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ICES CIEM
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Executive summary

Faroe Bank Cod

The fishing area has been closed since 2009, and total reported landings in 2016 (19 t.) were among the lowest recorded since 1965.

Spring survey index suggests that the stock increased from 2013 to 2014 and declined substantially again in 2015 and 2016. The spring index increased slightly in 2017. 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. The stock is subject to a multiannual advice of zero catches in 2017, 2018 and 2019.

Faroe Plateau cod

The input data in this update assessment consisted of the catch-at-age starting in 1959 and the spring survey starting in 1994 as well as the summer survey starting in 1996. The maturities were obtained from the spring survey. The terminal year in the assessment was 2016.

A benchmark was in February where the assessment model was changed from the XSA to SAM. Since the assessment model was changed, the reference points were revised at the NWWG meeting. The SAM model was tuned with the two survey indices. The fishing mortality in the terminal year was estimated at 0.44, which was higher than the Fmsy of 0.23. The total stock size in the beginning of the terminal year was estimated at 26 300 tonnes and the spawning stock biomass at 20 300 tonnes, which was slightly below the limit biomass of 21 000 tonnes. The extremely low biomass since 2004 seems to be unprecedented the last three centuries.

The short-term prediction until year 2019 showed an increase of the spawning stock biomass to 34 000 tonnes. It is advised to reduce the fishing mortality in order to facilitate rebuilding of the stock.

Faroe haddock

The input data in this assessment consisted of the catch-at-age starting in 1957, the spring survey from 1994 onwards and the summer survey from 1996 onwards. The maturities were obtained from the spring survey. Stock weights were assumed the same as the catch weights.

A benchmark was held in February where the assessment model was changed from the XSA to SAM. The reference points were recalculated/revised during and after the NWWG meeting. The SAM model was tuned with the two survey indices. The fishing mortality in the terminal year was estimated at 0.28 compared to the revised Fmsy of 0.13. The spawning stock size in the beginning of the terminal year was estimated at 15 850 tonnes slighly below the revised Blim of 16 780 tonnes.

The short-term prediction showed an increase of the spawning stock biomass to 20 000, 34 500 and 75 400 tonnes in 1717-1719, respectively. This increase is mainly due to two incoming good year classes. It is adviced to reduce the fishing mortality in order to facilitate rebuilding of the stock and to ensure that biomass will stay above Blim.

Faroe Saithe

This stockwas benchmarked in 2017 (WKFAROE). Input data (new maturity ogives and incorporation of survey indices) and a new assessment method (SAM) were adopted as basis for the advice. Biological reference points were revised accordingly. New F_{msy} went down from F_{msy} =0.3 to F_{msy}=0.28. Bpa and BSMY trigger were revised down from 55 000 t. to 50 000t. Limit reference points B_{lim}=34 000 t. and F_{lim}=0.61 were defined for this stock.

Nominal landings in 2016 are estimated at 29 450 t. (historical average=37 000 t.) Estimated fishing mortality in 2017 (average of ages 4 to 8) is F=0.42, which is higher than the historical average (F=0.37) and above F_{MSY}=0.28. Fishing mortality has declined since 2010 as a consequence of declining catches. Estimated SSB was below Btrigger from 2011 to 2015 but above Btrigger in 2016 and 2017 as a result of low fishing mortalities, improved weights and increasing maturity ogives.

The 2012 year class (age 4 in 2016) is estimated as the second strongest since 1961. As a result SSB is predicted to increase to 101 000 t. and 118 000 t. in 2017 and 2018 respectively with status quo F=0.42. Predicted catches in 2017 are 46 000 t.

Icelandic Saithe

The 2017 reference biomass (B_{4+}) is estimated as 327 kt, 25% above the average in the assessment period (1980 to the present). Spawning stock biomass is estimated as 161 kt, the highest 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 the last 3 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. However, a smaller than estimated stock cannot be excluded. The current assessment is an upward revision of last year's assessment, mostly caused by the strong 2012 yearclass.

Recruitment has been above average since 2009 and relatively stable. Yearclass 2012 is estimated to be strong and the survey in 2017 indicates that yearclass 2013 is above 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 result of the assessment changes somewhat with settings of the assessment model, with estimated reference biomass in 2017 varying from 297-354 thous tonnes from models with "plausible settings". The lowest and highest values are from SAM models with little different settings of observation variance. The assessment is considered relatively uncertain but this year's assessment is similar to last year's assessment

According to the adopted harvest control rule, the TAC will be 60 kt in the next fishing year compared to 55 kt in current fishing year. The fact that the TAC has not been caught in recent fishing year and substantial effort is required to catch saithe makes this increase questionable.

Icelandic cod

A formal HCR has been in place to set the TAC for this stock since 1994. The primary essence of the rule has been that the TAC for the next fishing year (starting September 1st in the assesment year and ending 31. August next year) is based on a multiplier on the reference biomass of four years and older in the assessment year ($B(4+)$).

The rule has gone through some amendments and revisions over time. 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. The current rule has in addition a catch stabilizer. When the SSB in the assessment year is estimated to be above $SSB\_trigger$ (220 kt) the decsison rule is:

$$TAC(y/y+1) = (0.20 * B\_(4+, y) + TAC(y-1/y))/2$$

The TAC for the current fishing year (2016/2017) based on last years assesment was 244 kt.

The results of this years assessment show that the spawning stock in 2017 is estimated to be 617 kt. The values estimated in recent years are higher than have been observed during the last five decades. The reference biomass B_{4+} in 2017 is estimated to be 1356 kt, and has not been so high since the late 1970's. Fishing mortality, being 0.28 in 2016, has declined significantly in recent years and is presently the lowest observed. Year classes since the mid-1980s are estimated to be relatively stable but with the mean around 33% lower than observed in the period 1955 to 1985. Estimates of year classes 2014 and 2015 indicate that they are in the upper range of that observed in the recent decades, while the first estimate of the 2016 year class indicates that it is below average. That year class will not enter into the fishery until 2020.

Given the above HCR rule the catch for the coming fishing year (2017/2018) is 258 kt.

The input in the analytical assessments are catch at age 1955-2016 (age 3 to 14) and spring groundfish survey (SMB) indices at age from 1985-2017 and fall survey groundfish survey (SMH) indices at age from 1996-2016 (ages 1 to 10). The model framework has been the same since 2002, spring survey only used as input up to the 2009 assessment, both surveys since then.

Icelandic haddock

A formal HCR has been in place for haddock in 5.a since 2013. According to the adopted Harvest Control Rule the advice for the fishing year 2017/2018 (September 1st 2017–August 31st 2018) is 41 390 tonnes. The advice for the following fishing year is predicted to be approximately 47 600 tonnes and remain at that level, as the catches will mainly be from a large year class.

The 2014 year class is estimated to be large, after 6 consecutive small year class from 2008–2013. The 2015 and 2016 year classes are, however, expected to be close to the geometric mean recruitment. The current assessment shows similar stock status 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 expected that 2014 year class will be substantially present in the fishery in 2018.

Growth in 2016 was above average since 1985 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. This difference has been apparent since 2009, although now this difference is now decreasing. Sensitivity analysis based on different models, using the same tuning series, exhibit similar properties.

Icelandic summer spawning herring

The total reported landings in 2016/17 fishing season were 60.4 kt (including summer fishery 2016) but the TAC was set at 63 kt. The index of biomass age 4+ in the winter surveys 2016/17 was estimated at 339 kt, compare to 372 kt in the winter 2015/16. The 2015 year class (age 1 in 2016) appears to be below average size.

This is an update assessment where the 2016 data have been added to the input data. A revision of last year's data on natural mortality, M, was also done. New estimates on the *Ichthyophonus* mortality were applied, which implies that infection mortality took place over three years instead of two, but only 30% of infected herring died. This results in overall less M and lower estimations of SSB over the years ~2003-2011.

There are compelling evidence for serious new infection by *Ichthyophonus* in the stock in the winter 2016/17. This calls for applying additional infection mortality in 2017 until spawning. The level of the additional M was based on samples and analyses and corresponds to the 2009-2011 levels.

The analytical assessment model, NFT-Adapt, gives a downward revision of SSB in 2016 (11%) and indicates that the biomass of age 4+ was 258 kt in the beginning of 2017 and SSB will be 238 kt at the spawning time in 2017 and below MSY $B_{trigger}$=273 kt when accounting for additional M. Continuation of small year classes entering the spawning stock, in addition to the infection, explains the downward trend in the stock size. In conformity with the MSY approach the adviced TAC is based on F=0.192 giving TAC of 41 kt and resulting in SSB in 2018 at 245 kt.

Capelin in the Iceland–East Greenland–Jan Mayen area

In May 2016 ICES advised that the initial (preliminary) quota should be 54 000 t. In October, the Icelandic Marine Research Institute (MRI) adviced an intermediate TAC of 0 t based on an acoustic survey in September. In January 2017, MRI adviced TAC of 57 000 t based on an acoustic survey in January. Lastly, a final TAC of 299 000 t was advised by MRI on the basis of an acoustic survey in February 2017. All advice was based on the HCR from ICES WKICE (2015).

The total landings in the fishing season 2016/2017 amounted to 300 thousand t (preliminary data). All catches were caught in winter months (January–March) 2017.

The acoustic survey in autumn 2016 had extensive spatial coverage. The acoustic estimates of immatures (9.4 bill.) were well below the HCR-value (50 bill.) that triggers an initial quota. Consequently, ICES advices an initial quota of 0 t for the fishing season 2017/18.

Offshore West Greenland Cod

The West Greenland offshore stock component is 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 commercial catches in 2016 amounted to 3 740 t. The TAC was 5 000 t in 2016. The 2009 and 2010 YC's dominates the catches in 2015 and 2016.

Both the German and Greenland survey indices show that the biomass and abundance increased in the period 2010-2015 due primarily to the 2009 YC and in part the 2010 YC. In 2016 the German survey did not cover the area and the Greenland survey showed a reduction of 86% in biomass index.

The spatial distribution of the 2009 YC changed between 2015 to 2016, where the YC had a more easterly distribution in 2016 than in 2015 where it was abundant in South-West Greenland.

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 34 204 t in 2016 which is the highest since early 1990s. Several year classes were caught in the fishery but catches were dominated by the 2011 YC (5 yr old).

Survey recruitment indices from the inshore area show that incoming year classes (2013 and 2014) are around average.

The survey biomass index suggests that the adult part of the stock has fluctuated without trend in recent years, but at a relatively high level.

The advice is based on the DLS approach (3.2) using the biomass index as basis for advice.

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 2016 was conducted as an experimental fishery with a TAC of 16 000 tons. Total catches were 14 818 tons. The year class dominating the catches was the 2010 YC in Southwest Greenland and the 2009 YC in East Greenland. The largest cod (mean length of 89 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 of 30%. The biomass has been declining for 3 years in the Greenland survey and for 2 years in the German survey.

In both surveys the 2009 YC has been dominating in the period 2013-2015. In 2016 the YC was still dominating the Greenland survey however in low numbers compared to previous years. The spatial distribution of the 2009 YC shifted from Southwest Greenland to East Greenland. In the German survey the 2009 YC was found in small numbers in 2016 and the 2010 YC was dominating the survey.

Advice is based on an F_{proxy} multiplier generated from the relationship between the catches and smoothed 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 24 kt in 2016. 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 decrease in 2016.

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 72% of B_{MSY}. Fishing mortality has since 2013 been around F_{MSY} and is in 2016 7% 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 overall recent trend in the assessment. However, in 2016 the fishery in East Greenland experienced a further increase in catch rates consistent in the entire East Greenland suggesting different population dynamics for this area. In an eventual upcoming benchmark the stock ID issue will be dealt with.

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

Total landings in 2016 were 59 698 t, which is about 8 000 t more than in 2015. About 91% 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 65% 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 2018 will be 50 800 t.

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

Total landings of demersal *S. mentella* in Icelandic waters in 2015 were about 9 536 t, 200 t more than in 2015. 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, increased in 2014 and 2015, but decreased again in in 2016.

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 2018 should be no more than 11 786 t. All catch are assumed to be landed.

Shallow Pelagic *Sebastes mentella*

Total landings of shallow pelagic *S. mentella* in 2016 were 1 967 t, a decrease of about 3 600 t compared to 2015. 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 28 654 t, which is about 1 200 t more than in 2016.

The stock was benchmarked in August 2016 (WKDEEPRED). At the workshop an age-length-based assessment model was applied for the first time to give relative estimates of abundance and exploitation rates for this stock. The assessment is at present considered to be in Category 2. WKDEEPRED also derived precautionary and MSY reference points (Blim, Bpa, Flim, Fpa, FMSY and MSY Btrigger). It further agreed the settings to be used in short-term projections.

The SSB has decreased since 1994 and is now below B_{lim} of 559 kt. Since the start of the fishery in 1991 fishing mortality increased sharply and has been high and fluctuating since the early 2000s. Fishing mortality has exceeded F_{lim} (0.057) since 1994. Recruitment has been overall stable with a few good year classes (corresponding to age 5 recruitment in 1990 and 1995) that presently contribute to the fishable biomass.

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.

ICES advised in the autumn 2016 that when the MSY approach is applied, there should be zero catch in each of the years 2017 and 2018.

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 2016 were 3 061 tons, which is the lowest value the last six years. The proportion of *S. mentella* in the mixed-stock fishery has been declining the last five to six years and in 2016, the proportion of *S. norvegicus* exceeds the proportion of *S. mentella* for the first time. Catch depth has at the same time been reduced and is now primarily in the range of 350-400 m compared to 350-400 m back in 2011-2012.

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 along with the cpue been declining since 2010, however in 2016 the indices increased. Recruitment has for the last four years been at a low level. Given the biology of the species, the low level of recruits and the nature of the fishery the advice has to be conservative. Resent survey indices increased slightly thus no uncertainty parameters was applied. The advice for 2017 is 1 142 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, met at ICES Headquarters, 27 April – 4 May, 2017 to:

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

b) Estimate MSY proxy reference points for the category 3 and 4 stocks in need of new advice in 2017 (see table below).

   i) Collate necessary data and information for the stocks listed below prior to the Expert Group meeting. An official ICES data call was made for length and select life history parameters for each stock in the table below;

   ii) Propose appropriate MSY proxies for each of the stocks listed below by using methods provided in the ICES Technical Guidelines (i.e. peer reviewed methods that were developed by WKLIFE V, WKLIFE VI, and WKProxy) along with available data and expert judgment.

Stock Code	Stock name description	EG	Data Category
smn-grl	Beaked redfish (Sebastes mentella) in Division 14.b, demersal (Southeast Greenland)	NWWG	3.2
smn-con	Beaked redfish (Sebastes mentella) in Subarea 14 and Division 5.a, Icelandic slope stock (East of Greenland, Iceland grounds)	NWWG	3.2
cod-segr	Cod (Gadus morhua) in ICES Subarea 14 and NAFO Division 1.F (East Greenland, South Greenland)	NWWG	3.3
cod-wgr	Cod (Gadus morhua) in NAFO divisions 1.A–E, offshore (West Greenland)	NWWG	3.14
cod-ingr	Cod (Gadus morhua) in NAFO Subarea 1, inshore (West Greenland cod)	NWWG	3.2

Additionally the NWWG were tasked with completing a template indicating the current status of the same stocks, and what it would require to promote them to full analytical assessments.

1.1.2 Generic ToRs for Regional and Species Working Groups

The working group should focus on:

a) Consider and comment on ecosystem and fisheries overviews where available;

b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:

   i) descriptions of ecosystem impacts of fisheries

   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, summarising where the item is relevant:
  - i) Input data and examination of data quality;
  - 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 (i.e., all stocks with catches in the NEAFC area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in the last year.
  - 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) Review progress on benchmark processes of relevance to the expert group;
- f) Prepare the data calls for the next year update assessment and for the planned data evaluation workshops;
- g) Identify research needs of relevance for the expert group.

1.2 NWWG 2016 work in relation to the generic ToR

The ecosystem overview for the Icelandic Ecoregion has recently been published, and that section was removed from the report. A working document demonstrated that there appears to be a relationship between primary production, temperature and the behaviour of 1 year old cod on the Faroe Plateau. This was shown to potentially improve the assessment for Faroe Plateau cod through improved recruitment estimates, and it was added to the ecosystem overview. It was not implemented in the assessment procedure. Beyond this, the ecosystem overviews were not elaborated on. The sections have been given consideration in the last years, and the group was additionally tasked with more work than usual and this work was given higher priority by the group; especially the work with recently benchmarked stocks and the definition of stock status for the category 3 stocks.

All Faroese stocks (except the bank cod) underwent a benchmark prior to the meeting (WKFAROE), but no finalized report was available. Nevertheless, stock annexes were produced during the benchmark and the external reviewers had produced their comments. The draft advice was produced according to these annexes under the assumptions that they remain unchanged following the finalization of the report. The benchmark output was not clear in relation to reference points. The NWWG opted to recalculate the reference points for all three stocks, so they are in accordance with the adopted assessment procedure and ICES methodology. However, the setting of reference points requires assumption on selection pattern, S-R relationship etc. and it was not optimal to work on these things during the meeting. The work was finalized and the stock annexes were updated. However, this work should be re-visited.

For Icelandic herring work had been done on the persisting *Ichthyophonus hoferi* infection in the stock. In short, the annual mortality estimates caused by the infection were modified. This altered the historical stock development, but had little effect on the current stock estimates. The NWWG implemented the change as it is an improvement of the assessment.

For all other stocks, the NWWG adopted the assessment which formed the basis for stock status and the premise for the forecasts. Based on the assessments the group produced a draft advice for all stocks.

The individual stock report sections were not reviewed in plenary due to time constraints. The summary sheets for all stocks were all reviewed and agreed upon in plenary.

1.3 NWWG 2016 work in relation to the specific ToR

The North group was tasked with: "*Estimate MSY proxy reference points for the category 3 and 4 stocks in need of new advice in 2017*". Hence, current stock status (B/BMSY) and relative fishing pressure (F/FMSY) should be estimated for each of the following stocks:

- Beaked redfish (*Sebastes mentella*) in Division 14.b (reb.27.14b)
- Beaked redfish (*Sebastes mentella*) in Subarea 14 and Division 5.a (reb.27.5a14)
- Cod (*Gadus morhua*) in ICES Subarea 14 and NAFO Division 1.F (cod.2127.1f14)
- Cod (*Gadus morhua*) in NAFO divisions 1.A–E, offshore (cod.21.1a-e)
- Cod (*Gadus morhua*) in NAFO Subarea 1, inshore (cod.21.1)

These are all category 3 stocks, and MSY proxies have not previously been defined for any of them. To assist the expert groups in estimating stock status, several methods were proposed as a result of multiple ICES workshops. These are described in detail in the "*ICES Technical guidance for providing reference points for stocks in categories 3 and 4*". The methods are a mix of length based indicators and a stock production model (SPiCT). The working group applied all methods to all stocks in order to evaluate if any of them produced reliable estimates and could be used to determine stock status. To provide an overview, all the stocks, methods and assumptions are listed in table X. For each combination it is indicated whether or not the assumptions are met and if the group suggests the method as basis for estimating stock status.

There were some generic issues relevant for all five stocks. L_{inf} is a central parameter when comparing commercial length distributions to the suggested reference points from the length based methods. Although L_{inf} is relatively easily determined from the available data, it is not clear which L_{inf} to use. The modelled mean estimate, the median, bounds of the 95% confidence interval limits, the largest observed individual, the mean length of old individuals etc. The MSY proxies varied between "green" and "red" depending on the L_{inf} input.

Migration is a defining characteristic of especially the three cod stocks. The West Greenland areas offshore and inshore are nursery grounds for all three stocks, but in unknown proportions. Hence, the length distributions are affected by spawning migrations and changes in length distribution do not necessarily reflect a stock change. Similarly, the pelagic redfish in the Irminger Sea are to some extent present on both the Greenland and Iceland slopes, influencing catch length distributions.

SPiCT, being a production model, relies on contrast in the input data. Most of the stocks addressed did not have this, and generally the output was not convincing. The age disaggregated data available for the cod stocks also allowed for a SAM model to be developed for the inshore and West Greenland offshore stocks and the group agreed that these exploratory runs provided a better basis for estimating stock status.

The choice of method and estimated stock status is explained for each stock in the relevant report sections. The templates indicating the current status of the stocks, and what it would require to promote them to full analytical assessments are found in an annex to the report.

Table X: Stocks, methods and assumptions. It is indicated if the assumptions are met (Y) or not (N) for each stock and method. For each method and stock it is indicated whether the group used the method as basis for MSY Proxies.

ASSUMPTION	EAST GREENLAND SLOPE REDFISH (MENTELLA)	ICELAND SLOPE REDFISH (MENTELLA)	EAST GREENLAND COD	WEST GREENLAND COD	INSHORE GREENLAND COD	GENERAL
Method: Length Based indicator						
Length frequencies have a unimodal distribution	Y	Y	Y	Y	Y	
Input parameters are known (L_{MAT}, L_{inf})	Y	Y	Y, L_{inf} very high	Y	Y	Concern about influence of these; impacted by migrating fish; big difference using individual obs vs mean length at age
Not domed-shaped selectivity	Y	Y	Y	Y	N (unknown to what extent)	Affects reference levels
$L_{F=M}$						M poorly estimated; F=M not necessarily a good indicator of sustainable F.
No migration in/out	N	N	N	N	N	None of the stocks are fully closed units, fish migrate in and out at different ages
Other	Redfish is long lived and slow growing. Will take long time for overfishing to result in changes in length frequency. Very little growth	Same issue of slow growth. Limited length measurements. Fishing on a schooling species	Fishing on spawning aggregations			

	once mature.	(within schools could be limited range in sizes) – may not notice changes in length frequency till last school gone.				
USE AS BASIS?	**NO**		**NO**	**NO**	**NO?**	
Method: mean length Z	**East Greenland slope mentella**	**Iceland slope mentella**	**East Greenland cod**	**West Greenland cod**	**Inshore cod**	**General**
Recruitment (R) constant over time	N	N	N	N	N	Also complicated by migration. Redfish often very variable
Growth Deterministic, following a von Bertalanffy growth equation; Time-invariant.	Limited data	Very broad spread of data	Y	Y	Y	
Selectivity Knife-edge above the length of full selectivity (L_c); Time invariant	Y	Y	Y	Y	N (different gears)	
Fishing effort proportional to fishing mortality.	Schooling behaviour (time searching more NB than time fishing)	Schooling behaviour (time searching more NB than time fishing)	Fishing on spawning aggregations; Searching time not included in effort	No effort time series	N	
Other	Short time series; Model estimates of M not very good	Model estimates of M not very good	Model estimates of M not very good			Age data available for the cod stocks – would be preferable to use this for Z estimation
USE AS BASIS?	**NO**	**N**	**NO**	**NO**	**NO**	

Method: Length based SPR	**East Greenland slope mentella**	**Iceland slope mentella**	**East Greenland cod**	**West Greenland cod**	**Inshore cod**	**General**
No **variability of recruitment or mortality** (i.e. method assumes constant recruitment and fishing pressure)	N	N	N	N	N	
Growth Adequately described by **von Bertalanffy equation**	Limited data	Very broad spread of data	Y	Y	Y	
L∞, CV[L∞], M/κ, and t0=0 known	N (M/k issues)	N (M/k issues)	Y	Y	Y	Same issue with L_{inf} as for cod – large effect on results.
Length composition data representative of the exploited **population at steady state**						Unclear on meaning of this
Length structure of the catch **Representative** (i.e. not subject to biased sampling)	Y, but limited data	Y	Y	Y	Y	
Commercial **selectivity follows a logistic curve** (not limited to this)	Y	Y	Y	Y	Dome-shaped probably more appropriate	Used logistic for all
USE AS BASIS?	**NO**		**NO**	**NO**		
Method: Stock Production in Continuous Time	**East Greenland slope mentella**	**Iceland slope mentella**	**East Greenland cod**	**West Greenland cod**	**Inshore cod**	**General**

(SPiCT)						
No migration; changes in biomass only occur through growth via r and K and through fishing.	N	N	N	N	N	
No **lagged effects in the dynamics** of the biomass as caused by variability of the size/age-distribution.	?	?	Y	Y	Y	Uncertainty in source of recruits for redfish, but some large year classes move through.
Constant catchability i.e. no change in technology of fishing technique that changes q.	N	Y	Y	Y	Y	
Gear selectivity (depends on index; should be constant – i.e. available biomass should be same)	Y	Y	Y	N (shifts between trawls and long liners)	Y	
Other	Cropped the time series	Model only converged for 1981 onwards (catch series starts at 1950)		Did not converge		
USE AS BASIS?	**NO**		**NO (rather use exploratory SAM)**	**NO**	**NO (rather use exploratory SAM)**	

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	Qualitative evaluation	Survey
Faroe Plateau cod	SAM	Survey
Faroe haddock	SAM	Survey
Faroe saithe	SAM	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	DLS category 3.2	Survey
Deep pelagic S. mentella	Gadget	Survey + cpue
Shallow pelagic S. mentella	Qualitative evaluation	Survey + cpue
S. mentella Greenland Slope	DLS category 3.2	Survey

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

1.5 Benchmarks and workshops

There are currently no stocks in a benchmark progress. The group recommends that Greenland halibut is benchmark in 2019 and that cod in East Greenland and inshore in West Greenland are scheduled for an interim benchmark in 2017. Promising SAM model runs were presented for both cod stocks and the data should support a "lift" from category 3 to category 1. For all three stocks, condensed issue lists were prepared and are listed in the relevant report sections. Lastly, the group recommends that the stock structure of redfish on the East Greenland slope is revisited, with the objective of determining if the East Greenland and Iceland slope *S. mentella* stocks could be assessed together

1.6 Chair

This is the third and final year for Chair, Rasmus Hedeholm, Greenland. The group nominated Kristján Kristinsson, Iceland, as chair for the group from 2018-2020.

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 less than 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 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 al-most 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

A benchmark was in February where the assessment model was changed from the XSA to SAM. Since the assessment model was changed, the reference points were recalculated/revised at the NWWG meeting, according to the ICES guidelines (ICES fisheries management reference points for category 1 and 2 stocks, January 2017, http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/12.04.03.01_Reference_points_for_category_1_and_2.pdf).

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 (see ICES 2016) 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.

The government is currently working on a new fisheries reform that is supposed to be set in force in the beginning of 2018. According to the current version of the reform, the fishing days will be replaced by quotas, antitrust regulations will be introduced to prevent that single companies are getting too large, and auctions will be applied to a part of the quotas. Importantly, the fisheries reform intends to follow principles of sustainability.

2.1.7 Other issues

In order to put assessments into a wider context, the biomass of Faroe saithe, cod and haddock on the Faroe Plateu has been estimated over centuries (ICES 2016). The biomass of Faroe Plateu cod, was in the years 2006-2015, the lowest compared to the last 300 years. The biomass of Faroe haddock in the same time period was the lowest for a century. Saithe on the other hand, shows an opposite trend, its biomass in the same time period is well above average and it had a lower biomass prior to 1960, when there was little fishery for saithe. The stock dynamics of saithe is therefore a bit contradictory since an increase in fishing mortality is associated with increased biomass.

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

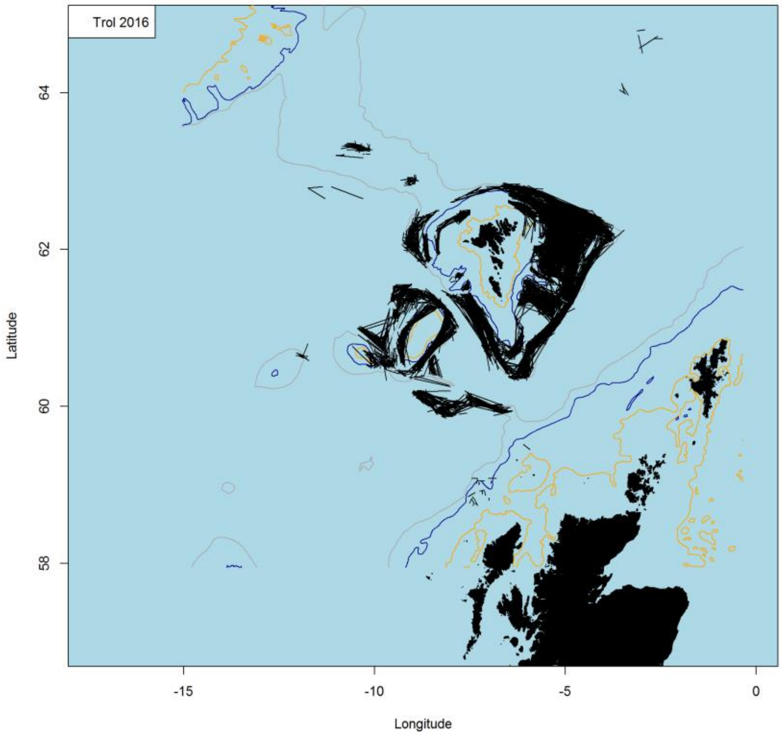
Number of allocated days													Available	
Bólkur	Smb. Ll.:	Serlig viðm.	1 ytri	1 innaru	2 ytri	2 innari	3	4 A	4 B	4 D	4 T	5	(at ráða yvir)	Dagar tils.
1996/97	(50 20/5-96)	(12/15 mdr!)				8225	3040	4700	3080	1540		22000	1000	43585
1996/97	(84 6/6-97)	(12/15mdr!)				8225	3040	5600	3410	1650		27000	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
2016/17	(L-82-17/8-16)	Basis			1530	4386	2029	859	1323		1178	8879		20184
		Umframt			0	0	179	76	117		104	0		476

Table 2.2. Number of days allocated and the number actually used for the fiscal year 2016/2017

	pr. 31 aug. 2016 (12/12)			pr 15. mai 2017 (2016/17)			Estim. for the whole year:		Tillutað	Tillutað
Fleet segment	Allocated	Used	% used	Allocated	Used	% used	Mett ársnýtsla (8½ mdr.)		smb.	smb.
	days	days	days	days	days	days	Faktor	1.412	Vørn	Vørn
	2015/16	pr. Dato		2016/17	pr. Dato		Væntandi:		(05/10-15)	(10/03-/16)
Reference:	(L108-5/8-15)			(L-82-17/8-16)			(L108-5/8-15)	Framskivað:	Óbroytt	sama
Group 1 - innaru leiðir									(10/3-16)	2/10-16
Group 1 - ytri leiðir										
Group 2 - (innaru leiðir)	4455	3784.41	85%	4386+0	1449.51	33%	4386+0	2046.4	4,354.27	4,354.27
Group 2 - ytri leiðir	1530	-1,446.11	-95%	1530+0	855.41	56%	1530+0	1207.8	1,523.30	1,523.30
Group 3	2387	1451.71	61%	(2029+179)	1210.81	55%	(2029+179)	1709.7	2,148.22	2,148.22
Group 4A	1029	314.65	31%	(859+76)	383.6	41%	(859+76)	541.6	642.02	642.02
Group 4B	1530	698.59	46%	(1323+117)	618.8	43%	(1323+117)	873.7	1,125.59	1,125.59
Group 4T	1386	920.03	66%	(1178+104)	701.29	55%	(1178+104)	990.2	1,180.84	1,180.84
Group 5A	2310	883	38%	2750	442	16%	2750	624.1	2310	
Group 5B	7555	4343	57%	6129	2074	34%	6129	2928.5	7555	
Total	22182	10949.28	49%	20184+476	7735.42	49%	20184+476	10922.1	20,839.24	

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	none		Fishing days, have from 2011/12 been merged with the pairtrawlers, area closures
2	Pairtrawlers > 400 HP	none		Fishing days, area closures
3	Longliners > 110 GRT	none		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



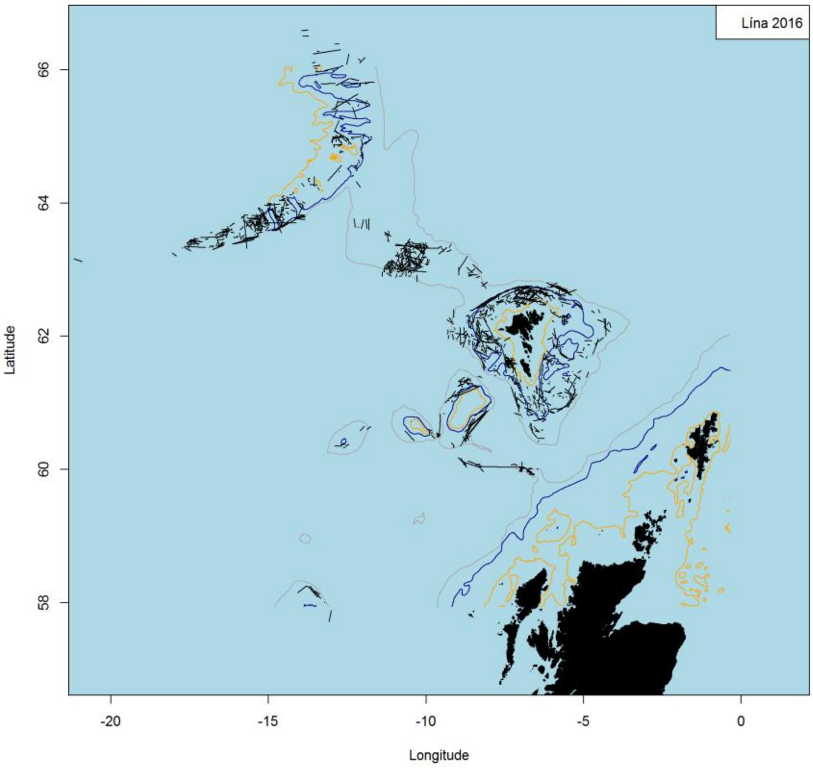


Figure 2.1. The 2015 distribution of fishing activities by some major fleets. From top: 1010HP, trap and trawl > Gillnet, longline . The longline fleet below 110 GRT is not shown here since they are not obliged to keep logbooks.

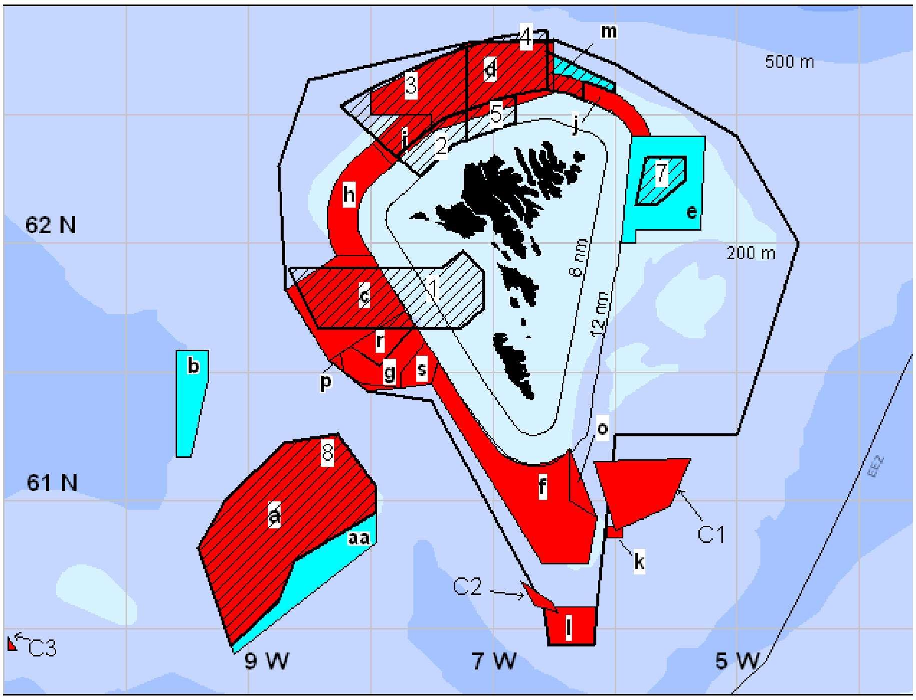
Figure 2.2. Fishing area regulations in Division 5b. Allocation of fishing days applies to the area inside the outer thick line on the Faroe Plateau. Holders of effort quotas who fish outside this line can triple their numbers of days. Longliners larger than 110 GRT are not allowed to fish inside the 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.

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



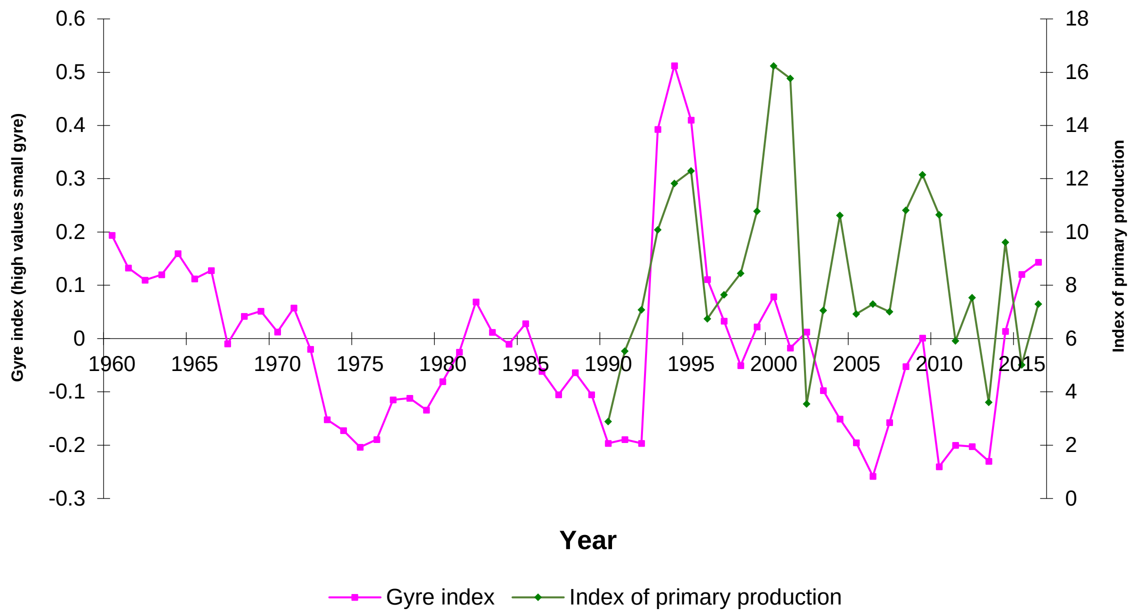


Figure 2.3. Temporal development of the phytoplankton index over the Faroe Shelf area (< 130 m) and the Subpolar Gyre index which indicates productivity in deeper waters.

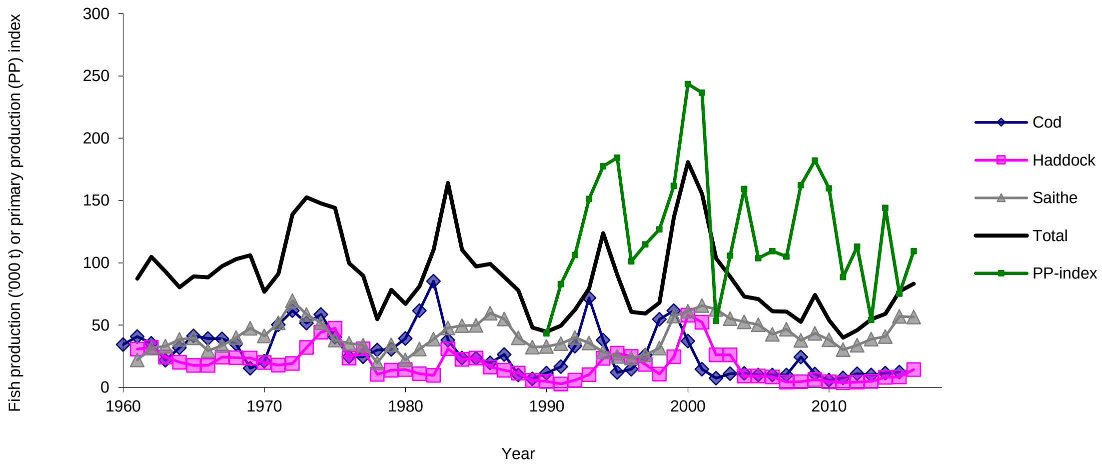


Figure 2.4. Relationship between primary production and production of cod, haddock and saithe.

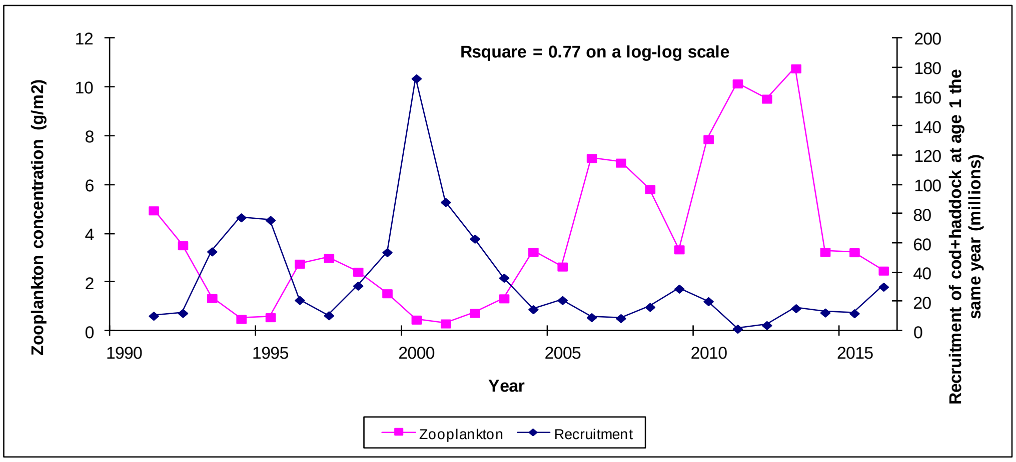


Figure 2.5. Relationship between zooplankton concentration in June/July and recruitment of cod and haddock on the Faroe Plateau.

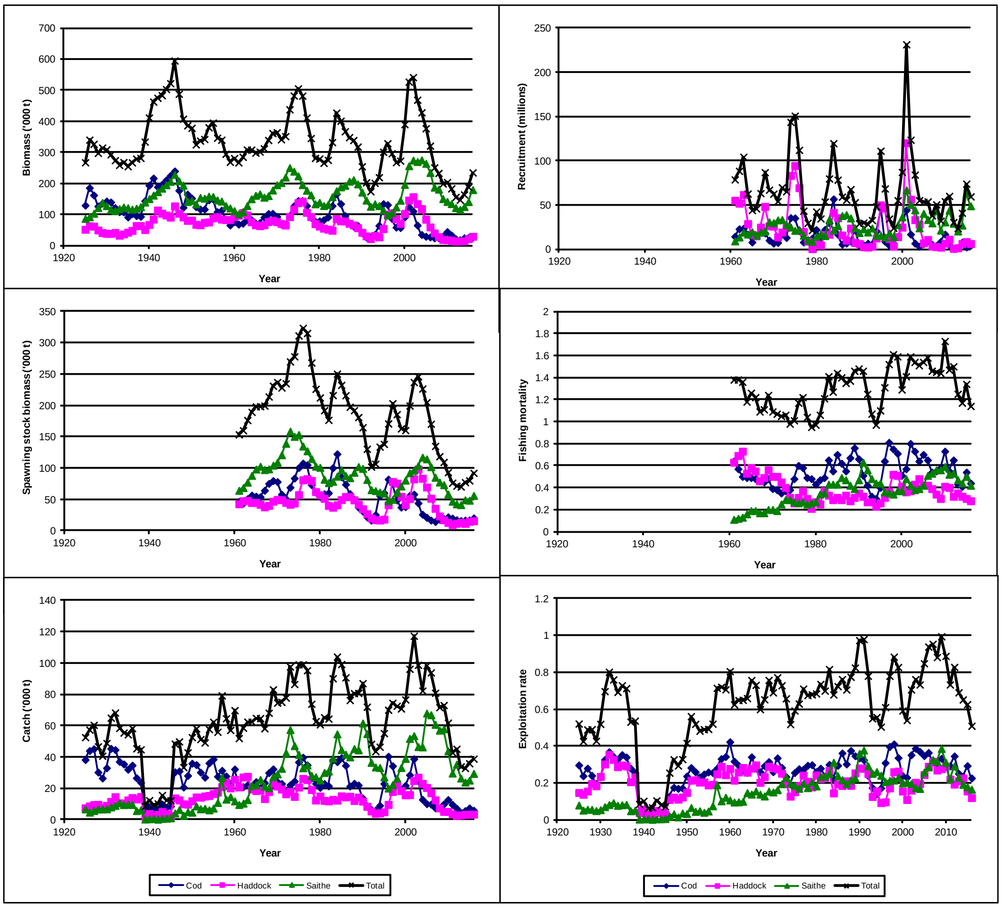


Figure 2.6. Summary of the stock dynamics for Faroe Plateau cod, Faroe haddock and Faroe saithe.

3 Faroe Bank Cod

3.1 State of the stock

Total nominal catches of the Faroe Bank cod from 2002 to 2016 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. Landings have declined sharply from a peak of almost 6000 t. in 2004 to 19 in 2016. (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). Since 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 and in 2013 and 2014 but it decreased rapidly in 2015 and 2016 well below the average of the 1996–2002 period. The index increased again in 2017. The summe index was high from 1996 to 2003 but declined substantially in 2004 and it has remained at low levels since then. There are conflicting signals between both indices from 2013 to 2014. The agreement between summer and spring index is good during 1996 to 2001 , but they diverged in the 2002–2003 and 2013—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). The spring index shows poor recruitment from 2006–2017 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.

Surplus production models have been run from 2014 to 2016 but not in 2017. 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 low catches 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. The spring index suggests an increasing stock biomass from 2013–2014 which it is however not confirmed by the summer index.

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 2016 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.

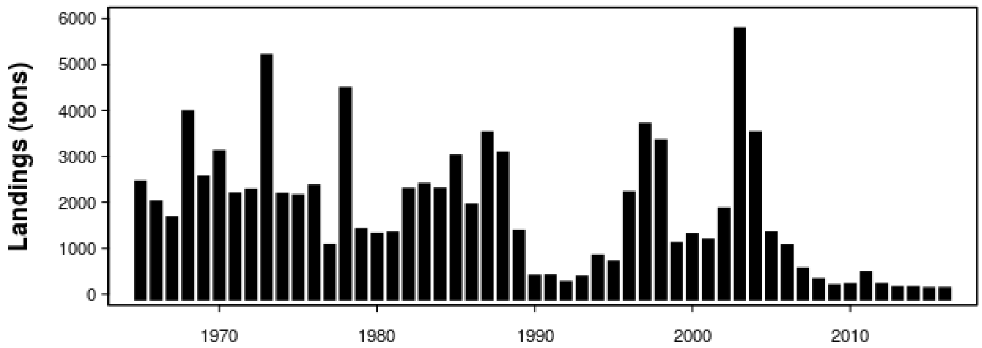
3.5 Regulations and their effects

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 2002-2016 as officially reported to ICES. From 1992 the catches by Faroe Islands and Norway are used in the assessment.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Faroe Islands	1840	5957	3607	1270	1005	471	231	81	111	393	115	40	40	18	19 *
Norway	25	72	18	37	10	7	1	4	1		0			0	1
France															3
Greenland	-	-	-	-	-	-	-	-	5		1				
UK (E/W/NI)	42 [3]	15 [3]	15 [3]	24 [3]	1 [3]										
UK (Scotland)	218 [3]	254 [3]	244 [3]	1129 [3]	278 [3]	53	32	38	54				45		
Total	2125	6298	3884	2460	1294	531	264	123	171	393	116	40	85	18	23
Correction of Faroese catches in Vb2	-109	-353	-214	-75	-60	-28	-14	-5	-7	-23	-7	-2	-2	-1	-1
Used in assessment	1756	5676	3411	1232	955	450	218	80	105	370	108	38	38	17	19



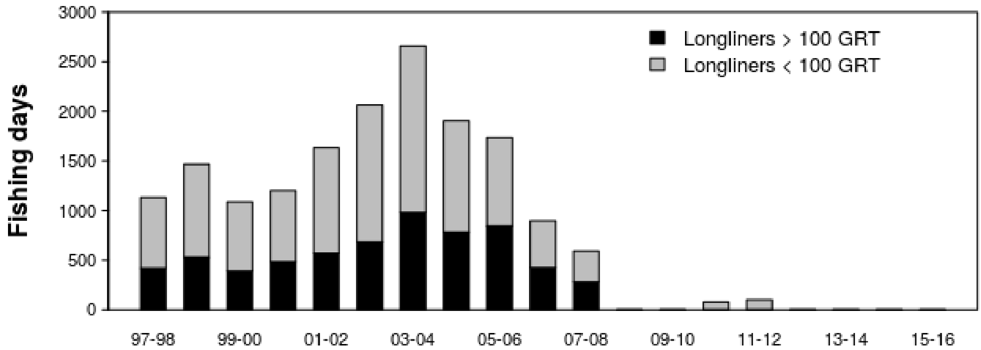


Figure 3.1. Faroe Bank (subdivision Vb2) cod. Reported landings 1965–2016. Since 1992 only catches from Faroese and Norwegian vessels are considered to be taken on Faroe Bank. Lower plot: fishing days (fishing year) 1997–2016 for longline gear type in the Faroe Bank.

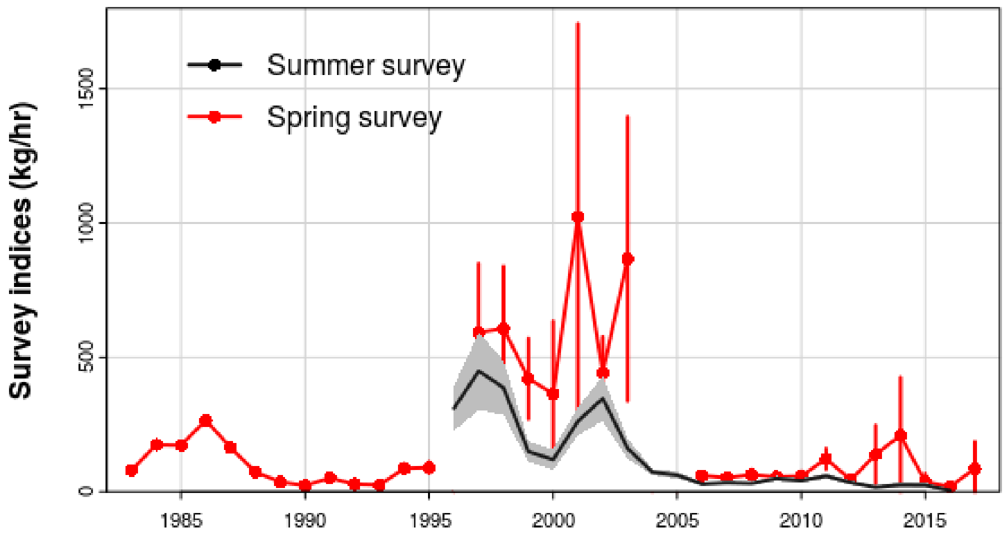


Figure 3.2. Faroe Bank (subdivision Vb2) cod. Catch per unit of effort in spring groundfish survey (1983–2017)(red line) and summer survey (1996–2016)(black line). Vertical bars and shaded areas show the standard error in the estimation of indices.

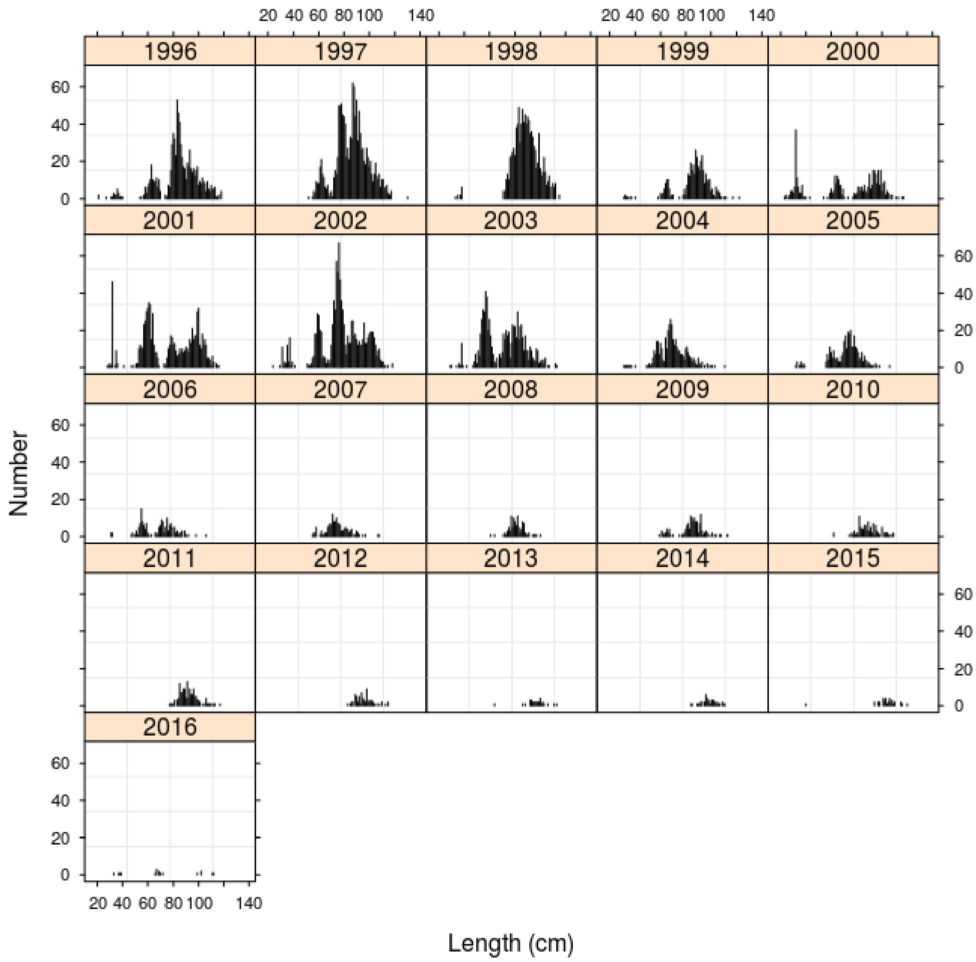


Figure 3.3. Faroe Bank (subdivision Vb2) cod. Length distributions in summer survey (1996–2016)

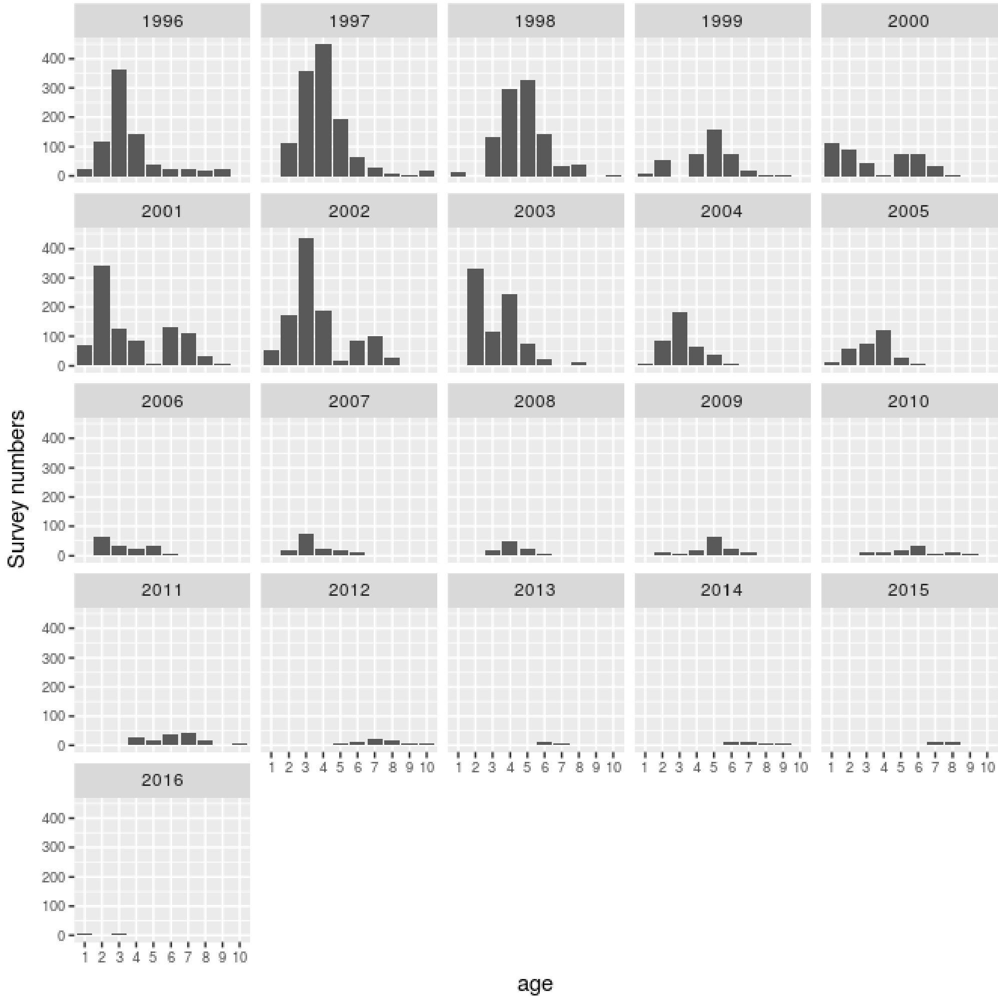


Figure 3.4. Faroe Bank (subdivision Vb2) cod. Age-disaggregated indices in summer survey (ages 1–10)(1996–2016)

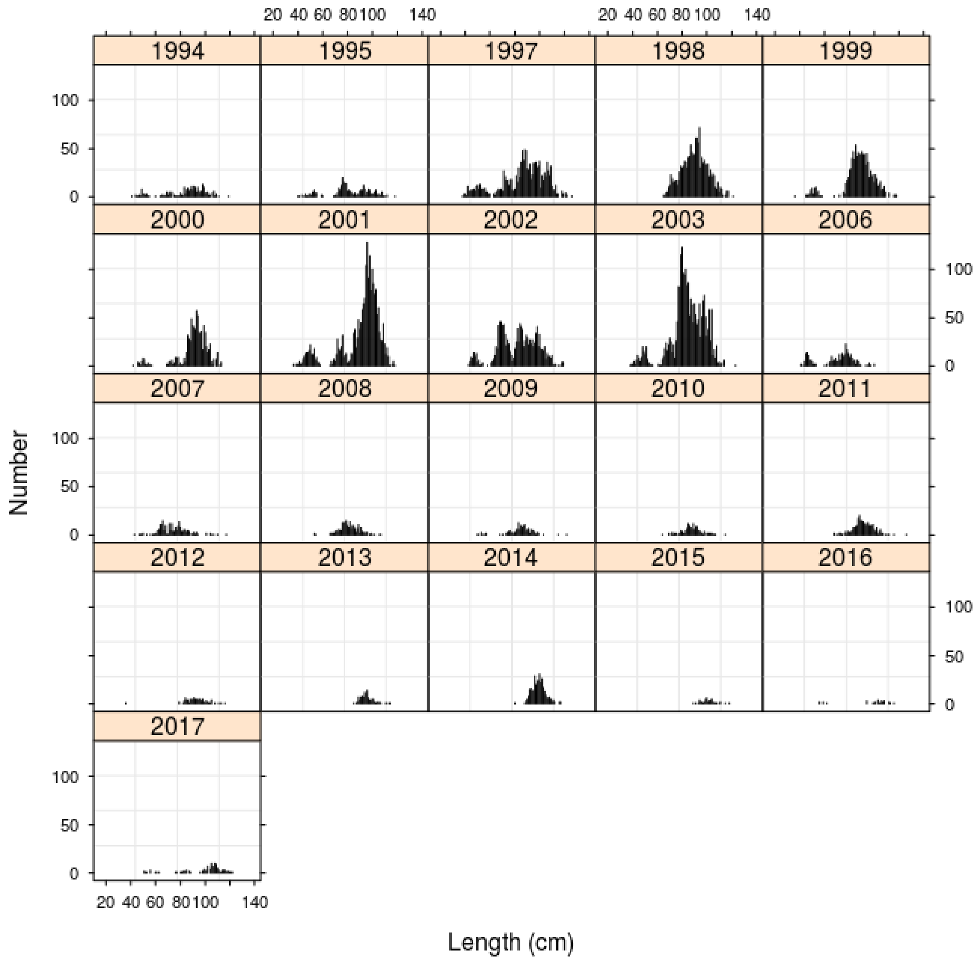


Figure 3.5. Faroe Bank (subdivision Vb2) cod. Length distributions in spring survey (1994–2017). No surveys were conducted in 1996, 2004 and 2005.

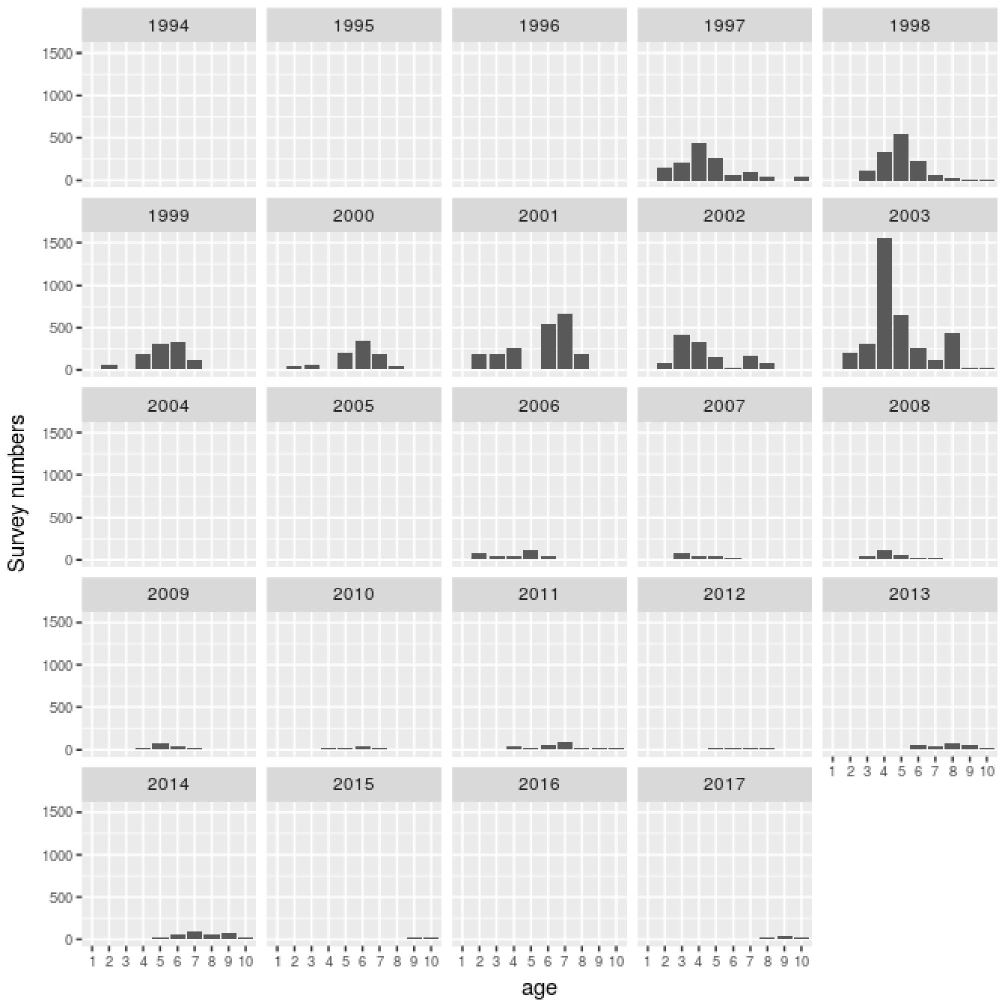


Figure 3.6. Faroe Bank (subdivision Vb2) cod. Age-disaggregated indices in spring survey (ages 1–10) (1994–2015). No surveys were conducted in 1996, 2004 and 2005.

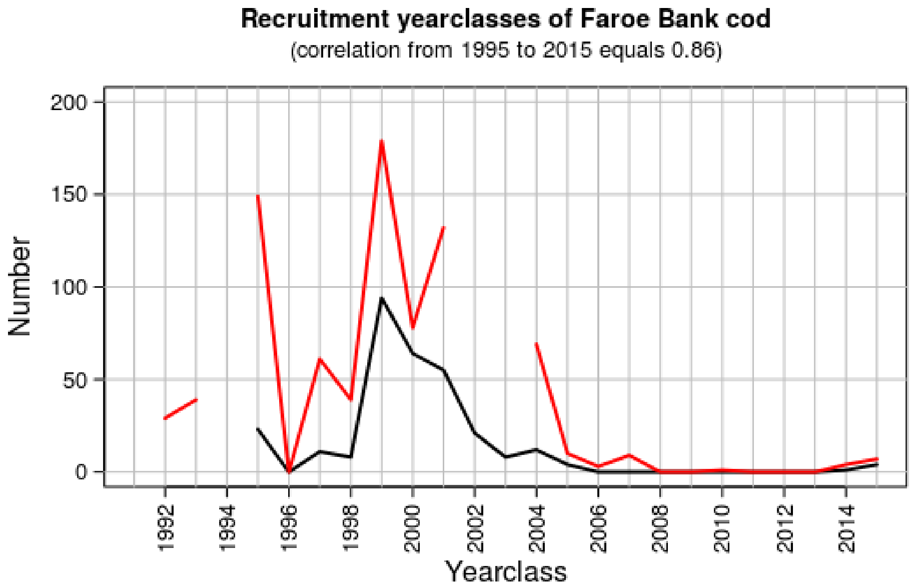


Figure 3.7. Faroe Bank (subdivision Vb2) cod. Correlation between recruitment year classes in both survey indices.

4 Faroe Plateau cod

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 single trawlers and the large longliners were not included in the catch-at-age calculations (Table 4.2.3).

4.2.2 Catch-at-age

Landings-at-age for 2016 are provided for the Faroese fishery in Table 4.2.4. Faroese landings from most of the fleet categories were sampled (Table 4.2.5). The catch-at-age is shown in Table 4.2.6. Catch curves are shown in Fig. 4.2.1.

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 2016 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. Maturities were slightly revised during the benchmark in February 2017. The maturities prior to 1983 were set to the average for 1983 to 1996.

4.2.5 Catch, effort and research vessel data

Fisheries independent cpue series

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

The other tuning series used is the Summer Groundfish Survey. The stratified mean catch of cod per unit effort has been low in recent years (Figure 4.2.5). The catch curves (Figure 4.2.6) show that the fish are fully recruited to the survey gear at an age of 4 or 5 years. Both tuning series are presented in Table 4.2.9 and they show that there are few small cod in the stock. Catch per tow in the spring and summer survey shows that there were occasional large hauls in both surveys (Figure 4.2.7 and Figure 4.2.8).

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 an extremely high cpue in recent years compared with the the fishable biomass (Figure 4.2.10, Figure 4.2.11), a feature also observed for the larger longliners (Figure 4.2.9). When that happens, the recruitment of cod tends to be low (Steingrund et al., 2010).

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

The benchmark in February 2017 decided to change the traditional assessment tool from XSA to SAM although it was recognised that the results of the assessment were mainly data-driven. The SAM model had some beneficial characteristics, e.g. that it provided uncertainty estimates for the catch in numbers, surveys and the output from the assessment (biomasses and fishing mortalities).

4.5 Reference points

Since the assessment model was replaced at the benchmark in February 2017, it was necessary to recalculate reference points at the NWWG meeting in 2017 (this was not finally conducted during the benchmark).

The Blim was kept unchanged at 21 thousand tons, since this previously defined Bloss was the lowest spawning biomass from which the stock had made a recovery. The biomass has been lower in recent years but the stock has not recovered yet.

The Bpa = Btrigger = 29226 tons (changed from 40000 tons). The uncertainty in the SAM assessment one the final year of SSB was found to be $\sigma = 0.20$ and the Bpa was found by using the formula Bpa = Blim $\times \exp(\sigma \times 1.645)$. The Btrigger was, according to ICES guidelines, set equal to Bpa since the stock had not been fished at Fmsy for five or more years.

Flim = 0.90 (changed from 0.68). Flim was derived from Blim. A stock was simulated with a segmented regression on the spawning stock – recruitment function having the point of inflection at Blim. Flim was set to the F that, in equilibrium, gave a 50% probability that SSB > Blim. This simulation was based on a fixed F, i.e., without inclusion of a Btrigger and without inclusion of assessment/advice errors.

Fpa = 0.69 (changed from 0.35). Fpa was derived from Flim in the reverse of the way Bpa was derived from Blim, i.e., Fpa = Flim $\times \exp(-\sigma \times 1.645)$, where $\sigma = 0.16$.

The calculations were conducted using EQSIM following ICES guidelines. Decisions made involved the spawning stock – recruitment relationship, the weights at age, the selection pattern and the level of advice error. The full time series (1959-2015) was used as basis for the spawning stock – recruitment relationship where the S-R function was based on the segmented regression (weight 0.61), Ricker (weight 0.36) and Beverton and Holt (weight 0.03), see Figure 4.5.1. The Ricker curve was included because recruitment at very large stock sizes was low according to extension of stock biomass back to 1710 (ICES, 2016). The autocorrelation between SSB-R data points was approximately 0.55. The weights at age were based on the last 10 years (2007-2016), see Figure 4.5.2. The selection pattern was also based on the last 10 years (Figure 4.5.3). The selection pattern has been very stable over time, so the use of the last 20 years would not make any big difference for the Fmsy. The advice error was estimated from advice sheets back to 1999: cvF = 0.44, phiF = 0.47, cvSSB = 0.38, phiSSB = 0.24. In total 2000 iterations were performed that projected the stock 200 years into the future, of which, the last 50 years were kept to calculate 'equilibrium' values.

The result of the analyses was that Fmsy = 0.23 (changed from 0.32). The fishing mortality that is associated with a risk of 5% to fall below Blim, Fp0.5, was estimated to be 0.41, greater than Fmsy.

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

As other years the two surveys were used for tuning. The commercial series showed a similar overall tendency as the surveys (Figure 4.2.9) but were not used in the tuning. At the benchmark in February 2017 the traditional XSA was replaced by a SAM assessment model. The SAM model settings and the model parameters are shown in Table 4.6.1, e.g. the fishing mortality is assumed equal for ages 7+. The variation in the catchability coefficients for the survey at age was set equal for ages 2+, although different for each survey, and age 1 was set different from the other ages, but different for the two surveys. An AR covariance structure was applied for the summer survey, eliminating year effects, but not for the spring survey. The observation residuals looked quite random (Figure 4.6.1) as well as the process residuals (Figure 4.6.2).

The results from the SAM-run shows that fishing mortality (F3-7) has decreased in re-cent years (Table 4.6.2, 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 4.6.3). The poor state of the stock since 2004 has been due to poor recruitment (not poor individual growth). Prior to that time, extremely weak year classes (< 5 million individuals at age 2) were only observed three times, whereas it has happened seven times since 2004. 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 slightly below Blim and the fishing mortality above Fmsy, but less than Fpa (Table 4.6.4).

The decade of low biomass of Faroe Plateau cod since 2004 has been unprecedented the last 300 years, although there were short periods of low biomass between 1700 and 1750 and around 1813 (Figure 4.6.5); for data before 1959 see ICES (2016).

4.7 Short term forecast

4.7.1 Input data

The short term prediction was changed with respect to previous years. The SAM model provides predictions that carry the signals from the assessment into the short term forecast. The forecast procedure starts from the last year's (assessment year) estimate of the state (log(N) and log(F) at age). One thousand replicates of the last state are simulated from its estimated joint distribution. Each of these replicates are then simulated forward according to the assumptions and parameter estimates found by the assessment model. In the forward simulations a 5 year average (years up to the assessment year) is used for catch mean weight, stock mean weight, proportion mature, and natural mortality. Recruitment is re-sampled from the last 10 years (up to the year before the assessment year). In each forward simulation step the fishing mortality is scaled, such that the median of the distribution is matching the requirement in the scenario (e.g. hitting a specific mean F value or a specific catch).

4.7.2 Results

The landings in 2017 are expected to be 6600 tonnes (Table 4.6.4) with status quo fishing mortality. 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 28 thousand tonnes in 2018, 34 thousand tonnes in 2019 and eventually 38 thousand tonnes in 2020.

4.8 Long term forecast

The yield per recruitment calculations were performed in the SAM model and were based on the last 20 years (up to the year before the assessment year). The Fmax was estimated at 0.19 (Figure 4.8.1).

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 annex was changed substantially this year as a consequence of the benchmark in February 2017 and the new assessment model (SAM instead of XSA). The effect of changing assessment model was investigated by comparing the SAM run with an XSA run using the traditional XSA settings. There was little difference in population numbers (Figure 4.10.1) as well as fishing mortalities (Figure 4.10.2), although deviations were seen in the fishing mortalities for the older ages.

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 sub-area 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 newly revised Fmsy of 0.23 but below the newly revised Fpa of 0.69. Some work has been done in the Faroes to move away from the Ftarget of 0.45 to be more consistent with the ICES advice. The government is currently working on a new fisheries reform that is supposed to be set in force in the beginning of 2018. According to the current version of the reform, the fishing days will be replaced by quotas, antitrust regulations will be introduced to prevent that single companies are getting too large, and auctions will be applied to a part of the quotas. Importantly, the fisheries reform intends to follow principles of sustainability.

4.12 Management considerations

The cod stock is assessed to be in a very poor state and is predicted to remain so for the next two years due to poor recruitment. Although the environmental conditions have been rather special since 2007 (lots of mackerel) and may partly be responsible for the poor state of the cod stock, it is certainly necessary to protect the cod stock as much as possible. The reason is not only that it may prevent a total collapse of the stock but also that the stock may recover faster in the future. Hence, a reduction in fishing mortality is urgently needed. The recent increase in haddock recruitment and biomass may provide some hope that the cod stock will also recover in the near future based on the fact that the two stocks have fluctuated in a similar way since the 1960s.

4.13 Ecosystem considerations

Regarding the ecosystem effects on fishing, this issue is partly addressed in the overview section for Faroese stocks. Although the fishery has changed substantially during the last century the total biomass of cod+haddock+saithe has fluctuated around the same level. However, the proportion of saithe has increased steadily over the time period, whereas cod has decreased. This could indicate some effect of fishing on the ecosystem, although other factors cannot be ruled out.

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). The potential introduction of quotas instead of fishing days could lead to a stronger regulation of fishing pressure if discarding is prevented.

4.15 Changes in fishing technology and fishing patterns

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

The fishing pattern in recent years has changed in comparison to previous years. The large longliners seem to have exploited the deep areas (> 200 m) to a larger extent (ling and tusk) because the catches in shallower waters of cod and haddock have been so poor – which was also observed in the beginning of the 1990s. 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 to 2010, but it is not believed that this has any relationship with a change in the environment. The temperature has been high in recent years (although it has been a little bit cooler in 2014-2016), which may have a negative effect on cod recruitment (Planque and Fredou, 1999).

Table 4.2.1. Faroe Plateau cod (sub-division 5.b.1). Nominal catch (t) by countries, as officially re-ported to ICES.

	Denmark	Faroe Islands	France	Germany	Iceland	Norway	Greenland	Portugal	UK (E/W/NI)	UK (Scotland)	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			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			0	226	6887
2015		7812				33	14		0	382	8241
2016		6736				31	5		0	515	7289

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

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

		Faroese 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
2016	7289 *		-399	-958									5933

) 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 (sub-division 5.b.1). The landings of Faroese fleets (in percents) of total catch (t). Note that the catches on the Faroe-Iceland ridge (mainly belonging to single trawlers and longliners) are included in this table, but excluded in the catch in numbers.

Year	Open boats	Long liners <100 GRT	Sing trawl <400 HP	Gill net	Jigg ers	Sing trawl 400-1000 HP	Sing trawl >1000 HP	Pair trawl <1000 HP	Pair trawl >1000 HP	Long liners >100 GRT	Indus trial trawl ers	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
2016	9.7	21.0	10.9	0.7	9.4	2.4	2.0	3.7	12.9	27.2	0.0	0.0	5,562
Avg:	5.2	26.0	6.0	0.7	9.0	3.9	7.3	7.3	12.4	21.8	0.3	0.1	

Table 4.2.4. Faroe Plateau cod (sub-division 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 longline	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	Sum Catch-at-a	Scaled Catch-at-age
2	0	132	40	0	9	1	1	15	9	0	207	156
3	0	216	66	0	55	2	3	36	66	0	444	1035
4	0	303	93	0	161	6	10	127	135	0	835	522
5	0	69	21	0	48	3	5	58	49	0	253	210
6	0	73	22	0	18	1	2	24	33	0	173	282
7	0	62	17	0	16	1	2	20	52	0	170	221
8	0	15	4	0	9	1	1	15	34	0	79	47
9	0	8	2	0	3	0	0	3	5	0	21	23
10+	0	0	0	0	1	0	0	0	2	0	3	7
Sum	0	878	265	0	320	15	24	298	385	0	2185	2503
G.weight	0	1542	471	0	666	236	51	647	739	0	4352	6001

Table 4.2.5. Faroe Plateau cod (sub-division 5.b.1). Number of samples, lengths, otoliths, and indi-vidual weights in terminal year.

Fleet	Size	Samples	Lengths	Otoliths	Weights
Open boats		5	388	276	388
Longliners	<100 GRT	12	2,377	540	2,377
Longliners	>100 GRT	17	3,505	736	3,505
Jiggers		4	531	240	531
Gillnetters		0	0	0	0
Sing. traw lers	<400 HP	7	1,377	239	1,377
Sing. traw lers	400-1000 HP	0	0	0	0
Sing. traw lers	>1000 HP	0	0	0	0
Pair traw lers	<1000 HP	0	0	0	0
Pair traw lers	>1000 HP	21	4,733	560	4,156
Total		66	12,911	2,591	12,334

Table 4.2.6. Faroe Plateau cod (sub-division 5.b.1). Catch in numbers at age.

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
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
2016	0	177	378	709	216	147	144	67	19	2

Table 4.2.7. Faroe Plateau cod (sub-division 5.b.1). Mean weight at age (kg) in the catches. Stock weights are set equal to catch weights.

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
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	1.358	1.993	2.752	3.937	4.419	5.399	7.059	10.227	10.975
2017	1.271	2.067	2.935	3.675	4.531	5.357	6.256	7.782	9.386

Table 4.2.8. Faroe Plateau cod (sub-division 5.b.1). Proportion mature at age. The average for 1983 to 1996 is used prior to 1983.

	Age									
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
1959	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1960	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1961	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1962	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1963	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1964	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1965	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1966	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1967	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1968	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1969	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1970	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1971	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1972	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1973	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1974	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1975	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1976	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1977	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1978	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1979	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1980	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1981	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1982	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1983	0.00	0.03	0.71	0.93	0.94	1.00	1.00	1.00	1.00	1.00
1984	0.00	0.07	0.96	0.98	0.97	1.00	1.00	1.00	1.00	1.00
1985	0.00	0.00	0.50	0.96	0.96	1.00	1.00	1.00	1.00	1.00
1986	0.00	0.00	0.38	0.93	1.00	1.00	0.96	0.94	1.00	1.00
1987	0.00	0.00	0.67	0.91	1.00	1.00	1.00	1.00	1.00	1.00
1988	0.00	0.06	0.72	0.90	0.97	1.00	1.00	1.00	1.00	1.00
1989	0.00	0.05	0.54	0.98	1.00	1.00	1.00	1.00	1.00	1.00
1990	0.00	0.00	0.68	0.90	0.99	0.96	0.98	1.00	1.00	1.00
1991	0.00	0.00	0.72	0.86	1.00	1.00	1.00	1.00	1.00	1.00
1992	0.00	0.06	0.50	0.82	0.98	1.00	1.00	1.00	1.00	1.00

1993	0.00	0.03	0.73	0.78	0.91	0.99	1.00	1.00	1.00	1.00
1994	0.00	0.05	0.33	0.88	0.96	1.00	0.96	1.00	1.00	1.00
1995	0.00	0.09	0.35	0.33	0.66	0.97	1.00	1.00	1.00	1.00
1996	0.00	0.04	0.43	0.74	0.85	0.94	1.00	1.00	1.00	1.00
1997	0.00	0.00	0.64	0.91	0.97	1.00	1.00	1.00	1.00	1.00
1998	0.00	0.00	0.62	0.90	0.99	0.99	1.00	1.00	1.00	1.00
1999	0.00	0.02	0.43	0.88	0.98	1.00	1.00	1.00	1.00	1.00
2000	0.00	0.02	0.39	0.69	0.92	0.99	1.00	1.00	1.00	1.00
2001	0.00	0.07	0.47	0.86	0.94	1.00	1.00	1.00	1.00	1.00
2002	0.00	0.04	0.37	0.76	0.97	0.93	0.97	1.00	1.00	1.00
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
2016	0.00	0.21	0.89	0.91	0.97	1.00	1.00	1.00	1.00	1.00
2017	0.00	0.10	0.73	0.98	0.98	0.97	1.00	1.00	1.00	1.00

Table 4.2.9. Faroe Plateau cod (sub-division 5.b.1). Summer survey tuning series (number of indi-viduals per 200 stations) and spring survey tuning series (number of individuals per 100 stations) used as tuning series in the assessment model.

	Effort (hours)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8
1996	200	38.1	707	6576.5	3705.1	1298.1	701.5	233.1	48.5
1997	200	70.3	512.7	1500.7	6754.6	1466.6	178.4	137.8	30.1
1998	200	393.4	524.9	505.1	979.4	3675.2	902.6	50	37
1999	200	112.6	373.3	1256.8	753.1	675.3	1422.5	238	40.4
2000	200	441.1	1364.1	1153.3	673.8	309.6	436.9	600.8	35.4
2001	200	203.9	3422.1	2458.7	1537.8	415.9	234.8	283	242
2002	200	734.2	2326	5562.9	1816.5	810.8	147.7	83.3	69.5
2003	200	64	354	1038.8	2209.2	565.9	123.4	17.6	11.9
2004	200	200.9	437	839.9	1080.2	1550.2	344.2	80.2	25.7
2005	200	212.7	616.5	735.1	872.1	1166.3	756	142.5	44.8
2006	200	126.2	978.4	684.2	349.3	312	256.6	123	28.2
2007	200	83	234.1	448.7	314.2	179.7	134.5	75.9	30.9
2008	200	177.9	68.8	370.1	328	401.2	160.1	52.4	27.5
2009	200	599.1	428.2	1980.6	817.7	551.4	393.1	132.1	47.8
2010	200	256.1	1239.3	1543.9	1012	363.4	243.6	148.9	41.5
2011	200	7.2	301.7	1373.6	1084.2	380.1	160.6	104.6	37.4
2012	200	38	22.1	230.8	1081.8	511.7	88.4	35.7	19.5
2013	200	380.1	101.7	205.9	209.3	888.4	542.5	104.2	43.9
2014	200	12.9	642.3	861.2	357.6	358.2	401.5	124.3	36.6
2015	200	195.3	235.3	2230.4	1696.1	414.7	363.4	242.3	67.2
2016	200	203.5	584	839	1852.7	690.8	146.8	142.8	72.9

Year	Effort (hours)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
1994	100	7.8	612.5	336.9	912.8	508.5	129.7	187.2	28.6	0.0
1995	100	4.2	623.2	845.7	1528.4	1525.2	1191.4	285.6	350.8	48.9
1996	100	0.0	215.5	4043.9	3984.4	1892.1	1372.0	420.8	82.8	169.7
1997	100	1.8	72.5	834.4	5398.3	2359.5	333.9	227.0	58.8	5.3
1998	100	1.2	69.7	425.2	1572.1	4919.3	1136.0	82.3	40.7	35.2
1999	100	10.0	704.7	674.9	991.3	1225.2	2079.2	252.1	25.2	13.4
2000	100	2.0	316.0	1432.4	746.1	441.0	506.7	836.7	63.8	3.1
2001	100	1.4	938.4	2387.8	1993.8	456.2	324.4	578.6	128.6	3.9

2002	100	0.2	383.0	4564.1	2892.1	1579.7	331.9	231.8	178.9	131.9
2003	100	0.0	90.2	719.0	3915.0	1260.4	528.7	67.4	51.7	39.7
2004	100	0.2	609.5	575.8	844.6	1175.1	292.9	66.0	22.2	11.9
2005	100	0.0	383.1	438.2	1151.7	1440.2	844.5	140.6	14.0	3.8
2006	100	1.1	167.5	156.7	177.3	360.1	292.0	95.0	15.5	4.0
2007	100	0.0	41.1	270.9	286.6	155.2	170.4	105.1	37.8	14.4
2008	100	5.6	176.6	474.5	851.9	479.2	151.5	83.9	39.4	13.3
2009	100	71.5	307.8	475.5	977.7	1159.1	427.3	73.7	31.6	24.9
2010	100	35.0	697.6	1318.8	745.6	538.1	381.0	98.9	41.0	17.2
2011	100	0.0	148.4	1319.0	1240.3	562.4	300.2	237.8	85.2	21.9
2012	100	0.0	1.4	273.8	1303.8	326.7	73.6	27.0	23.7	6.2
2013	100	3.2	68.0	377.6	1699.8	2053.2	295.6	32.6	22.4	17.7
2014	100	1.0	130.9	113.4	159.6	419.7	333.0	74.8	22.0	13.6
2015	100	0.0	22.4	533.3	225.6	193.9	305.2	138.9	32.6	8.0
2016	100	6.2	81.7	280.1	697.3	151.8	73.4	77.3	27.2	7.7
2017	100	26.6	107.6	526.8	695.4	1087.8	136.0	55.9	31.3	9.9

Table 4.2.10. Faroe Plateau cod (sub-division 5.b.1). Pair trawler abundance index (number of indi-viduals per 1000 fishing hours). This series was not used in the tuning in the assessment model. The season is June – December. The otoliths are selected from deep (> 150 m) locations.

	Age							
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1989	1200	1638	1783	1381	928	719	297	194
1990	116	2856	2057	834	465	419	200	0
1991	8	148	1401	869	329	225	65	93
1992	84	487	696	1234	760	353	129	62
1993	51	1081	2192	746	1062	398	67	107
1994	1314	2129	1457	2208	697	1241	461	53
1995	577	3645	5178	4199	2769	543	539	106
1996	242	10608	16683	7985	4410	194	0	723
1997	28	674	6038	9375	2413	944	113	0
1998	80	731	1805	5941	4904	801	286	0
1999	444	2082	1933	3008	5136	2220	218	4
2000	3478	3956	1737	956	1003	1694	382	0
2001	3385	6700	3009	555	415	797	862	25
2002	571	6409	5019	1235	432	400	41	228
2003	63	1341	4450	3630	870	270	152	145
2004	23	0	278	2534	2831	1733	274	184
2005	42	399	655	1766	2171	860	148	70
2006	93	135	699	755	1580	612	787	71
2007	64	916	1767	1392	802	656	206	46
2008	54	295	418	573	387	456	487	182
2009	11	734	801	756	448	247	147	105
2010	1578	2917	1787	543	603	190	0	81
2011	22	1487	4078	1967	622	441	95	25
2012	0	95	1531	1789	950	223	40	107
2013	35	102	761	1583	670	103	57	36
2014	292	1631	1006	1690	1812	477	94	101
2015	43	967	1943	1019	1190	1086	320	96
2016	130	485	2227	1521	905	691	362	177

Table 4.2.11. Faroe Plateau cod (sub-division 5.b.1). Longliner abundance index (number of indi-vid-uals per 100 000 hooks). This series was not used in the tuning in the assessment model. The age composition was obtained from all longliners > 100 GRT. The area was restricted to the area west of Faroe Islands at depths between 100 and 200 m.

	Age							
Year	1	2	3	4	5	6	7	8
1993	405	2610	9306	3330	806	2754	847	258
1994	101	8105	14105	7863	4659	962	1187	71
1995	0	15249	23062	2895	2505	1568	708	1073
1996	0	2269	18658	13265	4153	8435	4513	1147
1997	0	1738	5837	26368	18089	2805	2807	402
1998	1892	4490	2025	2565	11738	2732	131	19
1999	849	10968	3811	985	1891	3759	548	109
2000	2695	10983	6710	998	780	1473	2136	109
2001	287	12999	7409	2660	515	1135	1808	2545
2002	105	6862	20902	10819	7759	1561	1945	1265
2003	16	2099	6057	15910	7778	1830	708	650
2004	59	510	1773	2438	3214	1059	293	71
2005	297	2169	1543	2313	2327	1360	170	13
2006	151	5813	5319	674	2205	2352	1148	56
2007	274	3578	6383	2778	1927	1159	1118	134
2008	1270	2243	4449	4773	2564	1133	816	716
2009	294	2670	15107	6308	3028	2491	683	132
2010	23	20287	16914	8733	2595	4780	1878	864
2011	160	2817	28218	14391	4295	2207	1252	195
2012	0	1833	9562	8309	2364	1296	403	197
2013	0	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
2016	157	1790	3118	5109	1985	873	1370	1548

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 assessment model. The age composition was obtained from all longliners.

	Age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1983	0.9	7.5	4.7	3.8	1.6	0.9	0.5	0.2
1984	0.0	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
2016	3.2	30.5	40.6	36.9	7.8	4.9	5.6	0.0

Table 4.6.1. Faroe Plateau cod (sub-division 5.b.1). Configuration in the SAM-run and the model parameters.

```
> conf
$minAge
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$maxAge
[1] 10

$maxAgePlusGroup
[1] 1

$keyLogFsta
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[1,]   -1    0    1    2    3    4    5    5    5     5
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1

$corFlag
[1] 2

$keyLogFpar
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[2,]    0    1    2    3    4    5    6    7    7    -1
[3,]    8    9   10   11   12   13   14   15   15    -1

$keyQpow
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1

$keyVarF
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    0    0    0    0    0    0    0    0     0
```

```
[2,]   -1  -1  -1  -1  -1  -1  -1  -1  -1   -1
[3,]   -1  -1  -1  -1  -1  -1  -1  -1  -1   -1

$keyVarLogN
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$keyVarObs
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    0    0    0    0    0    0    0    0     0
[2,]    1    2    2    2    2    2    2    2    2    -1
[3,]    3    4    4    4    4    4    4    4    4    -1

$obsCorStruct
[1] ID AR ID
Levels: ID AR US

$keyCorObs
     1-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10
[1,]  NA  NA  NA  NA  NA  NA  NA  NA   NA
[2,]   0   0   0   0   0   0   0   0   -1
[3,]  NA  NA  NA  NA  NA  NA  NA  NA   -1

$stockRecruitmentModelCode
[1] 0

$noScaledYears
[1] 0

$keyScaledYears
numeric(0)

$keyParScaledYA
<0 x 0 matrix>

$fbarRange
[1] 3 7
```

$keyBiomassTreat

[1] -1 -1 -1

$obsLikelihoodFlag

[1] LN LN LN

Levels: LN ALN

$fixVarToWeight

[1] 0

> fit

SAM model: log likelihood is -805.3597 Convergence OK

Table of model parameters:

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	-9.25	0.229	0	0	0
logFpar_1	-7.8	0.151	0	0	0.001
logFpar_2	-6.607	0.144	0.001	0.001	0.002
logFpar_3	-6.157	0.141	0.002	0.002	0.003
logFpar_4	-5.916	0.139	0.003	0.002	0.004
logFpar_5	-5.842	0.136	0.003	0.002	0.004
logFpar_6	-5.741	0.133	0.003	0.002	0.004
logFpar_7	-5.657	0.133	0.003	0.003	0.005
logFpar_8	-13.454	0.372	0	0	0
logFpar_9	-8.387	0.16	0	0	0
logFpar_10	-6.692	0.151	0.001	0.001	0.002
logFpar_11	-5.735	0.148	0.003	0.002	0.004
logFpar_12	-5.414	0.146	0.004	0.003	0.006
logFpar_13	-5.391	0.145	0.005	0.003	0.006
logFpar_14	-5.484	0.144	0.004	0.003	0.006
logFpar_15	-5.698	0.112	0.003	0.003	0.004
logSdLogFsta_0	-1.442	0.125	0.236	0.184	0.304
logSdLogN_0	-0.271	0.132	0.763	0.585	0.994
logSdLogN_1	-1.23	0.123	0.292	0.228	0.374
logSdLogObs_0	-1.385	0.119	0.25	0.197	0.318

logSdLogObs_1	-0.083	0.181	0.92	0.641	1.321
logSdLogObs_2	-0.594	0.094	0.552	0.457	0.666
logSdLogObs_3	0.551	0.154	1.735	1.276	2.359
logSdLogObs_4	-0.421	0.057	0.656	0.586	0.735
transfIRARdist_0	-0.598	0.249	0.55	0.334	0.905
itrans_rho_0	1.651	0.22	5.21	3.358	8.084

Model fitting:

Model	log(L)	#par	AIC
Current	-805.36	26	1662.72

Table 4.6.2. Faroe Plateau cod (sub-division 5.b.1). Fishing mortality at age from the SAM model

	1	2	3	4	5	6	7	8	9	10
1959	0	0.226	0.466	0.496	0.54	0.527	0.579	0.579	0.579	0.579
1960	0	0.29	0.603	0.651	0.719	0.723	0.802	0.802	0.802	0.802
1961	0	0.25	0.523	0.579	0.655	0.672	0.749	0.749	0.749	0.749
1962	0	0.214	0.456	0.517	0.592	0.608	0.666	0.666	0.666	0.666
1963	0	0.177	0.386	0.453	0.525	0.551	0.605	0.605	0.605	0.605
1964	0	0.146	0.335	0.416	0.502	0.552	0.625	0.625	0.625	0.625
1965	0	0.129	0.31	0.403	0.499	0.567	0.656	0.656	0.656	0.656
1966	0	0.11	0.278	0.376	0.484	0.579	0.703	0.703	0.703	0.703
1967	0	0.1	0.262	0.361	0.463	0.557	0.675	0.675	0.675	0.675
1968	0	0.094	0.259	0.361	0.453	0.535	0.631	0.631	0.631	0.631
1969	0	0.093	0.267	0.38	0.478	0.574	0.687	0.687	0.687	0.687
1970	0	0.071	0.213	0.309	0.389	0.475	0.572	0.572	0.572	0.572
1971	0	0.063	0.197	0.293	0.377	0.473	0.576	0.576	0.576	0.576
1972	0	0.06	0.188	0.278	0.348	0.427	0.512	0.512	0.512	0.512
1973	0	0.063	0.203	0.299	0.366	0.439	0.538	0.538	0.538	0.538
1974	0	0.061	0.201	0.301	0.373	0.451	0.568	0.568	0.568	0.568
1975	0	0.072	0.248	0.381	0.474	0.566	0.726	0.726	0.726	0.726
1976	0	0.077	0.279	0.451	0.584	0.72	0.969	0.969	0.969	0.969
1977	0	0.071	0.274	0.452	0.576	0.687	0.89	0.89	0.89	0.89
1978	0	0.062	0.243	0.399	0.496	0.582	0.746	0.746	0.746	0.746
1979	0	0.061	0.248	0.403	0.488	0.563	0.703	0.703	0.703	0.703
1980	0	0.056	0.234	0.371	0.435	0.49	0.595	0.595	0.595	0.595
1981	0	0.06	0.256	0.407	0.477	0.543	0.665	0.665	0.665	0.665
1982	0	0.061	0.267	0.427	0.499	0.571	0.707	0.707	0.707	0.707
1983	0	0.079	0.356	0.574	0.665	0.75	0.901	0.901	0.901	0.901
1984	0	0.069	0.312	0.504	0.573	0.633	0.742	0.742	0.742	0.742
1985	0	0.072	0.346	0.594	0.707	0.833	1.018	1.018	1.018	1.018
1986	0	0.061	0.302	0.532	0.633	0.745	0.9	0.9	0.9	0.9
1987	0	0.055	0.268	0.474	0.555	0.652	0.792	0.792	0.792	0.792
1988	0	0.069	0.331	0.587	0.68	0.792	0.949	0.949	0.949	0.949
1989	0	0.081	0.381	0.68	0.785	0.894	1.043	1.043	1.043	1.043
1990	0	0.067	0.313	0.577	0.686	0.794	0.944	0.944	0.944	0.944
1991	0	0.05	0.229	0.433	0.527	0.619	0.749	0.749	0.749	0.749
1992	0	0.039	0.18	0.344	0.428	0.514	0.641	0.641	0.641	0.641
1993	0	0.031	0.139	0.259	0.321	0.384	0.492	0.492	0.492	0.492
1994	0	0.032	0.137	0.247	0.299	0.354	0.454	0.454	0.454	0.454

1995	0	0.044	0.181	0.324	0.397	0.481	0.635	0.635	0.635	0.635
1996	0	0.058	0.24	0.446	0.601	0.796	1.129	1.129	1.129	1.129
1997	0	0.069	0.28	0.514	0.724	1.016	1.529	1.529	1.529	1.529
1998	0	0.076	0.287	0.489	0.663	0.922	1.407	1.407	1.407	1.407
1999	0	0.085	0.302	0.481	0.622	0.848	1.306	1.306	1.306	1.306
2000	0	0.078	0.262	0.382	0.458	0.587	0.856	0.856	0.856	0.856
2001	0	0.089	0.298	0.429	0.514	0.661	0.958	0.958	0.958	0.958
2002	0	0.117	0.4	0.59	0.736	0.952	1.33	1.33	1.33	1.33
2003	0	0.101	0.352	0.529	0.683	0.89	1.194	1.194	1.194	1.194
2004	0	0.076	0.274	0.426	0.582	0.802	1.103	1.103	1.103	1.103
2005	0	0.094	0.332	0.492	0.648	0.875	1.174	1.174	1.174	1.174
2006	0	0.104	0.356	0.496	0.617	0.789	0.991	0.991	0.991	0.991
2007	0	0.094	0.318	0.429	0.511	0.636	0.788	0.788	0.788	0.788
2008	0	0.092	0.317	0.433	0.518	0.658	0.845	0.845	0.845	0.845
2009	0	0.103	0.359	0.478	0.557	0.679	0.83	0.83	0.83	0.83
2010	0	0.116	0.419	0.575	0.698	0.879	1.078	1.078	1.078	1.078
2011	0	0.082	0.306	0.43	0.528	0.664	0.799	0.799	0.799	0.799
2012	0	0.08	0.313	0.468	0.614	0.826	1.045	1.045	1.045	1.045
2013	0	0.052	0.209	0.315	0.413	0.548	0.687	0.687	0.687	0.687
2014	0	0.055	0.216	0.32	0.406	0.512	0.598	0.598	0.598	0.598
2015	0	0.065	0.263	0.396	0.519	0.693	0.843	0.843	0.843	0.843
2016	0	0.052	0.209	0.314	0.414	0.568	0.69	0.69	0.69	0.69
2017	0	0.052	0.208	0.313	0.413	0.568	0.69	0.69	0.69	0.69

Table 4.6.3. Faroe Plateau cod (sub division 5.b.1). Stock number at age from the SAM model

	1	2	3	4	5	6	7	8	9	10
1959	20517	11810	12106	2382	4271	596	507	155	25	0
1960	18774	17018	8620	5981	1175	1876	334	228	96	12
1961	26633	14413	8133	3667	2518	514	697	140	69	40
1962	27310	22869	7911	3628	1837	1114	233	220	51	42
1963	19889	23511	13887	3817	1779	761	493	123	80	39
1964	11279	16893	13450	7344	1826	870	346	220	76	53
1965	17823	7945	12841	7992	3729	884	394	133	121	57
1966	22607	15071	5079	7909	4094	1615	382	187	65	76
1967	20930	19384	12486	3417	5112	2124	710	124	66	57
1968	12595	18254	15812	8587	2401	3087	996	297	35	51
1969	8762	10095	14004	10808	4571	1224	1625	401	168	38
1970	9826	6689	6639	8560	6054	2258	573	773	132	86
1971	18947	7430	5026	3852	4706	3621	1176	246	427	103
1972	18040	17205	7225	3691	2308	2573	1619	497	86	283
1973	38875	13102	15351	5856	2525	1377	986	691	282	220
1974	39863	35493	8975	9088	3503	1579	921	435	352	237
1975	24373	35210	25869	6669	6171	2120	822	405	228	297
1976	11150	20823	23685	13761	3554	3343	1103	473	154	207
1977	12882	7968	14994	17809	7675	1637	1618	395	211	38
1978	15463	10488	6582	8831	9230	2918	631	451	132	99
1979	24061	12186	8287	4967	4608	4735	1306	273	162	80
1980	17770	21976	10675	5121	2763	2245	2203	684	114	64
1981	26745	13105	18105	6777	2765	1477	1068	1112	309	105
1982	36749	22191	9935	10583	3836	1365	682	413	480	215
1983	56195	29619	18422	6784	5879	2175	745	271	183	226
1984	20546	56760	20544	9444	3324	2409	799	215	81	147
1985	7854	16712	37976	10657	4063	1429	1211	390	99	115
1986	8523	5517	13631	21058	5052	1689	450	314	96	66
1987	11372	6770	5810	7673	8898	2038	583	140	113	51
1988	20331	8919	7053	4394	3700	4313	921	277	51	47
1989	6062	21651	7023	4495	2149	1710	1637	333	102	21
1990	5785	4184	12708	3741	1830	813	557	471	95	42
1991	7793	4503	2686	6529	1633	703	304	185	129	47
1992	8289	6605	3486	1692	2868	733	281	124	71	75
1993	23391	5881	6361	2854	903	1268	297	98	58	66
1994	42660	20418	6209	5047	2112	505	686	140	43	60
1995	11687	45761	16863	6066	3666	1514	339	522	93	83
1996	4970	8730	30988	12909	3484	2524	937	192	392	77
1997	7073	4320	6298	21292	6959	1119	924	268	42	146

1998	16369	6581	3342	4470	11515	2798	283	150	48	33
1999	29119	13711	5391	2495	2713	4900	761	83	24	12
2000	42486	25938	10582	2957	1352	1696	1944	163	18	4
2001	18499	44332	15968	6605	1369	917	1200	747	54	9
2002	8960	16886	26393	8550	3452	792	621	541	299	13
2003	4399	6657	8524	12727	3760	1189	267	156	158	45
2004	6786	3131	3778	4270	4953	1286	340	85	56	56
2005	9469	6147	2512	2546	2707	1828	386	80	24	34
2006	6316	9580	3707	1413	1382	1285	568	108	21	8
2007	5709	5208	4767	2132	820	644	475	177	45	7
2008	13305	4061	3820	2477	1315	471	283	199	92	27
2009	21057	8659	5812	2325	1507	735	216	106	81	37
2010	6709	16882	6760	2605	1073	792	334	97	45	43
2011	1100	4777	9275	3613	994	437	283	100	39	9
2012	2531	728	2410	4594	1509	364	170	105	32	25
2013	8583	1741	1070	1400	2123	584	109	53	28	11
2014	2864	7702	2338	922	1130	982	231	46	24	5
2015	5228	2379	5203	1730	564	642	434	102	27	12
2016	7374	4372	2146	3077	828	298	289	144	37	7
2017	12523	5851	3580	1556	1974	431	142	118	55	18

Table 4.6.4. Faroe Plateau cod (sub-division 5.b.1). Summary table from the SAM model (catch is also provided) and forecast with status quo fishing mortality

Year	R(age 1)	Low	High	SSB	Low	High	**Catch**	TSB	Low	High	Fbar(3-7)	Low	High
1959	20517	10248	41078	47701	37851	60114	**22415**	65491	52208	82154	0.52	0.4	0.67
1960	18774	9780	36041	53127	43373	65074	**32255**	76415	62011	94165	0.7	0.55	0.88
1961	26633	13882	51096	46618	38027	57150	**21598**	68209	55091	84451	0.64	0.5	0.81
1962	27310	14185	52579	43918	35590	54196	**20967**	71227	56231	90222	0.57	0.44	0.73
1963	19889	10341	38253	50954	40662	63850	**22215**	82939	64635	106427	0.5	0.39	0.65
1964	11279	5822	21848	56575	44742	71537	**21078**	82366	64767	104748	0.49	0.38	0.63
1965	17823	9210	34490	54975	43724	69121	**24212**	71136	56564	89461	0.49	0.38	0.63
1966	22607	11653	43855	53990	42924	67909	**20418**	72999	57965	91931	0.48	0.37	0.63
1967	20930	10787	40611	64341	51464	80439	**23562**	90853	72041	114577	0.46	0.36	0.6
1968	12595	6476	24495	75370	60201	94360	**29930**	102475	81350	129086	0.45	0.35	0.58
1969	8762	4479	17140	79830	63599	100203	**32371**	102942	81738	129647	0.48	0.37	0.62
1970	9826	4992	19340	78136	62260	98059	**24183**	93150	74338	116723	0.39	0.3	0.51
1971	18947	9668	37130	58015	46478	72415	**23010**	68757	55240	85580	0.38	0.3	0.5
1972	18040	9251	35179	50844	41250	62668	**18727**	66179	53321	82138	0.35	0.27	0.45
1973	38875	19950	75753	69201	55364	86496	**22228**	95429	75276	120976	0.37	0.29	0.47
1974	39863	20533	77392	83773	67203	104428	**24581**	127446	99995	162433	0.38	0.3	0.48
1975	24373	12576	47235	100568	81361	124308	**36775**	144143	114678	181178	0.48	0.39	0.6
1976	11150	5720	21737	107642	87318	132696	**39799**	144373	116047	179612	0.6	0.49	0.74
1977	12882	6634	25015	105152	84138	131414	**34927**	127955	102415	159864	0.58	0.46	0.72
1978	15463	7959	30041	73277	58869	91212	**26585**	90215	72809	111782	0.49	0.39	0.62
1979	24061	12378	46770	61343	50095	75116	**23112**	77709	63354	95317	0.48	0.38	0.61
1980	17770	9168	34443	54552	44915	66255	**20513**	78884	63416	98126	0.43	0.34	0.54
1981	26745	13862	51601	58756	47930	72028	**22963**	82457	66103	102858	0.47	0.37	0.59
1982	36749	19053	70881	60222	49176	73748	**21489**	91310	72808	114513	0.49	0.4	0.61
1983	56195	28790	1E+05	100271	80811	124417	**38133**	127588	100896	161343	0.65	0.53	0.8
1984	20546	10646	39652	122500	97428	154024	**36979**	165678	126997	216141	0.55	0.45	0.68
1985	7854	4012	15374	85830	68721	107199	**39484**	134108	105227	170916	0.7	0.57	0.86
1986	8523	4388	16555	73939	57807	94572	**34595**	95743	75961	120676	0.62	0.5	0.77
1987	11372	5909	21886	58926	47185	73587	**21391**	70902	57387	87599	0.55	0.44	0.68
1988	20331	10376	39836	50180	41606	60521	**23182**	61858	51224	74699	0.67	0.55	0.82
1989	6062	3100	11854	37235	31099	44581	**22068**	63717	50520	80363	0.76	0.62	0.92
1990	5785	2955	11327	30928	25042	38196	**13692**	40926	32698	51224	0.66	0.53	0.82
1991	7793	3942	15405	22016	17441	27789	**8750**	26976	21515	33825	0.51	0.4	0.65
1992	8289	4187	16411	16615	13254	20829	**6396**	26801	21054	34117	0.42	0.33	0.54
1993	23391	12150	45035	25407	19880	32471	**6107**	35250	27132	45796	0.32	0.25	0.41
1994	42660	22248	81798	55852	43800	71220	**9046**	64346	49825	83099	0.3	0.23	0.38
1995	11687	6300	21682	60334	49576	73428	**23045**	134123	104412	172290	0.4	0.33	0.5
1996	4970	2697	9156	82137	67916	99336	**40422**	131061	106528	161245	0.64	0.53	0.77
1997	7073	3890	12860	75189	60891	92845	**34304**	86503	70360	106351	0.81	0.68	0.97
1998	16369	9202	29118	48902	39625	60350	**24005**	58474	48155	71004	0.75	0.63	0.9
1999	29119	16201	52338	37472	31035	45243	**19245**	57308	47845	68644	0.71	0.59	0.86
2000	42486	23670	76259	38201	32179	45351	**21833**	91603	73371	114365	0.51	0.41	0.63
2001	18499	10343	33085	56177	46845	67368	**28577**	124887	99081	157413	0.57	0.47	0.69
2002	8960	4949	16222	58186	48325	70058	**38834**	110501	89713	136107	0.8	0.67	0.96
2003	4399	2445	7916	44089	35833	54249	**25167**	65075	53348	79379	0.73	0.61	0.88
2004	6786	3809	12089	26057	21516	31556	**12840**	34738	28946	41689	0.64	0.53	0.77
2005	9469	5314	16872	21080	17724	25072	**10119**	29172	24593	34604	0.7	0.58	0.85
2006	6316	3548	11241	16707	14169	19700	**9844**	27043	22512	32485	0.65	0.53	0.79
2007	5709	3197	10196	14594	12339	17261	**7511**	24060	20049	28873	0.54	0.44	0.66
2008	13305	7336	24132	17976	15081	21427	**7315**	24553	20409	29538	0.55	0.45	0.68
2009	21057	11345	39083	19074	15991	22753	**9979**	30031	24748	36443	0.58	0.48	0.71
2010	6709	3656	12311	21981	18394	26267	**12757**	44335	35333	55630	0.73	0.6	0.89
2011	1100	596	2032	19897	16295	24295	**9692**	33195	26829	41071	0.55	0.44	0.68
2012	2531	1404	4565	17296	14117	21193	**7204**	20874	17046	25560	0.65	0.53	0.81
2013	8583	4623	15935	15945	12911	19692	**4473**	17889	14557	21983	0.43	0.34	0.55
2014	2864	1513	5423	16773	13834	20335	**5715**	24294	19500	30267	0.41	0.32	0.52
2015	5228	2729	10016	16920	13860	20655	**7394**	25285	20250	31573	0.54	0.42	0.7
2016	7374	2983	18226	20277	15410	26681	**5933**	26297	19814	34903	0.44	0.32	0.6
2017	12523	2347	66805	21720	14532	32464		30701	20127	46828	0.44	0.26	0.75
For-cast:	rec med	rec low	rec high	ssb med	ssb low	ssb high	**catch med**	**catch low**	**catch high**		fbar med	fbar low	fbar high
2017	12987	2371	71717	22723	15586	33702	**6630**	**4172**	**10663**		0.44	0.26	0.71
2018	5709	1100	21057	27725	15270	52215	**8267**	**4381**	**15339**		0.44	0.23	0.87
2019	5709	1100	21057	34292	15723	97859	**10105**	**4658**	**26412**		0.45	0.19	0.97
2020	5709	1100	21057	38115	14816	115471	**11294**	**4597**	**35360**		0.45	0.18	1.14

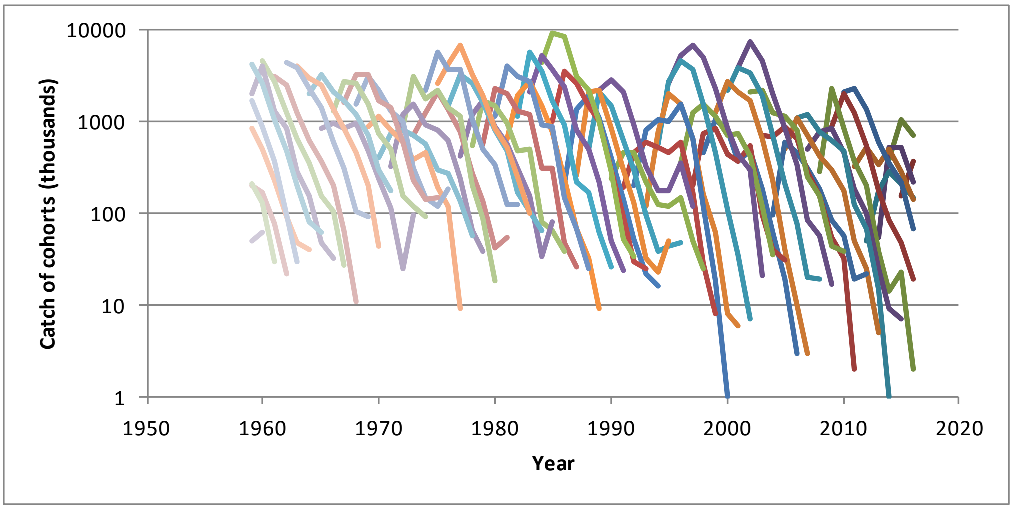


Figure 4.2.1. Faroe Plateau cod (sub-division 5.b.1). Catch in numbers at age shown as catch curves.

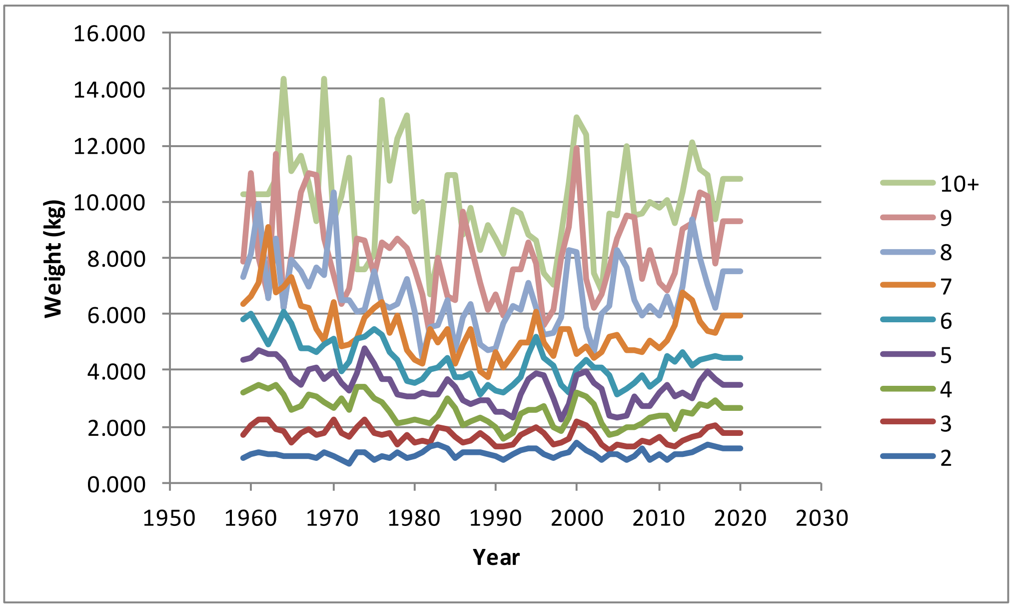


Figure 4.2.2. Faroe Plateau cod (sub-division 5.b.1). Mean weight at age in the catches. The last three years are based on a previous 5 year average.

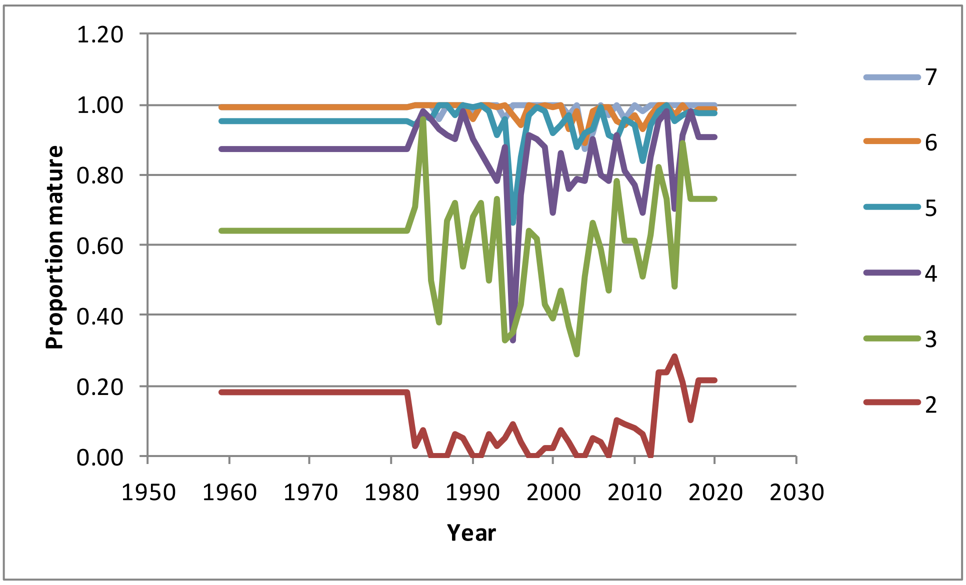


Figure 4.2.3. Faroe Plateau cod (sub-division 5.b.1). Proportion mature at age as observed in the spring groundfish survey. The last three years are based on a previous 5 year average.

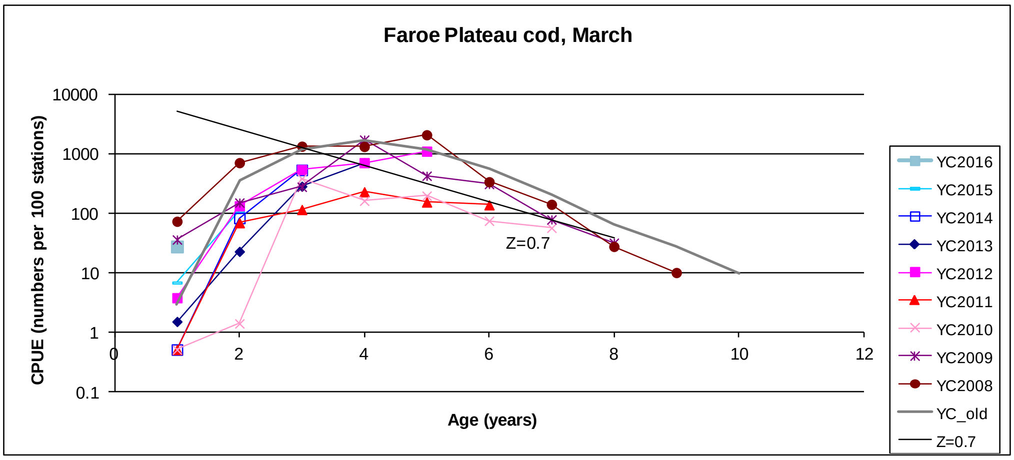


Figure 4.2.4. Faroe Plateau cod (sub-division 5.b.1). Catch curves from the spring groundfish survey.

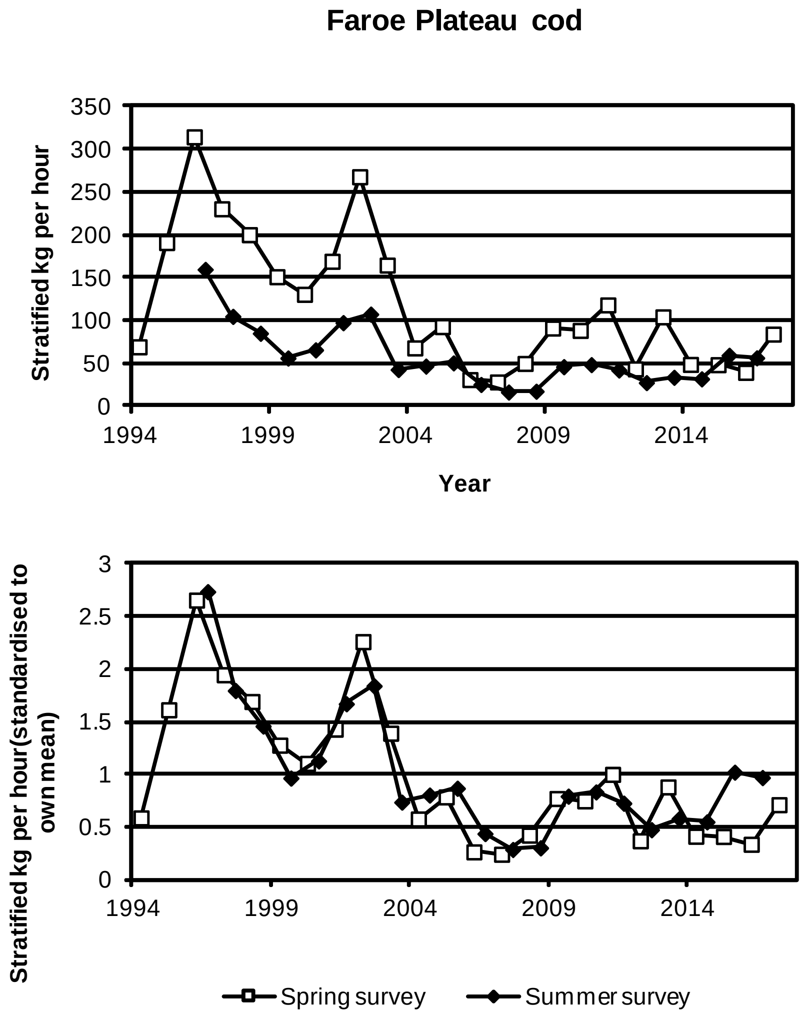


Figure 4.2.5. Faroe Plateau cod (sub-division 5.b.1). Stratified kg/hour in the spring and summer surveys.

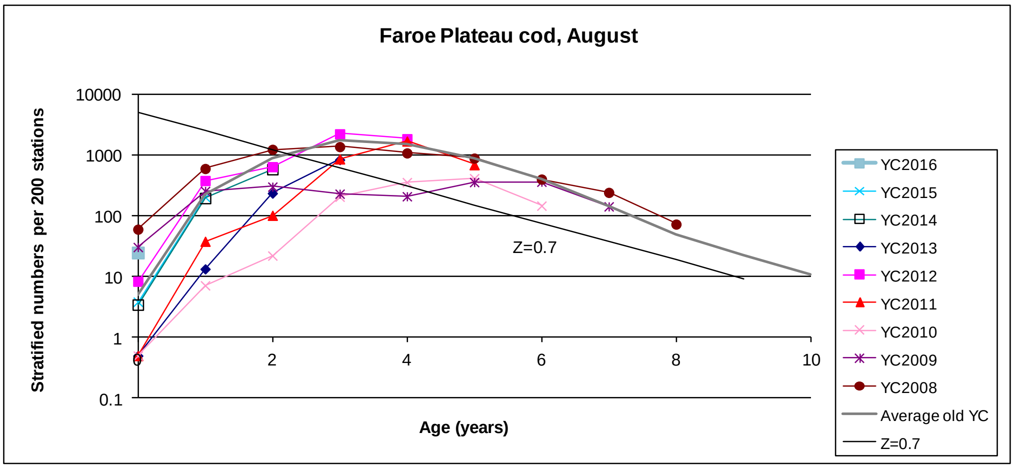


Figure 4.2.6. Faroe Plateau cod (sub-division 5.b.1). Catch curves from the summer groundfish survey.

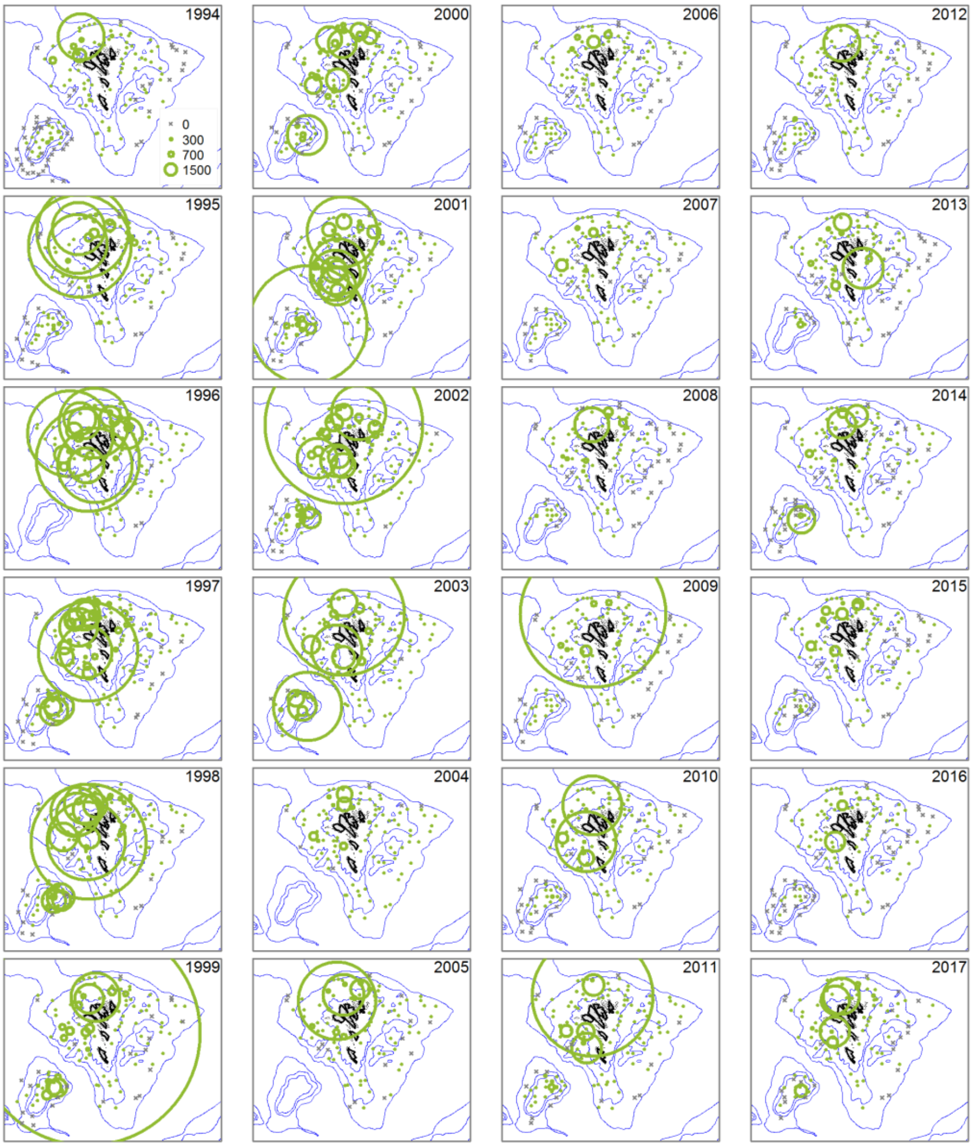


Figure 4.2.7. Faroe Plateau cod (sub-division 5.b.1). Catch per tow in the spring groundfish survey.

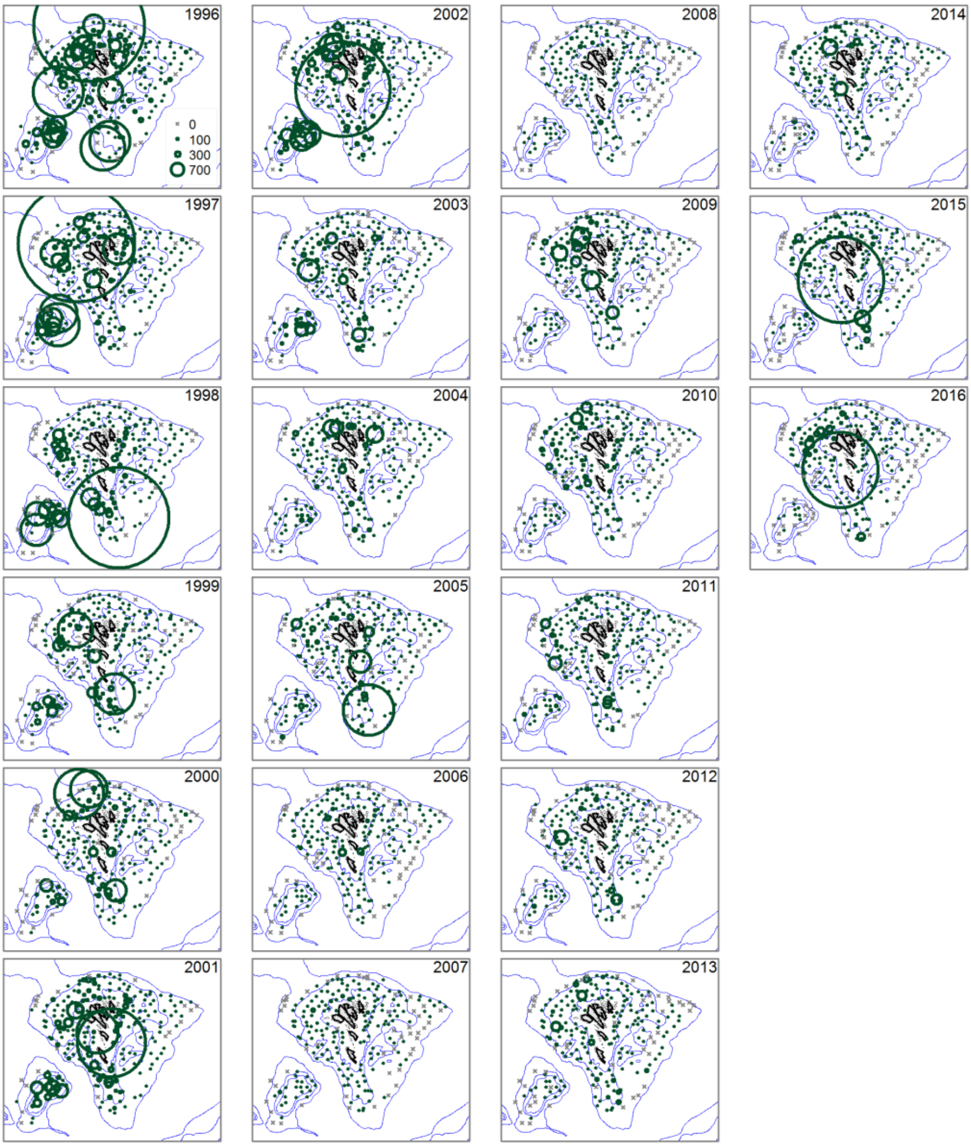


Figure 4.2.8. Faroe Plateau cod (sub-division 5.b.1). Catch per tow in the summer groundfish survey.

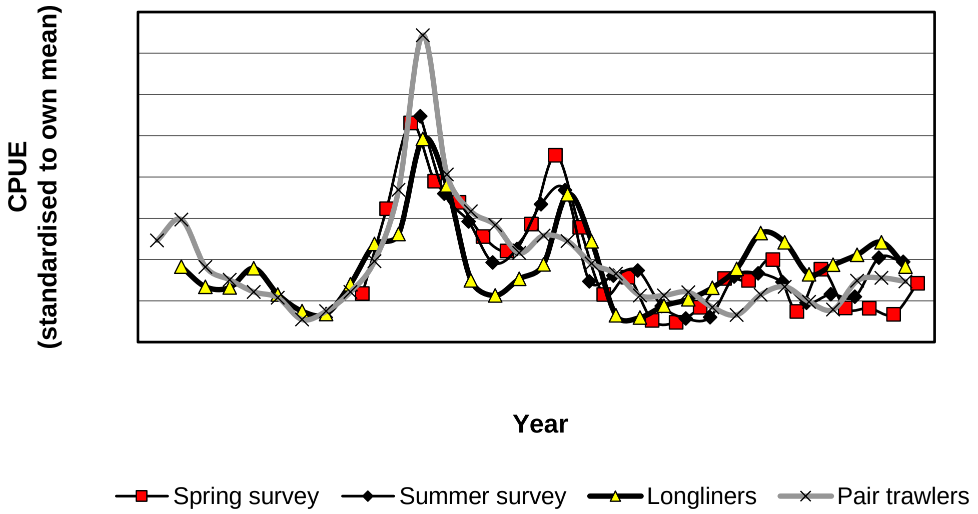


Figure 4.2.9. Faroe Plateau cod (sub-division 5.b.1). Standardised catch per unit effort for pair trawlers and longliners. The two surveys are shown as well.

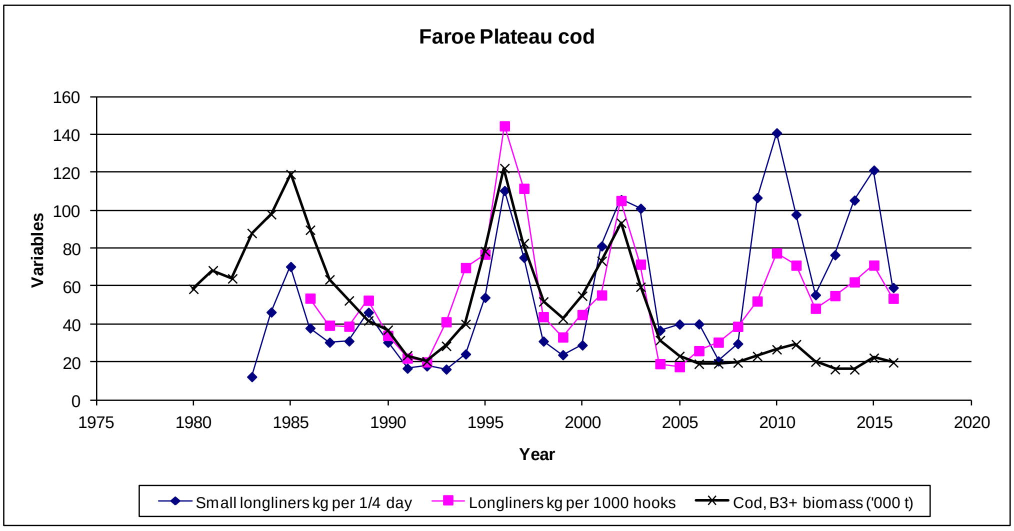


Figure 4.2.10. Faroe Plateau cod (sub-division 5.b.1). Catch per unit effort for small and large longliners compared with the fishable (age 3+) biomass.

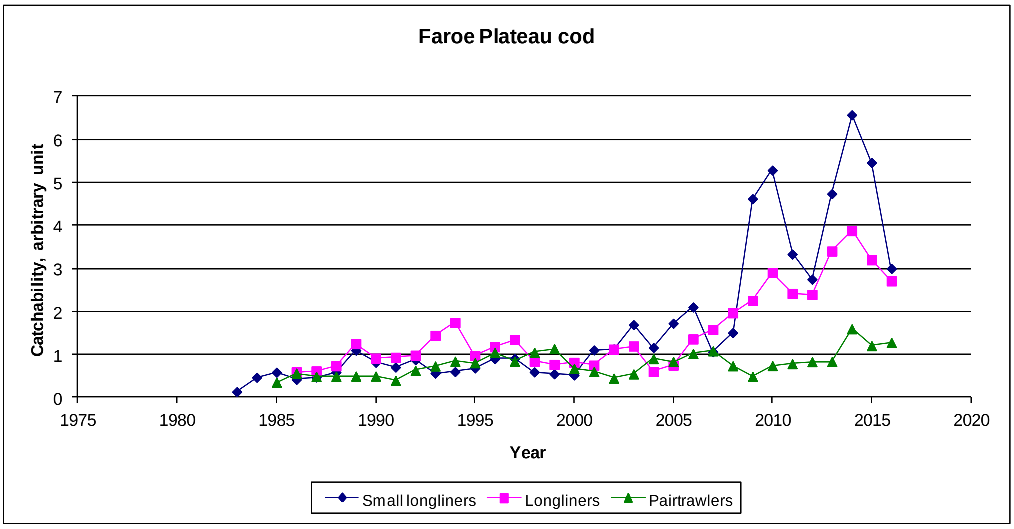


Figure 4.2.11. Faroe Plateau cod (sub-division 5.b.1). Catchability (cpue divided by age 3+ biomass) for small and large longliners and pair trawlers.

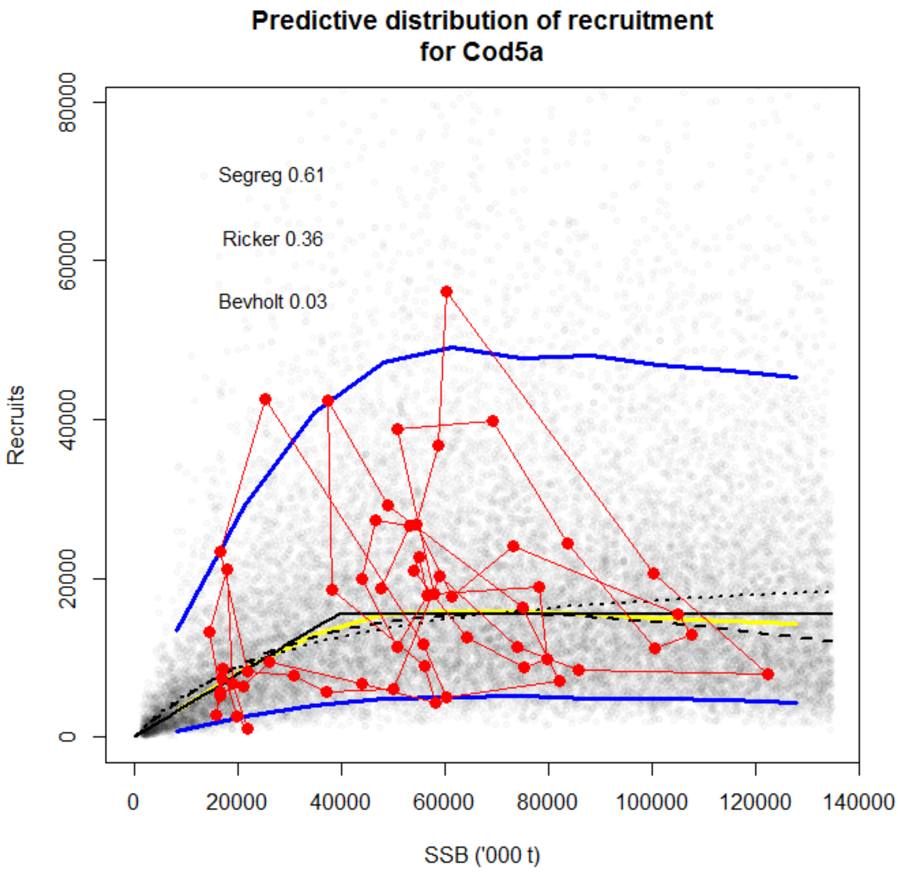


Figure 4.5.1. Faroe Plateau cod (sub-division 5.b.1). Spawning stock – recruitment relationship and 2000 simulations using the weighted function of segmented regression, Ricker, and Beverton and Holt.

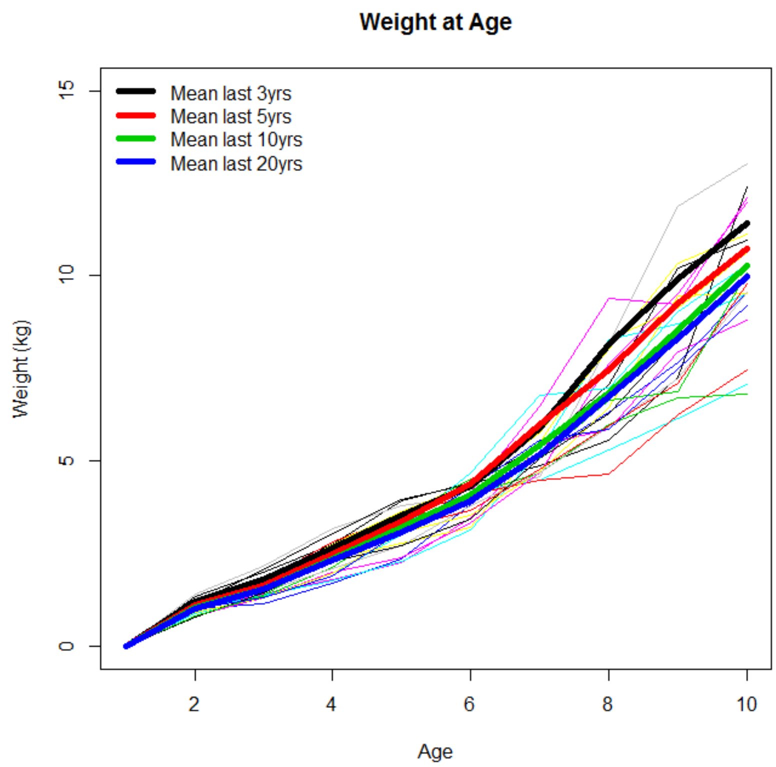


Figure 4.5.2. Faroe Plateau cod (sub-division 5.b.1). Weight at age for different periods back in time.

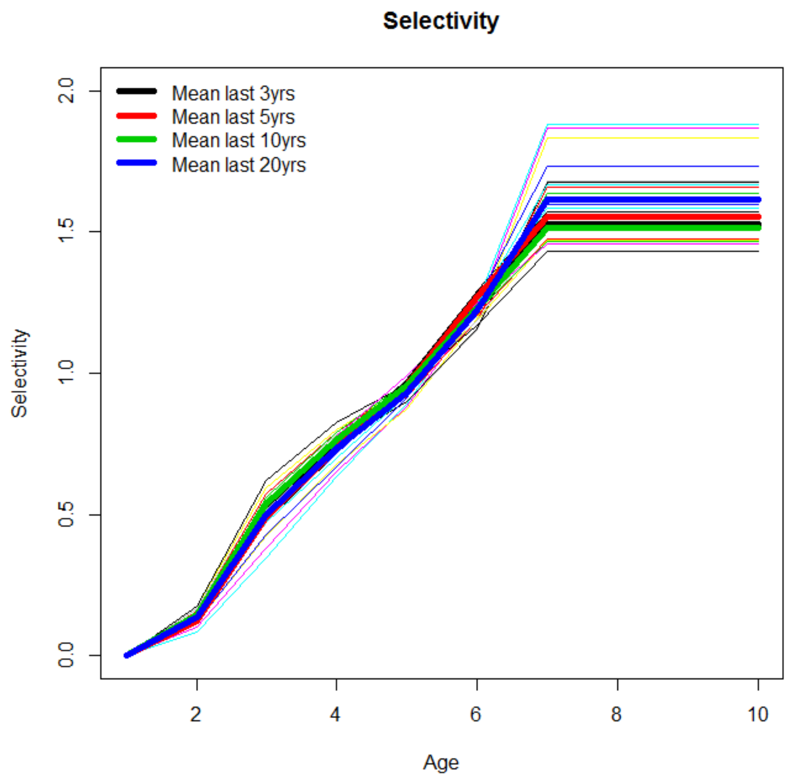


Figure 4.5.3. Faroe Plateau cod (sub-division 5.b.1). Selection pattern for different periods back in time.

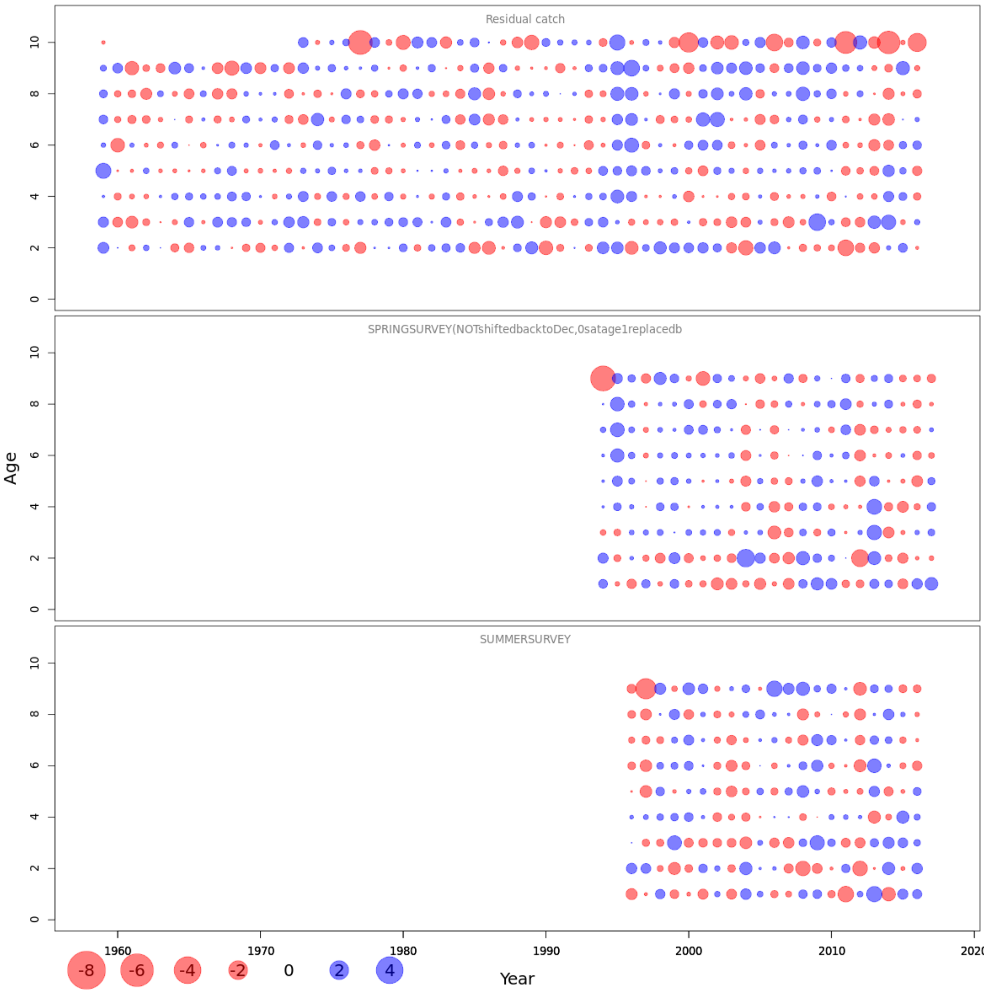


Figure 4.6.1. Faroe Plateau cod (sub-division 5.b.1). Observation residuals for the catch, spring survey and the summer survey as estimated by the SAM model.

Figure 4.6.2. Faroe Plateau cod (sub-division 5.b.1). Process residuals for the population numbers and fishing mortality as estimated by the SAM model.

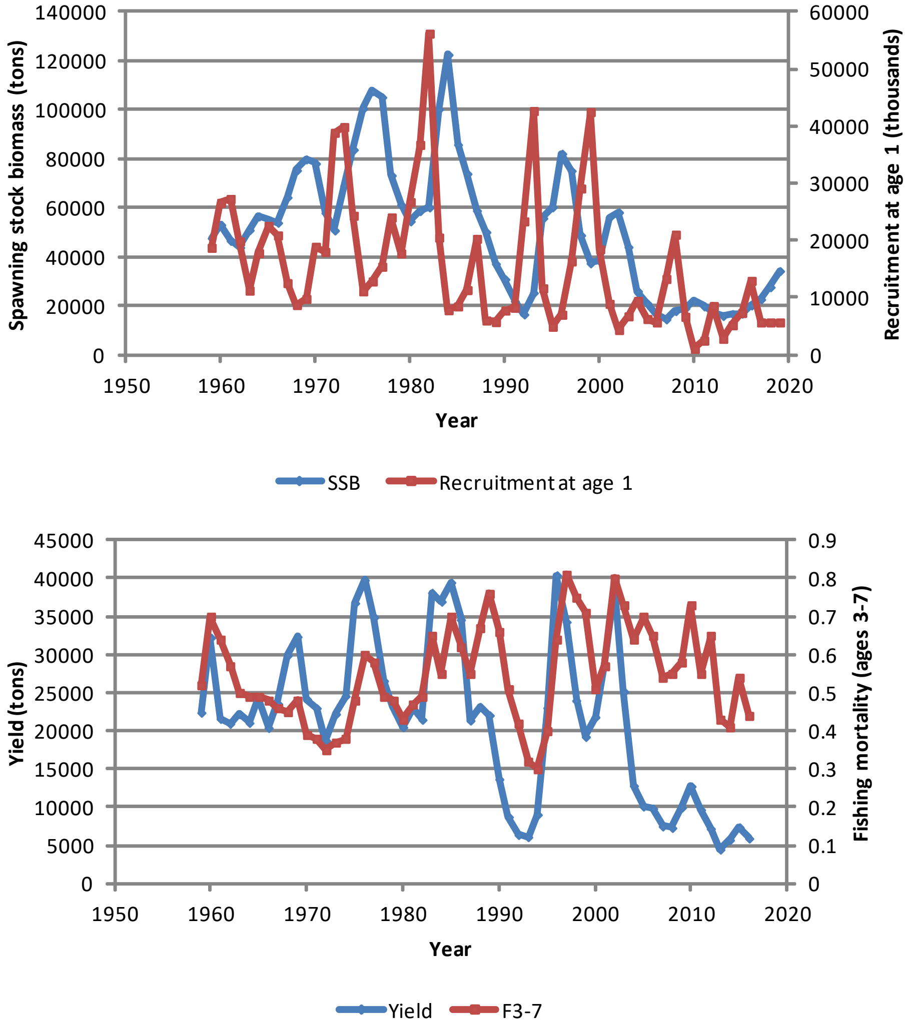


Figure 4.6.3. Faroe Plateau cod (sub-division 5.b.1). Spawning stock biomass (SSB) and the resulting recruitment at age 1 one year later (upper panel). SSB values for 2017-2020 are taken from the short term projection with status quo F. Yield and fishing mortality (lower panel).

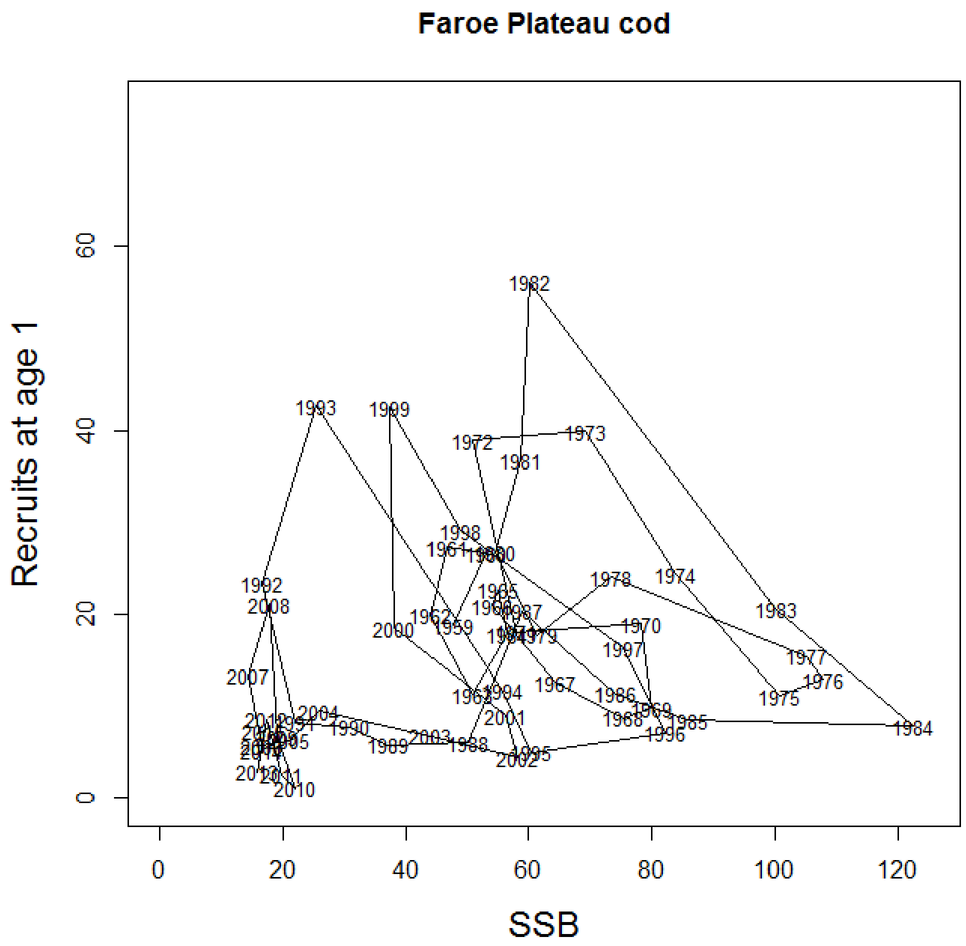


Figure 4.6.4. Faroe Plateau cod (sub-division 5.b.1). Spawning stock (tons) – recruitment (thousands) relationship. Years are shown at each data point.

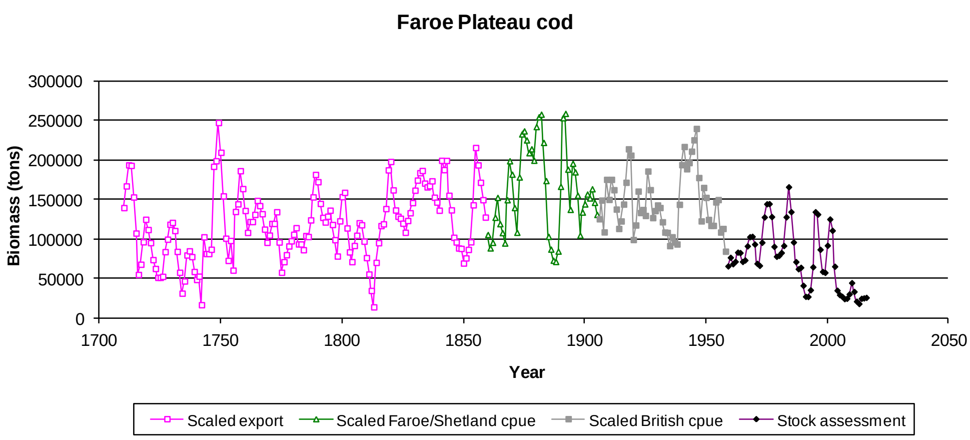


Figure 4.6.5. Faroe Plateau cod (sub-division 5.b.1). Age 2+ biomass during three centuries, see text.

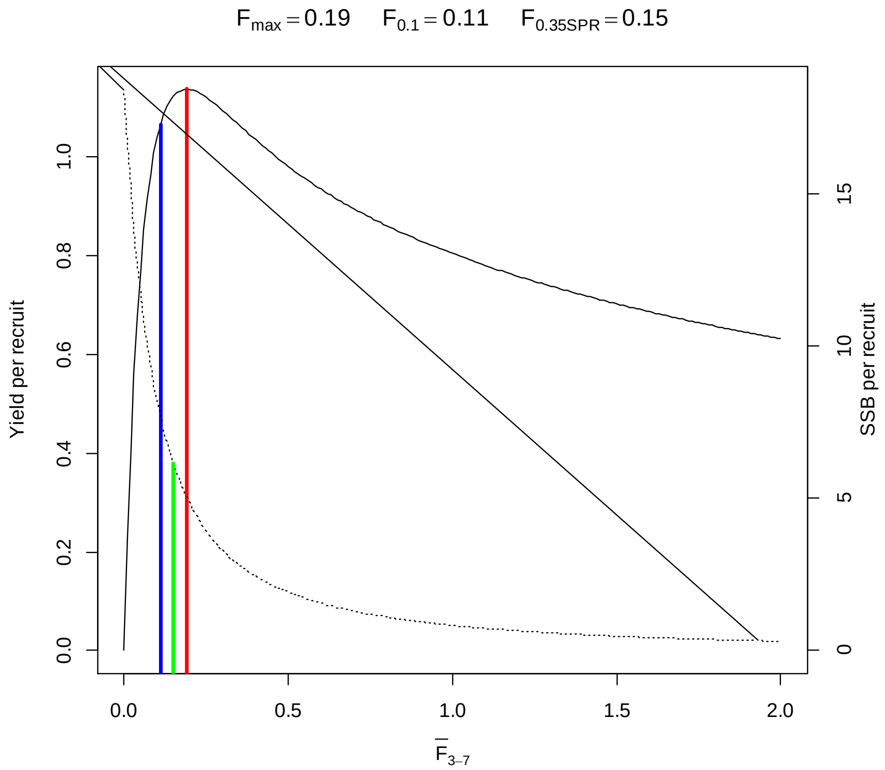


Figure 4.8.1. Faroe Plateau cod (sub-division 5.b.1). Yield per recruit and spawning stock biomass (SSB) per recruit versus fishing mortality.

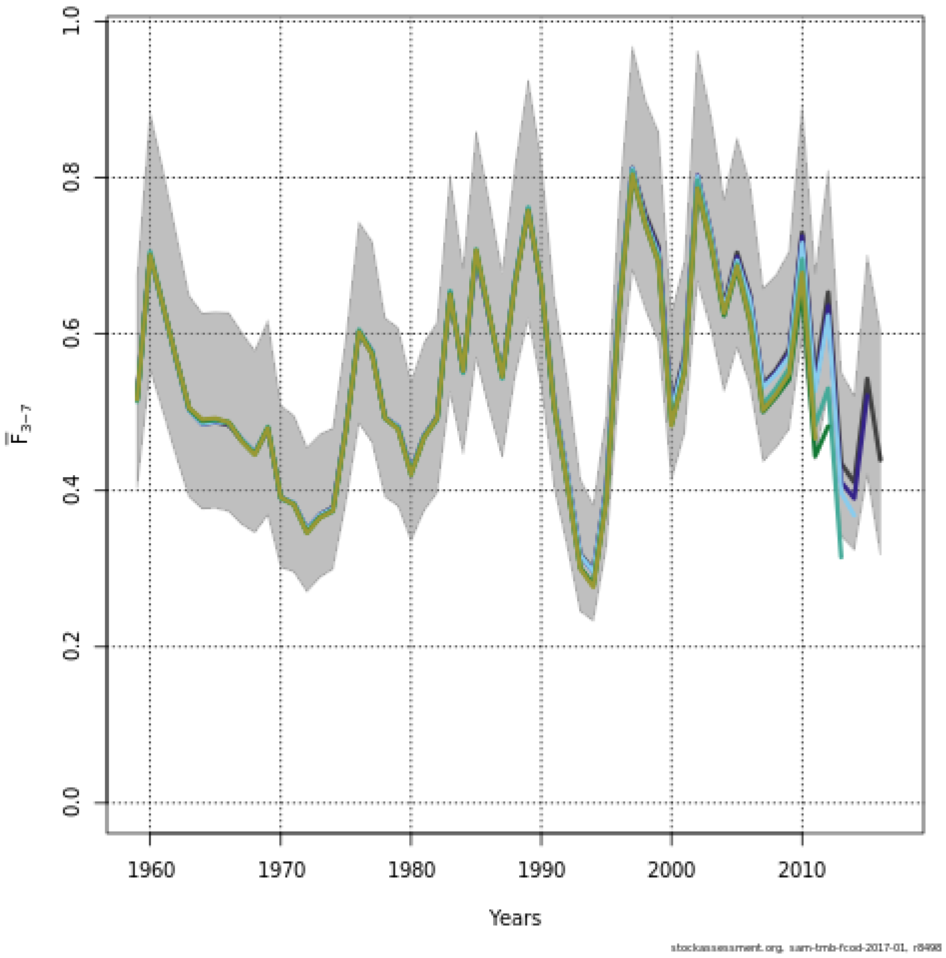


Figure 4.9.1. Faroe Plateau cod (sub-division 5.b.1). Results from the SAM retrospective analysis of fishing mortality (ages 3-7).

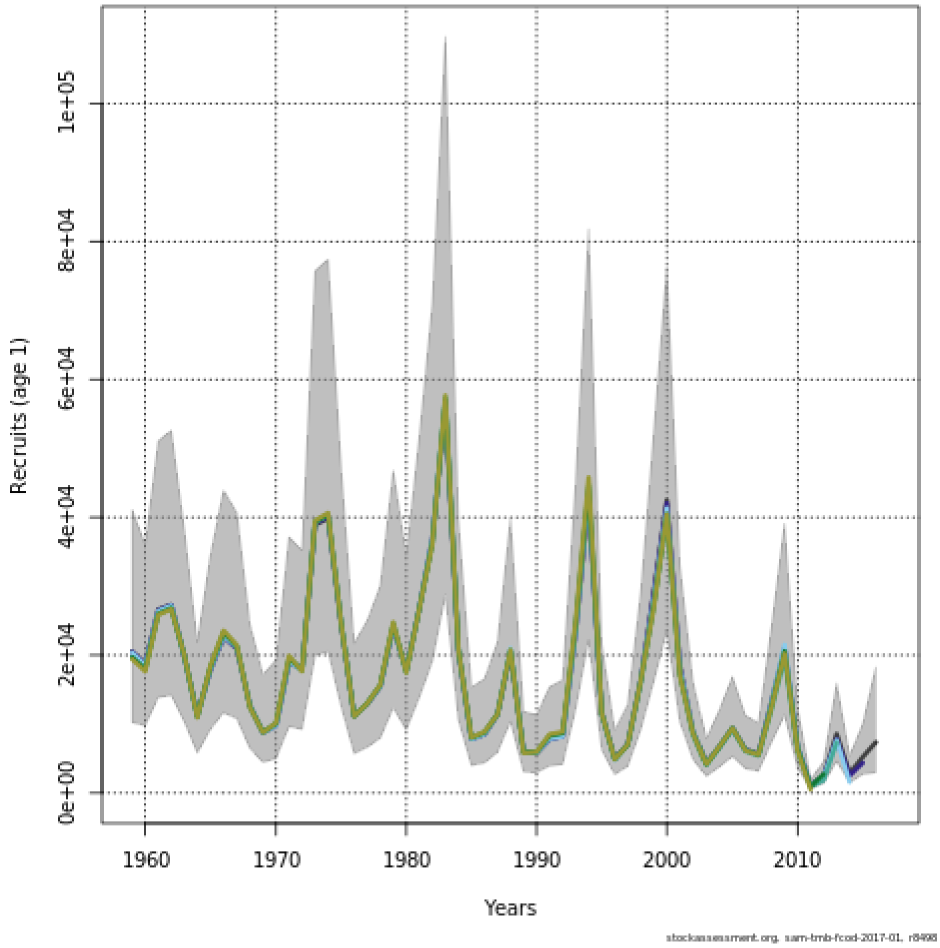


Figure 4.9.1. Faroe Plateau cod (sub-division 5.b.1). Results from the SAM retrospective analysis (continued). Recruitment at age 1.

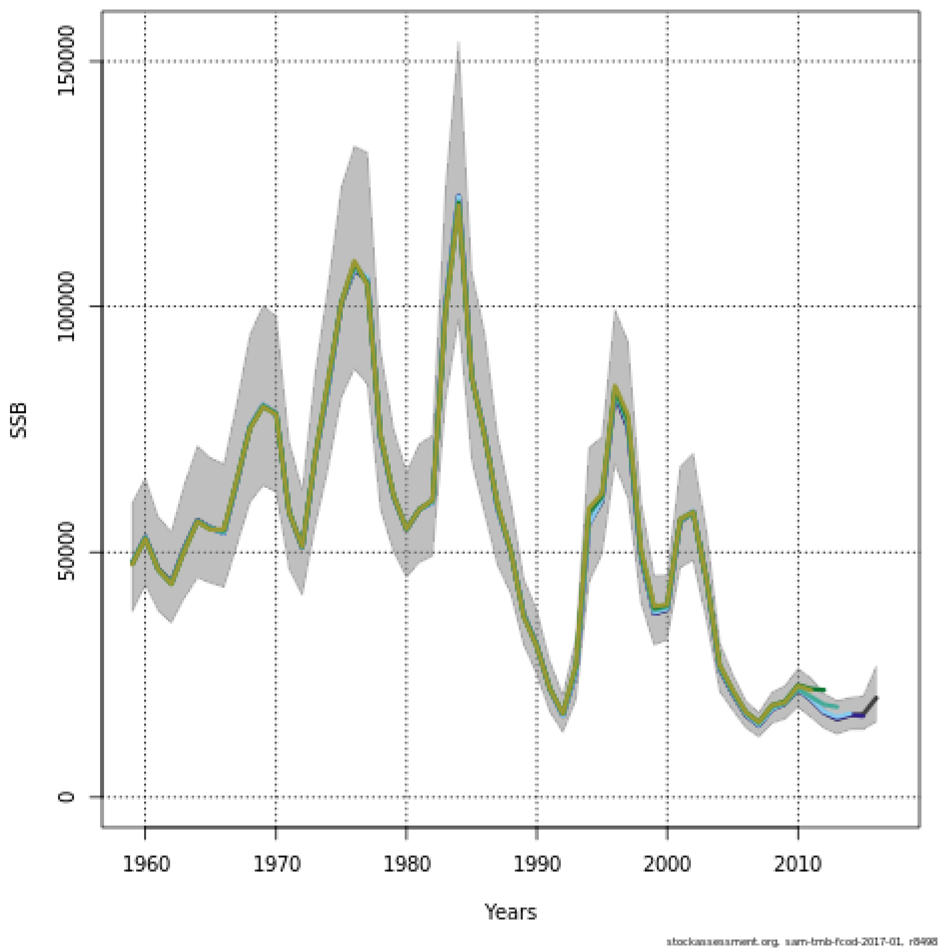


Figure 4.9.1. Faroe Plateau cod (sub-division 5.b.1). Results from the SAM retrospective analysis (continued). Spawning stock biomass.

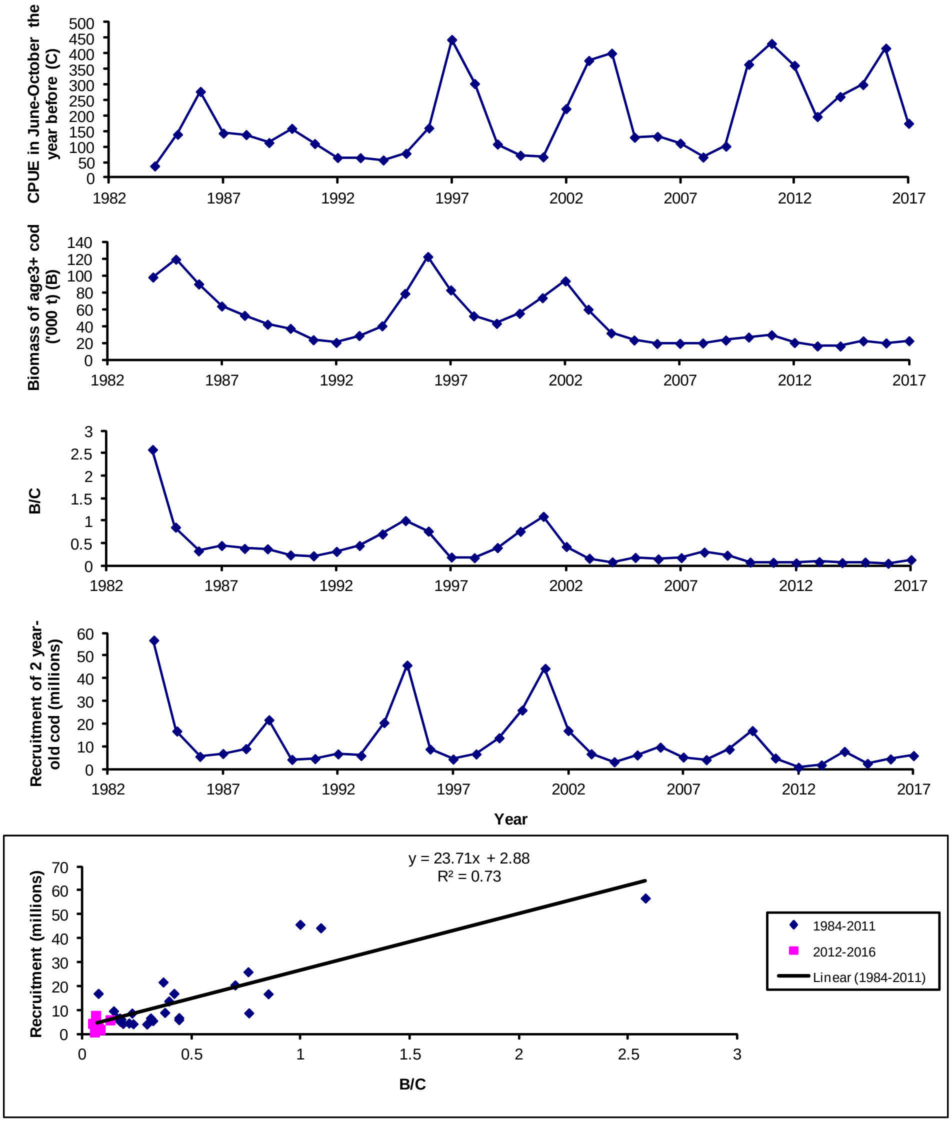


Figure 4.9.2. Faroe Plateau cod (sub-division 5.b.1). Modelling cod recruitment in three steps. First, the catch-per-unit –effort of cod (C) for small boats operating close to land, as being indicative of the amount of cannibalistic cod. Second, the amount of cod (older than the recruiting cod) (B),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

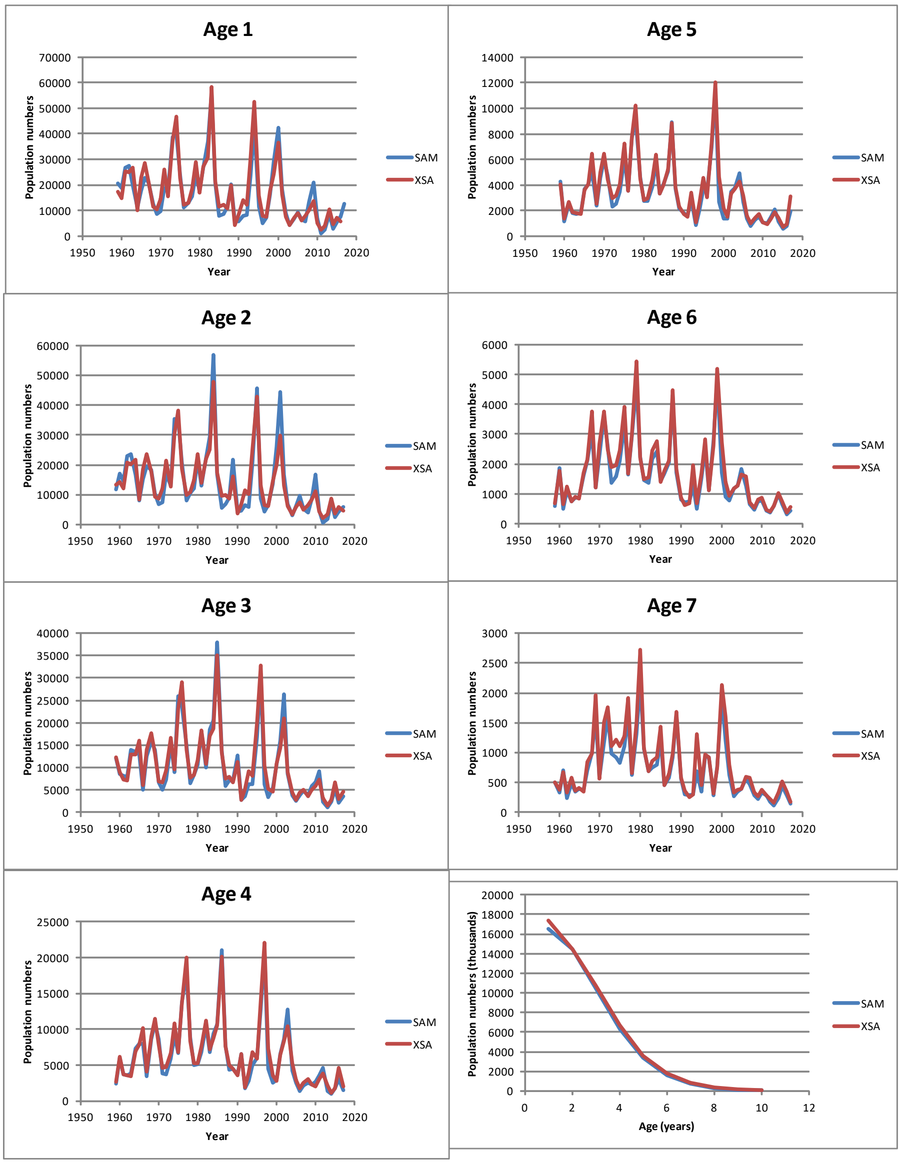


Figure 4.10.1. Faroe Plateau cod (sub-division 5.b.1). Comparison between the results from the current SAM assessment (2017 settings) and the XSA assessment (2016 settings). Population number by age and year as well as average values by age over the time period (right, bottom panel).

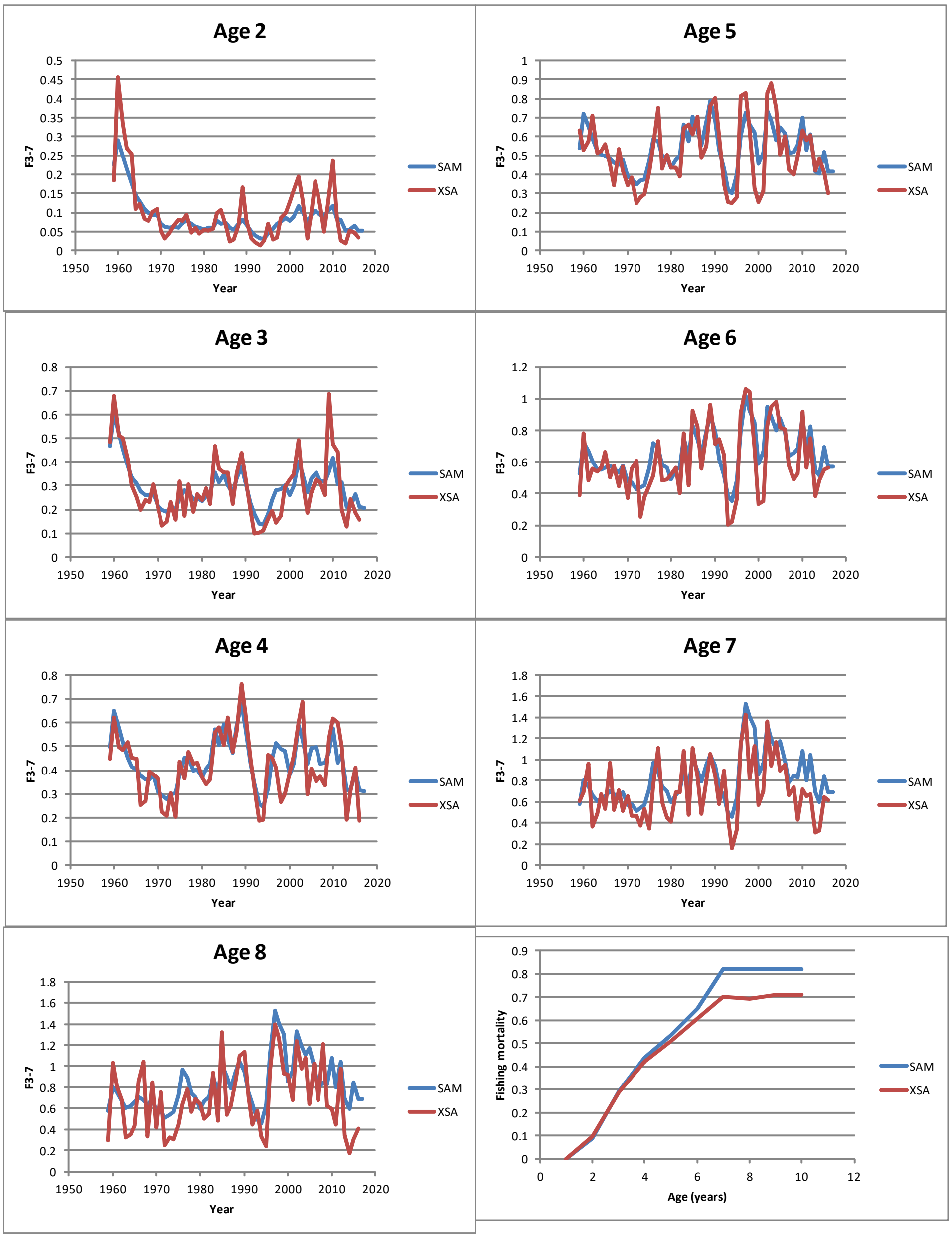


Figure 4.10.2. Faroe Plateau cod (sub-division 5.b.1). Comparison between the results from the current SAM assessment (2017 settings) and the XSA assessment (2016 settings). Fishing mortality by age and year as well as average values by age over the time period (right, bottom panel).

