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28 August– 3 September 2018

Torshavn, Faroe Islands

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

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

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Executive Summary

The Working Group on Widely Distributed Stocks (WGWIDE) met in Tórshavn, Faroe Islands, during 28 August3 September 2018. The meeting, chaired by Guðmundur J. Óskarsson, was attended by 31 delegates and 5 by correspondence from 14 countries. The WG reports on the status and considerations for management of Northeast-Atlantic mackerel, blue whiting, Western and North Sea horse mackerel, Northeast-Atlantic boarfish, Norwegian spring-spawning herring, striped red mullet (Subareas 6, 8 and Divisions 7.a-c, e-k and 9.a), and red gurnard (Subareas 3, 4, 5, 6, 7, and 8) stocks. Additionally, a special request from the European Commission on interarea flexibility of horse mackerel fishery was addressed.

Northeast-Atlantic (NEA) Mackerel. This species is widely distributed throughout the ICES area and currently supports one of the most valuable European fisheries. Mackerel is fished by a variety of fleets from many countries (ranging from open boats using handlines on the Iberian coasts to large freezer trawlers and Refrigerated Sea Water (RSW) vessels in the Northern Area). The stock was benchmark in 2017 and the 2018 assessment was an update assessment, incorporating a new year for the catch information, for the IESSNS survey and for the RFID tagging recapture data (no new egg survey and recruitment index not available). The 2018 assessment revises the stock downward, and indicates that the SSB has been declining continuously since 2011, while the fishing mortality has been increasing. SSB in 2018 is estimated to be below MSY $B_{trigger}$ and F larger that F_{pa}, which represents a deterioration of stock status compared to last year.

Blue Whiting. This pelagic gadoid is widely distributed in the eastern part of the North Atlantic. The assessment this year followed the Stock Annex based the conclusions from the Inter-Benchmark Protocol of Blue Whiting (IBPBLW 2016). Most of the annual catches are taken in the first half-year, which makes it possible to use preliminary catches for 2018 in the assessment. This is done to reduce the effect of potential biases from the single survey used for this assessment. The SSB of the stock is large but declining since 2017. F has been reduced in recent years, but is still above F_{MSY}. Recruitments in 2017 and 2018 are estimated to be low, following a period of high recruitments.

Western Horse Mackerel. This species is widely distributed throughout the Northeast Atlantic: it spawns in the Bay of Biscay, and in UK and Irish waters; after spawning, parts of the stock migrate northwards into the Norwegian Sea and the North Sea. The stock is assessed using the Stock Synthesis integrated assessment model. The 2018 assessment is an update of the benchmark assessment with the inclusion of the 2017 data. According to the assessment results, the 20152017 recruitment estimates are the highest observed since 2008 (and higher than the geometric mean estimated over the years 19832017). Fishing mortality since 2012 has been decreasing, dropping to low values in 20152017 due to lower catches and a reduced proportion of fraction of the adult population in the exploited stock; it is currently below F_{MSY}. SSB in 2017 is estimated as the lowest in the time-series, below the precautionary reference point but above the limit reference point. The updated assessment shows the same trend as the previous ones, but rescales the absolute level of SSB and F over the most recent decade and, although this years' revision is smaller, this indicates that there is still considerable uncertainty associated with it. An inter-benchmark workshop has been scheduled for 2019: the workshop will aim at the revision of the biomass reference points and at investigate the causes of the instability in the assessment.

North Sea Horse Mackerel. After being benchmarked in January 2017, the CGFS and NS-IBTS survey indices were modelled with a zero inflated model to produce a combined index. The observed trend in the last years suggest that the stock is still at low levels in comparison with values in the early time-series. In 2017, the survey index shows a steep decline in comparison with year 2016. Despite this abrupt change in the survey abundance index, the catch advice for 2019 (decided in 2017) was not modified. The result of Length Based Methods to estimate proxy MSY reference points for the North Sea Horse Mackerel indicate that in 2016 and 2017 fishing mortality was slightly above F_{MSY}.

Northeast Atlantic Boarfish. This is a small, pelagic, planktivorous, shoaling species, found at depths of 0 to 600 m. The species is widely distributed from Norway to Senegal. The directed fishery for boarfish in the NEA is a relatively new one with large catches during the early 2000s when the fishery was unregulated. Catches have reduced significantly since 2012 to the current level. Annual catch advice is provided using the data limited category 3 approach based on output from an exploratory Bayesian surplus production assessment model. The assessment model utilises catch data, an acoustic survey estimate of stock size and indices from a number of bottom-trawl surveys. The current assessment indicates that since a historic high in 2012 biomass has declined sharply to a stable and low level since 2014.

Norwegian Spring Spawning Herring. This is one of the largest herring stocks in the world. It is highly migratory and distributed throughout large parts of the NE Atlantic. This stock was benchmarked in 2016 (WKPELA). The assessment model introduced in the benchmark (XSAM), incorporates uncertainty in the input data, and has been used to provide advice after the benchmark. The SSB on 1 January 2018 is estimated by XSAM to be above B_{pa} (3.184 million t). The stock is declining and the SSB time-series from the 2018 assessment is in line with the SSB time-series from the 2017 assessment. Fishing mortality in 2017 is estimated to be above the management plan F that was used to give advice for 2017. A new management plan is being developed for the 2019 advisory year

Striped Red Mullet in North Sea, Bay of Biscay, Southern Celtic Seas, Atlantic Iberian Waters. 2016 was the first year this stock was considered by WGWIDE. This is a category 5 stock without information on abundance or exploitation, and the evaluation is based on commercial landings. The advice for this stock was given last year for 2018, 2019 and 2020.

Northeast-Atlantic Red Gurnard. 2016 was the first year this stock was been considered by WGWIDE. This is a category 6 stock for which there is no indication of where fishing mortality is relative to proxies and no stock indicators, and the evaluation is based on commercial landings. The advice for this stock was given last year for 2018 and 2019.

1 Introduction

1.1 Terms of References (ToRs)

The Working Group on Widely Distributed Stocks (WGWIDE), chaired by Guðmundur J. Óskarsson, Iceland, met at The Faroe Marine Research Institute, Tórshavn, Faroe Islands 28 August – 3 September 2018 to:

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

b) Estimate MSY proxy reference points for the category 3 stocks in need of new advice in 2018.

c) Address a special request from the European Commission on interarea flexibility in catches for horse mackerel in divisions 8c and 9a.

1.1.1 The WG work 2018 in relation to the ToRs

With respect to ToR a, WGWIDE adopted the assessments of all the eight stocks, which formed the basis for stock status and the premise for the forecasts and advice. Based on the assessments the group produced a draft advice on TAC for four of the stocks, while a multi-annual advice from 2017 was in force for the other four (boarfish, red gurnard North Sea horse mackerel and striped red mullet). The individual stock report sections were not reviewed in plenary due to time constraints but audited by WG members right after the meeting. The summary sheets for all stocks were reviewed and agreed upon in plenary.

ToR b did not apply to any stock within the WG this year. This was because ICES gave a multi-annual advice on fishing opportunities for the two stocks in category 3 (boarfish and North Sea horse mackerel) in 2017. Next advice on these stocks will be given in 2019.

The progress on the work to address ToR c was introduced to the WG and discussed. Considering the time constrain to answer the request, a multispecies model was not considered feasible approach. In the absence of recent MSE work for the western stock, SimpSIM was selected for testing the impact of the flexibility for that stock while the southern stock has already a fully developed MSE approach. Some preliminary results were presented, but some work is still needed, including compiling the results with the southern stock results. It will be done in the coming weeks. In the WG it was pointed out that since F_{MSY} is limited by F_{pa} for the western stock, fishing above an advice based on F_{MSY} will not be in accordance with a precautionary approach, which gives a short answer to the request.

1.2 Participants at the meeting

WGWIDE 2018 was attended by 31 delegates from the Netherlands, Ireland, Spain, Norway, Portugal, Iceland, UK (England and Scotland), Faroe Islands, Denmark, Greenland, and Russia. Five other fisheries scientists participated by correspondence. The full list of participants is in Annex 1.

1.3 Overview of stocks within the WG

Currently there are eight widely distributed and highly migratory stocks assessed in the WG with different methods, as indicted in the table below:

Stock	ICES code	Category	Assessment method
Boarfish	Boc.27.6-8	3	Fproxy multiplier/ DLS category 3
Red gurnard	Gur.27.3-8	6	Qualitative evaluation
Norwegian spring-sp. herring	Her.27.1-24a514a	1	XSAM
Western horse mackerel	Hom.27.2a4a5b6a7a-ce-k8	1	Stock Synthesis (SS)
North Sea horse mackerel	Hom.27.3a4bc7d	3	Fproxy multiplier/ DLS category 3.1.0
NE-Atlantic mackerel	Mac.27.nea	1	SAM
Striped red mullet	Mur.27.67a-ce-k89a	5	Qualitative evaluation
Blue whiting	Whb.27.1-91214	1	SAM

1.4 Quality and Adequacy of fishery and sampling data

1.4.1 Sampling Data from Commercial Fishery

The working group again carried out a brief review of the sampling data and the level of sampling on the commercial fisheries. Details are given in the relevant sections of this report.

Information on sampling data on the species newly included into WGWIDE, boarfish (*Caprosaper*), Striped red mullet (*Mullussurmuletus*) and Red Gurnard (*Chelidonichthy-scuculus*) are also given in the relevant sections.

Length frequency data on gurnards are available from France and Spain, meaning that approximately two thirds of total landings are sampled. Provision of length data by métier from other countries would improve the understanding of exploitation patterns for this species.

Given the high value of striped red mullet, sampling and aging opportunities have been limited. The patchy distribution of the species and the noisy survey data limits the usefulness of these fishery-independent data sources. Further efforts should be made to improve precision of cpue series from French reference fleets as an indicator of stock status.

In general, to facilitate age-structured assessment, samples should be obtained from all countries with catches of the relevant species.

1.4.2 Catch Data

The WG has on a number of occasions discussed the accuracy of the catch statistics and the possibility of large scale under reporting or species and area misreporting.

The working group considers that the best estimates of catch it can produce are likely to be underestimates.

A specific issue on the catch data was reported to the WG. An issue on species allocation of catches exists for red gurnard. Before 1977, red gurnard was not specifically reported. Still, gurnards are not always reported by species, but rather as mixed gurnards. This makes interpretations of the records of official landings difficult and needs to be improved.

1.4.3 Discards

From 2015 onwards a landing obligation for European Union fisheries was introduced for fisheries directed on small pelagic fish including mackerel, horse mackerel, blue whiting and herring. However, as the landing obligation is introduced stepwise by fisheries at present discarding of small pelagic species can still legally occur in other fisheries. A general discard ban is already in place for Norwegian, Faroese and Icelandic fisheries.

Historically discarding in pelagic fisheries was more sporadic than in demersal fisheries. This is because the nature of pelagic fishing is to pursue schooling fish, creating hauls with low diversity of species and sizes. Consequently, discard rates typically show extreme fluctuation (100% or zero discards). High discard rates occurred especially during ´slippage´ events, when the entire catch is released. The main reasons for ´slipping´ are daily or total quota limitations, illegal size and mixture with unmarketable bycatch. Quantifying such discards at a population level is extremely difficult as they vary considerably between years, seasons, species targeted and geographical region.

Discard estimates of pelagic species from pelagic and demersal fisheries have been published by several authors. Discard percentages of pelagic species from demersal fisheries were estimated between 3% to 7% (Borges *et al.*, 2005) of the total catch in weight, while from pelagic fisheries were estimated between 1% to 17% (Pierce *et al.* 2002; Hofstede and Dickey-Collas 2006, Dickey-Collas & van Helmond 2007, Ulleweit &Panten 2007, Borges *et al.* 2008, van Helmond *et al.* 2009, 2010, 2011, van Overzee*et al.* 2013, Ulleweit *et al.* 2016). Slipping estimates have been published for the Dutch freezer trawler fleet only, with values at around 10% by number (Borges *et al.* 2008) and around 2% in weight (van Helmond *et al.* 2009, 2010 and 2011) over the period 2003—2010. Nevertheless, the majority of these estimates were associated with very large variances and composition estimates of ´slippages´ are liable to strong biases and are therefore open to criticism.

Because of the potential importance of significant discarding levels on pelagic species assessments, the Working Group again recommends that observers should be placed on board vessels in those areas in which discarding occurs, and existing observer programmes should be continued. Furthermore, agreement should be made on sampling methods and raising procedures to allow comparisons and merging of dataset for assessment purposes. The newest update on discards for the different stocks assessed by the WG is provided in the sections for each of the stocks.

1.4.4 Age-reading

Reliable age data are an important prerequisite in the stock assessment process. The accuracy and precision of these data, for the various species, is kept under constant review by the Working Group. The newest updates on this aspect for the different stocks are addressed below.

1.4.4.1 Mackerel

The last otolith exchange was carried out in 2013/2014 by TI-SF. In order to increase the agreement between the laboratories involved in stock assessment especially for older fish, a workshop on age estimation of Atlantic Mackerel (*Scomberscombrus*) is scheduled for October 2018.

The sensitivity of the mackerel assessment to the effect of ageing errors on the input data to the assessment was investigated in the Workshop on Mackerel biological Quality Indicators (WKMACQI, ICES 2018c). An ageing error matrix was first derived from an otolith exchange workshop conducted in 2010 (ICES, 2010). The approach taken by the group was to start from the assumption that data currently used for the assessment were not affected by ageing errors. The error matrix was used to "pollute" the input data structured by age (catch-at-age, survey-at-age, weights-at-age, proportion mature-at-age) and the assessment run on these data. Results show that the estimated stock trajectory in the recent year is very sensitive to the effect of ageing errors on input data (+12% for the SSB and -17% for F_{bar}), specifically those used in model fitting (catches and survey at age). Changes in these data result in different estimated parameters (leading to a slightly different weighting of the difference data sources). Ageing errors therefore appear to be an additional source of uncertainty in the mackerel assessment that has not been considered so far.

1.4.4.2 Horse mackerel

Following the workshop in 2012 and the exchange in 2015 the last workshop on age reading of *Trachurus trachurus*, *T. mediterraneus* and *T. picturatus* was carried out in October 2015.

The workshop achieved quite a lot in terms of overcoming some of the major difficulties in ageing otoliths of *Trachurus* species. The results of the comparison between different ageing techniques on the same set of fish, showed a bias between readers and so it is recommended to use only one ageing technique by each reader. Moreover, the precision of reading is the same between slices and whole otoliths and so there is not one best ageing technique for *T. trachurus*. The progress of reading showed a percentage of agreement close to 65% for *T. trachurus*.

The next workshop on age reading of horse mackerel, Mediterranean horse mackerel and blue jack mackerel is scheduled for the beginning of November 2018.

1.4.4.3 Norwegian Spring-spawning Herring

A workshop on age reading of Norwegian Spring-spawning herring was carried out in November 2015. The meeting was attended by 12 experts from four countries. The workshop was a request from WGWIDE to WGBIOP to review any technical problems regarding age-reading of Norwegian spring-spawning herring between Norway, Denmark, Iceland and the Faroe Islands. This workshop was initiated after the IESNS survey in 2015, because there were concerns regarding dissimilarities between the age distributions from the different nations.

The workshop concluded that the different ages obtained from scale and otolith readings could be due to a number of issues relating to identification of the first winter ring and age interpretation of older fish, additionally confounded by stock mixing issues. Final conclusions could not be reached based on the samples from this workshop. With regards to the issue with sampling methods, WKPELA in March 2016 concluded that in general the biological samples are representative with regards to length distribution of NSS herring in the IESNS survey.

Therefore, it was recommended, that a follow up Workshop on Age estimation on Norwegian spring-spawning herring should consider the short-comings of the 2015 workshop and develop an ageing protocol that contains robust procedures for a quality check. The ageing issues should be addressed in full based on a larger sample set of

good quality scales and otoliths from the same fish and defined instructions for annotation. Prior to the follow up workshop within-country disagreements need to be resolved. Also, stock mixing issues need to be addressed (potentially by genetics combined with otolith shape analysis) and sampling protocols need to ensure that both otoliths and scales are sampled from the same fish (at least subsamples). This workshop has not yet been held, but a scale- and otolith exchange has taken place, and WGWIDE group members recommend that the workshop is held in the winter 2018/19.

1.4.4.4 Blue Whiting

The last workshop on age reading of blue whiting (WKARBLUE2) took place this year (2017), in June. This workshop was preceded by an otolith exchange, which was undertaken using WebGR in the year prior to the workshop. The actual otoliths were also sent around to all participating institutes. The exchanged otolith collection included 245 images. The overall agreement with modal age of the pre-workshop exercise was 64.1% considering all readers and 70% for the assessment readers. During the workshop 129 otoliths with annotations were discussed in plenary and 85% agreement was achieved. There were no clear signs of seasonal misinterpretations, but the Mediterranean and most northern areas (ICES area 27.14.b and NAFO 1C) proved to be quite difficult.

Different methods to help age readers determining a zone was discussed during the workshop. The burning of otoliths showed some potential in interpreting the inner ring, but not to be used as a routine. The sliced technique besides being time consuming do not show advantages on ring interpretation, and in turn can also introduces more misinterpretation on ageing. During the workshop some of the otoliths from the exercise were polished, to help readers in the cases were the age rings were not so evident, completely absent, or showing a growth pattern different from the expected. The polishment results revealed to be useful on the ring interpretation and to help during the plenary discussion, although we do not recommend this technique to be used as a routinely procedure, as it is very time consuming. Plug-in for ImageJ (OtoRing), which can detect variation in opacity in the otolith surface and be used as a tool on age rings identification as presented (Gonçalves *et al.* 2017a). Furthermore, a criteria table with possible otolith ring diameters from an IPMA study was tested during the workshop. The table showed potential, but a larger dataset is still needed before it can be implemented as a guideline. This dataset will consider samples by area and sex to achieve criteria's classification which take into account those differences in growth patterns, due to the blue whiting sexual dimorphism (Gonçalves *et al.* 2017b).

A study on the otoliths from the Portuguese coast showed differences between the first ring length in this area and the described in the literature (8.33 and 9.33 mm). Rings measurements of the first annulus, taken during the workshop, revealed also differences between ICES areas (27.2.a – 27.9.a), 27.14.b and Mediterranean.

The reoccurring problems among age readers were identification of the position of the first annual growth ring, false rings and interpretation of the edge. In order to outcome those problems, age validations studies on blue whiting otoliths were further recommended and should be conducted until the next age reading workshop. The next workshop on the age estimation of blue whiting will be carried out in June 2020. An exchange on age reading calibration was in preparation and is planning to start at the beginning of 2019.

1.4.4.5 Boarfish

This stock will be part of the EU data collection framework from 2017 onwards. Age length keys were produced in 2012. The age reading was conducted by DTU Aqua on samples from all three countries in the fishery: Ireland, Denmark and UK (Scotland).

1.4.4.6 Striped red mullet

In 2011, an Otolith Exchange Scheme has been realized, which was the second exercise for the striped red mullet. For details see section 12.7.

1.4.4.7 Red gurnard

Age data were available for red gurnards from the EVHOE and IGFS surveys. Understanding of this stock would be improved by reading otoliths from other surveys in the assessment area (e.g. NS-IBTS, SCO-WCS, CGFS) which contribute to perceptions of red gurnard stock status in terms of their cpue series.

1.5 Quality Control and Data Archiving

1.5.1 Current methods of compiling fisheries assessment data

Information on official, area misreported, unallocated, discarded and sampled catches have again this year been recorded by the national laboratories on the WG-data exchange sheet (MS Excel; for definitions see text table below) and sent to the stock co-ordinators and uploaded through the InterCatch hosted application. Co-ordinators collate data using the either the sallocl (Patterson, 1998) application which produces a standard output file (Sam.out) or the InterCatch hosted application.

There are at present no specified criteria on the selection of samples for allocation to unsampled catches. The following general process is implemented by the species co-ordinators. A search is made for appropriate samples by gear (fleet), area, and quarter. If an exact match is not available the search will extend to adjacent areas, should the fishery extend to this area in the same quarter. Should multiple samples be available, more than one sample may be allocated to the unsampled catch. A straight mean or weighted mean (by number of samples, aged or measured fish) of the observations may be used. If there are no samples available the search will move to the closest non-adjacent area by gear (fleet) and quarter, but not in all cases.

It is not possible to formulate a generic method for the allocation of samples to unsampled catches for all stocks considered by WGWIDE. However full documentation of any allocations made are stored each year in the data archives (see below). It should be noted that when samples are allocated the quality of the samples may not be examined (i.e. numbers aged) and that allocations may be made notwithstanding this. The Working Group again encourages national data submitters to provide an indication of what data could be used as representative of their unsampled catches.

Following the introduction of the landings obligations for EU fisheries new catch categories had to be introduced from 2015 onwards. The catch categories used by the WGWIDE are detailed below:

OFFICIAL CATCH	CATCHES AS REPORTED BY THE OFFICIAL STATISTICS TO ICES
Unallocated Catch	Adjustments (positive or negative) to the official catches made for any special knowledge about the fishery, such as under- or over-reporting for which there is firm external evidence.
Area misreported Catch	To be used only to adjust official catches which have been reported from the wrong area (can be negative). For any country the sum of all the area misreported catches should be zero.
BMS landing	Landings of fish below minimum landing size according to landing obligation
Logbool registered discards	Discards which are registered in the logbooks according to landing obligation
Discarded Catch	Catch which is discarded
WG Catch	The sum of the 6 categories above
Sampled Catch	The catch corresponding to the age distribution

1.5.2 Quality of the Input data

Primary responsibility for the accuracy of national biological data lies with the national laboratories that submit such data. Each stock co-ordinator is responsible for combining, collating, and interpolating the national data where necessary to produce the input data for the assessments. A number of validation checks are already incorporated in the data submission spreadsheet currently in use, and these are checked by the co-ordinators who in the first instance report anomalies to the laboratory which provided the data.

The working group acknowledges the effort some members have made to provide "corrected" data, which in some cases differ significantly from the officially reported catches. Most of this valuable information is gathered on the basis of personal knowledge of the fishery and good relations between the responsible scientist and the fishermen. The WG is aware of the problem that this knowledge may be lost if the scientist resigns, and asks the national laboratories to ensure continuity in data provision. In addition, the working group recognises and would like to highlight the inherent conflict of interest in obtaining details of unallocated catches by country and increasing the transparency of data handling by the Working Group.

Overall, data quality has improved and sampling deficiencies have been reduced compared to earlier years, partly due to the implementation of the EU sampling regulation for commercial catch data. However, some nations have still not or inadequately aged samples. Occasionally, no data are submitted such that only catch data from EuroStat is available, which are not aggregated quarterly but are yearly catch data per area.

The Working Group documents sampling coverage of the catches in two ways. National sampling effort is tabulated against official catches of the corresponding country (see stock specific sections). Furthermore, tables showing total catch in relation to numbers of aged and measured fish by area give a picture of the quality of the overall sampling programme in relation to where the fisheries are taking place. These tables are contained in the species sections of this report.

The national data on the amount and the structure of catches and effort are archived in the ICES Intercatch database. The data are provided directly by the individual countries and are highly aggregated for the use of stock assessments.

There exist gaps in some dataseries, in particular for historical periods. The WG has requested members to provide any national data reported to previous working groups

(official catches, working group catches, catch-at-age and biological sampling data) not currently available to the WG. Furthermore, the WG recommends that national institutes increase national efforts to collate historic data.

1.5.3 Stock data problems relevant to data collections

A number of other stock data problems were brought forward to the contact person and are listed in table below for the information of ICES-Working Groups and RCMs as specified.

Stock	Data Problem	How to be addressed in	By who
Northeast Atlantic Mackerel	Submission of data	Data submissions must include all the data outlined in the data call and be submitted by the deadline. Should the data submitter be unavailable after the data has been submitted (e.g. vacation) an alternative contact should be available who can be contacted in the event of any queries.	National laboratories
Northeast Atlantic Mackerel	Discard and slippage information	Discard and slippage information is incomplete. All fleets should be monitored and sampled for discard and slipping. Data should be supplied to the coordinator by the submission deadline, accompanied by documentation describing the sampling protocol.	National laboratories, RCG NA, RCG NS&EA
Northeast Atlantic Mackerel	Sampling deficiencies– general	All countries involved should provide sampling information. Increased cooperation between countries would help reduce redundancy and increase coverage.	National laboratories, RCG NA, RCG NS&EA
Northeast Atlantic Mackerel	Sampling of foreign vessels	Any information available from the sampling of foreign vessels should be forwarded to the appropriate person in the national laboratory in order that they may use this information when compiling the data submission.	National laboratories; RCG NA, RCG NS&EA
Boarfish	Boarfish only measured to the 1 cm on the IBTS by some countries	Following the MoU between ICES and EU, boarfish (*Capros aper*) was included into WGWIDE. Boarfish should be measured to the 0.5 cm on the IBTS due to the small length range and the relatively high ages observed.	ICES IBTSWG

Stock	Data Problem	How to be addressed in	By who
Horse Mackerel – Western Stock	Uncertainties in the use of the current egg production method for the assessment	Investigate spawning biology and investigate potential methods to incorporate time varying fecundity in the assessment.	Future Benchmark
Horse Mackerel – Western Stock	Assumed value of 0.15 for M.	Value of 0.15 should be investigated.	Future Benchmark
Horse Mackerel – Western Stock	No ageing error included in the assessment.	Different values for ageing error should be investigated.	Future Benchmark
Horse Mackerel – Western Stock	Partial information from acoustic survey in division 8.	Information from all the surveys carried out in the area should be pulled together.	Future Benchmark
Horse Mackerel – North Sea Stock	Incomplete report of discards by non-pelagic fleet.	Reporting of discards by national institutes.	National Institutes
Horse Mackerel – North Sea Stock	Low level of sampling and survey data. Currently IBTS and CGFS data are available.	Collection of information from other working groups. Possible implementation of an acoustic survey for horse mackerel in 3rd or 4th Quarter.	WGBIOP, WGCATCH, RCG NS&EA
Horse Mackerel – North Sea Stock	Lack of maturity ogive both by age or length	Collection of information about maturity stage during regular biological sampling (otoliths) in commercial and survey fleets	National institutes
Horse Mackerel – North Sea Stock	Absence of length distribution in the discard component	Sampling of length distribution of discarded individuals	National institutes
Horse Mackerel – North Sea Stock	Low contribution of countries to the estimation of the age and length distribution of catches	Sampling of age and length information from commercial with a distribution of sampling effort over the year and areas in the North Sea	National institutes
Norwegian Spring-spawning Herring	Low sampling effort on some nations (considerably lower than the 1 sample/1000 tonnes recommended for this stock by EU)	Sampling effort should be increased by nations with little or no samples.	National laboratories; RCG NS&EA

Stock	Data Problem	How to be addressed in	By who
Northeast Atlantic Blue Whiting	Submission of data	Data submissions must inlcude all the data outlined in the data call and be submitted by the deadline. Should the data submitter be unavailable after the data has been submitted (e.g. vacation) an alternative contact should be available who can be contacted in the event of any queries.	National laboratories
Red gurnard	Discard and slippage information	Discard rates for this species can be very high (up to 100% of catch at a trip level). Alternative data sources and methods for estimation (e.g. CCTV systems) should be investigated.	National laboratories
Red gurnard	Stock area	Red gurnard is found all along the Iberian continental shelf. There are no records of catches of red gurnards in SA5, and this area could be removed from the data call.	

1.6 Comment on update and benchmark assessments

Update assessments were presented to the WG for all the eight stocks in the group. Western and North Sea horse mackerel, and NEA Mackerel were assessed on basis of benchmark that took place in January 2017 (ICES 2017a). In same way, blue whiting and Norwegian spring-spawning herring were assessed by the latest benchmarks (ICES 2016b and ICES 2016f, respectively). The other three stocks addressed by the WG have not been benchmarked recently but were still assessed by the WG. Result from the assessment model for boarfish is used as indicator of trends in the stock development. The catch data were updated for Red gurnard (*Chelidonichthyscuculus*) in Subareas 3–8 (Northeast Atlantic) and Striped red mullet (*Mullussurmuletus*) in Subareas 6 and 8 and Divisions 7.a–c, e–k and 9.a (West of Scotland, Bay of Biscay, Southern Celtic Seas, Atlantic Iberian Waters).

1.7 Latest benchmark results

None of the eight fish stocks within the WG have been taken to benchmark assessment since presented in the last year's report.

1.8 Planning future benchmarks

While five of the major stocks within the group has been benchmarked recently (2016-2017), boarfish has not been benchmarked yet at all, and there is a need for a benchmarked assessment. The WG propose that a benchmark for boarfish could take place in 2020 and have made an issue list to be addressed to support it. The WG discussed also if red gurnard was potential candidate for benchmark assessment in 2020. The conclusion was that it was not realistic, especially considering lack of essential information on stock´s identity, mixing and distribution.

During the WGWIDE meeting, several potentially serious problems were identified in the analytical assessment of mackerel. Consequently, a list of issues specifically related to this was made to support an inter-benchmark to take place as soon as possible.

In the same way, an issue list was made to support inter-benchmark for western horse mackerel to take place as soon as possible. The issues are related to the reference points for the stock and to a lack of an alternative assessment model for a comparison.

1.9 Special Requests to ICES regarding stocks within WGWIDE

Two requests were directed to WGWIDE, on evaluation of a long-term management strategy for Norwegian spring-spawning herring (addressed by WKNSSHMSE; ICES 2018b), and on Horse mackerel in areas 8c and 9a – interarea flexibility (addressed by WGWIDE, this report).

1.9.1 Request to ICES from NEAFC concerning a long-term management strategy for Norwegian spring-spawning herring.

In order to revise the long-term management plan for Norwegian spring-spawning herring consistent with the new stock assessment model (ICES 2016; 2017) and the corresponding updated reference points (ICES 2018a; 2018b), a Management Strategy Evaluation is needed. The objective is to ensure harvest of the stock within safe biological limits. The Parties therefore request ICES to evaluate the following harvest control rules.

Rule 1

- *A range of $B_{trigger}$ from 1 to 6 million tonnes with a range of target Fs from 0.05 to 0.25.*
- *The fishing mortality is the average for age groups 5 to 12+ weighted by stock numbers.*
- *Time of comparison for SSB is the same as used in the assessment.*
- *A harvest control rule with a fishing mortality equal to the target F when SSB is at or above $B_{trigger}$.*
- *In the case that the SSB is forecast to be less than $B_{trigger}$, the TAC shall be fixed consistently with a fishing mortality that is given by: $F = F_{target}*SSB/B_{trigger}$*
- *The following special case is to be evaluated: $B_{trigger}$=3.184 (=MSY $B_{trigger}$=B_{pa}) and the target fishing mortality of 0.102 (F_{MSY}).*

Rule 2

- *A range of $B_{trigger}$ from 2.5 to 6 million tonnes with a range of target Fs from 0.05 to 0.25.*
- *The fishing mortality is the average for age groups 5 to 12+ weighted by stock numbers.*
- *Time of comparison for SSB is the same as used in the assessment.*
- *A harvest control rule with a fishing mortality equal to the target F when SSB is at or above $B_{trigger}$.*
- *In the case that the SSB is forecast to be less than B_{lim}, the target F is 0.05.*
- *In the case that the SSB is forecast to be between B_{lim} and $B_{trigger}$, the target F will decrease linearly between those two points.*
- *The following special case is to be evaluated: $B_{trigger}$=3.184 (=MSY $B_{trigger}$=B_{pa}) and the target fishing mortality of 0.102 (F_{MSY}).*

Rule 3

- *A proxy for SSB (SSB_{proxy}) is defined as the biomass of herring aged 5 and older or an appropriate age range as identified by ICES.*
- *The reference biomass (B_{ref}) is defined as the biomass of herring aged 4 and older or an appropriate age range as identified by ICES.*

- *Time of comparison for SSB_{proxy} is the same as used for SSB in the assessment.*
- *A range of $B_{trigger}$ from 1 to 6 million tonnes with an appropriate range of harvest rate (HR_{target}).*
- *A harvest control rule with $TAC=HR_{target}*B_{ref}$ when SSB_{proxy} is at or above $B_{trigger}$.*
- *In the case that the SSB_{proxy} is forecast to be less than $B_{trigger}$, the $TAC = HR_{target}*B_{ref} * (SSB_{proxy}/B_{trigger})$*
- *The following special case is to be evaluated: Btrigger=3.184 (=MSY $B_{trigger}=B_{pa}$) and a harvest rate equivalent to 0.102 (F_{MSY}).*

Rule 4

A biomass rule intended to be equivalent to Rule 2 with two levels of harvest rate: target harvest rate = HR_{target} when SSB_{proxy} is greater than $B_{trigger}$; harvest rate = HR_{lowest} when SSB_{proxy} is below B_{lim}; and harvest rate decreasing linearly between these bounds.

Evaluation and performance criteria

Starting point of the evaluations should be the current stock status as estimated by the most recent assessment and be consistent across time.
Each alternative shall be assessed in relation to how it performs in the short term (2019-2023), medium term (2024-2033) and long term (2034-2053) in relation to:

- *Average SSB*
- *Average yield*
- *Indicator for year-to-year variability of SSB and yield*
- *Risk of SSB falling below B_{lim}*

Evaluation of the management strategies shall be simulated:

- *With no constraint on the interannual variation of TAC.*
- *With a constraint on the interannual variation of TAC:*
    - *When the rules would lead to a TAC, which deviates by more than 20% below or 25% above the TAC of the preceding year, the TAC is to be set respectively no more than 20% less or 25% more than the TAC of the preceding year.*
    - *The TAC is to be set as the average of a) the current TAC and b) the TAC that would result from the application of the harvest control rule without constraint for the TAC year.*
- *The TAC constraint shall not apply if the SSB (rule 1 and 2) or SSB_{proxy} (rule 3 and 4) in the year for which the TAC is to be set is less or equal to Btrigger.*
- *Allowing a maximum of 10% to be banked or borrowed any year.*

ICES is also requested to assess what, if any, other measures in addition to those contained in the present Management Strategy might contribute to attaining the objectives of the strategy, and provide estimates of their efficiency.

Finally, it is expected that the Parties will, as appropriate, review and revise these management measures and strategies on the basis of any new advice provided by ICES.

References:

ICES. 2016. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA), 29 February–4 March 2016, ICES Headquarters, Copenhagen, Denmark. ICES CM 2016/ACOM:34. 106 pp.

ICES. 2017. Report of the Working Group on Widely Distributed Stocks (WGWIDE), 30 August–5 September 2017, ICES Headquarters, Copenhagen, Denmark. ICES CM 2017/ACOM:23. 994 pp.

ICES. 2018a. Workshop on the determination of reference points for Norwegian Spring-spawning (WKNSSHREF), 10-11 April 2018, ICES Headquarters, Copenhagen, Denmark. ICES CM 2018/ACOM:45. 83 pp.

ICES. 2018b. *Special Request Advice Northeast Atlantic and Arctic Ocean Ecoregions, 26 April 2018 sr.2018.06*

https://doi.org/10.17895/ices.pub.4295

1.9.2 Special request to ICES from European Commission, DG MARE, C1 on an interarea flexibility between 8.C and 9.A for horse mackerel (Western and Southern stock).

Background: The Horse mackerel (*Trachurustrachurus*) stocks in Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a–c, and 7.e–k (the Northeast Atlantic) and in Division 9.a (Atlantic Iberian waters) are both classified by ICES as category 1 stock and apply the MSY approach. The TACs for horse mackerel will be set separately for 2018 as follows:

Species:	Horse mackerel *Trachurus spp.*		Zone:	8c (JAX/08C.)
Spain	14 335	(1)	Analytical TAC	
France	248			
Portugal	1 417	(1)		
Union	16 000			
TAC	16 000			
(1)	Special condition: up to 5 % of this quota may be fished in 9 (JAX/*09.).			

Species:	Horse mackerel *Trachurus spp.*		Zone:	9 (JAX/09.)
Spain	14 373	(1)	Analytical TAC	
Portugal	41 182	(1)	Article 7(2) of this Regulation applies	
Union	55 555			
TAC	55 555			
(1)	Special condition: up to 5 % of this quota may be fished in 8c (JAX/*08C).			

During the Council negotiations on TACs and quotas for 2018 the Commission received a request from Spain, asking for a change to the special condition by increasing the interarea flexibility from 5% to 15%.

Request: To allow the Commission to consider a proposal for an amendment of the 2018 TAC regulation on the special condition applied to horse mackerel, ICES is requested to analyse any information deemed suited:

a) to evaluate the impact of an increased interarea flexibility, from 5% to 15%, to facilitate the implementation of the landing obligation, notably whether such an increase would be in line with the precautionary approach.

b) to evaluate what % of interarea flexibility could be considered to be in line with the precautionary approach, if a negative opinion is given to a).

1.10 General stock trends for widely distributed and migratory pelagic fish species

This working group has carried out the stock assessments of the following widely distributed and migratory pelagic species: boarfish, red gurnard, Norwegian spring-spawning herring, Western horse mackerel, North Sea horse mackerel, Northeast Atlantic mackerel, Striped red mullet and Blue whiting.

Analytical (category 1) type of assessments are available for the four main species that make up the bulk of the biomass of pelagic species in the Northeast Atlantic:

- Northeast Atlantic mackerel
- Norwegian spring-spawning herring
- Blue whiting
- Western horse mackerel.

The fluctuations in the catches of the four stocks since 1988 are shown in Figure 1.10.1.

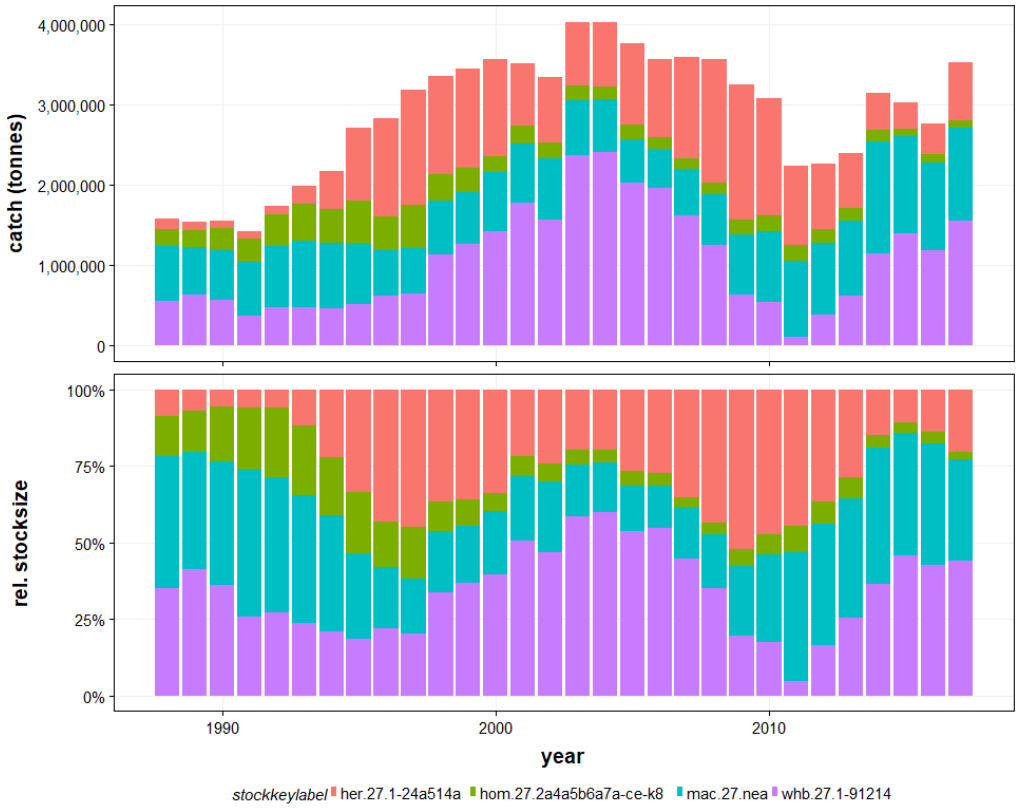

Figure 1.10.1: Catch of mackerel, western horse mackerel, blue whiting and Norwegian spring-spawning herring

The trends in SSB of the four stocks are shown in Figure 1.10.2, both in absolute biomass (tonnes) and in relative proportions. At the maximum, pelagic biomass of these species has been around 15 million tonnes. Recently the biomass appears to have decreased to around 12 million tonnes. The contributions of Norwegian Spring-spawning herring, Western horse mackerel and Northeast Atlantic mackerel has decreased in recent year while blue whiting has increased.

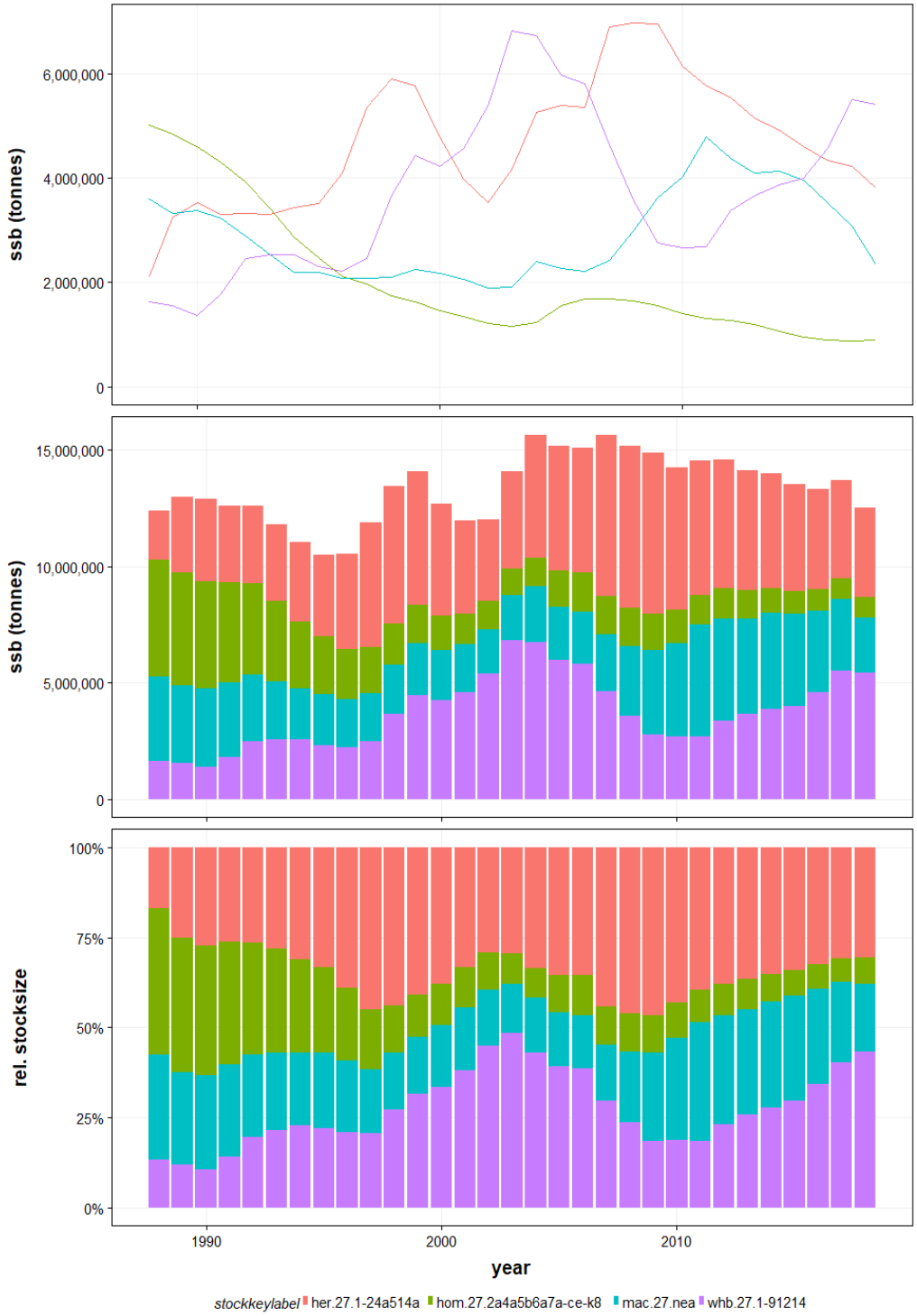

Figure 1.10.2: SSB of mackerel, western horse mackerel, blue whiting and Norwegian spring-spawning herring

An overview of the key variables for each of the stocks (Fishing pressure (F), recruitment (R) and Spawning-stock biomass (SSB)) is shown in Figure 1.10.3. From these comparisons it can be concluded that the fishing mortality of mackerel and blue whiting has generally been higher than the fishing mortality of horse mackerel and herring. Recruitment levels of blue whiting and herring are on a comparable scale and substantially higher and horse mackerel (except for the 1982 year class) and mackerel. Biomass

trends of the different stocks are somewhat on the same level but show very different tendencies.

