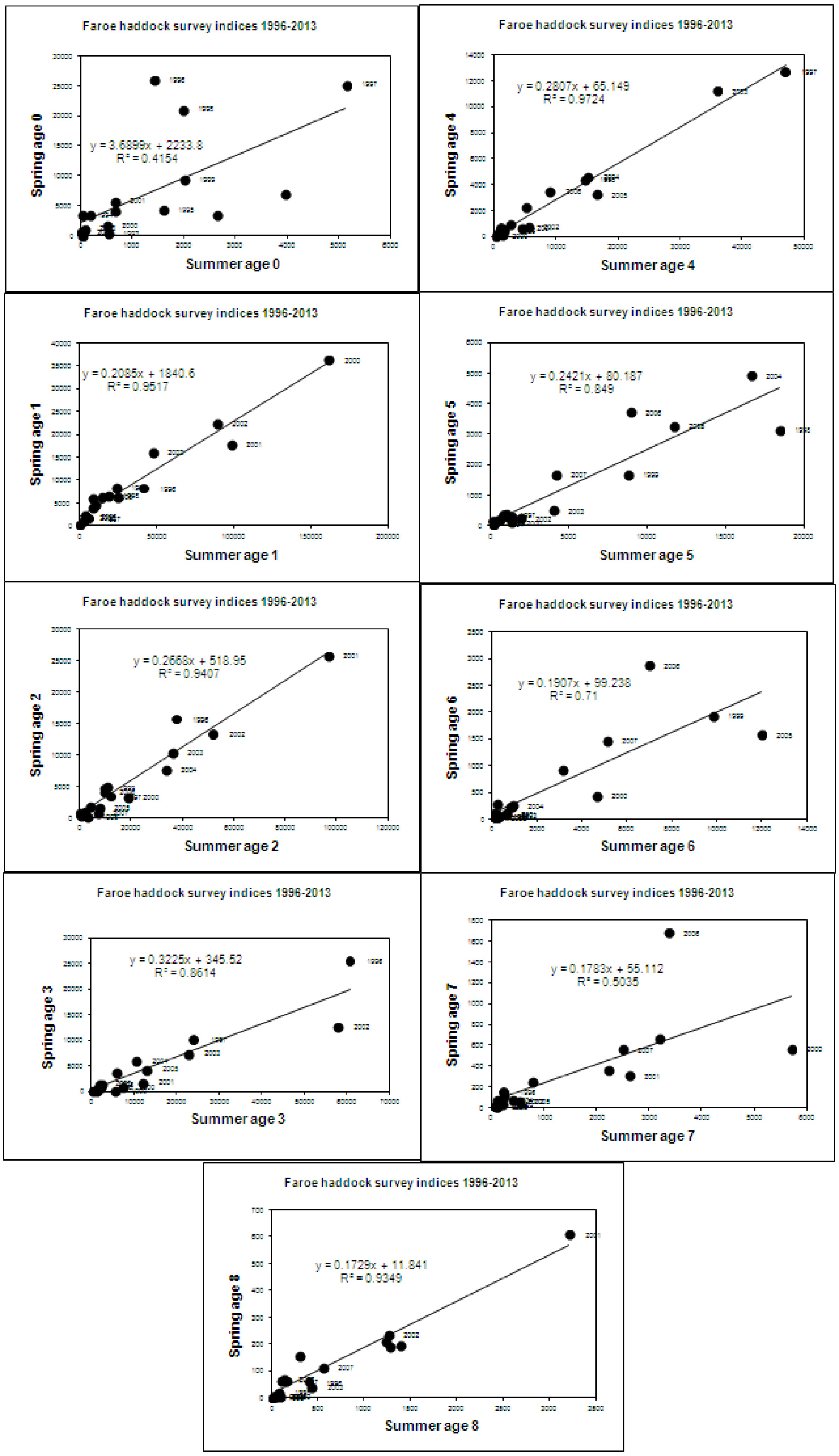


Figure 5.15. Faroe haddock. Comparison between indices at age from the spring survey (shifted) and the summer survey.

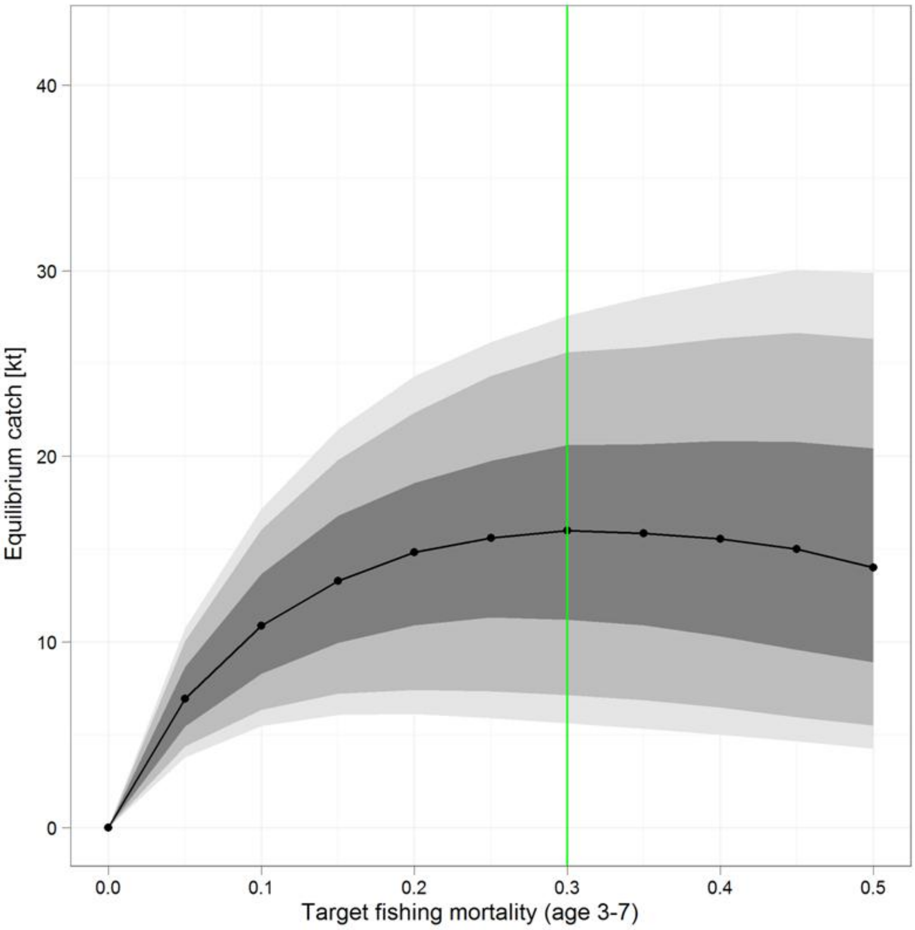


Figure 6. Equilibrium yield, vertical line showing F_{msy} = 0.3. The different shades of grey refer to 90%, 80% and 50% pseudo-confidence intervals.

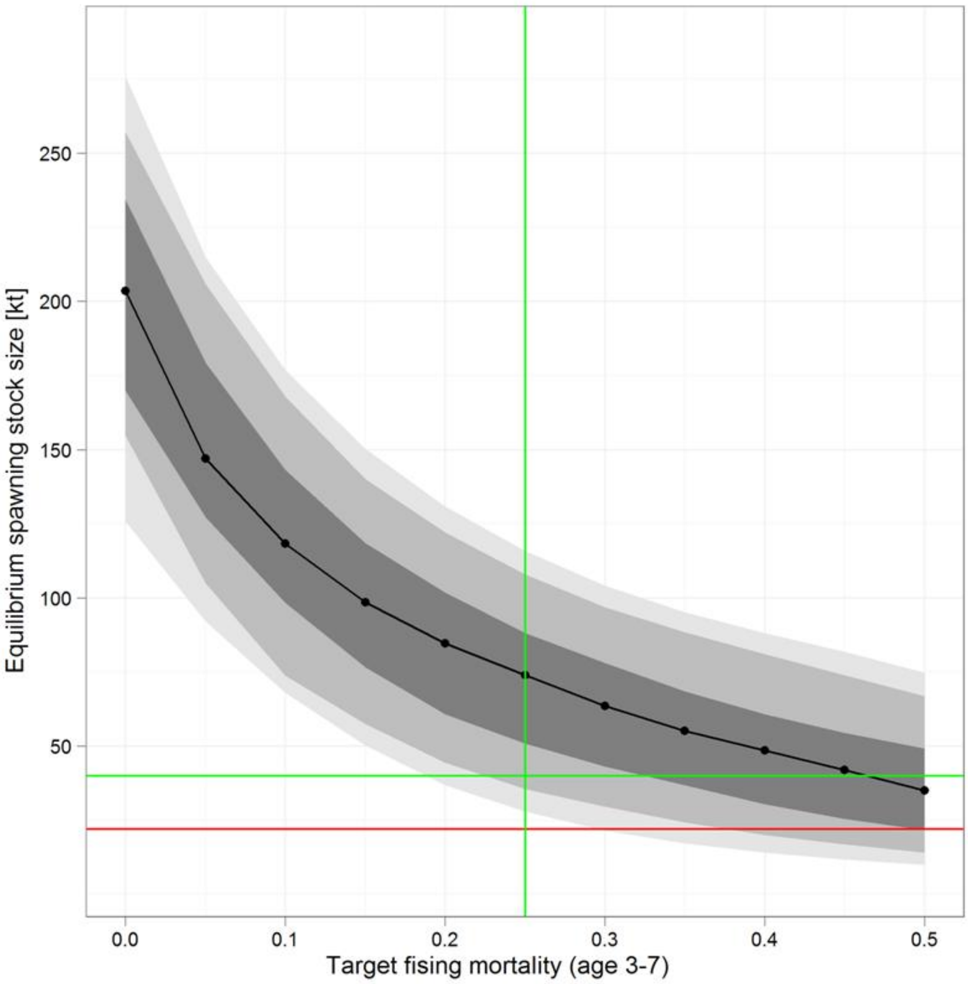
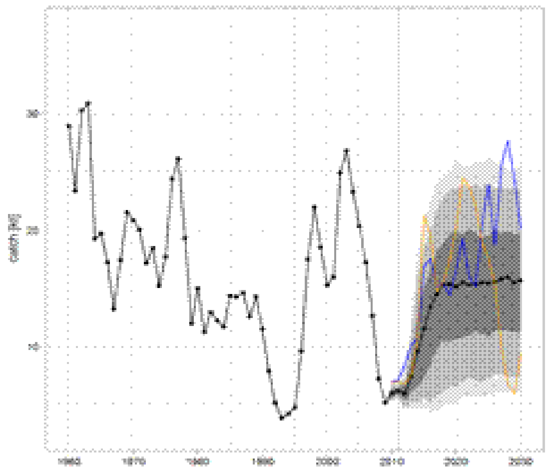
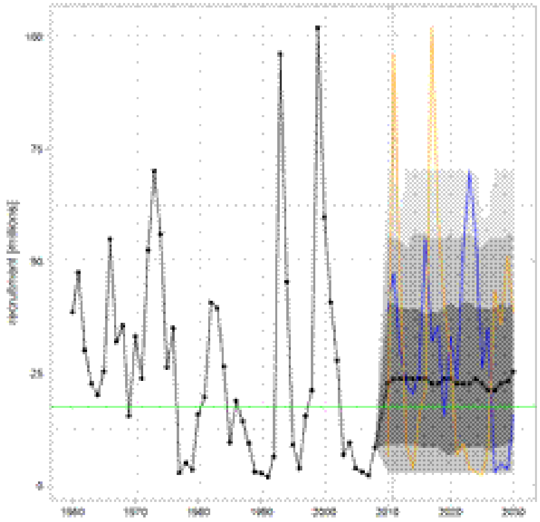
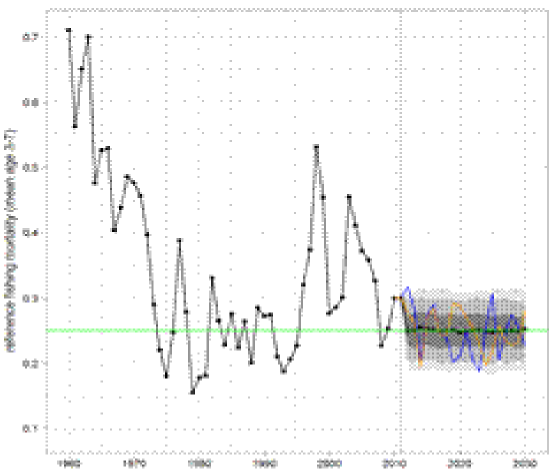


Figure 7. Spawning stock size as a function of target fishing mortality. B_{lim}: horizontal red line, B_{pa}: horizontal green line. Vertical line: Proposed preliminary F_{msy} of 0.25. The different shades of grey refer to 90%, 80% and 50% pseudo-confidence intervals.







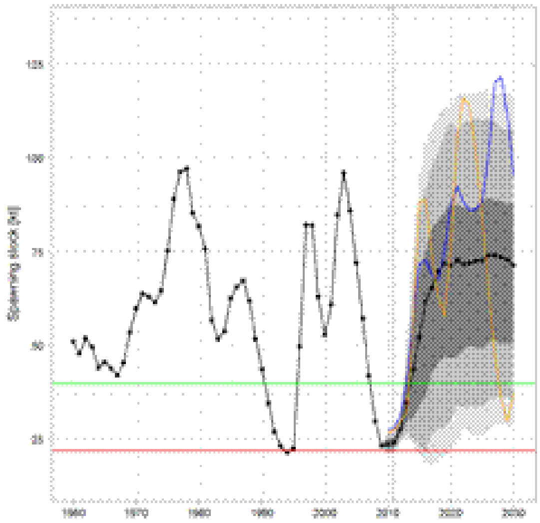


Figure 8. Medium term simulation based on F_{target} = 0.25. Top figure shows development of catch, the next recruitment, then fishing mortality and bottom figure spawning stock size. The different shades of grey refer to 90%, 80% and 50% pseudo-confidence intervals. Note that the x-axis does not cross the y-axis at zero.

Stock Annex: Faroe Saithe (Division Vb)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	**Faroe saithe (Division Vb)**
Working Group:	**North-Western Working Group**
Date:	**Feb 2010**
Revised by	**Luis Ridao & Petur Steingrund**
	Faroe Marine Research Institute

A. General

A.1. Stock definition

Saithe is widely distributed around the Faroes, from shallow inshore waters to depths of 500 m. The main spawning areas are found at 150-250 meters depth east and north of the Faroes. Spawning takes place from January to April, with the main spawning in the second half of February. The pelagic eggs and larvae drift with the clockwise current around the islands until May/June, when the juveniles, at lengths of 2.5-3.5 cm, migrate inshore. The nursery areas during the first two years of life are in very shallow waters in the littoral zone. Young saithe are also distributed in shallow depths, but at increasing depths with increasing age. Saithe enter the adult stock at the age of 3 or 4 years (Jákupsstovu 1999).

Saithe in Division Vb is regarded as a management unit although tagging experiments have demonstrated migrations between the Faroes, Iceland, Norway, west of Scotland and the North Sea (Jákupsstovu 1999). Jakobsen and Olsen (1987) investigated taggings of saithe at the Finmark coast (off Northern Norway) during the 1960s-1970s. They found that emigration rates to the Faroe area by some 2-3 % of the North-east arctic saithe stock was sufficient to explain the tagging results, and that the emigration likely occurred before sexual maturity. Bearing in mind that the North-east arctic saithe stock is larger than the saithe stock at the Faroes (by a factor of 1 to 6), up to some 20 % of the saithe stock at the Faroes may be of norwegian origin, according to this study. However, it might be expected that the emigration rate of saithe from more southerly locations along the Norwegian coast could be higher than in Jakobsen and Olsen's (1987) study (see Jakobsen (1981) for emigration to the North Sea). On the other hand, the emigration rate in the opposite direction also has to be accounted for. English tagging experiments (Jones and Jónsson, 1971) with Faroe Plateau saithe in the 1960s indicated an emigration rate to the Faroe Bank of 5 % (2 out of 41), North Sea of 15 %, and a rate of 20 % to Iceland (2 % had unknown recapture site). Regarding the migration between Icelandic and Faroese waters, there have been tagged some 18463 juvenile saithe in Icelandic waters in 2000-2005 (Armansson *et al*., 2007), and 1649 have been recaptured up to now, 7 of them in Faroese waters (Marine Research Institute, Iceland, pers. comm.). This indicates that emigration rate of saithe to Faroese waters might be limited. In conclusion, Faroe saithe seem to receive recruits from own waters as well as recruits from the North-east arctic saithe stock and probably also the North Sea stock. In addition there might be a net emigration to Icelandic waters (Jones and Jónsson, 1971; Jakobsen and Olsen, 1987).

A.2. Fishery

Since the introduction of the 200 miles EEZ in 1977, the saithe fishery has been prosecuted mostly by Faroese vessels. The principal fleet consists of large pair trawlers (>1000 HP), which have a directed fishery for saithe, about 50 - 60% of the reported landings in since 1992. The smaller pair trawlers (<1000 HP) and larger single trawlers have a more mixed fishery and they have accounted for about 10-20% of the total landings of saithe since 1997. The share of landings by the jigger fleet accounts for less than 4% of the total landings since 2000.

Since early-1980s the bulk of catches consists of age groups 4 to 7 while the contribution of older age groups was more substantial from 1961 to 1980 (WD 08)

Nominal landings of saithe in Division Vb have varied cyclically between 10 000 t and 68 000 t with three distinctive cycles of around 15 years period since 1960.

Catches used in the assessment include foreign catches that have been reported to the Faroese Authorities but not officially reported to ICES. Catches in Subdivision IIa, which lies immediately north of the Faroes, have also been included. Little discarding is thought to occur in this fishery.

A.3. Ecosystem aspects

The rapid recovery of the cod stock in the mid 1990s strongly indicated that 'strange things' had happened in the environment. It became clear that the productivity of the ecosystem affected both cod and haddock recruitment and growth (Gaard *et al*., 2002), a feature outlined in Steingrund and Gaard (2005). The primary production on the Faroe Shelf (< 130 m depth), which took place during May-June, varied interannually by a factor of five, giving rise to low- or high-productive periods of 2-5 years duration (Steingrund and Gaard, 2005). Saithe, however, seem to be more affected by the productivity over the outer areas. The productivity over the outer areas seems to be negatively correlated with the strength of the Subpolar Gyre (Hátún *et al*., 2005; Hátún *et al*., 2009; Steingrund *et al*., 2010), which may regulate the abundance of saithe in Faroese waters (Steingrund and Hátún, 2008). When comparing a gyre index (GI) to saithe in Faroese waters there was a marked positive relationship between annual variations in GI and the total biomass of saithe lagged 4 years.

There is a negative relationship between mean weight-at-age and the stock size of saithe in Faroese waters. This could be due to simple density-dependence, where there is a competition for limited food resources. Stomach content data show that blue whiting, Norway pout, and krill dominate the food of saithe, and the annual variations in the stomach fullness are mainly attributable to variations in the feeding on blue whiting. There seemed to be no relationship between the way stomach fullness is related to weights-at-age (í Homrum *et al*. 2009). One explanation for this might be the influx of fish (3 to 5 years old) to Faroese waters from other saithe stocks given that weights-at-age are very similar, e.g. for NEA and Faroe saithe in years when the Faroe saithe stock is large (4 years after a high GI) whereas Faroe saithe has up to two times larger individual weights when the stock size is low.

B. Data

B.1. Commercial catch

In order to compile catch-at-age data, the sampling strategy is to have length, length-age, and length-weight samples from all major gears (jiggers, single trawlers > 1000

HP, pair trawlers < 1000 HP, pair trawlers > 1000 HP and others) during three periods: January-April, May-August and September-December. When sampling was insufficient, length-age and length-weight samples were used from similar fleets in the same time period while avoiding if possible the use of length measurements. Landings were obtained from the Fisheries Ministry and Statistics Faroe Islands. Catch-at-age for fleets covered by the sampling scheme were calculated from the age composition in each fleet category and raised by their respective landings. Fleet based catch-at-age data was summed across all fleets and scaled to the correct catch.

Mean weight-at-age data were calculated using the length/weight relationship based on individual length/weight measurements of landing samples.

B.2. Biological

B.3. Surveys

The spring groundfish surveys in Faroese waters were initiated in 1983 with the research vessel Magnus Heinason. Up to 1991 three cruises per year were conducted between February and the end of March, with 50 stations per cruise selected each year based on random stratified sampling (by depth) and on general knowledge of the distribution of fish in the area. In 1992 the first cruise was not conducted and one third of the stations used up to 1991 were fixed. Since 1993 all stations are fixed.

The summer (August-September) groundfish (bottom trawl) survey was initiated in 1996 and covers the Faroe Plateau with 200 fixed stations distributed within the 65 to 520 m contour. Effort for both surveys is recorded in terms of minutes towed (~60 min). Survey data for Faroe saithe are available to the WG from both the spring- (since 1994) and summer- (since 1996) surveys. The usual way was to calculate the index as the stratified mean number of saithe at age. The age length key was based on otolith samples pooled for all stations. Due to incomplete otolith samples for the youngest age groups, all saithe less than 20 cm were considered being 0 years and between 20-40 cm 1 year. Since the age length key was the same for all strata, a mean length distribution was calculated by stratum and the overall length distribution was calculated as the mean length distribution for all strata weighted by stratum area. Having this length distribution and the age length key, the number of fish at age per station was calculated, and scaled up to 200 stations in the summer survey.

Both survey indices are available to the Working Group. However the survey series have not been used due to high CVs. In order to address this issue, a data-driven post-stratification analysis was applied in 2008. The analysis suggested that the optimal number of strata to estimate relative stock abundances should be between 5 and 7 for both surveys. The new stratification results in less variable survey estimates while improving year class consistency from one year to the next (Ridao Cruz, L. 2008, WD 5). A similar approach was used at the Benchmark Assessment Workshop (WKROUND) in 2010 (WD 03). In this case one large haul was windsorized to the second largest in the spring series prior to the analysis proper. With these revised survey indices several age-based models were run, e.g., XSA, NTF-Adapt and Separable models. A strong bias was observed in the retrospective pattern for all models and therefore the revised survey series were yet regarded as not suitable for model tuning. However, WKROUND in 2010 noted that the surveys were able to capture annual changes in the range of the spatial distribution of saithe on the Faroe Plateau. This variability (proportion of all 300 hauls containing at least one saithe) was used as a scaling factor of the commercial cpue (based on the pairtrawlers, see later).

Maturity at age data from the spring survey is available since 1983. Some of the 1983-1996 values were revised in 2003 but not the maturities for the 1961-1982 period (Steingrund, 2003). The proportion mature was obtained from the spring survey, where all aged individuals were pooled, i.e., from all stations, being in the spawning areas or not. Due to poor sampling in 1988 the proportion mature for that year was calculated as the average of the two adjacent years. At the 2012 working group a model using maturity at age from the Faroese groundfish spring survey was implemented to derive smoothed trends in maturity by age and year. The fitting was done locally and the smoothing level was chosen as a trade-off between retaining the trend in maturities and reducing the data noise.

B.4. Commercial CPUE

The CPUE series from pair trawlers that has been used in the assessment since 2000 was introduced in 1998 (ICES C.M. 1998/ACFM:19), and consists of saithe catch at age and effort in hours, referred to as the pair trawler series. All vessels use 135mm mesh size, the catch is stored on ice on board and landed as fresh fish. The vessels are greater than 1000 HP and have specialized in fishing on saithe and account for 5 000-20 000 t of saithe each year. The tuning series data are based on available logbooks of 4-10 trawlers since 1995. Data are stored in the database at the Faroe Marine Research Institute in Torshavn where they are quality controlled and corrected if necessary. Effort is estimated as the number of fishing (trawling) hours, i.e. from the time the trawl meets the bottom until hauling starts. It is not possible to determine effort in fishing days because day and time of fishing trips are not recorded in the logbooks. The effort distribution of the pair trawlers fleet covers most of the fishing areas in the deeper parts (bottom depth > 150 m) at the Faroes. Distribution of combined trawl catches (single- and pair-trawlers) from logbooks is shown in figure 1.

During 2002-2005 four pairs of these trawlers were decommissioned. In 2004 and 2005 two new pairs of trawlers (>1000 HP) were introduced in the tuning series; one pair had been fishing saithe since 1986 and the other since 1995. These two new pairs showed approximately the same trends as the other pair trawlers in the series during 1999-2003. In 2009 two new pairs of trawlers were used to extend the tuning series. These trawlers were build in 2003 and 2004 and they show the same trends in CPUE as the others, but higher in absolute numbers. At the 2010 benchmark assessment the CPUE series were compiled based on hauls where saithe contributed more than 50% of the total catch, discarding a pair (pair-6) and constraining the spatial distribution to those statistical squares where most of the fishing activity takes place. A GLM model using year, month, pair and depth as explanatory variables (WD 09) was applied to the resulting input data. If 'fishing square' was added as an explanatory variable, the year-effect in the GLM model remained the same. However, 'fishing square' was excluded from the model in order to keep the number of the degrees of freedom as low as possible. In addition to the pairtrawler cpue, which is a measure of saithe density in the core area of saithe, the range of the spatial distribution of saithe was considered when constructing an abundance index for saithe. The pairtrawler cpue was scaled by the proportion of survey survey hauls in March and August (approximately 300 each year, except 100 in 1995) containing at least one saithe. The revised annual indices resulted in a substantial reduction in the bias observed in the retrospective pattern. The WKROUND working group regarded this novel approach to the commercial series as satisfactory.

B.5. Other relevant data

C. Historical Stock Development

The last benchmark assessment for Faroe Island saithe was conducted in 2005. The model explored during that benchmark workshop, an XSA model, was not used for interim assessments or to provide management advice after that workshop because of a retrospective pattern observed in model outputs at that time. It was hypothesized that the retrospective pattern was likely due to changes in selectivity due to changes in fish growth as it was observed that the average weight at age in the catch was dropping. The 2010 benchmark workshop further explored the XSA model as well as an ADAPT, TSA and separable statistical models. The CPUE series that has been used in the assessment since 2000 was introduced in 1998 (ICES C.M. 1998/ACFM:19), and consists of saithe catch at age and effort in hours, referred to as the pair trawler series. The commercial CPUE series was standardized and the density indices were multiplied by an area expansion factor to better represent a measure of total stock abundance (Sec. 6.2.5.2.) These data updates were found to significantly reduce the retrospective pattern previously observed in the assessment. The SSB, F and recruitment estimates generated by both models were comparable and the XSA assessment was adopted as the benchmark assessment because it had been the model historically used for this stock. The model settings are described below. In 2013 the spring groundfish survey (FGFS1) was introduced in the current assessment framework along with the commercial fleet. Spring survey data were considered superior to the summer survey for calibrating the assessment. Commercial catch-at age data (ages 3-14+, years 1961-2012) were calibrated in the XSA model using the spring survey at age data (ages 3-10, years 1993-2012) and the commercial pair-trawl fleet (ages 3-11, years 1995-2012).

Model used: FLXSA, Extended Survivors Analysis for FLR

Software used: FLR, version 2.0

Model Options chosen:

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 3 oldest ages. S.E. of the mean to which the estimates are shrunk = 2.000. Minimum standard error for population estimates derived from each fleet = .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	1961-last data year	3 – 14+	Yes
Canum	Catch at age in numbers	1961-last data year	3 – 14+	Yes
Weca	Weight at age in the commercial catch	1961-last data year	3 – 14+	Yes

West	Weight at age of the spawning stock at spawning time.	1961-last data year	3 – 14+	Yes, assumed to be the same data as weight at age in the catch
Mprop	Proportion of natural mortality before spawning	1961-last data year	3 – 14+	No, set to 0 for all ages and years
Fprop	Proportion of fishing mortality before spawning	1961-last data year	3 – 14+	No, set to 0 for all ages and years
Matprop	Proportion mature at age	1983- last data year + 1 (2009)	3 – 14+	Predicted ogives. Data prior to 1983 is average of 1983-1996 values.
Natmor	Natural mortality	1961-last data year	3 – 14+	No, set to 0.2 for all ages and years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Pair trawlers	1995- last data year	3-11

D. Short-Term Projection

Model used: Age structured.

Software used: Multi Fleet Deterministic projection (MFDP1a), prediction with management option table

Initial stock size: Taken from the final VPA run (table 10). Recruitment at age 3 is geometric mean from 2007-2011.

Natural mortality: Set to 0.2 for all ages in all years.

Maturity: In the assessment year is the average of weight in assessment year and previous year. For the two following years after the assessment year an average of the most three recent years is used.

F and M before spawning: Set to 0 for all ages in all years.

Weight at age in the stock: weight-at-age for 3-years old saithe is predicted by the year class strength (number of 3-years old in the stock) with a 3 year time lag (Eq. 1) whereas weight for ages 4 to 8 is estimated by weight-at-age the previous year from the same year class (Eq. 2). Weight for ages 9 to 14+ is an average of the most 3 recent years (Eq. 3)

$W_{3,y} = \alpha N_{3,y-3} + \beta$ for $a = 3$ (Eq. 1)

$W_{a+1,y+1} = \alpha W_{a,y} + \beta$ for $4 \leq a \leq 8$ (Eq. 2)

$W_{a,y} = (W_{a-3,y}\ W_{a-2,y}\ W_{a-1,y})/3$ for $9 \leq a \leq 14+$ (Eq. 3)

Weight at age in the catch: The same value as in the last data year.

Exploitation pattern: Average exploitation pattern in the final VPA for the last two years rescaled to terminal F if pattern is present in recent years, otherwise unscaled.

Intermediate year assumptions: None

Stock recruitment model used: None

Procedures used for splitting projected catches: None

E. Medium-Term Projections

Not performed.

F. Long-Term Projections

Model used: Yield and biomass per recruit over a range of F-values.

Software used*:* Multi Fleet Yield Per Recruit (MFYPR2a).

Maturity: Average for 1983 to last data year +1 (2009).

F and M before spawning: Set to 0 for all ages and 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 weights from 1983 to last data year.

Exploitation pattern: Average exploitation pattern of the last five years

Procedures used for splitting projected catches: None.

G. Biological Reference Points

In the 2011 assessment for Faroe saithe a Management Strategy Evaluation (MSE) was performed using a harvest control rule in the FLR environment. In the 2012 assessment some changes were included in the simulation framework. Maturity by age and year were modified (and therefore SSB) according to the smoothing technique reported in Section 6.2.4. Extra stochasticity was added to weights at age in the form of autocorrelation and the constraint of running XSAs in the simulations was dropped to reduce the simulation running time. All these changes caused a upward revision of the F_{msy} point estimate from F_{msy}=0.28 to F_{msy}=0.32. The simulation framework is explained below.

The MSE approach requires mathematical representations of two systems: a 'true' system and an 'observed' one. The 'true' system is represented by the operating model (OM) that simulates the real world. In contrast, the 'observed' system represents the conventional management procedure (MP), from the data collection through stock assessment to the management implementation. The present MSE evaluation uses the working group stock assessment as the basis for the Operating Model and makes assumptions about the selection pattern of the fishing fleet and its dynamics. The model comprises a single stock that is fished by a single fleet. It implements a harvest control rule through a management procedure that explicitly models the stock assessment process and time lag in implementing the management advice (delay between the gathering of data and making a management decision, i.e. setting the current fishing effort) which explicitly address uncertainty in recent parameter estimates. The stock recruitment relation used is the Hockey-stick or segmented regression with random noise on top of it reflecting the high variability in historical recruitment estimates (CV=0.5). Fishing mortality is estimated from effort, catchability (constant) and the selection pattern. The observed selection pattern since 1996 is used in the simulations which correspond with the implementation of the fishing days quota in the Faroese management system. Maturity-at-age is fixed and taken from the smoothing method implemented in 2012 while stochasticity is included in weights-at-age with a CV=0.18 and autocorrelation of Rho=0.35 applied to all age groups to somehow replicate the observed fluctuations pattern. The data sampling of catches and tuning fleets is carried out by multiplying by random errors. Natural mortality is fixed to M=0.2. Simulations were performed 1000 times on a 40-year forward period with the historical period being replicated in the OM.

Unlike the flat curves obtained from traditional yield-per-recruit calculations simulations curve show a relatively well defined maximum at F_{msy} =0.32. The reason for this difference is that when fishing mortality is above certain level (>0.3) some of the stochastic runs will lead to spawning stock being below the break point in the stock-recruitment function so recruitment and subsequent landing s will be reduced. The breakpoint of 55 kt. in the segmented regression or the revised B_{pa}=60 000 t. (see Section 2. Demersal stocks in the Faroe Area, Subsection 2.1.7 Faroe saithe) could be candidates for $B_{trigger}$ the point at which fishing mortality should be reduced according to the MSY framework. The results of the simulations are shown in Figure 3

MSY and revised precautionary reference points (Section 2. Demersal stocks in the Faroe Area, Subsection 2.1.7 Faroe saithe) for faroe saithe are listed below:

Biological reference points		Proposed in 2011
Btrigger	55 000 t.	
Blim	45 000 t.	
Bpa	60 000 t.	
Flim	0.4	
Fpa	0.28	
Fmsy	0.32	0.28

H. Other Issues

Response to technical minutes

2006

Technical minutes suggested that a length based assessment should be attempted. This will be further investigated with Bormicon for next year's meeting, time permitting.

The question of migration has been brought up previously. Although tagging data indicate that saithe migrates between management areas, and some indications are seen in the assessment as well, no attempts have been made to quantify the migration rate of saithe.

Bycatch has been mentioned in the latest technical minutes. The results presented in NWWG 2007 indicate that the bycatch issue is a minor problem in the saithe assessment (ICES C.M. 2007/ACFM:17). Mandatory use of sorting grids in the blue whiting fishery was introduced from April 15, 2007 in the areas west and northwest of the Faroe Islands.

2007

Technical minutes pointed out the problem of variability in weight-at-age and suggested the possibility of using different modelling approaches that the WG could explore in the future. It was discussed whether there was possibility for Faroe Saithe to be part of the benchmark workshop in winter 2008; but this session was already closed for additional participants. Alternatively the group discussed the possibility of working intersessionally to explore usable models for next year's meeting.

2008

Technical minutes pointed out the problem of variability in pelagic/demersal occurrence of saithe, hence the problems in reliability of survey indices (high CV). Commercial CPUE indices were used for tuning. However, declining weight-at-age leading to declining catchability not accounted for in XSA.

At this point, there is no improvement in the 2009 year assessment compared to previous year. In the benchmark assessment the surveys should be closer investigated. The summer survey shows that the spatial distribution of saithe on the Faroe Plateau has become wider. An attempt should be made to incorporate this information into the index of stock size.

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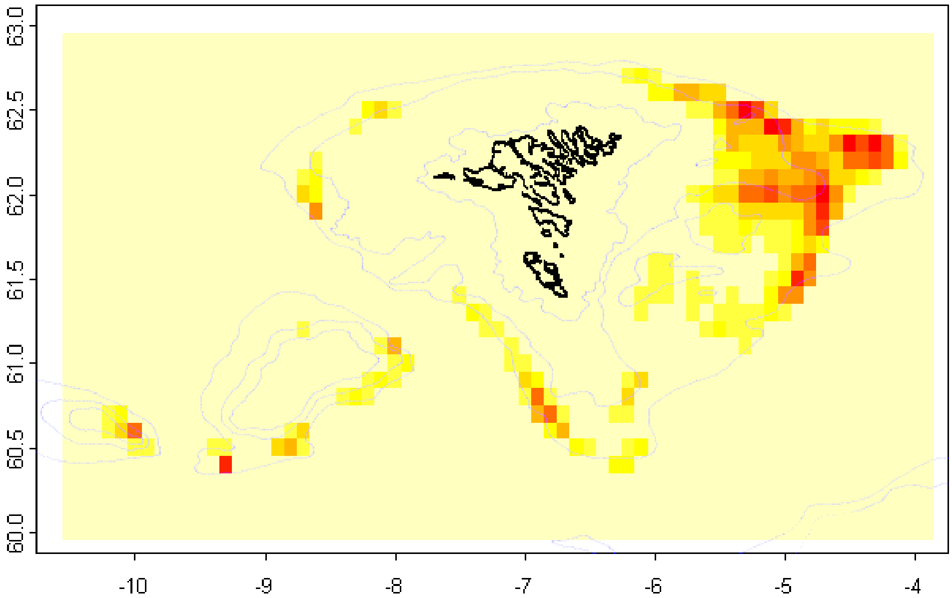


Figure 1. Faroe Saithe Vb. Distribution of combined trawl catches (single- and pair-trawlers) from 1995-2008 (logbooks.) Depth contour lines of 100, 200 and 400m are shown.

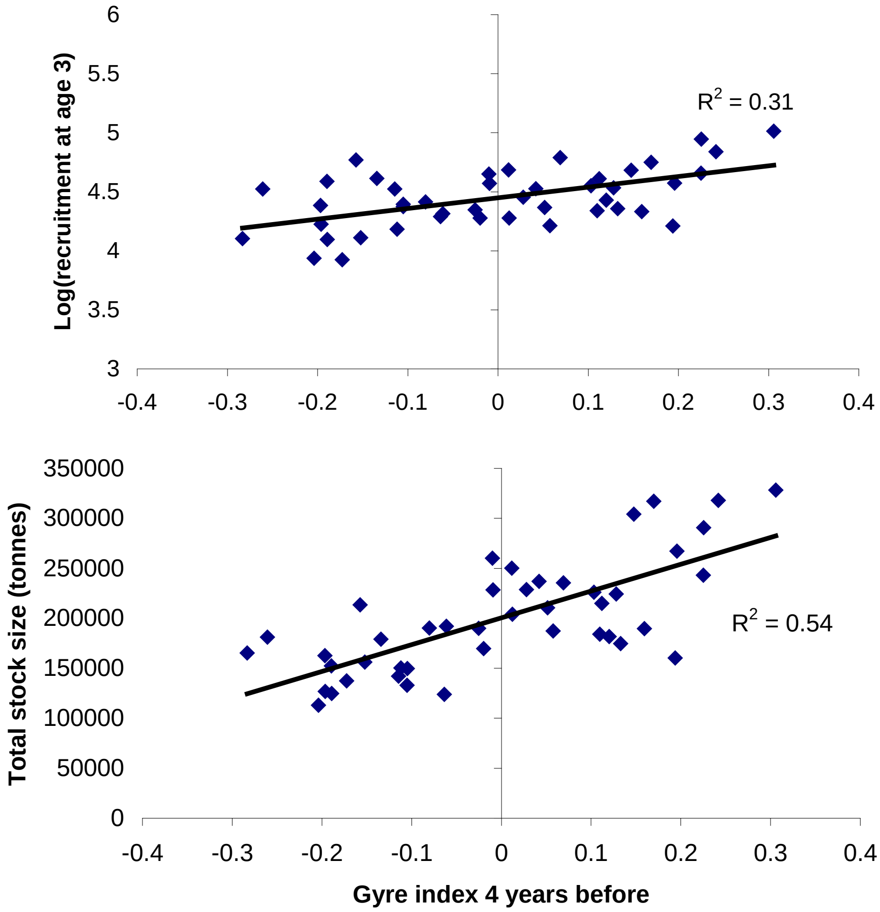


Figure 2. Relationship between the gyre index and both recruitment (top figure) and total stock biomass estimates (bottom figure.) Note that a large gyre index indicates a small subpolar gyre, and, consequently, a large influx of plankton-rich warmer-than-average water to the outer areas (bottom depth > 150 m) around the Faroes, where saithe typically are found.

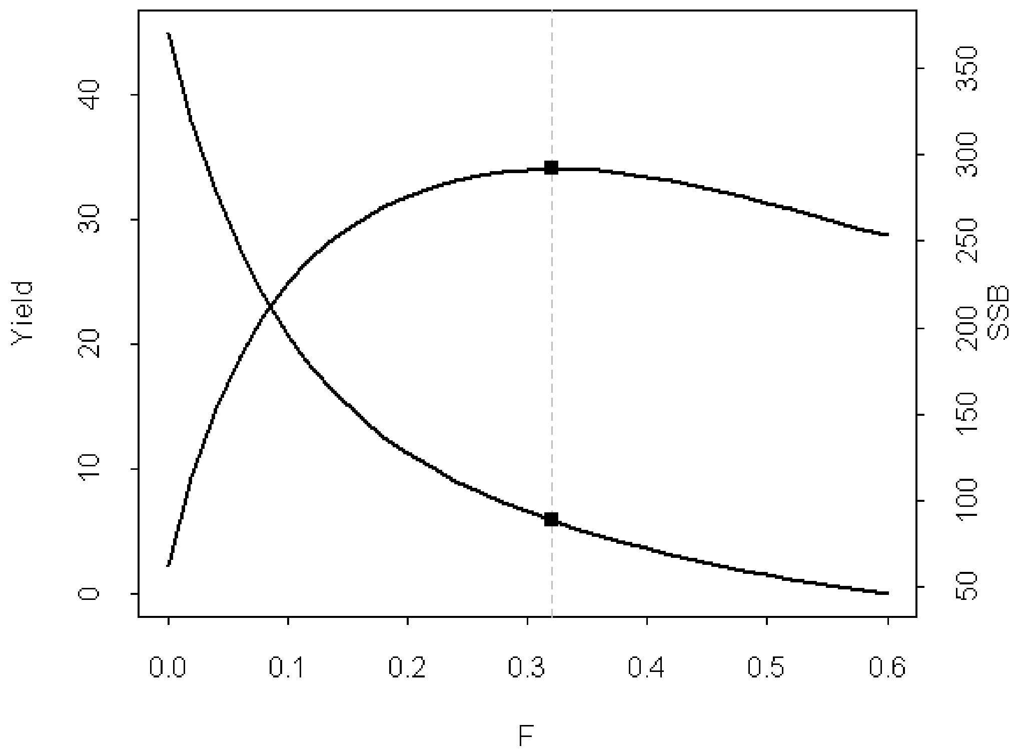


Figure 3. Yield and spawning per-recruit from the simulations. Fmsy=0.32, Ymsy=34 kt. and SSBmsy=89 kt.

Stock Annex: Cod in inshore waters of NAFO Subarea 1 (Greenland cod)

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Cod in inshore waters of NAFO Subarea 1 (Greenland cod)

Working Group: North-Western Working Group

Date: May 2014

Revised by:

A. General

A.1. Stock definition

Cod found in Greenland is a mixture of four separate "stocks" that are defined by their spawning areas: I) offshore West Greenland waters; II) West Greenland fiords cod III) offshore East Greenland and offshore Icelandic waters and IV) inshore Icelandic waters (Therkildsen *et al*. 2013).

Inshore spawning cod is verified in many fjords between 64 and 67°N in West Greenland (Hansen 1949, Smidt 1979, Buch *et al*., 1994). Recent summaries of the stock structure and developments includes: Buch *et al*. (1994), Wieland and Hovgård (2002), Storr-Paulsen *et al*. (2004), Wieland and Storr-Paulsen (2005), Hovgård and Wieland (2008), and Therkildsen *et al.* (2013).

Tagging information show that cod tagged in the fjords are predominately recaptured in the same fjord as tagged or in the adjacent coastal areas (Hansen (1949), Hovgård and Christensen (1990), Storr-Paulsen *et al.* (2004)). Tagged bank cod are predominately recaptured on the Banks and to a lesser extent in the coastal areas. In contrast, cod tagged in coastal areas are re-captured in all the three areas. Hence, the tagging experiments indicate that the offshore and inshore cod are generally separated but that the coastal area is a mixing zone, especially in the juvenile stages. A considerable number of tags are returned from Icelandic waters, especially from tagging in the coastal areas in South West Greenland (south of 61 °N) and the banks in East and Southwest Greenland (ICES XIV, NAFO Div. 1EF).

A.2. Fishery

A short historical review

The inshore Greenland commercial cod fishery in West Greenland started in 1911 by opening the cod trading at localities where cod seemed to occur regularly. The fishery expanded over the next decades through a development of a number of new trading places. Annual catches above 20 000t have been taken inshore during the period 1955-1969 but declined to around 5,000t in the 1970s. In the 1980s catches fluctuated between 5,000 and 35,000 tons, partly driven by a few strong year classes (1979 and 1984) entering from the offshore stock (Horsted 2000). From 1993 to 2001 the inshore catches were low – in the range 500-2,000t. In the 2000s catches have gradually increased with maximum catches in 2007 and 2008 of 13,000 tons. No license was required until 2009 and the fishery has historically not been constrained by a TAC (for 2009 a TAC of 10,000 tons was introduced) but a minimum landing size of 40 cm has been enforced.

The present fishery

Coastal vessels in the inshore fishery are defined as vessels below 75BT/120BT. A licence was not required until 2009 and has historically not been constrained by catch ceilings until 2009. The most important gear is pound-net (taking ca. 60-80% of the annual catches) anchored at shore and fishing the upper 20 m. Due to the ice conditions pound nets are not used during November-April. In winter the inshore fishery uses jigs, longlines and gill nets. Trawling is not allowed within 3 nm off the base line. Inshore catches have since 00s increased with highest catches of 12,000 tons in 2008.

A.3. Ecosystem aspects

There is little by-catch in the poundnet or jig fishery. Additionally, fish below the minimum size are easily released from the net and are believed to survey. Poundnet selectivity means that fish ages 6 and older are not caught in proportion to the stock composition.

B. Data

B.1. Commercial catch

Data from the commercial fishery are currently not directly used in the assessment, but are used as supplementary information on stock trends and developments. Information on landings in weight are compiled and processed by the Greenland Fisheries License Control (GFLK). Inshore catches are in addition documented by sale slips and from logbooks which have been mandatory since 2008 for vessels larger than 30ft. However the quality of the logbook data has been low and in 2011 only 1,000t out of the total catch of 11,000t were documented in logbooks. Sampling of length frequencies and information on age, weights and maturities are collected and compiled by the Greenland Institute of Natural Resources.

Sampling of the Greenland coastal fleet catches has always been impeded by the geographical conditions, i.e. the existence of many small landing sites separated along the 1000 km coast. Except for the Nuuk area, that is easily covered, samplings relies on dedicated sampling trips supplemented with ad hoc samplings. The sampling coverage was especially poor in the late 1990s when catches were very low (< 1,000t annually) and length frequencies are missing in 1998 and 2001. The sampling coverage has improved since around 2004 through a formal cooperation with GFLK observers. Currently, sampling is considered adequate to reliably describe catch age composition.

Recent genetic studies have documented the presence of different stock in Greenland waters (see section A1). Furthermore, results show that these stocks are present in catches in varying proportions in offshore regions, and something similar may apply to inshore landings. Hence, catches of the inshore stock may be overestimated but the proportions are unknown. This stock mixing also influence the recruitment index, as stock input from other regions may cause overestimation of recruitment.

B.2. Biological

Spawning

Spawning cod have been collected from 2008 in order to investigate the extent of spawning. In addition a spawning survey was conducted in spring 2011 in order to investigate those fjords without samples of spawning cod. The results show that spawning occurs in the coastal zone and in the fjords and is especially pronounced between Sisimiut (NAFO 1B) and Paamiut (NAFO 1E).

B.3. Surveys

At present, an inshore gill-net survey provides the information relevant for stock assessment purposes. The advice is based on a DLS approach, were a biomass index of age 2 and 3 fish is used. Older year classes are excluded as it is evaluated that these are not properly surveyed with the current gear type and setup.

Inshore gill net survey

The objective of the gill-net survey is to assess the abundance and distribution of pre recruit cod in fjord areas in West Greenland. The survey has been conducted annually since 1985 covering three inshore areas along the cost of West Greenland: Sisimiut (NAFO Division 1B), Nuuk (NAFO Division 1D) and more occasionally Qaqortoq (NAFO Division 1F, Figure 3.1.1).

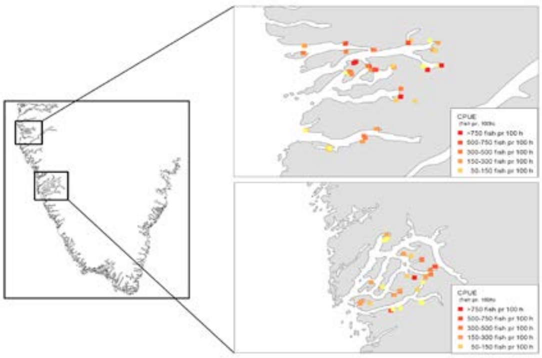
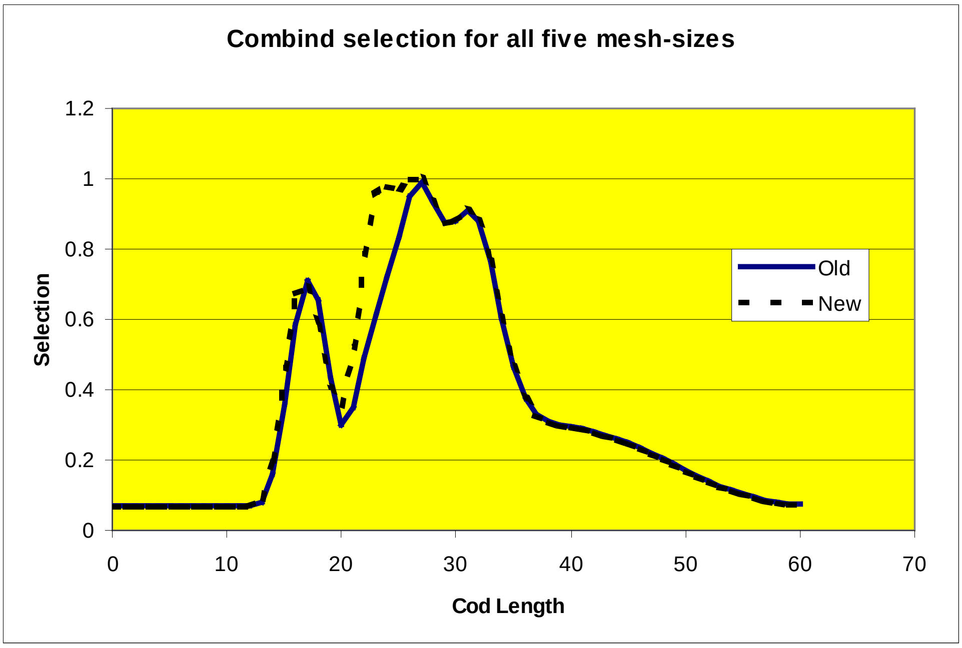


Figure 3.1.1: Map with two fjord system most regularly surveyed in the West Greenland inshore gill net survey. Data shown are 2013 results.

