ICES NWWG REPORT 2016

ICES ADVISORY COMMITTEE

ICES CM 2016/ACOM:08

REF. ACOM

Report of the North-Western Working Group (NWWG)

27 April–4 May 2016

ICES HQ, Copenhagen, Denmark

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

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

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

Recommended format for purposes of citation:

ICES. 2016. Report of the North-Western Working Group (NWWG), 27 April- 4 May 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM:08. 703pp.

For permission to reproduce material from this publication, please apply to the General Secretary.

The document is a report of an Expert Group under the auspices of the International Council for the Exploration of the Sea and does not necessarily represent the views of the Council.

© 2016 International Council for the Exploration of the Sea

Executive summary

Faroe Bank Cod

The fishing area has been closed since 2009, and total reported landings in 2015 were the lowest recorded since 1965 (17 tonnes).

Spring survey index suggests that the stock increased from 2012 to 2014 and declined substantially again in 2015 and 2016. Both summer and spring index suggest that the stock size has been well below average since 2004, and there are no indications of strong incoming year classes. Since 2008 the stock is mostly comprised of large individuals (>80 cm). Correlation of recruitment year classes between the surveys since 1995 is R=0.86.

The advice is that no fishing effort should take place on this stock until significant rebuilding has taken place.

Faroe Plateau cod

The input data in this update assessment consisted of the catch-at-age starting in 1959 and spring survey starting in 1994 as well as summer survey starting in 1996. The maturities were obtained from spring survey. The terminal year in the assessment was 2015.

The assessment settings were the same as last year. An Extended Survivor Analysis was tuned with the two survey indices. The fishing mortality in the terminal year was estimated at 0.46, which was higher than the F_{MSY} of 0.32. The total stock size at the beginning of the terminal year was estimated at 28 500 tonnes and the spawning-stock biomass at 19 700 tonnes, which was slightly below the limit biomass of 21 000 tonnes. Based on preliminary analyses, the extremely low biomass since 2005 seems to be unprecedented in the last three centuries.

The short-term prediction until year 2018 showed a slightly decreasing total-stock biomass to 25 000 tonnes and a spawning-stock biomass to 19 000 tonnes. It is advised to reduce the fishing mortality to the lowest possible level to rebuild the stock. This stock is scheduled for a benchmark in 2017.

Faroe haddock

Being an update assessment, the changes compared to last year are additions of new data from 2015 and 2016 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 2015, 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 below B_{lim}, but with an improved recruitment, especially of the 2015 YC, combined with substantially earlier maturity-at-age, it is predicted to increase to just above B_{lim} in 2017, and be above B_{pa} in 2018 - with the assumption of status quo fishing mortality in all years. Fishing mortality in 2015 is estimated at 0.26 and the average fishing mortality 2013–2015 at 0.27 (FMSY and F_{pa} = 0.25). Landings in 2015 were only 3 395 t, slightly higher than in 2012 to 2014. This year's assessment indicates that the 2015 assessment underestimated the 2014 recruitment by 42% (2.6 million vs. 4.5 million, , overestimated the fishing mortality in 2014 by 10% (0.26 vs. 0.29 and underestimated the 2014 total- and spawning-stock biomasses by 7% and 27%, respectively (20 and 18 thous. t vs. 18 and 14 thous. t). This stock is scheduled for a benchmark in 2017.

Faroe Saithe

Nominal landings in 2015 are estimated at 25 kt. Estimated fishing mortality in 2015 (average of ages 4 to 8) is F=0.25, which is lower than the historical average (F=0.35) and below F_{MSY}=0.30 (=F_{pa}). Due to high fishing mortality SSB decreased substantially from 2005 to 2013 but it increased again in 2014 and 2015 as a consequence of low fishing mortalities, improved weights and increasing maturity ogives.

Numbers of the most recent yearclass (2012, age 3 in 2015) is estimated at 63 mill. A statistical separable model (used as a diagnostic tool to the spaly assessment) suggests that recruitment in 2015 is not as strong as the spaly assessment estimate and it predicts recruitment for 2015 at 36 mill. Retrospective plots indicate an overestimation of yearclass strength in recent years.

With a status-quo F_{bar} (2016)=0.25 and recruitment of 30 mil., the SSB is predicted to increase to 97 kt. in 2016.

This stock is scheduled for a benchmark in 2017.

Icelandic Saithe

The 2016 reference biomass (B_{4+}) is estimated at 273 kt, around the average in the assessment period (1980 to the present). Spawning biomass is estimated as 139 kt, above the average in the assessment period and well above $B_{trigger}$ = 65 kt and B_{lim} = 44 kt.

Harvest rate has been below the target of 0.2 in last two years and fishing mortality is also predicted to be low. The reason is that the TAC has not been caught, most likely a problem of availability but a smaller than predicted stock cannot be excluded.

Weights of ages 3-6 have been low in recent years, but older ages are close to average weight. Maturity-at-ages 4-9 has decreased in recent years and is currently around average.

Recruitment has been above average since 2009 and relatively stable. There are indications from the survey in 2016 that the 2012 yearclass might be strong.

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. The result of the assessment is relatively insensitive to settings of the assessment model and resulting reference biomass in 2016 varies from 252-310 thous tonnes with the lowest values obtained from models with random walk constraint on fishing mortality. The assessment is considered relatively uncertain but this year's assessment introduces slight downward revision from last year's assessment.

In 2013, the Icelandic government adopted a harvest control rule for managing the Icelandic saithe fishery; evaluated by ICES (2013). It is similar to the 20% rule used for the Icelandic cod fishery. When the population is above $B_{trigger}$, the TAC equals the average of 0.2 B_{4+} in the assessment year and last year's TAC.

According to the adopted harvest control rule, the TAC will be 55 kt in 2016/2017, the same as in the current fishing year.

Icelandic cod

A formal HCR has been in place to determine the TAC for this stock since 1994. The rule has gone through amendments and revisions. The last significant change occurred in 2007, when the harvest rate multiplier upon which the TAC for the next fishing season is based was changed from 0.25 to 0.20 of the reference biomass (B_{4+} - biomass of age 4 years and older) as estimated at the beginning of the assessment year. According to this decision rule the TAC will be 244 kt in the 2016/2017 fishing season. ICES evaluated the plan in 2009 and concluded that it is in accordance with the both the precautionary approach and the ICES MSY framework.

The decision on the TAC each year is based on an analytical stock assessment carried out each year. The results from the assessment show that the spawning stock in 2016 is estimated at 469 kt. The values estimated in recent years are higher than has been observed over the last five decades. The reference biomass ($B_{4+,2016}$) is estimated to be 1243 kt, and has not been so high since the late 1970's. Fishing mortality, being 0.27 in 2015, has declined significantly in recent years and is currently the lowest observed in the last six 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 first indication of year classes 2014 and 2015 indicate that they may be larger than that observed in the recent decades.

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. Spring survey weights in some of the important age groups have, however, declined in 2016 compared with 2015. Catch weights are hence estimated to be lower in 2016 compared to 2015.

The inputs in the analytical assessments are catch-at-age 1955–2015 and spring groundfish survey (SMB) indices at age from 1985-2016 and fall survey groundfish survey (SMH) indices at age from 1996–2015. The Catch-at-age Model (ADCAM) has been used as the basis for the advice since 2002 (spring survey only up to the 2009 assessment, both surveys since then).

Icelandic haddock

The 2014 year class is estimated to be large, after six consecutive small year classes from 2008–2013. The 2015 yearclass is expected to be close to the geometric mean. The current assessment shows some upward revision of the stock compared to last year's assessment. The main features are though the same; that the fisheries are currently mostly based on relatively small yearclasses. It is not until 2018 that the 2014 yearclass affects the fisheries.

Growth in 2015 was above the 1985–2015 average but less than predicted. The mean weight of young fish is above average while old fish are close to average. The assessment procedure was the same as last year (SPALY), an Adapt type model tuned with both surveys.

There are differences in the perception of the state of stock in assessments based on either spring or autumn survey, with autumn survey indicating a larger stock. It has been like that since 2009. Different models using the same tuning data show similar results.

Advice is given according to the adopted Harvest Control Rule, and the advice for the fishing year 2016/2017 is 34 600 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.

Icelandic summer spawning herring

The total reported landings in 2015/16 fishing season were 69.7 kt (including summer fishery 2015) but the TAC was set at 71 kt –the difference being transfer of quota between years. The fishable stock (age 4+) in winter surveys 2015/16 was estimated at 372 kt, compare to 433 kt in winter 2014/15. The 2014 year class (age 1 in 2015) appears small.

This is an update assessment where the 2015 data have been added to the input data and no revisions of last year's data. The analytical assessment model, NFT-Adapt, indicates that the biomass of age 3+ will be 393 kt and SSB is 318 kt at the spawning time in 2016. Continuation of relatively small year classes entering the spawning stock causes a further decline in SSB even if still above B_{PA} of 300 kt. Fishing at $F_{MSY}=F_{0.1}= 0.22$ in the fishing season 2016/17 will give a catch of 63 thousand tons resulting in SSB in 2017 expected to be 303 kt.

There are indications for new infection by *Ichthyophonus* in the stock for the second year in row even if all data support that additional natural mortality in the stock due to the infection should only be applied for the first two years of the main outburst that started in 2009. This calls however, for continuation of the extensive monitoring and studies.

Capelin in the Iceland–East Greenland–Jan Mayen area

In May 2015 ICES advised that the initial (preliminary) quota should be 54 000 t. In June 2015 the coastal states agreed on an initial quota of 300 000 t. In October, the Icelandic Marine Research Institute (MRI) declared an intermediate TAC of 44 000 based on an acoustic survey in September and the HCR from ICES WKICE (2015). Lastly, a final TAC of 173 300 t was declared by MRI on the basis of an acoustic survey in January 2016 and the HCR from ICES WKICE (2015).

The total landings in the fishing season 2015/2016 amounted to 174 thousand t (preliminary data). One vessel tried capelin fishery in summer 2015 without success, 2 500 t were caught in autumn 2015 and the rest during winter months January–March 2015.

The acoustic surveys in autumn 2015 were conducted under difficult weather and ice conditions and the entire distribution area was not covered. The acoustic estimates (6 bill.) were well below 50 bill. The HCR-value that triggers an initial quota. Consequently, ICES advices an initial quota of 0 t for the fishing season 2016/17.

Offshore West Greenland Cod

From 2015 the advice for cod in Greenland offshore waters has been split in two stock components (advice year 2016). The West Greenland offshore stock component is now comprised of the NAFO subdivisions 1A-E in West Greenland. The East Greenland stock component is comprised of the area NAFO subdivision 1F in South Greenland and ICES Subarea 14 in East Greenland.

Some mixing occurs between the two stocks in West Greenland which at present is considered to act as a nursing area for juveniles of the East Greenland stock component. A TAC of 5 000 t was introduced in 2015 and 4 860 t was fished which is the first time in 25 years that a considerable fishery has taken place. The 2009 YC dominated the catches.

Both the German and Greenland survey indices show that the biomass and abundance has increased due to the 2009 YC, which is present in considerable numbers and a 2010 YC, which is dominating the survey especially in the southern part of the survey area.

The spatial distribution of the 2009 YC is different from previous year classes that usually migrate out of the area at age 4, but a large part of the 2009 YC still remains in the southern area (NAFO 1E) at age 6 in 2015.

No analytical assessment was conducted and there are no biological reference points for the stock. Information from survey indices (German Groundfish survey and Greenland Shrimp and Fish survey) are used as basis for advice. No significant spawning has been observed in the area.

Inshore Greenland cod

Total catches from the inshore fishery were 25 272 t in 2015 which is the highest since early 1990s. Several year classes were caught in the fishery but catches were dominated by the 2010 YC (5 yr old).

Survey recruitment indices from the inshore area show that incoming year classes (2012 and 2013) are below average.

The same advice as last year was given as the survey index suggest that the adult part of the stock has fluctuated without trend in recent years, but a relatively high level.

Cod in East Greenland, South Greenland

From 2014 the management for cod in Greenland offshore waters has been split in two stock components according to areas: NAFO subdivisions 1A-E in West Greenland and NAFO subdivision 1F in South Greenland combined with ICES Subarea 14 in East Greenland. The ICES advice for 2016 has for the first time been given according to these two areas.

The offshore fishery in East and South Greenland in 2015 was conducted as an experimental fishery with a TAC of 18 000 tons. Total catches were 15 755 tons. The year class dominating the catches was the 2009 YC in Southwest Greenland and the 2008 YC in East Greenland. The largest cod (mean length of 78 cm) were caught by trawlers on Dohrn Bank close to the Iceland EEZ.

Available survey biomass indices from the Greenland and German surveys show a decline in biomass but the magnitude of decline differs. The Greenland biomass index declined by 16% but the German biomass index declined by 76%. The index for 2014 was, however, record high in the German survey, increasing 94% compared to 2013).

In both surveys the 2009 YC has been dominating in 2013 and 2014 in Southwest Greenland. In 2015 the YC was still dominating the Greenland survey and was still found in Southwest Greenland in large numbers. In the German survey the YC was found in small numbers in 2015 and in equal amount in both South and East Greenland.

Advice was based on an F_{proxy} multiplier generated from the relationship between the catches and Greenland survey index in a period with a considered sustainable fishery, multiplied by the latest year's smoothed survey index.

Greenland Halibut in Subareas 5, 6, 12, and 14

Catches of Greenland halibut in Subareas 5,6,12 and 14 have ranged between 20 and 30 kt in the last two decades and amounts to 25 kt in 2015. The biomass indices used as input to the assessment (combined survey index at Greenland and Iceland) and logbook information from Iceland trawler fishery all show a slight increase in 2015.

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 along with the high catches in the late 1980s and early 1990s. Since 2004/2005 the stock has increased slowly and is now at 71% of B_{MSY}. Fishing mortality has since 2013 been around F_{MSY} and is in 2015 10% above F_{MSY}. The remaining available indices that are not currently used in the analytical assessment, i.e. logbook from East Greenland trawl fishery and from Faroese trawl fishery and a Faroese survey suggest high biomass in recent years, and therefore supports the recent trend in the assessment. An alternative assessment model (Gadget) was presented in the working group, suggesting similar trends and advice, although slightly more pessimistic about recent trends.

Golden redfish (*Sebastes norvegicus*) in Subareas 5, 6 and 14

Total landings in 2015 were 51 645 t, which is about 900 t more than in 2014. About 95% of the catches were taken in Division 5.a. A substantial increase in landings from 14.b since 2010, the highest since early 1990s, and is in relation to a re-established redfish fishery in 2010. Very little redfish is now taken in 5.b.

Catch-at-age data from 5.a show that the catch was dominated by two strong year classes from 1985 and 1990. From 2008—2011 year classes 1996–1999 were the most important in the fisheries. Their share has reduced relatively fast and the 2000–2005 year classes are now most important contributing about 75% of the total catch.

Recruitment seems to be low in all areas, both according to the Icelandic groundfish surveys, and the German survey and the Greenland shrimp and fish survey in East Greenland.

The management plan is based on F_{9-19}=0.097 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. The 2016 SSB was estimated at 354 800 t, and according to the management plan the TAC advice for 2017 will be 52 800 t.

Icelandic slope (*Sebastes mentella)* in 5.a and 14

Total landings of demersal *S. mentella* in Icelandic waters in 2015 were about 9 300 t, 200 t less than in 2014. No analytical assessment was conducted and there are no biological reference points for this stock. Survey indices from the Icelandic autumn survey since 2000 are used as basis for advice.

Survey biomass indices show that in Division 5.a the biomass has gradually decreased from 2006–2013, but increased in 2014 and 2015.

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 survey conducted in the area.

Icelandic slope *S. mentella* is considered a data limited stock (DLS) and follows the ICES framework for such (Category 3.2). When the precautionary approach is applied, catches in 2017 should be no more than 12 922 t. All catch are assumed to be landed.

Shallow Pelagic *Sebastes mentella*

Total landings of shallow pelagic *S. mentella* in 2015 were 5 595 t, a decrease of about 1 000 t compared to 2014. The catches were taken in ICES Subarea 12 and NAFO Division 1F.

No analytical assessment was conducted and there are no biological reference points for this stock. Survey indices from the international acoustic redfish survey conducted in the Irminger Sea and adjacent waters since 1991 are used as basis for advice.

The last international redfish survey was conducted in June/July 2015, but it did not cover the shallow pelagic stock. The last biomass estimates are from 2013. The results of the acoustic survey show a drastic decrease from 2.2 million t in 1994 to 91 000 t in 2013. The next survey is expected to be conducted in June/July 2018.

No signs of recruitment have been observed in the latest German and Greenland surveys on the East Greenland shelf.

Deep Pelagic *Sebastes mentella*

Total landings of deep pelagic *S. mentella* s in 2015 were 27 433 t, which is 4 000 t more than in 2014.

No analytical assessment was conducted and there are no biological reference points for this stock. 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 2015. A total biomass of 196 000 t was estimated, 43% less than in 2013 (280 000 t). Trawl survey estimates in 2013 and 2015 are lowest since the survey started in 1999. The next international trawl-acoustic redfish survey in the Irminger Sea is expected to be conducted in June/July 2018.

No signs of recruitment have been observed in the latest German and Greenland surveys on the East Greenland shelf. Advice for this stock will be given in autumn 2016 following a workshop (WKDEEPRED).

Greenlandic slope *Sebastes mentella* in 14.b

In the decade before 2009 *S. mentella* was mainly a valuable bycatch in the fishery for Greenland halibut. However, since 2009 a fishery directed towards demersal redfish has taken place. Total landings of demersal *S. mentella* in East Greenland waters in 2015 were 5 977 tons, which, except for 2014, is the lowest value the last five years. The proportion of *S. mentella* in the mixed-stock fishery is declining compared to earlier years.

The advice is based on the DLS approach (3.2) using the Greenland survey as basis for advice. *Sebastes mentella* is a slow growing, late maturing species and is therefore considered vulnerable to overexploitation. Biomass and abundance index for both adult and juvenile redfish have together with the cpue been declining since 2010. Furthermore, on the Greenlandic slope, *S. mentella* is primarily distributed in a relatively small area, which is also the hot spot area for the fishery. Given the biology of the species, the nature of the fishery and the decline in all stock indicators the advice has to be conservative. Due to the dynamics of the stock and coincident decrease in all stock indicators, the indicator ratio (50% decline) was used and no other uncertainty parameters applied. The advice for 2017 is 1 120 tonnes.

1 Introduction

1.1 Terms of Reference (ToR)

1.1.1 Specific ToR

The **North-Western Working Group** (NWWG), chaired by Rasmus Hedeholm, Greenland, will meet at ICES Headquarters, 27 April–4 May, 2016 to:

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

b) Answer the special requests from NEAFC: " Pursuant to the Interim guidelines on management of deep sea species [as defined by NEAFC], adopted at the 2014 NEAFC Annual Meeting, ICES is requested to evaluate the provisional categorization of deep sea species adopted by PECMAS and provide necessary clarification on issues highlighted in the document."

c) Prepare for the upcoming workshop of deep pelagic redfish in the Irminger Sea (WKDEEPRED); discuss the approach to be taken by WKDEEPRED to address the ToRs including preliminary analyses/assessments, and additional improvements required in advance of WKDEEPRED.

The assessments will be carried out on the basis of the stock annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant to the meeting must be available to the group no later than 5 April 2016 according to the Data Call 2016.

For capelin in Iceland-East Greenland-Jan Mayen area, NWWG will agree any changes to the WG type report and the draft advice no later than 10 May 2016.

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting.

For capelin in Iceland-East Greenland-Jan Mayen area, Iceland will provide a WG type report and a draft advice sheet on 4 May 2016. NWWG will agree any changes to the WG type report and the Advice sheet no later than 10 May. An ADG will work 24–27 May 2016, and the Advice Release date 10 June 2016.

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

NWWG will report by 10 May 2016 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	Update
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
cod-ingr	Cod (Gadus morhua) in NAFO Subarea 1, inshore (Inshore West Greenland)	Greenland	Greenland	Greenland	Update
cod-segr	Cod (Gadus morhua) in ICES Subarea XIV and NAFO Subdivision 1F (East Greenland, South Greenland)	Greenland	Greenland	Germany	Update
cod-wgr	Cod (Gadus morhua) in NAFO Subdivision 1A-E (Offshore West Greenland)	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	Update
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:

a) Consider and comment on ecosystem overviews where available;

b) For the fisheries relevant to the working group consider and comment on:

  i) descriptions of ecosystem impacts of fisheries where available

  ii) descriptions of developments and recent changes to the fisheries

  iii) mixed fisheries overview, and

  iv) emerging issues of relevance for the management of the fisheries;

c) Conduct an assessment to update advice on the stock(s) using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a brief report of the work carried out regarding the stock, summarizing where the item is relevant:

  i) Input data (including information from the fishing industry and NGO that is pertinent to the assessments and projections);

  ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

  iii) For relevant stocks estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area by year in the recent three years.

  iv) The developments in spawning-stock biomass, total-stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;

  v) The state of the stocks against relevant reference points;

  vi) Catch options for next year;

  vii) Historical performance of the assessment and catch options and brief description of quality issues with these;

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

e) With reference to the Frequency of Assessment criteria agreed by ACOM (see section 5.1 of WGCHAIRS document 03): (1) Complete the calculation of the first set of criteria, by calculating Mohn's rho index for the final assessment year F; (2) Comment on the list of stocks initially identified as candidates for less frequent assessment from the first set of criteria (adding stocks to the list or removing them would require a sufficient rationale to be provided).

f) Estimate precautionary reference points for all the category 1 stocks with undefined PA reference points, following the Technical Guidelines document on reference points developed by ACOM and the WKMSYREF4 report.

The working group is furthermore requested to:

g) Consider and propose stocks to be benchmarked;

h) Review progress on benchmark processes of relevance to the expert group;

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

j) Prepare the data calls for the next year update assessment and for the planned data evaluation workshops;

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

   i) Load fisheries data on effort and catches into the INTERCATCH database by fisheries/fleets;

   ii) Abundance survey results;

   iii) 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.

m) Identify research needs of relevance for the expert group.

1.2 NWWG 2016 work in relation to the generic ToR

The ToRs were not addressed systematically for all stocks. 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. Individual report stock sections were not reviewed in plenary due to time constraints, but relevant issues were discussed in plenary and each section was reviewed externally. The summary sheets were all reviewed and agreed upon in plenary.

ad a) Ecosystem overviews were available for the Faroe Islands, 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 was previously used directly in the assessment (predicting individual weights of cod). This relationship became less clear in recent years and the weights of cod were therefore estimated in other ways. The assessment of capelin uses an escapement biomass stragtegy, including estimating the removal of capelin biomass by predators. 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.

ad b) In the overview sections there is a description of the fisheries, including mixed fisheries. In the Icelandic ecoregion the ecosystem effect of fisheries is briefly mentioned with corals being destroyed by fishing gears. Other than this, ecosystem effects of the fisheries were not considered. For Greenland cod both inshore and offshore, the mixing of stocks and apparent changes in distribution was discussed as it is relevant to managers.

ad c-d) All stocks were assessed according to the stock annexes, including forecasts, catch options and retrospective analyses were relevant. This is briefly summarized for all stocks in the report. Only the pelagic redfish stocks are to some extent caught in the

NEAFC regulatory area, and this was quantified. Accordingly, advice drafts were produced for all stocks.

ad e) The group discussed biennial assessment in general under the ICES MSY advice. Here, the derived F_{MSY}_depends on the assumption of assessment errors. The current values used are probably in all cases based on annual assessment errors. If advice were to be set multi-annually, the input assessment error would need to be set significantly higher when estimating of the advisory F_{MSY}, particularly in stocks were no direct measurements are available of future recruits. The effect of setting higher CV's to accommodate the assessment error would be most pronounced in stocks where the derived F_{MSY}_is bounded by precautionary consideration (low probability of going below B_{lim}). The net effect is that a multi-annual advice should in most cases be based on a lower advisory fishing mortality than used if the advice were annual.

ad f) Precautionary reference points were defined for all relevant stocks according to the guidelines.

ad g-j) No new stocks proposed for a benchmark in 2018. Hence, the Faroese stocks of cod, saithe and haddock are still on schedule to be benchmarked in 2017. The issue lists for these stocks were discussed in plenary as was the data evaluation workshop agenda. The 2015 data call was evaluated for all stocks and updated to facilitate the 2016 data call. There were few issues with the 2015 data call and these were of minor importance to the assessment.

ad k-l) INTERCATCH is not used extensively for any stocks considered in this WG as they are mostly national non-EU stocks, and no data were loaded into INTERCATCH that was not already uploaded. The members of the group were however encouraged to use it and to provide the status on the use of INTERCATCH.

ad m) These needs as they relate to the assessment procedure were discussed in plenary and summarized in the report.

1.3 NWWG 2016 work in relation to the specific ToR

ad a) see above

ad b) The NWWG evaluated the provisional categorization of NEAFC of small redfish (*Sebastes viviparus*) and Greenland halibut (*Reinhardtius hippoglossoides*). In both cases the NWWG confirmed the categorization made by NEAFC.

ad c) A subgroup discussed the progress being made and the outstanding issues to address before WKDEEPRED. The co-chair of WKDEEPRED attended as did persons from almost all intuitions expected to participate the working group. Several approaches to generate advice were proposed by WKDEEPRED participants, and all were encouraged to develop these further. A video conference was scheduled in late June, at which point the assessment methods and other material relevant according to the ToR should be presented.

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	Trend based assessment	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	Linear regression	Survey
Inshore West Greenland cod	DLS category 3.2	Survey
East Greenland, South Greenland cod	Fproxy multiplier/ DLS category 3.2	Survey
Offshore West Greenland cod	Descriptive	Survey
Greenland halibut	Stock production model (Bayesian)	Survey + cpue
S. norvegicus	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.**

1.5 Benchmarks and workshops

No stocks were benchmarked in the preceding year. Faroe cod (plateau and bank), Faroe saithe and Faroe haddock are scheduled for a 2017 benchmark. Faroe saithe was added to the list of stocks to benchmark in 2017 along with the other Faroese stocks in 2017.

1.6 Chair

This is the second year for Chair, Rasmus Hedeholm, Greenland, who is scheduled to chair the group from 2015–2017.

2 Demersal Stocks in the Faroe Area (Division 5b and Subdivision 2a4)

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 changed in 2011, however, since no mutual agreement could be reached between the Faroe Islands and the EU and Norway, respectively, due to the dispute regarding the share of mackerel. From 2013, the agreement has been re-established.

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.

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 number of licenses can be found in Table 2.3. The grouping of the vessels under the management scheme can be seen in section 2.1.3.

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 UK with the result that a large part of the Faroese fishing fleet became specialized 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 multifleet and multispecies 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 portions of the catches. Reorganization 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 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 pairtrawlers (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 pairtrawlers, have increased in area and time. Their catch of cod and haddock was before 2011 limited by maximum bycatch allocation. This fleet started to pair-trawl, and since the fiscal year 2011/12, merged with the pairtrawlers group. The single trawlers less than 400 HP are given special licenses to target flatfish inside 12 nautical miles with a bycatch allocation of 30% cod and 10% haddock. In addition, they are obliged to use sorting devices in their trawls in order to minimize their bycatches. 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 summertime.

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 been almost at 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 was 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 Seawater, 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 of 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 2016 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 Subpolar 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. If all three species are combined, the positive correlation becomes stronger (Figure 2.4). However, 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. The catchability of cod with longlines also increased by a factor of 2–3 in the same period.

2.1.4 Summary of the 2016 assessment of Faroe Plateau cod, haddock and saithe

A summary of selected parameters from the 2016 assessment of Faroe Plateau cod, Faroe haddock and Faroe saithe is shown in Figure 2.6. 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 (Figure 2.6). For haddock, the exploitation rate was high in the 1930s and decreasing from the 1950s and 1960s, while it has been fluctuating since the mid-1970s. For saithe, the exploitation rate was low in the 1930s and 1950s and increased until the 1970s, it decreased from the early 1990s–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. Moreover, while the sum of cod, haddock and saithe biomasses has been rather constant over time (varied between 300–500 thousand tonnes most years), the proportion of saithe has increased during the period from 1924 up to today whereas the proportion of cod has decreased (Figure 2.6).

2.1.5 Reference points for Faroese stocks

As explained elsewhere in this report, MSY reference points were estimated for cod and haddock in 2011 and for saithe in 2014 in addition to the already existing PA reference points. These reference points are all estimated based on single-species models. Multispecies 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). For example, adding the recruitment of cod and haddock and relating them to zooplankton concentration shows a strong negative correlation (Figure 2.5), but a potential causal relationship is unknown.

Faroe saithe stock dynamics is puzzling. If the biomass estimates prior to 1961 are approximately correct then there has been an increase in biomass from 1925 up to now as well as in catch and exploitation rate. There might be an interaction with cod, since the cod biomass has decreased over the same period. It might be speculated that trawling activity in the deep areas (> 150 m) from the 1950s has had a negative effect on cod and a positive effect on saithe. Hence, it might not be possible to maximize cod and saithe catches at the same time.

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 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 Oher issues

In order to put the current assessment into a wider context, the biomass of Faroe saithe was estimated back to 1925 by scaling cpue values for English steam trawlers to the biomass obtained from the stock assessment, see Working Document 13. The cpue series was from 1924– 1978 and the stock assessment from 1961–2015. The overlapping years 1961–1971 were used as a basis to scale the saithe biomass back to 1924. Since the biomass estimates were rather noisy, a three-year moving average was taken as the final estimate of biomass back in time (Table 2.1.7.1). The table shows that the saithe biomass prior to 1960, when there was little fishery for saithe, was lower than during the fishery intensive period after 1970.

2.1.8 References:

Gaard. E., Hansen, B., Olsen, B and Reinert, J. 2001. Ecological features and recent trends in physical environment, plankton, fish stocks and seabirds 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.

Allocated number of days:													Available	
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
2014/15	(L89-18/8-14)				1530	4455	2387	1029	1530		1386	9865		22182
2015/16	(L108-5/8-15)				1530	4455	2387	1029	1530		1386	9865		22182

Table 2.2. Number of days allocated and the number actually used since the fiscal year 2014/2015

Fleet segment	Allocated days 2014/15	Used days pr. Dato	% used days	Allocated days 2015/16 (pr. 10. mars. 2016 (6 1/3 mdr))	Used days pr. Dato	% used days
Reference:	(L89-18/8-14)			(L108-5/8-15)		
Group 1 - innaru leiðir						
Group 1 - ytri leiðir						
Group 2 - (innaru leiði	4455	4,307.87	97%	4455	2000.70	45%
Group 2 - ytri leiðir	1530	1,125.41	74%	1530	524.34	34%
Group 3	2387	1234.57	52%	2387	939.92	39%
Group 4A	1029	253.59	25%	1029	167.07	16%
Group 4B	1530	565.34	37%	1530	424.94	28%
Group 4T	1386	716.83	52%	1386	371.1	27%
Group 5A	2640	1297	49%	2310	486	21%
Group 5B	7225	3709	51%	7555	1697	22%
Total	22182	13,209.61	60%	22182	6611.07	30%

Estimation of the whole year Mett ársnýtsla Faktor 1.895 Væntandi: (L108-5/8-15)	Predicted	Tillutað smb. Vørn (05/10-15) Óbroytt (10/3-16)
3,791.00	82%	4,353.25
993.54	65%	1,522.83
1,780.99	69%	2,148.22
316.57	31%	595.76
805.19	53%	932.62
703.17	51%	1,180.84
920.89	19%	2310
3,215.54	55%	7555
12,526.90	54%	20,598.52

.

Table 2.3. Main regulatory measures by fleet in the Faroese fisheries in 5b. 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	Subgroups		Main regulation tools
1	Single trawlers > 400 HP	non e		Fishing days, have from 2011/12 been merged with the pairtrawlers, area closures
2	Pairtrawlers > 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

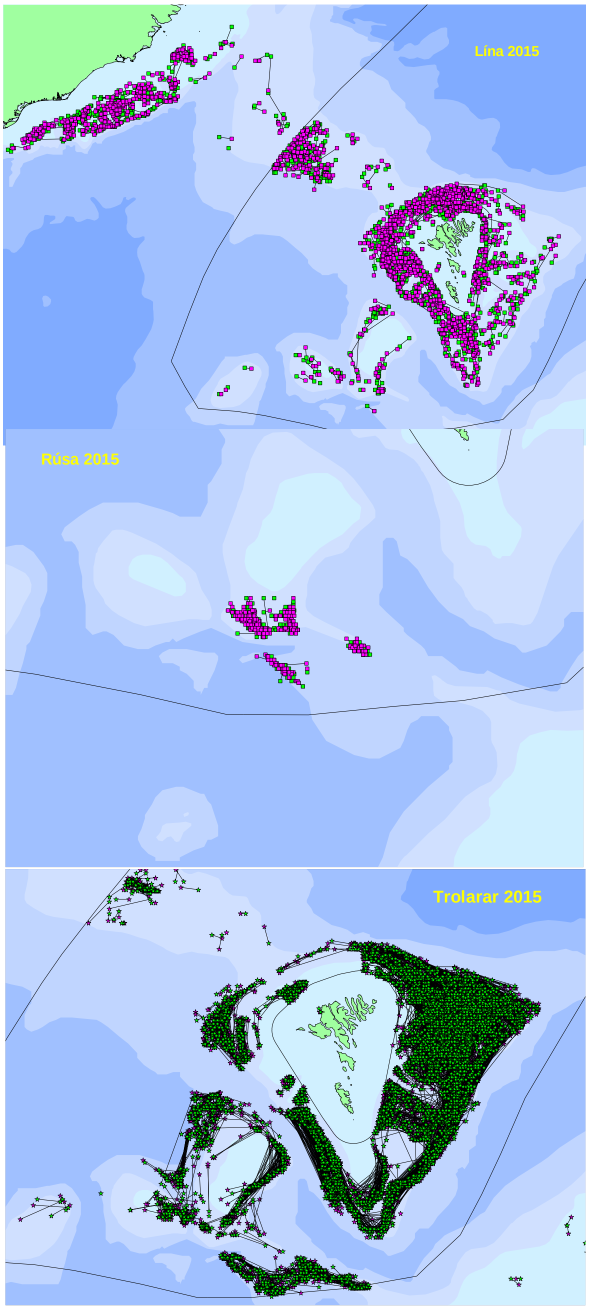


Figure 2.1. The 2015 distribution of fishing activities by some major fleets. From top: Gillnet, long-line>1010HP, trap and trawl. The longline fleet below 110 GRT is not shown here since they are not obliged to keep logbooks.

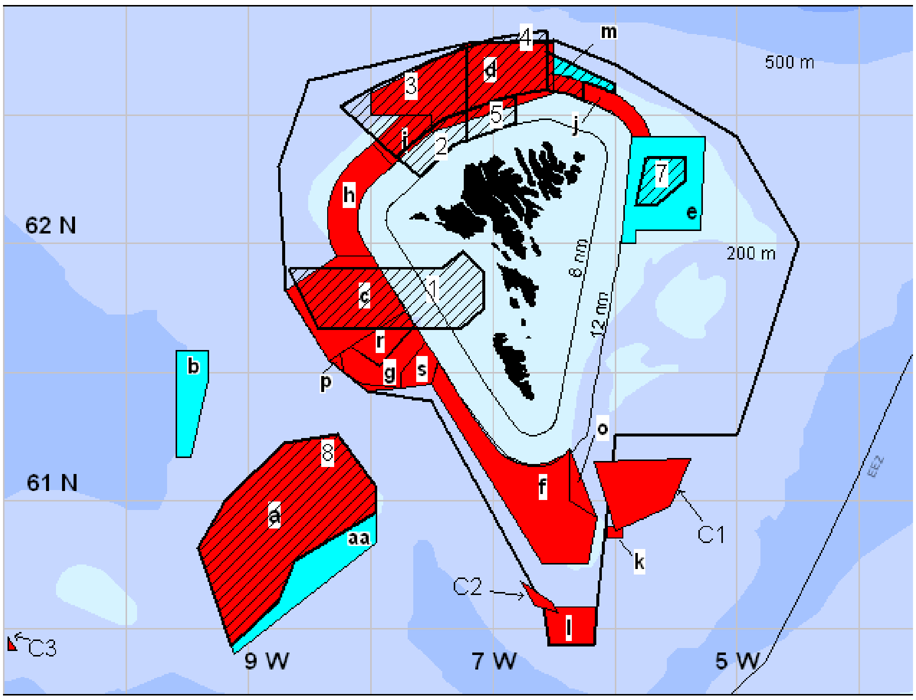
Exclusion zones for trawling

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 5b. 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.



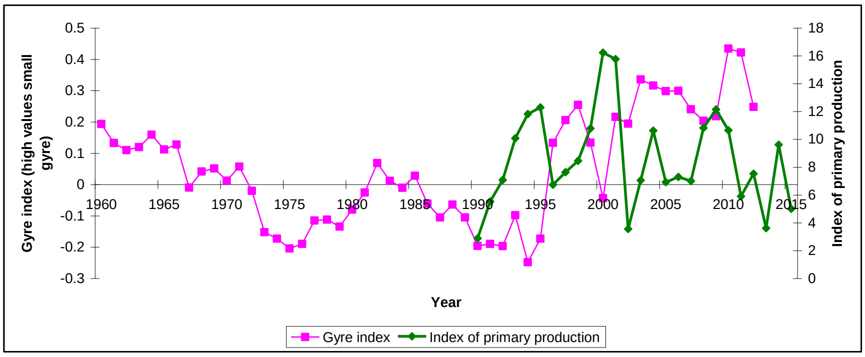


Figure 2.3. Temporal development of the phytoplankton index over the Faroe Shelf area (< 130 m) and the Subpolar Gyre index which indicates productivity in deeper waters.

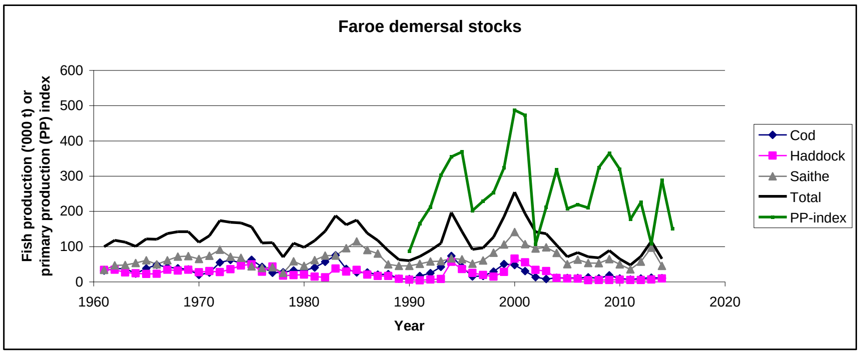


Figure 2.4. Relationship between primary production and production of cod, haddock and saithe.

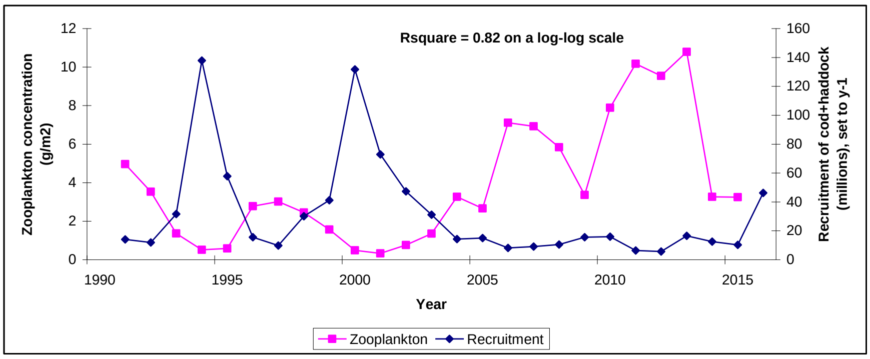


Figure 2.5. Relationship between zooplankton concentration and recruitment of cod and haddock on the Faroe Plateau.

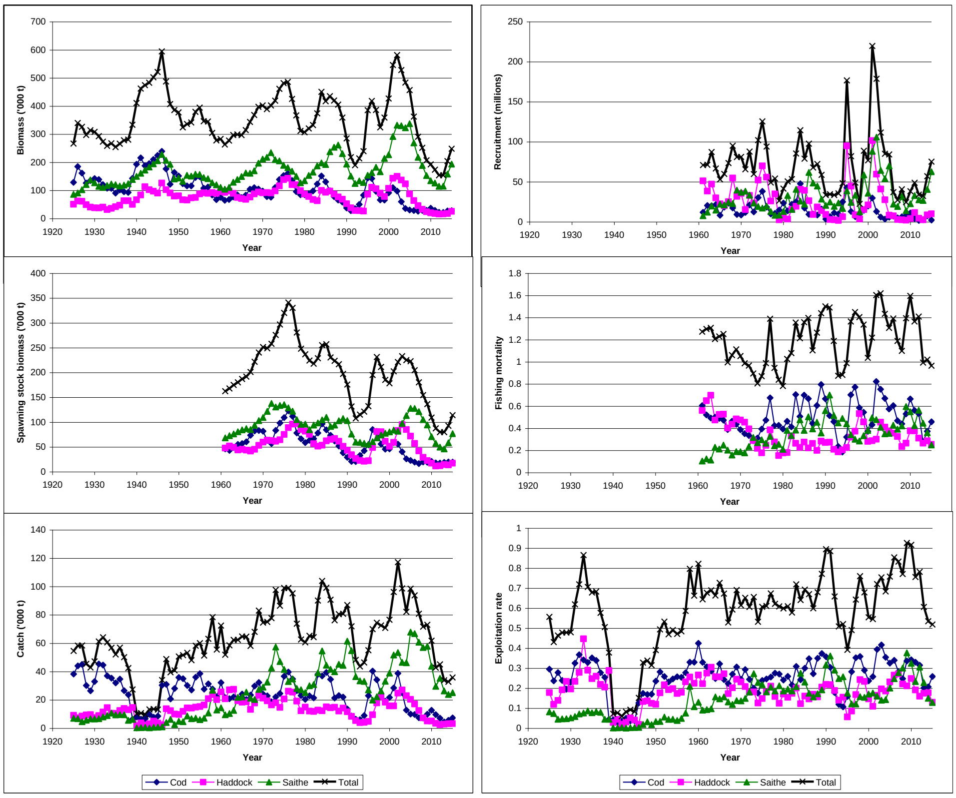


Figure 2.6. Summary of the stock dynamics for Faroe Plateau cod, Faroe haddock and Faroe saithe.

Table 2.1.7.1. Saithe biomass (age 3+) 1925–2015 in tons. Year label is sum of first row and first column.

	1925	1950	1975	2000
0	86621	144660	189794	227759
1	91614	133220	181587	292429
2	102955	154250	168856	332716
3	121390	151612	150481	330728
4	137929	158206	127858	323589
5	127712	157146	134902	338048
6	115346	146198	153827	269512
7	111440	142441	165608	218366
8	118018	127763	187681	189274
9	123435	120344	198291	153457
10	121033	111550	192715	134874
11	116390	105008	238071	126661
12	119400	111502	254322	115439
13	124442	129760	261993	115660
14	139453	139221	231424	158781
15	150543	150302	193901	194118
16	161634	162609	151523	
17	172724	161578	125365	
18	183815	170304	134696	
19	194905	197298	128717	
20	205996	212238	154403	
21	228522	218372	163848	
22	207472	234819	183162	
23	193811	210057	166861	
24	141145	205557	214410	

3 Faroe Bank Cod

3.1 State of the stock

Total nominal catches of the Faroe Bank cod from 1987 to 2015 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 3500t in 1987 to only 330 t in 1992 before increasing to 3 600t in 1997. In 2015 landings were estimated at 17t which is the lowest ever recorded since 1965 (Figure 3.1). 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 2005–2007 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 have been allocated since 2012.

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.

Spring survey was initiated in 1983 and discontinued in 1996, 2004 and 2005. Summer survey has been carried out since 1996. The cpue of spring survey was low during 1988–1995 varying between 73 and 95 kg per tow. Although noisy, the survey suggests higher, possibly increasing biomass during 1995–2003. Spring index suggests that the stock increased in 2013 and 2014 but it decreased rapidly in 2015 and 2016 well below the average of that of the period 1996–2002. The 2015 summer index is estimated at 25 kg per tow and the 2016 spring survey at 19 kg per tow, which are among the lowest values in both series. There are conflicting signals between both indices from 2012 to 2014. The agreement between summer and spring index is good during 1996 to 2001 and since 2006, but they diverged in the 2002–2003 and 2012—2014 periods. Both indices 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 summer survey from 2000–2002 (lengths 26–45 cm), corresponding to good recruitment of 2 years old in spring surveys from 2001 to 2003 (40–60 cm). Spring index shows poor recruitment from 2006–2016 reflecting the weak year classes observed in 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 spring index, recruitment was estimated as total number of fish below 60 cm (2-year old) and in summer index as number of fish below 45 cm (1-year old). According to 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) Spring recruitment index in 2015 shows no sign of incoming year classes. Correlation between spring and summer survey recruitment indices is fairly good (r=0.86). 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, $B1/B_{MSY}$ 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 1983-2015 including spring survey and 1996–2015 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=0.34 and F_{MSY}=0.17 (using autumn 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 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 autumn 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 spring and summer indices suggest the stock is well below average while there are no indications of incoming recruitment. Spring index suggests an increasing stock biomass from 2012–2014 which it is however not picked up by summer survey. The exploratory production model performed since 2013 confirms the poor status of the stock.

3.3 Management plans and evaluations

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 in 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 2015 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–1 May) has been enforced since 2005. In 2009, fishing was restricted to all fishing gears from 1 January–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 have been allocated since 2012.

Table 3.1. Faroe Bank (subdivision Vb2) cod. Nominal catches (tonnes) by countries 1986-2015 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	1350
														1089

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Faroe Islands		1094	1840	5957	3607	1270	1005	471	231	81	111	393	115	40	40	18[*]
Norway	49	51	25	72	18	37	10	7	1	4	1		0			0
Greenland	-	-	-	-	-	-	-	-	-	-	5		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				45	
Total	312	1483	2125	6298	3884	2460	1294	531	264	123	171	393	116	40	85	
Correction of Faroese catches in Vb2		-65	-109	-353	-214	-75	-60	-28	-14	-5	-7	-23	-7	-2	-2	-1
Used in assessment	1194	1080	1756	5676	3411	1232	955	450	218	80	105	370	108	38	38	17

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

Table 3.2. Faroe Bank (subdivision Vb2) cod. Surplus production model output using summer index.

Faroe Bank Cod RV Page 1
28 Apr 2016 at 13:32.23
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: 51 Number of bootstrap trials: 0
Number of dataseries: 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

Weighted Weighted Current Suggested R-squared
Loss component number and title SSE N MSE weight weight in cpue

Loss(-1) SSE in yield 0.000E+00
Loss(0) Penalty for B1R > 2 0.000E+00 1 N/A 1.000E-01 N/A
Loss(1) Survey cpue Spring 1.545E+01 33 4.983E-01 1.000E+00 1.000E+00 0.443
TOTAL OBJECTIVE FUNCTION: 1.54481033E+01

Number of restarts required for convergence: 10
Est. B-ratio coverage index (0 worst, 2 best): 0.7964 < These two measures are defined in Prager
Est. B-ratio nearness index (0 worst, 1 best): 0.8438 < *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	7.438E-01	1.000E+00	1	1
MSY	Maximum sustainable yield	2.568E+03	3.000E+03	1	1
r	Intrinsic rate of increase	3.455E-01	8.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	Survey cpue Spring	2.158E-02	1.000E-02	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	Related quantity
MSY	Maximum sustainable yield	2.568E+03	Kr/4	
K	Maximum stock biomass	2.973E+04		
Bmsy	Stock biomass at MSY	1.486E+04	K/2	
Fmsy	Fishing mortality at MSY	1.728E-01	r/2	
F(0.1)	Management benchmark	1.555E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	2.542E+03	0.99*MSY	
B-ratio	Ratio of B(2016) to Bmsy	2.545E-01		
F-ratio	Ratio of F(2015) to Fmsy	3.011E-02		
F01-mult	Ratio of F(0.1) to F(2015)	2.989E+01		
Y-ratio	Proportion of MSY avail in 2016	4.443E-01	2*Br-Br^2	Ye(2016) = 1.141E+03
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	Survey cpue Spring	8.004E+00	r/2q(1)	f(0.1) = 7.203E+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	0.211	1.106E+04	1.109E+04	2.341E+03	2.341E+03	2.402E+03	1.222E+00	7.438E-01
2	1966	0.168	1.112E+04	1.138E+04	1.909E+03	1.909E+03	2.426E+03	9.711E-01	7.479E-01
3	1967	0.130	1.163E+04	1.209E+04	1.569E+03	1.569E+03	2.478E+03	7.510E-01	7.827E-01
4	1968	0.328	1.254E+04	1.181E+04	3.871E+03	3.871E+03	2.457E+03	1.898E+00	8.438E-01
5	1969	0.221	1.113E+04	1.110E+04	2.457E+03	2.457E+03	2.403E+03	1.281E+00	7.487E-01
6	1970	0.279	1.107E+04	1.075E+04	3.002E+03	3.002E+03	2.371E+03	1.617E+00	7.451E-01
7	1971	0.196	1.044E+04	1.058E+04	2.079E+03	2.079E+03	2.355E+03	1.137E+00	7.026E-01
8	1972	0.200	1.072E+04	1.083E+04	2.168E+03	2.168E+03	2.378E+03	1.159E+00	7.212E-01
9	1973	0.544	1.093E+04	9.385E+03	5.101E+03	5.101E+03	2.211E+03	3.146E+00	7.353E-01
10	1974	0.258	8.040E+03	8.017E+03	2.068E+03	2.068E+03	2.023E+03	1.493E+00	5.409E-01
11	1975	0.255	7.995E+03	7.985E+03	2.036E+03	2.036E+03	2.018E+03	1.476E+00	5.379E-01
12	1976	0.288	7.977E+03	7.842E+03	2.258E+03	2.258E+03	1.995E+03	1.667E+00	5.366E-01
13	1977	0.116	7.713E+03	8.260E+03	9.590E+02	9.590E+02	2.060E+03	6.720E-01	5.189E-01
14	1978	0.583	8.814E+03	7.507E+03	4.379E+03	4.379E+03	1.933E+03	3.376E+00	5.930E-01
15	1979	0.198	6.368E+03	6.603E+03	1.306E+03	1.306E+03	1.774E+03	1.145E+00	4.284E-01
16	1980	0.168	6.837E+03	7.174E+03	1.203E+03	1.203E+03	1.880E+03	9.706E-01	4.599E-01
17	1981	0.156	7.514E+03	7.901E+03	1.229E+03	1.229E+03	2.004E+03	9.005E-01	5.055E-01
18	1982	0.266	8.288E+03	8.223E+03	2.184E+03	2.184E+03	2.055E+03	1.537E+00	5.576E-01
19	1983	0.285	8.160E+03	8.027E+03	2.284E+03	2.284E+03	2.024E+03	1.647E+00	5.490E-01
20	1984	0.281	7.900E+03	7.797E+03	2.189E+03	2.189E+03	1.987E+03	1.625E+00	5.315E-01
21	1985	0.407	7.698E+03	7.161E+03	2.913E+03	2.913E+03	1.877E+03	2.355E+00	5.179E-01
22	1986	0.277	6.663E+03	6.635E+03	1.836E+03	1.836E+03	1.781E+03	1.602E+00	4.482E-01
23	1987	0.605	6.607E+03	5.630E+03	3.409E+03	3.409E+03	1.574E+03	3.505E+00	4.445E-01
24	1988	0.785	4.772E+03	3.777E+03	2.966E+03	2.966E+03	1.136E+03	4.546E+00	3.210E-01
25	1989	0.465	2.942E+03	2.728E+03	1.270E+03	1.270E+03	8.560E+02	2.694E+00	1.979E-01
26	1990	0.103	2.528E+03	2.815E+03	2.890E+02	2.890E+02	8.801E+02	5.944E-01	1.701E-01
27	1991	0.085	3.119E+03	3.491E+03	2.970E+02	2.970E+02	1.064E+03	4.925E-01	2.098E-01
28	1992	0.035	3.886E+03	4.441E+03	1.540E+02	1.540E+02	1.304E+03	2.007E-01	2.614E-01
29	1993	0.047	5.036E+03	5.677E+03	2.660E+02	2.660E+02	1.585E+03	2.712E-01	3.388E-01
30	1994	0.105	6.355E+03	6.900E+03	7.250E+02	7.250E+02	1.829E+03	6.082E-01	4.275E-01
31	1995	0.074	7.459E+03	8.172E+03	6.010E+02	6.010E+02	2.045E+03	4.257E-01	5.018E-01
32	1996	0.236	8.904E+03	8.931E+03	2.106E+03	2.106E+03	2.159E+03	1.365E+00	5.990E-01
33	1997	0.441	8.956E+03	8.143E+03	3.594E+03	3.594E+03	2.040E+03	2.555E+00	6.026E-01
34	1998	0.488	7.403E+03	6.637E+03	3.239E+03	3.239E+03	1.779E+03	2.825E+00	4.980E-01
35	1999	0.159	5.943E+03	6.297E+03	1.001E+03	1.001E+03	1.714E+03	9.201E-01	3.998E-01
36	2000	0.171	6.656E+03	6.981E+03	1.194E+03	1.194E+03	1.845E+03	9.900E-01	4.478E-01
37	2001	0.139	7.308E+03	7.755E+03	1.080E+03	1.080E+03	1.980E+03	8.061E-01	4.916E-01
38	2002	0.210	8.207E+03	8.370E+03	1.756E+03	1.756E+03	2.078E+03	1.214E+00	5.522E-01
39	2003	0.899	8.529E+03	6.312E+03	5.676E+03	5.676E+03	1.703E+03	5.205E+00	5.738E-01
40	2004	1.074	4.556E+03	3.176E+03	3.411E+03	3.411E+03	9.746E+02	6.217E+00	3.065E-01
41	2005	0.696	2.119E+03	1.769E+03	1.232E+03	1.232E+03	5.744E+02	4.031E+00	1.426E-01
42	2006	0.830	1.462E+03	1.151E+03	9.550E+02	9.550E+02	3.819E+02	4.804E+00	9.833E-02
43	2007	0.567	8.885E+02	7.932E+02	4.500E+02	4.500E+02	2.667E+02	3.284E+00	5.977E-02
44	2008	0.304	7.052E+02	7.170E+02	2.180E+02	2.180E+02	2.418E+02	1.760E+00	4.744E-02
45	2009	0.097	7.290E+02	8.235E+02	8.000E+01	8.000E+01	2.766E+02	5.623E-01	4.904E-02
46	2010	0.101	9.256E+02	1.042E+03	1.050E+02	1.050E+02	3.475E+02	5.831E-01	6.227E-02
47	2011	0.314	1.168E+03	1.179E+03	3.700E+02	3.700E+02	3.911E+02	1.817E+00	7.858E-02
48	2012	0.080	1.189E+03	1.351E+03	1.080E+02	1.080E+02	4.455E+02	4.626E-01	8.000E-02
49	2013	0.021	1.527E+03	1.785E+03	3.800E+01	3.800E+01	5.793E+02	1.233E-01	1.027E-01
50	2014	0.016	2.068E+03	2.415E+03	3.800E+01	3.800E+01	7.662E+02	9.107E-02	1.391E-01
51	2015	0.005	2.796E+03	3.268E+03	1.700E+01	1.700E+01	1.004E+03	3.011E-02	1.881E-01
52	2016		3.783E+03						2.545E-01

Faroe Bank Cod RV Page 3

RESULTS FOR DATASERIES # 1 (NON-BOOTSTRAPPED) Survey cpue Spring

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	*	2.393E+02	0.2112	2.341E+03	2.341E+03	0.00000	0.000E+00
2	1966	*	2.456E+02	0.1678	1.909E+03	1.909E+03	0.00000	0.000E+00
3	1967	*	2.610E+02	0.1297	1.569E+03	1.569E+03	0.00000	0.000E+00
4	1968	*	2.548E+02	0.3279	3.871E+03	3.871E+03	0.00000	0.000E+00
5	1969	*	2.396E+02	0.2213	2.457E+03	2.457E+03	0.00000	0.000E+00
6	1970	*	2.320E+02	0.2793	3.002E+03	3.002E+03	0.00000	0.000E+00
7	1971	*	2.284E+02	0.1964	2.079E+03	2.079E+03	0.00000	0.000E+00
8	1972	*	2.337E+02	0.2003	2.168E+03	2.168E+03	0.00000	0.000E+00
9	1973	*	2.026E+02	0.5435	5.101E+03	5.101E+03	0.00000	0.000E+00
10	1974	*	1.730E+02	0.2580	2.068E+03	2.068E+03	0.00000	0.000E+00
11	1975	*	1.724E+02	0.2550	2.036E+03	2.036E+03	0.00000	0.000E+00
12	1976	*	1.693E+02	0.2879	2.258E+03	2.258E+03	0.00000	0.000E+00
13	1977	*	1.783E+02	0.1161	9.590E+02	9.590E+02	0.00000	0.000E+00
14	1978	*	1.620E+02	0.5833	4.379E+03	4.379E+03	0.00000	0.000E+00
15	1979	*	1.425E+02	0.1978	1.306E+03	1.306E+03	0.00000	0.000E+00
16	1980	*	1.549E+02	0.1677	1.203E+03	1.203E+03	0.00000	0.000E+00
17	1981	*	1.705E+02	0.1556	1.229E+03	1.229E+03	0.00000	0.000E+00
18	1982	*	1.775E+02	0.2656	2.184E+03	2.184E+03	0.00000	0.000E+00
19	1983	7.899E+01	1.733E+02	0.2845	2.284E+03	2.284E+03	0.78546	0.000E+00
20	1984	1.752E+02	1.683E+02	0.2807	2.189E+03	2.189E+03	-0.04023	0.000E+00
21	1985	1.735E+02	1.546E+02	0.4068	2.913E+03	2.913E+03	-0.11540	0.000E+00
22	1986	2.661E+02	1.432E+02	0.2767	1.836E+03	1.836E+03	-0.61957	0.000E+00
23	1987	1.640E+02	1.215E+02	0.6055	3.409E+03	3.409E+03	-0.30001	0.000E+00
24	1988	7.311E+01	8.152E+01	0.7853	2.966E+03	2.966E+03	0.10885	0.000E+00
25	1989	3.655E+01	5.889E+01	0.4655	1.270E+03	1.270E+03	0.47703	0.000E+00
26	1990	2.324E+01	6.075E+01	0.1027	2.890E+02	2.890E+02	0.96093	0.000E+00
27	1991	5.097E+01	7.535E+01	0.0851	2.970E+02	2.970E+02	0.39090	0.000E+00
28	1992	2.843E+01	9.585E+01	0.0347	1.540E+02	1.540E+02	1.21539	0.000E+00
29	1993	2.576E+01	1.225E+02	0.0469	2.660E+02	2.660E+02	1.55957	0.000E+00
30	1994	8.674E+01	1.489E+02	0.1051	7.250E+02	7.250E+02	0.54054	0.000E+00
31	1995	9.017E+01	1.764E+02	0.0735	6.010E+02	6.010E+02	0.67094	0.000E+00
32	1996	3.105E+02	1.928E+02	0.2358	2.106E+03	2.106E+03	-0.47675	0.000E+00
33	1997	4.491E+02	1.758E+02	0.4414	3.594E+03	3.594E+03	-0.93826	0.000E+00
34	1998	3.871E+02	1.433E+02	0.4880	3.239E+03	3.239E+03	-0.99397	0.000E+00
35	1999	1.495E+02	1.359E+02	0.1590	1.001E+03	1.001E+03	-0.09548	0.000E+00
36	2000	1.199E+02	1.507E+02	0.1710	1.194E+03	1.194E+03	0.22854	0.000E+00
37	2001	2.626E+02	1.674E+02	0.1393	1.080E+03	1.080E+03	-0.45023	0.000E+00
38	2002	3.471E+02	1.807E+02	0.2098	1.756E+03	1.756E+03	-0.65318	0.000E+00
39	2003	1.618E+02	1.362E+02	0.8992	5.676E+03	5.676E+03	-0.17170	0.000E+00
40	2004	7.303E+01	6.856E+01	1.0739	3.411E+03	3.411E+03	-0.06323	0.000E+00
41	2005	6.187E+01	3.818E+01	0.6964	1.232E+03	1.232E+03	-0.48266	0.000E+00
42	2006	2.927E+01	2.484E+01	0.8299	9.550E+02	9.550E+02	-0.16419	0.000E+00
43	2007	3.331E+01	1.712E+01	0.5673	4.500E+02	4.500E+02	-0.66560	0.000E+00
44	2008	3.117E+01	1.548E+01	0.3040	2.180E+02	2.180E+02	-0.70013	0.000E+00
45	2009	4.926E+01	1.778E+01	0.0971	8.000E+01	8.000E+01	-1.01932	0.000E+00
46	2010	4.164E+01	2.250E+01	0.1007	1.050E+02	1.050E+02	-0.61562	0.000E+00
47	2011	5.854E+01	2.544E+01	0.3139	3.700E+02	3.700E+02	-0.83345	0.000E+00
48	2012	3.425E+01	2.917E+01	0.0799	1.080E+02	1.080E+02	-0.16067	0.000E+00
49	2013	1.737E+01	3.852E+01	0.0213	3.800E+01	3.800E+01	0.79638	0.000E+00
50	2014	2.575E+01	5.214E+01	0.0157	3.800E+01	3.800E+01	0.70542	0.000E+00
51	2015	2.481E+01	7.054E+01	0.0052	1.700E+01	1.700E+01	1.04488	0.000E+00

* Asterisk indicates missing value(s).

Faroe Bank Cod RV Page 4

UNWEIGHTED LOG RESIDUAL PLOT FOR DATASERIES # 1

```
                -2        -1.5      -1        -0.5      0         0.5       1         1.5       2
                |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year  Residual  ---------------------------------------------------------------------------------
1965    0.0000                                          |
1966    0.0000                                          |
1967    0.0000                                          |
1968    0.0000                                          |
1969    0.0000                                          |
1970    0.0000                                          |
1971    0.0000                                          |
1972    0.0000                                          |
1973    0.0000                                          |
1974    0.0000                                          |
1975    0.0000                                          |
1976    0.0000                                          |
1977    0.0000                                          |
1978    0.0000                                          |
1979    0.0000                                          |
1980    0.0000                                          |
1981    0.0000                                          |
1982    0.0000                                          |
1983    0.7855                                          |================
1984   -0.0402                                         =|
1985   -0.1154                                        ==|
1986   -0.6196                              ============|
1987   -0.3000                                    ======|
1988    0.1088                                          |==
1989    0.4770                                          |==========
1990    0.9609                                          |===================
1991    0.3909                                          |========
1992    1.2154                                          |========================
1993    1.5596                                          |===============================
1994    0.5405                                          |===========
1995    0.6709                                          |=============
1996   -0.4767                                ==========|
1997   -0.9383                       ===================|
1998   -0.9940                      ====================|
1999   -0.0955                                        ==|
2000    0.2285                                          |=====
2001   -0.4502                                 =========|
2002   -0.6532                             =============|
2003   -0.1717                                       ===|
2004   -0.0632                                         =|
2005   -0.4827                                ==========|
2006   -0.1642                                       ===|
2007   -0.6656                             =============|
2008   -0.7001                            ==============|
2009   -1.0193                      ====================|
2010   -0.6156                              ============|
2011   -0.8335                         =================|
2012   -0.1607                                       ===|
2013    0.7964                                          |================
2014    0.7054                                          |==============
2015    1.0449                                          |=====================
                ---------------------------------------------------------------------------------
```

```
Faroe Bank Cod RV                                                    Page  5

        Observed (O) and Estimated (*) cpue for Dataseries # 1 -- Survey cpue Spring
      :
 480. -:
      :
      :                                  O
      :
      :
 400. -:
      :                                   O
      :
      :                                       O
      :
 320. -:
      :                                  O
      :
      :                         O
      :      * *                              O
 240. -:     * *   **   *
      :          *
      :            *
      :                                  *
      :            * ** *     ** * 2O          *  *       *
 160. -:                * *      *  O              *  O
      :               *       *        *     * O*    *
      :                      *      *      *
      :                                     O
      :                          *   O
  80. -:                  O     2   *   O           O
      :                        * *               * O      O    *
      :                          O                    O O     *
      :                        O   O O              *2 O O   *2 * OO
      :                         O                  * ** *    O
   0. -:
      :........................................................................
      :      :      :      :      :      :      :      :      :      :      :
    1959.  1965.  1971.  1977.  1983.  1989.  1995.  2001.  2007.  2013.  2019.
              Time Plot of Estimated F-Ratio and B-Ratio
      :
 7.2 -:
      :
      :
      :
      :                                         F
 6.0 -:
      :
      :
      :                                       F
      :
 4.8 -:                                           F
      :                            F
      :
      :                                         F
      :
 3.6 -:                             F
      :                 F                           F
      :              F
      :                                    F
      :                              F         F
 2.4 -:                          F
      :
      :        F                                          F
      :          F       F      F F  F                   F
      :              F F      F                F
 1.2 -:       F     F  F F      F                     F
      :  -- - --- - 2- 2 -- - -- - -- - -- 2 2- - -- - -- - -- - -- - --- - 22 - -- - -- - -- - -- - -- - -- - -
      :       B B2   BB B BB     F                 F    B     F
      :              B BB B BB B BB B BB B B    FF    B 2 B  B BB B BB        F F  F
      :                          B B BB 2 2             B B          F BB B
 0.0 -:                                               B B BB B BB B FF
      :........................................................................
      :      :      :      :      :      :      :      :      :      :      :
    1959.  1965.  1971.  1977.  1983.  1989.  1995.  2001.  2007.  2013.  2019.
```

Table 3.3. Faroe Bank (subdivision Vb2) cod. Surplus production model output using spring index.

Faroe Bank Cod RV Page 1

28 Apr 2016 at 13:24.32

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:	51	Number of bootstrap trials:	0
Number of dataseries:	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	0.000E+00	1	N/A	1.000E-01	N/A	
Loss(1) Survey cpue Spring	2.279E+01	30	8.140E-01	1.000E+00	1.000E+00	0.102
TOTAL OBJECTIVE FUNCTION:	2.27906013E+01					

Number of restarts required for convergence: 33

Est. B-ratio coverage index (0 worst, 2 best): 0.3202 < These two measures are defined in Prager

Est. B-ratio nearness index (0 worst, 1 best): 0.3595 < *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	2.964E-01	1.000E+00	1	1
MSY	Maximum sustainable yield	4.789E+03	3.000E+03	1	1
r	Intrinsic rate of increase	3.328E-01	8.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	Survey cpue Spring	2.786E-02	1.000E-02	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	Related quantity
MSY	Maximum sustainable yield	4.789E+03	Kr/4	
K	Maximum stock biomass	5.756E+04		
Bmsy	Stock biomass at MSY	2.878E+04	K/2	
Fmsy	Fishing mortality at MSY	1.664E-01	r/2	
F(0.1)	Management benchmark	1.498E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	4.741E+03	0.99*MSY	
B-ratio	Ratio of B(2016) to Bmsy	2.953E-01		
F-ratio	Ratio of F(2015) to Fmsy	1.382E-02		
F01-mult	Ratio of F(0.1) to F(2015)	6.513E+01		
Y-ratio	Proportion of MSY avail in 2016	5.034E-01	2*Br-Br^2	Ye(2016) = 2.411E+03
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	Survey cpue Spring	5.973E+00	r/2q(1)	f(0.1) = 5.376E+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	0.273	8.530E+03	8.574E+03	2.341E+03	2.341E+03	2.428E+03	1.641E+00	2.964E-01
2	1966	0.214	8.618E+03	8.916E+03	1.909E+03	1.909E+03	2.507E+03	1.287E+00	2.994E-01
3	1967	0.160	9.216E+03	9.776E+03	1.569E+03	1.569E+03	2.700E+03	9.646E-01	3.202E-01
4	1968	0.397	1.035E+04	9.741E+03	3.871E+03	3.871E+03	2.692E+03	2.388E+00	3.595E-01
5	1969	0.266	9.169E+03	9.230E+03	2.457E+03	2.457E+03	2.579E+03	1.600E+00	3.186E-01
6	1970	0.332	9.291E+03	9.055E+03	3.002E+03	3.002E+03	2.539E+03	1.992E+00	3.228E-01
7	1971	0.230	8.828E+03	9.058E+03	2.079E+03	2.079E+03	2.540E+03	1.379E+00	3.067E-01
8	1972	0.228	9.289E+03	9.528E+03	2.168E+03	2.168E+03	2.646E+03	1.368E+00	3.227E-01
9	1973	0.614	9.767E+03	8.312E+03	5.101E+03	5.101E+03	2.363E+03	3.688E+00	3.393E-01
10	1974	0.295	7.029E+03	7.020E+03	2.068E+03	2.068E+03	2.051E+03	1.770E+00	2.442E-01
11	1975	0.290	7.012E+03	7.019E+03	2.036E+03	2.036E+03	2.051E+03	1.743E+00	2.436E-01
12	1976	0.327	7.027E+03	6.908E+03	2.258E+03	2.258E+03	2.023E+03	1.964E+00	2.442E-01
13	1977	0.130	6.792E+03	7.370E+03	9.590E+02	9.590E+02	2.138E+03	7.821E-01	2.360E-01
14	1978	0.655	7.971E+03	6.683E+03	4.379E+03	4.379E+03	1.963E+03	3.938E+00	2.769E-01
15	1979	0.227	5.555E+03	5.763E+03	1.306E+03	1.306E+03	1.726E+03	1.362E+00	1.930E-01
16	1980	0.191	5.975E+03	6.303E+03	1.203E+03	1.203E+03	1.868E+03	1.147E+00	2.076E-01
17	1981	0.174	6.639E+03	7.048E+03	1.229E+03	1.229E+03	2.058E+03	1.048E+00	2.307E-01
18	1982	0.293	7.468E+03	7.456E+03	2.184E+03	2.184E+03	2.160E+03	1.760E+00	2.595E-01
19	1983	0.310	7.444E+03	7.370E+03	2.284E+03	2.284E+03	2.139E+03	1.862E+00	2.586E-01
20	1984	0.302	7.299E+03	7.259E+03	2.189E+03	2.189E+03	2.111E+03	1.812E+00	2.536E-01
21	1985	0.432	7.221E+03	6.740E+03	2.913E+03	2.913E+03	1.980E+03	2.597E+00	2.509E-01
22	1986	0.291	6.288E+03	6.304E+03	1.836E+03	1.836E+03	1.868E+03	1.750E+00	2.185E-01
23	1987	0.635	6.320E+03	5.370E+03	3.409E+03	3.409E+03	1.619E+03	3.815E+00	2.196E-01
24	1988	0.846	4.529E+03	3.508E+03	2.966E+03	2.966E+03	1.094E+03	5.082E+00	1.574E-01
25	1989	0.530	2.658E+03	2.395E+03	1.270E+03	1.270E+03	7.638E+02	3.186E+00	9.235E-02
26	1990	0.121	2.152E+03	2.380E+03	2.890E+02	2.890E+02	7.590E+02	7.299E-01	7.476E-02
27	1991	0.102	2.622E+03	2.925E+03	2.970E+02	2.970E+02	9.237E+02	6.103E-01	9.110E-02
28	1992	0.041	3.249E+03	3.731E+03	1.540E+02	1.540E+02	1.161E+03	2.481E-01	1.129E-01
29	1993	0.055	4.255E+03	4.837E+03	2.660E+02	2.660E+02	1.474E+03	3.305E-01	1.478E-01
30	1994	0.121	5.463E+03	5.979E+03	7.250E+02	7.250E+02	1.782E+03	7.288E-01	1.898E-01
31	1995	0.083	6.520E+03	7.253E+03	6.010E+02	6.010E+02	2.108E+03	4.980E-01	2.265E-01
32	1996	0.259	8.028E+03	8.138E+03	2.106E+03	2.106E+03	2.325E+03	1.555E+00	2.789E-01
33	1997	0.479	8.247E+03	7.508E+03	3.594E+03	3.594E+03	2.172E+03	2.877E+00	2.865E-01
34	1998	0.533	6.825E+03	6.077E+03	3.239E+03	3.239E+03	1.808E+03	3.203E+00	2.371E-01
35	1999	0.174	5.393E+03	5.748E+03	1.001E+03	1.001E+03	1.722E+03	1.047E+00	1.874E-01
36	2000	0.185	6.114E+03	6.468E+03	1.194E+03	1.194E+03	1.910E+03	1.110E+00	2.124E-01

37	2001	0.147	6.830E+03	7.347E+03	1.080E+03	1.080E+03	2.132E+03	8.834E-01	2.373E-01
38	2002	0.215	7.882E+03	8.170E+03	1.756E+03	1.756E+03	2.333E+03	1.292E+00	2.739E-01
39	2003	0.892	8.459E+03	6.360E+03	5.676E+03	5.676E+03	1.876E+03	5.364E+00	2.939E-01
40	2004	1.024	4.659E+03	3.331E+03	3.411E+03	3.411E+03	1.042E+03	6.153E+00	1.619E-01
41	2005	0.624	2.290E+03	1.975E+03	1.232E+03	1.232E+03	6.347E+02	3.748E+00	7.956E-02
42	2006	0.666	1.692E+03	1.433E+03	9.550E+02	9.550E+02	4.649E+02	4.005E+00	5.880E-02
43	2007	0.386	1.202E+03	1.167E+03	4.500E+02	4.500E+02	3.805E+02	2.317E+00	4.177E-02
44	2008	0.179	1.133E+03	1.221E+03	2.180E+02	2.180E+02	3.975E+02	1.073E+00	3.936E-02
45	2009	0.053	1.312E+03	1.508E+03	8.000E+01	8.000E+01	4.885E+02	3.189E-01	4.560E-02
46	2010	0.053	1.721E+03	1.974E+03	1.050E+02	1.050E+02	6.343E+02	3.196E-01	5.979E-02
47	2011	0.151	2.250E+03	2.450E+03	3.700E+02	3.700E+02	7.806E+02	9.075E-01	7.818E-02
48	2012	0.035	2.661E+03	3.072E+03	1.080E+02	1.080E+02	9.673E+02	2.113E-01	9.245E-02
49	2013	0.009	3.520E+03	4.107E+03	3.800E+01	3.800E+01	1.269E+03	5.561E-02	1.223E-01
50	2014	0.007	4.751E+03	5.527E+03	3.800E+01	3.800E+01	1.661E+03	4.132E-02	1.651E-01
51	2015	0.002	6.374E+03	7.393E+03	1.700E+01	1.700E+01	2.142E+03	1.382E-02	2.215E-01
52	2016		8.499E+03				2.953E-01		

Faroe Bank Cod RV Page 3

RESULTS FOR DATASERIES # 1 (NON-BOOTSTRAPPED) Survey cpue Spring

----

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	*	2.389E+02	0.2730	2.341E+03	2.341E+03	0.00000	0.000E+00
2	1966	*	2.484E+02	0.2141	1.909E+03	1.909E+03	0.00000	0.000E+00
3	1967	*	2.723E+02	0.1605	1.569E+03	1.569E+03	0.00000	0.000E+00
4	1968	*	2.713E+02	0.3974	3.871E+03	3.871E+03	0.00000	0.000E+00
5	1969	*	2.571E+02	0.2662	2.457E+03	2.457E+03	0.00000	0.000E+00
6	1970	*	2.523E+02	0.3315	3.002E+03	3.002E+03	0.00000	0.000E+00
7	1971	*	2.523E+02	0.2295	2.079E+03	2.079E+03	0.00000	0.000E+00
8	1972	*	2.654E+02	0.2275	2.168E+03	2.168E+03	0.00000	0.000E+00
9	1973	*	2.315E+02	0.6137	5.101E+03	5.101E+03	0.00000	0.000E+00
10	1974	*	1.956E+02	0.2946	2.068E+03	2.068E+03	0.00000	0.000E+00
11	1975	*	1.955E+02	0.2900	2.036E+03	2.036E+03	0.00000	0.000E+00
12	1976	*	1.924E+02	0.3269	2.258E+03	2.258E+03	0.00000	0.000E+00
13	1977	*	2.053E+02	0.1301	9.590E+02	9.590E+02	0.00000	0.000E+00
14	1978	*	1.862E+02	0.6553	4.379E+03	4.379E+03	0.00000	0.000E+00
15	1979	*	1.605E+02	0.2266	1.306E+03	1.306E+03	0.00000	0.000E+00
16	1980	*	1.756E+02	0.1909	1.203E+03	1.203E+03	0.00000	0.000E+00
17	1981	*	1.963E+02	0.1744	1.229E+03	1.229E+03	0.00000	0.000E+00
18	1982	*	2.077E+02	0.2929	2.184E+03	2.184E+03	0.00000	0.000E+00
19	1983	7.899E+01	2.053E+02	0.3099	2.284E+03	2.284E+03	0.95525	0.000E+00
20	1984	1.752E+02	2.022E+02	0.3015	2.189E+03	2.189E+03	0.14337	0.000E+00
21	1985	1.735E+02	1.878E+02	0.4322	2.913E+03	2.913E+03	0.07919	0.000E+00
22	1986	2.661E+02	1.756E+02	0.2913	1.836E+03	1.836E+03	-0.41561	0.000E+00
23	1987	1.640E+02	1.496E+02	0.6348	3.409E+03	3.409E+03	-0.09212	0.000E+00
24	1988	7.311E+01	9.772E+01	0.8455	2.966E+03	2.966E+03	0.29011	0.000E+00
25	1989	3.655E+01	6.673E+01	0.5302	1.270E+03	1.270E+03	0.60194	0.000E+00
26	1990	2.324E+01	6.629E+01	0.1214	2.890E+02	2.890E+02	1.04815	0.000E+00
27	1991	5.097E+01	8.148E+01	0.1015	2.970E+02	2.970E+02	0.46909	0.000E+00
28	1992	2.843E+01	1.039E+02	0.0413	1.540E+02	1.540E+02	1.29632	0.000E+00
29	1993	2.576E+01	1.347E+02	0.0550	2.660E+02	2.660E+02	1.65448	0.000E+00
30	1994	8.674E+01	1.666E+02	0.1213	7.250E+02	7.250E+02	0.65241	0.000E+00
31	1995	9.017E+01	2.020E+02	0.0829	6.010E+02	6.010E+02	0.80681	0.000E+00
32	1996	*	2.267E+02	0.2588	2.106E+03	2.106E+03	0.00000	0.000E+00
33	1997	5.934E+02	2.092E+02	0.4787	3.594E+03	3.594E+03	-1.04282	0.000E+00
34	1998	6.074E+02	1.693E+02	0.5330	3.239E+03	3.239E+03	-1.27765	0.000E+00
35	1999	4.210E+02	1.601E+02	0.1741	1.001E+03	1.001E+03	-0.96669	0.000E+00
36	2000	3.645E+02	1.802E+02	0.1846	1.194E+03	1.194E+03	-0.70467	0.000E+00

37	2001	1.022E+03	2.047E+02	0.1470	1.080E+03	1.080E+03	-1.60839	0.000E+00
38	2002	4.439E+02	2.276E+02	0.2149	1.756E+03	1.756E+03	-0.66803	0.000E+00
39	2003	8.671E+02	1.772E+02	0.8925	5.676E+03	5.676E+03	-1.58807	0.000E+00
40	2004	*	9.281E+01	1.0239	3.411E+03	3.411E+03	0.00000	0.000E+00
41	2005	*	5.503E+01	0.6236	1.232E+03	1.232E+03	0.00000	0.000E+00
42	2006	6.051E+01	3.992E+01	0.6664	9.550E+02	9.550E+02	-0.41589	0.000E+00
43	2007	5.206E+01	3.251E+01	0.3855	4.500E+02	4.500E+02	-0.47070	0.000E+00
44	2008	6.402E+01	3.400E+01	0.1786	2.180E+02	2.180E+02	-0.63283	0.000E+00
45	2009	5.550E+01	4.200E+01	0.0531	8.000E+01	8.000E+01	-0.27870	0.000E+00
46	2010	5.808E+01	5.500E+01	0.0532	1.050E+02	1.050E+02	-0.05455	0.000E+00
47	2011	1.224E+02	6.826E+01	0.1510	3.700E+02	3.700E+02	-0.58401	0.000E+00
48	2012	4.454E+01	8.557E+01	0.0352	1.080E+02	1.080E+02	0.65294	0.000E+00
49	2013	1.390E+02	1.144E+02	0.0093	3.800E+01	3.800E+01	-0.19452	0.000E+00
50	2014	2.092E+02	1.540E+02	0.0069	3.800E+01	3.800E+01	-0.30657	0.000E+00
51	2015	3.719E+01	2.060E+02	0.0023	1.700E+01	1.700E+01	1.71162	0.000E+00

* Asterisk indicates missing value(s).

Faroe Bank Cod RV Page 4

UNWEIGHTED LOG RESIDUAL PLOT FOR DATASERIES # 1

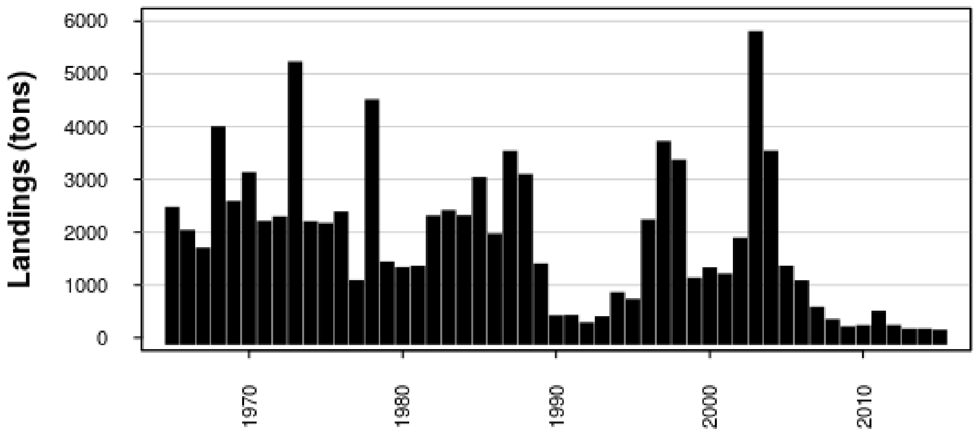
```
                -2        -1.5      -1        -0.5      0         0.5       1         1.5       2
                |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year  Residual  ---------------------------------------------------------------------------------
1965    0.0000                                          |
1966    0.0000                                          |
1967    0.0000                                          |
1968    0.0000                                          |
1969    0.0000                                          |
1970    0.0000                                          |
1971    0.0000                                          |
1972    0.0000                                          |
1973    0.0000                                          |
1974    0.0000                                          |
1975    0.0000                                          |
1976    0.0000                                          |
1977    0.0000                                          |
1978    0.0000                                          |
1979    0.0000                                          |
1980    0.0000                                          |
1981    0.0000                                          |
1982    0.0000                                          |
1983    0.9552                                          |===================
1984    0.1434                                          |===
1985    0.0792                                          |==
1986   -0.4156                                  ========|
1987   -0.0921                                        ==|
1988    0.2901                                          |======
1989    0.6019                                          |============
1990    1.0481                                          |=====================
1991    0.4691                                          |=========
1992    1.2963                                          |==========================
1993    1.6545                                          |=================================
1994    0.6524                                          |=============
1995    0.8068                                          |================
1996    0.0000                                          |
1997   -1.0428                     =====================|
1998   -1.2777                ==========================|
1999   -0.9667                       ===================|
2000   -0.7047                            ==============|
2001   -1.6084          ================================|
2002   -0.6680                             =============|
2003   -1.5881          ================================|
2004    0.0000                                          |
```

```
2005   0.0000                  |
2006  -0.4159          ========|
2007  -0.4707         =========|
2008  -0.6328     =============|
2009  -0.2787            ======|
2010  -0.0545                 =|
2011  -0.5840      ============|
2012   0.6529                  |=============
2013  -0.1945              ====|
2014  -0.3066            ======|
2015   1.7116                  |==================================
         ----------------------------------------------------------------------------------------
```

Faroe Bank Cod RV   Page 5

```
          Observed (O) and Estimated (*) cpue for Dataseries # 1 -- Survey cpue Spring
      :
 1200. -:
      :
      :
      :
      :                                    O
 1000. -:
      :
      :
      :                                     O
      :
  800. -:
      :
      :
      :
      :
  600. -:                                 O O
      :
      :
      :
      :                                  O    O
  400. -:
      :                                   O
      :
      :       * *    *           O
      :     * *   ** *  *                  *     *
  200. -:             * ** * *   ** * **       * *   * *           O*
      :                * *    OO * 2     *   * *   *         *
      :                           * *             O  2
      :                    O     2 * **   O O        *  O  O   **
      :                         O OO O O           ** 2 *2 2  O   O
    0. -:
      :....................................................
      :    :    :    :    :    :    :    :    :    :    :
```

```
   1959.    1965.    1971.    1977.    1983.    1989.    1995.    2001.    2007.    2013.    2019.
                    Time Plot of Estimated F-Ratio and B-Ratio
    :
7.2 -:
    :
    :
    :
    :                                                       F
6.0 -:
    :
    :
    :                                                      F
    :                                   F
4.8 -:
    :
    :
    :                                                         F
    :                        F          F                     F
3.6 -:                   F
    :
    :                                    F          F
    :                                           F
    :                                F
2.4 -:         F                                              F
    :
    :          F       F        F F
    :     F     F     F F       F     F
    :            F F       F                     F
1.2 -:       F               F                       F  F
    :  -- - -- - -2 - -- - -- - -- - --- - 2- - -- - -- - -- - -- - -- - 2- 2 -- - -- - 2- - 2- - -- - -- - -
    :                      F                FF    F
    :                                         F
    :      B BB B BB B BB B BB B BB B BB B BB B BB     F 2B B BB B BB B BB B      F F  F B BB B
0.0 -:                                 B BB B                   BB B BB B BB F FF
    :..........................................................................................
     :     :     :     :     :     :     :     :     :     :     :
   1959.    1965.    1971.    1977.    1983.    1989.    1995.    2001.    2007.    2013.    2019.
```



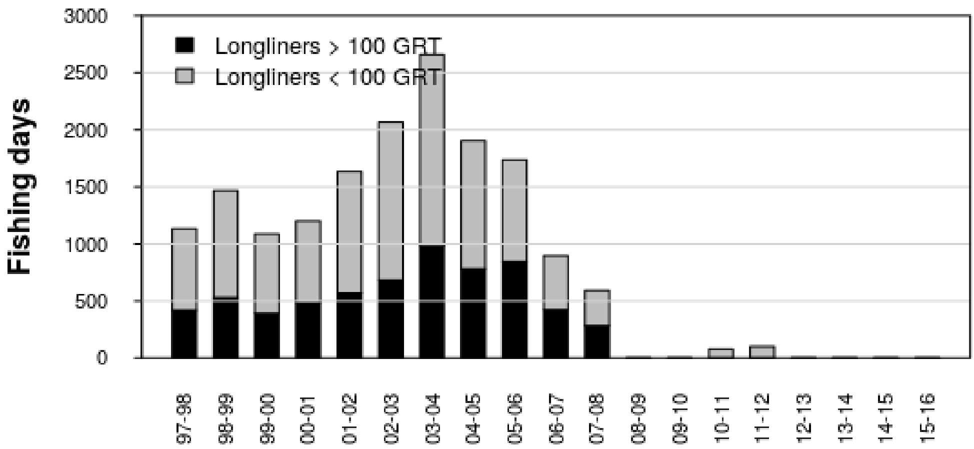


Figure 3.1. Faroe Bank (subdivision Vb2) cod. Reported landings 1965–2015. Since 1992 only catches from Faroese and Norwegian vessels are considered to be taken on Faroe Bank. Lower plot: fishing days (fishing year) 1997–2016 for longline gear type in the Faroe Bank.

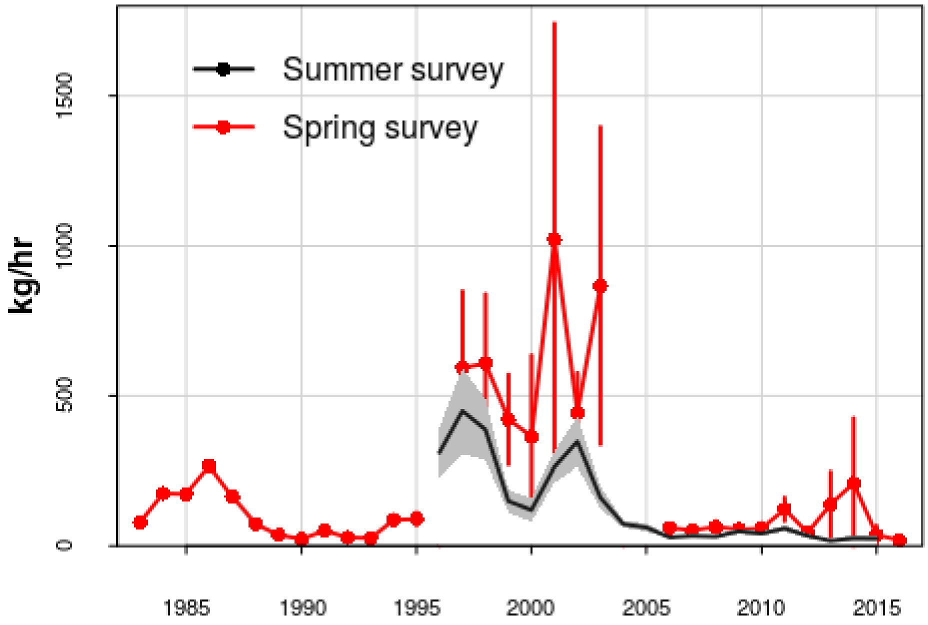


Figure 3.2. Faroe Bank (subdivision Vb2) cod. Catch per unit of effort in spring groundfish survey (1983–2016)(red line) and summer survey (1996–2015)(black line). Vertical bars and shaded areas show the standard error in the estimation of indices.

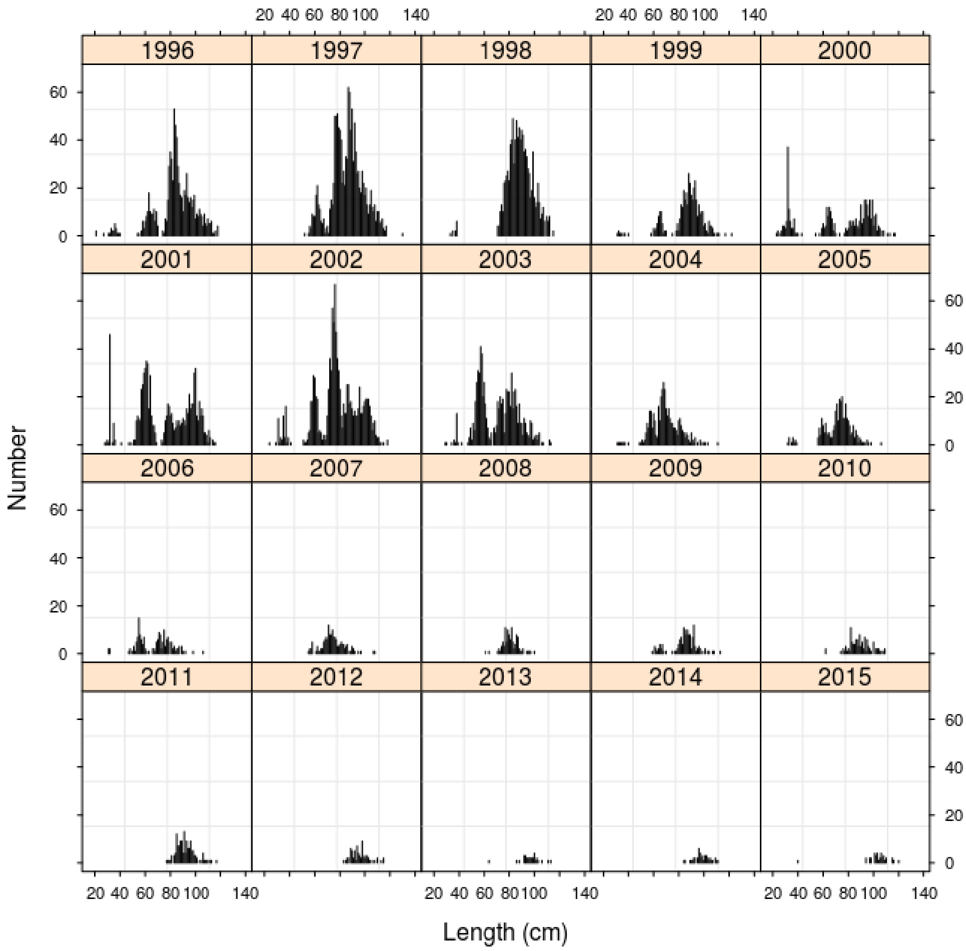


Figure 3.3. Faroe Bank (subdivision Vb2) cod. Length distributions in summer survey (1996–2015)

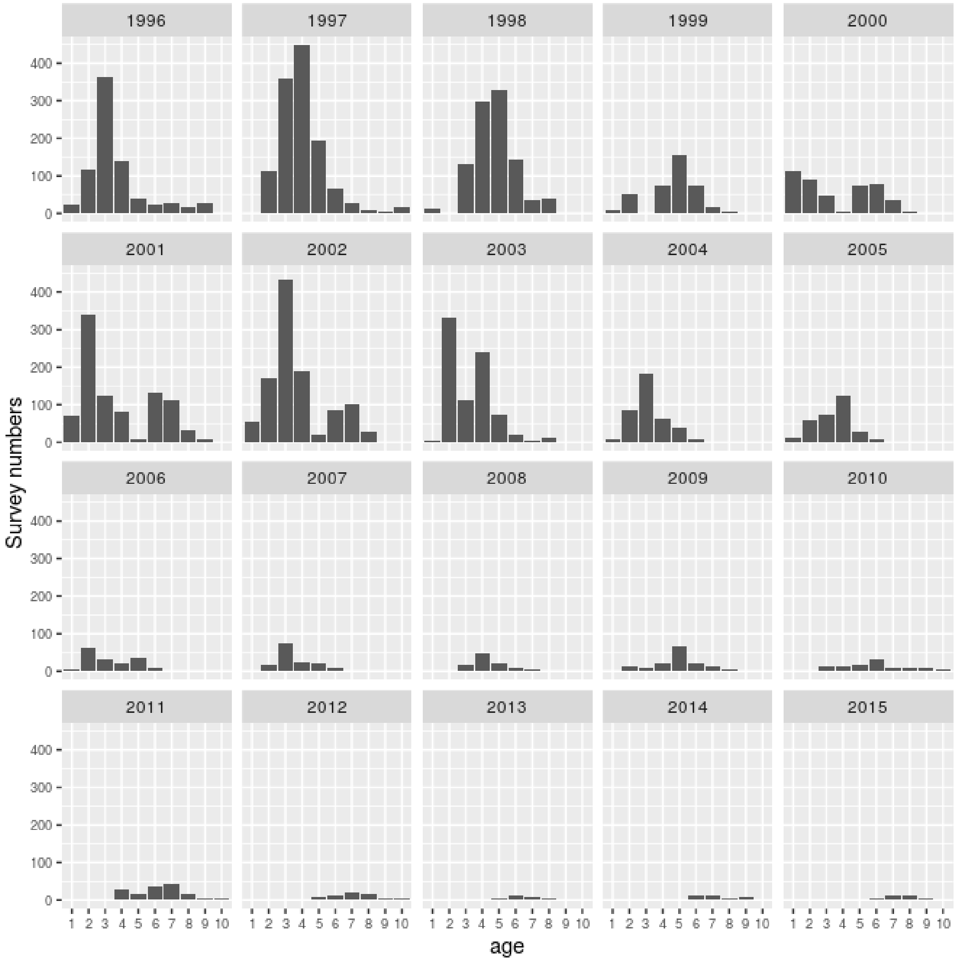


Figure 3.4. Faroe Bank (subdivision Vb2) cod. Age-disaggregated indices in summer survey (ages 1–10)(1996–2015)

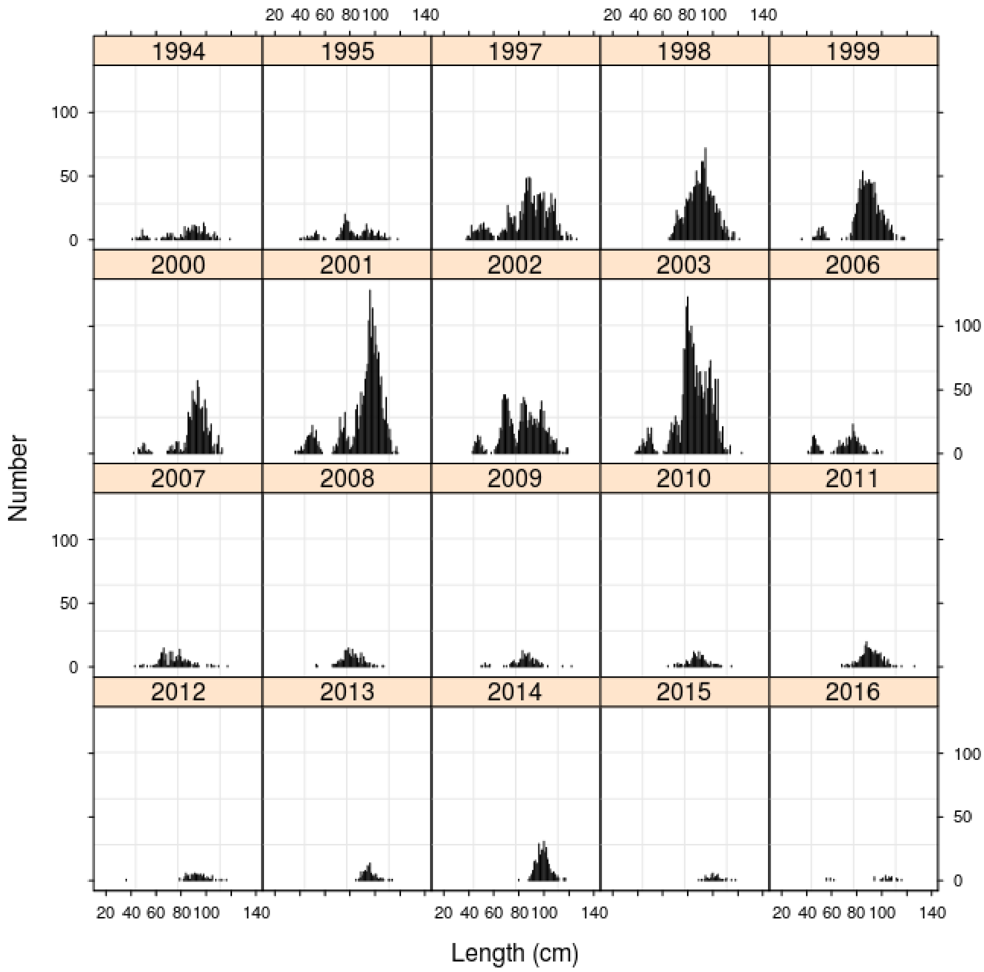


Figure 3.5. Faroe Bank (subdivision Vb2) cod. Length distributions in spring survey (1994–2016). No surveys were conducted in 1996, 2004 and 2005.

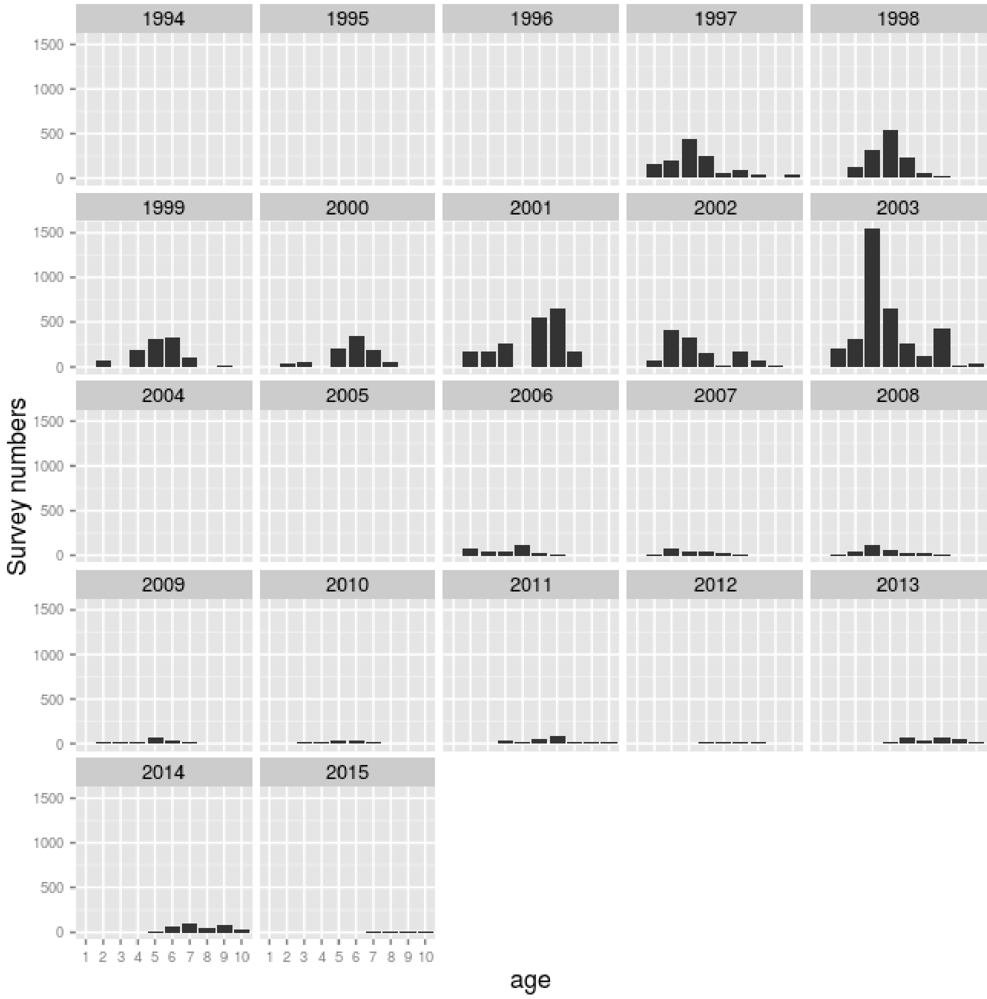


Figure 3.6. Faroe Bank (subdivision Vb2) cod. Age-disaggregated indices in spring survey (ages 1–10) (1994–2015). No surveys were conducted in 1996, 2004 and 2005. Data for 2016 were not available due to lack of age readings.

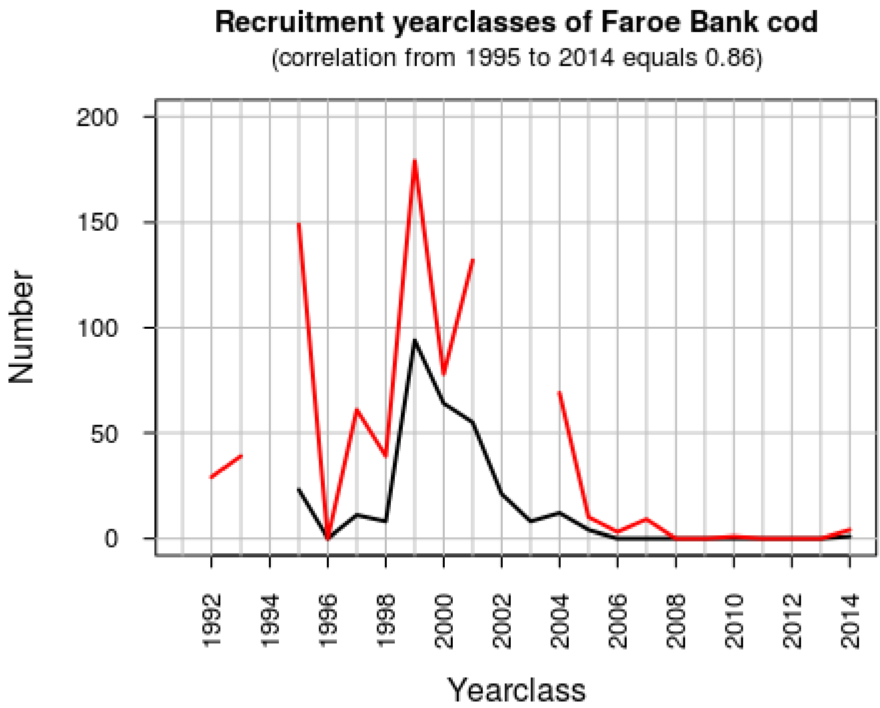


Figure 3.7. Faroe Bank (subdivision Vb2) cod. Correlation between recruitment year classes in both survey indices.

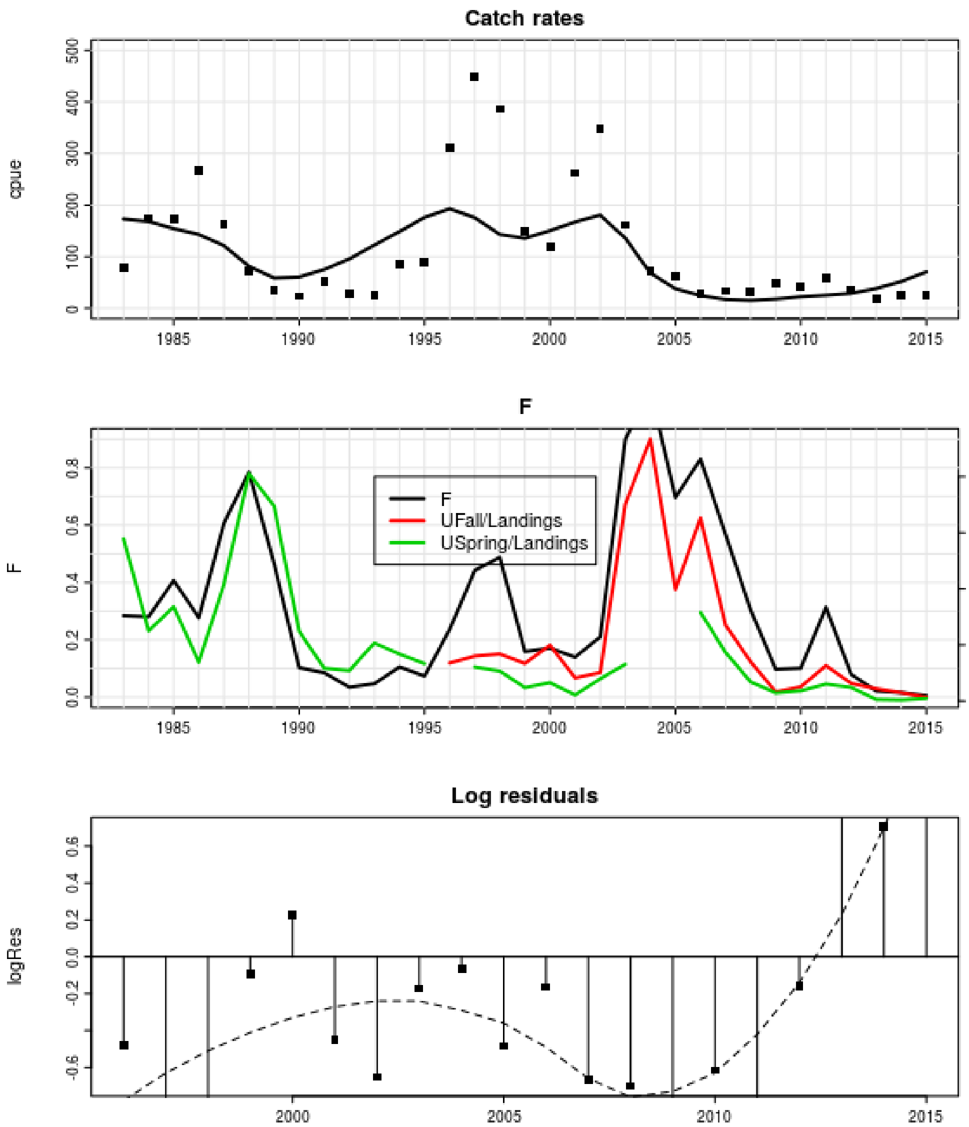


Figure 3.8. Results from the surplus production model using summer index. Observed (points) and expected catch rates (kg/hour) (top panel). Estimated fishing mortality (black line) and exploitation ratios (ratio of spring index to landings)(green line) (ratio of summer index to landings)(red line)(middle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

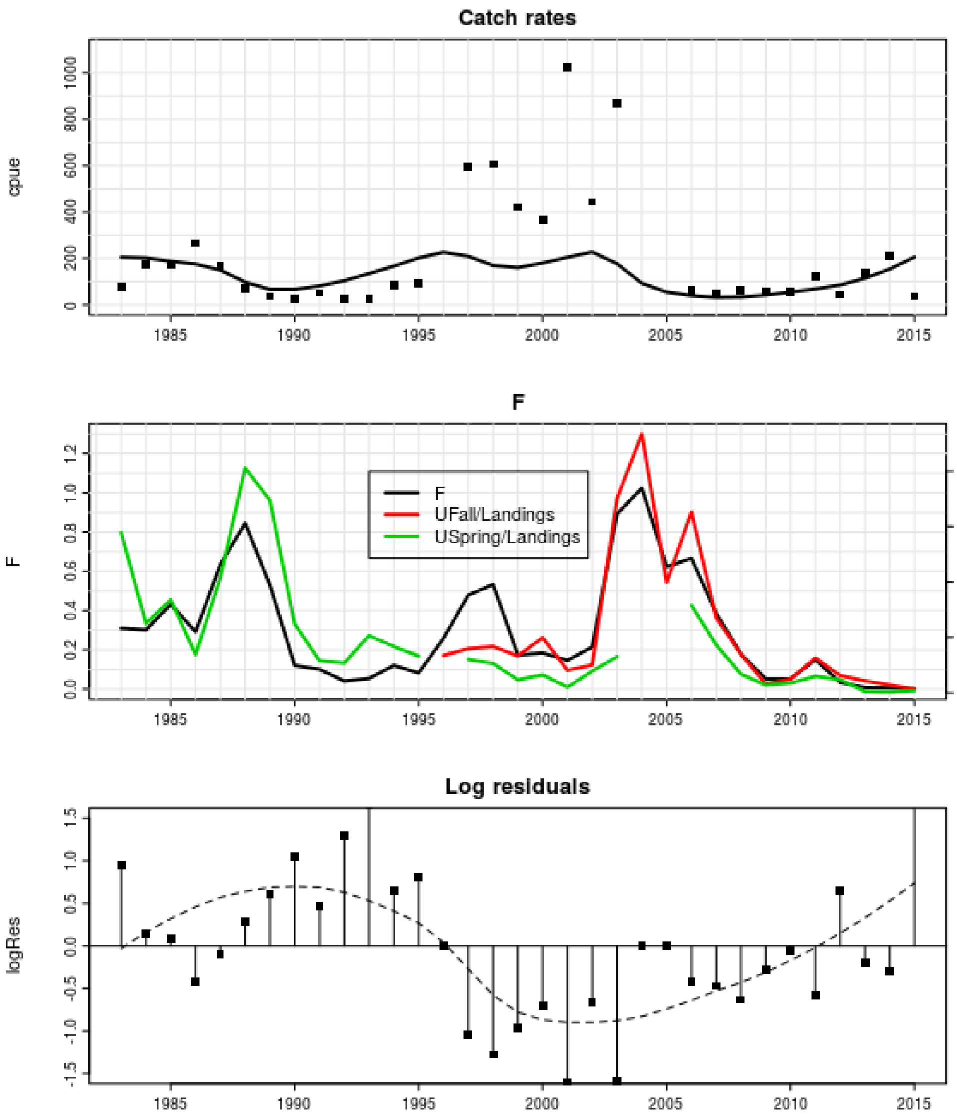


Figure 3.9. Results from the surplus production model using spring index. Observed (points) and expected catch rates (kg/hour) (top panel). Estimated fishing mortality (black line) and exploitation ratios (ratio of spring index to landings)(green line) (ratio of summer index to landings)(red line)(middle 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 1959–2015 and two age-disaggregated abundance indices obtained from the two Faroese groundfish surveys: spring survey 1994-2016 (shifted back to the previous year) and summer survey 1996-2015. The maturities were obtained from spring survey 1983-2016.

The assessment settings were the same as in the 2015 assessment. An XSA was run and tuned with the two survey indices. The fishing mortality in 2015 (average of ages 3-7 years) was estimated at 0.46, which was higher than the F_{MSY} of 0.32. The total stock size (age 2+) at the beginning of 2015 was estimated at 28 500 tonnes and the spawning-stock biomass at 19 700 tonnes, which was slightly below the limit biomass of 21 000 tonnes.

The short-term prediction until year 2018 showed a slightly decreasing total-stock biomass to 25 000 tonnes and a spawning-stock biomass to 19 000 tonnes.

It is advised to reduce the fishing mortality substantially to rebuild the stock.

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 5.b.2), on the Faroe Plateau (Division 5.b.1) 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. This year the catch figures back to 1999 on the Faroe-Iceland Ridge were revised. They were extracted from the database on the Faroese Coastal Guard directly using their definition of the relevant area. 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 2015 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 Figure 4.2.1.

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 2015 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) is 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

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 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. The YC2009 was present in nearly constant numbers in summer groundfish survey. 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 (Figure 4.2.8 and Figure 4.2.9), although the larger longliners also have had a high catchability in recent years. 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 little difference in the assessment results by using another method.

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, Blim = 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, $F_{0.1}$ = 0.12, F35%SPR = 0.18, F_{med} = 0.37, F_{low} = 0.10, F_{high} = 0.91.

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 increased in recent years (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 four times since 2005. In the past there has been a poor relationship between the size of the spawning stock and subsequent recruitment (Figure 4.6.4), but the increasing number of low data points in recent years have strengthened the stock–recruitment relationship. The spawning-stock biomass in the terminal year was below B_{lim} and the fishing mortality above F_{MSY} and F_{pa} (Figure 4.6.5).

To put the recent low biomass of Faroe Plateau cod into a wider context, and also to provide a basis to evaluate ecosystem properties and biomass reference points, the stock size (age 2+) of Faroe Plateau cod has been estimated back to 1710 (Table 4.6.5, Table 4.6.6, Figure 4.6.6). The first step, estimating the 1906–1958 period, was done in NWWG 2015 whereas the rest was done this year. Scaling Shetland and Faroese cpue series 1859–1914 gave biomass estimates from 1860–1905 (Working Document 24). In the same period there was information about occasional 'good' and 'bad' cod years. It happened that 'bad' years corresponded to approximately 80 thousand tons of cod and 'good' years to approximately 220 thousand tons of cod. Information about occasional 'good' and 'bad' years were available back to the seventeenth century, i.e. the biomass was roughly known for these years. From 1709 to 1856 the Royal Monopoly Trade (Den Kongelige Monopolhandel) recorded export of dried cod from the Faroes almost every year. Based on this export and an effect of year (taking into account an increasing tendency to export dried cod over the years) gave estimates of cod for the 1710–1859 period (Working Document 25, Model 1). An attempt (Model 2, and a factor between dried cod export and biomass 1841–1856) was also made to take account of a possible increased access to landing places during the 1841–1856 period, i.e. that the relationship between dried cod export and biomass had changed compared with the 1710–1840 period. The biomass estimates were quite different for the 1841–1859 period and more work could therefore be done to evaluate the importance of the potential increased access to landing sites and other technological improvements in the fishery. The results prior to 1906 should be interpreted with care, especially prior to 1860. The results indicate that the poor state of the stock in recent years is unprecedented the last three centuries.

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 YC2013 and YC2014, 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 2013–2015 and scaled to the 2015 value. The weights at age in the catches in 2016 were estimated from spring survey (ages 2 and 6–8 years) whereas the other ages were estimated from the catch weights in January-February 2016. The weights in the catches in 2017 were set to the values in 2016 and the average of 2014–2016 was expected for 2018. The proportion mature in 2016 was set to the 2016 values from spring groundfish survey, and for 2017–2018 to the average values for 2014–2016.

4.7.2 Results

The landings in 2016 are expected to be 7500 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 5.b.1 area). The spawning-stock biomass is expected to be 22400 tonnes in 2016, 20200 tonnes in 2017 and eventually 18900 tonnes in 2017. Many year classes contribute to the SSB in 2017–18 (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 2011 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.

The retrospective pattern indicates less uncertainty in the assessment than seen some years ago (Figure 4.9.1).

Steingrund *et al.* (2010) found that the recruitment of Faroe Plateau cod (age 2) could be rather precisely estimated as there is a relationship 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 recent year classes were extremely weak (Figure 4.9.2).

4.10 Comparison with previous assessment and forecast

The assessment settings were according to the Stock Annex. The 2016 assessment was much in line with the 2015 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 subarea 5.b. 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 F_{target} of 0.45 to be more consistent with the ICES advice. A committee set by Faroese authorities to evaluate the management system will deliver its recommendations in summer 2016. The recommendations along with political modifications are expected to be set in force in 2018.

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 future. Hence, a reduction in fishing mortality is urgently needed.

4.13 Ecosystem considerations

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 compared with 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 at the beginning of the 1990s. They also have fished in other areas, e.g. in Greenland and on the Flemish Cap. 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 2008–2010, but it is not believed that this has any relationship with a change in the environment. The temperature has been high in recent years (although it has been a little bit cooler in 2014–2015), 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.

ICES, 2011. Report of the North Western Working Group. ICES CM 2011/ACOM:7. 975 pp.

ICES, 2012. Report of the North Western Working Group. ICES CM 2012/ACOM:7. 850 pp.

Jákupsstovu, S. H. and Reinert, J. 1994. Fluctuations in the Faroe Plateau cod stock. ICES Marine Science Symposia, 198:194–211.

Jones, B. W. 1966. The cod and the cod fishery at the Faroe. Fishery Investigations, London, 24.

Planque, B., and Fredou, T. 1999. Temperature and the recruitment of Atlantic cod (Gadus morhua). Canandian Journal of Fisheries and Aquatic Sciences. 56: 2069–2077.

Steingrund, P., Gaard, E., Reinert, J., Olsen, B., Homrum, E., and Eliasen, K. 2012. Trophic relationships on the Faroe Shelf ecosystem and potential ecosystem states. Manuscript in PhD-thesis by Eydna í Homrum, defended in 2012.

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.

4.18 Tables

Table 4.2.1. Faroe Plateau cod (subdivision 5.b.1). 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	34492	4	8		83	-		0	0	-	34595
1987	30	21303	17	12		21	-		8	0	-	21391
1988	10	22272	17	5		163	-		0	0	-	22467
1989	-	20535	-	7		285	-		0	0	-	20827
1990	-	12232	-	24		124	-		0	0	-	12380
1991	-	8203	- **	16		89	-		1	0	-	8309
1992	-	5938	3 ***	12		39	-		74	0	-	6066
1993	-	5744	1 ***	+		57	-		186	0	-	5988
1994	-	8724	-	2 ***		36	-		56	0	-	8818
1995	-	19079	2 ***	2		38	-		43	0	-	19164
1996	-	39406	1 ***	+		507	-		126	0	-	40040
1997	-	33556	-	+		410	-		61 ***	0	-	34027
1998	-	23308	- *	-		405	-		27 ***	0	-	23740
1999	-	19156	- *	39	-	450	-		51	0		19696
2000		0	1	2	-	374	-		18	0		395
2001		29762	9 ***	9	-	531 *	-		50	0		30361
2002		40602	20	6	5	573			42	0		41248
2003		30259	14	7	-	447	-		15	0		30742
2004		17540	2	3 ***		414		1	15	0		17975
2005		13556	-			201			24	0		13781
2006		11629	7	1 ***		49	5		0	0		11691
2007		9905	1 ***			71	7		0	360		10344
2008		9394	1			40			0	383		9818
2009		10736	1			14	7		0	300		11058
2010		13878	1			10.338			0	312		14201
2011		11348	-			0			0	0		11348
2012		8437	0		28	0			0	0		8465
2013		5331	0		20	0	2		0	0		5333
2014		6655				6.414			0	226		6887
2015 *		7812				33	14		0	382		8241

* Preliminary, ** Included in 5.b.2, *** Reported as 5.b.

Table 4.2.2. Faroe Plateau cod (subdivision 5.b.1). Nominal catch (t) used in the assessment.

	Faroese catches:					Catches reported as 5.b.2:		Foreign catches:					
	Officially reported	in 5.b.1	Corrections in 5.b.1	On Faroe-Iceland ridge	in IIA within Faroe area jurisdiction	UK (E/W/NI)	UK (Scotland)	UK	French***	Greenland ***	Russia ***	UK ***	Used in the 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 ****				-	551						23045
1996	40040					-	382						40422
1997	34027					-	277						34304
1998	23740					-	265						24005
1999	19696			-661		-	210						19245
2000	395	21793 *		-600		-	245						21833
2001	30361		-1766	-306		-	288						28577
2002	41248		-2409	-223		-	218	-				-	38834
2003	30742		-1795	-4034		-	254	-				-	25167
2004	17975		-1041	-4338		-	244	-				-	12840
2005	13781		-804	-3987			1129	-				-	10119
2006	11691		-690	-1435			278						9844
2007	10344		-588	-2304			53			6			7511
2008	9818		-557	-1978			32						7315
2009	11058		-637	-510			38			26	4		9979
2010	14201		-823	-680			54			5			12757
2011	11348		-673	-986						3			9692
2012	8465		-500	-766						5			7204
2013	5333		-316	-544							0		4473
2014	6887		-395	-777									5715
2015	8241 *		-463	-384									7394

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

Table 4.2.3. Faroe Plateau cod (subdivision 5.b.1). The landings of Faroese fleets (in percent) of total catch (t). Note that the catches on the Faroe-Iceland ridge (mainly belonging to single trawl-ers > 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
2014	8.7	28.0	6.4	0.4	6.4	1.2	5.2	2.5	12.3	28.7	0.0	0.0	5,699
2015	9.0	26.0	9.6	0.1	9.1	2.1	4.2	2.2	10.9	26.9	0.0	0.0	5,890
Average	5.0	26.1	5.8	0.8	9.0	3.9	7.5	7.4	12.4	21.6	0.3	0.1	

Table 4.2.4. Faroe Plateau cod (subdivision 5.b.1). 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 boat	Longliners < 100 GRT	Jiggers	Single trwl 0-399HP	Single trwl 400-1000H	Single trwl > 1000 HP	Pair trwl 700-999 HI	Pair trwl > 1000 HP	Longliners > 100 GRT	Gillnetters	Others (scaling)	Catch-at -age
2	0	119	18	0	5	1	0	2	21	0	-10	156
3	0	491	106	0	90	26	3	60	330	0	-71	1035
4	0	171	40	0	48	38	3	73	183	0	-34	522
5	0	69	17	0	22	18	2	35	61	0	-14	210
6	0	96	26	0	36	23	2	48	71	0	-20	282
7	0	68	21	0	26	19	2	43	56	0	-14	221
8	0	15	5	0	3	4	0	9	13	0	-2	47
9	0	11	3	0	1	2	0	3	5	0	-2	23
10+	0	1	1	0	1	1	0	1	3	0	-1	7
Sum	0	1041	237	0	232	132	12	274	743	0	-168	2503
G.weight	0	2313	585	0	627	509	48	1049	1986	0	-456	6661

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 (subdivision 5.b.1). Number of samples, lengths, otoliths, and individual weights in terminal year.

Fleet	Size	Samples	Lengths	Otoliths	Weights
Open boats		4	794	80	794
Longliners	<100 GRT	8	1,561	160	1,561
Longliners	>100 GRT	17	3,529	358	3,529
Jiggers		0	0	0	0
Gillnetters		0	0	0	0
Sing. trawlers	<400 HP	0	0	0	0
Sing. trawlers	400-1000 HP	11	1,981	200	1,981
Sing. trawlers	>1000 HP	0	0	0	0
Pair trawlers	<1000 HP	0	0	0	0
Pair trawlers	>1000 HP	29	5,575	439	4,412
Total		69	13,440	1,237	12,277

Table 4.2.6. Faroe Plateau cod (subdivision 5.b.1). Catch in numbers-at-age used in the XSA model.

Year\age	1	2	3	4	5	6	7	8	9	10+
1959	0	2002	4239	858	1731	200	207	50	10	0
1960	0	4728	4027	2574	513	876	171	131	61	0
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	1246	1044	840	1164	2339	461	62	18	8

Year\age	1	2	3	4	5	6	7	8	9	10+
2000	0	2170	2737	811	443	700	840	108	8	1
2001	0	3967	3812	2130	373	372	728	443	36	6
2002	0	2099	7354	3405	1688	474	538	417	293	7
2003	0	697	2186	4696	1979	657	182	94	118	21
2004	0	98	673	1230	2051	717	234	63	41	36
2005	0	504	604	896	1146	841	208	41	19	31
2006	0	1110	1097	469	663	801	333	76	10	3
2007	0	506	1226	723	315	289	255	85	20	3
2008	0	287	761	783	430	187	157	156	57	19
2009	0	873	2262	861	618	296	85	55	43	17
2010	0	2113	2034	861	468	481	178	58	33	38
2011	0	328	2343	1234	365	188	126	50	19	2
2012	0	49	517	1346	555	200	99	69	25	22
2013	0	55	173	333	587	175	39	25	15	5
2014	0	387	518	286	499	350	86	14	9	1
2015	0	156	1035	522	210	282	221	47	23	7

Table 4.2.7. Faroe Plateau cod (subdivision 5.b.1). Mean weight at age (kg) in the catches.

Year\age	2	3	4	5	6	7	8	9	10+
1959	0.850	1.730	3.230	4.400	5.800	6.370	7.340	7.880	10.270
1960	1.000	2.030	3.370	4.420	6.020	6.650	8.120	11.000	10.270
1961	1.080	2.220	3.450	4.690	5.520	7.090	9.910	8.030	10.270
1962	1.000	2.270	3.350	4.580	4.930	9.080	6.590	6.660	10.270
1963	1.040	1.940	3.510	4.600	5.500	6.780	8.710	11.720	10.820
1964	0.970	1.830	3.150	4.330	6.080	7.000	6.250	6.190	14.390
1965	0.920	1.450	2.570	3.780	5.690	7.310	7.930	8.090	11.110
1966	0.980	1.770	2.750	3.510	4.800	6.320	7.510	10.340	11.650
1967	0.960	1.930	3.130	4.040	4.780	6.250	7.000	11.010	10.690
1968	0.880	1.720	3.070	4.120	4.650	5.500	7.670	10.950	9.280
1969	1.090	1.800	2.850	3.670	4.890	5.050	7.410	8.660	14.390
1970	0.960	2.230	2.690	3.940	5.140	6.460	10.310	7.390	9.340
1971	0.810	1.800	2.980	3.580	3.940	4.870	6.480	6.370	10.220
1972	0.660	1.610	2.580	3.260	4.290	4.950	6.480	6.900	11.550
1973	1.110	2.000	3.410	3.890	5.100	5.100	6.120	8.660	7.570
1974	1.080	2.220	3.440	4.800	5.180	5.880	6.140	8.630	7.620
1975	0.790	1.790	2.980	4.260	5.460	6.250	7.510	7.390	8.170
1976	0.940	1.720	2.840	3.700	5.260	6.430	6.390	8.550	13.620
1977	0.870	1.790	2.530	3.680	4.650	5.340	6.230	8.380	10.720
1978	1.112	1.385	2.140	3.125	4.363	5.927	6.348	8.715	12.229
1979	0.897	1.682	2.211	3.052	3.642	4.719	7.272	8.368	13.042
1980	0.927	1.432	2.220	3.105	3.539	4.392	6.100	7.603	9.668
1981	1.080	1.470	2.180	3.210	3.700	4.240	4.430	6.690	10.000

Year\age	2	3	4	5	6	7	8	9	10+
1982	1.230	1.413	2.138	3.107	4.012	5.442	5.563	5.216	6.707
1983	1.338	1.950	2.403	3.107	4.110	5.020	5.601	8.013	8.031
1984	1.195	1.888	2.980	3.679	4.470	5.488	6.466	6.628	10.981
1985	0.905	1.658	2.626	3.400	3.752	4.220	4.739	6.511	10.981
1986	1.099	1.459	2.046	2.936	3.786	4.699	5.893	9.700	8.815
1987	1.093	1.517	2.160	2.766	3.908	5.461	6.341	8.509	9.811
1988	1.061	1.749	2.300	2.914	3.109	3.976	4.896	7.087	8.287
1989	1.010	1.597	2.200	2.934	3.468	3.750	4.682	6.140	9.156
1990	0.945	1.300	1.959	2.531	3.273	4.652	4.758	6.704	8.689
1991	0.779	1.271	1.570	2.524	3.185	4.086	5.656	5.973	8.147
1992	0.989	1.364	1.779	2.312	3.477	4.545	6.275	7.619	9.725
1993	1.155	1.704	2.421	3.132	3.723	4.971	6.159	7.614	9.587
1994	1.194	1.843	2.613	3.654	4.584	4.976	7.146	8.564	8.796
1995	1.218	1.986	2.622	3.925	5.180	6.079	6.241	7.782	8.627
1996	1.016	1.737	2.745	3.800	4.455	4.978	5.270	5.593	7.482
1997	0.901	1.341	1.958	3.012	4.158	4.491	5.312	6.172	7.056
1998	1.004	1.417	1.802	2.280	3.478	5.433	5.851	7.970	8.802
1999	1.050	1.586	2.350	2.774	3.214	5.496	8.276	9.129	10.652
2000	1.416	2.170	3.187	3.795	4.048	4.577	8.182	11.895	13.009
2001	1.164	2.076	3.053	3.976	4.394	4.871	5.563	7.277	12.394
2002	1.017	1.768	2.805	3.529	4.095	4.475	4.650	6.244	7.457
2003	0.820	1.362	2.127	3.329	4.092	4.670	6.000	6.727	6.810
2004	1.037	1.154	1.693	2.363	3.830	5.191	6.326	7.656	9.573
2005	0.986	1.373	1.760	2.293	3.138	5.287	8.285	8.703	9.517
2006	0.839	1.304	1.988	2.386	3.330	4.691	7.635	9.524	11.990
2007	0.937	1.324	1.970	3.076	3.529	4.710	6.464	9.461	9.509
2008	1.209	1.478	2.104	2.714	3.804	4.669	5.915	7.233	9.559
2009	0.805	1.431	2.287	2.723	3.435	5.081	6.281	8.312	9.959
2010	1.049	1.642	2.400	3.212	3.678	4.774	5.973	7.094	9.800
2011	0.815	1.367	2.413	3.493	4.525	5.076	6.631	6.863	10.089
2012	1.007	1.315	1.893	3.102	4.279	5.573	5.871	7.482	9.206
2013	1.011	1.527	2.528	3.180	4.672	6.776	6.966	9.028	10.324
2014	1.099	1.653	2.466	3.000	4.148	6.489	9.394	9.236	12.120
2015	1.198	1.733	2.769	3.650	4.403	5.768	8.035	10.334	11.127
2016	1.057	1.857	2.706	3.686	4.237	5.057	6.472	9.644	9.644

Table 4.2.8. Faroe Plateau cod (subdivision 5.b.1). Proportion mature at age. From 1961-1982 the average from 1983-1996 is used (as it was used in the 1990s). In 2002, the high maturities for age 2 in 1983 (0.63), 1984 (0.4) and in 1993 (0.25) were revised, but not the maturities back in time.

YEAR/AGE	1	2	3	4	5	6	7	8	9	10+
1959	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
1960	0.00	0.17	0.64	0.87	0.95	1.00	1.00	1.00	1.00	1.00
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

YEAR/AGE	1	2	3	4	5	6	7	8	9	10+
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
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
2014	0.00	0.24	0.73	0.98	1.00	1.00	1.00	1.00	1.00	1.00
2015	0.00	0.28	0.48	0.70	0.95	0.97	1.00	1.00	1.00	1.00

Table 4.2.9. Faroe Plateau cod (subdivision 5.b.1). 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 5.B.1)        Surveys_re-
vised.TXT
102
SUMMER SURVEY
1996 2015
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
 200  642.3     861.2    357.6    358.2   401.5  124.3   36.6
 200  235.3    2230.4   1696.1    414.7   363.4  242.3   67.2
```

```
SPRING SURVEY (shifted back to december)
1993 2015
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
100   22.4    533.3      225.6      193.9     305.2     138.9
32.6      8
100   81.7    280.1      697.3      151.8      73.4      77.3
27.2      7.7
```

Table 4.2.10. Faroe Plateau cod (subdivision 5.b.1). Pairtrawler 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.

YEAR\AGE	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
2014	292	1631	1006	1690	1812	477	94	101
2015	43	967	1943	1019	1190	1086	320	96

Table 4.2.11. Faroe Plateau cod (subdivision 5.b.1). 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.

YEAR\AGE	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	52	209	2887	5132	2654	1222	359
2014	93	5898	9602	4695	4398	3475	1289	116
2015	0	1260	10417	8202	3167	3342	2428	414

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.

Year\age	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	0.0	33.3	32.1	13.2	5.8	6.3	1.0	0.7
1985	0.0	3.7	50.1	35.0	25.3	14.1	19.6	5.8
1986	0.0	5.6	41.6	24.0	15.3	6.8	6.2	2.2
1987	0.0	6.8	11.3	16.6	27.5	12.4	5.3	0.9
1988	0.0	3.1	6.4	13.0	8.5	19.1	6.5	2.6
1989	0.1	43.7	21.3	20.5	13.9	7.5	16.1	2.2
1990	0.0	7.9	40.3	8.6	12.2	6.5	7.7	4.2
1991	0.0	0.0	5.2	27.0	8.7	3.9	2.4	0.7
1992	0.0	6.2	17.1	6.9	3.9	3.6	1.8	1.4
1993	0.4	4.6	19.2	7.3	1.4	1.3	0.3	1.3
1994	0.1	14.9	18.4	15.4	6.6	2.1	2.6	0.5
1995	0.0	53.6	47.8	12.2	8.4	5.1	2.0	3.1
1996	0.0	5.9	76.2	52.1	13.1	28.8	14.3	4.2
1997	0.0	4.6	16.6	71.8	54.5	7.9	7.6	0.9
1998	5.8	12.1	5.6	8.2	33.1	9.9	0.4	0.4
1999	0.3	29.2	10.0	4.7	7.0	15.9	2.5	0.1
2000	9.6	40.4	23.5	1.3	1.3	2.4	4.2	0.5
2001	0.6	96.6	48.7	17.1	3.0	5.7	12.6	12.9
2002	0.1	47.6	97.2	43.4	30.0	7.3	11.5	6.8
2003	0.0	17.5	37.4	106.4	59.1	12.9	4.1	1.5
2004	0.0	7.0	21.5	21.0	31.1	8.2	0.3	0.0
2005	0.6	14.7	20.5	18.5	32.9	15.6	1.5	0.0
2006	2.0	58.7	47.0	9.1	10.6	13.6	4.1	0.4
2007	0.2	11.2	23.2	8.9	4.2	4.9	3.5	0.6
2008	0.3	3.4	16.2	21.1	14.4	3.3	1.5	2.1
2009	3.1	33.3	154.6	57.5	33.9	23.5	9.6	5.9
2010	2.6	135.7	147.1	62.4	27.3	28.5	8.5	1.8
2011	0.0	19.7	156.5	65.0	25.2	15.6	8.5	1.9
2012	0.3	4.6	39.3	59.0	15.1	5.2	2.6	1.3
2013	1.2	16.6	23.8	63.6	58.0	7.8	2.9	0.0
2014	2.1	103.4	102.0	46.9	27.3	17.1	1.4	0.0
2015	0.9	25.4	148.6	65.3	23.0	17.9	10.7	0.7

Table 4.6.1. Faroe Plateau cod (subdivision 5.b.1). The XSA-run.

```
Lowestoft VPA Version 3.1

   12/04/2016   8:57

 Extended Survivors Analysis

 COD FAROE PLATEAU (ICES SUBDIVISION 5.b.1)                COD_ind_Surveys_re-
vised

 cpue data from file Surveys_revised_1replacedvalue.TXT

 Catch data for  57 years. 1959 to 2015. Ages  1 to  10.

      Fleet,            First, Last, First, Last, Alpha,  Beta
                  ,    year, year,  age ,  age
 SUMMER SURVEY      ,   1996, 2015,   2,     8,   .600,   .700
 SPRING SURVEY (shift,   1993, 2015,   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 converged after   29 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,  2006,  2007,  2008,  2009,  2010,  2011,  2012,  2013,  2014,  2015

      1,  .000,  .000,  .000,  .000,  .000,  .000,  .000,  .000,  .000,  .000
      2,  .181,  .118,  .050,  .125,  .231,  .088,  .029,  .021,  .057,  .075
      3,  .326,  .313,  .261,  .687,  .474,  .435,  .195,  .137,  .284,  .215
      4,  .352,  .371,  .337,  .531,  .614,  .597,  .482,  .186,  .350,  .518
      5,  .601,  .426,  .396,  .489,  .627,  .578,  .595,  .400,  .469,  .472
      6,  .808,  .577,  .486,  .524,  .914,  .558,  .741,  .376,  .443,  .533
      7,  .946,  .661,  .730,  .426,  .706,  .650,  .655,  .303,  .320,  .562
      8, 1.004,  .675, 1.204,  .616,  .585,  .434,  .946,  .336,  .169,  .290
      9,  .292,  .811, 1.562, 1.542,  .978,  .383,  .403,  .542,  .193,  .461

 XSA population numbers (Thousands)

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

 2006 ,    6.14E+03, 7.39E+03, 4.36E+03, 1.75E+03, 1.62E+03, 1.60E+03,
6.02E+02, 1.33E+02, 4.36E+01,
 2007 ,    7.90E+03, 5.03E+03, 5.05E+03, 2.58E+03, 1.00E+03, 7.28E+02,
5.83E+02, 1.91E+02, 3.98E+01,
```

2008 , 1.01E+04, 6.46E+03, 3.66E+03, 3.02E+03, 1.45E+03, 5.37E+02,
3.35E+02, 2.46E+02, 7.97E+01,
2009 , 1.38E+04, 8.24E+03, 5.03E+03, 2.31E+03, 1.77E+03, 8.02E+02,
2.71E+02, 1.32E+02, 6.05E+01,
2010 , 5.24E+03, 1.13E+04, 5.95E+03, 2.07E+03, 1.11E+03, 8.88E+02,
3.89E+02, 1.45E+02, 5.84E+01,
2011 , 2.30E+03, 4.29E+03, 7.34E+03, 3.03E+03, 9.19E+02, 4.86E+02,
2.91E+02, 1.57E+02, 6.60E+01,
2012 , 3.53E+03, 1.88E+03, 3.22E+03, 3.89E+03, 1.37E+03, 4.22E+02,
2.28E+02, 1.25E+02, 8.34E+01,
2013 , 9.35E+03, 2.89E+03, 1.50E+03, 2.17E+03, 1.97E+03, 6.17E+02,
1.65E+02, 9.68E+01, 3.96E+01,
2014 , 2.92E+03, 7.65E+03, 2.32E+03, 1.07E+03, 1.47E+03, 1.08E+03,
3.47E+02, 9.95E+01, 5.66E+01,
2015 , 4.12E+03, 2.39E+03, 5.92E+03, 1.43E+03, 6.17E+02, 7.55E+02,
5.68E+02, 2.06E+02, 6.88E+01,

Estimated population abundance at 1st Jan 2016

, 0.00E+00, 3.37E+03, 1.81E+03, 3.91E+03, 6.97E+02, 3.15E+02, 3.63E+02,
2.65E+02, 1.26E+02,

Taper weighted geometric mean of the VPA populations:

, 1.39E+04, 1.16E+04, 8.91E+03, 5.41E+03, 2.99E+03, 1.48E+03, 6.66E+02,
2.70E+02, 1.08E+02,

Standard error of the weighted Log(VPA populations) :

, .7233, .7048, .6634, .6680, .6456, .6312, .6644,
.7107, .8305,

Log catchability residuals.

Fleet : SUMMER SURVEY

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	No data for this fleet at this age									
2	-.19	.17	.32	-.90	.11	.64	1.10	-.05	.64	.52
3	.06	-.30	-.68	.44	-.49	.00	.54	-.40	.01	.38
4	.09	.20	-.72	-.24	-.04	.00	-.01	.02	-.27	.16
5	.59	-.15	.14	-.79	-.87	-.19	.04	-.40	.38	.23
6	.08	-.26	.49	.03	-.73	-.67	-.42	-.77	.21	.62
7	.21	-.11	-.44	.46	-.03	-.40	-.49	-1.44	.07	.44
8	-.20	-.34	.08	.43	-.26	-.10	-.55	-1.13	.16	.49

Age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	No data for this fleet at this age									
2	.80	-.28	-1.80	-.17	.65	.11	-1.72	-.63	.27	.44
3	-.10	-.68	-.58	1.05	.50	.15	-.97	-.36	.73	.70
4	-.25	-.74	-.88	.43	.81	.48	.16	-1.09	.26	1.63
5	-.34	-.53	-.11	.07	.21	.41	.32	.38	-.19	.82
6	-.42	-.43	-.01	.51	.18	.14	-.20	1.00	.18	.50
7	-.09	-.73	-.50	.44	.38	.28	-.54	.62	.06	.39
8	-.02	-.50	-.53	.26	.01	-.27	-.36	.31	-.01	-.05

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, -7.8746, -6.7078, -6.2936, -6.0845, -6.0486, -6.0486,
-6.0486,
S.E(Log q), .7723, .5560, .6124, .4451, .4861, .5222,
.4091,

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,	.74,	1.413,	8.13,	.63,	20,	.56,	-7.87,
3,	.95,	.273,	6.80,	.66,	20,	.54,	-6.71,
4,	1.15,	-.719,	6.00,	.56,	20,	.71,	-6.29,
5,	1.13,	-.847,	5.87,	.69,	20,	.51,	-6.08,
6,	1.11,	-.587,	5.94,	.60,	20,	.55,	-6.05,
7,	1.06,	-.327,	6.11,	.59,	20,	.56,	-6.12,
8,	1.37,	-1.958,	6.54,	.61,	20,	.49,	-6.18,

Fleet : SPRING SURVEY (shift

Age	1993	1994	1995
1	.00,	-.51,	-.39
2	-.92,	-.90,	.18
3	-.62,	.02,	.12
4	-.56,	-.01,	.59
5	-.56,	.76,	.39
6	-.60,	.89,	.52
7	-.36,	.39,	.19
8	-4.60,	.71,	.09

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	-.79,	-.75,	.69,	-.43,	.26,	.18,	-.50,	1.97,	.99,	-.07
2	-.25,	-.24,	.36,	.24,	.47,	.74,	-.25,	.24,	.42,	-1.06
3	-.04,	-.17,	.09,	.05,	.20,	.31,	.38,	-.47,	.43,	-.92
4	-.06,	.18,	-.24,	-.52,	-.14,	.33,	-.02,	-.23,	.28,	-.43
5	-.12,	.25,	.17,	-.58,	-.34,	.08,	.27,	-.39,	.41,	-.60
6	-.09,	-.03,	.22,	.39,	.33,	.11,	-.26,	-.43,	.29,	-.52
7	-.14,	-.21,	-.19,	.17,	-.71,	.04,	.13,	-.24,	-.64,	-.82
8	-1.44,	.92,	.13,	-1.18,	-1.51,	.18,	-.06,	-.15,	-.74,	-1.05

Age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	-1.09,	.12,	.43,	.94,	.36,	-.10,	-.03,	-.35,	-.95,	.00
2	-.66,	.22,	-.09,	.76,	.54,	-.20,	.89,	-.75,	-.14,	.40
3	-.83,	.10,	.51,	.33,	.47,	.27,	1.13,	-.53,	-.48,	-.35
4	-.79,	-.03,	.66,	.35,	.58,	-.36,	1.12,	-.17,	-.08,	-.45
5	-.36,	-.16,	.47,	.25,	.61,	-.65,	.36,	-.07,	.19,	-.36
6	-.39,	-.05,	.04,	-.03,	1.12,	-.79,	-.29,	-.19,	-.06,	-.20
7	-.30,	-.50,	-.10,	.09,	.72,	-.33,	-.13,	-.16,	-.49,	-.94
8	.30,	-.46,	.42,	.11,	.24,	-1.25,	.51,	-.08,	-.79,	-1.45

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,	-8.3359,	-6.8864,	-5.9989,	-5.7133,	-5.7378,	-5.9828,	-5.9828,	-5.9828,
S.E(Log q),	.7023,	.5683,	.4869,	.4573,	.4211,	.4557,	.4400,	1.2634,

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,	1.00,	-.024,	8.33,	.57,	23,	.72,	-8.34,
2,	1.04,	-.221,	6.81,	.65,	23,	.60,	-6.89,
3,	.89,	.833,	6.29,	.75,	23,	.44,	-6.00,
4,	.91,	.756,	5.95,	.77,	23,	.42,	-5.71,
5,	.90,	.858,	5.93,	.79,	23,	.38,	-5.74,
6,	.89,	.776,	6.10,	.71,	23,	.41,	-5.98,

```
  7,     .97,     .199,      6.18,     .75,     23,     .39,   -6.18,
  8,     .64,    1.579,      6.03,     .48,     23,     .72,   -6.47,


 Terminal year survivor and F summaries :

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

 Year class = 2014

 Fleet,                 Estimated,    Int,       Ext,    Var,    N, Scaled,
Estimated
      ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,
F
 SUMMER SURVEY       ,         1.,   .000,       .000,    .00,   0,  .000,
.000
 SPRING SURVEY (shift,      3374.,   .717,       .000,    .00,   1, 1.000,
.000

   F shrinkage mean  ,         0.,   2.00,,,,                        .000,
.000

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
      3374.,       .72,      .00,    1,    .000,   .000

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

 Year class = 2013

 Fleet,                 Estimated,    Int,       Ext,    Var,    N, Scaled,
Estimated
      ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,
F
 SUMMER SURVEY       ,      2810.,   .791,       .000,    .00,   1,  .236,
.049
 SPRING SURVEY (shift,      1586.,   .451,       .659,   1.46,   2,  .725,
.085

   F shrinkage mean  ,      1576.,   2.00,,,,                        .040,
.086

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
      1815.,       .38,      .35,    4,    .917,   .075


 Age  3   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       ,      6838.,   .463,       .206,    .44,   2,  .338,
.128
 SPRING SURVEY (shift,      2949.,   .334,       .070,    .21,   3,  .639,
.276

   F shrinkage mean  ,      2609.,   2.00,,,,                        .023,
.307

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
      3908.,       .27,      .19,    6,    .708,   .215
```

```
 Age  4   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       ,      1625.,   .376,       .587,   1.56,   3,  .341,
.255
 SPRING SURVEY (shift,       439.,   .275,       .115,    .42,   4,  .635,
.730

   F shrinkage mean  ,       833.,   2.00,,,,                        .024,
.449

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
       697.,       .22,      .30,    8,   1.365,   .518


 Age  5   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       ,       394.,   .296,       .459,   1.55,   4,  .395,
.393
 SPRING SURVEY (shift,       273.,   .236,       .212,    .90,   5,  .588,
.529

   F shrinkage mean  ,       267.,   2.00,,,,                        .017,
.538

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
       315.,       .18,      .21,   10,   1.127,   .472

 Age  6   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       ,       322.,   .264,       .302,   1.14,   5,  .416,
.584
 SPRING SURVEY (shift,       398.,   .219,       .193,    .88,   6,  .567,
.495

   F shrinkage mean  ,       302.,   2.00,,,,                        .017,
.612

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
       363.,       .17,      .16,   12,    .924,   .533


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

 Year class = 2008
```

```
 Fleet,                Estimated,    Int,       Ext,    Var,    N, Scaled,
Estimated
     ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,
F
 SUMMER SURVEY       ,       361.,   .263,       .053,    .20,   6,  .419,
.441
 SPRING SURVEY (shift,       210.,   .226,       .270,   1.19,   7,  .562,
.669

   F shrinkage mean  ,       285.,   2.00,,,,                        .019,
.531

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
       265.,       .17,      .16,   14,    .912,   .562


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

 Year class = 2007

 Fleet,                Estimated,    Int,       Ext,    Var,    N, Scaled,
Estimated
     ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,
F
 SUMMER SURVEY       ,       156.,   .243,       .155,    .64,   7,  .558,
.241
 SPRING SURVEY (shift,        99.,   .235,       .180,    .77,   8,  .427,
.359

   F shrinkage mean  ,        66.,   2.00,,,,                        .015,
.498

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
       126.,       .17,      .13,   16,    .731,   .290


 Age  9   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       ,        42.,   .259,       .150,    .58,   7,  .571,
.402
 SPRING SURVEY (shift,        28.,   .258,       .121,    .47,   8,  .405,
.555