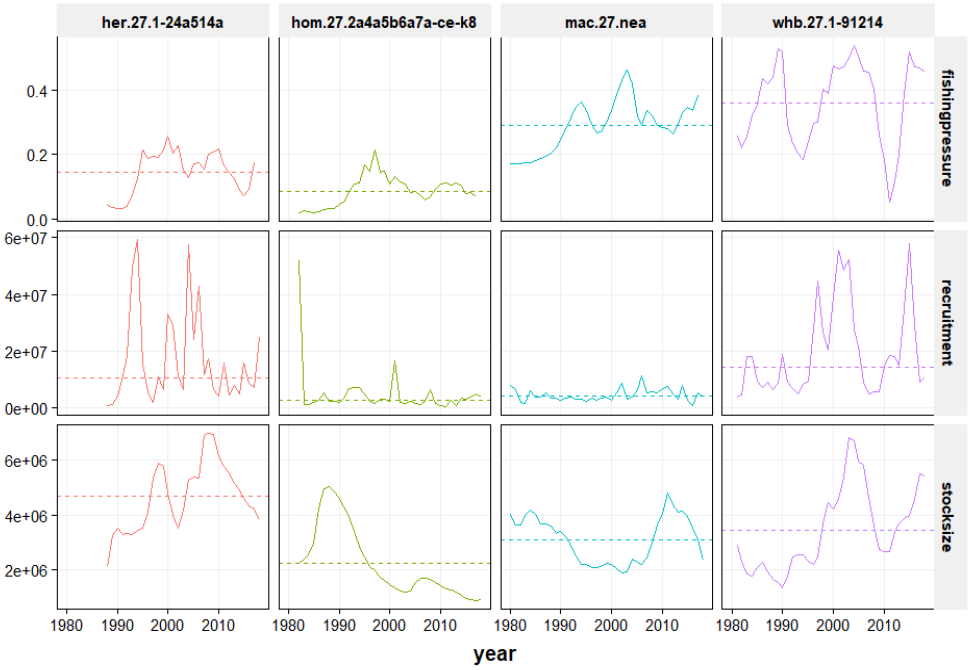

Figure 1.10.3: SSB of mackerel, western horse mackerel, blue whiting and Norwegian spring-spawning herring

An overview of stock weight at age for mackerel and blue whiting is shown in figure 1.10.4. Older mackerel has experienced a substantially lower weight at in the recent years although this tendency appears to have changed for the younger ages. Weight at age of blue whiting shows substantial fluctuations which appear to be somewhat related to the stock size.

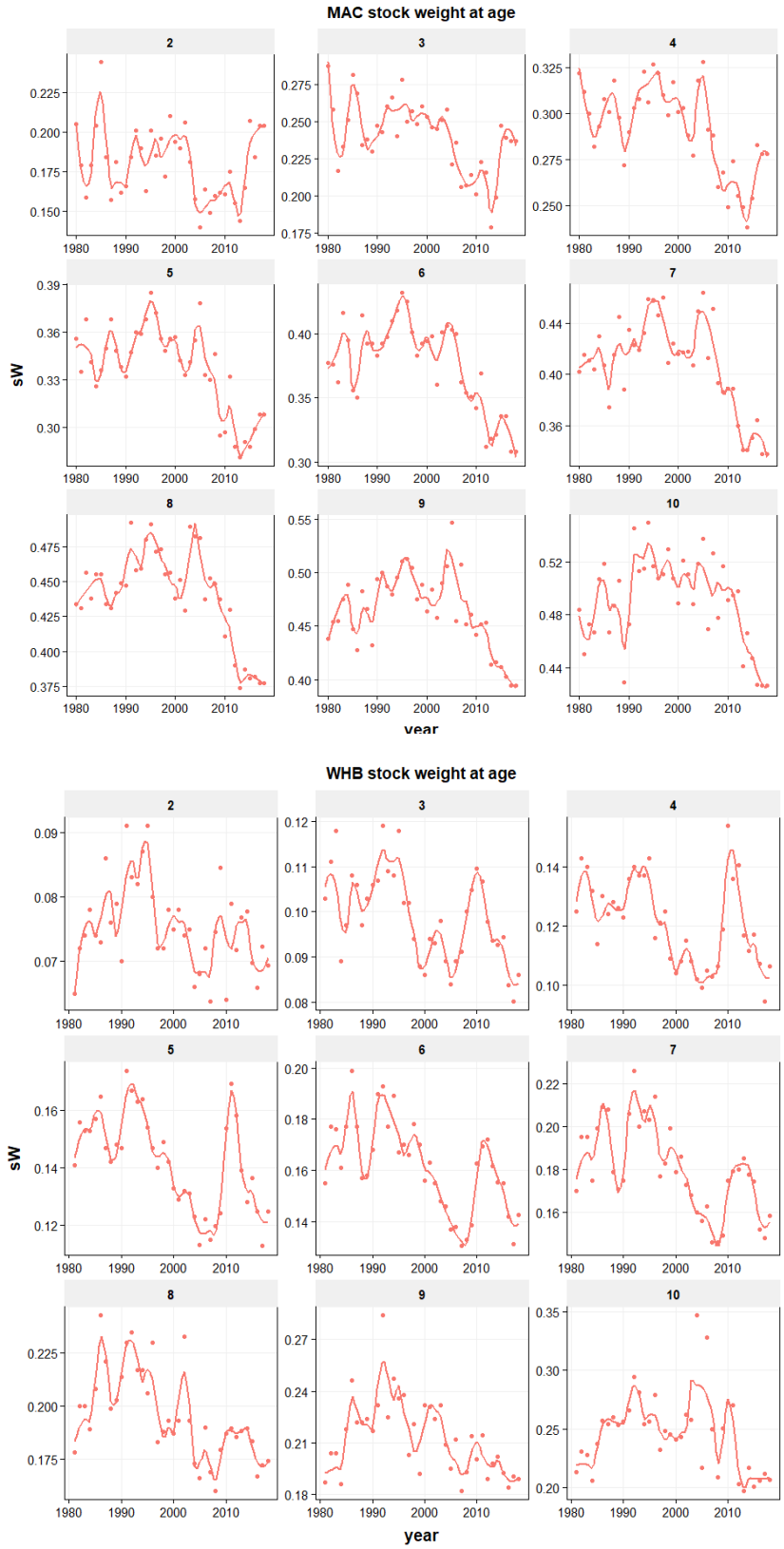

Figure 1.10.4 Trends in stock weight-at-age for mackerel and blue whiting.

1.11 Ecosystem considerations for widely distributed and migratory pelagic fish species

Number of studies demonstrate that environmental conditions (physical, chemical and biological) largely influence fish stocks productivity by changing the level of recruitment, growth rates, survival rates, or inducing variations in their geographical distribution (Skjoldal *et al.*, 2004, Sherman and Skjoldal 2002). It has been acknowledged that future lines of work in stock assessment should take ecosystem considerations into account in order to reduce the levels of uncertainty regarding the present and future status of commercial stocks. Hence, WGWIDE encourages further work to be carried out on ecosystem considerations linked to widely distributed fish stocks including NEA mackerel, Norwegian spring-spawning herring, blue whiting and horse mackerel. A close collaboration with the Working Group on Integrated Assessment of Norwegian Sea (WGINOR; ICES 2018a), and hopefully others relevant Integrated Assessment groups within ICES in the near future, will help in operationalizing ecosystem approach for the widely distributed pelagics assessed in WGWIDE. The text below was largely provided by WGINOR (ICES 2016e; 2018).

1.11.1 Climate variability and climate change

The North Atlantic Oscillation (NAO) corresponds with the alternation of periods of strong and weak differences between Azores high and Icelandic low pressure centres. Variations in the NAO influence winter weather over the North Atlantic and has a strong impact on oceanic conditions (sea temperature and salinity, Gulf Stream intensity, wave height). The 2015 winter NAO index was high, and simultaneously cold/freshwaters on the Canadian site of the Atlantic that winter and spring because of increase advection resulted in relative low temperatures in the Sub Polar Gyre (SPG) and low temperatures at all depths in 2015 in the large part of the Northeast Atlantic in comparison to 20 years long-term mean (ICES, 2015). This positive NAO continued in 2016 and 2017.

The classical measure of global warming is the northern hemisphere Temperature anomaly (NHT) (Jones and Moberg, 2003) which is computed as the anomaly in the annual mean of seawater and land air surface temperature over the northern hemisphere. During the last three decades, NHT anomalies have exhibited a strong warming trend. Pelagic planktivorous species such as Northeast Atlantic mackerel (Astthorsson *et al.*, 2012; ICES, 2013; Nøttestad *et al.* 2016), Norwegian spring-spawning herring and blue whiting may and have been taken advantage of warming oceans by extending their possible feeding opportunities further north, e.g. in Arctic waters. If such changes are, however, directly or indirectly driven by the warming are not fully understood (Olafsdóttir *et al.* 2018; Nikolioudakis *et al.*2018).

Acidification of the oceans is another event related to accumulation of anthropogenic greenhouse gases in the atmosphere. During the last 30 years, pH has decreased significantly in most water layers in Lofoten and the Norwegian basins. Different components like CO_2, aragonite and number of other factors such as temperature, salinity, and alkalinity may affect pH and carbon systems in the ocean. The impacts of the acidification on the ecosystem remains to be explored.

1.11.2 Circulation pattern

The circulation of the North Atlantic Ocean is characterized by two large gyres: the Subpolar Gyre (SPG) and subtropical gyre (Rossby, 1999). When the SPG is strong it

extends far eastwards bringing cold and fresh Subarctic water masses to the NE Atlantic, while a stronger SPG allows warmer and more saline subtropical water to penetrate further northwards and westwards over the Rockall plateau area. Changes in the oceanic environment in the Porcupine/Rockall/Hatton areas have been shown to be linked to the strength of the Subpolar Gyre (Hátún *et al.*, 2005). The large oceanographic anomalies in the Rockall region spread directly into the Nordic Seas, regulating the living conditions there as well as further south. Such changes are likely to have an impact on the spatial distribution of spawning and feeding grounds and on migration patterns of widely distributed pelagic fish species.

1.11.3 Recent trends in oceanography and zooplankton in Norwegian Sea

The time-series of ocean heat content in the Atlantic Water of the Norwegian Sea starting in 1951 show that the recent warm period continues (Figure 1.11.1). In fact, there is a continuing increase in 2017 compared to 2016 that was the previous record high value. This positive anomalous heat content is mainly confined to the Lofoten Basin. At the same time the freshwater content shows a slight increase, i.e. freshening, which is not expected from the usual T-S relation of warm/saline and cold/fresh varying in concert. Such change could be either due to anomalous air-sea exchange or changes in the volume or characteristics of the source water masses.

In the southern entrance to the Norwegian Sea there is a tendency toward slightly colder water compared to the recent years. However, more remarked is a prominent freshening trend pointing toward increased influence of water from the western Atlantic.

The index of Arctic water into the southern Norwegian Sea with the East Icelandic Current appears still weak compared to the condition previous to about 2002. This is further reflected in lower biomass of zooplankton in this region after around 2002 (Figure 1.11.2).

Upstream analysis of satellite sea surface height data indicates that the Subpolar gyre, which has been in a weak state for many years, has been strengthening during the last three years. If this trend continues, we should expect increased levels of silicate entering the Norwegian Sea over the coming years and consequently a reversal in the declining trend of silicate observed in the Norwegian Sea since 1990 (Rey 2012; Pacariz *et al*., 2016; Hátún *et al*., 2017).The atmospheric forcing represented by the winter NAO-index was positive, for the third consecutive winter. In the Labrador-Irminger Sea this normally means higher windstress curl and larger ocean to air heat loss and thus enhanced Subpolar gyre. For the Norwegian Sea, however, the averaged windstress curl showed low values, indicating that the atmospheric lows did not follow their normal route through the Norwegian Sea.

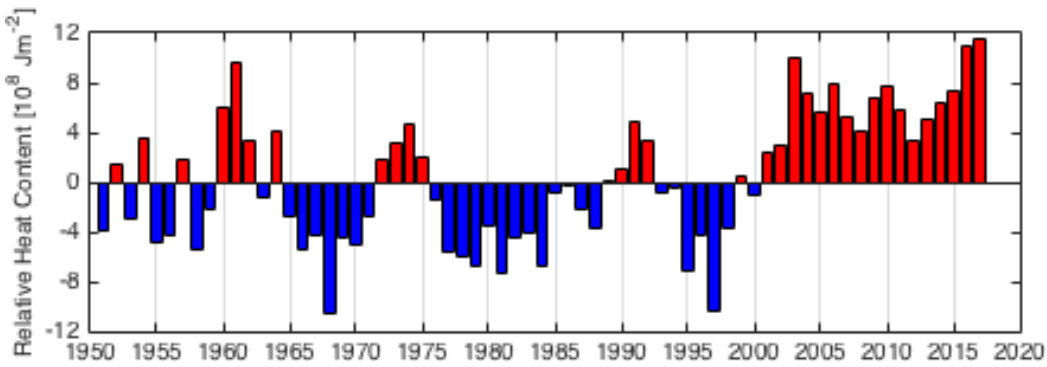

Figure 1.11.1. Time-series of anomalies of heat content of the Atlantic waters in Norwegian Sea (source:

http://www.imr.no/temasider/klima/klimastatus/norskehavet/norskehavet_2/nb-no).

The time-series of meso-zooplankton biomass in the Norwegian Sea from the International Ecosystem Survey in Norwegian Sea (IESNS) in May shows strong long-term variability (Figure 1.11.2). Following a maximum in biomass during the early 2000s the biomass declined with a minimum in 2006. From 2010 the downward trend reversed and reached back to the long-term mean again in 2014. Biomass dropped again in 2015 but have been increasing since then. Interestingly, all the areas, excluding east of Iceland and on few occasions Jan Mayen AF, show parallel changes in zooplankton biomass.

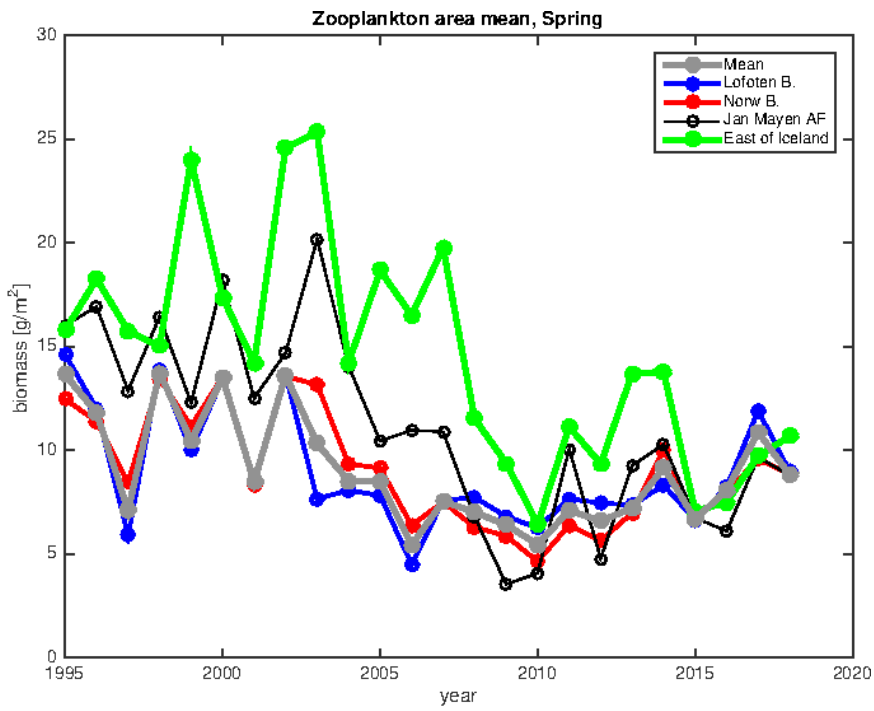

Figure 1.11.2. Indices of zooplankton dry weight (g m^{-2}) sampled by WP2 in May in different areas in and near Norwegian Sea from 1995 to 2018 as derived from interpolation using objective analysis utilizing a Gaussian correlation function (ICES 2018b; see details on methods and areas in ICES 2016a).

1.11.4 Species interactions

The distribution of species considered by WGWIDE can overlap to a large extent during some part of the year, and density-dependent competition for food could be expected. All the species are potential predators on eggs and larvae and the larger species (mackerel and horse mackerel) are also potential predators of the juveniles. Consequently, cannibalism and interspecific predation is likely to play an important role in the dynamics of these pelagic stocks. As examples, density-dependent growth has been observed both for mackerel (Olafsdottir *et al.* 2015) and Norwegian spring-spawning herring (Hömrum *et al.* 2016). Furthermore, several studies on diet composition have shown a high overlap (see overview in ICES 2016a) and even intraguild predation between species, e.g. NEA mackerel predation on NSS herring larvae on the Norwegian shelf area (Skaret *et al.* 2015) and sardine predation on anchovy eggs in the Bay of Biscay (Bachiller *et al*. 2015).

The Norwegian Sea and adjacent waters are the main feeding ground for the three main small pelagic fish stocks (NSS herring and blue whiting in spring and summer) and NEA mackerel (in summer) (Skjoldal *et al*., 2004; Langøy*et al.* 2012; ICES 2018b). The three species are able to adapt their feeding strategy to different conditions, including preying in cold water masses, where they show significantly higher feeding incidence and stomach fullness (Bachiller *et al*. 2016). The increasing spatial overlap between herring and mackerel in recent years could be enhancing their interspecific competition, given the higher feeding efficiency of mackerel, as demonstrated by significantly higher stomach fullness indices, contrasting earlier periods with limited spatial overlap (Langøy *et al*. 2012, Debes *et al*. 2012, Oskarsson *et al*. 2015, Bachiller *et al*. 2016).

NEA mackerel and NSS herring share a similar diet based on calanoid copepods, especially *C. finmarchicus*, whereas blue whiting shows lower diet overlap with these two species, broader diet composition and dominance of larger prey like euphausiids and amphipods (Langøy *et al*. 2012, Bachiller *et al*. 2016). Recent estimates based on bioenergetics show that these three species consume on average 135 million tonnes of zooplankton per year (2005-2010; Bachiller *et al*. 2018), which are higher than previous estimates (e.g. Utne *et al*., 2012; Skjoldal *et al*., 2004). NEA mackerel consumed 23-38%, NSS herring 38–51% and blue whiting 14–39% of the total zooplankton eaten by pelagic fish during the feeding season. This means that, in terms of consumption/biomass ratios, NEA mackerel feeding rates can be as high as that of the NSS herring during some years. Together, these three stocks were estimated to have consumed annually 53–81 million tonnes of copepods, 26–39 million tonnes of euphausiids and amphipods, 8–42 million tonnes appendicularians and 0.2–1 million tonnes of fish.

Sardine, mackerel, horse mackerel, blue whiting and herring have all been found in the diet of several cetacean and seabird species and are also part of the diet of other fish species (e.g. hake, tuna found with sardine and anchovy) (Anker-Nilssen and Lorentzen, 2004; Nøttestad et al. 2014). Comparison of population estimates of pelagic fish with those of top predators (e.g. minke whale, fin whale, killer whales) suggests that predation on pelagic fish by other pelagic fish has a much bigger potential for impact in regulating populations than that the predation by marine mammals and seabirds in the North Sea (Furness, 2002). Nevertheless, top predators could play a bigger role in pelagic fish dynamics at regional or local scales particularly when fish biomass is low (Nøttestad *et al*., 2004). In this WGWIDE report, several aspects of interaction between the pelagic fish stocks are addressed in the stock specific sections.

1.12 Future Research and Development Priorities

As part of the planning towards future benchmark assessments, the working group started in 2014 preparing a list of research priorities for each stock that can potentially improve the quality of the advice generated for each stock. This list is updated in every WG meeting, by removing issues as they have been solved and adding new ones when they arise. We have considered scientific research, improvements to data collection and development of assessment techniques, both generally and on a stock-by-stock basis, as appropriate. The most important of these developments are described below.

In general, more focus should be towards integrated ecosystem assessments for the stocks within WGWIDE. Some of the WGWIDE members also participate in the work of the Working Group on Integrated Assessment for Norwegian Sea (WGINOR), which help in communication between these two groups. However, there are also other regional Integrated Ecosystem Assessment groups that could be relevant to WGWIDE and the stocks assessed by it. We hope to put more emphasis on this in the coming years.

1.12.1 NEA Mackerel

Since the last benchmark of the mackerel assessment, the perception of the stock in the recent years has undergone several revisions. This was assumed to be a consequence of the short time-series (IESSNS and RDIF tagging data), whose catchability (survival rate for the tags) were not yet well estimated by the model. In addition, there was a conflicting signal between the egg survey and the IESSNS, and due to the changes in the relative weights of these surveys in the successive assessments (becoming more in favor of the egg survey), this would cause a downward revision of the stock size. At the WGWIDE 2018, it appeared that the sensitivity of the assessment to the tagging data had until now been overlooked, and that this data source (especially the RFID series) might be the most influential data source for this assessment. The tagging data are treated differently from conventional survey indices and the group lacks experience and proper diagnostics to understand its influence. Another problem with the RFID tags is that survival rate is estimated very low (ca. 0.1). This survival rate is a proxy for a number of factors: tagging mortality, scanning efficiency, tag loss and underestimation of the stock. The old steel tags indicated higher survival of 0.4. Furthermore, there is a strong pattern in the process error (model artificially adding fish to the stock) in the period where the stock and the catches increased rapidly, which also corresponds with the time the IESSNS and the RFID series started.

In order to get a better understanding to this behavior of the current assessment, and investigate potential modifications to remediate to some of the issues identified, WGWIDE recommends that an interbenchmark process should be conducted as soon as possible, preferably early in 2019. This interbenchmark would have the following tasks:

1) Improve the understanding on the behavior of the current model and its sensitivity to each data source :

- Understand the behavior and the importance of the process error in the current assessment.
    - Look for any retrospective pattern in the process error
    - Investigate the process error for leave one out runs (to check if the pattern is due to any particular survey)

    - Exploration of model behavior with a process error variance fixed at a very low value.
- Quantify the relative weight of the different data sources. Compute a metrics that would measure the weight of each individual data point. . Individual data sources are not necessary ignored but their weight reduced/increased and the contribution to the likelihood of that and other components investigated similar what is done in the Gadget model (Stefánsson 2003 and Taylor et al. 2007)
- Understand how the tagging data influence the model :
    - Why does their exclusion result in a much larger stock
    - How does each new year of recapture influence abundance at age estimates (i.e. how far back in time, which age range).

2) Investigate possible changes in the model :

- Revisit the formulation used to incorporate the tagging data. (e.g. how to interpret output of a model having at the same time normal and negative binomial error distributions)
- Revisit the selection operated on the RFID tag data (inclusion of age 2, age 12 not treated as a plus group, number of years spent before recapture)
- Consider fixing the relative weight of the tags (probably down weight them) compared to the surveys (possibly based on external information).
- post release survival estimated by periods of years (reflecting the tagging practices) instead of estimated by type of tag used. The idea is that post release survival for the last years of the steel tags should be similar to the survival for the RFID tags (since tagging protocol changed before steel tags where replaced by RFID tags).
- Revisit the down weighting of the catches prior to 2000, and consider either estimating a catch multiplier (as it is possible to do in SAM) or fix the multiplier based on external information (and test the sensitivity to the multiplier used).
- Investigate alternative use of the tagging data (e.g. as an biomass index or a Z estimate)
- Reassess the relevance of using a correlation structure for the IESSNS. Potentially use the empirical correlation in the index (estimated by stoX) with an additional variability.
- Revisit other aspect of model configuration (is it overparameterised or should we give it more freedom, for instance in the observation error for the catches).

1.12.2 Blue Whiting

Numerous scientific studies have suggested that blue whiting in the North Atlantic consists of multiple stock units. The ICES Stock Identification Methods Working Group (SIMWG) reviewed this evidence in 2014 (ICES, SIMWG 2014) and concluded that the perception of blue whiting in the NE Atlantic as a single-stock unit is not supported by

the best available science. SIMWG further recommended that blue whiting be considered as two units. There is currently no information available that can be used as the basis for generating advice on the status of the individual stocks. However, there are some studies going on and more data being collected to allow clarify the stock definition for this species. In the future, the newly collected information on stock composition should be evaluated on the behalf of a benchmark of this stock.

Since 2016, the summer survey in the Nordic Seas (IESSNS) has provided acoustical survey indices for blue whiting (ICES. 2016c), the relevance of including that new tuning series in the assessment should be explored in next benchmark process.

1.12.3 NSS Herring

The 2016 benchmark assessment of Norwegian spring-spawning herring tackled most of the issues raised in last year's WGWIDE report with the aim of improving the assessment of the stock. The remaining issues and general future research of relevance for the assessment includes the following:

The Norwegian spawning ground survey was reintroduced in 2015 as part of the tuning series (fleet 1). However, changes had been made to the survey compared to the older part of the series. The 2016 benchmark accepted the inclusion of the surveys from 2015 as part of the same tuning series, but it would be relevant to explore further if the series since 2015 should be a separate tuning series due to the changes in the survey, particularly since 2019 will provide the fifth estimate from the survey since it was reintroduced.

The relevance of inclusion of a new tuning series (IESSNS) in the assessment.

Get information about uncertainty in catches from all countries (currently only available from Norway).

1.12.4 Western horse mackerel

Considering the potential of mixing between Western and North Sea horse mackerel occurring in Division 7.d and 7.e, better insight into the origin of catches from that area will be a major benefit for improvement of the quality of future scientific advice and thus management of the North Sea and Western horse mackerel stocks. A project addressing stock structure and boundaries of horse mackerel was initiated by the Pelagic Freezer-trawler Association (PFA) and other pelagic industries, in collaboration with Wageningen Marine Research (formerly: IMARES) and University College Dublin recently. Some preliminary results were presented to WGWIDE in 2016 but none in 2017. Further work is ongoing. The WG acknowledge the importance of this kind of research and encourage further work in this field.

Further analysis on the mixing between the Western stock and the Southern stock in area 8c should be carried out: the fishery in the area targets mainly juveniles, would be therefore be very important to understand the impact of this fishery on each of the two stocks.

1.12.5 North Sea horse mackerel

To improve the knowledge base for North Sea horse mackerel about the degree of connection and migrations in between the North Sea and the Western Stock, catch sampling carried out by several pelagic fishery companies is being explored to give information on the separation between North Sea and Western horse mackerel. To improve the abundance indicators the potential application of a commercial fishery

search time index will be explored. Horse mackerel is fished while it is very close to the bottom in relatively dispersed, small schools. The fishery is mostly executed using long hauls and there may be extensive search time involved. Handled in an appropriate statistical framework, taking into account the nature of the fishery and other factors such as seasonality and alternative fishing opportunities, the search time and catch rates could provide for an indication of changes in stock size over time. Catch rates in areas 27.7.e, 27.7.d and southern North Sea will be analysed from skippers' private logbooks.

The exploration of additional survey data has already been initiated in 2015 and resulted in the inclusion of the French CGFS index into the assessment of North Sea horse mackerel. In January 2017, the North Sea horse mackerel was benchmarked (ICES, 2017a). Based on capacity to model the overdispersion and the high proportion of zero values in the survey catch data the hurdle models was concluded the best option to combine the NS-IBTS and the CGFS survey information and estimating a joint annual survey index to be used for assessing the status of the stock. Future work will focus on the assessment of the importance of considering the spatial component when modelling the joint CGFS and IBTS survey index.

1.12.6 Boarfish

From 2017 onwards, this stock will be included on the list of stocks sampled under the data collection framework (DCMAP). This will permit sampling of commercial catch for both length and age. However, age reading is difficult and expertise is limited. An increase in the number of age readers would help develop a time-series of commercial catch-at-age which would in turn enable the development of an age-based assessment methodology. The current ALK is static and is based on a limited number of age readings.

Improvements in the survey data can be realized through a change in sampling protocol on groundfish surveys to ensure boarfish are measured to the 0.5cm. The acoustic time-series should continue to be developed. The current survey does not contain the stock. The use of information from other acoustic surveys should also be explored.

At WGWIDE 2018, an issue list was prepared for the stock and sent to ACOM for consideration of having a benchmark assessment in 2020.

1.13 Decision made on next year´s meeting

The WG aim for next meeting in Vigo or Santa Cruz Tenerife, Spain, in the period 27 August – 3 September 2019.

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2 Blue whiting (*Micromesistius poutassou*) in subareas 27.1–9, 12, and 14 (Northeast Atlantic)

Blue whiting (*Micromesistius poutassou*) is a small pelagic gadoid that is widely distributed in the eastern part of the North Atlantic. The highest concentrations are found along the edge of the continental shelf in areas west of the British Isles and on the Rockall Bank plateau where it occurs in large schools at depths ranging between 300 and 600 meters but is also present in almost all other management areas between the Barents Sea and the Strait of Gibraltar and west to the Irminger Sea. Blue whiting reaches maturity at 2—7 years of age. Adults undertake long annual migrations from the feeding grounds to the spawning grounds. Most of the spawning takes place between March and April, along the shelf edge and banks west of the British Isles. Juveniles are abundant in many areas, with the main nursery area believed to be the Norwegian Sea. See the Stock Annex for further details on stock biology.

2.1 ICES advice in 2017

ICES notes that fishing mortality has increased from a historical low in 2011 to above F_{MSY} since 2014. Spawning-stock biomass increased since 2010 and is above MSY $B_{trigger}$. Recruitment in 2017 is estimated to be low, following a period of high recruitments.

ICES advised that when the MSY approach is applied, catches in 2018 should be no more than 1 387 872 tonnes.

2.2 The fishery in 2017

The total catch in 2017 was 1558 kt. The main fisheries on blue whiting were targeting spawning and post-spawning fish (Figures 2.2.1 and 2.2.2). Most of the catches (90%) were taken in the first two quarters of the year and the largest part of this west of the British Isles and south and east of the Faroes. Smaller quantities were taken along the coast of Spain and Portugal. The fishery in the latter half of the year was concentrated in the central Norwegian Sea. The multinational fleet currently targeting blue whiting consists of several types of vessels. The bulk of the catch is caught with large pelagic trawlers, some with capacity to process or freeze on board. The remainder is caught by RSW vessels.

2.3 Input to the assessment

At the Inter-Benchmark Protocol on Blue Whiting (IBPBLW 2016) it was decided to use preliminary catch-at-age data from 2016 in the assessment to get additional information to the within year IBWSS result. In most recent years more than 90% of the annual catches of the age 3+ fish are taken in the first half year, which makes it reasonable to estimate the total annual catch-at-age from reported first semester data. The catch data sections in this report give first a comprehensive description of the 2017 data as reported to ICES and then a section including a brief description of the 2018 preliminary catch data.

2.3.1 Officially reported catch data

Official catches in 2017 were estimated to 1558061 tonnes based on data provided by WGWIDE members. Data provided as catch by rectangle represented more than 99% of the total WG catch in 2017. Total catch by country for the period 1988 to 2017 is presented in Table 2.3.1.1 and in Figure 2.3.1.1.

After a minimum of 104 000 tonnes in 2011, catches peaked in 2017 (1 558 061 tonnes tonnes) (Figure 2.3.1.2.A).The spatial and temporal distribution in 2017 (Figure 2.2.1, 2.2.2 and Table 2.3.1.2), is quite similar to the distribution in previous years. The majority of catches is coming from the spawning area. The 2017 catches have largest contribution from ICES area 27.5.b, 27.6.a and 27.7.c (Figures 2.3.1.1 to 2.3.1.8). The temporal allocation of catches has been relatively stable in recent years (Figure 2.3.1.4). In the first two quarters, catches are taken over a broad area, with the highest catches in 27.5.b, 27.6.a, 27.7.c and 27.7.k, while later in the year catches is mainly taken further north in area 27.2.a and in the North Sea (27.4.a) (Figure 2.3.1.6 and 2.3.1.7 and Table 2.3.1.3). The proportion of catches originating from the Northern areas has been decreasing from 2014 to 2016, in 2017 an increase of 8% was observed.

Discards of blue whiting are small. Most of the blue whiting caught in directed fisheries are used for reduction to fish meal and fish oil. However, some discarding occurs in the fisheries for human consumption and as bycatch in fisheries directed towards other species.

Reports on discarding from fisheries which catch blue whiting were available from the Netherlands for the years 2002—2007 and 2012—2014. A study carried out to examine discarding in the Dutch fleet found that blue whiting made a minor contribution to the total pelagic discards when compared with the main species mackerel, horse mackerel and herring.

The blue whiting discards data produced by Portuguese vessels operating with bottom otter trawl within the Portuguese reaches of ICES Division 27.9.a is available since 2004. The discards data are from two fisheries: the crustacean fishery and the demersal fishery. The blue whiting estimates of discards in the crustacean fishery for the period of 2004–2011 ranged between 23% and 40% (in weight). For the same period the frequency of occurrence in the demersal fishery was around zero for the most of the years, in the years were it was significant (2004, 2006, 2010) was ranging between 43% and 38% (in weight). In 2017, discards were 21% of the total catches for blue whiting in the Portuguese coast (Table 2.3.1.5). The total catch from Portugal is less than a half percentage of the total international catches.

Information on discards was available for Spanish fleets since 2006. Blue whiting is a bycatch in several bottom-trawl mixed fisheries. The estimates of discards in these mixed fisheries in 2006 ranged between 23% and 99% (in weight) as most of the catch is discarded and only last day catch may be retained for marketing fresh. The catch rates of blue whiting in these fisheries are however low. In the directed fishery for blue whiting for human consumption with pair trawls, discards were estimated to be 5% (in weight) in 2015 (Table 2.3.1.5). Spanish catches are around 2% of the international catches.

In general, discards are assumed to be small in the blue whiting directed fishery. Discard data are provided by the Denmark, Portugal, Spain, UK (England and Wales) and UK(Scotland), to the working group. The discards constituted 0.13% of the total catches, 2 030 tonnes.

The total estimated catches (tonnes) inside and outside the NEAFC regulatory area by country were reported on Table 2.3.1.6. Lithuania and Sweden have not provided data concerning NEAFC area, but their catches are negligible.

2.3.1.1 Sampling intensity

Sampling intensity for blue whiting with detailed information on the number of samples, number of fish measured, and number of fish aged by country and quarter is given in Table 2.3.1.1.1 and are presented and described by year, country and area (Tables 2.3.1.1.2 Table 2.3.1.4). In total 1779 samples were collected from the fisheries in 2017, 147297 fish were measured and 15828 were aged. The percentage of catches covered by the sampling program was 91% in 2017. The most intensive sampling took place in the area 27.4.a, 27.5.b, 27.7.c, 27.8.b, 27.8.c and 27.9.a. No sampling was carried out by Greenland, Lithuania, Poland, Sweden and the UK (England, Wales, Northern Ireland) representing together 3% of the total catches. The sampled and estimated catch-at-age data are shown on Figure 2.3.1.1.1.

Sampling intensity for age and weight of blue whiting are made in proportion to landings according to CR 1639/2001 and apply to EU member states. The Fisheries Regulation 1639/2001, requires EU Member States to take a minimum of one sample for every 1000 tonnes landed in their country. Various national sampling programs are in force.

2.3.1.2 Length compositions

The length distribution in numbers of around 67% of catches was provided for some of the areas sampled (Figure 2.3.1.2.1), fish from length between 20 and 30 cm dominated the catches composition.

2.3.1.3 Age compositions

The age-length key for the sampled catches on ICES area 27.6.a (as an example) is presented by quarter and country (Figure 2.3.1.3.1). The mean length (mm) by ages reveals that age classifications do not present significant differences between countries.

The Inter Catch program was used to calculate the total international catch-at-age, and to document how it was done.

2.3.2 Preliminary 2018 catch data (Quarters 1 and 2)

The preliminary catches in 2018, for quarters 1 and 2, were estimated to 1351802 tonnes (Table 2.3.2.1) based on data provided WGWIDE members.

The spatial distribution of these 2018 preliminary catches is similar to the distribution in 2017. The majority of catches are coming from the areas 27.5.b, 27.6.a, 27.6.b, 27.7.c and 27.7.k (Figure 2.3.2.1 and Table 2.3.2.2).

Sampling intensity for blue whiting from the preliminary catches by area and quarter with detailed information on the number of samples, number of fish measured, and number of fish aged is presented in Table 2.3.2.2. The preliminary catches for 2018, quarters 1 and 2, and the expected whole 2018 catches were reported by the WGWIDE members (Table 2.3.2.3).

A comparison of the preliminary and the final catch for 2016 and 2017 (Table 2.3.2.4) shows a good agreement (i.e. max 2.9 % deviation).

2.3.2.1 Raising procedure

The 2016 Benchmark concluded that the first semester(=first half year=quarter 1 and quarter 2) catch-at-ages for the preliminary year are raised to annual total catch-at-age from a 3 years average of the observed proportion of annual catches, taken in the first semester. Average proportion landed in the first semester and raising factor by age are presented in Table 2.3.2.1.1.

The WGWIDE Advice Drafting Group in 2016 proposed to further raise the preliminary first semester catches to "best available estimate" on the final catch weight. This approach is easier to communicate to the public as the raised catch is the same at the expected. The approach suggested by the ADG has been used since the 2016.

WGWIDE estimated the expected total catch for 2018 from the sum of declared national quotas, corrected for expected national uptake and transfer of these quotas (Table 2.3.2.3).

2.3.3 Catch-at-age

Catch-at-age numbers are presented in Table 2.3.3.1. Catch proportions at age are plotted in Figure 2.3.3.1. Strong year classes that dominated the catches can be clearly seen in the early 1980s, 1990 and the late 1990s. In recent years, the age compositions are dominated by the younger ages (ages 35).

Catch curves for the international catch-at-age dataset (Figure 2.3.3.2) indicate a consistent decline in catch number by cohort and thereby reasonably good quality catch-at-age data. Catch curves for year class 2004-2008 show a more flat curve compared to previous year classes indicating a lower F or changed exploitation pattern, probably related to the low year-class strengths for some of the year classes. Year classes 2008-2010 show a consistent decline in the stock numbers with an estimated total mortality (Z=F+M) around 0.6-0.7 for the ages fully recruited to the fisheries.

2.3.4 Weight at age

Table 2.3.4.1 and Figure 2.3.4.1show the mean weight-at-age for the total catch during 1983—2018 used in the stock assessment. Mean weight at age for ages 3—9 reached a minimum around 2007, followed by an increase until 2010—2012, and a decrease in the recent years. Mean weight for the preliminary 2018 catches are calculated as the mean weight of catches in the period 2015-2017.

The weight-at-age for the stock is assumed the same as the weight-at-age for the catch.

2.3.5 Maturity and natural mortality

Blue whiting natural mortality and proportion of maturation-at-age are shown in Table 2.3.5.1. See the Stock Annex for further details.

2.3.6 Information from the fishing industry

No new information available.

2.3.7 Fisheries independent data

Data from the International Blue Whiting spawning stock survey are used by the stock assessment model, while recruitment indices from several other surveys are used to qualitatively adjust the most recent recruitment estimate by the assessment model and to guide the recruitments used in the forecast.

2.3.7.1 International Blue Whiting spawning stock survey

The Stock annex gives an overview of the surveys available for the blue whiting. The International Blue Whiting Spawning Stock Survey (IBWSS) is however the only survey used as input to the assessment model. The cruise report from IBWSS in spring 2018 is available as a working document to this report. The survey group considers that the 2018 estimate of abundance as robust.

The updated survey time-series (2004-2018) show an high internal consistency for the main age groups are given in Figure 2.3.7.1.1. B.

The distribution of acoustic backscattering densities for blue whiting for the last 4 years is shown in Figure 2.3.7.1.2. The bulk of the mature stock was located from the north Porcupine to the Hebrides core area in a corridor close to the shelf edge. This is comparable to what was observed in 2017.

The abundance estimate of blue whiting for IBWSS are presented in Table 2.3.7.1.1. In comparison to the results in 2017, there is an increase in the observed stock biomass (+29%) and in stock numbers (+15%).

The stock biomass within the survey area was dominated by 3, 4, 5 year old fish, contributing over 86% of total-stock biomass. The age structure of the 2018 estimate is consistent with the age structure from the 2017 estimate.

Length and age distributions for the period 2014 to 2018 are given in Figure 2.3.7.1.3.

Survey indices as applied in the stock assessment are shown in Table 2.3.7.1.2. (identical to the numbers, ages 1-8, in Table 2.3.7.1.1)

2.3.7.2 Other surveys

The Stock Annex provides information and time-series from surveys covering parts of the stock area. A brief survey description and survey results are provided below.

The International ecosystem survey in the Nordic Seas (IESNS) in May which is aimed at observing the pelagic ecosystem with particular focus on Norwegian spring-spawning herring and blue whiting (mainly immature fish) in the Norwegian Sea (Table 2.3.7.2.1).

Norwegian bottom-trawl survey in the Barents Sea (BS-NoRu-Q1(Btr)) in February-March where blue whiting are regularly caught as a bycatch species. This survey gives the first reliable indication of year-class strength of blue whiting. 1 group is defined in this survey as less than 19cm (Table 2.3.7.2.2).

Icelandic bottom-trawl surveys on the shelf and slope area around Iceland. Blue whiting is caught as bycatch species and 1-group is defined as greater than 15 cm and less than 22cm in March (Table 2.3.7.2.3).

Faroese bottom-trawl survey on the Faroe plateau in spring where blue whiting is caught as bycatch species. 1 group is defined in this survey as less than 23cm in March (Table 2.3.7.2.4).

The International Survey in Nordic Seas and adjacent waters in July-August (IESSNS). Blue whiting are from 2016 included as a main target species in this survey and methods are changed to sample blue whiting. This was a recommendation from WGWIDE 2015 to try to have one more time-series for blue whiting. The time-series is currently too short for assessment purposes.

This year, IEO joined the IBWSS, covering the adjacent area of the core spawning ground in Porcupine Seabight from 14th to 20th March, thus before the coverage of the core area. Blue whiting occurred in a pelagic layer located as usually at around 500 m depth, from the slope to open sea. In the southern part (from 49ºN up to 51º30'N) the outer limit was reached while northwards, there was a continuity towards Porcupine Bank (Figure 2.3.7.2.1). A total of 100 kt were assessed, corresponding to 1.1 billion fish. Length distribution shown 3 modes, located 19, 25 and 29 cm, with mean length esti-

mated at 25.2 cm (Figure 2.3.7.2.2). This length distribution had not significant differences with that estimated in the Spanish area (see Carrera et al. WD004 for further details). Data from the IEO survey were not included in the IBWSSS survey index.

2.4 Stock assessment

The presented assessment in this report follows the recommendations from the Inter-Benchmark Protocol of Blue Whiting (IBPBLW) convened by correspondence from 10 March to 10 May 2016 (ICES, 2016) to use the SAM model.

The configuration of the SAM model (see the Stock Annex for details) includes the same settings as agreed during IBPBLW 2016, but due to a new version of SAM, the actual values have changed in 2017. The new SAM version begins with 0 for parameters, while the old version begins with 1. The Stock Annex has been updated accordingly.

For a model as SAM, Berg and Nielsen (2016) pointed out that the so-called "One Step Ahead" (OSA) residuals should be used for diagnostic purposes. The OSA residuals (Figure 2.4.1) show a quite random distribution of residuals. There might be an indication of "years effect" (too low index) for the IBWSS 2015 observations.

The estimated parameters from the SAM model from this year's assessment and from previous years (retrospective analysis) are shown in Table 2.4.1. There are only a very few abrupt changes in the estimated parameters over the time-series presented. The increase in process error for age 1 in the 2017 run is probably a reflection of the low 2017 recruitment. Process errors for N ages 2-10 increase slightly for the period2015-2018. Observation noises for the IBWSS decrease from 2017 to 2018, except for the for ages 7-8.The lowest observation noise and thereby the largest influence on the stock assessment is from catches, age 3-8, and these ages also contribute most to the international catches.

The process error residuals ("Joint sample residuals") (Figure 2.4.2) are reasonable randomly distributed.