The survey uses gangs of gill nets with different mesh-sizes (16.5, 18, 24, 28 and 33mm, ½ mesh). 100-150 nets are set annually and are set perpendicular to the coast in order to keep depth constant. The survey effort is allocated evenly between the depth zones of 0-5 m, 5-10 m, 10-15 m and 15-20 m. The abundance index used in the survey is defined as 100*(# caught/net*hour).

The original net materials are no longer commercial available for the three smallest mesh sizes. From 2004 this has implied a change in twine thickness (particularly for the 24mm mesh) that is expected to changes the fishing power of the nets.

Mesh-size (mm)	16.5	18.5	24	28	33
Old twine Ø (mm)	0.24	0.20	0.38	0.28	0.33
New twine Ø (mm)	0.20	0.22	0.25	0.28	0.33



The selection curve for the individual meshes is bi-modal with cod being either gilled or snagged (Hovgård, 1996a). For cod, as well as the by-catch of other species, the fishing power depends on the twine thickness (Hovgård, 1996b). The effect of the potential change in fishing power, associated with the change in net material, can be evaluated from parameters in Hovgård and Lassen (2000) that updates the selectivity estimates based on an improved version of the selection model (Hovgård *et al.*, 1999). The change in the fishing power appears limited and confined to cod lengths between 20 and 27 cm.

B.4. Commercial CPUE

The CPUE data quality depends very much on the gear used. Gill net catches are usually by-catch. Jigs are only used from smaller boats that are not obligated to fill out logbooks. Finally, poundnet data are not useful in CPUE calculations as nets are left in the water until they are full, and the information from the fishery does not allow for an evaluation of the fishing time.

Hence, commercial CPUE are only available for a limited part of the fishery, and the data obtained are not considered an indicator of stock size and CPUE are not used in the assessment.

B.5. Other relevant data

C. Historical Stock Development

D. Short-Term Projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Procedures used for splitting projected catches:

E. Medium-Term Projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Uncertainty models used:

1. Initial stock size:
2. Natural mortality:
3. Maturity:
4. F and M before spawning:
5. Weight at age in the stock:
6. Weight at age in the catch:
7. Exploitation pattern:
8. Intermediate year assumptions:
9. Stock recruitment model used:

F. Long-Term Projections

Model used:

Software used*:*

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

H. Other Issues

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Stock Annex: Cod in offshore waters of ICES Subarea XIV and NAFO Subarea 1 (Greenland cod)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	**Cod in offshore waters of ICES subarea XIV and NAFO Subarea 1**
Working Group:	**North-Western Working Group**
Date:	**May 2014**
Revised by:	

A. General

A.1. Stock definition

Cod found in Greenland is a mixture of four separate "stocks" that are defined by their spawning areas: I) offshore West Greenland waters; II) West Greenland fiords cod III) offshore East Greenland and offshore Icelandic waters and IV) inshore Icelandic waters (Therkildsen *et al*. 2013).

A minor amount of spawning from the western offshore component is believed to take place. However a substantial part of the offspring from the East Greenland and Icelandic component is assumed to settle along the western coast of Greenland and subsequently start a migration back when reaching the age of 5-6 years. The larval drifts from Iceland are believed to occur irregularly (Buch et al, 1994, Schopka, 1994).

Tagging information show that cod tagged in the fjords are predominately recaptured in the same fiord as tagged or in the adjacent coastal areas (Hansen, 1949, Hovgård and Christensen, 1990, Storr-Paulsen *et al.*, 2004). Tagged bank cod are predominately recaptured on the Banks and to a lesser extent in the coastal areas. As a contrast cod tagged in the coastal areas are found distributed over all the three habitats. Hence, the tagging experiments indicate that the offshore and inshore cod are generally separated but that the coastal area is a mixing zone. A considerable number of tags are returned from Icelandic waters, especially from tagging in the coastal areas in South West Greenland (south of 61 °N) and the banks in East and Southwest Greenland (ICES XIV, NAFO Div. 1EF).

A.2. Fishery

A short historical review

The offshore fishery took off in 1924 when Norwegian fishers discovered dense concentrations of cod on Fylla Bank in NAFO division 1D. The West Greenland offshore fishery rapidly expanded to reach 120 000t in 1931 – a level that remained for a decade (Horsted 2000). During World War II landings decreased by 1/3 as only Greenland and Portugal participated in the fishery. Less is known about the offshore cod fisheries off East Greenland waters, but since 1954 landing statistics have been available. In the next 15 years the East Greenland landings were only contributing between 2-10 % of the total offshore landings. During a period from the mid 1950s to 1960 the total annual landings taken offshore averaged about 270 000t. In 1962 the offshore landings culminated with landings of 440 000t. After this historic high, landings decreased sharply by 90 % to 46 000t in 1974 and even further down to 20 000t in 1980. Annual catch level of

40 000t was only exceeded in the periods 1982-1983 and 1988-1990 due to the occurrence of a few strong year classes. During 1989–92 the fishery, which almost exclusively depended on one YC (1984 YC) shifted from West to East Greenland. The offshore fishery completely collapsed in 1993.

No directed offshore fishery was allowed for the period 1993-2005, except for some minor allocations to Norway and the Faeroe Islands. In this period cod was mainly caught as bycatch in East Greenland at levels around 300t.

The present fishery

Vessels in the offshore fisheries are vessels above 75BT/120BTand restricted to the area more than 3nm off the base line. The vessels require a license that stipulates a unique vessel quota. Trawl is the dominating gear but long lining also occurs especially in recent years long lining is becoming more abundant and constituted almost half of the total catch in 2013.

Since 2005 directed cod fishery was introduced and catches peaked in 2008 with 13 000t primarily taken primarily in SouthWest Greenland (NAFO division 1F), the fishery depended exclusively on one YC (2003 YC). Since 2008 catches declined to around 5 000t. Except the years 2008 and 2009 the majority of the catches have been taken in East Greenland.

In the period 2008-2010 management included closed area in order to protect the spawning stock. More specific the area north of 63°N latitude off East Greenland was closed in 2008 and in 2009 this area was extended to north of 62°N latitude and north of 61°N latitude off West Greenland. In 2010 the non-fishable area included all of the offshore area in West Greenland (west of 44°W) and north of the 62° parallel off East Greenland, which left only a small area in South East Greenland open for directed cod fishery. However a Norwegian longliner was permitted to fish in West Greenland as an experimental fishery in 2010.

A.3. Ecosystem aspects

Some studies indicate that cod recruitment in Greenland waters is significantly influenced by environmental factors like air and sea surface temperatures in the Dohrn Bank region during spawning, in addition with the zonal wind component in the region between Iceland and Greenland during the first summer (Stein and Borokov, 2004). In addition emergence and especially decline of the cod stock in Greenland waters can be linked to sea temperature leaving the stock vulnerable to overfishing in cold periods (Hovgård & Wieland 2008).

B. Data

B.1. Commercial catch

The information on landings in weight are compiled and processed by the Greenland Fisheries License Control (GFLK). The offshore information is available on the haul-by-haul scale provided by logbooks. Sampling of length frequencies and information on age, weights and maturities are collected and compiled by the Greenland Institute of Natural Resources.

Offshore sampling is laborious to acquire as most vessels produce frozen fillets that are commonly landed outside Greenland. However when it is done, it is by GFLK observers or in some cases skippers that organize the length measuring of random samples and/or to freeze individual cod for later analysis at the laboratory.

In 2011, 2012 and 2013 the offshore TAC was set as an experimental fishery which meant that the vessels themselves took length measurement and biological sampling of the catches and coverage of the fishery has therefore been very well.

B.2. Biological

Spawning

The recent offshore fishery has shown dense concentrations of large spawning cod off East Greenland from at least 2004. In 2007 the Greenland Institute of Natural Resources (GINR) carried out an observer program onboard two Greenland trawler in April and May to document spawning in East Greenland. 14 000 cod were measured and 1 000 examined for maturity. The average length was 70 cm. Cod maturity was determined according to Tomkiewicz *et al*. (2002). All maturity stages were recorded (non-mature 27%; maturing 23%; active spawning 36% and spent 14% spent). Length at 50% maturity was 58 cm.

In April-May 2009 an Icelandic survey in East Greenland found dense concentrations of spawning cod north of 62° at the banks between “Skjoldungen” (62°30′) and “Kleine Bank” (64°30′). The major contribution to the spawning biomass was made by the 2003 YC. Length at 50% maturity was approx. 60 cm which was consistent with the results in the 2007 observer program.

B.3. Surveys

At present, two offshore trawl surveys provide the core information relevant for stock assessment purposes.

Trawl survey by Greenland (West Greenland Shrimp and Fish survey)

Since 1988, GINR has conducted an annual stratified random trawl survey at West Greenland. The survey was initially designed as a shrimp survey with the focus to evaluate the biomass and abundance of the Northern shrimp (*Pandalus borealis).* The survey has been continuously developed during the years particularly reflecting the needs of the shrimp assessments, as shrimp was the only important resource in the survey area after the cod stock collapsed. Fish catches in trawl hauls have been recorded since 1992. Since 2005 an increasing number of hauls have been allocated to the southern areas as greater amount of cod have been found there. The numbers of trawl hauls have varied between 187-299 per year. The survey design, in respect to area coverage, trawl type and its rigging has been unchanged since 2005, i.e. coinciding with the period where significant cod year-classes have been seen. The years prior to 2005 experienced a number of survey development that are detailed below.

<u>Survey area and stratification</u>: The trawl survey covered initially the traditional offshore shrimp area, between 60º - 72º North, depth 150-600m. In 1991 the area was extended to include the Disco Bay. The area is delimited by a line 3nm off the base line and the 600 m depth curve. The areas shallower than 150 m was initially rather unsystematically covered, but from 2004 two extra depth zones have been formally included (50-100m and 100-150m). The stratification is based on designated ‘Shrimp Areas’ that is divided into depth zones of: 151-200, 201-300, 301-400 and 401-600m, as based on

depth contour lines. The depth zones 0-100m and 100-150m are delimited by the NAFO Subdivision boundaries. The "shrimp Areas" are shown in fig. 3.2.1 and their sizes are provided in table 1.

Trawl stations in West Greenland are allocated to strata with the objective to minimise the variances of the shrimp biomass, Atlantic cod abundance and Greeland halibut biomass. The allocation algorithm utilises the historically observed variances for the three species where highest weight is placed on the most recent information. The allocation procedure is set to minimise a weighted combination of the expected survey precision for the three species. Stations positions were initially selected at random but since 1999 station positions were chosen to secure a minimum distance between stations. Since 1998 about half of the haul positions were randomly selected from the previous year hauls; the rest of the hauls being selected at random.

Cod, as well as other ground fish species that has been assessed by NAFO, was up to 2007 analysed using a stratification that followed the NAFO divisions. Restratification implies a bias and the survey information from 2005 and onwards has therefore been reanalysed in accordance with the shrimp strata used in the survey. A recalculation of the entire time series back to 1992 is possible but complicated by a change in the data base system. Given that the 1992-2004 period is characterized by an almost lack of cod in the West Greenland offshore area such a reanalysis is given a low priority.

The East Greenland area was for the first time properly covered in 2008. The area was intended covered in 2007, but due to a vessel breakdown only 8 days were available, allowing only for a short pilot investigation.

The survey is carried out with the same gear and survey protocols as used in West Greenland. Stratification is based on the "Q-areas" used for the East Greenland survey for Greenland halibut. The areas are further depth stratified into 0-200m, 200-400m and 400-600m zones, the areas are shown in fig. 3.2.1. and the sizes are given in table 3.2.1.

The major difference between West and East Greenland is the bottom conditions that severely restrict the areas that can be trawled off East Greenland. Stations were randomly selected from historical known trawlable sites, however, a number of the selected positions were not deemed trawlable.

<u>The survey trawl and its operation</u>: The initially used trawl was a 3000/20-mesh "Skjervøy" trouser trawl, but was from 2005 replaced by a "Cosmos" trouser trawl. Calibration experiments with the two trawls were conducted in the main shrimp areas in 2004 and 2005 and a formal analysis of conversion factors were established for shrimp (Rosing and Wieland, 2005). The catch of cod in the calibration experiments was low. However a comparison of the catch efficiency towards cod indicates that the Cosmos trawl is ca. 1.5 times as efficient as the Skjervøy (Rosing and Wieland 2005, ICES 2008). Tow duration has over the years been gradually reduced from 60 min to 30 and is from 2005 fixed at 15 min. Survey abundance and biomass is expressed per swept area: Wingspread*towed distance, where wingspread is inferred from Scanmar recordings and the towed distance is measured by GPS.

Table 3.2.1: The survey area (km²) in the Greenland shrimp and fish survey.

West Greenland							
	Depthstrata						
Area	<100	100-150	150-200	200-300	300-400	400-600	Total
W1	-	-	2885	6138	7343	921	17287
W2	-	-	1581	2468	1512	805	6366
W3	-	-	2216	4653	2188	2883	11940
W4	-	-	4006	1781	886	2027	8700
W5	-	-	2424	3584	2180	2865	11053
W6	-	-	1252	1916	1707	1206	6081
W7	-	-	1977	880	244	220	3321
W8	-	-	357	516	476	636	1985
W9	-	-	2003	991	740	477	4211
C0	-	-	-	895	2202	1210	4307
I1	-	-	321	1818	2325	1407	5871
I2	-	-	330	728	1000	1294	3352
U1	-	-	2431	4587	4687	5061	16766
U2	-	-		6334	8360	7983	22677
U3	-	-	1975	3332	1704	2737	9748
1A	3039	5220	-	-	-	-	8259
1B	11346	4966	-	-	-	-	16312
1C	4183	8169	-	-	-	-	12351
1D	4136	1538	-	-	-	-	5673
1E	494	2721	-	-	-	-	3215
1F	1497	5248	-	-	-	-	6745
All strata							186221

East Greenland				
Area	0001-0200	0201-0400	0401-0600	Total
Q1	217	35445	6975	42637
Q2	93	7657	1246	8996
Q3	3363	22547	9830	35740
Q4	1337	7770	2054	11161
Q5	469	2785	1819	5073
Q6	6307	6130	2063	14500
All strata				118107

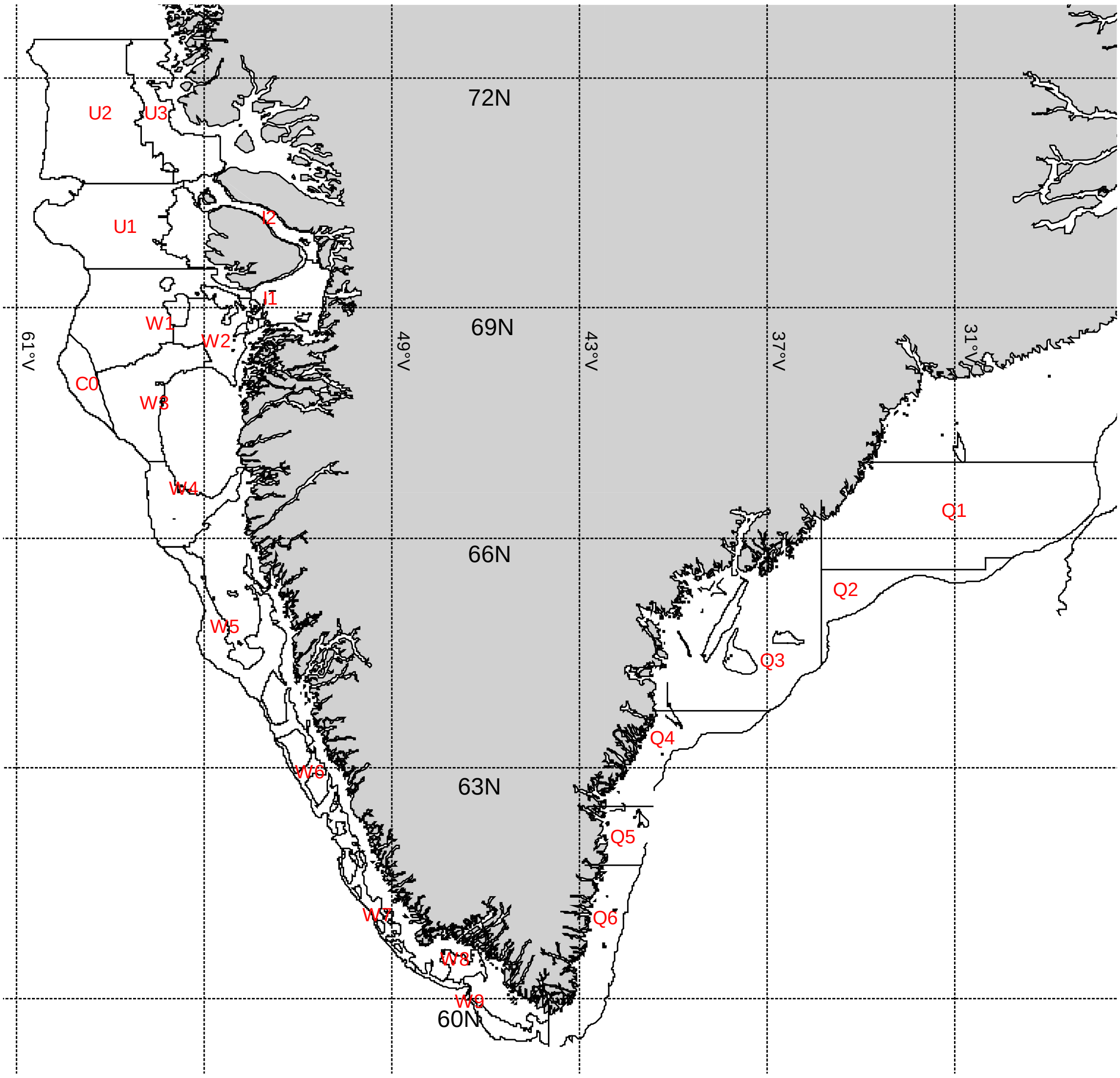


Figure 3.2.1: The stratification areas used in the Greenland shrimp and fish survey. In West Greenland each strata is divided in depth strata of 150-200m, 200-300m, 300-400m and 400-600m. "Shallow" water strata of 0-100m and 100-150m are delimited by the 3 nm line and the NAFO Divisions (not shown). In East Greenland each strata is divided in depth strata of 200-400m and 400-600m. "Shallow" water strata of 0-200m is delimited by the 3 nm line (not shown).

German Greenland groundfish survey

The survey commenced in 1982 and was designed for the assessment of cod. Up to 2012, the surveyed area ranged from 0-400m depth divided into 7 geographical strata and two depth zones, 0-200m and 200-400m (Table 3.3.1.). Numbers of hauls were initially ca. 200 per year but were reduced from the early 1990s to 80-100 per year.

In 2013, the survey was re-stratified, with 4 strata in West Greenland resembling NAFO division structure, and 5 strata in East Greenland for the depth intervals 0-200m and 200-400m (Table 3.3.1.). Biomass indices for the time series was accordingly recalculated. For further information about the restratification see WD 25, ICES NWWG 2013.

The surveys were carried out by the research vessel (R/V) WALTHER HERWIG II 1982-1993 (except in 1984 were R/V ANTON DOHRN was used) and since 1994 by R/V WALTHER HERWIG III. The fishing gear used was a standardized 140-feet wide bottom trawl, composed of a net frame rigged with heavy ground gear due to the rough nature of the fishing grounds. A small mesh liner (10mm) was used inside the cod end.

The horizontal distance between wing-ends was 25m and the vertical net opening being 4m at 300m depth.. In 1994 smaller Polyvalent doors (4.5m², 1 500kg) were used for the first time in order to reduce net damages due to overspread caused by bigger doors (6m², 1 700kg), which have been used earlier.

Up to 2008 strata with less than 5 hauls were excluded in the annual stock calculations. From 2009 all valid hauls have been included and biomass indices for the entire time series have been corrected. For strata with less than 5 haul samples, GLM and quasi-likelihood estimates have been recalculated based on year and stratum effects from the time series. In some years (notable 1992 and 1994) several strata were uncovered, implying that the survey estimate implicitly refers to varying geographical areas.

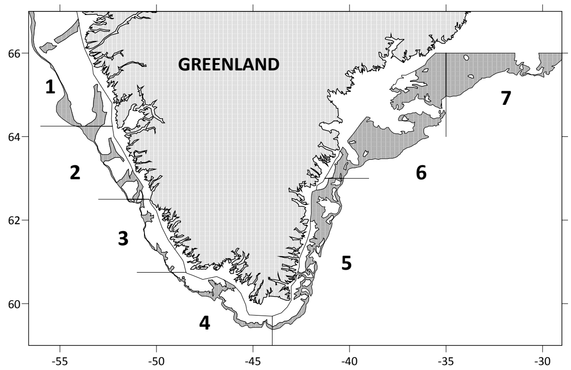
Table 3.3.1: The survey area (nm²) in the German groundfish survey in Greenland. Old stratification.

	Depthstrata (m)	Area (nm2)
1.1	1-200	6805
1.2	201-400	1881
2.1	1-200	2350
2.2	201-400	1018
3.1	1-200	1938
3.2	201-400	742
4.1	1-200	2568
4.2	201-400	971
5.1	1-200	2468
5.2	201-400	3126
6.1	1-200	1120
6.2	201-400	7795
7.1	1-200	92
7.2	201-400	4589
Total		37463

Table 3.3.2: New stratification in the German groundfish survey in the Greenland survey area (nm²). In West GLD stratification equals NAFO stratification, in East GLD based on assignment to ICES rectangles, therefore geographic boundaries given as ca-values.

Stratum boundaries					depth	area
	south	north	east	west	(m)	(nm²)
1.1	64°15'N	67°00'N	50°00'W	57°00'W	1-200	6805
1.2	64°15'N	67°00'N	50°00'W	57°00'W	201-400	1881
2.1	62°30'N	64°15'N	50°00'W	55°00'W	1-200	2350
2.2	62°30'N	64°15'N	50°00'W	55°00'W	201-400	1018
3.1	60°45'N	62°30'N	48°00'W	53°00'W	1-200	1938
3.2	60°45'N	62°30'N	48°00'W	53°00'W	201-400	742

4.1	59°00'N	60°45'N	44°00'W	50°00'W	1-200	2568
4.2	59°00'N	60°45'N	44°00'W	50°00'W	201-400	971
5&6.1	59°00'N	ca 63°50'N	40°00'W	44°00'W	1-200	1562
5&6.2	59°00'N	ca 63°50'N	40°00'W	44°00'W	201-400	2691
7.1	ca 63°50'N	66°00'N	ca 33°00'W	41°00'W	1-200	298
7.2	ca 63°50'N	66°00'N	ca 33°00'W	41°00'W	201-400	2919
8.1	ca 63°50'N	66°00'N	ca 33°00'W	41°00'W	1-200	49
8.2	ca 63°50'N	66°00'N	ca 33°00'W	41°00'W	201-400	3895
9.1	64°45'N	67°00'N	29°00'W	33°00'W	1-200	0
9.2	64°45'N	67°00'N	29°00'W	33°00'W	201-400	1946
Sum						31607



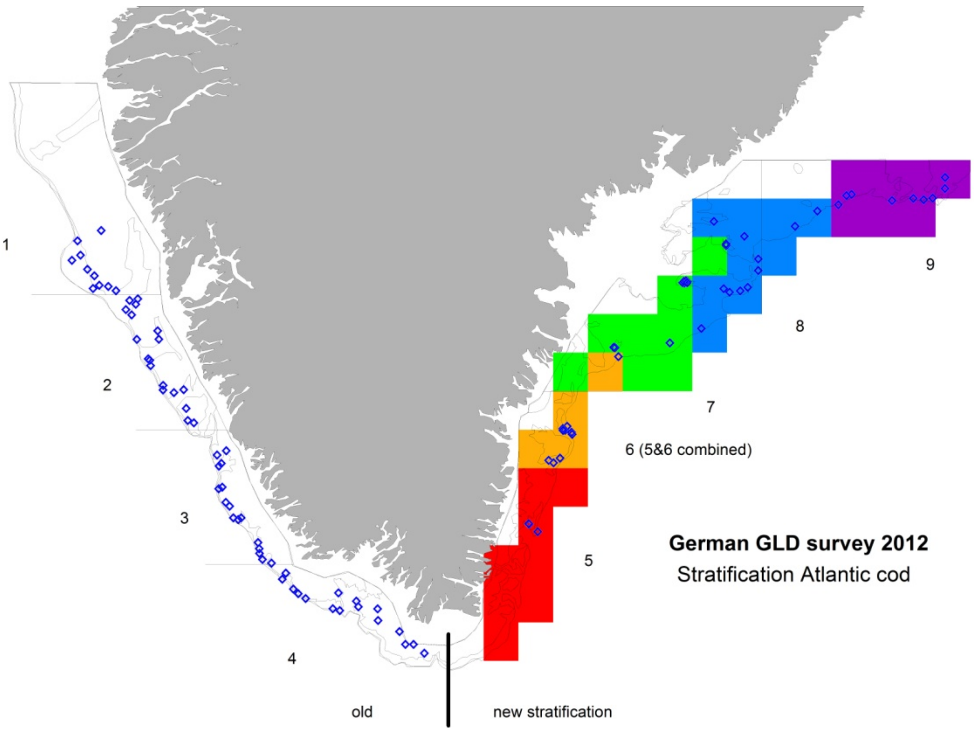


Figure 3.3.1: The Stratification areas used in the German Greenland groundfish survey. Each stratum is divided into two depth zones, 0-200m and 201-400 m. Top: until 2012, bottom: after 2012.

B.4. Commercial CPUE

Commercial CPUE data are available. However, due to the limited fisheries in recent years they are of little use for stock assessment.

B.5. Other relevant data

C. Historical Stock Development

D. Short-Term Projection

Model used:

Software used*:*

Initial stock size:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Procedures used for splitting projected catches:

E. Medium-Term Projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Uncertainty models used:

10. Initial stock size:
11. Natural mortality:
12. Maturity:
13. F and M before spawning:
14. Weight at age in the stock:
15. Weight at age in the catch:
16. Exploitation pattern:
17. Intermediate year assumptions:
18. Stock recruitment model used:

F. Long-Term Projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

Not available for this stock

H. Other Issues

I. References

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STOCK ANNEX: Icelandic summer-spawning herring

Stock specific documentation of standard assessment procedures used by ICES.

Stock	**Icelandic summer-spawning herring (Her-Va)**
Working Group:	**NWWG**
Date:	**31.01.2011 -at WKBENCH (revised 1st May 2014 at NWWG)**
Revised by	**Guðmundur J. Óskarsson and Ásta Guðmundsdóttir**

A. General

A.1. Stock definition

The Icelandic summer-spawning herring is constrained to Icelandic waters throughout its lifespan. Results from various researches including, tagging experiments around middle of last century, studies on larval transport, and studies on migration pattern and distribution, all suggest that the stock is local to Icelandic waters. Until 2010, no specific genetic studies have taken place to distinct the stock from the two other herring stocks around Iceland (Icelandic spring-spawning herring and Norwegian spring-spawning herring). However, a project (HERMIX) with that as one of the objectives started in 2009 and is ongoing in cooperation with several institutes in Iceland, Faroe Island, Denmark, and Norway (Libungan et al. 2012). These three stocks are distinguished on the basis of their spawning time and spawning area, as presented by their names. In practice, the maturity stage of catch samples is used to distinguish Her-Va from the other stocks in a mixed fishery.

A.2. Fishery

Since at least the year 2000, the herring fishery has been conducted by big vessels that in most cases have onboard both purse seines and mid-water-trawls that are used as needed in the fishery. Usually, most of the catch is taken by purse seine (ICES 2008). Bycatch in the herring fishery is normally insignificant as the fishing season is during the over-wintering period when the herring is in large dense schools. However, in the summers 2010-2011 some herring from the stock has been caught as bycatch in the mackerel fishery off the east-, southeast-, south- and west coast of Iceland in pelagic trawls. That has amounted to around 6 thousands tons annually.

A2.1. Prior to 1980

The catches of Icelandic summer-spawning herring increased rapidly in the early 1960s due to the development of the purse seine fishery off the south coast of Iceland. This resulted in a rapidly increasing exploitation rate until the stock collapsed in the late 1960s. A fishing ban was enforced during 1972–1975. The annual catches have since increased gradually to over 100 000 t.

A2.2. 1980 onwards

Until the autumn 1990, the herring fishery took place during the last three months of the calendar year. During 1990-2008 the autumn fishery continued until January or early February of the following year, and has started in September/October since 1994. In 2003 the season was further extended to the end of April and in the summers of 2002 and 2003 an experimental fishery for spawning herring with a catch of about 5 000 t each year was conducted at the south coast.

In the beginning of this period, the fleet consisted of multi-purpose vessels, mostly under 300 GRT, operating with purse-seines and driftnets. In recent 20 years, larger vessels (up to 1500 GRT) have been gradually taking over the fishery, and today they represent the whole herring fishing fleet. Consequently, the number of vessels participating in the fishery has shown decreasing trend in the 2000s from around 30 down to 15 in 2010. Simultaneously, the average size of the vessels has increased. These vessels are combination of purse-seiners and pelagic trawlers operating in the herring (Her-Va and Norwegian spring-spawners), capelin (*Mallotus villosus*), blue whiting (*Micromesistius poutassou*) fisheries, and in recent years also the NE-Atlantic mackerel (*Scombrus scombrus*) and Mueller's pearlside (*Maurolicus muelleri*) fisheries.

Since the 1997/1998 fishing season to around 2007/08, there was a fishery for Her-Va both west and east off Iceland, with gradual increase off the west coast. This west coast fishery of the stock had until then hardly taken place since the middle of the 1960s (Jakobsson 1980; Óskarsson et al. 2009a). In the most recent years (2006 to 2012), most of the catches have been taken in a small area off the west coast in the southern part of the bay Breiðafjörður (Fig. 1; e.g. ICES, 2008; 2009; 2012). As a consequence, it is nearly exclusive purse seine fisheries, while the pelagic trawl fisheries, first introduced in 1997/98, contributed earlier to around 20–60% of the catches for several years.

A2.3. Fishery regulations

The fishery of the summer-spawning herring is currently regulated by regulations set by the Icelandic Ministry of Fisheries in 2006 (no. 770, 8. September 2006). According to it, fishery of juveniles herring (27 cm and smaller) is prohibited and to prevent such a fishery, area closures are enforced.

The fishery can take place from 1st September to 31st May each fishing season (1st September-31st August) in nets, purse seines and mid-water trawls. The mid-water trawling is only allowed outside of the 12 nautical miles zones with some additional areal restrictions. Use of sorting grids in the mid-water trawls can be required in some areas, if necessary to avoid bycatch.

If nets are used in the herring fishery, the minimum mesh size (stretched) is 63 mm.

The annual total allowable catch is decided by the Ministry of Fisheries. Since 1985, the decision has more or less been based on the advices given by the Marine Research Institute, with very small discrepancy (ICES 2010).

A.3. Ecosystem aspects

A3.1. Geographic location and timing of spawning

The spawning of the stock takes place in July off the SE, S and SW coast (Jakobsson and Stefansson, 1999) with the maximum activity around middle of July (Óskarsson and Taggart 2009). The nursery grounds are mainly in coastal areas off the NW and N coast, but occasionally also in coastal areas off the E, SE, and SW and W Iceland (Gudmundsdottir *et al.* 2007). The location of the overwintering of the mature and fishable stock has varied during the last 30 years (Óskarsson *et al.* 2009a). Prior to 1998 it was mainly off the SE and E Iceland but from 1998 to 2006, the overwintering took place both off the east and west coast, with increasing proportion being in the western part. Since then (winters 2006/07 to 2011/12), most of the stock has been located in high density in coastal waters in northern part of Breidafjördur in western Iceland.

A3.2. Diet

The variation in the diet composition of the Icelandic summer-spawning herring has been studied recently in comparison to diet of Northeastt Atlantic mackerel and Norwegian spring spawning herring (Óskarsson et al. 2012). is poorly known due to limited examinations. Stomach samples showed that the diet of the Icelandic summer-spawning herring consisted mostly of crustacea (86 to 100%) where copepoda, euphausiacea or hyperiidae weighed most of the identified prey groups. Euphausiacea was generally in more mass than copepoda. The only identified fish prey species in herring was capelin and sandeel (*Ammodytes* sp.). An older research made by MRI on stomach contents of herring in a relatively restricted area SW off Iceland in 2008 showed in addition that fish eggs and larvae could be a significant part of the diet (Óskarsson et al. 2008).

A3.3. Predators

Adult herring is food resource for various animals in Icelandic waters according to various researches. The animals include mink whale (*Balaenoptera acutorostrata*), humpback whale (*Megaptera novaeangliae*), several sea bird species, cod (*Gadus morhua*) and pollack (*Pollachius virens*), but the annual consumption of herring by the different predators is relatively unknown. An increased predation of herring by cod has been observed in stomach analyses in the Icelandic groundfish survey since the *Ichthyophonus* outbreak started in the herring stock in November 2008, even if it has not been quantified.

A3.4. Diseases and parasites

In November 2008, the Marine Research Institute in Iceland got the information from the commercial fleet fishing on Her-Va that the stock was seemingly infected by some parasite or had some disease. Within few days it was identified as a major outbreak of the protista parasite *Ichthyophonus hoferi*. A thorough examination of the fishable stock during the winter 2008/09 indicated that 32% of the stock was infected (Oskarsson et al. 2009; Oskarsson and Pálsson 2009) and 43% during the winter 2009/10 (Óskarsson et al. 2010). During the period from 1991 to 2000, the prevalence of *Ichthyophonus* infection in the stock was determined inter-annually but only a minor infection was observed during that period, or in around 1 per every 1000 individuals examined. The source of the infection outbreak is unknown (Oskarsson and Pálsson 2009) but the infection is transmitted with resting spores of the parasite that must be eaten in one way or another by the herring since they need an acid environment to be activated (Spanggard et al. 1995). Since the stock is not feeding during the overwintering period, the stock get the infection on the feeding grounds, which is also supported by the development of the infection in the stock as seen from an extensive sampling of the stock throughout the winters (Óskarsson et al. 2009; 2010). In the winter 2010/2011 the infection rate was still high (Óskarsson and Pálsson 20112011/2012, and the same applied for the winter 2011/2012 (Óskarsson et al. 2012) and 2012/2013 in the older part of the stock but significantly less in age 5 and hardly any in age 4 and below (Óskarsson and Pálsson 2013).

In juvenile herring the prevalence of infection was also high in most of the distribution area during the first two winters and the infection reached over a very extensive area, or all coastal areas around Iceland except for the east coast. Until in the assessment in 2013, the assumption was applied that all infected herring would die because of it within few months and maximum 12 months from getting infected on the feeding grounds. This assumption was used as this infection was believed to be fatal to all infected herring (Sinderman 1958).

A thorough exploration in 2013 of all available data since the infection started in 2008 led to changes on perception of infection mortality in the stock (Óskarsson and Pálsson 2013). The main conclusion was that the infection was only causing significant additional mortality in the first two years, despite a high prevalence of infection for five years. It means that the infection was considered to be less lethal for herring than had been assumed previously. This was based on several observations: (1) Development in the infection in both the first two winters was apparent where the infection was progressing from light to extreme infection, while no development was apparent the years after; (2) New infection was apparently occurring in the autumns 2008, 2009, and 2010 while not in the autumns thereafter where young age groups (< age 4) were almost without infection in all areas; (3) The proportion of the different year classes with light infection remained relatively constant since the autumn 2010; (4) Despite strong indications of no or insignificant new infection in the stock since the autumn 2010, the prevalence of the infection remained high, which strongly suggested a little or insignificant mortality in the stock because of the infection since 2010; (5) Constant prevalence of infection with no changes in the infection staging throughout the winter and spring 2012.

A3.5. Recruitment variation of the stock

The recruitment variation of the stock has been examined in two papers, first by Jakobsson et al. (1993)_and then more thoroughly by Óskarsson and Taggart (2010). The main conclusions from Jakobsson et al. (1993) by analysing the period from 1947 to 1991 was that the stock-recruitment relationship was most adequately fitted with a Cushing model and the recruitment increased strictly with increasing stock size with no signs of decreased recruitment at high stock level (i.e. a dome-shaped relation). Furthermore, environmental changes, and particularly the sea temperature affects the recruitment even if it was noted that two of the four largest year classes were produced in periods considered to be warm and two in periods considered to be cold.

Óskarsson and Taggart (2010) examined the recruitment variation of the stock during 1963-1999 with generalized linear models (GLM) with special focus on the impact of the maternal effects as well as various ecological and environmental factors. The best model explained 64% of the variation in the recruitment of the stock and incorporates total egg production constrained to the repeat spawners (40%), the NAO winter-index (18%), and ocean temperature (6%). The latter two represent the winter and spring period subsequent to year-class formation. Contribution of recruit spawners to the total egg production were of no significance in explaining variation in the recruitment despite the fact that they could contribute to as much as 55% of the egg production. The spawning potential of the repeat spawners was suggested to replace total SSB when determining recruitment potential in the stock assessment, which in addition to the incorporation of oceanographic factors, was considered to provide a more precautionary and risk-adverse approach. The ocean temperature off northern Iceland (Siglunes) was found to have a marginal effect on the recruitment of the stock; consistent with the results of Jakobsson et al. (1993) where average recruitment was reduced during the relatively cold period of 1965 through 1971. The primary nursery grounds for the stock are off northern Iceland (Fig. 1), though larvae and juveniles are also found elsewhere (Gudmundsdottir et al., 2007). They concluded that oceanographic variability, as reflected in the positive effects of lagged winter NAO index and ocean temperature indices, influences recruitment through the survival of larvae during their first winter–

spring. The conclusion is substantiated by the positive relation between age-3 recruitment and larval and post-larval abundance indices at age-1 and -2 in the ISS stock that indicate that the year class strength is determined during the first year of larval development (Gudmundsdottir *et al.,* 2007).

Similar to Jakobsson et al. (1993), Óskarsson and Taggart (2010) observed that the recruitment of the stock increased continuously with increases in total egg production of repeat spawners and there is no indication of density-dependence even as SSB and the egg production increased above historical estimates. In the end they conclude that it is more appropriate to use size structured estimates of fecundity as well a spawning experience (e.g. egg production of repeat spawners) in place of simply total egg production and SSB, especially, from a management perspective, at low SSB and when the size structure is truncated, and to do so prior to assessing potential oceanographic influences. Doing so should result in more accurate short-term predictions of the recruitment. Their best generalized linear model (GLM) explained 64% of the variation in the recruitment variation during 1963 to 1998 and incorporated total egg production constrained to the repeat spawners (40%), the North-Atlantic Oscillation (NAO) winter-index (18%), and ocean temperature (6%).

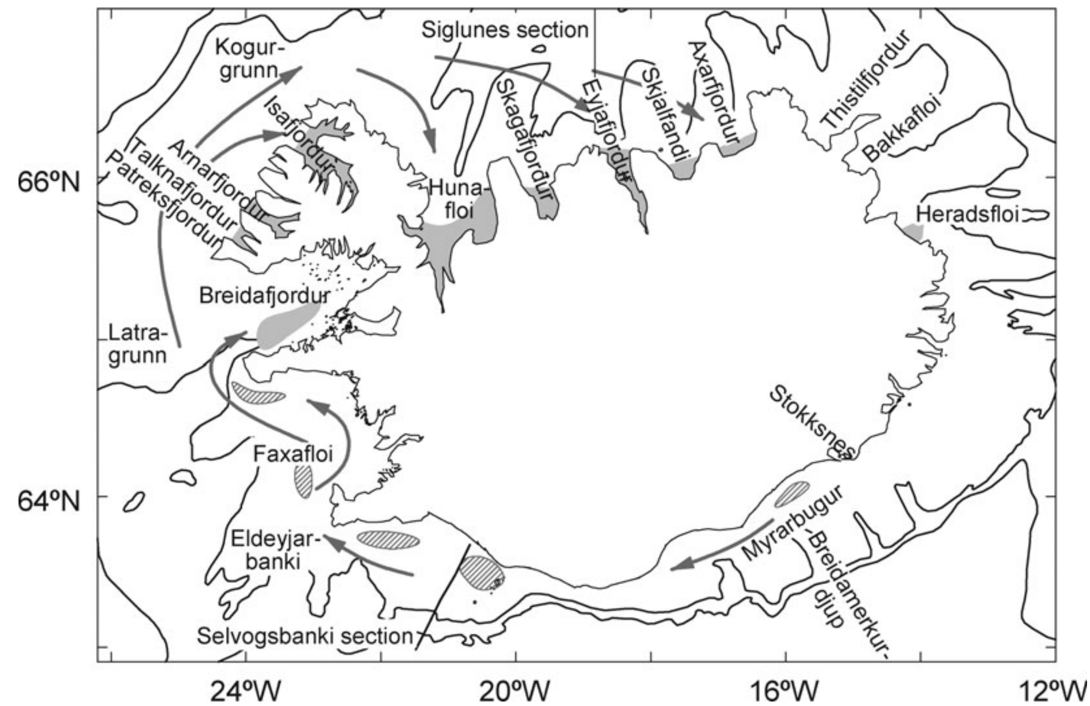

Figure 1. The names of some fjords and banks around Iceland referred to in the text. Grey shading indicates the nursery areas, and stripes the spawning areas, and the arrows show the directions of larval drift (adopted from Gudmundsdottir et al. 2007).

B. Data

B.1. Commercial catch

B1.1. Landings

Information about landings of the fishery fleet is collected by the Icelandic Directorate of Fisheries. They have access to both landings in the harbours (the official landing) and the registered catch in the digital logbook kept by all the vessels. The logbooks keep information about timing (day and time), location (latitude and longitude), fishing gear, catch size, and species composition in the catch of each fishing operation for each vessel.

Biological samples from the catch are taken at sea by the fishermen or in the harbours by people from MRI and/or inspectors from the Directorate of Fisheries and then analysed by MRI (record at least the fish length, weight, age (from scales), sex, maturation, and weight of sexual organs). The information from the samples is then used along with the total landing data and the logbook data to estimate the composition of the total landings. It includes estimating **Caton** (catch-in-weight), **Canum** (catch-at-age-in numbers), **Weca** (weight-at-age-in-the-catch), and length composition in the catch.

The annual estimations of the composition of the total landings (e.g. the catch at age matrix) are based on dividing the annual landings into cells according to the fishing gear, geographical location and month of fishing. The number of cells used in the calculation each year depends on number of factors, including the spatial and temporal distribution of the fishery, the fishing gear used and intensity of biological sampling, and has ranged from 3 to 10 during the years 2004 to 2010. The number of weight-at-length relationships and length-at-age relationships applied differs between years and is in the range of 1-2 in both cases. Since 1990 to present, all available length measurements are used for the estimations in the cells, while length of aged fish was only used in earlier estimations. Length measurements done by inspectors of the Directorate of Fisheries are though usually omitted as inspectors tend to focus on catches that are suspected to consist of small herring and give therefore often biased length distributions.

A planed re-aging of herring from the catch samples in the fishing seasons 1994/95 through 1997/98 was not finished in February 2010 and because of limited manpower at the Marine Research Institute it will be postponed further. When the re-aging is accomplished the number at age in the catch will be re-estimated. Previous work suggests though that only small changes can be expected.

B1.2. Discards

Discards are illegal in Icelandic waters. Normally, discards are considered to be insignificant in the fishery of Icelandic summer-spawning herring. There are few exceptions in the past 35 years where discards were estimated to be significant (1990-95; ICES 2008). These exceptions are related to large year classes being entering the fishery and juveniles have been numerous in the catch. Surveillance by inspectors from the Directorate of Fisheries during each fishing season is considered adequate in verifying if a discard is ongoing.

B.2. Biological

B.2.1. Weight at age of the stock

The weight at age in the stock is estimated from the commercial catch samples combined over the whole fishing area. Since the fishery takes place in the autumns and the winters (around September through January), the weight at age represents that period.

B.2.2. Natural mortality, M

Natural mortality is assumed to be constant, M=0.1, for the whole range of ages and years. There are no direct estimates of M but the estimate of M=0.1 has been evaluated numerically by Jakobsson *et al.* (1993). They concluded, through comparison of acoustics- and VPA based stock size estimations that the assessed level of M ranged from 0.1 to 0.15. Because of the *Ichthyophonus* infection in the stock, a higher M has been set for the years 2008-2011 (see Table B.2.2.1, year referring to autumns; Óskarsson and Pálsson 2011, Óskarsson et al. 2012). It has been considered appropriate to add $M_{infection}$ to the fixed natural mortality of the stock, M=0.1, so that M used in the assessment is consistent with the observed infection levels. For sensitivity, alternative values for M will be conducted and include scenarios where we assume the infection rate becomes unimportant (say in about five years) and M returns to the base rates for projection purposes. For future assessments, the prevalence of infection will need to be monitored.

Table B.2.2.1. The estimated natural mortality caused by *Ichthyophonus* infection ($M_{infected}$) in Icelandic summer-spawning herring in the winter 2008/09 to 2011/12 (years referring to the autumns) for age groups 3 to 13+.

Age (years)	Minfected 2008	Minfected 2009	Minfected 2010	Minfected 2011
3	0.39	0.64	0.10	0.02
4	0.39	0.64	0.53	0.20
5	0.39	0.59	0.52	0.48
6	0.39	0.53	0.50	0.41
7	0.39	0.5	0.44	0.37
8	0.39	0.48	0.46	0.35
9	0.39	0.47	0.49	0.30
10	0.39	0.46	0.46	0.25
11	0.39	0.44	0.34	0.26
12	0.39	0.43	0.35	0.23
13+	0.39	0.44	0.35	0.10

B.2.3. Age at maturity

The age at maturity of the Icelandic summer-spawning stock was until 2006 estimated annually from the commercial catches alone (ICES 2008). Such estimates are a subject to various source of errors including that the year classes that are becoming mature might have spatial distribution that is linked to if they are mature or not. For example, mature individuals of a given year class would be more likely to join the older fully mature age groups than the immature individuals. It indicates also that the estimate of age at maturity from the catch samples can be incorrect because the most important age groups are poorly representative in the commercial catches. That was the main reason for the decision taken in 2006 that the maturity-at-age from 2006 and onwards was assumed to be constant (Óskarsson and Guðmundsdóttir 2006), which was based on analyses of catch and survey data and is as follows:

Age	<3	3	4	5+
Proportion mature	0.00	0.20	0.85	1.00

Analyses and comparison of estimates from commercial catch data, survey data and estimates based on fish scale growth layers indicate, however, that the maturity ogive of the non-fishable part of each age class in the stock is equivalent to the fishable part for the years 1962 to 2002 (Óskarsson and Guðmundsdóttir 2011). It gives support to the age at maturity values used in the assessment of the stock until 2006, originating from the traditional method in estimating the age at maturity from simply commercial catch samples. However, since the spatial distribution of the stock is completely different in recent years, where most of the fishable stock is overwintering in a small area off the west coast (Óskarsson et al. 2009a), compared to the period which the analyses cover, using the commercial catch samples to estimate the age at maturity cannot be recommended for the most recent years. Thus, to get reliable estimates of age at maturity that is independent of the stock distribution, Óskarsson and Guðmundsdóttir (2011) recommend a re-establishment of determination of age of first spawning from the fish scales growth layer, which took place during the period 1964 to 1992. Until then and following analyses of those data, the maturity ogive of the stock in the assessment should be fixed as shown in the table above.

B.2.4. Ageing of the stock

The age of the stock is determined from the fish scales and the number of annual winter-rings +1 gives the age in years

B.2.5. Fecundity of the stock

The fecundity variation of the Icelandic summer-spawning herring has been estimated in two papers, by Jakobsson et al. (1969) and later more thoroughly by Óskarsson and Taggart (2006). The latter paper indicates that the fecundity at length relation to be: Fecundity [$\times 10^3$] = 15.9 × Length [cm] - 382.2. It indicates that herring at average length in the catch (32 cm) spawns around 127 thousands eggs in a season and release all the eggs at once. Furthermore, Fulton's condition factor K (=100×Weight×Length^{-3}) explains a trivial (1.5%) but significant amount of the residual variation in potential fecundity of the stock, and appears to have the greatest effect among smaller length classes.

B.3. Surveys

A. Autumn/winter survey (IS-Her-Aco-Q4/Q1)

Currently, one survey is available and applied as a tuning series for the analytical assessment of the Icelandic summer-spawning herring stock. It is an acoustic research survey, which has been ongoing annually since 1974 except for the winters 1976/77, 1982/83, 1986/87, and 1994/95. These surveys have been conducted in October-December and/or January. The survey area varies spatially as the survey is focused on the adult and incoming year classes. The surveyed area is decided on the basis of all available information on the distribution of the stock in previous and the current year, which include information from the fishery. Thus, the survey area varies spatially as the survey is focused on the adult and incoming year classes. As normally practiced in acoustic surveys, trawl samples are used to get information about the schools species-and length composition. Detailed information and the results of the surveys are given inter-annually in internal reports at MRI, and later summarized in the assessment reports.

B. Spawning survey (IS-Her-Aco-Q3)

In the summer 2009 and 2010, acoustic surveys were conducted on the spawning grounds of the Icelandic summer-spawning herring. The surveys, which took place in a ten day period in the beginning of July, just before the maximum of the spawning activity, around the middle of July (Óskarsson and Taggart 2009), covered all the known spawning grounds of the stock. The main purpose of these surveys was to get estimates of the prevalence of *Ichtyhophonus* infection in the stock, but also to get acoustic abundance estimates of the stock. The working group involved in the assessment of the stock considers that the results of this acoustic survey can be used as a tuning series within an analytical assessment when and if the time series becomes sufficiently long. The main advantage of this survey above the traditional autumn/winter survey (above) is that its spatial and temporal coverage is consistent and fixed between years. Thus, hopefully this survey will continue for some years, so the quality and reliability can be verified including how well it is following the stock trend according to the assessment and the autumn/winter survey.