5 Faroe haddock

5.1 Stock description and management units

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

5.2 Scientific data

5.2.1 Trends in landings and fisheries

Nominal landings of Faroe haddock increased very rapidly from only 4 000 t in 1993 to 27 000 t in 2003, but have declined drastically since and amounted in 2012 to only about 2 600 t; they have increased a bit to 3 460 t in 2016. Most of the landings are taken from the Faroe Plateau; the 2016 landings from the Faroe Bank (Sub-Division 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 111 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). . The longliners have taken most of the catches in recent years followed by the trawlers. This was also the case in 2016, where the share by longliners was 79% and that by trawlers 21% (Figure 5.3).

5.2.2 Catch-at-age

Catch-at-age data were provided for fish taken by the Faroese fleets from 5.b. The sampling intensity in 2016 is shown in Table 5.3 and it was improved somewhat as compared to 2015. There is, however, a need to improve the sampling level. Reasons for the inadequate sampling level is a shortage of resources (people, money) but also that the total catches (and stock) are so small that it is difficult to obtain enough samples. From late 2011, a landing site has been established in Tórshavn close to the Marine Research Institute and it is the intention that technicians from the Institute will be sampling these landings regularly; In addition, a new technician will be hired to sample the landings in Klaksvík, where a large proportion of the landings occur. This is expected to improve the sampling level considerable.

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 (above and below 100 GRT), and all trawlers were also grouped into 1 fleet, and the 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 the foreign catch by trawlers and longliners and they were assumed to have the same age composition as the corresponding Faroese fleets. The most recent data were revised according to the final catch figures. The resulting total catch-at-age in numbers is given in Table 5.3 of the 2016 NWWG report, and in Figure 5.4 of the report the LN(catch-at-age in numbers) is shown for the whole assessment period from 1957 onwards in the stock annex.

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

5.2.3 Weight-at-age

Mean weight-at-age data are provided for the Faroese fishery (Table 5.5). 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 most recent years they have been fluctuated without a clear trend (Figure 5.5). The mean weights at age in the stock are assumed equal to those in the landings.

5.2.4 Maturity-at-age

Maturity-at-age data is available from the Faroese Spring Groundfish Surveys 1982–2017. 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 2017 assessment but catch per unit effort for some selected fleets (logbook data) is used as an additional information on the status of the stock (see section 5.4.1.1).

5.4 Methods

The benchmark in February 2017 decided to change the traditional assessment tool from XSA to SAM although it was recognized that the results of the assessment were mainly data-driven. The SAM model has some beneficial characteristics as compared to XSA, e.g. it provides uncertainty estimates for the catch in numbers, surveys and the output from the assessment (biomasses and fishing mortalities). See the stock annex for more information.

5.4.1.1 Tuning and estimates of fishing mortality

Commercial cpue series. Several commercial catch per unit effort series are updated every year, but as discussed in previous reports of this WG they are not used directly for tuning of the VPA but as additional information on stock trends (for details see the stock annex). The age-aggregated cpue series for longliners and pair trawlers are presented in Figure 5.7. In general the two series show the same trends although in some periods the two series are conflicting; this has been explained by variations in catchability of the longlines due to changes in productivity of the. Both series, however, indicate that the stock is very low, but possibly slowly increasing. 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".

<u>Fisheries independent cpue series</u>. 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 artifacts may be introduced because the smoothing can assign wrong ages to some lengths, especially for the youngest and oldest specimen. As in recent years, the length distributions have been used more directly for calculation of indices at age (ages 0-2), since these ages have length distributions almost without overlap. LN(numbers at age) for the surveys are presented in Figures 5.10-5.11.

5.5 Reference points

Since the assessment model was replaced at the benchmark in February 2017, it was necessary to recalculate reference points at the NWWG meeting in 2017 (this was not finally conducted during the benchmark).

The Blim was changed from 22 thousand tons to 16780, the lowest spawning biomass from which the stock had made a recovery. The biomass has been lower in recent years but the stock has not recovered yet.

The Bpa = Btrigger = 22 843 tonnes (changed from 35 000 tons). The uncertainty in the SAM assessment in the final year of SSB was found to be $\sigma = 0.188$ and the Bpa was found by using the formula Bpa = Blim × exp(σ × 1.645). The Btrigger was, according to ICES guidelines, set equal to Bpa since the stock had not been fished at Fmsy for five or more years.

Flim = 0.35 (changed from 0.4). Flim was derived from Blim. A stock was simulated with a segmented regression on the spawning stock – recruitment function having the point of inflection at Blim. Flim was set to the F that, in equilibrium, gave a 50% probability that SSB > Blim. This simulation was based on a fixed F, i.e., without in-clusion of a Btrigger and without inclusion of assessment/advice errors.

Fpa = 0.26 (changed from 0.25). Fpa was derived from Flim in the reverse of the way Bpa was derived from Blim, i.e., Fpa = Flim × exp($-\sigma$ × 1.645), where $\sigma = 0.185$.

The calculations were conducted using EQSIM following ICES guidelines. Decisions made involved the spawning stock – recruitment relationship, the weights at age, the selection pattern and the level of advice error. The period since 1978 was used as basis for the spawning stock – recruitment relationship where the S-R function was based on the segmented regression (weight 0.7), Ricker (weight 0.24), and Beverton and Holt (weight 0.06) (Figure 5.20). The autocorrelation between SSB-R data points was approximately 0.52. The weights at age were based on the last 20 years (Figure 5.22). The selection pattern was based on the last 5 years (Figure 5.23). The advice error was estimated from advice sheets back to 1999: cvF = 0.48, phiF = 0.37, cvSSB = 0.40, phiSSB = 0.43. In total 2000 iterations were performed that project-ed the stock 200 years into the future, of which, the last 50 years were kept to calculate 'equilibrium' values.

The result of the analyses was that Fmsy = 0.13 (changed from 0.25). The fishing mortality that is associated with a risk of 5% to fall below Blim, Fp0.5, was estimated to be 0.09.

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

At the benchmark in February 2017 the traditional XSA was replaced by a SAM assessment model. The SAM model settings and the model parameters are shown in Table 5.8, e.g. the fishing mortality is assumed equal for ages 7+. The variation in the catchability coefficients for the survey at age was set equal for ages 1. An AR covariance structure was applied for both t surveys, eliminating year effects. The observation residuals looked quite random (Figure 5.12) as well as the process residuals (Figure 5.13).

The results from the SAM-run shows that fishing mortality (F3-7) has decreased in re-cent years (Table 5.11, Figure 5.19). The spawning stock biomass have been low since 2009 but is now increasing (Table 5.11 Figure 5.18). The poor state of the stock since 2009 has been due to poor The spawning stock biomass in the terminal year was slightly below Blim and the fishing mortality above Fmsy and slightly above Fpa (Table 5.11).

5.7 Short term forecast

Input data

The short term prediction was changed with respect to previous years. The SAM model provides predictions that carry the signals from the assessment into the short term forecast. The forecast procedure starts from the assessment year's estimate of the state (log(N) and log(F) at age). One thousand replicates of the last state are simulated from its estimated joint distribution. Each of these replicates are then simulated forward according to the assumptions and parameter estimates found by the assessment model. In the forward simulations a 5 year average (years up to and includingthe assessment year) is used for catch mean weight, stock mean weight, proportion mature, and natural mortality. Recruitment is re-sampled from the period 2000-2016. In each forward simulation step the fishing mortality is scaled, such that the median of the distribution is matching the requirement in the scenario (e.g. hitting a specific mean F value or a specific catch).

Results

The landings in 2017 are expected to be 4 265 tonnes (Table 5.11) with status quo fishing mortality. The spawning stock biomass is expected to be 34 500 tonnes in 2018, 75 400 tonnes in 2019 and eventually 82 000 tonnes in 2020.

5.8 Yield per recruit

The yield-per-recruit calculations were performed in the SAM model based on the last 20 years. The Fmax was estimated at 0.7, but due to the very flat topped curve this value is very uncertain. F0.1 was estimated at 0.14 and F0.35SPR at 0.27 (Figure 5.14).

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.

The sampling of the catches for length measurements, otolith readings and length-weight relationships has increased 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

The assessment settings were according to the Stock Annex. The annex was changed substantially this year as a consequence of the benchmark in February 2017 and the new assessment model (SAM instead of XSA). The effect of changing assessment model was investigated by comparing the SAM run with an XSA run using the traditional XSA settings. There was little difference in population numbers from the 1996 and to recent date (Figure 5.18) as well as fishing mortalities (Figure 5.19).

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. 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 haddock exploitable stock in numbers would be harvested annually. This translates into an average F of 0.45, above the newly revised Fmsy of 0.13 and yhe newly revised Fpa of 0.26. Some work has been done in the Faroes to move away from the Ftarget of 0.45 to be more consistent with the ICES advice. The government is currently working on a new fisheries reform that is supposed to be set in force in the beginning of 2018. According to the current version of the reform, the fishing days will be replaced by quotas, the fishing year will become equal to the calendar year, antitrust regulations will be introduced to prevent that single companies are getting too large, and auctions will be applied to a part of the quotas. Importantly, the fisheries reform intends to follow principles of sustainability. Management considerations

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

5.12 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.

5.13 Regulations and their effects

As explained in the overview (section 2), the fishery for haddock in Vb is regulated through a maximum number of allocated fishing days, gear specifications, closed areas during spawning times, closed areas for longlining close to land and large areas closed to trawling. As a consequence, around 80% of the haddock landings derive from long line fisheries. Since the minimum mesh size in the trawls (codend) is 145 mm, the trawl catches consist of fewer small fish than the long line fisheries. Other nations fishing in Faroese waters are regulated by TAC's obtained during bilateral negotiations; their total landings are minimal, however, and in 2011-2013 no agreement could be made between the Faroe Islands and EU and Norway, respectively, due to the dispute on mackerel quota sharing. In 2014 2016, however, the parties managed to get an agreement in place again. Discarding of haddock is considered minimal and there is a ban to discarding.

5.14 Changes in fishing technology and fishing patterns

See section 2.

5.15 Changes in the environment

See section 2.

Table 5.1 Faroe Plateau (Sub-division 5b) HADDOCK. Nominal catches (tonnes) by countries 2000–2016 and Working Group estimates in 5b

Table 5.1 Faroe Plateau (Sub-division 5b1) HADDOCK. Nominal catches (tonnes) by countries 2000-2016 and Working Group estimates in 5b .

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016 [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	3,091
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	11
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	252
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	3,354
Used in the assessment in 5b	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	3,465

1) Including catches from Sub-division 5b2. Quantity unknown 1989-1991, 1993 and 1995-2001.
2) Preliminary data

4) Reported as Division 5b, to the Faroese coastal guard service.
5) Reported as Division 5b.
6) Includes Faroese landings reported to the NWWG by the Faroe Marine Research Institute

Table 5.2 Faroe Bank (Sub-division 5b2) HADDOCK. Nominal catches (tonnes) by countries, 2000–2016.

Table 5.2 Faroe Bank (Sub-division 5b2) HADDOCK. Nominal catches (tonnes) by countries, 2000-2016.

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016 [2]
Faroe Islan	1,565 [5]	1,948	3,698	4,934	3,594	2,444	1,375	810	556	192	178		141	47	71	30	111
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 (Scotla	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	111

1) Catches included in Sub-division Vb1.
2) Provisional data
3)From 1983 to 1996 includes also catches taken in Sub-division Vb1 (see Table 2.4.1)
4) Reported as Division Vb.
5) Provided by the NWWG

Table 5.3

Catch at age 2016

Age	5.b LLiners < 100GRT	5.b LLiners > 100GRT	5.b Trawlers	Others	5.b All Faroese fleets	5.b Foreign Trawlers	5.b Foreign Lliners	5.b Total All fleets
1	7	0	0	0	8	0	0	8
2	198	18	49	13	277	2	0	280
3	474	180	269	44	967	12	2	981
4	231	189	179	29	627	8	2	637
5	75	101	32	10	218	1	1	220
6	213	170	45	20	449	2	2	453
7	62	41	7	5	115	0	0	116
8	7	5	9	1	22	0	0	22
9	21	1	0	1	24	0	0	24
10	3	0	1	0	4	0	0	4
11	3	2	0	0	5	0	0	5
12	1	1	0	0	3	0	0	3
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
Total no.	1295	709	590	124	2718	27	8	2753
Catch, t.	1426	923	588	147	3084	27	10	3121

Notes: Numbers in 1000'
Catch, gutted weight in tonnes
Others includes netters, jiggers, other small categories and catches not otherwise accounted for
LLiners = Longliners

Comm. Sampling 2016	5.b LLiners < 100GRT	5.b LLiners > 100GRT	5.b Trawlers	5.b All Faroese Fleets	5.b Foreign Trawlers	5.b Foreign Lliners	5.b Total
No. samples	11	16	20	47	0	0	47
No. lengths	2504	3941	5090	11535	0	0	11535
No. weights	2504	3941	5090	11535	0	0	11535
No. ages	419	719	480	1618	0	0	1618

Table 5.4 Faroe haddock. Catch number-at-age

Year\age	1	2	3	4	5	6	7	8	9	10+
1957	45	4133	7130	8442	1615	894	585	227	94	58
1958	116	6255	8021	5679	3378	1299	817	294	125	105
1959	525	3971	7663	4544	2056	1844	721	236	98	47
1960	854	6061	10659	6655	2482	1559	1169	243	85	28
1961	941	7932	7330	5134	1937	1305	838	236	59	13
1962	784	9631	13977	5233	2361	1407	868	270	72	22
1963	356	13552	8907	7403	2242	1539	860	257	75	23
1964	46	2284	7457	3899	2360	1120	728	198	49	7
1965	39	1368	4286	5133	1443	1209	673	1345	43	8
1966	90	1081	3304	4804	2710	1112	740	180	54	9
1967	70	1425	2405	2599	1785	1426	631	197	52	13
1968	49	5881	4097	2812	1524	1526	923	230	68	12
1969	95	2384	7539	4567	1565	1485	1224	378	114	20
1970	57	1728	4855	6581	1624	1383	1099	326	68	10
1971	55	717	4393	4727	3267	1292	864	222	147	102
1972	43	750	3744	4179	2706	1171	696	180	113	95
1973	665	3311	8416	1240	2795	919	1054	150	68	11
1974	253	5633	2899	3970	451	976	466	535	68	147
1975	94	7337	7952	2097	1371	247	352	237	419	187
1976	40	4396	7858	6798	1251	1189	298	720	258	318
1977	0	255	4039	5168	4918	2128	946	443	731	855
1978	0	32	1022	4248	4054	1841	717	635	243	312
1979	1	1	1162	1755	3343	1851	772	212	155	74
1980	0	143	58	3724	2583	2496	1568	660	99	86
1981	0	74	455	202	2586	1354	1559	608	177	36
1982	0	539	934	784	298	2182	973	1166	1283	214
1983	0	441	1969	383	422	93	1444	740	947	795
1984	25	1195	1561	2462	147	234	42	861	388	968
1985	0	985	4553	2196	1242	169	91	61	503	973
1986	0	230	2549	4452	1522	738	39	130	71	712
1987	0	283	1718	3565	2972	1114	529	83	48	334
1988	0	655	444	2463	3036	2140	475	151	18	128
1989	0	63	1518	658	2787	2554	1976	541	133	81
1990	0	105	1275	1921	768	1737	1909	885	270	108
1991	0	77	1044	1774	1248	651	1101	698	317	32
1992	0	40	154	776	1120	959	335	373	401	162
1993	43	113	298	274	554	538	474	131	201	185
1994	1	277	191	307	153	423	427	383	125	301
1995	0	804	452	235	226	132	295	290	262	295
1996	1	326	5234	1019	179	163	161	270	234	394
1997	0	77	2913	10517	710	116	123	93	220	516
1998	0	106	1055	5269	9856	446	99	87	95	502
1999	9	174	1142	942	4677	6619	226	26	20	192
2000	73	1461	3061	210	682	2685	2846	79	1	71
2001	19	4380	3128	2423	173	451	1151	1375	17	18
2002	0	1515	14039	2879	1200	133	239	843	1095	33
2003	0	133	3436	13551	2224	949	163	334	858	924
2004	3	243	2007	4802	10426	1163	409	89	166	811
2005	0	85	1671	3852	6753	6127	542	147	28	154
2006	0	247	446	2566	3949	5423	3278	136	63	70
2007	0	76	982	547	2732	3309	2758	1117	89	9
2008	6	66	204	918	424	1471	1706	1254	320	39
2009	0	27	329	402	555	514	1133	739	285	48
2010	0	389	445	426	279	484	553	718	444	159
2011	0	170	773	324	198	186	280	353	367	187
2012	0	8	960	513	156	114	123	94	171	114
2013	0	83	510	1118	219	95	78	88	71	119
2014	0	238	395	642	1141	102	61	32	15	48
2015	0	384	1144	318	560	322	49	27	23	20
2016	8	280	981	637	220	453	116	22	24	12

Table 5.5. Faroe Haddock. Catch weight at age

Year\age	1	2	3	4	5	6	7	8	9	10+
1957	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1958	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1959	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1960	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1961	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1962	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1963	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1964	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1965	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1966	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1967	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1968	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1969	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1970	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1971	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1972	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1973	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1974	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1975	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1976	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1977	0	0.311	0.633	1.044	1.426	1.825	2.241	2.205	2.57	2.591
1978	0	0.357	0.79	1.035	1.398	1.87	2.35	2.597	3.014	2.92
1979	0.3	0.357	0.672	0.894	1.156	1.59	2.07	2.525	2.696	3.519
1980	0	0.643	0.713	0.941	1.157	1.493	1.739	2.095	2.465	3.31
1981	0	0.452	0.725	0.957	1.237	1.651	2.053	2.406	2.725	3.25
1982	0	0.7	0.896	1.15	1.444	1.498	1.829	1.887	1.961	2.856
1983	0	0.47	0.74	1.01	1.32	1.66	2.05	2.26	2.54	3.04
1984	0.359	0.681	1.011	1.255	1.812	2.061	2.059	2.137	2.368	2.686
1985	0	0.528	0.859	1.391	1.777	2.326	2.44	2.401	2.532	2.686
1986	0	0.608	0.887	1.175	1.631	1.984	2.519	2.583	2.57	2.922
1987	0	0.605	0.831	1.126	1.462	1.941	2.173	2.347	3.118	2.933
1988	0	0.501	0.781	0.974	1.363	1.68	1.975	2.344	2.248	3.295
1989	0	0.58	0.779	0.923	1.207	1.564	1.746	2.086	2.424	2.514
1990	0	0.438	0.699	0.939	1.204	1.384	1.564	1.818	2.168	2.335
1991	0	0.547	0.693	0.884	1.086	1.276	1.477	1.574	1.93	2.153
1992	0	0.525	0.724	0.817	1.038	1.249	1.43	1.564	1.633	2.126
1993	0.36	0.755	0.982	1.027	1.192	1.378	1.643	1.796	1.971	2.24
1994	0	0.754	1.103	1.254	1.465	1.593	1.804	2.049	2.225	2.423
1995	0	0.666	1.054	1.489	1.779	1.94	2.182	2.357	2.49	2.678
1996	0.36	0.534	0.858	1.459	1.993	2.33	2.351	2.469	2.777	2.582
1997	0	0.519	0.771	1.066	1.799	2.27	2.34	2.475	2.501	2.676
1998	0	0.622	0.846	1.016	1.283	2.08	2.556	2.572	2.452	2.753
1999	0.278	0.504	0.624	0.974	1.22	1.49	2.456	2.658	2.598	2.953
2000	0.28	0.661	0.936	1.166	1.483	1.616	1.893	2.821	3.749	3.196
2001	0.28	0.608	0.94	1.374	1.779	1.971	2.119	2.373	2.75	3.966
2002	0	0.584	0.857	1.405	1.799	1.974	2.301	2.37	2.626	3.13
2003	0	0.571	0.715	1.008	1.537	1.911	2.091	2.301	2.406	2.535
2004	0.367	0.574	0.77	0.887	1.159	1.638	1.87	2.438	2.357	2.417
2005	0	0.538	0.649	0.797	1.02	1.245	1.843	2.061	2.263	2.579
2006	0	0.475	0.601	0.768	0.911	1.126	1.374	2.158	2.211	2.569
2007	0	0.628	0.669	0.859	0.969	1.06	1.245	1.475	2.266	2.256
2008	0.491	0.636	0.754	0.86	0.991	1.082	1.151	1.379	1.727	2.435
2009	0	0.482	0.734	0.985	1.13	1.264	1.357	1.545	1.792	2.154
2010	0	0.692	0.87	1.149	1.308	1.386	1.429	1.568	1.74	1.841
2011	0	0.553	0.815	1.086	1.303	1.387	1.469	1.538	1.702	1.862
2012	0	0.619	0.786	1.069	1.405	1.616	1.656	1.675	1.727	1.905
2013	0	0.576	0.83	1.149	1.465	1.71	1.827	1.886	1.856	2.085
2014	0	0.547	0.902	1.165	1.354	1.693	1.841	1.872	1.856	1.823
2015	0.424	0.533	0.889	1.353	1.64	1.729	2.424	2.003	2.218	2.302
2016	0.396	0.645	0.934	1.22	1.571	1.908	2.066	2.187	2.276	2.789
2017	0.41	0.575	0.908	1.156	1.667	2.24	2.196	2.677	2.433	2.809

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

Year\age	1	2	3	4	5	6	7	8	9	10+
1957	0	0.06	0.48	0.91	1	1	1	1	1	1
1958	0	0.06	0.48	0.91	1	1	1	1	1	1
1959	0	0.06	0.48	0.91	1	1	1	1	1	1
1960	0	0.06	0.48	0.91	1	1	1	1	1	1
1961	0	0.06	0.48	0.91	1	1	1	1	1	1
1962	0	0.06	0.48	0.91	1	1	1	1	1	1
1963	0	0.06	0.48	0.91	1	1	1	1	1	1
1964	0	0.06	0.48	0.91	1	1	1	1	1	1
1965	0	0.06	0.48	0.91	1	1	1	1	1	1
1966	0	0.06	0.48	0.91	1	1	1	1	1	1
1967	0	0.06	0.48	0.91	1	1	1	1	1	1
1968	0	0.06	0.48	0.91	1	1	1	1	1	1
1969	0	0.06	0.48	0.91	1	1	1	1	1	1
1970	0	0.06	0.48	0.91	1	1	1	1	1	1
1971	0	0.06	0.48	0.91	1	1	1	1	1	1
1972	0	0.06	0.48	0.91	1	1	1	1	1	1
1973	0	0.06	0.48	0.91	1	1	1	1	1	1
1974	0	0.06	0.48	0.91	1	1	1	1	1	1
1975	0	0.06	0.48	0.91	1	1	1	1	1	1
1976	0	0.06	0.48	0.91	1	1	1	1	1	1
1977	0	0.06	0.48	0.91	1	1	1	1	1	1
1978	0	0.06	0.48	0.91	1	1	1	1	1	1
1979	0	0.06	0.48	0.91	1	1	1	1	1	1
1980	0	0.06	0.48	0.91	1	1	1	1	1	1
1981	0	0.06	0.48	0.91	1	1	1	1	1	1
1982	0	0.08	0.62	0.89	1	1	1	1	1	1
1983	0	0.08	0.62	0.89	1	1	1	1	1	1
1984	0	0.08	0.76	0.98	1	1	1	1	1	1
1985	0	0.03	0.62	0.96	1	1	1	1	1	1
1986	0	0.03	0.43	0.95	0.99	1	1	1	1	1
1987	0	0.05	0.32	0.91	0.98	1	1	1	1	1
1988	0	0.05	0.24	0.89	0.98	1	1	1	1	1
1989	0	0.02	0.22	0.87	0.99	1	1	1	1	1
1990	0	0.08	0.37	0.9	1	1	1	1	1	1
1991	0	0.16	0.58	0.93	1	1	1	1	1	1
1992	0	0.18	0.65	0.91	1	1	1	1	1	1
1993	0	0.11	0.5	0.85	0.97	0.99	1	1	1	1
1994	0	0.05	0.42	0.86	0.96	0.99	1	1	1	1
1995	0	0.03	0.47	0.91	0.96	0.99	1	1	1	1
1996	0	0.03	0.47	0.93	0.98	1	1	1	1	1
1997	0	0.01	0.47	0.91	1	1	1	1	1	1
1998	0	0.01	0.36	0.87	0.99	1	1	1	1	1
1999	0	0.01	0.35	0.86	0.99	1	1	1	1	1
2000	0	0.02	0.36	0.87	0.99	1	1	1	1	1
2001	0	0.09	0.54	0.93	1	1	1	1	1	1
2002	0	0.08	0.49	0.97	1	1	1	1	1	1
2003	0	0.07	0.45	0.97	0.99	1	1	1	1	1
2004	0	0	0.35	0.94	0.99	1	1	1	1	1
2005	0	0.01	0.34	0.91	0.99	1	1	1	1	1
2006	0	0.01	0.42	0.91	1	1	1	1	1	1
2007	0	0.02	0.52	0.91	1	1	1	1	1	1
2008	0	0.01	0.64	0.95	1	1	1	1	1	1
2009	0	0.01	0.61	0.93	1	1	1	1	1	1
2010	0	0.03	0.65	0.96	1	1	1	1	1	1
2011	0	0.09	0.74	0.97	1	1	1	1	1	1
2012	0	0.13	0.79	0.99	1	1	1	1	1	1
2013	0	0.17	0.83	0.99	1	1	1	1	1	1
2014	0	0.17	0.83	1	1	1	1	1	1	1
2015	0	0.19	0.9	1	1	1	1	1	1	1
2016	0	0.14	0.89	1	1	1	1	1	1	1
2017	0	0.12	0.9	1	1	1	1	1	1	1

Table 5.7. Faroe haddock. 2017 tuning file.

```
FAROE Haddock (ICES SUBDIVISION VB)       COMB-SURVEY-SPALY-17-jr.txt
102
SUMMER SURVEY
1996 2016
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
200   36244.78  3396.08  3092.06   1892.62   263.82   519.12  342.84   40.07
SPRING SURVEY
1994 2017
1 1 0.20 0.25
1 7
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
100  57368.90  17879.60   4110.20   3400.70   1048.60   237.30    475.30
```

Table 5.8 Faroe haddock 2017. Configuration in the SAM-run and the model parameters.

```
attr(,"fleetNames")
[1] "Residual catch" "SUMMERSURVEY"   "SPRINGSURVEY"

$conf
$conf$minAge
[1] 1

$conf$maxAge
[1] 10

$conf$maxAgePlusGroup
[1] 1

$conf$keyLogFsta
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    1    2    3    4    5    6    7    8     8
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1

$conf$corFlag
[1] 2

$conf$keyLogFpar
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[2,]    0    1    2    3    4    5    6    6   -1    -1
[3,]    7    8    9   10   11   12   12   -1   -1    -1

$conf$keyQpow
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
```

```
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1

$conf$keyVarF
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    0    0    0    0    0    0    0    0     0
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1

$conf$keyVarLogN
 [1] 0 1 1 1 1 1 1 1 1 1

$conf$keyVarObs
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    0    0    0    0    0    0    0    0     0
[2,]    1    1    1    1    1    1    1    1   -1    -1
[3,]    2    2    2    2    2    2    2   -1   -1    -1

$conf$obsCorStruct
[1] ID AR AR
Levels: ID AR US

$conf$keyCorObs
     1-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10
[1,]  NA  NA  NA  NA  NA  NA  NA  NA   NA
[2,]   0   0   0   0   0   0   0  -1   -1
[3,]   1   1   1   1   1   1   1  -1   -1

$conf$stockRecruitmentModelCode
[1] 0

$conf$noScaledYears
```

[1] 0

$conf$keyScaledYears
numeric(0)

$conf$keyParScaledYA
<0 x 0 matrix>

$conf$fbarRange
[1] 3 7

$conf$keyBiomassTreat
[1] -1 -1 -1

$conf$obsLikelihoodFlag
[1] LN LN LN
Levels: LN ALN

$conf$fixVarToWeight
[1] 0

Table of model parameters.

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	-4.887	0.143	0.008	0.006	0.010

logFpar_1	-5.401	0.129	0.005	0.003	0.006
logFpar_2	-5.619	0.121	0.004	0.003	0.005
logFpar_3	-5.573	0.116	0.004	0.003	0.005
logFpar_4	-5.631	0.114	0.004	0.003	0.005
logFpar_5	-5.615	0.113	0.004	0.003	0.005
logFpar_6	-5.494	0.099	0.004	0.003	0.005
logFpar_7	-5.747	0.168	0.003	0.002	0.004
logFpar_8	-5.165	0.154	0.006	0.004	0.008
logFpar_9	-5.643	0.144	0.004	0.003	0.005
logFpar_10	-5.660	0.138	0.003	0.003	0.005
logFpar_11	-5.814	0.133	0.003	0.002	0.004
logFpar_12	-5.919	0.123	0.003	0.002	0.003
logSdLogFsta_0	-1.033	0.119	0.356	0.281	0.452
logSdLogN_0	0.028	0.107	1.028	0.830	1.274
logSdLogN_1	-1.278	0.086	0.279	0.234	0.331
logSdLogObs_0	-1.069	0.081	0.343	0.292	0.404
logSdLogObs_1	-0.993	0.073	0.371	0.320	0.429
logSdLogObs_2	-0.545	0.085	0.580	0.489	0.688
transfIRARdist_0	3.384	516.806	29.481	0.000	Inf
transfIRARdist_1	-0.252	0.260	0.777	0.462	1.306

itrans_rho_0	1.195	0.126	3.303	2.568	4.248

Model fitting.

Model	log(L)	#par	AIC
Current	-862.17	22	1768.34

Table of selected sd.

Year	sd(log(R))	sd(log(SSB))	sd(log(Fbar))
2016	0.282	0.128	0.185
2017	0.506	0.188	0.357

Table 5.9. Faroe haddock (division 5.b.). Fishing mortality at age from the SAM model.

	1	2	3	4	5	6	7	8	9	10
1957	0	0.124	0.346	0.492	0.392	0.485	0.747	0.76	0.865	0.865
1958	0	0.172	0.444	0.603	0.494	0.636	1.014	1.074	1.279	1.279
1959	0	0.19	0.451	0.58	0.477	0.632	1.034	1.136	1.401	1.401
1960	0	0.228	0.529	0.668	0.543	0.713	1.18	1.299	1.581	1.581
1961	0	0.215	0.478	0.584	0.47	0.61	1.001	1.139	1.327	1.327
1962	0	0.232	0.53	0.649	0.517	0.662	1.09	1.344	1.564	1.564
1963	0	0.212	0.521	0.683	0.561	0.707	1.184	1.638	1.992	1.992
1964	0	0.112	0.316	0.47	0.422	0.553	0.896	1.367	1.621	1.621
1965	0	0.093	0.284	0.45	0.431	0.624	1.109	1.694	1.795	1.795
1966	0	0.088	0.28	0.442	0.417	0.587	1.004	1.338	1.513	1.513
1967	0	0.072	0.236	0.367	0.345	0.494	0.853	1.076	1.311	1.311
1968	0	0.088	0.281	0.414	0.372	0.511	0.855	0.992	1.231	1.231
1969	0	0.095	0.325	0.482	0.435	0.588	0.968	1.029	1.272	1.272
1970	0	0.082	0.305	0.447	0.411	0.519	0.797	0.714	0.779	0.779
1971	0	0.074	0.308	0.454	0.442	0.525	0.792	0.741	0.893	0.893
1972	0	0.073	0.33	0.446	0.42	0.433	0.612	0.583	0.757	0.757
1973	0	0.107	0.409	0.476	0.394	0.347	0.387	0.341	0.377	0.377
1974	0	0.075	0.288	0.363	0.307	0.286	0.314	0.324	0.398	0.398
1975	0	0.055	0.222	0.294	0.263	0.249	0.265	0.317	0.434	0.434
1976	0	0.041	0.198	0.308	0.322	0.343	0.365	0.454	0.596	0.596
1977	0	0.018	0.125	0.267	0.381	0.495	0.585	0.799	1.11	1.11
1978	0	0.008	0.074	0.185	0.294	0.404	0.538	0.798	1.124	1.124
1979	0	0.007	0.064	0.156	0.224	0.273	0.337	0.492	0.678	0.678
1980	0	0.015	0.121	0.259	0.316	0.323	0.341	0.448	0.578	0.578
1981	0	0.019	0.141	0.275	0.302	0.277	0.249	0.285	0.353	0.353
1982	0	0.032	0.233	0.421	0.447	0.397	0.337	0.394	0.481	0.481
1983	0	0.03	0.197	0.362	0.388	0.38	0.33	0.42	0.508	0.508
1984	0	0.028	0.171	0.316	0.335	0.353	0.294	0.407	0.498	0.498
1985	0	0.027	0.162	0.308	0.354	0.402	0.335	0.484	0.596	0.596

1986	0	0.022	0.127	0.252	0.318	0.394	0.372	0.583	0.716	0.716
1987	0	0.024	0.135	0.259	0.339	0.447	0.477	0.694	0.792	0.792
1988	0	0.02	0.113	0.216	0.283	0.364	0.399	0.538	0.641	0.641
1989	0	0.017	0.107	0.214	0.301	0.414	0.508	0.67	0.809	0.809
1990	0	0.022	0.142	0.263	0.338	0.451	0.562	0.706	0.903	0.903
1991	0	0.027	0.166	0.287	0.323	0.389	0.438	0.468	0.544	0.544
1992	0	0.024	0.142	0.25	0.281	0.32	0.351	0.364	0.428	0.428
1993	0	0.032	0.178	0.29	0.289	0.293	0.298	0.292	0.329	0.329
1994	0	0.015	0.112	0.222	0.252	0.278	0.299	0.304	0.338	0.338
1995	0	0.014	0.111	0.241	0.291	0.319	0.345	0.344	0.366	0.366
1996	0	0.01	0.102	0.25	0.34	0.404	0.457	0.447	0.442	0.442
1997	0	0.011	0.112	0.246	0.363	0.479	0.6	0.602	0.568	0.568
1998	0	0.021	0.197	0.343	0.47	0.663	0.928	1.016	0.853	0.853
1999	0	0.027	0.256	0.381	0.468	0.612	0.85	1.108	0.847	0.847
2000	0	0.036	0.277	0.383	0.418	0.465	0.522	0.625	0.507	0.507
2001	0	0.028	0.218	0.343	0.393	0.415	0.41	0.444	0.399	0.399
2002	0	0.021	0.17	0.312	0.409	0.473	0.478	0.517	0.526	0.526
2003	0	0.011	0.107	0.246	0.421	0.627	0.744	0.806	0.881	0.881
2004	0	0.012	0.101	0.227	0.409	0.682	0.977	1.144	1.331	1.331
2005	0	0.014	0.106	0.213	0.354	0.57	0.869	1.084	1.366	1.366
2006	0	0.02	0.134	0.237	0.35	0.539	0.843	1.065	1.542	1.542
2007	0	0.025	0.158	0.255	0.332	0.467	0.714	0.943	1.251	1.251
2008	0	0.027	0.165	0.252	0.29	0.384	0.584	0.824	1.205	1.205
2009	0	0.025	0.173	0.262	0.28	0.338	0.46	0.591	0.846	0.846
2010	0	0.037	0.259	0.375	0.388	0.446	0.57	0.683	0.973	0.973
2011	0	0.027	0.214	0.341	0.385	0.455	0.609	0.724	1.031	1.031
2012	0	0.022	0.164	0.259	0.312	0.371	0.486	0.587	0.848	0.848
2013	0	0.038	0.236	0.296	0.336	0.38	0.488	0.596	0.868	0.868
2014	0	0.042	0.247	0.303	0.339	0.34	0.386	0.429	0.623	0.623
2015	0	0.043	0.237	0.288	0.325	0.319	0.328	0.354	0.524	0.524
2016	0	0.038	0.21	0.262	0.315	0.308	0.29	0.305	0.443	0.443

2017	0	0.038	0.205	0.256	0.308	0.301	0.283	0.3	0.436	0.436

Table 5.10. Faroe haddock (division 5.b). Stock number at age from the SAM model.

	1	2	3	4	5	6	7	8	9	10
1957	26530	36391	25388	20833	5417	2604	1226	470	201	118
1958	31896	30314	25136	14210	9561	2982	1332	479	181	126
1959	59499	29070	23081	12821	6300	4402	1277	390	134	68
1960	78895	39660	24143	13288	6209	3295	1793	380	104	39
1961	79881	55111	24057	12839	5710	3035	1350	417	89	22
1962	80073	51852	35746	12377	6516	3009	1361	398	108	27
1963	40716	61702	27175	16489	5487	3579	1264	368	84	25
1964	17917	28829	33296	11574	6570	2587	1711	303	60	11
1965	17307	16588	20871	17272	5245	3111	1145	796	63	11
1966	32436	15019	13867	13513	8413	2729	1278	301	99	11
1967	47006	24816	12480	9196	7061	4140	1213	361	68	19
1968	28386	48212	18899	8903	5559	4205	1928	417	102	19
1969	32633	26213	33286	11905	5243	3418	2132	668	129	29
1970	19878	25978	20684	19482	5768	3177	1621	682	200	29
1971	24055	13823	20041	13404	9920	3179	1590	513	277	118
1972	27202	19261	10324	13143	7209	5045	1480	576	184	139
1973	125775	24594	19974	4746	7670	3560	3205	585	304	82
1974	113579	83302	15603	12005	2267	4121	1936	1976	309	320
1975	72284	94423	50269	9451	6733	1454	2397	1103	1238	427
1976	27482	69314	54635	28605	5862	4267	1104	1814	688	910
1977	10019	19840	44380	29779	15093	3932	2412	762	1012	917
1978	861	9115	16478	29063	17339	6845	1686	1095	311	490
1979	5802	512	13447	13324	18540	9772	3285	644	366	189
1980	5975	6006	624	14142	9891	11481	6159	1805	271	212
1981	18569	4509	4188	727	10475	6028	7091	3708	829	182
1982	21309	16348	3408	2745	620	7244	3770	4440	2915	601
1983	47375	16608	12682	1628	1446	348	4533	2235	2608	1987
1984	42570	41425	12580	8592	761	791	219	2629	1175	2531
1985	19972	35365	32305	9071	4684	443	423	170	1348	2041
1986	13301	15928	26271	21526	5691	2498	208	261	108	1539

1987	25604	10070	15094	18991	12946	3363	1284	131	109	671
1988	9544	23635	6279	12822	12864	7787	1740	542	49	297
1989	7429	7400	16299	4409	9500	8233	4605	1006	265	155
1990	3338	6331	8212	10260	3108	5614	4613	2117	393	160
1991	2908	2603	5882	6804	5975	2007	2990	2154	855	135
1992	4293	2290	1730	4032	4453	3704	1155	1483	1144	482
1993	31254	3126	2023	1249	2620	2708	2247	658	846	833
1994	35270	12503	1882	1541	800	1723	1797	1495	438	1095
1995	64456	49970	5613	1188	966	535	1163	1137	944	985
1996	16474	46351	62944	3370	620	528	414	787	705	1207
1997	3897	11857	35664	57173	1996	358	249	263	473	1172
1998	14894	3487	7313	25237	35844	1083	133	139	140	858
1999	25027	13998	2495	4564	16046	19057	437	30	40	369
2000	130456	24737	13635	933	2459	8472	9212	163	5	154
2001	69922	120177	18539	8117	476	1391	4253	4939	66	72
2002	54446	56275	99426	10689	4024	339	830	2471	2871	81
2003	32299	33158	40779	63310	6094	1834	223	608	1368	1564
2004	8371	28135	27506	28530	37874	2688	632	103	230	1053
2005	11939	6941	20763	22529	21536	19026	1083	188	32	270
2006	3379	10765	4358	14883	15409	13776	6935	351	60	70
2007	3343	3366	6882	2864	9735	9704	6377	1862	126	19
2008	3416	2785	2134	4558	2076	5902	4979	2444	506	42
2009	8156	2100	1918	1598	2703	1700	3595	2074	715	115
2010	13947	6595	1868	1458	1007	1473	1297	1849	847	283
2011	724	11146	4095	1043	716	580	638	678	673	328
2012	1748	743	9525	2216	564	360	362	248	293	262
2013	7244	1451	1507	7107	1225	340	223	186	119	201
2014	10045	6309	1673	1957	4088	542	192	113	57	104
2015	7171	8499	6036	1278	2051	1618	230	109	58	60
2016	23162	6237	6333	3453	765	1451	646	101	67	48
2017	98629	18393	5455	4637	2118	486	968	396	61	60

Table 5.11 . Faroe haddock (division 5.b). Summary table from the SAM model (catch is also provided) and forecast with status quo fishing mortality.

Year	R (age 1)	High	Low	SSB	High	Low	Catch	Fbar(3-7)	High	Low
	thousands			tonnes			tonnes	per year		
1957	26530	50372	13972	50158	65958	38143	20995	0.49	0.67	0.36
1958	31896	58006	17538	50504	64310	39662	23871	0.64	0.83	0.49
1959	59499	106659	33191	45336	57139	35972	20239	0.63	0.82	0.49
1960	78895	141597	43959	45184	56562	36096	25727	0.73	0.93	0.57
1961	79881	144464	44170	42774	53713	34063	20831	0.63	0.81	0.49
1962	80073	144998	44219	47550	59688	37879	27151	0.69	0.89	0.54
1963	40716	73964	22413	48179	61041	38027	27571	0.73	0.94	0.57
1964	17917	32738	9806	44843	57396	35036	19490	0.53	0.7	0.41
1965	17307	31695	9451	44989	58022	34883	18479	0.58	0.76	0.44
1966	32436	59330	17733	41844	54112	32357	18766	0.55	0.72	0.42
1967	47006	86048	25678	37826	48389	29569	13381	0.46	0.61	0.35
1968	28386	51822	15549	40214	50474	32040	17852	0.49	0.64	0.37
1969	32633	59476	17904	46984	59171	37307	23272	0.56	0.73	0.43
1970	19878	36319	10880	49721	64123	38553	21361	0.5	0.66	0.37
1971	24055	43924	13174	49357	63386	38434	19393	0.5	0.68	0.38
1972	27202	49866	14839	45001	58149	34826	16485	0.45	0.61	0.33
1973	125775	237607	66578	42038	54032	32707	18035	0.4	0.56	0.29
1974	113579	214940	60017	43996	56264	34403	14773	0.31	0.43	0.22
1975	72284	137730	37936	57436	74136	44497	20715	0.26	0.36	0.19
1976	27482	53018	14245	81012	106595	61570	26211	0.31	0.42	0.22
1977	10019	22460	4469	82909	110126	62419	25555	0.37	0.52	0.27
1978	861	1943	381	80031	108481	59042	19200	0.3	0.43	0.21
1979	5802	11438	2943	62235	84356	45915	12424	0.21	0.31	0.14
1980	5975	12635	2825	57002	75956	42778	15016	0.27	0.39	0.19
1981	18569	39319	8770	51449	68857	38442	12233	0.25	0.35	0.18
1982	21309	45190	10048	40072	52014	30871	11937	0.37	0.51	0.27
1983	47375	100850	22255	37402	48661	28748	12894	0.33	0.46	0.24
1984	42570	83166	21791	41150	52991	31955	12378	0.29	0.41	0.21
1985	19972	42642	9355	49568	65427	37554	15143	0.31	0.44	0.22
1986	13301	28488	6211	54455	73141	40542	14477	0.29	0.41	0.21
1987	25604	55155	11886	54261	72469	40627	14882	0.33	0.46	0.24
1988	9544	20513	4440	48946	64963	36878	12178	0.28	0.38	0.2

1989	7429	15833	3486	41816	54419	32131	14325	0.31	0.43	0.22
1990	3338	7099	1570	34817	44855	27025	11726	0.35	0.49	0.25
1991	2908	6169	1371	26982	35049	20772	8429	0.32	0.45	0.23
1992	4293	9177	2008	20141	26505	15304	5476	0.27	0.38	0.19
1993	31254	62535	15620	17474	23010	13269	4026	0.27	0.38	0.19
1994	35270	61825	20121	16780	21704	12974	4252	0.23	0.32	0.17
1995	64456	114591	36256	18269	22897	14577	4948	0.26	0.35	0.19
1996	16474	26064	10412	41129	53116	31847	9642	0.31	0.41	0.23
1997	3897	6361	2388	78402	102958	59702	17924	0.36	0.48	0.27
1998	14894	23973	9253	75743	96930	59187	22210	0.52	0.68	0.4
1999	25027	39070	16031	54561	69084	43090	18482	0.51	0.67	0.4
2000	130456	203778	83516	41580	51496	33573	15821	0.41	0.54	0.31
2001	69922	109497	44650	51146	61275	42692	15890	0.36	0.47	0.27
2002	54446	88267	33584	82414	103067	65899	24933	0.37	0.48	0.28
2003	32299	52223	19976	98249	125991	76615	27072	0.43	0.56	0.33
2004	8371	13190	5313	83579	105276	66353	23101	0.48	0.63	0.37
2005	11939	19295	7387	69544	85655	56463	20455	0.42	0.55	0.32
2006	3379	5456	2093	51700	62919	42482	17154	0.42	0.55	0.32
2007	3343	5390	2073	35408	42811	29285	12631	0.39	0.51	0.29
2008	3416	5416	2155	23292	27915	19435	7388	0.34	0.44	0.25
2009	8156	13165	5052	17149	20490	14352	5197	0.3	0.4	0.23
2010	13947	22599	8608	12908	15260	10918	5202	0.41	0.53	0.31
2011	724	1193	439	9597	11394	8084	3540	0.4	0.53	0.3
2012	1748	2833	1079	11717	14701	9340	2634	0.32	0.43	0.24
2013	7244	11722	4477	13038	16703	10176	2950	0.35	0.46	0.26
2014	10045	16305	6188	11432	14349	9108	3276	0.32	0.44	0.24
2015	7171	11857	4338	14625	18193	11757	3395	0.3	0.41	0.22
2016	23162	40729	13172	15852	20461	12281	3465	0.28	0.4	0.19
2017	98629	271357	35848	19210	27952	13202		0.27	0.55	0.13

Forecast table. SQ all years.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high
2017	0.273	0.14	0.544	99114	36709	249894	19980	14140	29166	4265	2247	7331
2018	0.28	0.11	0.686	8371	724	130456	34435	20420	58421	7367	3138	16556
2019	0.278	0.092	0.859	8371	724	130456	75407	34149	191875	15271	5036	48914
2020	0.276	0.082	0.914	8371	724	130456	81881	30537	243653	16812	4894	64790

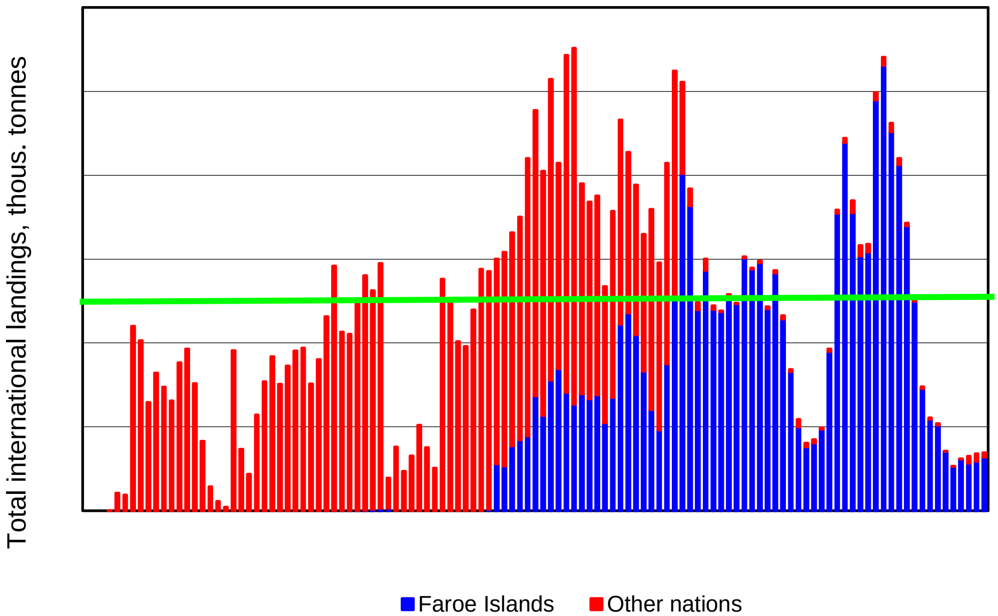


Figure 5.1. Haddock in ICES Division 5b. Landings by all nations 1904-2016. Horisontal line average for the whole period.

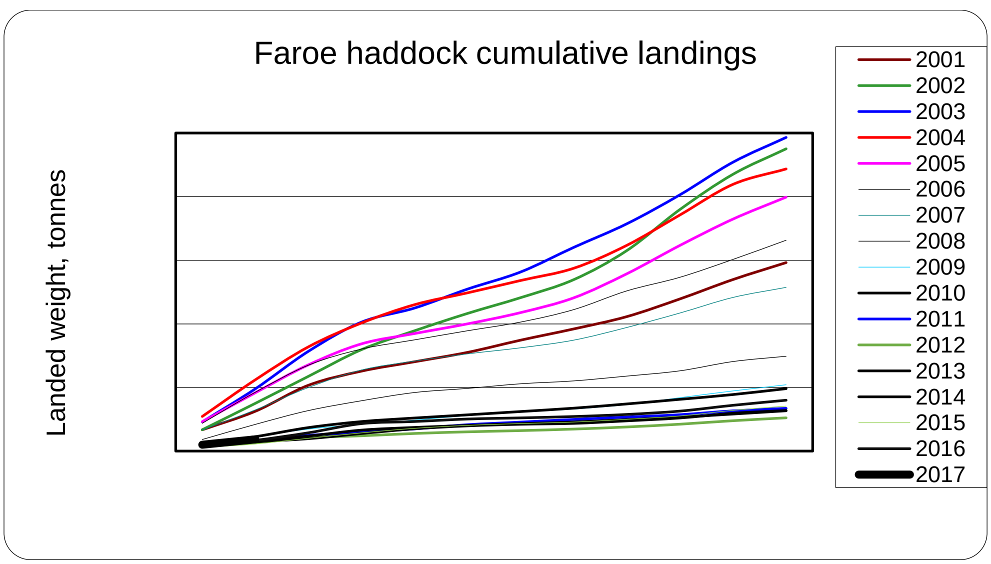


Figure 5.2. Faroe haddock. Cumulative Faroese landings from 5b.

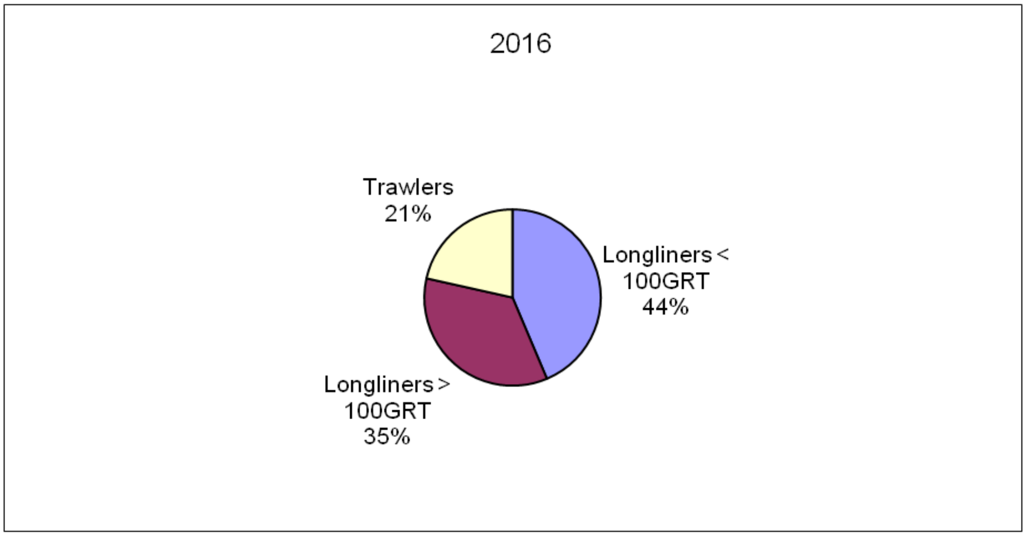


Figure 5.3. Faroe haddock. Contribution (%) by fleet to the total Faroese landings 2016.

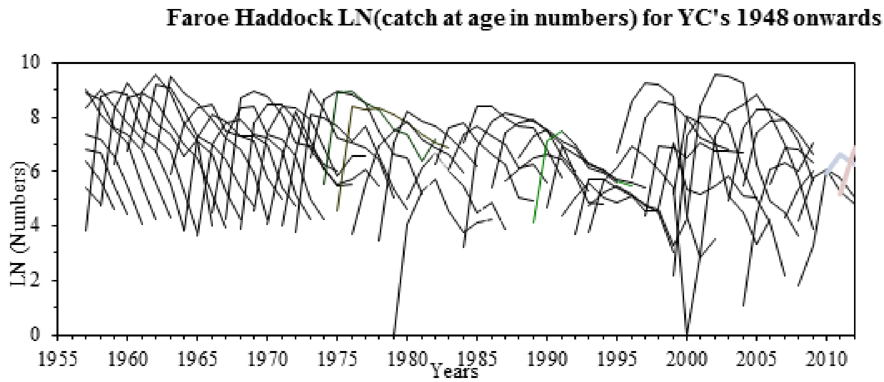


Figure 5.4 Faroe Haddock LN

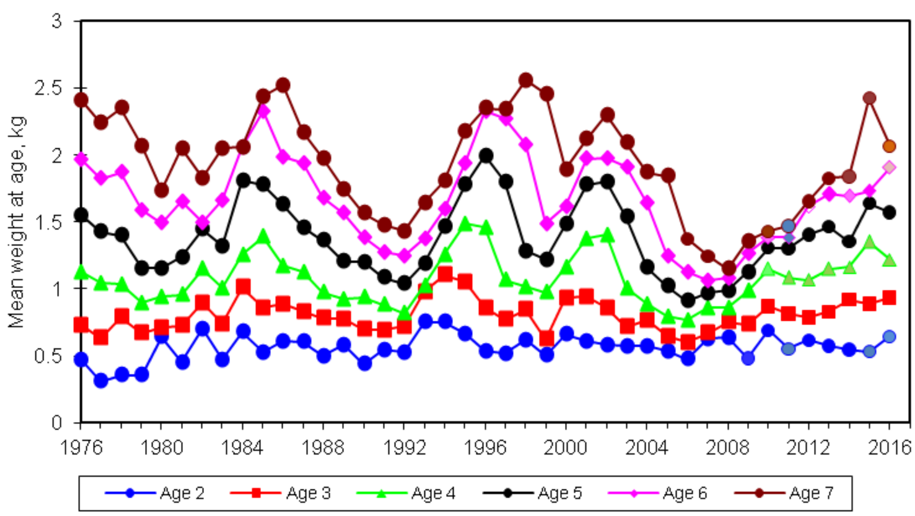


Figure 5.5. Faroe haddock. Mean weight at age (2-7).

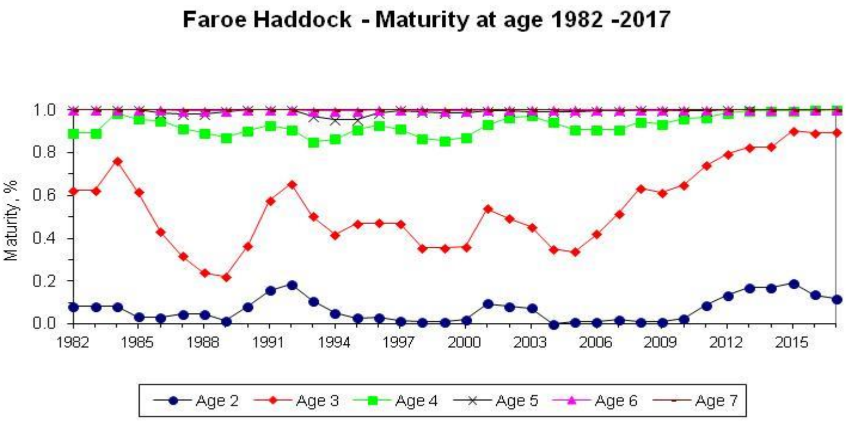


Figure 5.6. Faroe haddock. Maturity at age since 1982. Running 3-years average of survey observations

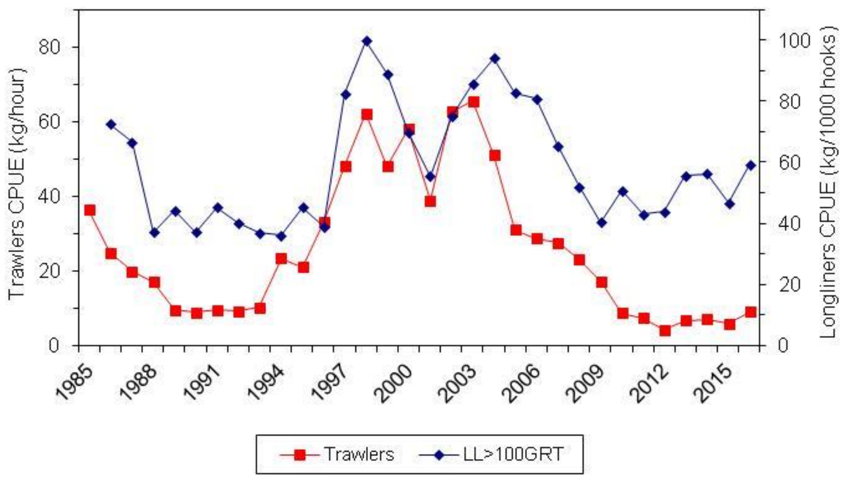


Figure 5.7. Commercial CPUE's for Pairtrawlers > 1000 HP and longliners > 100 HP.

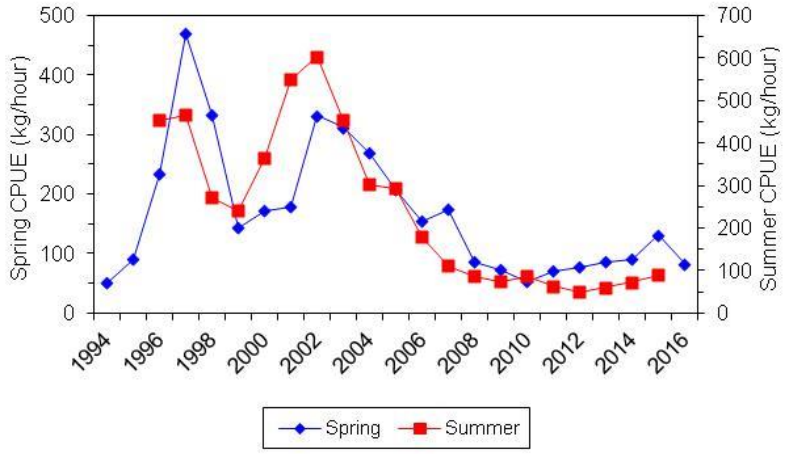
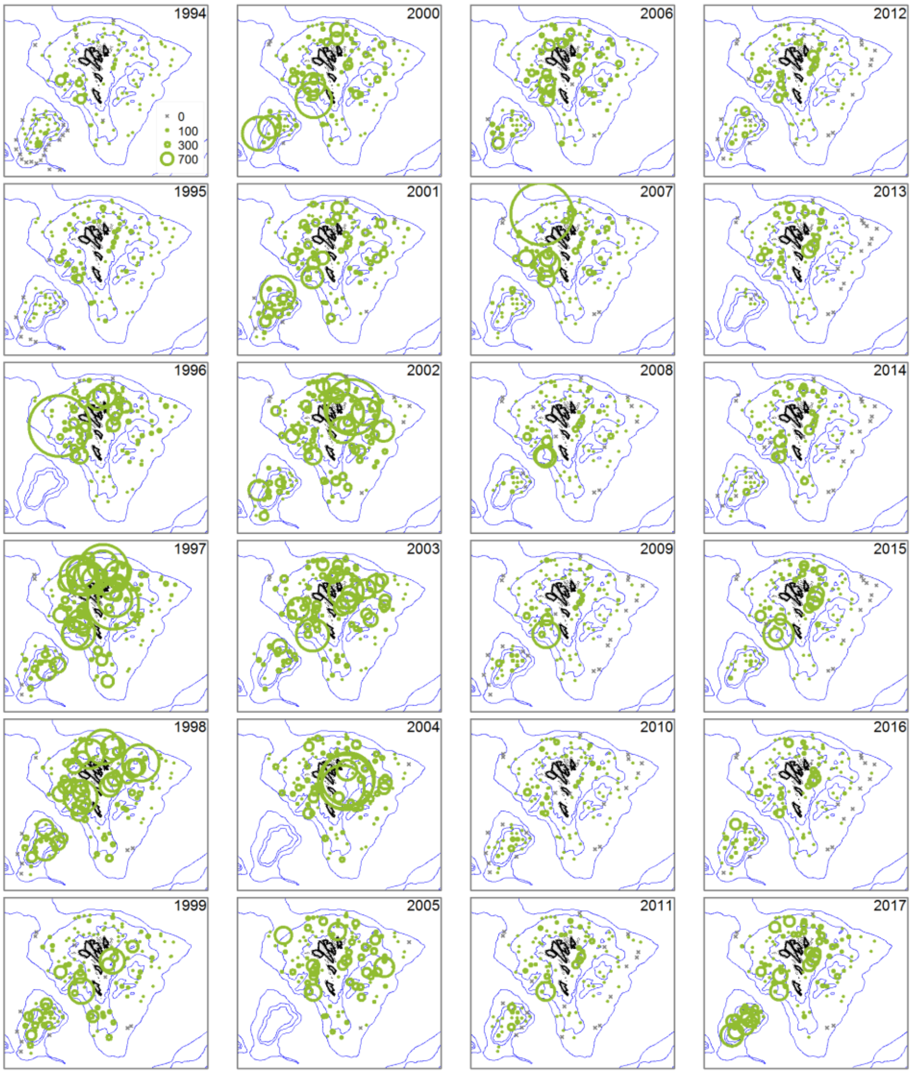


Figure 5.8. Faroe haddock. CPUE (kg/trawlhour) in the spring and summer surveys.


1994
0
100
300
700
2000
2006
2012
1995
2001
2007
2013
1996
2002
2008
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2015
1998
2004
2010
2016
1999
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2011
2017

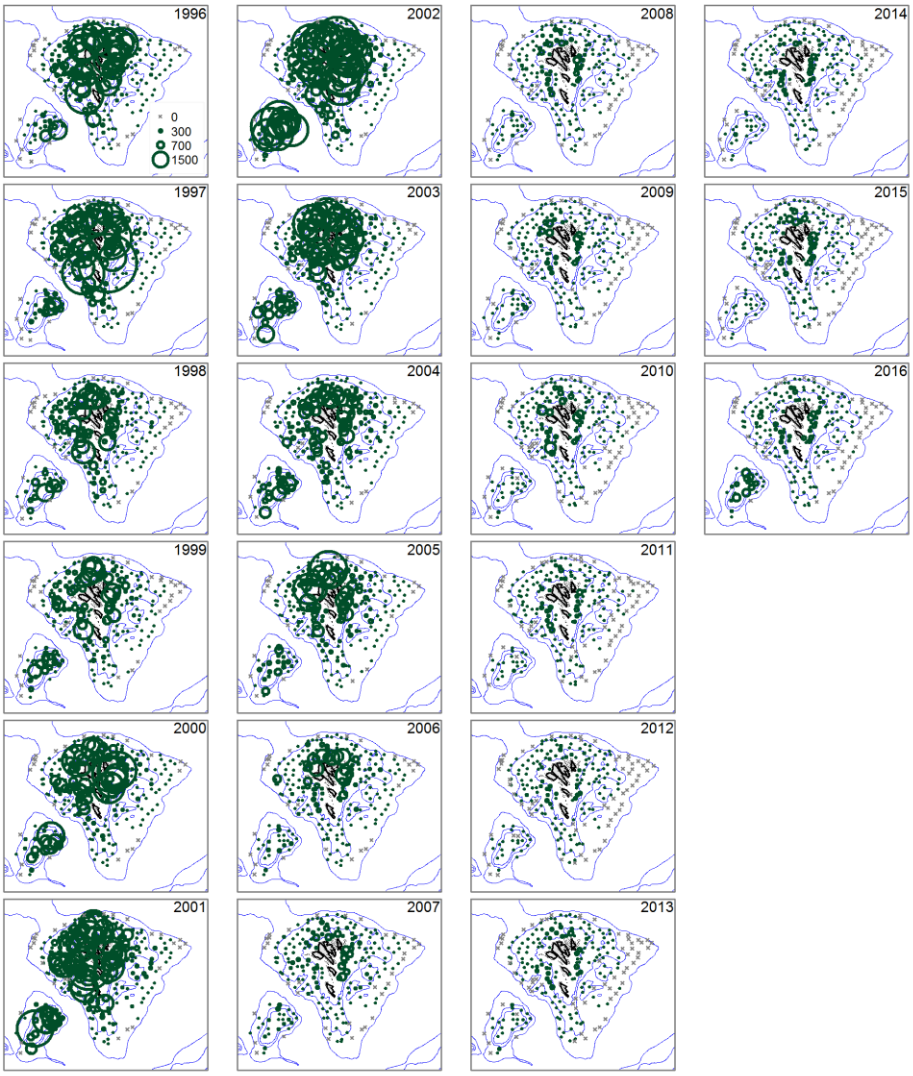


Figure 5.9. Distribution of Faroe haddock catches in the spring survey (upper page) and in the summer survey (this page).

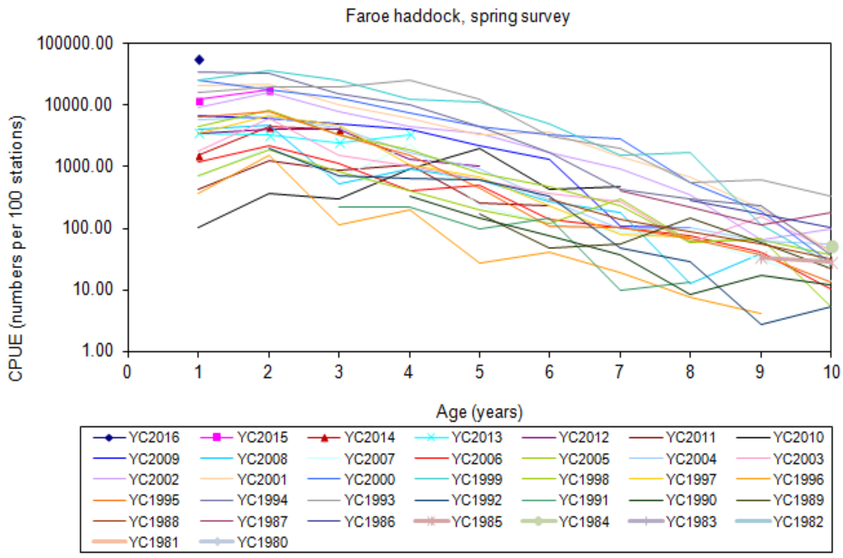


Figure 5.10. Faroe haddock. LN (catch at age in numbers) in the spring survey

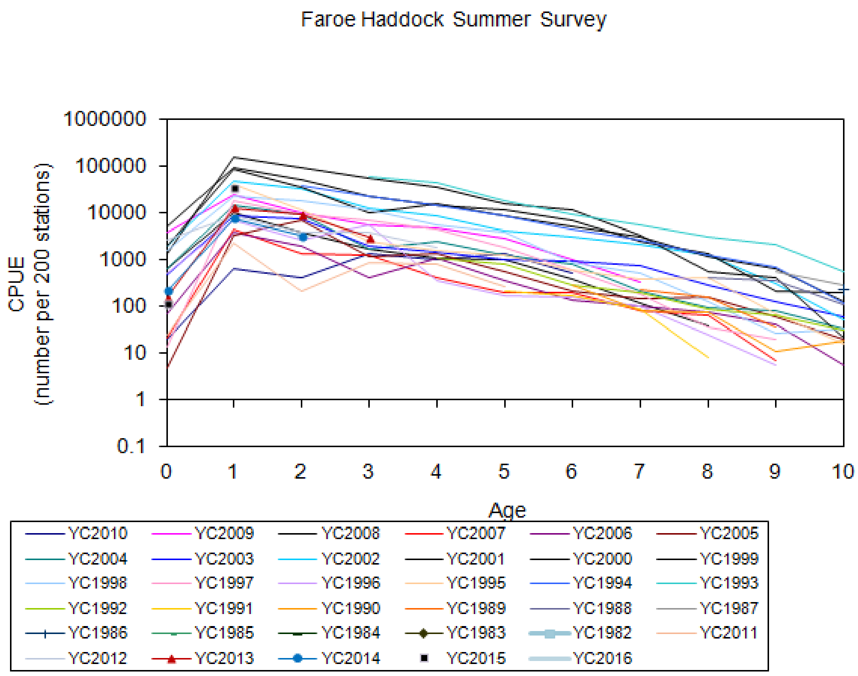


Figure 5.11. Faroe haddock. LN (catch at age in numbers) in the summer survey

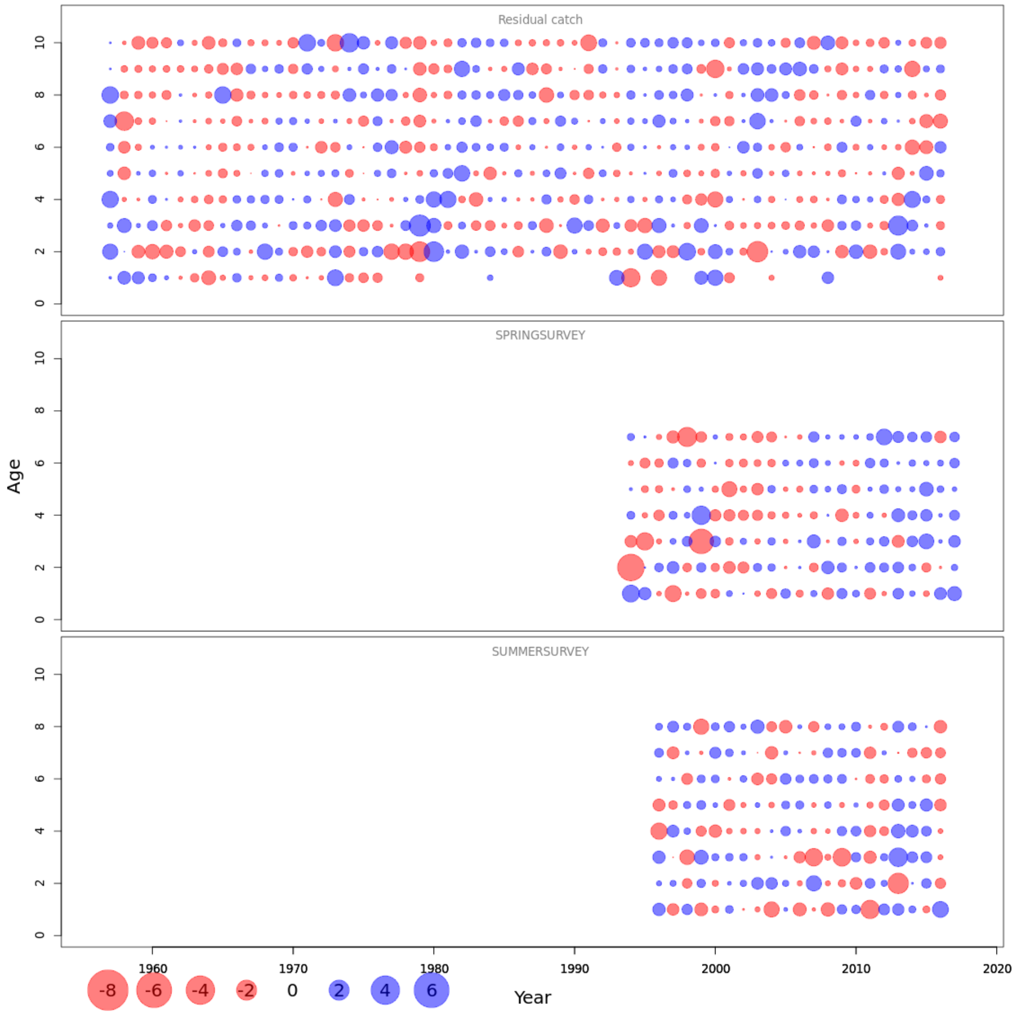


Figure 5.12. Faroe haddock (division 5.b). Observation residuals for the catch, spring survey and the summer survey as estimated by the SAM model.

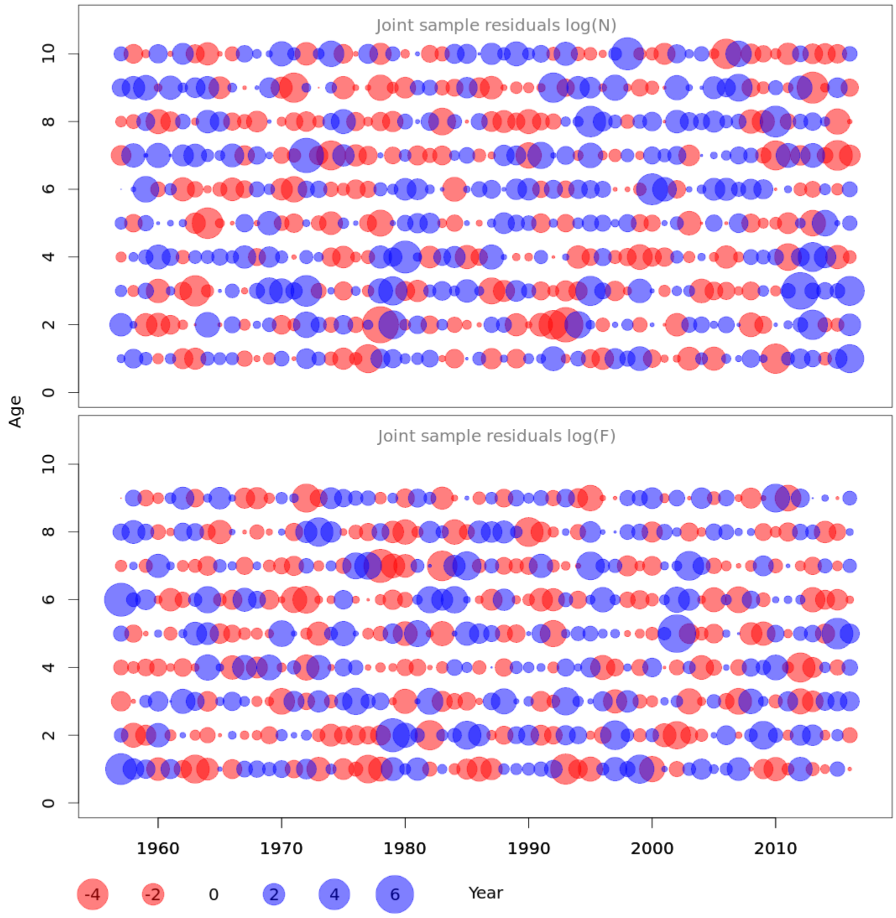


Figure 5.13. Faroe haddock (division 5.b). Process residuals for the population numbers and fishing mortality as estimated by the SAM model.

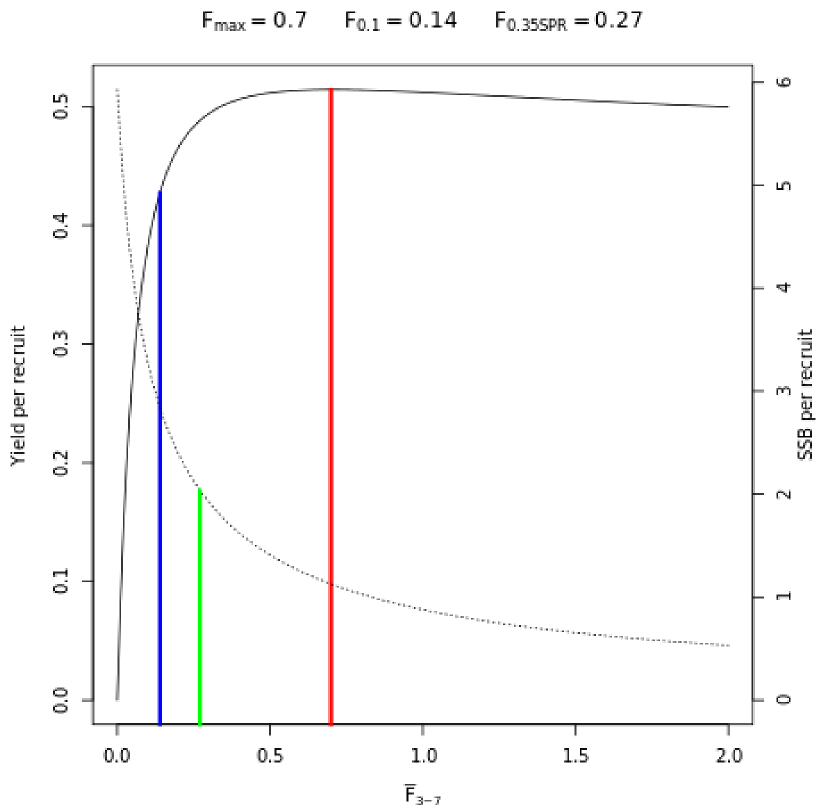


Figure 5.14. Faroe haddock (division 5.b). Yield per recruit and spawning stock biomass (SSB) per recruit versus fishing mortality.

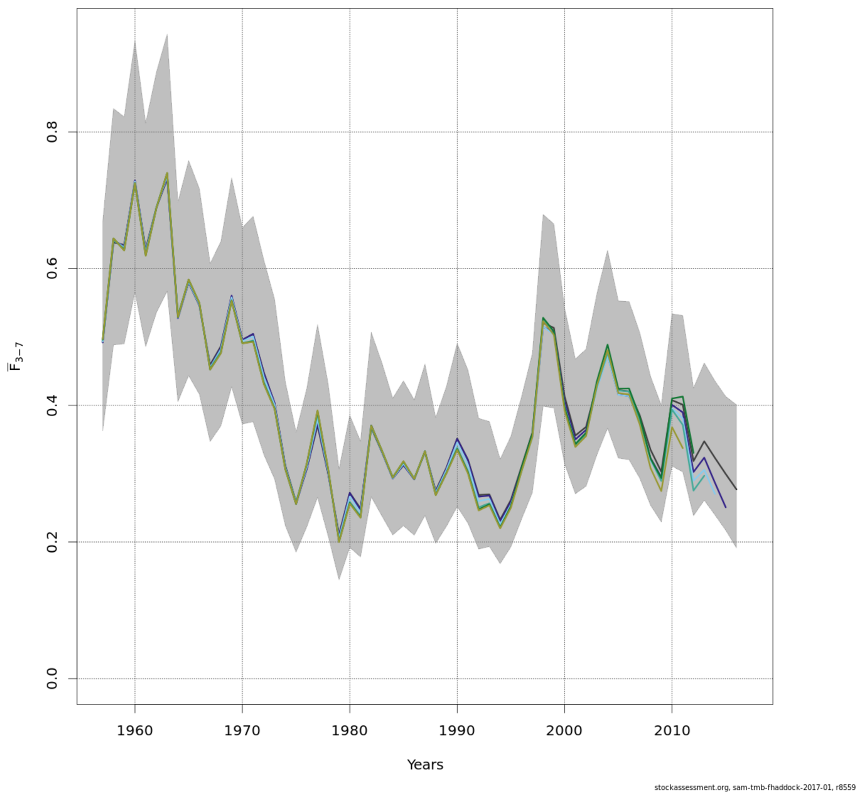


Figure 5.15. Faroe haddock (division 5.b.) Results from the SAM retrospective analysis of fishing mortality (ages 3–7).

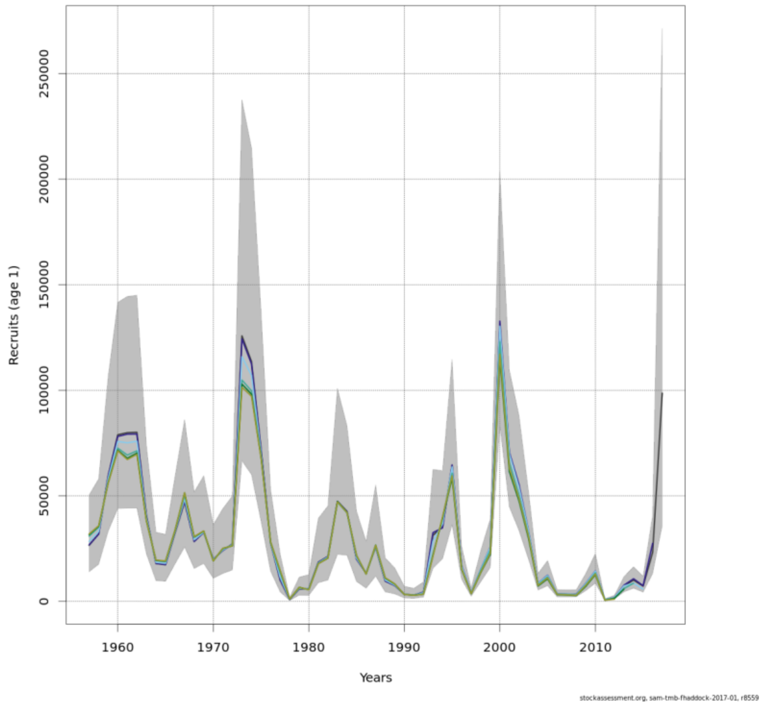


Figure 5.16. Faroe haddock (division 5.b). Results from the SAM retrospective analysis (continued). Recruitment at age 1.

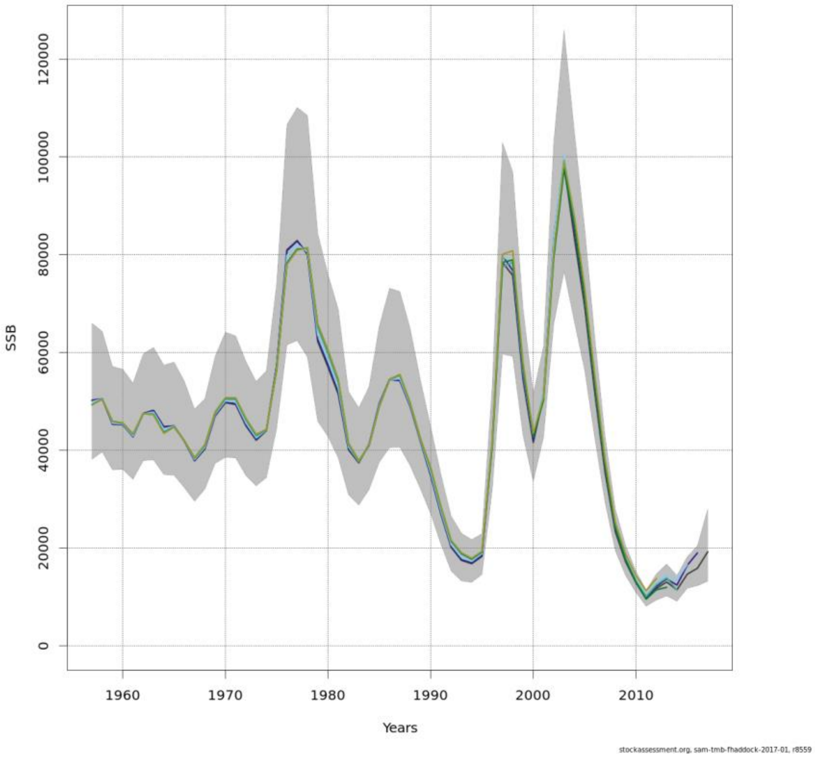


Figure 5.17. Faroe haddock (division 5.b). Results from the SAM retrospective analysis (continued). Spawning stock biomass.

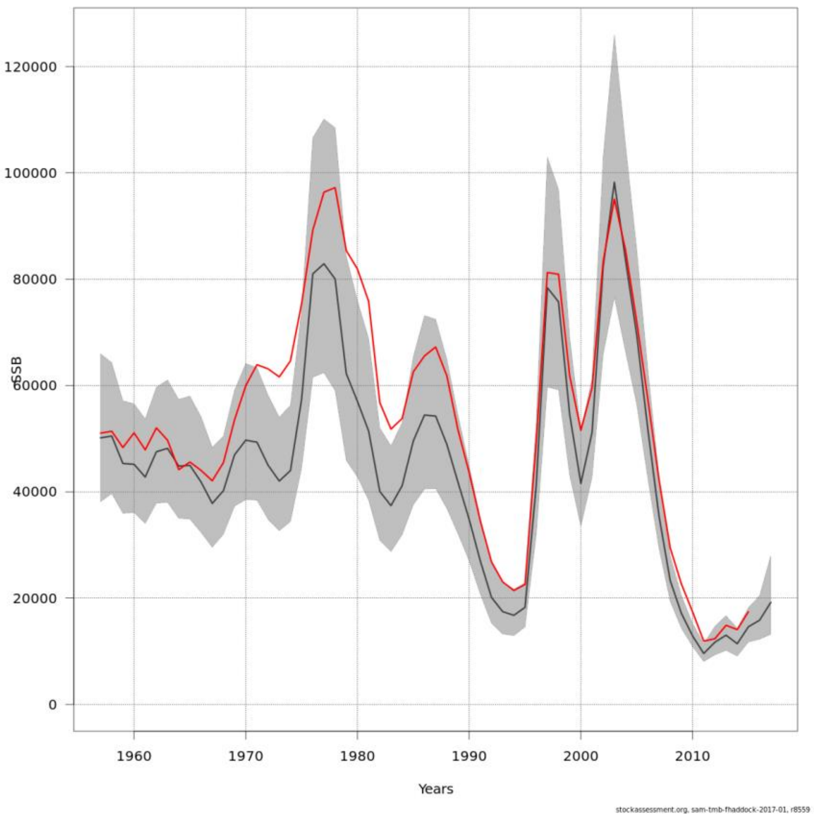


Figure 5.18. Faroe haddock (division 5.b). Comparison between population numbers by year from the current SAM assessment (2017 settings), black line (grey area represent 95% confidence intervals), and the XSA assessment (2016 settings), red line.

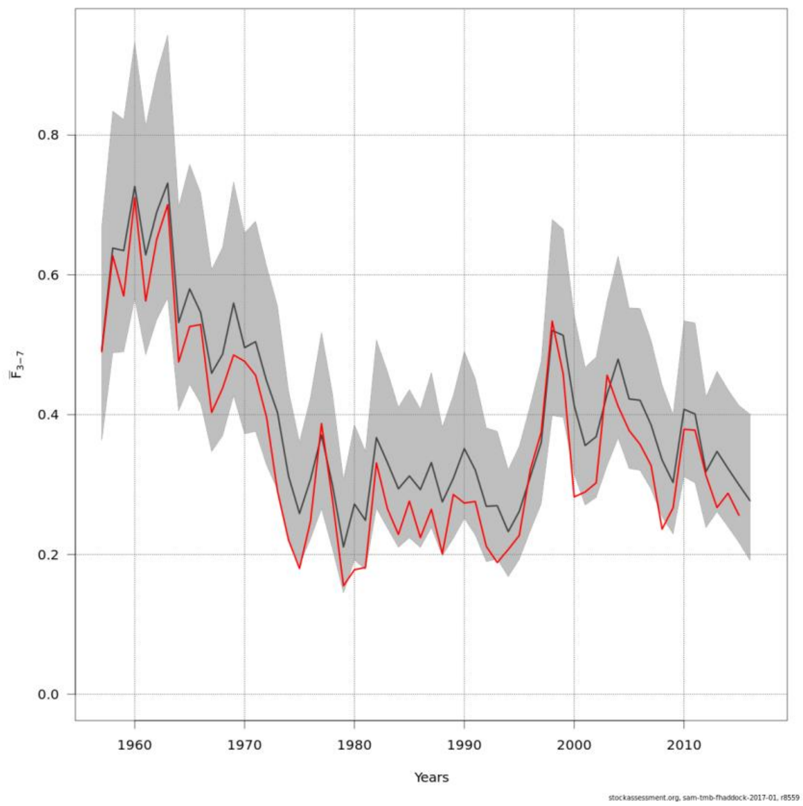


Figure 5.19. Faroe haddock (division 5.b). Comparison between fishing mortality from the current SAM assessment (2017 settings), black line (grey area represent 95% confidence intervals), and the XSA assessment (2016 settings), red line.

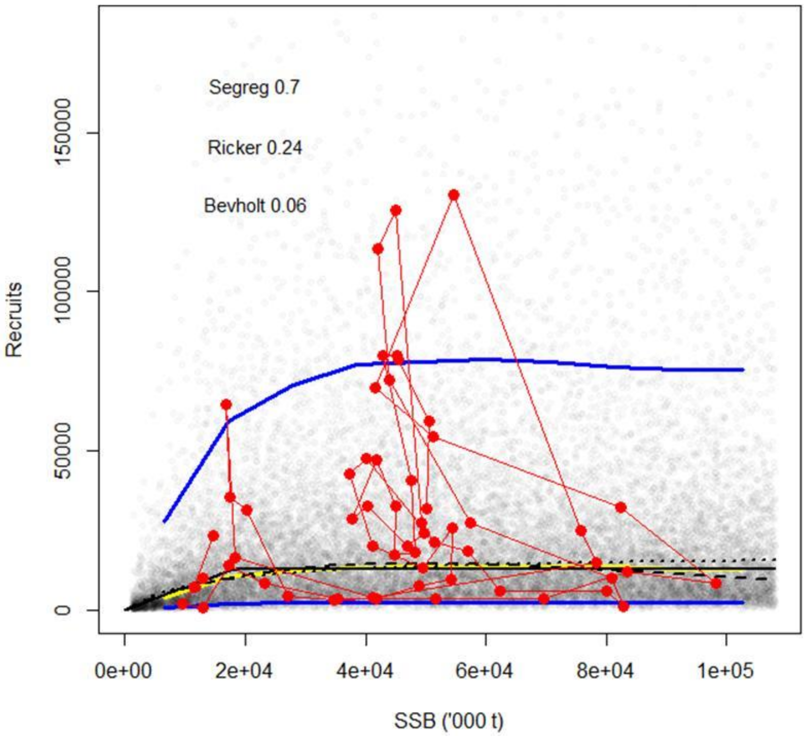


Figure 5.20. Stock-recruitment relationships since 1978. Driven by segreg, breakpoint near Blim.

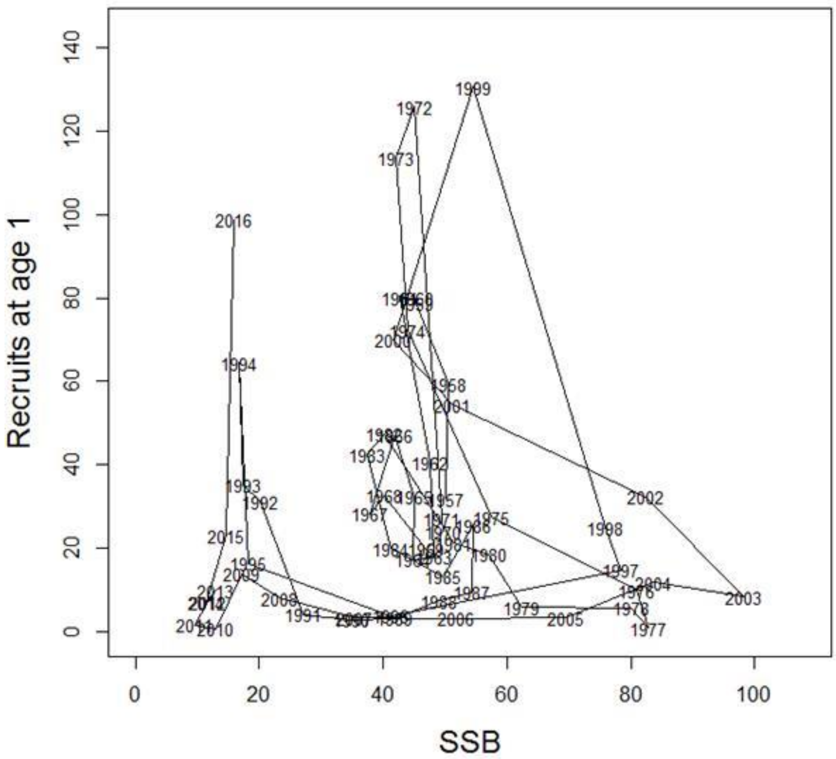


Figure 5.21. Faroe haddock. SSB and R age 1. Blim is chosen as the lowest SSB which have produced good recruitment (16 780 tonnes).

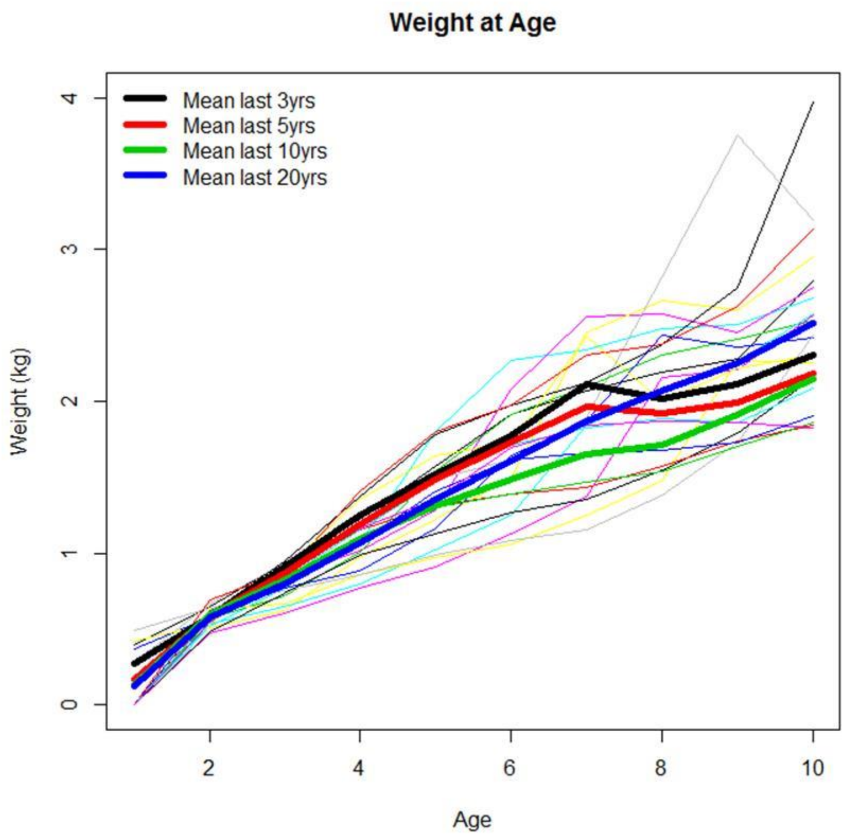


Figure 5.22. Faroe haddock. Weight at age for different periods back in time.

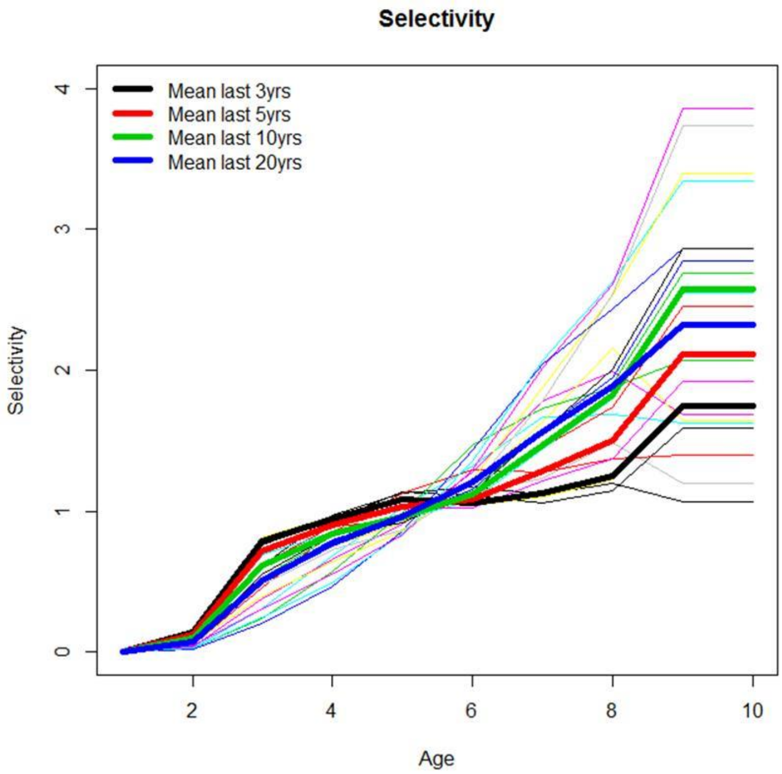


Figure 5.23. Faroe haddock. Selection patterns for different periods back in time.

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 2016 increased from 25 000 t. in 2015 to is 29 450t. in 2016.

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 96% in 2016 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 2016. 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 2015/2016 fishing season 20% of the allocated days for the trawl fleet were not used.

Cumulative landings of saithe for the domestic fleets since 2000 are shown in Figure 6.2.1.2. The period from 2011 to 2016 is among the poorest in the time-series. The progression of landings in the first two months of 2016 is below monthly averages.

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 4 -years old (10471 thous.) in 2016 were the largest observed since 1984 while catch of 3-years old saithe were less than half of those in 2015. For age groups 4 to 7 numbers were lower in 2016 than in 2015.

The sampling program and sampling intensity in 2016 as well as the approach used in compiling catch numbers is the same as in preceding years. Sampling levels of catches in 2015 was 9.9% and it went down to 5.8% in 2016 (Table 6.2.2.3.) The average amount sampled per tonnes landed since 2000 is 6.1%.

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 above historical average since 2014 whereas younger age groups (3–6) 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. Weights are lower in 2016 than in 2015 across all age classes but age 3. For the short-term forecast weights are predicted according to the following model:

$\log(CW_{y,a}) = \beta 0 + \beta 1 * \log(CW_{y-1,a-1}) + \beta 2 * \log(SW_{y,a})$ (Eq.1)

where $CW_{y,a}$ is catch-weight-at age *a* and year *y* and $SW_{y,a}$ is stock-weight-at age *a* and year *y*

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 benchmark workshop in 2017 (WKFAROE) maturity ogives were smoothed via a 10-year running average. The time period for averaging was chosen as a compromise between retaining long-term trends and reducing noise in the data.For 1962–1982 the average maturity of estimated maturities of the 1983-1996 period was used.Maturity decreased from the mid-1990s to 2006 and it has increased since 2007 and it is above the historical average in 2017 (Table 6.2.4.1 and Figure 6.2.4.1.)

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 surveys design is a classical random stratified design with fixed stations. The number of stations in the spring survey are 100 and the number of stations in the summer are 200. Both survey cover depths from 60 to 500 meters. The coverage of both surveys is however very poor for juvenile saithe, which is largely distributed in coastal areas very close to shore and therefore the surveys do not provide reliable measurements of incoming recruits. Moreover as a result of the schooling nature of saithe variablity in indices is higher than that for species like cod and haddock. The spring survey consists of time series data since 1994 while the summer series were initiated in 1996. Historical data dating back to early 1980's exist but are unfortunately not available for analysis although work is in progress to recover and compile these data in upcoming meetings. Both time series cover to a large degree the traditional fishing grounds of saithe in the Faroe shelf

Catch rates of both surveys are presented in figure 6.2.5.1.1. There are seasonal effects in the series but both surveys suggest low abundances of saithe in the 1990's, followed by an increase in stock biomass until 2004 and a decline from 2005 to around 2010. Since 2011 both indices are in good agreement and indicate that stock abundances are quite stable. The most recent estimate of the spring survey suggests an increase in stock biomass in 2017. The coefficient of variation (CV) of the summer index (CV=18%, log-scale) is higher than the spring survey (CV=13%, log-scale). The agreement between the survey indices measured by their correlation is estimated at R^2=0.37 .

Survey numbers for age 4 in 2016 and 2017 are the largest since 2009. The corresponding numbers of age 5 in 2017 are also the largest since 2004 (Figures 6.2.5.1.2 and 6.2.5.1.2). The summer survey also agrees that the 2013 year-class is quite strong in 2016. The pattern is consistent with catch-numbers of 4-year old in 2016.Length compositions support the trends observed in the age-diassagregated indices (Figures 6.2.5.1.4 and 6.2.5.1.5)

The internal consistency of the summer survey measured as the correlation between the indices for the same year class in two adjacent years is good with R^2 ranging from 0.5 to 0.7 for the best-defined age groups, and R^2 varying between 0.3 and 0.4 for some other age classes (Figures 6.2.5.1.6 and 6.2.5.1.7). The internal consistency of the summer index is overall superior to the spring index. The spring survey shows a weaker internal consistency with R^2 ranging from 0.40 to 0.56 for the best-defined ages.

6.2.5.2 Commercial cpue

The CPUE data from pair-trawlers have been used for tuning the assessment of saithe from 2000 to 2016. At the benchmark working group (WKAFAROE 2017) the series were replaced by fisheries-independent survey indices. A description of the commercial CPUE data can be found in the stock annex.

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

Faroe saithe was benchmarked in 2017 (WKFAROE). The SAM (state-space assessment model) model was adopted as the basis for advice. Input data for the assessment was revised, e.g. maturity ogives (Section 6.2.4) and survey indices (Section 6.2.5.1) Configuration of the SAM model was slightly modified at the NWWG meeting in 2017.

See stock annex (sai-faro_SA.docx, https://community.ices.dk/ExpertGroups/StockAnnexes/SitePages/HomePage.aspx) for detailed information on the configuration options for the adopted SAM model. Age dissagregated indices incorporated in the SAM model are shown in table 6.3.1.

6.4 Reference points

6.4.1 Biological reference points and MSY framework

At the NWWG in 2017 reference points points were revised according to the ICES guidelines (ICES fisheries management reference points for category 1 and 2 stocks, January 2017, http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/12.04.03.01_Reference_points_for_category_1_and_2.pdf). The software used to implement the calculations was EqSim. The procedure was as follows:

B_{pa}=$B_{trigger}$ was set to 41 4000 t (lowest historical SSB).

B_{lim} was calculated according the equation: $B_{pa} = B_{lim} \times \exp(\sigma \times 1.645)$=29 571 t. where σ= 0.20 (as suggested by ACOM)

The F_{msy} estimation process consisted of 3 simulations:

1. Simulation 1. Get F_{lim}

F_{lim} is derived from B_{lim} by simulating the stock with segmented regression S-R function with the point of inflection at B_{lim}.

F_{lim} is the F that, in equilibrium, gives a 50% probability of SSB > B_{lim}

The simulation was conducted with:

- fixed F (i.e. without inclusion of a $B_{trigger}$)
- without inclusion of assessment/advice errors.

2. Simulation 2. Get initial F_{msy}

F_{msy} should initially be calculated based on:

- a constant F evaluation
- with the inclusion of stochasticity in population and exploitation as well as assessment/advice error.
- SRRs (using all; Ricker, Beverton-Holt, Segmented)
- Uncertainty parameters used:

Assessment error

sigmaF <- 0.18 # SAM value of uncertainty from 2016

sigmaSSB <- 0.2 # 0.23 SAM value of uncertainty from 2017 ,changed to default=0.2 (ACOM)

Advice error

cvF <- 0.39 ; phiF <- 0.81

cvSSB <- 0.28 ; phiSSB <- 0.82

```
## Biological parameters and selectivity
numAvgYrsB <- 20   # Biological
numAvgYrsS <- 20   # Selection
```

To ensure consistency between the precautionary and MSY frameworks, F_{msy} is not allowed to be above F_{pa}, i.e., F_{msy} is set to F_{pa} if this initial F_{msy} estimate is higher than F_{pa}

3. Simulation 3. Get final F_{msy}

   MSY Btrigger should be selected to safeguard against an undesirable or unexpected low SSB when fishing at F_{msy}. The ICES MSY advice rule should be evaluated to check that the F_{msy} and MSY Btrigger combination adheres to precautionary considerations; in the long term, $P(SSB<B_{lim})<5\%$

   The evaluation includes:

   - realistic assessment/advice error (see above)
   - stochasticity in population biology and fishery exploitation.
   - SRRs (using all; Ricker, Beverton-Holt, Segmented)

The new reference points are illustrated in the table below:

Biological reference points	NWWG 2017	Basis	Basis
Btrigger	41 400 t.	B_{loss}	
B_{lim}	29 571 t.	$B_{pa}/1.4$	
B_{pa}	41 400 t.	B_{loss}	
F_{lim}	0.7	Stochastic simulations (ICES, 2017) F50% F that,gives a 50% probability of SSB > B_{lim}	
F_{pa}	0.52	Flim*exp(-1.645*sigma) where sigma=0.18	
F_{msy}	0.30	Stochastic simulations (ICES, 2017).	

Graphical output of the simulations are presented in figures 6.4.1.1 and 6.4.1.2.

6.5 State of the stock

Recruitment of saithe (numbers of 3-years old individuals) oscilated between 10 to 40 million from 1961 to 2000 with higher numbers than the historical average (27 millions) from late 1960's to early 1970's and in late 1980's (Figure 6.5.1). Estimated recruitment increased substantially to 67 millions in 2001 as the strong 1998 year-class entered the fishery. Since 2000 recruitment has fluctuated around an average of 39 million between 20 to 60 millions. Average fishing mortality (Fbar=average F of ages 4 to 8) increased almost monotonously from Fbar=0.1 in 1961 to Fbar=0.47 in 1990 with peak catches of 57 000 t. in 1973. The spawning stock biomass (SSB) was estimated at its highest in the mid 1970's due to low fishing mortality (~Fbar=0.26) and higher than average recruitment. Although individual growth was large in the early 1980's the SSB decreased substantially at a level of 90 000 t. as a consequence of increasing catches and subsequent F's. Estimated F in 1991 (Fbar=0.63) was the highest in the time series and although it went down to 0.37 in 2000 this did not prevent the SSB to decrease at around 48 000 t. in 1996 followed by a long period of low productivity (low recruitment) throughout the 1990's. SSB increased substantially from 1997 to 2005 due to the maturation of the strongest observed 1998 year class (age 3 in 2001). F increased from Fbar=0.42 in 2005 to Fbar=0.59 in 2010 resulting in the largest landings of the whole time period (above 60 000 t.) and as a consequence the SSB dropped below BMSYtrigger=50 000 t. from 2010 to 2015. The 2012 year-class (age 3 in 2015) is estimated at around 63 million and the subsequent year classes are also predicted to be around 50 millions. SSB has risen above BMSYtrigger in 2016 and 2017 due to decreasing F's from 2010 to 2016 caused by substantial reductions in catches and predicted strong year classes since 2015. Patterns in landings follow approximately a cycle of three distinctive peaks. Catches have remained below historical average (37 000 t.) since 2010. Nominal landings of saithe were 29 450 t. in 2016. Catches are assumed equal to landings.

Age-disaggregated fishing mortalities and stock numbers are presented in tables 6.5.1 and 6.5.2 respectively. The stock summary table is shown in table 6.5.3 and a summary of the model parameter estimates is presented in table 6.5.4. The residuals plots are illustrated in figure 6.5.2. Year effects are observed in the spring series with blocks of positive and negative residuals in 1998 and 2007 respectively but otherwise they are randomly distributed in all the series to a great extent. The relation between SSB and recruitment of saithe is shown in figure 6.5.3.

6.6 Short-term forecast

6.6.1 Input data

SAM provides a forecast module which can simulate the stock in the period following the assessment year under certain assumptions and taking into account the uncertainty estimated in the model fit. The input data for the short-term forecast are described in the stock annex. The main features of the input for prognosis is the estimation of catch-weights in the assessment year by the model described in section 6.2.3 and assuming mean maturity ogives over the previous five years. Recruitment is taken randomly from the last five years and therefore the uncertainty in the recruitment pattern is captured in the forecast. The exploitation pattern used is a 3 year average.

Input data for the prediction are presented in Table 6.6.1.1 and the projection of the stock from 2017 to 2019 in figure 6.6.2.1.

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=0.42 landings would increase to 46 kt. in 2017 and 60 kt. in 2018 while spawning-stock biomass is predicted to around 101 kt. in 2017 and increase to 118 kt. tonnes in 2018. Landings in 2017 are predicted to rely on the 2012, and 2013 year classes (74%) while these year classes will contribute to around 72% of the spawning stock biomass in 2017 (Figure 6.6.2.2.)

6.7 Yield-per-recruit

Input data to yield-per-recruit

For the yield-per-recruit calculations the average of last 15 years are assumed both in the selection pattern and in the biological parameters.

Results from the yield-per-recruit analysis are shown in Table 6.7.1 and Figure 6.7.1

6.8 Uncertainties in assessment and forecast

In 2016 the amount of catch sampled was 5.8%. The average since 2000 is 6.1%.

Historically the assessment of saithe was based on a XSA model calibrated with fisheries-dependent data (see section 6.2.5.2). In 2017 the assessment framework adopted was SAM using fisheries-independent indices (see section 6.2.5.1)

The assessment of Faroe saithe is relatively uncertain due to lack of good tuning data. Survey data for saithe are not as reliable of stock trends as for other gadoid species like cod and haddock. Saithe is a highly schooling and widely migrating species. Moreover saithe shows up in surveys with few year classes (usually one or two) dominating the entire haul composition making difficult to assess the true state of the stock.

The retrospective pattern of F in the adopted SAM model shows periods of overestimation from 2000 to 2010 and years of underestimation since around 2011 (Figure 6.8.1) However most of the retrospective runs are within the confidence intervals of the final assessment. In terms of SSB SAM tends to overestimate the true stock size of the stock but to a lesser extent. The retrospective pattern in recruitment strength has somehow stabilised in comparison with the historical XSA model. Most of the recruitment retrospective runs but two are between the uncertainty levels of the final model.

6.9 Comparison with previous assessment and forecast

The Faroe saithe assessment was benchmarked in 2017. Input data (new maturity ogives and adoption of survey indices) and assessment method were modified and therefore the historical stock perception of the stock has changed to some extent. Thus it's not possible to compare directly both the assessment and the forecast results from 2016 and 2017.

6.10 Management plans and evaluations

No management plan exists for saithe in Division 5.b. In 2017 the Faroese government is working on a fisheries reform which is supposed to be implemented by 2018. According to the current version of the reform, the fishing days will be replaced by a quota system under principles of sustainability.

6.11 Management considerations

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

Biological reference points were revised (see section 6.4). F_{msy} was estimated at the current F_{msy}=0.30 while F_{lim}=0.7 and B_{lim}=29 571 t. were defined (see section 6.4.1.)

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 Tables

Table 6.2.1.1. Faroe saithe (Division 5.b). Nominal catches (tonnes round weight) by countries 1988–2016 as officially reported to ICES.

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Denmark	94	-	2	-	-	-	-	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-	-	-	16	-	-	-	-
Faroe Islands	44402	43.624	59.821	53.321	35.979	32.719	32.406	26.918	19.267	21.721	25.995	32.439		49.676
France [3]	313	-	-	-	120	75	19	10	12	9	17	-	273	934
Germany	-	-	-	32	5	2	1	41	3	5	-	100	230	667
German Dem.Rep.	-	9	-	-	-	-	-	-	-	-	-	-	-	-
German Fed. Rep.	74	20	15	-	-	-	-	-	-	-	-	-	-	5
Greenland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	-	-	-	-	0	0	0
Netherlands	-	22	67	65	-	-	-	-	-		-	160	72	60
Norway	52	51	46	103	85	32	156	10	16	67	53	-	-	-
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	20	1
UK (Eng. & W.)	-	-	-	5	74	279	151	21	53	-	19	67	32	80
UK (Scotland)	92	9	33	79	98	425	438	200	580	460	337	441	534	708
USSR/Russia [2]	-	-	30	-	12	-	-	-	18	28	-	-	-	-
Total	45027	43.735	60.014	53.605	36.373	33.532	33.171	27.200	19.949	22.306	26.065	33.207	1.161	52.131
Working Group estimate [4,5]	45285	44.477	61.628	54.858	36.487	33.543	33.182	27.209	20.029	22.306	26.421	33.207	39.020	51.786

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016 [1]
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	26.796	30.837
France	607	370	147	123	315	108	97	68	46	135	40	31	0	122	336
Germany	422	281	186	1	49	3	3	0	-	-		-	-	-	-
Greenland	125	-			73	239	0	1	-	-	1	-	-	-	-
Irland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iceland	-	-	-	-	-	-	-	148	-	-	-	-	-	-	19
Netherlands	0	0	0	0	0	3	0	0	0	-	-	-	-	-	1
Norway	77	62	82	82	35	81	38	23	28	-	-	-	165	40	198
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	304	601
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	27.262	31.992
Working Group estimate [4,5,6,7]	53.546	46.555	46.355	67.967	66.902	60.785	57.044	57.949	43.885	29.658	35.314	26.463	23.885	25.128	29.450

Table 6.2.1.2. Faroe saithe (Division 5.b). Total Faroese landings (rightmost column) and the contribution (%) by each fleet category (1985-2016). Averages for 1985-2016 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
2016	0.1	0.1	1.7	0.0	1.6	0.2	0.2	21.7	73.8	0.3	0.0	0.4	22505
Avg.	0.3	0.2	0.8	0.1	5.1	1.5	13.5	19.4	58.5	0.3	0.4	0.1	38034

Table 6.2.2.1. Faroe saithe (Division 5.b). Catch number-at-age by fleet categories in 2016 (calculated from gutted weights).

Age	Jiggers	Single trawlers >1000 HP	Pair trawlers <1000 HP	Pair trawlers >1000HP	Others	Total Division Vb
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	9	17	0	27
3	7	1	183	473	10	674
4	124	15	1706	5997	156	7997
5	25	3	317	1124	35	1504
6	27	3	335	1048	44	1458
7	11	1	118	398	21	548
8	5	0	45	163	10	222
9	2	0	19	61	4	86
10	1	0	10	37	2	50
11	2	0	16	50	3	71
12	1	0	2	3	0	7
13	1	0	4	9	1	15
14	0	0	0	0	0	1
15	0	0	0	0	0	1
Total No.	205	25	2763	9380	287	12660
Catch, t.	392	45	4879	16607	570	22494

Table 6.2.2.2. Faroe saithe (Division 5.b). Catch number-at-age (thousands) from the commercial fleet (1961-2016)

YEAR	3	4	5	6	7	8	9	10	11	12	13	14	15
1961	183	379	483	403	216	129	116	82	45	27	6	1	48
1962	562	542	617	495	286	131	129	113	71	29	13	16	47
1963	614	340	340	415	406	202	174	158	94	169	61	8	36
1964	684	1908	1506	617	572	424	179	150	100	83	47	30	14
1965	996	850	1708	965	510	407	306	201	156	120	89	30	46
1966	488	1540	1201	1686	806	377	294	205	156	94	52	34	45
1967	595	796	1364	792	1192	473	217	190	97	75	38	11	16
1968	614	1689	1116	1095	548	655	254	128	89	59	40	29	59
1969	1191	2086	2294	1414	1118	589	580	239	115	100	36	30	24
1970	1445	6577	1558	1478	899	730	316	241	86	48	46	15	23
1971	2857	3316	5585	1005	828	469	326	164	100	54	13	18	15
1972	2714	1774	2588	2742	1529	1305	1017	743	330	133	28	28	21
1973	2515	6253	7075	3478	1634	693	550	403	215	103	25	21	37
1974	3504	4126	4011	2784	1401	640	368	340	197	124	45	44	52
1975	2062	3361	3801	1939	1045	714	302	192	193	126	64	41	67
1976	3178	3217	1720	1250	877	641	468	223	141	96	60	54	77
1977	1609	2937	2034	1288	767	708	498	338	272	129	80	57	64
1978	611	1743	1736	548	373	479	466	473	407	211	146	95	83
1979	287	933	1341	1033	584	414	247	473	368	206	136	98	251
1980	996	877	720	673	726	284	212	171	196	156	261	133	236
1981	411	1804	769	932	908	734	343	192	92	128	176	310	407
1982	387	4076	994	1114	380	417	296	105	88	56	49	110	687
1983	2483	1103	5052	1343	575	339	273	98	98	99	25	127	289
1984	368	11067	2359	4093	875	273	161	52	65	59	18	25	151
1985	1224	3990	5583	1182	1898	273	103	38	26	72	41	8	154
1986	1167	1997	4473	3730	953	1077	245	104	67	33	56	7	62
1987	1581	5793	3827	2785	990	532	333	81	43	5	11	15	66
1988	866	2950	9555	2784	1300	621	363	159	27	43	15	1	1
1989	451	5981	5300	7136	793	546	185	83	55	10	2	11	16
1990	294	3833	10120	9219	5070	477	123	61	60	18	19	9	33
1991	1030	5125	7452	5544	3487	1630	405	238	128	77	22	8	11
1992	521	4067	3667	2679	1373	894	613	123	63	37	52	8	11
1993	1316	2611	4689	1665	858	492	448	245	54	34	10	6	2
1994	690	3961	2663	2368	746	500	307	303	150	28	19	1	1
1995	398	1019	3468	1836	1177	345	241	192	104	73	25	14	5
1996	297	1087	1146	1449	1156	521	132	77	64	45	29	1	7
1997	344	832	2440	1767	1335	624	165	71	29	48	29	15	8
1998	163	1689	1934	3475	1379	683	368	77	32	28	24	14	7
1999	322	655	3096	2551	4113	915	380	147	24	27	5	23	14
2000	811	2830	1484	4369	2226	2725	348	186	56	18	2	3	2
2001	1125	2452	8437	2155	3680	1539	1334	293	90	24	19	13	0
2002	302	8399	5962	9786	862	1280	465	362	33	36	8	1	0
2003	330	2432	11152	3994	4287	417	419	304	91	40	3	0	0
2004	76	2011	8544	8762	2125	1807	265	293	146	100	10	2	0
2005	454	2948	9486	16606	7099	843	810	32	102	27	3	0	0
2006	1475	5045	7781	7712	10296	3760	640	282	32	12	12	5	0
2007	831	3320	11305	6473	3781	4294	1538	406	81	11	9	3	0
2008	4784	3108	3598	9370	3594	2223	2048	444	159	12	6	0	0
2009	459	7412	4978	1842	5167	2009	1696	1069	292	41	3	1	0
2010	2324	2916	5298	1125	1009	2098	1248	832	376	51	22	0	0
2011	1897	2744	1940	1804	477	530	704	521	439	138	34	4	0
2012	859	9833	4142	1252	901	304	307	399	229	136	91	21	0
2013	721	5172	4219	2242	511	209	122	96	146	85	39	33	3
2014	879	2323	3143	1681	865	330	99	92	70	55	16	1	0
2015	2135	2269	2577	1928	863	283	179	86	69	33	31	9	6
2016	882	10471	1969	1909	718	291	112	66	92	9	19	1	1

Table 6.2.2.3. Faroe saithe (Division 5.b). Sampling intensity in 2005–2016.

Year		Jiggers	Single trawlers >1000 HP	Pair trawlers <1000 HP	Pair trawlers >1000 HP	Others	Total	Amount sampled pr tonnes landed (%)
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	8,3
	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	
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	
2016	Lengths	479	0	671	20282	2613	24045	5,8
	Otoliths	120	0	179	3118	776	4193	
	Weights	479	0	671	15512	2613	19275	

Table 6.2.3.1. Faroe saithe (Division 5.b). Catch weights at age (kg)(equal to stock-weights) from the commercial fleet (1961-2016).

year	3	4	5	6	7	8	9	10	11	12	13	14	15
1961	1.43	2.302	3.348	4.287	5.128	6.155	7.06	7.265	7.497	8.198	9.154	9.6	10
1962	1.273	2.045	3.293	4.191	5.146	5.655	6.469	6.706	7.15	7.903	8.449	8.654	10
1963	1.28	2.197	3.212	4.568	5.056	5.932	6.259	8	7.265	8.551	9.02	9	10
1964	1.175	2.055	3.266	4.255	5.038	5.694	6.662	6.837	7.686	8.348	8.123	9.154	10
1965	1.181	2.125	2.941	4.096	4.878	5.932	6.321	7.288	8.074	7.878	9.479	9.617	10
1966	1.361	2.026	3.055	3.658	4.585	5.52	6.837	7.265	7.662	8.123	10.21	9.728	10
1967	1.273	1.78	2.534	3.572	4.368	5.313	5.812	6.554	7.806	7.591	8.551	7.878	10
1968	1.302	1.737	2.036	3.12	4.049	5.183	6.238	7.52	8.049	8.654	8.298	9.234	10
1969	1.188	1.667	2.302	2.853	3.673	5.002	5.714	6.405	6.554	7.591	7.951	8.373	10
1970	1.244	1.445	2.249	2.853	3.515	4.418	5.444	5.733	6.662	7.31	9.047	9.073	10
1971	1.101	1.316	1.818	2.978	3.702	4.271	5.388	5.972	6.49	7.173	7.38	9.288	10
1972	1.043	1.485	2.055	2.829	3.791	4.175	4.808	5.294	6.948	6.727	7.591	9.315	10
1973	1.306	1.754	1.899	2.7	4.426	5.264	6.156	6.334	8.076	8.777	9.782	9.546	12.006
1974	1.615	1.723	2.493	2.824	3.524	5.197	6.279	6.454	7.07	7.773	8.763	10.279	11.296
1975	1.293	1.924	2.623	3.621	4.128	4.754	5.952	7.073	8.352	9.032	9.984	10.225	11.607
1976	1.162	1.79	3.074	3.291	4.579	4.648	5.116	6.314	7.069	7.069	7.808	8.337	10.68
1977	1.223	1.641	2.66	3.79	4.239	5.597	5.35	5.912	6.837	6.727	6.948	8.424	10
1978	1.493	2.324	3.068	3.746	4.913	4.368	5.276	5.832	6.053	6.706	7.686	7.219	10
1979	1.22	1.88	2.62	3.4	4.18	4.95	5.69	6.38	7.02	7.26	8.15	8.64	10
1980	1.23	2.12	3.32	4.28	5.16	6.42	6.87	7.09	7.93	8.07	8.59	9.79	10.34
1981	1.31	2.13	3	3.81	4.75	5.25	5.95	6.43	7	7.47	8.14	8.55	10.1
1982	1.337	1.851	2.951	3.577	4.927	6.243	7.232	7.239	8.346	8.345	8.956	9.584	10.33
1983	1.208	2.029	2.965	4.143	4.724	5.901	6.811	7.051	7.248	8.292	9.478	10.893	10.34
1984	1.431	1.953	2.47	3.85	5.177	6.347	7.825	6.746	8.636	8.467	8.556	11.127	10.748
1985	1.401	2.032	2.965	3.596	5.336	7.202	6.966	9.862	10.67	10.46	10.202	9.644	13.232
1986	1.718	1.986	2.618	3.277	4.186	5.589	6.05	6.15	9.536	9.823	7.303	11.869	12.875
1987	1.609	1.835	2.395	3.182	4.067	5.149	5.501	6.626	6.343	10.245	8.491	11.634	10.22
1988	1.5	1.975	1.978	2.937	3.798	4.419	5.115	6.712	9.04	9.364	9.142	10.346	10.086

1989	1.309	1.735	1.907	2.373	3.81	4.667	5.509	5.972	6.939	8.543	9.514	11.73	9.627
1990	1.223	1.633	1.83	2.052	2.866	4.474	5.424	6.469	6.343	8.418	7.383	5.822	9.408
1991	1.24	1.568	1.864	2.211	2.648	3.38	4.816	5.516	6.407	7.395	8.079	7.187	9.756
1992	1.264	1.602	2.069	2.554	3.057	4.078	5.012	6.768	7.754	8.303	7.786	9.575	9.102
1993	1.408	1.86	2.323	3.131	3.73	4.394	5.209	6.54	8.403	7.275	9.414	9.281	10.715
1994	1.503	1.951	2.267	2.936	4.214	4.971	5.657	5.95	6.891	8.752	9.752	8.629	7.349
1995	1.456	2.177	2.42	2.895	3.651	5.064	5.44	6.167	7.08	7.736	7.295	5.885	10.518
1996	1.432	1.875	2.496	3.229	3.744	4.964	6.375	6.745	7.466	7.284	8.47	10.001	10.143
1997	1.476	1.783	2.032	2.778	3.598	4.766	5.982	7.658	7.882	8.539	9.488	10.355	10.523
1998	1.388	1.711	1.954	2.405	3.3	4.22	4.999	6.391	6.665	8.214	8.485	8.668	9.2
1999	1.374	1.712	1.905	2.396	2.845	4.124	5.256	5.526	6.956	8.03	8.349	8.083	10.262
2000	1.477	1.606	2.077	2.36	2.977	3.48	4.851	5.268	6.523	4.727	8.807	8.002	10.427
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	10
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	10
2003	1.123	1.304	1.614	1.977	2.532	3.97	4.834	5.499	6.099	6.987	5.961	9.044	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	10
2005	1.148	1.325	1.516	1.672	2.087	2.975	3.79	6.087	6.134	6.651	7.424	9.113	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	10
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	10
2008	1.146	1.312	1.672	1.816	2.395	2.902	3.1	3.728	4.769	6.072	6.451	7.96	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	10
2010	1.429	1.706	2.166	2.551	3.172	3.411	3.972	4.352	5.083	4.941	5.305	9.011	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	10
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	10
2013	1.208	1.466	1.778	2.069	3.553	4.292	5.191	5.742	5.919	6.417	7.941	7.154	6.963
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	10
2015	0.932	1.555	2.091	3.17	4.208	5.032	6.715	7.858	7.428	7.565	7.629	9.87	8.613
2016	1.07	1.25	2.09	2.61	3.98	4.93	5.88	7.43	6.967	8.153	7.89	7.36	8.233

Table 6.2.4.1. Faroe saithe (Division 5.b). Proportion mature at age (1983-2017). Maturities for ages 12 to 15 are set to 1.00

year	3	4	5	6	7	8	9	10	11
1983	0.04	0.25	0.55	0.84	0.92	0.98	1.00	1.00	1.00
1984	0.03	0.26	0.58	0.85	0.93	0.98	1.00	1.00	1.00
1985	0.04	0.26	0.57	0.86	0.93	0.99	1.00	1.00	1.00
1986	0.04	0.28	0.60	0.87	0.94	0.99	1.00	1.00	1.00
1987	0.05	0.28	0.58	0.86	0.95	0.99	1.00	1.00	1.00
1988	0.06	0.28	0.57	0.86	0.95	0.98	1.00	1.00	1.00
1989	0.06	0.27	0.58	0.85	0.94	0.97	1.00	1.00	1.00
1990	0.05	0.26	0.58	0.82	0.92	0.97	1.00	1.00	1.00
1991	0.05	0.26	0.57	0.82	0.91	0.97	1.00	1.00	1.00
1992	0.04	0.24	0.54	0.81	0.91	0.98	1.00	1.00	1.00
1993	0.04	0.25	0.56	0.79	0.91	0.98	1.00	1.00	1.00
1994	0.05	0.22	0.54	0.78	0.90	0.97	1.00	1.00	1.00
1995	0.05	0.22	0.57	0.79	0.91	0.97	1.00	1.00	1.00
1996	0.04	0.18	0.54	0.77	0.90	0.97	1.00	1.00	1.00
1997	0.02	0.17	0.55	0.77	0.89	0.97	1.00	1.00	1.00
1998	0.01	0.16	0.53	0.73	0.88	0.98	1.00	1.00	1.00
1999	0.01	0.16	0.50	0.71	0.86	0.99	0.99	1.00	1.00
2000	0.02	0.17	0.48	0.72	0.87	0.98	0.99	1.00	1.00
2001	0.02	0.16	0.47	0.72	0.87	0.98	0.99	1.00	1.00
2002	0.02	0.18	0.48	0.68	0.84	0.96	0.98	1.00	1.00
2003	0.02	0.17	0.47	0.67	0.82	0.96	0.98	1.00	1.00
2004	0.02	0.16	0.42	0.62	0.79	0.94	0.98	1.00	1.00
2005	0.01	0.16	0.39	0.59	0.77	0.92	0.98	1.00	1.00
2006	0.01	0.18	0.38	0.58	0.75	0.91	0.97	1.00	1.00
2007	0.01	0.19	0.37	0.57	0.74	0.90	0.97	1.00	1.00
2008	0.01	0.20	0.39	0.59	0.75	0.90	0.97	1.00	1.00
2009	0.01	0.19	0.38	0.61	0.77	0.90	0.98	1.00	1.00
2010	0.01	0.18	0.41	0.63	0.79	0.91	0.98	1.00	1.00
2011	0.01	0.19	0.44	0.64	0.80	0.91	0.98	1.00	1.00
2012	0.01	0.20	0.43	0.65	0.81	0.91	0.98	1.00	1.00
2013	0.01	0.19	0.42	0.64	0.83	0.91	0.97	1.00	1.00
2014	0.02	0.25	0.48	0.69	0.86	0.94	0.97	1.00	1.00
2015	0.03	0.24	0.47	0.7	0.88	0.94	0.98	1.00	1.00
2016	0.04	0.26	0.5	0.73	0.91	0.96	0.98	1.00	1.00
2017	0.05	0.26	0.53	0.75	0.91	0.97	0.99	1.00	1.00

Table 6.3.1. Faroe saithe (Division 5.b). Effort (hours) and catch in number-at-age for the survey indices used in the SAM model. Summer index (ages 3-10, years 1996-2016). Spring index (ages 3-10, years 1994-2017)

SummerSurveyStrattified								
200	293	818	403	334	166	84	31	26
200	1266	981	1614	644	459	236	77	19
200	223	843	798	1101	220	110	56	19
200	302	418	1298	918	1235	206	80	39
200	1621	5005	1338	2958	1198	1325	171	95
200	27060	14830	28221	1878	2494	783	799	192
200	4640	13148	4691	5021	334	419	208	144
200	15749	21047	14624	2277	1986	162	105	93
200	1372	14471	32436	11964	1619	711	51	49
200	4693	5808	6037	6801	1787	262	168	32
200	8986	20294	8842	3767	3057	791	72	57
200	1647	2081	5559	2046	1007	722	252	69
200	6864	2415	965	2373	690	378	233	72
200	2350	2339	6939	938	1690	669	431	359
200	2790	1240	1461	213	134	245	126	98
200	5895	1713	519	388	107	88	163	94
200	6457	6018	3012	393	193	86	58	86
200	1086	3777	3931	1853	202	86	30	31
200	2481	1484	1251	550	235	39	26	20
200	5882	2177	2122	847	333	88	38	23
200	4357	11484	1620	669	205	110	39	44
SpringSurveyStrattified								
100	127	847	470	423	108	68	51	54
100	157	527	914	916	357	85	58	24
100	63	270	115	131	105	57	34	16
100	79	107	252	131	94	63	23	26
100	335	941	805	1358	323	145	104	23
100	218	208	699	557	662	89	39	19
100	215	381	310	1256	503	568	28	12
100	797	363	1112	291	427	163	130	23
100	419	6989	2717	2574	206	211	79	39
100	838	927	3306	964	585	76	49	46
100	531	5326	7993	4765	297	120	13	28
100	1417	1208	2774	4592	1497	218	83	26
100	2726	1145	1991	1470	1480	457	41	25
100	254	410	1401	536	226	242	111	13
100	5922	648	481	1333	334	343	223	27
100	1292	7699	978	274	466	217	206	16
100	146	401	674	180	200	297	194	14
100	3723	647	210	235	65	46	92	60
100	255	2305	602	140	73	43	58	64
100	281	2203	1130	524	89	82	32	31
100	488	1215	1434	447	238	65	55	26
100	2343	988	1067	538	139	88	20	6
100	1001	6118	176	189	59	47	19	12
100	1126	4372	5213	190	83	72	27	21

Table 6.3.2. Faroe saithe (Division 5.b). Parameter estimates of the SAM model.

ID	par	sd(par)	exp(par)	Low	High
logFpar_0	-7.56992795	0.22949362	0.00051573	0.000325902	0.000816127
logFpar_1	-6.94702328	0.16517771	0.000961493	0.000690995	0.001337882
logFpar_2	-6.54626418	0.13441767	0.001435468	0.001097084	0.001878224
logFpar_3	-6.681561	0.13244178	0.001253819	0.00096205	0.001634077
logFpar_4	-6.82959472	0.13094338	0.001081296	0.000832164	0.001405014
logFpar_5	-6.9072868	0.12844511	0.001000469	0.000773816	0.001293509
logFpar_6	-6.897837	0.12515788	0.001009968	0.000786315	0.001297234
logFpar_7	-8.65218814	0.22069835	0.000174744	0.000112385	0.000271706
logFpar_8	-7.6606516	0.19416703	0.000471	0.000319426	0.000694501
logFpar_9	-7.32347996	0.12179693	0.000659862	0.000517204	0.000841869
logFpar_10	-7.15069525	0.11981289	0.000784319	0.000617198	0.000996691
logFpar_11	-7.30993054	0.11934111	0.000668864	0.000526841	0.000849172
logFpar_12	-7.20938296	0.11879689	0.000739613	0.000583202	0.000937973
logFpar_13	-7.26818308	0.09136414	0.000697378	0.000580912	0.000837194
logSdLogFsta_0	-1.49169252	0.12510483	0.22499153	0.175186845	0.288955422
logSdLogN_0	-0.8290461	0.16496831	0.436465433	0.313805249	0.607071024
logSdLogN_1	-1.34060819	0.11330645	0.261686464	0.208624122	0.328244906
logSdLogObs_0	-0.93865449	0.04803767	0.391153783	0.355322365	0.430598513
logSdLogObs_1	-0.04409782	0.15446388	0.956860353	0.702559218	1.303209339
logSdLogObs_2	-0.42063856	0.14989448	0.656627388	0.486544205	0.886167222
logSdLogObs_3	-0.669362	0.12086427	0.512035153	0.402085496	0.652050373
logSdLogObs_4	-0.02373558	0.15561861	0.976543889	0.715357536	1.333092781
logSdLogObs_5	-0.13633359	0.15499216	0.872551505	0.639980275	1.189639992
logSdLogObs_6	-0.69795784	0.0688726	0.497600448	0.433569559	0.571087616
transfIRARdist_0	-1.37430415	0.28312899	0.253015595	0.143623191	0.445728095
itrans_rho_0	1.39064197	0.15991202	4.017428296	2.917765072	5.531538596

Table 6.5.1. Faroe saithe (Division 5.b). Estimated fishing mortality-at-age (1961-2017) from the SAM model (median F). F for ages 12 to 15 are equal to F for age 11.

year	3	4	5	6	7	8	9	10	11
1961	0.029	0.064	0.098	0.116	0.126	0.122	0.136	0.163	0.2
1962	0.033	0.073	0.112	0.132	0.144	0.141	0.159	0.193	0.238
1963	0.034	0.075	0.117	0.14	0.16	0.164	0.188	0.233	0.29
1964	0.042	0.096	0.15	0.177	0.199	0.202	0.223	0.265	0.316
1965	0.045	0.106	0.167	0.2	0.231	0.242	0.272	0.326	0.39
1966	0.044	0.108	0.169	0.203	0.234	0.25	0.279	0.331	0.385
1967	0.04	0.099	0.151	0.176	0.199	0.212	0.233	0.267	0.298
1968	0.044	0.109	0.161	0.181	0.199	0.213	0.235	0.27	0.301
1969	0.055	0.138	0.199	0.214	0.226	0.237	0.256	0.287	0.307
1970	0.062	0.154	0.21	0.212	0.21	0.21	0.217	0.234	0.242
1971	0.068	0.165	0.218	0.208	0.195	0.186	0.184	0.189	0.188
1972	0.084	0.207	0.28	0.275	0.26	0.249	0.245	0.246	0.235
1973	0.103	0.258	0.339	0.314	0.275	0.247	0.229	0.22	0.205
1974	0.11	0.278	0.351	0.314	0.263	0.232	0.211	0.2	0.191
1975	0.105	0.273	0.338	0.295	0.241	0.211	0.188	0.176	0.171
1976	0.098	0.264	0.323	0.285	0.234	0.206	0.183	0.167	0.162
1977	0.088	0.252	0.321	0.298	0.254	0.232	0.207	0.185	0.178
1978	0.067	0.208	0.277	0.276	0.254	0.25	0.234	0.213	0.208
1979	0.055	0.187	0.266	0.287	0.282	0.288	0.277	0.251	0.245
1980	0.049	0.178	0.263	0.303	0.307	0.319	0.312	0.278	0.277
1981	0.046	0.188	0.299	0.376	0.398	0.425	0.419	0.361	0.369
1982	0.043	0.186	0.311	0.402	0.422	0.451	0.445	0.375	0.399
1983	0.046	0.213	0.376	0.491	0.514	0.543	0.538	0.448	0.497
1984	0.043	0.212	0.391	0.51	0.521	0.532	0.519	0.434	0.491
1985	0.041	0.207	0.396	0.516	0.519	0.525	0.513	0.444	0.525
1986	0.039	0.21	0.434	0.594	0.603	0.624	0.621	0.548	0.642
1987	0.036	0.199	0.422	0.579	0.576	0.579	0.563	0.491	0.556
1988	0.031	0.174	0.38	0.524	0.513	0.495	0.457	0.383	0.41
1989	0.029	0.169	0.369	0.5	0.479	0.448	0.408	0.352	0.397
1990	0.033	0.203	0.455	0.609	0.579	0.525	0.482	0.442	0.539
1991	0.044	0.269	0.601	0.793	0.762	0.706	0.677	0.65	0.812
1992	0.04	0.243	0.536	0.7	0.686	0.652	0.653	0.659	0.853
1993	0.038	0.216	0.464	0.591	0.582	0.551	0.543	0.538	0.665
1994	0.034	0.19	0.408	0.527	0.54	0.521	0.506	0.484	0.562
1995	0.029	0.166	0.379	0.517	0.575	0.588	0.591	0.576	0.678
1996	0.022	0.123	0.287	0.406	0.474	0.499	0.5	0.478	0.548
1997	0.019	0.107	0.259	0.382	0.469	0.516	0.538	0.529	0.624
1998	0.016	0.097	0.242	0.367	0.47	0.542	0.584	0.577	0.695
1999	0.015	0.095	0.248	0.389	0.503	0.593	0.647	0.641	0.788
2000	0.015	0.096	0.255	0.404	0.511	0.583	0.613	0.582	0.702
2001	0.016	0.108	0.306	0.521	0.682	0.802	0.878	0.856	1.103
2002	0.013	0.09	0.266	0.459	0.597	0.699	0.758	0.731	0.961
2003	0.011	0.077	0.231	0.41	0.547	0.654	0.739	0.702	0.955
2004	0.011	0.077	0.228	0.405	0.553	0.689	0.819	0.785	1.124
2005	0.016	0.107	0.286	0.458	0.57	0.657	0.744	0.655	0.924
2006	0.025	0.161	0.391	0.576	0.672	0.751	0.846	0.74	1.032
2007	0.033	0.202	0.448	0.606	0.663	0.729	0.833	0.74	1.076
2008	0.042	0.255	0.523	0.652	0.66	0.685	0.77	0.688	1.025
2009	0.045	0.28	0.548	0.666	0.649	0.646	0.706	0.627	0.937
2010	0.051	0.316	0.602	0.718	0.669	0.644	0.682	0.612	0.937
2011	0.044	0.275	0.521	0.63	0.589	0.563	0.596	0.563	0.943
2012	0.043	0.275	0.517	0.641	0.617	0.587	0.624	0.621	1.165
2013	0.038	0.247	0.464	0.578	0.558	0.526	0.549	0.562	1.171
2014	0.034	0.22	0.423	0.54	0.521	0.482	0.478	0.476	1.008
2015	0.035	0.229	0.456	0.617	0.61	0.575	0.577	0.588	1.349
2016	0.029	0.192	0.387	0.53	0.519	0.477	0.469	0.465	1.073
2017	0.029	0.191	0.384	0.527	0.515	0.473	0.465	0.46	1.063

Table 6.5.2. Faroe saithe (Division 5.b). Stock number-at-age (start of year) (Thousands)(1961-2017).

year	3	4	5	6	7	8	9	10	11	12	13	14	15
1961	9177	7234	5781	3531	1922	1335	1010	673	311	121	59	6	292
1962	13633	7122	5728	4324	2420	1361	1001	723	493	221	71	49	200
1963	19085	9538	4899	4113	3097	1636	1046	734	494	382	180	41	143
1964	16987	17285	8406	3799	3090	2181	1138	745	472	333	209	116	93
1965	19533	11743	12964	5881	2657	2075	1373	796	504	300	217	116	133
1966	15728	15573	8450	9299	3922	1742	1333	796	502	294	154	114	135
1967	18999	11829	11337	5698	6200	2441	1084	827	434	291	165	74	120
1968	20467	16530	9375	8110	3909	3867	1479	668	502	250	176	102	140
1969	30773	15958	12924	7392	5908	2812	2410	917	419	336	144	108	125
1970	29881	30783	10785	8916	5316	4063	1873	1341	508	238	203	81	126
1971	32953	23149	22296	7343	6199	3871	2789	1303	782	314	143	123	118
1972	33356	22004	15914	13010	5532	4765	3217	2214	1028	521	195	115	153
1973	27643	25739	17857	11218	7298	3488	3020	2043	1306	614	291	132	200
1974	24930	19589	15541	10553	6889	4053	2231	1973	1275	811	378	226	262
1975	21118	15656	11905	8727	6192	4522	2542	1512	1301	827	518	268	374
1976	21977	13974	8401	6231	5293	4169	3257	1881	1132	870	533	360	463
1977	15562	14764	7588	4702	3624	3628	3037	2473	1530	894	644	376	527
1978	10008	10533	8577	3774	2518	2141	2452	2247	1975	1135	703	508	625
1979	8721	6756	6408	5047	2362	1626	1211	1653	1521	1418	786	491	940
1980	14406	6395	4259	3704	3082	1404	966	690	938	911	1125	557	1047
1981	16977	10301	4296	2745	2328	1864	883	587	373	531	591	845	1199
1982	15202	18519	6081	2892	1463	1182	908	456	315	195	294	341	1377
1983	33557	10315	14986	3792	1576	812	553	435	271	168	101	205	882
1984	21488	31403	7347	9317	1977	771	384	211	246	141	65	56	523
1985	26325	19028	18149	4217	4663	924	380	176	101	152	69	29	310
1986	37796	17454	13016	8610	2414	2216	478	219	105	52	82	27	153
1987	38941	35462	11734	6887	3271	1295	893	206	111	43	20	32	74
1988	35160	29104	28411	6276	3145	1434	704	392	97	56	33	7	27
1989	23896	32460	22272	17724	2804	1453	625	357	178	51	22	25	29
1990	18530	20803	23179	15124	9326	1437	676	301	215	78	34	15	40
1991	22840	16418	14568	11028	6818	3962	742	407	174	124	37	16	25
1992	19263	19153	9719	6233	3742	2587	1565	302	182	59	49	13	15
1993	23782	15000	12701	4415	2493	1556	1219	686	130	80	18	14	7
1994	15380	18945	9868	6498	1967	1205	811	653	347	57	44	6	7
1995	15426	9139	11371	5973	3180	933	607	428	299	164	25	25	7
1996	13385	13438	5119	5026	2794	1268	396	252	202	127	69	7	16
1997	18244	10035	11177	4231	3035	1580	555	187	104	107	64	32	13

1998	13878	17326	9403	12930	3203	1691	830	239	88	45	52	29	18
1999	27472	9095	14113	8257	10515	1837	785	347	90	38	16	23	19
2000	36497	33679	6183	12681	5603	6126	812	370	132	36	13	6	11
2001	66997	26586	36864	4191	7237	2841	2488	461	156	49	15	8	7
2002	50405	71757	20977	25328	2188	2724	1250	774	132	40	14	3	4
2003	44313	56289	50750	11558	11060	1058	897	615	251	49	10	4	2
2004	23904	43983	65308	33852	6038	3970	413	405	233	79	16	3	2
2005	40340	29210	32324	47106	17138	2507	1422	175	141	58	15	4	1
2006	33478	44446	25647	19187	22306	7685	987	516	70	38	19	6	2
2007	29571	18357	34235	15035	9127	7921	2598	512	143	22	12	5	2
2008	43606	21477	8748	21768	7779	4965	3494	916	234	29	7	3	2
2009	21348	21664	16942	4278	9605	4021	2536	1546	422	75	7	2	2
2010	30629	11841	12835	3705	2334	4300	2084	1130	766	138	27	2	1
2011	44110	18704	5254	4586	1412	1110	1833	975	546	296	54	8	1
2012	29029	30630	13302	2671	1738	762	618	844	438	161	123	20	3
2013	20413	22748	15165	7372	1296	777	357	320	322	118	34	38	6
2014	27040	15175	11534	6071	2863	670	388	225	160	82	30	5	12
2015	63047	14730	10054	5289	2569	921	396	208	102	58	23	9	6
2016	48906	66447	7408	4473	1839	985	339	237	109	19	17	4	3
2017	51644	42101	52209	3804	1980	943	489	202	122	31	5	5	2

Table 6.5.3. Faroe saithe (Division 5.b). Summary table (1961-2017).

year	Recruits (age 3)	SSB	Fbar(4-8)	Landings
1961	9177	64187	0.11	9592
1962	13633	68581	0.12	10454
1963	19085	77255	0.13	12693
1964	16987	88050	0.16	21893
1965	19533	98159	0.19	22181
1966	15728	102611	0.19	25563
1967	18999	97372	0.17	21319
1968	20467	98458	0.17	20387
1969	30773	104398	0.2	27437
1970	29881	109182	0.2	29110
1971	32953	120998	0.19	32706
1972	33356	139214	0.25	42663
1973	27643	158701	0.29	57431
1974	24930	150301	0.29	47188
1975	21118	153389	0.27	41576
1976	21977	134904	0.26	33065
1977	15562	127312	0.27	34835
1978	10008	114899	0.25	28138
1979	8721	102702	0.26	27246
1980	14406	100869	0.27	25230
1981	16977	81927	0.34	30103
1982	15202	76474	0.35	30964
1983	33557	78536	0.43	39176
1984	21488	86756	0.43	54665
1985	26325	97099	0.43	44605
1986	37796	87688	0.49	41716
1987	38941	84457	0.47	40020
1988	35160	92989	0.42	45285
1989	23896	102112	0.39	44477
1990	18530	99192	0.47	61628
1991	22840	81502	0.63	54858
1992	19263	65266	0.56	36487
1993	23782	63803	0.48	33543
1994	15380	61408	0.44	33182
1995	15426	59729	0.44	27209
1996	13385	47695	0.36	20029
1997	18244	49700	0.35	22306
1998	13878	61146	0.34	26421
1999	27472	71033	0.37	33207
2000	36497	80544	0.37	39020
2001	66997	92231	0.48	51786
2002	50405	96505	0.42	53546
2003	44313	103900	0.38	46555
2004	23904	117073	0.39	46355
2005	40340	114394	0.42	67967
2006	33478	102030	0.51	66902
2007	29571	85134	0.53	60785
2008	43606	77408	0.56	57044
2009	21348	73308	0.56	57949
2010	30629	58407	0.59	43885
2011	44110	46897	0.52	29658
2012	29029	42630	0.53	35314
2013	20413	41400	0.47	26463
2014	27040	49035	0.44	23885
2015	63047	48507	0.5	25128
2016	48906	56022	0.42	29450
2017	51644	98930	0.42	
Mean	27154	88498	0.37	36648

Table 6.6.1.1. Faroe saithe (Division 5.b). Input data for short-term forecast for the SAM assessment. Natural mortality (nm), maturity (mat), catch weights (cw), selection pattern(sel), stock weights (sw). Units for catch and stock weights are kg.

"age"	"nm"	"mat"	"pf"	"pm"	"sw"	"sel"	"cw"
3	0.2	0.03	0	0	1.158	0.06	1.158
4	0.2	0.24	0	0	1.49	0.43	1.49
5	0.2	0.48	0	0	1.914	0.86	1.914
6	0.2	0.7	0	0	2.675	1.18	2.675
7	0.2	0.88	0	0	3.728	1.15	3.728
8	0.2	0.94	0	0	5.097	1.06	5.097
9	0.2	0.98	0	0	5.992	1.04	5.992
10	0.2	1	0	0	6.966	1.03	6.966
11	0.2	1	0	0	6.798	2.39	6.798
12	0.2	1	0	0	7.294	2.39	7.294
13	0.2	1	0	0	7.559	2.39	7.559
14	0.2	1	0	0	9.462	2.39	9.462
15	0.2	1	0	0	8.631	2.39	8.631

Table 6.6.2.1. Faroe saithe (Division 5.b). Output of the SAM short-term-forecast including confidence intervals (low and high columns). Units for ssb and catch are tonnes, thousands for recruitment.

YEAR	FBAR:MEDIAN	FBAR:LOW	FBAR:HIGH	REC:MEDIAN	REC:LOW	REC:HIGH	SSB:MEDIAN	SSB:LOW	SSB:HIGH	CATCH:MEDIAN	CATCH:LOW	CATCH:HIGH
2017	0.425	0.251	0.719	51740	19683	133131	101492	65895	154106	46375	26690	79724
2018	0.423	0.215	0.816	29029	20413	63047	117718	66539	217488	59934	31386	112929
2019	0.431	0.193	0.953	29029	20413	63047	130221	60496	274814	61405	30927	127362

Table 6.7.1. Faroe saithe (Division 5.b). Input data for the yield-per-recruitcalculations of the SAM assessment. Natural mortality (nm), maturity (mat), catch weights (cw), selection pattern(sel), stock weights (sw). Units for catch and stock weights are kg.

"age"	"nm"	"mat"	"pf"	"pm"	"sw"	"sel"	"cw"
3	0.2	0.02	0	0	1.135	0.06	1.135
4	0.2	0.2	0	0	1.433	0.4	1.433
5	0.2	0.43	0	0	1.766	0.8	1.766
6	0.2	0.64	0	0	2.297	1.1	2.297
7	0.2	0.81	0	0	3.004	1.08	3.004
8	0.2	0.93	0	0	3.837	0.99	3.837
9	0.2	0.98	0	0	4.566	0.97	4.566
10	0.2	1	0	0	5.381	0.97	5.381
11	0.2	1	0	0	5.816	2.23	5.816
12	0.2	1	0	0	6.48	2.23	6.48
13	0.2	1	0	0	6.957	2.23	6.957
14	0.2	1	0	0	8.491	2.23	8.491
15	0.2	1	0	0	9.609	2.23	9.609

6.17 Figures

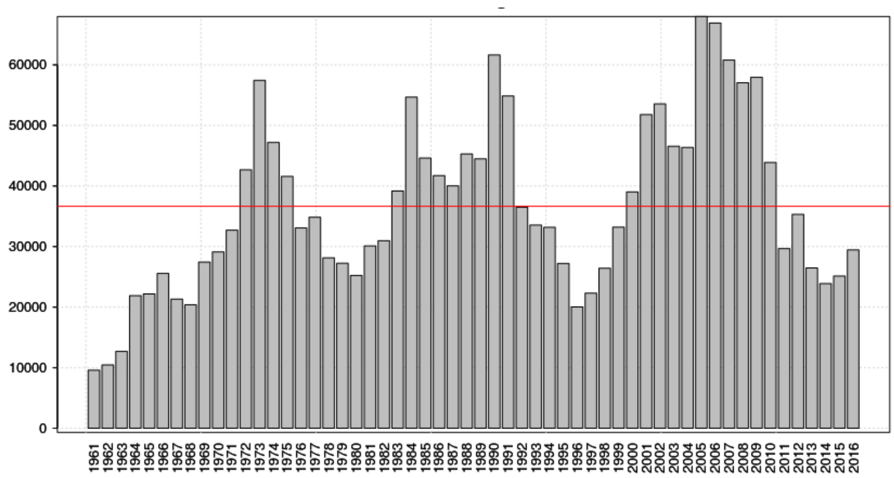


Figure 6.2.1.1. Faroe saithe (Division 5.b). Landings in 1000 tonnes (1961–2016). Horizontal red line represents historical average landings.

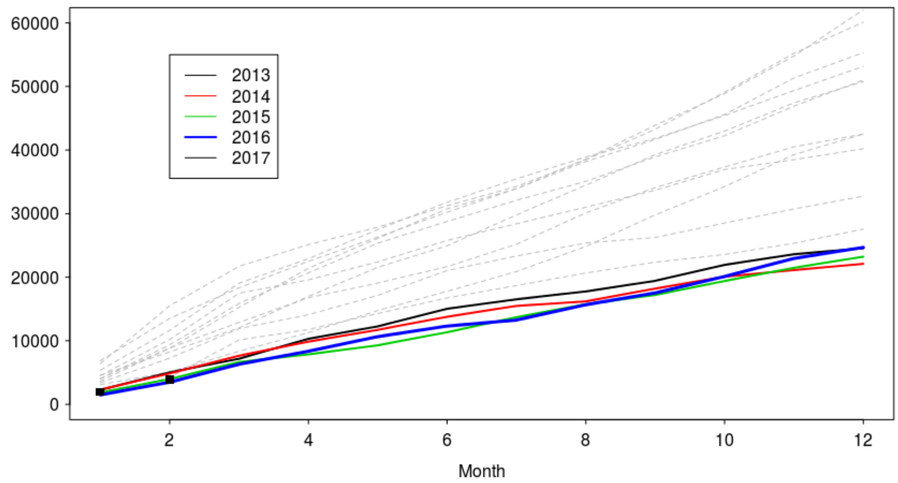


Figure 6.2.1.2. Saithe in the Faroes (Division 5.b). Cumulative domestic landings (2000–2017). The first two months in 2017 are indicated as square black points.

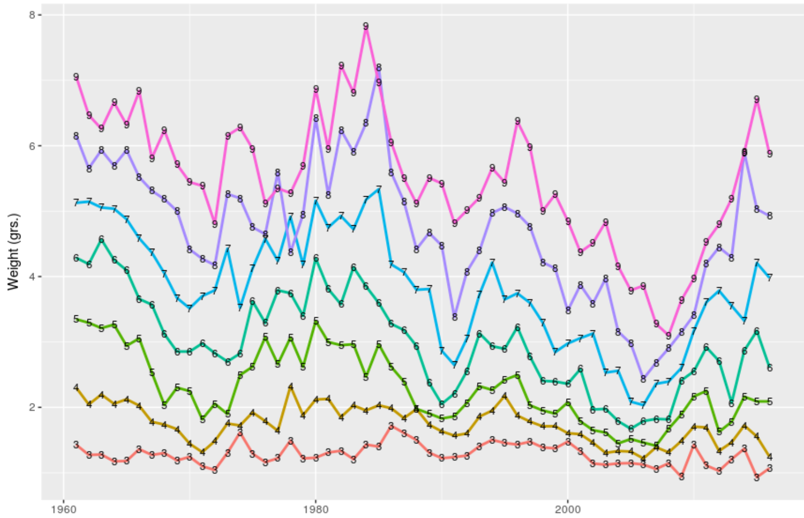


Figure 6.2.3.1. Faroe saithe (Division 5.b). Mean weight at age (kg) in commercial catches (ages 3–9) (1961–2016).

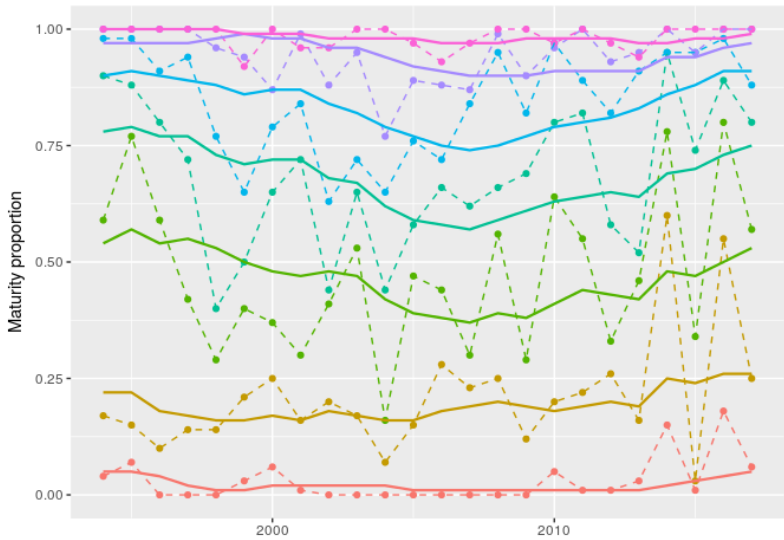


Figure 6.2.4.1. Faroe saithe (Division 5.b). Observed and smoothed maturity ogives (ages 3-9)(1994–2017) from FGFS1 (spring survey).

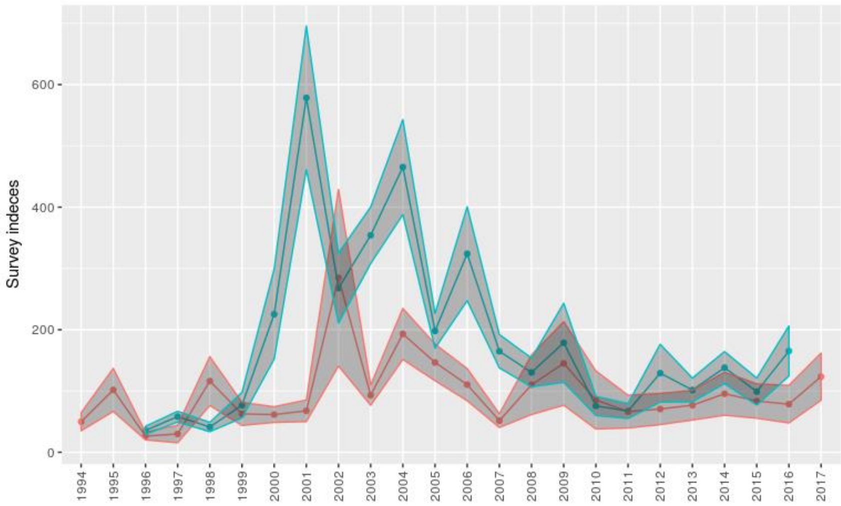


Figure 6.2.5.1.1. Faroe saithe (Division 5.b). Survey indices (kg/hour) from the Faroese bottom-trawl spring FGFS1 (1994–2017)(red line) and summer survey FGFS2 (1996–2016)(blue line). Shade areas show standard errors in the estimation of indices.

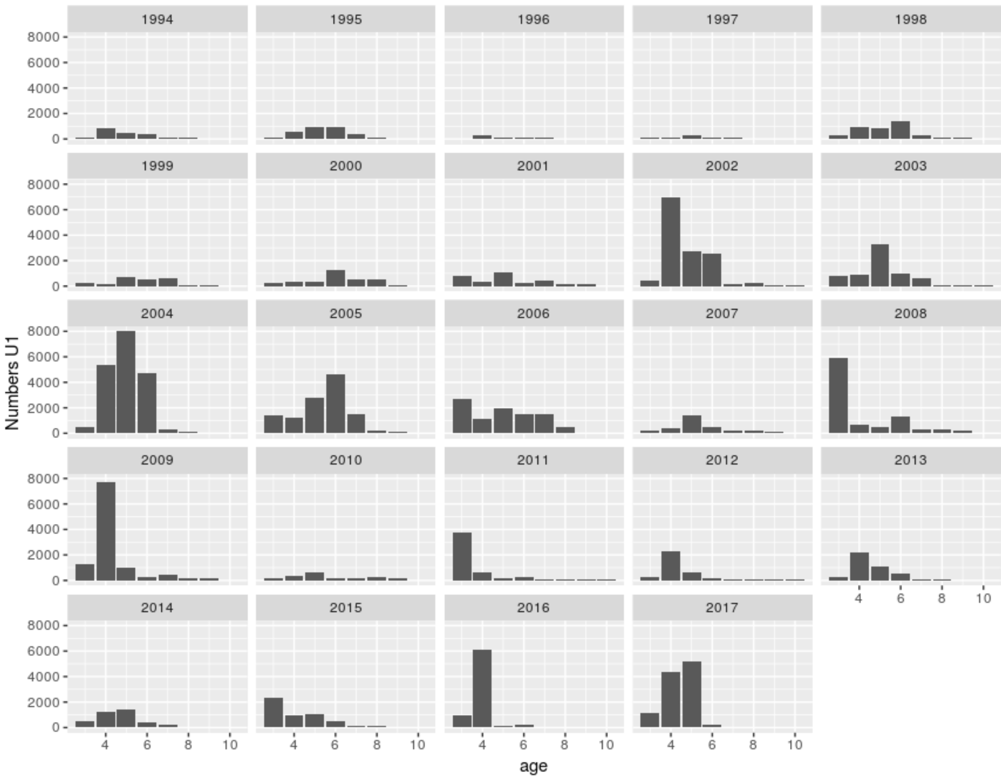


Figure 6.2.5.1.4. Faroe saithe (Division 5.b). Age-disaggregated indices in the Faroese bottom-trawl spring survey FGFS1 (ages 3–10, years 1994–2017)

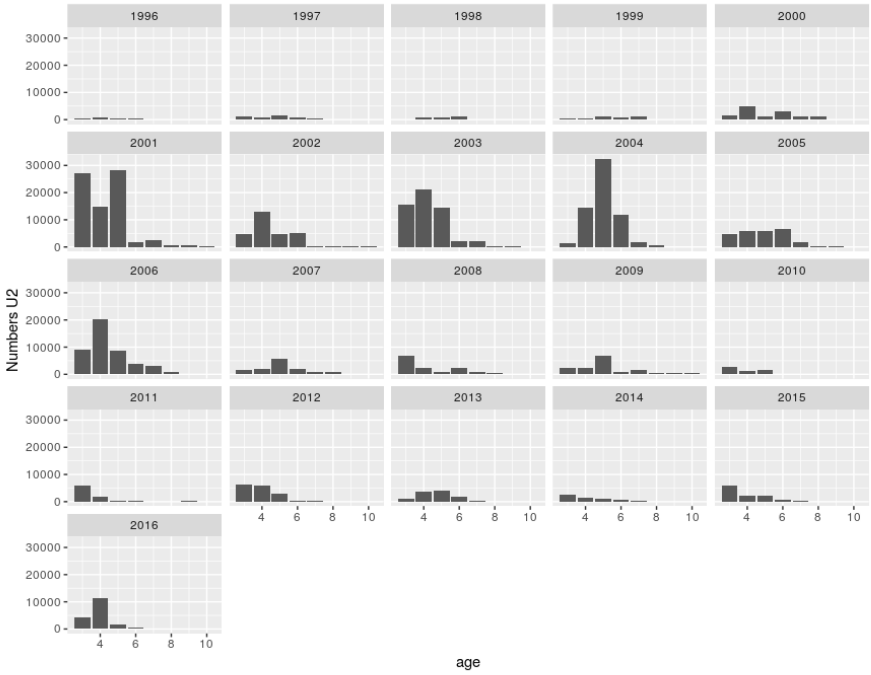


Figure 6.2.5.1.5. Faroe saithe (Division 5.b). Age-disaggregated indices in the Faroese bottom-trawl fall survey FGFS2 (ages 3–10, years 1996–2016)

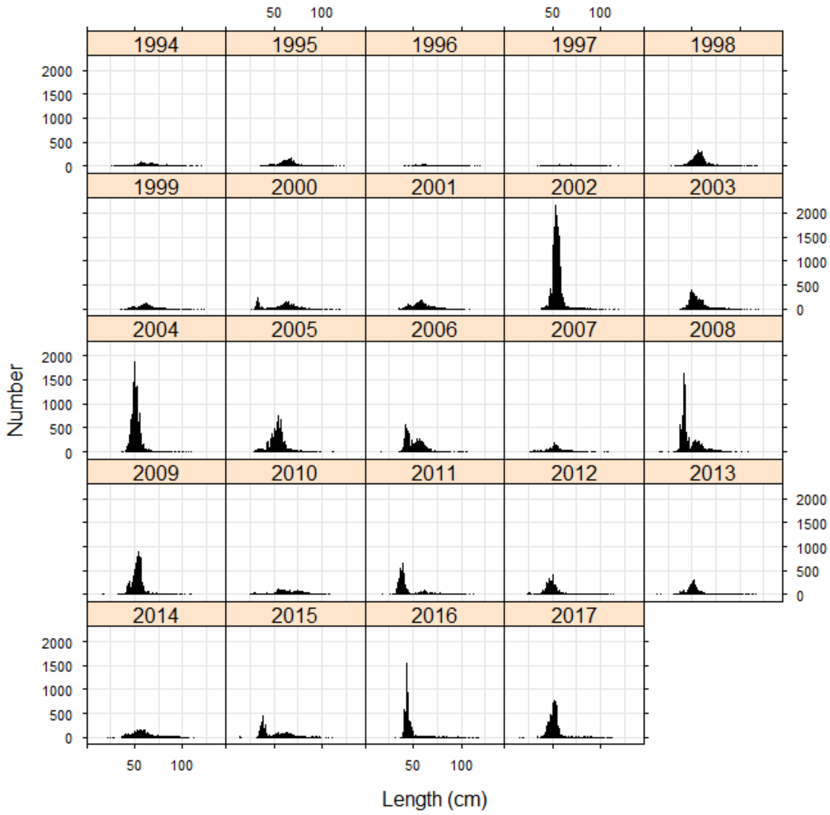


Figure 6.2.5.1.4. Faroe saithe (Division 5.b). Length composition from the Faroese bottom-trawl spring survey FGFS1 (1994–2017)

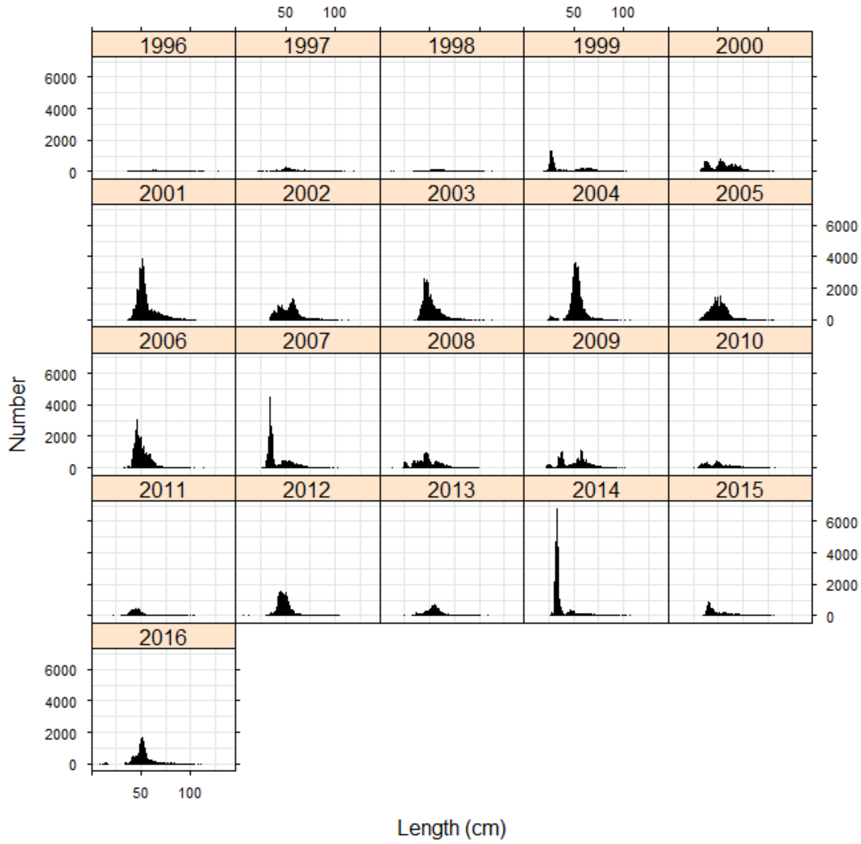


Figure 6.2.5.1.5. Faroe saithe (Division 5.b). Length composition from the Faroese bottom-trawl summer survey FGFS2 (1996–2016)

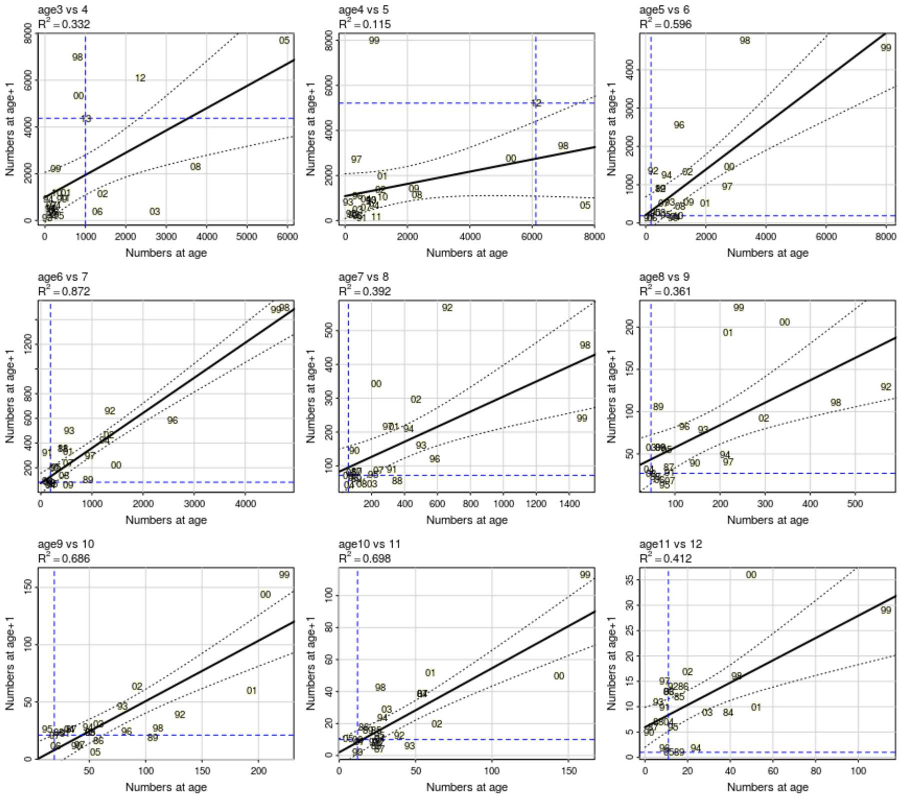


Figure 6.2.5.1.6. Faroe saithe (Division 5.b). Numbers from spring survey (FGFS1) plotted against numbers of the same year class one year later. Letters in the figures represent year classes. Horizontal and vertical lines crossing is the most recent pair.

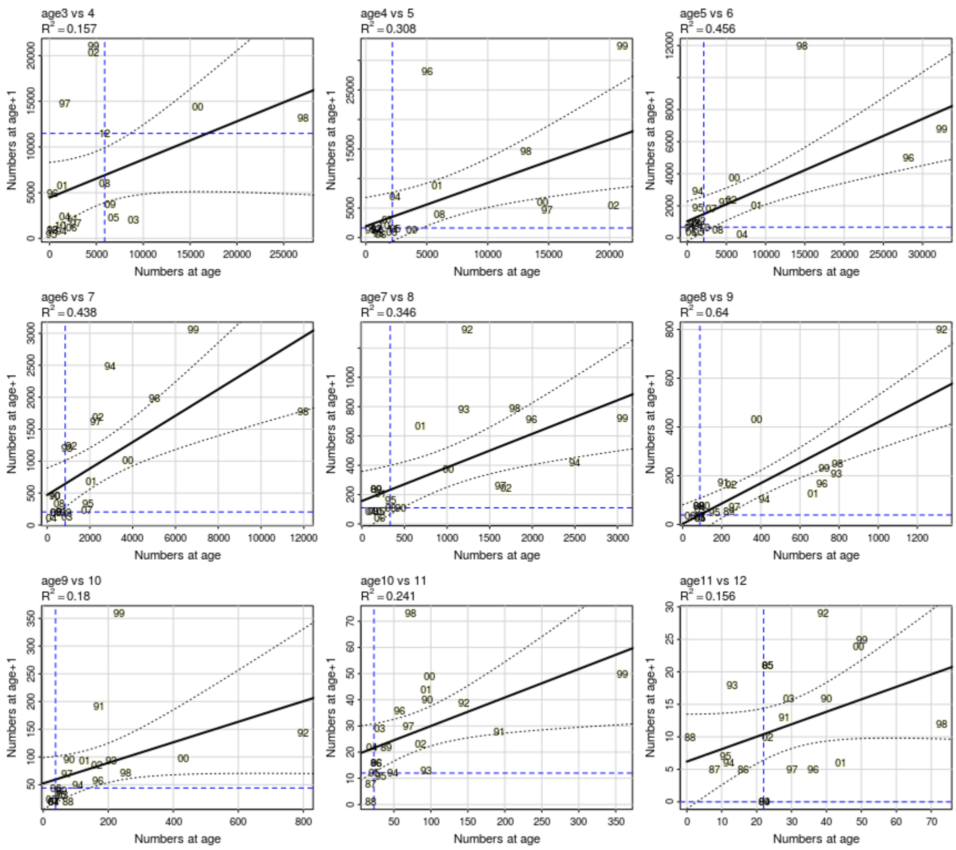


Figure 6.2.5.1.7. Faroe saithe (Division 5.b). Numbers from summer survey (FGFS2) plotted against numbers of the same year class one year later. Letters in the figures represent year classes. Horizontal and vertical lines crossing is the most recent pair.

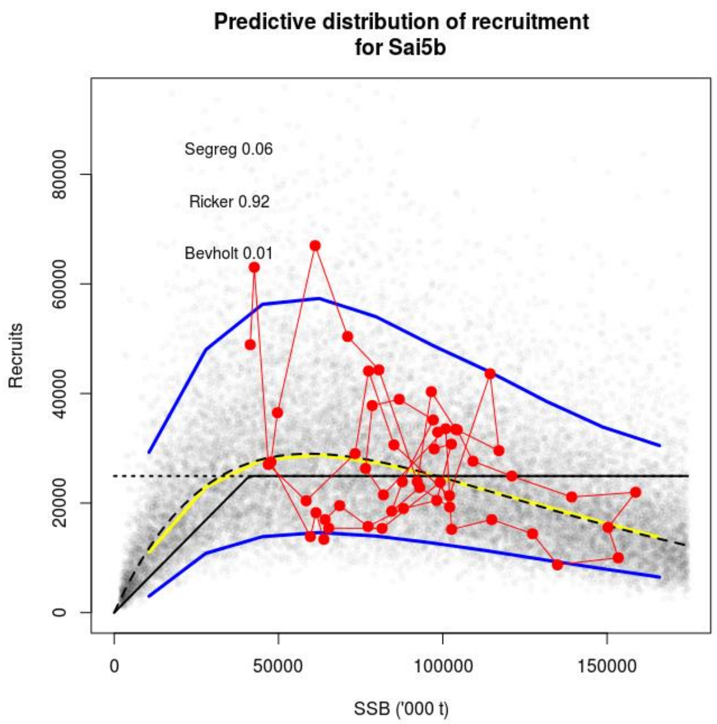


Figure 6.4.1.1. Faroe saithe (Division 5.b). EqSim simulation. Stock–recruitment functions used in the simulations (Ricker, Bevton-Holt and Segmented).