   F shrinkage mean  ,        34.,   2.00,,,,                        .024,
.478

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
        36.,       .19,      .10,   16,    .548,   .461
```

Table 4.6.2. Faroe Plateau cod (subdivision 5.b.1). Fishing mortality-at-age from the XSA model.

YEAR\AGE	2	3	4	5	6	7	8	9	10+	FBAR 3-7
1959	0.1829	0.4853	0.4463	0.6303	0.3909	0.6060	0.3005	0.4784	0.4784	0.5117
1960	0.4570	0.6793	0.6222	0.5290	0.7826	0.6920	1.0328	0.7389	0.7389	0.6610
1961	0.3346	0.5141	0.4986	0.5737	0.4863	0.9566	0.8116	0.6715	0.6715	0.6059
1962	0.2701	0.4982	0.4838	0.7076	0.5569	0.3662	0.6826	0.5641	0.5641	0.5226
1963	0.2534	0.4138	0.5172	0.5124	0.5405	0.4879	0.3269	0.4806	0.4806	0.4944
1964	0.1086	0.2997	0.4523	0.5229	0.5659	0.6677	0.3531	0.5164	0.5164	0.5017
1965	0.1209	0.2518	0.4498	0.5622	0.6604	0.5305	0.4345	0.5318	0.5318	0.4909
1966	0.0829	0.1969	0.2552	0.4499	0.5016	0.9680	0.8520	0.6106	0.6106	0.4743
1967	0.0789	0.2389	0.2687	0.3442	0.5779	0.5203	1.0438	0.5556	0.5556	0.3900
1968	0.1010	0.2318	0.3949	0.5339	0.4472	0.7132	0.3331	0.4882	0.4882	0.4642
1969	0.1099	0.3063	0.3806	0.4180	0.5709	0.5118	0.8457	0.5499	0.5499	0.4375
1970	0.0530	0.2081	0.3654	0.3409	0.3709	0.6559	0.4208	0.4339	0.4339	0.3882
1971	0.0309	0.1337	0.2225	0.3845	0.5572	0.4651	0.7528	0.4800	0.4800	0.3526
1972	0.0464	0.1476	0.2070	0.2497	0.6058	0.4686	0.2464	0.3578	0.3578	0.3358
1973	0.0657	0.2322	0.3048	0.2813	0.2526	0.3722	0.3259	0.3091	0.3091	0.2886
1974	0.0816	0.1568	0.2046	0.2953	0.3797	0.5330	0.3052	0.3457	0.3457	0.3139
1975	0.0774	0.3193	0.4359	0.4134	0.4544	0.3504	0.4485	0.4235	0.4235	0.3947
1976	0.0933	0.1723	0.3665	0.5568	0.5167	0.7619	0.6429	0.5738	0.5738	0.4749
1977	0.0481	0.3036	0.4748	0.7532	0.7333	1.1138	0.7776	0.7783	0.7783	0.6757
1978	0.0588	0.1896	0.4291	0.4289	0.4850	0.5968	0.5674	0.5054	0.5054	0.4259
1979	0.0433	0.2623	0.4309	0.5049	0.4906	0.4480	0.6903	0.5170	0.5170	0.4273
1980	0.0544	0.2391	0.3695	0.4337	0.5182	0.4119	0.6437	0.4790	0.4790	0.3945
1981	0.0523	0.2877	0.3409	0.4369	0.5644	0.6940	0.5015	0.5115	0.5115	0.4648
1982	0.0586	0.2227	0.3602	0.3887	0.4047	0.6926	0.5526	0.4834	0.4834	0.4138
1983	0.0991	0.4672	0.5585	0.6411	0.7835	1.0779	0.9417	0.8087	0.8087	0.7056
1984	0.1073	0.3712	0.5790	0.6609	0.4533	0.4761	0.4792	0.5340	0.5340	0.5081
1985	0.0658	0.3543	0.5075	0.6134	0.9235	1.1081	1.3203	0.9042	0.9042	0.7014
1986	0.0247	0.3545	0.6225	0.7030	0.8256	0.8400	0.5408	0.7131	0.7131	0.6691
1987	0.0291	0.2208	0.4754	0.4850	0.5555	0.4896	0.6222	0.5298	0.5298	0.4453
1988	0.0666	0.3531	0.5639	0.5490	0.7735	0.7980	0.8641	0.7165	0.7165	0.6075
1989	0.1659	0.4394	0.7614	0.7620	0.9617	1.0574	1.0994	0.9386	0.9386	0.7964
1990	0.0780	0.3355	0.6371	0.8016	0.7141	0.8518	1.1365	0.8369	0.8369	0.6680
1991	0.0324	0.1997	0.4499	0.5980	0.7462	0.5816	0.7180	0.6242	0.6242	0.5151
1992	0.0201	0.1001	0.3270	0.3478	0.6366	0.8918	0.4457	0.5342	0.5342	0.4607
1993	0.0132	0.1021	0.1869	0.2550	0.2027	0.4403	0.5790	0.3350	0.3350	0.2374
1994	0.0254	0.1130	0.1910	0.2503	0.2228	0.1588	0.3209	1.1015	1.1015	0.1872
1995	0.0698	0.1615	0.4658	0.2809	0.3620	0.3394	0.2344	0.7368	0.7368	0.3219
1996	0.0301	0.1916	0.4512	0.8130	0.9099	1.1481	0.9542	1.0211	1.0211	0.7028
1997	0.0341	0.1459	0.4082	0.8299	1.0584	1.4231	1.3855	1.1287	1.1287	0.7731
1998	0.0866	0.1719	0.2665	0.6381	1.0420	0.8124	1.2396	0.9235	0.9235	0.5862
1999	0.0989	0.2922	0.2987	0.3267	0.6857	1.1262	0.9085	0.6112	0.6112	0.5459

Year\age	2	3	4	5	6	7	8	9	10+	FBAR 3-7
2000	0.1279	0.3268	0.3887	0.2539	0.3338	0.5659	0.9070	0.2657	0.2657	0.3738
2001	0.1586	0.3465	0.4580	0.3104	0.3517	0.7000	0.6738	0.9194	0.9194	0.4333
2002	0.1939	0.4930	0.6010	0.8261	0.8322	1.3642	1.2352	1.4999	1.4999	0.8233
2003	0.1347	0.3177	0.6873	0.8792	0.9433	0.9388	0.9717	1.8512	1.8512	0.7532
2004	0.0312	0.1864	0.2971	0.7491	0.9767	1.1465	1.0737	2.0794	2.0794	0.6712
2005	0.0995	0.2725	0.4053	0.5004	0.8175	0.8836	0.6153	1.2362	1.2362	0.5758
2006	0.1815	0.3260	0.3524	0.6008	0.8083	0.9459	1.0038	0.2921	0.2921	0.6067
2007	0.1179	0.3125	0.3714	0.4256	0.5770	0.6611	0.6755	0.8110	0.8110	0.4695
2008	0.0503	0.2611	0.3371	0.3956	0.4856	0.7299	1.2043	1.5623	1.5623	0.4419
2009	0.1246	0.6865	0.5315	0.4886	0.5243	0.4263	0.6160	1.5416	1.5416	0.5314
2010	0.2314	0.4741	0.6140	0.6268	0.9135	0.7058	0.5852	0.9782	0.9782	0.6668
2011	0.0882	0.4349	0.5969	0.5779	0.5580	0.6496	0.4336	0.3831	0.3831	0.5635
2012	0.0292	0.1954	0.4817	0.5952	0.7415	0.6551	0.9463	0.4027	0.4027	0.5338
2013	0.0213	0.1365	0.1861	0.3999	0.3758	0.3035	0.3360	0.5422	0.5422	0.2804
2014	0.0575	0.2839	0.3501	0.4690	0.4433	0.3199	0.1690	0.1931	0.1931	0.3732
2015	0.0749	0.2148	0.5177	0.4715	0.5328	0.5624	0.2899	0.4610	0.4610	0.4599

Table 4.6.3. Faroe Plateau cod (subdivision 5.b.1). Stock number-at-age from the XSA model.

Year\Age	1	2	3	4	5	6	7	8	9	10+	TOTAL
1959	17399	13238	12185	2634	4092	683	503	213	29	0	50976
1960	14680	14245	9027	6141	1380	1784	378	225	129	0	47989
1961	25227	12019	7385	3747	2699	666	668	155	66	0	52630
1962	24782	20654	7042	3616	1863	1245	335	210	56	0	59804
1963	26668	20290	12907	3503	1825	752	584	190	87	0	66807
1964	10100	21834	12893	6986	1710	895	358	294	112	0	55183
1965	22676	8269	16037	7823	3639	830	416	151	169	0	60009
1966	28643	18566	5999	10207	4085	1698	351	200	80	0	69829
1967	21475	23451	13990	4034	6475	2133	842	109	70	0	72579
1968	11390	17582	17744	9020	2525	3757	980	410	31	0	63439
1969	10514	9325	13012	11522	4976	1212	1967	393	240	0	53161
1970	14569	8608	6840	7843	6447	2682	561	965	138	0	48654
1971	26041	11928	6684	4548	4456	3754	1516	238	519	0	59683
1972	15356	21320	9469	4788	2981	2483	1760	779	92	0	59029
1973	37229	12573	16664	6689	3187	1901	1109	902	499	400	81153
1974	46803	30480	9639	10816	4037	1969	1209	626	533	342	106456
1975	22687	38319	23000	6747	7217	2460	1103	581	378	476	102968
1976	12208	18575	29035	13683	3572	3908	1279	636	304	466	83665
1977	13128	9995	13853	20010	7765	1676	1909	489	274	18	69116
1978	18318	10748	7799	8372	10190	2993	659	513	184	154	59931
1979	28804	14998	8298	5282	4463	5433	1509	297	238	103	69424
1980	17100	23582	11759	5226	2811	2206	2723	789	122	52	66370
1981	27027	14000	18286	7580	2957	1491	1076	1477	339	150	74384
1982	30732	22128	10878	11228	4413	1564	694	440	732	348	83159
1983	58342	25161	17086	7128	6412	2450	854	284	207	200	118126
1984	21157	47766	18656	8767	3339	2765	916	238	91	174	103870
1985	11616	17322	35130	10538	4023	1412	1439	466	121	146	82212
1986	12108	9511	13279	20181	5194	1784	459	389	102	81	63087
1987	10661	9913	7597	7627	8866	2105	640	162	185	69	47826
1988	19749	8729	7884	4987	3882	4469	989	321	71	53	51135
1989	4441	16169	6686	4535	2323	1835	1688	365	111	16	38170
1990	8132	3636	11214	3528	1734	888	574	480	99	50	30336
1991	13900	6658	2754	6565	1527	637	356	201	126	56	32780
1992	12320	11380	5277	1846	3428	688	247	163	80	90	35520
1993	30804	10087	9132	3909	1090	1982	298	83	85	96	57567
1994	52357	25220	8150	6751	2655	692	1325	157	38	26	97371
1995	15991	42867	20130	5960	4566	1692	453	926	93	102	92780
1996	8049	13092	32730	14024	3062	2823	965	264	599	80	75688
1997	7407	6590	10401	22125	7312	1112	930	251	83	192	56403
1998	17868	6064	5214	7359	12043	2611	316	184	51	45	51755
1999	24393	14629	4553	3595	4616	5209	754	115	44	19	57926

Year\Age	1	2	3	4	5	6	7	8	9	10+	Total
2000	36505	19972	10850	2783	2183	2726	2148	200	38	5	77409
2001	16074	29888	14388	6406	1545	1387	1598	999	66	11	72361
2002	7466	13160	20880	8331	3318	927	799	650	417	10	55957
2003	4308	6112	8875	10441	3739	1189	330	167	155	27	35344
2004	7182	3527	4374	5288	4300	1271	379	106	52	44	26522
2005	9029	5880	2799	2972	3217	1664	392	99	30	47	26129
2006	6143	7393	4358	1745	1623	1597	602	133	44	13	23649
2007	7896	5030	5048	2576	1004	728	583	191	40	6	23102
2008	10060	6465	3660	3024	1454	537	335	246	80	26	25887
2009	13806	8237	5033	2308	1767	802	271	132	60	23	32439
2010	5244	11303	5954	2074	1111	888	389	145	58	66	27231
2011	2301	4294	7343	3034	919	486	291	157	66	7	18898
2012	3530	1884	3218	3892	1368	422	228	125	83	73	14822
2013	9349	2890	1498	2167	1968	617	165	97	40	13	18804
2014	2918	7654	2316	1070	1473	1080	347	100	57	6	17022
2015	4121	2389	5917	1428	617	755	568	206	69	21	16090
2016	0	3374	1815	3908	697	315	363	265	126	46	10908

Table 4.6.4. Faroe Plateau cod (subdivision 5.b.1). Summary table from the XSA model. The re-sults from the short-term prediction are shown in bold.

Year	Recruitment	Biomass	Biomass	Biomass	Landings	Mean F
	Age 2	Age 2+	Age 3+	SSB		Ages 3–7
	thousands	tonnes	tonnes	tonnes	tonnes	
1959	13238	67803	56550	48869	22415	0.5117
1960	14245	75862	61619	54447	32255	0.661
1961	12019	65428	52459	46439	21598	0.6059
1962	20654	68225	47568	43326	20967	0.5226
1963	20290	77602	56500	49054	22215	0.4944
1964	21834	84666	63483	55362	21078	0.5017
1965	8269	75043	67442	57057	24212	0.4909
1966	18566	83919	65724	60629	20418	0.4743
1967	23451	105289	82778	73934	23562	0.39
1968	17582	110433	94958	82484	29930	0.4642
1969	9325	105537	95372	83487	32371	0.4375
1970	8608	98398	90131	82035	24183	0.3882
1971	11928	78218	68559	63308	23010	0.3526
1972	21320	76439	62363	57180	18727	0.3358
1973	12573	110713	96756	83547	22228	0.2886
1974	30480	139266	106341	98434	24581	0.3139
1975	38319	153664	123391	109566	36775	0.3947
1976	18575	161260	143807	123077	39799	0.4749
1977	9995	136211	127520	112057	34927	0.6757
1978	10748	96227	84269	78497	26585	0.4259
1979	14998	85112	71659	66723	23112	0.4273
1980	23582	85038	63178	58887	20513	0.3945
1981	14000	88411	73287	63562	22963	0.4648
1982	22128	98963	71739	67033	21489	0.4138
1983	25161	123255	89581	78542	38133	0.7056
1984	47766	152158	95072	96773	36979	0.5081
1985	17322	131240	115566	84786	39484	0.7014
1986	9511	99271	88821	73693	34595	0.6691
1987	9913	78362	67522	62241	21391	0.4453
1988	8729	66177	56912	52125	23182	0.6075
1989	16169	59031	42701	38406	22068	0.7964
1990	3636	38276	34837	29270	13692	0.668
1991	6658	28679	23491	21069	8750	0.5151
1992	11380	35684	24430	20755	6396	0.4607
1993	10087	51034	39378	33068	6107	0.2374
1994	25220	83914	53804	42475	9046	0.1872
1995	42867	144645	92428	54320	23045	0.3219
1996	13092	143005	129704	85321	40422	0.7028
1997	6590	97233	91293	81714	34304	0.7731
1998	6064	66872	60784	56284	24005	0.5862
1999	14629	66269	50916	45830	19245	0.5459

Year	Recruitment	Biomass	Biomass	Biomass	Landings	Mean F
	Age 2	Age 2+	Age 3+	SSB		Ages 3–7
	thousands	tonnes	tonnes	tonnes	tonnes	
2000	19972	91995	63718	46396	21833	0.3738
2001	29888	110410	75622	59118	28577	0.4333
2002	13160	98445	85066	56006	38834	0.8233
2003	6112	60392	55378	40542	25167	0.7532
2004	3527	36140	32490	26435	12840	0.6712
2005	5880	31066	25273	22942	10119	0.5758
2006	7393	28949	22757	19879	9844	0.6067
2007	5030	26543	21832	16786	7511	0.4695
2008	6465	29423	21607	20129	7315	0.4419
2009	8237	29617	22981	19359	9979	0.5314
2010	11303	37225	25370	21047	12757	0.6668
2011	4294	29310	25810	18135	9692	0.5635
2012	1884	22838	20946	17848	7204	0.5338
2013	2890	22114	19196	19083	4473	0.2804
2014	7654	27567	19156	20087	5715	0.3732
2015	2389	28520	25663	19729	7394	0.4599
2016	3374	26625	25663	22408	7514	0.4599
2017	4311	25745		20162	7170	0.4599
2018	4311	25020		18911		
Average	14736	79908	64677	55347	21832	0.5102

Table 4.6.5. Faroe Plateau cod (subdivision 5.b.1). Biomass (age 2+, tons) from 1710–1859 based on two approaches. The left part of the table is modelled by scaled dried cod export (taking account of increasing tendency to export more fish over time) 1710-1859. The right part of the table is modelled by the same model, but fitted for the 1710–1840 period, and a separate model, a factor, is used for the 1841–1859 period. This was an attempt to take account of a possible increased dried cod export caused by better possibilities of fishers to sell their landings. The value in 1860 (taken from next table) is also shown. Missing years are modelled by linear interpolation. Year label = first row + first column.

	1700	1750	1800	1850	1700	1750	1800	1850
0		203118	145689	163103		209334	153202	69133
1		150800	150618	168040		154170	158624	75653
2		100949	109427	175508		100590	113557	86379
3		74141	81679	181495		72481	83220	95999
4		98616	70210	205909		97678	70898	142806
5		62191	89050	236862		60147	91333	215365
6		131926	100897	210540		134388	104274	193343
7		141252	115479	184218		144056	120134	171320
8		180782	113116	157896		186010	117581	149298
9		159904	93431	131574		163392	96800	127275
10	142041	133776	73745	105252	139327	135636	76018	105252
11	168323	107648	54060		166755	107881	55236	
12	193811	120502	34374		193421	121629	34455	
13	193026	120502	14689		192735	121629	13673	
14	154233	128892	67502		152771	130692	69965	
15	109779	145077	90579		107070	148357	94857	
16	58303	139000	111302		54676	141834	116549	
17	70962	129309	113210		67616	131610	118767	
18	98712	111100	130165		96031	112061	138050	
19	127083	95355	173807		124525	95335	187049	
20	114273	103794	183183		111543	104507	197681	
21	98139	117533	151025		94963	119275	161727	
22	77036	117533	128521		73459	119275	136272	
23	65720	131271	121350		62238	134044	128310	
24	54404	94983	119010		51018	95739	125814	
25	54404	58694	113337		51018	57434	119552	
26	55649	71518	102938		52294	70870	108042	
27	86296	79834	116320		83531	79659	122965	
28	101645	90404	124944		99323	90772	132793	
29	120159	96467	136327		118226	97236	145626	
30	122389	104086	150109		120593	105556	161352	
31	112436	111704	161142		110278	113876	174088	
32	86199	92367	169340		83857	93305	183519	
33	59963	92367	171628		57435	93305	186276	
34	33726	85472	157524		31014	86016	170288	
35	49250	102178	153222		46434	103919	165504	
36	81195	100998	154433		79333	102688	167039	
37	86494	120264	159721		84577	123750	173188	

	1700	1750	1800	1850	1700	1750	1800	1850
38	79128	146668	141223		77256	152842	152440	
39	61034	172556	135717		58429	181282	146245	
40	50622	164087	156283		48317	172091	135996	
41	54594	138988	219704		52530	144576	199136	
42	18387	122896	238434		16411	126933	187345	
43	103720	117417	243695		102334	121048	199009	
44	83076	124089	223875		81115	128422	154909	
45	83076	130899	210972		81115	136024	136441	
46	88182	113963	188260		86580	117918	101729	
47	186414	96159	184208		191549	98703	95822	
48	193149	77125	177024		198624	77981	88167	
49	237895	117737	175956		247009	122529	87678	

Table 4.6.6. Faroe Plateau cod (subdivision 5.b.1). Biomass (age 2+, tons) from 1860–2015. The biomass from 1860–1905 is based on scaled cpue from Faroese and Shetland vessels. The biomass from 1906–1958 is based on scaled cpue from British steam trawlers. The results from the age-based assessment from 1959–2015 are shown for completeness. Year label = first row + first column.

	1850	1875	1900	1925	1950	1975	2000
0		236420	143952	129353	152207	153664	91995
1		224948	156472	185574	124325	161260	110410
2		208758	151509	162034	116783	136211	98445
3		213729	163172	126611	116783	96227	60392
4		199256	145938	135524	146493	85112	36140
5		241850	130638	142608	149464	85038	31066
6		254217	125162	139409	108327	88411	28949
7		257567	148793	121354	112898	98963	26543
8		221818	108532	108327	84102	123255	29423
9		173547	175051	107870	67803	152158	29617
10	105252	102923	149669	91187	75862	131240	37225
11	88276	86780	175051	102385	65428	99271	29310
12	95349	72702	161922	95758	68225	78362	22838
13	127038	71090	137415	93244	77602	66177	22114
14	152220	84268	112908	143439	84666	59031	27567
15	118946	166257	122391	193635	75043	38276	28520
16	107629	253036	143731	216611	83919	28679	
17	94463	258572	171332	188465	105289	35684	
18	149274	187962	213691	196270	110433	51034	
19	198563	137071	205685	210683	105537	83914	
20	181645	195446	98904	225096	98398	144645	
21	139371	184553	117284	239509	78218	143005	
22	108056	155015	160172	177346	76439	97233	
23	178060	104436	133039	122497	110713	66872	
24	232567	133637	136895	164777	139266	66269	

Table 4.7.1. Faroe Plateau cod (subdivision 5.b.1). Input to management option table.

Year	Yearclass	Recr.	Source
2013	YC2011	2890	
2014	YC2012	7654	
2015	YC2013	2389	XSA-output
2016	YC2014	3374	XSA-output
2017	YC2015	4311	Avg13-15
2018	YC2016	4311	Avg13-15

	Stock size	
Age	2016	Source
2	3374	XSA-output
3	1815	XSA-output
4	3908	XSA-output
5	697	XSA-output
6	315	XSA-output
7	363	XSA-output
8	265	XSA-output
9	126	XSA-output
10+	46	XSA-output

	Maturity			Exploitation pattern (rescaled to final year)			Weights		
	Observed	Avg14-16	Avg14-16	Avg13-15	Avg13-15	Avg13-15		= 2016	Avg14-16
Age	2016	2017	2018	2016	2017	2018	2016	2017	2018
2	0.21	0.24	0.24	0.0635	0.0635	0.0635	1.057	1.057	1.118
3	0.89	0.70	0.70	0.2624	0.2624	0.2624	1.857	1.857	1.748
4	0.91	0.86	0.86	0.4353	0.4353	0.4353	2.706	2.706	2.647
5	0.97	0.97	0.97	0.5536	0.5536	0.5536	3.686	3.686	3.445
6	1.00	0.99	0.99	0.5584	0.5584	0.5584	4.237	4.237	4.263
7	1.00	1.00	1.00	0.4898	0.4898	0.4898	5.057	5.057	5.771
8	1.00	1.00	1.00	0.3283	0.3283	0.3283	6.472	6.472	7.967
9	1.00	1.00	1.00	0.4941	0.4941	0.4941	9.644	9.644	9.738
10+	1.00	1.00	1.00	0.4941	0.4941	0.4941	9.644	9.644	10.964
			Fbar:	0.4599	0.4599	0.4599			

Table 4.7.2. Faroe Plateau cod (subdivision 5.b.1). Management option table.

MFDP VERSION 1

Run: Cod_farp

Index file 29/4-2016

Time and date: 15:12 29/04/2016

Fbar age range: 3-7

2016				
Biomass	SSB	FMult	FBar	Landings
26625	22408	1.0000	0.4599	7514

2017					2018	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
25745	20162	0.0000	0.0000	0	33196	26726
.	20162	0.1000	0.0460	869	32203	25774
.	20162	0.2000	0.0920	1700	31254	24864
.	20162	0.3000	0.1380	2494	30347	23995
.	20162	0.4000	0.1840	3254	29481	23166
.	20162	0.5000	0.2300	3980	28652	22374
.	20162	0.6000	0.2759	4676	27860	21617
.	20162	0.7000	0.3219	5341	27102	20894
.	20162	0.8000	0.3679	5978	26377	20203
.	20162	0.9000	0.4139	6587	25684	19542
.	20162	1.0000	0.4599	7170	25020	18911
.	20162	1.1000	0.5059	7729	24385	18307
.	20162	1.2000	0.5519	8265	23777	17730
.	20162	1.3000	0.5979	8777	23194	17178
.	20162	1.4000	0.6439	9269	22637	16650
.	20162	1.5000	0.6899	9740	22102	16144
.	20162	1.6000	0.7358	10192	21591	15661
.	20162	1.7000	0.7818	10625	21100	15198
.	20162	1.8000	0.8278	11040	20630	14755
.	20162	1.9000	0.8738	11439	20179	14330
.	20162	2.0000	0.9198	11821	19747	13924

Input units are thousands and kg–output in tonnes

Table 4.8.1. Faroe Plateau cod (subdivision 5.b.1). Input to yield-per-recruit calculations (long-term prediction).

	Expl.	Weight	Prop
	pattern	at age	mature
	Average	Average	Average
Age	2002–2015	1978–2015	1983–2016
	Not rescaled		
2	0.103	1.044	0.06
3	0.328	1.571	0.58
4	0.452	2.296	0.84
5	0.572	3.097	0.94
6	0.681	3.903	0.98
7	0.735	4.999	0.99
8	0.725	6.254	1.00
9	0.988	7.820	1.00
10+	0.988	9.676	1.00

Table 4.8.2. Faroe Plateau cod (subdivision 5.b.1). Output from yield-per-recruit calculations (long-term prediction).

Reference point	F multiplier	Absolute F
F_{bar}(3–7)	1.0000	0.5536
F_{Max}	0.4576	0.2533
$F_{0.1}$	0.2112	0.1169
$F_{35\%}$SPR	0.3175	0.1758
F_{low}	0.1862	0.1031
F_{med}	0.6715	0.3717
F_{high}	1.6421	0.9091
Weights in kilograms		

4.19 Figures

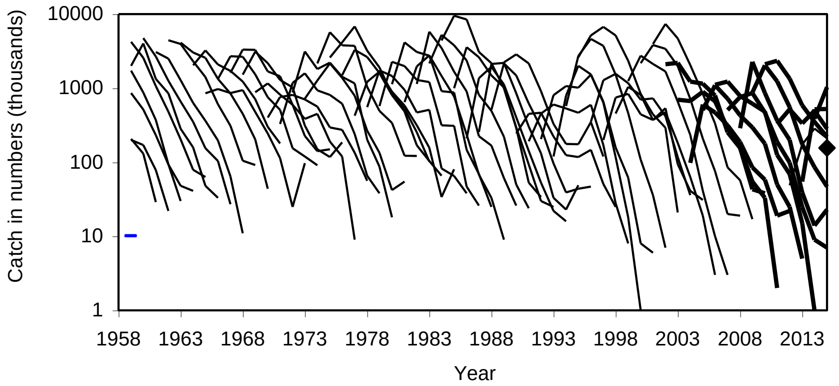


Figure 4.2.1. Faroe Plateau cod (subdivision 5.b.1). Catch in numbers-at-age shown as catch curves.

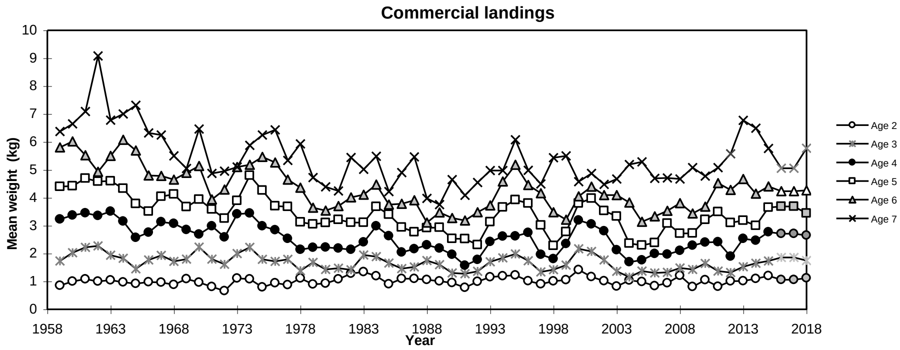


Figure 4.2.2. Faroe Plateau cod (subdivision 5.b.1). Mean weight at age. The predicted weights are also shown.

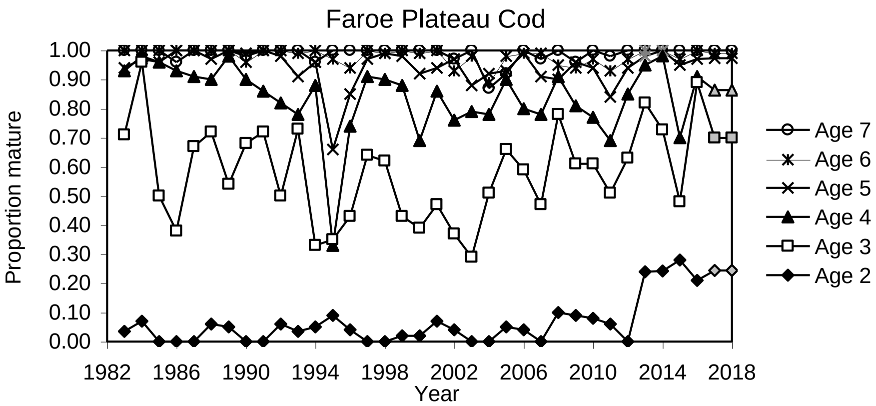


Figure 4.2.3. Faroe Plateau cod (subdivision 5.b.1). Proportion mature at age as observed in spring groundfish survey. The predicted values are shown in grey.

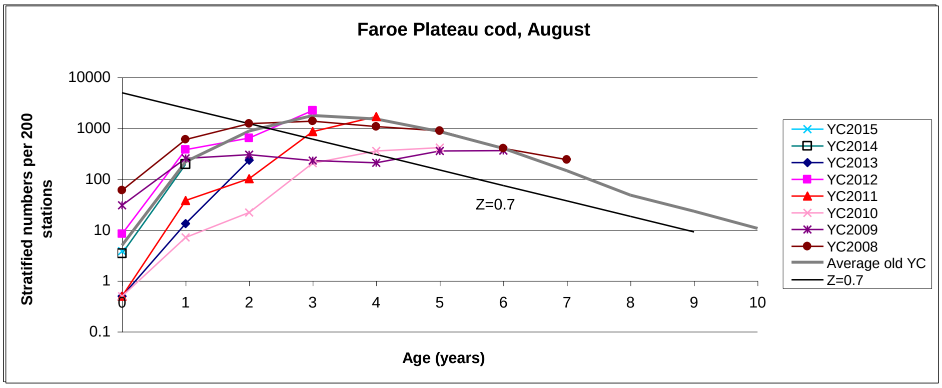


Figure 4.2.4. Faroe Plateau cod (subdivision 5.b.1). Catch curves from spring groundfish survey.

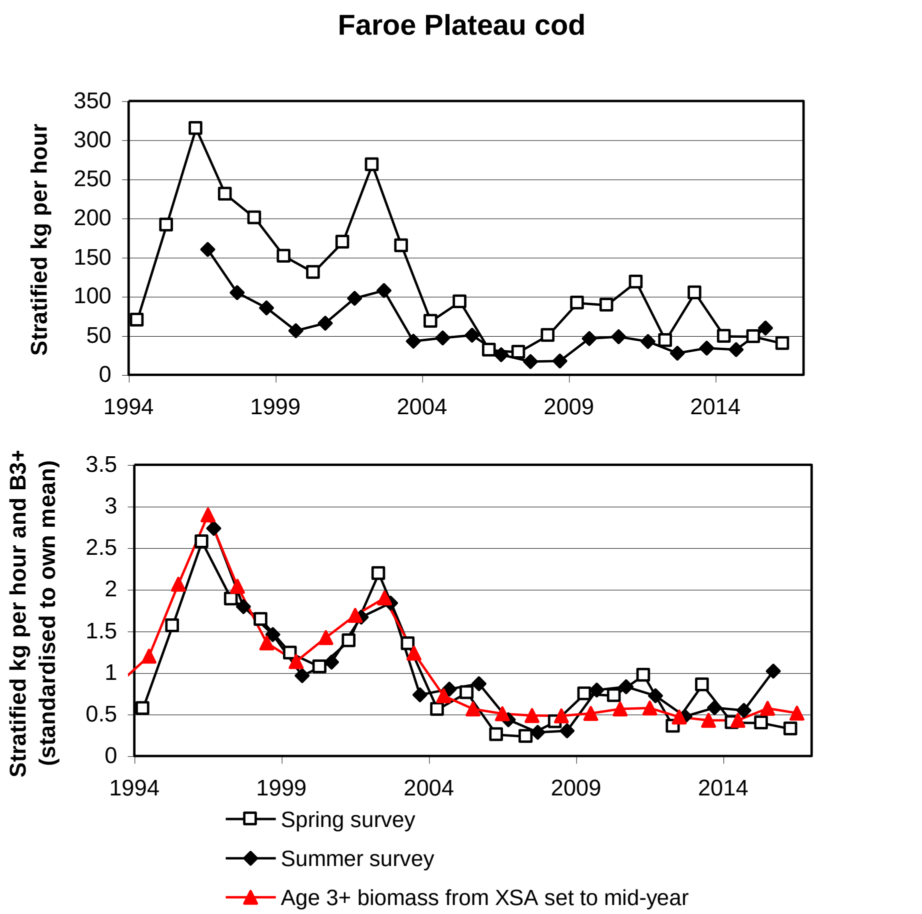


Figure 4.2.5. Faroe Plateau cod (subdivision 5.b.1). Stratified kg/hour in spring and summer surveys (upper figure). The age 3+ biomass obtained from the assessment is also included as an index.

Figure 4.2.6. Faroe Plateau cod (subdivision 5.b.1). Catch curves from summer groundfish survey.

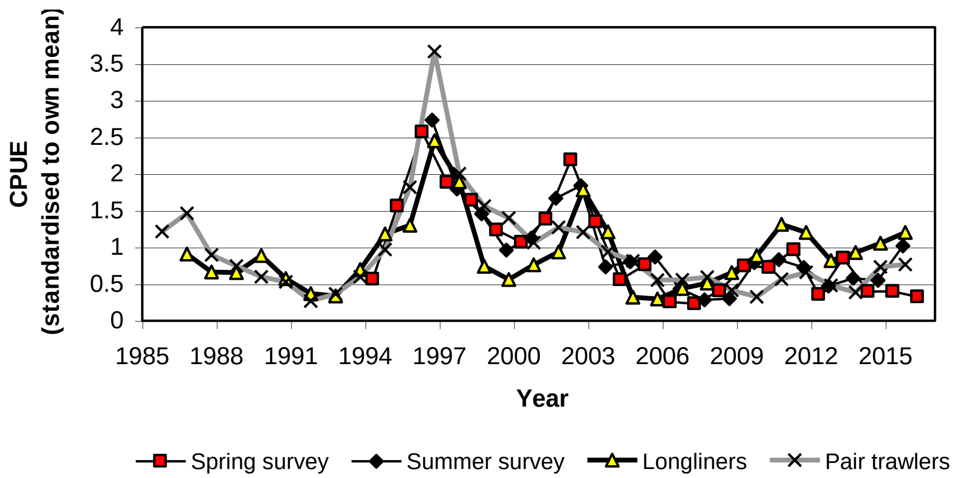


Figure 4.2.7. Faroe Plateau cod (subdivision 5.b.1). Standardized catch per unit of effort for pairtrawlers and longliners. The two surveys are shown as well.

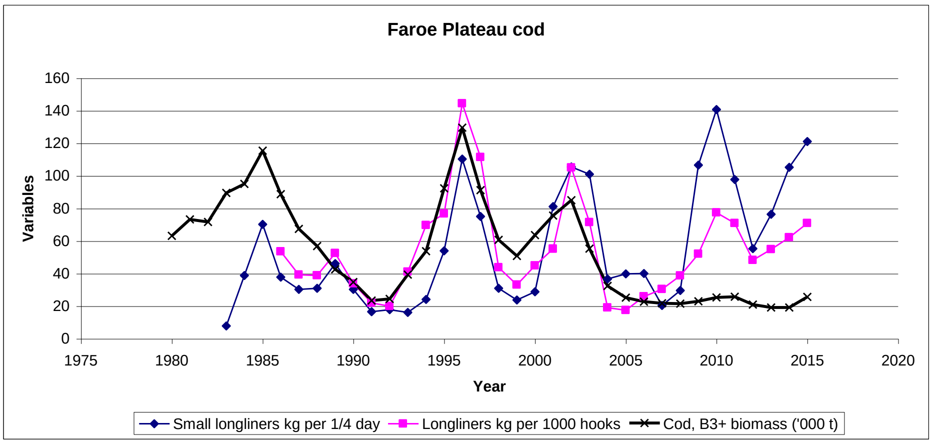


Figure 4.2.8. Faroe Plateau cod (subdivision 5.b.1). Catch per unit of effort for small and large longliners compared with the fishable (age 3+) biomass.

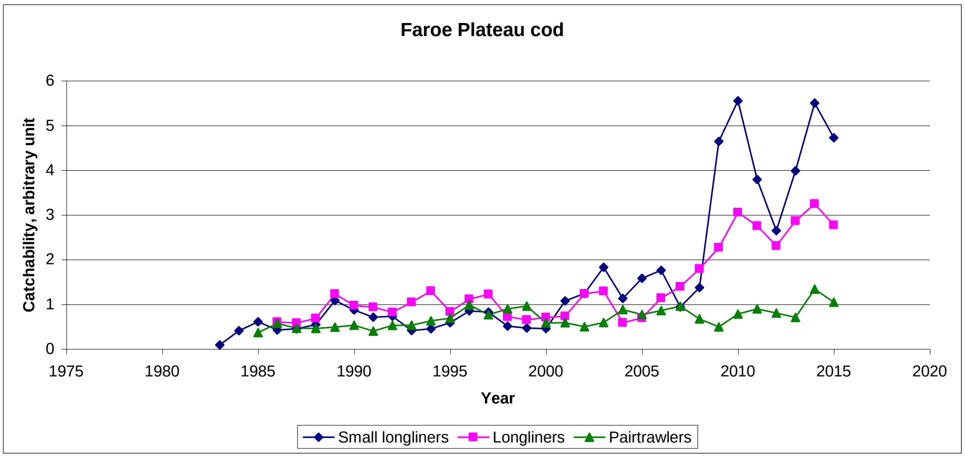


Figure 4.2.9. Faroe Plateau cod (subdivision 5.b.1). Catchability (cpue divided by age 3+ biomass) for small and large longliners and pairtrawlers.

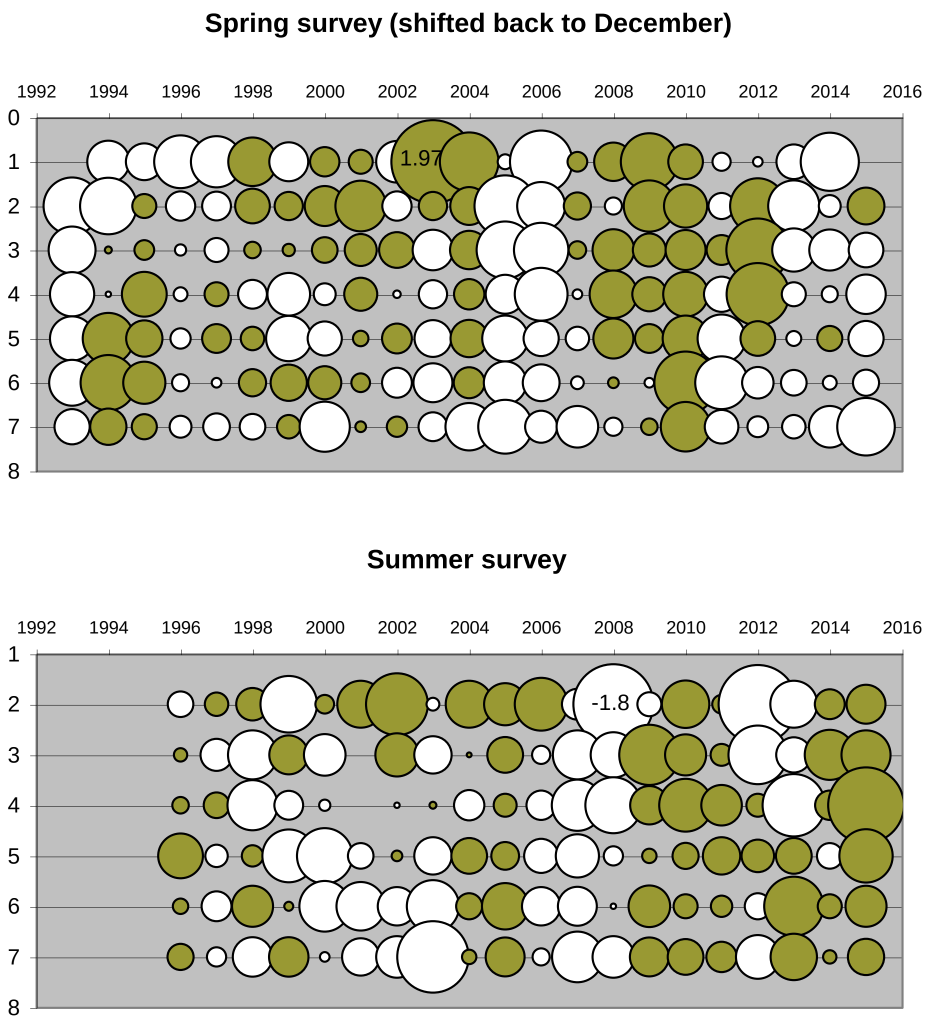
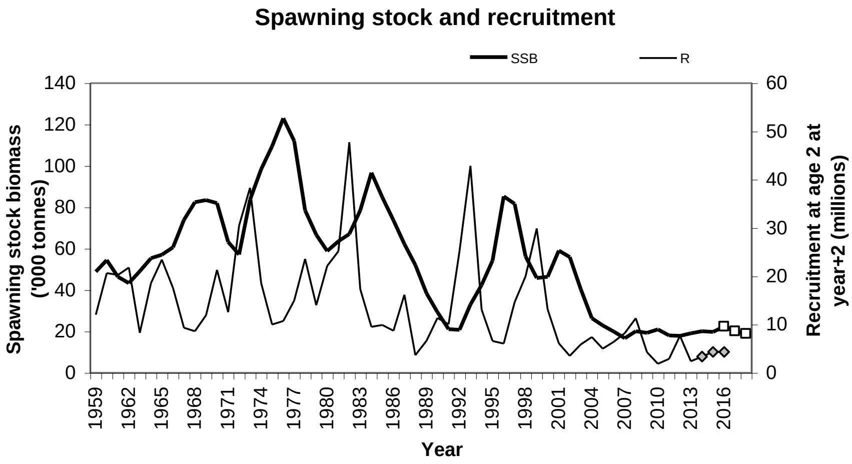


Figure 4.6.1. Faroe Plateau cod (subdivision 5.b.1). Log catchability residuals for age 2–7 for spring (upper figure) and summer survey. The residuals for age 8 are not presented because some values were off scale. White bubbles indicate negative residuals.



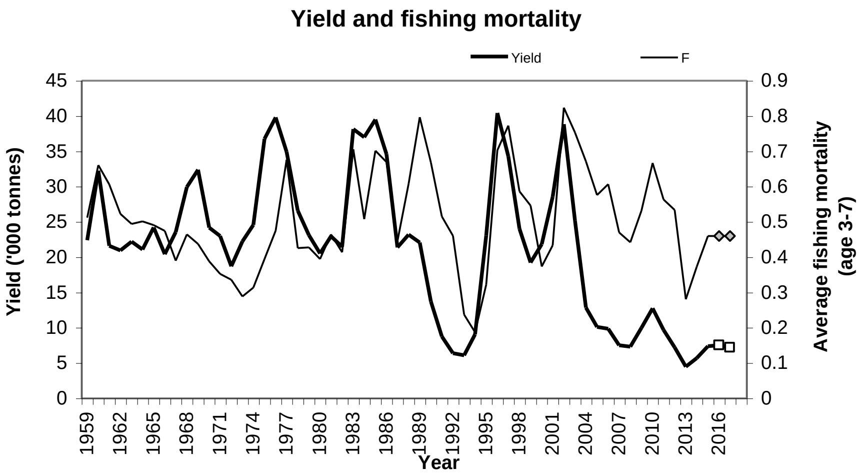


Figure 4.6.2. Faroe Plateau cod (subdivision 5.b.1). Spawning-stock biomass (SSB) and recruitment (year class) vs. year (upper figure) and yield and fishing mortality vs. year. Points (white and grey) are taken from the short-term projections.

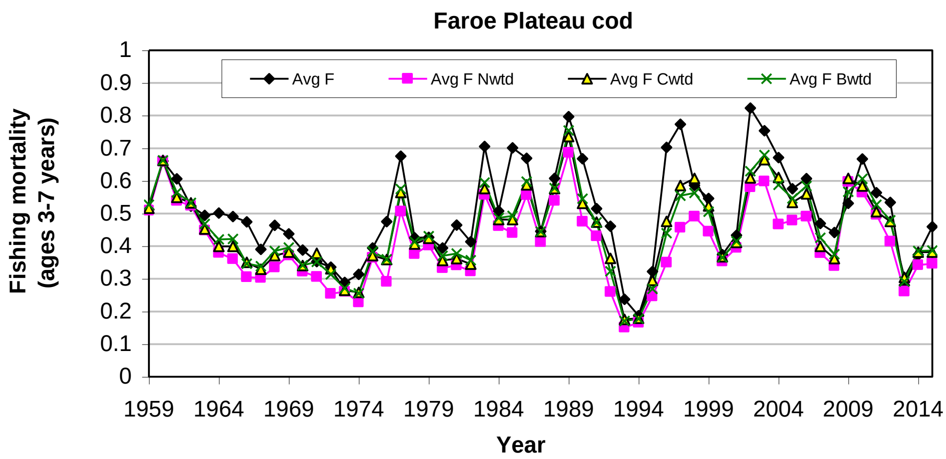


Figure 4.6.3. Faroe Plateau cod (subdivision 5.b.1). Different measures of fishing mortality: straight arithmetic average (Avg F), weighted by stock numbers (Nwtd), weighted by stock biomass (Bwtd) or weighted by catch (Cwtd).

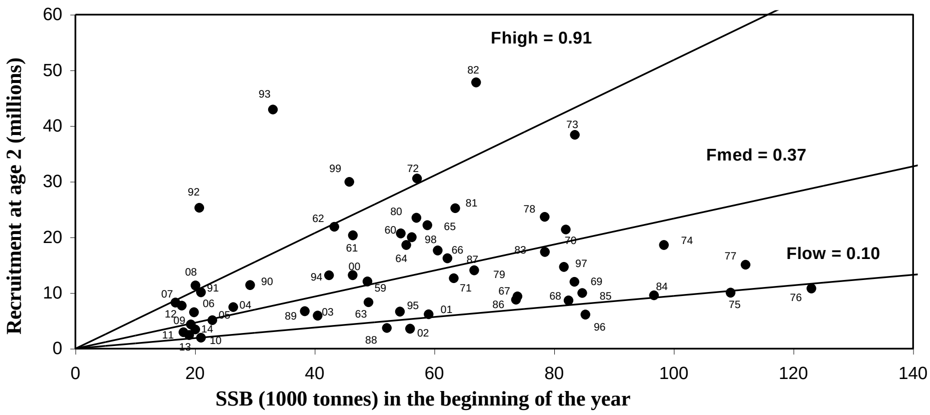


Figure 4.6.4. Faroe Plateau cod (subdivision 5.b.1). Spawning stock – recruitment relationship. Years are shown at each data point.

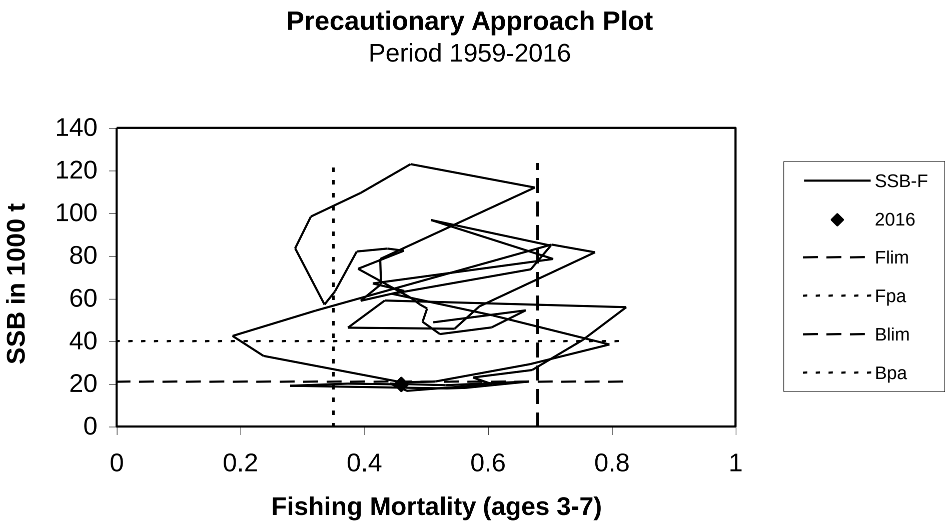


Figure 4.6.5. Faroe Plateau cod (subdivision 5.b.1). Spawning-stock biomass vs. fishing mortality.

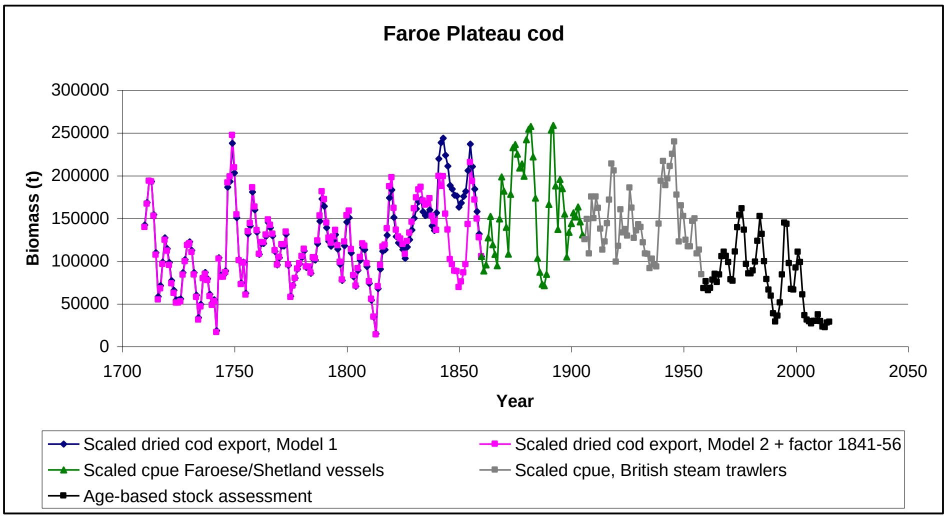


Figure 4.6.6. Faroe Plateau cod (subdivision 5.b.1). Biomass (age 2+) obtained from the age-based assessment as well as from cpue of British trawlers and Faroe/Shetland vessels that were scaled to biomass. Prior to 1860 the export of dried cod was used as a basis to estimate the biomass also accounting for increased tendency to export dried cod during the period. The high estimates around 1850 are based on the assumption that the high values of dried cod export were due to an increased biomass alone. The lower estimates are based on the assumption that dried cod export increased, not only due to increased biomass, but also due to better possibilities to land fish during this period.

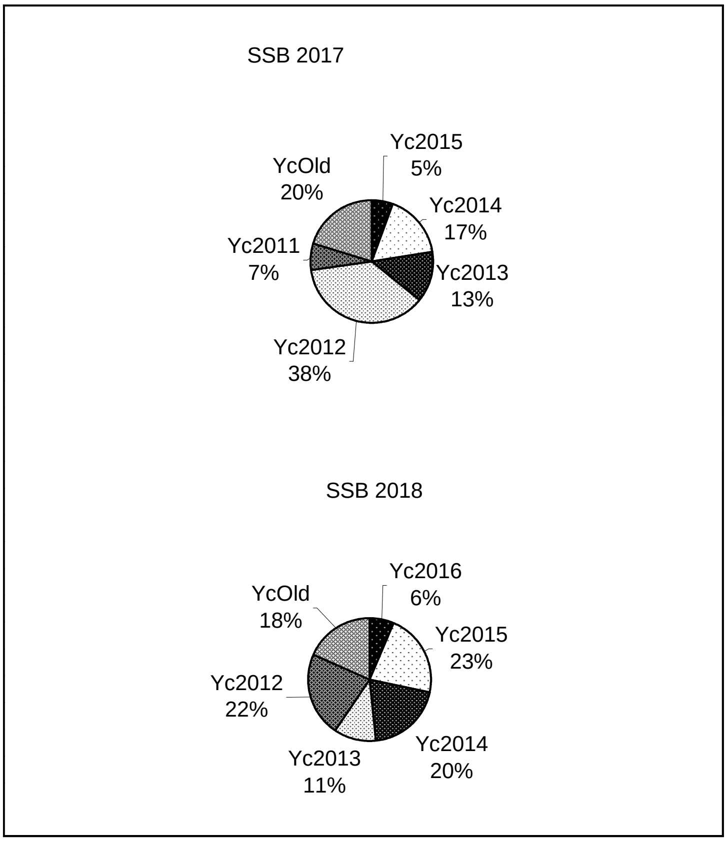


Figure 4.7.1. Faroe Plateau cod (subdivision 5.b.1). Predictions of the contribution of various year classes to the spawning-stock biomass in terminal year +1 (upper figure) and terminal year +2 (lower figure).

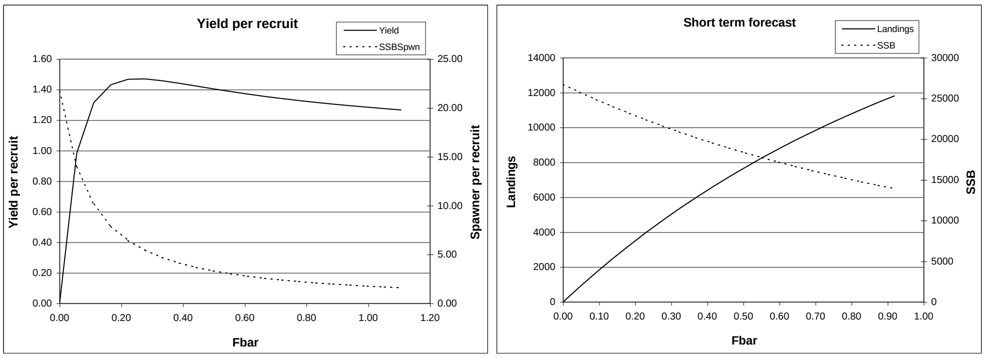


Figure 4.8.1. Faroe Plateau cod (subdivision 5.b.1). Yield-per-recruit and spawning-stock biomass (SSB) per recruit vs. fishing mortality (left figure). Landings and SSB versus F_{bar} (3-7) (right figure).

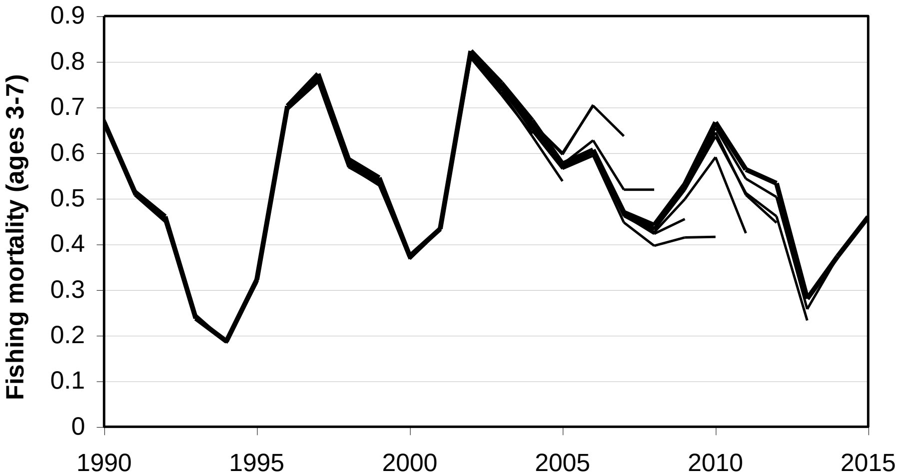


Figure 4.9.1. Faroe Plateau cod (subdivision 5.b.1). Results from the XSA retrospective analysis of fishing mortality (ages 3-7).

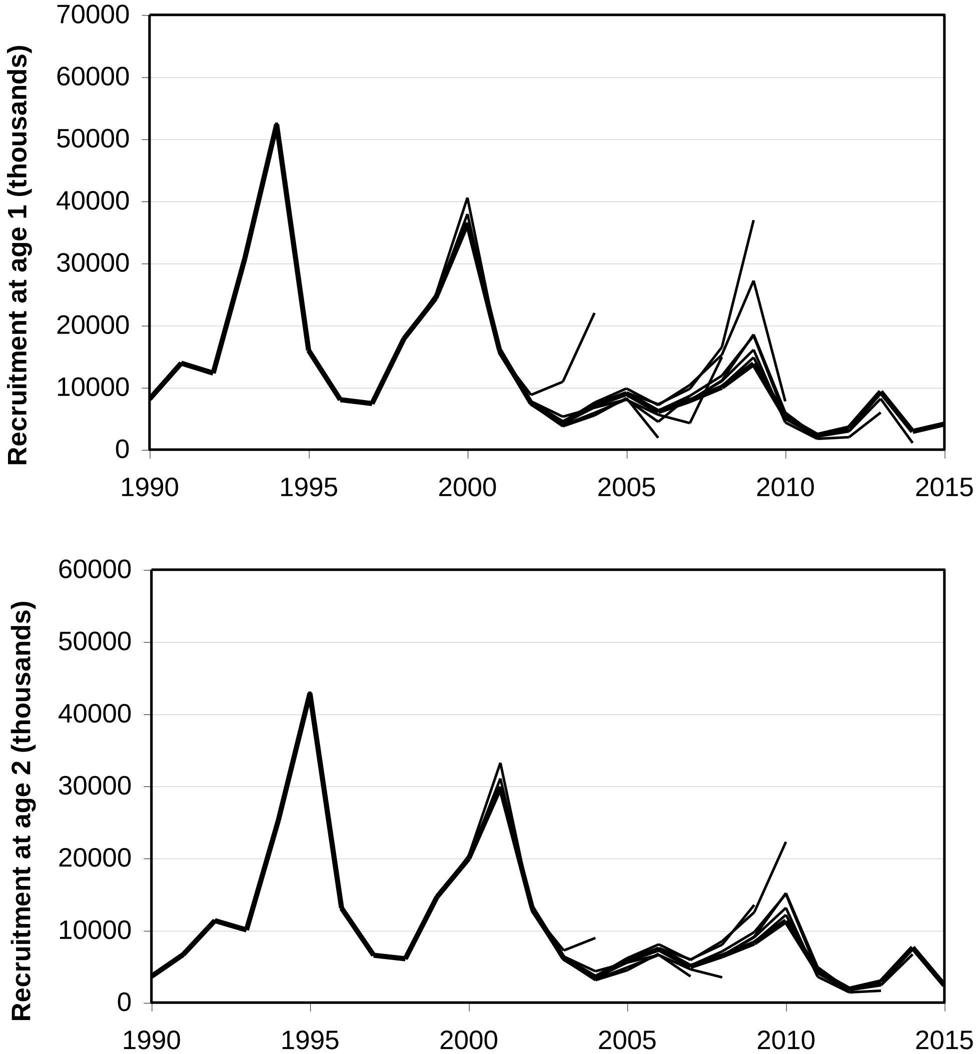


Figure 4.9.1. Faroe Plateau cod (subdivision 5.b.1). Results from the XSA retrospective analysis (continued). Recruitment-at-age 1 (upper figure) and at age 2.

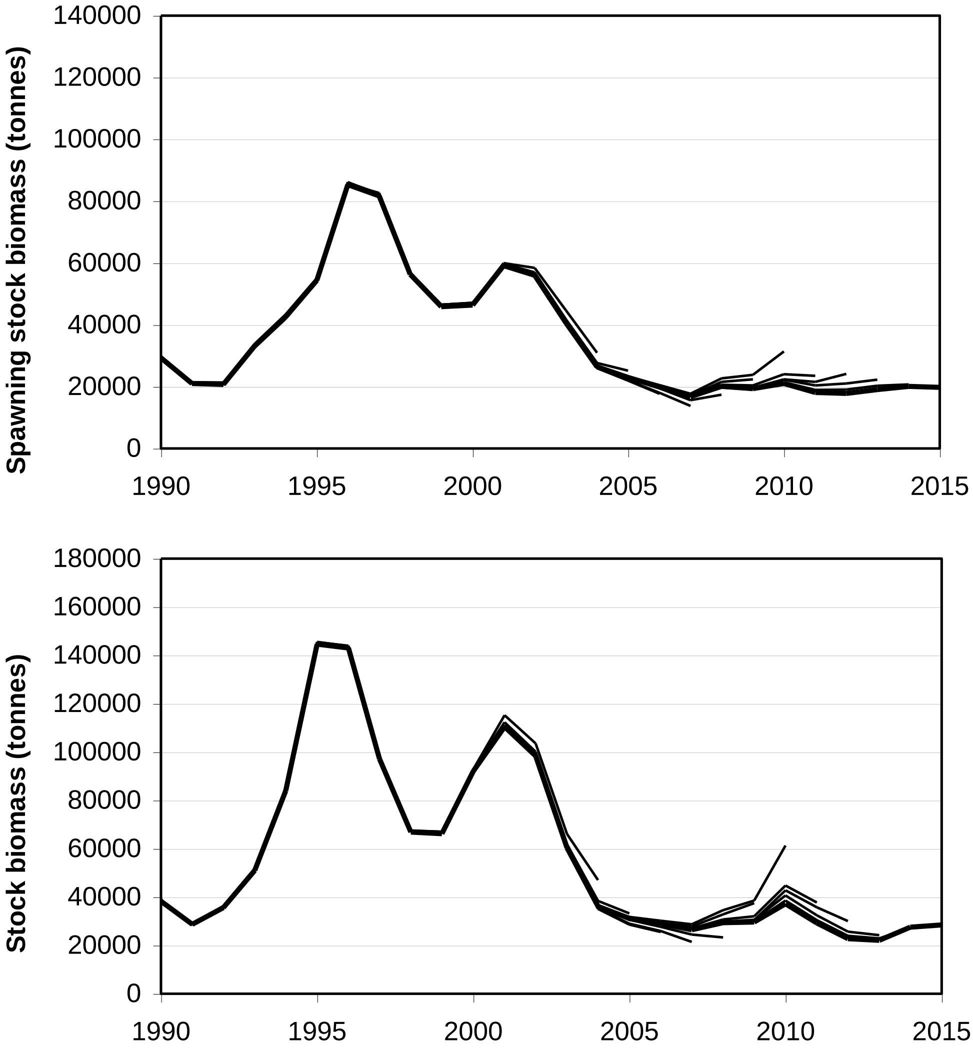


Figure 4.9.1. Faroe Plateau cod (subdivision 5.b.1). Results from the XSA retrospective analysis (continued). Spawning-stock biomass (upper figure) and total-stock biomass.

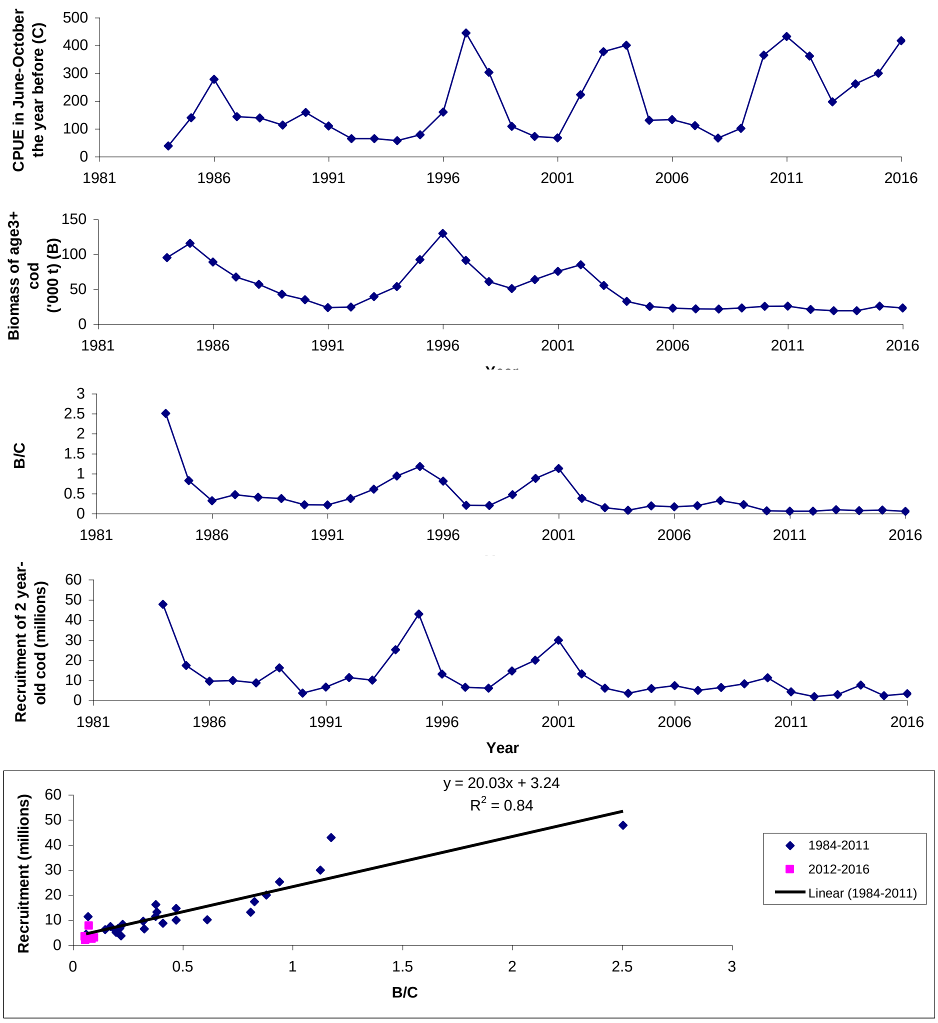


Figure 4.9.2. Faroe Plateau cod (subdivision 5.b.1). Modelling cod recruitment in three steps. First, the catch-per-unit –effort of cod (C) for small boats operating close to land, as being indicative of the amount of cannibalistic cod. Second, the amount of cod (older than the recruiting cod) (B), as 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 recent years is very poor.

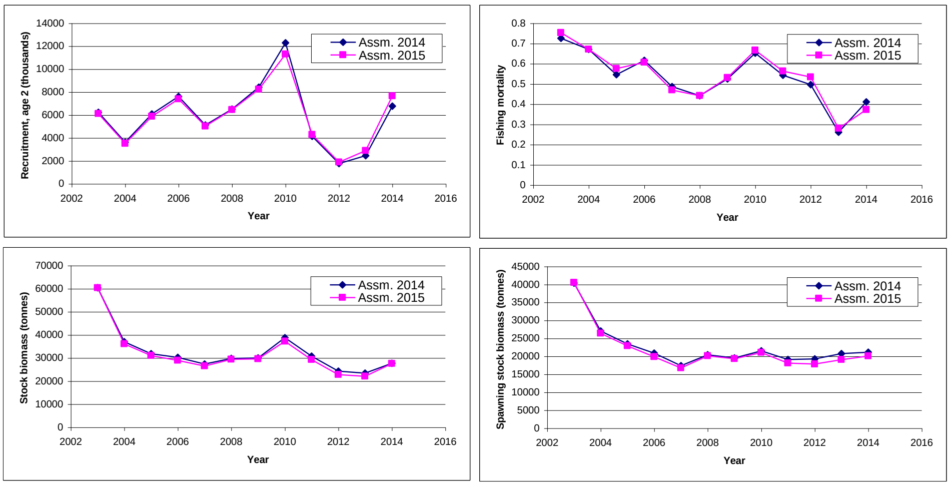


Figure 4.10.1. Faroe Plateau cod (subdivision 5.b.1). Comparison between the results from the current assessment (Assm. 2016) and the assessment last year (Assm. 2015) for recruitment (upper left), fishing mortality (upper right), stock biomass (lower left) and spawning-stock biomass (lower right).

5 Faroe haddock

5.1 Stock description and management units

Haddock in Faroese Waters, i.e. ICES Subdivisions 5.b.1 and 5.b.2 and in the southern part of ICES Division 2.a, close to the border of Subdivision 5.b.1, 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 Faroes waters is given in the stock annex. The spatial distribution of the haddock in the summer survey and in spring survey is shown in figure 5.9. The figure do clearly illustrate the drastic decrease in the stock biomass in recent years.

5.2 Scientific data

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 2012 to only about 2 600 t; they have increased a bit to 3 400 t in 2015. Most of the landings are taken from the Faroe Plateau; the 2015 landings from the Faroe Bank (Subdivision 5.b.2), 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 31 t (Tables 5.1 and 5.2). The cumulative landings by month are shown in Figure 5.2.

Faroese vessels have taken almost the entire catch since the late 1970s (Figure 5.1). Due to the dispute on mackerel quota share, there was 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 5.b in 2012 and 2013; in 2014 the parties happened to make an agreement again. The proportion of the Faroese landings taken by each fleet category since 1985 are shown in the annex. The longlines have taken most of the catches in recent years followed by the trawlers. This was also the case in 2015, where the share by longlines was 81% and that by trawlers 19% (Figure 5.3).

Catch-at-age

Catch-at-age data were provided for fish taken by the Faroese fleets from 5.b.1 and 5.b.2. The sampling intensity in 2015 is shown in Table 5.3 showing some decrease in intensity as compared to 2014. There is 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. This has also turned out to be difficult of the above mentioned reasons but the outlook is very positive regarding raising enough money to hire a new technician to among other things do the sampling. 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, respectively). The longliner samples had to be treated by using 2 seasons only (Jan-Jun, Jul-Dec. The results are given in Table 5.3. No catch-at-age data were available from other nations (Norwegian longliners and British trawlers) and they were assumed to have the same age composition as the Faroese corresponding fleets. 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 1957.

In general the catch-at-age matrix in recent years appears consistent although from time to time some 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 F_{BAR} 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 fish 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). Next year there will be a benchmark assessment of this stock, and all issues will be carefully investigated. 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 highgrade 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.

Weight-at-age

Mean weight-at-age data are provided for the Faroese fishery (Table 5.5). 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.

Maturity-at-age

Maturity-at-age data are available from the Faroese Spring Groundfish Surveys 1982–2016. 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, mostly in April, 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 5.6 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 2016 assessment but catch per unit of 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 2015 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 2015data.

5.4.1 Tuning and estimates of fishing mortality

Commercial cpue series. Several commercial catch per unit of 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 pairtrawlers 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. 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".

In order to illustrate stock biomass further back in time, historical cpue series from British trawlers have been used together with the 2015 assessment. The method is described in WD12, "Faroe haddock biomass 1914-56". The results are given in Table 5.17, and in section 02 of this report. The biomass of Faroe haddock was estimated back to 1914 by scaling cpue values to the biomass obtained from the stock assessment. There was an overlap between cpue values from Aberdeen trawlers 1914-1959 and the age based assessment 1957–2015 by three years (1957-1959). Cpue values for English steam trawlers from 1922 to 1976 (with gaps) confirmed that the former overlap of three years was sufficient to provide a scaling of Aberdeen trawler cpue back to 1914 (Table 5.17). The table shows that the low biomass since 2006 has been unprecedented the last century.

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). 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; both surveys indicate a slow increase in recent years. 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 artefacts 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.

A SPALY (same procedure as last year) run, with the same settings of the XSA as in 2015 (tuned with the two surveys combined) (Table 5.8), with 2016 data included and some minor revisions of recent catch figures, gave in general similar results as last year (Table 5.9), although this year's assessment indicates that the 2015 assessment underestimated the 2014 recruitment by 42% (2.6 million vs. 4.4.5 million, which still is among the lowest on record), underestimated the fishing mortality in 2014 by 10% (0.26 vs. 0.29) and overestimated the 2014 total and spawning-stock biomasses by 7% and 27%, respectively (20 and 18 thous. t vs. 18 and 14 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 F_{BAR} 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 are being carefully inspected.

It has been questioned if a rather heavy shrinkage of 0.5 is the most appropriate to 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 5.9 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 a bit 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 5.16 and Figure 5.16. From Table 5.16, $\mathbf{F}_{med}$, and $\mathbf{F}_{high}$ were calculated at 0.22 and 0.82, respectively. The F_{max} of 0.6 should not be used since it is very poorly determined due to the flat YPR curve. $F_{0.1}$ is estimated at 0.2. 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 F_{MSY} 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 2010 and 2014 YC's, which are estimated somewhat higher than the other small year classes. Fishing mortality has been relatively high since 2003, highest when the stock was large leading to large variability of catches. Currently fishing mortality is estimated close to F_{MSY} (0.25).

5.7 Short-term forecast

Input data

The input data for the short-term predictions are estimated in accordance with the procedures last year and explained in Tables 5.12-13. The YC 2016 at age 2 in 2018 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 2018 has little effect on the short-term prediction.

Results

Although the allocated number of fishing days for the fishing year 2015-2016was reduced for some fleets as compared to the year before (see section 2), it should not be unrealistic to assume fishing mortalities in 2016 as the average of some recent years, here the average of F(2013–2015), 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 2016 are then predicted to be about 4000 t, and continuing with this fishing mortality will result in 2017 landings of about 5300 t (Table 5.15). The SSB will increase to 20 000 t in 2016, and increase further in 2017 and 2018 to 24 000 t and 41 000 t, respectively. This prediction should however be treated with great care since most of the increase is based on number of 1 year old in the 2016 spring survey. The results of the short-term prediction are shown in Table 5.16 and in Figure 5.14. The contribution (%) by year classes to the age composition of the predicted 2016 and 2017 SSB's is shown in Figure

5.17. It should be noted that young YC's which not have really entered the fishery in 2015/16, will contribute by a large proportion of the SSB in 2017/18.

5.8 Medium term forecasts and yield-per-recruit

No medium term projections were made this year; however, the 2013 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 5.15. Mean weights-at-age (stock and catch) are averages for the 1977–2015 period. The maturity o-gives are averages for the years 1982-2015. The exploitation pattern is the same as in the short-term prediction.

The results are given in Table 5.16, in Figure 5.16 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 year's assessment indicates that the 2015 assessment underestimated the 2014 recruitment by 42% (2.6 million vs. 4.5 million, which still is among the lowest on record), underestimated the fishing mortality in 2014 by 10% (0.29 vs. 0.26) and overestimated the 2014 total- and spawning-stock biomasses by 7% and 27%, respectively (20 and 18 thous. t vs. 19 and 14 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 decreased somewhat compared to 2015. 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 2015 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 2015 data.

Following differences in the 2014 estimates were observed as compared to last year (see text above):

Comparisons between 2015 and 2016 assessment of 2014 data
The year of comparison is 2014

	R at age 2 (thousands)	Total B (tonnes)	SSB (tonnes)	Landings (tonnes)	F (3-7)
2015 spaly	2596	19643	17931	2950	0.2595
2016 spaly	4513	18411	14083	3276	0.2876
%-change	42	-7	-27	10	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. There is ongoing work with a revision on most aspect of the fisheries legislation. 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 5.b 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 longline fisheries. Since the minimum mesh size in the trawls (codend) is 145 mm, the trawl catches consist of fewer small fish than the longline fisheries. Other nations fishing in Faroese waters are regulated by TACs 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 and 2015, 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.

5.17 Tables

Table 5.1 Faroe Plateau (Sub-division 5.b.1) HADDOCK. Nominal catches (tonnes) by countries 2000-2015 and Working Group estimates in 5.b .

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015 [2]
Faroe Islands	13,620 [8]	13,457 [8]	20,776 [6]	21,615	18,995	18,172	15,600	11,689	6,728	4,895	4,932	3,350	2,490	2,877	2,756	2,910
France1	6	8 [7]	2	4	1 [5]	+	12 [5]	4 [5]	3 [5]	2 [5]	1 [7]	3				+
Germany	1	2	6	1	6		1									
Greenland	22 [6]	0 [6]	4 [4]				1	9 [4]		6 [4]	12 [6]	+	1 [4]			
Iceland			4										2	26 [4]		
Norway	355	257 [2]	227	265	229	212	57	61	26	8	5				2	5
Russia					16				10							
Spain					49											
UK (Engl. and Wales)	19 [7]	4 [7]	11 [5]	14	8	1	1									
UK (Scotland)5				185	186	126	106	35	60	64						
United Kingdom											73 [4]				350	449
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	2,903	3,130	3,364
Used in the assessment in 5.b.	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	2,950	3,276	3,395

1) Including catches from Sub-division 5.b.2. Quantity unknown 1989-1991, 1993 and 1995-2001.
2) Preliminary data
3)From 1983 to 1996 catches included in Sub-division 5.b.2.
4) Reported as Division 5.b, to the Faroese coastal guard service.
5) Reported as Division 5.b.
6) Includes Faroese landings reported to the NWWG by the Faroe Marine Research Institute

Table 5.2 Faroe Bank (Sub-division 5.b.2) HADDOCK. Nominal catches (tonnes) by countries, 2000-2015.

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015 [2]
Faroe Island	1,565 [5]	1,948	3,698	4,934	3,594	2,444	1,375	810	556	192	178	194	141	47	71	30
France1						+										
Norway	48	66	28	54	17	45	1	8		3	1				1	1
UK (Engl. and Wales)	[1]	[1]	[1]	[1]	[1]	1	4									
UK (Scotlar	185	148	177	[4]	[1]	1	4	15	5	27	33				74	
Total	1,798	2,162	3,903	4,988	3,611	1,944	1,376	833	561	222	212	194	141	47	146	31

1) Catches included in Sub-division 5.b.1.
2) Provisional data
3)From 1983 to 1996 includes also catches taken in Sub-division 5.b.1. (see Table 2.4.1)
4) Reported as Division 5.b.
5) Provided by the NWWG

Table 5.3

Catch at age 2015

Age	5.b LLiners < 100GRT	5.b LLiners > 100GRT	5.b Trawl < 1000HP	5.b Trawl > 1000HP	5.b Regulator	5.b All Faroese fleets	5.b Foreign Trawlers	5.b Foreign Lliners	5.b Total All fleets
1	0	0	0	1	0	0	1	0	1
2	260	81	4	16	2	362	24	0	384
3	633	211	71	92	0	1007	137	1	1144
4	87	59	43	52	2	242	77	0	318
5	212	193	42	47	3	493	70	1	560
6	114	116	23	28	2	281	42	1	322
7	12	17	4	6	0	40	10	0	50
8	4	11	2	4	0	21	5	0	27
9	3	14	1	2	0	20	3	0	23
10	4	3	1	1	0	10	2	0	11
11	1	3	0	1	0	4	1	0	5
12	0	0	0	1	0	1	1	0	2
13	1	1	0	0	0	2	0	0	2
14	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0
Total no.	1333	709	192	251	16	2485	373	4	2847
Catch, t.	1296	896	201	273	17	2665	405	5	3058

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 tra\ Pair Trawl. = Pair trawlers

Comm. Sampling 2015	5.b LLiners < 100GRT	5.b LLiners > 100GRT	5.b Trawl <1000HP	5.b Trawl <1000HP	5.b Regulator	5.b All Faroese Fleets	5.b Foreign Trawlers	5.b Foreign Lliners	5.b Total
No. samples	7	14	9	34	0	64	0	0	73
No. lengths	1525	2947	1599	7476	0	13547	0	0	16942
No. weights	1525	2947	1599	7476	0	13547	0	0	16942
No. ages	140	300	159	589	0	1188	0	0	1379

As compared to 2014, the sampling in 2015 was:
no samples - 7%, no of lengths - 8%, no of weights 5%, no of otoliths - 4%.

Table 5.4 Faroe haddock. Catch number-at-age

Run title : FAROE HADDOCK (ICES DIVISION 5.b) HAD_IND

At 29/04/2016 11:08

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

YEAR	1957	1958	1959	1960	1961	1962	1963	1964	1965
AGE									
0	0	0	0	0	0	0	0	0	0
1	45	116	525	854	941	784	356	46	39
2	4133	6255	3971	6061	7932	9631	13552	2284	1368
3	7130	8021	7663	10659	7330	13977	8907	7457	4286
4	8442	5679	4544	6655	5134	5233	7403	3899	5133
5	1615	3378	2056	2482	1937	2361	2242	2360	1443
6	894	1299	1844	1559	1305	1407	1539	1120	1209
7	585	817	721	1169	838	868	860	728	673
8	227	294	236	243	236	270	257	198	1345
9	94	125	98	85	59	72	75	49	43
+gp	58	105	47	28	13	22	23	7	8
TOTALNUM	23223	26089	21705	29795	25725	34625	35214	18148	15547
TONSLAND	20995	23871	20239	25727	20831	27151	27571	19490	18479
SOPCOF %	89	90	90	88	88	89	89	101	94

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

YEAR	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
AGE										
0	0	0	0	0	0	0	0	0	0	0
1	90	70	49	95	57	55	43	665	253	94
2	1081	1425	5881	2384	1728	717	750	3311	5633	7337
3	3304	2405	4097	7539	4855	4393	3744	8416	2899	7952
4	4804	2599	2812	4567	6581	4727	4179	1240	3970	2097
5	2710	1785	1524	1565	1624	3267	2706	2795	451	1371
6	1112	1426	1526	1485	1383	1292	1171	919	976	247
7	740	631	923	1224	1099	864	696	1054	466	352
8	180	197	230	378	326	222	180	150	535	237
9	54	52	68	114	68	147	113	68	68	419
+gp	9	13	12	20	10	102	95	11	147	187
TOTALNUM	14084	10603	17122	19371	17731	15786	13677	18629	15398	20293
TONSLAND	18766	13381	17852	23272	21361	19393	16485	18035	14773	20715
SOPCOF %	109	101	102	108	102	97	96	97	97	117

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

YEAR,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,	1985,
AGE										
0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
1,	40,	0,	0,	1,	0,	0,	0,	0,	25,	0,
2,	4396,	255,	32,	1,	143,	74,	539,	441,	1195,	985,
3,	7858,	4039,	1022,	1162,	58,	455,	934,	1969,	1561,	4553,
4,	6798,	5168,	4248,	1755,	3724,	202,	784,	383,	2462,	2196,
5,	1251,	4918,	4054,	3343,	2583,	2586,	298,	422,	147,	1242,
6,	1189,	2128,	1841,	1851,	2496,	1354,	2182,	93,	234,	169,
7,	298,	946,	717,	772,	1568,	1559,	973,	1444,	42,	91,
8,	720,	443,	635,	212,	660,	608,	1166,	740,	861,	61,
9,	258,	731,	243,	155,	99,	177,	1283,	947,	388,	503,
+gp,	318,	855,	312,	74,	86,	36,	214,	795,	968,	973,
TOTALNUM,	23126,	19483,	13104,	9326,	11417,	7051,	8373,	7234,	7883,	10773,
TONSLAND,	26211,	25555,	19200,	12424,	15016,	12233,	11937,	12894,	12378,	15143,
SOPCOF %,	107,	98,	99,	104,	100,	109,	92,	106,	106,	106,

Table 5.4 Faroe haddock. Catch number-at-age (cont.)

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

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
AGE										
0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
1,	0,	0,	0,	0,	0,	0,	0,	43,	1,	0,
2,	230,	283,	655,	63,	105,	77,	40,	113,	277,	804,
3,	2549,	1718,	444,	1518,	1275,	1044,	154,	298,	191,	452,
4,	4452,	3565,	2463,	658,	1921,	1774,	776,	274,	307,	235,
5,	1522,	2972,	3036,	2787,	768,	1248,	1120,	554,	153,	226,
6,	738,	1114,	2140,	2554,	1737,	651,	959,	538,	423,	132,
7,	39,	529,	475,	1976,	1909,	1101,	335,	474,	427,	295,
8,	130,	83,	151,	541,	885,	698,	373,	131,	383,	290,
9,	71,	48,	18,	133,	270,	317,	401,	201,	125,	262,
+gp,	712,	334,	128,	81,	108,	32,	162,	185,	301,	295,
TOTALNUM,	10443,	10646,	9510,	10311,	8978,	6942,	4320,	2811,	2588,	2991,
TONSLAND,	14477,	14882,	12178,	14325,	11726,	8429,	5476,	4026,	4252,	4948,
SOPCOF %,	101,	102,	97,	100,	102,	106,	106,	103,	100,	103,

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

YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE										
0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
1,	1,	0,	0,	9,	73,	19,	0,	0,	3,	0,
2,	326,	77,	106,	174,	1461,	4380,	1515,	133,	243,	85,
3,	5234,	2913,	1055,	1142,	3061,	3128,	14039,	3436,	2007,	1671,
4,	1019,	10517,	5269,	942,	210,	2423,	2879,	13551,	4802,	3852,
5,	179,	710,	9856,	4677,	682,	173,	1200,	2224,	10426,	6753,
6,	163,	116,	446,	6619,	2685,	451,	133,	949,	1163,	6127,
7,	161,	123,	99,	226,	2846,	1151,	239,	163,	409,	542,
8,	270,	93,	87,	26,	79,	1375,	843,	334,	89,	147,
9,	234,	220,	95,	20,	1,	17,	1095,	858,	166,	28,
+gp,	394,	516,	502,	192,	71,	18,	33,	924,	811,	154,
TOTALNUM,	7981,	15285,	17515,	14027,	11169,	13135,	21976,	22572,	20119,	19359,
TONSLAND,	9642,	17924,	22210,	18482,	15821,	15890,	24933,	27072,	23101,	20455,
SOPCOF %,	100,	103,	101,	100,	103,	100,	100,	100,	99,	100,

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

YEAR	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AGE										

0	0	0	0	0	0	0	0	0	0	0
1	0	0	6	0	0	0	0	0	0	0
2	247	76	66	27	389	170	8	83	238	384
3	446	982	204	329	445	773	960	510	395	1144
4	2566	547	918	402	426	324	513	1118	642	318
5	3949	2732	424	555	279	198	156	219	1141	560
6	5423	3309	1471	514	484	186	114	95	102	322
7	3278	2758	1706	1133	553	280	123	78	61	49
8	136	1117	1254	739	718	353	94	88	32	27
9	63	89	320	285	444	367	171	71	15	23
+gp	70	9	39	48	159	187	114	119	48	20
TOTALNUM	16178	11619	6408	4032	3897	2838	2253	2381	2674	2847
TONSLAND	17154	12631	7388	5197	5202	3540	2634	2950	3276	3395
SOPCOF %	100	100	101	100	101	101	102	101	101	100

Table 5.5 Faroe haddock. Catch weight-at-age.

Run title : FAROE HADDOCK (ICES DIVISION 5.b) HAD_IND

At 29/04/2016 11:08

Table 2 Catch weights at age (kg)

YEAR	1957	1958	1959	1960	1961	1962	1963	1964	1965
AGE									
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.2500	.2500	.2500	.2500	.2500	.2500	.2500	.2500	.2500
2	.4700	.4700	.4700	.4700	.4700	.4700	.4700	.4700	.4700
3	.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
5	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
7	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
9	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
SOPCOFAC	.8937	.8983	.9034	.8832	.8832	.8929	.8915	1.0111	.9383

Table 2 Catch weights at age (kg)

YEAR	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
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	1.0885	1.0117	1.0246	1.0787	1.0249	.9688	.9597	.9690	.9678	1.1696

Table 2 Catch weights at age (kg)

YEAR	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
AGE										
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.2500	.0000	.0000	.3000	.0000	.0000	.0000	.0000	.3590	.0000

2,	.4700,	.3110,	.3570,	.3570,	.6430,	.4520,	.7000,	.4700,	.6810,	.5280,
3,	.7300,	.6330,	.7900,	.6720,	.7130,	.7250,	.8960,	.7400,	1.0110,	.8590,
4,	1.1300,	1.0440,	1.0350,	.8940,	.9410,	.9570,	1.1500,	1.0100,	1.2550,	1.3910,
5,	1.5500,	1.4260,	1.3980,	1.1560,	1.1570,	1.2370,	1.4440,	1.3200,	1.8120,	1.7770,
6,	1.9700,	1.8250,	1.8700,	1.5900,	1.4930,	1.6510,	1.4980,	1.6600,	2.0610,	2.3260,
7,	2.4100,	2.2410,	2.3500,	2.0700,	1.7390,	2.0530,	1.8290,	2.0500,	2.0590,	2.4400,
8,	2.7600,	2.2050,	2.5970,	2.5250,	2.0950,	2.4060,	1.8870,	2.2600,	2.1370,	2.4010,
9,	3.0700,	2.5700,	3.0140,	2.6960,	2.4650,	2.7250,	1.9610,	2.5400,	2.3680,	2.5320,
+gp,	3.5500,	2.5910,	2.9200,	3.5190,	3.3100,	3.2500,	2.8560,	3.0400,	2.6860,	2.6860,
SOPCOFAC,	1.0741,	.9784,	.9947,	1.0380,	1.0017,	1.0870,	.9238,	1.0554,	1.0593,	1.0559,

Table 5.5 Faroe haddock. Catch weight-at-age (cont.).

Table 2 Catch weights at age (kg)

YEAR,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,	1995,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.3600,	.0000,	.0000,
2,	.6080,	.6050,	.5010,	.5800,	.4380,	.5470,	.5250,	.7550,	.7540,	.6660,
3,	.8870,	.8310,	.7810,	.7790,	.6990,	.6930,	.7240,	.9820,	1.1030,	1.0540,
4,	1.1750,	1.1260,	.9740,	.9230,	.9390,	.8840,	.8170,	1.0270,	1.2540,	1.4890,
5,	1.6310,	1.4620,	1.3630,	1.2070,	1.2040,	1.0860,	1.0380,	1.1920,	1.4650,	1.7790,
6,	1.9840,	1.9410,	1.6800,	1.5640,	1.3840,	1.2760,	1.2490,	1.3780,	1.5930,	1.9400,
7,	2.5190,	2.1730,	1.9750,	1.7460,	1.5640,	1.4770,	1.4300,	1.6430,	1.8040,	2.1820,
8,	2.5830,	2.3470,	2.3440,	2.0860,	1.8180,	1.5740,	1.5640,	1.7960,	2.0490,	2.3570,
9,	2.5700,	3.1180,	2.2480,	2.4240,	2.1680,	1.9300,	1.6330,	1.9710,	2.2250,	2.4900,
+gp,	2.9220,	2.9330,	3.2950,	2.5140,	2.3350,	2.1530,	2.1260,	2.2400,	2.4230,	2.6780,
SOPCOFAC,	1.0141,	1.0197,	.9695,	1.0025,	1.0195,	1.0635,	1.0554,	1.0320,	.9969,	1.0331,

Table 2 Catch weights at age (kg)

YEAR,	1996,	1997,	1998,	1999,	2000,	2001,	2002,	2003,	2004,	2005,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.3600,	.0000,	.0000,	.2780,	.2800,	.2800,	.0000,	.0000,	.3670,	.0000,
2,	.5340,	.5190,	.6220,	.5040,	.6610,	.6080,	.5840,	.5710,	.5740,	.5380,
3,	.8580,	.7710,	.8460,	.6240,	.9360,	.9400,	.8570,	.7150,	.7700,	.6490,
4,	1.4590,	1.0660,	1.0160,	.9740,	1.1660,	1.3740,	1.4050,	1.0080,	.8870,	.7970,
5,	1.9930,	1.7990,	1.2830,	1.2200,	1.4830,	1.7790,	1.7990,	1.5370,	1.1590,	1.0200,
6,	2.3300,	2.2700,	2.0800,	1.4900,	1.6160,	1.9710,	1.9740,	1.9110,	1.6380,	1.2450,

7,	2.3510,	2.3400,	2.5560,	2.4560,	1.8930,	2.1190,	2.3010,	2.0910,	1.8700,	1.8430,
8,	2.4690,	2.4750,	2.5720,	2.6580,	2.8210,	2.3730,	2.3700,	2.3010,	2.4380,	2.0610,
9,	2.7770,	2.5010,	2.4520,	2.5980,	3.7490,	2.7500,	2.6260,	2.4060,	2.3570,	2.2630,
+gp,	2.5820,	2.6760,	2.7530,	2.9530,	3.1960,	3.9660,	3.1300,	2.5350,	2.4170,	2.5790,
SOPCOFAC,	1.0043,	1.0250,	1.0106,	.9973,	1.0349,	.9960,	1.0010,	1.0049,	.9929,	.9988,

Table 2 Catch weights at age (kg)

YEAR,	2006,	2007,	2008,	2009,	2010,	2011,	2012,	2013,	2014,	2015,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0000,	.0000,	.4910,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.4240,
2,	.4750,	.6280,	.6360,	.4820,	.6920,	.5530,	.6190,	.5760,	.5470,	.5330,
3,	.6010,	.6690,	.7540,	.7340,	.8700,	.8150,	.7860,	.8300,	.9020,	.8890,
4,	.7680,	.8590,	.8600,	.9850,	1.1490,	1.0860,	1.0690,	1.1490,	1.1650,	1.3530,
5,	.9110,	.9690,	.9910,	1.1300,	1.3080,	1.3030,	1.4050,	1.4650,	1.3540,	1.6400,
6,	1.1260,	1.0600,	1.0820,	1.2640,	1.3860,	1.3870,	1.6160,	1.7100,	1.6930,	1.7290,
7,	1.3740,	1.2450,	1.1510,	1.3570,	1.4290,	1.4690,	1.6560,	1.8270,	1.8410,	2.4240,
8,	2.1580,	1.4750,	1.3790,	1.5450,	1.5680,	1.5380,	1.6750,	1.8860,	1.8720,	2.0030,
9,	2.2110,	2.2660,	1.7270,	1.7920,	1.7400,	1.7020,	1.7270,	1.8560,	1.8560,	2.2180,
+gp,	2.5690,	2.2560,	2.4350,	2.1540,	1.8410,	1.8620,	1.9050,	2.0850,	1.8230,	2.3020,
SOPCOFAC,	.9987,	.9999,	1.0065,	.9955,	1.0076,	1.0060,	1.0190,	1.0077,	1.0112,	.9994,

Table 5.6 Faroe haddock. Proportion mature-at-age.

Run title : FAROE HADDOCK (ICES DIVISION 5.b) HAD_IND

At 29/04/2016 11:08

Table 5 Proportion mature at age

YEAR,	1957,	1958,	1959,	1960,	1961,	1962,	1963,	1964,	1965,
AGE									
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
2,	.0600,	.0600,	.0600,	.0600,	.0600,	.0600,	.0600,	.0600,	.0600,
3,	.4800,	.4800,	.4800,	.4800,	.4800,	.4800,	.4800,	.4800,	.4800,
4,	.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,
6,	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,
8,	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,
+gp,	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,	1966,	1967,	1968,	1969,	1970,	1971,	1972,	1973,	1974,	1975,
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,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,	1985,
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,   .0800,   .0800,
.0800,   .0300,
          3,        .4800,   .4800,   .4800,   .4800,   .4800,   .4800,   .6200,   .6200,
.7600,   .6200,
          4,        .9100,   .9100,   .9100,   .9100,   .9100,   .9100,   .8900,   .8900,
.9800,   .9600,
          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 5.6 Faroe haddock. Proportion mature-at-age (cont.).

Table 5 Proportion mature at age

YEAR,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,	1995,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
2,	.0300,	.0500,	.0500,	.0200,	.0800,	.1600,	.1800,	.1100,	.0500,	.0300,
3,	.4300,	.3200,	.2400,	.2200,	.3700,	.5800,	.6500,	.5000,	.4200,	.4700,
4,	.9500,	.9100,	.8900,	.8700,	.9000,	.9300,	.9100,	.8500,	.8600,	.9100,
5,	.9900,	.9800,	.9800,	.9900,	1.0000,	1.0000,	1.0000,	.9700,	.9600,	.9600,
6,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	.9900,	.9900,	.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,	1996,	1997,	1998,	1999,	2000,	2001,	2002,	2003,	2004,	2005,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
2,	.0300,	.0100,	.0100,	.0100,	.0200,	.0900,	.0800,	.0700,	.0000,	.0100,
3,	.4700,	.4700,	.3600,	.3500,	.3600,	.5400,	.4900,	.4500,	.3500,	.3400,
4,	.9300,	.9100,	.8700,	.8600,	.8700,	.9300,	.9700,	.9700,	.9400,	.9100,
5,	.9800,	1.0000,	.9900,	.9900,	.9900,	1.0000,	1.0000,	.9900,	.9900,	.9900,
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,	2006,	2007,	2008,	2009,	2010,	2011,	2012,	2013,	2014,	2015,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
2,	.0100,	.0200,	.0100,	.0100,	.0300,	.0900,	.1300,	.1700,	.1700,	.1900,
3,	.4200,	.5200,	.6400,	.6100,	.6500,	.7400,	.7900,	.8300,	.8300,	.9000,
4,	.9100,	.9100,	.9500,	.9300,	.9600,	.9700,	.9900,	.9900,	1.0000,	1.0000,
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. 2016 tuning file.

```
FAROE Haddock (ICES DIVISION 5.b)       COMB-SURVEY-SPALY-16-jr.txt
102
SUMMER SURVEY
1996 2015
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
200   13337.55  4051.10   889.30   1042.92  2866.25   393.81   81.02
76.70
200    7730.19  9372.86  4026.61    841.18  1374.75  1016.83  117.22
65.82
SPRING SURVEY SHIFTED
1993 2015
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
100	1545.00	3327.70	4123.00	1086.10	2026.30	1296.40	184.10
100	12458.90	4441.90	2487.80	1332.90	263.00	428.50	107.00

Table 5.8 Faroe haddock 2016 xsa.

```
Lowestoft VPA Version 3.1

   29/04/2016  11:07

 Extended Survivors Analysis

 FAROE HADDOCK (ICES DIVISION 5.b)                HAD_IND

 cpue data from file D:\Vpa\vpa2016\input-files\comb-survey-spaly-16-jr.txt

 Catch data for  59 years. 1957 to 2015. Ages  0 to  10.

      Fleet,            First, Last, First, Last, Alpha,  Beta
                  ,    year, year,  age ,  age
 SUMMER SURVEY       ,   1996, 2015,   1,     8,   .600,   .700
 SPRING SURVEY SHIFTE,   1993, 2015,   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   35 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,  2006,  2007,  2008,  2009,  2010,  2011,  2012,  2013,  2014,  2015

      0,  .000,  .000,  .000,  .000,  .000,  .000,  .000,  .000,  .000,  .000
      1,  .000,  .000,  .002,  .000,  .000,  .000,  .000,  .000,  .000,  .000
      2,  .037,  .028,  .028,  .013,  .107,  .016,  .002,  .034,  .030,  .043
      3,  .075,  .200,  .096,  .188,  .308,  .322,  .120,  .166,  .224,  .200
      4,  .184,  .124,  .291,  .279,  .397,  .387,  .367,  .200,  .325,  .284
      5,  .287,  .306,  .133,  .287,  .318,  .324,  .326,  .263,  .323,  .526
      6,  .541,  .415,  .268,  .237,  .438,  .363,  .314,  .337,  .188,  .141
      7,  .699,  .591,  .391,  .341,  .433,  .492,  .437,  .369,  .378,  .129
      8,  .366,  .547,  .593,  .292,  .378,  .550,  .302,  .652,  .253,  .285
      9,  .621,  .435,  .294,  .255,  .287,  .338,  .569,  .393,  .212,  .291
```

Table 5.8 Faroe haddock 2016 xsa (cont.)

XSA population numbers (Thousands)

YEAR	AGE 0	1	2	3	4	5	6	7	8	9
2006	3.97E+03	3.77E+03	7.59E+03	6.83E+03	1.68E+04	1.75E+04	1.43E+04	7.20E+03	4.91E+02	1.51E+02
2007	3.43E+03	3.25E+03	3.09E+03	5.99E+03	5.19E+03	1.15E+04	1.08E+04	6.83E+03	2.93E+03	2.79E+02
2008	6.30E+03	2.81E+03	2.66E+03	2.46E+03	4.01E+03	3.75E+03	6.91E+03	5.82E+03	3.10E+03	1.39E+03
2009	1.74E+04	5.16E+03	2.29E+03	2.12E+03	1.83E+03	2.45E+03	2.69E+03	4.33E+03	3.22E+03	1.40E+03
2010	6.73E+03	1.42E+04	4.22E+03	1.85E+03	1.44E+03	1.13E+03	1.51E+03	1.74E+03	2.52E+03	1.97E+03
2011	4.10E+03	5.51E+03	1.17E+04	3.11E+03	1.12E+03	7.90E+02	6.75E+02	7.97E+02	9.22E+02	1.41E+03
2012	1.31E+04	3.35E+03	4.51E+03	9.39E+03	1.84E+03	6.20E+02	4.68E+02	3.84E+02	3.99E+02	4.36E+02
2013	1.51E+04	1.07E+04	2.75E+03	3.69E+03	6.82E+03	1.05E+03	3.67E+02	2.80E+02	2.03E+02	2.41E+02
2014	1.02E+04	1.24E+04	8.80E+03	2.17E+03	2.56E+03	4.57E+03	6.58E+02	2.14E+02	1.58E+02	8.67E+01
2015	6.24E+04	8.34E+03	1.01E+04	6.99E+03	1.42E+03	1.51E+03	2.71E+03	4.46E+02	1.20E+02	1.01E+02

Estimated population abundance at 1st Jan 2016

	0	1	2	3	4	5	6	7	8	9
	0.00E+00	5.11E+04	6.83E+03	7.94E+03	4.69E+03	8.77E+02	7.32E+02	1.93E+03	3.21E+02	7.40E+01

Taper weighted geometric mean of the VPA populations:

	0	1	2	3	4	5	6	7	8	9
	2.37E+04	1.94E+04	1.63E+04	1.27E+04	8.58E+03	5.26E+03	3.16E+03	1.74E+03	8.64E+02	4.18E+02

Standard error of the weighted Log(VPA populations) :

	0	1	2	3	4	5	6	7	8	9
	1.0889	1.0879	1.0855	1.0622	1.0649	1.0380	1.0191	1.0355	1.1488	1.3676

Log catchability residuals.

Fleet : SUMMER SURVEY

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	No data for this fleet at this age									
1	1.22	.27	-.14	-.20	.13	.17	.44	.21	-.26	.32
2	.16	.65	.05	-.16	.25	.30	.20	.19	.52	.23
3	.34	.18	-.40	1.52	.20	.40	.36	-.15	-.22	.04
4	-.45	.42	.03	-.53	-.71	.26	.11	.33	-.18	.17
5	-.21	-.06	.02	.07	-.20	-1.01	.09	.51	.23	.00
6	.19	.41	-.29	.06	.09	-.35	-.53	-.15	-.10	.74
7	-.04	-.37	.95	.28	.05	.00	-.36	-.30	-.45	.24
8	-.09	.14	.61	.43	.29	-.08	-.26	.40	-.75	-1.21

Age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	No data for this fleet at this age									
1	-.21	.05	.38	.57	.41	-2.28	-.49	-.32	-.06	-.21
2	.57	1.16	.03	-.17	.27	.22	-2.09	-2.20	-.44	.27
3	-.65	-.61	-.16	-.99	.39	.12	.10	-.35	-.22	.11
4	-.02	-.66	.22	.36	.47	-.27	.19	.32	-.20	.15
5	.05	-.27	-.71	.06	.06	-.05	-.36	.70	.28	.78
6	.26	.15	.00	-.28	.29	-.31	-.41	.25	.24	-.26
7	.32	.00	.28	.19	.09	-.32	-.05	-.14	-.10	-.62
8	-.50	-.68	.20	-.15	.19	-.17	-.60	.79	.07	.21

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,	-5.0345,	-5.4842,	-5.6978,	-5.6563,	-5.7041,	-5.7964,	-5.7964,	-5.7964,
S.E(Log q),	.6641,	.8064,	.5220,	.3637,	.4181,	.3231,	.3521,	.5034,

Table 5.8 Faroe haddock 2016 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
1,	.90,	.806,	5.48,	.77,	20,	.60,	-5.03,
2,	.83,	1.314,	6.14,	.76,	20,	.65,	-5.48,
3,	.94,	.662,	5.91,	.87,	20,	.50,	-5.70,
4,	.94,	1.084,	5.86,	.94,	20,	.34,	-5.66,
5,	.96,	.616,	5.81,	.92,	20,	.41,	-5.70,
6,	.94,	1.229,	5.91,	.96,	20,	.30,	-5.80,
7,	.96,	.621,	5.86,	.94,	20,	.34,	-5.82,
8,	1.09,	-1.034,	5.81,	.88,	20,	.54,	-5.85,

Fleet : SPRING SURVEY SHIFTE

Age	1993	1994	1995
0	-.57,	.98,	.91
1	-.46,	-.86,	.43
2	-.64,	-.74,	-.16
3	-.23,	-.24,	-.45
4	-.52,	-.40,	-.34
5	-.48,	-1.28,	-.44
6	.15,	-.62,	-.53
7	No data for this fleet at this age		
8	No data for this fleet at this age		

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	-1.09,	-.28,	-.35,	-.15,	.35,	.55,	.13,	-.32,	.94,	-.26
1	.63,	-.16,	-.11,	-.21,	-.31,	-.49,	.11,	.18,	.39,	.54
2	.38,	.45,	-2.05,	.28,	-.33,	.10,	-.05,	.04,	.16,	-.25
3	.43,	.28,	.07,	-.70,	-.70,	-.41,	-.16,	-.31,	-.17,	-.07
4	.23,	.33,	.06,	-.55,	-2.13,	-.31,	-.58,	.43,	-.26,	-.25
5	.83,	.43,	-.37,	-.20,	-1.34,	-1.13,	-.63,	-.14,	.44,	.12
6	-.33,	-.91,	-.46,	-.03,	-.78,	-.68,	-1.18,	-.59,	.20,	.30
7	No data for this fleet at this age									
8	No data for this fleet at this age									

Age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	.41,	-.02,	1.19,	.69,	-2.59,	-.67,	.27,	.16,	-.27,	.00
1	.22,	.53,	.63,	.82,	.11,	-1.78,	-.08,	-.04,	-.39,	.29
2	.87,	.12,	.59,	.16,	.71,	.58,	-1.28,	.31,	.69,	.06
3	-.38,	.39,	-.24,	.03,	.34,	.55,	.73,	.25,	.99,	.00
4	.25,	-.40,	.45,	-.32,	.32,	.43,	.91,	.72,	1.72,	.23
5	.53,	.17,	-.38,	-.09,	.44,	.41,	.48,	.71,	.86,	1.06
6	.95,	.44,	.28,	-.05,	.64,	1.55,	.83,	.96,	.94,	-1.07
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,	-6.0219,	-5.3341,	-5.8327,	-5.8721,	-6.0498,	-6.2134,	-6.4387,
S.E(Log q),	.8089,	.5742,	.6749,	.4384,	.7231,	.6814,	.7497,

Table 5.8 Faroe haddock 2016 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,     .89,     .804,      6.42,     .73,     23,     .73,   -6.02,
  1,    1.15,   -1.247,      4.71,     .77,     23,     .65,   -5.33,
  2,     .93,     .637,      6.08,     .79,     23,     .64,   -5.83,
  3,    1.03,    -.373,      5.78,     .89,     23,     .46,   -5.87,
  4,     .95,     .451,      6.18,     .79,     23,     .70,   -6.05,
  5,    1.02,    -.181,      6.17,     .78,     23,     .71,   -6.21,
  6,     .99,     .071,      6.45,     .75,     23,     .76,   -6.44,
1


 Terminal year survivor and F summaries :

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

 Year class = 2015

 Fleet,                 Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
     ,                  Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 SUMMER SURVEY       ,         1.,   .000,       .000,    .00,   0,  .000,     .000
 SPRING SURVEY SHIFTE,     51118.,   .826,       .000,    .00,   1, 1.000,     .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,
     51118.,       .83,      .00,    1,    .000,   .000


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

 Year class = 2014

 Fleet,                 Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
     ,                  Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 SUMMER SURVEY       ,      5536.,   .680,       .000,    .00,   1,  .331,     .000
 SPRING SURVEY SHIFTE,      7573.,   .478,       .268,    .56,   2,  .669,     .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,
      6828.,       .39,      .19,    3,    .478,   .000
```

Table 5.8 Faroe haddock 2016 xsa (cont.)

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

 Year class = 2013

 Fleet,                 Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
      ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 SUMMER SURVEY       ,      8543.,   .525,       .159,    .30,   2,  .254,     .040
 SPRING SURVEY SHIFTE,      7056.,   .393,       .175,    .44,   3,  .454,     .048

   F shrinkage mean  ,      8957.,    .50,,,,                         .292,     .038

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
      7942.,       .27,      .10,    6,    .370,   .043
 Age  3   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       ,      4106.,   .375,       .172,    .46,   3,  .303,     .225
 SPRING SURVEY SHIFTE,      5441.,   .295,       .157,    .53,   4,  .486,     .174

   F shrinkage mean  ,      4021.,    .50,,,,                         .211,     .229

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
      4688.,       .21,      .10,    8,    .496,   .200
Age  4   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       ,       701.,   .266,       .380,   1.43,   4,  .442,     .344
 SPRING SURVEY SHIFTE,      1259.,   .275,       .273,    .99,   5,  .374,     .206

   F shrinkage mean  ,       717.,    .50,,,,                         .184,     .337

 Weighted prediction :
```

```
Survivors,        Int,      Ext,    N,    Var,     F
at end of year,   s.e,      s.e,     ,   Ratio,
      877.,       .18,      .21,   10,  1.138,   .284
```

Table 5.8 Faroe haddock 2016 xsa (cont.)

```
Age  5   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       ,       624.,   .230,       .487,   2.12,   5,  .466,     .595
 SPRING SURVEY SHIFTE,       609.,   .260,       .617,   2.37,   6,  .323,     .606

   F shrinkage mean  ,      1381.,    .50,,,,                         .210,     .313

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
       732.,       .17,      .33,   12,   1.914,   .526


Age  6   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       ,      2011.,   .193,       .122,    .63,   6,  .586,     .135
 SPRING SURVEY SHIFTE,      2710.,   .249,       .272,   1.09,   7,  .286,     .102

   F shrinkage mean  ,       745.,    .50,,,,                         .128,     .330

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
      1928.,       .15,      .16,   14,   1.093,   .141


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

 Year class = 2008

 Fleet,                 Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
     ,                  Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 SUMMER SURVEY       ,       330.,   .177,       .195,   1.10,   7,  .676,     .126
 SPRING SURVEY SHIFTE,       702.,   .264,       .072,    .27,   7,  .196,     .061

   F shrinkage mean  ,        84.,    .50,,,,                         .128,     .425

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
       321.,       .15,      .20,   15,   1.363,   .129
```

Table 5.8 Faroe haddock 2016 xsa (cont.)

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

 Year class = 2007

 Fleet,                 Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
     ,                  Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 SUMMER SURVEY       ,        76.,   .179,       .089,    .49,   8,  .663,     .278
 SPRING SURVEY SHIFTE,       122.,   .264,       .115,    .44,   7,  .145,     .182

   F shrinkage mean  ,        45.,    .50,,,,                        .192,     .430

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
        74.,       .16,      .10,   16,    .621,   .285


 Age  9   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       ,        55.,   .177,       .113,    .64,   8,  .626,     .323
 SPRING SURVEY SHIFTE,        94.,   .260,       .112,    .43,   7,  .145,     .199