C. Juvenile survey (IS-Her-Aco-Juv-Q4/Q1)

In addition to the acoustic survey aimed at the fishable part of the stock, there have been occasionally acoustic surveys off the NW, N, and NE coast of Iceland aimed to estimate the year class strength of the juveniles. This survey was undertaken in November to December in most years during 1980 to 2003, but had not taken place since 2003, until it was resurrected in January 2009. It was again undertaken in the autumns 2009 and 2010. The results of these measurements have normally not been used in the assessment or stock projection directly, even if the year class indices at age-1 herring derived from the survey showed a significant relationship to recruitment of the stock at age 3 (Gudmundsdóttir *et al.* 2007). Because of this relationship, and to utilize the information from this survey, the survey abundance index of age 1 herring will be used to predict the number at age 3 for the stock in the short-term projections from the assessment 2011 and on, given that survey information are available.

B.4. Commercial CPUE

The commercial CPUE data is not considered relevant to the assessment because of the nature of the fishery and due to the continuous development of the vessels and the equipment used in the fishery.

B.5. Other relevant data

None

C. Assessment: data and method

<u>Model:</u> Age structured

<u>Software:</u> NFT-ADAPT (VPA/ADAPT version 3.0.3 NOAA Fisheries Toolbox)

Alternatives evaluated and available for future comparisons include a new version of TSA (older version see Gudmundsson 1994). Also, a statistical catch-at-age was presented (Coleraine) and it was consistent with other models and may be useful for presenting and comparing uncertainty estimates in the future.

The NFT-ADAPT has been used for point estimate and final assessment of the stock since 2005 to 2010.

Model Options: The model options differ slightly between years, but are given in tables or text in the WG assessment reports (e.g. ICES 2008).

The youngest age groups in the assessment runs from catchdata is age 3 and oldest age 13+.

The data used from the tuning series (IS-Her-Aco-Q4/Q1) are age groups 4-11.

Years used are 1987 onwards.

The IMSL parameters used are the defaults except the following three:

Scaled gradient tolerance of 6.055454E-05

Scaled step tolerance of 1.0E-18

Relative function tolerance of 1.0E-18

Survey weighting factors were 1.0 for each age except:

In 1989 weighting factors used as 0.01 for 8 years and older

In 1990 and 1991 weighting factors used as 0.01 for 9 years and older

In 1992 weighting factors used as 0.01 for 10 years and older

In 1993 weighting factor used as 0.01 for age 11 year

In 2004 weighting factor used as 0.01 for age 10 year and older

In 2005 and 2007 weighting factor used as 0.01 for age 11

Earliest age in Terminal Year+1: Geometric mean over 1987-2006

Calculation Method Full-F in Terminal Year: Classic Method

F at oldest age in Terminal Year: Use F at oldest true age calculation method

F at oldest true age calculation method: Use arithmetic average

F oldest age calculation method: Use ages 8-11

Plus group calculation: Forward

F-plus group ration: 1 for all years.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1947-last data year	2-15+	Yes
Canum	Catch at age in numbers	1947-last data year	2-15+	Yes
Weca	Weight at age in the commercial catch	1947-last data year	2-15+	Yes
West	Weight at age of the stock .	1947-last data year	2-15+	Yes

Mprop	Proportion of natural mortality before spawning	1947-last data year	2-15+	No –set to 0.5 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1947-last data year	2-15+	No –set to 0 for all ages in all years
Matprop	Proportion mature at age	1947-last data year	2-15+	No- since 2005 set 0.2 for age-3 and 0.85 for age-4
Natmor	Natural mortality	1947-last data year	2-15+	No – set to 0.1 for all ages in all years*

*Because of the *Ichthyophons* outbreak in the stock, M that accounted for the mortality caused by the infection (0.39) was added to 0.1 for the year 2009, giving M=0.49 (see section B.2.2.).

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	IS-Her-Aco-Q4/Q1	1974-last data year	2-15+ (age 3-10 used in tuning)
Tuning fleet 2			
Tuning fleet 3			
….			

D. Short-Term Projection

Model used: Age structured

Software used: An Excel spreadsheet prepared in MRI, which has been compared to results from a Fortran script used at MRI for years for herring and other species, and they have giving identical results.

Initial stock size: Taken from NFT-Adapt in most recent years. The number of the youngest age groups (age 3) is determined as described below (in *Stock recruitment model used)*.

Until in the stock assessment in 2013, this procedure was followed: *If and when the stock is found to be infected by Ichthyophonus hoferi in the autumn of the most recent year in the assessment, the number-at-age for that year should be decreased according to the estimation of the infection prevalence before doing the projection (ICES, WKBENCH 2011). The reason is that all infected fish at that time is considered to die because of it in the spring, or before the spawning occur and can therefore be considered to be ineffective.* From 2013 and on, it was however suggested, and adopted, to ignore the estimates of the infection prevalence in the stock projection on basis of conclusive explorations indicating that the infection was less lethal than assumed earlier (Óskarsson and Pálsson 2013).

Maturity: The same ogive as in the assessment for the year 2006 to present.

Natural mortality: Set to 0.1 for all ages in all years.

F and M before spawning: Set to 0 for F and to 0.5 for M.

Weight at age in the stock: The weight at age (W_{y+1}) is predicted from the mean weight of the same year class a year earlier (W_y) by applying the relationship obtained by Óskarsson (2011): $W_{y+1} - W_y = -0.2229 \times W_y + 90.27$.

Weight at age in the catch: Same as used for the stock

Exploitation pattern: Average of three last years for age-3 and 4, but set 1.0 for age-5+ (ICES, WKBENCH 2011).

Intermediate year assumptions: Not relevant

Uncertainty: Estimated by using *the upper and lower 95% confidence interval* of the estimation of the initial stock size as estimated with NFT-Adapt for the most recent year.

Stock recruitment model used: Number at age 3 (N_{age3}, i.e. recruitment) is derived from index of number at age 1 in the Juvenile survey ($N_{age-1, survey}$; Survey C) two years earlier if available by applying the relationship obtained by Gudmundsdottir et al. (2007):

$\log N_{age\ 2} = 0.390 \times \log N_{age-1,\ survey} + 5.34$

Then N_{age3} is calculated as $\ln (N_{age2}) - Z = \ln (N_{age3})$, where Z=M=0.1. If the survey index is not available, then the number at age 3 is equal to the geometrical mean over the whole assessment period, as done previously.

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

Medium-term projections have not been completed in recent assessments for this stock. The reason was reliance of the fishery on intermittent large year-classes, and the fluid nature of the fishery and related assessment, which was considered to make the usefulness of medium-term projections questionable.

At WKBENCH (ICES 2011a), it was considered relevant to include also a medium-term projection (~five years) for the stock. The model used and input data are the same as described above for the short-term projection concerning, *initial stock size, maturity, F and M before spawning, weight-at-age in the stock and catch, and exploitation pattern*. The *number of recruits* (age-3) for each year is derived from the index of number at age 1 in the Juvenile survey if available (see above in short-term projections), but otherwise it is set equal to the geometric mean over the whole assessment period.

F. Long-Term Projections

It has not been completed in recent assessments.

G. Biological Reference Points

Precautionary reference points:

The Working Group has pointed out that managing this stock at an exploitation rate at or above $\mathbf{F}_{0.1}$ has been successful in the past, despite biased assessments (ICES 2008). The Northern Pelagic and Blue Whiting Fisheries Working Group agreed in 1998 with the SGPAFM on using $\mathbf{F}_{pa} = \mathbf{F}_{0.1} = 0.22$, $\mathbf{B}_{pa} = \mathbf{B}_{lim} * e^{1.645\sigma} = 300\ 000$ t where $\mathbf{B}_{lim} = 200\ 000$ t. The Study Group on Precautionary Reference Points for Advice on Fishery Management met in February 2003 and concluded that it was not considered relevant to change the $\mathbf{B}_{lim}$ from 200 000 t.

The fishing mortality during 1990 to 2007 has been on the average 0.308 (ICES 2008) or approximately 40% higher than the intended target of $F_{0.1}$=0.22. This is despite the fact that the managers have followed the scientific advice and restricted quotas with the aim of fishing at the intended target. During this time period the SSB has remained above B_{lim}. As there is an agreed management strategy that have been applied since the fishery was reopened after it collapsed in late 1960's, it is proposed to use $F_{0.1}$ **=** $\mathbf{F}_{pa}$ as F_{target}.

MSY based reference points:

The MSY based reference points have not been set for Icelandic summer-spawning herring, but exploratory work was present at the NWWG meeting in 2011 in a form as requested by ICES (ICES 2011b). The HCS program Version 10.3 (Skagen, 2010) was used to evaluate possible points based on the MSY framework that could be a basis for a management plan and Harvest Control Rule later.

Number of different runs was made with varying settings. The results implied that the MSY framework was confirmative with the currently used precautionary reference points. It means that the currently used F0.1=0.22 could be a valid candidate for FMSY. This however, needs to be explored more thoroughly later.

H. Other Issues

In November 2008, an *Ichthyophonus hoferi* infection was observed in the Icelandic summer-spawning herring (see above). This infection was believed to be lethal for the stock and would increase M in the stock accordingly. However, conclusion from thorough data explorations of all available data over the period 2008-2013 was that the mortality was less lethal than assumed and insignificantly low since 2010 (Óskarsson and Pálsson 2013). The issue about the mortality caused by the infection will be revisited every year as new data becomes available and allow more accurate retrospective analyses that can strengthen the conclusions made. Another source of uncertainty regarding the infection relates to the period prior to the autumn 2008. Information given by fishermen in the autumn 2008, indicates that they had started to observe infected herring already in the winter 2007/08. MRI did not have any information about it at that time and were not running a program to determine *Ichthyophonus* infection. Thus, the magnitude of infection prior to the autumn 2008 is unknown and thereby the additional natural mortality rate related to the infection.

Two incidents of mass mortalities in the herring stock took place in a fjord off west Iceland (Kolgrafafjörður) where the stock had overwintered in the winter 2012/2013. On basis of fieldwork there, the causes of the mortalities are believed to very low levels of oxygen saturation there. Even if unexpected and particularly the first one, similar incidents in the future there can not be disregarded. If this has something to do with a road construction and a bridge crossing the fjord can not be concluded for the time being. The currents in the fjord and the impacts of the bridge will be explored in the coming months. Thus, the ecosystem in this fjord and the herring belongs to while there, could be threatened by this bridge and/or the topographic and oceanographic conditions as long as this huge biomass of herring decides to overwinter there. The numerical estimates of fish that died in these two incidents (i.e. number-at-age) were added to the catch matrix from 2012 in the 2014 assessment. In that way, no additional M was required in the time series in the assessment.

H.1. Historical overview of previous assessment methods

The summer-spawning herring stock collapsed in late 1960s due to overfishing and environmental changes (Jakobsson *et al.* 1993). The spawning stock has increased from about 10 thous. tonnes in 1972 to about 700 thous. tonnes around the middle of the 2000s.

During the recovery period, the assessments were based on acoustic surveys. These surveys, during the early and mid-1970s, were considered very uncertain. During late 1980s and early 1990s the assessment tool used was a homemade Adapt type of VPA. The stock was consistently overestimated during the late 1980s and the early 1990s. The difference between the acoustic values and those obtained from VPA was about 30%. The most likely cause of this error was considered to be the use of too low target strength (TS) values in the acoustic surveys (Jakobsson *et al.*, 1993). The TS value was raised about 30% or to similar value as used for other herring stocks in the NE Atlantic and the old acoustic values in the tuning file corrected. Until 2002 the homemade Adapt-type of VPA was used for the final assessment of the Icelandic summer-spawning herring stock. Assessment tools like XSA and AMCI were run along as well for some years. In 2003-2004, AMCI runs were accepted as the final assessment. NFT-Adapt, which was first applied in the 2004 assessment, has been the main assessment tool since 2005, even if it was first in 2008 accepted as the final assessment. Both TSA (Gudmundsson, 1994) and XSA have been run along with NFT-Adapt for comparison as alternative tools. In all these assessments, one sided retrospective pattern is seen, especially in the years 2002-2005, but it has diminished in the last years. The reasoning for this pattern is not known.

In 2005 there was a large uncertainty regarding the assessment of the stock and no assessment was considered reliable enough by ACFM. The same happened in the 2006 and 2007 assessments. Assessments use to be consistently biased in overestimating the spawning stock for some years. Several reasons have been mentioned to account for this overestimation problem, including: (1) discrepancies in the catch and survey; (2) a possible higher natural mortality because of much more widespread spatial distribution of the stock since 1997, which means more accessibility for predators; (3) higher mortality related to the fishery with the pelagic trawl, but from 1997 to 2006 around 20-60% of the catch was taken by pelagic trawl; (4) the reduction of the part of the stock that was acoustically measured east of Iceland.

Summary of data ranges used in recent assessments:

Data	2007 assessment	2008 assessment	2009 assessment	2010 assessment
Catch data	Years: 1986–(AY-1) Ages: 3–12+	Years: 1978–(AY-1) Ages: 3–12+	Years: 1978–(AY-1) Ages: 3–12+	Years: 1978–(AY-1) Ages: 3–12+
Survey: IS-Her-Aco-Q4/Q1	Years: 1986–(AY-1) Ages: 4–10	Years: 1986–(AY-1) Ages 4–10	Years: 1986– (AY-1) Ages 4–10	Years: 1986– (AY-1) Ages 4–10
Survey: B	Not used	Not used	Not used	Not used
Survey: C	Not used	Not used	Not used	Not used

Data	2011 assessment	2012 assessment	2013 assessment	2014 assessment
Catch data	Years: 1987–(AY-1) Ages: 3–12+	Years: 1987–(AY-1) Ages: 3–12+	Years: 1987–(AY-1) Ages: 3–12+	Years: 1987–(AY-1) Ages: 3–12+
Survey: IS-Her-Aco-Q4/Q1	Years: 1987–(AY-1) Ages: 3–10	Years: 1987–(AY-1) Ages 3–10	Years: 1987–(AY-1) Ages 3–10	Years: 1987–(AY-1) Ages 3–10
Survey: B	Not used	Not used	Not used	Not used
Survey: C	Not used	Not used	Not used	Not used

AY – Assessment year

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Stock Annex – Icelandic slope beaked redfish (*Sebastes mentella*) Divisions Va and XIVb

Stock specific documentation of standard assessment procedures used by ICES.

Stock Icelandic slope beaked redfish (*Sebastes mentella*) in Divsions Va and XIVb

Working Group: NWWG

Date: May 2012

Revised by: Kristján Kristinsson, Elena Guijarro-Garcia

A. General

A.1. Stock definition

The "Workshop on Redfish Stock Structure" (WKREDS, 22-23 January 2009, Copenhagen, Denmark; ICES 2009) reviewed the stock structure of beaked redfish (*Sebastes mentella*) in the Irminger Sea and adjacent waters. ACOM concluded, based on the outcome of the WKREDS meeting, that there are three biological stocks of beaked redfish in the Irminger Sea and adjacent waters:

- a 'Deep Pelagic' stock (NAFO 1–2, ICES V, XII, XIV >500 m) – primarily pelagic habitats, and including demersal habitats west of the Faeroe Islands;
- a 'Shallow Pelagic' stock (NAFO 1–2, ICES V, XII, XIV <500 m) – extends to ICES I and II, but primarily pelagic habitats, and includes demersal habitats east of the Faeroe Islands;
- an 'Icelandic Slope' stock (ICES Va, XIVb) – primarily demersal habitats.

This conclusion is primarily based on genetic information, i.e. microsatellite information, and supported by analysis of allozymes, fatty acids and other biological information on stock structure, such as some parasite patterns.

The adult redfish on the Greenland shelf has traditionally been attributed to several stocks, and there remains the need to investigate the affinity of adult beaked redfish in this region. The East-Greenland shelf is most likely a common nursery area for the three biological stocks.

The Icelandic slope beaked redfish is treated as a separate management unit.

A.2. Fishery

Annual landings and spatial and temporal distribution of catches

The fishery of Icelandic slope beaked redfish started in the early 1950s (Figure A.2.1). The annual catch 1950-1977 was on average 33,000 t. Annual landings gradually decreased from a record high of 57 000 t in 1994 to 17 000 t in 2001 t. Landings in 2003 increased to 28 500 t but have since then fluctuated between 16 000 t and 21 000 t.

The fishery for beaked redfish in Icelandic waters is predominantly conducted by the Icelandic bottom trawl fleet directed towards the species. Prior to 2000, between 10-40% of the total landings were taken by pelagic trawl. In general, the pelagic fishery has mainly been in the same areas as the bottom trawl fishery, but usually in later months of the year. In 2001-2010, no pelagic fishery occurred or it was negligible, except in 2003 and 2007.

The catch pattern was different in 2003 and in 2007 than in other years. The catches peaked in July in 2003 and in June 2007, which was unusual. This pattern is associated with the deep pelagic beaked redfish stock fishery within the Icelandic EEZ. The deep pelagic beaked redfish fishery has in some years moved further north, and in 2003 and 2007 it merged with the Icelandic slope beaked redfish fishery on the redfish line (a line defined by Icelandic authorities in 1993 to separate catches of pelagic and Icelandic slope beaked redfish) in July. When the deep pelagic beaked redfish crossed the redfish line to the east, it was recorded as Icelandic slope beaked redfish and caught either with pelagic or bottom trawls. This explains the pelagic catches of Icelandic slope beaked redfish in those two years.

The most important fishing grounds are southwest, west, and north-west (close to the Iceland-Greenland midline EEZ) of Iceland at depths from 450 to 800 m. A historically important fishing ground for the Icelandic slope beaked redfish stock is south-east of Iceland along the slope of the Iceland-Faroe Islands Ridge. Fishing in this area has gradually decreased since 2000 and in recent years there has not been a directed fishery for Icelandic slope beaked redfish.

Although no direct measurements are available on discards, it is believed that there are no significant discards of Icelandic slope beaked redfish.

Fleet composition

The fishing fleet operating in Icelandic waters consists of diverse boat types and sizes, operating various types of gear. The majority of the Icelandic slope beaked redfish catches are taken by trawlers larger than 40 BRT using bottom trawls. The remainder of the catch comes from vessels targeting Greenland halibut (*Reinhardtius hippoglossoides*) and in recent years greater silver smelt (*Argentina silus*). Most of the vessels that target Icelandic slope beaked redfish are the same vessels that fish the pelagic beaked redfish stocks and the majority of the golden redfish (*S. marinus*) catch.

Management

The Ministry of Fisheries and Agriculture is responsible for management of all Icelandic fisheries, including the Icelandic slope beaked redfish fishery, and for the implementation of the legislation in the Icelandic Exclusive Economic Zone (EEZ). There is, however, no explicit management plan for Icelandic slope beaked redfish.

The Ministry issues regulations for commercial fishing for each fishing year (from September 1st to August 31st), including allocation of the TAC for each of the stocks subject to such limitations. Below is a short account of the main feature of the management system with emphasis on Icelandic slope beaked redfish when applicable. Further and detailed information on the management and regulations can be found at http://www.fisheries.is/.

A system of transferable boat quotas was introduced in 1984, but was changed to an individual transferable quota (ITQ) system in 1990. The fisheries are subjected to vessel catch quotas. The quotas represent shares in the national total allowable catch (TAC). Since 2006/2007 fishing season, all boats operate under the TAC system. Until 1990, the quota year corresponded to the calendar year but since then the quota, or fishing year, starts on September 1 and ends on August 31 the following year. The agreed quotas are based on the Marine Research Institute's TAC recommendations, taking some socio-economic effects into account.

Within this system, individual boat owners have substantial flexibility to exchange quota, both among vessels within an individual company and among different companies. The latter can be done via temporary or permanent quota transfer. In addition, some flexibility is allowed by individual boats with regard to transfer allowable catch of one species to another. These measures, which can be acted on more or less instantaneously, are likely to reduce initiative for discards (which is effectively banned by law) and misreporting than can be expected if individual boats are restricted by TAC measures alone. They may, however, result in fishing pressures of individual species to be different than intended under the single species TAC allocation.

Furthermore, a vessel can transfer some of its quota between fishing years. There is a requirement that the net transfer of quota between fishing years must not exceed 10% of a given species (was changed from 33% in the 2010/211 fishing year). This may result in higher catch in one fishing year than the set TAC and subsequently lower catches in the previous year.

Landings in Iceland are restricted to particular licensed landing sites, with information being collected on a daily basis time by the Directorate of Fisheries (the native enforcement body). All fish landed has to be weighted, either at harbour or inside the fish processing factory. The information on landing is stored in a centralized database maintained by the Directorate and is available in real time on the internet (www.fiskistofa.is). Up to 10% of the amount of the Icelandic slope *S. mentella* caught annually in Icelandic waters is landed in foreign ports. The accuracy of the landings statistics are considered reasonable although some bias is likely.

All boats operating in Icelandic waters have to maintain a log-book record of catches in each haul. For the larger vessels (for example vessels using bottom and pelagic trawls) this has been mandatory since 1991. The records are available to the staff of the Directorate for inspection purposes as well as to the stock assessors at the Marine Research Institute.

With some minor exceptions it is required by law to land all catches. Consequently, no minimum landing size is in force. No formal harvest control rule exists for this stock. The minimum allowable mesh size is 135 mm in the trawl fisheries, with the exception of targeted shrimp fisheries in waters north of the island.

Redfish (golden refish and Icelandic slope beaked redfish) has been within the ITQ system from the beginning. Icelandic authorities gave, however, until the 2010/2011 fishing year a joint quota for these two species. MRI has since 1994 provided a separate advice for the species. The separation of quotas was implemented in the fishing year that started September 1, 2010.

A.3. Ecosystem aspects

Beaked redfish is an ovoviviparous fish species, meaning that eggs are fertilized, develop and hatch internally. The male and female mate several months before the female extrudes the larvae. The females carry sperm and non-fecundated eggs for months before fertilisation takes place in winter. Females are thought to have a determinate fecundity. Beaked redfish produce many, small larvae (40-400 thousand larvae) that are extruded soon after they hatch from eggs and disperse widely as zooplankton zooplankton (Jónsson and Pálsson 2006). The extrusion of larvae may take place over several days or weeks in a number of batches. Knowledge on the biology, behaviour and dynamics of Icelandic slope beaked redfish reproduction is very scarce.

Little is known about the geographic location and timing of fertilization (mating grounds where copulation occurs) and extrusion of larvae (larval extrusion grounds) of Icelandic slope beaked redfish, but it is similar to those for the pelagic beaked redfish stocks (Magnusson and Magnusson 1995). It is known that mating and copulation takes place in the autumn (September-November), but the exact location of copulation is not known (most likely southwest and south of Iceland). The fertilization of eggs occurs in the winter (February-March). The extrusion of larvae occurs in the spring (April-June), but its exact location of the extrusion area is unknown. The extrusion areas of the pelagic beaked redfish stocks and the Icelandic stocks may merge to some extend, and they are in the open seas in the Irminger Sea, southwest of Iceland (Magnusson and Magnusson, 1995). The extrusion takes place mainly at 500-700 m depth in waters with temperature around 6°C.

Larvae drift to the continental shelf of East Greenland and to some extent to West Greenland, where they settle to the bottom. They are difficult to distinguish from their sibling species golden redfish (*S. marinus*), which has the same nursery areas.

Only the fishable stock of Icelandic slope beaked redfish is found in Icelandic waters, i.e. mainly fish larger than 30 cm. The East Greenland shelf is most likely the main nursery area for the Icelandic slope stock. The nursery areas of both pelagic and the stock found on the continental shelf of Iceland are believed to be on the continental shelf of East Greenland at depths of 200-400 m and reach the shelf off West-Greenland. The proportion of juveniles recruiting to each stock is not known.

Growth and maturity

Icelandic slope beaked redfish is like the pelagic beaked redfish and golden redfish are long lived, slow-growing and late-maturing fish species.

Diet

The food consists of dominant plankton crustaceans such as amphipods, copepods and euphausids. Small fish and cephalopods (small squids) can also be important food items in certain areas.

B. Data

B.1. Commercial catch

Sampling from the Icelandic fleet

	Kind of data				
Country/area	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
Iceland (Va)	X				X

Icelandic commercial catch in tonnes by month, area and gear are obtained from Statistical Iceland and Directorate of Fisheries. The geographical distribution of catches (since 1991) is obtained from log-book statistics, where location of each haul, effort, depth of trawling and total catch of Icelandic slope beaked redfish are given.

B.1.1. Splitting the redfish catch between golden redfish and Icelandic slope beaked redfish in Icelandic waters

Until the 2010/2011 fishing season, Icelandic authorities gave a joint quota for golden redfish and Icelandic slope beaked redfish in Icelandic waters. Icelandic fishermen were not required to divide the redfish catch into species. This was a problem when catch statistics of those two species were determined. Since 1993, a so-called *split-catch* method has been used to split the Icelandic redfish catches between the two species.

B.1.1.2. Data

The following data were used:

1. Data from log-books of the Icelandic fleet (information on the location of each haul, how much was caught of redfish, and if available, the species composition of the catch).
2. Information on landed products from Icelandic factory (freezer) trawlers.
3. Biological samples from the Icelandic fresh-fish trawlers sampled by MRI and Icelandic Catch Supervision (ICS) personnel.
4. Landing statistics from Germany and UK if available.
5. Landing statistics from foreign vessels fishing in Icelandic waters.
6. Official landings by gear type provided by Directorate of Fisheries in Iceland.

B.1.1.3. Splitting the redfish catch from freezer trawlers

The redfish landings statistics of the freezer fleet are divided into species in landing reports and considered reliable. However, the official landings for each fishing trip are not divided by gear type if more than one was used (in this case bottom trawl and pelagic trawl), but set on one gear type (usually bottom trawl). The freezer trawlers mainly use bottom trawl in the redfish fishery, but in some years, especially in the 1990s, they also used pelagic trawls. According to log-books, the redfish caught with pelagic trawl was Icelandic slope beaked redfish.

To get reliable species composition of the bottom trawl catch, the total catch of the freezer trawler for each species was estimated. If, for a given year, redfish was caught with pelagic trawl (total catch was based on log-books) the catch was subtracted from the total beaked redfish catch.

B.1.1.4. Splitting the redfish catch from the fresh fish trawlers

The catch is first divided into defined strata and split into species according to the ratio of golden redfish/beaked redfish observed in biological samples from each strata. Each stratum is a rectangle measuring 15 minutes Latitude by 30 minutes Longitude.

1. **For each year:** The redfish catch from each year was divided into strata and scaled to the total un-split catch of the two species for each rectangle. It is assumed that the distribution of catch not reported in logbooks was the same as for the reported catch. Catch taken by other gears was included (usually about 2% of the total catch).
2. **For each stratum and each year:** The biological samples taken from the commercial catch were used to split the catch in each stratum into species. In this step, the average species composition in the samples in each stratum is estimated and then applied to the total catch of the fleet in that stratum (see previous step). If no information on species composition in a stratum for any given year was available, the species composition one year before was used.If it was not available either, then the species composition two years before was applied, and so forth, up to a maximum of five years before a given year. If no samples were available in this five years period, the splitting was done according to depth and the captain's experience. Only a small proportion of the catch was split into species using the last criterion.
3. The split into species of redfish landings in Germany and UK (containers or fresh landings) is based on landings reports and are considered reliable.
4. For other nations operating in Icelandic waters, the catches are split according to information given by those nations. In recent years, only Faroe Islands and Norway have operated in ICES Division Va.

B.1.1.5. Other gears

Between 92-98% of the annual redfish catch is caught with bottom trawls. The redfish caught with other gear types, i.e. long-line, gillnet, hook and line, Danish seine, and lobster trawl is assumed to be golden redfish. This is because boats using these gear types mainly operate in shallow waters were beaked redfish is not found.

B.1.2. Biological data from the commercial catch

Biological data from the commercial catch were collected from landings by scientists and technicians of the Marine Research Institute (MRI) in Iceland and directly on board on the commercial vessels (mainly length samples) by personnel of the Directorate of Fisheries in Iceland. The biological data collected are length (to the nearest cm), sex, maturity stage, weight, and otoliths for age reading. Age reading has so far been very limited.

The general process of the sampling strategy is to take one sample of Icelandic slope beaked redfish for every 500 tonnes landed. Each sample consists of 200 fishes: otoliths are extracted from 30 fishes which are also length measured, weighed, and sex and maturity determined; 70 fishes are length measured, weighted, sex and maturity determined; the remaining 100 are length measured and sex and maturity determined.

The data are stored in a data base at the Marine Research Institute.

B.2. Biological

B.3. The Icelandic Autumn Groundfish Survey

The Icelandic Autumn Groundfish Survey has been conducted annually in October since 1996 by the Marine Research Institute (MRI). The objective is to gather fishery independent information on biology, distribution and biomass of demersal fish species in Icelandic waters, with particular emphasis on Greenland halibut and Icelandic slope beaked redfish. This is because the Spring Survey conducted annually in March since 1985 does not cover the distribution of these deep-water species. The secondary aim of the survey is to have another fisheries independent estimate on abundance, biomass and biology of demersal species, such as cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and golden redfish, in order to improve the precision of stock assessment.

The text in the following description of the surveys is mostly a translation from Björnsson et al. (2007). The emphasis has been put on golden redfish where applicable. The report, written in Icelandic with English abstract and English text under each table and figure, can be found at the MRI website under the following link: http://www.hafro.is/Bokasafn/Timarit/rall_2007.pdf. An English version of the survey manual can be found at http://www.hafro.is/Bokasafn/Timarit/fjolrit-156.pdf.

B.3.1. Timing, area covered and tow location

The Autumn Survey is conducted in October as it is considered the most suitable month in relation to diurnal vertical migration, distribution and availability of Greenland halibut and Icelandic slope beaked redfish. The research area is the Icelandic continental shelf and slopes within the Icelandic Exclusive Economic Zone (EEZ) to depths down to 1500 m. The research area is divided into a shallow-water area (0-400 m) and a deep-water area (400-1500 m). The shallow-water area is the same area covered in the Spring Survey. The deep-water area is directed at the distribution of Greenland halibut, mainly found at depths from 800-1400 m west, north and east of Iceland, and deep-water redfish, mainly found at 500-1200 m depths southeast, south and southwest of Iceland and on the Reykjanes Ridge.

B.3.2. Preparation and later alterations to the survey

Initially, a total of 430 stations were divided between the shallow and deep-water areas. Of them, 150 stations were allocated to the shallow-water area and randomly selected from the Spring Survey station list. In the deep-water area, half of the 280 stations were randomly positioned in the area. The other half were randomly chosen from log-books of the commercial bottom-trawl fleet fishing for Greenland halibut and Icelandic slope beaked redfish in 1991-1995. The locations of those stations were, therefore, based on distribution and pre-estimated density of the species.

Because MRI was not able to finance a project of this magnitude, it was decided to focus the deep water part of the survey on the Greenland halibut main distributional area. Important Icelandic slope beaked redfish areas south and west of Iceland were omitted. The number and location of stations in the shallow-water area were unchanged. For this reason, only the years from 2000 can be compared for Icelandic slope beaked redfish.

The number of stations in the deep-water area was therefore reduced to 150. A total of 100 stations were randomly positioned in the area. The remaining stations were located on important Greenland halibut fishing grounds west, north and east of Iceland and randomly selected from a log-book database of the bottom trawl fleet fishing for Greenland halibut 1991-1995. The number of stations in each area was partly based on total commercial catch.

In 2000, with the arrival of a new research vessel, MRI was able finance the project according to the original plan. Stations were added to cover the distribution of Icelandic slope beaked redfish and the location of the stations selected in a similar manner as for Greenland halibut. A total of 30 stations was randomly assigned to the distribution area of deep-water redfish and 30 stations were randomly assigned to the main deep-water redfish fishing grounds based on log-books of the bottom trawl fleet 1996-1999 (Figure B.3.1).

In addition, 14 stations were randomly added in the deep-water area in areas where great variation had been observed in 1996-1999. Because of rough bottom which made it impossible to tow, five stations have been omitted. Finally, 12 stations were added in 1999 in the shallow-water area, increasing the total number of stations in the shallow-water area to 162. The total number of stations taken in 2000-2009 has been around 381 (Table B.3.1).

In 2010, 16 stations were omitted in the deep water area and the total number of stations in the area was reduced from 219 to 203. All these stations have in common that they are in areas where stations are many and dense (close to each other), and with little variation. Four stations, aimed at Icelandic slope beaked redfish, were omitted south-east of Iceland. The rest or 12 stations were omitted west and north-west of Iceland, these were stations originally aimed at Greenland halibut.

B3.3. Vessels

The r/v ''Bjarni Sæmundsson'' has been used in the shallow-water area from the beginning of the survey. For the deep-water area, the MRI rented one commercial trawler 1996-1999, which was replaced in 2000 by the r/v ''Árni Friðriksson'' (Table B.3.1).

B3.4. Fishing gear

Two types of the bottom survey trawl "Gulltoppur" are used for sampling: "Gulltoppur" is used in the shallow water and "Gulltoppur 66.6m" is used in deep waters. The shape of the trawls is the same but the trawl used in deep waters is larger. The trawls were common among the Icelandic bottom trawl fleet in the mid 1990's and are well suited for fisheries on cod, Greenland halibut, and redfish.

The towing speed is 3.8 knots over the bottom. The trawling distance is 3.0 nautical miles calculated with GPS from the moment when the trawl touches the bottom until the hauling begins (i.e. excluding setting and hauling of the trawl).

B.3.5. Data sampling

B.3.5.1. Length measurements and counting

All fish species are length measured, the majority of them, including Icelandic slope beaked redfish, to the nearest cm from the tip of the snout to the tip of the longer lobe of the caudal fin. At each station, the general rule is to measure at least 5 times the length interval of deep-water redfish. Example: If the continuous length distribution of beaked redfish at a given station is between 15 and 45 cm, the length interval is 30 cm and the number of measurements needed is 120. If the catch of beaked redfish at this station exceeds 120 individuals the rest is counted.

Care is taken to ensure that the length measurement sampling is random so that the fish measured reflect the length distribution of the haul in question.

Each beaked redfish that is length measured is both sex and maturity determined.

B.3.5.2. Otolith sampling

For beaked redfish, a minimum of one and a maximum of 25 otoliths are collected in the Autumn Survey. Otoliths are sampled at a 10 fish interval, so that if in total 200 deep-water redfish are caught in a single haul, 20 otoliths are sampled.

Each beaked redfish taken in the otolith sampling is sex and maturity determined, weighed ungutted, and the stomach content is analysed onboard.

Only otoliths from the Autumn Survey in 2000 have been age-read.

B.3.5.3. Information on tow, gear and environmental factors

At each station/haul, relevant information on the haul and environmental factors is recorded by the captain and the first officer in co-operation with the cruise leader.

- Tow information:

General: Station, Vessel registry no., Cruise ID, Day/Month/Year, Statistical Square, Sub-square, Tow number, Gear type no., Mesh size, Briddles length (m).

Start of haul: Position North, Position West, Time (hour:min), Tow direction in degrees, Bottom depth (m), Towing depth (m), Vertical opening (m), Horizontal opening (m).

End of haul: Position North, Position West, Time (hour:min), Warp length (fm), Bottom depth (m), Tow length (nautical miles), Tow time (min), Tow speed (knots).

- Environmental factors:

Wind direction, Air temperature (°C), Wind speed, Bottom temperature (°C), Sea surface, Surface temperatrue (°C), Cloud cover, Air pressure, Drift ice.

B.3.6. Data processing

Abundance and biomass estimates at a given station

As described above the normal procedure is to measure at least 4 times the length interval of a given species. The number of fish caught of the length interval L_1 to L_2 is given by:

$$P = \frac{n_{measured}}{n_{counted} + n_{measured}}$$

$$n_{L_1-L_2} = \sum_{i=L_1}^{i=L_2} \frac{n_i}{P}$$

where $n_{measured}$ is the number of fished measured and $n_{counted}$ is the number of fish counted. Biomass of a given species at a given station is calculated as:

$$B_{L_1-L_2} = \sum_{i=L_1}^{i=L_2} \frac{n_i \alpha L_i^{\beta}}{P}$$

where L_i is length and α and β are coefficients of the length-weight relationship.

B.3.6.1. Index calculation

For calculation of indices the Cochran method is used (Cochran 1977). The survey area is split into strata (see Section B.3.6.2). Index for each stratum is calculated as the mean number in a standardized tow, divided by the area covered multiplied with the size of the stratum. The total index is then a summed up estimates from the strata.

A "tow-mile" is assumed to be 0.00918 NM^2. That is the width of the area covered is assumed to be 17 m (17/1852=0.00918).

The following equations are a mathematical representation of the procedure used to calculate the indices:

$$\overline{Z}_i = \frac{\sum_i Z_i}{N_i}$$

where $\overline{Z}_i$ is the mean catch (number or biomass) in the *i*-th stratum, Z_i is the total quantity of the index (abundance or biomass) in the *i*-th stratum and N_i the total number of tows in the *i*-th stratum. The index (abundance or biomass) of a stratum (I_i) is:

$$I_i = \overline{Z}_i \left(\frac{A_i}{A_{tow}} \right)$$

And the sample variance in the *i*-th stratum:

$$\sigma_i^2 = \left(\frac{\sum_i (Z_i - \overline{Z}_i)^2}{N_i - 1} \right) \left(\frac{A_i}{A_{tow}} \right)^2$$

where A_i is the size of the *i*-th stratum in NM^2 and A_{tow} is the size of the area surveyed in a single tow in NM^2.

$$I_{region} = \sum_{region} I_i$$

and the variance is

$$\sigma_{strata}^2 = \sum_{region} \sigma_i^2$$

and the coefficient of variation is

$$CV_{region} = \frac{\sigma_{region}}{I_{region}}.$$

B.3.6.2. Stratification

The strata used for survey index calculation for Icelandic slope beaked redfish in the Autumn Survey are shown in Figure B.3.2. The stratification is in general based on depth stratification and similar oceanographic conditions within each stratum.

The stratification for the Autumn Survey was revised in 2008. This was because the majority of the total catch of species, such as golden redfish, comes in a few but large tows, leading to high uncertainties in the estimates of the biomass/abundance indices (high CV). The aim of this revision was, therefore, to reduce the weight of certain tows (the few but large tows that account for the bulk of the total catch) and to reduce the area weight. The number of strata was reduced from 74 to 33. Figure B.3.3 shows the stratification of the survey area that was used before 2008. The average size of stratum subsequently increased and number of tows within stratum increased. It should also be noted that some strata at the edge of the survey area were reduced.

Comparison of total biomass index for Icelandic slope beaked redfish based on the old and new stratification is shown in Figure B.3.4. In general, the measurement errors of the indices based on the new stratification are lower than the ones based on the old one. The indices are similar and show the same trend (except for 2010).

B.4. Commercial CPUE

Catch per unit of effort are routinely calculated during the annual assessment process. Data used to estimate CPUE for Icelandic slope *S. mentella* in Division Va since 1978 were obtained from log-books of the Icelandic bottom trawl fleet. Only those hauls taken below 450 m depth (combined golden redfish and Icelandic slope *S. mentella*) and that were comprised of at least 50% Icelandic slope *S. mentella* (assumed to be the directed fishery towards the species – between 70-90% of the total annual catch were from those hauls) were used. Non-standardized CPUE and effort are calculated for each year:

$$E_y = \frac{Y_y}{CPUE_y},$$

where E is the total fishing effort and Y is the total reported landings.

CPUE indices were also estimated from this data set using a GLM multiplicative model (generalized linear models). This model takes into account changes in vessels over time, area (ICES statistical square), month and year effects:

glm(log(catch) ~ log(effort) + factor(year) + factor(month) + factor(area) + factor(vessel),

family=gaussian())

C: Modelling framework (Historical stock development)

Icelandic slope beaked redfish in ICES Division Va has previously been assessed based on trends in survey biomass indices from the Icelandic Autumn survey in terms of the ICES "trends based assessment" approach. Supplementary data used includes relevant information from the fishery and length distributions from the commercial catch and the Autumn Survey.

At the WKRED-2012 meeting working document (# 12) was presented where the trend in survey indices for the Icelandic slope beaked redfish was estimated as well as F_{proxy} (catch divided by index for the same stock). The trend in the survey indices was estimated to be around 5% per year (uncertain estimate) so assuming F=M 10% reduction in total mortality was required to stop the trend and 20% to reverse it. If F > M, which is considered a likely hypotheses considering the state of the stock, less than 20% reduction in F is needed to get the intended 10% reduction in Z. The only data available to support that F and M are similar are results from limited age-readings that indicate Z to be around 0.1 and M "is known" to be 0.05. The approach in the working document #12 makes no special reference to the status of the stock which is considered difficult to assess. Similar ideas are put forward in working document #16 for the deep pelagic beaked redfish in the Irminger Sea.

The method proposed in working document #12 has three major shortcomings.

- The survey data are noisy and the trend is not clear
- The survey series are short (11 years) compared to the lifespan of the species. One year class can take more than five years to recruit to the stock so the survey period might be characterized by abnormally high or low recruitment leading to trend in indices reflecting recruitment anomaly rather than deviations from sustainable fishing effort.
- Catches may not be correctly allocated to stocks. Spatial distribution of the catches west of Iceland in some years indicate that part of the catch for deep sea pelagic beaked redfish could be Icelandic slope beaked redfish and vice versa.

The external panel rejected the approaches of working documents #12 and #16 as they did not make any reference to the state of the stock and depended on the assumption F=M. In response it was stated that most likely F > M and therefore the method is if anything conservative.

Some participants in the Working Group considered that at present analytical assessments cannot be conducted because, for example, of little age data and the relative shortness of the time-series available.

The external panel considered that although the biomass dynamic model (specifically the Schaefer form off this approach) is preliminary and should be improved, it is possible to use this approach to initially assess stock status and current replacement yield (RY, being the annual catch estimated to maintain abundance at its present level) based on information on past catches, the autumn survey, and external information used to inform on the likely range of the value for stock productivity parameter. For the values of stock productivity parameter considered the most realistic (r = 0.05 to r = 0.10), this approach provides estimates of the current depletion (the present to pre-exploitation abundance ratio) of this resource to be from 18-19% with CVs between 40% and 50%. Estimates of RY range from about 10 (SE 4) to 13 (SE 4) thousand tons, by comparison with an average annual catch over the 2000 to 2010 period of about 21 thousand tons. Although the precision of these RY estimates is poor, the panel draws attention to the approach suggested in the general recommendations section whereby the requirements of the precautionary approach can be addressed by decreasing catch limit estimates by some multiple of the associated SE estimate. The panel does not suggest that the Schaefer model approach used here is to be final; to the contrary it is offered as a first step (from which interim management advice might be formulated) while the assessment is extended to an Age Structured Production Model framework which could, for example, also take account of the commercial catch-at-length and limited ageing data available for this resource. While the projection and reference point computations referenced below are possible within this Schaefer model framework, the panel did not consider it appropriate to report them at this stage, given the interim and intermediate nature of this approach. The difficulties found by the panel with the "trends based assessment" approach are set out in the general recommendations section.

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1978-2010		
Canum	Catch at age in numbers			
Weca	Weight at age in the commercial catch			
West	Weight at age of the spawning stock at spawning time.			
Mprop	Proportion of natural mortality before spawning			
Fprop	Proportion of fishing mortality before spawning			
Matprop	Proportion mature at age			
Natmor	Natural mortality			

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Autumn Survey	2000-2010	Not available
Tuning fleet 2			
Tuning fleet 3			

D. Short-Term Projection

No short-term predictions are performed.

E. Medium-Term Projections

No medium-term predictions are performed.

F. Long-Term Projections

No long-term predictions are performed.

G. Biological Reference Points

No biological reference points are defined for Icelandic slope beaked redfish in Division Va.

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Table B.3.1. Vessels used in the Autumn Groundfish Survey in ICES Divistion Va, their survey area, and the number of station taken.

Year	Shallow waters Vessel name	No.Stations	Deep waters Vessel name	No.Stations	Total stations
1996	r/v Bjarni Sæmundsson	146	Múlaberg ÓF32	144	290
1997	r/v Bjarni Sæmundsson	150	Brettingur NS50	149	299
1998	r/v Bjarni Sæmundsson	153	Brettingur NS50	144	297
1999	r/v Bjarni Sæmundsson	166	Brettingur NS50	149	315
2000	r/v Bjarni Sæmundsson	163	r/v Árni Friðriksson	219	382
2001	r/v Bjarni Sæmundsson	161	r/v Árni Friðriksson	219	380
2002	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	221	383
2003	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	220	382
2004	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	220	382
2005	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	219	381
2006	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	219	381
2007	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	219	381
2008	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	219	381
2009	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	219	381
2010	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	203	365

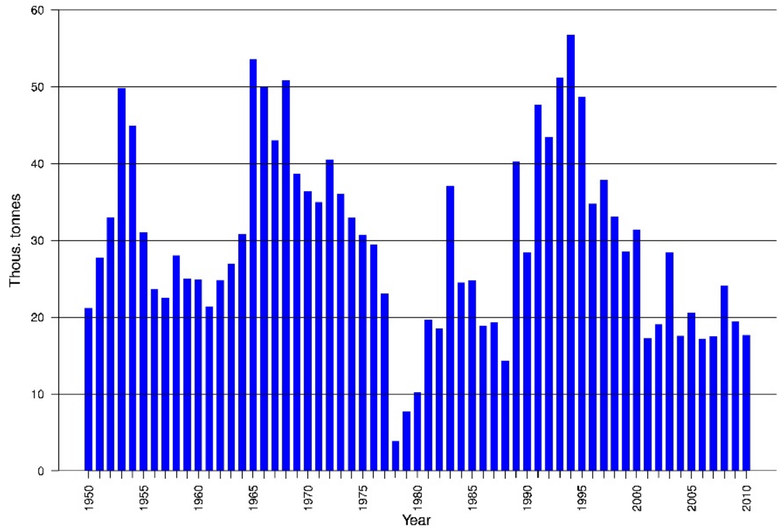

Figure A.2.1. Nominal landings (in tonnes) of beaked redfish (*S. mentella*) from Icelandic waters (ICES Divisions Va and XIVb) 1950-2010.

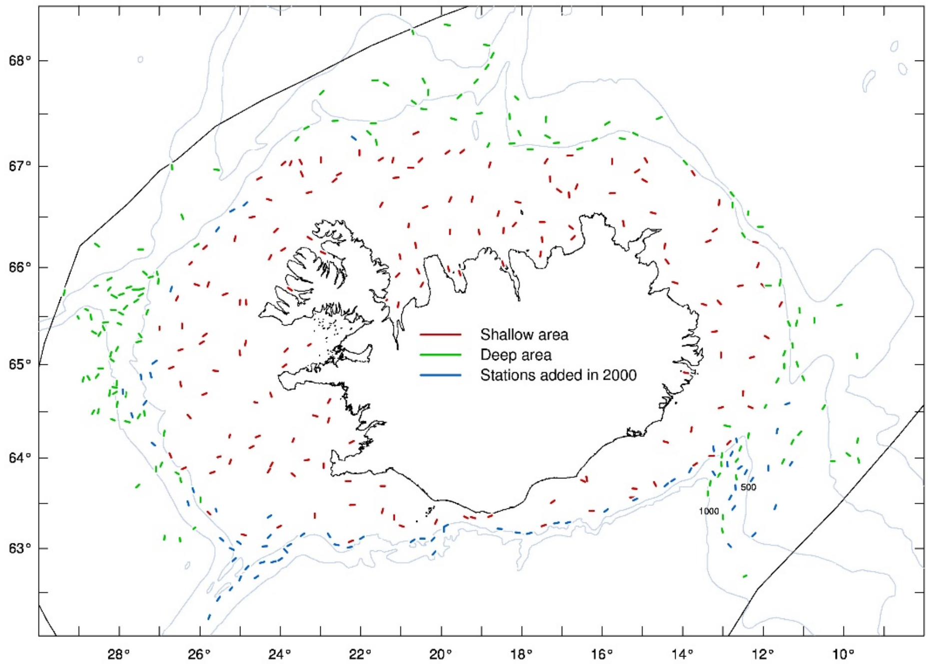

Figure B.3.1. Stations in the Autumn Groundfish Survey (AGS). R/v "Bjarni Sæmundsson" takes stations in the shallow-water area (red lines) and r/v "Árni Friðriksson" takes stations in the deep-water areas (green lines), the blue lines are stations added in 2000.

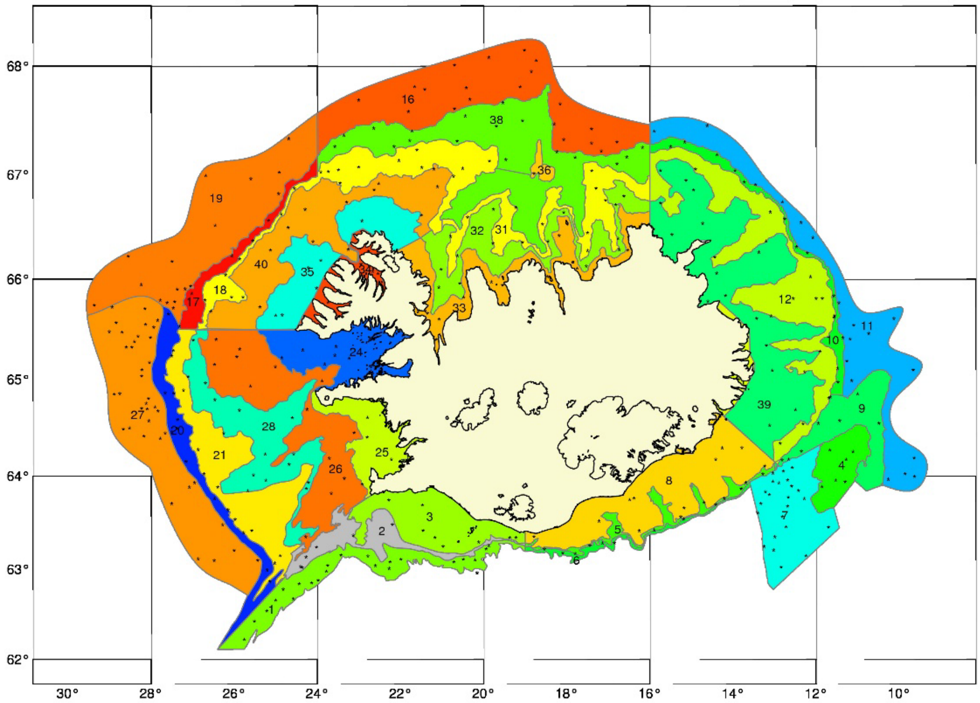

Figure B.3.2. Sub-areas or strata used for calculation of survey indices for Icelandic slope *S. mentella* from the Autumn Survey in Icelandic waters. This stratification has been applied since 2008.