The correlation matrix between ages for the catches and survey indices (Figure 2.4.3) show a modest observation correlation for the younger ages and stronger correlation for the older ages. The same is seen for survey observations.

Figure 2.4.4 presents estimated F at age and exploitation pattern for the whole time-series. There are no abrupt changes in the exploitation pattern from 2010 to 2018, even though the landings in 2011 were just 19% of the landings in 2010, which might have given a different fishing practice. The estimated rather stable exploitation pattern might be due to the use of correlated random walks for F at age with a high estimated correlation coefficient (rho = 0.94, Table 2.4.2.1). However, the rather large changes in exploitation pattern for age 8 and 9+ in the most recent years might be due to aging problems.

The retrospective analysis (Figure 2.4.5) shows an unstable assessment with substantial downward revision of SSB in the 2015 assessment(due to the 2015 low survey indices) followed by an increase in 2016. The use of "preliminary" catches (here in the retrospective analysis it is actually the final catches that are used for the period before 2017) gives a more stable assessment in the most recent 3 years. The Mohn's rho by year and as the average value over the last five years are presented in (Table 2.4.2). Even though the annual values might be high (reflecting large changes from one year to the next) the average Mohn's rho is rather low indicating no bias.

Stock summary results with added 95% confidence limits (Figure 2.4.6 and Table 2.4.5) show a decrease in fishing mortality in the period 2004—2011, followed by a steep increase in F up to 2015 and a small decrease in F in 2016-2018. Recruitment increased from low recruitments in 2006–2009 to a historically high recruitment in 2015. This is followed by a lower recruitment in 2016 and a much lower recruitment in 2017-2018. SSB has increased since 2010, followed by a small reduction in 2018.

2.4.1 Alternative model runs

The assessment models TISVPA and XSA were run for a better screening of potential errors in input and for comparison with the SAM results. All three models gave a similar result with respect to F, SSB and recruitment (Figure 2.4.1.1).

2.5 Final assessment

Following the recommendations from Inter-Benchmark Protocol on Blue Whiting (IBPBLW 2016) the SAM model is used for the final assessment. The model settings can be found in the Stock annex. Alternative model runs give similar results.

Input data are catch numbers-at-age (Table 2.3.3.1), mean weight-at-age in the stock and in the catch (Table 2.3.4.1) and natural mortality and proportion mature in Table 2.3.5.1. Applied survey data are presented in Table 2.3.7.1.2

The model was run for the period 1981—2018, with catch data up to 2017 and preliminary catch data for the first semester of 2018 raised to expected annual catches, and survey data from March-April, 2004–2018. SSB 1st January in 2019 is estimated from survivors and estimated recruits (for 2019 estimator outside the model, see short-term forecast section). 11% of age group 1 is assumed mature thus recruitment influences the size of SSB. The key results are presented in Tables 2.4.2–2.4.3 and summarized in Table 2.4.5 and Figure 2.4.6. Residuals of the model fit are shown in Figures 2.4.1–2.4.2.

2.6 State of the Stock

F has increased from a historic low at 0.052 in 2011 to 0.518 in 2015 followed by a decrease in F to 0.454 in 2018. F has been above F_{MSY}(0.32) since 2014. SSB increased from 2010 (2.68 million tonnes) to 2017 (5.50 million tonnes), followed by a decline to 2019 (4.33 million tonnes). SSB has been above B_{pa} (2.25 million tonnes) since 1997.

Recruitment (age 1 fish) in 2006—2009 are in the very low end of the historical recruitments, but recruitment 2010-2016 are estimated much higher. The uncertainty around the recruitment in the most recent year is high, but recruitments in 2017 and 2018 are estimated low.

2.7 Biological reference points

In spring of 2016, the Inter-Benchmark Protocol on Blue Whiting (IBPBLW 2016) delegated the task of re-evaluating biological reference points of the stock to the ICES Workshop on Blue Whiting Long Term Management Strategy Evaluation (WKBWMSE). During the WGWIDE meeting 2017, WKBWMSE concluded to keep B_{lim} and B_{pa} unchanged but revised F_{lim}, F_{pa}, and F_{MSY} (See Table below)

The table below summaries the currently used reference points.

FRAMEWORK	REFERENCE POINT	VALUE	TECHNICAL BASIS	SOURCE
MSY approach	MSY $B_{trigger}$	2.25 million t	B_{pa}	ICES (2013a, 2013b, 2016b)
	F_{MSY}	0.32	Stochastic simulations with segmented regression stock–recruitment relationship	ICES (2016b)
Precautionary approach	B_{lim}	1.50 million t	Approximately B_{loss}	ICES (2013a, 2013b, 2016b)
	B_{pa}	2.25 million t	B_{lim} exp(1.645 × σ), with σ = 0.246	ICES (2013a, 2013b, 2016b)
	F_{lim}	0.88	Equilibrium scenarios with stochastic recruitment: F value corresponding to 50% probability of (SSB< B_{lim})	ICES (2016b)
	F_{pa}	0.53	Based on F_{lim} and assessment uncertainties. F_{lim} exp(−1.645 × σ), with σ = 0.299	ICES (2016b)

References

ICES.2013a. NEAFC request to ICES to evaluate the harvest control rule element of the long-term management plan for blue whiting. Special request, Advice May 2013. *In* Report of the ICES Advisory Committee, 2013.ICES Advice 2013, Book 9, Section 9.3.3.1.

ICES.2013b. NEAFC request on additional management plan evaluation for blue whiting. Special request, Advice October 2013.*In* Report of the ICES Advisory Committee, 2013.ICES Advice 2013, Book 9, Section 9.3.3.7.

ICES. 2016b. Report of the Workshop on Blue Whiting Long Term Management Strategy Evaluation (WKBWMS), 30 August 2016ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM:53

2.8 Short-term forecast

2.8.1 Recruitment estimates

The benchmark WKPELA in February 2012 concluded that the available survey indices should be used in a qualitative way to estimate recruitment, rather than using them in a strict quantitative model framework. The WGWIDE has followed this recommendation and investigated several survey time-series indices with the potential to give quantitative or semi-quantitative information of blue whiting recruitment. The investigated survey series were standardized by dividing with their mean and are shown in Figure 2.8.1.1.

The International Ecosystem Survey in the Nordic Seas (IESNS) only partially covers the known distribution of recruitment from this stock. Both the 1–group (2017 year class) and 2–group (2016 year class) indices from the survey in 2018 were below the median of the historical range.

The International Blue Whiting Spawning Stock Survey (IBWSS) is not designed to give a representative estimate of immature blue whiting. However, the 1-group indices appear to be fairly consistent with corresponding indices from older ages. The 1-group (2017 year class) index from the survey in 2018 was the below the middle of the historic range. The 2-group in 2018 (2016 year class) was in the low end in the time-series.

The Norwegian bottom-trawl survey in the Barents Sea (BS-NoRu-Q1(Btr)) in February-March 2018, showed that 1-group blue whiting was absent (Table 2.3.7.2.2). This index should be used as a presence/absence index, in the way that when blue whiting is present in the Barents Sea, this is usually a sign of a strong year class, as all known strong year classes have been strong also in the Barents Sea.

The 1-group estimate in 2018 (2017 year class) from the Icelandic bottom-trawl survey showed a decrease compared to 2017 and was in the low end in the time-series.

The 1-group estimate in 2018 (2017 year class) from the Faroese Plateau spring bottom-trawl survey was lower than in 2016 and were below the median of the historical range.

In conclusion, the indices from available survey time-series indicate that the 2016 year class is in the low end and it corresponds to the SAM assessment results. The 2017 year classes estimated from surveys are also in the low end, which also is the result of the SAM assessment where it is in the lower end. It was therefore decided not to change the SAM estimate of the 2016 and 2017 year classes.

No information is available for the 2018 and 2019 year classes and the geometric mean of the full time-series (1981—2017) was used for these year classes (14.6 billion at age 1 in 2018) (Table 2.8.1.1).

2.8.2 Short-term forecast

As decided at WGWIDE 2014, a deterministic version of the SAM forecast was applied.

2.8.2.1 Input

Table 2.8.2.1 lists the input data for the short-term predictions. Mean weight at age in the stock and mean weight in the catch are the same and are calculated as three year averages (2015—2017). The 2018 mean weights in the assessment are a three years average (2015—2017). Selection (exploitation pattern) is based on F in the most recent year. The proportion mature for this stock is assumed constant over the years and values are copied from the assessment input.

Recruitment (age 1) in 2017 and 2018 are assumed as estimated by the SAM model, as additional survey information was not conflicting this result. The recruitment in 2019 and 2020 are assumed at the long-term average (geometric mean for the full time-series, minus the last year (1981-2017).

As the assessment uses preliminary catches for 2018 an estimate of stock size exist for the 1 January 2019. The normal use of an “intermediate year “calculation is not relevant anymore. F in the “intermediate year” (2018) is as calculated by the assessment model. Catches in 2018 is the (model input) preliminary catches (1712874 tonnes). Intermediate year assumptions are summarised in Table 2.8.2.1.1

2.8.2.2 Output

A range of predicted catch and SSB options from the deterministic short-term forecast used for advice are presented in Table 2.8.2.2.1.

Following the ICES MSY framework implies fishing mortality to be at F_{MSY} = 0.32 which will give a TAC in 2018 at 1143629 tonnes (33.2 % decrease compared to the ICES estimate of catches in 2018 and 17.2 % decrease compared to the ICES advice for 2018). SSB is predicted to decrease by 13.2 %.

2.9 Comparison with previous assessment and forecast

Comparison of the final assessment results from the last 5 years is presented in Figure 2.9.1. The last three assessments, with the inclusion of the preliminary catches in 2016, show a tendency for overestimating SSB and underestimating F.

2.10 Quality considerations

Based on the confidence interval produced by the assessment model SAM there is a moderate to high uncertainty of the absolute estimate of F and SSB and the recruiting year classes (Figure 2.4.6). The retrospective analysis (Figure 2.4.5), the comparison of SSB and F estimated by three different assessment programs TISVPA, XSA and SAM (Figure 2.4.3.1) and the comparison of the 2010-2017 assessments (Figure 2.9.1) suggest a consistent assessment for the last three years (with inclusion of preliminary catch data). The preliminary 2016 and 2017 catches in weight correspond well with the final catch statistics (Table 2.3.2.4).

There are several sources of uncertainty: age reading, stock identity, and survey indices. As there is only one survey (IBWSS) that covers the spawning stock, the quality of the survey influences the assessment result considerably. The Inter-Benchmark Protocol on Blue Whiting (IBPBLW 2016) introduced a configuration of the SAM model that includes the use of estimated correlation for catch and survey observations. This handles the "year effects" in the survey observation in a better way than assuming an uncorrelated variance structure as usually applied in assessment models. However, biased survey indices will still give a biased stock estimate with the new SAM configuration.

During the WGWIDE 2017 (ICES 2017), a comparison between the mean length-at-age, by quarter and ICES division was been made. This comparison reveals a considerable lower mean length-at-age from the Faroese catch-at-age data. The 2017 catch-at-age from Faroese Islands, provided for this year assessment, were based on the age reading guidelines from the last workshop on blue whiting ageing (WKARBLUE2) and no significant deviations of the mean length-at-age have been found (Figure 2.3.1.10.). The Faroese catch-at-age data from the previous years are under revision and the assessment will be updated, when the data become available.

Utilization of preliminary catch data provides the assessment with information for the most recent year in addition to the survey information. This should give a less biased assessment as potential biased survey data in the final year are supplemented by additional catch data.

2.11 Management considerations

The expected catches for 2018 (1.712 million tonnes) are considerably higher than the ICES advice for 2018 (1.388 million tonnes) based on the long-term management strategy agreed by the European Union, the Faroe Islands, Iceland and Norway. This higher catch in combination with the small recruitment in 2017 and 2018 lead to the reduction in the ICES TAC advice for 2019. Without a strong recruitment in 2019 the decline in stock size and TAC will probably continue.

2.12 Ecosystem considerations

An extensive overview of ecosystem considerations relevant for blue whiting can be found in the stock annex.

2.13 Regulations and their effects

There is an agreed long-term management strategy agreed by the European Union, the Faroe Islands, Iceland and Norway. However there is no agreement between the Coastal States EU, Norway, Iceland and the Faroe Island on the share of the blue whiting TAC.

WGWIDE members estimate the total expected catch from the stock to be around 1.712 million tonnes in 2018 (close to the sum of declared quotas) whereas the TAC advice, according to the long-term management strategy was≤ 1.388 million tonnes.

2.13.1 Management plans and evaluations

A response to NEAFC request to ICES to evaluate a long-term management strategy for the fisheries on the blue whiting ICES WKBWMSE was established in the fall of 2015. The ICES Advice September 2016, "NEAFC request to ICES to evaluate a long-term management strategy for the fisheries on the blue whiting (*Micromesistius poutassou*) stock" concluded that:

- That the harvest control rule (HCR) proposed for the Long-Term Management Strategy (LTMS) for blue whiting, as described in the request, is precautionary given the ICES estimates of Blim (1.5 million t), Bpa (2.25 million t), and FMSY (0.32).
- The HCR was found to be precautionary both with and without the 20% TAC change limits above Bpa. However, the 20% TAC change limits can lead to the TAC being lowered significantly if the stock is estimated to be below Bpa, while also limiting how quickly the TAC can increase once the stock is estimated to have recovered above Bpa.
- The evaluation found that including a 10% interannual quota flexibility ('banking and borrowing') in the LTMS had an insignificant effect on the performance of the HCR.

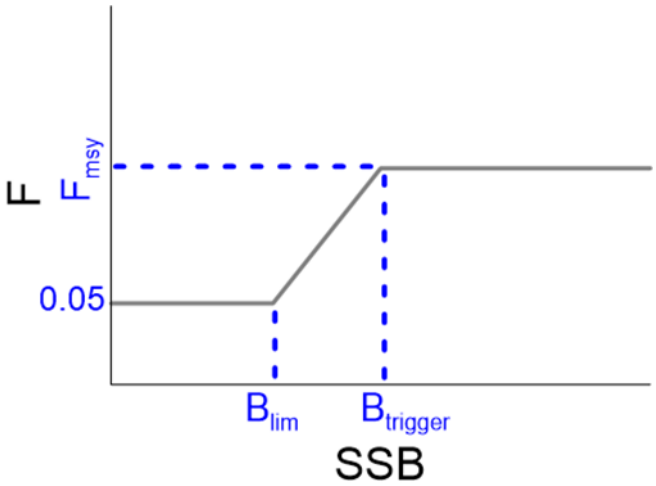


Diagram of the requested long-term management strategy to be evaluated for blue whiting. $B_{trigger} = B_{pa}$.

2.14 References

Berg, C. W., and Nielsen, A. 2016.Accounting for correlated observations in an age-based state-space stock assessment model. ICES Journal of Marine Science, doi: 10.1093/icesjms/fsw046.

ICES CM 2016/SSGIEOM:05. First Interim Report of the Working Group of International Pelagic Surveys (WGIPS) 18-22 January 2016.

ICES 2012b. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2012) 13–17 February 2012 Copenhagen, Denmark. ICES CM 2012/ACOM:47

ICES 2016.Report of the Inter-Benchmark Protocol for Blue Whiting (IBPBLW).10 March–10 May 2016.By correspondence. ICES CM 2016/ACOM:36

Nielsen, A., and Berg, C.W. 2014.Estimation of time-varying selectivity in stock assessments using state-space models. Fisheries Research, 158: 96-101

2.15 Tables

Table 2.3.1.1.Blue whiting. ICES estimated catches (tonnes) by country for the period 1988–2017.

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2003
Denmark	18 941	26 630	27 052	15 538	34 356	41 053	20 456	12 439	52 101	26 270	61 523	82 935
Estonia					6 156	1 033	4 342	7 754	10 982	5 678	6 320	
Faroes	79 831	75 083	48 686	10 563	13 436	16 506	24 342	26 009	24 671	28 546	71 218	329 895
France		2 191				1 195		720	6 442	12 446	7 984	14 149
Germany	5 546	5 417	1 699	349	1 332	100	2	6 313	6 876	4 724	17 969	22 803
Iceland		4 977						369	302	10 464	68 681	501 493
Ireland	4 646	2 014			781		3	222	1 709	25 785	45 635	22 580
Japan					918	1 742	2 574					
Latvia					10 742	10 626	2 582					
Lithuania						2 046						
Netherlands	800	2 078	7 750	17 369	11 036	18 482	21 076	26 775	17 669	24 469	27 957	48 303
Norway	233 314	301 342	310 938	137 610	181 622	211 489	229 643	339 837	394 950	347 311	560 568	834 540
Poland	10											
Portugal	5 979	3 557	2 864	2 813	4 928	1 236	1 350	2 285	3 561	2 439	1 900	2 651
Spain	24 847	30 108	29 490	29 180	23 794	31 020	28 118	25 379	21 538	27 683	27 490	13 825
Sweden ***	1 229	3 062	1 503	1 000	2 058	2 867	3 675	13 000	4 000	4 568	9 299	65 532
UK (England + Wales)****												
UK (Northern Ireland)												
UK (Scotland)	5 183	8 056	6 019	3 876	6 867	2 284	4 470	10 583	14 326	33 398	92 383	27 382
USSR / Russia *	177 521	162 932	125 609	151 226	177 000	139 000	116 781	107 220	86 855	118 656	130 042	355 319
Greenland***												
Unallocated												
TOTAL	557 847	627 447	561 610	369 524	475 026	480 679	459 414	578 905	645 982	672 437	1 128 969	2 321 406

*** From 1992 only Russia.**

Table 2.3.1.1.(continued). Blue whiting. ICES estimated catches (tonnes) by country for the period 1988–2017.

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Denmark	89 500	41 450	54 663	48 659	18 134	248	140	165	340	2 167	35 256	45 178	39 395	60 868
Estonia	**													
Faroes	322 322	266 799	321 013	317 859	225 003	58 354	49979	16405	43290	85 768	224 700	282 502	282 416	356 501
France		8 046	18 009	16 638	11 723	8 831	7839	4337	9799	8 978	10 410	9 659	10 345	13 369
Germany	15 293	22 823	36 437	34 404	25 259	5 044	9108	278	6239	11 418	24 487	24 107	20 025	45 555
Iceland	379 643	265 516	309 508	236 538	159 307	120 202	87942	5887	63056	104 918	182 879	214 870	186 914	228 934
Ireland	75 393	73 488	54 910	31 132	22 852	8 776	8324	1195	7557	13 205	21 466	24 785	27 657	43 238
Lithuania			4 635	9 812	5 338						4 717		1 129	5 300
Netherlands	95 311	147 783	102 711	79 875	78 684	35 686	33762	4595	26526	51 635	38 524	56 397	58 148	81 156
Norway	957 684	738 490	642 451	539 587	418 289	225 995	194317	20539	118832	196 246	399 520	489 439	310 412	399 363
Poland														15 889
Portugal	3 937	5 190	5 323	3 897	4 220	2 043	1482	603	1955	2 056	2 150	2 547	2 586	2 046
Spain	15 612	17 643	15 173	13 557	14 342	20 637	12891	2416	6726	15 274	32065	29 206	31 952	28 920
Sweden	19 083	2 960	101	464	4	3	50	1	4	199	2	32	42	90
UK (England + Wales) +	2 593	7 356	10 035	12 926	14 147	6 176	2475	27	1590	4 100	11	131	1 374	3 447
UK (Northern Ireland)										1 232	2 205	1 119		
UK (Scotland)	57 028	104 539	72 106	43 540	38 150	173	5496	1331	6305	8 166	24 630	30 508	37 173	64 724
Russia	346 762	332 226	329 100	236 369	225 163	149 650	112553	45841	88303	120 674	152 256	185 763	173 655	188 449
Greenland										2 133				20 212
Unallocated									3 499					
TOTAL	2380161	2034309	1976176	1625255	1260615	641818	526357	103620	384021	628169	1155279	1396244	1 183 224	**1 558 061**

**** Reported to the EU but not to the ICES WGNPBW (Landings of 19,467 tonnes).**

+ data from 2017 updated in the 2018.

Table 2.3.1.2.Blue whiting. ICES estimated catches (tonnes) by country and area for 2017.

	Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	Sweden	UK (England)	UK(Scotland)	Grand Total
27.14.a					27													**27**
27.14.b					0													**0**
27.2.a	1	47 377		5 857	2 931	36 305	9		1 942	8 066			21 736		3	108		**124 335**
27.3.a	41	5								185					87			**317**
27.3.d	0																	**0**
27.4.a	26	3 708	46	1 938	2 942	9 595			1 805	24 113	170		795		0			**45 138**
27.4.b	2									17					0		0	**18**
27.4.c	0															0		**0**
27.5.a		250				11 953												**12 203**
27.5.b		217 002	453	5 133	12 612	125 237			7 555	2 143			86 285					**456 419**
27.6.a	18 255	31 136	5 641	21 242	1 700	35 023	18 787		35 274	139 826	13 405		12 778	1		3 332	37 383	**373 783**
27.6.b	479	5 900	231			10 821	1 208		338	32 790			7 573	4			1 323	**60 668**
27.7.b	2 597			16			1 450		272					25		2		**4 362**
27.7.c	35 493	36 797	5 784	10 245			21 750	3 099	33 888	183 677	1 604		30 467	52			26 018	**388 873**
27.7.d			0															**0**
27.7.e			36													2		**38**
27.7.f																0		**0**
27.7.g			11													0		**11**
27.7.h			8	10										4		2		**23**
27.7.j			206	19			35		81					210				**550**
27.7.k	3 974	14 327	830	1 095				2 201		8 548	711		28 815	2				**60 502**
27.8.a			71											2				**73**
27.8.b			26											218				**245**
27.8.c			0											21 449				**21 449**
27.8.d			26											1				**27**
27.9.a												2 046		6 951				**8 997**
Total	**60 868**	**356 501**	**13 369**	**45 555**	**20 212**	**228 934**	**43 238**	**5 300**	**81 156**	**399 363**	**15 889**	**2 046**	**188 449**	**28 920**	**90**	**3 447**	**64 724**	**1 558 061**

Table 2.3.1.3.Blue whiting. ICES estimated catches (tonnes) by quarter and area for 2017.

Area	Quarter 1	Quarter 2	Quarter 3	Quarter 4	2017	Total
27.2.a	354	61145	43238	19598		**124335**
27.3.a	0	1	313	3		**317**
27.3.d	0					**0**
27.4.a	105	14313	15789	14932		**45138**
27.4.b	1	16	2	0		**18**
27.4.c	0	0	0	0		**0**
27.5.a		7553		4650		**12203**
27.5.b	57472	314429	1436	83082		**456419**
27.6.a	86698	286366	0	707	12	**373783**
27.6.b	59304	1339	2	2	22	**60668**
27.7.b	2941	1403	7	11		**4362**
27.7.c	384291	4540	17	26		**388873**
27.7.d	0					**0**
27.7.e	1	5	30	2		**38**
27.7.f		0				**0**
27.7.g		11	0			**11**
27.7.h	1	19	2	2		**23**
27.7.j	15	186	44	305		**550**
27.7.k	60500	1	1			**60502**
27.8.a	1	68	3	2		**73**
27.8.b	62	76	35	72		**245**
27.8.c	6074	5171	5362	4843		**21449**
27.8.d	0	1		26		**27**
27.9.a	1536	2945	2508	2007		**8997**
27.14.a		0	27			**27**
27.14.b			0			**0**
Grand total	**659354**	**699587**	**68817**	**130269**	**34**	**1558061**

*** Discards data from UK(Scotland) were provided by year, due to sampling intensity.**

Table 2.3.1.4.Blue whiting. ICES estimated catches (tonnes) from the main fisheries 1988–2017 by area.

Area	Norwegian Sea fishery (SAs1+2;Divs .5.a,14a-b)	Fishery in the spawning area (SA 12.; Divs. 5.b, 6.a-b, 7.a-c)	Directed- and mixed fisheries in the North Sea (SA4; Div.3.a)	Total northern areas	Total southern areas (SAs8+9;Divs.7.d-k)	Grand total
1988	55 829	426 037	45 143	**527 009**	30 838	**557 847**
1989	42 615	475 179	75 958	**593 752**	33 695	**627 447**
1990	2 106	463 495	63 192	**528 793**	32 817	**561 610**
1991	78 703	218 946	39 872	**337 521**	32 003	**369 524**
1992	62 312	318 018	65 974	**446 367**	28 722	**475 026**
1993	43 240	347 101	58 082	**448 423**	32 256	**480 679**
1994	22 674	378 704	28 563	**429 941**	29 473	**459 414**
1995	23 733	423 504	104 004	**551 241**	27 664	**578 905**
1996	23 447	478 077	119 359	**620 883**	25 099	**645 982**
1997	62 570	514 654	65 091	**642 315**	30 122	**672 437**
1998	177 494	827 194	94 881	**1 099 569**	29 400	**1 128 969**
1999	179 639	943 578	106 609	**1 229 826**	26 402	**1 256 228**
2000	284 666	989 131	114 477	**1 388 274**	24 654	**1 412 928**
2001	591 583	1 045 100	118 523	**1 755 206**	24 964	**1 780 170**
2002	541 467	846 602	145 652	**1 533 721**	23 071	**1 556 792**
2003	931 508	1 211 621	158 180	**2 301 309**	20 097	**2 321 406**
2004	921 349	1 232 534	138 593	**2 292 476**	85 093	**2 377 569**
2005	405 577	1 465 735	128 033	**1 999 345**	27 608	**2 026 953**
2006	404 362	1 428 208	105 239	**1 937 809**	28 331	**1 966 140**
2007	172 709	1 360 882	61 105	**1 594 695**	17 634	**1 612 330**
2008	68 352	1 111 292	36 061	**1 215 704**	30 761	**1 246 465**
2009	46 629	533 996	22 387	**603 012**	32 627	**635 639**
2010	36 214	441 521	17 545	**495 280**	28 552	**523 832**
2011	20 599	72 279	7 524	**100 401**	3 191	**103 592**
2012	24 391	324 545	5678.346	**354 614**	29401.78	**384016***
2013	31 759	481 356	8749.051	**521 864**	103973.5	**625837****
2014	45 580	885 483	28 596	**959 659**	195 620	**1 155 279**
2015	150 828	895 684	44 661	**1 091 173**	305 071	**1 396 244**
2016	59 744	905 087	55 774	**1 020 604**	162 583	**1 183 187**
2017	**136 565**	**1 284 105**	**45 474**	**1 466 144**	**91 917**	**1 558 061**

*** Data from UK(England + Wales) not included (2004-2007).**

**** Data from UK(England + Wales) and Sweden not included (2008-2011).**

Table 2.3.1.5. Blue whiting. ICES estimates(tonnes) of catches, landings and discards by country for 2017.

Country	Catches	Landings	Discards	% discards
Denmark	60868	60864	4	0.01
Faroe Islands	356501	356501		0.00
France	13369	13221	148	1.11
Germany	45555	45555		0.00
Greenland	20212	20212		0.00
Iceland	228934	228934		0.00
Ireland	43238	43238	0	0.00
Lithuania	5300	5300		0.00
Netherlands	81156	81156		0.00
Norway	399363	399363		0.00
Poland	15889	15889		0.00
Portugal	2046	1625	421	20.58
Russia	188449	188449		0.00
Spain	28920	27500	1419	4.91
Sweden	90	90		0.00
UK (England)	3447	3442	4	0.12
UK(Scotland)	64724	64690	34	0.05
Total	**1558061**	**1556030**	**2030**	**0.13**

Table 2.3.1.6. Blue whiting. ICES estimated catches (tonnes) inside and outside NEAFC area for 2017 by country.

	Catches inside NEAFC area	Catches outside NEAFC area	Total catches
Denmark	3935	56933	60868
Faroe Islands	45731	310770	356501
France	230*	13139	13369
Germany	41471	4084	45555
Greenland	1	20211	20212
Iceland	8127	220807	228934
Ireland	9	43229	43238
Lithuania**	0	5300	5300
Netherlands	1073	80082	81156
Norway	77714	321649	399363
Poland	0	15889	15889
Portugal	0	2046	2046
Russia	84620	103829	188449
Spain	0	28920	28920
Sweden**	0	90	90
UK (England)	108	3339	3447
UK(Scotland)	0	64724	64724
Total in 2017	**263019**	**1295042**	**1558061**

*** landings only.**
**** those values are assumed, since data of catches inside/outside NEAFC was not available.**

Table 2.3.1.1.1. Blue whiting. ICES estimated catches (tonnes), the percentage of catch covered by the sampling programme, No. of samples, No. of fish measured and No. of fish aged for 2000-2017.

Year	Catch (tonnes)	% catch covered by sampling programme	No. samples	No. Measured	No. Aged
2000	1412928	*	1136	125162	13685
2001	1780170	*	985	173553	17995
2002	1556792	*	1037	116895	19202
2003	2321406	*	1596	188770	26207
2004	2377569	*	1774	181235	27835
2005	2026953	*	1833	217937	32184
2006	1966140	*	1715	190533	27014
2007	1610090	87	1399	167652	23495
2008	1246465	90	927	113749	21844
2009	635639	88	705	79500	18142
2010	524751	87	584	82851	16323
2011	103591	85	697	84651	12614
2013	625837	96	915	111079	14633
2014	1155279	89	912	111316	39738
2015	1396244	94	1570	102367	29821
2016	1183187	89	1092	120329	13793
2017	**1558061**	**91**	**1779**	**147297**	**15828**

Table 2.3.1.1.2. Blue whiting. ICES estimated catches (tonnes), the percentage of catch covered by the sampling programme (catch-at-age numbers), No. of samples, No. of fish measured, No. of fish aged, No. of fish aged by 1000 tonnes and No. of fish measured by 1000 tonnes by country for 2017.

Country	Catch (ton)	% catch covered by sampling programme	No. samples	No. Measured	No. Aged	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
Denmark	60868	88	43	1402	1402	23	23
Faroe Islands	356501	89	32	3159	1710	5	9
France	13369	0	118	7004	0	0	524
Germany	45555	58	59	23277	563	12	511
Greenland	20212	0	0	0	0	0	0
Iceland	228934	100	84	7545	2112	9	33
Ireland	43238	94	14	2997	1426	33	69
Lithuania	5300	0	0	0	0	0	0
Netherlands	81156	83	74	16866	1850	23	208
Norway	399363	100	287	11868	1120	3	30
Poland	15889	0	0	0	0	0	0
Portugal	2046	100	69	3725	1045	511	1821
Russia	188449	100	41	36931	1702	9	196
Spain	28920	99	951	31012	2526	87	1072
Sweden	90	0	0	0	0	0	0
UK (England)	3447	0	0	0	0	0	0
UK(Scotland)	64724	87	7	1511	372	6	23
Total	**1558061**	**91**	**1779**	**147297**	**15828**	**10**	**95**

Table 2.3.1.2.3.Blue whiting. ICES estimated catches (tonnes), No. of samples, No. of fish measured and No. of fish aged by country and quarter for 2017.

	Catch (tonnes)	No. samples	No. Length Measured	No. Age Samples
Denmark				
1	42554	39	1243	1243
2	18246	4	159	159
3	58	0	0	0
4	9	0	0	0
Total	60868	43	1402	1402
Faroe Islands				
1	118066	16	1504	810
2	174329	13	1365	700
3	14778	2	190	100
4	49328	1	100	100
Total	356501	32	3159	1710
France				
1	4317	52	4078	0
2	8084	57	2488	0
3	37	0	0	0
4	931	9	438	0
Total	13369	118	7004	0
Germany				
1	11380	0	0	0
2	27524	59	23277	563
3	3677	0	0	0
4	2973	0	0	0
Total	45555	59	23277	563
Greenland				
2	15260	0	0	0
3	29	0	0	0
4	4924	0	0	0
Total	20212	0	0	0
Iceland				
1	10821	5	451	120
2	169503	65	5986	1642
3	5279	2	147	50
4	43331	12	961	300
Total	228934	84	7545	2112
Ireland				
1	33829	13	2817	1323
2	9400	1	180	103
4	9	0	0	0
Total	43238	14	2997	1426
Lithuania				
1	5300	0	0	0
Total	5300	0	0	0
Netherlands				
1	33162	66	14854	1650
2	37306	8	2012	200
3	1286	0	0	0
4	9401	0	0	0
Total	81156	74	16866	1850
Norway				
1	274147	32	1368	647
2	98041	71	2653	362
3	21716	152	6768	90
4	5459	32	1079	21
Total	399363	287	11868	1120
Poland				
1	2315	0	0	0
2	13575	0	0	0
Total	15889	0	0	0
Portugal				
1	456	15	779	159
2	462	18	741	136
3	541	20	1393	412
4	587	16	812	338
Total	2046	69	3725	1045
Russia				
1	83298	13	11113	597
2	84503	17	14997	822
3	13800	5	5503	120
4	6848	6	5318	163
Total	188449	41	36931	1702
Spain				
1	7231	257	8702	602
2	7803	270	9456	446
3	7425	194	5900	703
4	6460	230	6954	775
Total	28920	951	31012	2526
Sweden				
1	0	0	0	0
2	0	0	0	0
3	86	0	0	0
4	3	0	0	0
Total	90	0	0	0
UK (England)				
1	3	0	0	0
2	3334	0	0	0
3	104	0	0	0
4	6	0	0	0
Total	3447	0	0	0
UK(Scotland)				
1	32474	5	1159	250
2	32216	2	352	122
3	0	0	0	0
4	0	0	0	0
2017	34	0	0	0
Total	64724	7	1511	372
Grand Total	**1558061**	**1779**	**147297**	**15828**

*** Discards data from UK(Scotland) were provided by year, due to sampling intensity.**

Table 2.3.1.1.4. Blue whiting. ICES estimated catches (tonnes), the percentage of catch covered by the sampling programme, No. of samples, No. of fish measured, No. of fish aged, No. of fish aged by 1000 tonnes and No. of fish measured by 1000 tonnes by ICES division for 2017.

Division	Catch (ton)	No. samples	No. Measured	No. Aged	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
27.2.a	124335	68	20694	961	8	166
27.3.a	317	26	442	0	0	1392
27.3.d	0	0	0	0	0	0
27.4.a	45138	219	14615	364	8	324
27.4.b	18	0	0	0	0	0
27.4.c	0	0	0	0	0	0
27.5.a	12203	8	575	198	16	47
27.5.b	456419	105	30633	3207	7	67
27.6.a	373783	98	12055	2073	6	32
27.6.b	60668	9	689	240	4	11
27.7.b	4362	0	0	0	0	0
27.7.c	388873	163	25530	4350	11	66
27.7.d	0	0	0	0	0	0
27.7.e	38	0	0	0	0	0
27.7.f	0	0	0	0	0	0
27.7.g	11	18	136	0	0	12293
27.7.h	23	6	59	0	0	2514
27.7.j	550	0	0	0	0	0
27.7.k	60502	29	6982	864	14	115
27.8.a	73	0	0	0	0	0
27.8.b	245	182	4319	0	0	17652
27.8.c	21449	439	19712	1335	62	919
27.8.d	27	0	0	0	0	0
27.9.a	8997	409	10856	2236	249	1207
27.14.a	27	0	0	0	0	0
27.14.b	0	0	0	0	0	0
TOTAL	**1558061**	**1779**	**147297**	**15828**	**385**	**36807**

Table 2.3.2.1 .Blue whiting. ICES estimated preliminary catches (tonnes) in 2018 by quarter and area.

	Landings		
ICES div.	**Quarter 1**	**Quarter 2**	**Total**
27.2.a	346	21902	**22248**
27.2.a.1		1023	**1023**
27.2.a.2	20	4421	**4441**
27.4.a	14	13105	**13119**
27.4.b		7	**7**
27.5.a		2403	**2403**
27.5.b	74661	376864	**451525**
27.5.b.1		1222	**1222**
27.6.a	31506	310952	**342457**
27.6.b	140727	300	**141027**
27.6.b.2	22083	788	**22870**
27.7.b	4017	756	**4773**
27.7.c	181026	6416	**187442**
27.7.c.2	91345	4781	**96127**
27.7.j.2	1	21	**22**
27.7.k	39508		**39508**
27.9.a	177	364	**541**
Total	**585430**	**745323**	**1330754**

Table 2.3.2.2.Blue whiting. ICES estimated preliminary catches (tonnes), the percentage of catch covered by the sampling programme, No. of samples, No. of fish measured, No. of fish aged, No. of fish aged by 1000 tonnes and No. of fish measured by 1000 tonnes by ICES division for 2018 preliminary data (quarters 1 and 2).

ICES div.	Catch (ton)	No. samples	No. Measured	No. Aged
27.2.a	22248	3	261	74
27.2.a.1	1023	0	0	0
27.2.a.2	4441	0	0	0
27.4.a	13119	0	0	0
27.4.b	7	0	0	0
27.5.a	2403	0	0	0
27.5.b	451525	56	16213	2215
27.5.b.1	1222	2	34	34
27.6.a	342457	22	4157	1210
27.6.b	141027	14	2582	452
27.6.b.2	22870	5	502	301
27.7.b	4773	0	0	0
27.7.c	187442	33	7108	1338
27.7.c.2	96127	19	1960	755
27.7.j.2	22	0	0	0
27.7.k	39508	26	5496	360
27.9.a	541	11	749	251
Total	**1330754**	**191**	**39062**	**6990**

Table 2.3.2.3. Blue whiting. ICES estimates of catches (tonnes) in 2018, based on (initial) declared quotas and expected uptake estimated by WGWIDE.

Country	Prelim Q1–Q2 catch	National Quota	Deviation from quota
Denmark	87289	61,277	26,012
Faroe Islands	307,353	493,081	-99,500
Germany	39,281	23,825	15,456
Greenland	14,839	16,000	0
Iceland	224,009	275971	0
Ireland	47,620	47,451	0
Lithuania	0	5,300	0
Netherlands	0	74,720	40,013
Norway	420,161	421,100	10,000
Portugal	541	4,826	-2,413
Russia	145,206	207,345	-47,345
UK(Scotland)	65,503	79,513	-9,513
UK (England)	0	0	0
Sweden	0	15,158	-15,000
France	0	42,644	-25,000
Spain	0	51,949	0
Total	1,351,802	1,819,860	-106,990
EU	240,234	401,363	
	Best guess on catches in 2018		**1,712,870**

Table 2.3.2.4. Blue whiting. Comparison of preliminary and final catches (tonnes).

Year	Preliminary	Final	Deviation %*
2016	1147000	1180786	2.9
2017	1559437	1555069	-0.3
2018	1712874		

*** (final-preliminary)/final*100**

Table 2.3.2.1.1 .Blue whiting. Proportion of the annual catch taken in the first half-year of 2015-2017, average proportion and scaling factor used for raising the preliminary first half year of 2018 catch data.

VALUES	2015	2016	2017	AVERAGE	RAISING FACTOR
Age 1	76.6	76.4	73.3	75.4	1.326
Age 2	83.7	85.9	82.5	84.0	1.190
Age 3	87.4	92.2	87.9	89.2	1.122
Age 4	89.5	92.3	91.0	90.9	1.100
Age 5	91.7	97.0	93.8	94.2	1.062
Age 6	88.9	97.1	94.5	93.5	1.069
Age 7	88.9	96.2	98.1	94.4	1.059
Age 8	90.8	98.1	97.2	95.4	1.048
Age 9	95.2	96.3	98.6	96.7	1.034
Age 10	90.3	95.0	97.2	94.2	1.062

Table 2.3.3.1.Bluewhiting. Catch-at-age numbers (thousands) by year. Discards included since 2014. Values for 2018 are preliminary.

Year Age	1	2	3	4	5	6	7	8	9	10+
1981	258000	348000	681000	334000	548000	559000	466000	634000	578000	1460000
1982	148000	274000	326000	548000	264000	276000	266000	272000	284000	673000
1983	2283000	567000	270000	286000	299000	304000	287000	286000	225000	334000
1984	2291000	2331000	455000	260000	285000	445000	262000	193000	154000	255000
1985	1305000	2044000	1933000	303000	188000	321000	257000	174000	93000	259000
1986	650000	816000	1862000	1717000	393000	187000	201000	198000	174000	398000
1987	838000	578000	728000	1897000	726000	137000	105000	123000	103000	195000
1988	425000	721000	614000	683000	1303000	618000	84000	53000	33000	50000
1989	865000	718000	1340000	791000	837000	708000	139000	50000	25000	38000
1990	1611000	703000	672000	753000	520000	577000	299000	78000	27000	95000
1991	266686	1024468	513959	301627	363204	258038	159153	49431	5060	9570
1992	407730	653838	1641714	569094	217386	154044	109580	79663	31987	11706
1993	263184	305180	621085	1571236	411367	191241	107005	64769	38118	17476
1994	306951	107935	367962	389264	1221919	281120	174256	90429	79014	30614
1995	296100	353949	421560	465358	615994	800201	253818	159797	59670	41811
1996	1893453	534221	632361	537280	323324	497458	663133	232420	98415	82521
1997	2131494	1519327	904074	577676	295671	251642	282056	406910	104320	169235
1998	1656926	4181175	3541231	1044897	383658	322777	303058	264105	212452	85513
1999	788200	1549100	5820800	3460600	412800	207200	151200	153100	68800	140500
2000	1814851	1192657	3465739	5014862	1550063	513663	213057	151429	58277	139791
2001	4363690	4486315	2962163	3806520	2592933	585666	170020	97032	76624	66410
2002	1821053	3232244	3291844	2242722	1824047	1647122	344403	168848	102576	142743
2003	3742841	4073497	8378955	4824590	2035096	1117179	400022	121280	19701	27493
2004	2156261	4426323	6723748	6697923	3044943	1276412	649885	249097	75415	36805
2005	1427277	1518938	5083550	5871414	4450171	1419089	518304	249443	100374	55226
2006	412961	939865	4206005	6150696	3833536	1718775	506198	181181	67573	36688
2007	167027	306898	1795021	4210891	3867367	2353478	935541	320529	130202	88573
2008	408790	179211	545429	2917190	3262956	1919264	736051	315671	113086	126637
2009	61125	156156	231958	594624	1596095	1156999	592090	251529	88615	48908
2010	349637	222975	160101	208279	646380	992214	702569	256604	70487	43693
2011	162997	101810	63954	53863	69717	116396	120359	55470	25943	12542
2012	239667	351845	663155	141854	106883	203419	363779	356785	212492	157947
2013	228175	508122	848597	896966	462714	224066	321310	397536	344285	383601
2014	588717	584084	2312953	2019373	1272862	416523	386396	462339	526141	662747

Year Age	1	2	3	4	5	6	7	8	9	10+
2015	2944849	2852384	2427329	2465286	1518235	707533	329882	258743	239164	450046
2016	1239331	3518677	2933271	1874011	1367844	756824	339851	185368	131039	288635
2017	401947	1999011	7864694	4063916	1509651	777185	263007	110351	63945	149369
2018	497019	575187	3292297	6825720	3034801	1026145	312013	112844	69289	166324

Table 2.3.4.1. Blue whiting. Individual mean weight (kg) at age in the catch. Preliminary values for 2018 (average of 2015-2017) are included.