   F shrinkage mean  ,        66.,    .50,,,,                        .229,     .275

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
        62.,       .16,      .08,   16,    .509,   .291
```

Table 5.9 Faroe haddock. Fishing mortality (F) at age.

Run title : FAROE HADDOCK (ICES DIVISION 5.b) HAD_IND

At 29/04/2016 11:08

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR,	1957,	1958,	1959,	1960,	1961,	1962,	1963,	1964,	1965,
AGE									
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0010,	.0024,	.0132,	.0150,	.0219,	.0149,	.0106,	.0018,	.0017,
2,	.1394,	.1939,	.1066,	.2074,	.1875,	.3232,	.3801,	.0876,	.0691,
3,	.3707,	.4378,	.3860,	.4599,	.4162,	.5866,	.5639,	.3723,	.2354,
4,	.6163,	.5737,	.4782,	.6926,	.4209,	.5980,	.7261,	.5193,	.4767,
5,	.3909,	.5386,	.4195,	.5260,	.4387,	.3480,	.5591,	.5369,	.3678,
6,	.4380,	.6346,	.6458,	.6591,	.5879,	.6706,	.4026,	.6107,	.5882,
7,	.6340,	.9504,	.9184,	1.2130,	.9483,	1.0499,	1.2493,	.3375,	.9618,
8,	.5599,	.7839,	.8206,	.9667,	.8742,	.9736,	1.1139,	1.2027,	2.3618,
9,	.5321,	.7028,	.6625,	.8198,	.6600,	.7351,	.8185,	.6472,	.9619,
+gp,	.5321,	.7028,	.6625,	.8198,	.6600,	.7351,	.8185,	.6472,	.9619,
FBAR 3- 7,	.4900,	.6270,	.5696,	.7101,	.5624,	.6506,	.7002,	.4753,	.5260,

Table 8 Fishing mortality (F) at age

YEAR,	1966,	1967,	1968,	1969,	1970,	1971,	1972,	1973,	1974,	1975,
AGE										
0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0032,	.0012,	.0014,	.0024,	.0033,	.0015,	.0016,	.0114,	.0033,	.0015,
2,	.0610,	.0641,	.1261,	.0860,	.0551,	.0526,	.0253,	.1677,	.1266,	.1230,
3,	.2370,	.1873,	.2647,	.2363,	.2528,	.1936,	.4226,	.4320,	.2172,	.2650,
4,	.4515,	.2971,	.3483,	.5320,	.3344,	.4186,	.2853,	.2392,	.3730,	.2412,
5,	.5006,	.2997,	.2847,	.3330,	.3639,	.2754,	.4517,	.3143,	.1279,	.2116,
6,	.5421,	.5406,	.4540,	.4975,	.5561,	.5560,	.1495,	.2703,	.1714,	.0957,
7,	.9128,	.6906,	.8367,	.8277,	.8740,	.8385,	.6721,	.1951,	.2134,	.0859,
8,	.7509,	.6634,	.5851,	1.0631,	.5430,	.4224,	.4066,	.2907,	.1433,	.1599,
9,	.6373,	.5022,	.5057,	.6566,	.5386,	.5061,	.3957,	.2633,	.2068,	.1595,
+gp,	.6373,	.5022,	.5057,	.6566,	.5386,	.5061,	.3957,	.2633,	.2068,	.1595,
FBAR 3- 7,	.5288,	.4031,	.4377,	.4853,	.4762,	.4564,	.3962,	.2902,	.2206,	.1799,

Table 8 Fishing mortality (F) at age

YEAR,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,	1985,
AGE										

0,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,	.0000,
1,	.0014,	.0000,	.0000,	.0002,	.0000,	.0000,	.0000,	.0000,	.0006,	.0000,
2,	.0908,	.0108,	.0010,	.0004,	.0325,	.0237,	.0383,	.0252,	.0329,	.0280,
3,	.1878,	.1128,	.0547,	.0458,	.0285,	.1374,	.4618,	.1917,	.1167,	.1695,
4,	.3810,	.1815,	.1665,	.1255,	.2025,	.1314,	.3709,	.3481,	.3896,	.2392,
5,	.2216,	.5273,	.2116,	.1913,	.2750,	.2112,	.2918,	.3498,	.2171,	.3475,
6,	.2871,	.7246,	.3820,	.1409,	.2136,	.2264,	.2775,	.1383,	.3336,	.4163,
7,	.1601,	.3904,	.5760,	.2721,	.1702,	.2004,	.2524,	.2991,	.0853,	.2084,
8,	.2539,	.3788,	.4969,	.3303,	.3954,	.0920,	.2266,	.3102,	.2929,	.1720,
9,	.2621,	.4437,	.3690,	.2130,	.2526,	.1730,	.2854,	.2907,	.2651,	.2782,
+gp,	.2621,	.4437,	.3690,	.2130,	.2526,	.1730,	.2854,	.2907,	.2651,	.2782,
FBAR 3- 7,	.2476,	.3873,	.2782,	.1551,	.1780,	.1814,	.3309,	.2654,	.2285,	.2762,

Table 5.9 Faroe haddock. Fishing mortality (F) at age (cont.).

Table 8 Fishing mortality (F) at age

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
AGE										
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0061	.0000	.0000
2	.0097	.0337	.0394	.0050	.0125	.0290	.0167	.0709	.0489	.0094
3	.0941	.0927	.0680	.1207	.1313	.1654	.0745	.1662	.1645	.1053
4	.2491	.1846	.1863	.1363	.2211	.2724	.1782	.1842	.2582	.3128
5	.2598	.2623	.2368	.3328	.2335	.2185	.2763	.1865	.1484	.3077
6	.3589	.3082	.3062	.3210	.3575	.3178	.2604	.2067	.2122	.1846
7	.1573	.4748	.2083	.5175	.4240	.4045	.2681	.1979	.2518	.2248
8	.5179	.5848	.2381	.3887	.4633	.2690	.2310	.1588	.2433	.2712
9	.3104	.3653	.2363	.3414	.3420	.2981	.2440	.1876	.2239	.2616
+gp	.3104	.3653	.2363	.3414	.3420	.2981	.2440	.1876	.2239	.2616
FBAR 3- 7	.2239	.2645	.2011	.2857	.2735	.2757	.2115	.1883	.2070	.2271

Table 8 Fishing mortality (F) at age

YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE										
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0001	.0000	.0000	.0004	.0006	.0003	.0000	.0000	.0003	.0000
2	.0081	.0096	.0319	.0125	.0793	.0487	.0284	.0036	.0098	.0112
3	.0781	.0929	.1756	.5561	.3159	.2431	.2175	.0833	.0684	.0860
4	.3651	.2222	.2423	.2349	.1828	.4449	.3701	.3376	.1604	.1815
5	.4181	.4700	.3352	.3528	.2667	.2255	.4139	.5493	.4738	.3550
6	.3819	.5291	.6169	.3954	.3519	.2836	.2711	.6838	.6303	.5710
7	.3596	.5598	1.2984	.7509	.2940	.2495	.2385	.6277	.7269	.6928
8	.3310	.3643	1.0446	1.9269	.6496	.2253	.2923	.6158	.8732	.6332
9	.3668	.4951	.7948	.7283	.3225	.2750	.2820	.5484	.7272	.7676
+gp	.3668	.4951	.7948	.7283	.3225	.2750	.2820	.5484	.7272	.7676
FBAR 3- 7	.3206	.3748	.5337	.4580	.2823	.2893	.3023	.4563	.4119	.3773

Table 8 Fishing mortality (F) at age

YEAR	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
AGE										
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0000	.0000	.0024	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.0367	.0276	.0278	.0131	.1073	.0162	.0020	.0340	.0303	.0428
3	.0749	.2000	.0962	.1884	.3082	.3216	.1199	.1659	.2242	.1995

4,	.1844,	.1238,	.2914,	.2786,	.3974,	.3871,	.3674,	.1999,	.3250,	.2839,
5,	.2866,	.3057,	.1333,	.2875,	.3179,	.3244,	.3257,	.2633,	.3227,	.5263,
6,	.5413,	.4150,	.2681,	.2372,	.4381,	.3634,	.3140,	.3374,	.1880,	.1408,
7,	.6995,	.5909,	.3915,	.3415,	.4334,	.4919,	.4369,	.3686,	.3779,	.1294,
8,	.3657,	.5473,	.5931,	.2924,	.3784,	.5499,	.3018,	.6516,	.2527,	.2853,
9,	.6209,	.4352,	.2943,	.2545,	.2867,	.3385,	.5687,	.3931,	.2123,	.2909,
+gp,	.6209,	.4352,	.2943,	.2545,	.2867,	.3385,	.5687,	.3931,	.2123,	.2909,
FBAR 3- 7,	.3573,	.3271,	.2361,	.2666,	.3790,	.3777,	.3128,	.2670,	.2876,	.2560,

Table 5.10 Faroe haddock. Stock number (N) at age.

Run title : FAROE HADDOCK (ICES DIVISION 5.b) HAD_IND

At 29/04/2016 11:08

Terminal Fs derived using XSA (With F shrinkage)

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

YEAR,	1957,	1958,	1959,	1960,	1961,	1962,	1963,	1964,	1965,
AGE									
0,	64927,	54061,	77651,	58761,	71715,	45399,	33843,	30192,	37948,
1,	47944,	53158,	44261,	63576,	48109,	58715,	37170,	27709,	24719,
2,	35106,	39212,	43417,	35763,	51279,	38537,	47362,	30110,	22644,
3,	25440,	25003,	26445,	31954,	23796,	34806,	22837,	26515,	22585,
4,	20280,	14377,	13213,	14717,	16517,	12850,	15850,	10638,	14961,
5,	5517,	8965,	6632,	6706,	6028,	8877,	5786,	6278,	5182,
6,	2786,	3055,	4284,	3570,	3245,	3182,	5132,	2708,	3005,
7,	1377,	1472,	1326,	1839,	1512,	1476,	1332,	2809,	1204,
8,	585,	598,	466,	433,	448,	480,	423,	313,	1641,
9,	252,	274,	224,	168,	135,	153,	148,	114,	77,
+gp,	154,	227,	106,	54,	29,	46,	45,	16,	14,
TOTAL,	204367,	200401,	218024,	217540,	222811,	204522,	169929,	137402,	133981,

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

YEAR,	1966,	1967,	1968,	1969,	1970,	1971,	1972,	1973,	1974,	1975,
AGE										
0,	81923,	47768,	53237,	23136,	49621,	35418,	78970,	104847,	83625,	39127,
1,	31069,	67073,	39109,	43587,	18942,	40627,	28998,	64655,	85842,	68466,
2,	20203,	25356,	54851,	31975,	35600,	15457,	33213,	23702,	52333,	70052,
3,	17302,	15563,	19470,	39587,	24022,	27583,	12006,	26513,	16410,	37750,
4,	14613,	11176,	10566,	12234,	25590,	15275,	18608,	6442,	14092,	10812,
5,	7604,	7617,	6798,	6106,	5884,	14996,	8229,	11454,	4152,	7946,
6,	2937,	3774,	4622,	4187,	3583,	3348,	9322,	4288,	6849,	2992,
7,	1366,	1398,	1800,	2403,	2084,	1682,	1572,	6572,	2680,	4724,
8,	377,	449,	574,	638,	860,	712,	595,	657,	4427,	1772,
9,	127,	146,	189,	262,	180,	409,	382,	325,	402,	3141,
+gp,	21,	36,	33,	45,	26,	281,	319,	52,	865,	1396,
TOTAL,	177542,	180355,	191249,	164160,	166393,	155787,	192213,	249509,	271678,	248178,

Terminal Fs derived using XSA (With F shrinkage)

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

YEAR,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,	1985,
AGE										

0,	52360,	4153,	7376,	5208,	23620,	29255,	60791,	58809,	39475,	14060,
1,	32035,	42868,	3400,	6039,	4264,	19339,	23952,	49772,	48148,	32319,
2,	55970,	26192,	35098,	2784,	4944,	3491,	15833,	19610,	40750,	39398,
3,	50715,	41847,	21213,	28707,	2278,	3918,	2791,	12475,	15656,	32282,
4,	23712,	34412,	30607,	16443,	22452,	1813,	2796,	1440,	8432,	11406,
5,	6955,	13262,	23498,	21215,	11874,	15012,	1301,	1580,	832,	4676,
6,	5265,	4562,	6408,	15570,	14345,	7385,	9951,	796,	912,	548,
7,	2226,	3235,	1810,	3581,	11073,	9486,	4821,	6173,	567,	535,
8,	3549,	1553,	1792,	833,	2233,	7647,	6356,	3067,	3747,	427,
9,	1237,	2254,	870,	893,	490,	1231,	5711,	4149,	1841,	2289,
+gp,	1515,	2613,	1109,	424,	423,	249,	946,	3460,	4566,	4400,
TOTAL,	235538,	176951,	133181,	101696,	97996,	98825,	135250,	161330,	164927,	142340,

Table 5.10 Faroe haddock. Stock number (N) at age (cont.).

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

YEAR,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,	1995,
AGE										
0,	27960,	20970,	13967,	4444,	3984,	2723,	9619,	141703,	66628,	13321,
1,	11512,	22892,	17169,	11436,	3638,	3262,	2229,	7875,	116016,	54551,
2,	26461,	9425,	18742,	14057,	9363,	2979,	2671,	1825,	6409,	94985,
3,	31365,	21456,	7460,	14752,	11452,	7570,	2369,	2150,	1392,	4996,
4,	22310,	23373,	16012,	5706,	10705,	8222,	5254,	1800,	1491,	967,
5,	7351,	14238,	15911,	10881,	4077,	7026,	5127,	3599,	1226,	943,
6,	2705,	4642,	8968,	10279,	6387,	2643,	4623,	3184,	2445,	865,
7,	296,	1547,	2792,	5406,	6105,	3657,	1575,	2917,	2120,	1619,
8,	355,	207,	788,	1856,	2638,	3271,	1998,	986,	1960,	1349,
9,	294,	173,	95,	508,	1030,	1359,	2047,	1298,	689,	1258,
+gp,	2929,	1197,	668,	307,	409,	136,	822,	1189,	1650,	1408,
TOTAL,	133538,	120120,	102572,	79633,	59787,	42848,	38332,	168528,	202026,	176262,

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

YEAR,	1996,	1997,	1998,	1999,	2000,	2001,	2002,	2003,	2004,	2005,
AGE										
0,	5566,	23046,	31610,	151922,	89144,	61342,	41236,	12594,	11316,	4603,
1,	10906,	4557,	18869,	25880,	124383,	72985,	50223,	33761,	10311,	9265,
2,	44662,	8928,	3731,	15448,	21180,	101770,	59738,	41119,	27641,	8439,
3,	77040,	36271,	7240,	2959,	12491,	16019,	79359,	47538,	33545,	22411,
4,	3682,	58339,	27061,	4973,	1389,	7457,	10285,	52271,	35812,	25648,
5,	579,	2092,	38248,	17388,	3219,	947,	3913,	5816,	30534,	24975,
6,	567,	312,	1071,	22396,	10004,	2019,	619,	2118,	2749,	15566,

7,	589,	317,	150,	473,	12348,	5761,	1245,	386,	875,	1198,
8,	1059,	337,	148,	34,	183,	7534,	3675,	803,	169,	346,
9,	842,	623,	191,	43,	4,	78,	4924,	2246,	355,	58,
+gp,	1407,	1446,	997,	405,	283,	82,	147,	2393,	1711,	313,
TOTAL,	146900,	136268,	129316,	241920,	274627,	275995,	255364,	201045,	155018,	112822,

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

YEAR,	2006,	2007,	2008,	2009,	2010,	2011,	2012,	2013,	2014,	2015,	2016,
AGE											
0,	3966,	3432,	6301,	17390,	6731,	4097,	13129,	15105,	10186,	62435,	0,
1,	3769,	3247,	2810,	5159,	14238,	5511,	3354,	10749,	12367,	8340,	51118,
2,	7585,	3085,	2659,	2295,	4224,	11657,	4512,	2746,	8801,	10125,	6828,
3,	6833,	5987,	2457,	2117,	1854,	3106,	9390,	3687,	2173,	6990,	7942,
4,	16836,	5191,	4013,	1827,	1436,	1116,	1844,	6819,	2557,	1422,	4688,
5,	17514,	11463,	3755,	2455,	1132,	790,	620,	1045,	4572,	1512,	877,
6,	14338,	10766,	6913,	2690,	1508,	675,	468,	367,	658,	2710,	732,
7,	7200,	6832,	5820,	4329,	1738,	797,	384,	280,	214,	446,	1928,
8,	491,	2929,	3098,	3221,	2519,	922,	399,	203,	158,	120,	321,
9,	151,	279,	1387,	1402,	1969,	1413,	436,	241,	87,	101,	74,
+gp,	165,	28,	168,	235,	701,	715,	287,	401,	276,	87,	115,
TOTAL,	78847,	53237,	39381,	43120,	38048,	30797,	34822,	41644,	42048,	94289,	74622,

Table 5.11. Faroe haddock. Stock summary of the 2016 VPA.

Run title : FAROE HADDOCK (ICES DIVISION 5.b)			HAD_IND				
14/04/2016	16:59						
Table 16	Summary	(without SOP correction)					
	Terminal Fs derived using XSA (With F shrinkage)						
	RECRUIT	RECRU	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	45399	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	81923	20203	68774	44027	18766	0.4262	0.5288
1967	47768	25356	77101	42086	13381	0.3179	0.4031
1968	53237	54851	87971	45495	17852	0.3924	0.4377
1969	23136	31975	94878	53583	23272	0.4343	0.4853
1970	49621	35600	92142	59957	21361	0.3563	0.4762
1971	35418	15457	92929	63920	19393	0.3034	0.4564
1972	78970	33213	91506	63133	16485	0.2611	0.3962
1973	104847	23702	98976	61620	18035	0.2927	0.2902
1974	83625	52333	116873	64629	14773	0.2286	0.2206
1975	39127	70052	138898	75403	20715	0.2747	0.1799
1976	52360	55970	143617	89217	26211	0.2938	0.2476
1977	4153	26192	121035	96371	25555	0.2652	0.3873
1978	7376	35098	120568	97225	19200	0.1975	0.2782
1979	5208	2784	99492	85392	12424	0.1455	0.1551
1980	23620	4944	87629	81895	15016	0.1834	0.178
1981	29255	3491	78954	75838	12233	0.1613	0.1814
1982	60791	15833	68298	56797	11937	0.2102	0.3309
1983	58809	19610	63951	51803	12894	0.2489	0.2654
1984	39475	40750	100634	53808	12378	0.23	0.2285
1985	14060	39398	93926	62576	15143	0.242	0.2762
1986	27960	26461	98457	65563	14477	0.2208	0.2239
1987	20970	9425	87574	67247	14882	0.2213	0.2645
1988	13967	18742	77340	61842	12178	0.1969	0.2011
1989	4444	14057	69437	51668	14325	0.2773	0.2857
1990	3984	9363	53438	43617	11726	0.2688	0.2735
1991	2723	2979	38613	34532	8429	0.2441	0.2757
1992	9619	2671	28972	26835	5476	0.2041	0.2115
1993	141703	1825	28639	23072	4026	0.1745	0.1883
1994	66628	6409	27298	21444	4252	0.1983	0.207
1995	13321	94985	86938	22571	4948	0.2192	0.2271
1996	5566	44662	111696	49203	9642	0.196	0.3206
1997	23046	8928	106263	81257	17924	0.2206	0.3748
1998	31610	3731	91219	80936	22210	0.2744	0.5337
1999	151922	15448	78812	61819	18482	0.299	0.458
2000	89144	21180	107887	51599	15821	0.3066	0.2823
2001	61342	101770	143907	59520	15890	0.267	0.2893
2002	41236	59738	150576	83361	24933	0.2991	0.3023
2003	12594	41119	137270	95070	27072	0.2848	0.4563
2004	11316	27641	124158	85459	23101	0.2703	0.4119
2005	4603	8439	88241	72052	20455	0.2839	0.3773
2006	3966	7585	64448	57336	17154	0.2992	0.3573
2007	3432	3085	46441	42218	12631	0.2992	0.3271
2008	6301	2659	33351	29458	7388	0.2508	0.2361
2009	17390	2295	24503	22676	5197	0.2292	0.2666
2010	6731	4224	20905	17439	5202	0.2983	0.379
2011	4097	11657	18478	11917	3540	0.2971	0.3777
2012	13129	4512	16375	12376	2634	0.2128	0.3128
2013	15105	2746	16814	14903	2950	0.1979	0.267
2014	10186	8801	18411	14082	3276	0.2326	0.2876
2015	62435	10125	25984	17455	3395	0.1945	0.256
Arith.							
Mean	40914	25890	99094	68560	15339	0.2501	0.2915
Units	(Thousands)	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 5.12. Management options table INPUT DATA descriptions.

Stock size

The stock in numbers 2016 is taken directly from the 2016 XSA. The yearclass 2015 at age 2 (in 2017) is estimated from the 2016 XSA age 1 applying a natural mortality of 0.2in forward calculation of the number using the standard VPA equation. The yearclass 2016 at age 2 (in 2018) is estimated as the geomean of the numbers-at-age 2 since 2005.

Age	2016	2017	2018
2	6828	41852	5930
3	7942		
4	4688		
5	877		
6	732		
7	1928		
8	321		
9	74		
10+	115		

Numbers in thousands (predicted values rounded).

Proportion mature at age

The proportion mature at age in 2016 is estimated as the average of the observed data in 2015 and 2016. For 2017 and 2018, the average of 2014–2016 is used.

Age	2016	2017	2018
2	0.18	0.18	0.18
3	0.89	0.87	0.87
4	1.00	1.00	1.00
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 5.12. 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 2016–2018 are simply the average of the estimated point-values for 2013–2015 not re-scaled to 2015 since most weights have been fluctuating without any trend during the last 3 years (no model was available to predict future mean weights at age).

Age	2016	2017	2018
2	0.552	0.552	0.552
3	0.874	0.874	0.874
4	1.122	1.122	1.122
5	1.486	1.486	1.486
6	1.711	1.711	1.711
7	2.031	2.031	2.031
8	1.920	1.920	1.920
9	1.977	1.977	1.977
10+	2.070	2.070	2.070

Exploitation pattern

The exploitation pattern 2016 is estimated like last year as the average fishing mortality matrix in the 3 preceding years (2013-2015) from the final VPA in 2016, without re-scaling to the terminal year (2015) 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	2016	2017	2018
2	0.0357	0.0357	0.0357
3	0.1965	0.1965	0.1965
4	0.2696	0.2696	0.2696
5	0.3708	0.3708	0.3708
6	0.2221	0.2221	0.2221
7	0.2920	0.2920	0.2920
8	0.3965	0.3965	0.3965
9	0.2988	0.2988	0.2988
10+	0.2988	0.2988	0.2988

Table 5.13 Faroe haddock. Management option table - Input data

MFDP version 1
Run: jr1
Time and date: 15:31 20/04/2016
Fbar age range: 3-7

2016

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	6828	0.2	0.18	0	0	0.552	0.036	0.552
3	7942	0.2	0.89	0	0	0.874	0.197	0.874
4	4688	0.2	1	0	0	1.222	0.270	1.222
5	877	0.2	1	0	0	1.486	0.371	1.486
6	732	0.2	1	0	0	1.711	0.222	1.711
7	1928	0.2	1	0	0	2.031	0.292	2.031
8	321	0.2	1	0	0	1.920	0.397	1.920
9	74	0.2	1	0	0	1.977	0.299	1.977
10	115	0.2	1	0	0	2.070	0.299	2.070

2017

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	41852	0.2	0.18	0	0	0.552	0.036	0.552
3	.	0.2	0.87	0	0	0.874	0.197	0.874
4	.	0.2	1	0	0	1.222	0.270	1.222
5	.	0.2	1	0	0	1.486	0.371	1.486
6	.	0.2	1	0	0	1.711	0.222	1.711
7	.	0.2	1	0	0	2.031	0.292	2.031
8	.	0.2	1	0	0	1.920	0.397	1.920
9	.	0.2	1	0	0	1.977	0.299	1.977
10	.	0.2	1	0	0	2.070	0.299	2.070

2018

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	5930	0.2	0.18	0	0	0.552	0.036	0.552
3	.	0.2	0.87	0	0	0.874	0.197	0.874
4	.	0.2	1	0	0	1.222	0.270	1.222
5	.	0.2	1	0	0	1.486	0.371	1.486
6	.	0.2	1	0	0	1.711	0.222	1.711
7	.	0.2	1	0	0	2.031	0.292	2.031
8	.	0.2	1	0	0	1.920	0.397	1.920
9	.	0.2	1	0	0	1.977	0.299	1.977
10	.	0.2	1	0	0	2.070	0.299	2.070

Input units are thousands and kg - output in tonnes

Table 5.14 Faroe haddock. Management option table - Results

MFDP version 1
Run: jr1
Index file 20/04/2016
Time and date: 15:31 20/04/2016
Fbar age range: 3-7

2016				
Biomass	SSB	FMult	FBar	Landings
23910	20056	1	0.2702	4251

2017					2018	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
43375	23818	0	0	0	53195	46619
.	23818	0.1	0.027	597	52532	45970
.	23818	0.2	0.054	1178	51887	45338
.	23818	0.3	0.0811	1745	51257	44723
.	23818	0.4	0.1081	2297	50643	44123
.	23818	0.5	0.1351	2835	50045	43538
.	23818	0.6	0.1621	3359	49461	42968
.	23818	0.7	0.1891	3870	48892	42412
.	23818	0.8	0.2161	4368	48337	41871
.	23818	0.9	0.2432	4854	47795	41342
.	23818	1	0.2702	5328	47267	40827
.	23818	1.1	0.2972	5790	46751	40325
.	23818	1.2	0.3242	6240	46247	39835
.	23818	1.3	0.3512	6680	45756	39356
.	23818	1.4	0.3783	7109	45276	38890
.	23818	1.5	0.4053	7527	44807	38434
.	23818	1.6	0.4323	7936	44350	37990
.	23818	1.7	0.4593	8335	43903	37556
.	23818	1.8	0.4863	8724	43466	37132
.	23818	1.9	0.5134	9104	43039	36719
.	23818	2	0.5404	9476	42622	36315

Input units are thousands and kg - output in tonnes

Table 5.15 **Faroe haddock. Long-term Prediction - Input data**

MFYPR version 1
Run: jr2
Index file 20/04/2016
Time and date: 16:20 20/04/2016
Fbar age range: 3-7

Age	M	Mat	PF	PM	SWt	Sel	CWt
2	0.2	0.064	0	0	0.569	0.036	0.569
3	0.2	0.527	0	0	0.809	0.197	0.809
4	0.2	0.926	0	0	1.075	0.270	1.075
5	0.2	0.993	0	0	1.376	0.371	1.376
6	0.2	0.999	0	0	1.650	0.222	1.650
7	0.2	1.000	0	0	1.913	0.292	1.913
8	0.2	1.000	0	0	2.117	0.397	2.117
9	0.2	1.000	0	0	2.333	0.299	2.333
10	0.2	1.000	0	0	2.629	0.299	2.629

Weights in kilograms

Table 5.16 **Faroe haddock. Long-term Prediction - Results**

MFYPR version 1
Run: jr2
Time and date: 16:20 20/04/2016
Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0	0	0	0	5.5167	8.2937	4.1398	7.3883	4.1398	7.3883
0.1	0.027	0.1035	0.1726	5.0011	7.0969	3.6269	6.1942	3.6269	6.1942
0.2	0.054	0.1831	0.2925	4.605	6.2018	3.2336	5.3018	3.2336	5.3018
0.3	0.0811	0.2463	0.378	4.2911	5.5115	2.9224	4.614	2.9224	4.614
0.4	0.1081	0.2976	0.4402	4.0362	4.9658	2.6701	4.0708	2.6701	4.0708
0.5	0.1351	0.3403	0.4863	3.8248	4.5256	2.4613	3.6331	2.4613	3.6331
0.6	0.1621	0.3763	0.5208	3.6467	4.1643	2.2857	3.2743	2.2857	3.2743
0.7	0.1891	0.4071	0.547	3.4943	3.8634	2.1359	2.9758	2.1359	2.9758
0.8	0.2161	0.4338	0.567	3.3625	3.6096	2.0065	2.7243	2.0065	2.7243
0.9	0.2432	0.4572	0.5824	3.2472	3.3931	1.8936	2.5101	1.8936	2.5101
1	0.2702	0.4779	0.5943	3.1454	3.2066	1.7942	2.3259	1.7942	2.3259
1.1	0.2972	0.4963	0.6035	3.0548	3.0445	1.7061	2.166	1.7061	2.166
1.2	0.3242	0.5129	0.6107	2.9737	2.9024	1.6272	2.0261	1.6272	2.0261
1.3	0.3512	0.5278	0.6162	2.9005	2.777	1.5564	1.9029	1.5564	1.9029
1.4	0.3783	0.5414	0.6205	2.8341	2.6656	1.4922	1.7937	1.4922	1.7937
1.5	0.4053	0.5538	0.6238	2.7736	2.5661	1.434	1.6962	1.434	1.6962
1.6	0.4323	0.5652	0.6263	2.7181	2.4767	1.3808	1.6089	1.3808	1.6089
1.7	0.4593	0.5757	0.6282	2.6672	2.3959	1.332	1.5302	1.332	1.5302
1.8	0.4863	0.5854	0.6296	2.6201	2.3227	1.287	1.4589	1.287	1.4589
1.9	0.5134	0.5944	0.6306	2.5765	2.2559	1.2456	1.3941	1.2456	1.3941
2	0.5404	0.6028	0.6312	2.5359	2.1949	1.2071	1.335	1.2071	1.335

Reference point	F multiplier	Absolute F
Fbar(3-7)	1	0.2702
FMax	2.2356	0.604
F0.1	0.7341	0.1984
F35%SPR	0.8628	0.2331
Flow	-99	
Fmed	0.812	0.2194
Fhigh	3.0515	0.8245

Weights in kilograms

Table 5.17 Haddock biomass (age 2+) 1914-2015 in tons. Year label is sum of first row and first column.

	1900	1925	1950	1975	2000
0		51433	81427	138898	107887
1		62983	67514	143617	143907
2		61870	66118	121035	150576
3		49631	73973	120568	137270
4		41313	75493	99492	124158
5		38518	88337	87629	88241
6		38412	91960	78954	64448
7		41379	90264	68298	46441
8		32637	92975	63951	33351
9		36717	89969	100634	24503
10		42386	96422	93926	20905
11		48161	93296	98457	18478
12		63897	98262	87574	16375
13		63738	90204	77340	16814
14	68122	50969	75561	69437	18411
15	60228	67182	71884	53438	25984
16	59115	84454	68774	38613	
17	58850	113753	77101	28972	
18	145265	103316	87971	28639	
19	195704	97594	94878	27298	
20	92229	90918	92142	86938	
21	101713	126946	92929	111696	
22	63831	103104	91506	106263	
23	61076	91342	98976	91219	
24	44757	80374	116873	78812	

5.18 Figures

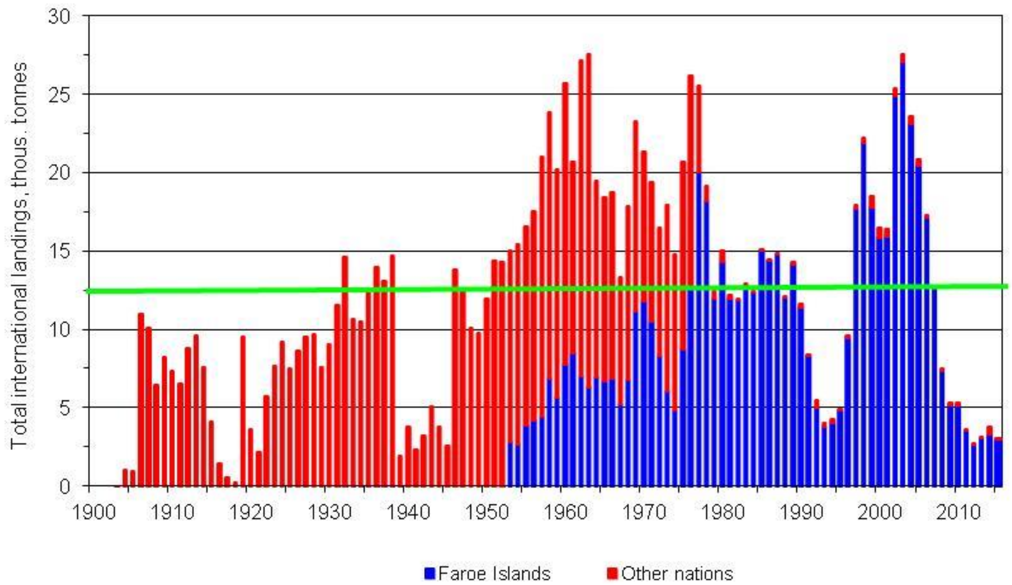


Figure 5.1. Haddock in ICES Division 5.b. Landings by all nations 1904–2015. Horisontal line average for the whole period.

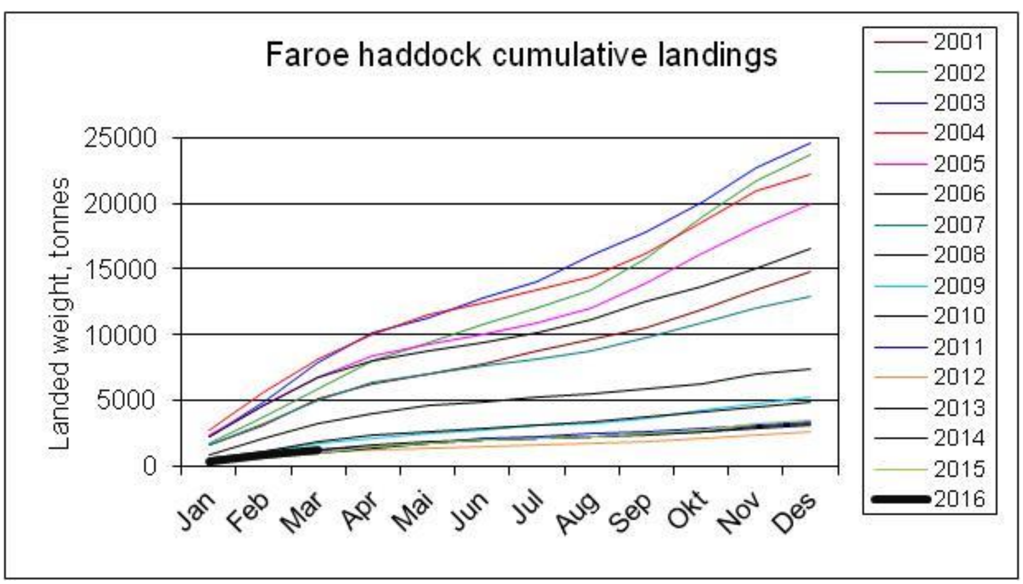


Figure 5.2. Faroe haddock. Cumulative Faroese landings from 5.b.

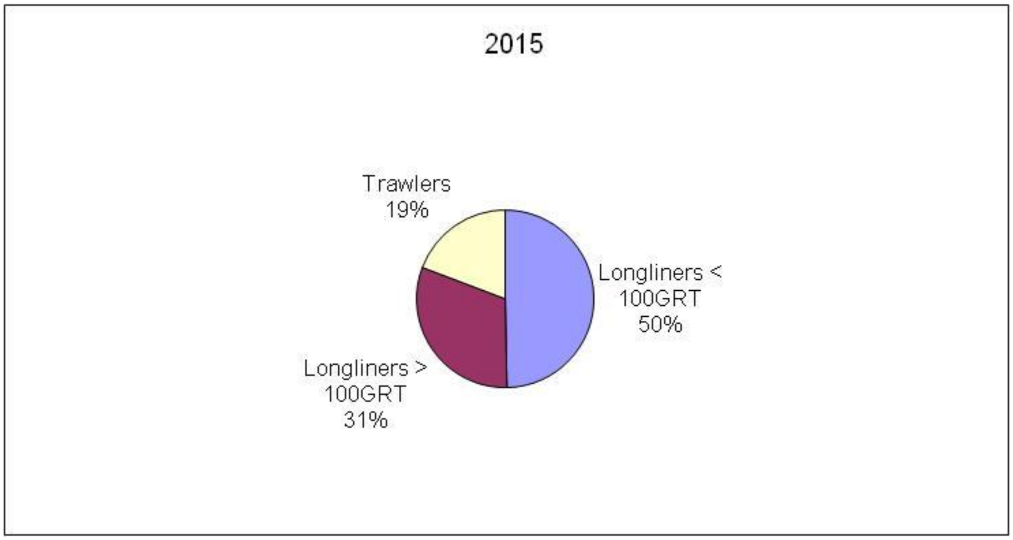


Figure 5.3. Faroe haddock. Contribution (%) by fleet to the total Faroese landings 2015.

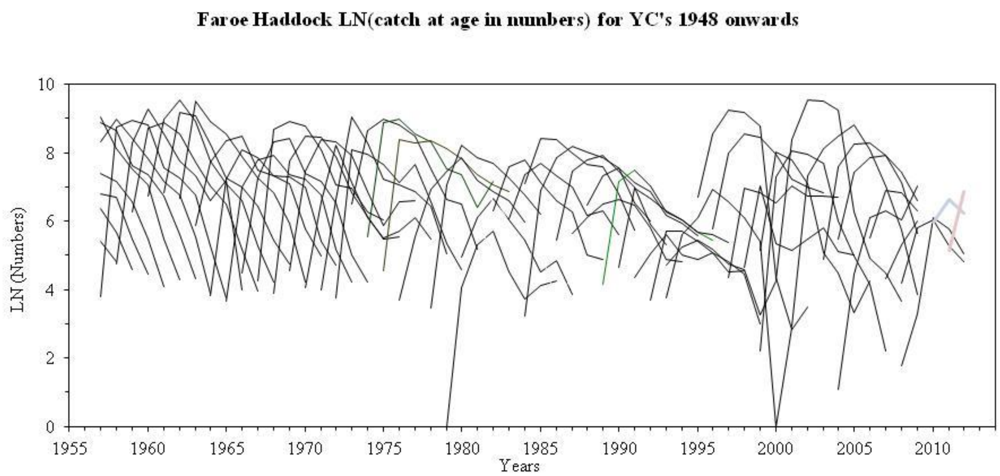


Figure 5.4.

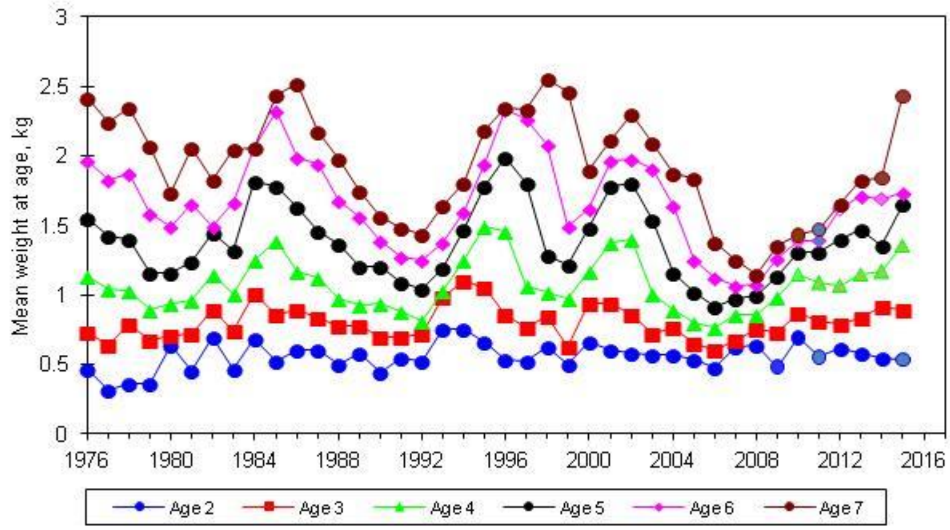


Figure 5.5. Faroe haddock. Mean weight at age (2-7).

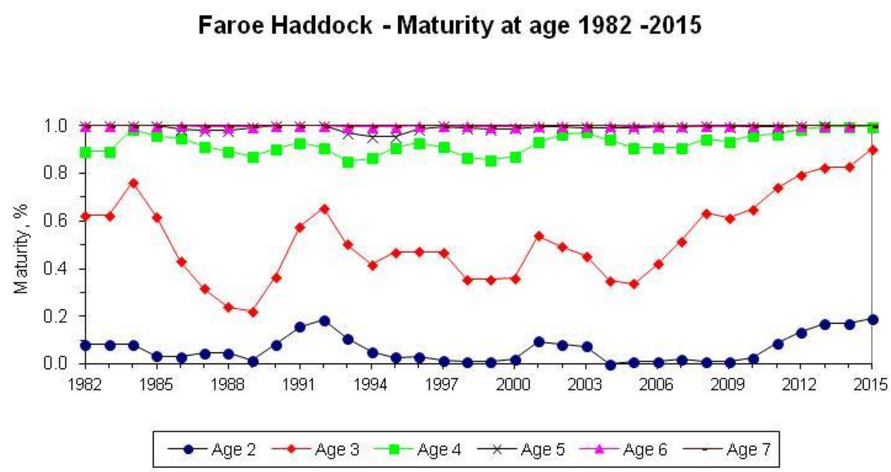


Figure 5.6. Faroe haddock. Maturity-at-age since 1982. Running 3–years average of survey observations.

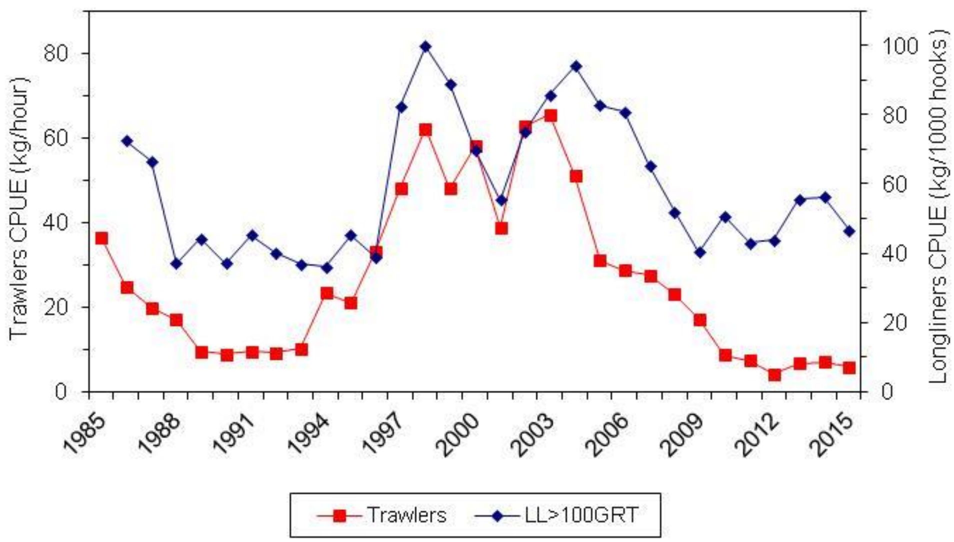


Figure 5.7. Commercial cpue's for Pairtrawlers > 1000 HP and longliners > 100 HP.

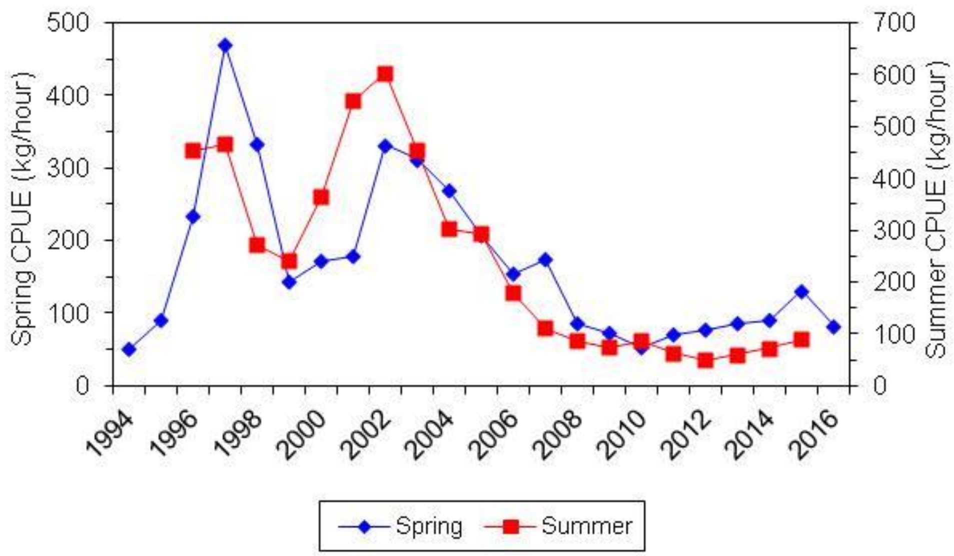
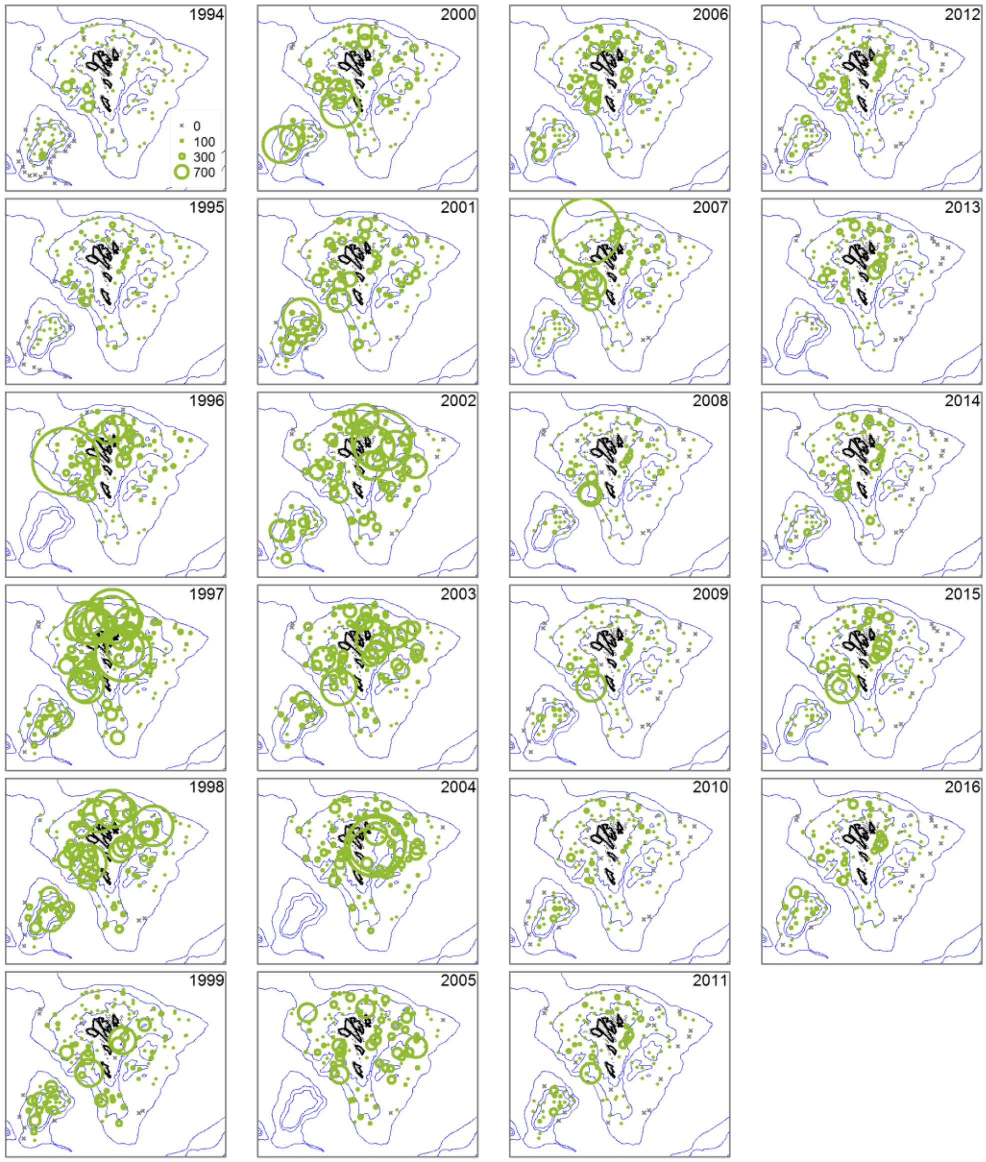


Figure 5.8. Faroe haddock. cpue (kg/trawlhour) in the spring and summer surveys.


1994
0
100
300
700
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

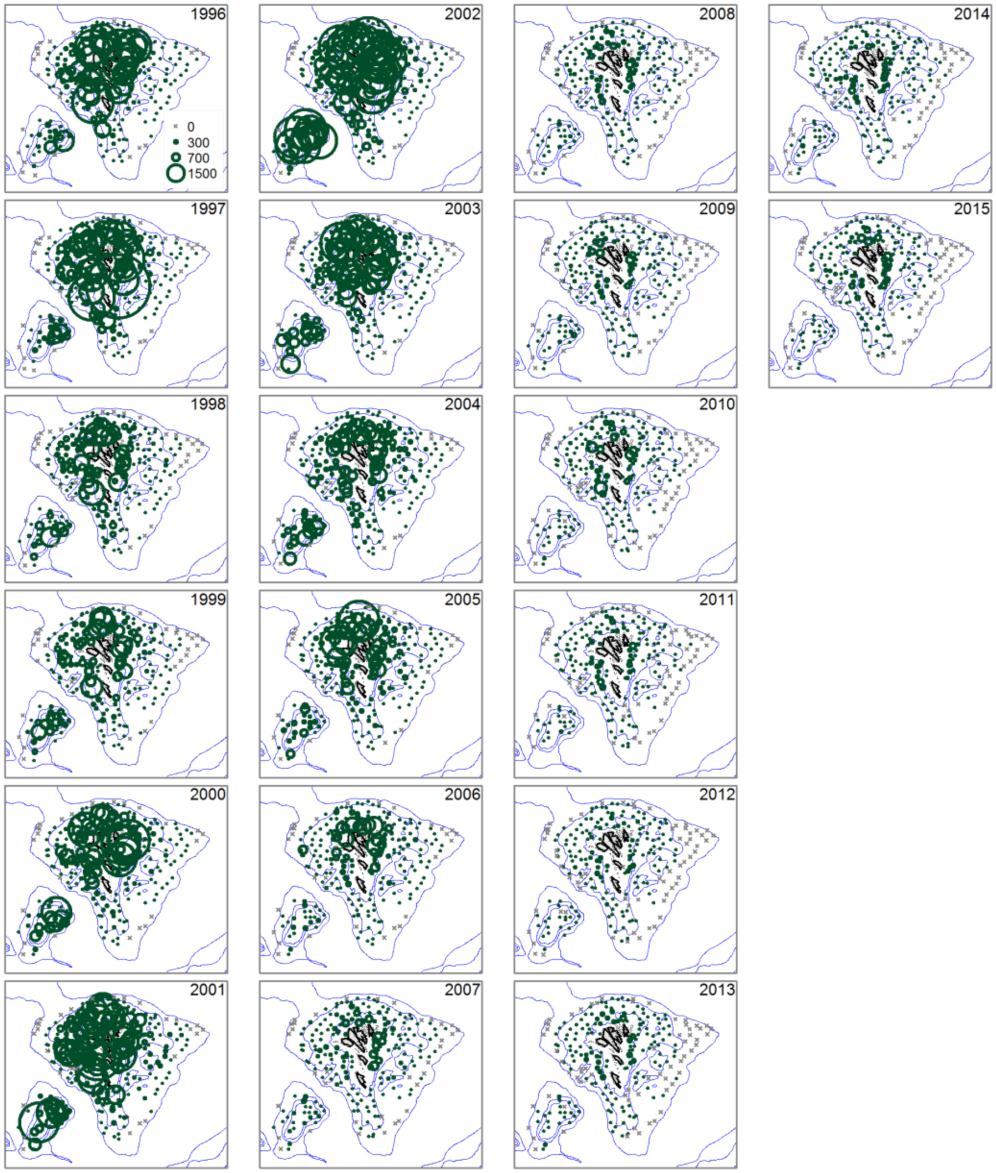


Figure 5.9. Distribution of Faroe haddock catches in the spring survey (page above) and in the summer survey (this page).

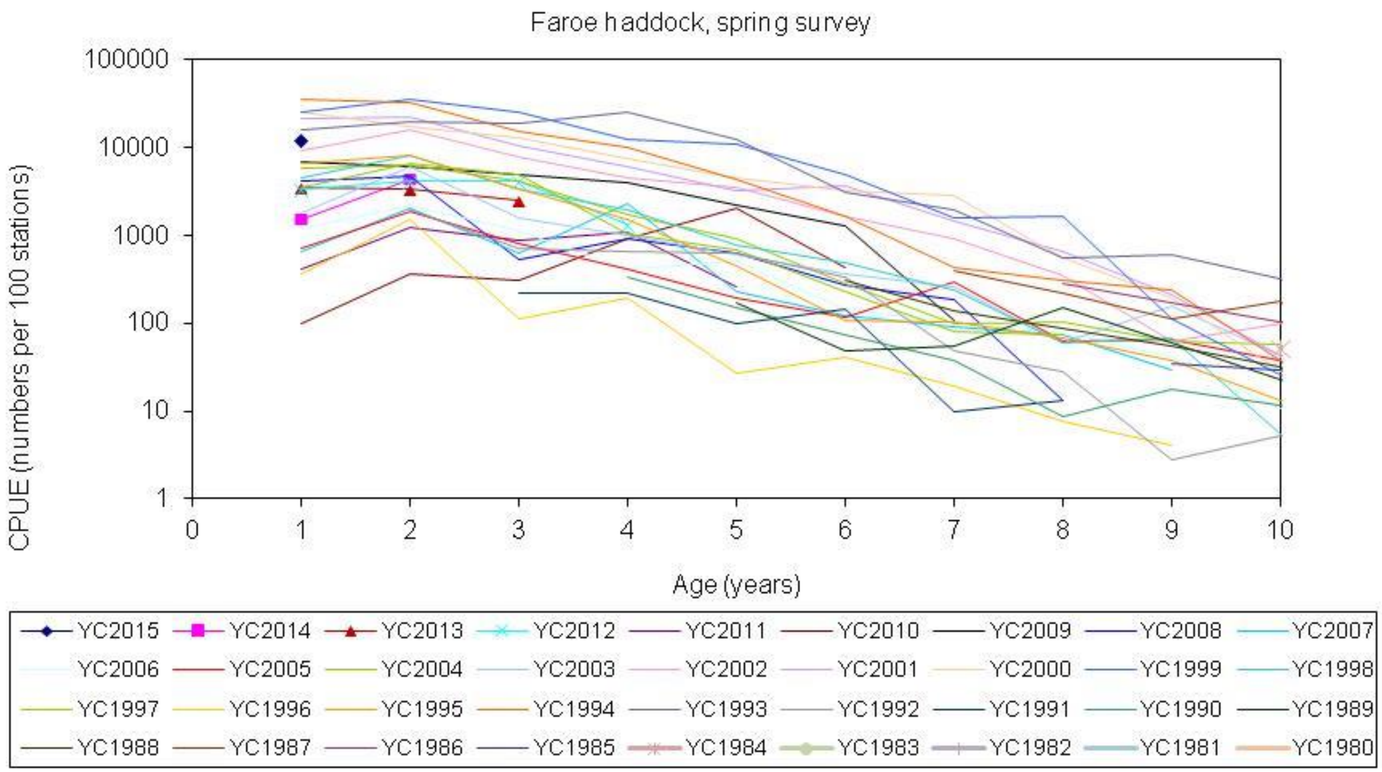


Figure 5.10. Faroe haddock. LN (c@age in numbers) in the spring survey.

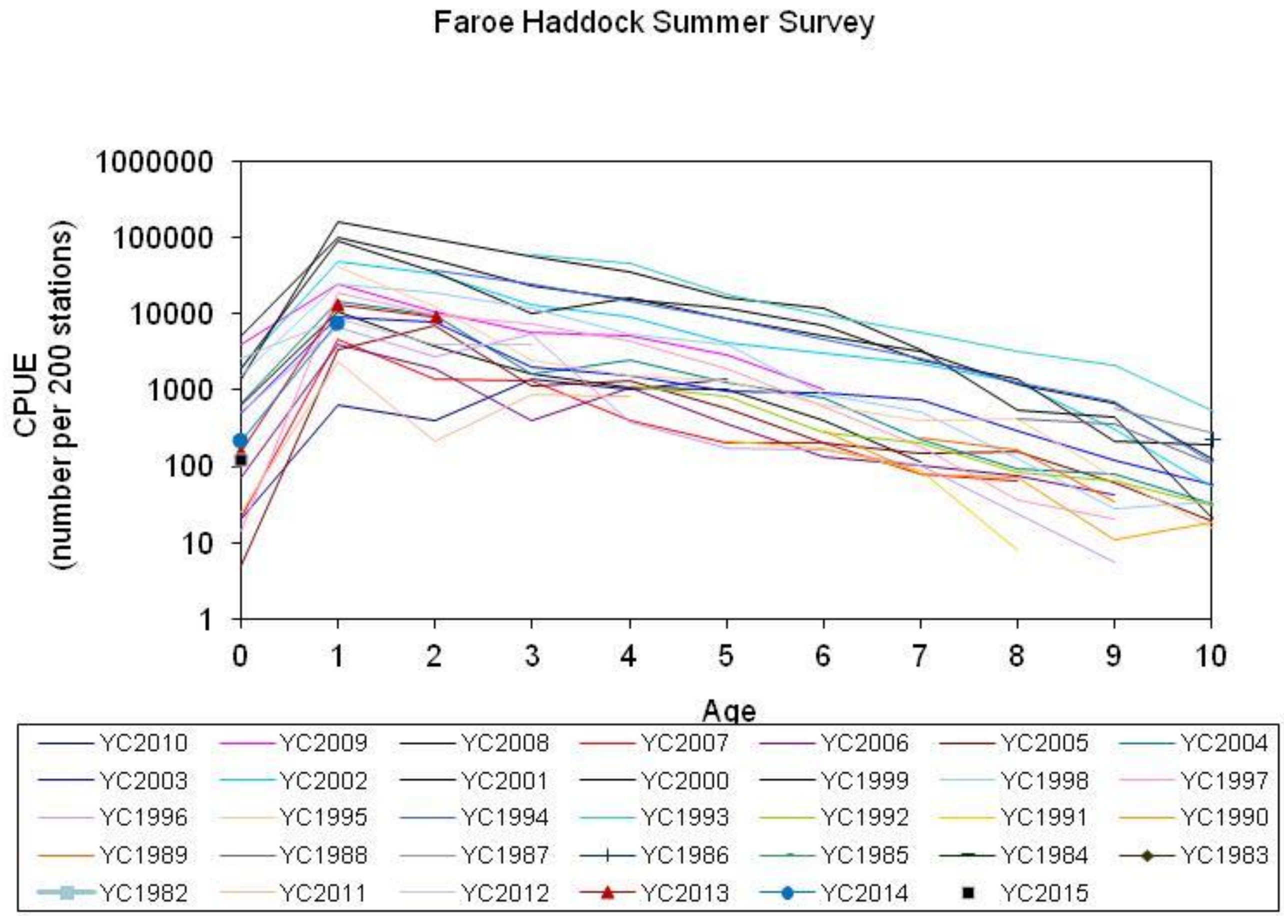
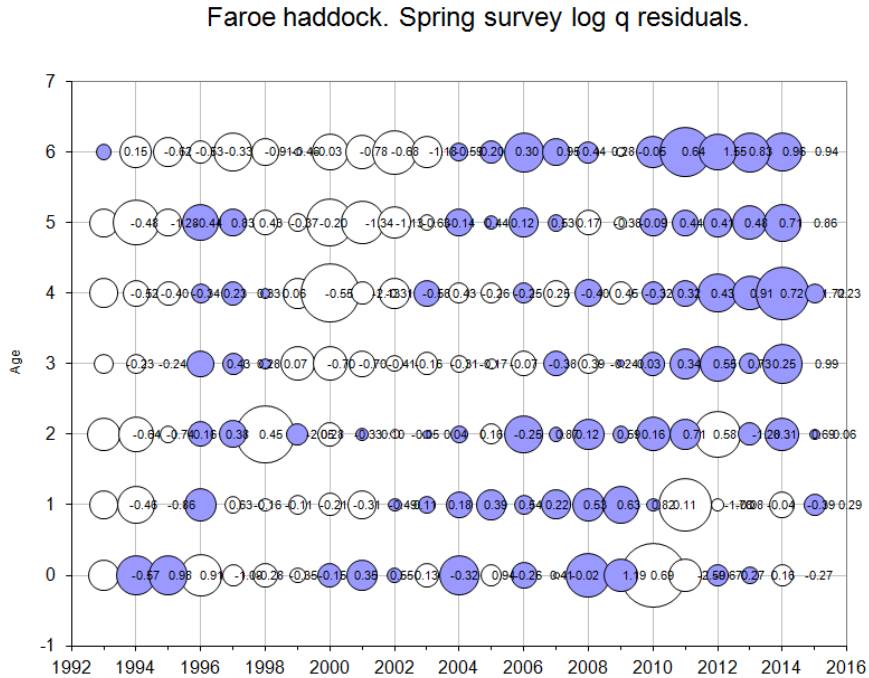


Figure 5.11. Faroe haddock. LN (c@age in numbers) in the summer survey.



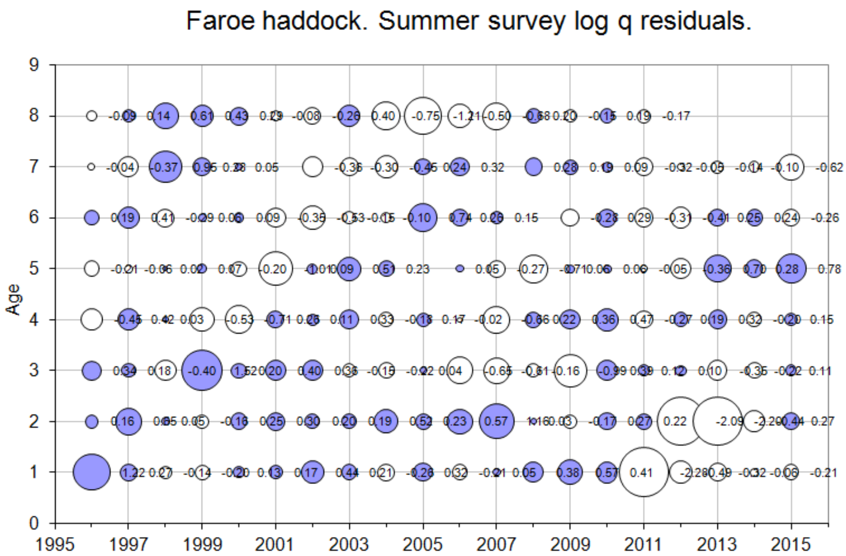


Figure 5.12. Faroe haddock survey log q residuals.

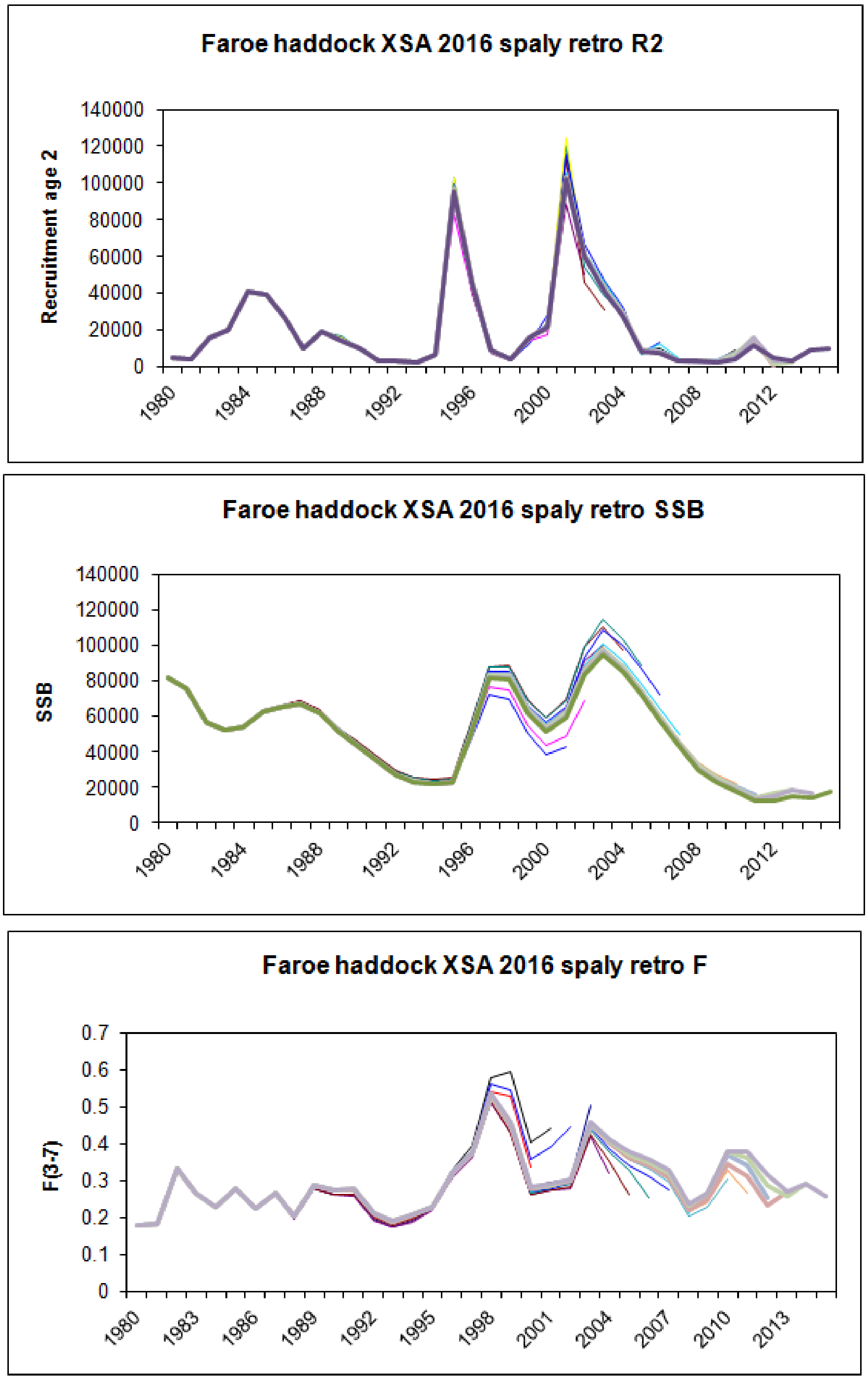


Figure 5.13. Faroe haddock. Retrospective analysis on the 2015 XSA.

6 Faroe Saithe

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 5.b) 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. Since 2011 landings have remained below historical average (37 000 t.) The total tonnage in 2015 is 25 000t.

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 pairtrawlers (>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 pairtrawlers (<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 pairtrawler fleet has accounted for about 75% of the total tonnage for saithe but since 2007 it has increased gradually up to 93% in 2015 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 0.5 % since 2000 and it now accounts for only 2% of the total domestic landings for saithe in 2014. 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. Effort (measured as the ratio of nominal to used fishing days by the pair-trawl fleet segment) has diminished considerably in recent years. In the 2013/2014 fishing year only 58% and 41% of fishing days were utilized in the inner and outer areas respectively while in the 2014/2015 fishing year these ratios went up to 97% and 74%, i.e. 29% of fishing days were not used in the last finished year season.

Cumulative landings of saithe for the domestic fleets since 2000 are shown in Figure 6.2.1.2. The period from 2011 to 2015 are among the poorest in the time-series. The progression of landings in the first three months of 2016 is below monthly averages and suggests 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 pairtrawlers, 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 2014 due to revised final catch statistics (Tables 6.2.2.1 and

6.2.2.2). Most of the age-disaggregated 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. Numbers of 3 and 6-years old were higher in 2015 than in 2014. While catches of 4 and 5-years old saithe decreased from 2323 and 3143 thous. to 2269 and 2577 thous. respectively in 2015. Numbers of age 3 (recruiting age) in 2015 (2135 thous.) is the largest since 2010 (2324 thous.)

The sampling program and sampling intensity in 2015 as well as the approach used in compiling catch numbers is the same as in preceding years. Sampling levels of catches in 2014 was 8.9% and it went up to 9.9% in 2015 (Table 6.2.2.3.) The average amount sampled per tonnes landed since 2000 is 6.2%.

6.2.3 Weight at age

Mean weights at age have varied by a factor of about 2 during since 1961. 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. In 2011 age classes 4 to 6 were close or at long-term average. From 2012 to 2014 weight was below average for age groups 3 to 7. Age classes 7 and older are in 2015 above mean values whereas younger age groups (3–5) are lower than average. Mean weight of the 2012 year class (age 3 in 2015) is estimated at 0.932 kg. which is the lowest ever observed in the time-series. On the other hand weight for 9-years old saithe (6.715 kg.) is the largest since 1985. 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 1962–1982 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 above historical average since 2012.

Faroe saithe begins to mature at 3 years old, approximately 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 randomized 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 is considerable.

Survey catch rates (kg per hour), length composition and age-disaggregated 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 2005 although they differ in the order of this magnitude. Since 2007 the indices show that the saithe stock is at low levels while there are indications of a slight upward trend since 2011. Both surveys agreed not only in the direction but also in the magnitude of this positive trend. The most recent estimate of the spring survey suggest a slightly decrease in stock biomass in 2016 but given the uncertainty associated with the index the point estimate ought to be taken with cautioagreement between survey indices and the commercial series used in the model tuning is good. Both survey at age numbers agreed in the lack of year classes present in the stock since 2007. The spring index suggests that the 2002 year class (age 3 in 2015) is quite strong, which is confirmed by very abundant individuals of the same year class in 2016. Year-class strength in the summer index also suggests that the 2012 year class is strong.

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 other age classes (Figure 6.2.5.1.6). Internal consistency in the age-disaggregated fall survey is displayed in figure 6.2.5.1.7. In terms of internal consistency the spring survey outperforms the fall survey.

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 pairtrawler series. A GLM model and a survey spatial scaling factor is used to standardized 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 suggest that stock abundance was low in the 1990s and increased subsequently in the 2000's and a sharp downward trend from 2006 to 2011. Since 2012 the predicted cpue has remained remarkably stable at approximately 384 kg/hour (Figure 6.2.5.1.1)

The correlation between predicted cpue and the spring and summer surveys is R^2=0.55 and R^2=0.70 respectively. The agreement between the survey indices measured by their correlation is estimated at R^2=0.36.

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 (Section C) and in the benchmark report (WKROUND 2010.) The 2010 XSA was calibrated with the standardized pairtrawlers 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 4 age classes (Figure 6.3.1.). Residuals from a separable statistical model predicting catch numbers-at-age and survey data and modelling catchability, selectivity over 4 distinct periods and including a stock–recruitment relationship are also presented (Figure 6.3.3)

6.4 Reference points

6.4.1 Biological reference points and MSY framework

In 2014 at the WKMSYREF2 workshop the EqSim simulation framework was used to explore candidates to F_{MSY}. The work was presented at the NWWG meeting in 2014 and the results agree with the previous simulations (see above) in that estimates of F_{MSY} are in the range of F_{MSY}=0.30 and F_{MSY} y=0.34 and not as the present level of F_{MSY} =0.28. In the 2014 meeting ACOM adopted the EqSim framework and agreed to set F_{MSY} =0.30, which agrees with the estimation of Fmed=0.31. 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 6.4.1.1 and 6.4.1.2 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) 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 B_{lim} is defined for faroe saithe but for the purposes of the analysis a value of B_{lim}=B_{pa}/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
F_{lim}	0.34	87327.43	36479.8	ass. Error
F_{lim}	0.37	79116.87	35447.45	ass. Error
F_{lim}	0.46	38905.3	22023.28	ass. Error
MSY:median	0.34	88565.78	36665.24	ass. Error
Maxmeanland	0.30	101372.9	37109.88	ass. Error
F_{Crash}5	0.41	63312	31637.31	ass. Error
F_{Crash}50	0.52	855.73	550.19	ass. Error
F_{lim}	0.40	78435.72	38526.07	No ass. Error
F_{lim}	0.42	73052.08	37660.27	No ass. Error
F_{lim}	0.50	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
F_{Crash}5	0.43	69750.99	37114.99	No ass. Error
F_{Crash}50	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	NWWG2015
$B_{trigger}$	55 000 t.	55 000 t.
B_{lim}	not defined.	
B_{pa}	60 000 t.	
F_{lim}	not defined	
F_{pa}	0.28	0.30
F_{MSY}	0.32	0.30

The Yield/R and SSB-R calculations with respect to reference fishing mortalities (Fmax, Fmed and F0.1) is presented in the table below. The SSB-R plot in relation to Fhigh, Fmed and Flow is shown in Figure 6.4.1.3.

	FISH MORT AGES 4–8	YIELD/R	SSB/R
Average last 3 years	0.35	1.28	2.84
F_{max}	0.42	1.29	2.36
$F_{0.1}$	0.15	1.15	6.10
F_{med}	0.31	1.28	3.29

6.5 State of the stock

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 million (Figures 6.5.1–6.5.4. 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. Since 2006 estimated recruitment has remained at low levels compared with the exceptionally high recruitment pulses observed from 2001–2005. However the 2012 year class (numbers of age-3 saithe in 2015) is estimated at 63 million and therefore far above the historical average of 32 million. Nevertheless the most recent recruitment estimate is highly unreliable and it contradicts with the estimate from a separable statistical model, which predicts recruitment at N_3(2015)=36 million and thus in line with the present low productivity period.

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 662 000 millions, i.e. double the average from 1961 to 2014. 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 2015 spaly assessment indicates that the point estimator of SSB (2014) is approximately 77 000 t. From 2005 to 2013 SSB has been declining sharply but it has increased again since 2013 above $B_{trigger}$=55 000 t. due to improving maturity ogives and growth. Figure 6.5.6 illustrates the numbers of mature fish in the stock forage-groups from 3 to 9 in 2006, 2013 and 2014. It is quite clear that there has been a substantial increase in the numbers of mature fish over the age groups 3 to 6 a phenomenon supported by increased maturity ogives in recent years The separable catch-at-age model predicts SSB(2015)=68 000 t.

In 2015 average fishing mortality over age groups 4 to 8 (F_{bar}) is estimated at F(2015)=0.25, which is the lowest since 1980 (F=0.21) and therefore below F_{MSY}=0.30. On the other hand the statistical model framework suggests that F(2015)=0.32 is higher than that of the spaly assessment. The assessment model suggests a drop in fishing mortality since 2013 reflecting the abrupt decline in landings since 2011. The relation between stock and recruitment is presented in figure 6.5.7.

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 2010–2014. 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 4–8 is estimated by weight-at-age the previous year from the same year class (Eq. 2) Weight for ages 9–14+ 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.

$W3,y = \alpha N3,y\text{-}3 + \beta$ for a = 3(Eq. 1)

$Wa+1,y+1 = \alpha Wa,y + \beta$ for $4 \leq a \leq 8$ (Eq. 2)

Wa,y = (Wa-3,y Wa-2,y Wa-1,y)/3 for 9 ≤ a ≤ 14+ (Eq. 3)

Proportion mature for 2016-2018 is taken as the average of predicted maturity ogives from 2014 and 2016. The exploitation pattern used is a 3 year average rescaled to last year as specified in the stock annex.

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 option is presented in Table 6.6.2.1 and Figure 6.6.2.1.

At status quo F=0.25 landings would increase to 32 kt. in 2016 and 40 kt. in 2017 while spawning-stock biomass is expected to around 97 kt. in 2016 and increase to 126 kt. tonnes in 2017. Landings in 2016 are predicted to rely on the 2010, 2011 and 2012 year classes (69%) while in the SSB these year classes will contribute to around 62% of the spawning biomass in 2016 (Figure 6.6.2.2.)

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 (as suggested from ACFM, 2004). Results from the yield-per-recruit analysis is shown in Figure 6.7.1.1.

6.8 Uncertainties in assessment and forecast

In 2015 the amount of catch sampled was 9.9%, 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 highly schooling and widely migrating behaviour of the species. 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 phenomenon, e.g. by changes in the vertical distribution of the stock or changes in the selection pattern that have been observed in recent years. The retrospective plots show very small revisions in SSB and F in 2014 and 2015.

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 of maturities.

6.9 Comparison with previous assessment and forecast

The 2015 assessment predicted recruitment for 205 to around 27 million while the observed year class strength was 63 million (Table 6.9.1). Fishing mortality was overestimated from F=0.31 to F=0.25. The spawning-stock biomass was overestimated by around 5%. Landings for 2015 were predicted at Land(2015)=35 kt. while actual observed catches in that year reached Land(2015)=25 kt an overestimation of 40%. Landings and recruitment estimates from the statistical model were however closer to the actual measurements Land(2015)=26 kt. and recruitment Rec(2015)=36 mill.than the spaly run.

6.10 Management plans and evaluations

No management plan exists for saithe in Division 5.b

6.11 Management considerations

Management consideration for saithe is under the general section for Faroese stocks.

In 2014 ACOM adopted F_{MSY}=0.30 (F_{pa}=0.30) presented at the NWWG meeting for the same year and produced in the WKMSYREF2 workshop on reference points. $B_{trigger}$ is set at B_{loss} =55 kt. ($B_{trigger}$=55 kt).

6.12 Ecosystem considerations

No evidence is available to indicate that the fishery is impacting the marine environment. A PhD. 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

ICES. 2014. Report of the Workshop to consider reference points for all stocks (WKMSYREF2). ICES CM 2014/ACOM:47. Section 7.3.

í Homrum, E., Ofstad, L.H. and Steingrund, P. 2009. Diet of Saithe on the Faroe Plateau. WD , NWWG 2009.

ICES C.M. 1993/Assess:18.

ICES C.M. 1998/ACFM:19.

ICES C.M. 2003/ACFM:24.

ICES C.M. 2005/ACFM:21.

ICES C.M. 2006/ACFM:26.

ICES C.M. 2007/ACFM:17

ICES C.M. 2008/ACOM:03

Hatun, H., Sando, A. B., Drange, H., Hansen, B., and Valdimarsson, H. 2005b: Influence of the Atlantic subpolar gyre on the thermohaline circulation. Science, 309: 1841–1844.

Ridao Cruz, L. 2005. Some exploratory analysis on the GLM model used to predict maturity for Faroe Saithe. WD 12, NWWG 2005.

Ridao Cruz, L. 2008. Post-Stratification of the survey indices for Faroese saithe. WD 5, NWWG 2008.

Ridao Cruz, L. 2010. Post-Stratification of the survey indices for Faroese saithe. WD 3, WKROUND 2010.

Ridao Cruz, L. 2010. Length Cohort Analysis (LCA) of Faroe Saithe. WD 5, WKROUND 2010.

Ridao Cruz, L. 2010. Faroese Groundfish Surveys for Saithe in Vb. WD 6, WKROUND 2010.

Ridao Cruz, L. 2010. NTF- ADAPT model for Faroese Saithe. WD 7, WKROUND 2010.

Ridao Cruz, L. 2010. Overview on the Faroese saithe fishery. WD 8, WKROUND 2010.

Ridao Cruz, L. 2010. GLM model diagnostics of Pair-trawl catch rates for saithe in Vb. WD 9, WKROUND 2010.

Steingrund, P. and Hatun, H., 2008. Relationship between the North Atlantic Subpolar Gyre and fluctuations of the saithe stock in Faroese waters. WD 20, NWWG 2008.

Steingrund, P. April 2003. Correction of the maturity stages from Faroese spring groundfish survey. WD 14, NWWG 2003.

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., 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.

6.17 Tables

Table 6.2.1.1. Faroe saithe (Division 5.b). Nominal catches (tonnes round weight) by countries 1988–2015 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	44 402	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	45 027	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	45 285	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	2013	2014	2015
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	28 609	25 474	26796
France	607	370	147	123	315	108	97	68	46	135	40	31	0	122
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				165	40
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	340	204
Total	57 004	49 377	49 546	76 266	72 405	65 557	61 693	62 858	47 469	32 210	38 216	28 642	25 979	27262
Working Group estimate	53 546	46 555	46 355	67 967	66 902	60 785	57 044	57 949	43 885	29 658	35 314	26 463	23 885	25128

Table 6.2.1.2. Faroe saithe (Division 5.b). Total Faroese landings (rightmost column) and the contribution (%) by each fleet category (1985-2015). Averages for 1985-2015 are given at the bottom.

Year	Open boats	Long- line <100 GRT	Single trawl <400 HP	Gillnet	Jigger	Single trawl 400-1000 HP	Single trawl >1000 HP	Pair trawl <1000 HP	Pair trawl >1000 HP	Long- line >100 GRT	Industrial trawl	Others	Total round weight (tons)
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
2014	0.2	0.3	0.5	0.0	1.9	0.2	0.2	15.6	80.7	0.3	0.0	0.1	20793
2015	0.2	0.4	1.1	0.0	2.3	0.0	0.2	18.0	75.5	0.3	0.0	0.0	20956
Avg.	0.3	0.2	0.8	0.1	5.2	1.5	13.9	19.3	58.0	0.3	0.4	0.0	38535

Table 6.2.2.1. Faroe saithe (Division 5.b). Catch number-at-age by fleet categories in 2015 (calculated from gutted weights).

Age	Jiggers	Single trawlers >1000 HP	Pairtrawlers <1000 HP	Pairtrawlers >1000HP	Others	Total Division 5.b
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	4	22	0	27
3	27	28	447	1233	45	1781
4	48	40	349	1414	41	1892
5	58	39	358	1645	49	2149
6	37	40	296	1206	30	1608
7	17	15	118	556	14	719
8	5	5	37	185	4	236
9	5	3	25	111	4	149
10	3	1	10	55	2	72
11	1	1	7	48	1	58
12	0	1	6	20	0	27
13	0	1	5	20	0	26
14	0	0	1	6	0	7
15	0	0	1	3	0	5
Total No.	202	174	1665	6525	192	8757
Catch, t.	498	428	3764	15818	449	20957

Table 6.2.2.2. Faroe saithe (Division 5.b). Catch number-at-age (thousands) from the commercial fleet (1961-2014)

CN	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

CN	3	4	5	6	7	8	9	10	11	12	13	14+
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	721	5172	4219	2242	511	209	122	96	146	85	39	36
2014	879	2323	3143	1681	865	330	99	92	70	55	16	1
2015	2135	2269	2577	1928	863	283	179	86	69	33	31	15

Table 6.2.2.3. Faroe saithe (Division 5.b). Sampling intensity in 2001–2015.

Year		Jiggers	Single trawlers >1000 HP	Pairtrawlers <1000 HP	Pairtrawlers >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	5.6
	Otoliths	6	0	120	2516	0	2642	
	Weights	6	0	1060	17593	211	18870	
2013	Lengths	0	0	1465	18015	920	20400	5.2
	Otoliths	0	0	360	1979	120	2459	
	Weights	0	0	1465	13544	1325	16334	

Year		Jiggers	Single trawlers >1000 HP	Pairtrawlers <1000 HP	Pairtrawlers >1000 HP	Others	Total	Amount sampled pr tons landed (%)
2014	Lengths	0	201	0	22131	920	23252	8.9
	Otoliths	0	0	0	2542	120	2662	
	Weights	0	0	0	15448	920	16368	
2015	Lengths	0	0	173	22455	753	23381	9.9
	Otoliths	0	0	20	2169	90	2279	
	Weights	0	0	173	17199	753	18125	

Table 6.2.3.1. Faroe saithe (Division 5.b). Catch weights at age (kg)(equal to stock-weights) from the commercial fleet (1961-2015). The value for 2016 is used for short-term projections.

CW	3	4	5	6	7	8	9	10	11	12	13	14+
1961	1.43	2.302	3.348	4.287	5.128	6.155	7.06	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	7.15	7.903	8.449	9.658
1963	1.28	2.197	3.212	4.568	5.056	5.932	6.259	8	7.265	8.551	9.02	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	5.52	6.837	7.265	7.662	8.123	10.21	9.883
1967	1.273	1.78	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	3.12	4.049	5.183	6.238	7.52	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	7.31	9.047	9.634
1971	1.101	1.316	1.818	2.978	3.702	4.271	5.388	5.972	6.49	7.173	7.38	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	2.7	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	7.07	7.773	8.763	10.83
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	1.79	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	2.66	3.79	4.239	5.597	5.35	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	1.22	1.88	2.62	3.4	4.18	4.95	5.69	6.38	7.02	7.26	8.15	9.618
1980	1.23	2.12	3.32	4.28	5.16	6.42	6.87	7.09	7.93	8.07	8.59	10.142
1981	1.31	2.13	3	3.81	4.75	5.25	5.95	6.43	7	7.47	8.14	9.43
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	2.47	3.85	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	10.67	10.46	10.202	13.055
1986	1.718	1.986	2.618	3.277	4.186	5.589	6.05	6.15	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	1.5	1.975	1.978	2.937	3.798	4.419	5.115	6.712	9.04	9.364	9.142	10.216
1989	1.309	1.735	1.907	2.373	3.81	4.667	5.509	5.972	6.939	8.543	9.514	10.484
1990	1.223	1.633	1.83	2.052	2.866	4.474	5.424	6.469	6.343	8.418	7.383	8.64
1991	1.24	1.568	1.864	2.211	2.648	3.38	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	1.86	2.323	3.131	3.73	4.394	5.209	6.54	8.403	7.275	9.414	9.64

CW	3	4	5	6	7	8	9	10	11	12	13	14+
1994	1.503	1.951	2.267	2.936	4.214	4.971	5.657	5.95	6.891	8.752	9.752	7.989
1995	1.456	2.177	2.42	2.895	3.651	5.064	5.44	6.167	7.08	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	8.47	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	3.3	4.22	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	8.03	8.349	8.907
2000	1.477	1.606	2.077	2.36	2.977	3.48	4.851	5.268	6.523	4.727	8.807	8.972
2001	1.33	1.59	1.785	2.586	3.059	3.871	4.374	5.565	6.703	5.776	7.745	7.773
2002	1.142	1.46	1.652	1.969	3.13	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	3.97	4.834	5.499	6.099	6.987	5.961	10
2004	1.143	1.333	1.45	1.789	2.56	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	3.79	6.087	6.134	6.651	7.424	10
2006	1.126	1.218	1.462	1.79	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	3.1	3.728	4.769	6.072	6.451	10
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	10
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	1.369	1.724	2.163	2.868	3.325	5.903	5.899	6.877	6.784	7.467	7.121	11.31
2015	0.932	1.555	2.091	3.17	4.208	5.032	6.715	7.858	7.428	7.565	7.629	9.367
2016	1.295	1.120	1.997	2.719	4.076	5.373	5.935	6.826	6.710	7.150	7.564	9.272

Table 6.2.4.1. Faroe saithe (Division 5.b). Proportion mature at age (1982-2015). Maturities-at-age from 1961 to 1981 are fixed and equal to those in 1982.

Mat	3	4	5	6	7	8	9	10	11	12	13	14+
1982	0.03	0.22	0.52	0.79	0.92	0.98	1.00	1.00	1.00	1.00	1.00	1.00
1983	0.03	0.27	0.61	0.91	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1984	0.04	0.28	0.60	0.88	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1985	0.05	0.29	0.59	0.85	0.97	0.99	1.00	1.00	1.00	1.00	1.00	1.00
1986	0.05	0.28	0.57	0.82	0.94	0.98	1.00	1.00	1.00	1.00	1.00	1.00
1987	0.05	0.27	0.55	0.79	0.92	0.97	1.00	1.00	1.00	1.00	1.00	1.00
1988	0.05	0.26	0.53	0.77	0.90	0.96	1.00	1.00	1.00	1.00	1.00	1.00
1989	0.04	0.23	0.51	0.76	0.89	0.96	1.00	1.00	1.00	1.00	1.00	1.00
1990	0.03	0.19	0.49	0.75	0.89	0.96	1.00	1.00	1.00	1.00	1.00	1.00
1991	0.03	0.17	0.48	0.75	0.88	0.96	1.00	1.00	1.00	1.00	1.00	1.00
1992	0.02	0.17	0.48	0.75	0.89	0.97	1.00	1.00	1.00	1.00	1.00	1.00
1993	0.02	0.17	0.49	0.77	0.91	0.99	1.00	1.00	1.00	1.00	1.00	1.00
1994	0.01	0.17	0.49	0.78	0.93	1.00	0.99	1.00	1.00	1.00	1.00	1.00
1995	0.01	0.17	0.49	0.78	0.93	1.00	0.99	1.00	1.00	1.00	1.00	1.00
1996	0.01	0.17	0.47	0.75	0.90	1.00	0.99	1.00	1.00	1.00	1.00	1.00
1997	0.01	0.16	0.44	0.70	0.87	0.98	0.99	1.00	1.00	1.00	1.00	1.00
1998	0.02	0.16	0.41	0.64	0.83	0.96	0.99	1.00	1.00	1.00	1.00	1.00
1999	0.02	0.16	0.38	0.60	0.79	0.94	0.98	1.00	1.00	1.00	1.00	1.00
2000	0.02	0.16	0.37	0.58	0.77	0.92	0.98	1.00	1.00	1.00	1.00	1.00
2001	0.01	0.17	0.37	0.56	0.75	0.91	0.98	1.00	1.00	1.00	1.00	1.00
2002	0.01	0.17	0.37	0.56	0.74	0.89	0.98	1.00	1.00	1.00	1.00	1.00
2003	0.01	0.18	0.37	0.56	0.74	0.88	0.97	1.00	1.00	1.00	1.00	1.00
2004	0.01	0.18	0.38	0.57	0.74	0.88	0.97	1.00	1.00	1.00	1.00	1.00
2005	0.00	0.18	0.39	0.59	0.76	0.89	0.97	1.00	1.00	1.00	1.00	1.00
2006	0.00	0.18	0.40	0.62	0.78	0.90	0.97	1.00	1.00	1.00	1.00	1.00
2007	0.00	0.19	0.42	0.64	0.80	0.91	0.97	1.00	1.00	1.00	1.00	1.00
2008	0.01	0.20	0.43	0.66	0.82	0.92	0.97	1.00	1.00	1.00	1.00	1.00
2009	0.01	0.21	0.45	0.68	0.84	0.94	0.97	1.00	1.00	1.00	1.00	1.00
2010	0.02	0.23	0.47	0.71	0.87	0.95	0.97	1.00	1.00	1.00	1.00	1.00
2011	0.03	0.24	0.49	0.72	0.88	0.96	0.98	1.00	1.00	1.00	1.00	1.00
2012	0.03	0.25	0.50	0.73	0.89	0.97	0.98	1.00	1.00	1.00	1.00	1.00
2013	0.04	0.25	0.50	0.74	0.90	0.97	0.98	1.00	1.00	1.00	1.00	1.00
2014	0.04	0.26	0.51	0.74	0.90	0.98	0.98	1.00	1.00	1.00	1.00	1.00
2015	0.05	0.26	0.51	0.74	0.9	0.98	0.98	1.00	1.00	1.00	1.00	1.00

Table 6.3.1. Faroe saithe (Division 5.b). Effort (hours) and catch in number-at-age for the commercial pairtrawlers (1995-2015)

YEAR	EFFORT	3	4	5	6	7	8	9	10	11
1995	10883	47	180	577	236	146	49	24	19	14
1996	47531	310	958	821	1119	503	282	133	127	70
1997	34606	199	533	1488	1013	768	333	73	33	10
1998	34144	107	656	1148	1486	730	325	170	40	13
1999	43218	174	487	1554	2016	2024	817	190	83	12
2000	43920	434	1566	913	2700	1333	1604	192	106	31
2001	41534	611	1438	4946	1165	1855	748	618	127	29
2002	41575	133	3976	3964	6888	520	682	246	177	25
2003	38076	141	1494	6560	2373	2263	197	212	124	35
2004	35237	43	1200	5089	5116	1035	762	113	116	53
2005	32493	188	1189	4039	7266	3130	320	291	7	43
2006	25068	140	1176	2410	2584	3700	1376	268	85	14
2007	24885	204	879	2913	1815	1034	1215	435	110	19
2008	25014	796	762	947	2641	1063	726	611	156	51
2009	67648	154	4082	3377	1283	3612	1402	1153	751	195
2010	61407	459	2019	3586	737	657	1325	814	518	245
2011	58209	397	1936	1367	1257	323	356	488	366	310
2012	58244	366	5652	2332	756	554	187	189	252	143
2013	43770	424	3047	2462	1295	293	122	71	56	83
2014	48449	625	1624	2226	1200	613	216	72	70	50
2015	37639	437	1414	1645	1206	556	185	111	55	48

Table 6.3.2. Faroe saithe (Division 5.b). Diagnostics from XSA with commercial pairtrawler tuning series (spaly)

FLR XSA Diagnostics 2016-04-12 10:28:36

cpue data from indices

Catch data for 55 years 1961 to 2015. Ages 3 to 14.

	fleet	first age	last age	first year	last year	alpha	beta
1	PairTrawlers_GLM_SD	3	11	1995	2015	<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

age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

age	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
3	0.076	0.049	0.182	0.037	0.119	0.066	0.035	0.030	0.024	0.038
4	0.103	0.245	0.258	0.476	0.343	0.202	0.560	0.301	0.129	0.080
5	0.296	0.353	0.458	0.860	0.760	0.404	0.532	0.500	0.302	0.206
6	0.414	0.432	0.558	0.451	0.472	0.641	0.498	0.624	0.380	0.307

7	0.619	0.367	0.456	0.701	0.480	0.374	0.795	0.388	0.524	0.342
8	0.715	0.574	0.384	0.501	0.700	0.503	0.436	0.422	0.469	0.322
9	0.488	0.737	0.600	0.572	0.681	0.537	0.620	0.312	0.362	0.505
10	0.908	0.667	0.485	0.743	0.621	0.688	0.678	0.398	0.411	0.621
11	0.518	0.731	0.605	0.696	0.641	0.808	0.758	0.569	0.571	0.626
12	0.120	0.335	0.217	0.303	0.241	0.515	0.637	0.721	0.434	0.586
13	0.224	0.124	0.308	0.077	0.264	0.251	0.783	0.374	0.278	0.469
14	0.224	0.124	0.308	0.077	0.264	0.251	0.783	0.374	0.278	0.469

XSA population number (Thousand)

	age											
year	3	4	5	6	7	8	9	10	11	12	13	14
2006	22264	56937	33524	25132	24659	8136	1833	522	87	117	66	27
2007	19345	16894	42051	20407	13598	10873	3259	922	173	43	85	28
2008	31701	15086	10828	24200	10851	7712	5017	1277	387	68	25	0
2009	14068	21626	9539	5609	11335	5632	4303	2254	644	173	45	15
2010	22830	11102	10999	3306	2926	4605	2793	1988	878	263	105	0
2011	33045	16589	6451	4211	1689	1482	1872	1158	875	379	169	20
2012	27788	25338	11099	3526	1816	951	734	895	476	319	185	42
2013	26799	21974	11848	5339	1754	671	503	323	372	183	138	127
2014	40622	21289	13311	5883	2343	974	360	302	178	173	73	5
2015	62836	32463	15328	8054	3295	1135	499	206	164	82	91	44

Estimated population abundance at 1st Jan 2016

	age											
year	3	4	5	6	7	8	9	10	11	12	13	14
2016	47	49515	24526	10218	4850	1917	673	246	90	72	37	47

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 2012 2013 2014 2015

3 -0.441 0.440 -0.006 0.355 -0.926 0.475 -0.031 -1.746 -1.102 -2.037 -0.737 0.407 0.918 1.844 -0.050 0.694 0.207 0.284 0.750 0.618 0.083

4 -0.057 -0.755 -0.550 -0.638 -0.202 -0.588 -0.090 0.036 -1.101 -0.738 -0.478 -0.470 0.528 0.499 0.921 0.921 0.466 1.275 0.969 0.190 -0.141

5 0.437 -0.670 -0.690 -0.441 -0.656 -0.208 0.023 0.381 0.062 -0.479 -0.050 -0.100 -0.104 0.171 0.747 0.720 0.187 0.235 0.496 0.088 -0.148

6 -0.196 -0.175 -0.078 -0.665 -0.053 0.009 0.344 0.650 0.206 0.050 0.096 -0.049 -0.179 0.077 -0.225 -0.145 0.274 -0.120 0.344 -0.038 -0.128

7 0.164 -0.398 0.231 0.066 -0.164 -0.031 0.331 0.214 0.375 -0.006 0.179 0.295 -0.489 -0.201 0.091 -0.259 -0.413 0.237 -0.257 0.151 -0.117

8 0.138 0.198 0.145 0.029 0.608 0.315 0.153 0.182 0.043 0.208 -0.545 0.391 -0.076 -0.337 -0.307 0.021 -0.192 -0.422 -0.222 -0.103 -0.225

9 0.005 0.435 0.041 0.286 0.021 -0.078 0.453 -0.158 -0.123 0.523 0.315 0.147 0.171 0.016 -0.202 0.025 -0.095 -0.072 -0.525 -0.256 0.169

10 -0.344 1.103 0.101 0.231 0.218 0.287 0.564 0.336 -0.002 0.124 -1.292 0.433 0.030 -0.031 0.089 -0.113 0.163 0.042 -0.281 -0.085 0.404

11 -0.041 0.147 -0.363 -0.043 -0.526 0.052 0.081 -0.007 -0.293 0.137 0.068 0.251 -0.024 0.096 -0.026 -0.036 0.328 0.140 0.048 0.179 0.496

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	-15.4706	-13.3917	-12.4239	-12.0639	-11.9395	-11.8752	-11.8752	-11.8752	-11.8752
S.E_Logq	0.4616	0.4616	0.4616	0.4616	0.4616	0.4616	0.4616	0.4616	0.4616

Terminal year survivor and F summaries:

,Age 3 Year class =2012

source

	scaledWts	survivors	yrcls
PairTrawlers_GLM_SD	0.816	53809	2012
fshk	0.184	34201	2012

,Age 4 Year class =2011

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.887 21303 2011

fshk 0.113 5676 2011

,Age 5 Year class =2010

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.944 8813 2010

fshk 0.056 3562 2010

,Age 6 Year class =2009

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.97 4268 2009

fshk 0.03 2513 2009

,Age 7 Year class =2008

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.969 1705 2008

fshk 0.031 1155 2008

,Age 8 Year class =2007

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.97 538 2007

fshk 0.03 385 2007

,Age 9 Year class =2006

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.964 292 2006

fshk 0.036 246 2006

,Age 10 Year class =2005

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.909 135 2005

fshk 0.091 103 2005

,Age 11 Year class =2004

source

scaledWts survivors yrcls

PairTrawlers_GLM_SD 0.96 118 2004

fshk 0.04 65 2004

,Age 12 Year class =2003

source

scaledWts survivors yrcls

fshk 1 44 2003

,Age 13 Year class =2002

source

scaledWts survivors yrcls

fshk 1 33 2002

Table 6.5.1. Faroe saithe (Division 5.b). Fishing mortality-at-age (1961-2015). The value for 2016 is used for short-term prognosis.

F	3	4	5	6	7	8	9	10	11	12	13	14+
1961	0.026	0.058	0.109	0.143	0.12	0.1	0.11	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	0.04	0.085	0.118	0.185	0.142	0.185	0.25	0.178	0.491	0.308	0.308
1964	0.052	0.144	0.251	0.218	0.236	0.301	0.18	0.241	0.248	0.235	0.243	0.243
1965	0.05	0.085	0.186	0.253	0.283	0.263	0.37	0.316	0.424	0.532	0.427	0.427
1966	0.026	0.103	0.167	0.283	0.348	0.35	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	0.03	0.099	0.098	0.14	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	0.25	0.493	0.586	0.639	0.518	0.586	0.586
1970	0.044	0.262	0.142	0.179	0.16	0.202	0.206	0.39	0.431	0.609	0.48	0.48
1971	0.086	0.135	0.373	0.128	0.144	0.117	0.13	0.157	0.277	0.534	0.325	0.325
1972	0.094	0.07	0.148	0.316	0.293	0.354	0.4	0.49	0.541	0.73	0.592	0.592
1973	0.125	0.325	0.438	0.304	0.315	0.209	0.246	0.272	0.253	0.32	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	0.18	0.141	0.132	0.12	0.205	0.198	0.175	0.175
1976	0.196	0.34	0.298	0.328	0.208	0.16	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	0.13	0.246	0.156	0.178	0.178
1978	0.085	0.233	0.267	0.163	0.18	0.375	0.272	0.259	0.228	0.307	0.266	0.266
1979	0.037	0.18	0.283	0.251	0.261	0.31	0.338	0.49	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	0.188	0.477	0.329	0.502	0.399	0.191	0.315	0.477	0.33	0.33
1983	0.07	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	0.235	0.507	0.276	0.579	0.314	0.304	0.243	0.232	0.415	0.298	0.298
1986	0.021	0.137	0.452	0.774	0.375	0.785	0.518	0.578	0.895	0.518	0.67	0.67
1987	0.037	0.138	0.423	0.57	0.476	0.372	0.598	0.32	0.503	0.141	0.323	0.323
1988	0.022	0.089	0.355	0.631	0.576	0.629	0.47	0.649	0.167	1.598	0.813	0.813
1989	0.018	0.203	0.228	0.492	0.365	0.51	0.383	0.183	0.488	0.086	0.254	0.254
1990	0.016	0.203	0.626	0.783	0.8	0.391	0.202	0.208	0.196	0.29	0.232	0.232
1991	0.047	0.414	0.767	0.872	0.797	0.657	0.686	0.754	0.901	0.414	0.696	0.696
1992	0.03	0.262	0.595	0.707	0.547	0.48	0.556	0.455	0.452	0.726	0.549	0.549
1993	0.063	0.205	0.547	0.6	0.514	0.383	0.474	0.452	0.37	0.473	0.435	0.435
1994	0.046	0.274	0.333	0.596	0.598	0.651	0.44	0.695	0.557	0.333	0.533	0.533
1995	0.011	0.089	0.41	0.404	0.683	0.62	0.776	0.549	0.546	0.585	0.565	0.565
1996	0.014	0.039	0.137	0.3	0.484	0.755	0.513	0.612	0.353	0.484	0.487	0.487
1997	0.011	0.048	0.115	0.324	0.5	0.528	0.574	0.58	0.491	0.491	0.674	0.674
1998	0.014	0.071	0.15	0.238	0.454	0.52	0.694	0.583	0.567	1.376	0.49	0.49
1999	0.006	0.073	0.18	0.301	0.492	0.626	0.622	0.671	0.358	1.541	1.037	1.037
2000	0.025	0.068	0.234	0.417	0.469	0.721	0.518	0.724	0.588	0.502	0.403	0.403
2001	0.014	0.099	0.294	0.632	0.759	0.703	0.999	1.197	0.99	0.543	1.838	1.838
2002	0.003	0.14	0.371	0.66	0.563	0.659	0.472	0.841	0.382	1.753	0.348	0.348
2003	0.006	0.032	0.279	0.458	0.694	0.593	0.467	0.656	0.519	1.17	0.665	0.665
2004	0.002	0.043	0.148	0.369	0.474	0.726	0.988	0.711	0.786	2.449	1.134	1.134
2005	0.007	0.077	0.294	0.476	0.582	0.348	0.877	0.286	0.581	0.315	0.49	0.49

F	3	4	5	6	7	8	9	10	11	12	13	14+
2006	0.076	0.103	0.296	0.414	0.619	0.715	0.488	0.908	0.518	0.12	0.224	0.224
2007	0.049	0.245	0.353	0.432	0.367	0.574	0.737	0.667	0.731	0.335	0.124	0.124
2008	0.182	0.258	0.458	0.558	0.456	0.384	0.6	0.485	0.605	0.217	0.308	0.308
2009	0.037	0.476	0.86	0.451	0.701	0.501	0.572	0.743	0.696	0.303	0.077	0.077
2010	0.119	0.343	0.76	0.472	0.48	0.7	0.681	0.621	0.641	0.241	0.264	0.264
2011	0.066	0.202	0.404	0.641	0.374	0.503	0.537	0.688	0.808	0.515	0.251	0.251
2012	0.035	0.56	0.532	0.498	0.795	0.436	0.62	0.678	0.758	0.637	0.783	0.783
2013	0.03	0.301	0.5	0.624	0.388	0.422	0.312	0.398	0.569	0.721	0.374	0.374
2014	0.024	0.129	0.302	0.38	0.524	0.469	0.362	0.411	0.571	0.434	0.278	0.278
2015	0.038	0.08	0.206	0.307	0.342	0.322	0.505	0.621	0.626	0.586	0.469	0.469
2016	0.022	0.121	0.239	0.311	0.298	0.288	0.280	0.340	0.419	1.00	1.00	1.00

Table 6.3.2. Faroe saithe (Division 5.b). Stock number-at-age (start of year) (Thousands)(1961-2015). The value for 2016 is used for short-term prognosis.

YEAR	3	4	5	6	7	8	9	10	11	12	13	14+
1961	7827.26	7421.86	5158.38	3351.65	2113.91	1494.26	1232.82	904.51	468.22	179.78	53.02	431.33
1962	12256.26	6242.83	5733.57	3786.29	2379.45	1535.28	1106.68	904.39	666.35	342.63	122.76	592.7
1963	19837.08	9526.05	4620.77	4135.96	2652.05	1689.34	1138.44	789.35	638.21	481.32	254.28	182.18
1964	14811.8	15685.65	7491.63	3475.53	3010.73	1803.95	1200.34	774.64	503.3	437.46	241.15	224.48
1965	22362.95	11507.97	11115.9	4770.94	2287.23	1947.41	1093.3	820.79	498.49	321.58	283.06	239.61
1966	21229.3	17408.01	8652.81	7555.46	3032.95	1411.16	1226.14	618.24	490.13	266.98	154.71	232.85
1967	24897.69	16939.52	12859.03	5997.62	4660.34	1753.87	814.24	737.85	320.68	260.13	133.53	94.13
1968	22879.44	19846.12	13148.65	9293.88	4193.8	2736.99	1007.96	470.29	432.19	174.78	145.12	316.81
1969	39798.62	18176.53	14720.36	9755.41	6618.39	2937.74	1648.19	595.42	269.22	273.31	89.71	133.05
1970	37092.28	31506.69	12994.19	9976.32	6707.61	4407.07	1872.27	824.62	271.23	116.37	133.29	109.05
1971	38446.77	29061.1	19844.38	9229.01	6830.57	4678.28	2947.67	1246.96	457.08	144.25	51.84	130.67
1972	33424.52	28892.43	20792.77	11193.69	6646.71	4843.19	3405.88	2118.37	872.53	283.74	69.24	119.79
1973	23621.9	24909.95	22049.94	14681.96	6683.55	4058.37	2784.46	1868.28	1062.08	415.77	111.96	258.1
1974	19420.68	17064.31	14736.6	11651.24	8873.55	3993.53	2695.66	1782.06	1164.97	675.02	247.21	524.53
1975	17327.33	12729.76	10237.71	8436	7020.16	5997.37	2690.53	1874.04	1151.38	775.54	440.46	739.88
1976	19709.34	12320.65	7381.08	4942.64	5152.33	4802.07	4264.18	1929.56	1360.61	768.04	520.95	1132.95
1977	13106.22	13261.07	7176.43	4486.8	2915.65	3424.83	3351.6	3067.75	1378.01	986.39	541.95	815.92
1978	8333.03	9274.58	8199.74	4035.12	2508.05	1693.12	2163.39	2293.45	2205.83	882.1	690.86	837.17
1979	8686.42	6269.65	6016.26	5142.58	2807.83	1715.91	952.79	1349.58	1449.73	1437.71	531.28	1353.61
1980	13076.4	6852.15	4288.94	3712.31	3275.69	1770.43	1030.27	556.59	676.95	853.96	990.7	1390.35
1981	33145.83	9804.84	4816.52	2860	2430.42	2025	1192.53	651.69	300.97	376.9	558.01	2253.4
1982	15680.48	26765.62	6395.19	3247.62	1498.27	1168.27	993.78	666	359.83	163.17	192.76	3112.94
1983	40831.64	12487.92	18225.72	4336.53	1650.93	882.84	579.18	545.8	450.27	214.98	82.92	1368.23
1984	26079.33	31183.41	9226.21	10350.72	2335.26	831.39	416.07	227.17	358.19	279.98	86.43	840.01
1985	22341.19	21018.97	15516.98	5419.27	4770.95	1120.21	433.66	194.97	138.94	234.45	175.84	690.2
1986	61871.03	17183.9	13598.58	7652.52	3367.41	2188.74	670.13	261.85	125.24	90.23	126.8	154.27
1987	48649.53	49599.77	12262.02	7086.23	2890.31	1894.69	817.48	326.97	120.29	41.92	44.01	321.84
1988	44899.26	38400.32	35367.13	6576.48	3281.75	1470.6	1069.87	367.99	194.41	59.57	29.79	3.91
1989	28604.58	35976.81	28770.25	20310.44	2865.3	1510.58	642.12	547.48	157.41	134.74	9.87	132.42

YEAR	3	4	5	6	7	8	9	10	11	12	13	14+
1990	20720.44	23011.37	24043.49	18759.45	10171.86	1628.37	742.71	358.33	373.13	79.11	101.27	222.62
1991	24974.51	16698.44	15371.87	10528.19	7017.24	3740.49	901.59	496.79	238.18	251.21	48.48	41.33
1992	19604.36	19515.42	9034.23	5842.58	3603.33	2590.06	1587.57	371.7	191.38	79.19	136	49.16
1993	23784.03	15579.27	12297.9	4078.56	2359.44	1707.82	1311.64	745.13	193.03	99.69	31.35	24.86
1994	16884.95	18281.95	10392.7	5825.89	1832.69	1155.39	953.06	668.51	388.37	109.18	50.85	5.3
1995	38977.69	13199.89	11383.93	6099.24	2627.18	825.47	493.54	502.52	273.17	182.25	64.05	48.15
1996	24412.3	31552.11	9885.13	6182.4	3332.35	1085.96	363.67	186.01	237.7	129.55	83.16	22.72
1997	33577.13	19718.36	24849.12	7056.31	3750.61	1682.31	417.69	178.31	82.62	136.7	65.35	51.17
1998	12772.68	27179.37	15391.2	18136.94	4178.37	1862.78	812.74	192.67	81.74	41.4	68.49	59.35
1999	58856.59	10309.89	20724.31	10851.3	11704.96	2173.19	907.11	332.43	88.08	37.97	8.56	62.19
2000	35923.96	47896.34	7848.36	14166.25	6576.05	5861.61	951.33	398.84	139.16	50.39	6.66	16.51
2001	88189.56	28678.22	36653.52	5082.91	7645.11	3369.85	2333.4	464	158.25	63.27	24.97	16.57
2002	106023.28	71185.56	21261.08	22375.25	2211.61	2929.49	1366.45	703.37	114.78	48.13	30.08	3.73
2003	64513.04	86531.26	50682.08	12012.46	9464.56	1030.75	1240.27	698.01	248.32	64.11	6.83	0
2004	54075.99	52520.21	68645.24	31404.23	6221.05	3869.89	466.59	636.32	296.41	120.97	16.3	3.19
2005	70045.1	44204.91	41180.29	48471.04	17783.42	3170.59	1533.36	142.23	255.86	110.57	8.56	0
2006	22264.39	56937.28	33524.46	25132.28	24659	8136.39	1833.08	522.49	87.49	117.19	66.1	27.39
2007	19344.73	16893.91	42051.4	20406.97	13598.46	10872.87	3259.33	921.7	172.61	42.68	85.08	28.26
2008	31700.64	15086.21	10827.5	24199.58	10850.8	7712.29	5016.58	1276.87	387.26	68.03	24.99	0
2009	14067.61	21625.54	9539.31	5609.2	11334.62	5631.9	4302.84	2254.12	643.67	173.19	44.84	14.9
2010	22829.91	11102.26	10998.84	3305.84	2925.72	4604.7	2793.19	1988.26	878.25	262.78	104.7	0
2011	33044.78	16588.71	6451.26	4211.26	1688.65	1482.39	1871.66	1157.63	875.02	378.83	169	19.77
2012	27787.98	25338.3	11098.81	3526.46	1815.56	950.95	734.12	895.38	476.37	319.19	185.29	42.14
2013	26799.38	21973.62	11847.98	5339.1	1754.36	671.2	503.5	323.26	372.05	182.81	138.27	126.63
2014	40621.85	21289.09	13310.66	5882.8	2342.64	973.98	360.42	301.84	177.8	172.5	72.76	4.52
2015	62836.26	32463.01	15328.09	8053.94	3295.4	1135.31	498.83	205.51	163.88	82.23	91.47	43.84
2016	29626	49527.71	24535.02	10213.26	4850.89	1916..55	673.62	246.48	90.42	71.75	37.47	69.31

Table 6.3.3. Faroe saithe (Division 5.b). Summary table (1961-2015). Values for 2016-2018 are estimates.

YEAR	RECRUITS (AGE 3)	SSB (TONNES)	YIELD (TONNES)	YIELD/SSB	FBAR(4−8)
1961	7827	68467	9592	0.13	0.106
1962	12256	72862	10454	0.154	0.125
1963	19837	76441	12693	0.173	0.114
1964	14811	80928	21893	0.272	0.23
1965	22362	84690	22181	0.284	0.214
1966	21229	87313	25563	0.3	0.25
1967	24897	85361	21319	0.241	0.204
1968	22879	93938	20387	0.213	0.16
1969	39798	103452	27437	0.274	0.191
1970	37092	109688	29110	0.275	0.189
1971	38446	121970	32706	0.245	0.179
1972	33424	137957	42663	0.308	0.236
1973	23621	130735	57431	0.439	0.318
1974	19420	134010	47188	0.352	0.272
1975	17327	135485	41576	0.307	0.297
1976	19709	129100	33065	0.256	0.267
1977	13106	122228	34835	0.273	0.328
1978	8333	105218	28138	0.266	0.243
1979	8686	96038	27246	0.277	0.257
1980	13076	96219	25230	0.264	0.211
1981	33145	85058	30103	0.37	0.382
1982	15680	94394	30964	0.341	0.336
1983	40831	98647	39176	0.397	0.385
1984	26079	104718	54665	0.522	0.478
1985	22341	110024	44605	0.431	0.382
1986	61871	91607	41716	0.483	0.505
1987	48649	94334	40020	0.441	0.396
1988	44899	103062	45285	0.443	0.456
1989	28604	107481	44477	0.427	0.359
1990	20720	103321	61628	0.608	0.561
1991	24974	76297	54858	0.723	0.702
1992	19604	60153	36487	0.577	0.518
1993	23784	59452	33543	0.555	0.45
1994	16884	57615	33182	0.562	0.49
1995	38977	55735	27209	0.478	0.441
1996	24412	60797	20029	0.319	0.343
1997	33577	68468	22306	0.326	0.303
1998	12772	74278	26421	0.348	0.286
1999	58856	77828	33207	0.419	0.334
2000	35923	80608	39020	0.477	0.382
2001	88189	84237	51786	0.614	0.497
2002	106023	81993	53546	0.653	0.479
2003	64513	97592	46555	0.476	0.411
2004	54075	113454	46355	0.407	0.352

Year	Recruits (age 3)	SSB (tonnes)	Yield (tonnes)	Yield/SSB	Fbar(4–8)
2005	70045	128179	67967	0.53	0.355
2006	22264	127839	66902	0.525	0.429
2007	19344	121636	60785	0.501	0.394
2008	31700	105278	57044	0.537	0.423
2009	14067	94514	57949	0.606	0.598
2010	22829	70921	43885	0.618	0.551
2011	33044	57701	29658	0.514	0.425
2012	27787	49796	35314	0.709	0.564
2013	26799	46255	26463	0.572	0.447
2014	40621	58803	23885	0.406	0.361
2015	62836	77216	25128	0.325	0.251
2016	**29626**	**96770**	**32085**		**0.251**
2017	**29626**	**126058**	**40403**		**0.251**
2018	**29626**	**144712**			
Avg.	**31543**	**91844**	**36779**	**0.41**	**0.35**

Table 6.6.1.1. Faroe saithe (Division 5.b). Input data for prediction with management options for the SPALY assessment.

2016

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	29626	0.2	0.04	0	0	1.295	0.022	1.295
4	49528	0.2	0.26	0	0	1.120	0.121	1.120
5	24535	0.2	0.51	0	0	1.997	0.239	1.997
6	10213	0.2	0.74	0	0	2.719	0.311	2.719
7	4851	0.2	0.90	0	0	4.076	0.298	4.076
8	1917	0.2	0.98	0	0	5.373	0.288	5.373
9	674	0.2	0.98	0	0	5.935	0.280	5.935
10	246	0.2	1.00	0	0	6.826	0.339	6.826
11	90	0.2	1.00	0	0	6.710	0.419	6.710
12	72	0.2	1.00	0	0	7.150	1.000	7.150
13	37	0.2	1.00	0	0	7.564	1.000	7.564
14	69	0.2	1.00	0	0	9.272	1.000	9.272

2017

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	29626	0.2	0.04	0	0	1.295	0.022	1.295
4	-	0.2	0.26	0	0	1.120	0.121	1.120
5	-	0.2	0.51	0	0	1.997	0.239	1.997
6	-	0.2	0.74	0	0	2.719	0.311	2.719
7	-	0.2	0.90	0	0	4.076	0.298	4.076
8	-	0.2	0.98	0	0	5.373	0.288	5.373
9	-	0.2	0.98	0	0	5.935	0.280	5.935
10	-	0.2	1.00	0	0	6.826	0.339	6.826
11	-	0.2	1.00	0	0	6.710	0.419	6.710
12	-	0.2	1.00	0	0	7.150	1.000	7.150
13	-	0.2	1.00	0	0	7.564	1.000	7.564
14	-	0.2	1.00	0	0	9.272	1.000	9.272

2018

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	29626	0.2	0.04	0	0	1.295	0.022	1.295
4	-	0.2	0.26	0	0	1.120	0.121	1.120
5	-	0.2	0.51	0	0	1.997	0.239	1.997
6	-	0.2	0.74	0	0	2.719	0.311	2.719
7	-	0.2	0.90	0	0	4.076	0.298	4.076
8	-	0.2	0.98	0	0	5.373	0.288	5.373
9	-	0.2	0.98	0	0	5.935	0.280	5.935
10	-	0.2	1.00	0	0	6.826	0.339	6.826
11	-	0.2	1.00	0	0	6.710	0.419	6.710
12	-	0.2	1.00	0	0	7.150	1.000	7.150

Input units are thousands and kg - output in tonnes

Table 6.6.2.1. Faroe saithe (Division 5.b). Prediction with management option for SPALY assessment.

2016				
Biomass	SSB	FMult	FBar	Landings
208397	96770	1.000	0.251	32086

2017					2018	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
232095	126058	0.0000	0.0000	0	288608	185585
	126058	0.1000	0.0251	4520	283032	180964
	126058	0.2000	0.0503	8922	277606	176471
	126058	0.3000	0.0754	13209	272324	172103
	126058	0.4000	0.1006	17386	267181	167856
	126058	0.5000	0.1257	21455	262175	163726
	126058	0.6000	0.1508	25419	257301	159709
	126058	0.7000	0.1760	29282	252554	155803
	126058	0.8000	0.2011	33047	247933	152003
	126058	0.9000	0.2263	36715	243431	148308
	126058	1.0000	0.2514	40291	239048	144712
	126058	1.1000	0.2765	43776	234778	141215
	126058	1.2000	0.3017	47174	230619	137813
	126058	1.3000	0.3268	50486	226568	134503
	126058	1.4000	0.3520	53715	222622	131282
	126058	1.5000	0.3771	56864	218777	128148
	126058	1.6000	0.4022	59934	215031	125099
	126058	1.7000	0.4274	62928	211381	122131
	126058	1.8000	0.4525	65848	207825	119243

Input units are thousands and kg - output in tonnes

Table 6.7.1.1. Faroe saithe (Division 5.b). Yield-per-recruit input data.

AGE	M	MAT	PF	PM	WEST	SEL	WECA
3	0.2	0.02	0	0	1.304	0.048	1.304
4	0.2	0.21	0	0	1.668	0.278	1.668
5	0.2	0.47	0	0	2.031	0.467	2.031
6	0.2	0.71	0	0	2.602	0.5118	2.602
7	0.2	0.86	0	0	3.373	0.52	3.373
8	0.2	0.95	0	0	4.318	0.5648	4.318
9	0.2	0.99	0	0	5.085	0.5572	5.085
10	0.2	1	0	0	5.904	0.6514	5.904
11	0.2	1	0	0	6.777	0.7174	6.777
12	0.2	1	0	0	7.472	0.5888	7.472
13	0.2	1	0	0	7.835	0.4844	7.835
14	0.2	1	0	0	9.388	0.4844	9.388

Table 6.9.1. Faroe saithe (Division 5.b). Comparison between the current assessment (NWWG2016 SPALY) statistical assessment (NWWG2016 ADMB) and predictions from last year in the terminal year (2015).

	NWWG2015 PREDICTION	NWWG2016 (SPALY)	NWWG2016 (ADMB)
Recruitment	27 mill.	62 mill.	36 mill.
SSB	82 089 t.	77 000 t.	68 278 t.
Fbar(4-8)	0.310	0.25	0.32
Landings	35 360 t.	25 128 t.	26 482 t.

6.18 Figures

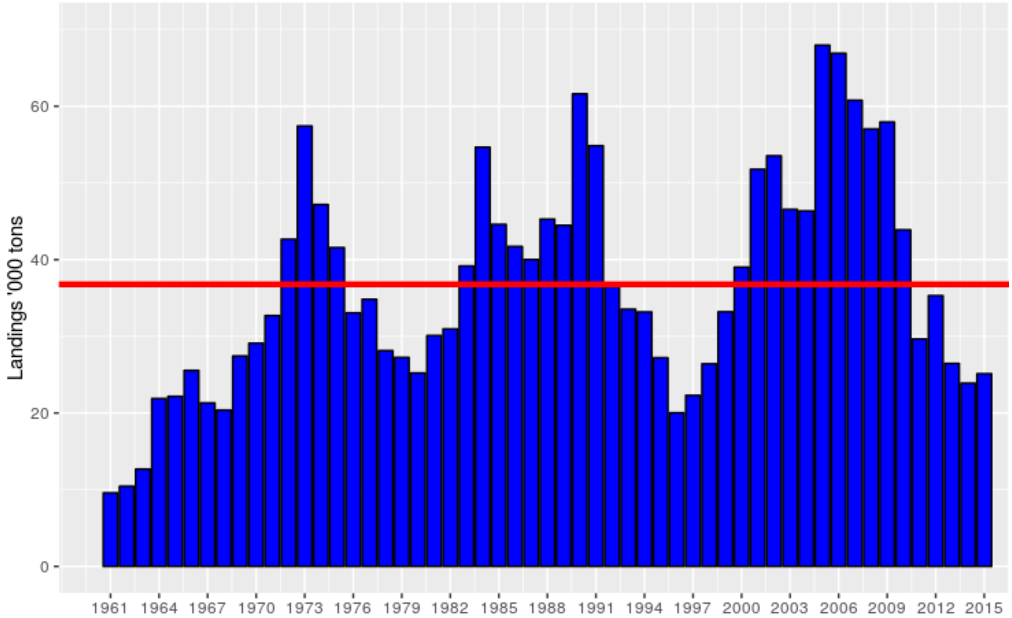


Figure 6.2.1.1. Faroe saithe (Division 5.b). Landings in 1000 tonnes (1961–2015). Horizontal red line represents historical average landings.

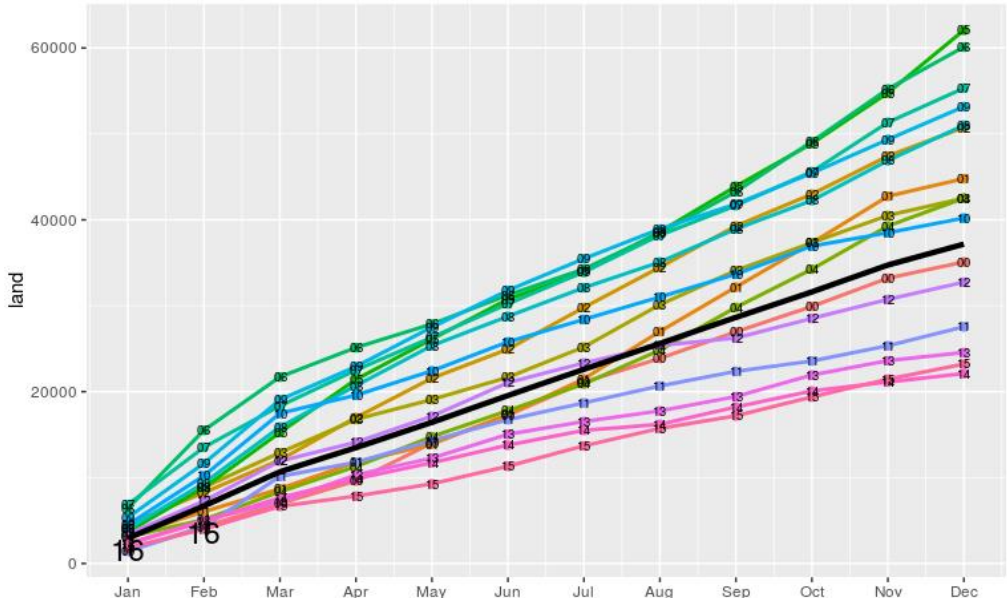


Figure 6.2.1.2. Saithe in the Faroes (Division 5.b). Cumulative domestic landings (2000–2016).

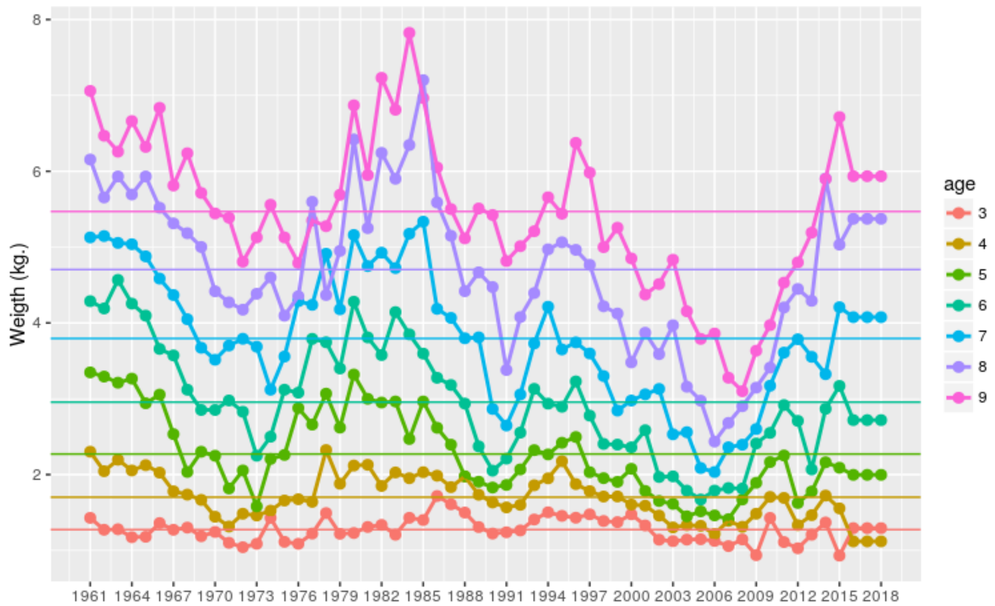


Figure 6.2.3.1. Faroe saithe (Division 5.b). Mean weight at age (kg) in commercial catches (ages 3–9) (1961–2018). Weights from 2016 to 2018 are estimates. Horizontal lines show historical average.

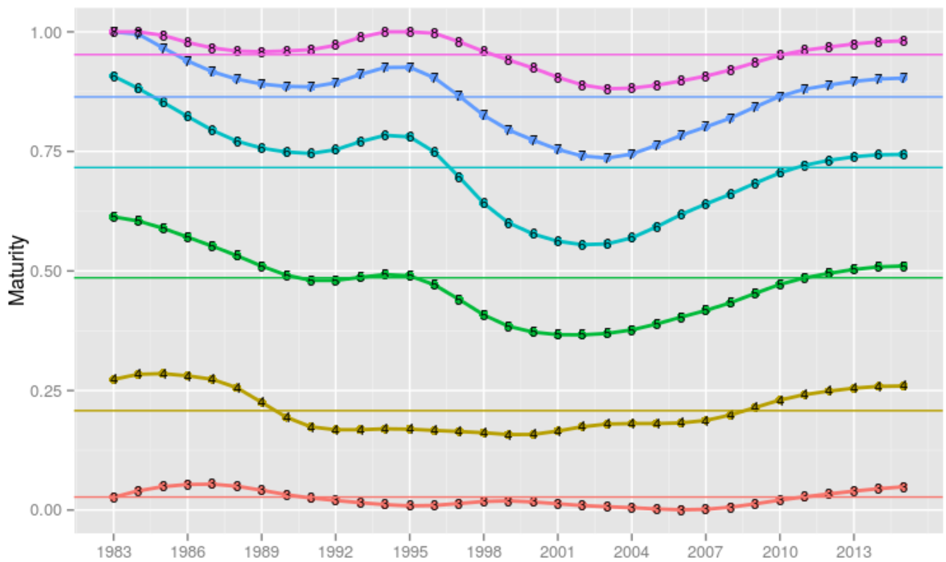


Figure 6.2.4.1. Faroe saithe (Division 5.b). Smoothed maturity ogives (ages 3-8)(1983–2015) from FGFS1 (spring survey). Horizontal lines show historical average.

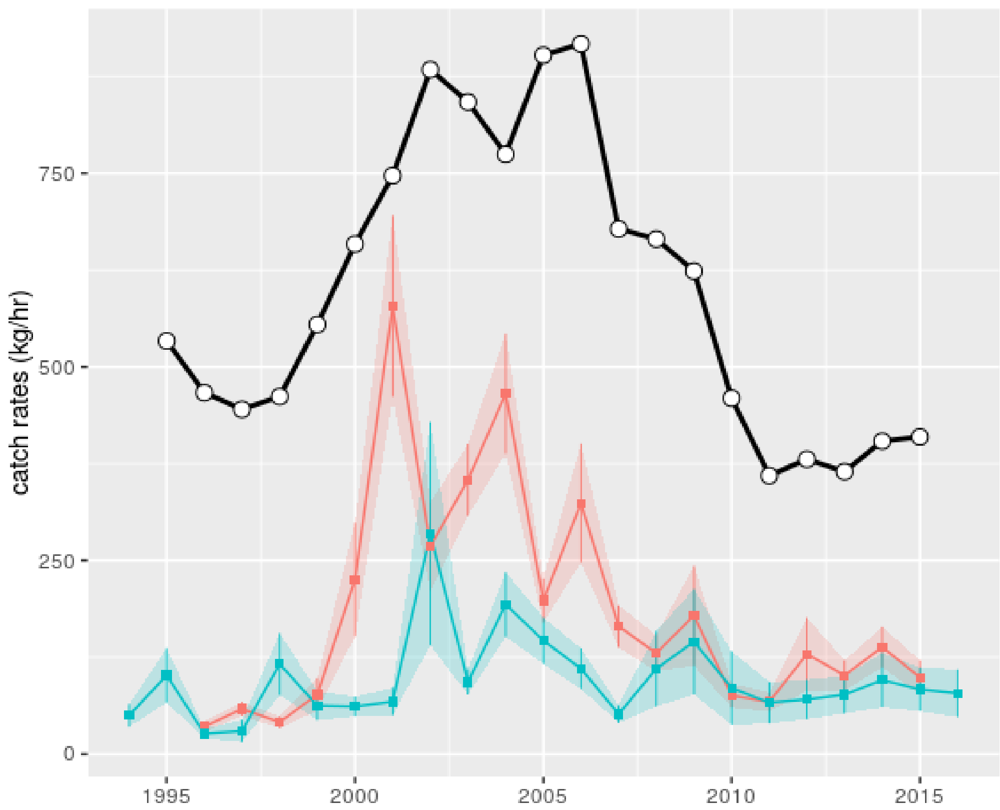


Figure 6.2.5.1.1. Faroe saithe (Division 5.b). Predicted catch rates from the commercial fleet (pairtrawlers) used for tuning the assessment (black line). Catch rates (kg/hour) from the Faroese bottom-trawl fall FGFS2 (1996–2015)(red line) and spring survey FGFS1 (1994–2016)(blue line). Shade areas show standard errors in the estimation of indices.

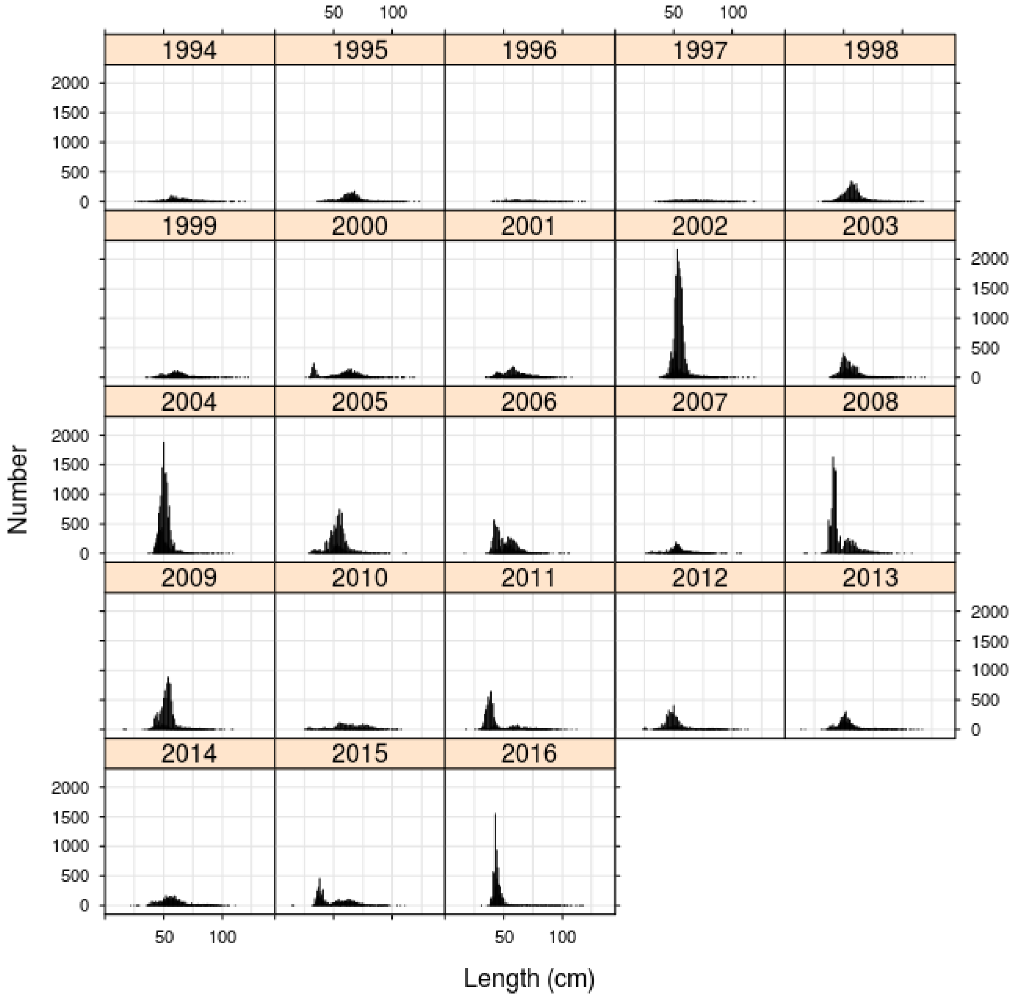


Figure 6.2.5.1.2. Faroe saithe (Division 5.b). Length composition from the Faroese bottom-trawl spring survey FGFS1 (1994–2016)

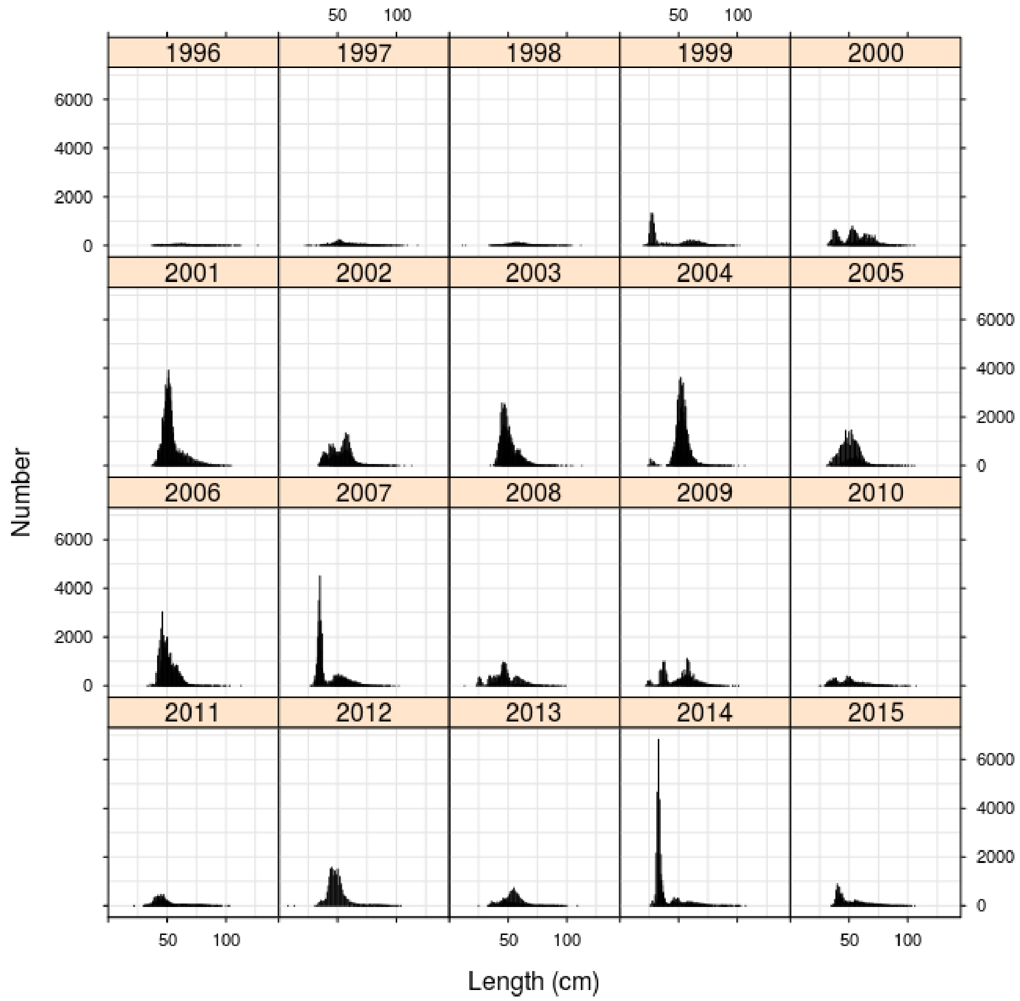


Figure 6.2.5.1.3. Faroe saithe (Division 5.b). Length composition from the Faroese bottom-trawl summer survey FGFS2 (1996–2015)

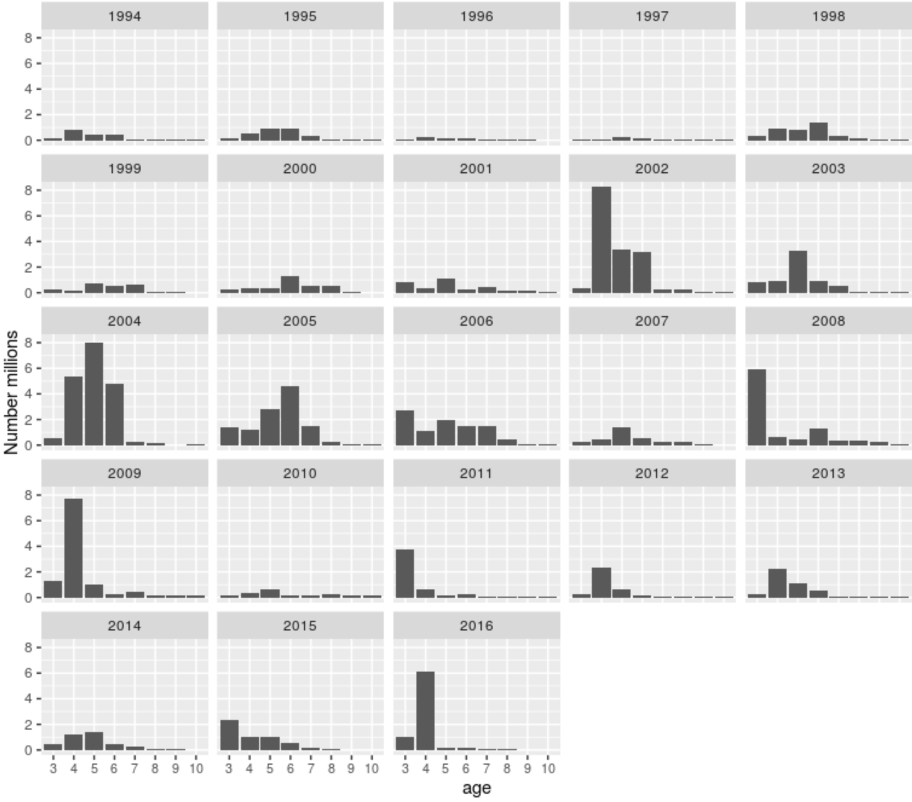


Figure 6.2.5.1.4. Faroe saithe (Division 5.b). Age-disaggregated indices in the Faroese bottom-trawl spring survey FGFS1 (ages 3–10, years 1994–2016)

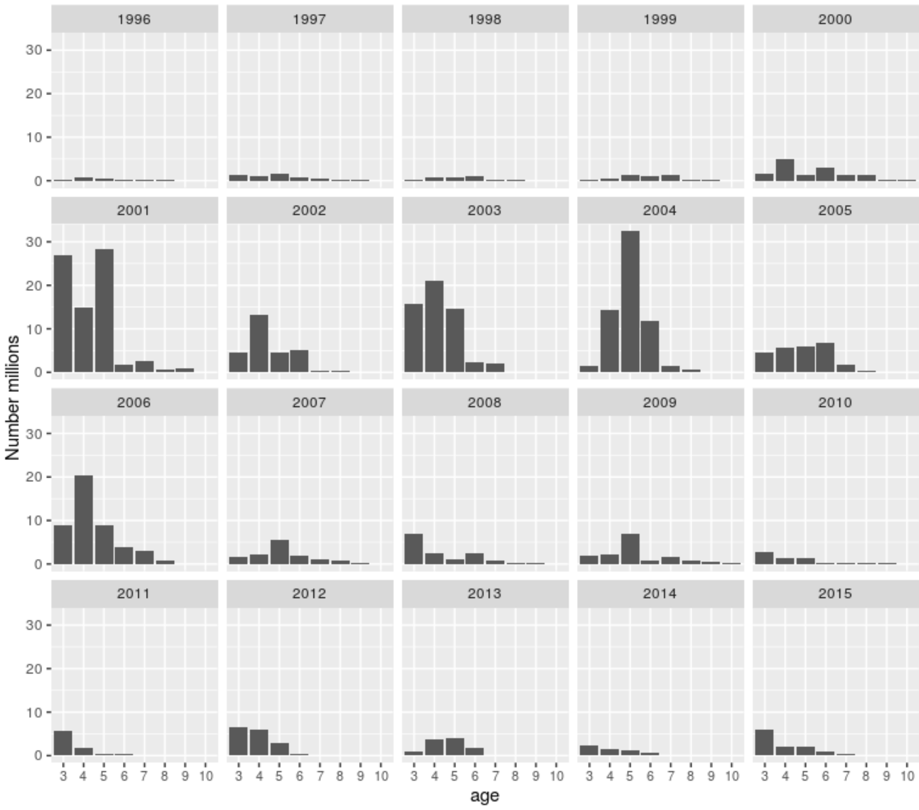


Figure 6.2.5.1.5. Faroe saithe (Division 5.b). Age-disaggregated indices in the Faroese bottom-trawl fall survey FGFS2 (ages 3–10, years 1996–2015)

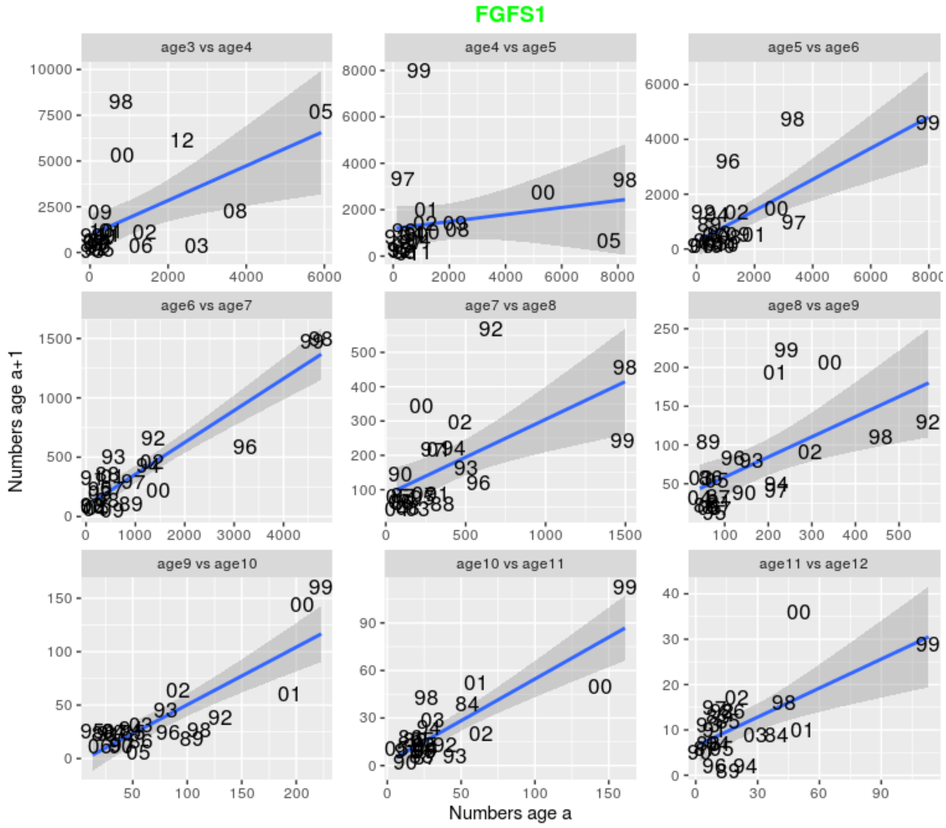


Figure 6.2.5.1.6. Faroe saithe (Division 5.b). Numbers from spring survey (FGFS1) plotted against numbers of the same year class one year later. Letters in the figures represent year classes.

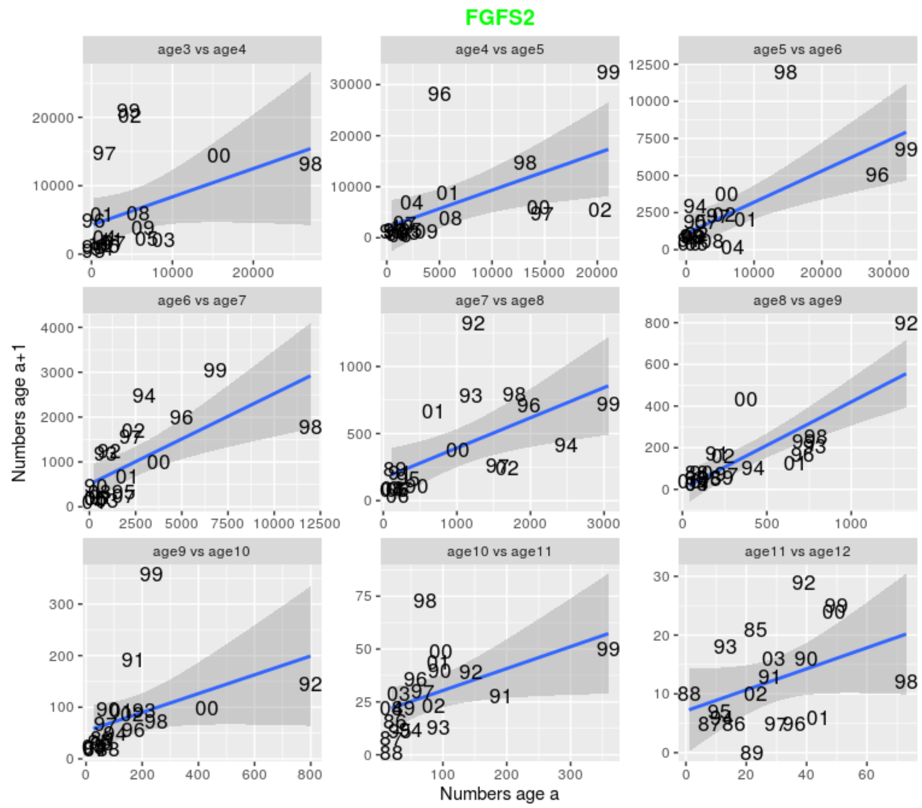


Figure 6.2.5.1.7. Faroe saithe (Division 5.b). Numbers from summer survey (FGFS2) plotted against numbers of the same year class one year later. Letters in the figures represent year classes.

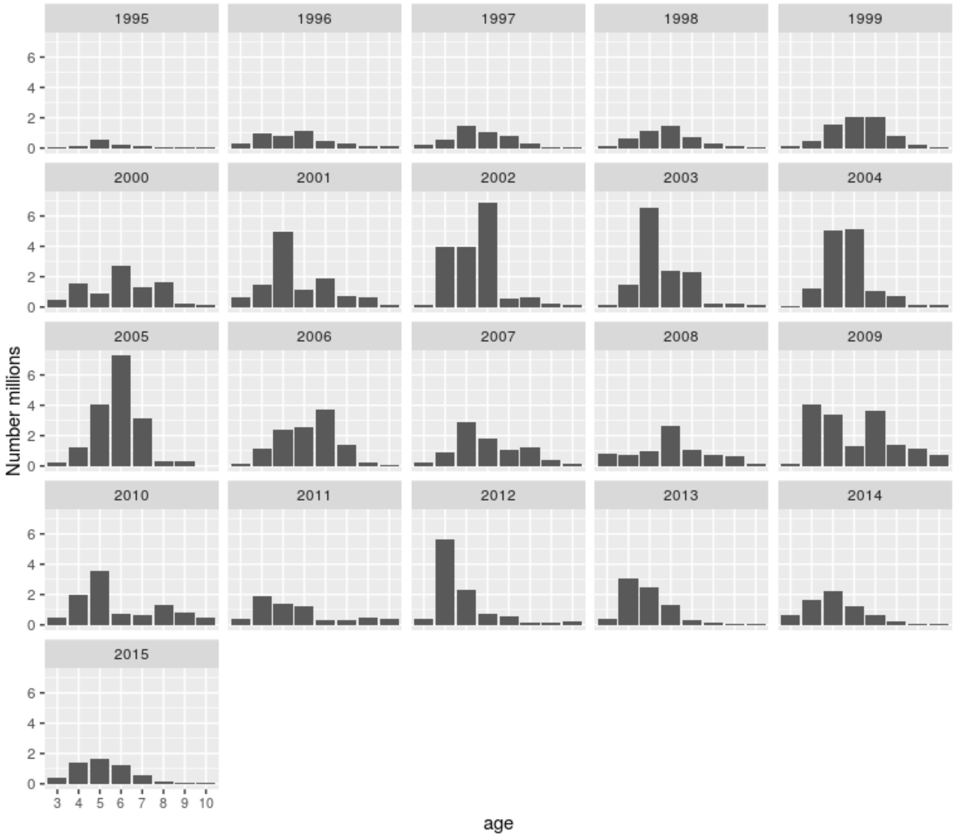


Figure 6.2.5.2.1. Faroe saithe (Division 5.b). Age-disaggregated indices in the commercial pair-trawl fleet (ages 3-10, years 1995-2015)

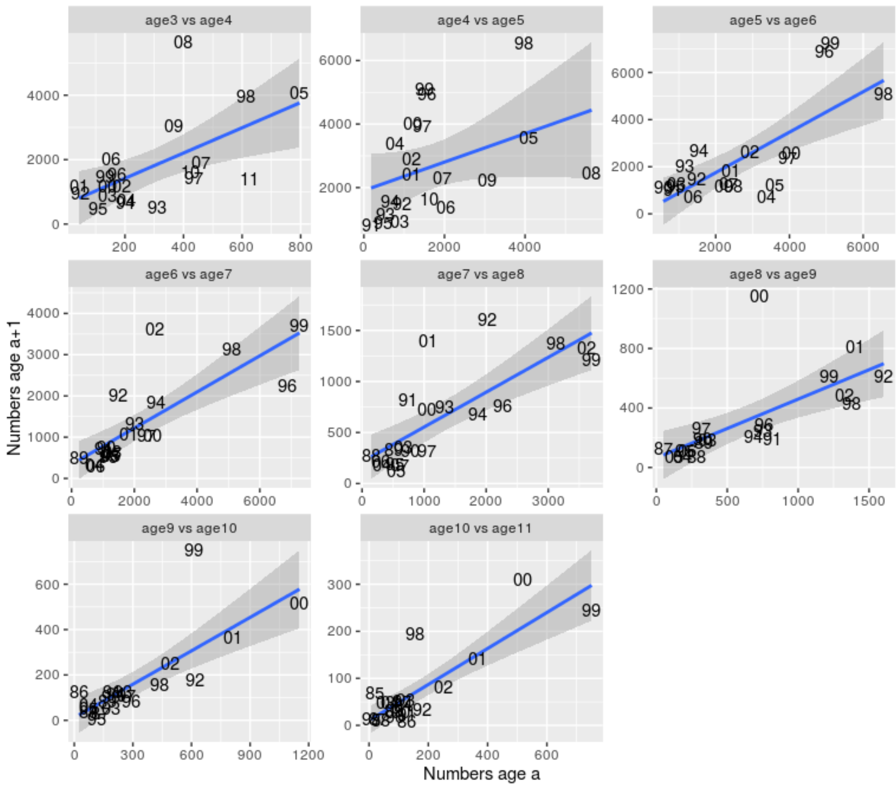


Figure 6.2.5.2.2. Faroe saithe (Division 5.b). Indices from in the commercial pair-trawl plotted against indices of the same year class one year later. Letters in the figures represent year classes.

Figure 6.3.1. Faroe saithe (Division 5.b). Log-catchability residuals of the spaly assessment calibrated with the commercial series (ages 3–11, years 1995–2015). Blue and red bubbles represent positive and negative residuals respectively.

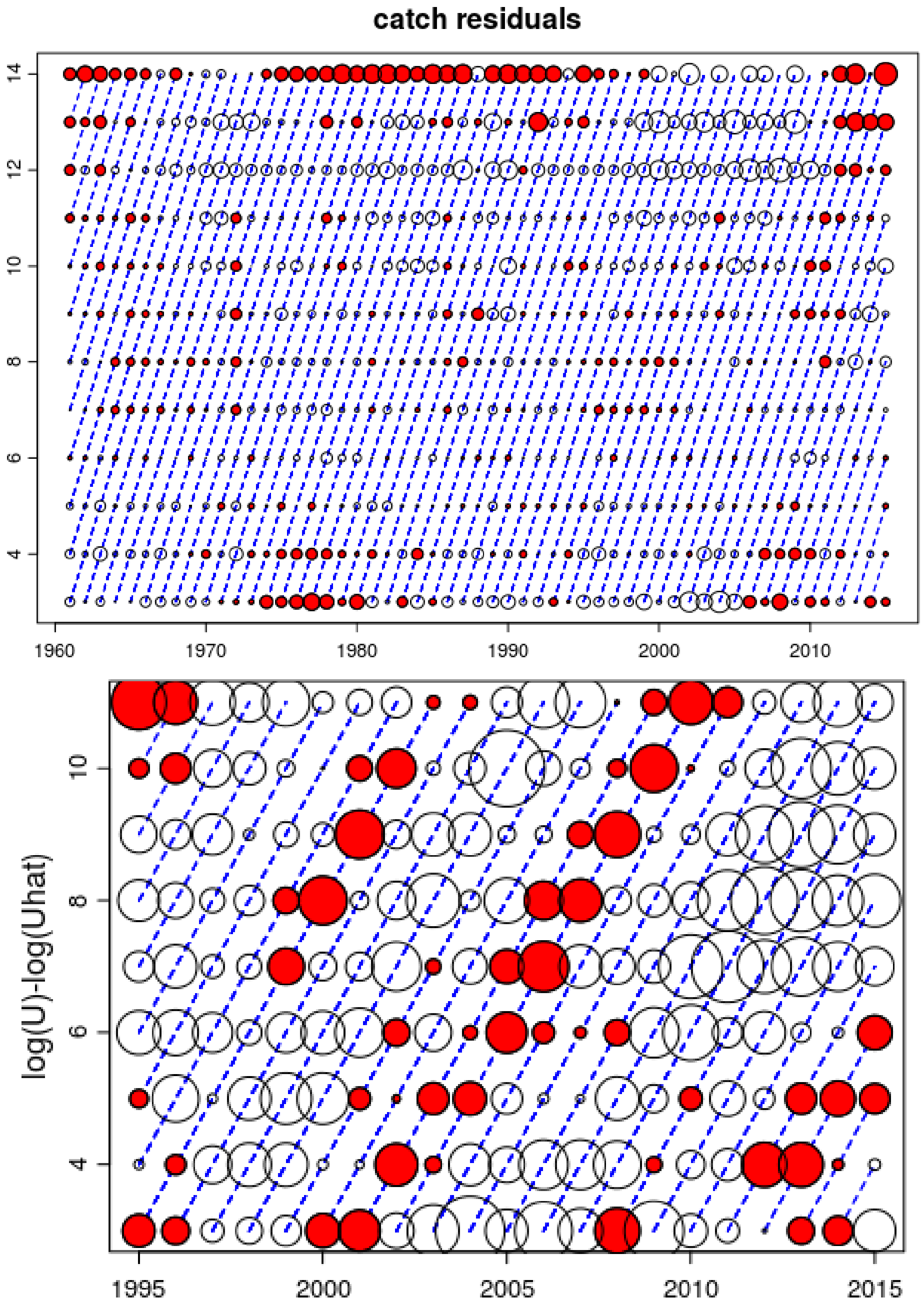


Figure 6.3.3. Faroe saithe (Division 5.b). Catch-(ages 3-14+, years 1961–2015)(top plot) and survey-at-age (ages 3–11, years 1995–2015)(bottom plot) residuals from a statistical catch-at-age model. Red and white bubbles represent positive and negative residuals respectively.

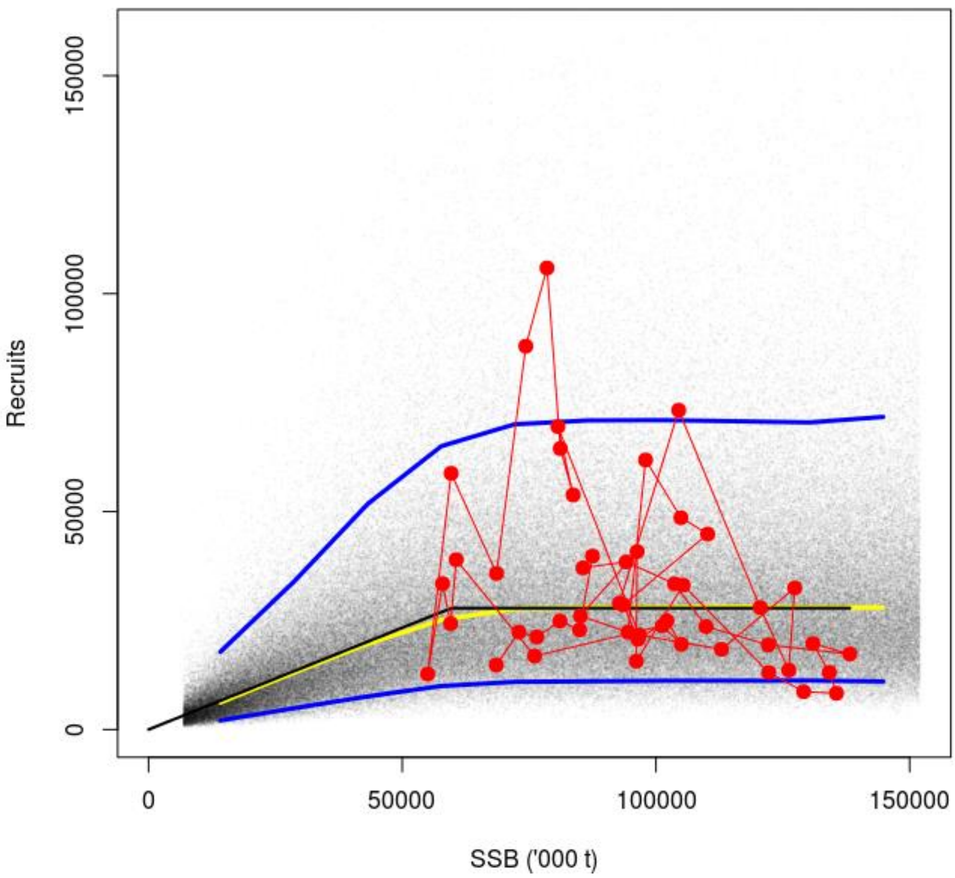


Figure 6.4.1.1. Faroe saithe (Division 5.b). EqSim simulation. Stock–recruitment function used in the simulations (Hockey-stick).

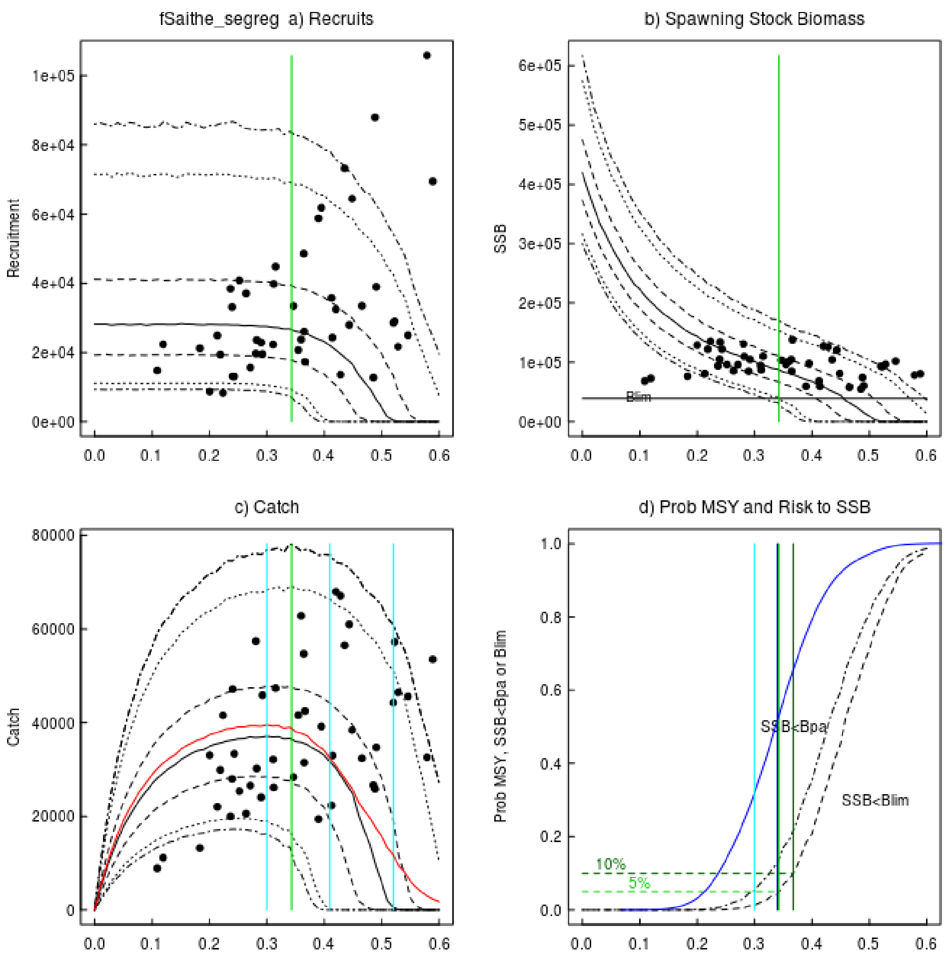


Figure 6.4.1.2. Faroe saithe (Division 5.b). EqSim simulation outputs with assessment errors and Hockey-stick function from WKMSYREF2 report. B_{lim} is undefined but was set as $B_{lim}=B_{pa}/1.4$.

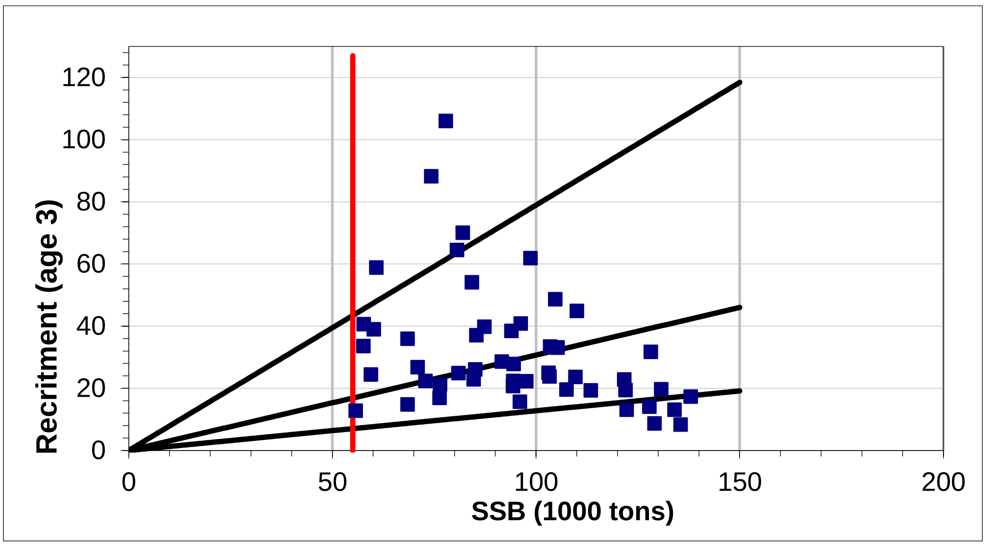


Figure 6.4.1.3. Faroe saithe (Division 5.b). Stock–recruitment plot in relation to F_{low}=0.13 (lowest regression line), F_{med}=0.31 (middle regression line) and Fhigh=0.79 (top regression line). Vertical red line represents $B_{trigger}$= 55 000 t.

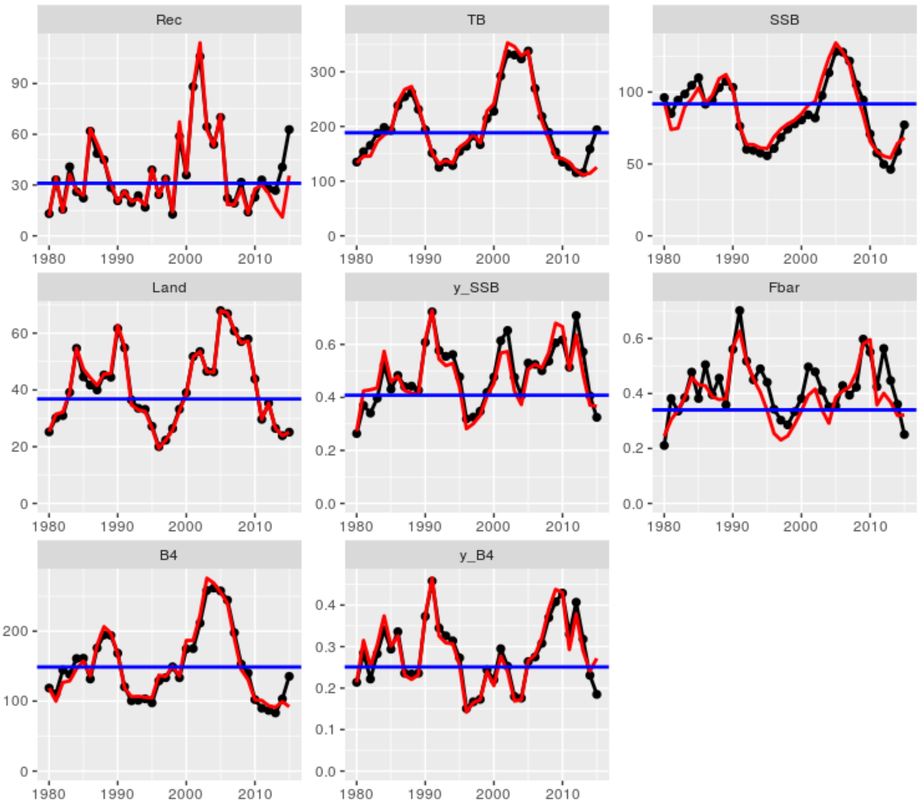


Figure 6.5.1. Faroe saithe (Division 5.b). Recruitment (age 3) in millions (top-left), total-stock biomass (thousand tonnes)(top-middle), spawning-stock biomass (thousand tonnes) (bottom-left), landings (thousand tonnes)(middle-left), landings SSB ratio (middle-middle), F_{bar} (ages 4 to 8)(middle-right), reference biomass (B4+) (thousand tonnes) (bottom-left) and landings B4+ ratio (bottom-right). Black line represents the spaly run. Red lines show estimates from a catch-at-age statistical model implemented in ADMB. Horizontal blue lines represent historical averages.

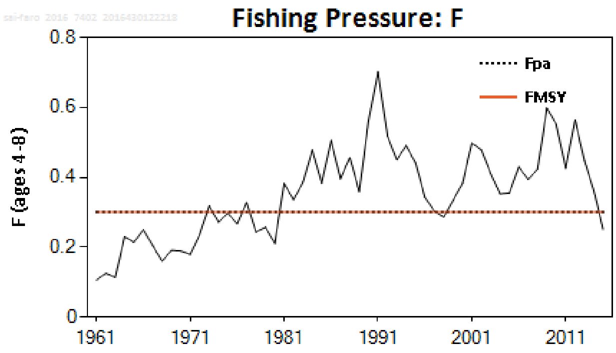


Figure 6.5.2. Faroe saithe (Division 5.b). Fishing mortality (average over ages 4–8)(1961–2015)

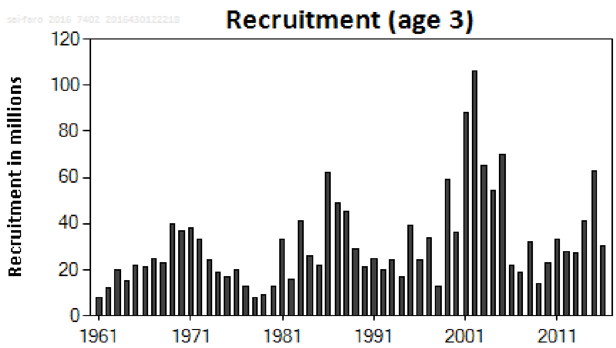


Figure 6.5.3. Faroe saithe (Division 5.b). Recruitment-at-age 3 (millions)(1961–2016). The 2016 recruitment estimate is used in the short-term forecast.

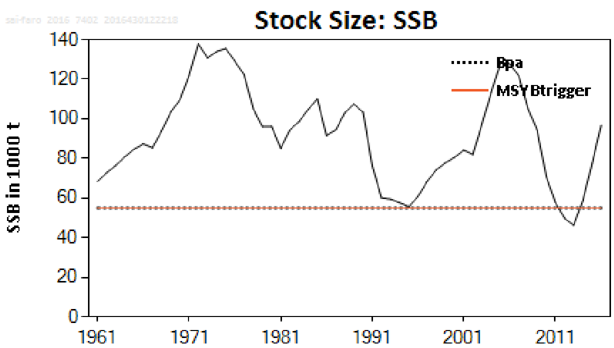


Figure 6.5.4. Faroe saithe (Division 5.b). Spawning-stock biomass ('000 tonnes)(1961–2016). The 2016 SSB estimate is used in the short-term forecast. Horizontal lines represent $B_{trigger}$=B_{pa}=55 000 t.

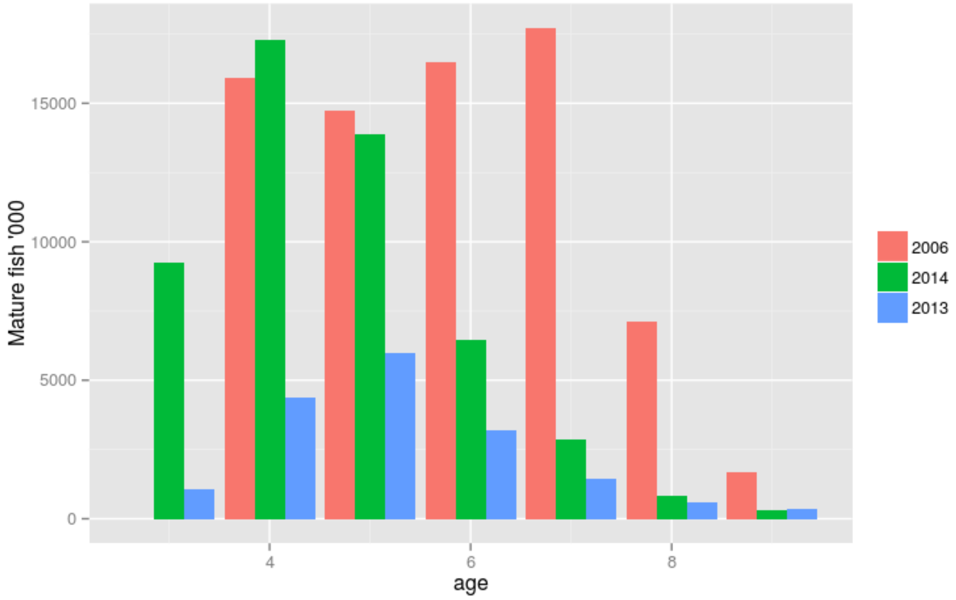


Figure 6.5.6. Faroe saithe (Division 5.b). Numbers of mature fish in the stock (ages 3–9) for 2006, 2013 and 2014.

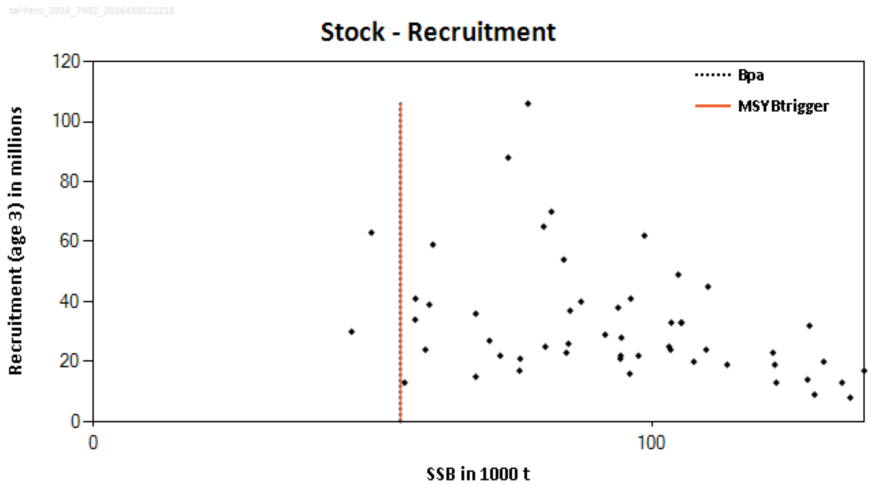


Figure 6.5.7. Faroe saithe (Division 5.b). SSB Recruitment (age 3) plot. $B_{trigger}$=B_{pa}=55 000 t.

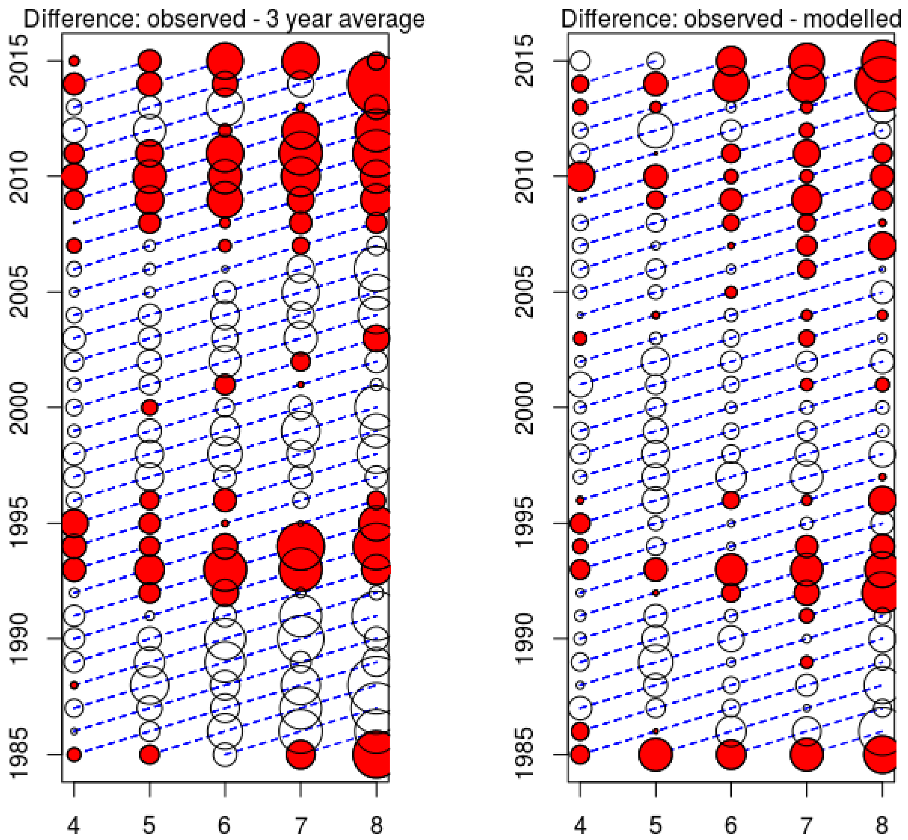


Figure 6.6.1.1. Faroe saithe (Division 5.b). Residual plots from a 3-year running average weight model and the model in which weights are predicted from the previous year in the same year class. Red and white bubbles represent positive and negative residuals respectively.

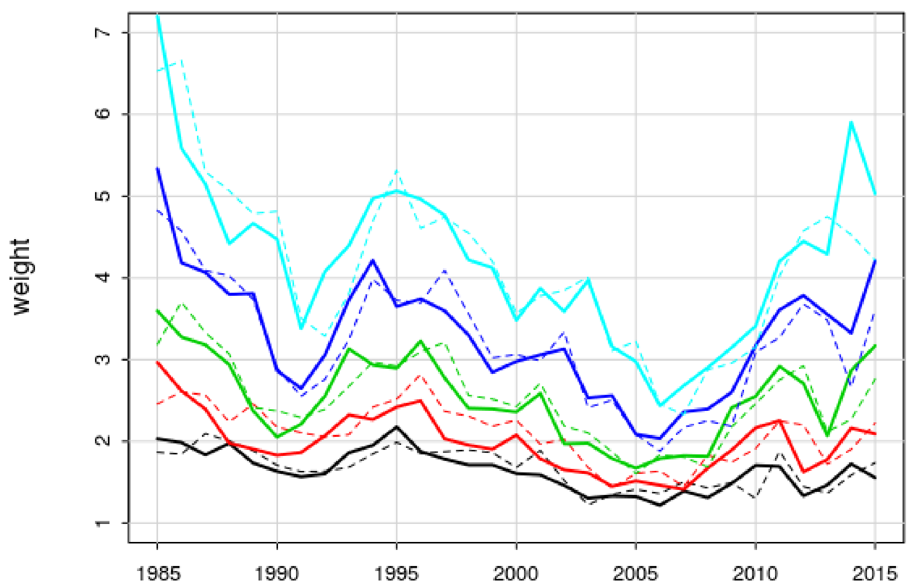


Figure 6.6.1.2. Faroe saithe (Division 5.b). Observed (stapled lines) and predicted weights (solid lines)(ages 4–8, years 1985–2015)

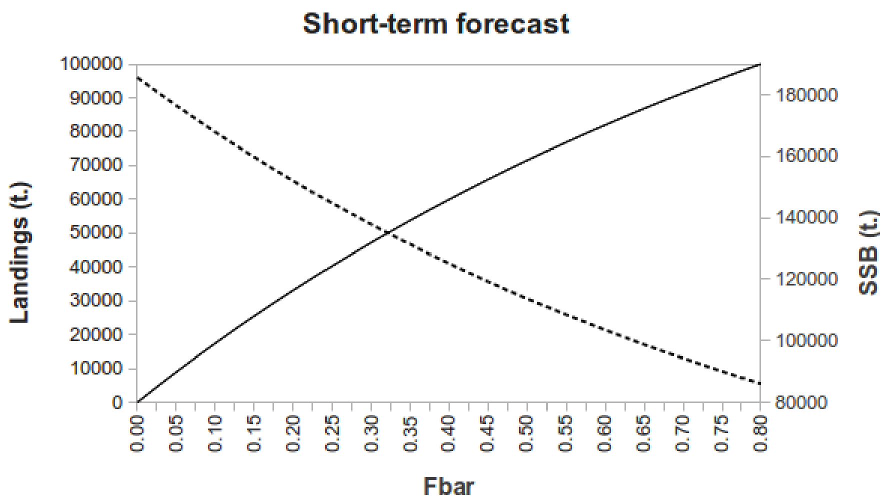
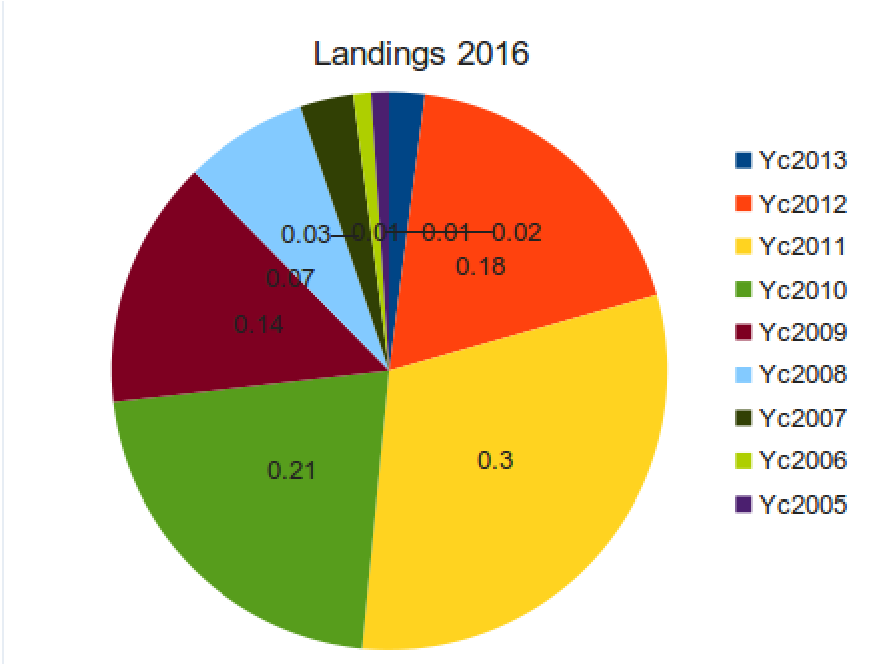


Figure 6.6.2.1. Faroe saithe (Division 5.b). Short-term prediction output (spaly assessment). Solid and broken lines represent landings (t) and spawning-stock biomass (t) respectively.



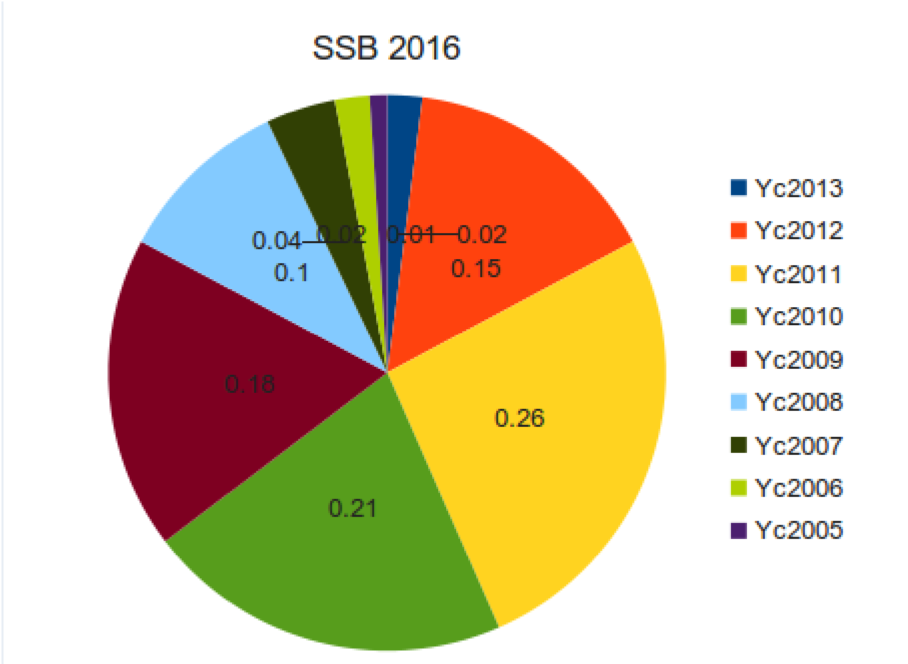


Figure 6.6.2.2 Faroe saithe (Division 5.b). Composition of landings (upper figure) and SSB (lower figure) by year classes in 2016.

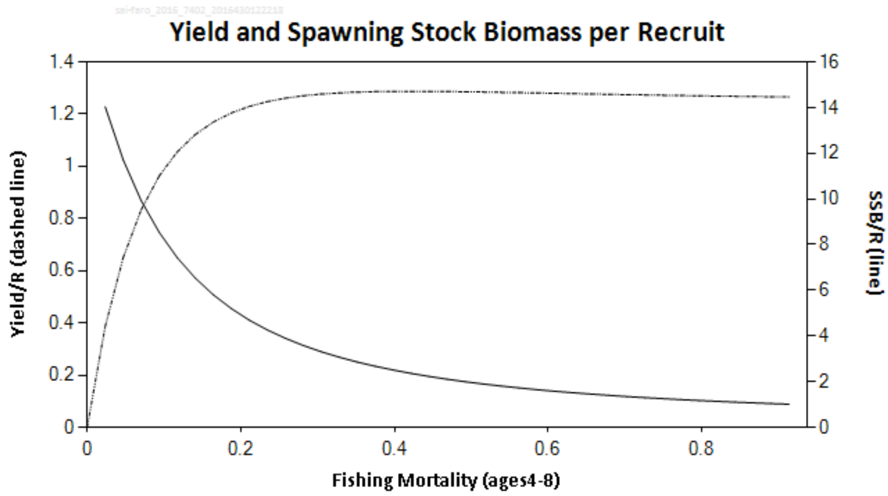


Figure 6.7.1.1. Faroe saithe (Division 5.b). Yield and spawning per-recruit calculations. Dashed and solid lines represent Yield/R and SSB/R respectively.

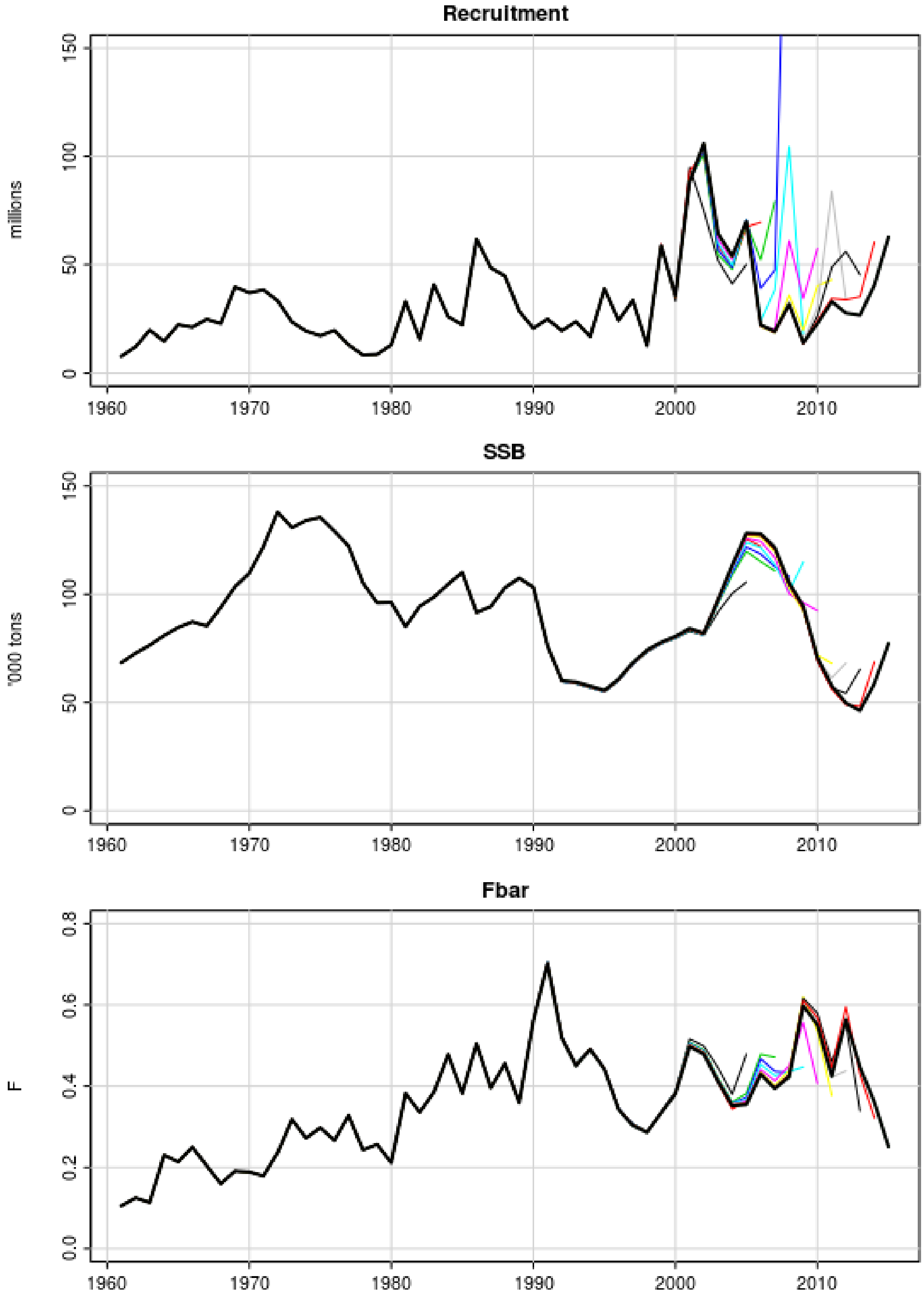


Figure 6.8.1. Faroe saithe (Division 5.b). Retrospective analysis of recruitment-at-age 3 (millions)(top figure), spawning-stock biomass ('000 tonnes)(middle figure) and average fishing mortality over age groups 4–8 (bottom figure) from the spaly assessment.

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 overwintering 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).

7.7 References

Anon. 1994. Hagkvæm nýting fiskistofna (On Rational Utilization of fish stocks). In Icelandic. Reykjavik, 27pp.

Astthorsson, O.S., Gislason, A, Jonsson, S. 2007. Climate variability and the Icelandic marine

ecosystem. Deep-Sea Research II. 54: 2456-2477.

Astthorsson, O.S., Vilhjalmsson, H. 2002. Icelandic shelf LME: Decadal assessment and resource sustainability. Pp. 219-249 in Sherman, K. and H.R. Skjoldal. Large marine ecosystems of the North Atlantic. Elsevier Press. Amsterdam.

Baldursson, F.M., Daníelsson, Á. and Stefánsson, G. 1996. On the rational utilization of the Icelandic cod stock. ICES Journal of Marine Science 53: 643-658.

Daníelsson, Á., Stefánsson, G., Baldursson, F.M. and Thórarinsson, K. 1997. Utilization of the Icelandic Cod Stock in a Multispecies Context. Marine Resource Economics 12: 329-244.

Gudmundsson, K. 1998. Long-term variability in phytoplankton productivity during spring in Icelandic waters. ICES Journal of Marine Science, 55:635-643.

ICES. 2008. Report of the Working group for Regional Ecosystem Description (WGRED),25-29 February 2008, ICES, Copenhagen, Denmark. ICES CM 2008/ACOM:47. 203 pp.

Pálsson, Ó K. 2003. A length based analysis of haddock discards in Icelandic fisheries. Fish. Res. **59**: 437-446 (http://www.sciencedirect.com).

Pálsson, Ó K. 2005. An analysis of by-catch in the Icelandic blue whiting fishery. Fish. Res. **73**: *135-146.* (http://www.sciencedirect.com).

Stefánsson, U. 1962. North Icelandic Waters.Rit Fiskideildar Vol IIII,1-269.

Stefánsson, G., Sigurjónsson, J. and Víkingsson, G.A. 1997. On Dynamic Interactions Between Some Fish Resources and Cetaceans off Iceland Based on a Simulation Model. Northw. Atl., Fish. Sci. 22: 357-370.

Stefánsson, G., Hauksson, E., Bogason, V., Sigurjónsson, J. and Víkingsson, G. 1997. Multispecies interactions in the C Atlantic. Working paper to NAMMCO SC SC/5/ME13 1380 (unpubl.).

Valdimarsson, H and S-A Malmberg, 1999. Near-surface circulation in Icelandic waters derived from saltellite tracked drifters. Rit Fiskideildar Vol XVI, 23-39.

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**

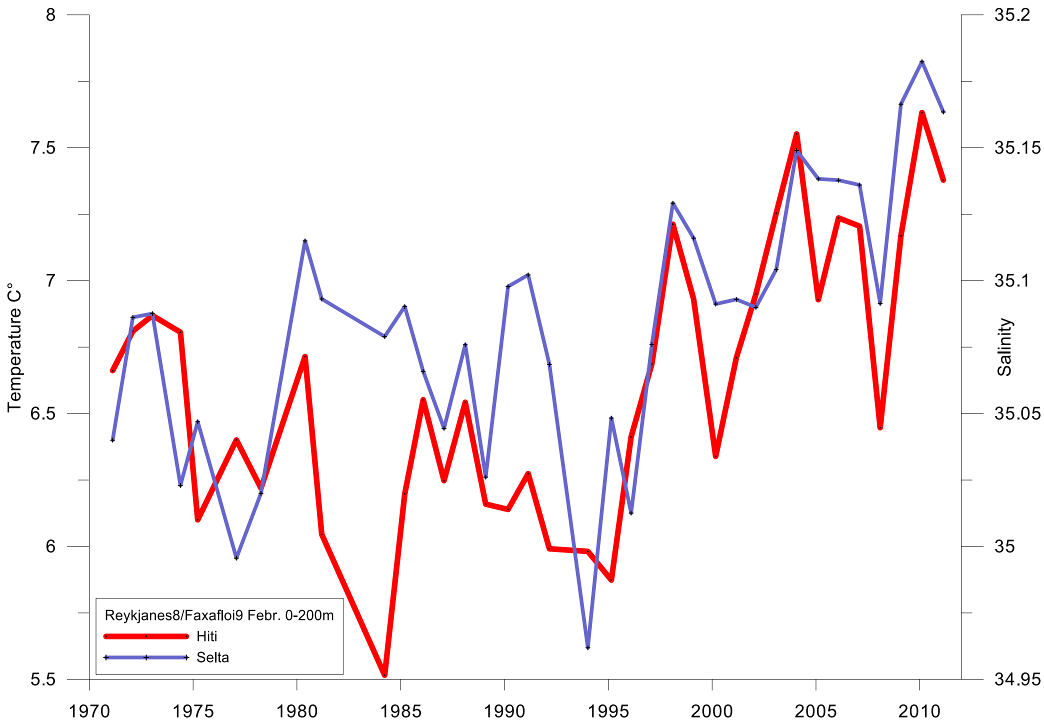


Figure 7.3.1. Temperature and salinity in winter west of Iceland 1971-2011. Mean 0-200m

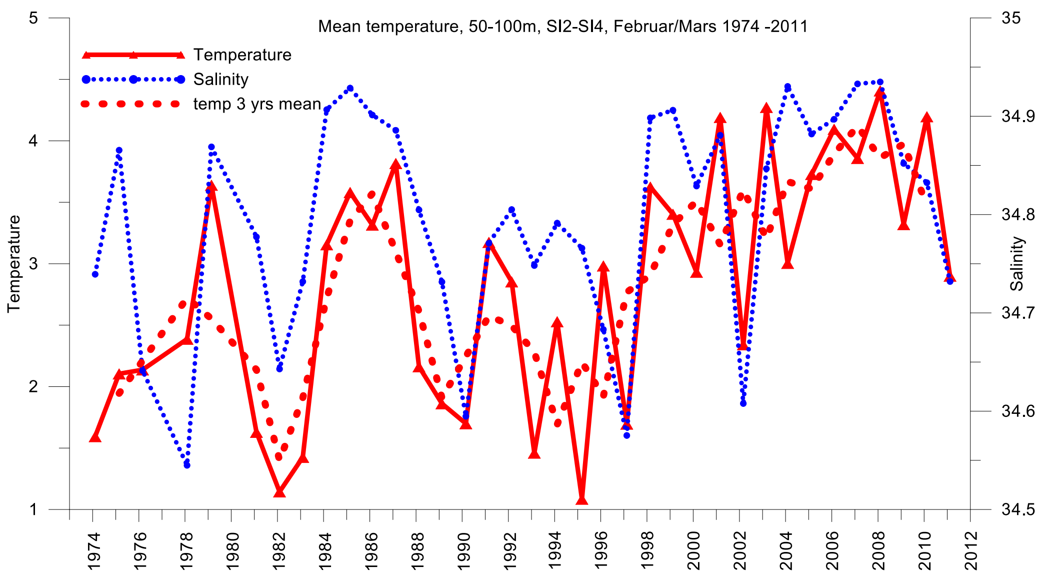


Figure 7.3.2. Temperature and salinity off central North-Iceland 1974-2011.

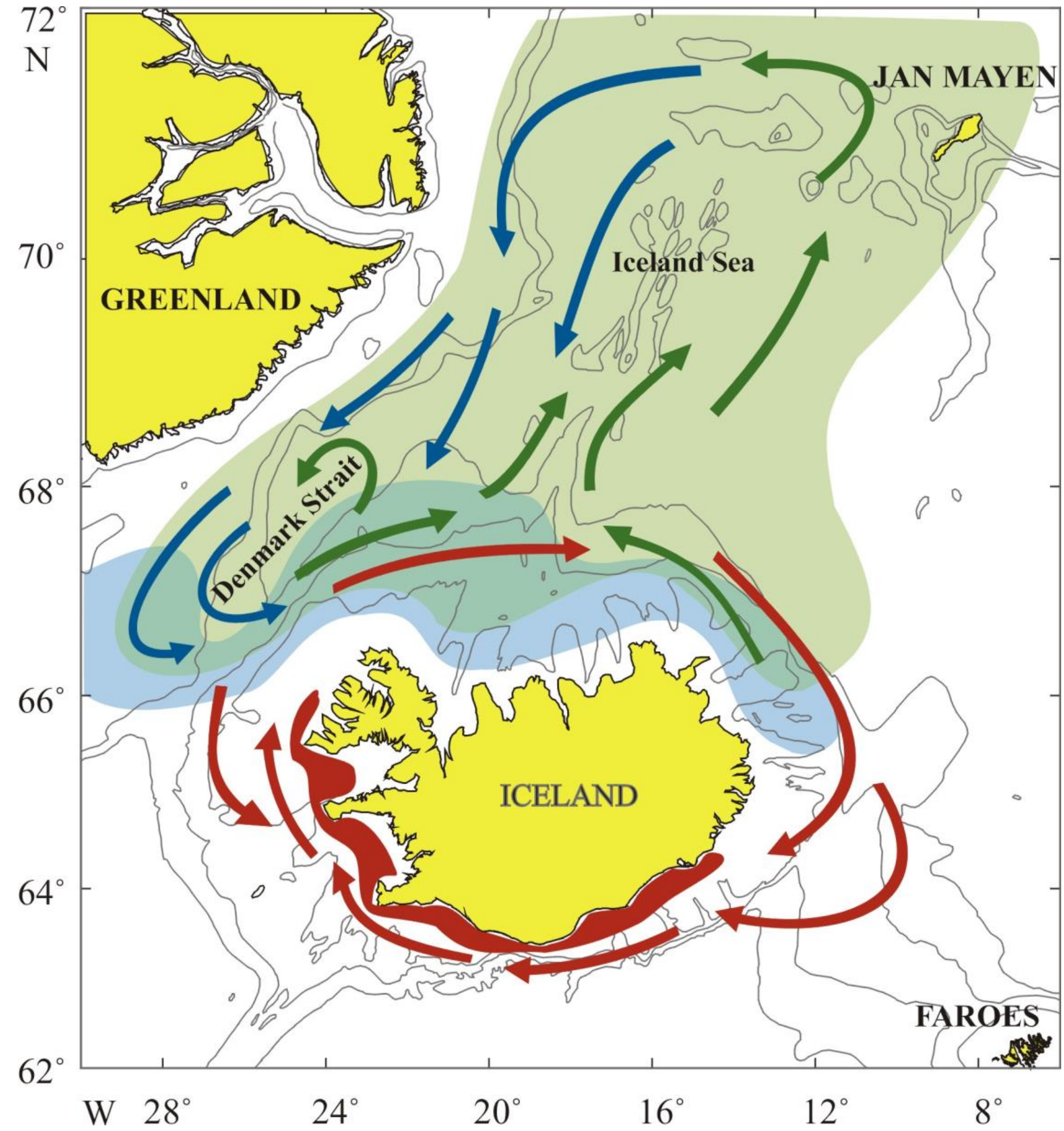


Figure 7.3.3. Distribution and migrations of capelin in the Iceland/East-Greenland/Jan Mayen area before 2001. Red: Spawning grounds; Green: Adult feeding area; Blue: Distribution and feeding area of juveniles; Green arrows: Adult feeding migrations; Blue arrows: Return migrations; Red arrows: Spawning migrations; Depth contours are 200, 500 and 1000 m (Vilhjalmsson 2002)

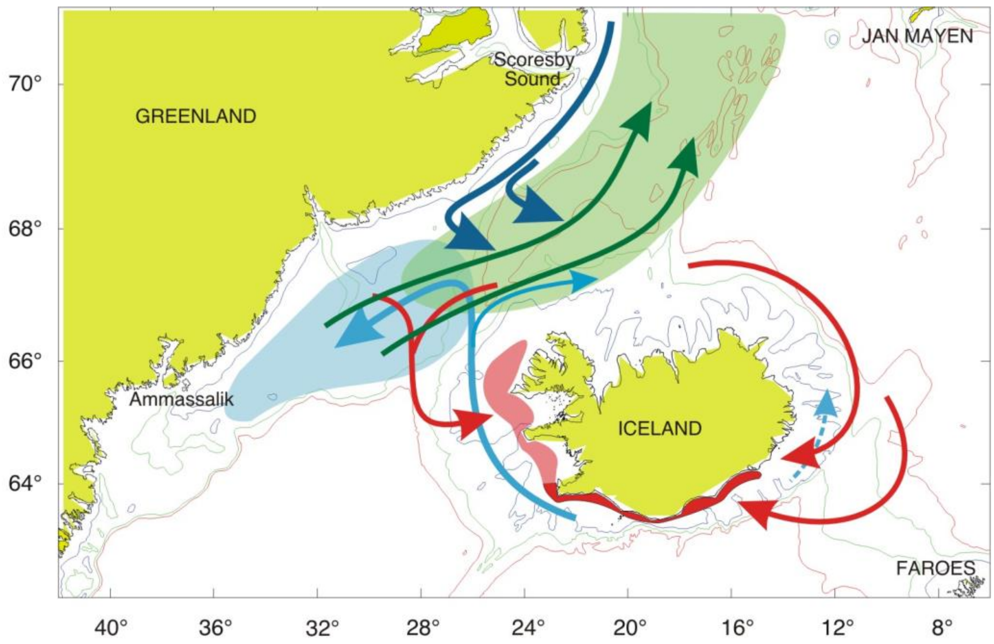


Figure 7.3.4. Likely changes of distribution and migration routes of capelin in the Iceland/Greenland/Jan Mayen area in the last 3-4 years. Green: Feeding area; Light blue: Juvenile area; Red area: Main spawning grounds; Lighter red colour: Lesser importance of W-Iceland spawning areas; Light blue arrows: Larval drift; Dark green arrows: Feeding migrations; Dark blue arrows: Return migrations; Red arrows: Spawning migrations. Depth contours are 200, 500 and 1000 m.

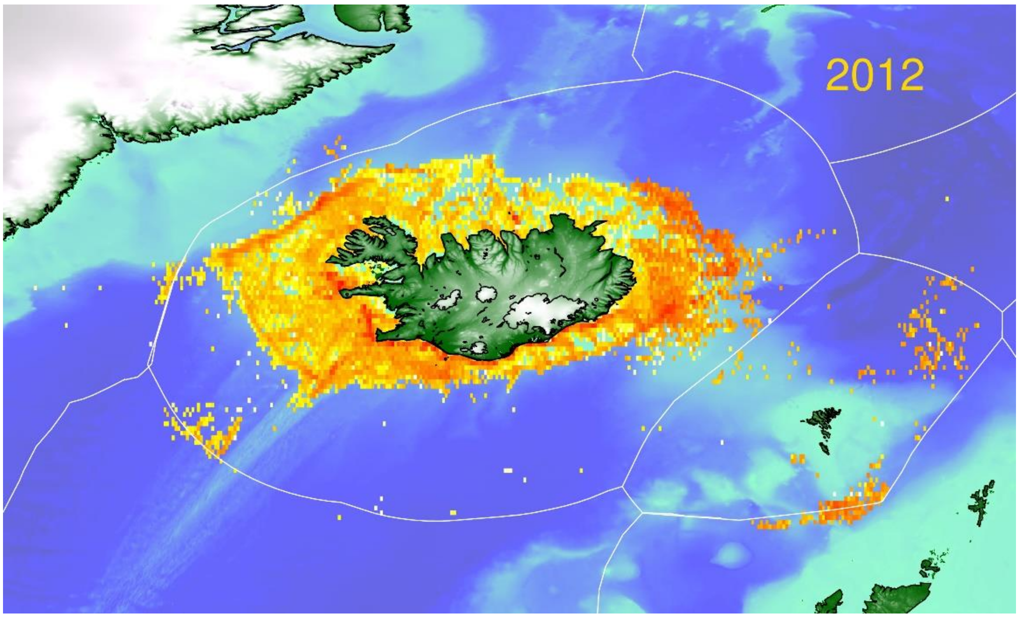


Figure 7.4.1. Distribution of total catch of all species by the Icelandic fishing fleet in Icelandic EEZ and adjacent waters in 2012. The EEZs are shown as white lines.

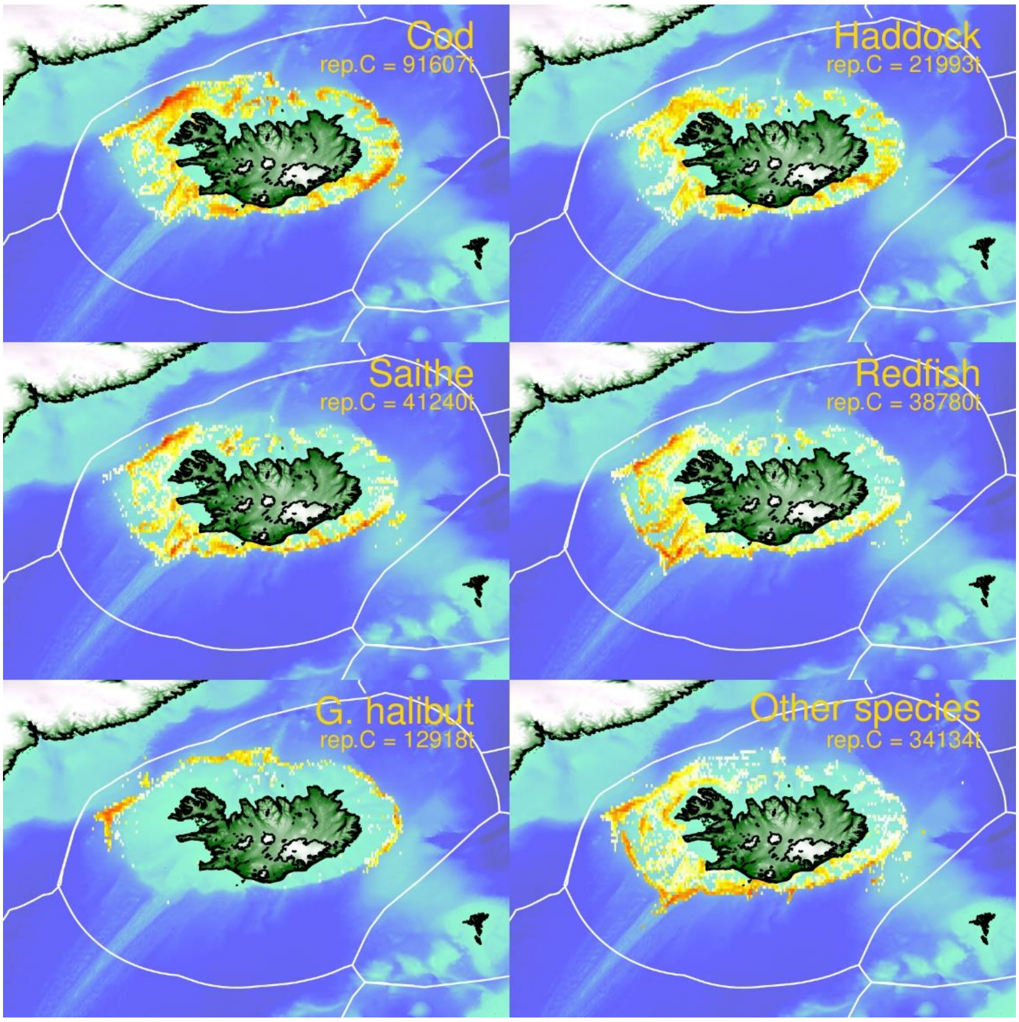


Figure 7.4.2. Location of catches of cod, saithe, haddock, redfish, Greenland halibut and others caught with bottom trawl in 2012.

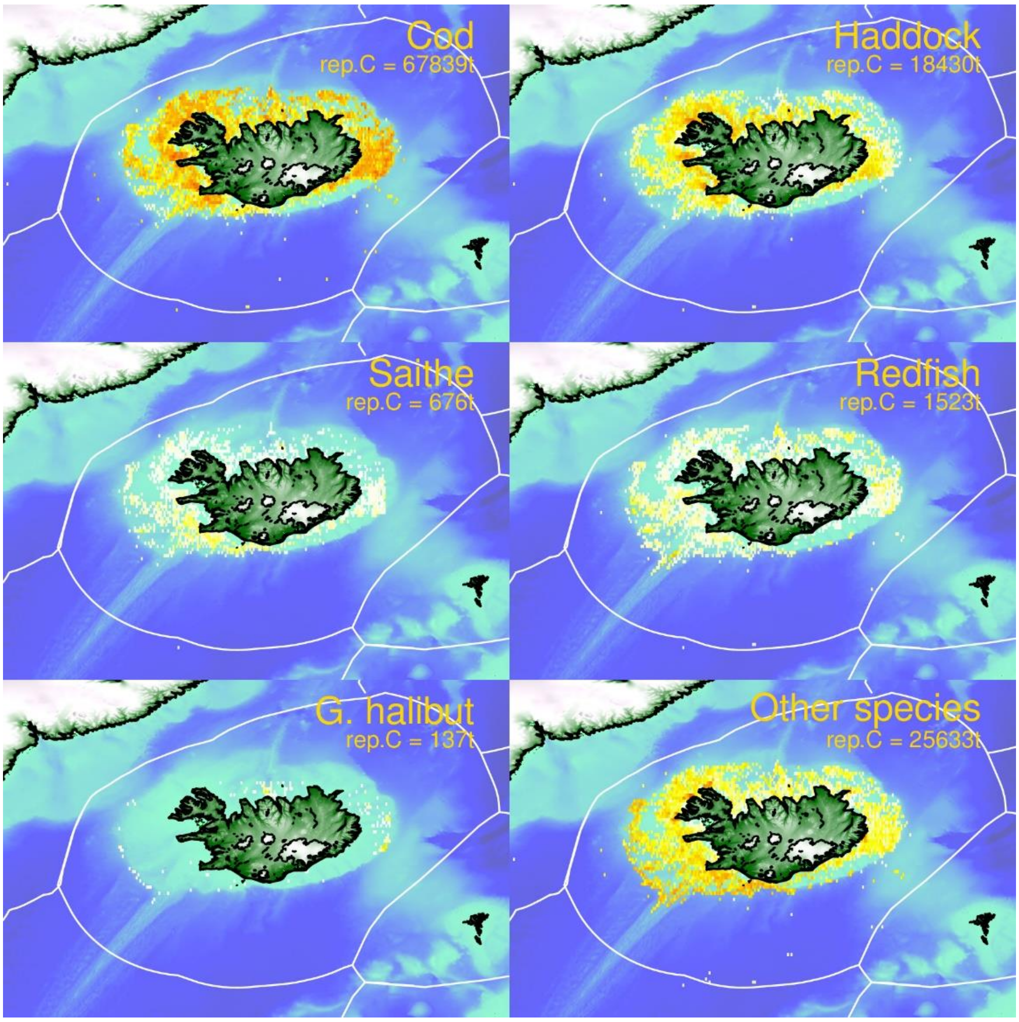


Figure 7.4.3. Location of catches of cod, saithe, haddock, redfish, Greenland halibut and others caught with long-line in 2012.

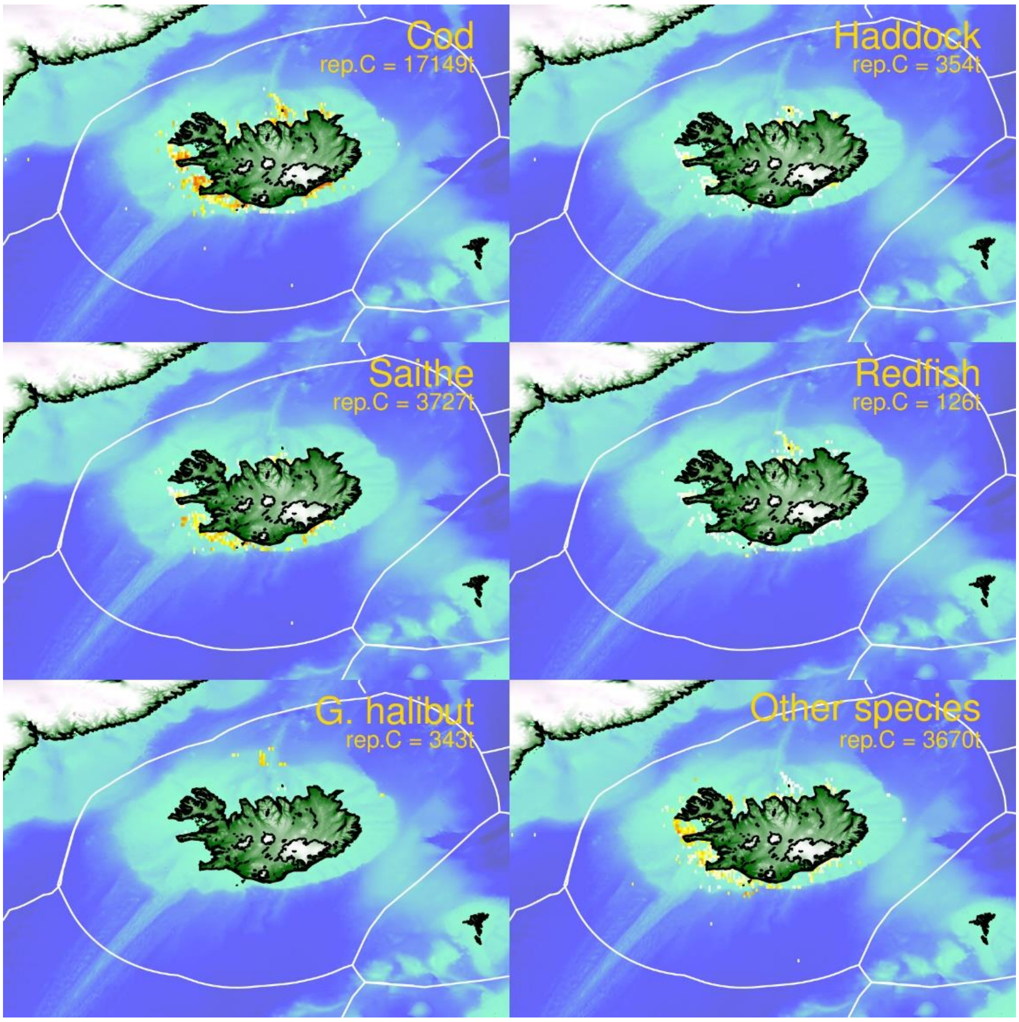


Figure 7.4.4. Location of catches of cod, saithe, haddock, redfish, Greenland halibut and others caught with gillnets in 2012.

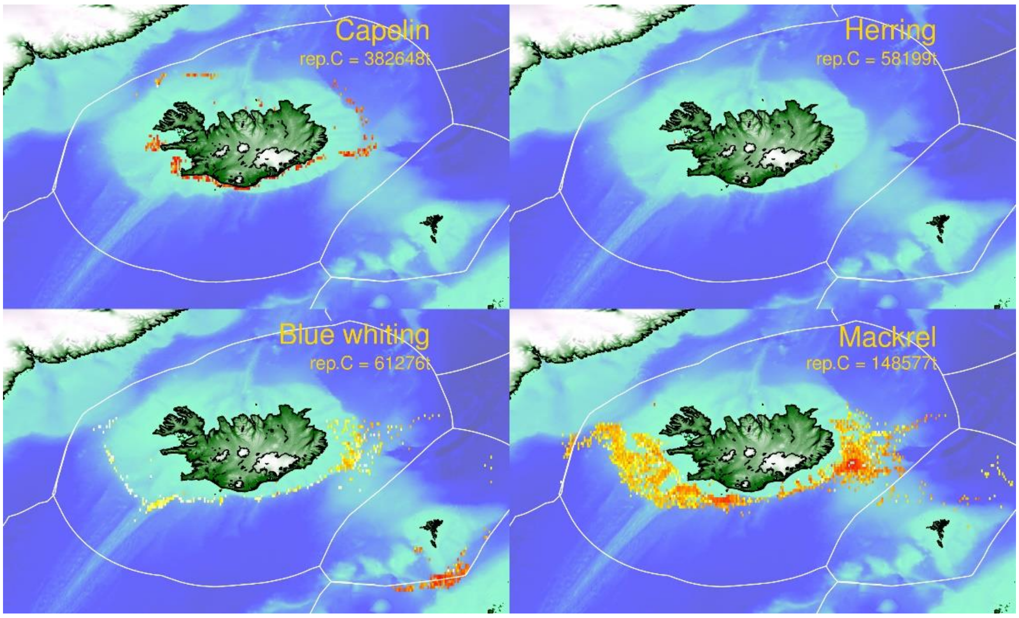


Figure 7.4.5. Location of catches of capelin, Icelandic summer spawning herring, blue whiting and mackerel with purse seine and pelagic trawls in 2012.

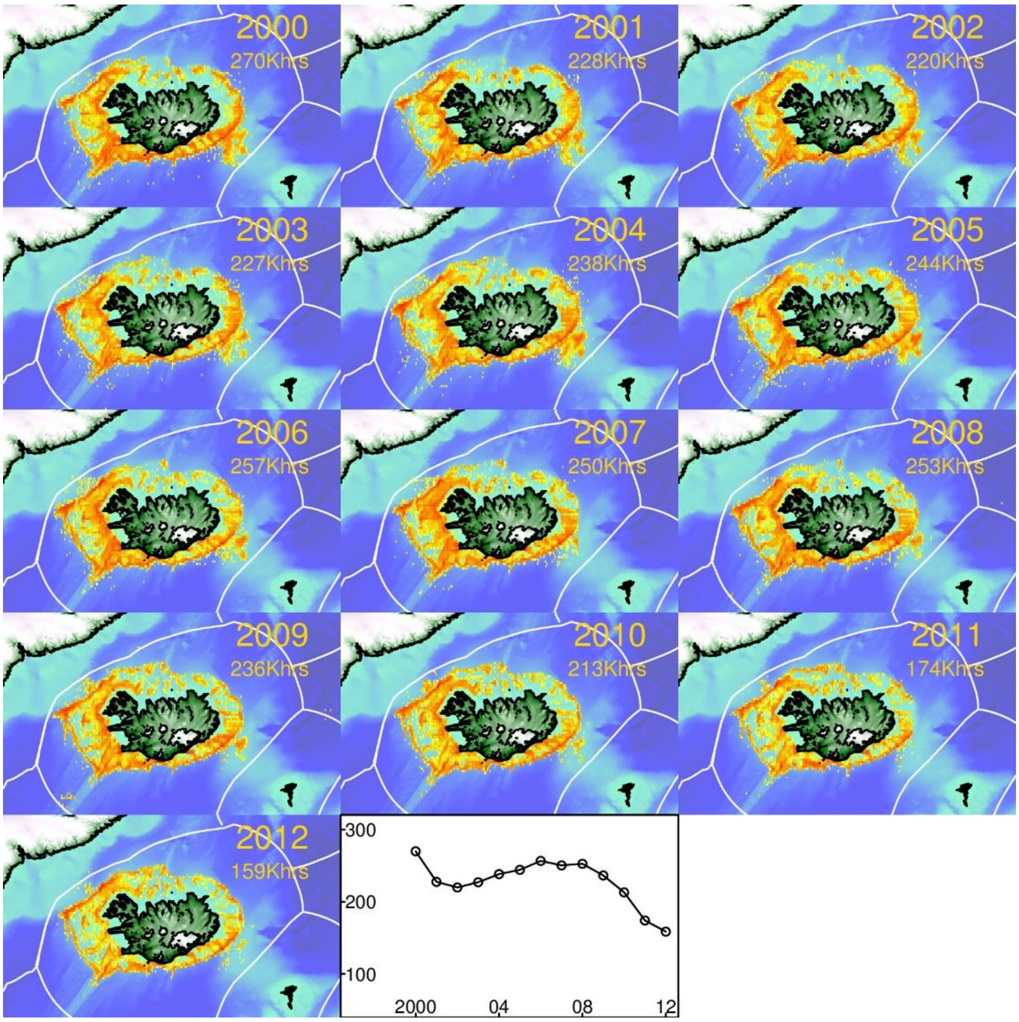


Figure 7.4.6 Spatial distribution of the trawler fleet effort (in hours trawled) in 2000-2012 and as a time-series.

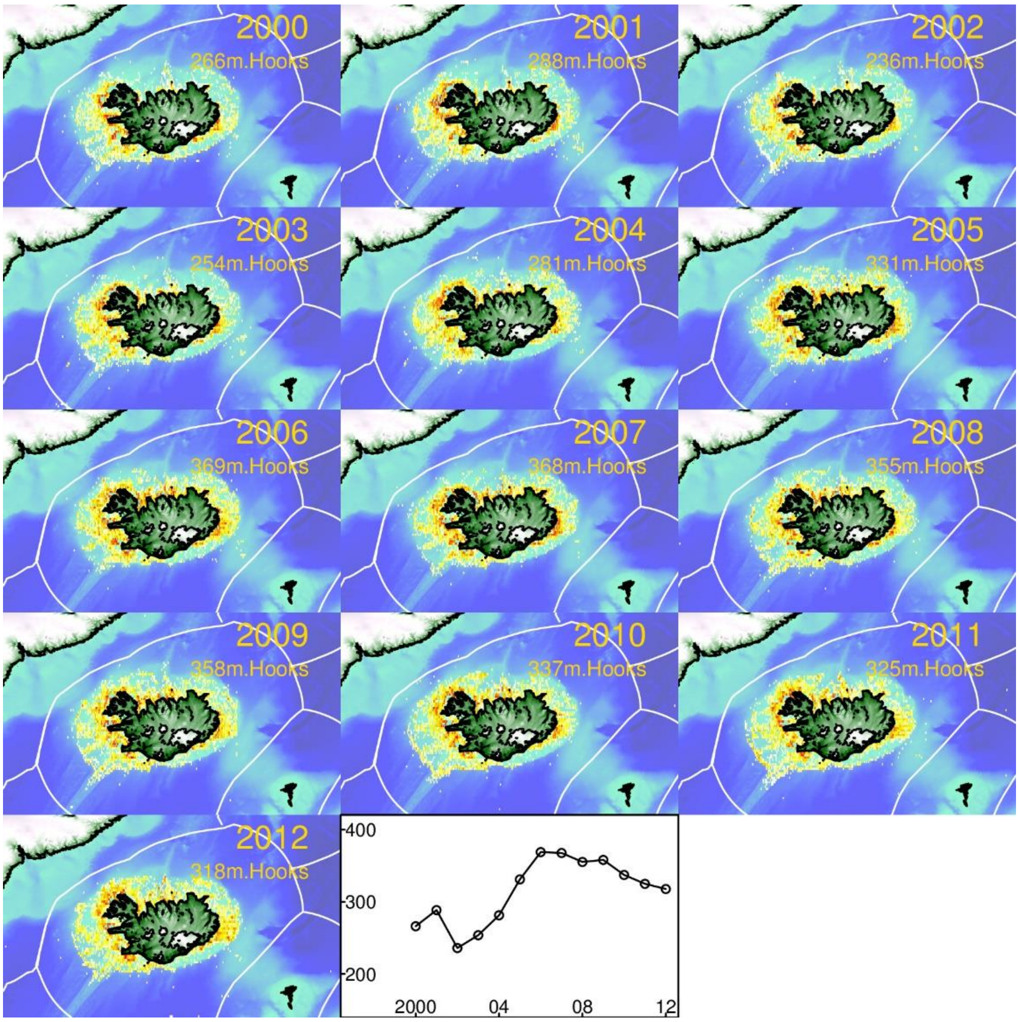


Figure 7.4.7. Spatial distribution of the longlinefleet effort (in number of hooks) in 2000-2012. The main targeted species for longline fishing are cod, haddock, catfish, tusk, ling and blue ling.

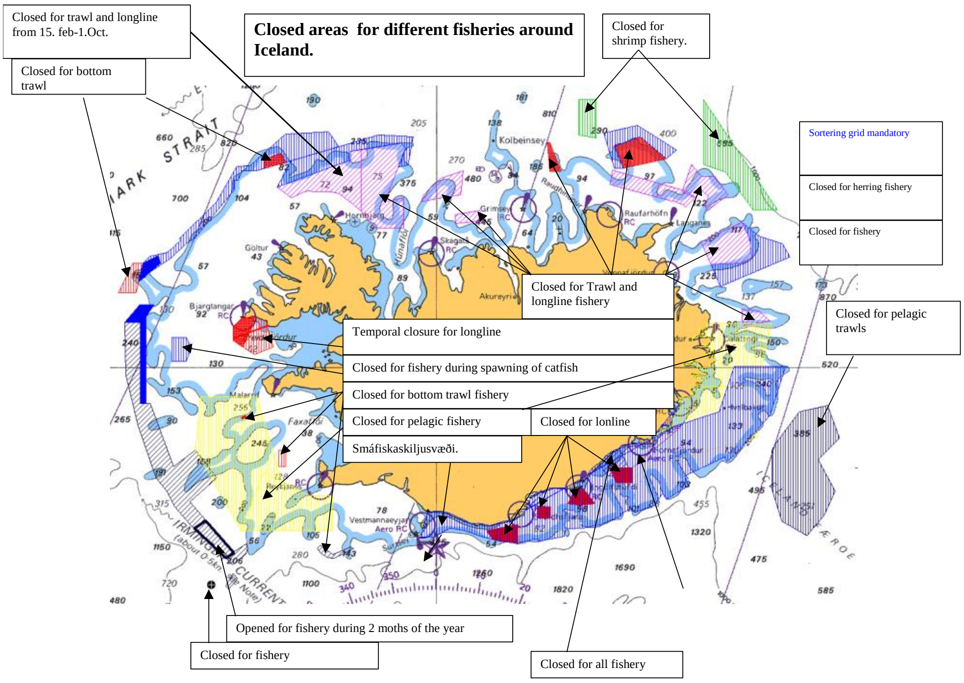
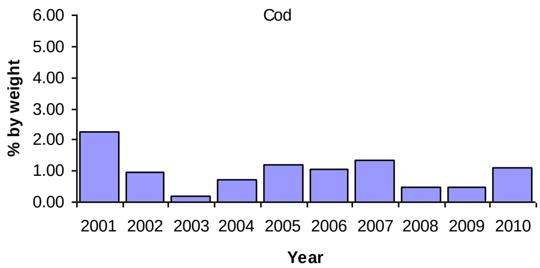


Figure 7.5.1. Overview of closed areas around Iceland in 2006 . The boxes are of different nature and can be closed for different time period and gear type.



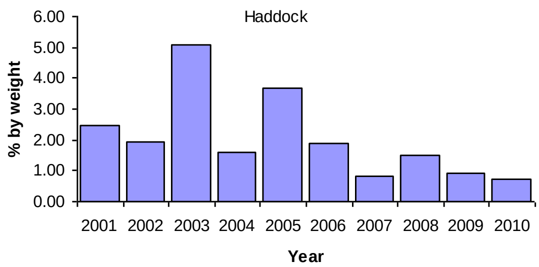


Figure 7.5.2. Estimates of discard percentage by weight for cod and haddock. Source: Ólafur K. Pálsson, Höskuldur Björnsson, Eyþór Björnsson, Guðmundur Jóhannesson , og Þórhallur Ottesen 2009. Discards in demersal Icelandic fisheries 2009. Marine Research Institute, report series Nr. 154. 2010 figures are preliminary .

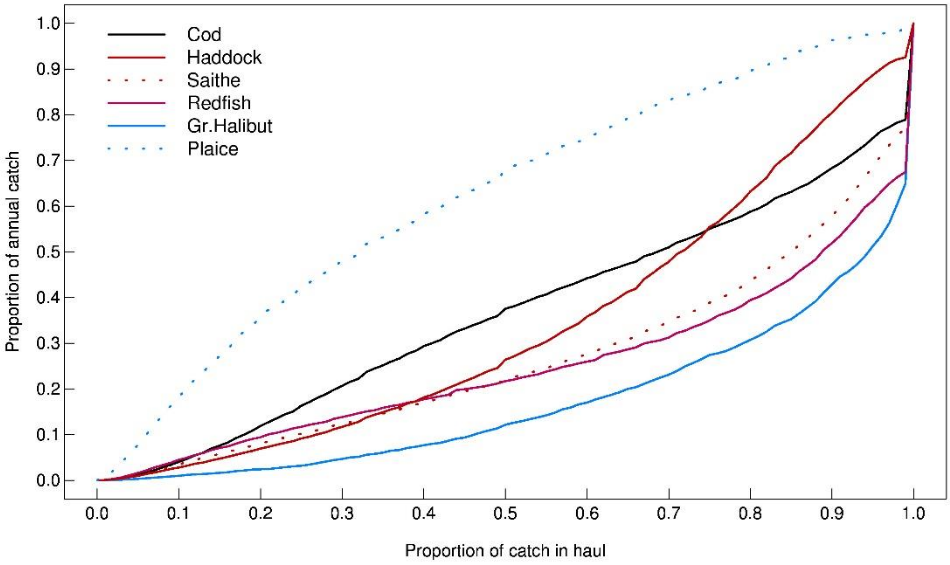


Figure 7.6.1. Cumulative plot for bottom trawl in 2008. An example describes this probably best. Looking at the figure above it can be seen from the dashed lines that 30% of the catch of haddock comes from hauls where haddock is less than 60% of the total catch while only 4% of the catch of greenland 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

Summary

The 2015 reference biomass (B_{4+}) is estimated as 255 kt, around the average in the assessment period (1980 to the present). Spawning biomass is estimated as 139 kt, above the average in the assessment period and well above B_{trigger} = 65 kt and B_{lim} = 61 kt.

Harvest rate has been around the HCR target of 20% since 2011, with fishing mortality rate between 0.19–0.25. Year classes 2008 and 2009 are above average, but recruitment has declined below average since then.

Weights of ages 3–6 have been low in recent years, but older ages are close to 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.

The default separable model (ADSEP) estimates a slightly larger stock size than alternative diagnostic models (ADAPT, TSA, SAM). The estimates of this year's B_{4+} range from 209 (TSA) to 255 kt (ADSEP).

In 2013, the Icelandic government adopted a harvest control rule for managing the Icelandic saithe fishery, evaluated by ICES (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 55 kt in the next fishing year.

8.1 Stock description and management units

Description of the stock and management units is provided in the stock annex.

8.2 Fisheries-dependent data

8.2.1 Landings, advice and TAC

Landings of saithe in Icelandic waters in 2014 are estimated to have been 46 500 t (Table 8.1 and Figure 8.1). Of the landings, 38 600 t were caught by trawl, 2 400 t by gillnets, and the rest caught by other fishing gear. The domestic as well as ICES advice for the fishing year 2014/2015 was based on the 20% harvest control rule and was 58 kt. The TAC issued was also 58 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 (80% in 2010-2014), with gillnet and jiggers taking the majority of the rest. The share taken by the gillnet fleet was larger in the past, 26% in 19821996 compared to 9% in 19972014 (Figure 8.1).

8.2.2 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, with an estimated discard proportion of 0.1% (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 6070% 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 was slightly revised in 2013 and 2014, but the approach used for calculating catch in numbers has not changed. In 2013, the sampling frequency was reduced for bottom trawl, while the sampling frequency was increased for gillnets, jiggers, and demersal seine in 2014. Also in 2014, the number of otoliths from each sample was halved from 5025 for all fishing gears. These revisions in the sampling program were based on the analysis of Thordarson (2012). The age and length sampling in 2014 is indicated in the following table:

Fleet	Landings (t)	No. of otolith samples	No. of otoliths read	No. of length samples	No. of length measurements
Gillnets	2355	9	250	10	1036
Jiggers	2115	14	370	15	1601
Demersal seine	1005	4	150	4	471
Bottom trawl	38634	52	1625	224	32251
Other gear	1624	-	-	189	2354
Foreign landings	750	-	-	-	-
Total	46483	79	2395	442	37713

Two 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.

8.2.3 Mean weight and maturity-at-age

Weights of ages 3-6 have been low in recent years, but older ages are close to average weight (Table 8.3 and Figure 8.3). The long-term trend since 1980 has been a gradual decline in the weight of all ages. 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).

Maturity-at-ages 49 has decreased in recent years and is currently around average (Table 8.4 and Figure 8.4). A model using maturity-at-age from the Icelandic groundfish spring survey is used to derive smoothed trends in maturity by age and year (see stock annex).

8.2.4 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.

8.3 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 fish to get reliable information on from bottom trawl surveys. In the spring survey, which has

500600 stations, a large proportion of the saithe is caught in relatively few hauls and there seems to be considerable interannual variability of the number of these hauls.

The survey biomass indices fluctuated greatly in 19851995, 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.

8.4 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 314 from 1980 onwards) and survey catch-at-age (ages 210 from 1985 onwards). 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 19972003 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 some years. The survey residuals are modelled as multivariate normal distribution with the correlation estimated (one coefficient).

8.5 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 (ICES 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:

$$TAC_t = 0.5 \times 0.20\, B_{t,4+} + 0.5\, TAC_{t-1} \qquad \text{(Eq. 1)}$$

When SSB is below B_{trigger}, the harvest rate is reduced below 0.20:

$$TAC_t = SSB_t/B_{\text{trigger}} \left[(1 - 0.5\, SSB_t/B_{\text{trigger}})\, 0.20\, B_{t,4+}) + 0.5\, TAC_{t-1} \right] \qquad \text{(Eq. 2)}$$

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).

8.6 State of the stock

The results of the principal stock quantities (Table 8.8 and Figure 8.8) show that the reference biomass has historically ranged from 410130 kt (in 1988 and 1999), but this range has been narrower since 2003, between 220320 kt. The current stock size of 255 kt is around the average in the assessment period (1980 to the present). Spawning biomass is estimated as 139 kt, above the average in the assessment period and well above $B_{trigger}$ and B_{lim}.

The harvest rate peaked around 30% in the mid-1990s, but has fluctuated around the HCR target of 20% since 2011, with fishing mortality rate between 0.19 and 0.25. 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 2008 and 2009 are above average, but recruitment has declined below average since then. The details of the fishing mortality and stock in numbers are presented in Tables 8.9 and 8.10.

8.7 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.

The landings for the ongoing calendar year are predicted based on the 20% 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.

Following the HCR, the predicted landings in 2016 are 54 kt and the resulting SSB in 2017 is predicted to be 130 kt.

8.8 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 distribution 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 (ICES 2013).

The results from the default separable assessment model (ADSEP) are compared to alternative diagnostic model runs, involving ADAPT, TSA, and SAM, in 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 a slightly larger stock size than the other models, which has also been the case for saithe assessments in recent years. The estimates of this year's B_{4+} range from 209 (TSA) to 255 kt (ADSEP).

8.9 Comparison with previous assessment and forecast

Compared to last year's assessment the estimated reference biomass B_{4+} in 2014 has decreased from 296265 kt, SSB 2014 has decreased from 150132 kt, and the harvest rate u_{2013} has increased from 19% to 22% (fishing mortality 0.220.25). Stock numbers-at-age 5 have increased slightly, while stock numbers-at-ages 6 and 7 have decreased as shown below.

	NWWG 2014	NWWG 2015
B4+(2014)	296	265
SSB(2014)	150	132
u(2013)	19%	22%
F4-9(2013)	0.22	0.25
N5(2014)	24	26
N6(2014)	21	17
N7(2014)	11	9

8.10 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, 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.

8.11 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 years. This can be partly explained by reduced use of gillnets in the saithe fishery.

8.12 References

Armannsson, H. and S.T. Jonsson. 2012. Vertical migrations of saithe (*Pollachius virens*) in Icelandic waters as observed with data storage tags. ICES J. Mar. Sci. 69:13721381.

Armannsson, H., S.T. Jonsson, J.D. Neilson, and G. Marteinsdottir. 2007. Distribution and migration of saithe (*Pollachius virens*) around Iceland inferred from mark-recapture studies. ICES J. Mar. Sci. 64:10061016.

Gudmundsson, G. 2013. Fish stock assessment by time-series analysis. ICES NWWG WD29.

i Homrum, E., B. Hansen, S.T. Jonsson, K. Michalsen, J. Burgos, D. Righton, P. Steingrund, T. Jakobsen, R. Mouritsen, H. Hatun, H. Armannsson, and J.S. Joensen. 2013. Migration of saithe (*Pollachius virens*) in the Northeast Atlantic. ICES J. Mar. Sci. 70:782792.

ICES. 2008. Report of the North-Western Working Group (NWWG). ICES CM 2008/ACOM:03.

ICES. 2010. Report of the Benchmark Workshop on Roundfish (WKROUND). ICES CM 2010/ACOM:36.

ICES. 2013. Report of the evaluation of the Icelandic saithe management plan. ICES CM 2013/ACOM:60.

Magnusson, A. 2012. Icelandic saithe: New model to predict current weight at age. ICES NWWG WD30.

Magnusson, A. 2013. Mathematical properties of the Icelandic saithe HCR. ICES NWWG WD 31.

Ministry of Industries and Innovation. 2013. Adoption of management plan for Icelandic saithe. Letter to ICES, dated 22 Apr 2013.

Palsson, O.K., G. Karlsson, A. Arason, G.R. Gislason, G. Johannesson, and S. Adalsteinsson. 2003. Discards in demersal Icelandic fisheries 2002. Mar. Res. Inst. Rep. 94.

Thordarson, G. 2012. Sampling of demersal fish stocks from commercial catches and surveys: Flatfish and elongated species. Report for the Marine Research Institute.

Table 8.1. Saithe in division Va. Nominal catch (t) by countries, as officially reported to ICES.

	Belgium	Faroes	France	Germany	Iceland	Norway	UK (E/W/NI)	UK (Scot)	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					102737
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
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
2014		746			45 733	4				46 483

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	2.284	4.363	4.031	2.472	1.942	0.285	0.438	0.289	0.196	0.028	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
2014	0.668	3.499	4.867	2.805	1.276	0.725	0.347	0.241	0.312	0.199	0.128	0.074

Table 8.3. Saithe in division Va. Mean weight at age (g) in the catches and in the spawning stock, with predictions in grey.

	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	1211	1575	2229	2983	4378	5598	6773	8023	7875	8646	9179	9749
2015	1142	1726	2217	3071	4030	5532	6846	7175	7491	8218	8575	9173
2016	1142	1726	2217	3071	4030	5532	6846	7175	7491	8218	8575	9173
2017	1142	1726	2217	3071	4030	5532	6846	7175	7491	8218	8575	9173

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	0.089	0.197	0.380	0.604	0.792	0.905	1	1	1	1	1
1986	0	0.080	0.178	0.351	0.575	0.772	0.894	1	1	1	1	1
1987	0	0.072	0.162	0.325	0.547	0.751	0.883	1	1	1	1	1
1988	0	0.065	0.148	0.303	0.521	0.731	0.871	1	1	1	1	1
1989	0	0.060	0.138	0.285	0.499	0.714	0.862	1	1	1	1	1
1990	0	0.057	0.131	0.273	0.484	0.701	0.854	1	1	1	1	1
1991	0	0.055	0.127	0.266	0.475	0.694	0.850	1	1	1	1	1
1992	0	0.055	0.127	0.266	0.476	0.694	0.850	1	1	1	1	1
1993	0	0.057	0.131	0.274	0.485	0.702	0.855	1	1	1	1	1
1994	0	0.062	0.141	0.290	0.505	0.718	0.864	1	1	1	1	1
1995	0	0.069	0.157	0.317	0.537	0.743	0.879	1	1	1	1	1
1996	0	0.081	0.181	0.355	0.579	0.775	0.896	1	1	1	1	1
1997	0	0.097	0.212	0.402	0.627	0.807	0.913	1	1	1	1	1
1998	0	0.117	0.248	0.451	0.673	0.837	0.928	1	1	1	1	1
1999	0	0.137	0.284	0.497	0.712	0.860	0.939	1	1	1	1	1
2000	0	0.154	0.313	0.532	0.740	0.877	0.947	1	1	1	1	1
2001	0	0.165	0.331	0.552	0.755	0.885	0.951	1	1	1	1	1
2002	0	0.169	0.337	0.560	0.760	0.888	0.952	1	1	1	1	1
2003	0	0.168	0.335	0.557	0.759	0.887	0.952	1	1	1	1	1
2004	0	0.163	0.328	0.549	0.753	0.884	0.950	1	1	1	1	1
2005	0	0.157	0.318	0.538	0.744	0.879	0.948	1	1	1	1	1
2006	0	0.152	0.309	0.527	0.736	0.874	0.946	1	1	1	1	1
2007	0	0.146	0.300	0.517	0.728	0.870	0.943	1	1	1	1	1
2008	0	0.141	0.291	0.506	0.719	0.865	0.941	1	1	1	1	1
2009	0	0.136	0.282	0.495	0.710	0.859	0.939	1	1	1	1	1
2010	0	0.130	0.272	0.483	0.700	0.853	0.936	1	1	1	1	1
2011	0	0.124	0.261	0.469	0.688	0.847	0.932	1	1	1	1	1
2012	0	0.118	0.250	0.455	0.676	0.839	0.929	1	1	1	1	1
2013	0	0.112	0.239	0.440	0.662	0.830	0.924	1	1	1	1	1
2014	0	0.106	0.228	0.424	0.648	0.821	0.920	1	1	1	1	1
2015	0	0.100	0.217	0.409	0.633	0.812	0.915	1	1	1	1	1
2016	0	0.100	0.217	0.409	0.633	0.812	0.915	1	1	1	1	1
2017	0	0.100	0.217	0.409	0.633	0.812	0.915	1	1	1	1	1

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
2015	0.06	0.04	1.07	1.90	3.16	1.72	0.81	0.72	0.68	0.45	0.26	0.23	0.21	0.15

Table 8.6. Saithe in division Va. Commercial catch-at-age residuals log(obs/fit).

	3	4	5	6	7	8	9	10	11	12	13	14
1980	-0.79	-0.60	0.25	0.16	-0.08	0.22	-0.05	0.22	-0.30	-0.41	-0.70	-0.04
1981	-0.51	-0.26	-0.56	0.36	-0.16	0.06	0.12	0.28	-0.85	0.93	1.19	1.88
1982	0.84	-0.25	0.13	-0.37	0.24	-0.03	0.37	-0.36	-1.20	-1.15	-0.53	-0.10
1983	-2.48	0.94	-0.67	0.11	0.46	0.20	-0.01	-0.80	-2.43	-2.79	-5.17	-3.83
1984	-4.23	-1.61	-1.29	0.22	0.47	0.79	-0.45	0.43	0.96	1.03	3.47	4.90
1985	-0.28	1.23	0.58	0.08	0.27	-0.19	-1.16	-0.75	-1.41	-3.07	0.65	2.46
1986	2.28	-0.72	0.24	-0.32	-0.09	0.10	-0.41	0.93	-1.09	-1.39	-1.83	-1.75
1987	-0.99	0.16	0.32	0.22	0.09	0.07	0.06	-0.18	-0.08	-2.91	-1.91	-0.24
1988	0.92	-0.31	0.06	0.04	-0.14	0.20	0.79	-0.66	0.48	-1.69	-3.27	-6.88
1989	-0.84	0.61	0.01	0.23	-0.58	0.04	0.27	-0.18	0.71	0.37	-1.13	-3.73
1990	-1.78	-0.54	0.07	0.01	0.34	0.06	0.11	-0.37	0.07	-0.78	0.16	-1.61
1991	-1.96	-1.11	0.06	0.33	0.03	-0.08	0.01	0.72	0.23	-1.38	-3.92	-3.95
1992	-0.22	0.58	1.05	0.43	0.06	-0.83	-0.25	-0.40	-0.28	-1.17	0.48	-0.88
1993	0.98	-0.16	-0.33	-0.14	-0.20	-0.08	0.40	0.04	0.33	0.75	0.65	-1.28