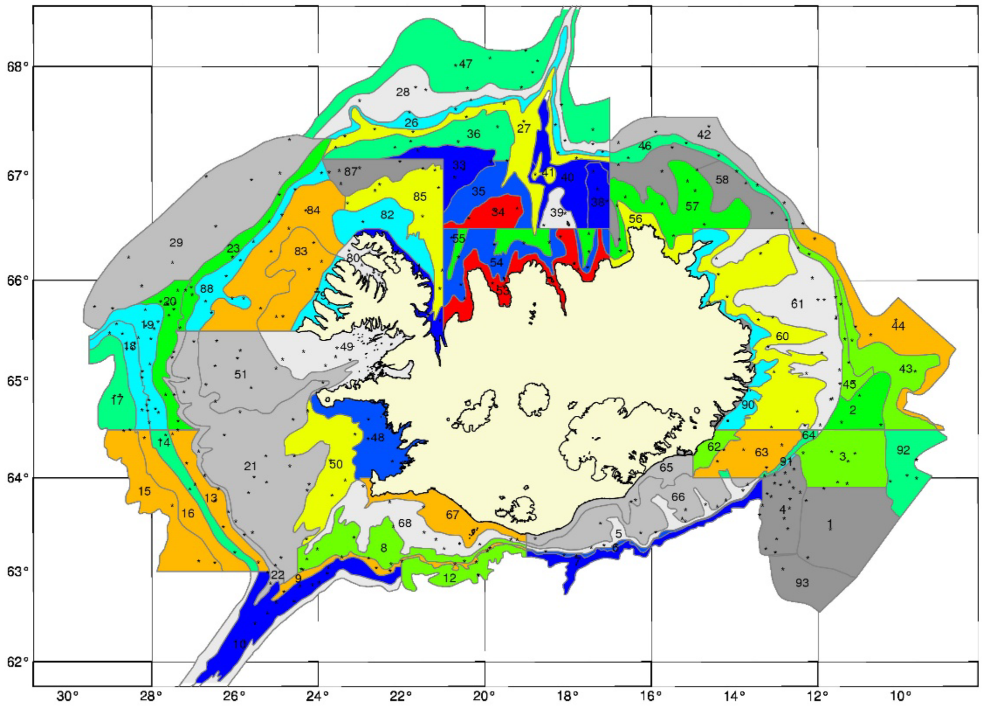

Figure B.3.3. The old stratification (before 2008) that was used for calculation of Icelandic slope *S. mentella* indices from the Autumn Survey in Icelandic waters.

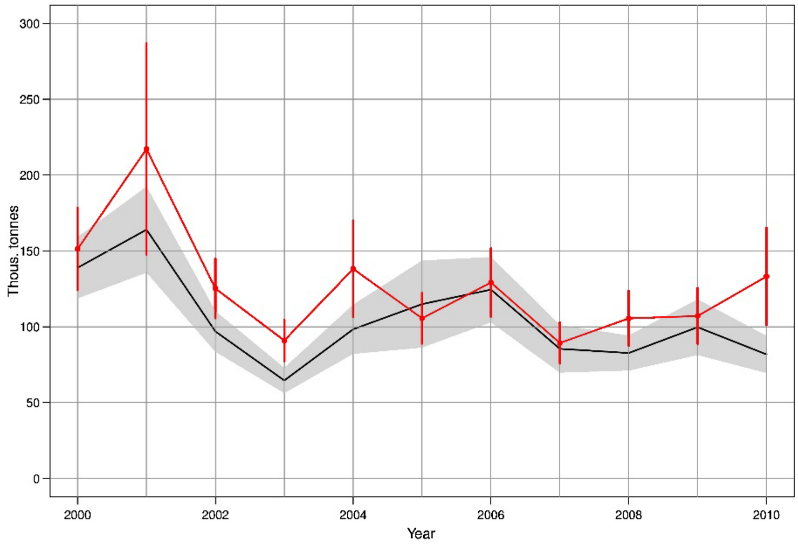

Figure B.3.4. Comparison of survey indices of Icelandic slope *S. mentella* in the Autumn Survey in ICES Division Va based on the new stratification (black line and shaded area, see Figure B.3.2) and the old stratification (red dots and lines, see Figure B.3.3).

STOCK ANNEX: Deep Pelagic beaked redfish (Sebastes *mentella*) in ICES

Stock specific documentation of standard assessment procedures used by ICES.

Stock	**Deep pelagic *Sebastes mentella***
Working Group:	**NWWG**
Date:	**May 2012**
Revised by	**Kristján Kristinsson, Elena Guijarro-Garcia**

A. General

A.1. Stock definition

The deep pelagic beaked redfish (*Sebastes mentella*) stock is distributed mostly in pelagic habitats within NAFO divisions 1–2, and ICES areas V, XII, XIV at depths >500 m, but it is also found in demersal habitats west of the Faeroe Islands (ICES, 2010).

The Workshop on Redfish Stock Structure (WKREDS) reviewed the stock structure of beaked redfish in the Irminger Sea and adjacent waters (ICES, 2009a). ICES Advisory Committee (ACOM) concluded, based on the outcome of the WKREDS meeting, that there are three biological stocks of the species in the Irminger Sea and adjacent waters:

- a **Deep Pelagic stock** (NAFO 1-2, ICES V, XII, XIV >500 m) – primarily pelagic habitats, and including demersal habitats west of the Faroe Islands;
- a **Shallow Pelagic stock** (NAFO 1-2, ICES V, XII, XIV <500 m) - extends to ICES I and II, but primarily pelagic habitats, and includes demersal habitats east of the Faroe Islands;
- an **Icelandic Slope stock** (ICES Va, XIV) – primarily demersal habitats.

The workshop reviewed the stock structure of *Sebastes mentella* in the Irminger Sea and adjacent waters, using genetic information (i.e. microsatellite information), supported by analysis of allozymes, fatty acids and other biological information on stock structure, such as some parasite patterns.

The adult redfish on the Greenland shelf has traditionally been attributed to several stocks, and there remains the need to investigate the affinity of adult *S. mentella* in this region. WKREDS also suggested that the East-Greenland shelf is most likely a common nursery area for the three biological stocks they distinguished.

Based on this new stock identification information, ICES recommended in 2009 the use of three potential management units that are geographic proxies for the newly defined biological stocks, which are partly limited by depth and whose boundaries are based on the spatial distribution pattern of the fishery to minimize mixed stock catches. Thus the newly described deep pelagic stock corresponds to the management unit in the northeast Irminger Sea: NAFO Areas 1 and 2, ICES areas Vb, XII and XIV at depths greater than 500m, including demersal habitats west of the Faroe Islands.

The decision to classify pelagic redfish as two stocks rather than one stock was not unanimous among ACOM members. Russia's position regarding the structure of the redfish stock in the Irminger Sea and adjacent waters remains unchanged, i.e. that there is a single-stock of *S. mentella* in that area (ICES, 2011c)

A.2. Fishery

The fishery for deep pelagic redfish started in the early 1990s and grew quickly, with vessels from Iceland, Faroese, Germany, Norway, Portugal and Russia (Sigurðsson et. al, 2006). In 1995, 17 nations participated in the fishery, but 9 of them retired soon or have participated occasionally.

In the period 1992-1996, the fishery gradually shifted from the traditional fishing grounds towards greater depths, developing a clear seasonal spatial pattern. The fleets moved systematically to different areas and depths as the season progressed, fishing the deep component in the north eastern Irminger Sea (north of 61°N and east of 32°W) during the first months of the fishing season, or from April to mid-June, and moving to the shallow fishing grounds later in the season. Fishing is scarce between November and late March or early April.

As more nations joined the fishery, annual landings increased quickly from 59 tonnes in 1991 to nearly 140,000 t in 1996, stabilising at 85,000- 105,000 t during the period 1997-2004, when some countries ceased fishing (Figure A.2.1). From 2005 onwards, annual landings have declined, being in the range 30,000 – 68,000 t. From 1997 onwards, logbook data from Russia, Iceland, Faroe Islands, Norway and Germany have been used to calculate landings by stock within each ICES Division. It is assumed that catches by other nations have the same spatial distribution. However, the figures for total catch are probably underestimated due to incomplete reporting of catches. A large percentage of annual landings (66% on average) were taken in ICES division XIV in 1991-2011.Total catches have fluctuated without trend between 45,000 and 70,000 t since 2005, and the percentages of catch taken in ICES division XIVb for these years are among the highest, reaching 86% in 2010 and being practically 100% in 2012 (Fig. A.2.1.).

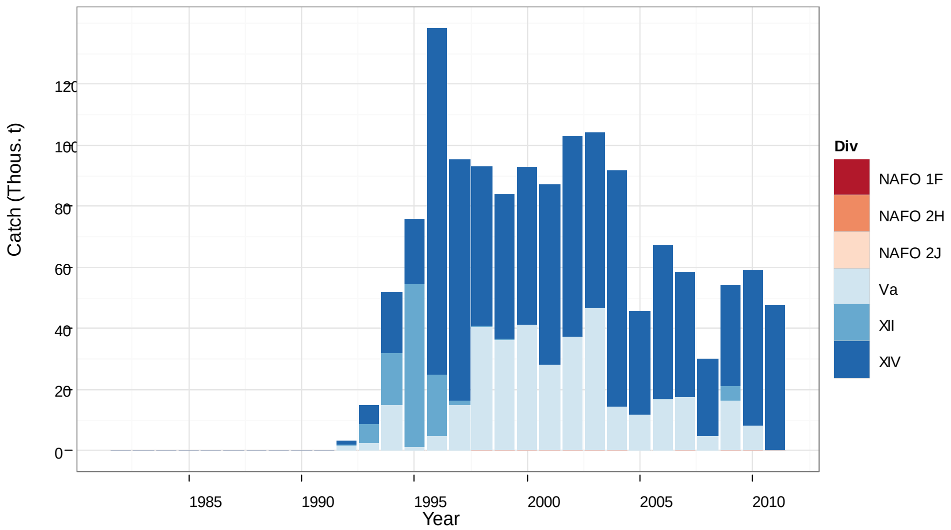

Figure A.2.1. Nominal landings of deep pelagic beaked redfish 1991-2011 by ICES areas.

The fleets participating in this fishery keep updating their fishing technology, and most trawlers now use large pelagic trawls ("Gloria"-type) with vertical openings of 80-150 m.

A.3. Ecosystem aspects

Beaked redfish is an ovoviviparous fish species, in which eggs are fertilized, develop and hatch internally. The male and female mate several months before the female extrudes the larvae. The females carry sperm and non-fecundated eggs for months before fertilisation takes place in spring (Sorokin, 1961).. Females are thought to have a determinate fecundity. Beaked redfish produce many small larvae that are extruded soon after they hatch from eggs and disperse widely as zooplankton. The extrusion of larvae may take place over several days or weeks in a number of batches. It occurs in large areas of the Irminger Sea during April and May, peaking in late April and early May (Noskov et al. 1984; Shibanov et al. 1984; Pavlov et al. 1989).. The main area of extrusion is found south of 65°N and east of 32°W (Magnússon and Magnússon 1977; Magnússon 1980, Zakharov 1964, 1966; Shibanov et al. 1995). The location of the mating grounds is unknown, but mating adults are found in the slopes. Knowledge on the biology, behaviour and dynamics of redfish reproduction is very scarce (Magnusson and Magnusson, 1995).

The adults of the deep pelagic stock move northwards and are found in May-July close to and within the Icelandic EEZ and to the continental shelf of Iceland. The international fishing fleet targets this adult population, with the main fishing areas being both close to the Icelandic-Greenland EEZ's and within Icelandic waters.

The larvae are pelagic and drift northward in the surface layer and to the continental slope of West- and East-Greenland. The nursery areas are believed to be on the continental shelf of East-Greenland and to some extend of West-Greenland. It is unknown to what extend juveniles recruit to the different stocks.

Early life history stages are described in Magnusson and Magnusson (1995). Larvae drift to the continental shelf of East Greenland and to some extent to West Greenland, where they settle to the bottom. It is difficult to distinguish from the sibling species golden redfish (*S. marinus*), which occupies the same nursery areas.

Young redfish dwell at the bottom at different depths, the youngest ages preferring lesser depths than older fish. The juveniles are predominantly distributed on the continental shelf of West- and East Greenland. Adults are found in the open ocean.

Age of recruitment to the fishery of both stocks is believed to be near maturity, maybe between ages 8 to 12 years. The causes for variability in recruitment are unknown.

Little is known about the trophic interactions in the Irminger Sea. However, a study by Petursdottir et al. (2008) shows that Euphausiids (*M.norwegica*) and *Calanus spp.* appear to play an important role in the diet of beaked redfish in pelagic ecosystem on the Reykjanes ridge. Pedersen and Riget (1993) investigated stomach contents of beaked redfish in W-Greenland waters and found planktonic crustaceans such as hyperiids, copepods and euphausiids to be the main food items in small redfish (5-19cm). Among shallow stock adults, the main food items are dominant plankton crustaceans such as amphipods, copepods and euphausids. Cephalopods (small squids), shrimp (*P. borealis*) and small fish (redfish included) are also important food items (Pedersen and Riget, 1993; Magnusson and Magnusson 1995).

There are indication that *Sebastes spp.* Play an important role as a prey item for Greenland halibut (Orr and Bowering, 1997; Solmundsson, 2007) and adult harp and hooded seals during pelagic feeding (Haug *et al.*, 2007; Tucker et al., 2009). The prey items in these studies were however not species specific observations.

Research is needed to get a better understanding of the following issues:

- migrations and locations of the different life stages,
- recruitment success,
- determination of population age structure,
- species identification for young specimens,
- standardization of maturity determination,
- natural mortality.

There has already been some effort conducted to validate and harmonise the methodologies used for age determination at an international level (ICES, 2006, 2009b). This should be further pursued, since there are still non-standard methodologies used by some Russian teams which forbid data compilation at an international level.

A maturity scale has been agreed at an international level (ICES WKMSREGH, 2011, unpublished report), but it is necessary to carry out workshops to guarantee that this scale is well understood and used in a standardised fashion across nations and research laboratories.

Regarding the impact of the fishery on pelagic redfish in the Irminger Sea and adjacent waters, it is generally regarded as having negligible impact on the habitat and other fish or invertebrate species due to very low bycatch and discard rates, characteristic of fisheries using pelagic gear.

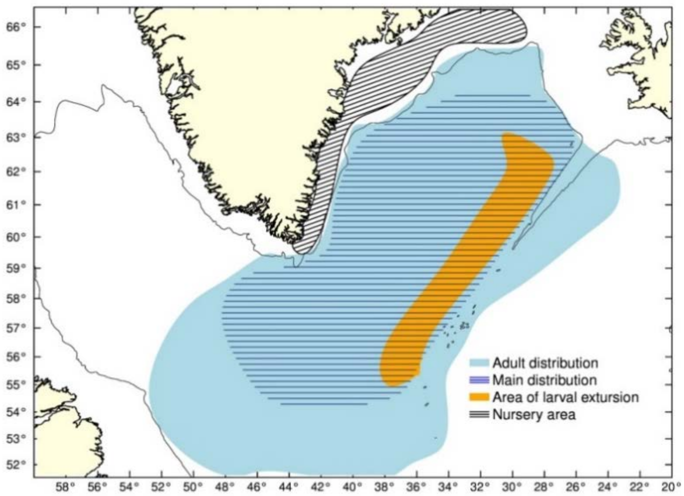

Figure A.3.1. Distribution of both pelagic redfish stocks (shallow and deep) in the Irminger Sea and adjacent waters at different stages of the life-cycle

A.4. Management

NEAFC is the responsible management body, and ICES the advisory body. Management of fisheries on pelagic redfish is based on setting total allowable catches (TAC) since 1996 and technical measures.

No harvest control rule does exists for the stock and there has been no agreement on, stock structure (see A.1), and the TAC and allocation key between contracting parties in NEAFC for several years. Some countries had set autonomous quotas. This has led to total annual catches far above the NEAFC TAC.

In March 2011, NEAFC agreed on interim measures for the deep pelagic beaked redfish fisheries until the end of 2014. These measures were agreed by all members of NEAFC except Russia. It is therefore expected that the total catch will exceed the TAC's set by NEAFC. The objective of these measures is to gradually decrease the catches until they comply with the ICES advice, and to establish harvest control rule in the long term.

The main measures that apply in 2011-2104 are the following (see detailed agreement on http://www.neafc.org/system/files/postalvote_redfish_Irmingersea_april2011.pdf):

1. TAC and quota allocation between Contracting Parties for the deep pelagic beaked redfish fishery in the Irminger Sea and adjacent waters 2011-2014 is fixed as follows: the TAC in 2011 was 38,000 tonnes, in 2012 it will be 32,000 tonnes, in 2013 26,000 tonnes, and in 2014 the TAC will be 20,000 tonnes. Additional quotas may be allocated to non-Contracting Parties for each year.
2. The level of the TACs for 2012 to 2014 may be adjusted in the light of new scientific advice from ICES.
3. The Contracting Parties are allocated the following quota shares of the established TACs for the period 2011 to 2014. These percentage shares are agreed on an *ad hoc* basis for the period 2011 to 2014 and do not prejudice quota allocation schemes for subsequent periods.

a.	Denmark, in respect of the Faroe Islands and Greenland	28.98 %
b.	European Union	15.45 %
c.	Iceland	31.02 %
d.	Norway	3.85 %
e.	Russian Federation	20.70 %

4. From 2011, each Party may transfer to the following year unutilised quantities of up to 5% of the quota allocated to that Party for the initial year. The quantity transferred shall be in addition to the quota allocated to the Party concerned in the following year. This quantity cannot be transferred further to the quotas for subsequent years. No transfers may be made from unfished quantities of quotas established for 2010 or for any earlier fishing seasons.
5. Each Party may authorise fishing by its vessels of up to 5% beyond the quota allocated to that Party in any one year. All quantities fished beyond the allocated quota for one year shall be deducted from that Party's quota allocated for the following year.
6. The fisheries shall not commence prior to 10 May each year to enhance the protection of areas of larval extrusion.
7. Catches in the deep pelagic fishery in the Irminger Sea and adjacent waters referred to in paragraph 1 shall be conducted from 2011 to 2014 within an area bounded by the lines joining the following coordinates (Area 1 in Figure A.4.1):

Point no.	Latitude	Longitude
1	64° 45' N	28° 30' W
2	62° 50' N	25° 45' W
3	61° 55' N	26° 45' W
4	61° 00' N	26° 30' W
5	59° 00' N	30° 00' W
6	59° 00' N	34° 00' W
7	61° 30' N	34° 00' W
8	62° 50' N	36° 00' W
9	64° 45' N	28° 30' W

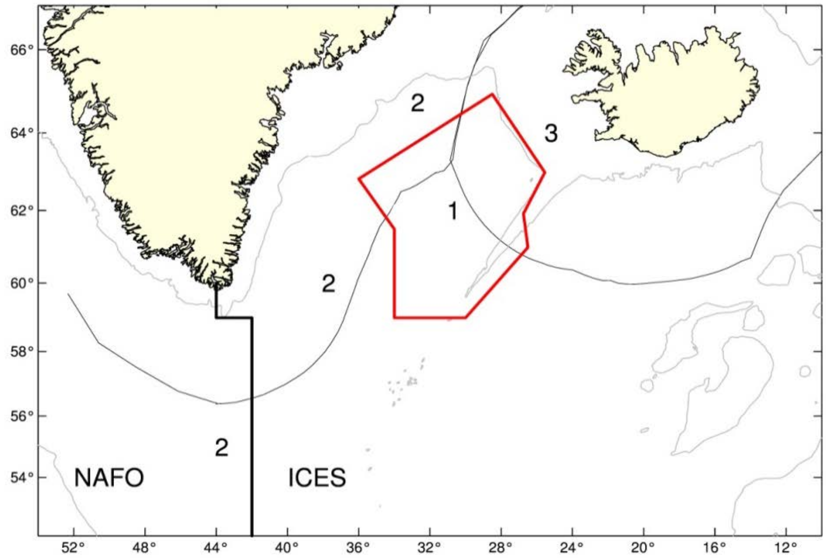

Figure A.4.1. Management unit boundaries for beaked redfish (*S. mentella*) in the Irminger Sea and adjacent waters. The polygon bounded by red lines, i.e. 1, indicates the region of the deep-pelagic management unit in the northwest Irminger Sea, 2 is the shallow-pelagic management unit in the Irminger Sea and adjacent waters including within the NAFO Convention areas, and 3 is the Icelandic slope management unit which is within the Icelandic EEZ.

8. Among reporting requirements are that masters of fishing vessels shall record the fishing depth in their fishing logbooks. Also, that Contracting Parties shall report to the Secretariat on a weekly basis the catches landed by their vessels. This information shall be made available to Contracting Parties and to the inspectors on the secure site of the NEAFC website.
9. The minimum mesh size of the trawl is 100 mm.
10. Finally, NEAFC will seek to establish a long-term management plan for redfish in the Irminger Sea and adjacent waters during the period of implementation of these interim management measures. This includes appropriate harvest control rule.

The objective of any such management plan shall be to establish such levels of catches and fishing effort, which will result in the sustainable exploitation of pelagic redfish in the Irminger Sea and adjacent waters. This long-term management plan should take due account of the interim management measures as set out in this recommendation.

B. Data

B.1. Commercial catch

Iceland, Greenland, Faroe Islands, Norway, Germany and Russia are the nations providing the most complete databases, including detailed vessel and gear information, as well as catch data on a haul to haul basis. The rest of the countries supply catch in weight and the length composition of the catch.

The preliminary official landing data are provided by the ICES Secretariat, NEAFC and NAFO, and various national data are reported to the Group. The Group, however, repeatedly faces problems in obtaining reliable data due to unreported catches of pelagic redfish and lack of catch data disaggregated by depth from some countries. There are indications that reported effort (and consequently landings) could represent only around 80% of the real effort in certain years (see Chapter 19.3.3 in the 2008 NWWG report). No new data in IUU have been available since 2008.

Splitting of catches: In the period 1992-1996, the fishery gradually shifted towards greater depths and developed a clear seasonal spatial pattern. The fleets fished first the deep stock and moved to the southwestern Irminger Sea (south of 60°N and west of about 32°W) from mid June to October, to fish the shallow stock. Landings from these years have been assigned to the different biological stocks according to several criteria, such as landings by ICES statistical areas, ICES Divisions, by nation, and logbook data. When a nation lacked data, the average from the other nations was used instead. Landings data disaggregated by biological stock from this period are considered to be the most unreliable and must be regarded as the WG's best estimates (guesstimates). This task was carried out according to the NWWG meeting celebrated in 2004, Bergen (ICES, 2004).

B.2. Biological

Biological information is collected from commercial catches (Iceland, Russia, Spain and other EU countries). For Iceland and Spain, the data consist of length measurements, weight, sex, maturity stage, and otolith collection. Otoliths have not been age read.

The Group started to collate an international database with length distributions from the sampling of the fisheries on a spatially disaggregated level. Once complete, the horizontal and vertical differences in mean length by fishing areas can be illustrated as alternative to the portrayals by ICES/NAFO Divisions. The database includes data from Iceland, Greenland, Faroe Islands, Norway, Germany and Russia.

B.3. Surveys

The surveys provide valuable information on the biology, distribution and relative abundance of oceanic redfish, as well as on the oceanographic conditions of the surveyed area. Until 1999, oceanic redfish was only surveyed by acoustics down to an approximate depth of 500 m. Attempts to obtain reliable stock size estimates and map the stock distribution below that depth did not succeed (Shibanov *et al*., 1996; ICES, 1998; Sigurðsson and Reynisson, 1998), mostly due to the "deep scattering layer" (DSL), which is a mixture of many vertebrate and invertebrate species mixed with redfish (Magnússon, 1996). However, since the fishery had moved towards greater depths it was very important to expand the vertical coverage of the survey. The 1999 survey provided for the first time an estimate on the abundance of the deep pelagic *S. mentella* deeper than 500 m depth, showing that the highest concentrations of redfish below 500 were associated with eddies and fronts.

Since 1999, an international trawl-acoustic survey has been conducted biennially by Iceland, Germany and Russia (with Norway participating in 2001) with two to five research vessels (ICES 2002, 2003, 2005, 2007b, 2009c, 2011b; Sigurdsson et. al 1999). In this survey, the deep pelagic beaked redfish stock is measured with so-called "trawl method". The surveys in 2005 and 2007 are not comparable with the other surveys due to changes in the depth range covered in the 2005 and 2007 surveys. However, it was agreed that the trawl data should be treated with great caution (ICES, 2002).

The Working Group for Redfish Survey (WGRS, formerly as SGRS and then PGRS) has organised and planned these international surveys since 1999, and distributed survey area and time among the participants.

Table 1. Deep pelagic redfish surveys carried out in the Irminger Sea and adjacent waters. Th. NM2; thousand square nautical miles surveyed, Depth: depth stratum reached during survey, above or below 500 m depth, Country: GER=Germany, ICE=Iceland, NOR=Norway, RUS=Russia.

Year	Country	# of vessles	Th. NM2	Depth	Ref
1999	GER/ICE/ RUS	3	296	> 500	Sigurðsson et al., 1999
2001	GER/ICE/RUS/NOR	5	420	> 500	ICES, 2002
2003	GER/ICE/ RUS	3	405	> 500	ICES, 2003
2009	GER/ICE	2	360	> 500	ICES 2009c
2011	GER/ICE/ RUS	3	343	> 500	ICES 2011b

Technical description

The technical details and description of the equipment used are described in (ICES, 2011a). Here a brief summary of the sampling methodology of the surveys 1999-2011 is given.

Acoustics

In the 2011 survey, 38 kHz Simrad EK60 split-beam echosounder was used for the acoustic data collection on RV "Árni Friðriksson" and RV "Vilnyus" whereas on RV "Walther Herwig III" an EK500 was used, also equipped with a 38 kHz split-beam transducer. The settings of the acoustic equipment used during the survey are given in Table 2 in ICES (2011a). During the survey on board of the Icelandic and German vessels, the post-processing system (EchoView V4.9, Myriax) was used for scrutinising the echograms, whereas FAMAS (a post-processing program developed by TINRO) was used in the Russian vessel. Mean integration values of redfish per 5 NM were used for the calculations.

The integration threshold of 80-84 dB/m^3 was used. A length based target

$$TS = 20\log L - 71.3\ dB$$

has been used for the estimation of the number of pelagic redfish in the survey area.

Earlier investigations (Magnússon *et al.*, 1994; Magnússon *et al.*, 1996; Reynisson and Sigurðsson, 1996) have shown that the acoustic values obtained from oceanic redfish exhibit a clear diurnal variation, due to a different degree of mixing with smaller scatter and to changes in target strength. In order to compensate for these effects, the acoustic data obtained when mixing is most pronounced (i.e. during the darkest hours of the night), are discarded and the values within the missing sections are estimated by interpolation.

In further data processing, the number of fish is calculated for statistical rectangles measuring 1° latitude x 2° longitude. Changes in the length range of redfish in the past acoustic surveys are taken into account by changing the length-based target strength formula accordingly (Reynisson, 1992; ICES, 2011a for details). The total number of fish within the subareas A-F in which the survey area is divided (Figure B.3.1) is then obtained by summation of the individual rectangles. The acoustic results were further divided into the number of individuals, and biomass based on the biological samples representative for each subarea.

For the entire survey area, single-fish echoes from redfish are expected to be detectable down to 350 m. In order to include all echoes of interest, a low integration threshold is chosen (i.e., -80 dB//m^3 for the 2011 survey). Based on the depth distribution of redfish observed during the survey and the expected target strength distribution, the method outlined by Reynisson (1996) is used to estimate the expected bias due to thresholding. The results of the biomass calculations were adjusted accordingly.

The measurements of echo-sounders can be disturbed by noise (from the ambient and the vessel) and reverberation (echoes reflected from unwanted targets). Because the amplitude of the signal decreases with depth whereas the amplitude of noise increases due to time varied gain, very small noise can prevent the measurements. Thus, to improve the signal to noise ratio, a threshold is usually applied (Bethke, 2004).

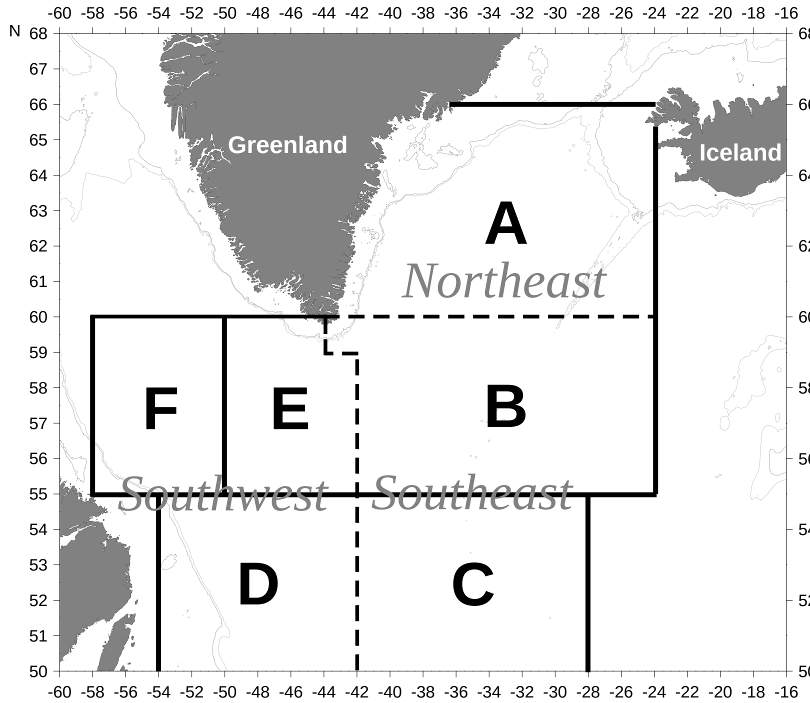

Figure B.3.1. Sub-areas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines).

When the redfish appears mixed with other deep-sea species, or the weather is bad and disturbs the measurements, echo counting is preferred over echo integration, as described in Bethke (2004). The counting procedure is based on the fact that fish are recognized as single targets according to the parameter settings of the echo-sounder. However, if redfish is found in dense aggregations, echo integration is more accurate. Switching between methods may be necessary during the survey (ICES, 2011a).

Trawling

The classic method of continuous echo integration deeper than 350 m (within and deeper than DSL) is applicable only under very specific conditions. The need for the vertical expansion of the survey led to the use of the trawl method since 1999. This method is based on a combination of standardized survey catches and the acoustic data, where the correlation between catch and acoustic values during trawling in the layer shallower than the DSL is used to obtain acoustic values for the deeper layer. There are three types of trawling depths (ICES, 2011a):

1. The depth zones shallower than the DSL, in which redfish could be acoustically identified. Trawling distance is 4 NM.
2. The depth shallower than 500 m depth, where acoustic redfish registration is hampered by the DSL: from the top of the DSL down to 450m. Trawling distance is 2 NM in each depth layer.
3. The depth zones deeper than 500 m depth, trawling at different depth layers. The deep identification covered the following three depth layers: 550 m, 700 m, 850 m. Trawling distance at each depth layer was 2 nautical miles.

In the 2005 and the 2007 surveys (ICES, 2005, 2007b) trawling was carried out within the depth range 350 - 950 m, i.e. within and deeper than the DSL. Thus, the abundance estimates by the trawl method are not comparable with the other years, as both stocks were sampled simultaneously, and have therefore been excluded from the analysis.

The net used on RV "Árni Friðriksson" and RV "Walther Herwig III" was a Gloria type #1024, with a vertical opening of approximately 50 m. The net used on RV "Vilnyus" was a Russian pelagic trawl (design 75/448) with a circumference of 448 m and a vertical opening of 47-50 m. Russia used a mesh opening of 40 mm in the codend, while Iceland and Germany used a mesh opening of 23 mm in the codend. The trawls used on RV "Árni Friðriksson" and RV "Walther Herwig III" were fitted with a multiple codend sampling device: the 'multisampler' (Engås *et al.*, 1997). This allowed for successive sampling at three distinct depth zones within one trawl haul and without 'contamination' from one depth to the next, as well as no sampling during shooting or heaving of the trawl. The catches were standardized by 1 NM and converted into acoustic values using a linear regression model between catches and acoustic values at depths shallower than the DSL.

A linear regression model between the acoustic values and catches (in kg/NM) of type 1 trawls (shallower than the DSL) was applied to predict the acoustic values (SA) for trawls type 2 and 3. The obtained sA values were then adjusted for the vertical coverage of the trawls and the depth range of each haul (ΔD/Htr; where ΔD is the difference between maximum and minimum depth of each haul, and Htr is the vertical opening during each tow). The S_A value for each trawl ($S_A$tr) is:

$$S_Atr = C * K * KH$$

where *C* is the catch in kg per NM of each type 2 and 3 trawl, *K* is the coefficient of the trawl obtained from the linear regression of type 1 trawls for each vessel and *K*H is the width of the depth range towed defined as:

$$KH = (HMAX - HMIN + dHTR) / dHTR$$

where *H*MAX and *H*MIN of the headline of the trawl during the tow and d*H*TR is mean vertical opening of the trawl.

Based on the regressions, confidence limits for the estimates are also calculated. After having calculated the SA values from the catches of each haul, the estimation of the abundance and biomass was calculated using the same target strength equation for redfish (20logL – 71.3 dB) and the same algorithm as used for the acoustic estimation. The area coverage was considered to be the same as for the acoustic results and applied to all subareas.

Biological sampling

Catch weight and number of all species are be recorded for each haul. The individual biological sampling of deep-water redfish is as follows (taken from ICES (2011a)):

1. The total length (cm below), individual weight, sex and maturity stage are measured on at least 300 redfish from each haul type.
2. Otolith sampling is carried out at each station. Sampling is conducted on 50 individuals following a random sampling procedure (i.e. not stratified by length).
3. Observations on the stomach fullness, the location and size of skin/muscular pigments as well as infestation with *Sphyrion lumpi* and its remnants are investigated on at least 50 randomly sampled fish (usually collected on individual fish from which otoliths are sampled).

B.4. Commercial CPUE

It is not known to what extent the CPUE reflects changes in the stock status of pelagic *S. mentella*. Since the fishery focuses on aggregations, the CPUE series might not indicate or reflect actual trends in stock size.

B.5. Other relevant data

C. Historical Stock Development

Deep pelagic beaked redfish in the Irminger Sea and adjacent waters has previously been assessed based on trends in survey biomass indices from the international redfish survey in terms of the ICES "trends based assessment" approach. Supplementary data used includes relevant information from the fishery and length distributions from the commercial catch and the international redfish survey.

At the WKRED-2012 meeting working document (# 16) was presented where the trend in survey indices for the deep pelagic beaked redfish was estimated as well as F_{proxy} (catch divided by index for the same stock). The trend in the survey indices was estimated to be around 5% per year (uncertain estimate) so assuming F=M 10% reduction in total mortality was required to stop the trend and 20% to reverse it. If F > M, which is considered a likely hypotheses considering the state of the stock, less than 20% reduction in F is needed to get the intended 10% reduction in Z. The only data available to support that F and M are similar are results from limited age-readings that indicate Z to be around 0.1 and M "is known" to be 0.05. The approach in the working document #16 makes no special reference to the status of the stock which is considered difficult to assess. Similar ideas are put forward in working document #12 for the Icelandic slope beaked redfish.

The method proposed in working document #16 has three major shortcomings.

The survey data are noisy and the trend is not clear

The survey series are short (11 years) compared to the lifespan of the species. One year class can take more than five years to recruit to the stock so the survey period might be characterized by abnormally high or low recruitment leading to trend in indices reflecting recruitment anomaly rather than deviations from sustainable fishing effort.

Catches may not be correctly allocated to stocks. Spatial distribution of the catches west of Iceland in some years indicate that part of the catch for deep sea pelagic beaked redfish could be Icelandic slope beaked redfish and vice versa.

The external panel rejected the approaches of working documents #12 and #16 as they did not make any reference to the state of the stock and depended on the assumption F=M. In response it was stated that most likely F > M and therefore the method is if anything conservative.

Some participants in the Working Group considered that at present analytical assessments cannot be conducted because, for example, of little age data and the relative shortness of the time-series available.

The external panel considered that although the biomass dynamic model (specifically the Schaefer form off this approach) is preliminary and should be improved, it is possible to use this approach to initially assess stock status and current replacement yield (RY, being the annual catch estimated to maintain abundance at its present level) based on information on past catches, the autumn survey, and external information used to inform on the likely range of the value for stock productivity parameter. For the values of stock productivity parameter considered the most realistic ($r = 0.05$ to $r = 0.10$), this approach provides estimates of the current depletion (the present to pre-exploitation abundance ratio) of this resource to be from 46-50% with CVs between 46% and 48%. Estimates of RY range from about 13 (SE 4) to 39 (SE 4) thousand tons, by comparison with an average annual catch over the 2000 to 2010 period of about 70 thousand tons. Although the precision of these RY estimates is poor, the panel draws attention to the approach suggested in the general recommendations section whereby the requirements of the precautionary approach can be addressed by decreasing catch limit estimates by some multiple of the associated SE estimate. The panel does not suggest that the Schaefer model approach used here is to be final; to the contrary it is offered as a first step (from which interim management advice might be formulated) while the assessment is extended to an Age Structured Production Model framework which could, for example, also take account of the commercial catch-at-length and limited ageing data available for this resource. While the projection and reference point computations referenced below are possible within this Schaefer model framework, the panel did not consider it appropriate to report them at this stage, given the interim and intermediate nature of this approach. The difficulties found by the panel with the "trends based assessment" approach are set out in the general recommendations section.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1982-		
Canum	Catch at age in numbers			
Weca	Weight at age in the commercial catch			
West	Weight at age of the spawning stock at spawning time.			
Mprop	Proportion of natural mortality before spawning			
Fprop	Proportion of fishing mortality before spawning			
Matprop	Proportion mature at age			
Natmor	Natural mortality			

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1			
Tuning fleet 2			
Tuning fleet 3			
….			

D. Short-Term Projection

Model used:

Software used*:*

Initial stock size:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Procedures used for splitting projected catches:

E. Medium-Term Projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:
5) Weight at age in the stock:
6) Weight at age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:
9) Stock recruitment model used:

F. Long-Term Projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

H. Other Issues

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STOCK ANNEX: Shallow Pelagic Beaked Redfish (*Sebastes mentella*)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	**Shallow pelagic beaked redfish (*Sebastes mentella*)**
Working Group:	**NWWG**
Date:	**May 2012**
Revised by	**Kristján Kristinsson, Elena Guijarro**

A. General

A.1. Stock definition

The deep pelagic beaked redfish (*Sebastes mentella*) stock is distributed mostly in pelagic habitats within NAFO divisions 1–2, and ICES areas V, XII, XIV at depths >500 m, but it is also found in demersal habitats west of the Faeroe Islands (ICES, 2010).

The Workshop on Redfish Stock Structure (WKREDS) reviewed the stock structure of beaked redfish in the Irminger Sea and adjacent waters (ICES, 2009a). ICES Advisory Committee (ACOM) concluded, based on the outcome of the WKREDS meeting, that there are three biological stocks of the species in the Irminger Sea and adjacent waters:

- a **Deep Pelagic stock** (NAFO 1-2, ICES V, XII, XIV >500 m) – primarily pelagic habitats, and including demersal habitats west of the Faroe Islands;
- a **Shallow Pelagic stock** (NAFO 1-2, ICES V, XII, XIV <500 m) - extends to ICES I and II, but primarily pelagic habitats, and includes demersal habitats east of the Faroe Islands;
- an **Icelandic Slope stock** (ICES Va, XIV) – primarily demersal habitats.

The workshop reviewed the stock structure of *Sebastes mentella* in the Irminger Sea and adjacent waters, using genetic information (i.e. microsatellite information), supported by analysis of allozymes, fatty acids and other biological information on stock structure, such as some parasite patterns.

The adult redfish on the Greenland shelf has traditionally been attributed to several stocks, and there remains the need to investigate the affinity of adult *S. mentella* in this region. WKREDS also suggested that the East-Greenland shelf is most likely a common nursery area for the three biological stocks they distinguished.

Based on this new stock identification information, ICES recommended in 2009 the use of three potential management units that are geographic proxies for the newly defined biological stocks, which are partly limited by depth and whose boundaries are based on the spatial distribution pattern of the fishery to minimize mixed stock catches. Thus the newly described deep pelagic stock corresponds to the management unit in the northeast Irminger Sea: NAFO Areas 1 and 2, ICES areas Vb, XII and XIV at depths greater than 500m, including demersal habitats west of the Faroe Islands.

The decision to classify pelagic redfish as two stocks rather than one stock was not unanimous among ACOM members. Russia's position regarding the structure of the redfish stock in the Irminger Sea and adjacent waters remains unchanged, i.e. that there is a single-stock of *S. mentella* in that area (ICES, 2011c)

A.2. Fishery

The historic development of the fisheries by nation is described in detail in the 2007 NWWG Report, and resumed here. Russian trawlers started the shallow pelagic beaked redfish fishery in 1982, covering wide areas of the Irminger Sea. Vessels from Bulgaria, the former GDR and Poland joined in 1984. Annual landings for most of the period 1982-1995 ranged between 60,000 t and 100,000 t, declining to around 30,000 t between 1989 and 1991 when the East European countries reduced their effort. Fishing took place mainly from April to August. First, on pre-spawning and spawning aggregations from early April to mid-May, on post-spawning fish from late May to mid-June, and on feeding aggregations from mid-July to August. During this first period of the fishery, 1982-1991, all landings were registered as oceanic *S. mentella* because the main fishing area was in the central Irminger Sea from 59°N to 62°N and between 30°W and 35°W, corresponding to the ICES Divisions XII and XIV, beyond Greenland and Icelandic national jurisdictions and at depths between 80 and 500 m (Sigurðsson *et al.*, 2006).

In the period 1992-1996, the fishery gradually shifted towards greater depths and developed a clear seasonal spatial pattern. Catches increased to 100, 000 t as more nations joined the fishery and effort from Russia and Germany rose again. The fleets moved systematically to different areas and depths as the season progressed, fishing the shallow component in the southwest Irminger Sea (57-58°30′N and 32-36°W) later in the season, or from mid-June to October. Fishing is scarce between November and late March or early April.

In 1996, annual landings decreased to 41,000 t, a 60% decline in comparison with previous years, and they oscillated between 24,000 and 57,000 t (averaging 35,000 t) during the years 1997-2005. From 1997 onwards, logbook data from Russia, Iceland, Faroe Islands, Norway and Germany have been used to calculate landings by stock within each ICES Division. It is assumed that catches by other nations have the same spatial distribution. However, the figures for total catch are probably underestimated due to incomplete reporting of catches. In 2006 there was another sharp decline in annual landings, which have been <3,000 t since 2007 and have followed a decreasing trend over the past years. A large percentage of annual landings (50% on average) were taken in NAFO Area 1F in 2000-2008 and 2009, but 81-100% of the 2009 and 2011 landings were caught in ICES division XIV. Since 1995, there is a decreasing trend in CPUE. These trends are probably influenced by changes in management.

A total of 19 nations have taken part in this fishery since 1982, with a minimum of two nations in 1982 and a maximum of 17 in 1995. The total number of vessels from each country it is not known for the whole period, but during the years 1995 - 2009, their number ranged between 45 and 92.The fleets participating in this fishery keep updating their fishing technology, and most trawlers now use large pelagic trawls ("Gloria"-type) with vertical openings of 80-150 m.

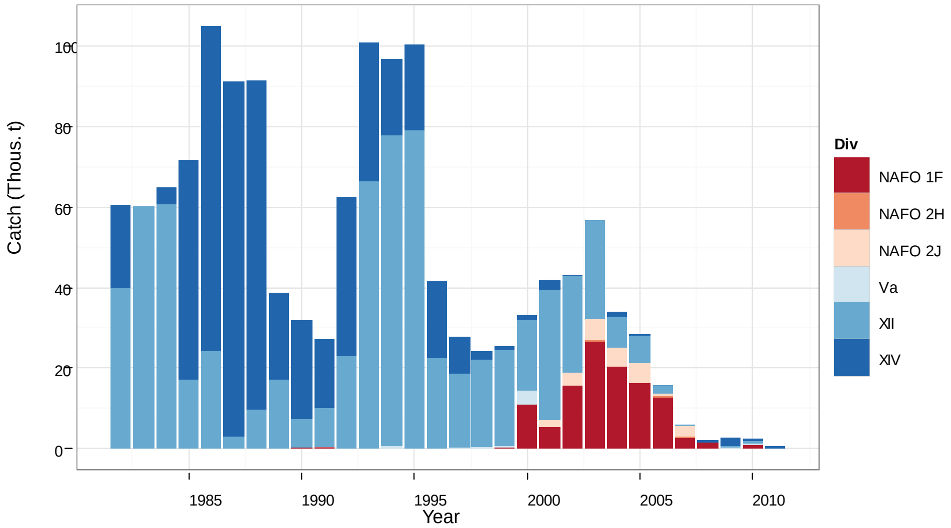

Figure A.2.1. Nominal landings (in thousand tonnes) of shallow pelagic beaked redfish 1982-2010 by ICES areas.

A.3. Ecosystem aspects

Beaked redfish is an ovoviviparous fish species, in which eggs are fertilized, develop and hatch internally. The male and female mate several months before the female extrudes the larvae. The females carry sperm and non-fecundated eggs for months before fertilisation takes place in spring (Sorokin, 1961). Females are thought to have a determinate fecundity. Beaked redfish produce many, small larvae that are extruded soon after they hatch from eggs and disperse widely as zooplankton. The extrusion of larvae may take place over several days or weeks in a number of batches. It occurs in large areas of the Irminger Sea during April and May, peaking in late April and early May (Noskov et al. 1984; Shibanov et al. 1984; Pavlov et al. 1989). The main area of extrusion is found south of 65°N and east of 32°W (Magnússon and Magnússon 1977; Magnússon 1980, Zakharov 1964, 1966; Shibanov et al. 1995). The location of the mating grounds is unknown, but mating adults are found in the slopes. Knowledge on the biology, behaviour and dynamics of redfish reproduction is very scarce (Magnusson and Magnusson, 1995).

After the larvae extrusion, the adults of the shallow pelagic stock move westwards towards Greenland for feeding and copulation. In the late summer the main concentration is found south and southwest of Greenland and it is the target of the international pelagic fishery.

Early life history stages are described in Magnusson and Magnusson (1995). The larvae are pelagic and drift northwards in the surface layer and to the continental slope of West- and East-Greenland. The nursery areas are believed to be on the continental shelf off East-Greenland, and to some extend off West-Greenland. The identification of beaked redfish and its sibling species golden redfish (*S. marinus*) occupying the same nursery areas is very difficult. It is unknown to what extent beaked redfish juveniles recruit to the different stocks.

Young redfish dwell at the bottom at different depths, the youngest ages preferring lesser depths than older fish. The juveniles are predominantly distributed on the continental shelf of West- and East Greenland. Age of recruitment to the fishery of both stocks is believed to be near maturity, maybe between ages 8 to 12 years. The causes for variability in recruitment are unknown. Adults are found in the open ocean.

Little is known about the trophic interactions in the Irminger Sea. However, a study by Petursdottir et al. (2008) shows that Euphausiids (*M.norwegica*) and *Calanus spp.* appear to play an important role in the diet of *S.mentella* in the pelagic ecosystem on the Reykjanes ridge. Pedersen and Riget (1993) investigated stomach content of *S.mentella* in W-Greenland waters and found planktonic crustaceans such as hyperiids, copepods and euphausiids to be the main food item in small redfish (5-19cm). Among shallow stock adults, the diet includes mainly dominant plankton crustaceans such as amphipods, copepods and euphausids. Cephalopods (small squids), shrimp (*P. borealis*) and small fish (including redfish) are also important food items (Pedersen and Riget, 1993, Magnusson and Magnusson 1995).

There are indications that *Sebastes spp.* play important role as a prey item for Greenland halibut (Orr and Bowering, 1997; Solmundsson, 2007) and adult harp and hooded seals during pelagic feeding (Haug et al., 2007; Tucker et al., 2009). The prey items in these studies were however not species specific observations.

Research is needed to get a better understanding of the following issues:

- migrations and locations of the different life stages,
- recruitment success,
- determination of population age structure,
- species identification for young specimens,
- standardization of maturity determination,
- natural mortality.

There has already been some effort conducted to validate and harmonise the methodologies used for age determination at an international level (ICES, 2006 and 2009b). This should be further pursued, since there are still non-standard methodologies used by some Russian teams which forbid data compilation at an international level.