Year Age	1	2	3	4	5	6	7	8	9	10+
1981	0.052	0.065	0.103	0.125	0.141	0.155	0.170	0.178	0.187	0.213
1982	0.045	0.072	0.111	0.143	0.156	0.177	0.195	0.200	0.204	0.231
1983	0.046	0.074	0.118	0.140	0.153	0.176	0.195	0.200	0.204	0.228
1984	0.035	0.078	0.089	0.132	0.153	0.161	0.175	0.189	0.186	0.206
1985	0.038	0.074	0.097	0.114	0.157	0.177	0.199	0.208	0.218	0.237
1986	0.040	0.073	0.108	0.130	0.165	0.199	0.209	0.243	0.246	0.257
1987	0.048	0.086	0.106	0.124	0.147	0.177	0.208	0.221	0.222	0.254
1988	0.053	0.076	0.097	0.128	0.142	0.157	0.179	0.199	0.222	0.260
1989	0.059	0.079	0.103	0.126	0.148	0.158	0.171	0.203	0.224	0.253
1990	0.045	0.070	0.106	0.123	0.147	0.168	0.175	0.214	0.217	0.256
1991	0.055	0.091	0.107	0.136	0.174	0.190	0.206	0.230	0.232	0.266
1992	0.057	0.083	0.119	0.140	0.167	0.193	0.226	0.235	0.284	0.294
1993	0.066	0.082	0.109	0.137	0.163	0.177	0.200	0.217	0.225	0.281
1994	0.061	0.087	0.108	0.137	0.164	0.189	0.207	0.217	0.247	0.254
1995	0.064	0.091	0.118	0.143	0.154	0.167	0.203	0.206	0.236	0.256
1996	0.041	0.080	0.102	0.116	0.147	0.170	0.214	0.230	0.238	0.279
1997	0.047	0.072	0.102	0.121	0.140	0.166	0.177	0.183	0.203	0.232
1998	0.048	0.072	0.094	0.125	0.149	0.178	0.183	0.188	0.221	0.248
1999	0.063	0.078	0.088	0.109	0.142	0.170	0.199	0.193	0.192	0.245
2000	0.057	0.075	0.086	0.104	0.133	0.156	0.179	0.187	0.232	0.241
2001	0.050	0.078	0.094	0.108	0.129	0.163	0.186	0.193	0.231	0.243
2002	0.054	0.074	0.093	0.115	0.132	0.155	0.173	0.233	0.224	0.262
2003	0.049	0.075	0.098	0.108	0.131	0.148	0.168	0.193	0.232	0.258
2004	0.042	0.066	0.089	0.102	0.123	0.146	0.160	0.173	0.209	0.347
2005	0.039	0.068	0.084	0.099	0.113	0.137	0.156	0.166	0.195	0.217
2006	0.049	0.072	0.089	0.105	0.122	0.138	0.163	0.190	0.212	0.328
2007	0.050	0.064	0.091	0.103	0.115	0.130	0.146	0.169	0.182	0.249
2008	0.055	0.075	0.100	0.106	0.120	0.133	0.146	0.160	0.193	0.209
2009	0.056	0.085	0.105	0.119	0.124	0.138	0.149	0.179	0.214	0.251
2010	0.052	0.064	0.110	0.154	0.154	0.163	0.175	0.187	0.200	0.272
2011	0.055	0.079	0.107	0.136	0.169	0.169	0.179	0.189	0.214	0.270
2012	0.041	0.072	0.098	0.140	0.158	0.172	0.180	0.185	0.189	0.203
2013	0.051	0.077	0.094	0.117	0.139	0.162	0.185	0.188	0.198	0.197

Year Age	1	2	3	4	5	6	7	8	9	10+
2014	0.049	0.078	0.093	0.112	0.128	0.155	0.178	0.190	0.202	0.217
2015	0.039	0.070	0.094	0.117	0.137	0.155	0.174	0.183	0.193	0.201
2016	0.047	0.066	0.084	0.107	0.125	0.142	0.152	0.167	0.184	0.206
2017	0.056	0.072	0.080	0.094	0.113	0.131	0.148	0.172	0.190	0.212
2018	0.047	0.069	0.086	0.106	0.125	0.143	0.158	0.174	0.189	0.206

Table 2.3.5.1.Blue whiting. Natural mortality and proportion mature.

AGE	0	1	2	3	4	5	6	7–10+
Proportion mature	0.00	0.11	0.40	0.82	0.86	0.91	0.94	1.00
Natural mortality	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Table 2.3.7.1.1.Bluewhiting.Time-series of StoX abundance estimates of blue whiting (millions) by age in the IBWSS. Total biomass in last column (1000 t).

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	TSB
2004	1 097	5 538	13 062	15 134	5 119	1 086	994	593	164		3 505
2005	2 129	1 413	5 601	7 780	8 500	2 925	632	280	129	23	2 513
2006	2 512	2 222	10 858	11 677	4 713	2 717	923	352	198	31	3 512
2007	468	706	5 241	11 244	8 437	3 155	1 110	456	123	58	3 274
2008	337	523	1 451	6 642	6 722	3 869	1 715	1 028	269	284	2 639
2009	275	329	360	1 292	3 739	3 457	1 636	587	250	162	1 599
2010*											
2011	312	1 361	1 135	930	1 043	1 712	2 170	2 422	1 298	250	1 826
2012	1 141	1 818	6 464	1 022	596	1 420	2 231	1 785	1 256	1 022	2 355
2013	586	1 346	6 183	7 197	2 933	1 280	1 306	1 396	927	1 670	3 107
2014	4 183	1 491	5 239	8 420	10 202	2 754	772	577	899	1 585	3 337
2015	3 255	4 565	1 888	3 630	1 792	465	173	108	206	247	1 403
2016	2 745	7 893	10 164	6 274	4 687	1 539	413	133	235	256	2 873
2017	275	2 180	15 939	10 196	3 621	1 711	900	75	66	144	3 135
2018	836	628	6 615	21 490	7 692	2 187	755	188	72	144	4 035

***Survey discarded.**

Table 2.3.7.1.2.Blue Whiting. Survey indices (IBWSS) as used in the assessment.

Year/ Age	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8
2004	1097	5538	13062	15134	5119	1086	994	593
2005	2129	1413	5601	7780	8500	2925	632	280
2006	2512	2222	10858	11677	4713	2717	923	352
2007	468	706	5241	11244	8437	3155	1110	456
2008	337	523	1451	6642	6722	3869	1715	1028
2009	275	329	360	1292	3739	3457	1636	587
2010	-1	-1	-1	-1	-1	-1	-1	-1
2011	312	1361	1135	930	1043	1712	2170	2422
2012	1141	1818	6464	1022	596	1420	2231	1785
2013	586	1346	6183	7197	2933	1280	1306	1396
2014	4183	1491	5239	8420	10202	2754	772	577
2015	3255	4565	1888	3630	1792	465	173	108
2016	2745	7893	10164	6274	4687	1539	413	133
2017	275	20180	15939	10196	3621	1711	900	75
2018	836	628	6615	21490	7692	2187	755	188

Table 2.3.7.2.1.Blue Whiting. Estimated abundance of 1 and 2 year old blue whiting from the International Norwegian Sea ecosystem survey, 2003–2018.

Year\Age	Age 1	Age 2
2003*	16127	9317
2004*	17792	11020
2005*	19933	7908
2006*	2512	5504
2007*	592	213
2008	25	17
2009	7	8
2010	0	280
2011	1613	0
2012	9476	3265
2013	454	6544
2014	3893	2048
2015	8563	2796
2016	4223	8089
2017	1236	2087
2018	441	1491

***Using the old TS-value. To compare the results all values were divided by approximately 3.1.**

Table 2.3.7.2.2.Blue whiting.1-group indices of blue whiting from the Norwegian winter survey (late January-early March) in the Barents Sea. (Blue whiting < 19 cm in total body length which most likely belong to 1-group.)

	Catch Rate	
Year	All	< 19 cm
1981	0.13	0
1982	0.17	0.01
1983	4.46	0.46
1984	6.97	2.47
1985	32.51	0.77
1986	17.51	0.89
1987	8.32	0.02
1988	6.38	0.97
1989	1.65	0.18
1990	17.81	16.37
1991	48.87	2.11
1992	30.05	0.06
1993	5.80	0.01
1994	3.02	0
1995	1.65	0.10
1996	9.88	5.81
1997	187.24	175.26
1998	7.14	0.21
1999	5.98	0.71
2000	129.23	120.90
2001	329.04	233.76
2002	102.63	9.69
2003	75.25	15.15
2004	124.01	36.74
2005	206.18	90.23
2006	269.2	3.52
2007	80.38	0.16
2008	17.97	0.04
2009	4.50	0.01
2010	3.30	0.08
2011	1.48	0.01
2012	127.71	125.93
2013	39.54	2.33
2014	31.48	24.97
2015	148.4	128.34
2016	86.99	11.31
2017	167.16	0.71
2018	9.52	0.007

Table 2.3.7.2.3.Blue whiting.1-group indices of blue whiting from the Icelandic bottom-trawl surveys, 1-group (< 22 cm in March).

Catch Rate	
Year	< 22 cm
1996	6.5
1997	3.4
1998	1.1
1999	6.3
2000	9
2001	5.2
2002	14.2
2003	15.4
2004	8.9
2005	8.3
2006	30.4
2007	3.9
2008	0.1
2009	1.6
2010	0.2
2011	10.8
2012	29.9
2013	11.7
2014	66.3
2015	43.8
2016	6.3
2017	1.8
2018	0.4

Table 2.3.7.2.4.Blue whiting.1-group indices of blue whiting from Faroese bottom-trawl surveys, 1-group (< 23 cm in March).

Catch Rate	
Year	< 23 cm
1994	1382
1995	1105
1996	4442
1997	1764
1998	360
1999	1330
2000	782
2001	3357
2002	3885
2003	929
2004	15163
2005	23750
2006	13364
2007	11509
2008	840
2009	3754
2010	824
2011	11406
2012	5345
2013	8855
2014	51313
2015	14444
2016	22485
2017	5286
2018	1948

Table 2.4.1.Blue whiting. Parameter estimates, from final assessment (2018) and retrospective analysis (2015-2017).

PARAMETER YEAR	2014	2015	2016	2017	2018
Random walk variance					
-F Age 1-10	0.40	0.41	0.39	0.38	0.38
Process error					
-log(N) Age 1	0.58	0.58	0.58	0.62	0.62
--- Age 2-10	0.15	0.17	0.17	0.18	0.19
Observation variance					
-Catch Age 1	0.41	0.46	0.45	0.44	0.44
--- Age 2	0.30	0.29	0.29	0.29	0.28
--- Age 3-8	0.21	0.20	0.20	0.20	0.19
--- Age 9-10	0.41	0.40	0.40	0.40	0.40
-IBWSS Age 1	0.91	0.77	0.75	0.77	0.73
--- Age 2	0.33	0.33	0.31	0.32	0.31
--- Age 3	0.42	0.46	0.46	0.44	0.42
--- Age 4-6	0.35	0.45	0.45	0.40	0.39
--- Age 7-8	0.29	0.37	0.41	0.48	0.51
Survey_catchability					
-IBWSS Age 1	0.06	0.07	0.07	0.07	0.07
--- Age 2	0.10	0.12	0.12	0.12	0.12
--- Age 3	0.33	0.38	0.36	0.38	0.38
--- Age 4	0.60	0.70	0.66	0.70	0.70
--- Age 5-8	0.86	0.92	0.86	0.89	0.88
Rho					
--	0.91	0.92	0.92	0.93	0.94

Table 2.4.2.Blue whiting. Mohn's rho by year and average over the last five years (n=5).

Year	R(age 1)	SSB	Fbar(3–7)
2013	-0.218	0.206	-0.140
2014	-0.350	0.353	-0.298
2015	-0.266	-0.094	0.203
2016	0.472	0.134	-0.167
2017	0.177	-0.009	0.026
Rho-mean	-0.037	0.118	-0.075

Table 2.4.3.Blue whiting. Estimated fishing mortalities. Catch data for 2018 are preliminary.

Year Age	1	2	3	4	5	6	7	8	9	10
1981	0.078	0.118	0.172	0.212	0.245	0.318	0.346	0.442	0.482	0.482
1982	0.067	0.102	0.148	0.183	0.208	0.270	0.293	0.371	0.401	0.401
1983	0.078	0.118	0.171	0.211	0.240	0.314	0.338	0.419	0.445	0.445
1984	0.096	0.143	0.212	0.265	0.305	0.397	0.418	0.509	0.528	0.528
1985	0.101	0.151	0.230	0.295	0.347	0.448	0.466	0.561	0.575	0.575
1986	0.113	0.169	0.269	0.358	0.432	0.553	0.573	0.692	0.703	0.703
1987	0.101	0.150	0.248	0.338	0.416	0.538	0.560	0.674	0.674	0.674
1988	0.098	0.148	0.253	0.349	0.438	0.574	0.588	0.693	0.677	0.677
1989	0.113	0.171	0.303	0.419	0.525	0.684	0.711	0.840	0.804	0.804
1990	0.105	0.159	0.292	0.407	0.510	0.663	0.711	0.846	0.813	0.813
1991	0.059	0.089	0.167	0.234	0.288	0.366	0.393	0.463	0.448	0.448
1992	0.049	0.073	0.140	0.195	0.233	0.286	0.311	0.369	0.362	0.362
1993	0.042	0.063	0.125	0.176	0.206	0.246	0.268	0.319	0.314	0.314
1994	0.036	0.054	0.113	0.160	0.186	0.219	0.241	0.292	0.285	0.285
1995	0.046	0.070	0.149	0.214	0.243	0.284	0.313	0.381	0.367	0.367
1996	0.056	0.085	0.185	0.270	0.297	0.347	0.382	0.471	0.450	0.450
1997	0.055	0.084	0.188	0.279	0.300	0.349	0.382	0.473	0.452	0.452
1998	0.070	0.110	0.250	0.380	0.407	0.472	0.508	0.627	0.590	0.590
1999	0.064	0.101	0.237	0.368	0.396	0.457	0.481	0.590	0.556	0.556
2000	0.074	0.118	0.279	0.444	0.496	0.575	0.587	0.703	0.664	0.664
2001	0.070	0.112	0.265	0.428	0.493	0.571	0.573	0.677	0.642	0.642
2002	0.066	0.105	0.251	0.417	0.502	0.593	0.595	0.698	0.664	0.664
2003	0.068	0.108	0.262	0.438	0.541	0.632	0.625	0.704	0.666	0.666

Year Age	1	2	3	4	5	6	7	8	9	10
2004	0.070	0.111	0.271	0.461	0.590	0.689	0.686	0.750	0.709	0.709
2005	0.061	0.097	0.241	0.420	0.557	0.651	0.656	0.704	0.668	0.668
2006	0.053	0.084	0.210	0.372	0.507	0.596	0.605	0.638	0.605	0.605
2007	0.050	0.080	0.198	0.356	0.502	0.602	0.625	0.657	0.626	0.626
2008	0.043	0.070	0.172	0.307	0.441	0.529	0.560	0.588	0.567	0.567
2009	0.028	0.046	0.113	0.196	0.285	0.340	0.368	0.384	0.373	0.373
2010	0.020	0.034	0.081	0.137	0.199	0.236	0.258	0.264	0.258	0.258
2011	0.006	0.010	0.024	0.040	0.057	0.067	0.073	0.076	0.075	0.075
2012	0.013	0.022	0.053	0.086	0.123	0.144	0.162	0.170	0.170	0.170
2013	0.022	0.038	0.094	0.152	0.217	0.252	0.285	0.305	0.304	0.304
2014	0.041	0.073	0.184	0.298	0.422	0.491	0.553	0.599	0.595	0.595
2015	0.055	0.097	0.245	0.396	0.561	0.659	0.729	0.792	0.784	0.784
2016	0.049	0.088	0.220	0.357	0.508	0.609	0.670	0.731	0.723	0.723
2017	0.050	0.089	0.222	0.358	0.506	0.608	0.655	0.716	0.712	0.712
2018	0.049	0.088	0.217	0.346	0.491	0.589	0.629	0.690	0.694	0.694

Table 2.4.4. Blue whiting. Estimated stock numbers-at-age (thousands). Preliminary catch data for 2018 have been used.

Year / Age	1	2	3	4	5	6	7	8	9	10
1981	3943692	3488784	4859060	2076248	2618264	2146444	1649518	1744321	1220346	2953625
1982	4664381	2960440	2521907	3288160	1587728	1502456	1297429	1015300	891437	1940099
1983	18115304	3773493	1878552	1823709	1908926	1219432	1012103	853821	626640	1273072
1984	18014177	14418718	2439230	1234269	1263492	1392379	813203	549695	481380	934332
1985	9611988	13503947	9735673	1453143	750716	910275	745441	457726	265989	724254
1986	7249682	6409196	9412823	5530414	943091	453109	470431	376132	229802	496885
1987	9122396	5061002	4097616	6843814	2562277	396719	253566	237646	156249	292857
1988	6427638	6873810	3531484	2884514	3707908	1260555	198998	125516	99236	171477
1989	8537748	4633873	4991355	2430816	2129918	1682807	352575	102615	60199	115895
1990	18736561	6005399	3106085	2737879	1482622	1189410	563082	121621	33337	84487
1991	8988548	15608671	4282592	1798497	1492165	870272	561713	190059	32994	45240
1992	6713109	7409881	12477451	3311350	1265977	794944	487709	288632	102008	39508
1993	4998700	5132861	5288210	9706302	2261567	978157	518320	283539	157823	74937
1994	8135997	3417183	4076316	3410694	6919250	1441441	764562	328596	205616	117856
1995	9335808	5886126	3141338	2577034	2857853	3751871	1039398	543237	219866	185984
1996	27984503	7110350	4084034	2399449	1558932	1867109	2242241	644926	306700	248522
1997	44654015	21276484	5494343	2574210	1424080	1071777	1064883	1218157	290420	333352
1998	26698034	37684012	16390067	3500268	1380547	928845	780824	604511	618616	294523
1999	20324984	20540726	27575781	10528634	1715494	776468	521586	410706	238132	428401
2000	39079520	15297659	16594148	15830032	4347296	1108867	472166	324122	155373	314533
2001	55497740	31482540	12072473	10747410	7479057	1704442	491788	227543	161849	180036
2002	48380225	45012302	20420467	8317975	5471791	3413372	695587	256524	102664	154653
2003	52143422	38633073	34816368	13565168	5063018	2969554	1214175	348189	90256	107123
2004	27840934	41597583	29708160	20801295	7277885	2454603	1318032	508010	152905	81304
2005	21854787	20958087	28217872	17943922	10759639	3244168	1107069	515249	193741	99173
2006	8915416	15214984	21736797	19133061	9422615	4457765	1359644	483782	218294	120636
2007	4873765	5916804	12980388	15742899	10276454	4686246	1836896	611595	228534	162864
2008	5730029	3456510	4319952	10977175	9140533	4906009	1864245	762892	237690	198625
2009	5577076	3930396	2416993	3700656	6945693	4727082	2206941	858654	327481	190213
2010	14802057	4904170	2336334	1860322	3357171	4327255	2843716	1206054	417629	268918
2011	18517015	12923098	3271120	1650914	1613891	2585190	2684504	1362763	816029	394679
2012	18200627	14807332	12169939	2276802	1178572	1603821	2319215	2089712	1076181	899308
2013	15173469	15156414	11246027	7226372	2191295	1069671	1355113	1601432	1329327	1363701
2014	34951221	12049711	13315826	7775563	4282644	1315215	905664	962744	984953	1461751

Year / Age	1	2	3	4	5	6	7	8	9	10
2015	57777072	30998427	10369579	8225393	4084705	1678424	708618	491099	454668	1011553
2016	29276819	51763155	20193887	7359970	4105291	1695049	657303	320562	199265	543064
2017	9104584	23379038	41023710	14373309	4332574	1911764	656796	240411	135352	321343
2018	11037772	6697833	18011646	26425229	8372176	2411845	738959	236217	102601	209397
2019		8604992	5024187	11875347	15302312	4195934	1096200	322551	97019	127623

Table 2.4.5. Blue whiting. Estimated recruitment in thousands, spawning-stock biomass (SSB) in tonnes, average fishing mortality for ages 3 to 7 (F3-7) and total-stock biomass (TBS) in tonnes. Preliminary catch data for 2018 are included.

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (3–7)	Low	High	TSB	Low	High
1981	3943692	2520198	6171224	2843780	2221416	3640508	0.258	0.186	0.359	3341965	2661374	4196604
1982	4664381	2946828	7383007	2303718	1821256	2913988	0.220	0.162	0.301	2772882	2232015	3444814
1983	18115304	11695267	28059578	1858444	1502264	2299072	0.255	0.190	0.342	2882436	2334841	3558459
1984	18014177	11740672	27639865	1752199	1441049	2130531	0.320	0.241	0.423	3080871	2473661	3837132
1985	9611988	6291195	14685653	2088626	1714249	2544764	0.357	0.273	0.468	3226731	2620479	3973239
1986	7249682	4776823	11002687	2271261	1867669	2762068	0.437	0.335	0.569	3113127	2566429	3776281
1987	9122396	5997119	13876349	1931350	1590580	2345128	0.420	0.321	0.549	2817310	2325903	3412539
1988	6427638	4223067	9783063	1637240	1359781	1971313	0.440	0.337	0.575	2426489	2011389	2927256
1989	8537748	5588110	13044327	1547528	1289249	1857550	0.528	0.406	0.687	2395234	1976026	2903376
1990	18736561	12078959	29063658	1360082	1122934	1647312	0.517	0.390	0.684	2500723	1988528	3144845
1991	8988548	5728713	14103339	1779458	1420075	2229791	0.290	0.211	0.397	3221695	2508294	4138000
1992	6713109	4333876	10398504	2459581	1936174	3124481	0.233	0.170	0.320	3529552	2782205	4477648
1993	4998700	3187939	7837980	2540869	2009014	3213523	0.204	0.149	0.279	3420516	2724355	4294568
1994	8135997	5237893	12637610	2535365	2026669	3171744	0.184	0.134	0.252	3418580	2759310	4235365
1995	9335808	6074990	14346906	2312732	1891556	2827686	0.240	0.179	0.322	3361400	2751602	4106337
1996	27984503	18249895	42911611	2212106	1827081	2678269	0.296	0.223	0.394	3728177	3018014	4605447
1997	44654015	29188410	68314138	2467411	2034689	2992161	0.299	0.226	0.397	5427534	4244969	6939538
1998	26698034	17560241	40590846	3674788	2986783	4521274	0.403	0.308	0.528	6810285	5413990	8566692
1999	20324984	13302894	31053766	4438043	3591370	5484320	0.388	0.295	0.509	7166282	5792673	8865611
2000	39079520	25520182	59843181	4235751	3497561	5129742	0.476	0.367	0.619	7456428	6049105	9191166
2001	55497740	36531341	84311145	4571904	3792756	5511112	0.466	0.358	0.606	8985204	7212545	11193538
2002	48380225	31821100	73556421	5397878	4469870	6518552	0.472	0.362	0.615	10294085	8290040	12782590
2003	52143422	34804230	78120861	6834267	5636111	8287133	0.500	0.388	0.643	11752059	9580906	14415221
2004	27840934	18409030	42105293	6730016	5610974	8072237	0.539	0.422	0.690	10293010	8540046	12405795
2005	21854787	14554141	32817581	5976941	4982409	7169991	0.505	0.392	0.650	8402061	6986988	10103727
2006	8915416	5871058	13538385	5824060	4830917	7021375	0.458	0.353	0.594	7639999	6342177	9203399
2007	4873765	3198282	7426981	4641908	3837586	5614809	0.456	0.348	0.599	5668818	4697569	6840878
2008	5730029	3706275	8858823	3584601	2920250	4400090	0.402	0.298	0.543	4396217	3597370	5372459
2009	5577076	3482285	8932002	2755802	2185478	3474958	0.260	0.187	0.362	3459138	2762543	4331386
2010	14802057	9497910	23068329	2676765	2079551	3445491	0.182	0.128	0.260	3720075	2917079	4744115
2011	18517015	11981809	28616700	2681413	2093175	3434960	0.052	0.035	0.078	4352159	3402862	5566282
2012	18200627	11951951	27716214	3379349	2706766	4219058	0.113	0.083	0.154	4982053	3987711	6224336
2013	15173469	9976381	23077923	3665883	2991885	4491716	0.200	0.150	0.267	5396783	4383191	6644762
2014	34951221	22594064	54066761	3870679	3185710	4702926	0.389	0.295	0.514	6361361	5125400	7895367
2015	57777072	36854356	90577896	4001425	3254742	4919409	0.518	0.395	0.680	7695209	5986917	9890940
2016	29276819	17996990	47626416	4575498	3546395	5903228	0.473	0.345	0.649	8320101	6256088	11065074
2017	9104584	5101379	16249224	5508728	4013548	7560914	0.470	0.315	0.702	7815325	5645224	10819641

Year	R(age 1)	Low	High	SSB	Low	High	Fbar (3–7)	Low	High	TSB	Low	High
2018	11037772	4815497	25300070	5422226	3586596	8197337	0.454	0.262	0.787	6952013	4582975	10545659
2019				4326857*								

***assuming long tem GM(1981-2017) recruitment (14580847)**

Table 2.4.6 .Blue whiting. Model estimate of total catch weight (in tonnes) and Sum of Product of catch number and mean weight at age for ages 1-10+ (Observed catch). Preliminary catch data for 2018 are included.

Year	Estimate	Low	High	Observed catch
1981	784934	556689	1106761	922980
1982	543231	409101	721340	550643
1983	512673	392727	669252	553344
1984	562099	430053	734690	615569
1985	638465	497039	820132	678214
1986	760762	592701	976476	847145
1987	638856	497827	819838	654718
1988	568654	443878	728504	552264
1989	618626	486149	787205	630316
1990	553978	432532	709524	558128
1991	406313	313193	527120	364008
1992	438851	342851	561731	474592
1993	439997	342045	565999	475198
1994	424834	328214	549897	457696
1995	507850	399237	646013	505176
1996	597801	470210	760014	621104
1997	641181	500273	821778	639681
1998	1077597	835390	1390027	1131955
1999	1243881	958805	1613717	1261033
2000	1503366	1167941	1935124	1412449
2001	1562271	1214242	2010053	1771805
2002	1716431	1333431	2209440	1556955
2003	2194967	1713850	2811144	2365319
2004	2314871	1814965	2952469	2400795
2005	1996040	1567578	2541613	2018344
2006	1841398	1444963	2346596	1956239
2007	1545598	1210851	1972889	1612269
2008	1162864	904241	1495455	1251851

Year	Estimate	Low	High	Observed catch
2009	654781	508179	843676	634978
2010	477149	364441	624713	539539
2011	136638	99573	187499	103771
2012	329201	258410	419384	375692
2013	592951	464578	756796	613863
2014	1108159	861440	1425539	1147650
2015	1355520	1064908	1725440	1390656
2016	1267922	991376	1621611	1180786
2017	1510357	1180296	1932717	1555069
2018	1688894	1292561	2206752	1712874

Table 2.8.1.1.Blue whiting. Input to short-term projection (median values for exploitation pattern and stock numbers).

Age	Mean weight in the stock (kg)	Mean weight in the catch (kg)	Proportion mature	Natural mortality	Exploi-tation pattern	Stock number(2019) (thousands)
Age 1	0.047	0.047	0.11	0.20	0.108	14580847
Age 2	0.069	0.069	0.40	0.20	0.193	8604992
Age 3	0.086	0.086	0.82	0.20	0.477	5024187
Age 4	0.106	0.106	0.86	0.20	0.762	11875347
Age 5	0.125	0.125	0.91	0.20	1.080	15302312
Age 6	0.143	0.143	0.94	0.20	1.296	4195934
Age 7	0.158	0.158	1.00	0.20	1.385	1096200
Age 8	0.174	0.174	1.00	0.20	1.519	322551
Age 9	0.189	0.189	1.00	0.20	1.528	97019
Age 10	0.206	0.206	1.00	0.20	1.528	127623

Table 2.8.2.1.1. Blue whiting. Deterministic forecast, intermediate year assumptions and recruitments.

VALUES	VALUE	NOTES
F ages 3-7 (2018)	0.454	From the assessment (preliminary 2018 catches)
SSB (2019)	4326857	From forecast
R age 1 (2018)	11037772	From assessment
R age 1 (2019)	14580847	GM (1981–2017)
R age 1 (2020)	14580847	GM (1981–2017)
Total catch (2018)	1712874	Preliminary 2018 catches as estimated by the WG, based on declaredquotas and expecteduptake.

Table 2.8.2.2.1.Blue whiting. Deterministic forecast(weights in tonnes).

Basis	Catch (2019)	F(2019)	SSB (2020)	% SSB change*	% Catch change**	% Advice change***
MSY approach: FMSY	1143629	0.320	3752236	-13.3	-33.2	-17.6
F = 0	4	0.000	4850444	12.1	-100.0	-100.0
Fpa	1725357	0.530	3201021	-26.0	0.7	24.3
Flim	2476742	0.880	2499796	-42.2	44.6	78.5
SSB (2020) = Blim	3587714	1.735	1500171	-65.3	109.5	158.5
SSB (2020 = Bpa	2747920	1.039	2250714	-48.0	60.4	98.0
SSB (2020) = MSY Btrigger	2747920	1.039	2250714	-48.0	60.4	98.0
F = F (2018)	1528542	0.454	3386825	-21.7	-10.8	10.1
SSB (2020) = SSB (2019)	544778	0.140	4325259	-0.0	-68.2	-60.7
Catch (2019) = Catch (2018)	1712790	0.525	3212862	-25.7	-0.0	23.4
Catch (2019) = Catch (2018) -20 %	1370342	0.397	3536701	-18.3	-20.0	-1.3
Catch (2019) = Advice (2018) -20 %	1109872	0.309	3784400	-12.5	-35.2	-20.0
F = 0.05	202887	0.050	4654469	7.6	-88.2	-85.4
F = 0.1	396102	0.100	4468252	3.3	-76.9	-71.5
F = 0.15	580153	0.150	4291275	-0.8	-66.1	-58.2
F = 0.16	615906	0.160	4256945	-1.6	-64.0	-55.6
F = 0.17	651316	0.170	4222960	-2.4	-62.0	-53.1
F = 0.18	686385	0.180	4189318	-3.2	-59.9	-50.5
F = 0.19	721119	0.190	4156014	-3.9	-57.9	-48.0
F = 0.2	755520	0.200	4123044	-4.7	-55.9	-45.6
F = 0.21	789591	0.210	4090406	-5.5	-53.9	-43.1
F = 0.22	823337	0.220	4058095	-6.2	-51.9	-40.7
F = 0.23	856761	0.230	4026108	-7.0	-50.0	-38.3
F = 0.24	889866	0.240	3994442	-7.7	-48.0	-35.9
F = 0.25	922655	0.250	3963093	-8.4	-46.1	-33.5
F = 0.26	955133	0.260	3932057	-9.1	-44.2	-31.2
F = 0.27	987302	0.270	3901331	-9.8	-42.4	-28.9
F = 0.28	1019165	0.280	3870912	-10.5	-40.5	-26.6
F = 0.29	1050726	0.290	3840796	-11.2	-38.7	-24.3
F = 0.3	1081989	0.300	3810980	-11.9	-36.8	-22.0
F = 0.31	1112955	0.310	3781462	-12.6	-35.0	-19.8
F = 0.32	1143629	0.320	3752236	-13.3	-33.2	-17.6
F = 0.33	1174013	0.330	3723302	-13.9	-31.5	-15.4
F = 0.34	1204111	0.340	3694655	-14.6	-29.7	-13.2
F = 0.35	1233925	0.350	3666292	-15.3	-28.0	-11.1

Year	Estimate	Low	High		Observed catch		
F = 0.45		1517116	0.450	3397635	-21.5	-11.4	9.3
F = 0.5		1649075	0.500	3272945	-24.4	-3.7	18.8

Weights in tonnes.

***) SSB 2020 relative to SSB 2019.**

****) Catch 2019 relative to expected catch in 2018 (1712874 tonnes).**

*****) Catch 2019 relative to advice for 2018 (1387872 tonnes).**

2.16 Figures

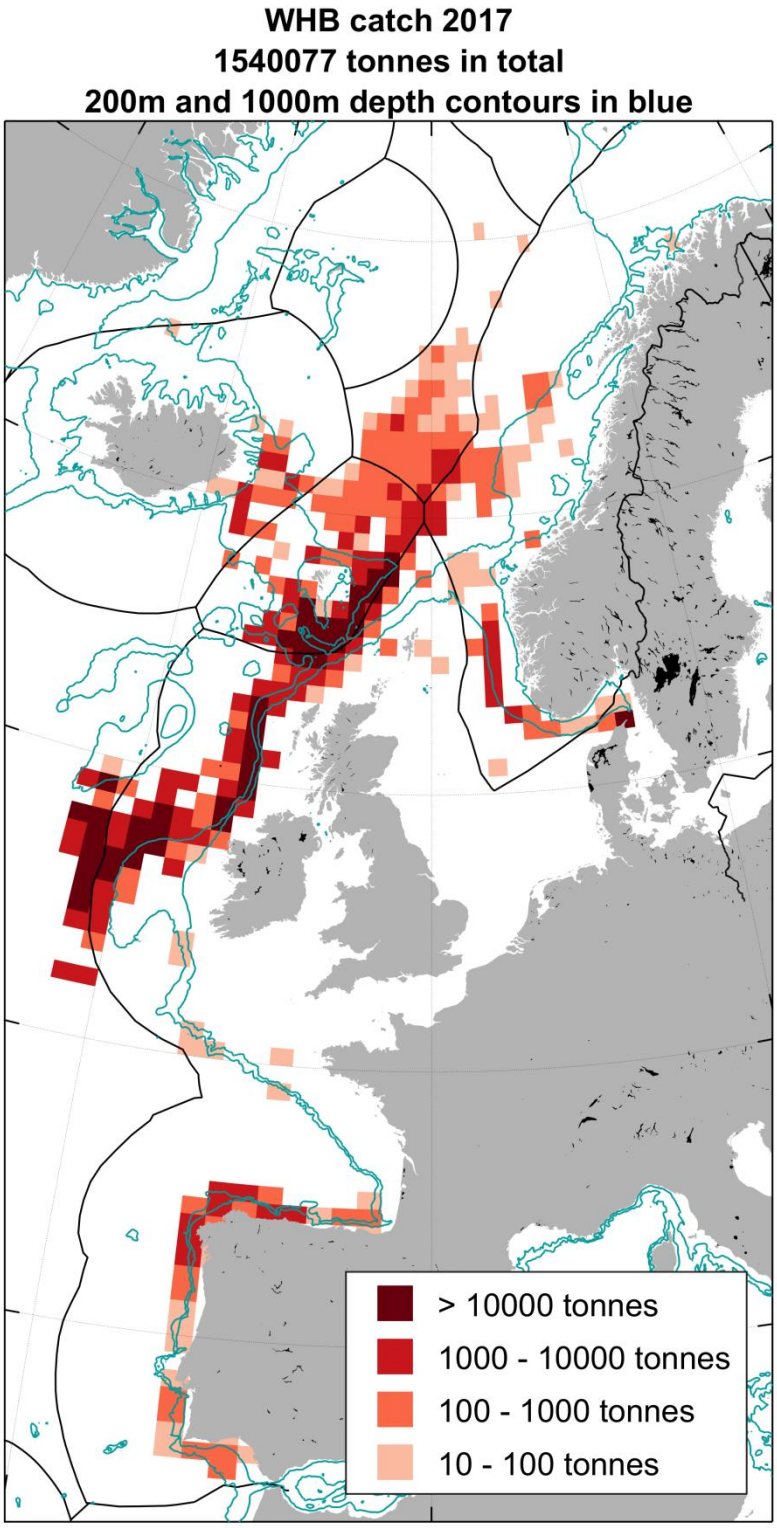


Figure 2.2.1. Blue whiting landings (ICES estimates) in 2017 by ICES rectangle. The 200 m and 1000 m depth contours are indicated in blue. The catches on the map constitute 98.8 % of the total landings.

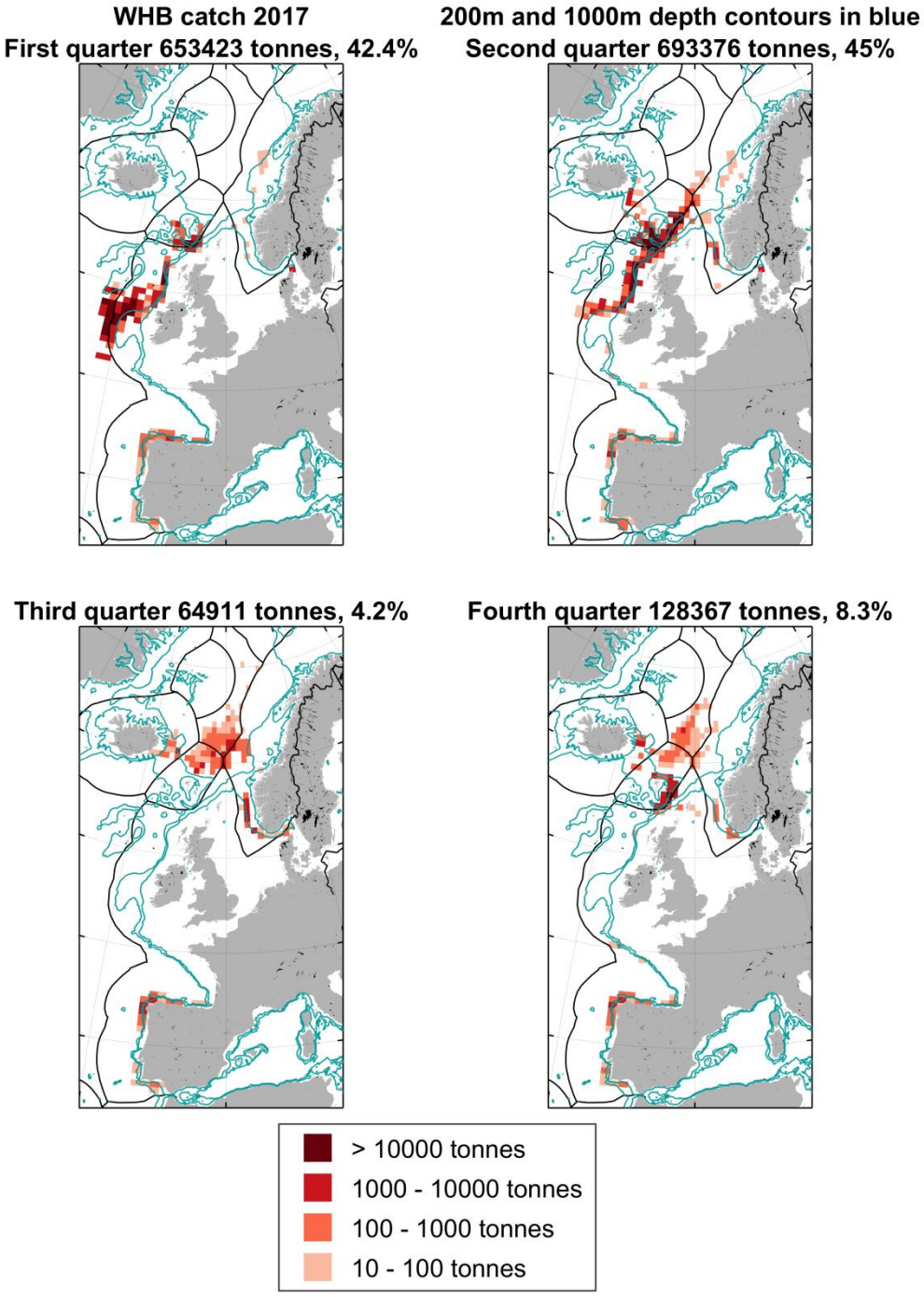


Figure 2.2.2. Blue whiting total catches pr quarter (ICES estimates) 2017 by ICES rectangle. The 200 m and 1000 m depth contours are indicated in blue. The catches on the map constitute 98.8 % of the total landings.

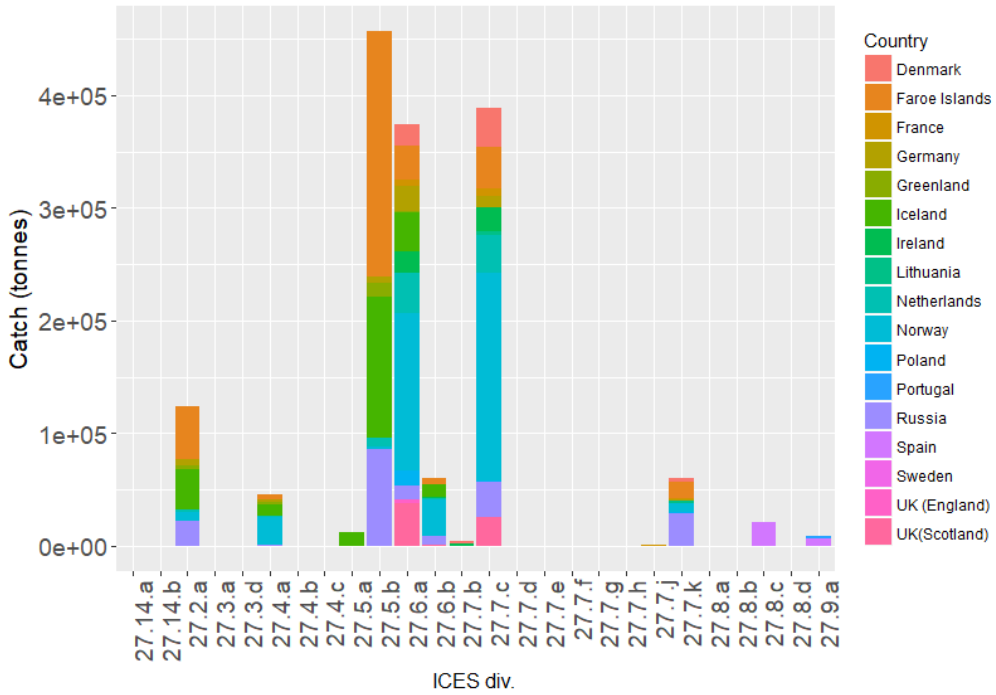
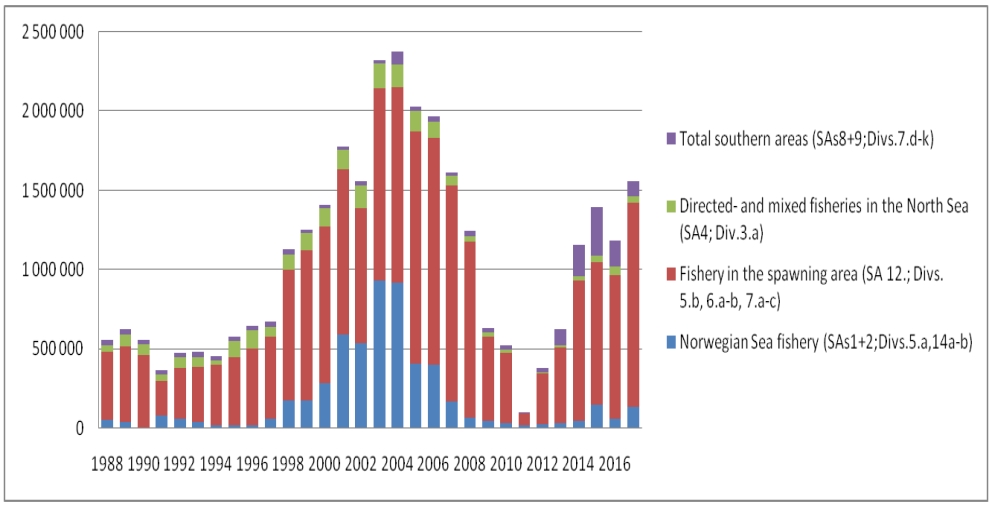


Figure 2.3.1.1. Blue whiting. ICES estimated catches (tonnes) in 2017 by ICES division area and country.

A



B

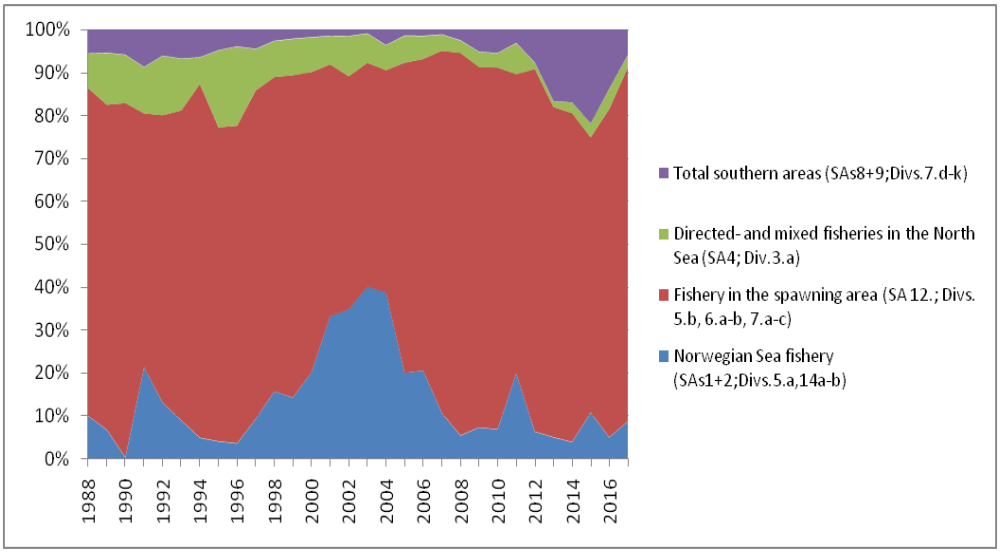


Figure 2.3.1.2. Blue whiting. (A) ICES estimated catches (tonnes) of blue whiting by fishery subareas from 1988-2017 and (B) the percentage contribution to the overall catch by fishery subarea over the same period.