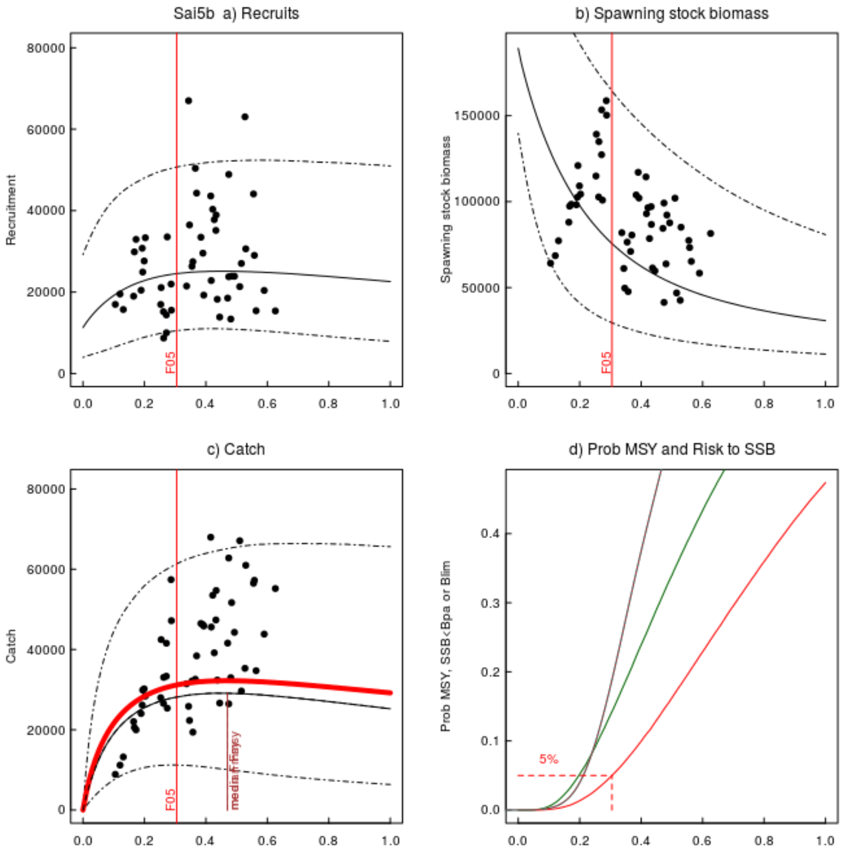


Figure 6.4.1.2. Faroe saithe (Division 5.b). EqSim simulation results. Fmsy=0.30 is the vertical red line in the bottom-left gragh.

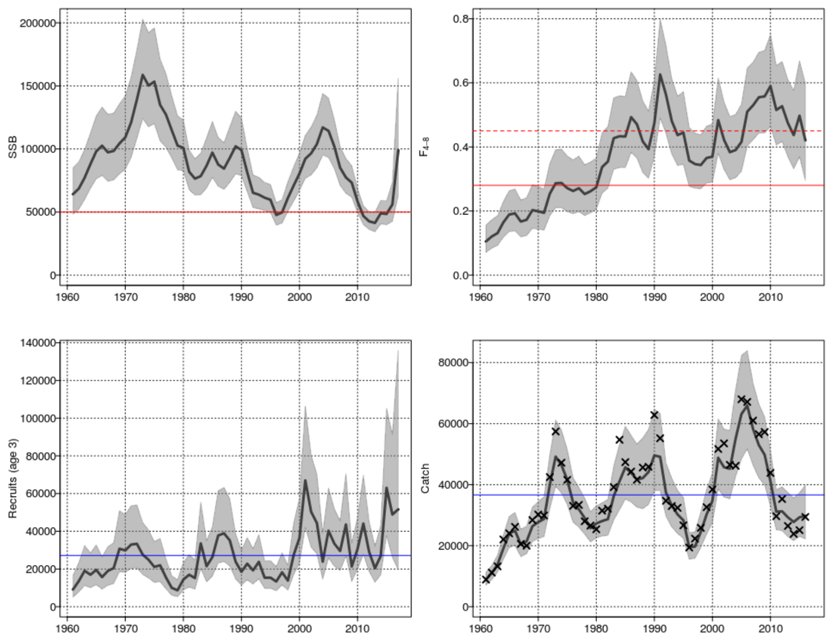


Figure 6.5.1. Faroe saithe (Division 5.b). spawning-stock biomass (thousand tonnes) (top-left), recruitment (age 3) in millions (bottom-left), , F_{bar} (ages 4 to 8)(top-right) and landings (thousand tonnes)(bottom-right) from the SAM assessment. Horizontal red lines in SSB and Fbar plots represent reference points (Btrigger=Bpa=55 kt, Fmsy=0.30 and Fpa=0.52 respectively. Horizontal blue lines in recruitment and catch plots show historical averages.

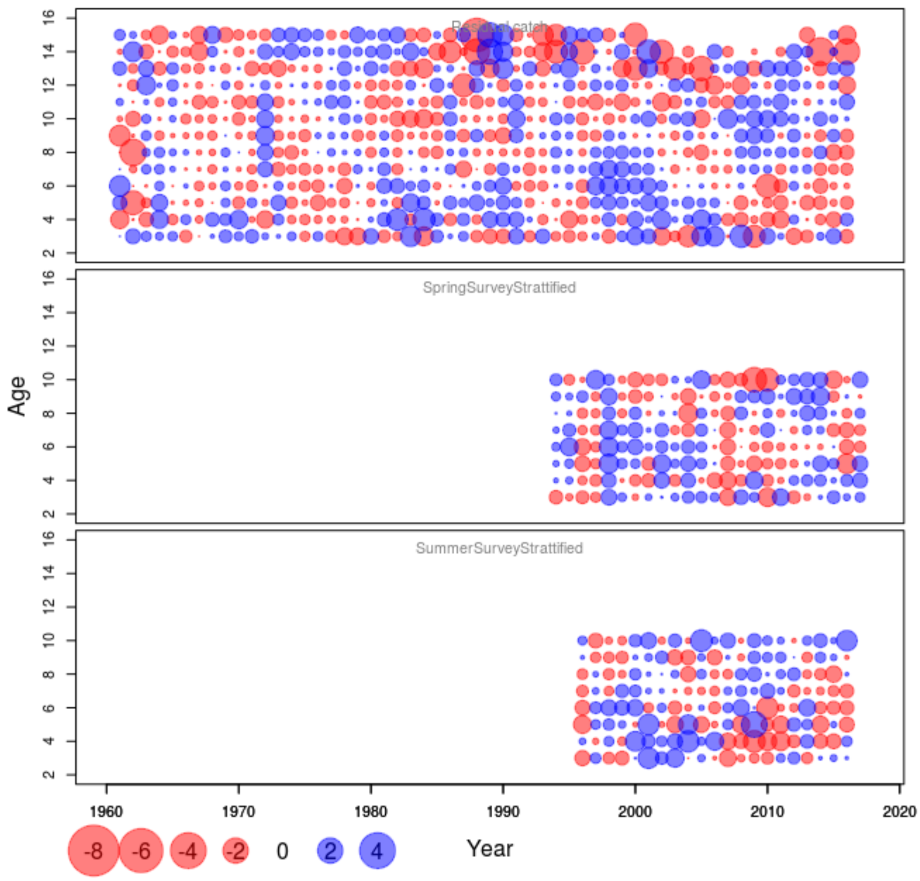


Figure 6.5.2. Faroe saithe (Division 5.b). Residuals of the SAM assessment calibrated with both survey indices. Blue and red bubbles represent positive and negative residuals respectively.

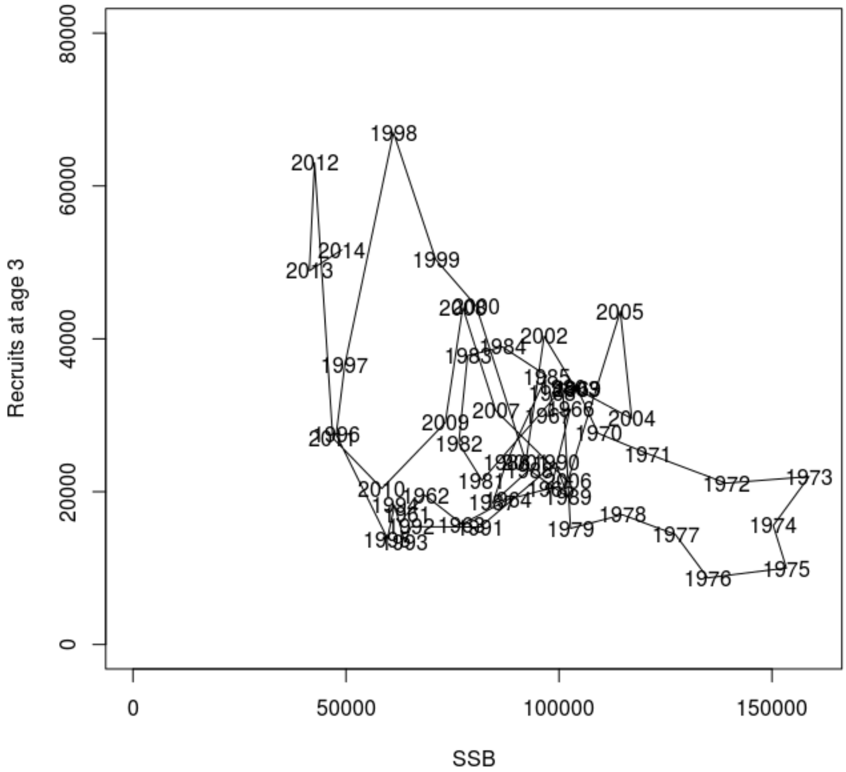


Figure 6.5.3. Faroe saithe (Division 5.b). Relation between SSB and recruitment (age 3).

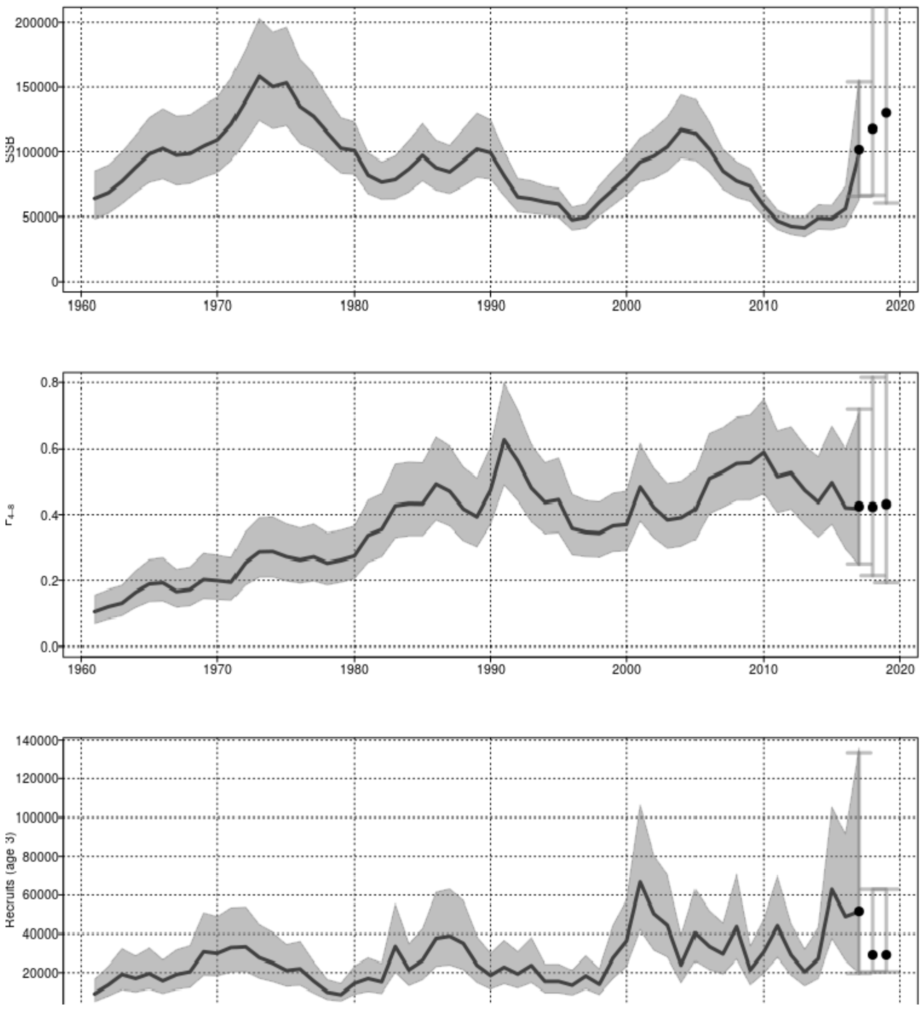


Figure 6.6.2.1. Faroe saithe (Division 5.b). Short-term prediction including historical assessment. Spawning stock biomass (top),average fishing mortality (F4-8) (middle) and recruitment (numbers age3 , bottom).

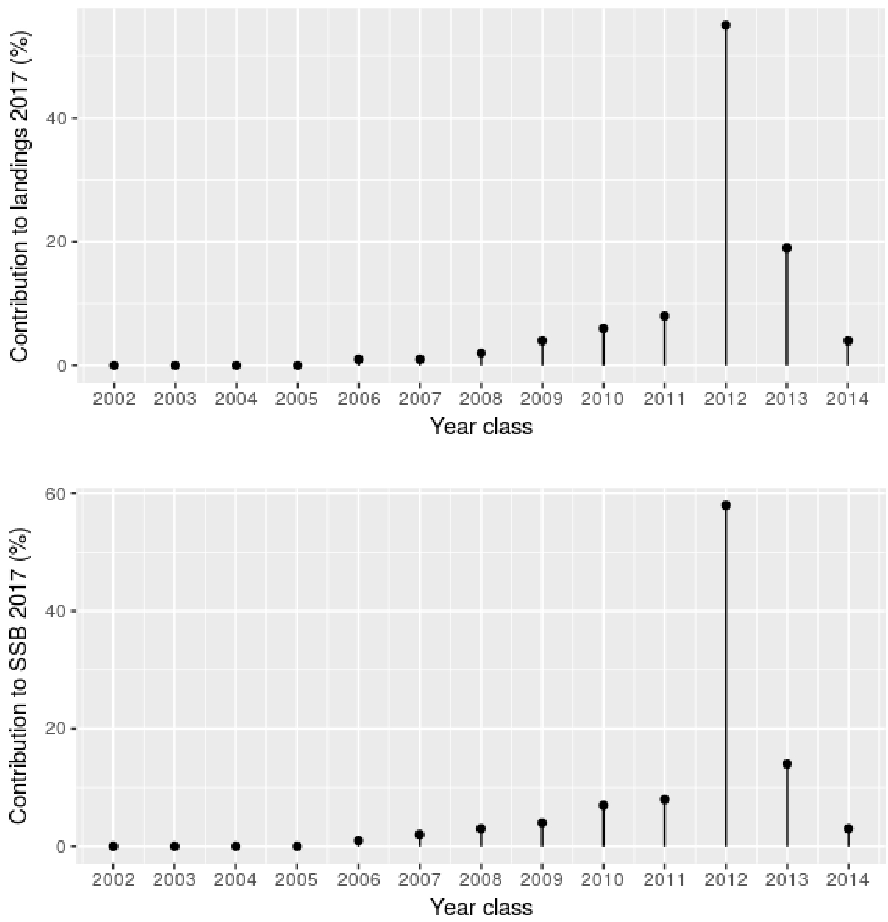


Figure 6.6.2.2. Faroe saithe (Division 5.b). Contribution of year classes to landings (top) and spawning stock biomass (bottom) in 2017.

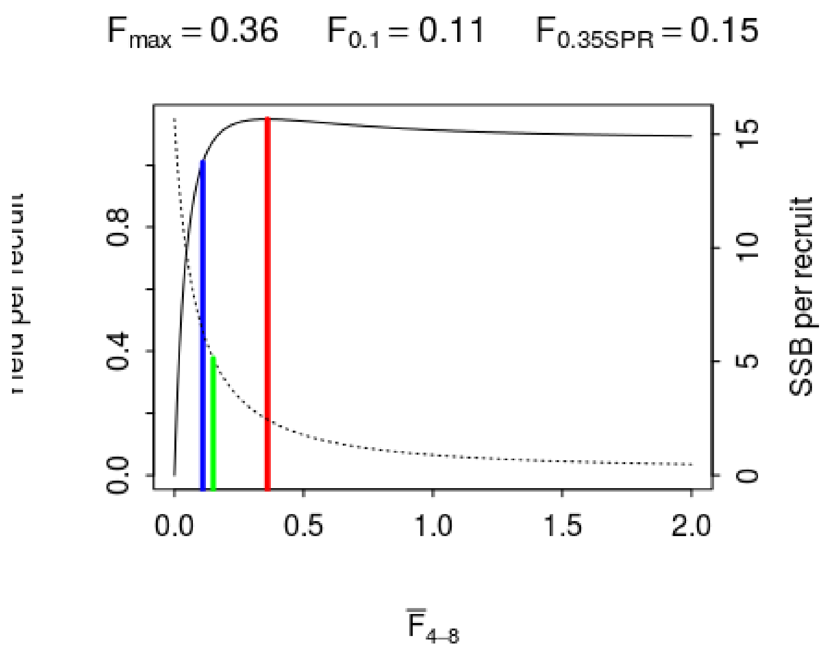


Figure 6.7.1. Faroe saithe (Division 5.b). Yield-per-recruit calculations.

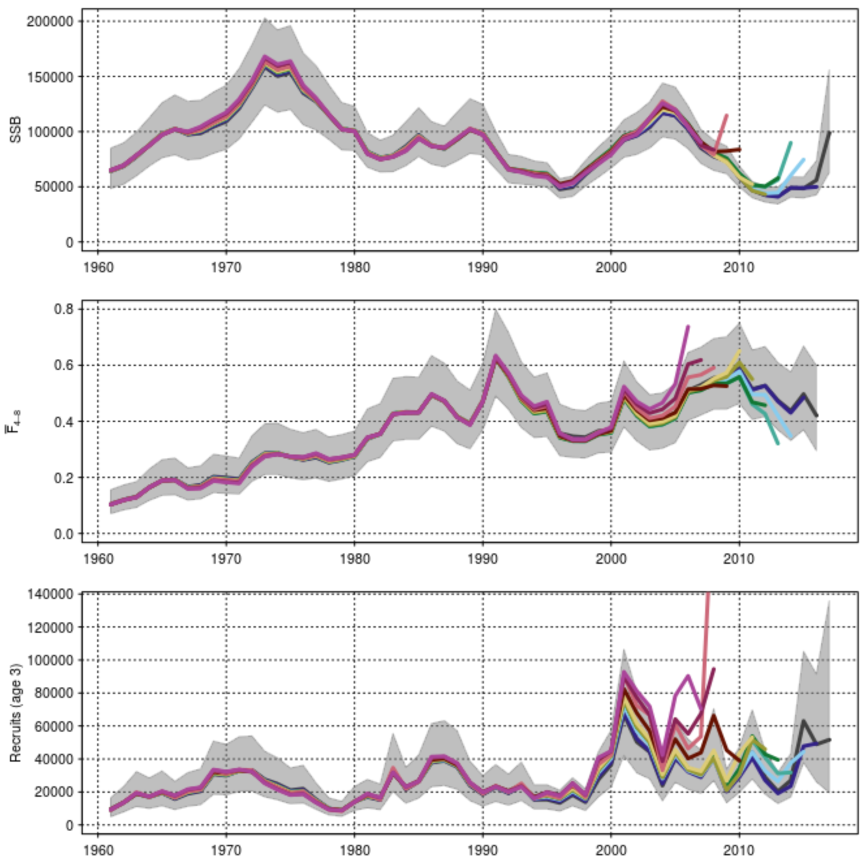


Figure 6.8.1. Faroe saithe (Division 5.b). Retrospective analysis of spawning-stock biomass (tonnes)(top), average fishing mortality over age groups 4–8 (middle) and recruitment-at-age 3 ('000)(bottom) from the SAM assessment.

7 Overview on Ecosystem, fisheries and their management in Icelandic waters

In 2017 the Icelandic Waters ecoregion – Ecosystem overview has been published as an ICES advice https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/Ecosystem_overview-Icelandic_Waters_ecoregion.pdf

This contains the information previously given in this section

8 Icelandic saithe

Summary

The 2017 reference biomass (B_{4+}) is estimated as 327 kt, 25% above the average in the assessment period (1980 to the present). Spawning stock biomass is estimated as 161 kt, the highest 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 3 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. Smaller than estimated stock can though not be excluded. The current assessment is an upward revision of last year's assessment mostly due to the strong 2012 yearclass.

Weights of ages 3-6 have been low in recent years, but older ages are close to average weight. Maturity at age of ages 4-9 has decreased in recent years and is currently around average since 1985.

Recruitment has been above average since 2009 and relatively stable. Yearclass 2012 is estimated to be strong and the survey in 2017 indicates that yearclass 2013 is above 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 result of the assessment changes somewhat with settings of the assessment model, with estimated reference biomass in 2017 varying from 297-354 thous tonnes from models with "plausible settings". The lowes and highest values are from SAM models with little different settings of observation variance. The assessment is considered relatively uncertain but this year's assessment is similar to 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 spawning stock is above $B_{trigger}$, the TAC set in year y for the fishing year $y/y+1$ equals the average of 0.2 B_{4+} in year y and last year's TAC.

According to the adopted harvest control rule, the TAC will be 60 kt in the next fishing year compared to 55 kt in current fishing year. The fact that the TAC has not been caught in recent fishing year and substantial effort is required to catch saithe makes this increase questionable. Reducing harvest rate to 16% keeping the current form of HCR would lead to same TAC in next fishing year as the current one and little change few years after that. The reason for reducing harvest rate is only mixed fisheries problems and change in gear technology, the state of the stock today is that the spawning stock is estimated the largest for at least 37 years.

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 2016 are estimated to have been 49 200 t (Table 8.1 and Figure 8.1). Of the landings, 42 700 t were caught by trawl, 2 500 t by gillnets, and the rest caught by other fishing gear. The domestic as well as ICES advice for the fishing year 2015/2016 was based on the 20% harvest control rule and was 55 kt. The TAC issued was also 55 kt but the landings are now estimated to be 49 300 tons. The trajectory of the landings in the current fishing year and calendar year is shown in Figure 8.2 indicating that the TAC of 55 kt will not be reached.

Most of the catch is caught in bottom trawl (82% in 2010-2016), with gillnet and jiggers taking the majority of the rest, 6% each fleet. The share taken by the gillnet fleet was larger in the past, 26% in 1982-1996 compared to 9% in 1997-2016 (Figure 8.1). Saithe does not appear much in the longline fishery that has been increasing in last 20 years. The share of longlines has gradually been increasing from 0.8% before 2000 to 2.5% in last 3 years.

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). 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.

In 2016 sea samples constitute about 80% of the length measured fish that is used in the calculation of the catch in number and 70% of the length samples. 87% of the length samples are taken from trawl that is accounting for 87% of the catches. On the other hand only 35% of the aged otholits come from sea samples.

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 50 to 25 for all fishing gears. These revisions in the sampling program were based on the analysis of Thordarson (2012) and lead to approximately 50% reduction in the number of age samples. The age and length sampling in 2016 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
Long lines	870	0	0	1	199
Gillnets	2520	12	298	13	1346
Jiggers	1720	4	100	11	1594
Danish seine	900	2	50	2	250
Bottom trawl	42770	65	1805	189	33312
Other gear	430	0	0	0	0
Total	49200	83	2253	216	36701

Foreign landings that are 291 tonnes are included in the numbers above. They are caught by longlines (105 tonnes) and handlines (185 tonnes).

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.

In recent years increased proportion of saithe catches has been caught north-west of Iceland (figure 8.3). This situation could lead to potential problem, if the sampling effort does not follow distribution in the catches. To look at this problem catch in numbers were recompiled using 12 cells, 3 gear (bottom trawl, gillnets and handlines), 2 areas (north and south) and 2 time periods (Jan-May and June-Dec). The resulting catch in numbers are nearly identical (figure 8.6) and using it in assessment leads to less than 1% difference of reference biomass in 2017 (329 vs 327). Catch in number 2016 is similar to last year's prediction. (Figure 8.5).

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 Figures 8.7 and 8.8). The large 2012 yearclass has the lowest mean weight of all yearclasses, both in catches and in the survey. The long-term trend since 1980 has been a gradual decline in the weight of all ages. Weighs at age in the landings are used to compile the reference biomass (B4+) that is the basis for the catch advice. Catch weights are also used to compile the spawning stock. Catch weights for the assessment year are predicted by applying a linear model using survey weights in the assessment year and the weight of a year class in the previous year as predictors (Magnusson 2012).

Maturity at ages 4-9 has decreased in recent years and is currently around average (Table 8.4 and Figure 8.9). 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 in 2011, spring survey data were considered superior to the autumn survey for calibrating the assessment, both due to more stations and longer time series. Saithe is among the most difficult demersal fishes to get reliable information on from bottom trawl surveys. In the spring survey, which has 500-600 stations, a large proportion of the saithe is caught in relatively few hauls and there seems to be considerable inter-annual variability in the number of these hauls.

The survey biomass indices fluctuated greatly in 1985-1995, but were consistently low in 1995-2001. Since 1995 the indices have been variable but compared to the period 1985 -1995 the variability seems "real" rather than noise. This difference is also seen by the estimated confidence intervals of the indices that are smaller after 1995. In 2017 the indices are among the highest in the series and have increased by 50% since 2014. (Table 8.5 and Figure 8.10). Most of the increase is caused by the 2012 yearclass that was strong in the surveys 2016 and 2017 (figure 8.12).

The high index in March 1986 (figure 8.10) is mostly the result of one large haul that is scaled down to the second largest haul when compiling indices for tuning. The scaling is from 16 tons to 1 ton.

When last benchmark was conducted (2010) the survey series for the autumn survey was relatively short and not considered suitable for tuning but "burn in period" of a survey is longer when the indices are noisy. This might change in the next benchmark and the 2004 autumn survey might require "special treatment" like the 1986 survey in March.

Internal consistency in the March survey measured by the correlation of the indices for the same year class in 2 adjacent surveys is relatively poor, with R^2 close to 0.3 where it is highest.

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.

The biomass index from the March survey indicates that the stock is above average level and and has been increasing in last 3 years. The autumn survey shows the stock at relatively high level but the vales before 2000 might be underestimate due to stations added in 2000 (figure 8.4) where some saithe is found The upward trend of last 3 years is not as obvious in the autumn survey indices that are more noisy than the indices from the March survey. Indices from the gillnet survey conducted south and west of Iceland since 1996 have been high from 2015-2017. (Figure 8.11). The gillnet survey is mostly targeting large saithe (mean weight in 2016 was 6.7 kg). To summarize all the surveys indicate that the stock is relatively large in 2017.

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 3-14 from 1980 onwards) and survey indices at age (ages 2-10 from 1985 onwards). The selectivity pattern is constant within each period (Figure 8.13). Natural mortality is set at 0.2 for all ages.

The commercial catch-at-age residuals (Figure 8.18) are relatively small in 2017 for younger ages. The survey residuals in 2016 (figure 8.17) show positive values in 2016 for ages 4-6, the agegroups accounting for most of the biomass. The survey catch-at-age residuals (Figure 8.17) 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).

The assessment model is also used for short term forecast.

The input for the short-term forecast is shown in Tables 8.3, 8.4 and 8.7. 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 which is essentially geometric mean when the stock is above estimated break point that is near B_{loss}.

The landings for the ongoing calendar year are predicted based on the 20% HCR, with the calendar year landings consisting of remainder the ongoing fishing year's TAC and 1/3 of the next fishing year's TAC. Looking at last two fishing years where the TAC was not caught and trends in landings (figure 8.2) the value obtained is likely to be an overestimate.

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 $SSB \geq B_{trigger}$, the TAC set in year *y* equals the average of 0.20 times the current biomass and last year's TAC:

$$TAC_{y+1/y} = 0.5 \times 0.20\, B_{y,4+} + 0.5\, TAC_{y/y-1} \quad \text{(Eq. 1)}$$

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

$$TAC_{y+1/y} = SSB_y/B_{trigger}\, [\, (1 - 0.5\, SSB_y/B_{trigger})\, 0.20\, B_{t,4+}) + 0.5\, TAC7_{y/y-1} \quad] \quad \text{(Eq. 2)}$$

Equation 1 is a plain average of two numbers. Equation 2 is continuous over $SSB_y/B_{trigger}$, so the rule does not lead to very different TAC when SSB_y is slightly below or above $B_{trigger}$.

At the NWWG meeting 2016 definition of B_{lim} and B_{pa} were revisited. Also F_{pa} and F_{lim} were defined but these points were not considered necessary when the HCR was evaluated in 2013. The new values of B_{lim} and B_{pa} were 44 and 61 thous. tonnes.

8.6 State of the stock

The results of the principal stock quantities (Table 8.6 and Figure 8.14) show that the reference biomass (B4+) has historically ranged from 130 to 410 kt (in 1999 and 1988), but this range has been narrower since 2003, between 220 and 327 kt. The current stock size of B4+ of 327 kt is among the highest in the time series (1980 to the present). Spawning biomass is estimated as 161 kt, the highest in the timeseries. In recent years B4+ has been below average since 1980 but SSB above. The reason is mostly low mean weight of younger cohorts that have more weight in B4+ than SSB (figure 8.8) but average mean weight at age of older age groups.

The harvest rate peaked around 30% in the mid 1990's, but has been below the HCR target of 20% since in last 3 years. Fishing mortality has been low since 2004 compared to before that. Part of the difference is caused by change in selection pattern that leads to F before and after 2004 not being comparable. SSB has been at a relatively high level during the last ten years.

Recruitment has been relatively stable since year class 2006, above average. Yearclass 2012 is estimated to be strong. The details of the fishing mortality and stock in numbers are presented in Tables 8.7 and 8.8.

The predicted landings in 2017 are 62 kt, what is left of the TAC 2016/17 in the beginning of the year 2017 plus 1/3rd of the TAC 2017/18 (60 kt). This value is most likely an overestimate as the TAC has not been reached in last fishing years and there are indications that the TAC for the fishing year 2016/17 will not be reached. Assumptions about catches in 2017 have no effect on the TAC 2017/18 that is based on the biomass in the beginning of the year 2017.

8.7 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 8.19) 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 model configuration, both in terms of how fishing mortality are modelled and treatment of survey indices.

NR	TYPE OF MODEL AND SETTINGS	B4+(2016)	TAC(Y+1/Y)
1	Separable 3 perids	327	60.2
2	Separable 1 period	346	62.1
3	Separable 3 periods less weight on survey*	214	48.9
4	Separable 3 periods survey outliers not included	334	60.9
5	Separable 3 periods random walk	303	57.8
6	Adapt	427	70.2
7	Cod model flexible selection pattern, random walk	314	58.9
8	Std SAM	354	62.9
9	Improved SAM	297	57.2

(* CV of survey is estimated automatically but weighted down to 5% here). All models except model 7-9 are based on more or less same code. Model 4 uses different data, i.e survey indices are compiled by Winchorizing. Std SAM are the devault settings while number of observation parameters has been increased in the other SAM run.

The results of the different models can be somewhat different (figure 8.21 and table above) with B4+ in 2017 (the number that matters for the advice) ranging from 200 thous. tonnes to 420 thous. tonnes. The highest number is from an Adapt type model and the lowest numbers from model with very low weight on the survey. Adapt type models have not been considered suitable for this stock as they do not utilize the information included in the catch data, which is a problem when survey data are as noisy as they are here. The extreme models are model not using the survey (#4) and model only using the survey (#6). The general trend is that the survey indicates larger stock than catch data.

Taking the catch at age models tuned with the survey the range of $B4+_{2017}$ is from 297-354. The extreme values are SAM models with different settings of the observation variances. This difference between models is well within what could be expected according to precision of the stock estimate CV(B4+)=0.2. The assessment indicates higher stock than last years assessment (figures 8.15, 8.19). The retrospective pattern shows that the results have often changed more by including one more year of data.

The main uncertainty in the current assessment is the fact that the TAC has not been fished in last 2 fishing years and there are indications that landings in the current fishing year will be below TAC. The assessment models indicate substantial reduction of fishing mortality and harvest rate in last 3 years, partly because the TAC has not been fished Random walk constrain on fishing mortality works against this reduction, therefore models with random walk constraint indicate smaller stock. The selection pattern observed since 2004 (figure 8.13) indicates that the fisheries are targeting younger fish than before, something that could be interpreted as lack of large fish. This trend is even greater than observed in the figure as mean weight at age of ages 4 – 5 have been low in recent years (figure 8.8) Other measures of stock size, not used directly in the assessment model like the autumn survey and gillnet survey (figures 8.10 and 8.11) do indicate good state of stock.

The problem seen in recent years is not new and the fact that fishing mortality of saithe was never really high indicates that it might be difficult to catch. One reason is that most of the gear is demersal while saithe is partly pelagic. Change of fleet and fishing practice in recent 10-20 years might also have effects. (See section 8.9) and the conclusions of that section is really that there is nothing wrong with the saithe assessment, change in fishing patterns and gear composition of the fleet is increasing the problem of catching the saithe quota.

8.8 Ecosystem considerations

Changes in the distribution of large pelagic stocks (blue whiting, mackerel, Norwegian spring-spawning herring, Icelandic summer-spawning herring) may affect the propensity of saithe to migrate off shelf and between management units. Saithe is a migrating species and makes both vertical and long-distance feeding and spawning migrations (Armannsson et al. 2007, Armannsson and Jonsson 2012, i Homrum et al. 2013). The evidence from tagging experiments (ICES 2008) show some migrations along the Faroe-Iceland Ridge, as well as onto the East Greenland shelf.

8.9 Changes in fishing technology and fishing patterns

Before 2000 the 15-40% of the saithe was caught in gillnets but only around 5% in recent years. This change is caused by substantial reduction of gillnet boats, especially since 2007. From 1998 to 2015 increased part of the catch of cod (main target species of the Icelandic demersal fleet) was caught by longliners. The fleet has changed so the number of longliners is increasing but the number of gillnets boats, boats operating Danish sein and trawlers is decreasing. Longliners do hardly catch saith but the other 3 gear types are all catching saithe.

Reduced harvest rate of cod that seems to be a more easily caught fish leads to saithe fishing being difficult without catching too much cod. Large part of the cod is exported fresh and the captains of many trawlers are asked to avoid cod except in the last 2 days of each fishing trip (5-6 days). Recent distribution of saithe in the North-west area could make this a difficult stragety and having to avoid cod is an extra constraint on saithe fisheries.

Many captains complain that finding saithe is difficult and the increased selection seen in last decade (figure 8.13) indicates that the fleet is targeting much smaller saithe than before (mean weight at age of ages 3-5 is also very low in recent years). The observed change in selection pattern indicates that the larger saithe is less available to the trawl fisheries than before. The selection pattern observed since 2004 leads to 10% less yield per recruit compared to average selection of the time period.

Looking at the catches of trawlers divided into those that freeze the catch and those that land it fresh, 45% of the catch of saithe by trawlers is taken by the freezing vessels, 55% of redfish but only 20% of the cod catch (figure 8.21). Freezing vessels are not required to catch the cod just before landing so some bycatch of cod is therefore not considered a problem there. The difference shown here could be an indication of the problem that the captains of the "fresh fish trawlers" are facing but "fresh fish trawlers" are majority of the trawlers.

Redfish is a species that has some effect on saithe fisheries. In recent years, catching redfish has been relatively easy as it can be found in very dense schools west of Iceland. Also, the distribution has changed so it is now abundant in the regions north-west of Iceland where cod and saithe is caught. Redfish is not a wanted bycatch in cod fisheries as it scratches the skin of the cod making it less valuable (less of a problem for freezing trawlers where the fish is unskinned). Therefore, the directed cod-fisheries are conducted with relatively large mesh size to get rid of most of redfish. A consequence is that bycatch of saithe is small as saithe in the area is relatively small.

If the conclusions above are correct, lowering the target harvest rate to get better balance in mixed fisheries. might be an option. A harvest rate of 16% next year would lead to unchanged TAC and probably little change in the following years. There are still no indications that the premises behind the HCR evaluations in 2013 need to be investigated again, the problem described is a mixed fisheries problem. Harvest rate of 16% is well below the maximum that would be considered in conformity with the ICES MSY approach that, is 20% or higher.

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					102 737
1992	195	1 570			77 832					79 597
1993	104	1 562			69 982					71 648
1994	30	975		1	63 333					64 339
1995		1 161		1	47 466	1				48 629
1996		803		1	39 297					40 101
1997		716			36 548					37 264
1998		997		3	30 531					31 531
1999		700		2	30 583	6	1	1		31 293
2000		228		1	32 914	1	2			33 146
2001		128		14	31 854	44	23			32 063
2002		366		6	41 687	3	7	2		42 071
2003		143		56	51 857	164			35	52 255
2004		214		157	62 614	1	105			63 091
2005		322		224	67 283	2			312	68 143

	Belgium	Faroes	France	Germany	Iceland	Norway	UK (E/W/NI)	UK (Scot)	UK	Total
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
2015		499			47 973	3				48 473
2016		287			48 920	5				49 212

Table 8.2. Saithe in division Va. Commercial catch at age (thousands).

YEAR	3	4	5	6	7	8	9	10	11	12+
1980	275	2540	5214	2596	2169	1341	387	262	155	209
1981	203	1325	3503	5404	1457	1415	578	242	61	417
1982	508	1092	2804	4845	4293	1215	975	306	59	129
1983	107	1750	1065	2455	4454	2311	501	251	38	18
1984	53	657	800	1825	2184	3610	844	376	291	546
1985	376	4014	3366	1958	1536	1172	747	479	74	166
1986	3108	1400	4170	2665	1550	1116	628	1549	216	95
1987	956	5135	4428	5409	2915	1348	661	496	498	133
1988	1318	5067	6619	3678	2859	1775	845	226	270	132
1989	315	4313	8471	7309	1794	1928	848	270	191	221
1990	143	1692	5471	10112	6174	1816	1087	380	151	168
1991	198	874	3613	6844	10772	3223	858	838	228	51
1992	242	2928	3844	4355	3884	4046	1290	350	196	125
1993	657	1083	2841	2252	2247	2314	3671	830	223	281
1994	702	2955	1770	2603	1377	1243	1263	2009	454	428
1995	1573	1853	2661	1807	2370	905	574	482	521	154
1996	1102	2608	1868	1649	835	1233	385	267	210	447
1997	603	2960	2766	1651	1178	599	454	125	95	234
1998	183	1289	1767	1545	1114	658	351	265	120	251
1999	989	732	1564	2176	1934	669	324	140	72	75
2000	850	2383	896	1511	1612	1806	335	173	57	57
2001	1223	2619	2184	591	977	943	819	186	94	69
2002	1187	4190	3147	2970	519	820	570	309	101	53
2003	2284	4363	6031	2472	1942	285	438	289	196	72
2004	952	7841	7195	5363	1563	1057	211	224	157	124
2005	2607	3089	7333	6876	3592	978	642	119	149	147
2006	1380	10051	2616	5840	4514	1989	667	485	118	229
2007	1244	6552	8751	2124	2935	1817	964	395	190	99
2008	1432	3602	5874	6706	1155	1894	1248	803	262	307
2009	2820	5166	2084	2734	2883	777	1101	847	555	373
2010	2146	6284	3058	997	1644	1571	514	656	522	409
2011	2004	4850	4006	1502	677	1065	1145	323	433	469
2012	1183	4816	3514	2417	903	432	883	1015	354	549
2013	1163	5538	6366	2963	1610	664	375	537	460	320
2014	668	3499	4867	2805	1276	725	347	241	312	401
2015	781	2712	6461	2917	1509	694	589	249	133	347
2016	1588	6230	2653	2838	1648	1059	526	337	148	131

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

YEAR	3	4	5	6	7	8	9	10	11	12+
1980	1428	1983	2667	3689	5409	6321	7213	8565	9147	9979
1981	1585	2037	2696	3525	4541	6247	6991	8202	9537	9523
1982	1547	2194	3015	3183	5114	6202	7256	7922	8924	10021
1983	1530	2221	3171	4270	4107	5984	7565	8673	8801	9445
1984	1653	2432	3330	4681	5466	4973	7407	8179	8770	10520
1985	1609	2172	3169	3922	4697	6411	6492	8346	9401	10767
1986	1450	2190	2959	4402	5488	6406	7570	6487	9616	11080
1987	1516	1715	2670	3839	5081	6185	7330	8025	7974	10886
1988	1261	2017	2513	3476	4719	5932	7523	8439	8748	9823
1989	1403	2021	2194	3047	4505	5889	7172	8852	10170	11194
1990	1647	1983	2566	3021	4077	5744	7038	7564	8854	11284
1991	1224	1939	2432	3160	3634	4967	6629	7704	9061	9547
1992	1269	1909	2578	3288	4150	4865	6168	7926	8349	10181
1993	1381	2143	2742	3636	4398	5421	5319	7006	8070	9842
1994	1444	1836	2649	3512	4906	5539	6818	6374	8341	10388
1995	1370	1977	2769	3722	4621	5854	6416	7356	6815	8799
1996	1229	1755	2670	3802	4902	5681	7182	7734	9256	9601
1997	1325	1936	2409	3906	5032	6171	7202	7883	8856	9865
1998	1347	1972	2943	3419	4850	5962	6933	7781	8695	10043
1999	1279	2106	2752	3497	3831	5819	7072	8078	8865	10872
2000	1367	1929	2751	3274	4171	4447	6790	8216	9369	10443
2001	1280	1882	2599	3697	4420	5538	5639	7985	9059	10419
2002	1308	1946	2569	3266	4872	5365	6830	7067	9240	10190
2003	1310	1908	2545	3336	4069	5792	7156	8131	8051	10825
2004	1467	1847	2181	2918	4017	5135	7125	7732	8420	9547
2005	1287	1888	2307	2619	3516	5080	6060	8052	8292	8569
2006	1164	1722	2369	2808	3235	4361	6007	7166	8459	9583
2007	1140	1578	2122	2719	3495	4114	5402	6995	7792	9848
2008	1306	1805	2295	2749	3515	4530	5132	6394	7694	9589
2009	1412	1862	2561	3023	3676	4596	5651	6074	7356	9237
2010	1287	1787	2579	3469	4135	4850	5558	6289	6750	8785
2011	1175	1801	2526	3680	4613	5367	5685	6466	6851	7739
2012	1160	1668	2369	3347	4430	5486	6161	6448	7220	8236
2013	1056	1675	2219	3244	4529	5628	6397	7055	7378	8342
2014	1211	1575	2229	2983	4378	5598	6773	8023	7875	9020
2015	1072	1639	2141	3122	4262	5555	6633	7697	8269	8773
2016	1105	1468	2260	3071	4127	5272	6379	7247	8566	8969
2017	1129	1595	2091	3099	4034	5276	6464	7656	8237	8965
2018	1129	1595	2091	3099	4034	5276	6464	7656	8237	8965

Table 8.4. Saithe in division Va. Maturity at age, with predictions in gray.

YEAR	3	4	5	6	7	8	9	10	11	12
1980	0	0.084	0.189	0.373	0.602	0.793	0.907	1	1	1
1981	0	0.084	0.189	0.373	0.602	0.793	0.907	1	1	1
1982	0	0.084	0.189	0.373	0.602	0.793	0.907	1	1	1
1983	0	0.084	0.189	0.373	0.602	0.793	0.907	1	1	1
1984	0	0.084	0.189	0.373	0.602	0.793	0.907	1	1	1
1985	0	0.084	0.189	0.373	0.602	0.793	0.907	1	1	1
1986	0	0.076	0.173	0.347	0.574	0.774	0.897	1	1	1
1987	0	0.069	0.158	0.323	0.548	0.755	0.887	1	1	1
1988	0	0.063	0.146	0.302	0.524	0.737	0.877	1	1	1
1989	0	0.058	0.136	0.285	0.504	0.721	0.868	1	1	1
1990	0	0.055	0.129	0.273	0.488	0.708	0.86	1	1	1
1991	0	0.053	0.125	0.266	0.48	0.701	0.856	1	1	1
1992	0	0.053	0.124	0.265	0.479	0.7	0.856	1	1	1
1993	0	0.054	0.128	0.271	0.486	0.706	0.859	1	1	1
1994	0	0.058	0.136	0.285	0.503	0.72	0.867	1	1	1
1995	0	0.065	0.149	0.308	0.531	0.742	0.88	1	1	1
1996	0	0.075	0.17	0.343	0.57	0.771	0.896	1	1	1
1997	0	0.09	0.2	0.389	0.618	0.805	0.913	1	1	1
1998	0	0.109	0.237	0.442	0.668	0.836	0.929	1	1	1
1999	0	0.131	0.277	0.494	0.712	0.863	0.941	1	1	1
2000	0	0.152	0.314	0.537	0.747	0.882	0.95	1	1	1
2001	0	0.168	0.34	0.567	0.769	0.894	0.955	1	1	1
2002	0	0.174	0.349	0.577	0.776	0.898	0.957	1	1	1
2003	0	0.172	0.345	0.573	0.773	0.896	0.956	1	1	1
2004	0	0.163	0.331	0.558	0.762	0.891	0.954	1	1	1
2005	0	0.152	0.314	0.537	0.747	0.882	0.95	1	1	1
2006	0	0.142	0.296	0.516	0.731	0.873	0.946	1	1	1
2007	0	0.134	0.283	0.5	0.718	0.866	0.943	1	1	1
2008	0	0.129	0.274	0.489	0.709	0.861	0.94	1	1	1
2009	0	0.126	0.268	0.482	0.703	0.857	0.939	1	1	1
2010	0	0.123	0.264	0.476	0.698	0.855	0.937	1	1	1
2011	0	0.121	0.259	0.47	0.693	0.852	0.936	1	1	1
2012	0	0.117	0.253	0.462	0.686	0.847	0.934	1	1	1
2013	0	0.113	0.244	0.451	0.676	0.841	0.931	1	1	1
2014	0	0.107	0.234	0.437	0.663	0.833	0.927	1	1	1
2015	0	0.101	0.222	0.42	0.648	0.824	0.922	1	1	1
2016	0	0.094	0.209	0.402	0.631	0.813	0.917	1	1	1
2017	0	0.088	0.197	0.384	0.613	0.801	0.911	1	1	1
2018	0	0.088	0.197	0.384	0.613	0.801	0.911	1	1	1

Table 8.5. Saithe in division Va. Survey indices at age.

YEAR	2	3	4	5	6	7	8	9	10
1985	0.59	0.56	3.1	5.31	1.8	1.09	0.51	1.4	0.16
1986	2.3	2.46	2.15	2.2	1.49	0.65	0.3	0.19	0.33
1987	0.38	11.84	13.22	6.61	4.08	3.18	0.82	0.37	0.27
1988	0.31	0.47	2.74	2.85	1.75	0.98	0.41	0.07	0.08
1989	1.42	3.95	5.09	6.65	2.53	1.81	0.92	0.4	0
1990	0.34	1.71	4.96	6.42	12.51	3.37	1.23	0.65	0.12
1991	0.22	1.38	1.7	2.18	1.12	2.49	0.31	0.02	0.03
1992	0.14	0.92	5.88	5.65	2.84	2.72	1.94	0.28	0.06
1993	1.27	11.03	1.89	6.59	2.34	2.19	1.02	3.94	0.66
1994	0.81	0.74	1.93	1.78	2	0.53	0.81	0.94	3.48
1995	0.48	1.98	1.12	0.52	0.29	0.34	0.1	0.15	0.15
1996	0.12	0.51	3.77	1.13	1.03	0.59	0.97	0.06	0.09
1997	0.32	0.91	4.73	3.96	0.96	0.4	0.15	0.1	0.05
1998	0.11	1.65	2.35	2.54	1.28	0.72	0.29	0.08	0.07
1999	0.73	3.75	0.94	1.27	1.71	0.59	0.16	0.02	0.02
2000	0.38	2.02	2.54	0.61	0.87	0.54	0.44	0.08	0.03
2001	0.92	2.07	2.73	1.68	0.21	0.23	0.39	0.15	0.07
2002	1.02	2.24	3.01	3.1	2.2	0.42	0.46	0.32	0.21
2003	0.05	9.78	5.14	2.97	1.39	0.78	0.2	0.05	0.1
2004	0.9	1.39	9.54	6.17	4.43	1.51	0.84	0.17	0.17
2005	0.25	4.29	2.41	7.5	4.72	2.36	0.88	0.45	0.13
2006	0	2.19	6.76	1.98	8.85	3.5	1.21	0.29	0.25
2007	0.06	0.31	1.75	3.27	0.82	1.64	0.71	0.29	0.16
2008	0.08	2.26	1.81	2.88	4.05	0.62	0.79	0.34	0.15
2009	0.21	2.45	1.85	0.69	0.91	0.84	0.12	0.26	0.15
2010	0.07	1.24	5.07	2.55	0.64	0.61	0.47	0.07	0.12
2011	0.15	3.84	4.24	3.1	1.17	0.41	0.39	0.44	0.17
2012	0.02	1.77	12.01	6.75	2.76	0.63	0.17	0.38	0.5
2013	0.11	4.28	7.57	6.85	4.67	2.58	1.12	0.3	0.44
2014	0.03	0.39	3.89	3.74	2.02	0.87	0.42	0.15	0.11
2015	0.04	1.08	1.93	3.22	1.73	0.82	0.72	0.66	0.43
2016	0.05	3.17	16.21	2.75	2.27	1.08	0.54	0.44	0.29
2017	0.02	1.48	6.67	14.64	3.03	1.68	0.87	0.45	0.32

Table 8.6. Saithe in division Va. Main population estimates.

YEAR	B4+	SSB	N3	YIELD	F4-9	HR
1980	312	113	28	58	0.29	18.5
1981	305	120	20	58	0.26	18.9
1982	294	137	22	68	0.3	23.1
1983	270	137	32	57	0.24	20.9
1984	287	140	42	60	0.23	21
1985	300	138	35	54	0.25	17.9
1986	319	136	67	65	0.28	20.5
1987	336	128	91	80	0.35	23.9
1988	415	125	51	77	0.32	18.6
1989	398	128	32	82	0.31	20.7
1990	377	135	21	98	0.35	25.9
1991	337	144	29	102	0.37	30.4
1992	288	136	15	80	0.37	27.6
1993	231	112	20	72	0.4	31
1994	187	93	18	64	0.45	34
1995	153	69	30	48	0.46	31.6
1996	149	60	26	39	0.4	26.4
1997	156	61	17	37	0.36	23.5
1998	154	68	9	31	0.3	19.9
1999	133	73	31	31	0.31	23.3
2000	144	75	31	33	0.32	22.8
2001	163	82	54	32	0.27	19.3
2002	221	100	63	42	0.3	19
2003	281	123	72	52	0.29	18.6
2004	322	142	26	65	0.26	20.1
2005	287	151	73	69	0.28	24
2006	313	157	42	75	0.3	24.1
2007	284	153	19	64	0.28	22.6
2008	254	151	27	69	0.32	27.4
2009	228	139	40	60	0.3	26.4
2010	229	129	39	54	0.27	23.5
2011	236	123	47	51	0.25	21.5
2012	246	121	45	51	0.24	20.8
2013	260	126	47	58	0.26	22.1
2014	266	129	28	46	0.2	17.1
2015	267	140	67	48	0.19	18.1
2016	306	150	46	49	0.18	16.1
2017	327	161	28			
Average 1980-2016	264	121	38	59	0.3	22.7

Table 8.7. Saithe in division Va. Stock in numbers. Shaded area is input to prediction.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1980	32.3	24.7	28.2	46.8	30.9	10.3	8.1	3.7	1.3	0.7	0.7	0.5	0.3	0.1
1981	48	26.4	20.2	22.7	35.2	21.2	6.3	4.6	2	0.7	0.4	0.4	0.3	0.2
1982	62.6	39.3	21.6	16.3	17.3	24.6	13.3	3.7	2.6	1.1	0.4	0.2	0.2	0.2
1983	52.8	51.2	32.2	17.4	12.2	11.8	14.8	7.5	1.9	1.4	0.6	0.2	0.1	0.1
1984	99.9	43.2	41.9	26	13.3	8.6	7.6	9	4.3	1.1	0.8	0.4	0.1	0.1
1985	136.1	81.8	35.4	33.9	19.9	9.5	5.6	4.7	5.2	2.5	0.7	0.5	0.2	0.1
1986	75.4	111.4	67	28.6	25.8	14	6.1	3.4	2.6	3.1	1.4	0.4	0.3	0.1
1987	47.5	61.7	91.2	54	21.5	17.8	8.7	3.5	1.8	1.5	1.6	0.8	0.2	0.2
1988	31	38.9	50.5	73.2	39.9	14.3	10.3	4.6	1.7	0.9	0.7	0.9	0.4	0.1
1989	44	25.4	31.8	40.6	54.6	26.9	8.5	5.7	2.3	0.9	0.5	0.4	0.5	0.2
1990	22.1	36	20.8	25.6	30.4	37.2	16.2	4.7	2.9	1.3	0.5	0.3	0.2	0.3
1991	29.6	18.1	29.5	16.7	19	20.2	31.4	8.6	2.3	1.5	0.6	0.2	0.1	0.1
1992	26.4	24.3	14.8	23.6	12.3	12.4	11.4	16.2	4	1.1	0.7	0.3	0.1	0.1
1993	44.5	21.6	19.9	11.9	17.4	8.1	7	5.9	7.7	2	0.5	0.4	0.2	0.1
1994	38.3	36.5	17.7	15.9	8.7	11.2	4.4	3.5	2.7	3.6	0.9	0.3	0.2	0.1
1995	25.2	31.3	29.9	14.1	11.4	5.4	5.8	2.1	1.5	1.2	1.5	0.4	0.1	0.1
1996	13	20.7	25.7	23.8	10.1	7.1	2.8	2.7	0.9	0.6	0.5	0.7	0.2	0.1
1997	45.5	10.6	16.9	20.5	17.4	6.5	3.9	1.4	1.2	0.4	0.3	0.2	0.4	0.1
1998	46.8	37.3	8.7	13.4	14.6	11.3	3.9	2.1	0.7	0.6	0.2	0.1	0.1	0.2
1999	80.6	38.3	30.5	6.9	9.7	9.9	7.2	2.3	1.1	0.4	0.3	0.1	0.1	0.1
2000	94.5	66	31.3	24.3	5	6.6	6.2	4.1	1.2	0.6	0.2	0.2	0.1	0
2001	107.4	77.4	54	24.9	17.5	3.3	4.1	3.5	2.1	0.6	0.3	0.1	0.1	0
2002	38.3	87.9	63.4	43.1	18.3	12	2.2	2.4	1.9	1.1	0.3	0.2	0.1	0
2003	108.2	31.4	72	50.4	31.3	12.4	7.6	1.3	1.3	1	0.6	0.2	0.1	0
2004	62.6	88.6	25.7	57.3	36.8	21.3	7.9	4.5	0.7	0.7	0.5	0.3	0.1	0
2005	28.1	51.3	72.6	20.2	38.5	23	13.2	5	2.8	0.4	0.4	0.3	0.2	0.1
2006	39.7	23	42	56.8	13.3	23.4	13.8	8.1	3.1	1.7	0.2	0.2	0.2	0.1
2007	59.2	32.5	18.8	32.8	36.9	7.9	13.8	8.3	4.9	1.8	1	0.1	0.1	0.1
2008	57.6	48.4	26.6	14.8	21.7	22.5	4.8	8.5	5.2	3	1	0.5	0.1	0.1
2009	70.5	47.2	39.7	20.7	9.4	12.7	13	2.8	5.1	3	1.6	0.5	0.3	0
2010	67.8	57.7	38.6	31	13.5	5.6	7.5	7.8	1.7	3	1.7	0.8	0.3	0.1
2011	69.8	55.5	47.3	30.3	20.6	8.3	3.4	4.6	4.9	1.1	1.7	0.9	0.5	0.2
2012	42.1	57.2	45.5	37.2	20.5	13	5.2	2.2	3	3.1	0.6	1	0.5	0.3
2013	100.3	34.4	46.8	35.8	25.3	13	8.2	3.3	1.4	1.9	1.9	0.4	0.6	0.3
2014	68.5	82.1	28.2	36.8	24	15.8	8	5.1	2.1	0.9	1.1	1	0.2	0.3
2015	41.3	56.1	67.2	22.4	25.9	16	10.4	5.4	3.5	1.4	0.6	0.7	0.6	0.1
2016	48.4	33.8	45.9	53.4	15.8	17.3	10.6	7	3.7	2.3	0.9	0.3	0.4	0.4
2017	50.9	39.7	27.7	36.5	38	10.7	11.6	7.2	4.8	2.5	1.5	0.6	0.2	0.3
2018	51.2	41.7	32.5	21.9	25.2	24.6	6.9	7.6	4.8	3.1	1.5	0.9	0.3	0.1
2019	51.2	41.9	34.1	25.7	15.1	16.4	15.9	4.5	5	3.1	1.9	0.9	0.5	0.2

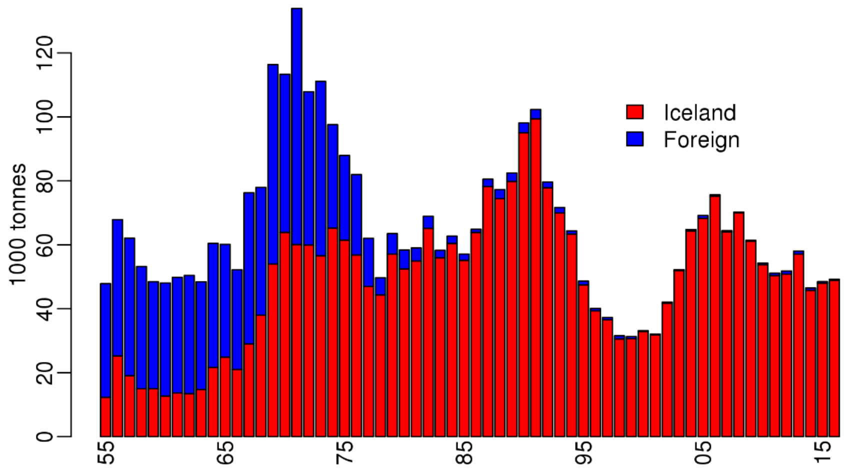
Table 8.8. Saithe in division Va. Fishing mortality rate.

YEAR	3	4	5	6	7	8	9	10	11	12	13	14
1980	0.016	0.085	0.178	0.295	0.363	0.437	0.407	0.437	0.358	0.358	0.358	0.358
1981	0.015	0.076	0.159	0.264	0.324	0.391	0.364	0.391	0.32	0.32	0.32	0.32
1982	0.017	0.088	0.183	0.304	0.374	0.451	0.42	0.451	0.369	0.369	0.369	0.369
1983	0.014	0.07	0.147	0.243	0.299	0.361	0.336	0.361	0.296	0.296	0.296	0.296
1984	0.013	0.067	0.139	0.232	0.285	0.343	0.32	0.343	0.281	0.281	0.281	0.281
1985	0.014	0.071	0.148	0.246	0.302	0.364	0.339	0.364	0.298	0.298	0.298	0.298
1986	0.016	0.082	0.17	0.283	0.348	0.419	0.39	0.419	0.343	0.343	0.343	0.343
1987	0.02	0.102	0.212	0.352	0.433	0.522	0.485	0.522	0.427	0.427	0.427	0.427
1988	0.018	0.094	0.195	0.323	0.398	0.479	0.446	0.479	0.393	0.393	0.393	0.393
1989	0.017	0.089	0.185	0.307	0.378	0.456	0.424	0.456	0.373	0.373	0.373	0.373
1990	0.019	0.101	0.211	0.351	0.431	0.52	0.484	0.52	0.426	0.426	0.426	0.426
1991	0.021	0.109	0.226	0.375	0.461	0.556	0.518	0.556	0.455	0.455	0.455	0.455
1992	0.02	0.106	0.221	0.368	0.452	0.545	0.507	0.545	0.446	0.446	0.446	0.446
1993	0.022	0.115	0.24	0.399	0.491	0.592	0.551	0.592	0.484	0.484	0.484	0.484
1994	0.025	0.131	0.272	0.452	0.556	0.671	0.624	0.671	0.549	0.549	0.549	0.549
1995	0.026	0.134	0.278	0.462	0.568	0.685	0.638	0.685	0.561	0.561	0.561	0.561
1996	0.022	0.117	0.243	0.404	0.497	0.599	0.558	0.599	0.491	0.491	0.491	0.491
1997	0.035	0.144	0.23	0.311	0.414	0.52	0.56	0.538	0.542	0.542	0.542	0.542
1998	0.029	0.117	0.187	0.253	0.336	0.422	0.455	0.437	0.44	0.44	0.44	0.44
1999	0.03	0.122	0.195	0.264	0.351	0.44	0.475	0.456	0.459	0.459	0.459	0.459
2000	0.032	0.129	0.206	0.278	0.37	0.464	0.501	0.481	0.484	0.484	0.484	0.484
2001	0.027	0.108	0.173	0.234	0.311	0.39	0.421	0.404	0.407	0.407	0.407	0.407
2002	0.029	0.118	0.189	0.255	0.339	0.426	0.459	0.441	0.445	0.445	0.445	0.445
2003	0.028	0.116	0.185	0.25	0.333	0.418	0.451	0.433	0.436	0.436	0.436	0.436
2004	0.041	0.197	0.27	0.279	0.261	0.252	0.279	0.327	0.382	0.382	0.382	0.382
2005	0.045	0.216	0.296	0.306	0.287	0.276	0.306	0.359	0.419	0.419	0.419	0.419
2006	0.048	0.233	0.318	0.329	0.309	0.297	0.329	0.387	0.451	0.451	0.451	0.451
2007	0.044	0.214	0.293	0.303	0.283	0.273	0.302	0.355	0.414	0.414	0.414	0.414
2008	0.051	0.247	0.337	0.349	0.327	0.315	0.349	0.409	0.478	0.478	0.478	0.478
2009	0.048	0.232	0.317	0.328	0.307	0.296	0.328	0.385	0.449	0.449	0.449	0.449
2010	0.043	0.208	0.284	0.294	0.275	0.265	0.294	0.345	0.402	0.402	0.402	0.402
2011	0.039	0.191	0.261	0.27	0.253	0.244	0.27	0.317	0.37	0.37	0.37	0.37
2012	0.038	0.185	0.253	0.261	0.245	0.236	0.261	0.307	0.358	0.358	0.358	0.358
2013	0.041	0.2	0.274	0.284	0.266	0.256	0.283	0.333	0.388	0.388	0.388	0.388
2014	0.031	0.15	0.205	0.212	0.199	0.192	0.212	0.249	0.291	0.291	0.291	0.291
2015	0.03	0.147	0.202	0.209	0.195	0.188	0.208	0.245	0.286	0.286	0.286	0.286
2016	0.029	0.14	0.192	0.199	0.186	0.179	0.198	0.233	0.272	0.272	0.272	0.272
2017	0.035	0.171	0.233	0.241	0.226	0.218	0.241	0.283	0.331	0.331	0.331	0.331
2018	0.035	0.17	0.232	0.24	0.225	0.217	0.24	0.282	0.329	0.329	0.329	0.329

Table 8.9. Saithe in division Va. Output from short-term projections.

2017						
B4+	SSB	Fbar	Landings			
327	161	0.222	62			
2018				2019		
B4+	SSB	Fbar	Landings	B4+	SSB	Rationale
311	168	0.221	60	297	171	20% HCR

20% HCR = average between 0.2 B4+ (current year) and last year's TAC. Landings in 2016 are most likely an overestimate as the quota remaining will not be caught (figure 8.2).



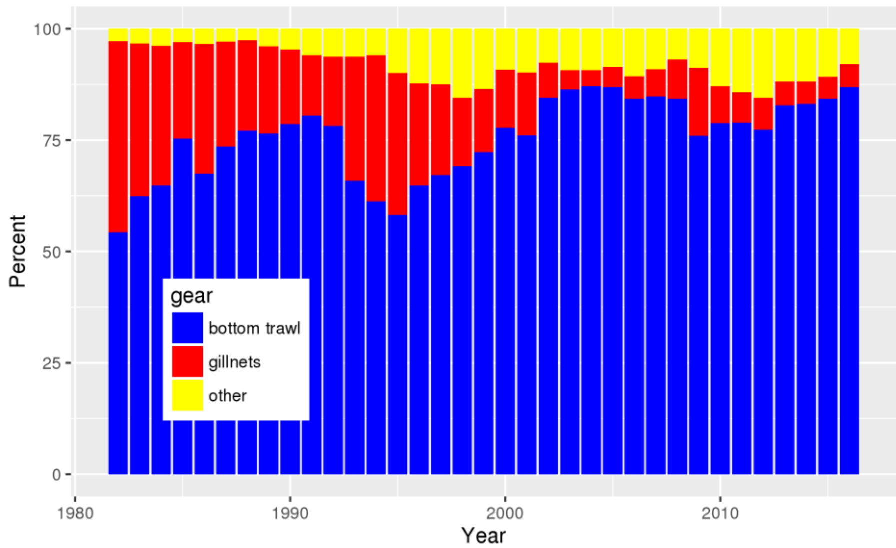
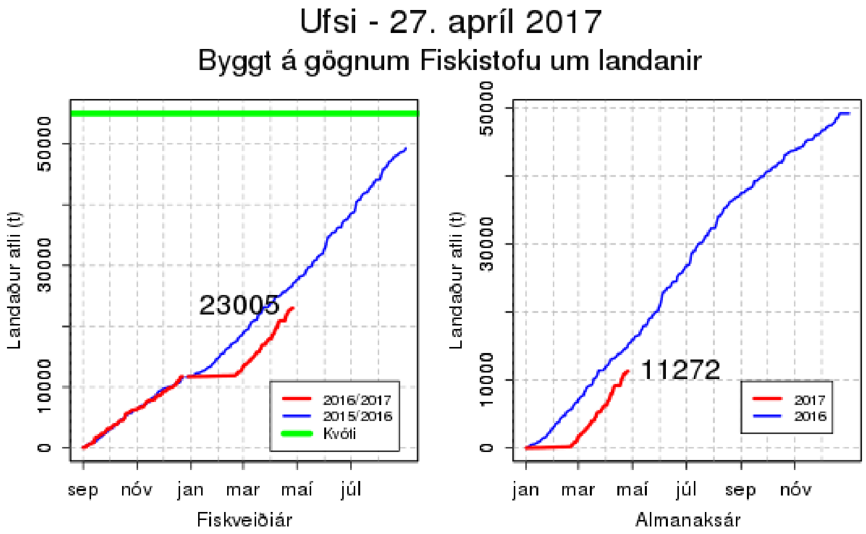


Figure 8.1 Saithe in Division Va. Total landings and percent by gear.



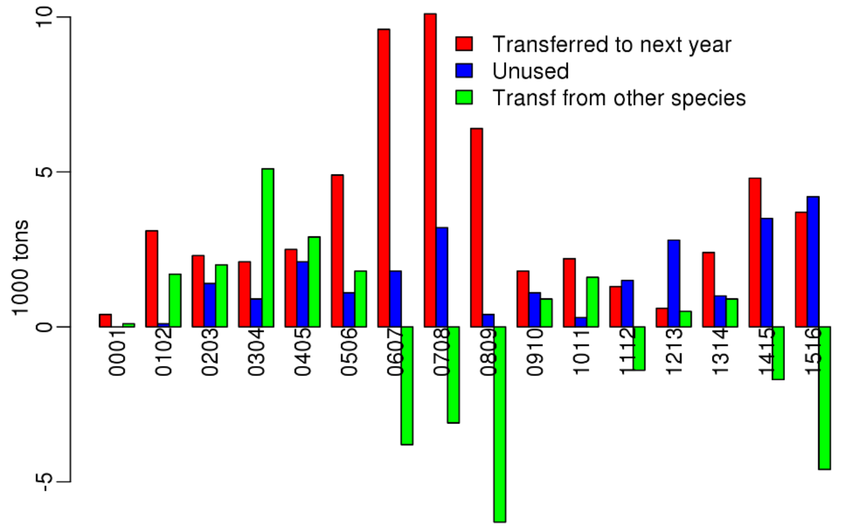


Figure 8.2 Saithe in division Va. Upper figure. Cumulative landings in the current fishing year (left) and calendar year (right). The vertical (green line) in the left figure shows the quota for the current fishing year. Lower figure. Transfer of quota to next fishing year, unused quota and transfer from other species (negative transfer from other species means transfer to other species).

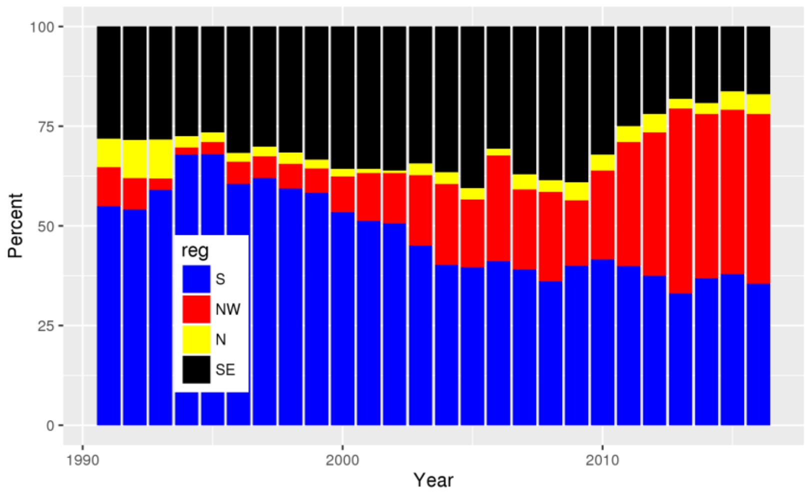


Figure 8.3 Saithe in division Va. Percent of landings by regions defined in figure 8.4.

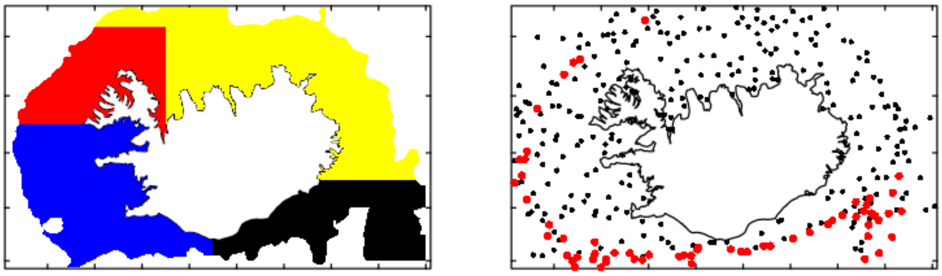


Figure 8.4 Saithe in division Va. Left, definitions of regions used in figures 8.3 and 8.6. Right, stations added in the autumnsurvey in 2000 (red dots).

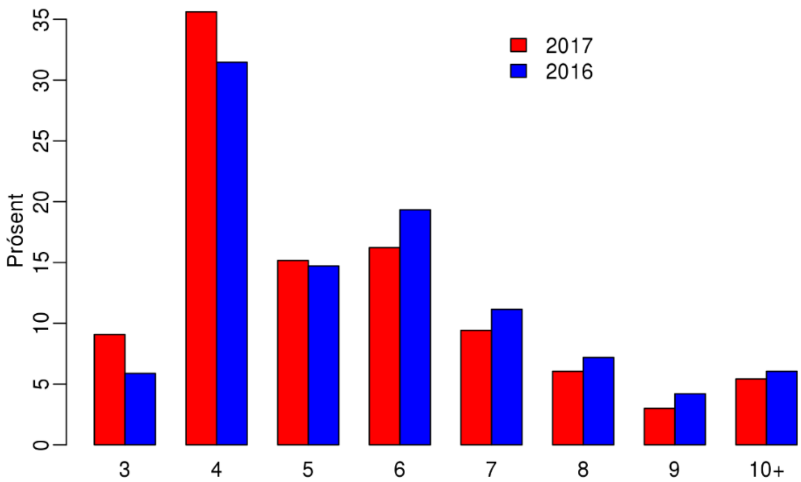


Figure 8.5. Catch in numbers 2015 compared to last years prediction.

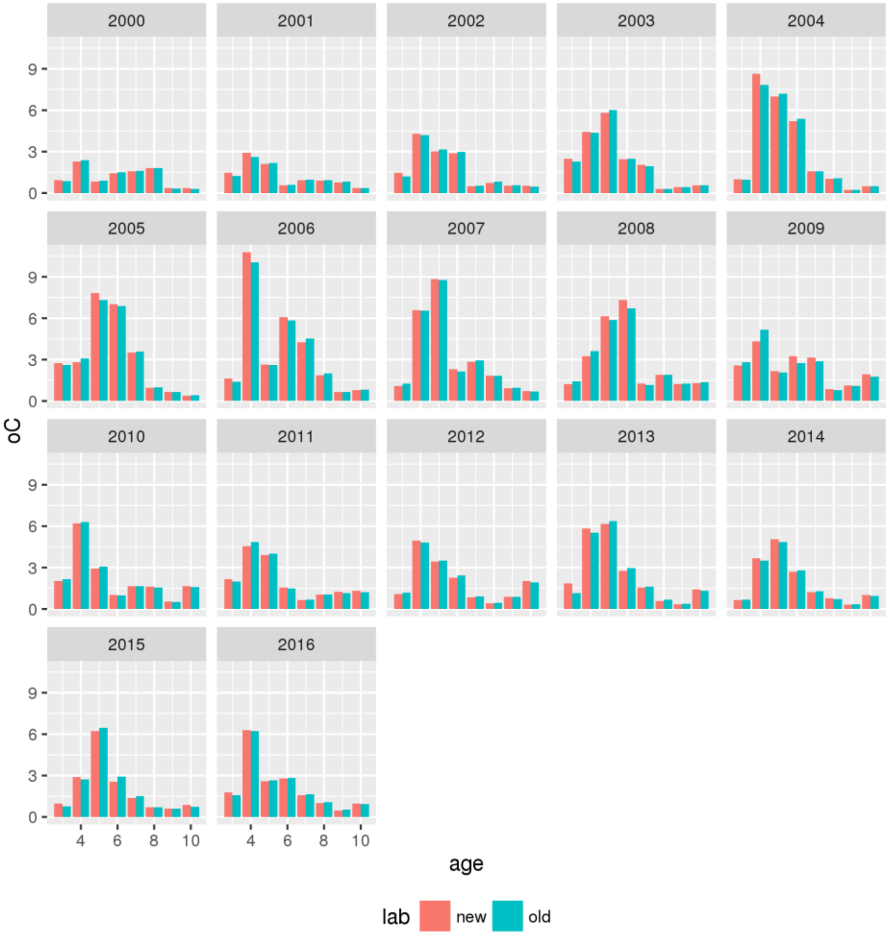


Figure 8.6. Catch in numbers 2000-2015 compiled by 1 region and 1 time interval (old) compared to catch in numbers compiled by 2 regions and 2 time interval (new) .   The regions are shown in figure 8.4, north red and yellow and south blue and black.

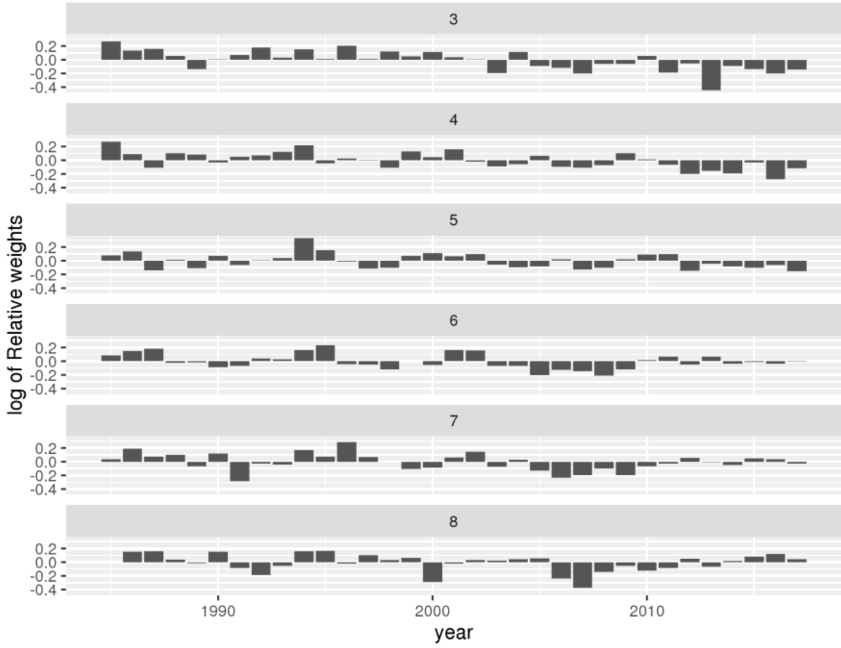


Figure 8.7 Saithe in division Va. Weight at age in the survey, as relative deviations from the mean.

Figure 8.8 Saithe in division Va. Weight at age in the catches, as relative deviations from the mean. Blue bars show prediction.

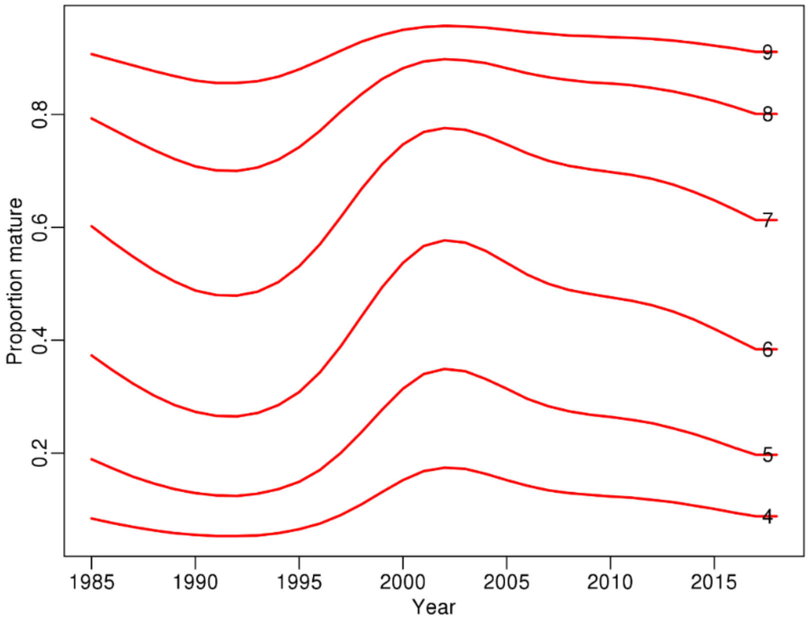


Figure 8.9 Saithe in division Va. Maturity at age used for calculating the SSB.

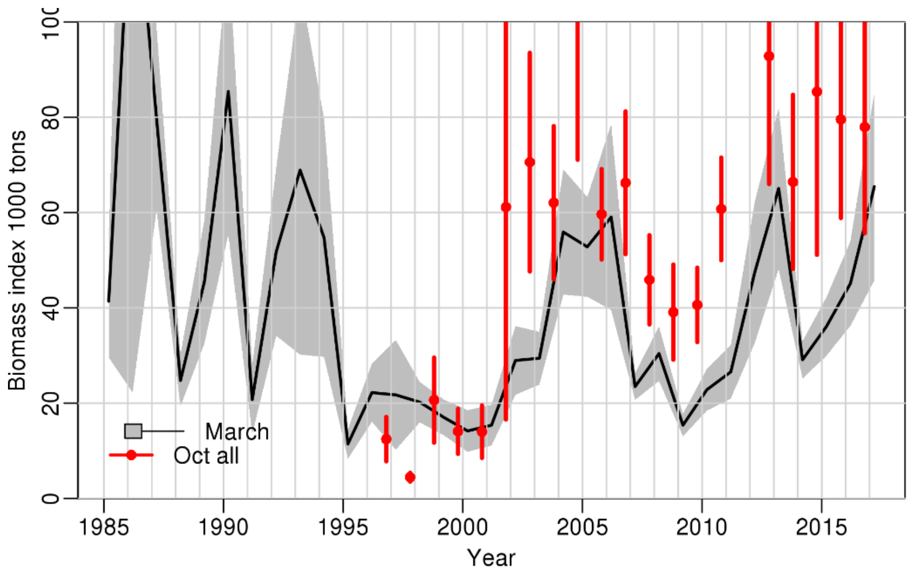


Figure 8.10 Saithe in division Va. Biomass index from the groundfish surveys in March and October.

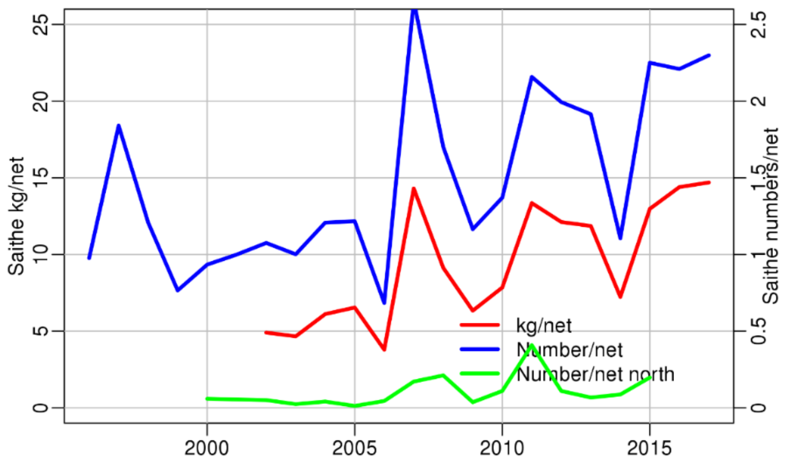


Figure 8.11 Saithe in division Va Indices from the gillnet survey in April 1996-2016. Saithe was not length measured in the survey before 2002 so catch in kg can not be compiled.

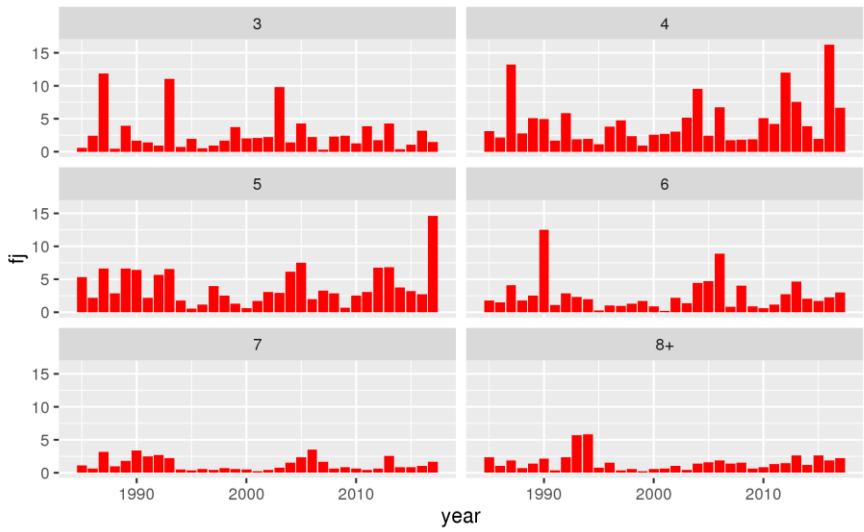


Figure 8.12 Saithe in division Va Survey indices by age from the spring survey.

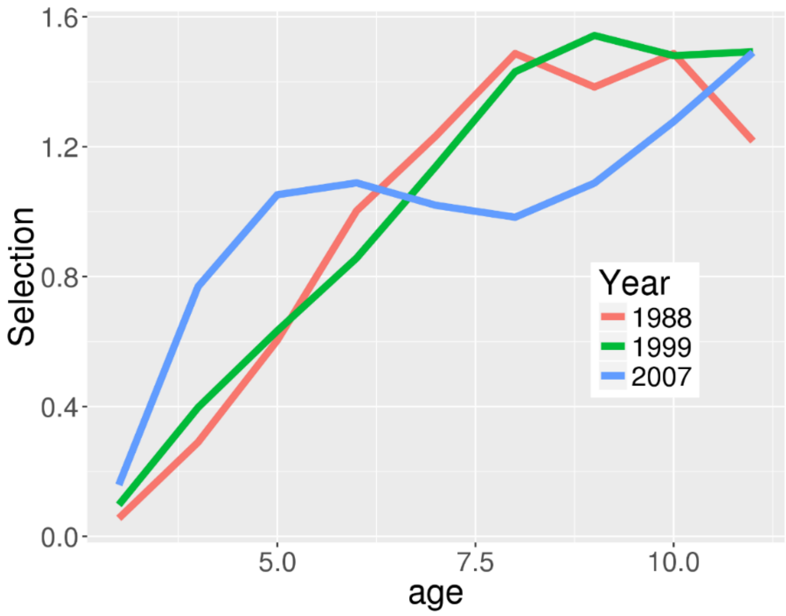


Figure 8.13. Estimated selectivity patterns for the 3 periods, 1980-1996, 1997-2003 and 2014-2016.

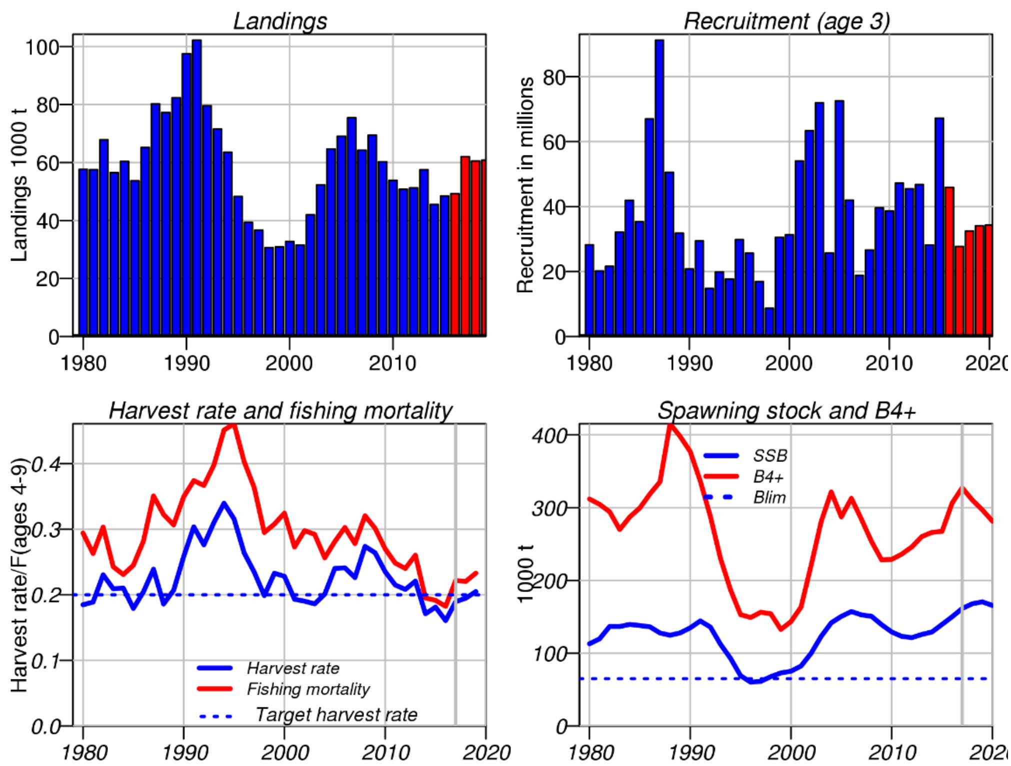


Figure 8.14. Saithe in division Va. Results from the fitted model and short-term forecast. The red line indicates the time of the current assessment.

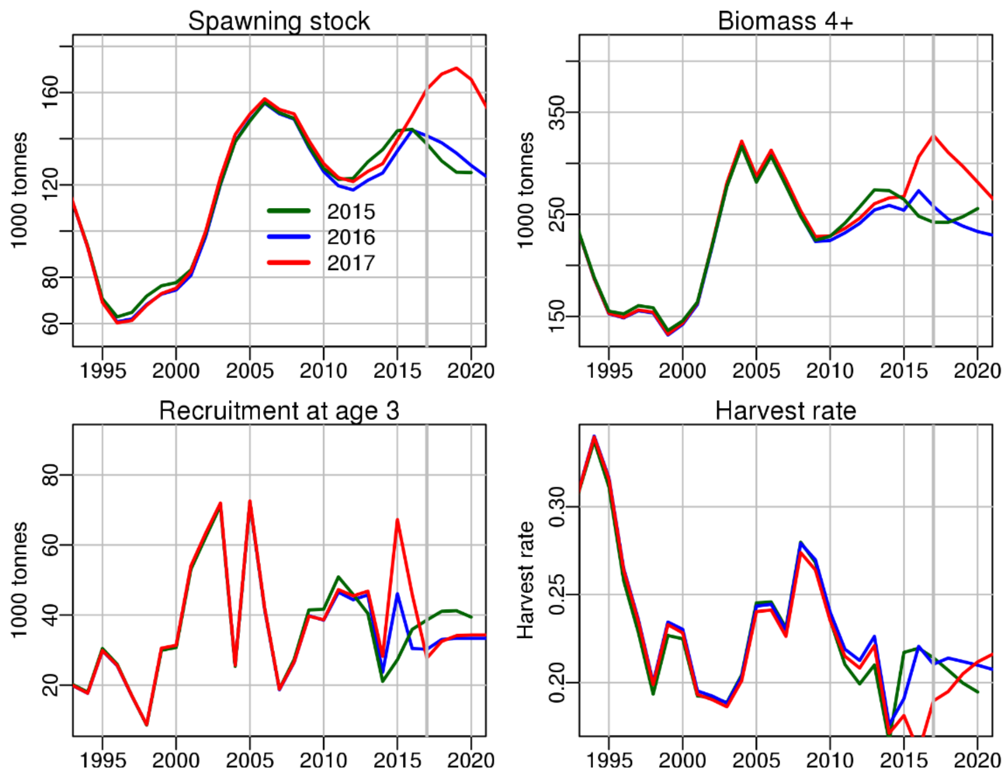


Figure 8.15. Saithe in division Va. Comparison of this year's assessment and short term forecast with results from two previous years.

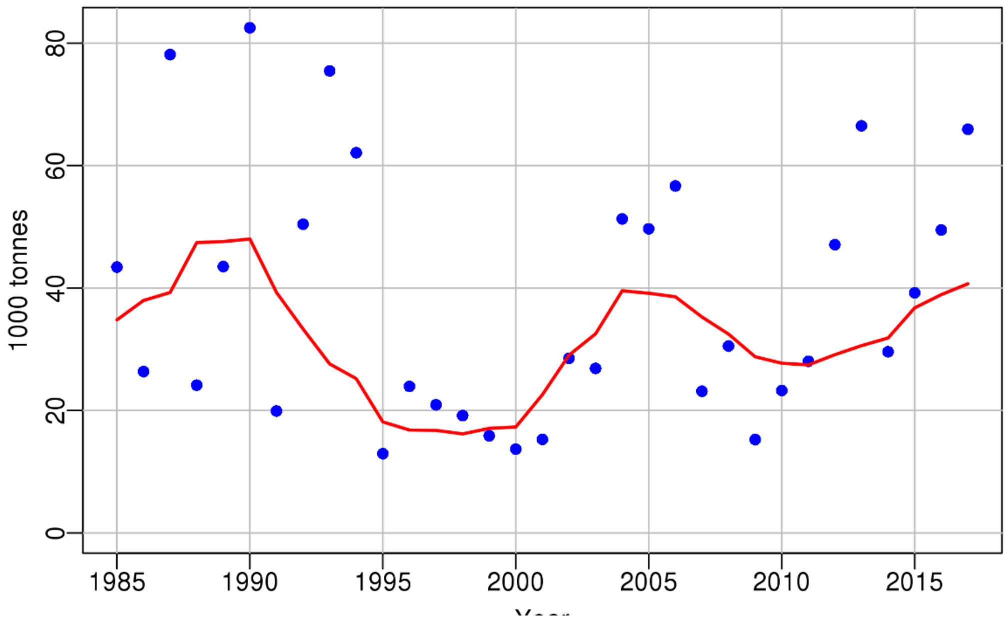


Figure 8.16. Saithe in division Va. Observed and predicted survey biomass from the "SPALY model".

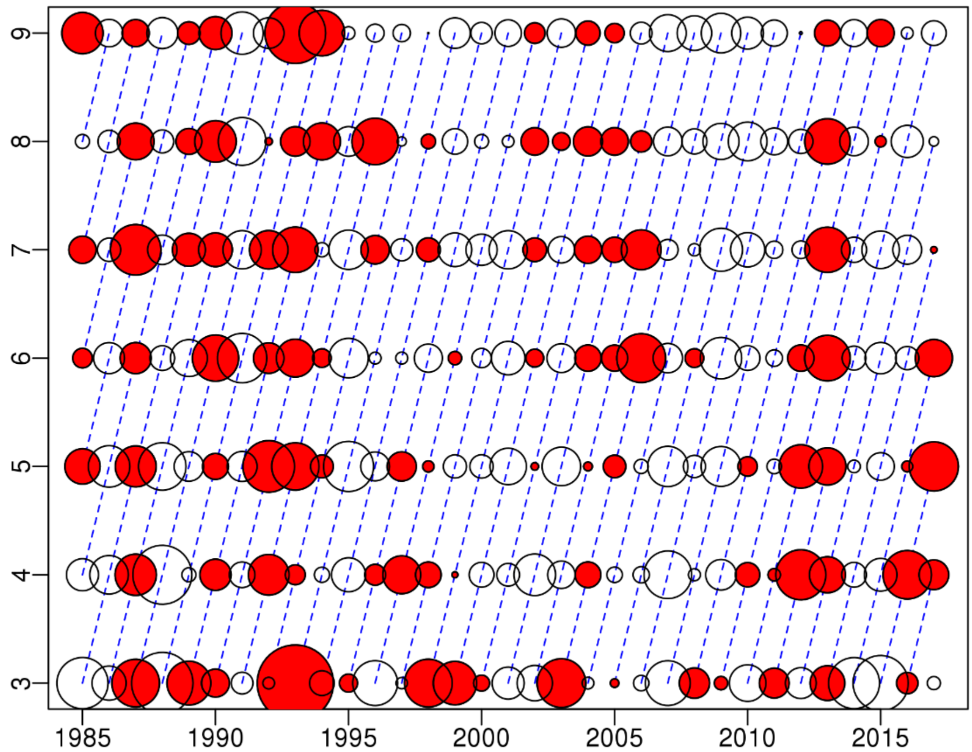


Figure 8.17. Saithe in division Va. Survey residuals from the "SPALY model".

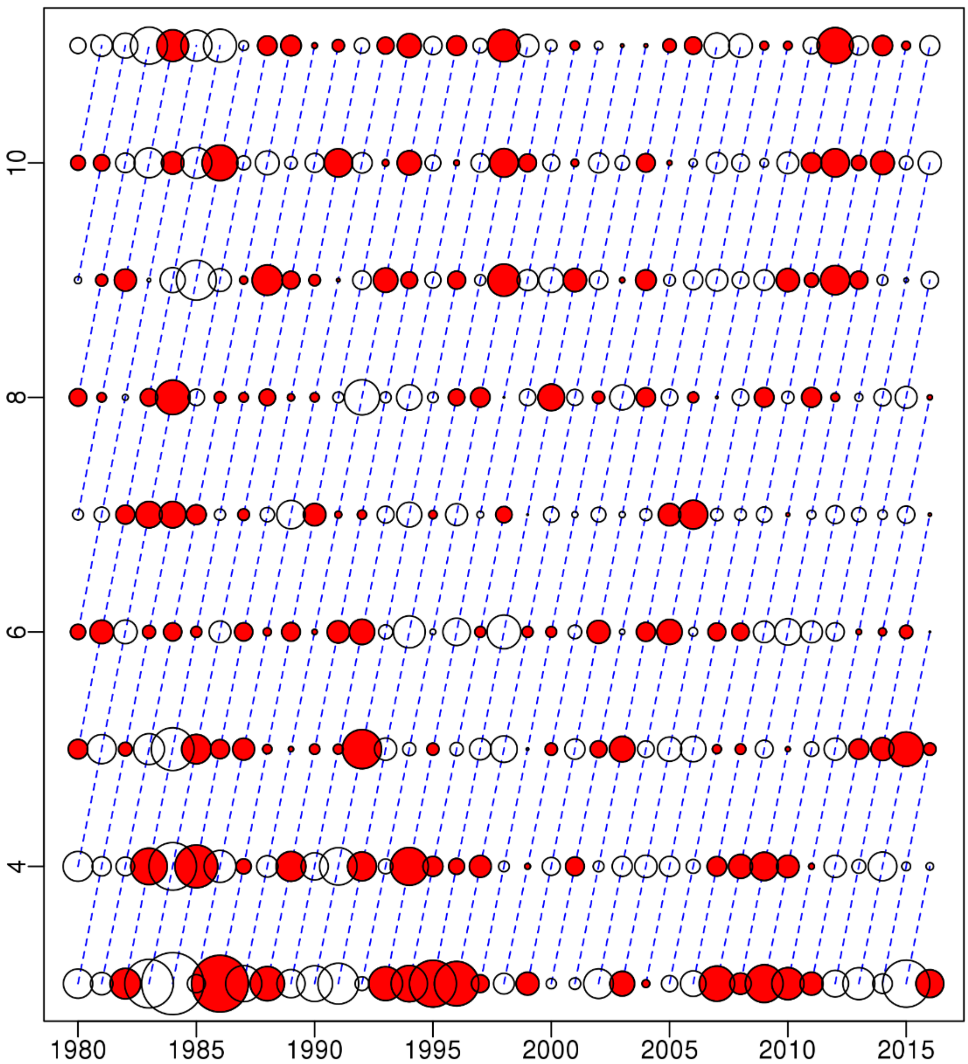


Figure 8.18. Saithe in division Va. Catch residuals from the "SPALY model".

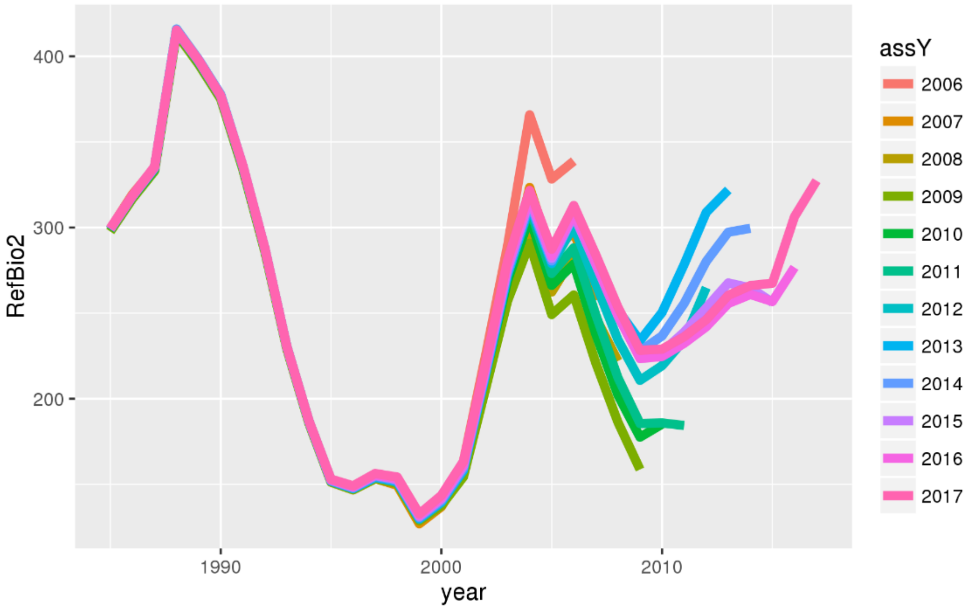
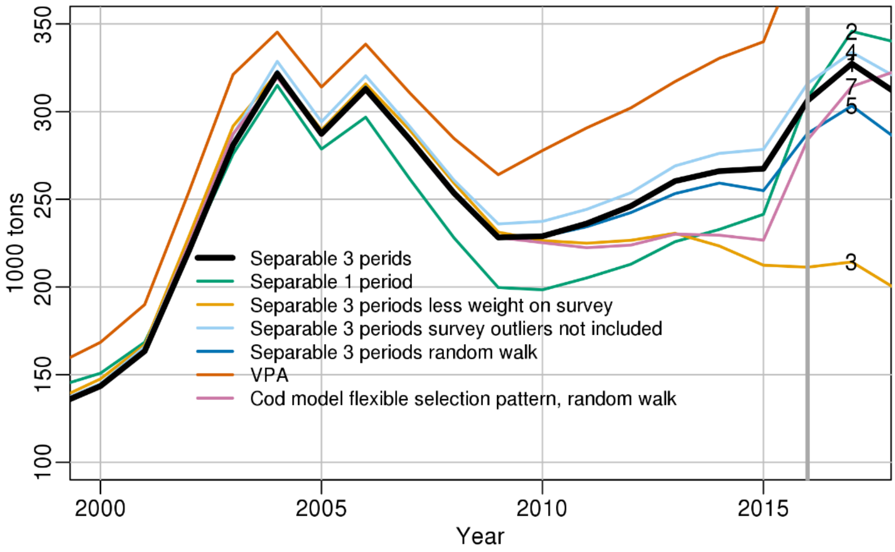


Figure 8.19. Saithe in division Va. Retrospective pattern for the assessment model. The figure shows estimate of B4+. Not finished



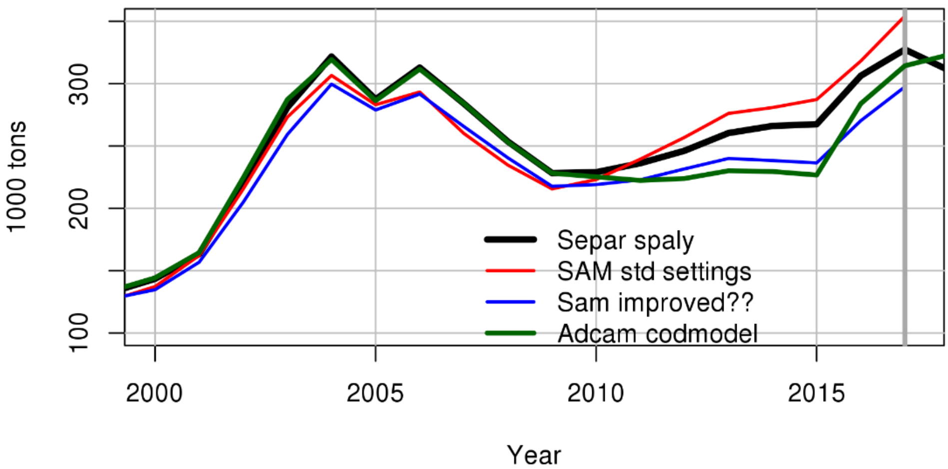


Figure 8.20. Saithe in division Va. Comparison between the default separable model (ADSEP) and alternative assessment model settings.

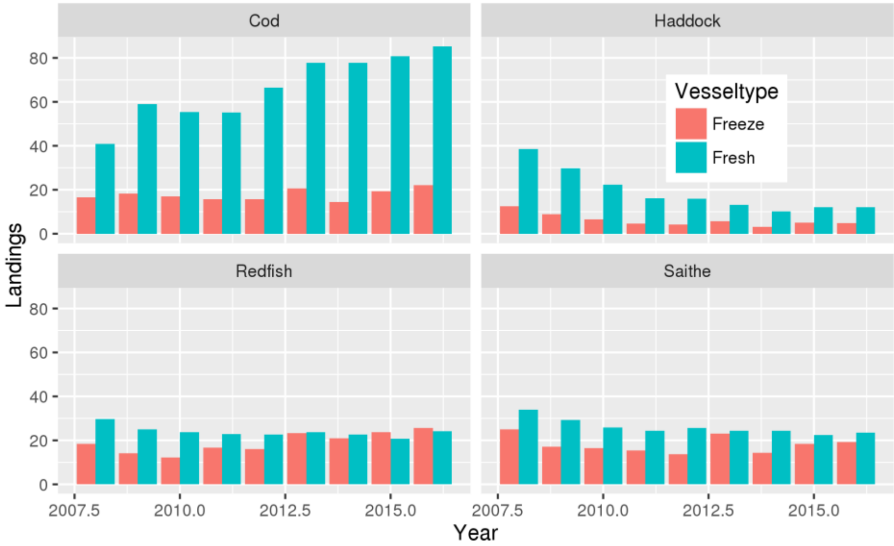


Figure 8.21. Saithe in division Va. Catch by trawlers divided between those that freeze the catch and those that do not. Number of trawler landing has been reducing gradually from 91 in 2008 to 66 in 2016 but the number of freezing trawlers has been 17-18 all the time. The freezing trawlers have therefore been 20-25% of the total number of trawlers.

9 Icelandic cod assesment

9.1 Overview

A formal HCR has been in place to set the TAC for this stock since 1994. The primary essence of the rule has been that the TAC for the next fishing year (starting 1. September in the assesment year and ending 31. August next year) is based on a multiplier on the reference biomass of four years and older in the assessment year ($B(4+)$).

The rule has gone through some amendments and revisions over time. The last significant change occurred in 2007, when the harvest rate multiplier upon which the TAC for the next fishing season was changed from 0.25 to 0.20. The current rule has in addition a catch stabilizer. When the SSB in the assessment year is estimated to be above $SSB\_trigger$ (220 kt) the decsison rule is:

$$TAC(y/y+1) = (0.20 * B\_(4+, y) + TAC(y-1/y))/2$$

The TAC for the current fishing year (2016/2017) based on last years assesment was 244 kt.

The results of this years assessment show that the spawning stock in 2017 is estimated to be 617 kt. The values estimated in recent years are higher than have been observed during the last five decades. The reference biomass B_{4+} in 2017 is estimated to be 1356 kt, and has not been so high since the late 1970's. Fishing mortality, being 0.28 in 2016, has declined significantly in recent years and is presently the lowest observed. Year classes since the mid-1980s are estimated to be relatively stable but with the mean around 33% lower than observed in the period 1955 to 1985. Estimates of year classes 2014 and 2015 indicate that they are in the upper range of that observed in the recent decades, while the first estimate of the 2016 year class indicate that it is below average. That year class will not enter into the fishery until 2020.

Given the above HCR rule the catch for the coming fishing year (2017/2018) is 258 kt.

The input in the analytical assessments are catch at age 1955-2016 (age 3 to 14) and spring groundfish survey (SMB) indices at age from 1985-2017 and fall survey groundfish survey (SMH) indices at age from 1996-2016 (ages 1 to 10). The model framework has been the same since 2002, spring survey only used as input up to the 2009 assessment, both surveys since then.

9.2 Some elaborations

9.2.1 Data

The data used for assessing Icelandic cod are landings and catch-at-age composition since 1955 and indices from two standardized bottom trawl surveys. The spring survey (SMB) was instigated in 1985, the fall survey (SMH) in 1996.

The sampling programs i.e log books, surveys, sampling from landings etc. have been described in previous reports.

9.2.1.1 Landings

Landings of Icelandic cod in 2016 are estimated to have been 251 kt of which 248 kt were 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 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 2015/2016 was supposed to be capped to 239 kt. Landings of the Icelandic fleet was 249 kt. Including additional landings of some 2 kt by the foreign fleet this amounts to 5.5% overshoot.

The estimates of landings for the current calendar year of 251 kt is based on the remainder of the quota from the current fishing year (2016/17) on 1. January 2017 (157 kt), the catch that is expected to be taken from 1. September to 31. December 2017 (91 kt) and the expected catch of the foreign fleet (3 kt).

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

9.2.1.2 Catch in numbers and weight by age

Catch in numbers by age: The method for deriving the catch at age is based on 20 metiers: two areas (north and south), two seasons (January-May and June-December) and four fleets (bottom trawl, longline, hooks (jiggers), gillnet and danish seine).

The catch at age matrix is reasonably consistent (Table), 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 and Figure) declined from 2001 to 2007, reaching then a historical low in many age groups. The weight at age have been increasing in recent years and are in 2016 around the average weights observed over the period from 1985 and close to the long term mean (1955-2016). 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 and Figure). The latest spring survey weight measurements (in 2017) are below average in younger ages but above average in older ages.

Prediction of catch weights in 2017: 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 (y) have been based on a prediction from the spring survey weight measurements in that year using the slope (β) and the intercept (α) from a linear relationship between survey and catch weights in preceding year ($y-1$}. The same approach was used this year for predicting weight at age in the catches for 2017. I.e. the α and β were estimated from :

$$cW\_(a, y-1) = \alpha + \beta * sW\_(a, y-1)$$

and the catch weights for 2017 then from:

$$cW\_(a, y) = alpha + beta * sW\_(a, y)$$

Based on this the mean weights at age in the catches in 2017 are predicted to be at or somewhat above the average (Figure). For ages 10 and older the mean weights from the previous year are used.

9.2.1.3 Surveys

Length based indices: The total biomass indices from the spring (SMB) and the fall (SMH) surveys (Figure) 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 and). 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).

9.2.2 Assessment

The framework: 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 annual advice is based since 2002. In the framework catch at age are modeled and the fishing mortality can change gradually over time, constrained by a random walk. The survey residuals are modeled as multivariate normal distribution to account for potential survey "year effects" - this being a feature in place since 2002. In addition the framework has ... (low survey values) ..

Diagnostics: The tuning with both the spring and the fall survey show similar diagnostics as that observed in previous years (see Tables , and and Figure 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.

Results: The detailed result from the assessment are provided in Tables , and the stock summary in Table and Figure . The reference biomass is estimated to be 1356 kt in 2017 and the fishing mortality 0.28 in 2016.

Alternatives: 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 1272 kt in 2017 and a fishing mortality of 0.3 in 2016. An assessment based on the fall survey only gave reference biomass of 1348 kt in 2017 and fishing mortality of 0.28 in 2016.

Comparison with last year: The reference stock (B_{4+}) in 2016 is now estimated to be 1330 kt compared to 1243 kt last year. The SSB in 2016 is now estimated to be 473 kt compared to 469 kt estimated last year. Fishing mortality in 2015 is now estimated 0.27 compared to 0.27 estimated last year. Year classes 2013-2015 were estimated to be 117, 208 and 208 million in last years assessment and are now estimated to be 114, 191 and 188 millions.

9.3 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 multiplier is reduced linearly. The $B\_(4+,y)$ refers to the reference 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 assessment year) and $y-1/y$ to the current fishing year (ending 31. August of the assessment year). The advice for the 2017/2018 fishing season is:

$$TAC\_(y/y+1) = (0.20 * 1356 + 244)/2 = 258kt$$

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 ($CV = 0.15,\ \rho = 0.45$ (auto-correlation)) were 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). The recent realized harvest rates are within the above range.

Icelandic cod in Division Va. Estimateded catch in numbers by year and age in millions of fish in 1955-2016.

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
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	5.225	13.346	10.372	13.887	9.407	5.611	2.440	1.561	0.950	0.407	0.125	0.037
2016	2.872	10.847	12.115	10.418	13.097	7.355	3.229	1.626	0.864	0.543	0.188	0.057

Icelandic cod in Division Va. Estimated mean weight at age in the landings (kg) in period the 1955-2016. The weights for age groups 3 to 9 in 2017 are based on predictions from the 2017 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
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	1.196	1.645	2.666	3.600	4.643	5.920	7.582	8.600	9.686	11.206	11.329	10.361
2016	1.099	1.786	2.508	3.804	4.617	5.944	7.163	8.487	10.113	10.695	11.365	13.904
2017	1.296	2.013	2.646	3.348	5.531	6.682	7.689	8.487	10.113	10.695	11.365	13.904

Icelandic cod in Division Va. Estimated weight at age in the spawning stock (kg) in period the 1955-2018. 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	1.309	1.397	1.764	2.737	3.482	4.764	7.311	10.320	12.197	14.683	16.175	19.050
1986	1.309	1.609	2.913	3.278	4.592	5.808	7.207	9.084	10.356	15.283	14.540	15.017
1987	1.714	1.596	2.437	3.531	4.888	6.414	7.509	9.243	10.697	10.622	15.894	12.592
1988	0.929	1.483	2.278	3.286	4.424	4.681	8.159	8.822	9.977	11.732	14.156	13.042
1989	0.821	1.523	2.361	3.425	4.702	7.282	8.453	9.831	11.986	10.003	12.611	16.045
1990	0.731	1.042	2.196	2.839	4.368	6.182	8.934	10.592	10.993	14.570	15.732	17.290
1991	0.114	1.286	2.066	2.797	3.476	6.011	8.834	9.804	9.754	14.344	14.172	20.200
1992	0.448	1.347	2.115	3.085	3.861	5.198	7.437	8.127	12.679	13.410	15.715	11.267
1993	0.773	1.374	2.316	3.276	4.179	5.730	6.442	8.641	10.901	12.517	14.742	16.874
1994	1.618	1.733	2.259	3.384	4.564	6.471	9.805	8.896	10.847	12.874	14.742	17.470
1995	0.514	1.639	2.354	3.197	4.492	5.544	8.582	10.273	11.022	11.407	13.098	15.182
1996	0.542	1.756	2.490	3.530	4.251	5.621	8.264	9.772	10.539	13.503	13.689	16.193
1997	1.111	1.346	2.267	3.740	5.417	5.963	6.966	8.537	10.797	11.533	10.428	12.788
1998	1.111	1.605	2.263	3.263	4.462	5.760	6.795	9.304	10.759	14.903	16.651	18.666
1999	1.311	1.471	1.936	2.999	3.968	5.132	6.523	9.946	11.088	12.535	14.995	15.151
2000	0.497	1.355	1.916	2.881	4.318	5.574	8.466	9.203	10.240	11.172	13.172	17.442

2001	0.816	1.583	2.080	2.676	4.112	6.237	6.927	9.055	8.769	9.526	11.210	13.874
2002	0.782	1.591	2.260	3.120	3.991	5.991	9.229	9.002	10.422	13.402	9.008	16.893
2003	1.150	1.326	2.241	3.051	4.229	5.051	6.824	7.819	8.802	10.712	12.152	13.797
2004	1.150	1.441	2.092	3.023	3.702	5.254	5.540	7.397	10.808	11.569	13.767	12.955
2005	0.648	1.123	1.908	2.979	3.901	4.790	7.239	5.495	7.211	9.909	12.944	18.151
2006	0.907	1.407	2.016	2.913	4.352	5.057	6.473	5.769	6.258	5.688	7.301	15.412
2007	1.439	1.261	2.023	2.640	4.116	5.697	6.632	6.481	7.142	6.530	9.724	10.143
2008	0.912	1.845	2.232	2.911	3.897	5.400	6.928	7.648	8.282	11.181	14.266	17.320
2009	0.644	1.465	2.041	2.887	3.943	4.924	7.044	8.505	10.126	12.108	12.471	15.264
2010	0.644	1.590	2.154	3.149	4.207	5.207	6.460	7.945	8.913	10.090	10.417	13.489
2011	0.794	2.467	2.666	3.216	4.546	5.989	6.851	7.850	8.810	9.797	13.534	13.033
2012	1.404	1.702	2.606	3.717	4.516	6.016	8.039	8.358	9.543	10.916	10.884	11.758
2013	0.944	2.323	2.991	3.834	5.207	6.532	8.260	8.415	9.336	9.926	11.195	12.691
2014	0.944	1.332	2.549	3.316	4.459	6.390	8.179	8.413	9.713	10.513	11.437	12.979
2015	0.704	1.043	3.320	3.836	4.895	6.218	8.677	9.694	9.688	11.212	11.334	10.356
2016	0.972	2.247	3.042	4.213	4.614	6.000	7.351	9.731	10.006	10.522	11.466	13.758
2017	1.773	2.582	3.513	3.935	5.697	6.715	7.636	9.698	9.973	10.487	11.428	13.712

Table 9.1. Icelandic cod in Division Va. Estimated maturity at age in period the 1955-2017.

YEAR	3	4	5	6	7	8	9	10	11	12	13	14
1955	0.019	0.022	0.033	0.181	0.577	0.782	0.834	0.960	1.000	1.000	1.000	1
1956	0.019	0.025	0.033	0.111	0.577	0.782	0.818	0.980	0.980	1.000	1.000	1
1957	0.019	0.026	0.043	0.100	0.549	0.801	0.842	0.990	1.000	1.000	1.000	1
1958	0.019	0.028	0.086	0.520	0.682	0.801	0.834	1.000	1.000	1.000	1.000	1
1959	0.019	0.029	0.070	0.535	0.772	0.818	0.834	0.990	1.000	1.000	1.000	1
1960	0.019	0.026	0.066	0.577	0.782	0.826	0.834	0.990	1.000	1.000	1.000	1
1961	0.019	0.025	0.053	0.450	0.772	0.818	0.834	0.990	0.990	1.000	1.000	1
1962	0.019	0.025	0.048	0.281	0.791	0.834	0.834	0.990	0.990	1.000	1.000	1
1963	0.019	0.025	0.048	0.237	0.706	0.834	0.849	1.000	1.000	1.000	1.000	1
1964	0.019	0.026	0.048	0.329	0.762	0.826	0.849	1.000	1.000	1.000	1.000	1
1965	0.019	0.025	0.045	0.354	0.751	0.826	0.842	1.000	1.000	1.000	1.000	1
1966	0.019	0.026	0.045	0.394	0.791	0.849	0.849	1.000	1.000	1.000	1.000	1
1967	0.019	0.028	0.051	0.341	0.772	0.842	0.849	1.000	1.000	1.000	1.000	1
1968	0.019	0.025	0.051	0.292	0.682	0.801	0.842	1.000	1.000	1.000	1.000	1
1969	0.019	0.028	0.043	0.227	0.682	0.801	0.842	1.000	1.000	1.000	1.000	1
1970	0.019	0.023	0.041	0.227	0.644	0.772	0.818	1.000	1.000	1.000	1.000	1
1971	0.019	0.025	0.037	0.074	0.657	0.706	0.772	0.979	0.994	0.982	0.993	1
1972	0.019	0.023	0.035	0.106	0.450	0.772	0.809	0.979	0.994	0.982	0.993	1
1973	0.022	0.028	0.163	0.382	0.697	0.801	0.834	0.996	0.996	1.000	1.000	1
1974	0.020	0.031	0.085	0.346	0.636	0.790	0.818	0.989	1.000	1.000	1.000	1
1975	0.020	0.035	0.118	0.287	0.715	0.809	0.839	1.000	1.000	1.000	1.000	1
1976	0.025	0.026	0.086	0.253	0.406	0.797	0.841	1.000	1.000	1.000	1.000	1
1977	0.019	0.024	0.060	0.382	0.742	0.817	0.842	1.000	1.000	1.000	1.000	1
1978	0.025	0.025	0.052	0.192	0.737	0.820	0.836	1.000	1.000	1.000	1.000	1
1979	0.019	0.021	0.053	0.282	0.635	0.790	0.836	0.919	1.000	1.000	1.000	1
1980	0.026	0.021	0.047	0.225	0.653	0.777	0.834	0.977	1.000	0.964	1.000	1
1981	0.019	0.022	0.030	0.090	0.448	0.751	0.811	0.962	0.988	1.000	1.000	1
1982	0.021	0.025	0.038	0.065	0.297	0.705	0.815	0.967	1.000	1.000	1.000	1
1983	0.019	0.030	0.047	0.116	0.264	0.530	0.715	0.979	0.985	1.000	1.000	1
1984	0.019	0.024	0.053	0.169	0.444	0.620	0.716	0.949	0.969	0.948	1.000	1
1985	NA	0.021	0.186	0.414	0.495	0.730	0.580	0.746	1.000	1.000	1.000	1
1986	0.001	0.023	0.154	0.398	0.681	0.727	0.936	0.667	1.000	1.000	1.000	1
1987	0.001	0.033	0.094	0.359	0.487	0.879	0.777	0.805	1.000	1.000	1.000	1
1988	0.006	0.029	0.220	0.498	0.446	0.677	0.932	0.890	1.000	1.000	1.000	1
1989	0.008	0.026	0.141	0.363	0.621	0.639	0.619	1.000	1.000	1.000	1.000	1
1990	0.006	0.012	0.154	0.428	0.576	0.781	0.774	0.714	1.000	1.000	1.000	1
1991	NA	0.055	0.149	0.368	0.629	0.787	0.654	0.901	1.000	1.000	1.000	1
1992	0.002	0.062	0.265	0.407	0.813	0.916	0.880	1.000	1.000	1.000	1.000	1
1993	0.006	0.085	0.267	0.462	0.684	0.795	0.843	0.834	1.000	1.000	1.000	1
1994	0.008	0.109	0.338	0.590	0.706	0.921	0.694	0.830	1.000	1.000	1.000	1
1995	0.005	0.109	0.383	0.527	0.747	0.790	0.859	1.000	1.000	1.000	1.000	1
1996	0.002	0.032	0.186	0.501	0.653	0.733	0.810	0.774	1.000	1.000	1.000	1
1997	0.006	0.037	0.247	0.424	0.686	0.786	0.804	0.539	1.000	1.000	1.000	1
1998	NA	0.061	0.209	0.486	0.782	0.807	0.809	0.852	1.000	1.000	1.000	1
1999	0.012	0.044	0.239	0.517	0.650	0.836	0.691	0.974	1.000	1.000	1.000	1
2000	0.001	0.065	0.248	0.512	0.611	0.867	0.998	0.999	1.000	1.000	1.000	1

2001	0.003	0.046	0.286	0.599	0.761	0.766	0.883	1.000	1.000	1.000	1.000	1
2002	0.006	0.086	0.321	0.656	0.759	0.920	0.559	0.724	1.000	1.000	1.000	1
2003	0.005	0.048	0.222	0.532	0.873	0.798	0.879	0.837	1.000	1.000	1.000	1
2004	NA	0.040	0.251	0.553	0.638	0.837	0.813	0.861	1.000	1.000	1.000	1
2005	0.003	0.108	0.281	0.494	0.795	0.808	0.949	0.904	1.000	1.000	1.000	1
2006	0.002	0.023	0.298	0.446	0.749	0.874	0.739	0.741	1.000	1.000	1.000	1
2007	0.012	0.031	0.156	0.504	0.696	0.797	0.836	0.926	1.000	1.000	1.000	1
2008	0.001	0.042	0.275	0.546	0.728	0.833	0.850	0.958	1.000	1.000	1.000	1
2009	0.002	0.015	0.134	0.451	0.684	0.884	0.752	0.631	1.000	1.000	1.000	1
2010	NA	0.015	0.057	0.380	0.821	0.868	0.927	0.813	1.000	1.000	1.000	1
2011	0.002	0.012	0.136	0.427	0.732	0.923	0.941	0.961	1.000	1.000	1.000	1
2012	0.004	0.031	0.127	0.414	0.730	0.884	0.963	0.850	1.000	1.000	1.000	1
2013	0.003	0.008	0.062	0.344	0.738	0.922	0.965	1.000	1.000	1.000	1.000	1
2014	NA	0.026	0.069	0.238	0.615	0.893	0.967	0.956	1.000	1.000	1.000	1
2015	0.003	0.007	0.110	0.353	0.636	0.907	0.978	0.988	1.000	1.000	1.000	1
2016	0.001	0.009	0.025	0.289	0.543	0.731	0.941	0.986	1.000	1.000	1.000	1
2017	0.005	0.008	0.089	0.262	0.765	0.906	0.979	0.987	1.000	1.000	1.000	1

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

YEAR	1	2	3	4	5	6	7	8	9
1985	0.014	0.136	0.388	1.121	1.736	2.589	3.242	4.730	5.975
1986	0.015	0.159	0.617	1.222	2.251	2.967	4.328	5.594	7.213
1987	0.014	0.117	0.468	1.199	1.752	2.982	4.195	6.327	6.931
1988	0.011	0.122	0.495	1.076	1.964	3.095	3.549	4.352	8.085
1989	0.022	0.151	0.544	1.144	1.946	3.065	4.393	6.254	7.009
1990	0.019	0.135	0.461	1.037	1.814	2.595	3.868	6.022	8.051
1991	0.018	0.147	0.554	1.167	1.842	2.587	3.268	5.722	7.588
1992	0.024	0.133	0.500	1.012	1.846	2.569	3.649	5.028	7.396
1993	0.012	0.171	0.576	1.167	1.945	2.991	3.959	5.354	5.975
1994	0.013	0.174	0.686	1.413	2.044	3.179	4.124	6.246	8.242
1995	0.010	0.134	0.606	1.378	2.285	2.990	4.449	5.333	8.056
1996	0.011	0.155	0.551	1.352	2.084	3.322	4.044	5.257	7.461
1997	0.018	0.139	0.546	1.194	2.170	3.214	4.856	5.494	6.462
1998	0.015	0.154	0.482	1.193	2.042	3.018	4.249	5.418	6.334
1999	0.014	0.140	0.578	1.070	1.849	2.869	3.821	4.981	5.630
2000	0.016	0.124	0.486	1.195	1.818	2.771	4.065	5.343	8.478
2001	0.017	0.152	0.530	1.185	1.845	2.625	3.781	5.491	6.473
2002	0.013	0.132	0.511	1.207	1.999	2.921	3.778	5.753	6.253
2003	0.016	0.131	0.466	1.179	1.919	2.787	4.137	4.673	6.247
2004	0.020	0.147	0.480	1.062	1.873	2.805	3.461	4.982	5.299
2005	0.011	0.118	0.451	1.029	1.760	2.644	3.646	4.359	7.232
2006	0.013	0.105	0.417	0.982	1.690	2.602	4.049	4.748	5.613
2007	0.014	0.101	0.409	0.969	1.664	2.344	3.636	5.011	6.104
2008	0.011	0.121	0.376	0.938	1.806	2.613	3.590	4.920	6.371
2009	0.012	0.113	0.412	0.845	1.605	2.637	3.679	4.712	5.852
2010	0.013	0.098	0.391	1.008	1.698	2.569	4.014	4.886	6.047
2011	0.012	0.102	0.395	1.127	2.115	2.987	4.224	5.871	6.630
2012	0.012	0.142	0.477	1.144	1.930	3.182	4.252	5.715	7.803
2013	0.013	0.111	0.497	1.053	1.786	3.024	4.771	6.377	8.096
2014	0.011	0.114	0.359	1.078	1.710	2.634	3.989	6.164	8.060
2015	0.013	0.150	0.418	0.897	2.059	3.022	4.403	6.066	8.635
2016	0.010	0.120	0.482	1.013	1.581	3.150	3.992	5.521	7.216
2017	0.014	0.091	0.424	1.227	1.940	2.722	5.166	6.457	7.583

Icelandic cod in Division Va. Survey indices of the spring bottom trawl survey (SMB).

YEAR	1	2	3	4	5	6	7	8	9	10
1985	17.18	111.09	35.37	48.22	64.39	22.82	15.02	5.02	3.37	1.86
1986	15.58	60.72	96.37	22.54	21.43	26.58	6.80	2.52	0.85	0.75
1987	3.66	28.10	103.72	81.99	21.11	12.27	12.07	2.57	0.90	0.38
1988	3.44	6.97	72.79	101.73	66.64	7.83	5.91	6.29	0.58	0.24
1989	4.02	16.40	21.19	73.01	64.90	33.49	4.16	1.44	1.13	0.24
1990	5.55	11.74	26.34	14.19	27.12	32.45	14.24	1.50	0.52	0.41
1991	3.95	15.96	18.10	30.06	15.20	18.05	20.90	4.24	0.79	0.29
1992	0.71	16.85	33.48	18.71	16.13	6.46	5.66	5.08	1.28	0.22
1993	3.56	4.71	30.64	36.33	13.18	9.86	2.12	1.74	1.16	0.36
1994	14.21	14.81	8.98	26.62	21.88	5.76	3.61	0.69	0.47	0.44
1995	1.08	29.10	24.72	8.99	23.92	17.73	3.80	1.81	0.36	0.17
1996	3.70	5.38	42.36	29.43	12.92	14.71	14.13	3.81	1.05	0.18
1997	1.20	22.35	13.52	56.20	29.01	9.47	8.77	6.58	0.56	0.21
1998	8.04	5.43	30.07	15.94	61.39	28.50	6.49	5.22	3.02	0.66
1999	7.37	33.04	6.98	41.92	12.94	23.61	11.12	2.36	1.32	0.70
2000	18.85	27.58	54.89	6.95	30.07	8.30	8.20	4.16	0.51	0.30
2001	12.09	21.80	36.29	37.84	4.94	14.97	3.28	1.94	0.82	0.29
2002	0.96	37.80	41.06	40.07	36.25	7.11	8.32	1.49	0.72	0.30
2003	11.15	4.16	46.30	36.58	28.47	16.92	3.83	4.34	1.03	0.20
2004	6.57	24.39	7.86	61.70	35.02	24.87	14.48	2.83	2.88	0.47
2005	2.56	14.54	38.70	9.67	43.55	22.99	10.86	5.77	0.93	0.92
2006	8.77	6.38	22.66	38.42	10.84	27.82	10.09	3.56	1.39	0.25
2007	5.59	18.25	8.58	20.99	27.44	9.03	9.73	5.07	2.10	0.74
2008	6.39	11.78	22.05	9.29	20.41	20.40	8.09	6.61	2.46	0.60
2009	21.45	11.73	15.67	21.43	14.39	23.30	14.51	4.13	2.72	1.03
2010	18.22	19.97	17.98	17.70	23.75	13.28	16.61	8.89	2.68	1.65
2011	3.54	21.45	26.59	19.89	22.50	25.37	13.55	12.35	4.55	0.91
2012	19.93	9.76	37.52	56.45	41.50	30.22	27.05	9.98	6.29	2.75
2013	10.75	31.42	17.72	43.71	46.35	25.18	16.43	13.73	6.85	3.31
2014	3.29	23.98	38.21	23.51	47.13	37.61	17.35	8.19	4.25	2.22
2015	20.86	10.68	27.42	41.68	20.88	40.89	28.27	16.55	4.99	3.12
2016	31.35	29.15	14.34	36.60	53.92	27.33	37.00	18.25	6.76	2.26
2017	3.77	23.20	31.85	17.79	35.93	39.72	23.06	22.10	11.63	5.09

Icelandic cod in Division Va. Survey indices of the fall bottom trawl survey (SMH).

YEAR	1	2	3	4	5	6	7	8	9	10
1996	6.32	3.43	19.59	14.19	5.57	7.70	6.49	1.65	0.31	0.08
1997	0.65	16.65	6.65	29.24	16.35	5.40	3.74	2.13	0.31	0.14
1998	5.72	2.58	15.34	7.29	16.10	16.16	5.24	2.25	1.27	0.20
1999	8.00	13.79	5.58	23.16	7.45	10.04	4.08	0.59	0.34	0.37
2000	4.52	12.74	15.24	3.76	11.54	3.64	2.71	1.14	0.34	0.28
2001	6.89	11.29	19.32	21.27	3.40	6.93	1.65	0.79	0.18	0.03
2002	0.93	13.19	15.84	23.39	16.21	5.53	4.86	1.13	0.63	0.08
2003	5.20	2.73	26.03	17.31	13.48	9.12	1.93	2.59	0.37	0.10
2004	3.57	15.82	6.89	30.30	19.39	12.08	7.61	1.92	1.68	0.23
2005	2.13	8.87	19.97	6.77	26.10	11.30	4.00	1.96	0.31	0.32
2006	4.41	4.41	15.86	22.85	7.78	14.47	6.31	2.12	1.05	0.17
2007	3.67	9.57	4.90	12.10	16.26	6.53	6.10	3.21	0.80	0.53
2008	5.17	11.84	15.08	7.67	18.06	19.13	5.80	5.67	1.50	0.79
2009	6.92	8.17	13.02	18.17	12.69	17.14	10.61	3.27	2.86	0.96
2010	10.32	19.10	16.40	15.59	18.12	10.01	11.42	6.90	2.30	1.24
2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	7.17	9.40	23.44	20.88	12.88	10.95	9.64	5.35	3.34	1.55
2013	6.04	19.00	13.18	26.67	21.82	12.67	7.85	6.04	2.96	1.88
2014	3.53	15.90	23.63	13.89	23.81	19.89	8.54	5.89	4.00	2.49
2015	16.72	8.81	26.39	36.28	17.48	27.86	16.46	5.64	3.32	1.18
2016	11.49	18.17	7.90	17.83	22.52	10.64	11.95	6.79	2.75	1.61

Icelandic cod in Division Va. Catch at age residuals from the ADCAM model tuned with the spring (SMB) and the fall (SMH) surveys.

YEAR	3	4	5	6	7	8	9	10	11	12	13	14
1955	-0.12	-0.21	0.08	0.12	0.21	-0.12	-0.16	0.13	-0.10	-0.45	-0.20	0.00
1956	-0.03	-0.05	0.03	-0.01	-0.13	-0.20	-0.01	0.01	0.18	0.09	0.23	0.22
1957	0.09	0.02	-0.02	0.17	-0.13	0.09	0.06	-0.15	-0.10	-0.11	-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	-0.21	0.21	0.26	-0.24	-0.22	-0.06	-0.07	0.28	-0.26	0.38	-0.23	-0.40
1960	0.10	-0.36	0.14	0.19	0.06	0.07	-0.03	-0.11	-0.04	0.03	-0.64	0.91
1961	0.05	0.04	-0.40	0.12	-0.02	0.27	0.20	-0.14	0.09	-0.19	-0.97	0.83
1962	0.09	-0.01	0.13	-0.24	0.12	-0.30	0.09	0.26	-0.06	0.03	-0.40	0.70
1963	-0.06	0.30	-0.17	0.01	-0.03	-0.07	-0.38	0.21	0.35	0.06	0.07	-0.61
1964	-0.13	-0.01	0.13	-0.25	-0.12	0.38	-0.10	-0.46	-0.01	0.27	-0.16	0.01
1965	-0.03	-0.11	0.09	0.16	-0.13	0.05	0.47	-0.48	-0.06	-0.51	-0.36	0.64
1966	-0.04	-0.04	-0.18	0.10	-0.07	0.12	-0.35	0.59	-0.83	0.28	0.01	1.06
1967	0.19	-0.13	0.02	-0.20	0.03	-0.37	0.49	0.05	0.67	-0.73	-0.83	-0.18
1968	0.03	-0.02	-0.27	-0.12	0.23	0.16	-0.42	0.37	-0.12	0.60	-0.66	0.66
1969	-0.09	-0.03	0.15	-0.01	0.05	-0.15	-0.32	-0.24	-0.04	-0.26	-0.81	-0.14
1970	-0.10	0.14	-0.05	-0.14	0.05	-0.16	0.48	-0.58	-0.12	0.25	0.30	0.45
1971	-0.10	0.07	0.09	0.18	-0.18	0.28	-0.17	0.05	-0.45	-0.02	0.12	0.36
1972	-0.17	-0.13	0.07	-0.03	0.12	-0.05	-0.10	0.29	-0.07	0.17	0.53	-2.77
1973	0.27	-0.02	-0.10	0.03	0.00	-0.24	0.09	0.17	0.16	-0.19	-1.25	-2.10
1974	-0.16	0.21	-0.02	-0.18	-0.01	0.00	-0.22	0.29	0.01	0.19	-0.43	0.80
1975	0.19	-0.07	0.04	-0.05	0.03	-0.15	-0.21	0.00	0.41	-0.02	-0.12	0.08
1976	0.10	0.00	-0.17	0.08	-0.09	0.25	-0.16	-0.15	0.06	0.27	-0.23	0.22
1977	-0.40	-0.06	0.05	-0.09	0.13	0.05	0.31	0.03	-0.70	-0.48	-1.22	-2.51
1978	0.08	-0.01	0.04	-0.10	0.04	-0.21	0.12	-0.19	0.01	-0.05	0.53	1.19
1979	0.16	0.09	-0.22	0.10	-0.05	0.03	-0.31	-0.08	0.04	-0.14	0.42	-0.20
1980	0.21	0.01	0.08	0.06	-0.01	-0.09	0.12	-0.49	0.29	0.10	0.16	-1.09
1981	-0.30	-0.21	0.08	-0.14	0.07	0.09	0.02	0.33	-0.08	0.60	-0.01	1.17
1982	0.01	0.15	0.07	-0.05	-0.22	0.19	0.18	0.14	-0.23	-0.87	0.05	-0.87
1983	-0.32	-0.36	0.11	0.14	0.04	0.01	-0.04	-0.03	0.00	0.37	-0.19	0.57
1984	0.34	0.03	-0.06	-0.04	-0.10	0.00	0.05	-0.14	-0.35	0.17	0.72	0.08
1985	0.04	0.18	-0.10	0.12	-0.10	-0.02	-0.14	0.13	0.03	-0.34	0.48	0.45
1986	0.14	-0.12	0.01	-0.01	0.18	-0.04	0.11	-0.21	0.08	0.05	-0.58	0.16
1987	-0.15	0.12	0.01	-0.17	0.07	0.04	-0.02	0.11	-0.38	-0.11	0.13	-0.32
1988	-0.09	-0.07	-0.06	0.13	-0.09	0.08	0.16	0.03	0.47	0.02	0.54	0.07
1989	-0.21	0.04	0.14	-0.08	0.00	-0.15	-0.31	-0.09	-0.02	0.52	-0.02	-1.47
1990	-0.01	-0.14	-0.11	0.00	0.04	0.09	-0.08	-0.21	0.29	0.12	-0.21	0.03
1991	0.06	0.04	-0.14	-0.07	0.10	-0.07	0.12	-0.07	-0.30	0.41	-0.55	0.07
1992	-0.24	0.07	0.04	0.02	0.10	0.00	-0.04	-0.06	-0.74	-0.75	-0.56	-0.21
1993	0.25	0.04	-0.21	-0.06	-0.07	-0.12	0.08	0.49	0.50	-0.21	-0.98	0.35
1994	0.02	0.24	-0.14	-0.20	-0.04	0.07	-0.19	-0.13	0.44	0.53	0.52	-0.47
1995	0.27	-0.04	0.08	-0.04	-0.04	-0.12	-0.12	-0.29	-0.20	0.75	1.13	0.54
1996	0.00	-0.05	-0.19	0.07	0.04	0.01	0.13	0.18	-0.36	-0.37	0.65	-0.10
1997	-0.17	0.03	-0.03	-0.14	-0.10	0.21	0.17	0.27	0.44	-0.70	-0.18	0.14

1998	-0.18	-0.17	0.07	0.07	0.01	-0.16	0.25	0.06	0.12	0.32	0.20	-0.77
1999	-0.12	0.04	0.04	0.04	0.09	-0.05	-0.23	-0.17	-0.24	-0.38	-0.46	-0.99
2000	0.15	-0.24	0.12	-0.04	0.01	0.11	0.03	-0.12	0.01	0.14	-0.16	-0.23
2001	0.24	0.22	-0.19	0.02	0.04	-0.25	0.07	0.33	-0.12	0.20	-0.65	0.93
2002	-0.10	0.05	0.03	-0.05	0.01	0.03	-0.09	0.25	0.32	-0.12	0.15	-0.85
2003	-0.07	0.03	0.00	-0.11	0.11	0.07	0.20	-0.18	0.10	0.25	0.13	0.80
2004	-0.27	0.06	0.08	-0.05	-0.04	0.24	-0.04	0.23	-0.33	0.21	0.31	-0.29
2005	0.18	-0.26	0.13	-0.06	-0.11	-0.07	0.30	-0.01	0.41	0.19	0.35	-0.20
2006	-0.05	0.04	-0.11	0.06	0.06	-0.07	-0.08	0.20	-0.22	-0.25	-0.61	-0.13
2007	-0.16	0.15	-0.05	0.02	-0.13	0.09	0.02	0.18	0.78	-0.25	1.18	-0.86
2008	0.12	-0.18	0.08	-0.15	0.05	-0.19	0.04	0.14	-0.08	0.42	0.27	-0.61
2009	0.08	-0.11	0.06	0.15	-0.01	0.23	-0.21	-0.24	-0.02	-0.36	0.24	-0.36
2010	0.09	0.03	-0.14	0.03	0.05	-0.06	0.18	-0.20	-0.17	0.14	0.35	0.71
2011	-0.01	-0.03	0.09	0.01	-0.02	-0.01	-0.11	0.10	-0.13	-0.18	-0.20	-0.38
2012	-0.14	0.03	0.01	-0.03	0.00	0.18	0.01	-0.24	-0.03	-0.15	0.09	-0.19
2013	0.29	-0.03	0.05	0.04	-0.07	-0.04	0.15	-0.02	-0.20	0.14	0.12	-0.40
2014	-0.12	0.03	0.03	0.00	0.00	-0.06	-0.06	0.12	0.00	-0.16	0.45	0.18
2015	0.05	0.07	0.09	0.02	-0.12	0.03	-0.05	-0.06	0.43	-0.18	-0.26	-0.21
2016	-0.07	0.01	-0.13	0.08	0.08	-0.03	0.05	-0.02	-0.09	0.40	-0.09	-0.72

Icelandic cod in Division Va. Spring survey (SMB) at age residuals from the ADCAM model, assessment tuned with both the spring and the fall survey.

YEAR	1	2	3	4	5	6	7	8	9	10
1985	-0.51	0.09	0.26	0.48	0.18	0.30	0.44	0.24	0.37	0.75
1986	0.45	-0.01	-0.33	-0.20	-0.04	0.02	-0.16	-0.29	-0.26	-0.05
1987	0.69	0.05	0.18	-0.43	0.00	-0.07	0.04	-0.09	-0.10	-0.02
1988	-0.19	0.06	0.55	0.18	-0.11	-0.35	0.07	0.43	-0.16	-0.14
1989	0.39	0.11	0.53	0.51	0.16	0.09	-0.19	-0.16	0.10	0.08
1990	-0.49	0.16	0.12	0.09	-0.14	-0.18	-0.01	-0.20	-0.06	0.11
1991	-0.16	-0.40	0.13	0.18	0.27	0.04	0.13	-0.21	0.15	0.20
1992	-0.21	0.07	-0.14	0.13	-0.08	-0.14	-0.18	-0.18	-0.16	0.02
1993	-0.52	-0.01	0.22	-0.02	0.06	-0.06	-0.25	-0.21	-0.30	-0.24
1994	0.51	-0.21	0.04	0.14	-0.17	-0.32	-0.19	-0.24	-0.20	-0.11
1995	-0.20	0.18	-0.18	-0.04	0.19	0.00	-0.22	-0.07	-0.05	-0.24
1996	-0.65	-0.09	0.14	-0.10	0.21	-0.04	0.25	0.37	0.20	0.02
1997	0.23	0.00	0.15	0.31	-0.02	-0.05	-0.05	0.22	-0.35	-0.31
1998	-0.11	0.16	-0.13	0.13	0.52	0.29	0.06	0.18	0.41	0.44
1999	-0.05	0.23	-0.02	0.07	-0.05	0.07	0.00	-0.06	-0.06	0.05
2000	0.89	0.17	0.33	-0.15	-0.07	-0.22	-0.23	-0.05	-0.29	-0.30
2001	0.17	0.02	0.05	-0.06	-0.45	-0.24	-0.41	-0.61	-0.39	0.10
2002	-0.08	0.28	0.19	0.10	0.07	-0.15	-0.20	-0.33	-0.48	-0.25
2003	0.04	-0.09	0.10	0.00	-0.09	-0.20	-0.21	-0.09	0.13	-0.58
2004	-0.09	0.17	-0.10	0.28	0.07	0.17	0.16	0.15	0.41	0.29
2005	-0.15	-0.01	0.19	-0.10	0.08	0.07	-0.05	0.02	0.05	0.28
2006	0.19	-0.11	-0.05	0.07	-0.11	0.09	-0.17	-0.36	-0.37	-0.18
2007	0.02	0.17	-0.33	-0.25	-0.19	-0.22	-0.38	-0.14	0.00	-0.09
2008	-0.07	-0.01	-0.07	-0.43	-0.30	-0.15	0.05	-0.13	0.01	-0.28
2009	0.37	-0.14	-0.19	-0.24	-0.21	-0.13	-0.12	-0.02	-0.21	-0.07
2010	0.03	-0.19	-0.22	-0.24	-0.19	-0.20	-0.10	-0.04	0.28	0.01
2011	-0.46	-0.26	-0.34	-0.28	-0.10	0.07	0.09	0.11	0.00	-0.09
2012	0.13	-0.19	-0.15	0.22	0.34	0.30	0.43	0.27	0.12	0.09
2013	-0.13	0.07	-0.14	-0.13	0.07	0.07	0.05	0.26	0.55	0.08
2014	-0.29	0.06	-0.13	-0.04	0.00	0.20	0.02	-0.14	-0.21	0.06
2015	0.06	0.01	-0.21	-0.16	-0.20	0.21	0.22	0.43	0.01	0.05
2016	0.50	-0.07	-0.17	-0.07	0.14	0.19	0.40	0.25	0.19	-0.20
2017	-0.25	-0.23	-0.37	-0.15	-0.07	0.18	0.32	0.36	0.44	0.48

Icelandic cod in Division Va. Fall survey (SMH) at age residuals from the ADCAM model, assessment tuned with both the spring and the fall survey.

YEAR	1	2	3	4	5	6	7	8	9	10
1996	-0.05	-0.11	-0.03	-0.18	-0.01	-0.07	0.19	0.21	-0.18	-0.08
1997	-0.13	0.12	-0.02	0.24	0.06	-0.02	-0.13	-0.11	-0.25	-0.15
1998	-0.27	-0.03	-0.21	0.02	-0.05	0.33	0.49	0.11	0.25	0.04
1999	0.16	-0.11	0.13	0.09	0.05	-0.03	-0.13	-0.31	-0.37	0.10
2000	-0.30	-0.08	-0.26	-0.08	-0.23	-0.24	-0.39	-0.33	-0.03	0.16
2001	-0.19	-0.14	0.04	0.00	-0.22	-0.26	-0.26	-0.51	-0.60	-0.39
2002	-0.11	-0.20	-0.13	0.16	0.00	0.11	-0.01	0.01	-0.03	-0.44
2003	-0.10	-0.10	0.11	-0.12	-0.11	-0.16	-0.13	0.08	-0.08	-0.45
2004	-0.12	0.16	0.14	0.15	0.18	0.10	0.23	0.35	0.49	0.21
2005	0.10	-0.06	0.10	0.08	0.25	0.01	-0.26	-0.25	-0.18	-0.04
2006	0.08	-0.09	0.11	0.11	0.08	0.06	0.05	-0.18	-0.04	-0.01
2007	0.12	0.00	-0.32	-0.22	-0.07	-0.02	-0.17	0.06	-0.22	0.15
2008	0.24	0.27	0.06	-0.13	0.12	0.24	0.29	0.28	0.07	0.38
2009	-0.10	-0.09	0.09	0.09	0.14	0.07	0.17	0.29	0.33	0.31
2010	0.11	0.14	0.15	0.11	0.08	-0.02	0.11	0.25	0.55	0.16
2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	-0.22	0.07	-0.04	-0.20	-0.20	-0.14	0.01	0.19	-0.05	-0.05
2013	-0.09	0.04	0.06	-0.08	-0.05	-0.09	-0.09	0.00	0.19	-0.06
2014	0.21	0.09	-0.03	-0.01	-0.06	0.05	-0.09	0.06	0.15	0.55
2015	0.48	0.14	0.26	0.20	0.14	0.28	0.24	-0.08	0.03	-0.47
2016	0.16	-0.06	-0.20	-0.21	-0.11	-0.19	-0.12	-0.16	-0.22	-0.13

Icelandic cod in Division Va. Estimates of fishing mortality 1955-2016 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	0.04	0.17	0.25	0.27	0.30	0.30	0.28	0.33	0.33	0.31	0.33	0.33
1956	0.05	0.18	0.25	0.26	0.29	0.30	0.30	0.34	0.36	0.34	0.34	0.34
1957	0.08	0.21	0.27	0.27	0.30	0.33	0.33	0.36	0.37	0.33	0.30	0.30
1958	0.11	0.25	0.30	0.29	0.32	0.37	0.40	0.44	0.45	0.39	0.33	0.33
1959	0.09	0.23	0.28	0.26	0.30	0.34	0.35	0.40	0.38	0.32	0.23	0.23
1960	0.10	0.23	0.29	0.29	0.34	0.40	0.43	0.48	0.48	0.39	0.27	0.27
1961	0.09	0.23	0.26	0.26	0.33	0.40	0.42	0.46	0.44	0.35	0.23	0.23
1962	0.11	0.25	0.28	0.26	0.35	0.42	0.47	0.51	0.49	0.38	0.24	0.24
1963	0.13	0.28	0.33	0.31	0.38	0.49	0.59	0.65	0.63	0.46	0.29	0.29
1964	0.13	0.29	0.37	0.36	0.43	0.57	0.74	0.81	0.84	0.61	0.39	0.39
1965	0.12	0.28	0.38	0.40	0.47	0.60	0.74	0.85	0.88	0.65	0.43	0.43
1966	0.09	0.25	0.34	0.38	0.49	0.62	0.78	0.92	1.01	0.78	0.53	0.53
1967	0.08	0.23	0.30	0.34	0.48	0.61	0.75	0.88	0.93	0.72	0.46	0.46
1968	0.08	0.25	0.34	0.41	0.58	0.77	1.04	1.20	1.36	1.08	0.73	0.73
1969	0.06	0.23	0.32	0.35	0.50	0.61	0.72	0.84	0.87	0.71	0.44	0.44
1970	0.07	0.27	0.39	0.43	0.55	0.65	0.76	0.89	0.95	0.80	0.51	0.51
1971	0.09	0.31	0.48	0.53	0.62	0.72	0.80	0.96	1.03	0.87	0.57	0.57
1972	0.09	0.30	0.48	0.55	0.65	0.73	0.79	0.96	1.06	0.90	0.59	0.59
1973	0.12	0.32	0.49	0.56	0.67	0.75	0.80	0.95	1.04	0.89	0.58	0.58
1974	0.11	0.32	0.50	0.57	0.70	0.83	0.92	1.05	1.17	1.02	0.68	0.68
1975	0.11	0.31	0.50	0.60	0.72	0.88	1.02	1.12	1.24	1.08	0.75	0.75
1976	0.07	0.26	0.43	0.55	0.69	0.85	0.94	1.00	1.05	0.92	0.63	0.63
1977	0.03	0.20	0.33	0.43	0.61	0.72	0.72	0.73	0.69	0.61	0.39	0.39
1978	0.03	0.17	0.28	0.35	0.52	0.60	0.54	0.54	0.48	0.44	0.27	0.27
1979	0.03	0.17	0.27	0.34	0.50	0.57	0.49	0.49	0.41	0.38	0.23	0.23
1980	0.03	0.17	0.31	0.39	0.54	0.62	0.55	0.54	0.46	0.43	0.28	0.28
1981	0.02	0.18	0.35	0.49	0.65	0.82	0.85	0.81	0.74	0.67	0.49	0.49
1982	0.03	0.19	0.39	0.56	0.70	0.90	0.95	0.86	0.73	0.65	0.48	0.48
1983	0.02	0.18	0.38	0.55	0.70	0.88	0.91	0.84	0.72	0.65	0.49	0.49
1984	0.04	0.20	0.38	0.53	0.67	0.80	0.75	0.69	0.58	0.54	0.40	0.40
1985	0.05	0.23	0.42	0.58	0.71	0.83	0.76	0.69	0.58	0.54	0.40	0.40
1986	0.06	0.26	0.52	0.72	0.82	0.95	0.87	0.76	0.64	0.58	0.45	0.45
1987	0.06	0.27	0.56	0.82	0.91	1.06	0.98	0.83	0.72	0.66	0.52	0.52
1988	0.05	0.26	0.53	0.80	0.92	1.10	1.07	0.93	0.85	0.78	0.64	0.64
1989	0.04	0.24	0.46	0.66	0.79	0.89	0.79	0.70	0.62	0.58	0.45	0.45
1990	0.05	0.25	0.47	0.66	0.79	0.85	0.74	0.67	0.59	0.55	0.42	0.42
1991	0.09	0.30	0.57	0.81	0.88	0.94	0.83	0.75	0.67	0.62	0.49	0.49
1992	0.10	0.32	0.60	0.87	0.92	1.00	0.88	0.78	0.70	0.64	0.51	0.51
1993	0.14	0.31	0.56	0.81	0.89	1.03	1.01	0.90	0.85	0.77	0.64	0.64
1994	0.09	0.24	0.38	0.53	0.68	0.76	0.70	0.67	0.61	0.57	0.45	0.45
1995	0.06	0.19	0.32	0.42	0.57	0.62	0.55	0.55	0.49	0.46	0.36	0.36
1996	0.04	0.16	0.28	0.41	0.56	0.62	0.57	0.57	0.51	0.48	0.38	0.38
1997	0.03	0.14	0.27	0.42	0.58	0.66	0.64	0.65	0.59	0.54	0.44	0.44

1998	0.03	0.15	0.33	0.52	0.66	0.77	0.79	0.77	0.72	0.65	0.55	0.55
1999	0.04	0.17	0.39	0.64	0.73	0.84	0.87	0.83	0.77	0.69	0.59	0.59
2000	0.06	0.18	0.38	0.61	0.73	0.85	0.89	0.86	0.81	0.72	0.63	0.63
2001	0.07	0.19	0.38	0.57	0.68	0.83	0.92	0.92	0.88	0.79	0.70	0.70
2002	0.05	0.16	0.34	0.48	0.60	0.71	0.80	0.83	0.79	0.71	0.62	0.62
2003	0.04	0.15	0.33	0.49	0.57	0.67	0.73	0.77	0.73	0.66	0.58	0.58
2004	0.03	0.14	0.33	0.52	0.58	0.68	0.74	0.77	0.74	0.67	0.59	0.59
2005	0.03	0.13	0.29	0.48	0.55	0.65	0.70	0.73	0.71	0.64	0.56	0.56
2006	0.03	0.12	0.27	0.46	0.54	0.64	0.69	0.70	0.68	0.60	0.52	0.52
2007	0.03	0.11	0.23	0.39	0.49	0.61	0.68	0.69	0.67	0.59	0.52	0.52
2008	0.02	0.09	0.18	0.30	0.41	0.50	0.52	0.52	0.48	0.43	0.35	0.35
2009	0.03	0.10	0.19	0.31	0.41	0.49	0.50	0.48	0.43	0.38	0.30	0.30
2010	0.03	0.09	0.16	0.25	0.36	0.42	0.40	0.38	0.33	0.30	0.22	0.22
2011	0.03	0.09	0.16	0.24	0.33	0.38	0.35	0.33	0.28	0.25	0.17	0.17
2012	0.03	0.09	0.16	0.24	0.32	0.37	0.33	0.32	0.27	0.24	0.17	0.17
2013	0.04	0.10	0.17	0.25	0.33	0.38	0.34	0.33	0.29	0.26	0.18	0.18
2014	0.03	0.10	0.16	0.23	0.31	0.36	0.32	0.32	0.29	0.26	0.17	0.17
2015	0.03	0.10	0.15	0.22	0.29	0.34	0.30	0.30	0.26	0.23	0.14	0.14
2016	0.03	0.10	0.15	0.23	0.31	0.35	0.32	0.32	0.28	0.25	0.14	0.14

Icelandic cod in Division Va. Estimates of numbers at age in the stock 1955-2017 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	254.572	186.604	151.968	217.559	211.739	115.303	35.992	24.517	12.911	87.011	9.155	7.765	8.081	2.627
1956	329.313	208.426	152.779	119.537	150.237	134.622	71.734	21.773	14.805	7.960	51.449	5.414	4.663	4.778
1957	431.465	269.619	170.645	118.869	81.567	95.840	85.086	43.938	13.152	9.020	4.620	29.475	3.164	2.730
1958	230.091	353.254	220.745	128.819	78.506	50.789	59.791	51.561	35.115	7.757	5.128	2.623	17.278	1.917
1959	287.645	188.383	289.220	161.207	82.269	47.529	31.092	35.410	51.350	19.304	4.088	2.689	1.457	10.199
1960	192.076	235.503	154.235	216.234	104.531	50.785	30.106	18.878	20.597	37.460	10.591	2.279	1.594	0.946
1961	264.592	157.259	192.814	114.184	140.224	63.733	31.059	17.579	10.383	10.984	19.025	5.384	1.266	0.993
1962	304.322	216.630	128.753	143.720	74.642	88.575	40.165	18.215	23.607	5.593	5.678	10.020	3.102	0.825
1963	322.718	249.158	177.361	94.286	91.812	46.108	55.712	23.253	9.759	12.115	2.740	2.852	5.611	1.996
1964	341.841	264.219	203.993	127.552	58.167	54.145	27.715	31.094	11.636	4.443	5.197	1.200	1.469	3.447
1965	477.822	279.876	216.324	147.281	78.115	32.830	30.915	14.691	14.391	4.545	1.618	1.846	0.534	0.814
1966	256.474	391.208	229.143	156.978	90.778	43.545	17.967	15.803	6.590	5.601	1.594	0.550	0.786	0.285
1967	369.256	209.983	320.294	170.760	99.751	52.844	24.347	9.004	6.946	2.473	1.836	0.477	0.206	0.378
1968	269.303	302.321	171.920	242.881	111.191	60.309	30.859	12.288	4.007	2.689	0.842	0.595	0.190	0.106
1969	281.456	220.487	247.519	130.352	155.379	64.675	32.920	41.220	4.681	1.165	0.664	0.177	0.166	0.075
1970	207.772	230.437	180.519	191.640	84.594	92.138	37.159	32.898	18.366	1.868	0.413	0.228	0.071	0.087
1971	407.496	170.109	188.666	137.989	119.823	46.925	49.274	17.533	14.060	7.035	0.628	0.131	0.084	0.035
1972	267.069	333.629	139.274	141.406	82.953	60.799	22.561	21.699	23.290	5.178	2.216	0.183	0.045	0.039
1973	389.159	218.657	273.152	104.463	85.617	42.043	28.623	9.649	8.567	8.647	1.627	0.631	0.061	0.020
1974	548.598	318.617	179.021	198.613	62.075	43.015	19.579	12.022	3.717	3.157	2.733	0.472	0.212	0.028
1975	213.827	449.154	260.861	130.871	117.555	30.864	19.821	7.968	4.287	1.213	0.902	0.692	0.140	0.088
1976	339.556	175.067	367.736	191.676	78.629	58.265	13.865	7.887	2.697	1.267	0.323	0.213	0.192	0.054
1977	362.970	278.005	143.333	281.763	121.228	41.980	27.490	5.670	2.759	0.859	0.381	0.093	0.069	0.084
1978	209.174	297.174	227.611	113.832	189.782	71.401	22.408	12.248	2.262	1.096	0.338	0.157	0.041	0.038
1979	209.118	171.257	243.306	181.345	78.325	117.298	41.029	10.859	5.498	1.075	0.521	0.172	0.083	0.026
1980	196.990	171.212	140.214	193.658	125.179	48.745	71.861	20.333	5.050	2.748	0.541	0.282	0.096	0.054
1981	345.635	161.281	140.176	111.613	133.120	75.475	27.134	47.131	8.963	2.374	1.310	0.279	0.151	0.060

1982	208.091	282.982	132.046	112.187	76.639	76.586	37.934	11.629	17.037	3.147	0.864	0.512	0.117	0.075
1983	210.371	170.370	231.686	105.166	75.790	42.287	35.916	15.453	3.887	5.377	1.090	0.339	0.219	0.059
1984	493.802	172.238	139.487	185.286	72.030	42.561	19.890	14.540	5.255	1.283	1.896	0.435	0.145	0.110
1985	390.327	404.291	141.016	109.884	124.153	40.411	20.496	8.304	5.332	2.038	0.525	0.866	0.208	0.080
1986	262.834	319.573	331.006	109.833	71.493	66.590	18.557	8.219	2.964	2.044	0.837	0.241	0.415	0.114
1987	133.331	215.190	261.644	254.845	69.230	34.892	26.652	6.664	2.598	1.020	0.784	0.360	0.110	0.218
1988	195.858	109.162	176.183	202.638	158.948	32.509	12.607	8.814	1.896	0.795	0.362	0.312	0.153	0.054
1989	160.549	160.355	89.375	137.610	128.108	76.888	11.986	4.103	2.395	0.532	0.258	0.127	0.118	0.066
1990	261.378	131.446	131.288	70.267	88.478	100.048	32.645	4.434	1.376	0.892	0.216	0.114	0.058	0.061
1991	202.944	213.998	107.619	102.238	44.797	45.165	42.139	12.144	1.544	0.539	0.374	0.098	0.054	0.031
1992	117.617	166.156	175.207	80.876	61.911	20.807	16.373	14.256	3.873	0.552	0.209	0.156	0.043	0.027
1993	227.008	96.296	136.037	129.505	48.084	27.808	7.118	5.322	4.298	1.321	0.208	0.085	0.067	0.021
1994	247.839	185.858	78.841	96.962	77.519	22.577	10.166	2.399	1.563	1.288	0.438	0.073	0.032	0.029
1995	133.343	202.913	152.168	59.105	62.370	43.198	10.851	4.235	0.918	0.633	0.538	0.195	0.034	0.017
1996	242.130	109.172	166.131	117.186	39.826	37.125	23.172	5.034	1.862	0.434	0.299	0.270	0.101	0.019
1997	106.741	198.239	89.382	131.202	81.783	24.607	20.145	10.873	2.218	0.864	0.200	0.147	0.137	0.056
1998	256.531	87.392	162.305	71.346	93.003	50.898	13.240	9.229	4.587	0.954	0.370	0.091	0.070	0.073
1999	242.611	210.030	71.551	129.129	50.151	54.865	24.866	5.616	3.510	1.712	0.360	0.147	0.039	0.033
2000	237.031	198.633	171.958	56.019	88.763	27.874	23.687	9.768	1.978	1.201	0.612	0.137	0.060	0.018
2001	266.183	194.065	162.627	132.601	38.336	49.483	12.401	9.358	3.420	0.665	0.416	0.224	0.054	0.026
2002	119.728	217.932	158.887	123.556	89.803	21.462	22.814	5.122	3.352	1.114	0.218	0.141	0.083	0.022
2003	228.757	98.025	178.428	124.132	85.917	52.528	10.823	10.295	2.060	1.232	0.400	0.081	0.057	0.037
2004	199.487	187.290	80.256	140.769	87.418	50.581	26.308	4.989	4.304	0.812	0.469	0.157	0.034	0.026
2005	146.450	163.326	153.340	63.605	100.034	51.697	24.639	12.028	2.067	1.682	0.309	0.183	0.066	0.016
2006	198.331	119.903	133.720	121.583	45.868	61.182	26.265	11.621	5.138	0.839	0.665	0.124	0.079	0.031
2007	180.177	162.380	98.168	106.196	88.210	28.747	31.572	12.558	5.002	2.104	0.341	0.277	0.056	0.039
2008	195.976	147.517	132.945	78.227	77.970	57.268	15.965	15.784	5.578	2.074	0.867	0.143	0.126	0.027
2009	256.543	160.451	120.777	106.355	58.496	63.725	34.723	8.674	7.851	2.719	1.011	0.440	0.076	0.073
2010	274.394	210.040	131.366	96.012	79.168	39.767	38.393	18.890	4.333	3.892	1.376	0.538	0.246	0.046
2011	186.372	224.655	171.966	104.662	71.865	55.035	25.233	22.033	10.146	2.378	2.171	0.809	0.327	0.161

2012	273.220	152.589	183.932	137.121	78.393	50.140	35.443	14.898	12.323	5.872	1.397	1.348	0.518	0.225
2013	241.399	223.694	124.929	146.360	102.390	54.567	32.226	21.016	8.422	7.232	3.492	0.875	0.869	0.359
2014	169.714	197.641	183.145	98.390	108.412	70.654	34.775	19.055	11.814	4.908	4.247	2.142	0.553	0.595
2015	284.837	138.950	161.815	145.252	73.217	75.770	45.891	20.905	10.913	6.995	2.913	2.615	1.358	0.380
2016	280.523	233.205	113.762	128.011	107.747	51.361	49.838	28.008	12.220	6.620	4.235	1.830	1.701	0.966
2017	174.951	229.673	190.932	90.370	95.135	75.793	33.416	29.982	16.091	7.253	3.935	2.616	1.172	1.207

Icelandic cod in Division Va. Landings (thousand tonnes, average fishing mortality of age groups 5 to 10, recruitment to the fisheries at age 3 (millions), reference fishing biomass (B4+, thousand tonnes), spawning stock biomass (thousand tonnes) at spawning time and harvest ratio.

Year	Yield	F5-10	SSB	Reference biomass	Recruits	Harvest rate
1955	545.250	0.29	936.957	2354.550	151.968	0.23
1956	486.909	0.29	791.479	2079.670	152.779	0.23
1957	455.182	0.31	771.545	1876.560	170.645	0.24
1958	517.359	0.35	871.819	1863.510	220.745	0.28
1959	459.081	0.32	849.812	1825.050	289.220	0.25
1960	470.121	0.37	707.616	1752.670	154.235	0.27
1961	377.291	0.36	466.533	1495.590	192.814	0.25
1962	388.985	0.38	568.226	1491.700	128.753	0.26
1963	408.800	0.46	507.238	1314.700	177.361	0.31
1964	437.012	0.55	450.537	1218.020	203.993	0.36
1965	387.106	0.58	317.427	1021.880	216.324	0.38
1966	353.357	0.59	277.117	1031.020	229.143	0.34
1967	335.721	0.56	256.385	1102.490	320.294	0.30
1968	381.770	0.72	221.564	1222.650	171.920	0.31
1969	403.205	0.56	313.646	1325.510	247.519	0.30
1970	475.077	0.61	331.062	1336.830	180.519	0.36
1971	444.248	0.68	242.547	1097.930	188.666	0.40
1972	395.166	0.69	221.848	997.062	139.274	0.40
1973	369.205	0.70	245.538	843.945	273.152	0.44
1974	368.133	0.76	187.230	918.545	179.021	0.40
1975	364.754	0.81	168.577	895.774	260.861	0.41
1976	346.253	0.74	138.864	955.975	367.736	0.36
1977	340.086	0.59	199.152	1290.500	143.333	0.26
1978	329.602	0.47	212.854	1298.840	227.611	0.25
1979	366.462	0.44	304.741	1398.130	243.306	0.26
1980	432.237	0.49	357.419	1490.310	140.214	0.29
1981	465.032	0.66	264.788	1242.870	140.176	0.37
1982	380.068	0.73	168.127	971.395	132.046	0.39
1983	298.049	0.71	131.064	792.556	231.686	0.38
1984	282.022	0.64	142.138	913.317	139.487	0.31
1985	323.428	0.67	162.773	927.603	141.016	0.35
1986	364.797	0.77	195.326	855.467	331.006	0.43
1987	389.915	0.86	149.477	1032.960	261.644	0.38
1988	377.554	0.89	167.110	1035.360	176.183	0.36
1989	363.125	0.72	170.219	1004.410	89.375	0.36
1990	335.316	0.70	208.954	841.679	131.288	0.40
1991	307.759	0.80	164.827	699.390	107.619	0.44
1992	264.834	0.84	152.750	552.524	175.207	0.48
1993	250.704	0.86	121.603	597.698	136.037	0.42
1994	178.138	0.62	157.885	578.481	78.841	0.31
1995	168.592	0.50	178.346	560.464	152.168	0.30
1996	180.701	0.50	160.307	675.467	166.131	0.27

1997	203.112	0.54	189.355	788.688	89.382	0.26
1998	243.987	0.64	201.252	727.708	162.305	0.34
1999	260.147	0.72	182.945	739.798	71.551	0.35
2000	235.092	0.72	172.963	601.354	171.958	0.39
2001	236.705	0.72	171.565	686.565	162.627	0.34
2002	209.537	0.63	201.024	729.368	158.887	0.29
2003	207.246	0.59	193.265	744.541	178.428	0.28
2004	228.337	0.60	201.184	804.839	80.256	0.28
2005	213.865	0.57	228.840	722.745	153.340	0.30
2006	197.247	0.55	220.981	696.877	133.720	0.28
2007	171.646	0.52	207.098	677.413	98.168	0.25
2008	147.668	0.40	263.861	698.956	132.945	0.21
2009	183.302	0.40	250.112	786.507	120.777	0.23
2010	170.009	0.33	288.159	847.814	131.366	0.20
2011	172.207	0.30	358.182	901.929	171.966	0.19
2012	196.177	0.29	404.550	1033.820	183.932	0.19
2013	223.594	0.30	440.439	1166.220	124.929	0.19
2014	221.990	0.28	413.113	1176.950	183.145	0.19
2015	230.229	0.27	532.915	1263.480	161.815	0.18
2016	251.134	0.28	472.782	1329.700	113.762	0.19
2017	NA	NA	616.906	1355.719	190.932	NA
2018	NA	NA	NA	NA	188.040	NA
2019	NA	NA	NA	NA	117.273	NA

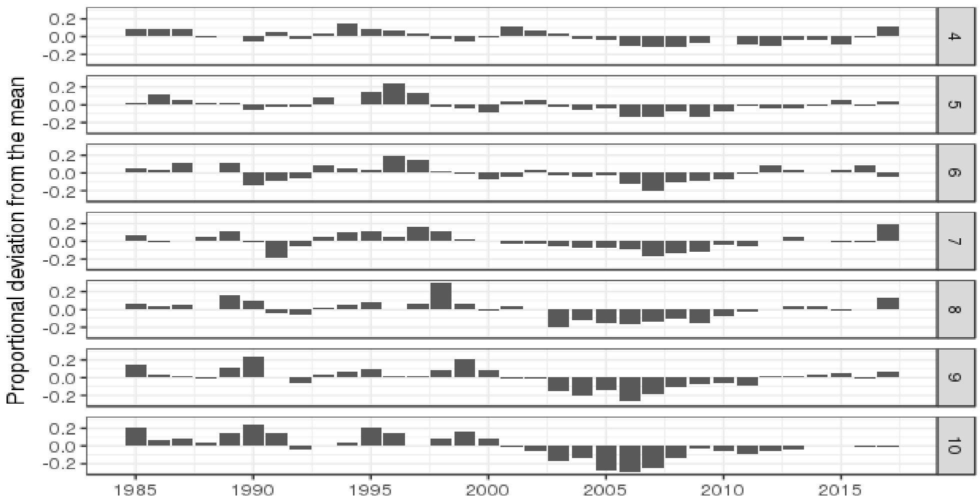
Icelandic cod in Division Va. Inputs in the deterministic predictions.

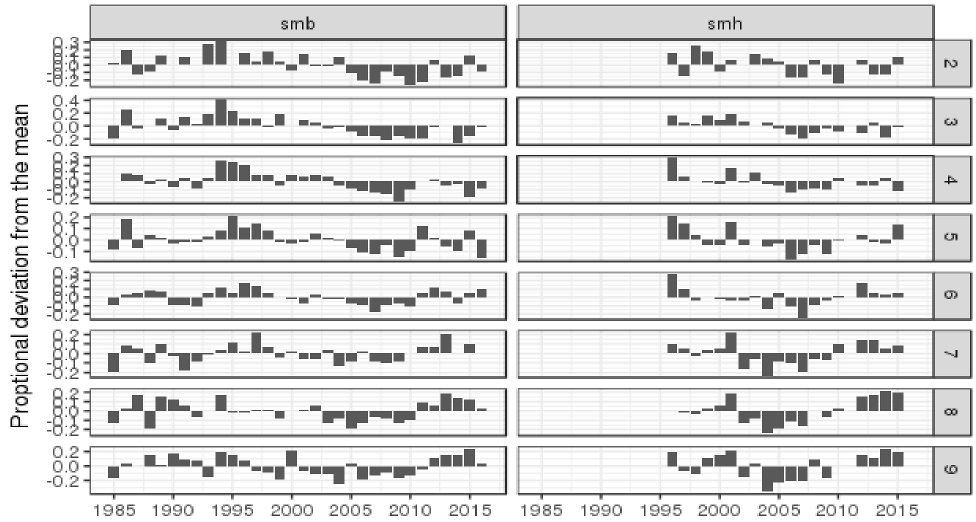
Age	2017	2018	2019	2020	Parameter
3	1.099	1.296	1.296	1.296	Catch weights
4	1.786	2.013	2.013	2.013	Catch weights
5	2.508	2.646	2.646	2.646	Catch weights
6	3.804	3.348	3.348	3.348	Catch weights
7	4.617	5.531	5.531	5.531	Catch weights
8	5.944	6.682	6.682	6.682	Catch weights
9	7.163	7.689	7.689	7.689	Catch weights
10	8.487	8.487	8.487	8.487	Catch weights
11	10.113	10.113	10.113	10.113	Catch weights
12	10.695	10.695	10.695	10.695	Catch weights
13	11.365	11.365	11.365	11.365	Catch weights
14	13.904	13.904	13.904	13.904	Catch weights
3	1.773	1.773	1.773	1.773	SSB weights
4	2.582	2.582	2.582	2.582	SSB weights
5	3.513	3.513	3.513	3.513	SSB weights
6	3.935	3.935	3.935	3.935	SSB weights
7	5.697	5.697	5.697	5.697	SSB weights
8	6.715	6.715	6.715	6.715	SSB weights
9	7.636	7.636	7.636	7.636	SSB weights
10	9.698	9.698	9.698	9.698	SSB weights

11	9.973	9.973	9.973	9.973	SSB weights
12	10.487	10.487	10.487	10.487	SSB weights
13	11.428	11.428	11.428	11.428	SSB weights
14	13.712	13.712	13.712	13.712	SSB weights
3	0.005	0.005	0.005	0.005	Maturity
4	0.008	0.008	0.008	0.008	Maturity
5	0.089	0.089	0.089	0.089	Maturity
6	0.262	0.262	0.262	0.262	Maturity
7	0.765	0.765	0.765	0.765	Maturity
8	0.906	0.906	0.906	0.906	Maturity
9	0.979	0.979	0.979	0.979	Maturity
10	0.987	0.987	0.987	0.987	Maturity
11	1.000	1.000	1.000	1.000	Maturity
12	1.000	1.000	1.000	1.000	Maturity
13	1.000	1.000	1.000	1.000	Maturity
14	1.000	1.000	1.000	1.000	Maturity
3	0.116	0.116	0.116	0.116	Selection
4	0.350	0.350	0.350	0.350	Selection
5	0.558	0.558	0.558	0.558	Selection
6	0.817	0.817	0.817	0.817	Selection
7	1.094	1.094	1.094	1.094	Selection
8	1.260	1.260	1.260	1.260	Selection
9	1.136	1.136	1.136	1.136	Selection
10	1.134	1.134	1.134	1.134	Selection
11	0.745	0.745	0.745	0.745	Selection
12	0.745	0.745	0.745	0.745	Selection
13	0.745	0.745	0.745	0.745	Selection
14	0.745	0.745	0.745	0.745	Selection
3	190.932	188.040	117.273	0.000	Stock numbers
4	90.370	NA	NA	NA	Stock numbers
5	95.135	NA	NA	NA	Stock numbers
6	75.793	NA	NA	NA	Stock numbers
7	33.416	NA	NA	NA	Stock numbers
8	29.982	NA	NA	NA	Stock numbers
9	16.091	NA	NA	NA	Stock numbers
10	7.253	NA	NA	NA	Stock numbers
11	3.935	NA	NA	NA	Stock numbers
12	2.616	NA	NA	NA	Stock numbers
13	1.172	NA	NA	NA	Stock numbers
14	1.207	NA	NA	NA	Stock numbers

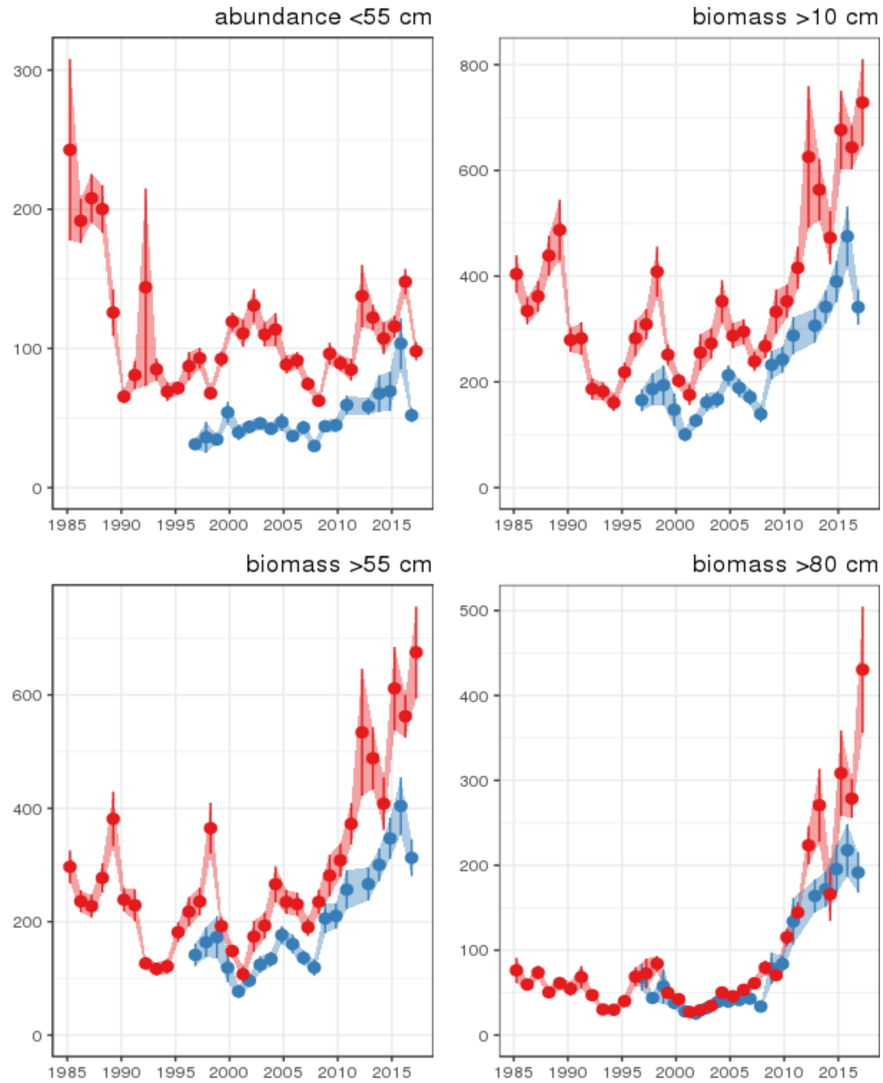
Icelandic cod in Division Va. Output of the deterministic predictions.