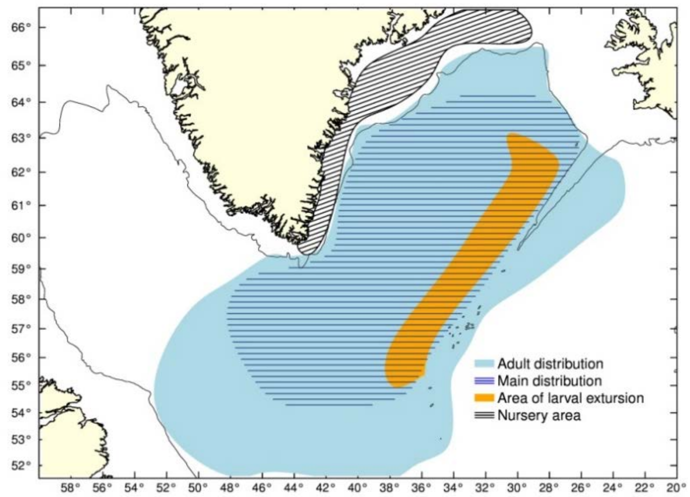

Figure A.3.1. Distribution of both pelagic redfish stocks (shallow and deep) in the Irminger Sea and adjacent waters at different stages of the life-cycle

Regarding the impact of the fishery on shallow pelagic redfish in the Irminger Sea and adjacent waters, it is generally regarded as having negligible impact on other fish or invertebrate species due to the very low bycatch and discard rates characteristic of pelagic fishing gear.

A.4. Management

NEAFC is the responsible management body, and ICES the advisory body. Management of fisheries on pelagic redfish is based on setting total allowable catches (TAC) since 1996 and technical measures (minimum mesh size in the trawls is set at 100 mm).

No harvest control rule does exists for the stock and there has been no agreement on, stock structure (see A.1), the TAC and allocation key between contracting parties in NEAFC for several years, and some countries (It is talked of NEAFC's "reference" TAC – 46000 t for the period from 2007-2010. In that period each Contracting Party (not only Russia) set national management measures itself) had set autonomous quotas. This has led in to total annual catches far above the NEAFC TAC.

In March 2011 NEAFC agreed on interim measures for the shallow pelagic beaked redfish fisheries until the end of 2014. These measures were agreed by all members of NEAFC except Russia.

Catches in the shallow pelagic fishery in the Irminger Sea and adjacent waters should take place outside Area 1 shown in Figure A.4.1 (Area 2 in the figure) of this measure. In accordance with the latest advice from ICES and in the absence of any agreed recovery plan, there shouhd have been no fishery during 2011 in the NEAFC Regulatory Area, and NAFO was informed of this prohibition. Fisheries from 2012 to 2014 will depend upon the establishment of a recovery plan for the shallow redfish in the Irminger Sea and adjacent waters, as well as on any new scientific advice.

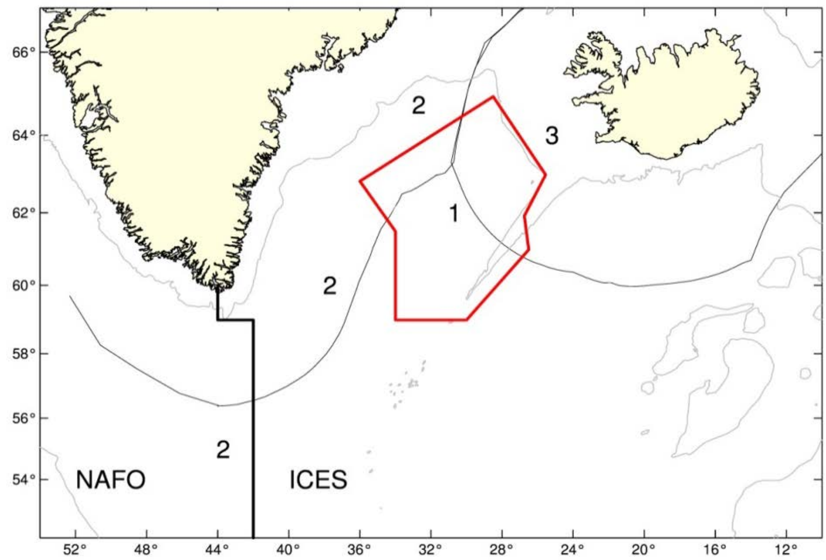

Figure A.4.1. Management unit boundaries for beaked redfish (*S. mentella*) in the Irminger Sea and adjacent waters. The polygon bounded by red lines, i.e. 1, indicates the region of the deep-pelagic management unit in the northwest Irminger Sea, 2 is the shallow-pelagic management unit in the Irminger Sea and adjacent waters including within the NAFO Convention areas, and 3 is the Icelandic slope management unit which is within the Icelandic EEZ.

B. Data

B.1. Commercial catch

Iceland, Greenland, Faroe Islands, Norway, Germany and Russia are the nations providing the most complete databases, including detailed vessel and gear information, as well as catch data on a haul to haul basis. The rest of the countries supply catch in weight and the length composition of the catch.

The preliminary official landing data are provided by the ICES Secretariat, NEAFC and NAFO, and various national data are reported to the Group. The Group, however, repeatedly faces problems in obtaining reliable data due to unreported catches of pelagic redfish and lack of catch data disaggregated by depth from some countries. There are indications that reported effort (and consequently landings) could represent only around 80% of the real effort in certain years (see Chapter 19.3.3 in the 2008 NWWG report). No new data in IUU have been available since 2008.

Splitting of catches: In the period 1992-1996, the fishery gradually shifted towards greater depths and developed a clear seasonal spatial pattern. The fleets fished first the deep stock and moved to the south western Irminger Sea (south of 60°N and west of about 32°W) from mid-June to October to fish the shallow stock. Landings from these years have been assigned to the different biological stocks according to several criteria, such as landings by ICES statistical areas, ICES Divisions, by nation, and logbook data. When a nation lacked data, the average from the other nations was used instead. Landing data disaggregated by biological stock from this period are considered to be the most unreliable and must be regarded as the WG's best estimates (guesstimates). This task was carried out according to the NWWG meeting celebrated in 2004, Bergen.

B.2. Biological

Biological information is collected from commercial catches (Iceland, Russia, Spain and other EU countries). For Iceland and Spain, the data consist of length measurements, weight, sex, maturity stage, and otolith collection. Otoliths have not been age read.

The Group started to collate an international database with length distributions from the sampling of the fisheries on a spatially disaggregated level. Once complete, the horizontal and vertical differences in mean length by fishing areas can be illustrated as alternative to the portrayals by ICES/NAFO Divisions. The database includes data from Iceland, Greenland, Faroe Islands, Norway, Germany and Russia.

There is still a lack of basic information regarding the following aspects:

- population age structure, with the need to validate and standardise the methods for age and maturity determination,
- species identification of young individuals,
- location of nursery and mating areas,
- estimation of natural mortality.

There has already been some effort conducted to validate and harmonise the methodologies used for age determination at an international level (ICES, 2006 and 2009b). This should be further pursued, since there are still non-standard methodologies used by some Russian teams which forbid data compilation at an international level.

A maturity scale has been agreed at an international level (ICES WKMSREGH 2011, unpublished report) but there is a requirement for workshops to be conducted in order to guarantee that this scale is well understood and used in a standardised fashion across nation and research laboratories.

B.3. Surveys

Acoustic surveys have been conducted on pelagic redfish in the Irminger Sea and adjacent waters since 1982 (Table B.3.1). These surveys provide valuable information on the biology, distribution and relative abundance of oceanic redfish, as well as on the oceanographic conditions of the surveyed area. Many of them were undertaken by single nations, but after several joint surveys during the 1990s, an international trawl-acoustic survey has been conducted by Iceland, Germany and Russia (with Norway participating also in 2001) since 1999.

The Working Group for Redfish Survey (WGRS, formerly as SGRS and then PGRS) has organised and planned these international surveys since 1999 and distribute survey area and time among the participants.

Technical description

The technical details and description of the equipment used are described in (ICES, 2011a). Here, a brief summary of the sampling methodology of the surveys 1999-2011 is given.

Acoustics

In the 2011 survey, 38 kHz Simrad EK60 split-beam echosounder was used for the acoustic data collection on RV "Árni Friðriksson" and RV "Vilnyus" whereas on RV "Walther Herwig III" an EK500 was used, also equipped with a 38 kHz split-beam transducer. The settings of the acoustic equipment used during the survey are given in Table 2 in ICES (2011b). During the survey on board of the Icelandic and German vessels the post-processing system (EchoView V4.9, Myriax) was used for scrutinising the echograms, whereas FAMAS (a post-processing program developed by TINRO) was used in the Russian vessel. Mean integration values of redfish per 5 NM were used for the calculations.

The integration threshold of 80-84 dB/m^3 was used. A length based target

$$TS = 20\log L - 71.3 \text{ dB}$$

has been used for the estimation of the number of pelagic redfish in the survey area.

Earlier investigations (Magnússon *et al.*, 1994; Magnússon *et al.*, 1996; Reynisson and Sigurðsson, 1996) have shown that the acoustic values obtained from oceanic redfish exhibit a clear diurnal variation, due to a different degree of mixing with smaller scatter and to changes in target strength. In order to compensate for these effects, the acoustic data obtained when mixing is most pronounced (i.e. during the darkest hours of the night), are discarded and the values within the missing sections are estimated by interpolation.

In further data processing, the number of fish is calculated for statistical rectangles measuring 1° latitude x 2° longitude. Changes in the length range of redfish in the past acoustic surveys are taken into account by changing the length-based target strength formula accordingly (Reynisson, 1992, ICES, 2011 for details). The total number of fish within the subareas A-F in which the survey area is divided (Figure B.3.1) is then obtained by summation of the individual rectangles. The acoustic results were further divided into the number of individuals and biomass based on the biological samples representative for each subarea.

For the entire survey area, single-fish echoes from redfish are expected to be detectable down to 350 m. In order to include all echoes of interest, a low integration threshold is chosen (i.e., -80 dB//m^3 for the 2011 survey). Based on the depth distribution of redfish observed during the survey and the expected target strength distribution, the method outlined by Reynisson (1996) is used to estimate the expected bias due to thresholding. The results of the biomass calculations were adjusted accordingly.

The measurements of echo-sounders can be disturbed by noise (from the ambient and the vessel) and reverberation (echoes reflected from unwanted targets). Because the amplitude of the signal decreases with depth whereas the amplitude of noise increases due to time varied gain, very small noise can prevent the measurements. Thus, to improve the signal to noise ratio, a threshold is usually applied (Bethke, 2004).

When the redfish appears mixed with other deep-sea species, or the weather is bad and disturbs the measurements, echo counting is preferred over echo integration, as described in Bethke (2004). The counting procedure is based on the fact that fish are recognized as single targets according to the parameter settings of the echo-sounder. However, if redfish is found in dense aggregations, echo integration is more accurate. Switching between methods may be necessary during the survey (ICES, 2011).

To get biological information on the redfish acoustically identified trawling for 4 NM is done. The net used on RV "Árni Friðriksson" and RV "Walther Herwig III" was a Gloria type #1024, with a vertical opening of approximately 50 m. The net used on RV "Vilnyus" was a Russian pelagic trawl (design 75/448) with a circumference of 448 m and a vertical opening of 47-50 m. Russia used a mesh opening of 40 mm in the codend, while Iceland and Germany used a mesh opening of 23 mm in the codends. The trawls used on RV "Árni Friðriksson" and RV "Walther Herwig III" were fitted with multiple codend sampling device: the 'multisampler' (Engås *et al.,* 1997). This allowed for successive sampling at three distinct depth zones within one trawl haul and without 'contamination' from one depth to the next, as well as no sampling during shooting or heaving of the trawl.

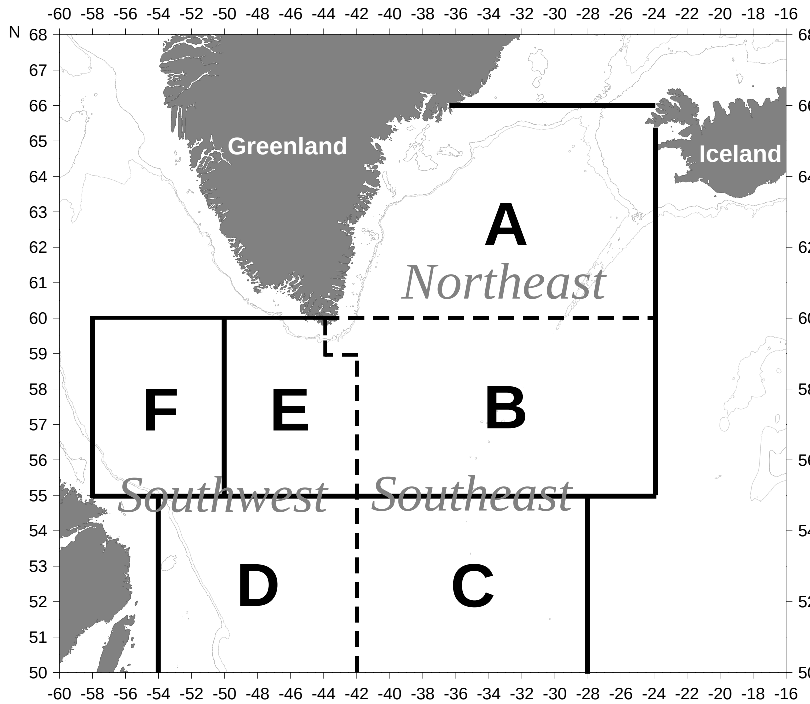

Figure B.3.1. Sub-areas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines).

Table B.3.1. Summary of trawl-acoustic surveys conducted in the Irminger Sea and adjacent waters 1982-2011. The surveys 1982-1997 were acoustic surveys whereas the surveys 1999-2011 were both acoustic and trawl surveys. In all surveys CTD station were taken down to 1000 m. AC=Acoustic survey; TR/AC=Trawl-acoustic survey; RUS=Russia; ICE=Iceland; GER=Germany; NOR=Norway

Year	Time	Type	Area surveyed NM2	Depth (m)	Nation	Reference
1982		AC	40		RUS	Pavlov and Mamylov, 1989.
1983		AC	50		RUS	Pavlov and Mamylov, 1989.
1984		AC	55		RUS	Pavlov and Mamylov, 1989.
1985		AC	71		RUS	Pavlov and Mamylov, 1989.
1986		AC	117		RUS	Pavlov and Mamylov, 1989.
1987		AC	215		RUS	Pavlov and Mamylov, 1989.
1988		AC	163		RUS	Pavlov and Mamylov, 1989.
1989	June/July	AC	148		RUS	Shibanov et al., 1996a.
1990	June/July	AC	73		RUS	Shibanov et al., 1996a.
1991	June/July	AC	105		RUS	Shibanov et al., 1996a.
1991	June	AC	60	0-500	ICE	Magnússon et al., 1992a.
1992	May/July	AC	190	0-500	ICE/RUS	Magnússon et al., 1992b.
1993	June/July	AC	121		RUS	Shibanov et al., 1996a.
1994	June/July	AC	190	0-500	ICE/NOR	Magnússon et al., 1994.
1995	June/July	AC	168	0-500	RUS	Shibanov et al. 1996b.
1996	June/July	AC	253	0-500	GER/ICE/RUS	Magnússon et al., 1996.
1997	June/July	AC	158	0-500	RUS	Melnikov et al., 1998.
1999	June/July	TR/AC	296	0-950	GER/ICE/RUS	Sigurdsson et al. 1999.
2001	June/July	TR/AC	420	0-950	GER/ICE/RUS/NOR	ICES, 2002.
2003	May/June	TR/AC	405	0-950	GER/ICE/RUS	ICES, 2003.
2005	June/July	TR/AC	386	0-950	GER/ICE/RUS	ICES, 2005.
2007	June/July	TR/AC	349	0-950	ICE/RUS	ICES, 2007b.
2009	June/July	TR/AC	360	0-950	GER/ICE	ICES, 2009c.
2011	June/July	TR/AC	343	0-950	GER/ICE/RUS	ICES, 2011b.

Biological sampling

Catch weight and number of all species are recorded for each haul. The individual biological sampling of deep-water redfish was done in following way (taken from ICES (2011a)):

4. The total length (cm below), individual weight, sex and stage of maturity are measured on at least 300 redfish from each haul type.

5. Otolith sampling is carried out at each station. Sampling is conducted on 50 individuals following a random sampling procedure (i.e. not stratified by length).
6. Observations on the stomach fullness, the location and size of skin/muscular pigments as well as infestation with *Sphyrion lumpi* and its remnants are investigated on at least 50 randomly sampled fish (usually collected on individual fish from which otoliths are sampled).

B.4. Commercial CPUE

It is not known to what extent the CPUE reflects changes in the stock status of pelagic *S. mentella*. Since the fishery focuses on aggregations, the CPUE series might not indicate or reflect actual trends in stock size.

B.5. Other relevant data

C. Historical Stock Development

Model used: Some participants in the WKRED-2012 Working Group considered that no model was suitable and that, the assessment of pelagic redfish in the Irminger Sea and adjacent waters should be based on survey indices, catches, CPUE and biological data.

The external panel noted that a concern with any assessment of this resource is possible violation of the assumption of a closed population. There may have been a distributional shift out of area covered by the survey due to environmental changes; this will be addressed in upcoming meeting on oceanographic drivers of stock distribution. A change in distribution has been observed in the surveys over time and will be the topic of that workshop.

However if the survey results are accepted as an index of population abundance, then the external panel considered that although the biomass dynamic models (the Schaefer model, and the aggregated model assuming very poor recruitment) are preliminary and should be improved, it is possible to use the former to initially assess stock status and current replacement yield (RY, being the annual catch estimated to maintain abundance at its present level) based on information from past catches, the acoustic-trawl survey, and external information used to inform on the likely range of the value for stock productivity parameter r. The poor recruitment model can (like the Schaefer model) be used to provide an estimate of the current depletion (the present to pre-exploitation abundance ratio), though naturally that model implies no sustainable yield for as long as such poor recruitment might continue. For the values of stock productivity parameter considered the most realistic ($r = 0.05$ to $r = 0.10$), the Schaefer model approach provides estimates of the current depletion (the present to pre-exploitation abundance ratio) of this resource to be about 4% with CVs of about 50%; these compare with estimates from the poor recruitment model (which provides a better fit to the data) of about 1% to 4%, depending upon the level of natural mortality (M) and survey catchability (q). Estimates of RY from the Schaefer model range from about 2 (SE 1) to 4 (SE 2) thousand tons, by comparison with an average annual catch over the 2000 to 2010 period of about 24 thousand tons. Although the precision of these RY estimates is poor, the panel draws attention to the approach suggested in the general recommendations section whereby the requirements of the precautionary approach can be addressed by decreasing catch limit estimates by some multiple of the associated SE estimate. The panel does not suggest that either the Schaefer or poor recruitment model approaches used here should be final; to the contrary they are offered as a first step (from which interim management advice might be formulated) while the assessment is extended to an Age Structured Production Model framework which could, for example, also take account of the commercial catch-at-length and ageing data available for this resource. While the projection and reference point computations referenced below are possible within the Schaefer model framework, the panel did not consider it appropriate to report them at this stage, given the interim and intermediate nature of this approach. The difficulties found by the panel with the "trends based assessment" approach are set out in the general recommendations section.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	Since 1982		Yes
Canum	Catch at age in numbers			
Weca	Weight at age in the commercial catch			
West	Weight at age of the spawning stock at spawning time.			
Mprop	Proportion of natural mortality before spawning			
Fprop	Proportion of fishing mortality before spawning			
Matprop	Proportion mature at age			
Natmor	Natural mortality			

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1			
Tuning fleet 2			
Tuning fleet 3			
….			

D. Short-Term Projection

Model used:

Software used*:*

Initial stock size:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Procedures used for splitting projected catches:

E. Medium-Term Projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Uncertainty models used:

1. Initial stock size:
2. Natural mortality:
3. Maturity:
4. F and M before spawning:
5. Weight at age in the stock:
6. Weight at age in the catch:
7. Exploitation pattern:
8. Intermediate year assumptions:
9. Stock recruitment model used:

F. Long-Term Projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

For pelagic redfish in the Irminger Sea and adjacent waters, no analytical assessment is carried out due to data uncertainties and the lack of reliable age data. Thus, no reference points can be derived.

H. Other Issues

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Stock Annex – Golden redfish (Subareas V and XIV)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	**Golden redfish (*Sebastes norvegicus*) in ICES Subareas V and XIV**
Working Group	**NWWG**
Date	**February 2014**
Revised by	**Kristján Kristinsson, Höskuldur Björnsson**

A. General

A.1. Stock definition

Golden redfish (*Sebastes norvegicus*) on the continental shelves of East Greenland, Iceland and Faroe Islands (ICES Subareas V and Division XIVb) is considered one stock. This stock definition is based on the location of copulation and extrusion area (Magnússon and Magnússon, 1977; Magnússon, 1980; ICES, 1983). The few population genetic studies that have been conducted do not provide definitive results (Nedreaas *et al.*, 1994; Pampoulie *et al.*, 2009).

Geographical range of golden redfish in the East Greenland/Iceland/Faroe Islands region is shown in Figure A.1.1. Golden redfish is most abundant in Icelandic waters (ICES Division Va) and where most of the commercial catches are taken. Golden redfish is found all around Iceland, but the areas of the highest abundance are west, southwest, south and southeast of Iceland at depths of 100–400 m. The main nursery areas are off East Greenland and Iceland. In Icelandic waters they are found all around the country, but are mainly located off the west and north coasts at depths between 50 m and 350 m. No nursery grounds are known in the Faroese waters (ICES, 1983; Einarsson, 1960; Magnússon and Magnússon, 1975; Pálsson *et al.*, 1997). As they grow, the juveniles migrate along the north coast towards the most important fishing areas off the west and southwest coast, but also to the Southeast fishing areas and to Faroese fishing grounds in ICES Division Vb.

A.2. Fishery

Exploitation of golden redfish of the East Greenland/Iceland/Faroe Islands stock (EGIF stock) started in the mid-1920s in Icelandic waters, and after the Second World War in the two other areas (Figure A.2.1).

The landings from the EGIF stock peaked in 1955 to 160 000 t (Figure A.2.1.), in the same year the fishery started in East Greenland waters. Between 1956 and 1978 the landings gradually decreased in all areas to 50 000 t but then increased again, especially in Icelandic waters. The total annual landings rose to a peak of 130 000 t in 1982. In the late 1980s the fishery collapsed in East Greenland waters and decreased in the two other areas. For the past 20 years the annual landings have been around 40 000 t and a 95–98% has been taken in Icelandic waters.

Annual landings and overview of the major fleet

Iceland

The fishery for golden redfish in Icelandic waters started in the early 1920s but annual landings started to increase in the late 1930s (Figure A.2.1). Annual landings in 1936–

1939 varied between 40–65 thousand tonnes, compared to an average of 10 thousand tonnes in 1922–1935. During the interwar period redfish was mainly caught by foreign vessels operating in Icelandic waters. This fishery was unimportant during World War II but increased rapidly after the war and to a record high of 140 thousand tonnes in 1951. Annual landings in 1956–1977 ranged between 60–115 thousand tonnes. The majority of the catches were taken by foreign vessels, mainly from West-Germany. Since 1977, with the expansion of the EEZ to 200 nautical miles, mainly Icelandic vessels have fished for golden redfish in Icelandic waters. Landings declined from about 98 000 t in 1982 to 39 000 t in 1994. Since then, landings have oscillated between 32 000 and 49 000 t. Average annual landings in 2000–2011 have been around 40 000 tonnes.

The fishery for golden redfish in Icelandic waters is directed and predominantly conducted by the Icelandic bottom-trawl fleet, and accounts for more than 90% of the total catch. The rest is partly caught as bycatch in the gillnet, longline, and lobster fisheries. The most important fishing grounds are southwest and west of Iceland at 200–400 m depth.

The fishing fleet operating in Icelandic waters consists of diverse boat types and sizes, operating various types of gear. Golden redfish is mostly caught by the same vessels that are fishing for the pelagic and Icelandic slope *S. mentella* stocks. These are trawlers larger than 40 BRT equipped with bottom trawls.

Greenland

The fishery for golden redfish in East-Greenland waters (ICES Subarea XIV) started in the early 1950s and annual landings have been more variable than in the other areas (Figure A.2.1). Until early 1980s the fishery was mainly conducted by West-Germany, except in 1976 when the former USSR exceeded the catches of West-Germany.

The landings peaked in 1955 to about 80 000 t shortly after the fishery commenced in the area. The annual landings then declined and ranged between 8000 and 41 000 t during the period 1957 to 1975, being on average 27 000 t. In 1976 the landings increased suddenly to 54 000 t mainly because of increased redfish fishery of the former Soviet Union. The annual landings immediately dropped to 15 000 t and were at that level for the next few years. After the landings reached 31 000 t in 1982, the golden redfish fishery drastically declined within the next three years. During the period 1985–1994, the annual landings from Subarea XIV varied between 600 and 4200 t, but from 1995 to 2008 there has been little or no direct fishery for golden redfish and landings were 200 t or even less, mainly taken as bycatch in the shrimp fishery. In 2009, a fishery targeting redfish was initiated in ICES XIV. In 2010, landings of golden redfish increased considerable and were 1600 t, similar to early 1990s levels. This increase is mainly due to increased directed redfish fishery in the area.

Faroe Islands

Directed fishery for golden redfish in Faroese waters (ICES Division Vb) was very little until 1978 (Figure A.2.1.). Landings rose to 9000 tonnes in 1985 but dropped gradually to 1500 t in 1999. Between 1999 and 2005 annual landings varied between 1500 and 2500 t, but afterwards they have oscillated between 460 to 690 t. Annual landings had never been so low.

The majority of the golden redfish caught in Division Vb is taken by pair and single trawlers (vessels larger than 1000 HP), mainly as bycatch in other fisheries.

Management and regulations

Iceland

The Ministry of Fisheries and Agriculture in Iceland is responsible for the management of all Icelandic fisheries and law enforcement within the Icelandic Exclusive Economic Zone (EEZ). The Ministry issues regulations for commercial fishing for each fishing year (from September 1st to August 31st the following year), including allocation of the TAC for each of the stocks subject to such limitations. Below is a short account of the main features of the management system, with emphasis on golden redfish when applicable. Further and detailed information on the management and regulations can be found at http://www.fisheries.is/.

A system of transferable boat quotas was introduced in 1984, but was changed to an individual transferable quota (ITQ) system in 1990. The fisheries are subjected to vessel catch quotas. The quotas represent shares in the national total allowable catch (TAC). Since the 2006/2007 fishing season, all boats operate under the TAC system. Until 1990, the quota year corresponded to the calendar year but since then the quota, or fishing year, starts on September 1 and ends on August 31 the following year. The agreed quotas are based on the Marine Research Institute's TAC recommendations, taking some socio-economic effects into account.

Within this system, individual boat owners have substantial flexibility in exchanging quota, both among vessels within the same company and among different companies. The latter can be done via a temporary or permanent quota transfer. In addition, some flexibility is allowed to individual boats regarding the transference of allowable catch of one species to another. These measures, which can be acted on more or less instantaneously, are likely to reduce initiative for discards (which is effectively banned by law) and misreporting than can be expected if individual boats are restricted by TAC measures alone. They may, however, result in fishing pressures of individual species to be different than intended under the single species TAC allocation.

Furthermore, a vessel can transfer some of its quota between fishing years. There is a requirement that the net transfer of quota between fishing years must not exceed 10% of a given species (was changed from 33% in the 2010/2011 fishing year). This may result in higher catch in one fishing year than the set TAC and subsequently lower catches in the previous year.

Landings in Iceland are restricted to particular licensed landing sites, with information being collected on a daily basis time by the Directorate of Fisheries (the native enforcement body). All fish landed has to be weighted, either at harbour or inside the fish processing factory. The information on landings is stored in a centralized database maintained by the Directorate and is available in real time on the Internet (www.fiskistofa.is). Between 5–10% of the golden redfish caught annually in Icelandic waters is landed in foreign ports. The accuracy of the landings statistics are considered reasonable although some bias is likely.

All boats operating in Icelandic waters have to maintain a logbook record of catches in each haul. For the larger vessels (for example vessels using bottom and pelagic trawls) this has been mandatory since 1991. The records are available to the staff of the Directorate for inspection purposes as well as to the stock assessors at the Marine Research Institute.

Redfish (golden redfish (*S. norvegicus*) and Icelandic slope *S. mentella*) has been within the ITQ system since the beginning. Icelandic authorities gave a joint quota for these two species until the fishing year 2010/2011, although the MRI has provided a separate advice for the species since 1994. The separation of quotas was implemented in the fishing year that started September 1, 2010. Since the 1994/1995 fishing year, the total annual landings of golden redfish have exceeded the recommended TAC in most years.

Regulations

With some minor exceptions, it is required by law to land all catches. For golden redfish there is no formal harvest control rule. The minimum allowable mesh size is 135 mm in the trawl fisheries, with the exception of targeted shrimp fisheries in waters north of the island.

The minimum legal catch size for golden redfish is 33 cm for all fleets, with allowance to have up to 20% undersized (i.e. <33 cm) specimens of golden redfish (in numbers) in each haul. If the number of redfish <33 cm in a haul is more than 20%, fishing is prohibited for at least two weeks in those areas. Below is a sort description of area closures in Icelandic waters.

Real-time area closure: A quick closure system has been in force since 1976 to protect juvenile fish. Fishing is prohibited up to two weeks in areas where the number of small fish in the catches has been observed by inspectors to exceed certain percentage (for example 25% or more of <55 cm cod and saithe, 25% or more of <45 cm haddock, and 20% or more of <33 cm redfish). If there are several consecutive quick closures in a given area the Minister of Fisheries can close the area for longer time with regulations, forcing the fleet to operate in other areas. Inspectors from the Directorate of Fisheries supervise these closures in collaboration with the Marine Research Institute.

Permanent area closures: In addition to allocating quotas on each species, there are other measures in place to protect fish stocks. Based on knowledge of the biology of various stocks, many areas have been closed temporarily or permanently aiming at juvenile protection. Figure 1 shows the map of such area closures that was in force in 2006. Some areas have been closed for decades.

Temporary area closures: The major spawning grounds of cod, plaice and wolfish are closed during the main spawning period of these species. This measure was partly initiated by the fishermen.

Since 1991, when the first redfish closure took place, there have been another 68 quick closures in golden redfish fishing grounds (Table A.2.1 and Figure A.2.2). Quick closures have been fewer for small golden redfish since 2001, or three every year on average, because large areas southwest and west of Iceland are permanently or temporarily closed to trawling to protect juvenile golden redfish (Figure A.2.3). These areas were closed partly because quick closures on redfish fisheries happened very often during the period 1991–1995 (Schopka, 2007).

Faroe Islands

Management measures and regulations

Since 1 June 1996, a management system based on a combination of area closures and individual transferable effort quotas in days within fleet categories has been in force for the Faroese demersal fisheries. The individual transferable effort quotas apply to all fleets (from 2010), except for gillnetters fishing for Greenland halibut and monkfish, which are regulated by a fixed number of licences, by fishing depth and technical measures like maximum allowed number of nets, mesh size and maximum fishing time for each set. Pelagic fisheries for herring, blue whiting and mackerel are regulated by TACs. Trawlers are in general not allowed to fish within the 12 nautical mile limit and large areas on the shelf are closed to them. Inside the 6 nautical miles limit only longliners less than 110 GRT and jiggers less than 110 GRT are allowed to fish. The Faroe Bank shallower than 200 m is closed to all trawl and gillnet fisheries.

Technical measures such as area closures during the spawning periods, to protect juveniles and young fish, and mesh size regulations are a natural part of fisheries regulations.

Vessels from other nations are licensed to fish in Faroese waters through bilateral and multilateral agreements, regulated by TACs. Only Norway and EU have permission to fish deep-water species, but since no agreement has been reached in the negotiations on mutual fishing rights between the Faroese and Norway/EU since 2010, these parties, for the moment, are not allowed to fish in Faroese waters.

Greenland

Management measures and regulations

Management of golden redfish in the Greenland EEZ is managed by the Greenland Ministry of Fisheries, Hunting and Agriculture. There was no redfish directed fishery for more than a decade in east Greenland, but in 2009 an experimental fishery was successful, and the fishery was reopened. The fisheries are subjected to vessel catch quotas, which represents a share of the total allowable catch (TAC). The TAC is set by the Ministry of Fisheries, Hunting and Agriculture and is based on a mixed fishery, with no distinction being made between *S. norvegicus* and *S. mentella*. Hence, the mixed species TAC for 2010 was 6000 t, and this increased to 8500 t in 2011–2012 (assuming an 80:20 split between *S. mentella* and *S. norvegicus*).

All vessels are required to fill out logbooks records of the catch in each haul, and the information is made available to the Greenland Institute of Natural Resources. The fishery has since 2009 also been obligated to provide frozen samples of whole fish to the Greenland Institute of Natural Resources, with the objective to provide a species splitting factor and the collection of samples for a genetically based stock assignment study. Continued sampling from catches is necessary to allow for a continued monitoring of shifts in the species composition.

Catches of Golden redfish in the redfish directed fishery reached approximately 1700 t in 2011 (estimated from an 80:20 split of 8381 t mixed catches of *S. mentella* and *S. norvegicus*). The catches are taken in a small area just east of Kleine Banke (64°N 36°W and just northeast from here at 64°30′ N–65°N and 35°W). The fishery contracted from 2009–2011, and it appears that the fishery is taking place on a large local aggregation of redfish.

Greenland opened an offshore cod fishery on the east coast of Greenland in 2008. To protect spawning aggregations of cod present management measures in Greenland EEZ prohibits trawl fishery for cod north of 63°N latitude. In 2009 and 2010 in this area was extended to 62°N. In 2012 this area closure was annulled, and instead all fishing directed for cod must take place after July 1st. This is done to protect spawning aggregations of cod in the Greenland EEZ. Due to the depth distribution of *S. norvegicus* (Hedeholm and Boje, 2012, WD#9) it is vulnerable to bycatch in the cod fishery, however, the current level of bycatch is considered insignificant (<1.5 t).

The introduction of grid separators in the shrimp fishery has reduced bycatch to very small amounts, and is not considered significant, especially since the shrimp fishery in the East Greenland area is limited (Sünksen, 2007).

A.3. Ecosystem aspects

Golden redfish is ovoviviparous, meaning that eggs are fertilized, develop and hatch internally. The male and female mate several months before the female extrudes the larvae. The females carry sperm and non-fecundated eggs for months before fertilization takes place in winter. Females are thought to have a determinate fecundity. Golden redfish produce many, small larvae (37–350 thousand larvae) that are extruded soon after they hatch from eggs and disperse widely as zooplankton (Jónsson and Pálsson, 2006). The extrusion of larvae may take place over several days or weeks in a number of batches. Knowledge of the biology, behaviour and dynamics of golden redfish reproduction is very scarce.

Growth and maturity

Golden redfish is, like most redfish species, long-lived, slow-growing and late-maturing. Males mature at age 8–10 at size 31–34 cm, whereas females mature age 12–15 at size 35–37 cm (Jónsson and Pálsson, 2006).

Diet

The food of golden redfish consists of dominant plankton crustaceans such as amphipods, copepods, calanoids, and euphausids (Pálsson, 1983).

B. Data

B.1. Commercial catch

The text table below shows landings data supplied from each area.

	Kind of data				
Country/area	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
Iceland (Va)	x	x	x	x	x
Faroe Islands (Vb)	x				x
Greenland (XIV)	x				x

B.1.1. Iceland

Icelandic commercial catch data, in tonnes by month, area and gear, are obtained from Statistical Iceland and the Directorate of Fisheries. The geographical distribution of catches (since 1991) is obtained from the logbooks, where location of each haul, effort, depth of trawling and total catch of golden redfish are recorded.

B.1.1.1 Splitting the redfish catches in ICES Division Va between S. norvegicus and Icelandic slope S. mentella

Until the 2010/2011 fishing season, Icelandic authorities gave a joint quota for *S. norvegicus* and Icelandic slope *S. mentella* in ICES Division Va. Icelandic fishermen were not required to divide the redfish catch into species. This was a problem when catch statistics of those two species were determined. Since 1993, a so-called *split–catch* method has been used to split the Icelandic redfish catches between the two species.

B.1.1.1.1. Data

The following data were used:

- Data from logbooks of the Icelandic fleet (information on the location of each haul, how much was caught of redfish, and if available, the species composition of the catch).
- Information on landed products from Icelandic factory (freezer) trawlers.
- Biological samples from the Icelandic fresh-fish trawlers sampled by MRI and Icelandic Catch Supervision (ICS) personnel.
- Landing statistics from Germany and UK if available.
- Landing statistics from foreign vessels fishing in Icelandic waters.
- Official landings by gear type provided by Directorate of Fisheries in Iceland.

B.1.1.1.2. Splitting the redfish catch from freezer trawlers

The redfish landings data of the freezer fleet are divided into species in landing reports and considered reliable. However, the official landings for each fishing trip are not divided by gear type if more than one was used (in this case bottom trawl and pelagic trawl), but set on one gear type (usually bottom trawl). The freezer trawlers mainly use bottom trawl in the redfish fishery, but in some years, especially in the 1990s, they also used pelagic trawls. Based on logbooks, the redfish caught with pelagic trawl was Icelandic slope *S. mentella*.

To get reliable species composition of the bottom-trawl catch, the total catch of the freezer trawler for each species was estimated. If for a given year redfish was caught with pelagic trawl (total catch was based on logbooks) the catch was subtracted from the total *S. mentella* catch.

B.1.1.1.3. Splitting the redfish catch from the fresh fish trawlers

The catch is first divided into defined strata and split into species according to the ratio of *S. norvegicus*/*S. mentella* observed in biological samples from each strata. Each stratum is a 15′ Latitude x 30′ Longitude rectangle.

1) **For each year:** The redfish catch from each year was divided into strata and scaled to the total un-split catch of the two species for each rectangle. It is assumed that the distribution of catch not reported in logbooks was the same as the reported catch. Catch taken by other gears was included (it usually represented about 2% of the total catch).

2) **For each stratum and each year:** The biological samples taken from the commercial catch were used to split the catch in each stratum into species. In this step, the average species composition in the samples in each stratum is estimated and then applied to the total catch of the fleet in that stratum (see previous step). If no information on species composition in a stratum for any given year was available, the species composition one year before was used if available. If not, then the species composition two years before was applied, and so forth up to a maximum of five years before a given year. If no

samples were available in a five year period, the splitting was done according to depth and the captain's experience. Only a small proportion of the catch was split into species using this last criterion.

3) The split into species of redfish landings in Germany and UK (containers or fresh landings) is based on landings reports and considered reliable.

4) For other nations operating in ICES Division Va, the catches are split according to information given by those nations. In 2009, only Faroe Islands and Norway operated in ICES Division Va.

B.1.1.1.4. Other gears

Between 92–98% of the annual redfish catch is caught with bottom trawls. The redfish caught with other gear types, i.e. longline, gillnet, hook and line, Danish seine, and lobster trawl is assumed to be *S. norvegicus*, because boats using these gear types mainly operate in shallow waters were only *S. norvegicus* is found.

B.1.2. Greenland

The Greenland authorities operate the quota uptake with three types of redfish:

- fish caught by bottom trawl and longlines on the bottom are named *Sebastes norvegicus*;
- fish caught pelagic in the Irminger Sea are named *Sebastes mentella*;
- fish caught as bycatch in the shrimp fishery are named *Sebastes* sp.

From the Greenland and German surveys we know that the demersal redfish found in the area is a mixture of *S. norvegicus* and *S. mentella*. All surveys report that *S. mentella* dominates the catch. According to survey background and one sample of fish from the commercial fishery, the amount of *S. mentella* caught in XIVb in 2009 and 2010 is estimated as 80% of the reported catch of demersal redfish derived from logbooks. This separation has been conducted with different proportions of *S. mentella* in years with significant catches (e.g. 1986), but it remains uncertain what have been done through the years with low catches.

B.1.3. Faroe Islands

Faroese commercial catch data are in tonnes by month, area and gear, and supplied by Statistics Faroe Islands and the Directorate of Fisheries. The geographical distribution of catches is obtained from the logbooks, where location of each haul, effort, depth of trawling and total catch of redfish are recorded.

Since golden redfish is landed just as redfish, there is a need to use all available information to split the catches into *S. norvegicus* and *S. mentella*, respectively.

For the Faroese catches, this split is based on data from Research Vessels surveys on horizontal and vertical distribution of the two species, from regular biological sampling of the redfish landings by fleet, and from logbooks (information on the location of each haul, effort, depth of trawling and how much redfish was caught).

For the catches from other nations, official landings statistics (STATLANT) and information from national laboratories are used to split catches into the two species.

B.1.4. Biological data from the commercial catch

Sampling from the Icelandic fleet

Biological data from the commercial catch were collected from landings by scientists and technicians of the Marine Research Institute (MRI) in Iceland and directly on board on the commercial vessels (mainly length samples) by personnel of the Directorate of Fisheries in Iceland. The biological data collected are length (to the nearest cm), sex, maturity stage and otoliths for age reading.

The general process of the sampling strategy by the MRI since 1999 is to take one sample of golden redfish for every 500 tonnes landed. Each sample consists of 200 individuals: otoliths are extracted from 30 fish which are also length measured, weighed, and sex and maturity determined; 70 fish are length measured, weighted, sex and maturity determined; the remaining 100 are length measured and sex and maturity determined.

Sampling data of size composition from the bottom-trawl fleet are available from 1956–1966 and 1970–2010, but sampling before 1976 is rather limited. Since 1999, 219–434 samples are taken annually and 35 000–74 000 individuals are length measured annually (Table B.1.2.1).

Sampling of age composition from the bottom-trawl fleet only started in 1995. For the first two years, age reading was scarce, but since 2000 the annual number of samples has been between 45 and 50 and 1600–1800 otoliths are age determined (Table B.1.2.1).

The data are stored in a database at the Marine Research Institute and are used to generate an age–length key (ALK) and as input data for the GADGET model.

Sampling from the Faroese fleet

Length samples from the Faroese fleet are available from 2001 and there are a few samples from the early 1990s.

Sampling from East Greenland

Length samples are available from the German commercial fleet operating in East Greenland waters 1975–1991, 1999, 2002 and 2004. Few length samples are available from the newly started Greenland fishery.

B.2. Biological

The total catch-at-age data in Va from 1995 is based on Icelandic otolith readings.

B.3 Surveys

Icelandic surveys in Va

Two bottom-trawl surveys, conducted by the Marine Research Institute in ICES Division Va, are considered representative for golden redfish: the Icelandic Groundfish Survey (IGS or the Spring Survey) and the Autumn Groundfish Survey (AGS or the Autumn Survey). The Spring Survey has been conducted annually in March since 1985 on the continental shelf, at depths shallower than 500 m, and it has a relatively dense station-grid (approximately 600 stations). The Autumn Survey has been conducted in October since 1996 and covers larger area than the Spring Survey. It is conducted on the continental shelf and slopes and extends to depths down to 1500 m. The number of stations is about 380 so the distance between stations is often larger.

The text in the following description of the surveys is mostly a translation from Björnsson *et al*. (2007). The emphasis has been put on golden redfish where applicable. The report, written in Icelandic with English abstract and English text under each table and figure, can be found at the MRI website under the following link: http://www.hafro.is/Bokasafn/Timarit/rall_2007.pdf. An English version of the survey manual can be found at http://www.hafro.is/Bokasafn/Timarit/fjolrit-156.pdf.

B.3.1. Spring Survey in Va

The stated aim of the Spring Survey has been since the beginning the estimation of abundance of demersal fish stocks, particularly the cod stock, with increased accuracy and thereby strengthening the scientific basis of fisheries management. That is, to get fisheries-independent estimates of abundance that would result in increased accuracy in stock assessment relative to the period before the Spring Survey. Another aim was to start and maintain dialogue with fishermen and other stakeholders.

To help in the planning, experienced captains were asked to map out and describe the various fishing grounds around Iceland and then they were asked to choose half of the tow-stations taken in the survey based on their fishing experience. The other half was chosen randomly by the scientists at the MRI, but the captains were asked to decide the towing direction for all the stations.

B.3.1.1. Timing, area covered and tow location

It was decided that the optimal time of the year to conduct the survey would be March, or during the spawning of cod in Icelandic waters. During this time of the year, cod is most easily available to the survey gear as diurnal vertical migrations are at minimum in March (Pálsson, 1984). Previous survey attempts had taken place in March and for possible comparison with those data it made sense to conduct the survey in the same month.

The total number of stations was decided to be 600 (Figure B.3.1), to decrease variance in indices and keep the survey within the constraints of what was feasible in terms of survey vessels and workforce available. With 500–600 tow-stations the expected CV of the survey would be around 13%.

The survey covers the Icelandic continental shelf down to 500 m and to the EEZ-line between Iceland and Faroe Islands. Allocation of stations and data collection is based on a division between northern and southern areas. The northern area is the colder part of Icelandic waters where the main nursery grounds of cod are located, whereas the main spawning grounds are found in the warmer southern area. It was assumed that 25–30% of the cod stock (in abundance) would be in the southern area at the survey time but 70–75% in the north. Because of this, 425 stations were allocated in the colder northern area and 175 stations were allocated in the southern area. The two areas were then divided into ten strata, four in the south and six in the north.

Stratification of the survey area and the allocation of stations were based on pre-estimated cod density patterns in different "statistical squares" (Pálsson *et al*., 1989). The statistical squares were grouped into ten strata depending on cod density. The number of stations allocated to each stratum was in proportion to the product of the area of the stratum and cod density. Finally, the number of stations within each stratum was allocated to each statistical square in proportion to square size. There are up to 16 stations in each statistical square in the Northern area and up to seven in the southern area.

B.3.1.2. Vessels, fishing gear and fishing method

In the early stages of the planning it was apparent that consistency in conducting the survey on both spatial and temporal scale was of paramount importance. It was decided to rent commercial stern trawlers built in Japan in 1972–1973 to conduct the survey. Each year, up to five trawlers have participated in the survey, each in a different area (NW, N, E, S, SW). The ten Japanese built trawlers were all built on the same plan and were considered identical for all practical purposes. The trawlers were thought to be in service at least until the year 2000. This has been the case and most of these trawlers still fish in Icelandic waters but have had some modifications since the start of the survey, most of them in 1986–1988.

The survey gear is based on the trawl that was the most commonly used by the commercial trawling fleet in 1984–1985. It has a relatively small vertical opening of 2–3 m. The headline is 105 feet, fishing line is 63 feet, footrope 180 feet and the trawl weight 4200 kg (1900 kg submerged).

Length of each tow was set at 4 nautical miles and towing speed at approximately 3.8 nautical miles per hour. The minimum towing distance so that the tow is considered valid for index calculation is 2 nautical miles. Towing is stopped if wind is more than 17–21 m/sec, (8 on Beaufort scale).

B.3.1.3. Later changes in vessels and fishing gear

The trawlers used in the survey have been changed somewhat since the beginning of the survey. The changes include alteration of hull shape (bulbous bow) and size (hull extended by several meters), larger engines, and some other minor alterations. These changes have most likely changed ship performance, but they are very difficult to quantify.

The trawlers are now considered old and it is likely that they will be decommissioned soon, so the search for replacements has started. In recent years, the MRI research vessels have taken part in the Spring Survey after carrying out elaborate comparison studies. The RV Bjarni Sæmundsson has surveyed the NW-region since 2007 and RV Árni Friðriksson has surveyed the Faroe–Iceland Ridge in recent years and will survey the SW area in 2010.

The trawl has not changed since the start of the survey. The weight of the otter-boards has increased from 1720–1830 kg to 1880–1970 kg, which may have increased the horizontal opening of the trawl and hence decreased the vertical opening. However, these changes should be relatively small as the size (area) and shape of the otter-boards is unchanged.

B.3.1.4. Later changes in trawl stations

Initially, the numbers of trawl stations surveyed was expected to be 600 (Figure B.3.1). However, this number was not covered until 1995. The first year 593 stations were surveyed but in 1988 the stations had been decreased down to 545 mainly due to bottom topography (rough bottom that was impossible to tow), but also due to drift ice that year. In 1989–1992, between 567 and 574 stations were surveyed annually. In 1993, 30 stations were added in shallower waters as an answer to fishermen's critique.

In short, until 1995 between 596 and 600 stations were surveyed annually. In 1996, 14 stations that were added in 1993 were omitted. Since 1991 additional tows have been taken at the edge of the survey area if the amount of cod has been high at the outermost stations.

In 1996, the whole survey design was evaluated to reduce costs. The number of stations was decreased to 532 stations. The main change was to omit all of the 24 stations from the Iceland–Faroe Ridge. This was the state of affairs until 2004 when in response to increased abundance of cod on the Faroe–Iceland Ridge, nine stations were added. Since 2005, all of the 24 stations omitted in 1996 have been surveyed.

In the early 1990s there was a change from Loran C positioning system to GPS. This may have slightly changed the positioning of the stations as the Loran C system was not as accurate as the GPS.

B.3.2. Icelandic Autumn Groundfish Survey

The Icelandic Autumn Groundfish Survey has been conducted annually in October since 1996 by the Marine Research Institute (MRI). The objective is to gather fishery-independent information on biology, distribution and biomass of demersal fish species in Icelandic waters, with particular emphasis on Greenland halibut (*Reinhardtius hippoglossoides*) and deep-water redfish (*Sebastes mentella*). This is because the Spring Survey conducted annually in March since 1985 does not cover the distribution of these deep-water species. The second aim of the survey is to have another fisheries-independent estimate on abundance, biomass and biology of demersal species, such as cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and golden redfish (*Sebastes norvegicus*), in order to improve the precision of stock assessment.

B.3.2.1. Timing, area covered and tow location

The Autumn Survey is conducted in October, as it is considered the most suitable month in relation to diurnal vertical migration, distribution and availability of Greenland halibut and deep-water redfish. The research area is the Icelandic continental shelf and slopes within the Icelandic Exclusive Economic Zone (EEZ) to depths down to 1500 m. The research area is divided into a shallow-water area (0–400 m) and a deep-water area (400–1500 m). The shallow water area is the same area covered in the Spring Survey. The deep-water area is directed at the distribution of Greenland halibut, mainly found at depths from 800–1400 m west, north and east of Iceland, and deep-water redfish, mainly found at 500–1200 m depths southeast, south and southwest of Iceland and on the Reykjanes Ridge.