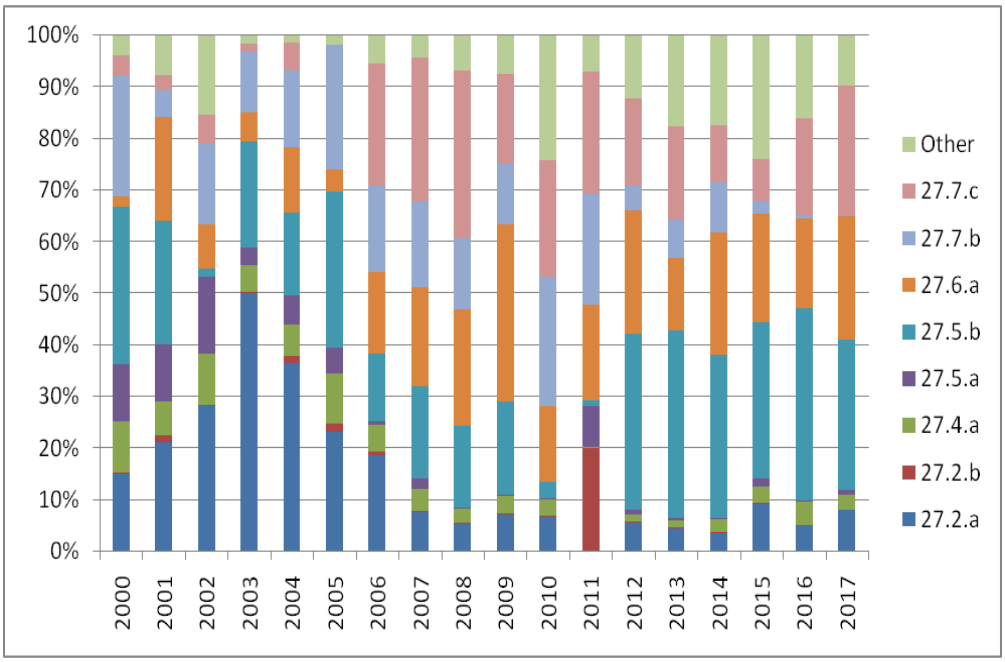


Figure 2.3.1.3. Blue whiting. Distribution of 2017 ICES estimated catches (in percentage) by ICES division area.

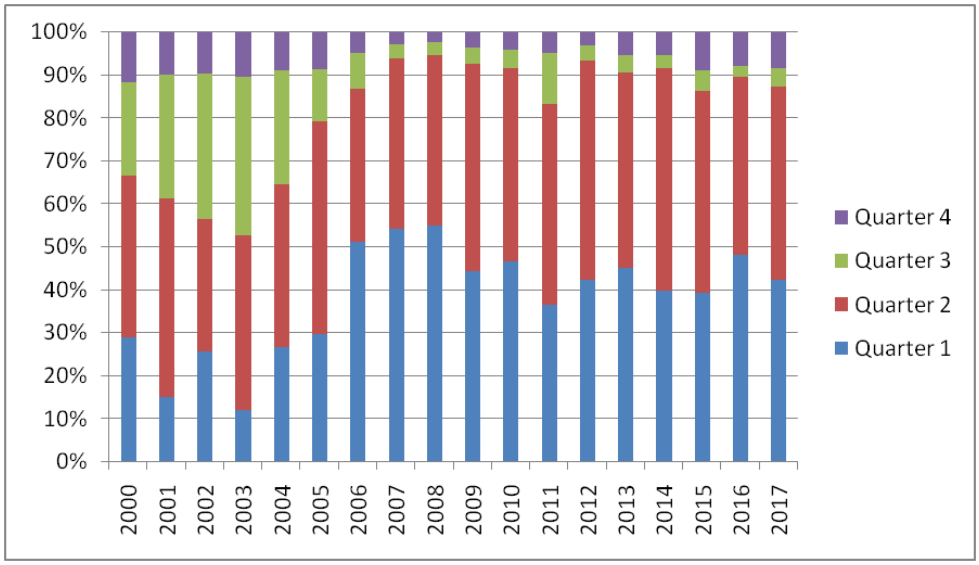


Figure 2.3.1.4. Blue whiting. Distribution of 2017 ICES estimated catches (in percentage) by quarter.

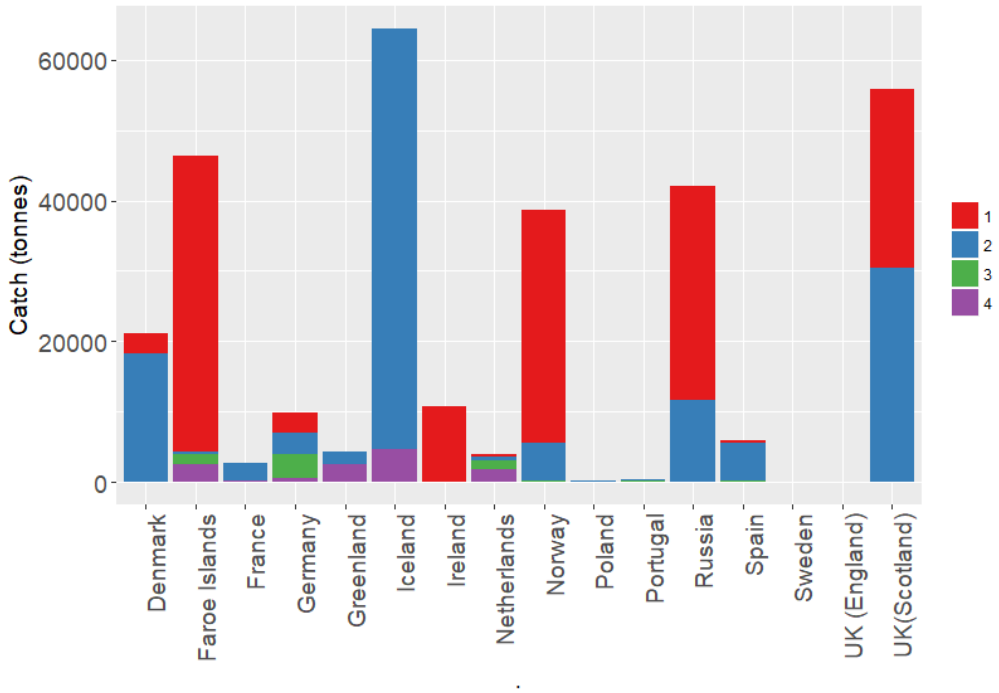


Figure 2.3.1.5. Blue whiting. Distribution of 2017 ICES estimated catches (tonnes) by country and by quarter.

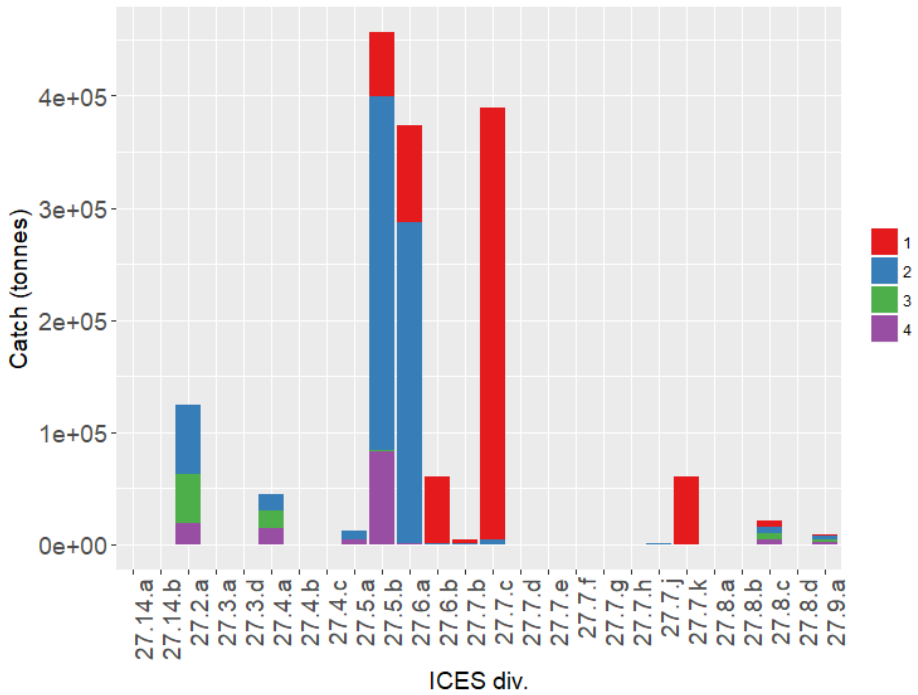


Figure 2.3.1.6. Blue whiting. Distribution of 2017 ICES estimated catches (tonnes) by ICES division area and by quarter.

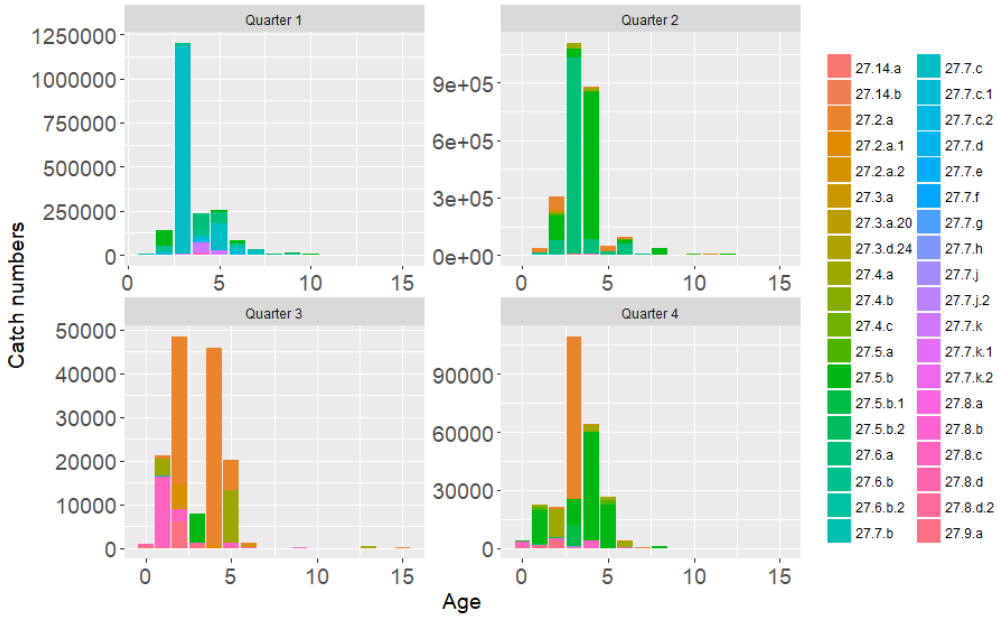


Figure 2.3.1.7. Blue whiting. Catch-at-age numbers (CANUM) distribution by quarter and ICES division area for 2017.

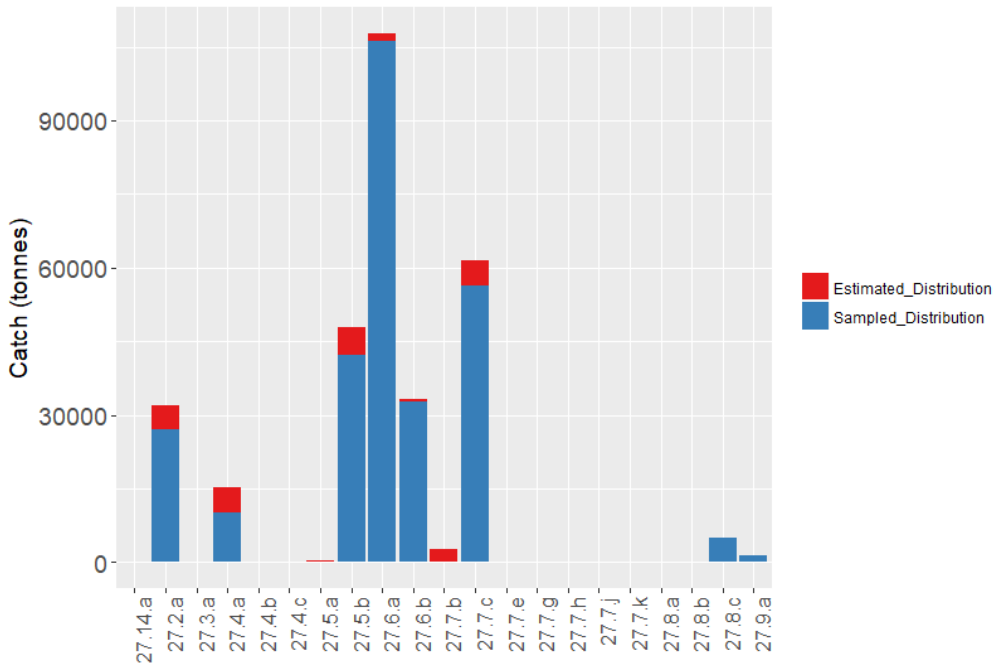
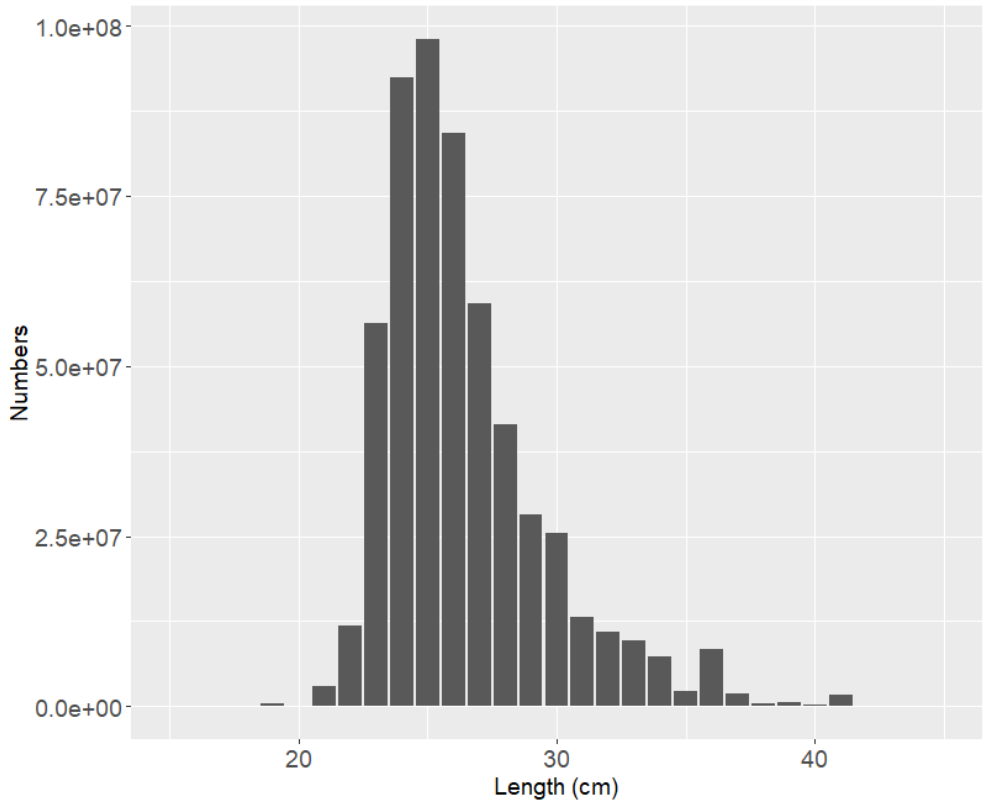


Figure 2.3.1.8. Blue whiting. 2017 ICES catches (tonnes) sampled and estimated by ICES division area.



2.3.1.2.1 .Blue whiting. Length (cm) for 2017 ICES estimated catches (tonnes).This length distribution represents only 67% of the 2017 ICES estimated total catches (tonnes).

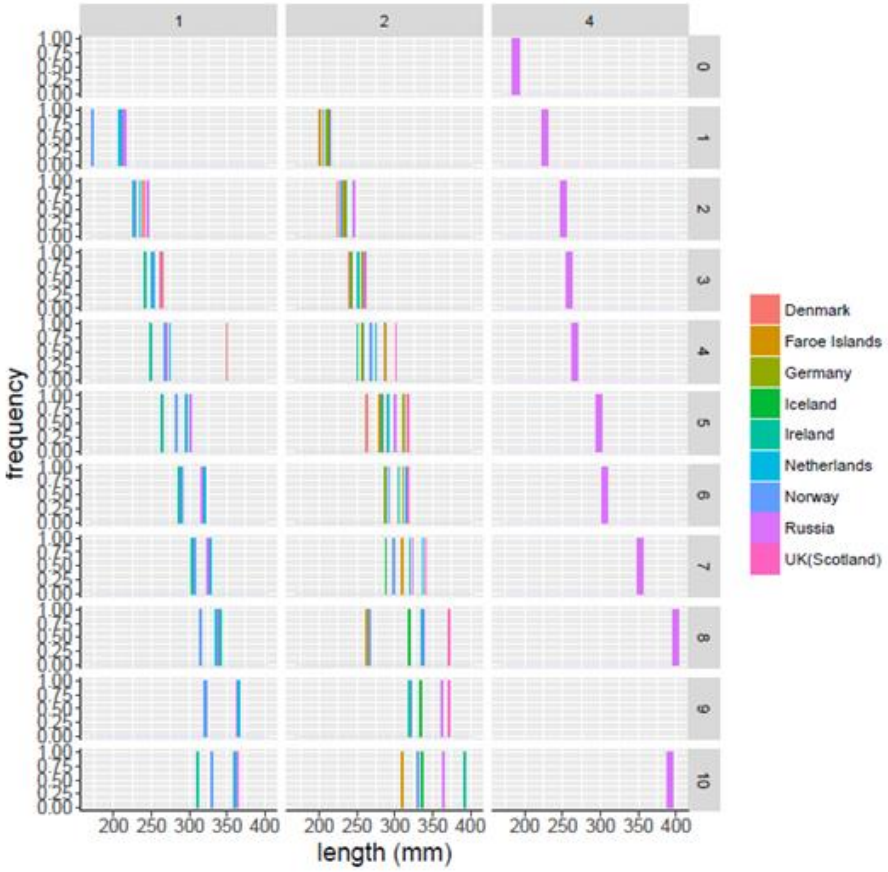


Figure 2.3.1.3.1. Blue whiting. Mean length (mm) by age (0-10 year), by quarter (1,2,4), by country for ICES division area 27.6.a. These data only comprises the 2017 ICES catch-at-age sampled estimates for ICES division area 27.6.a.

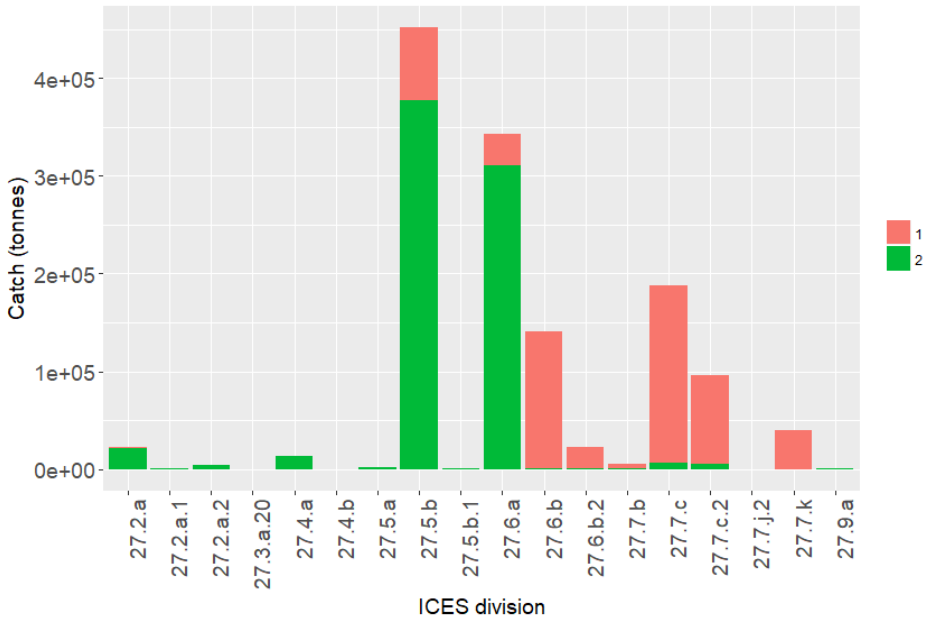


Figure 2.3.2.1. Blue whiting. Distribution of 2018 preliminary catches (tonnes) by ICES division area and quarter.

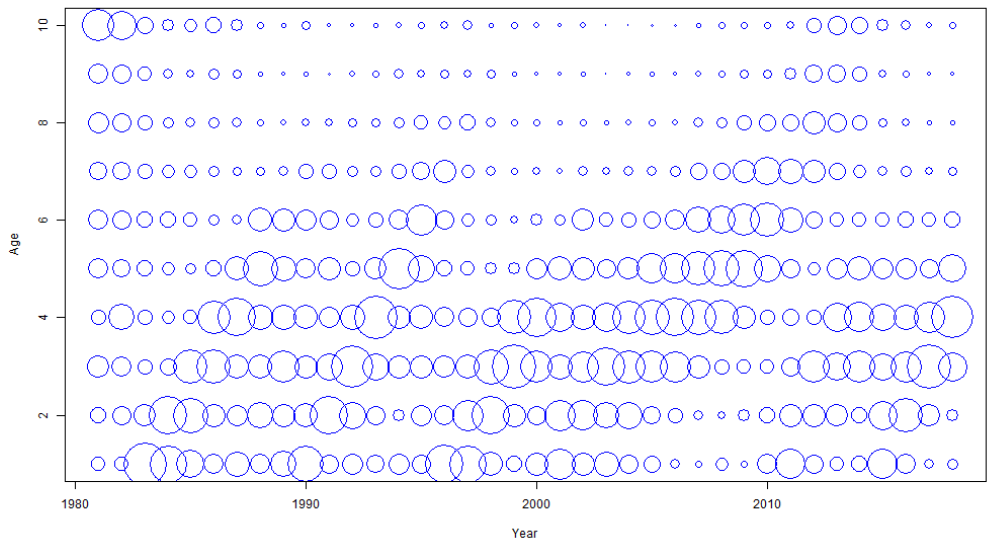


Figure 2.3.3.1. Blue whiting. Catch proportion at age, 1981-2018. Preliminary values for 2018 have been used.

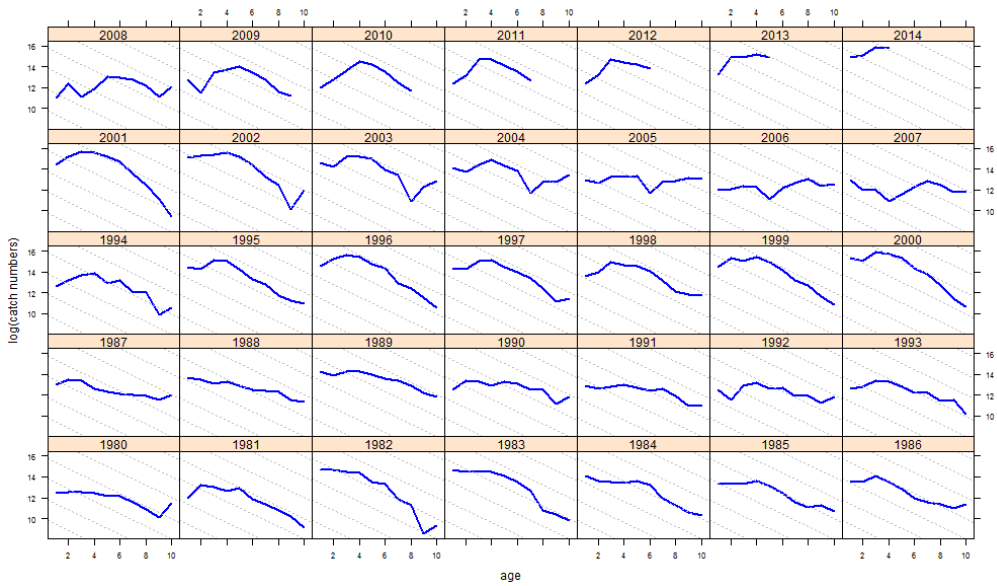


Figure 2.3.3.2. Blue whiting. Age disaggregated catch (numbers) plotted on log scale. The labels for each panel indicate year classes. The grey dotted lines correspond to *Z*=0.6. Preliminary catch-at-age for 2018 have been used.

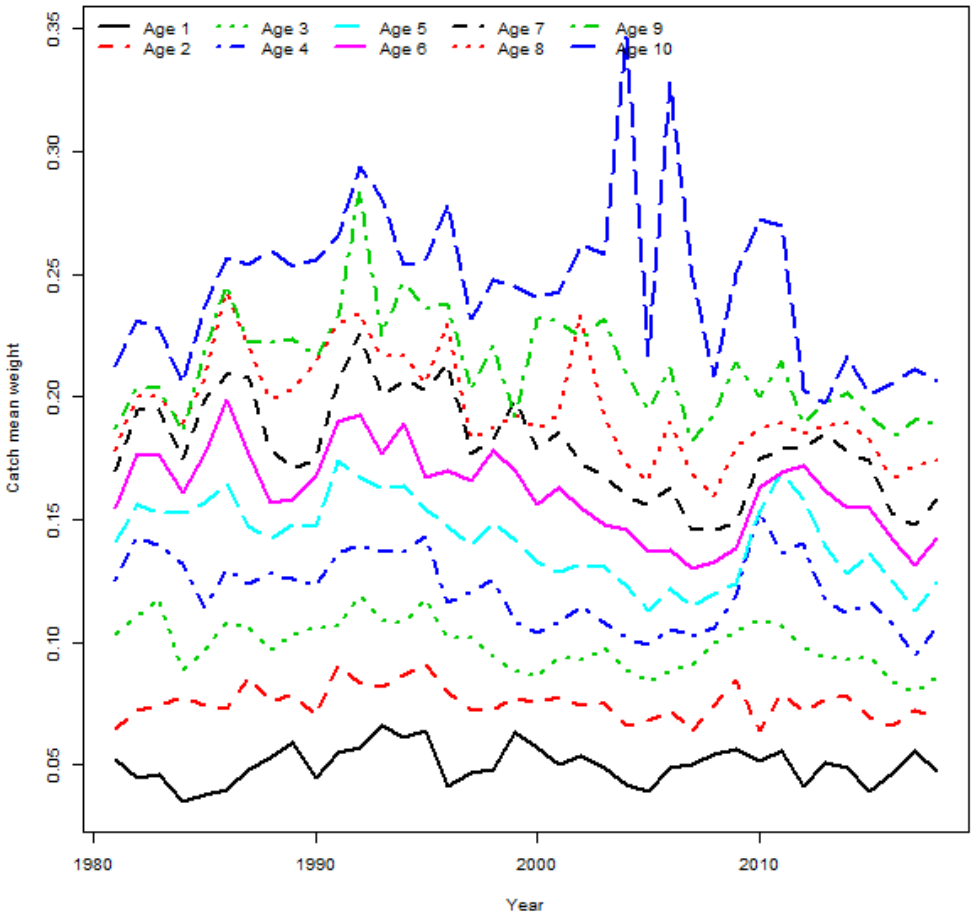


Figure 2.3.4.1. Blue whiting. Mean catch (and stock) weight (kg) at age by year. Preliminary values for 2018 (average of 2015-2017) have been used.

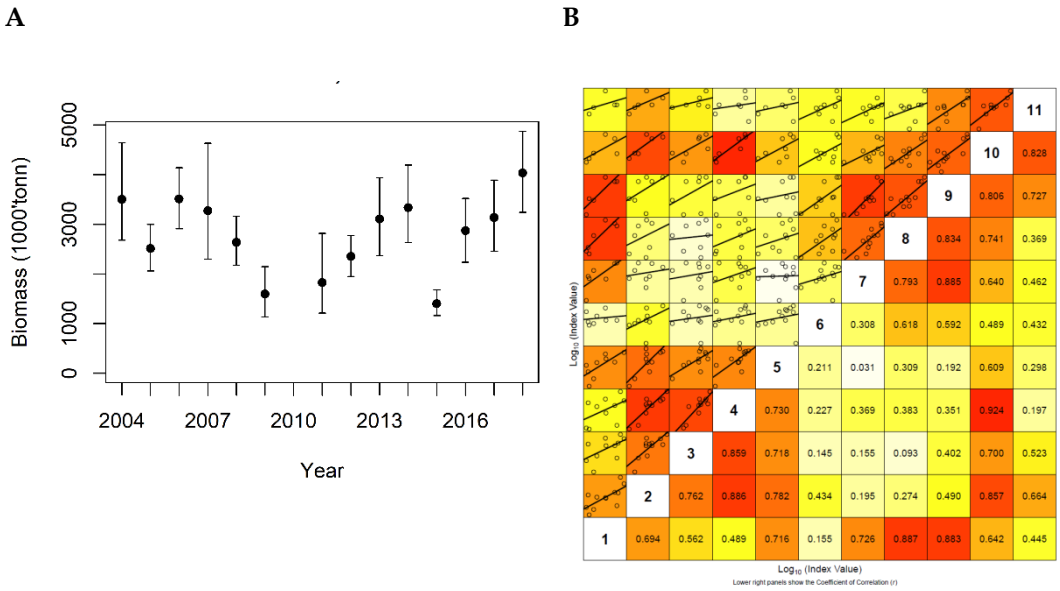


Figure 2.3.7.1.1. Blue whiting. (A) Estimate of total biomass from the International blue whiting spawning stock survey. The black dots and error bands are StoX estimates with 95 % confidence intervals. (B) Internal consistency within the International blue whiting spawning stock survey. The upper left part of the plots shows the relationship between log index-at-age within a cohort. Linear regression line shows the best fit to the log-transformed indices. The lower-right part of the plots shows the correlation coefficient (r) for the two ages plotted in that panel. The background colour of each panel is determined by the r value, where red equates to r=1 and white to r<0.

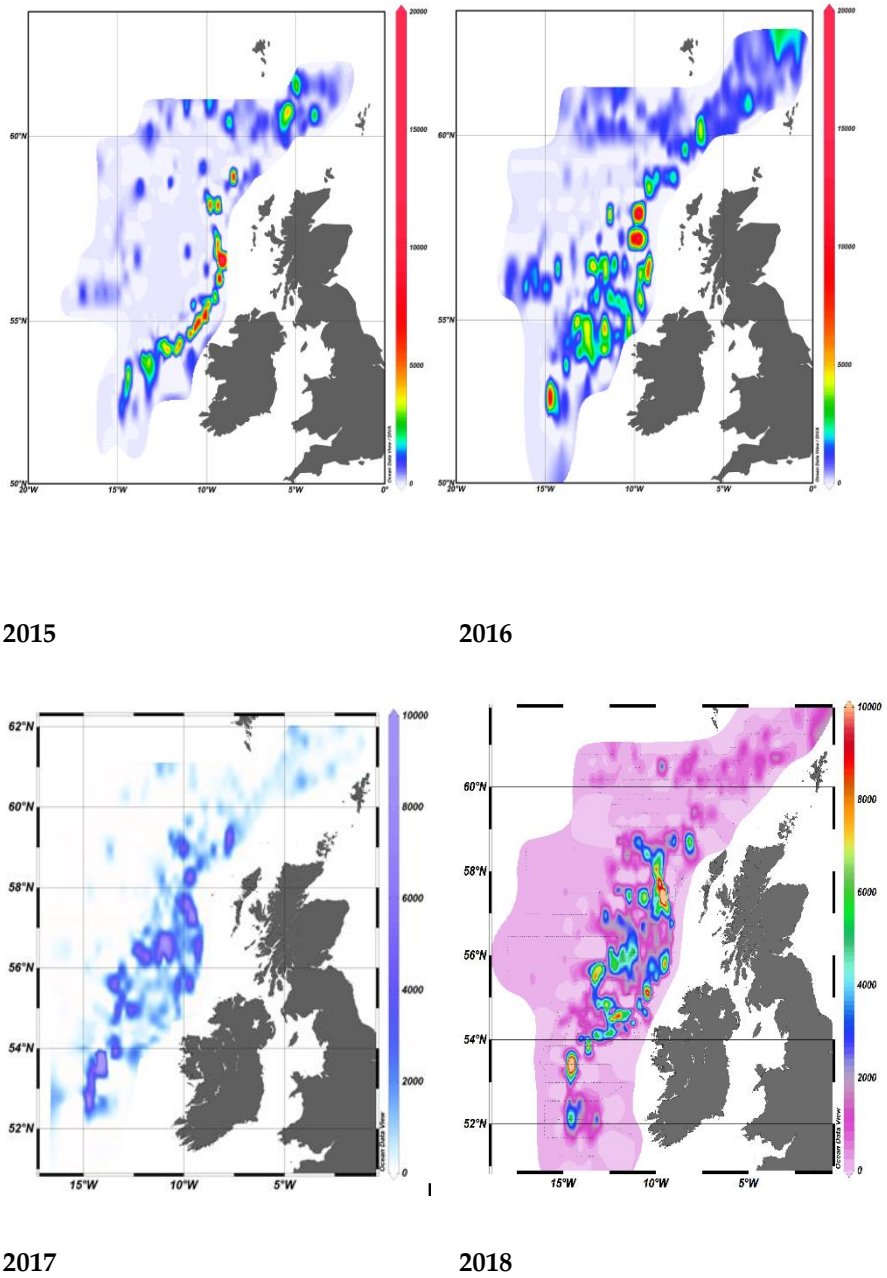


Figure 2.3.7.1.2. Map of blue whiting acoustic density (sA, m2/nm2) found during the spawning survey in spring 2015—2018.

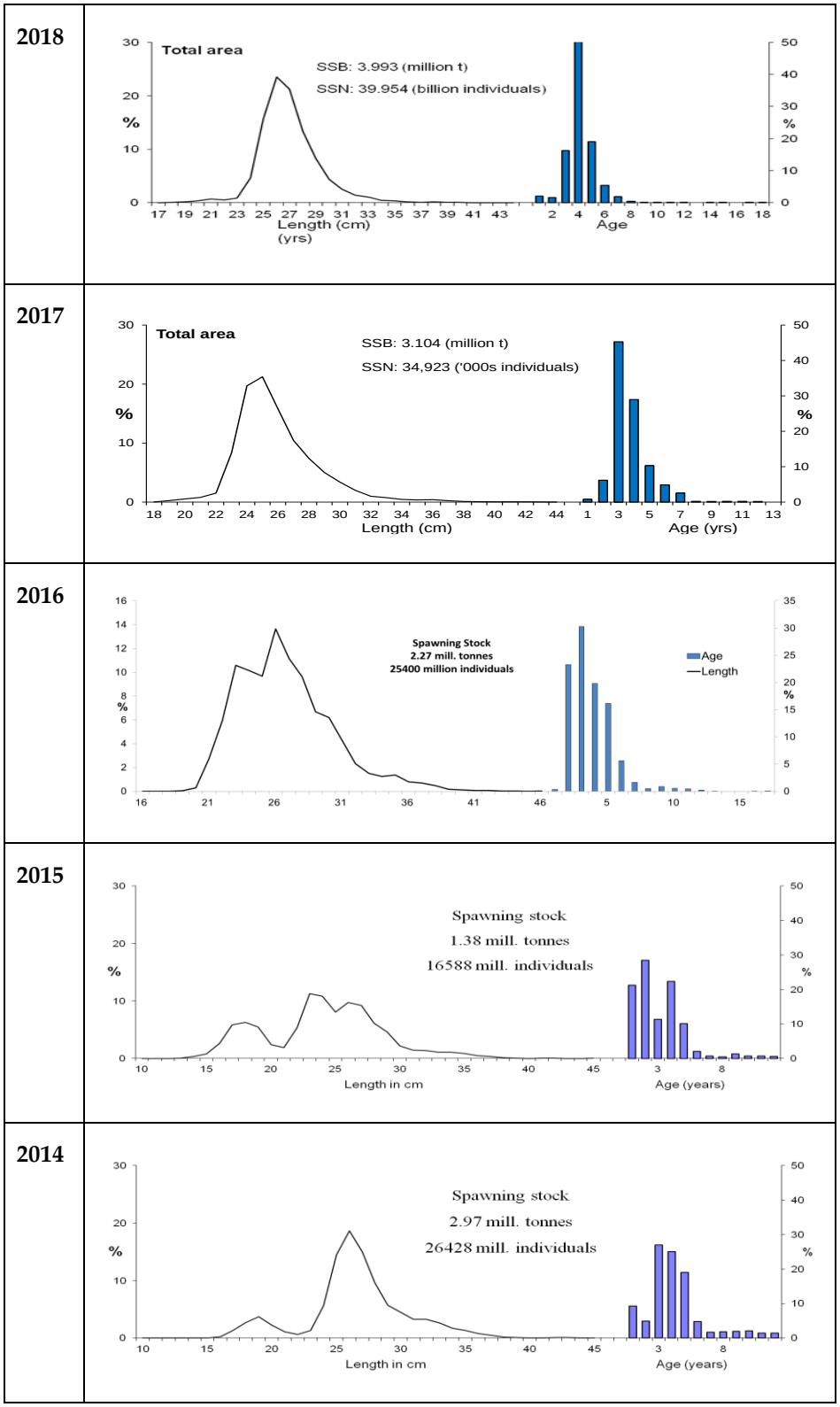


Figure 2.3.7.1.3. Blue whiting. Length (line) and age (bars) distribution of the blue whiting stock in the area to the west of the British Isles, spring 2014 (lower panel) to 2018 (upper panel). Spawning-stock biomass and numbers are given.

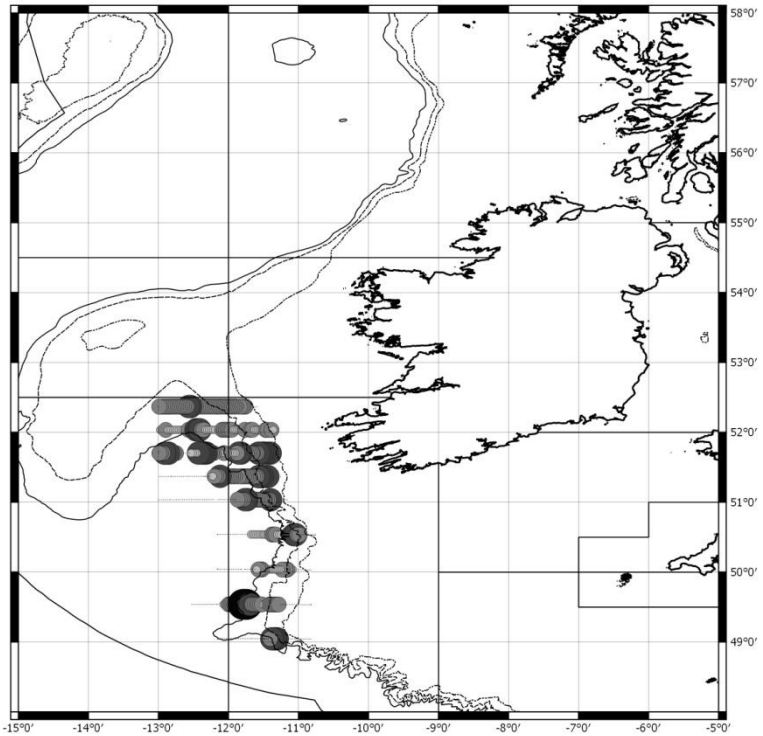


Figure 2.3.7.2..1 Blue whiting spatial distribution according to NASC values allocated to this species during PELACUS-IBWSS 0318.

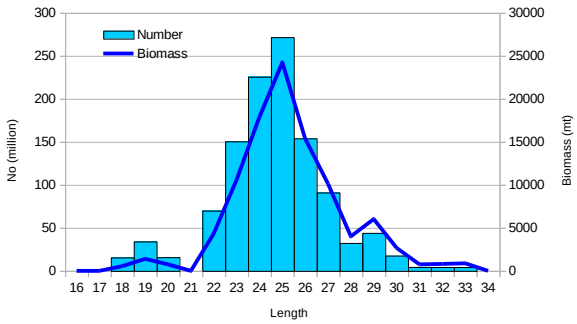


Figure 2.3.7.2.2. Blue whiting length distribution as estimated during PELACUS-IBWSS 0318.

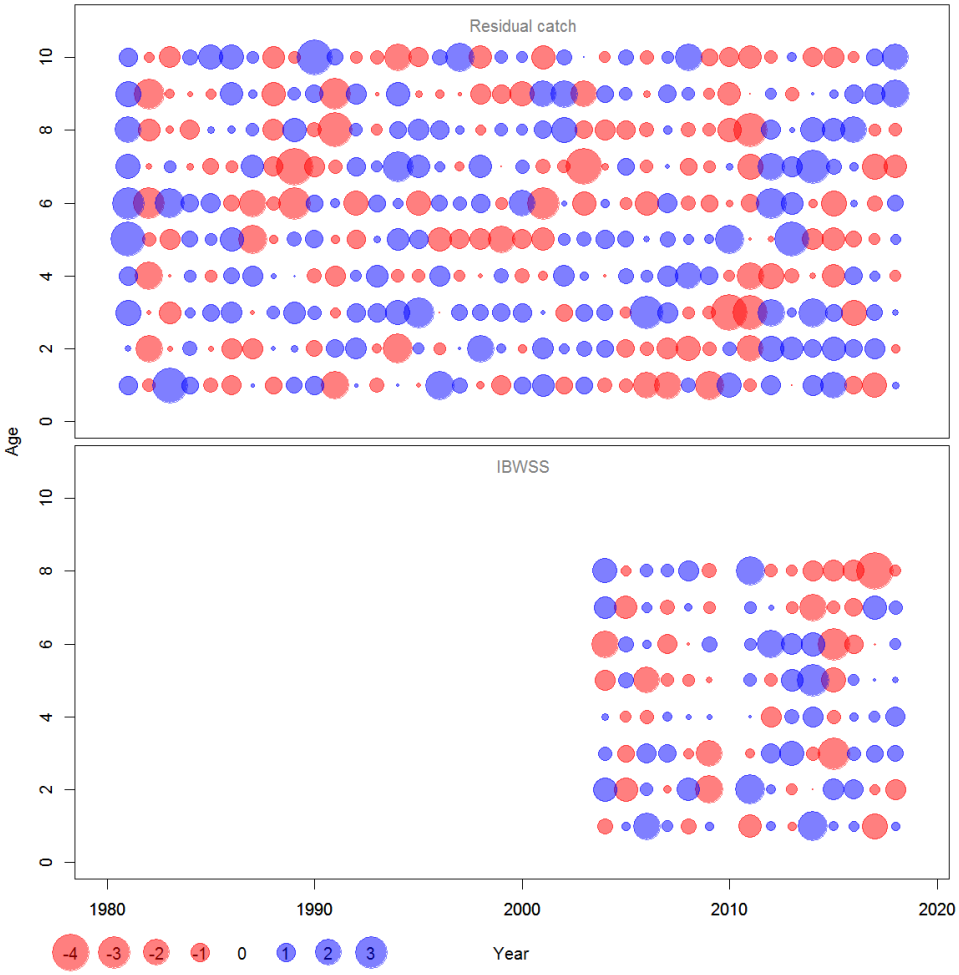


Figure 2.4.1. Blue Whiting. OSA (One Step Ahead) residuals (see Berg and Nielsen, 2016) from catch-at-age and the IBWSS survey. Red (lighter) bubbles show that the observed value is less than the expected value. Preliminary catch data for 2018 have been used.