1994	1.09	0.98	-0.12	-0.69	-0.43	-0.46	0.20	0.41	0.51	0.80	1.87	1.79
1995	1.59	0.28	0.10	-0.02	0.04	-0.08	-0.20	-0.19	-0.26	-0.87	-0.68	-1.83
1996	1.45	0.17	-0.12	-0.51	-0.34	0.19	0.27	0.03	0.39	-0.15	1.33	2.41
1997	0.25	0.33	-0.30	0.08	-0.03	0.29	-0.10	-0.40	-0.30	0.37	-1.12	0.20
1998	-0.36	-0.07	-0.47	-0.76	0.18	0.00	0.84	0.70	1.24	1.15	1.57	0.84
1999	0.38	0.03	0.00	0.08	0.00	-0.20	-0.35	0.33	-0.65	-0.57	0.31	0.17
2000	-0.07	-0.20	0.11	0.07	-0.16	0.48	-0.49	-0.27	-0.22	-0.93	-0.09	-1.12
2001	-0.09	0.23	-0.27	-0.14	-0.03	-0.18	0.39	0.06	0.13	0.04	0.37	1.00
2002	-0.62	-0.08	0.18	0.36	-0.17	0.12	-0.26	-0.35	-0.09	-1.20	-0.10	-0.36
2003	0.40	-0.28	0.42	-0.02	-0.02	-0.61	0.04	-0.20	0.04	-1.24	0.24	1.21
2004	-0.16	-0.39	-0.11	0.27	-0.10	0.28	0.61	0.41	-0.05	-0.47	0.75	-0.26
2005	-0.39	-0.32	-0.31	0.44	0.34	-0.23	-0.13	-0.01	0.31	-0.07	-0.31	-0.43
2006	-0.69	-0.16	-0.35	-0.03	0.56	0.07	-0.33	-0.10	0.76	0.95	1.05	0.12
2007	0.79	0.22	0.14	0.25	-0.13	-0.04	-0.40	-0.48	-0.82	0.30	0.25	-0.26
2008	0.11	0.36	0.18	0.23	-0.11	-0.23	-0.24	-0.30	-0.60	0.10	2.71	1.70
2009	0.75	0.49	-0.11	-0.27	-0.16	0.29	-0.34	-0.12	0.10	0.42	1.08	2.54
2010	0.46	0.28	0.11	-0.46	0.03	-0.12	0.47	-0.43	0.07	-0.06	0.84	1.18
2011	0.14	-0.06	-0.05	-0.30	-0.04	0.29	0.14	0.36	-0.24	-0.01	0.48	1.41
2012	-0.57	-0.37	-0.27	-0.20	-0.24	0.06	0.66	0.55	1.38	0.12	0.55	0.91
2013	-0.50	-0.04	0.33	-0.02	-0.19	-0.11	0.28	0.12	-0.36	0.35	-0.53	0.01
2014	0.16	-0.20	0.50	-0.04	-0.22	-0.37	-0.24	0.45	0.28	-0.38	1.99	0.16

Table 8.7. Saithe in division Va. Survey catch-at-age residuals log(obs/fit).

	2	3	4	5	6	7	8	9	10
1985	-0.43	-1.53	-0.46	0.55	0.20	0.36	-0.17	0.83	-1.01
1986	0.78	-0.61	-0.69	-0.80	-0.50	-0.35	-0.47	-0.68	-0.39
1987	-0.62	0.87	0.73	0.74	0.44	1.13	0.74	0.53	0.25
1988	-0.35	-2.15	-1.48	-0.96	-0.29	-0.46	-0.39	-1.31	-0.59
1989	1.95	0.86	-0.05	-0.34	-0.60	0.50	0.33	0.35	-5.74
1990	-0.12	0.36	0.45	0.33	0.91	0.48	0.88	0.65	-0.47
1991	0.15	-0.28	-0.27	-0.36	-1.18	-0.62	-1.45	-3.10	-2.26
1992	-0.64	0.03	0.74	1.23	0.46	0.66	-0.02	-0.70	-1.15
1993	2.00	2.63	0.31	1.07	0.80	1.02	0.44	1.69	0.97
1994	0.88	-0.44	-0.09	0.29	0.18	-0.12	0.84	1.31	2.32
1995	0.43	0.12	-0.56	-1.48	-1.24	-0.96	-1.03	-0.21	-0.09
1996	-0.62	-1.29	0.24	-0.41	-0.09	0.52	1.34	-0.87	0.00
1997	1.22	-0.13	0.70	0.44	-0.07	-0.32	-0.04	-0.47	-0.15
1998	-1.50	1.36	0.36	0.11	-0.41	0.34	0.23	-0.06	-0.18
1999	0.72	0.85	0.06	-0.24	0.09	-0.64	-0.57	-2.24	-1.04
2000	-0.72	0.10	-0.23	-0.30	-0.21	-0.55	-0.07	-0.87	-1.14
2001	0.10	-0.62	-0.22	-0.64	-1.11	-1.04	-0.08	-0.84	-0.22
2002	0.13	-0.61	-0.72	0.08	0.18	0.42	0.60	0.34	0.36
2003	-2.22	0.95	-0.28	-0.61	-0.41	-0.34	0.38	-1.36	-0.40
2004	-0.05	-0.12	0.31	0.07	0.34	0.37	0.45	0.80	0.59
2005	-0.87	0.00	-0.06	0.26	0.33	0.29	0.40	0.25	0.83
2006	-6.50	-0.16	-0.07	-0.03	1.07	0.72	0.23	-0.33	0.06
2007	-2.08	-1.51	-1.01	-0.67	-0.48	-0.20	-0.47	-0.90	-0.54
2008	-2.23	0.39	-0.03	-0.17	0.19	-0.09	-0.36	-0.77	-1.19
2009	-1.10	0.00	-0.45	-0.90	-0.89	-0.90	-1.27	-1.08	-1.22
2010	-2.62	-0.81	0.25	0.18	-0.39	-0.66	-0.85	-1.35	-1.41
2011	-1.60	0.30	0.04	-0.10	-0.17	-0.21	-0.50	-0.45	0.12
2012	-3.77	-0.50	1.04	0.82	0.31	-0.24	-0.60	-0.05	0.11
2013	-0.95	0.71	0.60	0.56	0.88	0.87	1.09	0.54	0.52
2014	-2.84	-1.35	-0.03	0.00	-0.32	-0.45	-0.62	-0.80	-0.24
2015	-2.74	-0.45	-0.10	-0.09	-0.43	-0.80	-0.06	0.38	0.85

Table 8.8. Saithe in division Va. Main population estimates. 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	148	35	69	0.30	23%
1983	270	147	67	58	0.24	22%
1984	287	149	91	63	0.23	22%
1985	299	139	50	57	0.25	19%
1986	318	137	32	65	0.28	20%
1987	335	128	21	81	0.35	24%
1988	415	125	29	77	0.32	19%
1989	397	127	15	82	0.31	21%
1990	377	134	20	98	0.35	26%
1991	336	143	18	102	0.37	30%
1992	288	135	30	80	0.37	28%
1993	230	112	25	72	0.40	31%
1994	187	93	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	153	68	53	32	0.30	21%
1999	131	72	63	31	0.31	24%
2000	141	74	72	33	0.33	23%
2001	161	80	26	32	0.28	20%
2002	217	96	72	42	0.31	19%
2003	276	118	42	52	0.30	19%
2004	316	137	19	65	0.26	20%
2005	282	147	27	69	0.29	25%
2006	307	156	41	76	0.31	25%
2007	278	152	41	64	0.28	23%
2008	248	149	50	70	0.32	28%
2009	224	137	45	61	0.30	27%
2010	227	127	39	54	0.27	24%
2011	239	122	21	51	0.24	21%
2012	253	122	26	52	0.23	20%
2013	268	128	32	58	0.25	22%
2014	265	132	33	46	0.19	18%
2015	255	139	33	57	0.26	22%

Table 8.9. Saithe in division Va. Stock in numbers.

	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	47.9	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	32.1	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	43.2	41.8	26.0	13.3	8.6	7.5	9.0	4.3	1.1	0.8	0.4	0.1	0.1
1985	136.4	81.6	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	111.7	66.8	28.6	25.8	14.0	6.0	3.4	2.6	3.0	1.4	0.4	0.3	0.1
1987	47.6	61.7	91.4	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	73.4	39.8	14.3	10.2	4.6	1.7	0.9	0.7	0.9	0.4	0.1
1989	44.0	25.4	31.9	40.6	54.7	26.8	8.5	5.6	2.3	0.9	0.5	0.4	0.5	0.2
1990	22.1	36.0	20.8	25.7	30.4	37.2	16.2	4.7	2.9	1.2	0.5	0.3	0.2	0.3
1991	29.5	18.1	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	26.3	24.2	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	11.9	17.4	8.0	7.0	5.9	7.7	2.0	0.5	0.4	0.2	0.1
1994	38.0	36.3	17.6	15.9	8.7	11.2	4.4	3.5	2.7	3.6	0.9	0.3	0.2	0.1
1995	25.0	31.1	29.7	14.1	11.4	5.4	5.8	2.1	1.5	1.2	1.5	0.4	0.1	0.1
1996	12.8	20.5	25.5	23.7	10.1	7.0	2.8	2.7	0.8	0.6	0.5	0.7	0.2	0.1
1997	44.9	10.5	16.8	20.4	17.3	6.5	3.8	1.4	1.2	0.4	0.3	0.2	0.4	0.1
1998	46.2	36.8	8.6	13.3	14.5	11.2	3.9	2.1	0.7	0.6	0.2	0.1	0.1	0.2
1999	79.7	37.8	30.1	6.8	9.6	9.8	7.1	2.3	1.1	0.3	0.3	0.1	0.1	0.1
2000	93.4	65.2	31.0	23.9	5.0	6.5	6.1	4.1	1.2	0.6	0.2	0.1	0.0	0.0
2001	106.8	76.5	53.4	24.6	17.2	3.3	4.0	3.5	2.1	0.6	0.3	0.1	0.1	0.0
2002	38.1	87.5	62.6	42.6	18.0	11.8	2.1	2.4	1.9	1.1	0.3	0.1	0.0	0.0
2003	107.7	31.2	71.6	49.8	30.9	12.2	7.4	1.2	1.3	1.0	0.6	0.2	0.1	0.0
2004	62.2	88.2	25.5	57.0	36.2	20.9	7.7	4.3	0.7	0.6	0.5	0.3	0.1	0.0
2005	28.1	50.9	72.2	19.9	38.0	22.8	13.0	4.8	2.7	0.4	0.4	0.3	0.2	0.0
2006	40.4	23.0	41.7	56.2	13.0	23.3	13.8	7.9	3.0	1.6	0.2	0.2	0.1	0.1
2007	61.0	33.1	18.8	32.4	36.2	7.9	13.8	8.2	4.8	1.7	0.9	0.1	0.1	0.1
2008	61.1	50.0	27.1	14.7	21.2	22.3	4.8	8.5	5.1	2.8	0.9	0.4	0.1	0.0
2009	74.2	50.0	40.9	21.0	9.3	12.6	13.0	2.8	5.0	2.9	1.5	0.5	0.2	0.0
2010	66.6	60.8	41.0	31.8	13.6	5.6	7.5	7.8	1.7	2.9	1.6	0.7	0.2	0.1
2011	58.4	54.5	49.7	32.0	21.1	8.5	3.5	4.7	4.9	1.0	1.6	0.8	0.4	0.1
2012	30.6	47.8	44.6	39.0	21.7	13.6	5.4	2.2	3.0	3.0	0.6	0.9	0.5	0.2
2013	39.3	25.1	39.2	35.1	26.7	14.1	8.7	3.5	1.4	1.9	1.8	0.3	0.5	0.3
2014	47.6	32.1	20.5	30.7	23.6	17.0	8.9	5.5	2.2	0.9	1.1	1.0	0.2	0.3
2015	48.8	39.0	26.3	16.2	21.6	16.0	11.4	6.0	3.7	1.5	0.6	0.7	0.6	0.1

Table 8.10. Saithe in division Va. Fishing mortality rate.

	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	0.43	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	0.46	0.57	0.69	0.64	0.69	0.56	0.56	0.56	0.56
1996	0.02	0.12	0.25	0.41	0.50	0.60	0.56	0.60	0.49	0.49	0.49	0.49
1997	0.04	0.14	0.23	0.31	0.42	0.53	0.57	0.55	0.56	0.56	0.56	0.56
1998	0.03	0.12	0.19	0.26	0.34	0.43	0.46	0.45	0.46	0.46	0.46	0.46
1999	0.03	0.12	0.20	0.27	0.36	0.45	0.49	0.47	0.48	0.48	0.48	0.48
2000	0.03	0.13	0.21	0.28	0.38	0.47	0.51	0.50	0.51	0.51	0.51	0.51
2001	0.03	0.11	0.18	0.24	0.32	0.40	0.43	0.42	0.43	0.43	0.43	0.43
2002	0.03	0.12	0.19	0.26	0.35	0.44	0.47	0.46	0.47	0.47	0.47	0.47
2003	0.03	0.12	0.19	0.26	0.34	0.43	0.47	0.45	0.46	0.46	0.46	0.46
2004	0.05	0.21	0.26	0.28	0.27	0.26	0.30	0.37	0.43	0.43	0.43	0.43
2005	0.05	0.22	0.29	0.31	0.29	0.29	0.32	0.40	0.47	0.47	0.47	0.47
2006	0.05	0.24	0.31	0.33	0.31	0.31	0.35	0.43	0.51	0.51	0.51	0.51
2007	0.05	0.22	0.28	0.30	0.29	0.28	0.32	0.39	0.46	0.46	0.46	0.46
2008	0.06	0.25	0.32	0.34	0.33	0.33	0.37	0.45	0.53	0.53	0.53	0.53
2009	0.05	0.24	0.30	0.32	0.31	0.30	0.34	0.42	0.50	0.50	0.50	0.50
2010	0.05	0.21	0.27	0.28	0.27	0.27	0.30	0.37	0.44	0.44	0.44	0.44
2011	0.04	0.19	0.24	0.26	0.25	0.24	0.27	0.34	0.40	0.40	0.40	0.40
2012	0.04	0.18	0.23	0.25	0.23	0.23	0.26	0.32	0.38	0.38	0.38	0.38
2013	0.04	0.20	0.25	0.27	0.25	0.25	0.28	0.35	0.41	0.41	0.41	0.41
2014	0.03	0.15	0.19	0.20	0.20	0.19	0.22	0.27	0.32	0.32	0.32	0.32
2015	0.05	0.20	0.26	0.28	0.26	0.26	0.29	0.36	0.43	0.43	0.43	0.43

Table 8.11. Saithe in division Va. Input values for short term projections. Same weights are used for catch weights and stock weights.

2015	3	4	5	6	7	8	9	10	11	12	13	14
N	26.3	16.2	21.6	16.0	11.4	6.0	3.7	1.5	0.6	0.7	0.6	0.1
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	0.100	0.217	0.409	0.633	0.812	0.915	1.000	1.000	1.000	1.000	1.000
w	1.142	1.726	2.217	3.071	4.030	5.532	6.846	7.175	7.491	8.218	8.575	9.173
sel	0.106	0.476	0.608	0.648	0.621	0.611	0.687	0.846	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	31.9											
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	0.100	0.217	0.409	0.633	0.812	0.915	1.000	1.000	1.000	1.000	1.000
w	1.142	1.726	2.217	3.071	4.030	5.532	6.846	7.175	7.491	8.218	8.575	9.173
sel	0.106	0.476	0.608	0.648	0.621	0.611	0.687	0.846	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
2017	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
N	32.7											
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	0.100	0.217	0.409	0.633	0.812	0.915	1.000	1.000	1.000	1.000	1.000
w	1.142	1.726	2.217	3.071	4.030	5.532	6.846	7.175	7.491	8.218	8.575	9.173
sel	0.106	0.476	0.608	0.648	0.621	0.611	0.687	0.846	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 short-term projections.

2015						
B4+	SSB	Fbar	Landings			
255	139	0.26	57			
2016				**2017**		
B4+	SSB	Fbar	Landings	B4+	SSB	Rationale
238	138	0.26	54	227	130	20% HCR

20% HCR = average between 0.2 B4+ (current year) and last year's TAC

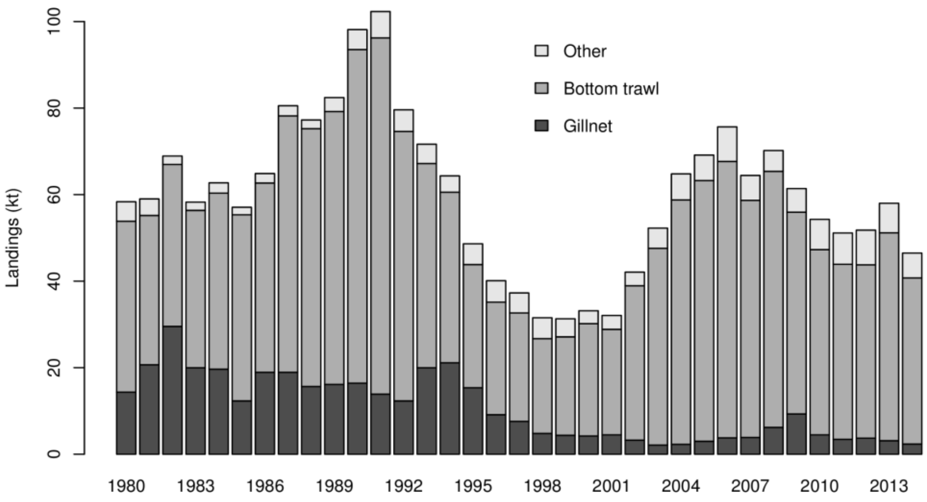


Figure 8.1 Saithe in Division Va. Landings by gear.

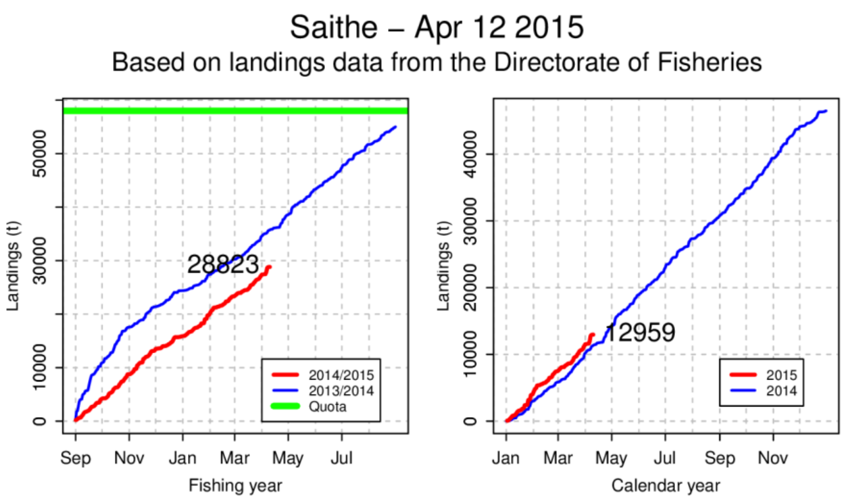


Figure 8.2 Saithe in division Va. Cumulative landings in the current fishing year (left) and calendar year (right). The vertical (green line) in the left figure shows the quota for the current fishing year.

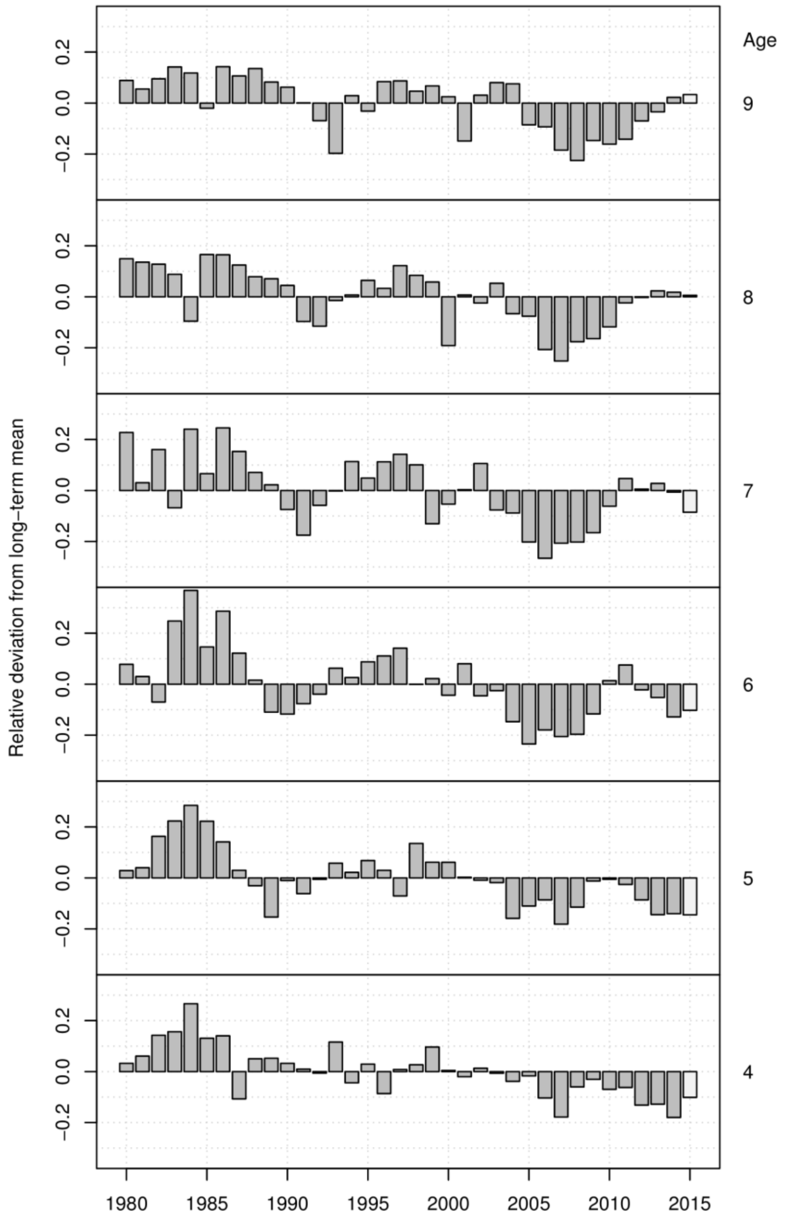


Figure 8.3 Saithe in division Va. Weight at age in the catches, as relative deviations from the mean. The current year's deviation is a preliminary prediction.

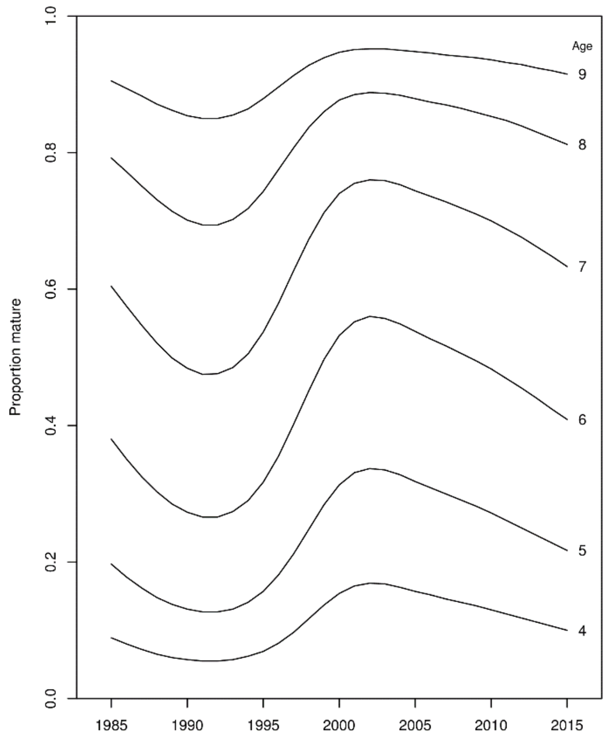


Figure 8.4 Saithe in division Va. Maturity-at-age used for calculating the SSB.

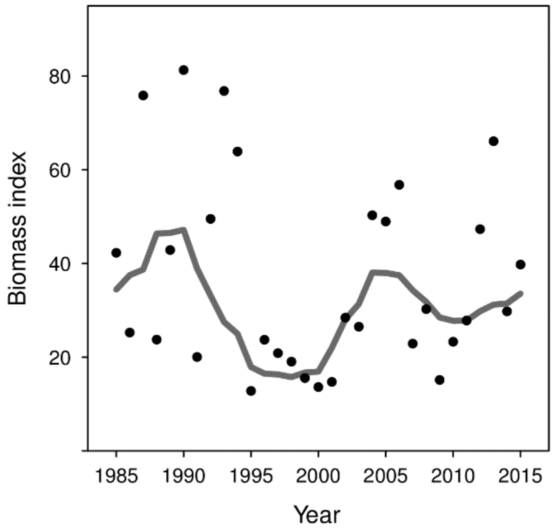


Figure 8.5 Saithe in division Va. Spring survey biomass index and model fit.

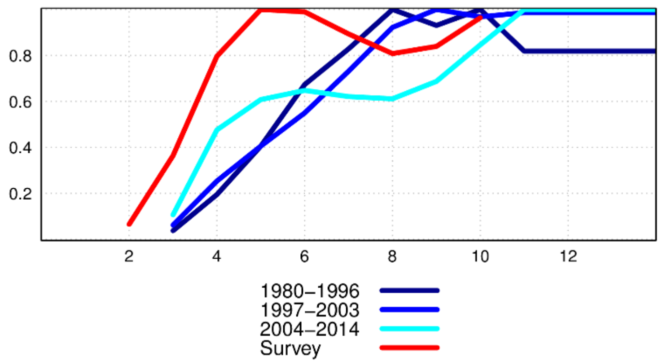


Figure 8.6. Estimated selectivity patterns for the 3 periods.

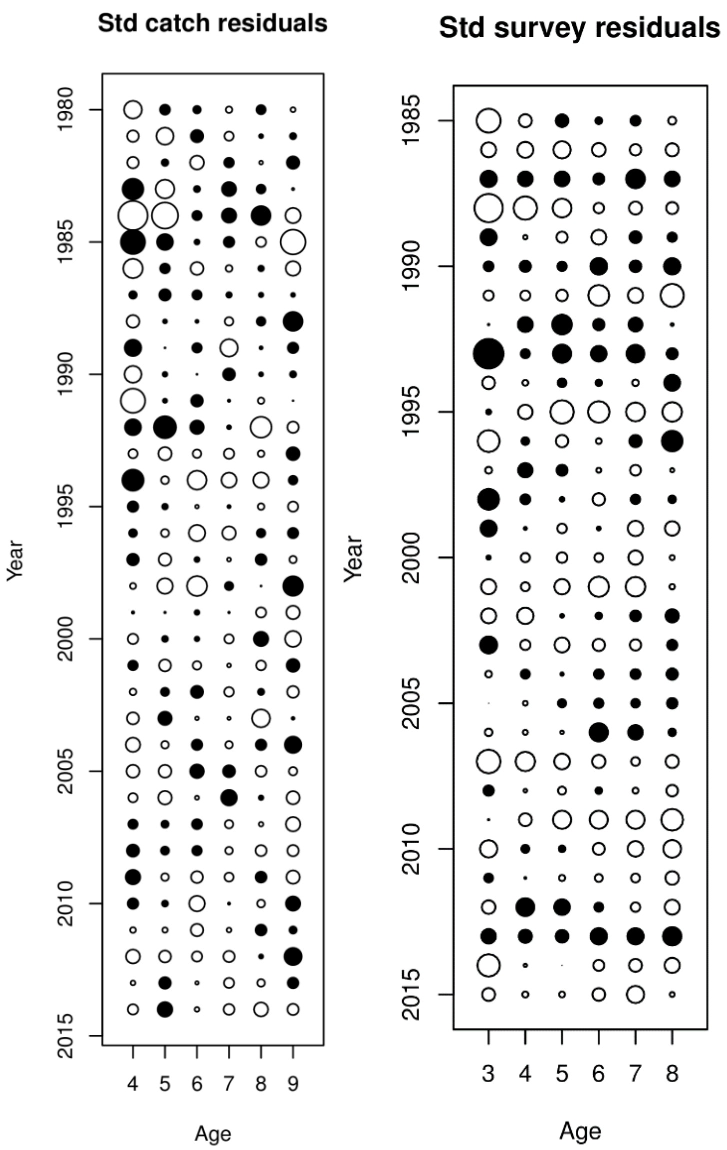


Figure 8.7. Saithe in division Va. Commercial and survey catch-at-age residuals from the fitted model. Filled circles are positive log residuals and hollow circles are negative log residuals.

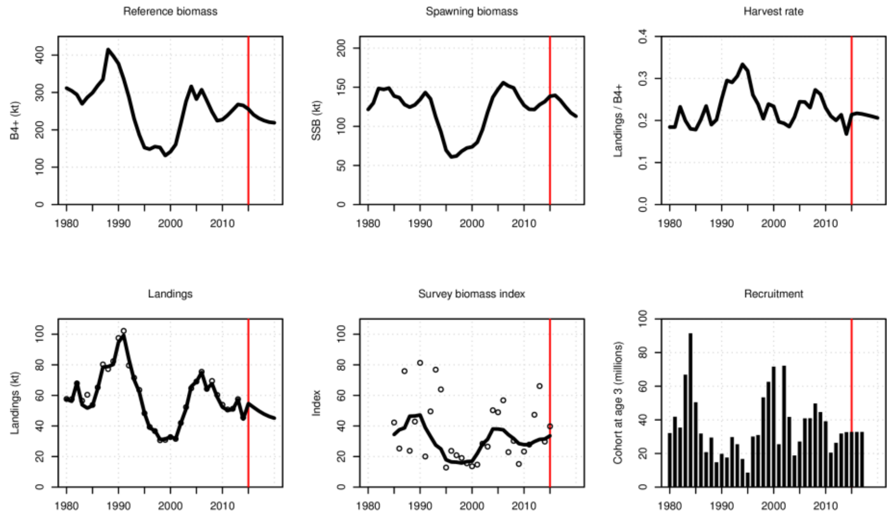


Figure 8.8. Saithe in division Va. Results from the fitted model and short-term forecast. The red line indicates the time of the current assessment.

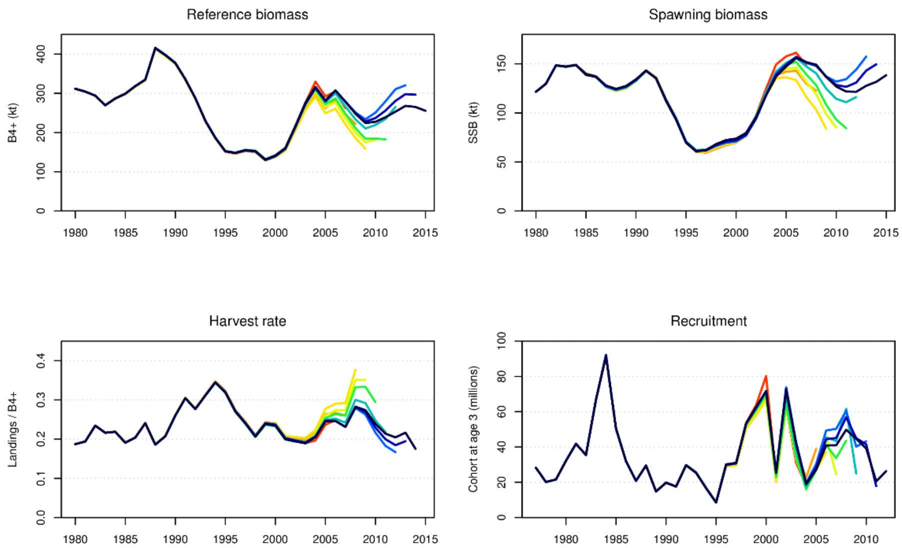


Figure 8.9. Saithe in division Va. Retrospective pattern for the assessment model.

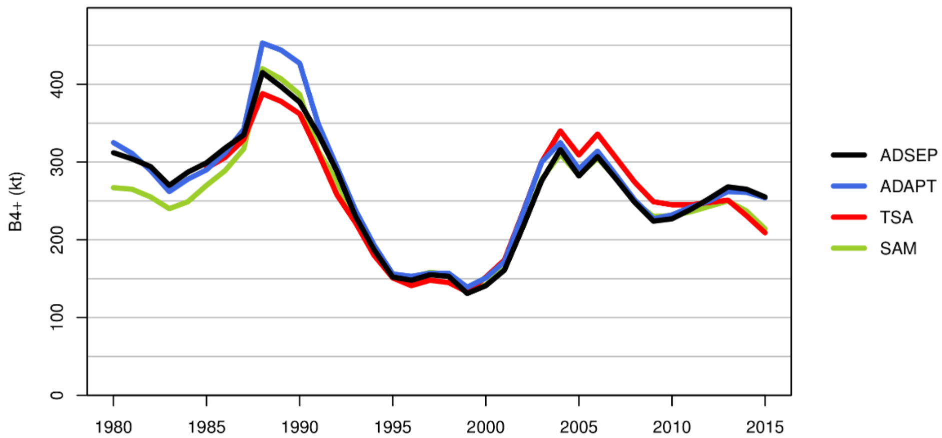


Figure 8.10. Saithe in division Va. Comparison between the default separable model (ADSEP) and alternative assessment models.

9 Icelandic cod (5.a)

Summary

This stock was benchmarked in 2015. A formal HCR is in place to determine the TAC for this stock since 1994. The rule has gone through amendments and revisions. The last significant change occurred in 2007, when the harvest rate multiplier upon which the TAC for the next fishing season is based was changed from 0.25–0.20 of the reference biomass (B_{4+} - biomass of age 4 years and older) as estimated in the beginning of the assessment year. The HCR upon which the TAC is set when the SSB in the assessment year is estimated to be above $SSB_{trigger}$ (220 kt) is as follows:

$$TAC_{y/y+1} = (0.20 * B_{4+,y} + TAC_{y-1/y})/2$$

The decision on the TAC each year is based on an analytical stock assessment carried out each year.

The results from the assessment show that the spawning stock (SSB_{2016}) is estimated to be 464 kt. The high values estimated in recent years are higher than has been observed over the last five decades. The reference biomass ($B_{4+,2016}$) is estimated to be 1241 kt, and has not been so high since the late 1970's. Fishing mortality, being 0.27 in 2015, 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. Estimates of year classes 2014 and 2015 indicate that they may be larger than that observed in the recent decades.

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. Spring survey weights in some of the important age groups have however declined in 2016 compared with 2015. Catch weights are hence estimated to be more pessimistic in 2016 compared to 2015.

The input in the analytical assessments are catch at age 1955-2015 and spring groundfish survey (SMB) indices at age from 1985-2016 and fall survey groundfish survey (SMH) indices at age from 1996-2015. The results from the AD-Model builder statistical Catch at Age Model (ADCAM) as was used as the final run. This framework has been the basis for the advice since 2002 (spring survey only up to the 2009 assessment, both surveys since then).

9.1.1 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.

9.1.1.1 Landings

Landings of Icelandic cod in 2015 are estimated to have been 230 kt of which 228 kt where taken by Icelandic fleet.

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. 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 landings statistics for the period 2001–2015 were re-evaluated in this year assessment. The details are described in WD27 (iCod - Some details), the revisions accounting changes within 1% of the total landings previously used.

The trend in landings in last two decades is largely a reflection of the TAC that is set for the fishing year (starting 1 September and ending 31 August). According to the HCR the catch for the fishing year 2014/2015 was supposed to be capped to 218 kt. Landings of the Icelandic fleet was 221 kt. Including additional landings of some 2 kt by the foreign fleet this amounts to an approximate 2% overshoot.

The estimates of landing for the current calendar year of 246 kt is based on the remainder of the quota from the current fishing year (2015/16) on 1. January 2016 (149 kt), the catch that is expected to be taken from 1. September to 31. December 2016 (95 kt) and the expected catch of the foreign fleet (2 kt).

Mean annual discard of cod over the period 2001–2012 is around 1% of landings (Ólafur Pálsson *et al* 2013). The method used for deriving these estimates assumes that discarding only occurs as high grading.

9.1.1.2 Catch in numbers and weight by age}

Catch in numbers by age: The method for deriving the catch at age is based on 20 métiers: two areas (north and south), two seasons (January–May and June–December) and four fleets (bottom trawl, longline, hooks (jiggers), gillnet and Danish seine). Until now an ad hoc method has been used when "borrowing" age-length keys and/or length distribution for métiers where catches and hence sampling have been low. The programs used are old prelude scripts that are difficult to maintain and atomize. Different approaches may have been taken in different years making the calculations non-reproducible. An equivalent algorithm is available as an R-script (has been used to derive the catch at age in Icelandic haddock for numerous years) and was used this year to derive the catch-at-age matrix for cod (period 2001-2015). The difference in the two algorithms (prelude vs R) pertain to the handling of métiers where the catches and hence samplings are low. In the latter case a low weight (0.01) of a combined age-length key is provided in addition the data available in each métier. This resulted in some difference in the catch at age within age groups (WD27: iCod - Some details), but effect on the key stock assessment metrics are insignificant (Figure 1).

The catch at age matrix is reasonably consistent (Table 1), 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 2 and Figure 2) declined from 2001–2007, reaching then a historical low in many age groups. The weight at age have been increasing in recent years and are in 2015 around the average weights observed over the period from 1985 and close to the long term mean (1955–2015). 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 5 and Figure 3). The latest spring survey weight measurements (in 2016) 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 2016. I.e. the $alpha$ and $beta$ were estimated from :

$$cW_{a,2015} = alpha + beta * sW_{a,2015}$$

and the catch weights for 2016 then from:

$$cW_{a,2016} = alpha + beta * sW_{a,2016}$$

Based on this the mean weights at age in the catches in 2016 are predicted to be at or somewhat below the average (Figure 2).

9.1.1.3 Surveys

Length based indices: The total biomass indices from the spring (SMB) and the fall (SMH) surveys (Figure 4) indicate that the stock biomass has been increasing substantially in recent years and is in the last 5 years among highest since the start of the spring survey in 1985. The increase in biomass is most pronounced in larger fish.

Age based indices: Abundance indices by age from the spring and the fall surveys (Tables 6 and 7). 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 5).

9.1.2 Assessment

The results from a statistical catch at age model (sometimes refer to as ADCAM) tuned with the spring and the fall survey have been used as the final point estimator upon which advice was based. In this framework the catch at age are modeled and the fishing mortality changes gradually over time, constrained by a random walk. The survey residuals in a given year are modeled by a multivariate normal distribution to account for potential survey "year effects".

The tuning with both the spring and the fall survey show similar diagnostics as that observed in previous years (see Tables 8, 9 and 10 and Figure 6 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 assessment is provided in Tables 11, 12 and the stock summary in Table 13 and Figure 7. The reference biomass is estimated to be 1241 kt in 2016 and the fishing mortality 0.27 in 2015.

Assessment based on 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. Tuning with spring survey only this year resulted in a reference biomass of 1136 kt in 2016 and a fishing mortality of 0.30 in 2015. An assessment based on the fall survey only gave reference biomass of 1291 kt in 2016 and fishing mortality of 0.26 in 2015.

The reference stock (B_{4+}) in 2015 is now estimated to be 1254 kt compared to 1302 kt last year. The SSB in 2015 is now estimated to be 533 kt compared to 547 kt estimated last year. Fishing mortality in 2014 is now estimated 0.29 compared to 0.28 estimated last year. Year classes 2012-2014 were estimated to be 161, 115 and 186 million in last year's assessment and are now estimated to be 165, 117 and 208 million.

9.1.3 HCR and reference points

The HCR upon which the TAC is set when the SSB in the assessment year is estimated to be above $SSB_{trigger}$ (220 kt) is as follows:

$$TAC_{y/y+1} = (0.20 * B_{4+,y} + TAC_{y-1/y})/2$$

In case the SSB is estimated to be below $SSB_{trigger} = 220kt$ the 0.20 multipler is reduced linearily. The $B_{4+,y}$ refers to the refence biomass (4 years and older) in the beginning of the assessment year (y). The notation $y/y+1$ refers to the next fishing year (starting 1. September of the assessent year) and $y-1/y$ to the current fishing year (ending 31. August of the assessment year). The advice for the 2016/2017 fishing season is:

$$TAC_{y/y+1} = (0.20 * 1241 + 239)/2 = 244kt$$

Although no prediction (besides catch weights in the assessment year) are needed to derive the advice, the basis as well as the calculation are provided (Table 14 and 15).

The rule was formally evaluated by ICES in 2009, but had been in place since the 2007/2008 fishing season. The evaluation showed that using the 0.20 multiplier would result in yield that was close to maximum (maximum yield when no catch stabilizer is used was estimated when applying a multiplier of around 0.22), while at the same time have a low probability that the stock would go below the $SSB_{trigger}$. The results were robust to numerous stock-recruitment scenarios tested, including assumption that future maximum mean recruitment would be around the mean observed since 1985 (Figure 8). All scenarios tested showed that there was very low probability that the stock would go below $B_{lim} = B_{loss} = 125kt$ (formally set in 2010) if the above rule is followed. ICES concluded that the HCR was in conformity both the ICES PA and MSY approach

Assessment errors ($CV = 0.15$, $\rho = 0.45$ (autocorrelation)) were implicitly included in the HCR evaluations. These errors were estimated from empirical retrospective pattern in the estimates of the reference biomass since the earliest available assessment in the 1970's. The distribution of the realized harvest rate when the HCR is followed showed that the 90% expected range are within a harvest rate of 0.15–0.27 (Figure 10). Hence classifying recent harvest rates above or below the 0.20 advisory multiplier is truly nonsensical. The recent realized harvest rates are within the above range.

In a ToR for the NWWG this year a request is made to derive pa-reference points for all ICES stocks for stock classification purpose. This is irrespective of which management jurisdiction a stock falls under.

The estimated CV of the spawning stock in the assessment year is around 0.08. The cv of the fishing mortality in the year before the assessment year is around 0.06. These estimates are an underestimates of the uncertainty.

Hence, for the derivation of pa-points from lim-points was based on a CV = 0.15. The B_{pa} is derived as:

$$B_{pa} = B_{lim}e^{1.645*cv} = 125e^{1.645*0.15} = 160$$

The fishing mortality reference points that lead to B_{lim} was derived using the same framework as was used in the HCR evaluation (with no $B_{trigger}$, no assessment error and no autocorrelation in recruitment) is around 0.74. Hence the F_{pa} is derived as:

$$F_{pa} = F_{lim}e^{-1.645*cv} = 0.74e^{-1.645*0.15} = 0.58$$

The F_{pa} reference point is higher than the approximate fishing mortality that correspond to the 0.20 harvest rate (fishing mortality around 0.30) that is the basis of the advice.

9.1.4 On frequency of assessment

ICES is considering if advice and hence assessments can be done less frequently than annually. As a part of that a ToR for this year was to provide a 7 year peel of the Mohn's statistic based on the analytical retrospective on reference F. For the cod the mean value is 0.04 for the assessment years 2009-2015 relative to the current assessment, the annual range being 0.02-0.08 (Figure 12).

Given the criterion that candidate stocks for inter-annual assessments are those that have a Mohn's based on the average of a 7 year peel of less than 0.2, this stock could be considered as a candidate. Counter to this is that this stock is under a management plan that includes annual setting of TAC based on a HCR. The evaluation of the HCR, including parameter settings such as assessment error (cv and autocorrelation) were set based on the CV in the assessment year. If TAC for 2–3 were to be set based on a less frequent assessment a re-evaluation of the HCR would be required because the CV in the prediction years would be significantly higher. It would most likely result in that the multiplier (harvest rate) in the HCR would be lower than at present.

In general the same argument could apply to stocks that are under the ICES MSY advice. Here, the derived F_{msy} is dependent on the assumption of assessment errors. The current values used are probably in all cases based on annual assessment errors. If advice were to be set multi-annually, the input assessment error would need to be set significantly higher when estimating of the advisory F_{msy}, particularly in stocks were no direct measurements is available of the future recruits. The effect of setting higher cv's would be most pronounced in stocks where the derived F_{msy} were bounded by precautionary consideration (low probability of going below B_{lim}). The net effect is that a multi-annual advice needs to be based on a lower advisory fishing mortality than used if the advice were annual.

9.2 Tables

Table 1. Icelandic cod in Division 5.a. Estimated catch in numbers by year and age in millions of fish in 1955–2015

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
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	13.566	25.935	9.107	20.183	5.848	3.763	2.029	0.508	0.199	0.136	0.013	0.031
2002	5.992	17.762	24.056	7.168	9.430	2.453	1.556	0.739	0.150	0.058	0.041	0.004
2003	5.489	16.312	22.045	16.629	4.840	4.933	1.201	0.507	0.211	0.046	0.026	0.033
2004	1.784	17.958	24.043	17.903	10.167	2.881	1.977	0.500	0.162	0.087	0.019	0.008

YEAR	3	4	5	6	7	8	9	10	11	12	13	14
2005	5.236	5.283	26.129	16.952	8.577	4.901	1.295	0.790	0.217	0.096	0.037	0.005
2006	3.456	13.066	8.784	21.926	10.577	4.703	2.170	0.472	0.241	0.040	0.016	0.010
2007	2.034	11.540	15.826	8.563	9.904	5.730	2.299	1.150	0.332	0.088	0.067	0.006
2008	3.109	5.118	12.808	11.597	5.141	4.700	2.138	0.881	0.279	0.069	0.044	0.004
2009	3.448	7.892	9.571	17.860	10.474	3.888	2.306	0.744	0.316	0.089	0.023	0.012
2010	3.498	7.673	9.478	8.407	10.953	5.561	1.567	0.927	0.297	0.145	0.063	0.017
2011	4.014	7.832	10.522	10.788	6.281	6.300	2.418	0.678	0.419	0.135	0.039	0.016
2012	4.072	11.276	10.795	9.494	8.896	5.011	3.202	1.148	0.291	0.225	0.079	0.026
2013	5.780	12.243	15.364	11.413	7.589	5.789	2.571	1.832	0.653	0.209	0.146	0.036
2014	4.623	8.378	14.913	13.288	8.427	4.928	2.814	1.393	0.964	0.376	0.127	0.104
2015	5.164	13.257	10.289	13.989	9.552	5.658	2.450	1.556	0.953	0.409	0.125	0.037

Table 2. Icelandic cod in Division 5.a. Estimated mean weight at age in the landings (kg) in period the 1955–2015. The weights for age groups 3–9 in 2016 are based on predictions from the 2016 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
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	1.486	2.021	2.631	3.364	4.558	6.190	7.124	8.445	9.313	9.569	10.234	9.505
2002	1.308	1.946	2.662	3.636	4.550	5.927	7.082	8.100	9.275	11.660	11.220	14.025
2003	1.350	1.866	2.459	3.391	4.380	4.756	6.141	7.138	9.580	10.260	11.479	10.720
2004	1.139	1.754	2.413	3.372	4.288	5.185	5.740	7.376	10.037	10.322	12.428	11.445
2005	1.195	1.734	2.419	3.392	4.292	5.057	6.232	6.123	7.961	10.067	12.776	13.717

YEAR	3	4	5	6	7	8	9	10	11	12	13	14
2006	1.089	1.625	2.210	3.059	4.270	4.983	5.290	6.040	8.448	11.155	12.611	15.382
2007	1.062	1.593	2.179	2.791	3.865	5.162	5.876	6.407	7.186	9.519	10.408	10.532
2008	1.100	1.600	2.369	3.147	3.996	5.278	6.495	7.383	7.822	10.391	11.562	18.087
2009	1.096	1.668	2.210	3.190	4.068	5.035	6.663	8.371	9.520	11.205	11.753	15.036
2010	1.100	1.827	2.360	3.222	4.485	5.471	6.748	8.038	8.975	10.395	11.629	12.222
2011	1.111	1.664	2.517	3.452	4.412	5.792	6.531	7.826	8.810	9.697	12.942	11.644
2012	1.184	1.631	2.452	3.760	4.717	5.934	7.368	8.011	9.098	10.718	12.037	11.596
2013	1.132	1.743	2.450	3.611	4.936	6.126	7.368	8.137	9.173	10.121	10.422	12.703
2014	1.117	1.740	2.521	3.515	4.675	6.158	7.486	8.583	8.962	10.516	10.281	12.324
2015	1.188	1.629	2.635	3.584	4.633	5.909	7.573	8.603	9.688	11.212	11.334	10.356
2016	1.401	1.815	2.265	3.500	4.153	5.338	6.664	8.603	9.688	11.212	11.334	10.356

Table 3. Icelandic cod in Division 5.a. Estimated weight at age in the spawning stock (kg) in period the 1955–2017. 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	0.750	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	1.306	1.382	1.752	2.710	3.443	4.675	7.220	10.320	12.197	14.683	16.175	19.050
1986	1.306	1.604	2.892	3.234	4.572	5.805	7.247	9.084	10.356	15.283	14.540	15.017
1987	1.706	1.589	2.426	3.516	4.879	6.459	7.656	9.243	10.697	10.622	15.894	12.592
1988	0.929	1.480	2.263	3.273	4.387	4.566	8.275	8.822	9.977	11.732	14.156	13.042
1989	0.822	1.501	2.346	3.428	4.676	7.388	8.506	9.831	11.986	10.003	12.611	16.045
1990	0.725	1.043	2.179	2.809	4.421	6.359	9.230	10.592	10.993	14.570	15.732	17.290
1991	0.114	1.286	2.042	2.752	3.404	6.091	9.152	9.804	9.754	14.344	14.172	20.200
1992	0.448	1.344	2.096	3.029	3.755	5.143	7.562	8.127	12.679	13.410	15.715	11.267
1993	0.773	1.363	2.309	3.236	4.111	5.710	6.352	8.641	10.901	12.517	14.742	16.874
1994	1.611	1.728	2.253	3.341	4.515	6.535	10.039	8.896	10.847	12.874	14.742	17.470
1995	0.514	1.636	2.346	3.186	4.488	5.528	8.620	10.273	11.022	11.407	13.098	15.182
1996	0.543	1.754	2.491	3.534	4.254	5.634	8.300	9.772	10.539	13.503	13.689	16.193

YEAR	3	4	5	6	7	8	9	10	11	12	13	14
1997	1.112	1.347	2.267	3.746	5.426	5.972	6.958	8.537	10.797	11.533	10.428	12.788
1998	1.112	1.821	2.261	3.263	4.468	5.784	6.812	9.304	10.759	14.903	16.651	18.666
1999	1.307	1.467	1.933	2.997	3.961	5.120	6.494	9.946	11.088	12.535	14.995	15.151
2000	0.496	1.355	1.916	2.881	4.318	5.580	8.497	9.203	10.240	11.172	13.172	17.442
2001	0.816	1.583	2.108	2.700	4.086	6.202	6.907	9.055	8.769	9.526	11.210	13.874
2002	0.780	1.590	2.259	3.120	3.985	5.958	9.234	9.002	10.422	13.402	9.008	16.893
2003	1.149	1.324	2.239	3.052	4.231	5.057	6.838	7.819	8.802	10.712	12.152	13.797
2004	1.149	1.430	2.099	3.049	3.743	5.319	5.682	7.397	10.808	11.569	13.767	12.955
2005	0.649	1.120	1.898	2.962	3.875	4.806	7.281	5.495	7.211	9.909	12.944	18.151
2006	0.907	1.384	1.999	2.907	4.384	5.122	6.536	5.769	6.258	5.688	7.301	15.412
2007	1.403	1.264	2.022	2.582	4.081	5.725	6.736	6.481	7.142	6.530	9.724	10.143
2008	0.912	1.842	2.232	2.925	3.915	5.462	7.075	7.648	8.282	11.181	14.266	17.320
2009	0.644	1.441	2.028	2.873	3.913	4.919	7.046	8.505	10.126	12.108	12.471	15.264
2010	0.644	1.588	2.153	3.131	4.173	5.197	6.356	7.945	8.913	10.090	10.417	13.489
2011	0.794	2.377	2.651	3.203	4.517	6.000	6.866	7.850	8.810	9.797	13.534	13.033
2012	1.403	1.698	2.594	3.683	4.483	5.921	7.988	8.358	9.543	10.916	10.884	11.758
2013	0.944	2.282	2.983	3.827	5.206	6.543	8.298	8.415	9.336	9.926	11.195	12.691
2014	0.944	1.333	2.539	3.307	4.460	6.424	8.225	8.413	9.713	10.513	11.437	12.979
2015	0.709	1.046	3.308	3.829	4.897	6.234	8.719	9.694	9.688	11.212	11.334	10.356
2016	0.973	2.223	3.035	4.198	4.610	6.018	7.389	9.731	9.688	11.212	11.334	10.356

Table 4. Icelandic cod in Division 5.a. Estimated maturity at age in period the 1955–2016.

YEAR	3	4	5	6	7	8	9	10	11	12	13
1955	0.019	0.022	0.033	0.181	0.577	0.782	0.834	0.960	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
1957	0.019	0.026	0.043	0.100	0.549	0.801	0.842	0.990	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
1959	0.019	0.029	0.070	0.535	0.772	0.818	0.834	0.990	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
1961	0.019	0.025	0.053	0.450	0.772	0.818	0.834	0.990	0.990	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
1963	0.019	0.025	0.048	0.237	0.706	0.834	0.849	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
1965	0.019	0.025	0.045	0.354	0.751	0.826	0.842	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
1967	0.019	0.028	0.051	0.341	0.772	0.842	0.849	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
1969	0.019	0.028	0.043	0.227	0.682	0.801	0.842	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
1971	0.019	0.025	0.037	0.074	0.657	0.706	0.772	0.979	0.994	0.982	0.993
1972	0.019	0.023	0.035	0.106	0.450	0.772	0.809	0.979	0.994	0.982	0.993
1973	0.022	0.028	0.163	0.382	0.697	0.801	0.834	0.996	0.996	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
1975	0.020	0.035	0.118	0.287	0.715	0.809	0.839	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
1977	0.019	0.024	0.060	0.382	0.742	0.817	0.842	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
1979	0.019	0.021	0.053	0.282	0.635	0.790	0.836	0.919	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
1981	0.019	0.022	0.030	0.090	0.448	0.751	0.811	0.962	0.988	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
1983	0.019	0.030	0.047	0.116	0.264	0.530	0.715	0.979	0.985	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
1985	NA	0.021	0.185	0.412	0.495	0.735	0.572	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
1987	0.002	0.033	0.093	0.360	0.490	0.885	0.782	1.000	0.979	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
1989	0.008	0.025	0.142	0.372	0.645	0.652	0.634	0.991	1.000	0.903	0.859
1990	0.006	0.012	0.155	0.437	0.581	0.796	0.814	0.986	1.000	1.000	1.000
1991	NA	0.055	0.149	0.369	0.637	0.790	0.682	0.842	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
1993	0.006	0.085	0.267	0.464	0.693	0.801	0.843	0.968	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
1995	0.005	0.109	0.384	0.528	0.752	0.787	0.859	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
1997	0.006	0.037	0.246	0.424	0.685	0.787	0.804	0.932	1.000	0.913	1.000

YEAR	3	4	5	6	7	8	9	10	11	12	13
1998	NA	0.061	0.209	0.491	0.782	0.814	0.810	0.925	0.998	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
2000	0.001	0.065	0.248	0.512	0.611	0.867	0.998	0.980	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
2002	0.008	0.086	0.322	0.656	0.759	0.920	0.550	0.979	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
2004	NA	0.038	0.246	0.549	0.626	0.843	0.816	0.990	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
2006	0.002	0.023	0.294	0.448	0.752	0.871	0.743	0.747	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
2008	0.001	0.041	0.276	0.549	0.727	0.827	0.846	0.954	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
2010	NA	0.016	0.058	0.377	0.822	0.869	0.923	0.802	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
2012	0.004	0.029	0.126	0.411	0.728	0.882	0.961	0.830	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
2014	NA	0.026	0.068	0.236	0.614	0.893	0.967	0.957	1.000	1.000	1.000
2015	0.004	0.007	0.109	0.353	0.638	0.910	0.979	0.988	1.000	1.000	1.000
2016	0.001	0.009	0.024	0.288	0.543	0.733	0.942	0.987	1.000	1.000	1.000

Table 5. Icelandic cod in Division 5.a. Estimated survey weight at age (g) in the spring survey (SMB).

YEAR	1	2	3	4	5	6	7	8	9	10
1985	14	137	388	1117	1733	2578	3221	4667	5858	7022
1986	15	159	616	1219	2246	2961	4326	5582	7216	8298
1987	14	117	467	1198	1751	2980	4194	6329	6932	10026
1988	11	122	495	1076	1964	3094	3549	4357	8119	9424
1989	22	150	548	1141	1932	3048	4384	6255	6999	12508
1990	19	135	460	1039	1815	2595	3871	6039	8141	9560
1991	18	147	553	1166	1842	2586	3267	5729	7601	14399
1992	24	134	501	1013	1845	2567	3651	5046	7433	13505
1993	12	171	576	1166	1944	2991	3961	5377	5983	9330
1994	13	174	686	1412	2044	3180	4132	6277	8310	10535
1995	10	134	605	1377	2284	2989	4449	5322	8063	9243
1996	11	155	551	1350	2082	3321	4044	5263	7475	9961
1997	18	140	546	1194	2168	3220	4863	5507	6457	6899
1998	15	158	485	1208	2041	3017	4253	5436	6346	8380
1999	14	140	578	1070	1847	2867	3819	4980	5625	8190
2000	16	124	486	1195	1817	2770	4066	5348	8499	8396
2001	17	152	531	1186	1852	2641	3760	5450	6440	8169
2002	11	132	510	1206	1998	2920	3779	5758	6259	6282
2003	16	131	466	1179	1918	2787	4139	4677	6258	9588
2004	20	147	481	1062	1873	2803	3458	4988	5312	7790
2005	11	118	451	1029	1760	2643	3646	4361	7246	6668
2006	13	105	417	982	1689	2600	4050	4749	5621	8374
2007	14	101	410	969	1663	2342	3635	5017	6120	7744
2008	11	121	376	937	1805	2612	3592	4932	6394	8404
2009	12	113	413	845	1602	2633	3659	4683	5768	6287
2010	13	98	391	1008	1697	2570	4021	4912	6100	7751
2011	12	102	395	1126	2114	2986	4225	5876	6644	7903
2012	12	142	477	1143	1929	3180	4249	5718	7825	7609
2013	13	111	495	1054	1785	3023	4774	6384	8114	9543
2014	11	114	359	1079	1710	2632	3987	6168	8068	10116
2015	13	150	418	898	2055	3016	4401	6074	8652	9618
2016	10	121	483	1013	1581	3146	3988	5522	7229	9683

Table 6. Icelandic cod in Division 5.a. 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	12.21	12.00	2.55	0.89	0.38
1988	3.44	6.96	72.09	101.49	66.56	7.81	5.90	6.29	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	30.81	36.46	13.22	9.90	2.13	1.75	1.17	0.36
1994	14.38	14.97	9.02	26.66	21.90	5.76	3.62	0.70	0.48	0.45
1995	1.08	29.13	24.75	8.98	23.88	17.69	3.78	1.80	0.35	0.17
1996	3.72	5.42	42.58	29.44	12.89	14.62	14.02	3.80	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	46.35	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	56.66	41.59	30.22	26.99	9.96	6.30	2.76
2013	10.80	31.36	17.67	43.84	46.48	25.25	16.50	13.81	6.88	3.33
2014	3.31	23.97	38.00	23.48	47.17	37.60	17.31	8.18	4.26	2.22
2015	20.85	10.66	27.42	41.87	20.93	40.85	28.14	16.41	4.99	3.13
2016	31.20	29.08	14.35	36.63	53.94	27.29	36.91	18.20	6.75	2.27

Table 7. Icelandic cod in Division 5.a. Survey indices of the fall bottom trawl survey (SMH).

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	12.21	12.00	2.55	0.89	0.38
1988	3.44	6.96	72.09	101.49	66.56	7.81	5.90	6.29	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	30.81	36.46	13.22	9.90	2.13	1.75	1.17	0.36
1994	14.38	14.97	9.02	26.66	21.90	5.76	3.62	0.70	0.48	0.45
1995	1.08	29.13	24.75	8.98	23.88	17.69	3.78	1.80	0.35	0.17
1996	3.72	5.42	42.58	29.44	12.89	14.62	14.02	3.80	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	46.35	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	56.66	41.59	30.22	26.99	9.96	6.30	2.76
2013	10.80	31.36	17.67	43.84	46.48	25.25	16.50	13.81	6.88	3.33
2014	3.31	23.97	38.00	23.48	47.17	37.60	17.31	8.18	4.26	2.22
2015	20.85	10.66	27.42	41.87	20.93	40.85	28.14	16.41	4.99	3.13
2016	31.20	29.08	14.35	36.63	53.94	27.29	36.91	18.20	6.75	2.27

Table 8. Icelandic cod in Division 5.a. 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	-0.12	-0.21	0.08	0.12	0.21	-0.12	-0.16	0.13	-0.10	-0.45	-0.21	0.00
1956	-0.03	-0.05	0.03	0.00	-0.13	-0.20	-0.01	0.01	0.17	0.09	0.23	0.22
1957	0.09	0.02	-0.01	0.17	-0.13	0.09	0.06	-0.15	-0.10	-0.12	-0.38	0.52
1958	0.15	0.18	-0.26	-0.07	0.06	0.08	0.13	-0.23	0.23	0.00	-0.23	0.39
1959	-0.22	0.21	0.26	-0.24	-0.22	-0.06	-0.06	0.28	-0.27	0.38	-0.23	-0.42
1960	0.10	-0.36	0.14	0.19	0.06	0.07	-0.03	-0.11	-0.04	0.03	-0.64	0.89
1961	0.05	0.04	-0.40	0.12	-0.02	0.27	0.20	-0.14	0.09	-0.19	-0.97	0.82
1962	0.09	-0.01	0.13	-0.24	0.12	-0.29	0.09	0.26	-0.06	0.04	-0.40	0.69
1963	-0.06	0.30	-0.18	0.01	-0.03	-0.07	-0.38	0.21	0.35	0.06	0.08	-0.62
1964	-0.13	-0.02	0.13	-0.25	-0.12	0.38	-0.10	-0.45	-0.01	0.27	-0.15	0.00
1965	-0.03	-0.11	0.09	0.16	-0.13	0.05	0.47	-0.48	-0.06	-0.51	-0.36	0.63
1966	-0.04	-0.04	-0.18	0.10	-0.07	0.12	-0.35	0.59	-0.83	0.28	0.01	1.05
1967	0.19	-0.13	0.02	-0.20	0.02	-0.37	0.49	0.05	0.67	-0.72	-0.83	-0.19
1968	0.04	-0.02	-0.27	-0.12	0.23	0.16	-0.42	0.37	-0.12	0.60	-0.66	0.64
1969	-0.09	-0.03	0.15	-0.01	0.05	-0.15	-0.33	-0.25	-0.04	-0.26	-0.81	-0.16
1970	-0.10	0.14	-0.05	-0.14	0.05	-0.16	0.48	-0.58	-0.12	0.25	0.30	0.44
1971	-0.10	0.07	0.09	0.18	-0.18	0.28	-0.17	0.06	-0.45	-0.02	0.13	0.35
1972	-0.17	-0.13	0.07	-0.03	0.12	-0.05	-0.10	0.29	-0.07	0.17	0.53	-2.78
1973	0.28	-0.02	-0.10	0.03	0.00	-0.24	0.09	0.17	0.16	-0.19	-1.25	-2.12
1974	-0.16	0.21	-0.02	-0.18	-0.01	0.00	-0.22	0.29	0.01	0.19	-0.43	0.78
1975	0.19	-0.07	0.04	-0.05	0.03	-0.15	-0.21	0.00	0.41	-0.01	-0.12	0.06
1976	0.10	0.00	-0.17	0.08	-0.09	0.25	-0.16	-0.15	0.06	0.27	-0.23	0.20
1977	-0.40	-0.06	0.05	-0.09	0.13	0.05	0.31	0.03	-0.70	-0.48	-1.22	-2.53
1978	0.08	-0.01	0.04	-0.10	0.04	-0.21	0.12	-0.19	0.01	-0.05	0.54	1.17
1979	0.16	0.09	-0.22	0.10	-0.05	0.03	-0.31	-0.08	0.04	-0.14	0.42	-0.22
1980	0.21	0.01	0.08	0.06	-0.01	-0.09	0.12	-0.49	0.29	0.10	0.17	-1.09
1981	-0.30	-0.21	0.08	-0.14	0.07	0.09	0.02	0.33	-0.08	0.60	0.00	1.16
1982	0.01	0.15	0.07	-0.05	-0.22	0.19	0.18	0.14	-0.23	-0.87	0.06	-0.88
1983	-0.32	-0.36	0.11	0.14	0.04	0.01	-0.04	-0.03	0.00	0.37	-0.19	0.55
1984	0.35	0.03	-0.06	-0.05	-0.10	0.00	0.05	-0.14	-0.36	0.17	0.72	0.07
1985	0.04	0.18	-0.10	0.12	-0.10	-0.02	-0.14	0.13	0.03	-0.34	0.49	0.44
1986	0.14	-0.12	0.01	-0.01	0.18	-0.05	0.12	-0.21	0.08	0.06	-0.57	0.15
1987	-0.15	0.12	0.01	-0.16	0.07	0.04	-0.03	0.11	-0.38	-0.11	0.14	-0.34
1988	-0.09	-0.06	-0.06	0.13	-0.08	0.07	0.16	0.03	0.47	0.02	0.54	0.04
1989	-0.21	0.04	0.14	-0.08	0.00	-0.15	-0.32	-0.09	-0.03	0.52	-0.02	-1.51
1990	0.00	-0.14	-0.11	0.00	0.04	0.09	-0.08	-0.23	0.29	0.13	-0.20	0.00
1991	0.07	0.04	-0.13	-0.07	0.10	-0.08	0.12	-0.07	-0.31	0.42	-0.55	0.04
1992	-0.23	0.08	0.04	0.03	0.10	0.00	-0.05	-0.07	-0.75	-0.76	-0.57	-0.25
1993	0.25	0.04	-0.20	-0.06	-0.07	-0.12	0.07	0.48	0.49	-0.21	-1.00	0.29
1994	0.03	0.25	-0.14	-0.19	-0.04	0.07	-0.19	-0.14	0.42	0.52	0.50	-0.56
1995	0.27	-0.04	0.08	-0.04	-0.04	-0.12	-0.13	-0.29	-0.21	0.75	1.12	0.48
1996	0.00	-0.05	-0.18	0.08	0.04	0.02	0.13	0.18	-0.38	-0.37	0.64	-0.16

YEAR	3	4	5	6	7	8	9	10	11	12	13	14
1997	-0.16	0.03	-0.03	-0.13	-0.09	0.21	0.18	0.26	0.42	-0.70	-0.19	0.08
1998	-0.19	-0.17	0.07	0.07	0.02	-0.16	0.25	0.06	0.10	0.31	0.17	-0.85
1999	-0.11	0.04	0.04	0.03	0.09	-0.04	-0.23	-0.18	-0.25	-0.39	-0.50	-1.09
2000	0.14	-0.23	0.12	-0.04	0.01	0.11	0.04	-0.12	-0.01	0.13	-0.21	-0.35
2001	0.24	0.22	-0.19	0.02	0.04	-0.25	0.07	0.33	-0.14	0.19	-0.71	0.80
2002	-0.10	0.05	0.03	-0.04	0.01	0.03	-0.08	0.25	0.31	-0.13	0.09	-0.98
2003	-0.07	0.03	0.00	-0.11	0.12	0.07	0.21	-0.18	0.10	0.26	0.08	0.68
2004	-0.26	0.06	0.08	-0.05	-0.05	0.25	-0.04	0.23	-0.34	0.23	0.27	-0.40
2005	0.17	-0.26	0.13	-0.05	-0.11	-0.08	0.31	-0.01	0.41	0.21	0.32	-0.30
2006	-0.06	0.04	-0.10	0.06	0.06	-0.07	-0.08	0.21	-0.22	-0.22	-0.64	-0.23
2007	-0.15	0.14	-0.05	0.02	-0.13	0.08	0.02	0.18	0.78	-0.22	1.15	-0.95
2008	0.12	-0.18	0.07	-0.15	0.05	-0.19	0.04	0.14	-0.08	0.46	0.25	-0.68
2009	0.08	-0.11	0.06	0.16	-0.02	0.23	-0.20	-0.24	-0.02	-0.32	0.23	-0.43
2010	0.08	0.03	-0.15	0.04	0.05	-0.07	0.20	-0.20	-0.17	0.19	0.34	0.67
2011	-0.02	-0.03	0.08	0.01	-0.02	-0.01	-0.11	0.10	-0.13	-0.12	-0.20	-0.42
2012	-0.15	0.03	0.00	-0.03	0.00	0.17	0.01	-0.25	-0.02	-0.09	0.09	-0.23
2013	0.26	-0.03	0.02	0.03	-0.07	-0.05	0.16	-0.01	-0.19	0.22	0.11	-0.44
2014	-0.11	0.03	0.01	0.00	0.02	-0.06	-0.06	0.12	-0.02	-0.11	0.40	0.09
2015	0.02	0.06	0.03	0.04	-0.10	0.03	-0.06	-0.07	0.41	-0.11	-0.37	-0.35

Table 9. Icelandic cod in Division 5.a. 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	-0.48	0.07	0.24	0.46	0.14	0.26	0.40	0.18	0.31	0.68
1986	0.44	-0.03	-0.38	-0.22	-0.07	0.00	-0.17	-0.28	-0.25	-0.03
1987	0.65	0.03	0.14	-0.44	-0.02	-0.07	0.04	-0.09	-0.10	0.00
1988	-0.19	0.04	0.52	0.17	-0.12	-0.34	0.08	0.48	-0.12	-0.09
1989	0.39	0.08	0.55	0.57	0.24	0.18	-0.13	-0.11	0.21	0.11
1990	-0.47	0.13	0.09	0.07	-0.15	-0.15	0.07	-0.16	-0.05	0.16
1991	-0.16	-0.43	0.12	0.17	0.27	0.04	0.12	-0.16	0.22	0.20
1992	-0.24	0.04	-0.18	0.13	-0.08	-0.13	-0.15	-0.15	-0.12	0.00
1993	-0.51	-0.03	0.20	-0.04	0.06	-0.04	-0.22	-0.16	-0.23	-0.22
1994	0.54	-0.24	0.04	0.13	-0.19	-0.32	-0.17	-0.23	-0.20	-0.06
1995	-0.23	0.16	-0.21	-0.04	0.18	-0.02	-0.23	-0.10	-0.07	-0.21
1996	-0.63	-0.11	0.11	-0.11	0.21	-0.05	0.24	0.39	0.19	0.05
1997	0.19	-0.03	0.14	0.29	-0.03	-0.05	-0.05	0.24	-0.36	-0.30
1998	-0.10	0.13	-0.17	0.13	0.51	0.29	0.08	0.19	0.42	0.49
1999	-0.04	0.20	-0.02	0.06	-0.05	0.07	0.01	-0.04	-0.04	0.11
2000	0.90	0.14	0.30	-0.16	-0.09	-0.23	-0.23	-0.04	-0.28	-0.28
2001	0.20	0.04	0.02	-0.08	-0.45	-0.24	-0.41	-0.60	-0.39	0.14
2002	-0.15	0.27	0.16	0.08	0.06	-0.15	-0.20	-0.32	-0.46	-0.22
2003	0.03	-0.12	0.06	-0.02	-0.11	-0.21	-0.21	-0.08	0.14	-0.56
2004	-0.07	0.19	-0.10	0.29	0.12	0.22	0.18	0.14	0.44	0.30
2005	-0.14	0.09	0.22	-0.11	0.09	0.10	-0.02	0.04	0.05	0.31
2006	0.21	-0.05	-0.01	0.08	-0.08	0.15	-0.12	-0.33	-0.32	-0.17
2007	0.03	0.17	-0.31	-0.22	-0.16	-0.18	-0.32	-0.07	0.04	-0.05
2008	-0.02	0.00	-0.06	-0.41	-0.27	-0.11	0.11	-0.05	0.10	-0.17
2009	0.41	-0.11	-0.16	-0.21	-0.17	-0.09	-0.08	0.03	-0.19	-0.09
2010	0.12	-0.16	-0.19	-0.24	-0.19	-0.20	-0.08	-0.04	0.36	0.05
2011	-0.45	-0.20	-0.35	-0.28	-0.11	0.06	0.10	0.09	-0.02	-0.08
2012	0.17	-0.14	-0.12	0.20	0.33	0.30	0.41	0.27	0.13	0.13
2013	-0.14	0.10	-0.14	-0.11	0.05	0.06	0.03	0.24	0.54	0.03
2014	-0.38	0.01	-0.16	-0.05	-0.01	0.17	-0.01	-0.17	-0.25	0.01
2015	-0.12	-0.05	-0.25	-0.18	-0.21	0.20	0.19	0.39	-0.02	0.02
2016	0.28	-0.19	-0.19	-0.10	0.11	0.18	0.39	0.22	0.17	-0.21

Table 10. Icelandic cod in Division 5.a. 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	0.01	-0.09	-0.02	-0.20	-0.02	-0.08	0.16	0.19	-0.18	-0.04
1997	-0.12	0.11	-0.03	0.24	0.04	-0.17	-0.14	-0.04	-0.34	-0.05
1998	-0.24	-0.02	-0.20	0.02	-0.05	0.34	0.50	0.11	0.25	0.05
1999	0.23	-0.09	0.12	0.10	0.06	-0.02	-0.12	-0.31	-0.37	0.09
2000	-0.28	-0.08	-0.27	-0.08	-0.24	-0.24	-0.41	-0.35	-0.02	0.16
2001	-0.16	-0.15	0.03	-0.02	-0.23	-0.27	-0.26	-0.53	-0.61	-0.38
2002	-0.13	-0.20	-0.13	0.15	-0.01	0.11	-0.02	0.00	-0.04	-0.43
2003	-0.12	-0.11	0.08	-0.15	-0.12	-0.16	-0.13	0.07	-0.06	-0.44
2004	-0.12	0.15	0.10	0.12	0.16	0.09	0.22	0.33	0.48	0.21
2005	0.10	-0.08	0.09	0.08	0.24	-0.02	-0.28	-0.28	-0.21	-0.06
2006	0.09	-0.08	0.09	0.09	0.07	0.04	0.02	-0.21	-0.06	-0.04
2007	0.14	0.00	-0.34	-0.27	-0.11	-0.03	-0.20	0.02	-0.27	0.08
2008	0.28	0.27	0.05	-0.14	0.09	0.22	0.27	0.25	0.05	0.35
2009	-0.08	-0.08	0.08	0.08	0.13	0.04	0.13	0.23	0.26	0.16
2010	0.19	0.11	0.14	0.11	0.09	-0.02	0.10	0.21	0.52	0.09
2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	-0.20	0.13	-0.03	-0.22	-0.21	-0.16	0.05	0.21	-0.09	-0.02
2013	-0.09	0.02	0.06	-0.05	-0.03	-0.07	-0.07	0.00	0.19	-0.06
2014	0.16	0.05	-0.04	-0.01	-0.02	0.08	-0.06	0.08	0.18	0.59
2015	0.32	0.10	0.22	0.18	0.15	0.30	0.24	-0.08	0.06	-0.43

Table 11. Icelandic cod in Division 5.a. Estimates of fishing mortality 1955-2015 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	0.252	0.273	0.301	0.302	0.280	0.319	0.319	0.304	0.319	0.319
1956	0.051	0.182	0.249	0.258	0.289	0.302	0.292	0.338	0.350	0.329	0.326	0.326
1957	0.081	0.215	0.273	0.271	0.300	0.326	0.325	0.359	0.359	0.325	0.291	0.291
1958	0.114	0.248	0.302	0.290	0.323	0.370	0.395	0.434	0.437	0.377	0.315	0.315
1959	0.091	0.233	0.282	0.256	0.298	0.341	0.350	0.396	0.377	0.314	0.223	0.223
1960	0.101	0.233	0.295	0.292	0.338	0.397	0.427	0.473	0.470	0.378	0.263	0.263
1961	0.094	0.225	0.259	0.262	0.333	0.398	0.418	0.457	0.436	0.343	0.221	0.221
1962	0.112	0.248	0.282	0.264	0.346	0.424	0.467	0.511	0.484	0.372	0.233	0.233
1963	0.130	0.283	0.328	0.309	0.383	0.492	0.587	0.644	0.622	0.456	0.279	0.279
1964	0.126	0.290	0.372	0.360	0.434	0.570	0.740	0.808	0.830	0.601	0.379	0.379
1965	0.121	0.284	0.384	0.403	0.471	0.601	0.743	0.845	0.874	0.645	0.415	0.415
1966	0.094	0.253	0.341	0.381	0.491	0.621	0.780	0.913	1.001	0.773	0.518	0.518
1967	0.077	0.229	0.303	0.338	0.483	0.609	0.749	0.875	0.923	0.712	0.446	0.446
1968	0.077	0.247	0.342	0.405	0.575	0.765	1.035	1.196	1.351	1.063	0.714	0.714
1969	0.056	0.232	0.322	0.354	0.504	0.608	0.718	0.834	0.864	0.701	0.428	0.428
1970	0.069	0.269	0.389	0.426	0.551	0.649	0.759	0.888	0.942	0.784	0.494	0.494
1971	0.088	0.309	0.478	0.532	0.620	0.716	0.799	0.953	1.025	0.861	0.553	0.553
1972	0.088	0.302	0.479	0.553	0.649	0.729	0.790	0.955	1.050	0.889	0.572	0.572
1973	0.119	0.320	0.488	0.564	0.667	0.753	0.798	0.949	1.032	0.877	0.560	0.560
1974	0.113	0.324	0.498	0.574	0.698	0.830	0.918	1.050	1.166	0.996	0.656	0.656
1975	0.108	0.309	0.501	0.600	0.721	0.881	1.016	1.116	1.231	1.060	0.717	0.717
1976	0.066	0.258	0.427	0.550	0.693	0.848	0.939	0.993	1.036	0.899	0.600	0.600
1977	0.030	0.195	0.329	0.427	0.607	0.717	0.719	0.725	0.676	0.593	0.370	0.370
1978	0.027	0.174	0.281	0.354	0.524	0.599	0.540	0.538	0.470	0.423	0.255	0.255
1979	0.028	0.171	0.274	0.344	0.501	0.564	0.491	0.482	0.407	0.370	0.223	0.223
1980	0.028	0.175	0.306	0.386	0.537	0.618	0.553	0.537	0.457	0.416	0.264	0.264
1981	0.023	0.176	0.353	0.488	0.647	0.816	0.843	0.804	0.730	0.652	0.468	0.468
1982	0.028	0.192	0.395	0.557	0.697	0.894	0.949	0.852	0.723	0.629	0.456	0.456
1983	0.023	0.179	0.377	0.554	0.704	0.877	0.904	0.834	0.708	0.626	0.463	0.463
1984	0.039	0.200	0.378	0.530	0.673	0.801	0.743	0.686	0.573	0.518	0.378	0.378
1985	0.050	0.230	0.422	0.577	0.712	0.827	0.754	0.681	0.568	0.514	0.378	0.378
1986	0.061	0.261	0.517	0.713	0.822	0.948	0.861	0.747	0.629	0.559	0.415	0.415
1987	0.055	0.272	0.555	0.816	0.903	1.052	0.976	0.823	0.705	0.624	0.477	0.477
1988	0.047	0.258	0.523	0.794	0.918	1.095	1.059	0.909	0.822	0.734	0.588	0.588
1989	0.041	0.241	0.463	0.653	0.790	0.885	0.779	0.688	0.599	0.543	0.407	0.407
1990	0.050	0.250	0.471	0.662	0.785	0.849	0.730	0.656	0.570	0.515	0.383	0.383
1991	0.086	0.301	0.565	0.811	0.879	0.936	0.820	0.732	0.650	0.580	0.443	0.443
1992	0.102	0.320	0.598	0.868	0.918	0.990	0.865	0.759	0.673	0.593	0.457	0.457
1993	0.138	0.313	0.554	0.801	0.882	1.015	0.988	0.878	0.810	0.706	0.568	0.568
1994	0.088	0.241	0.383	0.530	0.671	0.752	0.688	0.651	0.579	0.518	0.397	0.397
1995	0.061	0.195	0.318	0.421	0.564	0.614	0.536	0.531	0.463	0.421	0.315	0.315
1996	0.036	0.160	0.282	0.410	0.553	0.614	0.556	0.554	0.484	0.433	0.328	0.328

YEAR	3	4	5	6	7	8	9	10	11	12	13	14
1997	0.025	0.144	0.274	0.419	0.577	0.657	0.632	0.628	0.559	0.488	0.380	0.380
1998	0.029	0.152	0.328	0.516	0.655	0.762	0.774	0.752	0.689	0.590	0.478	0.478
1999	0.045	0.175	0.387	0.640	0.732	0.840	0.862	0.808	0.740	0.625	0.514	0.514
2000	0.060	0.179	0.384	0.609	0.727	0.846	0.879	0.839	0.777	0.656	0.551	0.551
2001	0.075	0.190	0.380	0.573	0.682	0.823	0.910	0.894	0.849	0.714	0.618	0.618
2002	0.047	0.163	0.335	0.483	0.593	0.707	0.789	0.805	0.759	0.641	0.550	0.550
2003	0.037	0.150	0.328	0.489	0.571	0.668	0.719	0.745	0.702	0.596	0.513	0.513
2004	0.032	0.141	0.324	0.515	0.578	0.676	0.726	0.745	0.708	0.598	0.522	0.522
2005	0.032	0.126	0.289	0.472	0.546	0.643	0.686	0.704	0.675	0.567	0.494	0.494
2006	0.030	0.120	0.264	0.454	0.530	0.632	0.671	0.671	0.634	0.523	0.452	0.452
2007	0.027	0.108	0.229	0.380	0.484	0.597	0.652	0.651	0.620	0.508	0.442	0.442
2008	0.023	0.090	0.181	0.294	0.401	0.484	0.491	0.485	0.434	0.359	0.292	0.292
2009	0.030	0.095	0.186	0.303	0.400	0.480	0.472	0.446	0.387	0.316	0.250	0.250
2010	0.028	0.090	0.165	0.253	0.350	0.411	0.376	0.354	0.294	0.243	0.182	0.182
2011	0.027	0.089	0.162	0.240	0.324	0.375	0.328	0.307	0.246	0.200	0.143	0.143
2012	0.029	0.092	0.166	0.244	0.322	0.370	0.322	0.299	0.240	0.194	0.137	0.137
2013	0.040	0.101	0.177	0.254	0.327	0.381	0.335	0.316	0.262	0.209	0.149	0.149
2014	0.031	0.096	0.164	0.232	0.307	0.363	0.327	0.318	0.276	0.214	0.155	0.155
2015	0.034	0.099	0.164	0.221	0.291	0.346	0.308	0.306	0.268	0.199	0.135	0.135

Table 12. Icelandic cod in Division 5.a. Estimates of numbers at age in the stock 1955–2016 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	254.563	186.621	152.016	217.665	212.115	115.674	36.147	24.683	13.037	88.714	9.306	7.913	8.261	2.680
1956	329.670	208.419	152.792	119.578	150.337	134.944	72.052	21.901	14.940	8.063	52.776	5.536	4.781	4.914
1957	431.693	269.911	170.639	118.882	81.607	95.953	85.376	44.193	13.258	9.131	4.709	30.454	3.262	2.825
1958	230.244	353.441	220.984	128.816	78.524	50.834	59.908	51.798	35.301	7.843	5.221	2.693	18.015	1.997
1959	288.032	188.508	289.373	161.372	82.270	47.548	31.134	35.512	51.461	19.463	4.159	2.761	1.512	10.766
1960	192.352	235.821	154.337	216.341	104.638	50.789	30.125	18.915	20.681	37.649	10.729	2.335	1.651	0.991
1961	264.814	157.485	193.074	114.255	140.289	63.794	31.062	17.596	10.412	11.044	19.204	5.492	1.309	1.040
1962	304.180	216.812	128.938	143.909	74.689	88.615	40.205	18.222	23.625	5.614	5.728	10.169	3.190	0.860
1963	322.813	249.041	177.510	94.417	91.934	46.136	55.737	23.281	9.767	12.131	2.758	2.890	5.737	2.069
1964	341.867	264.297	203.898	127.656	58.249	54.216	27.732	31.116	11.656	4.449	5.217	1.213	1.500	3.554
1965	477.837	279.897	216.388	147.222	78.184	32.876	30.956	14.704	14.408	4.554	1.624	1.862	0.544	0.840
1966	256.297	391.219	229.160	157.034	90.750	43.587	17.993	15.828	6.599	5.609	1.601	0.555	0.800	0.294
1967	369.071	209.839	320.303	170.783	99.797	52.835	24.373	9.020	6.961	2.477	1.843	0.482	0.210	0.390
1968	269.152	302.170	171.801	242.900	111.218	60.347	30.858	12.305	4.016	2.696	0.845	0.600	0.194	0.110
1969	281.354	220.363	247.395	130.267	155.406	64.703	32.947	41.239	4.690	1.168	0.667	0.179	0.170	0.078
1970	207.686	230.354	180.418	191.546	84.546	92.175	37.184	32.930	18.385	1.872	0.415	0.230	0.073	0.091
1971	407.528	170.039	188.597	137.914	119.777	46.911	49.309	17.552	14.083	7.045	0.631	0.132	0.086	0.036
1972	267.009	333.655	139.216	141.360	82.919	60.800	22.564	21.724	23.321	5.188	2.225	0.185	0.046	0.041
1973	389.158	218.609	273.174	104.426	85.604	42.046	28.639	9.655	8.583	8.663	1.634	0.637	0.062	0.021
1974	548.519	318.616	178.982	198.643	62.064	43.028	19.591	12.035	3.722	3.165	2.745	0.477	0.217	0.029
1975	213.808	449.089	260.861	130.851	117.590	30.871	19.836	7.978	4.296	1.216	0.907	0.700	0.144	0.092
1976	339.523	175.051	367.683	191.686	78.627	58.308	13.877	7.900	2.705	1.273	0.326	0.217	0.199	0.058
1977	363.166	277.978	143.320	281.726	121.245	41.995	27.530	5.681	2.770	0.866	0.386	0.095	0.072	0.089
1978	208.898	297.335	227.589	113.822	189.765	71.428	22.428	12.279	2.272	1.105	0.344	0.161	0.043	0.041

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1979	209.310	171.031	243.438	181.328	78.320	117.303	41.057	10.877	5.522	1.083	0.528	0.176	0.086	0.027
1980	196.438	171.368	140.028	193.763	125.168	48.747	71.952	20.359	5.065	2.766	0.548	0.288	0.099	0.056
1981	347.037	160.830	140.305	111.465	133.194	75.479	27.141	47.201	8.986	2.386	1.324	0.284	0.155	0.063
1982	207.404	284.130	131.676	112.290	76.536	76.639	37.945	11.640	17.089	3.166	0.874	0.523	0.121	0.080
1983	209.808	169.808	232.626	104.869	75.856	42.234	35.952	15.469	3.899	5.417	1.105	0.347	0.228	0.063
1984	494.102	171.776	139.027	186.039	71.823	42.603	19.869	14.565	5.272	1.292	1.927	0.446	0.152	0.117
1985	390.766	404.537	140.638	109.517	124.653	40.300	20.524	8.302	5.353	2.052	0.533	0.890	0.217	0.085
1986	262.203	319.932	331.207	109.531	71.247	66.889	18.521	8.242	2.972	2.062	0.850	0.247	0.436	0.122
1987	133.093	214.674	261.938	255.023	69.046	34.796	26.832	6.668	2.616	1.029	0.800	0.371	0.116	0.236
1988	195.353	108.968	175.760	202.897	159.143	32.467	12.597	8.905	1.907	0.807	0.370	0.323	0.163	0.059
1989	159.674	159.942	89.215	137.298	128.377	77.221	12.016	4.117	2.440	0.541	0.266	0.133	0.127	0.074
1990	261.581	130.730	130.949	70.142	88.312	100.144	32.911	4.463	1.391	0.917	0.223	0.120	0.063	0.069
1991	202.807	214.164	107.033	101.969	44.722	45.142	42.298	12.288	1.564	0.549	0.390	0.103	0.059	0.035
1992	116.698	166.044	175.343	80.431	61.761	20.806	16.424	14.373	3.945	0.564	0.216	0.167	0.047	0.031
1993	226.858	95.545	135.945	129.645	47.837	27.798	7.150	5.367	4.371	1.360	0.216	0.090	0.075	0.024
1994	248.163	185.735	78.225	96.939	77.651	22.502	10.211	2.424	1.593	1.332	0.463	0.079	0.036	0.035
1995	133.267	203.179	152.067	58.639	62.370	43.331	10.847	4.275	0.936	0.655	0.569	0.212	0.038	0.020
1996	242.305	109.110	166.349	117.102	39.508	37.148	23.296	5.052	1.893	0.448	0.316	0.293	0.114	0.023
1997	106.298	198.382	89.332	131.373	81.718	24.410	20.181	10.971	2.239	0.889	0.211	0.159	0.156	0.067
1998	257.325	87.029	162.422	71.306	93.128	50.866	13.139	9.275	4.656	0.974	0.389	0.099	0.080	0.087
1999	243.543	210.680	71.254	129.222	50.124	54.943	24.854	5.589	3.545	1.757	0.376	0.160	0.045	0.041
2000	238.075	199.396	172.490	55.782	88.824	27.860	23.713	9.784	1.976	1.226	0.641	0.147	0.070	0.022
2001	267.383	194.919	163.252	133.003	38.175	49.533	12.405	9.388	3.437	0.672	0.434	0.241	0.062	0.033
2002	120.230	218.915	159.586	124.034	90.094	21.384	22.872	5.136	3.374	1.133	0.225	0.152	0.097	0.028
2003	231.193	98.436	179.232	124.690	86.284	52.743	10.802	10.349	2.074	1.255	0.414	0.086	0.066	0.046
2004	202.232	189.285	80.593	141.425	87.864	50.869	26.486	4.995	4.347	0.827	0.487	0.168	0.039	0.032

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2005	146.510	165.573	154.973	63.885	100.580	52.053	24.874	12.161	2.080	1.721	0.321	0.197	0.076	0.019
2006	198.692	119.952	135.560	122.911	46.117	61.663	26.582	11.798	5.233	0.857	0.697	0.134	0.091	0.038
2007	179.378	162.675	98.209	107.686	89.279	28.992	32.063	12.812	5.134	2.190	0.359	0.302	0.065	0.048
2008	194.898	146.863	133.187	78.267	79.141	58.116	16.232	16.184	5.771	2.191	0.935	0.158	0.149	0.034
2009	256.886	159.569	120.241	106.549	58.558	64.199	35.454	8.899	8.165	2.891	1.105	0.496	0.090	0.091
2010	271.227	210.320	130.644	95.566	79.327	39.797	38.840	19.449	4.510	4.169	1.515	0.614	0.296	0.058
2011	185.783	222.062	172.196	104.057	71.531	55.069	25.292	22.415	10.561	2.536	2.396	0.925	0.395	0.202
2012	275.001	152.106	181.809	137.269	77.937	49.787	35.465	14.977	12.613	6.228	1.527	1.534	0.620	0.280
2013	245.814	225.152	124.534	144.591	102.484	54.043	31.936	21.039	8.469	7.487	3.780	0.983	1.035	0.443
2014	175.214	201.255	184.339	97.953	107.046	70.308	34.306	18.852	11.771	4.958	4.467	2.383	0.653	0.730
2015	310.866	143.453	164.774	146.283	72.848	74.394	45.651	20.667	10.732	6.947	2.952	2.776	1.574	0.458
2016	310.293	254.516	117.450	130.346	108.457	50.631	48.840	27.929	11.966	6.455	4.187	1.848	1.863	1.126

Table 13. Icelandic cod in Division 5.a. 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	0.288	953.278	2375.040	152.016	0.230
1956	486.909	0.288	806.298	2098.030	152.792	0.232
1957	455.182	0.309	785.078	1892.570	170.639	0.241
1958	517.359	0.352	883.799	1877.060	220.984	0.276
1959	459.081	0.321	859.929	1836.370	289.373	0.250
1960	470.121	0.370	712.439	1758.280	154.337	0.267
1961	377.291	0.354	469.374	1500.280	193.074	0.251
1962	388.985	0.382	571.614	1495.840	128.938	0.260
1963	408.800	0.457	510.186	1318.430	177.510	0.310
1964	437.012	0.547	453.246	1221.570	203.898	0.358
1965	387.106	0.575	318.588	1023.460	216.388	0.378
1966	353.357	0.588	277.969	1032.150	229.160	0.342
1967	335.721	0.560	257.009	1103.400	320.303	0.304
1968	381.770	0.720	221.959	1223.330	171.801	0.312
1969	403.205	0.557	314.034	1326.000	247.395	0.304
1970	475.077	0.610	331.527	1337.320	180.418	0.355
1971	444.248	0.683	242.925	1098.220	188.597	0.405
1972	395.166	0.692	222.252	997.449	139.216	0.396
1973	369.205	0.703	245.944	844.349	273.174	0.437
1974	368.133	0.762	187.669	919.100	178.982	0.401
1975	364.754	0.806	169.023	896.325	260.861	0.407
1976	346.253	0.742	139.357	956.674	367.683	0.362
1977	340.086	0.587	199.795	1291.280	143.320	0.263
1978	329.602	0.473	213.472	1299.590	227.589	0.254
1979	366.462	0.443	305.369	1398.860	243.438	0.262
1980	432.237	0.489	358.371	1491.730	140.028	0.290
1981	465.032	0.658	265.714	1243.880	140.305	0.374
1982	380.068	0.724	169.082	972.540	131.676	0.391
1983	298.049	0.708	132.004	793.209	232.626	0.376
1984	282.022	0.635	143.098	915.231	139.027	0.308
1985	323.428	0.663	165.594	928.906	140.638	0.348
1986	364.797	0.768	197.834	856.100	331.207	0.426
1987	389.915	0.854	152.472	1034.130	261.938	0.377
1988	377.554	0.883	169.571	1037.270	175.760	0.364
1989	363.125	0.710	174.449	1006.950	89.215	0.361
1990	335.316	0.692	215.606	843.547	130.949	0.398
1991	307.759	0.791	165.986	700.651	107.033	0.439
1992	264.834	0.833	152.494	553.175	175.343	0.479
1993	250.704	0.853	123.097	598.878	135.945	0.419
1994	178.138	0.612	158.854	580.018	78.225	0.307
1995	168.592	0.497	179.591	561.283	152.067	0.300
1996	180.701	0.495	161.850	676.221	166.349	0.267

Year	Yield	F5-10	SSB	Reference biomass	Recruits	Harvest rate
1997	203.112	0.531	192.442	789.808	89.332	0.257
1998	243.987	0.631	204.859	729.154	162.422	0.335
1999	260.147	0.712	183.618	741.204	71.254	0.351
2000	235.092	0.714	173.878	602.061	172.490	0.390
2001	236.705	0.710	167.932	687.981	163.252	0.344
2002	209.537	0.619	203.796	731.859	159.586	0.286
2003	207.246	0.587	193.407	748.012	179.232	0.277
2004	228.337	0.594	202.944	809.602	80.593	0.282
2005	213.865	0.557	230.364	728.167	154.973	0.294
2006	197.247	0.537	225.566	704.547	135.560	0.280
2007	171.646	0.499	210.642	687.892	98.209	0.250
2008	147.668	0.389	273.051	710.846	133.187	0.208
2009	183.302	0.381	257.608	798.076	120.241	0.230
2010	170.009	0.318	295.656	858.715	130.644	0.198
2011	172.207	0.289	368.713	911.069	172.196	0.189
2012	196.177	0.287	408.345	1042.220	181.809	0.188
2013	223.594	0.299	447.024	1169.130	124.534	0.191
2014	221.990	0.285	417.504	1175.370	184.339	0.189
2015	230.225	0.273	533.186	1253.850	164.774	0.184
2016	NA	NA	464.020	1240.700	117.450	NA
2017	NA	NA	NA	NA	208.380	NA
2018	NA	NA	NA	NA	207.996	NA

Table 14. Icelandic cod in Division 5.a. Inputs in the deterministic predictions.

Age	Parameter	2016	2017	2018	2019
3	Catch weights	1.401	1.401	1.401	1.401
4	Catch weights	1.815	1.815	1.815	1.815
5	Catch weights	2.265	2.265	2.265	2.265
6	Catch weights	3.500	3.500	3.500	3.500
7	Catch weights	4.153	4.153	4.153	4.153
8	Catch weights	5.338	5.338	5.338	5.338
9	Catch weights	6.664	6.664	6.664	6.664
10	Catch weights	8.603	8.603	8.603	8.603
11	Catch weights	9.688	9.688	9.688	9.688
12	Catch weights	11.212	11.212	11.212	11.212
13	Catch weights	11.334	11.334	11.334	11.334
14	Catch weights	10.356	10.356	10.356	10.356
3	SSB weights	0.973	0.973	0.973	0.973
4	SSB weights	2.223	2.223	2.223	2.223
5	SSB weights	3.035	3.035	3.035	3.035
6	SSB weights	4.198	4.198	4.198	4.198
7	SSB weights	4.610	4.610	4.610	4.610
8	SSB weights	6.018	6.018	6.018	6.018
9	SSB weights	7.389	7.389	7.389	7.389
10	SSB weights	9.731	9.731	9.731	9.731
11	SSB weights	9.688	9.688	9.688	9.688
12	SSB weights	11.212	11.212	11.212	11.212
13	SSB weights	11.334	11.334	11.334	11.334
14	SSB weights	10.356	10.356	10.356	10.356
3	Maturity	0.001	0.001	0.001	0.001
4	Maturity	0.009	0.009	0.009	0.009
5	Maturity	0.024	0.024	0.024	0.024
6	Maturity	0.288	0.288	0.288	0.288
7	Maturity	0.543	0.543	0.543	0.543
8	Maturity	0.733	0.733	0.733	0.733
9	Maturity	0.942	0.942	0.942	0.942
10	Maturity	0.987	0.987	0.987	0.987
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	0.123	0.123	0.123	0.123
4	Selection	0.345	0.345	0.345	0.345
5	Selection	0.589	0.589	0.589	0.589
6	Selection	0.825	0.825	0.825	0.825
7	Selection	1.080	1.080	1.080	1.080
8	Selection	1.273	1.273	1.273	1.273
9	Selection	1.134	1.134	1.134	1.134

Age	Parameter	2016	2017	2018	2019
10	Selection	1.099	1.099	1.099	1.099
11	Selection	0.673	0.673	0.673	0.673
12	Selection	0.673	0.673	0.673	0.673
13	Selection	0.673	0.673	0.673	0.673
14	Selection	0.673	0.673	0.673	0.673
3	Stock numbers	117.450	208.380	207.996	0.000
4	Stock numbers	130.346	NA	NA	NA
5	Stock numbers	108.457	NA	NA	NA
6	Stock numbers	50.631	NA	NA	NA
7	Stock numbers	48.840	NA	NA	NA
8	Stock numbers	27.929	NA	NA	NA
9	Stock numbers	11.966	NA	NA	NA
10	Stock numbers	6.455	NA	NA	NA
11	Stock numbers	4.187	NA	NA	NA
12	Stock numbers	1.848	NA	NA	NA
13	Stock numbers	1.863	NA	NA	NA
14	Stock numbers	1.126	NA	NA	NA

Table 15. Icelandic cod in Division 5.a. Output of the deterministic predictions.

Year	B4.	Fmult	Fbar	SSB	Landings	2018.B4.	2018.SSB	SSB.change	TAC.change
2016	1240.70	NA	0.30	464.020	246.000	NA	NA		
2017	1191.34	0.00	0.00	548.116	0.000	1542.862	747.033	36%	-100%
NA	NA	0.20	0.06	533.997	54.244	1481.375	686.418	29%	-78%
NA	NA	0.23	0.07	531.682	63.011	1471.446	676.835	27%	-74%
NA	NA	0.26	0.08	529.379	71.702	1461.605	667.394	26%	-71%
NA	NA	0.30	0.09	527.086	80.318	1451.853	658.093	25%	-67%
NA	NA	0.33	0.10	524.803	88.859	1442.187	648.930	24%	-64%
NA	NA	0.36	0.11	522.532	97.327	1432.607	639.903	22%	-60%
NA	NA	0.39	0.12	520.271	105.721	1423.112	631.010	21%	-57%
NA	NA	0.43	0.13	518.021	114.043	1413.701	622.249	20%	-54%
NA	NA	0.46	0.14	515.781	122.294	1404.374	613.617	19%	-50%
NA	NA	0.49	0.15	513.552	130.473	1395.129	605.112	18%	-47%
NA	NA	0.53	0.16	511.333	138.582	1385.967	596.734	17%	-44%
NA	NA	0.56	0.17	509.125	146.622	1376.885	588.478	16%	-40%
NA	NA	0.59	0.18	506.927	154.592	1367.883	580.345	14%	-37%
NA	NA	0.63	0.19	504.739	162.495	1358.961	572.332	13%	-34%
NA	NA	0.66	0.20	502.561	170.330	1350.117	564.436	12%	-31%
NA	NA	0.69	0.21	500.394	178.098	1341.352	556.657	11%	-28%
NA	NA	0.72	0.22	498.237	185.799	1332.663	548.993	10%	-24%
NA	NA	0.76	0.23	496.090	193.436	1324.050	541.441	9%	-21%
NA	NA	0.79	0.24	493.953	201.007	1315.513	534.000	8%	-18%
NA	NA	0.82	0.25	491.826	208.514	1307.051	526.668	7%	-15%
NA	NA	0.86	0.26	489.708	215.957	1298.662	519.444	6%	-12%
NA	NA	0.89	0.27	487.601	223.337	1290.347	512.325	5%	-9%
NA	NA	0.92	0.28	485.504	230.655	1282.105	505.311	4%	-6%
NA	NA	0.95	0.29	483.416	237.911	1273.934	498.400	3%	-3%
NA	NA	0.99	0.30	481.338	245.105	1265.835	491.590	2%	-0%
NA	NA	1.02	0.31	479.270	252.239	1257.806	484.879	1%	3%
NA	NA	1.05	0.32	477.212	259.313	1249.846	478.266	0%	5%
NA	NA	1.09	0.33	475.163	266.328	1241.956	471.750	-1%	8%
NA	NA	1.12	0.34	473.123	273.283	1234.134	465.329	-2%	11%
NA	NA	1.15	0.35	471.093	280.180	1226.380	459.001	-3%	14%
NA	NA	1.18	0.36	469.073	287.020	1218.693	452.766	-3%	17%
NA	NA	1.22	0.37	467.062	293.802	1211.072	446.621	-4%	19%
NA	NA	1.25	0.38	465.061	300.527	1203.517	440.566	-5%	22%
NA	NA	1.28	0.39	463.068	307.197	1196.027	434.599	-6%	25%
NA	NA	1.32	0.40	461.085	313.811	1188.601	428.719	-7%	28%
NA	NA	1.35	0.41	459.111	320.370	1181.239	422.923	-8%	30%
NA	NA	1.38	0.42	457.147	326.874	1173.940	417.212	-9%	33%
NA	NA	1.41	0.43	455.191	333.324	1166.704	411.584	-10%	35%
NA	NA	1.45	0.44	453.245	339.721	1159.530	406.037	-10%	38%
NA	NA	1.48	0.45	451.308	346.065	1152.417	400.570	-11%	41%
NA	NA	1.51	0.46	449.379	352.357	1145.365	395.183	-12%	43%

9.3

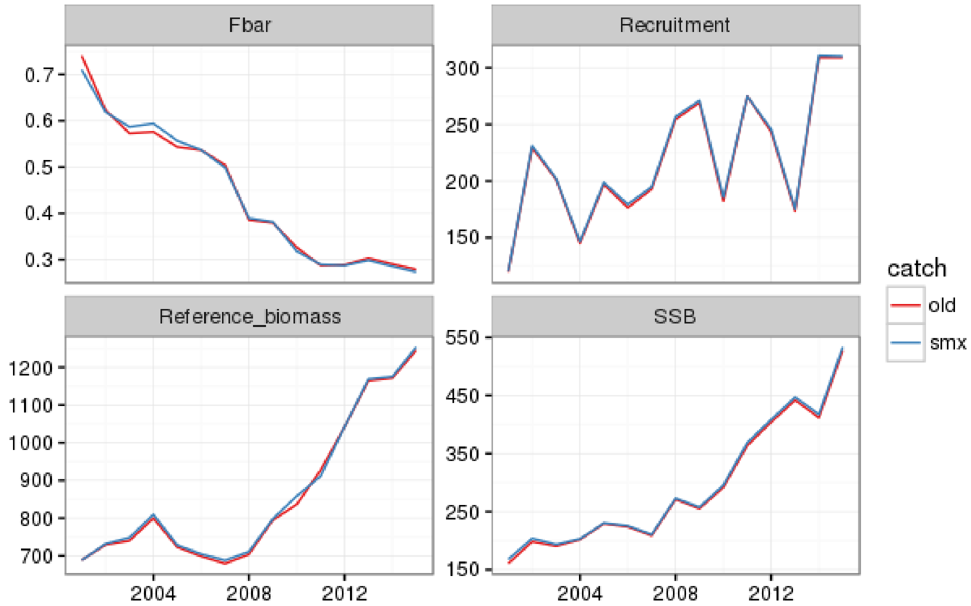


Figure 1. Icelandic cod division 5.a. Comparisons of key stock assessment metrics using the old and the revised catch at age matrix.

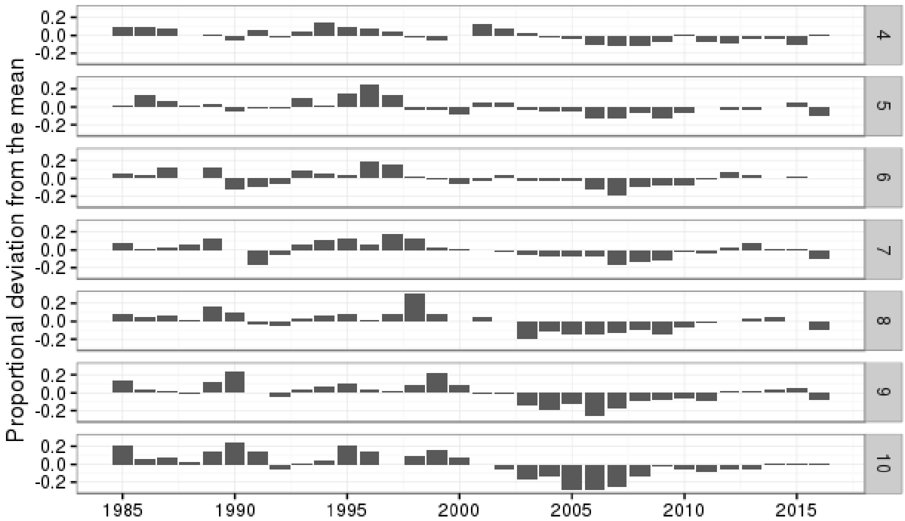


Figure 2. Icelandic cod division 5.a. Estimated weight at age (numbers in panels indicate age classes) in the catches 1985–2016 expressed as deviation from the mean. Weights at age in 2016 are predicted from 2016 spring survey weights. Note that values that are equal to the mean are not visible in this type of a plot.

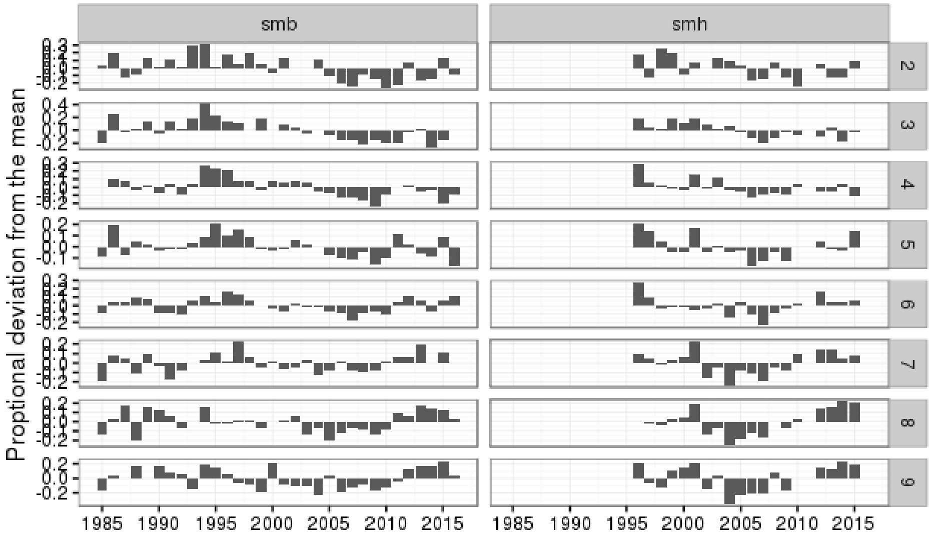


Figure 3. Icelandic cod division 5.a. Estimated weight at age (numbers in panel indicate age classes)
Figure 3. Icelandic cod division 5.a. Estimated weight at age (numbers in panel indicate age classes)
in the spring survey 1985–2016 (SMB) and fall survey 1996–2015 (SMH) expressed as proportional deviations 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.

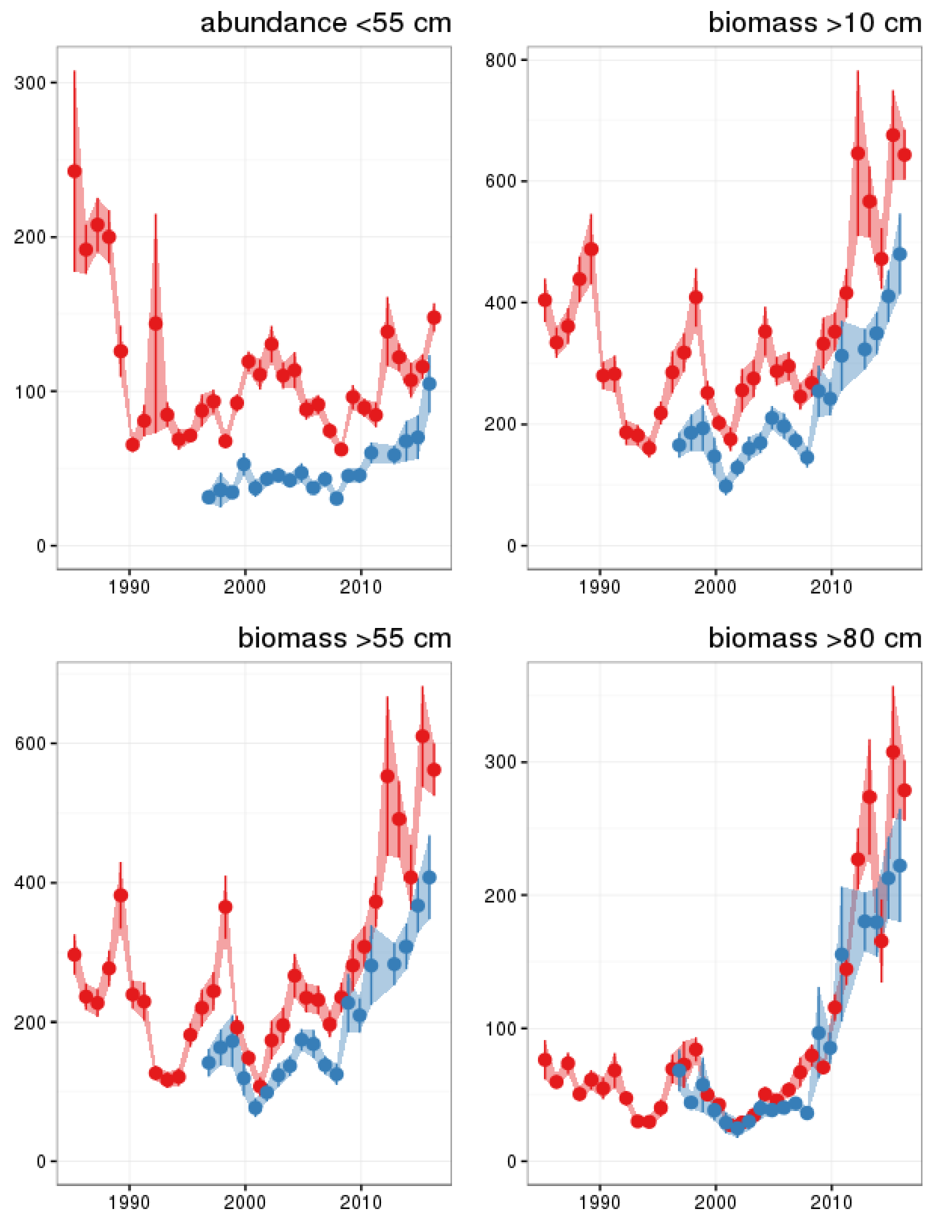


Figure 4. Icelandic cod division 5.a. Abundance indices of cod in the groundfish survey in spring 1985–2016 (SMB red, longer time series) and fall 1996–2015 (SMH blue, shorter time series). Bottom left) Biomass index of 55 cm and larger, bottom right) Biomass index 80 cm and larger, top right) Abundance 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.

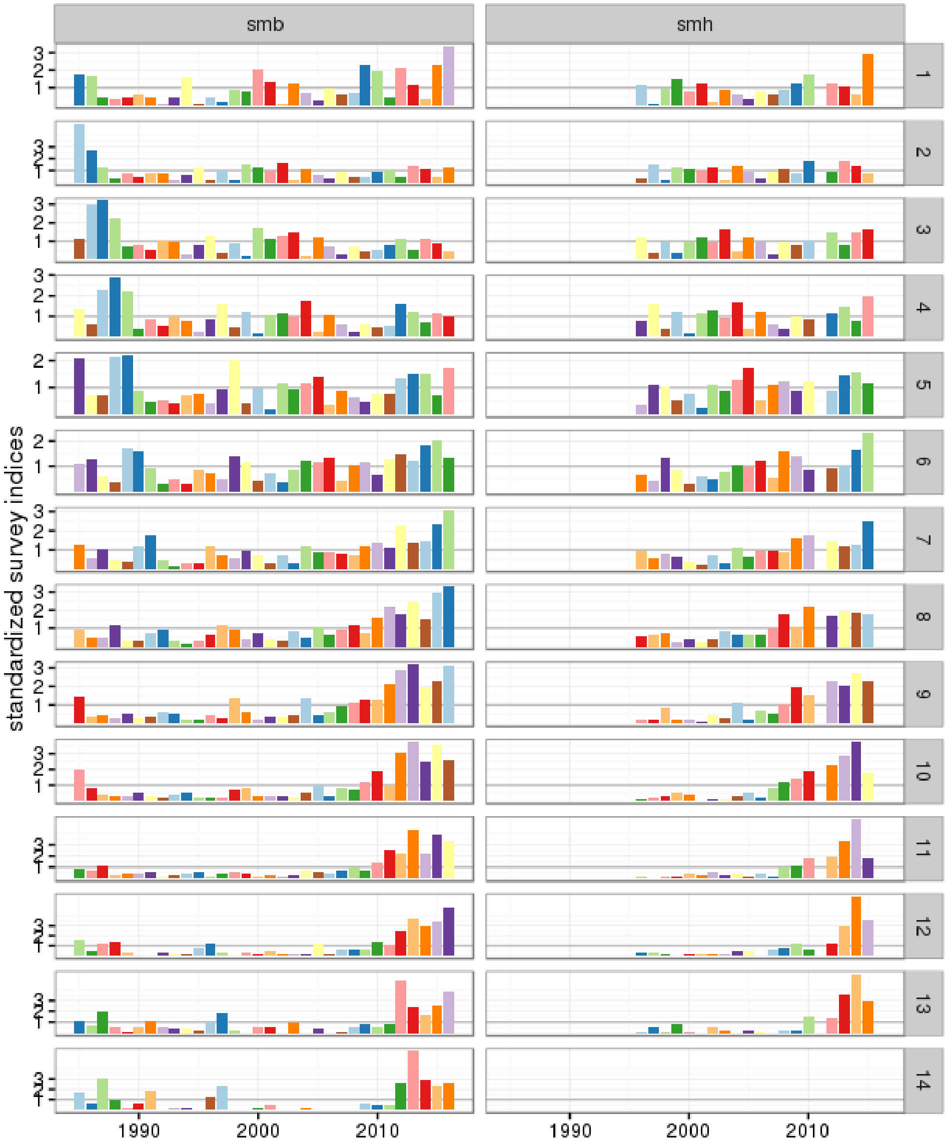


Figure 5. Icelandic cod division 5.a. Age based abundance indices of cod in the groundfish survey in spring 1985–2016(SMB) and fall 1996–2015 (SMH). The indices are standardized within each age group and within each survey.

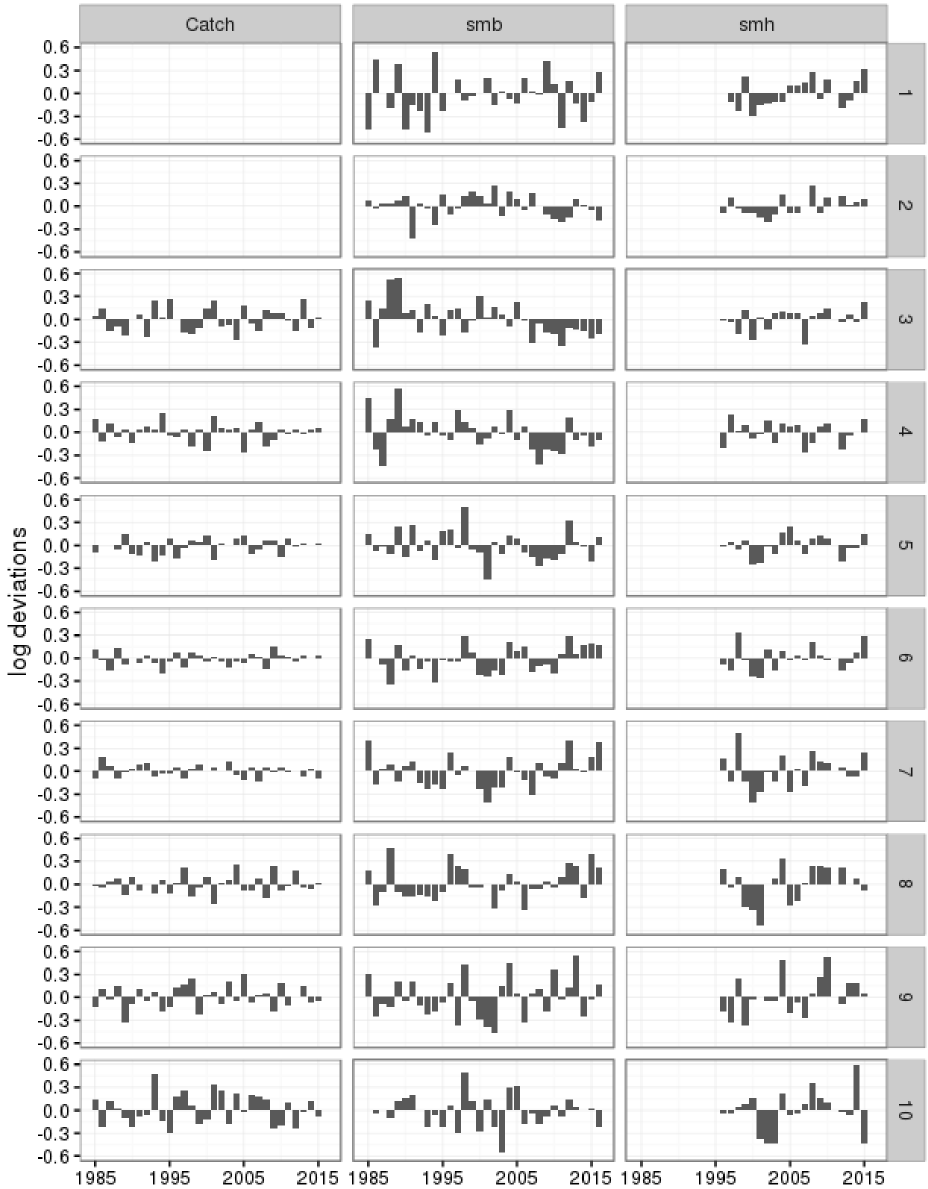


Figure 6. Catch residuals (left), spring survey residuals (SMB, middle) and fall survey residuals (SMH, right) by year and age from the spaly ADCAM run. Note that values that are equal to the mean are not visible in this type of a plot and that no survey was carried out in the fall 2011.

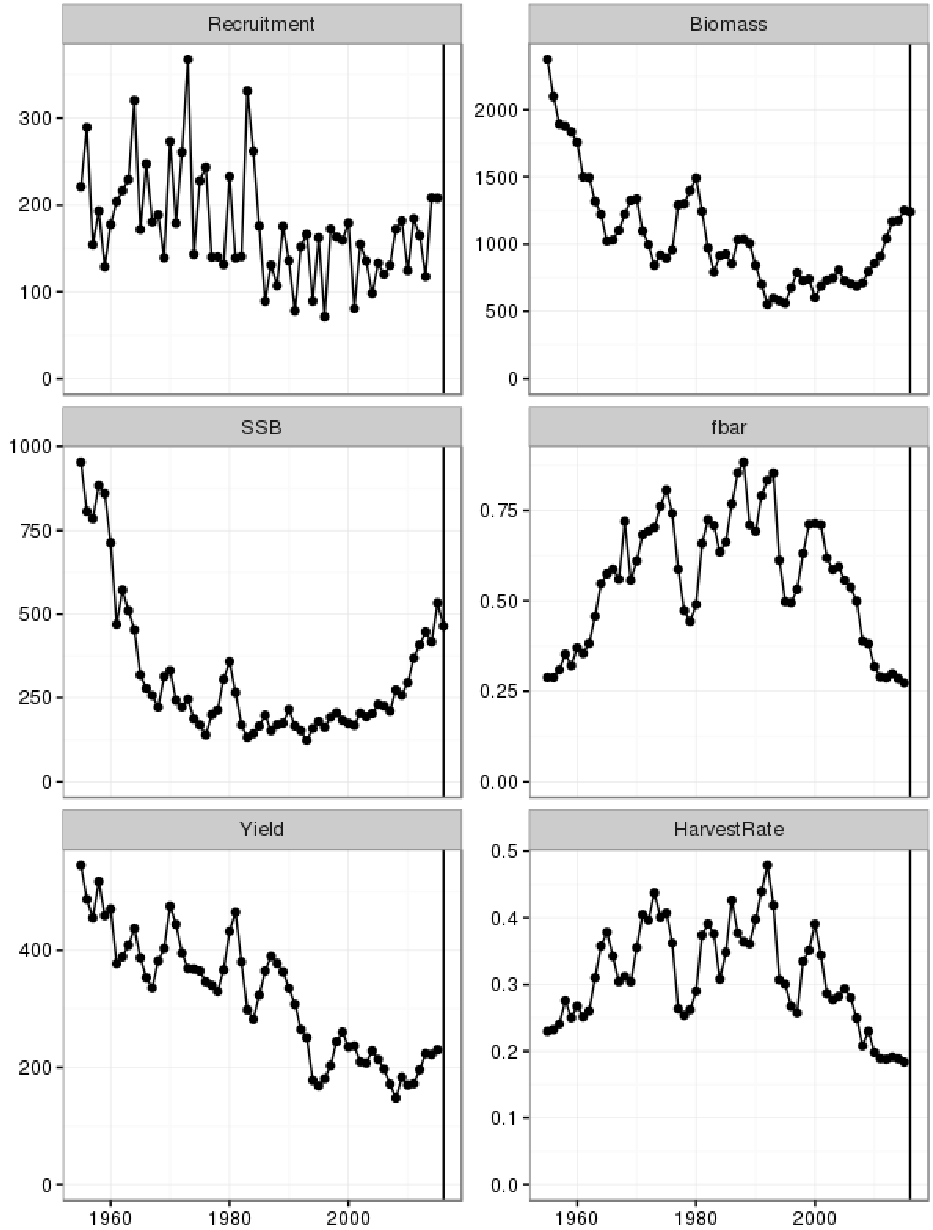


Figure 7. Icelandic cod in division 5.a. Assessment summary based ADCAM tuned with the spring and the fall survey. The x-axis for the recruitment refer to the year class

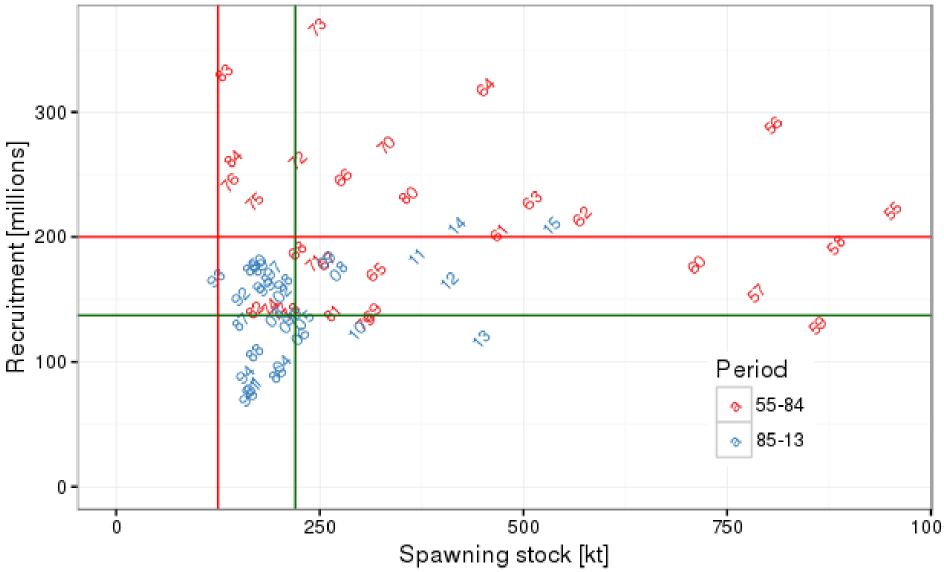


Figure 8. Icelandic cod in division 5.a. Spawning stock biomass and corresponding recruitment at age 3. The numerical values refer to year class with the horizontal lines referring to geometric mean recruitment for year classes 1954-1984 (red line) and 1985–2016 (green line). Vertical lines refer to B_{lim} (B_{loss}, red) and $B_{trigger}$ (green).

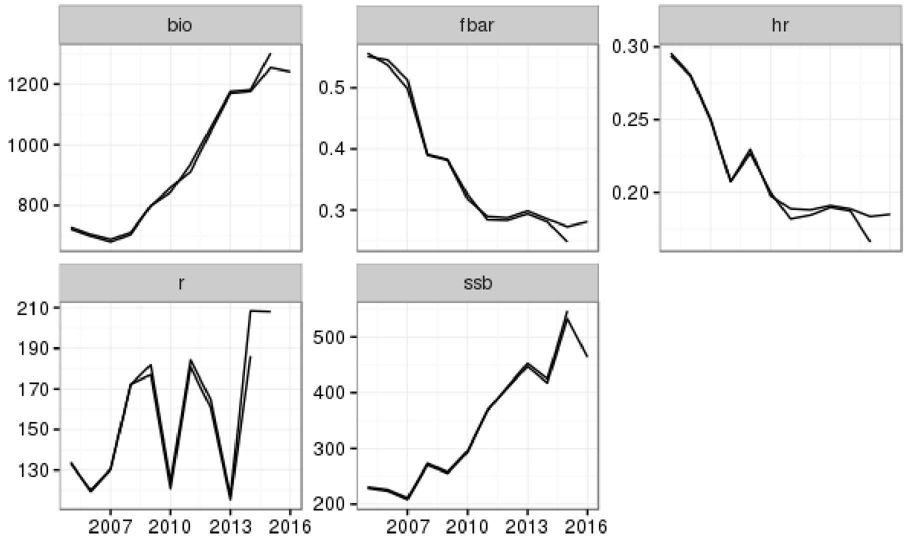


Figure 9. Icelandic cod in division 5.a. Empirical retrospective patterns from the 2004–2016 (this year's assessment, marked in red) assessments as summarized in ICES annual advisory sheet.

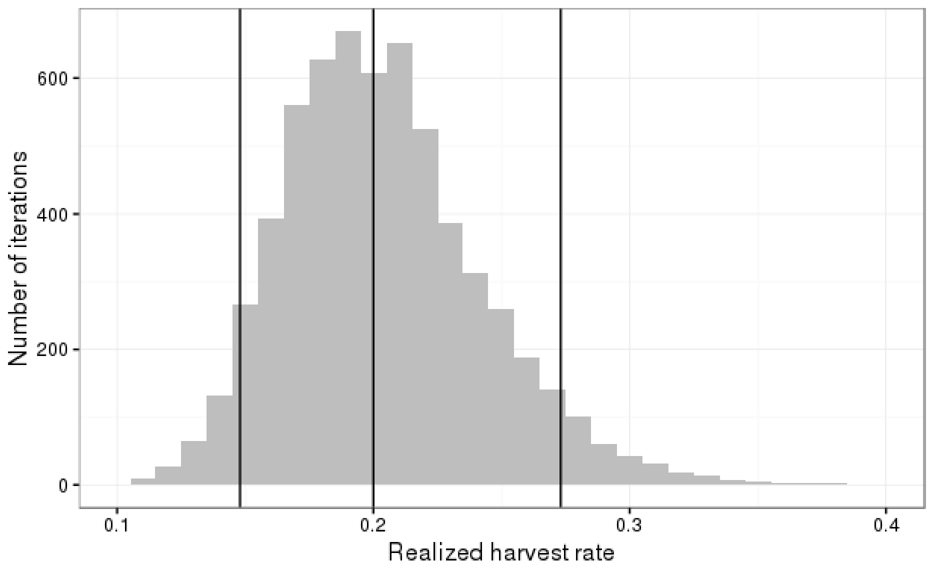


Figure 10. Icelandic cod in division 5.a. Distribution of realized harvest rate when TAC is based on the current catch rule (20% harvest rate and the catch stabilizer). The upper and lower 5% of the realized harvest rate is 0.15 and 0.27. The distribution is based on the last 5 years in the simulations, the number of iterations being 1225.

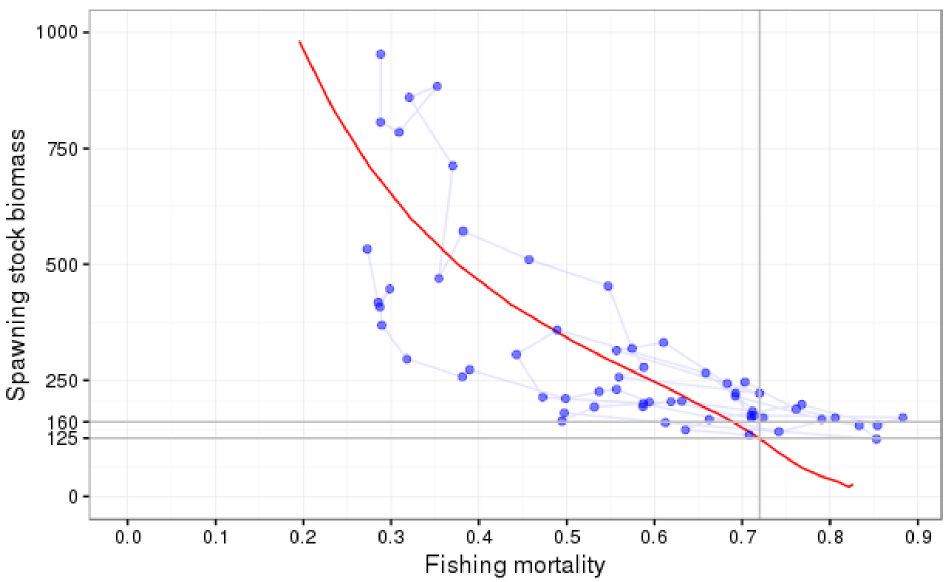


Figure 11. Icelandic cod in division 5.a. Median spawning stock biomass as a function of fishing mortality (age 5–10) (red line). The blue points indicate the historical estimates.

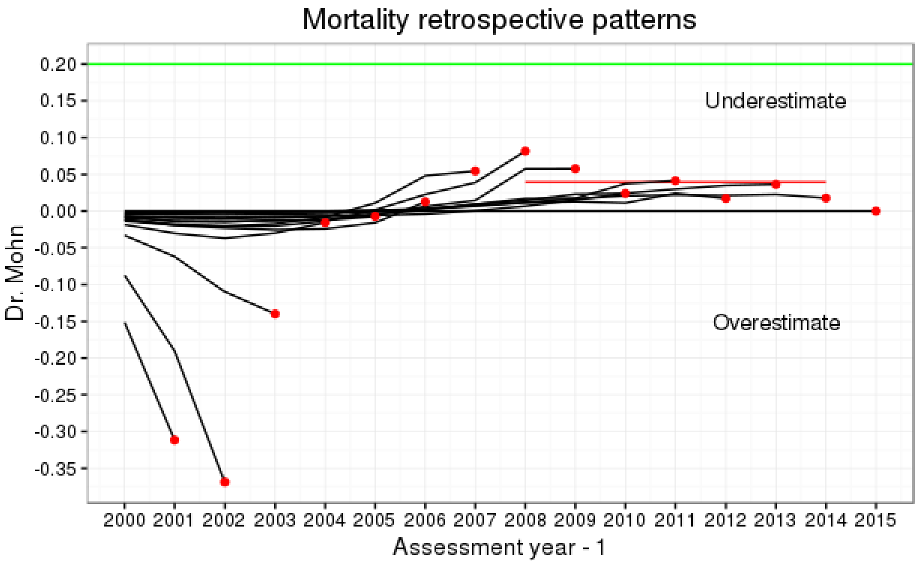


Figure 12. Icelandic cod in division 5.a. Mohn's rho statistics.

10 Icelandic haddock

The 2014 year class is estimated to be large, after 6 consecutive small year class from 2008–2013. The 2015 yearclass is expected to be close to geometric mean. The Current assessment shows some upward revision of the stock compared to last year's assessment. The main features are though the same that the fisheries are currently mostly based on relatively small year classes. It is first in 2018 that the 2014 year class affects the fisheries.

Growth in 2015 was above average since 1985 but less than predicted and the mean weight of young fish is above average while old fish are close to average. The assessment procedure was the same as last year (SPALY), an Adapt type model tuned with both the surveys.

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

Advice is given according to the adopted Harvest Control Rule, and the advice for the fishing year 2016/2017 (September 1st 2016–August 31st 2017) is 34 600 tonnes. The advice for the following fishing year is predicted to be approximately 43 000 tonnes but increasing to more 50 thous. tonnes that when the 2014 year class is fully recruited.

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.

10.1 Data

Landings of Icelandic haddock in 2015 are estimated to have been 39 600 tonnes, see Figure 10.1.1 and Table 10.1.1. Of the landings, 38 400 tonnes are caught by Iceland and 1200 tonnes by the Faeroese. The landings have decreased from 100 thous. tonnes between 2005–2008. The proportion of haddock caught by longliners was 44% in 2015, among the highest (Figure 10.1.2). On longer time-scale the share of longlines has increased in last 15 years, while the proportion of haddock caught in gillnets is now very small. 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 and 10.1.8).

Catch in numbers-at-age is shown in Table 10.1.2 and Figure 10.1.4. Age 8 accounted for 23% of the landings and age 9 and older for 10% while the average contribution of age 9 and older is 4.5%. Age 8 the 2007 year class is the last above average year class in the fisheries so 67% of the catch is from the small year classes 2008–2013. The number of year classes contributing to the catches is unusually many, the result of low fishing mortality in recent years and the last large yearclass is 8 years old. The results for are close to expectation (Figure 10.1.5).

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. In recent years the assessment has predicted reduced biomass while the reality has been unchanged biomass in the March survey and some increase in the autumn survey, causing upwards revision of the stock in each assessment compared to earlier assessments.

Age disaggregated indices from the March survey are given in Table 10.1.3 and indices from the autumn survey in Table 10.1.4. Abundance of age groups 3–7 in the 2016 March survey is low while age 9 is among the highest indices observed (Figure 10.1.9). The index of age 12 and 13 (2003 cohort) is much higher than seen before (large part of 11+ in the March survey), but that cohort will though not contribute much to the landings. Year classes 2008 and 2009 (age 8 and 7) are now close to average, mostly due to reduced fishing mortality in recent years but those year classes were originally small.

The survey results indicate that in recent decade higher and larger proportion of the haddock stock has gradually been inhabiting the waters north of Iceland (Figures 10.1.7 and 10.1.8.).

Mean weight at age in the catch is shown in Table 10.1.6 and Figure 10.1.10. Mean weight at age in the stock is given in Table 10.1.5 and Figure 10.1.9. 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 (2008–2013), but mean weight of the old fish is now also average. Mean weight of the 2014 cohort is more than 20% lower than of recent small year classes but close to average for a large cohorts.

Prediction of growth is a source of uncertainty for this stock. (Figures 10.2.8, and 10.4.2). In recent year's growth has shown interannual variability without any pattern, indicating that short-term prediction should rather been based on average growth of last 2-3 years instead of only last year's growth. This approach might though have to be changed if stock size increases much so care should be exercised in carving any approach in stone

Maturity-at-age data are given in Table 10.1.7 and Figure 10.1.11. Those data are obtained from the groundfish survey in March. Maturity-at-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 large proportion of those age groups north of Iceland where proportion mature has always been low.

Catch per unit of effort data (figure 10.1.12) give somewhat different picture of the development of the stock than the surveys and assessment, much less increase after 2000 but much less decrease in recent years (figures 10.1.8vs.10.1.15). The interesting thing for the current assessment is the relatively high cpue, in recent years, confirming fishers'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.
- When the stock was large slower growth lead to larger 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 200–2016 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 2004–2008 models calibrated with the October survey indicated smaller stock. In the last five years things have changed and models calibrated with the October survey indicate a better state of the stock, the difference did not decrease with addition of the most recent data points i.e. October 2015 and March 2016. 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 February 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 decreased from 2008–2011 when large year classes disappeared from the stock and were replaced by smaller yea classes. (Figure 10.2.1) Since 2011 the rate of reduction has slowed down as fishing mortality has been low. The spawning stock has though decreased more than the reference biomass as proportion mature by age/size has been decreasing. 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. The current assessment does indicate the bottom has been reached and the stock size will increase in next years.

The main features of the current assessment are the same as in the assessments 2011 to 2015. The current assessment indicates larger stock than the 2015 assessment (Figures 10.2.7 and 10.2.8). Most of the difference is explained by higher than predicted numbers-at-age (Figure 10.2.8). The tendency has been to underestimate recruitment and stock size in recent years.

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 2011-2015 are on the other hand below predictions. Similar thing seem to be happening in the fishery in 2012-2013 (Figure 10.1.15) so there are indication that the stock might be underestimated or availability of haddock is unusually high.

Standard errors in estimates of SSB in 2016 from the Adapt model are 9 thous. tons for the March survey and 16 thous. for the autumn survey. The difference between the stock biomass is 67 thous. tonnes (124vs.57 thous. tonnes) that does not fit within the confidence intervals (less than 1% probability of 65 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 4 years. The spawning stock according to the model tuned with both the surveys is 77 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.

There are indications that the autumn survey is a better predictor of haddock biomass than the March survey (Figure 10.2.3). The Adapt type model does though have some problems with using only the autumn survey and a separable model where selection is a function of stock weights (Björnsson 2013) gives biomass in 2016 as 108 thous. Tonnes when tuned only with the autumn survey. Also, including 10 shallow water stations added in 2008 might be questionable but excluding them gives 15% smaller stock when tuned with the autumn survey only. The conclusion is though that the current setting of tuning with both the surveys is a reasonable compromise, showing some underestimation in recent years. The assessment does also have many of the problems of low fishing mortality assessment i.e long periods of over/underestimation.

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 2–6. 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 age groups. This observation does partly have to do with the length of the series in.

To summarize there are indications from the autumn survey that the stock might be larger than predicted but from the March survey 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 $SSB_{trigger}$:

$$TAC_{y/y+1} = \alpha\ B_{45+,y+1}$$

2. When SSB_{y+1} is below $SSB_{trigger}$:

$$TAC_{y/y+1} = \alpha\ SSB_{y+1}/ SSB_{trigger}\quad B_{45+,y+1}$$

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 of 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.

The reason for relatively low harvest ratio or 0.4 was to try to have low and stable harvest ratio, an approach considered appropriate strategy for stock with haddock like recruitment pattern, for example to avoid bycatch problems in mixed fisheries in periods of poor recruitment.

When the HCR was evaluated in 2013 the understanding was the only reference point needed was Blim that was to be avoided by more than 95% probability according to the management plan.

At this meeting classification reference points B_{pa}, F_{lim} and F_{pa} were required. B_{pa} was supposed to be defined in such a way that if the stock was estimated at Bpa the probability of being below B_{lim} was less than 5%. Estimated CV of spawning stock at the beginning of the assessment year assessment year is 16% (Björnsson 2013) so $B_{pa} = B_{lim} \times e^{1.645\sigma} = 45 \times e^{1.645\times 0.16} = 59$ thous. Tonnes.

To get values of F_{lim} and F_{pa} or really H_{lim} and H_{pa} the model used for HCR evaluation was run with 3 changes in settings.

1. No autocorrelation of recruitment.
2. No assessment error.
3. No trigger.

The model is still stochastic, taking into account variability of recruitment as well as uncertainty in the parameters of the stock recruitment function and other parameters. What was used as basis for H_{lim} was the harvest rate where the average of the spawning stock was equal to B_{lim} The results of the model runs are show that $H_{lim} = 0.9$ and $H_{pa} = B_{lim} \times e^{-1.645\sigma} = 0.7$. (Figure 10.3.1). According to the HCR simulations the fifth percentile of SSB would hardly be positive if fishing at H_{lim} or even at H_{pa}. If a completely deterministic model was run the value of H_{lim} obtained would be even higher. The purpose of these values is hard to understand, but they have at least been provided.

According to the simulations done in 2013 the probability of SSB < B_{lim} was 0.07. Going back to the same results and the recently "invented" B_{pa} SSB < B_{pa} =0.07 but the probability of estimated SSB < B_{pa} is higher or 0.19%, i.e the probability of red light was 17%. As the HCR takes into account stochasticity in recruitment analysis based on fifth percentile of SSB lead to low probability of $H > H_{pa}$ (figure 10.3.2)

Those analysis show that the recently invented reference point should not be in the way of sound management of this stock. The reason is relatively large reduction in fishing pressure from historic values and no catch stabilizer. For stocks where either or both of those condition is not met (stocks that have never been overexploited) there might be a problem.

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 (WD #19 in 2006). The procedure is described in the advice part of the report of ADGISHA (Björnsson 2013) and also in the stock annex. The procedure was changed last year so instead of taking only last years value, average of last 2 values is used.

To summarize, TAC for the fishing year 2016/2017 is a function of the biomass of 45cm and larger haddock and the spawning stock at the beginning of 2016. To be able to predict the stock size in 2017, catch 2016, mean weight at age in the catch 2016, selection at age in the catch 2016, stock weights in 2017 and maturity-at-age in 2017 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 (2016) is the TAC left in the current fishing year at the beginning of the assessment year plus 1/3 of the predicted TAC next fishing year. The TAC for the fishing year 2015/2016 was 36 400 tonnes. The landings in September–December 2014 were 14 400 tonnes or 39% of the TAC. The average contribution of the first 4 month of the Fishing year is on the other hand around 33%. Landings for the fishing year 2014/2015 are now estimated to be 36 600 tonnes while the TAC issued was 30 400. tonnes. Looking at the rate of landings (Figure 10.4.1) they indicate that the TAC for the current fishing year could be exceeded. .

In the Icelandic fishery management system certain relatively small transfer is allowed between species, to increase flexibility in mixed fisheries. Currently net transfer is towards haddock, probably because haddock is easy to catch, as demonstrated by high cpue in 2015. The haddock quota does also seem to be limiting in some mixed fisheries. The reason that haddock has been underestimated in last years could also contribute to transfer towards haddock. Looking over longer period quota transfer towards/from haddock has on the average been close to zero. In predictions for current fishing year 1000 ton transfer towards haddock is assumed.

On January 1st 2016, 22 thous. tonnes of quota were left. To this are added 1/3rd of next year's TAC (11 500 000 tonnes). This leads to 33.500 tonnes catch in the calendar year 2015.

Mean weight and maturity-at-age in 2016 are available and are used to predict catch weights and selection at age (Figure 10.4.2). Growth in 2016 is predicted by the equation

$$\log\frac{W_{a+1,t+1}}{W_{a,t}} = \alpha + \beta \log W_{a,t} + \delta_{year}$$

Where according to the stock annex the factor δ_{year} for the assessment year (figure 10.4.2) is the average of δ_{year} of the growth in the 2 preceding years. Growth has been high but somewhat variable in recent years but was much less in when the stock was larger (figure 10.4.2).

Maturity, selection, catch weights at age and proportion of the biomass above 45cm are then predicted from stock weights 2017. 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 2016/2017 has some effect of the biomass at the beginning of 2017, which the TAC is based on. Advice for the following fishing year (2017/2018) is predicted to be approximately 42 000 tonnes but increasing after that when the 2014 year is fully recruited.

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 2016/2017 will be 34 600 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

ICES. 2014b. Report of the North-Western Working Group (NWWG), 24 April–1 May 2014, ICES Headquarters, Copenhagen, Denmark. ICES CM 2014/ACOM:07. 902 pp.

ICES 2015a. Report of the North-Western Working Group (NWWG), 28 April – 5 May, 2015, ICES Headquarters, Copenhagen, Denmark. ICES CM 2015/ACOM:07.

ICES 2015b Advice basis. *In* Report of the ICES Advisory Committee, 2015. ICES Advice 2015, Book 2, Section 2.3.11

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
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						
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			
Total	60884	84835	97231	97614	109966	102490	82043	64179	49437

COUNTRY	2012	2013	2014	2015
Belgium				
Faroe Islands	303	600	800	1259
Iceland	45888	43500	33100	38391
Norway				
Total	46191	44100	33900	39650

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	112
1980	595	1385	11481	4298	3798	3732	544	91	37
1981	10	514	4911	16900	5999	2825	1803	168	57
1982	107	245	3149	10851	14049	2068	1000	725	201
1983	34	1010	1589	4596	9850	8839	766	207	280
1984	241	1069	4946	1341	4772	3742	4076	238	80
1985	1320	1728	4562	6796	855	1682	1914	1903	296
1986	1012	4223	4068	4686	5139	494	796	897	400
1987	1939	8308	6965	2728	2042	1094	132	165	339
1988	237	9831	15164	5824	1304	1084	609	66	213
1989	188	2474	22560	9571	3196	513	556	144	141
1990	1857	2415	8628	23611	6331	816	150	67	74
1991	8617	2145	5397	7342	14103	2648	338	40	27
1992	5405	10693	5721	4610	3691	5209	999	120	16
1993	769	12333	12815	2968	1722	1425	2239	343	38
1994	3198	3343	28258	10682	1469	726	358	647	108
1995	4015	7323	5744	23927	5769	615	290	187	331
1996	3090	10552	7639	4468	12896	2346	208	79	125
1997	1364	3939	10915	4895	2610	5035	719	64	69
1998	279	8257	5667	7856	2418	1422	1897	261	45
1999	1434	1550	17243	4516	4837	915	620	481	64
2000	2659	6317	2352	13615	1945	1706	324	222	192
2001	2515	11098	6954	1446	6262	675	478	105	94
2002	1082	10434	15998	5099	1131	3149	262	169	100
2003	401	6352	16265	12548	2968	748	1236	91	70
2004	1597	4063	17652	19358	8871	1940	471	489	155
2005	2405	9450	6929	25421	13778	4584	809	251	237
2006	241	10038	21246	6646	18840	7600	2180	323	202
2007	782	3884	42224	22239	3354	9952	2740	519	181
2008	2316	4508	9706	53022	11014	1717	3033	815	192
2009	1066	3185	4886	8892	35011	5733	726	1381	509
2010	121	6032	7061	4806	6766	17503	1874	354	528
2011	253	1584	11797	5080	2853	3983	6220	494	183
2012	196	1322	3421	13107	2223	1231	2480	2662	370
2013	250	1042	2865	4008	9222	1206	668	1248	1599
2014	238	1478	1751	2725	2737	4742	447	387	1403

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	0.19
1986	123.87	108.48	58.97	12.79	16.31	13.12	0.97	2.71	1.22	2.25	0.19
1987	21.82	338.29	147.5	44.15	7.68	7.47	4.72	0.39	0.61	0.44	0.86
1988	15.77	40.73	184.79	88.87	22.86	1.34	2.18	1.76	0.16	0.22	0.31
1989	10.58	23.33	41.16	146.61	45.09	12.88	0.79	0.81	0.41	0.28	0.23
1990	70.48	31.8	26.73	38.84	92.82	30.89	3.44	0.88	0.23	0	0.02
1991	89.73	145.95	41.43	17.73	20.19	32.85	7.63	0.3	0.1	0.08	0.08
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	95.25	66.21	119.86	36.78	19.58	40.63	5.78	0.59	0.13	0.12	0.15
1997	8.6	119.35	50.81	53.33	10.88	7.37	10.9	1.35	0.07	0.03	0.13
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	111.59	97.54	282.28	244.81	113.45	18	2.55	4.48	0.48	0.82	0.15
2004	325.9	291.65	70.75	208.74	109.33	33.96	6.79	1.24	0.82	0	0.31
2005	57.96	698.48	289.43	44.58	157.2	57.52	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	0.03
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	0.2
2011	8.79	27.65	24.75	77.43	14.03	5.9	9.4	14.89	1.22	0.31	0.3
2012	12.47	14.9	31.27	27.22	58.3	5.23	2.92	5.3	6.87	0.8	0.49
2013	13.91	23.32	19.72	22.9	22.51	41.93	4.78	2.52	3.83	4.52	1.02
2014	14.01	24.78	30.27	17.74	16.44	14.79	16.44	1.33	1.05	1.68	1.63
2015	62.58	19.59	26.56	34.23	12.58	11.18	9.63	9.96	1.14	0.56	2.29
2016	30.02	163.8	4.08	22.2	22.26	7.17	7.27	5.05	4.2	0.93	1.79

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	11	12
1996	16	458	108	83.9	18	7.6	17.6	1.5	0	0	0	0	0
1997	52	32	210	53.5	37.6	6.8	5.6	5.8	0.3	0	0	0	0
1998	208	81	32	131.1	19.3	15.2	5	5.2	1.8	0	0	0.07	0
1999	174	396	66	28.3	95.7	11.6	10.1	0.5	2.1	0.29	0	0	0
2000	54	161	259	45.8	8.1	28.3	1.9	3.2	0.1	0.27	0.58	0	0
2001	46	382	277	172.1	34.9	3.9	13.9	0.7	0.9	0	0.21	0	0
2002	148	80	239	189.7	94.1	18.4	2.8	2.1	1	0.04	0	0	0
2003	315	344	145	247.6	164.9	54.5	8.9	2.4	0.6	0	0.04	0	0
2004	187	709	344	50	156.1	68.1	16.2	3.9	0.8	0.49	0	0	0
2005	90	73	552	178.9	26.4	93.6	25.5	9.7	1.8	0	0.12	0	0
2006	84	124	116	500.6	105.7	13.4	39.4	9.4	3.9	1.5	0	0	0
2007	233	97	78	89.2	328	56.8	7.9	12	3.6	0.54	0.19	0	0.09
2008	95	201	93	67.1	85.7	193.6	16.3	2.8	3.3	0.21	0.07	0	0
2009	51	47	268	67.2	30.4	47.5	94.2	9.2	1.4	2.09	0.05	0.36	0
2010	36	42	56	141.6	30	14.1	23.2	36.3	4.6	0.85	0.95	0.15	0
2012	26	53	29	33.7	37.1	69.2	9.1	3.5	9.6	10.09	0.97	0.18	0.5
2013	27	90	127	36.5	37.8	38.7	44.2	6.2	2.3	5.69	4.14	0.69	0
2014	248	34	41	65.5	23.4	26.4	23.8	25.8	2.2	1.46	2.94	1.44	0.54
2015	132	204	36	38.7	47.7	15.1	18	10.3	12	2.26	1.36	0.54	1.35

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	32	255	614	1073	1637	1926	2452	2774	3170	3173
2016	29	162	642	1099	1564	2094	2296	3068	3481	3248
2017	29	181	454	1174	1701	2170	2654	2828	3454	3769
2018	29	187	489	924	1780	2299	2720	3125	3265	3749

Year	2	3	4	5	6	7	8	9	10
1979	**620**	**960**	**1410**	**2030**	**2910**	**3800**	**4560**	**4720**	**5956**
1980	837	831	1306	2207	2738	3188	3843	4506	4983
1981	584	693	1081	1656	2283	3214	3409	4046	5261
1982	289	959	1455	1674	2351	3031	3481	3874	4123
1983	320	1006	1496	1921	2371	2873	3678	4265	4502
1984	691	1007	1544	2120	2514	3027	2940	3906	4033
1985	652	1125	1811	2260	2924	3547	3733	4039	4659
1986	336	1227	1780	2431	2771	3689	3820	4258	4456
1987	452	1064	1692	2408	3000	3565	4215	4502	4025
1988	362	780	1474	2217	2931	3529	3781	4467	4418
1989	323	857	1185	1996	2893	4066	3866	4734	4990
1990	269	700	1054	1562	2364	3414	4134	4946	4451
1991	288	699	979	1412	1887	2674	3135	4341	4957
1992	313	806	1167	1524	1950	2357	3075	4053	4703
1993	303	705	1333	1875	2386	2996	3059	3363	4409
1994	337	668	1019	1717	2391	2717	3280	3156	3278
1995	351	746	1096	1318	2044	2893	3049	3675	3137
1996	311	787	1187	1560	1849	2670	3510	3567	3731
1997	379	764	1163	1649	1943	2342	3020	3337	3236
1998	445	724	1147	1683	2250	2475	2834	3333	3596
1999	555	908	1101	1658	2216	2659	2928	3209	3513
2000	495	978	1333	1481	2119	2696	3307	3597	3757
2001	541	945	1456	1731	1832	2243	3020	3328	4236
2002	564	928	1253	1737	2219	2230	2911	3365	4387
2003	498	922	1283	1704	2274	2744	2635	2819	3742
2004	559	1006	1258	1579	2044	2809	3123	2945	3759
2005	339	886	1265	1506	1916	2323	3028	3211	2891
2006	402	749	1093	1495	1758	2163	2555	3054	3589
2007	510	748	988	1346	1840	2062	2350	2525	3143
2008	383	636	857	1125	1575	2149	2417	2802	2600
2009	452	841	960	1131	1352	1757	2364	2497	3074
2010	447	756	1092	1294	1448	1685	2188	2366	2646
2011	588	905	1122	1455	1688	1914	2094	2455	2986
2012	668	978	1222	1492	1903	2164	2366	2704	2940
2013	678	1084	1358	1675	2036	2400	2554	3097	3097
2014	536	1080	1433	1793	2121	2504	2624	3178	3349
2015	573	1084	1486	2011	2332	2823	3306	3258	3768
2016	406	1049	1521	1940	2373	2529	3089	3370	3356
2017	437	826	1591	2056	2432	2795	2920	3352	3556

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	5956
1980	837	831	1306	2207	2738	3188	3843	4506	4983
1981	584	693	1081	1656	2283	3214	3409	4046	5261
1982	289	959	1455	1674	2351	3031	3481	3874	4123
1983	320	1006	1496	1921	2371	2873	3678	4265	4502
1984	691	1007	1544	2120	2514	3027	2940	3906	4033
1985	652	1125	1811	2260	2924	3547	3733	4039	4659
1986	336	1227	1780	2431	2771	3689	3820	4258	4456
1987	452	1064	1692	2408	3000	3565	4215	4502	4025
1988	362	780	1474	2217	2931	3529	3781	4467	4418
1989	323	857	1185	1996	2893	4066	3866	4734	4990
1990	269	700	1054	1562	2364	3414	4134	4946	4451
1991	288	699	979	1412	1887	2674	3135	4341	4957
1992	313	806	1167	1524	1950	2357	3075	4053	4703
1993	303	705	1333	1875	2386	2996	3059	3363	4409
1994	337	668	1019	1717	2391	2717	3280	3156	3278
1995	351	746	1096	1318	2044	2893	3049	3675	3137
1996	311	787	1187	1560	1849	2670	3510	3567	3731
1997	379	764	1163	1649	1943	2342	3020	3337	3236
1998	445	724	1147	1683	2250	2475	2834	3333	3596
1999	555	908	1101	1658	2216	2659	2928	3209	3513
2000	495	978	1333	1481	2119	2696	3307	3597	3757
2001	541	945	1456	1731	1832	2243	3020	3328	4236
2002	564	928	1253	1737	2219	2230	2911	3365	4387
2003	498	922	1283	1704	2274	2744	2635	2819	3742
2004	559	1006	1258	1579	2044	2809	3123	2945	3759
2005	339	886	1265	1506	1916	2323	3028	3211	2891
2006	402	749	1093	1495	1758	2163	2555	3054	3589
2007	510	748	988	1346	1840	2062	2350	2525	3143
2008	383	636	857	1125	1575	2149	2417	2802	2600
2009	452	841	960	1131	1352	1757	2364	2497	3074
2010	447	756	1092	1294	1448	1685	2188	2366	2646
2011	588	905	1122	1455	1688	1914	2094	2455	2986
2012	668	978	1222	1492	1903	2164	2366	2704	2940
2013	678	1084	1358	1675	2036	2400	2554	3097	3097
2014	536	1080	1433	1793	2121	2504	2624	3178	3349
2015	573	1084	1486	2011	2332	2823	3306	3258	3768
2016	406	1049	1521	1940	2373	2529	3089	3370	3356
2017	437	826	1591	2056	2432	2795	2920	3352	3556

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 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	0.138	0.283	0.445	0.667	0.795	0.772	0.892	1	0.889
2016	0.067	0.417	0.696	0.827	0.894	0.912	0.935	1	1
2017	0.066	0.317	0.694	0.835	0.894	0.925	0.935	1	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	0.521	0.576
1980	37390	192244	116521	51110	0.398	0.439
1981	10426	206988	141628	63558	0.542	0.449
1982	42788	180380	136817	69428	0.444	0.507
1983	29306	148112	112589	65942	0.508	0.586
1984	20574	112797	82961	48282	0.515	0.582
1985	42788	102394	66652	51102	0.537	0.767
1986	86501	96480	59837	48859	0.739	0.817
1987	164036	105395	46298	40760	0.584	0.88
1988	48742	153708	69391	54204	0.675	0.781
1989	29778	168184	99537	62885	0.676	0.632
1990	27094	145507	110745	67198	0.611	0.607
1991	92280	122708	89825	54692	0.664	0.609
1992	175094	106310	66379	47121	0.728	0.71
1993	38437	130461	71000	48123	0.669	0.678
1994	46842	127836	83295	59502	0.641	0.714
1995	72857	124042	85054	60884	0.661	0.716
1996	36341	108036	70008	56890	0.675	0.813
1997	102509	87152	58993	43764	0.624	0.742
1998	17976	97121	64203	41192	0.627	0.642
1999	50160	91024	64439	45411	0.685	0.705
2000	117423	90674	63509	42105	0.636	0.663
2001	156535	115046	70366	39654	0.462	0.564
2002	187267	168427	99344	50498	0.461	0.508
2003	50394	219757	147523	60883	0.404	0.413
2004	151137	252826	181303	84828	0.491	0.468
2005	384765	258912	176994	97225	0.522	0.549
2006	90617	298798	143410	97614	0.577	0.681
2007	42783	297360	162516	109966	0.555	0.677
2008	44466	249662	158368	102872	0.475	0.65
2009	121069	192792	142494	82045	0.504	0.576
2010	41838	168658	114084	64168	0.469	0.562
2011	32441	153885	97987	49433	0.402	0.504
2012	21413	144883	95026	46208	0.331	0.486
2013	40472	138496	100228	44097	0.324	0.44
2014	27875	125286	77383	33900	0.275	0.438
2015	14093	127585	87450	39646	0.373	0.453
2016	119694	109241	76722			
Average 1979-2015	76240	154772	99657	58287	0.535	0.606

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	46	81	117.3	27.7	19.6	20.44	3.41	0.77	0.15	0.05
1980	13	37	66.1	94.3	19.3	10.54	8.57	1.21	0.23	0.07
1981	52	10	30.1	52.9	66.8	11.91	5.19	3.64	0.5	0.11
1982	36	43	8.5	24.2	38.9	39.42	4.33	1.69	1.35	0.26
1983	25	29	34.9	6.8	16.9	21.99	19.56	1.67	0.48	0.45
1984	52	21	24	27.7	4.1	9.7	9.09	8.02	0.68	0.21
1985	106	43	16.6	18.6	18.2	2.14	3.63	4.06	2.88	0.34
1986	200	86	33.8	12.1	11.1	8.75	0.98	1.45	1.59	0.63
1987	60	164	69.9	23.9	6.2	4.88	2.51	0.35	0.46	0.49
1988	36	49	132.6	49.7	13.2	2.59	2.15	1.07	0.17	0.23
1989	33	30	39.7	99.6	27	5.58	0.94	0.78	0.32	0.08
1990	113	27	24.2	30.3	61.1	13.43	1.68	0.31	0.14	0.13
1991	214	92	20.5	17.6	17	28.7	5.27	0.63	0.12	0.05