B.3.2.2. Preparation and later alterations to the survey

Initially, a total of 430 stations were divided between the two areas. Of them, 150 stations were allocated to the shallow water area and were randomly selected from the Spring Survey station list. In the deep-water area, half of the 280 stations were randomly positioned in the area. The other half were randomly chosen from logbooks of the commercial bottom-trawl fleet fishing for Greenland halibut and deep-water redfish in 1991–1995. The location of those stations was, therefore, based on distribution and pre-estimated density of the species.

Because MRI was not able to finance a project of this magnitude, it was decided to focus the deep-water part of the survey on the Greenland halibut main distributional area. Important deep-water redfish areas south and west of Iceland were omitted. The number and location of stations in the shallow-water area were unchanged. For this reason, only the years from 2000 onwards can be compared for Icelandic slope *S. mentella*.

The number of stations in the deep-water area was reduced to 150, 100 of which were randomly positioned in the area. The remaining stations were located on important

Greenland halibut fishing grounds west, north and east of Iceland, and randomly selected from the logbook database of the bottom-trawl fleet fishing for Greenland halibut 1991–1995. The number of stations in each area was partly based on total commercial catch.

In 2000, with the arrival of a new research vessel, MRI was able finance the project according to the original plan. Stations were added to cover the distribution of deep-water redfish and the location of the stations selected in a similar manner as for Greenland halibut. A total of 30 stations were randomly assigned to the distribution area of deep-water redfish and 30 stations were randomly assigned to the main deep-water redfish fishing grounds based on logbooks of the bottom-trawl fleet 1996–1999 (Figure B.3.2).

In addition, 14 stations were randomly added in the deep-water area in areas where great variation had been observed in 1996–1999. Because of rough bottom, which made it impossible to tow, five stations have been omitted. Finally, 12 stations were added in 1999 in the shallow water area, making the number of stations in the shallow water area 162. The total number of stations taken in 2000–2009 has been around 381 (Table B.3.1).

In 2010, 16 stations were omitted in the deep-water area and the total number of stations in the area reduced from 219 to 203. All these stations have in common that they are in areas where stations are many and dense (close to each other), and with little variation. Four stations, aimed at deep-water redfish, were omitted southeast of Iceland. The rest or 12 stations were omitted west and northwest of Iceland, stations originally aimed at Greenland halibut.

B3.2.3. Vessels

The RV "Bjarni Sæmundsson" has been used in the shallow water area from the beginning of the survey. For the deep-water area MRI rented one commercial trawler 1996–1999, but in 2000 the commercial trawler was replaced by the RV "Árni Friðriksson" (Table B.3.1).

B3.2.4. Fishing gear

Two types of the bottom survey trawl “Gulltoppur” are used for sampling: “Gulltoppur” is used in the shallow water and “Gulltoppur 66.6 m” is used in deep waters. The shape of the trawls is the same but the trawl used in deep waters is larger. The trawls were common among the Icelandic bottom-trawl fleet in the mid-1990s and are well suited for fisheries on cod, Greenland halibut, and redfish.

The towing speed is 3.8 knots over the bottom. The trawling distance is 3.0 nautical miles calculated with GPS when the trawl touches the bottom until the hauling begins (i.e. excluding setting and hauling of the trawl).

B.3.5. Data sampling

B.3.5.1. Length measurements and counting

All fish species are length measured. For the majority of species, including golden redfish, total length is measured to the nearest cm from the tip of the snout to the tip of the longer lobe of the caudal fin. At each station, the general rule is to measure at least four (Spring Survey) or five (Autumn Survey) times the length interval of golden redfish. Example: If the continuous length distribution of golden redfish at a given station is between 15 and 45 cm, the length interval is 30 cm and the number of measurements needed is 120. If the catch of golden redfish at this station exceeds 120 individuals, the rest is counted.

Care is taken to ensure that the length measurement sampling is random so that the fish measured reflect the length distribution of the haul in question.

B.3.5.2. Otolith sampling

Otolith sampling of golden redfish only started in 1998 in the Spring Survey. Annually 3100–3800 otoliths are taken but, only otoliths from the year 2010 have been age read. Otolith of golden redfish from the Autumn Survey has on the other been sampled since the beginning of the survey in 1996. Annually 1000–1600 otoliths are sampled and all of them have been age read.

For golden redfish, a minimum of five are collected in both surveys, but the maximum differ between the surveys. In the Spring Survey the maximum number of otoliths collected are ten but 15 in the Autumn Survey. Otoliths are sampled at a 20 fish interval in the Spring Survey and ten fish interval in the Autumn Survey. This means that if in total 200 golden redfish are caught in the Autumn Survey in a single haul, 20 otoliths are sampled.

Each golden redfish taken in the otolith sampling is sex and maturity determined, weighed ungutted, and the stomach content is analysed onboard.

B.3.5.3. Information on tow, gear and environmental factors

At each station/haul relevant information on the haul and environmental factors, are filled out by the captain and the first officer in cooperation with the cruise leader.

Tow information:

General: Station, Vessel registry no., Cruise ID, Day/Month/Year, Statistical Square, Subsquare, Tow number, Gear type no., Mesh size, Briddles length (m).

Start of haul: Position North, Position West, Time (hour:min), Tow direction in degrees, Bottom depth (m), Towing depth (m), Vertical opening (m), Horizontal opening (m).

End of haul: Position North, Position West, Time (hour:min), Warp length (fm), Bottom depth (m), Tow length (nautical miles), Tow time (min), Tow speed (knots).

Environmental factors:

Wind direction, Air temperature (°C), Windspeed, Bottom temperature (°C), Sea surface, Surface temperature (°C), Cloud cover, Air pressure, Drift ice.

B.3.6. Data processing

Abundance and biomass estimates at a given station.

As described above, the normal procedure is to measure at least four times the length interval of a given species. The number of fish caught of the length interval L_1 to L_2 is given by:

$$P = \frac{n_{measured}}{n_{counted} + n_{measured}}$$

$$n_{L_1-L_2} = \sum_{i=L_1}^{i=L_2} \frac{n_i}{P}$$

where $n_{measured}$ is the number of fished measured and $n_{counted}$ is the number of fish counted. Biomass of a given species at a given station is calculated as:

$$B_{L_1-L_2} = \sum_{i=L_1}^{i=L_2} \frac{n_i \alpha L_i^{\beta}}{P}$$

where L_i is length and α and β are coefficients of the length–weight relationship.

B.3.6.1. Index calculation

For calculation of indices the Cochran method is used (Cochran, 1977). The survey area is split into strata (see Section B.3.6.2). Index for each stratum is calculated as the mean number in a standardized tow, divided by the area covered multiplied with the size of the stratum. The total index is then a summed up estimate from the strata.

A "tow-mile" is assumed to be 0.00918 NM^2. That is the width of the area covered is assumed to be 17 m (17/1852=0.00918).

The following equations are a mathematical representation of the procedure used to calculate the indices:

$$\overline{Z}_i = \frac{\sum_i Z_i}{N_i}$$

where $\overline{Z}_i$ is the mean catch (number or biomass) in the *i*-th stratum, Z_i is the total quantity of the index (abundance or biomass) in the *i*-th stratum and N_i the total number of tows in the *i*-th stratum. The index (abundance or biomass) of a stratum (I_i) is:

$$I_i = \overline{Z}_i \left(\frac{A_i}{A_{tow}} \right)$$

And the sample variance in the *i*-th stratum:

$$\sigma_i^2 = \left(\frac{\sum_i (Z_i - \overline{Z}_i)^2}{N_i - 1} \right) \left(\frac{A_i}{A_{tow}} \right)^2$$

where A_i is the size of the *i*-th stratum in NM^2 and A_{tow} is the size of the area surveyed in a single tow in NM^2.

$$I_{region} = \sum_{region} I_i$$

and the variance is

$$\sigma_{strata}^2 = \sum_{region} \sigma_i^2$$

and the coefficient of variation is

$$CV_{region} = \frac{\sigma_{region}}{I_{region}}$$

B.3.6.2. Stratification

The strata used for survey index calculation for golden redfish in the Spring Survey are shown in Figure B.3.3 and for the Autumn Survey in Figure B.3.4. The stratification is the same in both surveys, but the area is larger in the Autumn Survey. The stratification is in general based on depth stratification and similar oceanographic conditions within each stratum.

The survey stratification and subsequent survey indices for golden redfish were recalculated for the Autumn Survey in 2008 and for the Spring Survey in 2011. This was done because the majority of the total catch of golden redfish comes in few but large tows leading to high uncertainties in the estimates of the biomass/abundance indices (high CV). Many of these hauls are in a region with relatively long intervals between stations and gaps in the station grid can be seen near these hauls (Figures B.3.3 and B.3.4). After the changes, fewer and larger strata were used and the strata with the holes in the station net reduced. The aim of this revision was to reduce the weight of certain tows, to reduce the area weight and hence, to reduce CV in the indices.

The numbers of strata in the Autumn Survey were reduced from 74 to 33. Figure B.3.5 shows the stratification of the survey area that was used before 2008. The average size of stratum subsequently increased and number of tows within stratum increased. It should also be noted that some strata at the edge of the survey area were reduced in size. The number of strata in the Spring Survey went from 45 to 24. Figure B.3.6 shows the stratification of the survey area that was used before 2011.

Diurnal variation

Golden redfish is known for its diurnal vertical migration showing semi-pelagic behaviour. Usually the species is in the pelagic area during the night-time and close to the bottom during the daytime. There may also be a size or age difference in this pelagic behaviour. This causes great diurnal variation in the catch rates of golden redfish in both the spring and autumn bottom-trawl surveys conducted in Icelandic waters, and it has a large effect on the abundance indices.

The surveys are conducted both during the day and the night (24 hours). Few stations in a limited area account for a large part of the total catches of golden redfish. Besides, interannual variability caused by the time of day when the stations are taken becomes large and hence, can greatly influence the results.

The general model without taking into account length is a generalized model (GML):

$$\log(catch) = \alpha_{year} + \beta_{station} + \gamma_{time}$$

The model uses quasi family with log link and variance proportional to the mean. The factor α_{year} could be interpreted as abundance index. The factor γ_{time} does on the other hand describe the development during the day.

The data were divided into 17 length groups and fitted for each length group.

$$\log(catch) = \alpha_{year} + \beta_{station} + ps(time, df = 7)$$

where is the periodic spline with seven degrees of freedom.

Scaled predictions for each length group in the Spring and Autumn Surveys by the model are shown in Figure B.3.7. As may be seen the smallest redfish has opposite diurnal vertical migration compared to the usual one of larger fish. The model results do also show that much less is caught of the smallest redfish in the survey compared to medium size. This scaled diurnal variation by length as seen in Figure B.3.7 was used for calculating Cochran index for redfish. The only difference from the traditional method is that the numbers caught in each length group at each station will be divided by the appropriate multiplier shown in Figure B.3.7.

Comparison of total biomass index for golden redfish based on the old and new stratification, and taking into account the diurnal variation is shown in Figure B.3.8 for the Spring Survey and Figure B.3.9 for the Autumn Survey. In general, the measurement errors of the indices based on the new stratification and taking into account diurnal variation are lower than the ones based on the old stratification.

Faroese surveys in Vb

Two annual groundfish surveys are conducted on the Faroe Plateau by the Faroe Marine Research Institute, the Spring Survey carried out in February–March since 1994 (100 stations per year down to 500 m depth, Figure B.3.10), and the Summer Survey in August–September since 1996 (200 stations per year down to 500 m depth, Figure B.3.11). Both surveys are bottom-trawl surveys and the same bottom trawl with 40 mm mesh size in the codend is used. Effort for both surveys is recorded in terms of minutes towed (60 min).

All stations are fixed stations. Half of the stations in the Summer Survey were the same as in the Spring Survey. The surveyed area is divided into 15 strata defined by depth and environmental conditions. For index calculation same method was applied as described in Section 2.4.3. The 'tow-mile' is assumed to be 0.0108 NM^2 and the width of the trawl is assumed to be 22 m. The tow length is set to 4 NM. It was not possible to calculate the sampling variance since the catch was aggregated by stratum, that is, only the total catch and number of tows per stratum was available.

Surveys in Greenland waters

Survey design

Abundance, biomass estimates and length structures have been derived using annual German groundfish surveys covering shelf areas and the continental slopes off West and East Greenland during 1982–2012. The survey was primarily designed for the assessment of cod, but it covers the entire groundfish assemblage down to 400 m depth (Rätz, 1999). Designed as a stratified random survey, the hauls are allocated to the strata off West and East Greenland according to both the area and the mean historical cod abundance at equal weights. Stations are randomly selected from successfully trawled grounds. Because of favourable weather and ice conditions and to avoid spawning concentrations, autumn was chosen for the time of the surveys.

The surveys were carried out by the research vessel RV Walther Herwig (II) 1982–1993 (except 1984 throughout RV Anton Dohrn was used) and since 1994 by RV Walther Herwig III.

Up to 2012, the surveyed area is the 0–400 m depth that is divided into seven geographical strata and two depth zones (0–200 m; 200–400 m, Figure B.3.12). The numbers of hauls were initially ca. 200 per year but were reduced from the early 1990s to 80–100 per year.

In 2013, the survey was re-stratified, with four strata in West Greenland resembling NAFO subarea structure, and five strata in East Greenland. Depth zones considered are 0–200 m and 200–400 m (Figure B.3.13). The time-series was recalculated accordingly.

For historical reasons strata with less than five hauls were not included in the annual stock calculations op to 2008. From 2009 on, all valid hauls have been included and the entire time-series have been corrected. For strata with less than five samples, GLM and quasi-likelihood estimates are recalculated based on year and stratum effects from the time-series. In some years (notable 1992 and 1994) several strata were not covered due to weather conditions/vessel problems, implying that the survey estimate implicitly refers to varying geographical areas.

Re-stratification of the survey in NWWG 2013 (NWWG WD 25)

The new stratification refers to 31 607 nm² excluding in particular areas for which no data were available (Table B.3.2), whereas the old stratification covered 37 463 nm² (Table B.3.3).

Stratification is undertaken to optimize sampling effort and design to obtain highly reliable estimates of a population, i.e. under minimizing sample variance.

Stratification on species level for Atlantic cod, golden redfish and deep-sea redfish was carried out according to the cumulative squared root frequency method by Dalenius and Hodges (Cochran, 1977, p.127–131; Dalenius and Hodges, 1959) based on average biomass per ICES rectangle.

Following the approach undertaken by Cornus (1986), survey samples were assigned to ICES rectangles prior to calculating stratum affiliations. Within ICES rectangles, the amount of trawlable area was estimated according to Cornus (1986).

Stratification on community level was undertaken with Ward's minimum variance method by means of clustering. Many simulation studies comparing various methods of cluster analysis have been performed. In these studies, artificial datasets containing known clusters are produced using pseudo-random number generators. The datasets are analysed by a variety of clustering methods, and the degree to which each clustering method recovers the known cluster structure is evaluated. See Milligan (1981) for a review of such studies. In most of these studies, the clustering method with the best overall performance has been either average linkage or Ward's minimum variance method. The method with the poorest overall performance has almost invariably been single linkage. However, in many respects, the results of simulation studies are inconsistent and confusing.

A six stratum design was analysed for community structure.

For each species, five strata were determined in terms of their assortment of ICES rectangles (Figure B.3.13). In a further step, adjacent ICES rectangles were combined into one stratum both defined through density level and geographic coherence.

Species stratification schemes were cross-checked with community schemes to outline general distribution patterns on the shelf.

In a third step, sampling frequency was checked, and strata 5 and 6 were joined to reach sufficient sample coverage.

Fishing gear

The fishing gear used was a standardized 140 feet bottom trawl, its net frame rigged with heavy groundgear because of the rough nature of the fishing grounds. A small mesh liner (10 mm) was used inside the codend. The horizontal distance between wingends was 25 m at 300 m depth, the vertical net opening being 4 m. In 1994, smaller Polyvalent doors (4.5 m², 1500 kg) were used for the first time to reduce net damages due to overspread caused by bigger doors (6 m², 1700 kg), which have been used earlier.

Index calculation

All calculations of abundance and biomass indices were based on the modified 'swept-area' method using 22 m horizontal net opening as trawl parameter, i.e. the constructional width specified by the manufacturer, and standardized to a towing time of 30 minutes, yielding a distance swept of 2.25 nm as derived from a speed of 4.5 knots. Hauls, which received net damage or became hang-up after less than 15 minutes, were rejected. Some hauls of the 1987 and 1988 surveys were also included although their towing time had been intentionally reduced to ten minutes because of the expected large cod catches as observed from echosounder traces.

Stratified abundance estimates calculated from catch-per-tow data using the stratum areas as weighting factor (Cochran, 1977). Strata with less than five valid sets were included but are indicated. The coefficient of catchability was set at 1.0, implying that estimates are fair indices of abundance and biomass. Respective confidence intervals (CI) were set at the 95% level of significance of the stratified mean. The length–frequency distributions (LFDs) were compiled by stratum and year and raised to the respective abundance.

The assumption of the swept-area approach are certainly overestimating abundance, since herding effects through trawl doors and bridles are not considered (Dickson, 1993a; Dickson, 1993b). According to measurements undertaken with rock-hopper equipped BT140, door spread is about 60 m, and applying extension factors derived from nets of similar size, 0.5 of the door spread effectively contributes to the herding effect and thus to catch (Dickson, 1993b). This indicates that the naïve swept-area estimate based on the horizontal net opening only realistically overestimates catch by a factor of two.

Fitted SI

Following Venables and Dichmont (2004), a quasi-likelihood model was applied with loglink function and negative binomial-distributed errors.

Biological measurements

Fish were identified to species or lowest taxonomic level, and the catch in number and weight was recorded. Redfish inhabiting the survey area close to the bottom are believed to belong to the traditional stocks off Greenland, Iceland and the Faroe Islands (ICES, 1995). In the German surveys off Greenland, fish (>17 cm) were separated into *S. norvegicus* L. and *S. mentella* Travin, whereas juvenile redfish (<17 cm) were classified as *Sebastes* spp. due to difficult - and in most cases impossible - species identification. Total fish lengths were measured to cm below.

Stratification, index calculation, and inclusion of the German Survey in East Greenland in the GADGET model

Area definition

The German Survey does not cover the East Greenland continental shelf very well and only the edges of the shelf from 150–450 m are covered. The area used to compile abundance indices from the survey is approximately 45 000 km² (Figure B.3.13), a large area looking at the coverage.

For inclusion of the German Survey in East Greenland waters in the GADGET model (See Chapter C for the description and setup of the GADGET model) the survey area was reduced. Instead of using the five defined strata proposed in 2013 and shown in Figure B.3.13, only one stratum was used around the stations taken (Figure B.3.14). This approach was taken to avoid extrapolation to areas not covered by the survey and hence, to reduce the weight of each station. After the changes the area behind each station in the German Survey is 75% larger than of an average station in the Icelandic Spring survey.

The size of this region is 22 500 km^2. Outer boundary of the region follows the 500 m contour while the inner boundary is more *ad hoc*. Results from the Icelandic autumn survey indicate that golden redfish is not common below 500 m depth. Using larger areas in compilation of survey indices leads to substantial extrapolation to areas not covered by the survey.

Survey indices calculations

The Icelandic data are converted to abundance by assuming 17 m width of the survey trawl. Also diurnal variability is taken into account and the results calibrated to the average of day and night but the survey is conducted 24 hours per day. Results from the German survey are converted to abundance per km^2 by assuming 22 m width of the survey trawl but not correcting for time of day as the German survey is only conducted during the day.

The Icelandic indices are compiled using stratified mean as described in Chapter B.3.6. The Greenland indices used in the GADGET setup are compiled by taking the average over the abundance/km^2 of the stations each year multiplied by $\frac{22m}{16m}$ (to account for different trawl width in the German and the Icelandic Spring Surveys respectively) and then by the size of the survey area, in this case 22 500 km^2.

Combination of the Icelandic Spring Survey and the German East Greenland Survey

The German survey in East Greenland waters is conducted in the autumn (September–October) or 4–5 months earlier than the Icelandic Spring survey the following year. When the survey indices were combined, the German survey in year y was added to the Icelandic Spring Survey conducted the year after ($y+1$). During this period of 4–5 months between the surveys, the fish grows. Furthermore, it might also migrate between areas. The former problem is taken care of by adding one cm to the length of all fish caught in the German survey but the latter problem is not considered specifically.

B.4. Commercial cpue

Iceland

Catch per unit of effort is routinely calculated during the annual assessment process. Data used to estimate cpue for golden redfish in Division Va since 1978 were obtained from logbooks of the Icelandic bottom-trawl fleet. Only those hauls were used that were taken above 450 m depth (combined golden redfish and Icelandic slope *S. mentella*) and that were comprised of at least 50% golden redfish (assumed to be the directed fishery towards the species; between 70–80% of the total annual catch were from those hauls). Non-standardized cpue and effort is calculated for each year:

$$E_y = \frac{Y_y}{CPUE_y},$$

where E is the total fishing effort and Y is the total reported landings.

Cpue indices were also estimated from this dataset using a GLM multiplicative model (generalized linear models). This model takes into account changes in vessels over time, area (ICES statistical square), month and year effects:

glm(log(catch) ~ log(effort) + factor(year) + factor(month) + factor(area) + factor(vessel),

family=gaussian())

C. Modelling framework (historical stock development)

C.1. Description of GADGET

GADGET is shorthand for the "Globally applicable Area Disaggregated General Ecosystem Toolbox", which is a statistical model of marine ecosystems. GADGET, previously known as BORMICON and Fleksibest, has been used for assessment of golden redfish in ICES Division Va since 1999 (Björnsson and Sigurdsson, 2003).

GADGET is an age–length structured forward-simulation model, coupled with an extensive set of data comparison and optimization routines. Processes are generally modelled as dependent on length, but age is tracked in the models, and data can be compared on either a length and/or age scale. The model is designed as a multispecies, multiarea, multifleet model, capable of including predation and mixed fisheries issues; however it can also be used on a single species basis. Worked examples, detailed manual, and further information on GADGET can be found on www.hafro.is/gadget. In addition the structure of the model is described in Björnsson and Sigurdsson (2003), Begley and Howell (2004), and a formal mathematical description is given in Frøysa *et al*. (2002).

GADGET is distinguished from many stock assessment models used within ICES that it is length based and takes into account the fact that fisheries are often targeting the largest individuals of age groups partly recruited to the fisheries thereby reducing the mean weight of the survivors.

Setup of a GADGET run

There is a separation of model and data within GADGET. The simulation model runs with defined functional forms and parameter values, and produces a modelled population, with modelled surveys and catches. These surveys and catches are compared against the available data to produce a weighted likelihood score. Optimization routines then attempt to find the best set of parameter values.

Growth

Growth is modelled by calculating the mean growth for fish in each length group for each time-step, using a parametric growth function. In the golden redfish model a von Bertalanffy function has been employed to calculate this mean growth. At each time-step the length distributions are updated according to the calculated mean growth by allowing some portion of the fish to have no growth, a proportion to grow by one length group and a proportion two length groups, etc. How these proportions are selected affects the spread of the length distributions but these two equations must be satisfied:

$$\sum p_{il} = 1$$

and

$$\sum ip_{il} = \mu_i$$

Here μ is the calculated mean growth and p_{il} is the proportion of fish in length group l growing i length groups. The proportions are selected from a beta-binomial distribution, that is a binomial distribution $f(n,p)$ where n is the maximum number of length groups that a fish can grow in one time interval. The probability p in the binomial distribution comes from a beta distribution described by α and β (Stefansson, 2001). As in all discrete probability distributions the condition $\sum p_{il} = 1$ is automatically satisfied. The mean of the distribution is given by:

$$\mu_l = \frac{n\alpha}{\alpha + \beta} = \sum_{i=0}^{n} p_{il} i$$

For a given value of β, a value of α is selected so that $\mu_l = G_l$ where G_l is the calculated mean growth from the parametric growth equation. β, which can either be estimated or specified in the input files, affects the spread of the length distribution.

Fleets

All fleets or predators in the model work on size. To be specific the predators have size preference for their prey and through predation can affect mean weight and length-at-age in the population. A fleet (or predator) is modelled so that either the total catch or the total effort in each area and time interval is specified. In the golden redfish assessment described here the commercial catch is given in weight but the survey is modelled as a fleet with a constant effort.

The first step in estimating catch in numbers by age and length in the model is to calculate the 'modelled cpue' for each fleet:

$$CPUE_{\text{mod}} = \sum_{prey} \sum_{l} S_{prey,l} N_{prey,l} W_{prey,l}$$

where $S_{prey,l}$ is the selection of prey length l, $N_{prey,l}$ is the number of fish and $W_{prey,l}$ is the mean weight of prey of length l. The total catch of each length group of each prey is then calculated from:

$$C_{prey,l} = C \frac{S_{prey,l} N_{prey,l} W_{prey,l}}{CPUE_{\text{mod}}}$$

where $C_{prey,l}$ is the amount caught by the predator of length group l of prey (in this case golden redfish) and C is the total amount caught by the fleet, either specified or calculated from:

$$C = E \times CPUE_{\text{mod}}$$

where E is the specified effort.

In the golden redfish assessment described here the commercial catches are set (in kg per six months), and the survey is modelled as fleet with small total landings. The total catch for each fleet for each six month period is then allocated among the different length categories of the stock according to their abundance and the catchability of that size class in that fleet.

Likelihood data

A major advantage of using an age–length structured model is that the modelled output can be compared directly to a wide variety of different data sources. It is not necessary to convert length into age data before comparisons. GADGET can use various types of data that can be included in the objective function. Length distributions, age–length keys, survey indices by length or age, cpue data, mean length and/or weight-at-age, tagging data and stomach content data can all be used.

Importantly this ability to handle length data directly means that the model can be used for stocks such as golden redfish where time-series of age data is relatively short compared to the lifespan of the species). Length data can be used directly for comparison to model output. The model is able to combine a wide selection of the available data by using a maximum likelihood approach to find the best fit to a weighted sum of the datasets.

Optimization

The model has three alternative optimizing algorithms linked to it: a wide area search Simulated Annealing (Corona *et al.*, 1987), a local search Hooke-Jeeves algorithm (Hooke and Jeeves, 1961) and finally one based on the Boyden-Fletcher-Goldfarb-Shanno algorithm hereafter termed BFGS (Bertsekas, 1999).

The simulated annealing and Hooke-Jeeves algorithms are not gradient based, and there is therefore no requirement for the likelihood surface to be smooth. Consequently neither of these two algorithms returns estimates of the Hessian matrix. Simulated annealing is more robust than Hooke-Jeeves and can find a global optimum where there are multiple optima, but needs about 2–3 times the number of iterations compared to the Hooke-Jeeves algorithm.

BFGS is a quasi-Newton optimization method that uses information about the gradient of the function at the current point to calculate the best direction in which to look for a better point. Using this information the BFGS algorithm can iteratively calculate a better approximation to the inverse Hessian matrix. Compared with the two other algorithms implemented in GADGET, BFGS is very local search compared to simulated annealing and more computationally intensive than the Hooke-Jeeves algorithm. However the gradient search in BFGS is more accurate than the stepwise search of Hooke-Jeeves and may therefore give a more accurate estimate of the optimum. The BFGS algorithm used in GADGET is derived from that presented by Bertsekas (1999).

The model is able to use all three algorithms in a single optimization run, attempting to utilize the strengths of all. Simulated annealing is used first to attempt to reach the general area of a solution, followed by Hooke-Jeeves to rapidly home in on the local solution, and finally BFGS is used for fine-tuning the optimization. This procedure is repeated several times to attempt to avoid converging to a local optimum.

Likelihood weighting

The total objective function to be minimized is a weighted sum of the different components. Selection of the weights follows the procedure laid out by Taylor *et al.* (2007) where an objective re-weighting scheme for likelihood components is described for GADGET models using cod as a case study. The iterative re-weighting heuristic tackles this problem by optimizing each component separately in order to determine the lowest possible value for each component. This is then used to determine the final weights. The iterative re-weighting procedure has now been implemented in the R statistical language as a part of the **rgadget** package (***rgadget***.*r-forge.r-project.org/*) which is written and maintained by B. Th. Elvarsson at MRI.

Conceptually the log-likelihood components can roughly be thought of as residual sums of squares (SS), and as such their variances can be estimated by dividing the SS concerned by the associated degrees of freedom. Then the optimal weighting strategy is the inverse of the variance. The variances, and hence the final weights are calculated according the following algorithm:

1) Calculate the initial SS given the initial parameterization. Assign the inverse SS as the initial weight for all log-likelihood components. With these initial weights the objective function will start off with a value equal to the number of likelihood components.
2) For each likelihood component, perform an optimization with the initial score for that component set to 10 000. Then estimate the residual variance using the resulting SS of that component divided by the effective number of datapoints, that is, all non-zero data-points.
3) After the optimization set the final weight for that all components as the inverse of the estimated variance from step 3 (weight = (1/SS) * df*).

The effective number of datapoints (df*) in 3) is used as a proxy for the degrees of freedom determined from the number of non-zero datapoints. This is viewed as a satisfactory proxy when the dataset is large, but for smaller datasets this could be a gross overestimate. In particular, if the survey indices are weighed on their own while the yearly recruitment is estimated they could be over-fitted. If there are two surveys within the year Taylor *et al*. (2007) suggest that the corresponding indices from each survey are weighed simultaneously in order to make sure that there are at least two measurements for each yearly recruit. In general problems such as those mentioned here could be solved with component grouping, that is, in step 2) above likelihood components that should behave similarly, such as survey indices, should be heavily weighted and optimized together.

Another approach for estimating the weights of each index component, in the case of a single survey fleet, would be to estimate the residual variances from a model of the form:

$$\log(I_{lt}) = \mu + Y_t + \lambda_l + \varepsilon_{lt}$$

where t denotes year, l length-group and the residual term, ε_{lt}, is independent normal with variance σ_s^2 where s denotes the likelihood component referenced. The inverses of the estimated residual variances are then set as weights for the survey indices. In the rgadget routines, this approach is termed **sIw** as opposed to **sIgroup** for the former approach.

C.2. Settings for the golden redfish assessment in GADGET

Below is the description of the GADGET settings for the golden redfish assessment as accepted by WKREDMP 2014. Changes from the previous settings are described.

Age and length range and growth: In the assessment one cm length groups are used, 10.5–68.5 cm. The year is divided into two time-steps. The age range is five to 30 years, with the fish 30 years and older treated as a plus group. The length at recruitment (age 5) is estimated and mean growth is assumed to follow the von Bertalanffy growth function. Mean length at recruitment (age 5) was estimated separately for year classes before 1996, for year classes 1996–2000 and year classes 2001 and later. This was done to take into account increase in mean weight-at-age that has been observed since year class 1996. As selection to the survey and catches is size based, faster growth will lead to cohorts recruiting earlier to the surveys and the fisheries and hence, leading to over-estimation if changed growth was not taken into account. Weight–length relationship is obtained from spring survey data. Before the 2012 assessment, age range in the model was 0–30 years old but the youngest age groups were excluded from the model as recruitment data were not considered usable in assessment due to changes in spatial distribution of recruits.

Natural Mortality (*M*): Natural mortality for this long-lived species is assumed to be low but has to be guessed like for most other stock. Since the 2012 assessment, *M* of all age groups, except the plus group, is 0.05 but 0.1 for the plus group. Before that *M* for 0 years old was 0.20 and then reducing gradually to 0.05 for age 5. *M* for age 5–29 was 0.05 but 0.1 for the plus group (30+). Changing *M* for ages 0–4 does not affect the results as they do not appear in the fisheries.

Time-Steps: The model starts in 1970 and the time-step is six months. The last tuning and catch data used are for the first half of the assessment year. Short-term predictions 5–8 years ahead are done with fixed effort and fixed catch. Landings data are available for all the period but biological data are scarce before 1985 and scarcer the further back in time we go. In the model all available data are used for tuning. One reason for starting the model so early is to have the burn in period of the model before the most important tuning data are sampled, but also try to have the time period comparable to the lifespan of the species.

Commercial Landings: The commercial landings are since the spring 2012 modelled as three fleets (Greenland, Iceland and the Faroese), each with selection patterns described by a logistic function and the total catch in tonnes specified for each six month period.

Surveys: Two surveys are used, the Icelandic Spring Survey (IS-SMB) and the German autumn groundfish survey in East Greenland waters (GER(GRL)-GFS-Q4). The indices are combined into one survey index.

The German autumn groundfish survey is conducted in the autumn (September–October) or 4–5 months earlier than the Icelandic Spring Survey (March) the following year. When the survey indices were combined, GER(GRL)-GFS-Q4 in year *y* was added to the IS-SMB conducted the year after (*y+1*). To compensate for growth during the period of 4–5 months that are between the surveys, one cm was added to the length of all fish caught in GER(GRL)-GFS-Q4. The length groups division used in the tuning are two cm length groups from 19 to 54 cm.

The combined surveys (1985-onwards) are modelled as one fleet with constant effort and a nonparametric selection pattern that is estimated for each length group.

In previous settings only the Icelandic Spring Survey (IS-SMB) was used.

General changes

Changes made in 2012

Some important changes have been done to the model setup in recent years, most of them due to problems with recruitment estimation but reasonably large year classes seen in recent years were not seen in Icelandic surveys as small fish. This has led to consistent underestimation of recruiting year classes in recent years.

Changes made in 2014

- Changes in growth, now modelled for three periods, before 1996 year class, 1996–2000 year class and 2001 and later year classes.
- Inclusion of the German Groundfish Survey in East Greenland waters (GER(GRL)-GFS-Q4). The survey biomass of the German survey at year *y* was added to the Icelandic spring survey the year after or *y+1*.
- Length range of tuning data 19–54 cm.
- In addition development of the model has been ongoing. Among the things developed in 2011–2014 is the likelihood weighting that was changed somewhat in the latter half of 2012.

Current setup

Data/constraints used in the objective function to be minimized are as follows:

Data used for tuning are:

- Length distributions from the commercial catches (Greenland, Iceland and the Faroese) and the surveys (the Icelandic Spring survey (IS-SMB) and German Groundfish Survey in East Greenland combined) in two cm length groups, using multinomial likelihood functions.
- Length disaggregated survey indices in two cm length group 19–54 cm using lognormal errors.
- Age–length keys and mean length-at-age from the Icelandic groundfish survey in October (IS-SMH): 1996–recent year. Based on two cm length groups using multinomial likelihood function.
- Age–length keys and mean length-at-age from the Icelandic commercial catch 1995–recent year. Based on two cm length groups using multinomial likelihood function.
- Mean length-at-age in IS-SMH. Based on sum of squares.
- Mean length-at-age in Icelandic commercial catches. Based on sum of squares.
- Landings by six month period.
- Understocking, i.e. too small biomass to cover the specified catch in tonnes.
- Bounds, a penalty function restricting the optimizing algorithms to the bounds specified for the estimated parameters.

The total objective function to be minimized is a weighted sum of the different components. Understocking and bounds are zero in the final solution they are only tools for guidance during the optimization process. Weights for the various log-likelihood components are assigned according to the reweighting procedure described above.

The parameters estimated are:

- The number of fish when simulation starts.
- Recruitment each year.
- Two parameters for the growth equation.
- Parameter β of the beta-binomial distribution controlling the spread of the length distributions.
- The selection pattern of the commercial catches. Two parameters for each fleet.

- Average size at recruitment. Three parameters estimated separately for year classes before the 1996 year class, year classes 1996–2000 and year classes 2001 and onwards.

The estimation can be difficult because some groups of parameters are correlated, and therefore the possibility of multiple optima cannot be excluded.

Description	period	Half-year	area	Likelihood component
Length distribution of landings	1970+	YES	Iceland East Greenland Faroese	ldist.catch
Combined survey length distribution of IS-SMB and GER(GRL)-GFS-Q4	1985+	-	Iceland East Greenland	ldist.survey
Abundace index of IS-SMB and GER(GRL)-GFS-Q4 of 19–24 cm individuals	1985+	-	Iceland	si1924
Abundace index of IS-SMB and GER(GRL)-GFS-Q4 of 25–54 cm individuals	1985+	-	Iceland	si2524
Age–length key of the landings	1995+	-	Iceland	alkeys.catch
Age–length key of the IS-SMH	1996+	-	Iceland	alkeys.survey
Mean length by age of landings	1995+	-	Iceland	meanl.catch

The **diagnostics** considered when reviewing the model's results are:

- Likelihood profiles plot. To analyse convergence and check for problematic parameters.
- Plots comparing observed and modelled proportions by fleet (catches). To analyse how estimated population abundance and exploitation pattern fits observed proportions.
- Plots of residuals in catchability models. To analyse precision and bias in abundance trends.
- Retrospective analysis. To analyse how additional data affects the historical predictions of the model.

Model setup

This file contains some information about the GADGET setup for golden redfish.

The selected base run is stored in the directory Baserun2014_2019. The most important files are:

TIME (first and last year of simulation and the number of time-step). Last year's file looked like. (In GADGET; means comment in similar way as # is used in R. # is on the other hand used to identify estimated variable in GADGET.)

;Optimisation Time file for the redfish example in 2013 assessment

;

firstyear 1970

firststep 1

lastyear 2013

laststep 1

notimesteps 2 6 6

;

The simulation time ends in first half of the assessment year to be able to use the tuning data in that quarter (Icelandic Spring survey). Catches in the first half of the assessment year are gestimated and part of the input to the model.

Another time file **TIME.SIMU** is used for prognosis six years ahead.

;

; Simulation Time file for the redfish example

;

firstyear 1970

firststep 1

lastyear 2019

laststep 2

notimesteps 2 6 6

;

The final year in those file is incremented by 1 each year.

AREA is a file required by the program. The file contains size of each area and temperature. These data are not needed in the redfish example so the values in this file do not matter, but the file must be there with the right "number of numbers". This file is in the directory and does not need to be updated.

Description of the stock is in the file **SMARINUS** and that file is not changed between years while same settings are used.

Three files are with the name **sebmar.rec, sebmar.init** and **sebrefw.dat** are stored in the directory InitFiles. Of those sebmar.rec is the only one that needs to be changed each assessment year.

Initial conditions are stored in the file **sebmar.init**. In this file there are ten estimated parameters but the data are not sufficient to estimate the number in each age group in 1970. This file will not be changed annually if the assessment settings are not changed.

The file **sebrefwt.dat** stores the length–weight relationship used in the simulations.

The file **sebmar.rec** contains information about recruitment. Recruitment is at age 5 in step 1. Recruitment is estimated for each year from 1970. Mean length-at-age is estimated separately for three time periods, 1970–2000, 2001–2005 and 2006 onwards. The last year class estimated is the year class that is eight years old in the assessment year. In the 2013 assessment year it is the year class 2005. In simulations other year classes are assumed as average (the name of the switch is #**recfuture** and the average value **0.8** and the minimum over five years is **0.45**). Assumptions about these year classes do not have much effect on the advice but substantial on short-term simulations (six years).

Next year the first line with #**recfuture** will be replaced with #**rec2011**. Every year possible changes in growth should be investigated. This investigation is similar to checking if selection pattern has changed in separable age-based model but changes in growth do often lead to change in selection by age.

The file **FLEET** in the top directory describes the fleets catching the fish. Each fleet has a type, specified catches in kg (totalfleet) or specified effort (linearfleet). Each fleet also has a name, selection function and a multiplier that can be used to scale up or down the effort or catches. Data files where catch or effort data are stored are also specified.

The directory **DataFiles** contains a number of files that will all have to be changed (or appended) every year. The files are:

FarCommLD.dat

IceCommLD.dat

GreenCommLD.dat

sebmar.meanlength.catch

fleet.data

IceMarGrlOctIndices.dat

sebmar.meanlength.surveys

fleet.predict

IceMarGrlOctLdr.dat

sebmar.surveys.alkeys

sebmar.catch.alkeys

The files **IceMarGrlOctIndices.dat** and **IceMarGrlOctLdr.dat** contain the combined survey indices for Iceland and Greenland. The difference between those files is just one column with the fleet name that is not in **IceMarGrlOctIndices.dat.** These files describe the use of the same data in two different ways.

All of the files in the **DataFiles** directory can be read in **R** with the command

read.table(file,comment.char=";")

fleet.data contains the catch per time period and fleet. There are four fleets defined, three commercial fleets and one survey, contains the landings in kgs per time-step (six months).

The three commercial fleets (column 4) used in this assessment are **Faroe, Greenland, Iceland.** The last catch data of those fleets are in the first half of the assessment year. The catch after that should be zero. A missing line is interpreted as 0. Each year, catch for the year before the assessment year is entered. The catch for the first half is already there, but as it was an estimate it has to be updated. An estimate for the first half of the assessment year will then be added. The exact division between the year halves does not matter as long as the total catches are correct.

The fourth fleet is the survey **IcelandMarchSurvey** with small amount caught every time-step (10 tons). When the Greenland survey data are added the fleet is still called **IcelandMarchSurvey**. Nothing needs to be changed for **IcelandMarchSurvey** for the next six years in the file **fleet.data**.

The file **fleet.predict** contains information about prediction with fixed effort. The effort is one but a multiplier is specified in the file **FLEET** in the top directory. There it is also specified that the fleet future is with specified effort and is called **linearfleet** but the others where the catch is specified are called **totalfleet**. The proposed HCR corresponds to the multiplier being *0.127.* Care should be taken to have the effort 0 in all time intervals where commercial catch in kg is given, **step 1 2013** and earlier in the **2013** assessment.

Other files in the folder **DataFiles** are likelihood data, all of them specified in the file **LIKELIHOOD** in the base directory where they are related to certain likelihood types (penalty, understocking, surveyindices, catchdistribution, catchstatistics). So-called aggregation files specify how the data are aggregated. Possible methods for aggregation are large, both across lengths, ages and areas. For example, the length distribution from the Icelandic commercial fleet, the file **LIKELIHOOD** looks like:

[component]

name Ice.CommLD

weight 0.0421227197

type catchdistribution

datafile DataFiles/IceCommLD.dat

function multinomial

overconsumption 1

minimumprobability 20

areaaggfile AggFiles/allarea.agg

ageaggfile AggFiles/allage.agg

lenaggfile AggFiles/len.agg

fleetnames Iceland

stocknames sebmar

;

Below are few lines from the file **IceCommLD.dat**. Order does not matter in that file

2011	**1**	**allareas**	**allages**	**len19–20**	**2**
2012	**1**	**allareas**	**allages**	**len19–20**	**22**

What does len19–20 and allages mean? For that we look at the files **AggFiles/allage.agg** and **AggFiles/len.agg**

allage.agg

.agg

;

; Age aggregation file - all ages aggregated together

;

allages 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

len.agg one line

;name	*minl*	*maxl*
len19–20	*18.5*	*20.5*

The number **weight** is what is later changed by the reweighting algorithm.

Generation of the likelihood data files will not be described here but the Icelandic data are generated by **R** scripts accessing the Icelandic databases. The German survey data from East Greenland are provided on cm basis for every station. Generation of the data file is just summing up available length and age measurements by length, age, and time interval, compiling survey indices by length or calculating mean length-at-age, standard deviation and number of aged fishes per age group and time interval. The only complication in the generation of likelihood data is the combination of the survey indices from Iceland and Greenland. Generally compiling data for GADGET is simpler than calculating, catch in numbers per age and survey indices by age.

After running the program large number of files will be generated as specified in **PRINTFILE**. The **rgadget** library (http://r-forge.r-project.org/projects/rgadget/) has a number of functions to read and plot these files.

The last thing to be done before starting a new run is to add the switch corresponding to the most recruitment to the most recent parameter file. This step can also be skipped but then the parameter starts with the value 0 and wide bounds, for example from **-9999** to **9999**. The negative bound might become a problem in optimization so setting the line in manually is recommended. Not starting from the best solution from the last year is recommended procedure if time allows. This can be achieved by randomly changing some of the value in the starting parameter file (**params.in** is the default name).

The order of things is as follows.

- Set up the data and likelihood files.
- Run the model with the final parameter file from last year *gadget -s -i params.final.*
- Look at the file *params.out* generated in each gadget run. If the data entered are correct the likelihood value (line 2) in *params.out* should not have increased by more than 50%.
- Copy *params.final* to *params.in*. Add the line with the most recent recruitment.
- Run the reweighing script. See below this list.
- Copy the file params.final from the **WGTS** directory and change #**recfuture** to the average value (0.8). Change the multiplier of the future fleet in the file FLEET to 0.127.
- Run the simulations with *gadget -s -i params.final -main main.simu*. The catch obtained for the year after the assessment year is the advice for that year.
- Plot results.

In reweighting data from the same source are combined so the command used is:

grouping<-list(sind=c("si1924","si2548"),survey=c("alkeys.sur","IceSurMar.LD","meanl.sur"),comm=c("Ice.CommLD","meanl.catch","alkeys.catch"),foreign=c("Far.Co

mmLD","Green.CommLD"))

gadget.iterative(rew.sI=TRUE,grouping=grouping)

gadget.iterative is obtained from the rgadget package.

D. Short-term projection

Short and medium-term forecasts for golden redfish in Va and XIV can be obtained from GADGET using the settings described below.

Model used: Age–length forward projection

Software used: GADGET (script: run.sh)

Initial stock size: abundance-at-age and mean length for ages 5 to 30+

Maturity: Fixed maturity ogive.

F and M before spawning: NA

Weight-at-age in the stock: modelled in GADGET with VB parameters and length–weight relationship

Weight-at-age in the catch: modelled in GADGET with VB parameters and length–weight relationship and selection by size

Exploitation pattern:

Landings: logistic selection parameters estimated by GADGET for the Icelandic fleet.

Intermediate year assumptions: First half, TAC constraint based on the TAC left from last year. Second half, F according to the Harvest Control Rule

Stock–recruitment model used: None

Procedures used for splitting projected catches: driven by selection functions and provide by GADGET.

E. Medium-term projections

See Section D.

F. Long-term projections

Model used: Age–length forward projection

Software used: GADGET

Initial stock size: one year class of 1 million individuals

Maturity: Fixed maturity ogive by size

F and M before spawning: NA

Weight-at-age in the stock: modelled in GADGET with VB parameters, length–weight relationship and selection of the fisheries

Weight-at-age in the catch: modelled in GADGET with VB parameters and length–weight relationship

Exploitation pattern:

Landings: logistic selection parameters estimated by GADGET for the Icelandic commercial fleet

Procedures used for splitting projected catches:

Driven by selection functions and provided by GADGET.

Yield-per-recruit is calculated by following one year class started at age 5 in 2002 of million fishes for 53 years through the fisheries calculating total yield from the year class as function of fishing mortality of fully recruited fish. Yield-per-recruit is then the total amount caught divided by the initial number of fish at age 5. In the model, the selection of the fisheries is length based so only the largest individuals of recruiting year classes are caught reducing mean weight of the survivors, more as fishing mortality is increased.

G. Biological reference points

Investigation of spawning stock–recruitment data do not show any apparent relationship from 1975–2003 that is approximately the period where reasonable estimates on those data can be obtained. Therefore B_{loss} was suggested in 2012 as candidate for B_{lim}. Then B_{loss} was 160 thousand tonnes that while it is now closer to 150 thousand tonnes due to changes in parameter settings. Still the proposed B_{lim} is 160 thousand tonnes, but will be revisited is changes are done to the assessment that lead to major change in stock size. (Changes in M).

$B_{trigger}$ was defined as 220 thousand tonnes in 2012 (160*exp(0.2*1.645)) where 0.2 was at that time estimated standard error of the biomass in the assessment year from a TSA assessment. This point does not have any biological meaning, it is just a trigger point in the harvest control rule and according to the simulations probability of SSB $<B_{trigger}$ should be low and in the simulations the trigger action is not included but it will lead small reduction in average fishing mortality. Without any $B_{trigger}$ the probability of SSB $<B_{lim}$ is still very low (<1%). Long periods of poor recruitment (not observed in those 30 years where data on recruitment are available) would be the scenario most likely leading to SSB $<B_{trigger}$. 30 years is short time for redfish so things not seen there are relatively likely to happen in the near future.

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Table A.2.1. Number of quick closures on golden redfish in Icelandic waters 1991–2011. See text for further description.

Year	Number of Closures
1991	1
1992	1
1993	2
1994	8
1995	3
1996	0
1997	0
1998	3
1999	6
2000	12
2001	3
2002	3
2003	1
2004	1
2005	6
2006	3
2007	4
2008	5
2009	2
2010	2
2011	2
Total	68

Table B.1.2.1. Biological sampling of golden redfish from the commercial catch in Icelandic waters 1995–2011. The table shows number of samples, how many individuals were sampled for length measurement and age determination.

	Length Measurements		Age Determination	
Year	# Samples	# Measured	# Samples	# Age Read
1995	177	38,403	7	596
1996	100	19,747	3	209
1997	172	38,990	23	1424
1998	174	35,336	26	1404
1999	253	52,407	37	1218
2000	323	73,965	49	1611
2001	269	52,833	46	1600
2002	341	62,926	48	1627
2003	260	45,568	48	1676
2004	219	35,741	48	1669
2005	434	71,681	44	1629
2006	336	52,873	46	1681
2007	311	49,673	45	1723
2008	327	47,122	48	1704
2009	283	46,995	52	1838
2010	328	56,807	47	1721

Table B.3.1. Vessels used in the Autumn Groundfish Survey in ICES Division Va, their survey area, and the number of station taken.

Year	Shallow waters Vessel name	No.Stations	Deep waters Vessel name	No.Stations	Total stations
1996	r/v Bjarni Sæmundsson	146	Múlaberg ÓF32	144	290
1997	r/v Bjarni Sæmundsson	150	Brettingur NS50	149	299
1998	r/v Bjarni Sæmundsson	153	Brettingur NS50	144	297
1999	r/v Bjarni Sæmundsson	166	Brettingur NS50	149	315
2000	r/v Bjarni Sæmundsson	163	r/v Árni Friðriksson	219	382
2001	r/v Bjarni Sæmundsson	161	r/v Árni Friðriksson	219	380
2002	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	221	383
2003	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	220	382
2004	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	220	382
2005	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	219	381
2006	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	219	381
2007	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	219	381
2008	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	219	381
2009	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	219	381
2010	r/v Bjarni Sæmundsson	162	r/v Árni Friðriksson	203	365

Table B.3.2. The survey area (nm²) based on the old stratification (used up to 2012) in the German Greenland groundfish Survey by stratum (see Figure B.3.12).