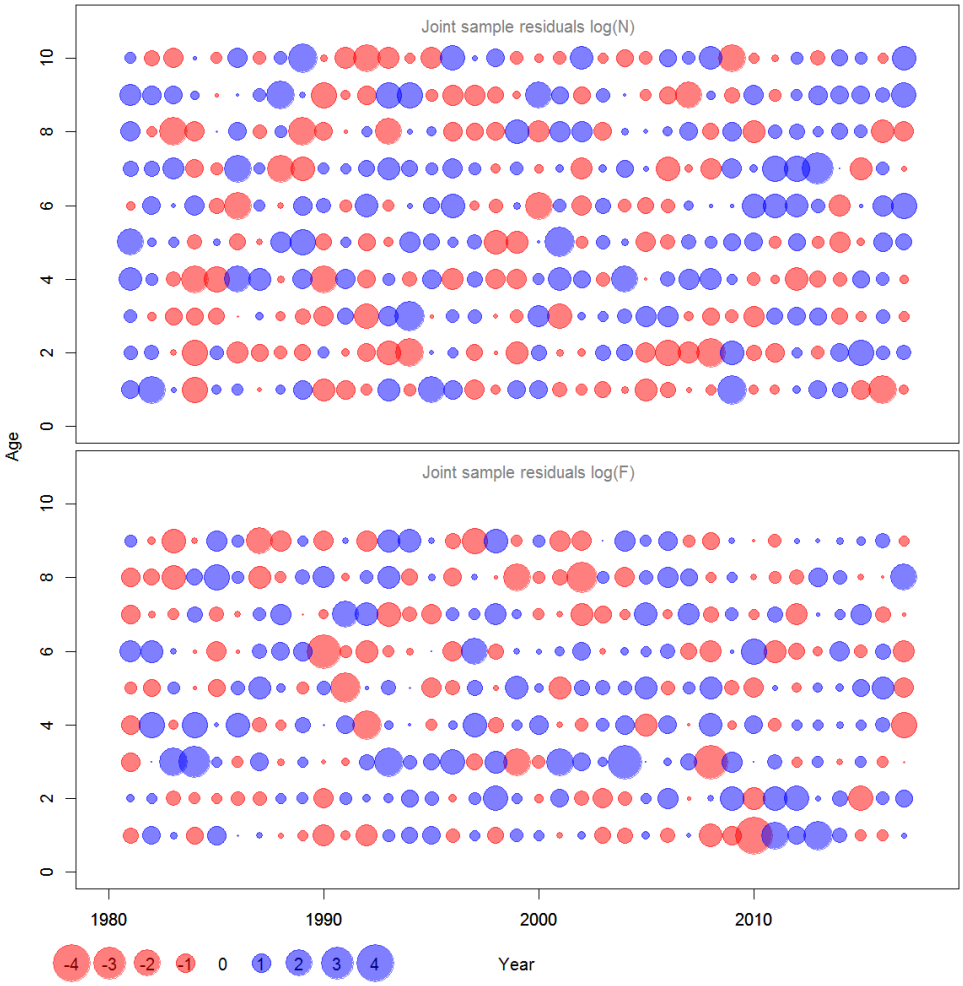


Figure 2.4.2. Blue whiting. Joint sample residuals (Process errors) for stock number and F at age. Red (lighter) bubbles show that the observed value is less than the expected value. Preliminary catch data for 2018 have been used.

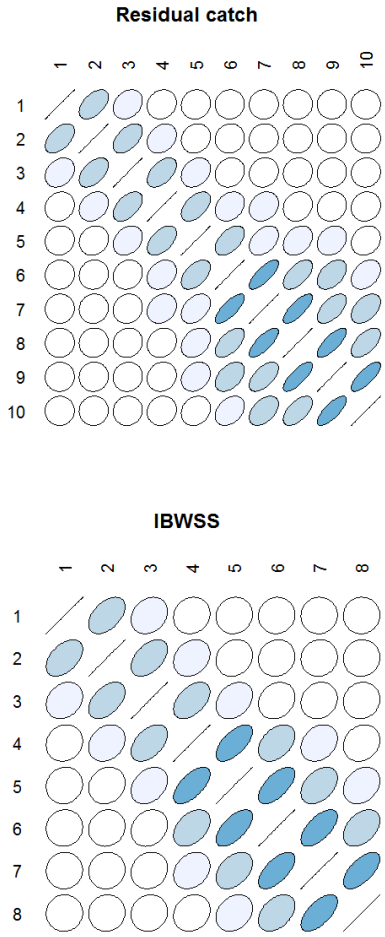


Figure 2.4.3. Blue whiting. The correlation matrix between ages for the catches and survey indices. Each ellipse represents the level curve of a bivariate normal distribution with the corresponding correlation. Hence, the sign of a correlation corresponds to the sign of the slope of the major ellipse axis. Increasingly darker shading is used for increasingly larger absolute correlations, while uncorrelated pairs of ages are depicted as circles with no shading.

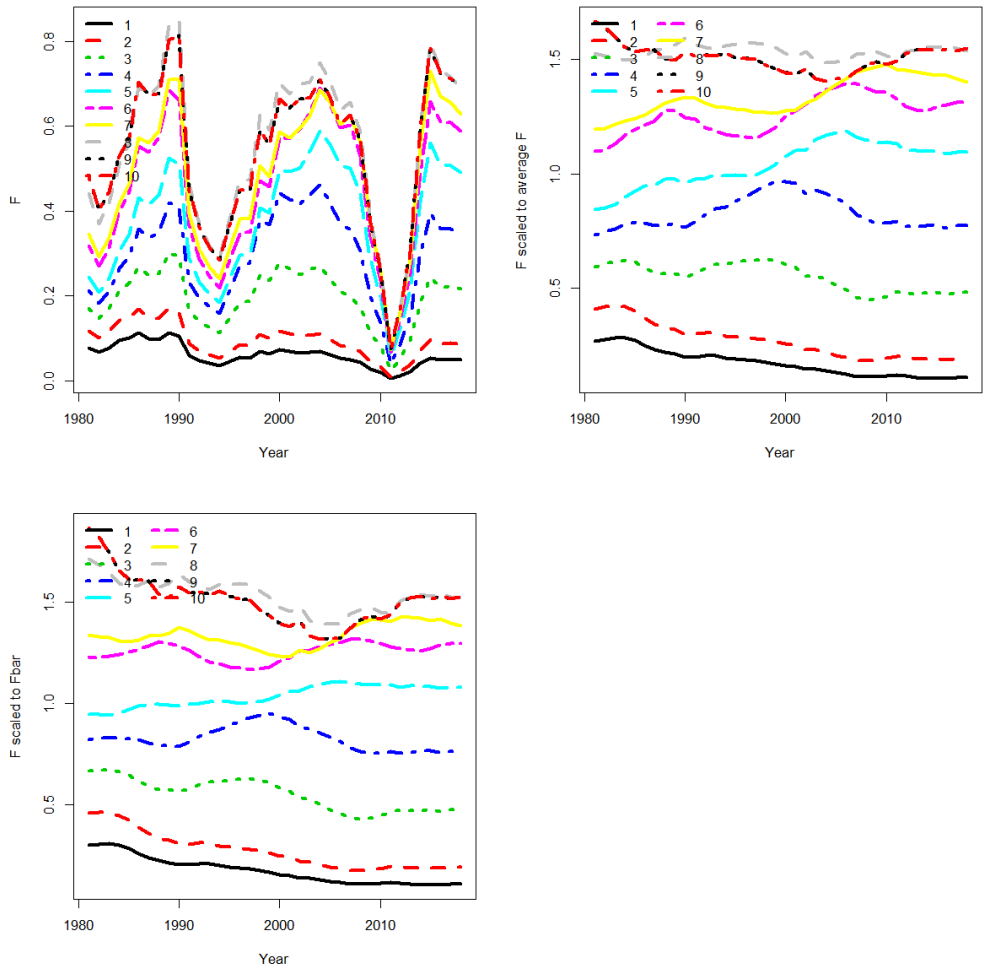


Figure 2.4.4. Blue whiting. F at age and exploitation pattern (F scaled to mean F all ages, and F scaled to mean F ages 3-7). Values for 2018 are preliminary.

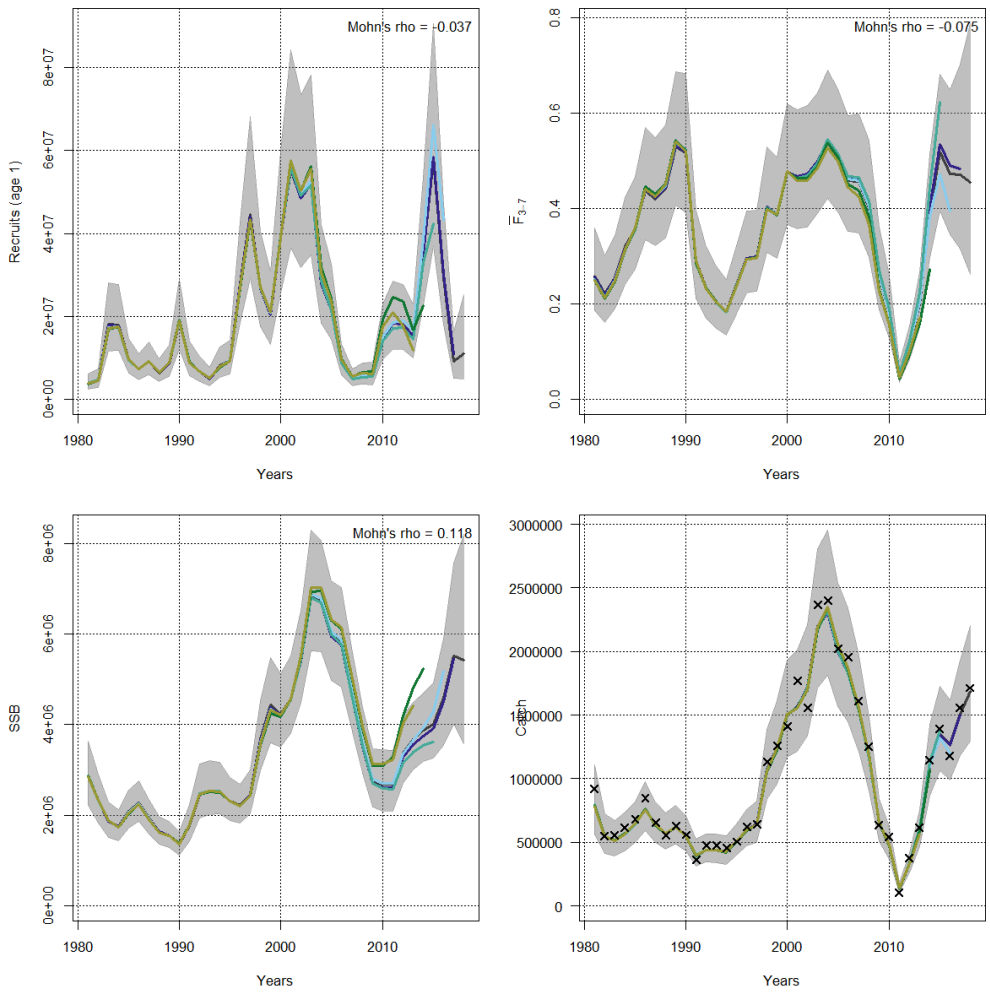


Figure 2.4.5. Blue whiting. Retrospective analysis of recruitment (age 1), SSB (tonnes), F and total catch using the SAM model. The 95% confidence interval is shown for the most recent assessment.

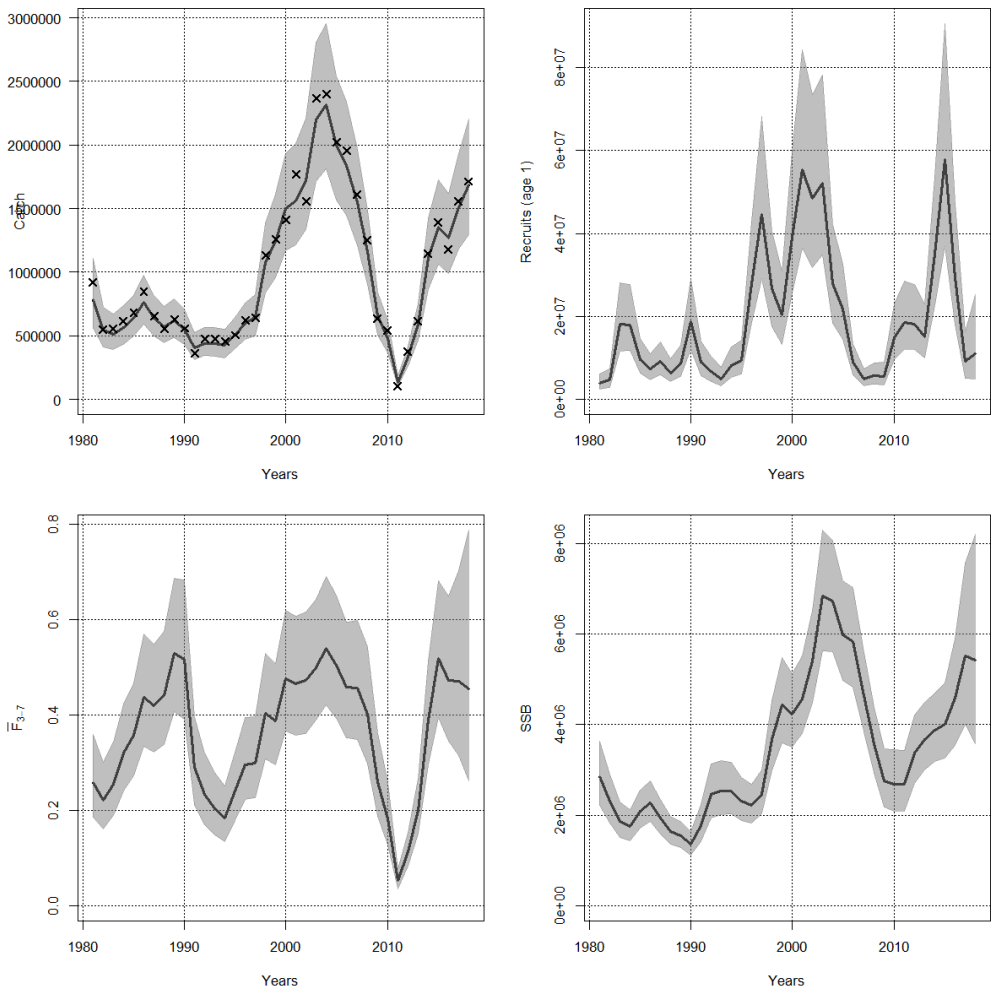


Figure 2.4.6.Blue whiting. SAM final run: Stock summary, total catches (tonnes), recruitment (age 1), F and SSB (tonnes). The graphs show the median value and the 95% confidence interval. The catch plot does also include the observed catches (x). Catches for 2018 are preliminary.

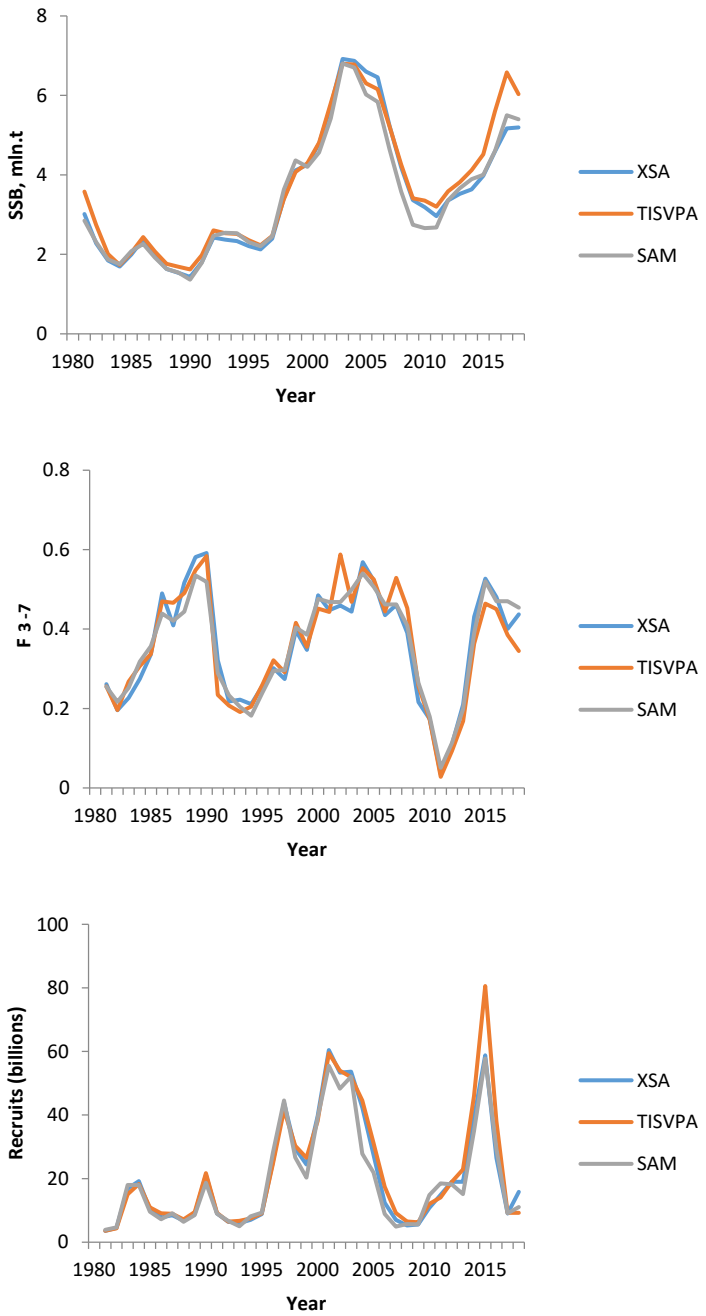


Figure 2.4.1.1. Blue whiting. Comparison of SSB, F and recruitment estimated by the assessment programs XSA, TISVPA and SAM. Catch values for 2018 are preliminary.

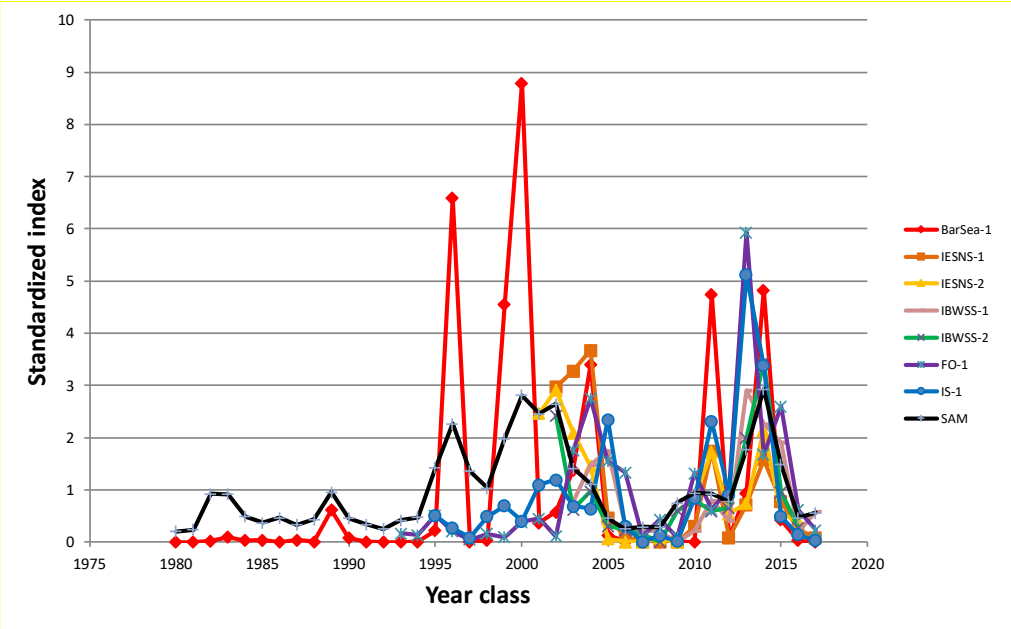


Figure 2.8.1.1. Blue whiting young fish indices from five different surveys and recruitment index from the assessment, standardized by dividing each series by their mean. BarSea - Norwegian bottom-trawl survey in the Barents Sea, IESNS: International Ecosystem Survey in the Nordic Seas in May (1 and 2 is the age groups), IBWSS: International Blue Whiting Spawning Stock survey (1 and 2 is the age groups), FO: the Faroese bottom-trawl surveys in spring, IS: the Icelandic bottom-trawl survey in spring, SAM: recruits from the assessment.

Figure 2.9.1. Blue whiting. Comparison of the 2010 - 2018 assessments.

3 Northeast Atlantic boarfish (*Capros aper*)

The boarfish (*Capros aper*, Linnaeus) is a deep bodied, laterally compressed, pelagic shoaling species distributed from Norway to Senegal, including the Mediterranean, Azores, Canaries, Madeira and Great Meteor Seamount (Blanchard & Vandermeirsch 2005).

Boarfish is targeted in a pelagic trawl fishery for fish meal, to the southwest of Ireland. The boarfish fishery is conducted primarily in shelf waters and the first landings were reported in 2001. Landings were at very low levels from 2001–2005. The main expansion period of the fishery was 2006–2010 when unrestricted landings increased from 2 772 t to 137 503 t. A restrictive TAC of 33 000 t was implemented in 2011. In 2011, ICES was asked by the European Commission to provide advice for 2012. In 2018, ICES has been considering this stock for 8 years.

An analysis of bottom trawl survey data suggests a continuity of distribution spanning ICES Subareas 27.4, 6, 7, 8 and 9 (Figure 3.1). Isolated occurrences appear in the North Sea (ICES Subarea 27.4) in some years indicating spill-over into this region. A hiatus in distribution was suggested between ICES Divisions 27.8.c and 9.a as boarfish were considered very rare in northern Portuguese waters but abundant further south (Cardador & Chaves 2010). Results from a dedicated genetic study on the stock structure of boarfish within the Northeast Atlantic and Mediterranean Sea suggests that this hiatus represents a true stock separation (Farrell *et al.* (2016); see section 3.11). Based on these data, a single stock is considered to exist in ICES Subareas 27.4, 6, 7, 8 and the northern part of 9.a. This distribution is slightly broader than the current EC TAC area (27.6, 7 and 8) and for the purposes of assessment in 2018 only data from these areas were utilized.

3.1 The fishery

3.1.1 Advice and management applicable from 2011 to 2018

In 2011 a TAC was set for this species for the first time, covering ICES Subareas 6, 7 and 8. This TAC was set at 33 000 t. Before 2010, the fishery was unregulated. In October 2010, the European Commission notified national authorities that under the terms of Annex 1 of Regulation 850/1998, industrial fisheries for this species should not proceed with mesh sizes of less than 100 mm. In 2011, the European Parliament voted to change Regulation 850/1998 to allow fishing using mesh sizes ranging from 32 to 54 mm.

For 2012, ICES advised that catches of boarfish should not increase, based on precautionary considerations. As supporting information, ICES noted that it would be cautious that landings did not increase above 82 000 t, the average over the period 2008-2010, during which the stock did not appear to be overexploited. In 2012 the TAC was set at 82 000 t by the Council of the European Union.

For 2013, ICES advised that catches of boarfish should not be more than 82 000 t. This was based on applying a harvest ratio of 12.2% (F0.1, as an F_{MSY} proxy). For 2013, the TAC was set at 82 000 t by the Council of the European Union.

For 2014, ICES advised that, based on FMSY (0.23), catches of boarfish should not be more than 133 957 t, or 127 509 t when the average discard rate of the previous ten years (6 448 t) is taken into account. For 2014 the TAC was set at 133 957 t by the Council of

the European Union. This advice was based on a Schaefer state space surplus production model (see section 3.6.3 for further details).

In 2014 there was concern about the use of the production model (see stock annex). ICES considered that the model was no longer suitable for providing category 1 advice and further model development was required. The model is still considered suitable for category 3 advice. The advised catch for 2015 of 53 296 t was based on the data limited stock HCR and an index calculated (method 3.1; ICES, 2012) using the total stock biomass trends from the model. Further work has been undertaken in 2015 to address the issues with the surplus production model and this work has been continued since then.

For 2016, ICES advised based on the precautionary approach that catches should be no more than 42 637 t.

For 2017, ICES advised based on the precautionary approach that catches should be no more than 27 288 t. For the first time, the precautionary buffer has been applied resulting in a 36% reduction compared to the year before. The acoustic survey suggested that the stock abundance was at an historic low.

In 2017, the Advice Drafting Group decided the advice of 21 830 proposed (20% reduction) would stand for 2 years. The assessment run in 2018 confirms that the biomass is rather stable and at a low level.

Since 2011, there has been a provision for bycatch of boarfish (also whiting, haddock and mackerel) to be taken from the Western and North Sea horse mackerel EC quotas. These provisions are shown in the text table below. The effect of this is that a quantity not exceeding the value indicated of these 4 species combined may be landed legally and subtracted from quotas for horse mackerel.

Year	North.Sea.(t)	Western.(t)
2011	2 031	7 779
2012	2 148	7 829
2013	1 702	7 799
2014	1 392	5 736
2015	583	4 202
2016	760	5 443
2017	912	4191
2018	759	5053

In 2010, an interim management plan was proposed by Ireland, which included a number of measures to mitigate potential bycatch of other TAC species in the boarfish fishery. A closed season from the 15th March to 31st August was proposed, as anecdotal evidence suggests that mackerel and boarfish are caught in mixed aggregations during this period. A closed season was proposed in ICES Division 7.g from 1st September to 31st October, in order to prevent catches of Celtic Sea herring, which is known to form feeding aggregations in this region at these times. Finally, if catches of a species covered by a TAC, other than boarfish, amount to more than 5% of the total catch by day by ICES statistical rectangle, then fishing must cease in that rectangle for 5 days.

In August 2012 the Pelagic RAC proposed a long term management plan for boarfish (see section 3.15). The management plan was not fully evaluated by ICES. However, in 2013, ICES advised that Tier 1 of the plan can be considered precautionary if a Category 1 assessment is available.

A revised draft management strategy was proposed by the Pelagic AC in July 2015. This management strategy aims to achieve exploitation of boarfish in line with the precautionary approach to fisheries management, FAO guidelines for new and developing fisheries, and the ICES form of advice. ICES evaluated the plan and considered it to be precautionary, in that that it follows the rationale for TAC setting enshrined in the ICES advice, but with additional caution.

The closed season, in the interim and revised management plans, has been enacted in legislation in Ireland, though not other countries.

3.1.2 The fishery in recent years

The first landings of boarfish were reported in 2001. Landings fluctuated between 100 and 700 t per year up to 2005 (Tables 3.1.2.1 & 3.1.2.2). In 2006 the landings began to increase considerably as a target fishery developed. Cumulative landings since 2001 are now over 500 000 t. The fishery targets dense shoals of boarfish from September to March. Catches are generally free from bycatch from September to February. From March onward a bycatch of mackerel can be found in the catches and the fishery generally ceases at this time. Information on the bycatch of other species in the boarfish fishery is sparse, though thought to be minimal. The fishery uses typical pelagic pair trawl nets with mesh sizes ranging from 32 to 54 mm. Preliminary information suggests that only the smallest boarfish escape this gear.

From 2001 to 2006 only Ireland reported landings of boarfish. In 2007 UK-Scotland reported landings of 772 t. Scottish landings peaked at 9 241 t in 2010 and have declined since then with no fishery in 2015. Denmark joined the fishery in 2008 and landed 3 098 t. Danish landings increased to 39 805 t in 2010 but have declined considerably to only 29 t in 2015 and were null in 2016 and 2017. The vast majority of catches have come from ICES Division 27.7.j and 27.7.h (Figure 3.1.2.1 and Table 3.1.2.1). Since 2011 landings have been regulated by a TAC.

In 2014 and subsequent years, the TAC has not been caught. This is thought to be partly due to lesser availability of fishable aggregations, and partly due to economic and administrative reasons. According to the industry, fishable aggregations were not always available during the fishery. The season coincides with the mackerel and horse mackerel fisheries. Also, the Irish quota was allocated to individual boats, with non-specialist vessels receiving allocations that were not used.

In 2015 Q3 and Q4 individual boat quotas have been removed in Ireland, in an attempt to allow the specialist 6-7 vessels to target the stock without (what the industry considers to be unnecessary) constraints. The same year, the Netherlands (375 t), UK England (104 t) and Germany (4 t) reported boarfish landings for the first time. These landings were mainly bycatch from freezer trawlers.

In 2016 a total of 19 315 t of boarfish were caught (Table 3.1.2.1). Ireland continued to be the main participant taking 17 496 t but is below its 29 464 quota. Denmark took only 337 t, significantly under its national quota of 10 463 t. Scotland reported no boarfish landings. Table 3.1.2.2 shows that two thirds of the Irish landings were taken in ICES divisions 7.h and 8.a. Thirty-two Irish registered fishing vessels reported catches with the majority made in Q1 (7 143 t) and Q4 (8 711 t).

Previous to the development of the target fishery, boarfish was a discarded bycatch in pelagic fisheries for mackerel in ICES Subareas 7 and 8. A study by Borges *et al.* (2008) found that boarfish may have accounted for as much as 5% of the total catch of Dutch

pelagic freezer trawlers. Boarfish are also discarded in whitefish fisheries, particularly by Spanish demersal trawlers (Table 3.1.2.3).

3.1.3 The fishery in 2017

In 2017 a total of 17 388 t of boarfish were caught (Table 3.1.2.1). Ireland continued to be the main participant landing 15 484 t but is almost 20% below its 18 858 quota. Denmark landed only 548 t, not even 10% of its national quota of 6 696 t. UK reported almost null boarfish landings. Discards accounted for 1 173 tonnes overall. Table 3.1.2.2 shows that about 90% of the Irish landings were taken in ICES divisions 7.h and 8.a. Thirty-five Irish registered fishing vessels reported catches with almost the entirety made in Q1 (8 570 t) and Q4 (6 270 t).

3.1.4 Regulations and their effects

In 2010, the fishery finished early when the European Commission notified member states that mesh sizes of less than 100 mm were illegal. However, in 2011, the European Parliament voted to change Regulation 850/1998 to allow fishing for boarfish using mesh sizes ranging from 32 to 54 mm. The TAC (33 000 t) that was introduced in 2011 significantly reduced landings.

3.1.5 Changes in fishing technology and fishing patterns

The expansion of the fishery in the mid-2000s was associated with developments in the pumping and processing technology for boarfish catches. These changes made it easier to pump boarfish ashore. Efforts are underway to develop a human consumption market and fishery for boarfish. To date the majority of boarfish landings by Danish, Irish and Scottish vessels have been made into Skagen, Denmark and Fuglafjorour, Faroe Islands to be processed into fishmeal. A small number of Irish vessels have landed into Killybegs and Castletownbere, Ireland. These landings into Irish ports were expected to increase in the future with the development of a human consumption fishery but this now seems unlikely.

3.1.6 Discards

Since 2003, the major sources of discards are the Dutch pelagic freezer trawlers and both the Irish and Spanish demersal fleets. More sporadic discards are observed in German pelagic freezer trawlers and the UK demersal fleet. In 2016, Lithuania declared discards for the first time. Discard estimates are not obtained from French freezer trawlers, though discard patterns in these fleets are likely to be similar to the Dutch fleet. Discard data from the Portuguese bottom otter trawl fleet in ICES Division 9.a are also available but are not included in the assessment as they are outside the TAC area. Table 3.1.2.3 shows available data.

It is to be expected that discarding occurred before 2003, in demersal fisheries, however it is difficult to predict what the levels may have been.

Discard data were included in the calculation of catch numbers at age. All discards were raised as one metier using the same age length keys and sampling information as for the landed catches. In the absence of better sampling information on discards, this was considered the best approach. This placed the stock in Category A2 for the ICES Advice in October 2013: Discards 'topped up' onto landings calculations. With the introduction of the discard ban in 2015 this stock was placed in A4: Discards known, with discard ban in place in year +1. As such the advice will be given for catch in ICES Advice October 2014 and onwards.

3.2 Biological composition of the catch

3.2.1 Catches in numbers-at-age

Catch number-at-age were prepared for Irish, Danish, Dutch, German and English landings using the ALK in Table 3.2.1.1 together with available samples from the fishery (Table 3.2.1.2). This general ALK was constructed based on 814 aged fish from Irish, Danish and Scottish caught samples from 2012 (see the stock annex for a description of ALKs prior to 2012). In 2017 allocations to unsampled metiers were made according to Table 3.2.1.3. In total 14 Irish and 4 Danish samples with the appropriate .5 cm length bin measurements were collected in 2017 (Table 3.2.1.4). These samples covered only the 4 most heavily fished areas out of a total of 16 (Table 3.2.1.5) and equated to one sample per 966 t landed. The samples comprised 1 440 fish measured for length frequency.

The results of the application of the ALK to commercial length-frequency data available for the years 2007-2017 to produce a proxy catch numbers-at-age are available in Table 3.2.1.6. Many old fish are still present in catches, though there appears to be a reduction of older ages since 2007. There have been no strong year classes with poor cohort tracking in the catch numbers. A high number of 2 year old are present in the 2015 data but this does not echo in the number of 3 year old fish in 2016. The modal age from 2007-2011 was 6 and in 2012-2017 it was 7. It should be noted that in WGWIDE 2011 and 2012 the +group for boarfish was 20+. This was reduced to 15+ in WGWIDE 2013 due to potential inaccuracy of the age readings of older fish. Ageing was based on the method that has been validated for ages 0-7 by Hussy *et al*. (2012a; b). The age range is similar to the published growth information presented by White *et al.* (2011).

3.2.2 Quality of catch and biological data

Table 3.2.1.3 shows allocations that were made to un-sampled metiers in 2017. Length-frequencies of the international commercial landings by year are presented in Table 3.2.2.1.

Sampling in the early years of the fishery (2006–2009) was sparse as there was no dedicated sampling programme in place. The sampling programme was initiated in 2010 and good coverage of the landings has been achieved since then. Full details of the sampling programme in the earlier years are presented in the stock annex. Until 2017, boarfish was not included on the DCF list of species for sampling. Irish sampling comprises only samples from Irish registered vessels. Samples are collected onboard directly from the fish pump during fishing operations and are frozen until returning to port, which ensures high quality samples. Each sample consists of approximately 6 kg of boarfish. This equates to approximately 150 fish which, given the limited size range of boarfish, is sufficient for determining a representative length frequency. The established sampling target is one sample per 1 000 t of landings per ICES Division, which is also standard in other pelagic fisheries such as mackerel. Since 2017, all fish in each sample should be measured to the 0.5cm below for length frequency. Following standard protocols 5 fish per 0.5cm length class should be randomly selected from each sample for biological data collection i.e. otolith extraction, measurement to the 1mm below and sex and maturity determination.

There is no sampling programme in place for Scottish catches.

The current surplus production model used to assess boarfish is considered an interim measure prior to the development of an aged-based assessment. In 2017, boarfish was included in the list of species to be sampled by the DCMAP which should provide

estimates of catch at age and facilitate the future development of an age-based stock assessment method.

3.3 Fishery Independent Information

3.3.1 Acoustic Surveys

A full description of the Boarfish Acoustic Survey (BFAS) which was initiated in July 2011 is given in the stock annex. This survey is run in conjunction with the Malin Shelf herring survey. These surveys are collectively known as the Western European Shelf Pelagic Acoustic Survey (WESPAS).

Change in abundance calculation method

Acoustic data collected during the WESPAS survey since 2016 were analysed using the StoX software package (ICES 2015a). This package was adopted for WGIPS coordinated surveys in 2016 and has been implemented for all international multi-vessel coordinated surveys within the group (IBWSS, IESSNS, IESSNS and HERAS). The Irish Marine Institute has adopted StoX as the primary abundance calculation tool for national and international acoustic survey data going forward as part of a transitional process initiated during WKEVAL (ICES 2015b). A detailed comparative review of the Irish national method and StoX was carried out on herring during WGIPS 2016 using HERAS and IBWSS data. A difference of 1% in the total herring biomass estimated by the national method compared to the StoX method for HERAS data was found. Abundances at age showed a greater difference which maybe more related to survey design for the 2015 data set. Regardless, the national abundance by age estimates were all contained within the uncertainty levels surrounding the StoX estimates (ICES 2016). The Irish national abundance is thus considered comparable with StoX going forward.

A description of the StoX application can be found at the following weblink: http://www.imr.no/forskning/prosjekter/stox/nb-no. Survey design and execution for the WESPAS survey adhere to guidelines laid out in the Manual for International Pelagic Surveys (IPS) (ICES 2015a).

Survey results 2018

The estimate of boarfish biomass from 2011 to 2018 is presented in Table 3.3.1.1 and the spatial distribution of the echotraces attributed to boarfish each year can be seen in Figure 3.3.1.1. In 2018, The WESPAS survey was carried out over a 42 day period beginning on the 09 June in the south (47°N) and working northwards to 59°N ending on 24 July. The survey direction was changed in 2017 from south to north to force containment in the southern area by aligning ourselves with the PELGAS survey. Spatial and temporal alignment has much improved with this move and the survey will be continued in this way in years to come. Overall the WESPAS survey provided continuous coverage from 47N° to 59N°over 42 days covering relating to an area coverage of almost 56, 403 nmi2 (boarfish strata) and transect mileage of over 5,200 nmi. In total 42 trawl stations were undertaken with 14 hauls containing boarfish providing 4,807 individual lengths, 2,234 weights and 945 otoliths for use during the analysis.

The 2018 estimate of biomass is 44,000t lower than observed in 2017 (230,000t in 2017, 186,000t in 2018). The low estimate in 2016 (70,000t) appears to be an outlier. Containment issues in 2016 were addressed and the survey has been conducted from south to north since 2017. The changes were implemented to increase the precision of the survey overall. Approximately 45% of the stock was observed in the southern survey area

(Celtic Sea, including Celtic Sea Deep and NW Bank areas). Boarfish were found further north than in previous years.

The age composition of the stock in 2018 is dominated by older age classes (> 7 years) with a peak at 10 year old fish. A second peak at 15+ years appears to be less in 2018 than in previous years. The numbers at age are variable across years, which may be a result of the fact that an age at length key is used.

The BFAS component of the WESPAS survey is still under development and adaptations have been necessary in an attempt to provide adequate coverage for these species. The survey currently provides an index for both the boarfish and Malin Shelf herring assessments, and in the future, this survey may provide a tuning index for western horse mackerel also. With this in mind, compromises are necessary. A visual comparison of boarfish distribution between years Figure 3.3.1.1 suggests that stock containment to the east, in the Celtic Sea shelf, was achieved in 2014 and possibly 2011 only.

3.3.2 International bottom trawl survey (IBTS) Indices Investigation

The western IBTS data and CEFAS English Celtic Sea Groundfish Survey were investigated for their use as abundance indices for boarfish for the first time in 2012. An index of abundance was constructed from the following surveys:

- EVHOE, French Celtic Sea and Biscay Survey, (Q4) 1997 to 2011
- IGFS, Irish Groundfish Survey, (Q4) 2003 to 2011
- WCSGFS, West of Scotland, (Q1 and Q4) 1986 to 2009 (survey design changed in 2010)
- SPPGFS, Spanish Porcupine Bank Survey, (Q3) 2001 to 2011
- SPNGFS, Spanish North Coast Survey, (Q3/Q4) 1991 to 2011
- ECSGFS, CEFAS English Celtic Sea Groundfish Survey, (Q4) 1982 to 2003

From the IBTS data, CPUE was computed as the number of boarfish per 30 min haul. The abundance of boarfish per year per ICES Rectangle (used for visualisation only) was then calculated by summing the boarfish in a given rectangle and dividing by the total number of hauls in that rectangle. Length frequencies are presented in Table 3.3.2.1 for each survey. These surveys cover the majority of the observed range of boarfish in the ICES Area (Figure 3.1). Figure 3.3.2.1 also includes the spatial range of the Portuguese Groundfish Survey (1990–2011), however this survey is outside the current EC TAC area and was never in the assessment.

A detailed analysis of the IBTS data was carried out in 2012 to investigate the main areas of abundance of boarfish in these surveys. This analysis included GAM modelling based on the probability of occurrence of boarfish. The full details of this work are presented in the stock annex. The IBTS appears to give a relative index of abundance, with good resolution between periods of high and low abundance. The main centres of abundance in the survey Figure 3.3.2.2 correspond to the main fishing grounds (Figure 3.1.2.1). Figure 3.3.2.3 shows the signal in abundance, increasing in the 1990s, declining again in the early 2000s, before increasing again.

For subsequent surplus production modelling (see Section 3.6.3), biomass indices were extracted from each of the IBTS surveys using a delta-lognormal model (Stefánsson 1996). Many of the surveys exhibited a large proportion of zero tows with occasionally very large tows, hence the decision to explicitly model the probability of a non-zero tow and the mean of the positive tows. A delta-lognormal fit comprises fitting two generalized linear models (GLMs). The first model (binomial GLM) is used to obtain

the proportion of non-zero tows and is fit to the data coded as 1 or 0 if the tow contained a positive or zero CPUE, respectively. The second model is fit to the positive only CPUE data using a lognormal GLM. Both GLMs were fit using ICES rectangle and year as explanatory factor variables. Where the number of tows per rectangle was less than 5 over the entire series, they are grouped into an "others" rectangle. An index per rectangle and year is constructed, according to Stefánsson (1996), by the product of the estimated probability of a positive tow times the mean of the positive tows. The station indices are aggregated by taking estimated average across all rectangles within a year. To propagate the uncertainty, all survey index analyses were conducted in a Bayesian framework using MCMC sampling (Kery 2010). As WinBugs is no longer updated, the analyses were migrated from WinBUGS to JAGS in 2017. Indeed, JAGS has an almost identical language to WinBUGS and its outputs have been proven equivalent to the previous software (Plummer 2003; Spiegelhalter *et al.* 2003). In 2018, the assessment was reverted back to WinBUGS as it MCMC sampler appeared more efficient than that of JAGS. Still, the outputs derived from both software are highly similar.

3.4 Mean weights-at-age, maturity-at-age and natural mortality

Mean weight-at-age was obtained from the ageing studies of Hüssy *et al.* (2012b). These mean weights are presented in the text table below. The variation in weight-at-age is due to small sample size and seasonal variation in weight and maturity stage.

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
MW (g)	0.84	6.65	14.6	19.5	23.7	26.8	33.3	37.7	40	47.1	50.2	51.2	62.8	56.4	62.2

Age	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
MW (g)	68.9	50.5	86.7	77.9	64.6	63.5	75	86	71	77	84.4	79.4	-	67.6	52.8

Maturity-at-age was obtained from the ageing studies of Hüssy *et al.* (2012a; b) and the reproductive study by Farrell *et al.* (2012).

AGE	0	1	2	3	4	5	6+
PROP MATURE	0	0	0.07	0.25	0.81	0.97	1

Natural mortality (M) was estimated over the life span of the stock using the method described by King (1995). This method assumes that M is the mortality that will reduce a population to 1% of its initial size over the lifespan of the stock. Based on a maximum age of 31, M is calculated as follows

$$M = -ln(0.01)/31$$

Following this procedure M = 0.16 year^{-1}. M = 0.16 is considered a good estimate of natural mortality over the life span of this boarfish stock, as it is similar to the total mortality estimate from 2007, (Z = 0.18, see Section 3.6.5). Given that catches in 2007 were relatively low, this estimate of total mortality is considered a good estimate of natural mortality, assuming negligible fishing mortality in previous years.

Similarly, total mortality was estimated from age-structured IBTS data from 2003 to 2006 (years from which data was available for all areas). The total mortality is considered a good estimate of natural mortality as fishing mortality was assumed to be negligible during this period. Total mortality ranged from 0.09 - 0.2 with a mean of 0.16.

The special review in 2012, questioned the validity of a single estimate of M across the entire age range. If an age based assessment is possible in the future, age specific estimates of natural mortality are required. However, the current estimate of M, which covers the whole age range, is considered appropriate in the context of the current situation where age data are used as an indicator approach, rather than as a full assessment method. Given that Z and F are also calculated over the entire (fully selected) range (Section 3.6.5) a single value of M is considered appropriate.

3.5 Recruitment

The IBTS data were explored as indices of abundance of 1 year old, and 1-5 years old as a composite recruitment index (Figures 3.5.1 & 3.5.2). The EVHOE and SPNGFS surveys provide the best indices of recruitment as this is where the juveniles appear to be most abundant (Table 3.3.2.1). It appears that recruitment was high in the late 1990s but declined to a low in 2003. However, this apparent dip in recruitment was not observed in the commercial catch-at-age data. The recruitment signal for ages 1-5 combined has been stable since 2004 with a small increase evident in 2015. The recruitment signal for 1 year old shows a more variable pattern with an increase in 2015 also evident (Figure 3.2.1.1). In 2016, almost all values for age 1 and combined ages 1-5 decreased compared to 2015. The decreases were rather important in the SPNGFS survey and led to historical lows for this survey.