Year	B4+	Fmult	Fbar	SSB	Landings	2019 B4+	2019 SSB	SSB change	TAC change
2017	1355.719	NA	NA	NA	NA	NA	NA	NA	NA
2018	1444.190	0.0000000	0.00	728.0256	0.00000	1816.539	964.7745	0.3251931	-1.0000000
NA	NA	0.2272246	0.06	709.0080	64.52416	1743.124	886.3000	0.2500563	-0.7429317
NA	NA	0.2650954	0.07	705.8904	74.94526	1731.272	873.8926	0.2380005	-0.7014133
NA	NA	0.3029662	0.08	702.7873	85.27379	1719.526	861.6695	0.2260743	-0.6602638
NA	NA	0.3408370	0.09	699.6989	95.51065	1707.887	849.6275	0.2142760	-0.6194795
NA	NA	0.3787077	0.10	696.6249	105.65677	1696.352	837.7641	0.2026044	-0.5790567
NA	NA	0.4165785	0.11	693.5654	115.71305	1684.920	826.0765	0.1910579	-0.5389918
NA	NA	0.4544493	0.12	690.5202	125.68040	1673.591	814.5619	0.1796352	-0.4992813
NA	NA	0.4923201	0.13	687.4893	135.55970	1662.364	803.2177	0.1683349	-0.4599215
NA	NA	0.5301908	0.14	684.4726	145.35183	1651.237	792.0413	0.1571556	-0.4209090
NA	NA	0.5680616	0.15	681.4701	155.05767	1640.209	781.0301	0.1460959	-0.3822404
NA	NA	0.6059324	0.16	678.4816	164.67806	1629.280	770.1816	0.1351547	-0.3439121
NA	NA	0.6438032	0.17	675.5072	174.21386	1618.449	759.4932	0.1243304	-0.3059209
NA	NA	0.6816739	0.18	672.5467	183.66593	1607.714	748.9626	0.1136218	-0.2682632
NA	NA	0.7195447	0.19	669.6000	193.03507	1597.075	738.5873	0.1030276	-0.2309360
NA	NA	0.7574155	0.20	666.6672	202.32214	1586.530	728.3650	0.0925466	-0.1939357
NA	NA	0.7952863	0.21	663.7481	211.52793	1576.079	718.2932	0.0821774	-0.1572592
NA	NA	0.8331570	0.22	660.8427	220.65326	1565.720	708.3698	0.0719189	-0.1209033
NA	NA	0.8710278	0.23	657.9509	229.69893	1555.453	698.5924	0.0617698	-0.0848648
NA	NA	0.9088986	0.24	655.0726	238.66572	1545.278	688.9588	0.0517288	-0.0491406
NA	NA	0.9467694	0.25	652.2078	247.55442	1535.192	679.4667	0.0417948	-0.0137274
NA	NA	0.9846401	0.26	649.3565	256.36580	1525.195	670.1142	0.0319666	0.0213777
NA	NA	1.0225109	0.27	646.5184	265.10063	1515.287	660.8989	0.0222429	0.0561778
NA	NA	1.0603817	0.28	643.6936	273.75967	1505.466	651.8188	0.0126227	0.0906760
NA	NA	1.0982525	0.29	640.8821	282.34366	1495.731	642.8719	0.0031048	0.1248751
NA	NA	1.1361232	0.30	638.0837	290.85335	1486.082	634.0561	-0.0063119	0.1587783
NA	NA	1.1739940	0.31	635.2983	299.28947	1476.517	625.3695	-0.0156287	0.1923883
NA	NA	1.2118648	0.32	632.5260	307.65275	1467.037	616.8100	-0.0248465	0.2257082
NA	NA	1.2497356	0.33	629.7667	315.94391	1457.640	608.3757	-0.0339665	0.2587407
NA	NA	1.2876063	0.34	627.0202	324.16365	1448.325	600.0647	-0.0429898	0.2914886
NA	NA	1.3254771	0.35	624.2866	332.31268	1439.091	591.8752	-0.0519174	0.3239549
NA	NA	1.3633479	0.36	621.5657	340.39171	1429.938	583.8053	-0.0607505	0.3561423
NA	NA	1.4012187	0.37	618.8576	348.40140	1420.865	575.8531	-0.0694900	0.3880534
NA	NA	1.4390894	0.38	616.1620	356.34246	1411.871	568.0170	-0.0781370	0.4196911
NA	NA	1.4769602	0.39	613.4791	364.21555	1402.955	560.2950	-0.0866926	0.4510580
NA	NA	1.5148310	0.40	610.8087	372.02134	1394.116	552.6856	-0.0951577	0.4821567
NA	NA	1.5527018	0.41	608.1507	379.76049	1385.355	545.1869	-0.1035333	0.5129900
NA	NA	1.5905725	0.42	605.5052	387.43366	1376.669	537.7973	-0.1118204	0.5435604
NA	NA	1.6284433	0.43	602.8720	395.04149	1368.059	530.5152	-0.1200201	0.5738705
NA	NA	1.6663141	0.44	600.2511	402.58461	1359.523	523.3389	-0.1281333	0.6039228
NA	NA	1.7041849	0.45	597.6423	410.06368	1351.061	516.2668	-0.1361609	0.6337198
NA	NA	1.7420556	0.46	595.0458	417.47930	1342.672	509.2974	-0.1441038	0.6632642



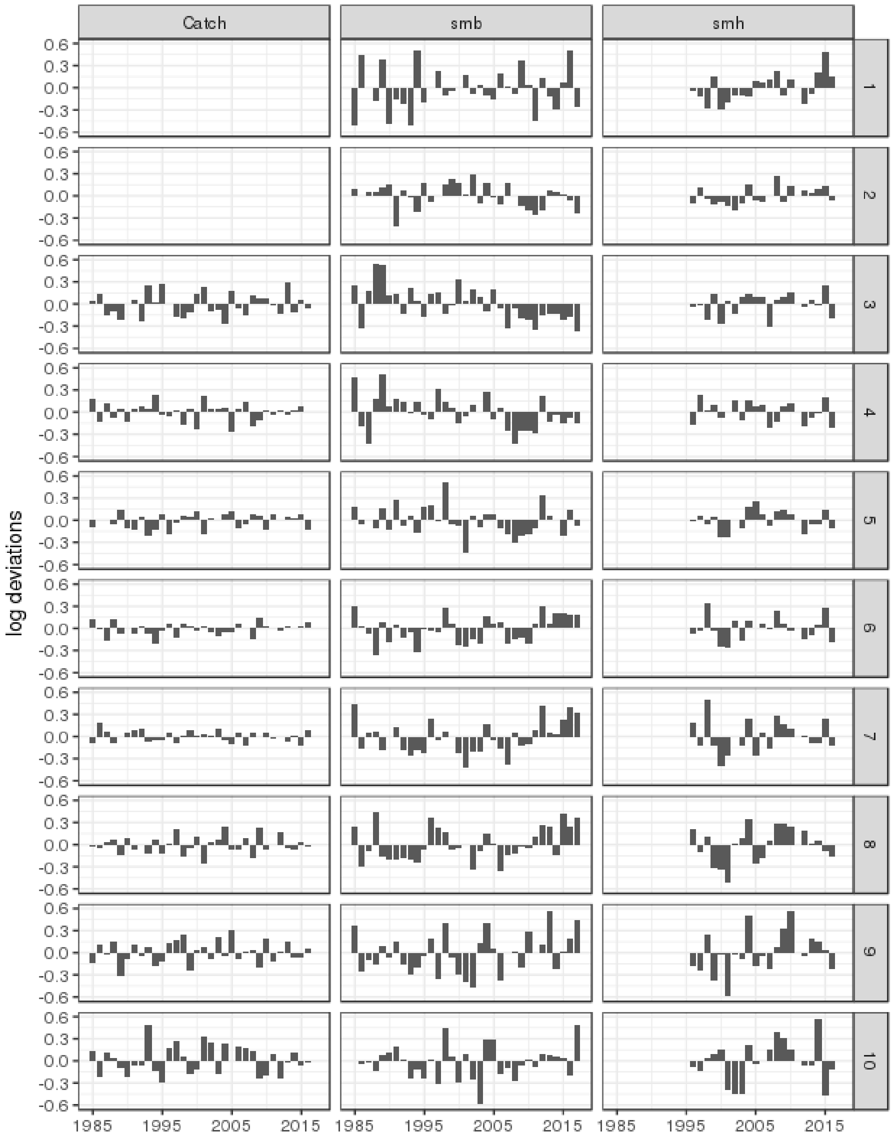


Icelandic cod division Va. Estimated weight at age (numbers in panel indicate age classes) in the spring survey (SMB) and fall survey (SMH) expressed as proportional deviations from the mean. No fall survey was conducted in 2011. Note that values that are equal to the mean are not visible in this type of a plot.

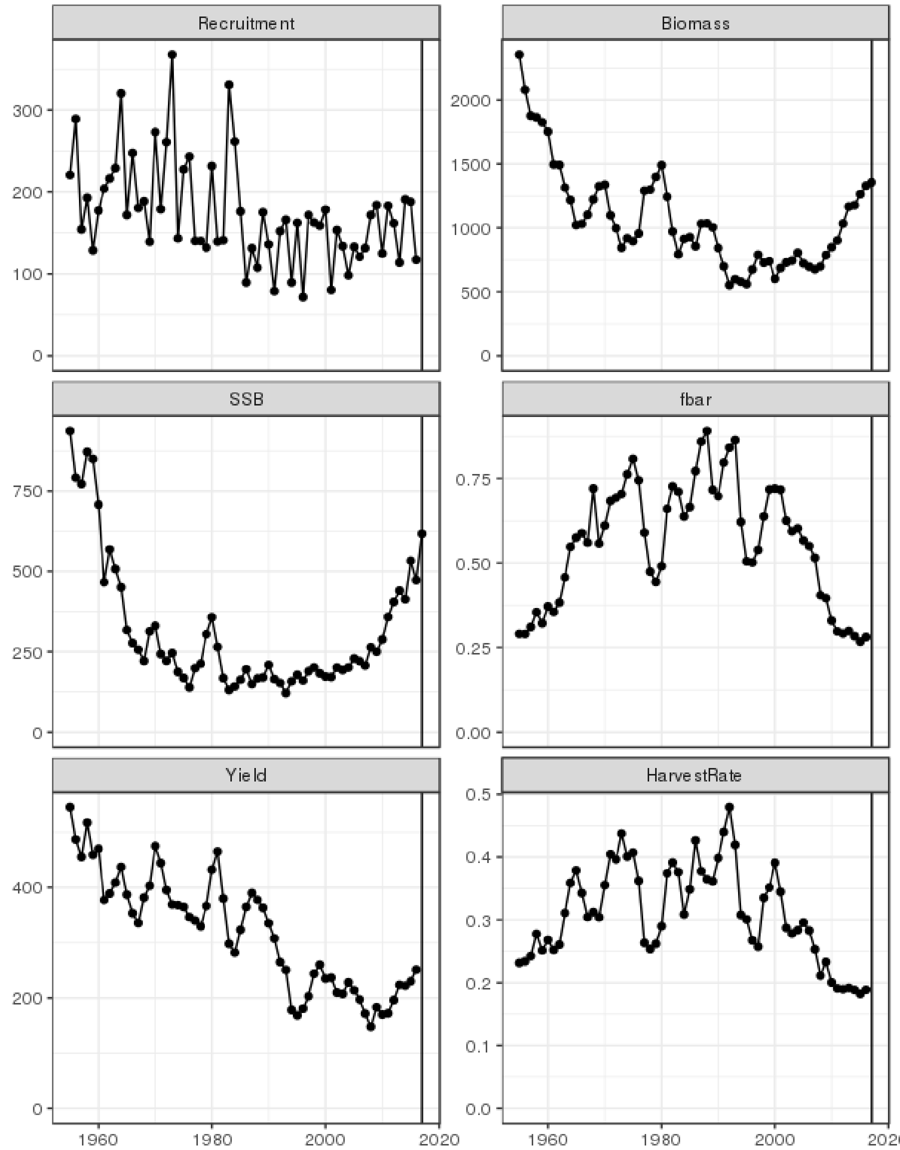


Icelandic cod division Va. Indices of cod in the spring (SMB, red) and fall (SMH, blue) groundfish surveys. Total biomass index (top right), biomass index of 55 cm and larger (bottom right), biomass index 80 cm and larger (bottom right) and abundance index of < 55 cm, (top left). The shaded area and the vertical bar show 1 standard error of the estimate.

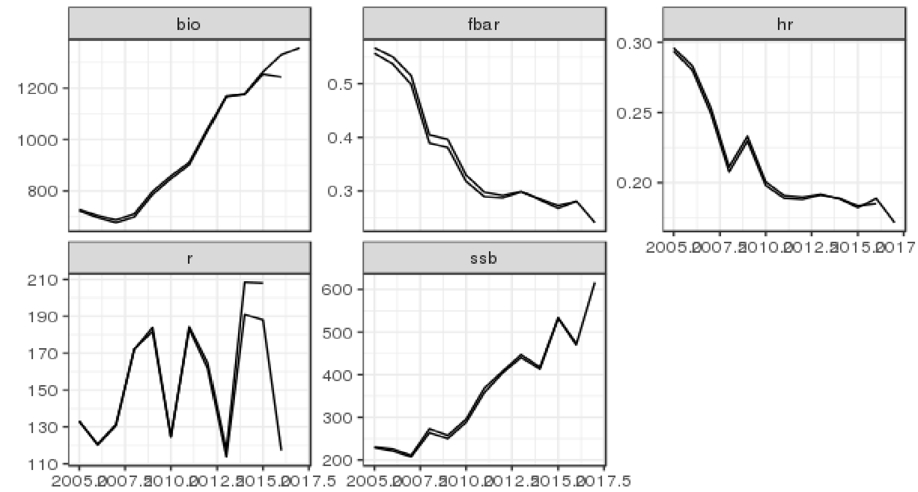
Icelandic cod division Va. Age based abundance indices of cod in the groundfish survey in spring (SMB) and fall (SMH). The indices are standardized within each age group and within each survey.



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.



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



Icelandic cod in division Va. Comparison with last years assessment

10 Icelandic haddock

A formal HCR has been in place for haddock in 5.a since 2013. According to the adopted Harvest Control Rule the advice for the fishing year 2017/2018 (September 1st 2017–August 31st 2018) is 41 390 tonnes. The advice for the following fishing year is predicted to be approximately 47 600 tonnes and remain at that level, as the catches will mainly be from a large year class.

The 2014 year class is estimated to be large, after 6 consecutive small year class from 2008–2013. The 2015 and 2016 year classes are, however, expected to be close to the geometric mean recruitment. The current assessment shows similar stock status 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 expected that 2014 year class will be substantially present in the fishery in 2018.

Growth in 2016 was above average since 1985 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. This difference has been apparent since 2009, although now this difference is now decreasing. Sensitivity analysis based on different models, using the same tuning series, exhibit similar properties.

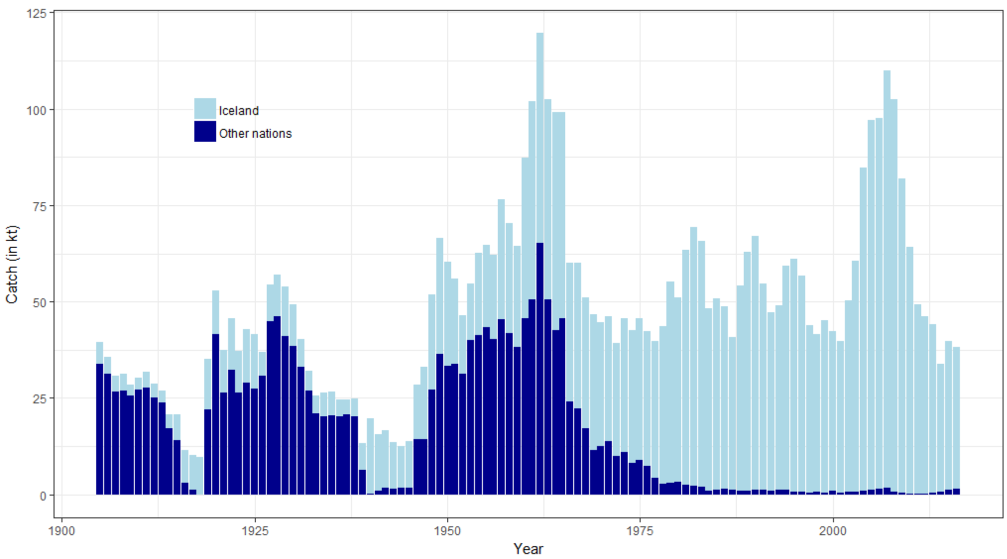


Figure 10.1.1 Haddock in division Va. Landings 1905 – 2016

10.1 Fishery

Landings of Icelandic haddock in 2016 are estimated to have been 38 100 tonnes, see Figure 10.1.1 and Table 10.1.1. Of the landings, 36 660 tonnes are caught by Iceland and 1440 tonnes by the Faeroese. The landings have decreased from 100 thous. tonnes between 2005–2008. The fishery for haddock in 5.a has not changed substantially in recent years. Around 250 longliners annually report catches of haddock, around 60 trawlers and 40 Danish seine boats. Most of haddock in 5.a is caught by trawlers and the proportion caught by that gear has decreased since 1995 from around 70% and is currently around 45%. At the same time the proportion caught by longlines has increased from around 15% in 1995 - 2000 to 40 % in 2011–2016. Catches in Danish seine have varied less and have been at around 15% of Icelandic catches of haddock in 5.a. Currently less than 2% of catches are taken by other vessel types, but historically up to 10 % of total catches were by gillnetters, but since 2000 these catches have been low.

(Table 10.1.2 and figure 10.1.2). Most of the haddock caught in 5.a by Icelandic longliners is caught at depths less than 200 m, by trawlers less than 300 m and Danish seine at depths (Figure 10.1.3). The main fishing grounds for haddock in 5.a, as observed from logbooks, are in the south, southwestern and western part of the Icelandic shelf (Figure 10.1.4). The main trend in the spatial distribution of haddock catches in 5.a according to logbook entries is the increased proportion of catches caught in the north and northeast. 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	2016
Belgium					
Faroe Islands	303	600	800	1259	1441
Iceland	45888	43500	33100	38391	36648
Norway					
Total	46191	44100	33900	39650	38100

Table 10.1.2. Haddock in 5.a. Number of Icelandic boats and catches by fleet segment participating in the haddock fishery in 5.a.

Year	Number of boats			Catches in tons				
	BOTTOM TRAWL	DANISH SEINE	LONGLINERS	BOTTOM TRAWL	DANISH SEINE	LONGLINERS	OTHER	TOTAL CATCH
1992	186	73	739	5969	282	5061	1858	13170
1993	283	142	809	30656	1787	8125	7110	47678
1994	226	152	843	41220	3430	8600	7179	60429
1995	196	137	753	42865	4317	8324	5188	60694
1996	180	146	631	39423	5550	7716	3746	56435
1997	170	151	475	27766	5330	7595	3026	43717
1998	170	136	473	24242	3687	9937	3039	40905
1999	161	128	491	25880	2772	13576	2304	44532
2000	142	117	480	23015	3101	13094	2024	41234
2001	119	91	449	21770	3036	11997	2321	39124
2002	111	90	418	29903	3596	13644	2469	49612
2003	104	96	436	35618	4804	17302	2285	60009
2004	109	95	449	49922	8095	23198	2586	83801
2005	107	89	449	51899	10493	30767	2719	95878
2006	97	89	437	45489	12708	36245	1696	96138
2007	97	81	408	56060	12862	37199	2060	108181
2008	88	78	363	50923	16456	33051	1250	101680
2009	85	71	335	38844	15157	26571	867	81439
2010	81	63	279	28458	10138	23916	1357	63869
2011	73	52	278	20509	6866	21175	682	49232
2012	76	54	289	20045	6048	18722	896	45711
2013	76	52	284	18587	4950	19229	645	43411
2014	66	45	295	13235	3776	16392	532	33935
2015	67	47	270	17082	4323	17641	619	39665
2016	68	44	250	16914	4452	16279	456	38101

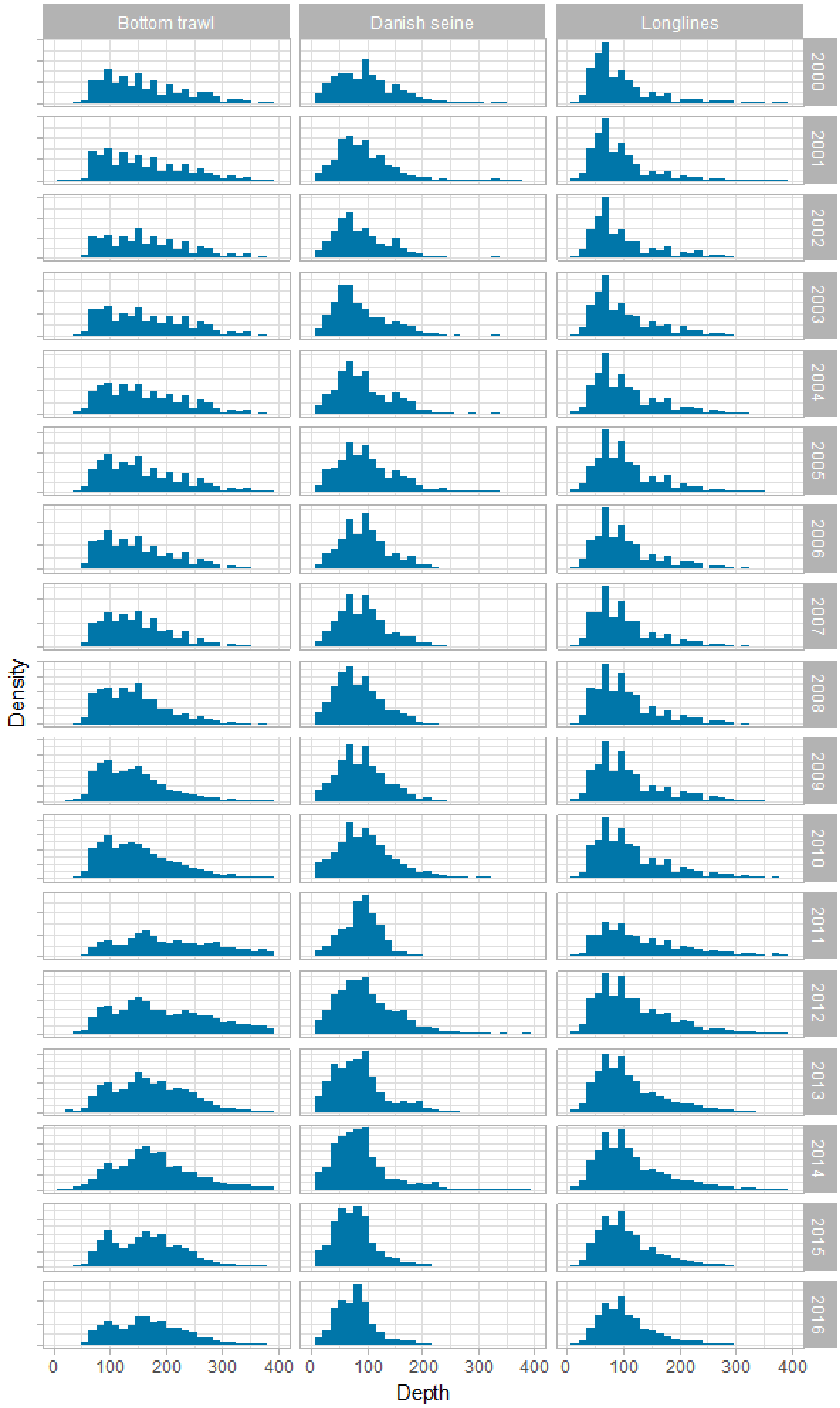


Figure 10.1.3. Haddock in 5.a. Depth distribution of haddock catches from bottom trawls, longlines, trawls and Danish seine from Icelandic logbooks

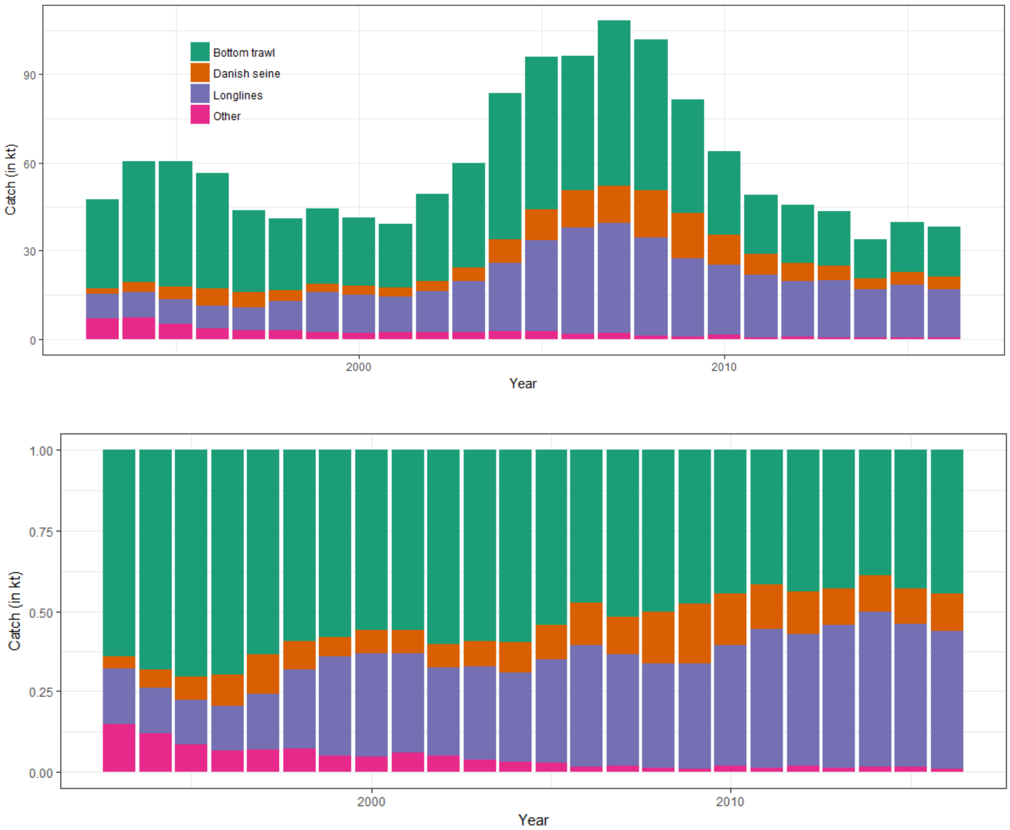


Figure 10.1.2 Haddock Division VA. Landings in tons and percent of total by gear and year.

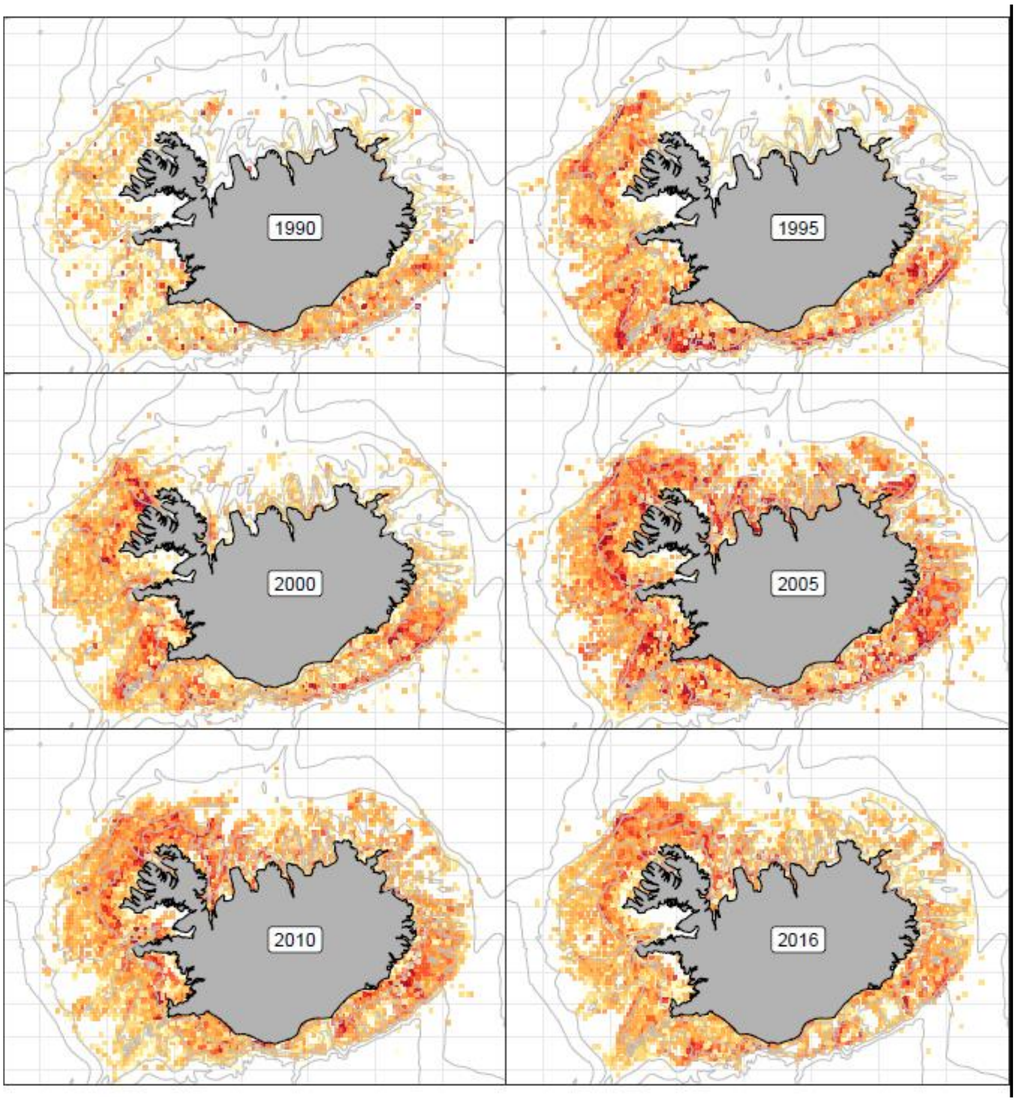


Figure 10.1.4 Haddock in 5.a. Spatial distribution of catches of haddock by all gears.

10.2 Data

10.2.1 Catch at age

Catch in numbers-at-age is shown in Table 10.2.1 and Figure 10.2.1. The catches in 2016 mainly composed of relatively small year classes as the last above average year class, the 2008 year class, accounted for roughly 12 % of the total catches. Older year classes contributed around 5% of total catches. So roughly 80 % 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 year class is 9 years old.

Table 10.2.1 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
2015	232	1532	4155	2317	2926	2623	2715	226	823
2016	482	1773	3437	4130	1727	1953	1420	1293	455

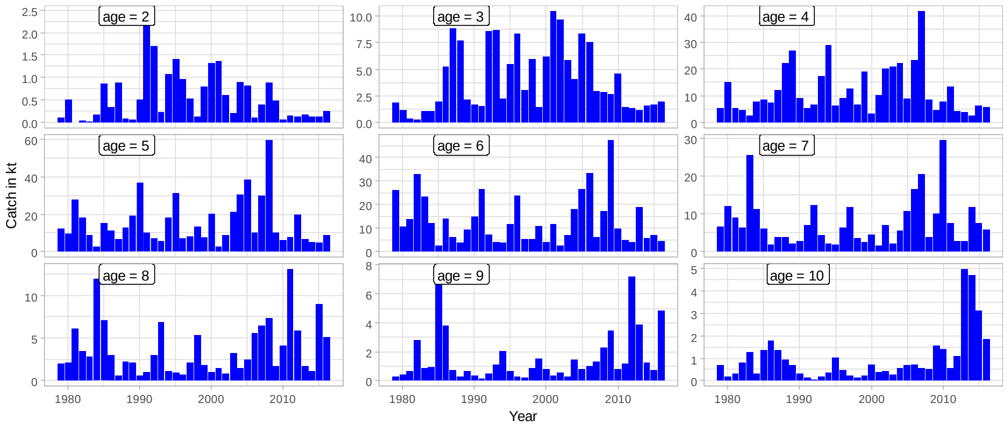


Figure 10.2.1 Haddock in division Va. Age disaggregated catch in tons.

10.2.2 Catch, effort and research vessel data

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 2016, however, a substantial decrease in the autumn survey was observed while the 2017 spring survey index was increased.

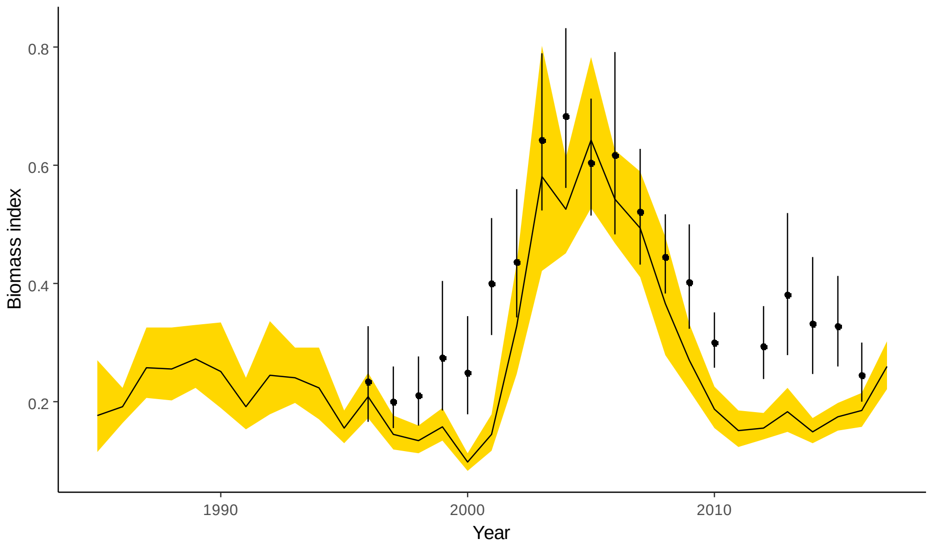


Figure 10.2.2 Icelandic haddock. Total biomass indices from the groundfish surveys in March (lines and shading) and the groundfish survey in October vertical segments. The standard error in the estimate of the indices is shown in the figure. Due to a strike the autumn survey was not conducted in October 2011.

Age disaggregated indices from the March survey are given in Table 10.2.2 and indices from the autumn survey in Table 10.2.3. Abundance of age groups 3–7 in the 2016 March survey is low while age 9 is among the highest indices observed (Table 10.2.2). 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.

Table 10.2.2 Haddock in 5.a. 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
2017	26.67	66.65	140.89	23.02	20.29	22.02	6.41	5.06	3.54	1.92	0.26

Table 10.2.3 Haddock in 5.a. 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
2016		78.9	125.27	23.15	18.18	19.41	7.15	7.88	3.92	3.04	0	0	0

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 10.2.2 and 10.2.3.).

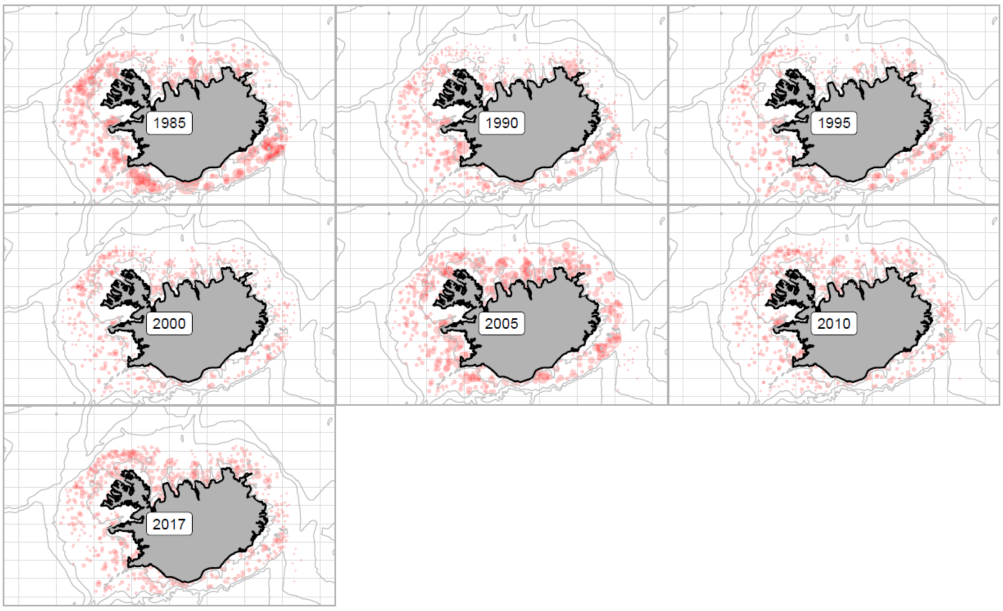


***Figure 10.2.2. Spatial distribution of haddock in the groundfish survey in March. The circles are indicative of tow size.**

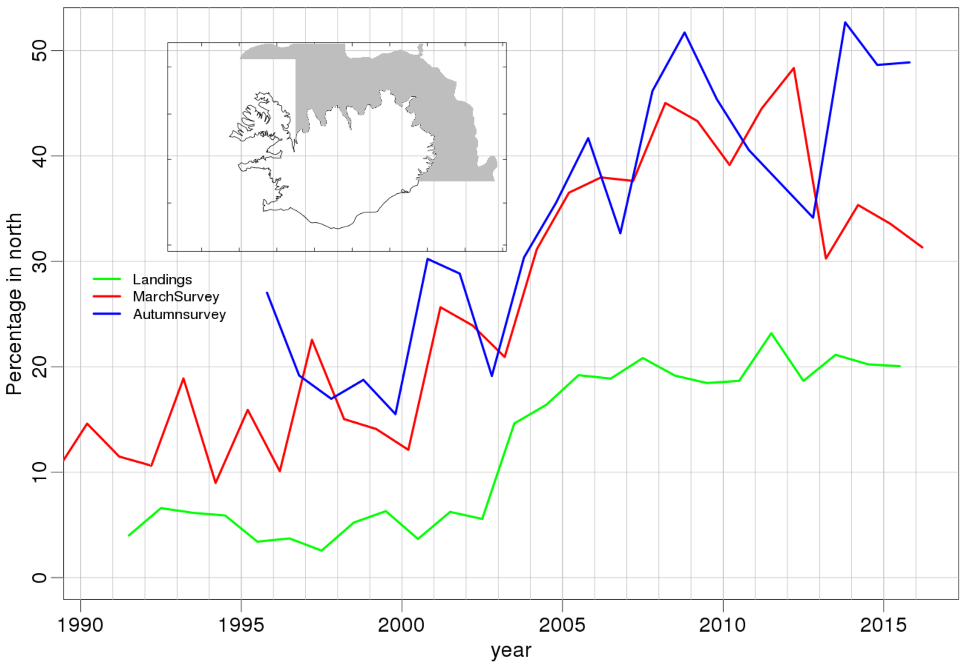


Figure 10.2.3. Proportion of the landings and the biomass of 42cm and larger haddock that is in the north area. The small figure shows the northern area.

10.2.3 Weight at age

Mean weight at age in the catch is shown in Table 10.2.4 and Figure 10.2.4. 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.

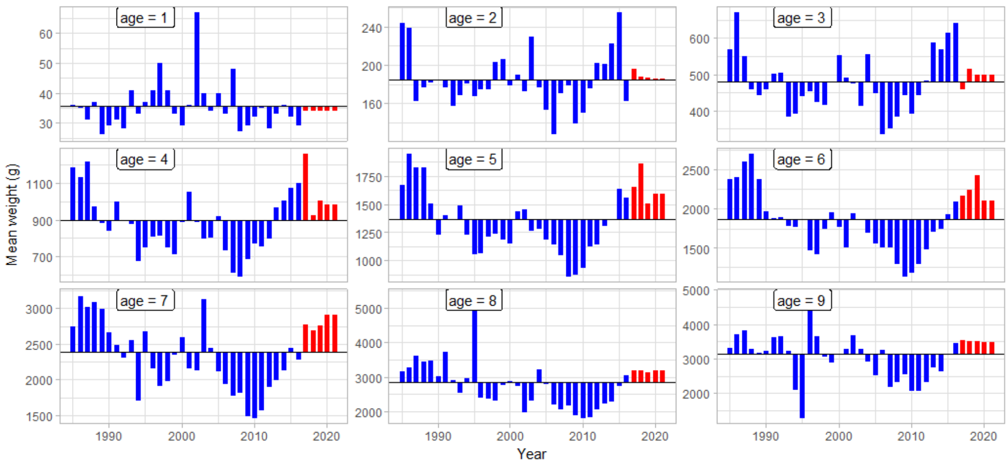


Figure 10.2.4 Haddock in division Va. Mean weight at age in the survey. Predictions are shown as red. The values shown are used as weight at age in the stock and spawning stock.

Table 10.2.4 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	34	196	459	1258	1657	2168	2780	3205	3564	3462
2018	34	188	516	927	1858	2247	2704	3210	3541	3810
2019	34	187	500	1004	1505	2431	2772	3150	3545	3793

Both stock and catch weights have been increasing in recent years, after being very low when the stock was large between 2005 and 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.

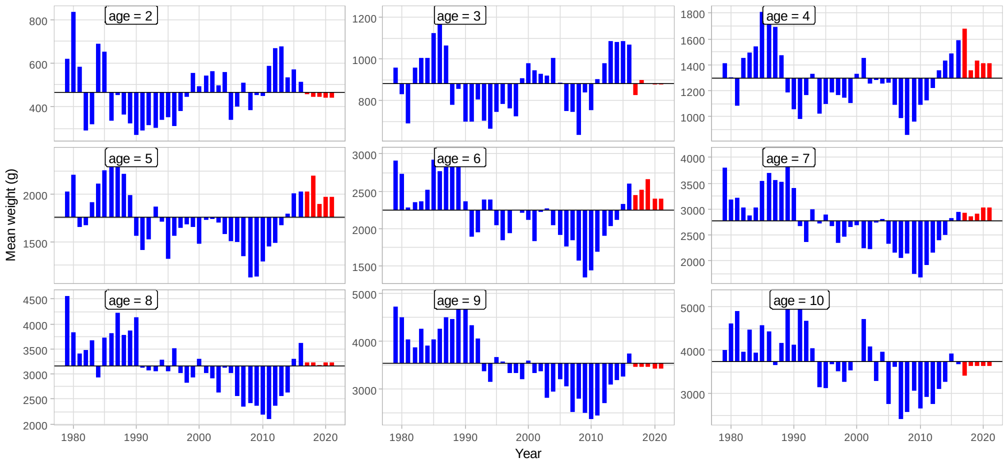


Figure 10.2.5 Haddock in division Va. Mean weight at age in the catches. Predictions are shown as red.

Table 10.2.5 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	513	1071	1590	2035	2607	2952	3616	3734	3679
2017	458	829	1678	2034	2454	2920	3225	3473	3404
2018	444	900	1355	2203	2516	2864	3229	3458	3639

10.2.4 Maturity at age

Maturity-at-age data are given in Table 10.2.6 and Figure 10.2.6. 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.

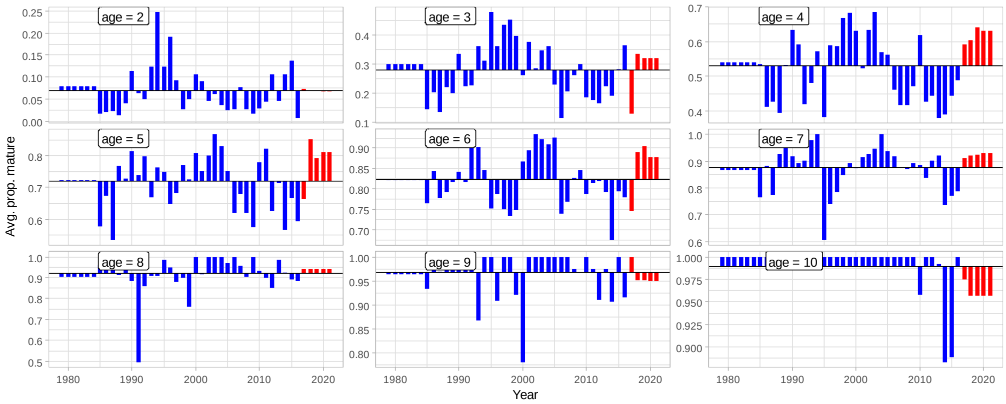


Figure 10.2.6 Haddock in division Va. Maturity-at-age in the survey. The red bars indicates predictions. The values are used to calculate the spawning stock.

Table 10.2.6 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.

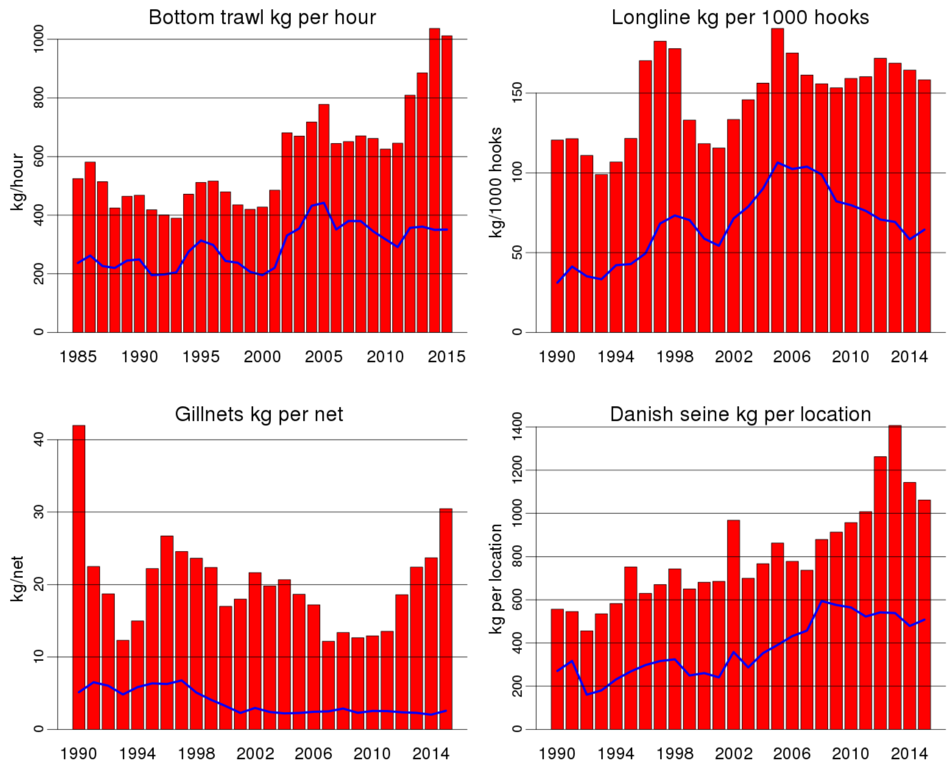
Year/Age	2	3	4	5	6	7	8	9	10
1979	0.08	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1
1980	0.08	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1
1981	0.08	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1
1982	0.08	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1
1983	0.08	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1
1984	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	0.008	0.366	0.487	0.594	0.779	0.787	0.883	0.915	1
2017	0.073	0.131	0.591	0.664	0.745	0.91	0.939	1	0.975
2018	0.069	0.335	0.605	0.851	0.891	0.921	0.942	0.951	0.957

10.2.5 Catch per unit effort from the commercial fishery

Catch per unit of effort data (figure 10.2.7) 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. The interesting thing for the current assessment is the relatively high CPUE, in recent years, confirming fishers's view that is now easier to catch haddock. 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.



- **Figure 10.2.7. 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 this year.**

10.3 Management

The Icelandic Ministry of Industries and Innovation (MII) is responsible for management of the Icelandic fisheries and implementation of legislation. The Ministry issues regulations for commercial fishing for each fishing year (1 September–31 August), including an allocation of the TAC for each stock subject to such limitations. Haddock in 5.a has been managed by TAC since the 1987. Landings have roughly followed the advice given by MRI and the set TAC in all fishing years (Table xxx.3). Since the 2001/2002 the catches have exceeded more that 5% the set TAC in five fishing years. The largest overshoot in landings in relation to advice/TAC was observed in the fishing year 2007/2008 when the landings of haddock exceeded the advice by 11%. The reasons for the implementation errors are related to the management system that allow for transfers of quota share between fishing years and conversion of TAC from one species to another. In addition these attributes of the TAC system catches are also taken by Norway and the Faroe Islands by bilateral agreement.

The level of those catches is known in advance but has until recently not been taken into consideration by the Ministry when allocating TAC to Icelandic vessels. There is no minimum landing size for haddock in 5.a. There are agreements between Iceland, Norway and the Faroe Islands relating to a fishery of vessels in restricted areas within the Icelandic EEZ. Faroese vessels are allowed to fish 5600 t of demersal fish species in Icelandic waters which includes maximum 1200 tonnes of cod and 40 t of Atlantic halibut. In 2016 total catches of Faroese vessels were 1 441 t.

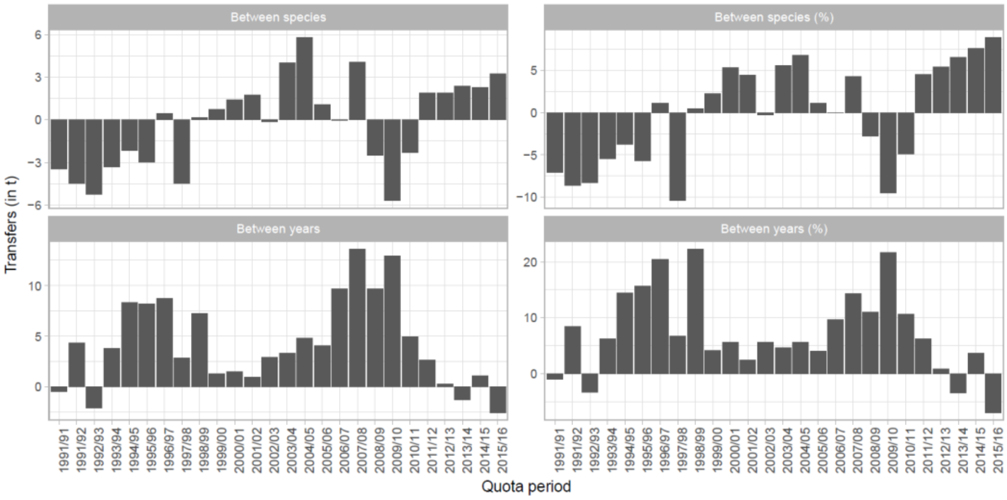


Figure 10.3.1 . Haddock in 5.a. Transfer between species and quota years both in tons and percentages.

The effect of these species conversions and quota transfers is illustrated in figure 10.3.1. The figure illustrates that when the biomass of haddock was high in the years between 2002 to 2007 the net transfers to haddock from other species increased. This may in part be explained by shifts in distribution of haddock, as illustrated in fig. 10., as the fisheries that traditionally target the northern area had lower amounts of haddock in their quota portfolio. However looking over longer period quota transfer towards/from haddock has on the average been close to zero. With the establishment a management plan in 2013 the transfers between quota years have decreased substantially, while at the same time transfers from other species have increased. This is likely due to the fact that haddock is easy to catch, as demonstrated by high CPUE in 2016. The haddock quota may also be limiting in some mixed fisheries and that haddock may have been underestimated in last years could also contribute to transfer towards haddock.

Table 10.3.1. Haddock in Division 5.a. History of ICES advice, the agreed TAC, and ICES estimates of landings by national fishing year. All weights are in thousand tonnes. * Calendar year ** Jan to August

Year	ICES advice	Predicted catch corresp. to advice	Agreed TAC	ICES landings for the fishing year	ICES landings for the calendar year
1987*	National advice	< 50	60		41
1988*	National advice	< 60	65		54
1989*	National advice	< 60	65		63
1990*	National advice	< 60	65		67
1991**	National advice	< 38	48		54
1991/1992	National advice	< 50	50	48	47
1992/1993	National advice	< 60	65	48	49
1993/1994	National advice	< 65	65	57	59
1994/1995	National advice	< 65	65	61	61
1995/1996	National advice	< 55	60	54	57
1996/1997	National advice	< 40	45	51	44
1997/1998	National advice	< 40	45	38	41
1998/1999	National advice	< 35	35	46	45
1999/2000	F reduced below Fmed	< 35	35	42	42
2000/2001	F reduced below provisional Fpa	< 31	30	40	40

2001/2002	F reduced below provisional Fpa	< 30	41	45	50
2002/2003	F reduced below provisional Fpa	< 55	55	56	61
2003/2004	F reduced below provisional Fpa	< 75	75	79	84
2004/2005	F reduced below provisional Fpa	< 97	90	98	97
2006/2007	F reduced below provisional Fpa	< 112	105	110	110
2007/2008	F reduced below provisional Fpa	120	100	102	102
2008/2009	F reduced below 0.35	< 83	93	82	82
2009/2010	F reduced below 0.35	< 57	63	73	64
2010/2011	F reduced below 0.35	< 51	50	53	49
2011/2012	F reduced below 0.35	< 42	45	49	46
2013/2014	TAC 0.4 × B45+cm,2014	< 38	38	39.6	34
2014/2015	TAC 0.4 × B45+cm,2015	< 30.4	30.4	36.6	39.6
2015/2016	TAC 0.4 × B45+cm,2016	< 36.4	36.4	36.8	38.1
2016/2017	TAC 0.4 × B45+cm,2017	< 34.6	34.6		
2017/2018	TAC 0.4 × B45+cm,2018	<41.4			

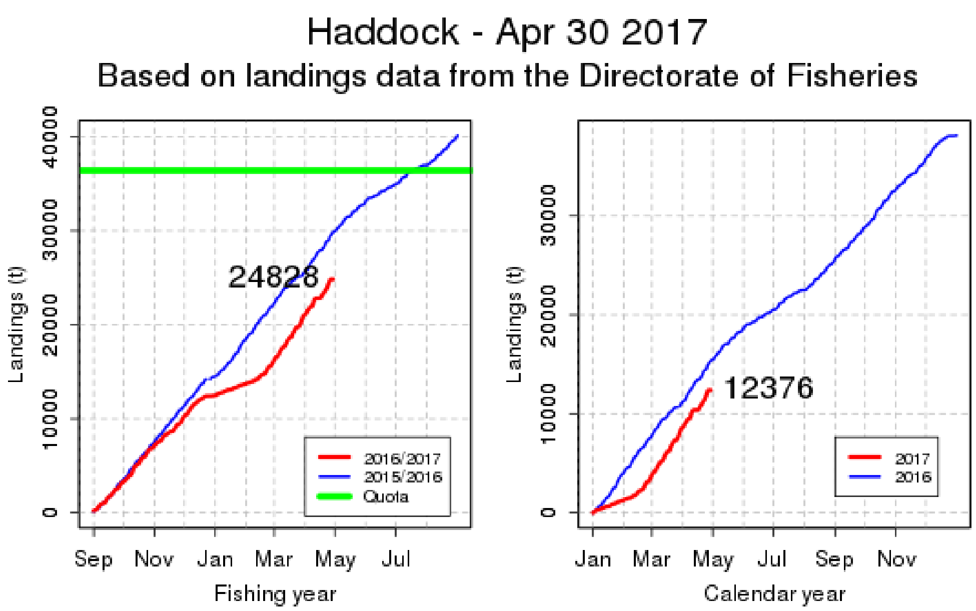


Figure 10.3.2 Haddock in division 5.a. Development of the landings during the fishing year 2016/17 (left side) and calendar year (2016) on the right. Fishing year 2015/2016 and calendar year 2016 shown for comparison. TAC for the fishing year shown in the left figure.

10.3.1 ICES advice

The ICES advice for the 2016/2017 fishing year states: ICES advises that when the Icelandic management plan is applied, catches in the fishing year 2016/2017 should be no more than 34 600 tonnes.

10.4 Assessment.

From 2007–2017 the final assessment was based on an Adapt type model calibrated with indices from both the groundfish surveys in March and October. The stock was benchmarked in February 2013, (WKROUND 2013) and this model setup was recommended for the use in the assessment. Prior to 2007 a 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, while this did decrease with addition of the most recent data points i.e. October 2016 and March 2017. 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).

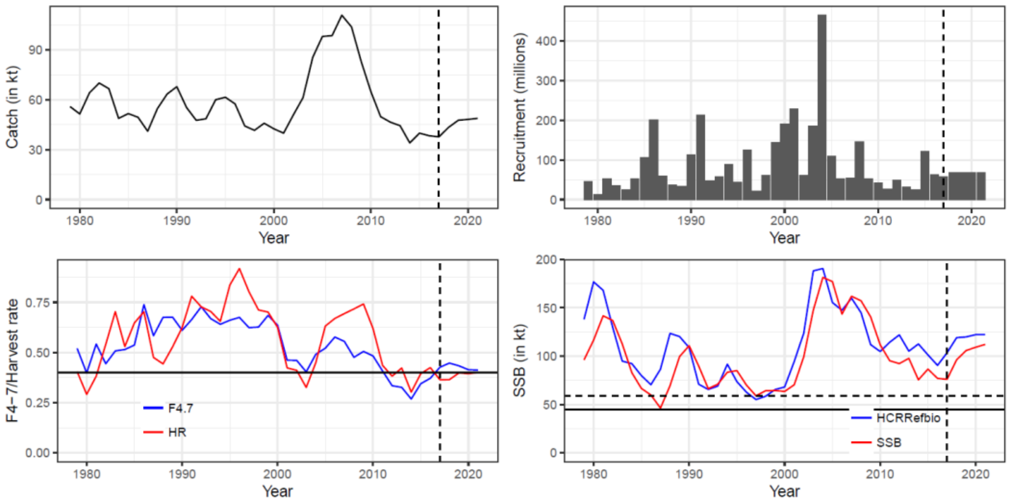


Figure 10.4.1 Haddock in division 5a. Summary from assessment. Dashed vertical line indicates the prediction period.

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 year classes (Figure 10.4.1). Since 2011 the rate of reduction has slowed down as fishing mortality has been low. In spite of this the spawning stock has decreased more than the reference biomass as proportion mature by age/size has been decreasing. Fishing mortality is now estimated to be low and is inline with the overall goal of the HCR. The current assessment does indicate the bottom has been reached and the stock size will increase in next years.

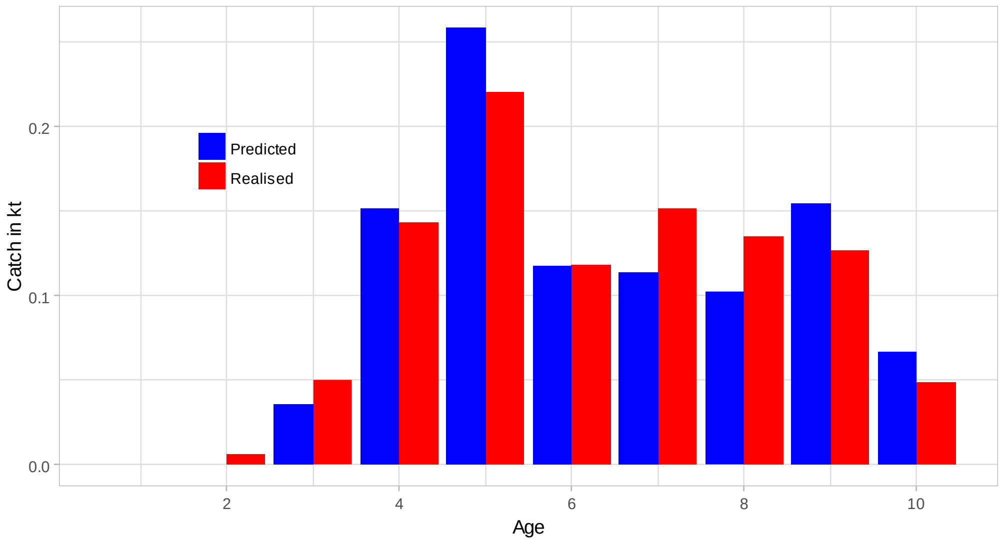
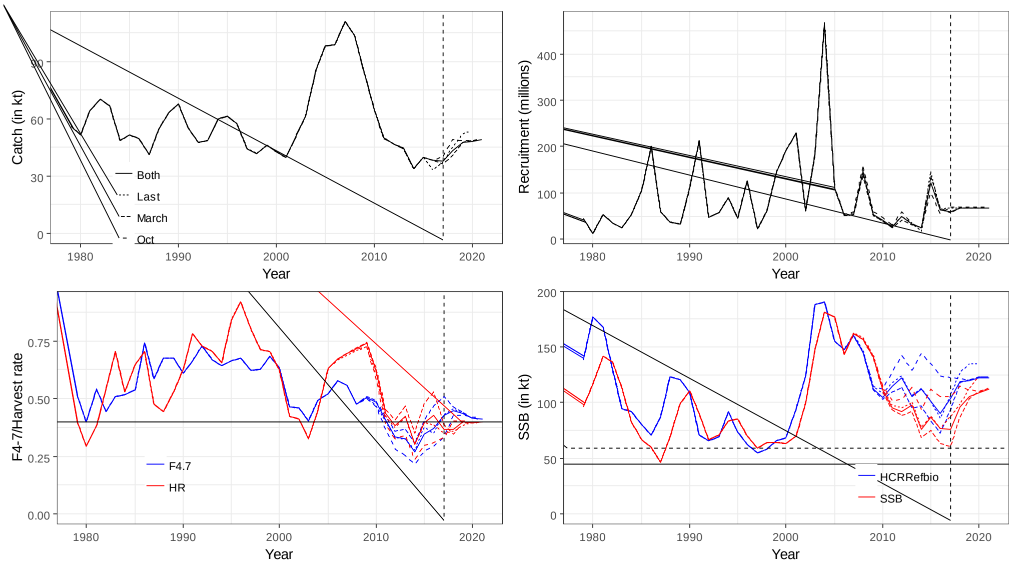


Figure 10.4.2 Haddock in division Va. Percent of catch in tonnes 201165 (red) compared to last year's predictions.

The main features of the current assessment are the same as in the assessments 2011 to 2016. The current assessment indicates similar stock as predicted by the 2016 assessment (Figure 10.4.2 and 10.4.3). Most of the difference is explained by lower than predicted catches from the 2012 year class (Figure 10.4.2). The tendency has been to underestimate recruitment and stock size in recent years.

Figure 10.4.3. Comparison of 2016 and 2017 assessment



10.4.4 Haddock in division 5a. Comparison of some of the results of 2017 assessment based on different tuning data and 2016 assessment tuned with both the surveys.

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.

Figure 10.2.2. Haddock in division Va. Residuals from the fit to survey data from Adapt run based on the both the surveys. Red circles indicate positive residuals (observed > modelled), while blue negative. Residuals are proportional to the area of the circles.

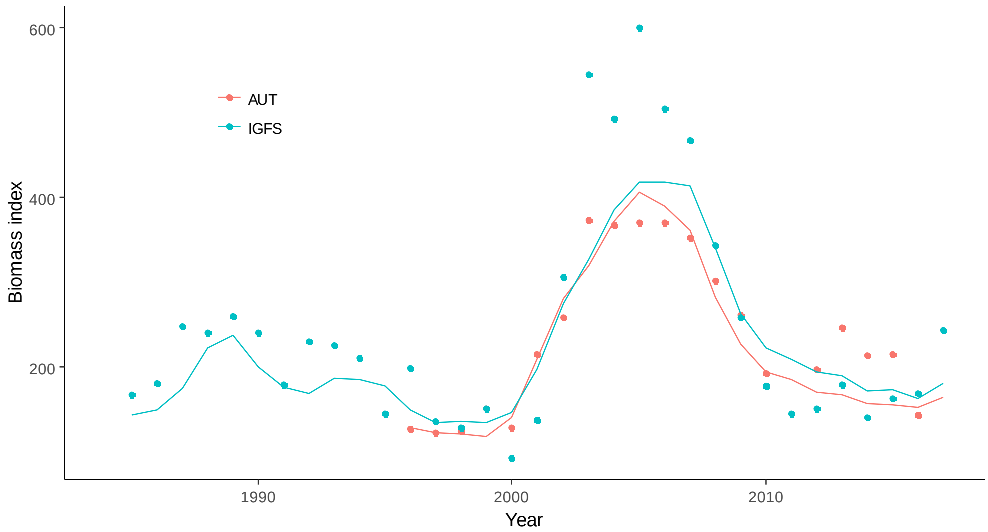


Figure 10.2.3. Haddock in division 5a. Observed and predicted biomass from the surveys according to the SPALY run.

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 (124 vs. 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 has been made last 5 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.

10.4.1 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 year's value, average of last 2 values is used.

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.

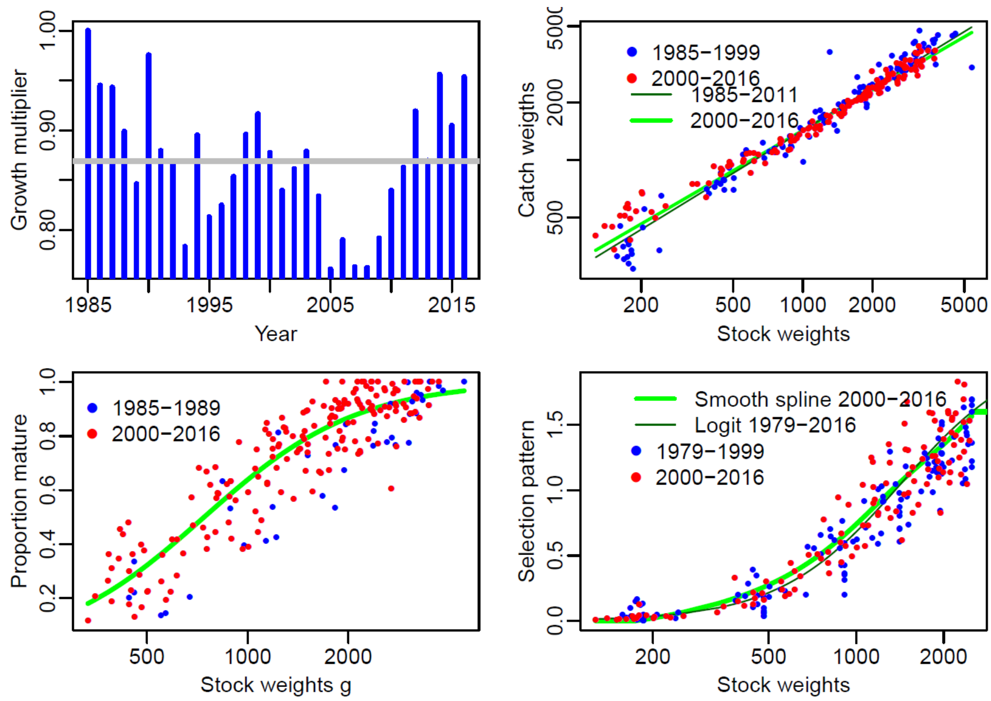


Figure 10.4.2 Haddock in division 5a. Input data to prediction. Predictions are based on the period since 2000. . Exponential of the yearfactor (growth multiplier) in the equation

$$\log \frac{W_{a+1,t+1}}{W_{a,t}} = \alpha + \beta \log W_{a,t} + \delta_{year}$$

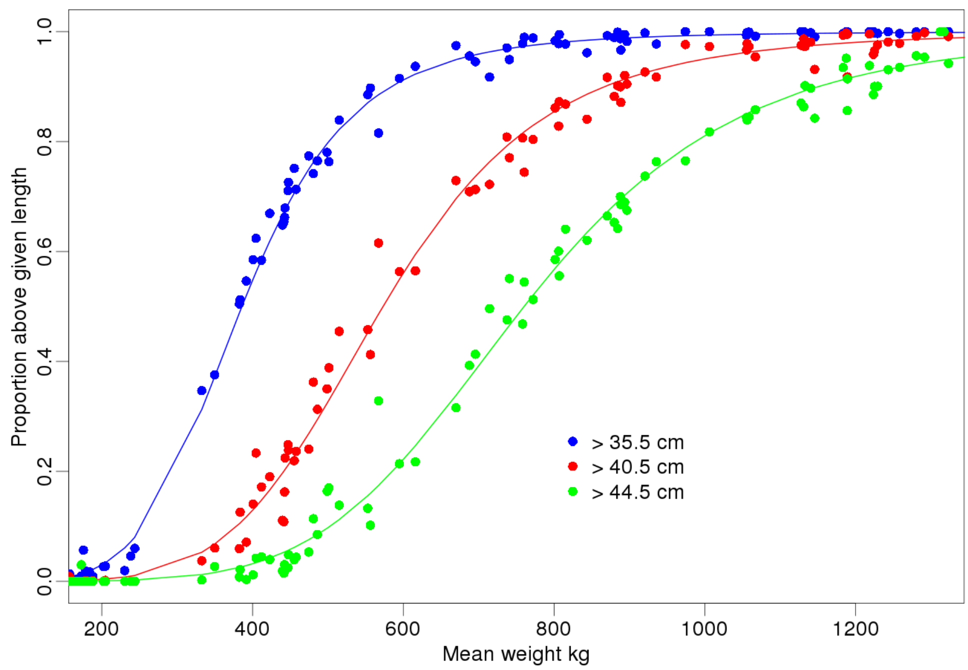


Figure 10.4.3 Haddock in division 5a. Proportion of the biomass of a yearclass above certain size. The points show data, compiled from the March survey and the lines a curve fitted to the data and used in simulations.

Mean weight and maturity-at-age in 2017 are available and are used to predict catch weights and selection at age (Figure 10.4.2). Growth in 2017 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 2018. 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 2017/2018 has some effect of the biomass at the beginning of 2018, which the TAC is based on. Advice for the following fishing year (2018/2019) is predicted to be approximately 48 000 tonnes and is projected to remain at that level as the 2014 year class will be fully recruited.

Results of the short-term prediction are shown in figure 10.2.1 assuming that the harvest control rule is followed. Summary of the assessment are in tables 10.4.1, 10.4.2 and 10.4.3. The TAC for the fishing year 2017/2018 will be 41 370 tons.

Table 10.4.1 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	80923,3	162,177	96,0722	55,3303	0,575924	0,52088
1980	37389,6	192,244	116,521	51,1104	0,438637	0,397891
1981	10426,4	206,988	141,628	63,5585	0,448771	0,542203
1982	42787,7	180,38	136,817	69,4278	0,50745	0,444141
1983	29305,6	148,112	112,589	65,9425	0,585692	0,508177
1984	20573,7	112,797	82,9611	48,2821	0,581985	0,515023
1985	42787,7	102,394	66,652	51,1016	0,766693	0,537229
1986	86501,1	96,4798	59,8372	48,8593	0,816537	0,738889
1987	164036	105,395	46,2981	40,7597	0,880375	0,583643
1988	48741,8	153,708	69,3913	54,2035	0,781128	0,675359
1989	29777,9	168,184	99,5369	62,8849	0,631775	0,676371
1990	27093,7	145,507	110,745	67,1975	0,606777	0,610767
1991	92280,5	122,708	89,8252	54,6918	0,608869	0,664292
1992	175094	106,31	66,3787	47,121	0,709881	0,728033
1993	38436,9	130,461	71,0004	48,1233	0,677789	0,668831
1994	46842	127,836	83,2949	59,5019	0,714352	0,640774
1995	72857	124,042	85,0535	60,8842	0,715834	0,660904
1996	36341,2	108,036	70,0083	56,8898	0,812615	0,675114
1997	102509	87,1523	58,9926	43,7638	0,741852	0,624108
1998	17975,8	97,1206	64,2033	41,1917	0,641582	0,626716
1999	50160,5	91,0235	64,4395	45,4108	0,704704	0,68486
2000	117423	90,6737	63,5091	42,1054	0,662982	0,636291

2001	156535	115,046	70,3664	39,6535	0,563529	0,461692
2002	187267	168,427	99,344	50,4975	0,50831	0,460974
2003	50393,9	219,757	147,523	60,8831	0,412702	0,403617
2004	151499	252,826	181,306	84,8281	0,467873	0,491146
2005	380385	259,044	177,009	97,2252	0,549267	0,521616
2006	89949,7	297,783	143,351	97,6139	0,680943	0,577149
2007	42734,5	295,572	161,863	109,966	0,679377	0,555256
2008	44106,5	247,505	157,129	102,872	0,654698	0,47605
2009	119577	190,27	140,53	82,0447	0,583823	0,505519
2010	43519,3	165,446	111,675	64,1685	0,5746	0,482894
2011	33990,5	150,825	95,2236	49,4331	0,519127	0,407959
2012	22236,9	142,401	92,2356	46,2077	0,500975	0,334525
2013	40644,3	136,966	97,7045	44,0972	0,451332	0,326602
2014	26208,8	124,409	75,5111	33,9001	0,448942	0,268533
2015	20388,3	126,688	86,5573	39,6456	0,458027	0,344764
2016	100236	111,606	77,0097	38,1093	0,494864	0,371789
Average 1979-2016	75787.79	154.3237	99.21296	58.40756	0.6094893	0.5355416

Table 10.4.2 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	58,68	52,25	81,63	11,89	9,99	10,43	3,24	2,61	1,9	2,37
2018	67,54	48,04	42,51	61,72	7,09	5,5	5,32	1,58	1,27	0,93
2019	67,54	55,29	39,18	31,36	39,7	3,66	2,67	2,48	0,74	0,59

Table 10.4.3 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	0,01	0,23	0,27	0,31	0,39	0,52	0,52	0,4	0,19
2017	0,01	0,08	0,32	0,4	0,47	0,52	0,52	0,52	0,52
2018	0	0,1	0,24	0,46	0,52	0,56	0,56	0,56	0,56
2019	0	0,1	0,26	0,39	0,54	0,55	0,55	0,55	0,55

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). Normally these surveys are conducted in the period of October-January, but also as late as end of 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 2016/2017 derives from two dedicated acoustic surveys in February and March 2017 (Óskarsson 2017). The nursery grounds of the stock were then in a survey in October 2016. 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 2017). 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 two main areas, west of Iceland (Kolluáll) and southeast of Iceland (Lónsdýpi) (Fig. 11.1.2.1; Óskarsson 2017). The majority of the stock was found in the west (Figure 11.1.2.2). The total acoustic estimate of Icelandic summer-spawning herring this winter, according to these three surveys came to 2.07 billions in numbers and total biomass estimate was 389 kt (Table 11.1.1.1). The fishable part of the stock (≥27 cm) accounted for 96% of the biomass, or 373 thousands tons. Apart from the one and two years olds, the three most numerous year classes were those from 2010 and 2008(19% and 18%, respectively, of the total number). Together, the 2008-2010 year classes contributed to ~51% of the total number and the biomass. The total abundance index is in line with the acoustic indices from recent years, which indicate a declining trend (Figure 11.1.2.2).

The juvenile survey, which was conducted for the second time as part of the shrimp survey (for the first time on RV Bjarni Sæmundsson), is specially aimed for assessing the number-at-age 1 because different from number-at-age 2, number-at-age 1 in the juvenile survey can be used to predict the year class strength later at age 3. The results indicate that the 2015 year class is below average. Applying the linear-regression provided by Gudmundsdottir et al. (2007) implied that the 2015 year class will be 496 millions at age 3 in the autumn 2018, or below average year class size of 666 millions at age 3 and geometric mean of 588 millions. This number should be used in the forecast in the 2017 assessment below.

Example where 2D AR1 on M could be useful

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 to 2013. Their main conclusions were that the infection was only causing significant additional mortality in the first two years, despite a high prevalence of infection for five years. These data have been revisted recently with updated data and lead to different estimates of the infection mortality (Óskarsson *et al*. 2017). Their results are considered to be more robust than previous estimates and are proposed to be used in the analytical assessment from now and on. The results imply that significant infection mortality took place in the first three years after the outbreak started (2009–2011) but not the years after (2012–2016). The level of the mortality was estimated with series of runs of the NFT-adapt assessment model, which gave the best fit to the data when applying infection mortality equivalent to 30% of the infected herring (heart inspection and survey abundance estimates provided $M_{infected}$) died annually in the first three years of the outbreak ($M_{year,\ age} = M_{fixed} + M_{infected,\ year,\ age} \times 0.3$; Table 11.3.2.1).

The prevalence of the *Ichthyophonus* infection in the stock in 2016/17 was estimated in a same way as has been done since the initiation of the infection in the autumn 2008 (Óskarsson and Pálsson 2017). The prevalence of infection west of Iceland was yet again highest for the 2005 and 2006 year classes according to the catch samples, or 47% and 42%, respectively (Figure 11.1.3.1). Prevalence in other year classes of herring at age 6+ were in the range of 24-33% this winter. Since 2009, the highest prevalence has been in the 2006, 2005 and 2004 year classes, and bit less in 2003 and 2002 even if it has varied, and that pattern continues. The prevalence of infection for the younger year classes (2008-2012) was low until the autumn 2014 when is it started to increase, which continued in 2015 and to a much larger extend now in 2016 (Figure 11.1.3.1). This indicates a new infection has been taken place in the stock in the last three years, particularly in the last year. This differs from the results obtained for the period 2010-2014, where analyses of younger age groups showed no indication of new infection, or at insignificant level.

During the winter 2016-17, no apparent trend in the staging of the infection was observed that can be used to tell something about the development of the infection. However, all the data indicate an ongoing new infection, which will most likely result in significant infection mortality in the coming months. It calls for applying additional infection mortality for 2017. It means that the abundance estimates from the final year of the assessment (1st Jan. 2017) and extrapolated to SSB near the beginning of the next fishing season (July 2017) to provide advice should be lowered by this additional M as done in 2009-2011 assessments. The subsequent question is, what should the additional M be? The estimated infection M for the whole stock (from prevalence of infection and survey abundance estimates) indicates age dependent infection. It is argued that applying the results by Óskarsson et al. (2017) is the most reasonable approach, which means that the estimates of $M_{infected}$ estimates should be multiplied by 0.3 and that value used in the prognosis in 2017 (Table 11.3.2.1). Furthermore, this increased M for 2017 should also be used in the analytical assessment in 2018 until better more reliable estimates become available.

11.2 Information from the fishing industry

The total landings of Icelandic summer-spawning herring in 2016/2017 season were about 60.4 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-September 2016 (6.6 kt), even if partly (70%) belonging to the official fishing season 2015/2016. 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 2016, was 63 kt and allowable TAC 63 kt. The difference between the catches in 2016 and TAC is partly due to 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 December in pelagic trawls, or 89% of the total catch (Fig. 11.2.2). The remaining of the catch 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 2016/2017.

This applied to the fishery in the west as maturity stage of the herring in catch samples in September-December indicated that 4.1% of the herring caught there 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.

All the catch in 2016/2017 was taken in pelagic trawls (Figure 11.2.1), which reflects that both the targeting and bycatch fisheries takes mainly place in offshore areas. 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 2016/17. 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 2016/2017:

The procedure for the catch at age estimations, as described in the Stock Annex, was followed for the 2016/17 fishing season. It involves calculations from catch data collected at the harbours by the research personnel (0%) or at sea by fishermen (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 (2017). 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 2016/2017 was somewhat different from the composition in the bycatch of herring in the mackerel and NSS-herring fishery in the summer 2016 (Figure 11.2.2.1). The summer fishery included to a higher degree younger age groups (age 2-4; 37% of the biomass) than the direct fishery in the west (14%), and consequently vice versa for older age groups. This difference is reflecting the geographical distribution of the different age groups, with higher proportion of younger age groups in the east and south than in the west, according to the acoustic surveys (79% vs 14% by biomass; Óskarsson 2017), where the main bycatch takes place. This pattern is in coherence with recent years.

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 2016/17 was 3130 and 2752 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 versus predictions of catch composition:

The relative contribution of the different year (age) classes was similar to what was predicted in the analytical assessment in 2016. The main difference was for age 5 (2011 YC) which was more numerous in the catches than predicted, as well as age 6, while other age groups were less numerous (Figure 11.2.2.1). This reflects that the size of the small 2011 year class (age 4), as well as for the 2010 year class, has been revised upwards in every assessments since 2015 (Figure 11.3.2.4).

11.3 Analytical assessment

11.3.1 Analysis of input data

Examination of catch curves for the year classes from 1985 to 2012 (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 1985-2012 (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 1996-2008 year classes. There is an indication that the fish is fully assessable to the survey at age 3-5.

Increased mortality in the stock because of the *Ichthyophonus* outbreak can not be detected clearly from the catch curves of the surveys. However, considering that F was reduced drastically in the beginning of the outbreak, similar Z must mean an increased M during that period.

11.3.2 Exploration of different assessment models

Input data:

In order to explore the data this year, only the assessment tool NFT-ADAPT (VPA/ADPAT version 3.3.0 NOAA Fisheries Toolbox) that has been used as the basis for the assessments since 2005 was run. Applying it was evaluated at benchmark assessment in January 2011 (ICES 2011a) and it found to be appropriate as the principal assessment tool for the stock. 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). 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 2009-2011 where additional age dependent mortality was applied because of the *Ichthyophonus* infection (see section 11.1.3; Table 11.3.2.1; Óskarsson et al. 2017); (iv) proportion of M before spawning was set to 0.5; and (v) proportion of F before spawning was set to 0. Thus, in comparison to last year's assessment, all the input data are the same with an additional year of data, except for M which has been reduced.

It should be noted that at a MSE work took place prior to the assessment meeting in 2017 (ICES 2017b), where a different model was applied on the same data as in the 2016 assessment (except for applying same M as in the final 2017 run). Applying the same input data resulted in similar stock size for both of the models (ICES 2017b).

Results:

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 to 12 in the beginning of year 2017, while the stock numbers at age 3 was derived from survey estimates in 2015 (i.e. projection from age-1 survey index to age-3 according to Gudmundsdóttir *et al*. 2007 and recommended by ICES (2011a)) instead of geometric mean as default in the model. 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 (2011a). In comparison to last year, the catchability of the survey has increased, which is caused by the lower total M applied during 2009-2011 since a comparison on Final 2017 and SPALY 2017 gave corresponding difference.

The output and model settings of the NFT-Adapt run (the adopted final assessment model) 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 to 2006 (i.e. referring to January 1st). 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. After 2008 the residuals are generally behaving well.

Retrospective analysis 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 (Figure 11.3.2.4). The same applies correspondingly to the fishing mortality. The retros observed for SSB in 2011 and 2012 are related to high survey indices in the preceding autumns as also seen as difference between observed and predicted survey values (Figure 11.3.2.5). The mass mortality, which was added to the catches in 2012 in the assessment as presented earlier (ICES 2014), are probably also partly explaining this pattern at that time. Furthermore, to sustain the high M in the input data for 2009-2011 because of the infection, SSB of the years prior to 2012 lifts in comparison to the preceding years. It required also an increase in recruitment estimates as apparent on the retrospective plots of number-at-age 3. 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.

Like demonstrated and analysed earlier (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 the fjord west of Iceland (Breiðafjörður; Óskarsson et al. 2010), while the the positive block during 2000-2004 was previoulsy found to be 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.

Comparisons to runs from previous year:

The final NFT-Adapt 2017 run was compared to the final run in 2016 and a SPALY run in 2017, which had the same updated input data as the final run in 2017 except for the using the approach for M as in the final assessment in 2016. As expected, the biomass estimates were lower for the period prior to the years of the *Ichthyophonus* outbreak in 2009-2011 in the final assessment in 2017 since it had lower total

M (Figure 11.3.3.2). For the other runs, the model gives higher biomass to sustain the higher total M applied. For the final year (2017), the runs give biomasses, particularly for age 3+.

The results of the final NFT run in 2017 gives a more pessimistic view on the stock size than the final run in 2016 as seen on biomass estimates (Figure 11.3.3.2) and abundance estimate at 1st Jan. 2016 (Figure 11.3.2.6). The 2008 and 2010 year classes were estimated slightly smaller in 2017 while the 2011 year class bigger. This resulted in 11.8% lower SSB in 2016 from the 2017 run, while the SPALY run gave 4.8% lower SSB than the 2016 run. This indicates that approximately half of the downward revision of the estimates is related to the changes in the approach regarding infection M and half to the addition of the new catch and survey data. The big difference for the 2013 year class is related to that the number-at-age 3 in 2016 was based on prediction from survey estimation of number-at-age 1 in the 2016 assessment while estimated by NFT in the 2017 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 0.25 in 2016 or above F_{pa}=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 0.20.

11.4 Reference points

Precautionary approach reference points:

The working group points 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. At the 2016 NWWG meeting, the PA reference points for the stock were verified and revised (ICES 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 σ = 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 σ = 0.18).

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}. During a Management Strategy Evaluation (MSE) for the stock in April 2017 (ICES 2017b), F_{MSY}=0.22 was not considered to be significantly different from results of simulation giving 0.24. Thus, it was concluded adequate to keep F_{MSY}=0.22. During a Management Strategy Evaluation for the stock in April 2017 (ICES 2017b) these reference points were evaluated and advised to be unchanged.

11.5 State of the stock

The stock was at high levels until around late 2000s but since then a substantial reduction has taken place despite a low fishing mortality. The reduction is consequence of mortality induced by *Ichthyophonus* outbreak in the stock in 2009-2011 and small year classes entering the stock since around 2005, particularly the 2011-2013 year classes. Hence, SSB will be below MSY $B_{trigger}$ in 2017 but above B_{lim}.

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, 2017, was used for the prognosis. All input values for the prognosis are given in Table 11.6.1.1. Because of the expected *Ichthyophonus* mortality in the stock in the spring 2017 (see section 11.1.3), the NFT-Adapt model output were reduced according to the infection ratios times 0.3 (Table 11.3.2.1), or the same approach as used in the assessments in 2009-2011 (ICES 2011b).

The weights were estimated from the last year catch weights (see Stock Annex) and as in the recent years, the weights are expected to continue to be high (Figure 11.6.1.1). The selection pattern used in the prognosis was based on averages over 2014 to 2016 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 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 millions at age 3 in 2017.

The 2015 year class: An acoustic survey aimed for getting an abundance index for this year class took place in September-October 2016 (Óskarsson 2016), and using a relation obtained by Gudmundsdóttir *et al.* (2007) provides estimate of 496 millions at age 3 in 2018.

The 2016 year class: No acoustic estimates are available for the year class yet thus the number-at-age 3 in 2019 was set to the geometrical mean for age-3 over 1987-2013, which give 528 millions.

In summary, the basis for the stock projection is as follows: SSB(2017)=238 kt; Biomass age 4+ (1st Jan. 2017) = 258 kt; Catch (2016/17) = 60 kt; WF_{5-10}(2016)=0.25.

11.6.2 Prognosis results

SSB in the beginning of the fishing season 2017/18 (approximately the same time as at spawning in July 2017) is estimated to be 238 kt, which is below MSY $B_{trigger}$ of 273 kt. Consequently adviced TAC on basis of MSY approach should be in accordance with $F = F_{MSY} \times (SSB_{2017}/B_{trigger}) = 0.22 \times 238/273 = 0.192$ (instead of 0.220).

The results of the short term prediction indicate that fishing at 0.192 would correspond to TAC in 2017/2018 fishing season of 41 kt and SSB at the spawning season in 2018 would be 245 kt, or below MSY $B_{trigger}$ but above B_{lim} (Table 11.6.1.2).

Table 11.6.1.3 provides TAC options for the different harvest control rules tested in the MSE in 2017 (ICES 2017b). A decision on HCR to be adoped by the managers from 2017 and onwards will be taken in the coming months. All of the four HCRs, as well as the currently applied harvest rule, were found to be precautionary and in conformity with the MSY approach.

The proposed composition of the catch in the season 2017/18 consists mainly of the 2009-2012 year classes and the plus group, each contributing to 12-16% in total biomass of the catch (Figure 11.6.2.1).

11.7 Medium term predictions

Because of the increased uncertainty of the assessment in relation to the development of the *Ichthyophonus* outbreak in the coming months and year and possibly changes in management of the stock in 2017 no medium term prediction is provided.

11.8 Uncertainties in assessment and forecast

11.8.1 Assessment

There are number of factors that could lead to uncertainty in the assessment. Two of them are addressed here. Different from previous four assessments where additional natural mortality caused by the *Ichthyophonus* infection was set for the first two years on full force, it was set for three years now but at lower level ($M_{infected, year}$ multiplied by 0.3 instead of 1; see section 11.1.3). This quantification of the infection mortality is considered to improve the assessment and reduce its uncertainty. The new approach changes the historical perception of the stocks size from last year's assessment but has minor impacts on the assessment of the final year and the resulting advice.

An apparent new infection in the stock in the winter 2014/15 and 2015/16 was not considered to cause induced natural mortality in the stock in the last two assessments. The indication for new infection again this winter (2016/17) are however, much stronger (11.1.3.1) so setting additional infection mortality in 2017 was considered unavoidable. The level of the mortality was based on estimates on prevalence of infection that winter multiplied by 0.3, which corresponds to the 2009-2011 infection mortality. More accurate estimation will be possible in the years to come but in the mean time this approach will add uncertainty to the assessment and the advice.

11.8.2 Forecast

The uncertainty in the assessment mentioned above related to the apparent new infection in the stock in last three years applies also for the forecast.

The number-at-age 3 in the beginning of 2017 used in the prognosis (391 millions) was predicted from a survey estimate of number at age 1 in 2015 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, even if it considered more appropriate than applying geometric mean.

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 four and this year's assessment are less than seen for many years for SSB and F (Figure 11.3.2.4). Simultaneously the residuals from the survey are behaving better than before (Figure 11.3.2.3). This together could be interpreted as indications for improvements in the assessment quality in recent years in comparison to the years before.

The revision of the infection mortality applied in the analytical assessment for the years 2009-2011 in accordance to the estimated mortality levels (section 11.1.3), is also considered as an improvement of the assessment. Thus the downward revision of the stock size over the period ~2003-2011 compared to the last year's assessment (Figure 11.3.2.2) is considered to provide more robust figure of development in the historical stock's size.

11.9 Comparison with previous assessment and forecast

This year's assessment was conducted in the same way as in last year, except for the changes in M in 2009-2011 (section 11.1.3). In the current assessment, SSB in 2016 is 11.8% lower (284 kt versus 318 kt), size of the 2011 year class at age 3 is 25% higher, size of the 2012 year class at age 3 is 9% lower, and WF_{5-10} in 2015 is 17% higher (0.219 versus 0.264), compare to the 2016 assessment. Thus there is a downward revision of stock size in this year's assessment. As pointed out in section 11.3.2 a further comparison with a SPALY run in 2017 indicates that half of the downward revision of the estimates is related to the changes in the approach regarding infection M and half to the addition of the new catch and survey data.

11.10 Management plans and evaluations

The practice has been to manage fisheries on this stock at $F = F_{0.1} = F_{MSY}$ (= 0.22 = F_{pa}) for more than 20 years. Formal management strategy evaluation took place in April 2017 where five different rules were tested (ICES 2017b). Selection of harvest rule for providing advice in the next years will be done by the managers in the coming weeks.

11.11 Management consideration

Inspections indicate still a high prevalence of heart lesions related to *Ichthyophonus hoferi* in the herring stock. More importantly, new infection has been taken place in the stock last three winters with an increased intensity in 2016/2017. Significant new infection was otherwise last observed in 2010. Correspondingly, induced mortality due to the infection was unavoidably applied for 2017 and this second outbreak might continue in the coming year. Considering the presently low stock size, the ongoing second outbreak, and seemingly continuation of poor year classes entering the fishable stock, the stock size will most likely remain at low level in the next years and be between B_{lim} and MSY $B_{trigger}$ which implies reduced fishing mortality.

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 planned to start at MFRI in 2017. It involves how the herring get infected, i.e. through intake of free floating spores or through zooplankton that contain spores etc. With respect to the impacts of the outbreak on the herring stock, recent analyses shows that significant additional mortality took place over the first three years only (Óskarsson *et al.* 2017), despite a high prevalence of infection for now nine years. As pointed out above, the new infection in 2016/17 is however, expected to cause significant mortality again. For how long time this outbreak will last is unknown as this is basically an unprecedented outbreak. The signs of the infection that is found in the stock will most likely remain for some years, even if no new infection will occur, and then decrease and disappear over some years as new year classes replace the older ones. The observed new infection will however delay this process.

All general ecosystem consideration with respect to the stock can be found in the Ecosystem Overview for the Icelandic Ecoregion (ICES 2017a).

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 is a regulation that prohibits use of pelagic trawls within the 12 nautical miles 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 to 2016/2017 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 North East Atlantic mackerel (NEAM) feeding in Icelandic waters since 2007 (Astthorsson *et a*l. 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 the reference points in 2016 and revised them in accordance to the ICES Advice Technical Guidelines (ICES 2016).

11.17 Comments on the assessment

The assessment implies that the stock size has been declining since end of 2000s due to a combination of *Ichthyophonus* mortality and series of below average and poor year classes entering the stock. A revision and lowering in this year's assessment of the *Ichthyophonus* mortality imposed over 2009–2011 resulted in lower estimations of SSB over the years ~2003–2011. It contributed also, along with adding the 2016/17 data, to slightly lower perception of the present stock size (section 11.9). However, this new approach is considered adequate and lead to improvements of the assessment.

There are compelling evidence for serious new infection by *Ichthyophonus* in the stock in the winter 2016/17, which called for applying additional infection mortality in 2017 until spawning. This decision and on the applied mortality level is rationalized by expert judgement derived from the experience from the previous outbreak. The mortality level for 2017 cannot be estimated at present, but can within several years. When depends on the development of the current outbreak in the coming months and years. This current outbreak adds uncertainty to the asssessment and advice.

Information from informal chats of the stock assessor with skippers of the herring fishing fleet and people from the industry in the winter 2016/17 implied more effort of the fleet this year to get the herring quota and observations of increased *Ichthyophonus* infection by inspection of the catches. These informations can be interpreted as a support to the assessment, advice and present perception on the condition of the stock.

Table 11.1.1.1. Icelandic summer-spawning herring. Acoustic estimates (in millions) in the winters 1973/74-2016/17 (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
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
2016/17	175.989	221.052	137.217	151.937	262.488	136.801	241.382	61.220	55.869	62.805	11.435	20.135	13.733	0.313	1552

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 1987/88-2016/17 (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
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§
2016/17	66	164	122	137	202	117	169	43	50	44	14	15	9	4	1162	14	12	2

***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
1972	0.31	0.31		
1973	0.254	0.254		
1974	1.275	1.275		
1975	13.28	13.28		
1976	17.168	17.168		
1977	28.925	28.925		
1978	37.333	37.333		
1979	45.072	45.072		
1980	53.268	53.268		
1981	39.544	39.544		
1982	56.528	56.528		
1983	58.867	58.867		
1984	50.304	50.304		
1985	49.368	49.368	50	50
1986	65.5	65.5	65	65
1987	75	75	70	73
1988	92.8	92.8	90	90
1989	97.3	101	90	90
1990/1991	101.6	105.1	80	110
1991/1992	98.5	109.5	80	110
1992/1993	106.7	108.5	90	110
1993/1994	101.5	102.7	90	100
1994/1995	132	134	120	120
1995/1996	125	125.9	110	110
1996/1997	95.9	95.9	100	100
1997/1998	64.7	64.7	100	100
1998/1999**	87	87	90	70
1999/2000	92.9	92.9	100	100
2000/2001	100.3	100.3	110	110
2001/2002	95.7	95.7	125	125
2002/2003*	96.1	96.1	105	105
2003/2004*	130.7	130.7	110	110
2004/2005	114.2	114.2	110	110
2005/2006	103	103	110	110
2006/2007	135	135	130	130

Year	Landings	Catches	Recom. TACs	Nat. TACs
2007/2008	158.9	158.9	130	150
2008/2009	151.8	151.8	130	150
2009/2010	46.3	46.3	40	47
2010/2011	43.5	43.5	40	40
2011/2012‡	49.4	49.4	40	45
2012/2013‡	72.0	72.0	67	68.5
2013/2014‡	72.0	72.0	87	87
2014/2015‡	95.0	95.0	83	83
2015/2016‡	69.7	69.7	71	71
2016/2017‡	60.4	60.4	63	63

***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
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
2016	0.072	10.740	25.575	29.908	41.952	25.823	24.925	9.516	7.734	6.088	4.284	7.154	3.108	0.827	60.403

*** Includes both the landings (73.4 kt) and the herring that died in the mass mortality (52.0 kt) 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
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
2016	129	202	242	281	303	322	336	355	359	368	369	379	386	402

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
1986-2016	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 for the different years (refers to the autumn) 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*	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
2010*	0.29	0.29	0.28	0.26	0.25	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23
2011*	0.13	0.26	0.26	0.25	0.23	0.24	0.25	0.24	0.20	0.21	0.21	0.21	0.21	0.21
2012-2016	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
2017**	0.11	0.12	0.13	0.17	0.18	0.21	0.19	0.26	0.29	0.21	0.18	0.19	0.10	0.10

*** Based on prevalence of infection estimates and acoustic measurements ($M_{infected}$multiplied by 0.3 and added to 0.1; Óskarsson et al. 2017).**

****Based on prevalence of infection estimates in the winter 2016/17 (multiplied by 0.3 and added to 0.1) and should by applied in the prognosis in the 2017 assessment.**

Table 11.3.2.2. Model settings and results of model parameters from the final NFT-Adapt run in 2017 for Icelandic summer spawning herring.

VPA Version 3.3.0	Input File: D:\NFT\VPA\2017\RUN1NWWG\RUN1NWWG.DAT
Model ID: k=0.3, 2009-2011 Ichtio.	Date of Run: 07-APR-2017 Time of Run: 17:03

Levenburg-Marquardt Algorithm Completed 5 Iterations

Residual Sum of Squares = 51.0119

Number of Residuals = 232
Number of Parameters = 9
Degrees of Freedom = 223
Mean Squared Residual = 0.233237
Standard Deviation = 0.482946

Number of Years = 30
Number of Ages = 11
First Year = 1987
Youngest Age = 3
Oldest True Age = 12
Number of Survey Indices Available = 10

Number of Survey Indices Used in Estimate =8

VPA Classic Method - Auto Estimated Q's

Stock Numbers Predicted in Terminal Year Plus One-2017

Age	Stock Predicted	Std. Error	CV
4	126724.446	6.23E+04	4.92E-01
5	112317.581	4.27E+04	3.80E-01
6	100959.834	3.49E+04	3.45E-01
7	112108.965	3.82E+04	3.41E-01
8	125709.946	3.76E+04	2.99E-01
9	63851.451	2.16E+04	3.39E-01
10	36695.24	1.14E+04	3.11E-01
11	27710.602	8.63E+03	3.11E-01
12	22396.729	9.10E+03	4.06E-01

Catchability Values for Each Survey Used in Estimate

INDEX	Catchability	Std. Error	CV
1	1.08E+00	9.89E-02	9.14E-02
2	1.36E+00	1.19E-01	8.77E-02

3	1.40E+00	9.54E-02	6.81E-02
4	1.44E+00	9.40E-02	6.54E-02
5	1.59E+00	1.28E-01	8.06E-02
6	1.72E+00	1.54E-01	8.97E-02
7	1.82E+00	2.04E-01	1.12E-01
8	1.77E+00	2.07E-01	1.17E-01

-- Non-Linear Least Squares Fit --

Maximum Marquadt Iterations = 100

Scaled Gradient Tolerance = 6.06E-05

Scaled Step Tolerance = 1.00E-18

RelativeFunction Tolerance = 1.00E-18

Absolute Function Tolerance = 4.93E-32

Reported Machine Precision = 2.22E-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 2017 = Geometric Mean of First Age Populations

Year Range Applied = 1991 to 2013

- 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 = 0.247

F in Oldest TRUE Age in Terminal Year = 0.2499

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	Calc	Partial	Fishing	Used	In			
Recruitment		Recruitment		Mortality		Full	F	Comments		
3	0.5	0.246	0.0775	NO	Stock	Estimate		in	T+1	
4	0.8	0.621	0.1957	NO	Stock	Estimate		in	T+1	
5	1	0.787	0.2477	YES	Stock	Estimate		in	T+1	
6	1	0.964	0.3037	YES	Stock	Estimate		in	T+1	
7	1	0.566	0.1782	YES	Stock	Estimate		in	T+1	
8	1	1	0.315	YES	Stock	Estimate		in	T+1	
9	1	0.699	0.22	YES	Stock	Estimate		in	T+1	
10	1	0.746	0.235	YES	Stock	Estimate		in	T+1	
	11	1	0.729	0.2295	YES	Stock	Estimate		in	T+1
		12	1	0.793	0.2499	F-Oldest				

Table 11.3.2.3. Icelandic summer spawners stock estimates (from NFT-Adapt in 2017) in numbers (millions) by age (years) at January 1st during 1987-2017.

Year\Age	3	4	5	6	7	8	9	10	11	12	13+	Total
1987	529.83	988.97	300.67	84.60	69.14	107.46	42.63	38.03	26.41	34.26	34.29	2256
1988	271.00	476.42	852.47	214.85	56.99	43.83	53.49	24.15	21.19	14.26	36.99	2066
1989	447.33	240.69	391.82	676.97	128.70	29.84	20.62	18.03	10.18	9.48	26.10	2000
1990	300.83	383.26	192.47	280.68	433.68	75.61	19.30	13.07	9.41	4.69	26.46	1739
1991	840.58	258.06	292.67	140.37	178.35	243.51	39.78	9.72	7.68	5.31	24.86	2041
1992	1033.14	676.35	186.92	183.02	94.01	109.04	116.17	26.44	4.86	4.36	24.19	2458
1993	635.48	844.70	495.59	132.71	110.07	58.60	62.27	54.88	12.96	2.77	23.67	2434
1994	691.77	526.40	595.63	360.47	100.34	72.51	40.39	37.75	35.19	7.69	22.92	2491
1995	202.74	498.19	368.82	403.42	243.45	67.16	46.36	21.12	19.31	17.95	23.14	1912
1996	181.42	163.50	320.66	251.32	261.55	147.52	40.53	27.52	11.03	8.38	27.53	1441
1997	772.67	148.98	109.71	208.42	162.05	156.44	95.87	22.71	16.93	4.47	22.16	1720
1998	320.56	661.84	106.20	74.32	153.72	114.65	112.11	65.61	12.47	12.10	10.03	1644
1999	552.81	246.96	432.41	74.56	59.06	100.31	79.13	71.06	45.47	9.27	13.41	1684
2000	391.66	446.71	171.48	257.74	52.20	40.63	60.94	52.77	43.42	29.19	11.68	1558
2001	469.30	300.00	275.03	108.44	160.59	36.28	28.89	39.62	38.38	28.54	25.27	1510
2002	1458.96	384.45	189.52	160.19	69.36	93.69	22.99	17.84	24.25	25.33	32.49	2479
2003	1077.26	1243.27	280.66	128.23	93.60	42.65	44.86	11.45	11.68	15.76	25.72	2975
2004	668.46	774.04	853.63	198.80	89.48	60.42	25.14	30.21	8.24	7.32	28.30	2744
2005	996.80	544.66	567.93	599.28	141.46	67.93	45.80	17.27	20.67	4.49	24.09	3030
2006	739.56	877.14	452.81	402.00	415.66	101.84	50.01	32.71	10.73	13.85	20.53	3117
2007	658.12	556.65	587.21	357.68	317.86	321.75	79.23	39.56	25.52	8.85	26.72	2979
2008	555.46	506.52	425.63	379.65	263.30	202.66	202.55	49.49	24.64	16.12	21.50	2648
2009	455.35	465.70	372.01	309.44	241.47	181.65	124.43	131.75	27.61	14.49	23.00	2347
2010	420.78	346.97	343.37	270.91	232.24	174.06	136.89	91.92	97.51	20.23	27.94	2163
2011	498.74	306.62	239.62	234.76	187.86	168.20	121.04	98.71	65.76	69.43	34.61	2025
2012	421.68	429.18	215.13	167.95	162.75	127.97	120.42	79.65	68.93	46.87	75.23	1916
2013	406.12	364.60	303.48	146.04	111.11	98.72	76.14	76.11	46.28	38.75	80.24	1748
2014	212.97	322.98	306.31	241.29	115.76	82.93	71.26	48.21	53.73	26.91	80.09	1562
2015	173.17	189.34	241.70	229.12	151.93	72.14	54.10	43.50	31.01	31.79	80.65	1298
2016	151.33	150.96	142.94	167.87	166.03	96.69	50.54	38.74	31.14	20.32	88.67	1105
2017*	391.30	126.72	112.32	100.96	112.11	125.71	63.85	36.70	27.71	22.40	84.02	1204

*** Number at age 3 in 2017 is predicted from an survey index of number at age 1 in 2015 (see section 11.6.1)**

Table 11.3.2.4. Estimated fishing mortality at age of Icelandic summer-spawning herring (from NFT-Adapt in 2017) by age (years) during 1987-2016 (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	0.336	0.356	0.550	0.674	0.479	0.111	0.322
1990	0.053	0.170	0.216	0.353	0.477	0.542	0.586	0.431	0.472	0.508	0.071	0.400
1991	0.117	0.223	0.369	0.301	0.392	0.640	0.309	0.592	0.466	0.502	0.055	0.436
1992	0.101	0.211	0.243	0.409	0.373	0.460	0.650	0.613	0.465	0.547	0.023	0.415
1993	0.088	0.249	0.218	0.180	0.317	0.272	0.400	0.345	0.421	0.360	0.011	0.248
1994	0.228	0.256	0.290	0.293	0.301	0.347	0.548	0.571	0.573	0.510	0.090	0.312
1995	0.115	0.341	0.284	0.333	0.401	0.405	0.421	0.550	0.735	0.528	0.154	0.343
1996	0.097	0.299	0.331	0.339	0.414	0.331	0.479	0.386	0.804	0.500	0.350	0.361
1997	0.055	0.239	0.290	0.205	0.246	0.233	0.279	0.500	0.235	0.312	1.042	0.250
1998	0.161	0.326	0.254	0.130	0.327	0.271	0.356	0.267	0.197	0.273	0.582	0.280
1999	0.113	0.265	0.417	0.257	0.274	0.398	0.305	0.393	0.343	0.360	0.734	0.377
2000	0.167	0.385	0.358	0.373	0.264	0.241	0.331	0.219	0.320	0.277	0.699	0.335
2001	0.099	0.359	0.441	0.347	0.439	0.356	0.382	0.391	0.315	0.361	0.456	0.414
2002	0.060	0.215	0.291	0.437	0.386	0.637	0.597	0.324	0.331	0.472	0.945	0.417
2003	0.231	0.276	0.245	0.260	0.338	0.429	0.295	0.229	0.367	0.330	0.254	0.279
2004	0.105	0.210	0.254	0.240	0.176	0.177	0.275	0.279	0.508	0.310	0.286	0.243
2005	0.028	0.085	0.246	0.266	0.229	0.206	0.237	0.376	0.300	0.280	0.222	0.252
2006	0.184	0.301	0.136	0.135	0.156	0.151	0.135	0.148	0.092	0.132	0.166	0.143
2007	0.162	0.168	0.336	0.206	0.350	0.363	0.371	0.373	0.359	0.367	0.416	0.319
2008	0.076	0.209	0.219	0.353	0.271	0.388	0.330	0.484	0.431	0.408	0.380	0.307
2009	0.055	0.088	0.100	0.070	0.110	0.066	0.086	0.084	0.094	0.083	0.074	0.088
2010	0.025	0.078	0.103	0.107	0.073	0.119	0.086	0.097	0.108	0.103	0.098	0.098
2011	0.020	0.095	0.099	0.116	0.152	0.096	0.172	0.121	0.137	0.131	0.095	0.122
2012*	0.045	0.247	0.287	0.313	0.400	0.419	0.359	0.443	0.476	0.424	0.260	0.357
2013	0.129	0.074	0.129	0.132	0.193	0.226	0.357	0.248	0.442	0.318	0.285	0.183
2014	0.018	0.190	0.190	0.363	0.373	0.327	0.394	0.341	0.425	0.372	0.127	0.301
2015	0.037	0.181	0.265	0.222	0.352	0.256	0.234	0.234	0.323	0.262	0.092	0.264
2016	0.078	0.196	0.248	0.304	0.178	0.315	0.220	0.235	0.230	0.250	0.141	0.251

*** Derived from both the landings ($WF_{5\text{-}10}$ ~0.209)) and the herring that died in the mass mortality (0.148) in the winter 2012/13 in Kolgrafafjörður**

Table 11.3.2.5. Summary table from NFT-Adapt run in 2017 for Icelandic summer spawning herring.

Year	Recruits, age 3 (millions)	Biomass age 3+ (kt)	Biomass age 4+ (kt)	SSB (kt)	Landings age 3+ (kt)	Yield/SSB	$WF_{age\ 5-10}$
1987	530	504	415	384	75	0.20	0.35
1988	271	495	452	423	93	0.22	0.27
1989	447	459	401	386	101	0.26	0.32
1990	301	410	371	350	104	0.30	0.40
1991	841	424	310	310	107	0.34	0.44
1992	1033	502	349	343	107	0.31	0.42
1993	635	546	454	424	103	0.24	0.25
1994	692	553	461	441	134	0.30	0.31
1995	203	462	435	406	125	0.31	0.34
1996	181	348	322	307	96	0.31	0.36
1997	773	368	267	269	65	0.24	0.25
1998	321	366	323	298	86	0.29	0.28
1999	553	373	297	290	93	0.32	0.38
2000	392	387	324	306	100	0.33	0.33
2001	469	348	283	272	94	0.34	0.41
2002	1459	513	278	298	96	0.32	0.42
2003	1077	580	412	390	129	0.33	0.28
2004	668	617	518	488	112	0.23	0.24
2005	997	709	540	528	102	0.19	0.25
2006	740	790	650	616	130	0.21	0.14
2007	658	703	600	572	158	0.28	0.32
2008	555	694	597	570	151	0.26	0.31
2009	455	640	554	497	46	0.09	0.09
2010	421	604	518	459	43	0.09	0.10
2011	499	570	476	430	49	0.11	0.12
2012*	422	536	449	429	73	0.17	0.21
2013	406	471	397	379	71	0.19	0.18
2014	213	458	415	391	95	0.24	0.30
2015	173	375	340	324	70	0.22	0.26
2016	151	329	298	284	60	0.21	0.25
2017	391	337	258	256			
Mean	546	499	412	391	97	0.25	0.29

*** The mass mortality of 52 thousands tons in Kolgrafafjörður in the winter 2012/13 is not included in the landings, yield/SSB, or WF, even if included as landings in the analytical assessment.**

§ Number at age 3 in 2017 is predicted from an survey index of number at age 1 in 2015 (see section 11.6.1)

Table 11.3.2.6. The residuals from survey observations and NFT-Adapt 2017 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	-0.251	-0.299	0.023	-0.360	-0.760	-0.266	-0.179	-0.462
1989	-0.258	-0.827	-0.912	0.019	-0.020	-0.003	0.000	0.000
1990	0.457	-0.376	-0.344	-0.049	0.403	-0.402	-0.001	-0.002
1991	-0.748	-0.430	-0.735	-0.293	0.286	0.150	0.008	-0.004
1992	0.360	0.334	0.221	-0.408	-0.224	0.253	-0.814	0.001
1993	-0.096	0.081	-0.158	-0.190	-0.541	-0.105	-0.032	0.069
1994	-0.121	0.088	-0.018	-0.767	-0.681	0.425	-0.340	-0.541
1995								
1996	-0.280	0.559	-0.237	0.025	-0.281	0.344	-0.031	-0.183
1997	0.518	-0.108	0.473	0.148	0.271	0.278	0.812	0.618
1998	-0.175	-0.576	-0.597	0.262	-0.154	0.055	-0.121	0.476
1999	-0.044	0.611	-0.011	-0.494	-0.163	-0.656	-0.240	-0.399
2000	0.551	0.026	0.517	0.163	-0.397	0.459	-0.065	0.458
2001	1.091	1.260	0.228	0.738	-0.516	-1.149	-0.641	-1.555
2002	-0.372	-0.169	0.148	0.480	0.844	0.458	0.566	-0.110
2003	0.355	0.373	0.135	0.669	0.815	1.277	1.562	0.836
2004	0.538	0.574	0.171	-0.163	0.049	-0.110	-0.186	-0.007
2005	0.191	0.282	0.220	-0.171	-0.547	-0.574	-1.054	-0.423
2006	-0.761	-0.578	0.374	0.715	0.554	0.352	0.779	1.353
2007	0.009	0.284	-0.201	-0.073	0.306	-0.349	0.543	0.078
2008	-0.183	-0.692	0.017	-0.201	0.225	0.703	0.901	1.726
2009	-0.944	-0.192	-0.409	0.277	-0.077	0.055	-0.349	-0.489
2010	-0.173	0.051	0.379	-0.206	0.169	-0.455	-0.689	-0.094
2011	-0.168	-0.352	-0.076	0.093	-0.655	0.371	-1.079	0.196
2012	0.743	0.398	0.287	0.152	0.164	-0.291	0.190	-0.365
2013	0.682	0.427	-0.206	-0.229	-0.099	-0.172	-0.355	-0.096
2014	-0.105	-0.643	0.020	-0.092	0.008	-0.014	0.301	-0.059
2015	-0.820	0.006	-0.208	0.172	0.495	0.186	0.147	-0.370
2016	0.005	-0.106	0.283	-0.054	0.338	0.077	-0.115	0.314
2017	0.000	-0.004	0.618	-0.163	0.190	-0.583	-0.177	0.249
Max. Residuals	1.091	1.260	-0.912	-0.767	0.844	1.277	1.562	1.726

Table 11.6.1.1. The input data used for prognosis of the Icelandic summer-spawning herring in the 2017 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 2017
3 (2014)	0.191	0.11	0.200	0.169	0.000	0.500	391.3
4 (2013)	0.247	0.12	0.850	0.684	0.000	0.500	126.7
5 (2012)	0.278	0.12	1.000	1.000	0.000	0.500	112.3
6 (2011)	0.309	0.17	1.000	1.000	0.000	0.500	101.0
7 (2010)	0.326	0.17	1.000	1.000	0.000	0.500	112.1
8 (2009)	0.340	0.17	1.000	1.000	0.000	0.500	125.7
9 (2008)	0.351	0.21	1.000	1.000	0.000	0.500	63.9
10 (2007)	0.366	0.19	1.000	1.000	0.000	0.500	36.7
11 (2006)	0.369	0.26	1.000	1.000	0.000	0.500	27.7
12 (2005)	0.376	0.28	1.000	1.000	0.000	0.500	22.4
13+ (2004+)	0.377	0.19	1.000	1.000	0.000	0.500	84.0

Table 11.6.1.2. Icelandic summer-spawning herring. Catch options table for the 2017/2018 season according to MSY approach where the basis is: SSB (1st July 2017) 238 kt; Biomass age 4+ (1st Jan. 2017) 258 kt; Catch (2016/17) 60 kt; $WF_{5\text{-}10}$(2016) 0.251. The fishery has been managed on basis of $F_{0.1}$=F_{MSY}=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	Catches (2017/2018)	Basis	F (2017/2018)	SSB 2017	%SSB change *	% TAC change **
MSY approach§	41	F_{MSY} × 0.87	0.19	246	3	-35
Zero catch	0	F = 0	0	280	18	-100
F_{pa}	47	F_{pa}=0.22	0.22	241	1	-25
F_{lim}	109	F_{lim}=0.61	0.61	188	-21	73
Other options	41	0.75 × $F_{2016/17}$	0.19	246	3	-35
	48	0.9 × $F_{2016/17}$	0.23	240	1	-24
	53	$F_{2016/17}$	0.25	236	-1	-16
	58	1.1 × $F_{2016/17}$	0.28	231	-3	-8
	63	1.25 × $F_{2016/17}$	0.31	227	-5	0

*** SSB 2018 relative to SSB 2017.**

**** TAC 2017/18 relative to landings 2016/17.**

§ SSB_{2017} < MSY $B_{trigger}$=273 kt, hence adviced F is: F_{MSY} × SSB_{2017}/$B_{trigger}$ = 0.22 × 238/273 = 0.19

Table 11.6.1.3. Icelandic summer-spawning herring. Alternative catch options table for the 2017/2018 season for different harvest control rules tested by ICES (2017b) where the basis is: SSB (1st July 2017) 238 kt; Biomass age 4+ (1st Jan. 2017) 258 kt; Catch (2016/17) 60 kt; $WF_{5\text{-}10}$(2016) 0.251. 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 (2017/18)	Basis	F (2017/2018)	SSB (2018)	Biomass of age 4+ (2018)	%SSB change*	% TAC change**
HCR 2 §	31	HR=0.19, $B_{trigger}$=273 kt, reduce HR by 33% when Icht. Outbreaks	0.14	254	260	7	-51
HCR 3 §§	29	HR=0.17, $B_{trigger}$=200 kt, reduce HR by 33% when Icht. outbreaks	0.13	256	262	8	-53
HCR 4	39	HR=0.15, $B_{trigger}$=150 kt	0.18	247	253	4	-39
HCR 5	39	HR=0.15, $B_{trigger}$=200 kt	0.18	247	253	4	-39

*** SSB 2018 relative to SSB 2017.**

**** TAC 2017/18 relative to landings 2016/17.**

§ Because $SSB_{2017} < B_{trigger}$=273 kt and *Ichthyophonus* outbreak is observed in 2017 the adviced HR of 0.19 is lowered: $0.19 \times 0.67 \times SSB_{2017}/B_{trigger} = 0.19 \times 256/273 \times 0.67 = 0.119$. The SSB_{2017} =256 kt is when no additional infection M is applied in 2017.

§§ Because *Ichthyophonus* outbreak is observed in 2017 the adviced HR of 0.17 is lowered: $0.17 \times 0.67 = 0.114$.

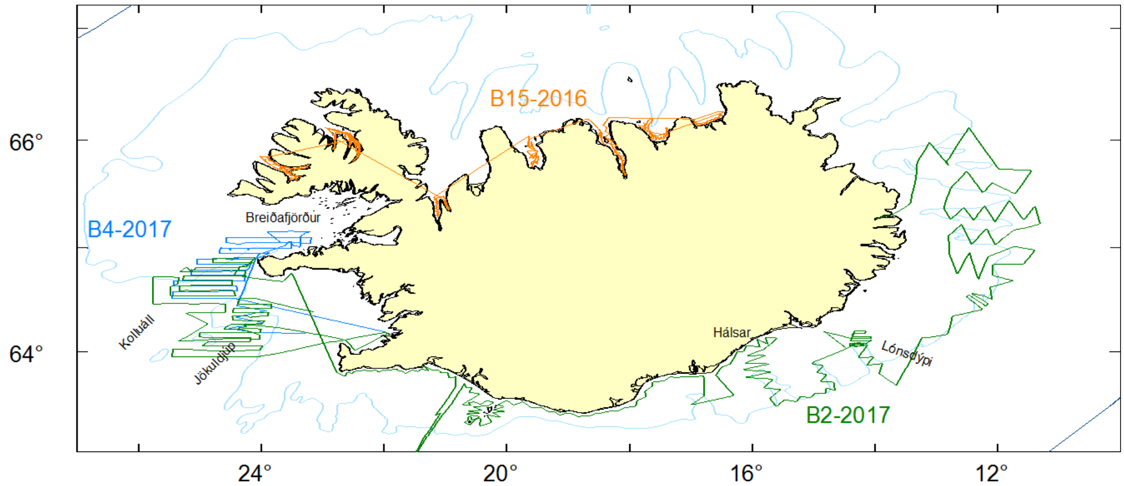


Figure 11.1.2.1. The survey tracks of three acoustic surveys on Icelandic summer-spawning herring in Sept.-Oct. 2016 (B15-2016 on juveniles; orange line), February 2017 (B2-2017 on adults; green line), and March 2017 (B4-2017 on adults; blue line) and locations of the areas that are referred to in the text.

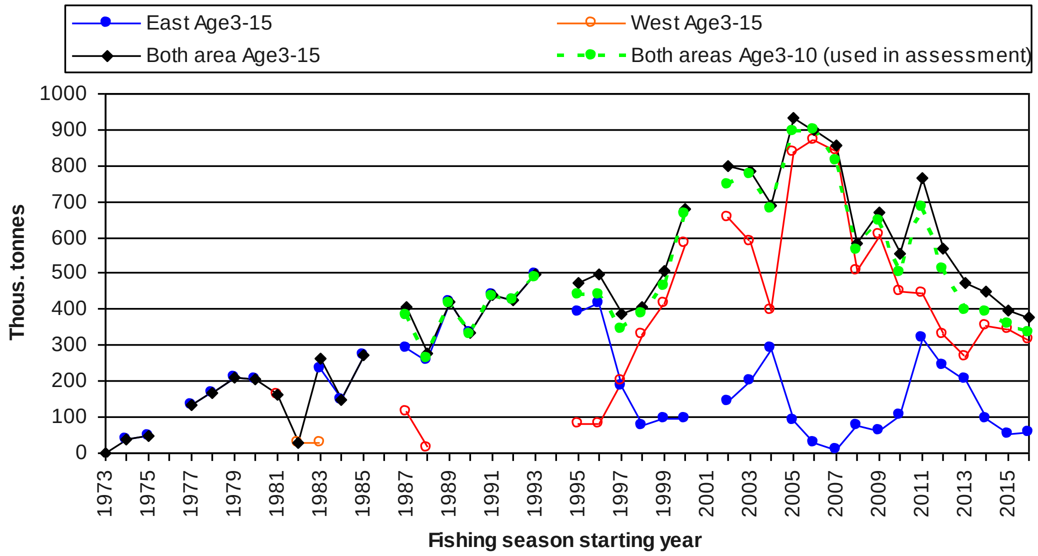


Figure 11.1.2.2 Total biomass index for Icelandic summer-spawning herring from the acoustic surveys for ages 3+ in the areas east and west of 18°W (except in 2011 and 2012 where fish outside of Breiðafjörður was set to the eastern part), combined over all areas and age 3-10 which are used in tuning of the analytical assessment. The years in the plot (1973-2016) refer to the autumn of the fishing seasons.

Argues for 3D year-age-cohort effect on M

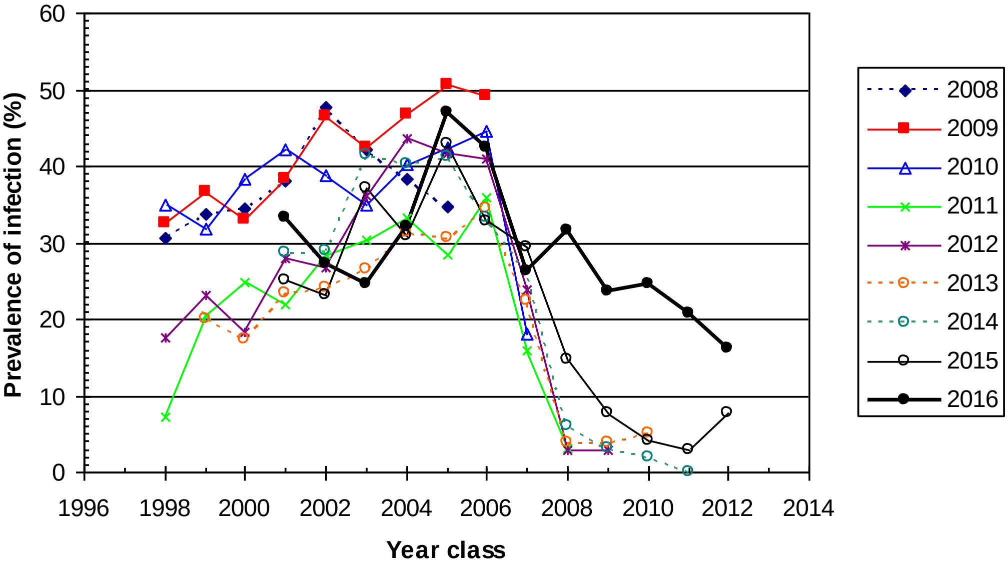


Figure 11.1.3.1. The prevalence of Ichthyophonus infection for the different year classes of Icelandic summer-spawning herring in Breiðafjörður and west of Iceland as estimated in the autumns 2008 to 2016.

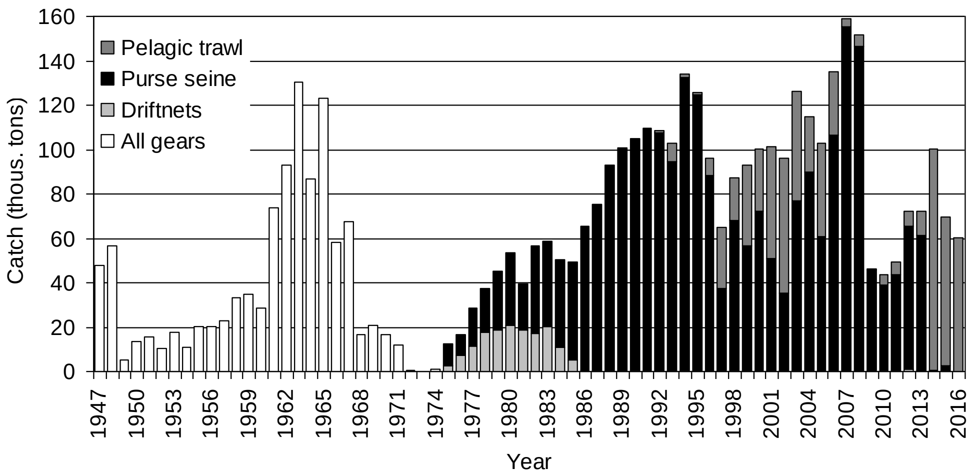


Figure 11.2.1. Icelandic summer spawning herring. Seasonal total landings (in thousand tonnes) during 1947-2016, referring to the autumns, by different fishing gears (from 1975-2016).

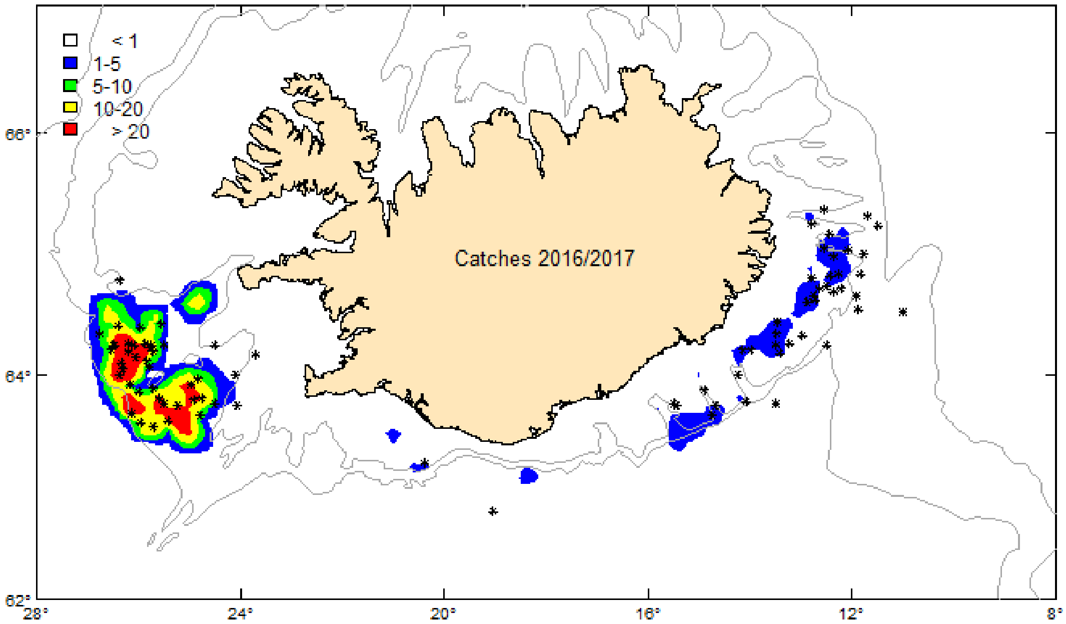


Figure 11.2.2. The distribution of the fishery (in tonnes) of Icelandic summer spawning herring during the fishing season 2016/17, including the bycatch in the mackerel fishery in June-September 2016, where the stars indicate the location of catch samples.

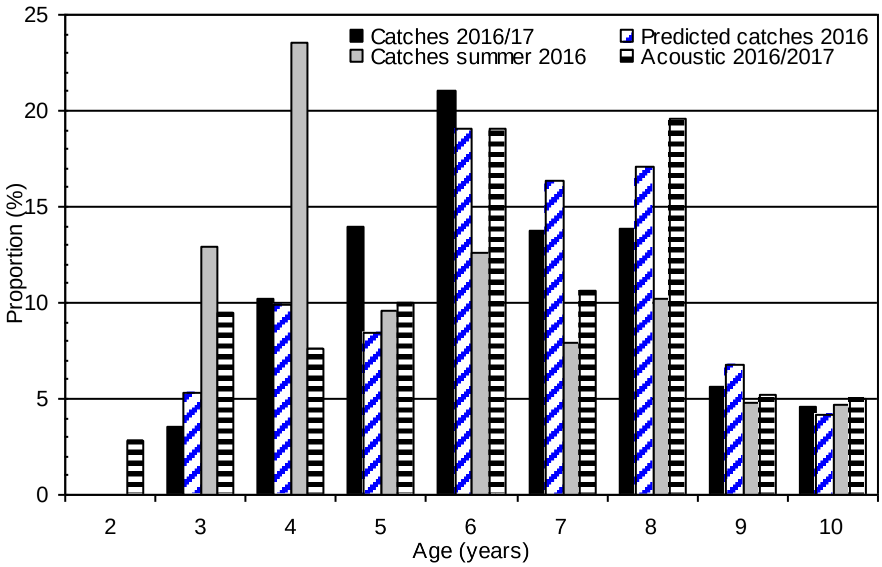


Figure 11.2.2.1. Proportion of the different age groups of Icelandic summer-spawning herring to the total catches (biomass) as observed in 2016/2017 fishing season (June 2016-Februay 2017), predicted in the 2016 assessment (ICES 2016) for the 2016/2017 fishing season, and the summer catches in June-September 2016 in comparison to the age composition in the stock according to the acoustic measurements in the winter 2016/2017.

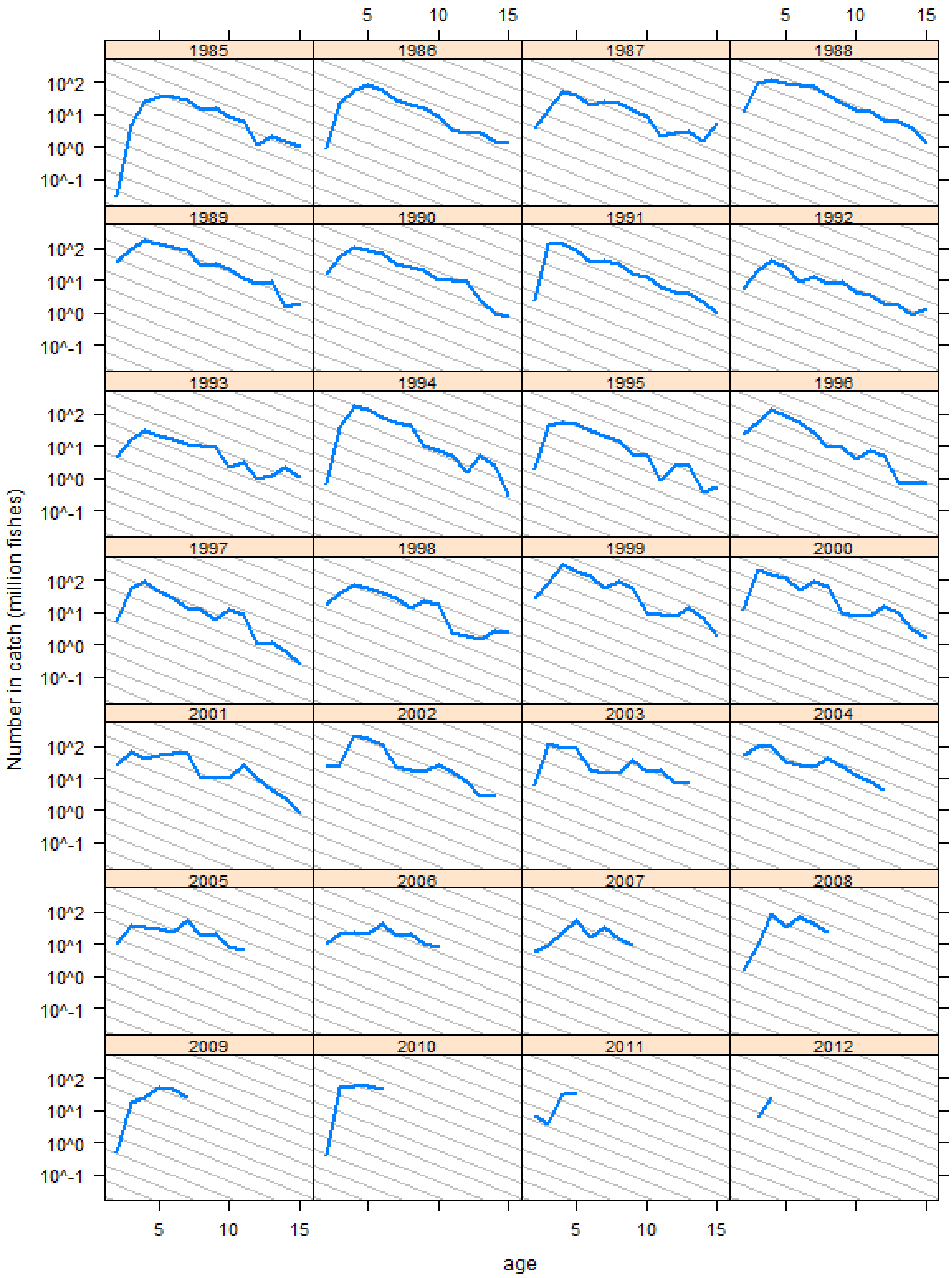


Figure 11.3.1.1. Icelandic summer-spawning herring. Catch curves by year classes 1985-2012. Grey lines correspond to Z=0.4. Note that the mass mortality in Kolgrafafjörður is added to the catches in 2012.

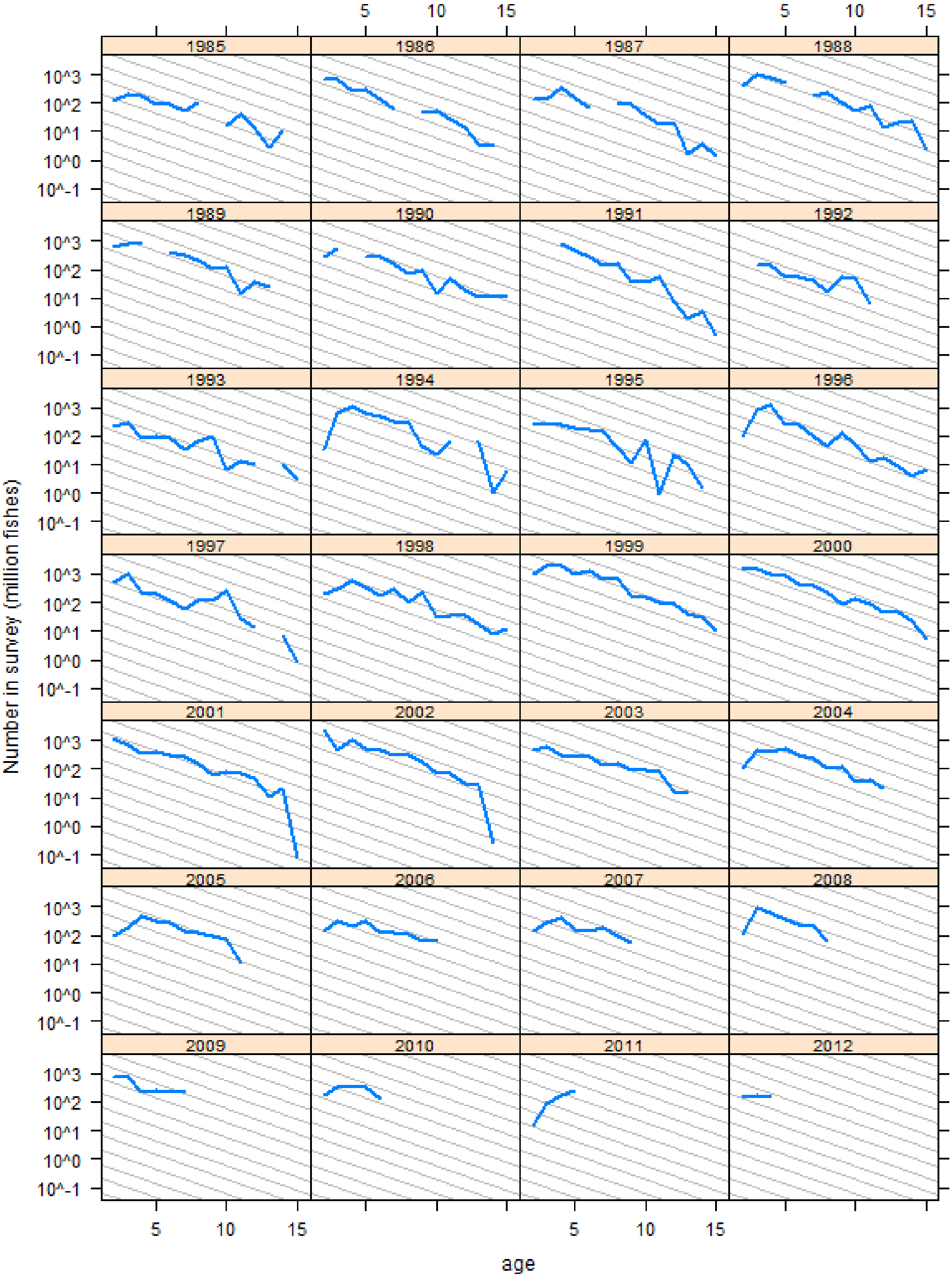


Figure 11.3.1.2. Icelandic summer spawning herring. Catch curves from survey data by year classes 1985-2012. Grey lines correspond to Z=0.4.

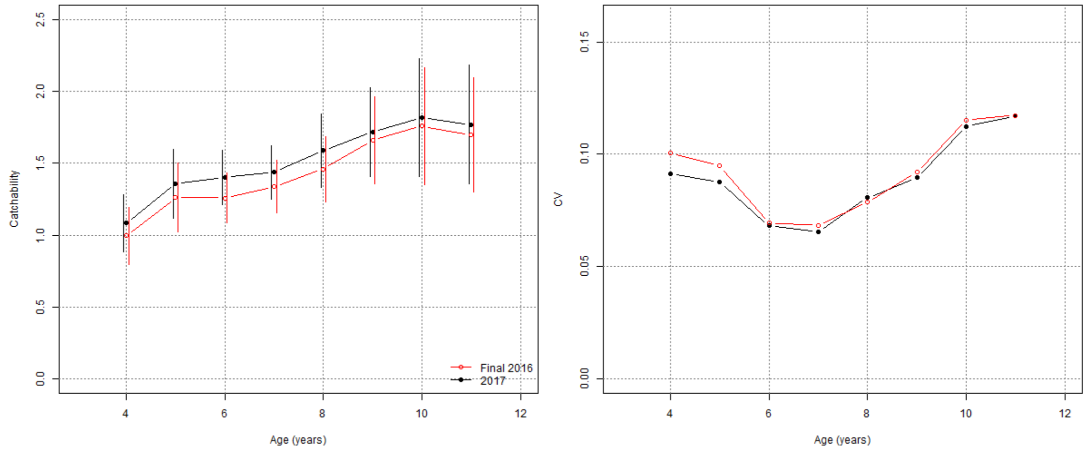


Figure 11.3.2.1. Icelandic summer-spawning herring. The catchability (± 2 SE) and its CV for the acoustic surveys used in the final Adapt run in 2017 (1987-2016) compare to the assessment in 2016.

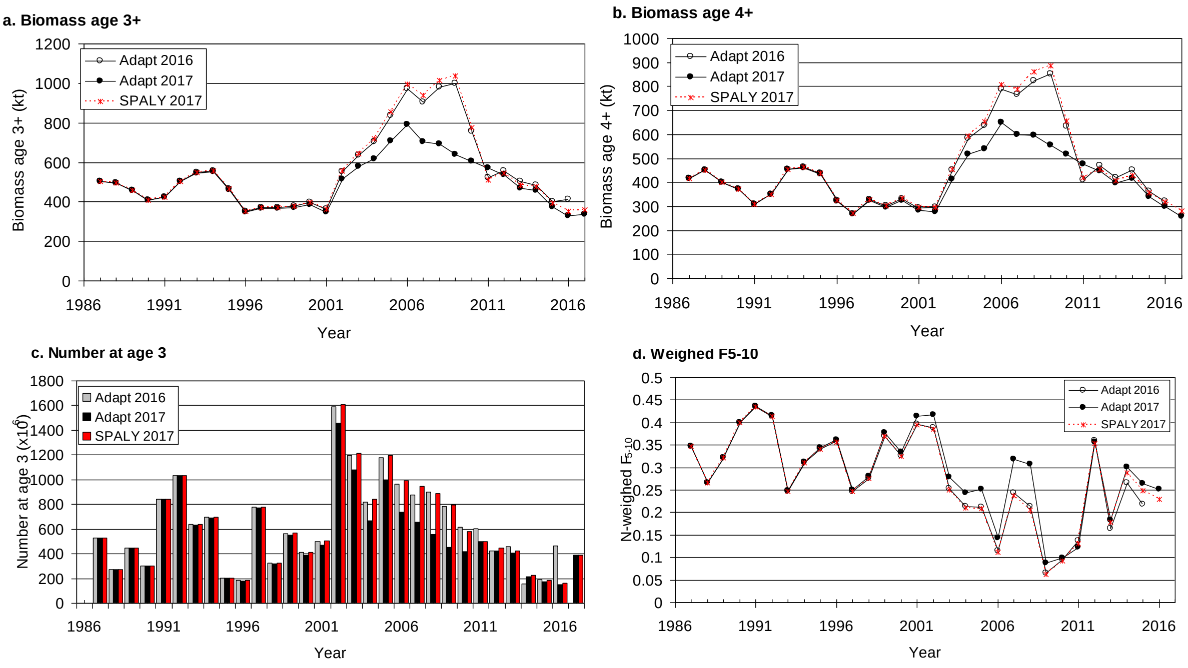


Figure 11.3.2.2. Icelandic summer-spawning herring. Comparisons of the final NFT-Adapt run in 2017, the final run in 2016, and SPALY run in 2017 (i.e. same estimates of M applied as in 2016) concerning (a) biomass of age 3-12, (b) biomass of age 4-12, (c) number at age 3, and N-weighed F for age 5-10. Note that the mass mortality in Kolgrafafjörður in the winter 2012/13 is included in weighed F for that year (WF$_{5-10}$ without the mass mortality was ~0.22) and the difference for the period ~2002-2011 is related to lower *Ichthyophonus* mortality set in the final run in 2017.

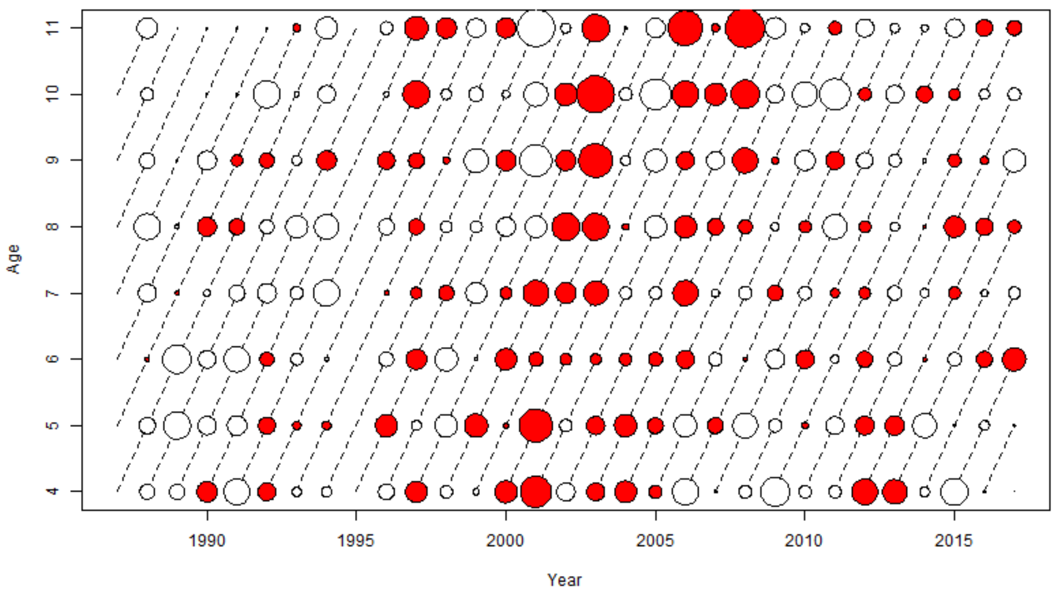


Figure 11.3.2.3. Icelandic summer spawning herring. Residuals of NFT-Adapt run in 2017 from survey observations (moved to 1st January). Filled bubbles are positive and open negative. Max bubble = 1.72.

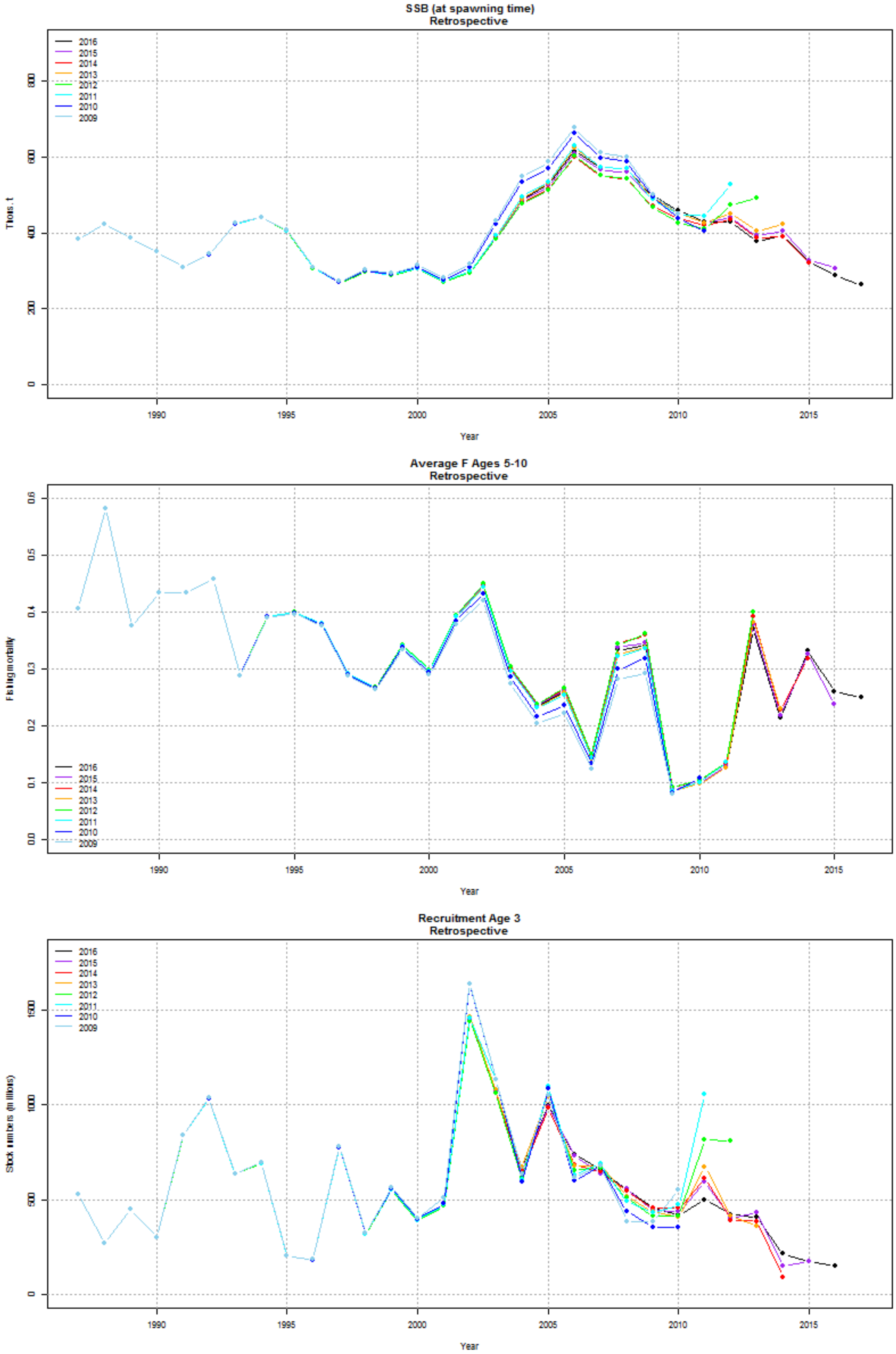


Figure 11.3.2.4. Icelandic summer spawning herring. Retrospective pattern from NFT-Adapt in 2017 in spawning stock biomass (the top panel), N weighted F_{5-10} (middle panel) and recruitment as number at age 3 (lowest panel).

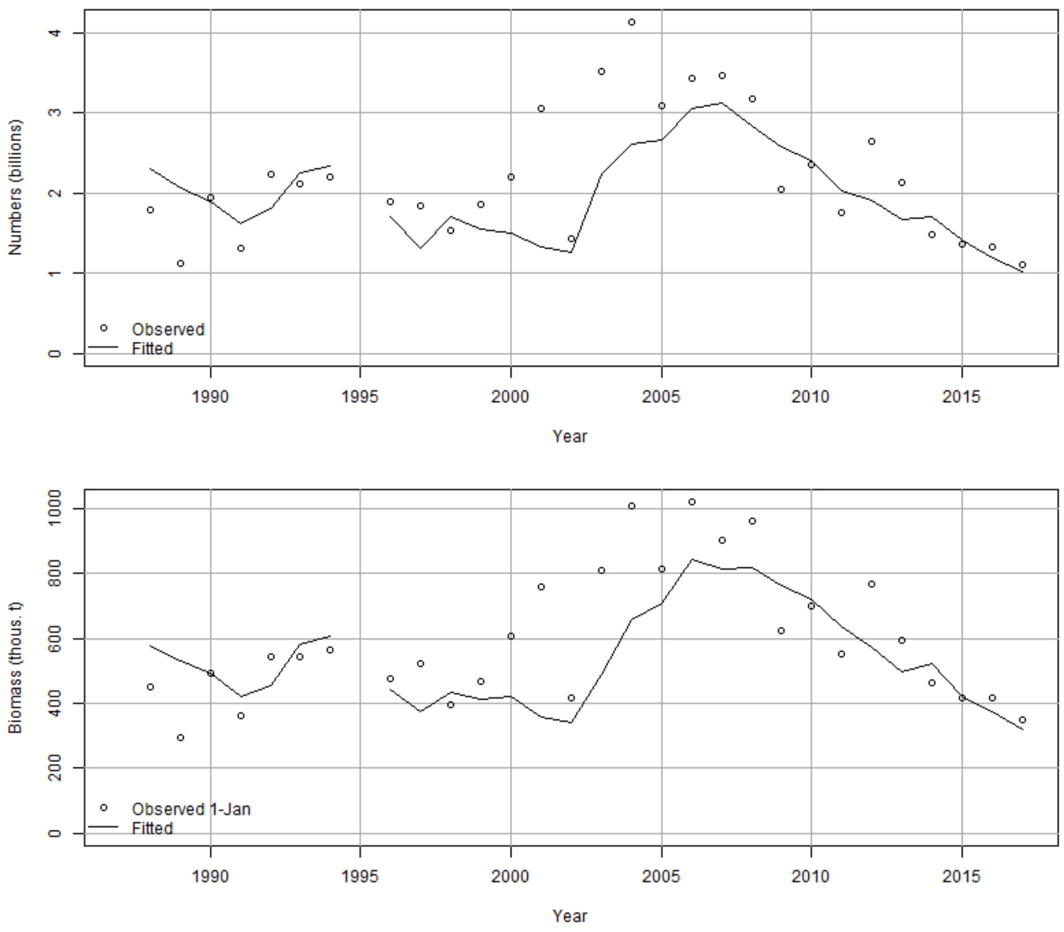


Figure 11.3.2.5. Icelandic summer-spawning herring. Observed versus. predicted survey values from NFT-Adapt run in 2017 for ages 4-11 with respect to numbers (upper) and biomass (lower).

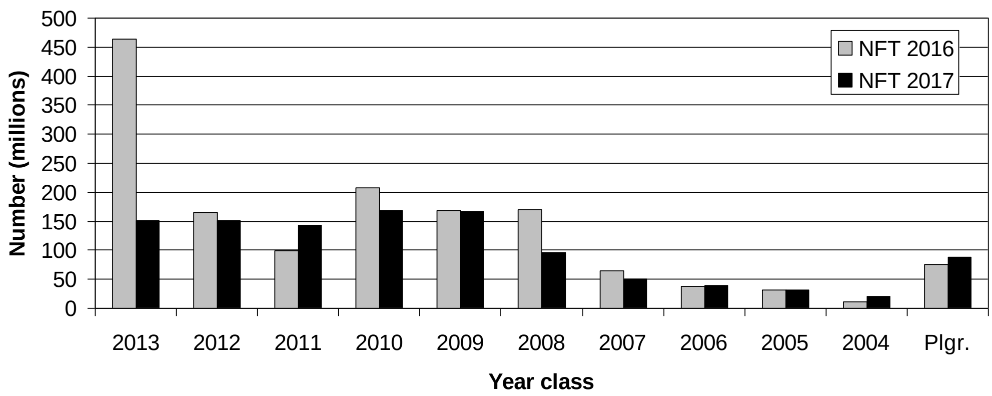


Figure 11.3.2.6. Icelandic summer-spawning herring. Comparison of number-at-age on Jan. 1st. 2016 from the final NFT model runs in 2016 and 2017 assessments.

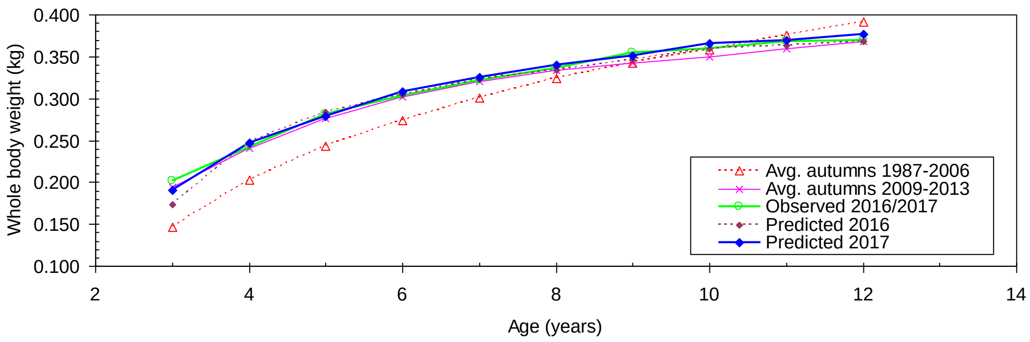


Figure 11.6.1.1. Icelandic summer spawning herring. The mean weight-at-age for age groups 3 to 12 (+ group) in 1987-2006, 2009-2013, in the catches in the winter 2015/2016, predicted weights for the winter 2016/2017 in the 2016 assessment (ICES 2016) and finally predicted weights for the autumn 2017 from the weights in 2016, which was used in the stock prognosis.

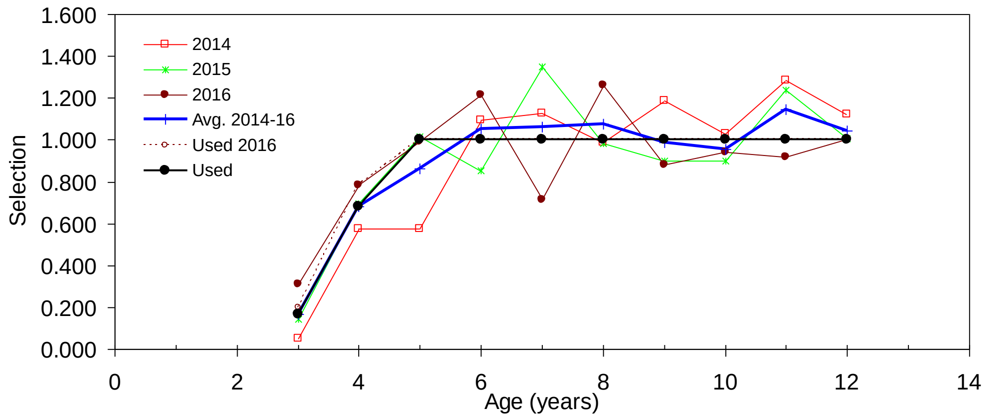


Figure 11.6.1.2. Icelandic summer spawning herring. The selection pattern for age groups 3 to 12 (+ group) for the years 2014 to 2016, the average selection across these three years, the selection used in 2016, and the selection used in the prognosis 2017 (three years average for age 3 and 4, but fixed at 1.0 for age 4+).

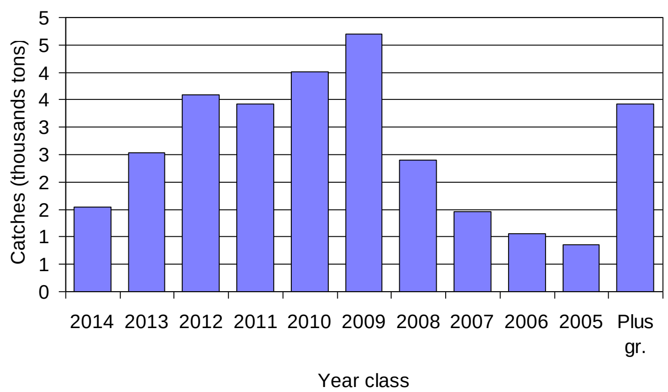


Figure 11.6.2.1. Icelandic summer spawning herring. The predicted biomass contribution of the different year classes to the catches in the fishing season 2017/2018 (total catch of 41 thousands tons).

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 been conducted in autumn (September-December) and in winter (January-February). An overview is given in the stock annex.

12.2.1 Autumn survey during 10. September – 4. October 2016

The survey was conducted 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 because of difficulties in covering the stock due to drift ice and weather during later months The survey was conducted on the research vessels Arni Fridriksson (10. September – 4. October) and Bjarni Saemundsson (10. – 29. September).

The survey area was on and along the shelf edge off East Greenland from about 73°30′N to about 63°15′ N, also covering the Denmark Strait and the slope off western and north Iceland to about 17°W. The Iceland Sea west of Jan Mayen ridge was also scouted (Bardarson and Jonsson 2016).

Both research vessels had to abort from an attempt to calibrate the echosounders in Hvalfjordur due to wind in the fjord. Hence, calibration settings for echosounders of both vessels during the survey were from a calibration in May 2016. Post survey calibrations of the echosounders of both vessels showed that the echosounders of both vessels were stable.

Bjarni Saemundsson started in the southwestern part of the survey area and measured northeastwards (Red track lines on Figure 12.2.1). Arni Fridriksson scouted through the area west of Jan Mayen ridge while heading to the northernmost part of the survey area and then measured southwards along the Greenland shelf edge (blue track lines on Figure 12.2.1).

There was no drift ice in the survey area, but weather conditions were at times adverse, and due to heavy storms in the Denmark Strait Arni had to seek shelter in Scoresby Sound from the evening of 21st until the morning of 26th September and for same reason Bjarni had to stop and eventually end the cruise on 22nd September. During 26st September – 4th October Arni Fridriksson continued and finished the acoustic measurements by covering Denmark Strait and the area off north Iceland reaching just east of Kolbeinsey-ridge.

Capelin was observed in scattered and generally low concentrations along the East Greenlandic continental shelf while very little was found off Vestfirdir peninsula and nothing along the continental shelf off northern Iceland (Figure 12.2.1). The total estimate of immature capelin (excluding age 0) was only 9.4 billion whereof 8.7 billion were 1 year olds) (Tables 12.2.1 and 12.2.2 and Figure 12.2.2). Immature capelin was generally found in the southwestern part of the surveyed area. Further north along the Greenland shelf up to 72°30′N older, maturing capelin predominated (Figure 12.2.2). Interestingly maturing capelin predominated in the southernmost sample, only about 20 miles from the Greenlandic coast although acoustic scatter showed very low concentrations. No capelin was recorded off N-Iceland east of 22° W. The distribution of capelin was westerly as in recent years while, similar to last year, no capelin was recorded in traditional areas north of Iceland.

Age and length disaggregated abundance is shown in table 12.2.1. The total number of capelin amounted to only 14.8 billion whereof the 1-group was estimated to 9.2 billion. The total estimate of 2-group capelin was about 4.7 billion. The total biomass estimate was 225 000 tonnes of which about

138 000 tonnes were 2 years and older. About 5.9 % in numbers of the 1- group was estimated to be maturing to spawn, about 85 % of the 2 year old and 99 % of the 3 year old appeared to be maturing. This gives 137 000 tonnes of maturing 1 - 3 year old capelin.

Tables 12.2.2 and 12.2.3 show the historic time series of abundance and mean weights by age and maturity in autumn.

The observed low capelin abundance estimates were at the time believed to demonstrate a very low stock size, because this autumn survey had an extensive spatial coverage and the estimates were in accordance with the low immature estimates from autumn 2015.

On the basis of the estimate of the maturing part of the stock the Marine and Freshwater Research Institute recommended no fishery (intermediate TAC of 0 t) for the fishing season 2016/2017 (Anon 2016). This recommendation was in accordance with existing HCR and management plan between Iceland, Norway and Greenland.

12.2.2 Surveys in winter 2017

Two winter surveys were conducted in 2017 with the aim of assessing the maturing part of the stock.

12.2.2.1 Winter survey during 11. – 21. January.

The survey was conducted by the research vessels Arni Fridriksson and Bjarni Saemundsson and the pelagic fishing vessel Polar Amaroq. Five Scientists from the Marine Research Institute of Iceland were onboard each vessel. The echosounders were calibrated and the acoustic measurements from all vessels were used in the stock assessment.

The original plan was to use four vessels (2 research vessels and 2 pelagic fisheries vessels) for acoustic measurements assisted by two more fisheries vessels for scouting. The aim was to map the capelin distribution beforehand by scouting vessels and then measure the areas containing capelin thoroughly by the four vessels equipped by calibrated acoustic echosounders, further assisted with two more scouting vessels. Emphasis was set on waiting for good weather forecast for several adjacent days to facilitate a full coverage of the area of interest in favourable weather conditions, because in this region the rare periods of calm seas are usually short. However, due to strike of Icelandic fishermen, all the Icelandic fishing vessels meant to participate in this project could not leave harbour. Consequently only 3 ships (two research vessels and one Greenlandic fishing vessel hired for the project) could participate.

The 10th of January the echosounder of Polar Amaroq was successfully calibrated in Nordfjordur. Echosounders of the research ships had already been calibrated before the cruise.

First coverage

The vessels were planned to be stand by in the period 7th – 17th January, waiting for promising weather forecasts. Arni Fridriksson and Bjarni Saemundsson surveyed eastward from Denmark Strait towards Kolbeinsey-ridge while Polar Amaroq covered the regions east of Kolbeynsey-ridge. Since no scouting had been performed, the three vessels had to cover a large area with rather coarse coverage to manage to get continuous coverage of measurements during the limited time of good weather conditions. Although, transect intervals were tighter in the north-western area where occurrence of mature capelin was believed to be more likely. Drift ice hindered the vessels only farthest off shore in Denmark Strait in areas where no capelin was observed and was not considered to affect the stock estimate of maturing capelin. The vessels just manged to join and finish their coverage in the Kolbeinsey-ridge area before they had to seek shelter in Siglufjordur the 16th January due to a storm. Mature capelin was mainly observed along the continental shelf edges north of the Vestfjords peninsula extending eastwards to about 40 nmi west of Kolbeinsey-ridge. Further east there was almost total absence of mature capelin. Immature capelin was more dominant in the western part of Denmark Strait.

Second coverage

The 17th January the three vessels left shelter in Siglufjordur to measure the north-western area where mature capelin had been observed in the earlier coverage. Since the research area had been narrowed down the three vessels could measure more thoroughly with about 10 nmi intervals between transects in relatively short time period. The 18th January both Bjarni Saemundsson and Polar Amaroq had to halt their survey for few hours due to bad weather but otherwise the survey extended fast and effectively westwards. Around 22°30′ W drift Ice started to limit the coverage of the vessels. Ice had drifted into the Denmark Strait and hindered measurements in the northern part of the planned coverage of the Denmark Strait. Capelin soundings were observed close to the ice edge. In general immature capelin dominated farthest to the west while mature capelin dominated further east.

The total number of capelin amounted to 26.7 billions whereof 7.2 billions were immature. About 26.6 % of the maturing stock was 2 years old while 54.4 % were 3 years old and 19 % were 4 years old. In total 446 000 tonnes of capelin (at age 2-5) were estimated to be maturing to spawn next spring. Further details are shown in Bardarson and Jonsson 2017a.

The double coverage (eastward and westward survey directions) should even out bias due to surveying with or against the prevailing migration direction. The big increase in SSB estimate compared to the autumn survey estimate suggested that considerable part of the spawning stock had not been covered in the autumn. Hence, TAC was updated only based on this 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 57 000 t for the fishing season 2016/2017 (Anon 2017a). This recommendation was in accordance with existing HCR established by WKICE (ICES, 2015).

12.2.2.2 Winter survey during 1. – 11. February

The capelin spawning stock had been estimated as 446 000 tonnes in a 3 ship survey conducted 11.-21. January, but it was decided to undertake second winter survey e.g. since there were limitations in coverage due to drift ice. This survey was financed by the pelagic fisheries industry.

The survey was conducted by the research vessel Arni Fridriksson and the Greenlandic pelagic fishing vessel Polar Amaroq. The research vessel Bjarni Saemundsson was simultaneously on a hydrographic survey but assisted by acoustic measurements in Eyjafjordur and proximity. There were 3-5 Scientist from the Marine Research Institute of Iceland on board each vessel. Echosounders of all participating vessels had been calibrated before the cruise.

The vessels were standby from late January waiting for promising weather conditions for acoustic measurements. Polar Amaroq left harbour from Neskaupstadur the 31. January with 3 scientists on-board although weather forecasts were not promising for coming days. This way the ship could go fishing while at the same time observing the eastern forefront of migrating capelin. Following fishing and biological sampling in the area, Polar Amaroq started acoustic sampling on the 3. of February along transects east of the Langanes peninsula. The same day Arni Fridriksson left harbour in Reykjavik to join Polar Amaroq and measure the capelin stock from east to west. Bjarni Saemundsson measured the Eyjafjordur and Eyjafjardarall areas in 8.-9. February.

The weather conditions were variable but generally rough in large parts of the survey area north of Iceland due to a series of lows passing the area. Still the vessels managed to get conditions for a continuous coverage of acoustic measurements from east to west with only few occasions where measurements had to be halted for few hours.

Capelin was observed along the continental slopes while also large quantities were found in shallow waters mainly north off Skagafjordur and Thistilfjordur (Fig. 12.2.3). Immature capelin predominated in the western part of the survey area, mainly by the shelf slopes north of Hunafloi, while larger maturing capelin dominated further east and in the shallow areas off north- and northeast-Iceland. Further details are shown in Bardarson and Jonsson 2017b.

12.3 % of the maturing stock was 2 years old while 56.1 % were 3 years old and 31.6 % were 4 years old. This shift in age distribution compared to the first winter survey indicated that older capelin had immigrated in the period between surveys.

The winter survey in February only measured the capelin in a westward direction. Simultaneous eastward migration of the capelin might have led to an underestimation of the stock size. Both the age composition and the considerable increase in estimated abundance suggest additional migration of capelin into the area after the January survey. Consequently, the TAC was updated only based on this 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 299 000 t for the fishing sea-son 2016/2017 (Anon 2017b). This recommendation was in accordance with existing HCR established by WKICE (ICES, 2015).

12.3 The fishery (fleet composition, behaviour and catch)

No initial catch quota was recommended for the 2016/2017 fishing season. The intermediate TAC advice based on the autumn survey also recommended no catches, but this advice was updated to a final quota of 299 000 t in winter 2017. In total, 300 000 t were caught in the 2016/2017 fishing season.

No summer or autumn fishery took place in 2016.

The distribution of the winter catches, based on logbooks for the Icelandic fleet, is shown in Figure 12.3.1.

The Norwegian fleet caught all of its quota in February, mainly north and east of Iceland. The Icelandic fleet started fishing the 20th of February targeting schools of capelin close to shore south off Iceland. This migration and the fishery moved westward and in the beginning of March it had reached west of Breidafjordur and Latrabjarg. In middle of March there was still ongoing some fishery west of Westfjords and north of northern coast of Iceland. In general this spawning migration was composed of large and dense schools.

The total annual catch of capelin in the Iceland-East Greenland-Jan Mayen area since 1964 is given by weight, season, and nationality of the vessels in Table 12.3.1 and Figure 12.3.2. 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 2017 as in the survey in February 2017.

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% to 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% to 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 TAC's are based on acoustic surveys.

a) The initial TAC advice for the coming fishing season is issued by ICES in May based autumn survey abundance estimate of immature 1 and 2 year old capelin. Starting in autumn 2017, this advice will be issued earlier (in December).

b) The intermediate TAC advice is issued by MRI in autumn based on the biomass estimate of maturing capelin.

c) The final TAC advice is issued by MRI 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 the abundance of 1 and 2 year old juveniles from the acoustic autumn surveys and the corresponding final TAC's nearly 1½ year later. This rule was applied by 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 TAC's are set so that there is at least 95 % probability that there will be at least 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 in the early 1990s. These models were not endorsed by the benchmark working group WKSHORT 2009.

12.6 Reference points

During WKICE, a B_{lim} of 150 000 t was defined (ICES, 2015). No other reference points are defined for this stock.

12.7 State of the stock

The spawning stock biomass (SSB) was estimated to 815 000 t in February 2017. The predation model (ICES 2015), accounting for the catches of 300 000 t and predation between survey and spawning by cod, saith and haddock, estimated that 361 000 t were left for spawning in spring 2017 (Table 12.7.1).

Given the uncertainty estimates, there was 95 % probability that at least 150 000 t was left far spawning. This was therefore in accordance to the sustainable HCR. Acoustic estimation of the immature part of the stock in autumn 2016 indicated very low abundance of immature capelin. Short term forecast

The acoustic estimate of immature capelin at age 1 and 2 from the autumn survey in September 2016 was 9.4 billions. The estimate is well below the trigger value of 50 billions and the initial advice according to the HCR is therefore 0 t in the fishing season 2017/18 (Figure 12.8.1).

12.8 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 aggregation of the capelin.

The uncertainty, mainly deriving from the aggregation behaviour of the capelin (high patchiness leads to high variance), is estimated by bootstrapping (see stock annex). The CV for the immature abundance was estimated to 0.32 in the 2016 autumn survey. The CV for the mature biomass was estimated to 0.46 in the 2016 autumn survey and 0.18 in the 2017 winter (February) survey.

The autumn survey in 2016 had more extensive spatial coverage than has been covered for many years before. Hence, although there was more than 4 day delay due to bad weather the observed low abundance estimates of both immature and maturing stock components were at the time believed to demonstrate a very low stock size. This was in line with the low number of 1 year olds measured in autumn 2015. However, a southward migration of the maturing stock component during the bad weather delays might have led to an overestimation of the spawning stock size.

The winter survey in January included a double, eastward and westward coverage that should even out bias due to eastward spawning migration in the surveyed area. During the second January coverage a drift ice caused some limitations in coverage in Denmark Strait. The big increase in SSB estimate compared to the autumn survey estimate suggests that there was considerable under estimate in the autumn.

The winter survey in February only measured the capelin in a westward direction. Simultaneous eastward migration of the capelin might have led to an underestimation of the stock size. Both age composition and considerable increase in estimated abundance suggest additional migration of capelin into the area after the January survey.