	Depthstrata (m)	Area (nm2)
1.1	1–200	6805
1.2	201–400	1881
2.1	1–200	2350
2.2	201–400	1018
3.1	1–200	1938
3.2	201–400	742
4.1	1–200	2568
4.2	201–400	971
5.1	1–200	2468
5.2	201–400	3126
6.1	1–200	1120
6.2	201–400	7795
7.1	1–200	92
7.2	201–400	4589
Total		37 463

Table B.3.3. The survey area (nm²) based on the new stratification (applied in 2013) in the German Greenland groundfish Survey by stratum (see Figure B.3.13).

In West GLD stratification equals NAFO stratification, in East GLD based on assignment to ICES rectangles, therefore geographic boundaries given as ca. values.

Stratum	boundaries				depth	area
	south	north	east	west	(m)	(nm2)
1.1	64°15'N	67°00'N	50°00'W	57°00'W	1–200	6805
1.2	64°15'N	67°00'N	50°00'W	57°00'W	201–400	1881
2.1	62°30'N	64°15'N	50°00'W	55°00'W	1–200	2350
2.2	62°30'N	64°15'N	50°00'W	55°00'W	201–400	1018
3.1	60°45'N	62°30'N	48°00'W	53°00'W	1–200	1938
3.2	60°45'N	62°30'N	48°00'W	53°00'W	201–400	742
4.1	59°00'N	60°45'N	44°00'W	50°00'W	1–200	2568
4.2	59°00'N	60°45'N	44°00'W	50°00'W	201–400	971
5&6.1	59°00'N	ca 63°50'N	40°00'W	44°00'W	1–200	1562
5&6.2	59°00'N	ca 63°50'N	40°00'W	44°00'W	201–400	2691
7.1	ca 63°50'N	66°00'N	ca 33°00'W	41°00'W	1–200	298
7.2	ca 63°50'N	66°00'N	ca 33°00'W	41°00'W	201–400	4615
ca 63°50'N	66°00'N	ca 33°00'W	41°00'W	1-200	49	
8.2	ca 63°50'N	66°00'N	ca 33°00'W	41°00'W	201–400	2173
9.1	64°45'N	67°00'N	29°00'W	33°00'W	1–200	0
9.2	64°45'N	67°00'N	29°00'W	33°00'W	201–400	1946

Sum	31 607

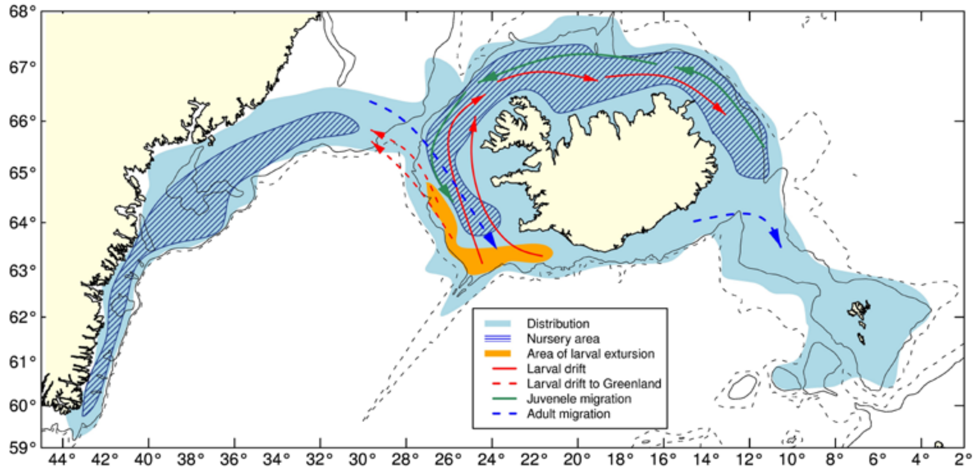

Figure A.1.1. Geographic range of golden redfish (*Sebastes norvegicus*) in East Greenland, Icelandic and Faroese waters, area of larval extrusion, larval drift and possible migration routes. The solid and dashed lines indicate the 500 m and 1000 m depth contour respectively.

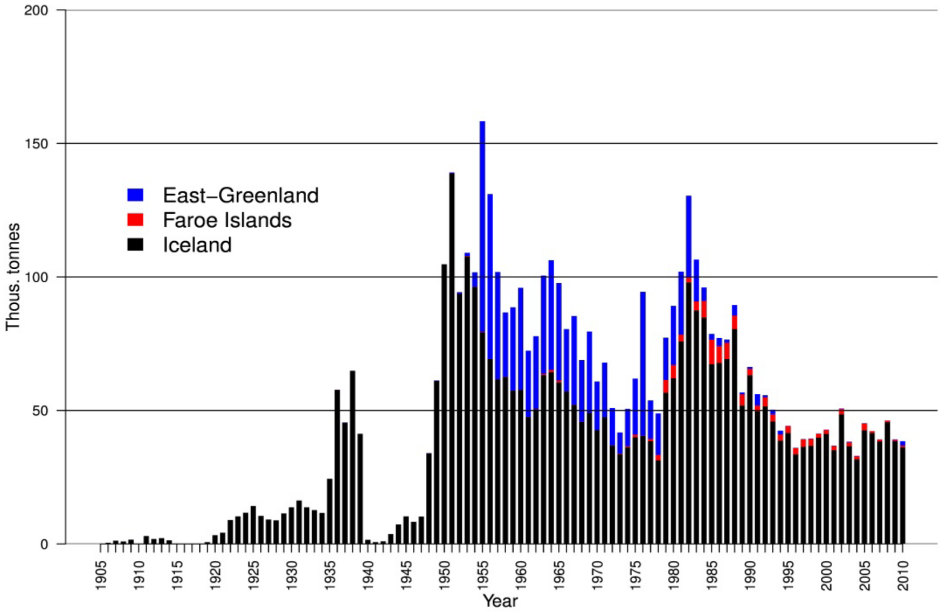

Figure A.2.1. Nominal landings (in tonnes) of golden redfish from Icelandic waters (ICES Division Va), Faroese waters (ICES Division Vb) and East-Greenland waters (ICES Division XIV) 1906–2010.

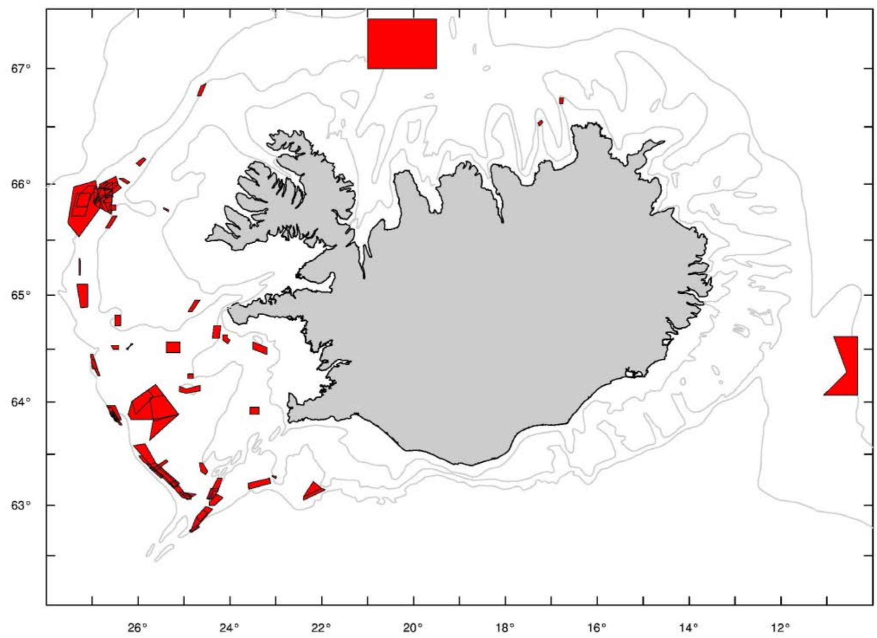

Figure A.2.2. Schematic overview of quick closures on golden redfish in Icelandic waters (ICES Division Va) 1991–2011.

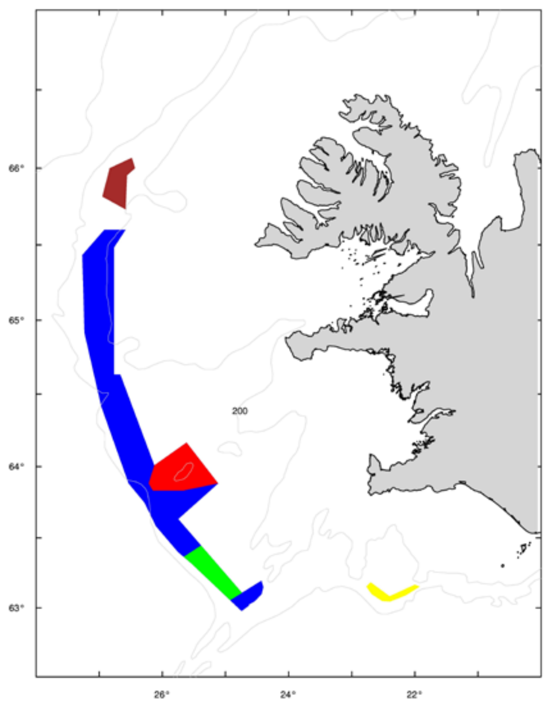

Figure A.2.3. Schematic overview of closed areas for protection of juvenile *S. norvegicus* in Icelandic waters (ICES Division Va). These areas are either closed permanently or temporarily. During closure bottom trawling is prohibited. The blue area is closed all year long; the red area is only open during the night or from 20:00–08:00 from October 1 to April 1 to allow fishing for saithe; the brown area is open for bottom trawling during the night or from 20:00 to 08:00; the green area is open for bottom trawling February 1 to April 15; the yellow area is closed for bottom-trawl fishery from June 1 to October 31.

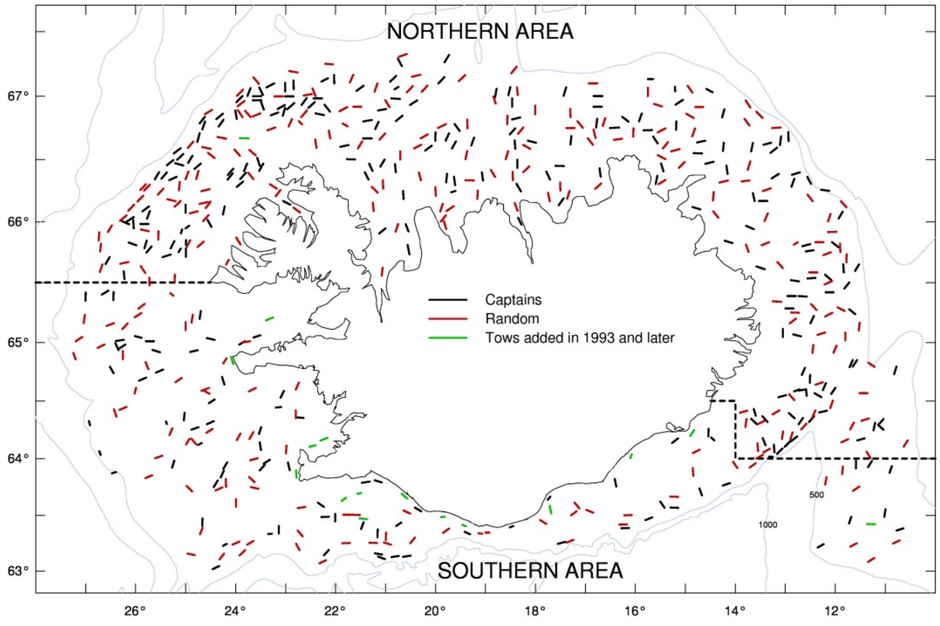

Figure B.3.1. Stations in the Spring Survey in March. Black lines indicate the tow-stations selected by captains of commercial trawlers, red lines are the tow-stations selected randomly, and green lines are the tow-stations that were added in 1993 or later. The broken black lines indicate the original division of the study area into Northern and Southern area. The 500 and 1000 m depth contours are shown.

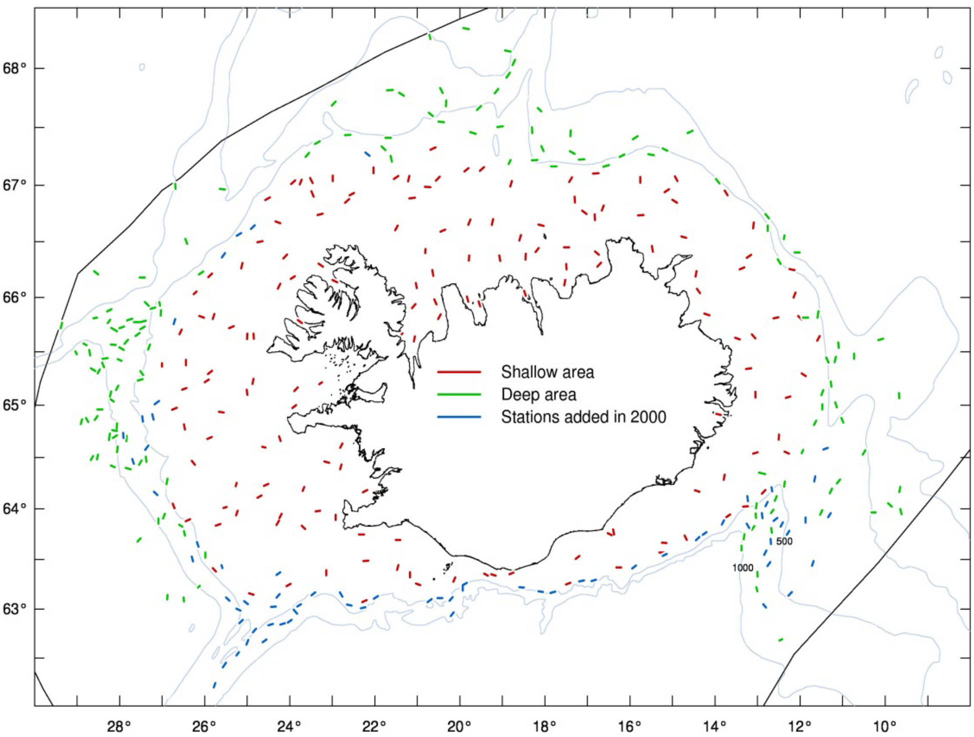

Figure B.3.2. Stations in the Autumn Groundfish Survey (AGS). RV "Bjarni Sæmundsson" takes stations in the shallow-water area (red lines) and RV "Árni Friðriksson" takes stations in the deep-water areas (green lines), the blue lines are stations added in 2000.

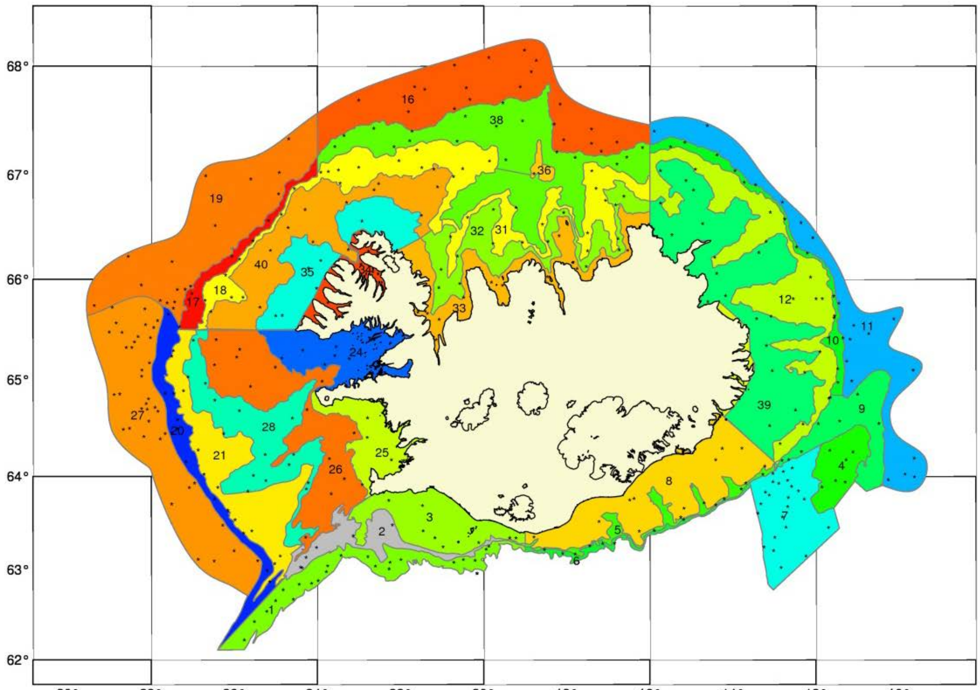

Figure B.3.3. Subareas or strata used for calculation of survey indices for golden redfish from the Autumn Survey in Icelandic waters. This stratification was applied in 2008.

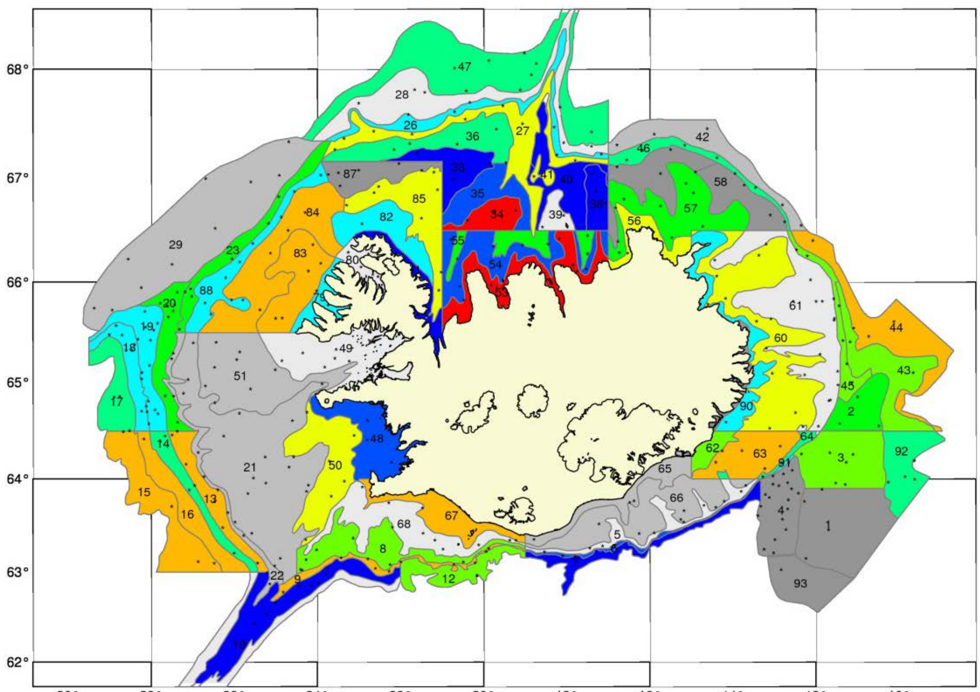

Figure B.3.4. The old stratification (before 2008) that was used for calculation of golden redfish indices from the Autumn Survey in Icelandic waters.

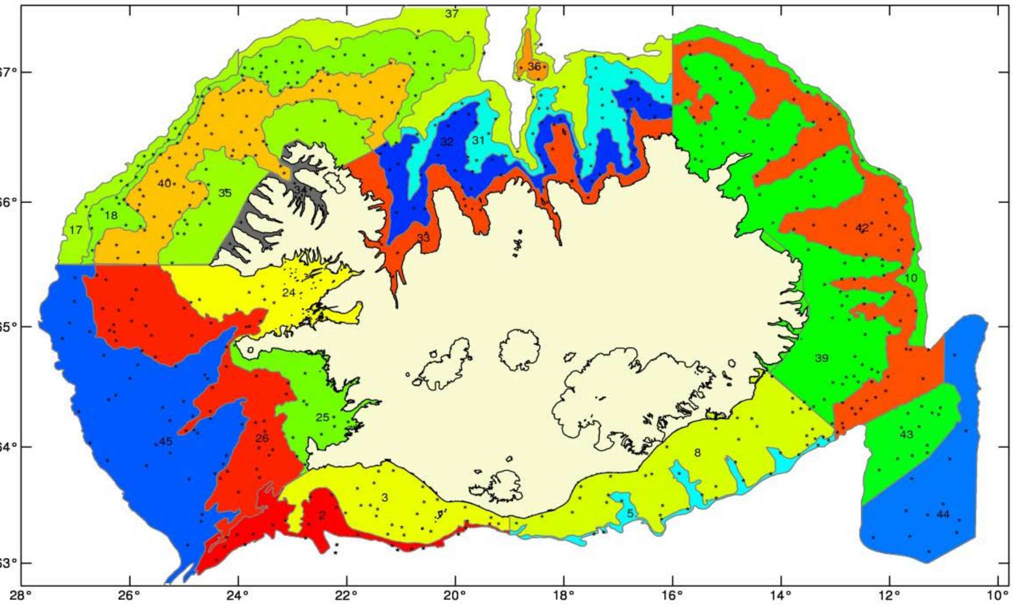

Figure B.3.5. Subareas or strata used for calculation of survey indices for golden redfish from the Spring Survey in Icelandic waters. This stratification was applied in 2011.

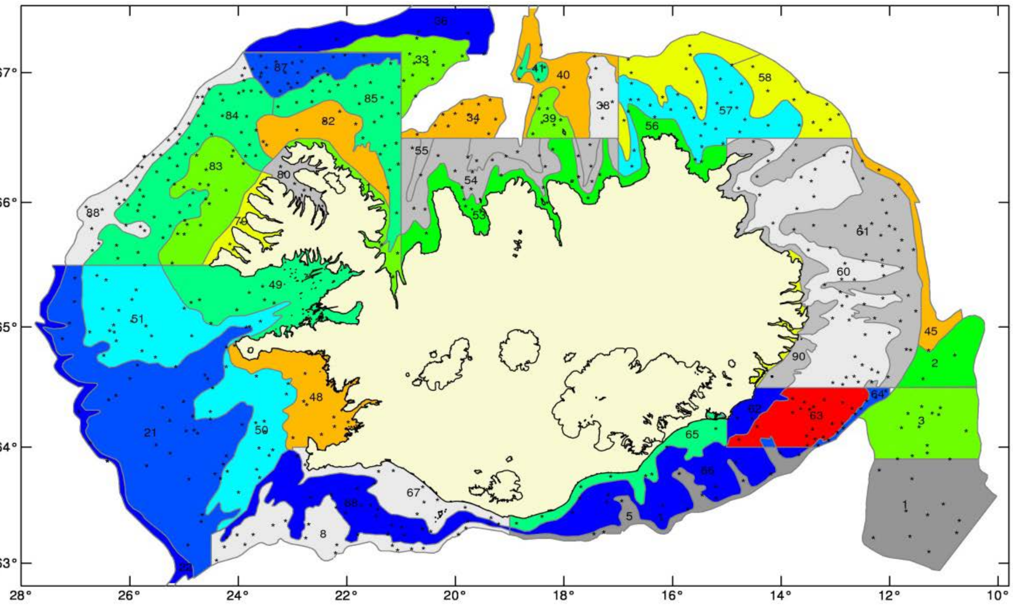

Figure B.3.6. The old stratification (before 2011) that was used for calculation of golden redfish indices from the Spring Survey in Icelandic waters.

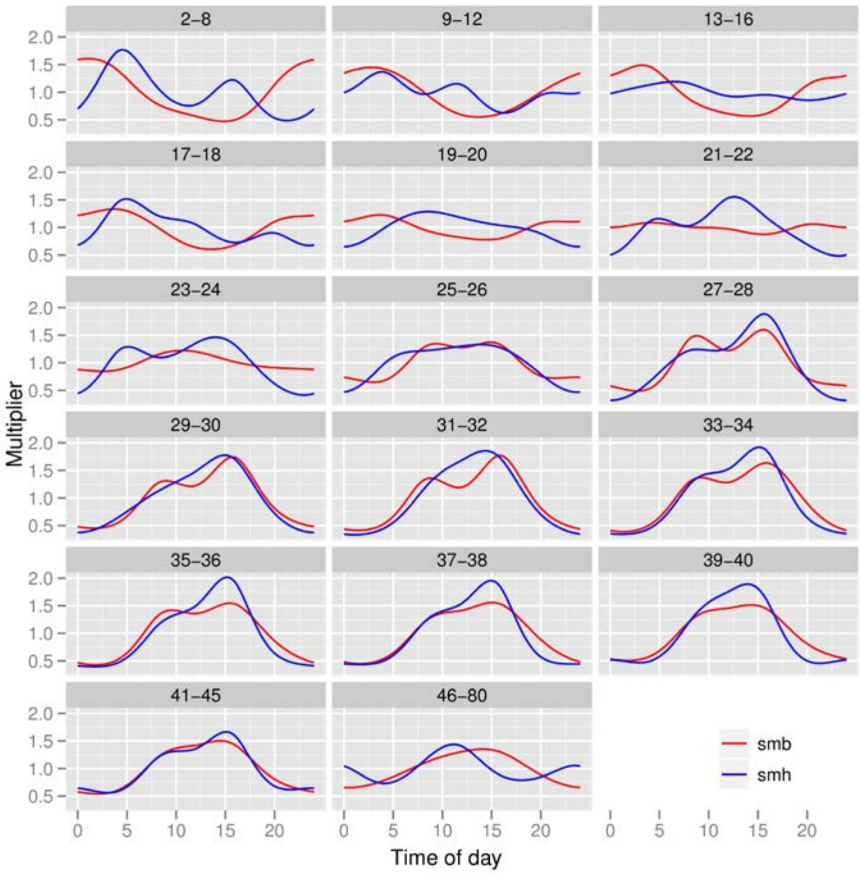

Figure B.3.7. Scaled multiplier for each length group in the Spring Survey (smb - red line) and the Autumn Survey (smh - blue line) based on the glm model with smoother applied to each length group.

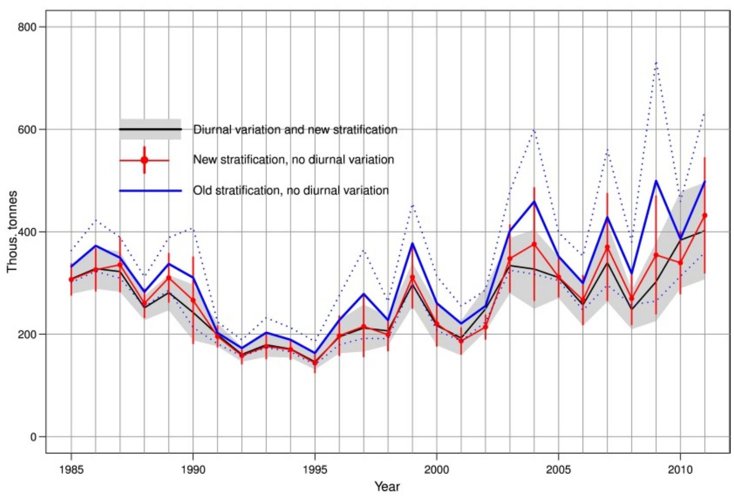

Figure B.3.8. Comparison in survey indices of golden redfish in the Spring Survey 1985–2011, calculated using the new stratification scheme (Figure 3) with and without diurnal vertical migration, and the old stratification scheme (Figure 4).

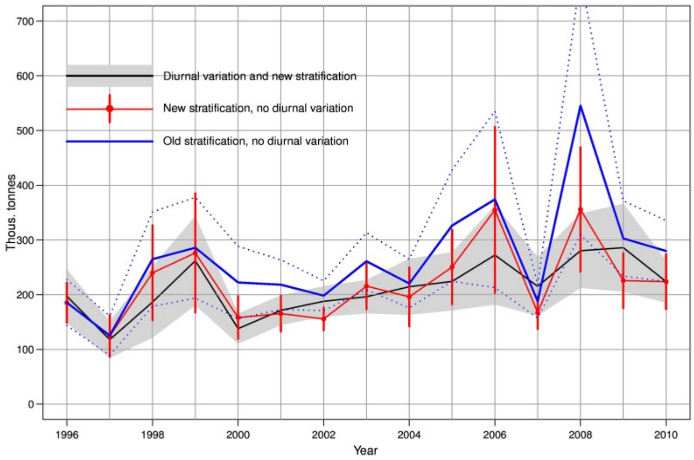

Figure B.3.9. Comparison in survey indices of golden redfish in the Autumn Survey 1996–2010, calculated using the new stratification scheme (Figure 3) with and without diurnal vertical migration, and the old stratification scheme (Figure 4).

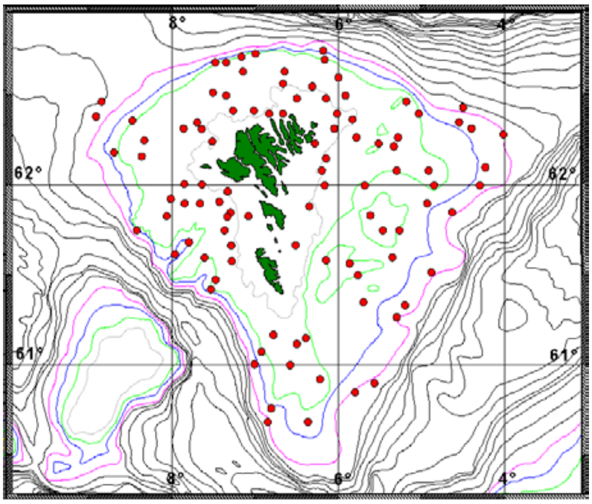

Figure B.3.10. Stations in the Spring Survey on the Faroe Plateau in March 2011.

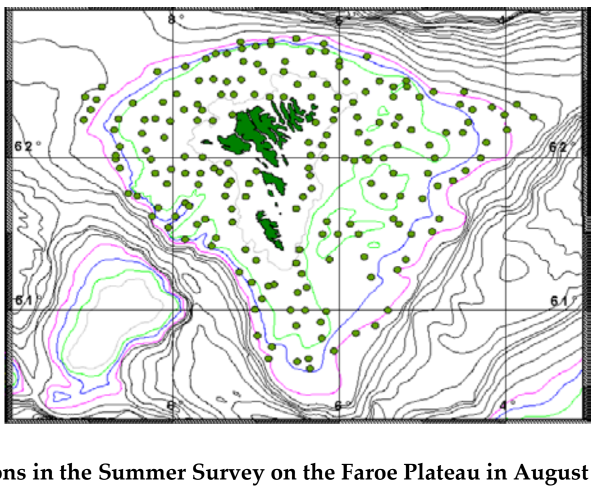

Figure B.3.11. Stations in the Summer Survey on the Faroe Plateau in August 2011.

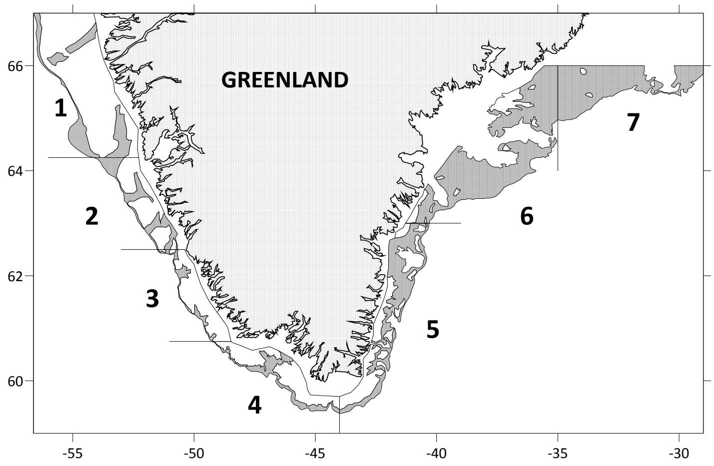

Figure B.3.12. Old stratification used for calculation of golden redfish survey indices of the German groundfish survey conducted on the Greenland shelf until 2012. Only strata off the East Greenland were used (strata 5–7).

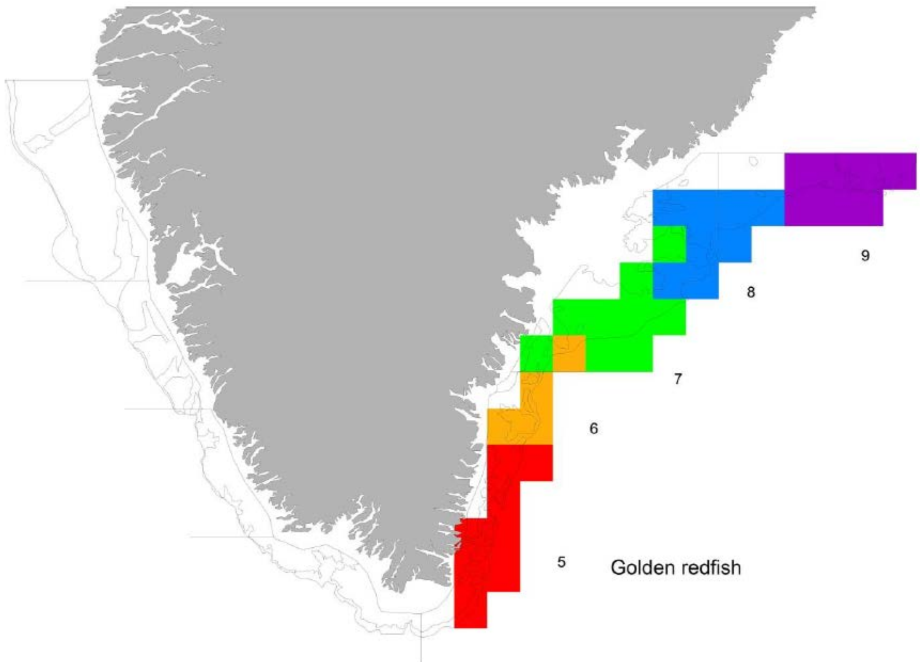

Figure B.3.13. The re-stratification in East Greenland undertaken in 2013. West Greenland strata remain unchanged. Each stratum is divided into two depth zones, 1–200 m and 201–400 m.

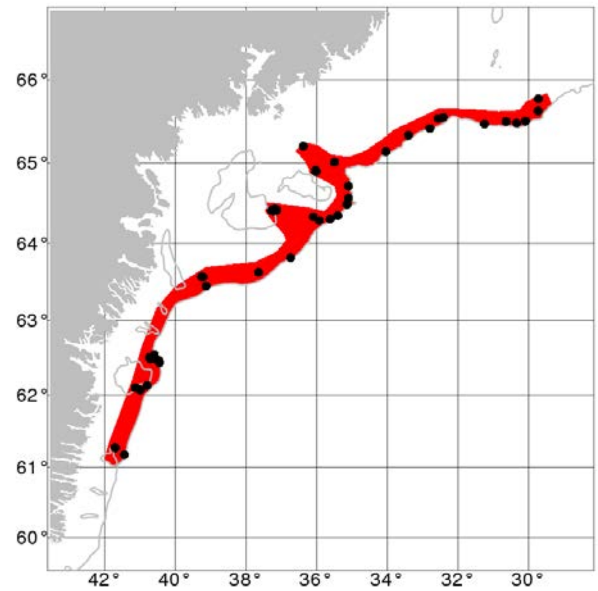

Figure B.3.14. The stratification of the German Survey conducted in East Greenland and used for calculation of survey indices of golden redfish to be used in the GADGET setup. The red area represents the proposed stratum (size = 22 500 km²) and the black points are the stations taken in the 2012 survey.

Stock Annex: Faroe Plateau cod (Division Vb1)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Faroe Plateau cod (Division Vb1)
Working Group:	North-Western Working Group
Last updated:	May 2013
Revised by:	Petur Steingrund, Lise H. Ofstad

A. General

A.1. Stock definition.

Extensive tagging experiments on the Faroe Plateau (Strubberg, 1916; 1933; Tåning, 1940; Joensen *et al.*, 2005; unpublished data) during a century strongly suggest that the cod stock on the Faroe Plateau is isolated from other cod stocks, e.g., from cod on the Faroe Bank and cod at Iceland. Only around 0.1% of recaptured tagged cod are recaptured in other areas than the Faroe Plateau (Joensen *et al.*, 2005). The immigration rate from Iceland is even lower. During 1948-86, around 90 000 cod were tagged at Iceland and 11 000 recaptured. Of these, five cod were recaptured in Faroese waters and only three of them on the Faroe Plateau (Jónsson, 1996). Of cod tagged in the North Sea, one specimen has been recaptured at the Faroes (Bedford, 1966).

Icelandic and Faroese tagging experiments suggest that the cod population on the Faroe-Icelandic ridge mainly belongs to the Icelandic cod stock. Faroe Marine Research Institute tagged about 29 000 cod in Faroese waters during 1997-2009 and about 8 500 have been recaptured to March 2009. Of these, one individual was caught on the Icelandic shelf and one on the Faroe-Icelandic ridge. In 2002, 168 individuals were tagged on the Faroe-Icelandic Ridge (Midbank). Twelve have been recaptured so far, 6 at Iceland, 3 on the Faroe-Icelandic Ridge and 0 on the Faroe Plateau (3 had unknown recapture position). The Marine Research Institute in Iceland tagged 25 572 cod in Icelandic waters during 1997-2004 and 3 708 were recaptured to April 2006. Of these, only 13 individuals were recaptured on the Faroe-Icelandic ridge and none on the Faroe Plateau.

Genetic investigations indicate that Icelandic cod might be composed by two components (Pampoulie *et al.*, 2006): a western component and an eastern component, which, genetically, is indistinguishable from the Faroe Plateau cod stock (Pampoulie *et al.*, 2008). While Faroe Plateau cod is dominated by the Pan I^A allele (above 0.8), the frequency is much lower (between 0.2 and 0.8) for Icelandic populations (Case *et al.*, 2005), especially on the Faroe-Icelandic Ridge (0.2). The cod populations in the North Sea are dominated by the Pan I^A allele (as the populations on the Faroe Plateau and the Faroe Bank) but they have a higher frequency of the HbI(1) hemoglobin allele (Sick, 1965). Hence, Faroe Plateau cod have a rather special combination of genetic traits, as they mainly possess the 'coldwater' hemoglobine allele (Hb-I(2)) and the 'warmwater' PanI^A allele.

Cod spawn in February-March at two main spawning grounds north and west of the islands at depths around 90-120 m. The larvae hatch in April and are carried by the

Faroe Shelf residual current (Hansen, 1992) that flows clockwise around the Faroe plateau within the 100-130 m isobath (Gaard *et al*. 1998; Larsen *et al.*, 2002). The fry settle in July-August and occupy the near shore areas, which normally are covered by dense algae vegetation. In autumn the following year (*i.e.* as 1 group), the juvenile cod begin to migrate to deeper waters (usually within the 200 m contour), thus entering the feeding areas of adult cod. They seem to be fully recruited to the fishing grounds as 3 year olds. Faroe plateau cod mature as 3-4 year old. The spawning migration seems to start in January and ends in May. Cod move gradually to deeper waters when they are growing older. The diet in shallow water (< 200 m) is dominated by sandeels and benthic crustaceans, whereas the diet in deeper water mainly consists of Norway pout, blue whiting and a few species of benthic crustaceans.

The geographical areas are presented in Figure 3.

A.2. Fishery

The cod fishery on the Faroe Plateau was dominated by British trawlers during the 1950s and 1960s. Faroese vessels took an increasing part of the share during the 1960s. In 1977, the EEZ was extended to 200 nautical miles, excluding most foreign fishing vessels from Faroese fishing grounds. In the 1980s, closed areas (mostly during the spawning time) were introduced and these were extended in the 1990s. Longliners and jiggers fished in shallow (< 150 m) waters, targeting cod and haddock, whereas trawlers exploited the deeper waters, targeting saithe. Small trawlers were allowed to exploit the shallow fishing grounds for flatfish during the summertime. After the collapse in the fishery in the beginning of the 1990s, which contributed to a serious national economic crisis in the Faroes, a quota system was introduced in 1994. It was in charge during 1994-1995, but was replaced by the effort management system in June 1996. The cod stock had by then recovered rapidly, which was in contrast with the scientific expectations.

A.3. Ecosystem aspects

The rapid recovery of the cod stock in the mid 1990s strongly indicated that ‘strange things’ had happened in the environment. It became clear that the productivity of the ecosystem affected both cod and haddock recruitment and growth (Gaard *et al*., 2002), a feature outlined in Steingrund and Gaard (2005). The primary production on the Faroe Shelf (< 130 m depth), which took place during May-June, varied interannually by a factor of five, giving rise to low- or high-productive periods of 2-5 years duration (Steingrund and Gaard, 2005). The productivity over the outer areas seems to be negatively correlated with the strength of the Subpolar Gyre (Hátún *et al*., 2005; Hátún *et al*., 2009; Steingrund *et al*.,2010), which may reglulate the abundance of saithe in Faroese waters (Steingrund and Hátún, 2008).

B. Data

B.1. Commercial catch

When calculating the catch-at-age, the sampling strategy is to have length, length-age, and length-weight samples from all major gears during three periods: January-April, May-August and September-December. In the period 1985-1995, the year was split into four periods: January-March, April-June, July-September, and October-December. The reason for this change was that the three-period splitup was considered to be in better agreement with biological cycles (the spawning period ends in April). When sampling was insufficient, length-age and length-weight samples were borrowed from similar fleets in the same time period. Length measurements were, if possible, not borrowed. The number of samples in 2005 and 2007-2008 was not sufficient to allow the traditional three period splitup for all the fleets, and a two period splitup (January-June and July-December) was adopted for those fleets.

The landing values were obtained from the Fisheries Ministry and Statistics Faroe Islands. The catches on the Faroe-Iceland ridge were not included in the catch-at-age calculations, a practice introduced in the 2005 WG. Catch-at-age for the fleets covered by the sampling scheme were calculated from the age composition in each fleet category and raised by their respective landings. The catch-at-age by fleet was summed across all fleets and scaled to the correct catch.

Mean weight-at-age data were calculated using the length/weight relationship based on individual length/weight measurements of samples from the landings.

B.2. Biological

B.3. Surveys

The spring groundfish surveys in Faroese waters with the research vessel Magnus Heinason were initiated in 1983. Up to 1991 three cruises per year were conducted between February and the end of March, with 50 stations per cruise selected each year based on random stratified sampling (by depth) and on general knowledge of the distribution of fish in the area. In 1992 the period was shortened by dropping the first cruise and one third of the 1991-stations were used as fixed stations. Since 1993 all stations are fixed stations. The standard abundance estimates is the stratified mean catch per hour in numbers at age calculated using smoothed age/length keys. In last years assessment, the same strata were used as in the summer survey and calculated in the same way (see below). All cod less than 25 cm were set to 1 year old.

In 1996, a summer (August-September) groundfish survey was initiated, having 200 fixed stations distributed within the 500 m contour of the Faroe Plateau. Half of the stations were the same as in the spring survey.

The abundance index was calculated as the stratified mean number of cod at age. The age length key was based on otolith samples pooled for all stations. Due to incomplete otolith samples for the youngest age groups, all cod less than 15 cm were considered being 0 years and between 15 and 34 cm 1 year (15-26 cm for 2005 because of abnormally small 2 year old fish). Since the age length key was the same for all strata, a mean length distribution was calculated by stratum and the overall length distribution was calculated as the mean length distribution for all strata weighted by stratum area. Having this length distribution and the age length key, the number of fish at age per station was calculated, and scaled up to 200 stations.

The proportion mature was obtained from the spring survey, where all aged individuals were pooled, i.e., from all stations, being in the spawning areas or not. The average maturity at age for 1983 to 1996 was used in years prior to 1983. Some of the 1983-1996 values were revised in 2003 but not the maturities for the 1961-1982 period.

B.4. Commercial CPUE

Two/three commercial cpue series (longliners and pair trawlers) are updated every year, but the WG decided in the benchmark assessment in 2004 not to use them in the tuning of the VPA. The cpue for the longliners was shown to be highly dependent upon environmental conditions whereas the cpue for the pair trawlers could be influenced by other factors than stock size, for example the price differential between cod and saithe. These two/three cpue series are presented in the report although they were not used as tuning series.

B.5. Other relevant data

C. Historical Stock Development

An XSA has been performed during a number of years. The use of tuning indices has, however, varied quite a lot since the mid 1990s. The Faroese spring groundfish survey was excluded as a tuning series in the mid 1990s because the catch-curves in the survey showed an anormal pattern. Two commercial tuning series (single trawlers 400-1000 HP and longliners > 100 GRT) were used during 1996-1998 where the effort was in number of days. In 1999, the tuning series constituted the pairtrawlers > 1000 HP (effort in the number of trawl hours) and the longliners > 100 GRT (effort in the number of hooks set). In 2002, the Faroese Summer Groundfish Survey was used as the only tuning series, as was the case in 2003. A benchmark assessment was performed in the 2004 NWWG, where the Faroese Spring Grounfish Survey was reintroduced, albeit with a modified stratification, i.e., the two surveys were used as the only tuning series. All assessments since then have been update assessments where only minor changes in settings have been made.

Model used: Extended Survivors Analysis.

Software used: Virtual Population Analysis, version 3.2, beta: Windows 95. Copyright: MAFF Directorate of Fisheries Research. License number: DFRVPA31M.DFR.

Model Options chosen:

Time series weights: Tapered time weighting not applied. Catchability analysis: Catchability independent of stock size for all ages. Catchability independent of age for ages >= 6. 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 = 2.00. Minimum standard error for population estimates derived from each fleet = 0.300. Prior weighting not applied.

Input data types and characteristics: (last data year = 2012)

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1961-last data year		Yes
Canum	Catch at age in numbers	1961-last data year	2-10+	Yes
Weca	Weight at age in the commercial catch	1961-last data year	2-10+	Yes
West	Weight at age of the spawning stock at spawning time.	1961-last data year	2-10+	Yes, the same data as for the commercial catch
Mprop	Proportion of natural mortality before spawning	1961-last data year	2-10+	No, set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1961-last data year	2-10+	No, so to 0 for all ages in all years
Matprop	Proportion mature at age	1983-last data year +1	2-10+	Yes, but constant values used prior to 1983, i.e., average maturities during 1983-1996
Natmor	Natural mortality	1961-last data year	2-10+	No, set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Summer Survey	1996- last data year	2-8
Tuning fleet 2	Spring Survey	1994- last data year+1 (shifted to 1993- last data year)	2-9

D. Short-Term Projection

Model used: Age structured.

Software used: MFDP prediction with management option table and yield per recruit routines.

Initial stock size. Taken from XSA for all ages (2-10+).

Natural mortality: Set to 0.2 for all ages in all years.

Maturity: The values observed in the spring survey 2013 are used for 2013 while average maturities 2011-2013 are used in 2014 and 2015.

F and M before spawning: Set to 0 for all ages in all years.

Weight at age in the stock: The same values as weight-at-age in the catch.

Weight at age in the catch: For each age, a regression was performed between the weight-at-age during the whole year and 1) the weight-at-age during January-February or 2) the weight-at-age in the spring survey 1994-2013. The relationship with the higher coefficient of correlation was used as a basis to predict the weight-at-age in 2013. The values for 2014-2015 were set to the 2013 value.

Exploitation pattern: Average for the three last years when there is no trend in the series or rescaled to terminal year when there is a trend in the series.

Intermediate year assumptions: average for the three last years, i.e., not rescaled to the terminal year.

Stock recruitment model used: none.

Procedures used for splitting projected catches: none.

E. Medium-Term Projections

Not performed.

F. Long-Term Projections

Model used: Yield and biomass per recruit over a range of F-values.

Software used: MFYPR version 1.

Maturity: Average for 1983-2013.

F and M before spawning: Set to 0 for all ages and years.

Weight at age in the stock: Same as the weights in the catch.

Weight at age in the catch: Average for 1978-2012 in order exclude the high values in former times.

Exploitation pattern: Average for 2000-2012 (not rescaled to the terminal year) in order to reflect a recent fishing pattern.

Procedures used for splitting projected catches: none.

A long-term simulation model is used, see text in the report.

G. Biological Reference Points

The reference points are dealt with in the general section of Faroese stocks. The reference points for Faroe Plateau cod are the following: B_{pa} = 40kt, B_{lim} = 21kt, F_{pa} = 0.35 and F_{lim} = 0.68.

H. Other Issues

I. References

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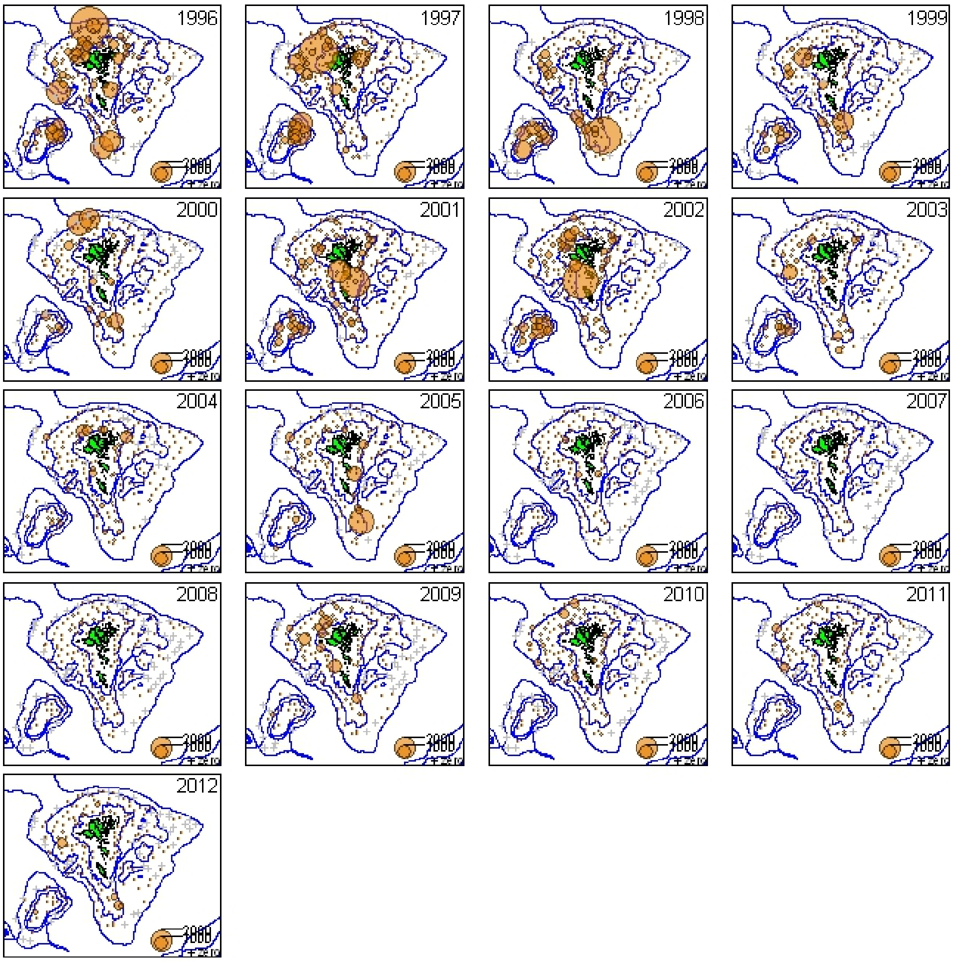


Figure 1. Cod in Division Vb1. The spatial distribution of cod according to the summer survey on the Faroe Plateau (kg per tow). 100, 200 and 500 m depth contours are shown. The figure is continued on the following page.