3.6 Exploratory assessment

In 2012, a new stock assessment method for Boarfish was tested. In 2013 this Bayesian state space surplus production model (BSP; Meyer & Millar (1999)) was further developed following reviewers' recommendations in 2012. Different applications of a Bayesian biomass dynamic model were run in 2013 incorporating combinations of catch data, abundance data from the groundfish surveys, and estimates of biomass (and associated uncertainty) from the acoustic surveys (see stock annex for more details of the sensitivity runs). The model and settings from the final accepted run in 2013 were used as the basis of ICES category 1 advice for catch in 2014. However, in 2014 there was concern about the use of the production model for a number of reasons and ICES considered this model as no longer suitable for providing category 1 advice. Since 2014, the assessment model has been used as a basis for trends for providing DLS advice (ICES category 3). ICES considers the current basis for the advice on this stock to be an interim measure prior to development of an age-based assessment.

3.6.1 IBTS data

The common ALK (Table 3.2.1.1) was applied to the IBTS number-at-length data. The length-frequency is presented in Table 3.3.2.1and the age-structured index in Table 3.6.1.1 and Figure 3.6.1.1. A cohort effect can be seen with those cohorts from the early 2000s appearing weak. This coincides with a decline in overall abundance in the early 2000s. From the mid-2000s onwards recruitment improved as observed in the abundance of 1-5 year olds in the EVHOE and Spanish northern shelf surveys (Figures 3.5.1 & 3.5.2). It should be noted however that the IBTS data is measured to the 1.0cm not the 0.5cm until 2015. Therefore, application of the common ALK to this data must be viewed with caution.

Some of the IBTS CPUE indices displayed marked variability with a large proportion of zero tows and occasionally very large tows (e.g. West of Scotland survey, Figure B.4.7 stock annex). More southern surveys displayed a consistently higher proportion

of positive tows. The variability of the data is reflected in the estimated mean CPUE indices (Figure 3.6.1.2). The West of Scotland survey index had been increasing between 2000 and 2009 but is uncertain, whereas the estimated indices from the other series are typically less variable (Figure 3.6.1.2). In 2014 four of the five current bottom trawl surveys experienced a sharp decline in CPUE, particularly the West of Scotland, the Spanish North Coast, the Spanish Porcupine and Irish Groundfish surveys. Both Spanish surveys remained low in 2015 whereas the latest IGFS and EVHOE surveys indicate an increase. In 2016, values were similar to those of the previous year for all surveys. In 2017, surveys suggest that the stock abundance increased compared to the year before. The only exception is the EVHOE survey but its coverage was only partial year due its research vessel breakdown. The CEFAS English Celtic Sea Groundfish Survey displays a steady increase from the mid-1980s to 2002 with a large but somewhat uncertain estimate in 2003 (Figures 3.6.1.2 & 3.6.1.3). The spatial extent of each survey is shown in Figure 3.3.2.1.

Diagnostics from the positive component of the delta-lognormal fits indicate relatively good agreement with a normal distribution on the natural logarithmic scale (Figure 3.6.1.4). There is an indication of longer tails in some of the surveys (e.g. WCSGFS, SPPGFS).

Pair-wise correlation between the annual mean survey indices varied. The IGFS, EVHOE and SPNGFS displayed positive correlation (Figure 3.6.1.5). The WCSGFS also displayed a negative correlation with the 2 Spanish surveys (SPPGFS and SPNGFS). The SPPGFS also displayed a negative correlations with EVHOE (Figure 3.6.1.5). Weighting the correlations by the sum of the pair-wise variances resulted in a largely similar correlation structure, though the WCSGFS and SPPGFS were more strongly correlated with the ECSGFS (Figure 3.6.1.6). Note that though some surveys displayed weak or no correlation, we did not a-priori exclude any surveys from the assessment. Sensitivity tests were conducted in 2013, which led to the exclusion of the surveys mentioned previously (see the stock annex).

3.6.2 Biomass estimates from acoustic surveys

The Boarfish Acoustic Survey (BFAS) series was initiated in July 2011 and is now in its 8 year. The initial survey in 2011 collected data over 24 hours. Since 2012, acoustic data has been collected between the hours of 04:00 and 00:00. The 2011 data was reworked in 2015 to exclude the data between 00:00 and 04:00. A TS model of -66.2dB was developed in 2013 [Fässler *et al.* (2013); odonnell_implementation_2013] and is applied to all surveys in the time series (Figure 3.3.1.1). Over the time series of the survey total biomass has been estimated in the range 863 kt (in 2012) to 70 kt (2016). The precision on the estimates has been good, with coefficients of variation in the range 11 to 21. An overall downward trend is evident in the first years while estimates have been more stables and rather low since 2014. No strong evidence exists for removing any of the survey points from the time series although 2016 may look like an outlier.

It should be noted that two acoustic surveys are conducted annually to the south of the southern limit of the dedicated Boarfish survey. In 2016 the PELACUS recorded an increase in biomass from 2015 although not of the order of the decrease seen further north. The Spanish PELGAS surveys recorded low levels of biomass, similar to that in 2015. Both these surveys take place 2-3 months prior to the boarfish survey.

3.6.3 Biomass dynamic model

In 2012 an exploratory biomass dynamic model was developed. This was a Bayesian state space surplus production model (Meyer & Millar 1999), incorporating the catch data, IBTS data, and acoustic biomass data. This assessment was then peer-reviewed by two independent experts on behalf of ICES. In 2013 a new assessment was provided, which was based on the previous year's work and the reviewers' comments and formed the basis of a category 1 assessment. Details of the review and the associated changes can be found in the stock annex.

In 2014 the Bayesian state space surplus production model was again fit using the catch data, delta-lognormal estimated IBTS survey indices, and the acoustic survey estimates. However, the inclusion of the low 2014 acoustic biomass estimate changed the perception on the stock, which raised concerns over the sensitivity and process error of the model. The stock was moved from a category 1 assessment to a category 3 with the results of the surplus production model being used to calculate an index for the data limited stock approach.

Since 2014, the procedure used to run the model did not change. Only the length of the time series used increase yearly. Details of this exploratory run used to calculate the DLS index are described below. Further model development work is undertaken since 2015 but did not lead to any change so far.

In the Bayesian state space surplus production model the biomass dynamics are given by a difference form of a Schaefer biomass dynamic model:

$$B_t = B_{t-1} + rB_{t-1}(1 - \frac{B_{t-1}}{K}) + C_{t-1}$$

where B_t is the biomass at time t, r is the intrinsic rate of population growth, K is the carrying capacity, and C_t is the catch, assumed known exactly. To assist the estimation the biomass is scaled by the carrying capacity, denoting the scaled biomass $P_t = B_t / K$. Lognormal error structure is assumed giving the scaled biomass dynamics (process) model:

$$P_t = (P_{t-1} + rP_{t-1}(1 - P_{t-1}) + \frac{C_{t-1}}{K})e^{\mu_t}$$

where the logarithm of process deviations are assumed normal $u_t = N(0, \sigma_2^{\mu})$ with σ_2^{μ} the process error variance.

The starting year biomass is given by aK, where a is the proportion of the carrying capacity in the first year. The biomass dynamics process is related to the observations on the indices through the measurement error equation:

$$I_{j,t} = q_j P_t K e^{\varepsilon_{j,t}}$$

where $I_{j,t}$ is the value of abundance index j in year t, q_j is survey-specific catchability, $B_t = P_t K$, and the measurement errors are assumed lognormally distributed with $u_t = N(0, \varepsilon_{e,j,t}^2)$ where $\varepsilon_{e,j,t}^2$ is the index-specific measurement error variance. $Var(I_{j,t})$ is obtained from the delta-lognormal survey fits. That is, the variance of the mean annual estimate per survey is inputted directly from the delta-lognormal fits (Figure 3.6.1.2) as opposed to estimating a measurement error within the assessment. The measurement error is obtained from:

$$\sigma_{e,j,t}^2 = ln(1 + \frac{Var(I_{j,t})}{(I_{j,t})^2})$$

For the acoustic survey, the CV of the survey was transformed into a lognormal variance via

$$\sigma^2_{\varepsilon,acoustic,t} = ln(CV^2_{acoustic,t} + 1)$$

Prior assumptions on the parameter distributions were:

- Intrinsic rate of population growth: *r ~ U(0.001, 2)*
- Natural logarithm of the carrying capacity: *ln(K) ~ U(ln(max(C), ln(10.sum(C)) = U(ln(144047), ln(4450407))*
- Proportion of carrying capacity in first year of assessment: *a ~ U[0.001, 1.0]*
- Natural logarithm of the survey-specific catchabilities $ln(q_i) \sim U(-16, 0)$ (for IBTS only). The acoustic survey prior is discussed below.
- Process error precision $\frac{1}{\sigma^2_u} \sim gamma(0.001,0.001)$

Specification

During the 2013 WGWIDE meeting a number of different iterations of the model were run to discern the best parameters for the assessment. After four initial runs and four sensitivity runs the settings for the final run (run 2.2) were chosen. These settings are shown below and were used for the assessment model since 2014. (More details of the trial runs in 2013 can be found in the stock annex).

The specifications for the final boarfish assessment model runs are:

Acoustic survey

Years: 2011–2018

Index value ($I_{acoustic,y}$): 'total' in tonnes (i.e. Definitely Boarfish + Probably Boarfish + Boarfish in a Mix)

Catchability ($q_{acoustic}$): A free, but strong prior (i.e. the acoustic survey is treated as a relative index but is strongly informed, this allows the survey to cover <100% of the stock).

IBTS surveys

6 delta log normal indices (WCSGFS, SPPGFS, IGFS, ECSGFS, SPNGFS, EVHOE)

First 5 and last 7 (since 2017, because of change in survey design) years omitted from WCSGFS

First 9 years omitted from ECSGFS

Following plenary discussion of the sensitivity runs in 2013, it was decided that the final run be based on a run that includes all surveys with the omission of the first 5 years of the WCSGFS and first 9 years of the ECSGFS. The reasons for this decision were: * it is unclear whether boarfish were consistently recorded in the early part of the ECSGFS, * the WCSGFS is thought to be at the northern extreme of the distribution and may not be an appropriate index for the whole stock, * the SPNGFS commences in 1991 such that running the assessment from 1991 onwards includes at least three surveys without relying, solely on the ECSGFS and WCSGFS, * surveys are internally weighted such that highly uncertain values receive lower weight.

Catches

2003–2018 time series

Priors

The final run assumes a strong prior $ln(q_{acoustic}) \sim N(1, 1/4)$ (mean 1, standard deviation 0.25), which has 95% of the density between 0.5 and 2. Given the short acoustic series (6 years) it is not possible to estimate this parameter freely (*i.e.* using an uninformative

prior). The prescription of a strong prior removes the assumption of an absolute index from the acoustic survey. This assumption will be continually updated as additional data accrue.

Run convergence

Parameters for the 2018 model run converged with good mixing of the chains and Rhat values lower than 1.1 indicating convergence (Figures 3.6.3.1 & 3.6.3.2). MCMC chain autocorrelation was rather high but was compensated by long MCMC chains providing representative samples of the parameter posteriors (Figure 3.6.3.3).

Diagnostic plots are provided in Figure 3.6.3.4 showing residuals about the model fit. A fairly balanced residual pattern is evident. In some cases outliers are apparent, for instance in the English survey in the final year (2003). However, these points are downweighted according to the inverse of their variance and hence do not contribute much to the model fit. The west of Scotland IBTS survey, located at the northern extreme of the stock distribution underestimates the stock in the early period (years) and overestimates it in the recent period from all fits. This could be indicative of stock expansion into this area at higher stock sizes and suggests that this index is not representative of the whole stock. `Figure 3.6.3.5 shows the prior and posterior distributions of the parameters of the biomass dynamic model. The estimate of q is less than 1.0, leading to a higher estimate of final stock biomass than the acoustic survey.

Results

Trajectories of observed and expected indices are shown in Figure 3.6.3.6, along with the stock size over time and a harvest ratio (total catch divided by estimated biomass). Parameter estimates from the model run are summarized in Table 3.6.3.1. Biomass in 2018 is estimated to be 284 770 t and it appears to be stable but low over the last 5 years. It is worth noting that the extremely low biomass estimate from the 2016 acoustic survey now appears considered as an outlier by the model. As a consequence the 2016 biomass estimate increased from 108 000 t last in 2016 to about 240 000 t in 2017 and 2018. Retrospective plots of TSB and F, presented in Figure 3.6.3.7, show that the perception of the stock is stable through time with the exception of 2013 prior to the inclusion of the lower biomass estimates of the acoustic surveys since 2014.

3.6.4 Pseudo-cohort analysis

Pseudo-cohort analysis is a procedure where mortality is calculated by means of catch curves derived from catch-at-age from a single year. This is in contrast to cohort analysis, which is the basis of VPA-type assessments. In cohort analysis, mortality is calculated across the ages of a year class, not within a single year. Because only seven years of sampling data were available and owing to the large age range currently in the catches a cohort analysis would only yield information for a very limited age and year range. Therefore, pseudo-cohort analysis was performed to supplement the Bayesian state space model.

Pseudo-cohort Z estimates increased with the rapid expansion of the fishery but decreased in 2011 due to the introduction of the first boarfish TAC (Table 3.6.4.1). By subtracting M (= 0.16), an estimate of F was obtained for each year (ages 7-14). This series was revised to represent ages 7-14, rather than 6-14 as in previous years, because in 2013 age 6 boarfish were not fully selected, *i.e.* age 7 had higher abundance at age.

It can be seen from the text table below that $Z = M$ in 2007, the initial year of the expanded fishery, while F is negligible. F increased to a high of 0.29 in 2012 and has gradually reduced down to 0.15 in 2015 and 2016. In 2017, it increased up to 0.17. There was

a weak correlation between catches and pseudo-cohort *F* ($r^2 = 0.48$). Recent *F* estimated this way is close to *FMSY* (0.149) and above *F0.1* (0.13).

Year	Z.(7–14)	F.(Z–M)	Catch.(t)
2007	0.17	0.01	21 576
2008	0.33	0.17	34 751
2009	0.36	0.2	90 370
2010	0.33	0.17	144 047
2011	0.29	0.13	37 096
2012	0.45	0.29	87 355
2013	0.36	0.2	75 409
2014	0.37	0.21	45 231
2015	0.31	0.15	17 766
2016	0.31	0.15	19315
2017	0.33	0.17	17388

3.6.5 State of the stock

According to this year assessment, total stock biomass appeared to increase from a low to average level from the early to mid-1990s (Figure 3.6.3.6). The stock fluctuated around this level until 2009, when it increased until 2012, followed by a sharp decline from 2013 to 2014. Since 2014, the abundance appear low but rather stable, fluctuating around 320 000 t. There was concern in 2014 that this decline was exaggerated by an unusually low acoustic biomass estimate that led to a downward revision in stock trajectory. However, the 2014 survey may now be viewed as one of the most successful in terms of containment. The comparably low 2014 biomass estimate was supported by results of the 2015 survey. The 2016 biomass estimate, the lowest of the time series now appears as an outlier and do no longer drive the stock abundance estimates to even lower values. The uncertainty surrounding the estimates of biomass the last years remain important with wide 95% credible interval (Table 3.6.5.1). This reflects the uncertainty in the survey indices, and short exploitation history of the stock and the treatment of the acoustic survey as a relative biomass index. As more data accumulates from this survey, it is expected that the prior will become increasingly updated, and potentially less variable.

Catch data are available from 2001, the first year of commercial landings, and reasonably comprehensive discard data are available from 2003. Peak catches were recorded in 2010, when over 140 000 t were taken. Elevated fishing mortality was observed, associated with the highest recorded catch in 2010. Fishing mortality, expressed as a harvest ratio (catch divided by total biomass), was first recorded in 2003. Before that time, it is to be expected that some discarding took place, and there were some commercial landings. Fishing mortality increased measurably from 2006, reaching a peak in 2009-2010. F declined in 2011 as catches became regulated by the precautionary TAC but increased year on year until 2015 when reduced catches resulted in a reduction. The considerable catches in recent years do not appear to have significantly truncated the size or age structure of the stock and 15+ group fish are still abundant (Figure 3.2.1.1).

Since 2017, MSY reference points have been developed for the boarfish stock and may be used to guide the advice. The ICES MSY framework specifies a target fishing mortality, FMSY (stock growth rate over 2), which, over the long term, maximises yield, and also a spawning biomass, MSY $B_{trigger}$ (stock carrying capacity over 4), below which target fishing mortality should be reduced linearly relative to the SSB $B_{trigger}$ ratio. In 2018, FMSY and MSY $B_{trigger}$ are estimated respectively equal to 0.185 (parameter r / 2)

and 165 420 t (parameter K / 4). Throughout the history of the fishery, estimates of stock biomass have remained above $MSYB_{trigger}$. Fishing mortality (F) was greater than FMSY in 2009, 2010 and 2014, but has decreased since. In 2018, the stock is in the green area of the Kobe plot (Figure 3.6.6.1).

Estimates of recruitment are not available from the stock assessment. However, an independent index of recruitment is available from groundfish surveys (Section 3.5). Observations from the survey recruitment of 1 year olds show strong negative trends since 2010 (Figure 3.5.1) and a weaker, but still negative, trend for ages 1-5 combined (Figure 3.5.2) for 2 out of 3 surveys. The trend within the IGFS is opposite.

3.7 Short Term Projections

As the assessment is exploratory, no short term projections were conducted.

3.8 Long term simulations

No long term simulations were conducted.

3.9 Candidate precautionary and yield based reference points

3.9.1 Yield per Recruit

A yield per recruit analysis was conducted in 2011 (Minto *et al.* 2011) and *F0.1* was estimated to be 0.13 whilst F_{MAX} was estimated in the range 0.23 to 0.33 (Figure 3.9.1.1). *F0.1* was considered to be well estimated (Figure 3.9.1.2). No new yield per recruit analyses were performed in subsequent years.

3.9.2 Precautionary reference points

It does not appear that boarfish is an important prey species in the NE Atlantic (Section 3.13). ICES (2007) considered that precautionary *F* targets (*Fpa*) should be consistent with F130 625 t based on the exploratory assessment in 2018).

3.9.3 Other yield based reference points

Yield per recruit analysis, following the method of Beverton & Holt (1957), found *F0.1* to be robustly estimated at 0.13 (ICES 2011; Minto *et al.* 2011).

3.10 Quality of the assessment

ICES considers the current basis for the advice on this stock to be an interim measure prior to development of an age-based assessment. In addition, the acoustic survey used (BFAS / WESPAS) is in a state of development at present and there are concerns that the acoustic survey may not be containing the stock sufficiently. The assessment was downgraded from Category 1 to Category 3 in 2014, and it has remained in this category since. The model is still considered suitable for category 3 advice, because it provides the best means of combining the available survey series. The assessment is very sensitive to the acoustic series. In addition, a substantial part of the year to year variations in the stock abundance is linked to the process error. The use of some priors (like ratio to virgin biomass in the first year of the assessment) and survey (WCSGFS for instance) may need to be revised.

Additional work to improve the surplus production model is undertaken since 2015 and will continue next year. A issue list has been provided and a benchmark is planned for 2020.

The bottom trawl survey data are considered to be a good index of abundance given that boarfish aggregate near the bottom at this time of year. The trawl surveys record high abundances of the species, but with many zero hauls. The delta-lognormal error structure used in the analyses is considered to be a good means of dealing with such data. The biomass dynamic model used in the stock assessment is based on the recent benchmarked assessment of megrim in Sub-divisions 4 and 6. The model was further developed by including acoustic survey biomass estimates. One drawback of the model is that it does not provide estimates of recruitment. However, an estimate of recruitment strength is available from the Spanish and French trawl surveys.

3.11 Management considerations

As this stock is now placed in category 3, the ICES advice for 2018 is based on harvest control rules for data limited stocks (ICES 2017). Since the biomass estimate from the Bayesian model is considered reliable for trend based assessment, an index can be calculated according to Method 3.1 of ICES (2012). The advice is based on a comparison of the average of the two most recent index values with the average of the three preceding values multiplied by the most recent catch. Table 3.6.5.1 shows the biomass estimates from the model from which the index was calculated.

ADG decided to use the advice given in 2017 and based on this framework for 2 years. This results in an advised catch of 21 830 t for 2019. More details can be found in last year report. The apparent stability of the assessment this year comforts this decision.

Although no longer accepted as the basis for an analytic assessment, the surplus production model still provides the best unified view of this stock (Figure 3.6.3.6).

3.12 Stock structure

A dedicated study on the stock structure of boarfish within the Northeast Atlantic and Mediterranean Sea commenced in October 2013 in order to resolve outstanding questions regarding the stock structure of boarfish and the suitability of assessment data. Results (Farrell *et al.* 2016) indicated strong population structure across the distribution range of boarfish with 7-8 genetic populations identified (Figure 3.12.1).

The eastern Mediterranean (*MED*) samples comprised a single population and were distinct from all other samples. Similarly the Azorean (*AZA*), Western Saharan (*MOR*) and Alboran (*ALM*) samples were distinct from all others. Of particular relevance to the assessment and management of the boarfish fishery is the identification and delineation of the population structure between southern Portuguese waters (*PTN2B-PTS*) and waters to the geographic north. A distinct and temporally stable mixing zone was evident in the waters around Cabo da Roca. The *PTN2A* sample appeared to be significantly different from all other samples however this sample was relatively small and was considered to represent a mixed sample rather than a true population.

No significant spatial or temporal population structure was found within the samples comprising the NEA population (Figure 3.12.1). A statistically significant but comparatively low level of genetic differentiation was found between this population and the northern Spanish shelf/northern Portuguese samples (NSA-PTN1). However, a high level of migration was revealed between these two populations and no barriers to gene flow were detected between them. Therefore, for the purposes of assessment and management these areas can be considered as one unit.

Analyses indicated a lack of significant immigration into this northeast Atlantic boarfish stock from populations to the south or from insular elements and the strong genetic differentiation among these regions indicate that the purported increases in abundance in the northeast Atlantic area are not the result of a recent influx from other regions. The increase in abundance is most likely the result of demographic processes within the northeast Atlantic stock (Blanchard & Vandermeirsch 2005; Coad *et al.* 2014).

Whilst the current assessment and management area constitutes the majority of the most northern population it should be extended into Northern Portuguese waters and repeated genetic monitoring of the stock in this region should be conducted to ensure the validity of this delineation. Based on analyses of IBTS data (ICES 2013) the biomass in this area is suspected to be small relative to the overall biomass in the TAC area.

3.13 Ecosystem considerations

The ecological role and significance of boarfish in the NE Atlantic is largely unknown. However, in the southeast North Atlantic, in Portuguese waters, they are considered to have an important position in the marine food web (Lopes *et al.* 2006). The diet has been investigated in the eastern Mediterranean, Portuguese waters and at Great Meteor Seamount and consists primarily of copepods, specifically *Calanus helgolandicus*, with some mysid shrimp and euphausiids (Macpherson 1979; Fock *et al.* 2002; Lopes *et al.* 2006). This contrasted with the morphologically similar species, the slender snipefish, *Macroramphosus gracilis* and the longspine snipefish, *M. scolopax*, whose diet comprised *Temora spp.*, copepods and mysid shrimps, respectively (Lopes *et al.* 2006). Despite the obvious potential for these species to feed on fish eggs and larvae, there was no evidence to support this conclusion in Portuguese waters and they were not considered predators of commercial fishes and thus their increase in abundance was unlikely to affect recruitment of commercial fish species. If the NE Atlantic population of boarfish is sufficiently large then there exists the possibility of competition for food with other widely distributed planktivorous species.

Both seasonal and diurnal variations were observed in the diet of boarfish in all three regions. In the eastern Mediterranean and Portuguese waters, mysids become an important component of the diet in autumn, which correlates with their increased abundance in these regions at this time (Macpherson 1979; Lopes *et al.* 2006). Fock *et al.* (2002) found that boarfish at Great Meteor Seamount fed mainly on copepods and euphausiids diurnally and on decapods nocturnally, indicating habitat dependent resource utilization.

Boarfish appear an unlikely target of predation given their array of strong dorsal and anal fin spines and covering of ctenoid scales. However, there is evidence to suggest that they may be an important component of some species' diets. Most studies have focused in the Azores and few have mentioned the NE Atlantic, probably due to the relatively low abundance in the region until recent years. In the Azores, boarfish was found to be one of the most important prey items for tope (*Galeorhinus galeus*), thornback ray (*Raja clavata*), conger eel (*Conger conger*), forkbeard (*Phycis phycis*), bigeye tuna (*Thunnus obesus*), yellowmouth barracuda (*Sphyraena viridensis*), swordfish (*Xiphias gladius*), blackspot seabream (*Pagellus bogaraveo*), axillary seabream (*Pagellus acarne*) and blacktail comber (*Serranus atricauda*) (Clarke *et al.* 1995; Morato *et al.* 1999, 2000, 2001, 2003; Arrizabalaga *et al.* 2008). Many of these species also occur in the NE Atlantic shelf waters although it is unknown whether boarfish represent a significant component of the diet in this region.

In the NE Atlantic boarfish have not previously been recorded in the diets of tope or thornback ray (Holden & Tucker 1974; Ellis *et al.* 1996). However, this does not prove that they are currently not a prey item. A study of conger eel diet in Irish waters from 1998-1999 failed to find boarfish in the diet (O\&\#39 *et al.* 2004). However, in Portuguese waters a recent study has found boarfish to be the most numerous species in the diet of conger eels (Xavier *et al.* 2010). It has been suggested that boarfish are an important component of the diet of hake (*Merluccius merluccius*), as they are sometimes caught together. However, a recent study of the diet of hake in the Celtic Sea and Bay of Biscay did not report any boarfish in the stomachs of hake caught during the 2001 EVHOE survey (Mahe *et al.* 2007).

The conspicuous presence of boarfish in the diet of so many fish species in the Azores is perhaps more related to the lack of other available food sources than to the palatability of boarfish themselves. Given the large abundance in NE Atlantic shelf waters it is likely that they would have been recorded more frequently if they were a significant and important prey item.

Boarfish are also an important component of the diet a number of sea birds in the Azores, most notably the common tern (*Sterna hirundo*, Granadeiro *et al.* (2002)) and Cory's shearwater (*Calonectris diomedea*, Granadeiro *et al.* (1998)). This is surprising given that in the Mediterranean discarded boarfish were rejected by seabirds whereas in the Azores they were actively preyed on (Oro & Ruiz 1997). Cory's shearwaters are capable of diving up to 15 m whilst the common tern is a plunge-diver and may only reach 2-3 m. It is therefore surprising that boarfish are such a significant component of their diet given that it is generally considered a deeper water fish. In the Azores boarfish shoals are sometimes driven to the surface by horse mackerel and barracuda where they are also attacked by diving sea birds (J. Hart, CW Azores, pers. comm.). Anecdotal reports from the Irish fishery indicate that boarfish are rarely found in waters shallower than 40 m. This may suggest that they are outside the range of shearwaters and gannets, the latter having a mean diving depth of 19.7±7.5 m (Brierley & Fernandes 2001). However, the upper depth range of boarfish is within maximum diving depth recorded for auks (50 m) as recorded by Barrett & Furness (1990). Given their frequency in the diets of marine and bird life in the Azores, boarfish appear to be an important component of the marine ecosystem in that region. There is currently insufficient evidence to draw similar conclusions in the NE Atlantic.

The length-frequency distribution of boarfish may be important to consider. IBTS data shows an increase in mean total length with latitude Table 3.3.2.1 and perhaps the smaller boarfish in the southern regions are more easily preyed upon. Length data of boarfish from stomach contents studies of both fish and sea birds in the Azores indicate that the boarfish found are generally < 10 cm (Granadeiro *et al.* 1998, 2002).

3.14 Proposed management plan

In 2015 the Pelagic Advisory Council submitted a revised draft management strategy for Northeast Atlantic boarfish. The EU has requested ICES to evaluate the following management plan:

This management strategy aims to achieve sustainable exploitation of boarfish in line with the precautionary approach to fisheries management, FAO guidelines for new and developing fisheries, and the ICES form of advice.

1) The TAC shall be set in accordance with the following procedure, depending on the ICES advice

a) If category 1 advice (stocks with quantitative assessments) is given based on a benchmarked assessment, the TAC shall be set following that advice.

b) If category 1 or 2 (qualitative assessments and forecasts) advice is given based on a non-benchmarked assessment the TAC shall be set following this advice.

c) Categories 3-6 are described below as follows:

i) Category 3: stocks for which survey-based assessments indicate trends. This category includes stocks with quantitative assessments and forecasts which for a variety of reasons are considered indicative of trends in fishing mortality, recruitment, and biomass.

ii) Category 4: stocks for which only reliable catch data are available.This category includes stocks for which a time series of catch can be used to approximate MSY.

iii) Category 5: landings only stocks. This category includes stocks for which only landings data are available.

2) Category 6: Category 6 - negligible landings stocks and stocks caught in minor amounts as bycatch

3) Notwithstanding paragraph 1, if, in the opinion of ICES, the stock is at risk of recruitment impairment, a TAC may be set at a lower level.

4) If the stock, estimated in the either of the 2 years before the TAC is to be set, is at or below B_{lim} or any suitable proxy thereof, the TAC shall be set at 0 t.

5) The TAC shall not exceed 75,000 t in any year.

6) The TAC shall not be allowed to increase by more than 25% per year. However, there shall be no limit on the decrease in TAC.

7) Closed seasons, closed areas, and moving on procedures shall apply to all directed boarfish fisheries as follows:

a) A closed season shall operate from 31st March to 31st August. This is because it is known that herring and mackerel are present in these areas and may be caught with boarfish.

b) A closed area shall be implemented inside the Irish 12-miles limit south of 52°30 from 12th February to 31st October, in order to prevent catches of Celtic Sea herring, known to form aggregations at these times.

c) If catches of other species covered by a TAC amount to more than 5% of the total catch by day by ICES statistical rectangle, then all fishing must cease in that rectangle for 5 consecutive days.

3.15 References

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Table 3.1.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Landings, discards and TAC by country by year (t), 2001–2017. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Years	Denmark	Germany	Ireland	The.Netherlands	UK.England	UK.Scotland	Unallocated	Discards	Total	TAC
2001			120						120	-
2002			91						91	-
2003			458					10929	11387	-
2004			675					4476	5151	-
2005			165					5795	5959	-
2006			2772					4365	7137	-
2007			17615			772		3189	21576	-
2008	3098		21585			0.45		10068	34751	-
2009	15059		68629					6682	90370	-
2010	39805		88457			9241		6544	144047	-
2011	7797		20685			2813		5802	37096	33000
2012	19888		55949			4884		6634	87355	82000
2013	13182		52250			4380		5598	75409	82000
2014	8758		34622			38		1813	45231	133957
2015	29	4	16325	375	104			929	17766	53296
2016	337	7	17496	171	21			1284	19315	47637
2017	548		15485	182	0.13			1173	17388	27288

Table 3.1.2.2. Boarfish in ICES Subareas 27.6, 7, 8. Landings by year (t), 2001–2017 (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Area	Denmark	Germany	Ireland	The.Netherlands	UKE	UKS	Total
2001	ALL			120				120
2002	ALL			91				91
2003	ALL			458				458
2003	6.a			65				65
2003	7.b			214				214
2003	7.j			179				179
2004	ALL			675				675
2004	6.a			292				292
2004	7.b			224				224
2004	8.d			38				38
2004	7.j			122				122
2005	ALL			165				165
2005	6.a			10				10
2005	7.b			105				105
2005	8.a			38				38
2005	7.j			12				12
2006	ALL			2772				2772
2006	6.a			21				21
2006	7.b			15				15
2006	7.g			375				375
2006	8.a			1				1
2006	7.j			2360				2360
2007	ALL			17615			772	18386
2007	5.b2			6				6
2007	6.a			93				93
2007	7.b			1259				1259
2007	7.g			120				120
2007	8.a			5				5
2007	7.j			16131			772	16903
2008	ALL			21584				21585
2008	6.a			28				28
2008	7.b			3				3
2008	7.g			184				184
2008	7.j			21370				21370
2009	ALL			68629				68629
2009	6.a			45				45
2009	7.b			73				73
2009	7.c			1				1
2009	7.g			4912				4912
2009	7.h			18225				18225
2009	7.j			45372				45372

Year	Area	Denmark	Germany	Ireland	The.Netherlands	UKE	UKS	Total
2010	ALL	39805		88457			9241	137503
2010	6.a			1349			10	1359
2010	6.aS			7				7
2010	7.b			2258				2258
2010	7.c			35			4	39
2010	7.e	2						2
2010	7.g	672		3649				4321
2010	7.h	1465		8453			1712	11629
2010	7.j	37667		72707			7515	117889
2011	ALL	7797		20685			2813	31295
2011	6.a			26				26
2011	7.b			274				274
2011	7.c			9				9
2011	7.g			811				811
2011	7.h	4155		8540			2813	15508
2011	8.a	18						18
2011	7.j	3624		11025				14648
2012	ALL	19888		55949			4884	80720
2012	6.a			125				125
2012	7.b	80		4501			838	5419
2012	7.c			108			907	1015
2012	7.g			616				616
2012	7.h	5837		10579			3139	19554
2012	8.a	1604		93				1697
2012	7.j	12366		39928				52294
2013	ALL	13182		52250			4380	69811
2013	6.a			538			15	553
2013	7.b			10405			100	10505
2013	7.e						883	883
2013	7.g			1808				1808
2013	7.h	955		11355			1728	14038
2013	8.a	1354		870				2224
2013	8.d			270				270
2013	7.j	10873		27003			1653	39529
2014	ALL	8758		34622			38	43418
2014	6.a			182			30	212
2014	7.b	12		3262				3274
2014	7.g			135				135
2014	7.h	4808		18389				23196
2014	8.a			119				119
2014	7.j	3886		12536			8	16429
2014	7.k	53						53
2015	ALL	29	5	16325	375	104		16837
2015	6.a	10		116		9		134
2015	7.b	8	4	2609		85		2706
2015	7.c			220				220

Year	Area	Denmark	Germany	Ireland	The.Netherlands	UKE	UKS	Total
2015	7.g			547				547
2015	7.h	5		8506				8510
2015	8.a	6	1	682				688
2015	7.j			3646		10		3655
2015	6				128			128
2015	7				33			33
2015	8				214			214
2016	ALL	337	7	17496	171	21		18031
2016	6.a			377	45			422
2016	7.b		5	1198	35	0.66		1239
2016	7.c				0.08			0.08
2016	7.e				0.02			0.02
2016	7.h	330		6771				7101
2016	7.j			1852	90	16		1959
2016	8.a	2	1	6173		5		6181
2016	8.b					0.11		0.11
2016	8.d	5		1124				1129
2017	ALL	548		15485	182	0.13		16215
2017	4.a				0.03			0.03
2017	6.a	37		907	34			979
2017	7.b			124	118			242
2017	7.c				20			20
2017	7.d	1						1
2017	7.e				0.08			0.08
2017	7.f					0.02		0.02
2017	7.g			1		0.02		1
2017	7.h	239		2961		0.09		3200
2017	7.j			33	9			43
2017	8.a	271		10543				10814
2017	8.d			915				915
ALL	ALL	90344	12	413378	727	126	22128	526711

Table 3.1.2.3. Boarfish in ICES Subareas 27.6, 7, 8. Discards of boarfish in demersal and non-target pelagic fisheries by year (t), 2003–2017. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	Germany	Ireland	Netherlands	Spain	UK	Danemark	Lituania	Total
2003		119	1998	8812				10929
2004		60	837	3579				4476
2005		55	733	5007				5795
2006		22	411	3933				4366
2007		549	23	2617				3189
2008		920	738	8410				10068
2009		377	1258	5047				6682
2010		85	512	5947				6544
2011	49	107	185	5461				5802
2012		181	88	6365				6634
2013	22	47	11	5518				5598
2014	117	50	477	1119	50			1813
2015		7		921	1			929
2016	869	20	41	348	4		1	1284
2017		640	146			386	1	1173

Table 3.2.1.1. Boarfish in ICES Subareas 27.6, 7, 8. General boarfish age length key produced from 2012 commercial samples. Figures highlighted in grey are estimated.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
7	1	1													
8	1	1													
8		1													
8		1	1												
9		1	1												
10			1												
10			1												
10			2	10	3										
11			1	29	14	2	2								
12				9	21	21	18	2	2	1					
12				4	17	22	38	12	8						1
12					5	9	42	37	14	6	2		1	1	1
13					2	4	31	28	24	12	6	2	3	1	5
14					1	3	25	22	21	14	6	5	4	2	11
14							6	8	18	22	8	3	7	1	20
14						1	1	2	3	8	1	6	6	6	30
15							1	1		2	2	2	5	2	19
16										2				2	19
16															8
16															1
17															1
18															1
18															1
18															1

Table 3.2.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Number of samples collected from the catch per year.

Year	Landings	% landings covered by sampling programme	No. samples	No. measured	No. aged
2001	120	0	0	0	0
2002	91	0	0	0	0
2003	11 387	0	0	0	0
2004	5 151	0	0	0	0
2005	5 959	0	0	0	0
2006	7 137	0	0	0	0
2007	21 576	NA	3	217	0
2008	34 751	NA	1	152	0
2009	90 370	NA	9	1 475	0
2010	144 047	NA	95	10 675	403*
2011	37 096	NA	27	4 066	704
2012	87 355	NA	80 (68)***	9 656 (8 565)***	814**
2013	75 409	NA	76	9 392	0****
2014	43 418	NA	54	7 008	0****
2015	17 766	NA	32	3 356	0****
2016	18031	NA	27	3861	0****
2017	16215	NA	18	1140	0****

Table 3.2.1.3. Boarfish in ICES Subareas 5, 27.6, 7, 8. The allocation of Age length keys to unsampled metiers in 2017.

COUNTRY	AREA	QUARTER	LANDED	ALK
DK	7.d	1	1	IE_8.d_Q1 IE_8.a_Q1 IE_7.j_Q1 IE_7.h_Q1 DK_7.h_Q1 DK_8.a_Q1
DK	7.h	1	239	IE_7.h_Q1 DK_7.h_Q1
DK	8.a	1	271	IE_8.a_Q1 DK_8.a_Q1
IE	7.b	1	95	IE_7.j_Q1
IE	7.b	4	29	IE_7.h_Q4
IE	7.g	4	1	IE_7.h_Q3 IE_7.h_Q4
IE	7.h	1	188	IE_7.h_Q1 DK_7.h_Q1
IE	7.h	3	95	IE_7.h_Q3
IE	7.h	4	2678	IE_7.h_Q4
IE	7.j	1	33	IE_7.j_Q1
IE	8.a	1	7357	IE_8.a_Q1 DK_8.a_Q1
IE	8.a	3	50	IE_8.a_Q3
IE	8.a	4	3135	IE_8.a_Q4
IE	8.d	1	915	IE_8.d_Q1
NL	7.b	1	65	IE_7.j_Q1
NL	7.b	2	0.42	IE_7.j_Q1
NL	7.b	3	53	IE_7.j_Q1
NL	7.c	4	20	IE_7.h_Q4
NL	7.e	1	0.08	IE_8.a_Q1 IE_7.h_Q1 DK_7.h_Q1 DK_8.a_Q1
NL	7.j	1	0.01	IE_7.j_Q1
NL	7.j	2	1	IE_7.j_Q1
NL	7.j	3	8	IE_7.h_Q3 IE_7.h_Q4
UKE	7.f	2	0.02	IE_7.j_Q1 IE_7.h_Q1 IE_7.h_Q3 DK_7.h_Q1
UKE	7.g	2	0.02	IE_7.j_Q1 IE_7.h_Q1 IE_7.h_Q3 DK_7.h_Q1
UKE	7.h	2	0.09	IE_7.h_Q1 IE_7.h_Q3 DK_7.h_Q1

Table 3.2.1.4. Boarfish in ICES Subareas 27.6, 7, 8. Catch per country and corresponding number of samples collected in 2017.

COUNTRY	OFFICIAL.CATCH	%.LANDINGS.COVERED	NO.SAMPLES	NO.MEASURED	NO.AGED
DK	548		4	374	
ES	640				
IE	15631		14	766	
NL	182				
UKE	386				
UKS	1				
Total					

Table 3.2.1.5. Boarfish in ICES Subareas 27.6, 7, 8. Catch per area and corresponding number of samples collected in 2017.

AREA	OFFICIAL.CATCH	NO.SAMPLES	NO.MEASURED	NO.MEASURED.PER.1000T
27.4.a	0.03			
27.6.a	980			
27.6.b	5			
27.7.b	276			
27.7.c	81			
27.7.d	1			
27.7.e	371			
27.7.f	2			
27.7.g	4			
27.7.h	3363	7	452	134
27.8.a	10814	9	595	55
27.8.b	6			
27.8.c	208			
27.8.d	915	1	24	26
27.7.j	361	1	69	191
27.7.k	1			

Table 3.2.1.6. Boarfish in ICES Subareas 27.6, 7, 8. Proxy catch numbers-at-age of the international catches (raised numbers in '000s) for the years 2007–2017

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1			1575	2415		28	301		5556	218	1862
2	352	5488	15043	11229	2894	893	7148	695	116135	2385	4387
3	2114	21140	65744	72709	41913	5467	156680	49503	32248	10737	8830
4	40851	105575	338931	294382	28148	41278	58522	127520	16588	25114	34448
5	48915	141300	475619	567689	30116	110272	59797	93705	24564	20263	27266
6	62713	195339	543707	878363	175696	146582	68949	67275	26566	18025	21103
7	26132	104031	307333	522703	143967	492078	302967	193061	74115	61229	55189
8	29766	66570	172783	293719	107126	365840	250341	139124	52052	47573	38229
9	56075	53159	155477	276672	77861	271916	212318	121042	44615	42478	32258
10	44875	46893	130148	232122	60022	173486	160137	94225	34264	35150	25716
11	14019	15289	42521	78588	46079	69396	63025	36078	12999	13297	9560
12	32359	21178	61350	114600	40468	40968	41490	24895	9114	9132	7564
13	4848	11854	39609	59932	24352	58888	59380	36309	13362	13774	10922
14	16837	13570	31569	59060	19724	30277	30355	19064	7152	6682	5924
15+	109481	112947	196967	349320	157707	217260	239366	150688	59139	49589	40797

Table 3.2.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Length-frequency distributions of the international catches (raised numbers in '000s) for the years 2007–2017.