12.9 Comparison with previous assessment and forecast

For the fishing season 2016/2017 no initial or intermediate quota was advised while the final TAC was set to 299 000 t. The landings were 299 832 t. This is the second year in a row where the initial quota has been set to zero, but later revised to a final quota In autumn 2015 there were severe spatial limitations in coverage of immature capelin distribution while in autumn 2016 the coverage was far more extensive.

12.10 Management plans and evaluations

See section 12.5.

12.11 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 between Iceland, Greenland and Jan Mayen, increasing rapidly in length, weight and fat content. By late September/beginning of October this period of rapid growth is over. The growth is fastest the first two years, but the weight increase is most in the year before spawning (Vilhjálmsson. 1994. The Icelandic Capelin Stock).

Given 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 in summer, even though the level of natural mortality is not well known during this time period. This should be considered for optimal timing of fishery in relation to yield and ecological impact. 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 juvenile 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 trawl net is unknown.

12.12 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).

12.13 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 (shuttering of migrating capelin schools by pelagic trawling has been hypothesized).

Consistent with ICES recommendations on taking precautionary measures to protect juvenile capelin, the coastal states (Iceland, Greenland and Norway) have agreed to prohibit the use of pelagic trawl in the summer fishery. Iceland has stated intention not to conduct summer fishing nor allow summer fishing in the Icelandic Economic zone. Furthermore, the coastal states have agreed to put in place closures in their respective zones when the proportion of juvenile capelin (defined as shorter than 14 centimetres) in the catch exceeds 20%. An area closure shall be enforced for up to 2 weeks.

12.14 Changes in fishing technology and fishing patterns

The landings in 2016/17 (300 kt, preliminary numbers) was primarily taken by purse-seining (97%). Only 3 % was caught by pelagic trawl, buthistorically a variable amounts of the catches have been taken with pelagic trawl through the fishing seasons. Discards are considered negligible.

12.15 Changes in the environment

Icelandic and East Greenlandic 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, 2012-2014 confirmed this change in distribution of immatures and maturing capelin. In autumn 2015 large part of the immatures was not detected, indicating uncertainty in location of the nursery areas. Fisheries data suggests that the major part of the spawning still takes place on the usual grounds by the South and Southwest coasts of Iceland and to some extent also by the North coast of Iceland.

More detailed environmental description is in section 7.3.

12.16 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. by refining the model for the initial TAC, reviewing the predation/prey relationships and how SSB estimates from autumn and winter surveys should be weighted when final TAC is calculated.

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.

Profound changes in the distribution, migration and productivity of this capelin stock, likely caused by environmental changes, urge the need for further biological studies i.e. regarding life history (including changes in spawning grounds, larval drift and migration at times not observed by autumn and winter surveys) and the role of capelin (predation/prey relationships) as a key species in the ecosystem.

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 planning acoustic surveys for capelin stock assessment, allocation of effort in terms of ship time, number of ships and manpower, should be sufficient for a likely full coverage in the first attempt given the demanding weather and ice conditions during autumn and winter surveys.

Table 12.2.1 Capelin. Acoustic assessment of capelin in the Iceland/Greenland/Jan Mayen area, by r/v Arni Fridriksson and r/v Bjarni Saemundsson 10/9-4/10 2016 (Numbers in billions, biomass in tonnes).

	Length	Numbers at Age (10^9)				Numbers	Biomass	Mean
	(cm)	1	2	3	4	(10^9)	(10^3 t)	weight (g)
	9.5	0.03	0.00	0.00	0.00	0.03	0.09	3.0
	10	0.07	0.00	0.00	0.00	0.07	0.28	3.9
	10.5	0.40	0.00	0.00	0.00	0.40	1.82	4.6
	11	0.63	0.00	0.00	0.00	0.63	3.48	5.5
	11.5	0.93	0.00	0.00	0.00	0.93	6.18	6.6
	12	1.42	0.01	0.00	0.00	1.44	10.80	7.5
	12.5	1.69	0.07	0.00	0.00	1.76	15.69	8.9
	13	1.46	0.13	0.00	0.00	1.59	16.21	10.2
	13.5	1.24	0.13	0.01	0.00	1.38	16.05	11.6
	14	0.65	0.18	0.00	0.00	0.83	10.75	12.9
	14.5	0.46	0.25	0.00	0.00	0.71	10.56	14.8
	15	0.17	0.35	0.00	0.00	0.52	8.94	17.0
	15.5	0.06	0.41	0.01	0.00	0.47	9.11	19.5
	16	0.02	0.70	0.05	0.00	0.77	17.26	22.4
	16.5	0.00	0.73	0.12	0.00	0.85	21.19	24.9
	17	0.00	0.80	0.13	0.00	0.93	26.06	27.9
	17.5	0.00	0.54	0.22	0.00	0.76	24.39	32.2
	18	0.00	0.29	0.20	0.00	0.49	17.81	36.0
	18.5	0.00	0.06	0.12	0.01	0.18	7.17	39.2
	19	0.00	0.01	0.01	0.00	0.01	0.47	36.3
	19.5	0.00	0.00	0.01	0.00	0.01	0.27	42.1
TSN (10^9)		9.24	4.66	0.88	0.01	14.8		
TSB (10^3 t)		87	110	28	0.3		224.58	
Mean W (g)		9.4	23.6	31.5	39.2			15.2
Mean L (cm)	13.7	12.6	16.1	17.4	18.5			
%TSN		62.5	31.5	5.9	0.0			
SSN (10^9)		0.5	4.0	0.9	0.01	5.4		
SSB (10^3 t)		8.3	101.0	27.6	0.3		**137.1**	
SMean W (g)		15.1	25.5	31.7	39.2			25.4
SMean L (cm)	16.4	14.4	16.5	17.4	18.5			
%SSN		10.2	73.6	16.1	0.1			
ISN (10^9)		8.7	0.7	0.0	0.0	**9.4**		
ISB (10^3 t)		78.3	9.1	0.1	0.0		87.5	
IMean W (g)		9.0	13.1	11.5				9.3
IMean L (cm)	12.6	12.5	13.9	13.5				
%ISN		92.5	7.4	0.1	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	Age2	Age3	Age3	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		
2016	9	10	8.7	0.5	0.7	4.5	0.0	0.9	0.01	

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		
2016	9	9.0	15.1	13.1	25.5	11.5	31.7	39.2	

Table 12.2.4. Icelandic Capelin. Assessment of mature capelin in the Iceland/EastGreenland/Jan Mayen area in February 2017 (Numbers in billions, biomass in tonnes).

	Length	Numbers at Age (10^9)					Numbers	Biomass	Mean
	(cm)	1	2	3	4	5	(10^9)	(10^3 t)	weight (g)
	10.5	0.02	0.00	0.01	0.00	0.00	0.03	0.10	3.3
	11	0.00	0.00	0.02	0.00	0.00	0.02	0.09	4.4
	11.5	0.00	0.02	0.00	0.00	0.00	0.02	0.09	5.0
	12	0.00	0.01	0.00	0.00	0.00	0.01	0.08	7.0
	12.5	0.00	0.09	0.02	0.00	0.00	0.11	0.80	7.6
	13	0.00	0.29	0.02	0.00	0.00	0.30	2.72	8.9
	13.5	0.00	0.89	0.16	0.00	0.00	1.05	10.70	10.2
	14	0.00	1.03	0.36	0.00	0.00	1.38	16.30	11.8
	14.5	0.00	1.03	0.57	0.00	0.00	1.60	21.25	13.3
	15	0.00	0.82	1.29	0.00	0.00	2.11	32.02	15.1
	15.5	0.00	0.44	1.80	0.07	0.00	2.31	39.76	17.2
	16	0.00	0.58	2.25	0.21	0.00	3.04	59.41	19.5
	16.5	0.00	0.34	3.24	0.56	0.03	4.17	91.07	21.8
	17	0.00	0.14	3.12	1.52	0.02	4.80	121.07	25.2
	17.5	0.00	0.00	2.76	2.31	0.03	5.11	144.33	28.3
	18	0.00	0.03	1.95	2.20	0.03	4.22	134.34	31.9
	18.5	0.00	0.00	0.84	1.70	0.02	2.56	89.78	35.1
	19	0.00	0.00	0.32	1.16	0.02	1.49	57.34	38.4
	19.5	0.00	0.00	0.04	0.46	0.00	0.50	20.53	40.8
	20	0.00	0.00	0.00	0.06	0.00	0.06	2.77	47.7
TSN (10^9)		0.02	5.70	18.75	10.24	0.16	34.9		
TSB (10^3 t)		0	82	441	316.8	4.8		844.56	
Mean W (g)		3.3	14.3	23.5	30.9	29.4			24.2
Mean L (cm)	16.3	10.5	14.6	16.6	17.9	17.6			
%TSN		0.1	16.3	53.8	29.4	0.5			
SSN (10^9)		0.0	4.0	18.1	10.22	0.16	32.3		
SSB (10^3 t)		0.0	61.1	432.8	316.5	4.8		**815.1**	
SMean W (g)		#DIV/0!	15.4	23.9	31.0	29.4			25.2
SMean L (cm)	16.8	#DIV/0!	14.9	16.7	17.9	17.6			
%SSN		0.0	12.2	55.8	31.5	0.5			
ISN (10^9)		0.0	1.7	0.6	0.0		2.4		
ISB (10^3 t)		0.1	20.0	9.1	0.4			29.5	
IMean W (g)		3.3	11.6	14.6	21.5				12.4
IMean L (cm)	14.4	10.5	14.1	15.1	17.0				
%ISN		0.8	72.5	26.0	0.8				

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
2004	478.8	15.8	30.8	17.5	542.9	46.0	34.0	-	12.0		92.0	634.9

	Winter season					Summer and autumn season						
Year	Iceland	Norway	Faroes	Greenland	Season total	Iceland	Noway	Faroes	Greenland	EU	Season total	Total
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	-	-	-	-	-	-	171.1
2017*	196.8	60.4	15.0	27.4	299.8							

***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
2016	-	-	-	-	-	-	-

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
2017		0.4	5.4	4.1	0.1	10.0	299.8

Table 12.3.4. Initial quota and final TAC by seasons.

Fishing season	Initial advice	Final TAC	Landings
1992/93[1]	500	900	788
1993/94[1]	900	1250	1179
1994/95	950	850	842
1995/96[1]	800	1390	930
1996/97[1]	1100	1600	1571
1997/98	850	1265	1245
1998/99	950	1200	1100
1999/00	866	1000	934
2000/01	650	1090	1065
2001/02	700	1300	1249
2002/03	690	1000	988
2003/04[2]	555	900	741
2004/05[3]	335	985	783
2005/06	No fishery	235	238
2006/07	No fishery	385	377
2007/08	207	207	202
2008/09[4]	No fishery		15
2009/10	No fishery	150	151
2010/11	No fishery	390	391
2011/12	366	765	747
2012/13	No fishery	570	551
2013/14[1]	No fishery	160	142
2014/15	225[5]	580	517
2015/16	No fishery[5]	173	174
2016/17[6]	No fishery[5]	299	300

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) as measured in autumn survey. 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*
2016/17	9.4	300**	361*

***Based on predation model in current HCR. ** preliminary**

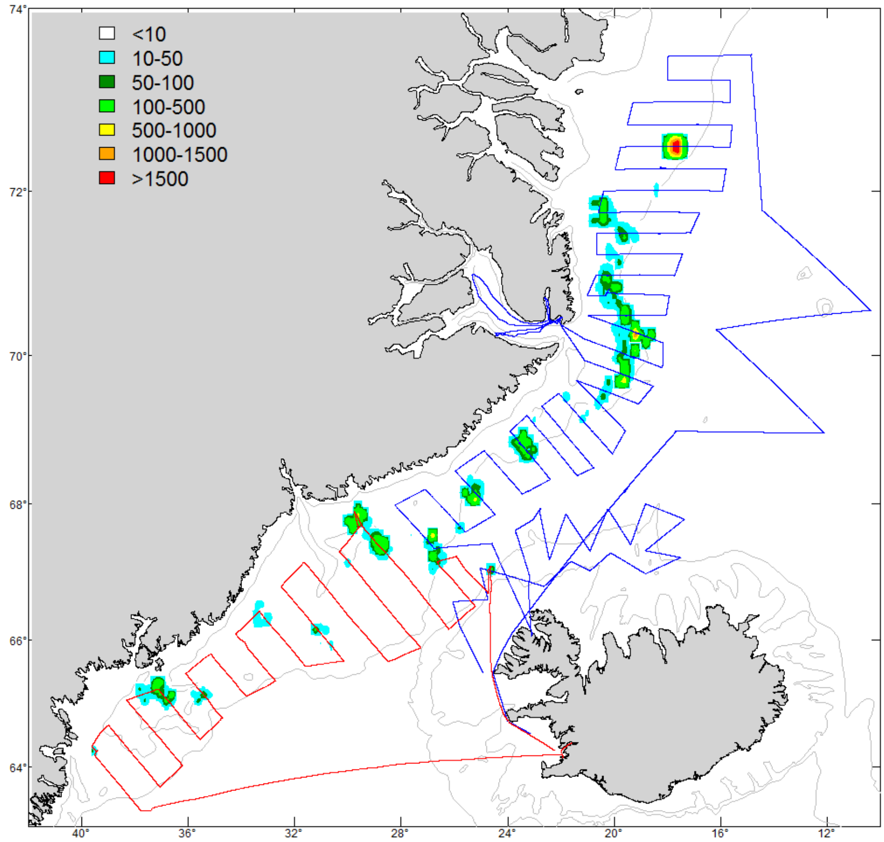


Figure 12.2.1. Icelandic capelin. Cruise tracks, relative density and distribution of capelin during an acoustic survey by r/v Arni Fridriksson (blue) and Bjarni Saemundsson (red) during 10 September - 4 October 2016.

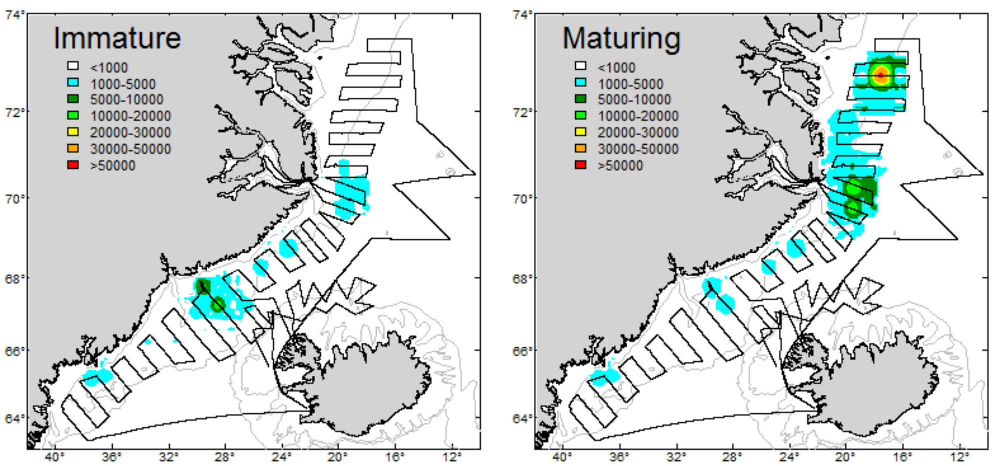


Figure 12.2.2. Icelandic capelin. Distribution of immature and maturing capelin biomass during the acoustic survey 10 September - 4 October 2016.

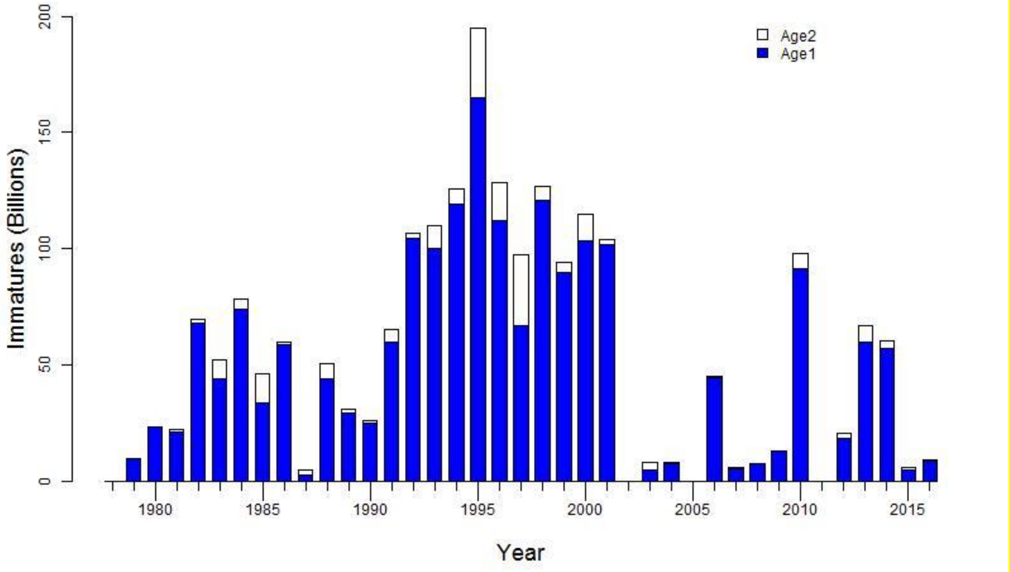
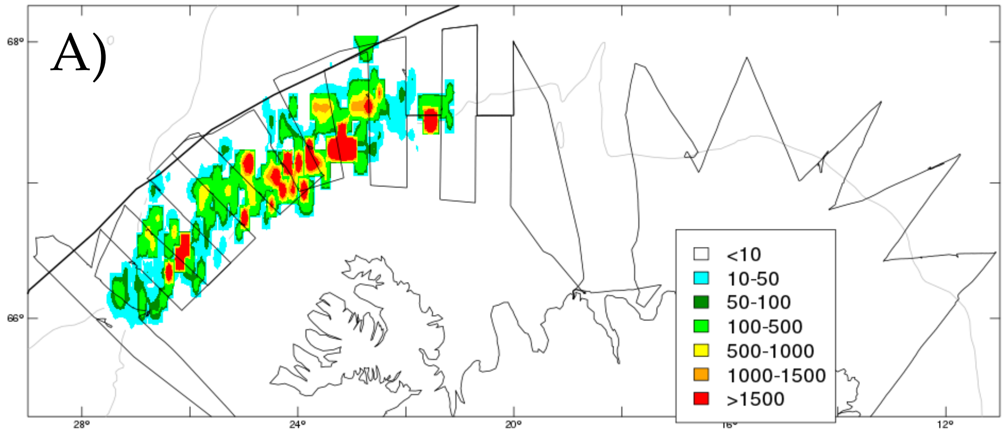


Figure 12.2.2. Icelandic capelin. Indices of immature 1 and immature 2 years old capelin from acoustic surveys in autumn since 1979.



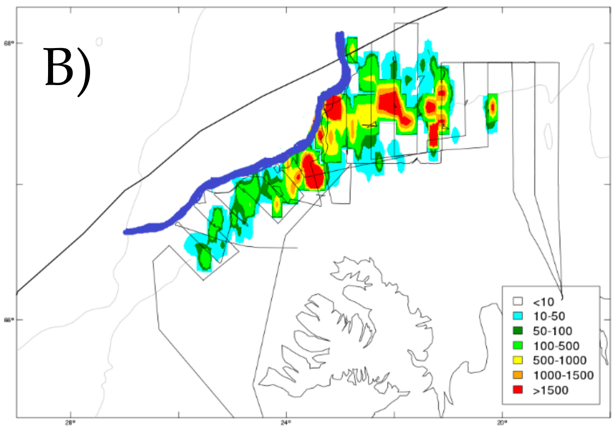


Figure 12.2.3. Icelandic capelin. Survey tracks of r/s Arni Fridriksson, Polar Amaroq and Bjarni Saemundssson during 11. – 21. January 2017. A) First coverage, B) Second coverage.

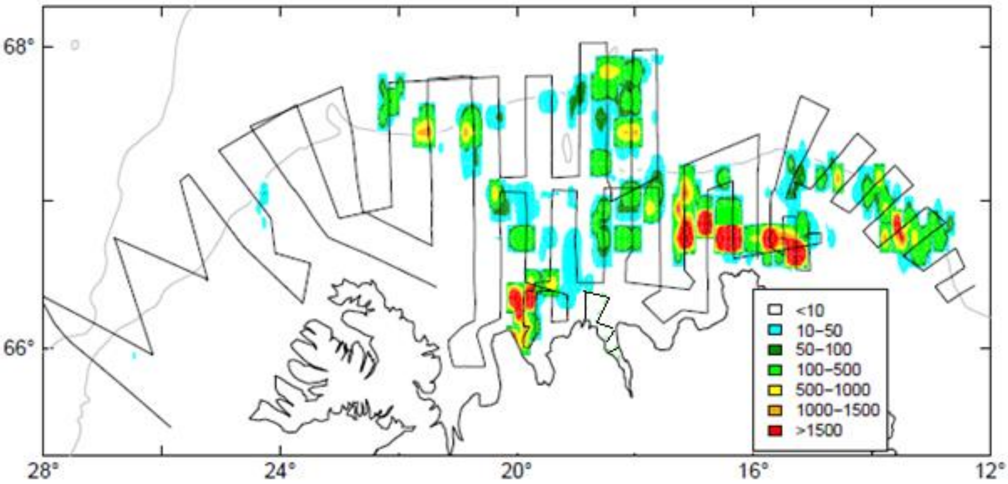


Figure 12.2.3. Icelandic capelin. Survey tracks of r/s Arni Fridriksson, Polar Amaroq and Bjarni Saemundssson during 1. – 11. February 2017.

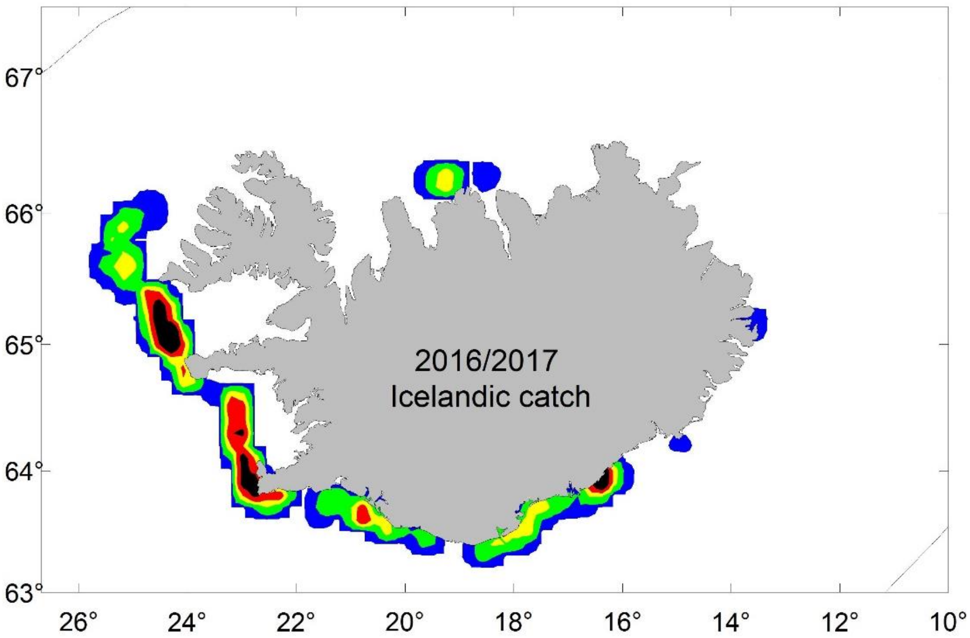


Figure 12.3.1. Icelandic capelin. Distribution of the catches in the fishing season 2016/17 based on data from logbooks of the Icelandic fleet.

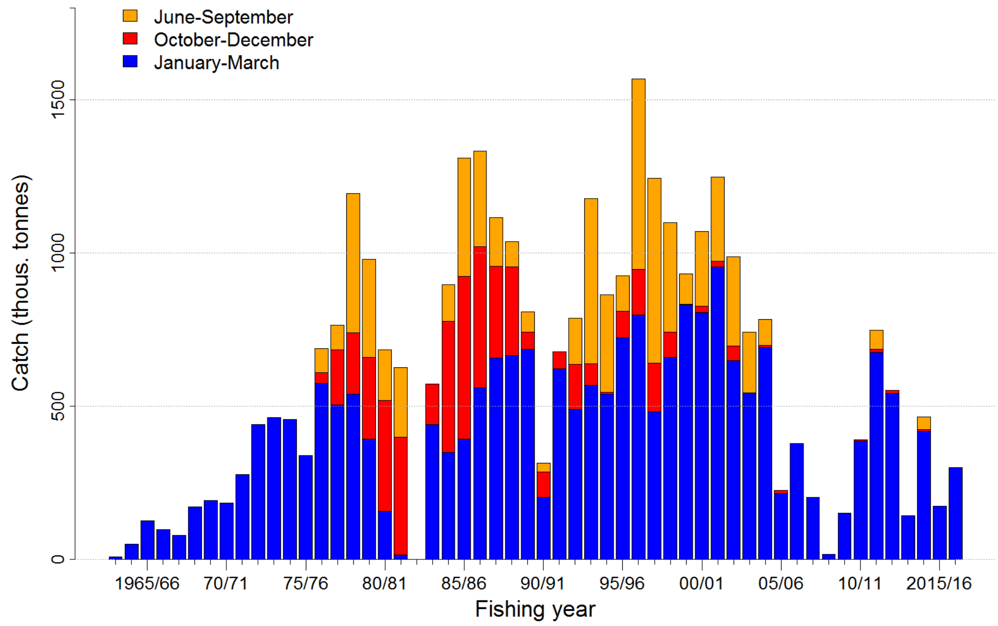


Figure 12.3.2. Icelandic capelin. The total catch (in thousand tonnes) of the Icelandic capelin since 1963/64 by season.

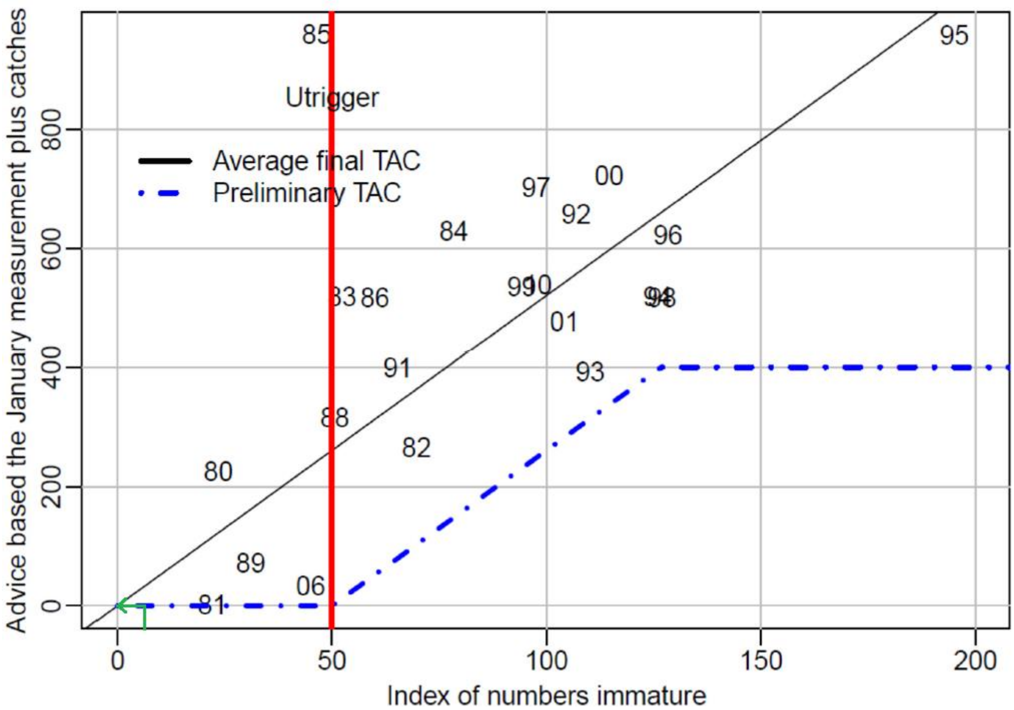


Figure 12.8.1 **Capelin in Subareas 5 and 14 and Division 2.a west of 5°W. Catch advice according to the proposed stochastic HCR, based on the measured number of immature capelin about 15 months earlier. The figure shows the estimated final TAC (black unbroken line) and the initial (preliminary) TAC (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).

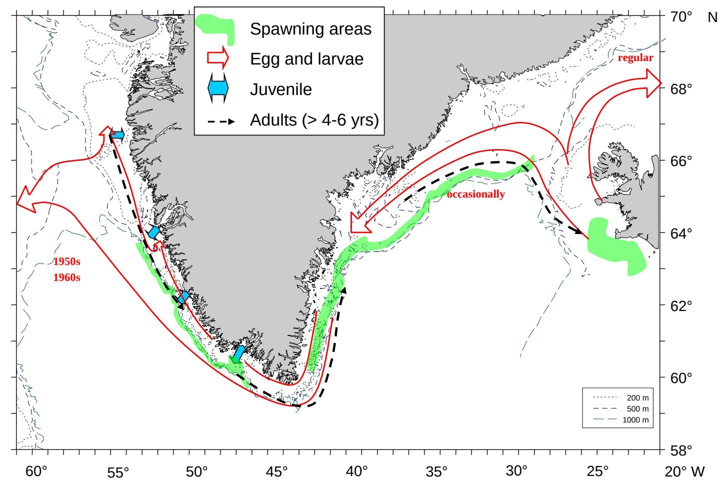


Figure 1. Spawning areas, egg and larval transport of Atlantic cod (*Gadus morhus*) in Greenlandic and Icelandic waters.

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).

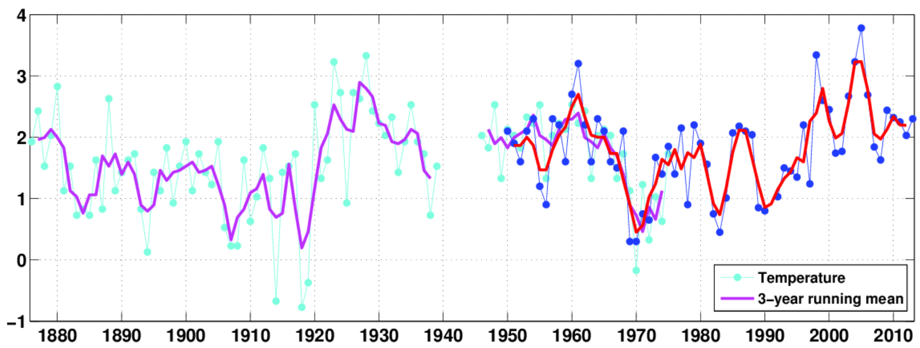


Figure 2. Mean temperature on top of Fylla Bank (located outside Nuuk Fjord, 0–40 m depth) in the middle of June for the period 1950–2013. The curves are 3 year running mean values. The magenta/purple line is extended back to 1876 using Smed-data for area A1. From Ribergaard (2014).

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.*

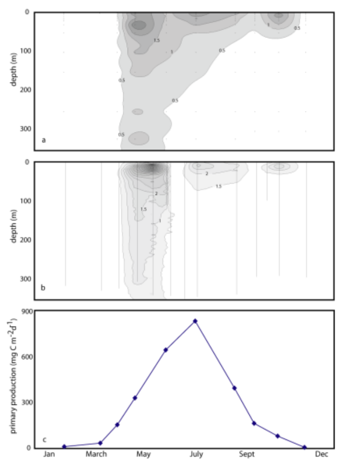


Figure 3. Annual variation in algal biomass and productivity at the inlet of Nuuk Fjord. a: chlorophyll (µg l^{-1}), b: fluorescence, c: primary production (mg C m^{-2} d^{-1}). Dots represent sampling points. From Mikkelsen *et al.* (2008).

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.

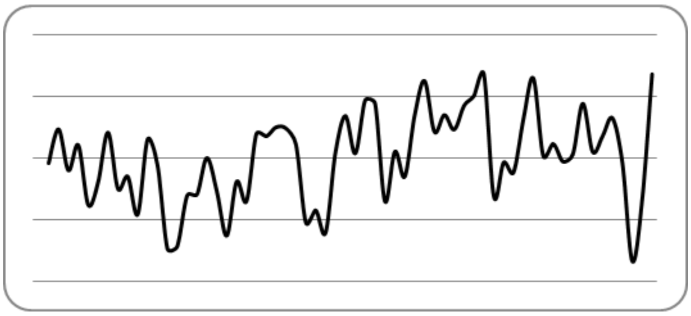


Figure 4. NAO Index (Dec-Feb) 1950–2012.

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).

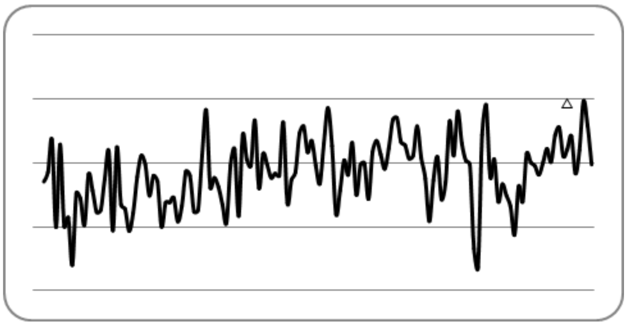


Figure 5. Time-series of annual mean winter (DEC-FEB) air temperature anomalies (K) at Nuuk (1876-2012, rel. 1961–1990)

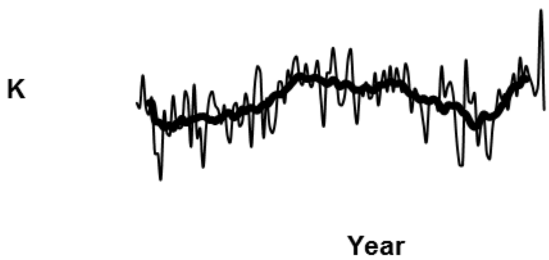


Figure 6. Time-series of annual mean air temperature anomalies (K) at Nuuk (1876–2011, rel. 1961–1990), and 13 year running mean.

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.

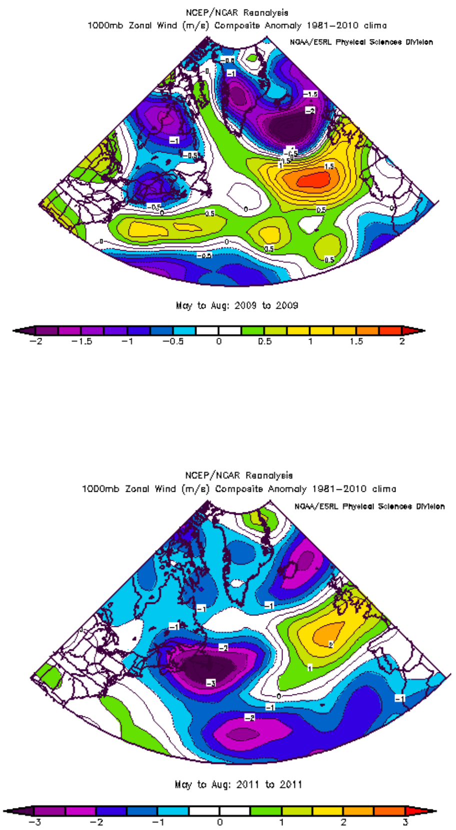


Figure 7. Zonal wind components for the North Atlantic (May-Aug), anomalies from 1981–2010. top left: 2009; top right: 2010; bottom left: 2011.

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).

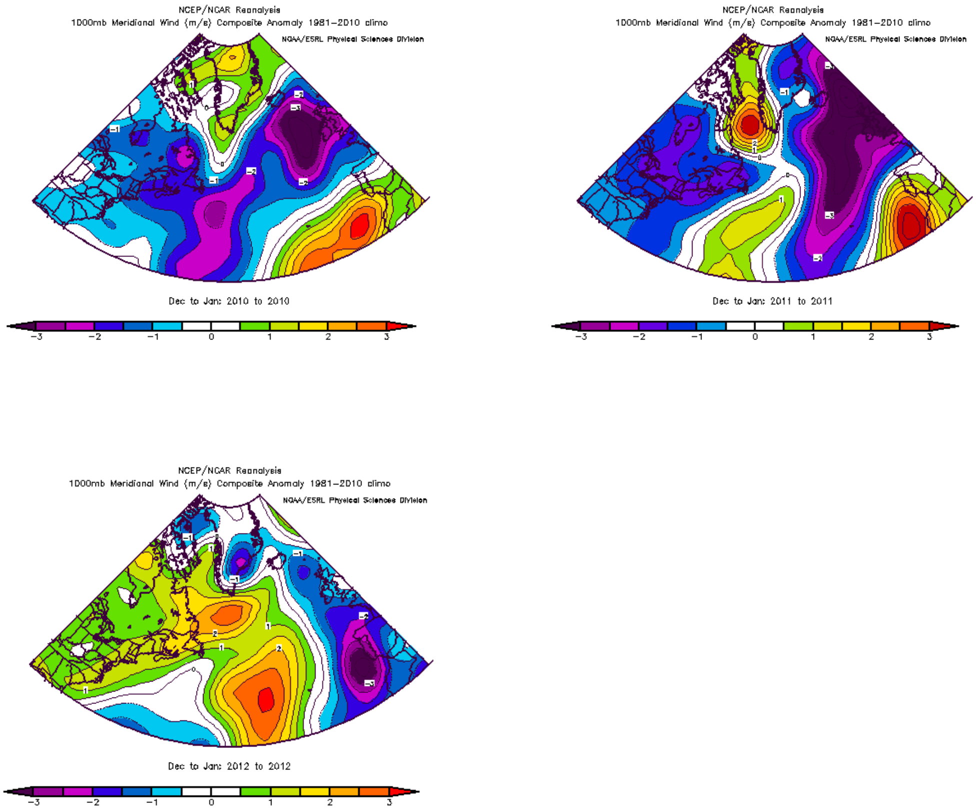


Figure 8. Meridional wind component (Dec-Jan), anomalies from 1981–2010. top left: 2009/2010; top right: 2010/2011; bottom left: 2011/2012;

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 35 000 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 2010-16 being around 8 000 t. This includes both redfish species. The majority (e.g. ~70%) has earlier been identified as *S. mentella*. However, recent East Greenland survey estimates indicate a decline in *S. mentella* while *S. norvegicus* is increasing, and based on samples from the fishery the proportion of *S. norvegicus* exceeded for the first time *S. mentella* in 2016.

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.

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), (Fig. 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 2016

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 and 2016 the management plan was overruled and a TAC of 5 000 tons was introduced as an experimental fishery. In adition it was allowed to fish offshore on the inshore quota.

Offshore catches in the fishery in 2016 amounted to a total of 3 740 tons caught primarily on Dana Bank (NAFO div 1D and 1E, between 62°00-63°00N, figure 14.2.2.1 and 14.2.2.2), of these 420 t where fished on the inshore quota.

The fishery occurred from June to November (table 14.2.2.1) and longlining was the dominating gear with 60% of the total catch (figure 14.2.2.3).

14.2.3 Length, weight and age distributions in the fishery.

Length measurement amounted to 1 928 cod measured. Length measurements were taken by crew members directly on the ships.

Overall mean length in the fishery was 61 cm and age 6 yr old (YC 2010) dominated the catches followed by the 2009 YC (figure 14.2.3.1 and 14.2.3.2). The 2009 YC also dominated the catches in 2014 and 2015 (table 14.2.3.1).

14.3 Surveys

At present, two offshore trawl surveys (Greenland and German) provide the core information relevant for 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 156 in 2016 (table 14.3.1.1).

The 2016 survey abundance of Atlantic cod in West Greenland was estimated at 20 million individuals and the survey biomass at 13.290 tons (table 14.3.1.2 & 14.3.1.3). Survey abundance and biomass decreased with 80% and 86% respectively compared to 2015. Abundance was primarily in area 1A, B and C and biomass was primarily in NAFO Div. 1C (figure 14.3.1.1 and 14.3.1.2).

The stock has been dominated by the 2009 YC since 2011 and by the 2010 YC since 2014 (table 14.3.1.4, figure 14,3,1,3). In 2016 only 3% of these YCs were left in the area.

Younger YC such as the 2012 and 2014 YC is dominating the survey in 2016 but in low numbers. The 2012 YC is more abundant in the southern part of the survey (NAFO 1C-1E), whereas the 2014 YC is more abundant in the northern part of the survey (NAFO 1A-1B (table 14.3.1.5). The distribution pattern is similar with previous years with 1 and 2 yr old in the northern part of the survey area, and at age 3 moving further to the south.

The cod found offshore in West Greenland are generally younger than 5 years, and the 2016 survey confirmed that older and larger cod barely exist offshore in West Greenland. The increasing trend for cod at age 5-7 in 2014 and 2015, where cod older than 5 years was record high, was reversed in 2016 and cod older than 5 yrs are once again almost absent in West Greenland (table 14.3.1.4, figure 14.3.1.3).

The offshore cod start to spawn at age 5-6 yrs, and the spawning stock biomass in the survey show an increasing trend in 2014 and 2015 but a major decline in 2016. The remaining spawning stock is concentrated in the mid area (NAFO 1C, figure 14.3.1.7 and 14.3.1.8). In 2014, the number of spent females have increased in the survey in area 1C-1E, but has since declined (figure 14.3.1.9).

The survey show a small decrease in abundance and an increase in biomass compared

In the offshore survey the 2009 YC is predominantly found in the spawning area in East Greenland (Retzel 2017a). After a period with almost no fishery in West Greenland (between 100-500 t) almost 5,000 t was caught in 2015 and 4,000 t in 2016 (Retzel 2017b). The main YCs in the fishery was the 2010 and the 2009 YCs and the fishery was concentrated in the sourthern part of the survey area on Dana Bank (NAFO 1D-1E). The inshore fishery was record high in 2016 with 34,200 tons being fished. The main YCs in this fishery was the 2010 and 2011 YCs (Retzel 2017c).

The reduction in the West Greenland stock component is described as a combined effect of fishing, eastward spawning migration of the 2009 YC and possible inshore migration of the 2010 and 2011 YCs.

14.3.2 Results of the German groundfish survey

Due to technical problems with the vessel the German survey did not manage to cover the West Greenland area in 2016.

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 was increasing until 2015. Especially the number of the 2009 YC at age 6 was record high in 2015, but not at age 7 in 2016 (table 14.3.1.4). Normally offshore 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, 2015 and 2016 (figure 14.3.1.9), indicating that some degree of spawning is occuring. 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 20 513 cod have been tagged in different regions of Greenland in the period of 2003—2016 (table 14.5.1). A total of 5 901 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 (356) 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 (44 individuals), but some also migrate eastward (23 individuals recaptured in East Greenland, and 30 in Iceland, table 14.5.2). 18 offshore tagged fish on Dana Bank have been recaptured in the inshore fjord system. Most of these were recaptured in the inshore area south of Dana Bank, but 1 is recaptured in the Nuuk fjord system north of Dana Bank and 4 have had a northward migration pattern from Dana Bank. 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 presently considered to act mainly as a nursing area for the East Greenland and Icelandic stock components.

Until 2015 the 2009 and 2010 YCs have been caught in considerable numbers and is believed to be of East Greenland and/or Icelandic origin. At age 7 in 2016 these YCs were caught in low numbers in the survey. The reason for the reduction of the 2009 and the 2010 YC in 2016 is considered to be caused by a combined effect of migration out of the area and fishery.

The stock is considered to be at a very low level compared to historic.

As described in section 1.3 MSY proxies should evaluated to determine stock status. ICES suggested four methods for this purpose, and all methods were tested on the stock (Hedeholm 2017). All the length based indicators rely heavily on length distributions from the commercial fishery. For this stock, the fishery has been very limited since the early 1990 collapse. Hence, commercial data are limited and not really suited for such analysis; especially with the general assumptions of no migration underlying most of the approaches.

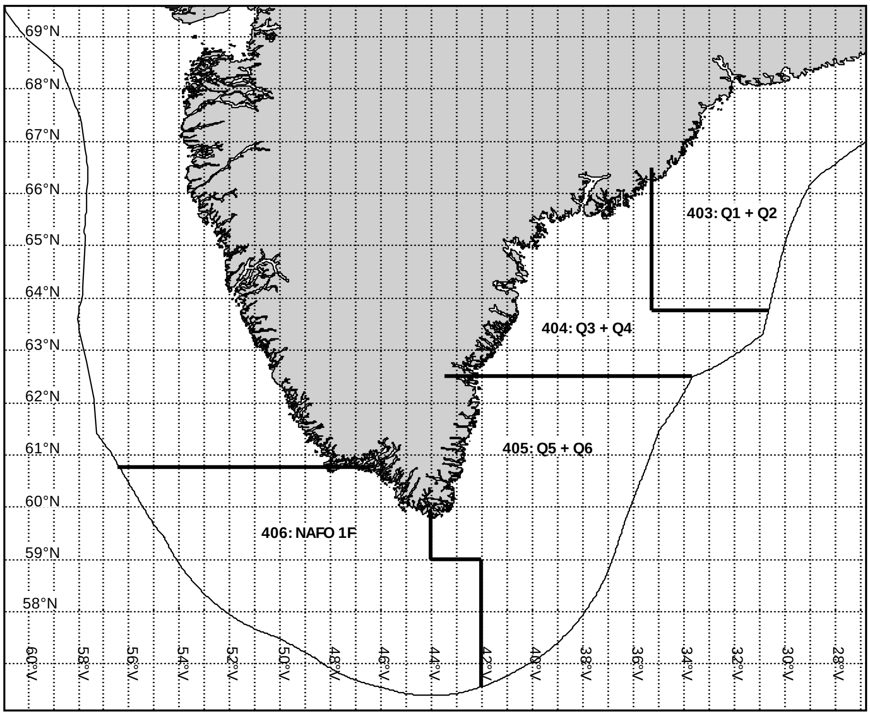
With these shortcomings, the results from all analysis support the general notion from surveys: this stock is at a low level, and the landings are being supported by inflow from other stocks to this area i.e large individuals are missing in the catches.

14.7 Implemented management measures for 2017

According to a management plan implemented in 2014 no offshore fishery is to take place in NAFO subdivision 1A-1E in 2017. The management plan has, however, been overruled, and a TAC of 5 000 tons has been introduced. In addition it is allowed to fish offshore on the inshore quota which is 36 500 tons. Dana bank (beween 62 and 63°N) is closed for fishery in the spawning season (April-May).

14.8 Management plan

In 2014 a management plan was implemented for the offshore cod fishery in Greenland . 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 in order to protect the West offshore stock component. The TAC in management area South East is 10 000 t/year.

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.

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 *

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A – 1E
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 *
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

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A – 1E
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
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
2016	0	0	67	1911	1762	2335	0	3740

1) 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.

2) 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: 2016 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										67			**67**	2%
1D						10	182	293	386	616	423	1	**1911**	51%
1E				165	72	623	348	233	255	1	33	32	**1762**	47%
Total				**165**	**72**	**633**	**530**	**526**	**641**	**684**	**456**	**33**	**3740**	
%				4%	2%	17%	14%	14%	17%	18%	12%	1%		

Table 14.2.2.3: 2016 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	1C										67			**67**
	1D						2	180	293	238	321	105		**1139**
	1E				163	39	258	263	180	138		30		**1071**
	Total				**163**	**39**	**260**	**443**	**473**	**376**	**388**	**135**		**2277**
Trawl	1D						8	2		147	295	319	1	**772**
	1E				2	33	366	84	53	117	1	3	32	**691**
	Total				**2**	**33**	**374**	**86**	**53**	**264**	**296**	**322**	**33**	**1463**

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 yearclasses 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
2016	1	12	198	923	490	69	20	5
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
2016	0.345	0.810	1.237	1.931	2.560	4.299	5.573	7.947

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
2016	0	59	38	26	14	19	156

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
2016		4892	3243	6961	1564	3437	20096	26

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
2016		2256	1174	5817	1347	2697	13290	32

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
2016	0	1155	5103	2746	5680	3487	1442	418	56	0	0

Table 14.3.1.5 Abundance indices ('000) by age from the Greenland Shrimp and Fish survey in West Greenland by NAFO divisions, 2016.

West Greenland											
Year-class	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	<2007
Age	0	1	2	3	4	5	6	7	8	9	10+
Div. 0A											
Div. 1A	0	244	1825	1118	1033	511	115	24	23	0	0
Div. 1B	0	333	1656	430	429	318	78	0	0	0	0
Div. 1C	0	18	826	626	2939	1797	624	123	8	0	0
Div. 1D	0	26	375	262	291	253	228	96	34	0	0
Div. 1E	0	534	421	311	989	608	396	176	0	0	0

Table 14.3.1.6 Mean weight of cod 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	0.002	0.031	0.146	0.298	0.596	1.208	1.800	3.338			
2006	0.004	0.025	0.120	0.338	0.477	0.680	2.581	2.714			
2007	0.002	0.026	0.138	0.320	0.601	1.446	4.375				
2008	0.006	0.025	0.098	0.239	0.497	0.939	1.774	2.742			
2009		0.024	0.104	0.329	0.620	1.353	2.103				
2010	0.003	0.017	0.136	0.291	0.683	1.191	1.952	3.066			
2011	0.001	0.038	0.164	0.377	0.626	1.151	2.081				
2012		0.019	0.137	0.419	0.763	1.200	1.371	3.396			
2013		0.038	0.112	0.337	0.611	0.781	1.722	2.905	3.560	6.460	
2014		0.014	0.133	0.300	0.675	0.977	1.708	2.704	4.108	5.710	9.245
2015		0.011	0.102	0.349	0.623	1.062	1.594	2.478	4.276	5.308	9.065
2016		0.028	0.094	0.314	0.711	1.145	1.742	2.542	3.844		

Table 14.3.2.1 ***German survey*. Numbers of valid hauls by stratum in West Greenland (NAFO 1C-E). . : No survey in 2016.**

	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
2016	.	.	.	.	.	.	.

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. . : No survey in 2016.**

	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
2016	.	.	.	.	.	.	.	.

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. . : No survey in 2016.**

	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
2016	.	.	.	.	.	.	.	.

Table 14.3.2.4 ***German survey*****, West Greenland (NAFO 1C-E). Age disaggregated abundance indices ('1000). . : No survey in 2016.**

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
2016	.	.	.	.	.	.	.	.	.	.	.	.	.

***) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (ICES, 1984).**

Table 14.3.2.5 ***German survey,*** **West Greenland (NAFO 1C-E). Mean weight at age. .: No survey in 2016**

Year	0	1	2	3	4	5	6	7	8	9	10	11+
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989		34	144	278	874	1636	1456				6535	
1990		20	135	288	474	877	2076					3935
1991		52	157	371	586	873	1173	1711	1260			
1992		61	220	332	797	974						
1993		35	119	356	457	832						
1994		50	157	418	573	1090		2240				
1995			172	410	511							
1996		51	90	480	690							
1997		65	288	360	1032							
1998		49		610	1320							
1999		67	354	658	950		2985					
2000		36	228	431	821							
2001		62	297	651	1229	1063						
2002		55	231	548	821							
2003		114	412	669	1169	1572	2415					
2004		78	314	534	1105	1508	3007					
2005		67	292	830	1254	3066	5383					
2006	21	49	226	543	1166	2314	4099	8710				
2007	21	121	227	540	937	3051	6899	5600	8010			
2008		52	143	449	738	1581	5246	0	5192			
2009		50	183	431	694	1453	3252	4796				
2010	59	102	294	540	944	1608	2010	6019	3729	8870		11360
2011		234	228	542	1041	1201	3356	4562	6962			
2012	93	135	355	665	1145	2147	3827	5337	7299	9150		
2013		71	269	706	1145	1907	3333	5707	8445	8907	18270	18200
2014			271	574	1099	1698	4118	4929	6418			28180
2015		57	216	697	1242	2003	2597	3211	6428	3145		
2016	.	.	.	.	.	.	.	.	.	.	.	.

Table 14.5.1. Number of tagged cod in the period of 2003 to 2016 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
2016		1297	1911

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)	442	18	2
Bank (West)	1	44	2
East Greenland		23	105
Iceland	3	30	139

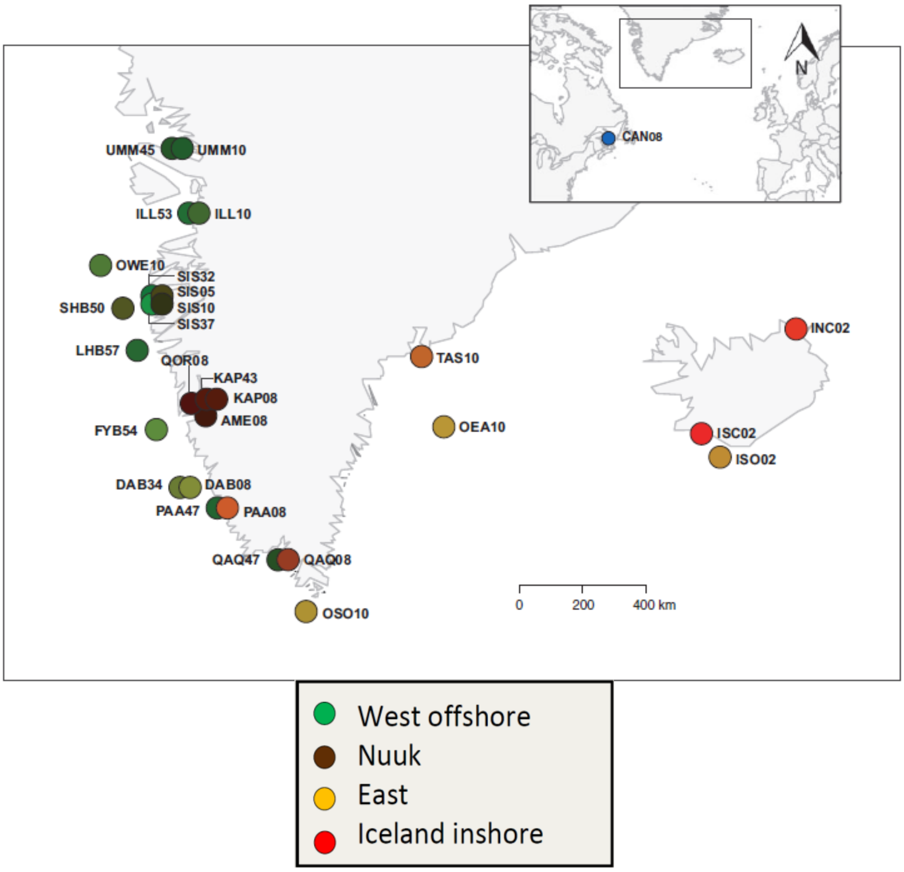


Figure. 14.1. Sampling location of spawning cod in Greenland and Iceland in the genetic project. The colours of the dots represent the blends of sample mean of the different spawning population: West offshore, Nuuk (inshore), East (Greenland and offshore Iceland) and Iceland inshore as signal intensities of green and red respectively. After Therkildsen *et al.* 2013.

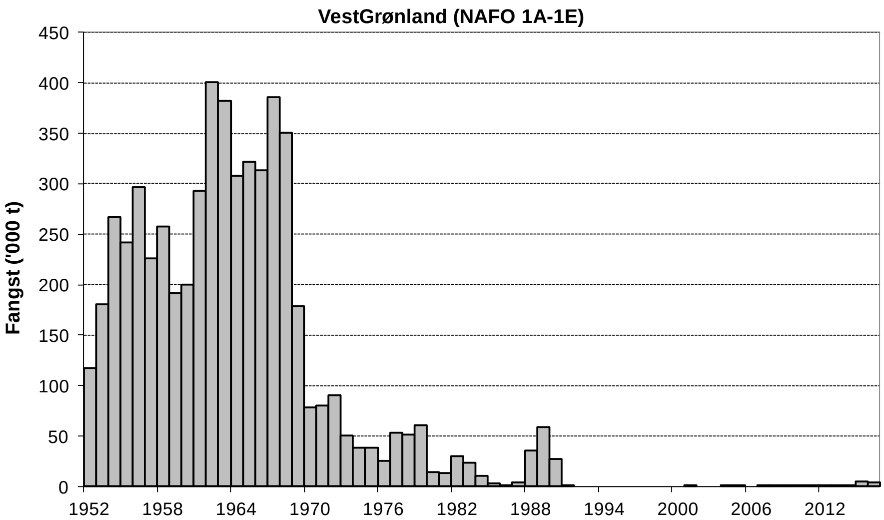


Figure 14.2.1. Annual catch of cod in offshore West Greenland (NAFO subdivisions 1A-1E) used by the Working Group.

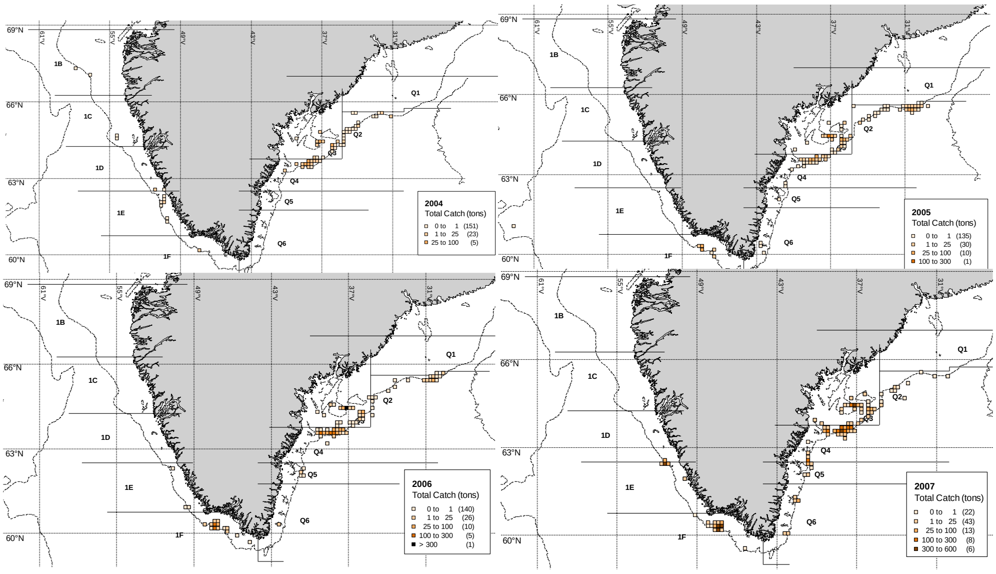


Figure 14.2.2.1: Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

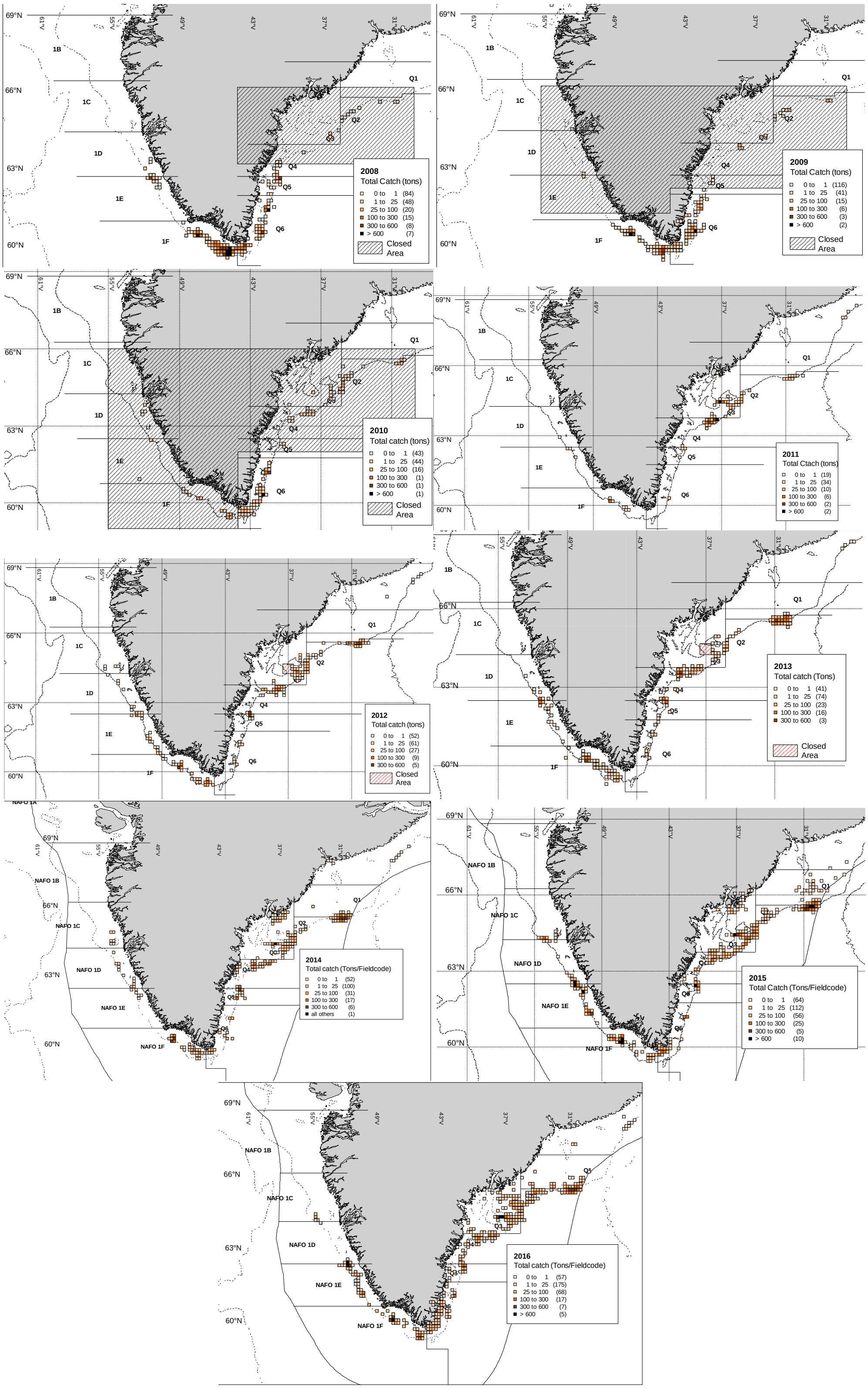


Figure 14.2.2.1: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

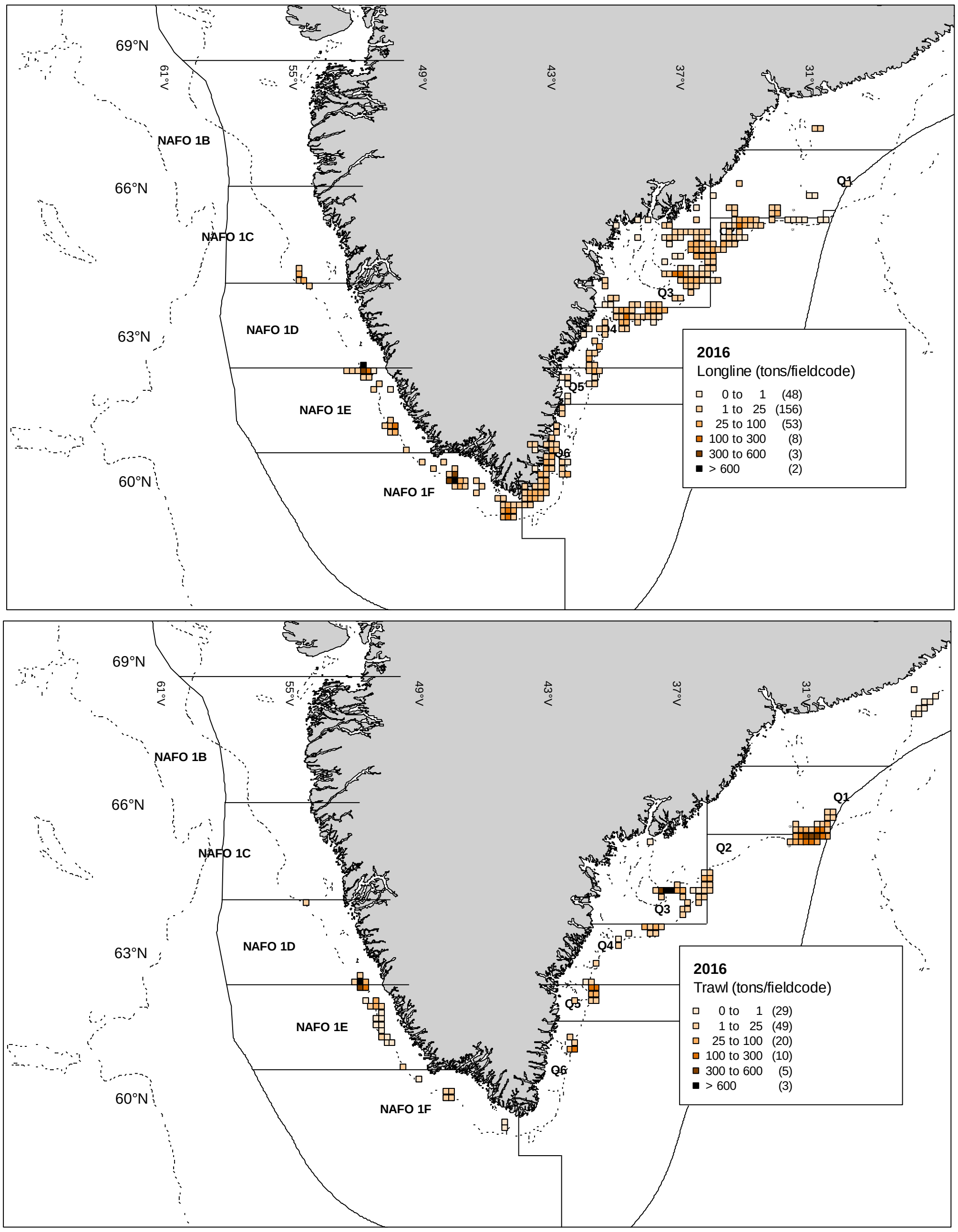


Figure 14.2.2.2: Distribution of Longline and Trawl catches of Atlantic cod in West and East Greenland 2016. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

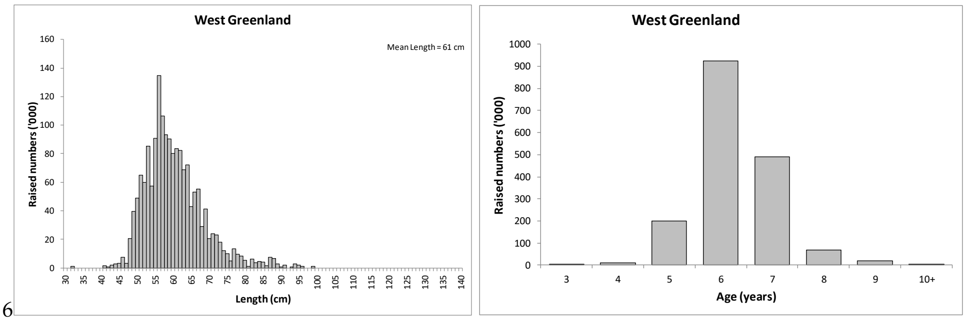


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Figure 14.2.3.1: Total length and age distributions of commercial cod catches in the West Greenland (NAFO 1A-1E) offshore fishery in 2016.

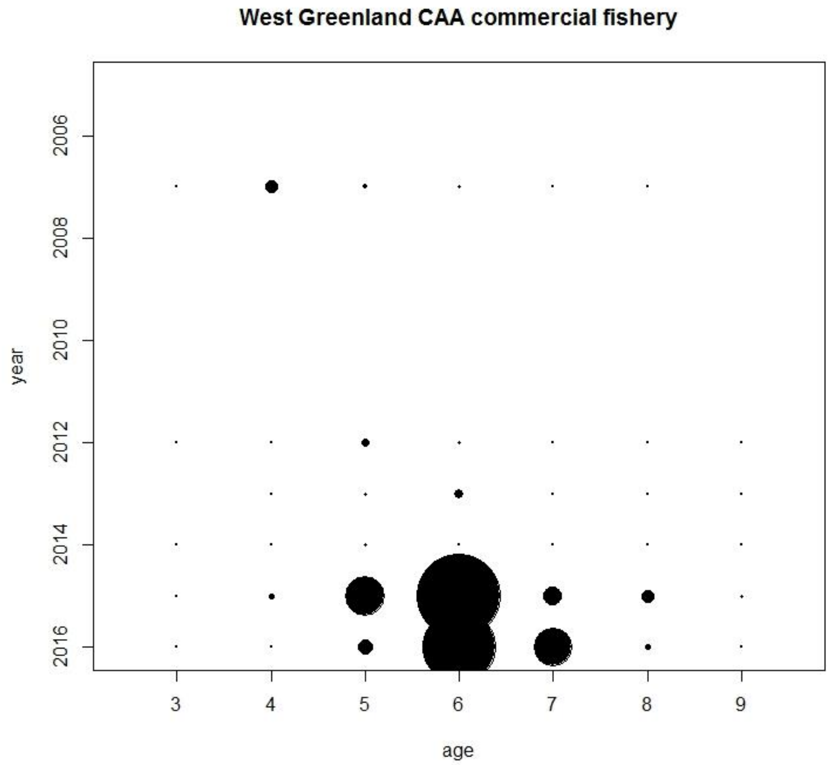


Figure 14.2.3.2: Catch at Age in the West Greenland (NAFO 1A-1E) commercial fishery. Size of circles represents size of catch numbers.

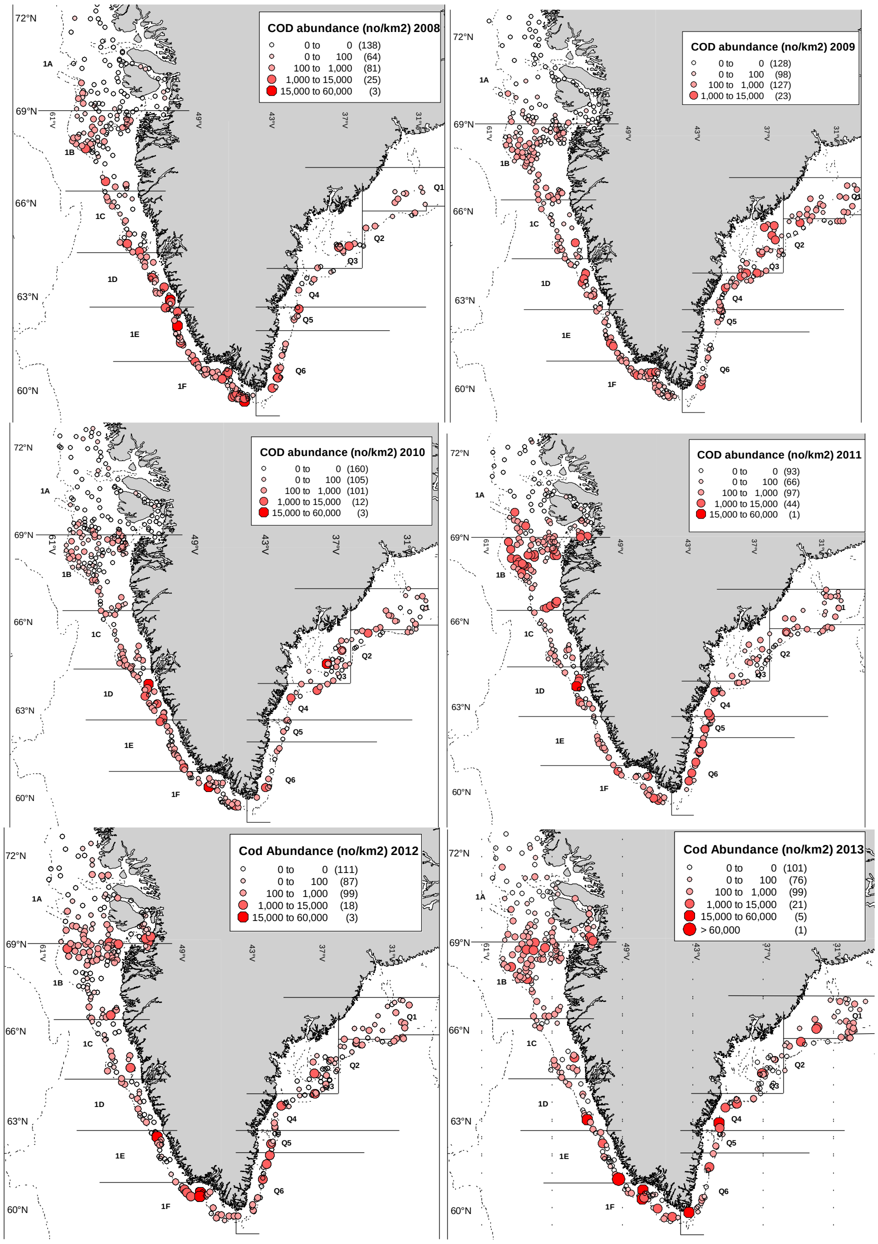


Figure14.3.1.1. Greenland shrimp and fish survey. Abundance per Km²

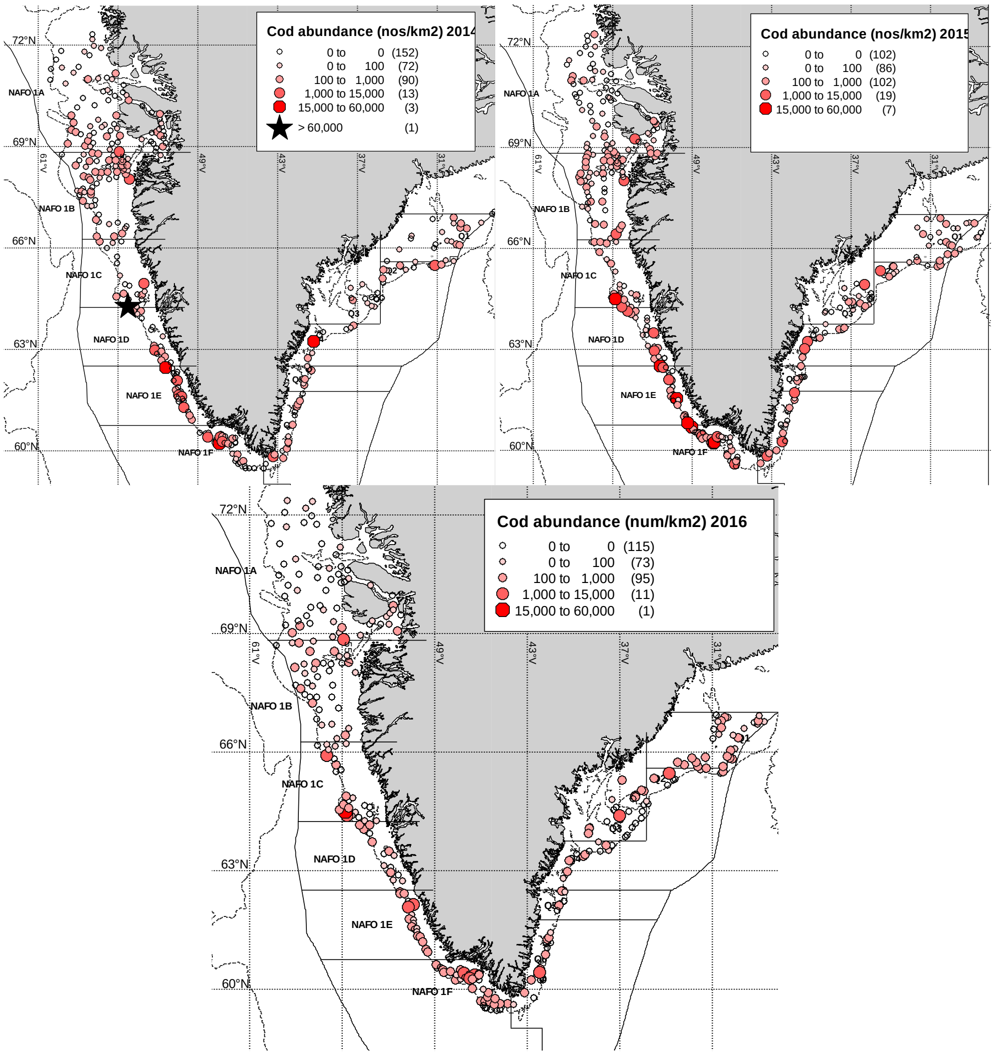


Figure14.3.1.1. continued. Greenland shrimp and fish survey. Abundance per Km²

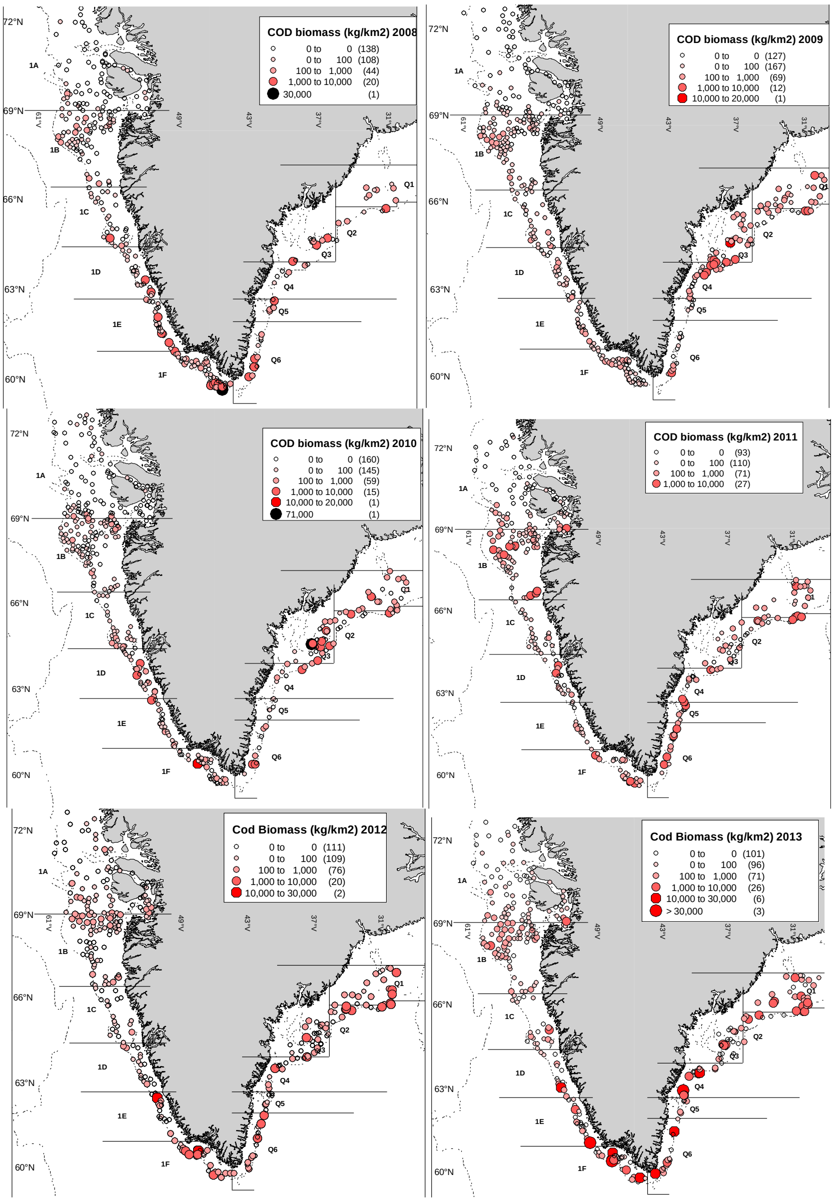


Figure 14.3.1.2. Greenland shrimp and fish survey. Catch weight kg per Km²

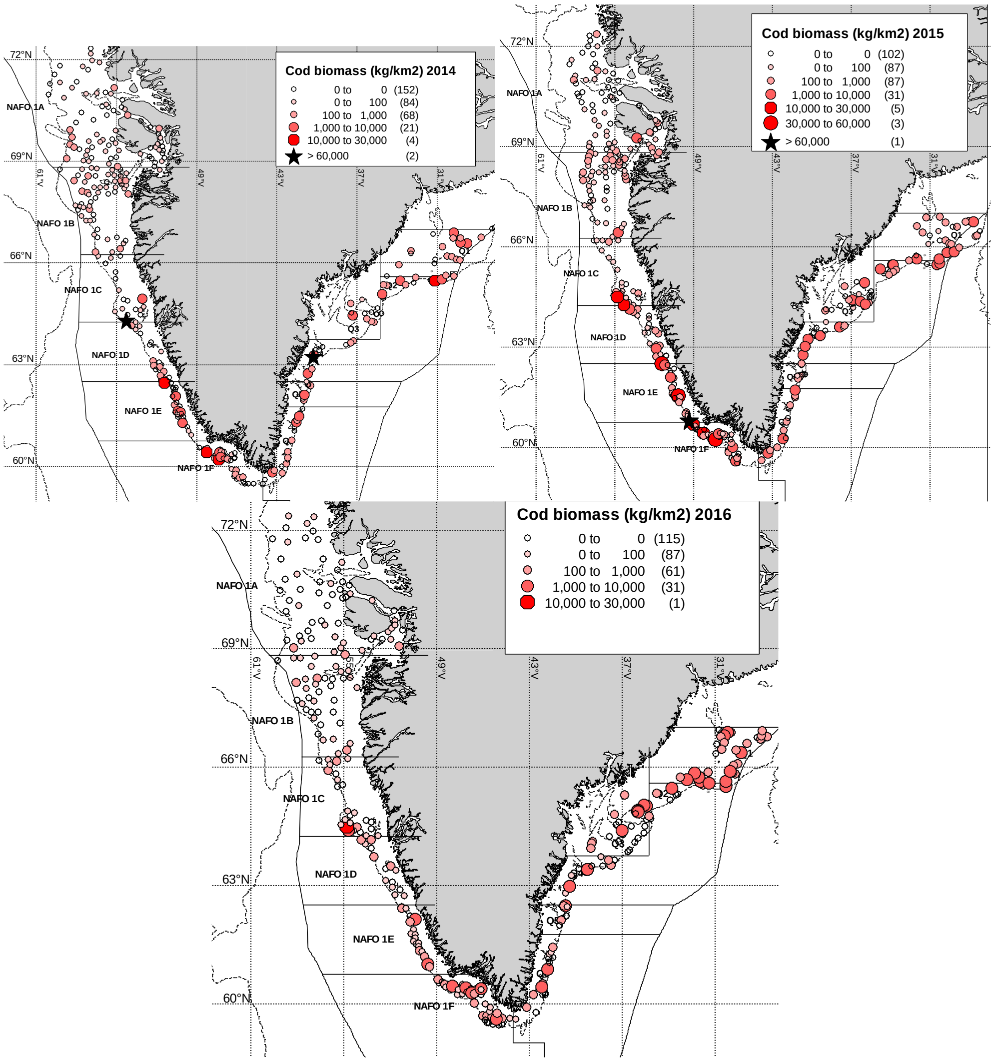


Figure 14.3.1.2. continued. Greenland shrimp and fish survey. Catch weight kg per Km²

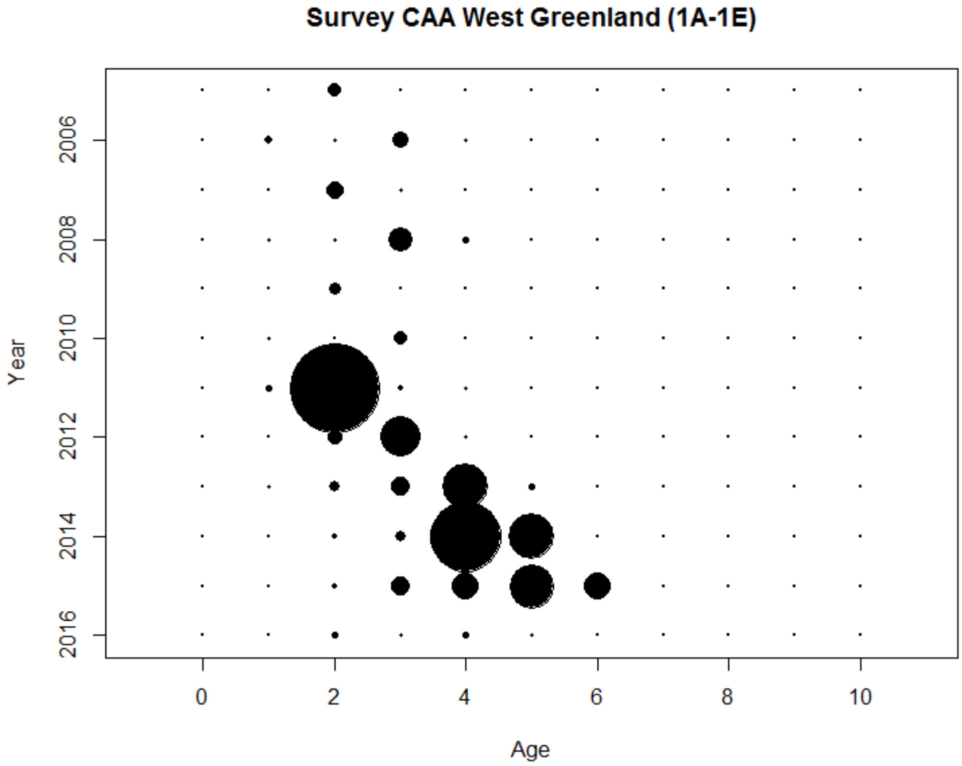


Figure 14.3.1.3: Abundance index by age in NAFO 1A-1E combined. Size of circles represents index size of index.

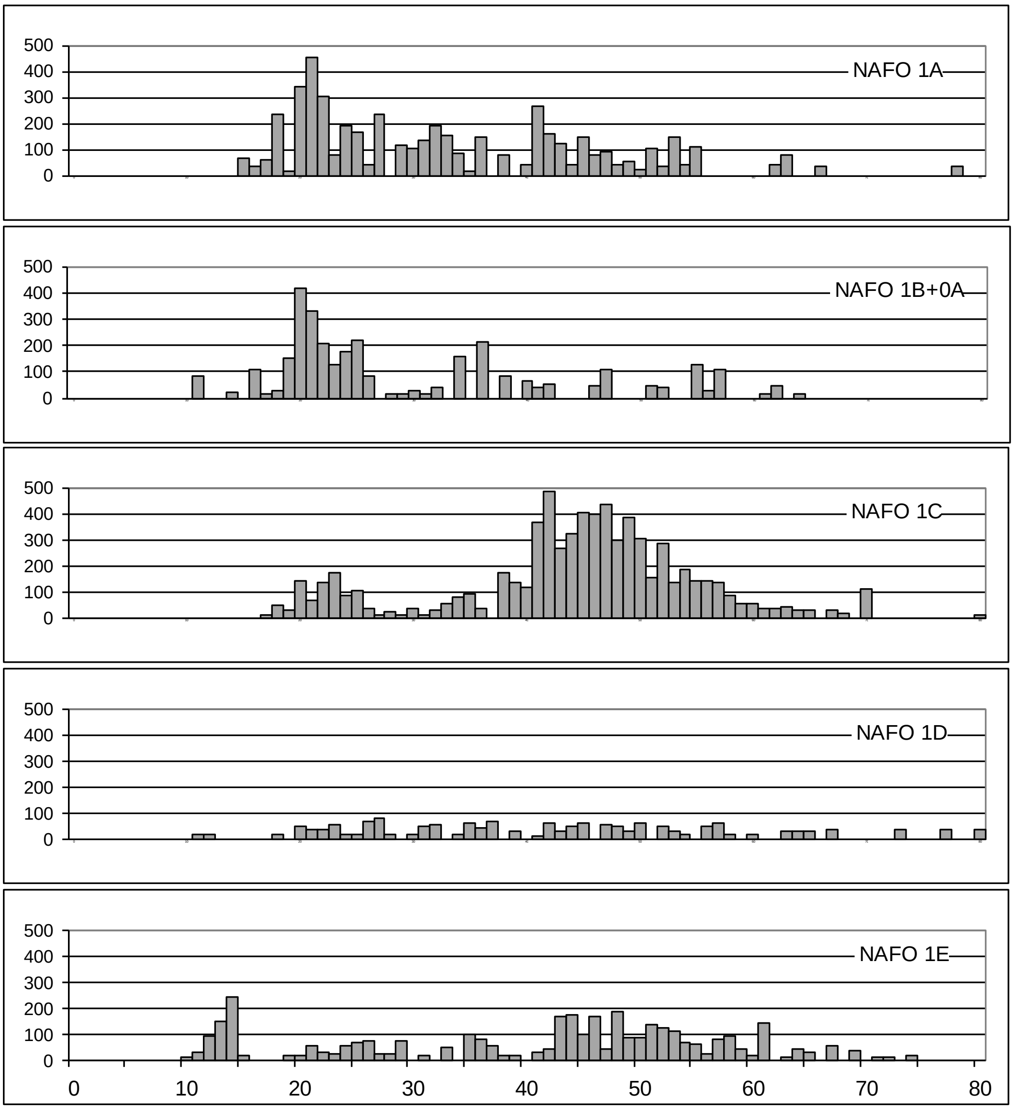


Figure 14.3.1.4: West Greenland Shrimp and fish survey, 2016. Abundance index by length (cm) and area . Areas from north (top) to south (bottom) are: NAFO div. 1A ; 1B+0A; 1C, 1D, 1E.

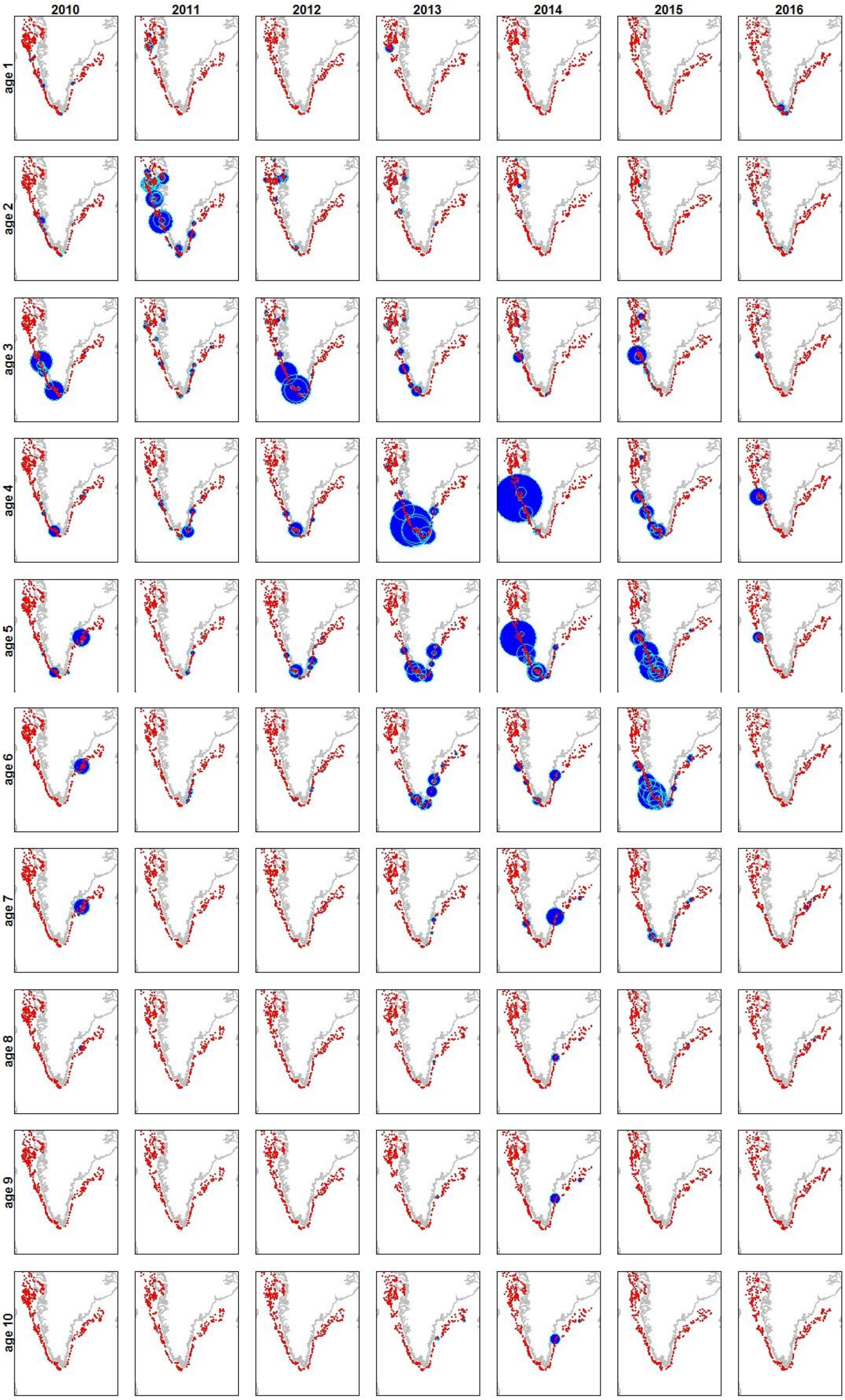


Figure 14.3.1.5. Abundace (no/km^2) pr. station of ages 1-10 in the years 2010-2016.

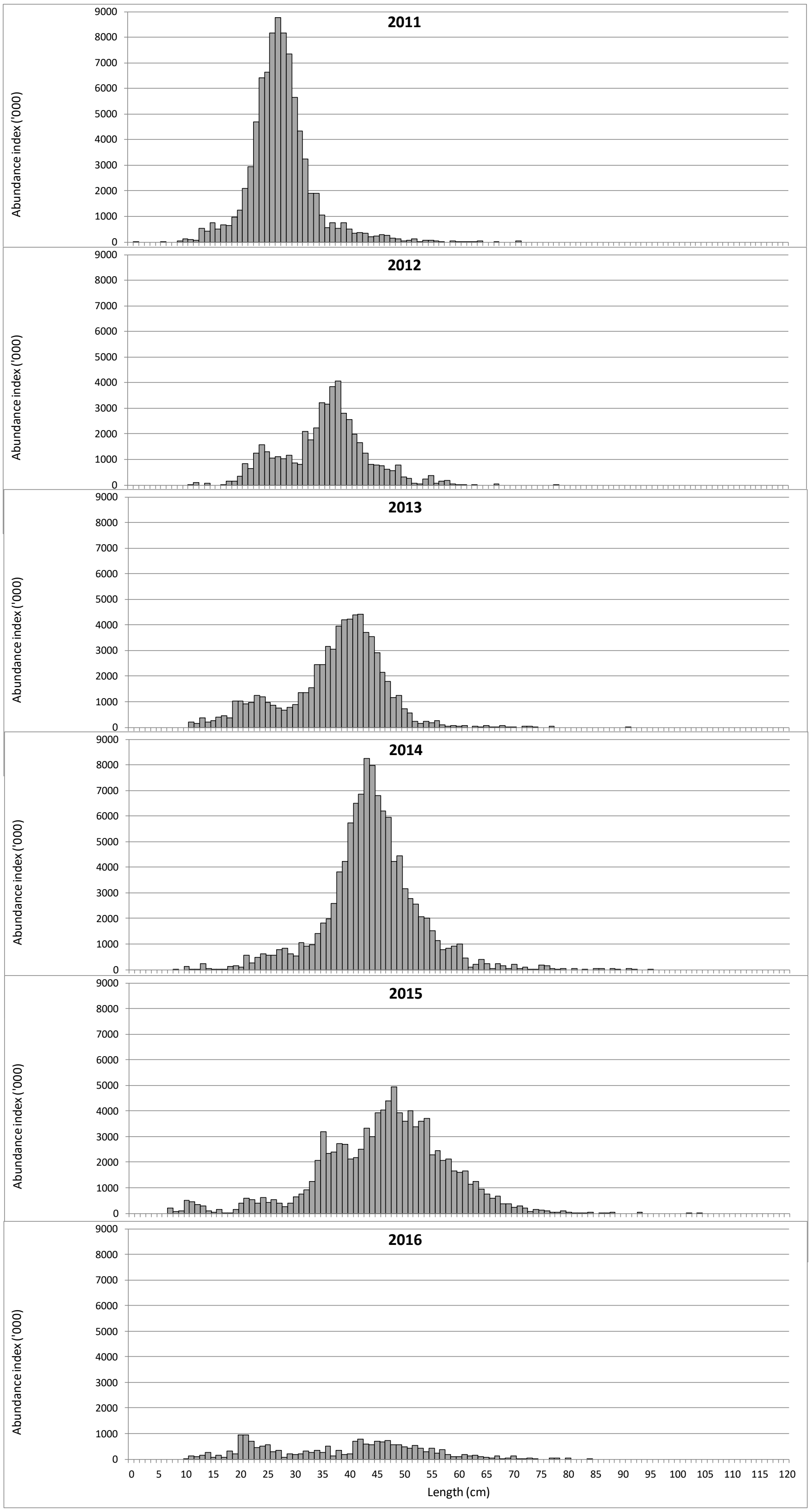


Figure 14.3.1.6: Total abundance indices by length in West Greenland shrimp and fish survey (NAFO 1A-1E).

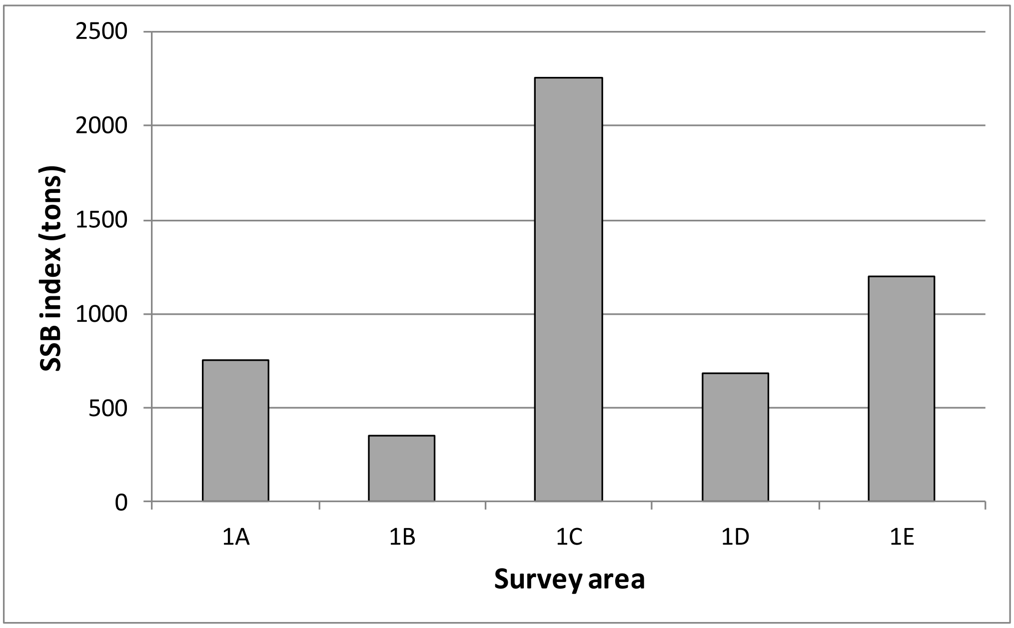


Figure 14.3.1.7: Estimated SSB (tons) by NAFO subdivisions from the West Greenland Shrimp and Fish survey, 2016. Maturity taken from proportion mature by length as recorded on observer trips off East Greenland in 2007.

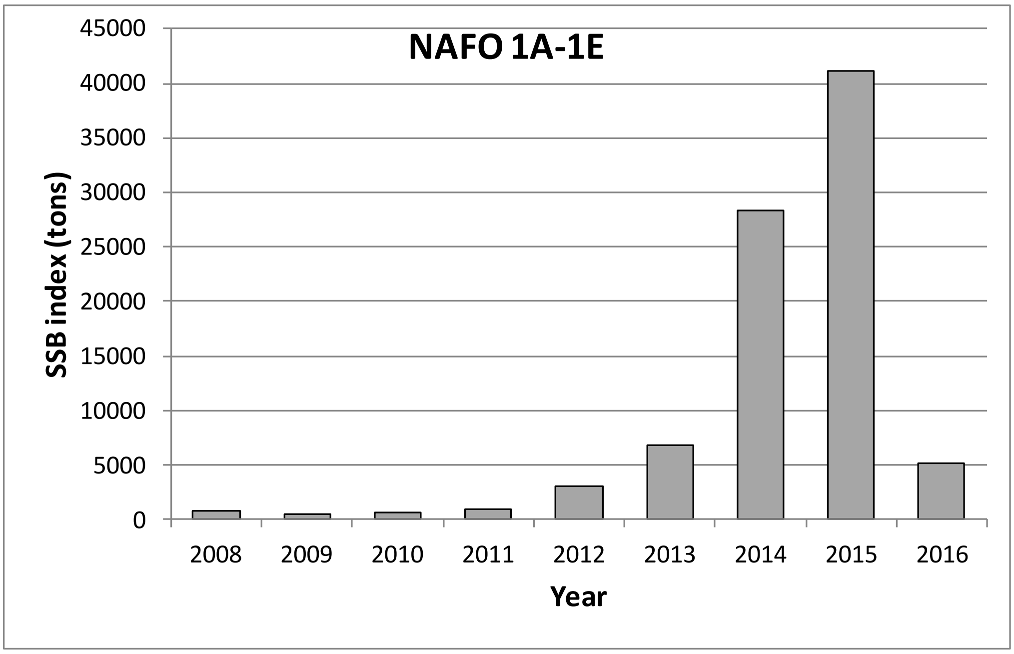


Figure 14.3.1.8: Estimated SSB (tons) by year from the West Greenland Shrimp and Fish survey (NAFO 1A-1E).

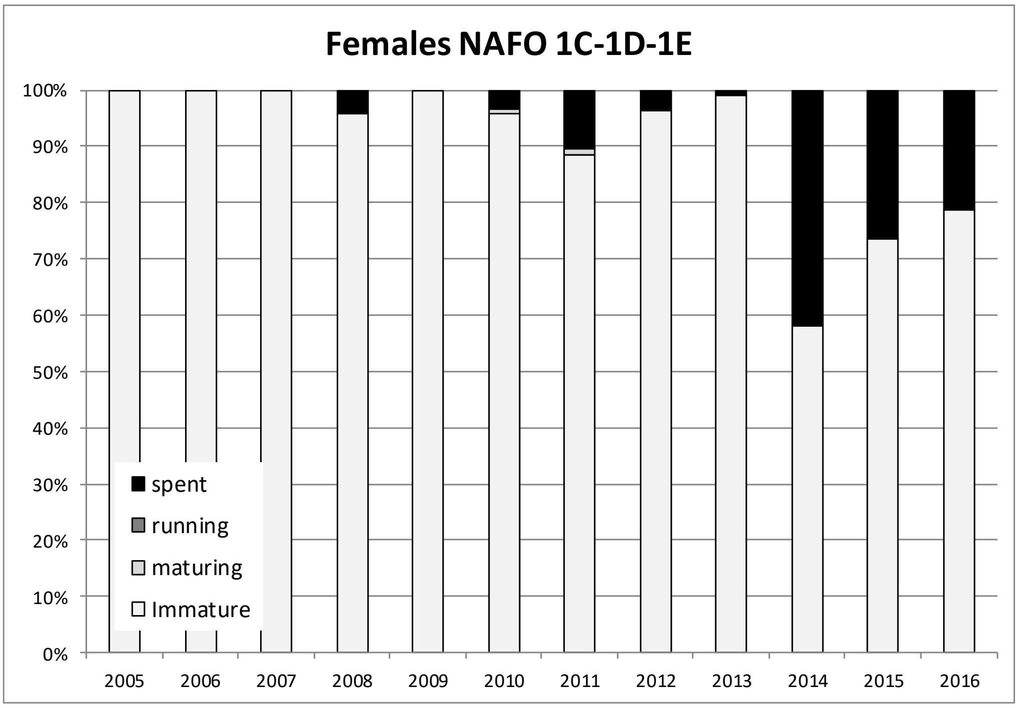


Figure 14.3.1.9: Composition of ogive state in females in survey in NAFO area 1D and 1E combined

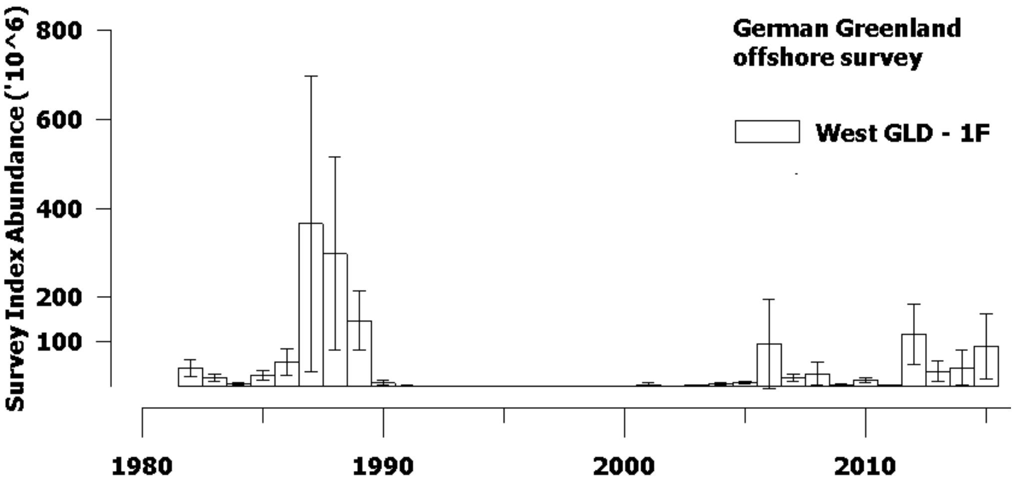


Figure 14.3.2.1 German survey, Cod off Greenland. Abundance indices for West Greenland (NAFO subdivisions 1C-1E). No survey in 2016.

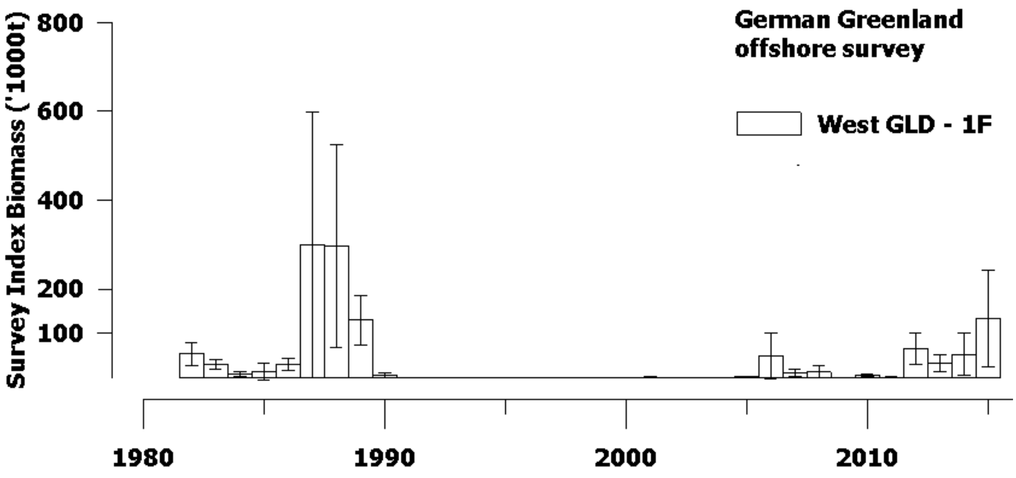


Figure 14.3.2.2 German survey, Cod off Greenland. Biomass indices for West Greenland (NAFO subdivisions 1C-1E). No survey in 2016.

15 Cod (*Gadus morhua*) in NAFO Subarea 1, inshore (West 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 26,000 tons. In October 8,000 tons was added. When this was fished in December another 1,400 t was added resulting in a total TAC of 35,400 t. In addition, it was allowed to fish offshore in West Greenland on the inshore quota. The offshore catch on the inshore quota amounted to 420 t and is not included as inshore catch here.

The coastal fishery caught 34,204 tons + 39 tons in Eastgreenland (Tasiilaq) in 2016, which is an increase of 35% compared to 2015 (table 15.2.1.1). 73% of the total catch is fished from May-October with a peak (16%) in July, and the most important fishery is the pound net fishery that takes place during summer and autumn (table 15.2.1.2 and 15.2.1.3). In 2014 and 2015, half of the total catch was taken by pound nets. This is a decrease compared to previous years where up to 3/4 of the total catch where taken by pound nets (figure 15.2.1.1). In 2016 the proportion of the total catch taken by poundnets increased to 62% compared to 2014 and 2015 (table 15.2.1.3). Since 2012, jigs have become more dominant from 7 % of the total catch in 2012 to 22 % of the total catch in 2015. In 2016 the catch taken by jigs declined to 14%. 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.

North Greenland (NAFO division 1A, subarea 1AX (Disco Bay))

From table 15.2.1.1 a change in the catches can be seen. The catches in North Greenland have gradually increased from 500 tons in 2012 to 5,900 tons in 2016 and catches now comprise 17% 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 has previously been gillnets 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 have however increased in recent years and in 2016 equal amount of cod have been caught in both the gillnets and poundnets (table 15.2.1.3). Directed cod fishery is presumed to be going on in this area and therefore poundnets are more frequently used than previous (figure 15.2.1.2 and 15.2.1.3). The 2010 YC (6 yr olds) is dominating the catch followed by the 2011 YC (5 yr old) (figure 15.2.1.4).

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) warrants for a more thorough investigation of the origin of the cod presently found in Disco Bay.

Midgreenland (NAFO divisions 1B and 1C)

Almost 23,000 tons cod were taken in this area in 2016 (table 15.2.1.1) corresponding to 67 % of the total catches (table 15.2.1.2, figure 15.2.1.3). Never before has catch been this high in the timeseries. In both areas the dominating gear are pound nets which caught almost 50% of the total catch in 2016 (table 15.2.1.3). In 2015 the poundnets in this region caught 25% of the total catch in all inshore areas. The fishery is concentrated around the towns of Kangatsiaq, Sisimiut and Maniitsoq (figure 15.2.1.2). The 2011 YC (5 yr olds) are dominating the catch followed by the 2010 YC (6 yr olds) (figure 15.2.1.4).

Midgreenland (NAFO divisions 1D)

The fishery in NAFO division 1D south of 1C has in contrast with the northern areas declined with 20% compared to 2015 and the catches here comprise only 15% of the total catch in 2016 compared to 26% in 2015. The catch in Disco bay (Nafo 1AX) are in 2016 higher than in 1D (table 15.2.1.1 and 15.2.1.2). The 2011 YC (5 yr olds) are dominating the catch followed by the 2010 YC (6 yr olds) and 2012 YC (4 yr olds) (figure 15.2.1.4).

South Greenland (NAFO divisions 1E and 1F)

The catches in South Greenland have the last couple of years gradually declined to 260 tons in 2016 corresponding to 1 % of the total inshore catch (table 15.2.1.1 and 15.2.1.2, figure 15.2.1.3). One company fished 420 t offshore on the inshore quota and landed the catch to a factory in Paamiut (Nafo 1E), the catch is not included here.

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 30,000 tons inshore was in 1989 where a large 1984 YC supported the fishery. Three years later the catch had declined to 6,000 t in 1992 and went below 1,000 t during the 1990ies. The 1984 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. Survey results from the offshore area found very few cod in West and South Greenland and the once strong 2009 YC is found mainly in the spawning grounds in East Greenland in declining numbers (Retzel 2017a, Retzel 2017b).

East Greenland (ICES subdivision XIVb)

A very small amount (39 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 2016, the Greenland inshore length frequencies were measured from 21,816 cod.

Several YC were caught in the inshore fishery in 2016, and ages 4-7 (YC 2009-2012) comprised the catches in 2016, with the 2011 YC dominating the catches followed by the 2010 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, 57 cm in 2015 and 56 cm in 2016.

Catch at age differed between regions with the 2010 YC (6 yr old) dominating the catches in Disko Bay (1AX) furthest to the north, whereas the 2011 YC (5 yr old) dominated the catches in midgreenland (figure 15.2.1.4). The 2011 YC was especially dominating the catch in region 1D and the amount of 6 yr olds were not as high as in Nafo division 1B and 1C and hence mean length in catch in 1D were smaller (52 cm) than in 1B+1C (56 cm).

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 30,000 tons (1984 and 1985) 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 pound nets 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 pound net 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 2016 was 58 in NAFO 1B and 40 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 (2014 YC) appear to be small and is smaller than the time series mean (Table 15.3.1.2, figure. 15.3.1.2). The size of the 2 yr old cod have been below timeseries mean since 2014 after being among the highest seen in the period 2010-2013. The 2013 YC (age 3) is about the size of the timeseries mean. 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) was slightly higher than in 2015. There are less numbers of the 4-6 yr olds than in 2015, but instead 3 yr olds are increasing

The 2016 catches in NAFO 1D were dominated by 3 and 2 years old cod (2013 and 2014 YC´s, Table 15.3.1.2). Catch rates of the 3 yr olds in 2016 were the second highest in the time series. The overall index for NAFO 1D (including all age groups) is the second highest in the time series, and increased by 6 % in 2016 compared to 2015 (Table 15.3.1.2).

Combining the two NAFO (1B and 1D) divisions in a joint index shows an overall increase of 43 % in total index for all ages from 2014 to 2016 (Figure. 15.3.1.4). Even though the index has increased the index is still low compared to the period 2010-2013. 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). 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 and 2016 the index is the same between the areas.

The combined index for 1B and 1D for age 2 and 3 jointly in 2016 has decreased by 46 % compared to the average of the period 2010-2013, but has increased compared to 2014 and 2015 caused by increasing numbers of 3 yr old (figure 15.3.1.2).

15.3.2 Surveys in North Greenland (Disco Bay)

Presently 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) Gill net survey targeting Greenland Halibut. Since 2011 increasing amount of cod have been caught in these surveys. The results are not used in the assessment and further details and results of these surveys can be found in working document nr 5 (Retzel 2017c).

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 20 513 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. Highest 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). 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. 18 offshore tagged fish on Dana Bank have been recaptured in the inshore fjord system. Most of these were recaptured in the inshore area south of Dana Bank, but 1 is recaptured in the Nuuk fjord system north of Dana Bank and 4 have had a northward migration pattern from Dana Bank.

15.6 State of the stock

There have been several years of high recruitment in the period 2010-2013. The recruitment has since been low in 2014 and 2015 but is increasing in 2016. Index of older ages (4+) are above average due to the high recruitment but is decreasing. Catches have risen since 2000 and are in 2016 at their highest level in 25 years. Combining these trends suggests a recent increase in exploitation rate.

Several year classes are in the catches. The 2011 YC is dominating the fishery at age 5 followed by the 2010 YC at age 6. These YC's are considered smaller than the strong 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 2014 and 2013 YC are considered around average. 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.

The inshore cod stock is categorized as a category 3 stock. Three length-based methods were applied to access the current stock status: Length Based Indicators (LBI), Mean Length Z (MLZ) and Length-Based Spawner Per Recruit (LB-SPR). Further, the stochastic surplus production model SPiCT was applied (Riget and Hedeholm 2017).

The input data for the length-based methods were length frequency and weight-at-length data in the period 2002-2016 from the commercial fishery. Based on the same period Von Bertalanffy growth parameters (k and L_{inf}) and the maturity ogive (only data from April and May) were estimated.

The LBI show "red" condition on the large-size related indicators and "green" or close to green for the smaller-size indicators (Table 1). The yield indicator was red and the MSY indicator was also red but close to 1. The Mean-Length Z estimated rather high F_{2016} (0.56) compared to the reference points $F_{0.1}$ and $F_{0.35}$ but also indicated a shift in F in 2010 (0.72 $\rightarrow$0.35). The SPR was estimated to be far below the

SPR=0.35% point and F/M was far above the value of 1. The reference points derived from the SPiCT model showed no sign of overexploitation with B_{2016}/B_{MSY} = 1.67 and F_{2016}/F_{MSY} = 0.75 (Table 2).
The output of these four methods all suggest that the stock biomass is relatively high, and should be considered above B_{MSY} but that F is currently above F_{MSY}.
In addition to these methods, the working group considered a SAM model for this stock.

Table 1: Inshore cod. Output table with indications of status compared to reference points.

	Conservation				Optimizing Yield	MSY
	L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max\ 5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Reference	> 1	> 1	> 0.8	> 30%	~1 (>0.9)	≥ 1
2014	0.95	1.14	0.63	0.2	0.68	0.90
2015	0.81	1.09	0.59	0.1	0.66	0.94
2016	1.02	1.09	0.57	0.0	0.67	0.84

Table 2: Output from the SPiCT model with stochastic reference points.

Parameter	Value
B_{MSY}	86 655 t
F_{MSY}	0.27
MSY	22 417 t
B_{2016}	144 476 t
F_{2016}	0.20
B_{2016}/B_{MSY}	1.67
F_{2016}/F_{MSY}	0.75

Inshore West Greenland cod, SAM

The State-space model (SAM) was applied for inshore cod stock in NAFO division 1A-1F (Riget et al. 2017).

Input

Catch at age and mean weight at age 3 to 10+ were available from port sampling for the period 1976-2016 except for the years 1998 and 2001 (Retzel 2017d).

The maturity ogive was applied constant for all years based on cod from NAFO 1A - 1F caught in spawning period April to May during the period 2007 -2016.

A natural mortality of 0.2 is assumed for all age groups for all years.

A random walk sampling approach was chosen for the stock recruitment model.

Data from three inshore gillnet surveys targeting juvenile fish (2-3 year olds) were used as biomass indicators (Retzel 2017c). Age groups 1-7 were included as only very few fish older than 7 years has been caught. The survey time-series are scattered; in NAFO division 1B the survey covers the periods 1987-1998, 2002-2007 and 2010-2016. In NAFO division 1D the survey covers the period 1987-2016 except for 2002 and 2007 where no survey was conducted. In NAFO division 1F the survey covers the periods 1987-1995, 1998, 2000 and 2007-2009.

Main settings of the SAM model

The landing fraction was assumed to be 1 (no discarding is observed) and fishery and natural maturity before spawning was set to 0. The Fbar range of 4 to 8 years old was applied covering the most abundant age groups in catches that are fully recruited. The three gillnet surveys were used as tuning fleets

SAM output

Some blockings are seen of the normalized model residuals for all of the surveys but not for the total catch. The historical development of F has increased to 1.32 in 1993 followed by a drop to 0.61 in 2002. Since then F has been fluctuating and increasing to 0.78. The SSB was high in the 1980s, record low from 1992 to about 2000 and has since been increasing again to about 30000 t. The recruitment is dominated by few large year classes prior to 1990 and some strong year classes in the 2000s, but recently low. The effect of leaving out fleets one at a time points to a robust assessment since historic perception of SSB and F does not change. Retrospective analyses show a tendency to slightly overestimate F. Also recruits have a tendency to be overestimated.

Alternative SAM runs

Often the SAM model did not converge. This is most likely because of the scattered survey series with missing years and zero catches for a number of age groups especially for the older ones. Another issue is that the historical high catch in 2016 (36 kt) falls outside the confidence limits of the SAM estimated catch, i.e. SAM "did not believe" in these catches. However, the catch figures are believed to be rather certain, so SAM was run with a decreased CV to 25% of the original. With this assumption the observed catch in 2016 are within the 95% confidence limits, but F_{2016} increased from 0.78 to 0.910 and SSB increased from 28 450 to 49 150 t.

Issue list

Further exploration of the SAM runs is needed before any decision on SAM usage for assessment of the inshore West Greenland cod stock can be taken. This includes:

- to combine the tuning fleets into one tuning fleet to avoid the scattered data
- The validity of the survey in IF should be considered because of the limited numbers of survey years.
- Omission some of the older yc in the tuning fleet because of the many zero observations.
- implement migrations out the inshore area especially of large yc into the model
- evaluate the use of different reliability on the absolute catches, i.e. changing to a lesser CV than predicted

Stock synthesis model exploratory runs

The West Greenland inshore cod was benchmarked in 2015 (WKICE). One of the external reviewers recommendations was that an attempt should be made in implementing Stock Synthesis (SS) (Methot 2000) as the basis for advice. The reason for this recommendation was that stock synthesis (SS) was regarded superior to the suggested analytical approach presented at the benchmark. SS is run with the ADMB software using Microsoft C++ Optimizing Compiler, all available from the NOAA Fisheries Stock Assessment Toolbox website: http://nft.nefsc.noaa.gov/ (Methot & Wetzel 2013). SS provides a statistical framework that can include both age and size structured data, several survey indices and commercial catches. It is moreover possible to apply separate selection curves for different surveys and fleets.

This paragraph summarizes the major findings from the various model runs that were performed. A detailed description of the settings is not currently available, and the presented runs should be considered exploratory.

Data

An overview of the input data time series can be seen in Fig 1. The inputs are commercial catches, two survey indices and length and age information. The major issue in this area is stock mixing and spawning migrations out of the area. To cope with this emigration, a “fleet” removing the year classes that are believed to have left the area in the past has been introduced (MIG Fleet). Fig. 2 shows catches and emigration, Fig 3 shows the survey indices. Survey indices are numbers of age 2 and 3 cod caught in gillnets targeting juvenile cod.

In addition to the time series on survey and landings, conditional age-at-length data from both surveys and commercial catches have been included in the model.

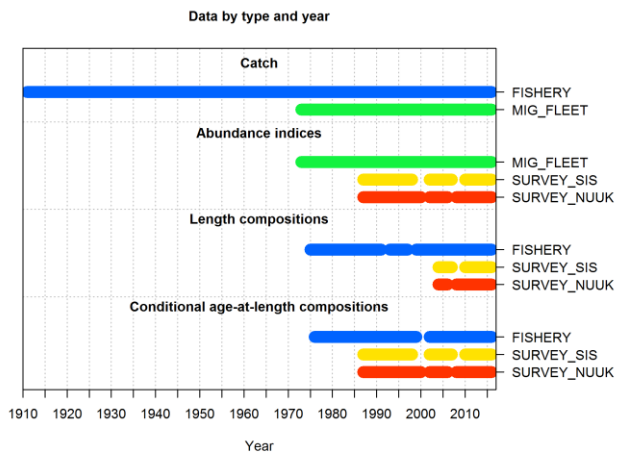


Fig 1: Data by type and year.

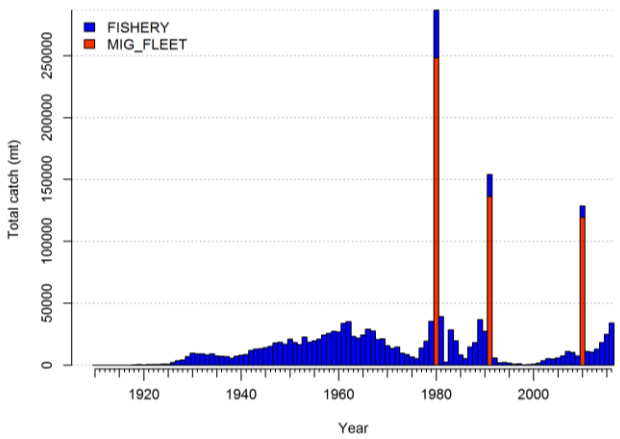


Fig 2: Catches from the fishery and the emigration (MIG Fleet).

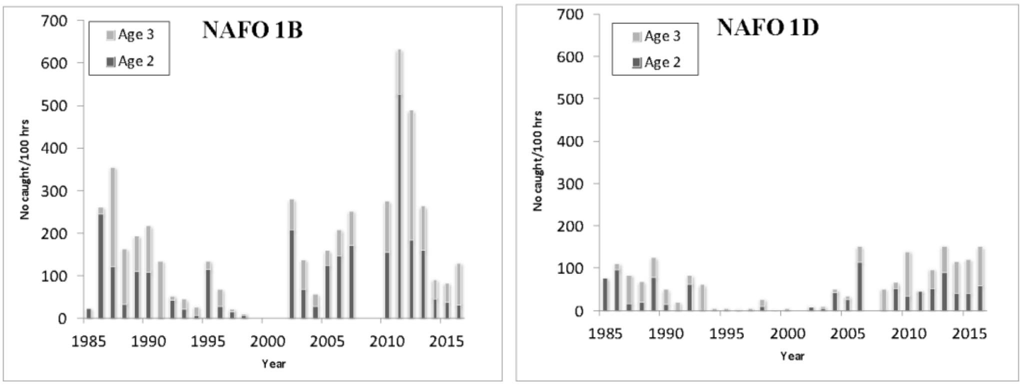


Fig 3: The two survey indices for area NAFO 1B and 1D, by age 2 and 3, which is used in the model.

Model settings

Natural mortality was fixed at 0.2 for all ages and a standard Beverton-Holt spawner-recruitment relationship was assumed. Emigration was assumed to have taken place in 1980 (1973 YC), 1991 (1984 YC) and 2010 (2003 YC). The selection curves are presumed to be dome shaped for both survey and fishery (Fig 4).

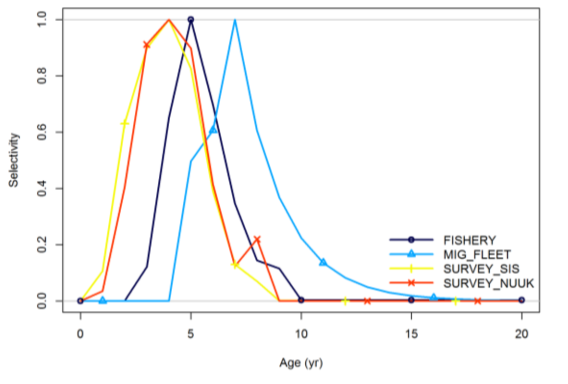


Fig 4: Age-based selection curves for the fishery, emigration (MIG fleet) and surveys.

Results

The overall fit to the length distributions is reasonably good (Fig. 5, top). The fit to the length distributions in the last part of the period by survey and fleet are shown in figure 5 (middle and bottom). The fits to the surveys are shown in fig. 6

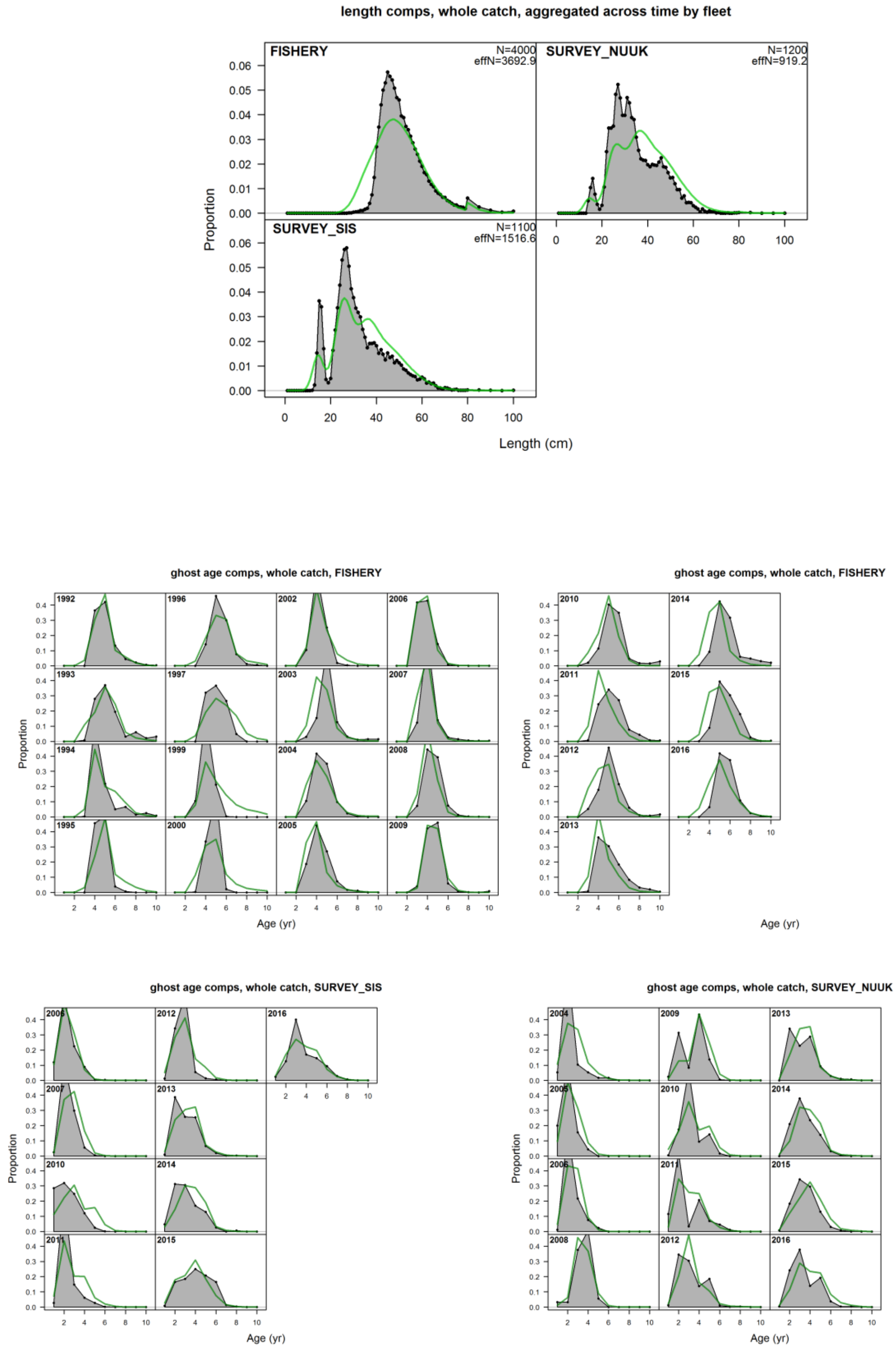


Fig 5: Top: the average model fit to the length composition in the fishery and surveys. Middle: fit to age distribution form fishery by year. Bottom: fit to age distribution form the two surveys by year.

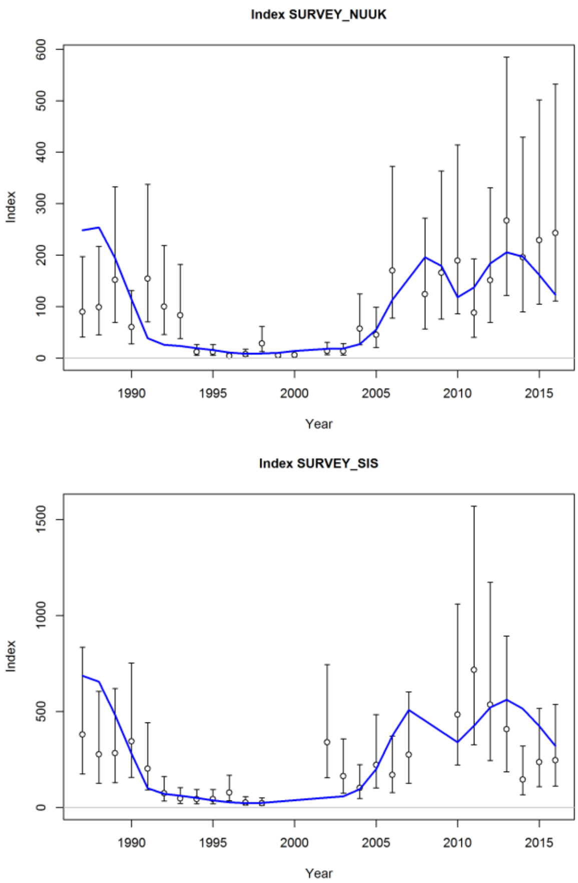
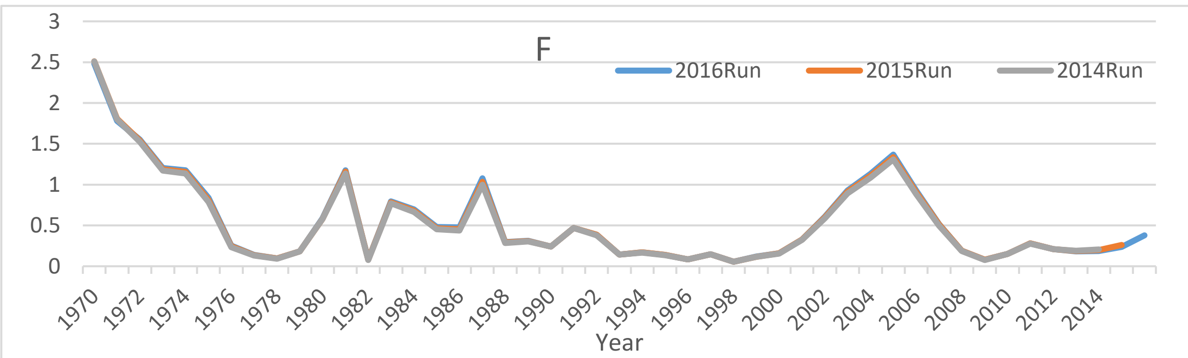


Fig. 6: Model fit to the surveys.

The F estimate since 1970 is within a reasonable range and the current F is estimated at 0.38 (Fig 7). The SSB also behaves well, with the current estimate being 200 000 t (Fig 7). To put this in perspective, the current catch in approximately 35 000 t. The retrospective pattern is good, indicating that the model is robust in recent years.



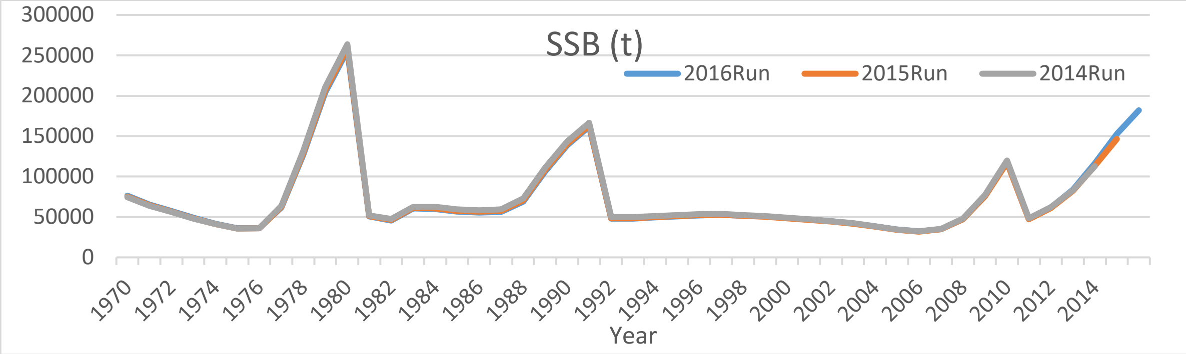


Fig 7: Top: Estimated fishing mortality F (excluding the MIG fleet) with retrospective runs. Bottom: Estimated SSB development with retrospective runs.

Conclusion

The work presented here should be considered preliminary. The model shows promise and should be explored further. This work should in particular focus on:

- The emigration events are highly important to both the current and historical stock trends. The extent of these events should be documented. Also, the current approach may not be the most appropriate (M variation etc.)
- Other cod stocks use this area as nursery grounds. There are studies documenting this, and this could be included – or at least considered – in any further model runs.
- The relative weights of the data have a large effect on the output. Descriptions of the weighting and the effect should be documented.
- The residuals are not scrutinized sufficiently.

15.7 Implemented management measures for 2016

Until 2009 the inshore fishery was unregulated by a TAC. The TAC in 2009-2015 can be seen in figure 15.1.1.2. The TAC for 2016 is set at 36 500 t. and it is alowed to fish offshore on the inshore TAC. No other management measures have been taken.

15.8 Managemant 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 stock went through a benchmark in 2015 (ICES, 2015). The assessment method 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 biomass index (figure 15.10.1) and therefore the same advice as last year was given. The same advice has now been given for four years and the advice is based on a 20% increase of average catch in 2010, 2011 and 2012. Using the DLS 3.2 approach could be implemented with the biomass survey index as a the stock indicator and basis for the advice.

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 14b
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	

Table 15.2.1.1. continued

	NAFO divisions								
Year	1A	1B	1C	1D	1E	1F	Unknown NAFO div	Total WestGreenland	ICES 14b
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	

Table 15.2.1.1. continued

	NAFO divisions								
Year	1A	1B	1C	1D	1E	1F	Unknown NAFO div	Total WestGreenland	ICES 14b
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
2016	5929	11466	11270	5279	87	173		34204	39

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	11	9	9	14	20	9	3	5	14	118	37	1	250	1%
1AUP	0.2				0.04						0.03		0.3	0.001%
1AX	192	239	264	167	159	275	884	1100	930	607	593	268	5678	17%
1B	353	251	215	563	1377	1310	1449	1473	1096	1266	1273	839	11465	34%
1C	509	298	160	301	1044	1636	1963	1366	1460	1341	781	415	11274	33%
1D	184	231	173	355	770	939	1046	509	369	321	211	169	5277	15%
1E	0.01	1	3	0.5	7	4	16	50	3	3	0.4	0.2	88	0.3%
1F	0.1	0.1	0.2	1	61	66	4	4	18	7	9	1	172	1%
Total	1249	1029	824	1402	3438	4239	5365	4507	3890	3663	2905	1693	34204	
%	4%	3%	2%	4%	10%	12%	16%	13%	11%	11%	8%	5%		
ICES 14b									23	4	12		39	

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	0.01%		0.003%	3%	9%	11%	13%	8%	6%	6%	4%	1%	62%
Gillnet	2%	2%	2%	1%	0.3%	0.1%	0.1%	0.2%	1%	2%	2%	2%	13%
Jig	0.2%	0.2%	0.2%	0.2%	0.2%	1%	3%	4%	3%	1%	1%	0.4%	14%
Longline	2%	1%	1%	0.4%	0.5%	0.4%	0.3%	0.3%	1%	2%	2%	1%	11%
Total	4%	3%	2%	4%	10%	12%	16%	13%	11%	11%	8%	5%	100%

Gear/NAFO	1AUM	1AUP	1AX	1B	1C	1D	1E	1F	ICES 14b	Total
Poundnet			5%	22%	23%	11%	0.2%	0.4%		62%
Gillnet	0.2%	0.0001%	5%	5%	1%	1%	0.02%	0.001%		13%
Jig	0.1%		4%	5%	3%	2%	0.04%	0.04%	0.1%	14%
Longline	0.5%	0.001%	3%	0.5%	5%	2%	0.02%	0.1%		11%
Total	1%	0.001%	17%	34%	33%	15%	0.3%	1%	0.1%	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	2006	5680	3008	1337	133	9	8	25272
2016	32	2146	9701	5732	1179	239	57	7	34203

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
2016	0.505	1.042	1.474	2.233	3.120	3.716	3.914	9.304

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)	R^2
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
2008	0.46	0.57

Table 15.3.1.1: Survey effort in the Greenland Inshore Gill-net survey (nos. of valid net settings).

Division	1B	1D	1F	Total
1985	3	38	27	68
1986	26	22	23	71
1987	24	27	26	77
1988	21	24	24	69
1989	28	19	32	79
1990	18	21	18	57
1991	23	24	20	67
1992	27	29	23	79
1993	23	25	19	67
1994	20	29	17	66
1995	24	21	20	65
1996	26	25	-	51
1997	20	23	-	43
1998	24	26	22	72
1999	-	24	-	24
2000	-	27	20	47
2001	-	-	-	-
2002	21	20	-	41
2003	33	27	-	60
2004	27	31	-	58
2005	25	28	-	53
2006	45	51	-	96
2007	52	-	39	91
2008	-	58	60	118
2009	-	58	18	76
2010	66	52	-	118
2011	57	44	-	101
2012	54	52	-	106
2013	58	52	-	110
2014	60	41	-	101
2015	59	44	-	103
2016	58	40	-	98

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 gill-net 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
2016	6	31	98	42	36	23	7	2	245

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 gill-net 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	0	0	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	1	2	0	0	0	4
1997	3	3	1	0.2	0.5	0.4	0.1	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
2016	1	59	92	34	47	9	1	1	243

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 gill-net survey.

Year/Age	1	2	3	4	5	6	7	8+	All
1985	204	8	1	1	1	1	1	0	217
1986	17	112	5	0	2	0	0	0	136
1987	0	143	147	1	0	0	0	0	291
1988	0	1	83	6	0	0	0	0	89
1989	0	5	2	19	2	0	0	0	29
1990	0	0	3	2	13	1	0	0	18
1991	2	2	0	2	0	1	0	0	7
1992	0	3	1	0	1	0	1	0	6
1993	0	5	2	1	0	0	0	0	8
1994	0	0	1	1	0	0	0	0	3
1995	0	0	0	0	0	0	0	0	0
1996	na	na	na	na	na	na	na	na	na
1997	na	na	na	na	na	na	na	na	na
1998	0	4	12	0	0	0	0	0	17
1999	na	na	na	na	na	na	na	na	na
2000	0	14	8	0	2	0	1	0	24
2001	na	na	na	na	na	na	na	na	na
2002	na	na	na	na	na	na	na	na	na
2003	na	na	na	na	na	na	na	na	na
2004	na	na	na	na	na	na	na	na	na
2005	na	na	na	na	na	na	na	na	na
2006	na	na	na	na	na	na	na	na	na
2007	6	90	9	21	1	0	0	0	108
2008	8	17	30	4	2	0	0	0	62
2009	3	39	14	15	0	0	0	0	71
2010-2016	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
2016		1297	1911

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)	442	18	2
Bank (West)	1	44	2
East Greenland		23	105
Iceland	3	30	139

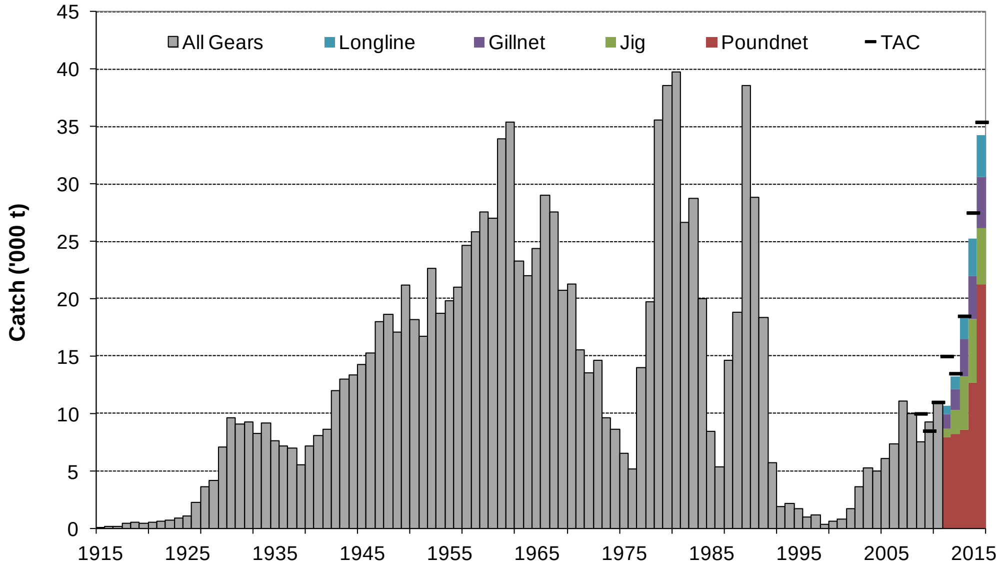


Figure 15.2.1.1 Inshore landings from West Greenland (Horsted 1994, 2000). From 2012 divided into gears.

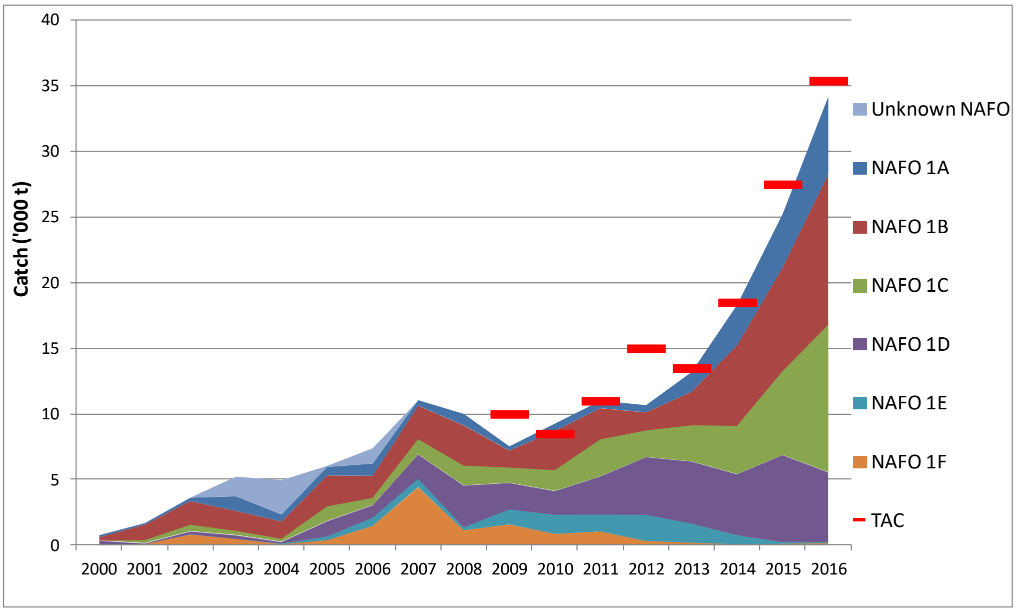


Figure 15.2.1.3. Total catches and TAC in the inshore fishery by NAFO Divisions from 2000.

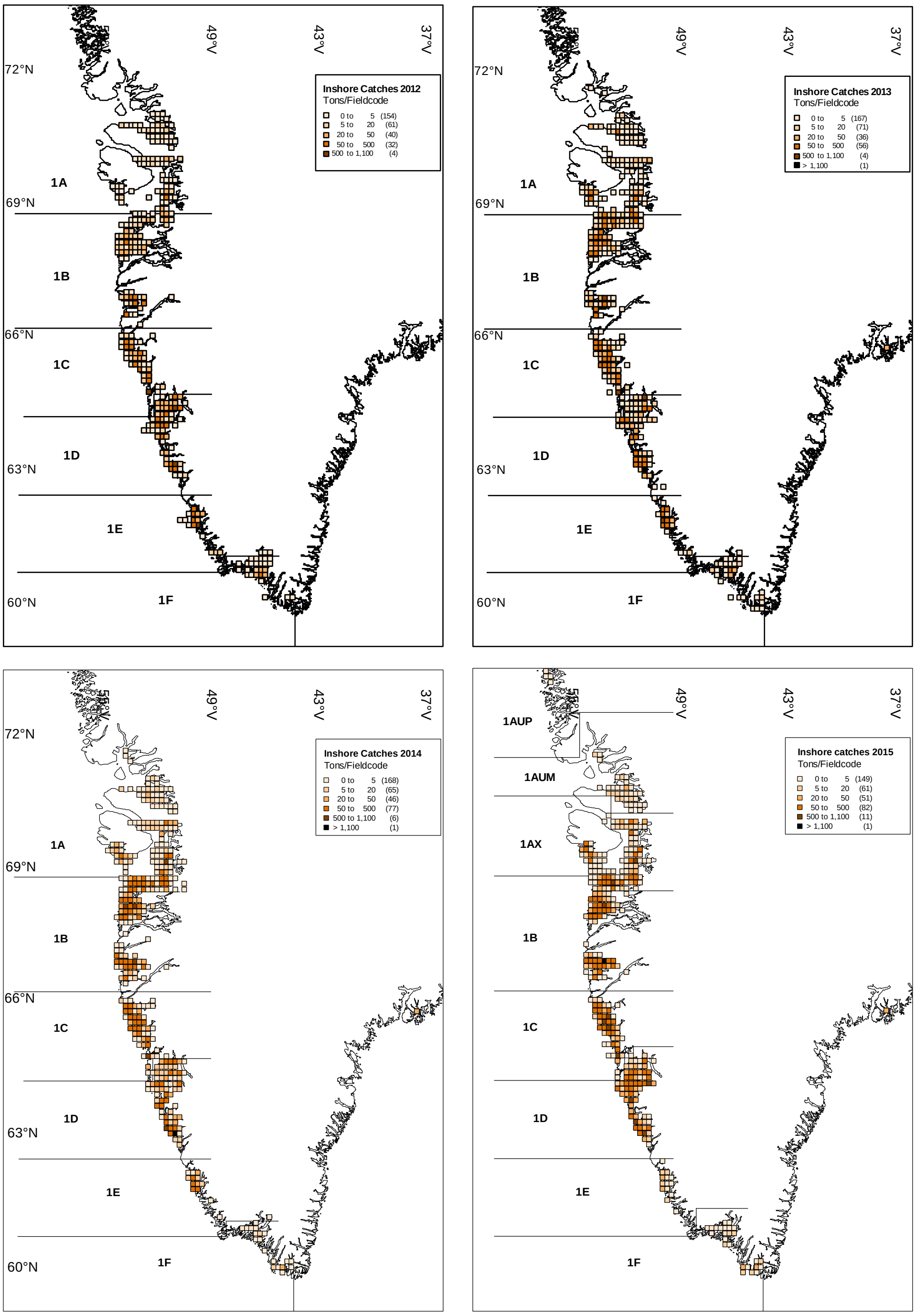


Figure 15.2.1.2. Distribution of commercial fishery along the coastline of West Greenland in total tons by field code.

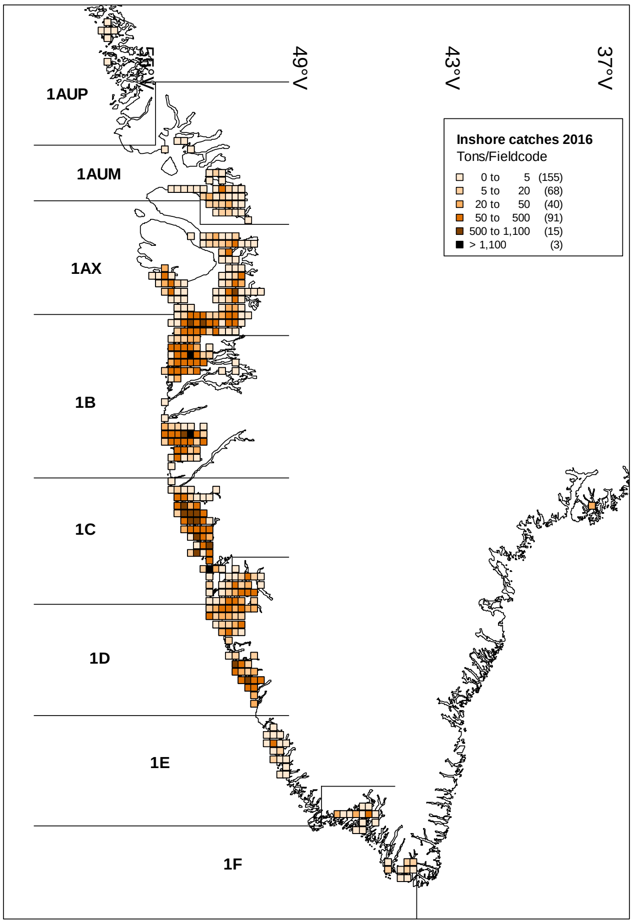


Figure 15.2.1.2. continued. Distribution of commercial fishery along the coastline of West Greenland in total tons by field code.

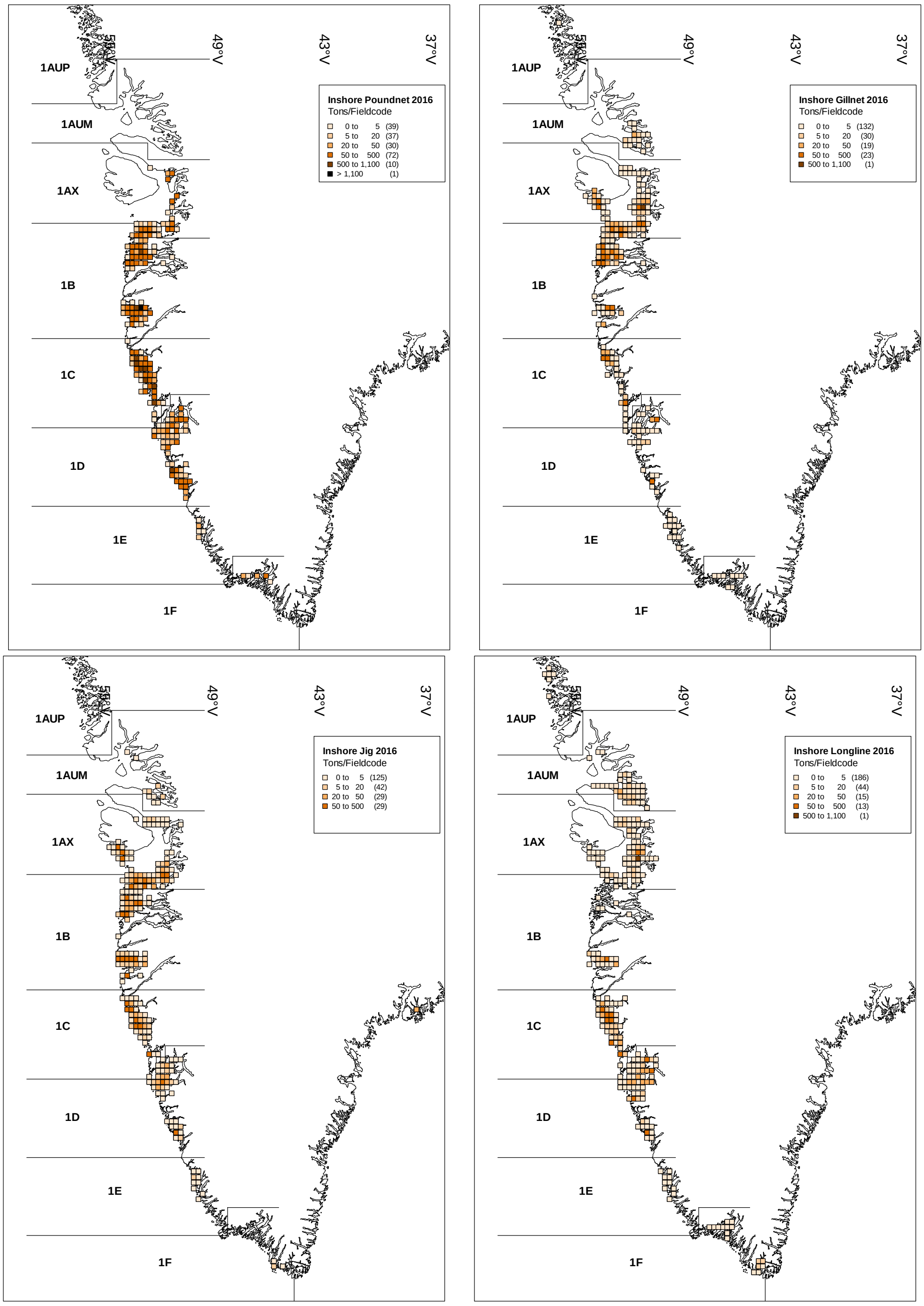


Figure 15.2.1.3.. Distribution of the inshore commercial fishery by gear (tons/fieldcode).

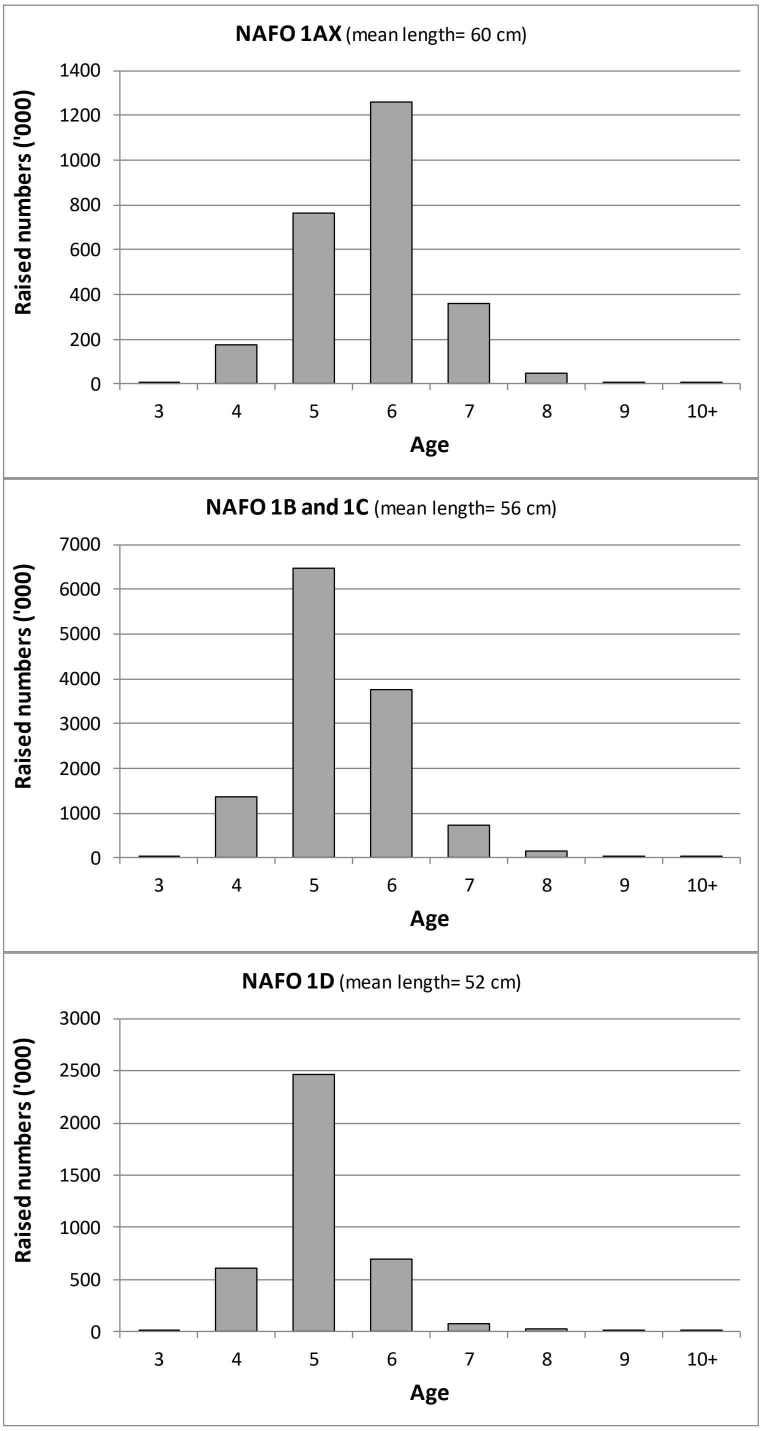


Figure 15.2.1.4: Catch at age in different regions of the inshore fishing area. 1AX= Disco Bay, 1B=Kangatsiaq and Sisimiut, 1C=Maniitsoq and 1D=Nuuk and Fiskenæsset.

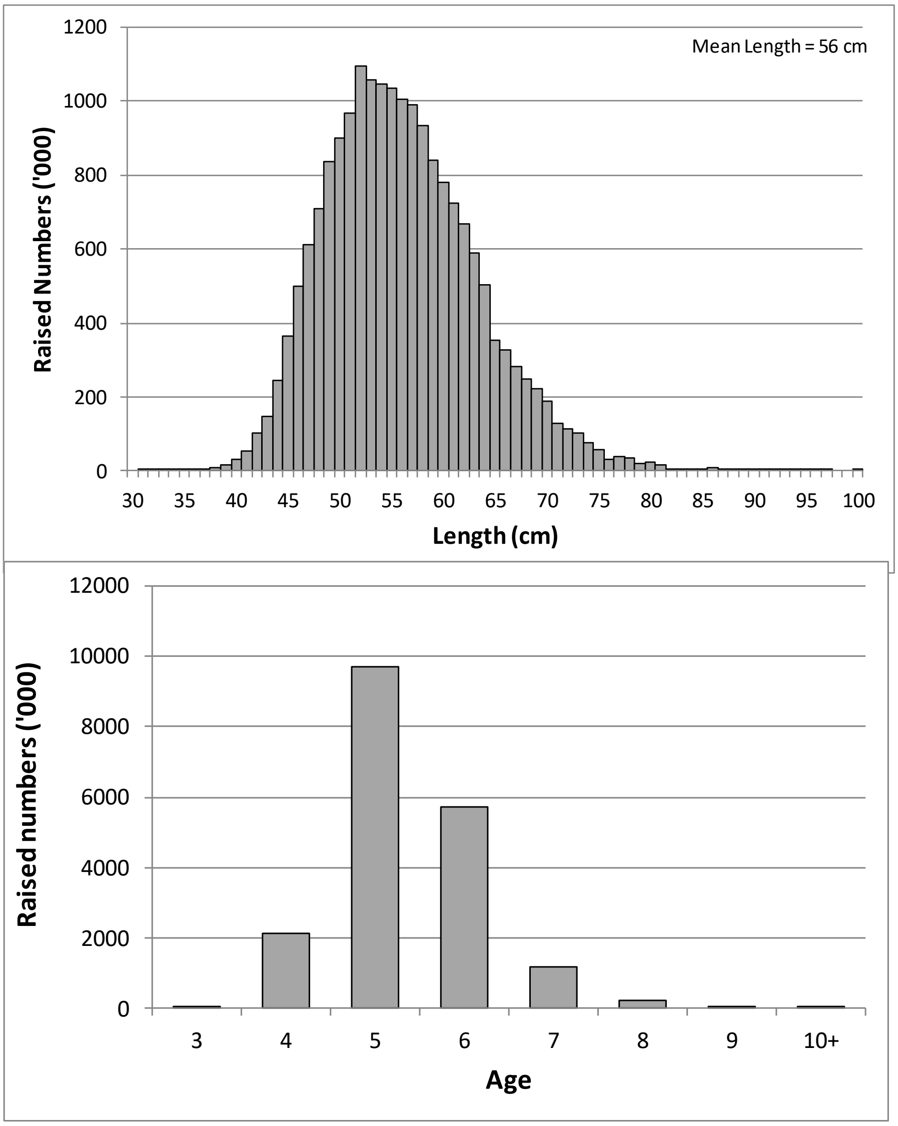


Figure 15.2.2.1. Total length and age distributions of inshore cod catches.

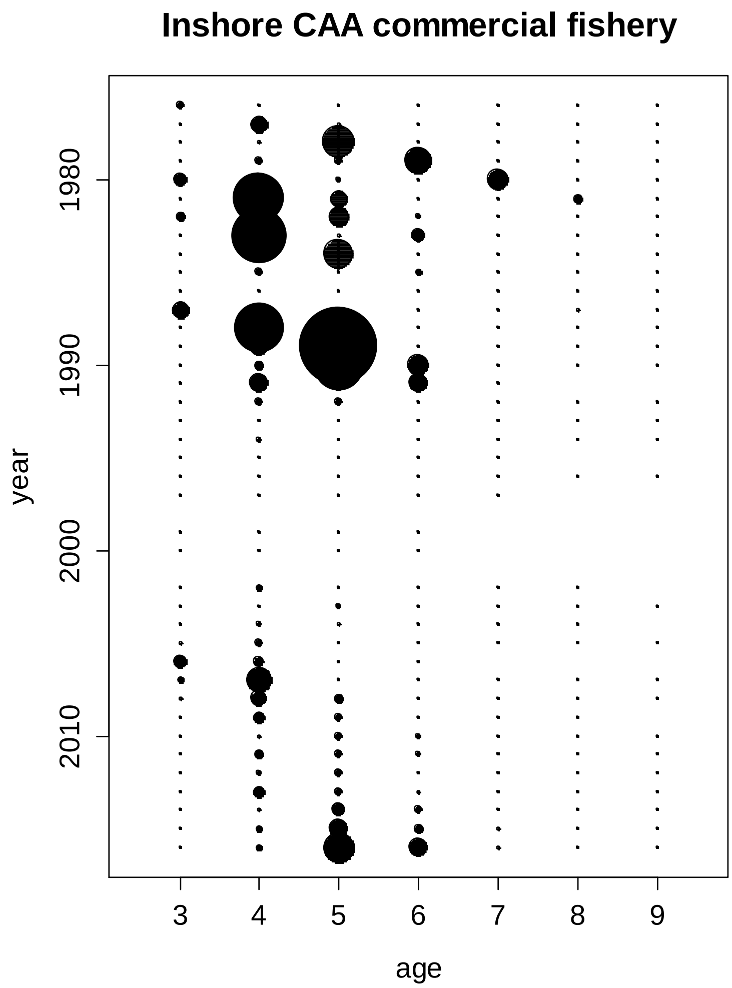


Figure 15.2.2.2. Catch at age in the commercial fishery in the West Greenland inshore area. Size of circles represents size of catch numbers.

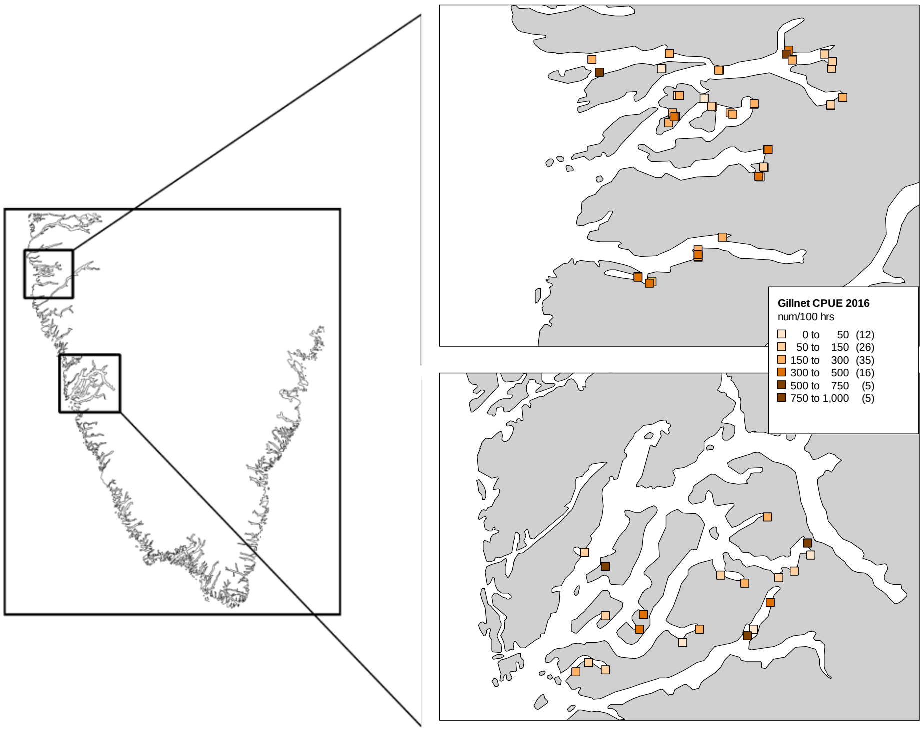


Figure 15.3.1.1. The inshore gill net survey area on the Greenland West coast. Top picture is the Sisimiut fjord system in NAFO 1B and bottom picture is the Nuuk fjord system in NAFO 1D. Survey estimates of catch rates are indicated on both maps as #caught/100h.

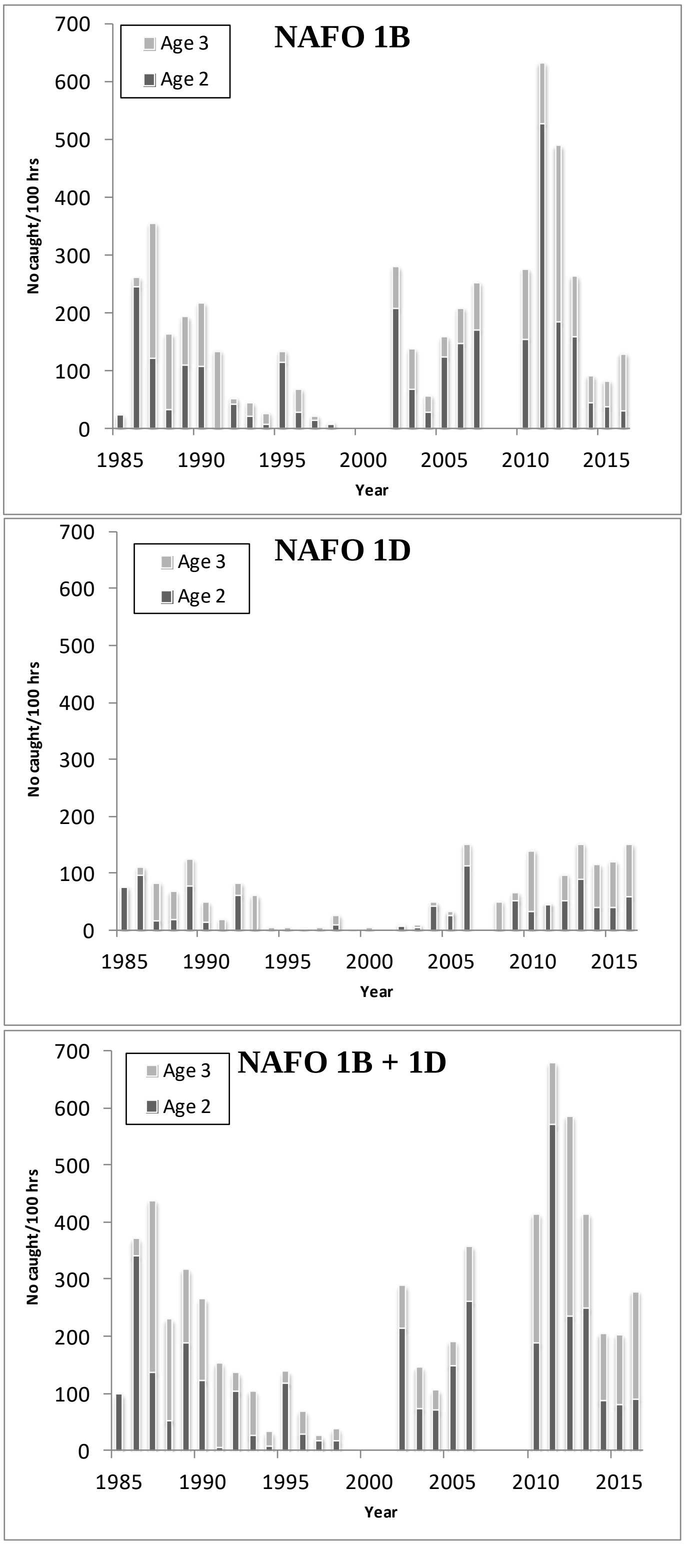


Figure 15.3.1.2. : Recruitment indices (numbers caught/100 hr.) for ages 2 and 3 in 1B (top), 1D (middle) and 1B and 1D combined (lower) in West Greenland. Simultaneous surveys were not carried out 1999-2001 and 2007-2009.

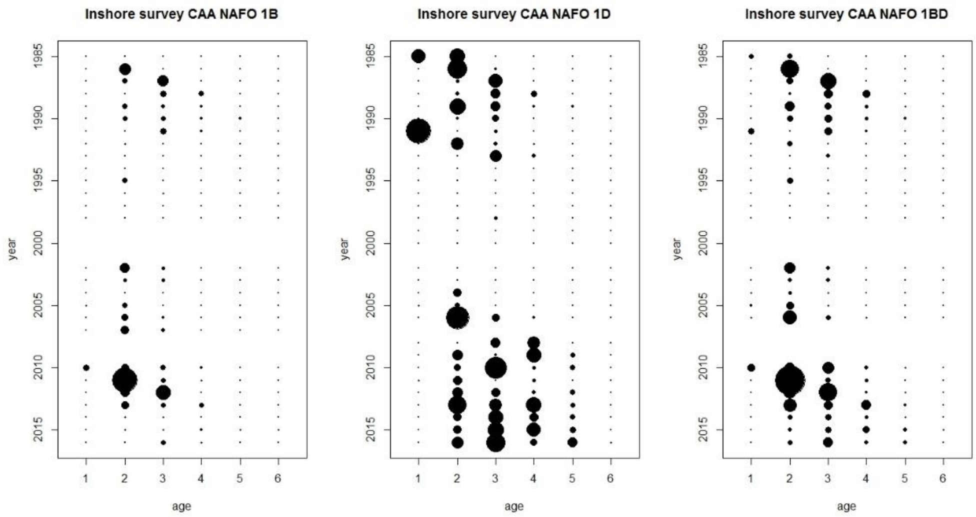


Figure 15.3.1.3. Recruitment indices (numbers caught/100 hr.) for ages 1-5 in 1B (left), 1D (middle) and 1B and 1D combined (right) in West Greenland from 1985-2015. Size of circles represents the size of the index values and the values are standardized within each area and are not comparable among each other.

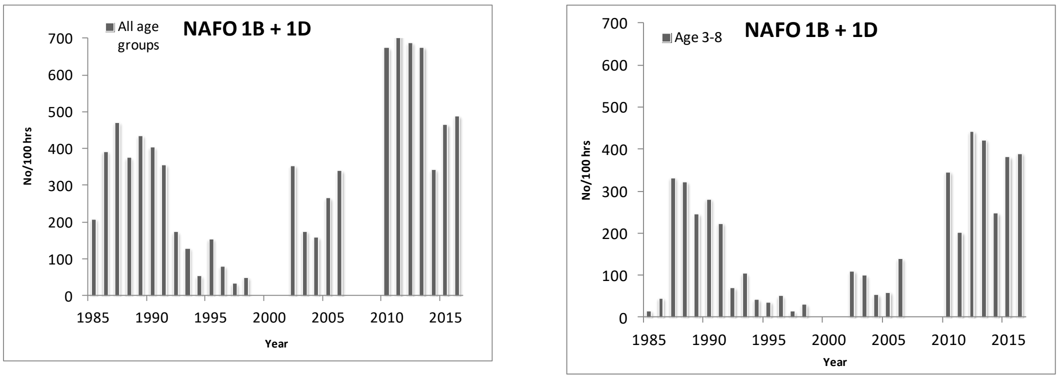


Figure 15.3.1.4. Abundance indices (numbers caught/100 hrs. netsetting) for all age groups (left) and age 3-8 (right) in 1B and 1D combined. Simultaneous surveys were not carried out 1999-2001 and 2007-2009.

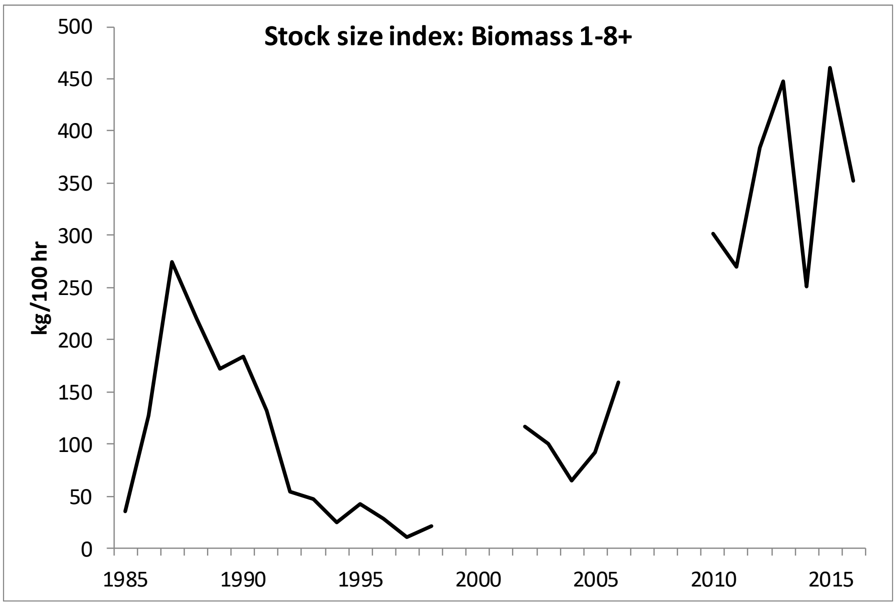


Figure 15.10.1. Biomass index (kg/100 hr) of all age groups in 1B and 1D combined. Simultaneous surveys were not carried out 1999-2001 and 2007-2009.