1992	47	175	67.8	14.8	9.6	7.25	10.74	1.92	0.21	0.06
1993	57	38	138.5	45.8	7	3.65	2.59	4.08	0.67	0.07
1994	89	47	30.8	102.2	25.9	3.03	1.43	0.83	1.31	0.23
1995	44	73	35.5	22.2	58.1	11.54	1.15	0.52	0.36	0.49
1996	125	36	56	22.4	12.9	25.93	4.23	0.38	0.16	0.13
1997	22	102	27	36.3	11.4	6.56	9.56	1.34	0.13	0.06
1998	61	18	82.7	18.5	19.9	4.93	3.01	3.27	0.45	0.05
1999	143	50	14.5	60.2	10	9.15	1.85	1.18	0.96	0.13
2000	191	117	39.8	10.4	33.7	4.12	3.11	0.69	0.4	0.35
2001	229	156	93.7	26.9	6.4	15.28	1.61	1.01	0.27	0.13
2002	62	187	125.9	66.7	15.7	3.95	6.85	0.71	0.39	0.12
2003	185	50	152.3	93.6	40.1	8.23	2.21	2.76	0.34	0.17
2004	470	151	40.9	119	61.9	21.5	4.05	1.13	1.14	0.2
2005	111	385	122.3	29.8	81.4	33.19	9.58	1.56	0.5	0.49
2006	52	91	312.8	91.6	18.1	43.68	14.71	3.7	0.55	0.18
2007	54	43	74	247.1	55.8	8.83	18.71	5.17	1.05	0.16
2008	148	44	34.3	57	164.1	25.52	4.2	6.31	1.75	0.39
2009	51	121	34.3	24	37.9	86.35	10.93	1.88	2.43	0.7
2010	40	42	98.2	25.2	15.2	23.01	39.02	3.76	0.88	0.74
2011	26	32	34.1	74.9	14.2	8.13	12.71	16.11	1.38	0.4
2012	49	21	26.3	26.5	50.6	7.07	4.08	6.8	7.56	0.69
2013	34	40	17.4	20.4	18.6	29.61	3.78	2.22	3.33	3.78
2014	17	28	32.9	13.3	14.1	11.62	15.9	2	1.22	1.59
2015	146	14	22.6	25.6	9.3	9.06	7.03	8.73	1.23	0.65
2016	66	120	11.3	17.1	17.2	5.5	4.78	3.39	4.69	0.81
2017	67	54	98	8.2	11	10.08	3.01	2.56	1.78	2.46
2018	67	55	43.8	74.1	5	5.93	5.09	1.46	1.24	0.86

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	0.116	0.179	0.424	0.609	0.753	0.616	0.645	0.71
2005	0.007	0.089	0.297	0.423	0.614	0.753	0.849	0.809	0.653
2006	0.003	0.036	0.296	0.519	0.648	0.846	1.056	1.057	0.829
2007	0.02	0.06	0.209	0.581	0.544	0.886	0.882	0.787	0.58
2008	0.059	0.157	0.208	0.442	0.648	0.602	0.757	0.723	0.636
2009	0.01	0.108	0.255	0.3	0.594	0.867	0.555	0.992	0.987
2010	0.003	0.07	0.37	0.428	0.393	0.685	0.8	0.584	0.963
2011	0.009	0.053	0.191	0.501	0.491	0.425	0.557	0.501	0.366
2012	0.01	0.057	0.154	0.337	0.427	0.406	0.515	0.493	0.491
2013	0.007	0.069	0.169	0.272	0.422	0.435	0.403	0.535	0.51
2014	0.009	0.051	0.158	0.241	0.302	0.4	0.283	0.433	0.521
2015	0.018	0.078	0.198	0.323	0.44	0.531	0.421	0.226	0.672
2016	0	0.117	0.241	0.335	0.402	0.423	0.444	0.444	0.444
2017	0.001	0.08	0.306	0.419	0.483	0.524	0.524	0.524	0.524
2018	0.003	0.098	0.25	0.467	0.542	0.568	0.568	0.568	0.568

Table 10.4.1 Output from short-term predictions. Numbers here apply to calendar years. The adopted HCR lead to TAC of 34.6 kt for the fishing year 2016/2017.

2016				
Bio 3+	SSB	Fmult	F4-7	Landings
109	77	0.955	0.356	34

			2017		2018	
Fmult	F4-7	Bio 3+	SSB	Landings	Bio 3+	SSB
0.1	0.037	129	88	4	177	127
0.2	0.075	129	88	7	173	124
0.3	0.112	129	88	11	170	121
0.4	0.149	129	88	14	167	118
0.5	0.186	129	88	18	163	115
0.6	0.224	129	88	21	160	112
0.7	0.261	129	88	24	157	110
0.8	0.298	129	88	27	154	107
0.9	0.335	129	88	30	151	105
1	0.373	129	88	33	148	102
1.1	0.41	129	88	35	146	100
1.2	0.447	129	88	38	143	98
1.3	0.484	129	88	41	141	96
1.4	0.522	129	88	43	138	94
1.5	0.559	129	88	45	136	92
1.6	0.596	129	88	48	134	90
1.7	0.633	129	88	50	131	88
1.8	0.671	129	88	52	129	86
1.9	0.708	129	88	54	127	84
2	0.745	129	88	56	125	83

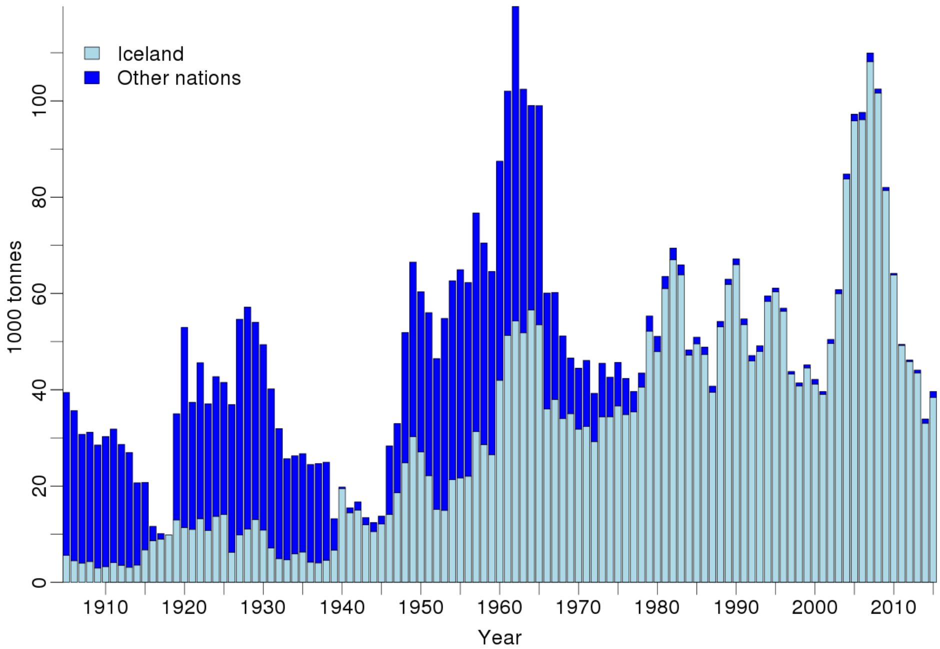


Figure 10.1.1 Haddock in division Va. Landings 1905 – 2015

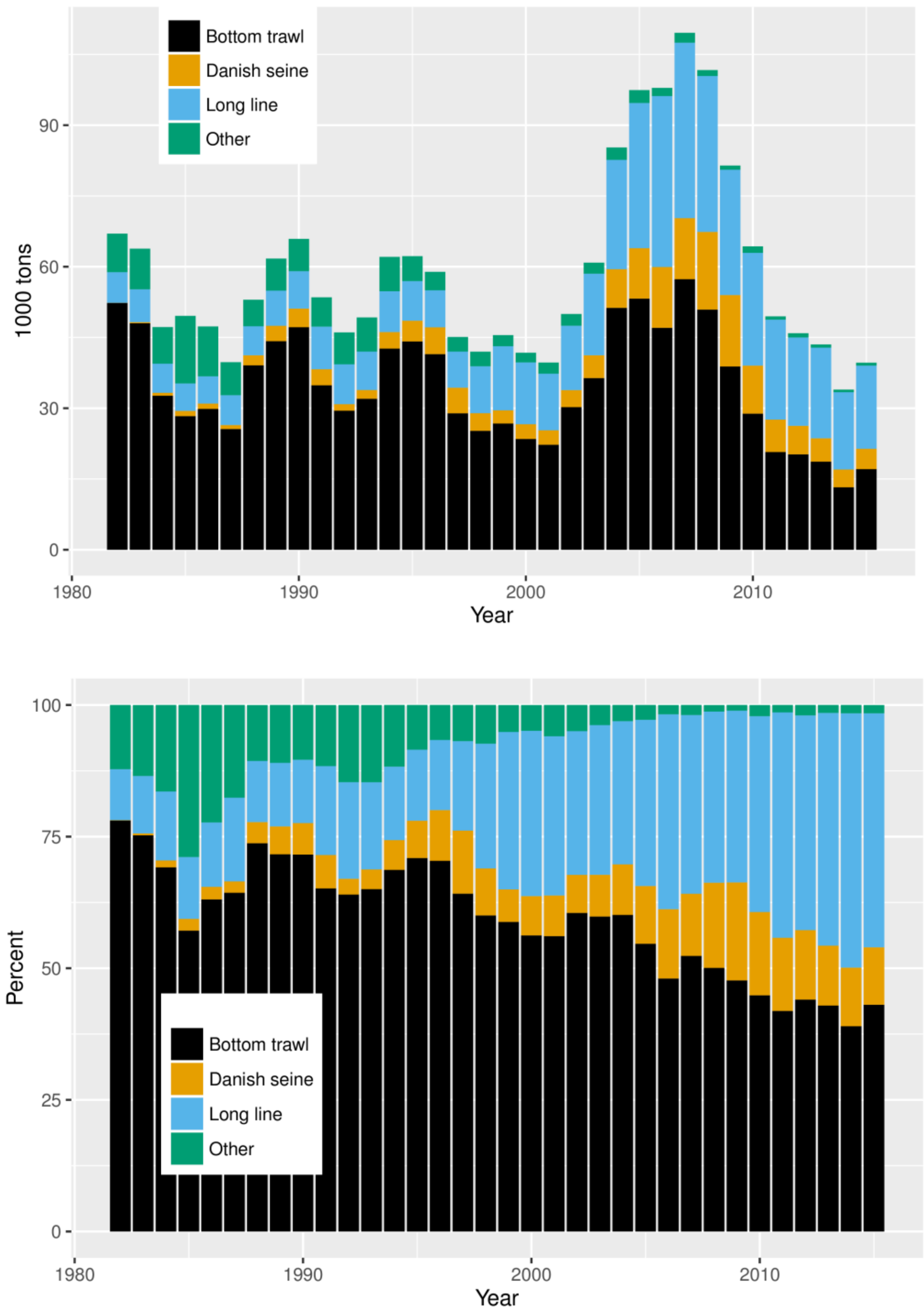


Figure 10.1.2 Haddock Division VA. Landings in tons and percent of total by gear and year.

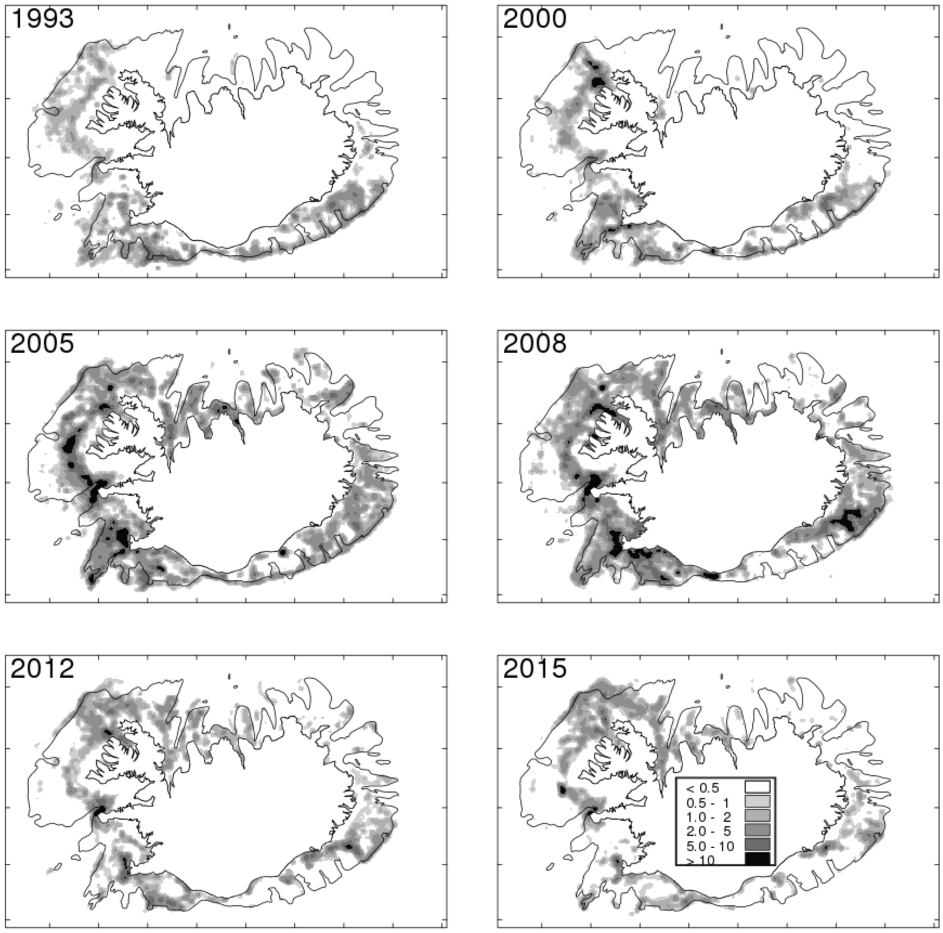


Figure 10.1.3 Haddock Division VA. Spatial distribution of landings. The legend show tonnes per square mile.

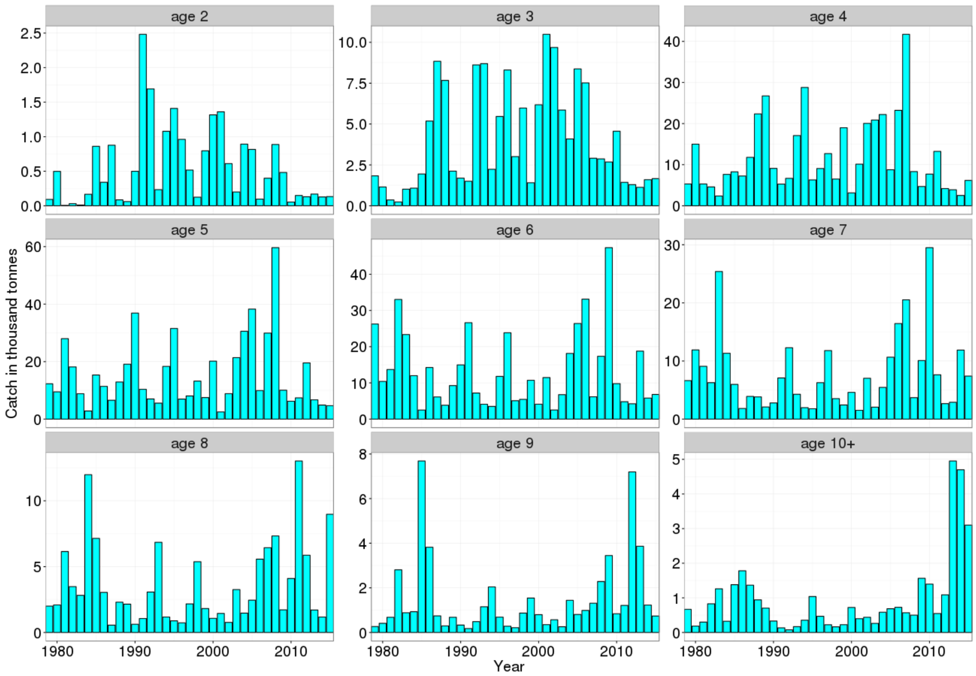


Figure 10.1.4 Haddock in division Va. Age disaggregated catch in tons.

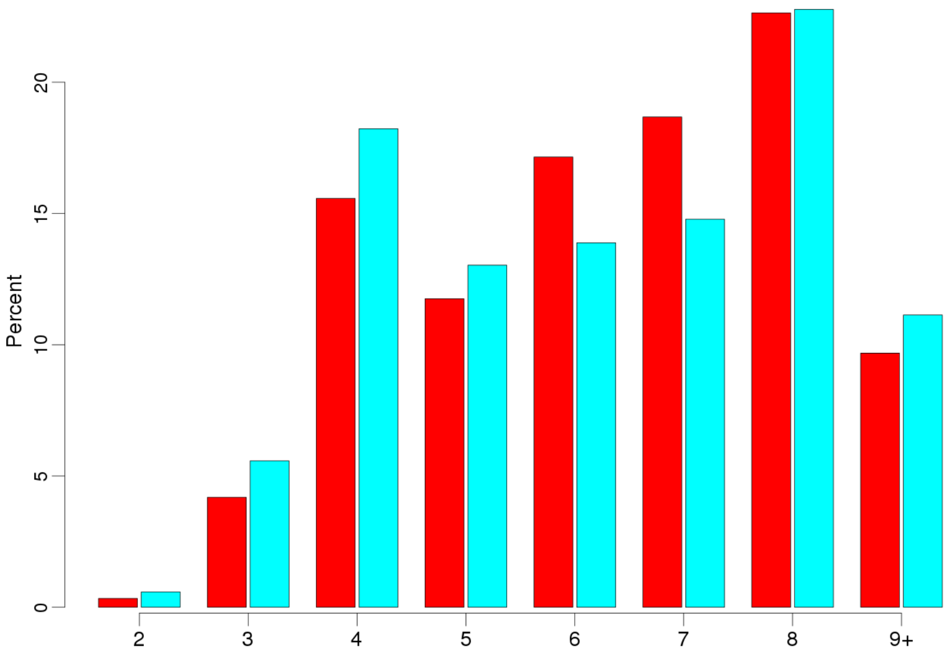


Figure 10.1.5 Haddock in division Va. Percent of catch in tonnes 2015 (red) compared to last year's predictions.

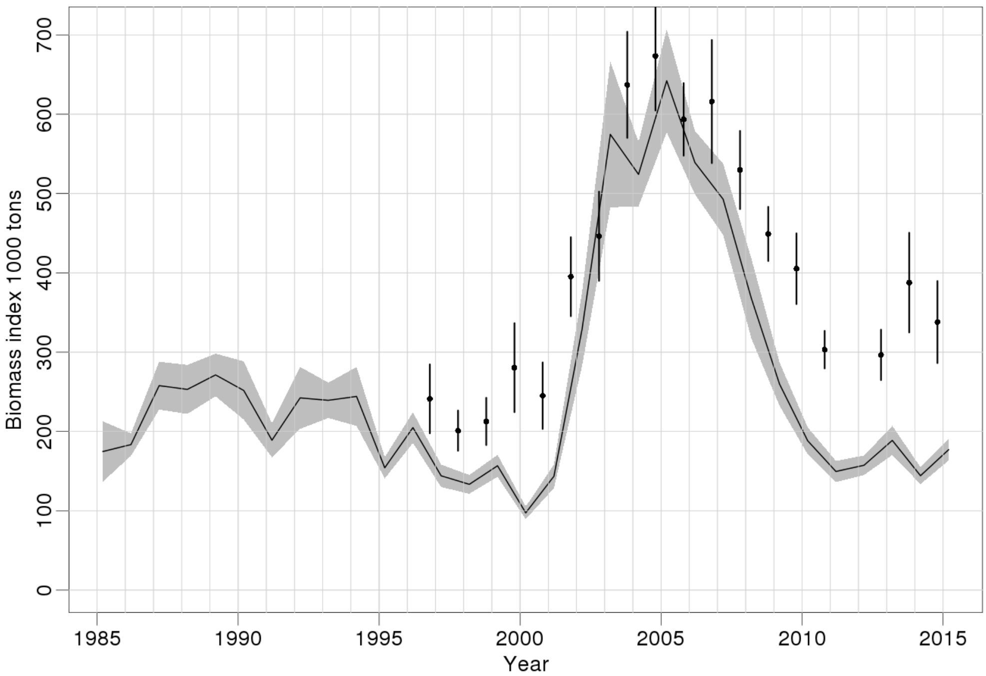


Figure 10.1.6 Icelandic haddock. Total biomass indices from the groundfish surveys in March (lines and shading) and the groundfish survey in October vertical segments. The standard error in the estimate of the indices is shown in the figure. Due to a strike the autumn survey was not conducted in October 2011.

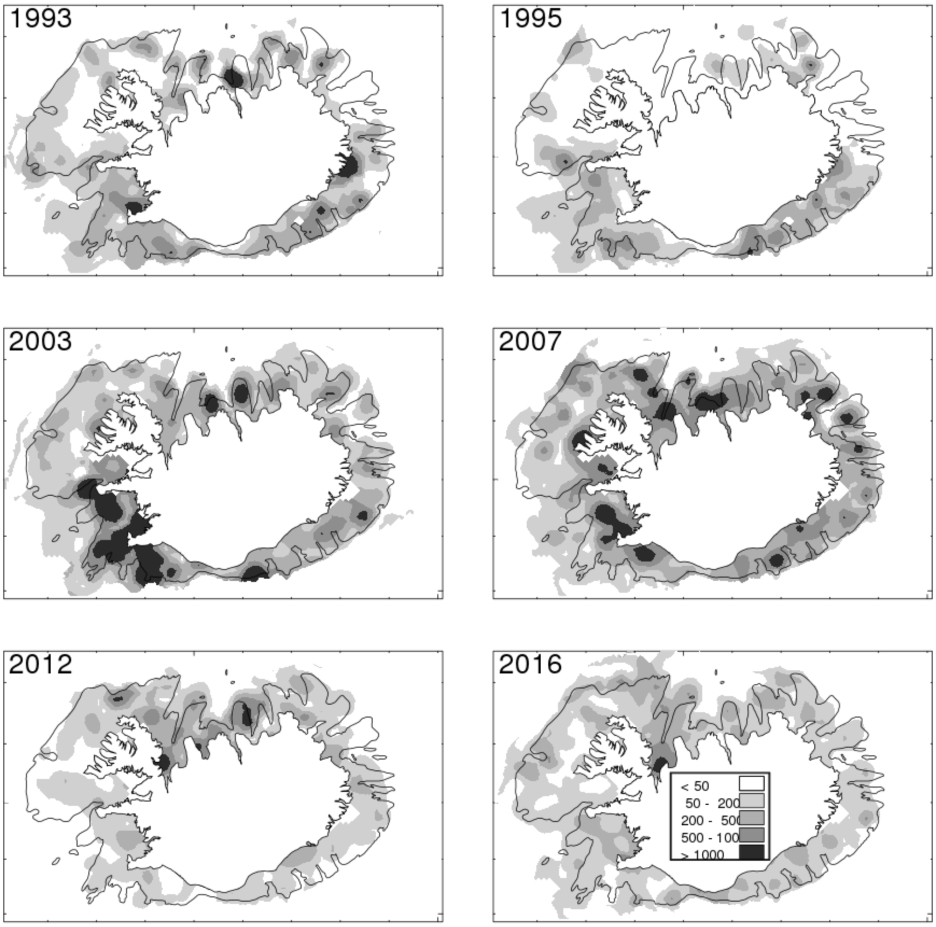


***Figure 10.1.7. Spatial distribution of haddock in the groundfish survey in March. The legend show kg per hour towed.**

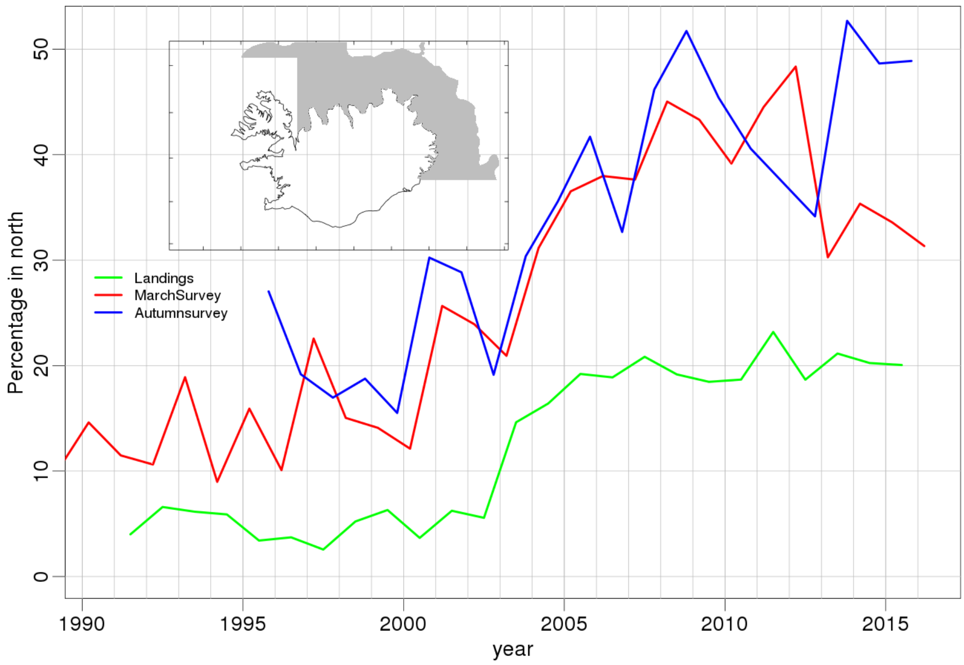


Figure 10.1.8. Proportion of the landings and the biomass of 42cm and larger haddock that is in the north area. The small figure shows the northern area.

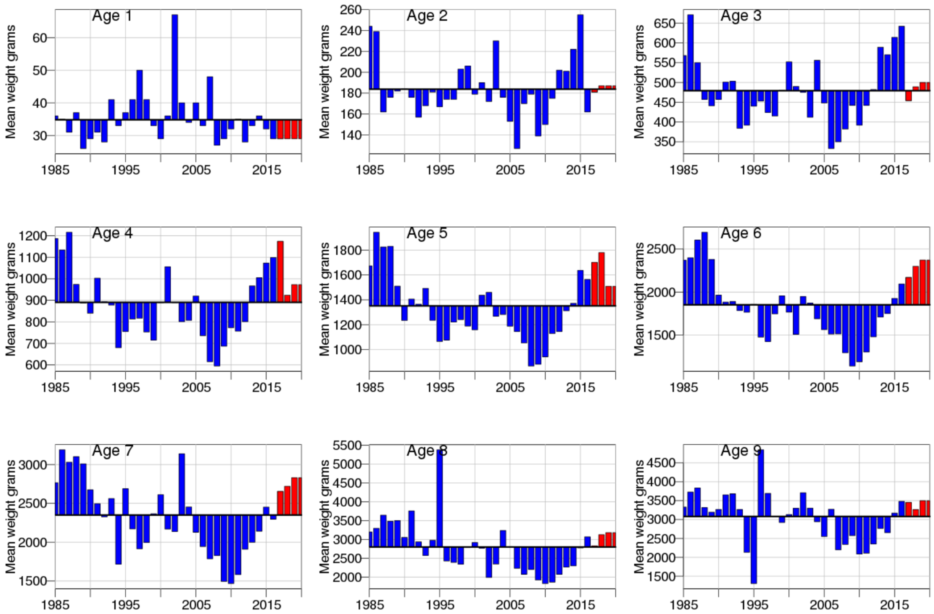


Figure 10.1.9 Haddock in division Va. Mean weight at age in the survey. Predictions are shown as red. The values shown are used as weight at age in the stock and spawning stock.

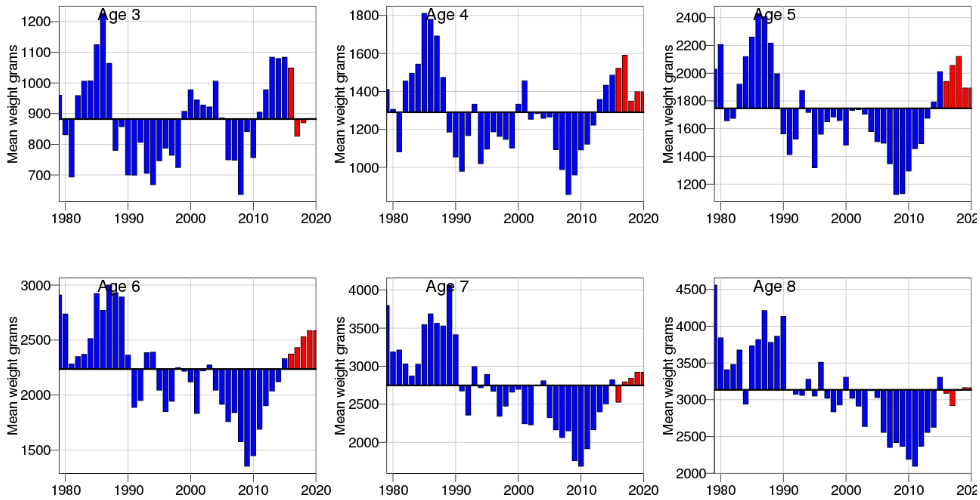


Figure 10.1.10 Haddock in division Va. Mean weight at age in the catches. Predictions are shown as red.

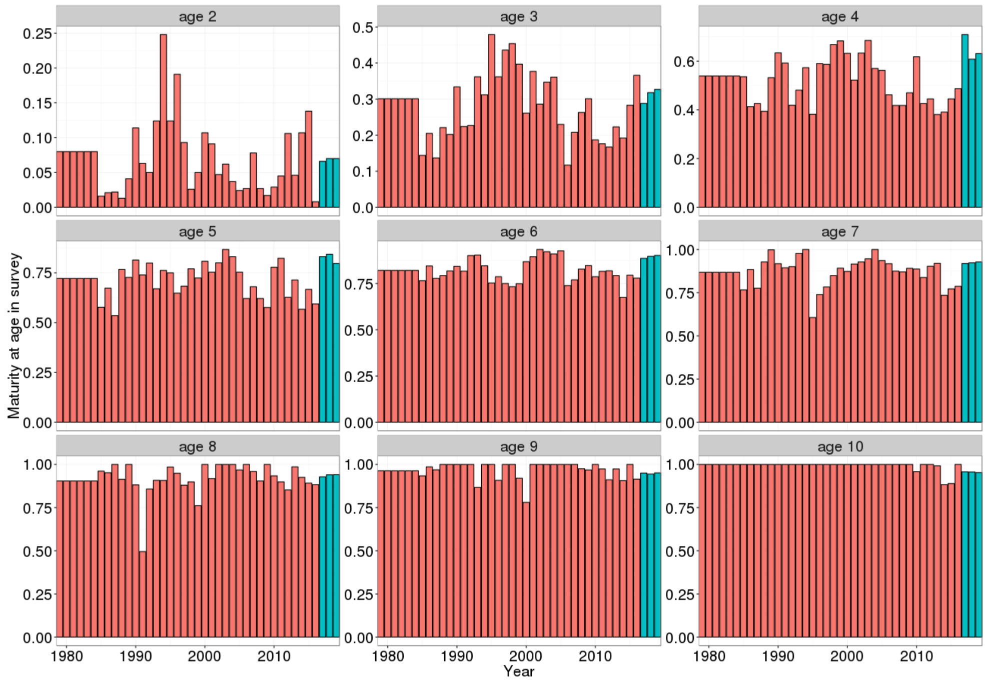


Figure 10.1.11 Haddock in division Va. Maturity-at-age in the survey. The blue bar indicates predictions. The values are used to calculate the spawning stock.

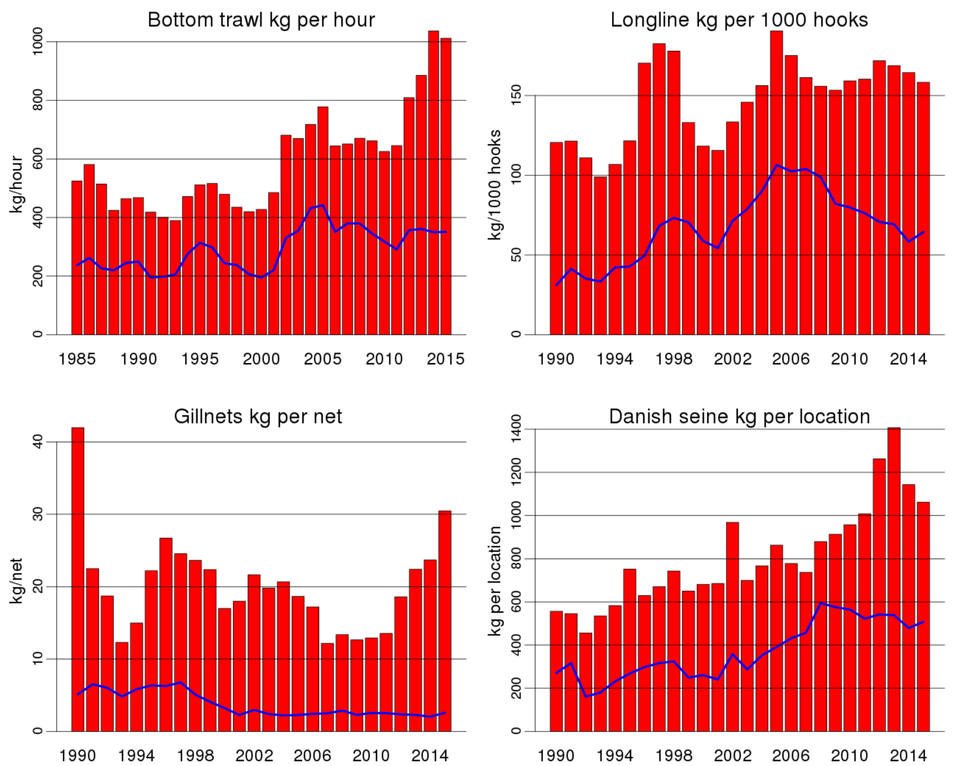


Figure 10.1.12. Catch per unit of effort in the most important gear types. The bars are based on locations where more than 50% of the catch is haddock and the lines on all records where haddock is caught. A change occurred in the longline fleet starting September 1999. Earlier only vessels larger than 10 BRT were required to return logbooks but later all vessels were required to return logbooks. Not updated

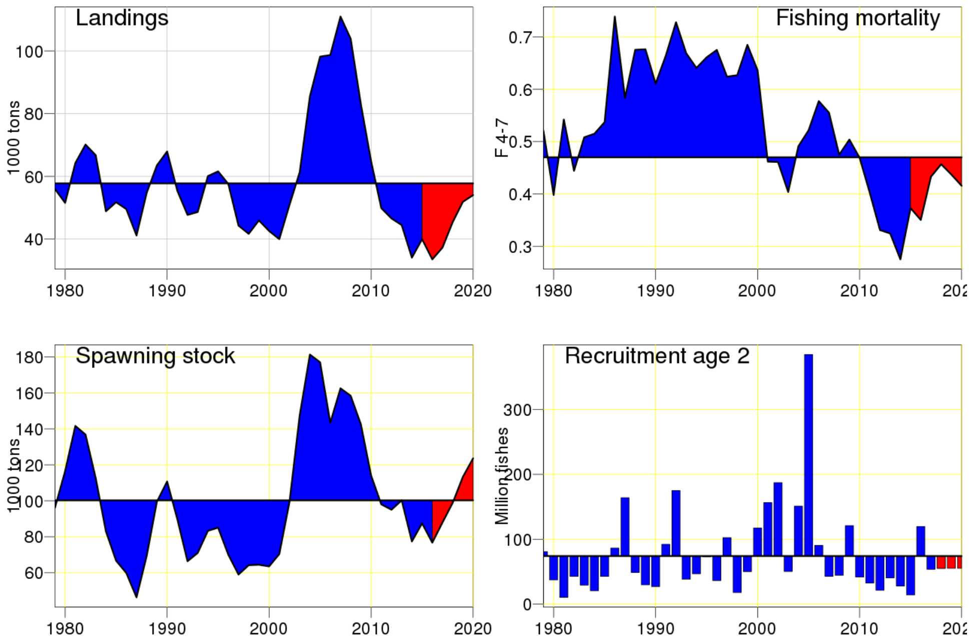


Figure 10.2.1 Haddock in division Va. Summary from assessment. Red colours in lower figure indicates predicted values.

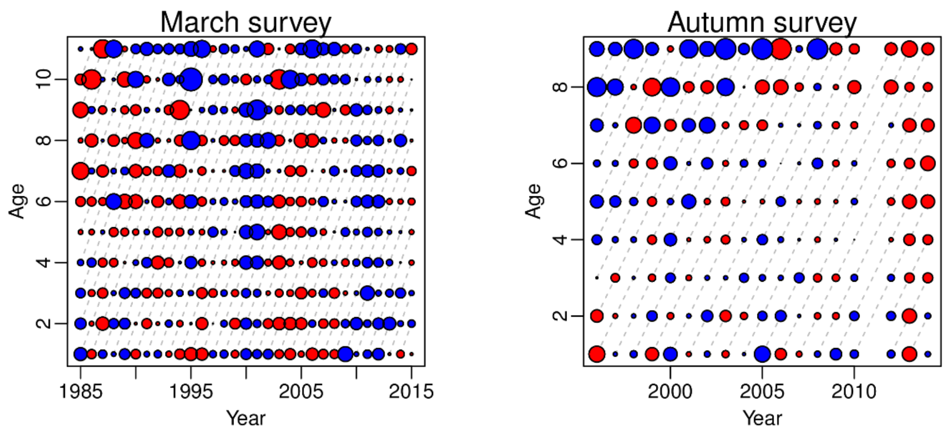


Figure 10.2.2. Haddock in division Va. Residuals from the fit to survey data from Adapt run based on the both the surveys. Coloured circles indicate positive residuals (observed > modelled). The largest circle corresponds to a value of 0.87. Residuals are proportional to the area of the circles. Lage efri harvest ratio

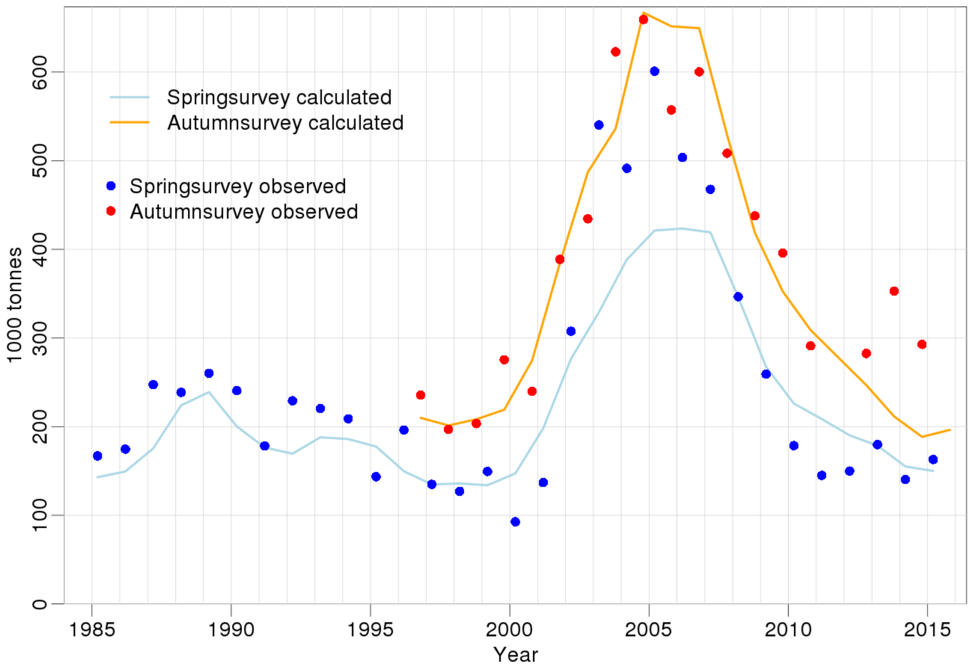


Figure 10.2.3. Haddock in division Va. Observed and predicted biomass from the surveys according to the SPALY run.

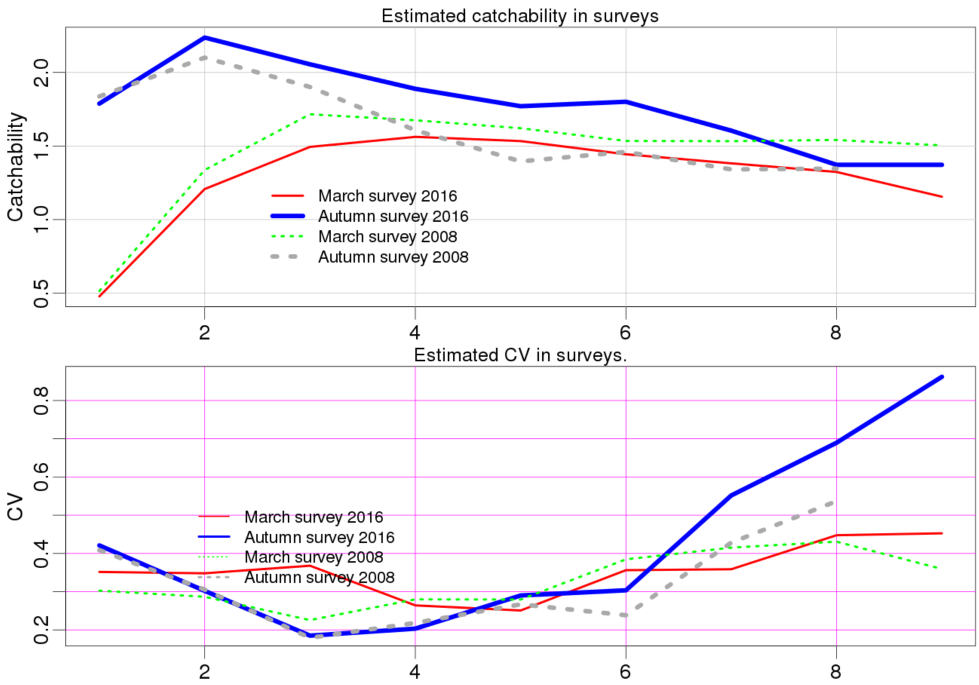
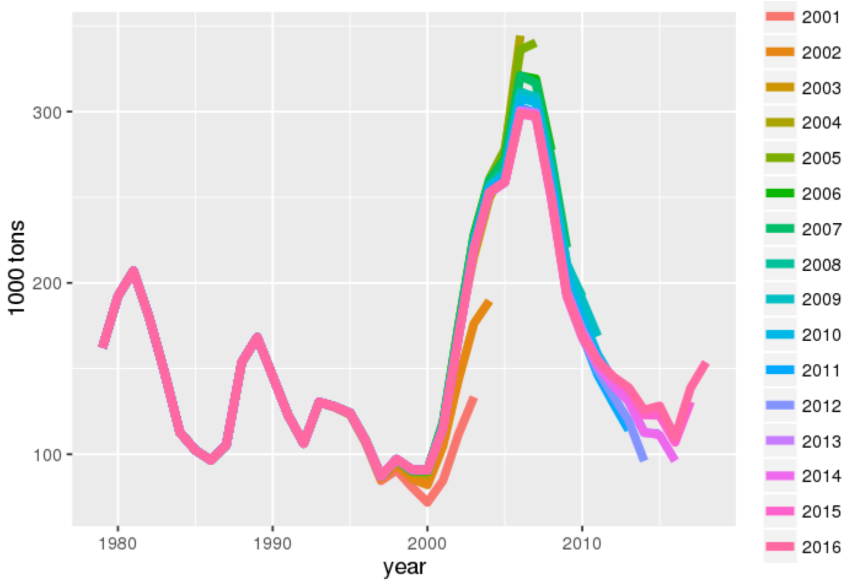


Figure 10.2.4. Haddock in division Va. Results from the SPALY run. Catchability and CV from the autumn survey (wide lines) and March survey (thinner lines). Estimates from 2008 shown dashed.



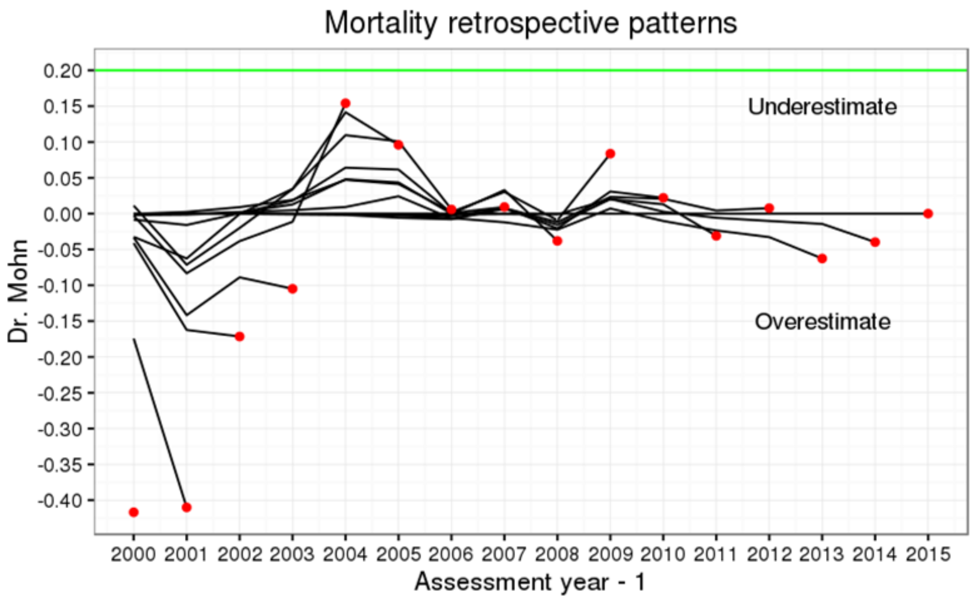
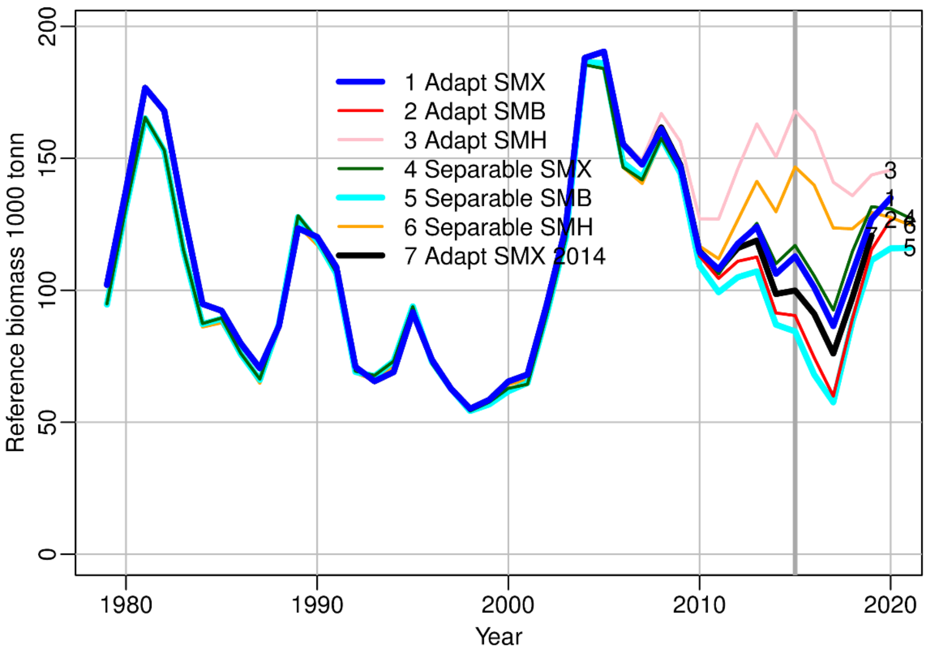
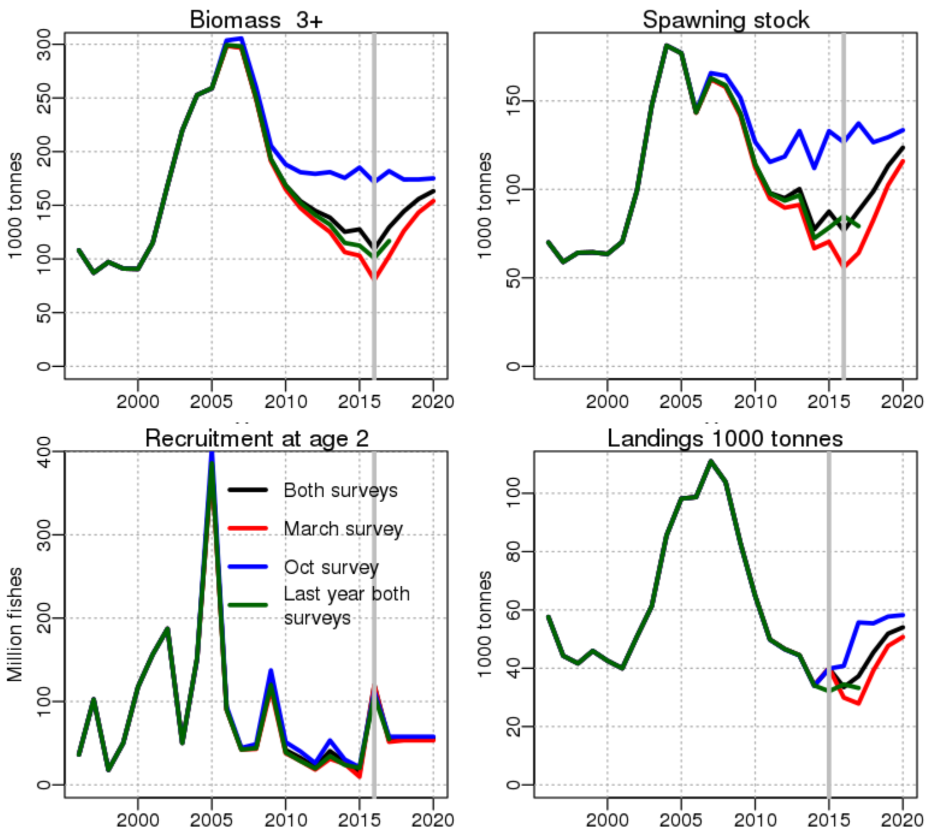


Figure 10.2.5. Haddock in division Va .Upper picture shows retrospective pattern of biomass 3+ from the SPALY run. Each retro ends 2 years after the assessment year i.e after the advisory year. The lower picture shows scaled retrospective pattern of fishing mortality. Average of Mohns rho over the last 7 years is -0.005. Errors in prediction of weight and maturity-at-age are not included and the assessment converges slowly.



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 2016 assessment based on different tuning data and 2015 assessment tuned with both the surveys. .

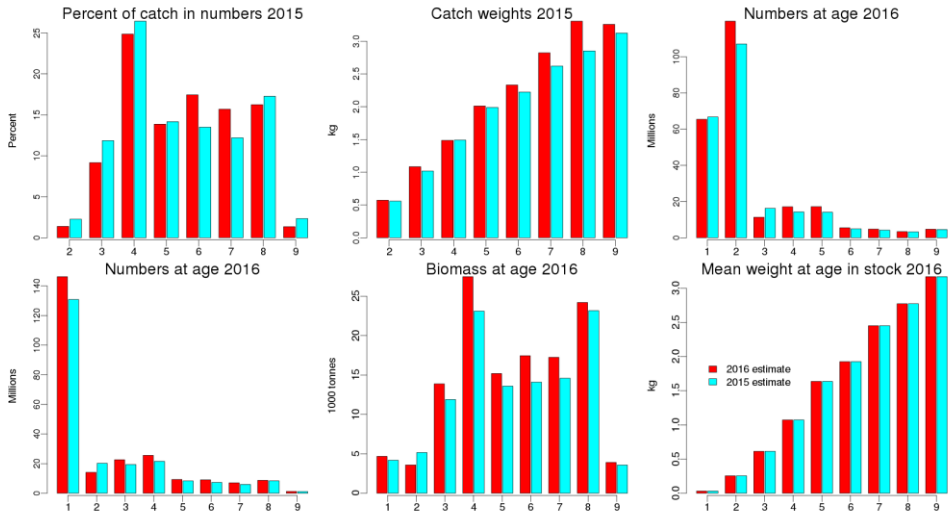


Figure 10.2.8. Comparison of 2015 and 2016 assessment

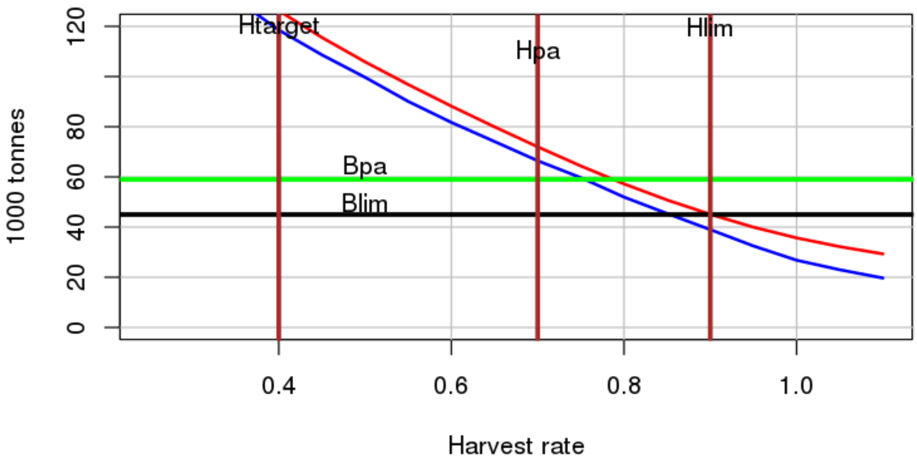


Figure 10.3.1. Average long term spawning stock as function of harvest rate. Results are based on simulations without trigger point, autocorrelation of recruitment and assessment error.

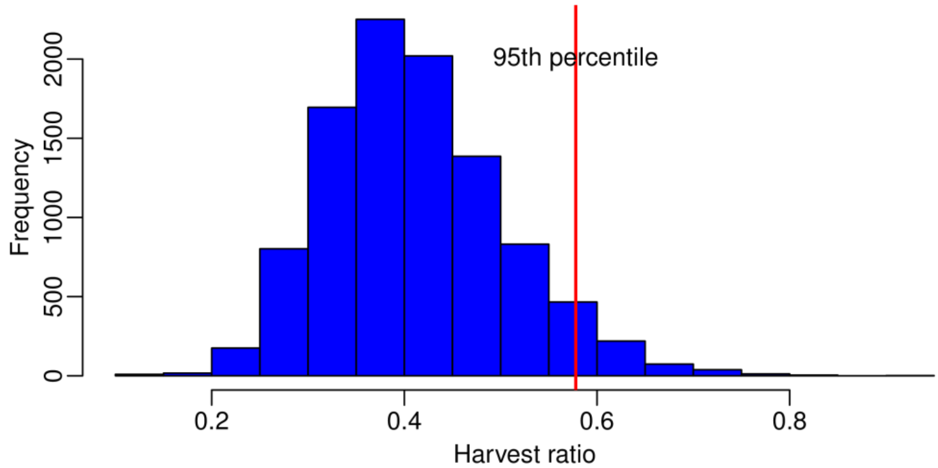


Figure 10.3.1. Distribution of harvest rate in the long term based on the Harvest Control Rule simulations done in 2013.

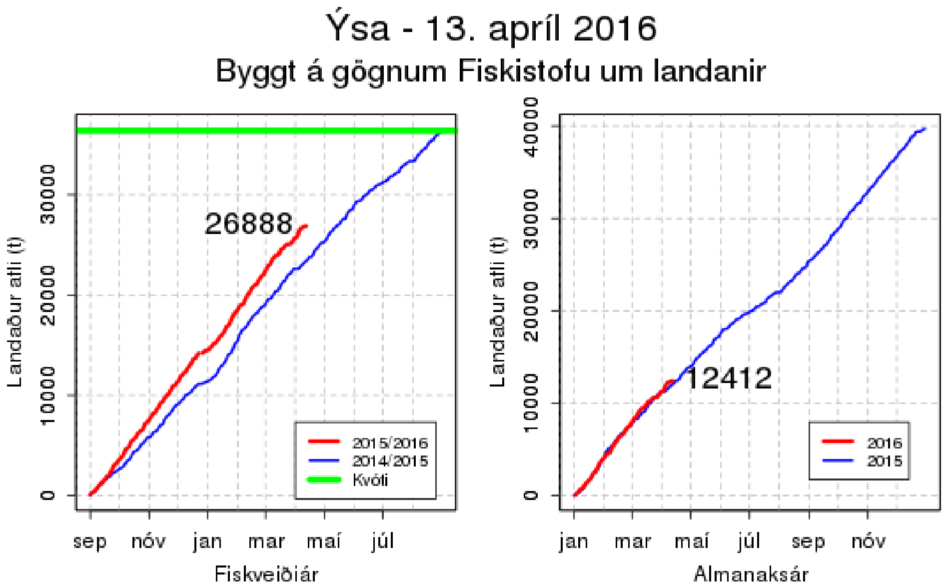


Figure 10.4.1 Haddock in division Va. Development of the landings during the fishing year 2015/16 (left side) and calendar year (2016) on the right. Fishing year 2014/2015 and calendar year 2015 shown for comparison. Tac (kvóti) for the fishing year shown in the left figure.

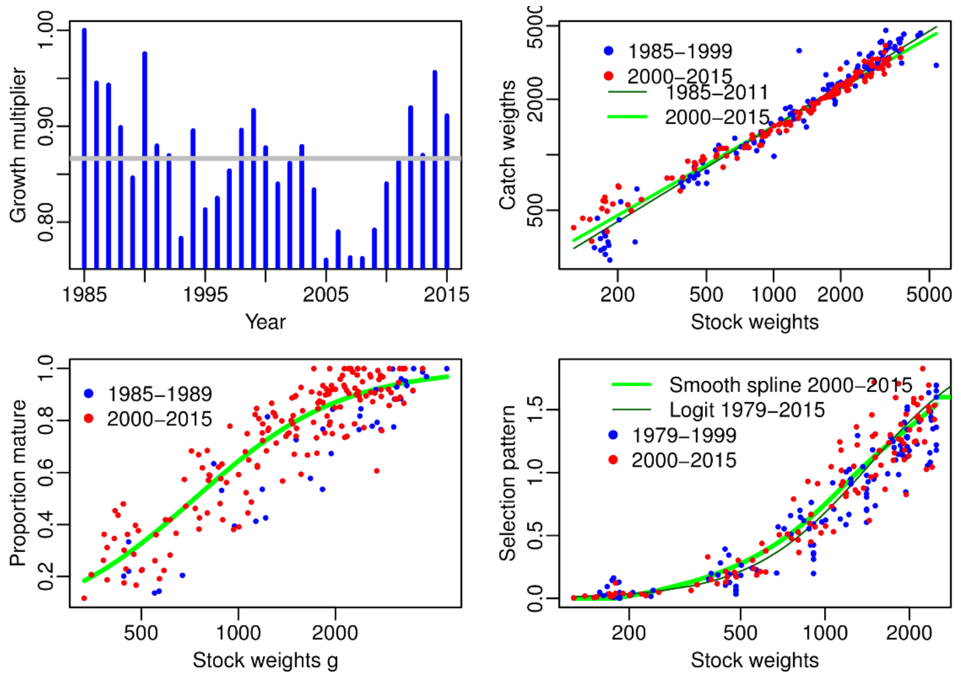


Figure 10.4.2 Haddock in division Va. Input data to prediction. Predictions are based on the period since 2000. . Exponential of the yearfactor (growth multiplier) in the equation

$$\log \frac{W_{a+1,t+1}}{W_{a,t}} = \alpha + \beta \log W_{a,t} + \delta_{year}$$

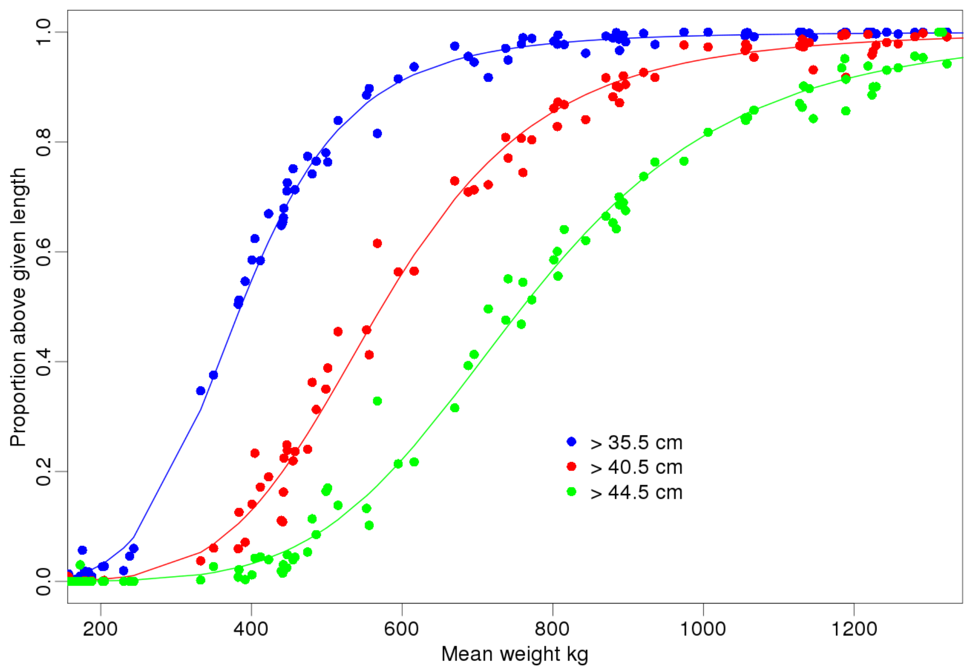


Figure 10.4.3 Haddock in division Va. Proportion of the biomass of a yearclass above certain size. The points show data, compiled from the March survey and the lines a curve fitted to the data and used in simulations.

11 Icelandic summer spawning herring

11.1 Scientific data

11.1.1 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-January, and even as late as March. 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 2015/2016 derives from two dedicated acoustic surveys in January and March 2016 (Óskarsson 2016). The nursery grounds of the stock were then covered on RV Dröfn in three surveys in September and October 2015. In addition to getting an acoustic estimate on the adult part and on juveniles at age 1, the objective was also to get an estimate of prevalence of *Ichthyophonus* infection in the stock. The instrument and methods in the surveys were the same as in previous years and described in the stock annex and all the results are detailed in a WD to NWWG (Óskarsson 2016). The biological sampling in the survey is detailed in Table 11.1.1.2.

11.1.2 The surveys' results

The fishable part of the herring stock was observed in three main areas, in an offshore area west of Iceland (Kolluáll and Jökuldjúp), south of Iceland around Vestmannaeyjar, and in offshore areas east of Iceland (Litladýpi og Reyðarfjarðardjúp) (Figure 11.1.2.1; Óskarsson 2016). As in previous years, most of the stock was measured acoustically west of Iceland (in Kolluáll) and to a smaller and decreasing degree east of Iceland (Figure 11.1.2.2.). The total amount of the adult stock (age 4+) came to 372 kt, compare to 433 kt in the autumn 2014. The total biomass of the fishable stock (>26 cm) was 396 kt compared with 450 kt in the autumn 2014, which represents 12% decrease in biomass while there was a 7% decrease in number (1411×10^6 compare to 1514×10^6, respectively).

The 2010 year class (age 5 in the autumn 2015) was the most numerous in the survey or 23% of the total number of herring (Table 11.1.1.1). The 2008 and 2009 year classes were also numerous (16 and 15%, respectively), and together these year classes contributed to 53% of the total number and biomass.

The number of juvenile herring (i.e. age 1) observed acoustically amounted to 382 million fish. Applying the linear-regression provided by Gudmundsdottir *et al.* (2007) implied that the 2014 year class will be 391 million at age 3 in the autumn 2017, or below average year class size (666 million at age 3 and geometric mean of 588 millions). This number is used in the forecast in the 2016 assessment below.

As discussed in Óskarsson (2016), the acoustic measurements in January east of Iceland are likely to have higher uncertainty than elsewhere and normally in this survey, because of sparse distribution of relatively large schools (i.e. only three schools provided the acoustic values), large distance between survey tracks, limited spatial coverage of the survey in the area and bad weather condition.

11.1.3 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 2008–2013. 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, 2014 and 2015 assessments (ICES 2013; 2014; 2015), where additional natural mortality because of the infection, and estimated from catch samples (e.g. Óskarsson *et al*. 2012; 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 2015/2016 west of Iceland was highest for the 2005 and 2003 year classes, or 43% and 37%, respectively (Figure 11.1.3.1). The 2004, 2006 and 2007 year classes were not far off with prevalence of infection 30–33% this winter. Thus this year's results are in agreement with previous results as the prevalence is still high for these year classes and at comparable levels to previous years. However, the prevalence of infection has been increasing for the recent two years in the 2007 and 2008 year classes, and for the last year in the 2009 year class. Moreover, two years old herring at the nursery grounds north of Iceland in the autumn 2015 had low level of prevalence of infection, which has not has been observed there since the autumn 2011 (Óskarsson and Pálsson 2016). This together indicates that some new infection, even if at much lower rate than in 2008–2009, has been taking place in the most recent two years.

Further work is still ongoing, including analysing the difference in fit (i.e. comparing the residuals sum of square) of the assessment model used for the stock (NFT-Adapt) by varying the M related to infection. The stable high level of prevalence of infection in the older age groups (year classes 2002–2006) for such a long period and they still being fishable (Figure 11.1.3.1), supports that the mortality rate caused by the infection is very low and insignificant. Thus, increase in prevalence of infection for year classes 2007–2009 does not necessarily, and probably not, mean induced mortality by infection in the near future. However, it calls for continuation of monitoring the situation closely.

11.2 Information from the fishing industry

The total landings of Icelandic summer-spawning herring in 2015/2016 season were about 69.7 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 2015 (4.5 kt), even if they belong to the official fishing season 2014/2015. 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 2015, was 71 kt and allowable TAC 68 kt because of 3 kt overshoot in the season before that was transferred to the next season.

The direct fishery started in October in offshore areas west of Iceland. Most of the catches were taken over a wide area there in October to January in pelagic trawls, or 89% of the total catch (Figure 11.2.2). In October and November 2.4 kt were caught east of Iceland (3%), while the remaining catch of 5.5 kt (8%) was taken as bycatch in the fishery for the Norwegian spring-spawning herring, NSSH, and Atlantic mackerel during June to September.

Like in some of the previous winters, spring-spawning herring (Icelandic spring spawners or NSSH) was mixed with the Icelandic summer-spawning herring stock in the catches in the winter 2015/2016. This applied to the fishery in the east in October and November where 24% was NSSH according to four catch samples, and consequently reported as NSSH. Based on maturity stage of the herring in catch samples, 2.4% of the herring caught west of Iceland in the winter 2015/2016 were spring spawners.

11.2.1 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 97% of the catch in 2015/2016 was taken in pelagic trawls and 3% in purse-seine (Figure 11.2.1), which reflects that both the targeting and bycatch fisheries take mainly place in offshore areas. No driftnets fishery took place in Breiðafjörður as in the most recent four years. During all fishing seasons since 2007/2008 to 2012/2013, most of the catches (~90%) were 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 was an indication for changes in this pattern, with less proportion in Breiðafjörður, and then in 2014/2015 almost all of the overwintering west of Iceland took place offshore which continued this winter. These changes in distribution explain the dominance of pelagic trawl in the fishery, which is preferred by the fleet over purse-seine in offshore areas.

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). No closure was enforced in this herring fishery in 2015/16. Normally, the age of first recruitment to the fishery is age-3, which is fish at length around 26-29 cm.

11.2.2 Catch in numbers, weight at age and maturity

Catch-at-age in 2015/2016:

The procedure for the catch-at-age estimations, as described in the Stock Annex, was followed for the 2015/16 fishing season. It involves calculations from catch data collected at the harbours by the research personnel (0%) or at sea by fishers (100%). 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 (2016). In the same way, five weight-at-length relationships derived from the length and weight measurements of the catch samples were used. On basis of difference in length-at-age between the summer months (June-Sept.) and the winter (Oct.-Jan.), two length-age keys were applied. 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 11.2.2.1. The geographical location of the sampling is shown on Figure 11.2.2.

The age composition of the total catches in 2015/2016 was somewhat different from the composition in the bycatch of herring in the mackerel and NSS-herring fishery in the summer 2015 (Figure 11.2.2.1). The summer fishery included to a higher degree younger age groups (age 3–5; 48% of the biomass) than the whole fishery (38%), and consequently vice versa for older age groups. This difference is probably reflecting the geographical distribution of the different age groups, with larger proportion of these age groups in the east and south than in the west, according to the acoustic surveys (57%vs.32% by biomass; Óskarsson 2016), where the main bycatch takes place.

Weight at age:

As stated in the stock annex, the mean weight-at-age of the stock is derived from the catch samples (Table 11.2.2.2). The total number of fish weighed from the catch in 2015/16 was 2537 and 1674 of them were aged from their fish scales.

Proportion mature:

The fixed maturity ogives were used in this year's 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 vs. predictions of catch composition:

The relative contribution of the different year (age) classes was similar to what was predicted in the analytical assessment in 2015 for age 5+ while age 3 was less and age 4 more seen in the catches than predicted (Figure 11.2.2.1). Again, this reflects both the difference in geographical location of the fishery and the stock (age 3 mainly in the east and south; Óskarsson 2016) but also that the 2011 year class (age 4) is maybe not as extremely small as predicted in the 2015 assessment (ICES 2015).

11.3 Analytical assessment

11.3.1 Analysis of input data

Examination of catch curves for the year classes from 1984 to 2011 (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 less meaningful.

Catch curves were also plotted using the age disaggregated survey indices for each year class from 1984–2011 (Figure 11.3.1.2). Even if the total mortalities look at bit noisy for some year classes, they seem to be fairly close to 0.4, for example for 1998-2005 year classes. 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 cannot 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 all fully in the survey prior to the infection outbreak. Further work on this matter is ongoing.

11.3.2 Exploration of different assessment models

In order to explore the data this year, two assessment tools were used, NFT-ADAPT (VPA/ADPAT version 3.3.0 NOAA Fisheries Toolbox) and TASACS (VPA module; Skagen and Skålevik 2009). 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 VPA module in TASACS was, on the other hand, the principal assessment model for Norwegian spring-spawning herring during 2008-2015 (ICES 2016) and a familiar tool to the assessment scientists. The catch data used were from 1987/88-2015/16 (Table 11.2.2.1) and survey data from 1987/88-2015/16 (Table 11.1.1.1) for NFT-Adapt but back to 1975 for TASACS (see below). Other input data consisted of: (i) mean weight at age (Table 11.2.2.2); (ii) maturity ogive (Table 11.2.2.3); (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. Thus, no changes in the input data from last except for one more year of data.

<u>NFT-Adapt</u>:

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 3.3.0, Reference Manual). The estimated parameters were stock numbers for ages 4–12 in the end of year 2015, while the stock numbers-at-age 3 were set to the geometric mean from 1991–2012. 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. The age groups 3-10 were used for tuning (Table 11.1.1.1 as decided at the benchmark 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. The main pattern is the same as presented in recent assessments. Positive residuals, where the model estimates is 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 and 2003 year classes. Year blocks of positive residuals are apparent for the years 2000–2006 (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 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 for the most recent three 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 four years lifts compared with the preceding years. It required also an increase in recruitment estimates as apparent on the retrospective plots of number-at-age 3. A revision of the number-at-age 3 of the 2008 and 2009 year classes (in 2011 and 2012) is also apparent retrospectively, which is related to their high survey indices at age 3. 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 as presented earlier (ICES 2014).

The estimated number-at-age 3 in the final year (2016) from the NFT-Adapt of 649 million (geometric mean) was replaced with 464 million, which derives from a projection from number-at-age 1 in the 2014 acoustic survey as described by Gudmundsdóttir *et al*. (2007) and recommended to use for the stock (ICES 2011a).

Like described before (ICES 2014), 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 2009 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 2009 is likely underestimate due to distribution of the stock that year in Breiðafjörður (Óskarsson *et al*. 2010), while the reason for the positive block during 2000-2004 is not fully known even if mainly caused by the large 1999 year class (ICES 2014) and possibly 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.

<u>TASACS</u>:

TASACS (Skagen and Skålevik 2009) is a toolbox with several assessment tools (VPA, a separable model and ISVPA) with a range of options for objective functions and for handling of the plus group. The VPA module was used for this stock, but it has been used in assessment of Norwegian spring-spawning herring since 2008 (ICES 2015b). The VPA module uses the catch numbers-at-age to reconstruct each year class backwards in time starting with the survivors at the end of the last year with catch data or the oldest true age. The survivor numbers are estimated by fitting the stock numbers-at-age to survey indices at age, calibrated with catchabilities.

TASACS model parameters that are used in the present configuration are:

- Stock numbers, N(a,Y) and N(A-1,y): Survivor numbers at the end of each year class cohort.
- Survey indices I are modelled as I=q*N, i.e. assuming a linear relation between survey index and stock number. Survey catchabilities are constant over time but dependent on age except for the ages older than 8.
- Natural mortalities M(a,y). The same as used in the NFT run that is only increased mortality in 2009 and 2010, other wise 0.1 for all years and ages.

The oldest age A is regarded as a plus group and modelled as a dynamic pool with mortality equal to that of the oldest true age: N(A,y+1) = N(A,y)*exp(-M(A,y)-F(A-1,y)) + N(A-1,y)*exp(-M(A-1,y)-F(A-1,y)). The plus group is not included in the likelihood function. The likelihood function is a sum of squared log residuals. In the present configuration, they are not weighted according to their variance.

Different from the NFT-Adapt updated assessment run where the input data ranged from the 1987/88–2015/16, the data used in TASACS began in 1975/76, the year starts on 1st July (1st January in NFT), and ages 2-13+ from catches and surveys are used (3-

13+ in NFT). The survey takes place 1-January in NFT, but in December in TASACS and proportion mature and the fishery before the survey is set as 0.42.

Comparisons of different models and to runs from previous year:

The results of the assessments made in NFT-Adapt and TASACS were very similar (Figure 11.3.2.6). SSB follows the same trend and is at very similar level throughout almost the whole time-series. The main difference is in the years with high M (2009-2010) and is caused by different assumption of timing of the survey in the year, i.e. NFT-Adapt assume it is at the beginning of the assessment year while TASACS a half year earlier, but the consequence of this high M becomes similar as seen in 2011. SSB in the final year (2016) was 318 kt in NFT-Adapt and 337 kt in TASACS and the difference is related to that number-at-age 3 in the final year in NFT-Adapt of 464 millions was projected from the survey index from 2014 (see above) while TASACS used unrealistic high and poorly determined estimated number of 770 millions from number-at-age 2 in the survey (Figure 11.3.2.6).

The results of the final NFT run in 2016 were in a good agreement to the run in 2015 (Figure 11.3.2.2). The main difference is related to the number-at-age 3 in 2015 (Figure 11.3.2.2c), which was based on prediction from survey estimation of number-at-age 1 in the 2015 assessment while estimated by NFT in the 2016 assessment.

11.3.3 Final assessment

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. The model settings and outputs 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 0.22 in 2015 or at $\mathbf{F_{pa}}$=$\mathbf{F_{MSY}}$=0.22, which is the target. The low F during 2009 to 2011 was related to cautious TAC and apparently overestimation of mortality induced by the *Ichthyophonus* outburst. Notice that the estimated number of herring that died in Kolgrafafjörður in the two incidents of the mass mortalities (Óskarsson *et al*. 2013) were added to the catches in 2012 and is also included in the high F that year (Table 11.3.2.5 and Figure 11.3.2.2). The F related only to landings in 2012 came to approximately 0.22.

11.4 Reference points

Precautionary approach reference points:

The Working Group has pointed out that managing this stock at an exploitation rate at or above $F_{0.1}$=F_{MSY}=0.22 has been successful in the past, despite biased assessments. 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. At this year's NWWG meeting, the PA reference points were verified and revised (Óskarsson and Guðmundsdóttir 2016). On basis of the stock–recruitment relationship deriving from time-series ranging from 1947–2015, keeping B_{lim}=200 kt was considered reasonable as the Study Group on Precautionary Reference Points for Advice on Fishery Management concluded also in February 2003. Other PA reference points were derived from B_{lim} and these data in accordance to the ICES Advice Technical Guidelines and became these: B_{pa}= 273 kt ($B_{pa} = B_{lim} \times e^{1.645\sigma}$, where $\sigma = 0.19$); F_{lim} = 0.61 (F that leads to SSB = B_{lim}, given mean recruitment); F_{pa}= 0.43 ($F_{pa} = F_{lim} \times \exp(-1.645 \times \sigma)$, where $\sigma = 0.18$).

In relation to the reference points it should be noted that 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, but below the revised F_{pa}. This high F was despite the fact that the managers followed the scientific advice and restricted quotas with the aim of fishing at the intended target. Nevertheless, during this period, SSB 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. Development and testing of harvest control rule for the stock is also planned in 2016/2017

11.5 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 was 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. The continuing negative trend in the stock size since then, even if SSB is still above B_{PA}, is due to a simultaneously negative trend in size of incoming of year classes, which have been below average size since appearance of the 2007 year class.

11.6 Short-term forecast

11.6.1 The input data

The final adopted model, NFT-Adapt, which gave the number-at-age on January 1st, 2016, was used for the prognosis. All input values for the prognosis are given in Table 11.6.1.1. Like done in the 2015 assessment for the first time, the number-at-age 3 in the assessment year (2013 year class) was set as the predicted number from juvenile survey (detailed below) instead of using geometric mean.

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 even if bit lower than predicted in last year's assessment (Figure 11.6.1.1). The selection pattern used in the prognosis was based on averages over 2013 to 2015 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 2013 year class: An acoustic survey aimed for getting an abundance index for this year class took place in November 2014 (Óskarsson and Reynisson 2015), and using a relation obtained by Gudmundsdóttir *et al.* (2007) provides estimate of 464 million at age 3 in 2016.

The 2014 year class: An acoustic survey aimed for getting an abundance index for this year class took place in September-October 2015 (Óskarsson 2016), and using a relation obtained by Gudmundsdóttir *et al*. (2007) provides estimate of 391 million at age 3 in 2017.

The 2015 year class: No acoustic estimates are available for the year class yet thus the number-at-age 3 in 2018 was set to the geometrical mean for age-3 over 1987-2012, which give 596 million.

11.6.2 Prognosis results

SSB and biomass of age 3+ are estimated to be 318 kt and 393 kt, respectively, at the beginning of the fishing season 2016/17 (approximately the same as at spawning in July 2016). 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 2016/2017 of 63 kt and SSB at the spawning season in 2016 would be 303 kt, or just above B_{pa} of 300 kt.

The proposed composition of the catch in the season 2016/17 consists mainly of the 2008, 2009 and 2010 year classes, each contributing to 16–19% in total biomass of the catch (Figure 11.6.2.1). The small 2011 year class, at age 5, will only give 8% of the catches.

11.7 Medium term predictions

Prognosis was made for the stock until the spawning season 2019 (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 above B_{pa} and increase slightly throughout the period.

11.8 Uncertainties in assessment and forecast

11.8.1 Assessment

There are number of factors that could lead to uncertainty in the assessment. Three of them are addressed here. As done in the recent three assessments, additional natural mortality caused by the *Ichthyophonus* infection is only set for the first two years instead of all years since 2009. While this approach is considered to reduce the uncertainty in the assessment, quantification of the infection mortality needs to be improved in the future, and is ongoing currently. However, it should be noted that changing M for 2009 and 2010 changes the historical perception of the stocks size but has insignificant impacts on the assessment of the final year and the resulting advice (ICES 2014).

The apparent new infection in the stock in last two years is not considered to cause induced natural mortality in the stock and the fixed M of 0.1 is applied for those years. This decision was taken on basis of studies of the infection outbreak since 2009. The possibility of increased M for these two years can however not be fully rejected and must be considered to add uncertainty to the assessment.

The part of the acoustic survey estimate deriving from east of Iceland in the autumn 2015 and represented 14% of the total biomass index, was considered to be with higher uncertainty, even if not estimated, than normally and elsewhere (see above and in Óskarsson 2016). This produces a small increase in uncertainty, even if unquantifiable, of the analytical assessment of the stock.

11.8.2 Forecast

The uncertainty in the assessment mentioned above related to the apparent new infection in the stock in last two years and the survey uncertainty applies also for the forecast.

The number-at-age 3 at the beginning of 2016 used in the prognosis (464 millions) was predicted from a survey estimate of number-at-age 1 in 2014 in accordance with the approach described in the Stock Annex. The size of the year class is therefore poorly determined and creates some uncertainty in the forecast.

11.8.3 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 three 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 compared with recent years.

11.9 Comparison with previous assessment and forecast

This year's assessment was conducted in the same way as in last year. In the current assessment, SSB at the beginning of the year 2015 is 1% higher (346 kt vs. 342 kt), size of the 2010 year class 13% higher, size of the 2011 year class 37% higher, and WF_{5-10} in 2014 is 4% higher (0.255 vs. 0.266), compare to the 2015 assessment. Thus the assessment results are in a good agreement.

11.10 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 developed and proposed but such work is planned to be initiated in 2016.

11.11 Management consideration

Inspections indicate still a high prevalence of heart lesions related to *Ichthyophonus hoferi* in the herring stock, as in the last seven years. Last winter, and to some degree the winter before, new infection has been taken place in the stock, which has not been seen since 2011. Induced mortality due to the infection is considered insignificant for the years 2011–2016 in the assessment, but for the most recent two years such an induced mortality cannot be fully rejected yet and must be considered to add uncertainty to the assessment.

11.12 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. However, with respect of the impacts of the outbreak on the herring stock, significant additional mortality was estimated to have taken place only in the first two years (ICES 2014; Óskarsson and Pálsson 2013), despite a high prevalence of infection for now eight years. Thus, the infection that is still found in the stock (Óskarsson and Pálsson 2016) will most likely decrease and disappear over some years as the fish gets older. The observed new infection in the winter 2015/16 can however delay this process.

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 larger 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.

11.13 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). No such closures took place in 2015/2016. Another regulation deals with the quantity of bycatch allowed. Then there are regulation that prohibit use of pelagic trawls within the 12 nm fishing zone (no. 770, 8. September 2006), which is enforced to limit bycatch of juveniles of other fish species.

11.14 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 2014/2015 and 2015/2016 was different from the previous seven seasons. Instead of fishing near only in a small inshore area off the west coast in purse-seine, the whole directed fishery took place in offshore areas west of Iceland by pelagic trawls. These changes are not considered to affect the selectivity of the fishery because the fishery is still targeting dense schools of overwintering herring in large fishing gears, getting huge catches in each haul and is by none means size selective.

Bycatch of Icelandic summer-spawning herring in summer fishery for NE-Atlantic mackerel and Norwegian spring-spawning herring has been taken place since around mid-2000s. Until that time, no summer fishery on this stock had taken place for decades. This bycatch of summer spawners is partly on the stock components (e.g. juveniles and herring east of Iceland) that are not fished in the direct fishery on the overwintering grounds in the west. However, this bycatches are well sampled and contributes to less than 10% of the total annual catch (except for 13% in 2014/2015) so the impacts of these changes on the assessment are considered to be insignificant.

The fishing pattern varies annually as noted in section 11.2 and it is related to variation in distribution of the different age classes of the stock. This variation can have consequences for the catch composition but it is impossible to provide a forecast about this variation.

11.15 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 Northeast Atlantic mackerel (NEAM) feeding in Icelandic waters since 2007 (Astthorsson *et al*. 2012; Nøttestad *et al*. 2016). Surveys in the summers since 2010 indicate a high overlap in spatial and temporal distribution of NEAM and Icelandic summer-spawning herring (Óskarsson *et al*. 2016). Moreover, 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*. 2016). 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. On the contrary the mean weights-at-age of the summer spawners have been high, for example record high in the autumn 2014 (Figure 11.6.1.1), and the mean weight-at-length have also been relatively high in recent years (Óskarsson and Pálsson 2015). 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 NAO winter index (North Atlantic Oscillation) and 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).

11.16 Comments on the PA reference points

The WG dealt with reference points at this year's meeting as mentioned in section 11.4 and have revised them in accordance to the ICES Advice Technical Guidelines and they are considered reasonable. The analyses are detailed in Óskarsson and Gudmundsdottir (2016).

11.17 Comments on the assessment

The assessment implies that the stock size has been rather unvarying in recent years following a period of depletion related to the *Ichthyophonus* infection. This is related to average size recruiting year classes entering the fishable stock, no infection mortality, and moderate fishing mortality. The assessment follows fairly well the pattern in the tuning series for recent years (Figure 11.3.2.5). However, small year class from 2009–2012, particularly 2011, entering the spawning stock causes a decline in SSB even if it still above B_{pa}. The size of the small 2011 year class is less pessimistic in this assessment but the downward trend is foreseen anyway.

This year's research on the *Ichthyophonus* infection in the stock supports the approach taken since 2013 (ICES 2013; Óskarsson and Pálsson 2013) that additional natural mortality in the stock due to *Ichthyophonus* infection should only be applied for the first two years of the outburst. Further research is ongoing to quantify the infection mortality for these two years, but it is important to note that changing the mortality in the assessment has mainly impacts on the historical perspective of the stock size and insignificant impacts on the present stock status.

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, the reference points issue was in part revisited (see above), while the other issue was not dealt with. 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, TASACS, TSA and Coleraine; ICES 2011a) 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 overwintering in offshore areas off the east and west coast, compare to mainly easterly distribution before and overwintering in inshore areas there after (from 2006–2013). These positive blocks could therefore reflect changes in catchability of the survey for these years. This must be kept in mind for the years to come since the stock has now started again to overwinter in offshore areas.

11.18 References

Astthorsson, O. S., Valdimarsson H., Gudmundsdottir, A., Óskarsson, G. J. 2012. Climate-related variations in the occurrence and distribution of mackerel (*Scomber scombrus*) in Icelandic waters. ICES Journal of Marine Science. 69: 1289–1297.

Debes, H., Homrum, E., Jacobsen, J. A., Hátún, H., and Danielsen, J. 2012. The feeding ecology of pelagic fish in the southwestern Norwegian Sea – Inter species food competition between herring (Clupea harengus) and mackerel (Scomber scombrus). ICES CM 2012/M:07. 19 pp.

Gudmundsdottir, A. 2011. Icelandic summer-spawning herring: An analysis of the signals in the catch- and survey data and preliminary assessments. ICES, WKBENCH, 24-31 January, 2011, Lisbon, Portugal. WD Her-Vasu No. 3. 32 pp.

Guðmundsdóttir, Á., G.J. Óskarsson, and S. Sveinbjörnsson 2007. Estimating year-class strength of Icelandic summer-spawning herring on the basis of two survey methods. ICES Journal of Marine Science, **64**: 1182–1190.

ICES 2011a. Report of the Benchmark Workshop on Roundfish and Pelagic Stocks (WKBENCH 2011), 24–31 January 2011, Lisbon, Portugal. ICES CM 2011/ACOM:38. 418 pp.

ICES 2011b. Report of the North Western Working Group (NWWG), 26 April - 3 May 2011, ICES Headquarters, Copenhagen. ICES CM 2011/ACOM:7. 975 pp

ICES. 2012. Report of the North-Western Working Group (NWWG), 26 April - 3 May 2012, ICES Headquarters, Copenhagen. ICES CM 2012/ACOM:07. 1425 pp.

ICES. 2013a. Report of the North Western Working Group (NWWG), 25 April - 02 May 2013, ICES Headquarters, Copenhagen. ICES CM 2013/ACOM:0076.

ICES. 2014. Report of the North Western Working Group (NWWG), 24 April-1 May 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:07. 902 pp.

ICES. 2015. Report of the North-Western Working Group (NWWG), 28 April-5 May, ICES HQ, Copenhagen Denmark. ICES CM 2015/ACOM:07. 717 pp.

Jakobsson J. and G. Stefánsson 1999. Management of summer-spawning herring off Iceland. ICES J. Mar. Sci. **56**: 827-833.

Jones, S.R.M. and Dawe, S.C., 2002. *Ichthyophonus hoferi* Plehn & Mulsow in British Columbia stocks of Pacific herring, *Clupea pallasi Valenciennes*, and its infectivity to chinook salmon, *Oncorhynchus tshawytscha* (Walbaum). Journal of Fish Diseases 25, 415-421.

Langøy, H., Nøttestad, L., Skaret, G., Broms, C. and Fernö, A. 2012. Overlap in distribution and diets of Atlantic mackerel (*Scomber scombrus*), Norwegian spring- spawning herring (*Clupea harengus*) and blue whiting (*Micromesistius poutassou*) in the Norwegian Sea during late summer. Marine biology research, 8: 442–460.

MRI 2012. Environmental conditions in Icelandic waters 2011. Hafrannsóknir, 162. 51 pp.

Nøttestad, L., Utne, K.R., Guðmundur J. Óskarsson, Sigurður Þ. Jónsson, Jacobsen, J.A., Tangen, Ø., Anthonypillai, V., Aanes, S., Vølstad, J.H., Bernasconi, M., Debes, H., Smith, L., Sveinn Sveinbjörnsson, Holst, J.C., Jansen, T. og Slotte, A. 2016. Quantifying changes in abundance, biomass and spatial distribution of Northeast Atlantic mackerel (Scomber scombrus) in the Nordic seas from 2007 to 2014. ICES Journal of Marine Science, 73: 359-373.

Óskarsson, G.J. 2008. Variation in body condition, fat content and growth rate of Icelandic summer-spawning herring (*Clupea harengus* L.). Journal of Fish Biology 72: 2655–2676

Óskarsson, G.J. 2016. Results of acoustic measurements of Icelandic summer-spawning herring in the winter 2015/2016. ICES North Western Working Group, 27 April - 4 May 2016, Working Document No. 4. 55 pp.

Óskarsson, G.J., and A. Gudmundsdottir 2016. Determination of precautionary approach reference points for Icelandic summer-spawning herring (Her-Vasu). ICES North Western Working Group, 27 April - 4 May 2016, Working Document No. 27. 5 pp.

Óskarsson, G.J. and J. Pálsson 2013. Development and nature of massive and long-lasting Ichthyophonus hoferi outbreak in Icelandic summer-spawning herring. ICES North Western Working Group, 26 April - 3 May 2013, Working Document No. 2. 17 pp.

Óskarsson, G.J. and J. Pálsson 2015. Estimation on number-at-age of the catch of Icelandic summer-spawning herring in 2014/2015 fishing season and the development of Ichthyophonus hoferi infection in the stock. ICES North Western Working Group, 28 April - 5 May 2015, Working Document No. 2. 15 pp.

Óskarsson, G.J. and J. Pálsson 2016. Estimation on number-at-age of the catch of Icelandic summer-spawning herring in 2015/2016 fishing season and the development of Ichthyophonus hoferi infection in the stock. ICES North Western Working Group, 27 April - 4 May 2016, Working Document No. 3. 16 pp.

Óskarsson G.J. and P. Reynisson 2015. Results of acoustic measurements of Icelandic summer-spawning herring in the winter 2014/2015. ICES North Western Working Group, 28 April - 5 May 2015, Working Document No. 1. 32 pp.

Óskarsson, G.J. and C.T. Taggart 2010. Variation in reproductive potential and influence on Icelandic herring recruitment. Fisheries Oceanography. 19: 412–426.

Óskarsson, G.J., J. Pálsson, and Á. Guðmundsdóttir 2009. Estimation of infection by Ichthyophonus hoferi in the Icelandic summer-spawning herring during the winter 2008/09. ICES North Western Working Group, 29 April - 5 May 2009, Working Document 1. 10 p.

Óskarsson, G.J., P. Reynisson, and Á. Guðmundsdóttir 2010. Comparison of acoustic measurements of Icelandic summer-spawning herring the winter 2009/10 and selection of measurement for stock assessment. Marine Research Institute, Reykjavik, Iceland. An Internal Report. 14 p.

Óskarsson, G.J., P. Reynisson and J. Pálsson 2012. Compilation of acoustic measurements of Icelandic summer-spawning herring in the winter 2011/2012 and estimate of prevalence of Ichthyophonus infection in the stock. ICES North Western Working Group, 26 April - 3 May 2012, Working Document No. 20. 42 pp.

Óskarsson, G.J., Sigurðsson, Þ., Ólafsdóttir, S.R. and Valdimarsson, H. 2013. Two incidents of mass mortalities of Icelandic summer-spawning herring in Kolgrafafjörður in the winter 2012/2013. ICES North Western Working Group, 26 April - 3 May 2013, Working Document No. 1. 11 pp.

Óskarsson, G.J., A. Gudmundsdottir, S. Sveinbjörnsson & Þ. Sigurðsson 2016. Feeding ecology of mackerel and dietary overlap with herring in Icelandic waters. Marine Biology Research, 12: 16-29

Skagen, D. 2012. HCS program for simulating harvest control rules. Program description and instructions for users. Version HCS12_2. Available from the author.

Skagen, D.W. and Skålevik, Å (2009). A Toolbox for Age-structured Stock Assessment using Catch and Survey data (TASACS) Institute of Marine Research: Fisken og Havet FH2009-1. (http://www.imr.no/publikasjoner/andre_publikasjoner/fisken_og_havet/2009/nb-no).

11.19 Tables

Table 11.1.1.1. Icelandic summer-spawning herring. Acoustic estimates (in millions) in the winters 1973/74-2015/16 (age refers to the autumns). No surveys (and gaps in the time-series) were in 1976/77, 1982/83, 1986/87, 1994/95.

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
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
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
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
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
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

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
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
2014/15	152.422	90,269	330.084	260.919	259.079	187.905	111.955	91.629	37.855	76.680	30.366	10.619	22.799	10.108	1667
2015/16	381.900	164.221	174.507	312.350	225.836	215.207	93.743	62.753	75.339	41.961	15.696	26.756	20.159	5.401	1816

Table 11.1.1.2. Icelandic summers-spawning herring. Number of scales by ages and number of samples taken in the annual acoustic surveys in the seasons 1987/88-2015/16 (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
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

	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
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
2014/15	83	50	96	71	72	53	32	26	11	22	8	3	6	4	534	10	8	2
2015/16	229	112	131	208	148	123	47	32	32	22	13	7	12	4	1120	14	7	7§

***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.

§3 samples were taken in the east and south in this survey (B1-2016), while four were taken in the west and used also in the age–length key.

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			2014/2015§	95.0	95.0	83	83
1980	53.268	53.268			2015/2016	69.7	69.7	71	71
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					

Year	Landings	Catches	Recom. TACs	Nat. TACs	Year	Landings	Catches	Recom. TACs	Nat. TACs
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).

§ The landings and catches in 2014/2015 consist of transfer of 7 kt from the year before and 5 kt from the year to come, which explains the discrepancy to the TACs.

Table 11.2.2.1. 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

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Catch
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	17.827	89.432	51.257	43.079	51.224	41.846	34.653	27.215	24.946	15.473	13.575	2.595	0.253	125.369
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	72.058
2014	0.000	3.537	53.241	50.609	70.044	34.393	22.084	22.138	13.298	17.761	7.974	4.461	2.862	1.746	94.975
2015	0.089	6.024	29.89	53.573	43.501	43.015	15.533	10.76	8.664	8.161	6.981	2.726	2.467	1.587	69.729

*** Includes both the catches and the herring that died in the mass mortality in the winter 2012/13 in Kolgrafafjörður**

Table 11.2.2.2. 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

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2014		202	259	288	306	328	346	354	362	366	367	380	383	403
2015	107	203	249	275	299	313	329	347	352	358	361	368	380	378

Table 11.2.2.3. 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
1986–2015	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
2011–2015	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 final NFT-Adapt run in 2016 for Icelandic summer spawning herring.

VPA VERSION 3.3.0	INPUT FILE: D:\NFT\VPA\2016\RUN1\RUN1.DAT	
Model ID: Run0 - final last year - test.	Date of Run: 11-APR-2016	Time of Run: 14:58

Levenburg-Marquardt Algorithm Completed 5 Iterations
Residual Sum of Squares = 51.5991

Number of Residuals =	224	Number of Years =	29
Number of Parameters =	9	Number of Ages =	11
Degrees of Freedom =	215	First Year =	1987
Mean Squared Residual =	0.239996	Youngest Age =	3
Standard Deviation =	0.489894	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 (2016):

Age	Stock Predicted	Std. Error	CV
4	165038.237	0.824108E+05	0.499344E+00
5	98590.480	0.389051E+05	0.394613E+00
6	207453.606	0.713928E+05	0.344139E+00
7	168231.145	0.535604E+05	0.318374E+00
8	169986.144	0.528620E+05	0.310979E+00
9	64530.831	0.200462E+05	0.310645E+00
10	38048.067	0.122208E+05	0.321194E+00
11	31940.033	0.105191E+05	0.329338E+00
12	10337.521	0.653617E+04	0.632277E+00

Catchability values for each survey used in estimate:

INDEX	Catchability	Std. Error	CV
1	0.995048E+00	0.100122E+00	0.100620E+00
2	0.126132E+01	0.119572E+00	0.947991E-01
3	0.125871E+01	0.872105E-01	0.692855E-01
4	0.133669E+01	0.913517E-01	0.683419E-01
5	0.145707E+01	0.114556E+00	0.786210E-01
6	0.165918E+01	0.152462E+00	0.918903E-01
7	0.175855E+01	0.202623E+00	0.115221E+00
8	0.169599E+01	0.198723E+00	0.117172E+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 2016
  = Geometric Mean of First Age Populations
  Year Range Applied = 1991 to 2012

- 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 = 0.2692
F in Oldest True Age in Terminal Year = 0.3076

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 Mortality	Fishing Full F	Used In	Comments
3	0.500	0.061	0.0341	NO	Stock Estimate in T+1
4	0.800	0.453	0.2528	NO	Stock Estimate in T+1
5	1.000	0.393	0.2192	YES	Stock Estimate in T+1
6	1.000	0.393	0.2195	YES	Stock Estimate in T+1
7	1.000	0.386	0.2153	YES	Stock Estimate in T+1
8	1.000	0.369	0.2058	YES	Stock Estimate in T+1
9	1.000	0.426	0.2377	YES	Stock Estimate in T+1
10	1.000	0.411	0.2291	YES	Stock Estimate in T+1
11	1.000	1.000	0.5580	YES	Stock Estimate in T+1
12	1.000	0.551	0.3076		F-Oldest

Table 11.3.2.3. Icelandic summer spawners stock estimates (from NFT-Adapt in 2016) in numbers (millions) by age (years) at January 1st during 1987–2016.

YEAR\AGE	3	4	5	6	7	8	9	10	11	12	13+	TOTAL
1987	529.96	989.11	300.70	84.61	69.14	107.47	42.64	38.04	26.41	34.26	34.29	2257
1988	271.11	476.53	852.60	214.88	57.00	43.84	53.49	24.15	21.19	14.26	37.00	2066
1989	447.75	240.79	391.92	677.09	128.73	29.84	20.63	18.03	10.18	9.49	26.11	2001
1990	301.25	383.64	192.56	280.77	433.79	75.63	19.31	13.07	9.41	4.70	26.47	1741
1991	842.50	258.43	293.01	140.45	178.44	243.60	39.80	9.72	7.69	5.32	24.86	2044
1992	1035.54	678.09	187.26	183.33	94.09	109.11	116.26	26.46	4.87	4.37	24.20	2464
1993	638.40	846.87	497.17	133.02	110.35	58.67	62.34	54.96	12.97	2.77	23.68	2441
1994	694.70	529.05	597.59	361.89	100.62	72.76	40.46	37.82	35.26	7.71	22.93	2501
1995	204.67	500.83	371.21	405.20	244.73	67.42	46.59	21.18	19.36	18.01	23.16	1922
1996	183.09	165.25	323.05	253.48	263.15	148.68	40.76	27.73	11.08	8.43	27.61	1452
1997	779.37	150.50	111.29	210.58	164.01	157.89	96.92	22.91	17.11	4.51	22.28	1737
1998	325.56	667.91	107.57	75.75	155.67	116.41	113.42	66.56	12.66	12.27	10.17	1664
1999	566.05	251.48	437.90	75.80	60.36	102.07	80.72	72.25	46.33	9.44	13.69	1716
2000	409.59	458.68	175.57	262.70	53.32	41.80	62.54	54.22	44.49	29.97	12.08	1605
2001	499.49	316.22	285.86	112.14	165.07	37.29	29.95	41.07	39.69	29.51	26.34	1583
2002	1590.97	411.76	204.18	169.97	72.70	97.73	23.91	18.80	25.55	26.51	34.33	2676
2003	1194.77	1362.71	305.37	141.48	102.43	45.68	48.51	12.27	12.54	16.94	28.44	3271
2004	818.36	880.32	961.64	221.15	101.47	68.41	27.87	33.51	8.99	8.10	31.83	3162
2005	1180.20	680.28	664.06	696.97	161.68	78.78	53.03	19.74	23.66	5.16	27.99	3592
2006	963.46	1043.09	575.52	488.95	504.00	120.12	59.82	39.25	12.96	16.55	24.66	3848
2007	878.45	759.21	737.28	468.69	396.52	401.67	95.77	48.43	31.43	10.87	32.90	3861
2008	901.20	705.85	608.87	515.34	363.73	273.79	274.81	64.44	32.67	21.46	28.92	3791
2009	782.89	778.53	552.32	475.20	364.16	272.48	188.73	197.09	41.12	21.74	34.54	3709

2010	613.47	462.71	449.72	313.71	276.56	205.54	158.87	108.50	113.36	23.46	32.54	2758
2011	605.22	286.73	205.52	205.20	149.74	141.30	102.31	82.42	56.35	59.38	29.69	1924
2012	424.97	538.73	236.05	166.92	163.95	112.99	114.79	76.47	65.04	43.75	70.54	2014
2013	459.60	367.58	402.57	164.96	110.18	99.80	62.61	71.02	43.41	35.24	73.18	1890
2014	158.78	371.36	309.00	330.94	132.87	82.09	72.24	35.98	49.13	24.31	70.54	1637
2015	188.72	140.30	285.47	231.55	232.98	87.61	53.33	44.39	19.96	27.63	69.66	1382
2016*	464.22	165.04	98.59	207.45	168.23	169.99	64.53	38.05	31.94	10.34	74.97	1678

*** Number-at-age 3 in 2016 is predicted from an survey index of number-at-age 1 in 2013 (see section 11.6.1)**

Table 11.3.2.4. Estimated fishing mortality-at-age of Icelandic summer-spawning herring (from NFT-Adapt in 2016) by age (years) during 1987–2015 (referring to the autumn of the fishing season) and weighed average F by numbers for age 5–10.

Year\Age	3	4	5	6	7	8	9	10	11	12	13+	WF5-10
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	0.335	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	0.399
1991	0.117	0.222	0.369	0.301	0.392	0.640	0.309	0.592	0.466	0.502	0.055	0.435
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	0.316	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	0.398	0.403	0.419	0.548	0.731	0.525	0.154	0.341
1996	0.096	0.295	0.328	0.335	0.411	0.328	0.476	0.383	0.799	0.496	0.348	0.358
1997	0.054	0.236	0.285	0.202	0.243	0.231	0.276	0.494	0.232	0.308	1.033	0.247
1998	0.158	0.322	0.250	0.127	0.322	0.266	0.351	0.262	0.194	0.268	0.571	0.275
1999	0.110	0.259	0.411	0.252	0.267	0.390	0.298	0.385	0.336	0.352	0.712	0.370
2000	0.159	0.373	0.348	0.365	0.258	0.233	0.321	0.212	0.311	0.269	0.665	0.326
2001	0.093	0.337	0.420	0.333	0.424	0.345	0.366	0.375	0.303	0.347	0.433	0.397
2002	0.055	0.199	0.267	0.406	0.365	0.601	0.567	0.305	0.311	0.446	0.865	0.388
2003	0.205	0.249	0.223	0.232	0.304	0.394	0.270	0.212	0.337	0.303	0.227	0.253
2004	0.085	0.182	0.222	0.213	0.153	0.155	0.245	0.248	0.455	0.276	0.250	0.213
2005	0.024	0.067	0.206	0.224	0.197	0.175	0.201	0.321	0.257	0.239	0.188	0.213
2006	0.138	0.247	0.105	0.110	0.127	0.127	0.111	0.122	0.076	0.109	0.136	0.115
2007	0.119	0.121	0.258	0.154	0.270	0.280	0.296	0.294	0.281	0.288	0.324	0.244
2008	0.046	0.145	0.148	0.247	0.189	0.272	0.232	0.349	0.307	0.290	0.268	0.213
2009	0.036	0.059	0.076	0.051	0.082	0.050	0.064	0.063	0.071	0.062	0.055	0.065
2010	0.021	0.072	0.095	0.110	0.072	0.118	0.086	0.095	0.107	0.101	0.097	0.096
2011	0.016	0.095	0.108	0.124	0.182	0.108	0.191	0.137	0.153	0.147	0.106	0.136
2012	0.045	0.191	0.258	0.315	0.396	0.490	0.380	0.466	0.513	0.462	0.280	0.360
2013	0.113	0.074	0.096	0.116	0.194	0.223	0.454	0.269	0.480	0.356	0.317	0.164
2014	0.024	0.163	0.189	0.251	0.317	0.331	0.387	0.489	0.476	0.421	0.145	0.266
2015	0.034	0.253	0.219	0.220	0.215	0.206	0.238	0.229	0.558	0.308	0.108	0.219

Table 11.3.2.5. Summary table from NFT-Adapt run in 2016 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	843	424	310	107	0.34	0.44
1992	1036	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	372	272	65	0.24	0.25
1998	326	371	302	86	0.28	0.28
1999	566	379	295	93	0.31	0.37
2000	410	397	314	100	0.32	0.33
2001	499	363	283	94	0.33	0.40
2002	1591	552	317	96	0.30	0.39
2003	1195	637	427	129	0.30	0.25
2004	818	706	552	112	0.20	0.21
2005	1180	838	623	102	0.16	0.21
2006	963	971	751	130	0.17	0.11
2007	878	906	733	158	0.22	0.24
2008	901	980	789	151	0.19	0.21
2009	783	1001	669	46	0.07	0.07
2010	613	759	467	43	0.09	0.10
2011	605	523	401	49	0.12	0.14
2012 *	425	557	445	125	0.28	0.36
2013	460	503	402	71	0.18	0.16
2014	159	483	421	95	0.23	0.27
2015	189	400	346	70	0.20	0.22
2016	464	413	318			
Mean	632	561	430	99	0.24	0.28

*** The mass mortality of 52 thousand tons in Kolgrafafjörður in the winter 2012/13 is included in the landings, yield/SSB, and WF.**

§ Number-at-age 3 in 2016 is predicted from an survey index of number-at-age 1 in 2013 (see section 11.6.1)

Table 11.3.2.6. The residuals from survey observations and NFT-Adapt 2016 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	-0.167	-0.226	0.130	-0.288	-0.675	-0.231	-0.146	-0.421
1989	-0.174	-0.753	-0.804	0.091	0.066	-0.003	0.000	0.000
1990	0.540	-0.303	-0.237	0.022	0.489	-0.368	-0.001	-0.002
1991	-0.665	-0.357	-0.628	-0.222	0.371	0.184	0.008	-0.003
1992	0.442	0.406	0.327	-0.337	-0.139	0.287	-0.782	0.002
1993	-0.014	0.151	-0.053	-0.120	-0.456	-0.071	0.000	0.109
1994	-0.041	0.158	0.086	-0.697	-0.598	0.459	-0.308	-0.502
1995								
1996	-0.206	0.625	-0.138	0.090	-0.203	0.373	-0.005	-0.146
1997	0.592	-0.049	0.570	0.208	0.348	0.302	0.836	0.648
1998	-0.099	-0.515	-0.508	0.322	-0.084	0.078	-0.102	0.502
1999	0.023	0.672	0.080	-0.443	-0.095	-0.642	-0.223	-0.376
2000	0.609	0.077	0.606	0.213	-0.340	0.468	-0.059	0.475
2001	1.123	1.295	0.302	0.782	-0.458	-1.151	-0.644	-1.548
2002	-0.356	-0.169	0.197	0.505	0.887	0.454	0.547	-0.121
2003	0.347	0.362	0.144	0.650	0.833	1.233	1.525	0.806
2004	0.494	0.529	0.173	-0.217	0.011	-0.178	-0.257	-0.008
2005	0.053	0.199	0.177	-0.232	-0.609	-0.686	-1.154	-0.516
2006	-0.849	-0.744	0.285	0.595	0.475	0.208	0.630	1.205
2007	-0.217	0.131	-0.364	-0.222	0.170	-0.504	0.374	-0.089
2008	-0.430	-0.976	-0.180	-0.452	0.010	0.433	0.671	1.486
2009	-1.374	-0.514	-0.730	-0.062	-0.397	-0.327	-0.718	-0.846
2010	-0.377	-0.145	0.340	-0.309	0.089	-0.569	-0.822	-0.203
2011	-0.017	-0.125	0.166	0.392	-0.395	0.574	-0.866	0.391
2012	0.601	0.379	0.401	0.217	0.374	-0.209	0.264	-0.266
2013	0.759	0.218	-0.220	-0.148	-0.024	0.058	-0.253	0.009
2014	-0.160	-0.578	-0.189	-0.158	0.104	0.007	0.626	0.072
2015	-0.436	-0.087	-0.111	-0.184	0.387	0.235	0.160	0.112
2016	0.000	0.339	0.179	0.004	-0.141	-0.133	-0.064	0.330

Table 11.6.1.1. The input data used for prognosis of the Icelandic summer-spawning herring in the 2016 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 2016
3 (2013)	0.173	0.10	0.200	0.201	0.000	0.500	464.2
4 (2012)	0.248	0.10	0.850	0.782	0.000	0.500	165.0
5 (2011)	0.284	0.10	1.000	1.000	0.000	0.500	98.6
6 (2010)	0.304	0.10	1.000	1.000	0.000	0.500	207.5
7 (2009)	0.323	0.10	1.000	1.000	0.000	0.500	168.2
8 (2008)	0.334	0.10	1.000	1.000	0.000	0.500	170.0
9 (2007)	0.346	0.10	1.000	1.000	0.000	0.500	64.5
10 (2006)	0.360	0.10	1.000	1.000	0.000	0.500	38.0
11 (2005)	0.364	0.10	1.000	1.000	0.000	0.500	31.9
12 (2004)	0.368	0.10	1.000	1.000	0.000	0.500	10.3
13+ (2003+)	0.371	0.10	1.000	1.000	0.000	0.500	75.0

Table 11.6.1.2. Icelandic summer-spawning herring. Short-term prediction for the 2016/2017 season where the basis is: SSB (2016): 318 kt; Biomass age 3+ (2016): 393 kt (at spawning time); Catch(2015/16): 70 kt; WF5-10(2015)=0.219. The fishery has been managed on basis of F0.1=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 2016/2017	Basis	F 2016/2017	SSB 2017	%SSB change 1)	% TAC change 2)
MSY approach	63	F_{MSY}	0.22	303	-7	-12
F0.1	63	$F_{0.1}$=F_{pa}=0.22	0.22	303	-7	-12
Zero catch	0	F=0	0.00	358	9	
Status quo	63	F(2013)	0.16	303	-7	-12
Fmult	6	0.1 × (F0.1)	0.02	353	8	-1011
	15	0.25 × (F0.1)	0.05	345	6	-355
	33	0.5 × (F0.1)	0.11	329	1	-113
	49	0.75 × (F0.1)	0.17	315	-3	-42
	57	0.9 × (F0.1)	0.20	308	-6	-22
	68	1.1 × (F0.1)	0.24	299	-9	-4
	75	1.25 × (F0.1)	0.27	292	-11	7
	89	1.5 × (F0.1)	0.33	280	-16	22

1) SSB 2017 relative to SSB 2016.

2) TAC 2016/17 relative to landings 2015/16.

Table 11.6.1.3. Icelandic summer-spawning herring. Medium term prediction where the basis is: SSB(2016): 318 kt; Biomass age 3+ (2016): 393 kt (at spawning time); Catch(2015/16): 70 kt; WF5-10(2015)=0.219. The prognosis of the Icelandic summer spawning herring for the next fishing season (2016/2017; grey shaded) and the two subsequent seasons under five different options ($F_{0.1}$=0.22, constant TAC of 60 kt, 70 kt, 80 kt and 90 kt) from the final NFT-Adapt run in 2016. SSBs are in the spawning seasons, which is approximately the beginning of the subsequent fishing season.

2016/2017		Spawning 2017		2017/2018		Spawning 2018		2018/2019		Spawning 2019	
TAC	F	Biomass 3+	SSB (kt)	TAC	F	Biomass 3+	SSB (kt)	TAC	F	Biomass 3+	SSB (kt)
(kt)	(5–10)	(kt)		(kt)	(5–10)	(kt)	(kt)	(kt)	(5–10)	(kt)	(kt)
63	0.22	386	303	60	0.22	431	321	63	0.22	475	358
60	0.21	389	306	60	0.22	433	322	60	0.21	536	414
70	0.25	379	297	70	0.27	413	304	70	0.26	452	335
80	0.29	370	288	80	0.33	394	286	80	0.33	424	309
90	0.33	361	279	90	0.39	375	268	90	0.41	395	282

11.20 Figures

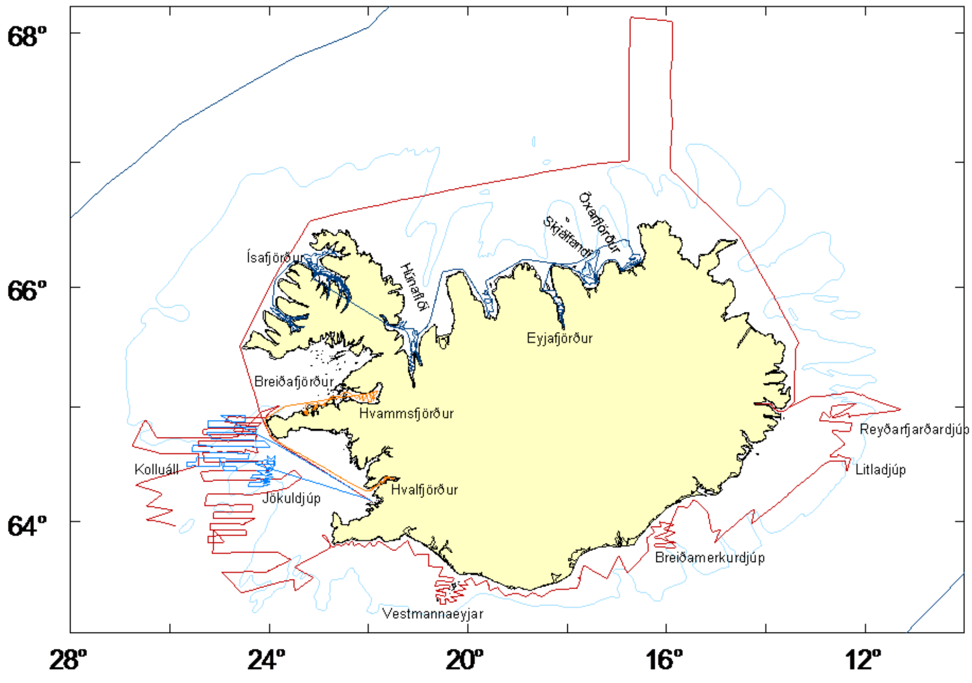


Figure 11.1.2.1. The survey tracks of five acoustic surveys on Icelandic summer-spawning herring in Sept.-Oct. 2016 (Surveys D4-2015 and D5-2015 on juveniles; blue line), October 2015 (D7-2015 on juveniles and adults; orange), January 2016 (B1-2016 on adults; red line) and in March 2016 (A4-2016 on adults; light blue line) and locations of the areas that are referred to in the text.

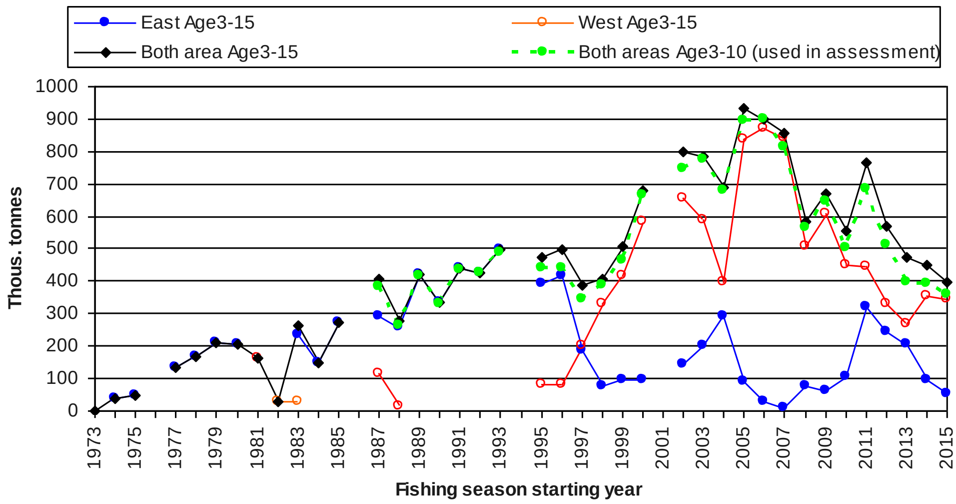


Figure 11.1.2.2 Total biomass index for Icelandic summer-spawning herring from the acoustic surveys for ages 3+ in the areas east and west of 18°W (except in 2011 and 2012 where fish outside Breiðafjörður was set to the eastern part), combined over all areas and age 3-10 which are used in tuning of the analytical assessment. The years in the plot (1973–2015) refer to the autumn of the fishing seasons.

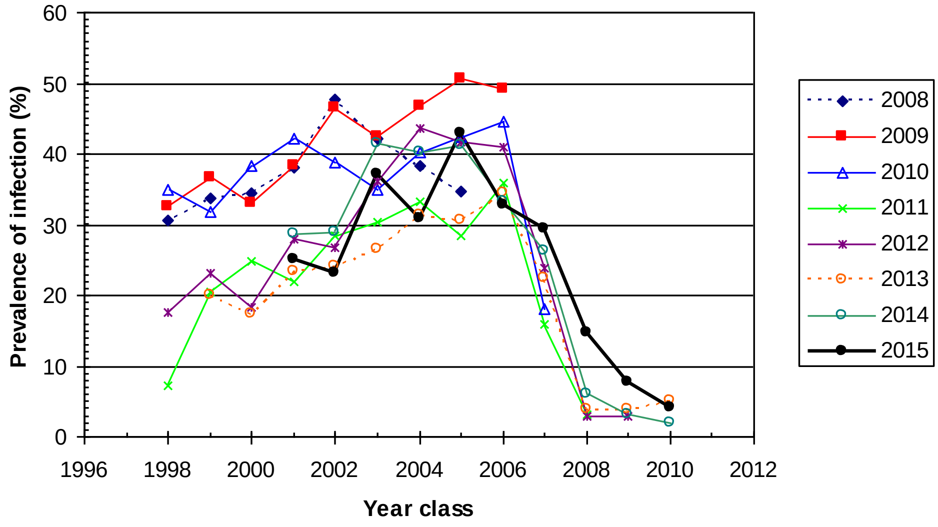


Figure 11.1.3.1. The prevalence of Ichthyophonus infection for the different year classes of Icelandic summer-spawning herring in Breiðafjörður and west of Iceland as estimated in the autumns 2008–2015.

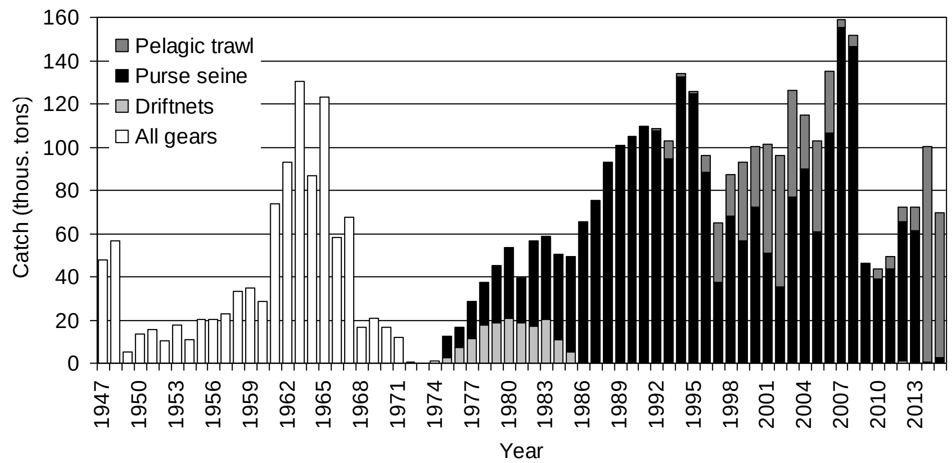


Figure 11.2.1. Icelandic summer spawning herring. Seasonal total landings (in thousand tonnes) during 1947-2015, referring to the autumns, by different fishing gears (from 1975–2015).

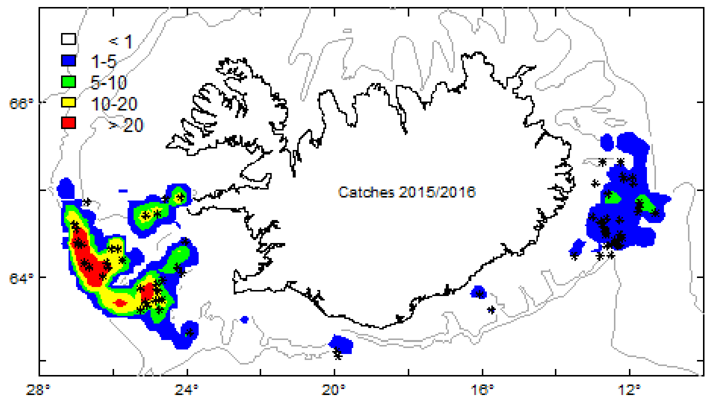


Figure 11.2.2. The distribution of the fishery (in tonnes) of Icelandic summer spawning herring during the fishing season 2015/16, including the bycatch in the mackerel fishery in June-September 2015, where the stars indicate the location of catch samples.

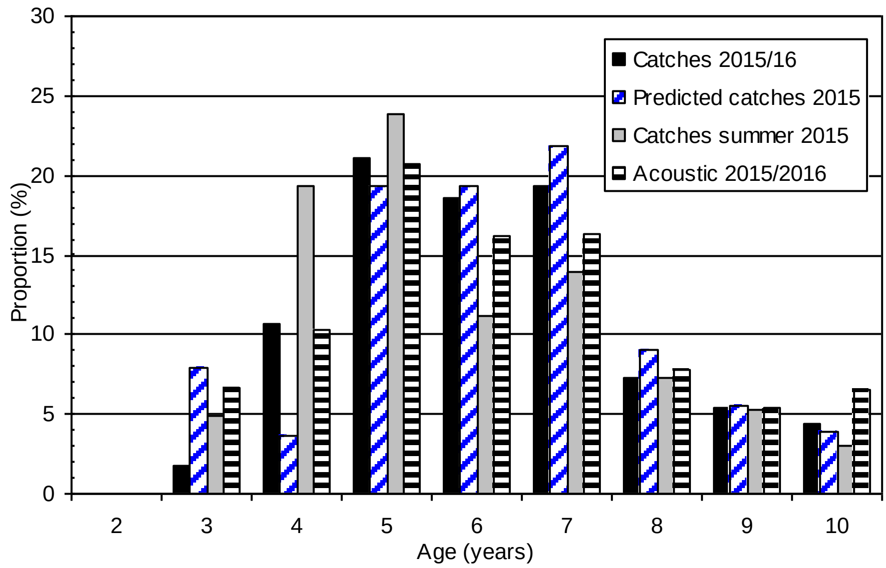


Figure 11.2.2.1. Proportion of the different age groups of Icelandic summer-spawning herring to the total catches (biomass) as observed in 2015/2016 fishing season (June 2015-Februay 2016), predicted in the 2015 assessment (ICES 2015) for the 2015/2016 fishing season, and the summer catches in June-September 2015 compared with the age composition in the stock according to the acoustic measurements in the winter 2015/2016.

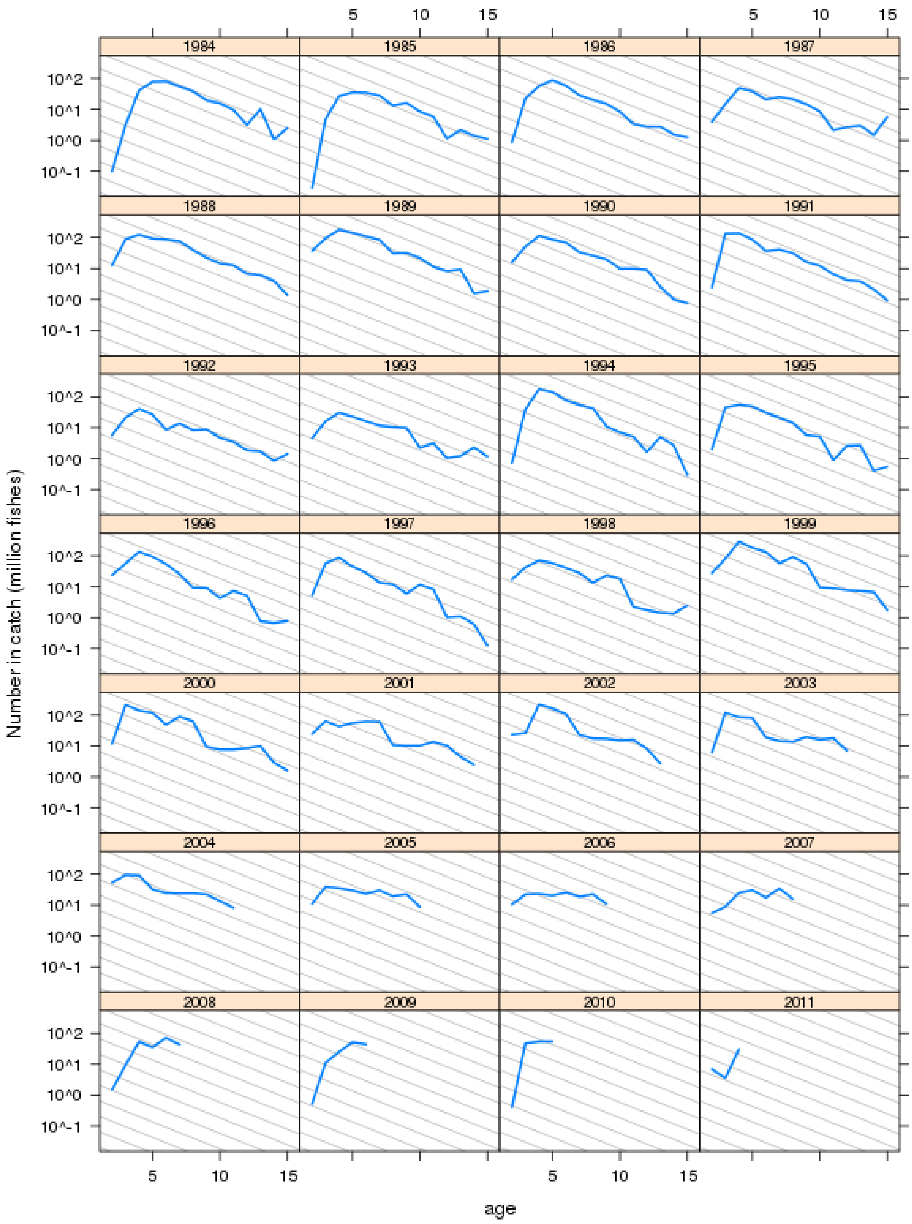


Figure 11.3.1.1. Icelandic summer-spawning herring. Catch curves by year classes 1984–2011. Grey lines correspond to Z=0.4. Note that the mass mortality in Kolgrafafjörður is added to the catches in 2012.

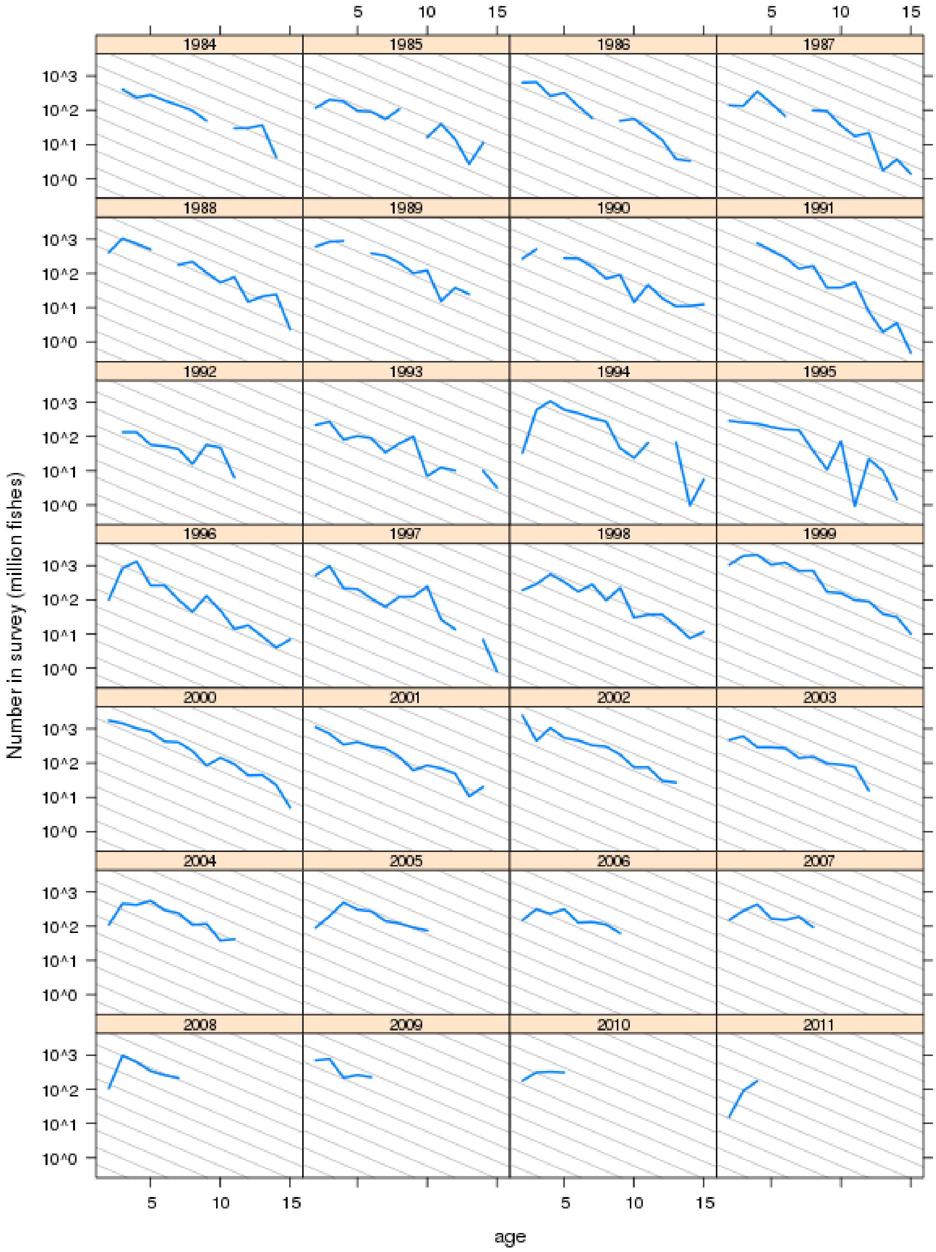


Figure 11.3.1.2. Icelandic summer spawning herring. Catch curves from survey data by year classes 1984-2011. Grey lines correspond to Z=0.4.

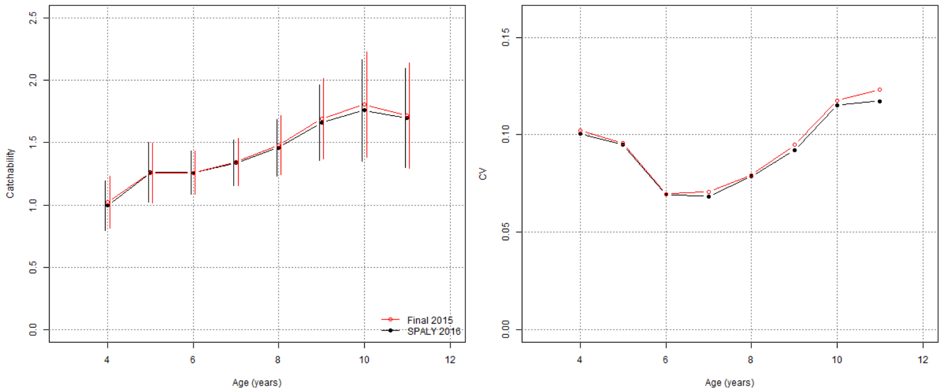


Figure 11.3.2.1. Icelandic summer-spawning herring. The catchability (± 2 SE) and its CV for the acoustic surveys used in the final Adapt run in 2016 (1987-2015) compare to the assessment in 2015.

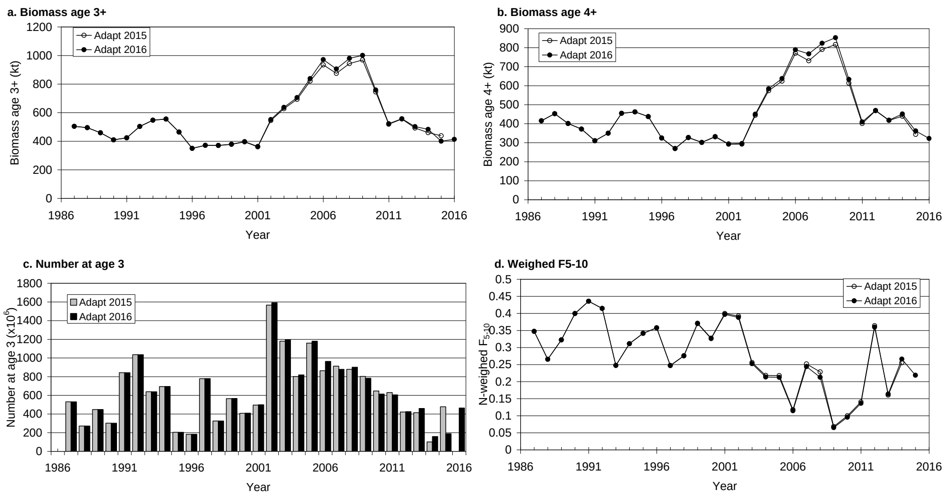


Figure 11.3.2.2. Icelandic summer-spawning herring. Comparisons of the final NFT-Adapt runs in 2016 and in 2015 concerning (a) biomass of age 3–12, (b) biomass of age 4–12, (c) number-at-age 3, and N-weighed F for age 5-10. Note that the mass mortality in Kolgrafafjörður in the winter 2012/13 is included in weighed F for that year (WF5-10 without the mass mortality was ~0.22) and the number-at-age 3 in 2015 from Adapt 2015 was geometric mean while number-at-age 3 in 2016 was predicted from juvenile index (see section 11.6.1).

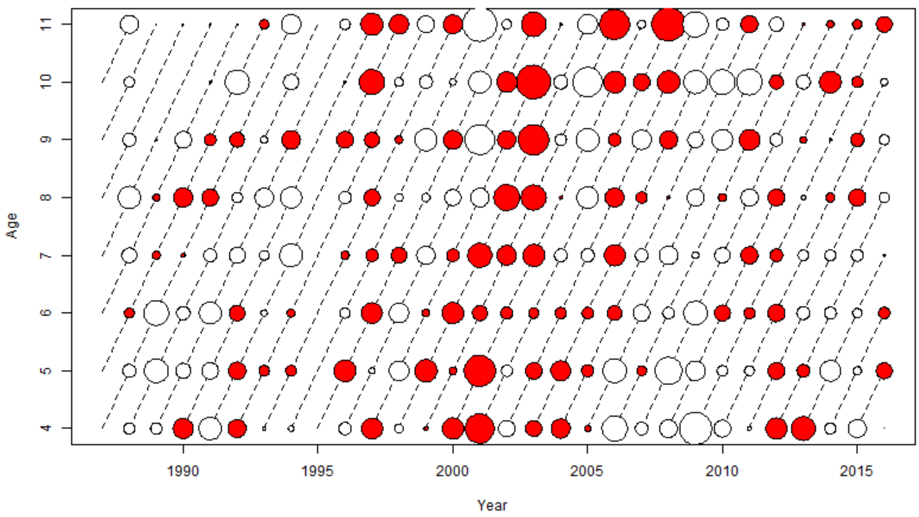


Figure 11.3.2.3. Icelandic summer spawning herring. Residuals of NFT-Adapt run in 2016 from survey observations (moved to 1st January). Filled bubbles are positive and open negative. Max bubble = 1.55.

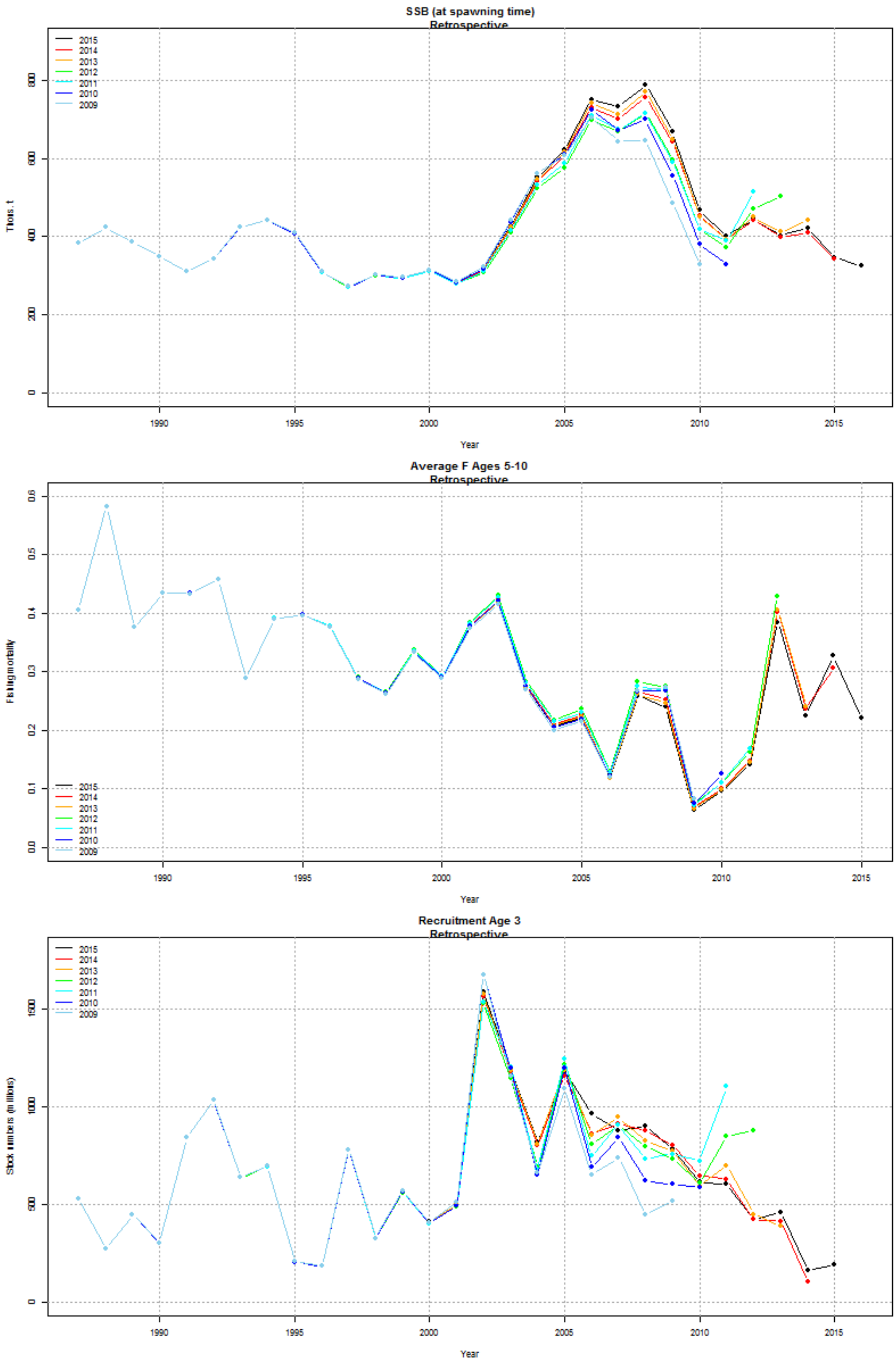


Figure 11.3.2.4. Icelandic summer spawning herring. Retrospective pattern from NFT-Adapt in 2016 in spawning-stock biomass (the top panel), N weighted F5-10 (middle panel) and recruitment as number-at-age 3 (lowest panel).

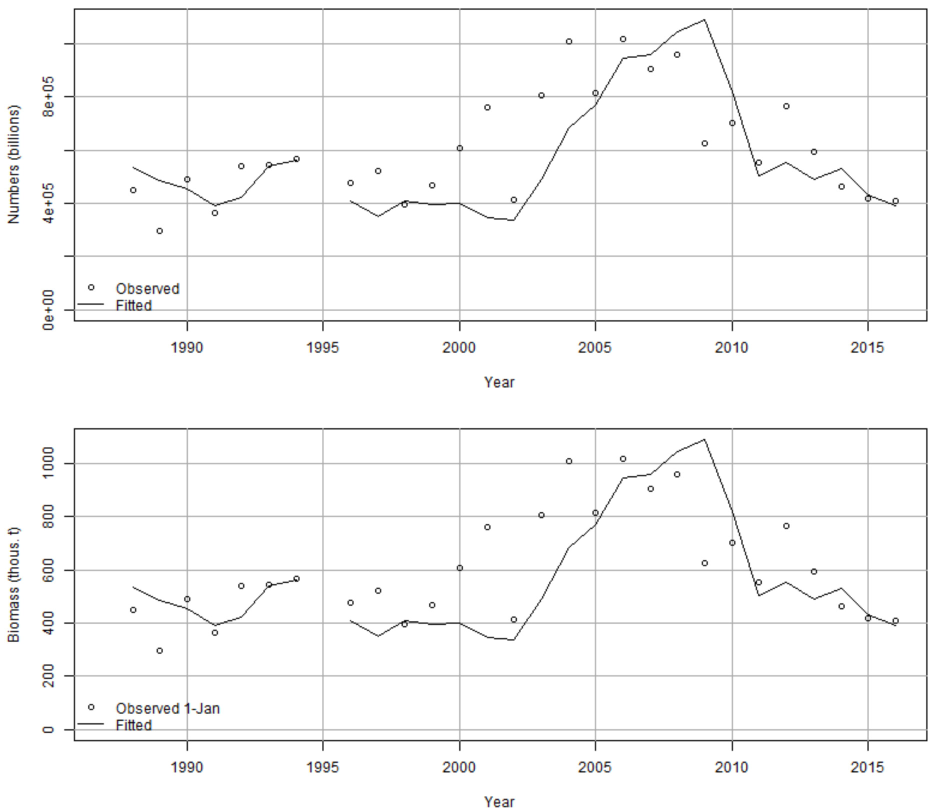


Figure 11.3.2.5. Icelandic summer-spawning herring. Observed vs.. predicted survey values from NFT-Adapt run in 2016 for ages 4–11 with respect to numbers (upper) and biomass (lower).

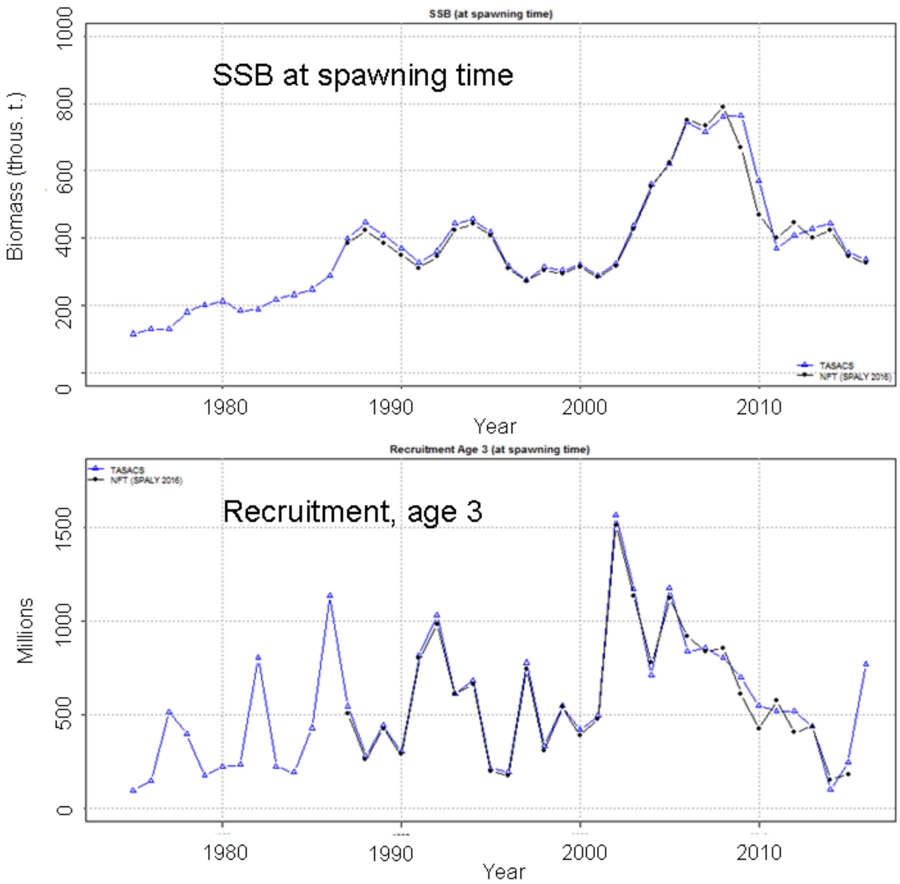


Figure 11.3.2.6. Icelandic summer-spawning herring. Comparison of SSB (upper panel) and recruitment (lower panel) from the final NFT-Adapt run in 2016 (dark blue circles) and TASACS run in 2016 (light blue triangles).

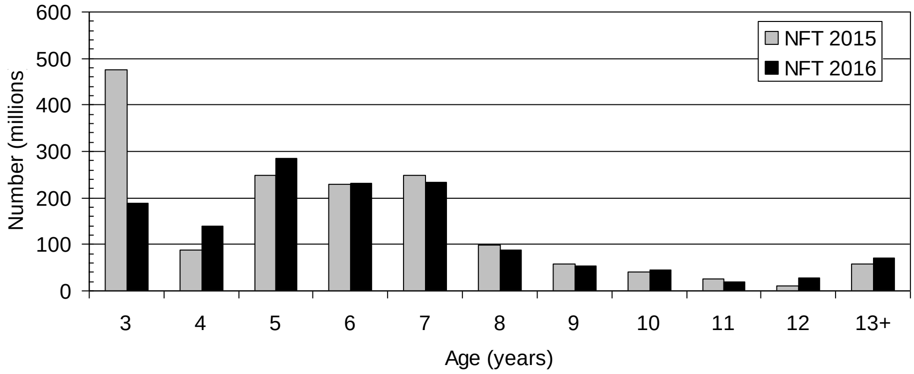


Figure 11.3.2.7. Icelandic summer-spawning herring. Comparison of number-at-age on Jan. 1st. 2015 from the final NFT model runs in 2015 and 2016 assessments.

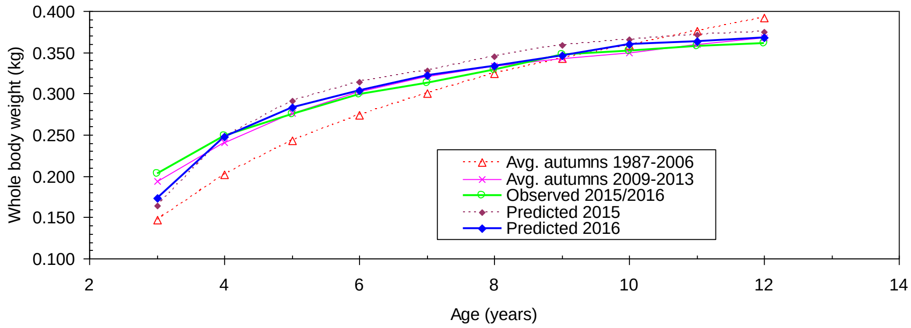


Figure 11.6.1.1. Icelandic summer spawning herring. The mean weight-at-age for age groups 3–12 (+ group) in 1987–2006, 2009–2013, in the catches in the winter 2015/2016, predicted weights for the winter 2015/2016 in the 2015 assessment (ICES 2015) and finally predicted weights for the autumn 2016 from the weights in 2015, which was used in the stock prognosis.

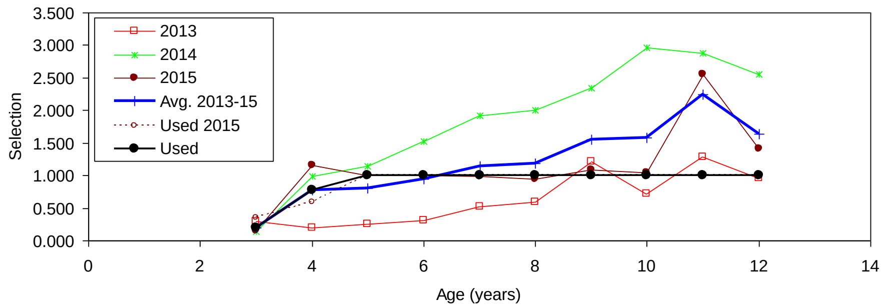


Figure 11.6.1.2. Icelandic summer spawning herring. The selection pattern for age groups 3–12 (+ group) for the years 2013–2015, the average selection across these three years, the selection used in 2015, and the selection used in the prognosis 2016 (three years average for age 3 and 4, but fixed at 1.0 for age 4+).

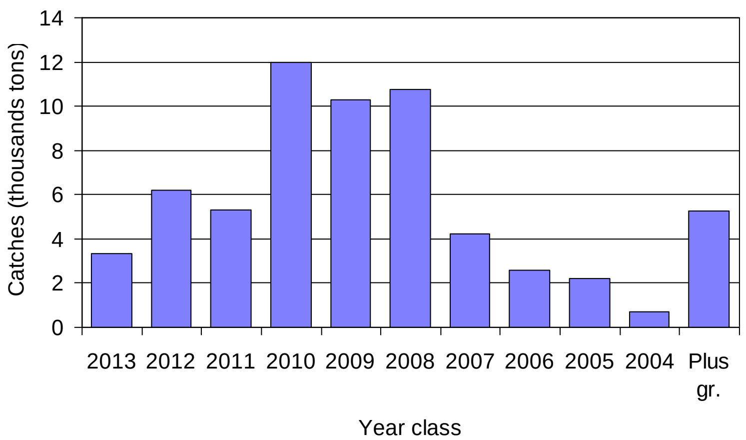


Figure 11.6.2.1. Icelandic summer spawning herring. The predicted biomass contribution of the different year classes to the catches in the fishing season 2016/2017 (total catch of 63 thousand tons).

12 Capelin in the Iceland–East Greenland–Jan Mayen area

12.1 Stock description and management units

See stock-annex.

12.2 Fishery-independent abundance 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). An overview is given in the stock annex.

12.2.1 Surveys in autumn 2015

Two autumn surveys were conducted in 2015 with the aim of assessing both the immature and the maturing part of the stock. Since 2010 the autumn surveys have started in September, a month earlier than in previous years.

12.2.1.1 Autumn survey during 16. September – 4. October.

The survey area was on and along the shelf edge off East Greenland from about 73° 30′N to about 65°30′ N and between 16°and 30°W including the Greenland Strait and the slope off western and north Iceland to about 16°W (Bardarson and Jonsson 2016a). Weather conditions during the survey were adverse but for the first few days and the survey had to be discontinued several times because of storms. Furthermore, drift ice in the northern part of the surveyed area (north of 72°N) restricted the coverage in that region. Both the drift ice and storms delayed the progress of the cruise.

Figure 12.2.1 shows the cruise tracks, distribution and relative density of the capelin of all ages and maturity stages. Immature capelin was found in unusually small numbers (6.2 billion, Tables 12.2.1 and 12.2.2 and Figure 12.2.2), mainly in the southwestern part of the surveyed area. Further north along the Greenland shelf up to 73°N older, maturing capelin predominated. No capelin was recorded off N-Iceland east of 21° W. The distribution of the capelin was very westerly both for the 1-group and older capelin as it was in recent years (2010–2014) while unlike 2014 now no capelin was recorded in the more traditional areas north of Iceland. In this survey around 550 thousand t of mature capelin were estimated (Tables 12.2.1–12.2.3).

The estimates of both mature and immature capelin are considered to be minimum estimates (likely underestimates) because the survey did not reach the edge of their respective distributions. The edge of the mature capelin stock was not reached towards north and west, and the edge of the immature part of the stock was not reached towards west and south (Figure 12.2.2).

On the basis of the estimate of the maturing part of the stock the Marine Research Institute recommended an intermediate TAC of 44 thousand t for the fishing season 2015/2016. This recommendation was in accordance with existing HCR and management plan between Iceland, Norway and Greenland.

12.2.1.2 Autumn survey during 17–29. November

This survey was limited by adverse weather and fast moving drift ice (Bardarson 2016). The survey covered the Denmark Strait and the slope off western and north Iceland from about 29°30′ W to 17° W and from 66°10′ N (in western part) towards 68°30′ N (eastern part) (Figure 12.2.1). At the beginning of the survey the edge of the drift ice was close to the centre of Denmark Strait but soon the ice started to drift southwards into the Denmark Strait, hence it was attempted to measure that region as early as possible eastwards through the Denmark Strait. The 20th November a southward moving protrusion of the drift ice hindered further eastward progression of the survey, limiting the exploration of that region to the shelf edge north of Westfjords. Subsequently the shelf edge north of Iceland was surveyed to the east of Kolbeinsey Ridge and then northwards to about 68°30′ N where further exploration had to stop due to a heavy storm. Finally, an attempt was made to cover the Denmark Strait again. This second attempt was restricted because of strong winds. The high densities that were found in the area during the first part of the survey were not found, suggesting that they were missed due to the wind conditions or because the fish had moved. The weather forecasts gave no hope for working conditions in the region for at least the next week, consequently the survey was ended and the ship returned to Reykjavik harbour the 29th November.

Capelin was only observed west of 23°W. About 6.1 billion of immature capelin were measured mainly in the southwestern part of the surveyed area, while it was mixed with mature capelin further northeast. Mature capelin predominated along the shelf edge northwest of the Westfjords peninsula, just out of the Kögurgrunn and Hali shelf areas. In this survey about 295 thousand t of mature capelin was measured. No capelin was found on the transect furthest to the west in Denmark Strait nor along the continental shelf edge north of north-Iceland

Given the limitations of coverage due to weather and ice conditions this survey estimate was not used for TAC advice.

12.2.2 Surveys in winter 2016

Two winter surveys were conducted in year 2016 with the aim of assessing the maturing part of the stock.

12.2.2.1 Winter survey during 3–21. January.

The survey area was in Denmark Strait and the slope off western and north Iceland from about 27° W to 12°30′ W and from 66°15′ N to 68° N (Bardarson and Jonsson 2016b). The survey was initiated by scouting of 5 vessels on transects with 20 nautical mile intervals. Followed by acoustic measurement from Kolbeinseyridge to Denmark Strait giving low quality acoustic data due to wind and rough seas. During 13–20. January the whole area eastwards from Denmark strait to Bakkafloadjup, northeast of Iceland was measured in calm seas and exceptionally good conditions that provided optimal conditions for collection of high quality acoustic data of the maturing part of the stock.

Main abundance of capelin was observed from the Denmark Strait to about 20 nautical mile west of Kolbeinsey ridge, while more scattered schools were found east of the ridge. Immature capelin estimated as 9.4 billion individuals dominated in the western part of Denmark Strait, but was mixed with mature capelin further east and along the shelf edge of the Westjords peninsula. Mature capelin predominated deep off Kögurgrunn shelf area and eastwards along the continental shelf edge off north- and north-east-Iceland. In this survey about 675 thousand t of mature capelin was measured. Direction and speed of capelin migration was not quantified. Simultaneous eastward migration of the capelin might have led to overestimate in stock size.

As the autumn survey used for calculating the intermediate TAC had limited coverage of the maturing stock the final TAC was based only on this winter survey. On the basis of this estimate of the mature stock and catch taken between autumn and winter survey the Marine Research Institute recommended a TAC of 173 300 t for the fishing season 2015/2016. This recommendation was in accordance with existing HCR established by WKICE (ICES, 2015).

12.2.2.2 Winter survey during 1–15. February

Although the first winter survey was conducted under optimal conditions, the Icelandic fishing industry offered to fund a second winter survey.

Acoustic measurements were made by two research vessels assisted by scouting of one Greenlandic fishing vessel. The survey area extended from Denmark Strait eastwards along the shelf break off north Iceland and southward along the shelf break off east Iceland (Bardarson and Jonsson 2016c). Also, shallower shelf areas were scouted.

Both research vessels left harbour on 1st February. Arni Fridriksson started acoustic measurements the 2nd February eastward from Vikurall the most western part of the survey area, but Bjarni Saemundsson started the 3d February northward from Seydisfjardardypi furthest to southeast. During 5th–7th of February strong winds and heavy seas forced Arni Fridriksson to stop measurements and head to Isafjordur for shelter, also Bjarni Saemundsson had to stop measurements and seek shelter in Thistilfjordur from the evening of 4th February until noon of 5th February. The 9th of February the research vessels met by parallel transects off Strandagrunn giving in total one coverage of the shelf edge survey area. Given scarce observations of capelin west of Kolbeinsey ridge, it was decided to measure again the area east of Iceland where the most capelin abundance had been observed, aiming at more precise measurements with denser transects by two research vessels assisted by one scouting fishing vessel. The second coverage of east Iceland started by both research vessels furthest to the south in the survey area (following information from fishing vessels in the area) on the morning of 10th February with 5 nautical mile distance between transects where each vessel sailed every second transect. Weather conditions became difficult early on and in several occurances during this coverage research vessels had to stop measurements for several hours each time. Capelin observations in shallower areas lead to extension of coverage into the shallower area in the vicinity of Nordfjardardjup and scouting within shallow areas further north. The 12th of February, Bjarni Saemundson finished participation due to other projects, but Arni Fridriksson and Polar Amaroq continued further to north with more distant transects as capelin observations decreased.

Given the limitations of coverage due to weather conditions this survey estimate was not used for TAC advice.

12.3 The fishery (fleet composition, behaviour and catch)

An initial catch quota of 54 000 t was recommended for the 2015/2016 fishing season, but 300 000 t was agreed upon. This was changed to an intermediate quota of 44 000 t in autumn 2016, and then updated to a final quota of 173 300 t in winter 2017. 174 thousand t were caught in total in the 2015/2016 fishing season.

In summer 2015 more than two weeks of search for capelin by Danish vessels resulted in 0 t catch. Further, in autumn 2015, a Greenlandic vessel caught 900 t in Denmark Strait.

The distribution of the winter catches, based on logbooks for the Icelandic fleet, is shown in Figure 12.3.1. The beginning of the 2016 winter fishery had a slow start due to a low intermediate TAC based on the autumn survey. Most vessels therefore waited for results from the January survey. During last week of January and first 3 weeks of

February the Norwegian, Greenlandic and Faroese fleets caught the bulk of their quota, mainly east of Iceland, where at times the capelin became available for seine fishing although often restricted by weather.

In week 8 the Icelandic fleet was fishing from schools of capelin close to shore south off Iceland. This migration moved westward and was followed by the fishery south of the coast of west-Iceland and ended west of Breidafjordur in weeks 11–12. This spawning migration seemed not to be composed of large or dense schools. The total landings of the 2015/2016 fishing season amounted 174 000 t (preliminary information), which is far below the average of catches since the beginning of the fishery.

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.

Sampling from commercial catches is not considered to be adequate. 19 samples from Icelandic and Greenlandic vessels have been analysed by MRI in Iceland (length measured and age read), although samples from Norway and Faroes have not yet been processed.

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 2016 as in the survey in January 2016.

Preliminary and final TAC as well as landings for the fishing seasons since 1992/93 are given in Table 12.3.4.

12.4 Biological data

12.4.1 Growth

Seasonal growth pattern, with considerably increased growth rate during summer and autumn has been observed in this capelin stock in a study of the period 1979–1992. Where immature fish had slower growth during winter, the maturing fish had faster summer growth that continued throughout the winter until spawning in March/April, followed by almost 100% spawning mortality (Vilhjalmsson, 1994). Further, examination of the growth of immature capelin at age 1 in autumn to mature at age 2 in autumn the year after in the period 1979–2013 showed on average almost 4 fold weight increase during one year (Gudmundsdottir and Thorsteinsson, WD in 2014). This considerable weight increase and seasonal pattern in growth the year before spawning should be taken into account when deciding the timing of the capelin fisheries.

Seasonal variation of fat content is also observed. During the summer period, the fat content rises from approximately 5%–20% in late autumn before spawning (Engilbertsson *et. al*. 2012). In the 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%–5% in mid-April. Immature capelin has much lower fat content, usually less than 3–4%.

12.5 Methods

The objective of the HCR for the stock is to leave at least 150 000 t (=B_{lim}) for spawning (escapement strategy). The initial (preliminary), intermediate and final TACs are based on acoustic surveys.

a) The initial TAC for the coming fishing season is advised in May based autumn survey abundance estimate of immature 1 and 2 year old capelin.

b) The intermediate TAC is advised in autumn based on the biomass estimate of maturing capelin.
c) The final TAC is advised in January/February based on the biomass estimate of maturing capelin.

The initial (preliminary) quota follows a simple forecast that is based on the relation between historic observations of age 1 and 2 juvenile abundance from the acoustic autumn surveys and the corresponding final TACs nearly 1½ year later. This was done in ICES NWWG 2016 to set the initial quota for the fishing season 2016/17. Figure 12.8.1 shows this relation and the associated precautionary initial quota (blue line).

The intermediate and final TACs are set so that there is at least 95 % probability that there will be 150 000 t (=B_{lim}) of mature capelin left for spawning at the spawning time (15 march). This was done for the first time in 2015/2016 by the Icelandic Marine Research Institute and was not evaluated by ICES.

These methods were endorsed by the benchmark working group WKICE in 2015. See WKICE (ICES, 2015) and the Stock Annex for the capelin in the Iceland-East Greenland-Jan Mayen area.

Previously, (since early 1980s) the stock has been managed according to an escapement strategy, leaving 400 thousand t to spawning (uncertainty of the estimates were not considered). To predict the TAC for the next fishing season a model was developed early 1990s. These models were not endorsed by the benchmark working group WKSHORT 2009.

12.6 Reference points

During WKICE (ICES, 2015) B_{lim} of 150 000 t was defined. No other reference points are defined for this stock.

12.7 State of the stock

It was estimated that 304 thousand t were left for spawning in spring 2016 (Table 12.7.1).

Acoustic estimation of the immature part of the stock was difficult due to adverse weather and ice conditions. The results indicate very low abundance of immature capelin.

12.8 Short-term forecast

The acoustic estimate of immature capelin at age 1 and 2 from the autumn survey in September 2015 was 6.2 billion which is considered a minimum estimate due to the incomplete coverage and adverse weather and ice conditions. The estimate is well below the trigger value of 50 billion and the advice according to the HCR is therefore no capelin fishery in the fishing season 2016/17 (Figure 12.8.1).

12.9 Uncertainties in assessment and forecast

The uncertainty of the assessment and forecast depends largely on the quality of the acoustic surveys in terms of coverage, conditions for acoustic measurements and the variance of aggregation of the capelin.

The uncertainty, mainly deriving from the variance of aggregation of the capelin, is estimated by bootstrapping (see stock annex). The CV for the immature abundance was estimated 0.19 in the 2015 autumn survey. The CV for the mature biomass was estimated 0.26 in the 2015 autumn survey and 0.16 in the 2016 winter survey.

The autumn survey had an incomplete coverage of both the immature and maturing stock components due to drift ice and weather. Furthermore, the winter survey only measured the capelin in an eastwards direction. Simultaneous eastward migration of the capelin might have led to an overestimation of the stock size

12.10 Comparison with previous assessment and forecast

For the fishing season 2015/2016 an initial quota of 54 000 t were advised, the intermediate TAC was 44 000 t (Gudmundsdottir *et. al*. 2016) and the final TAC was set to 173 300 t. (Bardarson *et. al*. 2016). The landings were 174 000 t.

12.11 Management plans and evaluations

See section 12.5.

12.12 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 have resulted in the setting of an initial (preliminary) catch quota. During summer, 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.

Timing of fishery should consider that; taken into account the large weight increase in the summer before spawning (section 12.4) it is likely that there will be more biomass of maturing fish in autumn than before the summer, although predation during the summer imposes a biomass loss. A calculation of the scale and timing of this biomass development through the fishing season cannot be done before new consumption estimates are provided. This is also supported by information for the Barents Sea capelin where it has been shown 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 and role in the ecosystem of these two capelin stocks are similar, this is considered to be also valid for the Icelandic capelin.

During the autumn surveys juveniles and adult capelin are often found together. This should be considered during summer fishing because the survival rate of juvenile capelin that escape through the trawlnet is unknown.

12.13 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).

The importance of capelin in East Greenlandic waters remains to be investigated.

In Icelandic waters, capelin is the main single item in the diet of Icelandic cod, a key prey to several species of marine mammals and seabirds and also important as food for several other commercial fish species (see e.g. Vilhjálmsson, 2002).

12.14 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 juvenile capelin 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.

12.15 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 2015/16 amounted 174 kt (preliminary numbers) (93% purse-seine, 7% pelagic trawl). Discards are considered negligible.

12.16 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 a spatial shift in spawning and nursery areas (Vilhjálmsson, 2007). The acoustic surveys in autumn 2010, 2012–2015 partly confirmed the change in distribution of immatures and maturing capelin. Fisheries data suggests that the major part of the spawning still takes place on the usual grounds.

More detailed environmental description is in section 7.3.

12.17 Recommendations

In coming years when experience of the new HCR will be gained it is recommended that assumptions and practical operation of the HCR will be evaluated. E.g. predation/pray relationships and how SSB estimates from autumn and winter surveys should be weighted when final TAC is defined.

Studies of optimal harvesting of capelin should be conducted. These estimates should take account of growth, mortality and gear selection in relation to the timing of the fishery. Furthermore, should the role of capelin in the ecosystem be quantified to allow for a recommendation on the biomass of capelin that should be reserved for predators and whether the population size and growth of capelin predators shows a response to changes in capelin abundance.

The assessment and advice on the final TAC for capelin based on the autumn and winter surveys are issued directly to the Coastal States by the Icelandic Marine Research Institute. This process is not internationally peer reviewed prior to the release of the advice. Among the reasons for using this process is the need for fast advice once the survey result is available. The ICES ACOM procedure is more time consuming. NWWG therefore recommends that a fast track workflow based on online meetings is established if possible.

When considering the effort of research surveys for assessment of the capelin stock in 2015/2016 the initial allocation of enough effort in terms of ship time, number of ships and manpower, is recommended such that full coverage in first attempt is more likely both during autumn and winter surveys, given the demanding weather and ice conditions.

12.18 References

Bardarson, B., and Jonsson, S.Th. 2016a. Acoustic assessment of the Iceland-Greenland-Jan Mayen capelin stock in autumn 2015. Cruise report: A09-2015 (16.09.-04.10. 2015). ICES North Western Working Group, 27 April–4 May 2016, Working Document No. 29. 7 pp.

Bardarson, B. 2016. Acoustic assessment of the Iceland-Greenland-Jan Mayen capelin stock in autumn 2015. Cruise report: Cruise: A11-2015 (17.11.-29.11. 2015). ICES North Western Working Group, 27 April–4 May 2016, Working Document No. 30. 5 pp.

Bardarson, B., and Jonsson, S.Th. 2016b. Acoustic assessment of the Iceland-Greenland-Jan Mayen capelin stock in winter 2016. Cruise report: A01-2016 (03.01.-21.01. 2016). ICES North Western Working Group, 27 April–4 May 2016, Working Document No. 31. 5 pp.

Bardarson, B., and Jonsson, S.Th. 2016c. Acoustic assessment of the Iceland-Greenland-Jan Mayen capelin stock in winter 2016. Cruise report: B2-2016 and A2-2016. ICES North Western Working Group, 27 April–4 May 2016, Working Document No. 32. 4 pp.

Bardarson, B., Gudmundsdottir, A. and Jonsson, S.Th. 2016. Advice for TAC of Capelin in the Iceland-Greenland-Jan Mayen area for the 2015/2016 fishing season. ICES North Western Working Group, 27 April - 4 May 2016, Working Document No. 34. 3 pp.

Engilbertsson, V., Óskarsson, G.J. and Marteinsdóttir, G. (201). Interannual 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.

Gudmundsdottir, A., and Vilhjalmsson, H. 2002. Predicting Total Allowable Catches for Icelandic capelin, 1978–2001. ICES Journal of Marine Science, 59: 1105–1115.

Gudmundsdottir, A., and Sigurdsson, Th. 2014. Growth of capelin in the Iceland-East Greenland-Jan Mayen area. NWWG 2014/WD:29.

Gudmundsdottir, A., Bardarson, B., and Jonsson, S.Th. 2016. Advice for Intermediate TAC of Capelin in the Iceland-Greenland-Jan Mayen area for 2015/2016 fishing season and data for preliminary TAC of 2016/2017 fishing season. ICES North Western Working Group, 27 April - 4 May 2016, Working Document No. 33. 5 pp.

ICES 2015. Report of the Benchmark Workshop on Icelandic Stocks (WKICE), 26–30 January, 2015. ICES Headquarters. ICES CM 2015/ACOM:31.

Vilhjálmsson, H. (2007). Impact of changes in natural conditions on ocean resources. Law, science and ocean management 11, 225.

Vilhjalmsson, H. 1994. The Icelandic capelin stock. Capelin, Mallotus villosus (Müller), in the Iceland–Greenland–Jan Mayen area. Rit Fiskideildar, 13: 281 pp.

12.19 Tables

Table 12.2.1 Capelin. Acoustic assessment of capelin in the Iceland/Greenland/Jan Mayen area, by r/v Arni Fridriksson 16/9-4/10 2015 (Numbers in millions, biomass in tonnes).

	Length (cm)	Numbers at Age (10^9) 1	2	3	Numbers (10^9)	Biomass (10^3 t)	Mean weight (g)
	10.5	0.12	0.00	0.00	0.12	0.54	4.6
	11	0.15	0.00	0.00	0.15	0.81	5.5
	11.5	0.46	0.00	0.00	0.46	2.98	6.5
	12	1.27	0.00	0.00	1.27	9.49	7.5
	12.5	1.34	0.00	0.00	1.34	11.45	8.6
	13	1.22	0.15	0.00	1.37	13.44	9.8
	13.5	0.63	0.70	0.02	1.35	15.41	11.4
	14	0.27	1.79	0.00	2.06	26.75	13.0
	14.5	0.00	3.39	0.13	3.52	51.59	14.7
	15	0.00	4.30	0.42	4.72	78.65	16.7
	15.5	0.00	4.57	0.77	5.33	97.37	18.3
	16	0.00	3.17	1.58	4.75	97.07	20.4
	16.5	0.00	3.00	1.38	4.38	100.97	23.1
	17	0.00	0.94	1.25	2.19	56.21	25.6
	17.5	0.00	0.35	0.64	0.99	27.65	28.0
	18	0.00	0.01	0.49	0.50	16.11	32.0
	18.5	0.00	0.00	0.08	0.08	2.74	36.2
	19	0.00	0.00	0.03	0.03	0.90	34.7
TSN (10^9)		5.45	22.36	6.78	34.59		
TSB (10^3 t)		48	406	157		610.13	
Mean W (g)		8.8	18.1	23.1			17.6
Mean L (cm)	15.1	12.5	15.4	16.5			
%TSN		15.8	64.6	19.6			
SSN (10^9)		0.4	21.2	6.7	28.4		
SSB (10^3 t)		5.0	390.1	155.7		550.9	
SMean W (g)		12.3	18.4	23.1			19.4
SMean L (cm)	15.6	13.7	15.4	16.5			
%SSN		0.0	0.1	0.0			
ISN (10^9)		5.0	1.2	0.0	6.2		
ISB (10^3 t)		42.8	15.5	1.0		59.3	
IMean W (g)		8.5	13.4	21.5			9.5
IMean L (cm)	12.8	12.4	14.1	15.9			
%ISN		0.1	0.0	0.0			

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	10	14	10.0			49.7		9.1	0.4	
1980	10	11	23.5			19.5		4.8		
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	
1987	11	18	21.3		2.5	52.0		13.5		
1988	10	6	43.9		6.7	53.0		17.0	0.4	
1989	10	26	29.2		1.8	2.9		0.6		
1990	11	8	24.9		1.3	16.4		2.7	0.1	
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	
2005	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	
2011	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	
2014	9	16	57.0	1.0	3.3	26.5	0.2	7.6	0.1	
2015	9	16	5.0	0.4	1.2	21.2		6.7		

1987 - The number-at-age 1 was from survey earlier in autumn.

2005 - Scouting vessels searched for capelin. r/s ÁF measured. No samples taken for age determination. Estimated to be < 50 thous. tonnes.

2011-Only limited coverage of the traditional capelin distribution area.

2001-2009 and 2016 – Not full coverage of stock.

Table 12.2.3. Icelandic Capelin. Mean weight (g) of age classes measured in acoustic surveys in autumn. (imm=immature, mat=mature). See footnotes in table 12.2.2.

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	10	6.2			15.7		23.0	20.8	
1980	10	7.3			19.4		26.7		
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	11	2.8		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		
1990	11	3.9		8.4	18.0		25.5	36.0	
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	
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	
2014	9	4.2	9.9	12.7	18.3	16.6	21.2	25.0	
2015	9	8.5	12.3	13.4	18.4	21.5	23.1		

Table 12.2.4. Icelandic Capelin. Assessment of mature capelin in the Iceland/EastGreenland/Jan Mayen area, by r/v Arni Fridriksson in January 2015 (Numbers in millions, biomass in tonnes).

	Length (cm)	Numbers at Age (10^9) 2	3	4	5	Numbers (10^9)	Biomass (10^3 t)	Mean weight (g)
	10	0.02	0.00	0.00	0.00	0.02	0.08	3.8
	10.5	0.03	0.00	0.00	0.00	0.03	0.14	4.0
	11	0.11	0.00	0.00	0.00	0.11	0.53	4.7
	11.5	0.71	0.04	0.00	0.00	0.75	4.01	5.3
	12	1.06	0.02	0.00	0.00	1.08	6.61	6.1
	12.5	1.55	0.13	0.00	0.00	1.68	12.35	7.4
	13	1.84	0.15	0.00	0.00	2.00	16.81	8.4
	13.5	1.20	0.27	0.00	0.00	1.47	14.42	9.8
	14	0.74	0.89	0.00	0.00	1.63	18.55	11.4
	14.5	0.29	1.79	0.13	0.00	2.22	29.20	13.2
	15	0.09	3.11	0.23	0.00	3.43	51.01	14.9
	15.5	0.00	4.64	0.64	0.07	5.34	90.67	17.0
	16	0.02	4.28	1.01	0.01	5.33	101.36	19.0
	16.5	0.01	5.11	1.61	0.00	6.73	141.87	21.1
	17	0.01	2.80	1.61	0.04	4.47	107.16	24.0
	17.5	0.04	1.91	1.69	0.04	3.68	98.54	26.8
	18	0.00	0.47	1.20	0.07	1.74	52.07	29.9
	18.5	0.00	0.03	0.37	0.00	0.40	12.93	32.4
	19	0.00	0.00	0.02	0.00	0.02	0.82	35.8
	19.5	0.00	0.00	0.03	0.00	0.03	1.19	35.8
TSN (10^9)		7.75	25.65	8.55	0.23	42.18		
TSB (10^3 t)		66	486	203	6		760.34	
Mean W (g)		8.5	19.0	23.7	24.0			18.0
Mean L (cm)	15.5	12.9	15.9	16.9	16.9			
%TSN		18.4	60.8	20.3	0.5			
SSN (10^9)		0.8	23.3	8.4	0.2	32.8		
SSB (10^3 t)		11.3	456.5	201.4	5.6		674.8	
SMean W (g)		13.4	19.6	23.9	24.0			20.6
SMean L (cm)	16.2	14.3	16.0	16.9	16.9			
%SSN		2.6	71.0	25.7	0.7			
ISN (10^9)		6.9	2.4	0.1	9.4	9.4		
ISB (10^3 t)		54.2	29.9	1.5	0.0		85.6	
IMean W (g)		7.8	12.6	13.6	0.0			9.1
IMean L (cm)	13.2	12.7	14.5	14.8	0.0			
%ISN		73.6	25.2	1.2	0.0			

Table 12.3.1 Capelin. The international catch since 1964 (thousand tonnes).