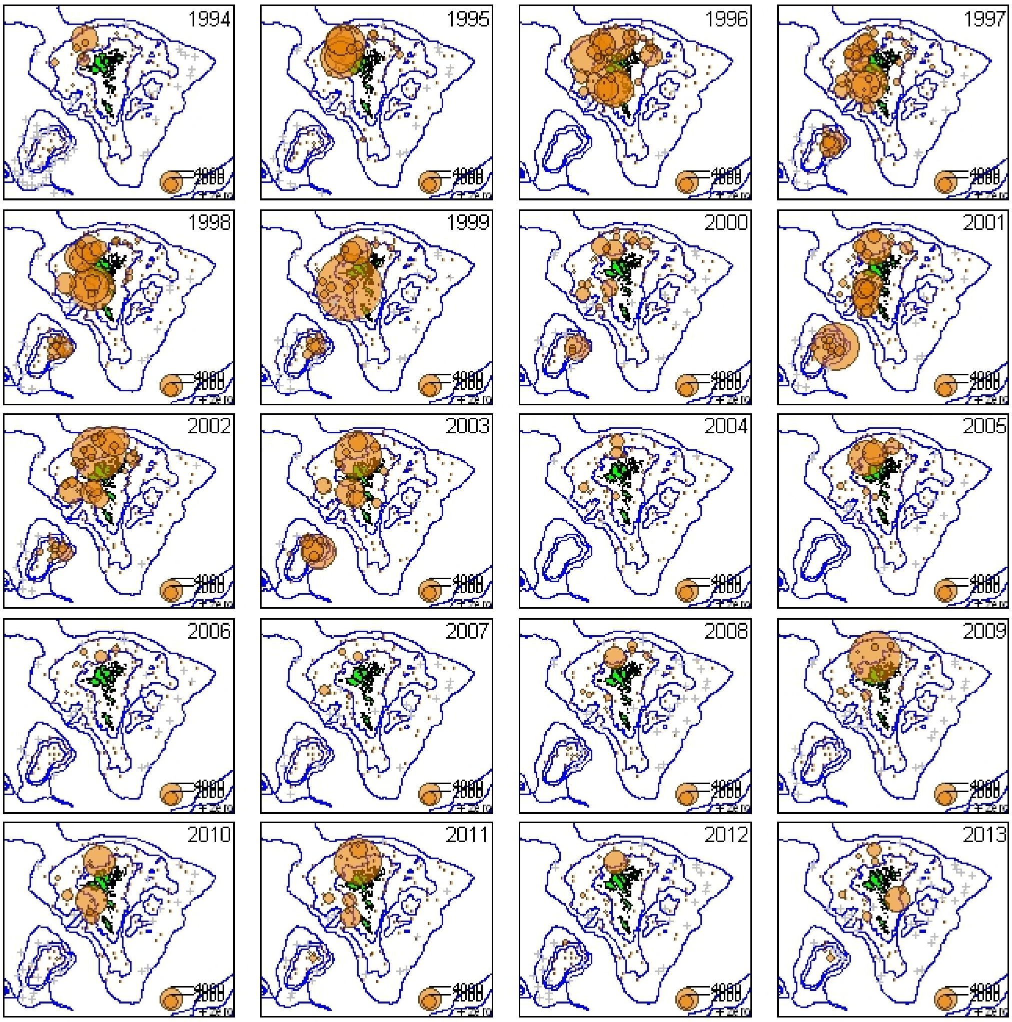


Figure 2. Cod in Division Vb1. The spatial distribution of cod according to the spring survey on the Faroe Plateau (kg per tow). 100, 200 and 500 m depth contours are shown.

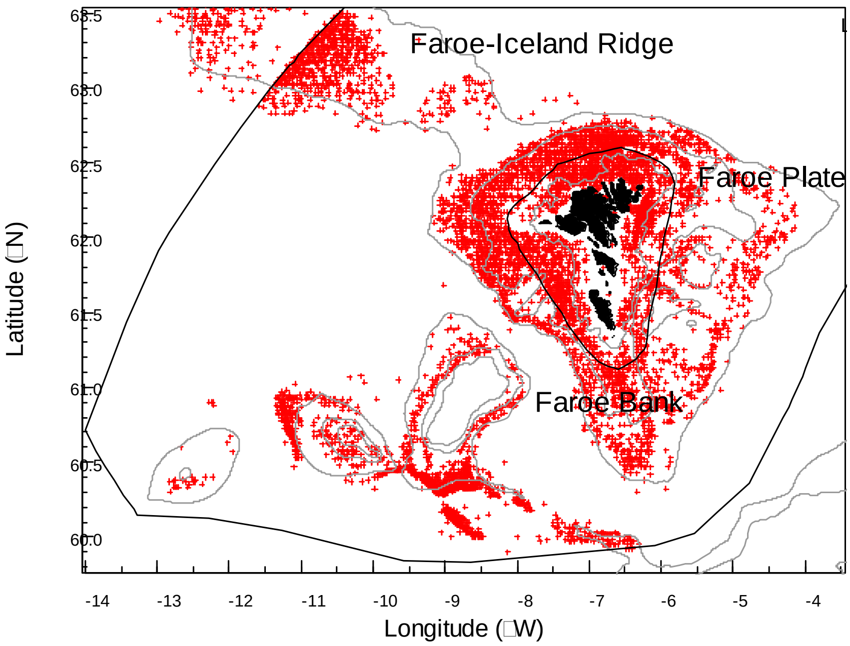


Figure 3. Map of geographical areas often used in the report. The red crosses show the start positions of all longliner settings in 2011.

Stock Annex: Faroe Bank cod (Division Vb2)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Faroe Bank Cod
Working Group:	North Western Working Group
Date:	April 2013
Revised by:	Luis Ridao Cruz

A. General

A.1. Stock definition

The Faroe Bank is located approximately 75 km Southwest of the Faroe Islands (60º15′ S, 61º30′ N,9º 40′W,7º40′ E)(Eyðfinn, 2002). The Faroe Bank cod is under ICES management unit Vb2. Inside the 200 m depth contour, the Faroe Bank covers an area of about 45 × 90 km and its shallowest part is less than 100 m deep. The Faroe Bank cod is distributed mainly in the shallow waters of the Bank within the 200 m depth contour. The cod stock on the Bank is regarded as an independent stock displaying a higher growth rate than that of cod on the Plateau. Tagging experiments have shown that exchanges between the two cod stocks are negligible. The stock spawns from March to May with the main spawning in the first-half of April in the shallow waters of the Bank (<200 m). The eggs and larvae are kept on the Bank by an anti-cyclonic circulation. The juveniles descend to the bottom of the Bank proper in July. No distinct nursery areas have been found on the Bank. It is expected that the juveniles are widely distributed on the Bank, finding shelter in areas difficult to access by fishing gear (Jákupsstovu, 1999).

A.2. Fishery

Due to the decreasing trend in cod landings the Bank was closed to all fishing in 1990. This advice was followed for depths shallower than 200 meters. In 1992 and 1993 longliners and jiggers were allowed to participate in an experimental fishery inside the 200-meter depth contour. The new management regime with fishing days was introduced on 1 June 1996 allowing longliners and jiggers to fish in depths below 200 m while trawlers are allowed to fish in waters deeper than 200 m.

A total fishing ban during the spawning period (1 March to 1 May) has been enforced since 2005.

A.3. Ecosystem aspects

The Faroe Bank is a geographically well-defined and self-contained ecosystem surrounded by an oceanic environment (Eyðfinn, 2002) in which cod spawns from March to May with the main spawning in the first-half of April in the shallow waters of the Bank (<200 m). The eggs and larvae are contained in the anti-cyclonic circulation on the Bank. The juveniles descend to the bottom of the Bank proper in July. No distinct nursery areas have been found on the Bank. It is anticipated that the juveniles are widely distributed on the Bank, finding shelter in areas difficult to access by fishing gear (Jákupsstovu, 1999).

Growth

Cod in the Faroe Bank is the fastest growing cod stock in the North Atlantic. For comparison the average size of 1-year old cod in the Bank is approximately 60 cm while the Faroe Plateau cod is slightly below 20 cm (Figure 1.)

Maturity

The majority of cod in the Faroe Bank mature at age three with usually all mature by age four.

Diet

The diet of cod in the Bank varies with the size of the fish and season. Adult cod feeds mainly of fish preys like sandeel and crustaceans specially crabs, shrimps, munida and galathea while whelks and worms may contribute to a lesser extent to its diet.

B. Data

B.1. Commercial catch

Faroese commercial catch in tonnes by month, area and gear are provided by the Faroese Statistical Office (Hagstova). Data on catch in tonnes from other countries are taken from ICES official statistics and/or from Coastal Guard reports.

The landing estimates are uncertain because since 1996 vessels are allowed to fish both on the Plateau and on Faroe Bank during the same trip, rendering landings from both areas uncertain. Given the relative size of the two fisheries, this is a bigger problem for Faroe Bank cod than for Faroe Plateau cod.

No discards are reported or accounted for in the assessment..

Only landings from Faroes islands and Norway are included in the assessment.

B.2. Biological

Biological samples have been taken from commercial landings since 1974 and from the groundfish survey since 1983.

B.3. Surveys

Biannual groundfish bottom-trawl surveys are carried out in the Bank since 1997. The spring survey was initiated in 1994 and was discontinued in 1996, 2004 and 2005. Series available to the WG are as follows:

Faroese spring groundfish survey (FGFS1): 1994-1995, 1997-2003,2006-2013–2003, 2006–2013

Faroese fall groundfish survey (FGFS2): 1996–2012.

	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10+
FGFS1	x	x		x	x	x	x	x	x	x			x	x	x	x	x
FGFS2			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

The design for both bottom-trawl surveys is depth stratified with randomised stations covering the shallow and deeper waters of the Bank. The total number of stations is 29 of which 20 are located within the 200 m. depth contour and the rest in deeper waters off the Bank. Effort is recorded in terms of minutes towed approximately 60 min.

Plots of the spatial distribution of the fall (2000-2004) and spring (2006-2008) faroese groundfish surveys mean catch rates are given in Figure 2 and 3.

The assessment of cod in the Bank is based on survey trends. It's regarded as an exploratory assessment.

In 2013 a surplus-production model was performed and the results indicate a good agreement between estimated fishing mortality and exploitation rates (ratio of survey biomass index to landings). No sensitivity analysis was carried out to explore the stability of parameter estimation. The model seemed to follow survey trends in the last decade but it failed to predict the abrupt changes in stock biomass observed from 1996 to 2002.

B.4. Commercial CPUE

A commercial cpue series from longliners is available but has never been used by the WG.

B.5. Other relevant data

The number of fishing days by the longline fleet is provided by the Faroese Coastal Guard and consist of realised days at sea.

C. Historical Stock Development

In 2000, an attempt was made to assess the stock using XSA with catch at age for 1992-1999, using the spring groundfish survey as a tuning series (1995-1999) but the WG and ACFM concluded that it could only be taken as indicative due to scarce catch-at-age data. No attempt was made to update the XSA in subsequent years given the poor sampling for age composition particularly for trawl landings. Since then several tools have been used to assess the status of the stock. In 2013 a surplus production model was implemented. The WG has agreed to use the survey catch rates (kg/hr) as indicative to follow stock trends.

D. Uncertainties in assessment and forecast

The landing estimates are uncertain because since 1996 vessels are allowed to fish both on the Plateau and on Faroe Bank during the same trip, rendering landings from both areas uncertain. Given the relative size of the two fisheries, this is a bigger problem for Faroe Bank cod than for Faroe Plateau cod, but the magnitude remains unquantified for both.

The catches of cod on Faroe Bank are sometimes reported on the landing slips and only the vessels larger than 15 GRT are obliged to have logbooks. The Faroes Coastal Guard is splitting the landings into Vb1 and Vb2 on the basis of landing slips and logbooks. Since small boats do not fill out logbooks and may not sell their catch, the catch figures on the Faroe Bank are actually estimates rather than absolute figures. The error in the catches of Faroe Bank cod may be in the order of some hundred tonnes, not thousand tonnes.

E. Short-Term Projection

None

F. Medium-Term Projections

None

G. Long-Term Projections

None

H. Biological Reference Points

There are not analytical basis to suggest reference points based on XSA, general production and statistical catch at age analysis.

J. Other Issues

None

K. References

Eyðfinn, 2002. Demersal fish assemblages of Faroe Bank: species composition, distribution, biomass spectrum and diversity

Jákupsstovu, 1999. The Fisheries in Faroese waters. Fleets, Activities, distribution and potential conflicts of interest with an offshore oil industry.

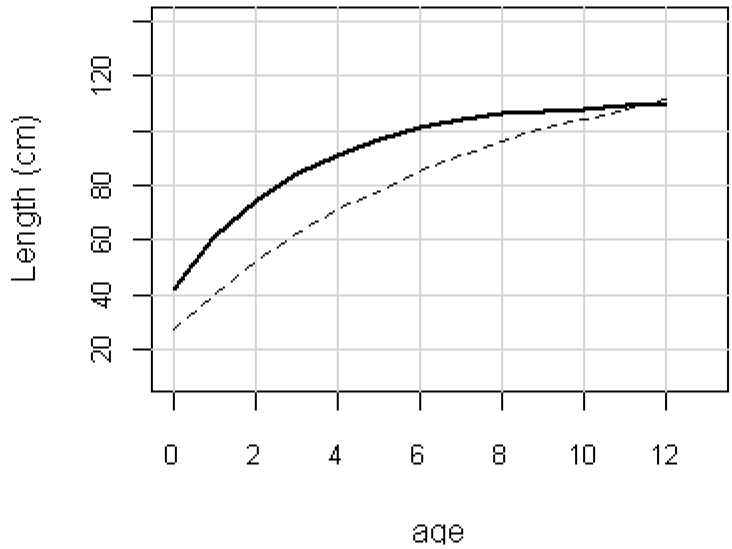


Figure 4. Von Bertalanfy growth equation for the Faroe Bank (thick line) and Faroe Plateau (dash line) cod stocks.

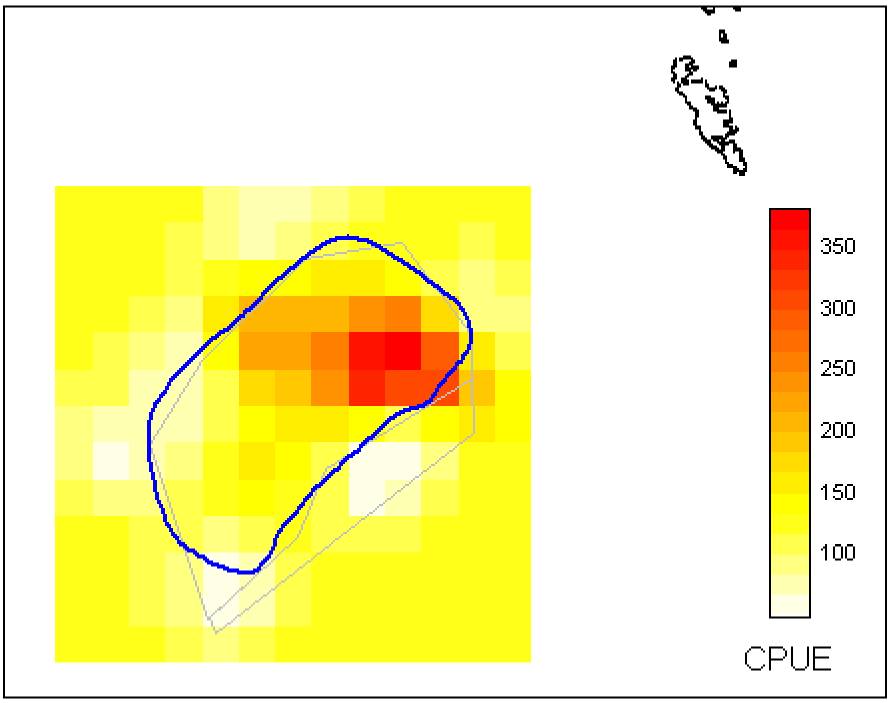


Figure 5. Cod in Division Vb2. Catch per unit of effort (CPUE) from the faroese summer groundfish survey 2000-2004.

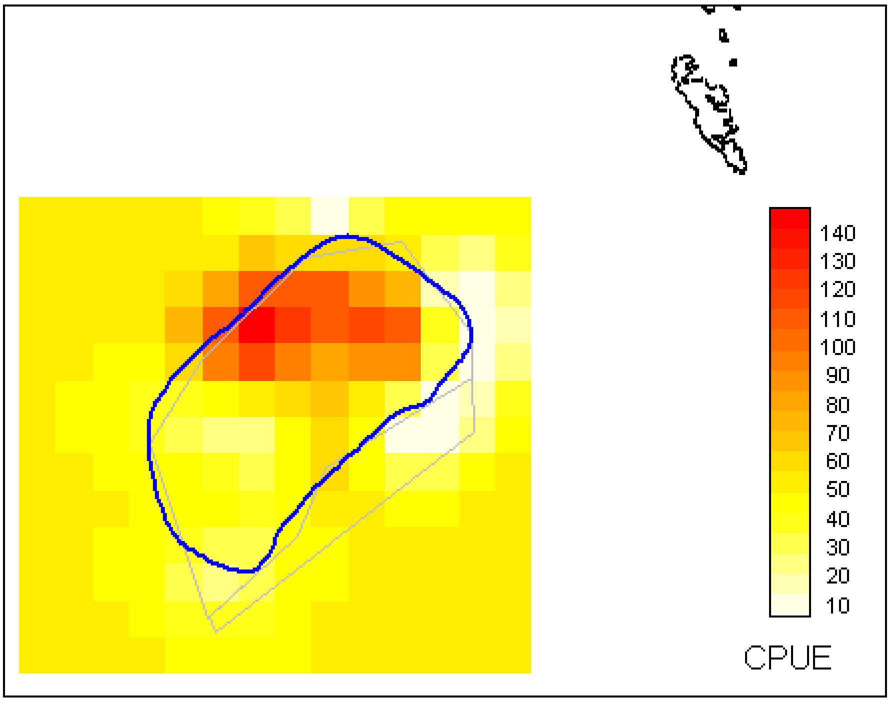


Figure 6. Cod in Division Vb2. Catch per unit of effort (CPUE) from the faroese spring groundfish survey 2006-2008.

Annex 03: Intercatch

As already mentioned in the Introduction the group has made little use of Intercatch this year. The main reason is that mostly one nation is fishing each stock, which requires more than a descriptive stock assessment. This does not necessarily mean that Intercatch is of no use to the group in the future. A few NWWG members got a short introductory course in Intercatch, which hopefully will stimulate the use of Intercatch.

Annex 04: List of Audits for NWWG 2014

Audit of Faroe Plateau Cod

Date: 07.05.2014

Reviewer: Rasmus Hedeholm

General

- The assessment follows the Stock Annex and is based on survey trends and landings. This is done in accordance with the stock annex.
- There is consistency between the information provided in the assessment report and the Advisory summary sheet.

For single stock summary sheet advice:

1) **Assessment type: Update**
2) **Assessment**: analytical
3) **Forecast**: short term forecast presented
4) **Assessment model**: XSA – tuning by 2 surveys
5) **Data issues:** All data is available as described in the Stock Annex
6) **Consistency**: New data on landings and indices from surveys does not change the perception of the low stock level since 2004. F estimates varies considerably between years.
7) **Stock status**: The biomass estimate increase slightly in 2014, but the stock is still believed to be around B_{lim}. Fishing mortality has decreased since 2010 and is now below F_{lim} and F_{MSY}.
8) **Man. Plan.**: An effort management system was implemented 1 June 1996. This targets an F of 0.45. ICES considers this to be inconsistent with the PA and MSY approaches. A new management plan is under development.

General comments

The most important messages from this assessment are well documented, which are that the status of the stock is poor but F has been reduced and at least the stock appears stable around B_{lim}. The report is well written and well structured.

Technical comments

NA

Conclusions

The assessment has been performed correctly as described in Stock Annex and can be used as basis for advice.

Audit of Faroe Bank Cod

Date: 01.05.2014

Reviewer: Guðmundur J. Óskarsson

General

- The assessment follows the Stock Annex by base it on survey trends and gives a valid basis for advice. Additionally, results of exploratory runs with a production model are introduced and they are in agreement with the survey indices of continuing poor condition of the stock size.
- There is a clear consistency between the information provided in the assessment report and the Advisory summary sheet.

For single stock summary sheet advice:

9) **Assessment type: Same Advice as Last Year**
10) **Assessment**: Survey trends and exploratory assessment
11) **Forecast**: not presented
12) **Assessment model**: Production model (ASPIC) exploratory – tuning by 2 surveys
13) **Data issues:** All data is available as described in the Stock Annex
14) **Consistency**: New data on landings and indices from the two annual surveys (2013 summer, 2014 spring) do not change the perception of the low stock level since 2008 and do not give reason to change the advice from 2013.
15) **Stock status**: No reference points are defined, but trends are showing continuation of low stock size and poor recruitment
16) **Man. Plan.**: No management plan is for the stock.

General comments

The most important messages from this assessment are well documented, which are that the status of the stock is poor and no indications for improvements. However, for clarity and easier reading, the order and structure of the report should be improved. The first section (3.1) should for example be divided into several sections, including Fishery, Survey, Analytical assessment, State of the stock or similar to what is done for other stocks.

Technical comments

References to figures in the text is incorrect in some cases (e.g. Figure 3.5.1 does not exists).

Conclusions

The assessment has been performed correctly as described in Stock Annex, and is based on survey trends and supported with exploratory runs of stock production model.

Audit of Faroe saithe (Division Vb)

Date 8 May 2014

Reviewer: Arni Magnusson

General

The stock has been assessed in agreement with the stock annex.

For single stock summary sheet advice:

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: XSA tuned with 1 commercial CPUE series
5) **Data issues:** All data available as described in the annex
6) **Consistency**: Last year a spring survey tuning series was proposed and rejected, but this year the assessment follows the 2010 benchmark; also Fmsy updated from 0.28 to 0.30 (ICES WKMSYREF2 2014).
7) **Stock status**: SSB_{2014} 70 kt, above Btrigger=55 kt; F_{2013} 0.45, above F_{MSY}=0.30
8) **Man. Plan.**: No management plan exists for this stock

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

The updated F_{MSY}=0.30 reference point is based on a more complete simulation analysis than the previous F_{MSY}=0.28. In the range of simulation options considered, F_{MSY}=0.30 was one of the lower estimates.

Conclusions

The results can be used as basis for advice.

Audit of Cod in Division Va (Icelandic cod; cod-iceg)

Date 1st of May 2014

Reviewer: Anja Retzel

General

The stock has been assessed in close agreement with the stock annex.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type: update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: statistical catch-at-age (ADCAM) tuned with two (spring and fall) surveys.
5) **Data issues:** All data is available as described in the Stock Annex.
6) **Consistency**: SPALY assessment was consistent with last year's assessment.
7) **Stock status**: Blim is 125 kt, MSY Btrigger is 220 kt and SSB in 2014 is estimated at 427 kt. Reference biomass, (B4+) is estimated at 1106 kt in 2014. PA and MSY reference points have not been set for this stock.
8) **Man. Plan.**: Because SSB> Btrigger, the $TAC_{2014/2015}$ is set as ($TAC_{2013/2014}$ + $0.2*B_{B4+,2014}$)/2. In accordance with this plan, the proposed TAC for 2014/2015 is 218 kt. According to the advice sheet, ICES has evaluated the plan and concludes that it is in accordance with the precautionary approach and the ICES MSY framework.

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

None

Conclusions

The assessment has been performed in as close proximity to the Stock annex and the results can be used as basis for advice.

Audit of Icelandic haddock (had-iceg)

Date 1-May-2014

Reviewer: Jákup Reinert

General

The stock has been assessed in agreement with the stock annex

For single stock summary sheet advice:

1) **Assessment type:** SPALY
2) **Assessment**: Analytical
3) **Forecast**: Short term forecast presented
4) **Assessment model**: Adapt type model + 2 surveys
5) **Data issues:** All data available as described in the annex
6) **Consistency**: The approach is consistent with last year; like last year the two surveys used for tuning give different perceptions of stock status
7) **Stock status**: The 2014 assessment shows some upward revision of stock as compared to the one in 2013. Although declining in recent years, SSB is well above B_{lim} and $B_{trigger}$ and the harvest rate is estimated below the H_{pa} and H_{MSY}. Recent year classess are well below average.
8) **Man. Plan.**: In March 2013 a Harvest Control Rule was evaluated by ICES. It was considered to be precautionary and in conformity with the MSY approach. In April 2013 this rule was adopted by the Icelandic Government. This Harvest Control Rule has a target harvest rate of 0.4 and this rate is used directly to advice on a TAC as long as the SSB is above $B_{trigger}$.

General comments

The assessment is well done and in accordance with stock annex; the report is well written and easy to understand.

Technical comments

There are several typographical errors which should be corrected. Retrospective analysis (Fig. 10.2.5 – not mentioned in the text?) should include estimates of F.

Conclusions

This assessment and report can be used as a basis for advice.

Annex 05 – List of working documents. (NWWG 2014)

Gudmundur Thordarson. 2014. A note on the Greenland halibut (Reinhardtius hippoglossoides) CPUE estimates from Va. ICES NWWG 2014 Working Document no. 01.

Rasmus Hedeholm and Jesper Boje. 2014. Greenland Shrimp and Fish Survey Results for Redfish in East Greenland Offshore Waters in 2013. ICES NWWG 2014 Working Document no. 02.

Jesper Boje and Rasmus Hedeholm. 2014 The fishery for Greenland halibut in ICES Div. XIVb in 2013. ICES NWWG 2014 Working Document no. 03.

Rasmus Hedeholm and Jesper Boje. 2014. Survey for Greenland halibut in ICES Division 14B, August – September 2013. ICES NWWG 2014 Working Document no. 04.

Rasmus Hedeholm and Anja Retzel. 2014. West Greenland inshore gillnet survey results for juvenile Atlantic cod in 2013. ICES NWWG 2014 Working Document no. 05.

Rasmus Hedeholm and Jesper Boje. 2014. The fishery for demersal Redfish (*S.mentella*) in ICES Div. XIVb in 2013. ICES NWWG 2014 Working Document no. 06.

Petur Steingrund. 2014. A transformation of the Faroese August survey CPUE so it becomes an index of population biomass of Greenland halibut on the slopes of the Faroe Plateau. ICES NWWG 2014 Working Document no. 07.

Petur Steingrund. 2014. Greenland halibut CPUE for commercial trawlers operating on the slope on the Faroe Plateau 1991-2013. ICES NWWG 2014 Working Document no. 08.

Anja Retzel. 2013. Greenland commercial data for Atlantic cod in Greenland inshore waters for 2013. ICES NWWG 2014 Working Document no. 09.

Heino Fock. 2013. Update of Groundfish Survey Results for the Atlantic Cod Greenland offshore component after re-stratification of the survey 1982-2013. ICES NWWG 2014 Working Document no. 10.

Petur Steingrund. 2013. Greenland halibut CPUE for the research vessel operating on the slope on the Faroe Plateau in May-June 1995-2013. ICES NWWG 2014 Working Document no. 11.

Petur Steingrund. 2013. A stock assessment production model for Greenland halibut in Faroese waters 1996-2013. ICES NWWG 2014 Working Document no. 12.

Anja Retzel and Søren Lorenzen Post. 2013. Greenland Shrimp and Fish survey results for Atlantic cod in 2013. ICES NWWG 2014 Working Document no. 13.

Anja Retzel and Søren Lorenzen Post. 2013. Greenland commercial data for Atlantic cod in Greenland offshore waters for 2013. ICES NWWG 2014 Working Document no. 14.

Matthias Bernreuther, Christoph Stransky and Heino Fock. 2014. German commercial fishery for beaked redfish (*Sebastes mentella*) in ICES Division XIVb in 2013. ICES NWWG 2014 Working Document no. 15.

Popov, V., and Rolskiy, A. 2014. Preliminary information on the results of Russian fishery and biological samples of pelagic redfish in the ICES subareas XII, XIV and NAFO NAFO Div. 1F in 2013. ICES NWWG 2014 Working Document no. 16.

Einar Hjørleifsson. 2014. iCod - Predicting catch weights. ICES NWWG 2014 Working Document no. 17.

Einar Hjørleifsson. 2014. iCod confrontation with surbar. ICES NWWG 2014 Working Document no. 18.

Einar Hjørleifsson. 2014. iCod confrontation with msy. ICES NWWG 2014 Working Document no. 19.

Guðmundur J. Óskarsson and Páll Reynisson. 2014. Results of acoustic measurements of Icelandic summer-spawning herring in the winter 2013/2014. ICES NWWG 2014 Working Document no. 20.

Guðmundur J. Óskarsson and Jónbjörn Pálsson. 2014. Estimation on number-at-age of the catch of Icelandic summer-spawning herring in 2013/2014 fishing season and the development *Ichthyophonus hoferi* infection in the stock. ICES NWWG 2014 Working Document no. 21.

Kristján Kristinsson. 2014. Fishery of Golden Redfish (*Sebastes marinus*) in ICES Division Va in 2013. ICES NWWG 2014 Working Document no. 22.

Kristján Kristinsson. 2014. Golden Redfish (*Sebastes marinus*) in ICES Division Va as observed in groundfish surveys. ICES NWWG 2014 Working Document no. 23.

Kristján Kristinsson. 2014. The Icelandic fishery for shallow and deep pelagic deep-water redfish (*Sebastes mentella*) in the Irminger Sea and adjacent waters. ICES NWWG 2014 Working Document no. 24.

Kristján Kristinsson. 2014. The Fishery of Icelandic Slope Deep-Water Redfish (*Sebastes mentella*) in ICES Division Va. ICES NWWG 2014 Working Document no. 25.

Kristján Kristinsson. 2014. Icelandic Slope Deep-Water Redfish (*Sebastes mentella*) in ICES Division Va as Observed in the Icelandic Autumn Survey 2000-2013. ICES NWWG 2014 Working Document no. 26.

Heino Fock, Christoph Stransky and Matthias Bernreuther. 2014. Abundance for *Sebastes norvegicus* L., deep sea *S. mentella* and juvenile redfish (*Sebastes spp.*) off Greenland based on groundfish surveys 1985-2013. ICES NWWG 2014 Working Document no. 27.

V.Babayan, I.Antonov. 2014. The assessment of stock status and commercial potential of redfish in the Irminger Sea. ICES NWWG 2014 Working Document no. 28.

Asta Gudmundsdottir and Thorsteinn Sigurdsson. 2014. Growth of capelin in the Iceland-East Greenland-Jan Mayen area. ICES NWWG 2014 Working Document no. 29.

Gudmundur Thordarson. 2014. Pondering the Bayesian Stock Production Model used for assessing Greenland halibut in V and XIV. ICES NWWG 2014 Working Document no. 30.

Carsten Hvingel and Michael CS Kingsley. 2014. Some comments on NWWG-2014:WD30. ICES NWWG 2014 Working Document no. 31.

Rasmus Hedeholm, Søren L. Post and Anja Retzel. 2014. New developments on Atlantic cod in Greenland. ICES NWWG 2014 Working Document no. 32.

S.P. Melnikov, G.P. Vanyushin and T.V. Bulatova. 2014. The impact of variations in environmental conditions on estimates *S. mentella* biomass during the surveys in the Irminger Sea by results of analysis of SST satellite monitoring data. ICES NWWG 2014 Working Document no. 33.

Gudmundur Thordarson. 2014. Trying out the DLS approach for Greenland halibut in V and XIV. ICES NWWG 2014 Working Document no. 34.

Petur Steingrund. 2014. Biomass of Greenland halibut in Faroese waters – how much in relation to Icelandic/East Greenlandic waters? ICES NWWG 2014 Working Document no. 35.

Arni Magnusson. 2014. Analysis of Greenland halibut (*Reinhardtius hippoglossoides*) CPUE using Pella-Tomlinson biomass models. ICES NWWG 2014 Working Document no. 36.

Carsten Hvingel and Michael CS Kingsley. 2014. On the possible rejection of the GHL assessment framework and some comments to WD36. ICES NWWG 2014 Working Document no. 37.

Arni Magnusson. 2014. TSA for Icelandic stocks. ICES NWWG 2014 Working Document no. 38.

V.N. Khlivnoy, P.A. Zavoloka, T.N. Gavrilik. 2014. Russian investigations of Greenland halibut (*Reinhardtius hippoglossoides*) off the East Greenland in 2006-2013. ICES NWWG 2014 Working Document no. 39.

Gudmundur Thordarson, Jesper Boje and Carsten Hvingel, 2014. A note on the Greenland halibut assessment and the process at the NWWG 2014. ICES NWWG 2014 Working Document no. 40.

Annex 05: Russian statements regarding the stock assessment, influence in environmental conditions on pelagic redfish distribution and estimates biomass during the surveys in the Irminger Sea

Statement regarding the justifiability of Russian assessment of the current stock state and potential withdrawal

According opinion of the Russian experts, survey-based assessment of redfish alone does not reflect actual state of the stock due to some methodical difficulties associated with surveys i.e. limited number of trawl stations, changes in survey methodology e.t.c.

Russian assessment is based on detailed data on fishing operations of Russian fishing vessels from 1986 to 2013 inclusive and data on total annual catches of redfish in the Irminger Sea. The reasons of using only Russian data to assessment standardized CPUE is provided in Working Document 28.

Abundance indices were assessed with GLM technique. On Figure 1 it's shown that approximate lines have tendency to growing. The management strategy, based on the MSY concept and the precautionary approach, is implemented through a nonlinear (sigmoid) harvest control rule. Given HCR ensure good stock protection when its biomass is low. For more assessment details see NWWG 2013, WD 24.

The analysis of risks associated with the suggested management strategy for the Irminger sea redfish (Figure 2) confirms that the stock and fishery will increase throughout the 6-year prognostic period (up to 2020 inclusive).

The calculations suggest that the redfish stock is currently in a stable state. Implementation of the selected, very precautionary, management strategy will produce the stock biomass of 1426 thou.tonnes by the end of the prognostic period, thus ensuring its high productivity. The relevant advised TAC for 2014 is 100 thou.tonnes (with MSY=185 thou.tonnes).

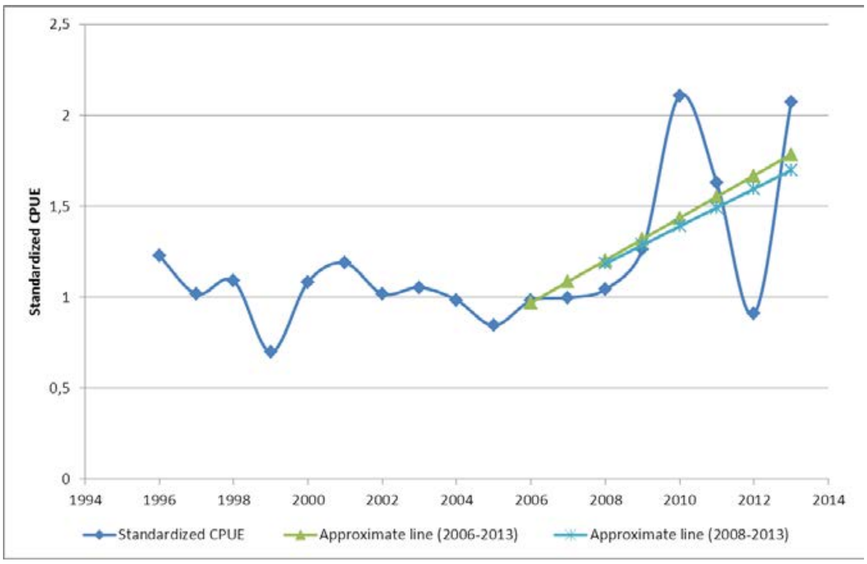


Figure 1. Dynamic of standardized CPUE in 1996-2013

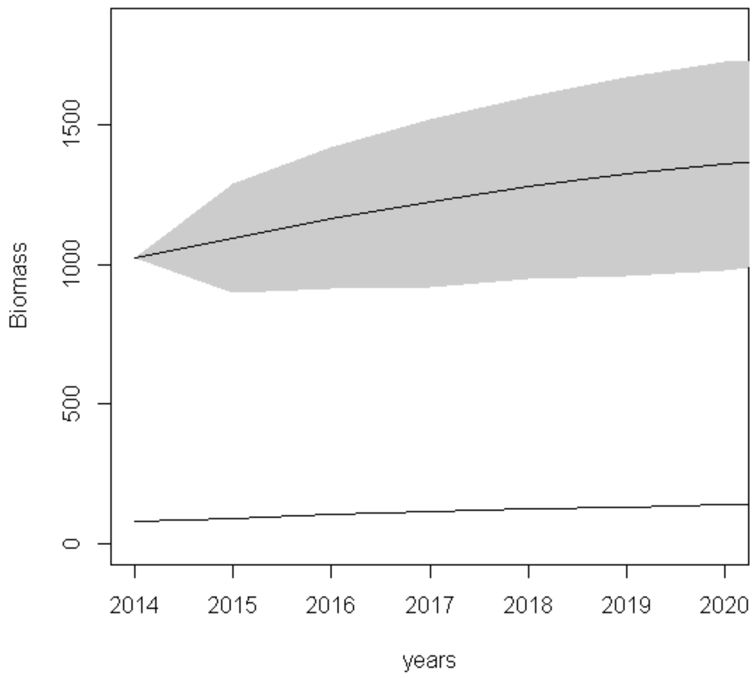


Figure 2. Forecasted values of biomass and TACs of redfish in 2014-2020

Statement regarding the impact of variations in environmental conditions on estimates *S. mentella* biomass during the surveys in the Irminger Sea by results of analysis of SST satellite monitoring data

According opinion of the Russian experts, survey-based assessment of redfish alone does not reflect actual state of the stock due to some methodical difficulties associated with surveys i.e. limited number of trawl stations, changes in survey methodology e.t.c.

In this connection for the first time used the satellite data from meteorological satellites during the studies of environmental long-term fluctuations' influence on distribution and evaluation of redfish biomass.

There have been analytical calculations of the average values of sea surface temperature (SST) for the reference zone, integral acoustic values (SA) for the reference zone, and the average values of the SA only for those places of the reference zone where the aggregations of redfish were found in the layer 0-500 m.

Obtained results demonstrates strong correlation between SST and average values of redfish density in upper layer of the Irminger Sea. (Figure 1, 2). Revealed: the lower the value of SST is in on the lower integral and average values on density of redfish. In other words, the cooling of the sea surface temperature leads to a decrease in the density of redfish aggregations above 500 m, and accordingly, to a decrease in the biomass estimated during international survey in 2001-2011.

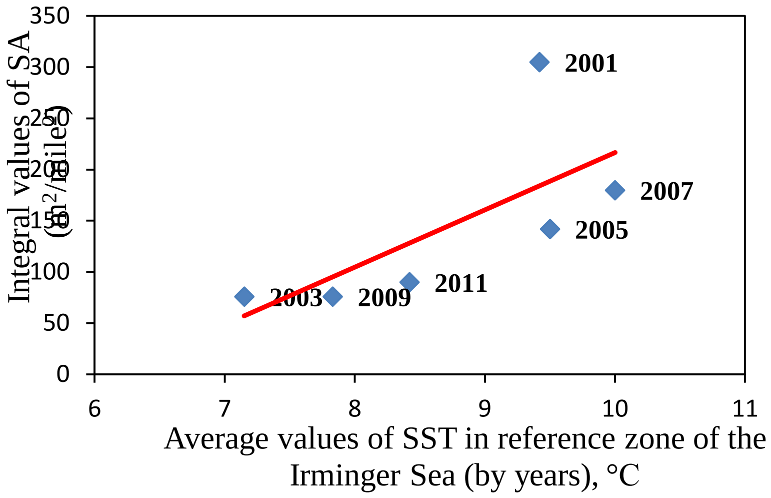
Revealed strong correlation between SST and average values of redfish density in upper layer of the Irminger Sea. The cooling of the sea surface temperature leads to a decrease in the density of redfish aggregations above 500 m. In contrast, analysis of oceanographic observations within the different depth layers suggests reduction of redfish density in upper layer with increasing of water temperature in the intermediate layers above 500 m depth. Both cases (variations in SST or changes in water temperature on the depth of redfish distribution) provide the evidence of the influence of oceanographic conditions on vertical (Melnikov et al., 2009) and spatial distribution of redfish aggregations (Riboni et al., 2013). It could be the one of the main reason of stock underestimation during the surveys.

The obtained results once again confirm the decisive role of fluctuations in environmental conditions on estimates of redfish biomass during the survey, rather than the impact of fishing on the stock.

References

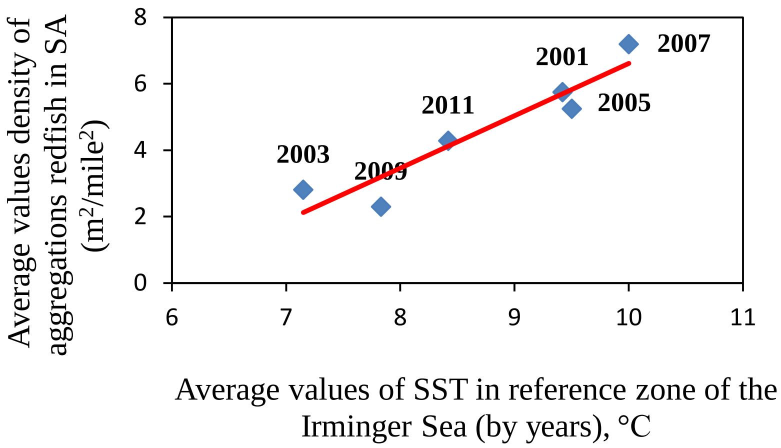
Melnikov S.P., Karsakov A.L., Popov V.I., Tretyak V.L., Tretyakov I.S. 2009. The impact of variations in oceanographic conditions on distribution, aggregation structure and fishery pattern of redfish (*Sebastes mentella* Travin) in the pelagial of the Irminger Sea and adjacent waters // ICES C.M. 2009/E:15. 25 pp.

Riboni I.N., Kristinsson K., Bernreuther M., Hendrik M., Stransky C., Cisewski B., Rolskiy A. 2013. Impact of interannual changes of large-scale circulation and hydrography on the spatial distribution of beaked redfish (Sebastes mentella) in the Irminger Sea, Deep Sea Research Part I: Oceanographic Research Papers, Vol. 82, P. 80-94



Y=56,2X-345,0 R^2=0,49   R=0,7

Figure 1. Comparison quasi-synchronous average values of SST and integral values of SA depended on the distribution and abundance of redfish in reference zone of the Irminger Sea



Y=1,58X-9,15 R^2=0,88   R=0,93

Figure 2. Comparison quasi-synchronous average values of SST and average density of aggregations redfish (in SA $m^2/mile^2$) in reference zone of the Irminger Sea for 1°x1° (only for places its discovery)

Statement about influence of the oceanographic condition on pelagic redfish distribution in the Irminger Sea

According to the international survey results, in 1999-2007 strong positive anomalies of water temperature in the upper 0-200 m layer of the Irminger Sea and adjacent waters were observed. This led to redistribution of part redfish aggregation (above 500 m) to southwestern part of the survey area (ICES, 2007). Surveys observations are also consistent with fishery development, which considerably spread since 1999 in the southwestern direction, covering Divisions 1F, 2GHJ of the NAFO area. (Fig. 1)

Later influence of oceanographic condition on abundance and distribution of pelagic redfish was studied during ICES Workshop on Redfish and Oceanographic Conditions (WKREDOCE) with the primary objective to compile and evaluate available hydrographical, hydroacoustic, and trawl data from the Irminger Sea and adjacent waters. A study examining changes in the distribution of redfish over 20 years revealed that at the interannual time scale, the spatial distribution of *S. mentella* in the Irminger Sea mainly in waters < 500 m appears strongly influenced by the Irminger Current Water (ICW) temperature changes, linked to the Subpolar Gyre (SPG) circulation and the North Atlantic Oscillation (NAO). Acceleration of the SPG due to increase of the NAO index leads to displacement of part redfish aggreagitons in the southwest. An SPG weakening has the opposite effect. A decrease in the NAO index strength since 2008 and the present deceleration of the SPG suggest a subsequent northeast displacement of part of the redfish aggreagitons in upper layer northward in the coming years (ICES, 2012, Riboni et. al, 2013).

In our opinion, these year-to-year northeast/southwest displacement of the redfish (above 500 m depth) influenced by the interannual hydrographic changes in the Irminger Sea - the one of the reason of periodic transformation of the fishery pattern. These fluctuations make impractical using of current management unit boundaries, which are based on spatial patterns of the fishery only (ICES, 2009).

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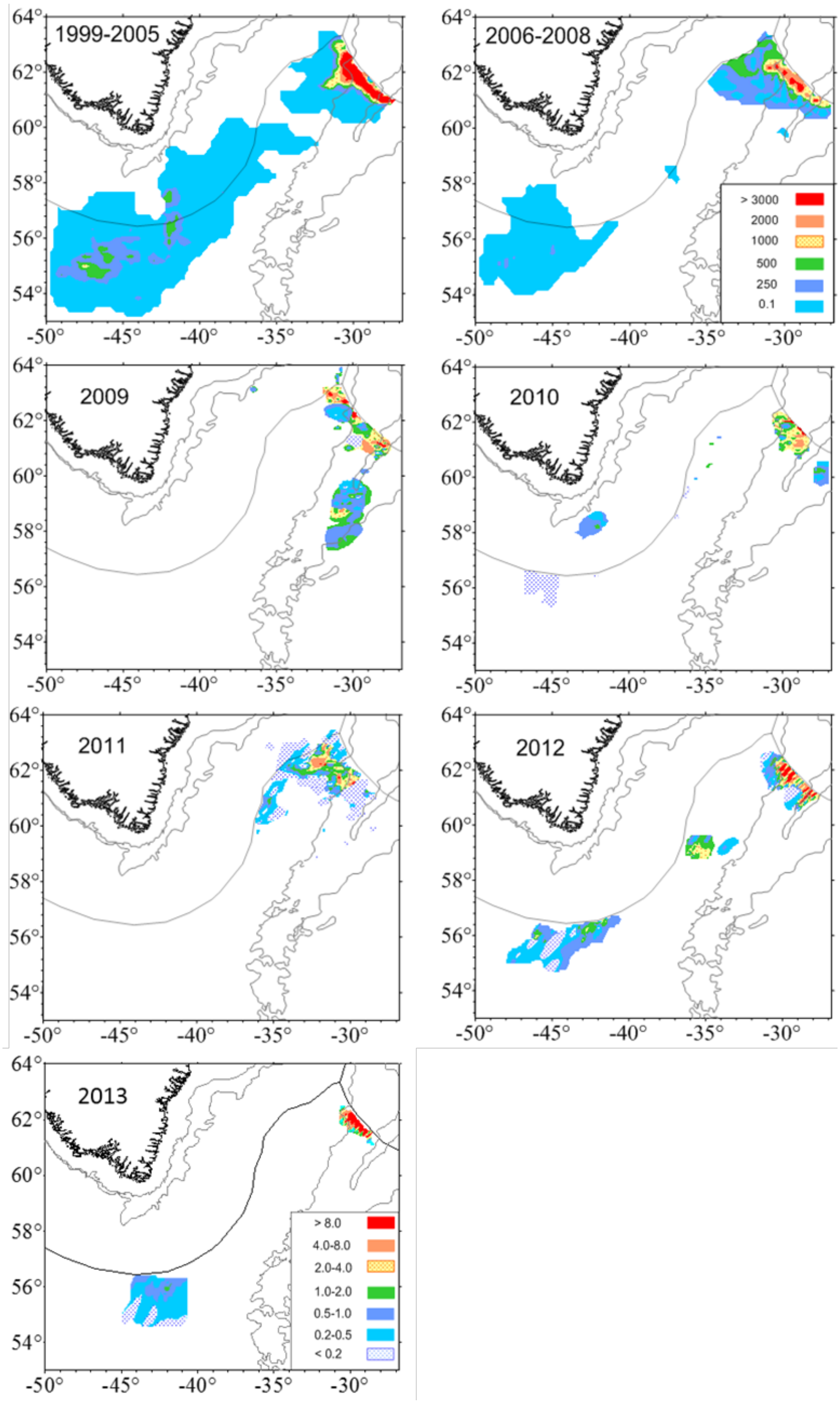

Figure 1. Fishing areas and total catch of pelagic redfish (*S. mentella*) in 1999-2013, derived from catch statistics provided by Russia. The colour scale indicates catches (tonnes per NM²).