16 Cod (*Gadus morhua*) in ICES Subarea 14 and NAFO Division 1.F (East Greenland, South Greenland)

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), (Fig. 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 subdiv. 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). More details on the historical development in the fisheries are provided in the stock annex.

16.2.2 The offshore fishery in 2016

TAC for 2016 was set at 16,000 tons. The TAC was divided between management areas: 2,692t in Q1Q2, 6,016t in Q3Q4, 467t in Q5Q6 and 5000t in NAFO 1F. The rest of the TAC was given as 1,825t in the whole area including inshore East Greenland.

The TAC was divided between the following countries: 11,875 tons to Greenland, 2,100 tons to EU, 1,200 tons to Norway and 825 tons to the Faroe Islands.

In 2016 EU and the Faroe Islands fished their quota. Norway fished 74% of their quota and Greenland fished 10,864 tons resulting in a total of 14,818 tons with 2,335 tons caught in SouthWest Greenland (NAFO 1F) and 12,483 tons caught in East Greenland (table 16..2.2.1).

84% of the total catches of the stock were taken in East Greenland where the fishery took place throughout the year but peaked in the first half of the year from January to July. The fishery shifted from Dohrn Bank (management area Q1Q2) in January to Kleine Bank (management area Q3Q4) in spring (March to June). One trawler fished without a license in the spawning period (April-May) on Kleine Bank where 32% of the total catch in this management area was caught in the closed period (April-May). Catches in SouthWest Greenland (1F) peaked in January-March, May-June and November-December (table 16.2.2.2). In general, the fishery was distributed from Julianehåbs Bight in SouthWest Greenland (60°N) to Dohrn Bank (66°N) in East Greenland, with highest concentrations on Kleine Bank (in area Q3Q4) and Dohrn Bank (area Q1Q2, figure 16.2.2.1).

58% of the total catch where taken by trawlers (figure 16.2.2.1, table 16.2.2.3) almost exclusively (90%) in East Greenland in two areas north of 64°N; Kleine Bank between 64-65°N ; 36-38°W and on Dohrn Bank (management area Q1Q2) in a small area between 65-66°N ; 29-31°W on the edge of the continental shelf.

The longline fishery, which accounted for ~ 42 % of the total catch, was more evenly distributed than the trawl fishery and extended from Julianehåbs Bight in SouthWest Greenland (60°N, 1F) to Dohrn Bank (66°N, Q1Q2) in East Greenland (figure 16.2.2.2). 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. Totally, these longline vessels caught about 300 tons concentrated around Cape Farewell (figure 16.2.2.1). No length measurements were available from this fishery.

16.2.3 Length, weight and age distributions in the offshore fishery 2016

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 by-catch. Sampling intensities have increased considerably in the later years, and in 2016 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).

Commercial length measurement in 2016 in South West Greenland amounted to 1 543 cod measured. In East Greenland length measurements amounted to 11 449.

The overall mean length in the catches was 74 cm, and the YC 2009 (7 yr old fish) dominated the catches (figure 16.2.3.1, table 16.2.3.1). The age and length composition in the catch changed from northeast to southwest. Old fish (>7 year old) dominated the catch furthest to the northeast on Dorhn Bank and younger ages (5-7 yrs) dominated the catch in South Greenland (figure 16.2.3.2). A strong and consistent trend of increasing average age in the catches from the southwest to the northeast is visible.

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). In 2016 this YC is dominating the catch furthest to the north in Dohrn Bank area at age 9 yr (Q1Q2, figure 16.2.3.2).

In 2015 and 2016 the 2009 YC dominated the total catch as 6 and 7 yr olds (figure 16.2.3.3). This YC was especially abundant in the catches in South Greenland in 2015. In 2016 this YC was most abundant in the catches in the spawning areas around Kleine Bank (Q3Q4) and in SouthEast Greenland (Q5Q6, figure 16.2.3.2). The overall dominance of the 2009 YC in the catches mainly results from its consistent distribution across all areas, while age classes older than 7 were only found in the northeast and age classes younger than 7 only in the southwest parts of Greenland.

16.2.4 CPUE index

Log books 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 by-catches.

The CPUE index was relatively stable in the first part of the time series (1975-1992, mean 0.701 ton/hr), except 1989 where CPUE increased to 1.694 ton/hr (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 steeply from 1993-2005 (0.140 ton/hr) 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 1.630 ton/hr) as catches started to increase. In 2009 however CPUE decreased to 0.400 ton/hr, which was most likely caused by the east ward migration of the 2003 YC out of the allowed fishing areas.

In 2010, where almost all of the offshore area was closed except of a small area in South East Greenland, the index increased to 0.681 ton/hr, 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 1.259 ton/hr. Since the strong 2009 YC dominated the fishery in 2015 the CPUE increased to a mean of 1.354 ton/hr in 2015-2016.

The CPUE index seems stable since 2008, but has an increasing trend in 2015 and 2016 probably caused by the strong 2009 YC entering the fishery. In contrast the survey biomass index is decreasing since 2013 especially in South Greenland (Retzel 2017). As the fishery is concentrated more to the north in East Greenland the downwards trend in survey biomass index since 2013 is not observed in the CPUE index.

16.3 Surveys

At present, two offshore trawl surveys (Greenlandic and German) provide the core information relevant for stock assessment purposes. For details of survey design see stock annex.

The German survey targets mainly cod and has since 1982 covered the main cod grounds off both 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. In 2016, the German survey did only cover the stock in East and Southwest Greenland in NAFO 1F but no data north of NAFO 1F were collected. 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 EastGreenland

A total number of 137 valid hauls were made in 2016 (**Error! Reference source not found.**).

For Atlantic cod the abundance index was estimated at 28 million individuals and the survey biomass at 94,000 tons.

Survey abundance and biomass decreased with 56% and 31% respectively compared to 2015 (table 16.3.1.2, 16.3.1.3). Only 16% of the total abundance and 5% of the total biomass was found in SouthWest Greenland (NAFO 1F). 80% of the total biomass and 65% of the total abundance was found north of 63°N in East Greenland (survey area Q1-Q3), indicating that larger cod inhabits this area.

The dominating cohort is the 2009 YC accounting for 24% in abundance (**Error! Reference source not found.** 16.3.1.4). This YC is found in all areas of the survey, but is dominating in the documented spawning areas in East Greenland (Q3) where 49% of the total 2009 YC abundance is found (**Error! Reference source not found.**16.3.1.5). The 2007 YC have been one of the most dominating cohorts since 2011 and is in 2016 the second highest registered number of 9-yr old in the timeseries (since 2008), and is in 2016 distributed further to the north in East Greenland (Dohrn Bank (Q1) – Kleine Bank (Q3)) (**Error! Reference source not found.**16.3.1.4).

Previously 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 (**Error! Reference source not found.**16.3.1.5, **Error! Reference source not found.**16.3.1.5). In 2016 young cod of ages 1 and 2 yr old are found in increasing numbers, but not at the level as in the beginning of the timeseries (table 16.3.1.4). They are however dominating in southwest Greenland (NAFO 1F, table 16.3.1.6).

Length in catches has increased from 2012 to 2015 and catches was mainly comprised of fish from 40-100 cm in 2015 (figure 16.3.1.6). In 2016 catches were comprised of large cod (50-100 cm), however totally at a lot lower numbers than previously, together with small cod of 10-20 cm.

SSB is concentrated in the documented spawning area in Mideast (Q3) and on Dohrn Bank in Northeast (Q1) (figure 16.3.1.8). SSB index has declined since 2014 to around 80,000 tons in 2016 (**Error! Reference source not found.**16.3.1.7).

The smoothed biomass estimates is above the observed mean estimates in 2016 (**Error! Reference source not found.**16.3.1.3, Figure 16.3.1.16.3.1.9) whereas it is below in 2013-2015. The observed CV was 0.18, while the smoothed CV estimate was 0.17. The process SD was 0.34.

16.3.2 Results of the German groundfish survey off West and East Greenland

In 2016, 63 valid trawl stations were sampled during autumn in the German Greenland offshore groundfish survey (Table 16.3.2.1).

Abundance and biomass decreased by 33% and 30% respectively from 2015 to 2016 (table 16.3.2.2 and 16.3.2.3). Both indices abundance and biomass decreased in 2016 . As in 2015, the YC 2009 was not found as dominant year class in the survey catches. (Table 16.3.2.4).

The survey time series 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 .

It has to be considered, that the German survey is conducted in October and November, whereas the Greenland survey from June-August. 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 Greeland 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 20 513 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 and 2016 on Dana Bak (NAFO 1DE). Cod offshore in East Greenland have been tagged in 2007—2009, 2011, 2012 and 2014-2016 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. Recaptured tags from Iceland are mostly tagged in East Greenland, but also in West Greenland typically in South Greenland. The majority of the recaptured tags in Iceland are caught in the northeast area close to Dohrn Bank. 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 lead 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 found in lower numbers than previously and has moved further northeast to the spawning grounds. Older cohorts such as the 2007 YC 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 and 2016 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 reduction in biomass index in the Greenland survey appeared gradually since 2013. The Greenland survey takes place during summer whereas the German survey takes place in October and November. 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 in comparison to the 1950's and 1960', where catches exceeded 30 000 tons for a number of years.

As described in section 1.3 MSY proxies should evaluated to determine stock status. ICES suggested four methods for this purpose, and all methods were tested on the stock (Hedeholm 2017). In general, the methods all suggested that the stock is above B_{MSY} and fished below F_{MSY}. However, a SAM model utilizing all available data provides a more robust estimate of stock status.

East Greenland cod, SAM

The State-space model (SAM) was applied for the offshore cod stock in ICES Div 14b and NAFO division 1F (Riget et al 2017).

Input

The input data composed of catch at age for the 3-years to 10+ were available for the period 1973-1995 and 2005-present (WD02). For the period 1996-2004 catch at age were not available due to missing sampling. Mean weight at age in catch are obtained from sampling onboard fishing vessels. For the period with no samplings (1996-2004) the average mean weight at age for the sampled period were applied.

Mean weight at age in the stock for the period 2008-2016 derive from the Greenland survey (GRL-GFS). The average mean weight at age for this period was applied back in time (1973-2007), where no survey data was available or where survey data was to scattered.

The maturity ogive was applied constant for all years based on estimation of cod caught in spawning period April to May during the period 2007-2016.

A natural mortality of 0.2 is assumed for all age groups for all years.

A random walk sampling was chosen for the stock recruitment model.

Data from the annual Greenland Shrimp and Fish survey GRL-GFS and the German groundfish survey, both annually stratified random bottom-trawl surveys (WD03), were used as biomass indices. The GRL-GFS survey have been carried out since 1992 in West Greenland (south of 72°00′ N) and since 2008 in East Greenland (ref). The German survey has been conducted since 1982 covering the West Greenland area (south of 67°00′ N) and the East Greenland area (south of 67°00′ N).

Main settings

The landing fraction was assumed to be 1 and fishery and natural maturity before spawning was set to 0. An Fbar range of 4 to 8 years old was applied as these age groups are both fully recruited to the fishery and fairly abundant in the catches. A random walk sampling option was used as stock recruitment relation.

The above described are used as base settings for the SAM model with the GRL-GFS and the German surveys in ICES Div 14b and NAFO division 1F, age groups 1 to 9.

SAM output

The normalized model residuals were acceptable in magnitude and showed no trends or blocks with either positive or negative residuals. The historical development of fishing mortality is increasing to a high of 1.28 in 1992 and then a decrease within a few years and has been between ca 0.1 and 0.2 since. In 2016 F(4-8) is just above 0.2. The SSB has peaked three times during the period with the first peak in late 1970s, the second around 1990 and then in the recent years. The recruits reflect the well-known large year-classes in 1973, 1984, 2003 and 2009, with the latest somewhat smaller than the preceding recruit peaks. In 2016 the number of recruits has markedly increased.

Sensitivity of the tuning fleets the assessment is provided in the ‘leave-one- out’ plots; leaving out the Greenland survey (2008-2016) does not affect the estimation of SSB, F and recruits. Only in the latest years the survey contributes to an increased SSB and decreased F. The German survey have a much larger influence on the stock historical pattern. Without this survey the F from 1993 until 2008 increases considerably and are outside the confidence limits; in this period no age disaggregated catch data were available.

Alternative SAM runs

The robustness of the model was explored with different inputs. In one alternative run the M was increased to 0.4 for the year-classes 1973, 1984, 2003 and 2009 from age 5 and older to simulate migration out of East Greenland of these large year-classes. Although the M=0.4 was arbitrary chosen, the numbers of “emigrants out of East Greenland” were comparable in those years where the numbers of immigrants to the Icelandic stock has been estimated from the assessment. This model resulted in a slightly better fit and only very small changes were observed on the historical pattern of F, SSB and recruits.

In a second alternative run two tuning fleets were added to represent recruits to ICES Div 14b and NAFO division 1F deriving from the West Greenland area; the Greenland and German survey for the 1 to 5 age-groups in West Greenland. The model normalized residuals showed some blockings in the two West Greenland surveys. In recent years the residuals were positive (observations larger than predicted) for the two West Greenland surveys while they were negative for the two East Greenland surveys. The overall historical pattern appears only to be slightly changed compared to the outcome of previous models, however, the SSB are higher during the peaks in 1979/1980 and in 1990 but lower in 2014. The $F_{4\text{-}8}$ in 2016 was 0.238 in this run compared to 0.227 in the previous model.

General conclusion

In general, the WG find the use of the SAM model for the cod stock in ICES Div 14b and NAFO promising and the method appropriate to assess the stock in the future.

It was noted that the procedure to divide the Greenland and German surveys into a West and East components may lead to unreliable results. However, there appear not to be any reasonable way to combine the surveys because of the period covered by the Greenland survey differ for the West (since 1992) and East Greenland area (since 2008).

The model has presently to be updated with the disaggregated age data from the 2016 German survey

Issue list

- The input data should be updated with the disaggregated age data from the last year of the German survey
- The estimated immigration to the Icelandic stock as the derived from the assessment should be considered to provide the basis for the increase of M in the SAM.
- It should be considered to look into further details of the normalized residuals for the surveys of especially the large yc in the western and eastern surveys

Reference points

The output from the different SAM models were very similar. Therefore, the SAM model including an emigration out of the East Greenland area and using the young cod in West Greenland surveys as tuning fleet has been used to evaluate the stock state and deriving explanatory reference points following the ICES Reference Points Guidance, January 2016. The estimation has been done using the simulation R-programme EqSim.

Cod in XIVb and NAFO division 1F.

Framework	Reference Point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	18561	MSY $B_{trigger}$ < 5% SSB last year
	F_{MSY}	0.240	F_{MSY} < simulated F05
Precautionary approach	B_{lim}	5300	breakpoint in segm. regression
	B_{pa}	7500	Blim * exp(1.645 * σ), σ = 0.21
	F_{lim}	0.622	F50 deterministic simulated
	F_{pa}	0.338	Flim * exp(1.645 * σ), σ = 0.37
Y/R approach	$F_{0.1}$	0.19	SAM estimated
	F_{max}	0.31	SAM estimated
	F_{35spr}	0.19	SAM estimated

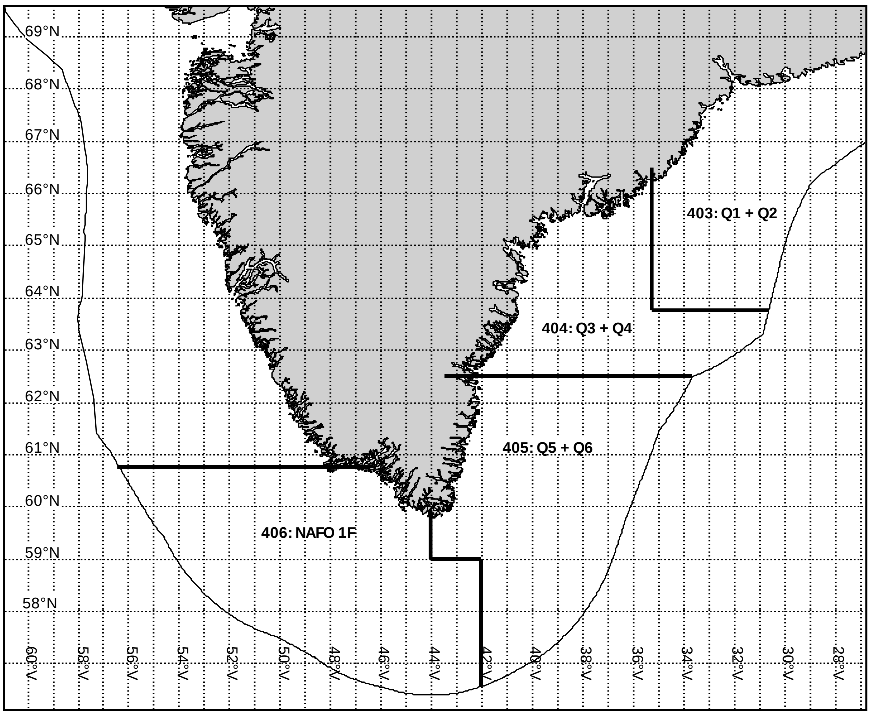
16.7 Implemented management measures for 2017

The offshore quota for the total international fishery is set at 16 000 tons divided into 2 management areas (see figure below).

To protect the spawning stock no fishing is allowed from April 1st to May 31st in all areas.

16.8 Management plan

In 2014 a management plan was implemented for the offshore cod fishery in Greenland 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. Until 2016 the management area East was divided into 4 management units. From 2017 that changed to two management units: South Greenland (1F+Q5Q6) and East Greenland (Q3Q4+Q1Q2).

According to the management plan the TAC in management area Southeast is 10 000 t/year and no fishery should be done north of 1F in West Greenland. However diviasions have been been the case in 2015 and 2016 where TAC was set higher than the proposed in the management plan.

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

As a period of relatively stable catches is co-occurring with rising survey indices (2011—2014), the DLS category 3.3 (ICES 2012) with an F_{proxy} as a reference point is used as basis for advice . The catch advice is 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 smoothed survey from 2011—2014 and the average of this (0.050407) was multiplied with the smoothed 2016 Greenland survey index (103 194) to give the 2018 catch advice. As the advice changed with more than 20% the uncertainty cap was used on last year advice to produce the final catch advice for 2018.

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*
1964	96	49049	49102	82936	33287	13844	99438	35577	55451*

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	ICES 14.b	NAFO 1F + ICES 14.b
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
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

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	ICES 14.b	NAFO 1F + ICES 14.b
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**
2016	0	0	67	1911	1762	2335	0	12483	**14818**

1) 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.

2) Estimates for assessment include estimates of unreported catches in East Greenland.

3) 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: 2016 cod catches (t) by area and month. East Greenland (14.b) divided into four management areas.

ICES/NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
14.b (Q1Q2)	1388	46	20	88	39	519	919	216	118	84	305	96	**3838**	26%
14.b (Q3Q4)	285	54	1339	1421	745	1874	390	64	178	172	35	279	**6836**	46%
14.b (Q5Q6)	137	0	206	248	240	34	1	100	177	208	401	57	**1809**	12%
1F	285	281	311	91	310	259	1	49	15	55	378	300	**2335**	16%
Total	**2095**	**381**	**1876**	**1848**	**1334**	**2686**	**1311**	**429**	**488**	**519**	**1119**	**732**	**14818**	
%	14%	3%	13%	12%	9%	18%	9%	3%	3%	4%	8%	5%		

Table 16.2.2.3: 2016 cod catches (t) by gear, area and month. East Greenland (14.b) divided into four management areas.

Gear	ICES/NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Longline	14.b (Q1Q2)				1	24	121	188	76	106		89	96	**701**
	14.b (Q3Q4)				127	57	833	387	61	178	171	3	279	**2096**
	14.b (Q5Q6)			54	29	97			98	177	208	394	57	**1114**
	1F	285	280	300	76	305	259	1	49	15	55	362	300	**2287**
	Total	**285**	**280**	**354**	**233**	**483**	**1213**	**576**	**284**	**476**	**434**	**848**	**732**	**6198**
Trawl	14.b (Q1Q2)	1388	46	20	87	14	399	731	141	12	85	215		3138
	14.b (Q3Q4)	285	54	1339	1293	688	1041	3	3		1	32		4739
	14.b (Q5Q6)	137		152	219	144	34	1	3			6		696
	1F	0.2	1	11	14	5						16		47
	Total	**1810**	**101**	**1522**	**1613**	**851**	**1474**	**735**	**147**	**12**	**86**	**269**		**8620**

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
2016	4	33	343	736	1130	766	427	257
				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
2016	0.406	0.845	1.420	2.135	3.267	4.693	6.693	10.071

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/HR)	SE
1975	82	-1.12298344	0.1565301
1976	5	-0.93211804	0.5890289
1977	304	0.13495066	0.1020935
1978	232	-0.17400859	0.1105423
1979	313	-0.12793958	0.1102152
1980	106	-0.78736282	0.1428277
1981	10	-1.36443204	0.4204402
1982	15	-1.22111142	0.3425675
1983	52	-0.66472691	0.2179683
1984	211	-0.5096031	0.1323799
1985	41	-0.32659413	0.217372
1986	0		
1987	0		
1988	368	-0.04024083	0.0850393
1989	1637	0.52691875	0.0641725
1990	4374	-0.02250391	0.0419041
1991	3007	-0.64804088	0.0446168
1992	2392	-0.46606892	0.0478605
1993	244	-2.12745427	0.0955871
1994	124	-3.71414714	0.1240113
1995	6	-3.65902313	0.5343203
1996	123	-2.19828586	0.1644561
1997	16	-0.7551939	0.3305615
1998	40	-2.36748898	0.2235989
1999	177	-2.48703521	0.1405159
2000	22	-2.15662104	0.2804137
2001	94	-1.95222299	0.1410675
2002	140	-2.9541519	0.1585364
2003	144	-1.79935424	0.1278446
2004	89	-2.28145266	0.1806765
2005	55	-1.17275617	0.3462037
2006	261	0.46217301	0.1041046
2007	358	0.7170482	0.0777388
2008	1530	0.22533679	0.0541204
2009	710	-0.91723397	0.0679717
2010	255	-0.38415269	0.0978474
2011	466	0.23032549	0.0781237
2012	493	-0.02200881	0.0755383
2013	429	-0.43731812	0.0877542
2014	854	-0.26225134	0.0761554
2015	1318	0.28044771	0.0665212
2016	928	0.32581858	0.0707032
Total	22025		

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
2016	29	10	26	13	7	16	36	137

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
2016	8338	909	9737	1031	233	3412	4393	28052	16

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	21236	68952	23	68491
2009	10844	8874	27251	7827	252	3094	503	58645	28	67490
2010	16014	3151	81064	6202	23	4203	3142	113799	51	82092
2011	27064	8128	5561	12486	5235	22664	3280	84418	19	85104
2012	24736	10058	9347	5802	160	14322	16213	80638	16	90533
2013	45018	9639	15017	48518	977	40319	47818	207306	22	161676
2014	17182	20637	15574	90795	734	8884	30754	184560	45	159237
2015	33105	13803	27050	11609	513	18724	49931	154735	20	143259
2016	40580	4831	33065	4841	426	5670	4671	94084	18	103194

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	326	1168	7460	6937	24058	5279	2227	613	1225	671
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
2016	279	3847	1818	998	555	2089	2399	6779	4874	3398	1018

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, 2016.

Year class	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	<2007
Age	0	1	2	3	4	5	6	7	8	9	10+
ICES Q1	95	636	253	239	0	176	212	1953	2049	2090	633
ICES Q2	0	0	3	3	0	0	18	251	401	230	3
ICES Q3	98	740	308	230	144	797	1341	3332	1873	631	243
ICES Q4	86	89	64	86	0	22	0	89	176	287	132
ICES Q5	0	87	22	0	5	37	0	31	32	19	0
ICES Q6	0	699	377	159	295	753	396	451	249	33	0
NAFO 1F	0	1596	789	281	111	303	432	672	94	108	8

Table 16.3.1.6: Mean weight (kg) at 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	0.003	0.019	0.088	0.262	0.520	1.067	1.982	3.385	5.699	8.447	8.564
2009	0.004	0.059	0.140	0.452	0.976	1.730	2.977	4.186	5.447	7.423	10.800
2010	0.002	0.041	0.206	0.406	0.823	1.728	2.499	3.496	5.480	7.363	10.686
2011	0.001	0.017	0.152	0.366	0.783	1.408	2.209	3.891	5.711	7.218	10.859
2012		0.025	0.201	0.367	0.916	1.519	2.634	4.068	5.658	7.565	10.000
2013		0.020	0.194	0.450	0.771	1.396	2.353	3.663	5.140	7.062	10.354
2014	0.001	0.003	0.129	0.360	0.773	1.402	2.758	4.145	5.173	6.217	9.060
2015		0.017	0.100	0.357	0.697	1.194	1.808	3.241	4.835	6.809	10.000
2016	0.001	0.025	0.116	0.327	0.831	1.623	2.245	3.557	5.299	6.879	9.973

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
2016	11	6	5	8	8	6	13	6	63

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
2016	1589	107	1483	264	336	1123	1248	1640	7790	1647

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
2016	4521	305	7360	1727	2129	6341	4906	9367	36656	6752

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
2016	12	443	88	115	725	1009	3036	1548	535	141	89	40	7781

Table 16.3.2.5 ***German survey*****, South and East Greenland (NAFO 1F and ICES 14.b). Mean weight at age (gram).**

Year	0	1	2	3	4	5	6	7	8	9	10	11
1982		100	357	718	1244	2084	3060	3867	4975	6363	5233	11650
1983												
1984												
1985												
1986												
1987		30	220	804	1413	2283	3671	4848	5505	7060	8293	11350
1988												
1989		36	130	368	802	2411	4190	4463	6310	6521	7774	9815
1990		70	329	369	792	1502	3012	4747	5200	6960		7764
1991		70	219	311	655	892	1357	1909	4608	5231	10195	8800
1992		103	198	236	224	610		1274				
1993		88	304	718	1323	2465	3002	3738	4987	6819		
1994		24	120	1120	2293	3472	6483	4623		8500		
1995		60	257	540	1491	3010	4127	5668	6219	9275	8351	6094
1996				685	2091	2975	4042	5445	6962			
1997			260	984	1672	3521	4478	4954	5019			6890
1998		100	162	990	1680	2930	3649	4497	6540			
1999		88	311	615	1218	3192	3814	5812		10095	10695	
2000		103	227	481	838	1457	1828	3035	5848	6789	8805	
2001		127	339	961	1992	2286	2850	4083	6481	7676	7368	7080
2002		25	281	690	1459	2166	2984	3736	4473	6940	6330	6648
2003		101	282	912	1479	2303	3651	4491	5711	6719		10960
2004		93	399	661	1447	2182	3099	4497	5120	7205	9631	
2005		143	424	1140	2395	3664	4671	8506	8870	10383		
2006		69	216	717	1968	3437	5365	5929	8285	8358	11490	
2007		132	239	576	1449	3008	4155	6811	8111	8799		
2008		82	266	605	1199	2140	4438	6996	9680	11208	14663	14900
2009		76	247	798	1405	2762	3815	6913	8565	11614	11201	
2010		97	403	957	1842	2390	3607	4858	6945	9361	14502	15659
2011		129	381	949	1598	2619	3893	5910	6684	10243	18396	19630
2012		35	640	995	2148	2777	5601	7193	8401	10318	13138	15450
2013		44	217	1498	1875	3128	3882	5618	7165	8713	9445	11976
2014		75	406	1048	2153	2944	4372	5290	7307	10185	10927	18193
2015		79	624	1270	2112	3547	4327	5836	6726	8671	11675	11612
2016		61	477	1390	2375	3518	4638	5406	7355	8066	11449	13726

Table 16.3.2.6 ***German survey,*** **South and East Greenland (NAFO 1F and ICES 14.b). The abundance indices ('000) by year class/age, 2016.**

YEAR CLASS	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	<2007
Age	0	1	2	3	4	5	6	7	8	9	10+
Strat 9	0	12	17	20	115	179	661	346	160	44	39
Strat 8	0	9	0	16	168	219	527	198	44	8	1
Strat 7	5	13	0	11	127	217	734	335	132	31	28
Strat 5	0	71	9	46	191	215	640	303	147	34	65
Strat 4	7	339	63	23	125	180	474	365	52	24	0

Table 16.5.1. Number of tagged cod in the period of 2003 to 2016 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
2016		1297	1911

Table 16.5.2: Number of recaptured cod in the period of 2003 to 2016 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)	443	18	2
Bank (West)		44	2
East Greenland		23	105
Iceland	3	30	139

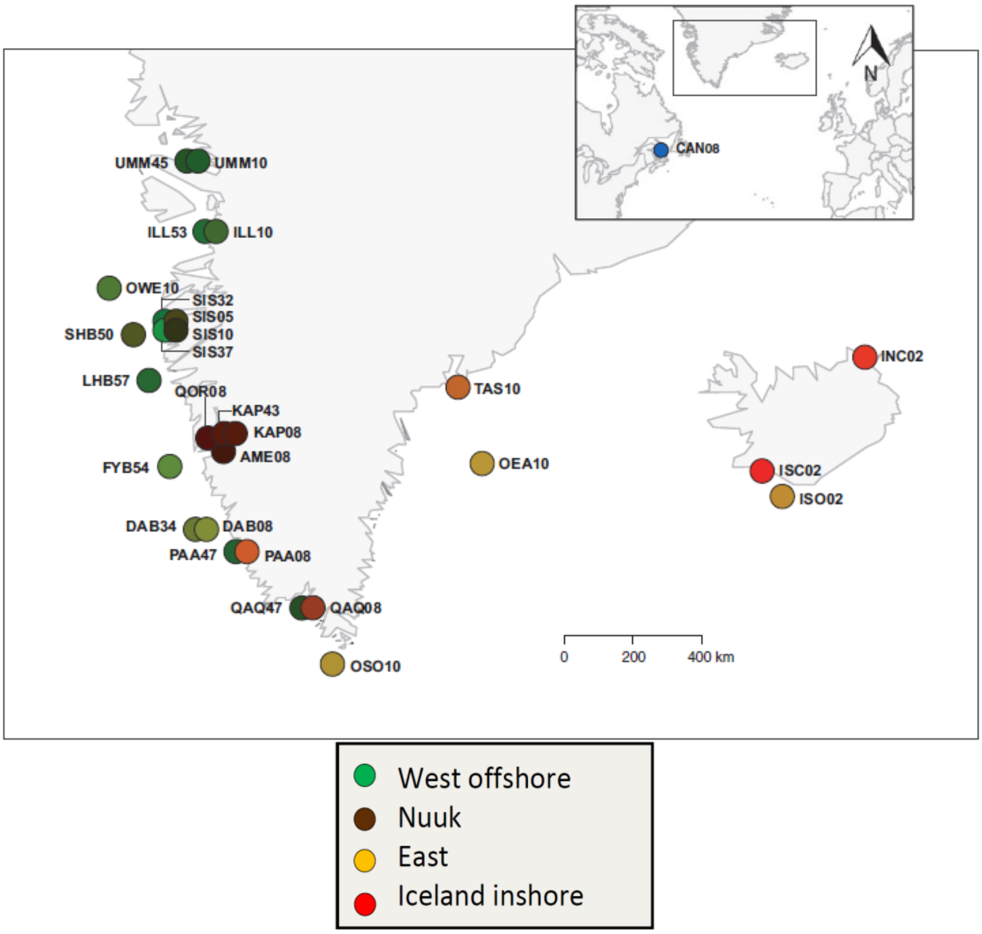


Figure. 16.1. Sampling location of spawning cod in Greenland and Iceland in the genetic project. The colours of the dots represent the blends of sample mean of the different spawning population: West offshore, Nuuk (inshore), East (Greenland and offshore Iceland) and Iceland inshore as signal intensities of green and red respectively. After Therkildsen et al. 2013.

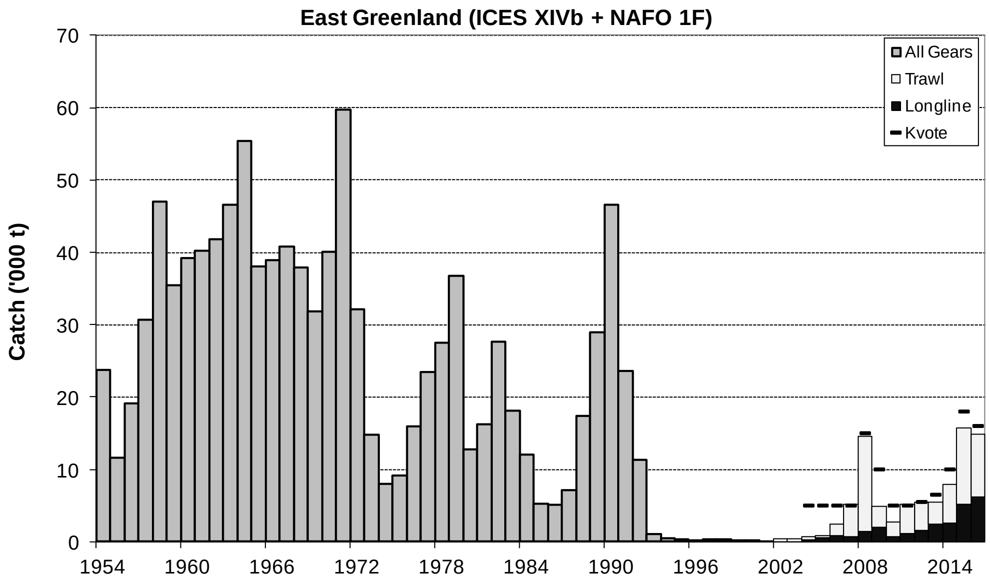


Figure 16.2.1. Annual total catch in South and East Greenland (NAFO subarea 1F and ICES subarea 14.b). From 2001 divided into gear. TAC until 2013 is for all the offshore area including West Greenland (NAFO subarea 1A-1E).

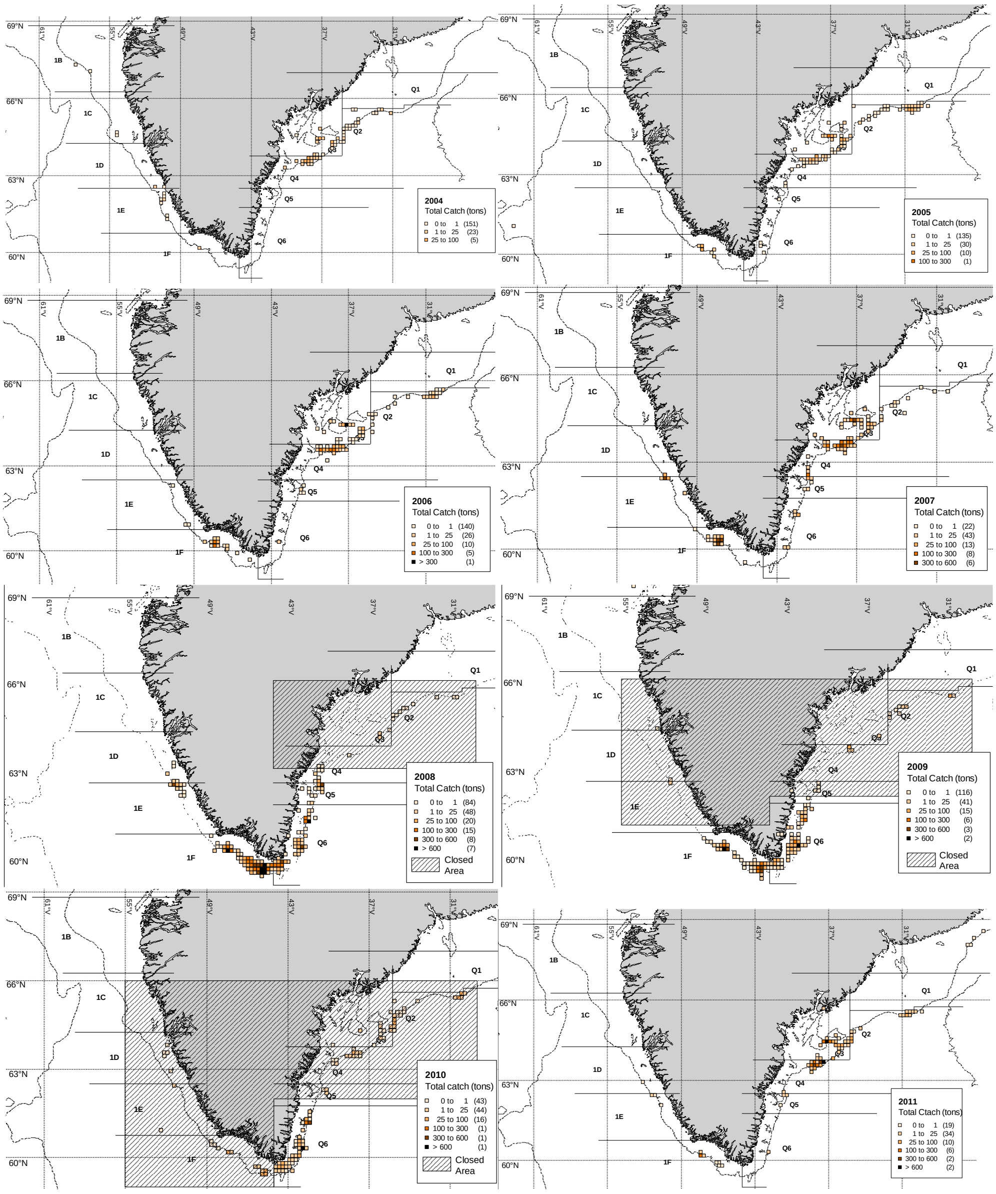


Figure 16.2.2.1: Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

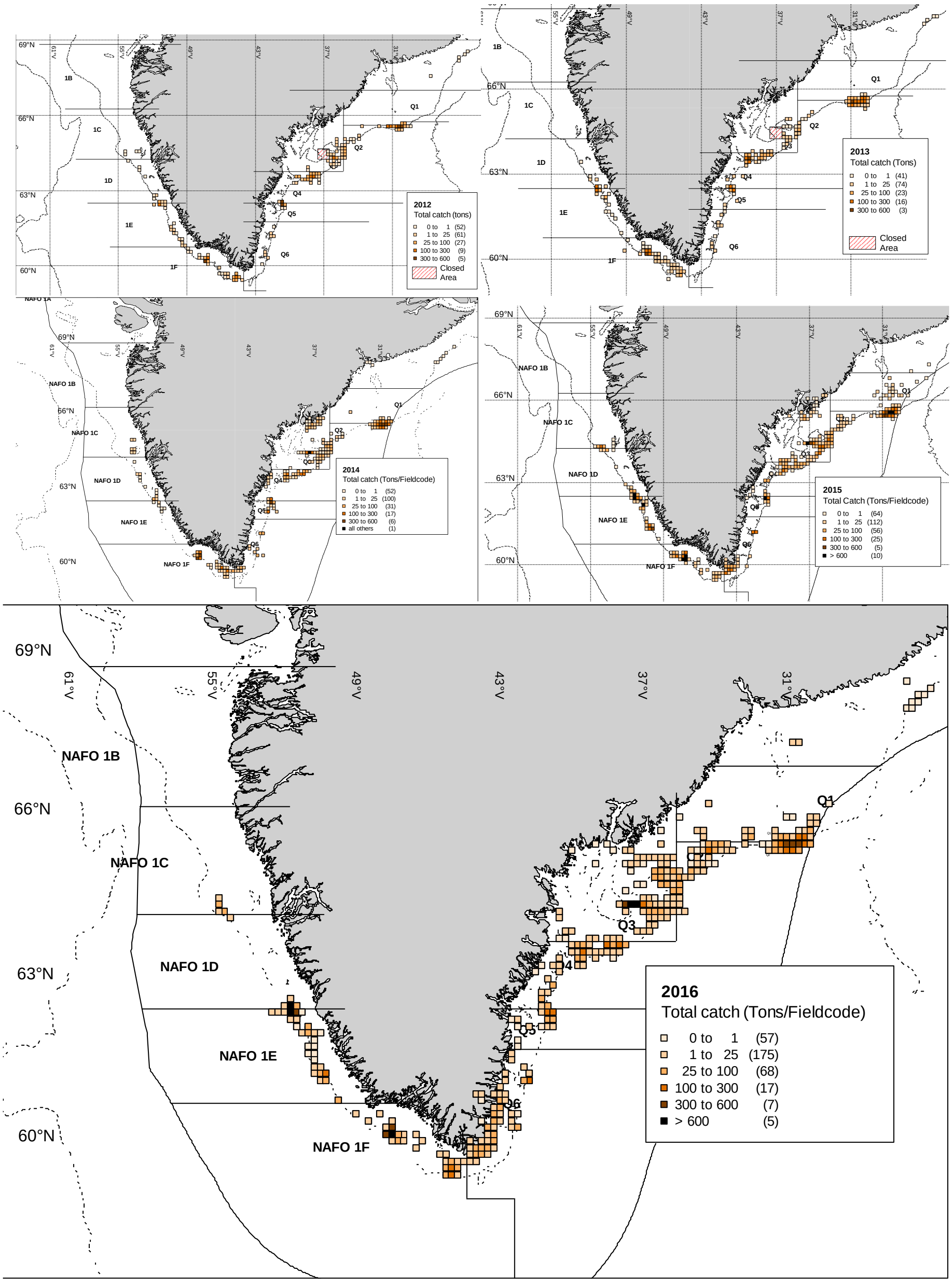


Figure 16.2.2.1: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

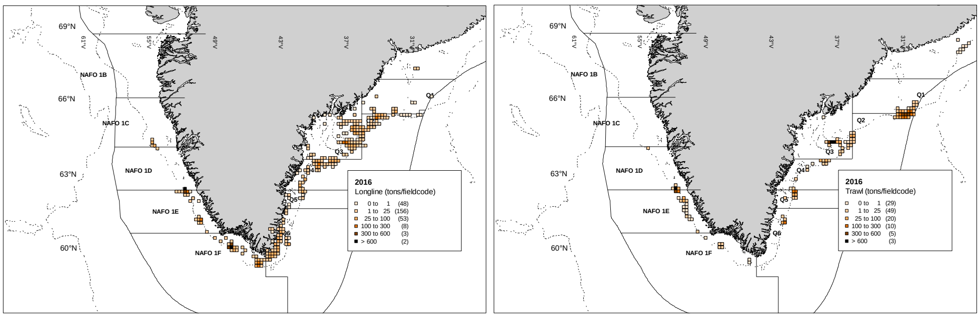


Figure 16.2.2.2: Distribution of Longline and Trawl catches of Atlantic cod in West and East Greenland 2016. Q1-Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

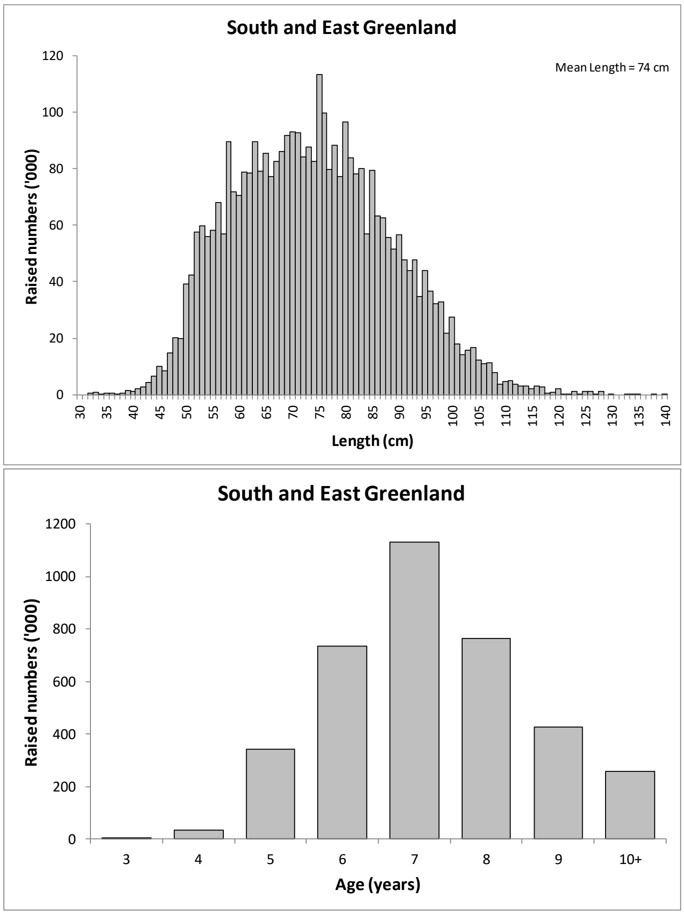


Figure 16.2.3.1: Combined length and age distributions of commercial cod catches in the South and East Greenland offshore fishery in 2016.

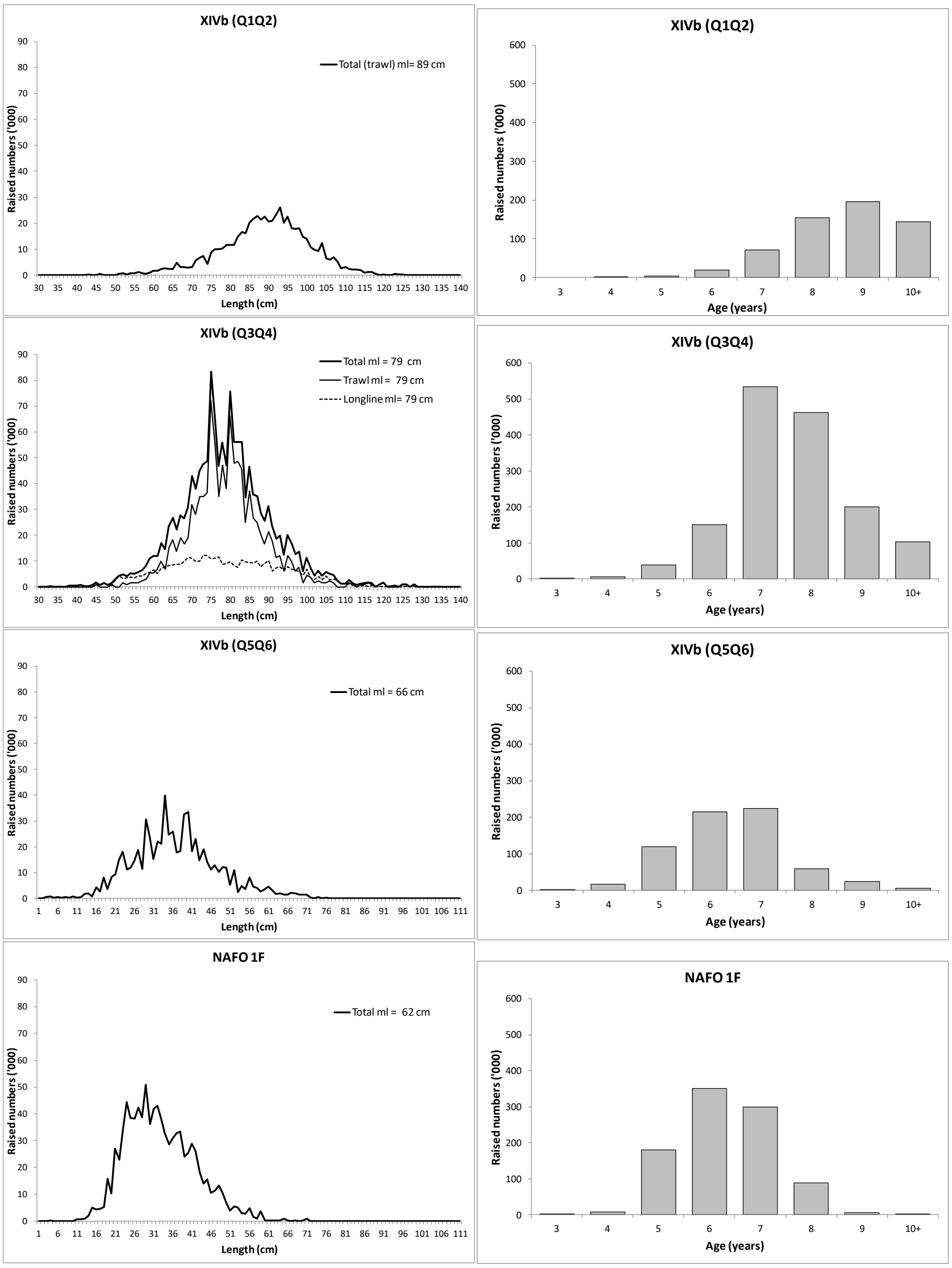


Figure 16.2.3.2: Length and age distributions of commercial cod catches in the four management areas of SouthWest (NAFO 1F) and East Greenland (Q1Q2 furthest north) in 2016.

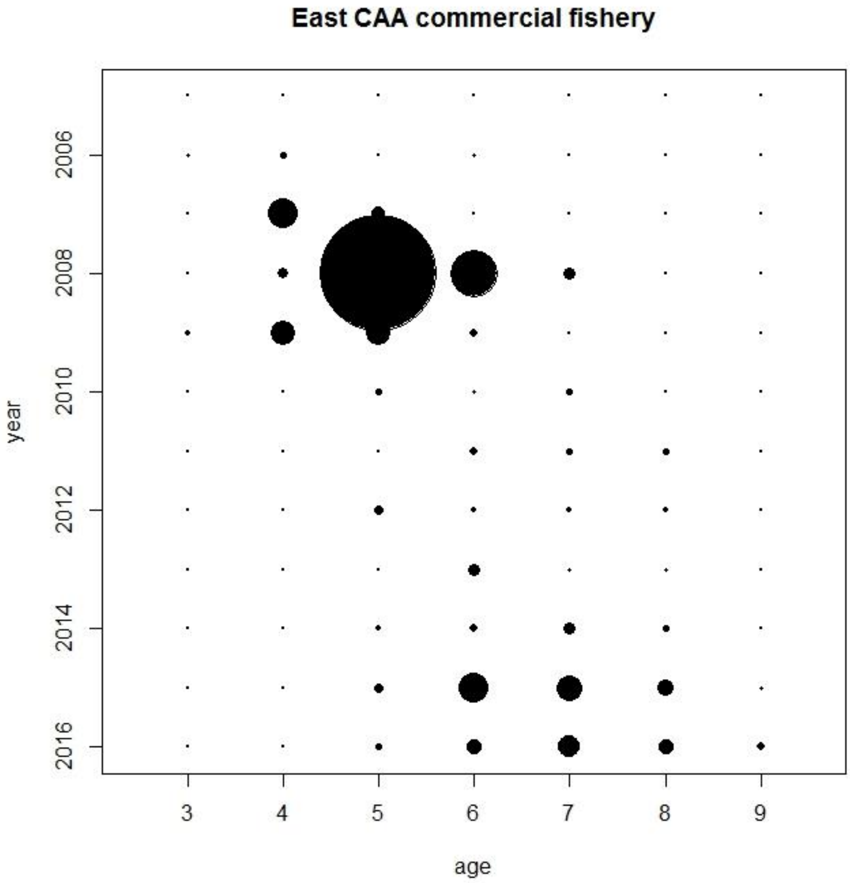


Figure 16.2.3.3: Catch at Age in the East Greenland (ICES 14b + NAFO 1F) commercial fishery. Size of circles represents size of catch numbers.

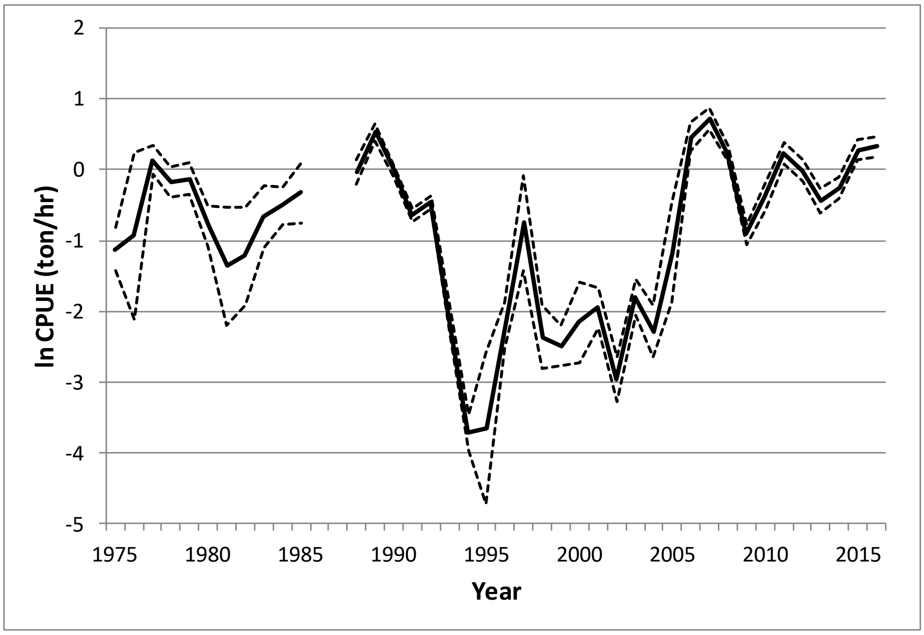


Figure 16.2.4.1: Ln CPUE (ton/hr) for Atlantic Cod caught in the fishery in East (ICES 14b) and SouthWest (NAFO 1F) Greenland. Based on model: lncpue = year + management area (Q1Q2, Q3Q4, Q5Q6 and 1F) + ship. Dashed lines are 2*SE.

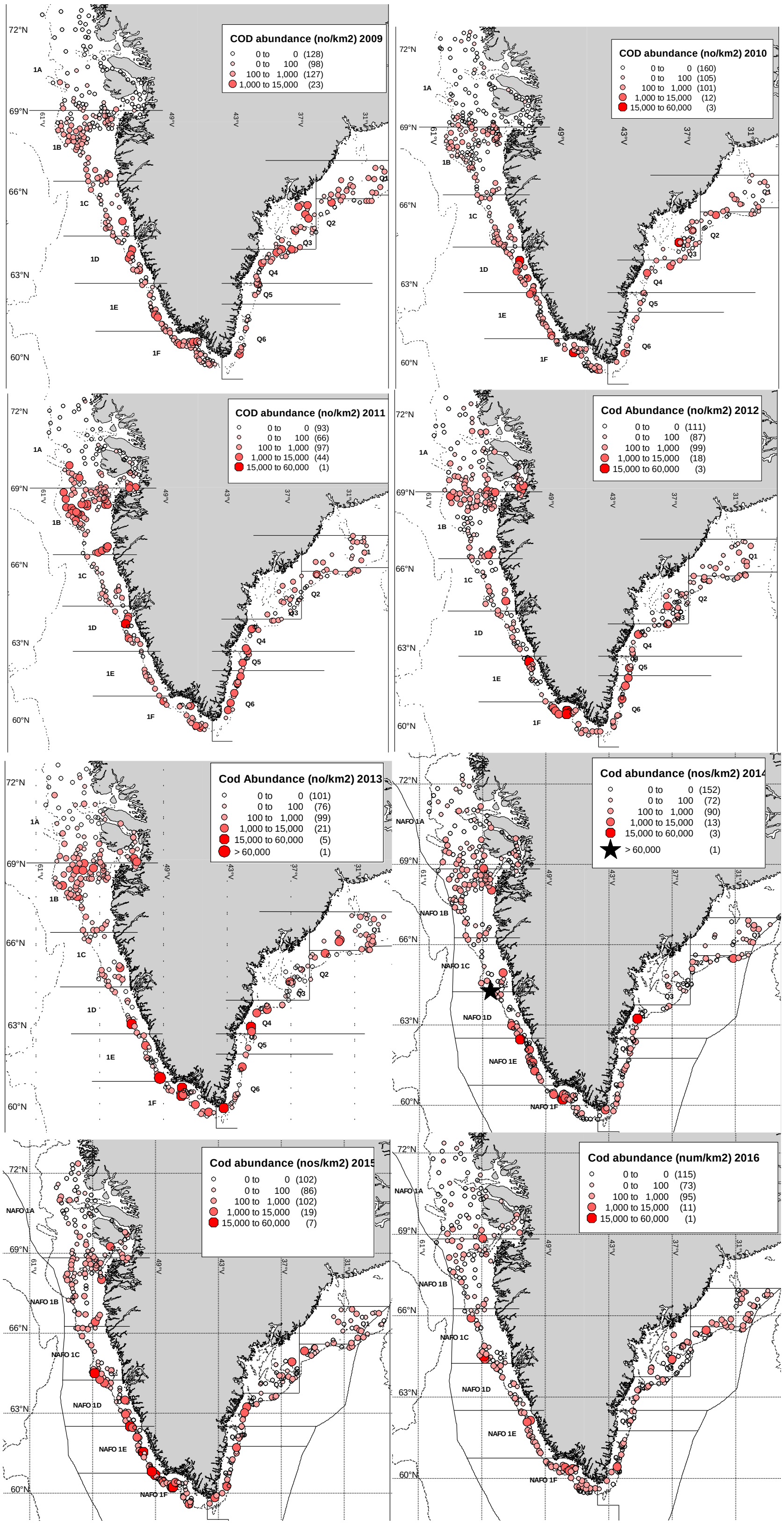


Figure16.3.1.1. Greenland shrimp and fish survey 2009-2016. Abundance per Km².

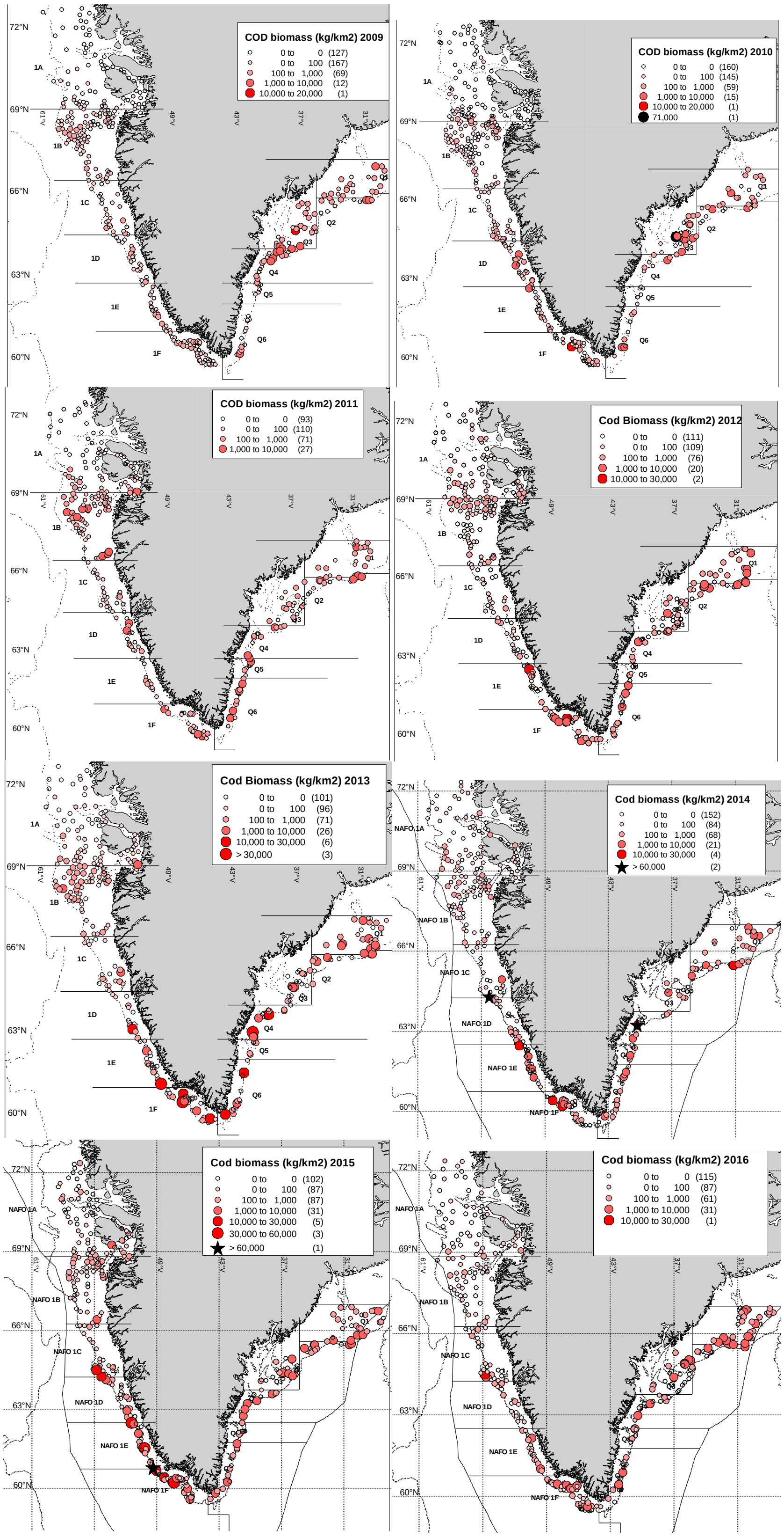


Figure 16.3.1.2. Greenland shrimp and fish survey 2009-2016. Catch weight kg per Km²

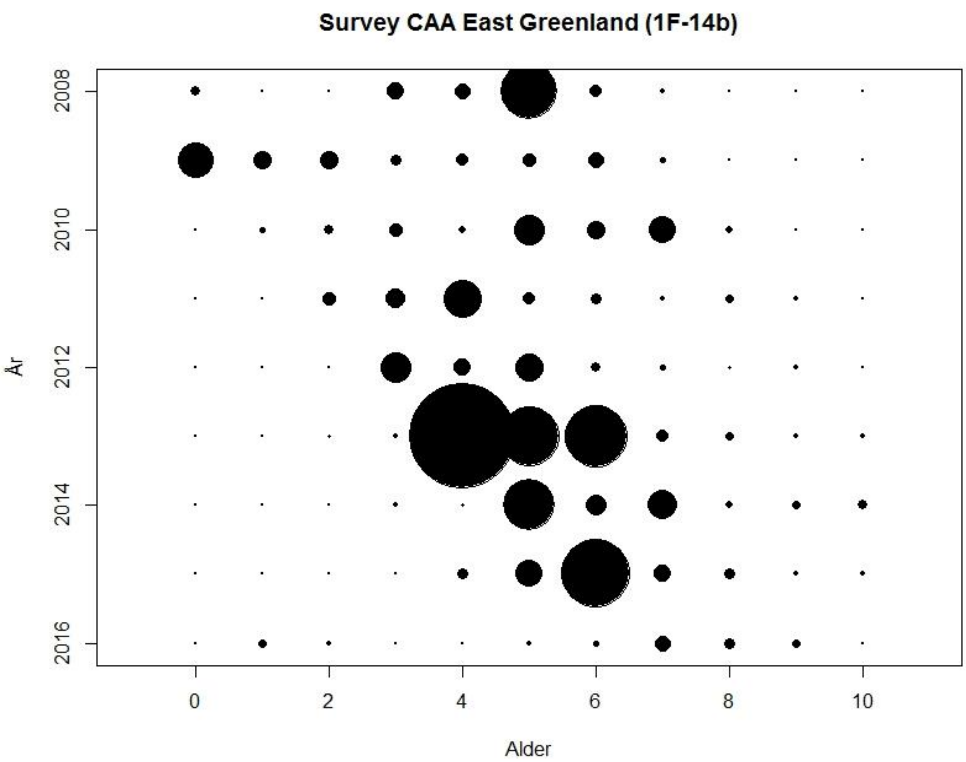


Figure 16.3.1.3: Abundance index pr. age in ICES 14b and NAFO 1F combined. Size of circles represents size of index.

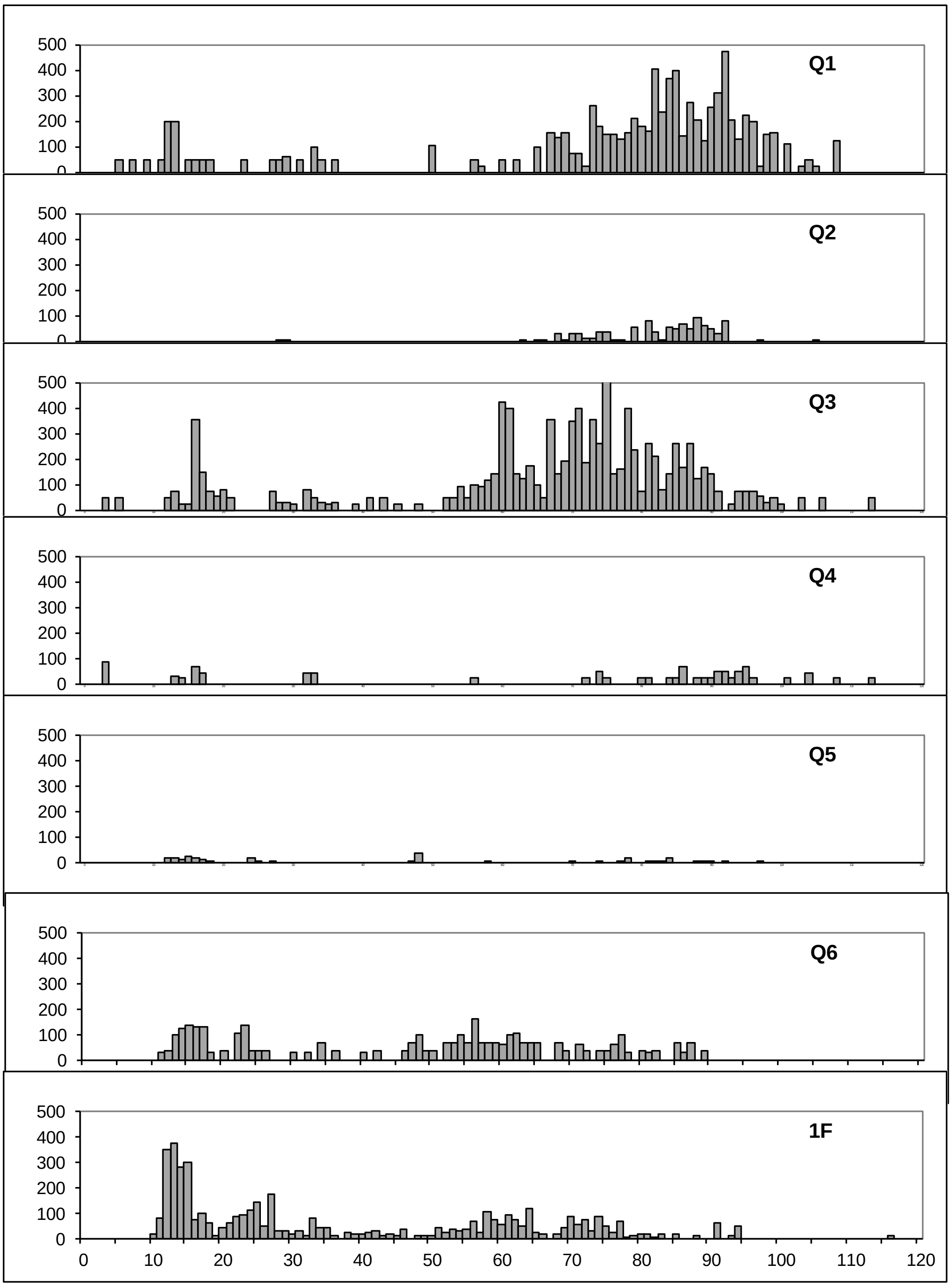


Figure 16.3.1.4: Abundance index by length (cm) and area in 2016. Areas from north (top) to south (bottom) is: Q1, Q2, Q3, Q4, Q5,Q6 (ICES 14b) and NAFO 1F.

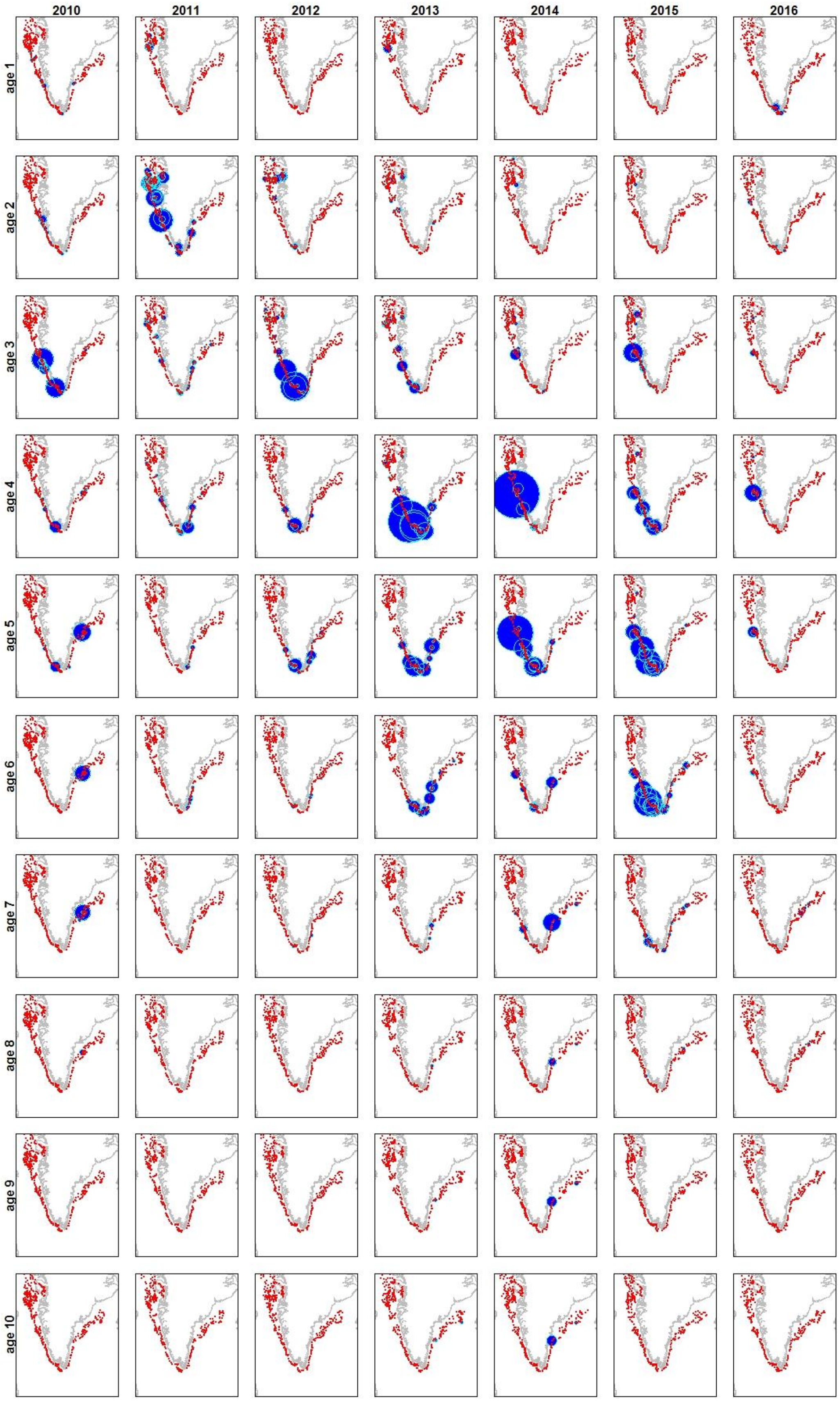


Figure 16.3.1.5. Abundace (no/km²) pr. station of ages 1-10 in the years 2010–2016.

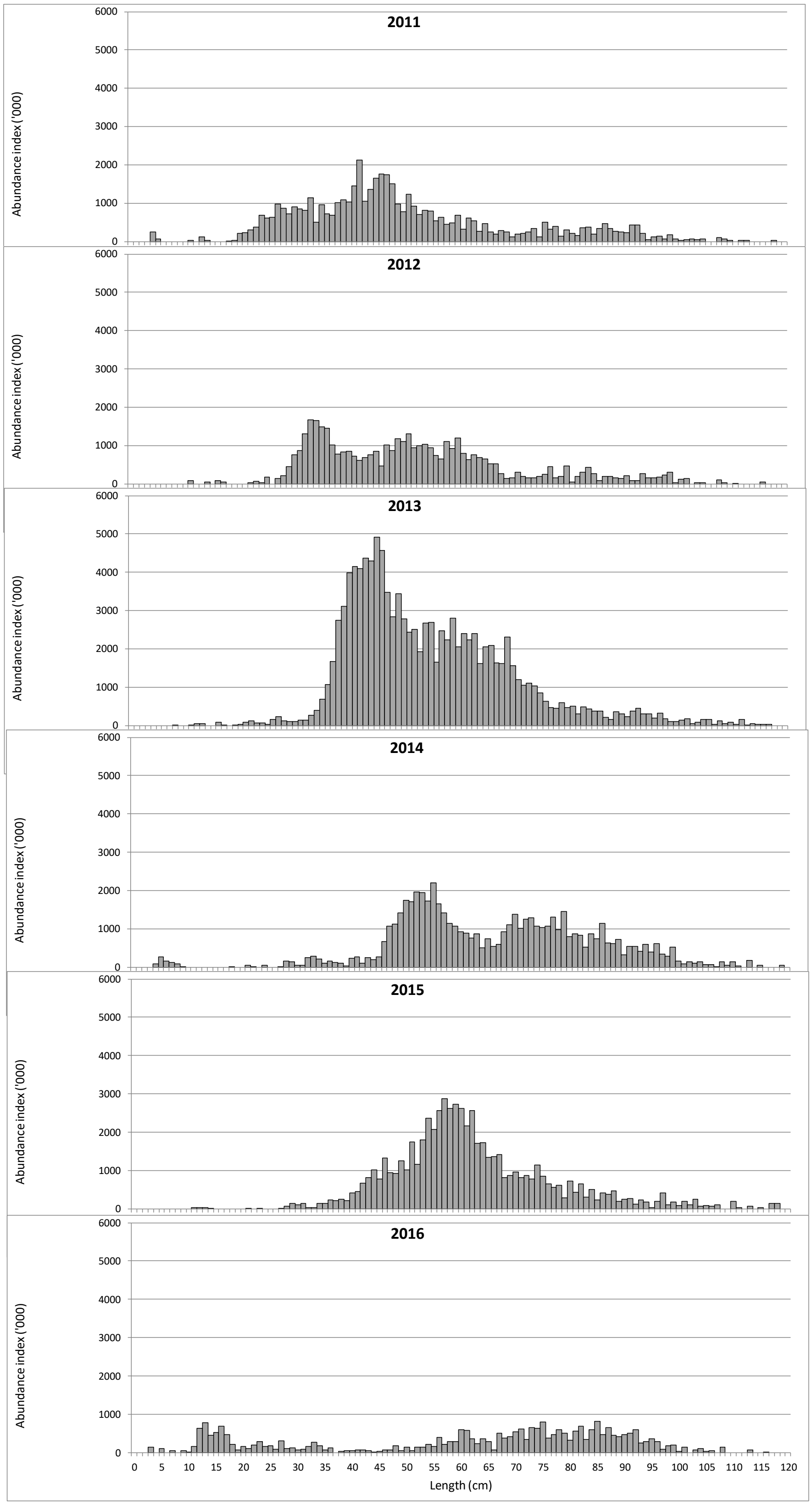


Figure 16.3.1.6: Total abundance indices by length in East Greenland (ICES 14b + NAFO 1F) shrimp and fish survey.

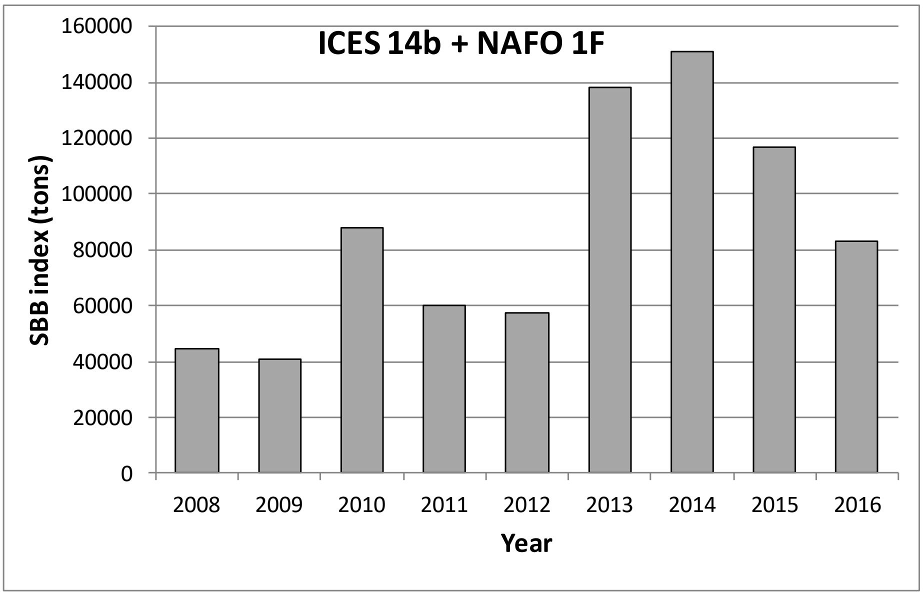


Figure 16.3.1.7: Estimated SSB (tons) by year from the East Greenland (ICES 14b + NAFO 1F) Shrimp and Fish survey.

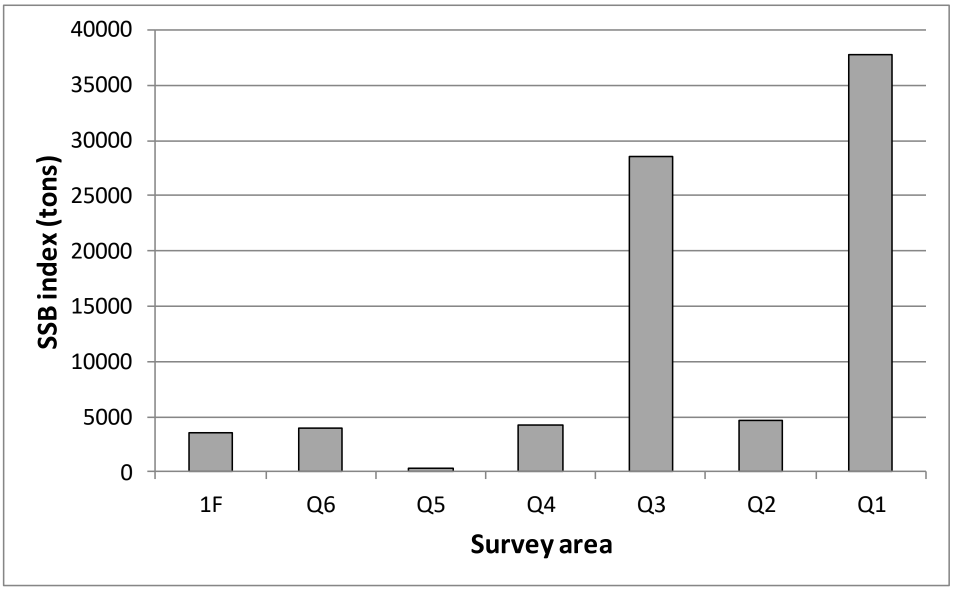


Figure 16.3.1.8: Estimated SSB (tons) by survey areas from the East Greenland (ICES 14b + NAFO 1F) Shrimp and Fish survey, 2016. NAFO Div 1F (SouthWest Greenland) to the left, "Q" areas (East Greenland) to the right. Cape Farewell is between 1F and Q6.

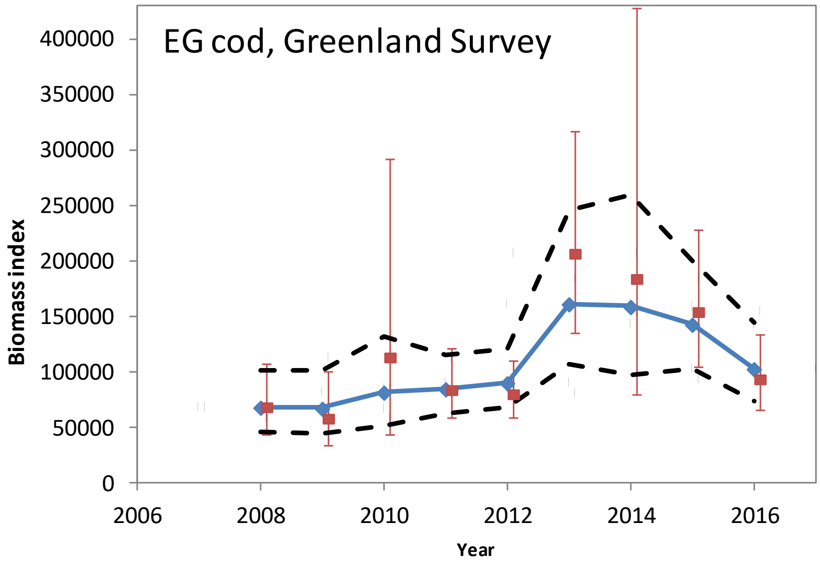


Figure 16.3.1.9: Biomass index for NAFO 1F and ICES Subarea 14b. Red squares are the estimated mean value from the survey and the vertical connected lines are upper and lower 95% confidence intervals. The smoothed estimates are displayed as the blue line and the 95% confidence intervals of the smoothed values are shown as dashed lines.

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

Greenland halibut in ICES Subareas V, VI, XII and XIV are assessed as one stock unit although precise stock associations are not known.

17.1 Catches, Fisheries, Fleet and Stock Perception

17.1.1 Catches

Total annual catches in Divisions 5a, 5b, and Subareas 6, 12 and 14 are presented for the years 1981–2016 in Tables 17.2.1–17.2.6 and since 1961 in Figure 17.2.1. Catches decreased in 2016 by 1% to 25,397 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 and 31 kt.

17.1.2 Fisheries and fleets

In 2016 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 by-catch regulations for the trawlers and depth and gear restrictions for the gillnetters. Catches in 5b increased substantially in 2016 from 3,231 t to 4,658 t.

Most of the fishery for Greenland halibut in Divisions 5a, 5b and 14b is a directed trawl fishery, but also an gillnet and longline fishery takes place. Only minor catches in 5a and 14b are taken as by-catches in a redfish fishery (see section 21 on Greenland slope redfish). No or insignificant discarding has been observed in this fishery.

Spatial distribution of the 2016 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 2016 the distribution of the fishery covered all areas but was discontinuous in its distribution (Fig 17.2.2).

In 2001-2008 a directed and a by-catch 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. Presently UK, France and Spain have a small fishery in the area. All catches in Subareas 6 and 12 is assumed to derive from the Hatton Bank area (Tables 17.2.5-17.2.6).

17.1.3 By-catch and discard

The Greenland halibut trawl fishery is commonly a clean fishery with respect to by-catches. Eventual by-catches are mainly redfish and cod. Southeast of Iceland the cod fishery and a minor Greenland halibut fishery are coinciding spatially. In East Greenland where fishery is on the steep slope, fishing grounds for cod and redfish are close to the Greenland halibut fishing grounds, but nevertheless the catches from single hauls are clean.

The mandatory use of sorting grids in the shrimp fishery in Icelandic and Greenland waters since 2002 is observed to have reduced by-catches considerably. Based on sampling in 2006 - 2007, scientific staff observed by-catches 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.

17.2 Trends in Effort and CPUE

17.2.1 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. The overall CPUE index for the Icelandic fishery are compiled as the average of the standardised 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 or slowly increasing. The overall tendency is the same for all fishing grounds in 5a (Figure 17.3.2) although the less important fishing grounds in north, east and southeast are more variable in trend.

17.2.2 Division 5b

Information from logbooks from the Faroese otterboard trawl fleet (>1000 hp) was available for the years 1991-2016 (Table 17.3.1, Figure 17.3.4.). The bulk of the fishery has historically been on the south-east slope of the Faroe Plateau. CPUE decreased drastically in the early period by more than 50 % coinciding with a significant increase in effort. Since 2005 CPUE has gradually increased and is recently above average of the time series.

17.2.3 Division 14b

CPUE and effort from logbooks in area 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 2016 a record high for the second year. It should be noted that CPUE series from Divisions 5a, 5b and 14b have different trends over the time indicating that the populations/areas most likely have different dynamics.

17.2.4 Divisions 6b and 12b

Since 2001 a fishery developed in Divisions 6b and 12b in the Hatton Bank area by Spain, UK and France. The recent catches are stable but small. Limited fleet information is available from this area (ICES WGDEEP).

17.3 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 stable over the entire period. Catch composition from all areas (5a,b and 14) by gear is provided for 2016 in Figure 17.4.2.

17.4 Survey information

The total surveyed area in 2016 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.

17.4.1 Division 5a

Since 2006 the total biomass of Greenland halibut has increased significantly in Icelandic waters (Figures 17.5.3) . Abundance of smaller fish (less than 40 cm) has been improving from a record low in recent two years .

17.4.2 Division 5b

The catch rates from the available time series of the Faroese survey have declined from a record high level in 2012-13 but is still high in 2016. (Figure 17.5.5).

17.4.3 Division 14b

A GLM analysis performed on the survey catch rates in 14b, taking into account the scattered coverage of area and depth between years did however showed a status quo from previous years (Figure 17.5.6-7.). The text table below provides information on the coverage and numbers of stations in 2016 along with the Iceland survey in Division 5a.

Survey /Division	No. hauls in 2016 (planned hauls)	Depth range (m)	Coverage (km2)
5a	203 (219)	32 - 1309?	-130 000
14b	100 (100)	400-1500	29 000

The stock annex provides more extensive descriptions of the surveys.

17.5 Stock Assessment

17.5.1 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.

17.5.1.1 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 are a revised and standardised series of annual commercial-vessel catch rates for 1985–2016, $CPUE_{t,}$; 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.

17.5.1.2 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 717-1067 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 realised ones given in the data series on stock size were in the range of 0.05 to 0.95 i.e. the observations did not lay in the extreme tails of their posterior distributions (Table 17.6.4). Exceptions are observed for the survey in 1997 (p=0.97) and in 2006 (p=0.03). 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).

17.5.1.3 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 2016 biomass was at 72% of B_{MSY}. The risk of the biomass being below B_{msy} in 2016 is 100% and 0 % of being below B_{LIM} (Table 17.6.5). The median fishing mortality ratio (F/Fmsy) has exceeded F_{msy} since the 1990s and estimated at 1.10 F_{msy} in 2016. (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 27 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 seven optional catch levels for 2018 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.

Scenarios of fixed levels of fishing mortality ratios within the range of 0.3 to 1.7 were conducted and are shown in Fig. 17.6.8. Present biomass is above the MSY Btrigger (50% of B_{MSY}) and a fishery at F_{MSY} is advised according the ICES MSY AR. Fishing at Fmsy will result in catches of 24 kt in 2018 (Figure 15.6.8 panel D) and a stock size of 74% of B_{MSY} in 2018 (Table 17.6.5).

17.5.2 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 2018 will correspond to fishing at F_{MSY}. This will result in an increase in biomass and risk of exceeding F_{LIM} will remain unchanged from 2017 (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.

17.5.3 Reference points

Reference points were unchanged from last benchmark in 2013 (WKBUT)

17.6 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.

A bilateral agreement between Iceland and Greenland have limited the overall catches in recent years and assured that fishing pressure is about Fmsy.

17.7 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). This lack of optimal usage af available biomass indices need to be solved at the next benchmark.

17.8 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 with 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 for assessment purposes. Such a compilation should be evaluated outside NWWG, eg. 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 potentially 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. Presently 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 (WKARGH). 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.

Table 17.2.1 Greenland halibut. Nominal landings (tonnes) by countries in Sub-area V.VI XII and XIV. as officially reported to ICES and estimated by WG

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	1984	1985	1986	1987	1988	1989	1990
Denmark	-	-	-	-	-	-	6	+	-	-
Faroe Islands	767	1,532	1,146	2,502	1,052	853	1,096	1,378	2,319	1,803
France	8	27	236	489	845	52	19	25	-	-
Germany	3,007	2,581	1,142	936	863	858	565	637	493	336
Greenland	+	1	5	15	81	177	154	37	11	40
Iceland	15,457	28,300	28,360	30,080	29,231	31,044	44,780	49,040	58,330	36,557
Norway	-	-	2	2	3	+	2	1	3	50
Russia	-	-	-	-	-	-	-	-	-	-
UK (Engl. and Wales)	-	-	-	-	-	-	-	-	-	27
UK (Scotland)	-	-	-	-	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-	-	-	-	
Total	19,239	32,441	30,891	34,024	32,075	32,984	46,622	51,118	61,156	38,813
Working Group estimate	-	-	-	-	-	-	-	-	61,396	39,326

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Denmark	-	-	-	-	-	1	-			0
Faroe Islands	1,566	2,128	4,405	6,241	3,763	6,148	4,971	3,817	3,884	-
France	-	3	2	-	-	29	11	8	-	2
Germany	303	382	415	648	811	3,368	3,342	3,056	3,082	3,265
Greenland	66	437	288	867	533	1,162	1,129	747	200	1,740
Iceland	34,883	31,955	33,987	27,778	27,383	22,055	18,569	10,728	11,180	14,537
Norway	34	221	846	1,173 [1]	1,810	2,164	1,939	1,367	1,187	1,750
Russia	-	5	-	-	10	424	37	52	138	183
Spain								89		779
UK (Engl. and Wales)	38	109	811	513	1,436	386	218	190	261	370
UK (Scotland)	-	19	26	84	232	25	26	43	69	121
United Kingdom									-	166
Total	36,890	35,259	40,780	37,305	36,006	35,762	30,242	20,360	20,226	22,913
Working Group estimate	37,950	35,423	40,817	36,958	36,300	35,825	30,309	20,382	20,371	26,644

Country	2001	2002	2003 [1]	2004 [1]	2005 [1]	2006 [1]	2007 [1]	2008 [1]	2009 [1]	2010
Denmark	-	-	-	-	-	-	-	-	-	-
Estonia	-	8	-	-	5	3	-	-	-	-
Faroe Islands	121	334	458	338	1,150	855	1,141	-	270	1,408
France	32	290	177	157	-	62	17	114	-	-
Germany	2,800	2,050	2,948	5,169	5,150	4,299	4,930	4,846	427	5,287
Greenland	1,553	1,887	1,459	-	-	-	-	-	2,819	-
Iceland	16,590	#REF!	20,366	15,478	13,023	11,798	-	-	-	13,293
Ireland	56	#REF!	-	-	-	-	-	-	-	-
Lithuania	-	-	2	1	-	2	3	566		-
Norway	2,243	1,998	1,074	1,233	1,124	1,097	692	639	124	233
Poland	2	16	93	207	-	-	-	1,354	988	960
Portugal	6	130	-	-	-	1,094	-	-	-	-
Russia	187	#REF!	-	262	-	552	501	799	762	1,070
Spain	1,698	1,395	3,075	4,721	506	33	-	-	-	-
UK (Engl. and Wales)	227	71	40	49	10	1	-	-	-	-
UK (Scotland)	130	181	367	367	391	1	-	-	-	-
United Kingdom	252	255	841	1,304	220	93	17	422	581	577
Total	25,897	27,609	30,900	29,286	21,579	19,890	7,301	9,744	5,974	22,901
Working Group estimate	20,703	19,714	20,680	27,102	24,978	21,466	21,873	15,379	28,197	25,995

Country	2011 [1]	2012 [1]	2013 [1]	2014	2015 [1]	2016 [1]
Estonia	-	-	-	429	-	-
Faroe Islands	1,705	2,811	2,788	3,393	3,214	4,656
France	150	67	133	-	117	88
Germany	5,782	4,620	3,814	3,701	3,808	4,420
Greenland	3,415	5,239	3,251	1,897	3,642	1,511
Iceland	13,192	13,749	14,859	9,861	12,400	12,652
Ireland	-	-	-	-	-	-
Lithuania	-	99	-	-	-	-
Norway	171	856	614	764	1,126	1,007
Poland	-	786	-	-	-	-
Portugal	-	-	-	-	-	-
Russia	1,095	1,168	1,369	587	600	600
Spain	-	-	-		110	94
United Kingdom	323	12	95		127	348
Total	25,693	29,407	26,923	20,743	25,145	25,377
Working Group estimate	26,347			21,069	25,677	25,397

1) Provisional data

Table 17.2.2 Greenland Halibut. Nominal landings (tonnes) by countries, in Division Va, as officially reported to ICES and estimated by WG.

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]	2016 [1]
Faroe Islands			37	123	585	103	30	18	15
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	12,652
Norway									
Russia	4								
Poland		270							
UK	179								
Total	187	693	14,128	14,048	7,313	15,440	10,476	12,593	12,667
Working Group estimate	11,859	15,782	14,128	14,048	7,313	15,440	10,476	12,593	12,667

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

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	0 [2]	5079	3,951	0	265	1,771	892	873	1,060

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark									
Faroe Islands			1,037	1,476	2,149	2,560	2,953	3,139	4633
France	36		35	1	13	20		28	16
Germany									
Iceland								45	
Ireland									
Norway	1	1	5				3	10	8
United Kingdom	32	117	336	11		2	2	9	
Total	69	118	1,413	1,489	2,162	2,582	2,958	3,231	4,658
Working Group estimate	1,759	1,739	1,413	1,489	2,162	2,582	2,958	3,231	4,658

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

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]	2016 [1]
Estonia							429		
Faroe Islands		270	333		77	125	409	57	7
Germany	4,842	4	4,490	5,206	4,351	3,428	3,114	3,543	4,420
Greenland		2,819		3,258	5,239	3,159	1,897	3,641	1,511
Iceland					7,290		3	46	
Ireland									
Norway	637	29	226	164	853	613	761	1,115	996
Poland	1,354	718	960		786				
Portugal									
Russia	763		1,070	1,095	1,168	1,369	587	600	600
Spain									
United Kingdom	131	452	229	309	1	1			0
Total	7,727	4,292	7,308	10,032	19,765	8,694	7,200	9,002	7,534
Working Group estimate	0	9,805	10,402	10,761			7,526	9,534	7,534

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 ICES and estimated by WG

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]	2016 [1]
Faroe Islands			
France			
Ireland			
Lithuania			
Poland			
Spain [2]	67	91	78
UK			
Russia			
Norway			0
Estonia			
Total	67	91	78
WG estimate	67	91	78

[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

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]	2016 [1]
Estonia			
Faroe Islands	1		1
France		89	72
Poland			
Spain [2]		18	17
UK	42	119	348
Russia			
Norway	0	1	3
Lithuania			
Total	43	227	440
WG estimate	43	227	440

[1] Provisional data

[2] Based on estimates by observers onboard vessels

Table 17.3.1 CPUE indices of trawl fleets in Div 5a, 5b and 14b as derived from GLM

Table 17.3.1. CPUE indices of trawl fleets in Div 5a, 5b and 14b as derived from GLM multiplicative models.

area	year	cpue	% change in CPUE between years	landings	relative derived effort	relative derived effort	% change in effort between years
Iceland 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	39
	1988	0.91	-5	49,379	54	117	-21
	1989	1.05	16	59,272	56	103	-12
	1990	0.75	-28	37,308	49	88	-15
	1991	0.74	-3	35,413	48	97	11
	1992	0.67	-9	31,978	48	100	2
	1993	0.54	-20	34,134	64	133	33
	1994	0.44	-18	28,608	65	102	-23
	1995	0.36	-19	27,391	77	118	16
	1996	0.30	-14	22,073	73	94	-20
	1997	0.32	5	16,792	52	72	-23
	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	0.60	1	16,752	28	114	-7
	2002	0.48	-20	19,714	41	147	29
	2003	0.36	-25	20,415	57	139	-6
	2004	0.30	-17	15,477	52	91	-35
	2005	0.28	-7	13,172	48	91	1
	2006	0.37	32	11,817	32	68	-26
	2007	0.46	25	10,525	23	71	5
	2008	0.40	-13	9,580	24	105	48
	2009	0.42	4	15,782	38	158	51
	2010	0.41	-1	13,565	33	87	-45
	2011	0.43	5	14,048	33	99	13
	2012	0.44	3	7,312	17	51	-49
	2013	0.45	2	15,439	34	206	307
	2014	0.42	-7	10,475	25	73	-65
	2015	0.45	8	12,593	28	112	53
	2016	0.44	-4	12,667	29	105	-6
Greenland, 14b	1991	1.00		875	1	100	0
	1992	0.92	-8	1,176	1	145	45
	1993	2.45	166	2,249	1	72	-50
	1994	3.16	29	3,125	1	108	50
	1995	3.22	2	5,077	2	159	48
	1996	3.19	-1	7,283	2	145	-9
	1997	3.32	4	8,558	3	113	-22
	1998	3.24	-2	5,940	2	71	-37
	1999	2.27	-30	5,376	2	129	81
	2000	2.11	-7	6,958	3	140	8
	2001	2.19	4	7,216	3	100	-29
	2002	2.38	8	6,621	3	85	-15
	2003	2.33	-2	8,017	3	124	46
	2004	2.28	-2	9,854	4	126	2
	2005	3.15	38	10,185	3	75	-41
	2006	3.25	3	8590	3	82	9
	2007	3.07	-5	10261	3	126	54
	2008	3.11	1	8,952	3	86	-32
	2009	2.57	-17	10,567	4	143	65
	2010	2.69	5	10,402	4	94	-34
	2011	2.66	-1	10,761	4	105	11
	2012	3.14	18	12,475	4	98	-6
	2013	2.93	-7	12,476	4	107	9
	2014	3.07	5	7,526	2	57	-46
	2015	3.39	10	9,534	3	115	100
	2016	4.29	26	7,534	2	63	-46
Faroe Islands, 5b	1991	1.00		1,662	2	100	34
	1992	1.84	27	2,269	1	74	-26
	1993	1.03	-82	4,434	4	350	373
	1994	0.36	-36	5,225	15	340	-3
	1995	0.93	56	3,832	4	28	-92
	1996	0.91	-6	6,469	7	173	513
	1997	0.89	-2	4,870	5	77	-56
	1998	0.36	-58	3,825	11	194	153
	1999	0.38	2	4,265	11	105	-46
	2000	0.59	56	5,079	9	78	-26
	2001	0.11	-125	3,245	30	348	347
	2002	0.11	0	2,694	25	83	-76
	2003	0.32	199	2,426	8	30	-63
	2004	0.38	57	1,771	5	61	102
	2005	0.13	-80	892	7	154	151
	2006	0.30	44	873	3	42	-73
	2007	0.33	24	1,060	3	110	165
	2008	0.69	124	1735	3	77	-30
	2009	0.91	67	1760	2	77	0
	2010	1.31	59	1,413	1	56	-28
	2011	1.95	70	1,489	1	71	28
	2012	3.11	88	2,163	1	91	29
	2013	3.33	11	2,560	1	111	21
	2014	2.89	-14	2,958	1	133	20
	2015	1.58	-39	3,139	2	194	46
	2016	2.00	15	4,658	2	117	-39

Table 17.6.1. Assessment input data series: Catch by the fishery; three indices of stock biomass – a standardized catch rate index based on fishery data (CPUE) from the Iceland EEZ, a Icelandic (Ice) and a Greenlandic (Green) research survey index.

Year	Catch (ktons)	CPUE (index)	Survey (ktons)
1960	0	-	-
1961	0.029	-	-
1962	3.071	-	-
1963	4.275	-	-
1964	4.748	-	-
1965	7.421	-	-
1966	8.030	-	-
1967	9.597	-	-
1968	8.337	-	-
1969	26.200	-	-
1970	33.823	-	-
1971	28.973	-	-
1972	26.473	-	-
1973	20.463	-	-
1974	36.280	-	-
1975	23.494	-	-
1976	6.045	-	-
1977	16.578	-	-
1978	14.349	-	-
1979	23.622	-	-
1980	31.157	-	-
1981	19.239	-	-
1982	32.441	-	-
1983	30.891	-	-
1984	34.024	-	-
1985	32.075	1.76	-
1986	32.984	1.75	-
1987	46.622	1.69	-
1988	51.118	1.60	-
1989	61.396	1.86	-
1990	39.326	1.33	-
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	0.54	66
1997	30.309	0.56	90
1998	20.382	0.89	91
1999	20.371	0.97	90
2000	26.644	1.04	101
2001	27.291	1.05	110
2002	29.158	0.84	84
2003	30.891	0.63	52
2004	27.102	0.52	36
2005	24.249	0.49	56
2006	21.432	0.64	39
2007	20.957	0.81	50
2008	22.169	0.70	58
2009	27.349	0.73	80
2010	25.995	0.72	59
2011	26.424	0.76	71
2012	29.309	0.78	82
2013	27.045	0.79	85
2014	21.069	0.74	75
2015	25.677	0.80	80
2016	25.397	0.77	79
2017*	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)	33.45	11.05	26.66	32.53	39.02
K (ktons)	899	250	717	884	1067
r	0.16	0.07	0.11	0.15	0.20
q_{cpue}	0.003	0.001	0.002	0.003	0.003
q_{Survey}	0.26	0.09	0.19	0.24	0.30
P_{1985}	1.57	0.12	1.49	1.57	1.66
P_{2016}	0.73	0.10	0.66	0.72	0.79
σ_{cpue}	0.09	0.02	0.08	0.09	0.11
σ_{Survey}	0.18	0.03	0.15	0.17	0.20
σ_P	0.16	0.03	0.14	0.16	0.17

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	-1.94	0.56		-
1986	-0.90	0.53		-
1987	0.36	0.49		-
1988	2.60	0.41		-
1989	-8.44	0.75		-
1990	3.21	0.39		-
1991	-1.45	0.55		-
1992	-2.96	0.59		-
1993	0.23	0.49		-
1994	0.82	0.48		-
1995	4.06	0.37		-
1996	11.44	0.17	-12.82	0.74
1997	16.73	0.09	-35.76	0.97
1998	-3.64	0.62	-10.30	0.70
1999	-1.68	0.56	1.19	0.47
2000	-1.50	0.55	-3.15	0.57
2001	-3.13	0.60	-12.71	0.75
2002	-1.20	0.54	-5.62	0.62
2003	-0.59	0.52	13.44	0.24
2004	-0.98	0.53	29.71	0.06
2005	6.61	0.28	-11.17	0.72
2006	-9.22	0.77	36.15	0.03
2007	-15.37	0.90	28.34	0.07
2008	-1.28	0.54	13.22	0.24
2009	0.76	0.47	-13.10	0.76
2010	-1.01	0.53	14.15	0.23
2011	-0.59	0.52	0.90	0.48
2012	1.53	0.45	-8.22	0.67
2013	1.19	0.46	-10.67	0.71
2014	3.38	0.39	-2.70	0.56
2015	-0.03	0.50	-4.38	0.59
2016	2.57	0.42	-5.05	0.60

Table 17.6.5. Upper: stock status for 2016 and predicted to the end of 2017. Lower: predictions for 2018 with catch options from 0 to 30 ktons and the catch option corresponding to Fmsy (50% prob of exceeding Fmsy).

Status	2016	2017 *
Risk of falling below $B_{msy\_trigger}$	0%	0%
Risk of falling below B_{MSY}	100%	93%
Risk of exceeding F_{MSY}	70%	56%
Risk of exceeding F_{lim} ($1.7F_{MSY}$)	16%	15%
Stock size (B/Bmsy), median	0.72	0.73
Fishing mortality (F/Fmsy),	1.10	1.07
Productivity (% of MSY)	92%	93%

*Predicted catch in 2017 = 25ktons

Catch option 2018 (ktons)	0	5	10	15	20	24	30
Prob. of falling below B_{LIM}	0%	0%	0%	0%	0%	0%	0%
Risk of falling below B_{MSY}	81%	82%	83%	85%	85%	87%	86%
Risk of exceeding F_{MSY}	-	1%	5%	15%	35%	**50%**	55%
Risk of exceeding F_{lim} ($1.7F_{MSY}$)	-	0%	1%	3%	8%	15%	16%
Stock size (B/Bmsy), median	0.80	0.79	0.77	0.76	0.75	0.74	0.74
Fishing mortality (F/Fmsy),	-	0.20	0.40	0.61	0.83	0.99	1.05
Productivity (% of MSY)	96%	95%	95%	94%	94%	93%	93%

Table 17.6.6. Summary of assessment.

Year	Catch (ktons)	low	B/Bmsy	high	low	F/Fmsy	high
1960	0.000	1.891	2.004	2.117	0.000	0.000	0.000
1961	0.029	1.896	2.005	2.110	0.000	0.000	0.001
1962	3.071	1.899	2.004	2.108	0.029	0.047	0.090
1963	4.275	1.894	1.995	2.099	0.040	0.066	0.125
1964	4.748	1.886	1.986	2.091	0.045	0.074	0.140
1965	7.421	1.878	1.977	2.083	0.071	0.116	0.219
1966	8.030	1.864	1.963	2.071	0.077	0.126	0.238
1967	9.597	1.851	1.950	2.060	0.092	0.152	0.287
1968	8.337	1.836	1.935	2.046	0.080	0.133	0.251
1969	26.200	1.824	1.927	2.038	0.253	0.420	0.794
1970	33.823	1.765	1.875	1.998	0.334	0.558	1.051
1971	28.973	1.685	1.813	1.949	0.293	0.496	0.930
1972	26.473	1.633	1.773	1.916	0.272	0.465	0.871
1973	20.463	1.594	1.743	1.894	0.212	0.366	0.688
1974	36.280	1.581	1.731	1.883	0.377	0.653	1.235
1975	23.494	1.518	1.682	1.848	0.248	0.436	0.827
1976	6.045	1.505	1.669	1.841	0.064	0.113	0.216
1977	16.578	1.543	1.700	1.865	0.173	0.303	0.589
1978	14.349	1.542	1.701	1.867	0.149	0.262	0.512
1979	23.622	1.547	1.708	1.873	0.244	0.429	0.846

1980	31.157	1.526	1.690	1.860	0.323	0.572	1.134
1981	19.239	1.488	1.657	1.835	0.202	0.361	0.717
1982	32.441	1.484	1.658	1.837	0.340	0.607	1.218
1983	30.891	1.442	1.626	1.813	0.328	0.590	1.189
1984	34.024	1.408	1.601	1.793	0.365	0.660	1.339
1985	32.075	1.369	1.570	1.772	0.348	0.635	1.296
1986	32.984	1.278	1.572	1.944	0.345	0.653	1.351
1987	46.622	1.236	1.536	1.927	0.496	0.944	1.958
1988	51.118	1.192	1.486	1.874	0.560	1.069	2.223
1989	61.396	1.229	1.549	1.960	0.639	1.237	2.566
1990	39.326	0.993	1.243	1.576	0.513	0.984	2.037
1991	37.950	0.919	1.152	1.456	0.534	1.027	2.130
1992	35.487	0.822	1.028	1.302	0.559	1.074	2.222
1993	41.247	0.684	0.853	1.077	0.785	1.505	3.114
1994	37.190	0.564	0.702	0.889	0.860	1.646	3.404
1995	36.288	0.477	0.593	0.752	0.997	1.899	3.934
1996	35.932	0.439	0.547	0.699	1.072	2.035	4.238
1997	30.309	0.477	0.597	0.775	0.817	1.574	3.275
1998	20.382	0.622	0.777	0.985	0.423	0.818	1.700
1999	20.371	0.693	0.864	1.087	0.383	0.735	1.524
2000	26.644	0.745	0.928	1.168	0.465	0.894	1.854
2001	27.291	0.737	0.921	1.164	0.478	0.924	1.914
2002	29.158	0.604	0.751	0.945	0.630	1.209	2.506
2003	30.891	0.458	0.568	0.709	0.893	1.692	3.508
2004	27.102	0.375	0.467	0.583	0.956	1.804	3.751
2005	24.249	0.382	0.473	0.596	0.837	1.590	3.293
2006	21.432	0.421	0.530	0.664	0.661	1.262	2.618
2007	20.957	0.497	0.631	0.793	0.540	1.037	2.153
2008	22.169	0.503	0.626	0.784	0.649	1.237	2.562
2009	27.349	0.536	0.666	0.839	0.667	1.279	2.653
2010	25.995	0.519	0.645	0.810	0.657	1.254	2.599
2011	26.424	0.551	0.684	0.859	0.629	1.203	2.495
2012	29.309	0.577	0.716	0.904	0.664	1.273	2.636
2013	27.045	0.581	0.723	0.913	0.606	1.164	2.411
2014	21.069	0.557	0.692	0.874	0.494	0.946	1.964
2015	25.677	0.582	0.724	0.912	0.576	1.103	2.297
2016	25.397	0.568	0.715	0.910	0.571	1.103	2.324
2017		0.513	0.7283	1.042	0.512	1.07	2.385

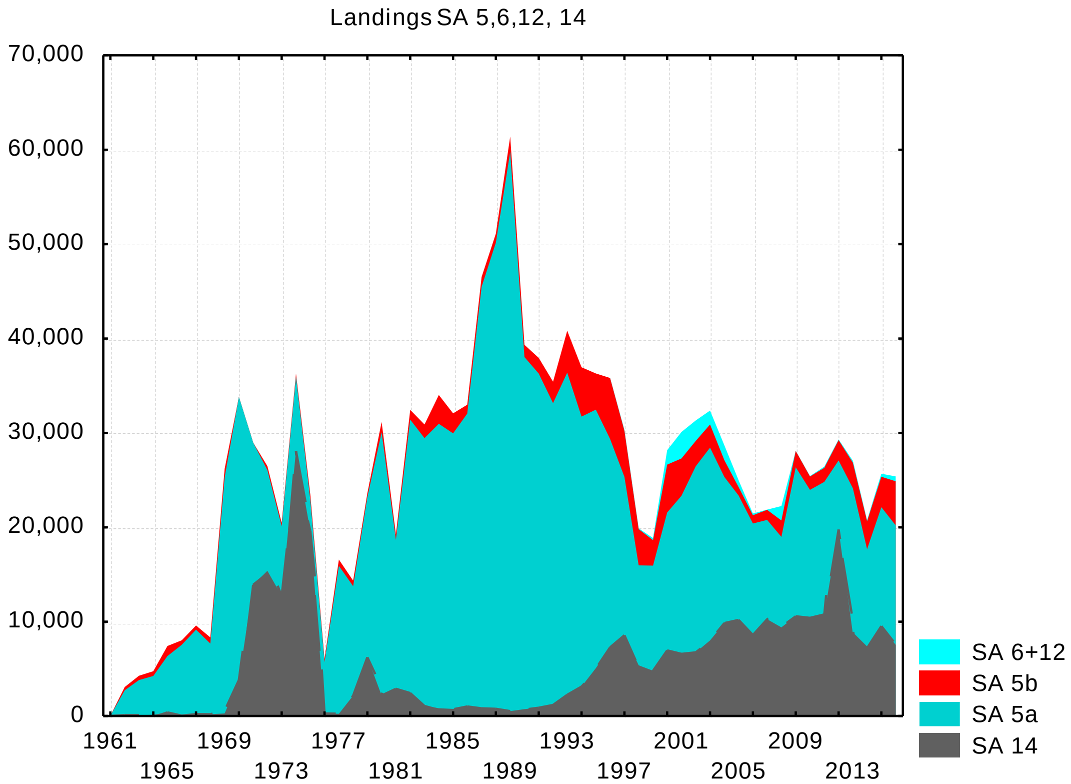


Fig. 17.2.1. Landings of Greenland halibut in Divisions 5, 6, 12 and 14. As the landings within Icelandic waters, since 1976, have not officially been separated and reported according to the defined ICES statistical areas, they are set under area 5a by the NWWG. In 2012 Icelandic landings in Div 14 were only partly recorded in 14, while for remaining years all landings are recorded in 5a.

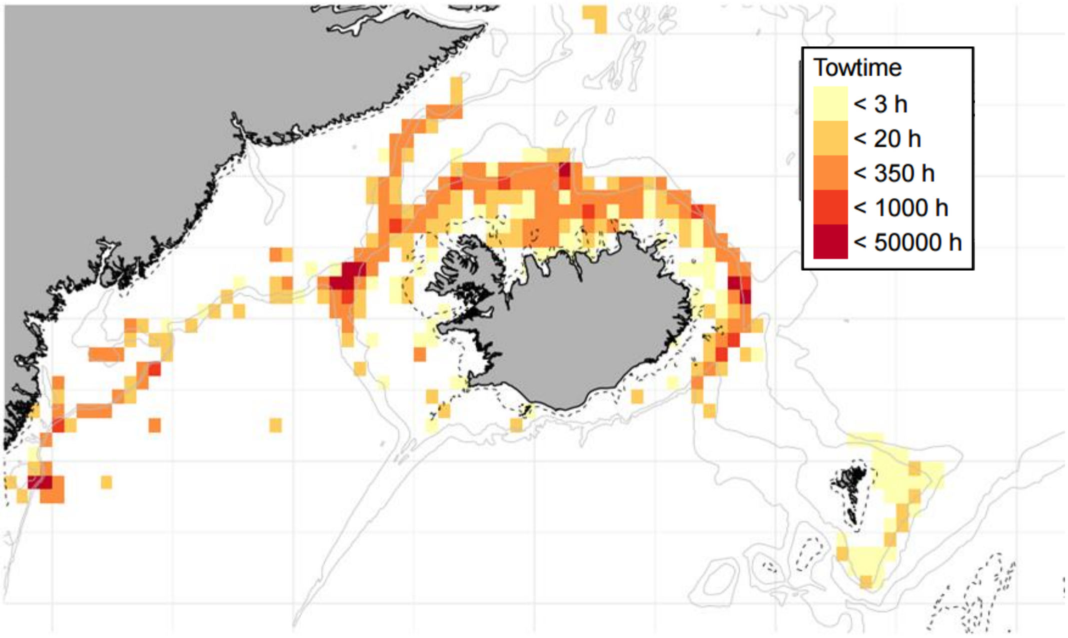


Fig. 17.2.2 Greenland halibut V+XIV. Distribution of fishing effort in 2016. 500m and 1000 m depth contours are shown.

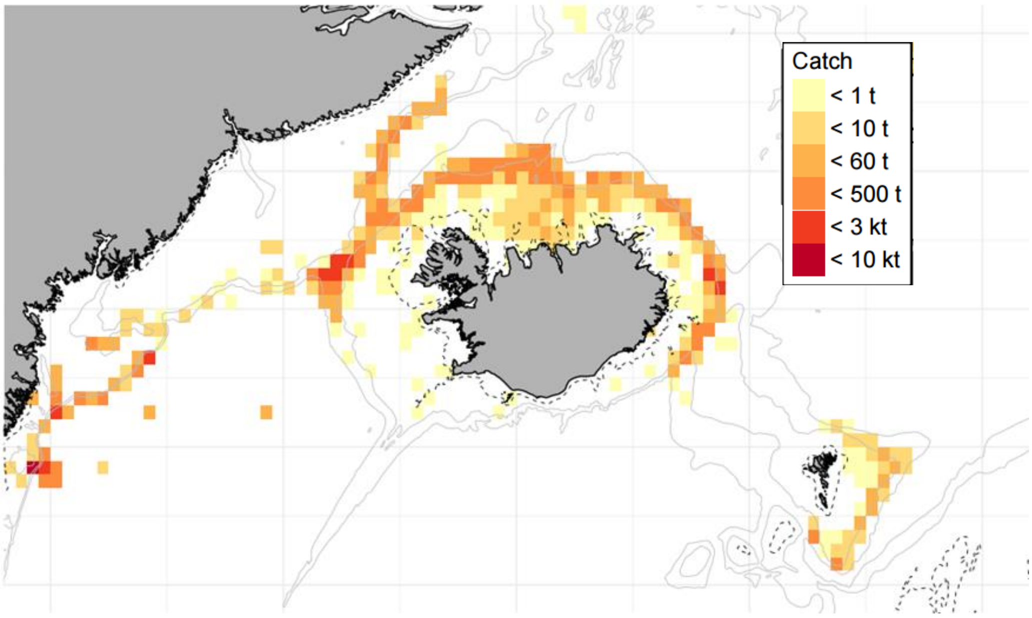


Fig. 17.2.3. Greenland halibut V+XIV. Distribution of catches in the fishery in 2016. 500m and 1000 m depth contours are shown.

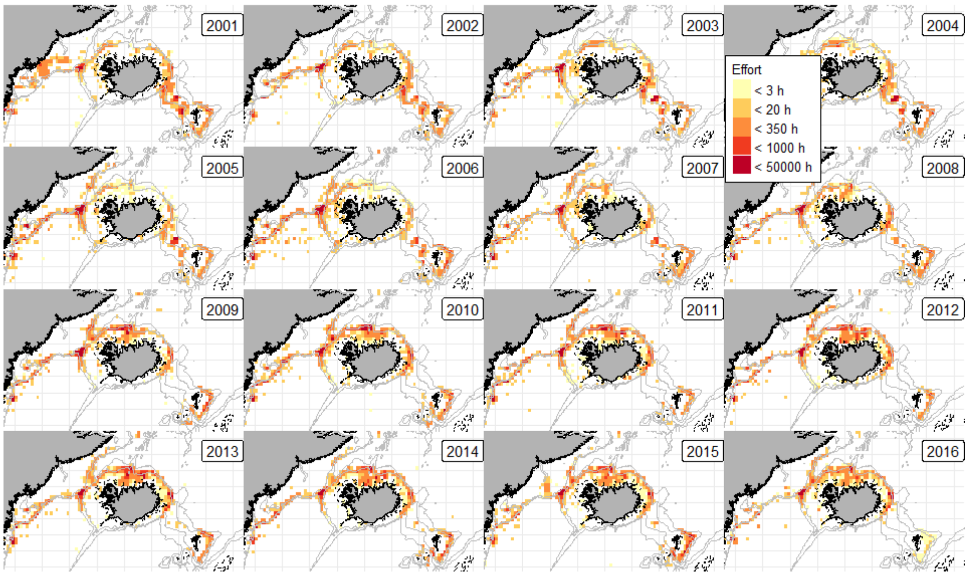


Fig. 17.2.4. Greenland halibut V+XIV. Distribution of total fishing effort 2000-2016. The 500m and 1000 m depth contours are shown.

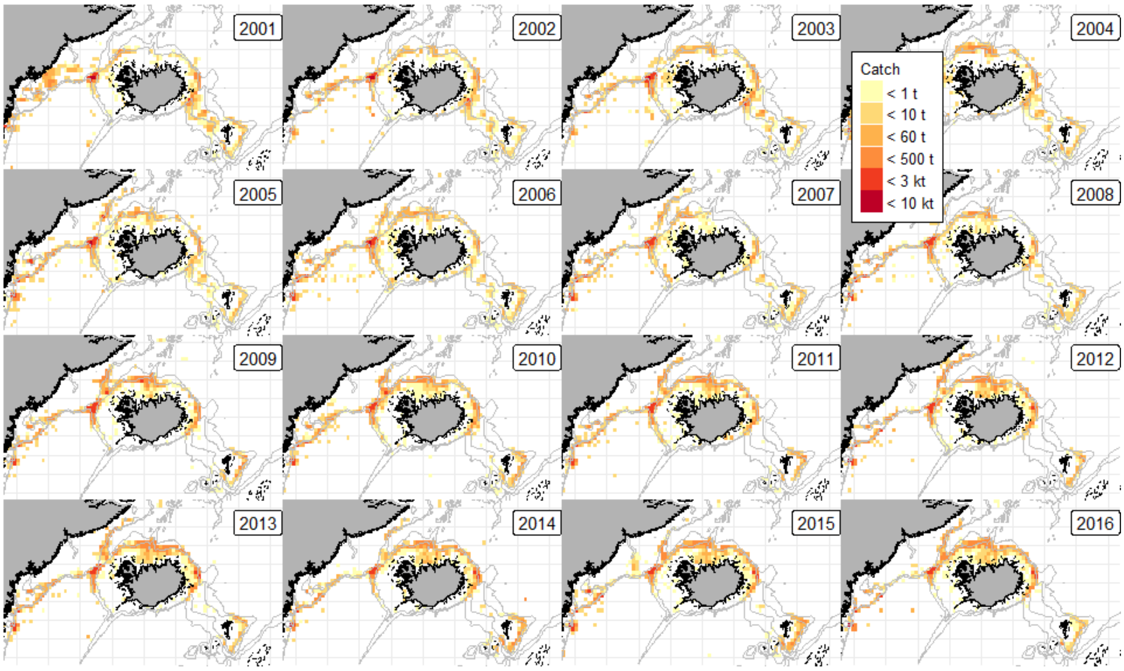


Fig. 17.2.5. Greenland halibut V+XIV. Distribution of total catches in the fishery 2000-2016 500m and 1000 m depth contours are shown.

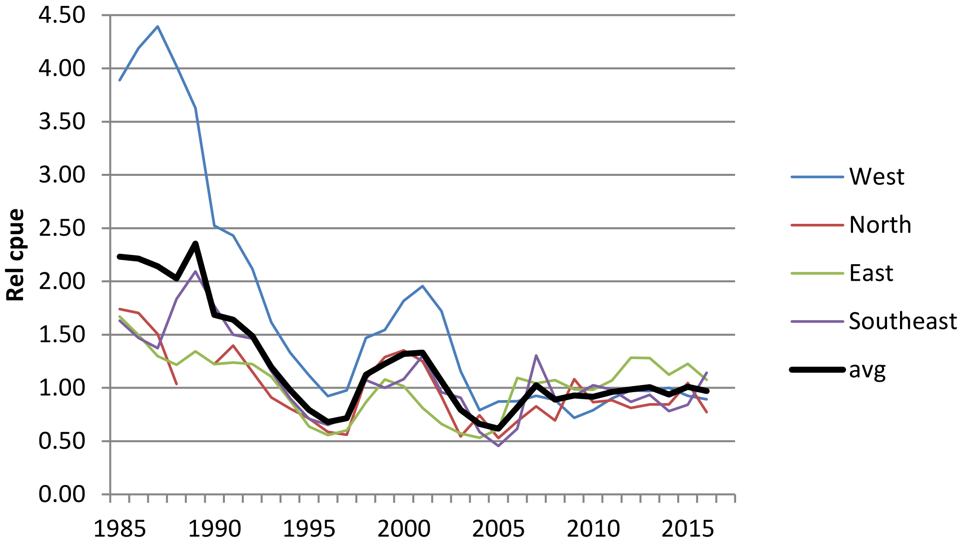


Fig. 17.3.1. Standardised CPUEs from the Icelandic trawler fleet in Va. Area 1-4 are west, north, east and south-east. The average index of the four areas are used as biomass indicator in the stock production model.

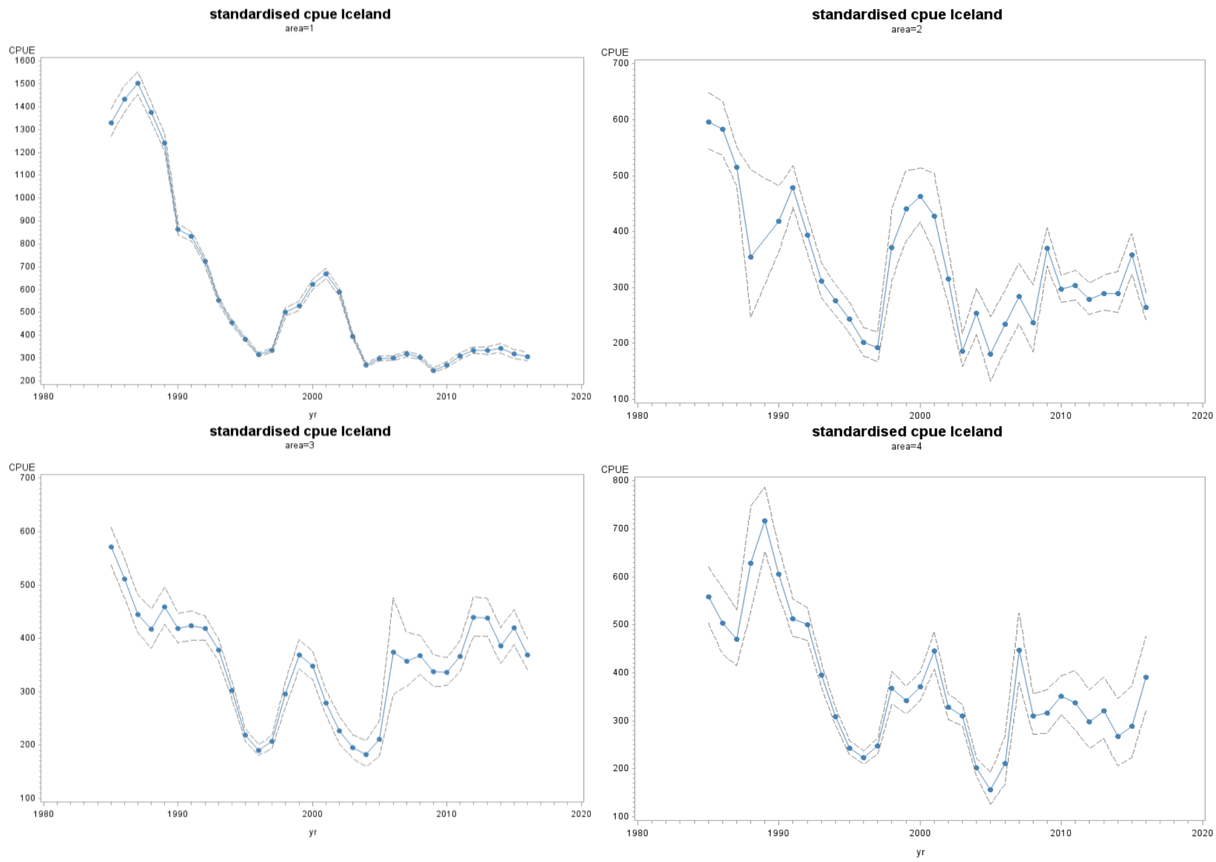


Fig. 17.3.2 Standardised CPUE from the Icelandic trawler fleet in 5a by four main fishing areas in 5a. 95% CI indicated.

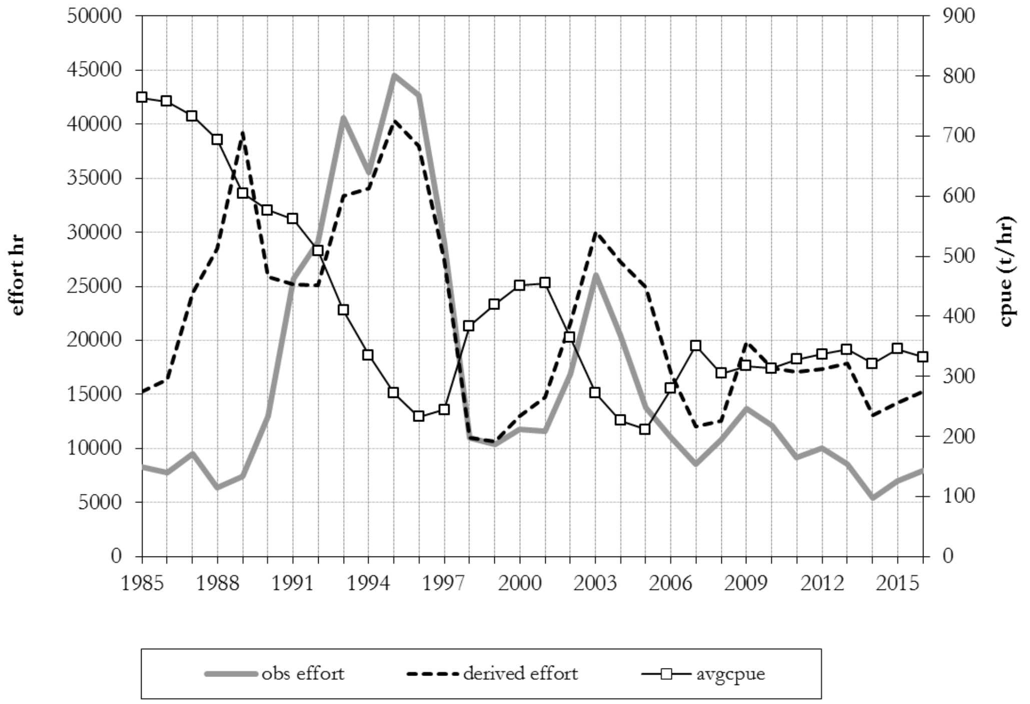


Fig. 17.3.3. Standardised CPUE, observed and derived effort from Icelandic trawl fishery.

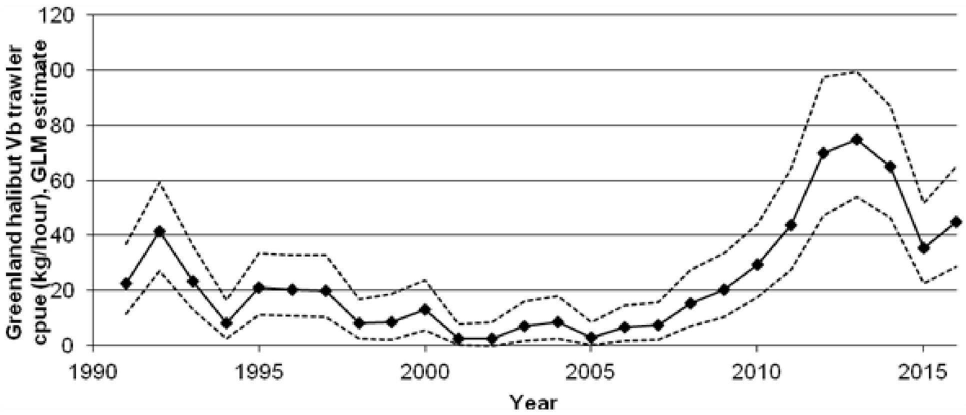


Figure 17. 3.4. Standardised CPUE from the Faroese trawler fleet. 95% CI indicated

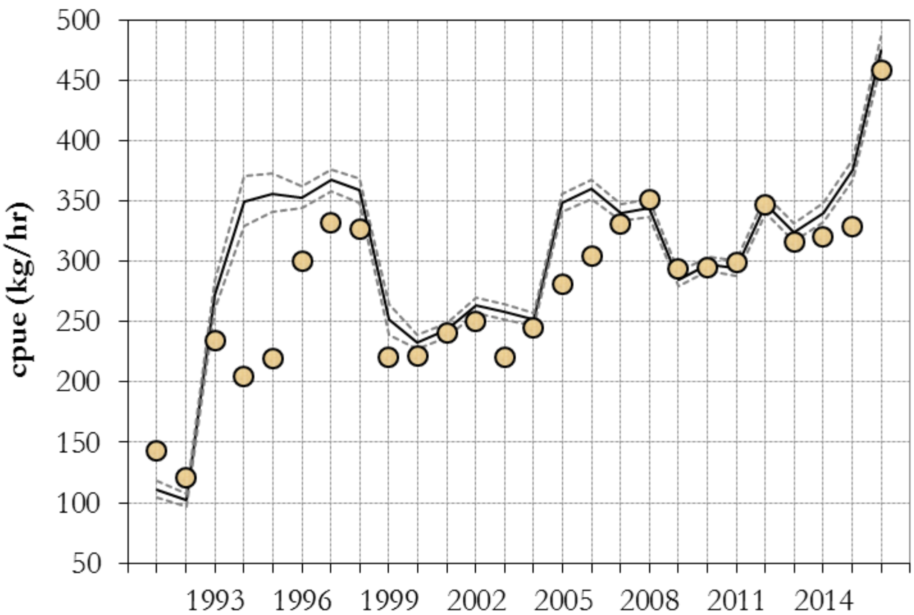


Fig. 17.3.5. Standardised CPUE from trawler fleets in 14b. 95% CI indicated. Points are observed CPUE (avg).

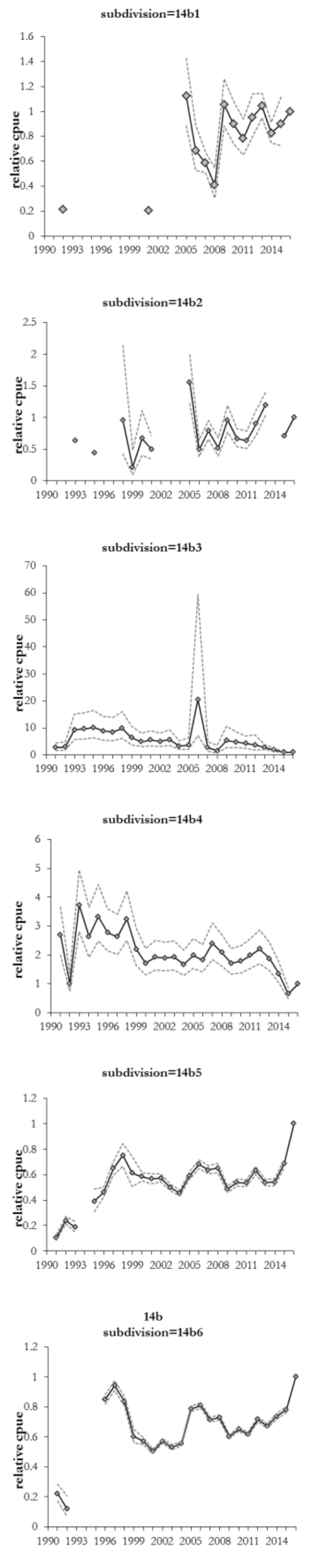


Fig. 17.3.6. Standardised CPUE from trawler fleets in 14b shown by subdivisions in a north-south direction. 95% CI indicated.

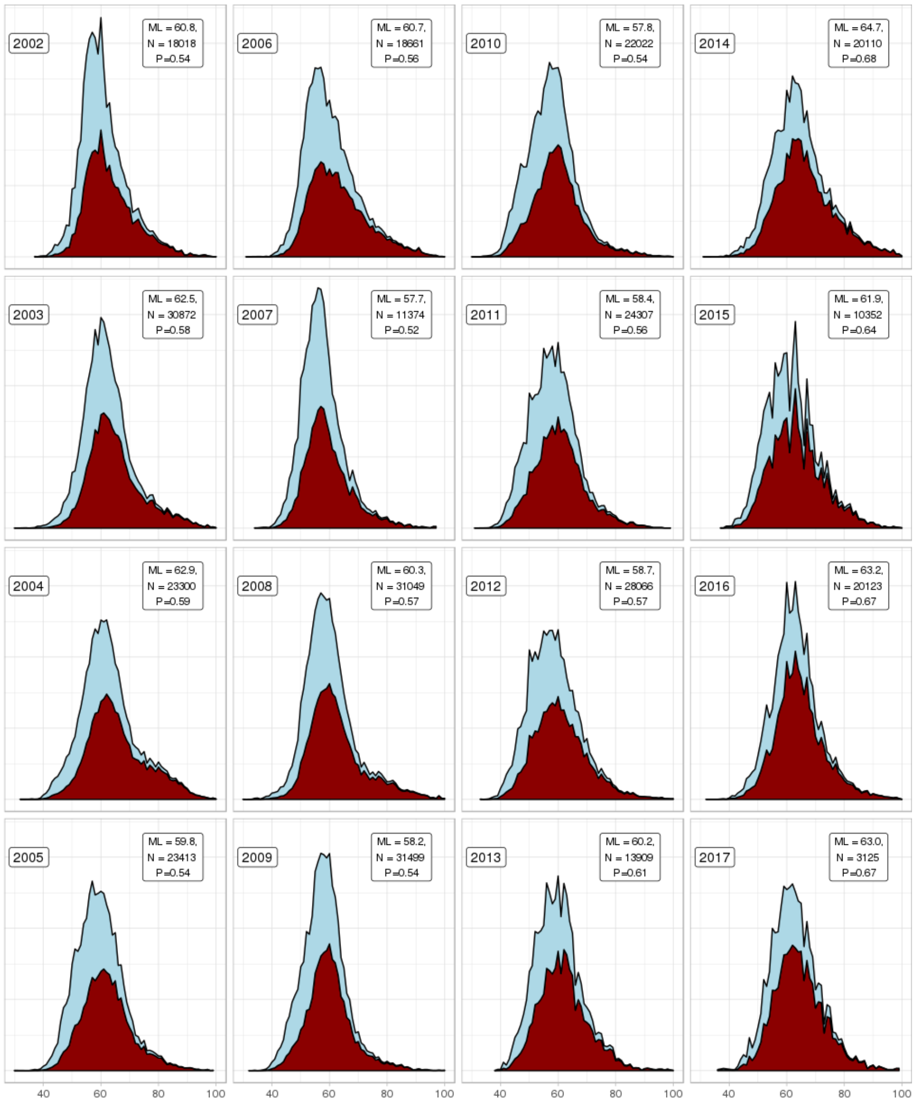


Fig. 17.4.1. Length distributions from the commercial trawl fishery in the western fishing grounds of Iceland (5a) in the years 2002-2017. Blue indicate males and red indicates females.

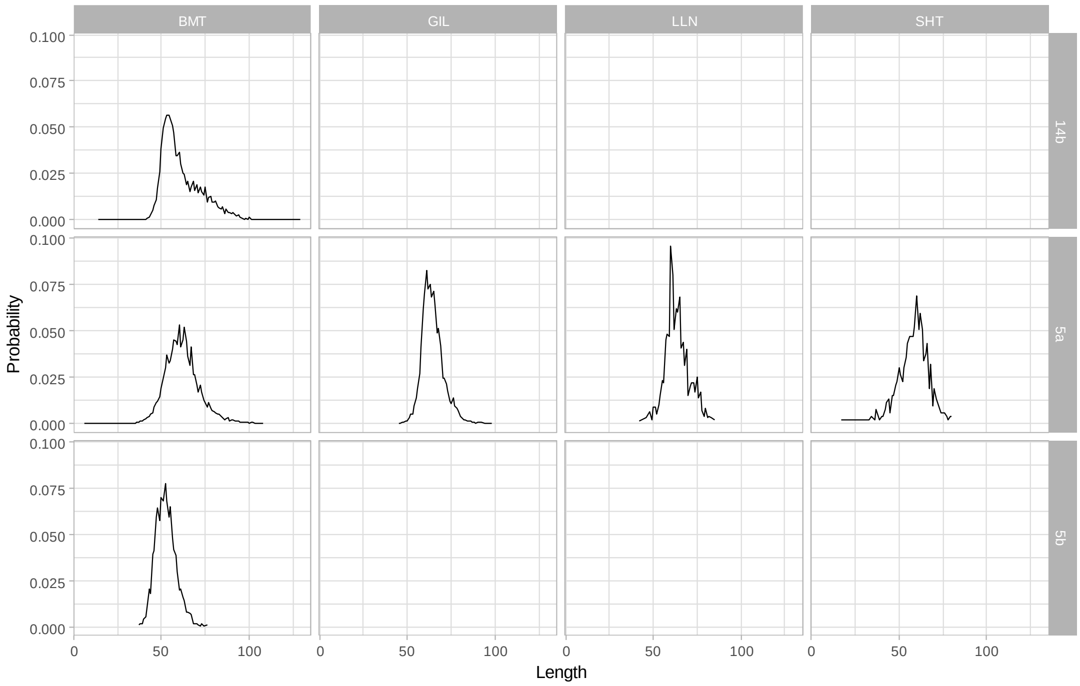


Fig. 17.4.2. Length distributions from the commercial fishery in Subareas 5 and 14 by gear (BMT=bottom trawl, LLN=longlines, SHT=shrimp trawl and GIL = gillnets) in 2016.

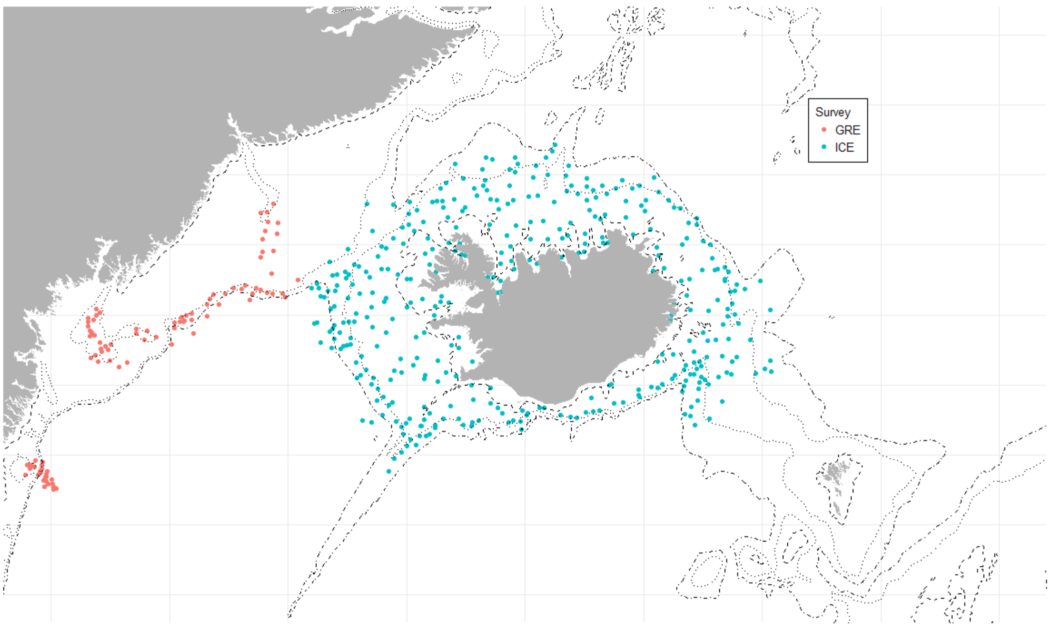


Fig. 17.5.1. Stations covered by scientific surveys in XIV+V indicated as station positions in 2016 by the Greenland (n= 97) and Iceland (n=372).

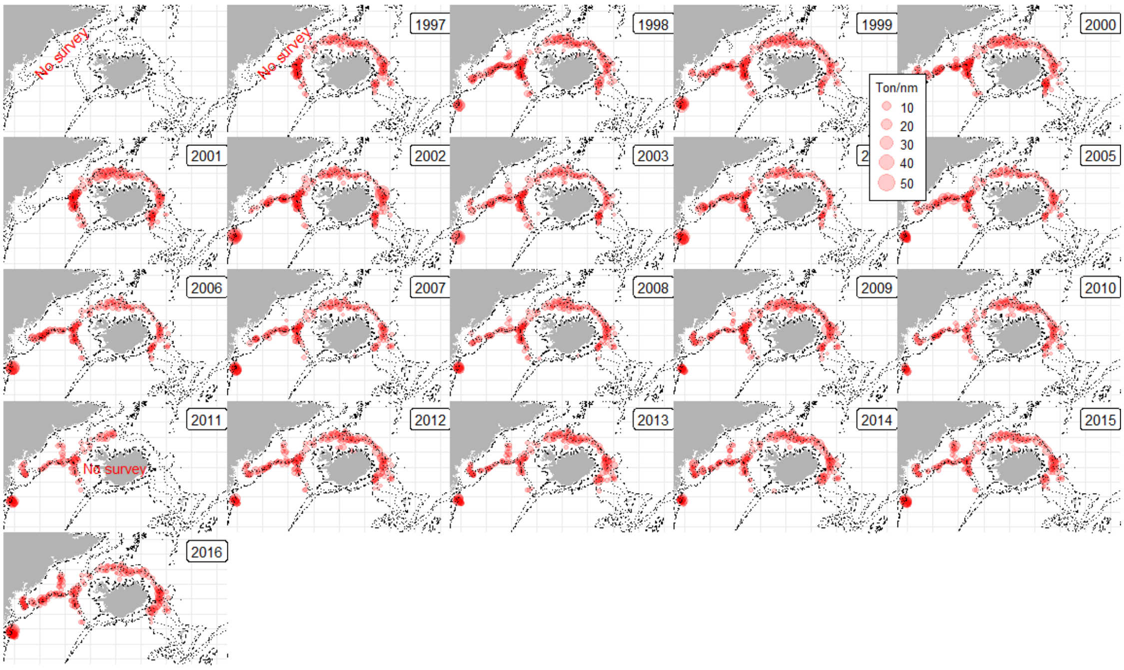


Fig. 17.5.2. Distribution of Greenland halibut catch rates from the combined Greenland-Icelandic fall survey since 1996.

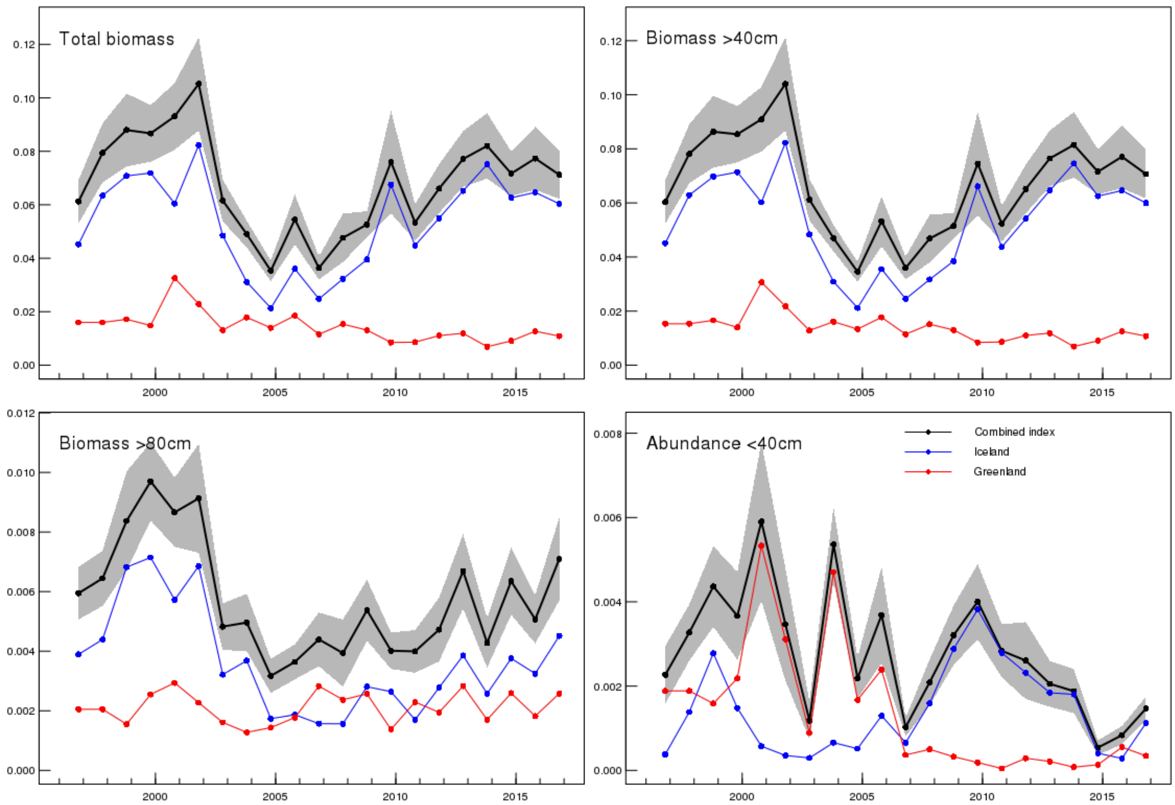


Fig. 17.5.3. Index of Greenland halibut in the Iceland, Greenland and the combined survey. No Iceland survey was conducted in 2011.

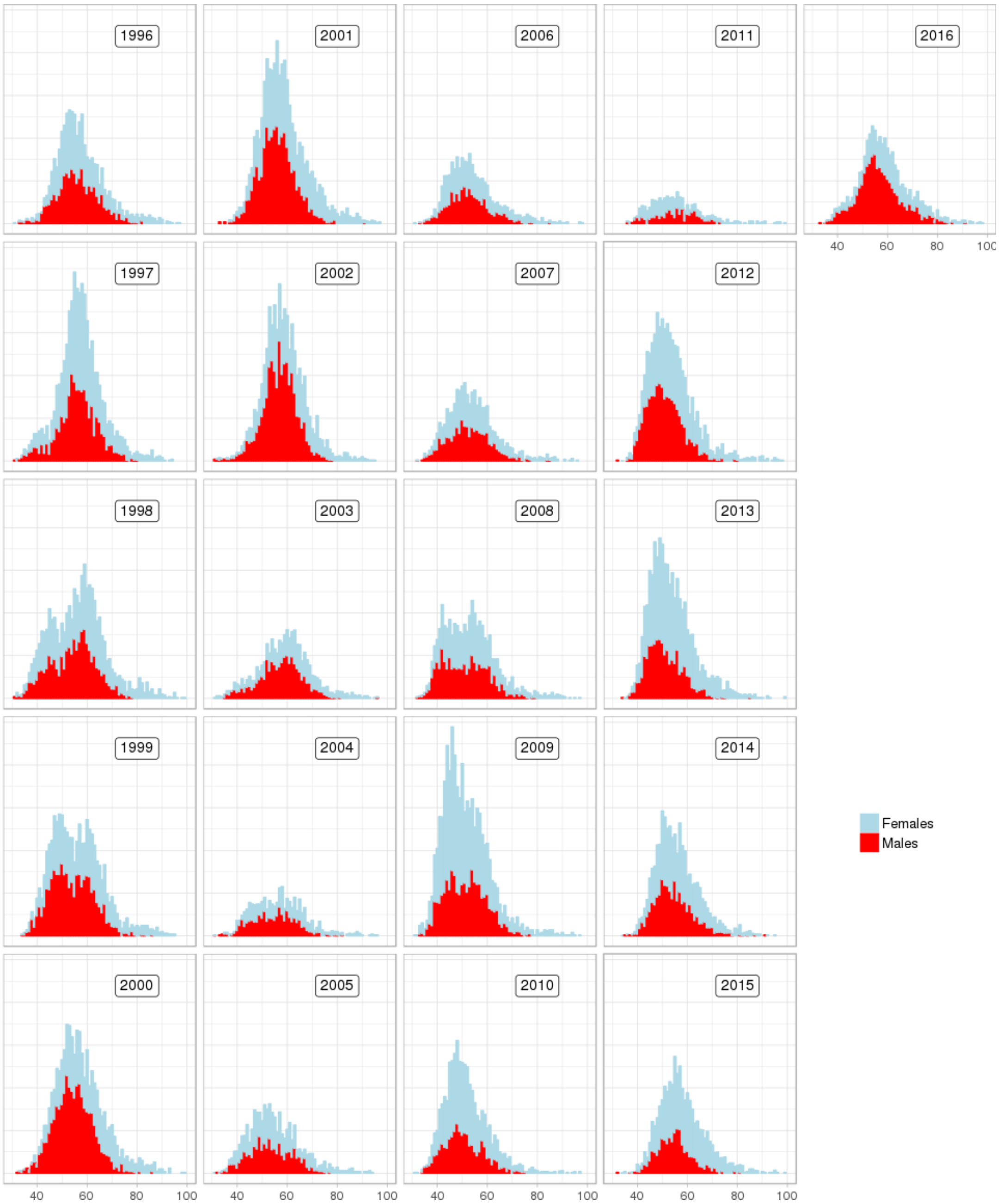


Fig. 17.5.4. Abundance indices by length for the Icelandic fall survey 1996-2015. No survey was conducted in 2011.

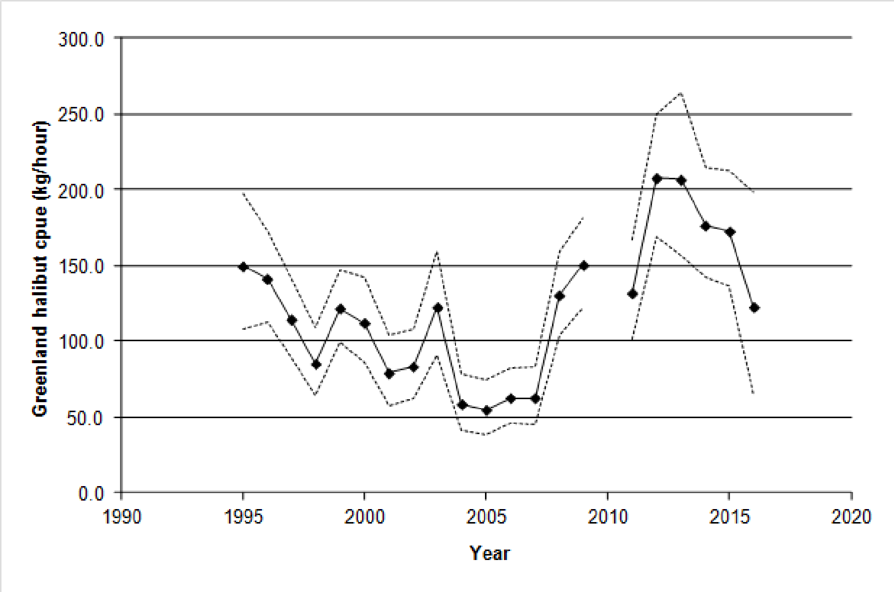


Figure 17.5.5. Catch rates from a combined survey/fisherman's survey in Vb. Estimates are from a GLM model.

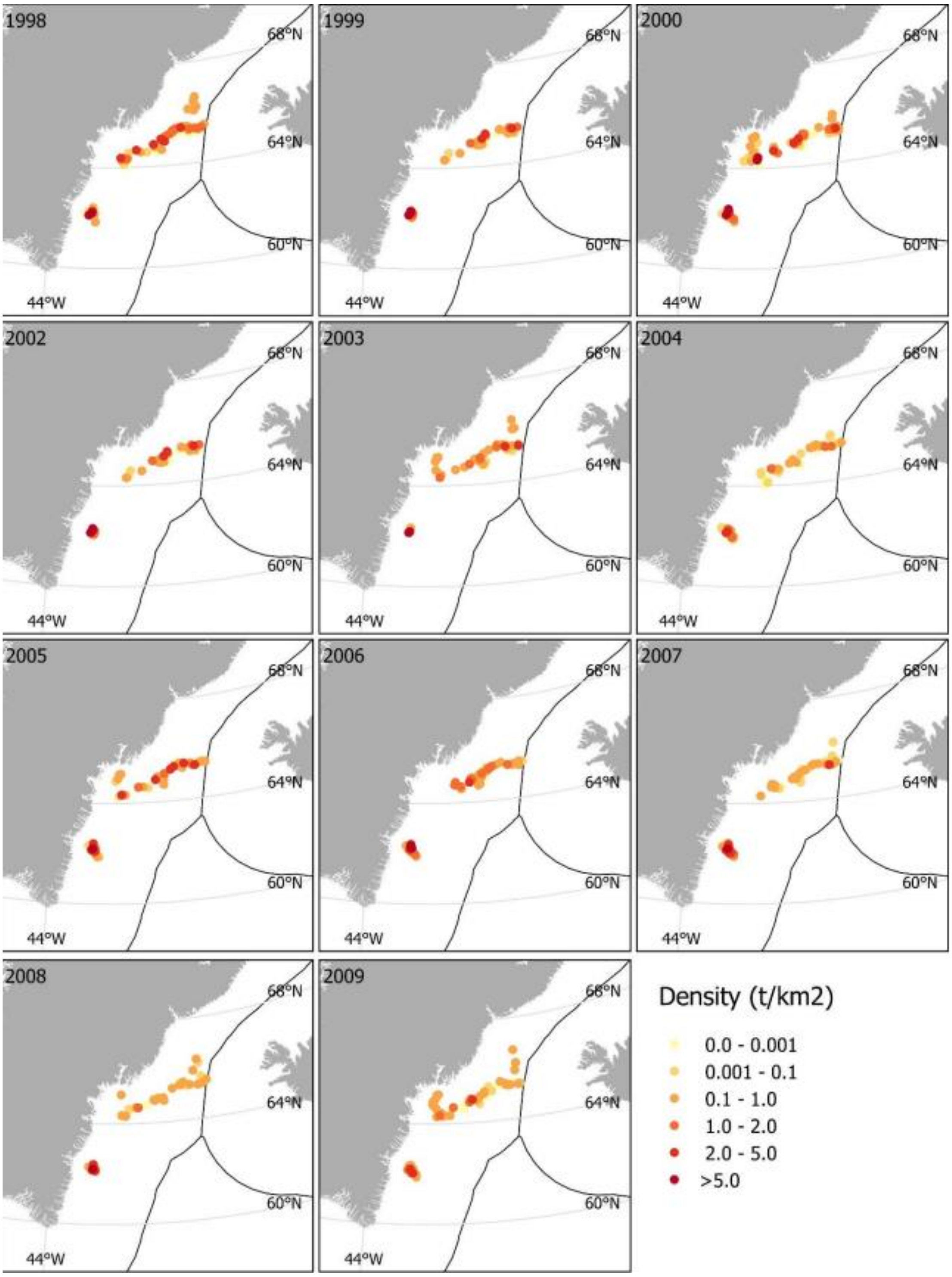


Fig. 17.5.6. Distribution of catches of Greenland halibut at East Greenland in 1998 – 2009 in the Greenland deep-water survey.

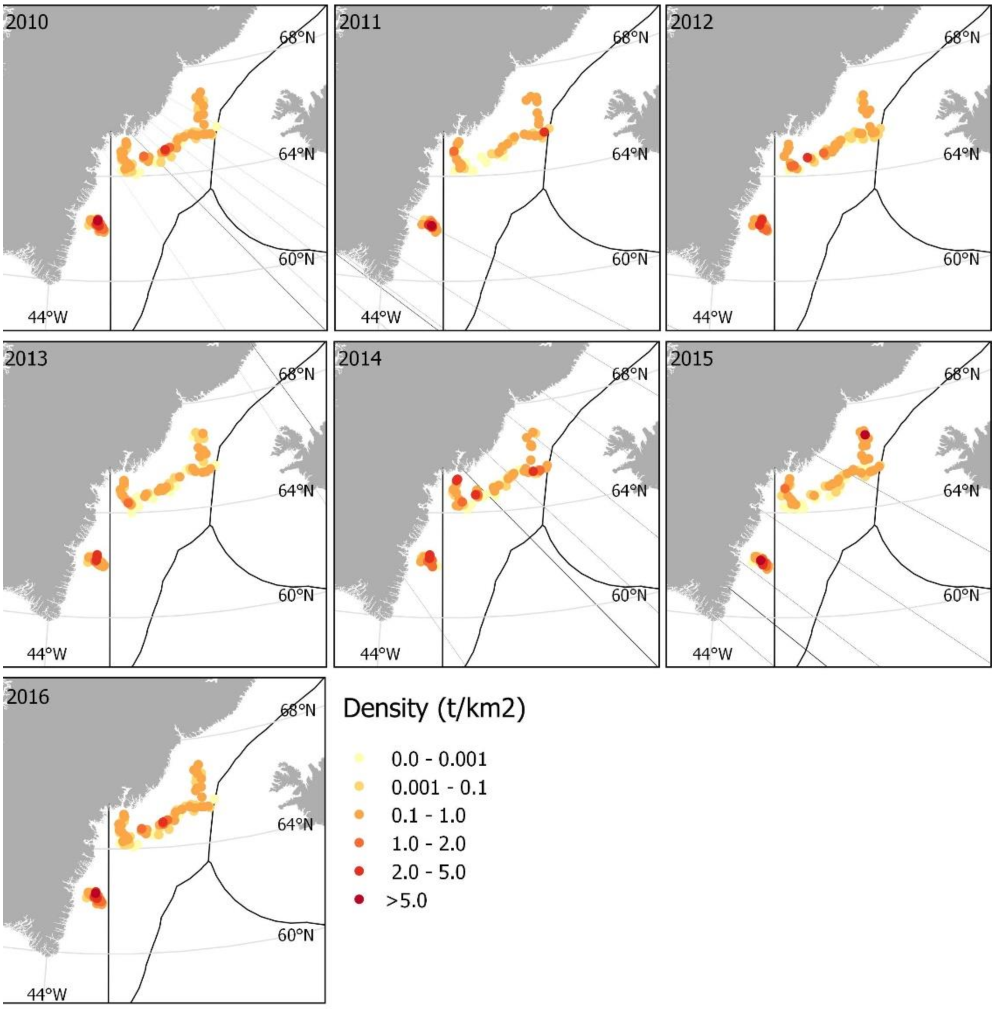


Fig. 17.5.6 continued. Distribution of catches of Greenland halibut at East Greenland in 2010 – 2016b in the Greenland deep-water survey.

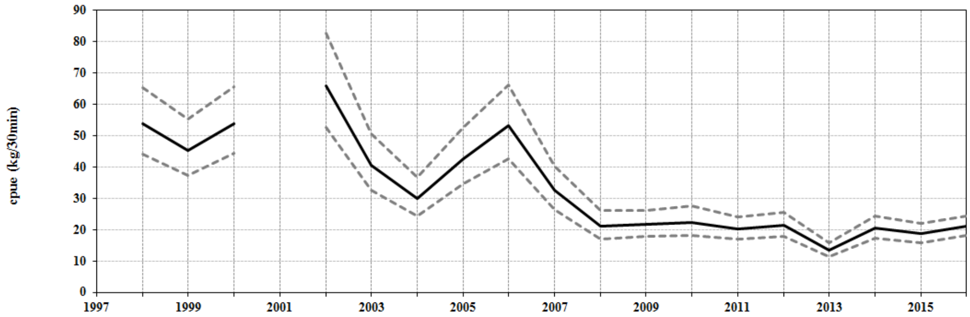


Fig. 17.5.7. Standardised catch rates from the Greenland survey.(95% CI indicated.)

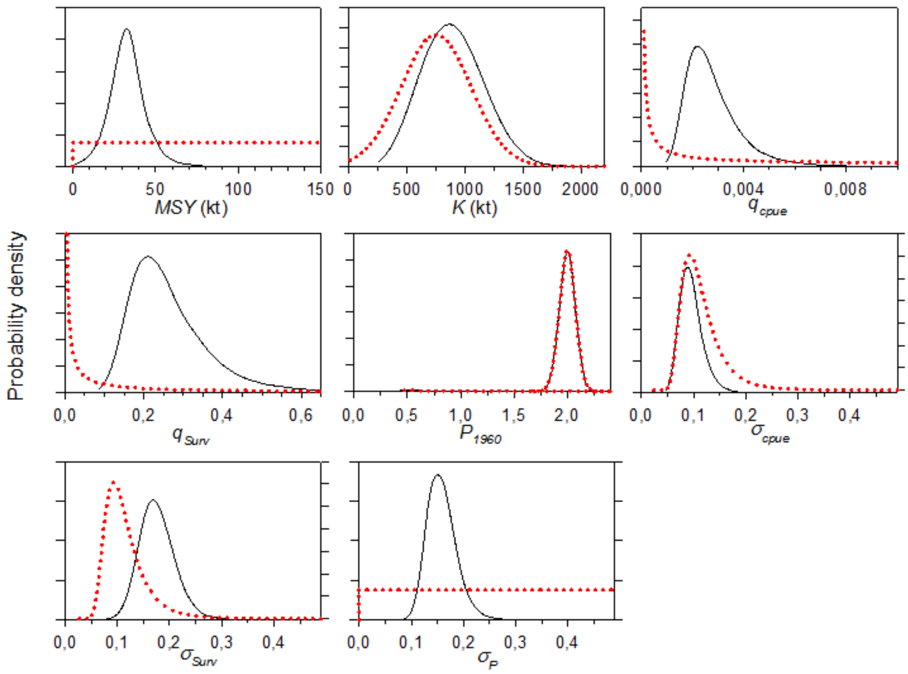


Figure 17.6.1. Probability density distributions of model parameters: estimated posterior (solid line) and prior (broken line) distributions.

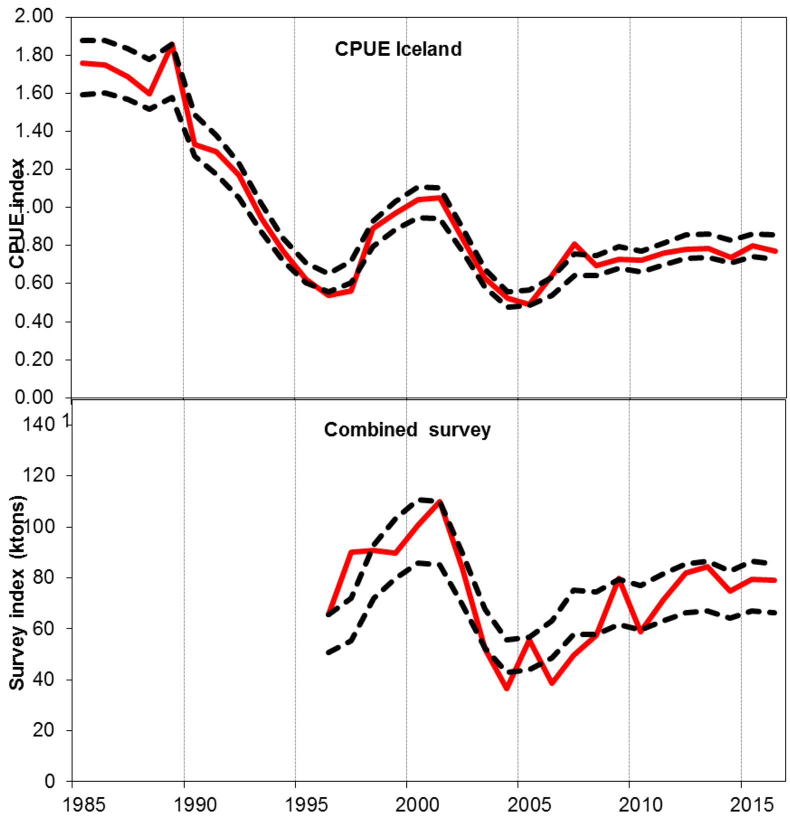


Figure 17.6.2. Observed (red curve) and predicted (dashed lines) series of the two biomass indices input to the model. Dashed lines are inter-quartile range of the posteriors.

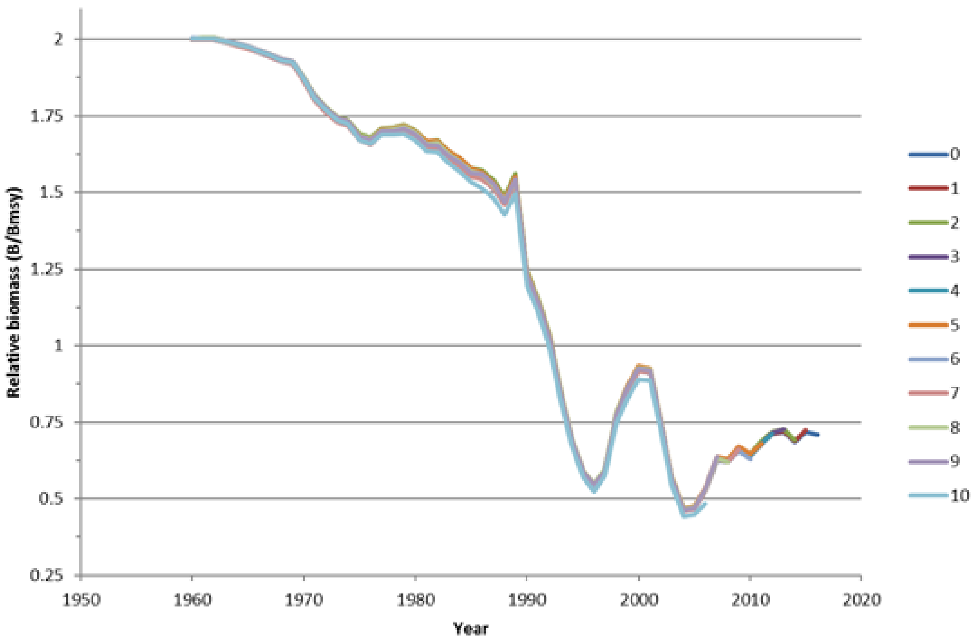


Figure 17.6.3. Retrospective plot of median relative biomass (*B*/*B*$_{msy}$).

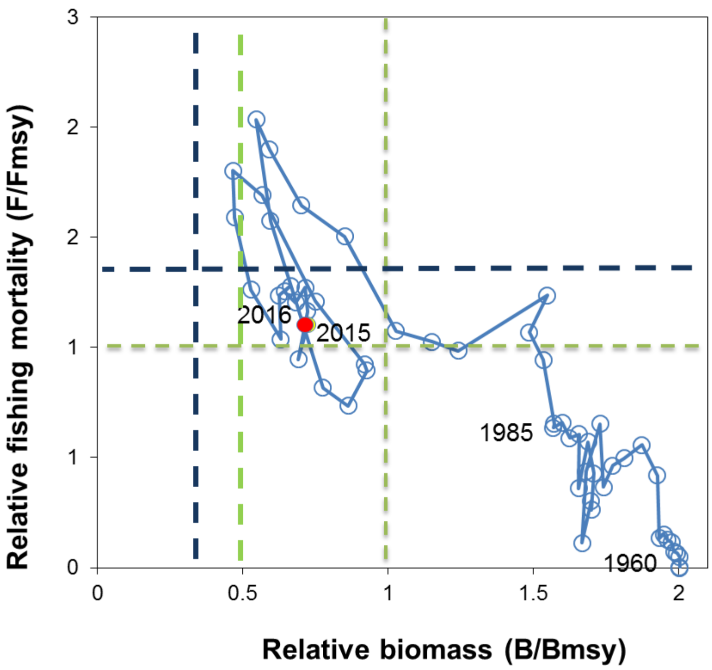


Figure 17.6.4. Stock trajectory. Estimated annual median biomass-ratio (B/BMSY) and fishing mortality-ratio (F/FMSY). B$_{lim}$, MSY B$_{trigger}$ and F$_{lim}$ are indicated. 2015 and 2016 estimates are nearly equal (points on top of each other).

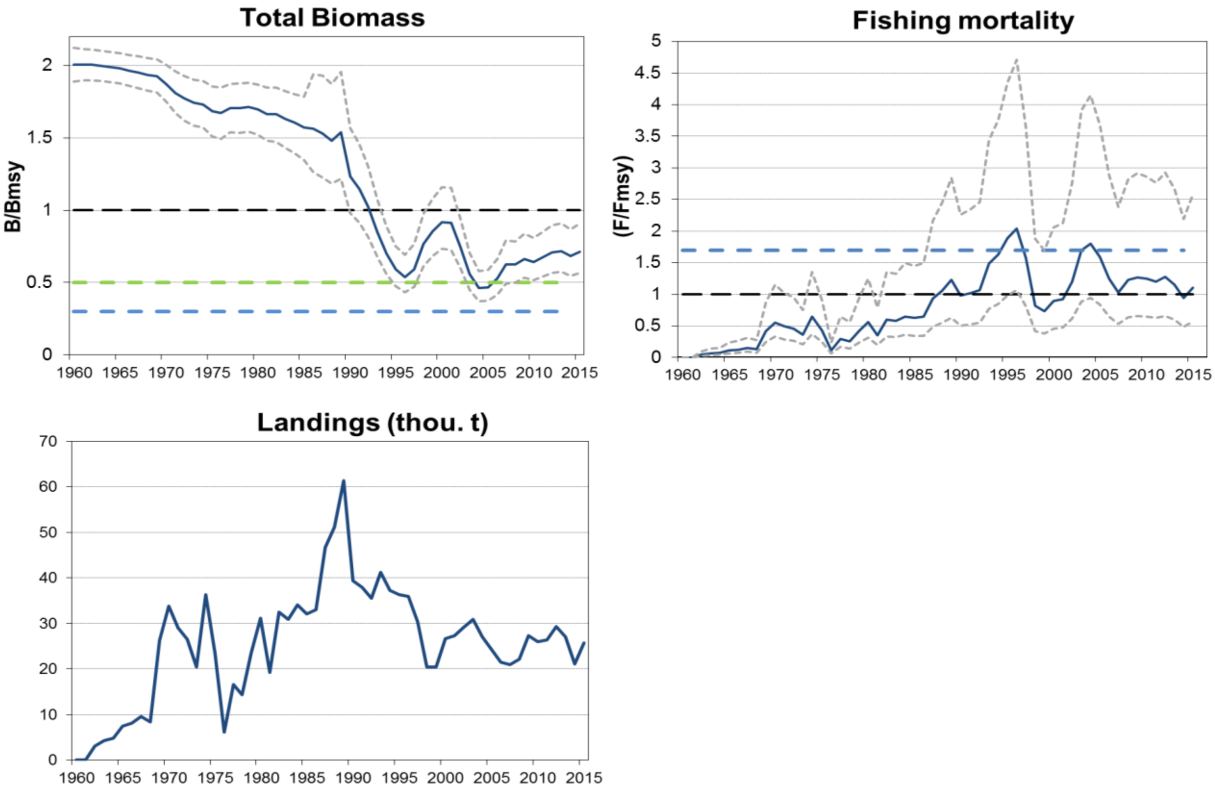


Figure 17.6.5. Stock summary, upper panel right: fishing mortality (F/Fmsy) and 95% conf limits, left: total biomass (B/Bmsy) and 95% conf limits and lower panel is landings since start of the fishery. MSY $B_{trigger}$ (green dashed line), B_{lim} and F_{lim} (blue dashed lines) are indicated.

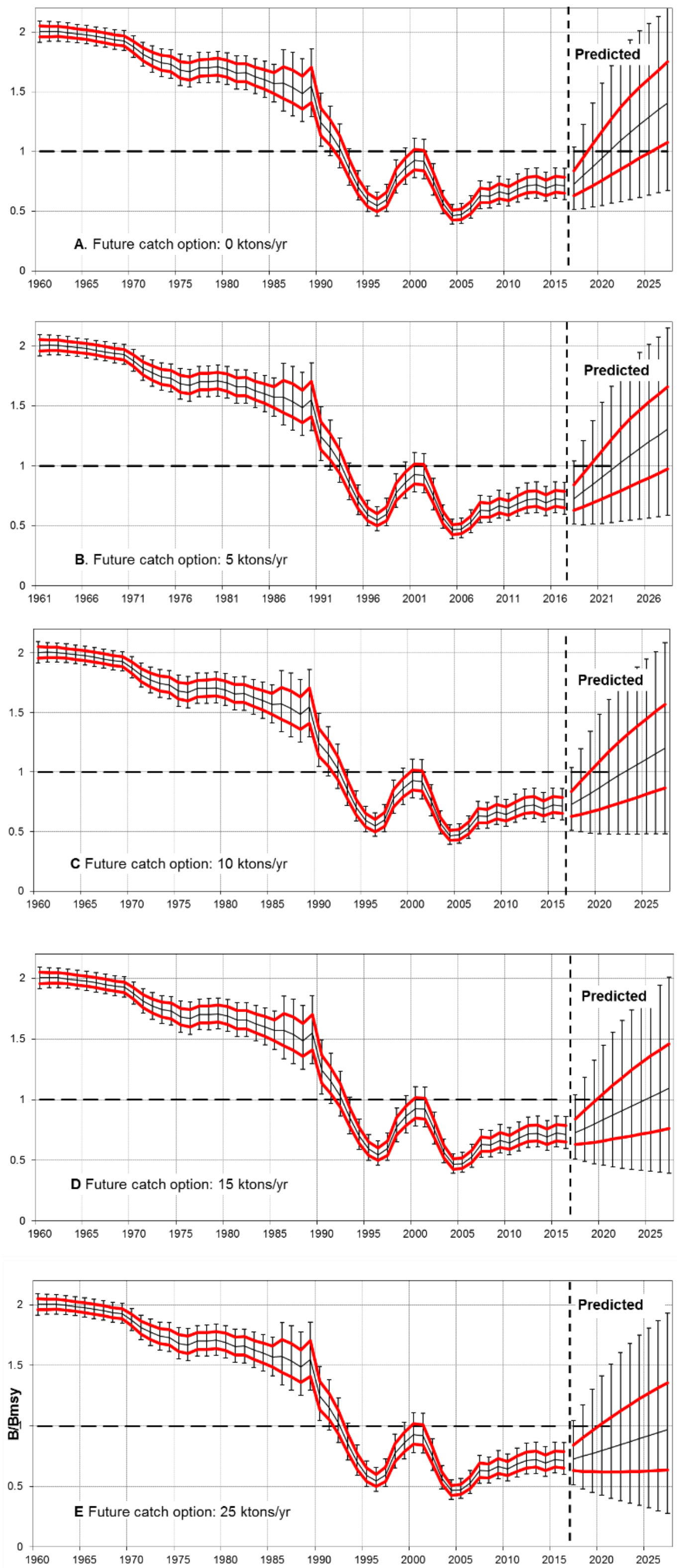


Fig. 17.6.6 Estimated time series of relative biomass (B_t/B_{msy}) under different catch option scenarios: 0, 5, 10, 15 and 25 kt from upper to lower panel. Bold red lines are inter-quartile ranges and the solid black line is the median; the error bars extend to cover the central 90 per cent of the distribution.