	Winter season					Summer and autumn season						
Year	Iceland	Norway	Faroes	Greenland	Season total	Iceland	Noway	Faroes	Greenland	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
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
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

	Winter season					Summer and autumn season						
Year	Iceland	Norway	Faroes	Greenland	Season total	Iceland	Noway	Faroes	Greenland	EU	Season total	Total
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	-	30.5	-	5.3	9.7	45.5	187.2
2015*	353.6	50.6	29.9	37.9	471.9	-	-	-	2.5	-	2.5	474.4
2016*	101.1	58.2	8.5	3.3	171.1							

***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	-	-	-	-	-	-	-
2014	0.01	2.22	0.6	0.02	-	2.8	45.5
2015	0.03	0.08	0.03			1.4	2.5

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
2015	-	0.3	17.5	4.7	0.1	22.7	471.9
2016		0.4	5.5	2.0	0.02	8.0	171.1

Table 12.3.4. Initial quota and final TAC by seasons.

Fishing season	Initial advice	Final TAC	Landings
1992/931	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
2003/042	555	900	741
2004/053	335	985	783
2005/06	No fishery	235	238
2006/07	No fishery	385	377
2007/08	207	207	202
2008/094	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
2014/15	2255	580	517
2015/166	No fishery5	173	174

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.

5) Initial advice based on low probability of exceeding final TAC.

6) Preliminary landings.

Table 12.7.1 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) is given for 1 August at 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	-	1195	600
1979/80	22	980	300
1980/81	23.5	684	170
1981/82	21	626	140
1982/83	68	0	260
1983/84	44.1	573	440
1984/85	73.8	896	460
1985/86	33.8	1312	460
1986/87	58.6	1334	420
1987/88	2.6	1116	400
1988/89	43.9	1036	440
1989/90	29.2	807	115
1990/91	27.2	313	330
1991/92	60	677	475
1992/93	104.6	788	499
1993/94	100.4	1178	460
1994/95	119	864	420
1995/96	165	930	830
1996/97	111.9	1570	430
1997/98	66.8	1246	492
1998/99	121	1100	500
1999/00	89.8	932	650
2000/01	103.7	1071	450
2001/02	101.8	1249	475
2002/03	-	988	410
2003/04	4.9	742	535
2004/05	7.9	784	602
2005/06	-	247	400
2006/07	44.7	377	410
2007/08	5.7	203	406
2008/09	12.6	150	328
2009/10	15.4	151	410
2010/11	101.2	391	411
2011/12	9.6	747	418
2012/13	19.4	551	417
2013/14	60.7	142	424
2014/15	58	518	460
2015/16	5.4	174**	304*

***Based on predation model in current HCR.**

**** preliminary**

12.20 Figures

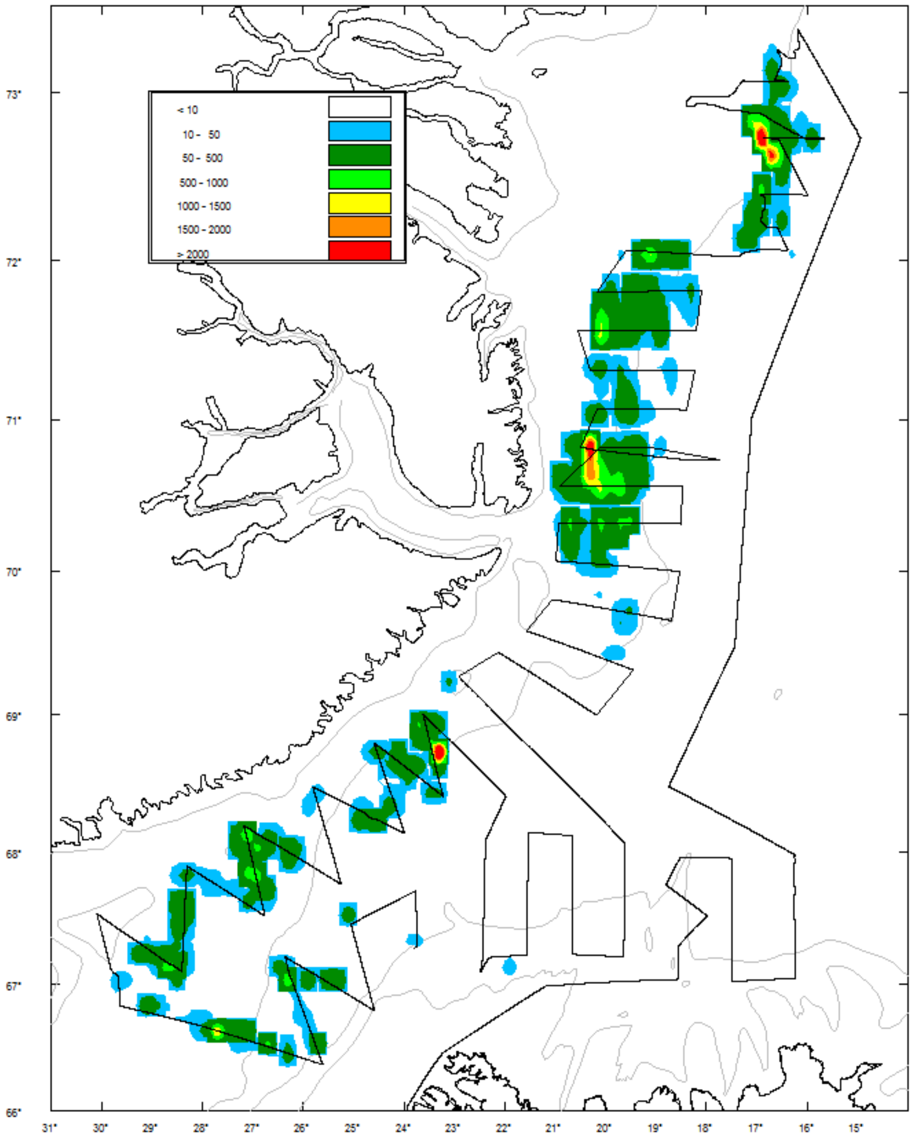


Figure 12.2.1. Icelandic capelin. Cruise tracks, relative density and distribution of capelin during an acoustic survey by r/v Arni Fridriksson during 16 September–4 October 2015.

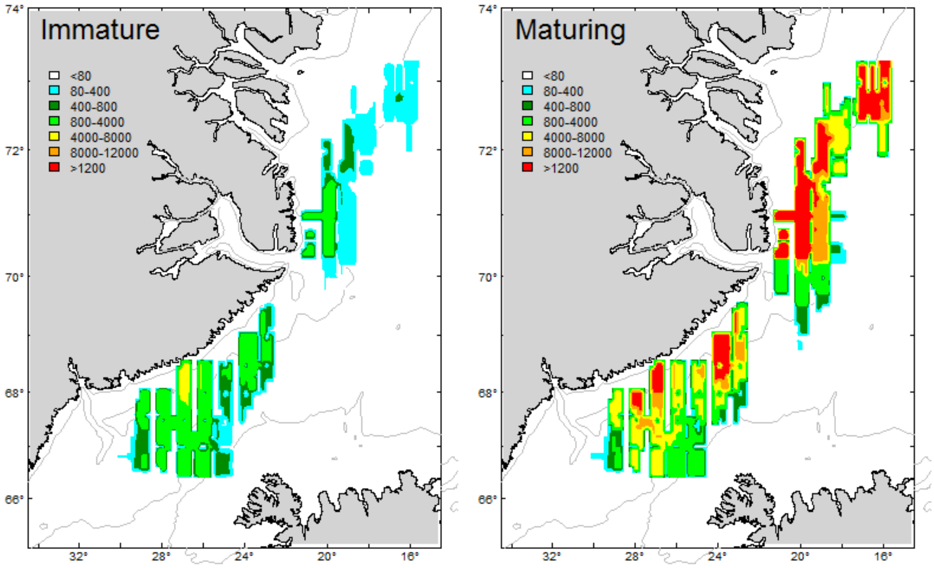


Figure 12.2.2. Icelandic capelin. Distribution of immature and maturing capelin biomass during an acoustic survey by r/v Arni Fridriksson during 16 September - 4 October 2015.

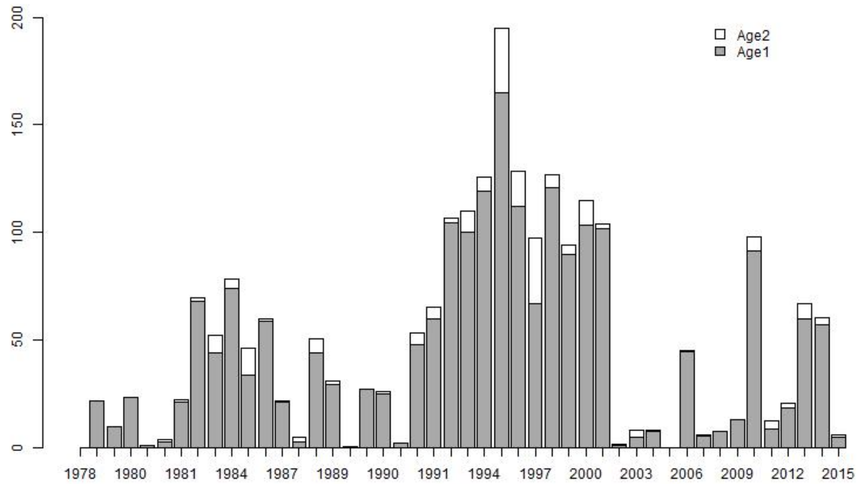


Figure 12.2.2. Icelandic capelin. Indices of immature 1 and immature 2 years old capelin from acoustic surveys in autumn since 1979.

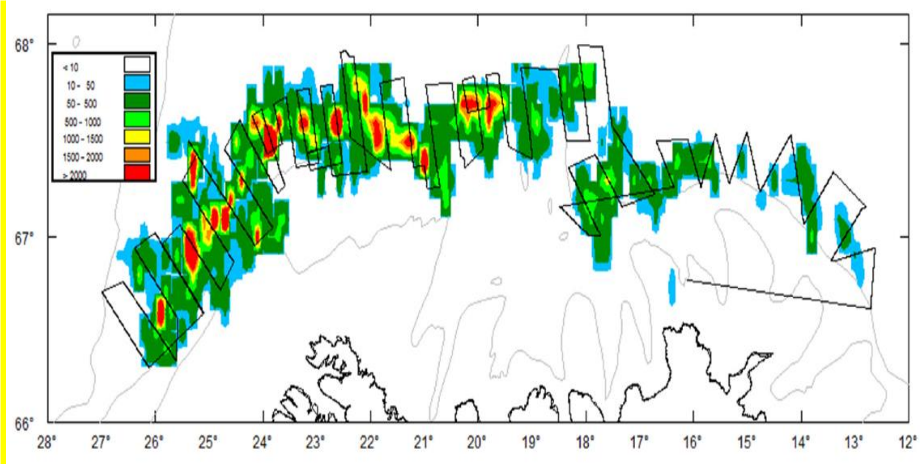


Figure 12.2.3. Icelandic capelin. Survey tracks of r/s Arni Fridriksson during 13 – 20 January 2016.

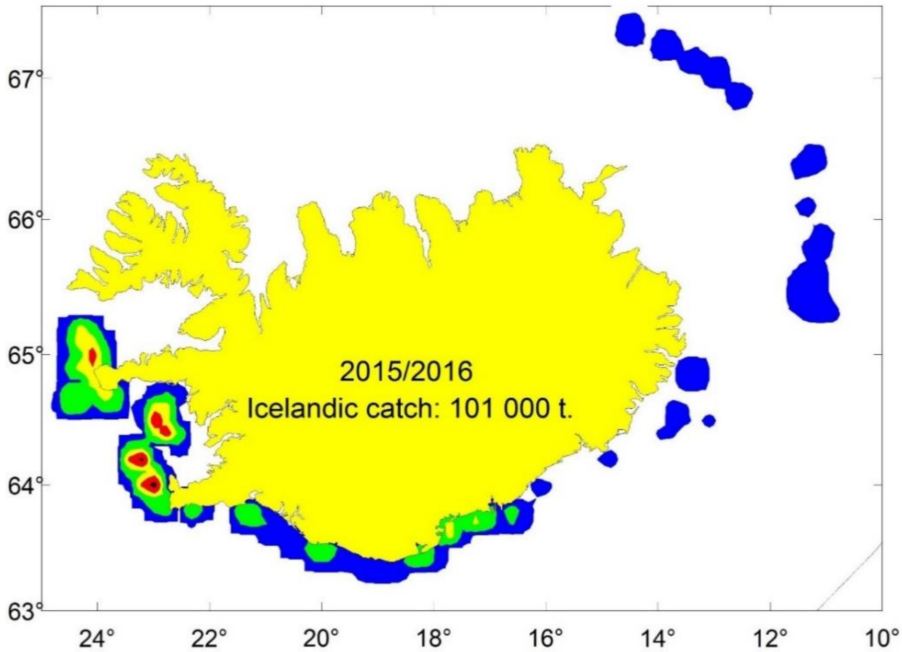


Figure 12.3.1. Icelandic capelin. Distribution of the catches in the fishing season 2015/16 based on data from logbooks of the Icelandic fleet.

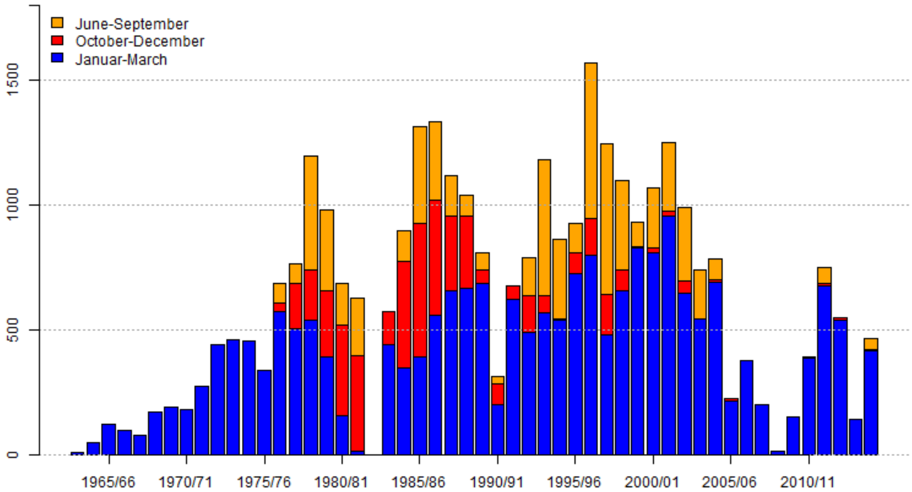


Figure 12.3.2. Icelandic capelin. The total catch (in thousand tonnes) of the Icelandic capelin since 1963/64 by season.

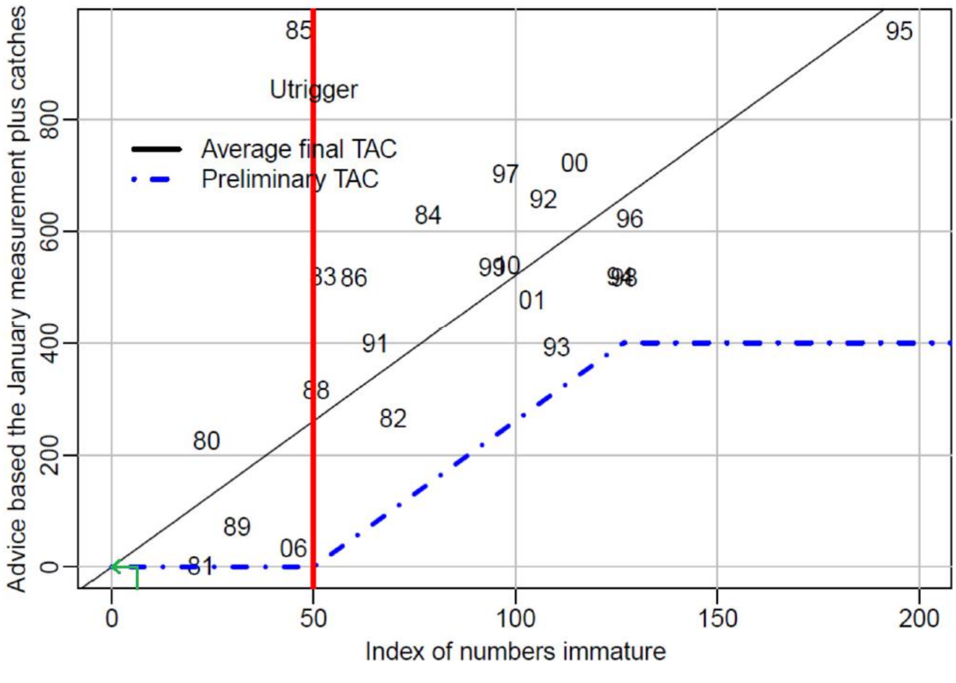


Figure 12.8.1 Capelin in Subareas 5 and 14 and Division 2.a west of 5°W. Catch advice according to the proposed stochastic HCR, based on the measured number of immature capelin about 15 months earlier. The figure shows the estimated final TAC (black unbroken line) and the initial (preliminary) TAC (blue dashed line). The latter is set using a $U_{trigger}$ (red vertical line) of 50 billion immature fish, with a cap on the initial (preliminary) TAC of 400 kt. The green lines show the index value from the autumn survey 2015, with the corresponding initial TAC for 2016/2017 shown on the *y*-axis. (The figure adapted from stock-annex, WKICE 2015).

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).

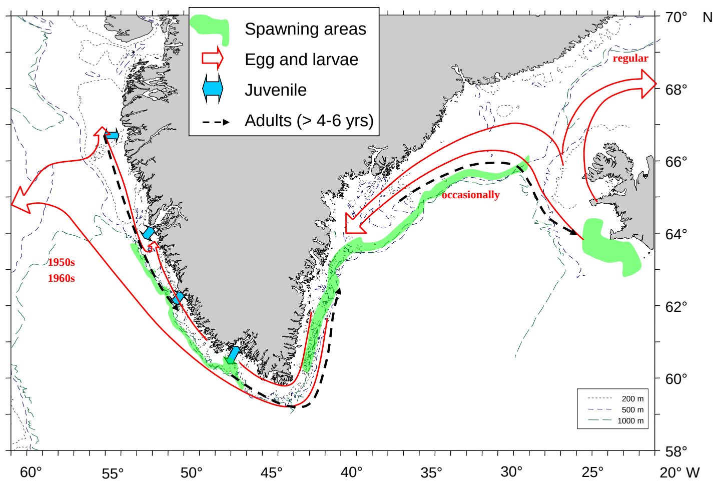


Figure 1. Spawning areas, egg and larval transport of Atlantic cod (*Gadus morhus*) in Greenlandic and Icelandic waters.

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 periods, 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 years, temperature have increased significantly in Greenland waters. In West Greenland the sea temperature have increased particularly compared to the years in 1970s–mid1990s and historical highs was registered in 2005 for the time-series 1880–2012 (Figure 2).

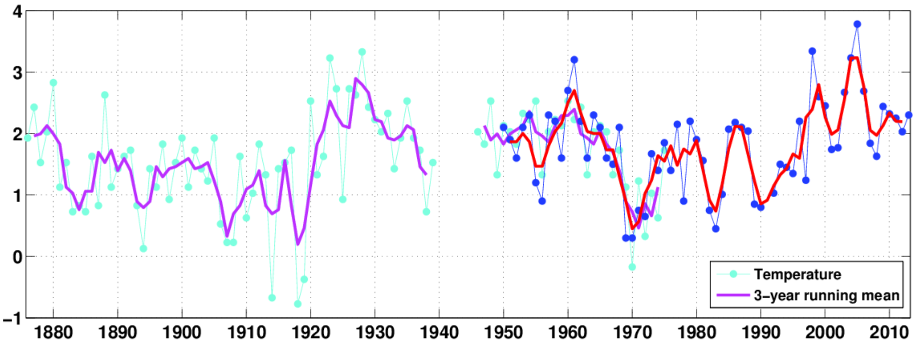


Figure 2. Mean temperature on top of Fylla Bank (located outside Nuuk Fjord, 0–40 m depth) in the middle of June for the period 1950–2013. The curves are 3 year running mean values. The magenta/purple line is extended back to 1876 using Smed-data for area A1. From Ribergaard (2014).

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 *et al.* (2012) finds that between 1998–2010, the salinity and temperature of the deep water in the Greenland Sea increased. Furthermore, increasing temperatures in 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.*

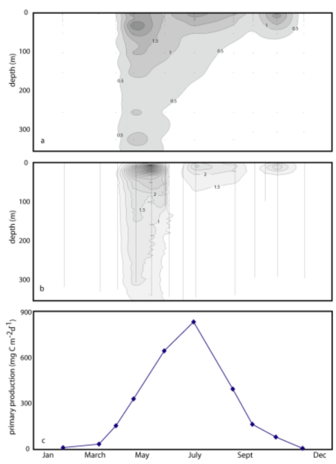


Figure 3. Annual variation in algal biomass and productivity at the inlet of Nuuk Fjord. a: chlorophyll (µg l^{-1}), b: fluorescence, c: primary production (mg C m^{-2} d^{-1}). Dots represent sampling points. From Mikkelsen *et al.* (2008).

Recently, the distribution of commercial species such as cod and shrimp has shifted considerably in the 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 fish 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 fish abundance and their distributional shifts on demersal fish 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 & 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.

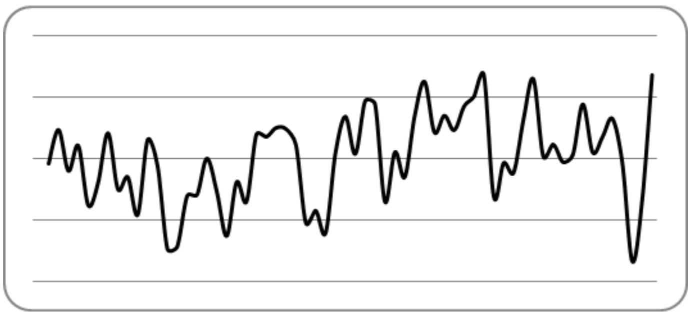


Figure 4. NAO Index (Dec-Feb) 1950–2012.

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 to 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 (Figure 5). The 2010 air temperature anomaly (4.0K) was the highest recorded, and was associated with the largest negative NAO anomaly (see Figure 6).

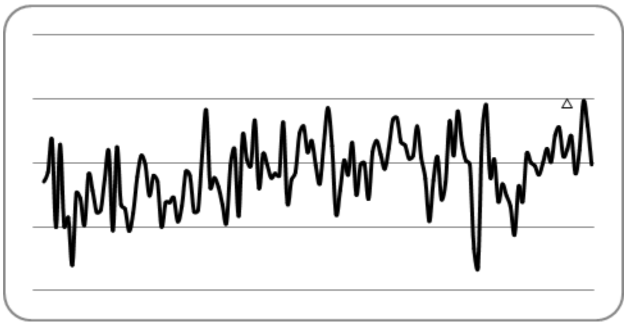


Figure 5. Time-series of annual mean winter (DEC-FEB) air temperature anomalies (K) at Nuuk (1876-2012, rel. 1961–1990)

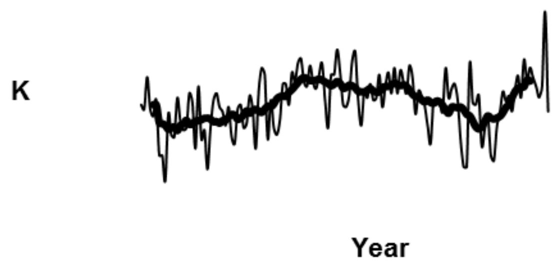


Figure 6. Time-series of annual mean air temperature anomalies (K) at Nuuk (1876–2011, rel. 1961–1990), and 13 year running mean.

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). 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.

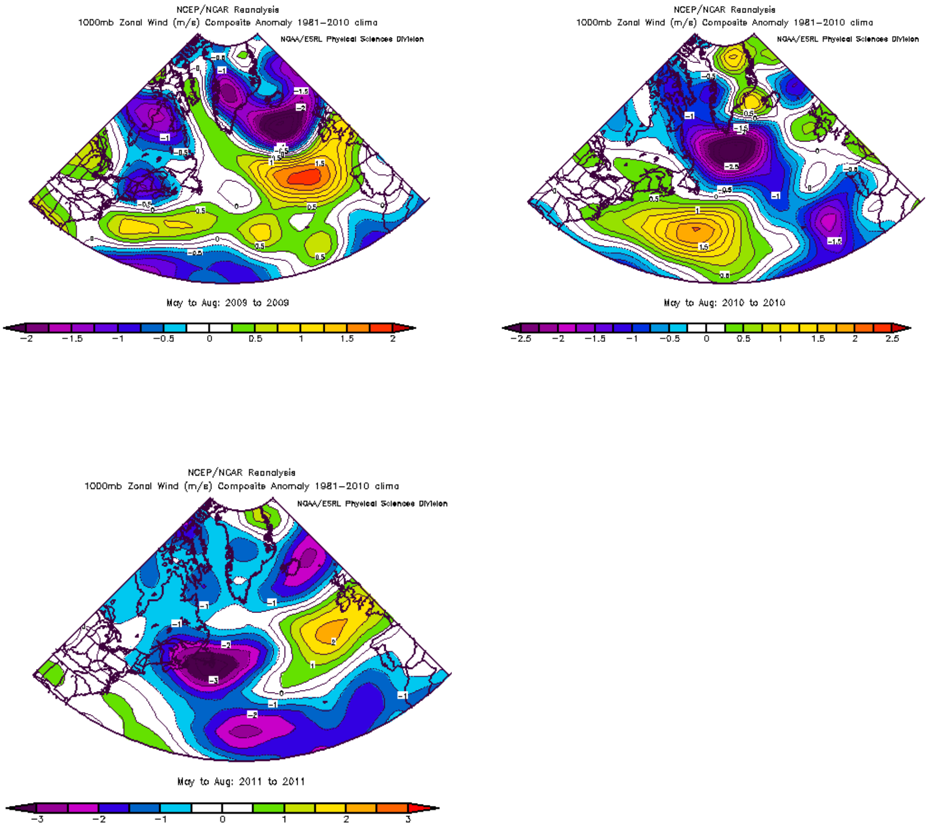


Figure 7. Zonal wind components for the North Atlantic (May-Aug), anomalies from 1981–2010. top left: 2009; top right: 2010; bottom left: 2011.

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 Figure 8).

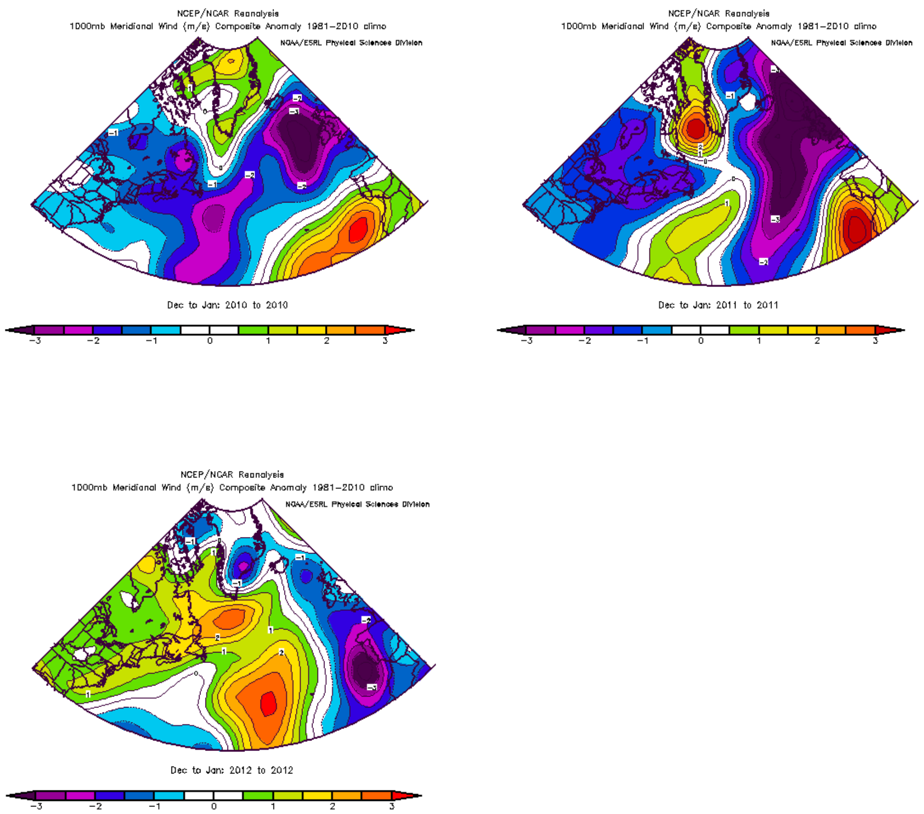


Figure 8. Meridional wind component (Dec-Jan), anomalies from 1981–2010. top left: 2009/2010; top right: 2010/2011; bottom left: 2011/2012;

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 poundnet 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 gillnets, poundnets, 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 bycatch from this fishery is redfish, Greenland shark, roughhead grenadier and in recent years' cod in Disko Bay.

The coastal shrimp fisheries are distributed along most of the West coast from 61–72ºN. The main bycatch with the inshore shrimp trawlers is juvenile redfish, cod and Greenland halibut. An inshore shrimp fishery is conducted mainly in Disko Bay. Sorting grid is mandatory for the shrimp fishery; however, several small inshore shrimp trawlers have dispensation for using sorting grid.

Cod is targeted all year, but with a peak in effort in June–July as cod in this period is accessible in shallow waters facilitating the use of the main gear types, pound and gillnets. Bycatches 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 gillnets. In small 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. Bycatch in this fishery is considered insignificant.

Snow crabs are caught in traps in areas 62–70ºN. Problems with bycatch 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 coastal 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 comprised 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 1992–2000s. In 2010 the cod fishery was closed off West Greenland and catches has been insignificant since. The Greenland offshore shrimp fleet consist of 15 freezer trawlers. They exclusively target shrimp stocks off West and East Greenland with landings slightly below 100 000 t. The shrimp fleet is close to or above 80 BT and 75% of the fleet process the shrimp on board. Shrimp trawls are used with a minimum mesh size of 44 mm and a mandatory sorting grid (22 mm) to avoid bycatch 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 bycatch.

However, when juvenile fish are caught, even small biomasses can correspond to relatively large numbers.

Longliners are operating on both the East and West coast with Greenland halibut and cod as targeted species. Bycatches 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 as the Greenland share of the TAC is taken in other waters. Generally, the pelagic fishery in Greenland is very clean, with small amounts of bycatch 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 450 000 t. 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 up to 2003 reaching a catch level close to 150 000 t. The stock decreased thereafter and is now at the low 1990 level with an advised TAC for 2015 of 60 000 t. The advised TAC for 2016 increased to 90 000 t.

13.2.1 Shrimp

The shrimp (*Pandalus borealis)* stock in Greenland waters has been declining since 2003. The stock in East Greenland is at a low level based on available information. The 2003 West Greenland shrimp biomass was at the highest in the time-series, but it has since 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 mid90s and offshore since 1999. Total landings have since 2010 been reported at around 2 000 t a decrease from a high level in 2001 at 15 000 t. 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 mid80s to the start 90s landings were between 4-600 t yearly, increased to around 2 000 t in late 1990ies. Catches decreased again and is below 600 tons in 2014. The fishery is based on license and is exclusively at the west coast between 20–60 m. The growth rate is considered very low reaching the minimum landing size on 65 mm in 10 years.

13.2.4 Squids

The status of squids in Greenland waters are unknown.

13.2.5 Cod

Since 2015, assessment and advice for cod in Greenland water take into account that three different stocks, based on spawning areas and genetics, are the basis for the cod fishery and the following management is therefore recommended for different three areas: a) inshore in Western Greenland (NAFO subdivision 1A-1F), b) offshore Western Greenland (NAFO subdivision 1A-1E) and offshore Eastern and South Greenland (ICES Subarea 14.b and NAFO subdivision 1F). Current landings for inshore cod are 25 200 t, and have steadily increased since 2009 where landings were 7 000 t. Landing from offshore Western Greenland was minor (less than 500 t since 2006) until 2015 where catches increased to 4 600 t. From offshore Eastern Greenland area 2015 landing was 15 800 t, an increase from the 2011–2013 level at 5 000 t.

Catches 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 in the time-series since 1982. 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 despite an increased fishing effort in later years. However in 2015 signs of increasing fishing pressure is seen as the biomass index in the inshore survey is stable and recruitment is low.

13.2.6 Redfish

Redfish (*Sebastes mentella* and *Sebastes norvegicus*) 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 catches in 2010-15 being around 8 000 t. This includes both redfish species, but the majority (e.g. ~70%) is identified as*S. mentella*. Recent East Greenland survey estimates indicate a decline in *S. mentella* while *S. norvegicus* 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 West Greenland (NAFO SA 0+1) is a part of a shared stock between Greenland and Canada. The stock has remained stable in the last decade, sustaining a fishery of about 30 000 t annually (15 000 t in Greenland water). 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. In 2015, catches were around 9 400 t.

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 (2 500 t (summer/autumn) landed in 2015 by Greenland, EU, Norway and Iceland). The capelin has shifted distribution more west and north in recent years, and are believed to spend 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 32 000 t in 2015. 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.

13.2.11 Herring

A fishery for Norwegian spring-spawning herring in Greenland water has increased in recent years and in 2014 catches increased to 9 000 t. The herring has shifted distribution more west in recent years.

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 bycatch in other fisheries deploying mobile gears capable of catching cod. Observers must monitor functionalism of measures.

13.4 References

Blicher, M. E., Rysgaard, S. and Sejr, M. K. 2007. Growth and production of sea urchin *Strongylocentrotus droebachiensis* in a high-Arctic fjord, and growth along a climatic gradient (64 to 77 degrees N) (vol. 341, pg 89, 2007). Marine Ecology-Progress Series, 346: 314–314.

Gordon, J.D.M., Bergstad, O.A., Figueiredo, I. And G. Menezes. 2003. Deep-water Fisheries of the Northeast Atlantic: I Description and current Trends. J. Northw. Atl. Fish. Sci. Vol: 31; 37–150.

ICES. 2013a. Report of the Ad hoc Group on the Distribution and Migration of Northeast Atlantic Mackerel (AGDMM). ICES CM 2013/ACOM:58. 215 pp.

ICES. 2013b. Report of the North-Western Working Group (NWWG), 26 April - 3 May 2012, ICES Headquarters, Copenhagen. ICES CM 2012/ACOM:07. 1425 pp.

ICES. 2013c. ICES Report on Ocean Climate 2012 Prepared by the Working Group on Oceanic Hydrography. No. 321 Special Issue. 74 pp.

Hovgård, H. and K. Wieland, 2008. Fishery and environmental aspects relevant for the emergence and decline of Atlantic cod (*Gadus morhua*) in West Greenland waters. In: Resiliency of gadid stocks to fishing and climate change, p 89–110 (Ed.: G.H. Kruse, K Drinkwater , J.N. Ianelle, J.S. Link, D.L. Stram, V. Wepestad and D.Woodby). Anchorage, Alaska, 2008.

Hvingel, C., Kingsley, M.C.S. 2006. A framework to model shrimp (Pandalus borealis) stock dynamics and quantity risk associated with alternative management options, using Bayesian methods, ICES J. Mar. Sci. 63; 68–82.

Langøy, H., Nøttestad, L., Skaret, G., Broms, C., and A. Fernø. 2012. Overlap in distribution and diets of Atlantic mackerel (*Scomber scombrus),* Norwegian spring-spawning herring (Clupea harengus) and blue whiting (*Micromesistius poutassou*) in the Norwegian Sea during late summer. Marine Biology Research 8: 442–460

Mikkelsen, D.M., Rysgaard, S., Mortensen, J., Retzel, A., Nygaard, R., Juul-Pedersen, T., Sejr, M., Blicher, M., Krause-Jensen, D., Christensen, P.B., Labansen, A., Egevang, C., Witting, L., Boye, T. K., Simon, M. 2008. Nuuk Basic: The Marine Basic programme 2007. GN Report 2008.

Møller, P. R., J.G. Nielsen, S. W. Knudsen, J. Y. Poulsen, K. Sünksen, O. A. Jørgensen. 2010. A checklist of the fish fauna of Greenland waters. Zootax 2378:1–84.

Ribergaard, M.H. 2014. Oceanographic Investigations off West Greenland 2013. Danish Meteorological Institute Centre for Ocean and Ice.

Rudels, B., Korhonen, M., Budéus, G., Beszczynska-Möller, A., Schauer, U., Nummelin, A., Quadfasel, D., and Valdimarsson, H. 2012. The East Greenland Current and its impacts on the Nordic Seas: observed trends in the past decade. – ICES Journal of Marine Science, 69:

Stein, M. 2004. Climatic Overview of NAFO Subarea 1, 1991-2000. *J.Northw.Atl.Fish.Sci.,* **34**: 29–41.

Stein, M. and V.A. Borovkov. 2004. Greenland cod (*Gadus morhua*): modelling recruitment variation during the second half of the 20th century. Fish. Oceanogr. 13(2): 111–120.

14 Cod (*Gadus morhua*) in NAFO Subdivisions 1A-1E (Offshore West Greenland)

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), (Figure 14.1).

From 2012 the inshore component (West Greenland, NAFO Subarea 1) was assessed separately from all offshore components. From 2015 the offshore West Greenland (NAFO subdivisions 1A–E) and East Greenland (NAFO subdivision 1F and ICES Subarea 14) components was assessed separately. The Stock Annex provides more details on the stock identities including the references to the primary literature.

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 at 400 000 tonnes 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 (Tab 14.2.1, Fig 14.2.1). No fishery has developed since. More details on the historical development in the fisheries are provided in the stock annex.

14.2.2 The fishery in 2015

In 2014 a management plan for the offshore fisheries for cod was implemented with the overall objective of rebuilding the stock in West Greenland by closing the area for fisheries.

In 2015 the management plan was overruled and a TAC of 5 000 tons was introduced as an experimental fishery.

Offshore catches in the fishery in 2015 amounted to a total of 4 860 tons caught primarily on Dana Bank (NAFO div 1D and 1E, between 62°00-63°00N). Other areas of minor catch was Tovqussaq/Fyllas Bank north of Dana Bank (NAFO 1CD) and Narssalik Bank south of Dana Bank (NAFO 1E, figure 14.2.2.1 and 14.2.2.2).

The fishery occurred in spring August–December and peaked in November (table 14.2.2.1). Longliners took 36% of the total catches and trawlers took 64% of the total catch (figure 14.2.2.3).

14.2.3 Length, weight and age distributions in the fishery.

Length measurement amounted to 3 555 cod measured. Length measurements were taken by crew members directly on the ships.

Overall mean length in the fishery was 62 cm and age 6 year old (YC 2009) dominated the catches followed by the 2010 YC (figure 14.2.3.1 and 14.2.3.2). The 2009 YC also dominated the catches in 2014 at age 5 years (table 14.2.3.1) and in 2015 dominated the catches in all areas. There were larger and older fish (7–8 years) present on Dana Bank than on Tovqussaq bank furthest to the north in the fishing area in 2015 (table 7).

14.3 Surveys

At present, two offshore trawl surveys (Greenland and German) provide the core information relevant to stock assessment purposes. For details of survey design see stock annexes.

The German survey targets cod and has since 1982 covered the main cod grounds off West Greenland up to 67°N at depths down to 400 m, thus including periods of both high and low cod abundance. The Greenland survey targets shrimp and cod off West Greenland up to 72°N and from 0 to 600 m from 1992, 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 this survey.

14.3.1 Results of the Greenland Shrimp and Fish survey

The numbers valid hauls were 185 in 2015 (table 14.3.1.1).

The 2015 survey abundance of Atlantic cod in West Greenland was estimated at 100 million individuals and the survey biomass at 95.487 tons (table 14.3.1.2 & 14.3.1.3). Survey abundance decreased with 9% and biomass increased with 12% compared to 2014. Abundance was primarily in area 1C, D and E and biomass was primarily in NAFO Div. 1D and E (figure 14.3.1.1 and 14.3.1.2).

The stock was dominated by the 2009 YC in 2011, 2012 and 2013 accounting for 84%, 64% and 52% of the total abundance respectively (table 14.3.1.4, figure 14,3,1,3). In 2014, the 2010 YC dominated the abundance with 51% of the total abundance followed by the 2009 YC accounting for 33% of the total abundance. In 2015, the 2010 YC was still the dominating YC accounting for 35% of the abundance followed by 2011 YC and 2009 YC that accounts for 21% each.

The 2009 YC was mainly found in the northern part of the survey (NAFO 1B) at age 2 in 2011 (figure 14.3.1.5). In 2012 and 2013, this YC was however mainly found in the southern part of the survey (NAFO Div. 1D and 1E). The 2010 and 2011 YC show the same distribution pattern of being in the northern part of the survey area (NAFO 1A and 1B) at ages 1 and 2, and moving further to the south at ages 3 and 4. Generally, younger YC's (age 1–2) are 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 7 years, and the 2015 survey confirmed that older and larger cod barely exist offshore in West Greenland, however there is an increasing trend for cod at age 5–7. Especially the 6 years old fish (2009 YC) are very well represented compared to earlier years, representing the absolute highest abundance in the time-series (table 14.3.1.4, figure 14.3.1.3).

The offshore cod start to spawn at age 5–6 years, and the spawning-stock biomass in the survey show an increasing trend in recent years with spawning stock being concentrated in the southern area (NAFO 1E, figure 14.3.1.7 and 14.3.1.8). Recently, the number of spent females have indeed increased in the survey in area 1D and 1E (Figure 14.3.1.9).

The survey show a small decrease in abundance and an increase in biomass compared to 2014. The decrease in abundance might be caused by southward migration, of a fraction of the 2009 YC, to NAFO area 1F, as the survey in this area register increased numbers of this YC (Retzel 2016). The increase in biomass can be explained by the growth of the remaining 2009 YC and the following 2010 and 2011 YC.

14.3.2 Results of the German groundfish survey

In 2015, 35 valid trawl stations were sampled during autumn in the German Greenland offshore groundfish survey in West Greenland NAFO 1C-1E (Table 14.3.2.1).

Overall, abundance increased by 117% from 2014–2015 (Table 14.3.2.2) and biomass increased by 154% (Table14.3.2.3). The main reason for the increase in abundance and biomass was one very large haul, located in NAFO 1D (figure 14.3.2.1 and 14.3.2.2) which contributed with 80% of the biomass estimate and resulted in high SD (table 14.3.2.3). Since 2012 the 2009 YC has dominated the survey and the 2010 has been the second most abundant YC in the survey. In 2015 the 2010 YC is the dominating YC at age 5 and the second largest YC is the 2009 and 2011 YC (age 6 and 4, table 14.3.2.4). These year classes are mainly observed in NAFO div. 1C and 1D in 2015 (figure 14.3.2.3) which is further to the north for the 2009 YC than in the Greenland survey.

The survey time-series shows three abundance peaks: one in 1987–1989 caused by the 1984 and 1985 YC, one in 2006 caused by the 2003 YC and one in 2012 caused by the 2009 YC (figure 14.3.2.4). Biomass indices show the same peaks, although an increase in biomass in the period 2012-2015 compared to the previous periods (figure 14.3.2.5).

Overall findings are the same in the Greenland and the German survey: the 2009 YC dominates the surveys in recent years and being record highest at age 6 in the time-series. A 2010 YC that is dominating the survey in 2015 and the presence of a 2011 YC.

14.4 Information on spawning

No spawning of significance has been documented on the banks in West Greenland. In recent years', however, larger cod have been observed in the survey, especially in the southern part (NAFO 1E), and biomass is increasing. Especially the 2009 YC at age 6 is record with large numbers in the time-series of the 6 year old in 2015. Normally off-shore cod start to spawn at age 6, but whether spawning occurs in significant extent remains unknown since the survey is conducted outside spawning season. However, ogive state is noted in the survey and the number of spent females have increased in 2014 and 2015, indicating that some degree of spawning is occurring. Further investigation should be conducted to document the degree of spawning in the southern area, and to determine which stock these larger cod belong to.

14.5 Tagging experiments

A total of 17 304 cod have been tagged in different regions of Greenland in the period of 2003–2015 (table 14.5.1). A total of 4 604 cod in the offshore area in West Greenland have been tagged in 2007, 2012 and 2013 on Dana Bank (NAFO 1DE) and a small amount (57) was tagged further to the north on Tovqussaq bank (NAFO 1C) in 2015.

Offshore recaptures are found both in West- and East Greenland and Iceland (table 14.5.2). Tagged fish in the offshore area in West Greenland are more often caught in the same area (34 individuals), but some also migrate eastward (12 individuals recaptured in East Greenland, and 21 in Iceland, table 14.5.2). Limited fishing in several areas and years influences the signal from the recaptures, and more analysis needs to be performed taking the fishing effort into account in order to investigate magnitude of the eastward migration rate.

14.6 State of the stock

The West Greenland offshore stock component has been severely depleted since the 1970ies and collapsed in the 1990ies. The surveys show only a minor increase in biomass in recent years. Abundance however has fluctuated since 2005, indicating that small fish enter the survey but are not caught at older ages. This is caused by an eastward migration out of the area, and the area is currently considered to act mainly as a nursing area for the East Greenland and Icelandic stock components.

Recently the 2009 YC has been caught in considerable numbers and is believed to be of East Greenland and/or Icelandic origin and will probably migrate out of West Greenland when reaching maturity. However, at age 6 a part of this YC still remains in the southern part of the area (NAFO 1E), which has not been the typical pattern observed with the recent larger than average YC's from 2003, 2005 and 2007.

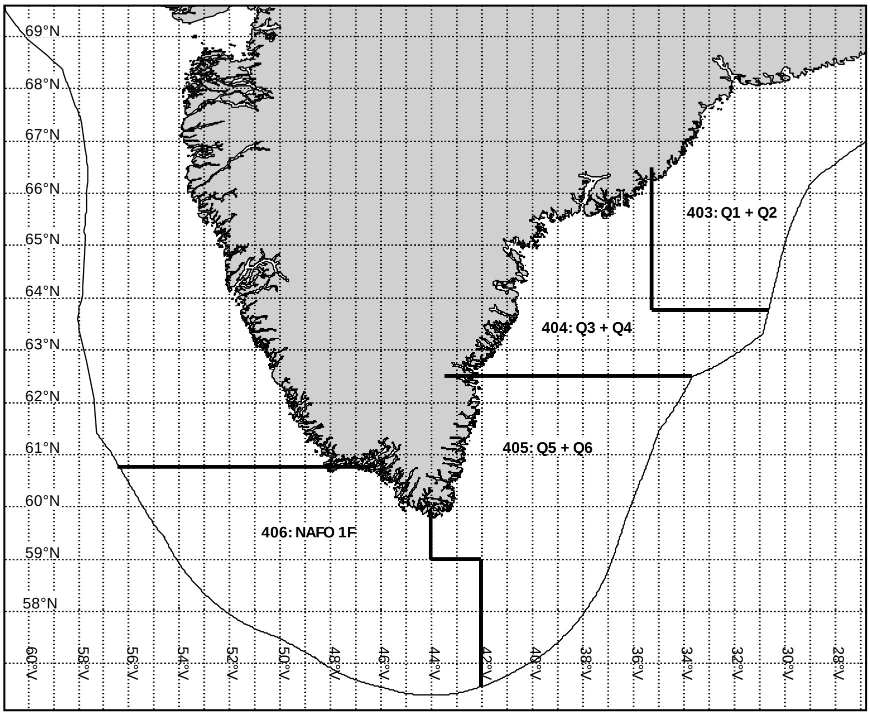
The stock is considered to be at a very low level compared to historic.

14.7 Implemented management measures for 2016

According to a management plan implemented in 2014 no offshore fishery is to take place in NAFO subdivision 1A–1E in 2016. The management plan has, however, been overruled, and a TAC of 5 000 tons has been introduced.

14.8 Management plan

In 2014 a management plan was implemented for the offshore cod fishery in Greenland (2014–2016). The management plan is built on the distinction between the inshore and two offshore stocks components.



Management area West Greenland covers NAFO Subdivisions 1A-E and management area Southeast Greenland covers ICES Subarea 14.b (survey area Q1–6) + NAFO Subdivision 1F corresponding to the ICES distinction.

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 stock component. The TAC in management area Southeast is 10 000 t/year between 2014 and 2016.

The management plan has not been evaluated by ICES.

14.9 Management considerations.

The fishery in West Greenland should be considered a mixed-stock fishery, containing fish from both Greenland and Iceland stocks. There is currently no standardized procedure to determine the proportional contribution of each stock to the landings. However, given the current state of the stock, catches taken in West Greenland waters will primarily consist of fish from other cod stocks.

The traditional spawning grounds in West Greenland are well described and if any fishing is allowed such areas should be protected. This will both protect any present spawning stock and minimize the proportion of the West Greenland stock in the catches.

14.10 Basis for advice

Basis for advice is the precautionary approach where biomass is extremely low and zero catch is advised.

14.11 References

Retzel, A. 2016. Greenland Shrimp and Fish survey results for Atlantic cod in ICES Subarea 14.b (East Greenland) and NAFO subarea 1F (SouthWest Greenland) in 2015. ICES North Western Working Group (NWWG) April 27- May 4, 2016, WD 16.

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

14.12 Tables

Table 14.2.1. Offshore catches (t) divided into NAFO divisions in West Greenland. 1924–1991: Horsted 2000, 2004–present: Greenland Fisheries License Control.

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A – 1E
1924							200	
1925							1871	
1926							4452	
1927							4427	
1928							5871	
1929							22304	
1930							94722	
1931							120858	
1932							87273	
1933							54351	
1934							88422	
1935							65796	
1936							125972	
1937							90296	
1938							90042	
1939							62807	
1940							43122	
1941							35000	
1942							40814	
1943							47400	
1944							51627	
1945							45800	
1946							44395	
1947							63458	
1948							109058	
1949							156015	
1950							179398	
1951							222340	
1952	0	261	2996	18188	707	37905	257488	117126 *
1953	4546	46546	10611	38915	932	25242	98225	180220 *
1954	2811	97306	18192	91555	727	15350	60179	266682 *
1955	773	50106	32829	87327	3753	4655	68488	241499 *
1956	15	56011	38428	128255	8721	4922	66265	296315 *
1957	0	58575	32594	62106	29093	16317	47357	225836 *
1958	168	55626	41074	73067	21624	26765	75795	258062 *
1959	986	74304	10954	30254	12560	11009	67598	191343 *
1960	35	58648	18493	35939	16396	9885	76431	200522 *
1961	503	78018	43351	70881	16031	14618	90224	293104 *
1962	1017	122388	75380	57972	25336	17289	125896	400719 *
1963	66	70236	73142	76579	46370	16440	122653	381917 *
1964	96	49049	49102	82936	33287	13844	99438	307878 *
1965	385	80931	66817	71036	15594	15002	92630	321829 *

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A – 1E
1966	12	99495	43557	62594	19579	18769	95124	313044 *
1967	361	58612	78270	122518	34096	12187	95911	385949 *
1968	881	12333	89636	94820	61591	16362	97390	350870 *
1969	490	7652	31140	65115	41648	11507	35611	179055 *
1970	278	3719	13244	23496	23215	15519	18420	78775 *
1971	39	1621	28839	21188	9088	20515	26384	80501 *
1972	0	3033	42736	18699	7022	4396	20083	90410 *
1973	0	2341	17735	18587	10581	2908	1168	50347 *
1974	36	1430	12452	14747	8701	1374	656	37999 *
1975	0	49	18258	12494	6880	3124	549	38188 *
1976	0	442	5418	10704	8446	2873	229	25215 *
1977	127	301	4472	7943	8506	2175	35477 [1]	53546 *
1978	0	0	11856	2638	3715	549	34563 [1]	51760 *
1979	0	16	6561	4042	1115	537	51139 [1]	60635 *
1980	0	1800	2200	2117	1687	384	7241 [1]	14705 *
1981	0	0	4289	4701	4508	255	0	13498
1982	0	133	6143	10977	11222	692	1174	29621 *
1983	0	0	717	6223	16518	4628	293	23703 *
1984	0	0	0	4921	5453	3083	0	10374
1985	0	0	0	145	1961	1927	2402	3360 *
1986	0	0	0	2	72	24	1203	982 *
1987	0	0	5	815	67	43	3041	3787 *
1988	0	0	919	17463	10913	6466	8101	35931 *
1989	0	0	0	11071	48092	14248	2	59165
1990	0	0	2	563	21513	10580	7503	27151 *
1991	0	0	0	0	104	1942	0	104
1992	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0
2004	0	0	0	5	3	1	0	8
2005	0	0	1	0	0	71	0	1
2006	0	0	0	0	0	414	0	0
2007	0	0	0	31	435	2011 [2]	0	466
2008	0	0	0	23	526	11370 [2]	0	549
2009	0	0	0	0	6	3323 [2]	0	6
2010	0	0	0	0	2	281	0	2
2011	0	0	0	0	8	542	0	8

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A – 1E
2012	0	0	1	95	236	1470	0	332
2013	0	0	0	209	270	1405	0	479
2014	0	0	30	68	18	1833	0	116
2015	0	0	341	954	3564	3984	0	4860

Estimates for assessment include estimates of unreported catches. The total estimated value for West Greenland (inshore + offshore) was 73000 t in 1977 and 1978, 1979: 99000 t, 1980: 54000 t. The value given in the table are these values minus the inshore catches minus known offshore NAFO division catches.

Include catches taken with small vessels and landed to a factory in South Greenland (Qaqortoq), 2007:597 t, 2008: 2262 t, 2009: 136 t.

***Unknown NAFO division catches added accordingly to the proportion of known catch in NAFO divisions 1A-1E to known total catch in all NAFO divisions.**

Table 14.2.2.1: 2015 cod catches (t) divided into month and NAFO areas, caught by the offshore fisheries.

NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
1C										1	163	177	341	7%
1D								28	4	305	615	2	954	20%
1E							4	302	746	878	1016	618	3564	73%
Total							4	330	749	1184	1795	798	4860	
%							0.1%	7%	15%	24%	37%	16%		

Table 14.2.2.3: 2015 cod catches (t) by gear, area and month in Westgreenland.

Gear	NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Longline	1D								28		304	242		574
	1E								46	437	265	297	127	1172
	Total								74	437	570	539	127	1746
Trawl	1C										1	163	177	341
	1D									4	1	373	2	379
	1E							4	256	309	613	720	491	2392
	Total							4	256	312	614	1256	671	3113

Table 14.2.3.1. Cod in Greenland. Catch-at-age ('000) and Weight at age (kg) for offshore fleets in Westgreenland (NAFO 1A-1E). Yellow highlights dominating year classes in the catches.

Catch-at-age								
Year/age	3	4	5	6	7	8	9	10+
2007	6	167	66	42	6	1		
2008								
2009								
2010								
2011								
2012	8	33	107	38	18	2	0.01	0.003
2013		15	44	113	29	15	4	1
2014	1	18	45	7	9	2	0.02	
2015	6	67	502	1061	240	158	45	16
Weight at age								
2007	0.647	0.906	1.949	3.440	5.817	6.053		
2008								
2009								
2010								
2011								
2012	0.560	0.935	1.395	2.139	3.232	4.194	8.325	12.500
2013		1.120	1.462	1.947	2.978	3.754	6.398	7.342
2014	0.488	0.693	1.199	1.738	3.040	4.817	5.318	
2015	0.474	0.734	1.316	1.982	3.186	5.043	7.167	10.329

Table 14.3.1.1. Number of hauls in the Greenland Shrimp and Fish survey in West Greenland by year and NAFO subdivisions.

				West Greenland			
Year/NAFO	0A	1A	1B	1C	1D	1E	Total
1992		92	44	18	18	11	183
1993		69	49	21	15	12	166
1994		76	58	23	8	9	174
1995		83	61	29	13	14	200
1996		71	57	29	12	9	178
1997		84	56	32	12	12	196
1998		77	80	27	19	14	217
1999		84	81	33	16	14	228
2000		56	62	37	23	14	192
2001		60	75	36	24	15	210
2002		50	80	32	18	20	200
2003		51	63	30	18	15	177
2004		54	55	24	22	20	175
				New Survey Gear Introduced			
2005	6	65	56	26	19	23	195
2006	5	86	60	26	20	21	218
2007	8	73	58	26	27	31	223
2008	6	69	61	28	23	25	212
2009	8	74	75	28	22	24	231
2010	10	95	76	30	23	25	259
2011	0	73	64	24	18	12	191
2012	0	73	64	21	18	18	194
2013	4	73	52	20	13	21	183
2014	0	78	57	19	17	23	194
2015	0	70	49	24	22	20	185

Table 14.3.1.2 Cod abundance indices ('000) from the Greenland Shrimp and Fish survey in West Greenland by year and NAFO subdivisions.

West Greenland								
Year	0A	1A	1B	1C	1D	1E	Total	CV
1992		4	53	243	345	0	645	
1993		2	16	54	135	286	493	
1994		10	41	87	0	6	144	
1995		0	51	380	44	62	537	
1996		0	0	46	68	87	201	
1997		0	7	31	0	0	38	
1998		0	4	0	26	26	56	
1999		32	136	16	23	6	213	
2000		585	437	71	58	9	1160	
2001		26	305	110	448	305	1194	
2002		13	203	78	3294	114	3702	
2003		492	1395	351	727	214	3179	
2004		197	152	379	2630	1538	4896	
New Survey Gear Introduced								
2005	143	198	871	1845	4796	6683	14537	25
2006	453	371	4454	2564	15703	3359	26905	45
2007	737	1318	3302	7353	3624	3296	19628	31
2008	1209	897	4185	4068	9008	11553	30913	27
2009	881	889	4195	3272	2788	1252	13277	12
2010	338	720	2837	2712	8295	2745	17647	23
2011		8756	47092	2179	26510	1013	85549	14
2012		7661	10228	3017	1270	27081	49258	54
2013	4613	8951	12864	5673	7887	29924	69911	43
2014		6911	5670	78854	2456	16254	110145	67
2015		6542	11213	27248	31703	23493	100198	34

Table 14.3.1.3. Cod biomass indices (tons) from the Greenland Shrimp and Fish survey in West Greenland by year and NAFO subdivisions.

West Greenland								
	0A	1A	1B	1C	1D	1E	Total	CV
1992		23	54	75	118	0	270	
1993		2	5	25	39	124	195	
1994		3	9	38	0	1	51	
1995		5	6	120	23	3	157	
1996		0	0	15	23	27	65	
1997		0	2	53	0	0	55	
1998		1	1	0	47	50	99	
1999		29	28	1	17	1	76	
2000		226	130	21	9	2	388	
2001		140	155	56	178	98	627	
2002		67	128	41	1489	42	1767	
2003		444	323	264	453	118	1602	
2004		542	53	176	680	685	2136	
New Survey Gear Introduced								
2005	38	69	364	458	1084	1141	3155	26
2006	114	62	677	537	5131	525	7046	64
2007	247	387	872	1562	628	659	4355	31
2008	413	377	2046	929	1633	3227	8625	28
2009	208	230	1251	711	439	253	3092	14
2010	180	263	999	543	2426	908	5319	22
2011		1569	9654	408	5316	191	17140	14
2012		1932	2938	1125	464	14103	20562	69
2013	2395	2692	3960	1732	4551	19017	34345	53
2014		2639	2305	56061	2511	21381	84897	64
2015		3463	4456	19705	33169	34695	95487	38

Table 14.3.1.4: Abundance indices ('000) by year class/age from the Greenland Shrimp and Fish survey in West Greenland (NAFO 1A-1E).

West Greenland											
Year/age	0	1	2	3	4	5	6	7	8	9	10+
2005	134	815	10247	1604	1514	186	35	2	0	0	0
2006	249	6543	3577	12677	3395	401	47	16	0	0	0
2007	152	270	13792	3439	1934	37	4	0	0	0	0
2008	31	3472	2692	18780	4904	868	121	44	0	0	0
2009	0	124	9442	1666	1717	326	3	0	0	0	0
2010	209	2703	2094	10566	1252	775	42	7	0	0	0
2011	19	4940	71837	4453	3735	391	175	0	0	0	0
2012	0	204	11264	31593	3648	2427	116	7	0	0	0
2013	0	2904	8912	15168	36226	5665	848	142	22	25	0
2014	0	471	4792	8088	56469	35839	2597	1718	125	35	11
2015	0	2210	3932	15038	21509	34766	21117	1196	348	70	12

Table 14.3.1.5 Abundance indices ('000) by age from the Greenland Shrimp and Fish survey in West Greenland by NAFO divisions, 2015.

West Greenland											
Year class	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	<2006
Age	0	1	2	3	4	5	6	7	8	9	10+
Div. 0A											
Div. 1A	0	149	1037	3066	1107	939	175	69	0	0	0
Div. 1B	0	1758	2245	3042	2469	1251	436	12	0	0	0
Div. 1C	0	205	569	6265	8255	8337	3404	184	29	0	0
Div. 1D	0	98	41	2000	7177	16214	5940	185	0	48	0
Div. 1E	0	0	39	665	2502	8026	11161	746	319	22	12

Table 14.3.2.1 ***German survey*****. Numbers of valid hauls by stratum in West Greenland (NAFO 1C-E).**

	NAFO 1C		NAFO 1D		NAFO 1E		
YEAR	STR 1.1	STR 1.2	STR 2.1	STR 2.2	STR 3.1	STR 3.2	SUM
1981	1	1	13	2	3	1	21
1982	20	11	16	7	9	6	69
1983	26	11	25	11	17	5	95
1984	25	13	26	8	19	6	97
1985	10	8	26	10	17	5	76
1986	27	9	21	9	16	7	89
1987	25	19	21	4	18	4	91
1988	34	21	28	5	18	5	111
1989	25	14	30	9	8	3	89
1990	19	7	23	8	16	3	76
1991	19	11	23	7	13	6	79
1992	6	6	6	5	6	6	35
1993	9	7	9	6	10	8	49
1994	16	13	13	8	10	6	66
1995	.	.	3	.	10	7	20
1996	5	5	8	5	12	5	40
1997	5	6	5	5	6	5	32
1998	9	5	10	7	11	6	48
1999	8	7	14	8	13	6	56
2000	13	6	15	6	14	5	59
2001	.	.	15	7	15	5	42
2002	.	.	7	2	5	6	20
2003	.	.	7	6	7	7	27
2004	8	8	11	9	9	5	50
2005	.	.	9	7	8	6	30
2006	6	5	7	5	7	7	37
2007	5	5	7	5	6	5	33
2008	5	.	7	7	7	9	35
2009	2	.	5	5	6	6	24
2010	5	5	10	5	7	9	41
2011	.	.	5	5	5	5	20
2012	5	5	10	8	9	7	44
2013	6	6	8	6	10	7	43
2014	5	5	10	8	10	7	45
2015	7	7	7	4	5	5	35

Table 14.3.2.2 ***German survey*****. Cod abundance indices ('000) from the German survey in West Greenland (NAFO 1C-1E) by year and stratum.**

	NAFO 1C		NAFO 1D		NAFO 1E			
year	str1_1	str1_2	str2_1	str2_2	str3_1	str3_2	Sum	SD
1982	2364	408	27594	920	7401	1801	40488	18605
1983	177	196	7079	2230	8678	1230	19590	7266

1984	189	90	2524	98	2666	364	5931	3629
1985	8094	1107	7237	2348	4984	840	24610	10809
1986	14716	630	22985	108	16570	609	55618	29631
1987	173517	482	115172	3790	72349	186	365496	331763
1988	46027	1106	186523	43090	21037	51	297834	216925
1989	1362	483	16280	325	129005	678	148133	65933
1990	619	299	2279	235	3827	61	7320	5462
1991	142	116	88	92	474	387	1299	412
1992	274	334	72	127	57	38	902	314
1993	327	243	105	109	53	21	858	195
1994	95	53	16	17	34	11	226	79
1995	.	.	27	.	72	34	133	60
1996	82	70	42	20	65	0	279	80
1997	0	24	17	0	57	3	101	45
1998	793	0	23	28	7	0	851	573
1999	103	33	33	11	197	7	384	171
2000	205	250	50	174	288	9	976	383
2001	.	.	584	36	3020	9	3649	3481
2002	.	.	238	21	342	23	624	257
2003	.	.	625	99	1625	73	2422	945
2004	503	213	1522	123	2709	638	5708	1592
2005	.	.	1586	264	5666	419	7935	3115
2006	495	485	87439	858	4481	1323	95081	99523
2007	1430	3261	3417	687	9861	71	18727	8645
2008	2666	.	916	911	23527	616	28636	26712
2009	72	.	1370	850	1068	378	3738	879
2010	2644	464	4451	631	5148	274	13612	6231
2011	.	.	716	375	1242	337	2670	782
2012	99609	1253	6007	442	8455	1251	117017	68441
2013	4457	1585	20122	221	7138	252	33775	22438
2014	9952	2008	28102	413	1261	86	41822	38616
2015	13315	906	73434	471	2432	102	90660	73453

Table 14.3.2.3 ***German survey,*** **Cod biomass indices (tons) from the German survey in West Greenland (NAFO 1C-1E) by year and stratum.**

	NAFO 1C		NAFO 1D		NAFO 1E			
year	str1_1	str1_2	str2_1	str2_2	str3_1	str3_2	Sum	SD
1982	1113	163	37404	1280	9970	4483	54413	26014
1983	144	87	9052	3381	12953	5015	30632	10295
1984	406	104	3998	137	3643	551	8839	5507
1985	1046	112	6543	1181	4700	506	14088	18209
1986	4858	254	11787	36	12381	651	29967	13885
1987	148896	156	93292	2446	54178	107	299075	299459
1988	47085	579	190073	39548	19663	54	297002	227428

1989	384	124	15061	211	113614	710	130104	55334
1990	130	66	1948	123	3652	56	5975	4986
1991	45	38	36	28	549	374	1070	529
1992	65	104	15	33	10	7	234	97
1993	77	45	27	27	30	6	212	53
1994	13	17	3	12	11	5	61	17
1995	.	.	14	.	13	7	34	12
1996	13	35	12	11	28	0	99	29
1997	0	21	11	0	50	3	85	43
1998	38	0	1	7	1	0	47	25
1999	16	11	6	3	63	5	104	57
2000	54	71	11	83	73	5	297	117
2001	.	.	163	17	1024	5	1209	1212
2002	.	.	89	16	136	7	248	108
2003	.	.	98	44	736	32	910	461
2004	172	83	274	45	547	186	1307	342
2005	.	.	605	124	1796	146	2671	1057
2006	102	138	45616	250	2046	614	48766	52298
2007	319	885	1579	244	7804	43	10874	7524
2008	872	.	193	206	11479	175	12925	13686
2009	19	.	309	293	372	153	1146	255
2010	1012	244	2234	312	2703	173	6678	3057
2011	.	.	189	128	1040	194	1551	602
2012	52497	588	4185	240	8203	848	66561	35693
2013	2703	1670	17316	142	11251	544	33626	18801
2014	10597	2154	35741	422	3561	397	52872	47451
2015	17221	1105	109073	522	5999	216	134136	108717

Table 14.3.2.4 ***German survey*, West Greenland (NAFO 1C-1D). Age disaggregated abundance indices ('1000).**

YEAR	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
1982		77	505	14266	5195	14798	4144	908	178	344	35	34	40484
1983*)													
1984	80	3	13	709	604	3495	289	628	32	61	13	0	5927
1985	202	16823	623	330	2271	1100	2982	112	164	2	3	0	24612
1986		3600	45772	1686	321	2386	652	1098	22	74	3	1	55615
1987		147	22578	318948	13977	2930	4603	649	1506		131	13	365482
1988		124	1357	44364	247618	2660	311	521	318	529	12	15	297829
1989	0	163	1293	3821	79642	62126	1008		47	7	24	0	148131
1990	11	17	595	1242	368	4089	990	6	0	0		1	7319
1991		86	94	193	350	36	461	57	2			0	1279
1992		88	672	100	17	25		0				0	902
1993		8	499	318	12	21						0	858
1994		98	18	90	14	3		2				0	225
1995			111	6	16							0	133

1996		76	6	193	5		0					0	280
1997		6	13	7	76							0	102
1998	0	845		3	3	0						0	851
1999	8	165	166	36	3		3					0	381
2000		60	524	328	62							0	974
2001		266	2753	527	65	20						0	3631
2002	0	6	309	290	17							0	622
2003		1368	205	511	284	36	9					0	2413
2004	132	3078	2008	307	108	55	15	0				0	5703
2005	91	156	6893	653	40	16	14	0	0			0	7863
2006	157	1949	6961	83106	2708	45	51	67	0			0	95044
2007	139	229	9402	1655	6989	227	35	38	12			0	18726
2008	8	1224	2317	20080	3747	1235	20	3	2	0	0	0	28636
2009	36	326	2513	363	406	37	40	14				0	3735
2010	208	1531	1726	9201	577	259	51	48	3	3		5	13612
2011		195	1572	385	368	68	33	26	24	0	0	0	2671
2012	142	1191	37872	66947	7682	2847	227	76	8	18		0	117010
2013		152	1562	12824	15859	1783	1135	234	86	23	18	4	33680
2014			880	4629	17021	17863	1080	277	32	0	4	0	41786
2015	159	189	1353	10921	16208	43991	16909	708	87	117	8	12	90660

***) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (ICES, 1984).**

Table 14.5.1. Number of tagged cod in the period of 2003 to 2015 in different regions. Bank (West) = NAFO division 1D+1E. East Greenland = NAFO division 1F + ICES division XIVb.

	Tagged		
Year	Fjord	Bank (West)	East Greenland
2003	599		
2004	658		
2005	565		
2006	41		
2007	1140	721	1387
2008	231		1296
2009	633		525
2010	88		
2011	28		403
2012	86	1563	2359
2013	183	2321	
2014			1203
2015		57	1218

Table 14.5.2: Number of recaptured cod in the period of 2003 to 2015 in different regions. Fjord (West) = NAFO divisions 1B-1F. Bank (West) = NAFO division 1D+1E. East Greenland = NAFO division 1F + ICES division 14.

Recaptures			
	Fjord (West)	Bank (West)	East Greenland
Fjord (West)	438	14	2
Bank (West)	1	34	2
East Greenland		12	99
Iceland	3	21	125

14.13 Figures

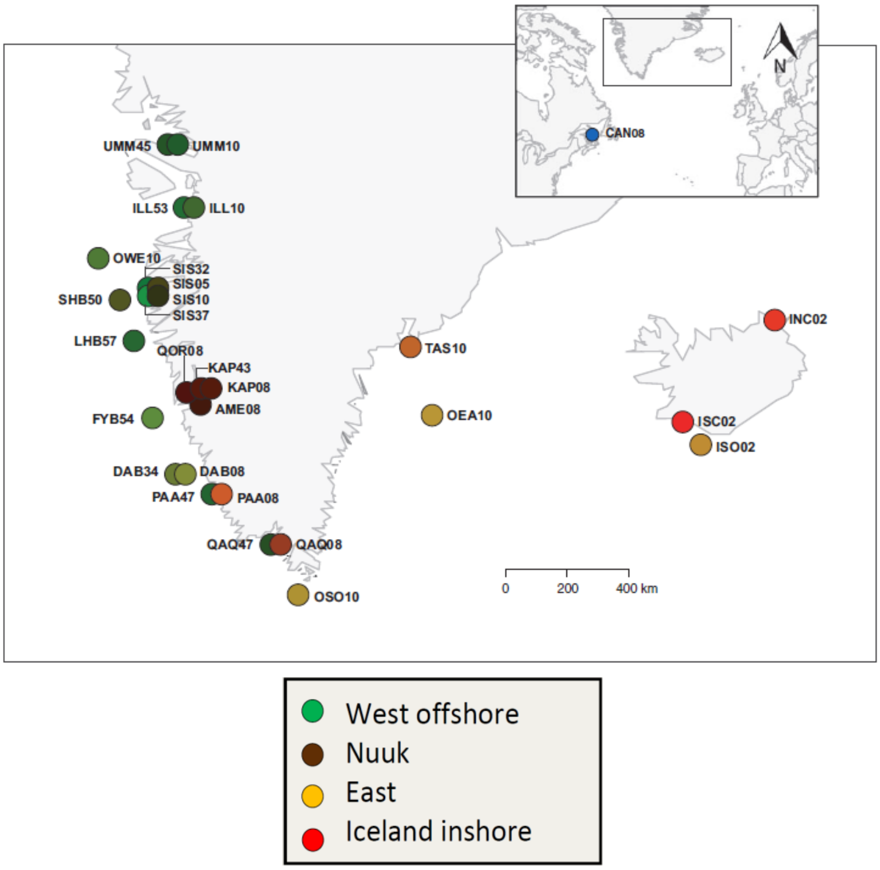


Figure. 14.1. Sampling location of spawning cod in Greenland and Iceland in the genetic project. The colours of the dots represent the blends of sample mean of the different spawning population: West offshore, Nuuk (inshore), East (Greenland and offshore Iceland) and Iceland inshore as signal intensities of green and red respectively. After Therkildsen *et al*. 2013.

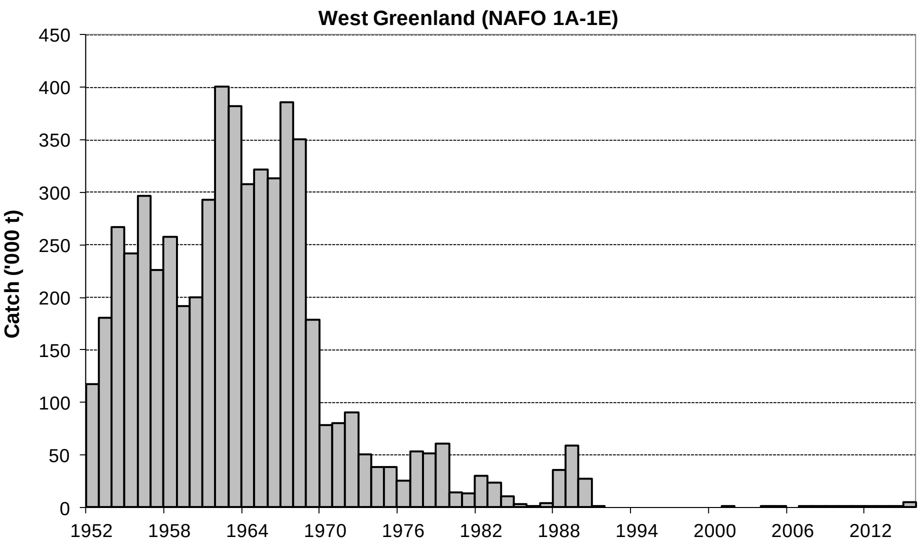


Figure 14.2.1. Annual catch of cod in offshore West Greenland (NAFO subdivisions 1A–1E) used by the Working Group.

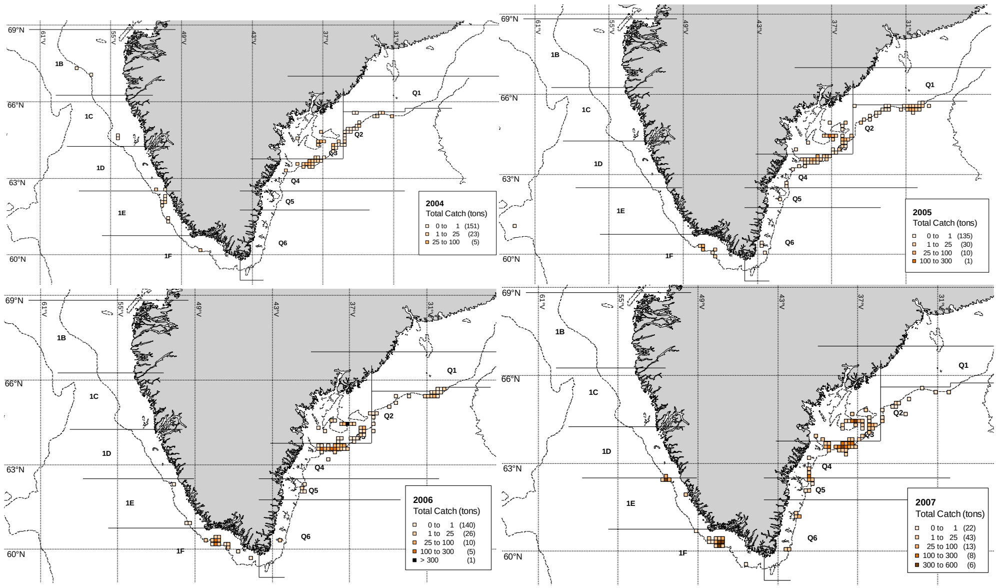


Figure 14.2.2.1: Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

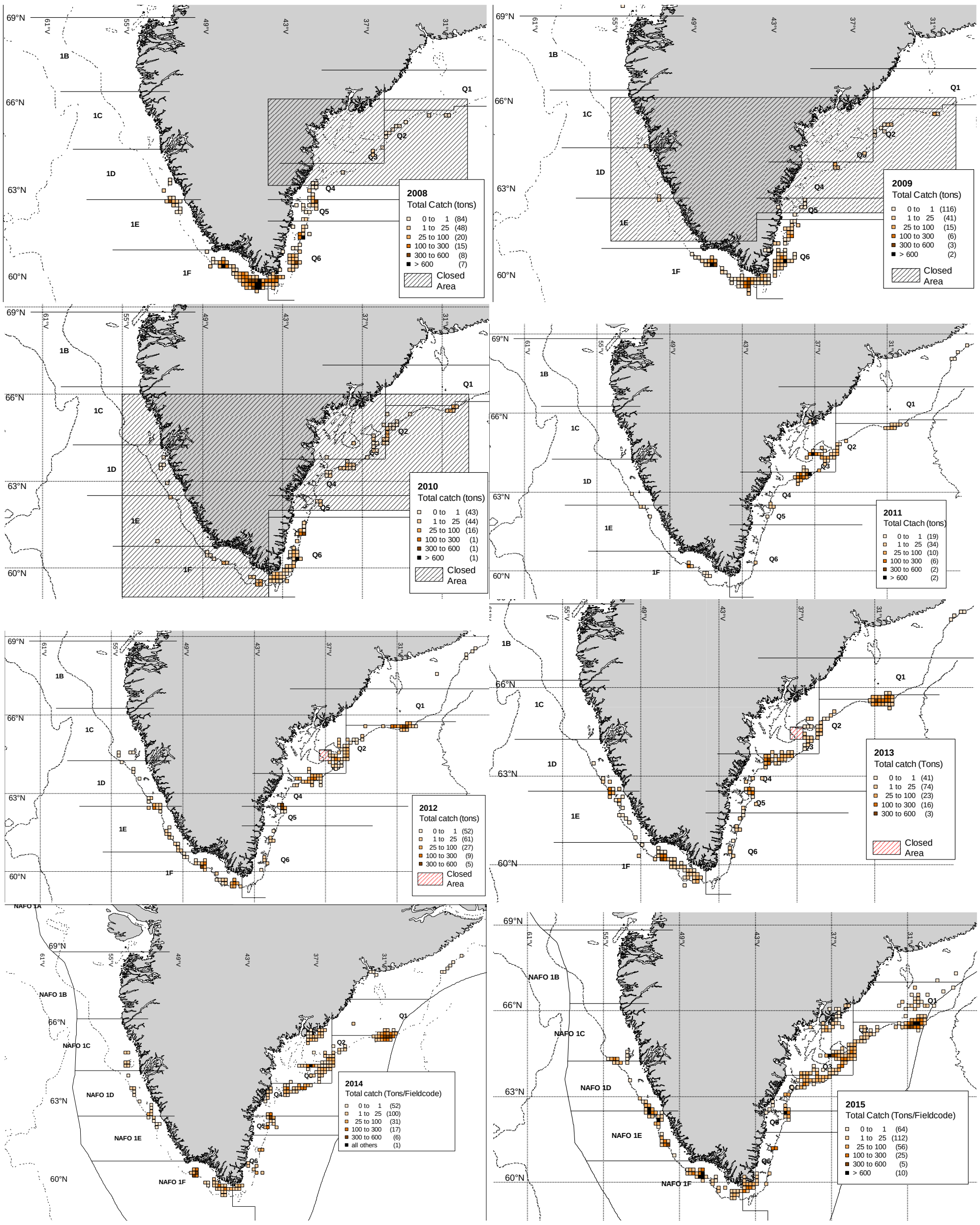


Figure 14.2.2.1: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

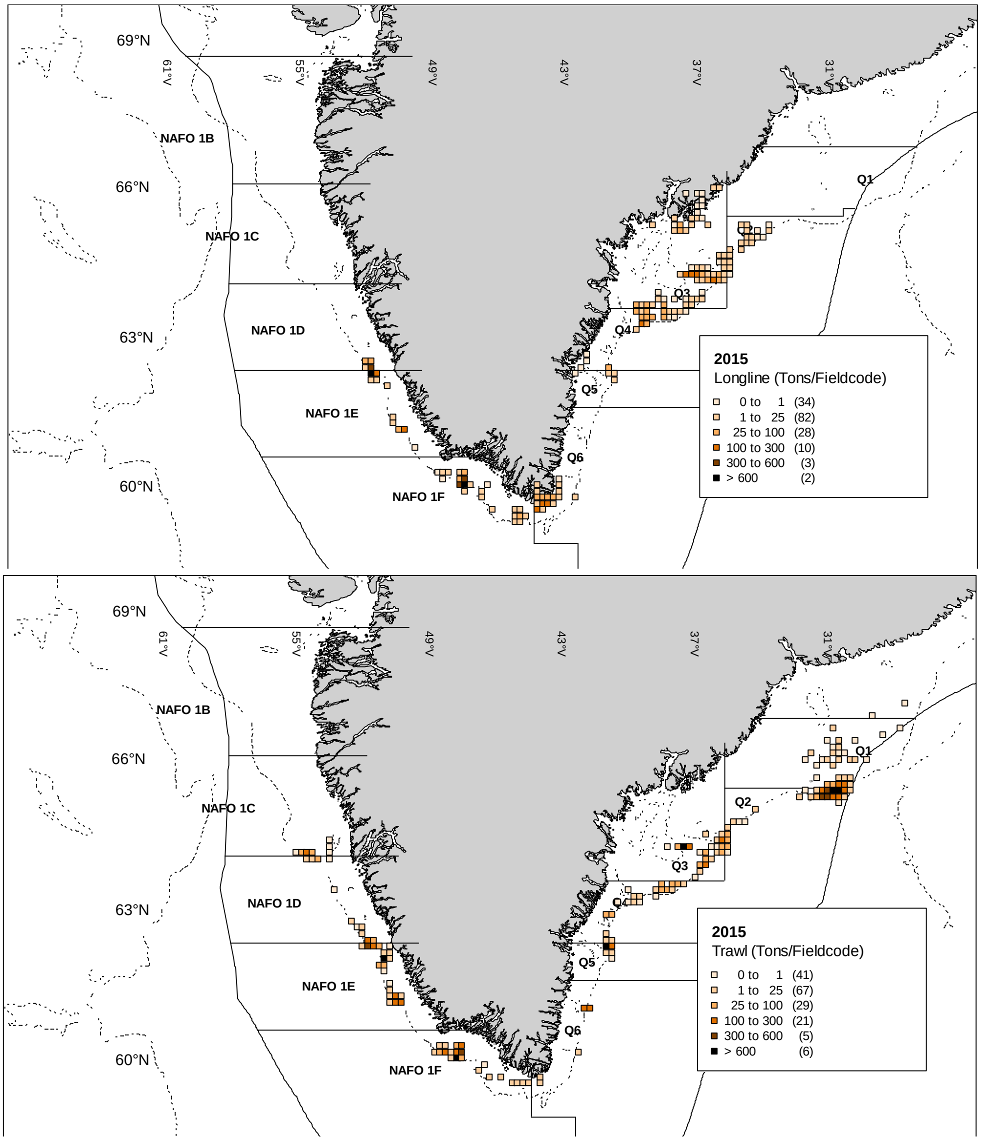


Figure 14.2.2.2: Distribution of Longline and Trawl catches of Atlantic cod in West and East Greenland 2015. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

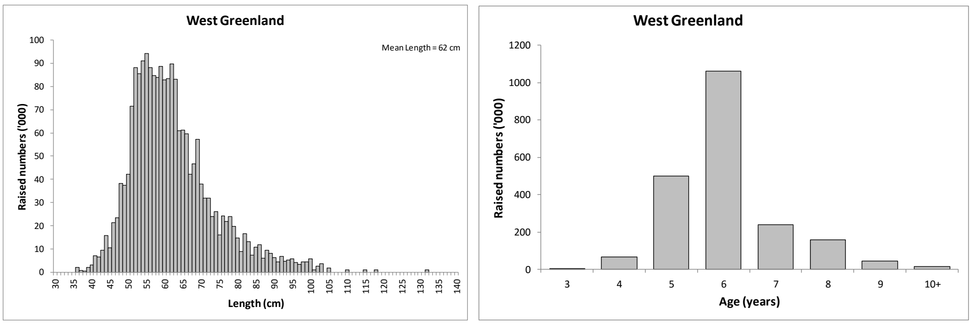


Figure 14.2.3.1: Total length and age distributions of commercial cod catches in the West Greenland (NAFO 1A–1E) offshore fishery in 2015.

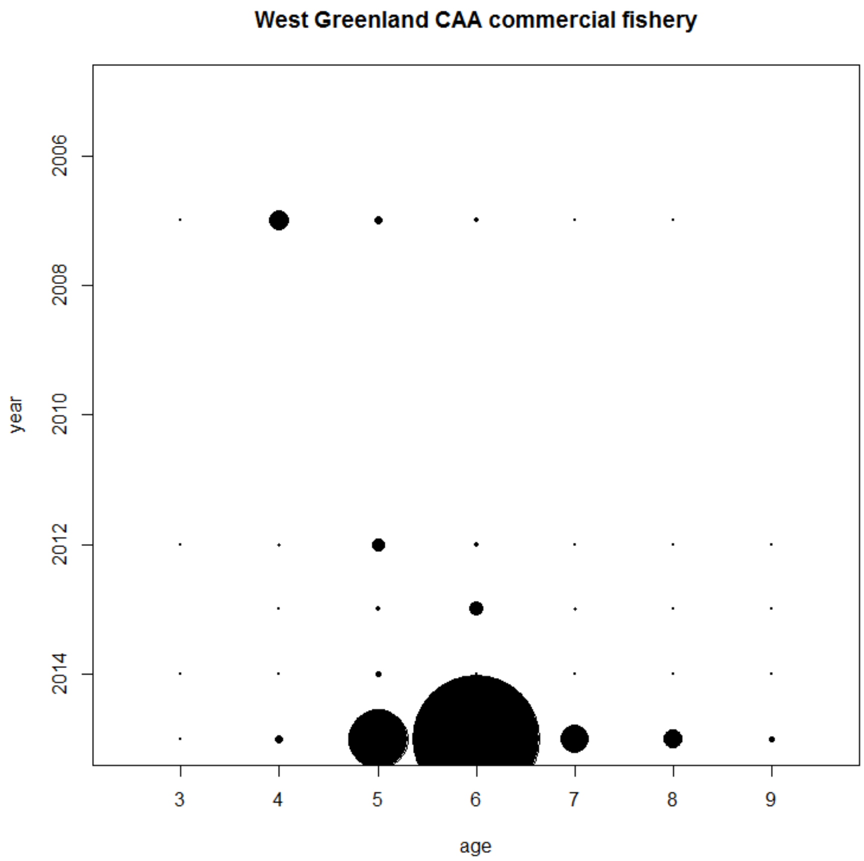


Figure 14.2.3.2: Catch-at-age in the West Greenland (NAFO 1A-1E) commercial fishery. Size of circles represents size of catch numbers.

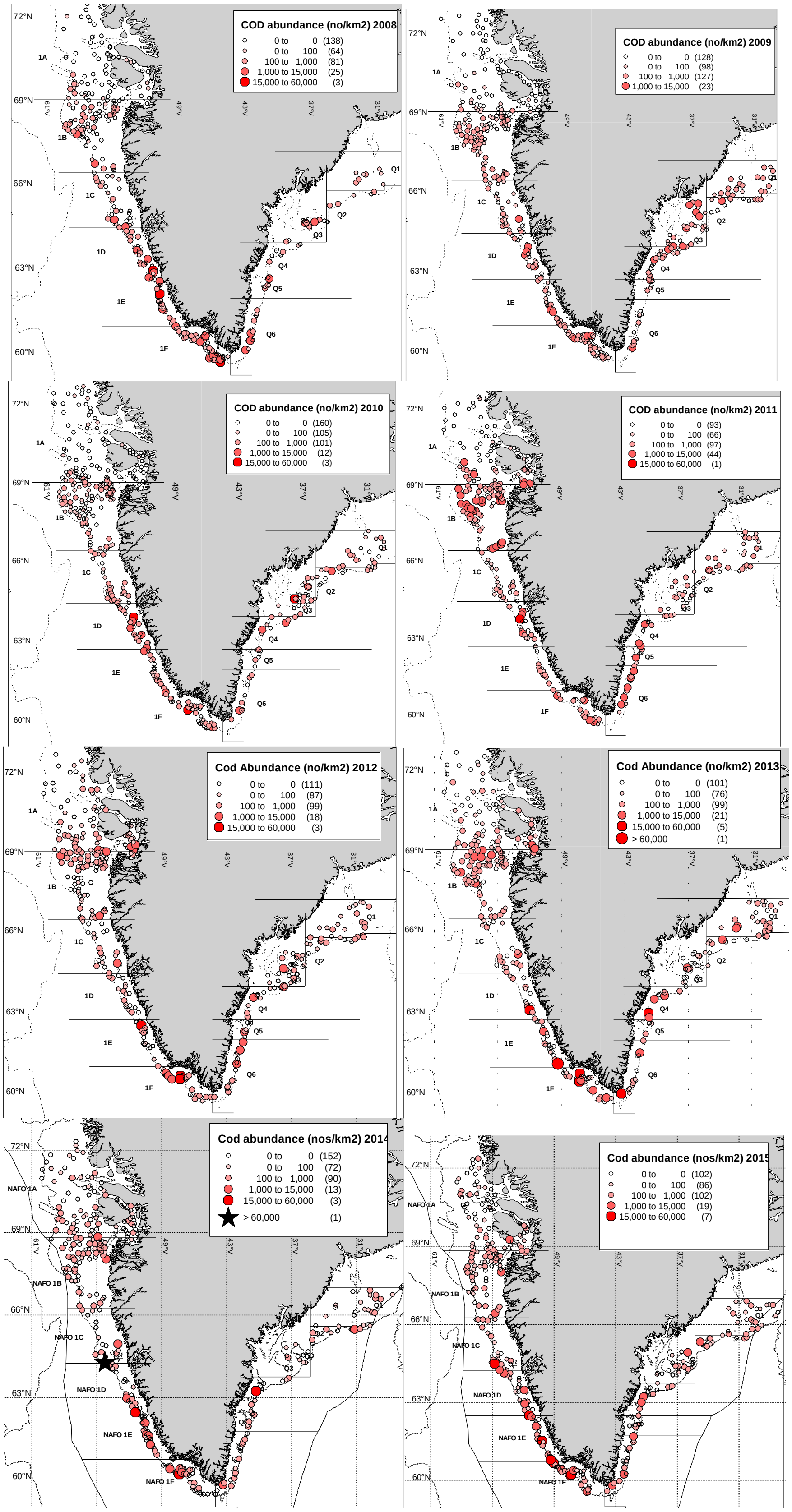


Figure14.3.1.1. Greenland shrimp and fish survey 2008–2015. Abundance per Km²

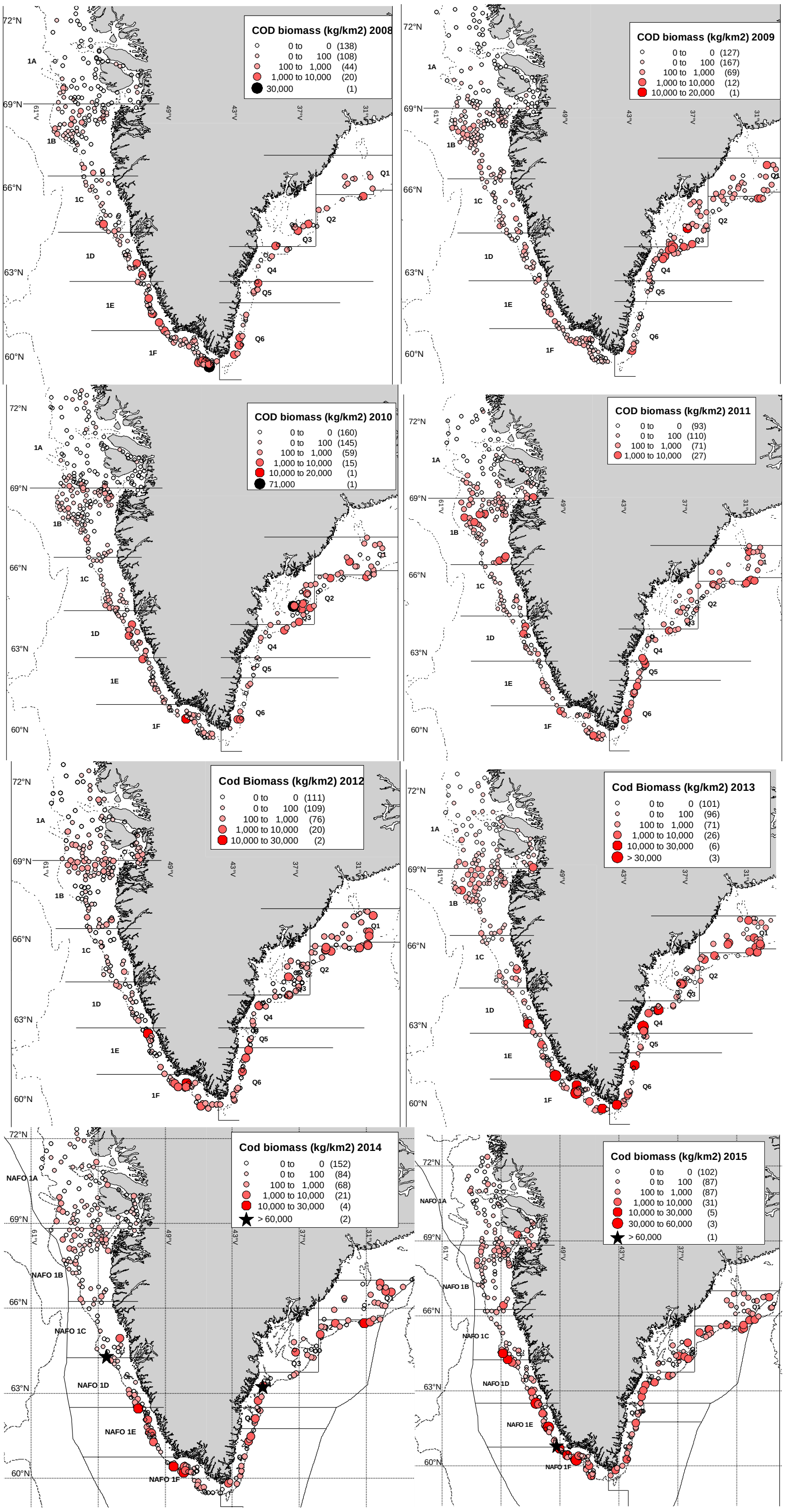


Figure 14.3.1.2. Greenland shrimp and fish survey 2008–2015. Catch weight kg per Km²

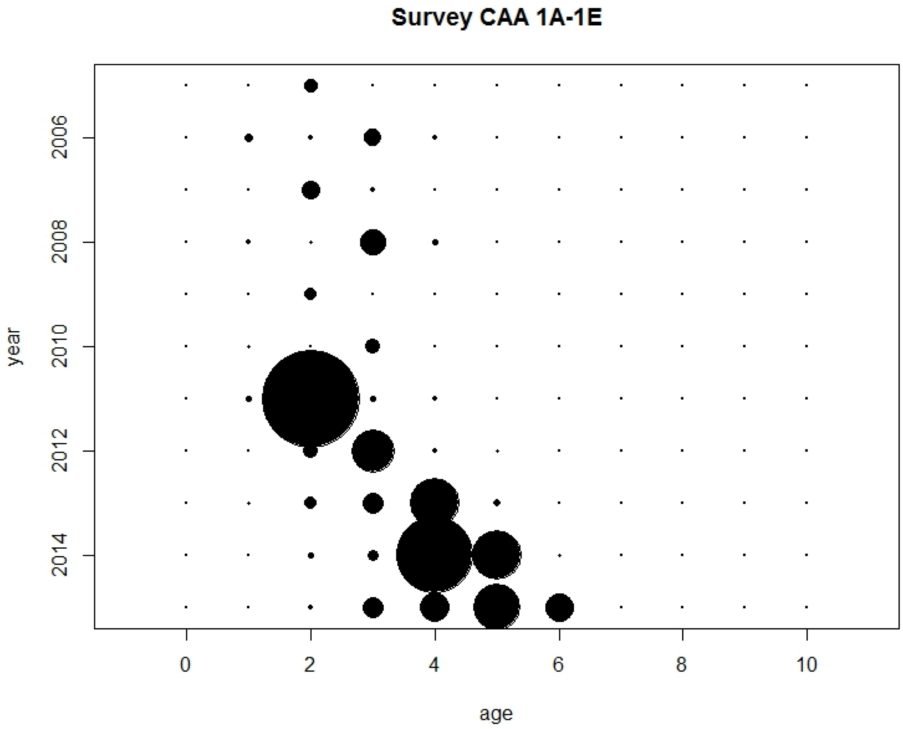


Figure 14.3.1.3: Abundance index by age in NAFO 1A–1E combined. Size of circles represents index size of index.

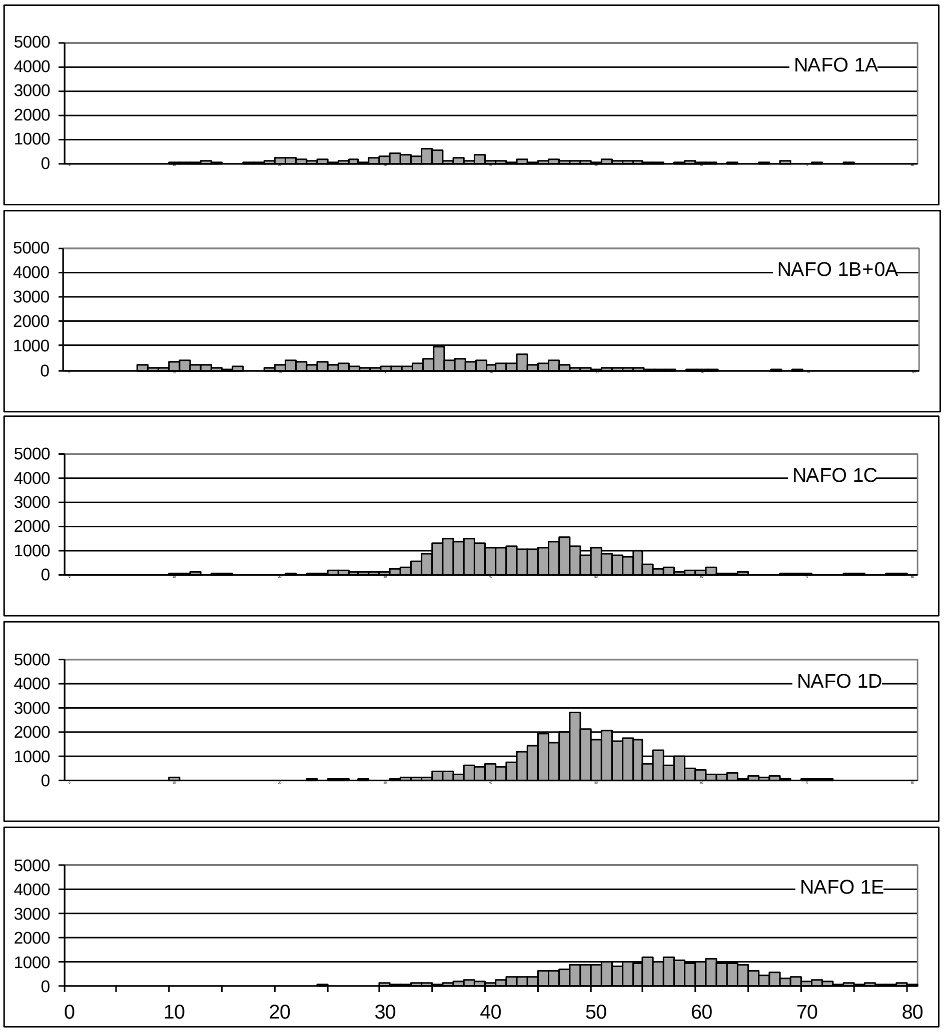


Figure 14.3.1.4: West Greenland Shrimp and fish survey, 2015. Abundance index by length (cm) and area. Areas from north (top) to south (bottom) are: NAFO div. 1A; 1B+0A; 1C, 1D, 1E.

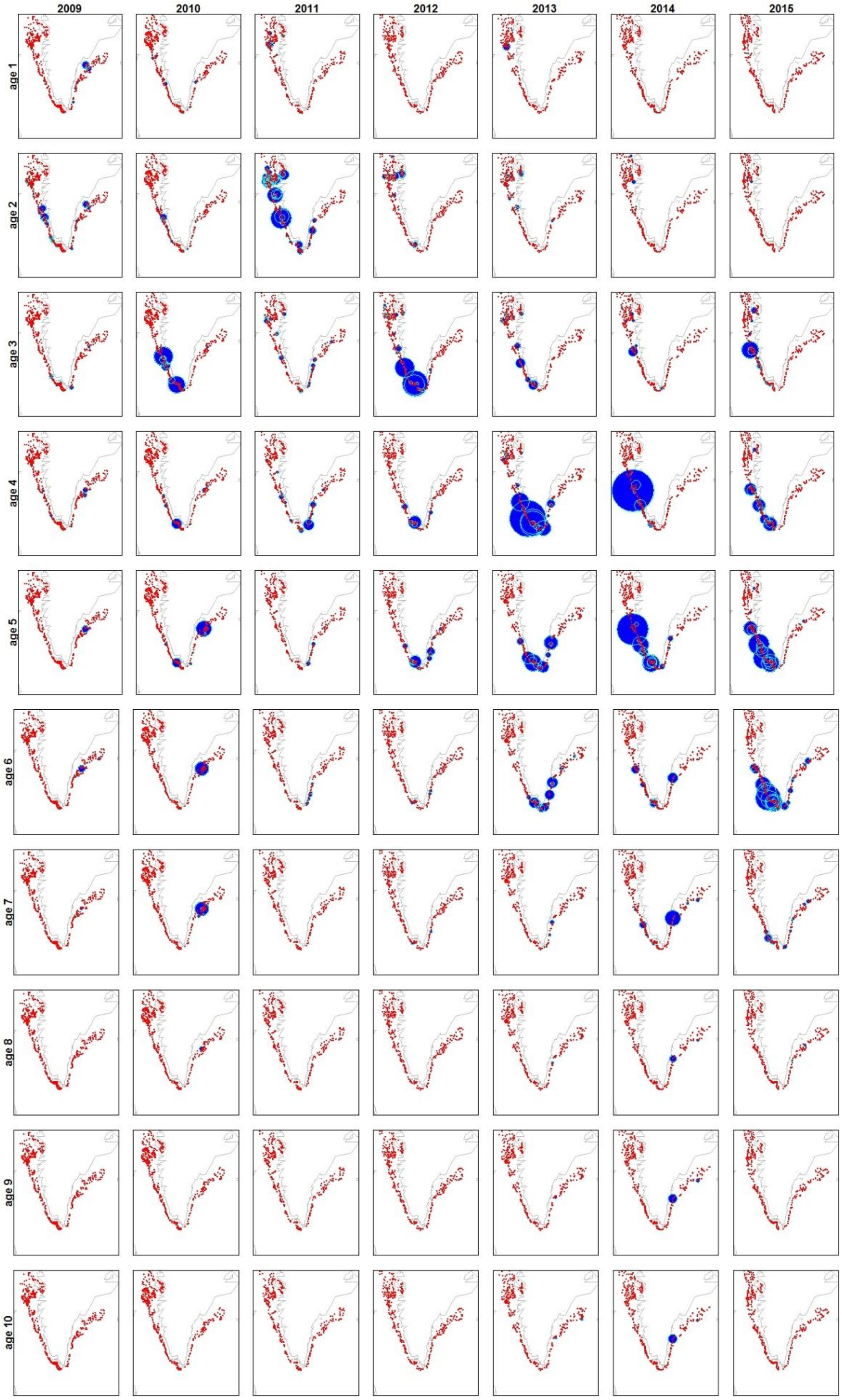


Figure 14.3.1.5. Abundance (no/km²) pr. station of ages 1–10 in the years 2009–2015.

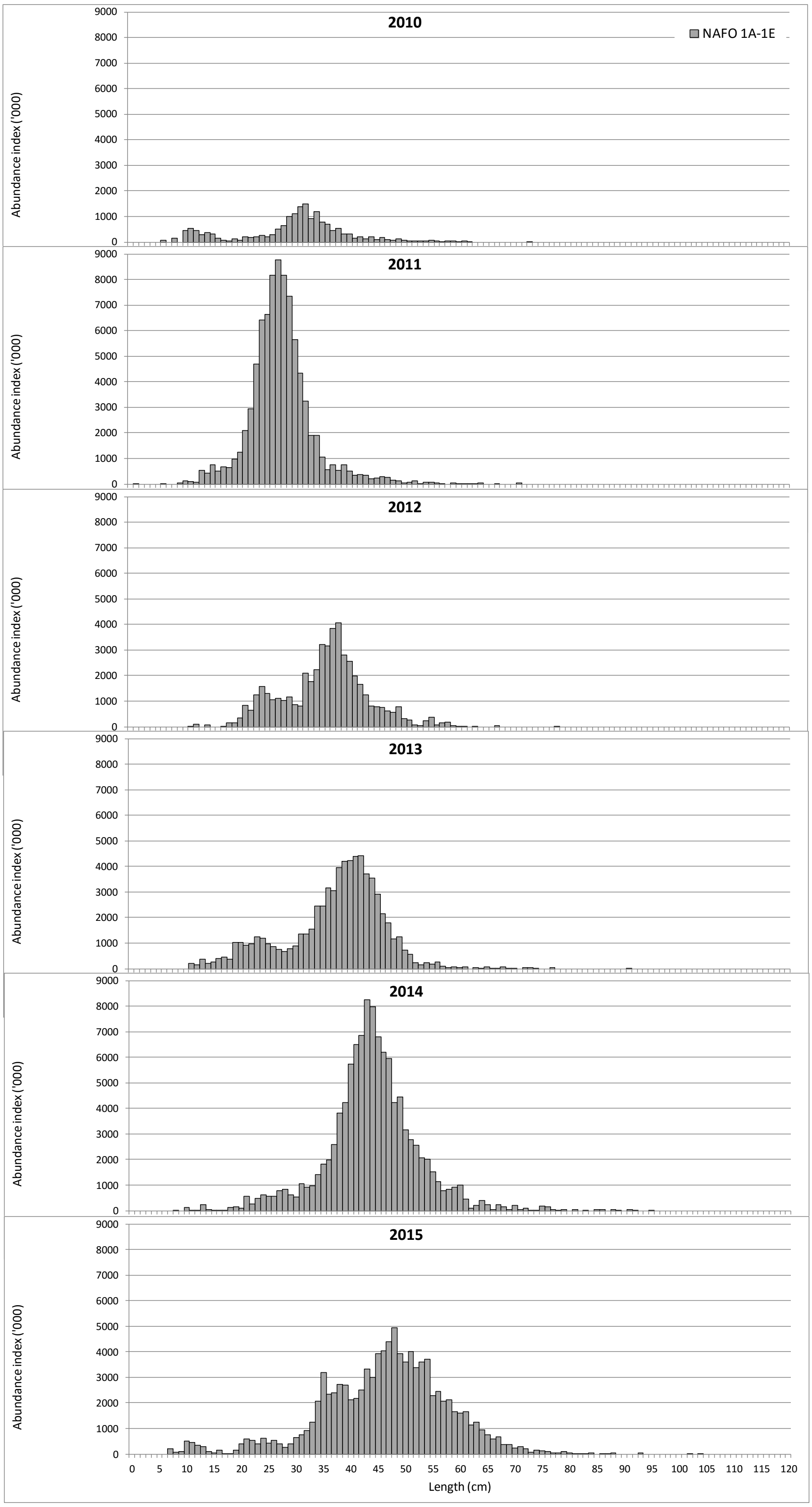


Figure 14.3.1.6: Total abundance indices by length in West Greenland shrimp and fish survey (NAFO 1A–1E).

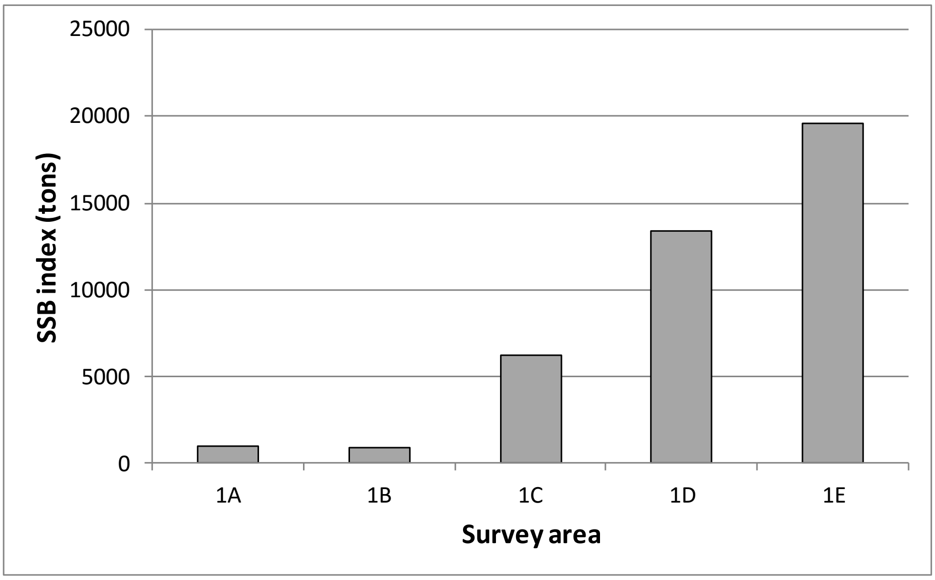


Figure 14.3.1.7: Estimated SSB (tons) by NAFO subdivisions from the West Greenland Shrimp and Fish survey, 2015. Maturity taken from proportion mature by length as recorded on observer trips off East Greenland in 2007.

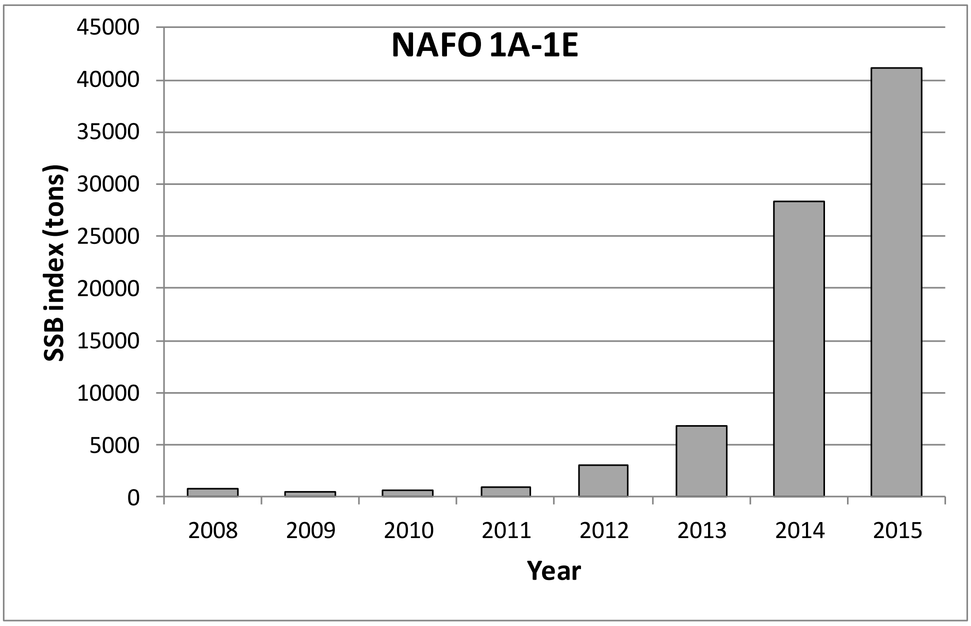


Figure 14.3.1.8: Estimated SSB (tons) by year from the West Greenland Shrimp and Fish survey (NAFO 1A–1E).

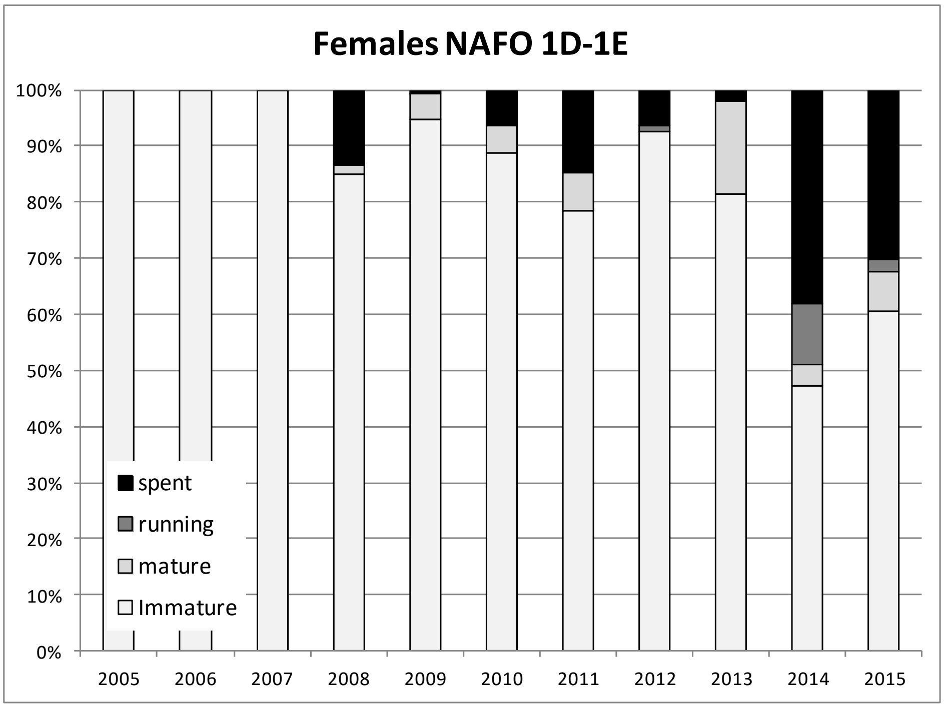


Figure 14.3.1.9: Composition of ogive state in females in survey in NAFO area 1D and 1E combined

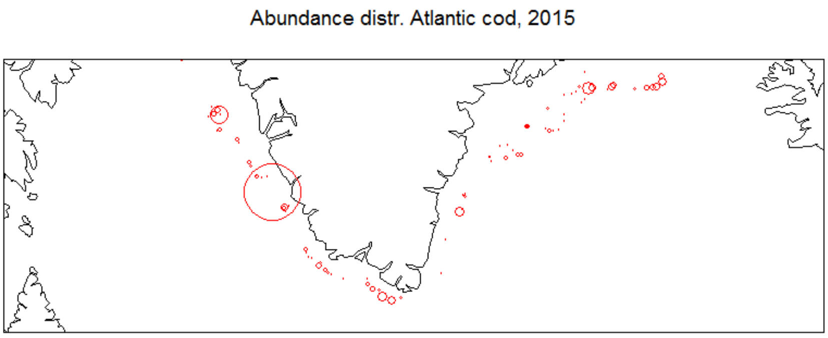


Figure 14.3.2.1 German survey, 2015. Abundance (num per km2) per haul.

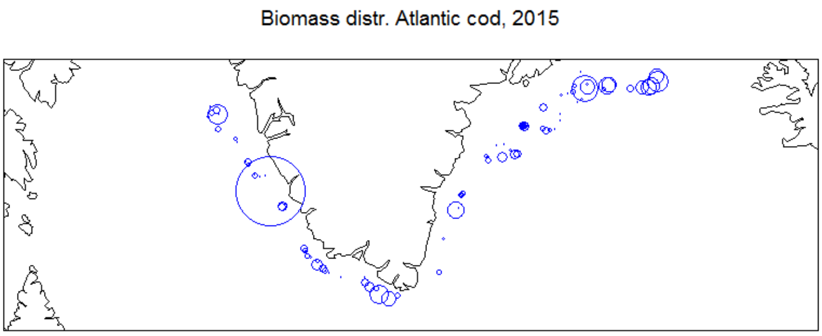


Figure 14.3.2.2 German survey, 2015. Biomass (kg per km2) per haul.

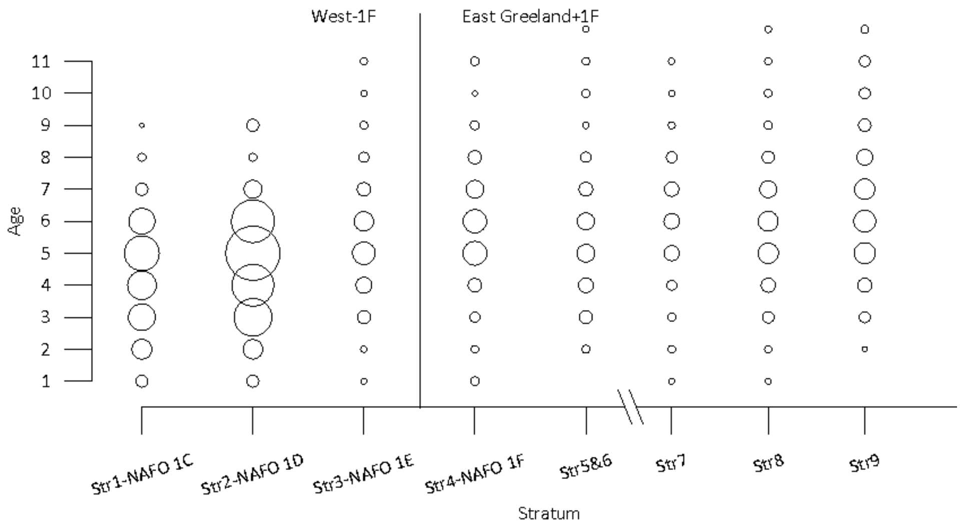


Figure 14.3.2.3 German survey, Cod off Greenland. Abundance per age group and stratum in 2015. Strata 1 –4 is West Greenland from north to south; strata 5-9 is East Greenland from south to north.

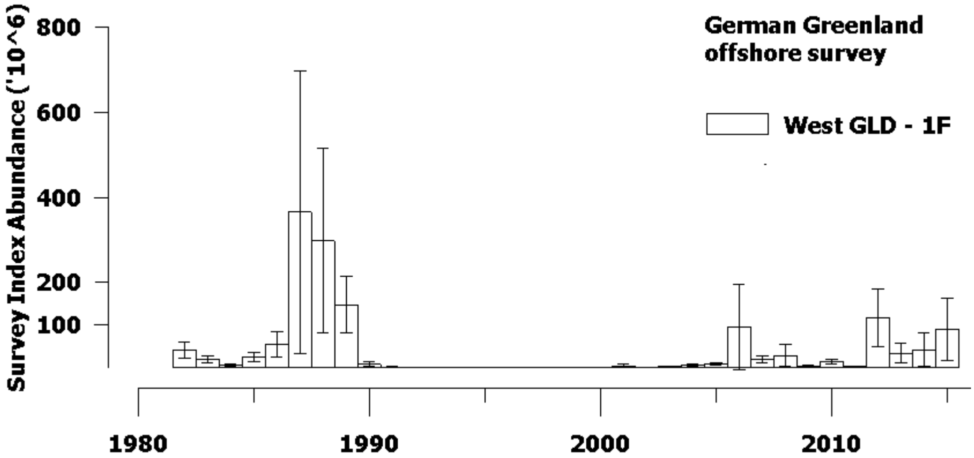


Figure 14.3.2.4 German survey, Cod off Greenland. Abundance indices for West Greenland (NAFO subdivisions 1C–1E).

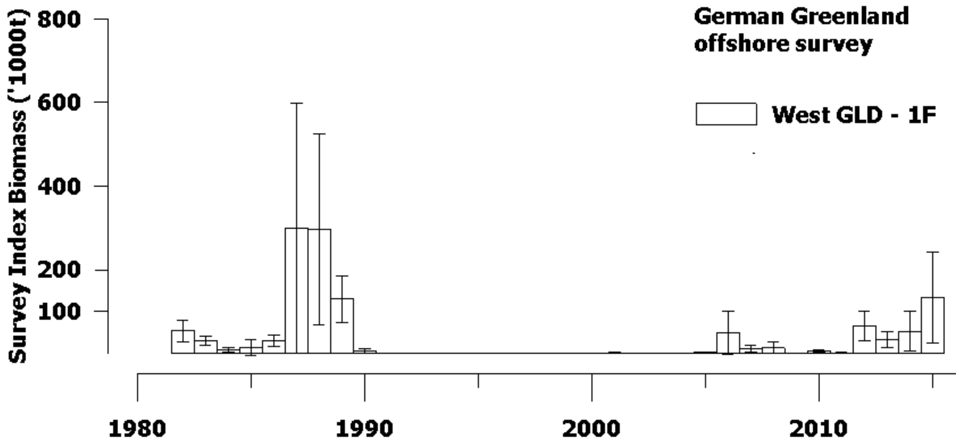


Figure 14.3.2.5 German survey, Cod off Greenland. Biomass indices for West Greenland (NAFO subdivisions 1C–1E).

15 Cod in inshore waters of NAFO Subarea 1 (Greenland cod)

15.1 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).

From 2012 the inshore component (West Greenland, NAFO Subarea 1) was assessed separately from all offshore components. From 2015 the offshore West Greenland (NAFO subdivisions 1A-E) and East Greenland (NAFO subdivision 1F and ICES Subarea 14) components was assessed separately. The Stock Annex provides more details on the stock identities including the references to the primary literature.

15.2 The fishery

Details on the historical development in the fisheries are provided in the stock annex.

15.2.1 The present fishery

The original TAC for the coastal fishery was set at 25,000 tons. In December 2,500 tons was added resulting in a total TAC of 27,500 t.

The coastal fishery took 25,272 tons + 50 tons in Eastgreenland (Tasiilaq) in 2015, which is an increase of 38% compared to 2014 (table 15.2.1.1). The most important fishery is the poundnet fishery that takes place during summer followed by the fishery with jigs that takes place in autumn (table 15.2.1.2 and 15.2.1.3, figure 15.2.1.1). In 2014 and 2015, half of the total catch was taken by poundnets. This is a decrease compared to previous years where up to 3/4 of the total catch where taken by poundnets (figure 15.2.1.1). Since 2012, jigs have become more dominant from 7 % of the total catch in 2012 to 22 % of the total catch in 2015. Gillnets and longlines constitutes the rest of the total catch. The increase in the use of jigs are most likely caused by the increase in small dinghies that are participating in the fishery.

15.2.1.1 North Greenland (NAFO division 1A, subarea 1AX (Disco Bay))

The catches in North Greenland have gradually increased from 500 tons in 2012 to 4,100 tons in 2015 and catches now comprise 16% of the total catch (table 15.2.1.2). Never before in the time-series has the catches in this area been this high. The dominating gear are gillnets (Table 15.2.1.3) properly due to the fishing industry being concentrated on Greenland Halibut, therefore in this area, cod is mostly caught as bycatch in the gillnet settings for Greenland Halibut. Cod catches, especially in the southern part of Disco Bay, have however increased in recent years and directed cod fishery is presumed to be going on in this area (Figure 15.2.1.2).

The genetic study of the spawning cod in Disco Bay concluded that the cod are more similar to the offshore Westgreenlandic cod stock than the inshore cod stock (Therkildsen *et al*. 2013). The increasing numbers of cod in recent years and the facts that previous large year classes of Eastgrenlandic/Icelandic origin (1984 and 2003 YC) where not registered in Disco Bay (Storr-Paulsen *et al.* 2004 and Retzel & Christensen 2016a) warrants for a more thorough investigation of the origin of the cod currently found in Disco Bay.

15.2.1.2 Midgreenland (NAFO divisions 1B, 1C and 1D)

Almost 21,000 tons cod were taken in this area in 2015 (table 15.2.1.1) corresponding to 83 % of the total catches (table 15.2.1.2, figure 15.2.1.3). The last time catches in this area were this high was in 1989 and 1990 were the fishery fished on the 1984 YC. In all areas the dominating gear are poundnets followed by jigs which are especially used in area 1B and 1C (table 15.2.1.3, figure 15.2.1.3).

15.2.1.3 South Greenland (NAFO divisions 1E and 1F)

The catches in South Greenland have the last couple of years gradually declined to 230 tons in 2015 corresponding to 1 % of the total inshore catch (table 15.2.1.1 and 15.2.1.2, figure 15.2.1.3). Never before in the time-series has a pattern with very little catches in South Greenland simultaneously with high catches in the other areas been observed. The last time there were catches over 25,000 tons inshore was in 1989 and 1990 where a large 1984 YC supported the fishery. This YC was of offshore East Greenland/Icelandic origin and distributed offshore and inshore along the coastline and the inshore fishery in South Greenland was high as the fish migrated inshore (Storr-Paulsen *et al*. 2004). The inshore cod stock is believed to be distributed from Midgreenland and northwards as there are no significant spawning taking place in South Greenland (Retzel & Hedeholm 2012), and the fishery here is therefore very much depending on offshore fish migrating inshore. Currently, there is a 2010 YC of average size distributed inshore and offshore in Midgreenland, while a 2009 YC of considerable size is distributed offshore in South Greenland (Retzel 2016a, Retzel & Christensen 2016a). The offshore fish of these year classes are believed to be of East Greenland origin. For some reason the 2009 YC do not migrate inshore in South Greenland.

15.2.1.4 East Greenland (ICES Subdivision 14b)

A very small amount (50 tons, table 15.2.1.1) of the inshore quota is fished in East Greenland with jigs in the Tasiilaq area (Figure 15.2.1.2 and 15.2.1.3). There are no length measurements from this fishery and the fish here are not presumed to belong to the inshore West Greenland cod stock. These fish are therefore not included the overall calculations of Catch and Weight at age.

15.2.2 Length, weight and age distributions

In 2015 the Greenland inshore length frequencies were measured from 116 inshore samples (21 854 cod measured).

Several YC were caught in the inshore fishery in 2015, and ages 4–7 (YC 2008–2011) comprised the catches in 2015, with the 2010 YC dominating the catches followed by the 2009 YC (table 15.2.2.1, figure 15.2.2.1 and 15.2.2.2). Mean length in catches have increased from 53 cm in 2010-2013 to 58 in 2014 and 57 cm in 2015. In 2013 and 2014, the 2009 YC was the dominating YC in the catches (table 15.2.2.1). However, from the offshore Shrimp and Fish survey (Retzel & Christensen 2016a, Retzel 2016a) it is documented that the 2009 YC is migrating southwards along the coast, and the 2010 YC is the dominating YC in the offshore area of NAFO 1C and 1D. Furthermore, as the 2009 YC increases their length with the growing age they do no longer get caught in the fishing gear used in the inshore fishery.

15.2.3 Catch Curve Analysis

A Catch Curve Analysis (CAA) was performed on the catch-at-age data for each YC from 1973–2007 and Z was calculated for the ages 4–8 (table 15.2.2.3). For the YC 1990–

1997 point/years were missing in the data as there was no sampling of the fishery in 1998 and 2001. In general, the CAA performed well with high R^2. Overall Z was high in most years. The relatively strong YC that produced catches above 10,000 tons (1984, 1985 and 2003) had Z values around 1.5. It is however, not easy to disentangle the effect of fishery and natural mortality, as the latter is subject to migration and a selective fishery with unknown age specific availability. Some input from the coastal and offshore region in the younger YC (ages 4-6) must be expected, but these fish tend to undertake spawning migrations when they reach maturity (ICES 2012). It is unknown in what quantity this contributes to the fishery. The availability changes with age due to the nature of the fishery, which is mainly conducted with poundnets in shallow water (table 15.2.1.3). Older fish (>8) tend to migrate away from the shallow water, and become unavailable to the fishery. This inflates the natural mortality but it has not been quantified. Hence, the combined effect of migration and age availability in the poundnet fishery causes the natural mortality to increase, but it is unknown to what extent. Nevertheless, Z remains high, but is likely an overestimate.

15.3 Survey

15.3.1 Results of the West Greenland gillnet survey

The numbers of valid net settings in 2015 was 44 in NAFO 1B and 59 in NAFO 1D (Table 15.3.1.1). Area and site-specific catch rates can be seen in figure. 15.3.1.1.

In 1B age 2 and 3 fish (2012 and 2013 YC's), which the survey mainly targets, appear to be small cohorts, and are smaller than the time-series mean (Table 15.3.1.2, figure. 15.3.1.2). The same pattern was seen in 2014 with the YC 2011 (as 3 years old) and the 2012 YC (as 2 years old). Since the 2009 YC, no strong YC has been documented in 1B and recruitment is low compared with earlier years (Table 15.3.1.2, Figure. 15.3.1.3). Overall, the NAFO 1B index (including all age groups) increased with 62 % from 2014 to 2015, caused by increased numbers of age 4, 5 and 6 year olds (YC 2009-2011).

The 2015 catches in NAFO 1D were dominated by 3 and 4 years old cod (2011 and 2012 YC´s, Table 15.3.1.2). Catch rates of 2012 YC in 2015 was the second highest in the time-series. The 2009 YC was not an outstanding cohort at age 2 and 3 in 2011 and 2012 in 1D, but the index increased for age 4 in 2013 and was one of the highest recorded indices in 2013, and at age 5 and 6 in 2014 and 2015, respectively. The overall index for NAFO 1D (including all age groups) is the second highest in the time-series, and increased by 17 % in 2015 compared to 2014 (Table 15.3.1.2).

Combining the two NAFO (1B and 1D) divisions in a joint index shows an overall decline of 49 % in total index for all ages from 2013–2014, which was the lowest index since 2006. Although the index increased by 36 % between 2014 and 2015 the index is still low compared to 2010-2013 (Figure. 15.3.1.4). The overall trend for the divisions is driven by the development in NAFO 1B, where the catch rates and index values are normally higher than 1D (Table 15.3.1.2, Figure. 15.2.1.3). However, in 2014 the total index was higher in 1D, caused by the index being higher for especially ages 3 and 4 (2011 and 2010 YC) in 1D. In 2015, age 3 and 4 (2011 and 2012 YC) dominated the index.

The combined index for 1B and 1D for age 2 and 3 jointly in 2014 and 2015 has decreased by 61 % compared to the average of the preceding four years (2010–2013).

15.3.2 Surveys in North Greenland (Disco Bay)

Currently two surveys are conducted in Disco Bay 1) a trawl survey targeting shrimp (part of the Greenland shrimp and fish survey covering all offshore waters in Greenland) and 2) Gillnet survey targeting Greenland Halibut. Since 2011 increasing amount of cod have been caught in these surveys, especially the 2009 YC. The results are not used in the assessment and further details and results of these surveys can be found in working document nr 18 (Retzel & Christensen 2016b).

15.4 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). Further information is provided in the stock annex.

15.5 Tagging experiments

A total of 17 304 cod have been tagged in different regions of Greenland in the period of 2003–2015 (table 15.5.1). 4 282 cod have been tagged in the inshore area in West Greenland primarily in NAFO 1B, 1D and 1F. Largest numbers of tagged fish occurred 2003-2009. Since 2009 limited amount of cod have been tagged inshore.

Innshore recaptures are found almost exclusively in the same fjord as tagged (table 15.5.2). Only one fish have been recaptured on the bank in West Greenland and 3 have been recaptured in Iceland. All three recaptures from Iceland were tagged in South Greenland (NAFO 1F).

15.6 State of the stock

There have been several years of steady and relatively high recruitment for ten years. The past two years however recruitment has been low and is below average for the whole time-series. Index of older ages (4+) are above average due to the high recruitment but is decreasing. Catches have risen since 2000 and are in 2015 at their highest level in 25 years. Combining these trends suggests a recent increase in exploitation rate.

Several year classes are in the catches, and the large 2009 YC is now the second largest YC in the fishery at age 6. The 2010 YC is dominating the fishery at age 5 and this YC is considered smaller than the 2009 YC. The fishery in concentrated on 4–6 yr old and after the 2009 YC has gone through the fishery no new incoming yearclasses of the same size has been observed, and recruitment of the 2012 and 2013 YC are considered very low. 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 as stable, but the lack of incoming large yearclasses is cause for concern.

15.7 Implemented management measures for 2015

Until 2009 the inshore fishery was unregulated by a TAC. The TAC in 2009-2014 can be seen in figure 15.1.1.2. The TAC for 2015 is set at 26 000 t. No other management measures have been taken.

15.8 Management plan

No management plan currently exists for the inshore cod stock.

15.9 Management considerations

When managing this stock, 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).

The fishery in this region is a mixed-stock fishery including other Greenland cod stocks (south and east Greenland cod, as well as offshore west Greenland cod) and Iceland cod. No operational procedure exists to evaluate the proportional contribution in the catches.

15.10 Basis for advice

The survey index in a given year was related to the catch in the next year (Figure D.1.1). The advice is then based on the survey index multiplied by a factor. The validity of this approach rests on a number of assumptions. Among others, the fishery has been at a stable sustainable level (ideally the same across years). Based on model outputs and catch curves (Hedeholm and Post, 2015) this seems to be a reasonable assumption, at least during the last 15 years. Some years in the 1980s did not follow the overall trend, and were most likely subjected to a very high fishing intensity and a very high offshore input to the fishery, and these years are therefore excluded from the regression analyses. The fish enter the fishery at age 4. Accordingly the survey index of ages 3–8 was used to generate advice.

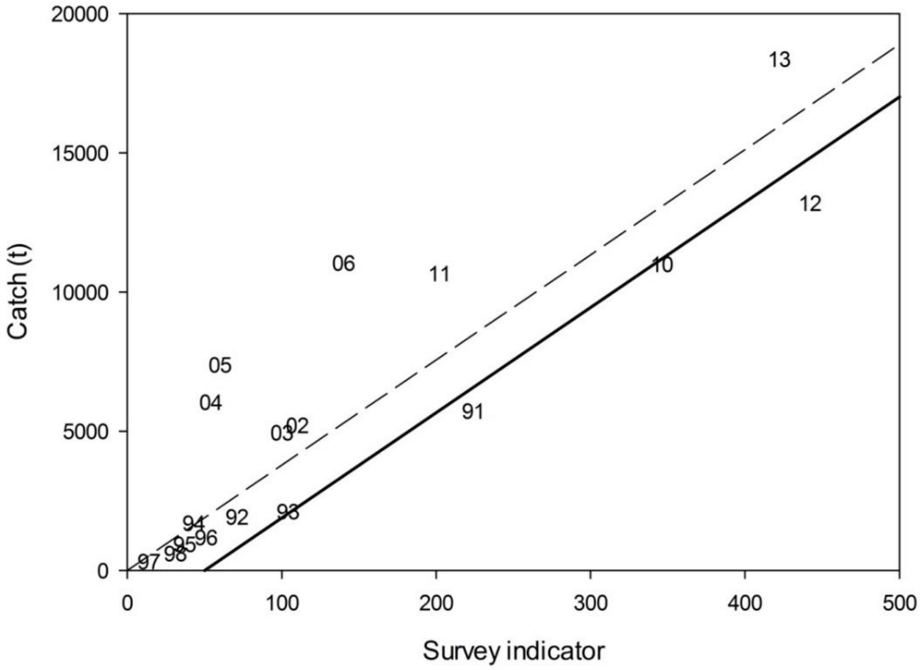


Figure D.1.1. Survey index of 3–8 year olds vs. the catch the following year. r^2 = 0.76. Based on data from 1991–2014. Points are labelled by survey year.

Given that this approach is based on variable data a precautionary approach should be taken. So rather than having the regression pass through the origin, the intercept with the x-axis is set at a survey index value of 50 and slope is 37.9. The survey tends to vary considerably between years, and to avoid having the advice fluctuate accordingly the average of the last two years survey index values were used when calculating the catch advice. Consequently, the advice is generated as follows:

$C_{y+1}=37.9 * (U_{3\text{–}8y}–U_{trigger})$ (1)

where $U_{3\text{–}8y}$ is the combined survey value for ages 3–8 and $U_{trigger}$ is 50.

The above described procedure agreed upon by the benchmark was considered less than optimal by ADG due to the possibility of fluctuating advice. The ADG concluded that there was no trend in the adult survey index (age 3–8) and therefore the same advice as last year was given. The same advice has now been given for three years and the advice is based on a 20% increase of average catch in 2010, 2011 and 2012.

The NWWG concluded that as the survey index of the adult part of the stock is still fluctuating without trend same advice as last year is still valid. However using the DLS 3.2 approach could also be implemented with the survey index for the 2 + 3 year as a stock indicator and basis for the advice. Advice is given 2 yrs later (2017) than the survey results (2015), and given a high degree of internal consistency in the survey between the 2+3 year old compared with the 4+5 year old two years later (figure 15.10.1 and 15.10.2). As the cod enter the fishery at age 4 the survey index for the 2+3 yr old is considered a good candidate for the stock indicator.

15.11 References

Horsted, S.A. 2000. A review of the cod fisheries at Greenland, 1910-1995. J.Northw.Atl.Fish.Sci. 28: 1–112.

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM:68. 42 pp.

ICES. 2015. Report of the Benchmark Workshop on Icelandic Stocks (WKICE), 26–30. January 2015, Copenhagen, Denmark. ICES CM 2015/ACOM:31. 133 pp.

Retzel, A., Christensen, H.T. 2016a. Greenland Shrimp and Fish survey results for Atlantic cod in NAFO subareas 1A-1E (West Greenland) in 2015. ICES North Western Working Group (NWWG) April 27–May 4, 2016, WD 20.

Retzel, A., Christensen, H. T. 2016b. West Greenland inshore survey results for Atlantic cod in 2015. ICES North Western Working Group (NWWG) April 27-–May 4, 2016, WD 18.

Retzel, A. 2016a. Greenland Shrimp and Fish survey results for Atlantic cod in ICES Subarea XIVb (East Greenland) and NAFO subarea 1F (SouthWest Greenland) in 2015. ICES North Western Working Group (NWWG) April 27-–May 4, 2016, WD 16.

Retzel, A. 2016b. Greenland commercial data for Atlantic cod in West Greenland offshore waters for 2015. ICES North Western Working Group (NWWG) April 27-–May 4, 2015, WD 19.

Storr-Paulsen M., Wieland K., Hovgård H. and Rätz H.-J. (2004) Stock structure of Atlantic cod (*Gadus morhua*) in West Greenland: implications of transport and migration. ICES Journal of Marine Science 61: 972–982.

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.

15.12 Tables

Table 15.2.1.1. Cod catches (t) divided into NAFO divisions, caught in the inshore fishery (1911-1993: Horsted 2000, 1994-2006: ICES 2007, Statistic Greenland, 2007-present: Greenland Fisheries License Control). ICES 14.b=inshore East Greenland.

	NAFO divisions								
Year	1A	1B	1C	1D	1E	1F	Unknown NAFO div	Total WestGreenland	ICES XIVb
1911				19				19	
1912				5				5	
1913				66				66	
1914				60				60	
1915		47	6	45				98	
1916		66	24	103				193	
1917		67	28	59				154	
1918		106	26	140		169		441	
1919		39	37	140	148	137		501	
1920		117	32	187	23	95		454	
1921		116	92	97	7	196		508	
1922		82	178	144	40	158		602	
1923		120	116	147	0	307		690	
1924		131	223	221	1	267		843	
1925		122	371	318	45	168		1024	
1926		97	785	673	170	499		2224	
1927		282	974	982	305	1027		3570	
1928		426	888	1153	497	1199		4163	
1929		1479	1572	1335	642	2052		7080	
1930	137	2208	2326	1681	994	2312		9658	
1931	315	1905	2026	1520	835	2453		9054	
1932	358	1713	2130	1042	731	3258		9232	
1933	304	1799	1743	1148	948	2296		8238	
1934	451	2080	1473	652	921	3591		9168	
1935	524	1870	1277	769	670	2466		7576	
1936	329	2039	1199	705	717	2185		7174	
1937	135	1982	1433	854	496	2061		6961	
1938	258	1743	1406	703	347	1035		5492	
1939	416	2256	1732	896	431	1430		7161	
1940	482	2478	1600	1061	646	1759		8026	
1941	636	3229	1473	823	593	1868		8622	
1942	879	3831	2249	1332	1003	2733		12027	
1943	1507	5056	2016	1240	1134	2073		13026	
1944	1795	4322	2355	1547	1198	2168		13385	
1945	1585	4987	2844	1207	1474	2192		14289	
1946	1889	5210	2871	1438	1139	2715		15262	
1947	1573	5261	3323	2096	1658	4118		18029	
1948	1130	5660	3756	1657	1652	4820		18675	
1949	1403	4580	3666	2110	2151	3140		17050	
1950	1657	6358	4140	2357	2278	4383		21173	
1951	1277	5322	3324	2571	2101	3605		18200	
1952	646	4443	2906	2437	2216	4078		16726	
1953	1092	5030	3662	5513	3093	4261		22651	

	NAFO divisions								
Year	**1A**	**1B**	**1C**	**1D**	**1E**	**1F**	**Unknown NAFO div**	**Total WestGreenland**	**ICES XIVb**
1954	950	6164	3118	3275	1773	3418		18698	
1955	591	5523	3225	4061	2773	3614		19787	
1956	475	5373	3175	5127	3292	3586		21028	
1957	277	6146	3282	5257	4380	5251		24593	
1958	19	6178	3724	5456	3975	6450		25802	
1959	237	6404	5590	5009	3767	6570		27577	
1960	188	6741	6230	3614	3626	6610		27009	
1961	601	6569	6726	4178	6182	9709		33965	
1962	315	7809	6269	3824	5638	11525		35380	
1963	295	4877	3178	2804	3078	9037		23269	
1964	275	3311	2447	8766	2206	4981		21986	
1965	325	5209	4818	6046	2477	5447		24322	
1966	483	8738	5669	7022	2335	4799		29046	
1967	310	5658	6248	6747	2429	6132		27524	
1968	142	1669	2738	6123	2837	7207		20716	
1969	57	1767	4287	7540	2017	5568		21236	
1970	136	1469	2219	3661	2424	5654		15563	
1971	255	1807	2011	3802	1698	3933		13506	
1972	263	1855	3328	3973	1533	3696		14648	
1973	158	1362	1225	3682	1614	1581		9622	
1974	454	926	1449	2588	1628	1593		8638	
1975	216	1038	1930	1269	964	1140		6557	
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	77	2366	423	6407	3602	1326	403	14604	
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	

	NAFO divisions								
Year	1A	1B	1C	1D	1E	1F	Unknown NAFO div	Total WestGreenland	ICES XIVb
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	1173	7388	
2007	416	2547	1195	1842	659	4391		11050	42
2008	870	3066	1539	3172	225	1133		10005	6
2009	325	1288	1189	2009	1142	1581		7534	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		10672	0.02
2013	1506	2552	2784	4711	1450	198		13202	35
2014	3084	6142	3710	4629	684	82		18331	38
2015	4088	7912	6426	6613	117	115		25272	50

Table 15.2.1.2: Catches (t) divided into month and NAFO Divisions, caught by the coastal fisheries.

NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
1AUM	3	9	13	2		1	0.4	0.2	37	29	29	1	123	0.5%
1AUP							0.01	0.01	0.1	0.003			0.1	0.001%
1AX	173	183	103	137	63	124	413	565	507	873	671	155	3965	16%
1B	86	86	317	282	706	873	1535	1005	894	996	980	153	7912	31%
1C	197	78	56	82	199	1159	1182	721	834	824	599	495	6426	25%
1D	240	107	180	314	543	1299	1516	644	770	533	274	193	6613	26%
1E	0.4	1	0.1	2	1	11	56	39	4	3	0.4	0.02	117	0.5%
1F	0.4	1		0.4	0.1	18	1	2	7	21	59	4	115	0.5%
Total	698	463	670	819	1511	3486	4703	2977	3052	3279	2612	1002	25272	
%	3%	2%	3%	3%	6%	14%	19%	12%	12%	13%	10%	4%		
ICES XIVb									24	25			50	

Table 15.2.1.3: Landings (%) divided into month and gear and NAFO Divisions and gear.

Gear/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Poundnet	0.003%			1%	5%	13%	14%	5%	4%	5%	4%	0.2%	50%
Gillnet	1%	1%	2%	1%	0.5%	0.1%	0.1%	0.2%	2%	3%	3%	1%	15%
Jig	0.03%	0.1%	0.3%	1%	0.2%	1%	4%	6%	6%	3%	1%	0.3%	22%
Longline	1%	1%	1%	1%	0.2%	1%	0%	0.5%	1%	2%	2%	2%	13%
Total	3%	2%	3%	3%	6%	14%	19%	12%	12%	13%	10%	4%	100%

Gear/NAFO	1AUM	1AUP	1AX	1B	1C	1D	1E	1F	ICES XIVb	Total
Poundnet			4%	16%	12%	18%	0.4%	0.1%		50%
Gillnet	0.1%		6%	6%	1%	2%	0.004%	0.1%		15%
Jig	0.05%		4%	8%	7%	3%	0.1%	0.1%	0.2%	22%
Longline	0.3%	0.001%	2%	1%	6%	3%	0.03%	0.2%		13%
Total	0.5%	0.001%	16%	31%	25%	26%	0.5%	0.5%	0.2%	100%

Table 15.2.2.1. Estimated catches in numbers ('000) at age, and total catch by year (t).

	Age								Tonnes
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Landed**
1976	2508	924	556	287	38	31	11	7	5174
1977	467	5437	1100	883	179	7	142	46	13999
1978	97	1262	9904	132	68	7	3		19679
1979	323	2297	2380	8281	170	96	4	14	35590
1980	4343	4334	1646	806	6492	106	29	37	38571
1981	87	15793	5225	725	499	2906	61	17	39703
1982	3013	1587	6309	1545	798	152	610	154	26664
1983	229	16877	1381	4352	368	139	65	75	28742
1984	520	4451	9269	346	634	18	42	12	19958
1985	5	2400	1028	2229	196	363	14	78	8441
1986	286	178	896	460	721	16	102	38	5302
1987	5503	1334	228	710	340	1084	46	265	14604
1988	419	15588	150	51	39	90	161	12	18791
1989	15	5962	23956	271	46	2	93	176	38529
1990	212	2997	15403	6732	33	11	7	16	28799
1991	124	6022	4910	5695	330	0			18312
1992	8	2408	2344	452	139	46	13	5	5727
1993	28	661	575	206	34	41	10	7	1926
1994	22	1468	342	62	45	8	11	1	2117
1995	1	834	773	37	5	0	0		1701
1996	2	165	362	130	25	3	1	0	944
1997	1	397	311	179	31	0			1186
1998*									322
1999	87	465	105	1	0	0			613
2000	4	228	336	7	0	0			764
2001*									1680
2002	532	2243	657	29	9	1	0	0	3622
2003	152	581	1547	258	51	16	15	11	5215
2004	530	1669	1095	228	37	3			4948
2005	1392	2408	944	186	36	10	4	0	6043
2006	4256	3363	680	22	0	0	0		7388
2007	1944	7910	1010	116	38	13	8	4	11050
2008	1176	5012	2793	319	36	6	2		10005
2009	487	3540	2372	194	13	3	0	4	7534
2010	301	1091	2475	1524	141	32	21	27	9268
2011	129	2929	2567	1480	255	90	12	7	11007
2012	735	1725	2681	850	182	21	13	13	10672
2013	143	3806	2477	1083	361	115	67	9	13202
2014	40	1389	4024	2292	328	168	103	52	18331
2015	20	2007	5683	3010	1338	133	9	8	25272

Table 15.2.2.2. West Greenland inshore cod. Estimated weight at age (kg).

	Age							
Year	3	4	5	6	7	8	9	10+
1976	0.811	1.114	1.662	2.738	3.226	4.062	5.831	12.747
1977	0.674	1.382	2.201	2.649	3.322	6.363	3.92	4.616
1978	0.668	0.965	1.801	2.472	2.845	3.649	4.733	
1979	0.8	1.309	2.111	3.153	3.696	4.371	6.861	8.007
1980	0.753	1.017	1.884	2.58	3.823	4.107	5.715	7.902
1981	0.308	1.045	1.576	2.19	2.59	4.029	3.529	7.831
1982	0.844	1.118	1.604	2.605	3.875	5.495	5.425	6.278
1983	0.552	0.937	1.337	2.039	2.795	3.378	4.218	4.109
1984	0.624	0.967	1.385	1.869	2.469	3.286	3.985	4.433
1985	0.42	0.754	1.134	1.662	2.065	2.669	3.486	4.337
1986	0.582	1.248	1.414	2.043	2.689	3.188	3.893	8.401
1987	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	0.82	1.239	1.83	1.802	2.873	3.976	8.777
1994	0.43	0.883	1.359	1.706	3.103	3.9	4.976	16.271
1995	0.768	0.93	1.093	1.799	2.493	4.13	6.49	
1996	0.501	0.814	1.201	2.176	2.955	4.151	5.507	6.577
1997	0.560	0.956	1.397	1.767	1.830	3.239		
1998*								
1999	0.739	0.895	1.24	2.254	3.387	4.556		
2000	0.642	1.121	1.453	2.378	2.621	2.409		
2001*								
2002	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	3.3	3.988	5.095	6.958
2004	0.988	1.236	1.584	2.158	3.149	6.132		
2005	0.811	1.106	1.728	2.415	2.81	6.955		
2006	0.724	0.944	1.560	3.102	4.522	9.931	9.931	
2007	0.703	0.95	1.543	2.574	4.003	5.136	6.541	10.25
2008	0.615	0.884	1.406	2.332	3.709	5.463	7.263	
2009	0.641	0.898	1.461	2.348	4.055	5.132	5.869	14.181
2010	0.659	0.976	1.517	2.12	3.204	4.872	6.929	9.796
2011	0.657	0.918	1.466	2.013	3.305	5.396	7.527	10.366
2012	0.764	1.109	1.81	2.7	3.554	5.964	6.91	14.345
2013	0.766	1.258	1.623	2.235	3.059	3.636	4.114	7.43
2014	0.690	1.226	1.935	2.534	3.408	5.327	5.746	7.766
2015	0.783	1.131	1.754	2.548	3.378	4.924	7.829	12.922

Table 15.2.2.3. West Greenland inshore cod. Catch curve analysis. YearClass mortalities at ages 4-8 estimated from commercial catch-at-age data. * few data due to years (1998 and 2001) with no sampling. Yellow highlights strong YearClasses.

YearClass	Z (4–8)	R2
1973	0.17	0.31
1974	0.58	0.78
1975	0.63	0.85
1976	1.36	0.85
1977	0.98	0.95
1978	1.11	0.89
1979	0.8	0.87
1980	0.89	0.96
1981	1.73	0.89
1982	0.72	0.87
1983	1.59	0.85
1984	1.59	0.87
1985	1.47	0.78
1986	1.68	0.91
1987	2.14	0.95
1988	1.81	0.97
1989	2.22	0.82
1990*	1.34	0.97
1991*		
1992*		
1993*		
1994*		
1995*	1.03	0.87
1996*	0.94	0.79
1997*	1.45	0.98
1998	1.43	0.94
1999	1.06	0.86
2000	1.46	0.87
2001	1.63	0.98
2002	1.37	0.86
2003	1.19	0.89
2004	1.32	0.91
2005	0.95	0.91
2006	0.57	0.74
2007	0.83	0.95

Table 15.3.1.1: Survey effort in the Greenland Inshore Gillnet 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
2014	60	41	-	101
2015	59	44	-	103

Table 15.3.1.2: NAFO Div. 1B. Cod abundance indices (numbers of cod caught per 100 hours net settings) by age in the West Greenland inshore gillnet survey. na= data not available.

	Age								
Year	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
2014	7	46	45	25	19	4	0	1	146
2015	2	39	44	59	49	39	3	1	236

Table 15.3.1.2, *continued* : NAFO Div. 1D. Cod abundance indices (numbers of cod caught per 100 hours net settings) by age in the West Greenland inshore gillnet survey.

	Age								
Year	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
2014	0	41	74	46	27	6	1	0	196
2015	2	42	79	68	30	7	2	0	229

Table 15.3.1.2, *continued* : NAFO Div. 1F. Cod abundance indices (numbers of cod caught per 100 hours net settings) by age in the West Greenland inshore gillnet 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
2010–2015	na	na	na	na	na	na	Na	na	na

Table 15.5.1. Number of tagged cod in the period of 2003 to 2014 in different regions. Bank (West) = NAFO division 1D+1E. East Greenland = NAFO division 1F + ICES division 14.b.

TAGGED			
YEAR	FJORD	BANK (WEST)	EAST GREENLAND
2003	599		
2004	658		
2005	565		
2006	41		
2007	1140	721	1387
2008	231		1296
2009	633		525
2010	88		
2011	28		403
2012	86	1563	2359
2013	183	2321	
2014			1203
2015		57	1218

Table 15.5.2: Number of recaptured cod in the period of 2003 to 2014 in different regions. Fjord (West) = NAFO divisions 1B-1F. Bank (West) = NAFO division 1D+1E. East Greenland = NAFO division 1F + ICES division 14.bb.

RECAPTURES			
	FJORD (WEST)	BANK (WEST)	EAST GREENLAND
Fjord (West)	438	14	2
Bank (West)	1	34	2
East Greenland		12	99
Iceland	3	21	125

15.13 Figures

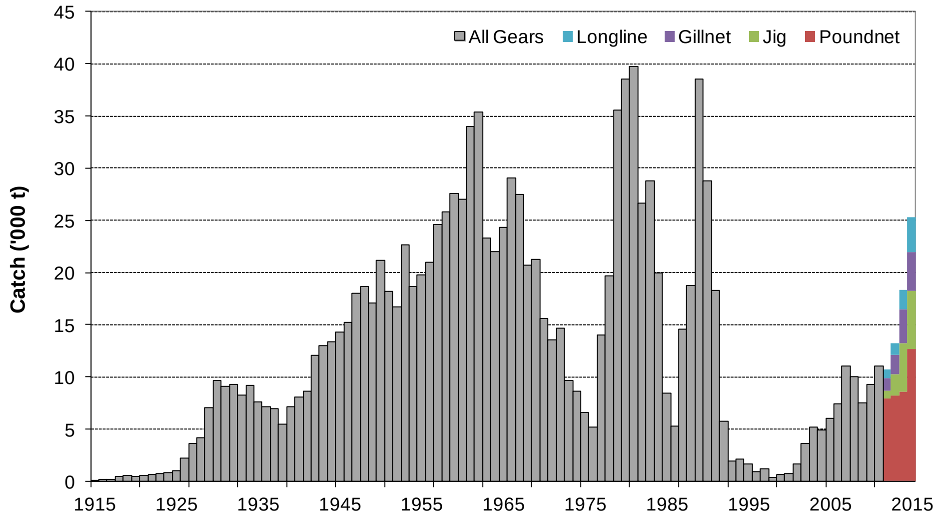


Figure 15.2.1.1 Inshore landings from West Greenland (Horsted 1994, 2000).

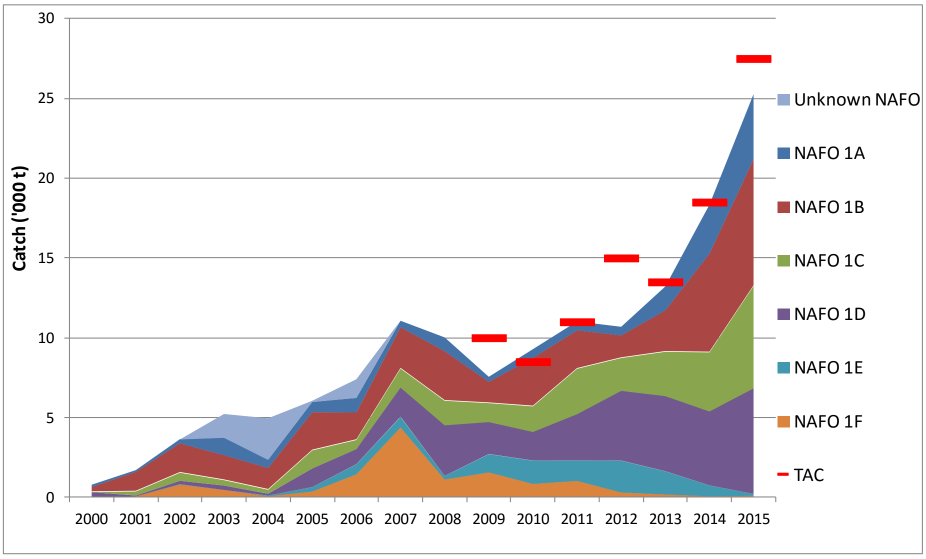


Figure 15.2.1.3. Total catches and TAC in the inshore fishery by NAFO Divisions.

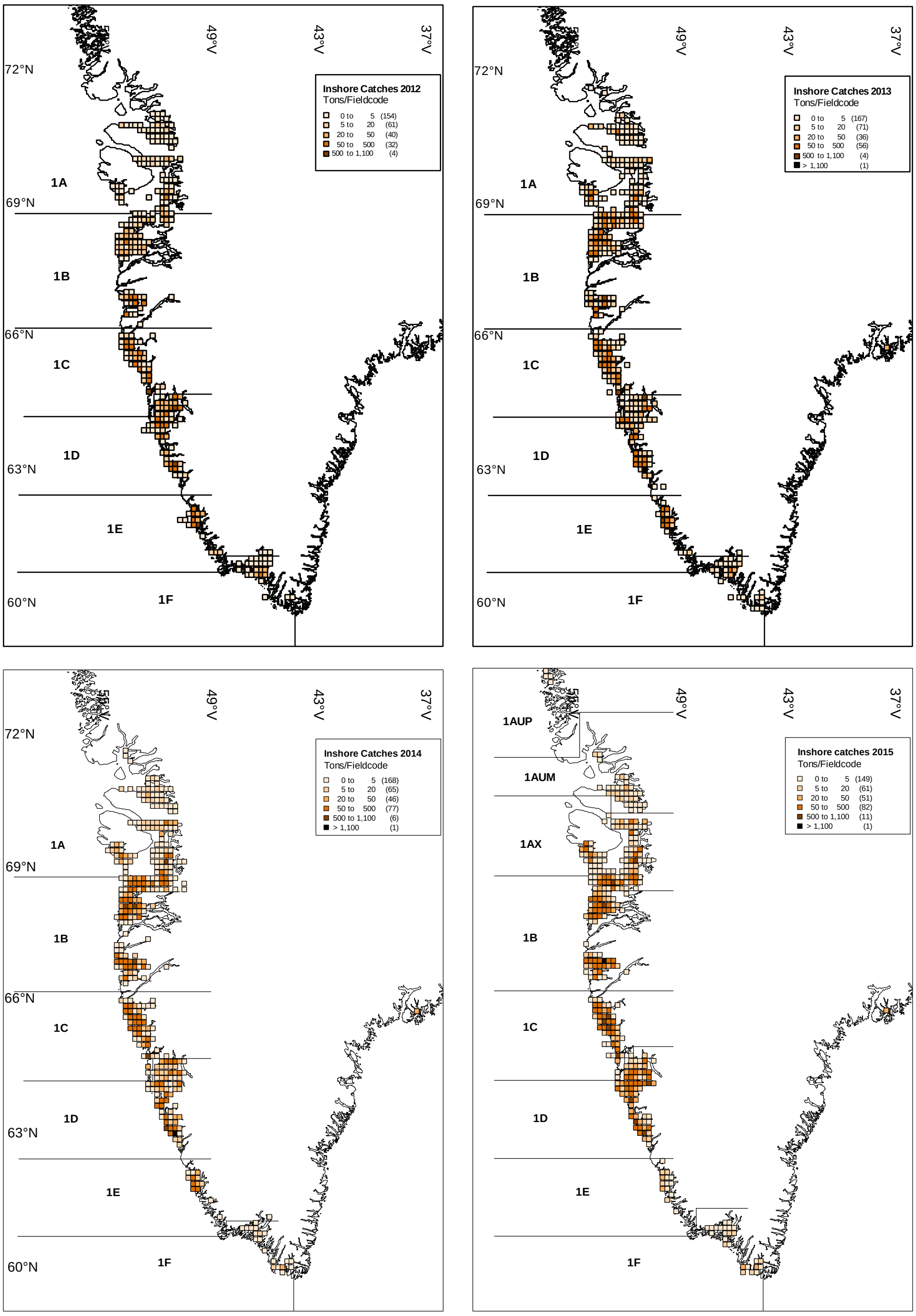


Figure 15.2.1.2. Distribution of commercial fishery along the coastline of West Greenland in total tons by field code.

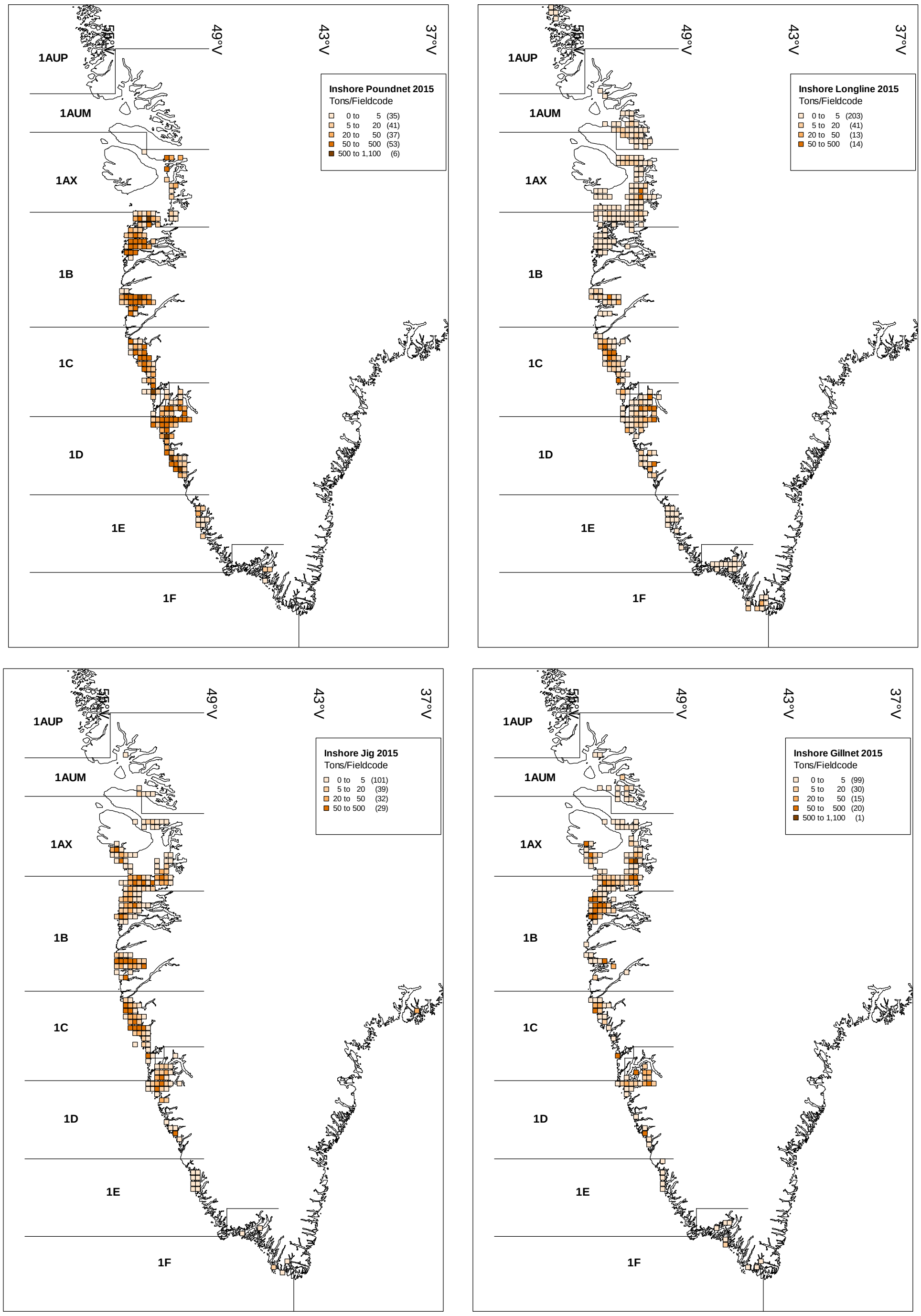


Figure 15.2.1.3. Distribution of the inshore commercial fishery by gear (tons/fieldcode).

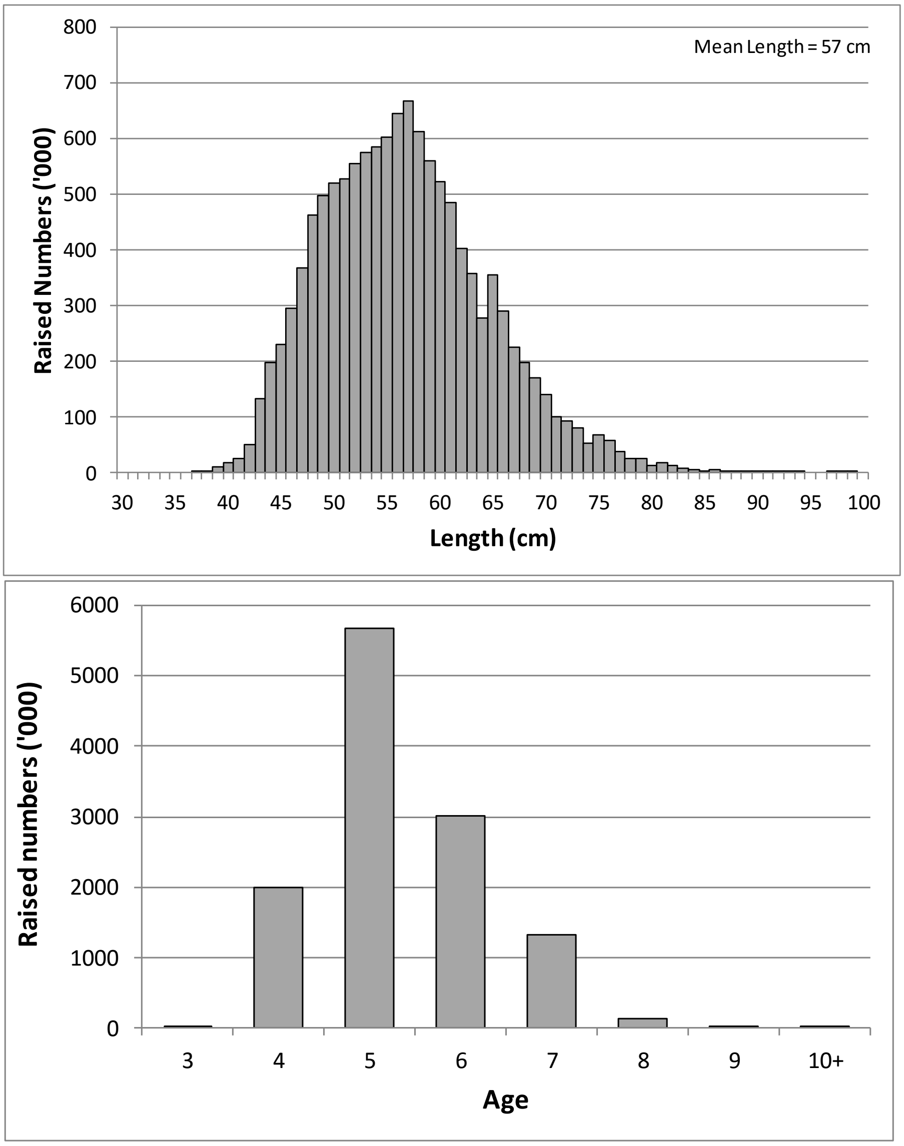


Figure 15.2.2.1. Total length and age distributions of inshore cod catches.

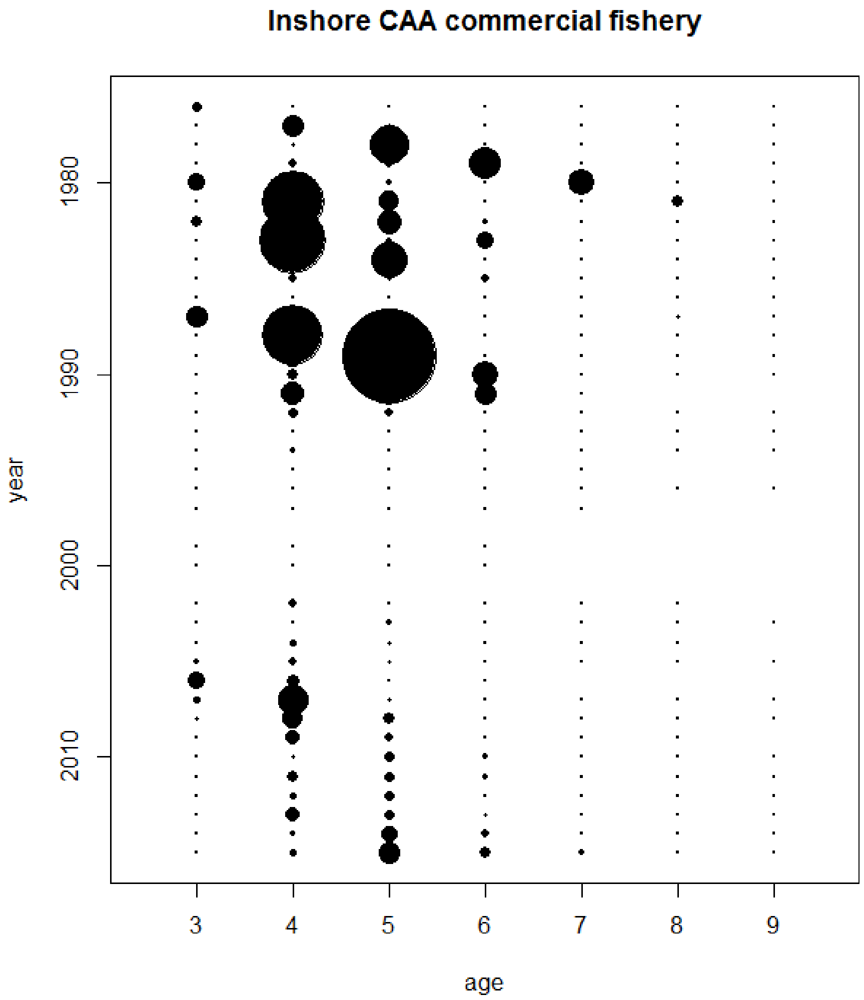


Figure 15.2.2.2. Catch-at-age in the commercial fishery in the West Greenland inshore area. Size of circles represents size of catch numbers.

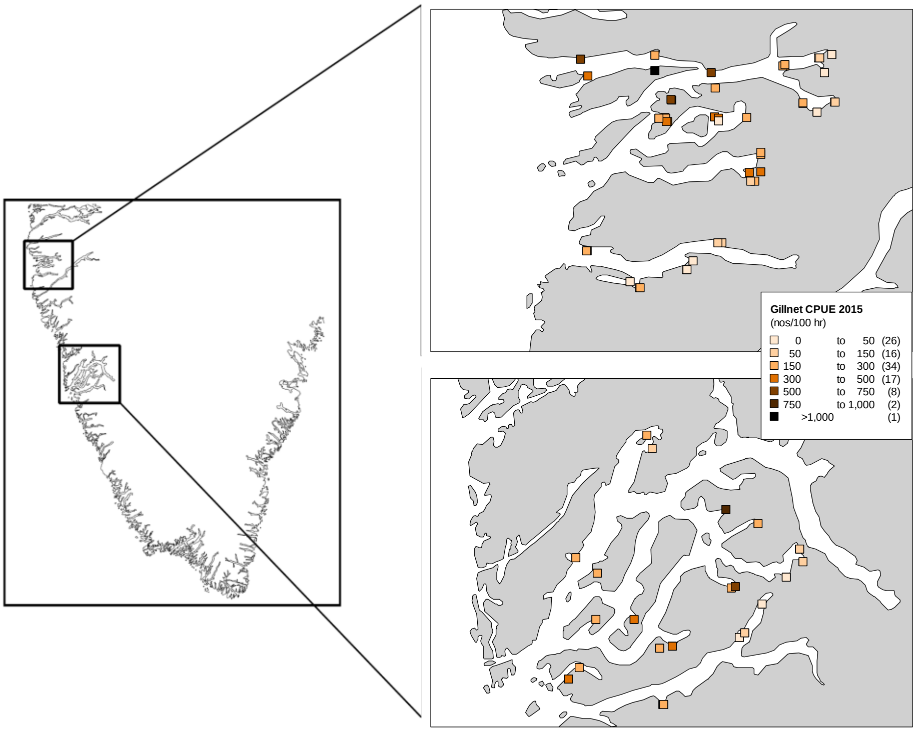


Figure 15.3.1.1. The inshore gillnet survey area on the Greenland West coast. Top picture is the Sisimiut fjord system in NAFO 1B and bottom picture is the Nuuk fjord system in NAFO 1D. Survey estimates of catch rates are indicated on both maps as #caught/100h.

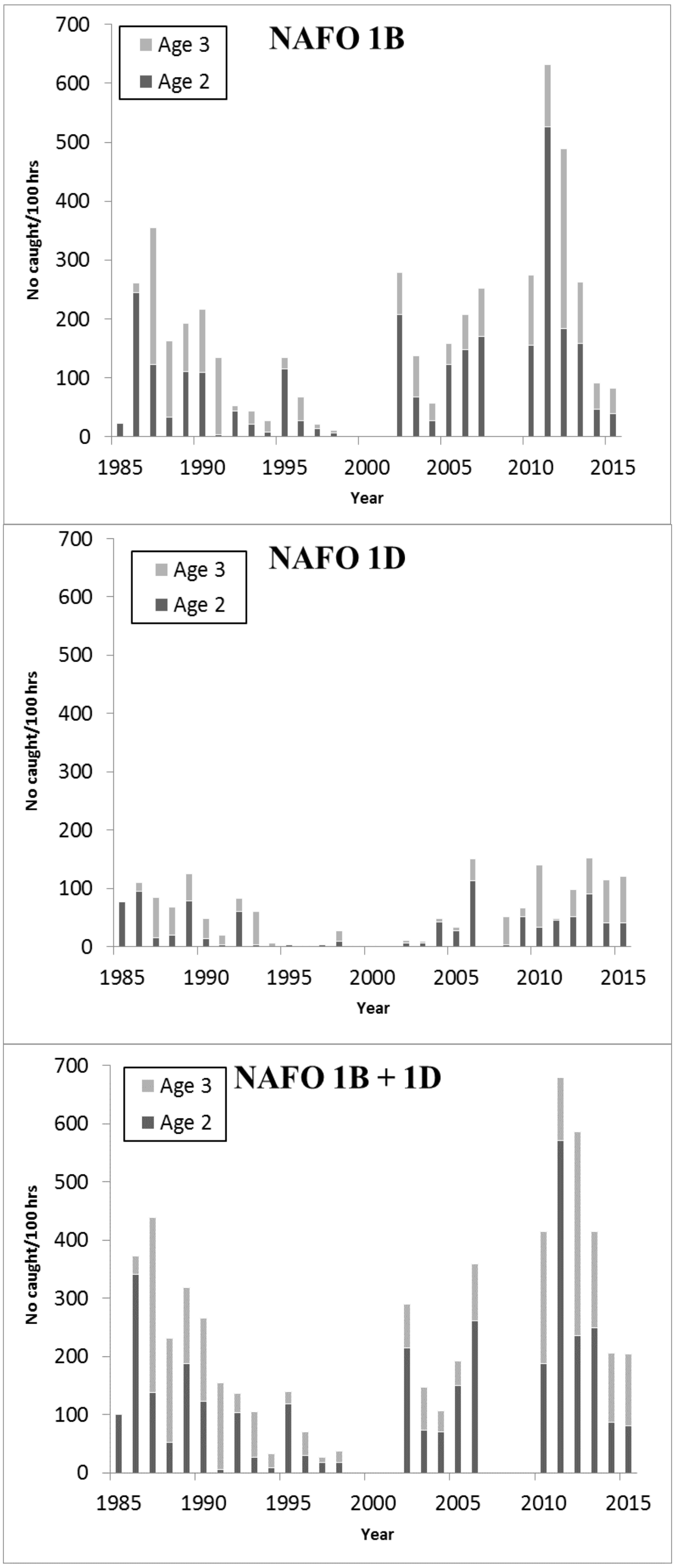


Figure 15.3.1.2. : Recruitment indices (numbers caught/100 hr.) for ages 2 and 3 in 1B (top), 1D (middle) and 1B and 1D combined (lower) in West Greenland. Simultaneous surveys were not carried out 1999–2001 and 2007–2009.

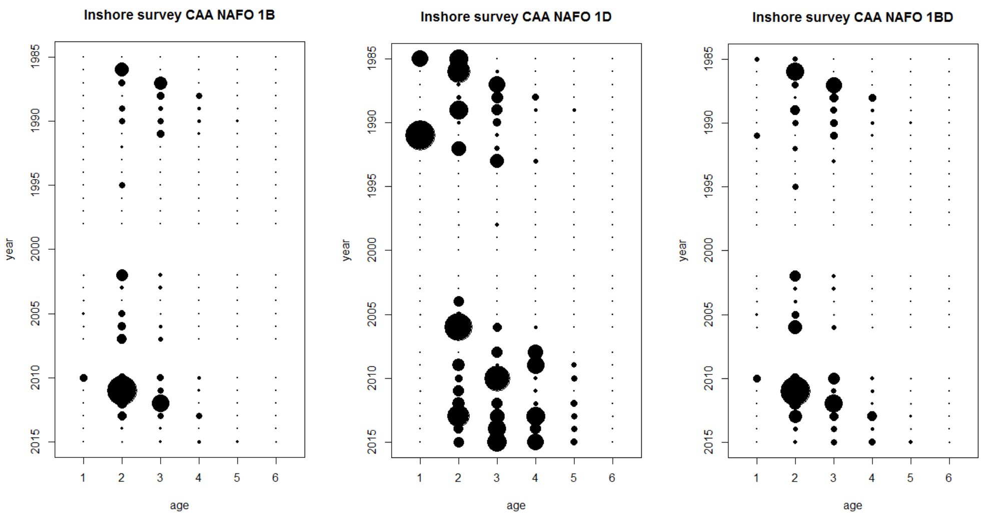


Figure 15.3.1.3. Recruitment indices (numbers caught/100 hr.) for ages 1-5 in 1B (left), 1D (middle) and 1B and 1D combined (right) in West Greenland from 1985–2015. Size of circles represents the size of the index values and the values are standardized within each area and are not comparable among each other.

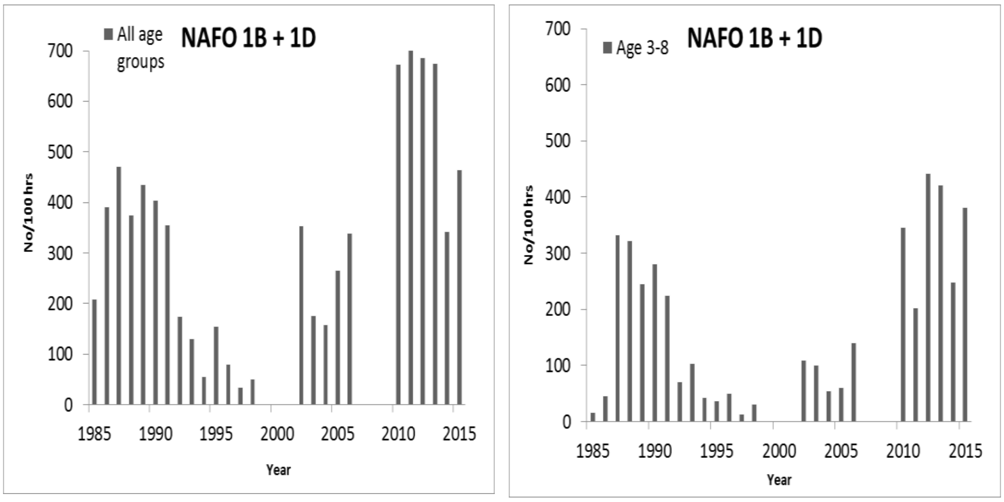


Figure 15.3.1.4. Abundance indices (numbers caught/100 hrs. netsetting) for all age groups (left) and age 3–8 (right) in 1B and 1D combined. Simultaneous surveys were not carried out 1999–2001 and 2007–2009.

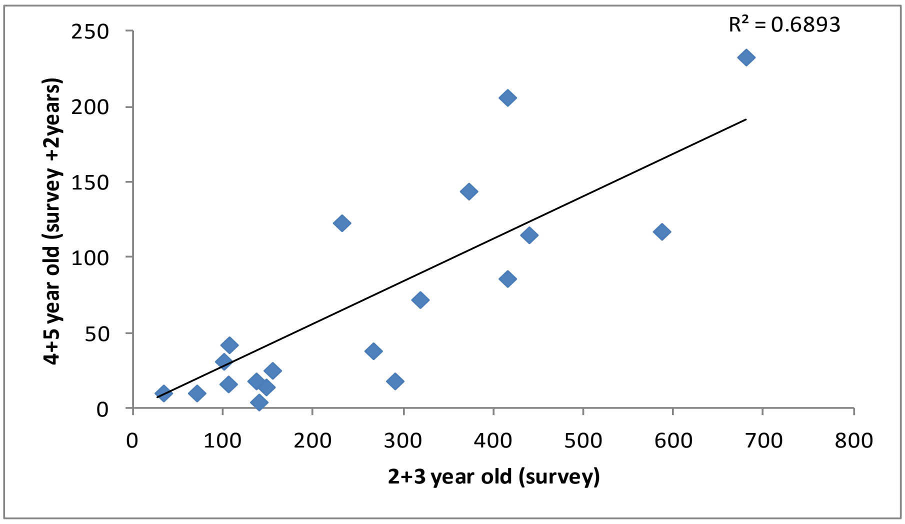


Figure 15.10.1. Sum of 2+3 yr old against sum of 4+5 year old two years later in the gillnet survey.

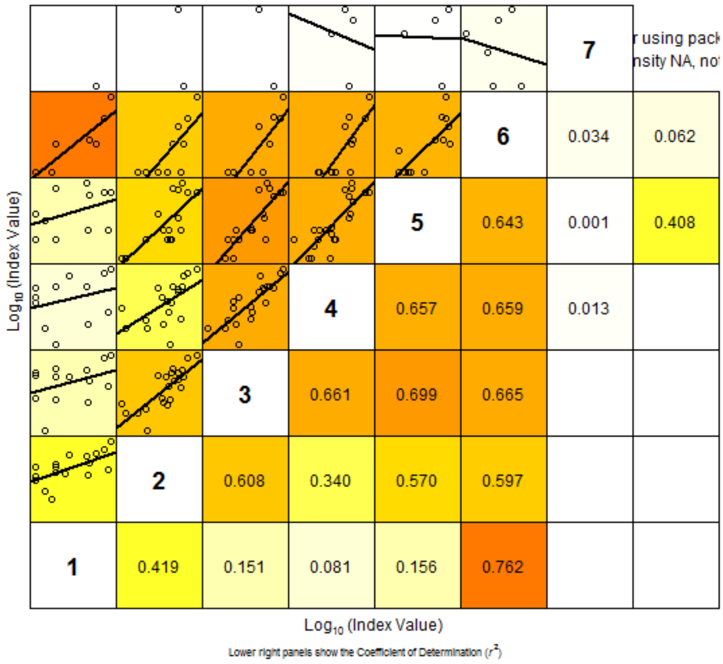


Figure 15.10.2 Internal consistency plot of the gillnet survey.

16 Cod in offshore waters of ICES Subarea 14 and NAFO subarea 1

16.1 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), (Figure 16.1).

From 2012 the inshore component (West Greenland, NAFO Subarea 1) was assessed separately from all offshore components. From 2016 the offshore West Greenland (NAFO subdivisions 1A-E) and East Greenland (NAFO subdivision 1F and ICES Subarea 14) components was assessed separately. The Stock Annex provides more details on the stock identities including the references to primary works.

16.2 Fishery

16.2.1 The emergence and collapse of the Greenland offshore cod fisheries

The Greenland commercial cod fishery in East Greenland started in 1954, but started earlier in Southwest Greenland (NAFO subdivision 1F, table 16.2.2.1). The fishery gradually developed culminating with catch levels above 40,000 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 16.2.1). In the 2000s catches have gradually increased with maximum catches in 2008 of 14 500 tons. Between 2008 and 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.

16.2.2 The offshore fishery in 2015

In 2014 a management plan was implemented for the offshore cod fishery in South and East Greenland. According to the management plan the TAC is 10 000 tons/year between 2014 and 2016, The TAC 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 subdivision 1F. Fishery is not allowed during spawning season 1st of April–31st of May. However a dispensation was given in 2014 and 2015 to fish in South Greenland (NAFO 1F + Q5Q6) during these months under the assumption that the spawning stock is concentrated further to the north in East Greenland (corresponding to management area Q1Q2 and Q3Q4).

The management plan contains a TAC regulation rule that allows for the final TAC to be adjusted if survey results show an increase of more than 30% or a decrease of more than 15% compared to a reference period (2010-2013). The survey results for 2014 from both the Greenlandic and German survey showed an increase of more than 30% and the final TAC was set at 18,104 tons divided between management areas: 4,800t in Q1Q2, 4,000t in Q3Q4, 3,000t in Q5Q6, 3,949t in NAFO 1F. The rest of the TAC was given as 2,000t as bycatch in the whole area, and 355t inshore in East Greenland. The TAC was divided between the following countries: 14,849 tons to Greenland, 2,000 tons to EU, 900 tons to Norway and 355 tons to the Faroe Islands.

In 2015 EU, Norway and the Faroe Islands fished their quota (Norway fished 330 t more than their quota) whereas Greenland fished 12,170 tons resulting in a total of

15,755 tons with 3,984 tons caught in SouthWest Greenland (NAFO 1F) and 11,771 tons caught in East Greenland (table 16.2.2.1).

75% of the total catches were taken in East Greenland where the fishery took place throughout the year except in spawning time (April and May) where directed fishery for cod in Q1Q2 and Q3Q4 were not allowed. Catches in these areas in this period are considered as bycatch. Catches in SouthWest Greenland peaked in June and July (table 16.2.2.2). The fishery where distributed from Julianehåbs Bight in SouthWest Greenland (60°N) to Dohrn Bank (66°N) in East Greenland (figure 16.2.2.1).

A dispensation was given to Greenlandic longliners to fish within the 3nm from the baseline in East Greenland where vessels larger than 75BRT/120BT are not allowed. In all the vessel caught almost 500 tons concentrated around the Tasiilaq area (65-66°N) and Cape Fraewell (figure 16.2.2.1). No length measurements were available from this fishery.

Trawlers caught 67% of the total catch (table 16.2.2.3). Half of the total trawl catches were taken on Dohrn Bank (management area Q1Q2) especially in a small area between 65-66°N and 29-31°W on the edge of the continental shelf on Dohrn Bank (figure 16.2.2.2).

Longliners caught 33% of the total catch (table 16.2.2.3). The longliners fished primarily north of Skjoldungen Bank and around Kleine Bank in management area Q3Q4 and in Julianehåbs Bight in Southwest Greenland (NAFO 1F, figure 16.2.2.2).

16.2.3 Length, weight and age distributions in the offshore fishery 2015

There is limited landing sample information from the 1990's where the cod fishery was very low in East Greenland. For that period length frequency information is generally lacking for the offshore fisheries where cod was only taken as a bycatch. Sampling intensities have increased considerably in the later years, and in 2015 the offshore fisheries was very well covered.

Catch-at-age and weight-at-age has been compiled for the offshore area since 2005 (table 16.2.3.1).

Length measurement in 2015 in SouthWest Greenland amounted to 7 144 cod measured. In East Greenland length measurements amounted to 4 900.

The overall mean length in the catches was 70 cm, and the YC 2009 (6 yr old fish) dominated the catches (figure 16.2.3.1). Mean length differed however between areas with the largest cod (mean length=78 cm) and oldest (7–8 yr old) being caught on Dohrn Bank furthest to the north in the fishing area in East Greenland (management area Q1Q2), and the smallest (mean length=62 cm) and youngest (6 yr old) being caught in SouthWest Greenland (NAFO 1F, figure 16.2.3.2). Especially in Southwest Greenland the 2009 YC (6 yr old) dominated the catches with 50% of the catch being of this YC.

In 2012, 2013 and 2014 the 2007 YC dominated the total catches as 5, 6 and 7 yr olds (Table 16.2.3.1, figure 16.2.3.3). This YC was especially abundant in the catches in South Greenland in 2013. In 2014 this YC was abundant in all areas but in 2015 the YC is more abundant in the northern part of the fishing area in East Greenland (management area Q1Q2, figure 16.2.3.2). The 2008 YC and 2009 YC were in 2014 (as 6 and 5 yr old) more abundant in SouthWest Greenland (NAFO 1F). In 2015 the 2008 YC is dominating in East Greenland as 7yr old whereas the 2009 YC is dominating in Southwest Greenland as 6 yr old (figure 16.2.3.2).

16.2.4 cpue index

Logbooks on a haul by haul basis from the cod fishery since 1975 where compiled in 2014. But due very low catches and few hauls in the 90'ies and closed areas in 2008-2010, the logbook data are not used in the assessment process. Nevertheless, cpue results generated by a GLM model are presented here.

As EU and Greenland vessels have participated in the fisheries in the entire period, data from these were used in the GLM model. Hauls made in the closed area in the period of 2008-2010 were excluded from the analysis, as they were considered being bycatches.

The cpue index was relatively stable in the first part of the time-series (1975–1992, mean 0.673 ton/h), except 1989 where cpue increased to 1.668 ton/h (table 16.2.4.1, figure 16.2.4.1). This increase was likely caused by the large 1984 YC entering the fishery. cpue then declined from 1993–2005 (0.130 ton/h) but sampling of the fishery was low in this period due to very low catches of about 200-300 tons total, and catches where taken primarily as bycatch in the redfish fishery. In 2006-2008 cpue increased (mean 1.632 ton/h) as catches started to increase. In 2009 however cpue decreased to 0.397 ton/h, which was most likely caused by the east ward migration of the 2003 YearClass out of the allowed fishing areas.

In 2010, where almost all of the offshore area was closed except of a small area in Southeast Greenland, the index increased to 0.655 ton/h, but catches were taken by very few vessels. In 2011 all closed areas where reopened and fishery started again especially in East Greenland north of 63°N resulting in an increase in cpue to 1.206 ton/h. Since 2011 cpue has declined to 0.420 ton/h in 2015 where cpue where half of the cpue in 2014.

Since 2011 the cpue index has declined and was in 2015 half of the cpue in 2014. In contrast the survey biomass index increased from 2012 to 2013 which is properly caused by the large 2009 YC entering the area and observed in the survey. This Yearclass however was not observed in the fishery until 2015 as the fishery in 2013 and 2014 where concentrated more to the north in East Greenland and therefore fished older and larger fish. The downwards trend in cpue index since 2013/2014 is also observed in the survey biomass index.

16.3 Surveys

At present, two offshore trawl surveys (Greenlandic and German) provide the core information relevant to 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 East and West Greenland at depths down to 400 m. The Greenland survey in West Greenland targets shrimp and cod down to 600 m. The Greenland survey is believed to provide a better coverage of the cod distribution in especially East Greenland as the survey has twice as many stations covering both shelf edge and top, whereas the stations in the German survey are usually concentrated at the shelf edge. The Greenland survey time-series is however limited as the survey in East Greenland first started in 2008.

16.3.1 Results of the Greenland Shrimp and Fish survey in South and East Greenland

A total number of 131 valid hauls were made in 2015 (**Error! Reference source not found.**).

For Atlantic cod the abundance index was estimated at 63 million individuals and the survey biomass at 154,700 tons. Survey abundance increased slightly with 9% compared to 2014, whereas biomass decreased with 16%. Half of the total abundance (53%) and one third of the total biomass (32%) was found in SouthWest Greenland (NAFO 1F) (**Error! Reference source not found.**16.3.1.2, 16.3.1.3, **Error! Reference source not found.**16.3.1.1 and 16.3.1.2). 21% of the total biomass was found on Dohrn Bank (survey area Q1), whereas only 10% of the total abundance was found here indicating that large cod inhabits this area.

The dominating cohort is the 2009 YC accounting for 46% in abundance and the second largest cohort was the 2010 YC (18%) (Table 16.3.1.4, figure 16.3.1.3). The 2009 YC is dominating in South Greenland (NAFO 1F and Q6) where 84% of the total 2009 YC abundance is found (table 16.3.1.5, figure 16.3.1.4). The 2010 YC is more dominant in Southwest Greenland (NAFO 1F) where 80% of the total 2010 YC abundance is found. In 2014 the 2007 YC was the second largest YC in the survey. In 2015 this YC is the highest registered number of 8-yr old in the time-series (since 2008) and as in 2014 this YC is distributed further to the north in East Greenland (Dohrn Bank (Q1) – Kleine Bank (Q3)).

In general younger cod (3–6 yrs) are predominantly found in South Greenland (NAFO 1F + Q6), whereas older cod (> 7 yrs) are found in the northern survey area in East Greenland (table 16.3.1.5, figure 16.3.1.5).

SSB index was estimated to 150,000t in 2014 which was the highest observed in the time-series. In 2015 index is estimated to 119,000t which is a decrease of 20% (figure 16.3.1.7). The spawning stock is distributed throughout the area, but is highest in Southwest (1F), Mideast (Q3) and Northeast (Q1) areas (figure 16.3.1.8). Spawning has however not been documented in Southwest Greenland as the survey is conducted outside the spawning season.

The smoothed biomass estimates are very close to the observed mean estimates in 2015 (table 16.3.1.3, figure 16.3.1.9) where the CV was low. The observed CV was 0.20, while the smoothed CV estimate was 0.18. The process SD was 0.32.

16.3.2 Results of the German groundfish survey off West and East Greenland

In 2015, 75 valid trawl stations were sampled during autumn in the German Greenland offshore groundfish survey (Table 16.3.2.1, Figure 16.3.2.1).

Abundance and biomass decreased by 95% and 88% respectively from 2014–2015 (table 16.3.2.2 and 16.3.2.3). The indices in 2015, both abundance and especially biomass, was highest recorded in the time-series since 1982 (figure 16.3.2.4 and 16.3.2.5). In contrast the indices in 2015 was the lowest recorded since 2011. The main reason for the increase in abundance and biomass since 2012 was increased numbers of the 2009 YC, which has dominated the survey in the period 2012-2014 (Table 16.3.2.4). The large increase in biomass is probably caused by a southward migration of the 2009 YC, which at a younger age was observed more in West Greenland than in South Greenland. In 2015 the 2009 YC was not caught in considerable numbers and it was especially missing in Southwest Greenland were the largest decline in abundance and biomass was observed. The 2010 YC first appeared in considerable numbers in the survey in 2014 where it was the second largest YC observed. In 2015 the 2009 and 2010 YC was dominating the survey (at age 6 and 5) but with a decrease of 94% (2009 YC) and 82% (2010 YC) compared with their indices at age 4 and 5 in 2014 (table 16.3.2.4).

The survey time-series (figure 16.3.2.4) shows three abundance peaks in 1987—1989 caused by the 1984 and 1985 YC, in 2005–2007 caused by the 2003 YC and in 2013—2014 caused by the 2009 YC. Biomass indices show the same peaks, although a large increase in biomass in 2014 compared to the previous periods (figure 16.3.2.5).

Overall findings where the same between the Greenland and the German survey, although the German survey show large fluctuations: a 2009 YC dominating the catches in recent years in South Greenland. However the German survey observed dramatic declining numbers of the 2009 YC in especially Southwest Greenland that was not observed in the Greenland survey. The German survey is conducted in October, whereas the Greenland survey in West Greenland is conducted in June/July. The Greenland survey has twice as many stations and a wider coverage area.

Both surveys show that older and larger cod are found furthest to the north in East Greenland, especially in the Dohrn Bank region.

16.4 Information on spawning

Adequate maturity information has been lacking for the offshore cod stock as the Greenland 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. The fishery showed that spawning is concentrated on-banks north of 62°N in East Greenland. For further information on spawning see stock annex.

16.5 Tagging experiments

A total of 17 304 cod have been tagged in different regions of Greenland in the period of 2003–2015 (table 16.5.1). Cod in the offshore area in West Greenland have been tagged in 2007, 2012 and 2013 on Dana Bak (NAFO 1DE). Cod offshore in East Greenland have been tagged in 2007–2009, 2011, 2012 and 2014-2015 from Julianhåbs Bight (NAFO 1F) in SouthWest Greenland to Dohrn Bank in East Greenland.

Inshore recaptures are almost exclusively recaptured in the same place as tagged (table 16.5.2). No tags from the inshore area have been recaptured offshore except 3 that were recaptured in Iceland. These three cod were tagged in the inshore area in South Greenland.

Offshore recaptures are found both in West-, East Greenland and Iceland (table 16.5.2). Most recaptured tags in both West Greenland are recaptured in the same place as they were tagged, but more tags tagged in East Greenland are recaptured in Iceland than in East Greenland (125 in Iceland compared to 99 in East Greenland). Fishing effort can influence the numbers of recaptures and more analysis needs to be performed on the tagging data in order to investigate the interaction between Iceland and East Greenland.

16.6 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, and estimated at sizes above the very small year classes seen in the 1990s. These YC's has led to a stock increase during the 00s and an increase in catches.

The overall trend in the two surveys is the same: the 2009 YC is distributed in South Greenland, whereas older yearclasses are distributed further north in East Greenland.

The German survey showed a doubling in biomass in 2014 and a reduction of 88% in 2015. The increase in 2014 was caused by increasing numbers of especially the 2009 YC, but also the 2010 YC in South Greenland. In 2015 the 2009 YC was not caught in significant numbers which caused the sharp decline in the survey.

The same increase in 2014 and sharp decline in 2015 was not observed in the Greenland survey and the biomass index in the survey seems stable over the past 3 years. The Greenland survey takes place during summer whereas the German survey takes place a couple of month later in autumn. Difference in season, haul numbers and coverage between the two surveys might explain the difference between the two surveys.

The fishery confirmed the distribution found in the surveys with younger yearclasses (< 7 yrs) dominating the catches in South Greenland, and older yearclasses dominating the catches further north in East Greenland, especially in the Dohrn Bank area.