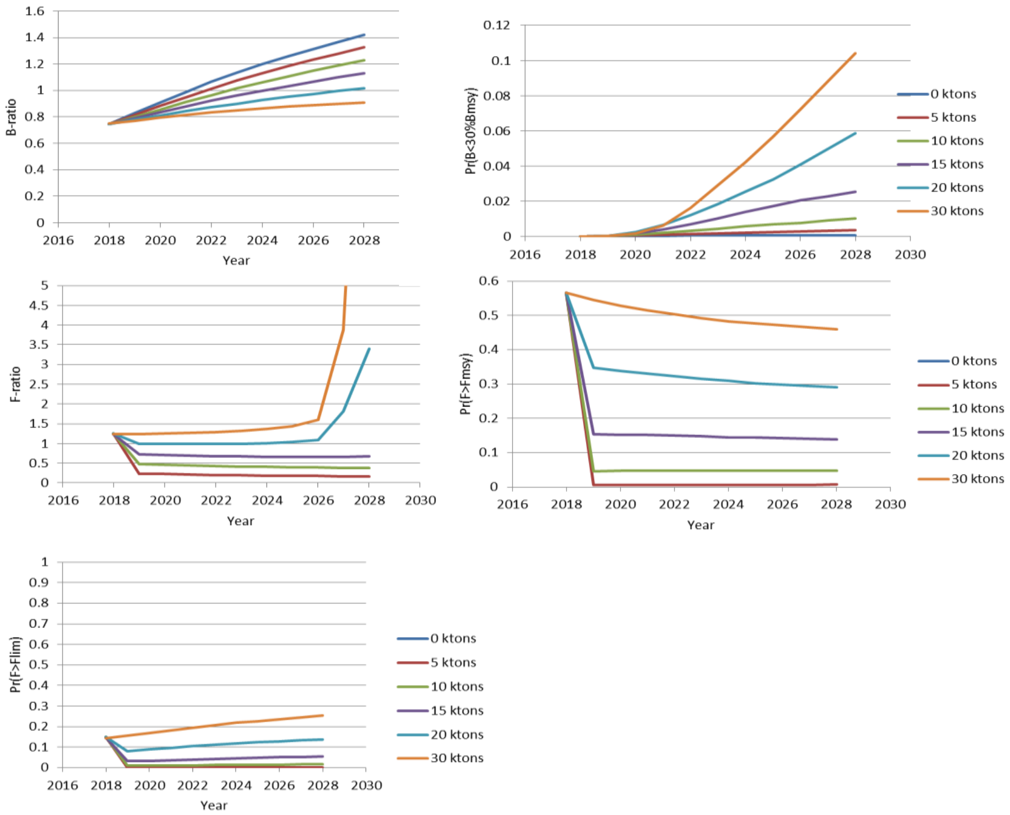


Figure 17.6.7. Projections: Medians of estimated posterior biomass- and fishing mortality ratios; estimated risk of exceeding F_{msy} or going below and $B_{MSYtrigger}$ given catch ranges at 0 -30 ktons.

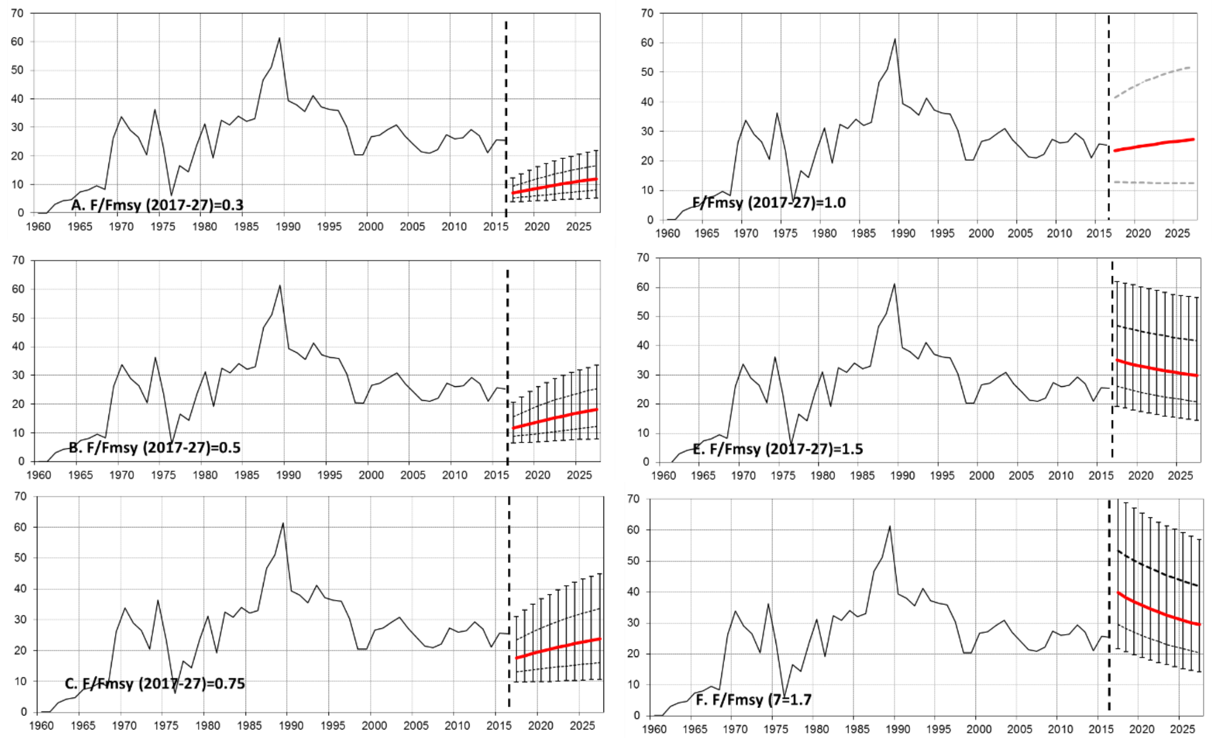


Figure 17.6.8. Historic landings and projected landings 2017-2027 under various F ratio options from 0.3-1.7 F/Fmsy Solid red line is median, quartiles and 90% conf limit indicated.

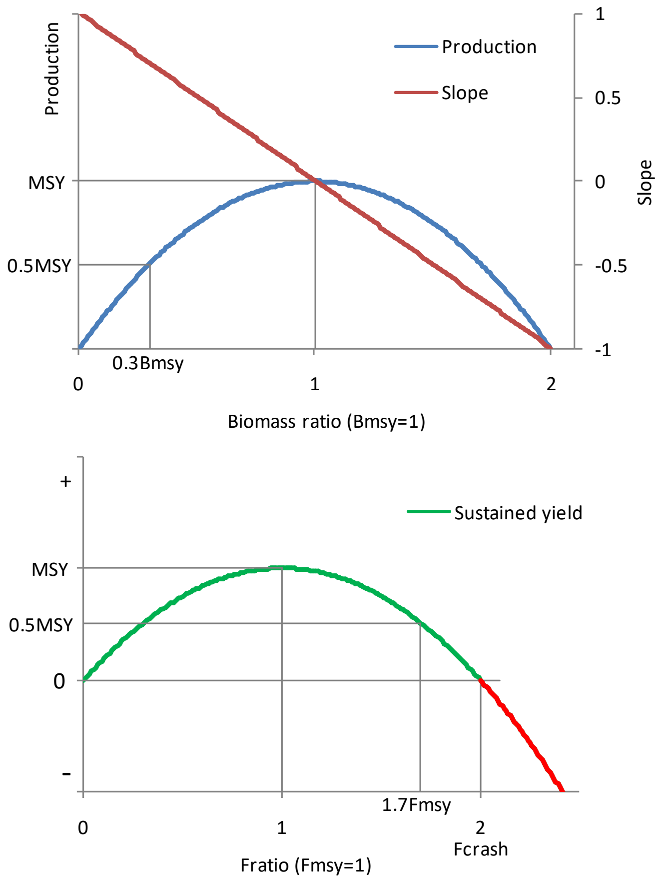


Figure 17.6.9. The logistic production curve in relation to stock biomass (B/Bmsy) (*upper*) and fishing mortality (F/Fmsy) (l*ower*). *Upper*: points of maximum sustainable yield (MSY) and corresponding stock size are shown as well as the slope (red line) of the production curve (blue line); *lower*: points of MSY and corresponding fishing mortality and Fcrash (F≥Fcrash do not have stable equilibriums and will drive the stock to zero).

18 Redfish in Subareas V, VI, XII and XIV

This chapter deals with fisheries directed to *Sebastes* species in Subareas V, VI, XII and XIV (chapters 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, XII, XIV >500 m) – primarily pelagic habitats, and including demersal habitats west of the Faeroe Islands;
- a 'Shallow Pelagic' stock (NAFO 1—2, ICES V, XII, XIV <500 m) – extends to ICES I and II, but primarily pelagic habitats, and includes demersal habitats east of the Faeroe Islands;
- an 'Icelandic Slope' stock (ICES Va, XIV) – primarily demersal habitats.

This conclusion is primarily based on genetic information, i.e. microsatellite information, and supported by analysis of allozymes, fatty acids and other biological information on stock structure, such as some parasite patterns. The Russian Federation maintains the point of view that there is only one stock of *S. mentella* in the pelagic waters of the Irminger Sea. Accordingly, the Russian Federation presented alternative approaches to stock assessment as well as environmental influence on stock dynamics. Briefly, it is claimed that the current survey based assessment does not adequately reflect stock status and that environmental factors – temperature causes major distributional changes of redfish – affect stock status more than fisheries and 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 Va, XII, and XIV.
- Management Unit in the southwest Irminger Sea: NAFO Areas 1 and 2, ICES areas Vb, XII and XIV.
- Management Unit on the Icelandic slope: ICES Areas Va and XIV, and to the north and east of the boundary proposed in the MU in the northeast Irminger Sea.

The pelagic fishery in the Irminger Sea and adjacent waters shows a clear distinction between two widely separated grounds fished at different seasons and depths. Spatial analysis of the pelagic fishery catch and effort by depth, inside and outside the boundaries proposed for the management units in the northeast Irminger Sea, indicate that the boundaries effectively delineate the pelagic fishery in the northeast Irminger Sea from the pelagic fishery in the southwest Irminger Sea, with a small portion of mixed-stock catches. In the last decade the majority (more than 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 Va, Vb and Subarea VI and XIV (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 Spitzbergen, in the Barents Sea, off the Faroe Islands, Iceland, East and West Greenland, and along the east coast of North America from Baffin Island to Cape Cod. All *Sebastes* species are viviparous. 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 analyzed in a special multistage workshop (ICES 2012). Based on 20 years of survey data, the results reveal the average relation of pelagic redfish to their physical habitat in shallow and intermediate waters: The most preferred latitude, longitude, depth, salinity and temperature for *S. mentella* are approximately 58ºN, 40ºW, 300 m, 34.89 and 4.4ºC, respectively. The spatial distribution of *S. mentella* in the Irminger Sea mainly in waters < 500 m (and thus mainly relating to the "shallow" stock) appears strongly influenced by the Irminger Current Water (ICW) temperature changes, linked to the Subpolar Gyre (SPG) circulation and the North Atlantic Oscillation (NAO). The fish avoid waters mainly associated with the ICW (>4.5ºC and >34.94) in the northeastern Irminger Sea, which may cause displacement of the fish towards the southwest, where fresher and colder water occurs.

Results based on international redfish survey data suggest that the interannual distribution of fish above 500 m will shift in a southwest/northeast direction depending on integrated oceanographic conditions (ICES 2012).

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 2013-2016 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 Sea water (Mortensen and Valdimarsson, 1999). Thus, temperature and salinity in the Irminger Current have increased since 1997 to the highest values seen for decades (ICES, 2001).

The 2003 survey detected high temperature anomalies within the 0-200 m layer in the Irminger Sea and adjacent waters. At 200—500 m depth and deeper waters, positive anomalies were observed in most of the surveyed area. However, increasing temperature as compared to the survey in June-July 2001 was detected only north of 60° N in the flow of the Irminger Current above the Reykjanes Ridge and the northwestern part of the Irminger Sea. These changes in oceanographic conditions might have an effect on the seasonal distribution of redfish and its aggregations in the layer shallower than 500 m in the survey area (ICES, 2003).

In June/July 2005 and 2007, water temperature in the shallower layer (0—500 m) of the Irminger Sea was higher than normal (ICES, 2005). As in the surveys 1999—2003, the redfish were aggregating in the southwestern part of the survey area, partly influenced by these hydrographic conditions. Favorable conditions for aggregation of redfish in an acoustic layer have been marked only in the southwestern part of the survey area with temperatures between 3.6—4.5°C, as confirmed by the survey results obtained in 2009.

The hydrography in the survey of June/July 2013 shows that temperature in the survey area is above average but it was lower than in 2011 in most of the surveyed area, except for the Irminger Current (ICES, 2013).

18.4 Description of fisheries

There are three species of commercially exploited redfish in ICES Subarea V, VI, XII, and XIV: *S. norvegicus* (in publication both names *S. norvegicus* and *S. marinus* can be found, but according to Fernholm and Wheeler (1983) the first name is the correct name), *S. mentella* and *S. viviparus*. *S. viviparus* has only been of a minor commercial value in Icelandic waters and it is exploited in two small areas south of Iceland at depths of 150—250 m. The landings of *S. viviparus* decreased from 1160 t in 1997 to 2—9 t in 2003—2006 (Table 18.4.1) due to decreased commercial interest in this species. The landings in 2009 amounted to 37 t, more than a twofold increase in comparison with 2008. After a directed fishery developed in 2010, with a total catch of 2 600 t, the MRI advised on a 1 500 t TAC for the 2012—2013 fishing year. Annual catches 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, south-western and southern continental slope of Iceland as part of the landing statistics of the demersal *S. mentella*. This practice has been in accordance with Icelandic legislation, where captains are obligated to report their *S. mentella* catch as either "pelagic redfish" or as "demersal redfish" depending in which fishing area they fish. According to this legislation, all catch outside the Icelandic EEZ and west of the 'redfish line' (red line shown in Figure 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 Icelandic slope *S. mentella* is given in chapter 20. The proportion of the total Icelandic slope *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 Icelandic slope *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 north-eastern area were on average about 5 cm larger than those caught in the south-western area. The length distribution also shows that the fish caught in north-east area since 2011 is smaller than during the period 1998-2010 and have now a size similar to that registered in 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 7; 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 2016 the fishery was conducted from April to October in ICES Subareas XII and XIV and NAFO Divisions 1F (Tables 21.2.1, 21.2.2, 22.2.1 and 22.2.2) with average CPUE 31.0 t /day and 28.4 t/ day in ICES Subareas XII and XIV, respectively; and 35.5 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 2016:

Country	Area	No. of samples	No. of fish measured
Russia	XIV		24,181
Russia	XII		
Russia	NAFO 1F		
Iceland	XIV (deep)	20	3,935
Greenland	XIVb		

18.7 Demersal *S. mentella* in Vb and VI

18.7.1 Demersal *S. mentella* in Vb

18.7.1.1 Surveys

The Faroese spring and summer surveys in Division Vb are mainly designed for species inhabiting depths down to 500 m and do not cover the vertical distribution of demersal *S. mentella* fully. Therefore, the surveys are not used to evaluate the stock status.

18.7.1.2 Fisheries

In Division Vb, 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 from 1,126 t in 2011 to 263 t but has since then gradually increased and were 717 t in 2016.

Length distributions from the landings in 2001-2016 indicate that the fish caught in Vb in 2016 are between 35-50 cm and the mode of the distribution is around 42 cm (Figure 18.7.1).

Non-standardized CPUE indices in Division Vb were obtained from the Faroese otter board (OB) trawlers (> 1000 HP) towing deeper than 450 m and where demersal *S. mentella* composed at least 70% of the total catch in each tow. The OB trawlers have in recent years landed about 50% of the total demersal *S. mentella* landings from Vb. CPUE decreased from 500 kg/hour in 1991 to 300 kg/hour in 1993 and remained at that level until 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 VI

18.7.2.1 Fisheries

In Subarea VI, the annual landings varied between 200 t and 1 100 t in 1978—2000 (Table 18.6.1). The landings from VI in 2004 were negligible (6 t), the lowest recorded since 1978. They increased again to 111 t in 2005 and 179 t in 2006. The reported landings in 2008 were 50 t and no catches 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, Icelandic slope *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 *S. mentella* 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 Va, if no direct information is available on the catches for a given vessel, the landings are allocated based on logbooks and samples from the fishery. According to the proportion of biological samples from each cell (one fourth of ICES statistical square), the unknown catches within that cell are split accordingly and raised to the landings of a given vessel. For other areas, samples from the landings are used as basis for dividing the demersal redfish catches between *S. norvegicus* and *S. mentella*.

Table 18.4.1. Landings of *S. viviparus* in Division Va 1996-2016.

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
2016	232

Table 18.6.1. Nominal landings (tonnes) of demersal *S. mentella* 1978-2016 in ICES DivisionsVb and VI.

Year	Vb	VI
1978	7 767	18
1979	7 869	819
1980	5 119	1 109
1981	4 607	1 008
1982	7 631	626
1983	5 990	396
1984	7 704	609
1985	10 560	247
1986	15 176	242
1987	11 395	478
1988	10 488	590
1989	10 928	424
1990	9 330	348
1991	12 897	273
1992	12 533	134
1993	7 801	346
1994	6 899	642
1995	5 670	536
1996	5 337	1 048
1997	4 558	419
1998	4 089	298
1999	5 294	243
2000	4 841	885
2001	4 696	36
2002	2 552	20
2003	2 114	197
2004	3 931	6
2005	1 593	111
2006	3 421	179
2007	1 376	1
2008	750	50
2009	1 077	0
2010	1 202	0
2011	1 126	0
2012	263	0
2013	398	0
2014	370	0
2015	537	0
2016[1)]	717	0

[1)] **Provisional**

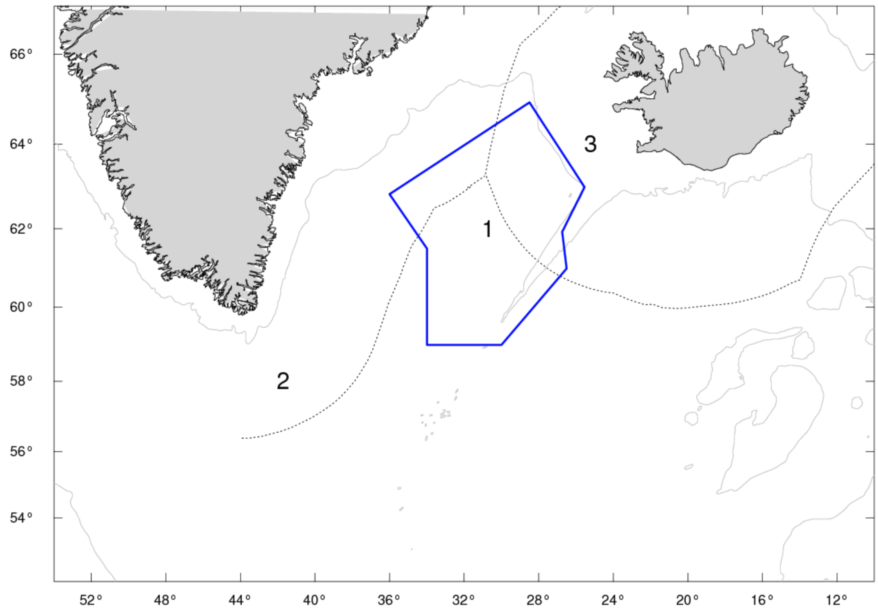


Figure 18.1.1 Potential management unit boundaries. The polygon bounded by blue lines, i.e. 1, indicates the region for the 'deep pelagic' management unit in the northwest Irminger Sea, 2 is the "shallow pelagic" management unit in the southwest Irminger Sea, and 3 is the Icelandic slope management unit.

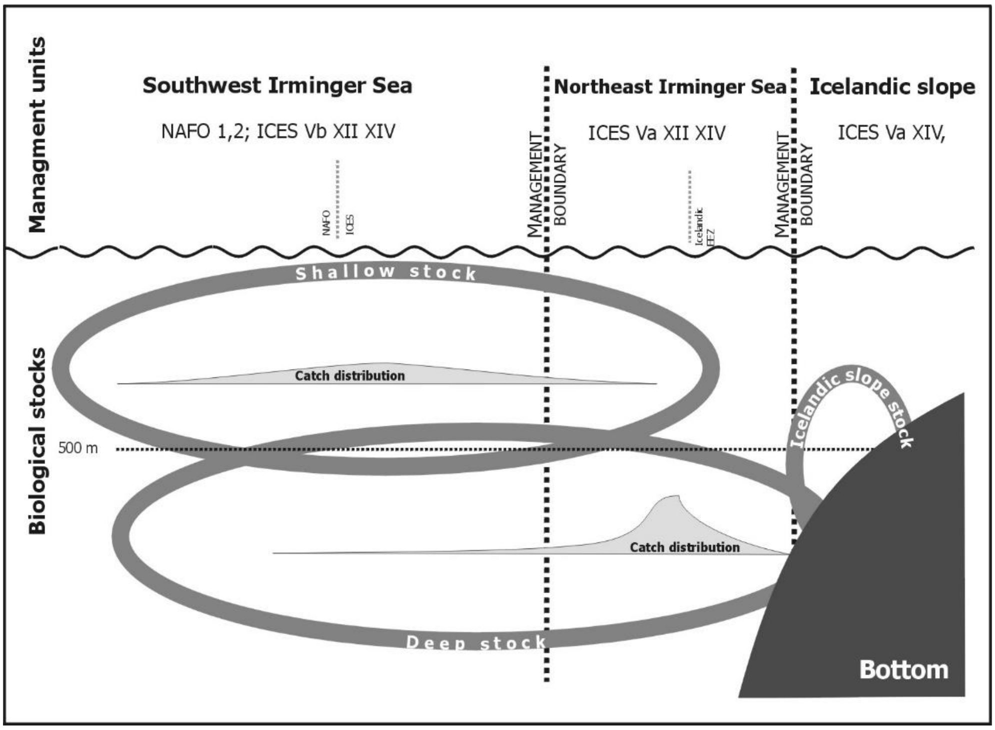


Figure 18.1.2 Schematic representation of biological stocks and potential management units of *S. mentella* in the Irminger Sea and adjacent waters. The management units are shown in Figure 18.1.1. Included is a schematic representation of the geographical catch distribution in recent years. Note that 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.

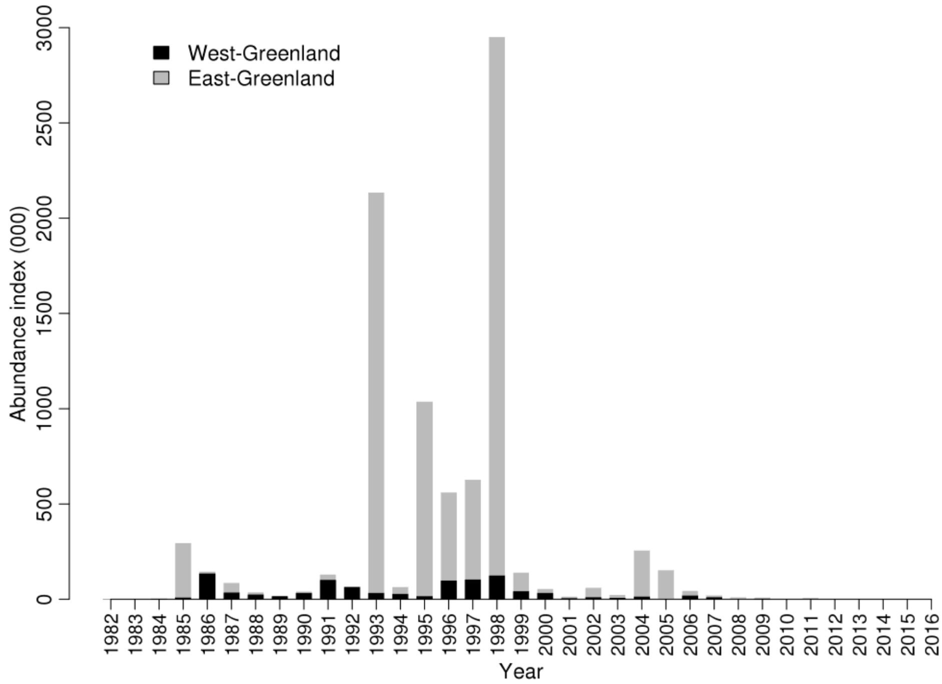


Figure 18.2.1 Survey abundance indices of *Sebastes spp.* (<17 cm) for East and West Greenland from the German groundfish survey 1982-2016.

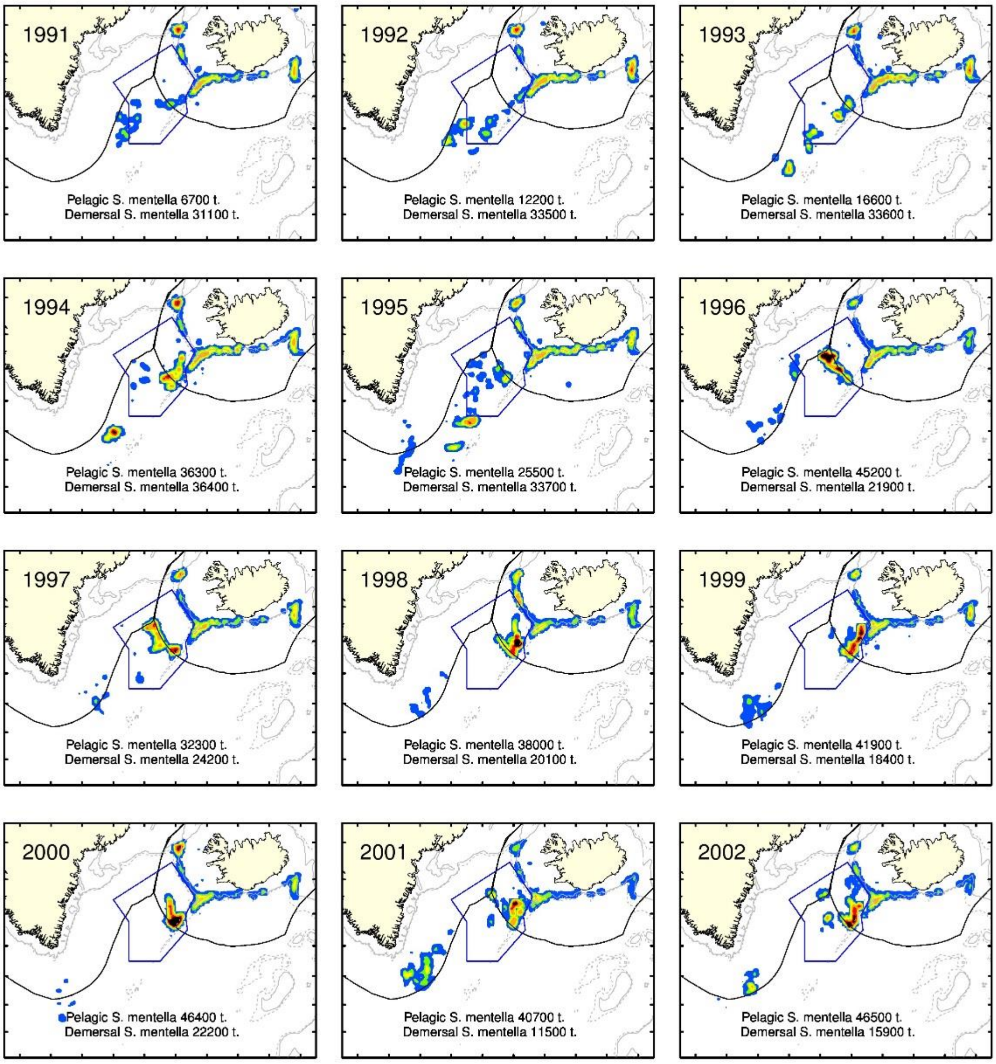


Figure 18.4.1Geographical distribution of the Icelandic catches of *S. mentella* 1991–2002. The color scale indicates catches (tonnes per NM²).

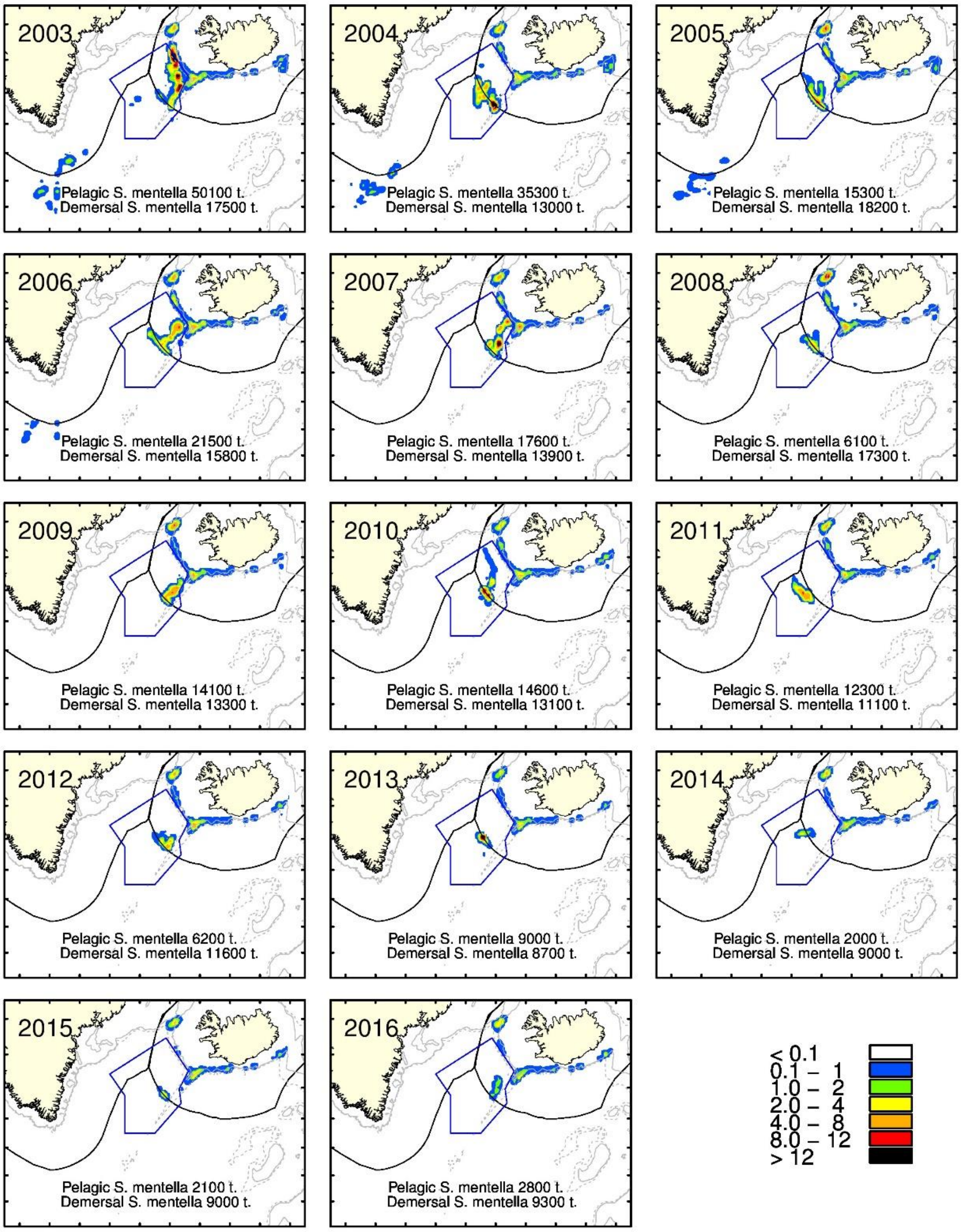


Figure 18.4.1 *cont.* Geographical distribution of the Icelandic catches of *S. mentella* 2003–2016. The color scale indicates catches (tonnes per NM²).

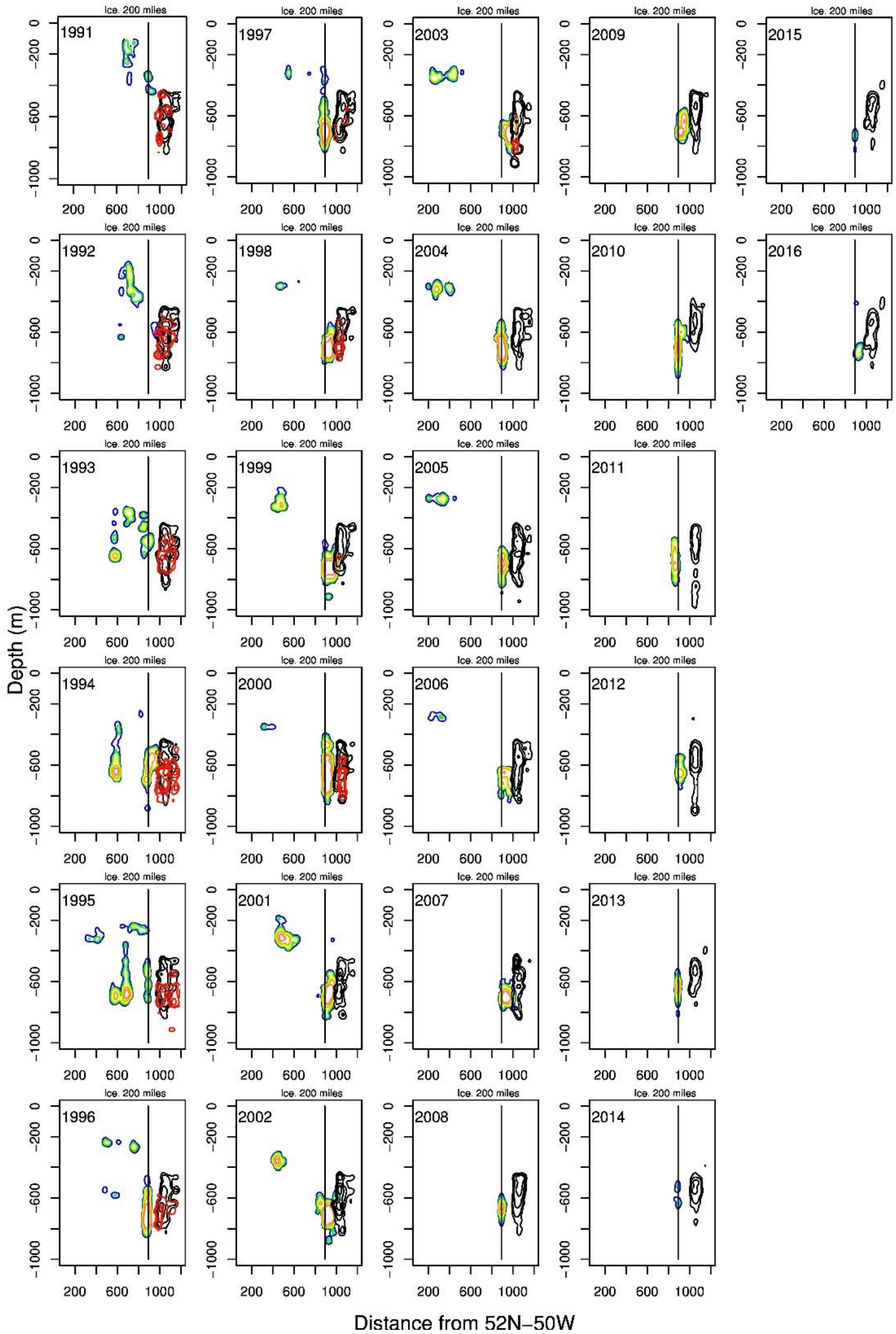


Figure 18.4.2Distance-depth plot for Icelandic *S. mentella* catches, where distance (in NM) from a fixed position (52°N 50°W) is given. The contour lines indicate catches in a given area and distance. The colored contours represent the fishery on pelagic *S. mentella*, the black contours indicate bottom trawl catches of demersal *S. mentella*, and the red contours represent catches of demersal *S. mentella* taken with pelagic trawls.

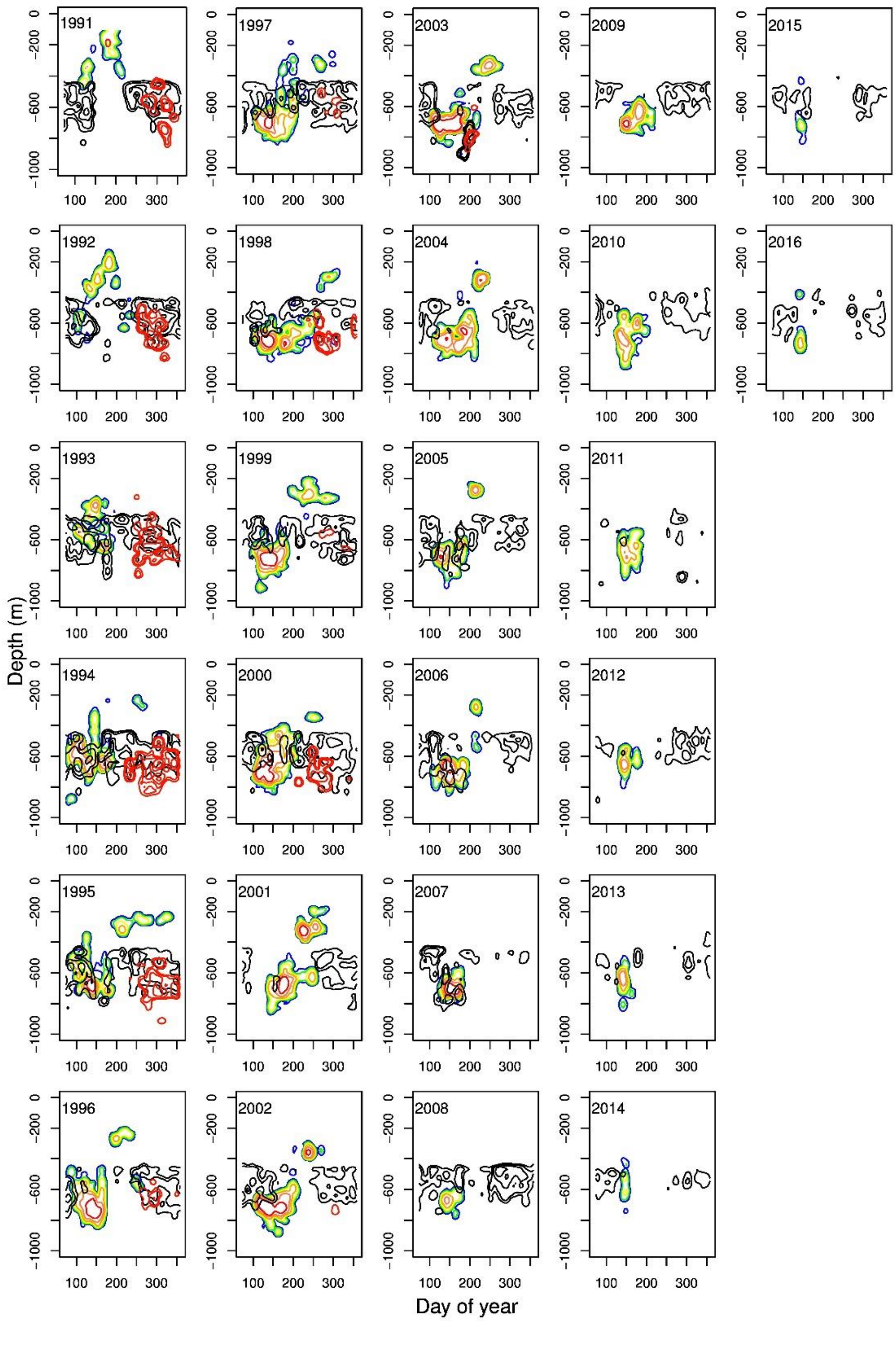


Figure 18.4.3 Depth-time plot for Icelandic *S. mentella* catches 1991-2016 where the y-axis is depth, the x-axis is day of the year and the color indicates the catches. The colored contours represent the fishery on pelagic *S. mentella*, the black contours indicate bottom trawl catches of demersal *S. mentella*, and the red contours represent catches of demersal *S. mentella* taken with pelagic trawls.

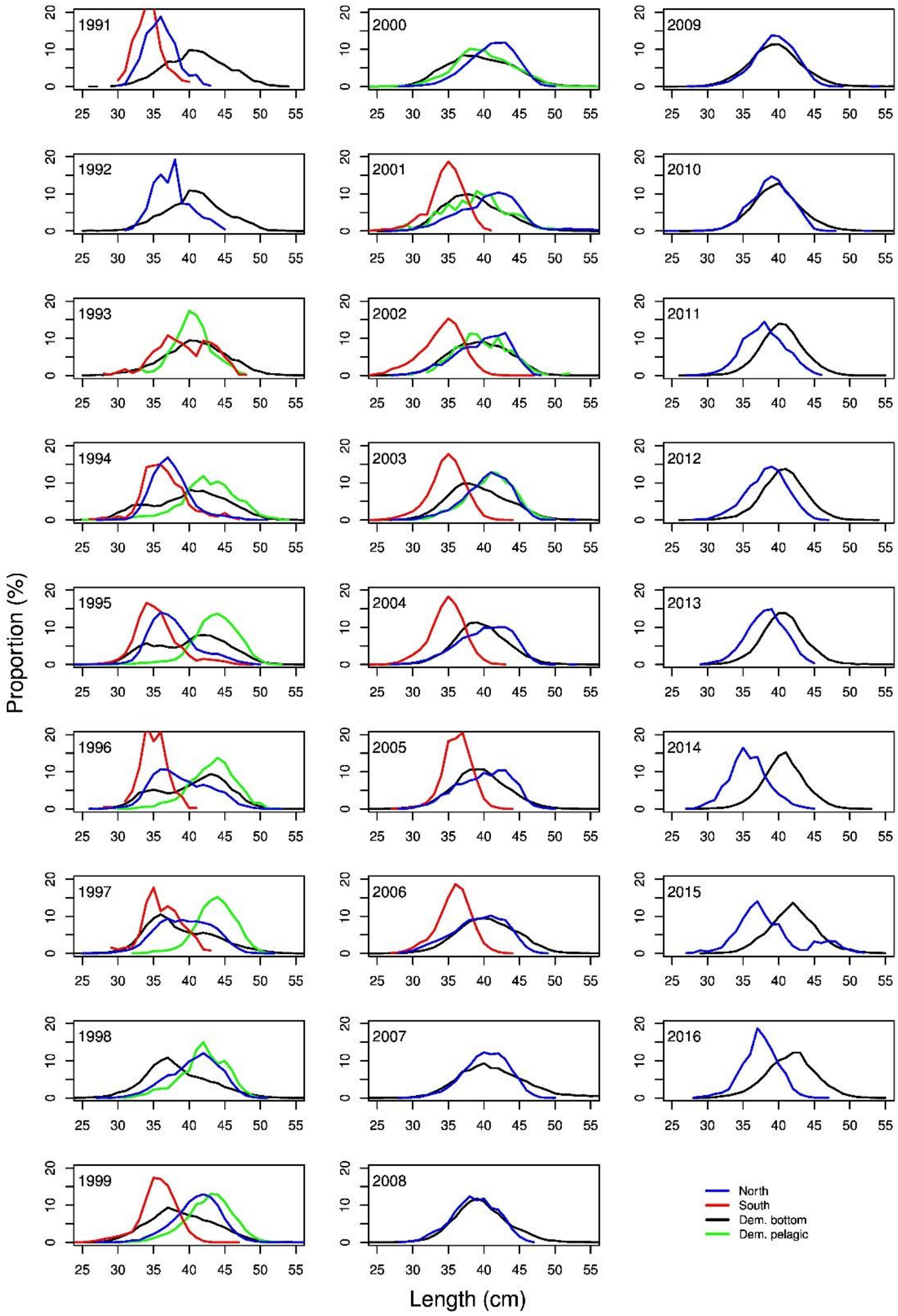


Figure 18.4.4 Length distributions from different Icelandic *S. mentella* fisheries, 1991-2016. The blue lines represent the fishery on pelagic *S. mentella* in the northeastern area, the red lines the pelagic fishery in the southwestern area, the black lines indicate bottom trawl catches of demersal *S. mentella*, and the green lines represent catches of demersal *S. mentella* taken with pelagic trawls.

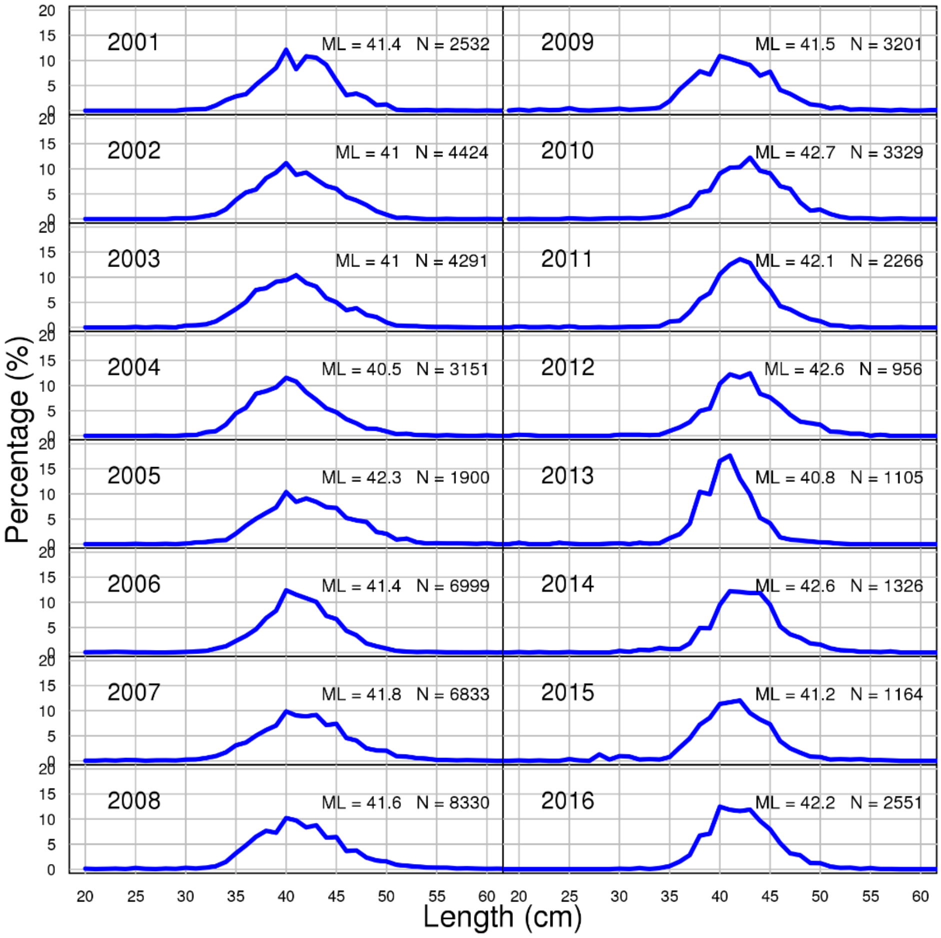


Figure 18.7.1 Length distribution of demersal *S. mentella* from landings of the Faeroese fleet in Division Vb 2001-2016.

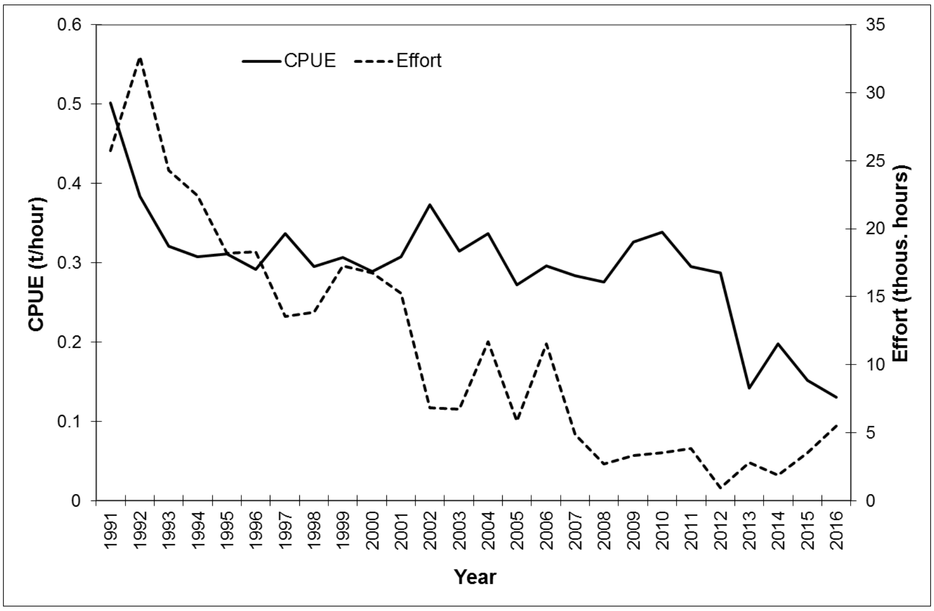


Figure 18.7.2 Demersal *S. mentella*, CPUE (t/hour) and fishing effort (in thousands hours) from the Faeroese CUBA fleet 1991-2016 and where 70% of the total catch was demersal *S. mentella*.

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—2017 and the Autumn Survey in October 1996—2016. 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 re-calculated for the Autumn Survey in 2008 and for the Spring Survey in 2011. The method is described in the Stock Annex for the species. Further changes were made in the calculation of the survey indices in 2012 by taking into account length dependent diurnal vertical migration of the species. Golden redfish is known for its diurnal vertical migration showing semi-pelagic behaviour. Usually the species is in the pelagic area during the night time and close to the bottom during the day time. However, there is also a size or age difference in this pelagic behaviour where smaller fish shows opposite vertical migration pattern compared to larger fish. The method is described in more details in the Stock Annex.

This scaled diurnal variation by length was used for calculating Cochran index for redfish. 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 to 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 total biomass index decreased in 2017 but is the second highest in the time series. The CV of the measurement error has been considerably higher since 2003 than before that.

The total biomass index from the autumn survey gradually increased from 2000 to 2014 when it was the highest in the time series and has since then been at that level (Figure 19.2.1).

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 since 2009 very little has been observed of small redfish (Figure 19.2.1). 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. The abundance of golden redfish less than 30 cm in both surveys has decreased since 2006 (Figure 19.2.1). In recent four years the abundance been at the lowest level in the time series with very few individuals less than 30 cm caught (Figures 19.2.1-19.2.3)

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—2017, the abundance of fish 7 years' old and younger was at the lowest level in the time series for all age groups indicating small year classes since 2009 (Table 19.2.2).

19.2.2 Division 5.b

In Division 5.b, CPUE of *S. norvegicus* were available from the Faeroes spring groundfish survey from 1994—2017 and the summer survey 1996—2016. Both surveys show similar trends in the indices from 1998 onwards with sharp declines between 1998 and 1999 (Figure 19.2.5). CPUE in the spring survey was between 2000 and 2008 stable at low level. In the period 2009—2015 it was at the lowest level since the beginning of the series, but increased substantially in 2016. The reason for this sharp increase in 2016 was one big haul that accounted most of the total index. 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 to 2016 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 sub-area structure, and 5 strata in East Greenland. Depth zones considered are 0—200 m and 200—400 m. The time series was recalculated accordingly. In general, the survey indices are much lower with the new stratification scheme but show similar trend (WD 30 of the 2013 NWWG report).

After a severe depletion of the *S. norvegicus* stock on the traditional fishing grounds around East Greenland in the early 1990's, the survey estimates showed a significant increase in both abundance and biomass with the highest value observed in 2007 (Figure 17.2.7). The survey indices 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 in 2015 and 2016 were the second highest in the time series but lower than in 2014. 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—2016 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 urvey show that juveniles were abundant in 1993 and 1995—1998 (Figure 18.2.1). Since 2008, the survey index has been very low and in recent years at 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—2016 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 60,000 t and has been gradually increasing since 2010. The total landings in 2016 were 59 698 t, which is about 8,000 t more than in 2016. The majority of the golden redfish catch has been taken in ICES Division Va that contributes to about 90—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 54 000 t, highest in 2016. The landings in 2016 were about 50 041 t, about 6 800 t more than in 2015. The landings were 14.5% higher than allocated quota of 47 205 t. This increase is because of the Icelandic ITQ system where part of the quota of a given species can be transferred between fishing years and also between species within the quota year. Detailed description of the Icelandic ITQ system is found in the Stock Annex for the species (smr-5614_SA) Between 90—95% of the golden redfish catch in Division 5.a is taken by bottom trawlers targeting redfish (both fresh fish and factory trawlers; vessel length 48—65 m). The remaining catches are partly caught as by-catch in gillnet, long-line, and lobster fishery. In 2016, as in previous years, most of the catches were taken along the shelf southwest, west and northwest of Iceland (Figure 19.3.2). Higher 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 to 1999 from 9000 t to 1500 t and varied between 1 500 and 2 500 t from 1999—2005 (Table 19.3.1). In 2006—2016 annual landings were less than 700 t which has not been observed before in the time series. The landings in 2016 were 165 t which is 105 t less than in 2015 and the lowest landings in the time series. The majority of the golden redfish caught in Division Vb is taken by pair and single trawlers (vessels larger than 1000 HP).

Annual landings from Subarea 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 by-catch 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, but increased to 5 442 t in 2016 which is the highest landings since 1983.

Annual landings from Subarea 6 increased from 1978 to 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—2016 and were 50 t in 2016.

19.3.2 Discard

Comparison of sea and port samples from the Icelandic discard sampling program does not indicate significant discarding due to high grading in recent years (Palsson *et al* 2010), possibly due to area closures of important nursery grounds west off Iceland. Substantial discard of small redfish took place in the deep-water shrimp fishery from 1986 to 1992 when sorting grids became mandatory. Since then the discard has been insignificant both due to the sorting grid and much less abundance of small redfish in the region.

Discard of redfish species in the shrimp fishery in 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 2016. 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	54 041	199	36 471	1 654
5.b	Faroe Islands	Bottom trawl	165	12	303	
14	Greenland	Bottom trawl	5 442			

19.3.4 Landings by length and age

The length distributions from the Icelandic commercial trawler fleet in 1976—2016 show that the majority of the fish caught is between 30 and 45 cm (Figure 19.3.3). The modes of the length distributions range between 35 and 38 cm. The length distributions in 2012—2016 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—2005 year classes (ages 11-16) contributed in total about 65% of the total catch in 2016.

The average total mortality (Z), estimated from the 22-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—2016 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 2016 the highest in the time series with sharp increase in recent 10 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 fishes recruit to the fisheries at younger age if selection is size dependent.

The German survey did get half weight compared to the results in Figure 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 about 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 19.2.1) has not lead to subsequent increase in large fish (Figure 19.2.1). Including the large fish from East Greenland does therefore affect model results and estimated SSB is 20% higher when the German survey is included, even though the German survey does only account for 10% of the total biomass as it is weighted. The recruitment signal from the German survey (Figure 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 data sets in the Gadget model is done using an iterative re-weighing algorithm. The process essentially assigns weights to each input data set on the basis of the inverse variance of the fitted residuals. This is done to reduce the effect of low quality input data. In this year assessment the weights were the same as in the benchmark runs in January 2014 and the assessment in 2014-2016.

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—2017 and the German survey in East Greenland 1984-2016. 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—2016.
- Age-length keys and mean length at age from the Icelandic commercial catch 1995—2016.
- The simulation period is from 1970 to 2021 using data until the first half of 2017 for estimation. Two time steps are used each year. The ages used were 5 to 30 years, where the oldest age is treated as a plus group (fish 30 years and older). Recruitment was set at age 5.

Estimated parameters are:

- Number of fishes when the simulation starts (8 parameters).
- Recruitment at age 5 each year (45 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 to 19 according to agreed management plan.

Assumptions done in the predictions:

- Recruitment at age 5 in 2016 and onwards was set as the average of the recruitment in 2011—2015.
- Catches in the first time step in 2017 (first 6 months) were set at the same as in the first time step of 2016 for all the fleets. In step 2 in 2017 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 increased gradually increased since 2010. The last year class estimated is the 2015 year class but the following year-classes are assumed to be the average of the 2011-2015 year classes. Compared to last year's assessment the 2007-2013 year-class is estimated larger than assumed last year (Figure 19.4.5). 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 (Figure 19.2.1). 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 Faeroese fleet catch much larger fish than the Icelandic fleet. This is in line with the results from the German survey in East Greenland that show most of the large fish in East Greenland (Figure 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, especially for fish smaller than 30 cm, 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 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 lower 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.

1. The cohorts grow faster and mature earlier than earlier cohorts. Natural mortality, M, might have increased
2. 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.

3. Compared to cohorts 1985—1990 the later cohorts seem to come from other nursery areas.
4. 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 auto-correlated 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 Vb, survey indices are stable at low level and do not indicate an improved situation in the area although the summer survey showed large increase in 2016. 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 2011—2015, that is at the lowest level in the time series (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 assessments in 2015 and 2016 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—2016. The fishery does not distinguish between species, but based on survey information, golden redfish is estimated to be between 1000 and 2 700 in 2010-2015, but 5 400 t in 2016.

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 presently advise that no fishery should take place on offshore cod in Greenland waters. ICES therefore recommend measures that will keep effort on cod low in the redfish fishery.

Greenland opened an offshore cod fishery in 2008. To protect spawning aggregations of cod present management measures in Greenland EEZ prohibits trawl fishery for cod north of 63°N latitude. Restrictions on cod bycatch in fisheries directed towards other demersal fish (i.e. redfish and Greenland halibut) provide some protection of cod, but additional measures such as a closure of potential redfish fisheries north of 63°N could be considered.

Subarea 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 Faeroe Islands by effort limitation. The regulation schemes of those states have previously resulted in catches well in excess of TACs advised by ICES.

Since 2009, surveys of redfish in the stock area have consistently shown very low abundance of young redfish (<30cm). While current indices of adult biomass are increasing, the absence of any indications of any incoming cohorts raises concerns about the future productivity of the stock.

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 by-catch of juveniles in the shrimp fishery north of Iceland. This was partly done to avoid redfish juveniles as a by-catch in the fishery, but also juveniles of other species. Since the large year classes of golden redfish disappeared out of the shrimp fishing area, there in the early 1990's, observers report small redfish as being negligible in the Icelandic shrimp fishery. If the sorting grids work where the abundance of redfish is high is a question but not a relevant problem at the moment in 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 by-catches 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.

19.17Changes in the environment

No information available.

Table 19.2.1 Survey indices and CV of golden redfish from the spring survey 1985-2017 and the autumn survey 1996-2016.

	Spring Survey		Autumn Survey	
Year	Biomass	CV	Biomass	CV
1985	307,926	0.095		
1986	327,765	0.120		
1987	322,081	0.122		
1988	253,763	0.094		
1989	281,117	0.122		
1990	242,450	0.223		
1991	199,128	0.114		
1992	160,545	0.088		
1993	179,275	0.130		
1994	171,080	0.097		
1995	146,100	0.102		
1996	195,630	0.164	199,786	0.248
1997	211,165	0.217	120,628	0.279
1998	206,487	0.136	186,505	0.348
1999	297,060	0.143	262,691	0.310
2000	221,279	0.176	141,335	0.200
2001	192,724	0.176	177,448	0.155
2002	250,420	0.173	192,813	0.150
2003	334,003	0.161	199,450	0.159
2004	326,868	0.236	220,308	0.241
2005	310,635	0.129	229,013	0.240
2006	257,002	0.157	279,333	0.335
2007	339,778	0.224	219,951	0.252
2008	247,887	0.154	288,149	0.244
2009	302,204	0.253	294,028	0.282
2010	383,407	0.245	227,335	0.171
2011	401,349	0.235		
2012	461,448	0.204	343,090	0.226
2013	457,448	0.177	312,063	0.158
2014	402,773	0.174	431,369	0.232
2015	405,696	0.281	361,380	0.175
2016	615,712	0.313	401,081	0.279
2017	504,419	0.203		

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	2016
1	0.3	1.0	3.6	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	0.0
2	2.4	0.2	1.5	3.3	1.7	1.0	0.9	0.5	0.2	0.1	0.6	1.2	0.3	0.3	0.0		0.0	0.0	0.3	0.1	0.0
3	0.7	2.2	0.9	3.3	1.4	1.9	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	0.0
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	4.4	0.3		1.4	0.2	0.1	0.3	1.8
5	8.3	2.2	0.9	4.7	1.2	5.4	5.8	12.3	3.3	4.2	5.0	2.1	4.1	12.0	4.3		4.1	1.0	0.8	0.1	0.3
6	40.0	6.9	3.5	2.8	7.9	2.1	11.8	17.7	28.6	4.8	6.8	10.4	7.9	11.6	14.2		3.1	4.1	1.8	1.2	0.8
7	11.3	22.5	16.6	10.5	6.7	10.8	3.3	38.2	36.7	39.7	15.6	26.0	39.2	13.9	15.1		23.5	3.0	12.8	7.6	3.9
8	19.1	14.3	58.2	47.2	6.4	10.9	26.9	9.9	65.4	44.9	81.9	35.8	75.1	73.9	23.4		70.3	41.7	24.6	28.3	29.1
9	15.1	13.0	22.4	99.9	26.2	7.1	11.2	48.5	21.0	62.7	81.5	76.6	67.9	96.4	54.4		60.6	84.5	96.9	33.1	63.9
10	28.9	11.1	26.1	43.7	95.0	17.3	16.6	12.7	45.6	24.9	85.7	37.4	106.4	58.7	69.0		62.9	55.7	151.8	86.4	48.0
11	102.7	17.6	18.9	20.7	11.5	111.2	32.0	17.0	19.3	44.2	26.3	36.1	63.2	100.9	32.5		103.8	40.7	90.8	100.8	87.5
12	16.2	67.8	19.1	16.8	14.2	23.6	116.3	39.7	13.4	19.6	37.5	19.0	55.1	45.9	57.4		74.2	67.3	69.6	52.9	97.2
13	10.1	6.2	104.5	20.8	7.9	23.6	20.0	111.3	26.6	15.4	18.0	23.8	13.5	42.9	28.6		43.3	46.6	67.5	47.6	54.2
14	16.8	5.3	10.1	147.1	8.0	7.9	11.5	12.4	103.9	26.8	15.1	8.2	18.2	10.2	19.6		39.1	26.0	50.4	41.7	45.3
15	33.9	7.2	7.6	6.0	51.4	9.2	9.8	10.8	13.6	82.1	18.3	6.8	9.1	18.3	9.1		19.6	31.1	27.0	40.3	35.8
16	16.1	10.0	7.8	9.6	5.3	58.9	10.4	6.1	9.6	9.5	75.4	16.9	7.8	6.9	10.9		16.7	18.3	26.5	21.1	31.9
17	1.9	6.9	14.1	10.9	2.5	4.3	45.4	7.5	6.0	6.7	8.7	49.4	13.1	6.4	4.7		6.1	12.6	17.1	20.0	20.3
18	1.7	3.9	7.6	11.1	2.5	5.0	4.6	32.7	6.1	3.7	4.3	10.4	36.6	7.4	3.1		5.9	7.0	12.3	10.0	22.1
19	4.3	2.0	0.5	8.4	4.6	3.6	3.0	4.5	21.6	5.0	2.8	4.5	6.2	28.4	6.6		3.9	5.1	6.0	10.0	16.1
20	6.6	1.4	3.2	3.9	6.5	4.1	3.2	1.6	3.1	22.0	3.1	1.5	5.7	4.7	22.2		3.9	4.4	5.9	9.9	8.9
21	1.1	0.8	2.3	2.8	1.0	3.7	3.9	1.1	1.8	2.5	17.8	4.0	2.1	2.1	3.1		3.5	4.7	4.8	3.3	3.0
22	5.0	1.5	0.8	1.0	1.6	2.3	3.2	2.7	1.7	2.1	2.0	13.8	2.3	1.3	1.2		18.3	2.4	3.6	2.5	3.9
23	3.9	2.4	2.2	2.1	0.4	0.3	0.8	1.1	2.5	2.4	1.7	1.3	11.0	2.0	1.6		2.9	17.8	3.4	2.1	3.7
24	4.6	0.8	0.4	0.6	1.0	0.5	0.4	0.3	0.0	0.9	1.0	1.3	1.4	10.2	0.7		2.0	2.5	12.7	1.1	2.8
25	3.9	2.7	1.4	2.8	0.8	0.3	0.5	0.3	1.2	1.2	1.7	0.2	0.8	0.8	5.7		1.2	1.2	1.5	13.1	3.4
26	0.9	1.1	0.2	1.2	0.7	0.5	0.6	0.2	0.4	0.3	0.9	0.6	0.9	1.0	0.6		1.7	1.1	0.9	1.5	15.0
27	0.9	0.2	0.9	2.9	0.5	0.8	0.3	0.3	0.0	0.1	0.9	0.3	1.2	1.3	0.4		7.5	0.8	0.9	1.4	1.0
28	0.8	0.4	0.5	1.5	0.7	0.5	0.2	0.0	0.2	0.2	0.2	0.0	0.6	0.2	0.7		0.4	8.5	0.5	1.6	1.0
29	0.1	0.0	0.5	1.2	0.5	0.2	0.7	0.1	0.2	0.0	0.4	0.4	0.8	1.6	0.4		0.4	0.4	3.3	1.0	0.9
30+	0.8	1.4	3.0	1.1	1.3	2.3	1.7	1.5	1.6	2.1	1.0	0.9	1.5	1.7	2.0		2.1	3.4	2.6	6.9	6.7

Total	360.0	214.6	341.6	492.7	271.8	322.1	352.7	393.2	436.4	429.4	515.6	391.3	557.2	565.9	393.5		582.5	492.1	696.7	546.5	608.5

Table 19.3.1 Official landings (in tonnes) of golden redfish, by area, 1978-2016 as officially reported to ICES. Landings statistics for 2016 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	48 769	270	44	2 562	51 645
2016[1)]	54 041	165	50	5 442	59 698

1) Provisional

Table 19.3.2 Golden redfish in 5.a. Observed catch in weight (tonnes) by age and years in 1995-2016. 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	2016
7	47	0	32	23	6	38	117	125	189	216	219	175	128	211	106	59	140	71	31	229	16	20
8	327	354	219	277	339	62	134	871	199	822	737	995	428	1,051	961	351	550	627	572	465	486	889
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	834	2,586
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	3,304	3,198
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	6,876	7,660
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	7,218	9,135
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	5,675	6,712
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	5,660	4,372
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	4,788	4,160
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	2,973	2,916
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	2,598	2,969
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	1,857	2,267
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	736	1,895
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	1,243	737
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	273	528
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	278	461
23	1,574	814	673	424	331	270	411	723	754	618	795	229	736	4,235	335	574	761	456	3,176	538	214	256
24	709	0	584	660	216	63	164	372	392	567	619	377	112	380	2,529	667	221	340	190	3,204	438	265
25	824	0	734	520	848	392	123	288	300	258	420	472	618	253	97	2,165	67	226	201	201	1,848	371
26	407	0	275	399	270	337	114	180	74	105	100	73	333	427	96	267	1,602	238	173	209	250	1,321
27	384	0	139	427	615	198	275	80	83	183	279	263	349	340	191	389	86	1,441	74	116	218	216
28	808	0	202	357	229	516	189	296	27	141	169	204	200	170	92	132	178	200	822	64	190	37
29	0	0	143	53	106	364	146	498	105	138	29	168	36	172	386	179	47	73	38	733	89	39
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	708	1,031

Total	41,515	33,558	36,339	36,771	39,823	41,188	35,066	48,569	36,576	31,688	42,591	41,520	38,363	45,539	38,441	36,153	43,774	43,088	51,330	47,768	48,770	54,041

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	607.5	375.4	206.5	67.9	0.097
1972	609.0	369.2	191.5	50.9	0.075
1973	651.5	376.8	457.9	43.7	0.065
1974	683.4	389.9	200.4	50.6	0.073
1975	701.4	399.0	122.1	61.9	0.087
1976	706.1	395.8	207.5	94.4	0.133
1977	715.7	399.4	196.3	53.8	0.079
1978	743.4	422.9	133.9	48.7	0.065
1979	760.5	439.7	157.7	77.2	0.099
1980	750.5	441.1	103.7	89.1	0.113
1981	721.1	431.2	74.8	102.0	0.135
1982	664.1	402.1	63.5	130.3	0.184
1983	598.7	365.7	67.9	106.0	0.162
1984	546.2	336.8	74.0	95.3	0.154
1985	509.0	313.6	131.8	78.5	0.131
1986	478.7	293.9	121.4	76.9	0.140
1987	442.7	271.6	64.2	76.6	0.152
1988	395.2	241.0	41.2	89.8	0.204
1989	354.6	214.7	44.9	56.6	0.145
1990	353.8	198.8	352.0	66.3	0.191
1991	332.7	181.7	58.7	56.0	0.179
1992	313.9	168.1	39.8	55.8	0.196
1993	297.6	156.9	54.1	50.2	0.194
1994	287.4	151.0	64.2	42.5	0.173
1995	305.9	150.5	336.3	44.3	0.182
1996	311.6	152.9	89.1	35.6	0.144
1997	311.5	154.8	41.3	39.0	0.154
1998	313.5	159.7	42.0	39.7	0.154
1999	311.2	160.8	85.2	42.5	0.163
2000	306.6	162.7	52.9	42.6	0.159
2001	313.1	166.8	113.3	36.7	0.132
2002	316.5	167.7	125.0	50.7	0.180
2003	332.0	171.5	189.3	38.2	0.135
2004	349.9	182.6	113.7	32.8	0.112
2005	371.1	191.3	180.3	46.6	0.156
2006	397.1	201.8	189.0	42.1	0.142
2007	414.9	214.0	117.2	39.2	0.126
2008	442.4	232.2	145.5	46.2	0.140
2009	479.2	250.7	234.0	39.3	0.111
2010	519.6	278.0	171.0	38.5	0.099
2011	542.4	303.0	70.5	45.1	0.106
2012	556.8	320.6	106.4	45.2	0.099
2013	563.8	338.0	56.2	53.1	0.109
2014	553.6	345.6	28.8	50.8	0.099

YEAR	BIOMASS	SSB	R(AGE5)	CATCHES	F9-19
2015	539.2	351.8	6.4	51.8	0.098
2016	519.0	348.5	51.0	59.7	0.111
2017	497.4	342.1	51.0	52.7	0.100
2018	*476.0*	*333.8*	*51.0*	*50.8*	*0.099*
2019	*453.6*	*322.5*	*51.0*	*48.9*	*0.099*
2020	*431.3*	*309.3*	*51.0*	*46.5*	*0.099*
2021	*409.9*	*295.2*	*51.0*	*43.9*	*0.099*

Table 19.4.2 Output from short term prognosis. Multiplier is based on reference to the adopted HCR $F_{9\text{-}19}$=0.097. Biomasses are in the beginning of the year to apply to ICES standard in short term prognosis in other places in the report they are in the middle of the year.

F(2016)=0.111 C(2016)=**59 700** tons.

2017				
Bio 5+	SSB	Fmult	F9-19	Landings
504	381	1.017	0.1	53

			2017		2018	
Fmult	F9-19	Bio 5+	SSB	Landings	Bio 5+	SSB
0.0	0.049	509	397	0	539	433
0.1	0.054	507	395	6	531	425
0.2	0.058	504	392	11	523	418
0.3	0.063	501	390	16	515	411
0.4	0.068	499	388	21	507	404
0.5	0.073	496	386	27	499	397
0.6	0.078	493	383	32	491	390
0.7	0.083	491	381	37	483	383
0.8	0.088	488	379	41	476	377
0.9	0.094	486	377	46	468	370
1.0	0.099	483	374	51	461	363
1.1	0.104	480	372	55	454	357
1.2	0.109	478	370	60	446	350
1.3	0.114	475	368	64	439	344
1.4	0.119	472	365	69	432	338
1.5	0.125	470	363	73	425	332
1.6	0.130	467	361	77	418	326
1.7	0.135	465	359	81	411	320
1.8	0.141	462	356	85	405	314
1.9	0.146	459	354	89	398	308
2.0	0.151	457	352	93	392	302

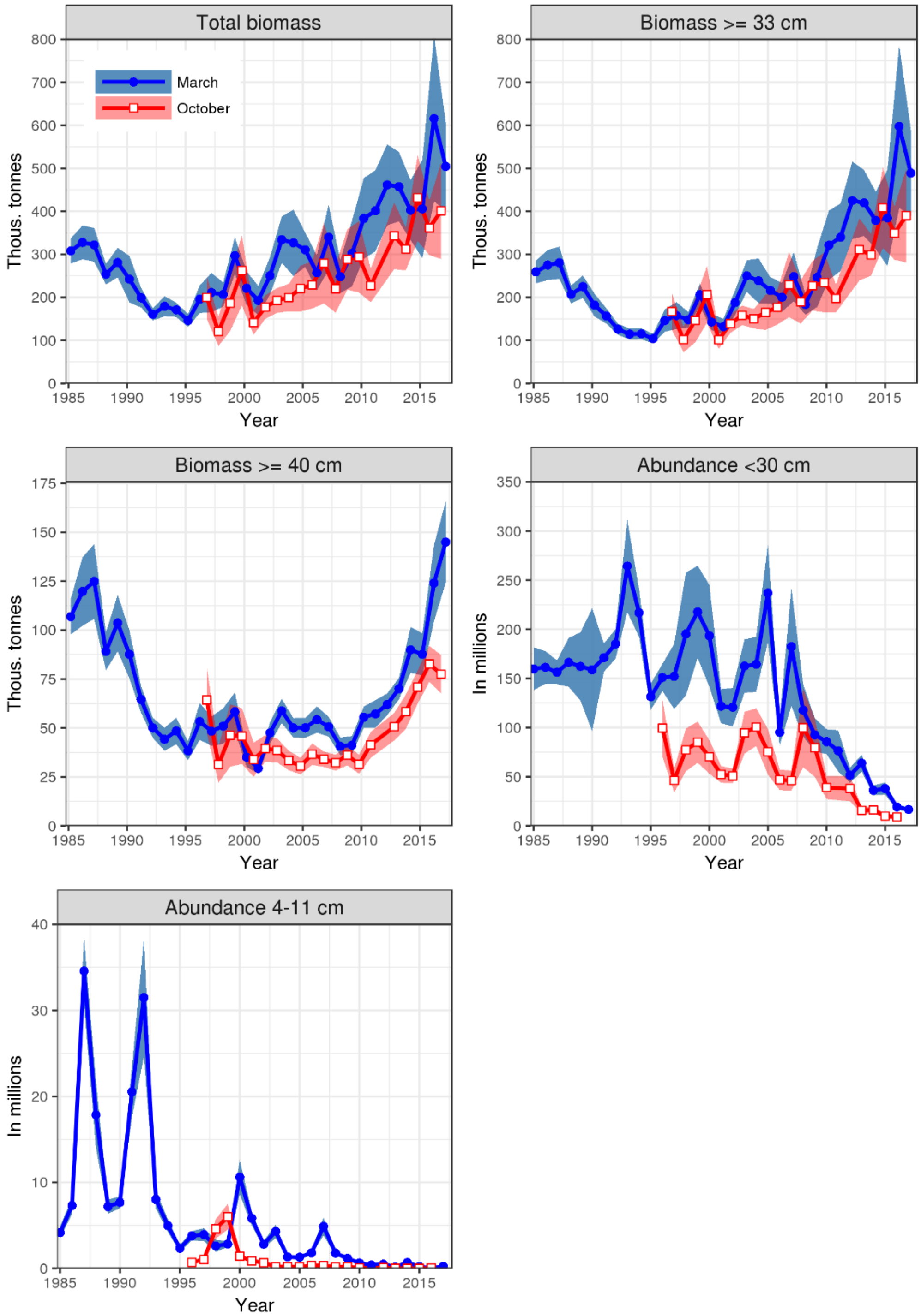


Figure 19.2.1 Indices of golden redfish in ICES Division 5.a (Icelandic waters) from the groundfish surveys in March 1985-2017 (blue line and shaded area) and October 1996-2016 (red lines and shaded areas). The shaded areas show ±1 standard error of the estimate.

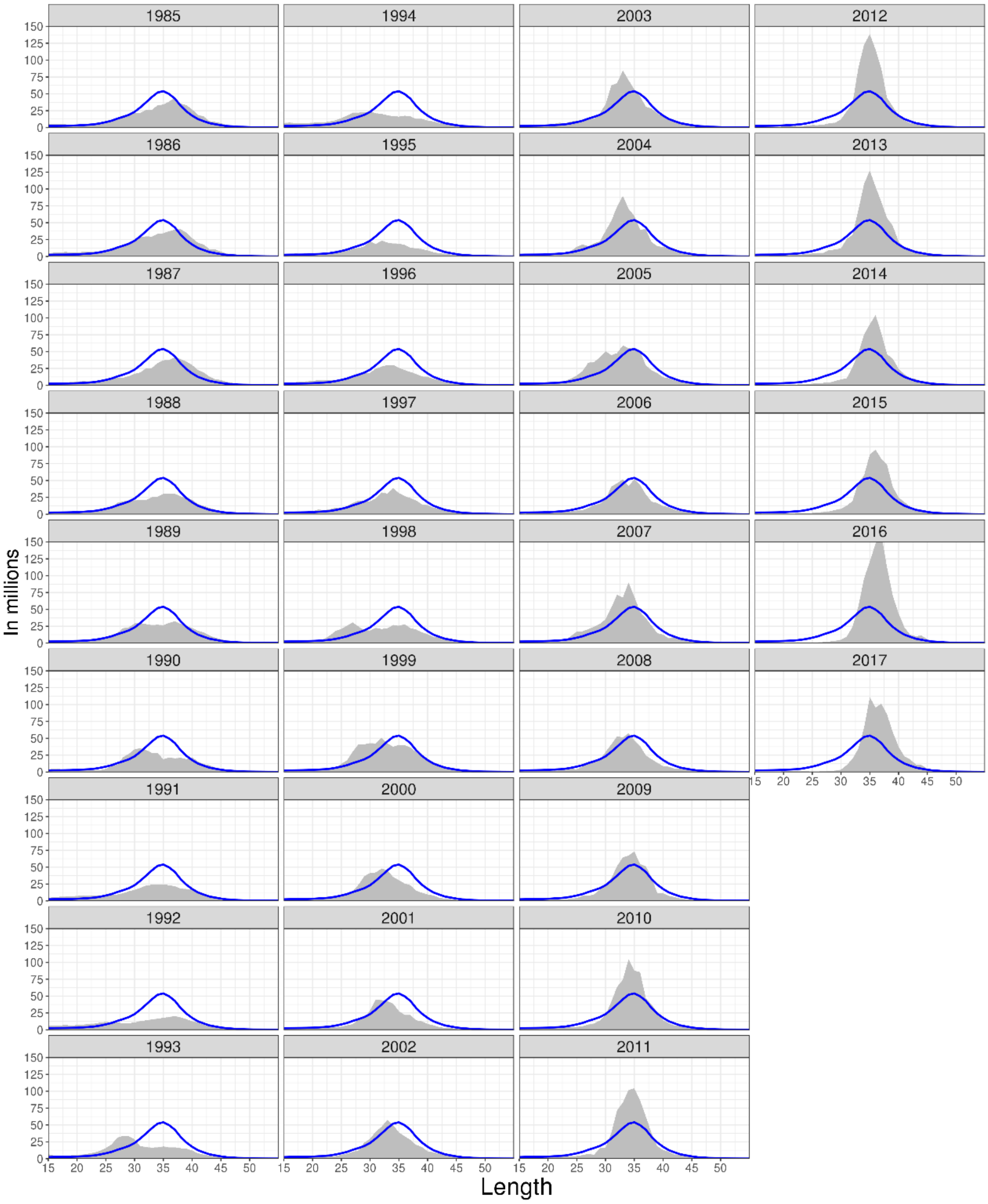


Figure 19.2.2. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in March 1985-2017 conducted in Icelandic waters. The blue line is the mean of total indices 1985-2017.

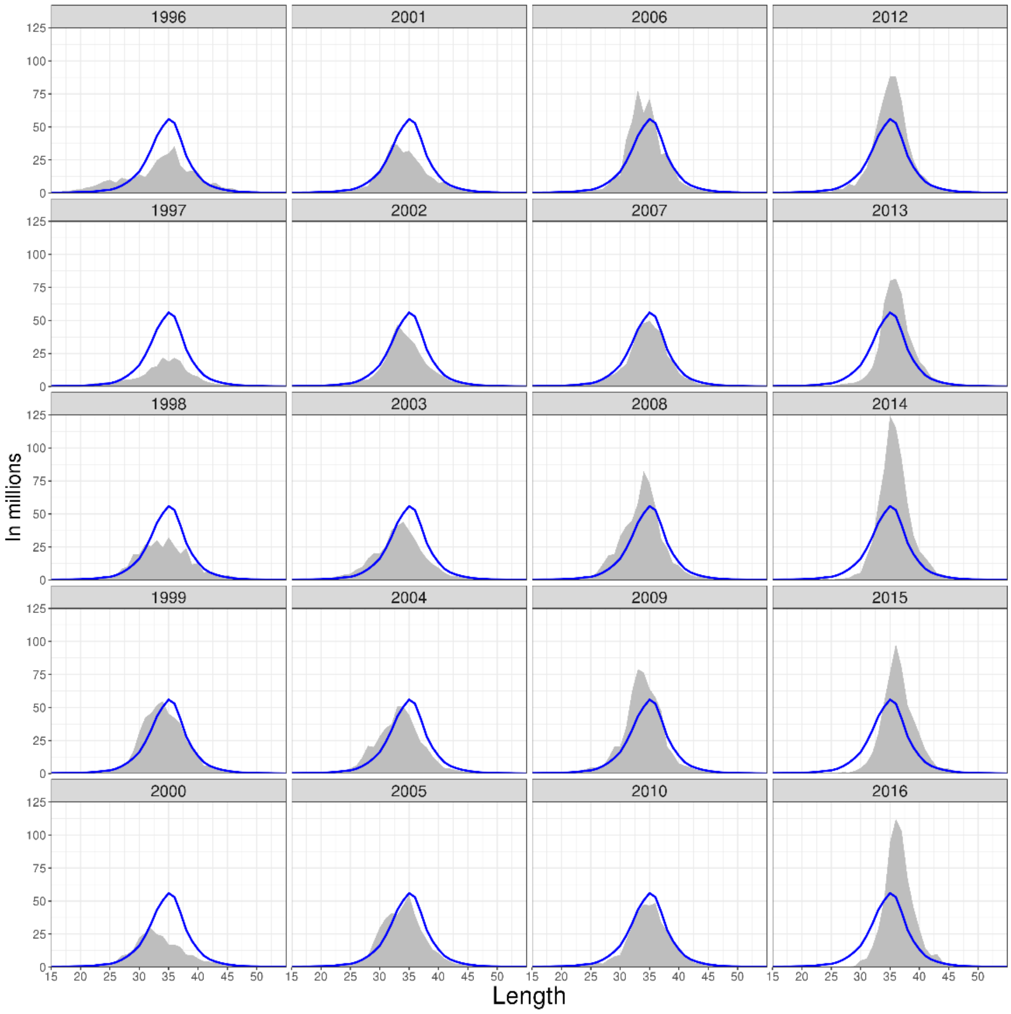


Figure 19.2.3. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in October 1996-2016 conducted in Icelandic waters. The blue line is the mean of total indices 1996-2016. The survey was not conducted in 2011.

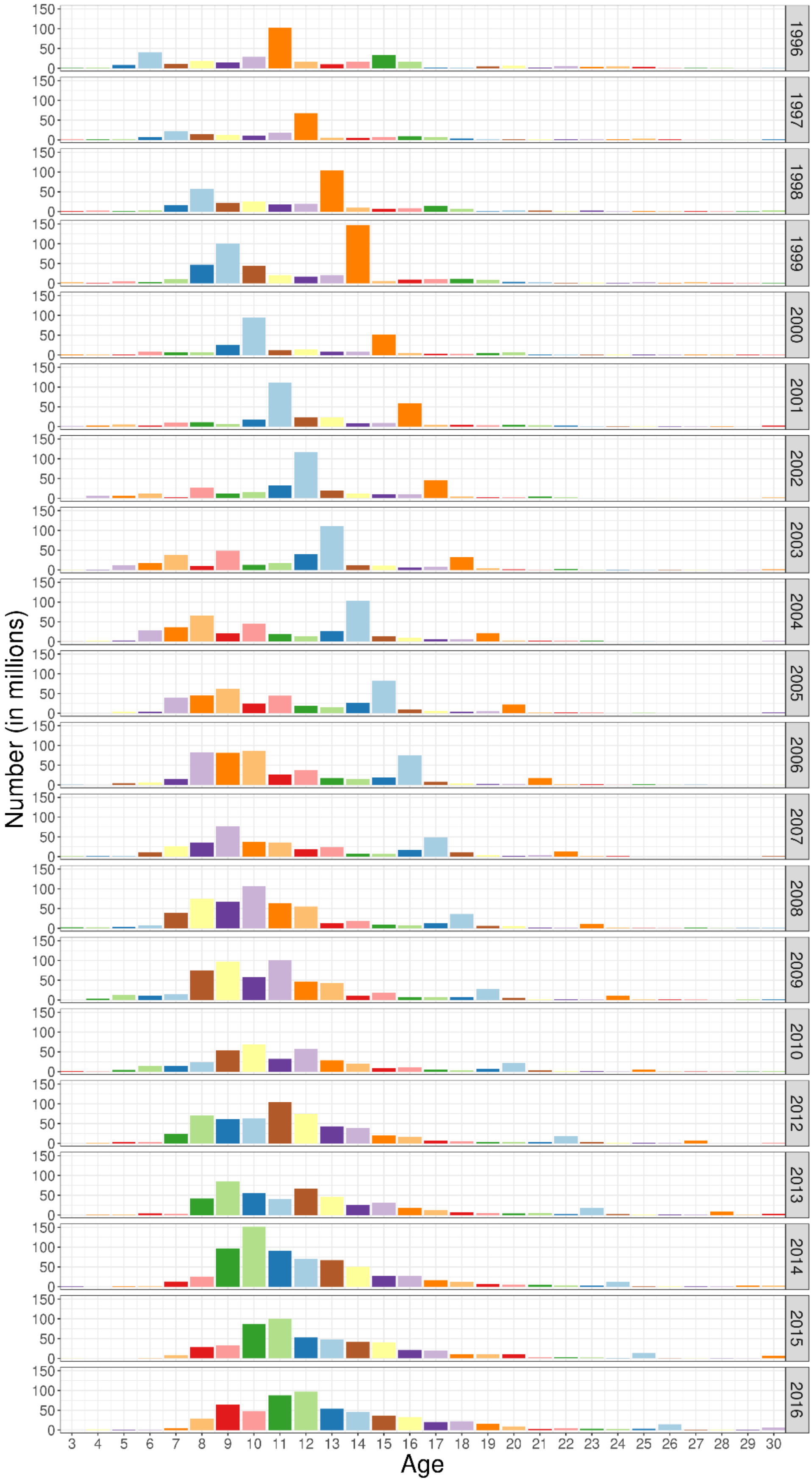


Figure 19.2.4 Age disaggregated abundance indices of golden redfish in the bottom trawl survey in October conducted in Icelandic waters 1996-2016. The survey was not conducted in 2011.

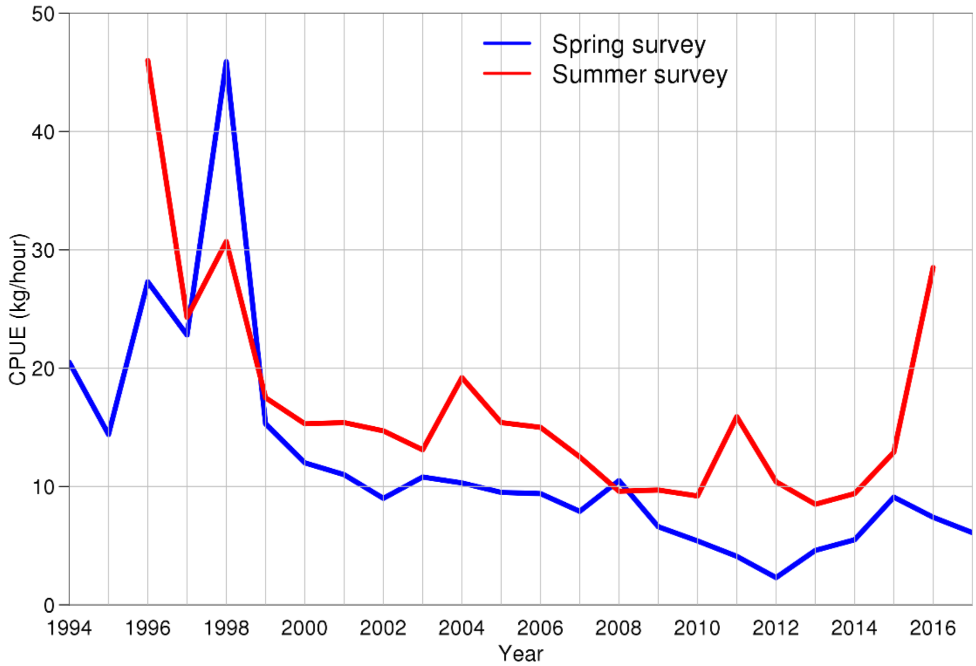


Figure 19.2.5 CPUE of golden redfish in the Faeroes spring groundfish survey 1994-2017 and the summer groundfish survey 1996-2016 in ICES Division 5.b.

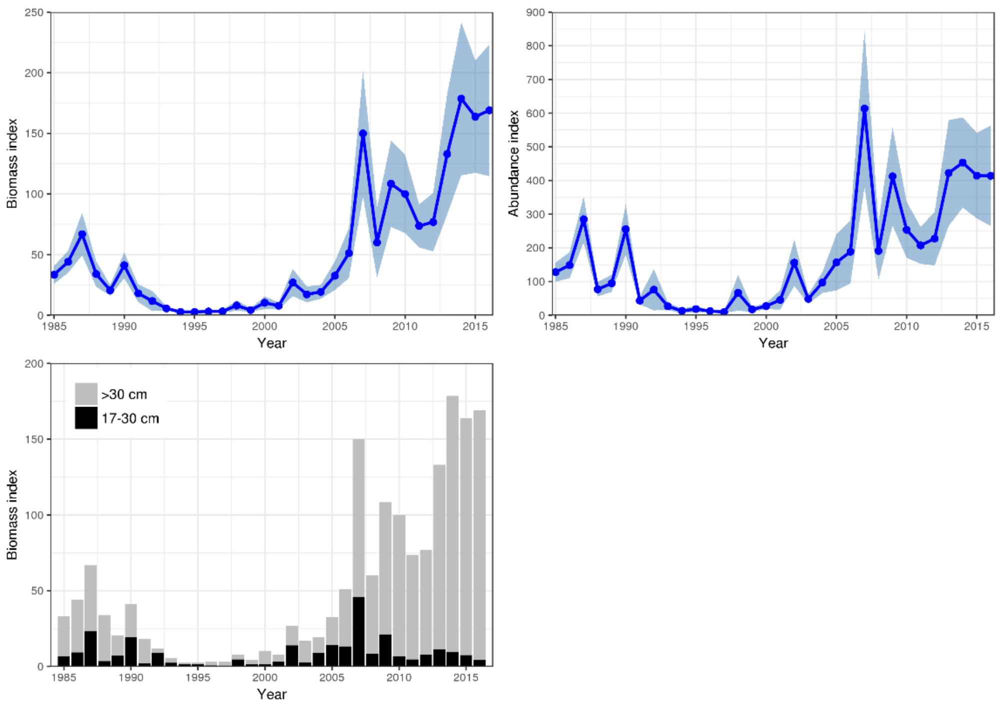


Figure 19.2.6 Golden redfish (>17 cm). Survey abundance indices for East Greenland (ICES Subarea 14) from the German groundfish survey 1985-2016. a) Total biomass index, b) total abundance index, c) biomass index divided by size classes (17-30 cm and > 30 cm).

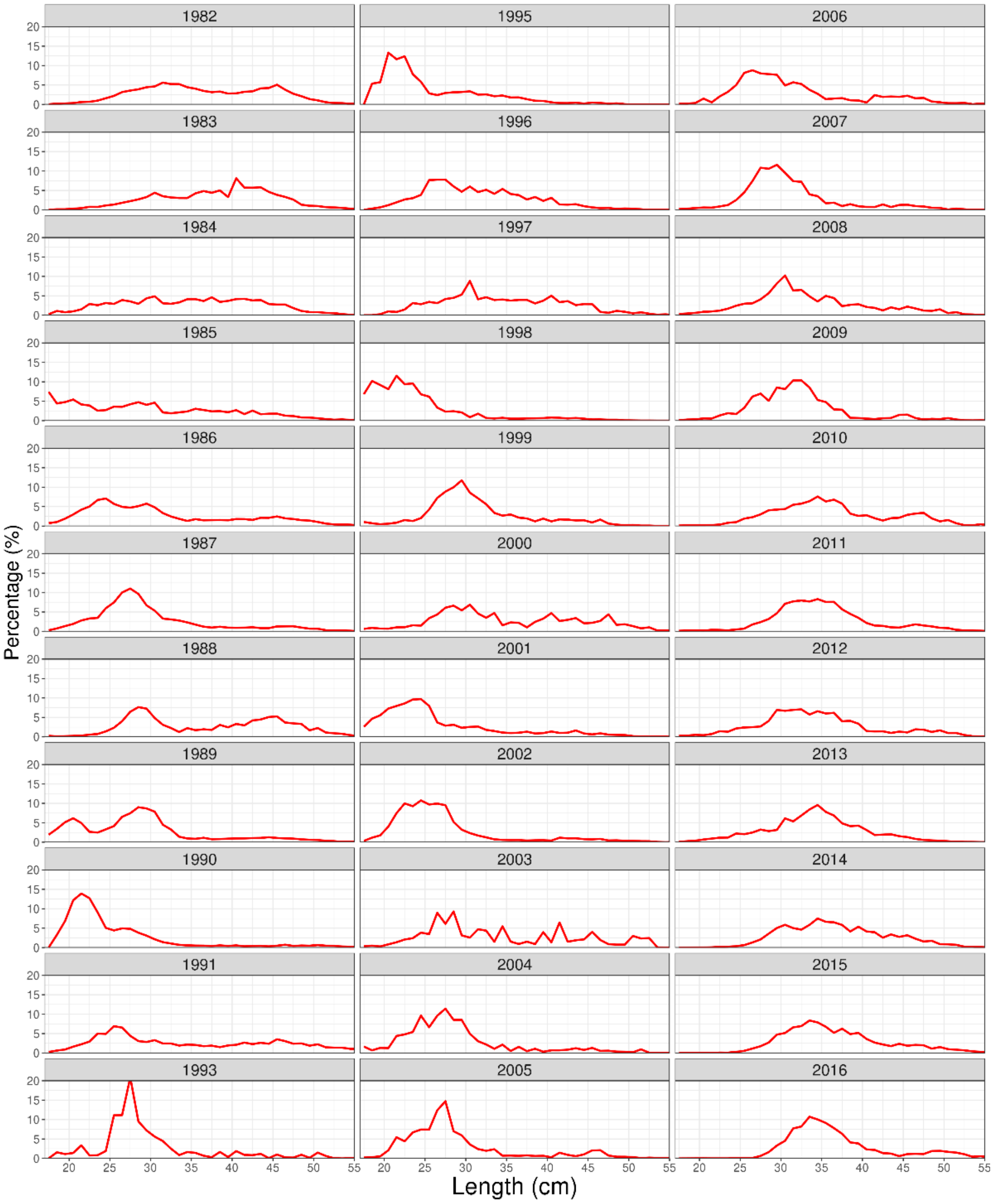


Figure 19.2.7 Golden redfish (>17 cm). Length frequencies for East Greenland (ICES Subarea 14) 1982-2016.

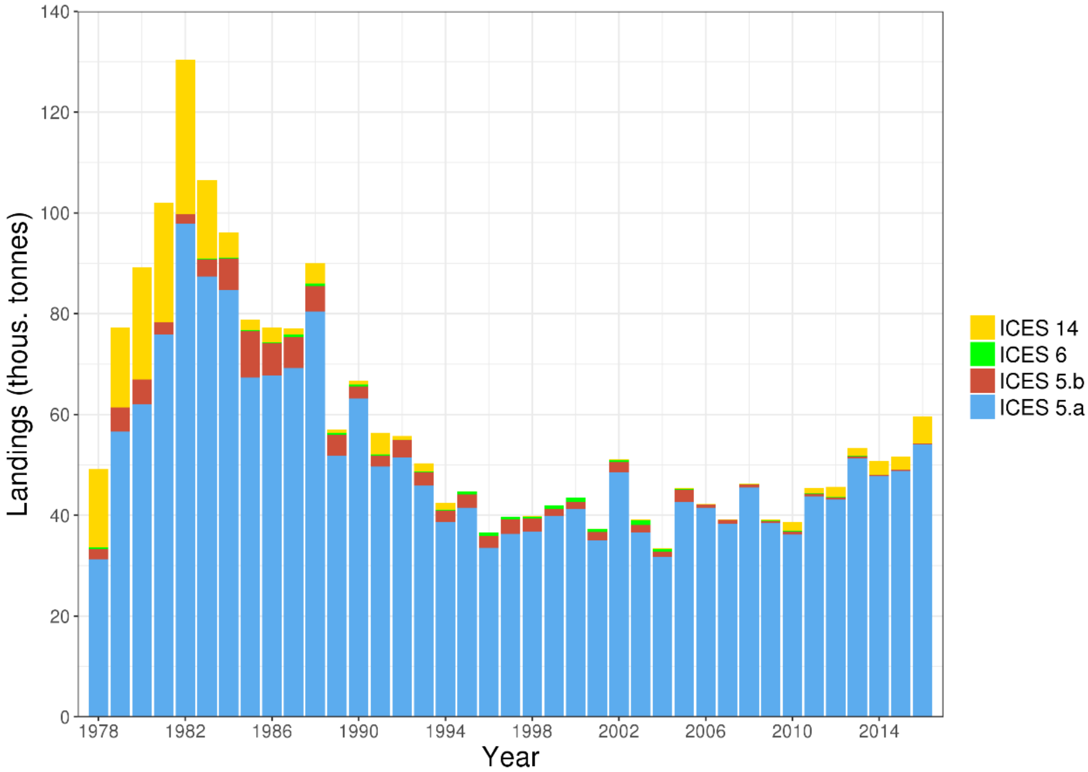


Figure 19.3.1 Nominal landings of golden redfish in tonnes by ICES Divisions 1978-2016. Landings statistics for 2016 are provisional.

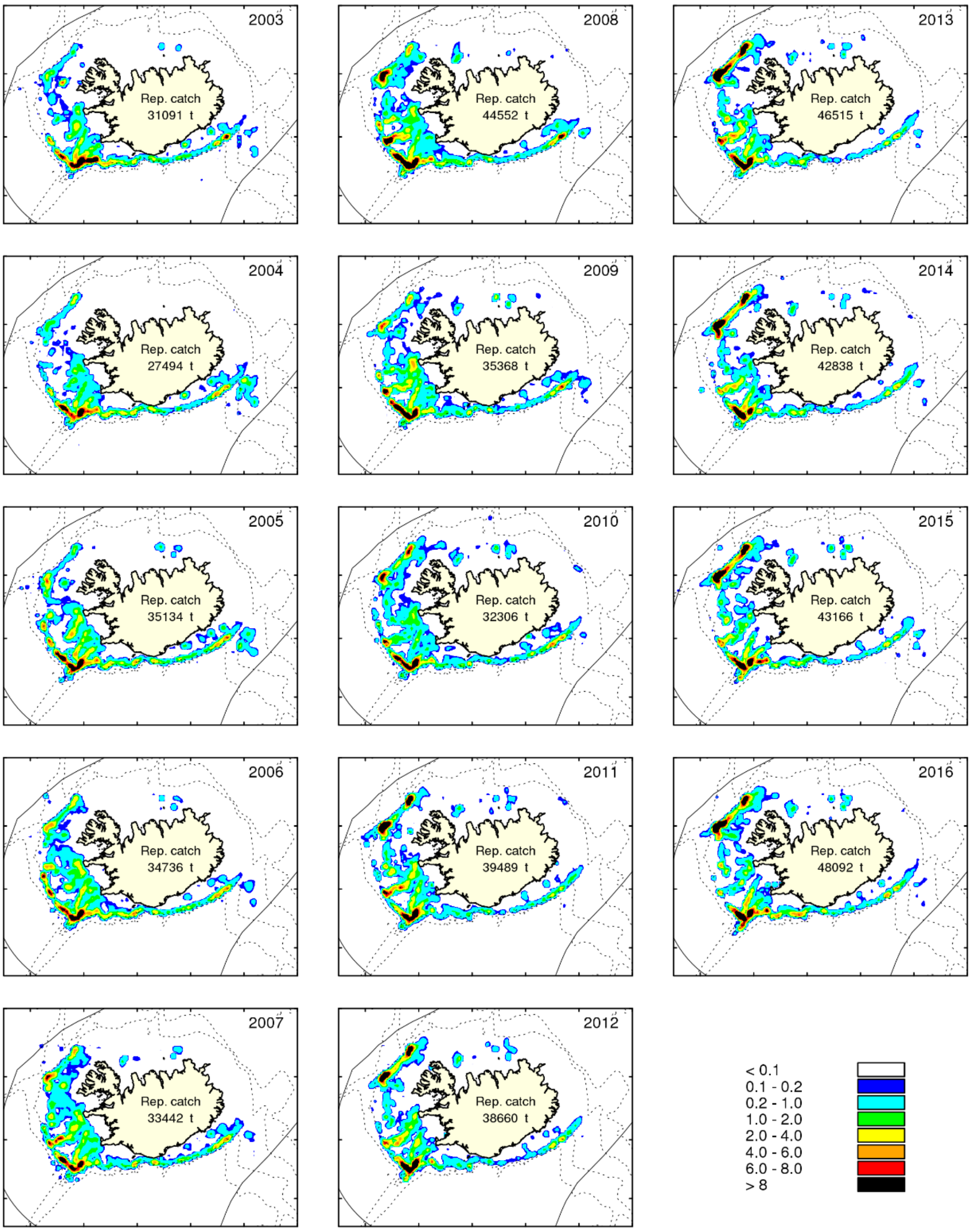


Figure 19.3.2 Geographical distribution of golden redfish bottom trawl catches in Division 5.a 2003-2016.

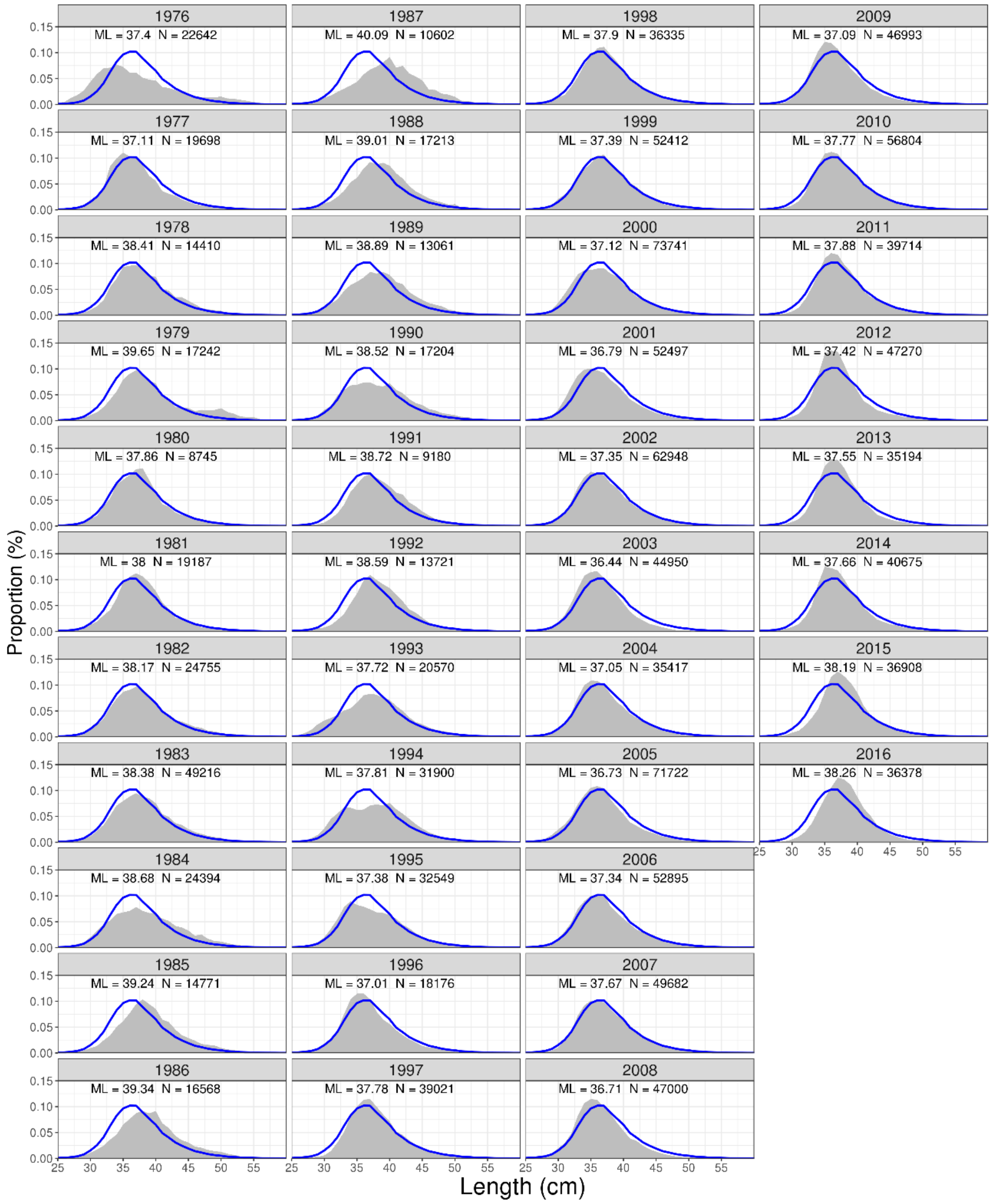


Figure 19.3.3 Length distribution (gray shaded area) of golden redfish in Icelandic waters (ICES Division 5.a) in the commercial landings of the Icelandic bottom trawl fleet 1976-2016. The blue line is the mean of the years 1976-2016.

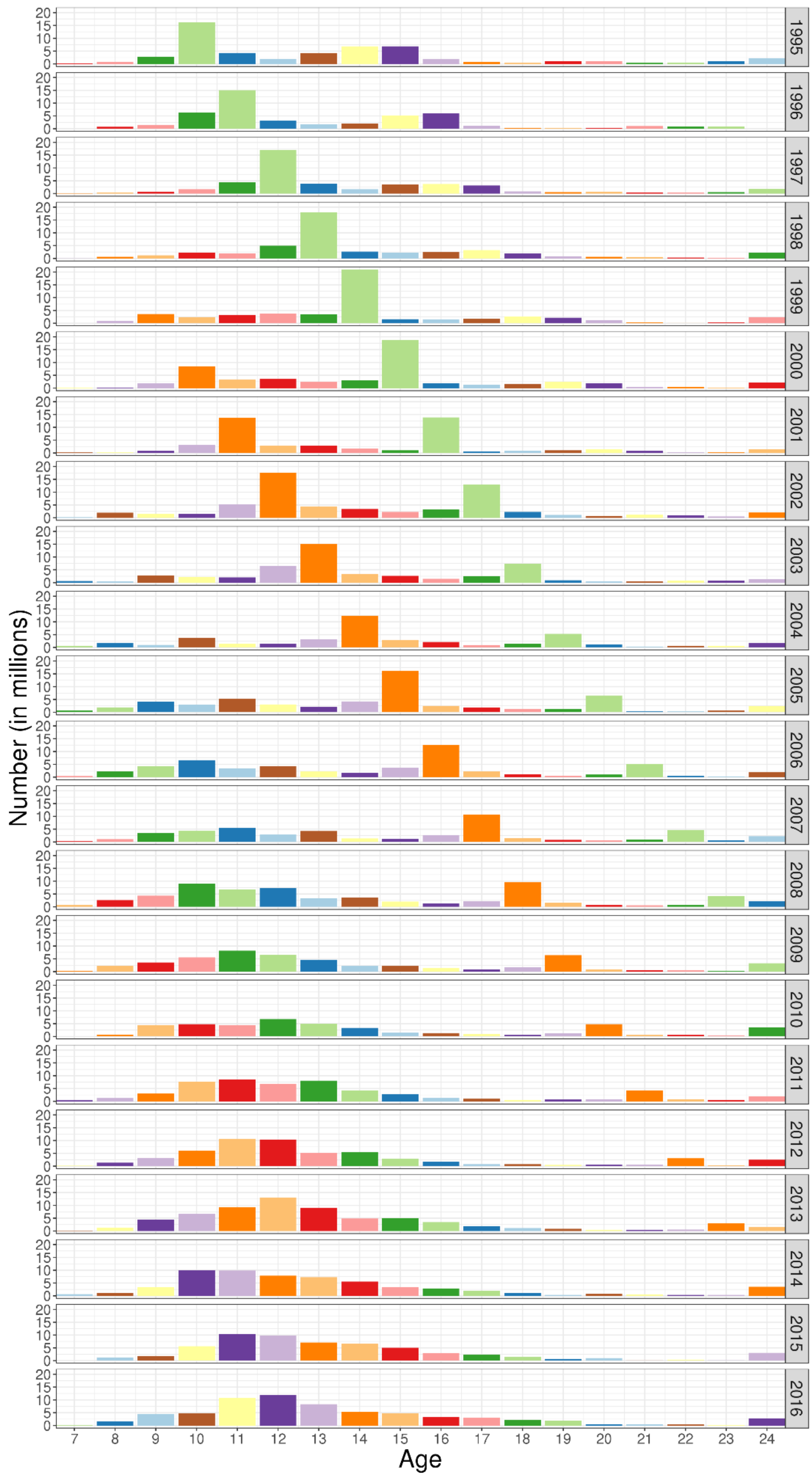


Figure 19.3.4 Catch-at-age of golden redfish in numbers in ICES Subdivision 5.a 1995-2016.

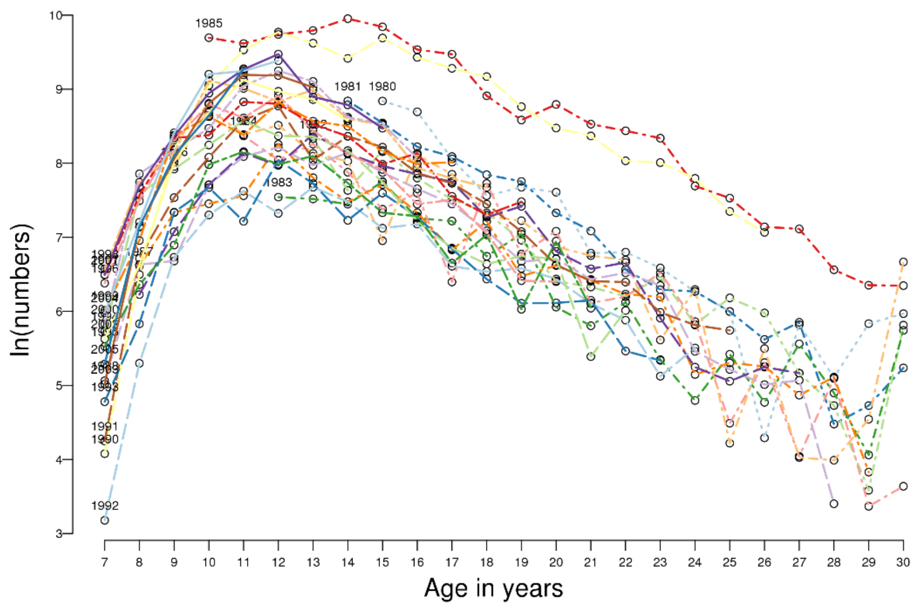


Figure 19.3.5 Catch curve of golden redfish based on the catch-at-age data in ICES Division 5.a 1995-2016.

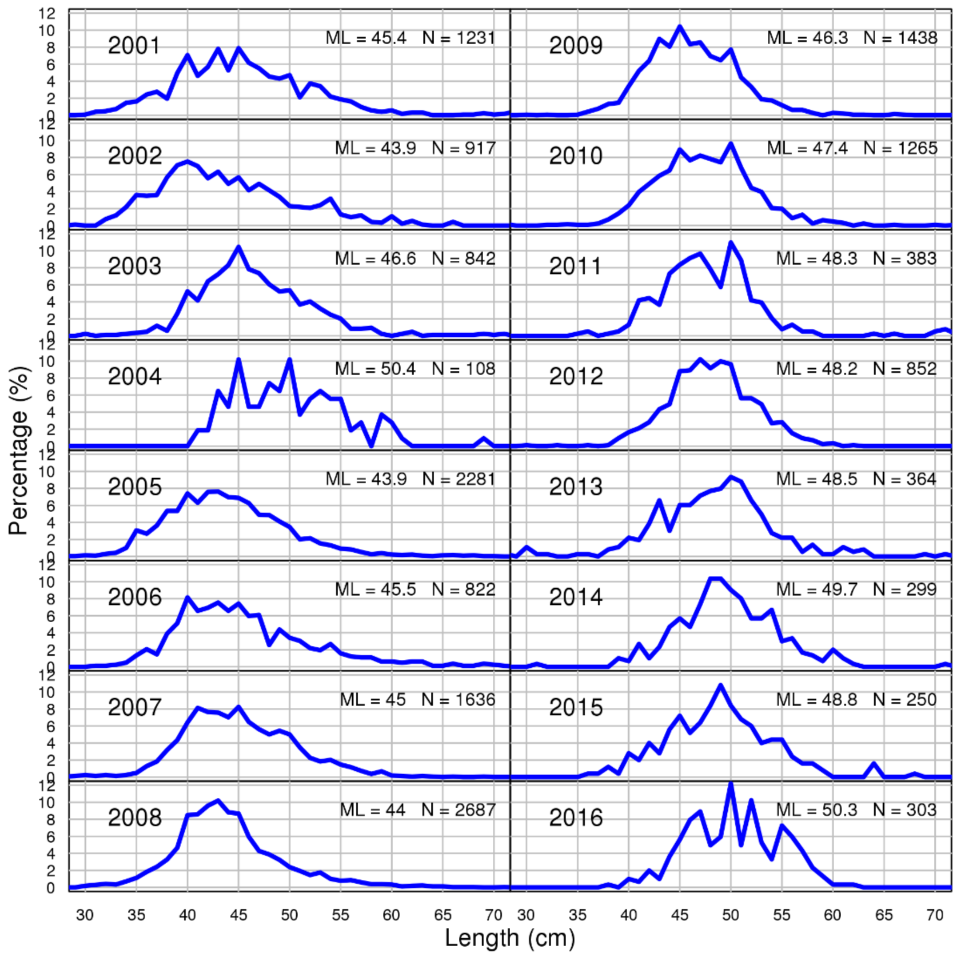


Figure 19.3.6 Length distribution of golden redfish from Faroese catches in ICES Division 5.b in 2001-2016.

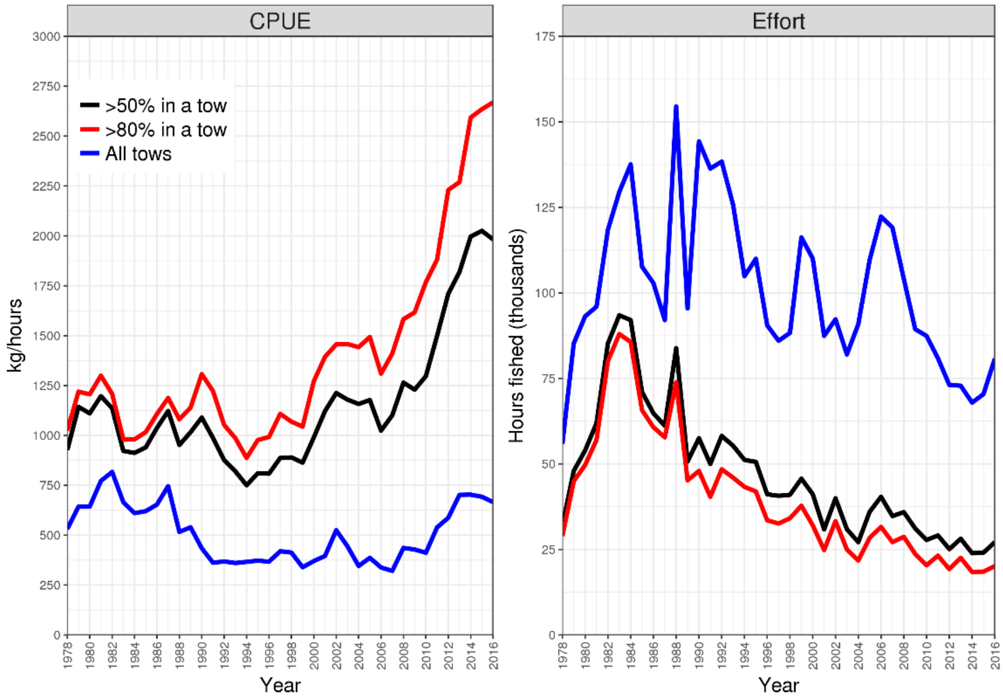


Figure 19.3.7 CPUE of golden redfish from Icelandic trawlers 1978-2016 where golden redfish catch composed at least 50% of the total catch in each haul (black line), 80% of the total catch (red line) and in all tows where golden redfish was caught (blue line). The figure shows the raw CPUE index (sum(yield)/sum(effort)) and effort.

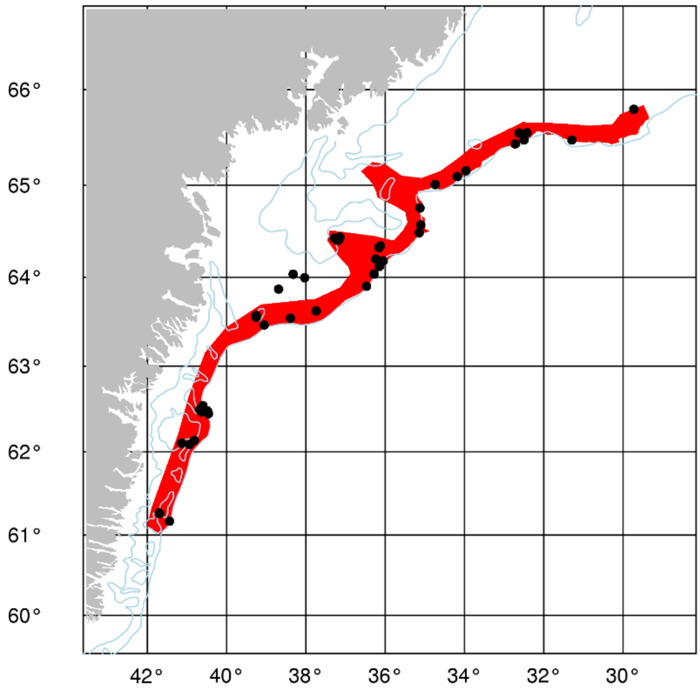


Figure 19.4.1 Stations in the German survey in East Greenland with an area used to compile the indices for Gadget shown. This area corresponds to giving a weight of 0.5 to the results in Figure 19.2.7.

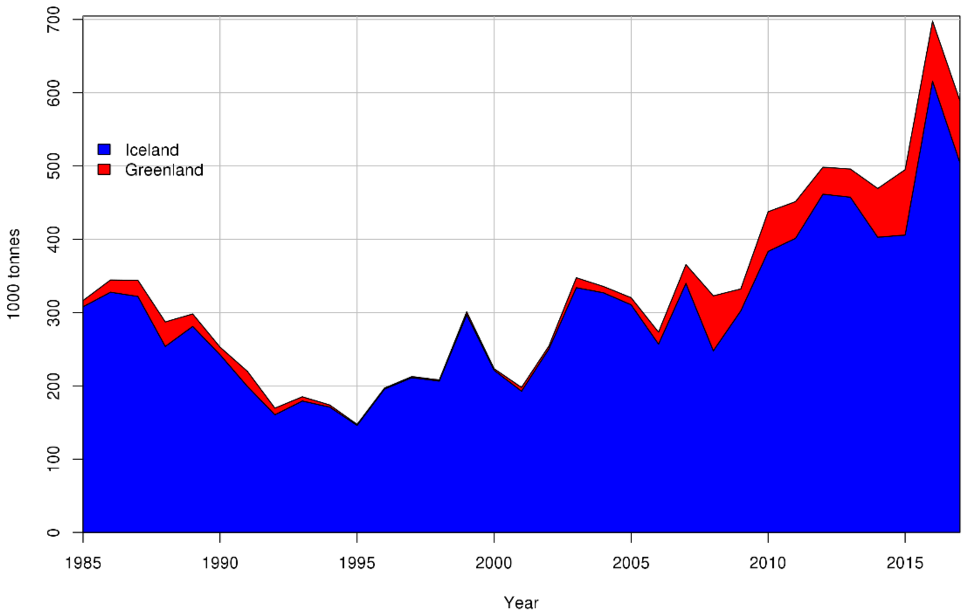


Figure 19.4.2 Biomass index from Iceland (blue) and Greenland black, based on weighting the German survey data in Figure 19.2.7 by 0.5.

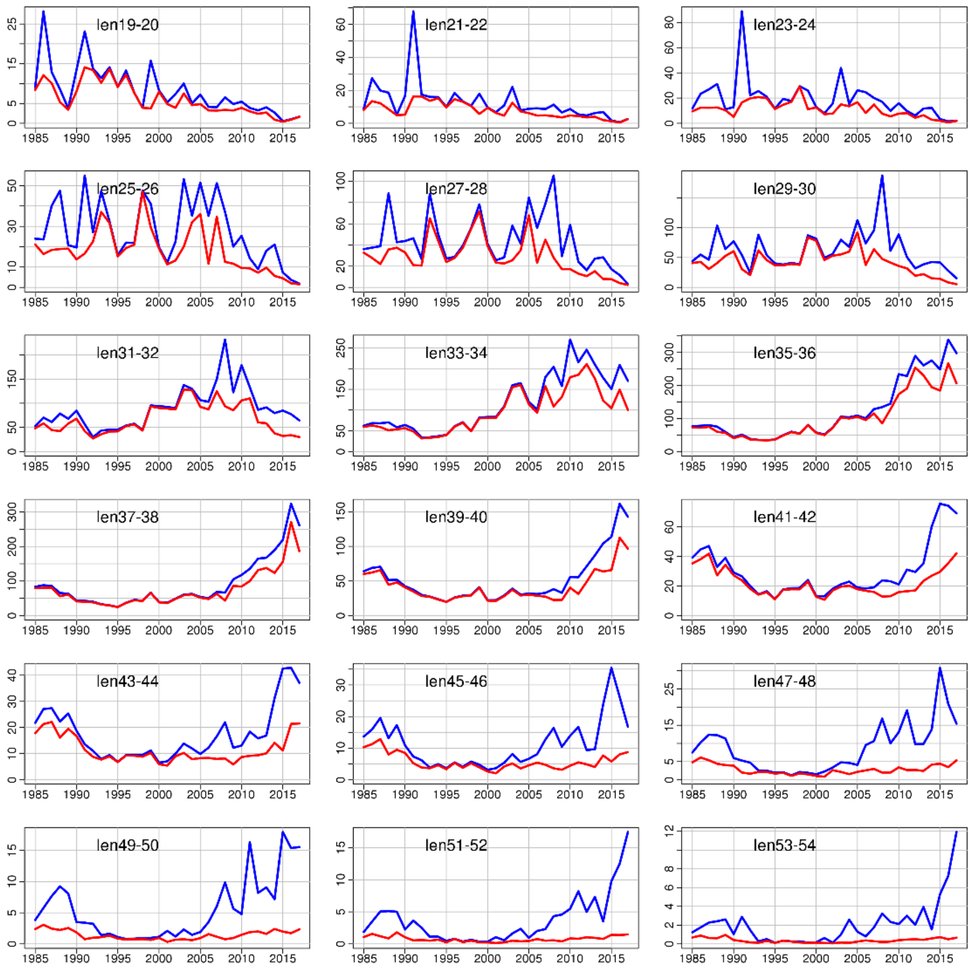


Figure 19.4.3. Indices from the Icelandic March survey (red) and the German survey in East Greenland (blue) by length group.

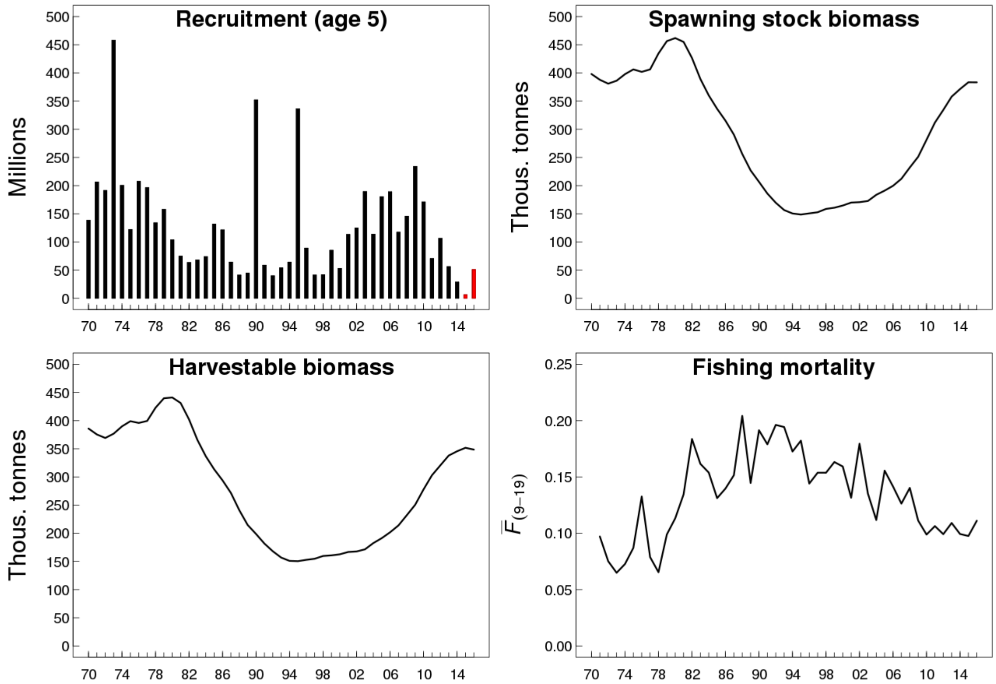


Figure 19.4.4. Summary from the assessment. Red values are predictions. Spawning stock is compiled using a fixed maturity ogive with L50=33cm.

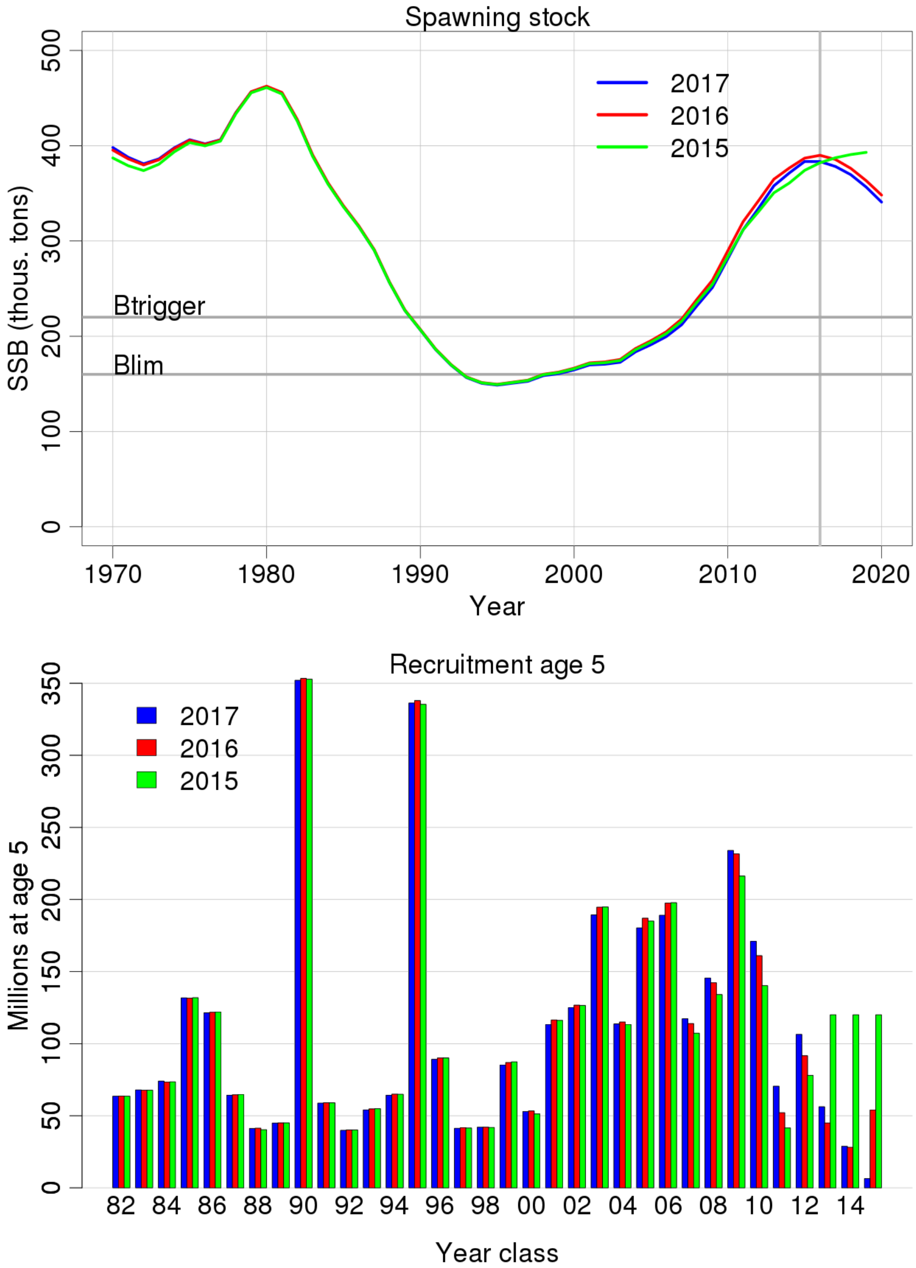


Figure 19.4.5. Comparison of the current assessment and the same assessment done in 2015 and 2016.

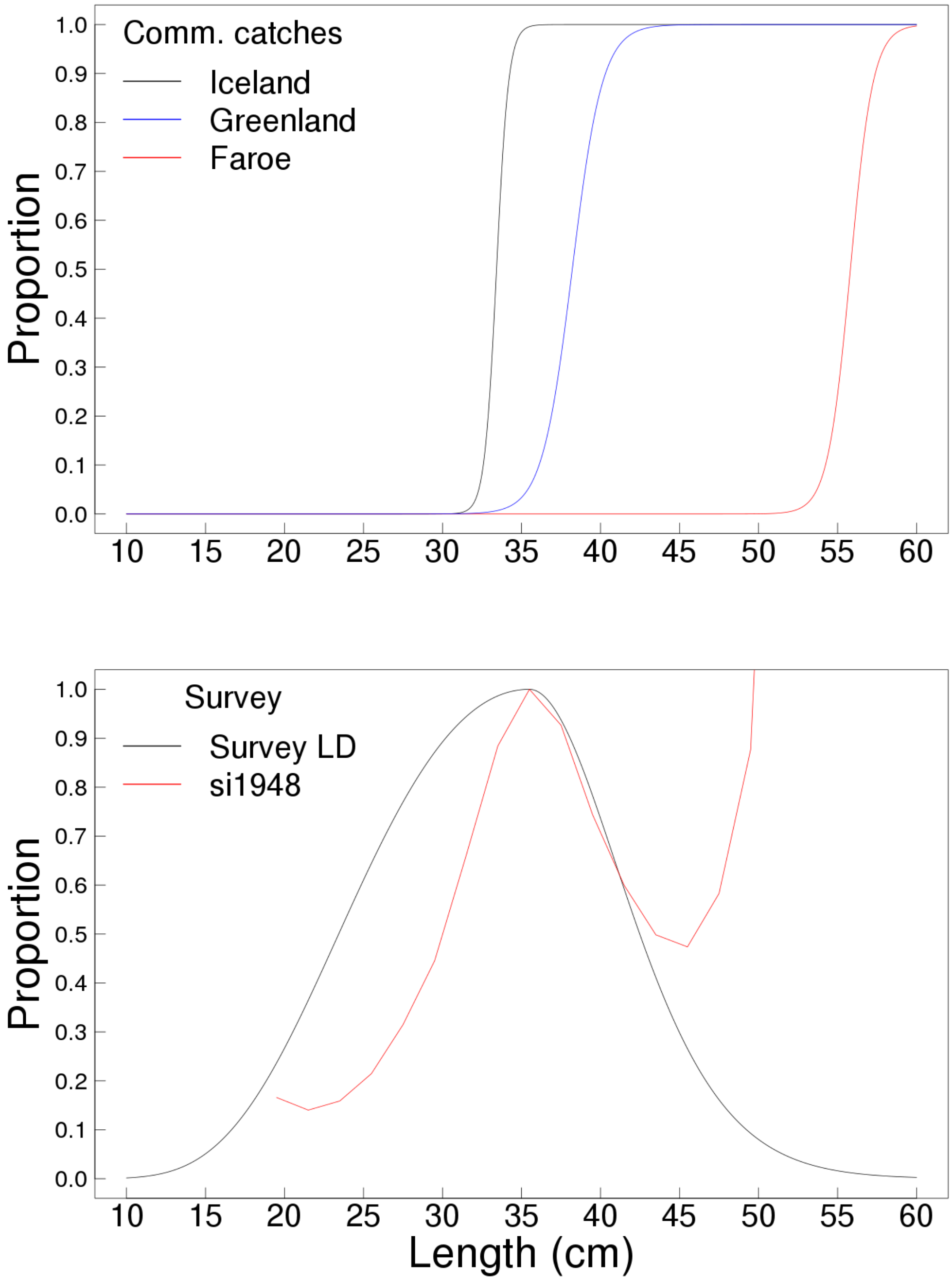


Figure 19.4.6. Estimates of selection curves from commercial catches (upper panel) and from the Icelandic March survey. The black line is the estimated selection curve fitted to the length distributional data and the red line is the estimated q from the disaggregated tuning indices, scaled to one.

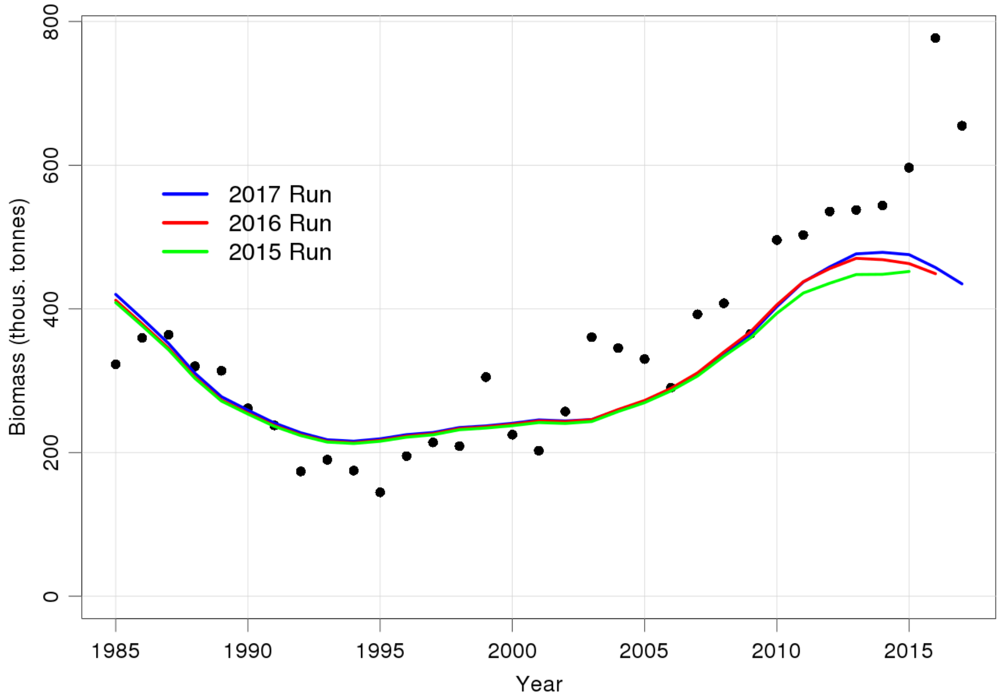


Figure 19.4.7. Comparison of observed and predicted survey biomass from the 2017 (blue line), 206 (red line) and 2015 (green line) runs.

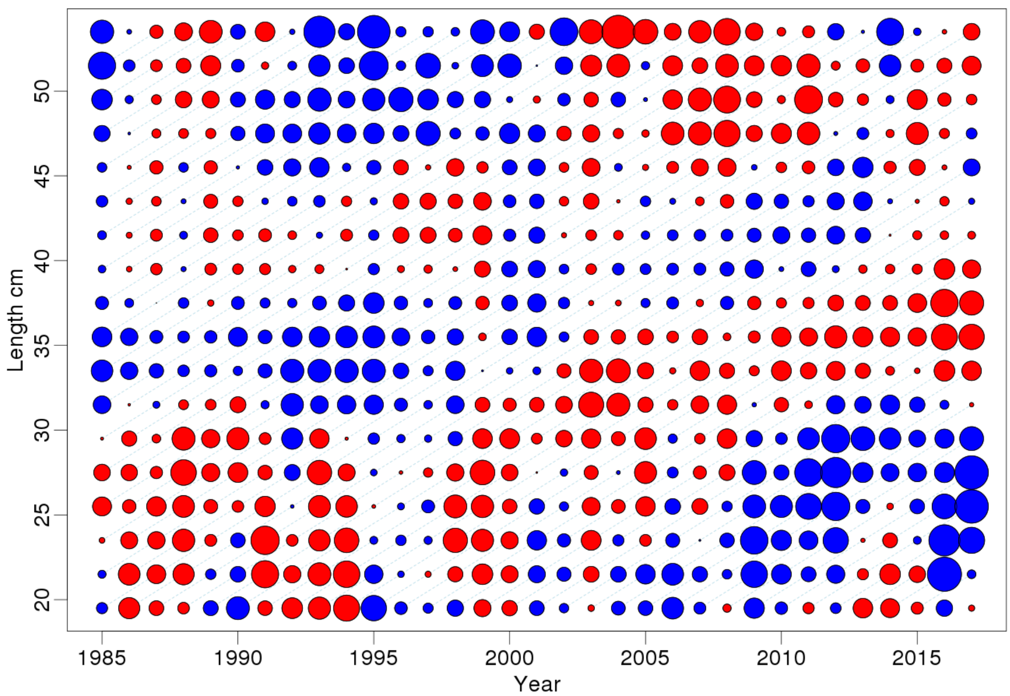


Figure 19.4.8. Residuals from the fit between model and survey indices. The red circles indicate positive residuals (survey results exceed model prediction). Largest residuals correspond to log(obs/mod) = 1

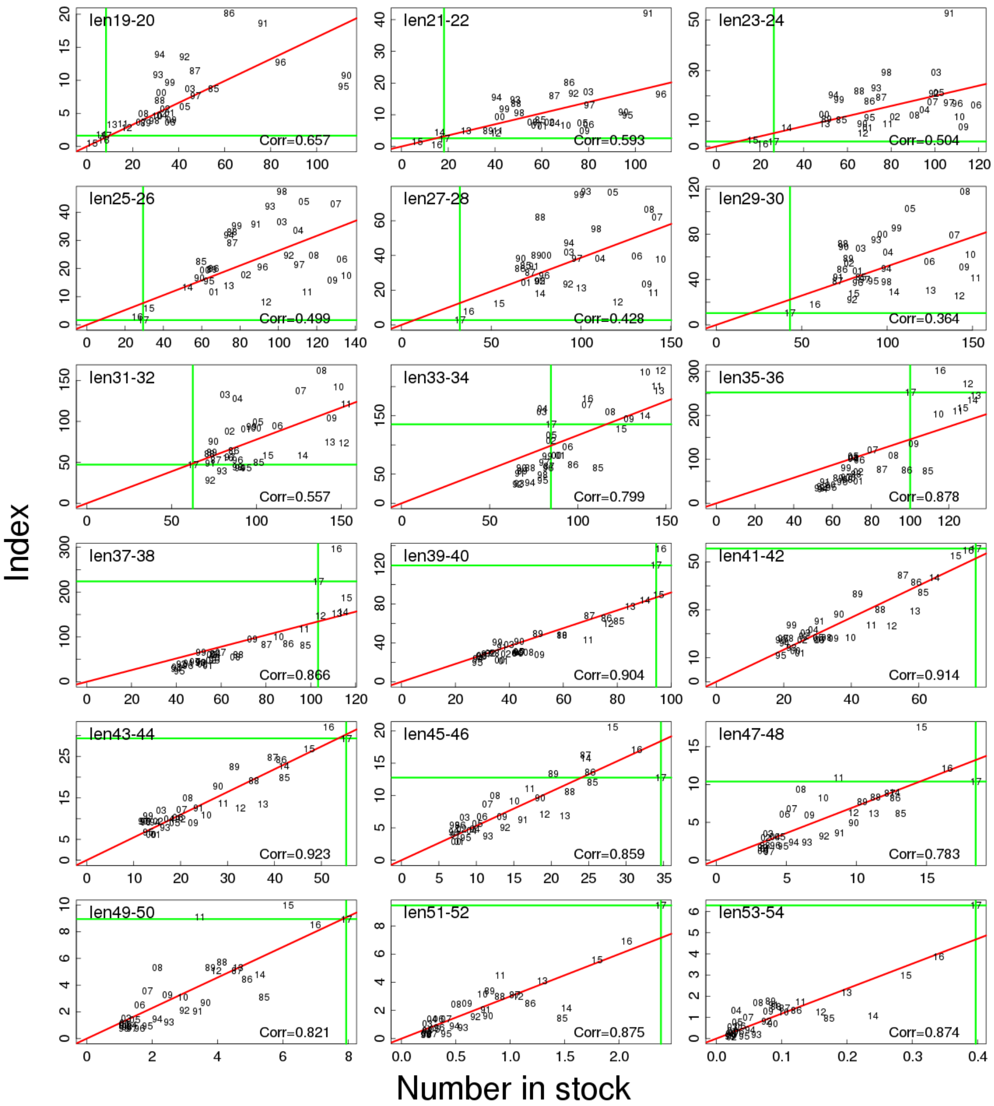


Figure 19.4.9. Fit to length disaggregated survey indices from Gadget run as XY-scatter. The red line is fitted going through the 0-point, the green cross goes over the terminal year.

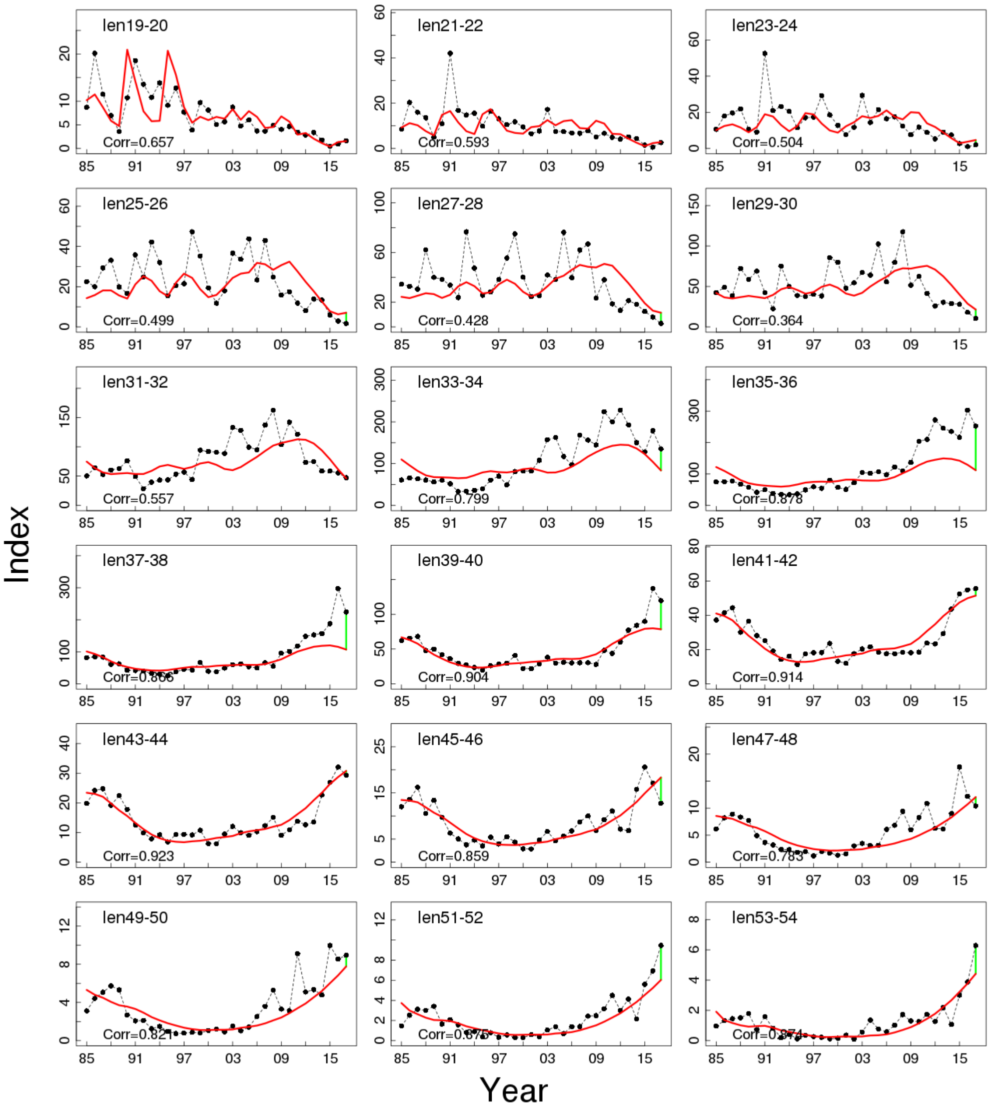


Figure 19.4.10. Fit (red lines) to length disaggregated survey indices (broken lines and points) from Gadget run as time series.

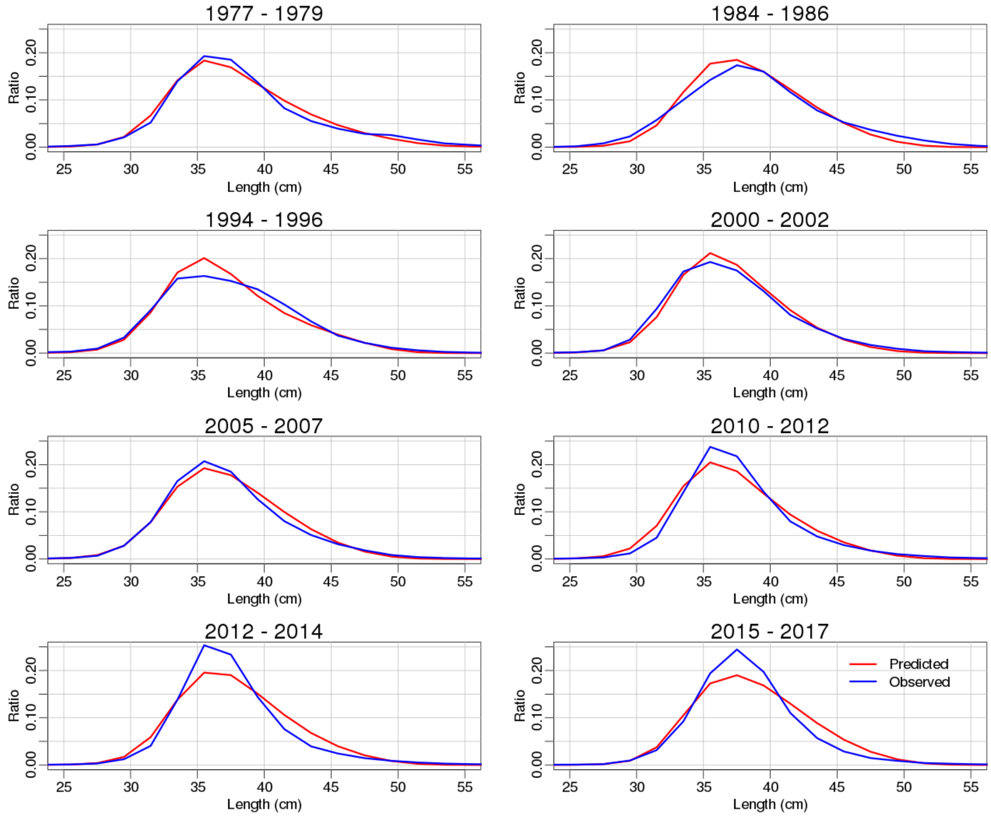


Figure 19.4.11. Fit (red line) to Icelandic commercial length distributions aggregated by 3 years.

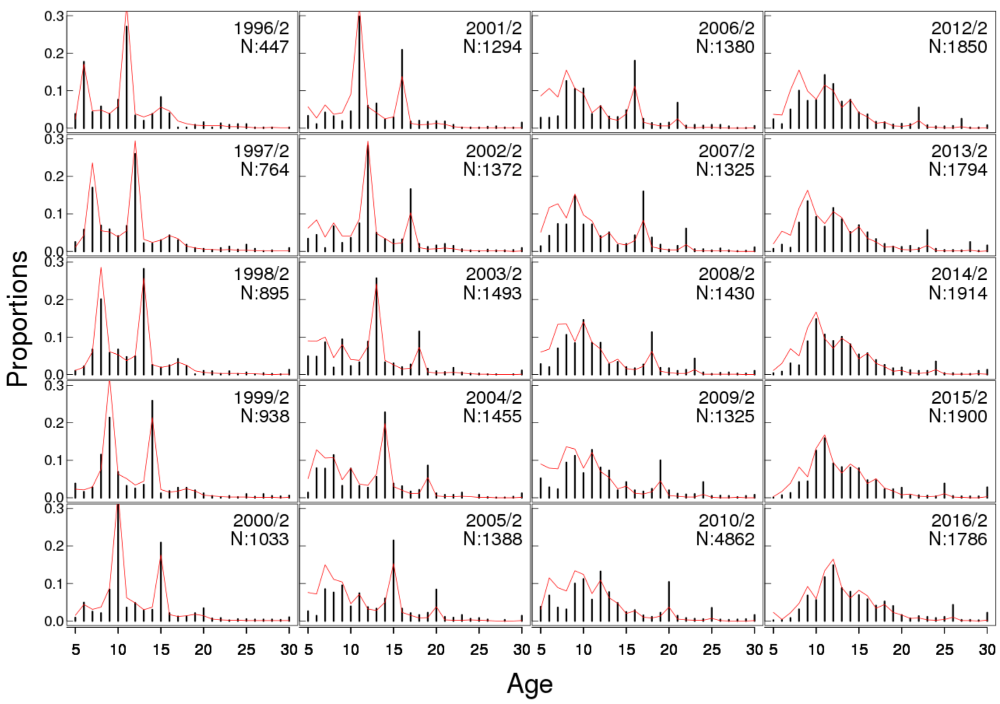


Figure 19.4.12. Fit to survey age data (run 1). Bars represent the data and red lines the fit. The likelihood data are used in the model as proportions in each 2 cm length group but presented here as total for each age group something that should only be comparable if catchability was independent of size (age).

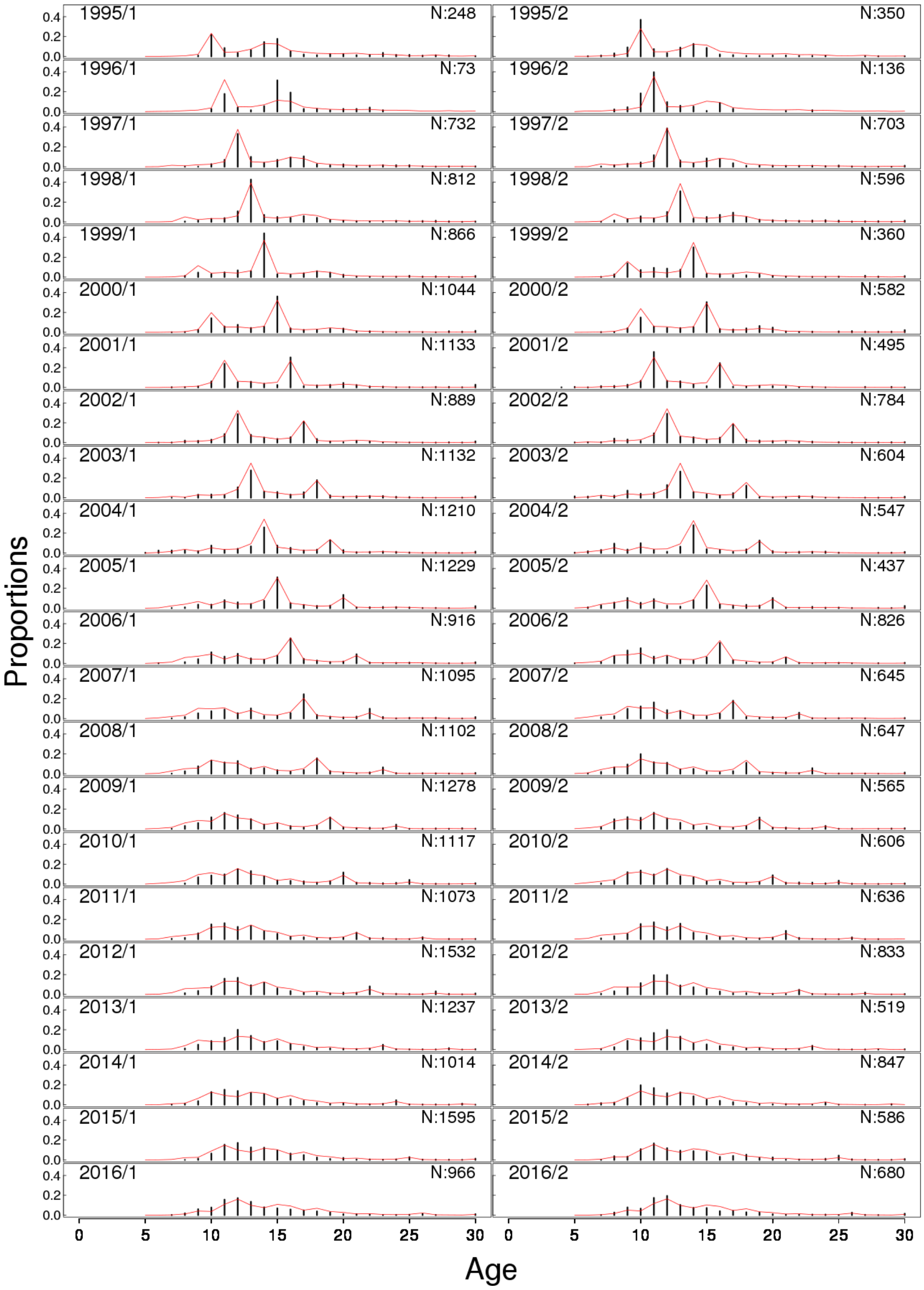


Figure 19.4.13. Predicted (red) and observed (blue) age distributions from Icelandic commercial fishery.

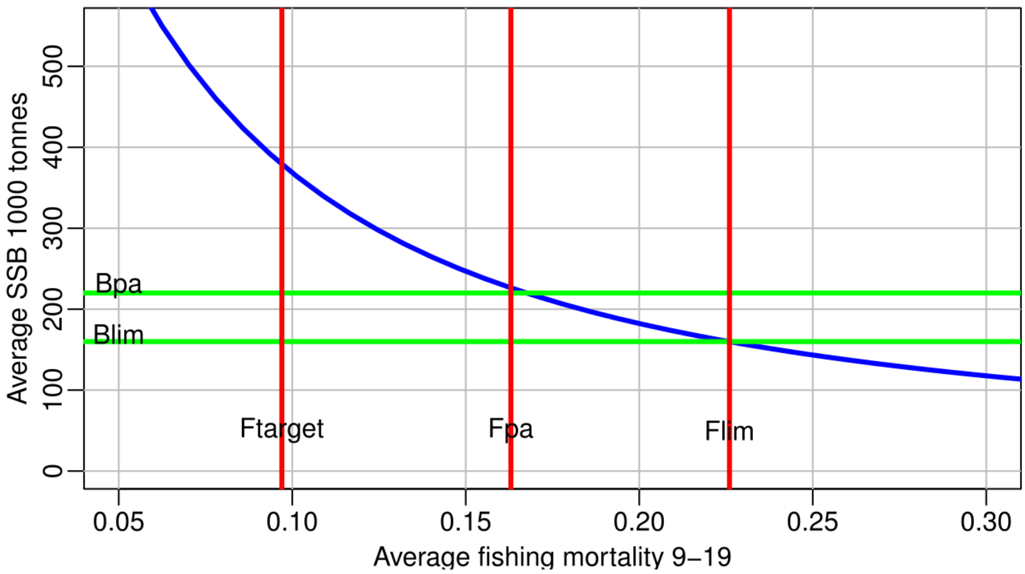


Figure 19.6.1. Average SSB against average fishing mortality and defined reference points.

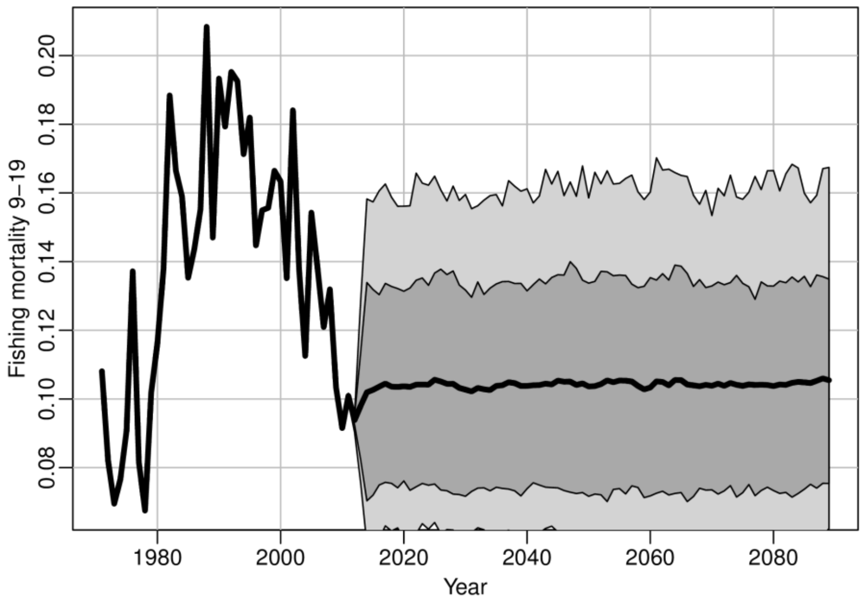


Figure 19.6.2. Development of F_{9-19} based on F_{9-19} = 0.097. The light grey area shows fifth and 95th quantile and the dark areas 16th and 84th quantile.

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—2016. 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, but decreased again in 2016 to a level similar to that observed in 2007-2013 (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 has increased since then and was in 2015 at the highest in the time series. In 2016 the index decreased to a similar level as in 2014.

The abundance index of fish 30 cm and smaller has in 2007—2016 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—2016 (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—2016 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—2016 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—2016, 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 2016 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	9 536	83	12 685

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—2016 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 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 2016 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 to 1994, when CPUE decreased, the fishing effort increased drastically. Since then, effort decreased and is now at similar level as in the early 1980s.

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.

As described in section 1.3 MSY proxy reference points need to be defined for the Icelandic slope *S. mentella* stock. ICES suggested four methods for this purpose, and all methods were tested on the stock. One of the method did not work for the stock: the Length-Based Spawner Per Recruit method. The other three methods, the Length Based Indicators, Mean Length Z, and SPiCT model, indicated that Icelandic slope *S. mentella* is exploited at reasonable level. The parameter uncertainty was however high.

The conclusion of NWWG was that, based on the caveats listed below and the declines seen in the autumn survey and little or no recruitment over the past decade, the determination of the stock status in relation to reference points should not be based on any of the suggested methods.

The caveats to consider in relation to the Icelandic slope *S. mentella* stock when concluding on the length based indicators and the SPiCT model.

- *S. mentella* is a long-lived and slow growing species. It will take long time for overfishing to result in changes in length frequency and these changes will be minor.
- If there are few year classes in the fishery the effect of overfishing the stock is more likely observed on biomass rather than length, especially on a slow growing species.
- Only the fishable stock is found in Icelandic waters and nursery areas are most likely on the East Greenland shelf. That is, the stock found on the Icelandic slope is not a closed unit.
- Surveys suggest that recruitment has been very low since 2006. In general, recruitment is sporadic in redfish. Strong recruitment to the stock seems to occur at time intervals of 5–10 years and these contribute to a stable fishery (Figure 20.2.3).
- The schooling behaviour of *S. mentella* means that the fishery can target a diminishing stock in a small area without seeing any effect on the length distribution.
- Any changes in length could just as well be related to migration.

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, increased again in 2014 and 2015, but decreased to the 2004-2013 level. The survey was not conducted in 2011. Standardised CPUE indices show a reduction from highs in the late 1980s, but there is an indication that the stock has started a slow recovery since the middle of 1990s, when CPUE was close to 50% of the maximum. The CPUE index 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 and 2003 by about 10 000 t when the fishery of pelagic *S. mentella* merged with the Icelandic slope fishery at the redfish line. Those two fisheries merged again in 2007.

There are no explicit management for Icelandic slope *S. mentella* but the species is within the TAC system described in Chapter 7.5. Icelandic authorities gave until the 2010/2011 a joint quota for golden redfish and Icelandic slope *S. mentella* in Icelandic waters, but now give separate quotas for the species.

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 2018 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 14.0% between average of 2012—2014 and 2015 and 2016 (average of the two years). This implies an increase of catches of 14.0% in relation to the last year advise (12 922 t), corresponding to catch of no more than 14 733 t. A precautionary buffer of 20% consistent with the ICES approach is applied which gives catch of no more than 11 786 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.

Table 20.2.1 Total biomass index of Icelandic slope *S. mentella* in the Icelandic Autumn Groundfish survey 2000-2016. No survey was conducted in 2011.

Year	Iceland	cv
2000	134 407	0.145
2001	161 733	0.182
2002	95 059	0.140
2003	63 179	0.127
2004	96 465	0.171
2005	109 196	0.250
2006	123 059	0.166
2007	82 062	0.183
2008	80 011	0.141
2009	93 653	0.174
2010	77 852	0.154
2011		
2012	74 604	0.145
2013	70 055	0.156
2014	103 051	0.191
2015	107 423	0.174
2016	80 855	0.123

Table 20.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* 1978-2016 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
2015	9 311	0	9 311
2016[1)]	9 536	0	9 536

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 1991-2016.

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%
2016	0%	100%

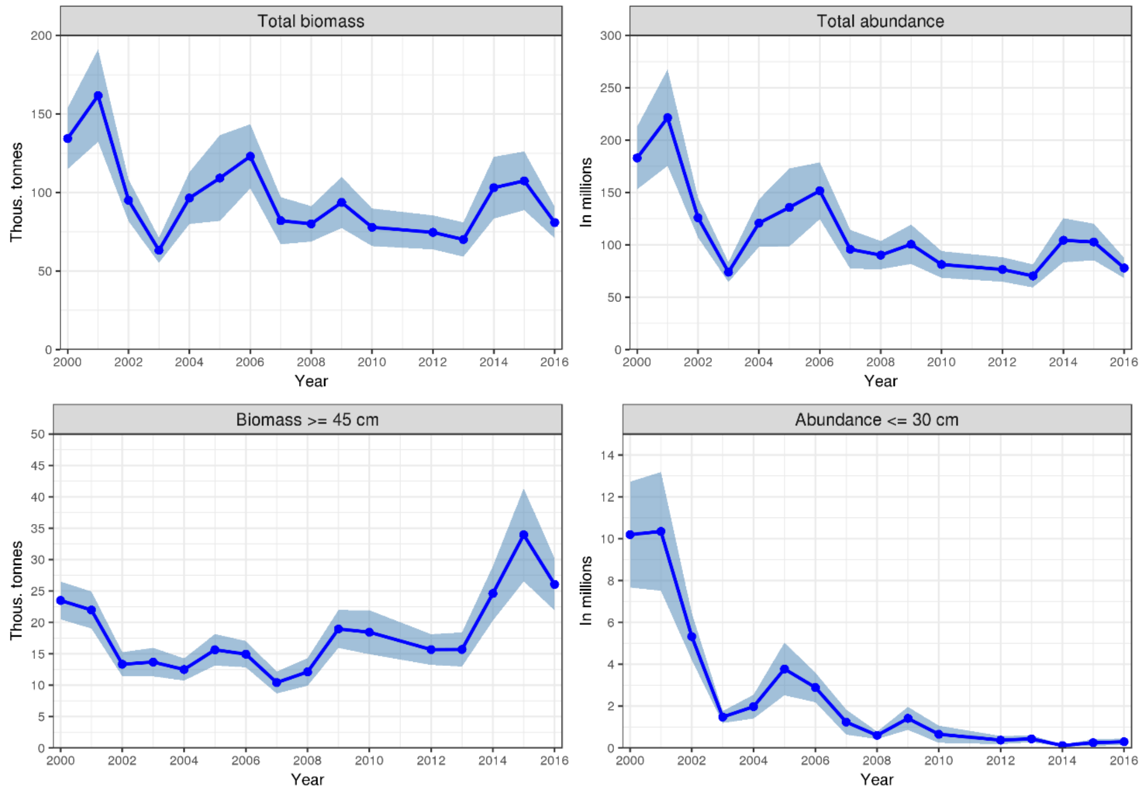


Figure 20.2.1 Survey indices of the Icelandic slope *S. mentella* in the autumn survey in ICES Division 5.a 2000-2016 No survey was conducted in 2011. The figure shows the total biomass index, total abundance index in millions of fish, biomass index of fish 45 cm and larger and abundance index of fish 30 cm and smaller.

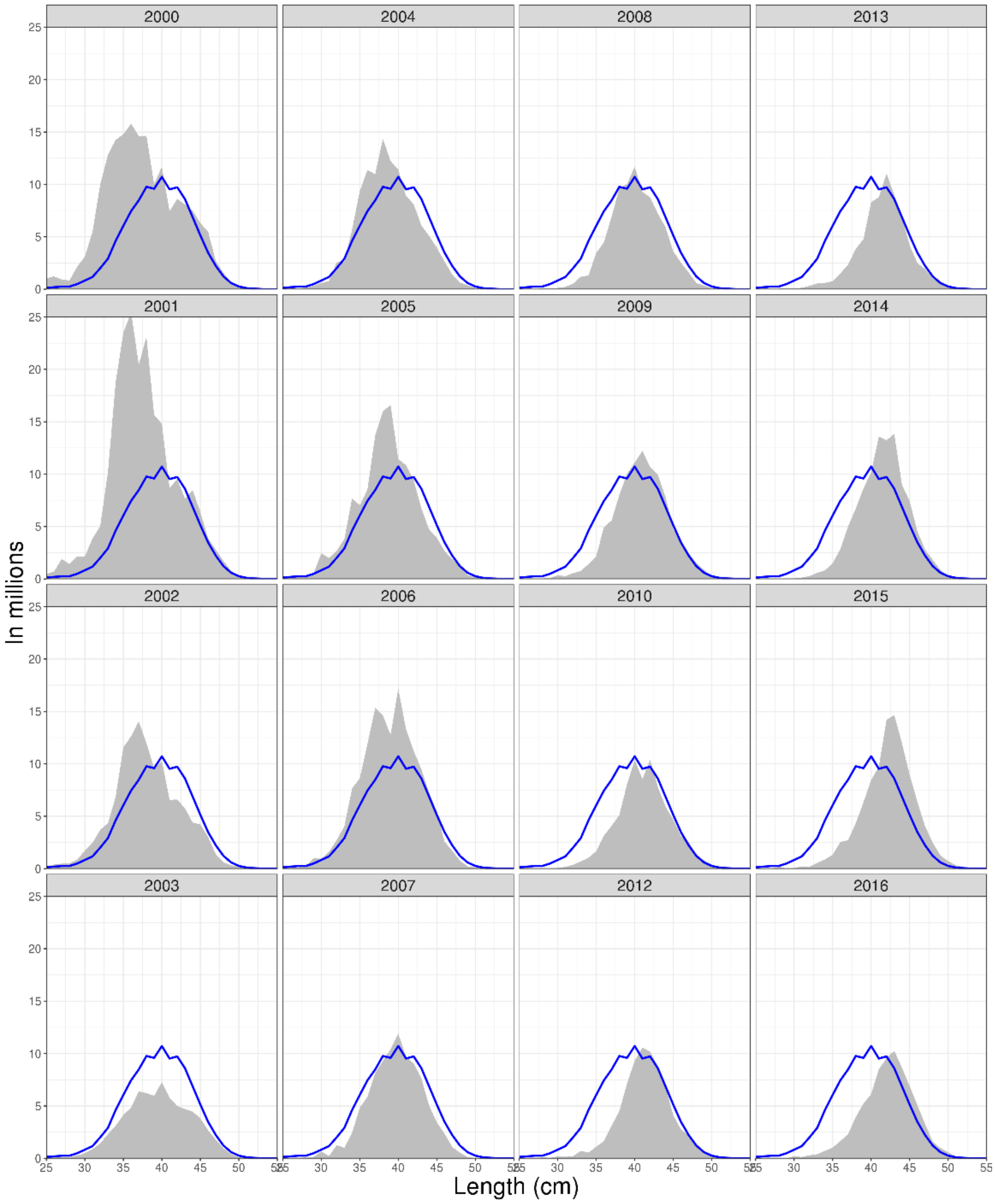


Figure 20.2.2 Length distribution of Icelandic slope *S. mentella* in the Autumn Groundfish Survey in October 2000-2016 in ICES Division 5.a. No survey was conducted in 2011. The blue line is the mean of 2000–2016.

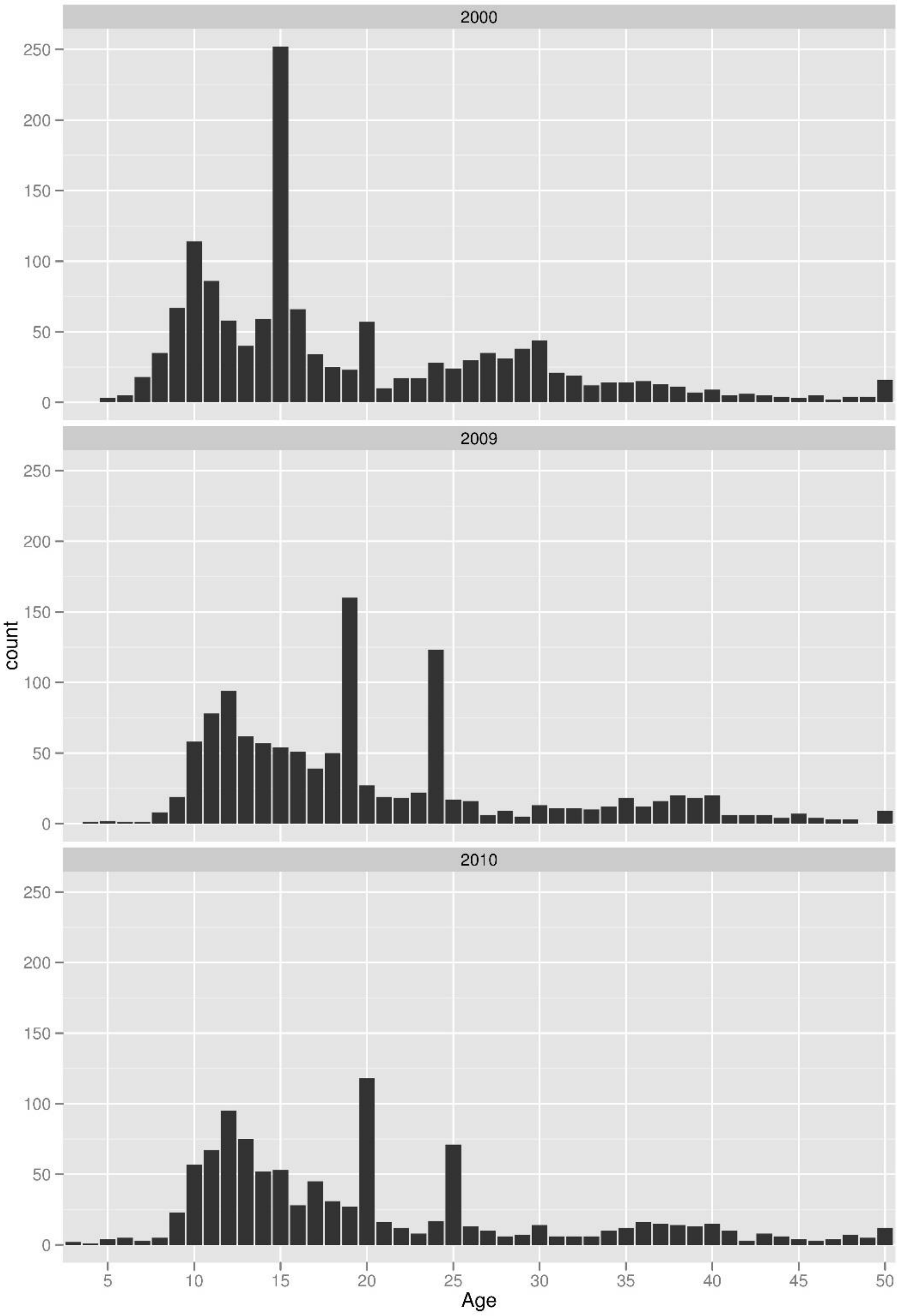


Figure 20.2.3 Age distribution of Icelandic slope *S. mentella* from the Autumn Survey in 2000 (n = 1 405), 2009 (n = 1 101), and 2010 (n = 1 206). The age class 50 are the combined age-classes of 50 years and older.

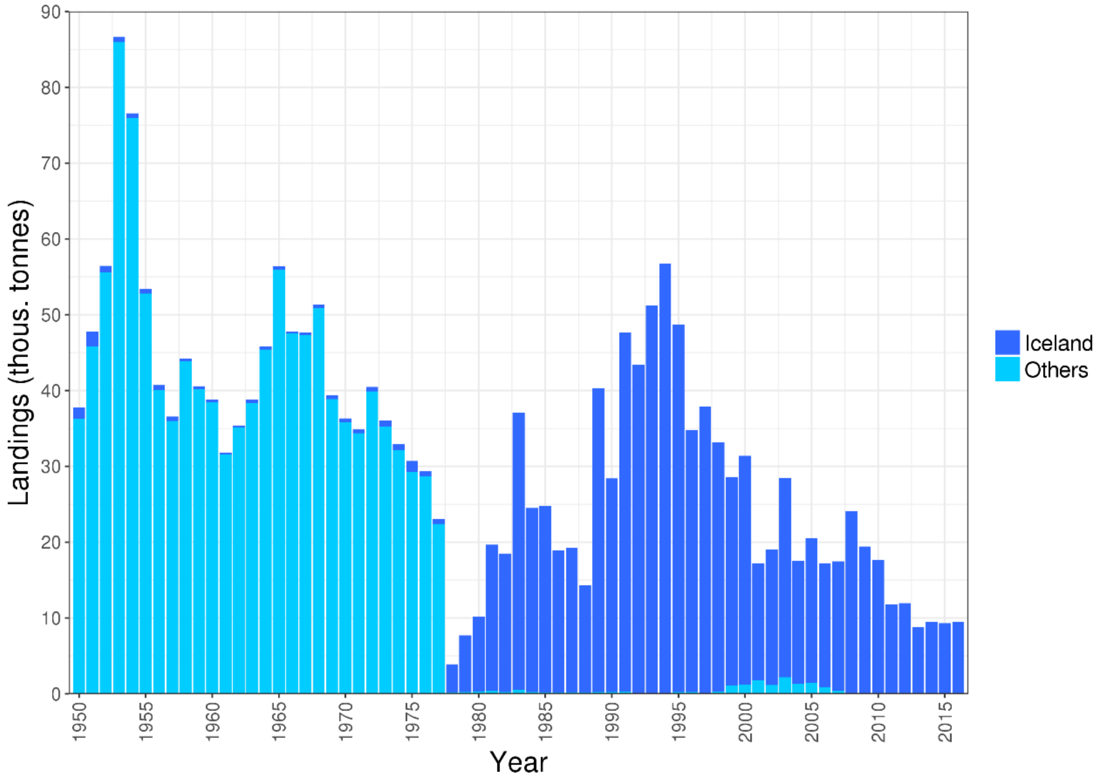


Figure 20.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* from Icelandic waters (ICES Division 5.a and Subarea 14) 1950–2016.

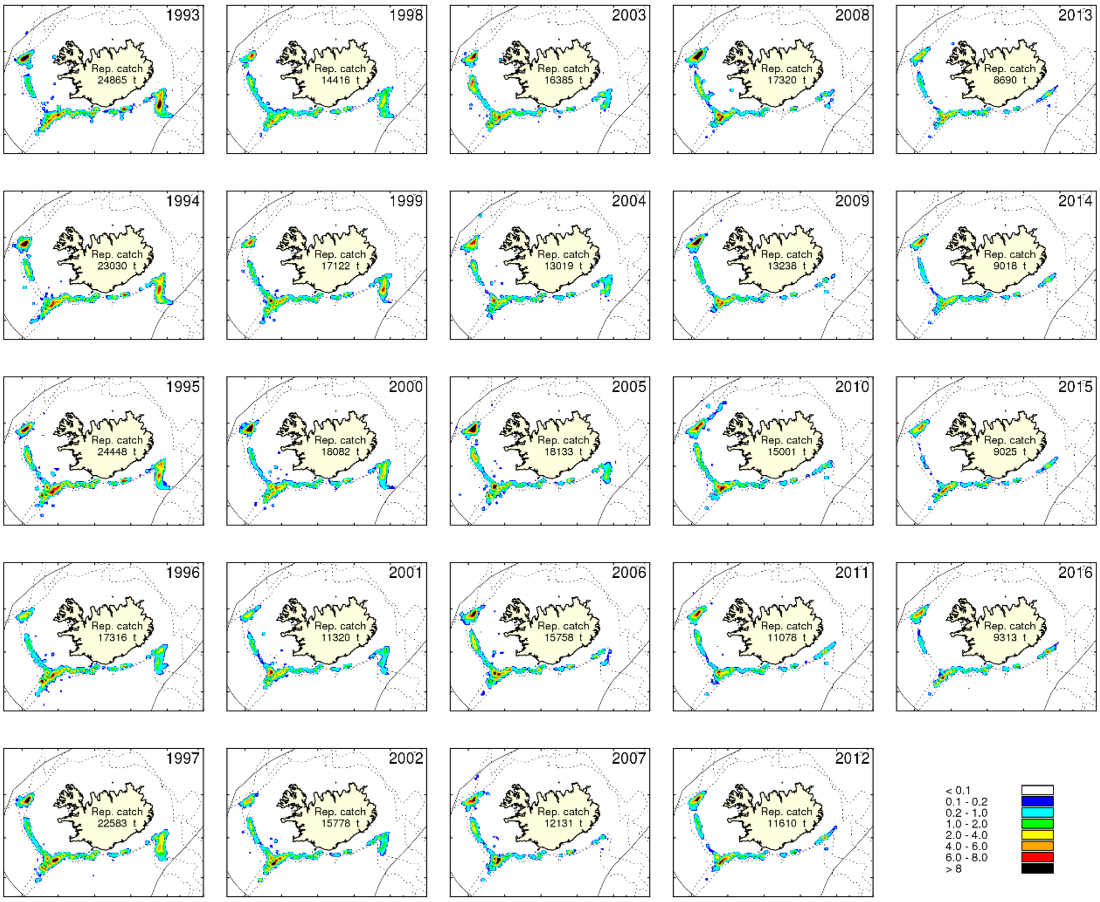


Figure 20.3.2 Geographical location of the Icelandic slope *S. mentella* catches in Icelandic waters (ICES Division 5.a and Subarea 14) 1993–2016 as reported in log-books of the Icelandic fleet using bottom trawl. The blue line indicates part of the management unit for the deep-pelagic redfish stock. The dotted line represents the 500 m isobaths.

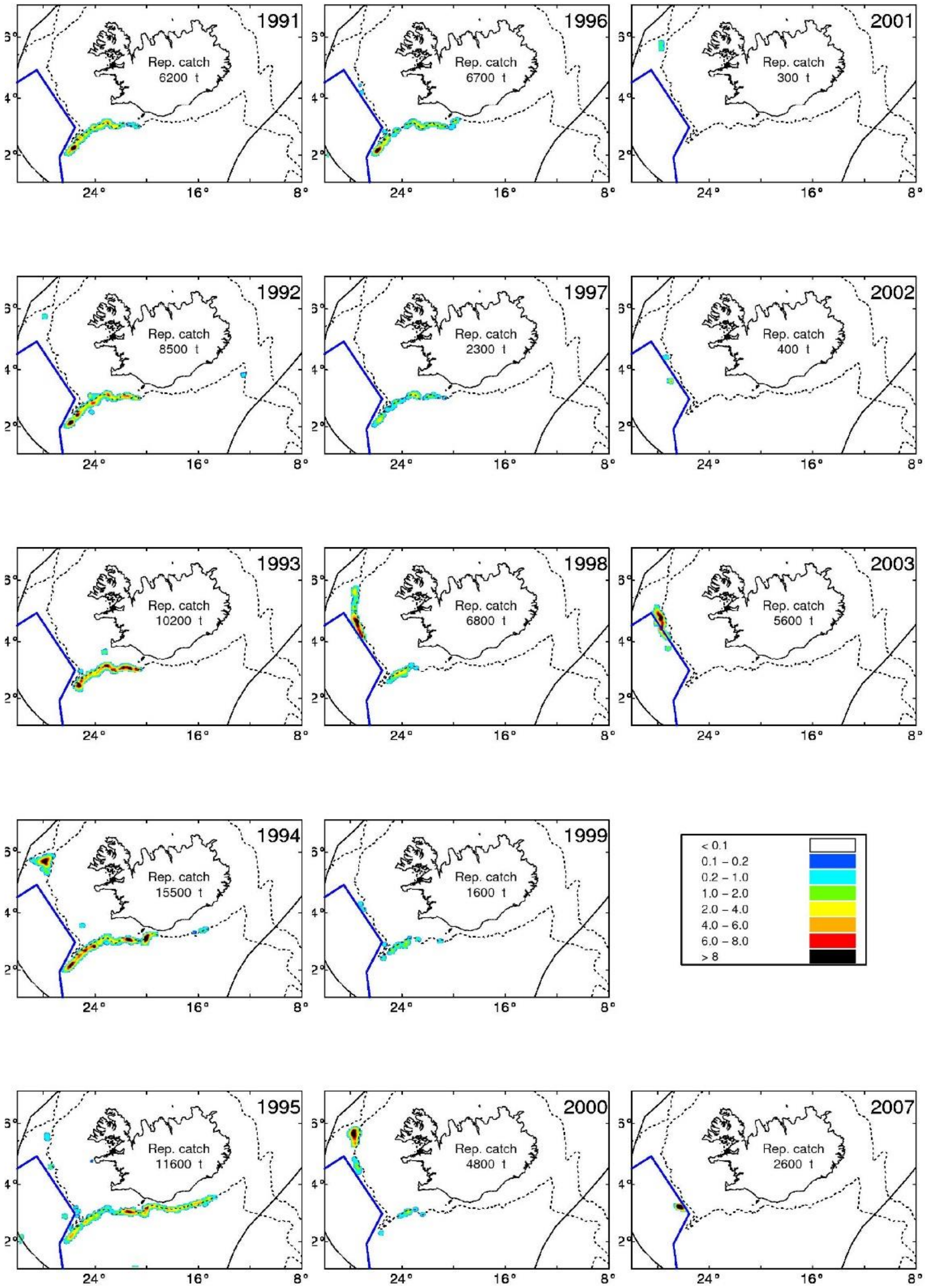


Figure 20.3.3 Geographical location of the Icelandic slope *S. mentella* catches in Icelandic waters (ICES Division 5.a and Subarea 14) 1991-2003 and 2007 as reported in log-books of the Icelandic fleet using pelagic trawl. The blue line indicates part of the proposed management unit for the deep-pelagic redfish stock. The dotted line represents the 500 m isobaths.

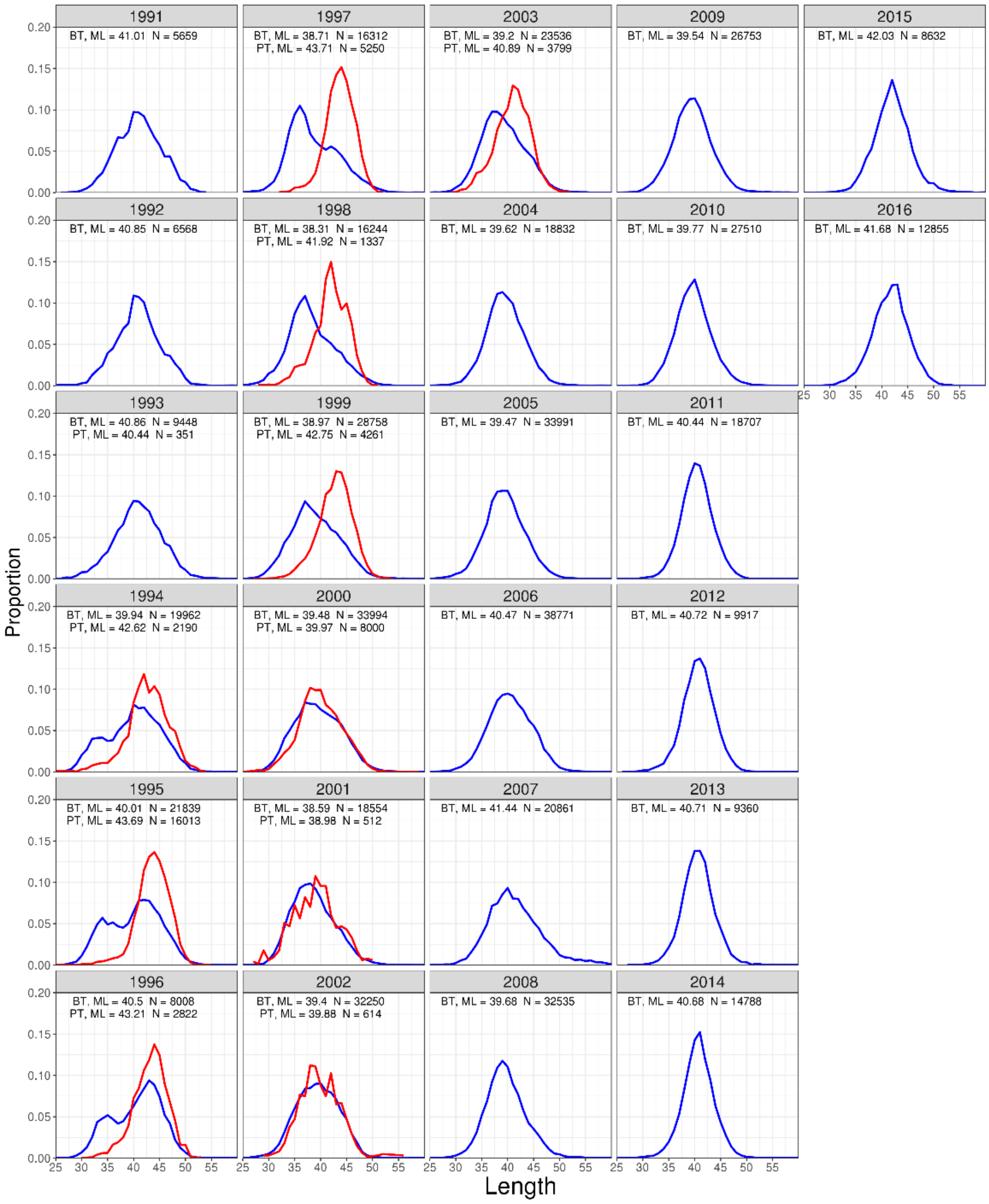


Figure 20.3.5 Length distributions of Icelandic slope *S. mentella* from the Icelandic landings taken with bottom trawl (blue line) and pelagic trawl (red line) in Icelandic waters (ICES Division 5.a and Subarea 14) 1991–2016.

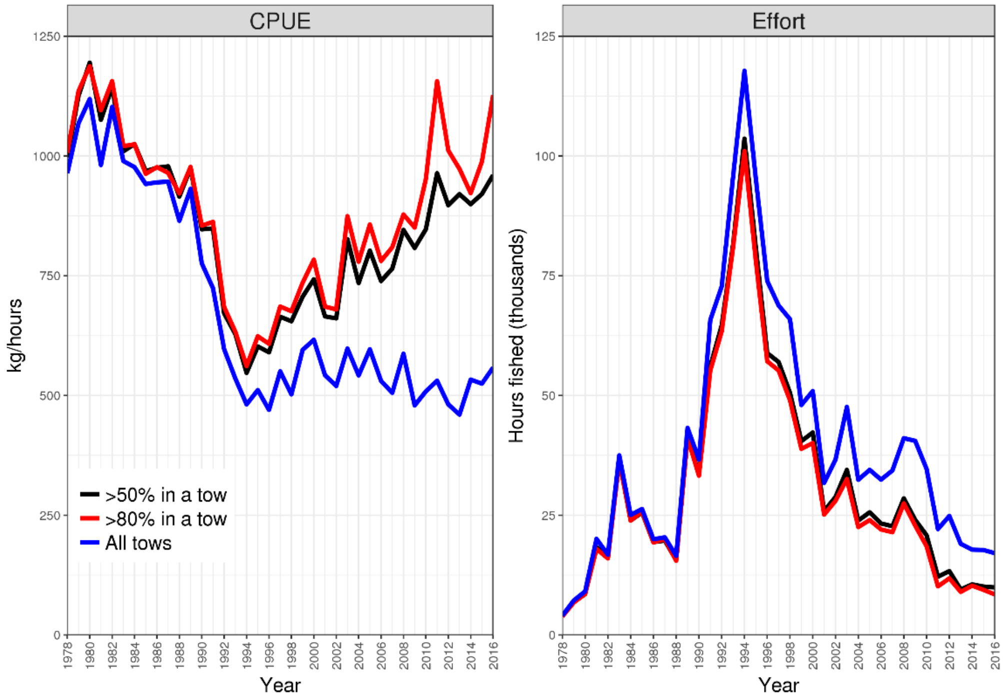


Figure 20.3.6 CPUE and effort of Icelandic slope *S. mentella* from the Icelandic bottom trawl fishery in Icelandic waters (ICES Division 5.a and Subarea 14) 1978–2016.

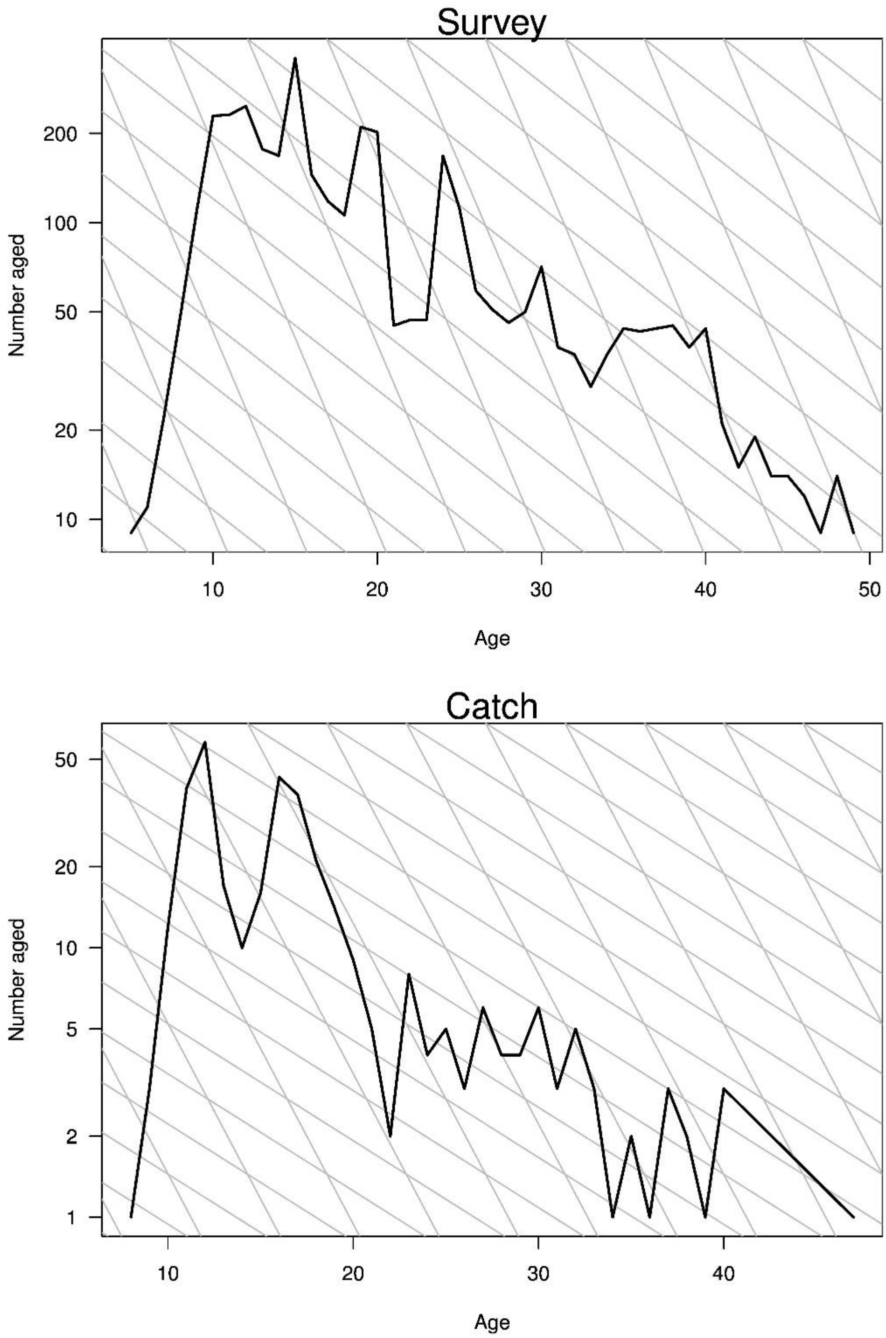


Figure 20.5.1. Icelandic slope *S. mentella*. Number aged plotted on log-scale. Grey lines correspond to *Z*=0.1 and *Z*=0.3.

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 Va, Subareas XII and XIV; eastern parts of NAFO Divisions 1F, 2H and 2J) at depths shallower than 500 m.

The following text table summarizes the available information from fishing fleets in the Irminger Sea and adjacent waters fishing for the shallow pelagic redfish in 2016. 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 logbook data from the Faroe Islands, Greenland, Iceland and Norway. A summary of the catches by ICES Divisions/NAFO regulatory area as estimated by the Working Group is given in Table 21.2.1 and Figure 21.2.2. The estimated catch for 2016 is 1 967 t, a decrease from the 5 595 t caught in 2015. The catches were almost entirely produced by Russia with 1 732 t from ICES XII and NAFO 1F (Tables 21.2.1 and 21.2.2).

There are no new CPUE data for 2016. 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 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 in the correlation between trawl and acoustic estimates as well as the assumptions that need to be made about constant catchability across depth and areas, the uncertainty of these estimates is very high.

The reduction in biomass observed in the surveys within the hydroacoustic layer (about 2 million t in the last decade) cannot be explained by the reported removal by the fisheries (about 500,000 t in the entire depth range in 1995—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 north-eastern Irminger Sea, which may cause displacing towards the southwest, where fresher and colder water occurs (ICES 2012).

Results based on international redfish survey data suggest that the interannual distribution of fish above 500 m will shift in a southwest/northeast direction depending on integrated oceanographic conditions (ICES 2012).

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
2016	235	1 671	0	61	0	0	1 967

1982-1991 All pelagic catches assumed to be of the shallow pelagic stock

1992-1996 Guesstimates based on different sources (see text)

1997-2016 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. Va, Subareas XII, XIV and NAFO Div. 1F, 2H and 2J by countries used by the Working Group. * Prior to 1991, the figures for Russia included Estonian, Latvian and Lithuanian catches.

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Russia*	Spain	UK	Ukraine	Total
1982														581		60 000				60 581
1983						155										60 079				60 234
1984	2 961					989								239		60 643				64 832
1985	5 825					5 438								135		60 273				71 671
1986	11 385			5		8 574								149		84 994				105 107
1987	12 270			382		7 023								25		71 469				91 169
1988	8 455			1 090		16 848										65 026				91 419
1989	4 546			226		6 797	567	3 816						112		22 720				38 784
1990	2 690					7 957		4 537					7 085			9 632				31 901
1991			2 195	115		201		8 724					6 197			9 747				27 179
1992	628		1 810	3 765	2	6 447	9	12 080		780	6 656		14 654			15 733				62 564
1993	3 216		6 365	6 812		16 677	710	10 167		6 803	7 899		14 112			25 229			2 782	100 771
1994	3 600		17 875	2 896	606	15 133		5 897		13 205	7 404		6 834		1 510	16 349			5 561	96 869
1995	2 660	421	11 798	3 667	158	10 714	277	8 733	841	3 502	16 025	9	4 288		2 170	28 314	1 934		2 230	100 136
1996	1 846	343	3 741	2 523		5 696	1 866	5 760	219	572	5 618		1 681		476	9 348	1 671	137	273	41 770
1997		102	3 405	3 510		9 276		4 446	28				330	776	367	3 693	1 812			27 746
1998			3 892	2 990		9 679	1 161	1 983	30		1 734		701	12	60	89	1 819			24 150
1999			2 055	1 190		8 271	998	3 662					2 098	6	62	6 538	447	183		25 512
2000			4 218	486		5 672	956	3 766			430		2 124		37	14 373	1 154			33 216
2001			9	4 364		4 755	1 083	14 745			8 269		947		256	5 964	1 433			41 825
2002				719		5 354	657	5 229		1 841	12 052		1 094	428	878	13 958	1 005			43 216
2003				1 955		3 579	1 047	4 274		1 269	21 629		3 214	917	1 926	15 418	1 461			56 688

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Russia*	Spain	UK	Ukraine	Total
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
2016								235								1 732				1 967

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

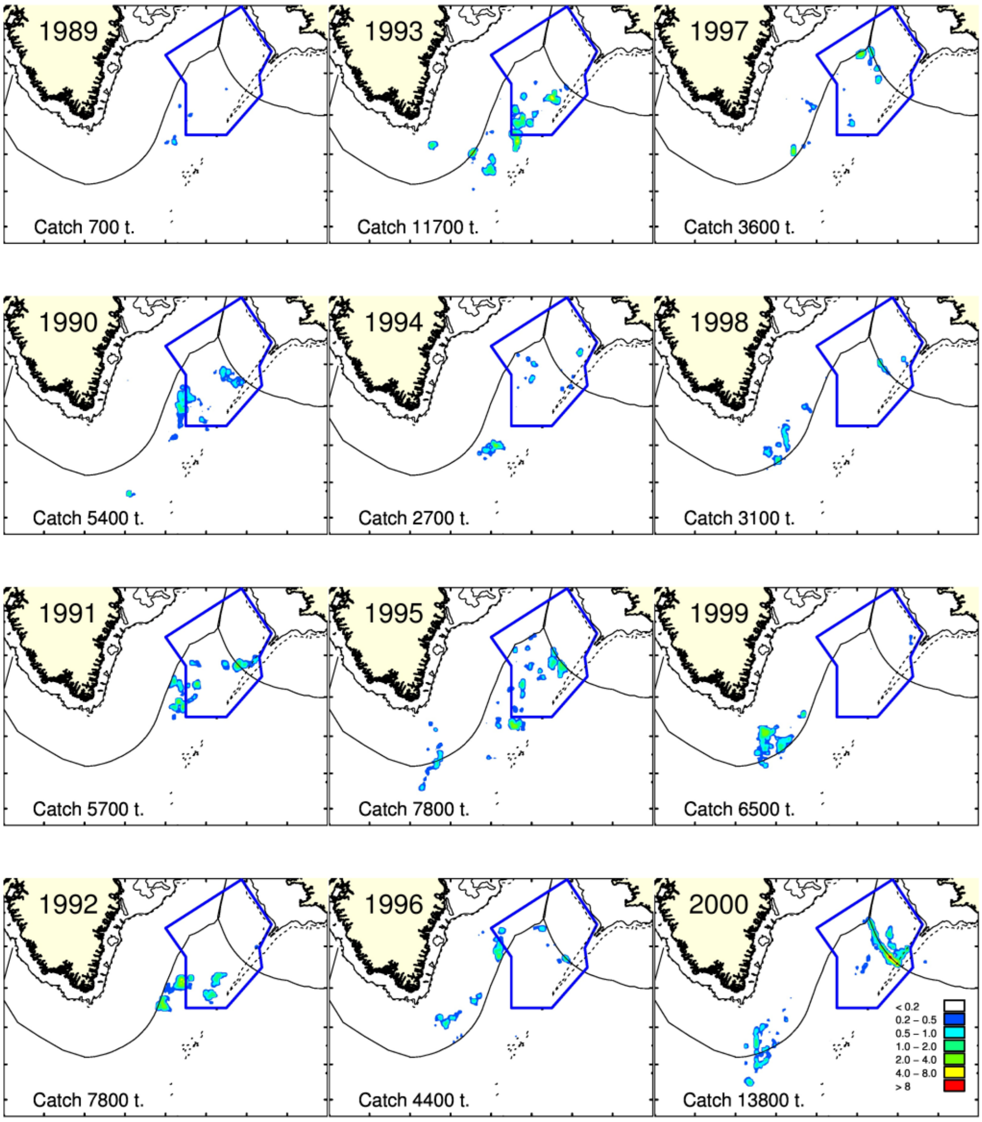


Figure 21.2.1 Fishing areas and total catch of pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1989-2012. Data are from the Faroe Islands (1995-2012), Iceland (1989-2012) and Norway (1992-2003). The catches in the legend are given as tonnes per square nautical mile. The blue box represents the management unit for the northern fishing area.

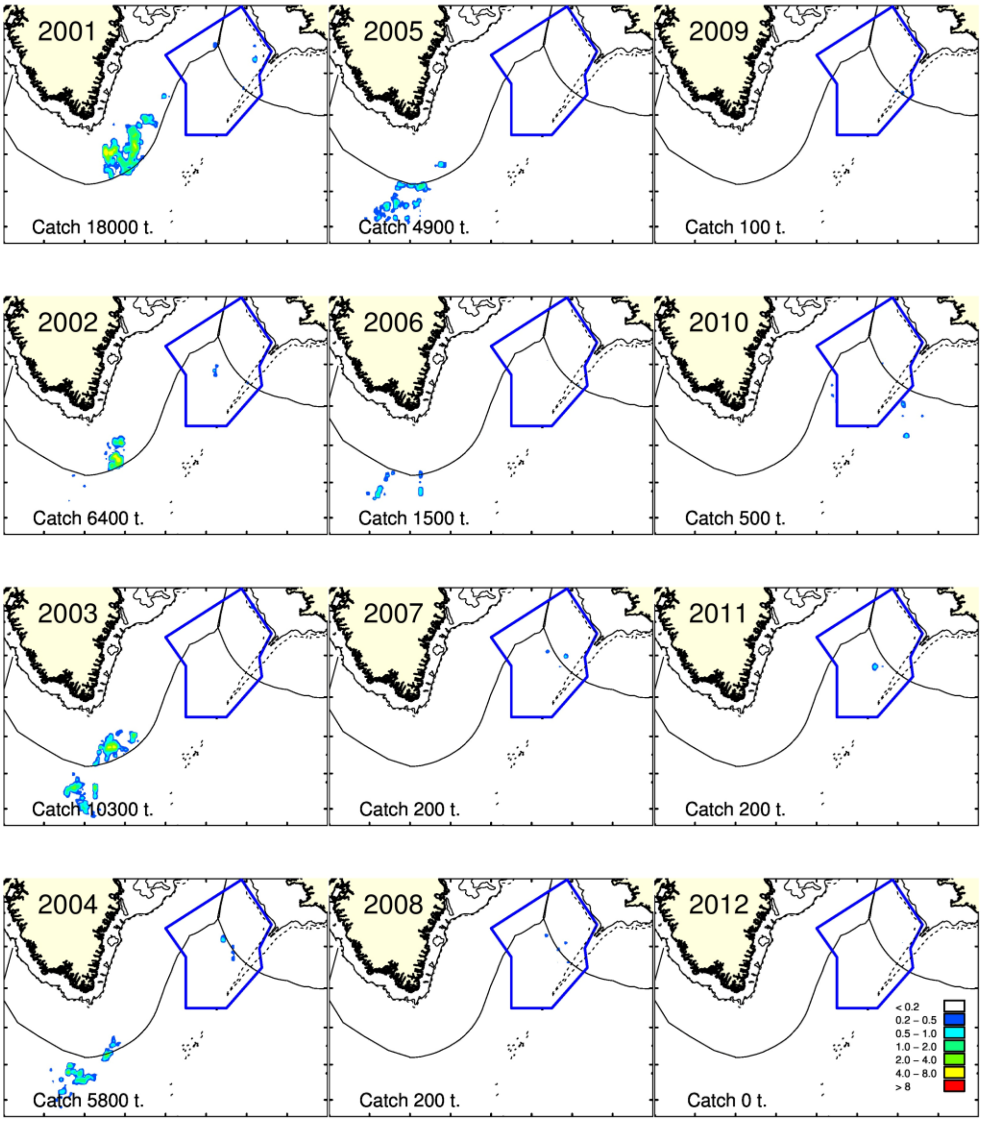


Figure 21.2.1 (Cont.) Fishing areas and total catch of pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1989-2012. Data are from the Faroe Islands (1995-2012), Iceland (1989-2012) and Norway (1992-2003). The catches in the legend are given as tonnes per square nautical mile. The blue box represents the management unit for the northern fishing area.

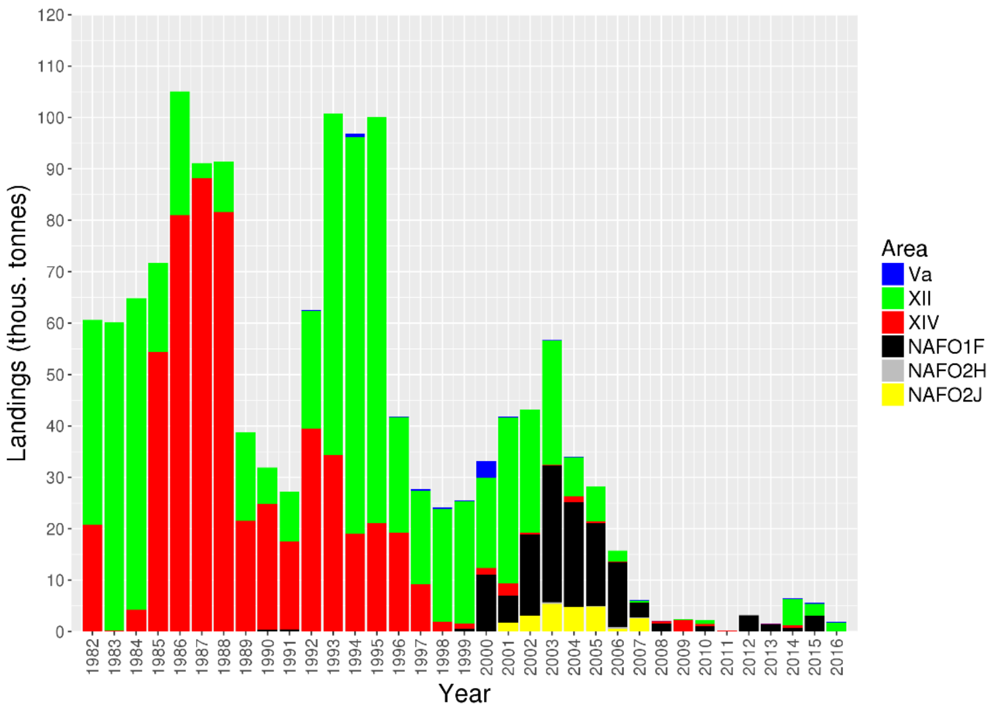


Figure 21.2.2 Landings of shallow pelagic *S. mentella* (Working Group estimates, see Table 21.2.1).

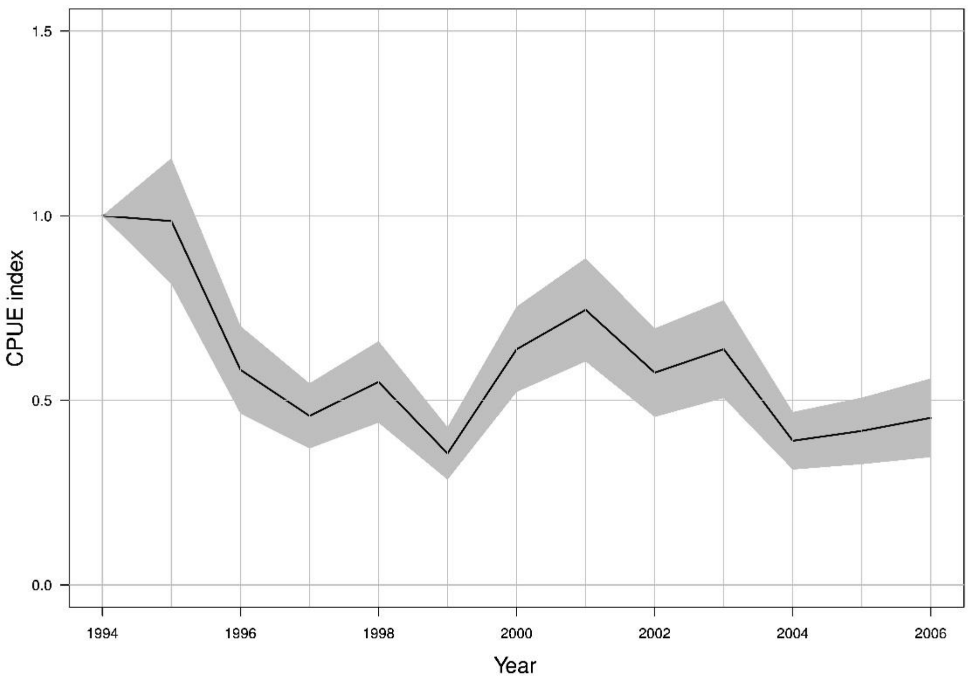


Figure 21.2.3 Trends in standardised CPUE of the shallow pelagic *S. mentella* fishery in the Irminger Sea and adjacent waters, based on log-book data from Faroes, Iceland, Norway, and Greenland.

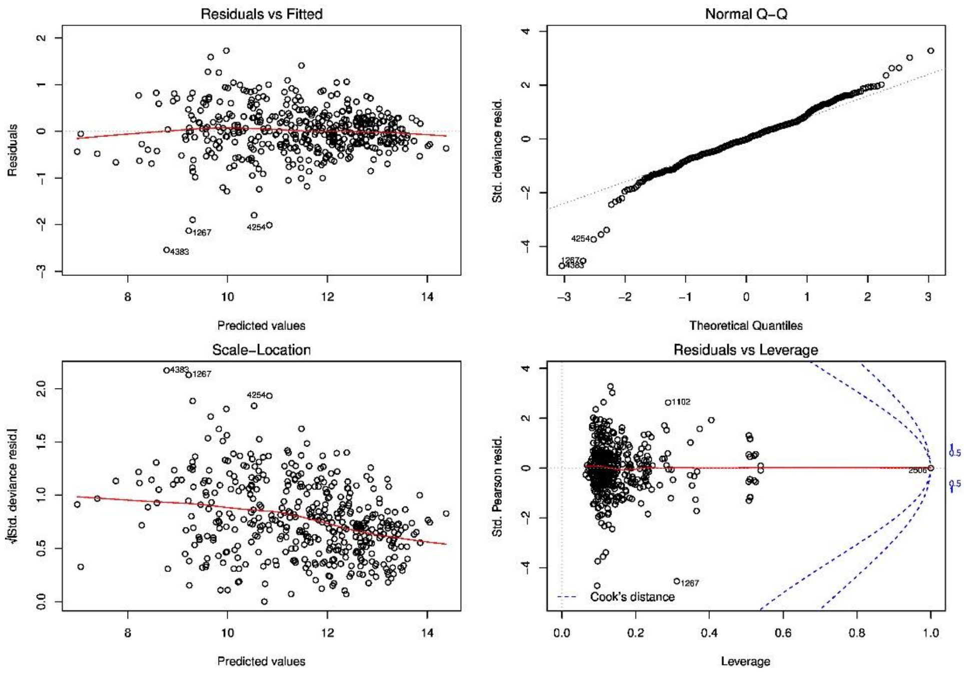


Figure 21.2.4 Residuals from the GLM model used to standardize CPUE, based on log-book data from Faroe Islands, Iceland, Greenland and Norway.

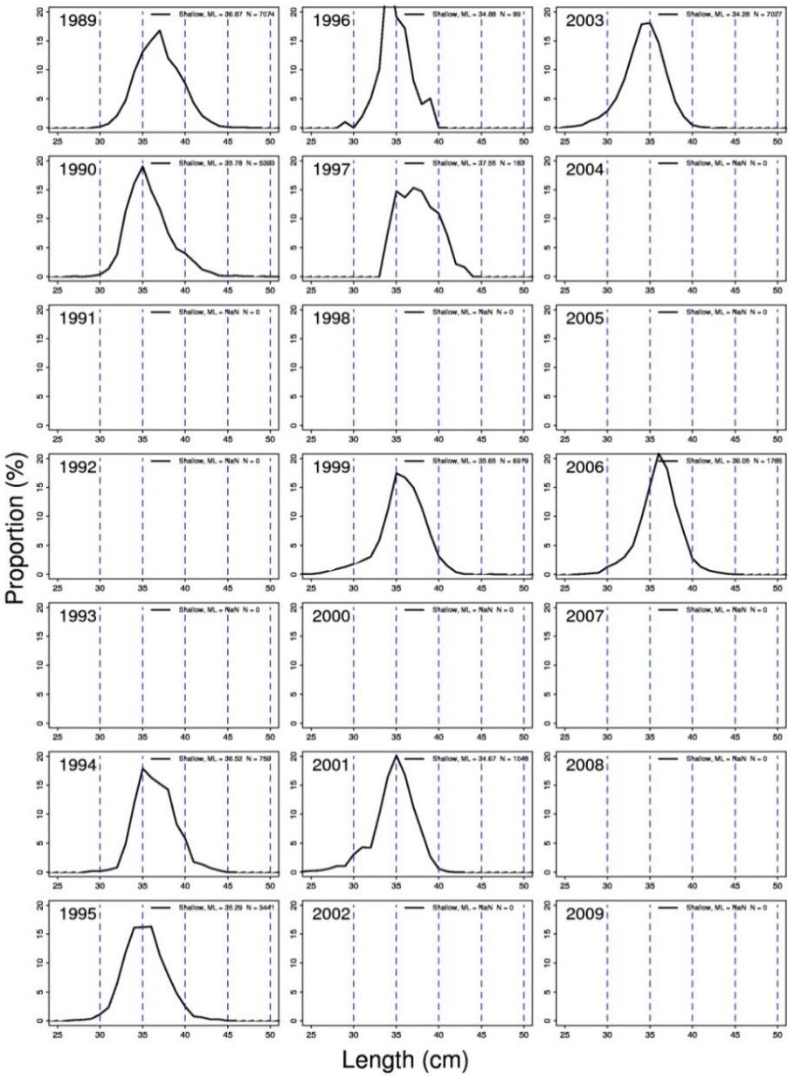


Figure 21.3.1 Length distribution from Icelandic landings of shallow pelagic *S. mentella*.

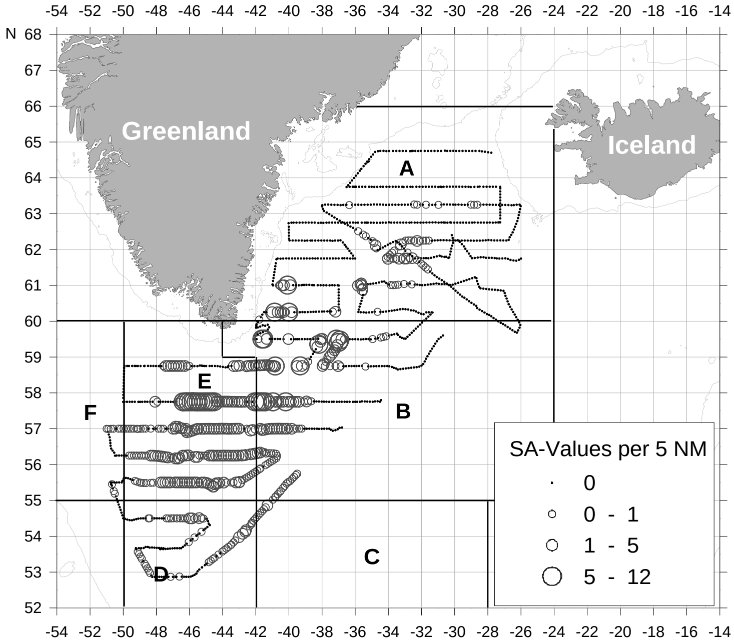
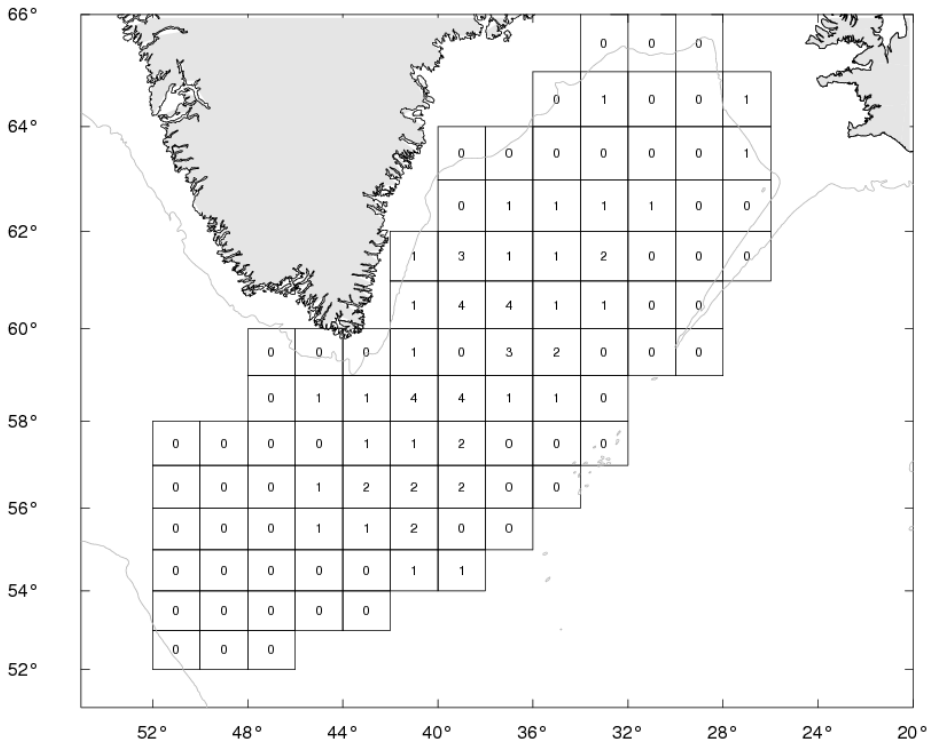


Figure 21.6.1 Pelagic *S. mentella*. Acoustic estimates (average sA values by 5 NM sailed) shallower than the deep-scattering layer (DSL) from the joint trawl-acoustic survey in June/July 2013.



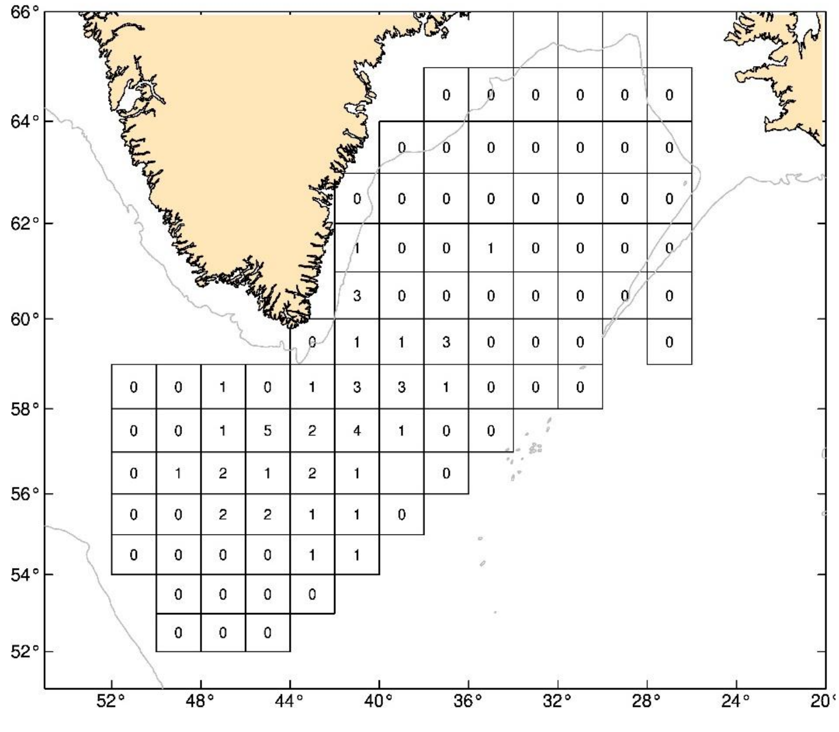


Figure 21.6.2. Redfish acoustic estimates shallower than the DSL. Average s_A values within statistical rectangles during the joint international redfish survey in June/July 2013.

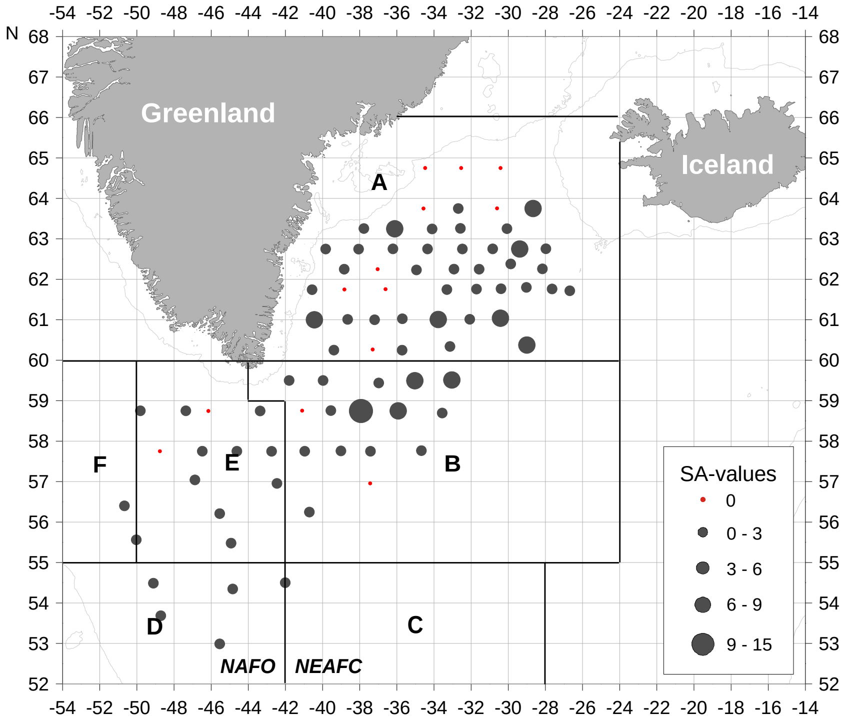


Figure 21.6.3 Redfish trawl estimates within the DSL shallower than 500 m (type 2 trawls). sA values calculated by the trawl method (chapter 2.2.3) during the joint international redfish survey in June/July 2013.

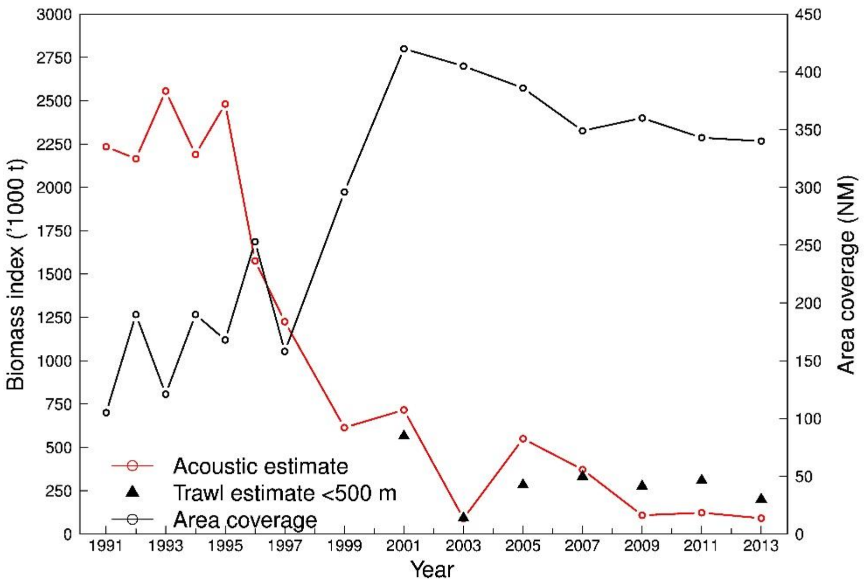


Figure 21.6.4. Overview of acoustic survey indices (thousand tonnes) from above the scattering layer (red filled circle), trawl estimates within the scattering layer and shallower than 500 m (black triangle), and aerial coverage (NM2) of the survey (black open circle) in the Irminger Sea and adjacent waters.

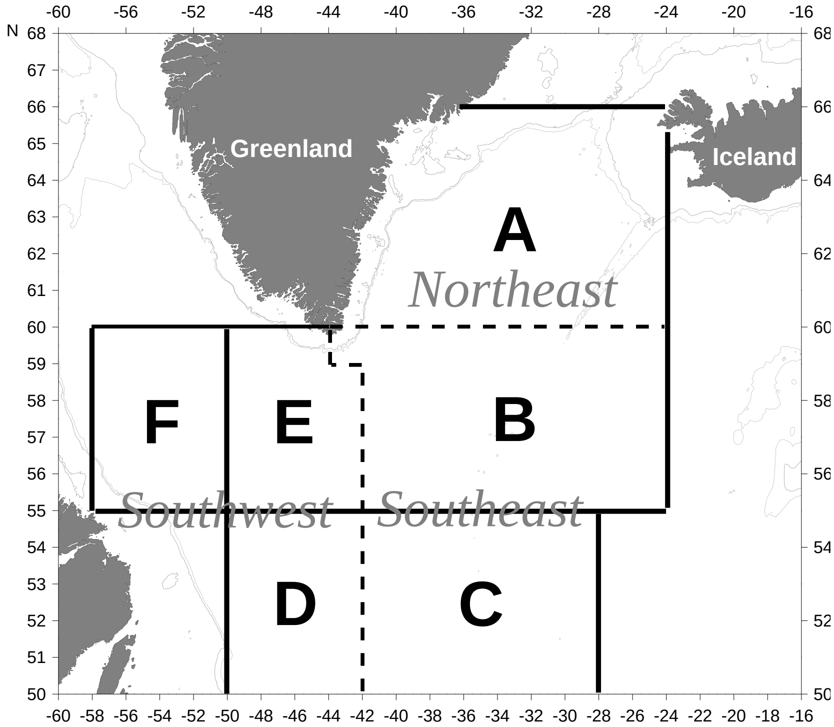


Figure 21.6.5 Sub-areas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines).

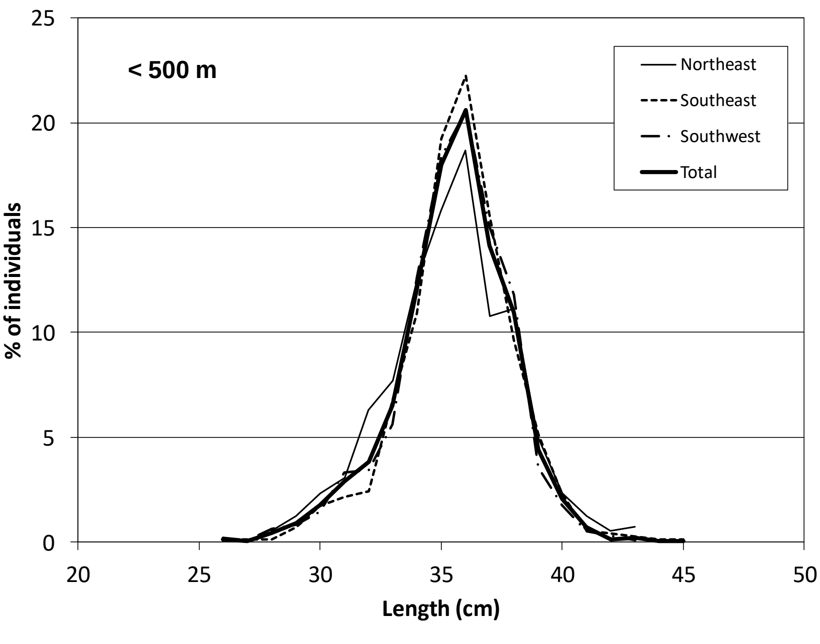


Figure 21.6.6 Length distribution of redfish in the trawls, by geographical areas and total, from fish caught shallower than 500 m (in 2013).

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 V, XII, and XIV at depths > 500 m, including demersal habitats west of the Faeroe Islands. This stock corresponds to the management unit in the northeast Irminger Sea (ICES areas Va, XII and XIV).

The following text table summarizes the available information from fishing fleets in the Irminger Sea and adjacent waters in 2016. It should be noted that some these fleets are also fishing the Shallow Pelagic stock:

Country	Number of trawlers
Faroes	2 factory trawlers
Iceland	6 factory trawlers
Germany	1 factory trawler
Latvia	1 factory trawler
Lithuania	1 factory trawler
Norway	2 factory trawlers
Russia	16 factory trawlers
Spain	2 factory trawlers
Total	**31 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—2016 are shown in Figure 22.2.1, and annual catches are presented in Figure 22.2.2. Catches increased by 1 200 t in 2016 to 28 654 t (Table 22.2.2).

Standardized CPUE series for Faroe Islands, Iceland, Greenland, and Norway 1994—2016 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 residuals are in Figure 22.2.4.

22.3 Biological information

Age reading of deep pelagic beaked redfish in the Irminger Sea and adjacent waters has not been systematic. Age data are available from Iceland and Norway for some years during 1996-2013. Most of the age data come from the commercial catch except in 1999 where 797 age readings come from the international redfish survey (note: as the age readings from the survey correspond to a similar depth range and location as other samples, they have been included together with the commercial fishery samples). In total, 6 566 otoliths have been age read. The number of age readings by year and nation is given in Table 22.3.1. Age distributions for the Icelandic data are shown in Figure 22.3.1 and for the Norwegian data in Figure 22.3.2.

Length data are available from the international redfish survey (see Section 22.6) and from the Icelandic commercial fishery. Biological information is collected from commercial catches from other nations (Russia, Norway, Spain and other EU countries). However, the data were not available to the group.

The length data from the Icelandic commercial fishery is considered to provide a reasonable representation for all nations participating in the fishery, as the fishery is conducted in a concentrated area along the Icelandic EEZ (Figure 22.2.1) in a relatively short period (mainly May and June).

The length samples from the Icelandic commercial catch are either collected by observers on board or by the fishers who send samples for further analysis to the MRI (Marine Research Institute, Iceland). The number of fish measured for length and the number of hauls sampled are given in Table 22.3.2. In each sample 100-200 fish are length measured. Length distributions are shown in Figure 22.3.3 and indicate that the bulk of the catches is at around 35-45 cm of length.

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 in 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 stock was benchmarked in August 2016 (The Workshop on Assessment and Catch Advice for Deep Pelagic Redfish in the Irminger Sea – WKDEEPRED, ICES 2016). At the WKDEEPRED meeting a Gadget model for deep pelagic beaked redfish in the Irminger Sea was proposed as an assessment model. A description of the model setup, data, results, diagnostics and recommendations for data and model needs are found in the WKDEEPRED report (ICES, 2016). A detailed description of Gadget and references to published papers can be found in the Stock Annex for deep pelagic redfish (smn-dp_SA).

An age-length structured stock assessment model was developed with Gadget; this model also used age and length composition data. The inclusion of these data in the assessment lent stability to the assessment results and no strong retrospective pattern emerged. Fits to the data were considered overall adequate and WKDEEPRED concluded that this model provides an appropriate way of assessing the stock at this time. Although the Gadget assessment appears to capture trends on stock biomass and fishing mortality reliably, some aspects of the assessment still require further exploration, the data currently available cover only a short period relative to the lifespan of the species, and additional age data that might bring in additional insights are expected to become available over the next few years. WKDEEPRED therefore concluded that at present this assessment should be considered as a Category 2 (instead of Category 1) assessment.

Summary of the assessment is shown in Figure 22.7.1. The SSB has decreased since 1994 and is now below B_{lim} of 559 kt. Since the start of the fishery in 1991 fishing mortality increased sharply and has been high and fluctuating since the early 2000s. Fishing mortality has exceeded F_{lim} (0.057) since 1994. Recruitment has been overall stable with a few good year classes (corresponding to age 5 recruitment in 1990 and 1995) that presently contribute to the fishable biomass.

22.8 Reference points

WKDEEPRED (ICES 2016) also derived precautionary and MSY reference points (B_{lim}, B_{pa}, F_{lim}, F_{pa}, F_{MSY} and MSY $B_{trigger}$) following the ICES technical guidelines for the calculation of reference points.

Below is a summary of reference points agreed by WKDEEPRED (ICES 2016). Note: the reference point values in the ICES advice sheet will be presented as relative values with respect to the average of the F and SSB estimates over the stock assessment series, as corresponds to Category 2 assessments.

Framework	Reference point	Value	Technical basis
MSY	MSY $B_{trigger}$	782 kt	Bpa

approach	F_{MSY}	0.041	F that maximizes median long-term catch in stochastic simulations with recruitment drawn from 1985-2006 estimates while incorporating a factor to gradually reduce recruitment when SSB < SSB(2001) (where SSB(2001) is the Bloss from the converged stock–recruitment period). FMSY is constrained not to exceed Fpa.
Precautionary approach	B_{lim}	559 kt	Bpa / 1.4
	B_{pa}	782 kt	SSB(2001), corresponding to Bloss from the years with converged SSB and recruitment estimates (year classes 1990-2001)
	F_{lim}	0.057	F corresponding to 50% long-term probability of SSB > Blim.
	F_{pa}	0.041	Flim / 1.4

22.9 State of the stock

22.9.1 Short term forecast

During WKDEEPRED (ICES, 2016) the workshop agreed settings to conduct short-term projection based for 2017 and 2018 as follows. The model used was the same age-length structured population dynamics model used in the stock assessment (implemented in Gadget). The results are as follows:

Assumptions needed for projections:

Recruitment (age 5) in 2016, 2017 and 2018 was assumed to be equal to the geometric mean of the estimated recruitment during 1985-2006, i.e. 90 million fish.

Catch in 2016 was assumed to be 29 kt, based on the fact that the fishery until mid-July had taken approximately 28 kt and that experts with knowledge of the fishery indicated that the 2016 fishery would be almost concluded by that time. This assumption about catch results in F(2016) = 0.279 and SSB(2017) = 336 kt (which is below B_{lim}).

Projections at different values of F in 2017 and 2018 are given in Table 22.9.1

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.

Additional age composition data could be available from currently un-aged otoliths sampled from Icelandic commercial catches and should be explored for possible incorporation in future assessments.

22.9.2.2 Assessment quality

The results of the international trawl-acoustic survey are given in section 21.6. Given the high variability in the correlation between trawl and acoustic estimates as well as the assumptions that need to be made about constant catchability across depth and areas, the uncertainty of these estimates is very high.

The reviewers of WKDEEPRED (ICES 2016) recommend that in the future the survey procedures and gear standardization should be considered and data should be examined to determine if the mean catch rate is better estimated across countries or by country.

For the first time an age–length-based assessment model has been applied to give relative estimates of abundance and exploitation rates for this stock. This model utilizes age and length information from the fishery in addition to the biomass index and lengths from the trawl–acoustic survey. Even though the time-series available from the fishery and the survey are short relative to the life-time of the species, the assessment captures trends in stock biomass and fishing mortality reliably and this framework is considered a major improvement to the quality of the assessment. As some aspects of the assessment and short-term forecast still require further exploration and the data presently available cover only a short period relative to the life-span of the species, ICES presently considers this assessment to be in Category 2.

Recruitment (age 5) estimates from the assessment take about 8–10 years to stabilize. For this reason, the original recruitment estimates obtained from the assessment model for the years 2007 and onwards have been replaced with the geometric mean of the estimates from 1985–2006. This has resulted in a 7% increase in the SSB and harvestable biomass estimates in 2016 in comparison with the estimates obtained from the assessment model without replacing recruitment. The assumed year classes, corresponding to fish at ages less than or equal to 15 in 2017, constitute approximately 55% of the SSB and 30% of the harvestable biomass in 2017. While this indicates uncertainty in the catch and SSB values presented in the catch options table, the conclusion that the SSB will remain below B_{lim} even without any catches in 2017 and 2018 is still valid.

It is not known to what extent CPUE reflect changes in the stock status of pelagic *S. mentella*, since the fishery focuses on aggregations. Therefore, stable or increasing CPUE series might not indicate or reflect actual trends in stock size, although decreasing CPUE indexes are likely to reflect a decreasing stock.

22.9.3 Comparison with previous assessment and forecast

As mentioned in Section 22.7 the stock was benchmarked in 2016 (ICES, 2016) and the age-length based stock assessment model was applied for the first time to give relative estimates of abundance and exploitation rates for this stock. Previously the assessment of pelagic redfish in the Irminger Sea and adjacent waters is based on survey indices, catches, CPUE and biological data.

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 8 500 t TAC set by NEAFC for 2016 was overshot by about 20 000 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 2016. It was taken from both Shallow and Deep pelagic (23 351 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 north-eastern Irminger Sea, which may cause displacing towards the southwest, where fresher and colder water occurs (ICES 2012b).

Results based on international redfish survey data suggest that the inter-annual distribution of fish above 500 m will shift in a southwest/northeast direction depending on integrated oceanographic conditions (ICES 2012). Whether the results of the study mentioned are applicable to the conditions for the deep pelagic stock needs further investigation.

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
2016	2 601	0	26 053	0	28 654

Table 22.2.2. Deep pelagic *S. mentella* catches (in tonnes) in ICES Div.Va, Subareas XII, XIV and NAFO Div. 1F, 2H and 2J by countries used by the Working Group.

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Nederland	Norway	Poland	Portugal	Russia	Spain	UK	Ukraine	Total
1991								59												59
1992								3 398												3 398
1993				310		1 135		12 741					878							15 064
1994						2 019		47 435					523		377	1 465				51 820
1995	1 140	181	5 056	1 572	68	8 271	1 579	25 898	396	1 501	6 868	4	3 169		2 955	15 868	227		956	75 707
1996	1 654	307	3 351	3 748		15 549	1 671	57 143	196	512	5 031		5 161		1 903	36 400	5 558	123	245	138 552
1997		9	315	435		11 200		36 830	3				2 849		3 307	33 237	6 895			95 079
1998			76	4 484		8 368	302	46 537	1		34		438		4 073	25 748	2 758			92 818
1999			53	3 466		8 218	3 271	40 261					3 337		4 240	11 419	9 885	5		84 153
2000			7 733	2 367		6 827	3 327	41 466			0		3 108		3 694	14 851	9 740			93 113
2001			878	3 377		5 914	2 360	27 727			7 515		4 275		2 488	23 810	8 649			86 993
2002			15	3 664		7 858	3 442	39 263			9 771		4 197		2 208	25 309	7 402			103 128
2003				3 938		7 028	3 403	44 620			0		5 185		2 109	28 638	9 374			104 296
2004				4 670		2 251	2 419	31 098			0		6 277	1 889	2 286	31 067	9 996			91 954
2005				1 800		1 836	1 431	12 919			1 027		3 950	1 240	1 088	16 323	3 871			45 485
2006				3 498		1 830	744	20 942			1 294		5 968	1 356	1 313	23 670	6 673			67 288
2007				2 902		1 110	1 961	18 097		575	1 394		4 628	636	2 067	21 337	3 810			58 516
2008				2 632			1 170	6 723			749		571	219	1 733	15 106	1 142			30 045
2009				3 206			1 519	15 125		1 355	2 613			178	1 596	25 309	2 907			54 006
2010				3 195			1 932	14 772		1 963	2 228		2 388	3	2 203	22 803	7 801			59 288
2011				2 028		1 787		11 994		845	1 348		1 066		1 540	22 364	4 361			47 333
2012				1 438		1 523		5 912		724	558		3 362		250	18 377	632			32 806
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				779		918		1 968			330		1 547		202	20 214	1 475			27 433
2016[1)]				567		715		2 601		549	803		1 396			21 619	404			28 654

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 22.3.1 Available age data (number of otoliths read) of deep pelagic beaked redfish in the Irminger Sea and adjacent waters.

Year	Iceland	Norway	Total
1996	304		304
1999	1052	258	1310
2001	158	758	916
2003		75	75
2004	399		399
2006	200		200
2009	783		783
2011	585		585
2012	672	628	1300
2013	535	159	694
Total	4688	1878	6566

Table 22.3.2 Number of length measurements of deep pelagic beaked redfish and number of hauls sampled from the Icelandic commercial fishery.

Year	Number of fish	Hauls sampled
1992	447	5
1994	6915	41
1995	8128	49
1996	12185	141
1997	19258	200
1998	10104	94
1999	16264	115
2000	11079	97
2001	10589	83
2002	3840	48
2003	6705	63
2004	14774	87
2005	5693	34
2006	15296	78
2007	14449	79
2008	4993	40
2009	9231	73
2010	4113	34
2011	7339	52
2012	9458	70
2013	4093	35
2014	2927	19
2015	998	6
2016	3935	20

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

Table 22.9.1: Short-term forecast. Values of catch and SSB are in kt

MAN.TYPE	F 2017	SSB 2017	CATCH 2017	F 2018	SSB 2018	CATCH 2018	F 2019	SSB 2019	CATCH 2019
0.1 * Status quo	0.028	335.79	3.011	0.028	361.68	3.439	0.025	387.00	3.884
0.2 * Status quo	0.056	335.79	5.908	0.056	358.82	6.658	0.05	381.07	7.422
0.3 * Status quo	0.084	335.79	8.695	0.084	356.15	9.672	0.076	375.43	10.650
0.4 * Status quo	0.112	335.79	11.378	0.112	353.55	12.498	0.102	370.43	13.598
0.5 * Status quo	0.14	335.79	13.961	0.14	351.04	15.148	0.13	365.01	16.293
0.6 * Status quo	0.167	335.79	16.449	0.167	348.62	17.637	0.158	360.19	18.761
0.7 * Status quo	0.195	335.79	18.846	0.195	346.30	19.974	0.187	355.60	21.023
0.8 * Status quo	0.223	335.79	21.155	0.223	344.05	22.172	0.217	351.23	23.099
0.9 * Status quo	0.251	335.79	23.381	0.251	341.89	24.240	0.247	347.07	25.006
1 * Status quo	0.279	335.79	25.531	0.279	339.81	26.187	0.279	343.09	26.763
Fmsy	0.041	335.79	4.386	0.041	360.34	4.978	0.041	384.18	5.587
Scale * Fmsy	0.018	335.52	1.953	0.019	362.79	2.378	0	387.63	0
Zero catch	0	335.79	0	0	364.6	0	0	393.27	0

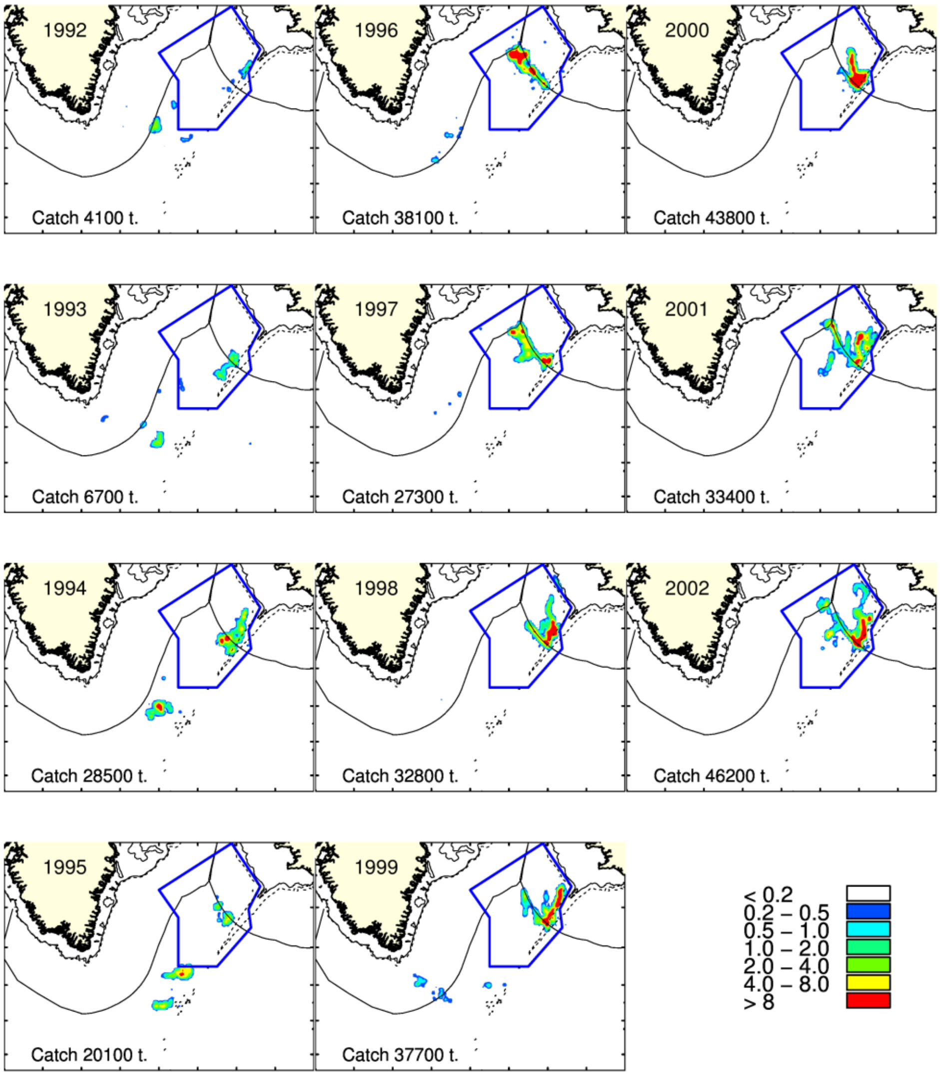


Figure 22.2.1 Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992-2016. Data are from the Faroe Islands (1995-2016), Germany (2011-2016) Greenland (1999-2003 and 2009-2010), Iceland (1995-2016), and Norway (1995-2003 and 2010-2016). The catches in the legend are given as tones per square nautical mile. The blue box represents the proposed management unit.

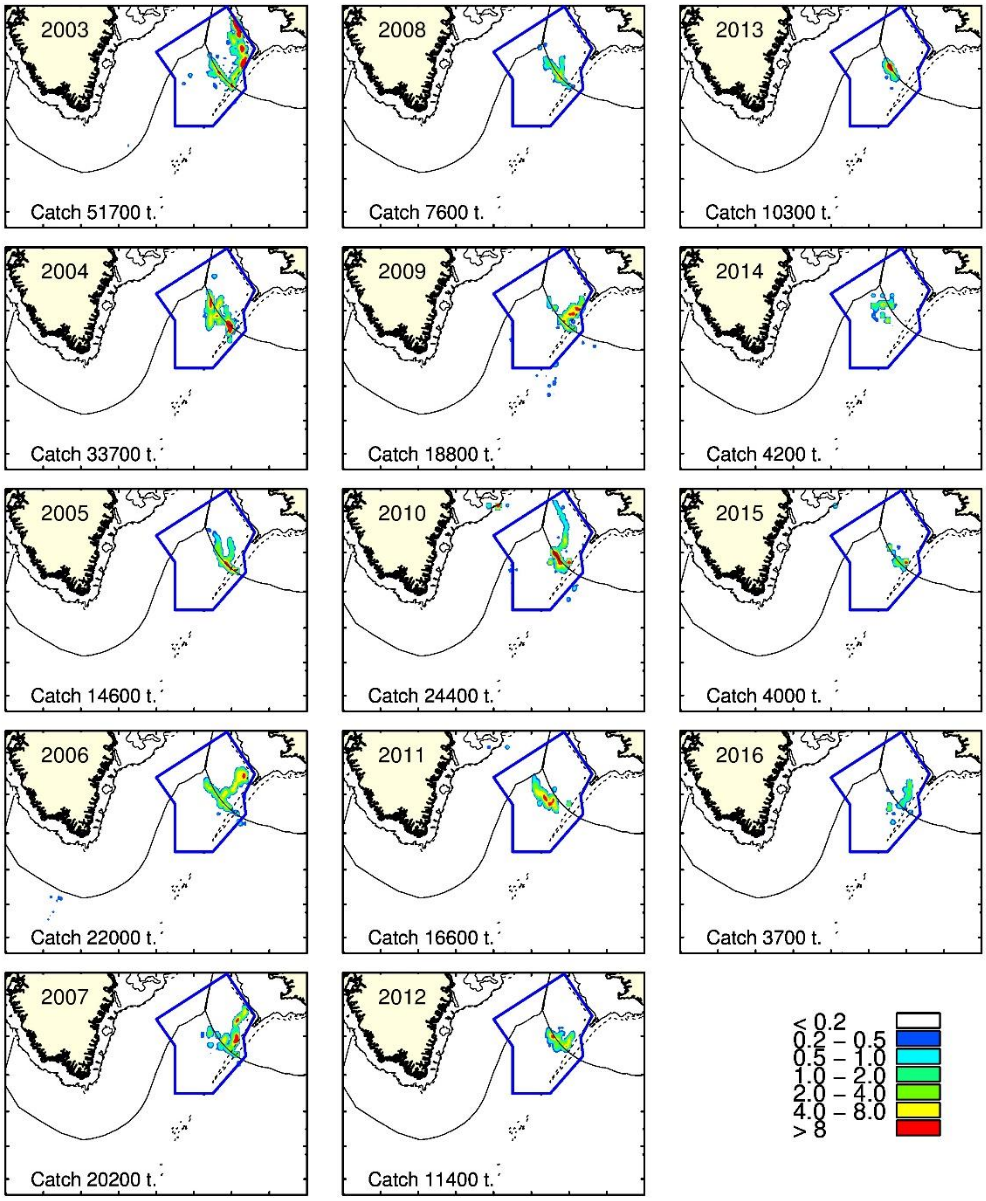


Figure 22.2.1 (Cont.) Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992-2016. Data are from the Faroe Islands (1995-2016), Germany (2011-2016) Greenland (1999-2003 and 2009-2010), Iceland (1995-2016), and Norway (1995-2003 and 2010-2016). The catches in the legend are given as tones per square nautical mile. The blue box represents the proposed management unit.

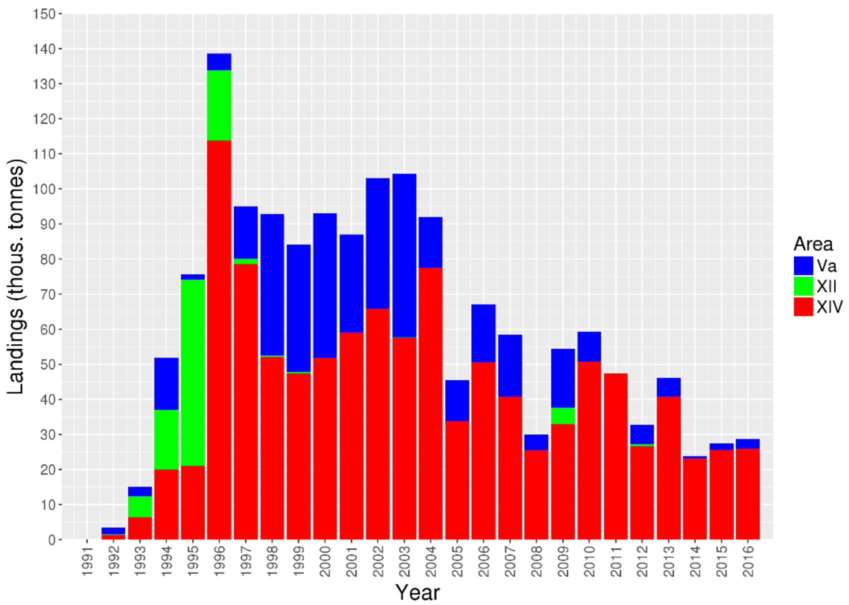


Figure 22.2.2 Landings of deep pelagic *S. mentella* (Working Group estimates, see Table 21.2.1).

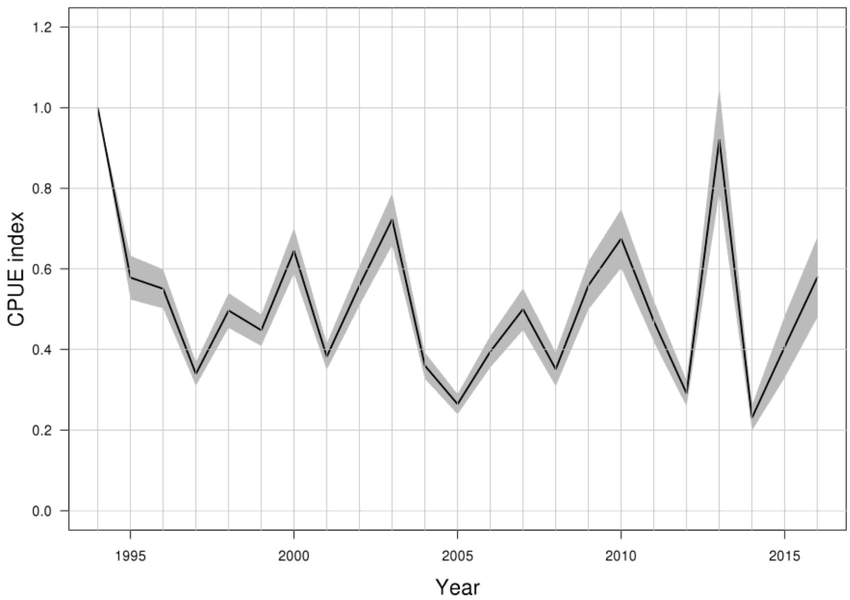


Figure 22.2.3 Trends in standardised CPUE of the deep pelagic *S. mentella* fishery in the Irminger Sea and adjacent waters, based on log-book data from Faroe Islands, Iceland, Germany, Greenland and Norway.

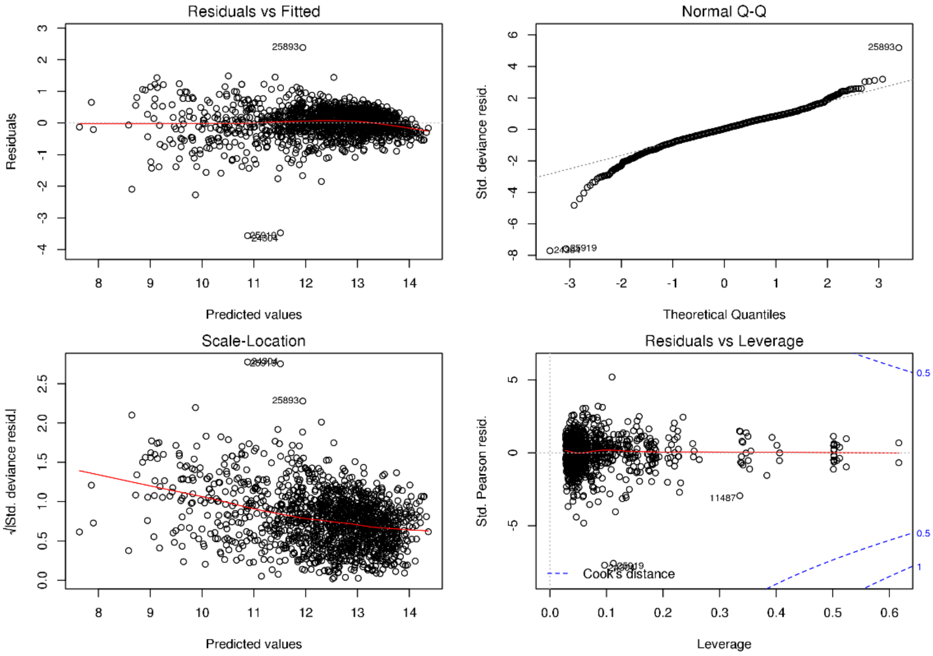


Figure 22.2.4 Residuals from the GLM model used to standardize CPUE, based on log-book data from Faroe Islands, Iceland, Greenland and Norway.

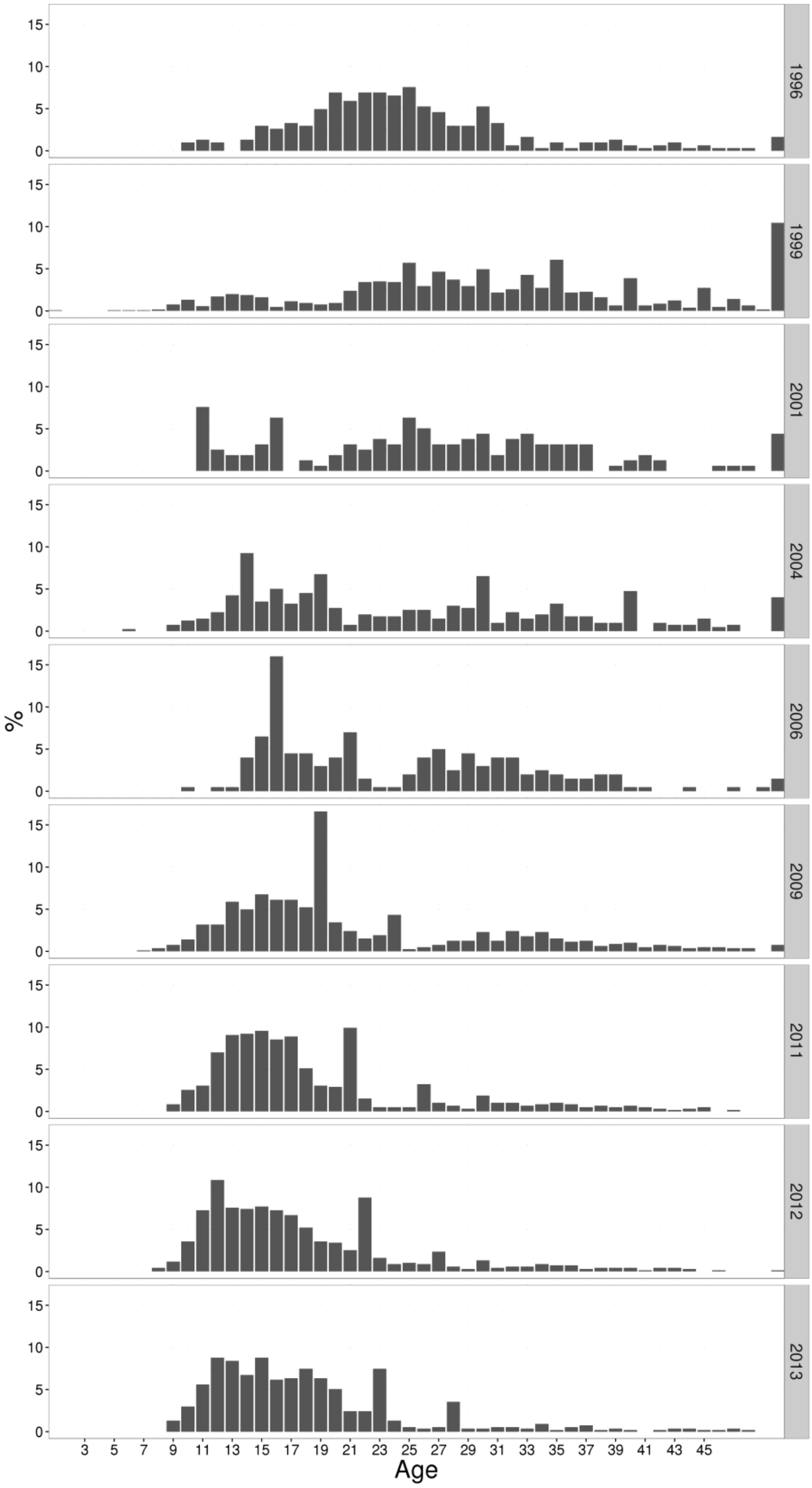


Figure 22.3.1 Age distribution of deep pelagic beaked redfish based on age reading from the Icelandic commercial catch.

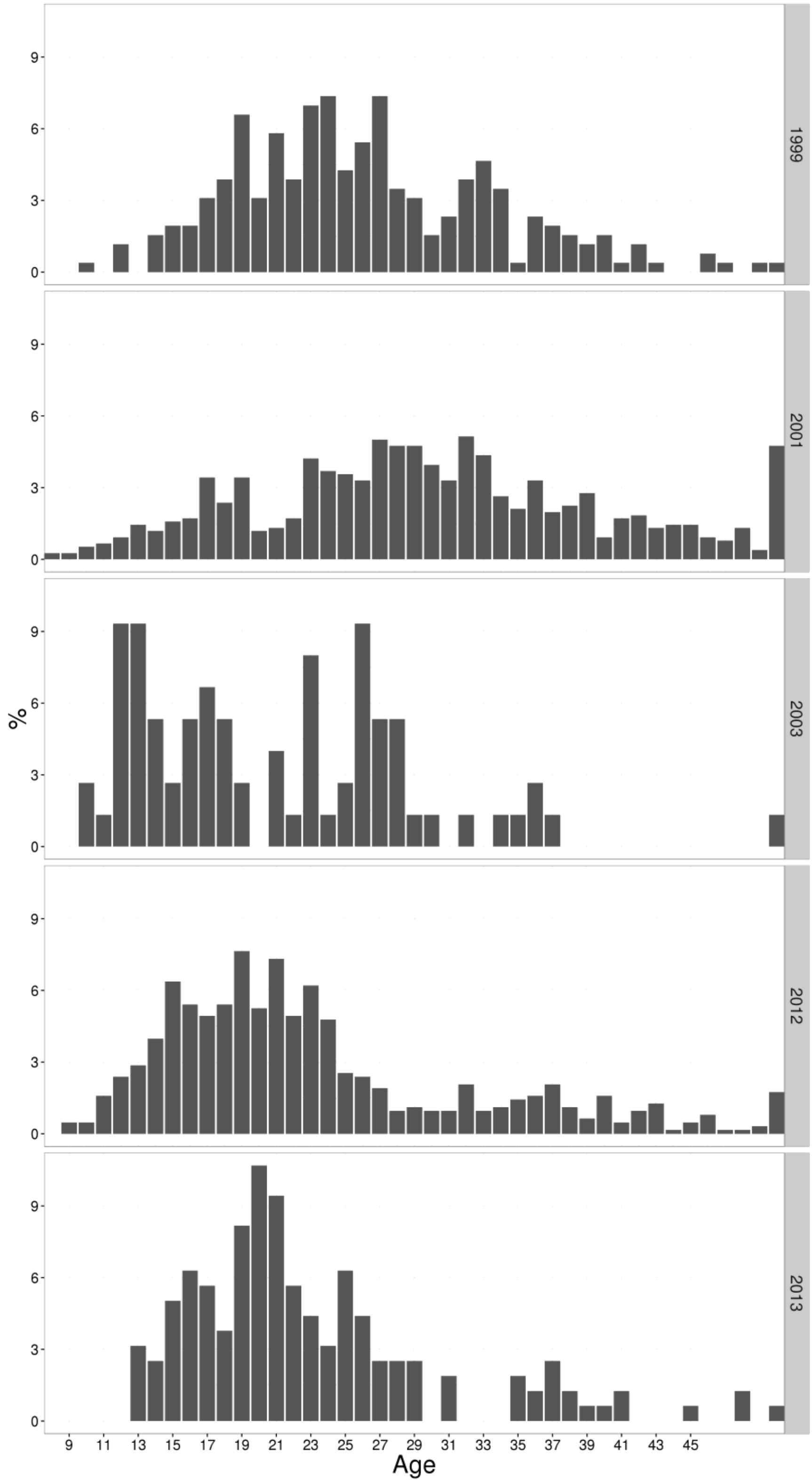


Figure 22.3.2 Age distribution of deep pelagic beaked redfish based on age reading from the Norwegian commercial catch.

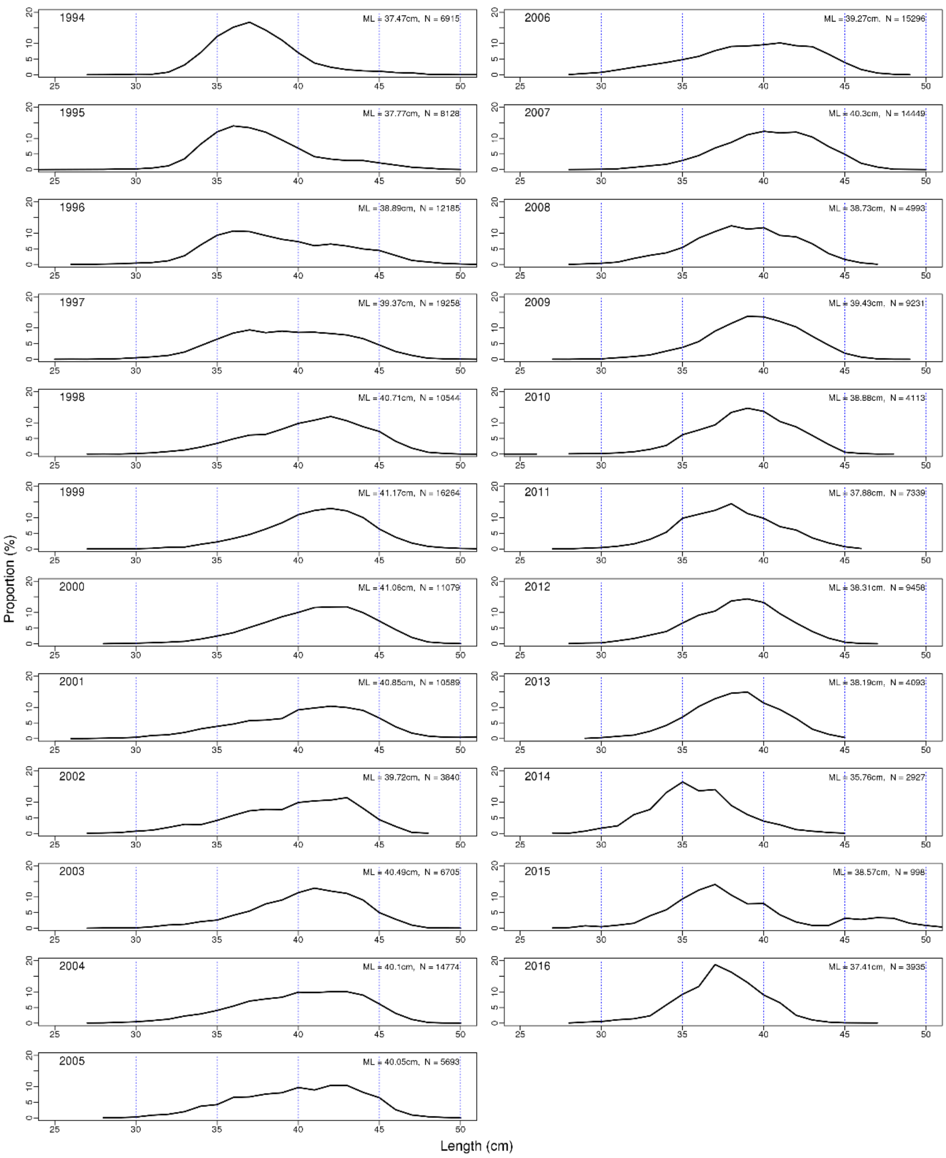


Figure 22.3.3 Length distribution from Icelandic landings of deep pelagic *S. mentella*.

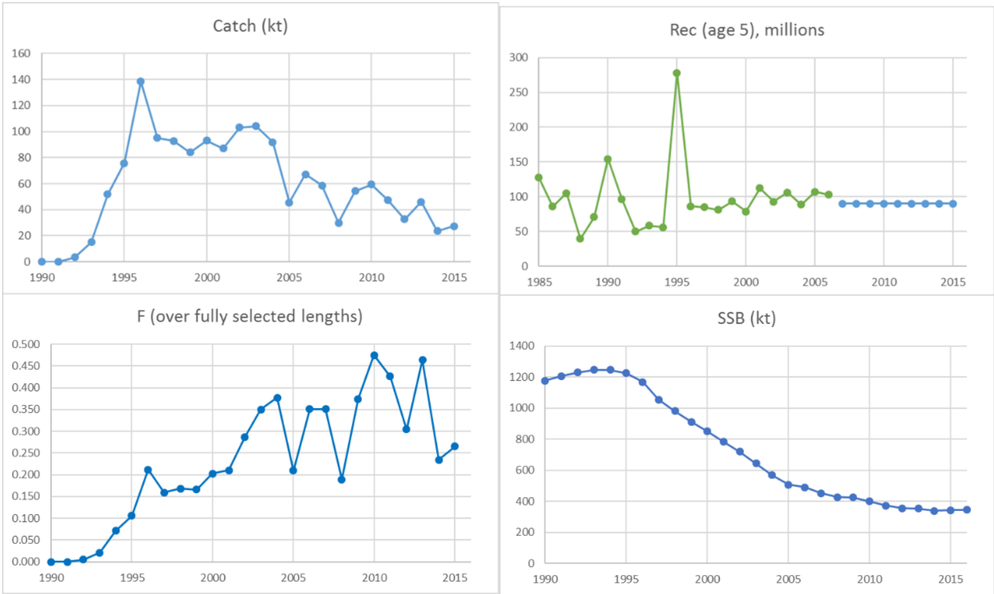


Figure 22.7.1: Summary of stock assessment agreed by WKDEEPRED, see Table 5.2.2 for a tabulation of results (to be presented as a Category 2 assessment, i.e. with Recruitment, F and SSB on relative, rather than absolute, scale). Recruitment after 2006 is not considered to be reliably estimated and has been replaced by the geometric mean of the estimated recruitment during 1985-2006. SSB and F values after 2006 were recalculated accordingly, so as to match the observed catches in those years.

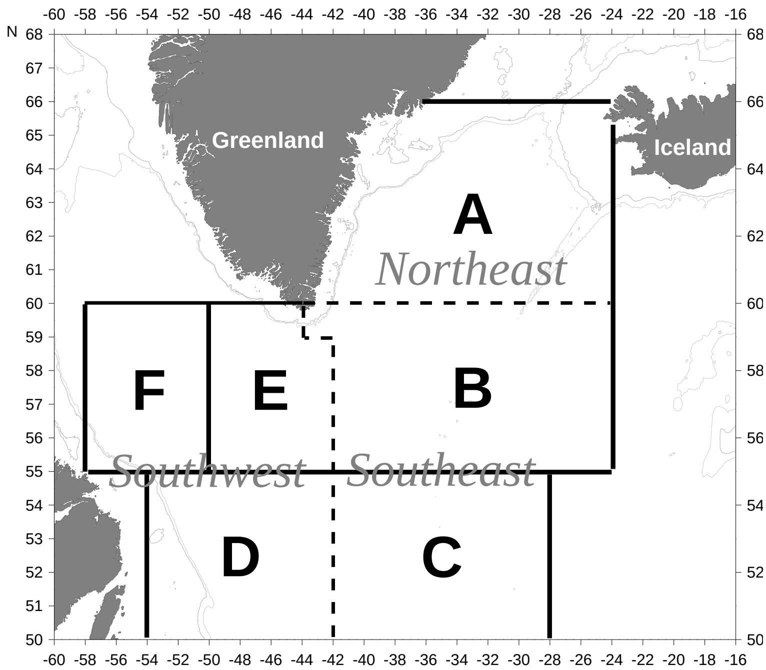


Figure 22.6.1 Sub-areas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines).

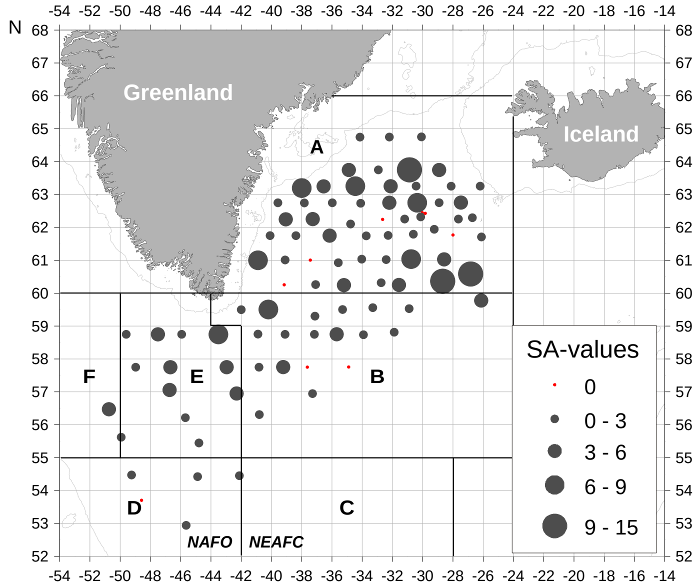


Figure 22.6.2. Redfish trawl estimates deeper than 500 m (type 3 trawls). sA values calculated by the trawl method (see WGRS Report, 2013) during the joint international redfish survey in June/July 2013.

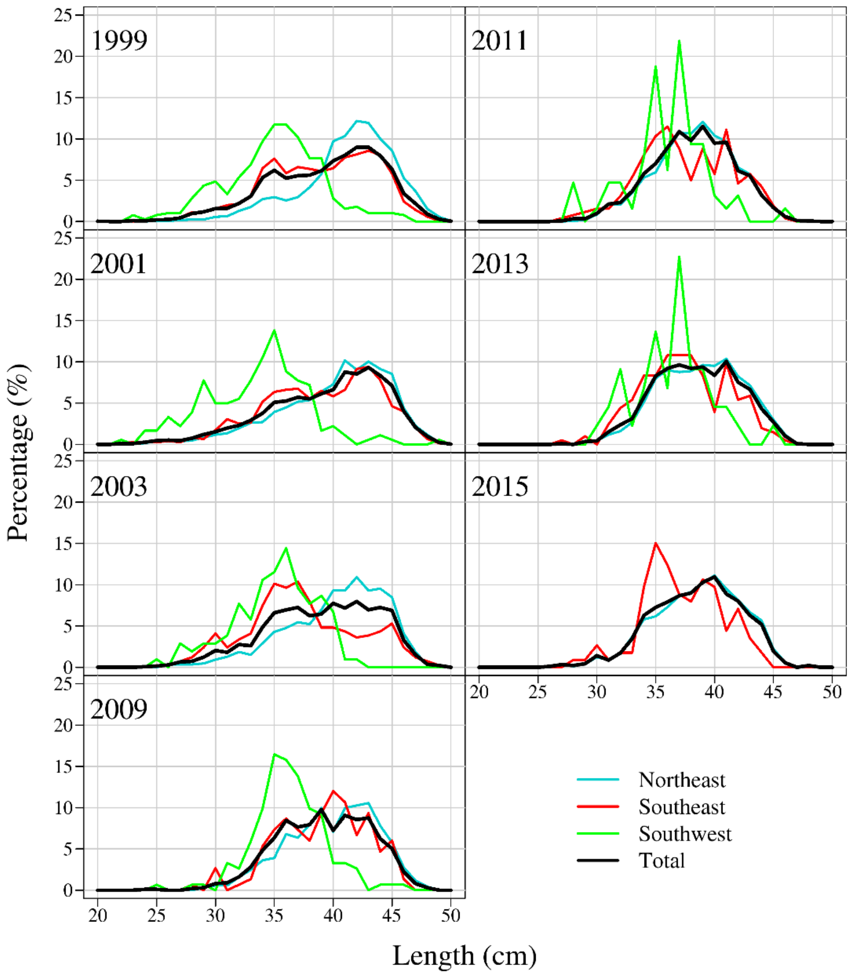


Figure 22.6.3 Length distribution of redfish 1999-2015 in the trawls, by geographical areas (see Fig. 22.6.1) and total, from fish caught deeper than 500 m.

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 and the Greenland shrimp and fish survey in shallow water (0–600 meters), which has been conducted since 2008 (Christensen and Hedeholm 2017). 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 2013-2016 (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 and 2016, 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 2016 biomass estimate for *S. mentella* increased from 61 Kt to 164 Kt from 2015 to 2016 (Figure 23.2.5). However, the estimate has large uncertainties since one haul accounted for 70 % of the total biomass estimate. The haul was taken in area Q2 close to Icelandic waters. The German survey shows very similar trends both with regards to adult fish and juveniles. In the Greenland shrimp and fish shallow water survey the biomass of juveniles stayed at the same low level as the last three years (Figure 23.2.5). The juveniles are at the lowest level in the 30-year time-series. Survey length distributions showed different modes for the Greenland and German survey, respectively. Based on the Greenland survey the mode was 39 cm, while the mode in the German survey was 34 cm. The difference can be attributed to the one large haul in the Greenland survey consisting of a high proportion of large *S. mentella* in the survey area close to Iceland (Figure 23.2.2. and 23.2.6). The German survey and the Greenland shrimp and fish shallow water survey both show overall declines in the *S. mentella* biomass indices. in 2016, the indices increased, however with large uncertainty of the estimate.

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 6 samples from the commercial fishery the 8 503 tonnes of demersal redfish caught in ICES 14.b, was estimated to be 36 % *S. mentella* (3 061) and 64 % *S. norvegicus* (5 442). Earlier *S. mentella* dominated the catches, but the proportion started to decline in 2014 (Figure 23.3.1.1). In 2016, the split changed and for the first time *S. norvegicus* now dominated the catches (Figure 23.3.1.1). Prior to 1974, all catches were reported as *S. norvegicus* and the split was determined by working groups on a yearly basis.

Catch depth has in the later years declined compared to earlier. In 2016, the catches were taken at a depth of 300-350 meters, while it in 2011-2012 were caught at 350-400 meters (Figure 23.3.1.2).

Total annual landings of demersal *S. mentella* from Divisions 14.b since 1974 are presented in Table 23.3.1.3. 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 2016 catches were 8 503 tonnes (Figure 23.3.1.3). 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 and include both *S. mentella* and *S. norvegicus* (Christensen and Hedeholm 2017), which covers redfish distribution better than data from the redfish directed fishery and covers a longer period (1999–2016). 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, while it increased again in 2016 (Figure 23.3.2.1).

The increase in the index follow the increase 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.

The cpue from the redfish directed fishery showed a drastic decline from 2010 to 2015, while it increases again in 2016 (1.7 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

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, Russia and Germany have had any significant catches. (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). From 1999-2009, the fishery 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 overlap (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 2016, the catch length distribution was estimated from 488 redfish and separated into *S. mentella* (N=232) and *S. norvegicus* (N=256) (Figure 23.3.5.1). The distribution showed a clear mode around 34 cm which is a reduction compared to earlier. All samples were analysed by the Greenland Institute of Natural Resources, and it was found that *S. mentella* constituted 36%% of the total sample weight. For *S. norvegicus* the mode was around 38 cm in 2016.

23.4 Methods

No analytical assessment was conducted.

23.5 Reference points

As described in section 1.3 MSY proxy reference points needs to be defined for the Greenlandic *S. mentella* slope stock. ICES suggested four methods for this purpose, and all methods were tested on the stock. The conclusion was that based on the caveats listed below and the declines seen in surveys, especially on recruitment over the past decade, the determination of the stock status in relation to reference points should not be based solely on any of the indicators presented here, but rather a holistic view combining surveys and expert judgment with the results presented in Hedeholm and Christensen 2017.

The caveats to consider in relation to the Greenlandic *S. mentella* slop stock when concluding on the length based indicators and the SPiCT model.

- If there are few year classes in the fishery, which is current for the present stock, the effect of overfishing the stock is more likely observed on biomass rather than length, especially on a slow growing species. There is no ageing done in this stock, why it is not possible to see if this is the case.
- *Sebastes mentella* is a slow growing species, thus the effect of the fishery on length may be very subtle. The relatively short time series on length distributions available for this analysis and the limited number of samples per year entails that any effect is easily missed.
- The schooling behavior of *S. mentella* in connection with the points made above means that the fishery can target a diminishing stock in a small area without seeing any effect on the length distribution. Indeed, the fishery is conducted with limited spatial extent.
- Several redfish stocks are present on the East Greenland slope, but in unknown quantities. Any changes in length could just as well be related to migration, timing of sampling, latitude of sampling as to actual stock changes.
- Based on the three length based methods the exploitation pattern appears reasonable. However, results from all three methods should be interpreted with some caution due to lack of knowledge of important input parameters (L_{inf}, M and k) for the specific stock (values from Fishbase are used).

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. In 2016, biomass indices increased but with high uncertainty of the estimate. In both surveys there have been a complete absence of small fish since 2013 After a gradual decline from 2010 to 2015, the redfish directed fishery cpue increased in 2016 to the same level as 2012-2014. Changes in length distributions in both surveys also suggests that no new cohorts are present on the slope and that the change in adult biomass 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 decreasing trend. 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 the decreasing trend in survey estimates no uncertainty parameters is applied. According to the guidelines the precautionary buffer was not applied. The advice for 2018 is 1 142 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.

23.8 Tables

Table 23.3.1.1 Nominal landings (tonnes) of demersal *S. mentella* 1974-2017 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
2016	3 061

Table 23.3.3.2 Landings (tonnes) of demersal redfish (*S. mentella* and *S. norvegicus*) caught in ICES 14.b by nation.

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
2016	1759	-	-	25	2	5859	-	858	-	-	-	8503
Sum	14146	3	162	1068	536	41390	336	6122	3	521	856	65143

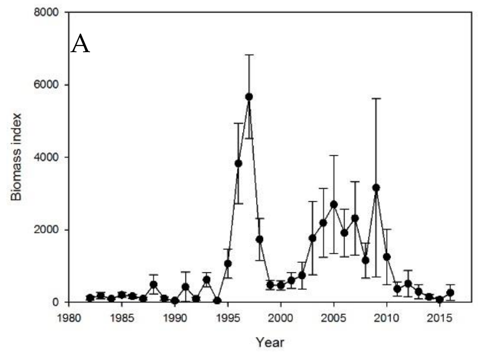
Table 23.3.4.1 Discarded bycatch (tonnes) of Sebastes sp. from the shrimp fishery in ICES 14.b.

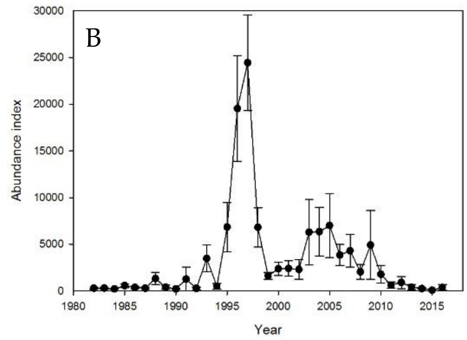
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
1999	6	16	17	5	1	13	2	48	22	30	40	33	234
2000	10	3	31	17	15	4	21	78	28	18	9	6	239
2001	7	9	10	16	9	11	4	5	3	3	28	6	111
2002	3	11	9	6	1	0	0	5	4	8	3	5	55
2003	5	6	8	5	5	8	8	15	2	10	12	4	88
2004	7	10	17	13	4	2	27	20	7	2	9	0	118
2005	7	14	16	8	7	5	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
2016	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 (*S. mentella* and *S. norvegicus*) caught in ICES 14.b. by month.

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
2016	306	214	1130	1185	1426	1864	1298	559	466	38	14	1	8501
Sum	3004	6250	6816	7904	7696	10266	6411	4620	2781	2430	3848	3101	65140

23.9 Figures





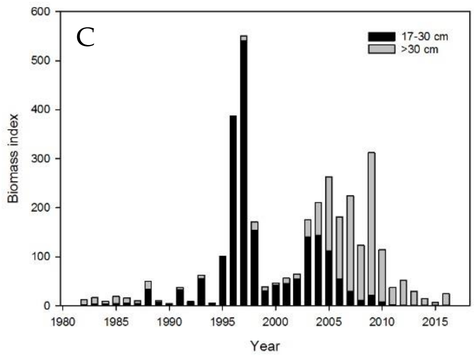


Figure 23.2.1. Indices from the German East Greenland survey of *S. mentella* larger than 17 cm. Biomass (A), abundance (B), and biomass split on length (C). On figure (C) the grey bars represent the biomass of *S. mentella* larger than 30 cm and the light bars biomass in fish from 17–30 cm.

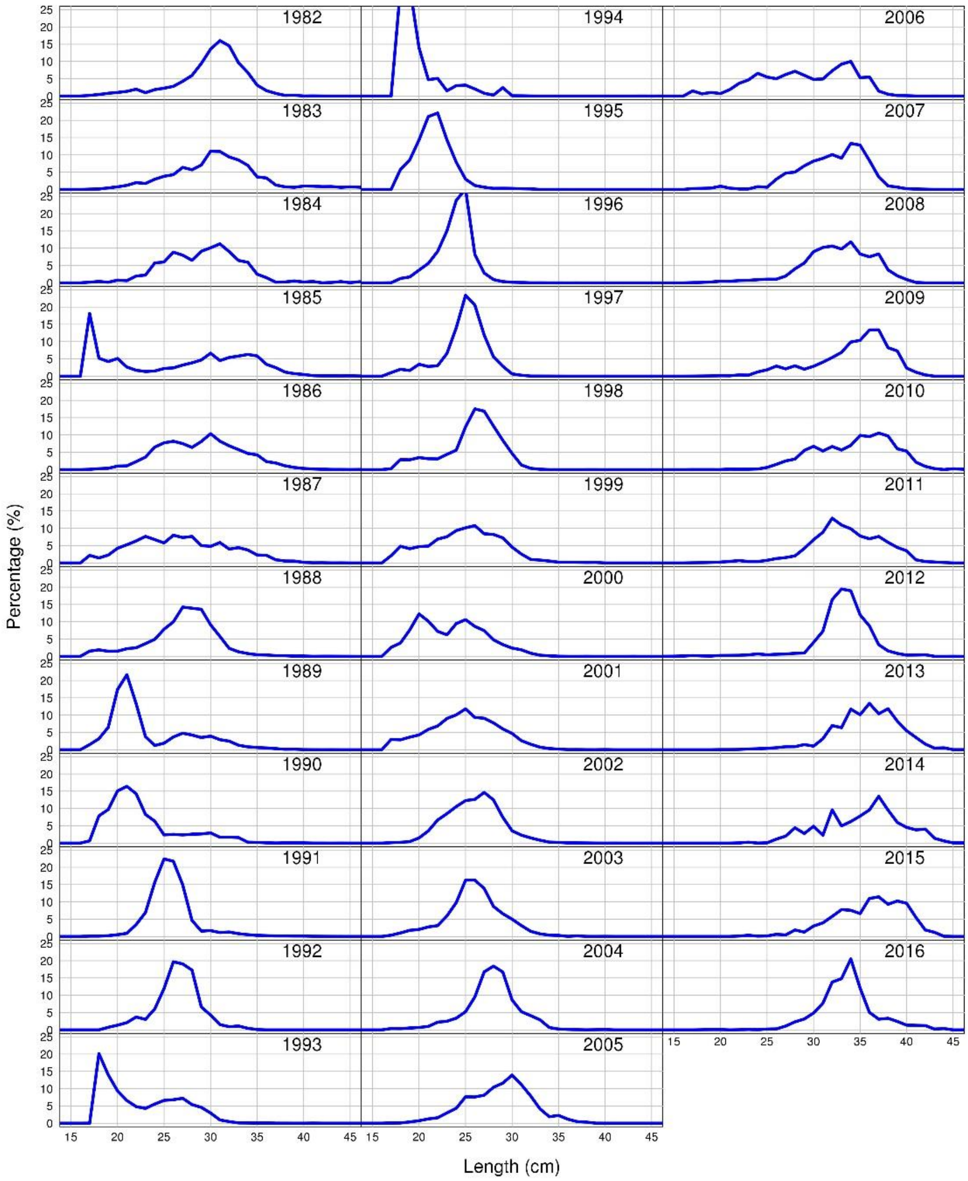


Figure 23.2.2. Length distributions from the German East Greenland survey 1985–2016.

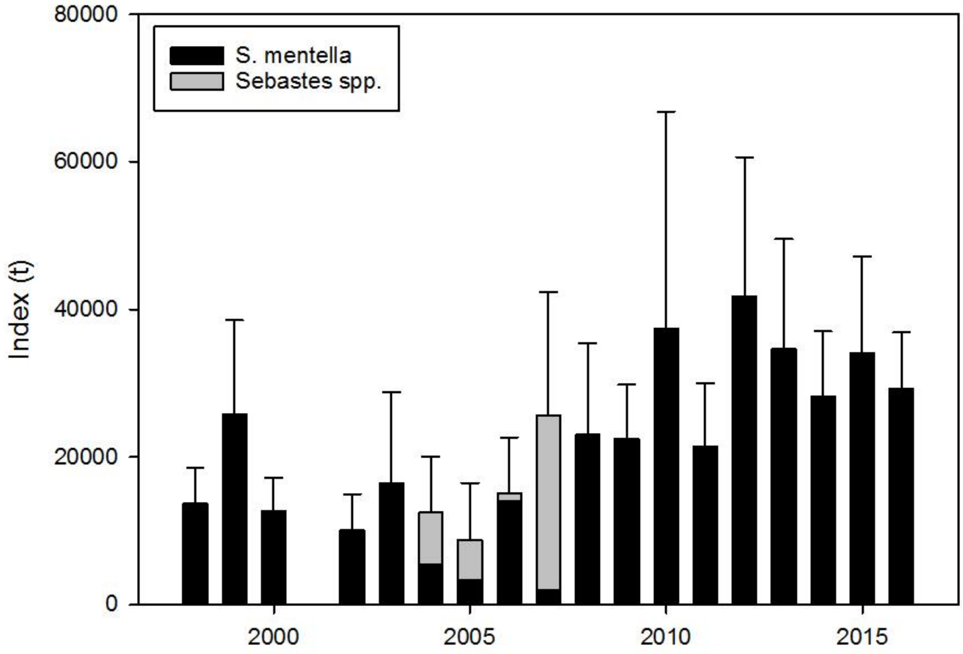


Figure 23.2.3. Biomass of *S. mentella* and *Sebastes* spp. derived from the deep Greenland survey. Bars indicate 2SE of the biomass of *S. mentella* including *Sebastes* spp. No survey in 2001. In 2004, 2005 and 2007 a large proportion of the redfish were not determined to species and only reported as "*Sebastes* spp". It is most likely that the majority of these fish were *S. mentella*.

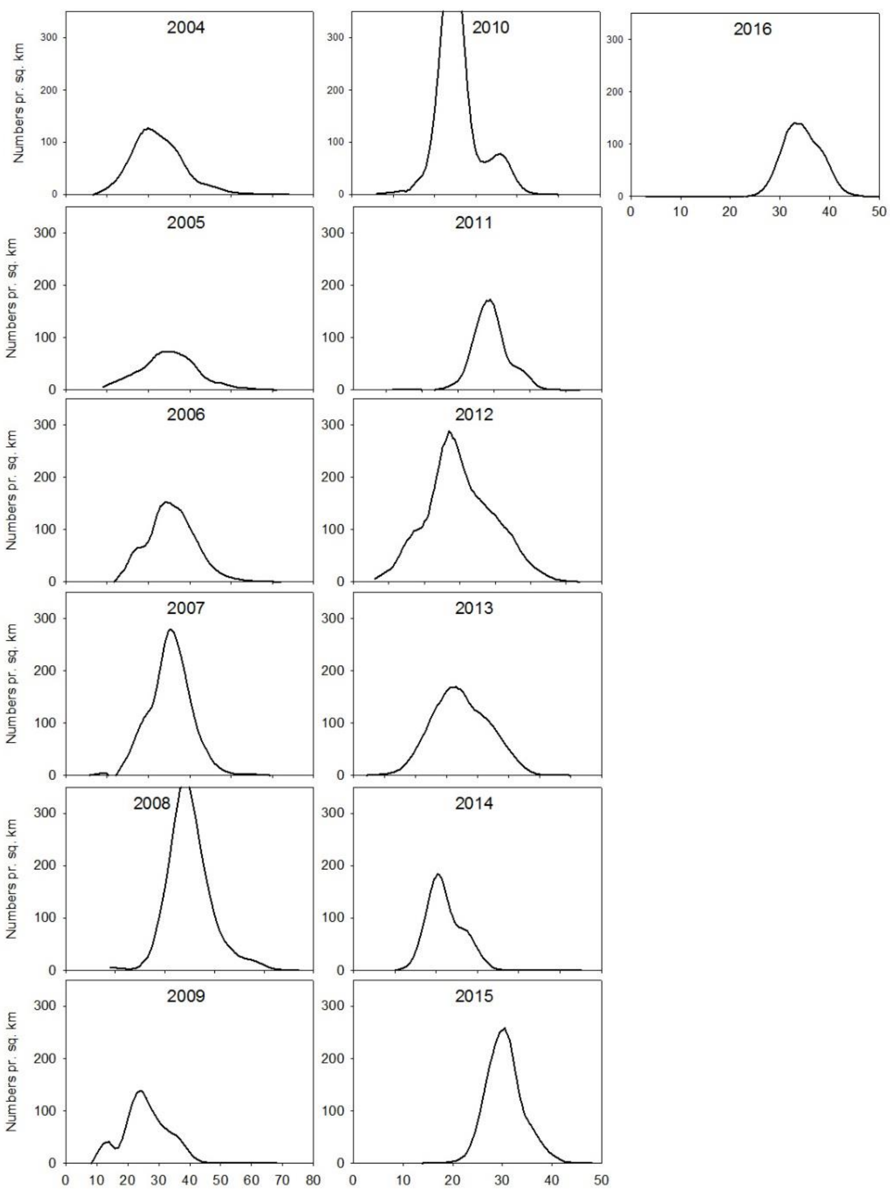


Figure 23.2.4. Overall length distribution of *Sebastes mentella* (number per km²) from the deep Greenland survey.

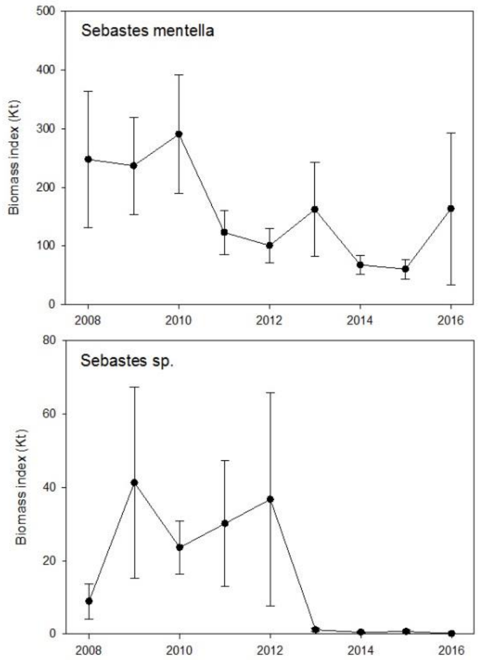


Figure 23.2.5: Biomass (kg*10⁶, Kt) (±CV%) indices for *S. mentella* (top) and *Sebastes* sp. (<18cm) (bottom) off East Greenland in 2008-2016 from the Greenlandic shallow water survey. All surveyed areas are combined (Q1–Q6).

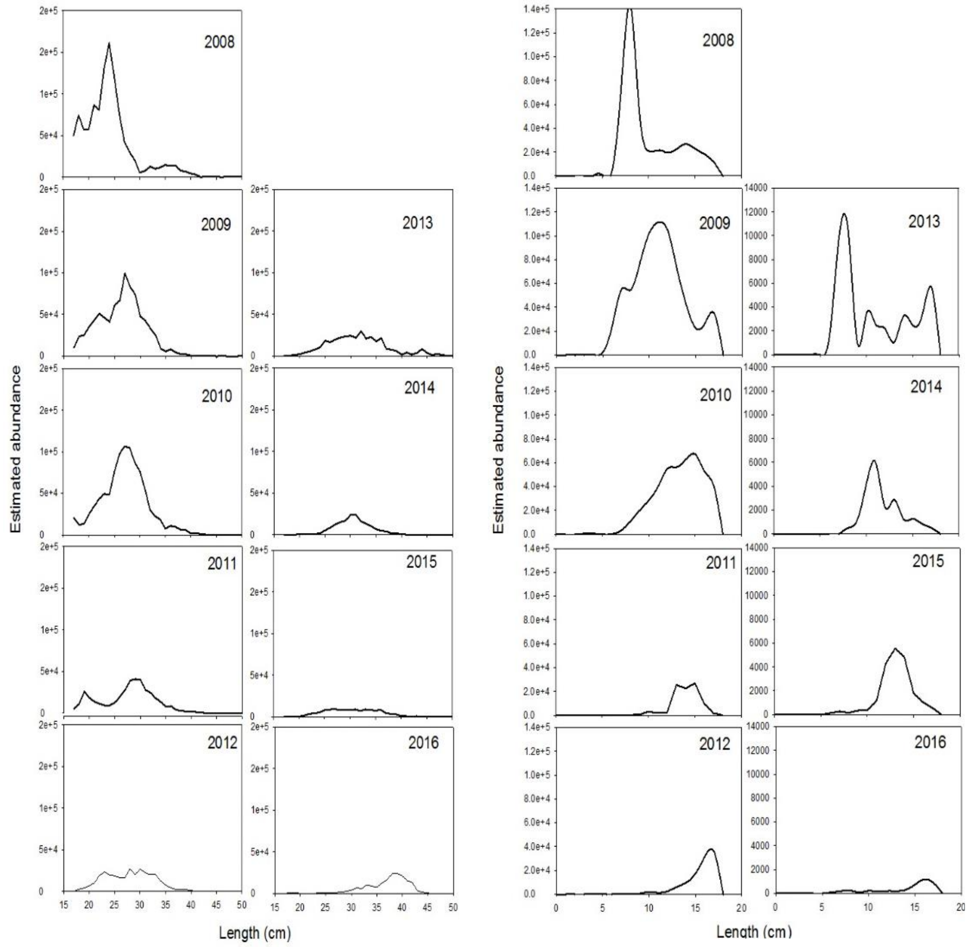


Figure 23.2.6. Overall length distributions for juvenile redfish *S. mentella* (left) and *Sebastes spp.* <18 cm (right) (note the change in scale from 2013) from the Greenlandic shallow water survey. All surveyed areas combined (Q1–Q6).

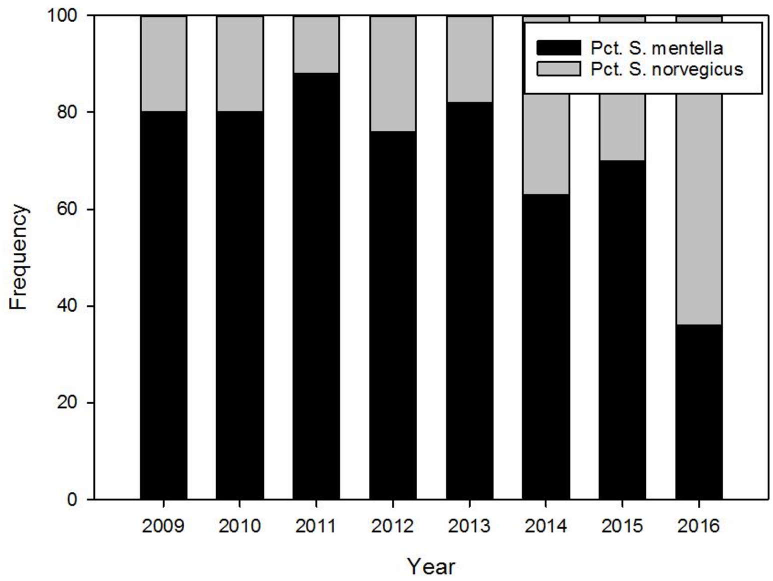


Figure 23.3.1.1. Development in split of *S. mentella* and *S. norvegicus* in the fisheries on the Greenland slope.

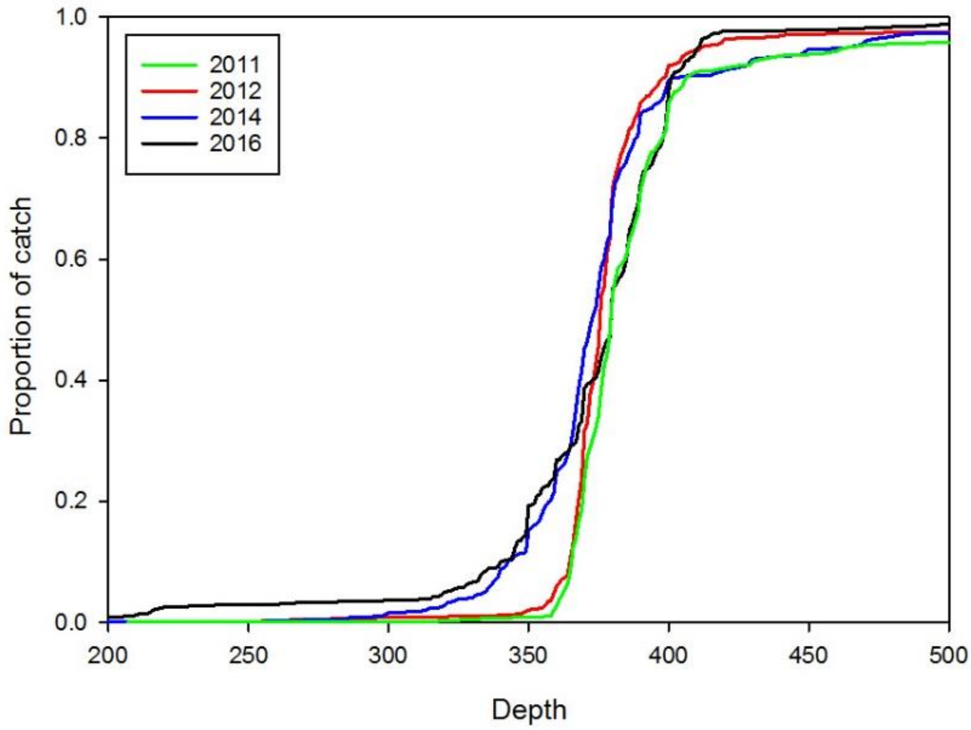


Figure 23.3.1.2 Development in catch depth of *Sebastes* (*S. mentella* and *S. norvegicus* combined).

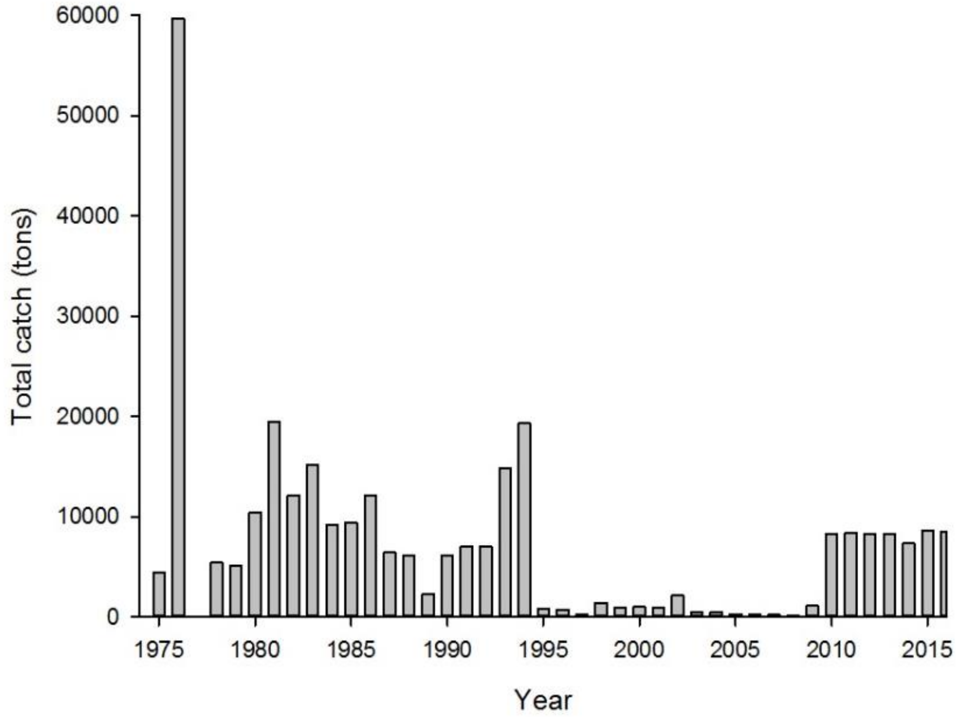


Figure 23.3.1.3 Landings of *S. mentella* in subarea 14.b. Landings of "redfish" have been split based on estimates from survey and commercial catches.

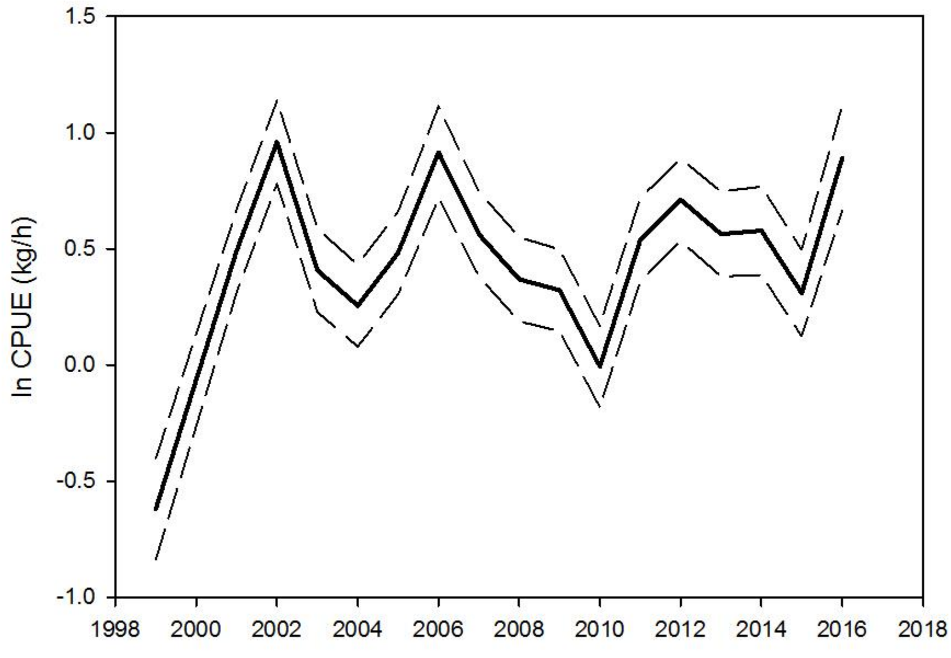


Figure 23.3.2.1 Standardized redfish bycatch cpue in the directed fishery for Greenland halibut in ICES 14.b as a function of year. cpue was estimated from the GLM model: lncpue=year+ICES Subdivision+depth. Bars represent standard error. Only hauls made below 1000m were used in the analyses.

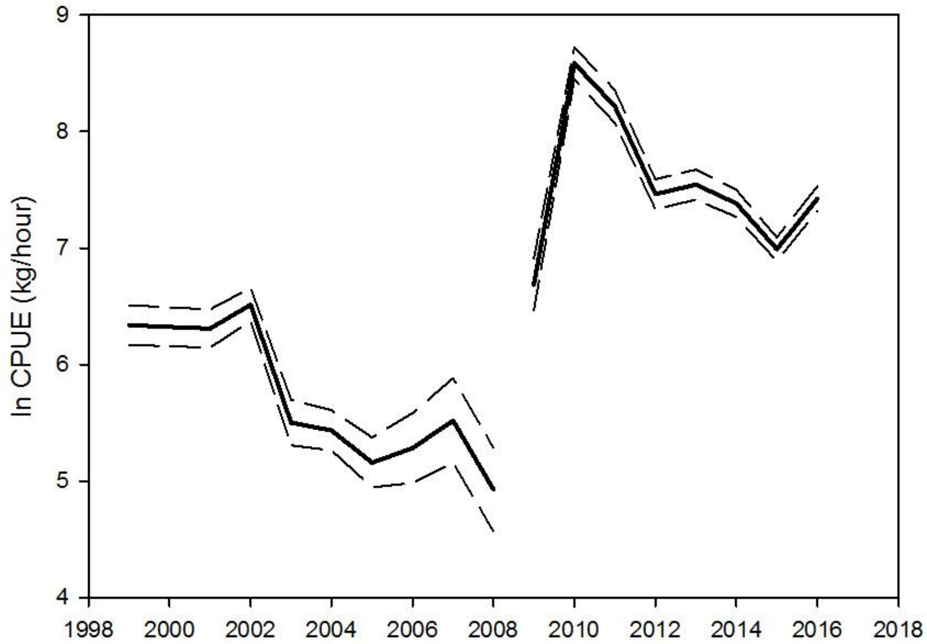


Figure 23.3.2.2 Standardized redfish cpue in the redfish directed fishery ICES 14.b as a function of year. cpue was estimated from the GLM model: lncpue=year+ICES Subdivision+depth. Dashed lines represent standard error.

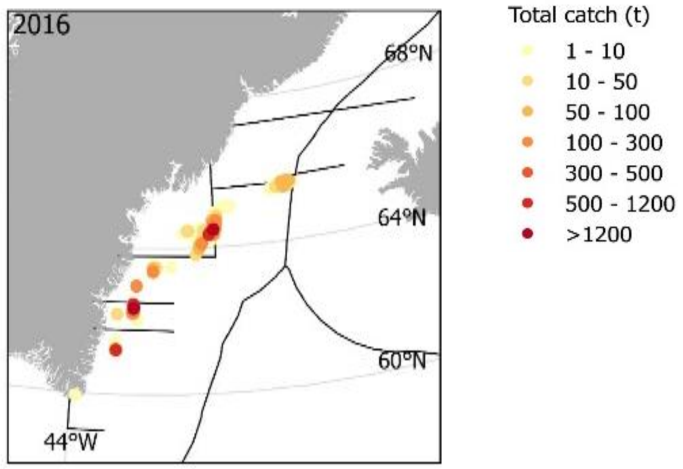


Figure 23.3.3.1 Distribution of catches of demersal redfish in 2016 in ICES 14.b.

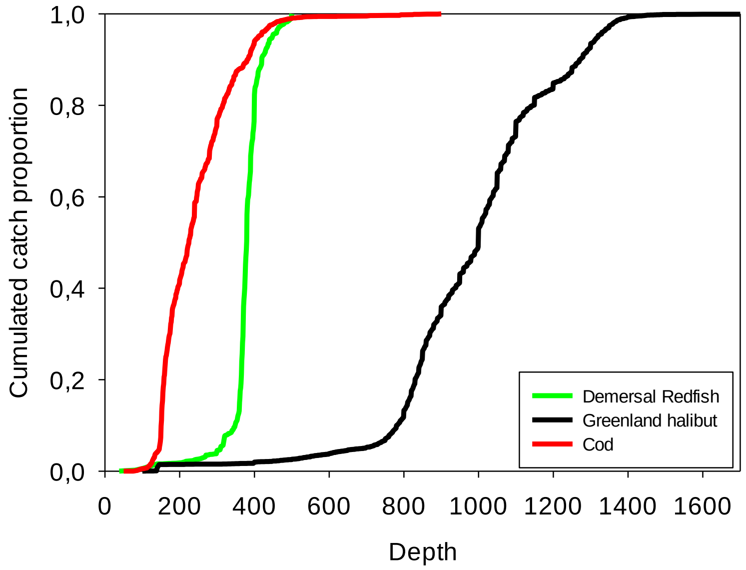


Figure 23.3.3.2. Lines represent the share of the total commercial catch caught at a given depth from 1999–2011 in *G. morhua*, demersal redfish (mixed *S. mentella* and *S. norvegicus)* and *R. hippoglossoides*.

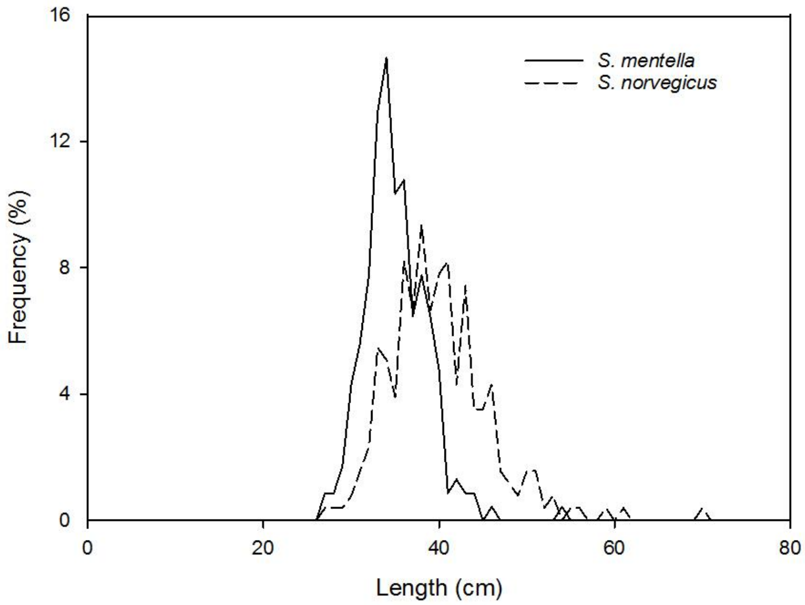


Figure 23.3.5.1: Length distribution of 488 redfish analysed by the Greenland Institute of Natural Resources separated into *S. mentella* (N=232) and *S. norvegicus* (N=256).

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Annex 1: List of Participants

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27 April – 05 May 2017

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Annex 2 Recommendations

To the attention of ACOM:

Greenland halibut (ghl.27.561214) is currently assessed using a stock production model. Age data is now becoming available and an alternative model (GADGET) has been developed over the past few years, incorporating age data. An issue list was prepared during the meeting, including tagging data, spatial analysis, and stock identification. NWWG recommends that the Greenland halibut is benchmarked in 2019.

To the attention of ACOM:

Different SAM models were presented for the East Greenland offshore cod (cod.2127.1f14) during the 2017 NWWG meeting. NWWG finds the SAM runs promising and an issue list was developed for further refinement of input data and model configuration. The present advice is based on an F-proxy approach, but with age disaggregated data available from two surveys and commercial catches this stock should be subject to an analytical assessment. NWWG recommends an interim benchmark in 2017.

To the attention of ACOM:

A SAM model was presented for the West Greenland inshore cod stock (cod.21.1) during the 2017 NWWG meeting. Further work with the SAM model was recommended especially with regard to the included survey data and taken emigration out of the area into account. The present advice is based on a qualitative evaluation of stock trends and has been static for the past four years. Age disaggregated data from survey and commercial landings allows for an analytical assessment although stock mixing in the area presents a challenge. NWWG recommends an interim benchmark in 2017.

To the attention of SCICOM/SIMWG:

In 2009, ICES reviewed the stock structure of beaked redfish, *Sebastes mentella* in the Irminger Sea and adjacent waters (WKREDS). The recognised that there are three biological stocks of *S. mentella* in the Irminger Sea and adjacent waters: ‘Deep Pelagic’; ‘Shallow Pelagic’ and ‘Icelandic Slope’.

This separation of the stocks did not include *S. mentella* on the Greenland continental slope. ICES therefore decided that NWWG should conduct a separate assessment for S. mentella in subarea 14.b until further information was available to assign stock origin. Since 2009, further studies on stock structure and species separation have been conducted. Based on the new information it is recommended that the separation of S. mentella on the Icelandic and Greenlandic slopes is revised. Specifically, that stock origin of S. mentella on the Icelandic and Greenlandic slopes is identified with the purpose to evaluate the possibility for a joint assessment.

Annex 03 ToRs for the next meeting

Generic ToRs for Regional and Species Working Groups

The working group should focus on:

a) Consider and comment on ecosystem and fisheries overviews where available;

b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:

  i) descriptions of ecosystem impacts of fisheries

  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, summarising where the item is relevant:

  i) Input data and examination of data quality;

  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 (i.e., all stocks with catches in the NEAFC area) estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in the last year.

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

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

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

Annex 04: List of Working Documents. (NWWG 2017)

Boje J. 2017. The fishery for Greenland halibut in ICES Div. XIVb in 2016. ICES NWWG 2017 Working Document no. 01.

Retzel A. 2017. Greenland commercial data for Atlantic cod in East Greenland offshore waters for 2016. ICES NWWG 2017 Working Document no. 02.

Retzel A. 2017. Greenland Shrimp and Fish survey results for Atlantic cod in ICES subarea 14b (East Greenland) and NAFO subarea 1F (SouthWest Greenland) in 2016. ICES NWWG 2017 Working Document no. 03.

Retzel A. 2017. Greenland commercial data for Atlantic cod in Greenland inshore waters for 2016. ICES NWWG 2017 Working Document no. 04.

Retzel A. 2017. West Greenland inshore survey results for Atlantic cod in 2016. ICES NWWG 2017 Working Document no. 05.

Retzel A. 2017. Greenland commercial data for Atlantic cod in West Greenland offshore waters for 2016. ICES NWWG 2017 Working Document no. 06.

Retzel A. 2017. Greenland Shrimp and Fish survey results for Atlantic cod in NAFO subareas 1A-1E (West Greenland) in 2016. ICES NWWG 2017 Working Document no. 07.

Hedeholm R. 2017. Length Based indicators and SPiCT in relation to reference points for the East Greenland offshore Atlantic cod stock (cod-segr). ICES NWWG 2017 Working Document no. 08.

Hedeholm R. 2017. Length Based indicators and SPiCT in relation to reference points for the West Greenland offshore Atlantic cod stock (cod-wegr). ICES NWWG 2017 Working Document no. 09.

Óskarsson G.J. 2017. Estimation on number-at-age of the catch of Icelandic summer-spawning herring in 2016/2017 fishing season and the development of Ichthyophonus hoferi infection in the stock. ICES NWWG 2017 Working Document no. 10.

Óskarsson G.J. 2017. Results of acoustic measurements of Icelandic summer-spawning herring in the winter 2016/2017. ICES NWWG 2017 Working Document no. 11.

Christensen H.T. and Hedeholm R. 2017. Greenland Shrimp and Fish Survey Results for Redfish in East Greenland Offshore Waters in 2016. ICES NWWG 2017 Working Document no. 12.

Christensen H.T. and Hedeholm R. 2017. The fishery for demersal Redfish (S.mentella) in ICES Div. 14b in 2016. ICES NWWG 2017 Working Document no. 13.

Hedeholm R. and Christensen H.T. 2017. Length Based indicators in relation to reference points for East Greenland slope Sebastes mentella (smn-grl). ICES NWWG 2017 Working Document no. 14.

Riget F., Boje J. and Retzel A. 2017. An assessment of Cod (Gadus morhua) in ICES Subarea 14 and NAFO Division 1F (East Greenland, South Greenland). ICES NWWG 2017 Working Document no. 15.

Riget F., Boje J. and Retzel A. 2017. An assessment of Cod (Gadus morhua) in inshore NAFO Division 1A-1F (West Greenland)). ICES NWWG 2017 Working Document no. 16.

Riget F. and Hedeholm R. 2017. Reference points for Inshore West Greenland cod. ICES NWWG 2017 Working Document no. 17.

Steingrund P. 2017. Greenland halibut CPUE for commercial trawlers operating on the slope on the Faroe Plateau 1991-2016. ICES NWWG 2017 Working Document no. 18.

Steingrund P. 2017. Greenland halibut CPUE for the research vessel operating on the slope on the Faroe Plateau in May-June 1995-2016. ICES NWWG 2017 Working Document no. 19.

Steingrund P. 2017. Survey biomass indices of Greenland halibut on the slopes of the Faroe Plateau 1983-2016. ICES NWWG 2016 Working Document no. 20.

Steingrund P. 2017. A combined biomass index of Greenland halibut on the slopes of the Faroe Plateau 1983-2016. ICES NWWG 2016 Working Document no. 21.

Boje J. and Hvingel C. 2017. An assessment of Greenland halibut (Reinhardtius hippoglossoides) off East Greenland, Iceland and the Faroe Islands. ICES NWWG 2017 Working Document no. 22.

Popov V. and Rolskiy A. 2017. Information on the results of Russian fishery for pelagic beaked redfish from the Irminger Sea, its stock status and structure. ICES NWWG 2017 Working Document no. 23.

Bardarson B. and Johnsson S.T. 2017. Acoustic assessment of the Iceland-Greenland-Jan Mayen capelin stock in autumn 2016. ICES NWWG 2017 Working Document no. 24.

Marine & Freshwater Research Institute, Iceland. 2017. Advice for Intermediate TAC of Capelin in the Iceland-Greenland-Jan Mayen area for 2016/2017 fishing season based on Autumn survey (10. September – 4. October 2016). ICES NWWG 2017 Working Document no. 25.

Bardarson B. and Jonsson S.T. 2017. Preliminary cruise report: Acoustic assessment of the Iceland-Greenland-Jan Mayen capelin stock in winter 2017. ICES NWWG 2017 Working Document no. 26.

Bardarson B. and Gudmundsdottir A. 2017. Advice for TAC of Capelin in the Iceland-Greenland-Jan Mayen area for 2016/2017 fishing season based on Winter survey (11. – 21. January 2017). ICES NWWG 2017 Working Document no. 27.

Bardarson B. and Jonsson S.T. 2017. Preliminary cruise report: Acoustic assessment of the Iceland-Greenland-Jan Mayen capelin stock in Februiary 2017. ICES NWWG 2017 Working Document no. 28.

Marine & Freshwater Research Institute, Iceland. 2017. Advice for TAC of Capelin in the Iceland-Greenland-Jan Mayen area for 2016/2017 fishing season based on Winter survey (3. – 11. February 2017). ICES NWWG 2017 Working Document no. 29.

Elvarsson B.T. 2017. Overview of the Greenland halibut fishery in 5a. ICES NWWG 2017 Working Document no. 30.

Khlivnoy V.N., Astakhov A.N. and Gavrilik T.N. 2017. Refining the assessment of the beaked redfish stock in the Irminger Sea. ICES NWWG 2017 Working Document no. 31.

Khlivnoy V.N. and Mishin T.V. 2017. Russian investigations of Greenland halibut (Reinhardtius hippoglossoides) off the East Greenland in 2006-2016. ICES NWWG 2017 Working Document no. 32.

Steingrund P. 2017. The effect of adding and adjusting youngfish tuning ages on the estimate of recruitment of Faroe Plateau cod. ICES NWWG 2017 Working Document no. 33.

Werner K-M. 2017. Updating the analytical assessment of the offshore stock of Atlantic cod (*Gadus morhua*) in West and East Greenland. ICES NWWG 2017 Working Document no. 34.

Höskuldur B. 2017. Evaluation of reference points for the Faroe stocks. ICES NWWG 2017 Working Document no. 34.

Fock H., Werner K-M., Stransky C. and Bernreuther M. 2017. Abundance for Sebastes norvegicus L., deep sea S. mentella and juvenile redfish (Sebastes spp.) off Greenland based on groundfish surveys 1982-2015. ICES NWWG 2017 Working Document no. 35.

Fock H. and Werner K-M. 2017. Update of Groundfish Survey Results for the Atlantic Cod Greenland offshore component After re-stratification of the survey 1982-2016. ICES NWWG 2017 Working Document no. 36.

Kristinsson K. 2017. Length Based indicators in relation to reference points for Icelandic slope *Sebastes mentella* (smn-con). ICES NWWG 2017 Working Document no. 37.

Annex 05 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 27.2a5.14_SA	Capelin in the Iceland-East Greenland-Jan Mayen area)	January 2015	cap-icel_SA.pdf
cod.21.1_SA	Cod (*Gadus morhua*) in NAFO Subarea 1, inshore (West Greenland cod)	May 2017	cod.21.1_SA.pdf
cod.2127.1f14_SA	Cod (*Gadus morhua*) in ICES Subarea 14 and NAFO Division 1F (East Greenland, South Greenland)	May 2017	cod.2127.1f14_SA.pdf
cod.27.5b2_SA	Cod (*Gadus morhua*) in subdivision 5.b.2 (Faroe Bank)	April 2013	cod-farb_SA.pdf
cod.27.5b1_SA	Cod (*Gadus morhua*) in subdivision 5.b.1 (Faroe Plateau)	May 2016	cod-farp_SA.pdf
cod.27.5a_SA	Icelandic cod	January 2015	cod-iceg_SA.pdf
cod.21.1a-e_SA	Cod (*Gadus morhua*) in NAFO divisions 1A-1E, offshore (West Greenland)	May 2016	cod-wgr_SA.pdf
ghl.27.561214_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.27.5b_SA	Haddock (*Melanogrammus aeglefinus*) in Division 5.b (Faroes grounds)	April 2014	had-faro_SA.pdf
had.27.5a_SA	Haddock (*Melanogrammus aeglefinus*) in Division 5.a (Iceland)	February 2013	had-iceg_SA.pdf
her.27.5a_SA	Herring (*Clupea harengus*) in Division 5.a, summer-spawning herring (Iceland grounds)	May 2017	her 275a_SA.pdf
pok.275b_SA	Saithe (*Pollachius virens*) in Division 5.b (Faroes grounds)	May 2017	pok.27.5b_SA.pdf
pok.275a_SA	Saithe (*Pollachius virens*) in Division 5.a (Iceland grounds)	May 2013	sai-icel_SA.pdf
reb.27.14b_SA	Beaked redfish (*Sebastes mentella*) in Division 14.b, demersal (Southeast Greenland)	May 2017	reb 27.14b_SA.pdf
reb.27.5a14_SA	Icelandic slope beaked redfish (*Sebastes mentella)* in Divisions 5.a and 14.b	May 2013	smn-con_SA.pdf
reb.2127.dp_SA	Deep Pelagic beaked redfish (*Sebastes mentella*) in ICES	May 2012	smn-dp_SA.pdf
reb.27.14b_SA	Beaked redfish (*Sebastes mentella*) in Division 14.b (Demersal) (Southest Greenland)	May 2016	smn-grl_SA.pdf
reb2127.sp_SA	Shallow pelagic Beaked redfish (*Sebastes mentella*)	May 2012	smn-sp_SA.pdf
reg27.561214_SA	Golden redfish in Subareas 5,6 12 and 14 (Iceland and Faroes grounds, West of Scotland, North of Azores, East of Greenland)	February 2014	smn-5614_SA.pdf

Annex 06 Audit reports

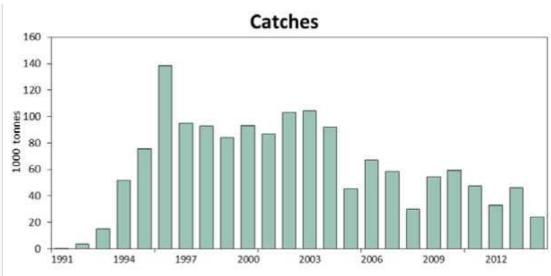
This section will be updated when all the audit reports are available.

Annex 07 Russian statements

Russian statements regarding the refining the beaked redfish stock assessment in the Irminger Sea (Working Document 31, NWWG2017)

In 2016, an assessment of the so-called “deep pelagic” redfish stock in the Irminger Sea was conducted during WKDEEPRED and was used by ICES as a basis for the catch advice. Biomass indices that had been obtained in trawl surveys mainly below 500 m were used for tuning the stock assessment. However, the fact that the area of survey coverage had been changing significantly during all years of surveys was not taken into consideration. It was gradually decreasing from 420 thousand nm² to 200 thousand nm², that means that the survey area has reduced more than twofold (Fig. 1).

Data, obtained in surveys of maximum coverage, indicate that a significant part of the stock was distributed in areas not surveyed in recent years, thus a significant part of biomass could be missed. Increasing of survey area would result in biomass indices rising. It is likely that indices used in the assessment are indicative of area changes rather than the stock dynamics. Consequently, applying these indices for the stock assessment could cause biased estimates.



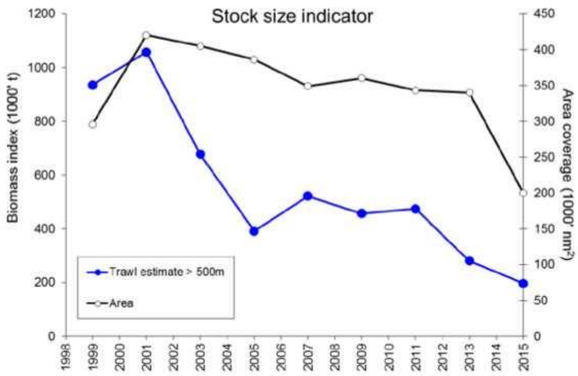


Figure 1. Beaked redfish in Subareas V, XII, and XIV and NAFO Subareas 1+2 (deep pelagic stock > 500 m). Top: Catches (thousand tonnes). Bottom: Survey indices from trawl estimates lower 500 m (blue line) and area coverage of the survey (black open circle) in the Irminger Sea and adjacent waters (ICES, 2015).

To exclude the effect of annual changes in the survey area, indices have been standardized by means of using only the standard area that was fully covered by surveys for the whole research period. This standard area is defined by ICES as “deep pelagic” management unit. It amounts to 62 052 nm².

Since Russian researchers do not accept stock subdivision of pelagic redfish in Irminger Sea, this estimation does not address the issue of the stock structure. Its objective is to refine the assessment, conducted by ICES in 2016, through rectifying errors, related to irrelevant use of tuning indices. The issue contains results of refining the assessment of the part of redfish stock in the Irminger Sea, distributed at the depth below 350-500 m, using area-standardized survey indices.

The refined stock assessment was based on data used for initial assessment at the WKDEEPRED in 2016 (see WKDEEPRED Report, ICES, 2016). The assessment has been conducted using the stochastic simulation StatCAM model, which operates with settings similar to Gadget model applied at the WKDEEPRED.

Data, obtained during the international trawl-acoustic redfish surveys in 1999-2015, was used as an input to the model. As opposed to the ICES assessment of 2016, the refined assessment used area-adjusted biological indices of the redfish stock.

Calculation of biomass indices in the area was carried out in the same manner as in the previous ICES estimation of all survey areas. Calculations were made in accordance with the adopted ICES guideline (Mamylov, 1999). Similar to the ICES assessment, calculations were conducted only for the "deep pelagic" redfish stock below 500 m (or below 350 m for 2005 and 2007).

The assessment showed that high abundance of 1961-1978 age classes led to increasing "deep pelagic" redfish stock. In 1994, spawning stock biomass exceeded 2 million tons. However, low recruitment, observed in 1994 and 1997-2004 along with increasing fishing mortality, caused drastic stock reduction. SSB was declining till 2009 when it reached its minimum of 0.668 million tons. Nevertheless, further recruitment increase led to the growth of biomass since 2010. Moreover, decrease in fishing mortality in 2014-2016 had a positive effect on the stock recruitment. According to calculations, in the beginning of 2017 SSB reached 0.790 million tons.

Biological reference points were determined using the ICES Eqsim STOCK method. The results are presented in Table 1.

Table 1. Estimated reference points

Framework	PA Reference points	Value	Rational
MSY approach	MSY $_{Btrigger}$	1002543 t	B_{pa} This is considered to ICES approach for causes when 5 percentile BFMSY<B_{pa} then F_{MSY} is reduced to F_{pa} (ICES, 2017)
	F_{MSY}	0.062	F_{pa} This is considered to ICES approach: if the F_{MSY} value calculated initially is above F_{pa}, F_{MSY} is reduced to F_{pa} (ICES, 2017).
Precautionary approach	B_{lim}	668362 t	B_{loss} (Year 2009)
	B_{pa}	1002543 t	B_{lim} * 1.5 This is considered to be the minimum SSB required to obtain a high probability (95%) of maintaining SSB above B_{lim}, taking into account the uncertainty of assessments (B_{pa}=B_{lim}*exp(1.645* σ), σ =0.25)
	F_{lim}	0.093	Based on segmented regression simulation of recruitment with B_{lim} as the breakpoint. F with 50% probability of SBB <B_{lim} (Tabl. 1)

	F_{pa}	0.062	F_{lim}/1.5 taking into account the uncertainty of assessments $F_{pa}=F_{lim}*\exp(-1.645 * \sigma)$, σ =0.25

According to the refined assessment, current SSB is above B_{lim} and MSY $B_{trigger}$, determined using Eqsim STOCK method, but it is below MSY $B_{trigger}$ = B_{pa} (Figure 2). However, the spawning stock has been increasing since 2010. Fishing mortality in 2014-2016 was below F_{lim}, F_{MSY} and F_{pa}.

Implementing ICES MSY approach to exploitation of "deep pelagic" redfish, the catch in 2018 could comprise 33.5 kt and SSB would increase to 0.826 million tons by 2019. Harvesting the stock at F_{pa} would result in the catch equal to 41.5 kt, stock increasing, though insignificant, would also occur.

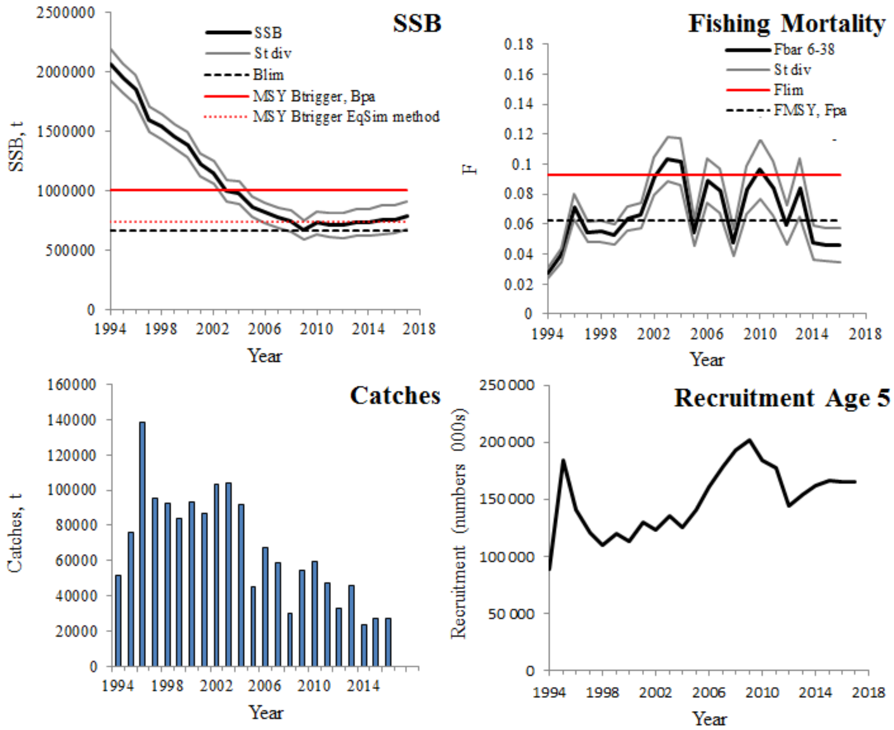


Figure 2. "Deep pelagic" redfish. Summary plots

References

Mamylov V.S., 1999, Methodical aspects of trawl-acoustic surveys on redfish stock in the Irminger Sea. Working Document 3, Report of the study group on redfish stocks. ICES CM 1999/G:9.

ICES, 2016. Report of the Workshop on Assessment and Catch Advice for Deep Pelagic Redfish in the Irminger Sea (WKDEEPRED)/ 23-25 August 2016. ICES HQ, Copenhagen, DenmarkICES CM 2016/ACOM:52. 55 pp.

ICES, 2017. ICES fisheries management reference points for category 1 and 2 stocks. ICES Advice Technical Guidelines. ICES CM 2017. Published 20 January 2017

http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/12.04.03.01_Reference_points_for_category_1_and_2.pdf

Annex 08 Category 3–6 to category 1 template

East Greenland cod

Table 2.1.1. Template to identify potential candidate stocks for category 1 assessment.

Species, Area

• Which is the current category number (3 or 4)?

Category 3

• Are there already plans for a benchmark in 1–2 years?

No, but have requested a 2017 benchmark

• What are the necessary requirements to do the upgrade to category 1?

An external review. Age-based model(s) are available, and have been presented at nwwg. Description i available in WD's and report.

o Resources needed:

▪ Within ICES

Secretarial support.

▪ Outside ICES

External reviewers

o Drivers for the process leading up to category 1:

▪ Revised stock identification and delineation

No

▪ New data that can be made available

No (all data are available)

▪ Want to achieve models with assessment and reference points

Yes

▪ Want to achieve models with forecasts (according to management requirements)

Yes

• Could there be sufficient data suitable for age or length based models and forecast?

Yes

o Necessary information on stock identity/delineation

The stock uses the West Greenland area a nursery grounds. this area is surveyed.

o Catch/landings by age or length time series (incl. levels of sampling)

Commercial C@A: 1976-2016

Commercial catches: 1956-2016

Commercial length measurements: 2002-2016

o Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)

Greenland shallow water survey: 2008-2016, age disaggregated

German shallow water survey: 1982-2016,, age disaggregated

CPUE from commercial catches (1979-2016)

o Weight, maturity and natural mortality at age or length

W@A from survey (1982-2016) and commercial catches (1976-2016)

M@A and M@L from survey/commercial 2007-2016

• Could there be sufficient data suitable for surplus production models and forecast?

Yes. SPiCT has been seet up for this stock.

o Necessary information on stock identity/delineation
Yes

o Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)
Yes

o Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast
See above

o Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)
See above

o If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})
Not a perfect fit.

o If necessary potential priors on model external or internal parameters
Model can be refined, bit work has focused on SAM model.

• Integrated stock assessment models (i.e. flexible models that can combine various types of biological and fishery data, e.g. data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may e.g. be developed with the Stock Synthesis software) considered?
No

• Assessment and forecasts consistent with client management needs
Yes

CONCLUSIONS:
This stock could with relatively little effort be upgraded from a cat. 3 stock to a cat. 1 stock. It would require an external review on the SAM model.

West Greenland inshore cod

Table 2.1.1. Template to identify potential candidate stocks for category 1 assessment.

Species, Area

• Which is the current category number (3 or 4)?
Category 3
• Are there already plans for a benchmark in 1–2 years?
No, but have requested a 2017 benchmark
• What are the necessary requirements to do the upgrade to category 1?
An external review. Age-based model(s) and a SPiCT model are available, and have been presented at nwwg. Description i available in WD's and report.
o Resources needed:
▪ Within ICES
Secretarial support.
▪ Outside ICES
External reviewers, and model refinement.

o Drivers for the process leading up to category 1:
▪ Revised stock identification and delineation
No
▪ New data that can be made available
No (all data are available)
▪ Want to achieve models with assessment and reference points
Yes
▪ Want to achieve models with forecasts (according to management requirements)
Yes

• Could there be sufficient data suitable for age or length based models and forecast?
Yes

o Necessary information on stock identity/delineation
The area is used as nursery grounds for two other stocks. This all contribute to the fishery and proportional contribution is not well described. This adds noise to the assessment.

o Catch/landings by age or length time series (incl. levels of sampling)
Commercial C@A: 1979-2016
Commercial catches: 1911-2016
Commercial length measurements: 1979-2016

o Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)
Greenland inshore gill net survey: 1985-2016, age disaggregated. From 2 areas. Indices are considered separately.

o Weight, maturity and natural mortality at age or length
W@A from survey and commercial catches (1979-2016)
M@A and M@L from survey/commercial 2007-2016

• Could there be sufficient data suitable for surplus production models and forecast?
Yes. SPiCT has been set up for this stock.

o Necessary information on stock identity/delineation
Yes

○ Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)
Yes

○ Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast
Yes

○ Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)
No

○ If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})
The diagnostics look reasonably good.

○ If necessary potential priors on model external or internal parameters
Model run is pretty basic and could be refined.

• Integrated stock assessment models (i.e. flexible models that can combine various types of biological and fishery data, e.g. data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may e.g. be developed with the Stock Synthesis software) considered?
No

• Assessment and forecasts consistent with client management needs
Yes

CONCLUSIONS:
This stock could with relatively little effort be upgraded from a cat. 3 stock to a cat. 1 stock. It would require an external review on the SAM/SPiCT/SS3 model.

West Greenland offshore cod

Table 2.1.1. Template to identify potential candidate stocks for category 1 assessment.

Species, Area

• Which is the current category number (3 or 4)?
Category 3
• Are there already plans for a benchmark in 1–2 years?
No
• What are the necessary requirements to do the upgrade to category 1?
The advice has been 0 for a number of years. Catches have been insignificant and there is not sufficient data to develop an analytical assessment for this stock.
o Resources needed:
▪ Within ICES
NA
▪ Outside ICES
An increasing stock and a fishery.

o Drivers for the process leading up to category 1:
▪ Revised stock identification and delineation
No
▪ New data that can be made available
No (all data are available)
▪ Want to achieve models with assessment and reference points
No
▪ Want to achieve models with forecasts (according to management requirements)
No

• Could there be sufficient data suitable for age or length based models and forecast?
No

o Necessary information on stock identity/delineation
The area is used as nursery grounds for another stock. This all contribute to the fishery and proportional contribution is not well described. This adds noise to the assessment.

o Catch/landings by age or length time series (incl. levels of sampling)
Commercial C@A: 2005-2016
Commercial catches: 1952-2016
Commercial length measurements: 2005-2016

o Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)
Greenland shallow water survey (1992-2016).
German shallow water survey (1982-2016)

o Weight, maturity and natural mortality at age or length
W@A from survey and commercial catches (1924-2016)
M@A and M@L from survey/commercial 2007-2016

• Could there be sufficient data suitable for surplus production models and forecast?
No, long periods of no catches and low stock size. Insufficient contrast in data.

o Necessary information on stock identity/delineation

Yes

o Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)
No

o Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast
Yes

o Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)
Yes

o If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})
the SPiCT model does not converge.

o If necessary potential priors on model external or internal parameters
No

• Integrated stock assessment models (i.e. flexible models that can combine various types of biological and fishery data, e.g. data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may e.g. be developed with the Stock Synthesis software) considered?
No

• Assessment and forecasts consistent with client management needs
No

CONCLUSIONS:
Until this stocks rebuilds to some unknown level no analytical assessment can be done.

Demersal slope *S. mentella* East Greenland

Table 2.1.1. Template to identify potential candidate stocks for category 1 assessment.

Species, Area

• Which is the current category number (3 or 4)?
Category 3
• Are there already plans for a benchmark in 1–2 years?
No
• What are the necessary requirements to do the upgrade to category 1?
Age data, longer time series (long lived species)
o Resources needed:
▪ Within ICES
Stock coordinator/assessor
Secretarial support
▪ Outside ICES
External reviewers

o Drivers for the process leading up to category 1:
▪ Revised stock identification and delineation
Yes – this redfish stock was "ignored" in earlier stock delineation workshops. New data should allow for reasonable assessment area to be defined (combined with Icelandic slop mentella perhaps)
▪ New data that can be made available
No, data is available.
▪ Want to achieve models with assessment and reference points
If possible.
▪ Want to achieve models with forecasts (according to management requirements)
Yes

• Could there be sufficient data suitable for age or length based models and forecast?

o Necessary information on stock identity/delineation
Not completely – complicated stock structure.

o Catch/landings by age or length time series (incl. levels of sampling)
Yes – logbook data including length data:
1974-2016 – S. norvegicus and S. mentella combined
2009-2016 - S. norvegicus and S. mentella divided into species

o Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)

Survey time series 1982-2016 is available by length (German survey).

o Weight, maturity and natural mortality at age or length

Weight and maturity by length survey time series 1982-2016

• Could there be sufficient data suitable for surplus production models and forecast?
A SPiCT model has been set up for the stock.

o Necessary information on stock identity/delineation
See above

○ Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)

No

○ Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast

Yes, 3 surveys in the area.

○ Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)

CPUE time series (but on a schooling species)

○ If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})

No, the diagnostics are not promising.

○ If necessary potential priors on model external or internal parameters

Does not improve model

• Integrated stock assessment models (i.e. flexible models that can combine various types of biological and fishery data, e.g. data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may e.g. be developed with the Stock Synthesis software) considered?

No

• Assessment and forecasts consistent with client management needs

NA

CONCLUSIONS:

The data on this stock does not currently allow for any analytical assessment.

Icelandic slope S. mentella *in 5.a and 14*

Table 2.1.1. Template to identify potential candidate stocks for category 1 assessment.

• Which is the current category number (3 or 4)?
Category 3.2
• Are there already plans for a benchmark in 1–2 years?
No
• What are the necessary requirements to do the upgrade to category 1?
Longer survey time series as it is a long lived species, age data.
o Resources needed:
▪ Within ICES
Secretarial support.
▪ Outside ICES
External reviewer.
o Drivers for the process leading up to category 1:
▪ Revised stock identification and delineation
Yes. There are evidence that there is a connection with East Greenland slope S. mentella.
▪ New data that can be made available
Yes. Age data.
▪ Want to achieve models with assessment and reference points
Yes.
▪ Want to achieve models with forecasts (according to management requirements)
Yes.
• Could there be sufficient data suitable for age or length based models and forecast?
Within next 1-2 years more age data could be available. A Gadget model would be used to access this stock as is done with S. norvegicus in 5 and 14 and for the deep pelagic S. mentella stock in the Irminger Sea.
o Necessary information on stock identity/delineation

o Catch/landings by age or length time series (incl. levels of sampling)
Otoliths are sampled from the fishery, but age reading needed.
o Fishery independent and/or fishery dependent index time series by age or length (representative of stock development; adequate time series, ability to track cohorts)
Survey series are short or from 2000-2016, but are available by length. Otoliths sampled but only three years have been age read. Little is known about recruitment.

o Weight, maturity and natural mortality at age or length
Data on weight and maturity available from the fishery and from the Autumn Survey (2000-2016).
• Could there be sufficient data suitable for surplus production models and forecast?
Surplus production models should not be considered for this stock as data series are short and the species is long-lived. The stock was benchmarked in 2012 but a surplus production model was rejected by the group.
o Necessary information on stock identity/delineation
It is necessary to observe whether there is a connection between the stocks found on Icelandic and East Greenland shelves and slopes.
o Catch/landings time series with sufficient contrast in data (taking into account discards and their causes)
Landings go back to 1950.
o Fishery independent and/or fishery dependent index time series (exploitable biomass; representative of stock development; adequate time series) with sufficient contrast.
One survey, the autumn survey, is from 2000-2016, which is short for a long-lived species (age up to 60 years and age at maturity 10-14 years). The survey is considered representative of the exploitable biomass. However, only fishable biomass is found in Icelandic waters and little information on recruitment are obtained from the survey. The nursery area for the stock is most likely in East Greenland.
o Potentially standardised effort data time series (i.e. taken care of issues such as technical creep… i.e. so that it could be consider as an indicator of F)

Effort and CPUE is available from 1978-2016. It is not known to what extent CPUE reflect changes in the stock status of S. mentella, since the fishery focuses on aggregations. Therefore, stable or increasing CPUE series might not indicate or reflect actual trends in stock size, although decreasing CPUE indexes are likely to reflect a decreasing stock.

o If available, are the diagnostics of a preliminary SPiCT (or similar surplus production model) assessment ok? (including uncertainty and retro pattern of F/F_{MSY} and B/B_{MSY})

The model has been tried but the diagnostic are not promising. The model was tried on the deep pelagic S. mentella stock in the Irminger Sea when that stock was benchmarked in 2016 and it was rejected by the group. Surplus production models are considered to not be applicable for S. mentella as survey time series are short (little contrast in the data) and the species long lived

o If necessary potential priors on model external or internal parameters

It is very unlikely to improve the model. A Gadged model, which is an age-length based model should rather be tried for this stock.

• Integrated stock assessment models (*i.e.* flexible models that can combine various types of biological and fishery data, *e.g.* data on age-frequencies, length-frequencies, age-at-length, growth, fecundity, biomass indices, tagging data, etc, and often allow for considerable data gaps; such models may *e.g.* be developed with the Stock Synthesis software) considered?

No

• Assessment and forecasts consistent with client management needs

NA.

CONCLUSIONS:

Gadget model (age-length based model) should be tried for this stock. Furthermore, a setup of the model combining data of the East Greenland slope S. mentella and Icelandic slope S. mentella should be tried as there are strong indication that this may be one stock (see above). If the results are promising the stock should be benchmarked within the next 2-3 years.