Indicators show that fishing pressure has been low the last 5—6 yrs and the stock is considered to be improving. The stock size is however still low compared with the 1950's and 1960', where catches exceeded 30 000 tons for a number of years.

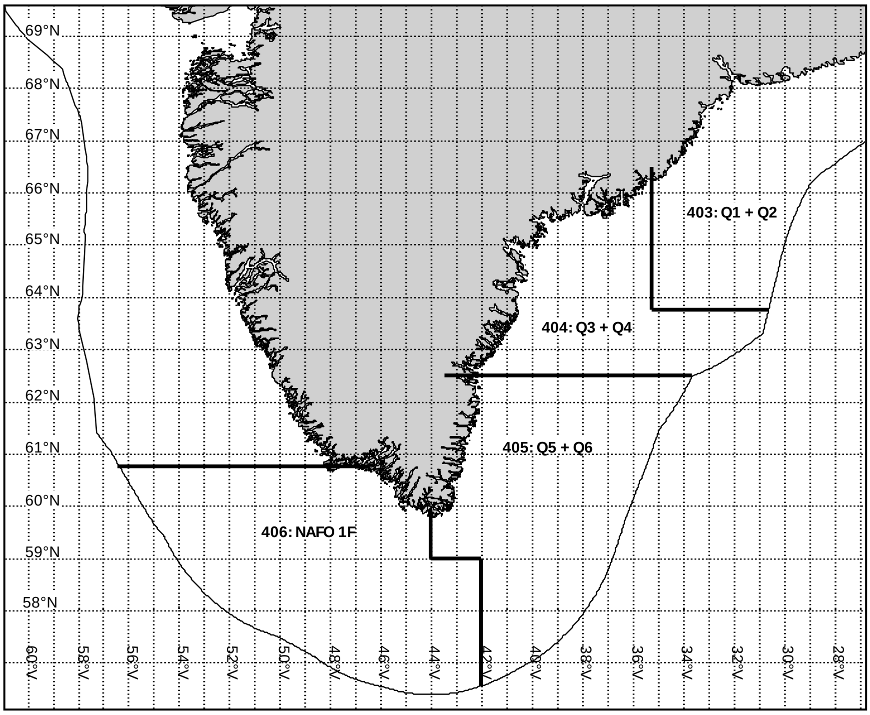
16.7 Implemented management measures for 2016

The offshore quota for the total international fishery is set at 16 000 tons divided into 4 management areas (see figure below).

To protect the spawning stock no fishing is allowed from April 1st–May 31st in all areas.

16.8 Management plan

In 2014 a management plan was implemented for the offshore cod fishery in Greenland (2014-2016) but it has not been evaluated by ICES. The management plan is built on the distinction between the inshore and two offshore stocks components.



Management area West covers NAFO Subarea 1A-E and management area Southeast covers ICES Subarea 14.b (survey area Q1-6) + NAFO 1F.

According to the management plan the TAC in management area Southeast is 10 000 t/year between 2014 and 2016 and no fishery should be done north of 1F in West Greenland. However deviations have been the case in 2015 and 2016 where TAC was set higher than the proposed in the management plan.

The TAC in management area South and East Greenland is divided equally between four areas: Survey area Q1+Q2, Q3+Q4, Q5+Q6 and NAFO area 1F.

The management plan has not been evaluated by ICES.

16.9 Management considerations.

Larger and older fish (7+ yr old) are located furthest to the north on Dohrn Bank, whereas younger fish dominate in the South (5–7 yr old). This reflects the eastward migration behaviour towards the spawning grounds in East Greenland. 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 unknown.

16.10 Basis for advice

This stock was benchmarked in 2015 and the benchmark concluded that catch advice for this stock should be based on the 3.2 DLS approach (ICES 2012, ICES 2015). The NWWG however concluded that this approach had some major drawbacks for this stock. At NWWG the applicability of the DLS approach was explored and several shortcomings in relation to this stock were found:

- Using the DLS is a slow responding approach not suited to a species with a very dynamic stock development. Applying it for this stock would not allow managers to react to sudden increases or decreases in biomass due to the 20% cap/change limit from catches. To adjust for this, additional exploratory analyses looked at the consequence of having a cap 10%, 20%, 40% and without (Figure 16.10.1). The 40% and no cap however entailed that the advice rose very quickly in response to increasing survey values. On the other hand, the lower caps were not able to react in periods with low biomasses.

- The level of advised catch depends to a very large extent on the offset (Figure 16.10.2). For instance, if the approach is implemented at a time of low catches (<500 t) it will take a long time for the advice to adjust to increasing biomass. The other case with a starting point with high catches could also be chosen and that would result in an advice that starts high and stays at that level for a long time.

These issues raised above are particularly important for this stock were large year-to-year variations are a natural occurrence. Therefore, the NWWG concluded that the DLS category 3.2 method was not the best available option, and instead DLS category 3.3 (ICES 2012) with an F_{proxy} as a reference point was a better alternative. As a period of relatively stable catches is co-occurring with rising survey indices (2011–2014), a derived F_{proxy} would be a better basis for advice and more precautionary. The fishing mortality in this period was explored by log catch ratios (Figure 16.10.3) and NWWG concluded that as F appeared to be very low in this period no precautionary buffer should be applied. Also, as the stock status is well described through two surveys no uncertainty cap should be applied. Hence, the catch advice should be based on an F_{proxy} multiplier on the Greenland survey (smoothed) which has the best coverage of the stock. The catch was divided by the survey from 2011–2014 and the average of this (0.049) was multiplied with the smoothed 2015 Greenland survey index (157 312) to give the 2017 catch advice.

16.11 References

ICES. 2012. ICES DLS Guidance Repost 2012. ICES implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68.

ICES (2015). Report of the Benchmark Workshop on Icelandic Stocks (WKICE), 26–30 January 2015, Copenhagen, Denmark. ICES CM 2015/ACOM:31. 133 pp.

Retzel, A. 2015.a. Greenland Shrimp and Fish survey results for Atlantic cod in NAFO subareas 1A-1E (West Greenland) in 2014. ICES North Western Working Group (NWWG) April 28–May 5, 2015, WD 19.

Retzel, A. 2015.b. Greenland commercial data for Atlantic cod in East Greenland offshore waters for 2014. ICES North Western Working Group (NWWG) April 28–May 5, 2015, WD 22.

Retzel, A., Post, S. L. 2015. Greenland Shrimp and Fish survey results for Atlantic cod in ICES Subarea 14.b (East Greenland) and NAFO subarea 1F (SouthWest Greenland) in 2014. ICES North Western Working Group (NWWG) April 28–May 5, 2015, WD 21.

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. Spatio-temporal SNP analysis reveal pronounced biocomplexity at the northern renge margin of Atlantic cod *Gadus morhua*. Evoltutionary Applications. DOI 10.1111/eva. 12055.

16.12 Tables

Table 16.2.2.1. Offshore catches (t) divided into NAFO divisions in West Greenland and East Greenland (ICES 14.b). 1924-1995: Horsted 2000, 1995-2000: ICES Catch Statistics, 2001-present: Greenland Fisheries License Control.

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	ICES 14.b	NAFO 1F + ICES 14.b
1924							200		
1925							1871		
1926							4452		
1927							4427		
1928							5871		
1929							22304		
1930							94722		
1931							120858		
1932							87273		
1933							54351		
1934							88422		
1935							65796		
1936							125972		
1937							90296		
1938							90042		
1939							62807		
1940							43122		
1941							35000		
1942							40814		
1943							47400		
1944							51627		
1945							45800		
1946							44395		
1947							63458		
1948							109058		
1949							156015		
1950							179398		
1951							222340		
1952	0	261	2996	18188	707	37905	257488		
1953	4546	46546	10611	38915	932	25242	98225		
1954	2811	97306	18192	91555	727	15350	60179	4321	23759*
1955	773	50106	32829	87327	3753	4655	68488	5135	11567*
1956	15	56011	38428	128255	8721	4922	66265	12887	19189*
1957	0	58575	32594	62106	29093	16317	47357	10453	30659*
1958	168	55626	41074	73067	21624	26765	75795	10915	46972*
1959	986	74304	10954	30254	12560	11009	67598	19178	35500*
1960	35	58648	18493	35939	16396	9885	76431	23914	39219*
1961	503	78018	43351	70881	16031	14618	90224	19690	40212*
1962	1017	122388	75380	57972	25336	17289	125896	17315	41874*
1963	66	70236	73142	76579	46370	16440	122653	23057	46626*

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	ICES 14.b	NAFO 1F + ICES 14.b
1964	96	49049	49102	82936	33287	13844	99438	35577	55451*
1965	385	80931	66817	71036	15594	15002	92630	17497	38063*
1966	12	99495	43557	62594	19579	18769	95124	12870	38956*
1967	361	58612	78270	122518	34096	12187	95911	24732	40738*
1968	881	12333	89636	94820	61591	16362	97390	15701	37844*
1969	490	7652	31140	65115	41648	11507	35611	17771	31879*
1970	278	3719	13244	23496	23215	15519	18420	20907	40023*
1971	39	1621	28839	21188	9088	20515	26384	32616	59789*
1972	0	3033	42736	18699	7022	4396	20083	26629	32188*
1973	0	2341	17735	18587	10581	2908	1168	11752	14725*
1974	36	1430	12452	14747	8701	1374	656	6553	7950*
1975	0	49	18258	12494	6880	3124	549	5925	9091*
1976	0	442	5418	10704	8446	2873	229	13025	15922*
1977	127	301	4472	7943	8506	2175	35477 1	18000 2	23455*
1978	0	0	11856	2638	3715	549	34563 1	26000 2	27561*
1979	0	16	6561	4042	1115	537	51139 1	34000 2	36775*
1980	0	1800	2200	2117	1687	384	7241 1	12000 2	12724*
1981	0	0	4289	4701	4508	255	0	16000 2	16255
1982	0	133	6143	10977	11222	692	1174	27000 2	27720*
1983	0	0	717	6223	16518	4628	293	13378	18054*
1984	0	0	0	4921	5453	3083	0	8914	11997
1985	0	0	0	145	1961	1927	2402	2112	5187*
1986	0	0	0	2	72	24	1203	4755	5074*
1987	0	0	5	815	67	43	3041	6909	7093*
1988	0	0	919	17463	10913	6466	8101	9457	17388*
1989	0	0	0	11071	48092	14248	2	14669	28917
1990	0	0	2	563	21513	10580	7503	33508	46519*
1991	0	0	0	0	104	1942	0	21596	23538
1992	0	0	0	0	0	0	0	11349	11349
1993	0	0	0	0	0	0	0	1135	1135
1994	0	0	0	0	0	0	0	437	437
1995	0	0	0	0	0	0	0	284	284
1996	0	0	0	0	0	0	0	192	192
1997	0	0	0	0	0	0	0	355	355
1998	0	0	0	0	0	0	0	345	345
1999	0	0	0	0	0	0	0	116	116
2000	0	0	0	0	0	0	0	152	152
2001	0	0	0	0	0	0	0	125	125
2002	0	0	0	0	0	0	0	401	401
2003	0	0	0	0	0	0	0	485	485
2004	0	0	0	5	3	1	0	774	775

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	ICES 14.b	NAFO 1F + ICES 14.b
2005	0	0	1	0	0	71	0	819	890
2006	0	0	0	0	0	414	0	2042	2456
2007	0	0	0	31	435	20113	0	3194	5205
2008	0	0	0	23	526	113703	0	3258	14628
2009	0	0	0	0	6	33233	0	1642	4965
2010	0	0	0	0	2	281	0	2388	2669
2011	0	0	0	0	8	542	0	4571	5113
2012	0	0	1	95	236	1470	0	3941	5411
2013	0	0	0	209	270	1405	0	4104	5509
2014	0	0	30	68	18	1833	0	6060	7893
2015	0	0	341	954	3564	3984	0	11771	**15755**

Estimates for assessment include estimates of unreported catches. The total estimated value for West Greenland (inshore + offshore) was 73000 t in 1977 and 1978, 1979: 99000 t, 1980: 54000 t. The value given in the table are these values minus the inshore catches minus known offshore NAFO division catches.

Estimates for assessment include estimates of unreported catches in East Greenland.

Include catches taken with small vessels and landed to a factory in South Greenland (Qaqortoq), 2007:597 t, 2008: 2262 t, 2009: 136 t.

***) Unknown NAFO division catches added accordingly to the proportion of known catch in NAFO division 1F to known total catch in all NAFO divisions.**

Table 16.2.2.2: 2015 cod catches (t) by area and month. East Greenland (14.b) divided into three management areas.

ICES/NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
14.b (Q1Q2)	423	88	509	78	32	689	585	118	691	430	392	1378	5413	34%
14.b (Q3Q4)	1389	153	77	15	127	613	576	478	185	4	0	212	3829	24%
14.b (Q5Q6)	83	6	219	319	660	75	41	122	201	297	244	262	2529	16%
1F	265	233	226	160	334	701	786	510	117	9	448	196	3984	25%
Total	2160	479	1030	572	1153	2078	1988	1227	1194	740	1085	2049	15755	
%	14%	3%	7%	4%	7%	13%	13%	8%	8%	5%	7%	13%		

Table 16.2.2.3: 2015 cod catches (t) by gear, area and month. East Greenland (14.b) divided into three management areas.

GEAR	ICES/NAFO	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Longline	14.b (Q1Q2)							13	65	51	3			131
	14.b (Q3Q4)	958				95	249	26	328	168	0.02			1824
	14.b (Q5Q6)				45	29			120	197	296	242	26	955
	1F	265	233	226	160	233	377	233	141	19	9	168	175	2237
	Total	1223	233	226	205	357	626	272	654	435	308	410	201	5148
Trawl	14.b (Q1Q2)	423	88	509	78	32	689	572	53	640	427	392	1378	5282
	14.b (Q3Q4)	431	153	77	15	32	364	550	150	16	4		212	2004
	14.b (Q5Q6)	83	6	219	273	632	75	41	2	4	1	2	236	1574
	1F					102	324	553	369	98		280	21	1747
	Total	937	247	804	367	797	1452	1716	574	759	432	675	1848	10607

Table 16.2.3.1. Cod in Greenland. Catch-at-age ('000) and Weight at age (kg) for offshore fleets in East Greenland (ICES 14.b + NAFO 1F).

Catch-at-age								
Year/age	3	4	5	6	7	8	9	10+
2005	5	33	57	103	94	57	16	7
2006	232	376	135	175	115	14	1	0
2007	49	1529	668	158	124	120	18	15
2008	77	586	6015	2417	592	44	26	12
2009	307	1287	1231	434	119	28	16	2
2010	10	87	331	193	334	58	8	5
2011	3	70	137	425	355	371	96	31
2012	13	109	471	281	258	253	148	59
2013	0	36	127	615	237	226	153	104
2014	1	4	279	434	658	335	173	131
2015	3	57	457	1554	1324	828	242	182
Weight at age								
2005	0.354	0.717	1.073	1.963	2.737	3.699	5.271	7.366
2006	1.323	1.602	2.349	3.608	4.420	5.440	7.191	8.127
2007	0.387	0.917	1.597	3.294	6.092	8.524	11.114	14.435
2008	0.359	0.644	1.266	1.799	3.025	4.936	5.840	8.290
2009	0.489	0.776	1.396	2.797	4.634	6.453	7.804	9.993
2010	0.699	1.125	1.636	2.494	3.354	5.334	8.063	10.475
2011	0.553	1.026	1.541	2.297	3.377	4.685	6.285	10.022
2012	0.502	0.892	1.440	2.380	3.570	5.142	7.172	11.417
2013	0.480	0.998	1.698	2.272	3.408	4.745	6.827	9.024
2014	0.564	1.163	1.853	2.603	3.636	4.732	6.400	8.841
2015	0.484	0.833	1.435	2.097	3.460	4.699	6.846	9.115

Table 16.2.4.1: Data used in the Atlantic cod cpue. N are number of hauls from vessels from EU and Greenland used in the analysis.

YEAR	N	LN CPUE (TON/H)	SE
1975	82	-1.1356837	0.1837926
1976	5	-0.9648581	0.6916295
1977	304	0.0759557	0.1199237
1978	232	-0.2357506	0.1298423
1979	313	-0.1948766	0.1294628
1980	106	-0.8420723	0.1677385
1981	10	-1.4465793	0.4936838
1982	15	-1.2515564	0.4022425
1983	52	-0.7002941	0.2559437
1984	211	-0.5794715	0.1554628
1985	41	-0.3401624	0.2552333
1986	0	0	0
1987	0	0	0
1988	368	-0.0616769	0.0998585
1989	1637	0.5118464	0.0753617
1990	4374	-0.0431842	0.0492198
1991	3007	-0.6929048	0.0524628
1992	2392	-0.5291326	0.0563145
1993	244	-2.1702938	0.1122777
1994	124	-3.7735774	0.1456914
1995	6	-3.7388718	0.627408
1996	123	-2.2475193	0.19314
1997	16	-0.8358301	0.3881681
1998	40	-2.4133971	0.2625715
1999	177	-2.5887944	0.1651539
2000	22	-2.2269905	0.3293105
2001	94	-2.0320493	0.1657239
2002	140	-3.0407629	0.1863067
2003	144	-1.8944053	0.1504092
2004	89	-2.3750714	0.2123546
2005	55	-1.2238767	0.4065565
2006	261	0.4300269	0.1222363
2007	358	0.7340622	0.0913542
2008	1530	0.2447458	0.0636558
2009	710	-0.9229665	0.0800496
2010	255	-0.4225995	0.1151019
2011	500	0.1876315	0.0898746
2012	493	-0.0729454	0.0893399
2013	435	-0.3109074	0.1062124
2014	947	-0.0703275	0.0892882
2015	1814	-0.867223	0.0772261
Total	21726		

Table 16.3.1.1. Number of hauls in the Greenland Shrimp and Fish survey in ICES 14.b and NAFO 1F.

	ICES 14.b						NAFO	
Year/Strata	Q1	Q2	Q3	Q4	Q5	Q6	1F	Total
1992							15	
1993							13	
1994							9	
1995							11	
1996							11	
1997							19	
1998							14	
1999							17	
2000							29	
2001							26	
2002							27	
2003							22	
2004							34	
2005							23	
2006							31	
2007							39	
2008	8	6	12	7	7	11	47	98
2009	22	11	25	20	6	13	48	145
2010	19	14	24	9	6	10	40	122
2011	20	11	21	12	7	14	25	110
2012	20	16	28	13	7	15	26	125
2013	25	12	22	14	5	14	28	120
2014	22	14	12	9	8	16	32	113
2015	26	11	24	12	8	14	36	131

Table 16.3.1.2 Cod abundance indices ('000) from the Greenland Shrimp and Fish survey by year and strata divisions in ICES 14.b and NAFO 1F. Q1 being the northern strata in East Greenland.

			ICES 14.b				NAFO		
Year	Q1	Q2	Q3	Q4	Q5	Q6	1F	Total	CV
1992							8		
1993							18		
1994							0		
1995							39		
1996							107		
1997							0		
1998							3		
1999							0		
2000							189		
2001							313		
2002							457		
2003							211		
2004							1610		
New survey Gear Introduced									
2005							86410		
2006							39475		
2007							32575		
2008	5456	1361	13043	1975	1635	7958	22887	54314	22
2009	14304	2191	28539	4374	548	4753	1776	56486	15
2010	5844	732	30042	3975	115	4633	6557	51897	45
2011	7843	1357	5178	7733	1470	19072	6330	48983	22
2012	5475	2164	3658	2453	352	8635	21238	43975	20
2013	11102	1420	5667	17360	537	27145	49874	113104	32
2014	4168	3445	2622	19267	493	5412	22702	58106	36
2015	6396	4074	6941	3093	231	8322	34032	63090	28

Table 16.3.1.3. Cod biomass indices (tons) from the Greenland Shrimp and Fish survey by year and strata divisions in ICES 14.b (Q1-Q6) and NAFO 1F. Smoothed index is a random effects survey smoother applied to the total index.

			ICES 14.b				NAFO			
Year	Q1	Q2	Q3	Q4	Q5	Q6	1F	Total	CV	Smoothed index
1992							2			
1993							5			
1994							0			
1995							4			
1996							49			
1997							0			
1998							3			
1999							0			
2000							46			
2001							100			
2002							150			
2003							46			
2004							305			
New survey Gear Introduced										
2005							56163			
2006							16828			
2007							23346			
2008	8692	2430	24101	1482	2173	8838	21232	68948	23	68597
2009	10844	8874	27251	7827	252	3094	502	58644	28	67919
2010	16014	3151	81064	6202	23	4203	3142	113798	51	81752
2011	27064	8128	5561	12486	5235	22665	3279	84417	19	85238
2012	24732	10058	9347	5802	160	14322	16212	80639	16	91343
2013	45018	9639	15017	48518	977	40319	47818	207306	22	160581
2014	17182	20637	15574	90795	734	8884	30751	184558	45	164103
2015	33105	13803	27050	11609	513	18724	49931	154736	20	157312

Table 16.3.1.4: Abundance indices ('000) by age from the Greenland Shrimp and Fish survey by year in ICES 14.b + NAFO 1F.

East Greenland											
Year/age	0	1	2	3	4	5	6	7	8	9	10+
2008	4355	372	1113	7968	6582	23794	5412	2235	736	1006	739
2009	14970	7642	8019	4504	5378	5664	6610	2537	225	554	385
2010	150	2436	3959	5759	3253	12785	7969	11264	2958	450	914
2011	315	162	5682	8288	16346	5409	4707	2226	3382	1834	634
2012	0	258	1208	12748	7154	12041	4155	2428	1345	1849	790
2013	0	157	1432	1954	44843	25373	26654	5209	3440	1852	2190
2014	692	15	207	1849	1558	21863	8805	12411	2875	3790	4041
2015	0	86	38	1259	4916	11445	29010	7407	4793	1954	2181

Table 16.3.1.5 The abundance indices ('000) by year class/age from the Greenland Shrimp and Fish survey subareas in ICES 14.b and NAFO 1F, 2015.

Year class	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	<2006
Age	0	1	2	3	4	5	6	7	8	9	10+
ICES Q1	0	0	0	173	250	187	869	1193	1442	1019	1262
ICES Q2	0	6	0	1	58	537	1620	974	514	214	150
ICES Q3	0	0	0	266	769	531	1158	1628	1671	428	491
ICES Q4	0	42	0	59	118	208	858	795	511	225	277
ICES Q5	0	7	0	54	0	0	70	14	80	7	0
ICES Q6	0	31	0	40	457	819	4805	1718	391	61	0
NAFO 1F	0	0	38	667	3264	9162	19630	1085	185	0	0

Table 16.3.2.1 ***German survey*****. Numbers of valid hauls by stratum in South and East Greenland, stratum 9 furthest to the north.**

	NAFO 1 F			ICES 14.B					
YEAR	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	2	2	12	4	12	19	10	62
1982	13	2	.	12	1	9	15	15	67
1983	18	4	1	26	8	14	25	10	106
1984	20	4	4	5	1	5	7	2	48
1985	21	4	5	22	11	26	35	18	142
1986	20	3	2	27	11	14	31	34	142
1987	21	5	16	25	7	21	26	11	132
1988	18	2	20	19	10	13	36	9	127
1989	25	3	37	.	20	.	26	4	115
1990	21	6	15	24	4	6	15	12	103
1991	14	5	9	18	11	7	45	13	122
1992	7	5	.	.	.	.	4	2	18
1993	7	.	9	9	5	5	15	10	60
1994	7	5	.	.	.	.	.	6	18
1995	10	5	8	8	5	4	16	8	64
1996	10	5	7	9	5	3	13	6	58
1997	8	5	5	6	4	1	9	5	43
1998	10	5	5	9	6	2	12	6	55
1999	9	3	5	7	4	4	10	6	48
2000	9	5	6	7	8	4	12	9	60
2001	11	6	5	8	8	2	17	12	69
2002	8	4	6	7	5	2	10	7	49
2003	7	5	5	5	5	1	12	10	50
2004	9	5	7	7	8	3	13	11	63
2005	6	5	6	7	8	4	12	9	57
2006	8	5	3	1	5	4	11	7	44
2007	9	5	4	6	4	3	13	8	52
2008	7	6	6	8	4	3	10	8	52
2009	5	5	2	5	5	4	9	8	43
2010	10	6	1	3	8	3	14	8	53
2011	6	6	5	8	6	4	14	9	58
2012	10	6	6	7	8	3	12	9	61
2013	9	6	5	9	7	5	15	9	65
2014	10	6	5	7	10	6	20	11	75
2015	8	6	6	8	9	10	19	9	75

Table 16.3.2.2 ***German survey*****. Cod abundance indices ('000) from the German survey in South and East Greenland by year and stratum.**

	NAFO 1F		ICES 14.B							
YEAR	STR4_1	STR4_2	STR5_1	STR5_2	STR7_1	STR7_2	STR8_2	STR9_2	SUM	SD
1982	8540	1245	.	366	297	1493	664	385	12990	4973
1983	5267	2870	209	715	149	564	529	726	11029	3796
1984	3296	42	1268	413	138	750	173	333	6413	3845
1985	3492	1164	920	166	560	1554	401	310	8567	1978
1986	8967	492	3509	359	776	2641	1207	337	18288	5097
1987	23219	306	5655	4145	399	6298	1293	234	41549	14816
1988	28259	17	2590	2073	302	1175	738	601	35755	16719
1989	31810	31442	9979	.	880	.	2128	639	76878	42682
1990	7052	6306	2808	1155	861	4295	2799	468	25744	7720
1991	1367	233	790	937	122	368	652	510	4979	1548
1992	113	134	.	.	.	.	228	367	842	192
1993	0	.	613	62	127	317	114	148	1381	521
1994	44	12	.	.	.	.	.	234	290	135
1995	27	8	89	25	450	3082	77	91	3849	1314
1996	156	0	109	0	37	279	29	160	770	173
1997	49	0	25	17	200	54	145	1107	1597	479
1998	40	8	97	0	57	57	24	266	549	142
1999	155	0	198	8	165	1267	116	105	2014	582
2000	76	13	348	15	431	180	25	143	1231	251
2001	343	3	319	27	309	299	204	1071	2575	544
2002	1739	0	116	273	769	459	186	875	4417	1352
2003	840	8	199	183	1250	1399	1100	1438	6417	1004
2004	10902	107	1684	133	285	1817	1401	1073	17402	8499
2005	24438	1399	16577	3078	718	7157	1580	2070	57017	11411
2006	28894	486	14733	3686	6044	7378	2779	2700	66700	15653
2007	67049	772	2283	3256	758	5363	2080	2093	83654	56843
2008	18730	292	2036	4898	2203	9460	1285	2678	41582	10268
2009	1286	283	1017	567	3129	8755	1566	3275	19878	3581
2010	2372	141	532	1703	1101	8875	933	1748	17405	2958
2011	7547	162	3027	1326	868	1971	1243	2816	18960	3196
2012	23964	132	5689	167	901	2117	1114	3982	38066	22168
2013	41722	1947	2193	818	874	3121	1157	1342	53174	43105
2014	73612	111	8612	4013	228	1089	1436	5461	94562	77704
2015	3187	361	1186	267	113	834	2265	3395	11608	3752

Table 16.3.2.3 ***German survey*****. Cod biomass indices (tons) from the German survey in South and East Greenland by year and stratum.**

	NAFO 1F		ICES 14.B							
YEAR	STR4_1	STR4_2	STR5_1	STR5_2	STR7_1	STR7_2	STR8_2	STR9_2	SUM	SD
1982	14607	3690	.	1201	1036	3342	2576	1900	28352	8415
1983	9797	6219	653	2209	402	2294	2605	4442	28621	8201
1984	5326	82	3115	1444	346	1782	540	2553	15188	6650
1985	2942	1976	1812	803	1393	3875	1187	1605	15593	3099
1986	8005	943	1044	873	2537	3921	2301	709	20333	6054
1987	17186	276	2889	3735	504	10243	4558	1414	40805	16521
1988	26349	17	2812	4605	964	2297	3475	2012	42531	18651
1989	36912	35281	23605	.	2518	.	6889	2174	107379	61579
1990	9212	5897	5361	3215	2517	10386	6551	1620	44759	10905
1991	2088	200	1465	2759	196	1008	2610	2100	12426	4657
1992	79	50	.	.	.	.	171	734	1034	286
1993	0	.	431	73	247	532	254	547	2084	588
1994	2	7	.	.	.	.	.	779	788	514
1995	6	4	32	62	166	11744	250	123	12387	5550
1996	101	0	63	0	109	708	99	511	1591	333
1997	53	0	18	20	358	70	337	4017	4873	1800
1998	12	11	29	0	87	122	123	986	1370	554
1999	39	0	24	1	162	2229	492	201	3148	1184
2000	13	9	132	17	206	616	75	540	1608	366
2001	88	5	130	19	345	382	387	3005	4361	1593
2002	976	0	38	224	1547	531	541	2214	6071	1306
2003	361	17	121	266	3787	2440	1716	4169	12877	2817
2004	1945	177	359	55	957	2319	3264	3240	12316	3070
2005	9055	1870	8135	2537	3155	17882	3590	6806	53030	7772
2006	31616	681	8616	4130	3557	10291	6084	11567	76542	24680
2007	74671	1045	3749	5042	1363	14456	5374	8540	114240	58452
2008	18543	344	3630	9790	5075	26506	3772	11908	79568	12433
2009	583	277	1361	1726	10145	28613	6351	15520	64576	13358
2010	3629	273	741	5085	5244	31745	4282	10932	61931	11626
2011	12398	385	5839	4364	1658	8051	5735	17487	55917	10240
2012	33871	370	15679	579	2596	6245	5445	26885	91670	30054
2013	74193	6525	6672	2737	2577	9752	4853	7575	114884	75148
2014	132706	428	31885	15935	1060	4322	6480	29358	222174	132209
2015	11848	1534	3938	1804	522	3645	9891	19119	52301	16354

Table 16.3.2.4 ***German survey*****, South and East Greenland (NAFO 1F and ICES 14.). Age disaggregate abundance indices ('1000).**

YEAR	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
1982		23	214	2500	1760	4451	1952	793	223	927	57	74	12974
1983													
1984	23	8	54	1134	507	2434	582	1242	229	125	17	49	6404
1985	279	2521	242	160	1658	947	1439	344	831	96	27	27	8571
1986		3367	9255	1128	273	1631	603	1300	165	473	31	58	18284
1987		4	10193	24656	2689	720	1368	296	966	80	487	49	41508
1988	6	18	335	9769	23391	876	200	559	83	337	31	146	35751
1989	12	2	111	732	23945	49864	1007	44	756	70	282	76	76901
1990	58	36	58	715	706	11679	12101	139	15	74		148	25729
1991		73	150	171	539	102	2128	1762	31	11	3	9	4979
1992	214	10	196	103	61	53	67	67	51			21	822
1993		4	15	869	152	95	97	31	83	34		2	1382
1994		71	5	16	84	39	22	38		8		0	283
1995		1	621	347	260	1399	372	120	403	32	192	102	3849
1996		0	0	353	130	131	110	23	25			0	772
1997		0	12	17	687	557	191	78	48			5	1595
1998	51	73	39	4	11	173	138	48	10			0	547
1999	105	426	389	346	118	257	174	156		29	16	0	2016
2000		202	243	323	208	40	72	20	46	61	15	0	1230
2001		166	568	493	631	362	190	60	50	18	10	2	2550
2002	40	1	395	2119	601	477	454	217	61	21	11	7	4404
2003	579	629	53	553	1761	1026	1015	541	220	37	.	4	6418
2004	386	10687	1770	448	617	1667	921	620	228	39	10	8	17401
2005	80	1603	39549	8091	1250	2819	2549	727	189	40		0	56897
2006	80	439	3375	48140	9269	1328	2404	1309	193	30	9	0	66576
2007	128	154	2007	5149	65974	8166	713	658	634	70		0	83653
2008	14	265	513	8213	4401	22939	4201	516	220	199	44	29	41554
2009	98	322	1057	391	1620	2863	11241	1964	111	134	64	17	19882
2010	22	700	1425	1388	845	2887	2518	5707	1362	236	163	139	17392
2011		120	1246	3475	4874	2402	2949	1179	2324	310	23	49	18951
2012	6	50	1624	10093	10233	9846	2827	1778	1166	379	35	5	38042
2013		17	35	4312	27014	11146	7455	1314	517	291	126	68	52295
2014		7	55	602	20847	58174	9275	3284	1316	494	441	52	94547
2015	105	37	68	341	752	3688	3598	1881	644	187	106	160	11567

Table 16.5.1. Number of tagged cod in the period of 2003 to 2015 in different regions Fjord (West) = NAFO divisions 1B-1F. Bank (West) = NAFO division 1C+1D+1E. East Greenland = NAFO division 1F + ICES division 14.b.

Year	Fjord	Bank (West)	East Greenland
2003	599		
2004	658		
2005	565		
2006	41		
2007	1140	721	1387
2008	231		1296
2009	633		525
2010	88		
2011	28		403
2012	86	1563	2359
2013	183	2321	
2014			1203
2015		57	1218

Table 16.5.2: Number of recaptured cod in the period of 2003 to 2015 in different regions Fjord = NAFO divisions 1B-1F. Bank (West) = NAFO division 1D+1E. East Greenland = NAFO division 1F + ICES division 14.b.

	Fjord	Bank (West)	East Greenland
Fjord (West)	438	14	2
Bank (West)	1	34	2
East Greenland		12	99
Iceland	3	21	125

16.13 Figures

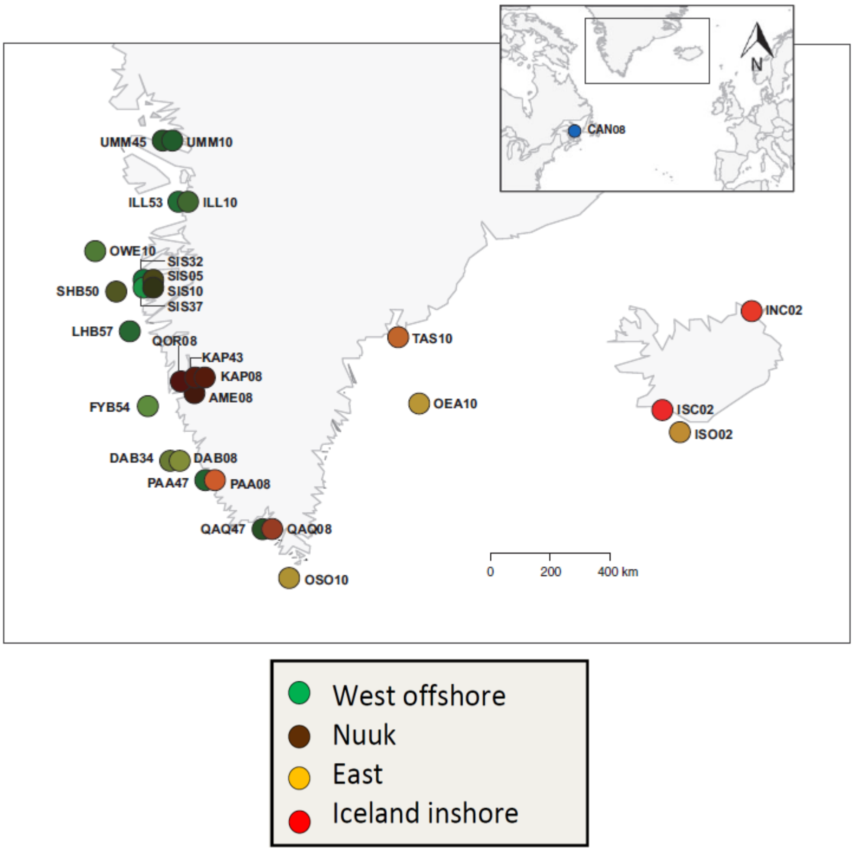


Figure. 16.1. Sampling location of spawning cod in Greenland and Iceland in the genetic project. The colours of the dots represent the blends of sample mean of the different spawning population: West offshore, Nuuk (inshore), East (Greenland and offshore Iceland) and Iceland inshore as signal intensities of green and red respectively. After Therkildsen *et al*. 2013.

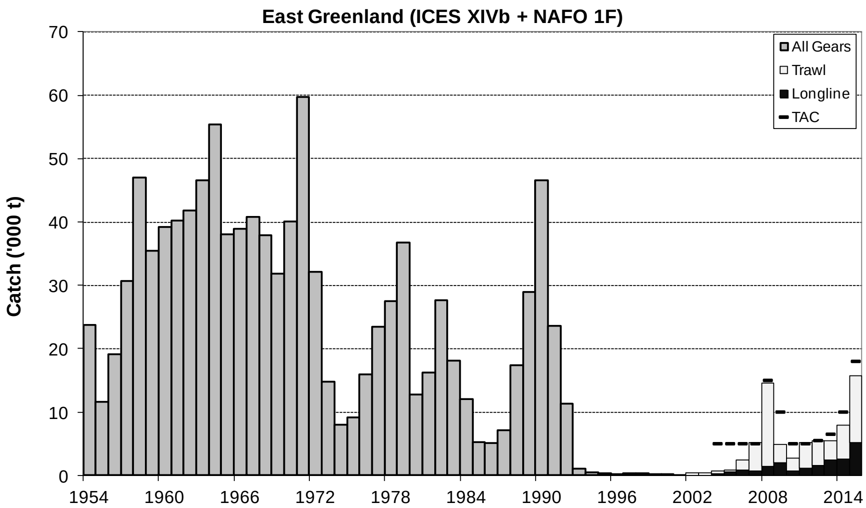


Figure 16.2.1. Annual total catch in South and East Greenland (NAFO subarea 1F and ICES Subarea 14.b). From 2001 divided into gear. TAC until 2013 is for all the offshore area including West Greenland (NAFO subarea 1A-1E).

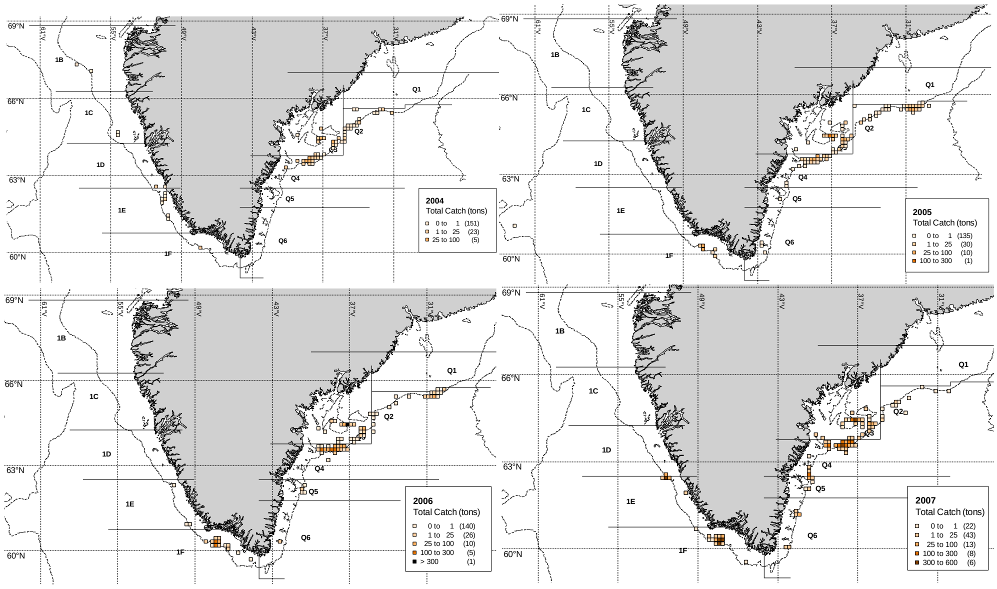


Figure 16.2.2.1: Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

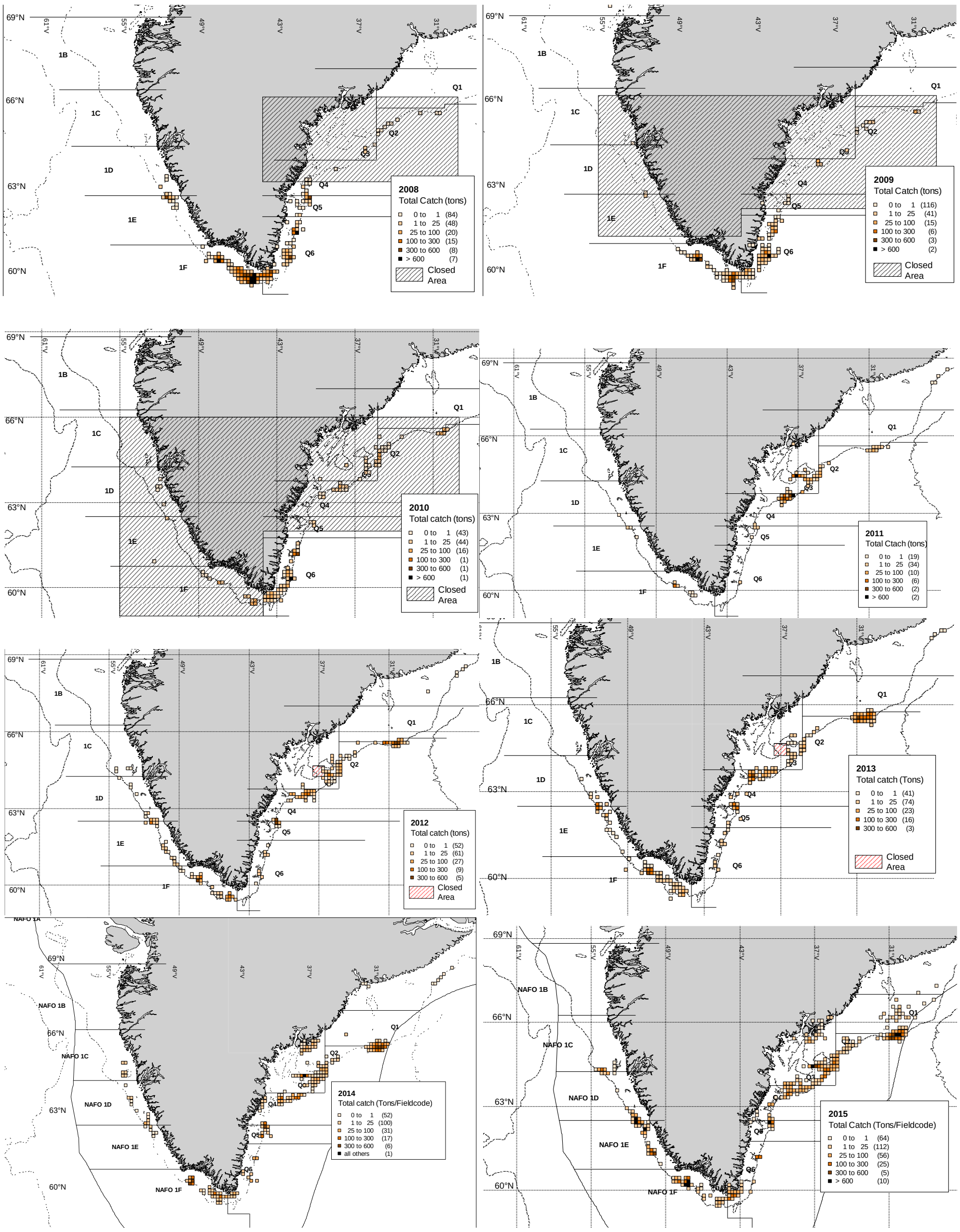


Figure 16.2.2.1: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

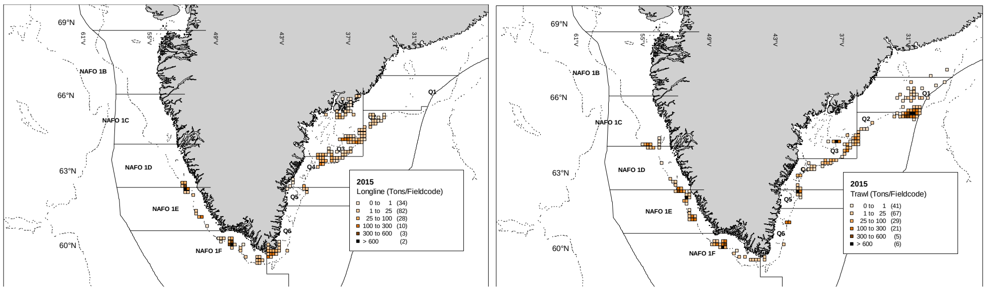


Figure 16.2.2.2: Distribution of Longline and Trawl catches of Atlantic cod in West and East Greenland 2015. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

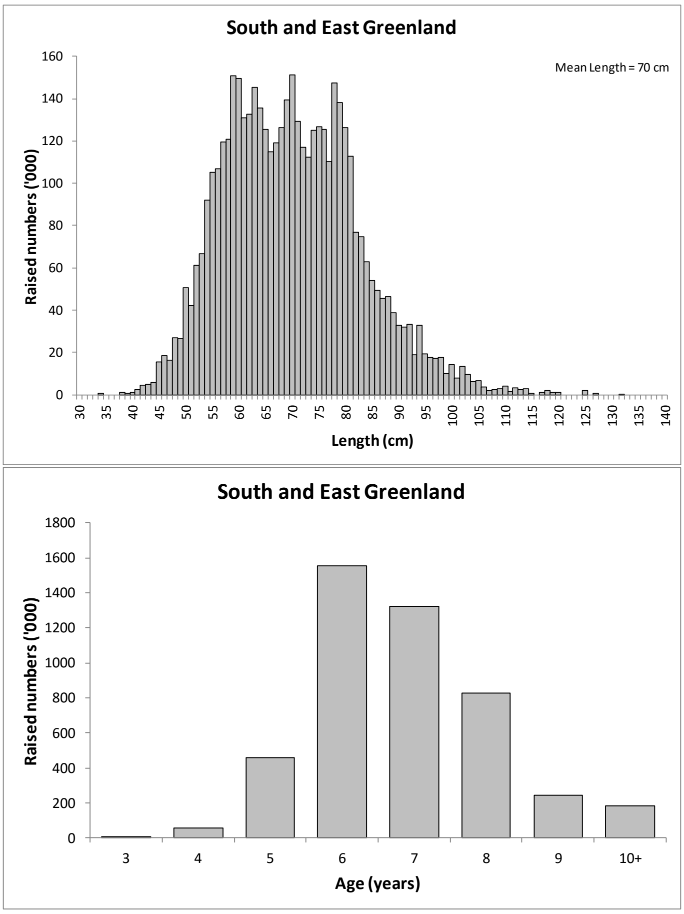


Figure 16.2.3.1: Combined length and age distributions of commercial cod catches in the South and East Greenland offshore fishery in 2015.

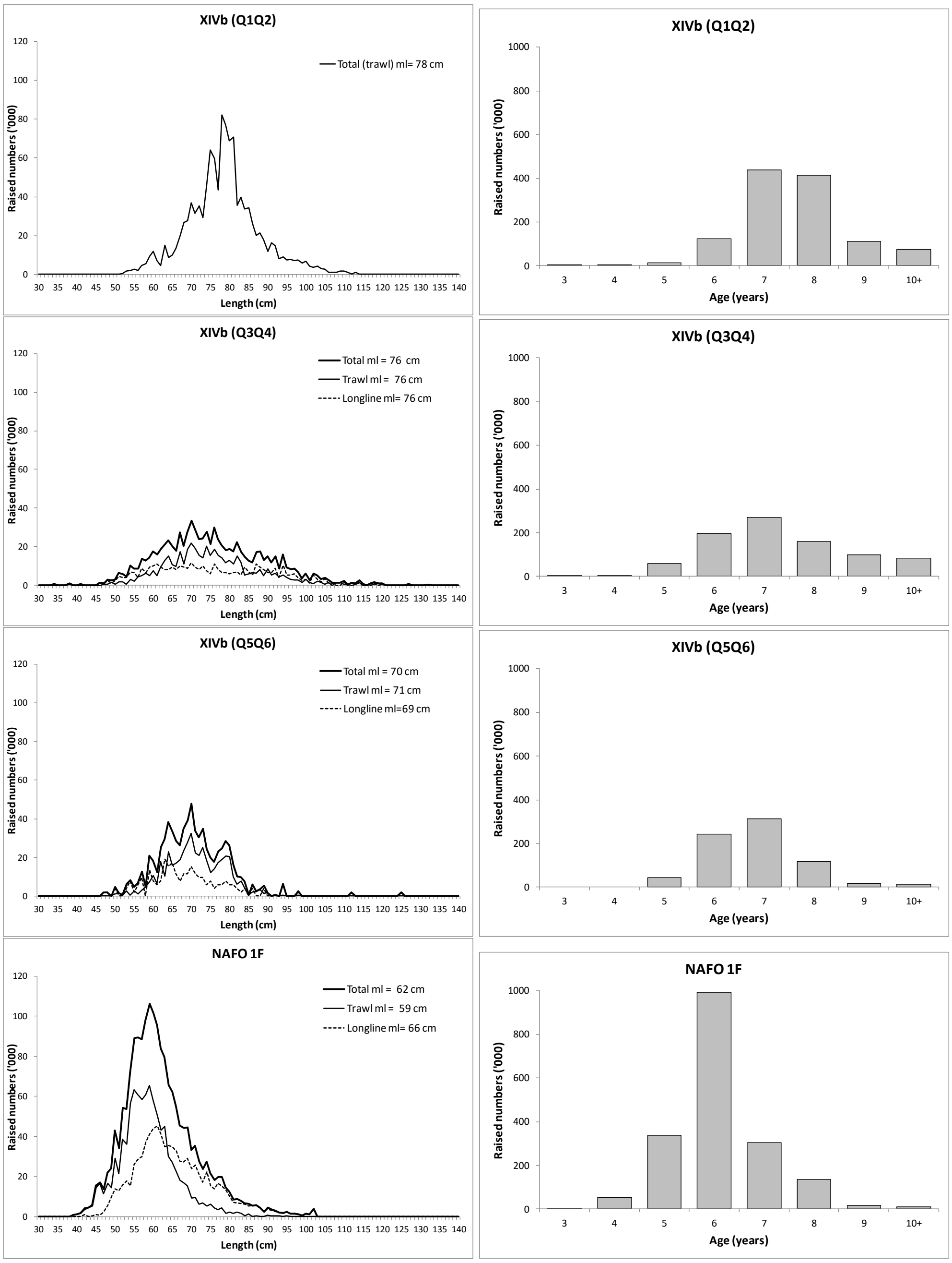


Figure 16.2.3.2: Length and age distributions of commercial cod catches in the four management areas of SouthWest (NAFO 1F) and East Greenland (Q1Q2 furthest north) in 2015.

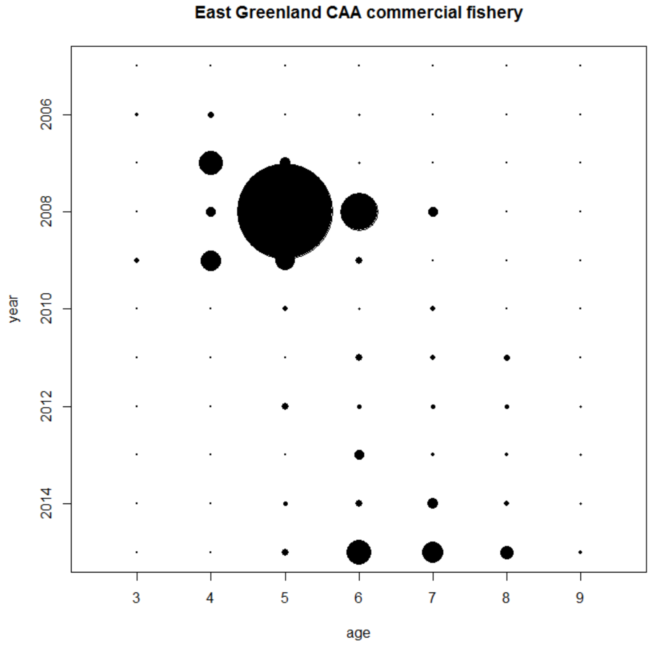


Figure 16.2.3.3: Catch-at-age in the East Greenland (ICES 14b + NAFO 1F) commercial fishery. Size of circles represents size of catch numbers.

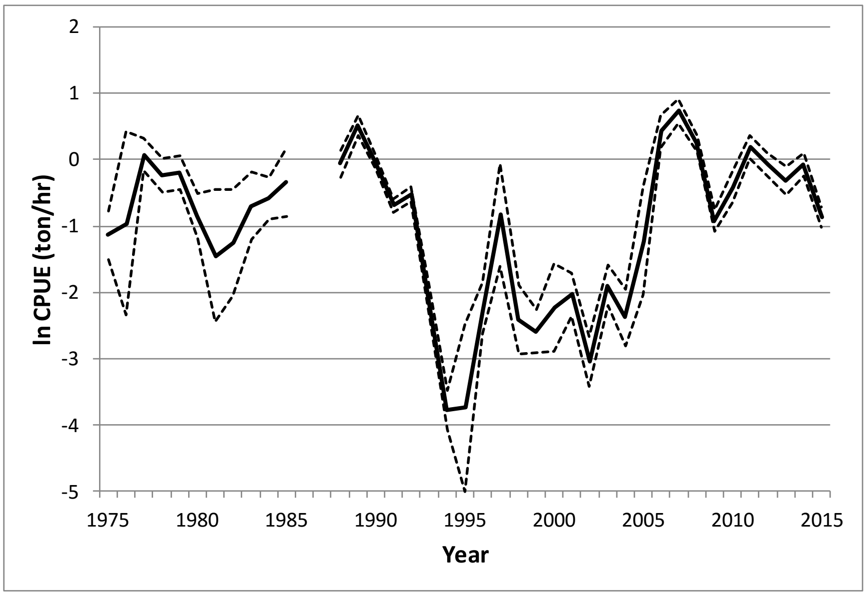


Figure 16.2.4.1: Ln cpue (ton/h) for Atlantic Cod caught in the fishery in East (ICES 14b) and South-West (NAFO 1F) Greenland. Based on model: ln cpue = year + management area (Q1Q2, Q3Q4, Q5Q6 and 1F) + ship. Dashed lines are 2*SE.

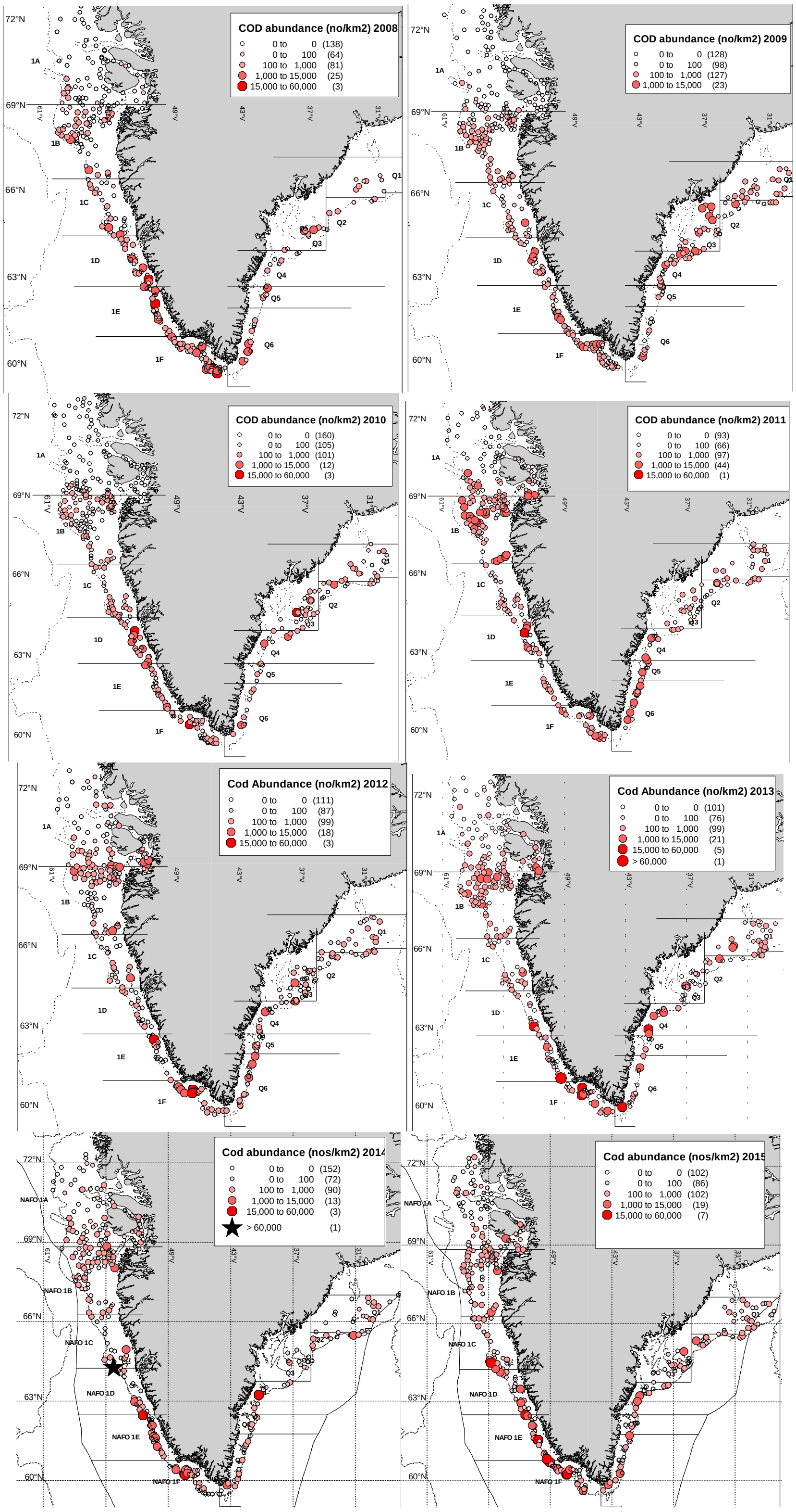


Figure16.3.1.1. Greenland shrimp and fish survey 2008–2015. Abundance per Km².

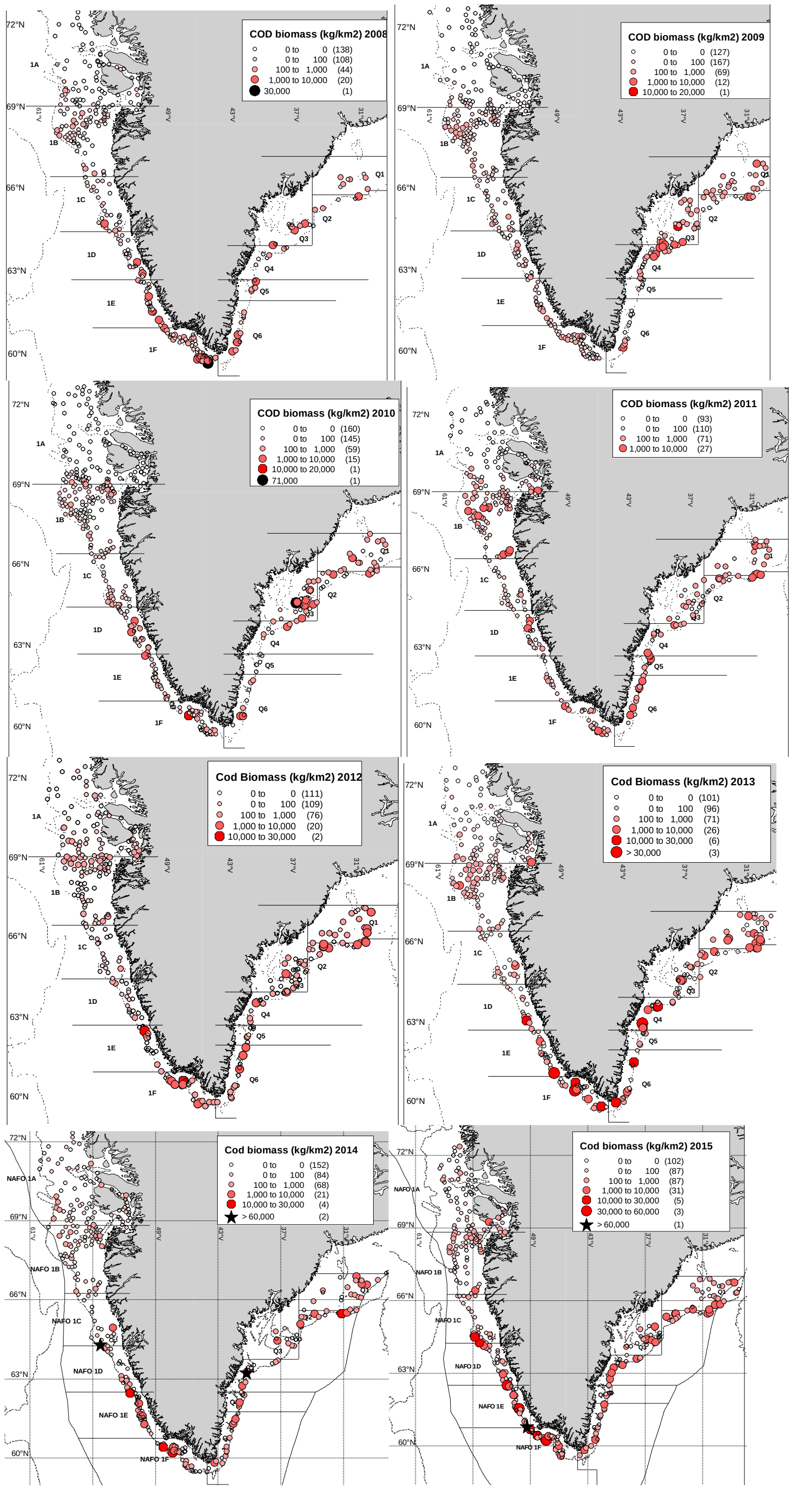


Figure 16.3.1.2. Greenland shrimp and fish survey 2008–2015. Catch weight kg per Km²

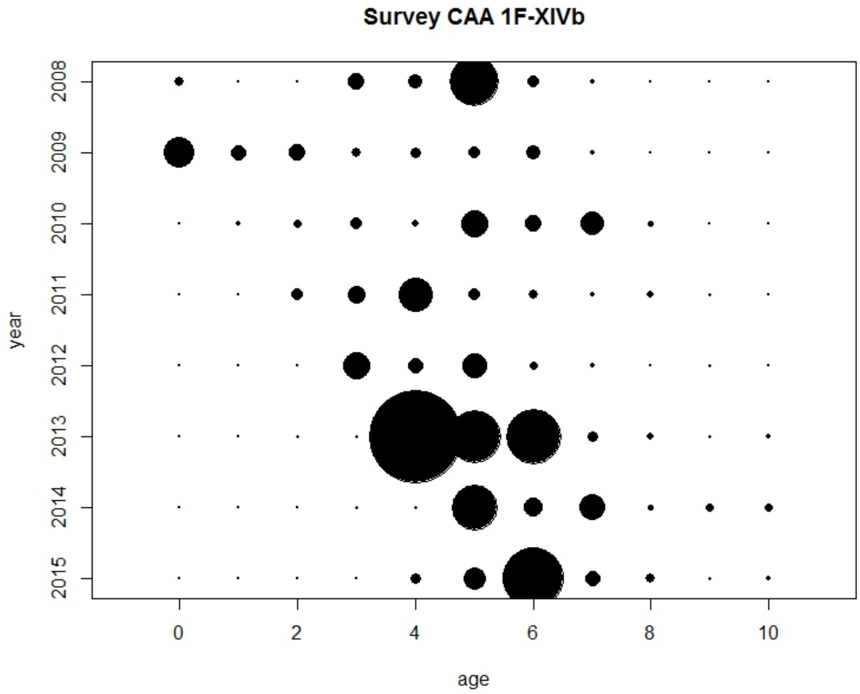


Figure 16.3.1.3: Abundance index pr. age in ICES 14b and NAFO 1F combined. Size of circles represents size of index.

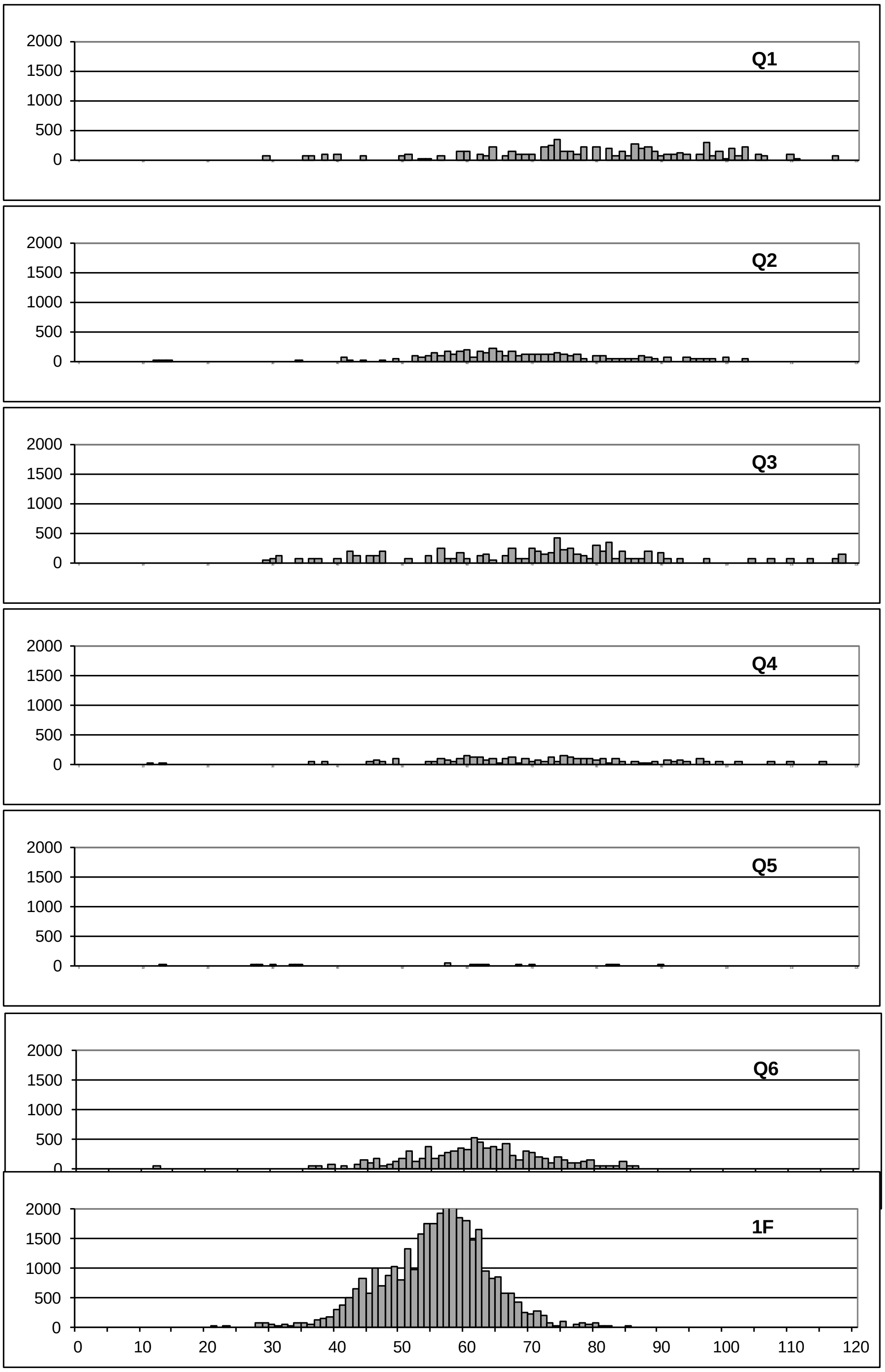


Figure 16.3.1.4: Abundance index by length (cm) and area in 2015. Areas from north (top) to south (bottom) is: Q1, Q2, Q3, Q4, Q5, Q6 (ICES 14b) and NAFO 1F.

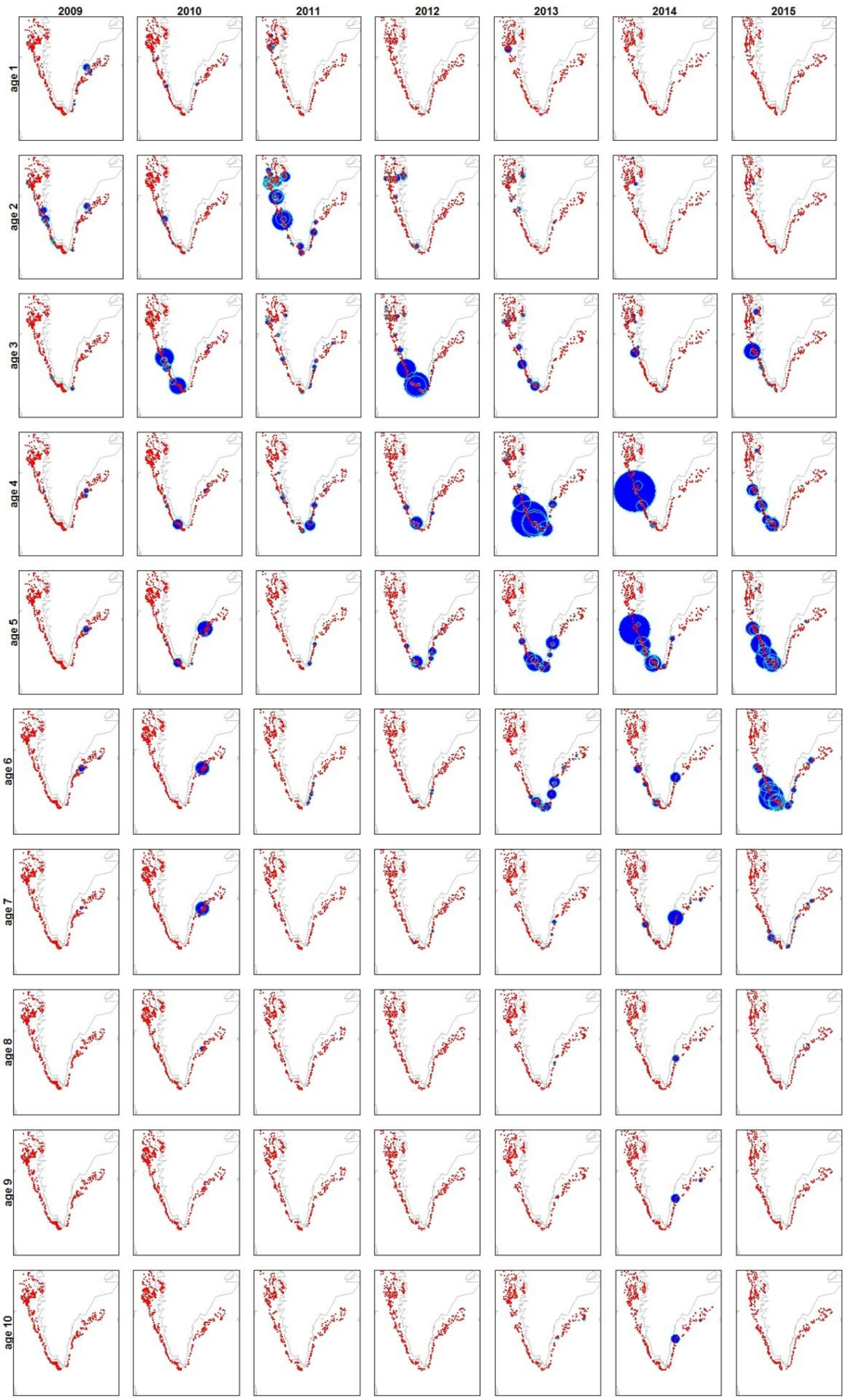


Figure 16.3.1.5. Abundance (no/km²) pr. station of ages 1-10 in the years 2009–2015.

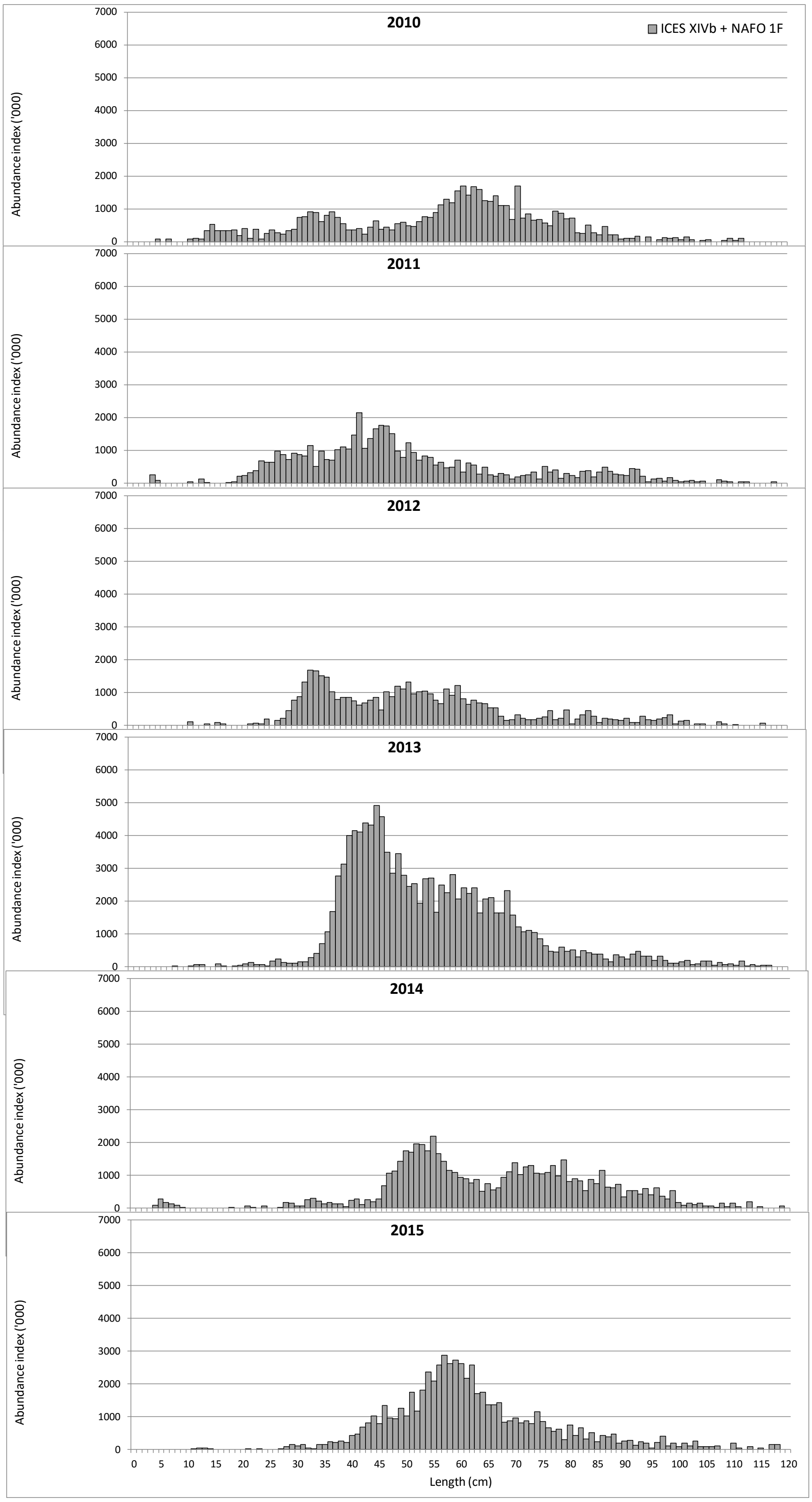


Figure 16.3.1.6: Total abundance indices by length in East Greenland (ICES 14b + NAFO 1F) shrimp and fish survey.

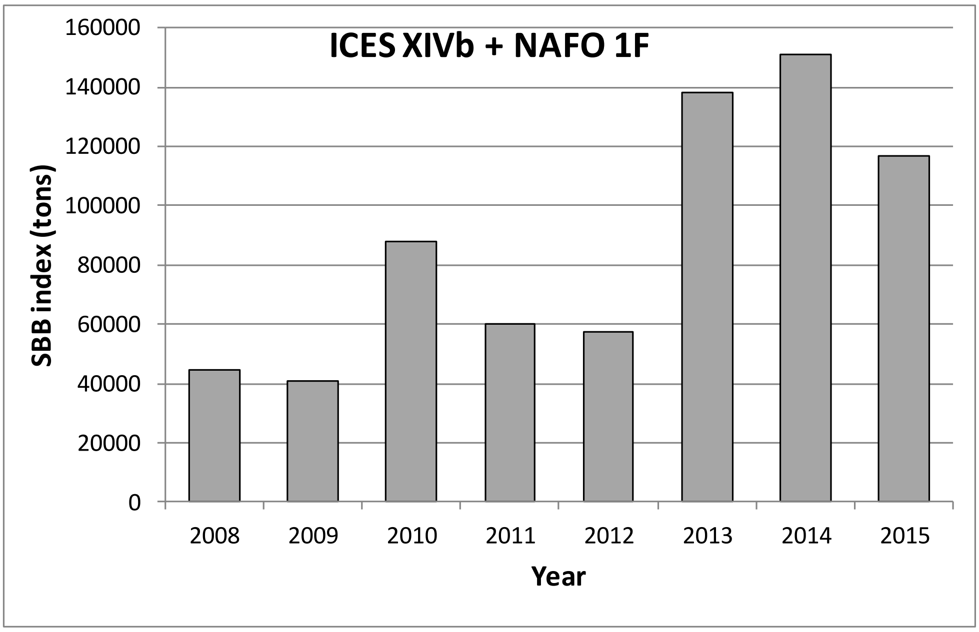


Figure 16.3.1.7: Estimated SSB (tons) by year from the East Greenland (ICES 14b + NAFO 1F) Shrimp and Fish survey.

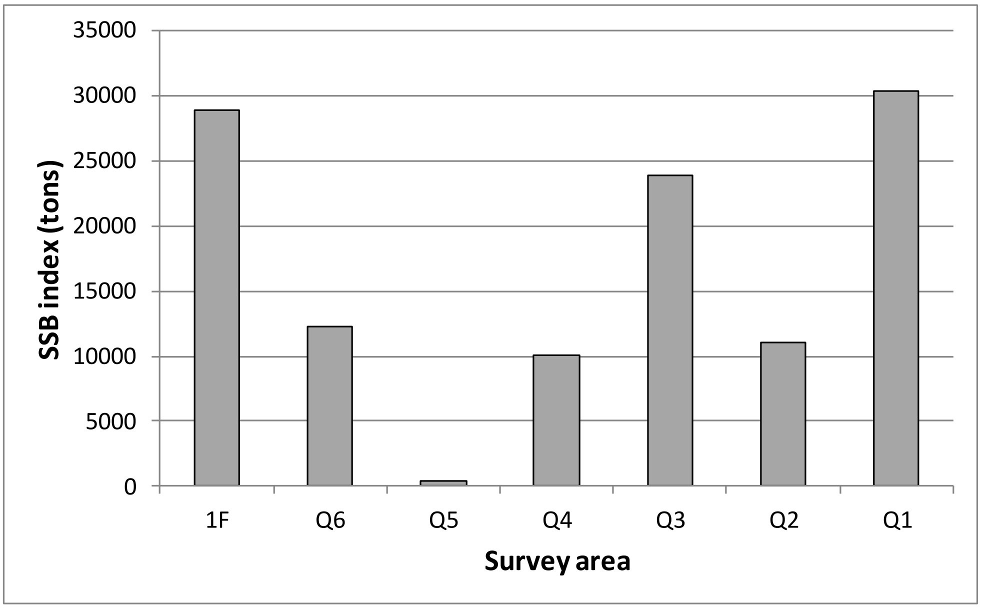


Figure 16.3.1.8: Estimated SSB (tons) by survey areas from the East Greenland (ICES 14b + NAFO 1F) Shrimp and Fish survey, 2015. NAFO Div 1F (SouthWest Greenland) to the left, "Q" areas (East Greenland) to the right. Cape Farewell is between 1F and Q6.

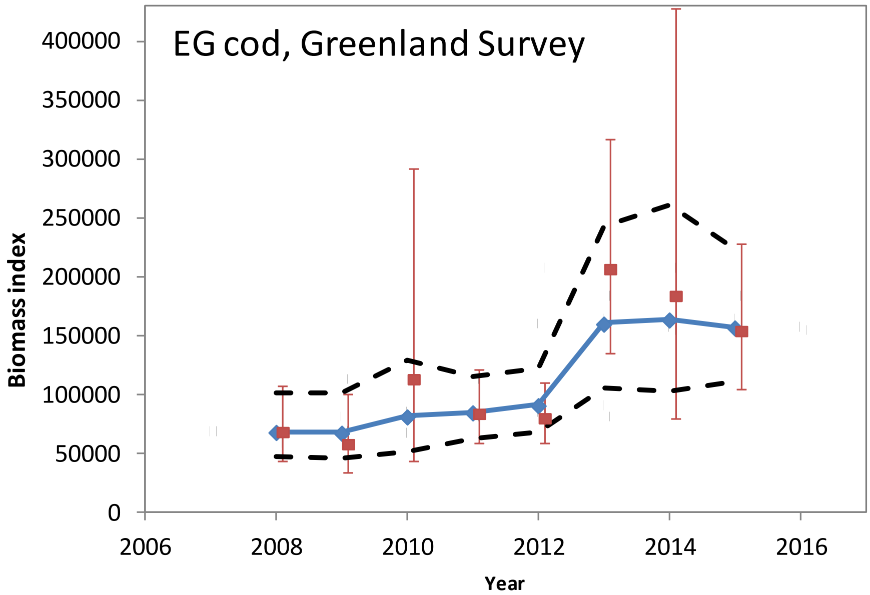


Figure 16.3.1.9: Biomass index for NAFO 1F and ICES Subarea 14b. Red squares are the estimated mean value from the survey and the vertical connected lines are upper and lower 95% confidence intervals. The smoothed estimates are displayed as the blue line and the 95% confidence intervals of the smoothed values are shown as dashed lines.

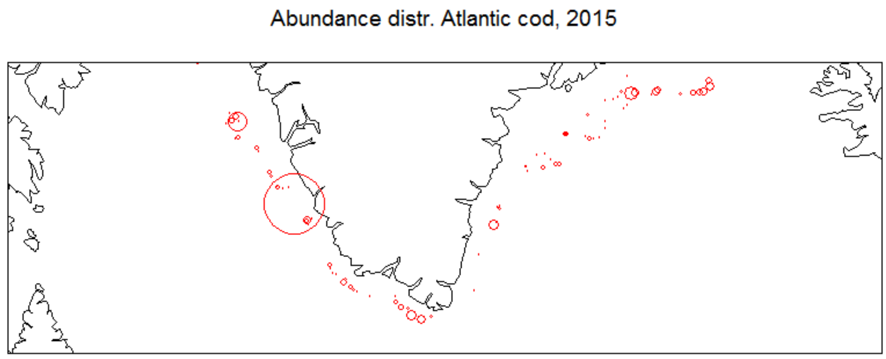


Figure 16.3.2.1 German survey, 2015. Abundance (num per km2) pr haul.

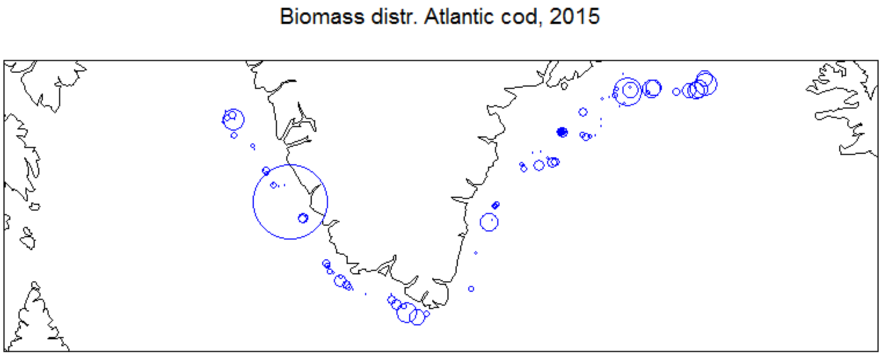


Figure 16.3.2.2 German survey, 2015. Biomass (kg per km2) pr haul.

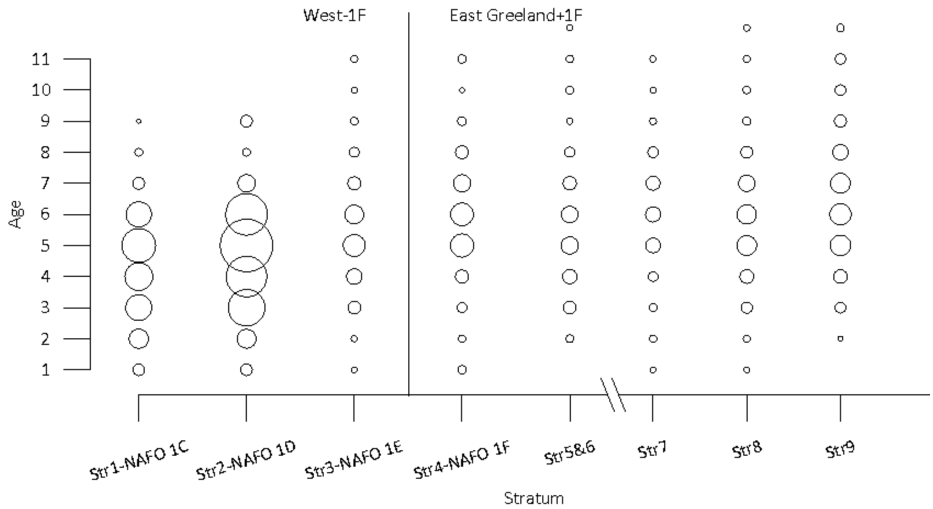


Figure 16.3.2.3 German survey, Cod off Greenland. Abundance per age group and stratum 2015. Strata 1 –4 is West Greenland from north to south; strata 5–9 is East Greenland from south to north.

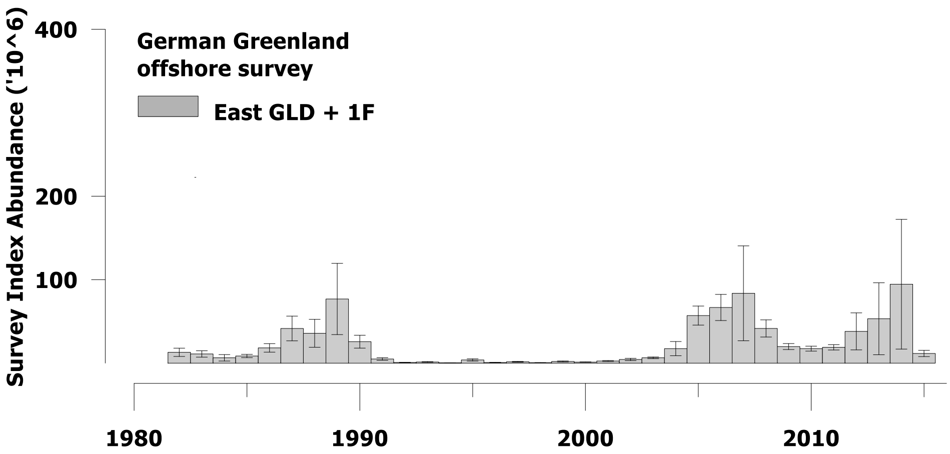


Figure 16.3.2.4 German survey, Cod off Greenland. Abundance indices for South and East Greenland.

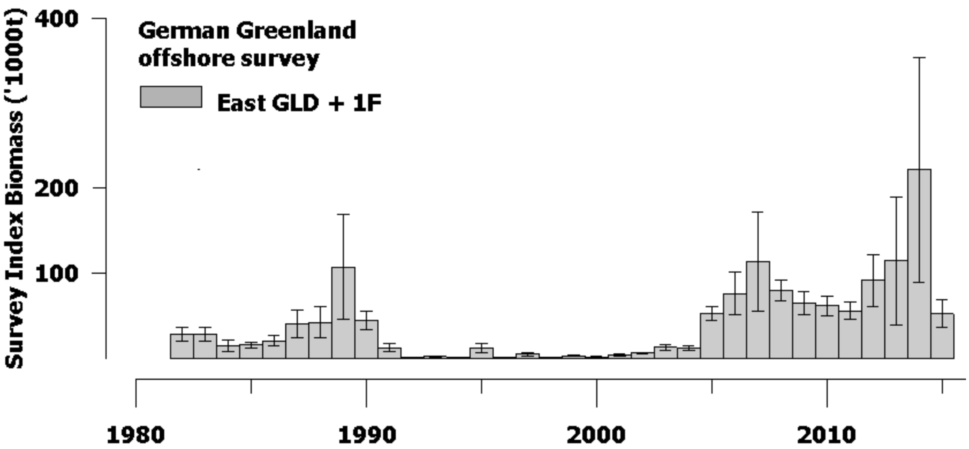
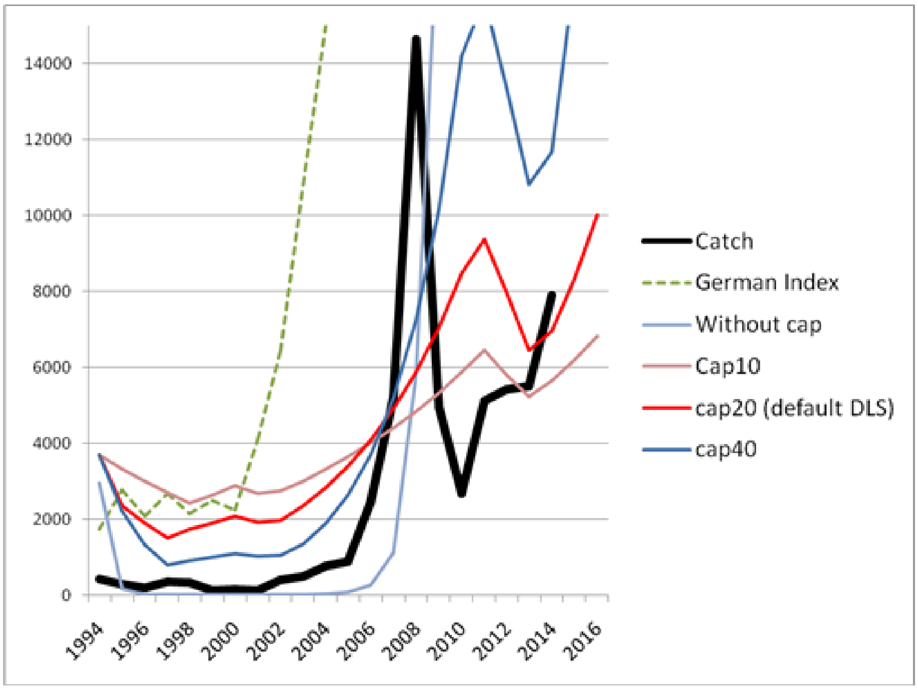


Figure 16.3.2.5 German survey, Cod off Greenland. Biomass indices for South and East Greenland.



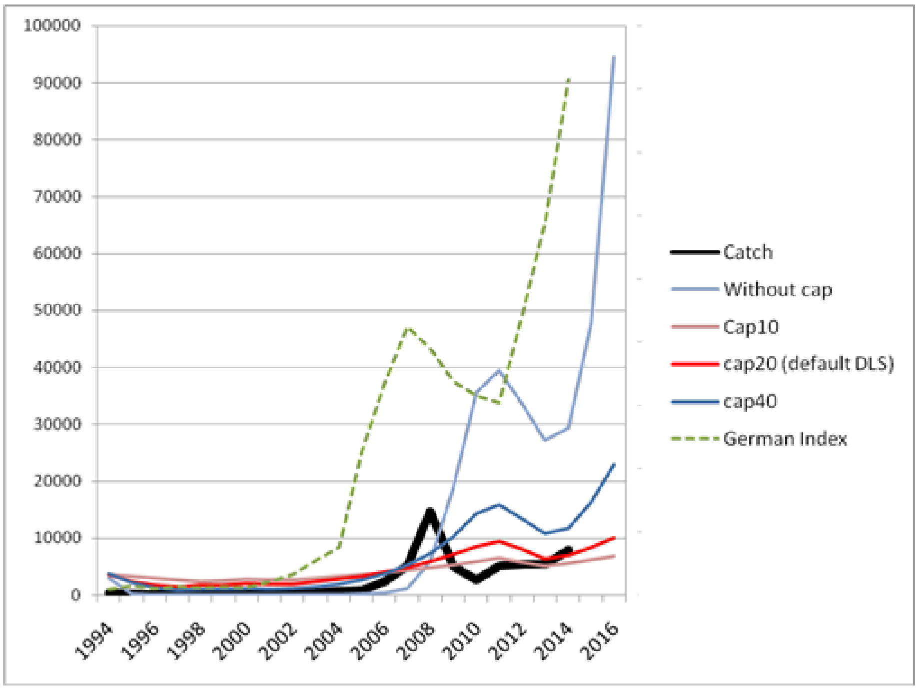


Figure 16.10.1: Catch, catch advice with different cap's on the 3.2 DLS approach and German survey index (without scale). The two figures show the same, but with two different scales on the Y-axis.

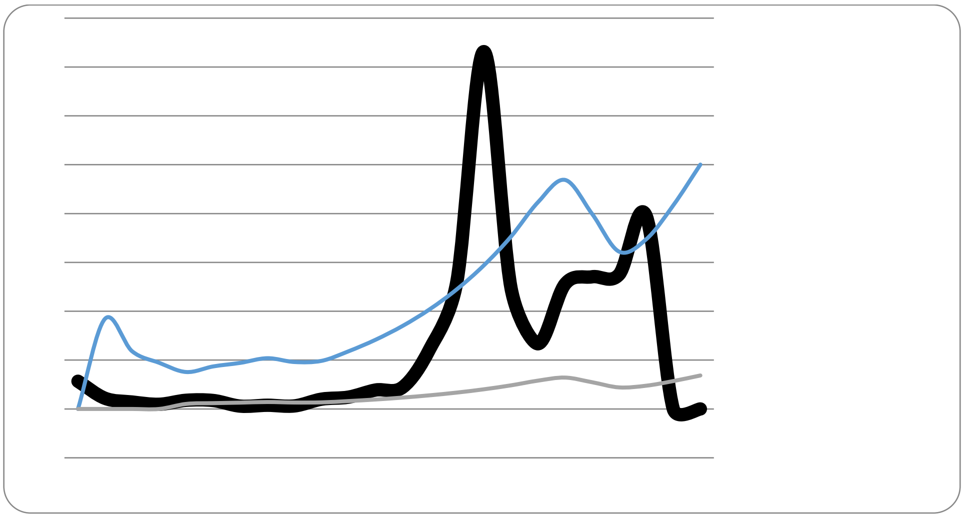


Figure 16.10.2: Catch (black), catch advice with setoff in year 1994 (blue), catch advice with setoff in year 1997 (green). Both 20%cap and 0.8 buffer were used for the two catch-advice calculations.

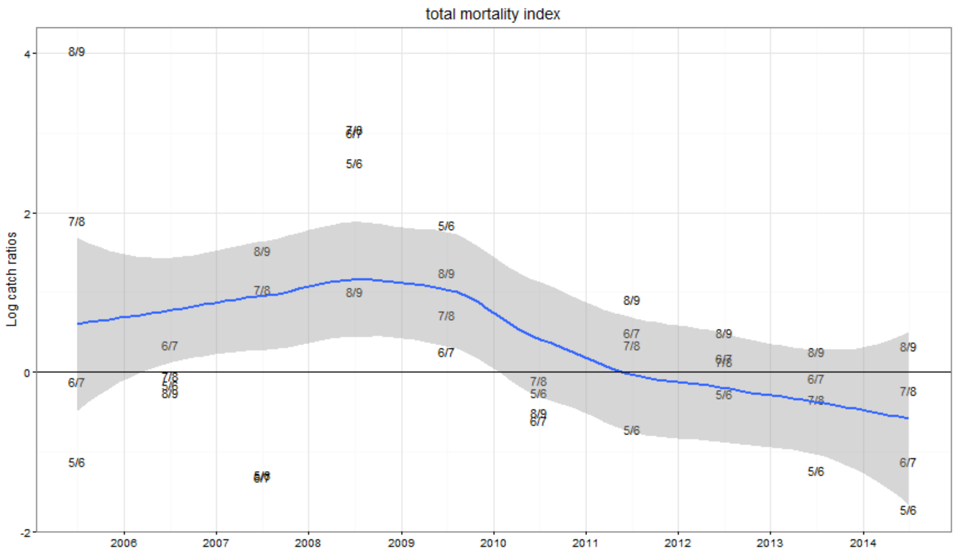


Figure 16.10.3: Log catch ratios from the commercial catches fitted with a Loess smoother. Labels are age specific log catch ratios in a given year.

17 Greenland Halibut in Subareas 5, 6, 12, and 14

Greenland halibut in ICES Subareas 5, 6, 12 and 14 are assessed as one stock unit although precise stock associations are not known.

17.1 Executive summary

Catches of Greenland halibut in Subareas 5,6,12 and 14 have ranged between 20 and 30 kt in the last two decades and amounted 25 kt in 2015.The biomass indices used as input to the assessment (combined survey index at Greenland and Iceland) and logbook information from Iceland trawler fishery all show a slight increase in 2015.,

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 along with the high catches in the late 1980s and early 1990s. Since 2004/2005 the stock has increased slowly and is now at 71%B_{MSY} .Fishing mortality have since 2013 been around F_{MSY} and is in 2015 10% above F_{MSY}. The remaining available indices that are not currently used in the analytical assessment, e.g. logbook from East Greenland trawl fishery and from Faroese trawl fishery and a Faroese survey suggest high biomass in recent years, and therefore supports the recent trend in the assessment.

17.2 Catches, Fisheries, Fleet and Stock Perception

17.2.1 Catches

Total annual catches in Divisions 5a, 5b, and Subareas 6, 12 and 14 are presented for the years 1981–2015 in Tables 17.2.1–17.2.6 and since 1961 in Figure 17.2.1. Catches increased in 2015 by 22% to 256.67 t. Landings in Icelandic waters (usually allocated to Division 5a) have historically predominated the total landings in areas 5+14, but since the mid 1990s also fisheries in Subarea 14 and Division 5b have developed. Landings have since 1997 been between 20–31 kt.

17.2.2 Fisheries and fleets

In 2015 quotas in Greenland EEZ and Iceland EEZ 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 bycatch regulations for the trawlers and depth and gear restrictions for the gillnetters.

Most of the fishery for Greenland halibut in Divisions 5a, 5b and 14b is a directed trawl fishery, and also an insignificant gillnet (~5% in 2015) and longline fishery (~1% in 2015) takes place. Only minor catches in 5a and 14b are taken as bycatches in a redfish fishery (see section 23 on Greenland slope redfish). No or insignificant discarding has been observed in this fishery.

Spatial distribution of 2015 fishery and historic effort and catch in the trawl fishery in Subareas 5, 6, 12 and 14 is provided in Figures 17.2.2-5. Fishery in the entire area did in the past occur 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 2015 the distribution of the fishery covered all areas but was discontinuous in its distribution.

In 2001–2008 a directed and a bycatch fishery by Spain, France, Lithuania, UK and Norway developed in the Hatton-bank area of Division 6b. However, most of these fisheries ceased after 2008 and is currently insignificant. Landings in Subareas 12 and 6 in Tables 17.2.5–17.2.6 derive from the Hatton-bank area.

17.2.3 Bycatch and discard

The Greenland halibut trawl fishery is commonly a clean fishery with respect to bycatches. Eventual bycatches 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 the shrimp fishery in Icelandic and Greenland waters since 2002 are observed to have reduced bycatches considerably. Based on sampling in 2006 - 2007, scientific staff observed bycatches of Greenland halibut to be less than 1% compared to about 50% by weight observed before the implementation of sorting grids (Sünksen 2007). No information has since been available but the fishery in 14b generally report discard rates less than 1% by weight in logbooks.

17.3 Trends in Effort and cpue

17.3.1 Division 5a

Indices of cpue for the Icelandic trawl fleet directed at Greenland halibut for the period 1985–2015 is provided in Table 17.3.1 and Figures 17.3.1-3. At latest benchmark (WKBUT 2013) the cpue series from this fishery was questioned due to a marked distributional change in fishing season and area, and also because the regulations might have caused a changed behaviour in the fishing fleets. The important fishing grounds west of Iceland, where approximately 70–80% of the landings historically came from, are the areas where the season shift mainly has affected the cpue. A simple standardization procedure was not considered sufficient to account for these changes (Figure 17.3.2.). A rough estimate on stock biomass distribution in Iceland is an equal quantity in each of the four areas and the overall cpue index for the Icelandic fishery was therefore compiled as the average of the standardized indices from the four areas (Fig 17.3.1-2.).

Catch rates of Icelandic bottom trawlers decreased for all fishing grounds during 1990–1996 (Figure 17.3.1) but have since peaked in 2001 and have in recent years been stable and slowly increasing. The overall tendency is the same for all fishing grounds in 5a (Figure 15.3.2) although the less important fishing grounds in north, east and southeast more variable in trend. Both observed and derived effort are about historic average in 2014 (Figure 17.3.3).

17.3.2 Division 5b

Information from logbooks from the Faroese otterboard trawl fleet (>1000 hp) was available for the years 1991-2015 (Table 17.3.1, Figure 17.3.4.). The bulk of the fishery has historically been on the southeast 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% until 2013 but has since decreased to 50% of that level.

17.3.3 Division 14b

cpue and effort from logbooks in 14 are provided in Table 17.3.1 and Figure 17.3.5-6. Following a period with relatively low cpues in 1999–2004, catch rates have been variable but increasing and reached in 2015 a record high. It should be noted that cpue series from Divisions 5a, 5b and 14b have different trends over the time indicating that the populations/areas do have different dynamics.

17.3.4 Divisions 6 and 12b

Since 2001 a fishery developed in Divisions 6b and 12b in the Hatton-bank area, but in both divisions the recent catches are relatively small. Limited fleet information is available from this area (ICES WGDEEP).

17.4 Catch composition

Length compositions of catches from the commercial trawl fishery in Div. 5a are rather stable from year to year. In Figure 17.4.1 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 Catch composition from all areas (5a,b and 14) by gear is provided for 2015 in Figure 17.4.2.

17.5 Survey information

The total surveyed area in 2015 for Greenland halibut in Divisions 5a and 14b is provided in Figure 17.5.1. The areas where commercial fishing takes place (Figure 17.2.2.) are covered by the annual surveys. The two surveys in 5a and 14b are combined to one index and used as input in the assessment model.

17.5.1 Division 5a

Since 2006 the total biomass of Greenland halibut has increased significantly in Icelandic waters (Figures 17.5.3). (Figures 17.5.3.–17.5.4.). Abundance of smaller fish (less than 40 cm) has been record low in recent two years indicating poor recruitment.

17.5.2 Division 5b

The catch rates from the available time-series of the Faroese survey have declined from a record high level in 2012 but is still high in 2015.(Figure 17.5.5).

17.5.3 Division 14b

Total biomass in the Greenlandic survey in 2015 was estimated 11285 tons (S.E. 3752) which is a 15% increase from the 2014 estimate. A GLM analysis performed on the survey catch rates, taking into account the scattered coverage of area and depth between years did however showed a slight decrease from 2014 (Figure 17.5.6.). The text table below provides information on the coverage and numbers of stations in 2015 along with the Iceland survey in Division 5a.

Survey /Division	No. hauls in 2015 (planned hauls)	Depth range (m)	Coverage (km2)
5a	203 (219)	32 - 1309?	-130 000
14b	84 (70)	400-1500	29 000

The stock annex provides more extensive descriptions of the surveys.

17.6 Stock Assessment

17.6.1 .Stock production model

The assessment uses a stochastic version of the logistic production model and Bayesian inference according to the Stock Annex in which a more detailed formulation of the model and its performance is found.

17.6.1.1 Input data

The model synthesize information from input priors and two independent series of Greenland halibut biomass indices and one series of catches by the fishery (Table 17.6.1). The two series of biomass indices were: a revised and standardized series of annual commercial-vessel catch rates for 1985–2015, $cpue_t$,; and a combined trawl-survey biomass index for 1996–2015, $Isur_t$.

Total reported catch or WGs best estimates in ICES Subareas 5, 6, 12 and 14 1961–2015 was used as yield data (Table 17.6.1, Figure. 17.2.1). Since the fishery has no major discarding problems or misreporting, the reported catches were entered into the model as error-free.

17.6.1.2 Model performance

The model parameters were estimated (posterior) based on the prior assumptions (Table 17.6.2–3 and Figure 17.6.1). 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 17.6.1). The prior for K was somewhat updated to slightly higher values. However, the posterior still had a wide distribution with an inter-quartile range of 701–1072 ktons (Table 17.6.3).

The model was able to produce a reasonable simulation of the observed data (Figure 17.6.2). The probabilities of getting more extreme observations than the realized ones given in the dataseries on stock size were in the range of 0.05 to 0.95 i.e. the observations did not lay in the extreme tails of their posterior distributions (Table 17.6.4). Exceptions are observed for the survey in 1997 (p=0.96) and in 2006 (p=0.04). The cpue series was generally better estimated than the survey series (Figure. 17.6.2).

The retrospective runs suggest high consistency (Figure. 17.6.3).

17.6.1.3. Assessment results

The time-series of estimated median biomass-ratios starts in 1960 as a virgin stock at K (Figure. 17.6.4 -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 the late 1990s. Since then the stock started to increase from its lowest level in 2004-5 of approx. 45% of B_{MSY}. In 2014 biomass was at 71% of B_{MSY}. The risk of the biomass being below B_{MSY} in 2014 is 100% and 0 % of being below B_{LIM} (Table 17.6.5). The median fishing mortality ratio (F/F_{MSY}) has exceeded F_{MSY} since the 1990s and estimated at 1.3 F_{MSY} in 2014. (Figure. 17.6.4 and 17.6.5). 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 26 ktons and 39 ktons (Table 17.6.3). 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 2016 are given in Table 17.6.5.

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. 17.6.6.-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 lead to an increase in stock size and annual catches of 15 kt or less will result in a 50% probability of reaching B_{MSY} within 10 years (Figure 17.6.6).

Scenarios of fixed levels of fishing mortality ratios within the range of 0.3 to 1.7 were conducted and are shown in Figure 17.6.8. Present biomass is above the MSY $B_{trigger}$ (50% of B_{MSY}) and a fishery at F_{MSY} is then advised according the ICES MSY approach. Fishing at F_{MSY} will result in catches of 22 kt in 2016 (Figure 15.6.8 panel D) and a stock size of 71% of B_{MSY} in 2016 (Table 17.6.5).

17.6.2 Short-term forecast and management options

Biomass scenarios at various catch options are provided in Table 17.6.5 and Figures 17.6.6-7. Catches below 30 kt is estimated to lead to an increase in biomass, while catches of 30 kt will remain biomass at current level over the next decade. Catches of 24 kt in 2017 will correspond to fishing at F_{MSY}. This will result in a slight increase in biomass and risk of exceeding F_{LIM} will remain unchanged from 2016 (Table 17.6.5). At catches of 24 kt the biomass is not expected to reach B_{MSY} within the next decade although biomass will increase over the period.

17.6.3 Reference points

Reference points were defined at the benchmark in 2013 (WKBUT) and further at WKMSYREF4 in 2015: B_{lim} as 30%B_{MSY} corresponding to production 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 F_{MSY} advice, was defined as 50%B_{MSY}. F_{lim} was defined as 1.7F_{MSY}.

17.7 Exploratory assessment: Gadget

An exploratory stock assessment for Greenland halibut in 5, 6, 12, and 14 using the Gadget modelling framework was presented at the NWWG-2016 meeting. Gadget can be viewed as a general framework for utilizing all available data and as such can detect inconsistencies in the data that are often ignored in other model types which are built on top of highly aggregated data and/or make stronger assumptions on the stock dynamics. In general the exploratory Gadget model did seem to capture the main trends in the data.

17.7.1 Input data

The data used in the model were sex and length dis-aggregated indices from the Icelandic and Greenland surveys (combined in one index). Length distributions from the Icelandic and Greenland trawler fleet. Data on sex-ratio from the Icelandic trawler fleet and preliminary length-at-age data from 5b in 2015 was used to estimate growth inside the model. Catches from Iceland, Greenland and the Faroe Islands are included in the model.

17.7.2 Model settings

The model time was 1980–2015, with recruitment estimated annually. Two stocks are defined in the model, females and males that have different growth rates. Recruitment to the two stocks is equal that is 50:50. Initial population sizes for the stock components were estimated at varying initial depletion to account for the different fishing pressure on the sexes.

In the model three fleets are defined, Icelandic, Greenland and Faroe Islands trawlers. The commercial fleet operations in 5a, 5b and 14b were implemented separately but had the same selection pattern. In the model, natural mortality is set at 0.1 for all ages. The age range in the model is from age 3 to 25 with 25 being a plus-group.

17.7.3 Likelihood components

The likelihood components in the assessment are listed in table 17.7.1. In all the model has 14 likelihood components but two of those are mainly for constraining the minimization routines (understocking and bounds).

Text Table: Components in Gadget model.

Component	Type	Notes
Comm.sex.ratio	stockdistribution	Sex ratio from Icelandic trawlers
ldist.f.survey	catchdistribution	Female length distribution from the combined survey
ldist.m.survey	catchdistribution	Male length distribution from the combined survey
comm.ldist	catchdistribution	Length distributions from the Icelandic trawl fleet
si.F.20-50	surveyindices	Female abundance survey index for length 20 to 50 cm
si.F.50-70	surveyindices	Female abundance survey index for length 50 to 60 and 60 to 70 cm
si.F.70-120	surveyindices	Female abundance survey index for length larger than 70 cm, split into 10 cm length bins
si.M.20-50	surveyindices	Male abundance survey index for length 20 to 50 cm
si.M.50-70	surveyindices	Male abundance survey index for length 50 to 60 and 60 to 70 cm
si.M.70-120	surveyindices	Male abundance survey index for length 70 to 80 and 80+
aldist.F.faroes	catchdistribution	Female age–length distribution from the Faroese trawl survey in 2015

aldist.M.faroes	catchdistribution	Male age–length distribution from the Faroese trawl survey in 2015
understocking	understocking	To constrain minimization so that the stock will always be larger than the catches
Bounds	bounds	To constrain minimization to respect the bounds of the parameters.

17.7.4 Fit to data

In general the model captures the changes in the length distributions from both from commercial catches and the survey. However the model has problems with estimating the proportions of males and females from commercial catches, where the proportion of large males in the catch is overestimated. The fit to the survey indices is mostly reasonable, the model following the main trends in them. Weights to individual likelihood components were assigned using an iterative reweighting heuristic described by Taylor *et. al* (2007).

17.7.5 Model estimates

Model estimates of spawning biomass, fishing mortality and recruitment are shown in figure 17.7.1. These biomass estimates follow similar patterns as expected, the spawning-stock biomass has been decreasing since 1985, to an all-time low in 2013. The recruitment indices, however, appear more sporadic which is believed, based on experience with similar models, to related to a lack of reliable information on age for at least three years. As noted by Taylor *et. al* (2007) this could result in a level change in the size of the biomass, hence reference points and assumptions on stock productivity could therefore change. As illustrated at WKBUT-2013, the range of SSB and harvestable biomass estimates differed considerably based on different assumption on growth, whereas the advice, based on F0.1, varied between 18 to 30 kt for 2014 with a base case advice around 20 kt.

Figure 17.7.2 illustrates the equilibrium catch and spawning-stock biomass as a function of harvest rate estimated using stochastic forward simulations. In the simulations the F_{msy} was estimated at 0.27, which was associated with the fishing mortality that has less 5% chance of going below B_{lim}, B_{lim} set as the estimate of the lowest spawning-stock biomass. For reference the harvest rates associated with $F_{0.1}$, F_{pa}, F_{MSY} and F_{max} are also illustrated on the figure. If the advice for 2016–2017 fishing year, set according to F_{MSY}, would be 21.5 kt as illustrated in figure 17.7.1

17.7.6 Future work

The model will need more work to be usable as basis for assessment. Main issues to explore at present is the length aggregation of the survey indices, for example it may be more prudent to have only one index for males and one for females rather than the 6 currently used for tuning the model. Work on aging is planned in Iceland-based on the Norwegian method for age determination. When this gets started and a few years of ageing data become available it is expected that the model will be more stable as was the case for tusk and ling in 5a (assessed in WGDEEP). Estimates of uncertainty were not presented based on the current model at the meeting due to time constraints.

17.8 Management Considerations

Available biological information and information on distribution of the fisheries suggest that Greenland halibut in East Greenland, Iceland and Faroe Islands belong to the same entity and do mix. Recent information of tagging experiments in the Barents Sea suggests high mixing between the Barents Sea and Iceland. This connectivity is not accommodated for in the present assessment.

In 2012 the coastal states initiated work on a common management plan for Greenland halibut. The aim was to have a common management plan to be implemented in 2015.

17.9 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 accommodate contrasting indices (Icelandic cpue and Greenlandic/Icelandic autumn surveys).

17.10A number of issues on data and assessment quality are addressed in section 17.10.Proposals and recommendations

Stock structure and connectivity between the main fishing areas remains partly unknown. Basic biological information on spawning and nursery grounds for the juveniles also remains poorly known. Biomass indices over the entire assessment area are not similar to respect to trend over time and may suggest different dynamics between areas. Further, recent tagging experiments in the Barents Sea suggest a high connectivity with Iceland waters. Therefore a compilation of present knowledge of stock identification for Greenland halibut in the East Greenland, Iceland, Faroese and Norwegian waters should be made in order to review whether present stock areas are appropriate to assessment purposes. Such a compilation should be evaluated outside NWWG, e.g. by WGSIM.

A number of issues on the quality of the input biomass indices to the present assessment model are questioned. The Icelandic cpue series that is based on the principal trawler fleet is assumed to have undergone marked changes with respect to management regulations and spatial distribution. The possibility to estimate these effects by standardization of catch rates should be explored. Similar analyses should be conducted on the remaining cpue series, in order to evaluate them as indicative of biomass development.

The present assessment model, a stock production model in Bayesian framework, is criticized for its behavior in relation to the biomass indices. The models use of process error and sensitivity to various priors should be further scrutinized. A generic review of the model's performance could be by WGMG.

At the benchmark in 2013 (WKBUT) an alternative assessment model, Gadget, was presented. The group encouraged this model to be fully developed in order to replace the stock production model. Currently the Gadget model is not fully developed and several issues need further exploration (see section 17.7) and especially age data from the stock is required.

Ageing of Greenland halibut ceased for many of the marine institutes in Greenland, Iceland, Faroe Island and Norway around 2000 due to reading difficulties and lack of calibration. However, IMR in Norway have now developed a promising method to age

Greenland halibut and an ageing workshop is scheduled in August 2016 (WKAGE???). With the aim to revert to an age based assessment, it is suggested that cooperation between institutes is initiated and an inter calibration protocol is established. This task is a major task since a number of sampled otoliths back in time have to be read, and the time horizon for this project is therefore expected to exceed the near future. It is foreseen that the stock will be benchmarked in within the next years addressing the above issues.

17.11 References

Sünksen,K. 2007. Bycatch in the fishery for Greenland halibut. WD 17, NWWG 2007.

Taylor L, Begley J, Kupca V, Stefansson G. 2007. A simple implementation of the statistical modelling framework Gadget for cod in Icelandic waters. African Journal of Marine Science 29: 223–245.

17.12 Tables

Table 17.2.1 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Sub-areas V, VI, XII and XIV , 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	20,703	22,874	27,102	24,978	21,466	21,873

Country	2008 [1]	2009 [1]	2010 [1]	2011 [1]	2012 [1]	2013 [1]	2014 [1]	2015 [1]
Estonia	-	-	-	-	-	-	429	-
Faroe Islands	-	270	1,408	1,705	2,811	2,788	3,392	3,214
France	114	-	-	9	67	133	-	117
Germany	4,846	427	5,287	5,782	4,620	3,814	3,701	3,808
Greenland	-	2,819	-	3,415	5,239	3,251	1,897	3,642
Iceland	-	-	13,293	13,192	13,749	14,859	9,861	12,400 [2]
Ireland	-	-	-	-	-	-	-	-
Lithuania	566		-	-	97	-	-	-
Norway	639	124	233	176	856	614	764	1,126
Poland	1,354	988	960	-	786	-	-	-
Portugal	-	-	-	-	-	-	-	-
Russia	799	762	1,070	1,095	1,168	1,369	587	600
Spain	-	-	-	-	-	-	-	110
United Kingdom	422	581	577	323	12	95	2	127
Total	9,744	5,974	22,901	25,618	29,405	26,923	20,633	25,145 [2]
Working Group estimate	15,379	28,197	25,995	26,347			21,069	25,677

1) Provisional data

2) Iceland has no official reportings in 2015

Table 17.2.2 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Division Va, 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
UK (E/W/I)	26	73	50	21	16	8	8	1	
UK Scotland	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 [1]	2013 [1]	2014 [1]	2015 [1]
Faroe Islands			37	123	585	103	30	18
Germany	4	423	797	576	269	386	587	265
Greenland				157		92		1
Iceland			13,293	13,192	6,459	14,859	9,859	12,309
Norway								
Russia	4							
Poland		270						
UK	179							
Total	187	693	14,128	14,048	7,313	15,440	10,476	12,593
Working Group estimate	11,859	15,782	14,128	14,048	7,313	15,440	10,476	12,593

1) Provisional data

2) Includes 223 t catch by Norway.

Table 17.2.3 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Division Vb 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	4,750	3,660
France	...	...	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	3,825
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	1,116
France		1	32	4	8	17		40	9
Germany	22								
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	1,060

Country	2008	2009	2010	2011	2012	2013	2014	2015
Denmark								
Faroe Islands			1,037	1,476	2,149	2,560	2,953	3,139
France	36		35	1	13	20		28
Germany								
Iceland								45
Ireland								
Norway	1	1	5				3	10
United Kingdom	32	117	336	11		2	2	9
Total	69	118	1,413	1,489	2,162	2,582	2,958	3,231
Working Group estimate	1,759	1,739	1,413	1,489	2,162	2,582	2,958	3,231

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 17.2.4 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Sub-area XIV 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	5,940
Working Group estimate	736 [2]	875 [3]	1,176 [4]	2,249 [5]	3,125 [6]	5,077 [7]	7,283	8,558	

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	3,047	3,243	2,750	2,019	2,925	5,159	5,144	4,298	4,702
Greenland	200 [1,4]	1,740	1,553	1,887	1,459				
Iceland	93	30	14,280	16,947	6				
Ireland			7						
Norway	1,100	1,161	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	4,806	6,627	20,316	22,889	8,720	11,991	6,515	7,013	5,202
Working Group estimate	0	6958	0 [6]	0 [6]	0	9,854	10,185	8,589	10,261

Country	2008 [1]	2009 [1]	2010 [1]	2011 [1]	2012 [1]	2013 [1]	2014 [1]	2015 [1]
Estonia							429	
Faroe Islands		270	333		77	125	409	57
Germany	4,842	4	4,490	5,206	4,351	3,428	3,114	3,543
Greenland		2,819		3,258	5,239	3,159	1,897	3,641
Iceland					7,290		3	46
Ireland								
Norway	637	29	226	164	853	613	761	1,115
Poland	1,354	718	960		786			
Portugal								
Russia	763		1,070	1,095	1,168	1,369	587	600
Spain								
United Kingdom	131	452	229	309	1	1		
Total	7,727	4,292	7,308	10,032	19,765	8,694	7,200	9,002
Working Group estimate	0	9,805	10,402	10,761			7,526	9,534

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 17.2.5 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

Country	2014 [1]	2015 [1]
Faroe Islands		
France		
Ireland		
Lithuania		
Poland		
Spain [2]	67	91
UK		
Russia		
Norway		
Estonia		
Total	67	91
WG estimate	67	91

[1] Provisional data

[2] Based on estimates by observers onboard vessels

Table 17.2.6 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

Country	2014 [1]	2015 [1]
Estonia		
Faroe Islands	1	
France		89
Poland		
Spain [2]		18
UK	42	119
Russia		
Norway	0	1
Lithuania		
Total	43	227
WG estimate	43	227

[1] Provisional data

[2] Based on estimates by observers onboard vessels

Table 17.3.1. Cpue indices of trawl fleets in Divisions 5a, 5b and 14b As Derived from Glm

MULTIPLICATIVE MODELS.

Area	Year	Cpue	% Change In Cpue Between Years	Land-ings	Rela-tive De-rived Effort	Relative Derived Effort	% Change In Effort Between Years
Iceland 5a	1985	1.00		29,197	29	100	
	1986	0.99	-1	31,027	31	107	7
	1987	0.96	-3	44,659	47	149	38
	1988	0.91	-5	49,379	54	117	-21
	1989	0.79	-13	59,272	75	138	18
	1990	0.75	-5	37,308	50	66	-52
	1991	0.73	-2	35,413	48	97	47
	1992	0.67	-9	31,978	48	100	2
	1993	0.53	-20	34,134	64	133	33
	1994	0.44	-18	28,608	65	102	-23
	1995	0.36	-19	27,391	77	118	15
	1996	0.30	-15	22,073	73	94	-20
	1997	0.32	5	16,792	53	72	-24
	1998	0.50	57	10,595	21	40	-44
	1999	0.55	9	11,138	20	96	139
	2000	0.59	7	14,607	25	122	27
	2001	0.59	1	16,752	28	113	-8
	2002	0.48	-20	19,714	41	147	29
	2003	0.35	-26	20,415	58	139	-5
	2004	0.30	-16	15,477	52	90	-35
	2005	0.27	-8	13,172	48	92	2
	2006	0.37	33	11,817	32	67	-27
	2007	0.46	25	10,525	23	71	6
	2008	0.40	-13	9,580	24	105	48
	2009	0.41	4	15,782	38	158	50
	2010	0.41	-1	13,565	33	87	-45
	2011	0.43	4	14,048	33	99	15
	2012	0.44	3	7,312	17	51	-49
	2013	0.45	2	15,439	35	208	309
	2014	0.41	-7	10,475	25	73	-65
	2015	0.45	8	12,593	28	112	53
Greenland, 14b	1991	1.00		875	1	100	0
	1992	0.92	-8	1,176	1	147	47
	1993	2.48	171	2,249	1	71	-52
	1994	3.19	29	3,125	1	108	53
	1995	3.26	2	5,077	2	159	47
	1996	3.24	-1	7,283	2	144	-9
	1997	3.35	3	8,558	3	114	-21

MULTIPLICATIVE MODELS.

Area	Year	Cpue	% Change In Cpue Between Years	Land-ings	Rela-tive De-rived Effort	Relative Derived Effort	% Change In Effort Between Years
	1998	3.28	-2	5,940	2	71	-38
	1999	2.29	-30	5,376	2	130	83
	2000	2.11	-8	6,958	3	141	9
	2001	2.19	4	7,216	3	100	-29
	2002	2.38	9	6,621	3	85	-15
	2003	2.33	-2	8,017	3	124	46
	2004	2.27	-2	9,854	4	126	2
	2005	3.14	38	10,185	3	75	-41
	2006	3.24	3	8590	3	82	9
	2007	3.07	-5	10261	3	126	54
	2008	3.11	1	8,952	3	86	-32
	2009	2.58	-17	10,567	4	143	66
	2010	2.70	5	10,402	4	94	-34
	2011	2.66	-2	10,761	4	105	12
	2012	3.14	18	12,475	4	98	-7
	2013	2.91	-7	12,476	4	108	10
	2014	3.09	6	7,526	2	57	-47
	2015	3.50	13	9,534	3	112	97
Faroe Islands, 5b	1991	1.00		1,662	2	100	34
	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	10	107	0
	2009	0.21	26	1760	8	87	-19
	2010	0.17	-21	1,413	8	98	13
	2011	0.31	65	1,489	5	59	-40
	2012	0.30	-4	2,163	7	148	153

MULTIPLICATIVE MODELS.

Area	Year	Cpue	% Change In Cpue Between Years	Land-ings	Rela-tive De-rived Effort	Relative Derived Effort	% Change In Effort Between Years
	2013	NA		2,560			
	2014	NA		2,958			
	2015	NA		3,139			

Table 17.6.1. Assessment input dataseries: 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	1.76	-
1986	32.984	1.74	-
1987	46.622	1.69	-
1988	51.118	1.60	-
1989	61.396	1.85	-
1990	39.326	1.32	-
1991	37.950	1.29	-
1992	35.487	1.17	-
1993	41.247	0.94	-
1994	37.190	0.77	-
1995	36.288	0.63	-
1996	35.932	0.53	66
1997	30.309	0.56	90
1998	20.382	0.88	91
1999	20.371	0.96	90
2000	26.644	1.03	101
2001	27.291	1.04	110
2002	29.158	0.84	84
2003	30.891	0.62	52
2004	27.102	0.52	36
2005	24.249	0.48	56
2006	21.432	0.64	39
2007	20.957	0.80	50
2008	22.169	0.70	58
2009	27.349	0.73	80
2010	25.995	0.72	59
2011	26.424	0.75	71
2012	29.309	0.77	82
2013	27.045	0.79	85
2014	21.069	0.73	75
2015	25.677	0.78	80
2016*	25.000		

*estimated

Table 17.6.2. 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 17.6.3. 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)	33.71	11.82	26.63	33.01	39.81
K (ktons)	893	272	701	878	1072
r	0.17	0.08	0.11	0.16	0.21
q_{cpue}	0.003	0.001	0.002	0.003	0.003
q_{Survey}	0.27	0.12	0.19	0.24	0.31
P_{1985}	1.57	0.13	1.48	1.57	1.66
P_{2016}	0.72	0.11	0.65	0.71	0.79
σ_{cpue}	0.10	0.02	0.08	0.09	0.11
σ_{Survey}	0.18	0.03	0.16	0.18	0.20
σ_P	0.16	0.03	0.14	0.16	0.18

Table 17.6.4. 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
1985	-1.73	0.55	-	-
1986	-0.67	0.52	-	-
1987	0.31	0.49	-	-
1988	2.43	0.42	-	-
1989	-8.26	0.75	-	-
1990	3.38	0.39	-	-
1991	-1.53	0.55	-	-
1992	-2.95	0.59	-	-
1993	0.21	0.49	-	-
1994	0.74	0.48	-	-
1995	3.81	0.38	-	-
1996	12.17	0.16	-14.16	0.76
1997	16.11	0.10	-35.72	0.96
1998	-3.39	0.62	-11.09	0.71
1999	-1.43	0.55	0.62	0.49
2000	-1.26	0.54	-3.68	0.58
2001	-2.95	0.60	-12.93	0.75
2002	-1.51	0.55	-5.90	0.62
2003	-0.04	0.50	13.18	0.25
2004	-1.59	0.55	30.79	0.06
2005	7.34	0.27	-12.45	0.74
2006	-9.44	0.78	35.77	0.04
2007	-14.73	0.88	27.99	0.08
2008	-1.42	0.54	12.96	0.25
2009	0.64	0.48	-12.90	0.75
2010	-1.33	0.54	14.24	0.23
2011	-0.30	0.51	0.87	0.48
2012	1.86	0.44	-8.90	0.68
2013	0.70	0.48	-10.88	0.71
2014	3.66	0.38	-3.37	0.57
2015	1.33	0.46	-5.62	0.61

Table 17.6.5. Upper: stock status for 2015 and predicted to the end of 2016. Lower: predictions for 2017 with catch options from 0–30 ktons and the catch option corresponding to F_{MSY}.

Status	2015	2016 *
Risk of falling below $B_{msy\_trigger}$	0%	0%
Risk of falling below B_{MSY}	100%	93%
Risk of exceeding F_{MSY}	43%	56%
Risk of exceeding F_{lim} (1.7F_{MSY})	9%	15%
Stock size (B/Bmsy), median	0.71	0.73
Fishing mortality (F/Fmsy),	1.10	1.06
Productivity (% of MSY)	92%	92%

*Predicted catch in 2016 = 25ktons

Catch option 2017 (ktons)	0	5	10	15	20	24	30
Prob. of falling belowB_{LIM}	0%	0%	0%	0%	0%	0%	0%
Risk of falling below B_{MSY}	81%	82%	84%	85%	86%	86%	88%
Risk of exceeding F_{MSY}	-	1%	5%	16%	34%	**50%**	71%
Risk of exceeding F_{lim} (1.7F_{MSY})	-	0%	2%	4%	9%	15%	27%
Stock size (B/Bmsy), median	0.80	0.78	0.77	0.76	0.75	0.75	0.73
Fishing mortality (F/Fmsy),	-	0.20	0.40	0.61	0.82	0.99	1.27
Productivity (% of MSY)	96%	95%	95%	94%	94%	94%	93%

17.13 Figures

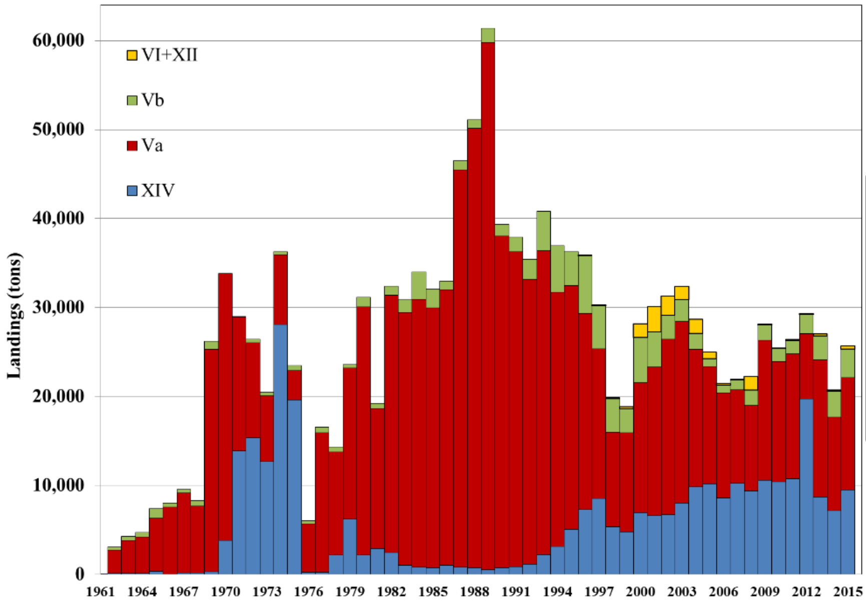


Figure 17.2.1. Landings of Greenland halibut in Divisions 5, 12 and 14. As the landings within Icelandic waters, since 1976, have not officially been separated and reported according to the defined ICES statistical areas, they are set under area 5a by the North Western Working Group. In 2012 Icelandic landings in 14 were partly recorded in 14, while for remaining years all landings are recorded in 5a.

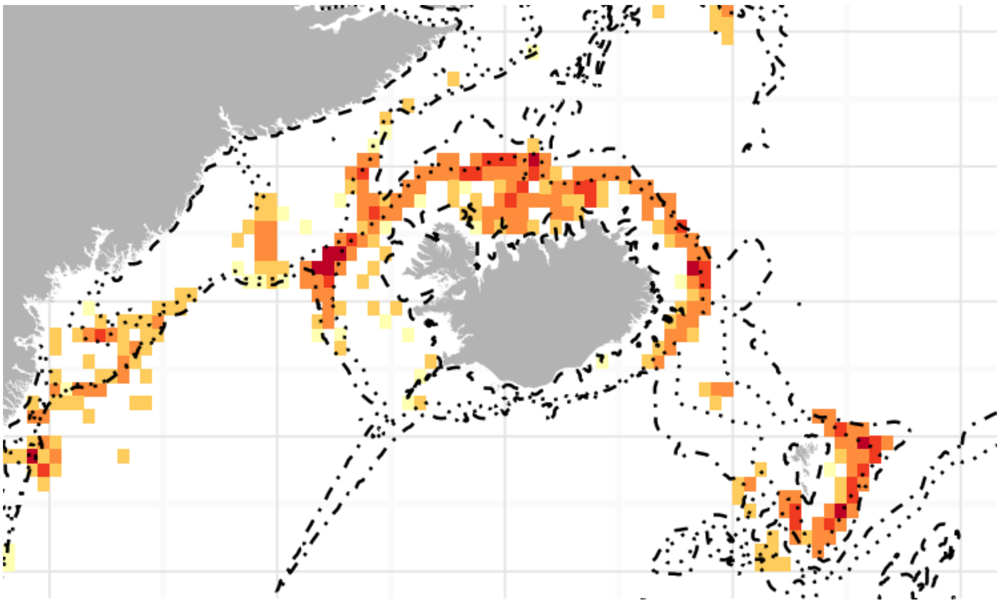


Figure 17.2.2 Greenland halibut 5+14. Distribution of fishing effort in 2015. 500m and 1000 m depth contours are shown.

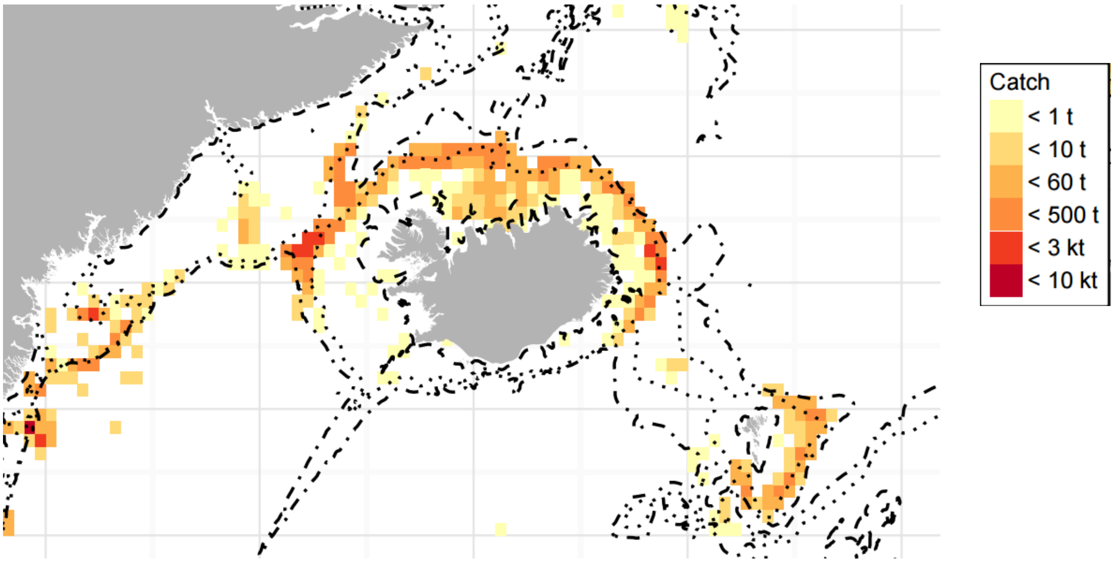


Figure 17.2.3. Greenland halibut 5+14. Distribution of catches in the fishery in 2015. 500m and 1000 m depth contours are shown.

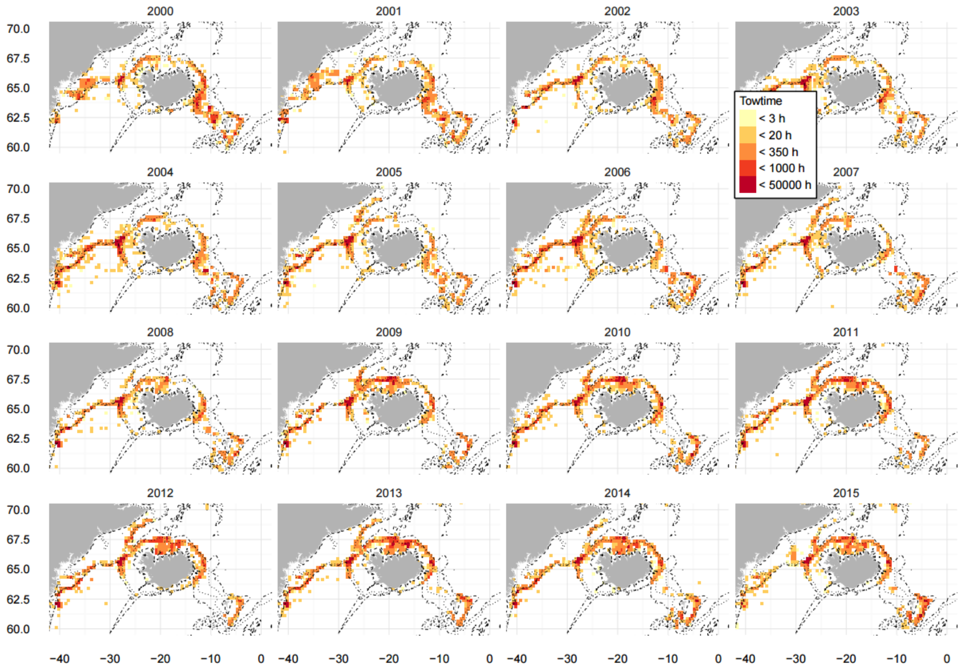


Figure 17.2.4. Greenland halibut 5+14. Distribution of total fishing effort 2000–2015. The 500m and 1000 m depth contours are shown.

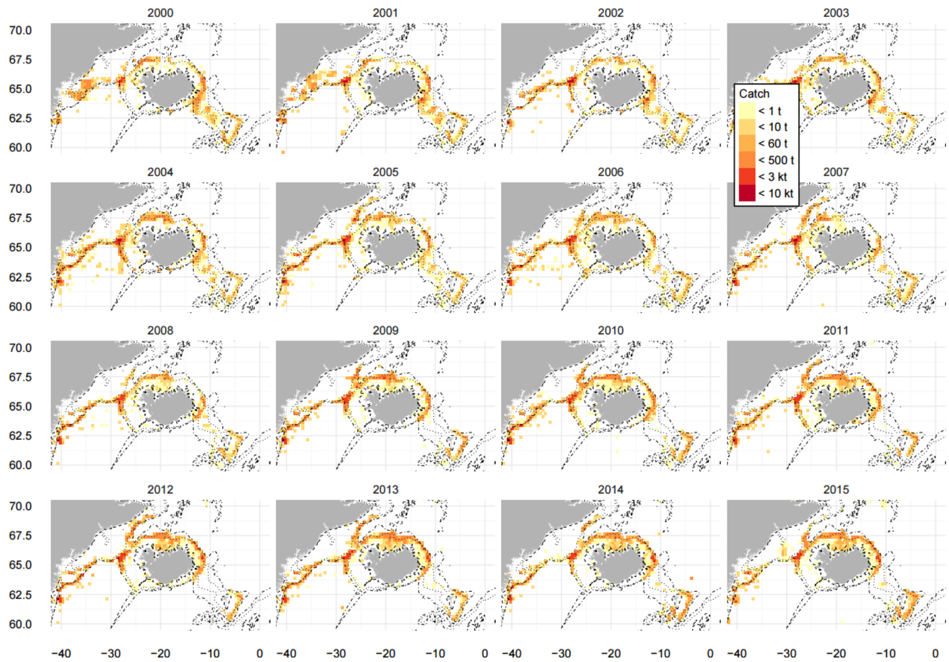


Figure 17.2.5. Greenland halibut 5+14. Distribution of total catches in the fishery 2000–2015 500m and 1000 m depth contours are shown.

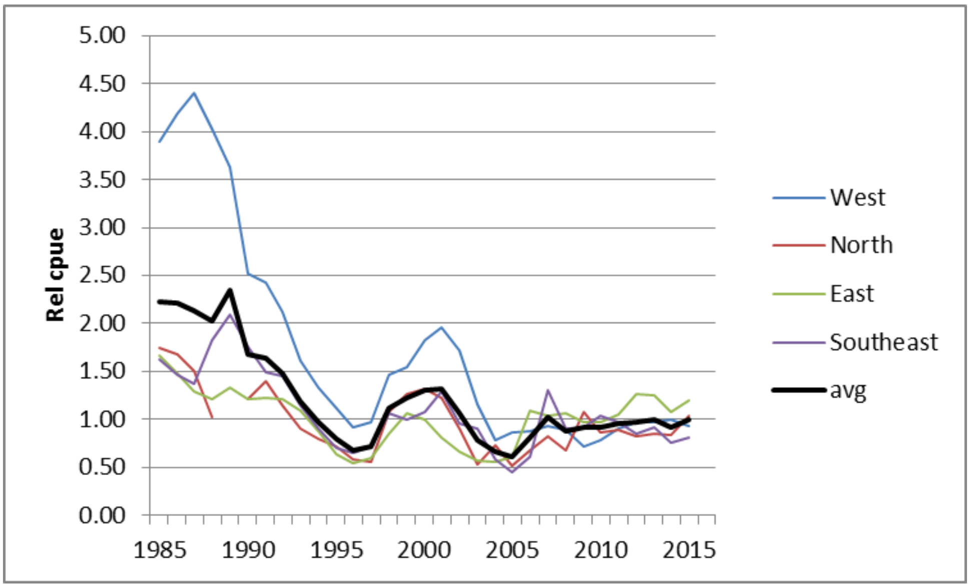


Figure 17.3.1. Standardized cpues from the Icelandic trawler fleet in Va. Area 1–4 are west, north, east and southeast. The average index of the four areas are used as biomass indicator in the stock production model.

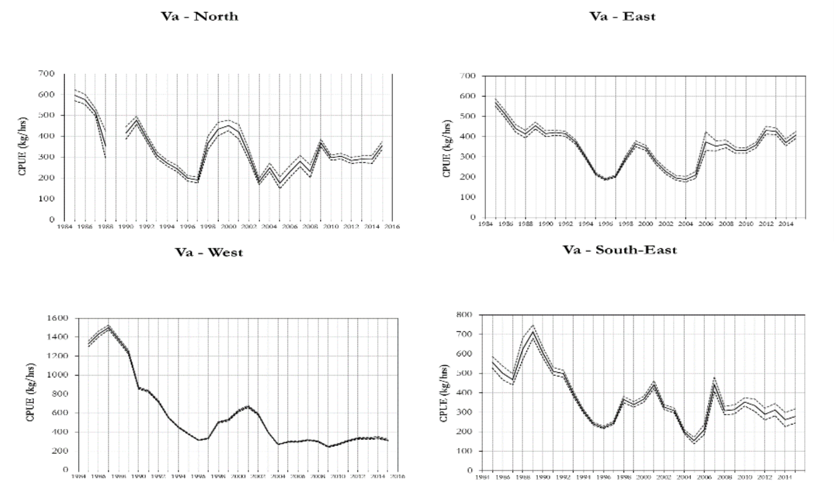


Figure 17.3.2 Standardized cpue from the Icelandic trawler fleet in 5a by four main fishing areas in Va. 95% CI indicated.

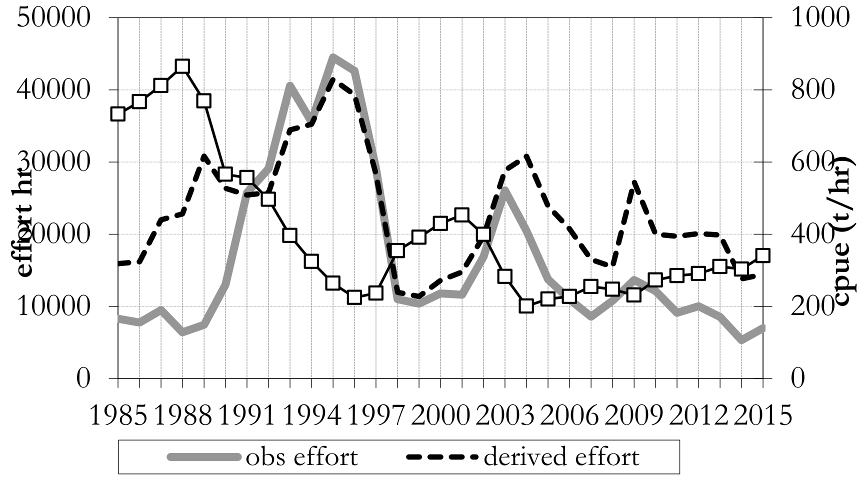


Figure 17.3.3. Standardized cpue, observed and derived effort from Icelandic trawl fishery.

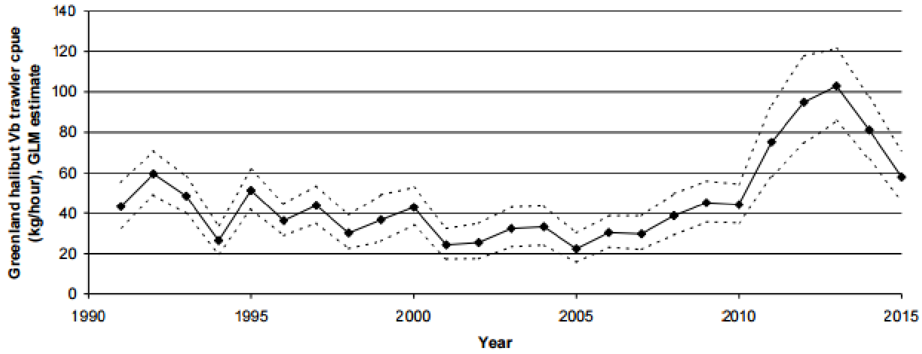


Figure 17. 3.4. Standardized cpue from the Faroese trawler fleet. 95% CI indicated

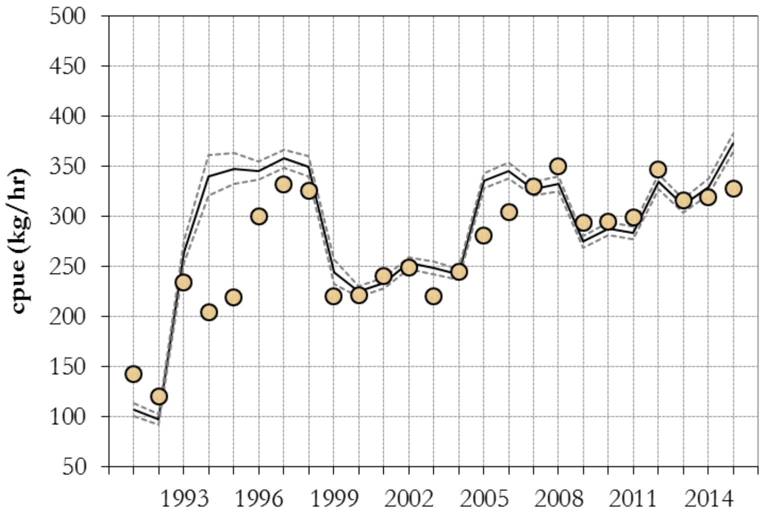


Figure 17.3.5. Standardized cpue from trawler fleets in 14b. 95% CI indicated. Points are raw observations.

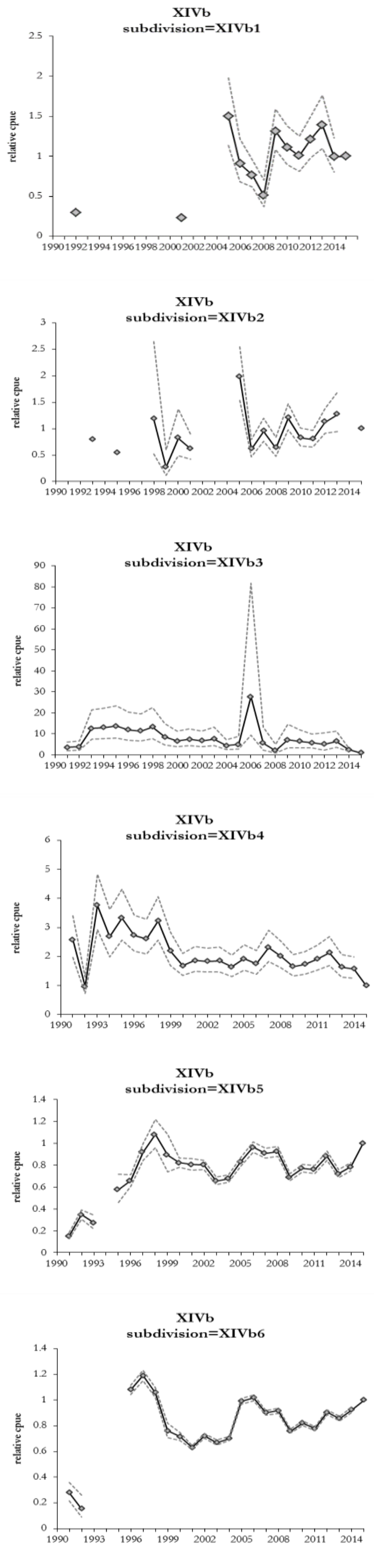


Figure 17.3.6. Standardized cpue from trawler fleets in 14b shown by subdivisions in 14b in a north–south direction. 95% CI indicated.

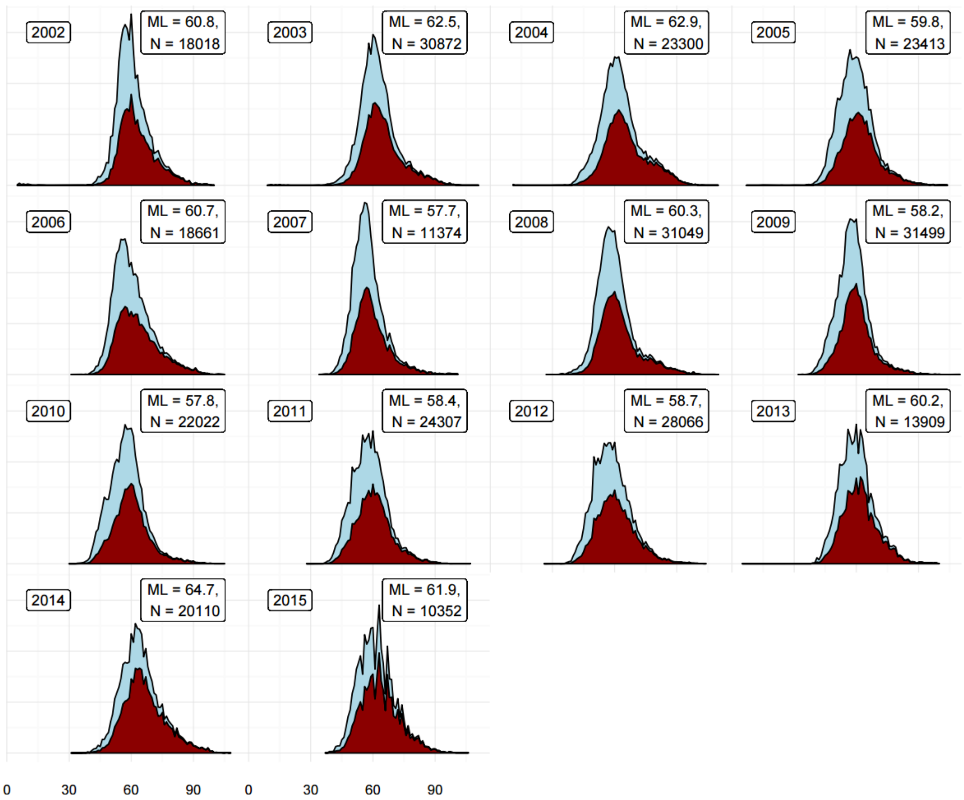


Figure 17.4.1. Length distributions from the commercial trawl fishery in the western fishing grounds of Iceland (5a) in the years 2002–2015. Blue indicate males and red indicates females.

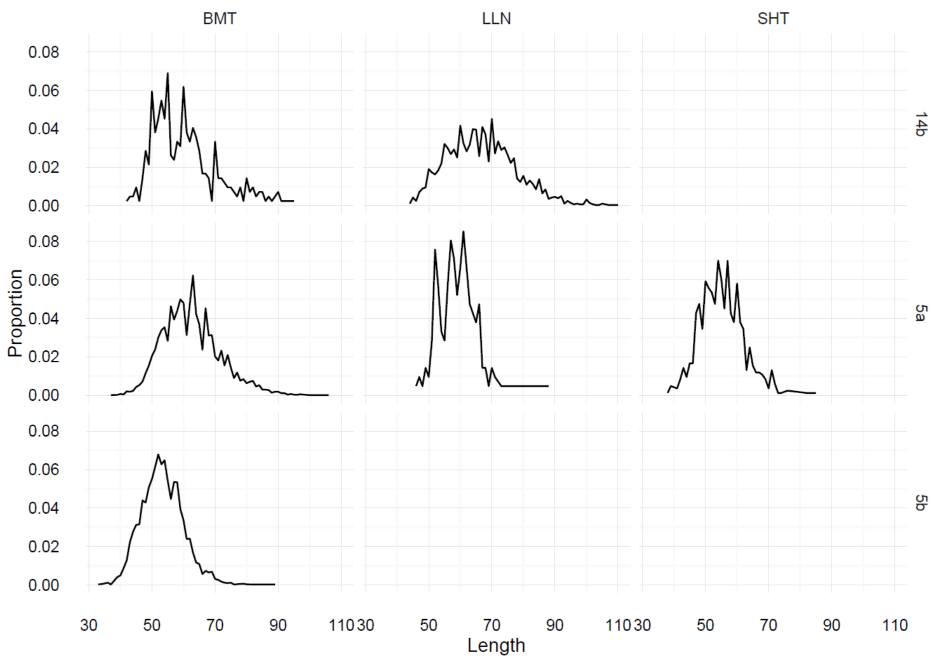


Figure 17.4.2. Length distributions from the commercial fishery in Subareas 5 and 14 by gear (BMT=bottom trawl, LLN=longlines, SHT=shrimp trawl).

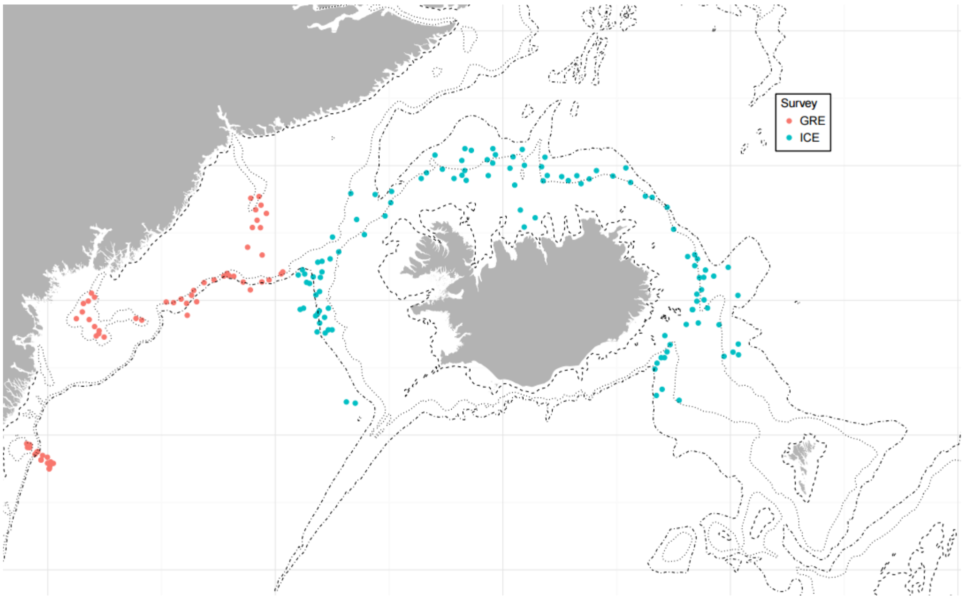


Figure 17.5.1. Stations covered by scientific surveys in 14+5 indicated as station positions in 2015 by the Greenland (n=76) and Iceland (n=203).

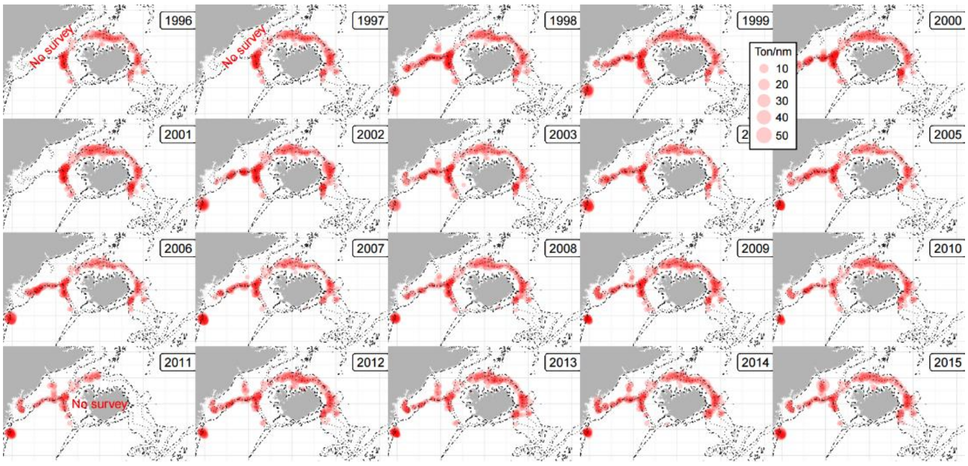


Figure 17.5.2. Distribution of Greenland halibut catch rates from the combined Greenland–Icelandic fall survey since 1996.

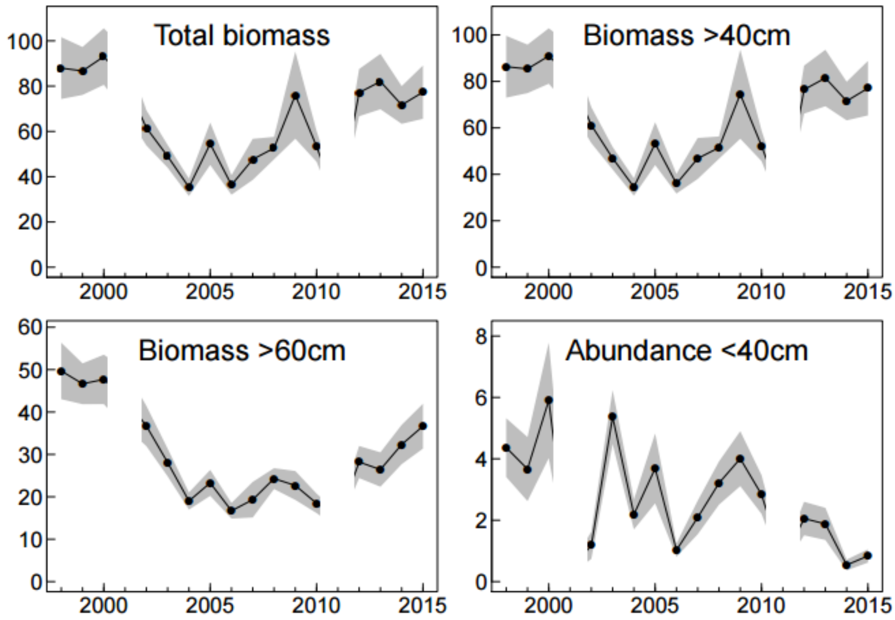


Figure 17.5.3. Greenland halibut in Icelandic fall groundfish survey. No survey was conducted in 2011.

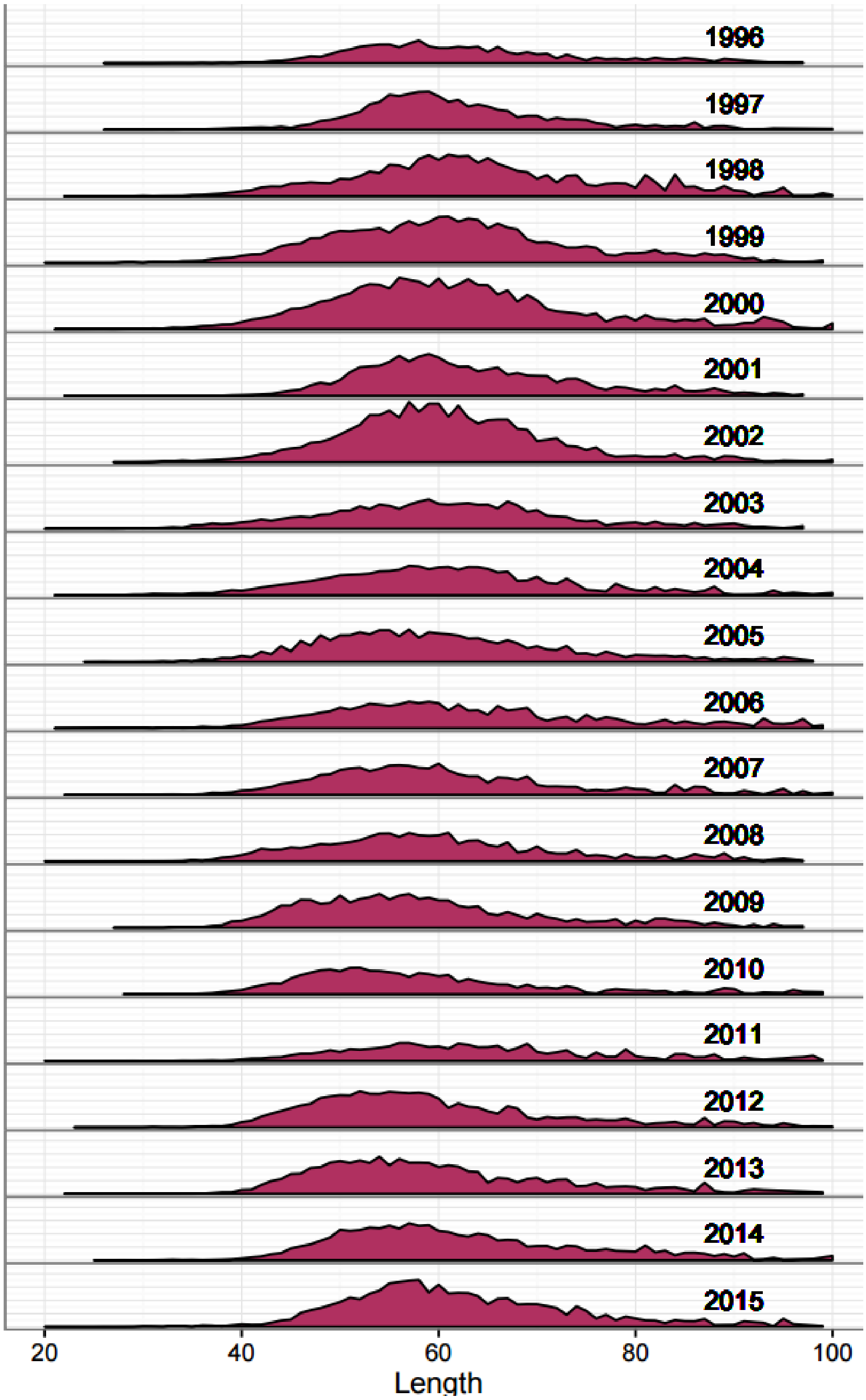


Figure 17.5.4. Abundance indices by length for the Icelandic fall survey 1996–2015. No survey was conducted in 2011.

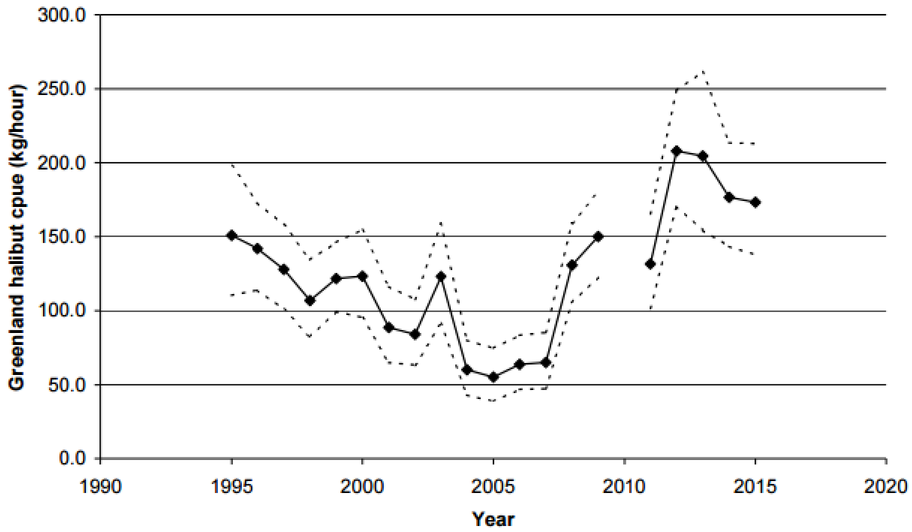


Figure 17.5.5. Catch rates from a combined survey/fisher's survey in 5b. Estimates are from a GLM model.

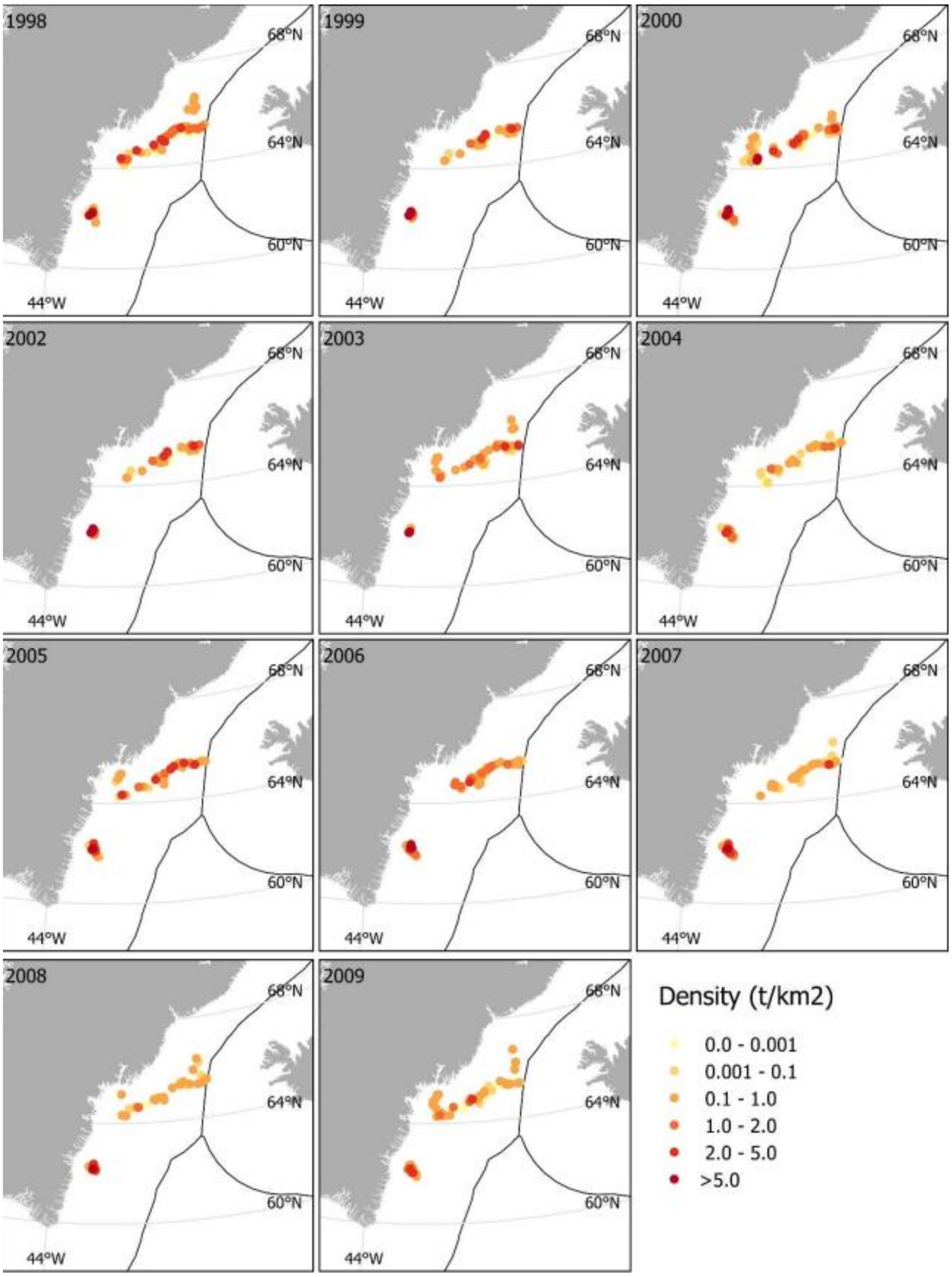


Figure 17.5.6. Distribution of catches of Greenland halibut at East Greenland in 1998–2009 in the Greenland deep-water survey.

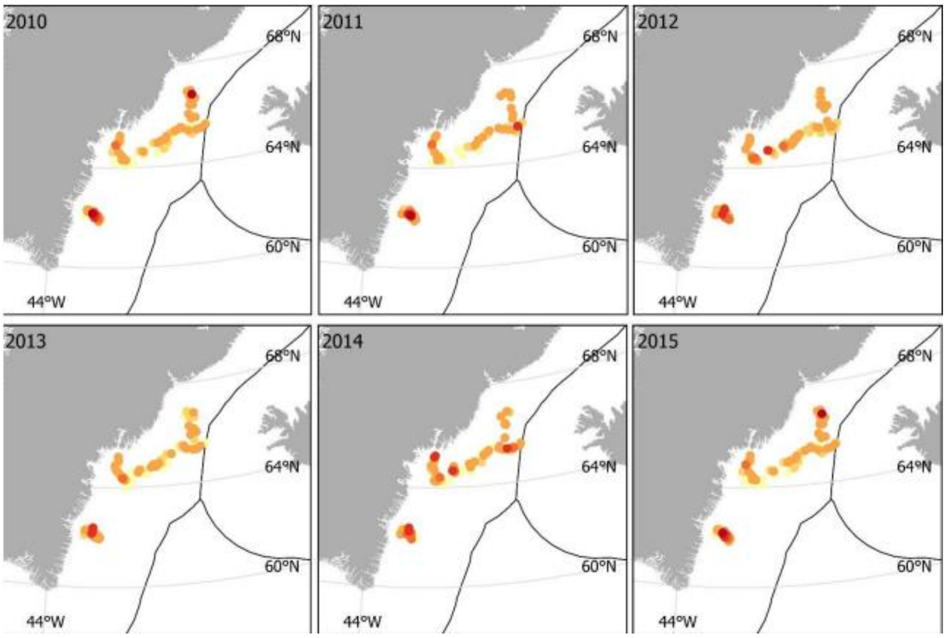


Figure 17.5.6 continued. Distribution of catches of Greenland halibut at East Greenland in 2010 – 2015 in the Greenland deep-water survey.

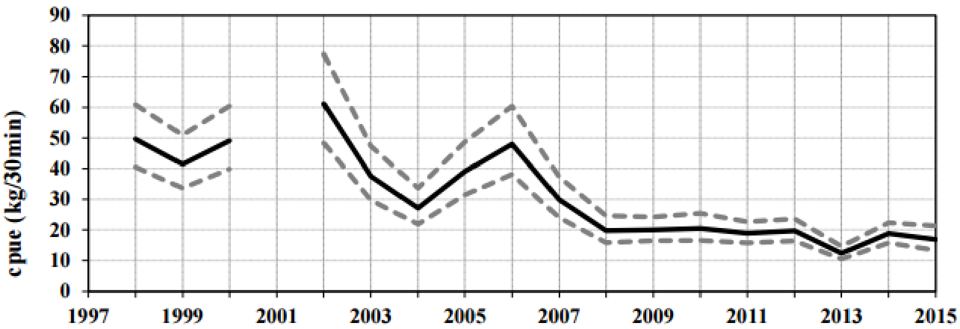


Figure 17.5.7. Standardized catch rates from the Greenland survey.(95% CI indicated.)

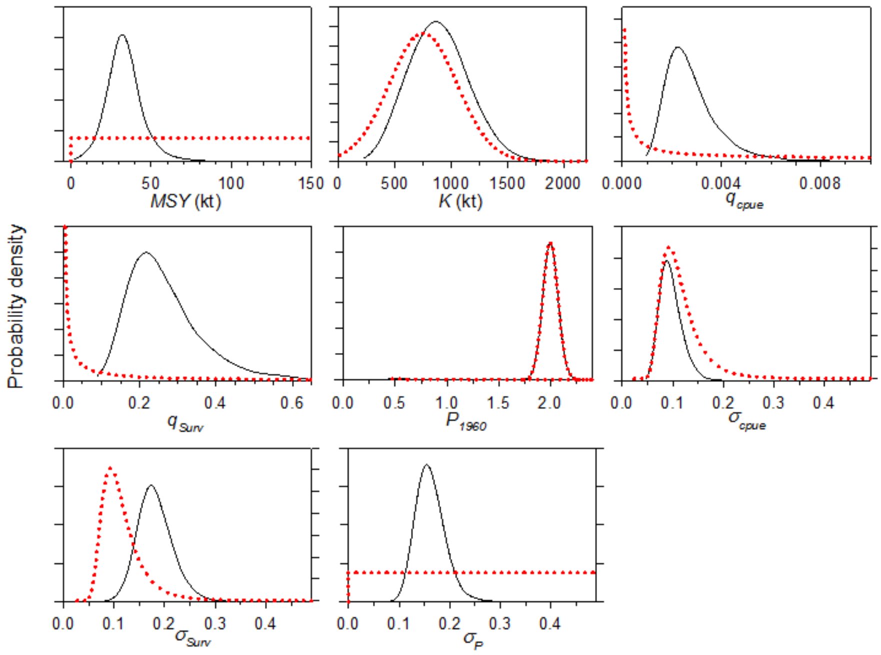


Figure 17.6.1. Probability density distributions of model parameters: estimated posterior (solid line) and prior (broken line) distributions

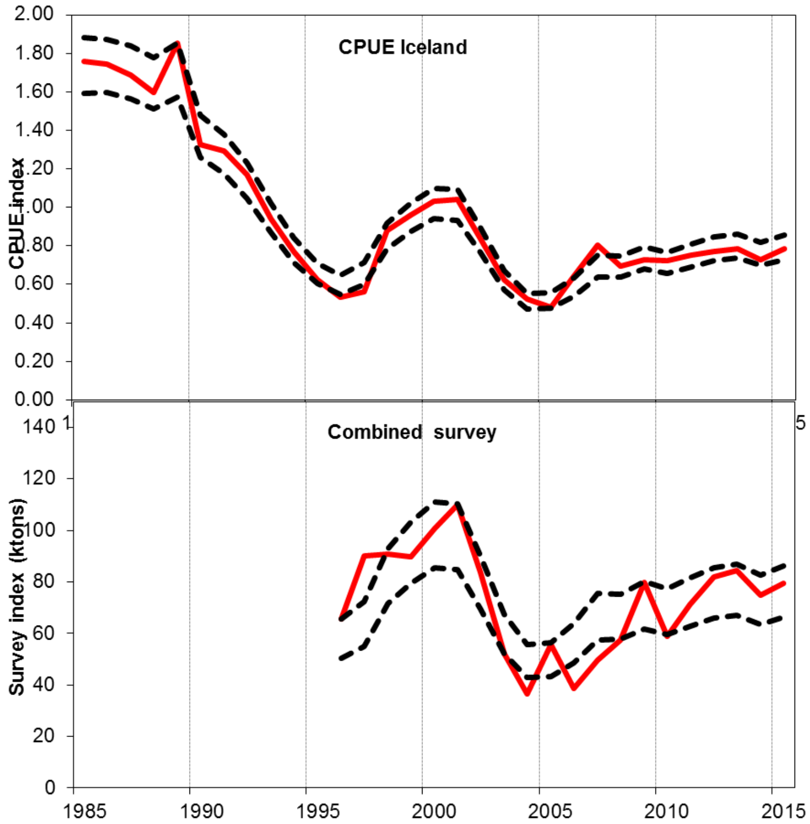


Figure 17.6.2. Observed (red curve) and predicted (dashed lines) series of the two biomass indices input to the model. Dashed lines are inter-quartile range of the posteriors.

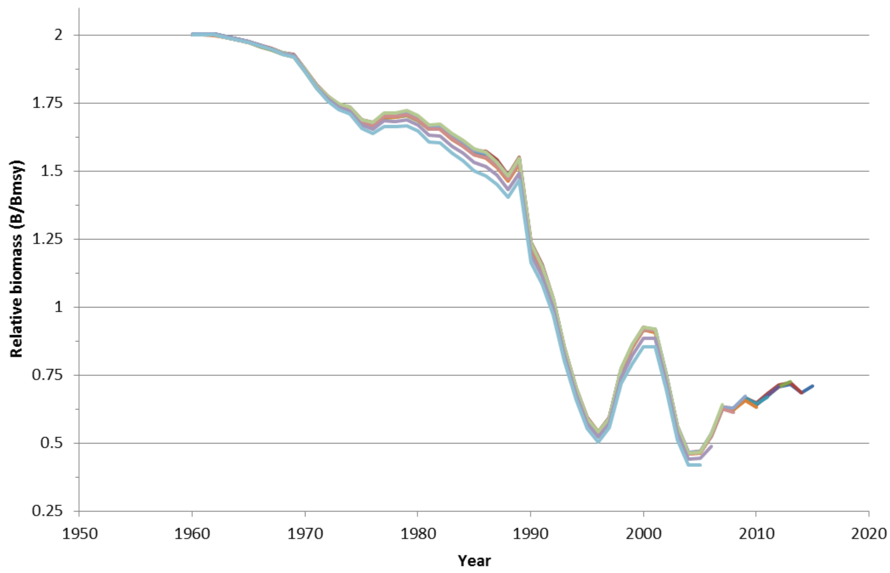


Figure 17.6.3. Retrospective plot of median relative biomass (B/B_{msy}).

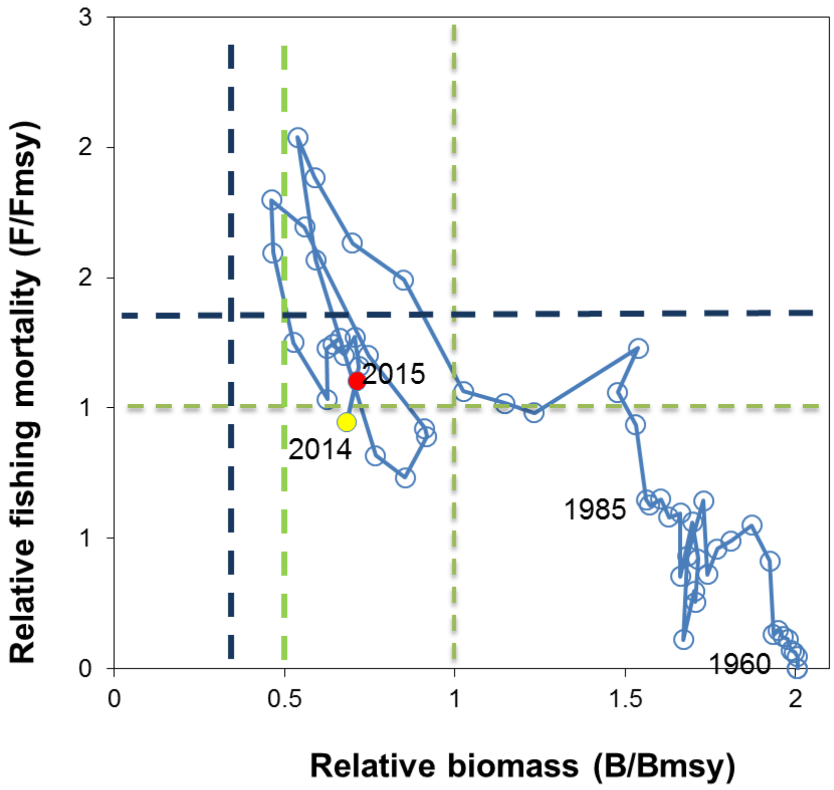


Figure 17.6.4. Stock trajectory. Estimated annual median biomass-ratio (B/B_{MSY}) and fishing mortality-ratio (F/F_{MSY}). B_{lim}, MSY $B_{trigger}$ and F_{lim} are indicated.

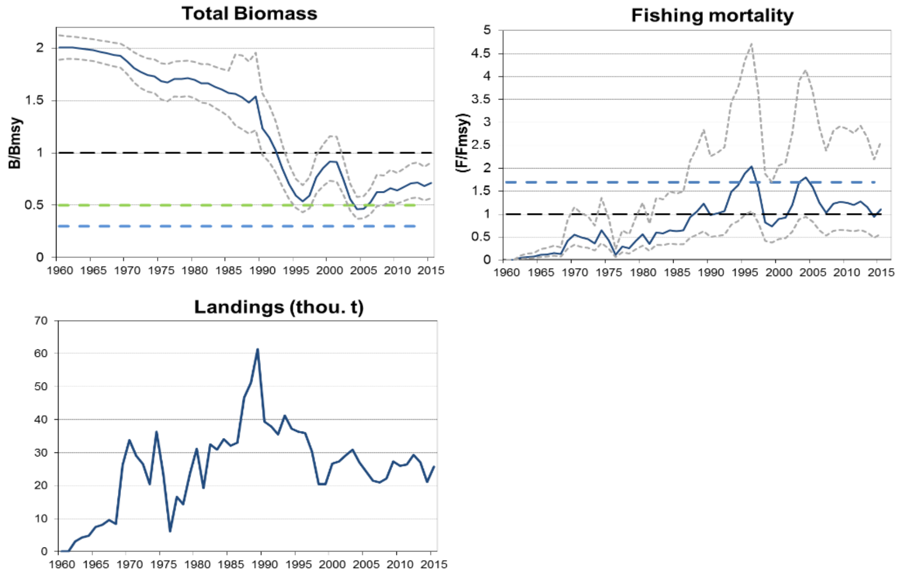


Figure 17.6.5. Stock summary, upper panel right: fishing mortality (F/F_{MSY}) and 95% conf limits, left: total biomass (B/B_{MSY}) and 95% conf limits and lower panel is landings since start of the fishery. MSY $B_{trigger}$ (green dashed line), B_{lim} and F_{lim} (blue dashed lines) are indicated.

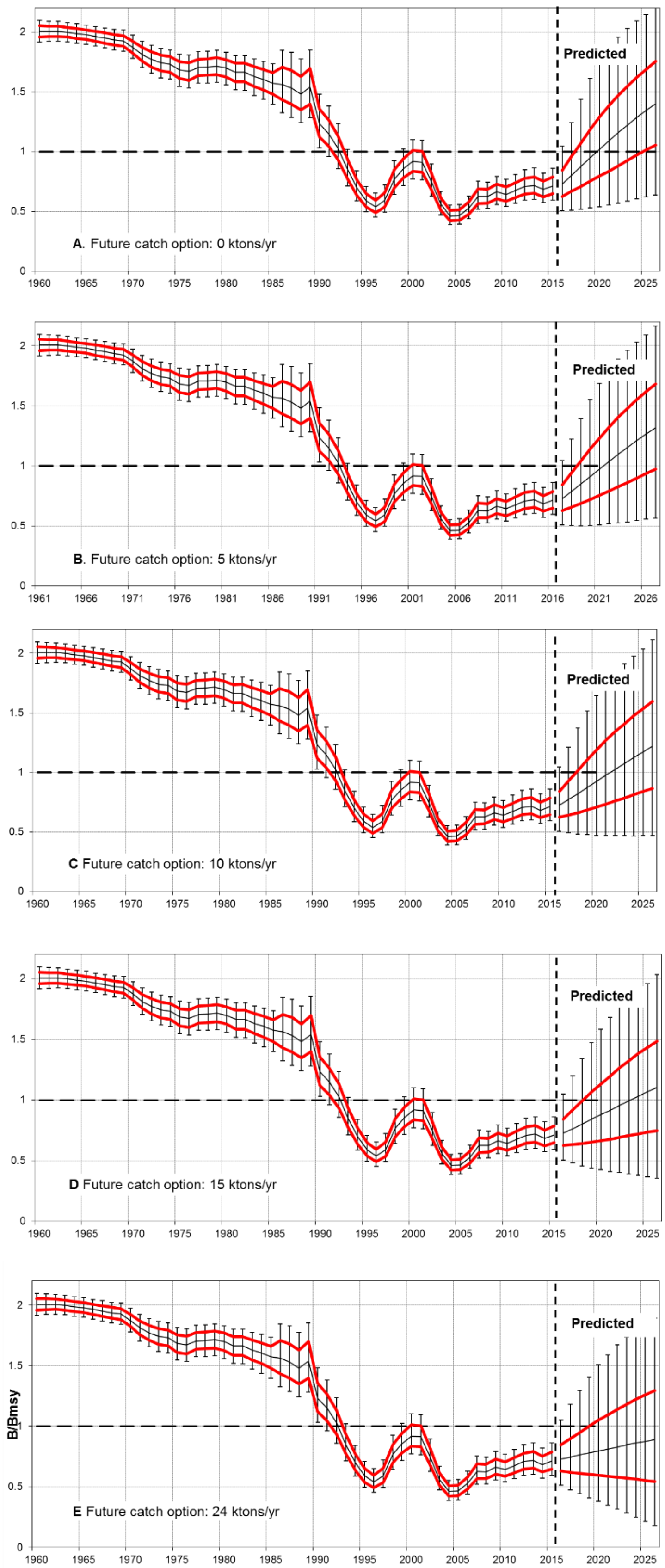


Figure 17.6.6 Estimated time-series of relative biomass (B_t/B_{msy}) under different catch option scenarios: 0, 5, 10, 15 and 24 kt from upper to lower panel. Bold red lines are inter-quartile ranges and the solid black line is the median; the error bars extend to cover the central 90 per cent of the distribution.

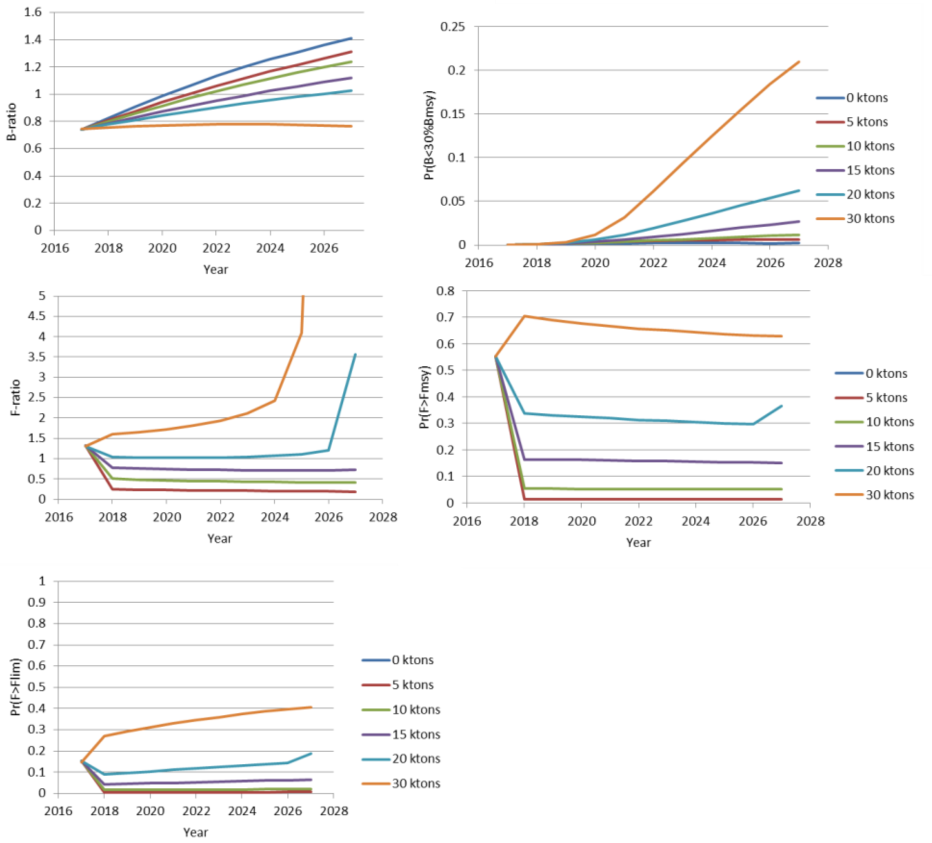


Figure 17.6.7. Projections: Medians of estimated posterior biomass- and fishing mortality ratios; estimated risk of exceeding F_{MSY} or going below and $B_{MSYtrigger}$ given catch ranges at 0–30 ktons.

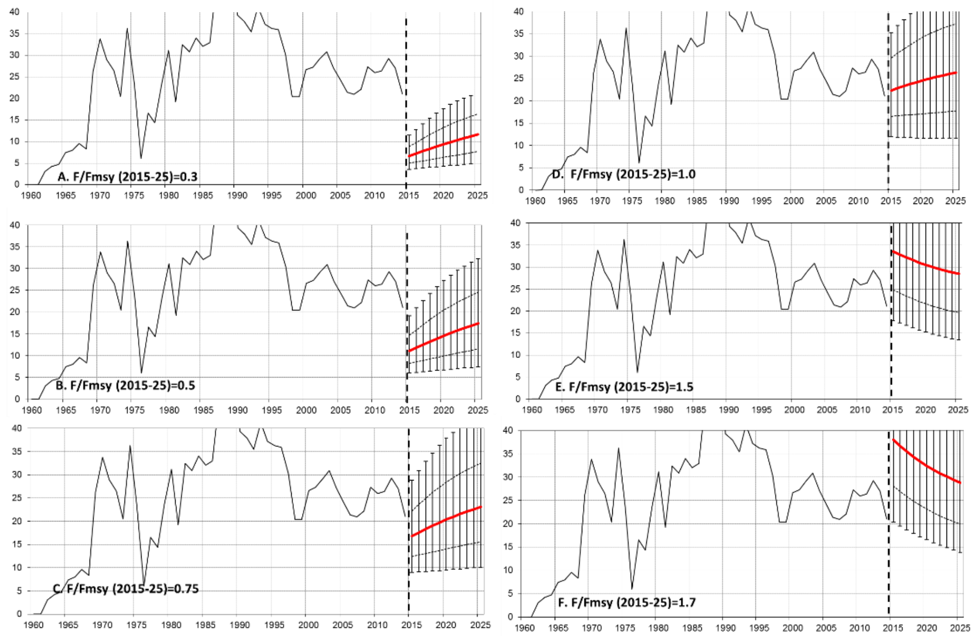


Figure 17.6.8. Historic landings and projected landings 2015–2025 under various F ratio options from 0.3–1.7 F/F_{MSY} Solid red line is median, quartiles and 90% conf limit indicated.

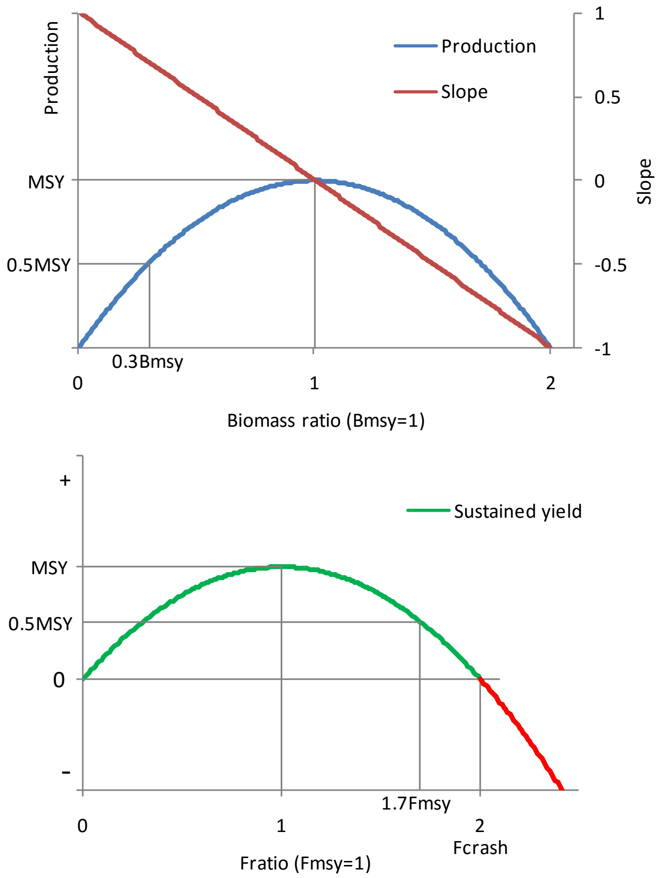


Figure 17.6.9. The logistic production curve in relation to stock biomass (B/B_{MSY}) (*upper*) and fishing mortality (F/F_{MSY}) (*lower*). *Upper*: points of maximum sustainable yield (MSY) and corresponding stock size are shown as well as the slope (red line) of the production curve (blue line); *lower*: points of MSY and corresponding fishing mortality and F_{crash} ($F \geq F_{crash}$ do not have stable equilibriums and will drive the stock to zero).

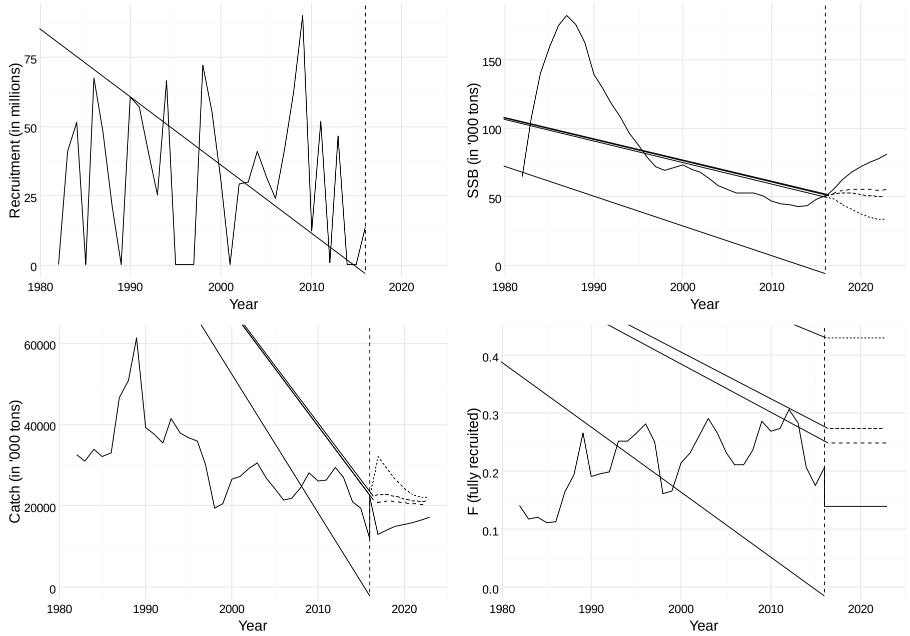


Figure 17.7.1: Population estimates from the exploratory Gadget assessment model. Dashed horizontal line indicates start of the deterministic projection period based on different values of F, i.e. $F_{0.1}$, F_{pa}, F_{msy} and F_{max}.

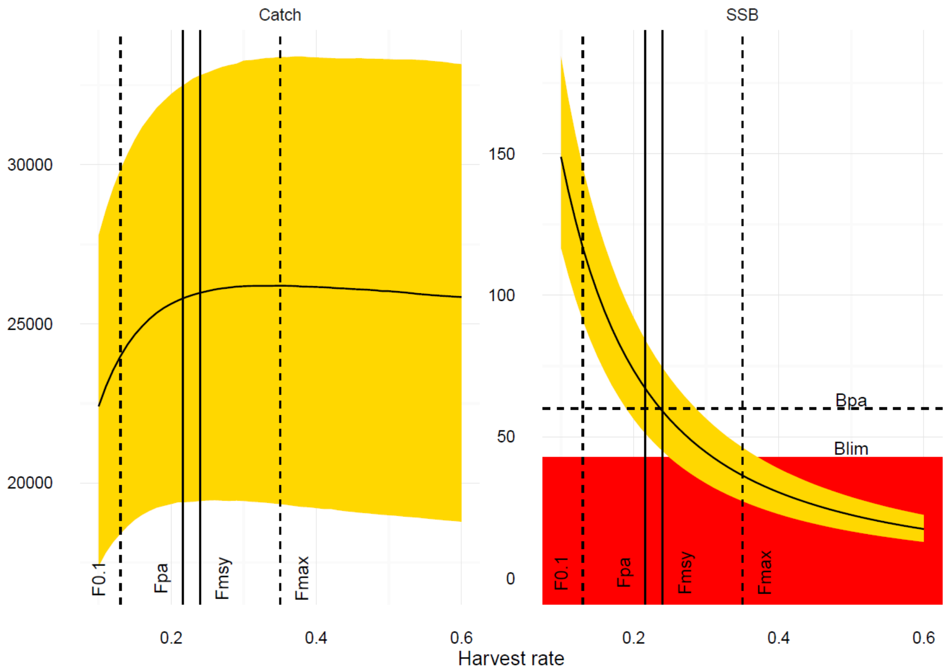


Figure 17.7.2 Estimates of the equilibrium catch curves and spawning-stock biomass by harvest rate (black solid line) with the associate 95% confidence regions (yellow). The red region illustrates the B_{lim}. The different F targets are illustrated with vertical lines.

18 Redfish in Subareas 5, 6, 12 and 14

This chapter deals with fisheries directed to *Sebastes* species in Subareas 5, 6, 12 and 14 (chapters 18.4 and 18.7), and the abundance and distribution of juveniles (chapter 18.2.1), 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, 12, 14 >500 m) – primarily pelagic habitats, and including demersal habitats west of the Faroe Islands;
- a 'Shallow Pelagic' stock (NAFO 1–2, ICES V, 12, 14 <500 m) – extends to ICES 1 and 2, but primarily pelagic habitats, and includes demersal habitats east of the Faroe Islands;
- an 'Icelandic Slope' stock (ICES 5a, 14)–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 the use of the current management areas is rejected (see WD27 and Annex 7). 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 18.1.1):

- Management Unit in the northeast Irminger Sea: ICES Areas 5a, 12, and 14.
- Management Unit in the southwest Irminger Sea: NAFO Areas 1 and 2, ICES areas 5b, 12 and 14.
- Management Unit on the Icelandic slope: ICES Areas 5a and 14, 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 90%) 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 18.1.2.

For the abovementioned reasons, the Group now provides advice for the following *Sebastes* units:

- the *S. norvegicus* on the continental shelves of ICES Divisions 5a, 5b and Subarea 6 and 14 (chapter 19);
- the demersal *S. mentella* on the Icelandic slope (chapter 20);
- the shallow and deep pelagic *S. mentella* units in the Irminger Sea and adjacent waters (chapters 21 and 22, respectively);
- the Greenland shelf *S. mentella* (chapter 23).

18.1 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 Spitsbergen, 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. Copulation occurs in autumn–early winter and larvae extrusion takes place in late winter–late spring/early summer. 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 analysed 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).

18.2 Environmental drivers of productivity

18.2.1 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. norvegicus* 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. norvegicus* off East Greenland. The nursery areas for *S. norvegicus* 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, 1973–1974, 1985–1991, and in 1995.

There are very few juvenile demersal *S. mentella* in Icelandic waters (see chapter 20), 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 18.2.1). The 1999–2006 survey results indicate low abundance and were similar to those observed in the late 1980s. Since 2008, the survey index has been very low and was in 2013-2015 the lowest value recorded since 1982. Juvenile redfish were only classified to the genus *Sebastes* spp., as identification of small specimens to species level is difficult due to very similar morphological features. 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.

18.3 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 Seawater (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).

18.4 Description of fisheries

There are three species of commercially exploited redfish in ICES Subarea 5, 6, 12, and 14: *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 18.4.1) due to decreased commercial interest in this species. The landings in 2009 amounted to 37 t, more than a twofold increase compared 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 since 2012 are about 500 t.

The Group has in the past included the fraction of *S. mentella* that are caught with pelagic trawls above the western, southwestern 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 18.1.1, 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 a 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 20. The proportion of the total demersal *S. mentella* catches taken by pelagic trawls has ranged since 1991 between 0% and 44% (Table 20.3.2), and is on average 15%. With exception of 2007, no demersal *S. mentella* has been caught with 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 18.4.1). The pelagic catches of demersal *S. mentella* were taken in similar areas and depths as the bottom trawl catches (Figure 18.4.2). 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 18.4.3) 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 18.4.4. 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 northeastern area were on average about 5 cm larger than those caught in the southwestern area. The length distribution also shows that the fish caught in this area since 2011 is smaller than during the period 1998–2010 and have now a size similar to that registered at the beginning of the fishery.

18.5 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 2015 the fishery was conducted from April to September in ICES Subareas 12 and 14 and NAFO Divisions 1F (Tables 21.2.1, 21.2.2, 22.2.1 and 22.2.2) with average cpue 20.6 t /day and 20.7 t/ day in ICES Subareas 12 and 14, respectively; and 36.7 t/day in NAFO.

18.6 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 2015:

Country	Area	No. of samples	No. of fish measured
Russia	14	350	40,053
Russia	12		7,244
Russia	NAFO 1F	150	15,356
Iceland	14 (deep)	6	996
Greenland	14b		

18.7 Demersal *S. mentella* in 5b and 6

18.7.1 Demersal *S. mentella* in 5b

18.7.1.1 Surveys

The Faroese spring and summer surveys in Division 5b 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.

18.7.1.2 Fisheries

In Division 5b, landings gradually decreased from 15 000 t in 1986 to about 5 000 t in 2001 (Table 18.6.1). Between 2002 and 2011 annual landings varied between 1 100 and 4,000 t. In 2012 landings decreased drastically and were about 500 t in 2015.

Length distributions from the landings in 2001-2015 indicate that the fish caught in 5b in 2015 are between 35–50 cm and the mode of the distribution is around 41 cm (Figure 18.7.1).

Non-standardized cpue indices in Division 5b 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 2013, when it reached a historical low (Figure 18.7.2). The cpue has since remained at that level.

Fishing effort has decreased since the beginning of the time-series and remains very low since 2008.

18.7.2 Demersal *S. mentella* in 6

18.7.2.1 Fisheries

In Subarea 6, the annual landings varied between 200 t and 1 100 t in 1978–2000 (Table 18.6.1). The landings from 6 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 have been taken since 2009.

18.8 Regulations (TAC, effort control, area closure, mesh size etc.)

Management of redfish differs between stock units and is described in sections 19.14 for *S. norvegicus*, section 20.7 for Icelandic slope *S. mentella*, section 21.10 for shallow pelagic *S. mentella*, section 22.10 for deep pelagic *S. mentella*, and section 23 for Greenland slope *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 18.4).

18.9 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 19.3, demersal *S. mentella* in chapter 20.3, shallow pelagic *S. mentella* in chapter 21.2, deep pelagic *S. mentella* in chapter 22.2 and Greenland slope redfish in chapter 23.3.

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 5a, 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. norvegicus* and *S. mentella*.

18.10 References

Artamonova V., Makhrov A., Karabanov D., Rolskiy A., Bakay Yu., Popov V. 2013. Hybridization of beaked redfish (*Sebastes mentella*) with small redfish (*S. viviparus*) and diversification of redfishes in the Irminger Sea. Journal of Natural History, DOI:10.1080/00222933.2012.752539.

Einarsson, H., 1960. The fry of Sebastes in Icelandic waters and adjacent seas. Rit Fiskideildar 2: 1–67.

ICES 1983. Report on the NAFO/ICES Study Group on biological relationships of the West Greenland and Irminger Sea redfish stocks. ICES CM 1983/G:3, 11 pp.

ICES 1998. Report of the Study Group on Redfish Stocks. ICES CM 1998/G:3, 30 pp.

ICES. 2009. Report of the Workshop on Redfish Stock Structure (WKREDS), 22-23 January 2009, ICES Headquarters, Copenhagen. 71 pp.

ICES. 2012. Report of the Third Workshop on Redfish and Oceanographic Conditions (WKRDOCE3), 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). ICES CM 2013/SSGESST:14. 37 pp.

ICES. 2013. ICES Advice 2013, Book 2.

Fernholm, B. and A. Wheeler 1983. Linnaean fish specimens in the Swedish Museum of Natural History, Stockholm. Zool. J. Linn. Soc. 78: 199–286.

Magnússon, J. and Magnússon, J.V. 1975. On the distribution and abundance of young redfish at Iceland 1974. Rit Fiskideilar 5(3), 22 pp.

Magnusson, J., Kosswig, K. and Magnusson, J.V. 1988. Young redfish on the nursery grounds in the East Greenland shelf area. ICES CM 1988/G:38, 13 pp.

Magnusson, J., Kosswig, K. and Magnusson, J.V. 1990. Further studies on young redfish in the East Greenland shelf area. ICES CM 1990/G:43, 15 pp.

Magnússon, J.V. and Jóhannesson, G. 1997. Distribution and abundance of 0-group redfish in the Irminger Sea and off East Greenland: relationships with adult abundance indices. ICES J. Mar. Sci. 54, 830-845.

Makhrov A. A., Artamonova V. S., Popov, V. I., Rolskiy A. Yu., and Bakay Y. I. 2011. Comment on: Cadrin*et al*. (2010) "Population structure of beaked redfish, *Sebastes mentella*: evidence of divergence associated with different habitats. ICES Journal of Marine Science, 67: 1617–1630.

Malmberg, S. A.. Mortensen, J., and Jonsson, S. 2001. Ocean fluxes in Icelandic waters, 2001. ICES CM 2001/W: 08

Mortensen, J., and Valdimarsson. H. 1999. Thermohaline changes in the Irminger Sea. ICES CM 1999/L: II. 11 pp

Palsson, У.К., Steinarsson, В.Ж., Jonsson, E., Gudmundsson, G, Stefansson, G., Bjornsson, H. and Schopka, S.A. 1997. Icelandic groundfish survey. ICES CM 1997/Y:29, 35 pp.

Pedchenko, A. P. 2005. The role of interannual environmental variations in the geographic range of spawning and feeding concentrations of redfish *Sebastesmentella* in the Irminger Sea. ICES Journal of Marine Science 62: 1501–1510.

Saborido-Rey, F., Garabana, D., Stransky, C., Melnikov, S. and Shibanov, V. 2004. Review of the population structure and ecology of S. mentella in the Irminger Sea and adjacent waters. Rev. Fish Biol. Fish. 14: 455–479.

Sigurdsson, T., Kristinsson, K., Rätz, H.-J., Nedreaas, K.H., Melnikov, S.P. and Reinert, J. 2006. The fishery for pelagic redfish (Sebastesmentella) in the Irminger Sea and adjacent waters. ICES J. Mar. Sci., 63: 725–736.

Stransky, C. 2000. Migration of juvenile deep-sea redfish (*Sebastes mentella*Travin) from the East Greenland shelf into the central Irminger Sea. ICES CM 2000/N:28, 10 pp.

Zelenina D.A., Shchepetov D.M., Volkov A.A., Barmitseva A.E., Mel'nikov S.P., Miuge N.S. 2011. Population structure of beaked redfish (*Sebastes mentella*Travin, 1951) in the Irminger Sea and adjacent waters inferred from microsatellite data. Genetika. 2011 Nov; 47(11):1501–13.

18.11 Tables

Table 18.4.1. Landings of *S. viviparus* in Division 5a 1996–2014.

YEAR	LANDINGS (T)
1996	22
1997	1159
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	2602
2011	1427
2012	535
2013	532
2014	550
2015	468

Table 18.6.1. Nominal landings (tonnes) of demersal *S. mentella* 1978–2015 in ICES Divisions5b and 6.

Year	5b	6
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
2013	398	0
2014	370	0
2015[1)]	537	0

[1)] Provisional

18.12 Figures

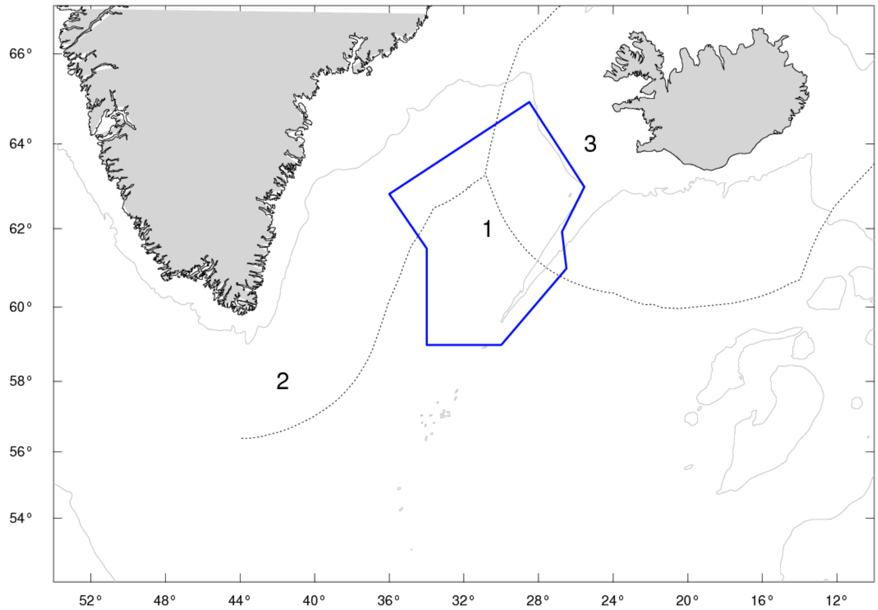


Figure 18.1.1 Potential management unit boundaries. The polygon bounded by blue lines, i.e. 1, indicates the region for the 'deep pelagic' management unit in the northwest Irminger Sea, 2 is the "shallow pelagic" management unit in the southwest Irminger Sea, and 3 is the Icelandic slope management unit.

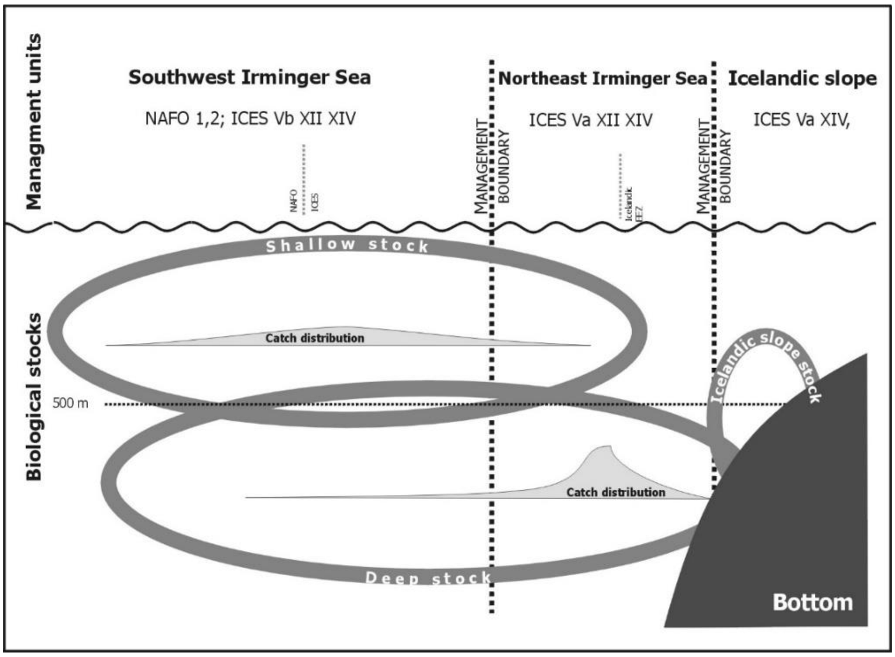


Figure 18.1.2 Schematic representation of biological stocks and potential management units of *S. mentella* in the Irminger Sea and adjacent waters. The management units are shown in Figure 18.1.1. Included is a schematic representation of the geographical catch distribution in recent years. Note that 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.

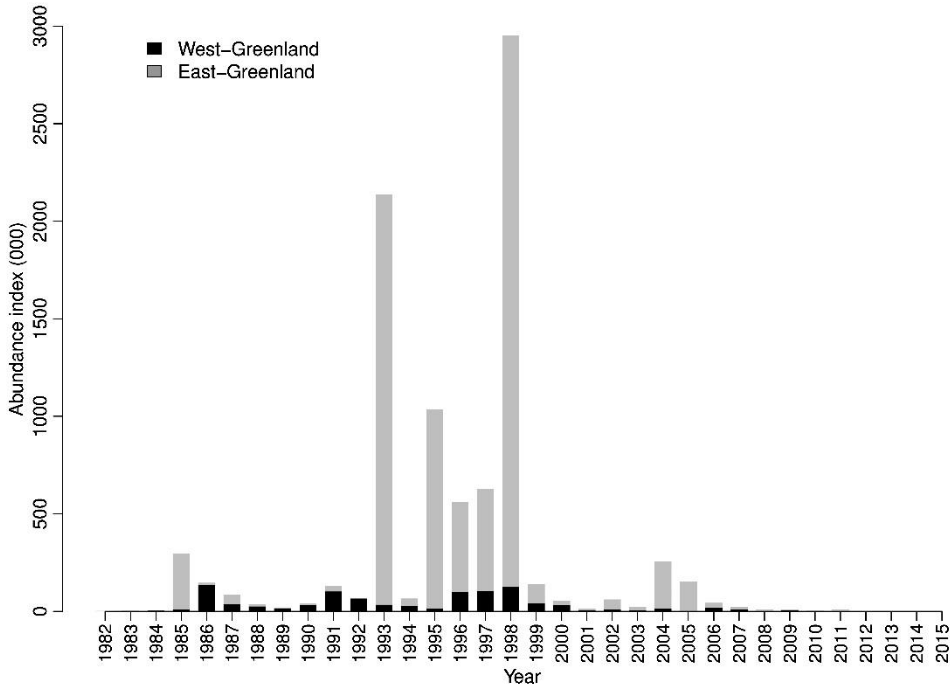


Figure 18.2.1 Survey abundance indices of *Sebastes spp*. (<17 cm) for East and West Greenland from the German groundfish survey 1982–2015.

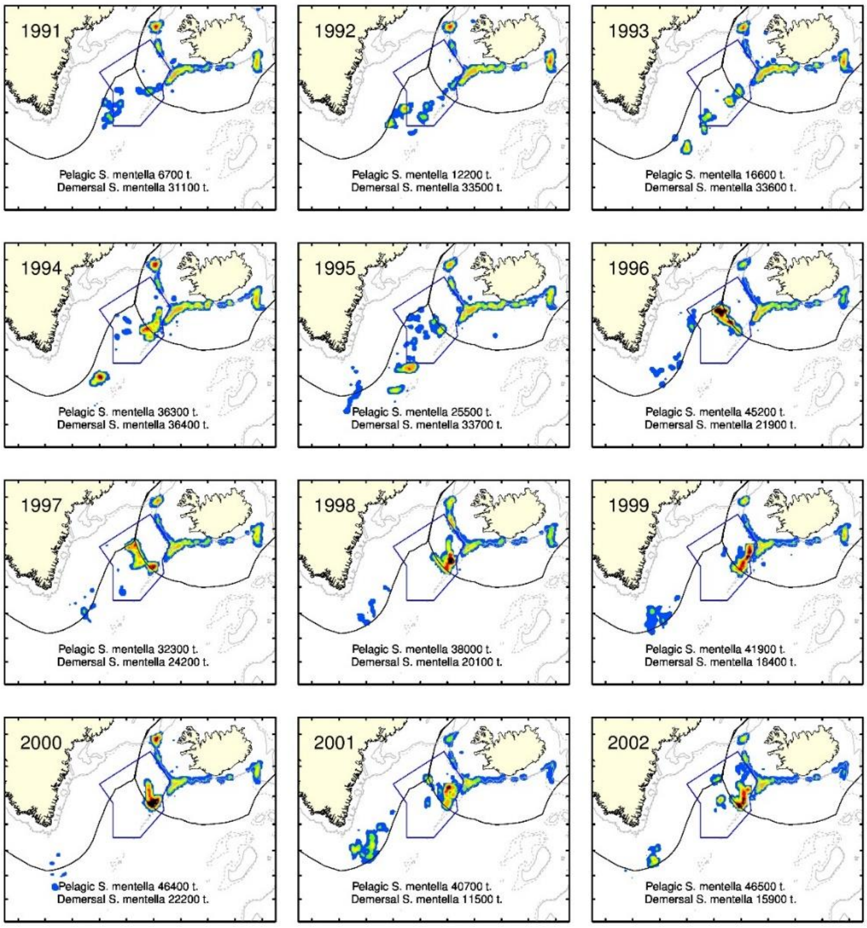


Figure 18.4.1Geographical distribution of the Icelandic catches of *S. mentella* 1991–2002. The color scale indicates catches (tonnes per NM²).

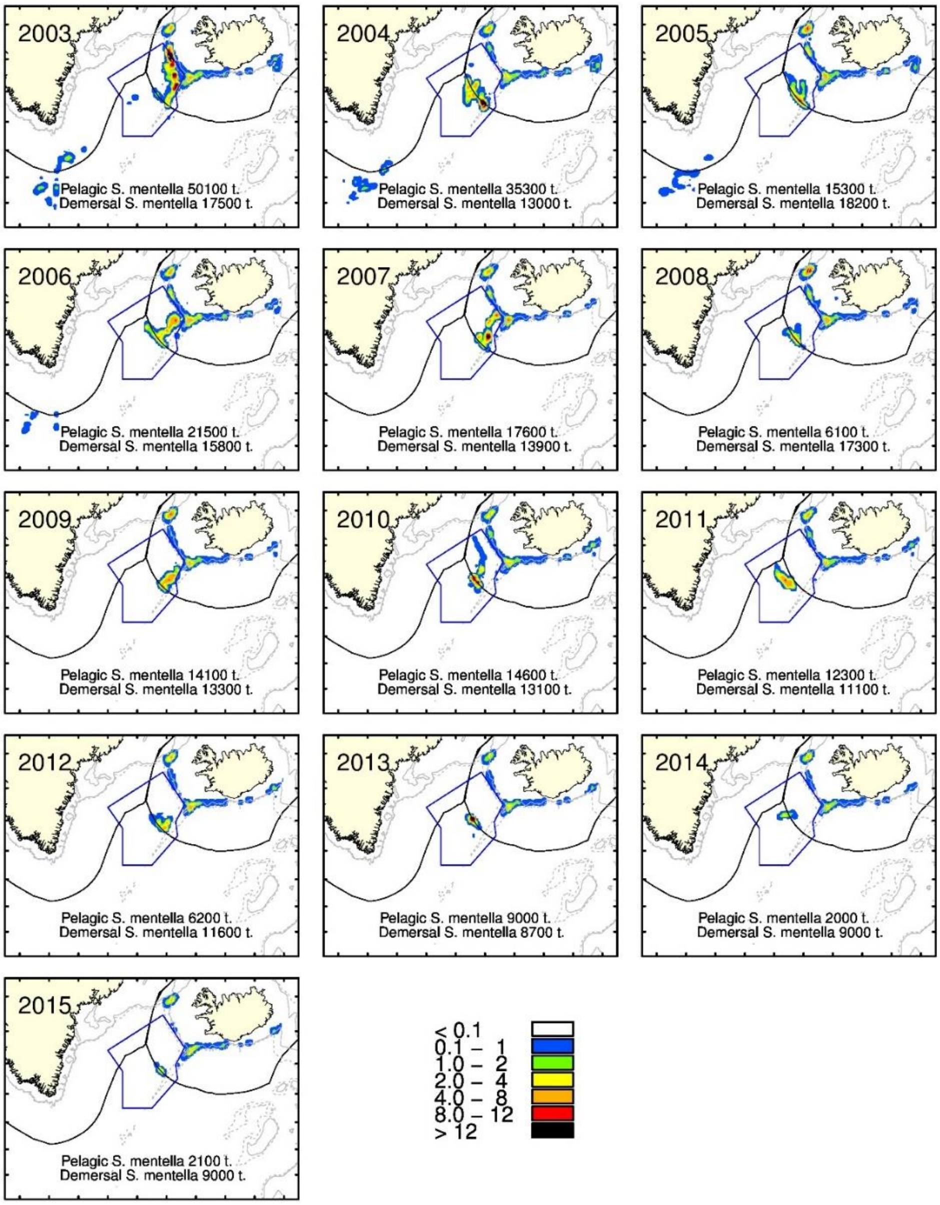


Figure 18.4.1 ***cont.*** **Geographical distribution of the Icelandic catches of** ***S. mentella*** **2003–2015. The color scale indicates catches (tonnes per NM²).**

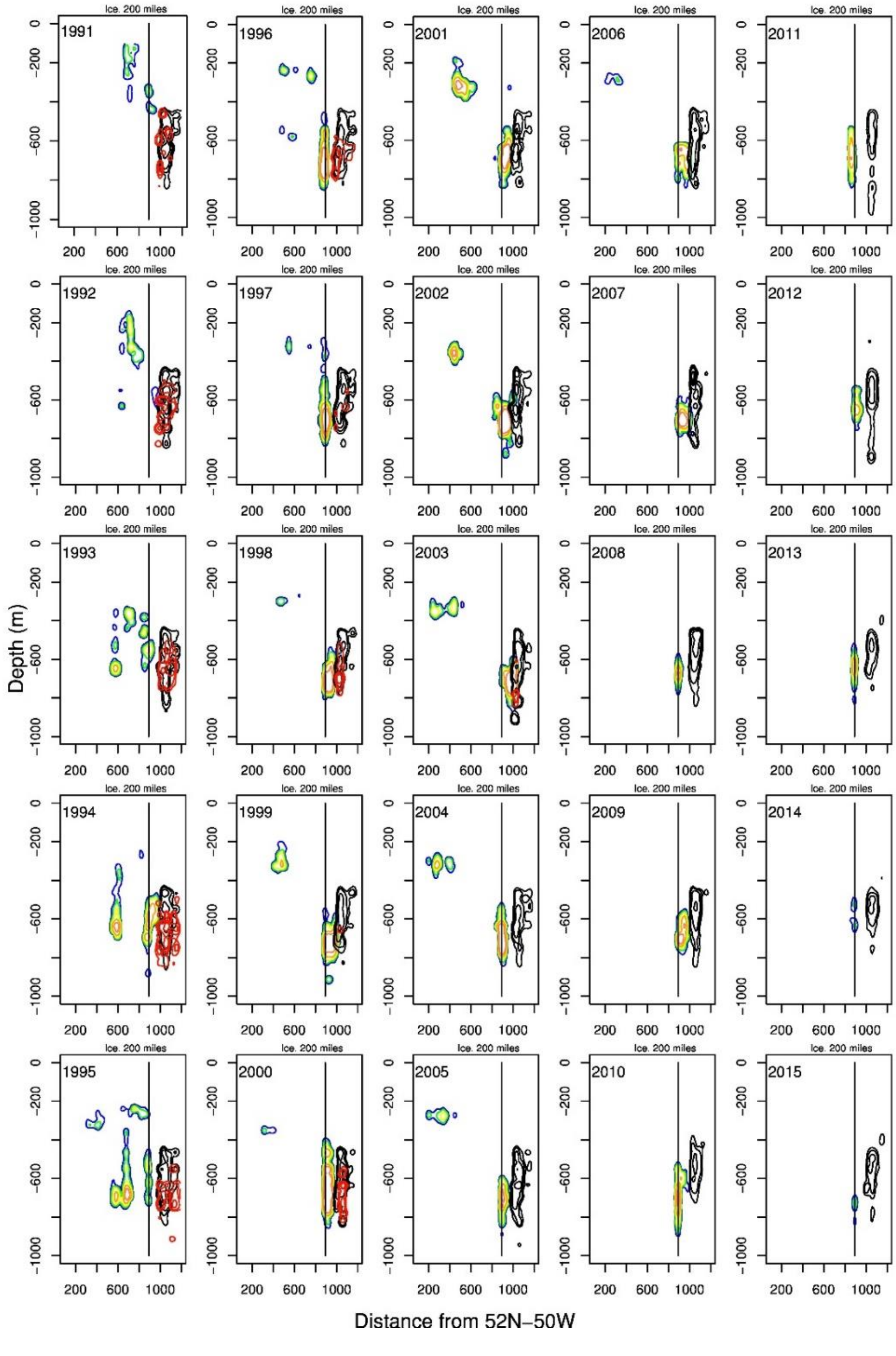


Figure 18.4.2 Distance-depth plot for Icelandic *S. mentella* catches, where distance (in NM) from a fixed position (52°N 50°W) is given. The contour lines indicate catches in a given area and distance. The colored contours represent the fishery on pelagic *S. mentella*, the black contours indicate bottom-trawl catches of demersal *S. mentella*, and the red contours represent catches of demersal *S. mentella* taken with pelagic trawls.

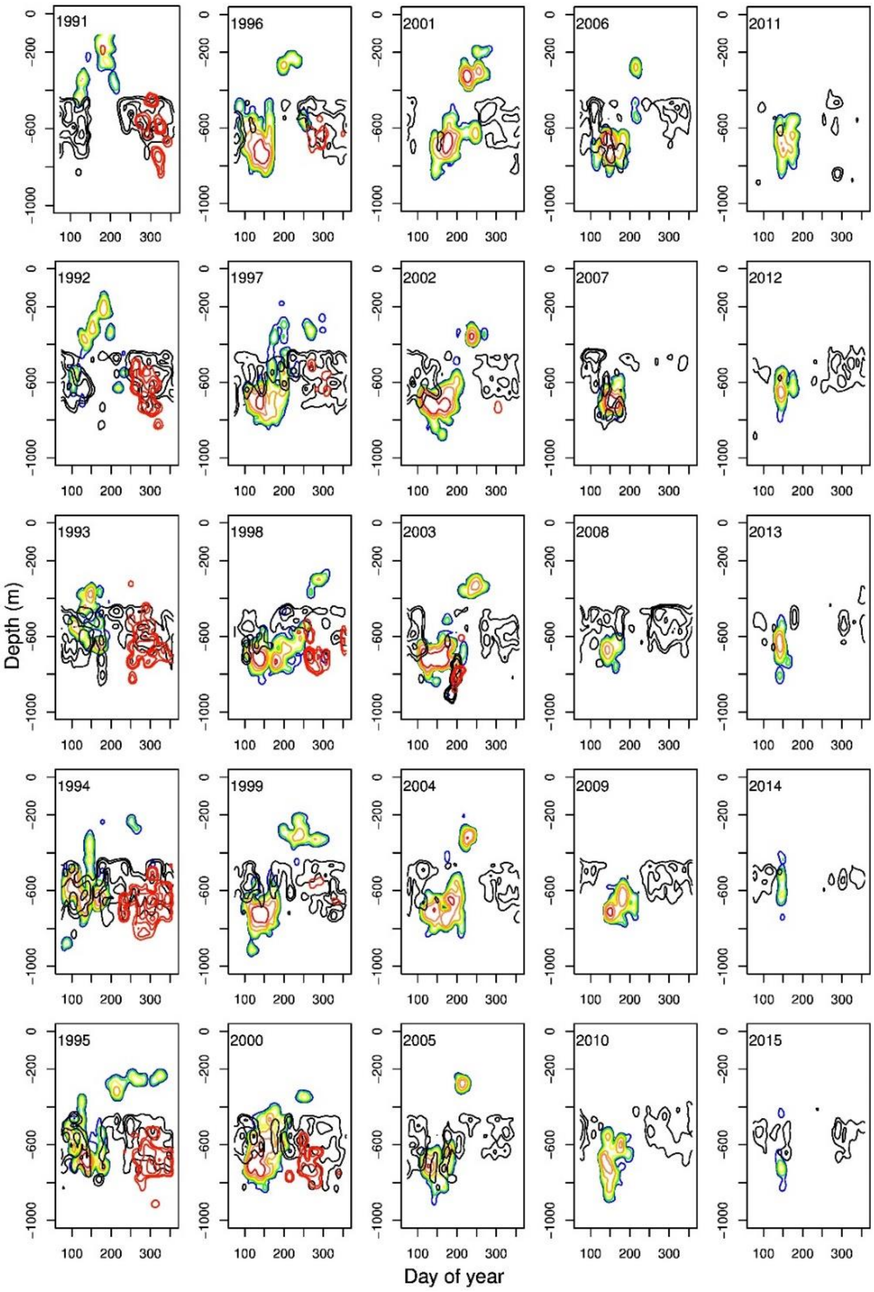


Figure 18.8.3 Depth-time plot for Icelandic *S. mentella* catches 1991–2015 where the y-axis is depth, the x-axis is day of the year and the color indicates the catches. The colored contours represent the fishery on pelagic *S. mentella*, the black contours indicate bottom-trawl catches of demersal *S. mentella*, and the red contours represent catches of demersal *S. mentella* taken with pelagic trawls.

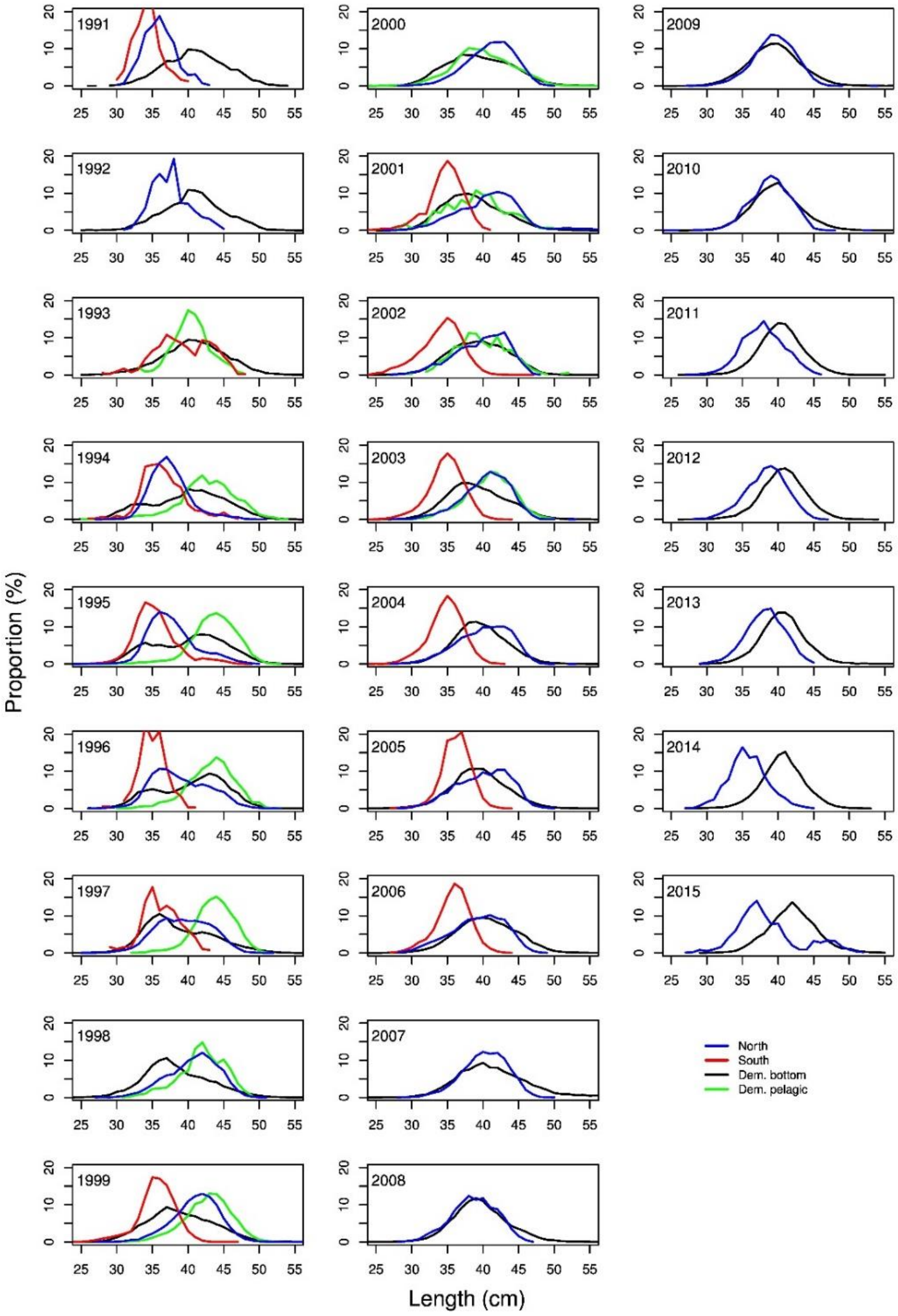


Figure 18.8.4 Length distributions from different Icelandic *S. mentella* fisheries, 1991–2015. The blue lines represent the fishery on pelagic *S. mentella* in the northeastern area, the red lines the pelagic fishery in the southwestern area, the black lines indicate bottom-trawl catches of demersal *S. mentella*, and the green lines represent catches of demersal *S. mentella* taken with pelagic trawls.

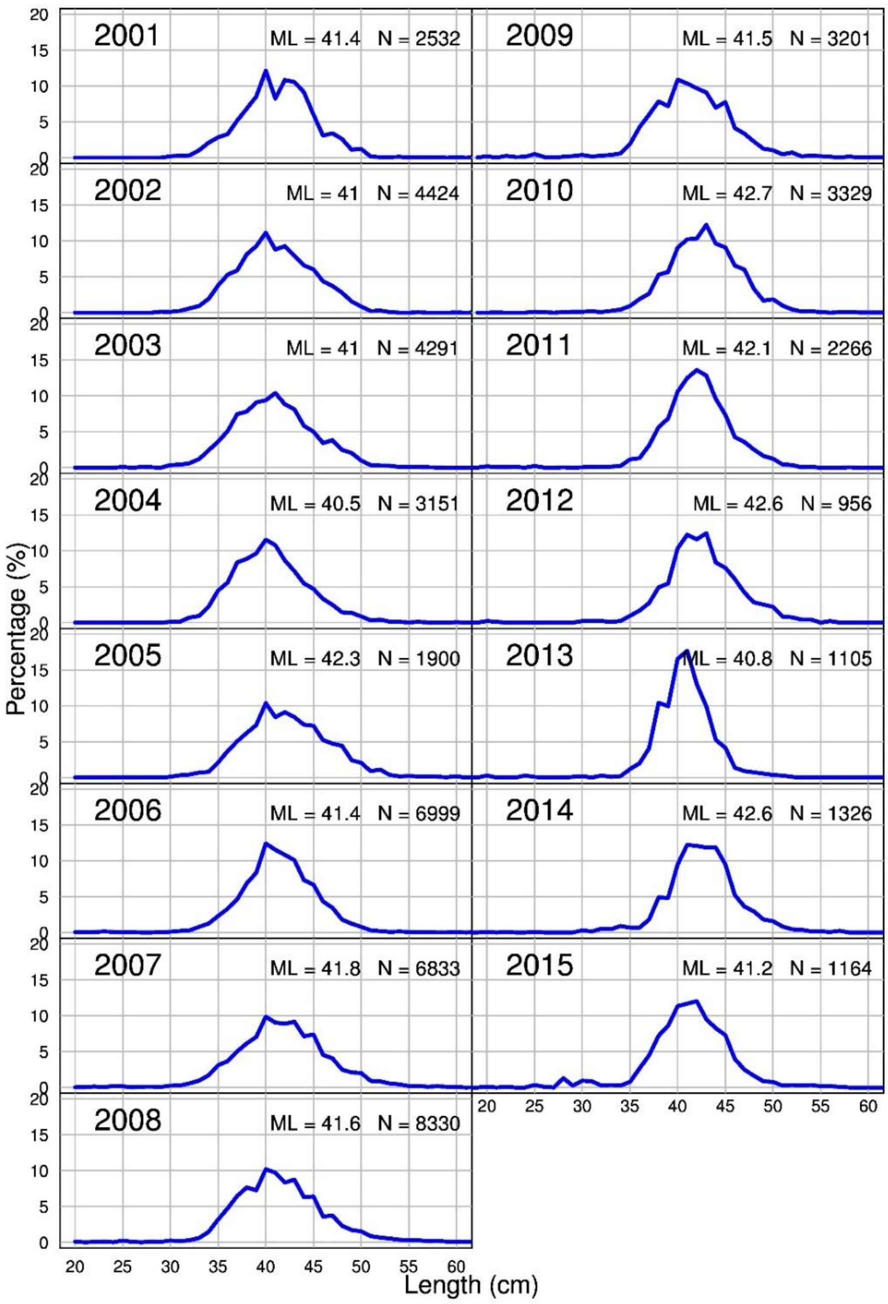


Figure 18.7.1 Length distribution of demersal *S. mentella* from landings of the Faroese fleet in Division 5b 2001–2015.

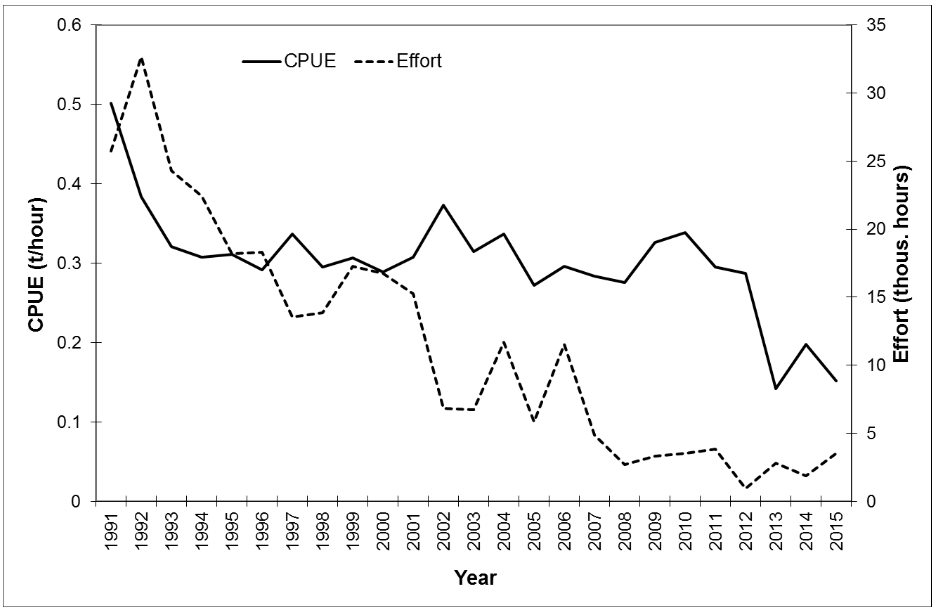


Figure 18.7.2 Demersal *S. mentella*, cpue (t/hour) and fishing effort (in thousands hours) from the Faroese CUBA fleet 1991–2015 and where 70% of the total catch was demersal *S. mentella*.

19 Golden redfish (*Sebastes norvegicus*) in Subareas 5, 6 and 14

19.1 Stock description and management units

Golden redfish (*Sebastes norvegicus*) in ICES Subareas 5 and 14 have been considered as one management unit.

Catches in ICES Subarea 6 have traditionally been included in this report and the Group continues to do so.

19.2 Scientific data

This chapter describes results from various surveys conducted annually on the continental shelves and slopes of Subareas 5 and 14

19.2.1 Division 5.a

Two bottom-trawl surveys are conducted in Icelandic waters: the Spring Survey in March 1985–2016 and the Autumn Survey in October 1996–2015. 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 ICES 5.a. Length disaggregated indices from the Spring Survey are used in the Gadget model. Age disaggregated indices from the autumn survey are used as age–length keys in 2 cm length groups in the Gadget model.

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 daytime. 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. The sum of those abundance indices multiplied by mean weight at length or age are the total indices shown in Figure 19.2.1 and Table 19.2.1.

Figure 19.2.1*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. From 2003–2012 the biomass increased significantly, but decreased again in 2014 and 2015 although remained high. The total biomass index in 2016 increased substantially (about 50% compared to 2015) and was the highest recorded. The index is twice as high as at 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 2000–2014 when it was the highest in the time-series, but decreased slightly in 2015 (Figure 19.2.1*a*).

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 19.2.2). 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 six years very little has been observed of small redfish (Figure 19.2.1*d*). This has been confirmed by age readings (Figure 19.2.4). In recent years the modes of the length distribution in both surveys has shifted to the right and is narrower. Much less is now observed of golden redfish less than 30 cm compared to other years (Figures 19.2.2 and 19.2.3).

Age disaggregated abundance indices from the autumn survey is shown in Figure 19.2.4 and Table 19.2.2. The sharp increase in the survey indices since 2005 reflects the recruitment of the year-classes from 1996–2005. The year-classes 1996–1999 are gradually disappearing from the stock. The 2000–2005 year-classes are now similar to the indices of the large 1990 year-class at same age. In 2013–2015, the abundance of fish 6 years' old and younger was at the lowest level in the time-series for all age groups (Table 19.2.2).

19.2.2 Division 5.b

In Division 5.b, cpue of *S. norvegicus* were available from the Faroes spring groundfish survey from 1994–2016 and the summer survey 1996–2015. Both surveys show similar trends in the indices from 1998 onwards with sharp declines between 1998 and 1999 (Figure 19.2.5). 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 2009–2016 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.

19.2.3 Subarea 14

Relative abundance and biomass indices from the German groundfish survey from 1982–2015 for *S. norvegicus* (fish >17 cm) are illustrated in Figure 19.2.6. In 2013, the survey was re-stratified, with 4 strata in West Greenland resembling NAFO subarea 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 were high although fluctuating until 2013. The survey index increased in 2014 to the highest level in the time-series and was almost two times higher than in 2013 (Figure 19.2.6*a* and Figure 19.2.6*b*). The index decreased in 2015 but was the second highest in the time-series. 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 19.2.7*c* and 19.2.8). In 2010–2015 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 18.2.1). Since

2008, the survey index has been very low and was in 2015 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 1999–2015 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.

19.3 Information from the fishing industry

19.3.1 Landings

Total landings gradually decreased by more than 70% from about 130 000 t in 1982 to about 43,000 t in 1994 (Table 19.3.1 and Figure 19.3.1). Since then, the total annual landings have varied between 33,500 and 54,000 t. The total landings in 2015 were 51 645 t, which is about 900 t more than in 2014. The majority of the golden redfish catch is taken in ICES Division 5.a that contributes to about 94–98% of the total landings.

Landings of golden redfish in Division 5.a declined from about 98 000 t in 1982 to 39 000 t in 1994 (Table 19.3.1). Since then, landings have varied between 32 000 t and 51 000 t, highest in 2013. The landings in 2015 were about 48 800 t, about 1 000 t more than in 2014. 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 bycatch in gillnet, longline, and lobster fishery. In 2015, as in previous years, most of the catches were taken along the shelf southwest, west and northwest of Iceland (Figure 19.3.2). Larger proportion of the catches is now taken along the shelf northwest of Iceland and less south and southwest.

In Division 5.b, landings dropped gradually from 1985–1999 from 9000 t–1500 t and varied between 1500 and 2500 t from 1999–2005 (Table 19.3.1). In 2006—2015 annual landings were less than 1 000 t which has not been observed before in the time-series. The landings in 2015 were 270 t which is 70 t more than in 2014. The landings in 2014 and 2015 are the lowest landings in the time-series. The majority of the golden redfish caught in Division 5b is taken by pair and single trawlers (vessels larger than 1000 HP).

Annual landings from Subarea 14 have been more variable than in the other areas (Table 19.3.1). 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 ICES Subarea 14 were about 2 000 t in 1985). During the period 1985–1994, the annual landings from Subarea 14 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 bycatch in the shrimp fishery. In 2010, landings of golden redfish increased considerable and were 1650 t, similar to it was in early 1990s. This increase is mainly due to increased *S. mentella* fishery in the area. Annual landings 2010–2015 have been between 1 000 t and 2 700 t, highest in 2014.

Annual landings from Subarea 6 increased from 1978–1987 followed by a gradual decrease to 1992 (Table 19.3.1). 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 6 in 2006–2015 and were 44 t in 2015.

19.3.2 Discard

Comparison of sea and port samples from the Icelandic discard sampling program does not indicate significant discarding due to highgrading 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 deep-water shrimp fishery from 1986–1992 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 ICES Division 14.b is currently considered insignificant (see Chapter 18).

19.3.3 Biological data from the commercial fishery

The table below shows the fishery related sampling by gear type and ICES Divisions in 2015. No sampling of the commercial catch from subdivision VI was carried out.

Area	Nation	Gear	Landings (t)	Samples	No. length measured	No. Age read
5.a	Iceland	Bottom trawl	48 769	211	36 756	1 836
5.b	Faroe Islands	Bottom trawl	270	8	248	
14	Greenland	Bottom trawl	2 457			

19.3.4 Landings by length and age

The length distributions from the Icelandic commercial trawler fleet in 1976–2015 show that the majority of the fish caught is 30–45 cm (Figure 19.3.3). The modes of the length distributions range between 35 and 37 cm. The length distributions in 2012—2015 are narrower than previously, with less than average of both small and large fish caught.

Catch-at-age data from the Icelandic fishery in Division 5.a show that the 1985-year class dominated the catches from 1995–2002 (Figure 19.3.4 and Table 19.3.2) 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. The share of these two year classes has gradually been decreasing in recent years. In 2007–2010 the 1996–1999 year classes dominated in the catches, but are now gradually decreasing. The 2000–2004 year classes contributed in total about 62% of the total catch in 2015.

The average total mortality (Z), estimated from the 21-year series of catch-at-age data (Figure 19.3.5) is about 0.24 for age groups 15 and older.

Length distribution from the Faroese commercial catches for 2001–2015 indicates that the fish caught are on average larger than 40 cm with modes between 45 cm and 50 cm (Figure 19.3.6).

No length data from the catches have been available for several years in Subareas 14 and 6.

19.3.5 cpue

The un-standardized cpue index was in 2015 the highest in the time-series with sharp increase in recent 8 years. Effort towards golden redfish has since 1986 gradually decreased and is at the lowest level recorded (Figure 19.3.7). 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.

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 5.b. This is because no separation of S. *norvegicus*/*S. mentella* is made in the catches.

19.4 Methods

19.4.1 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 five years on the Gadget model. The settings are described in the Stock Annex. The following changes were done to the model compared to previous runs:

- 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 fish 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 19.2.6. 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 19.4.1). By using the stratification used to calculate indices shown in Figure 19.2.6, 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 total is difficult to estimate and part of the benchmark work 2014 was to look at the sensitivity to the weight.

The German survey has in recent decade provided increased proportion of the total biomass, but is still only 10% of the total biomass (Figure 19.4.2). The contribution for each length group (Figure 19.4.3) does though show that large redfish is abundant in East Greenland and large part of the largest redfish (45+ cm) is found there. This affects the model results as the relatively large abundance of middle size redfish in the Icelandic spring survey (Figure 19.2.1a) has not lead to subsequent increase in large fish (Figure 19.2.1c). Including the large fish from East Greenland does therefore affect model results and estimated SSB is 20% higher when the German survey is included, although the German survey does only account for 10% of the total biomass as it is weighted. The recruitment signal from the German survey (Figure 19.4.3) is on the other hand not explaining much of the "missing recruitment" from Icelandic waters in recent years.

The weighing of individual datasets in the Gadget model is done using an iterative reweighing algorithm. The process essentially assigns weights to each input dataset on the basis of the inverse variance of the fitted residuals. This is done to reduce the effect of low quality input data. In this year assessment the weights were the same as in the benchmark runs in January 2014 and the assessment in 2014 and 2015.

19.4.2 Gadget model

19.4.2.1 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—2016 and the German survey in East Greenland 1984-2015. Indices are added together and the German survey gets half the weight compared to what is presented in Figure 19.2.6.
- 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 1996–2015.
- Age–length keys and mean length-at-age from the Icelandic commercial catch 1995–2015.
- The simulation period is from 1970 to 2020 using data until the first half of 2016 for estimation. Two time-steps are used each year. The ages used were 5–30 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 fish when the simulation starts (8 parameters).
- Recruitment-at-age 5 each year (44 parameters).
- Length at recruitment (3 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 9–19 according to agreed management plan.

Assumptions done in the predictions:

- Recruitment-at-age 5 in 2015 and onwards was set as the average of the recruitment in 2012–2014.
- Catches in the first time-step in 2016 (first 6 months) were set at the same as in the first time-step of 2015 for all the fleets. In step 2 in 2016 and onwards the model was run at fixed effort corresponding to $F_{9\text{-}19}$=0.097
- The estimated selection pattern from the Icelandic fleet was used for projections.

19.4.2.2 Results of the assessment model and predictions

Summary of the assessment is shown in Figure 19.4.4 and Table 19.4.1. 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 2014 year class but the following year-classes are assumed to be the average of the 2012–2014 year classes. Compared to last year's assessment the 2007–2012 year-class is estimated larger than assumed last year. Later year-classes are likely to be smaller than assumed here based on information from the surveys in East Greenland and Iceland that all indicate low abundance of small redfish. Assumptions about those year-classes will not have much effect on the advice this year but later advice will be affected as well as 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 19.4.5). 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 19.4.6. The Greenlandic and Faroese 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 19.4.3)

19.4.2.3 Fit to data

An aggregated fit to the survey index (converted to biomass) is presented in Figure 19.4.7. 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 14 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 (Figure 19.5.8).

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 19.4.7 the fit is still not good. That lack of fit is caused by too narrow length distribution, with both small and large 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 noted 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 (Figures 19.4.9 and 19.4.10). As the model converges slowly, 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 19.4.8).

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 (Figure 19.4.11). One explanation could be that selection in recent years is dome shaped as the large fish is in East Greenland where the fisheries are less.

The discrepancy between predicted and observed age distributions is not as apparent as for the length distributions (Figures 19.4.12 and 19.4.13). 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 overall 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 smaller proportion sampled in hauls with many fish.

19.5 Information from catch curves.

The discrepancy in different data sources can be seen by looking at catch curves from age disaggregated catch in numbers and survey indices. The 1995–1999 year-classes have disappeared more rapidly from the fisheries than predicted with average Z being 0.24 (F=0.19) for ages 12–20. Comparable number for year-classes 1985–1990 is Z=0.15.

The analyses indicate that fishing mortality was higher than predicted by the assessment models. One explanation is that we are overestimating the stock but there can be a number of alternative explanations.

- The cohorts grow faster and mature earlier than earlier cohorts. Natural mortality, M, might have increased
- The selection of the fisheries is more dome shaped than before. The fisheries concentrate on the dense schools west of Iceland where the length distribution is narrow.
- Compared to cohorts 1985—1990 the later cohorts seem to come from other nursery areas.
- Most of the biomass in the Icelandic surveys in the last decade comes from very dense schools west of Iceland. Catchability in those schools might be different from less dense aggregations.

19.6 Reference points

Harvest control rule (HCR) was evaluated at WKREDMP in January 2014 (ICES, 2014) based on stochastic simulations using the Gadget model. Taking into account conflicting information by different data continuing for many consequent years (sections 19.4–19.5), the simulations were conducted using large assessment error with very high autocorrelation (CV=0.25, rho=0.9).

Yield-per-recruit analysis show that when average size at age 5 was allowed to change after year class 1996, $F_{9\text{–}19,max}$ changed from 0.097 to 0.114. 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 autocorrelated assessment error.

The simulations done at WKREDMP 2014 (ICES, 2014) were repeated, but with deterministic recruitment and no assessment error. At WKREDMP 2014, B_{lim}=B_{loss}=160 kt was defined as the lowest SSB in the 2012 Gadget run. $B_{trigger}$=B_{pa} was defined as 220 kt by adding a precautionary buffer to the proposed B_{lim} of 160 kt: 160*exp(0.2*1.645). Recruitment in the stochastic simulations was the average of year-classes 1975–2003 but those year-classes were the basis for the simulations at WKREDMP 2014.

The plot of the average spawning stock against fishing mortality show that F_{lim}=0.226 and F_{pa} is then 0.226/exp(1.645*0.2)=0.163 (Figure 19.6.1). The spawning stock decreased considerably from early 1980s to mid-1990s or from 400 kt to 200 kt. The reduction in SSB was due to heavy fisheries, but increased again gradually because of improved recruitment and lower F (Figure 19.6.1).

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 $B_{trigger}$.

Figure 19.6.2 shows the development of $F_{9\text{–}19}$ based on $F_{9\text{–}19}$ = 0.097. F is expected to be within the range of the fifth and 95th quantile and the 16th and 84th quantile.

19.7 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 19.4.4). Spawning stock and fishable stock have been increasing in recent years and are now the highest since 1986.

In 5b, survey indices are stable at low level and do not indicate an improved situation in the area. In Subarea 14, the biomass of the fishable stock has been relatively high since 2007. No information is available on exploitation rates in Division 5.b and Subarea 14.

Results from surveys in Iceland and East Greenland indicate that most recent year classes are poor. The reliability of the surveys as an indicator of recruitment is not known.

19.8 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 19.4.4).

The results from the short-term simulations based on $F_{9\text{-}19}$ is shown in Figure 19.4.4 and from short-term prognosis with varying fishing mortality in 2017 and 2018 in Table 19.4.2.

19.9 Medium term forecast

No medium term forecast was carried out.

19.10 Uncertainties in assessment and forecast

Various factors regarding the uncertainty and modelling challenges are listed in the WKRED-2012 (ICES 2012) and WKREDMP-2014 (ICES 2014) reports. The main issues 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. These factors were discussed in sections 19.4–19.6 but a short list is repeated below.

- Immigration of intermediate sized redfish in to 5.a, 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

19.11 Comparison with previous assessment and forecast

The current assessment gives similar state of the stock compared to last year's assessment and the assessment presented at the benchmark 2014.

Management plans and evaluation, see chapter 19.6

19.12 Basis for advice

Harvest control rule accepted at WKREDMP 2014 (ICES 2014).

19.13 Management consideration

In 2009 a fishery targeting redfish was initiated in Subarea 14 with annual catches of between 7 300 and 8 500 t in 2010–2015. The fishery does not distinguish between species, but based on survey information, golden redfish is estimated to be between 1000 and 2 700, highest in 2014.

Redfish and cod in Subarea 14 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 currently 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 14 is an important nursery area for the entire resource. Measures to protect juvenile in Subarea 14 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 Faroe Islands. However, an agreement was made between Iceland and Greenland in October 2015 on the management of the golden redfish fishery based on the management plan applied in 2014. The agreement is from 2016 to the end of 2018. The agreement states that each year 90% of the TAC is allocated to Iceland and 10% is allocated to Greenland. Furthermore, 350 t are allocated each year to other areas.

In Greenland and Iceland the fishery is regulated by a TAC and in the Faroe Islands by effort limitation. The regulation schemes of those states have previously resulted in catches well in excess of TACs advised by ICES.

19.14 Ecosystem consideration

Not evaluated for this stock.

19.15 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 bycatch of juveniles in the shrimp fishery north of Iceland. This was partly done to avoid redfish juveniles as a bycatch 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 5.b as abundance of small redfish is low and shrimp fisheries limited.

There is no minimum landing size of golden redfish in Division 5.a. However, if more than 20% of a catch observed on board 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 Division 5.b.

Since 2002 it has been mandatory in the shrimp fishery in Subarea 14 to use sorting grids in order to reduce bycatches of juvenile redfish in the shrimp fishery.

19.16 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 5 and 14.

19.17 Changes in the environment

No information available.

19.18 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.

19.19 Tables

Table 19.2.1 Survey indices and CV of golden redfish from the spring survey 1985–2015 and the autumn survey 1996–2014.

	Spring Survey		Autumn Survey	
Year	Biomass	CV	Biomass	CV
1985	308,148	0.095		
1986	328,104	0.120		
1987	322,281	0.122		
1988	251,625	0.095		
1989	281,253	0.122		
1990	242,514	0.223		
1991	199,251	0.114		
1992	160,614	0.088		
1993	179,378	0.130		
1994	171,171	0.097		
1995	146,127	0.102		
1996	195,190	0.165	196,938	0.249
1997	212,254	0.216	118,785	0.282
1998	206,550	0.136	186,397	0.348
1999	297,014	0.143	261,868	0.311
2000	221,295	0.176	140,774	0.201
2001	192,749	0.176	176,532	0.156
2002	249,375	0.173	191,887	0.151
2003	334,011	0.161	199,374	0.159
2004	327,175	0.236	219,935	0.242
2005	310,708	0.129	229,105	0.240
2006	257,213	0.157	279,435	0.335
2007	339,975	0.224	220,157	0.251
2008	248,120	0.154	287,813	0.244
2009	302,501	0.253	293,618	0.283
2010	383,772	0.245	227,259	0.171
2011	401,870	0.235		
2012	461,192	0.204	342,800	0.226
2013	457,737	0.177	310,332	0.157
2014	403,085	0.174	430,585	0.233
2015	407,051	0.280	360,878	0.175
2016	608,992	0.317		

Table 19.2.2 Golden redfish in 5.a. Age disaggregated indices (in numbers) from the autumn groundfish survey 1996–2015. 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	2014	2015
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	0.0	0.0
2	2.4	0.2	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	0.3	0.1
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	0.3	0.6
4	1.6	1.6	2.3	1.5	1.6	2.4	6.1	1.1	1.8	1.0	0.5	1.1	2.7	4.6	0.3		1.1	0.2	0.1	0.2
5	8.4	2.2	0.9	4.7	1.2	5.4	5.7	12.1	3.2	4.2	5.0	2.1	4.1	12.2	4.3		3.9	1.1	0.8	0.1
6	40.4	6.9	3.5	2.8	7.7	2.1	11.6	17.4	28.1	4.8	6.8	10.2	7.7	11.6	14.3		3.1	4.0	1.7	1.2
7	11.4	22.4	16.7	10.5	6.6	10.6	3.2	37.5	35.9	39.0	15.2	25.5	38.3	13.7	15.0		23.0	3.0	12.6	7.3
8	19.1	14.2	58.4	47.2	6.2	10.6	26.3	9.7	63.8	43.9	79.7	35.0	73.1	72.3	23.0		68.6	40.7	23.9	27.4
9	15.0	12.9	22.5	100.0	25.5	6.9	10.9	47.5	20.4	61.2	79.2	74.7	65.8	94.1	53.4		58.9	82.2	93.7	32.0
10	28.9	11.0	26.1	43.7	92.7	16.9	16.1	12.4	44.3	24.3	83.2	36.5	103.3	57.1	67.8		61.1	54.1	146.8	83.5
11	102.6	17.4	18.9	20.6	11.1	108.5	31.1	16.6	18.7	43.1	25.6	35.2	61.3	98.1	31.9		100.8	39.4	87.7	97.5
12	15.9	67.0	19.0	16.7	13.8	22.9	113.5	39.0	13.0	19.1	36.4	18.6	53.5	44.6	56.5		72.0	65.2	67.2	51.1
13	9.9	6.0	104.8	20.7	7.7	23.0	19.5	109.3	25.9	15.0	17.5	23.2	13.2	41.7	28.2		42.1	45.2	65.3	46.0
14	16.6	5.2	10.0	147.2	7.8	7.6	11.2	12.1	101.2	26.2	14.7	8.0	17.8	9.9	19.3		38.0	25.1	48.8	40.3
15	33.6	7.0	7.6	5.9	50.4	8.9	9.6	10.7	13.3	80.5	17.9	6.6	8.9	17.8	9.0		19.1	30.1	26.1	39.1
16	15.9	9.8	7.8	9.6	5.1	57.4	10.2	6.0	9.4	9.3	73.7	16.6	7.6	6.7	10.8		16.2	17.8	25.7	20.4
17	1.8	6.8	14.1	10.8	2.5	4.1	44.3	7.5	5.8	6.5	8.5	48.6	12.8	6.2	4.6		6.0	12.2	16.5	19.4
18	1.6	3.8	7.6	11.0	2.5	4.9	4.5	32.3	5.9	3.7	4.2	10.2	35.9	7.1	3.0		5.7	6.8	11.9	9.7
19	4.1	2.0	0.5	8.3	4.5	3.5	2.9	4.5	21.1	5.0	2.7	4.4	6.0	27.6	6.5		3.8	4.9	5.8	9.7
20	6.5	1.4	3.2	3.9	6.4	4.0	3.1	1.6	3.0	21.7	3.0	1.5	5.6	4.5	21.9		3.8	4.3	5.7	9.6
21	1.0	0.8	2.3	2.8	1.0	3.6	3.9	1.1	1.8	2.5	17.5	3.9	2.0	2.1	3.1		3.4	4.6	4.7	3.2
22	4.9	1.5	0.8	1.0	1.6	2.2	3.2	2.7	1.7	2.0	1.9	13.5	2.3	1.3	1.2		17.9	2.3	3.5	2.4
23	3.9	2.4	2.2	2.1	0.4	0.3	0.8	1.0	2.4	2.3	1.7	1.3	10.8	1.9	1.6		2.9	17.3	3.3	2.1
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	9.9	0.7		2.0	2.4	12.3	1.1
25	3.8	2.6	1.4	2.8	0.7	0.3	0.5	0.3	1.2	1.2	1.7	0.2	0.8	0.7	5.6		1.2	1.2	1.4	12.7
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	0.9	1.5
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	1.2	0.4		7.4	0.8	0.8	1.4
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	0.5	1.5
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	3.2	1.0
30+	0.8	1.3	3.1	1.1	1.3	2.1	1.6	1.5	1.5	2.1	1.0	0.9	1.4	1.6	2.0		2.0	3.3	2.5	6.7
Total	358.1	212.1	342.2	492.0	265.4	314.0	344.5	386.5	425.4	420.5	502.5	382.9	542.4	551.9	387.8		566.5	478.0	674.0	528.8

Table 19.3.1 Official landings (in tonnes) of golden redfish, by area, 1978–2015 as officially reported to ICES. Landings statistics for 2015 are provisional.

	Area				
Year	5.a	5.b	6	14	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	1 005	45 354
2012	43 089	491	41	2 017	45 635
2013	51 330	372	92	1 499	53 263
2014	47 769	201	60	2 706	50 736
2015[1)]	48 769	270	44	2 562	51 645

1) Provisional

Table 19.3.2 Golden redfish in 5.a. Observed catch in weight (tonnes) by age and years in 1995–2015. 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.

YEAR/ AGE	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
7	47	0	32	23	6	38	117	125	189	216	219	175	128	211	106	59	140	71	31	229	0
8	327	354	219	277	339	62	134	871	199	822	737	995	428	1,051	961	351	550	627	572	465	539
9	1,452	803	470	584	1,576	830	389	737	1,330	485	1,840	2,113	1,689	2,101	1,730	2,179	1,545	1,642	2,256	1,715	804
10	8,698	3,654	1,014	1,189	1,237	4,216	1,608	815	1,095	2,059	1,470	3,573	2,403	5,012	3,119	2,685	4,492	3,504	3,954	5,931	3,428
11	2,583	9,026	2,641	1,115	1,823	1,861	7,611	3,097	1,178	777	3,052	2,077	3,273	3,990	5,030	2,751	5,435	6,808	6,008	6,543	7,105
12	1,284	2,078	11,406	3,215	2,498	2,245	1,786	10,777	3,899	965	1,873	2,774	1,886	4,710	4,482	4,875	4,866	7,324	9,423	5,748	7,522
13	3,574	1,313	2,796	12,421	2,428	1,678	1,912	3,021	9,675	2,001	1,349	1,622	3,039	2,309	3,421	3,865	6,248	4,014	6,897	5,806	5,624
14	5,718	1,468	1,363	2,073	15,444	2,344	1,235	2,571	2,342	8,548	2,984	1,287	1,042	2,820	1,829	2,724	3,815	4,582	4,087	4,725	5,661
15	6,124	4,376	3,125	2,031	1,236	14,675	826	1,823	1,960	2,127	11,727	2,813	949	1,519	1,981	1,373	2,464	2,606	4,494	2,990	4,533
16	1,801	5,533	3,648	2,408	1,254	1,753	11,529	2,956	1,212	1,677	2,067	10,126	2,155	1,082	1,233	1,194	1,383	1,527	3,080	2,608	2,738
17	889	927	3,016	3,407	1,812	1,172	518	11,787	2,249	809	1,445	2,091	9,323	1,843	667	814	916	830	1,747	1,946	2,618
18	384	385	893	2,043	2,641	1,592	780	2,055	6,402	1,380	1,249	1,182	1,323	8,265	1,488	645	640	797	1,218	1,282	1,757
19	1,218	266	637	1,015	2,212	2,383	1,043	1,133	756	5,194	1,246	688	741	1,515	6,064	1,084	808	494	776	410	682
20	1,216	339	943	723	1,259	2,124	1,730	636	411	1,115	6,463	970	726	925	947	5,002	846	789	459	1,214	1,256
21	559	1,188	453	520	461	535	935	1,392	607	336	391	5,641	878	531	641	906	5,174	612	523	525	274
22	684	1,034	525	394	214	438	411	1,003	798	489	469	631	4,809	837	568	762	1,173	3,460	714	531	274
23	1,574	814	673	424	331	270	411	723	754	618	795	229	736	4,235	335	574	761	456	3,176	538	233
24	709	0	584	660	216	63	164	372	392	567	619	377	112	380	2,529	667	221	340	190	3,204	475
25	824	0	734	520	848	392	123	288	300	258	420	472	618	253	97	2165	67	226	201	201	1,845
26	407	0	275	399	270	337	114	180	74	105	100	73	333	427	96	267	1,602	238	173	209	276
27	384	0	139	427	615	198	275	80	83	183	279	263	349	340	191	389	86	1,441	74	116	179
28	808	0	202	357	229	516	189	296	27	141	169	204	200	170	92	132	178	200	822	64	188
29	0	0	143	53	106	364	146	498	105	138	29	168	36	172	386	179	47	73	38	733	78
30+	251	0	408	493	768	1,102	1,080	1,333	539	678	1,599	976	1,187	841	448	511	317	427	417	35	681
Total	41,516	33,557	36,344	36,771	39,822	41,186	35,067	48,570	36,576	31,686	42,594	41,520	38,361	45,539	38,444	36,154	43,772	43,091	51,329	47,770	48,769

Table 19.4.1 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	607.6	373.0	214.4	67.9	0.098
1972	607.0	367.5	159.3	50.9	0.075
1973	649.8	375.6	457.9	43.7	0.065
1974	683.5	389.1	222.1	50.6	0.073
1975	703.1	398.7	135.4	61.9	0.087
1976	708.1	395.9	201.6	94.4	0.133
1977	717.2	399.6	185.3	53.8	0.079
1978	744.2	423.3	125.5	48.7	0.065
1979	761.8	440.3	163.6	77.2	0.099
1980	751.9	441.9	105.3	89.1	0.113
1981	722.4	432.1	75.0	102.0	0.134
1982	665.3	403.1	63.6	130.3	0.183
1983	599.8	366.6	67.7	106.0	0.161
1984	547.0	337.6	73.3	95.3	0.154
1985	509.8	314.3	131.5	78.5	0.131
1986	479.7	294.6	121.7	76.9	0.140
1987	443.7	272.3	64.5	76.6	0.151
1988	396.1	241.7	41.3	89.8	0.204
1989	355.4	215.4	45.0	56.6	0.144
1990	355.4	199.5	353.3	66.3	0.191
1991	334.2	182.5	59.0	56.0	0.179
1992	315.5	168.9	40.1	55.8	0.196
1993	299.2	157.8	54.7	50.2	0.194
1994	289.0	151.9	64.9	42.5	0.172
1995	308.3	151.6	337.9	44.3	0.181
1996	314.3	154.1	90.0	35.6	0.143
1997	314.3	156.2	41.7	39.0	0.153
1998	316.3	161.2	42.0	39.7	0.153
1999	314.3	162.5	86.9	42.5	0.162
2000	309.9	164.5	53.3	42.6	0.158
2001	317.2	169.0	116.4	36.7	0.130
2002	321.2	170.2	126.7	50.7	0.177
2003	338.0	174.5	194.7	38.2	0.133
2004	356.6	186.2	115.0	32.8	0.110
2005	379.5	195.6	187.0	46.6	0.153
2006	407.5	207.0	197.5	42.1	0.138
2007	425.6	219.9	113.9	39.2	0.123
2008	453.2	238.7	142.2	46.2	0.136
2009	490.0	257.8	231.6	39.3	0.108
2010	528.9	285.3	161.0	38.5	0.096
2011	548.3	309.9	52.1	45.1	0.103
2012	559.2	326.6	91.6	45.2	0.096
2013	562.7	342.7	44.9	53.1	0.106
2014	550.3	348.7	28.0	50.8	0.097
2015	541.9	354.6	54.0	51.8	0.096
2016	527.9	354.8	54.0	53.0	0.098
2017	509.1	349.8	54.0	52.8	0.099
2018	488.3	341.2	54.0	51.5	0.099
2019	466.9	330.1	54.0	49.6	0.099
2020	445.5	317.3	54.0	47.3	0.099

Table 19.4.2 Output from short-term prognosis. Multiplier is based on reference to the adopted HCR F_{9-19}=0.097. Biomasses are at 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(2015)=0.101 C(2015)=51.000 TONS.

2016				
BIO 5+	SSB	FMULT	F9-19	LANDINGS
532	371	0.997	0.097	53.0

			2017		2018	
FMULT	F9-19	BIO 5+	SSB	LANDINGS	BIO 5+	SSB
0.0	0	542	383	0	576	389
0.1	0.01	539	383	5.7	568	389
0.2	0.019	536	383	11.4	559	389
0.3	0.029	534	383	16.9	551	389
0.4	0.038	531	383	22.3	542	389
0.5	0.048	528	383	27.6	534	389
0.6	0.058	525	383	32.9	526	389
0.7	0.067	523	383	38.0	518	389
0.8	0.077	520	383	43.0	510	389
0.9	0.087	517	383	48.0	502	389
1.0	0.097	515	383	52.8	495	389
1.1	0.107	512	383	57.6	487	389
1.2	0.117	509	383	62.3	480	389
1.3	0.127	507	383	66.8	472	389
1.4	0.137	504	383	71.3	465	389
1.5	0.147	501	383	75.7	457	389
1.6	0.158	498	383	80.0	450	389
1.7	0.168	496	383	84.2	443	389
1.8	0.178	493	383	88.3	436	389
1.9	0.189	490	383	92.4	429	389
2.0	0.199	488	383	96.3	423	389

19.20 Figures

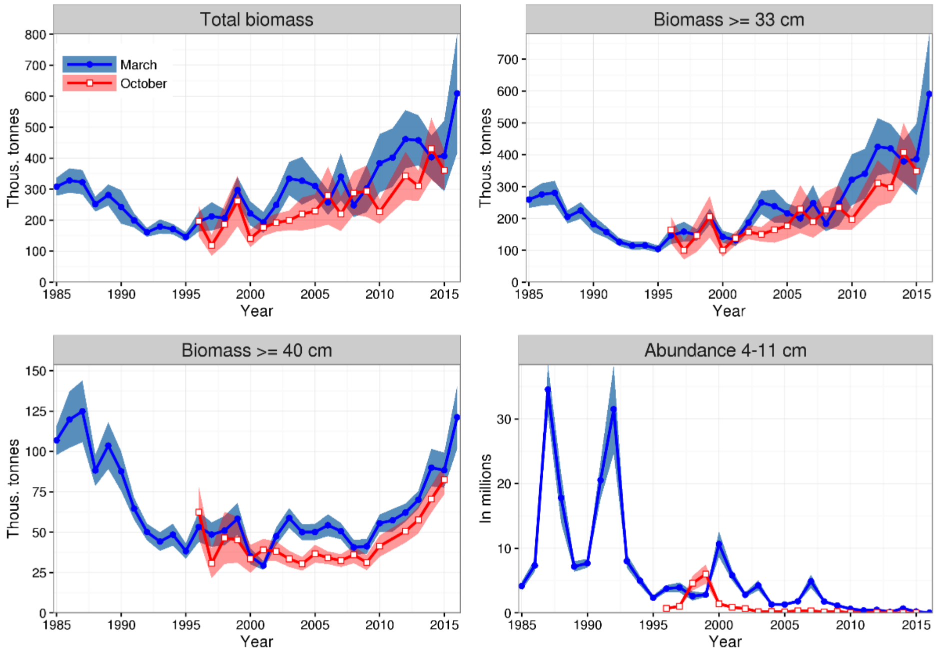


Figure 19.2.1 Indices of golden redfish in ICES Division 5.a (Icelandic waters) from the groundfish surveys in March 1985–2016 (blue line and shaded area) and October 1996–2015 (red lines and shaded areas). The shaded areas show ±1 standard error of the estimate.

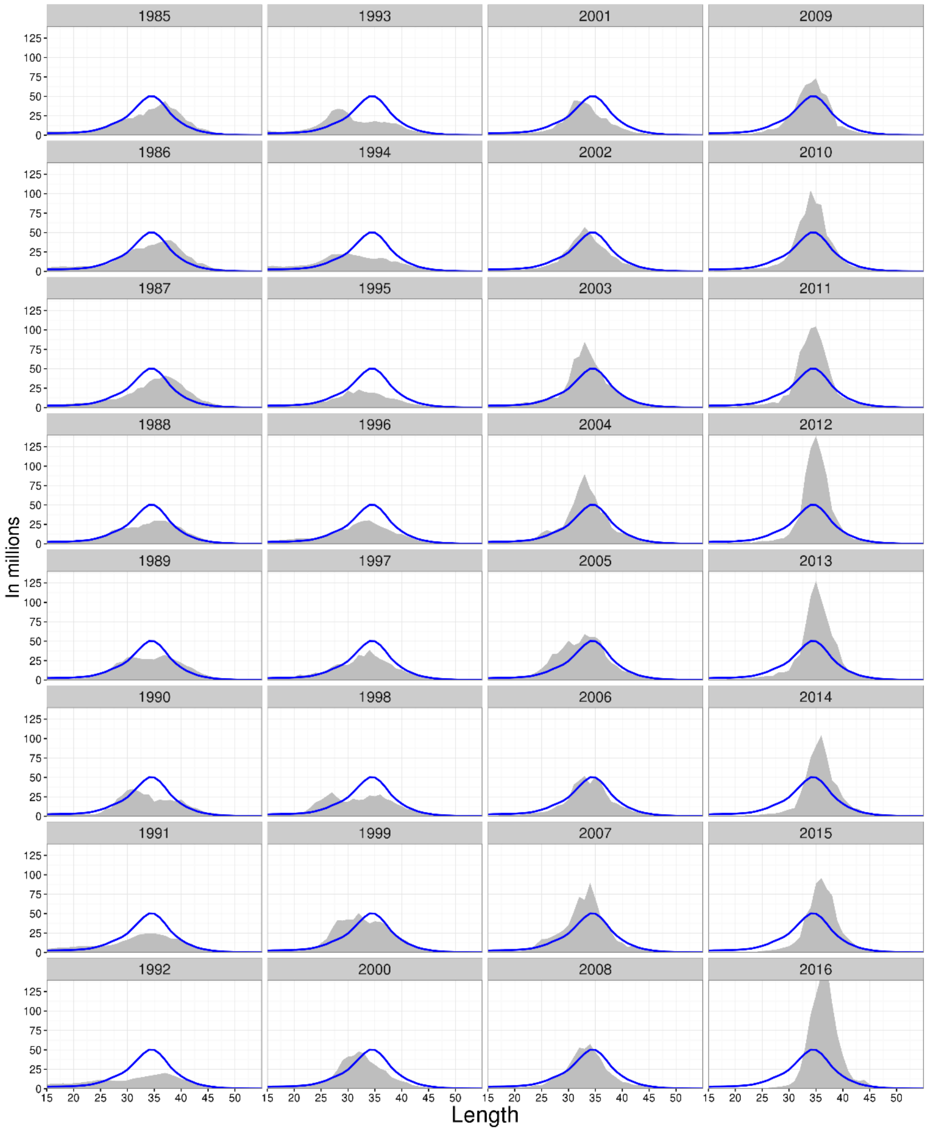


Figure 19.2.2. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in March 1985–2016 conducted in Icelandic waters. The black line is the mean of total indices 1985–2015.

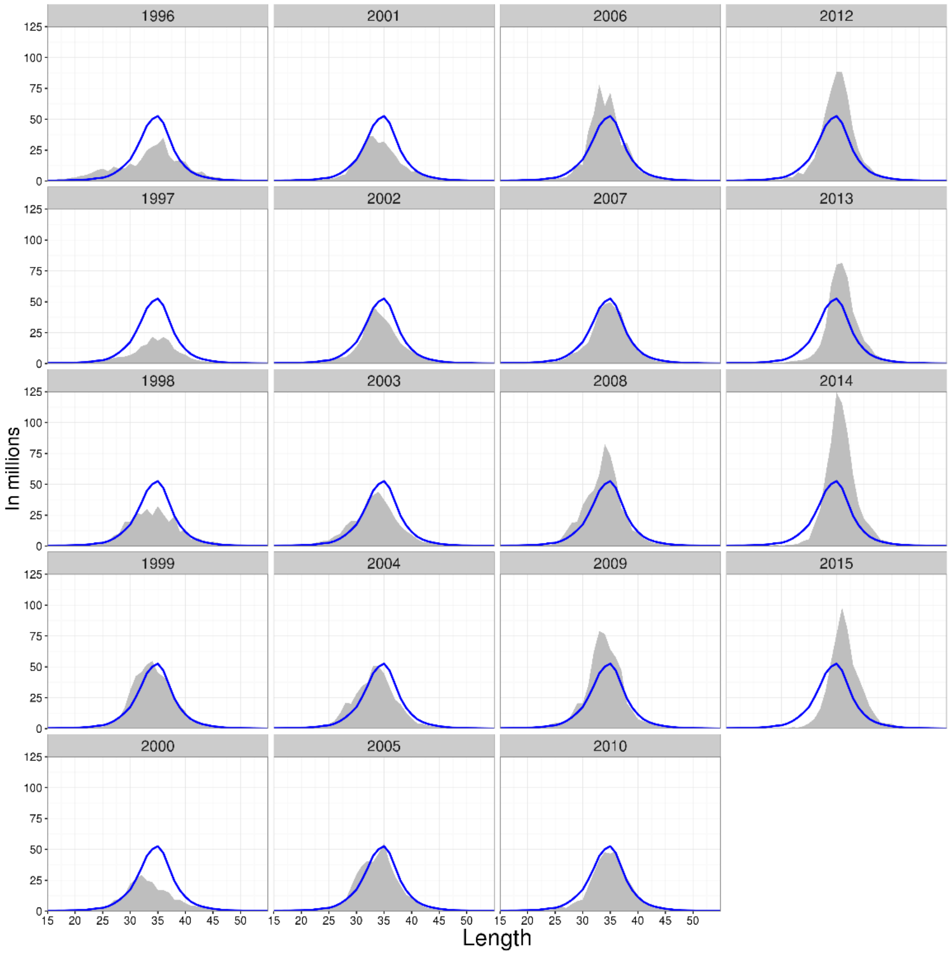


Figure 19.2.3. Length disaggregated abundance indices of golden redfish from the bottom-trawl survey in October 1996–2015 conducted in Icelandic waters. The black line is the mean of total indices 1996–2014. The survey was not conducted in 2011.

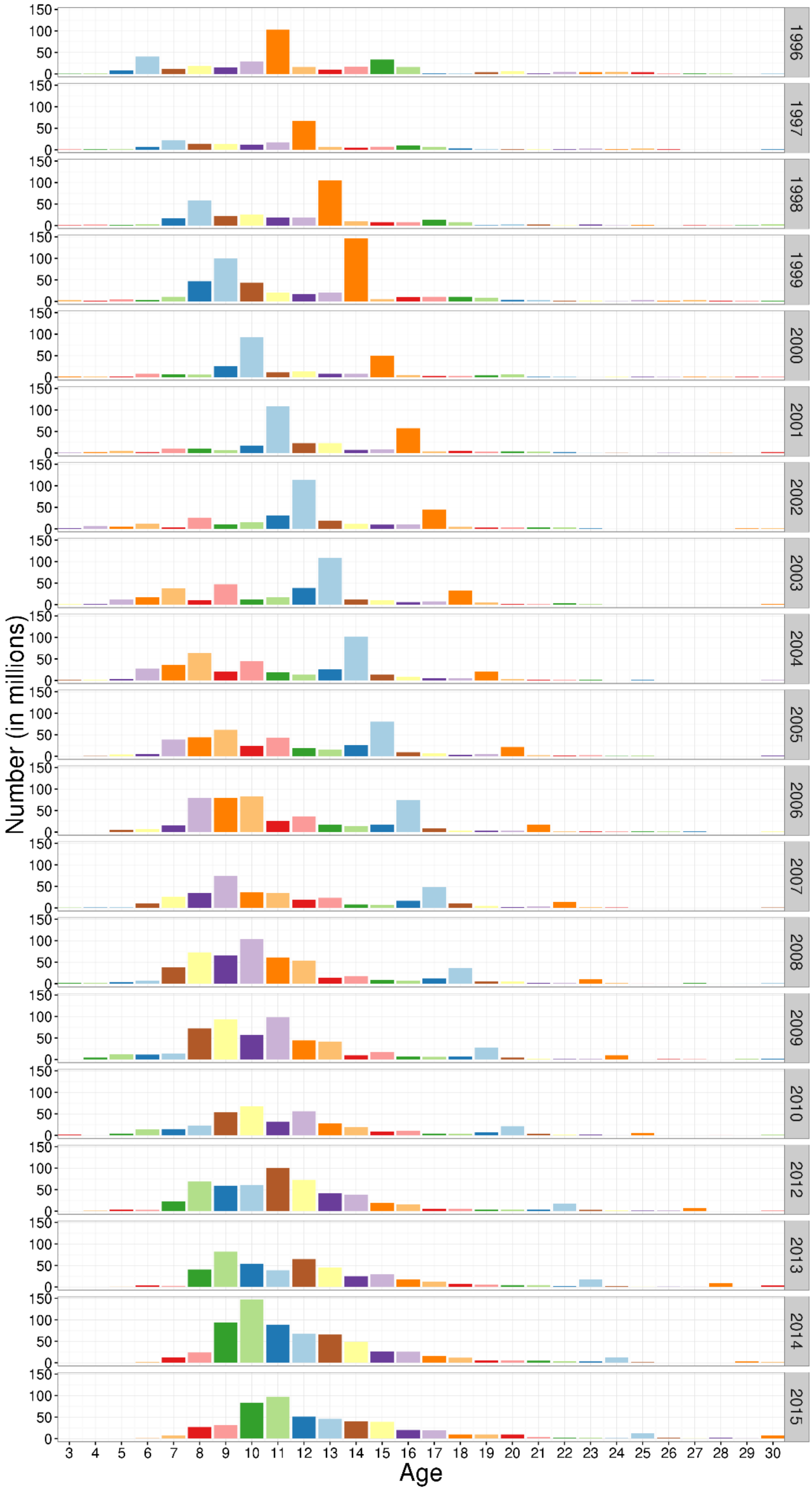


Figure 19.2.4 Age disaggregated abundance indices of golden redfish in the bottom-trawl survey in October conducted in Icelandic waters 1996–2015. The survey was not conducted in 2011.

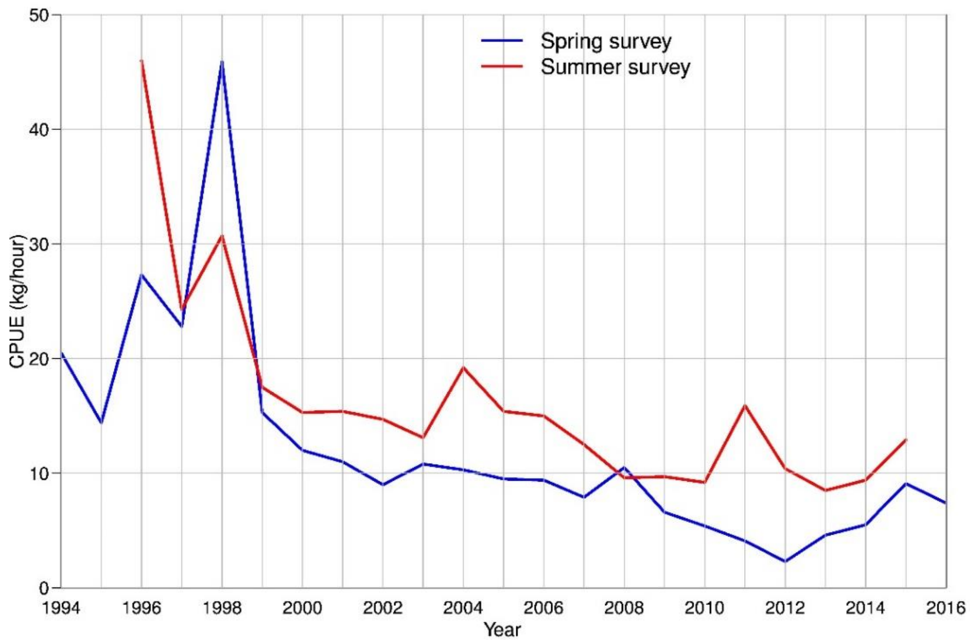


Figure 19.2.5 cpue of golden redfish in the Faroes spring groundfish survey 1994–2016 and the summer groundfish survey 1996–2015 in ICES Division 5.b.

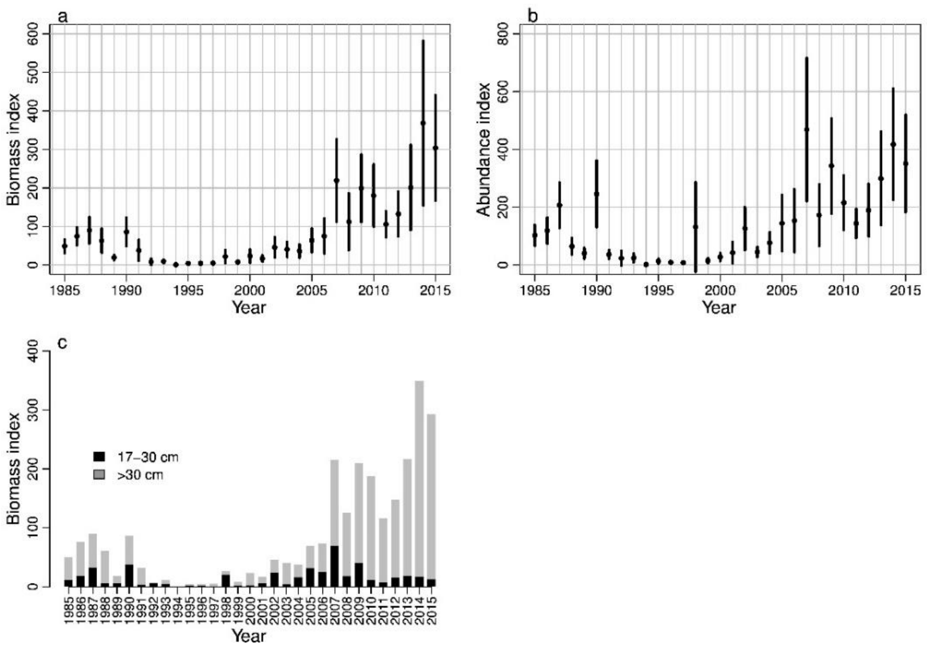


Figure 19.2.6 Golden redfish (>17 cm). Survey abundance indices for East Greenland (ICES Subarea 14) from the German groundfish survey 1985–2015. a) Total biomass index, b) total abundance index, c) biomass index divided by size classes (17-30 cm and > 30 cm).

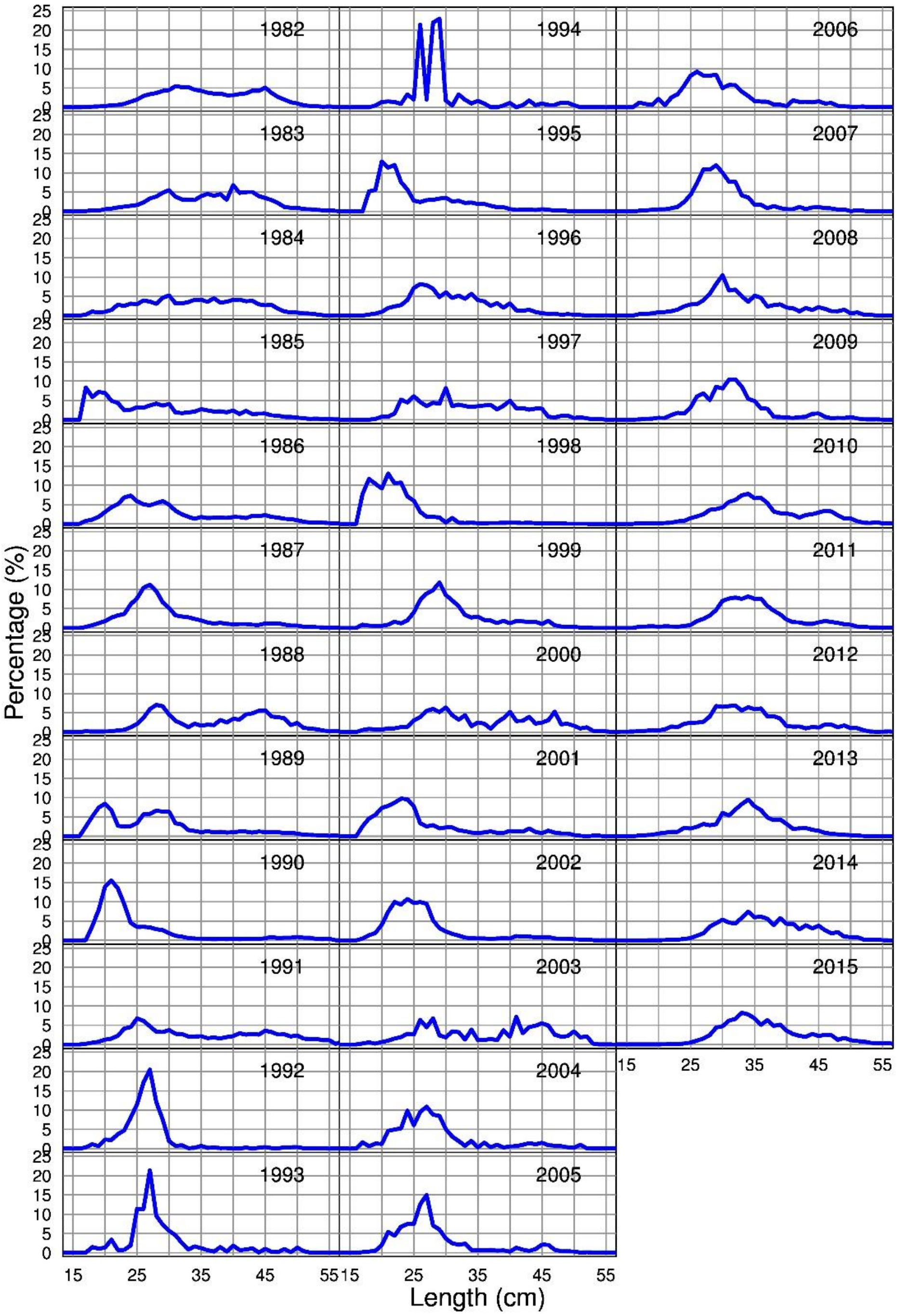


Figure 19.2.7 Golden redfish (>17 cm). Length frequencies for East Greenland (ICES Subarea 14) 1982–2015.

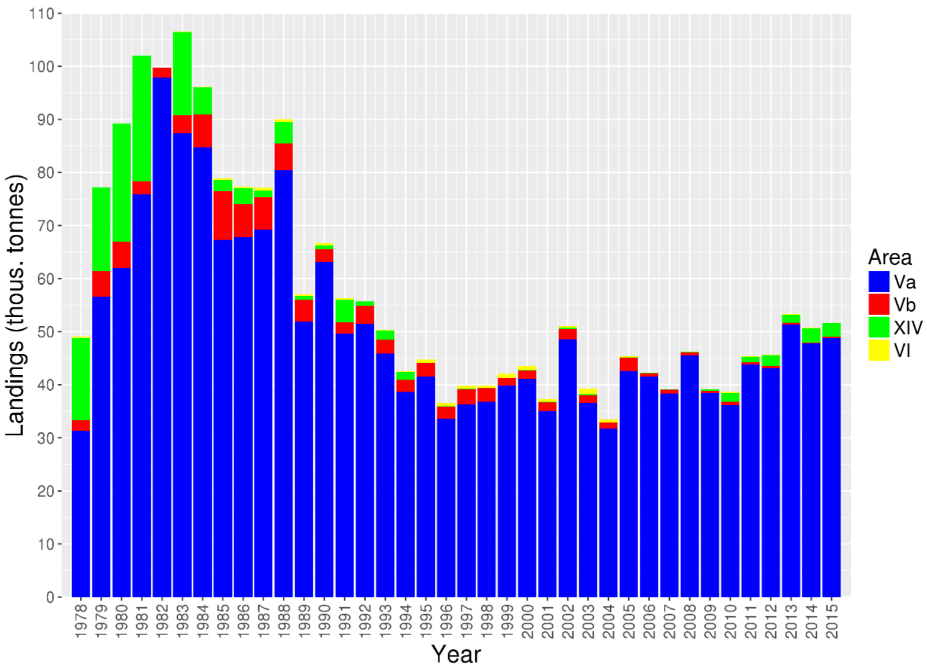


Figure 19.3.1 Nominal landings of golden redfish in tonnes by ICES Divisions 1978–2015. Landings statistics for 2015 are provisional.

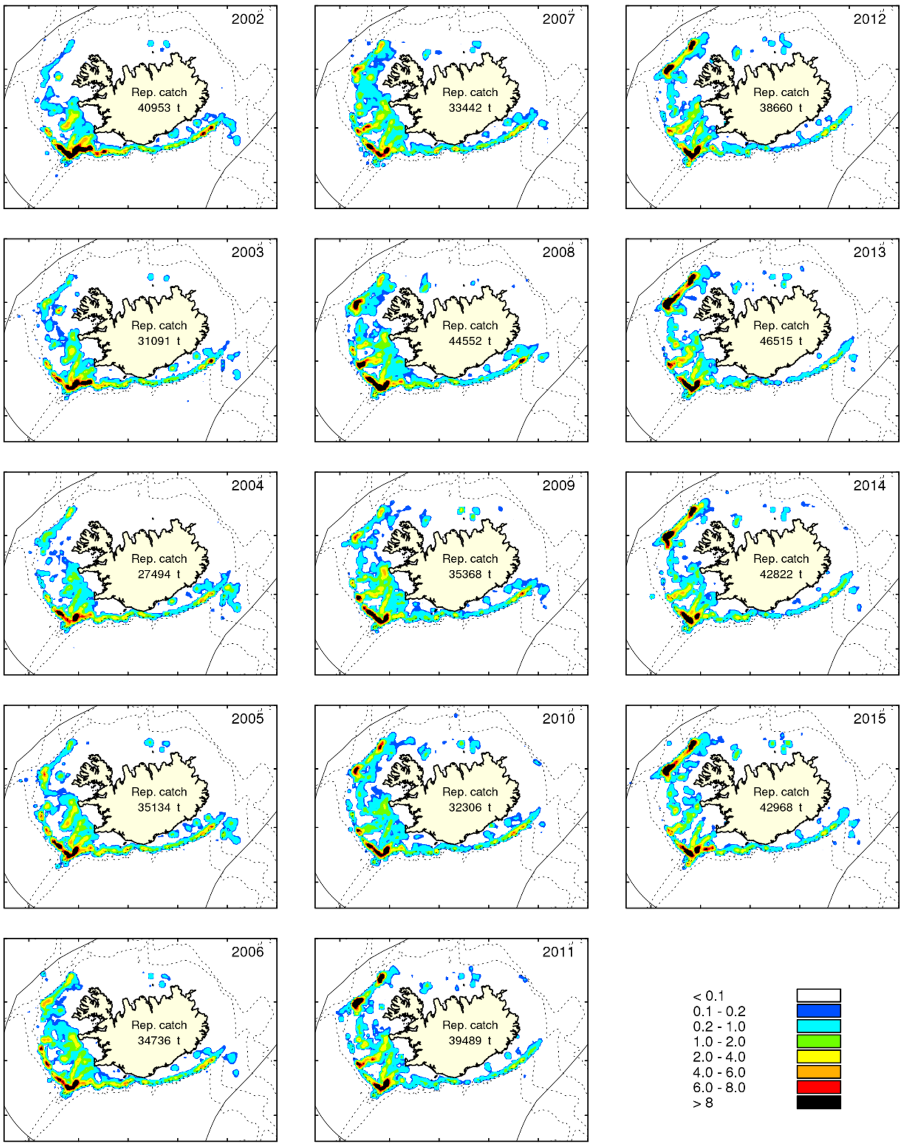


Figure 19.3.2 Geographical distribution of golden redfish bottom-trawl catches in Division 5.a 2002–2015.

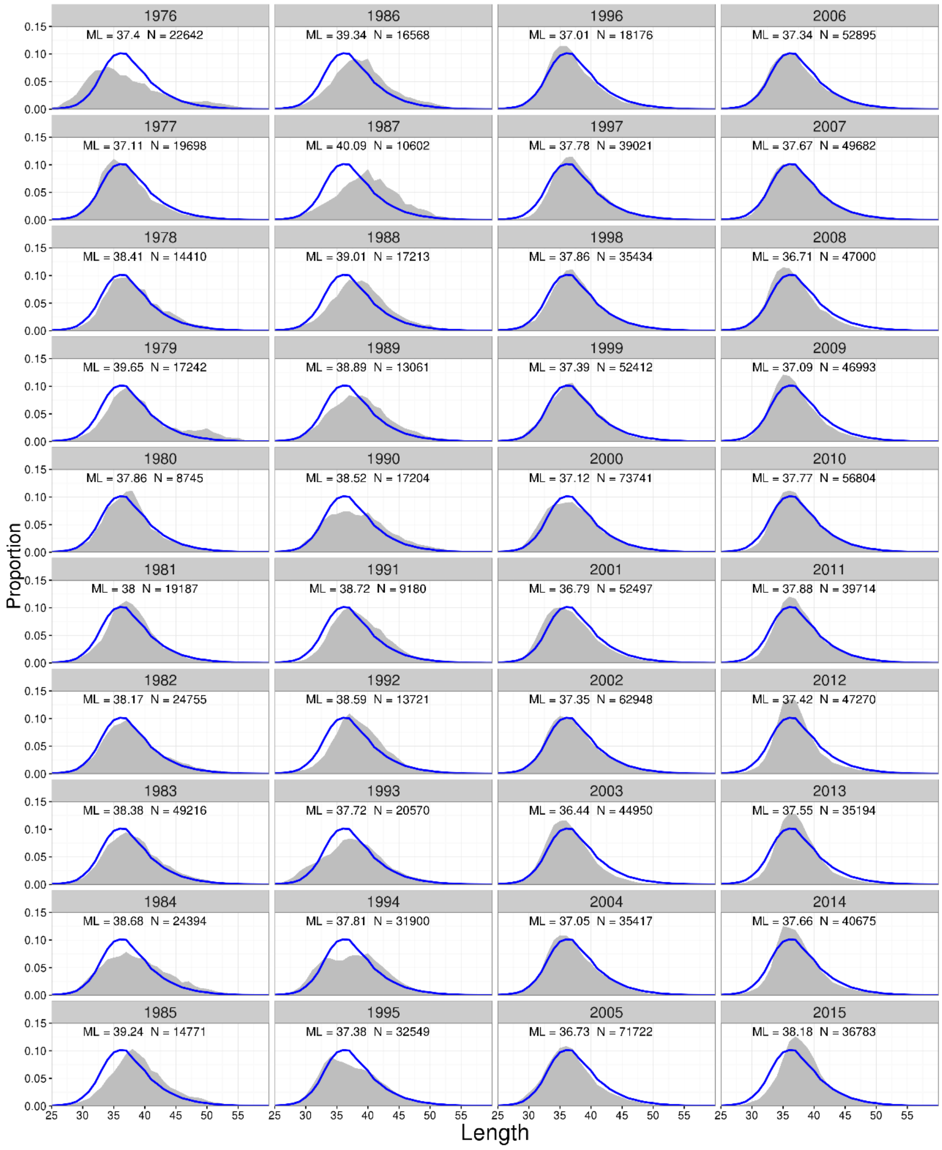


Figure 19.3.3 Length distribution (grey shaded area) of golden redfish in Icelandic waters (ICES Division 5.a) in the commercial landings of the Icelandic bottom-trawl fleet 1976-2015. The blue line is the mean of the years 1976–2014.

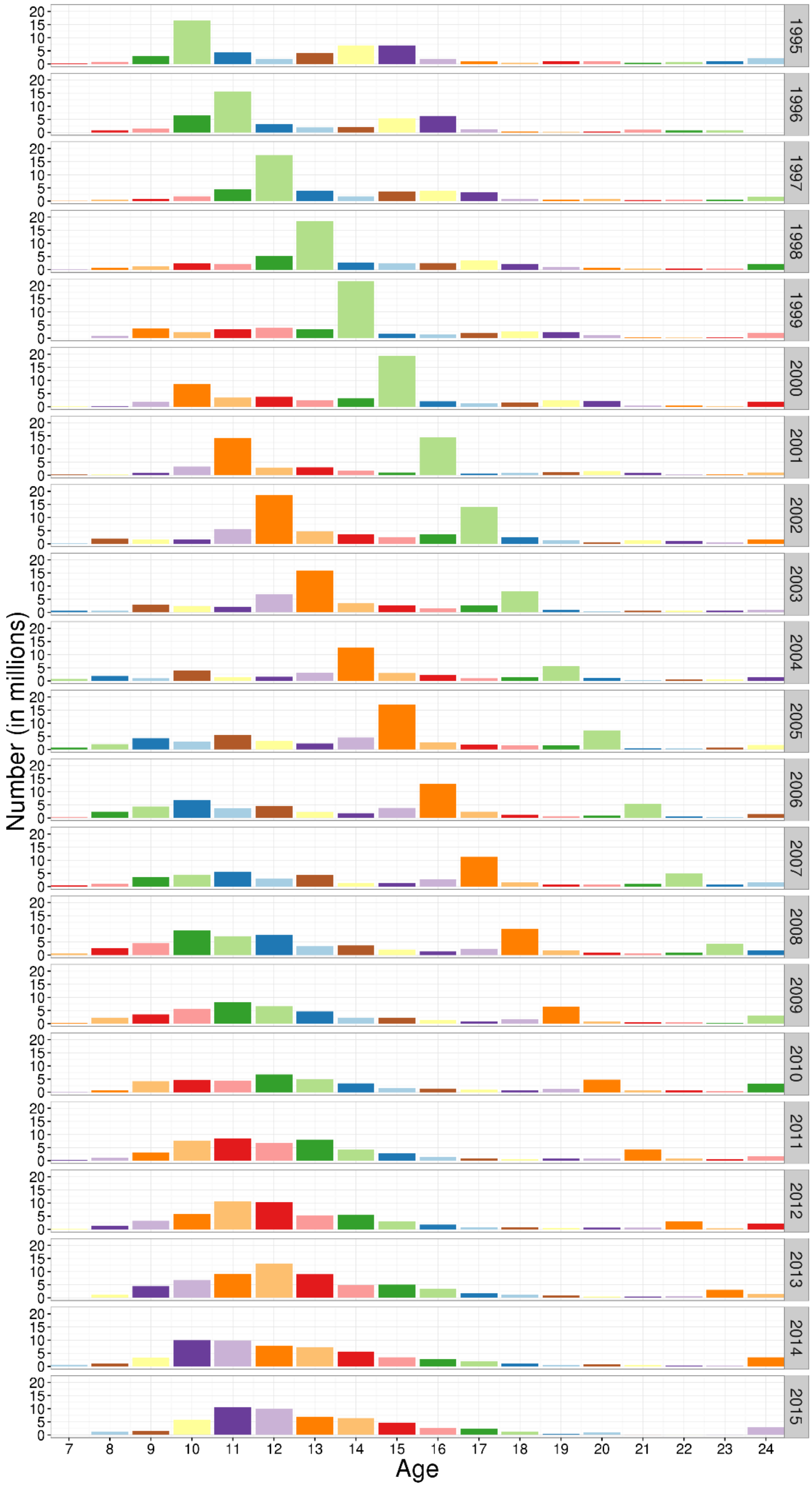


Figure 19.3.4 Catch-at-age of golden redfish in numbers in ICES Subdivision 5.a 1995–2015.

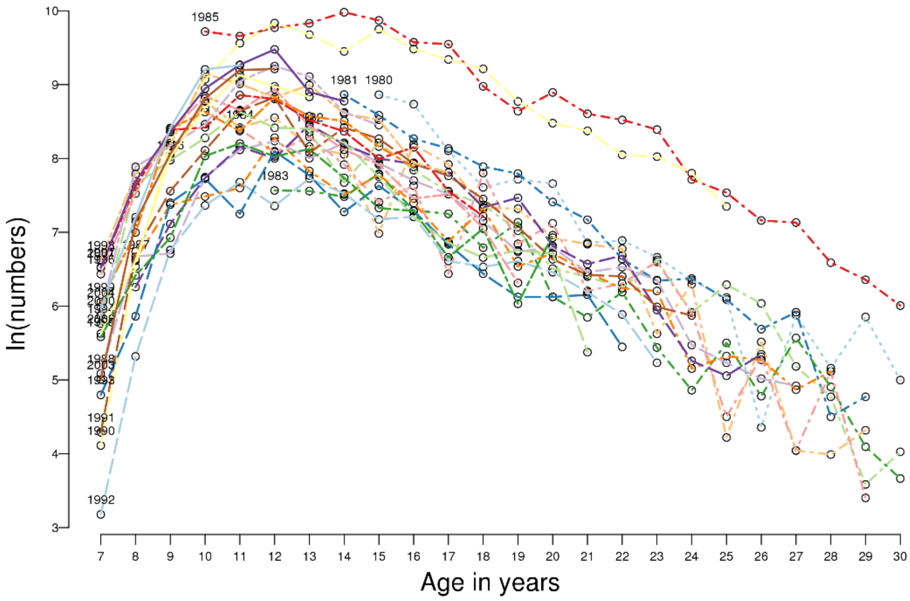


Figure 19.3.5 Catch curve of golden redfish based on the catch-at-age data in ICES Division 5.a 1995–2015.

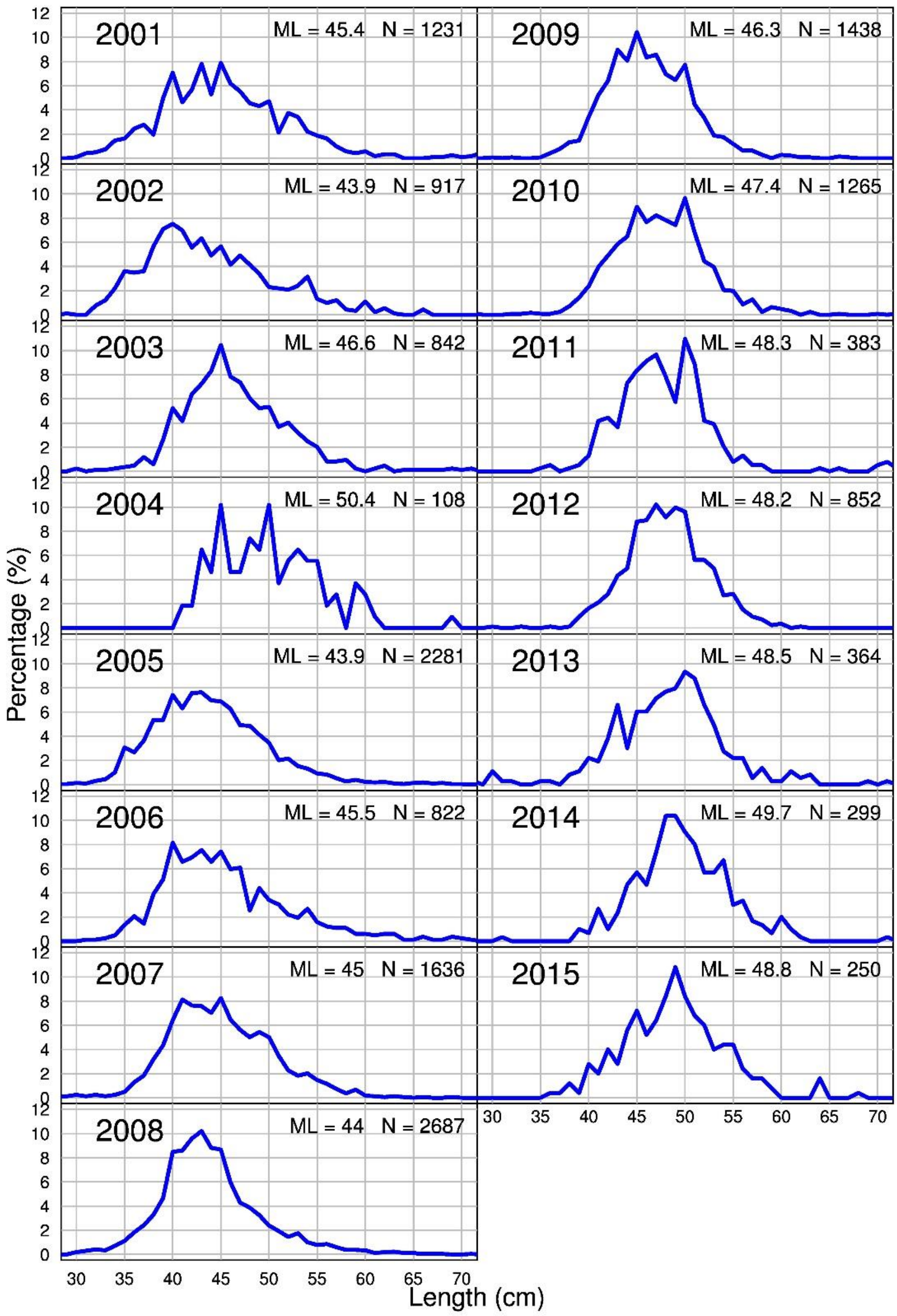


Figure 19.3.6 Length distribution of golden redfish from Faroese catches in ICES Division 5.b in 2001–2015.

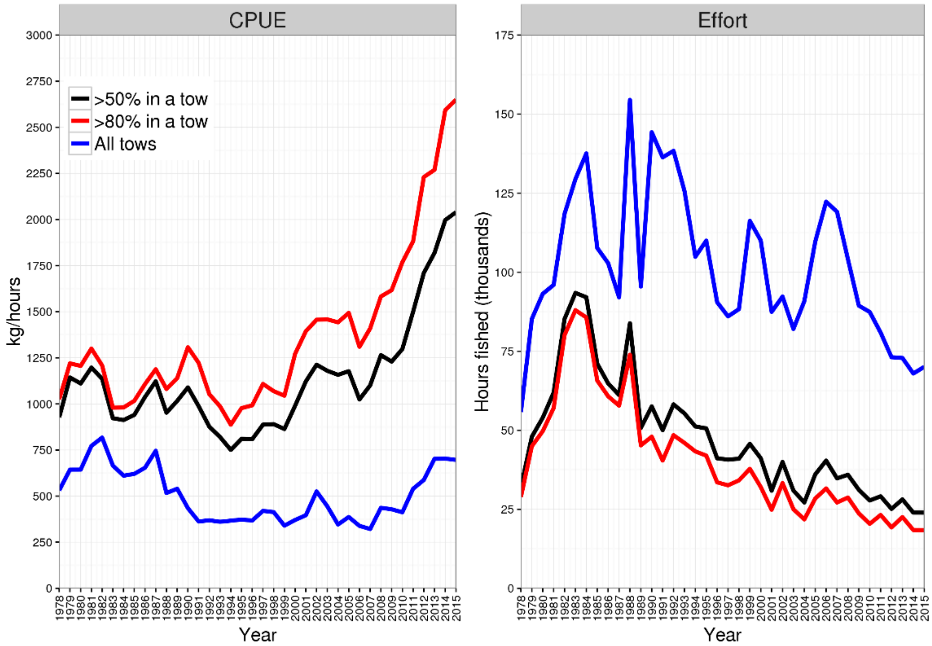


Figure 19.3.7 cpue of golden redfish from Icelandic trawlers 1978–2015 where golden redfish catch composed at least 50% of the total catch in each haul (black line), 80% of the total catch (red line) and in all tows where golden redfish was caught (blue line). The figure shows the raw cpue index (sum(yield)/sum(effort)) and effort.

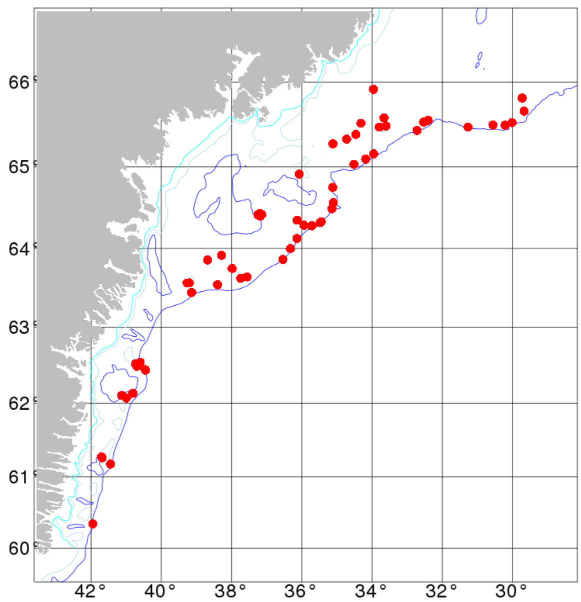


Figure 19.4.1 Stations in the German survey in East Greenland with an area used to compile the indices for Gadget shown. This area corresponds to giving a weight of 0.5 to the results in Figure 19.2.7.

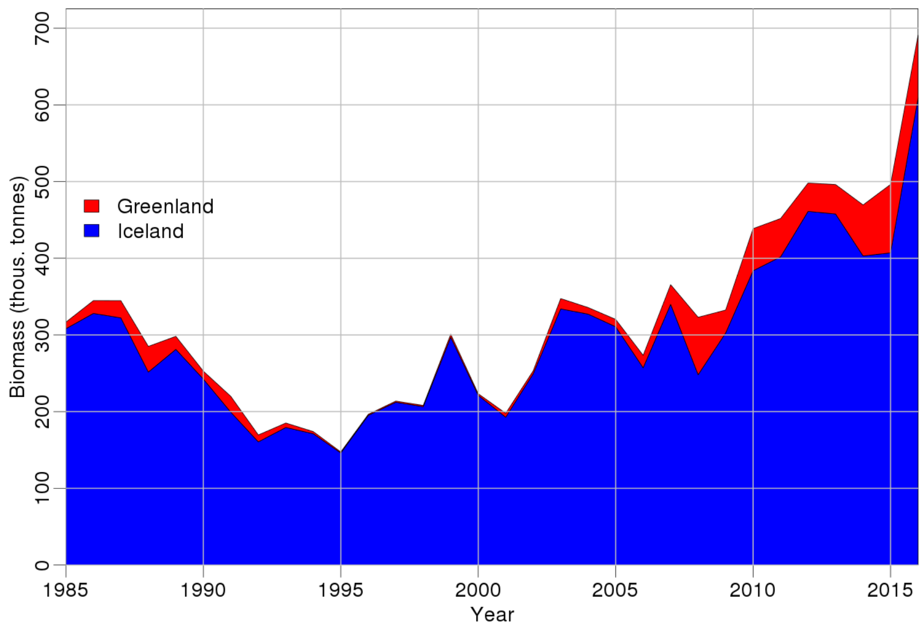


Figure 19.4.2 Biomass index from Iceland (blue) and Greenland black, based on weighting the German survey data in Figure 19.2.7 by 0.5.

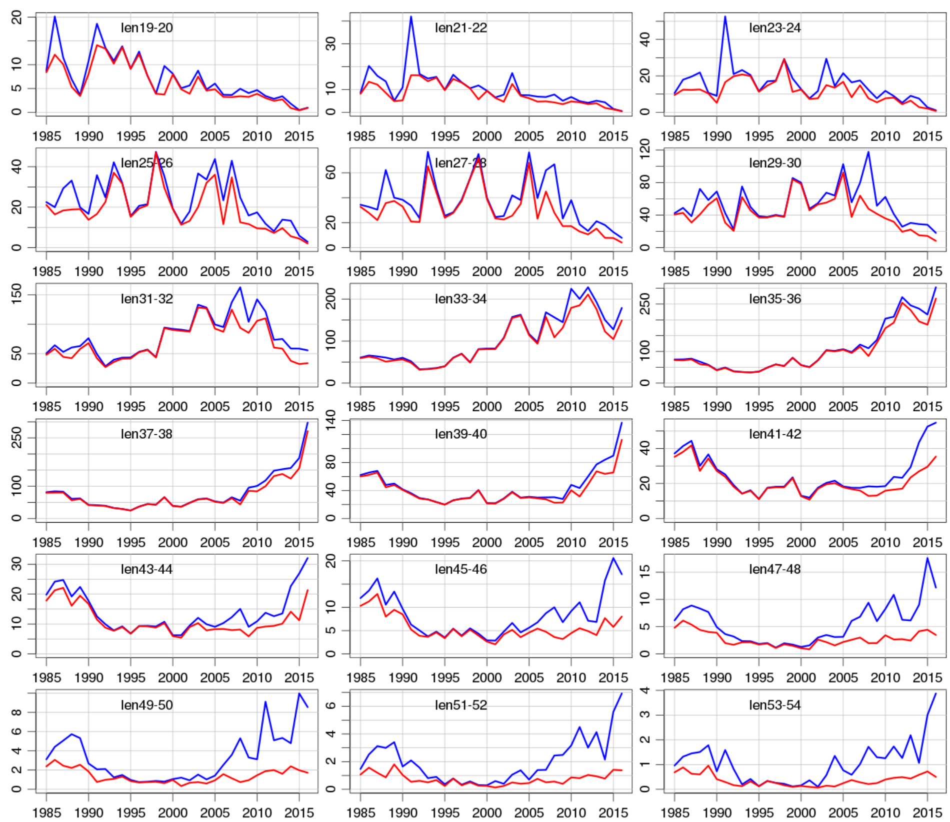


Figure 19.4.3. Indices from the Icelandic March survey (red) and Icelandic March survey plus German survey in Greenland (blue) by length group.

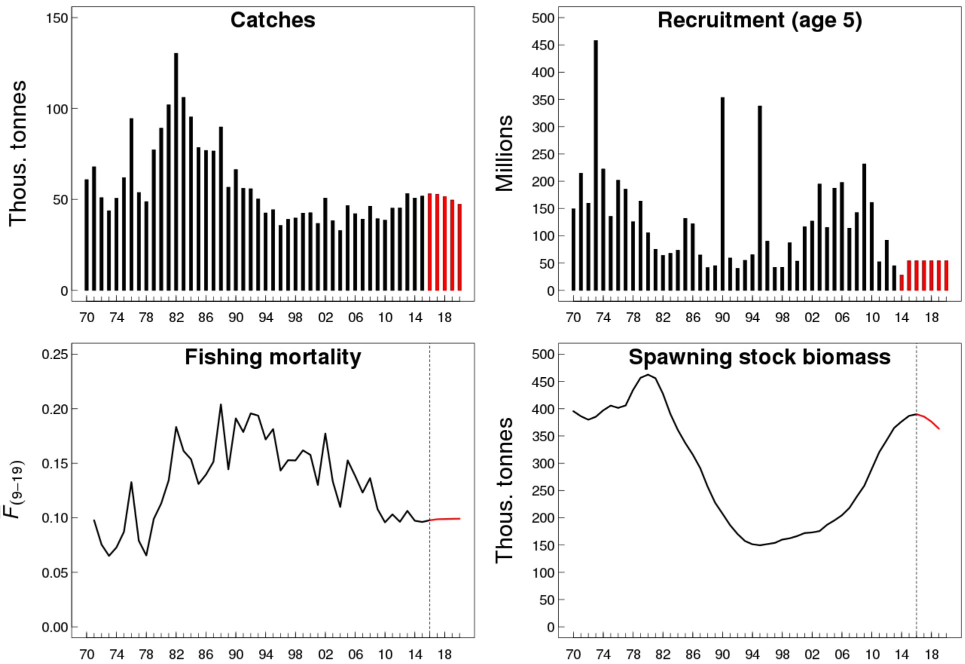


Figure 19.4.4. Summary from the assessment. Red values are predictions. Spawning stock is compiled using a fixed maturity ogive with L50=33cm.

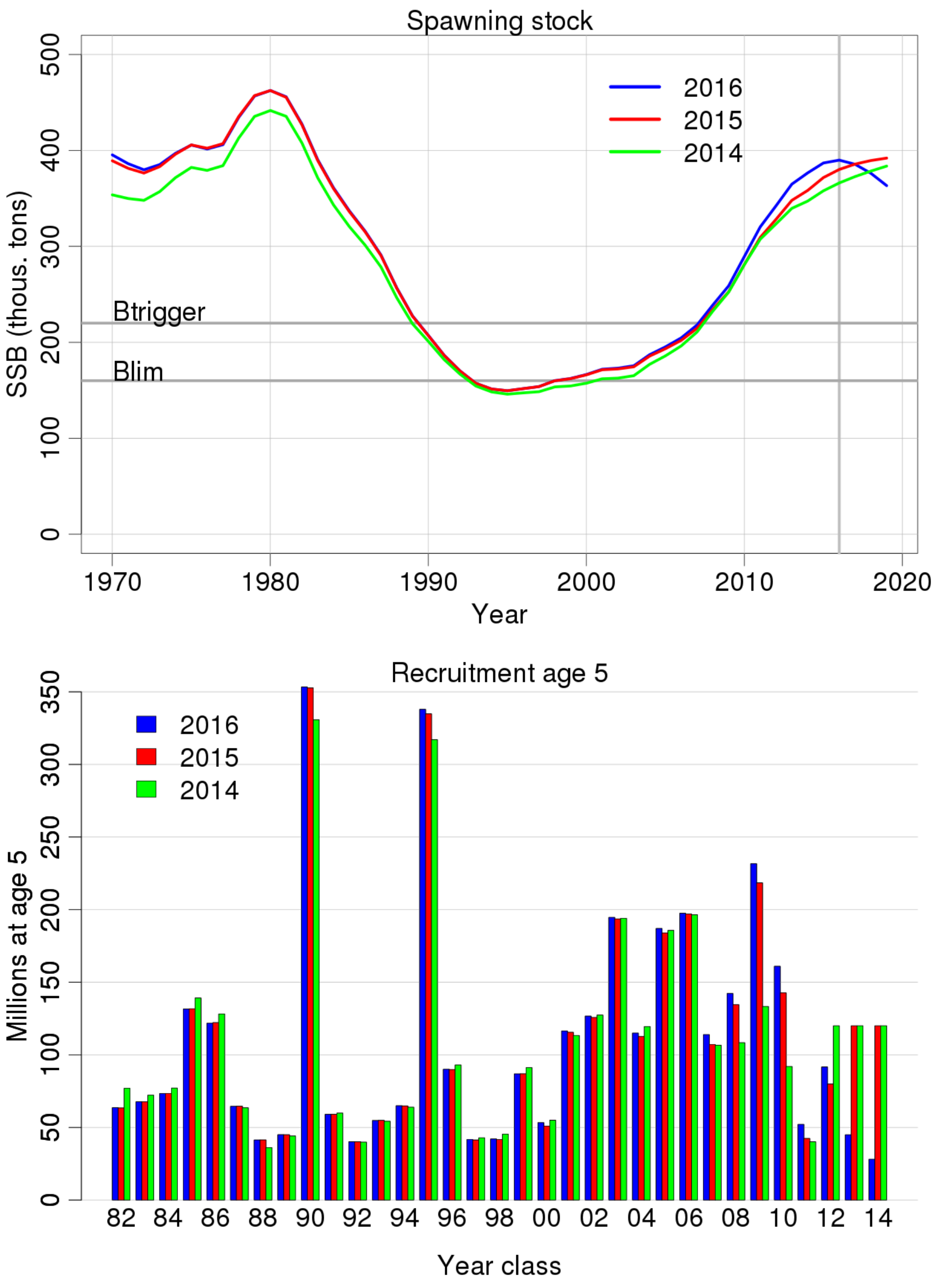


Figure 19.4.5. Comparison of the current assessment and the same assessment done in 2014 and 2015.

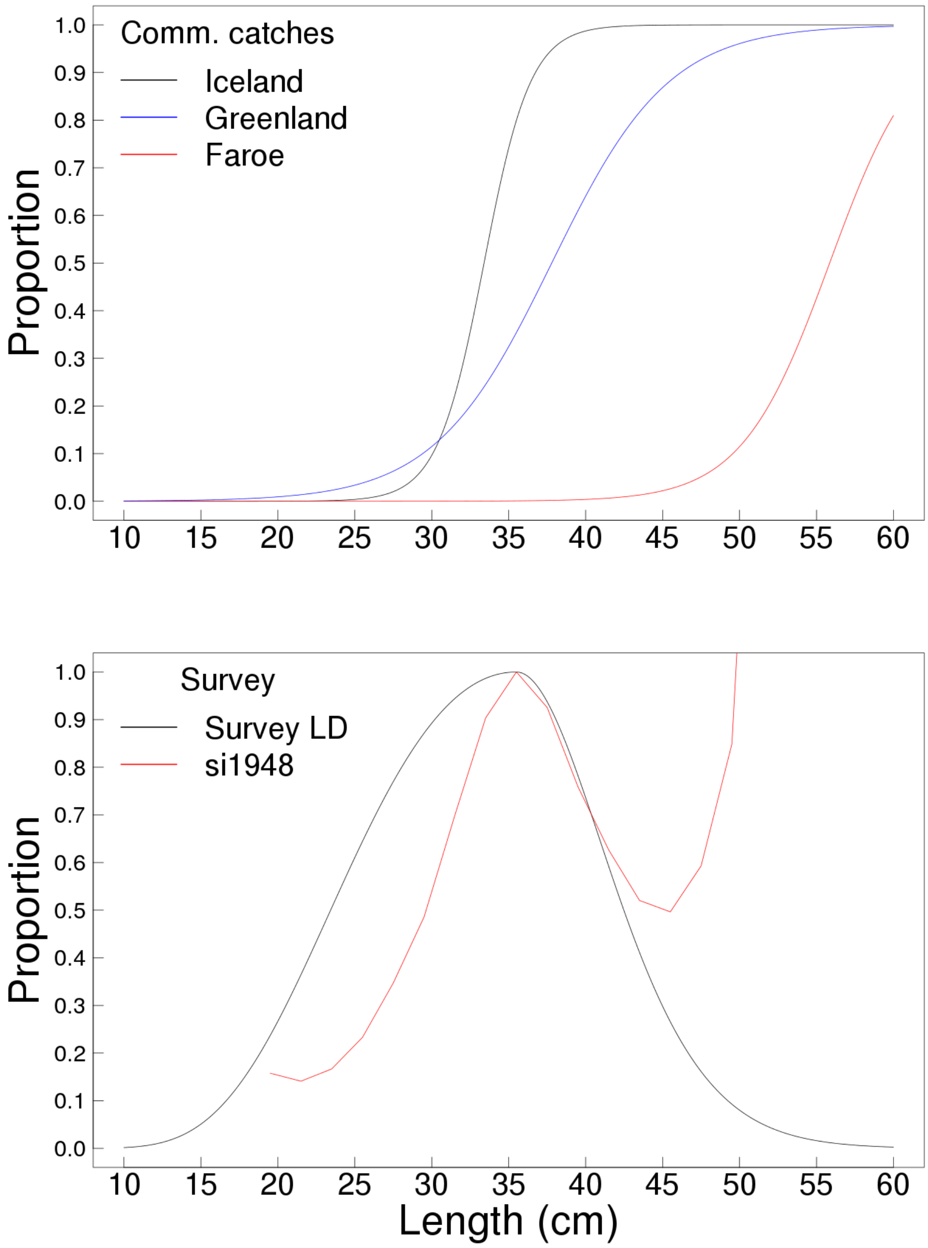


Figure 19.4.6. Estimates of selection curves from commercial catches (upper panel) and from the Icelandic March survey. The black line is the estimated selection curve fitted to the length distributional data and the red line is the estimated q from the disaggregated tuning indices, scaled to one.

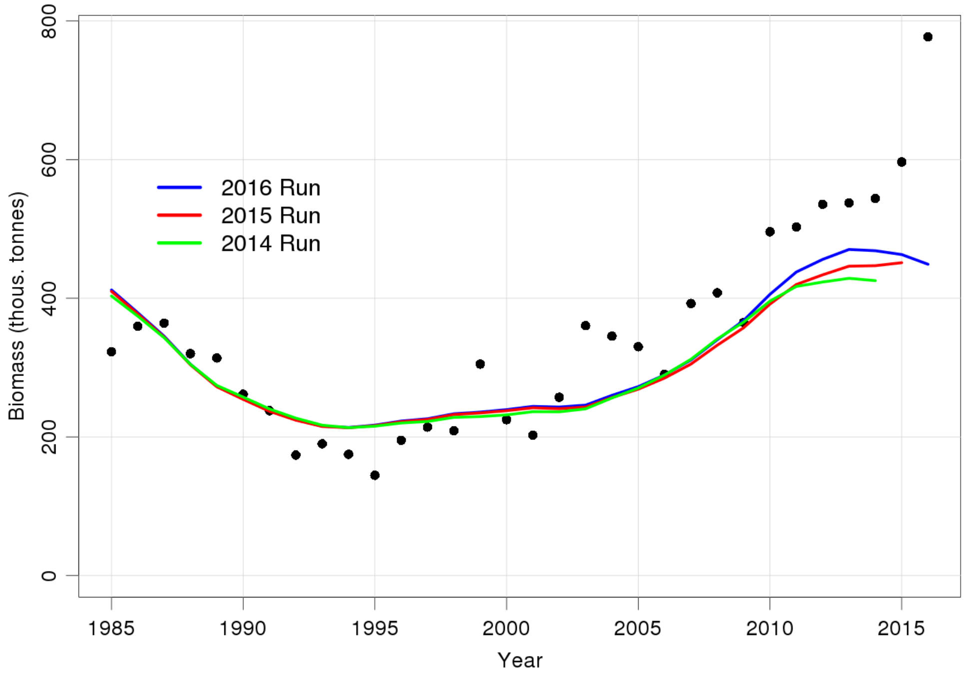


Figure 19.4.7. Comparison of observed and predicted survey biomass from the 2014 (red line) and 2015 (blue) runs.

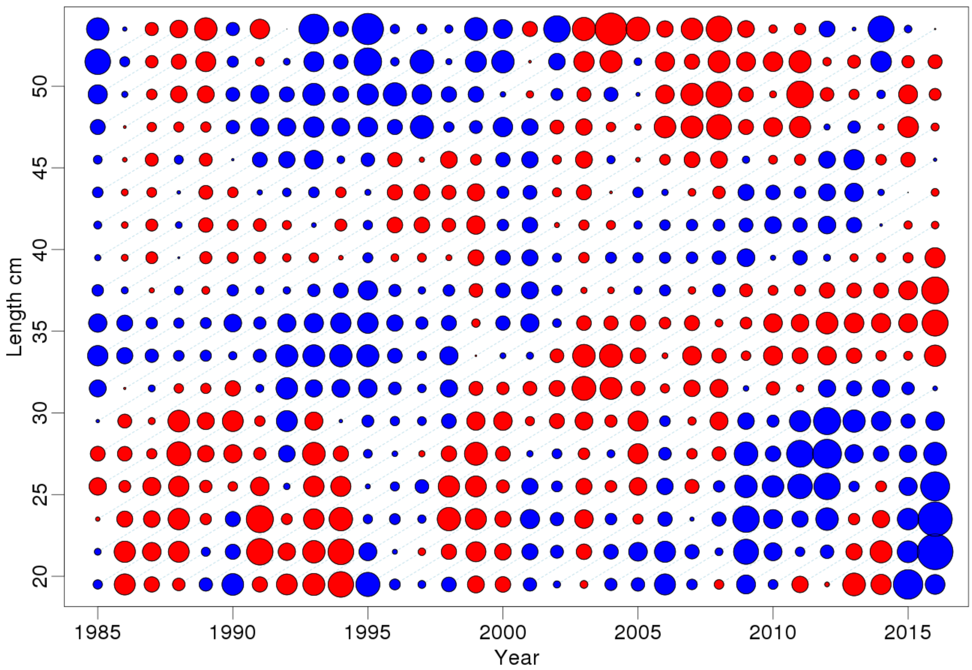


Figure 19.4.8. Residuals from the fit between model and survey indices. The red circles indicate positive residuals (survey results exceed model prediction). Largest residuals correspond to log(obs/mod) = 1

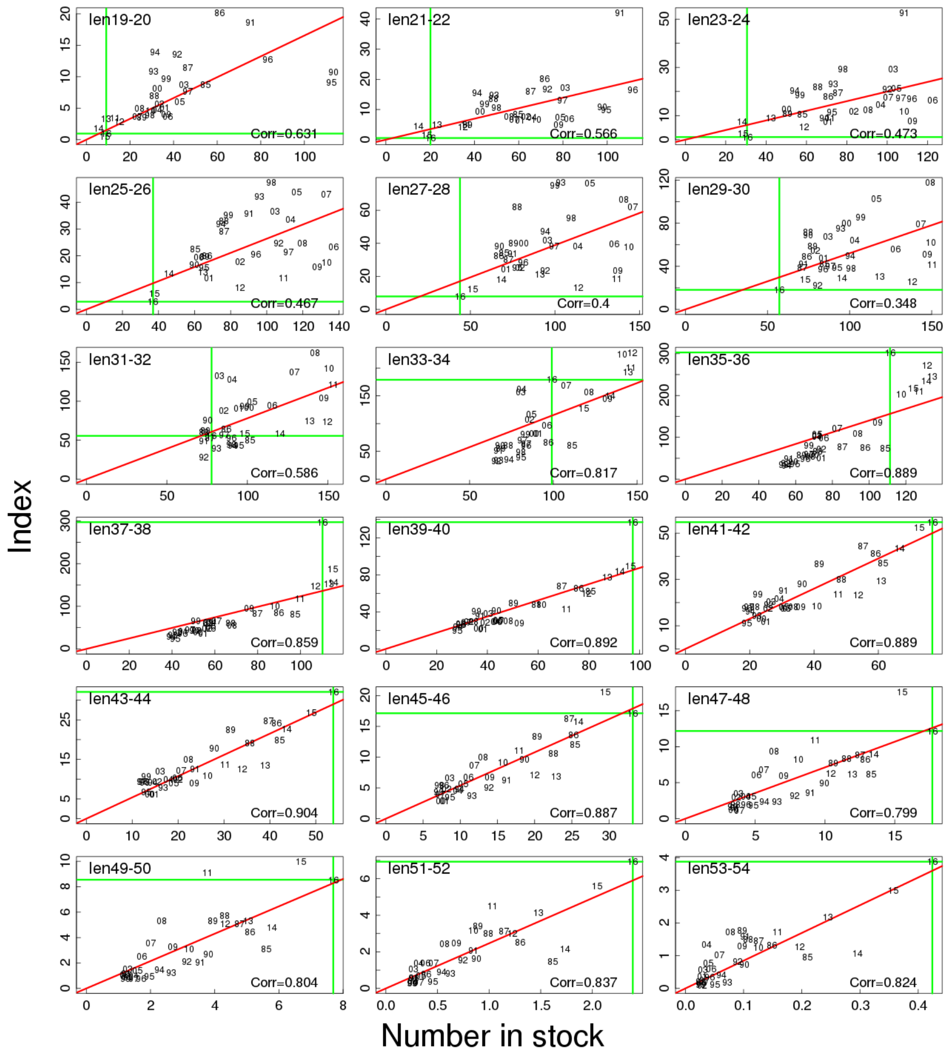


Figure 19.4.9. Fit to length disaggregated survey indices from Gadget run as XY-scatter. The red line is fitted going through the 0-point, the green cross goes over the terminal year.

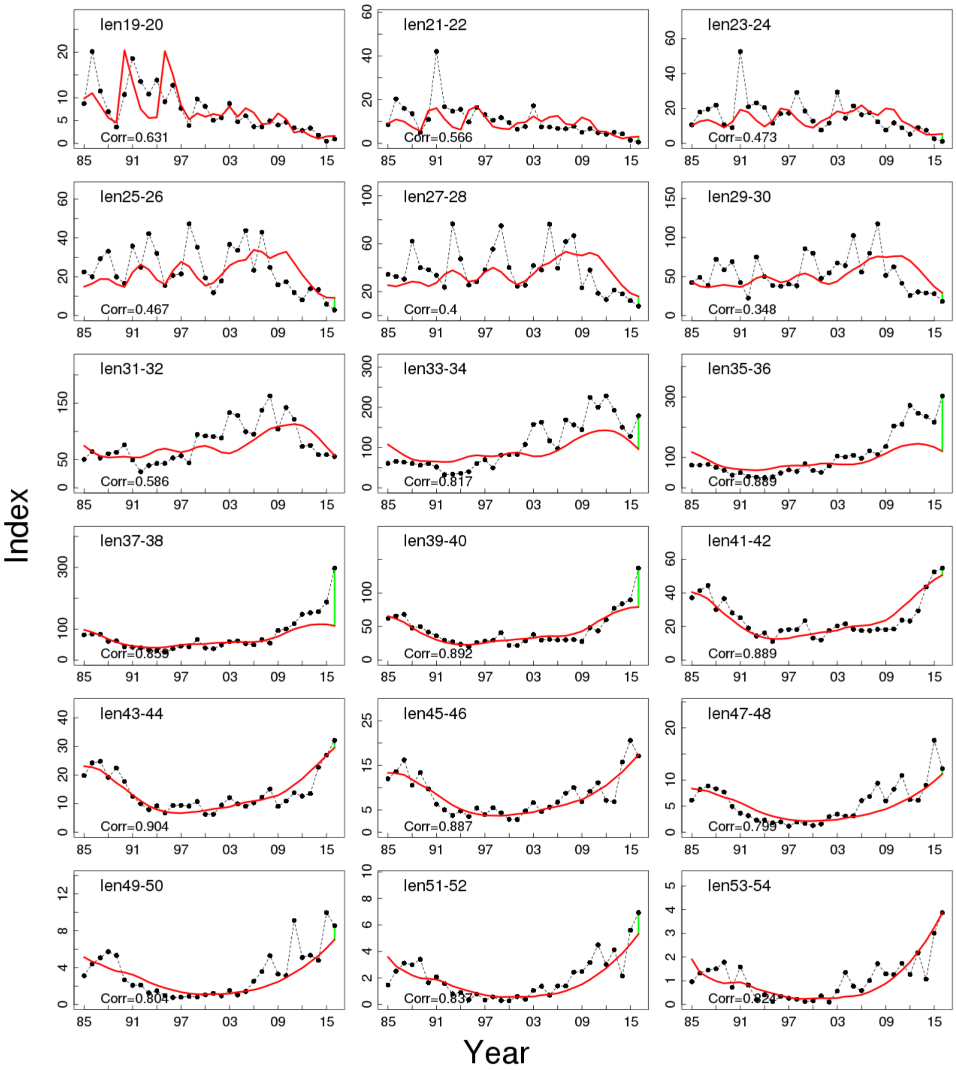


Figure 19.4.10. Fit (red lines) to length disaggregated survey indices (broken lines and points) from Gadget run as time-series.

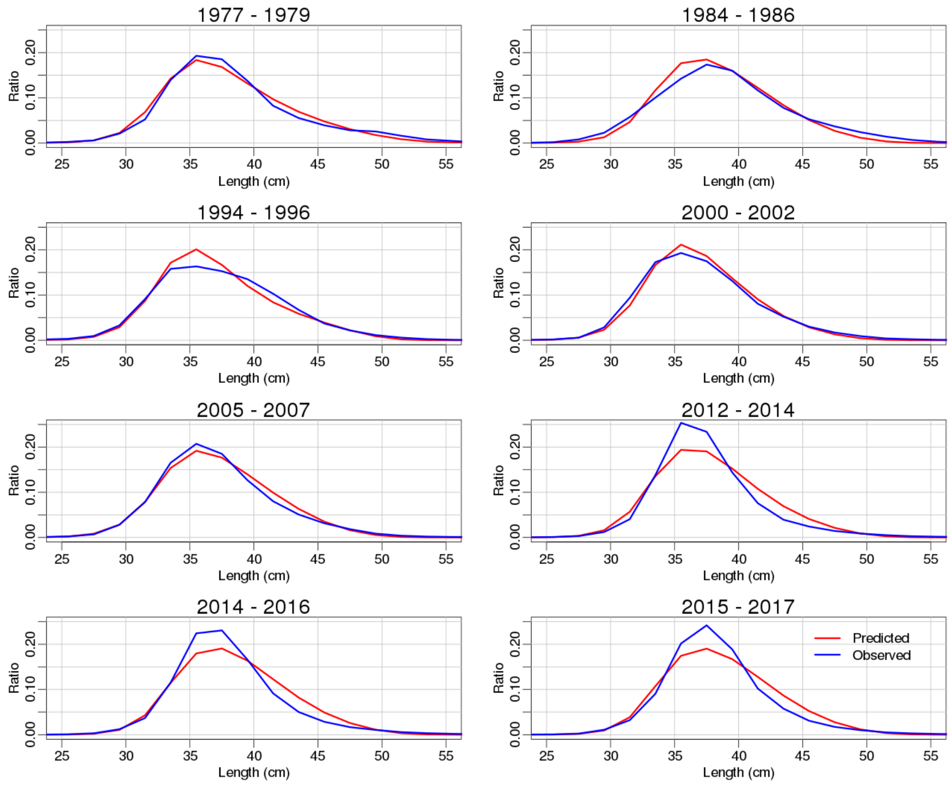


Figure 19.4.11. Fit (red line) to Icelandic commercial length distributions aggregated by 3 years.

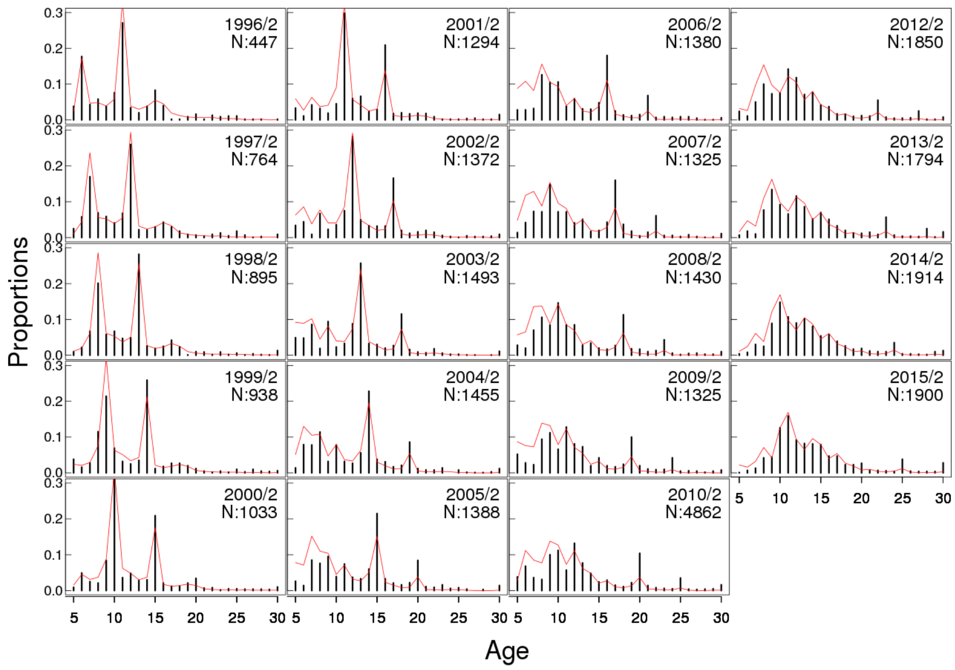


Figure 19.4.12. Fit to survey age data (run 1). Bars represent the data and red lines the fit. The likelihood data are used in the model as proportions in each 2 cm length group but presented here as total for each age group something that should only be comparable if catchability was independent of size (age).

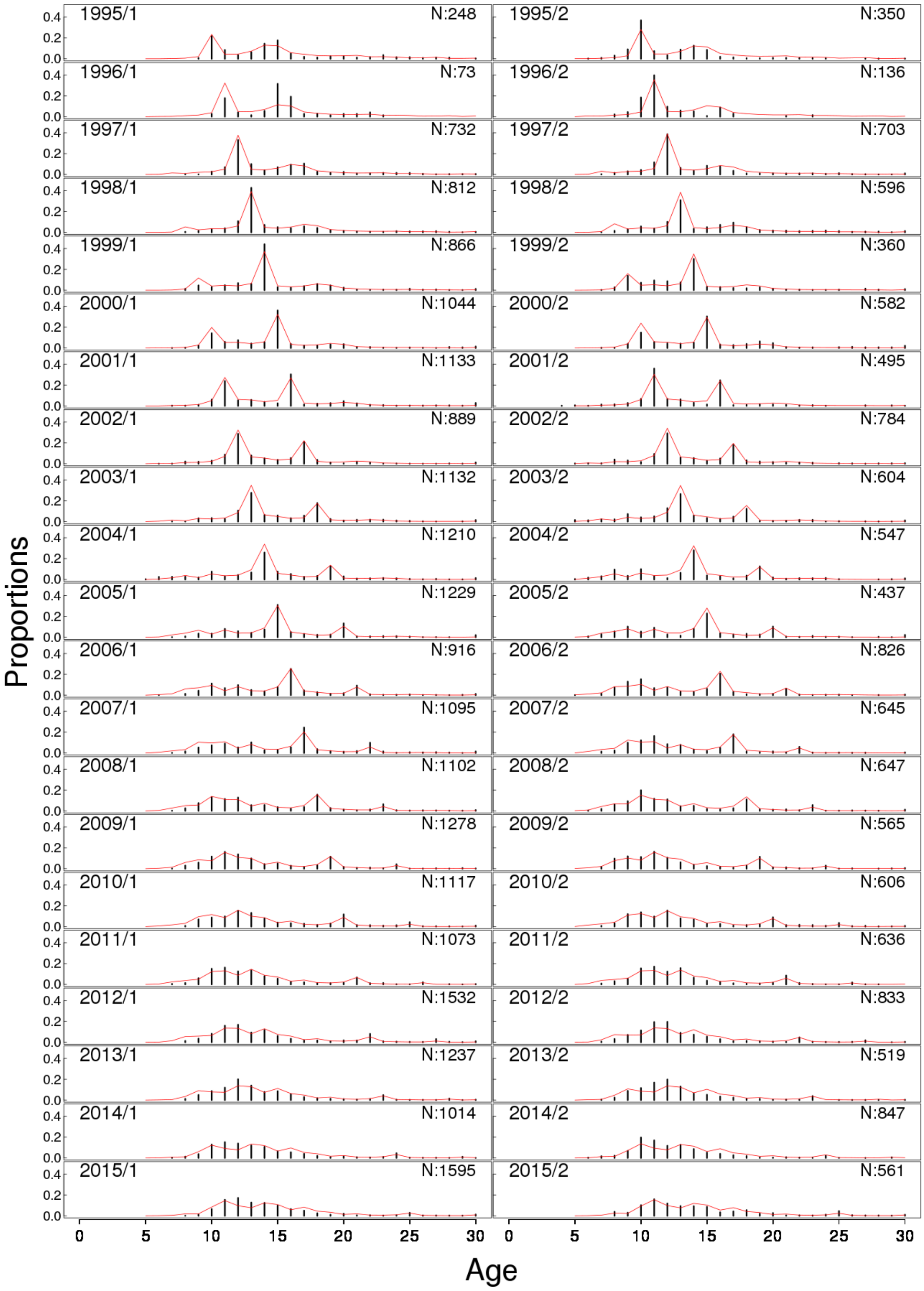


Figure 19.4.13. Predicted (red) and observed (blue) age distributions from Icelandic commercial fishery.

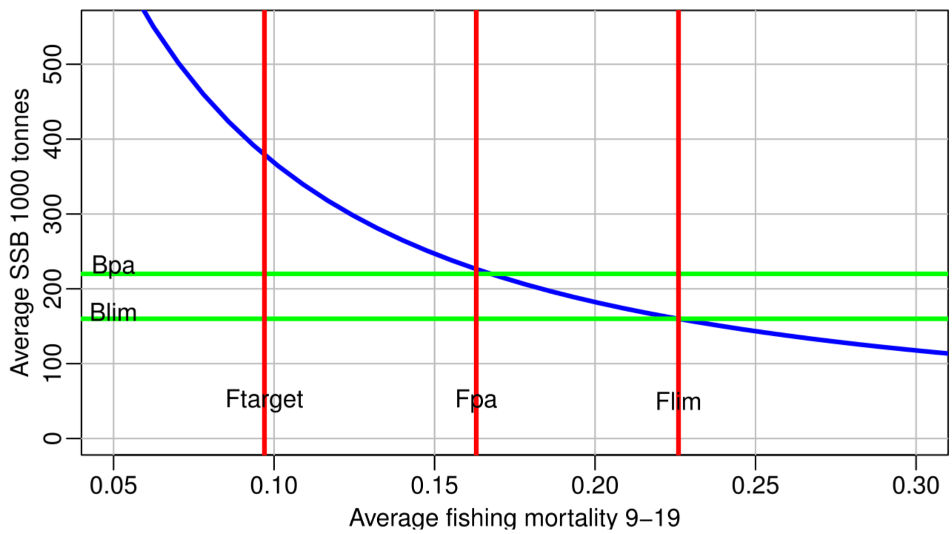


Figure 19.6.1. Average SSB against average fishing mortality and defined reference points.

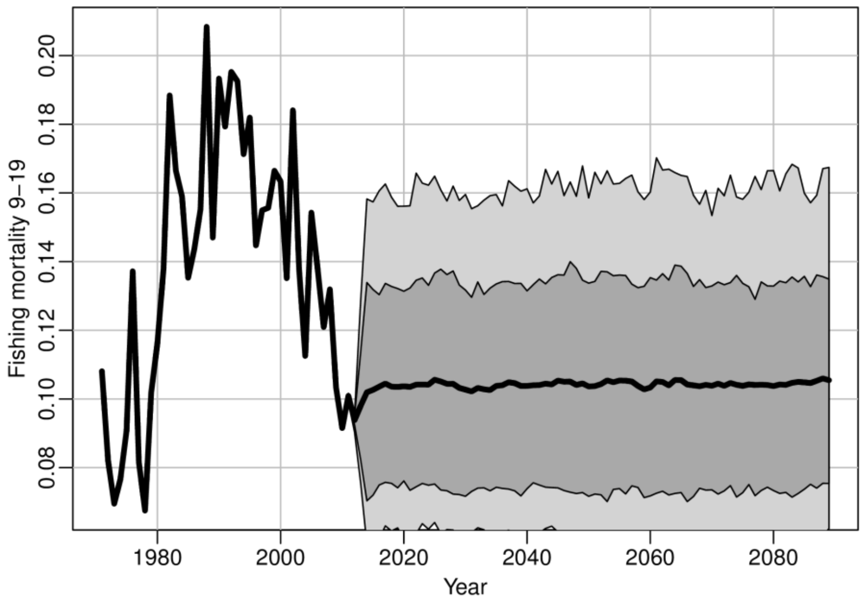


Figure 19.6.2. Development of F_{9-19} based on F_{9-19} = 0.097. The light grey area shows fifth and 95th quantile and the dark areas 16th and 84th quantile.

20 Icelandic slope *Sebastes mentella* in 5.a and 14

20.1 Stock description and management units

The stock structure of *Sebastes mentella* in the Irminger Sea and adjacent water is described in Chapter 18 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.

20.2 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 5.a, 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 2000–2015. No survey was conducted in 2011. A description of the autumn survey is given in Stock Annex for the species.

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 gradually decreased until 2013 and to similar level as in 2003 when it was lowest in the time-series (Table 20.2.1 and Figure 20.2.1*a* and *b*). The biomass index increased again and was in 2014 and 2015 similar as in 2004 (Table 20.2.1 and Figure 20.2.1*a* and *b*). The biomass index of fish 45 cm and larger was at lowest level in 2007 but increased again in 2009 were it was at similar level until 2013 (Figure 19.2.1*c*). The biomass index of 45 cm and larger fish increased sharply since then and was in 2015 the highest in the time-series.

The abundance index of fish 30 cm and smaller has in 2007–2015 been at lowest level (Figure 20.2.2*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 2012–2015 (Figure 20.2.2). Very little Icelandic slope *S. mentella* smaller than 35 cm was observed in the surveys in recent years.

Otoliths have been sampled since 2000 and otoliths from the 2000, 2009 and 2010 surveys have been age read. Figure 20.2.3 shows that the 1985 and the 1990 year classes are the most abundant ones in this samples.

20.3 Information from the fishing industry

20.3.1 Landings

Total annual landings of Icelandic slope *S. mentella* from ICES Division 5.a 1978—2015 are presented in Table 20.3.1 and from 1950—2015 in Figure 20.3.1. Annual landings gradually decreased from a record high of 57 000 t in 1994 to 17 000 t in 2001. 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 2013–2015 between 8 700–9 500 t and the decrease is related to lower TAC for the species.

20.3.2 Fisheries and fleets

Most of the fishery for Icelandic slope *S. mentella* in 5.a 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 20.3.2). The proportion of Icelandic slope *S. mentella* catches taken by pelagic trawls 1991–2000 varied between 10 and 44% of the total landings (Table 20.3.2). In 2001–2015, 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 20.3.3).

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 20.3.2). This area has historically been an important fishing area for Icelandic slope *S. mentella*.

20.3.3 Sampling from the commercial fishery

The table below shows the 2015 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
5.a	Iceland	Bottom trawl	9 311	53	8 530

20.3.4 Length distribution from the commercial catch

Length distributions of Icelandic slope *S. mentella* in 5.a from the bottom-trawl fishery show an increase in the number of small fish in the catch in 1994 compared to previous years (Figure 20.3.5). The peak of about 32 cm in 1994 can be followed by approximately 1 cm annual growth in 1996–2002. The fish caught in 2004–2014 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 20.3.5).

20.3.5 Catch per unit of effort

Trends in raw cpue and effort are shown in Figure 20.3.6. cpue gradually decreased from 1978 to a record low in 1994, but has since then slightly increased annually to 2000. The cpue estimate in 2015 was at similar level as in late 1980s and about 40% higher than it was in 1994. The cpue has been stable since 2010. From 1991–1994, when cpue decreased, the fishing effort increased drastically. Since then, effort decreased and is now at similar level as in the early 1980s.

20.3.6 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.

20.4 Methods

No analytical assessment was conducted on this stock.

20.5 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 5.a 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 in 2014. Same advice was applied for the 2015 fishing year, but was 10 775 t for 2016. Annual TAC set by the Icelandic government was 10 000 t in 2014–2016.

20.6 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 5.a.

The fishable biomass index of Icelandic slope *S. mentella* from the Icelandic autumn survey shows that the biomass index for 2004–2013 has decreased to similar level as in 2003 when it was at lowest level, but increased again in 2014 and 2015. The survey was not conducted in 2011. Standardized 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 gradually increased from 1995 -2010 to a similar level as in the late 1980s and has since then been at that level.

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.

20.7 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 and 2015 were 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 5.a between 2002–2003 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.

20.8 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). Below is the description of the formulation of the advice for the 2017 fishing year.

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 2017 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 advice last year. The biomass is estimated to have increased by 41.2% between average of 2011–2013 (no survey conducted in 2011, but was set to the average of 2010 and 2012) and 2014 and 2015 (average of the two years). This implies an increase of catches of 41.2% in relation to the last year advise (10 775 t), corresponding to catch of no more than 15 211 t. A precautionary buffer of 20% consistent with the ICES approach is applied which gives catch of no more than 12 922 t.

20.9 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. norvegicus*) 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.

20.10 Tables

Table 20.2.1 Total biomass index of Icelandic slope *S. mentella* in the Icelandic Autumn Groundfish survey 2000–2015. 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
2014	104 307	0.185
2015	110 512	0.176

Table 20.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* 1978–2015 ICES Division 5.a.

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
2013	8 761	0	8 761
2014	9 500	0	9 500
20151)	9 311	0	9 311

1) Provisional

Table 20.3.2 Proportion of the landings of Icelandic slope *S. mentella* taken in ICES Division 5.a by pelagic and bottom trawls 1991–2015.

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%
2014	0%	100%
2015	0%	100%

20.11 Figures

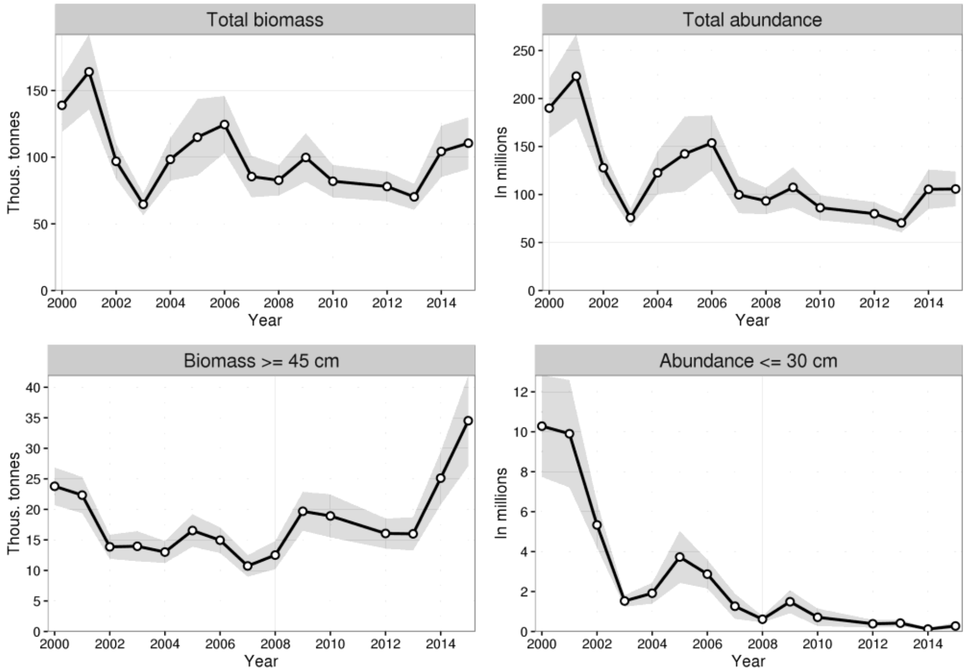


Figure 20.2.1 Survey indices of the Icelandic slope *S. mentella* in the autumn survey in ICES Division 5.a 2000–2015. No survey was conducted in 2011. The figure shows the total biomass index, total abundance index in millions of fish, biomass index of fish 45 cm and larger and abundance index of fish 30 cm and smaller.

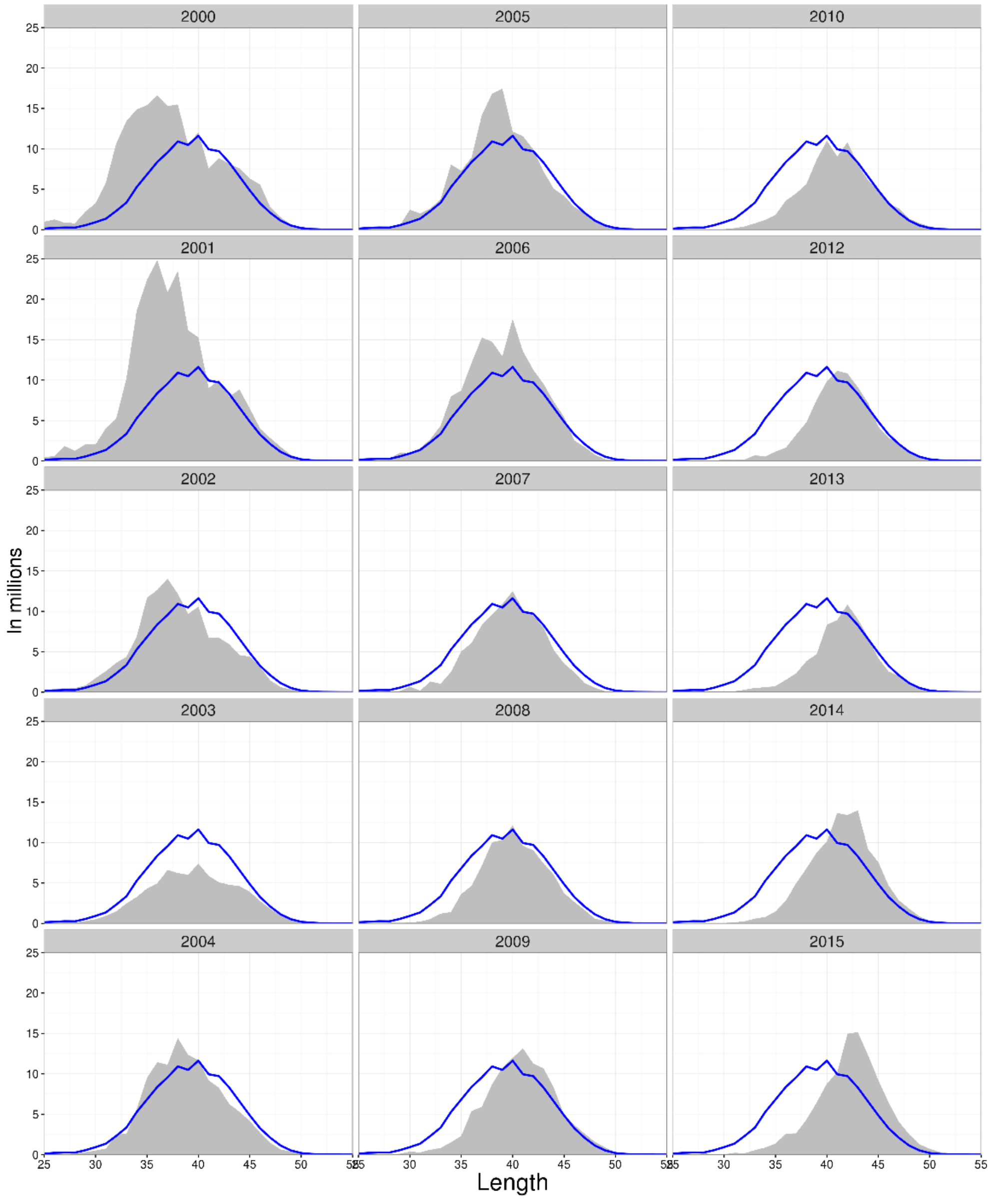


Figure 20.2.2 Length distribution of Icelandic slope *S. mentella* in the Autumn Groundfish Survey in October 2000–2015 in ICES Division 5.a. No survey was conducted in 2011. The blue line is the mean of 2000–2014.

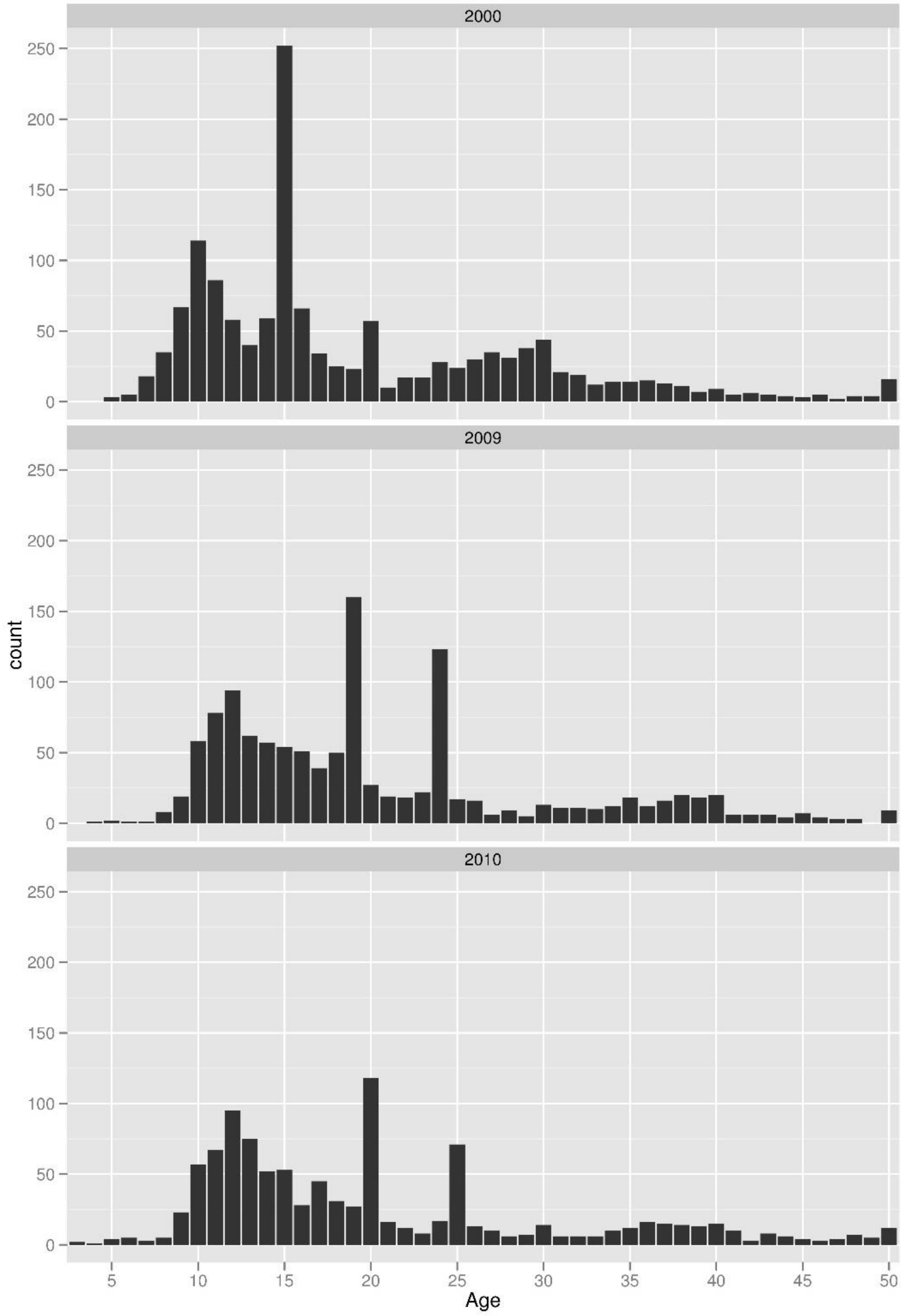


Figure 20.2.3 Age distribution of Icelandic slope *S. mentella* from the Autumn Survey in 2000 (n = 1 405), 2009 (n = 1 101), and 2010 (n = 1 206). The age class 50 are the combined age classes of 50 years and older.

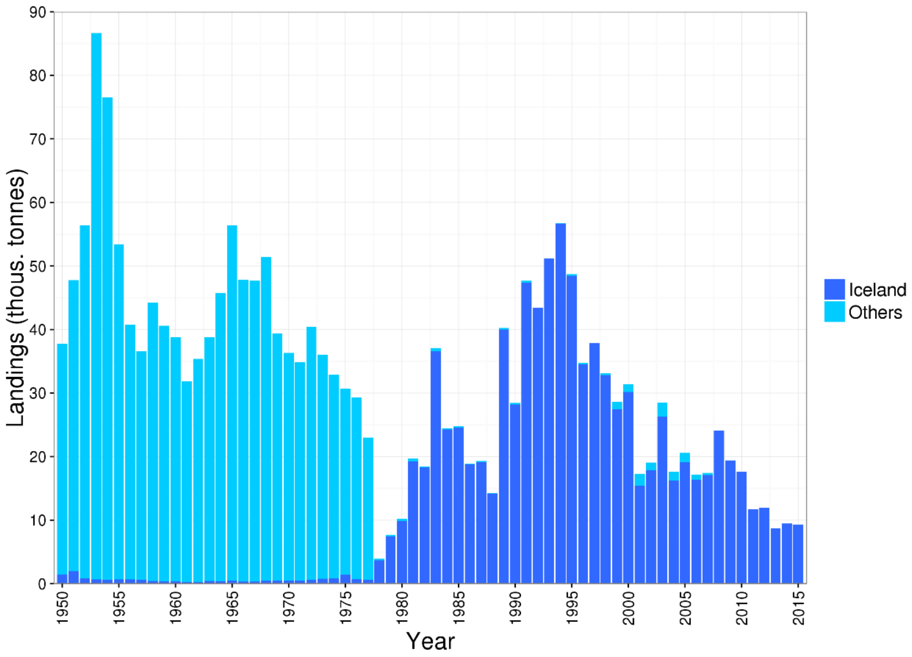


Figure 20.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* from Icelandic waters (ICES Division 5.a and Subarea 14) 1950–2015.

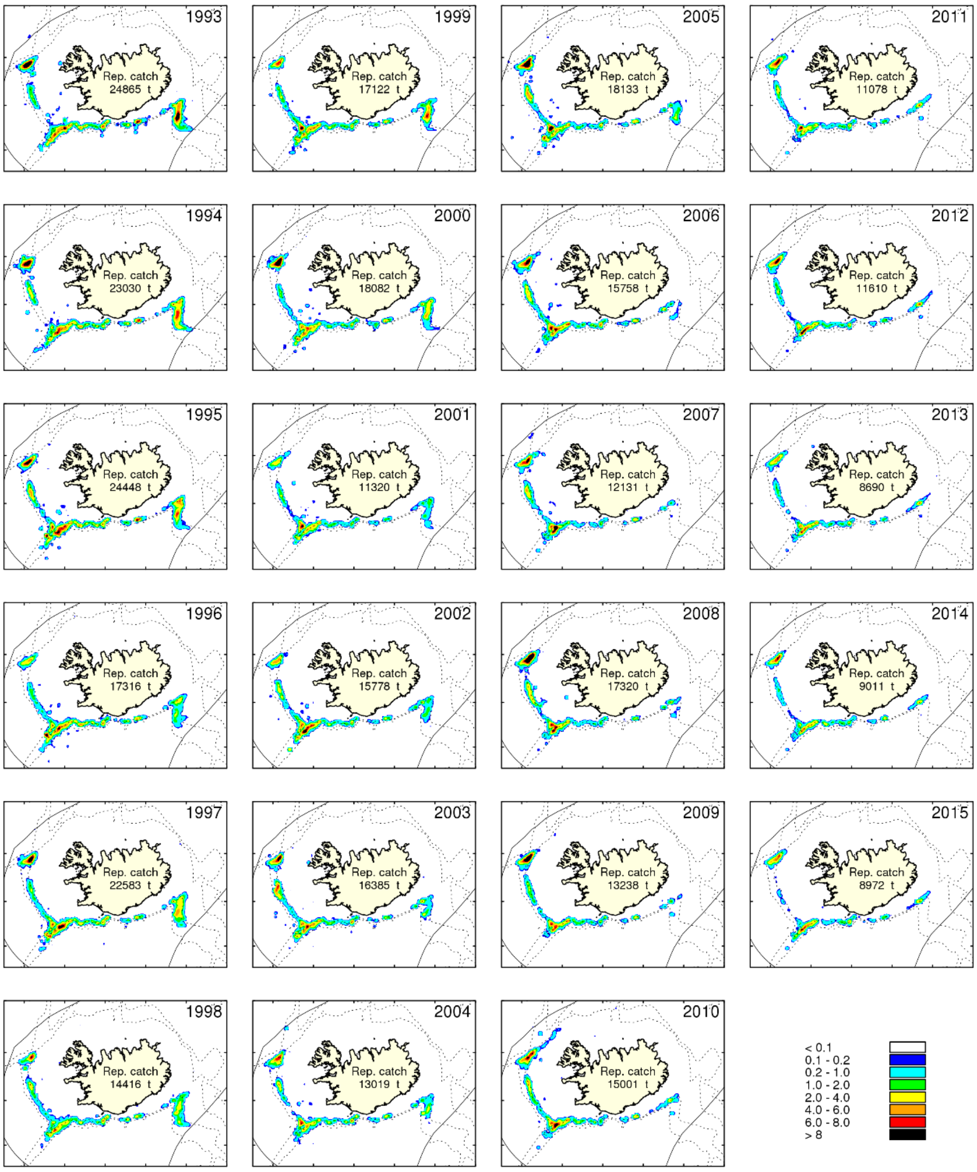


Figure 20.3.2 Geographical location of the Icelandic slope *S. mentella* catches in Icelandic waters (ICES Division 5.a and Subarea 14) 1993–2015 as reported in logbooks of the Icelandic fleet using bottom trawl. The blue line indicates part of the management unit for the deep-pelagic redfish stock. The dotted line represents the 500 m isobaths.

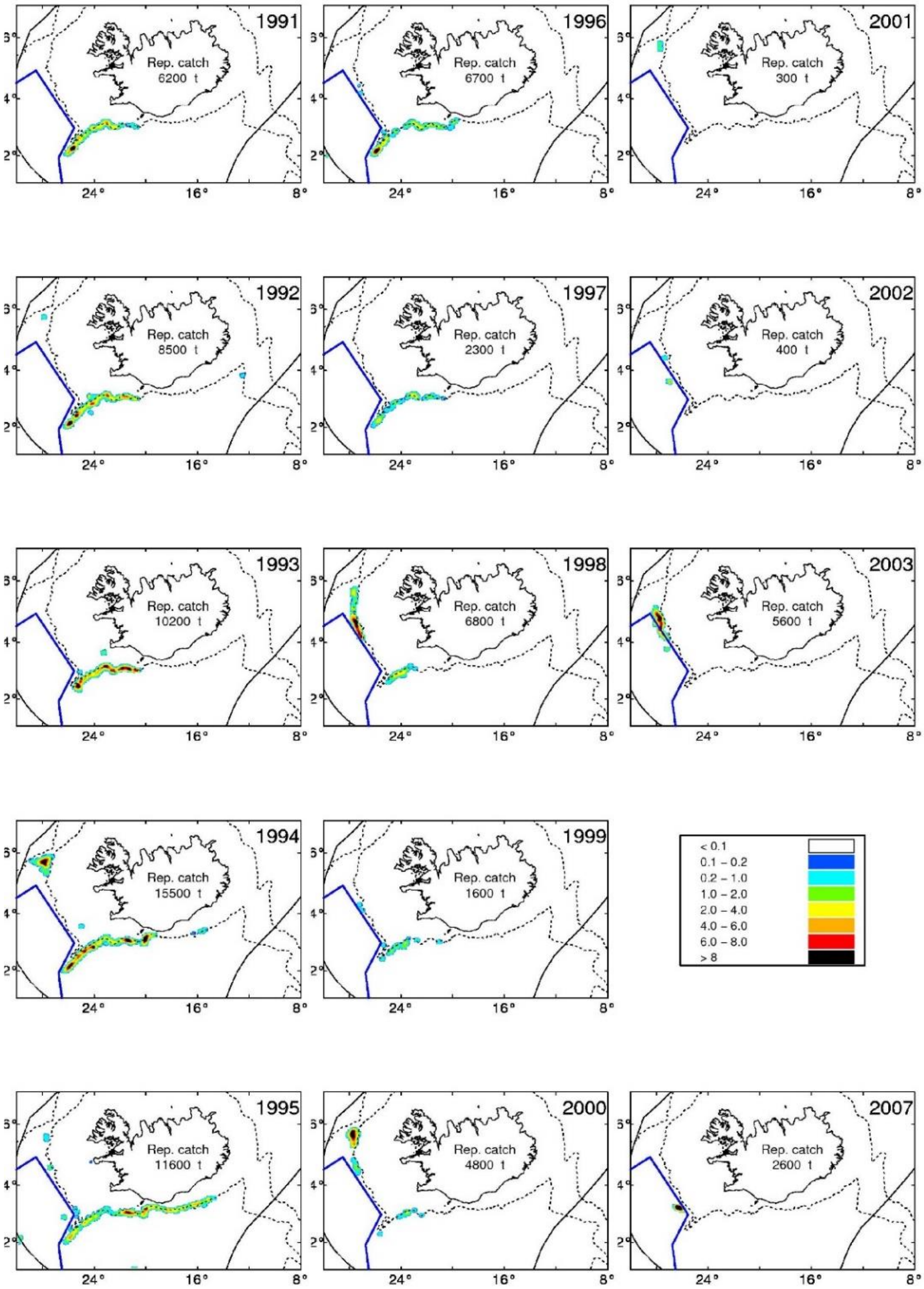


Figure 20.3.3 Geographical location of the Icelandic slope *S. mentella* catches in Icelandic waters (ICES Division 5.a and Subarea 14) 1991–2003 and 2007 as reported in logbooks of the Icelandic fleet using pelagic trawl. The blue line indicates part of the proposed management unit for the deep-pelagic redfish stock. The dotted line represents the 500 m isobaths.

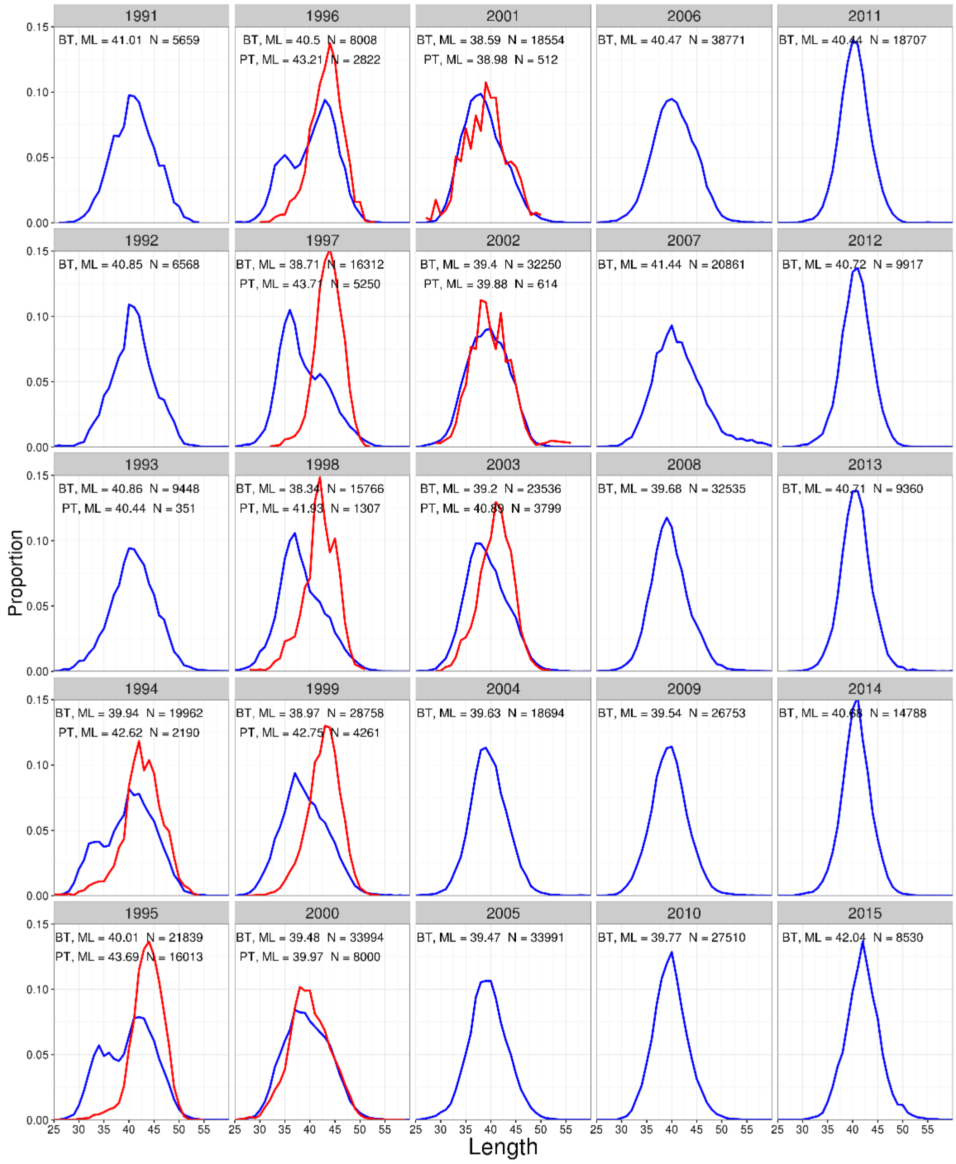


Figure 20.3.5 Length distributions of Icelandic slope *S. mentella* from the Icelandic landings taken with bottom trawl (blue line) and pelagic trawl (red line) in Icelandic waters (ICES Division 5.a and Subarea 14) 1991–2015.

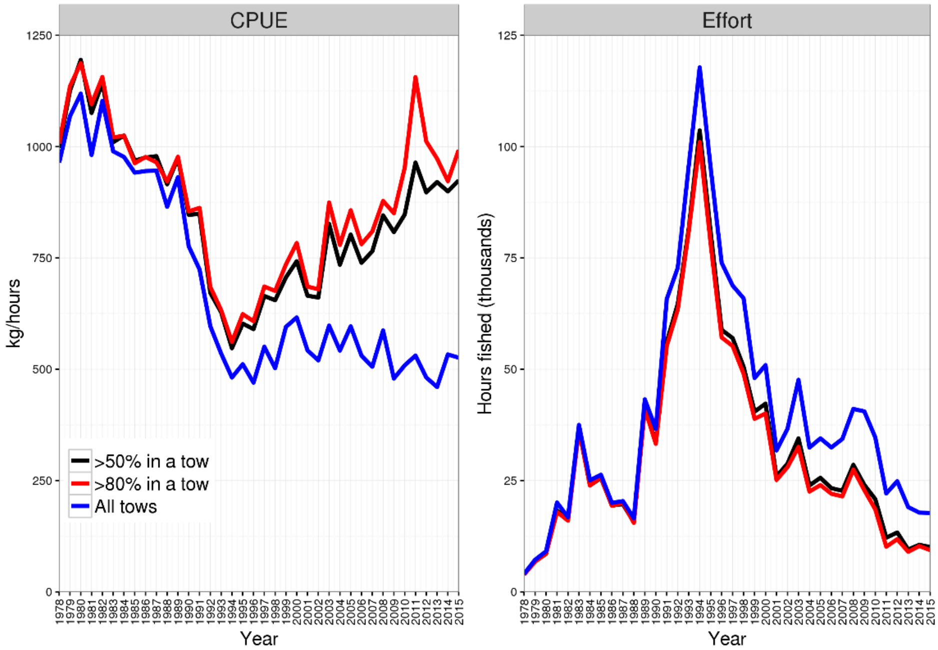


Figure 20.3.6 cpue and effort of Icelandic slope *S. mentella* from the Icelandic bottom-trawl fishery in Icelandic waters (ICES Division 5.a and Subarea 14) 1978–2015.

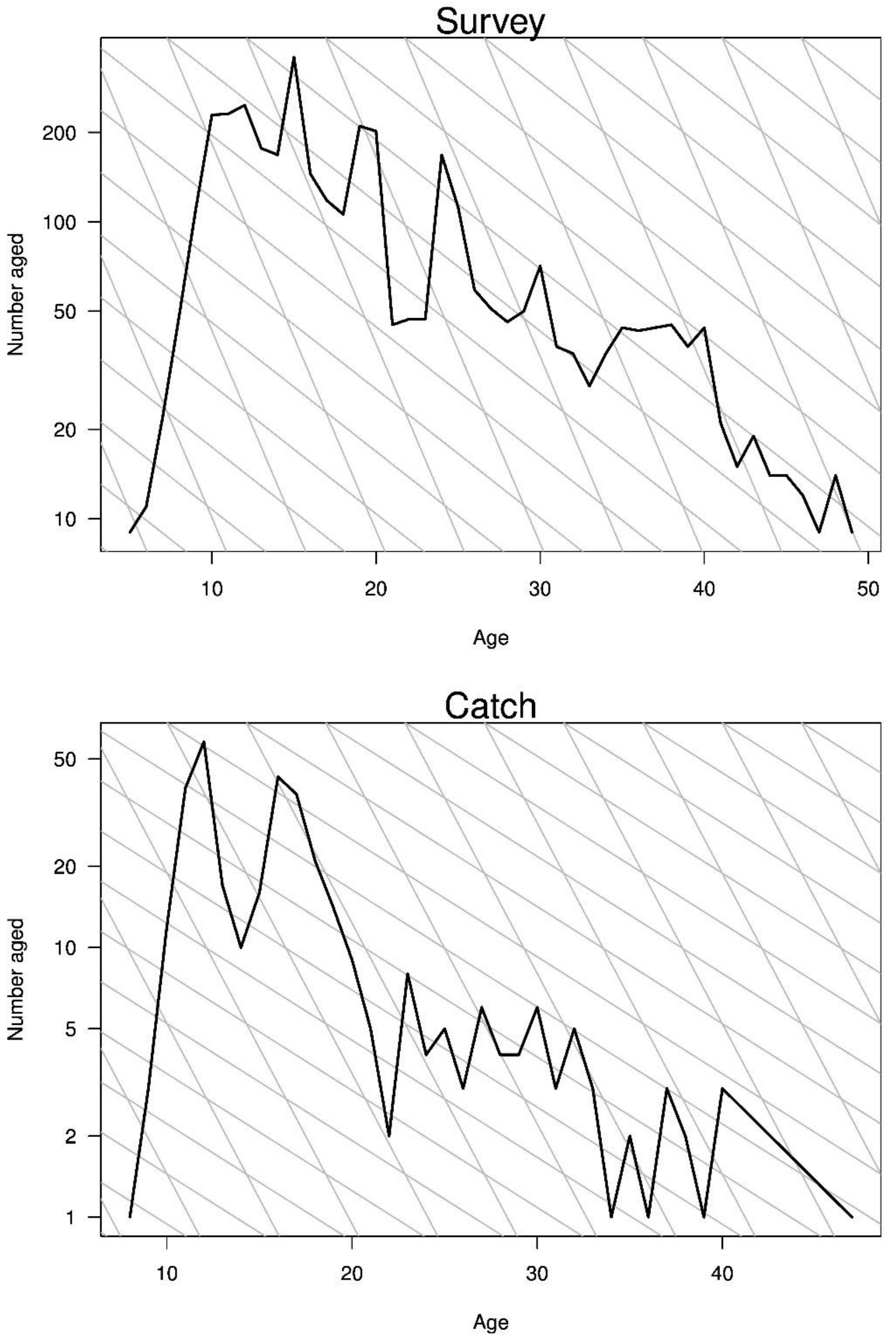


Figure 20.5.1. Icelandic slope *S. mentella*. Number aged plotted on log-scale. Grey lines correspond to *Z*=0.1 and *Z*=0.3.

21 Shallow Pelagic Sebastes mentella

21.1 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 5.a, Subareas 12 and 14; 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 2015. Only Russia conducted directed fishery on the stock. It should be noted that they also fished the deep pelagic stock:

RUSSIA	16 FACTORY TRAWLERS

21.2 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 21.2.1, based on log-book 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 21.2.1 and Figure 21.2.2. The estimated catch for 2015 is 5 595 t, a decrease from the 6 423 t caught in 2014. The catches were almost entirely produced by Russia with 5 434 t from ICES 12 and NAFO 1F (Tables 21.2.1 and 21.2.2).

There are no new cpue data for 2015. The standardized cpue index trend for the period 1994–2006 is shown in Figure 21.2.3. 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 21.2.3 and the residuals are in Figure 21.2.4.

21.3 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 21.3.1. The length of the largest proportion of caught fish oscillates around 35 cm for the whole period.

21.4 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.

21.5 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.

21.6 Surveys

The last international trawl-acoustic survey for the shallow pelagic stock was carried out in 2013 and it is described in detail in ICES WGRS Report 2013 (ICES, 2013). The next survey was scheduled to be carried out in June/July 2015 (ICES, 2013) but after Russia withdrew its participation it was not possible to cover the whole distribution of the stocks. Therefore, no new biomass estimates are available.

21.6.1 Survey acoustic data

Since 1994, the results of the acoustic survey show a drastic decreasing trend from 2.2 million t to 600 000 t in 1999 and have fluctuated between 700 000 t–90 000 t in 2001–2013 (Table 21.6.1). 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 21.6.1 and Figure 21.6.4). 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 21.6.2 and Figure 21.6.5 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 21.6.6).

21.6.2 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 21.6.1 and Figure 21.6.4). Figure 21.6.3 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 21.6.3). 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 21.6.3 shows the spatial distribution of samples used in the survey and Figure 21.6.6 shows the corresponding length distribution.

21.6.3 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 21.6 for details.

21.6.4 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.

21.7 State of the stock

21.7.1 Short-term forecast

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 short-term forecasts can be derived.

21.7.2 Uncertainties in assessment and forecast

21.7.2.1 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.

21.7.2.2 Assessment quality

The results of the international trawl-acoustic survey are given in section 21.6. Given the high variability of 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—2013) 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 2015 a 0 TAC for Shallow Pelagic *S. mentella*. However, the Russian Federation decided on a 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 and stock structure.

21.7.3 Comparison with previous assessment and forecast

The data available for evaluating the stock status are similar to last year.

21.7.4 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.

21.7.5 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.

21.7.6 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 northeastern 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).

21.8 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.

21.9 Tables

Table 21.2.1 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	13	40	1 443	1	0	1 529
2014	153	5 068	489	713	0	0	6 423
2015	161	2 281	0	3 119	34	0	5 595

1982–1991 All pelagic catches assumed to be of the shallow pelagic stock

1992–1996 Guesstimates based on different sources (see text)

1997–2015 Catches from calculations based on jointed catch database and total landings

Table 21.2.2 Shallow pelagic *S. mentella* catches (in tonnes) in ICES Div. 5.a, Subareas 12, 14 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
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								28								3 145				3 173
2013								72								1 457				1 529
2014								355			287					5 781				6 423
2015								161								5 434				5 595

Table 21.2.3 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. DfResid. 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 21.6.1 Shallow Pelagic *S. mentella*. Results for the acoustic survey indices 1991–2013 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. No estimates are available for 2015.

Year	Area covered (1,000 NM2)	Acoustic estimates (1,000 t)	Trawl estimates (1,000 t)
1991	105	2,235	
1992	190	2,165	
1993	121	2,556	
1994	190	2,190	
1995	168	2,481	
1996	253	1,576	
1997	158	1,225	
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 21.6.2. Results (biomass in ´000 t) for the international surveys conducted since 1994, for redfish shallower than the DSL for each subarea (see Figure 21.6.5 for area definition) and total.

	Sub-area						
Year	A	B	C	D	E	F	Total
1994	673	1,228	-	63	226		2,190
1996	639	749	-	33	155		1,576
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

21.10 Figures

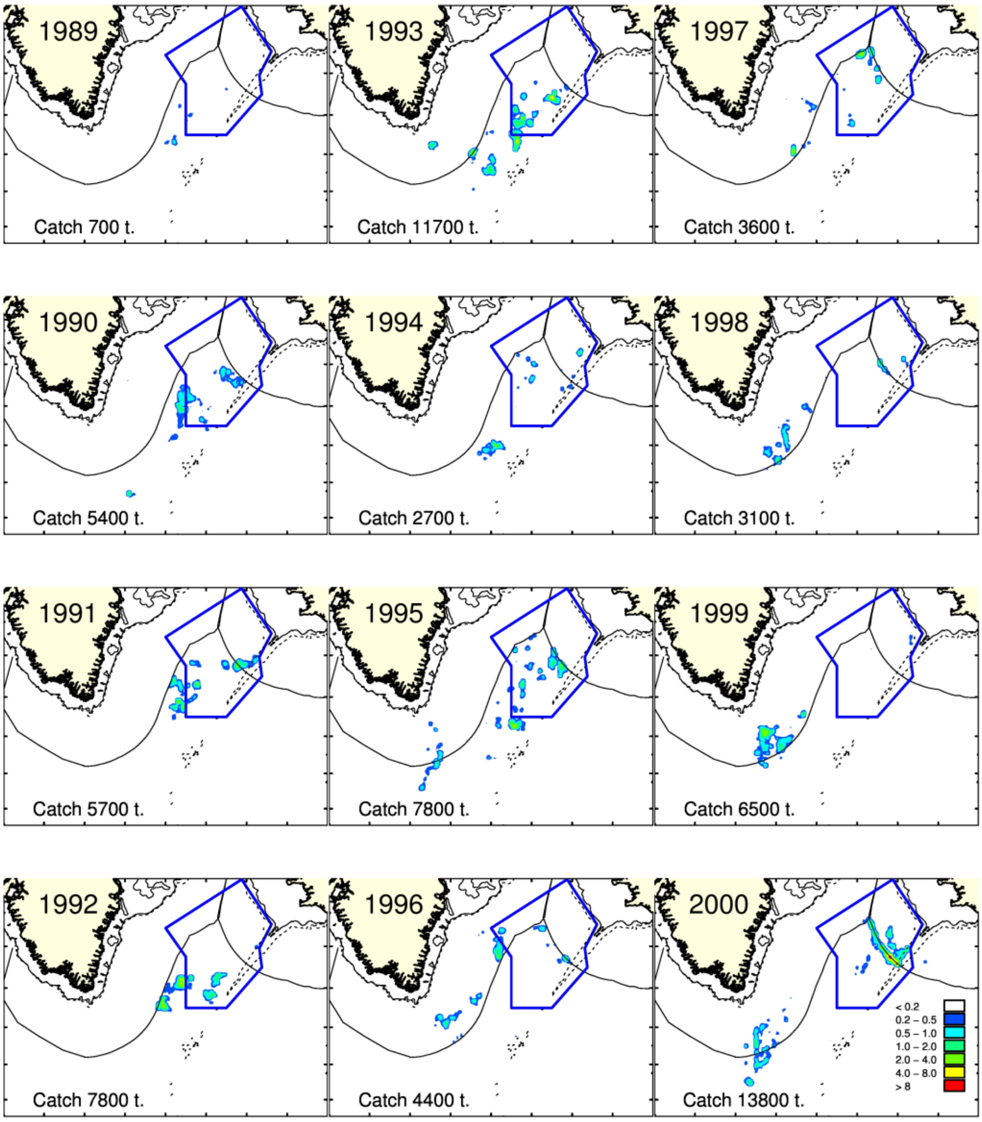


Figure 21.2.1 Fishing areas and total catch of pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1989–2012. Data are from the Faroe Islands (1995–2012), Iceland (1989–2012) and Norway (1992–2003). The catches in the legend are given as tonnes per square nautical mile. The blue box represents the management unit for the northern fishing area.

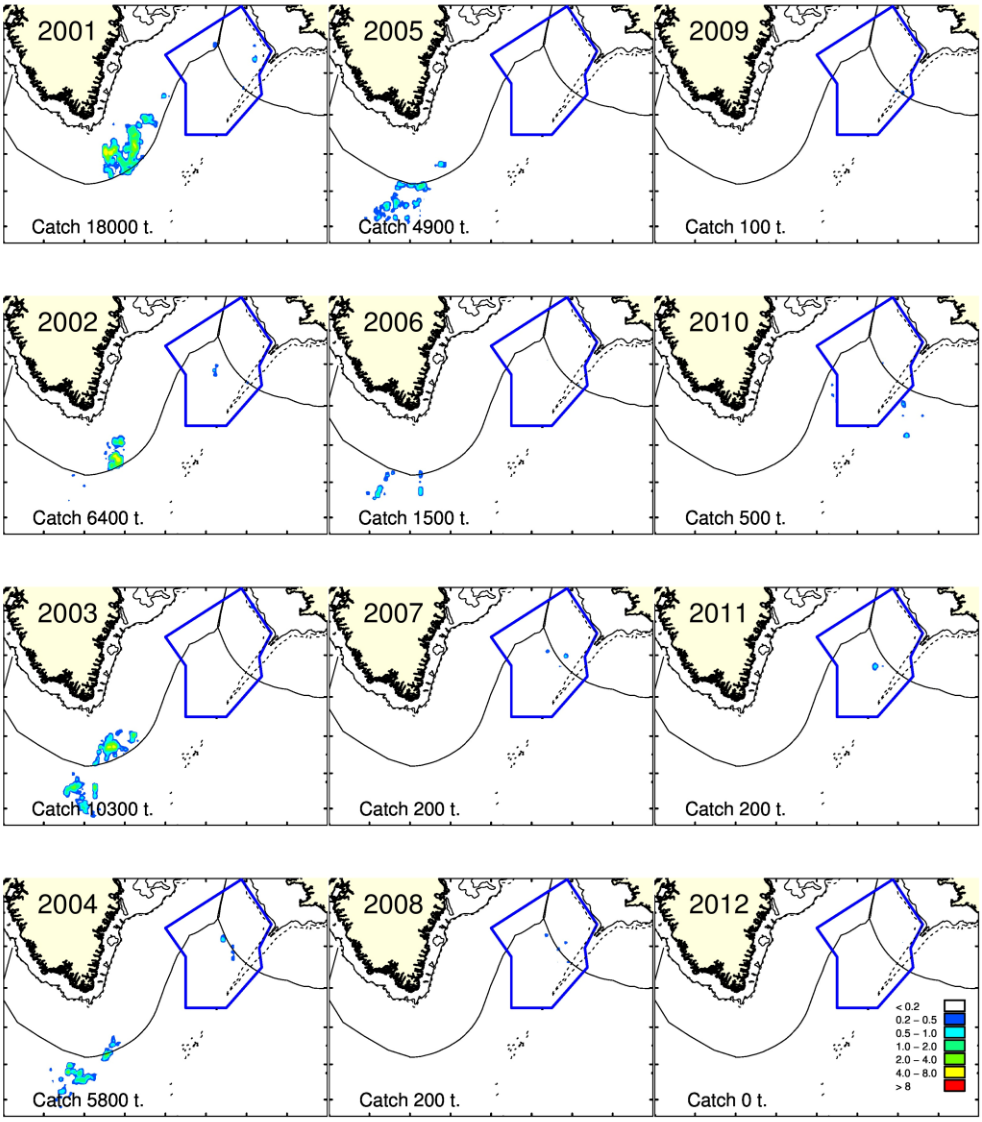


Figure 21.2.1 (Cont.) Fishing areas and total catch of pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1989–2012. Data are from the Faroe Islands (1995–2012), Iceland (1989–2012) and Norway (1992–2003). The catches in the legend are given as tonnes per square nautical mile. The blue box represents the management unit for the northern fishing area.

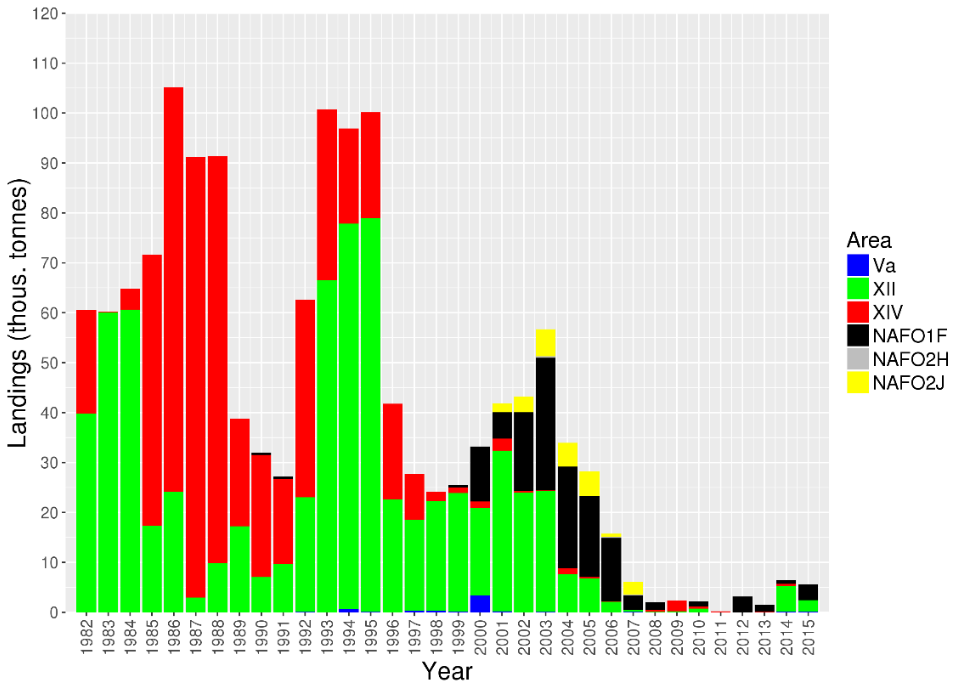


Figure 21.2.2 Landings of shallow pelagic *S. mentella* (Working Group estimates, see Table 21.2.1).

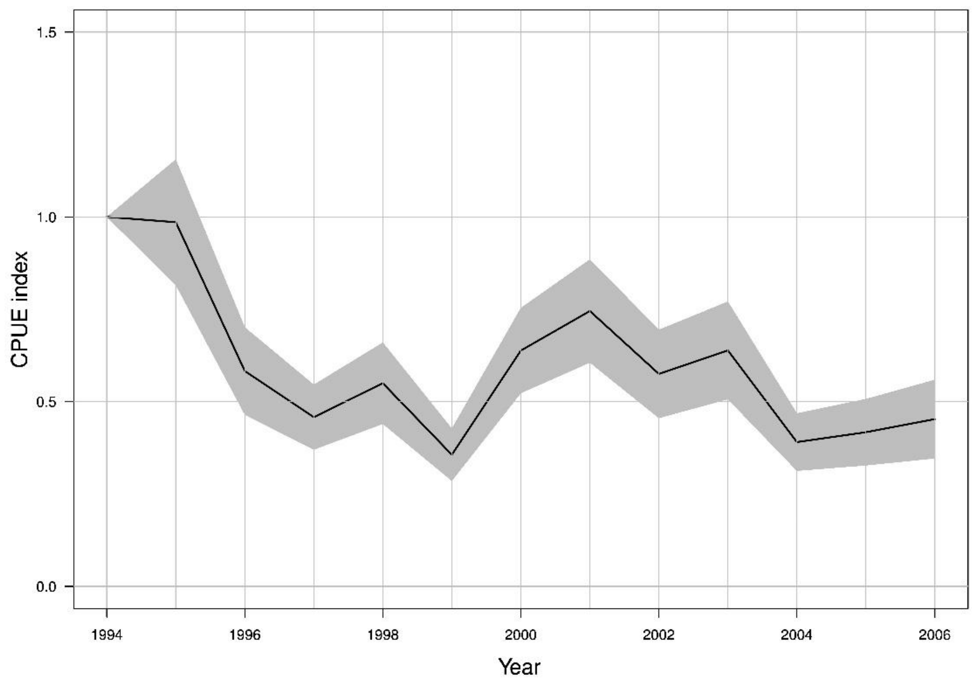


Figure 21.2.3 Trends in standardized cpue of the shallow pelagic *S. mentella* fishery in the Irminger Sea and adjacent waters, based on logbook data from Faroes, Iceland, Norway, and Greenland.

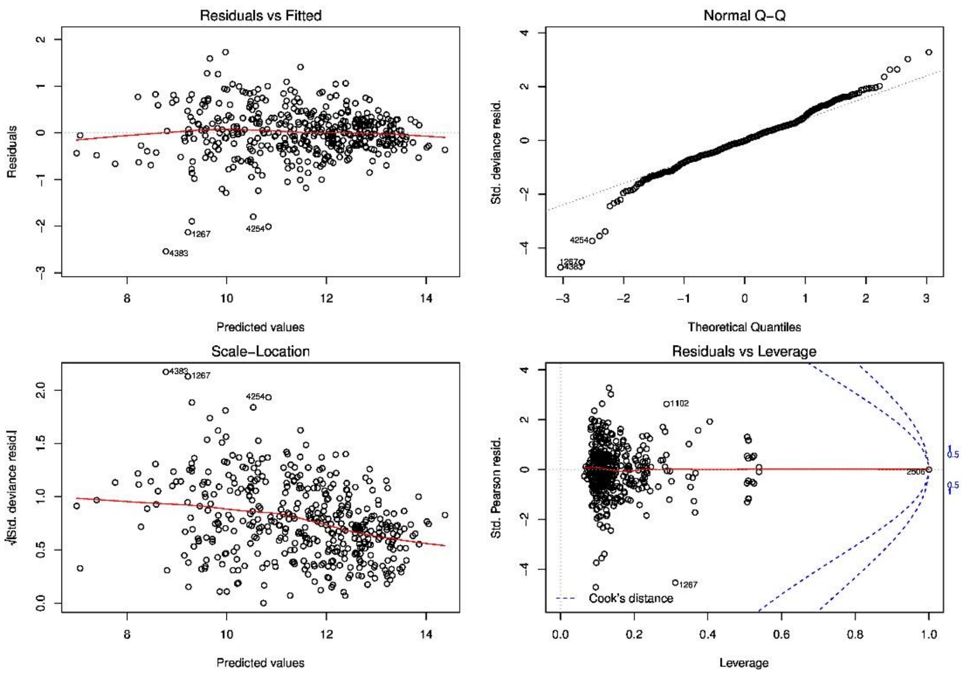


Figure 21.2.4 Residuals from the GLM model used to standardize cpue, based on logbook data from Faroe Islands, Iceland, Greenland and Norway.

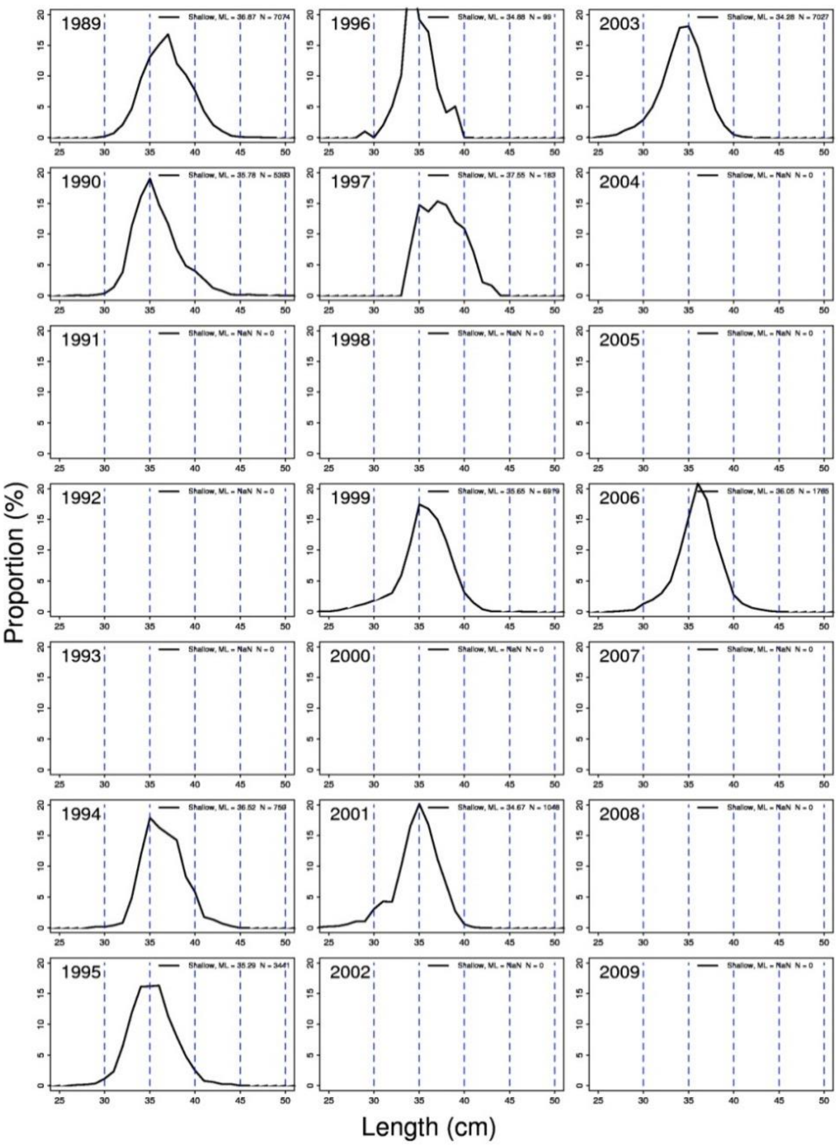


Figure 21.3.1 Length distribution from Icelandic landings of shallow pelagic *S. mentella*.

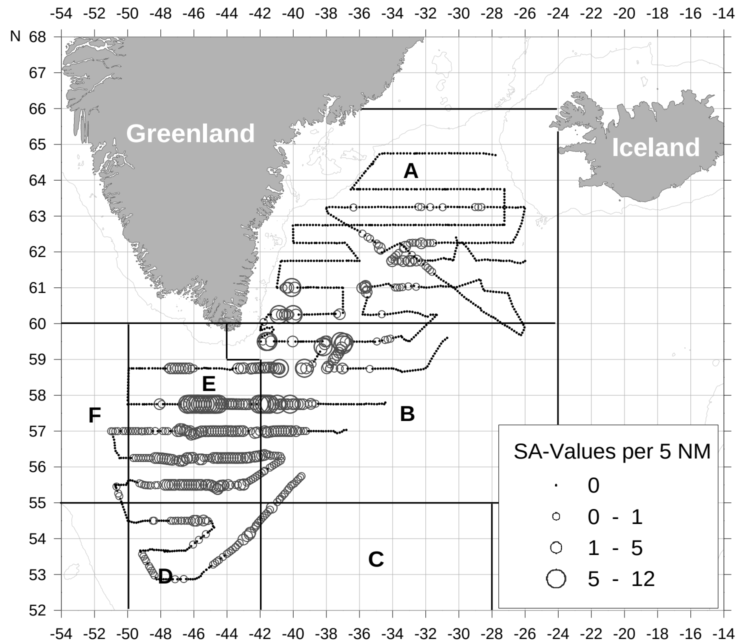


Figure 21.6.1 Pelagic *S. mentella*. Acoustic estimates (average s_A values by 5 NM sailed) shallower than the deep-scattering layer (DSL) from the joint trawl-acoustic survey in June/July 2013.

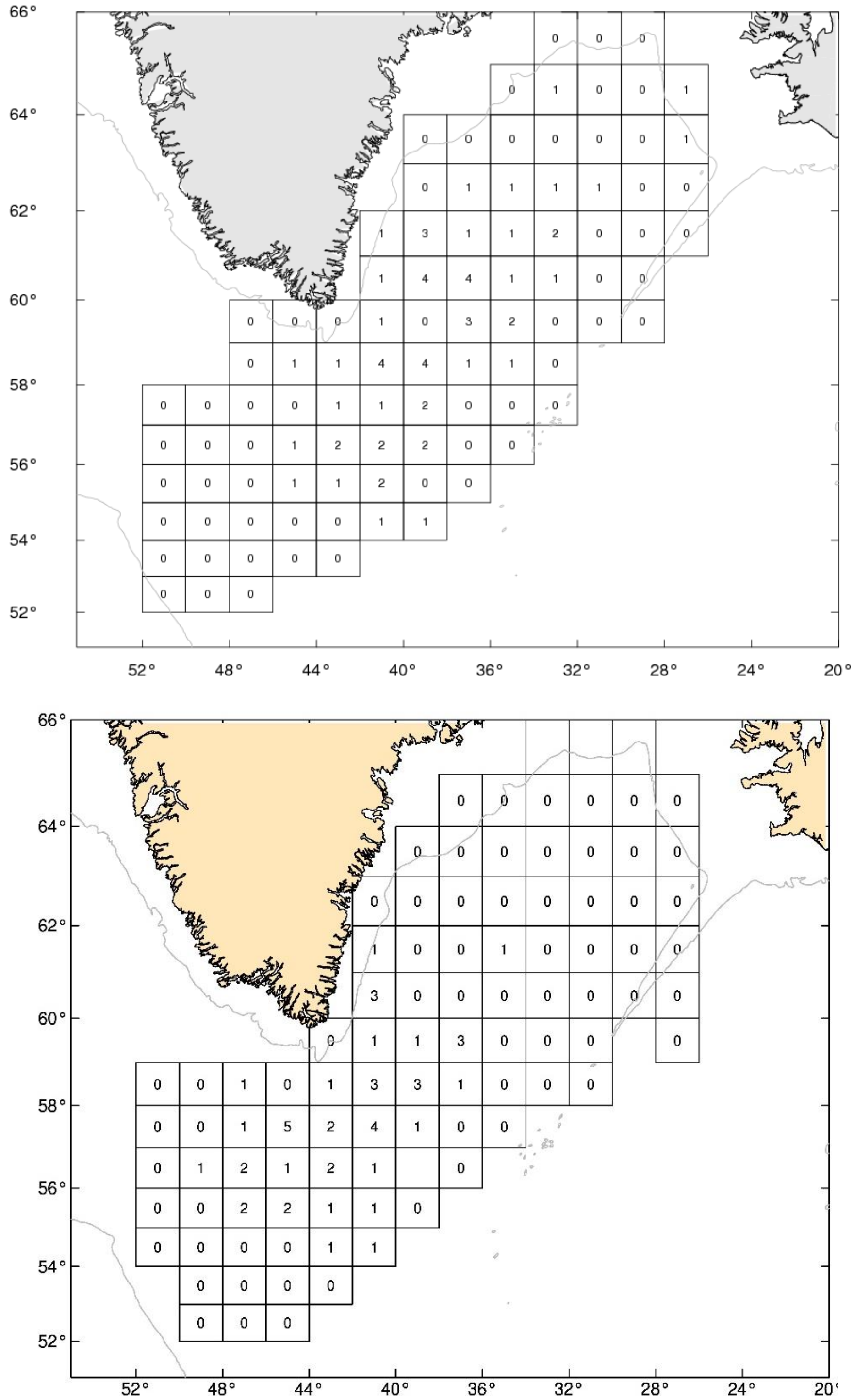


Figure 21.6.2. Redfish acoustic estimates shallower than the DSL. Average sA values within statistical rectangles during the joint international redfish survey in June/July 2013.

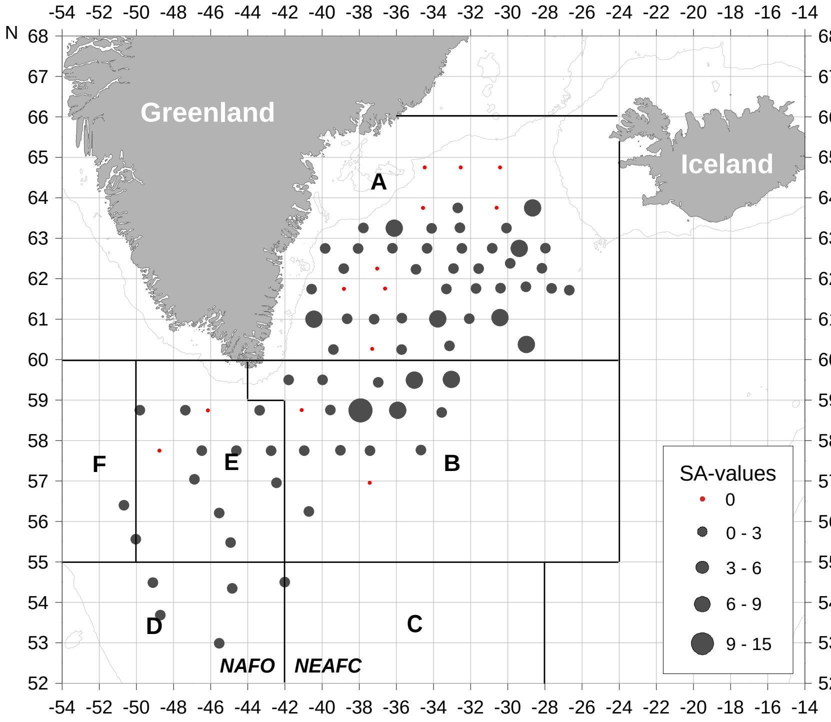


Figure 21.6.3 Redfish trawl estimates within the DSL shallower than 500 m (type 2 trawls). sA values calculated by the trawl method (chapter 2.2.3) during the joint international redfish survey in June/July 2013.

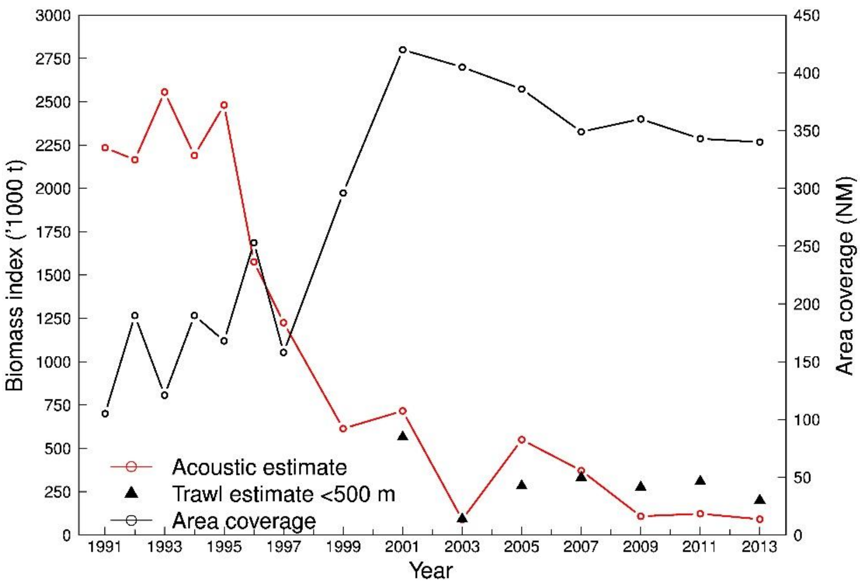


Figure 21.6.4. Overview of acoustic survey indices (thousand tonnes) from above the scattering layer (red filled circle), trawl estimates within the scattering layer and shallower than 500 m (black triangle), and aerial coverage (NM2) of the survey (black open circle) in the Irminger Sea and adjacent waters.

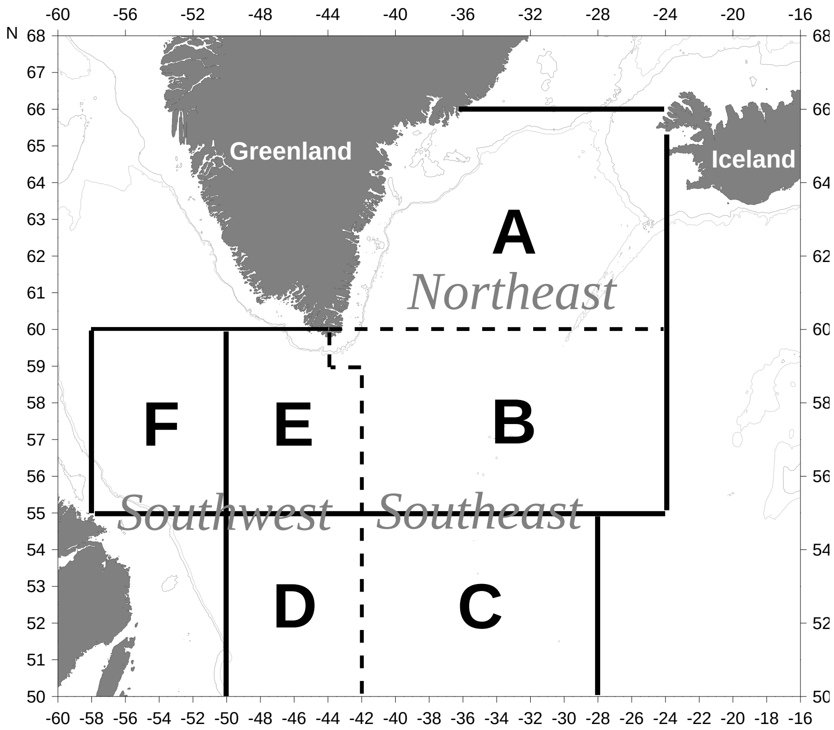


Figure 21.6.5 Sub-areas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines).

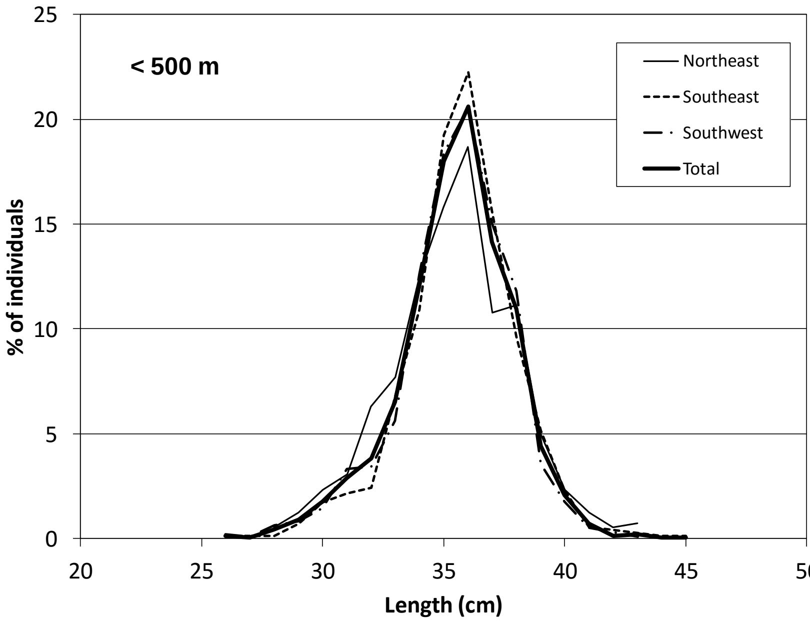


Figure 21.6.6 Length distribution of redfish in the trawls, by geographical areas and total, from fish caught shallower than 500 m (in 2013).

22 Deep Pelagic Sebastes mentella

22.1 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 5, 12, and 14 at depths > 500 m, including demersal habitats west of the Faroe Islands. This stock corresponds to the management unit in the northeast Irminger Sea (ICES areas 5.a, 12 and 14).

The following text table summarizes the available information from fishing fleets in the Irminger Sea and adjacent waters in 2015. It should be noted that some these fleets are also fishing the Shallow Pelagic stock:

Country	Number of trawlers
Faroes	2 factory trawlers
Iceland	5 factory trawlers
Germany	1 factory trawler
Lithuania	1 factory trawler
Norway	3 factory trawlers
Portugal	1 factory trawler
Russia	16 factory trawlers
Spain	4 factory trawlers

22.2 The fishery

The historic development of the fishery can be found in the Stock Annex. Tables 22.2.1 and 22.2.2 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 1992–2015 are shown in Figure 22.2.1, and annual catches are presented in Figure 22.2.2. Catches increased by 4 000 t in 2015 to 27 433 t (Table 22.2.2).

Standardized cpue series for Faroe Islands, Iceland, Greenland, and Norway 1994–2015 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 22.2.3). The model output is shown in Table 21.2.3 and the residuals are in Figure 22.2.4. The cpue index increased from about 0.3 in 2012 to >1.0 in 2013, but decreased again to the lowest level in 2014 and 2015.

22.3 Biological information

The length distribution from Icelandic landings for the period 1991–2015 is shown in Figure 22.3.1. Mean length ranged from 40.05 to 41.17 cm all years but 2002 and 2006, but since 2007 has oscillated between 37.88 and 39.43 cm.

22.4 Discards

Discards are not considered to be significant for the time being, according to available data from various institutes.

22.5 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.

22.6 Surveys

The last international trawl-acoustic survey took place in 2015 and it is described in detail in ICES CM WGRS REPORT 2015 (ICES, 2015). The survey was carried out by Iceland and Germany. The participation of Russia was cancelled at the beginning of May 2015 because of reasons not specified. For this reason the scope of the survey had to be altered and the emphasis was on covering the deep pelagic stock found below 500 m.

22.6.1 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 and Germany in June/ July 2015. Approximately 200 000 NM^2 were covered. A total biomass of 196 000 t was estimated, significantly below the 280 000 t of 2013 (Table 22.6.2). The results showed large biomass declines in subareas A and B, the main distribution area of the stock (see Figure 22.6.1 for area definition) (Table 21.6.2). Biological samples from the trawls taken at depth >500 m showed a mean length of 38.6 cm, which is similar as the mean length in 2013. Figure 22.6.2 shows the spatial distribution of samples used in the survey and Figure 22.6.3 shows the corresponding length distribution.

22.7 Methods

The assessment of pelagic redfish in the Irminger Sea and adjacent waters is based on survey indices, catches, cpue and biological data.

22.8 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.

22.9 State of the stock

22.9.1 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.

22.9.2 Uncertainties in assessment and forecast

22.9.2.1 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.

22.9.2.2 Assessment quality

The results of the international trawl-acoustic survey are given in section 21.6. Given the high variability of 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 indices are likely to reflect a decreasing stock.

22.9.3 Comparison with previous assessment and forecast

The data available for evaluating the stock status are similar to last year.

22.9.4 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 9 500 t TAC set by NEAFC for 2015 was overshot by about 18 000 t. This excess is due to the unilateral decision of the Russian Federation to self-allocate an annual TAC, which was 27 300 t for 2015. It was taken from both Shallow and Deep pelagic (20 214 t) stocks, since the Russian Federation does not agree on the division of the *S. mentella* management units.

22.9.5 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.

22.9.6 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 salinity >34.94) in the northeastern 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 interannual 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.

22.10 WKDEEPRED 2016

The Workshop on Assessment and Catch Advice for Deep Pelagic Redfish in the Irminger Sea (WKDEEPRED) will be held in 23–25 August 2016 in ICES HQ, Copenhagen, Denmark. The workshop will:

a) Agree on the most appropriate approach for the assessment of this stock;

b) If an analytical assessment is agreed for the stock (categories 1 or 2), estimate Biological Reference Points and agree on the short–term forecast method. Otherwise, consider proxy reference points to the extent possible and agree on a methodology for catch advice for the stock consistent with ICES advisory rules;

c) Document the agreed methodology in a stock annex;

d) In response to NEAFCs request to ICES "to review the approach that serves as basis for the catch advice for the deep pelagic redfish stock in the Irminger Sea to ensure conformity with ICES advisory rules", conduct a stock assessment and prepare catch advice for the stock for 2017 in accordance with a) and b).

22.11 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.

ICES. 2015. Third Interim Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS), 4–6 August 2015, Marine Research Institute, Reykjavík (Iceland). ICES CM 2015/SSGIEOM:03. 49 pp.

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.

22.12 Tables

Table 22.2.1 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	40 778	0	46052
2014	603	0	23 152	0	23 755
2015	1 821	0	25 612	0	27 433

Table 22.2.2. Deep pelagic *S. mentella* catches (in tonnes) in ICES Divisions 5.a, Subareas 12, 14 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
2013				1 882		1 176		8 545		1 200	1 163		2 979			26 463	2 644			46 052
2014				721		890		2 081		867	1 024		1 965			15 475	732			23 755
2015[1)]				779		918		1 968			330		1 547		202	20 214	1 475			27 433

1) Provisional. Official Spanish catch data were lower than the data provided by NEAFC and the WG decided to use the highest catch data as a precautionary measure.

Table 22.2.3 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
factor(yy)2013    0.008868325 0.15200923   0.058340700 9.534866e-01
factor(mm)3      -0.812659803 0.39174110  -2.074481862 3.823868e-02
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
factor(skip)118  -0.267350277 0.14387130  -1.858260004 6.336686e-02
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
factor(skip)1902 -0.122037774 0.13376781  -0.912310478 3.617811e-01
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
factor(skip)2165  0.072495588 0.13389141   0.541450638 5.882934e-01
factor(skip)2170 -0.090472494 0.12251178  -0.738479960 4.603614e-01
factor(skip)2182 -0.227474427 0.12989539  -1.751212416 8.015439e-02
factor(skip)2184 -0.083675892 0.12979356  -0.644684474 5.192499e-01
factor(skip)2203 -0.195064716 0.12387778  -1.574654639 1.155890e-01
factor(skip)2212  0.043365160 0.16082696   0.269638625 7.874828e-01
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
factor(skip)3135 -0.358279004 0.40653274  -0.881304184 3.783225e-01
factor(skip)3156 -1.276943431 0.36406219  -3.507487084 4.683906e-04
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. DfResid. 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 22.6.1 Deep pelagic *S. mentella*. Survey estimates for depth >500 m from trawl samples taken in 2015. Areas C-F (Figure 22.6.2) were not surveyed.

	A	B	C	D	E	F	Total
Area (NM2)	113 450	87 994					201 444
Mean length (cm)	38.6	37.2					38.3
Mean weight (g)	673	668					672
Biomass (t)	152 775	64 234					195 694

Table 22.6.2. Results (biomass in ´000 t) for the international redfish surveys conducted since 1999 for deep pelagic *S. mentella* for each subarea (see Figure 22.6.2) and total. Areas C-F were not surveyed in 2015

	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
2015	153	43	-	-	-	-	196

22.13 Figures

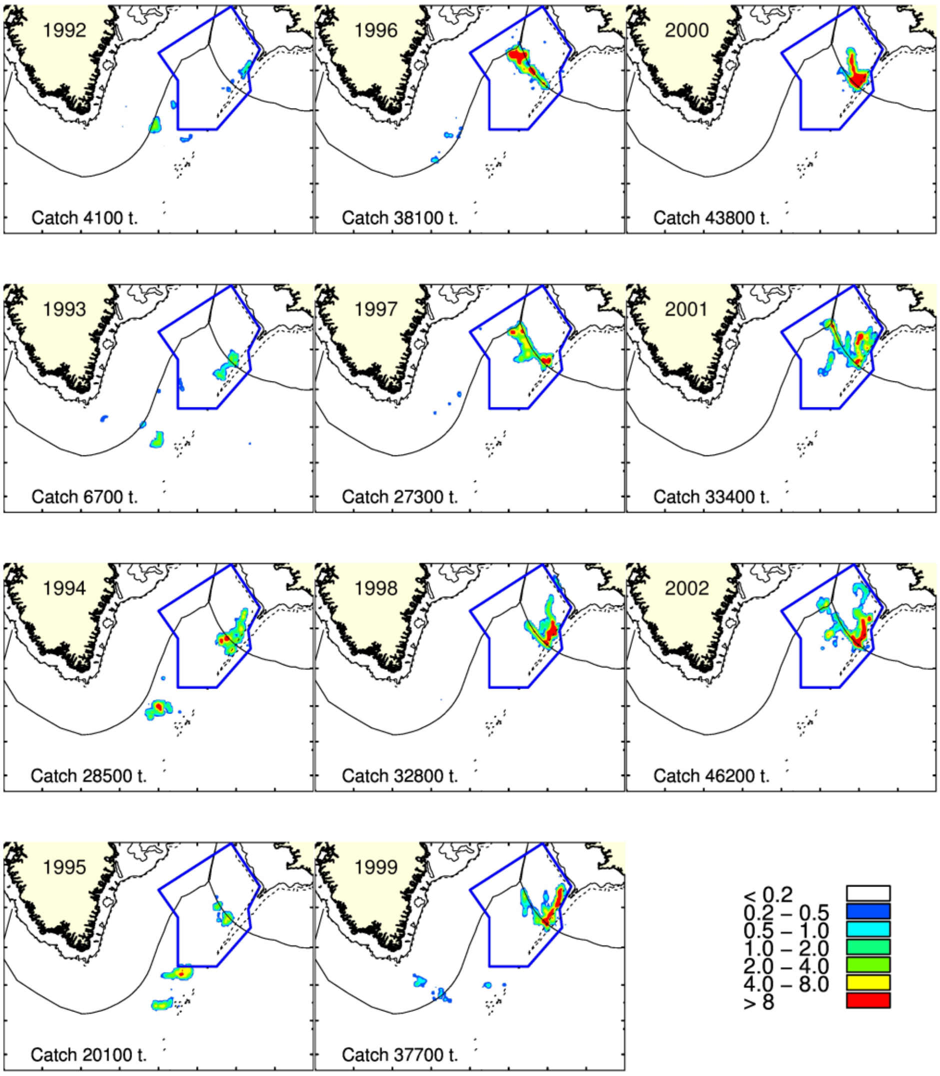


Figure 22.2.1 Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992–2014. Data are from the Faroe Islands (1995-2013), Germany (2011–2014) Greenland (1999–2003 and 2009–2010), Iceland (1995–2014), and Norway (1995–2003 and 2010–2014). The catches in the legend are given as tones per square nautical mile. The blue box represents the proposed management unit.

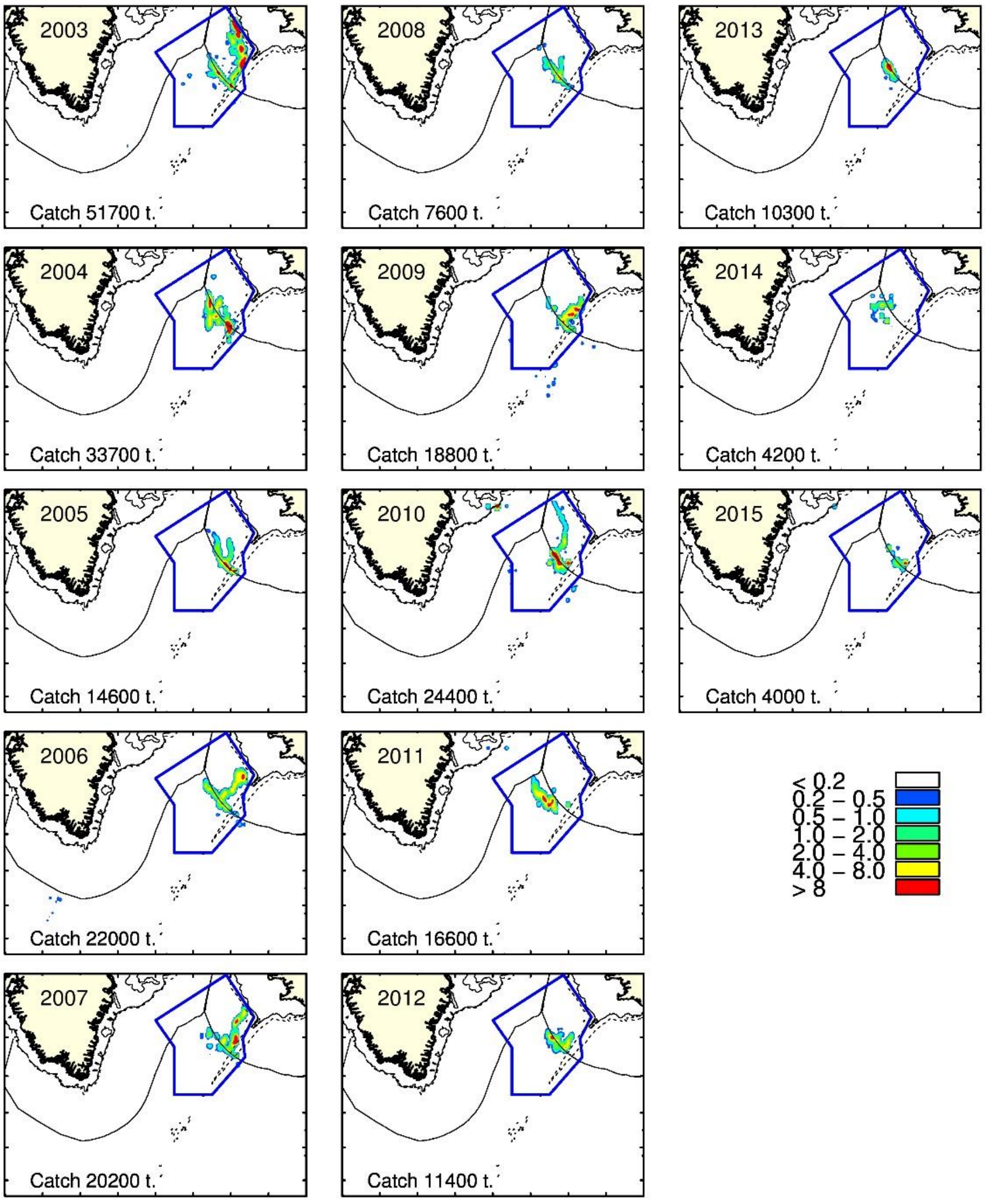


Figure 22.2.1 (Cont.) Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992–2015. Data are from the Faroe Islands (1995–2015), Germany (2011–2015) Greenland (1999–2003 and 2009–2010), Iceland (1995–2015), and Norway (1995–2003 and 2010–2014). The catches in the legend are given as tones per square nautical mile. The blue box represents the proposed management unit.

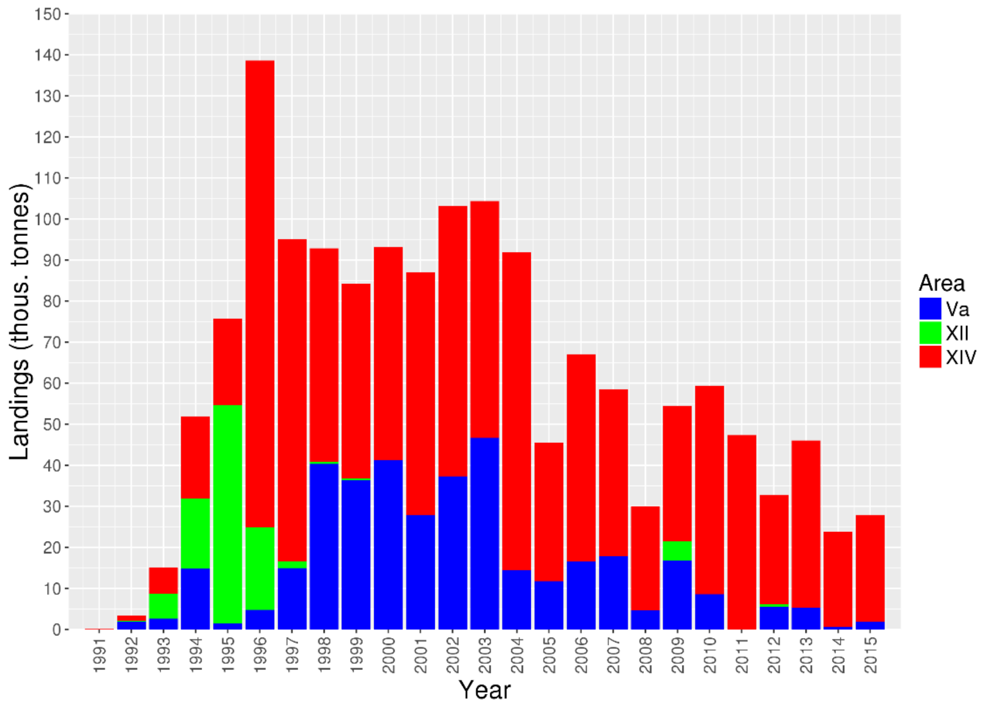


Figure 22.2.2 Landings of deep pelagic *S. mentella* (Working Group estimates, see Table 21.2.1).

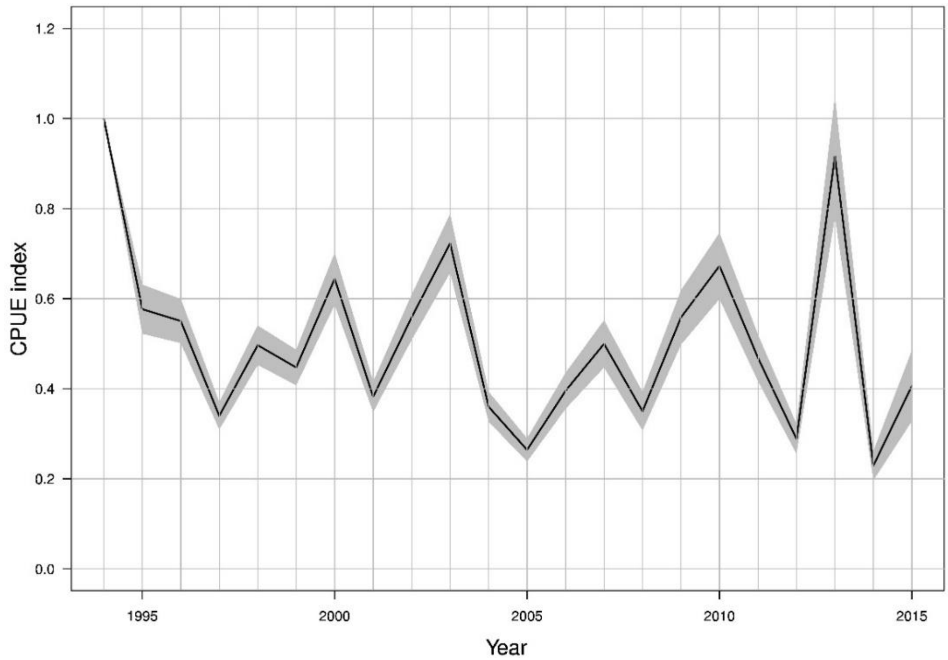


Figure 22.2.3 Trends in standardized cpue of the deep pelagic *S. mentella* fishery in the Irminger Sea and adjacent waters, based on logbook data from Faroe Islands, Iceland, Germany, Greenland and Norway.

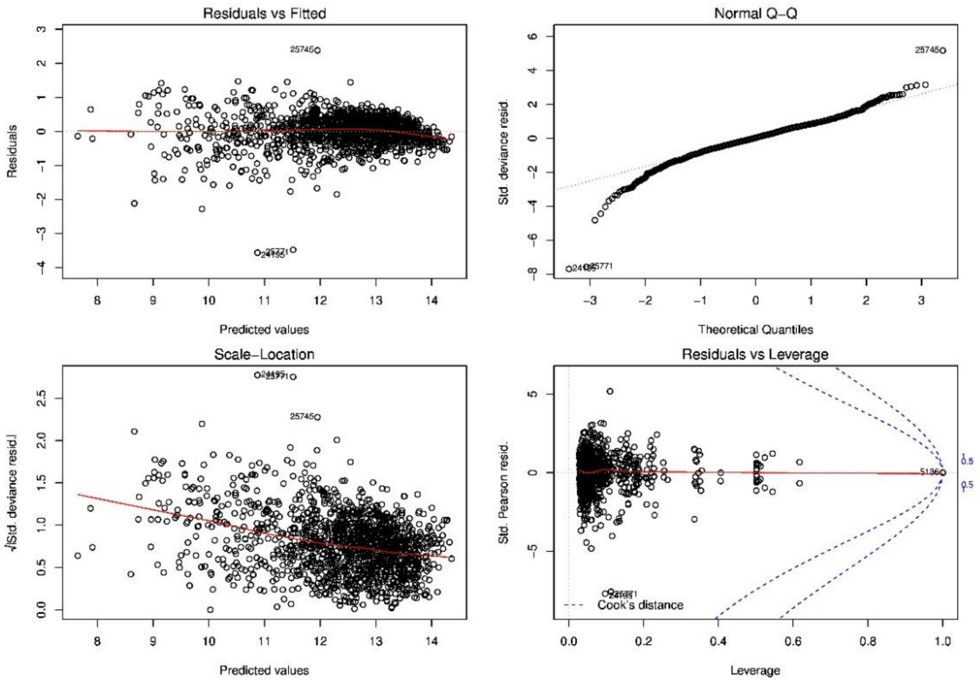


Figure 22.2.4 Residuals from the GLM model used to standardize cpue, based on logbook data from Faroe Islands, Iceland, Greenland and Norway.

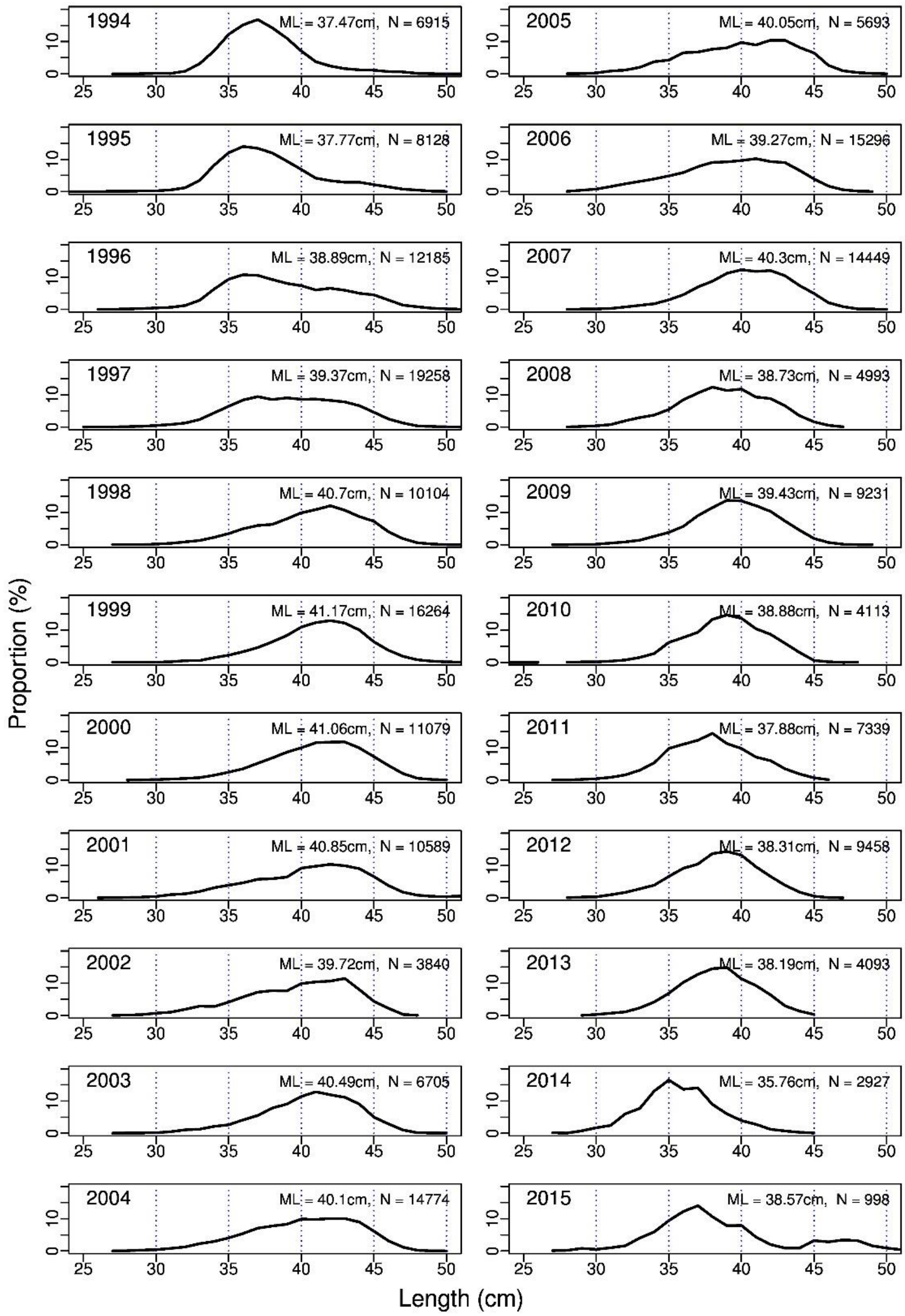


Figure 22.3.1 Length distribution from Icelandic landings of deep pelagic *S. mentella*.

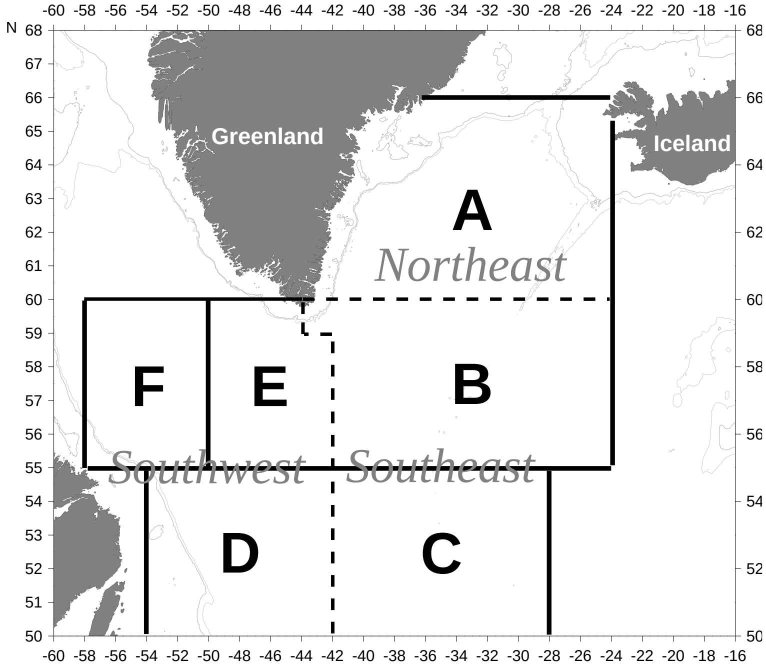


Figure 22.6.1 Sub-areas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines).

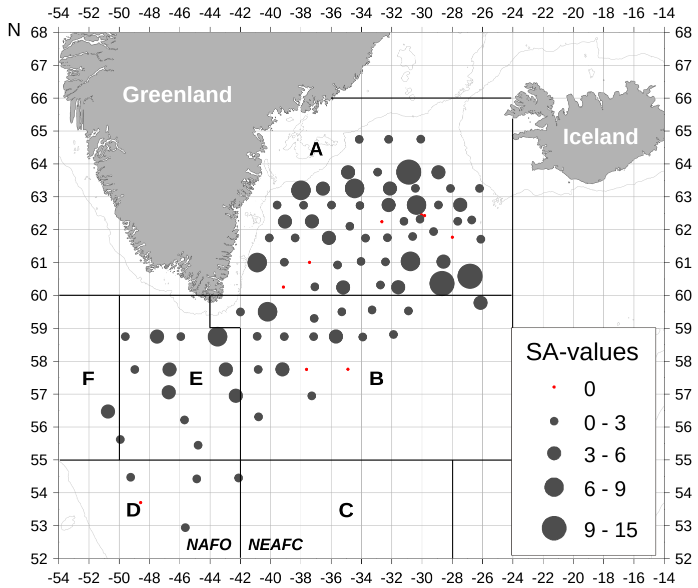


Figure 22.6.2. Redfish trawl estimates deeper than 500 m (type 3 trawls). sA values calculated by the trawl method (see WGRS Report, 2013) during the joint international redfish survey in June/July 2013.

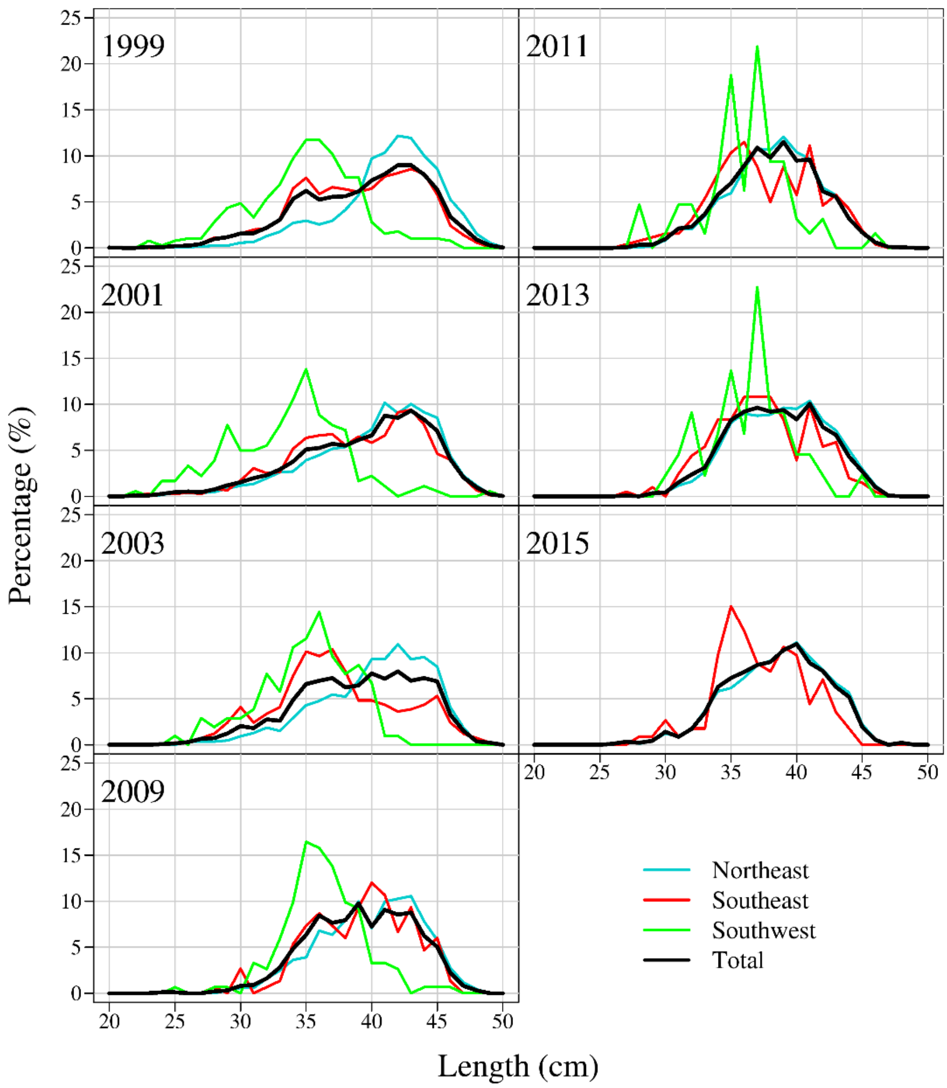


Figure 22.6.3 Length distribution of redfish 1999–2015 in the trawls, by geographical areas (see Figure 22.6.1) and total, from fish caught deeper than 500 m.

23 Greenlandic slope *Sebastes mentella* in 14.b

23.1 Stock description and management units

See chapter 18 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 14.b 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.

23.2 Scientific data

Indices were available from three surveys in 14.b. A German survey directed towards cod in Greenlandic waters (0–400 meters) (Fock *et al.* 2015), the Greenland deep-water survey (400–1500 meters) targeting Greenland halibut (Christensen and Hedeholm 2016) and the Greenland shrimp and fish survey in shallow water (0–600 meters), which has been conducted since 2008 (Hedeholm and Christensen. 2016). The German survey on the slope in 14.b 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* spp. smaller than 17 cm was found in the German survey (Figure 23.2.1). 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 in both biomass and abundance was observed, with 2015 representing the lowest biomass for the last 20 years (Figure 23.2.1). 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 23.2.1) 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 since 2012. This pattern is also reflected in the abundance estimates (Figure 23.2.1). 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. The distribution has become flat with no clearly defined mode in 2013-2015 (Figure 23.2.2).

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. The biomass indices in the Greenland deep-water survey peaked in 2012, but has decreased since then (Figure 23.2.3). The overall length distribution from the entire area in 2013 and 2014 shows a mode around 31 cm. In 2015, the mode increased slightly (Figure 23.2.4).

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 meters. 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 2015 biomass estimate for *S. mentella* was the lowest observed in the time-series (Figure 23.2.5). 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 is declining and is at the lowest level for the last 20 years. Both survey length distributions showed no clear mode, but a rather flat distribution (Figure 23.2.6). The German survey and the Greenland shrimp and fish shallow water survey both show overall declines in the *S. mentella* biomass

23.3 Information from the fishing industry

23.3.1 Landings

From the Greenland and German surveys we know that the demersal redfish found on the Greenland slope is a mixture of *S. norvegicus* and *S. mentella*. Based on the surveys and 11 samples from the commercial fishery the 8 539 tonnes of demersal redfish caught in ICES 14.b, was estimated to be 70 % *S. mentella* (5 977) and 30 % *S. norvegicus* (2 562). Together with the proportion in 2014, this is the smallest proportion of *S. mentella* observed, which can be interpreted as *S. norvegicus* is becoming more abundant in the area. Prior to 1974, all catches were reported as *S. norvegicus* and the split was determined by working groups on a yearly bases.

Total annual landings of demersal *S. mentella* from Divisions 14.b since 1974 are presented in Table 23.3.1.1. From 1976–1994 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 1998–2002 the landings ranged from 1000 to 2000 tonnes and from 2003 to 2008 landings remained at lower levels (<500 tonnes). In 2009, an exploratory fishery landed 895 tonnes 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 tonnes demersal redfish was initially given and of these, 400 tonnes were allocated to the Norwegian fleet. After this amount was fished, an extraordinary research quota of 1 000 tonnes was given to a Greenlandic vessel. Since 2010, the catches have been around 8 300 tonnes (*S. mentella* and *S. norvegicus* combined) and in 2015 catches were 8 539 tonnes (Figure 23.3.1.1). Since 2011 the TAC has been 8 500 tonnes. 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 tonnes) 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).

23.3.2 cpue and bycatch cpue

A redfish bycatch cpue was introduced at the redfish 2012 benchmark (WKRED). This is based on catches from the Greenland halibut directed fishery (Christensen and Hedeholm 2016), which covers redfish distribution better than data from the redfish directed fishery and covers a longer period (1999–2015). 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 decline in 2013–2015 (Figure 23.3.2.1).

The decline in the index follow the decline in biomass index seen in the shallow water surveys (German and Greenland). The Greenland halibut fishery is not as spatially restricted as the redfish fishery, thus it will not be as sensitive to local changes. Based on the cpue a decline in stock size seem to be present.

The cpue from the redfish directed fishery showed a drastic decline from 2010 (3.7 t/h) to 2015 (1.1 t/h) (Figure 23.3.2.2). The 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 (0–600 m) and the German survey (0–400 m) show that the main fishing area coincides with the area of highest overall abundance. Hence, the cpue decline indicates a severe local stock depletion, which is also reflected in the overall stock trend.

23.3.3 Fisheries and fleets

The fishery for *S. mentella* on the slopes in 14.b is mainly conducted with bottom trawl, only about 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 (Figure 23.3.3.1). The majority of the catches are taken at depths from 300 m– 400 m.

The directed fishery was stopped in 1995, but in 1998 Germany restarted a directed fishery for redfish with annual landings of approximately 1 000 tonnes in 1998–2001 increasing to 2 100 tonnes 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 14.b in 2003–2004 (less than 500 tonnes). This continued in 2005–2008 and most *S. mentella* were caught as bycatch in the Greenland halibut fishery.

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 2001–2005 and since 2006 only Greenland, Faroese Islands, Norway and Germany have had any significant catches. In 2015, also Russia had a notable catch in the area (Table 23.3.3.2).

In 2009, three Greenland vessels started a fishery targeting demersal redfish. Each was given an explorative quota of 250 tonnes. 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 23.3.3.2). 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.

23.3.4 Bycatch/discard in the shrimp fishery

To minimize bycatch 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 on the amount of bycatch in the shrimp fishery the mean length of the redfish that entered the codend 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 tonnes. Since 2006 limited shrimp fishery has taken place in ICES 14.b and the current level of bycatch must be considered negligible, and have for the last two years been 0 (Table 23.3.4.1). 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 23.3.4.2). Since 2010, the fishery has been starting already in

January. The depth distribution of cod and redfish overlaps (Figure 23.3.3.2) and therefore the fishery for redfish led to a bycatch of cod on 96 tonnes in 2013. The vessels are allowed a 10 % bycatch of cod.

23.3.5 Sampling from the commercial fishery

In 2015, the catch length distribution was estimated from 702 redfish and separated into *S. mentella* (N=560) and *S. norvegicus* (N=142) (Figure 23.3.5.1). The distribution showed a clear mode around 36 cm which is an increase compared to 2014. All samples were analysed by the Greenland Institute of Natural Resources, and it was found that *S. mentella* constituted 70% of the total sample weight. For *S. norvegicus* the mode was around 40 cm in 2015.

23.4 Methods

No analytical assessment was conducted.

23.5 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.

23.6 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 since 2013 (<18 cm). The adult stock decline is caused by a large decline in a small area which coincides with the main fishing area. The directed fishery cpue for this area has declined from 3.7 t/h (2010) to 1.1 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 change 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 of 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. 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 concern.

The advice is based on the Data Limited Stock approach (DLS) including biomass indices from the Greenland shallow water survey in the most recent 5 years combined with the recent advice. Due to the dynamic of the stock and decrease in all stock indicators the indicator ratio (50%) was used and the uncertainty cap not applied. According to the guidelines the precautionary buffer was not applied. The advice for 2017 is 1 120 tonnes.

23.7 Management considerations

Sebastes 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 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 hot spot 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 and the fishery should preferably cover a larger area.

23.8 References

Bernreuther, M., Stransky, C. and 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.

Christensen H.T. and Hedeholm R. 2016. The fishery for demersal Redfish (S. mentella) in ICES Div. 14.b in 2015. ICES NWWG WD#09.

Fock, H., C. Stransky and M. Bernreuther. 2013. Abundance and length composition for Sebastes marinus L., deep sea S. mentella and juvenile redfish (Sebastes spp.) off Greenland-based on groundfish surveys 1985-2012. ICES NWWG WD#30.

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

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

Hedeholm R. and Christensen H.T., 2016. Greenland Shrimp and Fish Survey Results for Redfish in East Greenland Offshore Waters in 2015. ICES NWWG WD#10

Sünksen, K. 2007. Discarded bycatch in shrimp fisheries in Greenlandic offshore waters 2006–2007. NAFO SCR doc. 07/88

23.9 Tables

Table 23.3.1.1 Nominal landings (tonnes) of demersal *S. mentella* 1974-2013 ICES division 14.b.

Demersal S.mentella	
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
2014	4 608
2015	5 977

Table 23.3.3.2 Landings (tonnes) of demersal redfish caught in ICES 14.b by nation. By far the largest proportion were probably *S. mentella* but none of these amounts were converted by the *mentella/norvegicus* ratio (70% *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
2014	1973		0.2	13		4611	98	613		5		7314
2015	1987			74		4979	208	822		469		8539
Sum	12387	3	162	1043	534	35531	336	5264	3	521	856	56640

Table 23.3.4.1 Discarded bycatch (tonnes) of Sebastes sp. from the shrimp fishery in ICES 14.b.

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
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	60	81	131	75	48	49	71	196	84	75	106	81	1056

Table 23.3.4.2 Landings (tonnes) of demersal redfish caught in ICES 14.b. by month. By far the largest proportion were probably *S. mentella* but none of these amounts were converted by the *mentella/norvegicus* 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
2014	10	421	206	1210	1187	1709	231	401	376	448	632	479	7314
2015	543	786	1016	451	507	1611	1160	1024	504	393	74	467	8539
Sum	2698	6036	5686	6719	6270	8402	5113	4061	2315	2392	3834	3100	56640

23.10 Figures

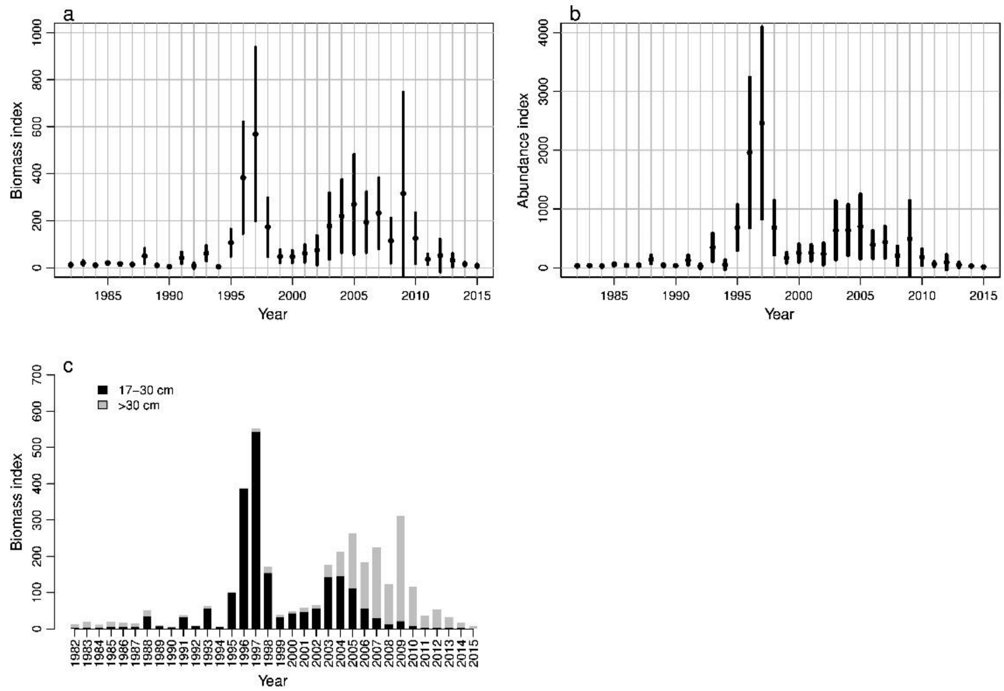


Figure 23.2.1. Indices from the German East Greenland survey of *S. mentella* larger than 17 cm. Biomass (a), abundance (b), and biomass split on length (c). On figure (c) the grey bars represent the biomass of *S. mentella* larger than 30 cm and the light bars biomass in fish from 17–30 cm.

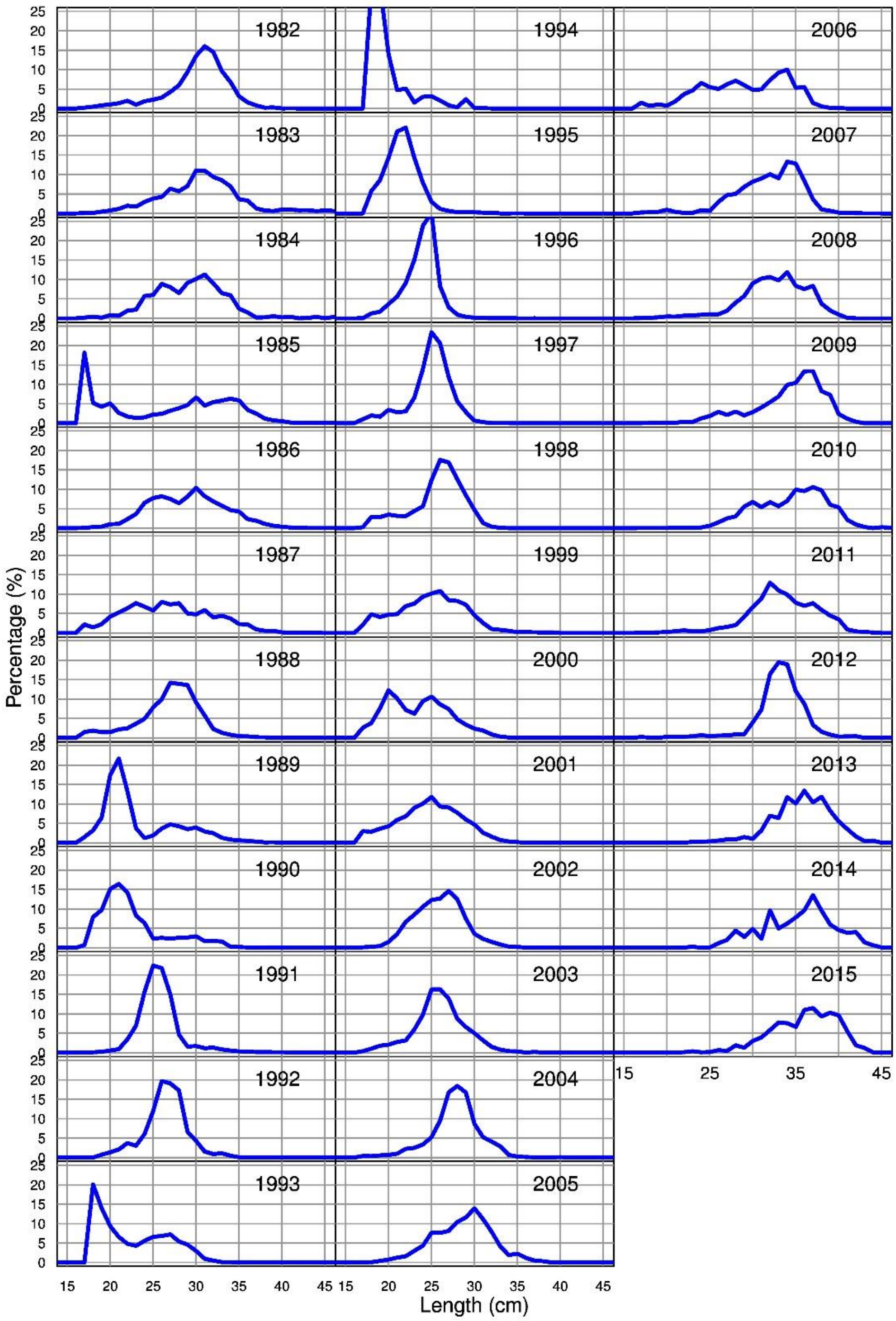


Figure 23.2.2. Length distributions from the German East Greenland survey 1985–2015.

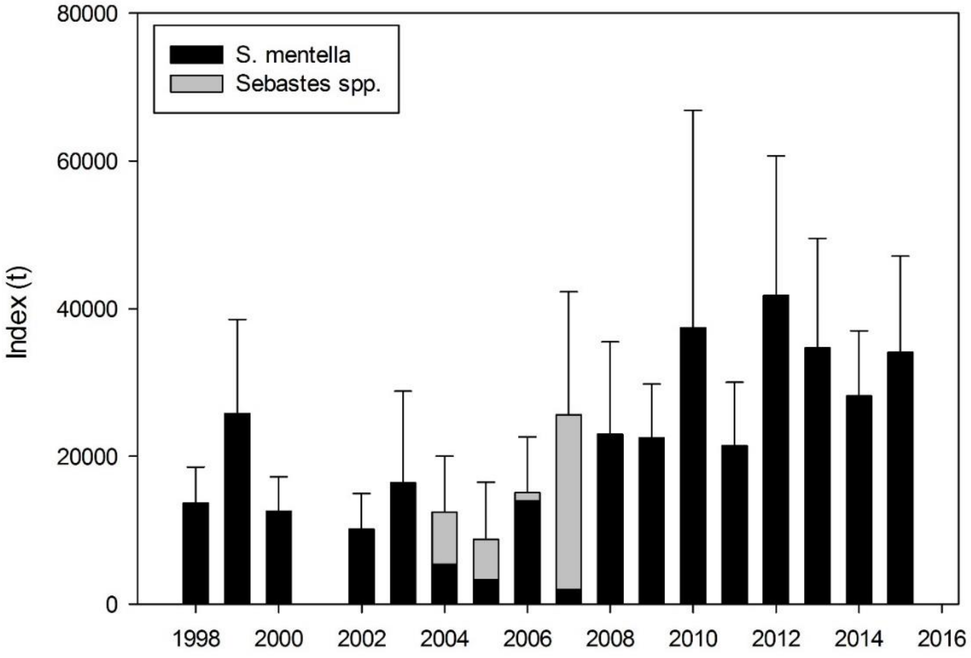


Figure 23.2.3. Biomass of *S. mentella* and *Sebastes* spp. derived from the deep Greenland survey. Bars indicate 2SE of the biomass of *S. mentella* including *Sebastes* spp. No survey in 2001. In 2004, 2005 and 2007 a large proportion of the redfish were not determined to species and only reported as "*Sebastes* spp". It is most likely that the majority of these fish were *S. mentella.*

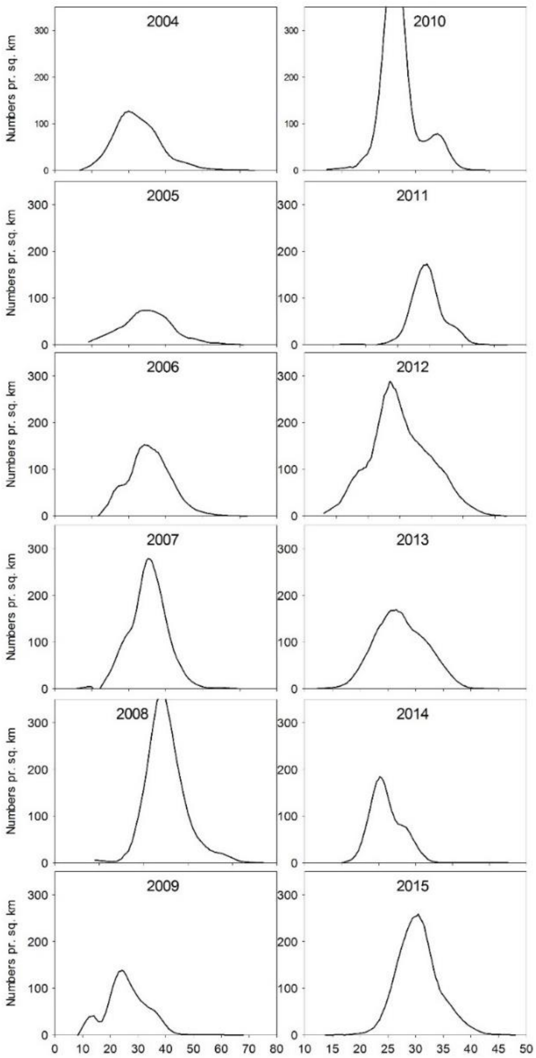


Figure 23.2.4. Overall length distribution of *Sebastes mentella* (number per km²) from the deep Greenland survey.

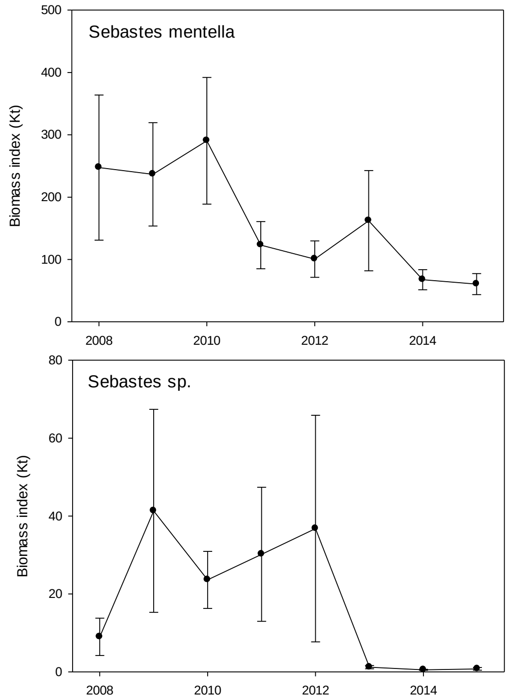


Figure 23.2.5: Biomass (kg*10^6, Kt) (±CV%) indices for *S. mentella* (top) and *Sebastes* sp. (<18cm) (bottom) off East Greenland in 2008-2015 from the Greenlandic shallow water survey. All surveyed areas (Q1–Q6) are combined.

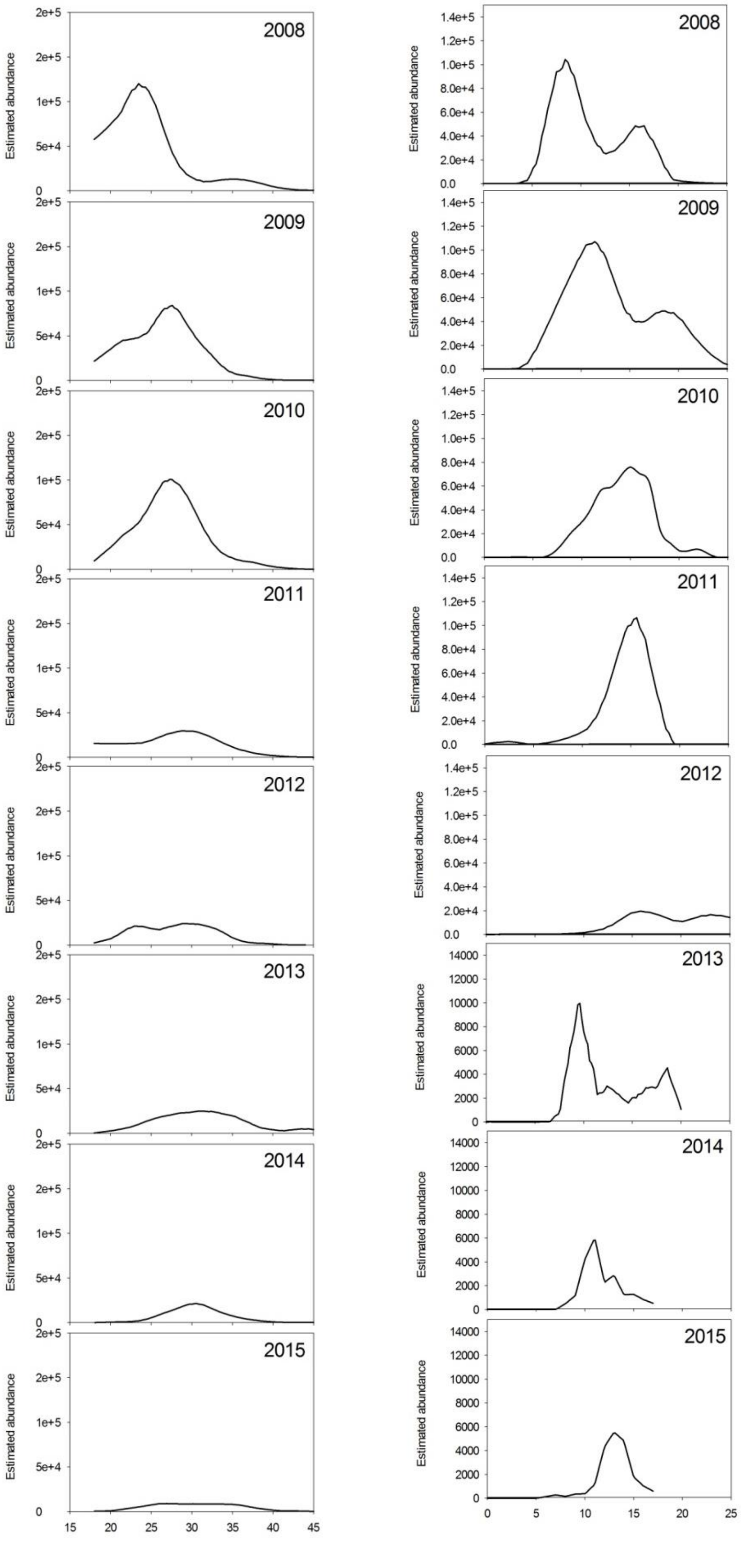


Figure 23.2.6. Overall length distributions for juvenile redfish *S. mentella* (left) and *Sebastes spp.* <18 cm (right) (note the change in scale from 2013) from the Greenlandic shallow water survey. All surveyed areas combined (Q1–Q6).

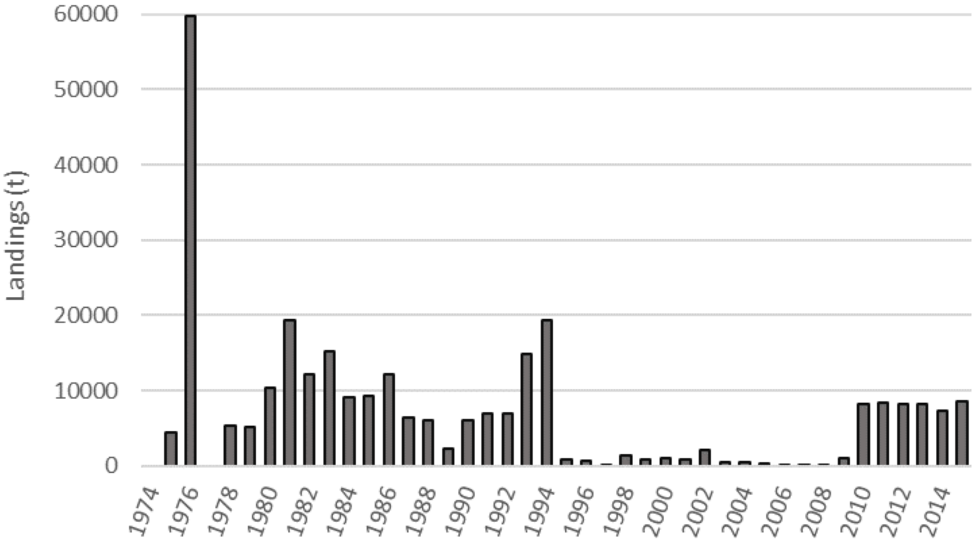


Figure 23.3.1.1 Landings of *S. mentella* in subarea 14.b. Landings of "redfish" have been split based on estimates from survey and commercial catches.

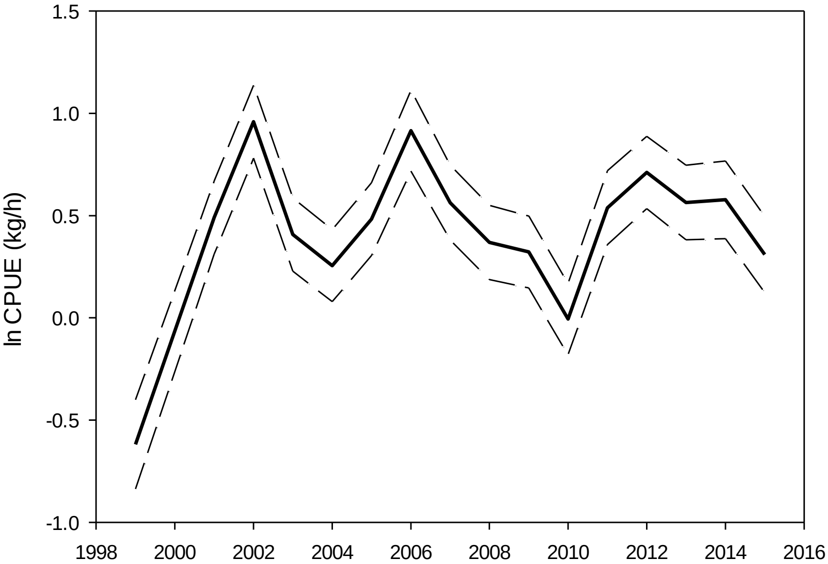


Figure 23.3.2.1 Standardized redfish bycatch cpue in the directed fishery for Greenland halibut in ICES 14.b as a function of year. cpue was estimated from the GLM model: lncpue=year+ICES Sub-division+depth. Bars represent standard error. Only hauls made below 1000m were used in the analyses.

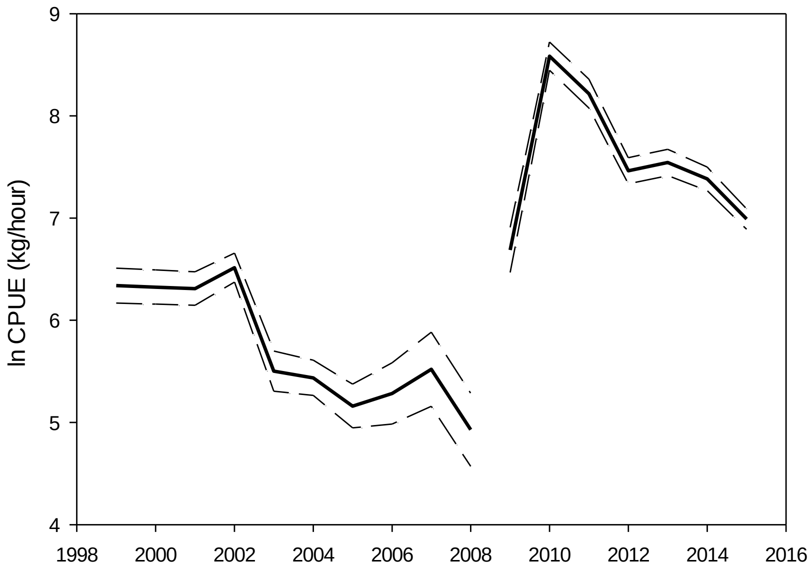


Figure 23.3.2.2 Standardized redfish cpue in the redfish directed fishery ICES 14.b as a function of year. cpue was estimated from the GLM model: lncpue=year+ICES Subdivision+depth. Dashed lines represent standard error.

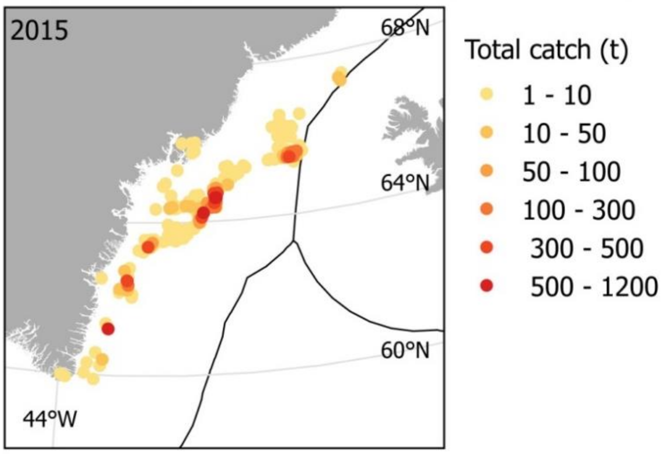


Figure 23.3.3.1 Distribution of catches of demersal redfish in 2015 in ICES 14.b.

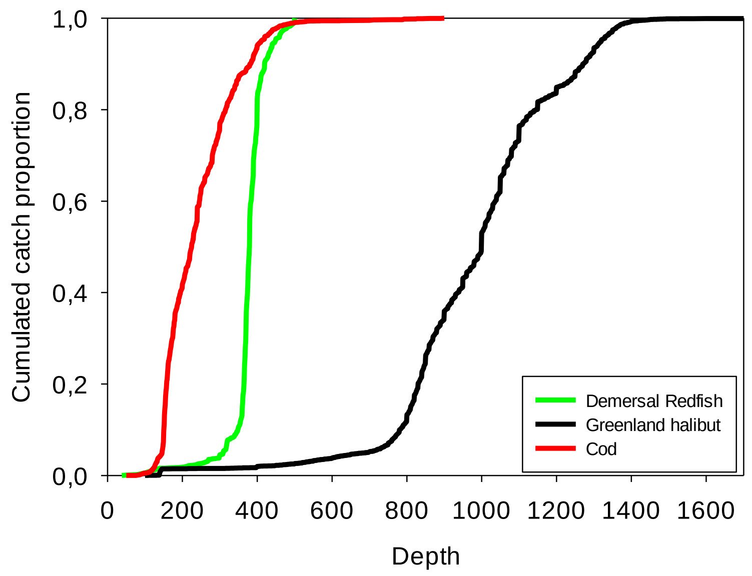


Figure 23.3.3.2. Lines represent the share of the total commercial catch caught at a given depth from 1999–2011 in *G. morhua*, demersal redfish (mixed *S. mentella* and *S. norvegicus)* and *R. hippoglossoides*.

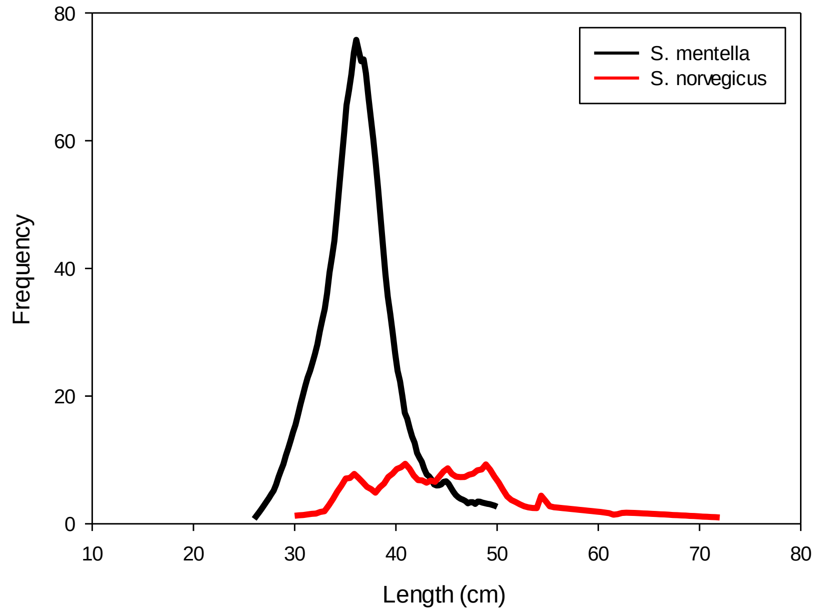


Figure 23.3.5.1: Length distribution of 702 redfish analysed by the Greenland Institute of Natural Resources separated into *S. mentella* (N=559) and *S. norvegicus* (N=143).

Annex 1: List of Participants

North-Western Working Group

27 April – 05 May 2016

Name	Address	Phone/Fax	Email
Agnes C. Gundersen	Møreforsking AS Møreforskning Aalesund NO-6021 Norway	+47 70111621	agnes@mfaa.no
Alexander Bobyrev	Russian Federal Research Institute of Fisheries & Oceanography (VNIRO) 17 Verkhne Krasnoselskaya 107140 Moscow Russian Federation		abobyrev@mail.ru
Alexey Rolskiy	Knipovich Polar Research Institute of Marine Fisheries and Oceanography(PINRO) 6 Knipovitch Street Murmansk 183038 Russian Federation	+7 8152450568	rolskiy@pinro.ru
Anja Retzel	Greenland Institute for Natural Resources Kivioq 2 Nuuk 3900 Greenland	+299 361200	AnRe@natur.gl
Birkir Bardarson	Marine Research Institute Skúlagata 4 IS-121 Reykjavík Iceland		birkir@hafro.is
Bjarki Thor Elvarsson	Marine Research Institute Skúlagata 4 IS-121 Reykjavík Iceland		bthe@hafro.is
Einar Hjörleifsson	Marine Research Institute Skúlagata 4 IS-121 Reykjavík Iceland	Phone +354 552 0240 Fax +354 562 3790	einarhj@hafro.is

NAME	ADDRESS	PHONE/FAX	EMAIL
Elena Guijarro Garcia	Centro Oceanográfico de Vigo Subiola a Radio Faro 50-52 Vigo E-36390 Spain	+34 986 492111	elena.guijarro@vi.ieo.es
Gudmundur J. Oskarsson	Marine Research Institute Skúlagata 4 IS-121 Reykjavík Iceland	Phone +354 575 2000 Fax +354 575 2001	gjos@hafro.is
Heino Fock	Johann Heinrich von Thünen-Institute, Institute for Sea Fisheries Palmaille 9 D-22767 Hamburg Germany	Phone +49 40 38905 169 Fax +49 40 389 05 263	heino.fock@thuenen.de
Helle Torp Christensen	Greenland Institute for Natural Resources P.O. Box 570 GL-3900 Nuuk Greenland		htch@natur.gl
Höskuldur Björnsson	Marine Research Institute PO Box 1390 121 Reykjavík Iceland	Phone +354 575 2000 Fax +354 575 2001	hoski@hafro.is
Jákup Reinert	Faroe Marine Research Institute P.O. Box 3051 FO-110 Tórshavn Faroe Islands	Phone +298 35 3900 Fax +298 353901	jakupr@hav.fo
Jesper Boje	The National Institute of Aquatic Resources Section for Fisheries Advice Charlottenlund Slot, Jægersborg Alle 1 DK-2920 Charlottenlund Denmark	Phone +45 339 634 64 Fax +45 339 63333	jbo@aqua.dtu.dk
Kristjan Kristinsson	Marine Research Institute Skúlagata 4 IS-121 Reykjavík Iceland	Phone +354 575 2000 Fax +354 575 2091	krik@hafro.is
Luis Ridao Cruz	Faroe Marine Research Institute P.O. Box 3051 FO-110 Tórshavn Faroe Islands	Phone +298 35 3900 Fax +298 353901	Luisr@hav.fo

NAME	ADDRESS	PHONE/FAX	EMAIL
Petur Steingrund	Faroe Marine Research Institute P.O. Box 3051 FO-110 Tórshavn Faroe Islands	Phone +298 35 3900 Fax +298 353901	peturs@hav.fo
Rasmus Hedeholm (Chair)	Greenland Institute for Natural Resources P.O. Box 570 GL-3900 Nuuk Greenland	Phone +299 361200 Fax +299 361212	rahe@natur.gl
Sergey Melinkov	Russian Federal Research Institute of Fisheries & Oceanography (VNIRO) 17 Verkhne Krasnoselskaya 107140 Moscow Russian Federation	Phone +7 (495) 2644583 Fax +7 (499) 264 31 87	melnikov@vniro.ru
Teunis Jensen	Greenland Institute for Natural Resources P.O. Box 570 GL-3900 Nuuk Greenland		tej@aqua.dtu.dk

Annex 2: ToRs for the Next Meeting

The North-Western Working Group (NWWG), chaired by Rasmus Hedeholm, Greenland, will meet at ICES Headquarters, 26 April – 3 May, 2017 to:

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

The assessments will be carried out on the basis of the stock annex. The assessments must be available for audit on the first day of the meeting. Material and data relevant to the meeting must be available to the group no later than 5 April 2017 according to the Data Call 2017.

For capelin in Iceland-East Greenland-Jan Mayen area, NWWG will agree any changes to the WG type report and the draft advice no later than 10 May 2017.

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting. For capelin in Iceland-East Greenland-Jan Mayen area, Iceland will provide a WG type report and a draft advice sheet on 3 May. NWWG will agree any changes to the WG type report and the Advice sheet no later than 10 May. An ADG will work by correspondence XX May. The WEBEX will be XX May, and the Advice Release date XX May.

Other material and data relevant to the meeting must be available to the group no later than 14 days prior to the starting date. NWWG will report by XX May 2017 for the attention of ACOM. For capelin in Iceland-East Greenland-Jan Mayen area NWWG will report by XX February 2018 for the attention of ACOM.

Annex 3: List of Stock Annexes

The table below provides an overview of the NWWG Stock Annexes. Stock Annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year*, *ecoregion*, *species*, and *acronym* of the relevant ICES expert group.

Stock ID	Stock name	Last updated	Link
cap-icel_SA	Capelin in the Iceland-East Greenland-Jan Mayen area)	January 2015	cap-icel_SA.pdf
cod-farb_SA	Cod (*Gadus morhua*) in Subdivision 5.b2 (Faroe Bank)	April 2013	cod-farb_SA.pdf
cod-farp_SA	Cod (*Gadus morhua*) in Subdivision 5.b1 (Faroe Plateau)	May 2016	cod-farp_SA.pdf
cod-iceg_SA	Icelandic cod	January 2015	cod-iceg_SA.pdf
cod-ingr_SA	Cod in inshore waters of NAFO Subdivision 1A–1F (Greenland cod)	January 2015	cod-ingr_SA.pdf
cod-segr_SA	Offshore cod in South (NAFO Subdivision 1F) and East Greenland	May 2016	cod-segr_SA.pdf
cod-wgr_SA	Offshore cod in West Greenland (NAFO Subdivision 1A–1E	May 2016	cod-wgr_SA.pdf
ghl-grn_SA	Greenland halibut (*Reinhardtius hippoglossoides*) in Subareas 5, 6, 12, and 14 (Iceland and Faroes grounds, West of Scotland, North of Azores, East of Greenland)	December 2013	ghl-grn_SA.pdf
had-faro_SA	Haddock (*Melanoggrammus aeglefinus*) in Division 5.b (Faroes grounds)	April 2014	had-faro_SA.pdf
had-iceg_SA	Haddock (*Melanogrammus aeglefinus*) in Division 5.a (Iceland)	February 2013	had-iceg_SA.pdf
her-vasu_SA	Herring *(Melanogrammus aeglefinus*) in Division 5.a (Iceland)	February 2013	her-vasu_SA.pdf
sai-faro_SA	Saithe (*Pollachius virens*) in Division 5.b (Faroes grounds)	May 2016	sai-faro_SA.pdf
sai-icel_SA	Saithe in Division Va (Icelandic waters)	May 2013	sai-icel_SA.pdf
smn-con_SA	Icelandic slope beaked redfish (*Sebastes mentella*) in Divisions 5.a and 14.b	May 2012	smn-con_SA.pdf
smn-dp_SA	Deep Pelagic beaked redfish (*Sebastes mentella*) in ICES	May 2012	smn-dp_SA.pdf

smn-grl_SA	Beaked redfish (*Sebastes mentella*) in Division 14.b (Demersal) (Southeast Greenland)	May 2016	smn-grl_SA.pdf
smn-sp_SA	Shallow Pelagic Beaked Redfish (*Sebastes mentella*)	May 2012	smn-sp_SA.pdf
smn-5614_SA	Golden redfish in Subareas 5 and 14 (Iceland, East Greenland and Faroe Islands)	February 2014	smn-5614_SA.pdf

Annex 4: Audit Reports

Audit of Cod (*Gadus morhua*) in NAFO Subarea 1, inshore (West Greenland cod) (cod-ingr).

Date: 4 May 2016

Auditor: Petur Steingrund

General

The report is well done although the language could be improved. The tables and figures are easy to understand and there is a considerable work done to highlight the different year classes and their spatial distribution. The basis for the advice has varied a lot during the years and is confusing because different ICES bodies have had different opinion. ICES should try to avoid this in the future.

For single-stock summary sheet advice:

There is no analytical assessment done for this stock. A catch curve analysis is performed, which gives information about total mortality (very high). An age-based assessment was performed a few years ago, but it was discontinued.

1) Assessment type: Catch curve analysis
2) Assessment: Total mortality (very high)
3) Forecast: Presented. A linear regression of survey indices and subsequent catch (under the assumption that the catch was a relative indication of stock size). This forecast model was suggested by a benchmark to be used as a basis for the advice, but the model was rejected by the Advice Drafting Group.
4) Assessment model: No assessment model.
5) Data aresues: No particular data aresues, although a reliable survey index of the fishable stock is missing (there is just a reliable survey index of recruitment).
6) Consistency: No assessment model, so this is not relevant.
7) Stock status: Unknown.
8) Management Plan: There is no management plan for this stock.

General comments

This stock has quite good data (catch-at-age and survey-at-age data) that could be used in an age-based stock assessment model. There is no reliable commercial cpue. The language could be improved and the frequent use of numbers hampers the reading. The mixture of cod stocks in the coastal areas may be a problem for the evaluation of Z-values and the perception of the stock status.

Technical comments

The advice procedure (how the advice is reached) is not present in the annex. In the annex there is a description of the model that was previously used as the basis for the advice (result of the benchmark), but later rejected by the Advice Drafting Group. The annex needs to be updated, e.g. the terminal year seems to be 2013 or 2014 and the table under the biological reference points has the notion "Explain".

Conclusions

Given the relatively good data (catch-at-age and survey-at-age) it is unfortunate that an age-disaggregated stock assessment model is not used for this stock. Although such a model may be associated with problems it may still be much better than the current procedure ("you see a scratch in the Ferrari and then you take the bike instead"). An age based stock assessment model is also an excellent way of checking the consistency in the data, e.g. how well the cohort data fit to the model and to which extent certain year classes migrate away.

Audit of Cod in Division 5.a (Icelandic cod; cod-iceg)

Date: 10 May 2016

Auditer: Anja Retzel

General

The stock has been assessed in close agreement with the stock annex.

For single-stock summary sheet advice:

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 aresues: All data are 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 2016 is estimated at 469 kt. Reference biomass, (B4+) is estimated at 1243 kt in 2016. B_{pa} is 160 kt, F_{lim} is 0.74 and F_{pa} is 0.69.
8) Man. Plan: Because SSB> Btrigger, the $TAC_{2016/2017}$ is set as ($TAC_{2015/2016}$ + 0.2*$B_{B4+,2016}$)/2. In accordance with this plan, the proposed TAC for 2016/2017 is 244 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 Faroe Bank Cod (cod-farb)

Date: 10 May 2016

Auditor: Anja Retzel

General

For single-stock summary sheet advice:

1) Assessment type: Update
2) Assessment: trends
3) Forecast: not presented
4) Assessment model: None
5) Data aresues: None, in relation to Stock Annex
6) Consistency: Same advice as in last year, the area closed for fishery.
7) Stock status: Poor status of the stock, the biomass indices below average and no signs of improvements
8) Man. Plan.: *There is no management plan for this stock*

General comments

The message in the text is clearly put forward and the graphs illustrative. However, the structure and subheadings of the Assessment report is a bit different from other stocks, and should be improved and made more along the lines with others at some point (e.g. during benchmark assessment). For example, the section "Status of the stock" is normally few sentences but fills 1.5 pages out of total 3 pages for this stock. Most of the text there should be under different sections (e.g. "Landings","Information from Surveys", "Exploratory assessment" etc).

Technical comments

I did not see any errors in the report and the assessment was done according to the Stock Annex.

Conclusions

The assessment has been performed correctly

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice? *-Yes*
- Is the assessment according to the stock annex description? *-Yes*
- Is general ecosystem information provided and is it used in the individual stock sections. *–Not provided in the stock report, and therefore not used*
- If a management plan has been agreed, has the plan been evaluated? *–Not relevant*

For update assessments

- Have the data been used as specified in the stock annex? *-Yes*

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? *–Not relevant, it is surveys trends based assessment*
- Is there any **major** reason to deviate from the standard procedure for this stock? *-No*
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? *-Yes, the update assessment gives a valid basis for advice.*

Audit of Capelin in the Iceland-East Greenland-Jan Mayen area (cap-icel)

Date: 25 May 2016
Auditor: Teunis Jansen

General

The basis for the advice was in accordance with the stock annex and the surveys were well described. However:

- Stock annex was missing in the 2015 report. It is available from the WKICE 2015 report, so the NWWG ensure that it is included in the 2016 report.
- Information about predation and growth data used as prediction model input is lacking. Discuss the estimates in relation to previous years. How sensitive is the forecast and thereby advice to uncertainties in predation. Did migration speed and route differ from the historic information used for the predation model?
- Assumptions about growth are not described (see Stock annex section C. Assessment: data and method, paragraph with the header "Following acoustic survey in autumn (September–October)": *"Bootstrap replicates of survey estimates of SSB are updated based on revised assumptions about growth, mortality, etc. Additional uncertainty is included due to variable mortality and fed into the predation model with same supporting data as when applied to winter survey results.")*

Audit of Faroe plateau cod (cod-farp)

Date: 11 May 2016
Auditor: Helle Torp Christensen

General

For single-stock summary sheet advice:

1) Assessment type: Update

2) Assessment: XSA with catch-at-age data and age-disaggregated indices, using catches in the model and in the forecast.

3) Forecast: The short-term prediction until year 2018 showed a slightly decreasing total-stock biomass to 25 000 tonnes and a spawning-stock biomass to 19 000 tonnes. Single species long-term forecasts for Faroe Plateau cod indicated Fmsy values lower than Fpa. The 2016 assessment was much in line with the 2015 assessment and forecast

4) Assessment model: Short term: Age structure and Long term: Yield and biomass per recruit over a range of F-values.

5) Data aresues: Landing data are considered accurate. There are no incentives to discard fish under the effort management system. The sampling of the landings is believed to be adequate.

6) Consistency: Consistent with last year

7) Stock status: The 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.

8) Management Plan: There is no management plan for this stock.

General comments

ToRs relevant to provide advice is presented and the report is well structured and text is clear. The stock is in very poor state and a management plan for recovery is suggested.

Technical comments

Assessment was conducted according to the Stock Annex.

Conclusions

The assessment has been performed correctly and the results can be used as basis for advice.

Audit of Cod (*Gadus morhua*) in NAFO Subarea 1A-1E (Offshore West Greenland) (cod-wgr).

Date: 4 May 2016
Auditor: Alexey Rolskiy

General

A comprehensive review of scientific and fishery data. Lots of detailed figures and tables including information about tagging. Some text corrections are needed.

For single-stock summary sheet advice:

There is no analytical assessment done for this stock.
Assessment type: Qualitative.

1) **Assessment**: Survey trends analysis.
2) **Forecast**: The surveys (GRL-GFS, Ger(GRL)-GFS-Q4) show only a minor increase in biomass in recent years, but it is assumed that survey uncertainty is high.
3) **Assessment model**: No assessment model.
4) **Data aresues:** All data are available as described in the Stock Annex.
5) **Consistency**: No assessment model, so this is not relevant.
6) **Stock status**: The stock is considered to be at a very low level compared to historic.
7) **Management Plan**: implemented for the offshore cod fishery in Greenland (2014-2016), based on the distinction between the inshore and two offshore stocks components.

General comments

No stock assessment can be undertaken for this stock, due to the lack of significant rebuilding since the stock collapsed in the late 1960s. Surveys indicate some increase of juveniles in the last decade, but it is believed that this increase is partly driven by juveniles from other cod stocks using the area as nursery grounds. This circumstance adds uncertainty to the utility of the survey indices. Commercial cpue data are available. However, due to the limited fisheries in recent years they are of little use for stock assessment.

Technical comments

None

Conclusions

Given the very low level of this stock, no catches should be taken in 2017. Further work should be invested into the data sources used for the assessment after any signs of significant rebuilding of the stock.

Audit of Icelandic slope Sebastes mentella (smn-con)

Date: 11 May 2016
Auditor: Helle Torp Christensen

General

For single-stock summary sheet advice:

1) **Assessment type:** Survey trend-based assessment

2) **Assessment**: Trends

3) **Forecast**: not presented

4) **Assessment model**: No analytical assessment. Survey indices from the annual survey since 2000 are used as basis for advice.

5) **Data aresues**: No particular data aresues. However, systematic age reading from the collected otolites could improve knowledge of the stock.

6) **Consistency**: Not applicable due to no assessment**.**

7) **Stock status**: 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 5.a. The fishable biomass index of Icelandic slope *S. mentella* from the Icelandic autumn survey shows that the biomass index for 2004—2013 has decreased to similar level as in 2003 when it was at lowest level, but increased again in 2014 and 2015. 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).

8) **Management Plan**: There is no management plan for the stock.

General comments

The report addresses the ToRs of the WD in proper and thorough manners, as achievable with these data limited stock. It is the perception of the stock that it is on a general low level, however it is stable or slightly recovering.

Technical comments

The report is in accordance with the stock annex.

Conclusions

The assessment has been performed correctly and is a valid basis for advice.

Audit of Shallow Pelagic Sebastes mentella (smn-sp-SA)

Date: 2 May 2016
Auditor: Gudmundur J. Óskarsson

General

For single-stock summary sheet advice:

1) Assessment type: update
2) Assessment: trends
3) Forecast: not presented
4) Assessment model: No analytical assessment, -the assessment is based on survey indices, catches, cpue and biological data
5) Data aresues: No new survey data available from 2015 because incomplete survey coverage (detailed in the report), thus the newest survey data derived from 2013. Consequently, lack of survey data for so long period is in contrast to the description in the stock annex.
6) Consistency: Not applicable due to no assessment or no new survey/cpue data presented in the report.
7) Stock status: The most recent survey estimate, in relation to the time-series, indicate a really poor status of the stock
8) Management Plan: No management plan exists for this stock

General comments

The report addresses the ToRs of the WD in proper and thorough manners, as achievable with these data limited stock. Due to lack of new information, particularly survey data, the changes in the report from previous year are small and consequently the perception of the stock size has not changed for some years. Considering the apparently very poor stock status, the countries still fishing from the stock must have obligations to participate in scientific surveys to assess the stock size. This last sentence reflects my thoughts after having read the report.

Technical comments

There were minor errors spotted in the report (kt instead of million t), that have been passed on to the stock coordinator. Otherwise, the content of the report is in accordance with the stock annex.

Conclusions

The assessment has been performed correctly

Audit of Greenland slope Sebastes mentella in 14.b. (smn-grl)

Date: 4 May 2016
Auditor: Kristján Kristinsson

General

For single-stock summary sheet advice:

1) Assessment type: update

2) Assessment: trend based assessment

3) Forecast: not presented

4) Assessment model: No analytical assessment. The assessment is based on survey biomass index from the Greenland shrimp and fish shallow water survey (GRL-GFS, 0-600m). Other surveys survey indicators are German survey (GER(GRL)-GFS-Q4, 0-400 m), and Greenland deep-water survey (GRL-DEEP, 400-1500 m). Catches, cpue and biological data.

5) Data aresues: Catch statistics do not separate *Sebastes mentella* from *Sebastes norvegicus*. The survey indices have large uncertainties, primarily due to the aggregating behaviour of the stock. Connection to other stocks of *S. mentella* in the area (shallow and deep pelagic stocks and the Icelandic slope stock remains unresolved.

6) Consistency: Not applicable due to no assessment.

7) Stock status: Biomass and abundance index for both adult and juvenile redfish have together with the cpue been declining since 2010. Biomass estimates from the Greenland shrimp and fish shallow water survey were in 2015 the lowest observed. Stock indicator from the other two surveys also show decline.

8) Management Plan: No management plan exists for this stock

General comments

The report addresses the ToRs of the WD in proper and thorough manners, as achievable with these data limited stock. Landings have in 2011-2015 been well above recommended TAC which is of concern because of sharp decline in stock indicators. Advice has to be conservative.

Technical comments

Conclusions

The assessment has been performed correctly and as described in the Stock Annex

Annex 5: List of Working Documents. (NWWG 2016)

Boje J. and Hedeholm R. 2016. The fishery for Greenland halibut in ICES Div. XIVb in 2015. ICES NWWG 2016 Working Document no. 01.

Boje J., Hvingel C. and Hedeholm R. 2016. An assessment of Greenland halibut (*Reinhardtius hippoglossoides*) off East Greenland, Iceland and the Faroe Islands. ICES NWWG 2016 Working Document no. 02.

Óskarsson G.J. 2016. Estimation on number-at-age of the catch of Icelandic summer-spawning herring in 2015/2016 fishing season and the development of *Ichthyophonus hoferi* infection in the stock. ICES NWWG 2016 Working Document no. 03.

Óskarsson G.J. 2016. Results of acoustic measurements of Icelandic summer-spawning herring in the winter 2015/2016. ICES NWWG 2016 Working Document no. 04.

Steingrund P. 2016. Greenland halibut CPUE for commercial trawlers operating on the slope on the Faroe Plateau 1991-2015. ICES NWWG 2016 Working Document no. 05.

Steingrund P. 2016. Greenland halibut CPUE for the research vessel operating on the slope on the Faroe Plateau in May-June 1995-2015. ICES NWWG 2016 Working Document no. 06.

Steingrund P. 2016. Survey biomass indices of Greenland halibut on the slopes of the Faroe Plateau 1983-2015. ICES NWWG 2016 Working Document no. 07.

Steingrund P. 2016. A combined biomass index of Greenland halibut on the slopes of the Faroe Plateau 1983-2015. ICES NWWG 2016 Working Document no. 08.

Christensen H.T. and Hedeholm R. 2016. The fishery for demersal Redfish (*S.mentella)* in ICES Div. XIVb in 2015. ICES NWWG 2016 Working Document no. 09.

Hedeholm R. and Christensen H.T. 2016. Greenland Shrimp and Fish Survey Results for Redfish in East Greenland Offshore Waters in 2015. ICES NWWG 2016 Working Document no. 10.

Christensen H.T. and Hedeholm R. 2016. Survey for Greenland halibut in ICES Division 14B, August – September 2015. ICES NWWG 2016 Working Document no. 11.

Steingrund P. and Reinert J. 2016. The biomass of Faroe haddock 1914-1956 estimated by catch per unit effort and stock assessment data. ICES NWWG 2016 Working Document no. 12.

Steingrund P. 2016. The biomass of Faroe saithe 1924-1960 estimated by catch per unit effort and stock assessment data. ICES NWWG 2016 Working Document no. 13.

Popov V. and Rolskiy A. 2016. Preliminary information on the results of Russian fishery and biological samples of pelagic redfish from the ICES subarea XII, XIV and NAFO Div. 1F in 2014. ICES NWWG 2016 Working Document no. 14.

Retzel A. 2016. Greenland commercial data for Atlantic cod in East Greenland offshore waters for 2015. ICES NWWG 2016 Working Document no. 15.

Retzel A. 2016. Greenland Shrimp and Fish survey results for Atlantic cod in ICES subarea XIVb (East Greenland) and NAFO subarea 1F (SouthWest Greenland) in 2015. ICES NWWG 2016 Working Document no. 16.

Retzel A. 2016. Greenland commercial data for Atlantic cod in Greenland inshore waters for 2015. ICES NWWG 2016 Working Document no. 17.

Retzel A. and Christensen H.T. 2016. West Greenland inshore survey results for Atlantic cod in 2015. ICES NWWG 2016 Working Document no. 18.

Retzel A. 2016. Greenland commercial data for Atlantic cod in West Greenland offshore waters for 2015. ICES NWWG 2016 Working Document no. 19.

Retzel A. 2016. Greenland Shrimp and Fish survey results for Atlantic cod in NAFO subareas 1A-1E (West Greenland) in 2015. ICES NWWG 2016 Working Document no. 20.

Fock H., Stransky C. and Bernreuther. 2016. Abundance for *Sebastes norvegicus* L., deep sea *S. mentella* and juvenile redfish (Sebastes spp.) off Greenland based on groundfish surveys 1985-2014. ICES NWWG 2016 Working Document no. 21.

Fock H. 2016. Update of Groundfish Survey Results for the Atlantic Cod Greenland offshore component After re-stratification of the survey 1982-2015. ICES NWWG 2016 Working Document no. 22.

Fock H. 2016. An age4plus index for the Atlantic Cod Greenland offshore component Based on recommendations from WKICE 2015 1989-2015. ICES NWWG 2016 Working Document no. 23.

Steingrund P. 2016. The biomass of Faroe Plateau cod 1860-1905 estimated by catch per unit effort and stock assessment data. ICES NWWG 2016 Working Document no. 24.

Steingrund P. 2016. The biomass of Faroe Plateau cod 1710-1859 estimated by qualitative cod years, dried cod export, and stock assessment data. ICES NWWG 2016 Working Document no. 25.

Vasilyev D. and Bobyrev A. 2016. *Sebastes mentella* fishery in the Irminger Sea: current state and perspectives. ICES NWWG 2016 Working Document no. 26.

Óskarsson G.J. and Guðmundsdóttir Á. 2016. Determination of F lim for Icelandic summer-spawning herring (Her-Vasu). ICES NWWG 2016 Working Document no. 27.