TL (cm)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
4.5									14			14
5									878			878
5.5									515			515
6				156					810		765	1731
6.5				439					14		4607	5060
7				1090	522	56	52		513	417	5250	7900
7.5			1354	1574			551		10598	1684	12616	28377
8			677	375	1345	185	1419		80716	8685	11473	104875
8.5				1082		555	3592	1064	49508	6412	10115	72328
9			677	5382	851	555	7263	327	10219	7104	3874	36252
9.5		7473	17367	7883	7012	641	47509	4916	213	23065	14047	130126
10	9609	11209	54130	29410	33243	2791	94702	31649	1211	46010	32346	346310
10.5		52308	174796	130889	15848	6132	59833	71344	3865	39071	36242	590328
11	84555	63517	343283	361774	70615	24571	18359	108261	12226	14181	32445	1133787
11.5		59781	321637	655875	93487	81928	20938	82470	28142	18249	31589	1394096
12	44199	119561	297737	739025	189434	264888	98564	84288	41613	30975	33618	1943902
12.5		70990	207739	564347	114904	398772	204868	112826	42461	51110	41650	1809667
13	82633	52308	147965	353484	133539	419060	315063	172416	59990	57000	46495	1839953
13.5		29890	149314	246146	51235	307533	285688	153742	52625	58696	43121	1377990
14	117224	22418	105782	224611	50857	176710	210137	138549	50139	76872	45353	1218652
14.5		14945	71273	127711	25309	89726	105571	74059	28771	37755	39524	614644
15	65338	33627	47816	125463	25569	52791	62175	43347	16087	23137	21854	517204
15.5		11209	13082	81386	5473	25065	31122	22629	8572	7841	4932	211311
16	13452	11209	19397	24256	4181	13149	14990	7672	4331	625	1020	114282
16.5		3736	4061	6209	2280	2738	4918	2134	2081	128		28285
17		3736	677	1913	456	827	1109	1361	289			10368
17.5							407		23			430
18				283			296					579

TL (cm)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
18.5							592					592

Table 3.3.1.1. Boarfish in ICES Subareas 27.6. 7, 8. Acoustic survey abundance and biomass estimates from 2011–2018

	Abundance							
Age.(Yrs)	2011	2012	2013	2014	2015	2016	2017	2018
0	-	-	-	-	-	-	-	-
1	5	21.5	-	-	198.5	4.6	110.9	76.7
2	11.6	10.8	78	-	319.2	35.7	126.7	31.2
3	57.8	174.1	1842.9	15	16.6	45.5	344.6	115
4	187.4	64.8	696.4	98.2	34.3	43.6	367.3	68.3
5	436.7	95	381.6	102.3	80	6	156	106.7
6	1165.9	736.1	253.8	104.9	112	10	209	165.9
7	1184.2	973.8	1056.6	414.6	437.4	169	493.1	320.7
8	703.6	758.9	879.4	343.8	362.9	112.6	468.3	197.7
9	1094.5	848.6	800.9	341.9	353.5	117.6	397.2	293.4
10	1031.5	955.9	703.8	332.3	360	96.6	285.8	624.7
11	332.9	650.9	263.7	129.9	131.7	17	120.9	339.2
12	653.3	1099.7	202.9	104.9	113	32	82.1	264.1
13	336	857.2	296.6	166.4	174	48.7	74.4	198.4
14	385	655.8	169.8	88.5	108	18.3	220.4	116.5
15+	3519	6353.7	1464.3	855.1	1195	400.1	931	302.4
TSN								
('000)	11104	14257	9091	3098	3996	1157	4387	3221
TSB (t)	670176	863446	439890	187779	232634	69690	230062	186252
SSB (t)	669392	861544	423158	187654	226659	69103		184624
CV	21.2	10.6	17.5	15.1	17	16.4	21.9	19.9

Table 3.3.2.1. Boarfish in ICES Subareas 27.6, 7, 8. IBTS length-frequency data

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SURVEY	YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.MATURE	TOTAL	TOTAL.MATURE
EVHOE	1997		5	11	7	17	197	2659	5020	3719	3598	4429	12065	16651	7198	3455	501	18	1			12	13	59548	47915
EVHOE	1998		1	4	26	76	2093	18283	8631	6125	5966	7095	11730	14078	9260	5076	934	8			1	11	13	89387	54148
EVHOE	1999			13	52	33	245	11177	26610	23947	6684	2899	4709	7868	6160	1353	267	7				10	12	92023	29947
EVHOE	2000		17	79	120	8	1504	26894	17674	9836	21967	16382	29585	36853	16522	5397	989	75				11	12	183903	127769
EVHOE	2001		1	45	687	489	913	21297	37171	13276	28355	31514	18309	12232	6471	3186	1270	81	4			10	12	175303	101422
EVHOE	2002		2	18	23	11	547	9631	29874	17777	13290	9470	9697	9751	6268	2484	641	37	1	1		10	12	109522	51639
EVHOE	2003			17	47	17	57	426	1655	7142	20018	24842	20989	21263	14494	7086	1550	36				12	12	119639	110277
EVHOE	2004			33	512	378	123	1248	1419	1307	1083	3102	7308	7224	6353	7866	3630	241	5			13	14	41833	36813
EVHOE	2005		2	93	975	1285	146	1100	2326	1229	1553	3183	13398	15758	9834	6010	1658	117	70			12	13	58738	51580
EVHOE	2006	1	26	112	79	75	15510	37566	10750	3622	2127	1521	1955	4131	3955	2535	921	94	2	12		8	13	84994	17253
EVHOE	2007		8	187	467	234	1503	22689	126065	64536	6341	6731	5431	6004	5911	4238	1409	118	11			9	12	251882	36193
EVHOE	2008		3	434	2807	827	5341	53189	247296	165392	163200	69382	38434	18390	17258	9178	3490	745	6	1		9	11	795371	320083
EVHOE	2009		6	128	194	72	1496	19769	35819	5264	3913	9556	12269	9402	10831	6720	775	38	1			10	13	116252	53505
EVHOE	2010		21	529	116	154	5755	46438	74986	27175	11952	37420	58313	34737	33774	14626	1561	249	8	1		10	12	347814	192641
EVHOE	2011		60	95	215	5	541	2247	8368	15256	33221	30237	50384	56559	36673	11867	3082	573	159	47		12	12	249590	222803
EVHOE	2012		9	145	584	137	2922	28865	26816	6124	11739	13606	22369	37135	44082	19963	4893	127	1			11	13	219516	153914
EVHOE	2013		3	48	91	10	306	2185	2165	2542	13649	9932	14987	37755	40524	20107	6918	666		2		13	13	151890	144540
EVHOE	2014		2	693	1386	508	84	1440	885	3074	8732	28586	39397	74122	69736	26871	3908	59	433			13	13	259915	251844
EVHOE	2015		5	183	5898	4143	607	19075	179269	119004	15765	18014	61575	62024	59904	21525	5487	541	429	8		10	13	573455	245271
EVHOE	2016	5	31	379	846	115	733	10284	14280	17251	42132	25304	68583	130633	131220	48538	11611	1358	26			13	13	503329	459405
EVHO	201		2	103	129	3	27	269	198	5												6		735	

Survey	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.mature	Total	Total.mature
E	7																								
IGFS	2003		1	32	22	7	22	129	172	879	2942	2322	1326	3822	4628	2898	896	163	38			13	13	20299	19035
IGFS	2004		23	63	34	8	96	532	1431	369	344	410	2253	4320	4698	3966	1017	87	2	1		13	14	19654	17098
IGFS	2005		8	59	52	20	203	1024	585	288	636	341	3463	11457	11348	7955	1744	382	2	0.97		13	14	39569	37330
IGFS	2006	5	60	68	48	35	212	969	621	2046	4190	8044	7946	24208	42119	32168	12296	2454	532			14	14	138021	133957
IGFS	2007	1	6	44	18	31	501	923	1251	1638	1166	2510	3581	8275	10740	7093	1934	92				13	14	39804	35391
IGFS	2008			26	18	23	127	672	531	2095	13780	17664	19268	16980	19484	15953	8789	1747	76	1		13	13	117231	113741
IGFS	2009		3	80	76	25	94	228	486	1000	1139	9081	7749	5138	6921	5592	1084	68	1			12	13	38763	36772
IGFS	2010		6	42	3	18	199	272	463	920	393	7914	34236	28611	16063	8161	1974	433				13	13	99709	97784
IGFS	2011		6	14	5	4	189	772	586	555	670	2578	20171	22082	10829	5298	2207	266	9	6		13	13	66247	64116
IGFS	2012		7	36	20	10	131	271	378	702	2144	1183	11105	34010	22742	10906	3903	525	4			13	13	88077	86521
IGFS	2013	1	3	9	9	20	127	352	340	1320	2833	3971	15572	51637	52868	20485	6560	492	20			14	14	156620	154439
IGFS	2014		10	68	54	4	18	13	25	60	130	1127	3251	19125	23016	10355	2988	284	18			14	14	60547	60295
IGFS	2015		3	11	16	24	193	1008	3708	848	105	713	6314	29727	48221	33024	17350	1885	531			14	14	143681	137870
IGFS	2016	4	31	121	63	7	67	186	1515	4057	2891	1349	4110	32753	57753	40907	15527	3670	86			14	14	165097	159046
IGFS	2017		6	53	10169	689915	6406	1751	715	11818	21886	10164	11841	25588	42311	35049	17110	3299	369			7	14	888449	167616
SPNGFS	1991		1			31	690	1311	313	49	9	6	7	7	4				6			7	13	2433	39
SPNGFS	1992		57	38	9	178	3290	2743	282	48	10	8	69	162	390	779	246	95				8	15	8404	1760
SPNGFS	1993		57	1206	488	97	3730	3753	421	105	54	7	4	8	3	2						6	11	9934	77
SPNGFS	1994	1	40	33		342	4789	10162	8920	3195	53	106	20	9	12	1						7	11	27685	202
SPNGFS	1995		84	108	4	342	3063	2157	220	84	65	58	105	105	90	20	4					7	12	6510	447
SPNGFS	1996		218	537	143	245	4457	4449	267	820	722	82	145	126	219	96	39	2				7	12	12566	14316
SPNG	199	2	10	809	441	235	3458	6824	2189	1923	534	156	353	161	88	3						7	11	1727	1295

Survey	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.mature	Total	Total.mature
FS	7		2																					7	
SPNGFS	1998	3	2	7	4	49	1920	4685	1815	337	153	125	88	147	135	86	13	2	3			8	12	9573	752
SPNGFS	1999		6	59	13	134	2736	3010	193	106	83	109	143	390	645	402	69					8	14	8098	1841
SPNGFS	2000		7	3729	2046	17	554	1947	489	277	486	756	1252	999	1021	199	34	13				7	12	13827	4760
SPNGFS	2001		68	4	1	153	3241	5085	659	225	206	205	236	692	407	120	22	9				8	13	11331	1896
SPNGFS	2002		4	20		133	2333	2013	284	50	58	54	60	231	314	72	9					8	13	5634	798
SPNGFS	2003		4	950	567	4	77	221	57	39	28	16	22	17	23	16	5	1				5	12	2047	128
SPNGFS	2004		6	22	4	43	2289	3808	443	110	83	58	219	931	776	303	2	1				8	13	9097	2372
SPNGFS	2005		16	451	25	9	754	1007	207	85	102	30	54	257	218	90	44	2				8	13	3349	797
SPNGFS	2006		14	156	160	50	2238	8913	4507	175	94	9	36	229	419	169	9	2				7	14	17181	968
SPNGFS	2007		49	40	1	111	3025	6620	1099	129	260	81	7	93	215	89	21	3				7	12	11843	768
SPNGFS	2008	7	4	92	247	1	936	1561	1326	234	1483	304	537	11	833	201	186	11				9	12	7974	3566
SPNGFS	2009	1	17	53	125	9	2582	3816	4105	119	250	45	142	59	819	120	17	1	1			8	13	12283	1456
SPNGFS	2010		55	102	5	232	13090	22032	3169	1160	1056	89	82	179	1007	1981	518	9				8	14	44766	4920
SPNGFS	2011		29	260	105	46	2805	5511	1278	148	340	145	100	144	591	724	134	3	1			8	14	12364	2182
SPNGFS	2012		29	132	35	556	7550	7844	1364	88	53	59	170	1051	2394	1553	432	21				8	14	23331	5734
SPNGFS	2013			2	11	126	2163	4664	854	302	609	251	61	110	123	140	64	7				8	12	9486	1364
SPNGFS	2014		75	117	6	12	263	465	79	1083	1175	1174	1266	998	2444	3623	817	31	1			12	13	13630	11530
SPNGFS	2015		13	67	3	58	1889	4248	534	75	465	750	970	695	1173	1473	453	70	1			10	13	12937	6050
SPNGFS	2016		0.16	0.85	0.04	0.39	9	24	4	9	7	3	6	5	6	2	0.25	0.03				9	12	77	29
SPNGFS	2017	0.01	0.2	0.18	0.01	0.14	6	18	7	1	2	3	4	6	10	9	2	0.11	0.03			10	14	67	34
SPPGFS	2001		2		2	2	4		88	10	104	266	323	1334	2259	460	81					13	14	4934	4827
SPPGF	200									1	4	90	212	791	843	313	60					14	14	2314	2313

Survey	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.mature	Total	Total.mature
S	2																								
SPPGFS	2003						1		3	15	22	21	62	268	426	249	51	2	1			14	14	1121	1102
SPPGFS	2004		1				5	2		4	5	18	100	312	483	319	43	1				14	14	1293	1281
SPPGFS	2005		1		1	6	1	18	10	9	14	7	101	530	935	705	226	18				14	14	2581	2536
SPPGFS	2006			1	1	6	91	89	21	34	75	27	45	335	670	555	197	10	1			13	14	2158	1914
SPPGFS	2007					3	4	9	15	12	9	27	25	72	151	144	26	4				13	14	501	458
SPPGFS	2008		1				1	13	7	16	13	55	106	237	457	302	78	5				14	14	1292	1254
SPPGFS	2009		6	5		2	7	8	1		1	154	318	924	1201	1172	324	7				14	14	4130	4101
SPPGFS	2010	1			1	5	14	3	1	5	2	31	284	521	717	459	123	10				14	14	2178	2148
SPPGFS	2011								3	16	18	5	147	671	792	429	122	13		2		14	14	2220	2200
SPPGFS	2012				1	1			2	2	1	8	70	369	468	218	66	3				14	14	1208	1202
SPPGFS	2013				1		7	22	6	9		1	42	435	889	480	141	12	1			14	14	2045	2000
SPPGFS	2014		10	9		1		3	17	62	11	6	85	2453	6703	3168	2115	162	82			14	14	14889	14787
SPPGFS	2015				2	1			1	1			32	300	471	316	151	43				14	14	1318	1313
SPPGFS	2016			0.04				0.02		0.16	0.06		0.1	2	4	3	1	0.25				14	14	11	11
SPPGFS	2017		1	0.35				0.2			0.02	0.35	0.52	3	10	10	5	0.33				14	15	31	29
WCSGFS	1986								0.5													8			
WCSGFS	1987								0.5	0.5	2	0.5										10	10	4	2
WCSGFS	1988				0.5																	4			
WCSGFS	1989							0.5														7			
WCSGFS	1990				1		0.5	1	2	24	54	50	43	12	1							11	11	188	160
WCSGFS	1991						1	0.5	8	38	183	266	316	48	16							11	11	876	829
WCSG	199						1		10	38	468	1145	4001	1626	486							12	12	7775	7726

Survey	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.mature	Total	Total.mature
FS	2																								
WCSGFS	1993							4		2	9	60	155	72	16		0.5					12	12	319	312
WCSGFS	1994									0.5	0.5	0.5			0.5							11	12	2	2
WCSGFS	1995									8	36	194	294	398	199	22						12	12	1150	1142
WCSGFS	1996				2		4	3				1	55	610	1574	304						14	14	2552	2544
WCSGFS	1997			4			0.5	6	9	4	6	25	108	203	157	40	4					13	13	568	544
WCSGFS	1998				1		1	5	2		1	2		3								9	12	15	6
WCSGFS	1999			1			2	5	1	1		1	2	1								8	12	14	4
WCSGFS	2000							2	2	39	110	216	288	182	92	46	6					12	12	983	940
WCSGFS	2001		1						1	4	15	28	59	134	240	103	10	4				14	14	599	593
WCSGFS	2002						1	8	2	1	82	742	3211	5601	5772	1497	167	1				13	13	17084	17072
WCSGFS	2003			1				3	52		53	281	1473	3066	4895	3083	309	28				14	14	13244	13188
WCSGFS	2004				1			2	2	43	82	743	4569	8600	9514	5692	948	84				14	14	30280	30232
WCSGFS	2005		2					24	3	23	25	110	435	1085	1708	792	130	6				14	14	4343	4291
WCSGFS	2006		1	2	1		1	4		10	218	232	452	1396	2852	2051	434	72				14	14	7726	7706
WCSGFS	2007			2	2		2	1	3	21	159	780	2923	5194	6888	5283	1523	116				14	14	22897	22866
WCSGFS	2008		1	1			16	37	36	187	468	1395	3213	9893	22758	18399	6288	575	71			14	14	63338	63060
WCSGFS	2009			1			1		4	52	2442	2093	440	331	287	246	129	10				11	11	6038	5978
WCSGFS	2010											530	1443	1384	1357	828	149	29				13	13	5720	5720
WCSGFS	2011		1	4	1		1	5	254	1015	2034	7613	18918	14478	6445	2006	236	23				12	12	53034	51753
WCSGFS	2012			1			1	2		103	9	1267	6545	26337	29361	27333	15857	1505	496			14	14	108817	108710
WCSGFS	2013				1			1			1	143	3201	15282	11288	3934	858	6	1			14	14	34716	34714
WCSG	201		48	457	386	48	3	7	63	21	98	876	1166	3026	3923	1093	1363	111	1			13	14	9558	94553

Survey	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ML	ML.mature	Total	Total.mature
FS	4												8	7	6	3								7	
WCSGFS	2015			4	18	14	115	102	18	5			30	262	345	220	86	10	1		1	12	14	1230	955
WCSGFS	2016				1	2	49	1413	2439	2065	342	436	4088	24632	33254	14568	3484	508	102			14	14	87383	81414
WCSGFS	2017																								

Table 3.6.1.1. Boarfish in ICES Subareas 27.6, 7, 8. IBTS length-frequency data converted to age-structured index by application of the 2010 common ALK rounded down to 1cm length classes.

Survey	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
EVHOE	1997	23	1876	6003	3741	3911	3938	7065	5867	4218	4832	4259	1461	2428	1699	1214	623	1215	159	659	623	848	768	214	325	543	100	158	51	314	416
EVHOE	1998	31	1297	1597	6248	6247	5591	7435	5732	3777	4806	4386	1463	2843	1635	1619	676	1224	232	904	676	965	1042	327	476	752	187	231	93	461	353
EVHOE	1999	65	7576	3123	1995	8732	3499	3308	2715	1905	2720	2357	743	1540	975	893	285	647	62	474	285	477	509	91	246	317	53	61	27	123	197
EVHOE	2000	217	17676	27730	12586	17986	15525	18740	14297	9737	11041	9490	3208	5160	3797	2556	1266	2604	253	1384	1266	1782	1538	374	714	1022	198	245		491	921
EVHOE	2001	733	14389	4113	2057	2567	2121	1611	9247	4525	4543	3951	1332	2057	1322	1098	578	959	153	684	578	780	710	304	456	508	254	147	129	290	306
EVHOE	2002	43	6719	3128	1855	1284	8399	7115	4767	2851	3429	3018	994	1806	1123	1009	421	796	117	573	421	617	625	192	324	429	128	113	65	227	244
EVHOE	2003	64	509	3993	7348	1871	1726	1613	1098	6270	7620	6852	2267	4294	2501	2456	1009	1838	326	1387	1009	1462	1557	491	763	1104	310	322	155	644	532
EVHOE	2004	545	1265	1976	1261	1722	2227	4124	3228	2061	2871	3058	1066	2426	939	1509	901	917	382	1142	901	1100	1160	817	925	962	726	360	366	715	181
EVHOE	2005	1070	2103	2603	1497	2098	3015	7160	5992	4177	5301	4873	1642	3144	1796	1776	833	1368	285	1065	833	1140	1184	486	639	877	332	308	201	546	394
EVHOE	2006	217	35834	2653	4803	2199	1386	1489	1332	947	1521	1484	485	1170	557	725	311	445	125	464	311	434	496	245	308	373	184	116	93	242	103
EVHOE	2007	661	16818	1220140	6969	1696	4919	4316	2967	1715	2452	2392	788	1802	820	1124	484	678	204	715	484	668	778	381	467	594	282	198	146	385	150
EVHOE	2008	3244	41611	258758	168378	134061	77106	37738	18750	8277	9132	8183	2660	4868	2458	2992	1226	1876	492	1919	1226	1765	2062	1064	1237	1523	698	420	352	835	460
EVHOE	2009	327	13338	36829	12194	5626	5982	7788	5443	3054	4443	4230	1364	3079	1382	1965	618	1114	309	1064	618	956	1295	398	493	957	155	306	78	611	235
EVHOE	2010	666	33601	83903	35048	21678	23503	34210	23037	12643	16303	14519	4647	9008	4716	5551	1689	3457	690	2957	1689	2745	3490	920	1368	2435	312	669	160	1331	868
EVHOE	2011	370	2221	12471	14982	28729	26114	31844	23915	15535	19473	16964	5542	10176	6534	5663	2262	4513	597	3197	2262	3408	3486	1077	1762	2339	616	619	388	1126	1414
EVHOE	2012	738	20089	34348	11535	11098	10795	14979	13308	9004	15662	14714	4598	11467	5540	7325	2325	4142	920	4164	2325	3703	4595	1447	2356	3218	979	908	490	1815	928
EVHOE	2013	142	1647	3695	3805	1038	9207	1138	1171	8299	1448	1397	4374	1096	5364	6893	2550	4068	981	4205	2550	3816	4494	1872	2650	3228	1384	914	692	1830	944
EVHOE	2014	2081	1524	2365	3805	1288	1735	2769	2494	1746	2741	2501	7911	1826	9918	1116	3465	7107	1227	5977	3465	5644	6813	1636	2961	4634	7842	1438	6007	2418	1853
EVHOE	2015	8533	19233	57572	10867	9118	17596	3370	2667	3362	2440	2062	7208	1596	8396	9445	3078	5952	1033	5325	3078	5040	5809	4417	6969	3937	9797	9393	763	6551	5151
EVHOE	2016	1256	7360	2855	1855	3737	7926	4381	4174	3297	4974	4444	3838	5499	1599	1515	3339	3939	4204	1104	3366	3434	8585	1023	2385	2522	1919	7474	1313	6666	

Survey	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
EVHOE	2017	234	187	263	50	0.91																									
IGFS	2003	55	126	517	930	2306	1858	1433	1244	842	1549	1545	494	1309	576	842	317	467	148	527	317	461	585	287	324	441	179	151	109	263	96
IGFS	2004	120	418	1422	594	396	484	1303	1341	993	1713	1773	589	1491	618	948	390	543	189	584	390	537	672	317	350	525	203	181	103	362	108
IGFS	2005	119	814	982	379	542	665	2302	2884	2364	4129	4140	1360	3431	1569	2142	822	1289	400	1283	822	1177	1509	689	703	1154	349	363	175	724	286
IGFS	2006	176	849	1572	1988	4719	5051	6885	7522	5179	12177	13018	4151	12178	4448	8189	3297	3989	1708	5570	3297	4613	6048	3673	3775	4731	2459	1728	1496	2924	605
IGFS	2007	68	1052	1866	1385	1605	1648	2625	2628	1855	3547	3577	1145	3059	1292	1987	723	1072	332	1196	723	1058	1335	553	722	999	387	322	193	645	207
IGFS	2008	44	588	1709	3445	12363	12597	13266	9219	5227	7773	7797	2576	6069	2491	3886	2028	2183	900	2996	2028	2637	3017	2303	2367	2408	1758	763	917	1451	424
IGFS	2009	158	267	776	1077	3174	4543	5513	3620	1839	2701	2706	886	2101	818	1373	491	727	261	802	491	707	954	390	433	738	217	255	109	508	128
IGFS	2010	51	374	747	902	3021	6590	17250	13258	8630	10098	8924	3002	5053	3150	2750	1284	2303	414	1616	1284	1786	1832	742	897	1331	395	371	197	742	715
IGFS	2011	25	641	951	598	1500	3223	10092	8433	5965	6989	6169	2095	3519	2333	1835	1014	1683	267	1165	1014	1352	1212	568	780	873	441	245	225	488	552
IGFS	2012	64	302	673	754	1774	2197	7201	8421	7104	10272	9476	3134	6741	3972	3834	1736	2907	548	2360	1736	2447	2518	1096	1491	1807	781	498	392	991	850
IGFS	2013	21	373	862	1243	3026	3903	10918	13284	10690	18929	17531	5483	13636	7177	8471	2878	5165	980	4941	2878	4530	5265	1784	2964	3613	1312	941	666	1862	1291
IGFS	2014	132	28	47	90	423	794	2958	4429	3697	7450	7127	2213	5965	2873	3818	1248	2146	499	2236	1248	1967	2437	883	1317	1717	598	480	308	941	478
IGFS	2015	30	815	3472	1377	516	943	4845	7454	5858	14016	14639	4623	13524	5243	9030	3979	4494	1690	6438	3979	5486	6393	3990	4977	4886	3470	1767	2001	3002	743
IGFS	2016	215	282	2400	2888	2682	1761	4458	7773	6173	16077	17088	5386	16240	6066	10938	4231	5302	2226	7389	4231	6036	8062	4880	4910	6258	3105	1902	1595	3719	819
IGFS	2017	1022 8	696 697	6080	9322	16417	11347	9585	8818	5853	12738	13721	4436	12670	4564	8475	3944	4195	1923	6278	3944	5266	6490	4624	4744	5168	3422	1778	1896	3186	640
SPNGFS	1991	1	1402	881	102	15	6	5	3	2	2	2	0.62	0.98	0.78	0.5	0.18	0.48		0.25	0.18	0.3	0.25		0.12	0.12		3	3		0.18
SPNGFS	1992	104	4609	1830	95	17	13	41	53	35	103	156	57	175	37	120	64	56	45	94	64	76	114	98	61	102	49	35	25	71	4
SPNGFS	1993	1751	5508	2424	163	49	18	5	3	2	2	2	0.64	1	0.75	0.56	0.28	0.56	0.09	0.28	0.28	0.37	0.37	0.09	0.09	0.28		0.09		0.18	0.19
SPNGFS	1994	73	10576	12411	3845	643	57	35	17	5	5	4	1	3	1	2	0.27	0.88	0.05	0.82	0.27	0.66	0.87	0.05	0.39	0.48		0.05		0.09	0.22
SPNGFS	1995	196	4231	1526	107	66	51	64	48	30	41	35	11	22	13	13	4	9	0.9	7	4	7	7	1	4	5	0.83	0.9	0.41	2	3
SPN	19	89	670	290	584	553	254	109	66	38	72	67	20	53	23	36	11	17	5	22	11	18	23	9	15	16	8	4	4	9	3

Survey --	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
GFS	96	7	7	8																											
SPN GFS	1997	1351	7306	5446	1609	681	249	203	121	67	69	56	18	22	18	11	4	11	0.14	6	4	7	6	0.14	3	3		0.14		0.27	4
SPN GFS	1998	13	4493	3640	638	175	101	79	58	37	54	53	17	40	19	25	9	15	4	14	9	13	17	6	7	12	3	5	3	8	4
SPN GFS	1999	79	4258	1802	116	93	80	112	121	85	191	195	61	175	70	117	35	58	18	65	35	55	77	25	34	57	14	18	7	37	10
SPN GFS	2000	5782	1661	1325	347	518	553	750	537	315	443	379	116	237	139	146	37	91	10	78	37	69	85	18	39	53	7	9	3	18	25
SPN GFS	2001	73	5952	3099	308	205	161	197	190	148	199	175	58	114	77	62	25	53	6	34	25	38	38	11	17	25	4	5	2	11	17
SPN GFS	2002	24	3315	1395	104	54	43	55	63	47	98	88	26	71	37	46	10	25	3	24	10	20	26	4	12	16	2	3	0.91	7	6
SPN GFS	2003	1521	203	155	38	26	16	14	10	5	9	9	3	7	3	4	2	2	0.83	3	2	2	3	2	2	2	1	0.73	0.5	1	0.42
SPN GFS	2004	32	4267	2243	177	82	68	171	219	186	303	279	89	209	118	124	37	85	14	63	37	61	76	14	25	52	0.4	14	0.2	28	23
SPN GFS	2005	492	1253	701	108	78	46	50	60	51	84	78	25	59	33	35	15	24	4	22	15	22	22	9	16	15	9	4	4	8	6
SPN GFS	2006	330	7297	7378	1191	85	34	36	56	44	116	112	33	100	43	68	14	32	8	35	14	27	42	9	15	29	2	8	0.9	15	6
SPN GFS	2007	90	6646	3990	367	180	106	37	30	18	55	54	16	50	20	35	8	15	4	20	8	15	22	7	11	15	4	4	2	8	2
SPN GFS	2008	343	1736	1886	629	908	597	329	178	62	202	183	47	158	53	122	28	36	10	81	28	54	73	32	63	47	37	9	19	18	0.28
SPN GFS	2009	195	4487	5077	1085	168	104	79	71	26	174	155	37	147	56	113	9	34	6	58	9	34	62	8	29	37	3	6	2	11	1
SPN GFS	2010	162	24558	13572	1504	792	346	101	85	41	222	365	132	436	76	306	146	130	91	206	146	178	245	146	135	213	104	90	52	180	4
SPN GFS	2011	393	5730	3656	432	244	163	94	77	38	140	182	61	198	48	140	50	59	33	84	50	68	103	48	45	85	27	33	14	66	4
SPN GFS	2012	196	11653	5359	383	62	55	160	276	202	620	657	201	638	228	441	140	198	73	266	140	215	295	122	161	220	86	71	43	141	26
SPN GFS	2013	13	4763	2947	446	439	276	110	59	30	44	49	17	44	16	28	15	16	7	21	15	19	22	16	17	18	13	6	6	13	3
SPN GFS	2014	198	542	611	767	1131	910	875	626	323	711	914	317	926	228	635	271	291	168	402	271	348	488	259	240	412	163	165	82	329	25
SPN GFS	2015	83	4207	2430	248	463	516	616	432	233	403	463	158	419	125	281	130	138	74	193	130	166	221	140	127	185	91	67	46	134	17
SPN GFS	2016	1	23	17	7	7	4	4	2	1	2	2	0.59	1	0.69	0.85	0.21	0.48	0.08	0.45	0.21	0.39	0.51	0.11	0.23	0.33	0.05	0.07	0.03	0.15	0.11
SPN GFS	2017	0.38	16	14	3	2	2	3	2	1	3	3	1	3	1	2	0.69	0.98	0.4	1	0.69	0.99	1	0.59	0.61	1	0.31	0.41	0.17	0.79	0.14
SPP	20	4	6	73	47	128	163	290	369	271	650	581	165	482	241	324	62	158	21	170	62	133	183	29	87	11	16	21	8	42	33

Survey	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
GFS	01																									2					
SPP GFS	2002		0.03	0.39	4	29	57	162	201	161	294	272	84	214	112	134	40	80	14	73	40	66	81	20	38	55	12	14	6	28	20
SPP GFS	2003		1	7	12	21	21	50	69	54	125	126	39	114	47	76	23	38	12	43	23	36	50	17	23	36	10	12	6	23	7
SPP GFS	2004	1	6	3	3	10	19	66	86	65	145	150	47	135	54	89	27	45	15	49	27	42	59	19	24	44	9	15	4	29	8
SPP GFS	2005	2	18	18	9	13	17	81	132	103	263	283	90	269	98	181	68	88	34	115	68	97	126	62	74	97	45	32	23	64	13
SPP GFS	2006	2	137	77	33	53	36	51	84	64	180	200	64	197	67	134	53	63	26	88	53	74	94	49	60	73	39	26	20	50	8
SPP GFS	2007		12	19	12	14	15	22	24	16	41	47	15	47	15	32	11	15	7	19	11	16	23	11	10	19	5	7	3	13	2
SPP GFS	2008	1	9	15	13	25	35	72	79	53	130	135	42	125	46	85	27	40	14	51	27	42	57	23	30	43	16	14	8	27	6
SPP GFS	2009	11	13	5	5	45	91	228	263	197	390	429	143	394	144	257	109	137	54	161	109	146	183	88	102	145	65	53	32	107	23
SPP GFS	2010	1	18	5	4	15	41	156	167	121	236	236	75	201	84	131	46	69	22	79	46	69	89	37	47	66	25	21	12	42	13
SPP GFS	2011		0.43	7	12	17	22	109	159	133	261	256	81	216	100	138	48	78	21	83	48	73	91	37	49	66	24	20	12	41	17
SPP GFS	2012	1	1	2	2	4	10	57	86	72	149	143	44	121	57	78	26	43	10	46	26	40	50	18	28	35	13	10	7	20	9
SPP GFS	2013	1	19	17	6	3	5	49	102	80	235	239	72	226	88	155	47	71	23	93	47	75	101	41	56	74	28	22	15	44	11
SPP GFS	2014	19	5	31	38	21	14	219	597	438	1632	1647	478	1602	603	1126	417	476	160	791	417	626	739	420	633	530	423	185	253	288	61
SPP GFS	2015	2	1	1	0.77	0.83	3	35	67	56	136	142	45	132	52	88	37	44	19	63	37	52	67	47	45	52	30	14	15	29	8
SPP GFS	2016	0.04	0.02	0.05	0.09	0.06	0.03	0.19	0.46	0.36	1	1	0.36	1	0.42	0.79	0.28	0.36	0.15	0.53	0.28	0.42	0.57	0.34	0.35	0.44	0.22	0.13	0.11	0.25	0.05
SPP GFS	2017	2	0.12	0.08	0.01	0.11	0.19	0.5	0.89	0.57	2	3	0.93	3	0.83	2	1	0.92	0.5	2	1	1	2	1	1	1	1	0.47	0.52	0.94	0.07
WCS GFS	1986			0.38	0.12																										
WCS GFS	1987		0.01	0.58	0.64	1	0.76	0.18	0.05	0.01																					
WCS GFS	1988	0.5																													
WCS GFS	1989		0.3	0.2																											
WCS GFS	1990	1	2	10	21	46	39	31	16	7	5	4	1	0.73	0.92	0.12	0.29	0.61		0.06	0.29	0.32	0.06		0.03	0.03					0.29
WCS	19		2	23	52	175	186	194	105	45	36	28	9	5	5	2	1	3		0.9	1	2	0.9		0.	0.					1

Survey	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
GFS	91																			7			7		48	48					
WCS GFS	1992		2	33	116	616	975	1952	1270	712	662	524	178	157	152	61	41	96		30	41	56	30		15	15					41
WCS GFS	1993		2	3	4	23	41	80	52	29	26	21	7	6	6	2	2	4		1	2	2	0.97	0.05	0.58	0.48	0.1		0.05		2
WCS GFS	1994		0.01	0.15	0.34	0.48	0.33	0.13	0.06	0.01	0.09	0.08	0.02	0.08	0.03	0.06		0.02		0.03		0.02	0.03		0.02	0.02					
WCS GFS	1995		0.2	3	15	74	113	189	151	103	121	101	33	54	42	27	11	27	0.98	13	11	17	14	0.98	6	8		0.98		2	10
WCS GFS	1996	2	5	2	0.03	1	6	67	153	112	391	353	95	318	144	224	29	93	14	112	29	78	126	14	49	77		14		28	15
WCS GFS	1997	4	4	11	6	12	22	63	62	47	69	60	19	40	25	23	7	17	2	12	7	12	13	2	6	9	0.8	2	0.4	4	5
WCS GFS	1998	1	4	4	0.67	1	1	0.72	0.65	0.56	0.45	0.38	0.15	0.15	0.22		0.08	0.15			0.08	0.08									0.08
WCS GFS	1999	1	5	3	0.8	0.47	0.58	1	0.7	0.4	0.31	0.25	0.09	0.05	0.08		0.02	0.05			0.02	0.02									0.02
WCS GFS	2000		2	16	41	124	142	179	116	65	68	59	20	30	19	16	7	14	2	8	7	10	10	3	4	7	1	2	0.6	4	5
WCS GFS	2001	1	0.11	2	5	17	21	40	44	30	70	67	20	58	25	39	9	19	5	21	9	17	25	7	10	18	2	5	1	9	3
WCS GFS	2002		6	8	35	291	631	1838	1814	1320	2184	1935	594	1386	781	858	225	528	68	446	225	405	497	85	214	317	33	68	17	136	140
WCS GFS	2003	1	2	42	28	127	272	867	971	691	1498	1519	476	1339	536	892	248	446	143	480	248	401	592	182	215	439	62	140	31	280	77
WCS GFS	2004	1	2	16	57	327	770	2590	2686	1983	3447	3359	1079	2693	1240	1707	569	986	267	957	569	866	1129	387	487	832	190	259	95	518	215
WCS GFS	2005	2	15	19	19	53	93	276	325	236	519	501	153	429	188	286	76	144	37	156	76	130	180	51	79	127	26	36	13	72	27
WCS GFS	2006	4	4	12	39	183	196	340	423	294	781	834	261	795	283	543	172	252	100	322	172	261	379	165	176	290	87	93	43	186	35
WCS GFS	2007	4	3	14	56	339	638	1707	1727	1220	2309	2385	775	2056	820	1341	522	715	252	835	522	738	934	439	520	719	305	240	152	480	130
WCS GFS	2008	2	41	110	208	689	989	2324	3054	2082	6013	6662	2108	6560	2164	4517	1712	2042	894	2945	1712	2424	3210	1695	1969	2499	1258	872	664	1673	247
WCS GFS	2009	1	2	100	387	1817	1538	759	363	137	139	136	46	95	43	58	32	37	12	43	32	41	42	28	35	33	26	11	13	22	8
WCS GFS	2010				17	160	347	785	626	398	580	549	179	394	189	245	87	149	41	140	87	130	166	64	72	123	30	38	15	75	35
WCS GFS	2011	6	31	531	1086	3514	5387	10238	7369	4589	4925	4157	1403	2004	1489	988	477	1016	93	520	477	678	590	124	249	388	47	91	24	182	362
WCS GFS	2012	1	5	28	97	469	1148	4804	6462	5298	9990	10765	3610	9632	3810	6155	3487	3477	1393	4814	3487	4404	4621	3430	4089	3703	3171	1491	1834	2485	658
WCS	20	1	0.6	0.43	5	101	381	242	337	300	467	422	136	306	185	176	64	129	17	971	64	999	106	26	52	71	17	17	86	35	38

Survey	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
GFS	13							0	8	3	0	8	1	4	2	9	7	6	9		7		4	7	4	2	2	9		8	2
WCS	20	89	56	60	67	509	154	699	847	650	128	116	347	913	472	589	13	323	50	309	13	261	346	67	14	22	27	49	13	99	75
GFS	14	1					9	9	2	2	49	22	5	5	2	8	90	6	8	7	90	6	8	8	99	42	3	7	7	4	7
WCS	20	22	173	73	7	2	3	31	57	49	106	109	34	97	41	63	25	34	11	41	25	36	44	23	28	33	17	11	9	20	8
GFS	15																														
WCS	20	1	945	297	173	751	680	354	569	473	102	985	301	841	392	548	16	293	71	314	16	266	350	12	17	24	69	71	39	13	61
GFS	16			8	0			4	5	5	64	0	6	4	6	1	26	3	3	0	26	6	4	14	36	65	7	3	9	24	6
WCS	20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GFS	17																														

Table 3.6.3.1. Boarfish in ICES Subareas 27.6, 7, 8. Key parameter estimates from the exploratory Schaeffer state space surplus production model. Posterior parameter distributions are provided in Figure 3.6.3.5.

	MEAN	SD	2.5	25	50	75	97.5
r	3.69e-01	1.91e-01	4.84e-02	2.28e-01	3.55e-01	4.89e-01	7.84e-01
K	6.62e+05	4.17e+05	3.09e+05	4.45e+05	5.50e+05	7.17e+05	1.78e+06
F_{MSY}	1.85e-01	9.53e-02	2.42e-02	1.14e-01	1.78e-01	2.45e-01	3.92e-01
B_{MSY}	1.65e+05	1.04e+05	7.72e+04	1.11e+05	1.38e+05	1.79e+05	4.44e+05
TSB	3.10e+05	1.86e+05	1.47e+05	2.17e+05	2.72e+05	3.49e+05	6.56e+05

Table 3.6.4.1. Boarfish in ICES Subareas 27.6, 7, 8. Pseudo-cohort derived estimates of fishing mortality (F) and total mortality (Z), in comparison with total catch per year. Pearson correlation coefficient of F vs. catch (tonnes) indicated.

Age	Raised numbers											Ln raised numbers										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	0	0	1575	2415	0	28	301	0	5556	218	1862	0	0	7	8	0	3	6	0	9	5	8
2	352	5488	15043	11229	2894	893	7148	695	116135	2385	4387	6	9	10	9	8	7	9	7	12	8	8
3	2114	21140	65744	72709	41913	5467	156680	49503	32248	10737	8830	8	10	11	11	11	9	12	11	10	9	9
4	40851	105575	338931	294382	28148	41278	58522	127520	16588	25114	34448	11	12	13	13	10	11	11	12	10	10	10
5	48915	141300	475619	567689	30116	110272	59797	93705	24564	20263	27266	11	12	13	13	10	12	11	11	10	10	10
6	62713	195339	543707	878363	175696	146582	68949	67275	26566	18025	21103	11	12	13	14	12	12	11	11	10	10	10
7	26132	104031	307333	522703	143967	492078	302967	193061	74115	61229	55189	10	12	13	13	12	13	13	12	11	11	11
8	29766	66570	172783	293719	107126	365840	250341	139124	52052	47573	38229	10	11	12	13	12	13	12	12	11	11	11
9	56075	53159	155477	276672	77861	271916	212318	121042	44615	42478	32258	11	11	12	13	11	13	12	12	11	11	10
10	44875	46893	130148	232122	60022	173486	160137	94225	34264	35150	25716	11	11	12	12	11	12	12	11	10	10	10
11	14019	15289	42521	78588	46079	69396	63025	36078	12999	13297	9560	10	10	11	11	11	11	11	10	9	9	9
12	32359	21178	61350	114600	40468	40968	41490	24895	9114	9132	7564	10	10	11	12	11	11	11	10	9	9	9
13	4848	11854	39609	59932	24352	58888	59380	36309	13362	13774	10922	8	9	11	11	10	11	11	10	10	10	9
14	16837	13570	31569	59060	19724	30277	30355	19064	7152	6682	5924	10	10	10	11	10	10	10	10	9	9	9
15+	109481	112947	196967	349320	157707	217260	239366	150688	59139	49589	40797	12	12	12	13	12	12	12	12	11	11	11
Z (age 7-14)												0.17	0.33	0.36	0.33	0.29	0.45	0.36	0.37	0.31	0.31	0.33
F (ZM), where M = 0.16												0.01	0.17	0.2	0.17	0.13	0.29	0.2	0.21	0.15	0.15	0.17
Catches (t)												21576	34751	90370	144047	37096	87355	75409	45231	17766	19315	17388
Correlation coefficient landings vs F.												0.46										

Table 3.6.5.1. Boarfish in ICES Subareas 27.6, 7, 8. Estimates of total stock biomass and F. 2018 catch data are not available thus the corresponding F estimate is not available.

Year	TSB.2.5	TSB.50	TSB.97.5	F.2.5	F.50	F.97.5
1991	106692	207600	520907			
1992	176295	323600	794332			
1993	227100	411950	987700			
1994	269800	506750	1231000			
1995	218480	405650	981522			
1996	220597	412100	1005000			
1997	198397	355800	867045			
1998	264787	483650	1172025			
1999	197797	356500	866605			
2000	161397	293200	715922			
2001	177900	313800	765800			
2002	156300	276850	668782			
2003	138197	241700	578712	0.00	0.00	0.00
2004	200797	354250	843325	0.00	0.00	0.00
2005	193800	336700	807927	0.02	0.05	0.08
2006	226800	395400	947322	0.01	0.01	0.03
2007	188597	325550	775912	0.01	0.02	0.03
2008	235892	400800	955522	0.01	0.02	0.03
2009	238200	404750	940012	0.03	0.07	0.11
2010	368597	627600	1477000	0.04	0.09	0.15
2011	332500	566200	1355150	0.10	0.22	0.38
2012	494497	811700	1887000	0.10	0.23	0.39
2013	347592	584500	1390075	0.03	0.07	0.11
2014	156700	261350	621905	0.05	0.11	0.18
2015	185597	313200	742927	0.05	0.13	0.22
2016	124400	212700	499207	0.07	0.17	0.29
2017	224695	384250	907027	0.02	0.06	0.10
2018	146800	272500	655515	NA	NA	NA

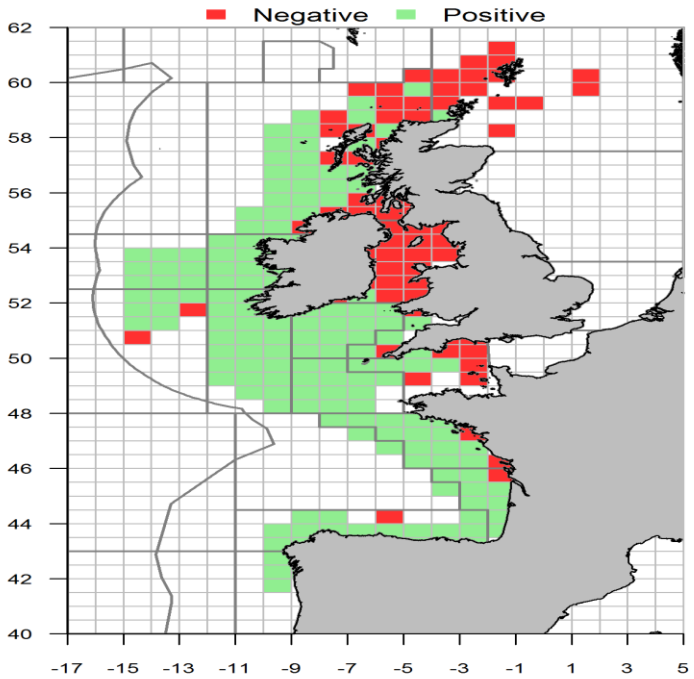

Figure 3.1. Boarfish in ICES Subareas 4, 27.6, 7, 8 and 9. Distribution of boarfish in the NE Atlantic area based on presence and absence in IBTS surveys (all years).

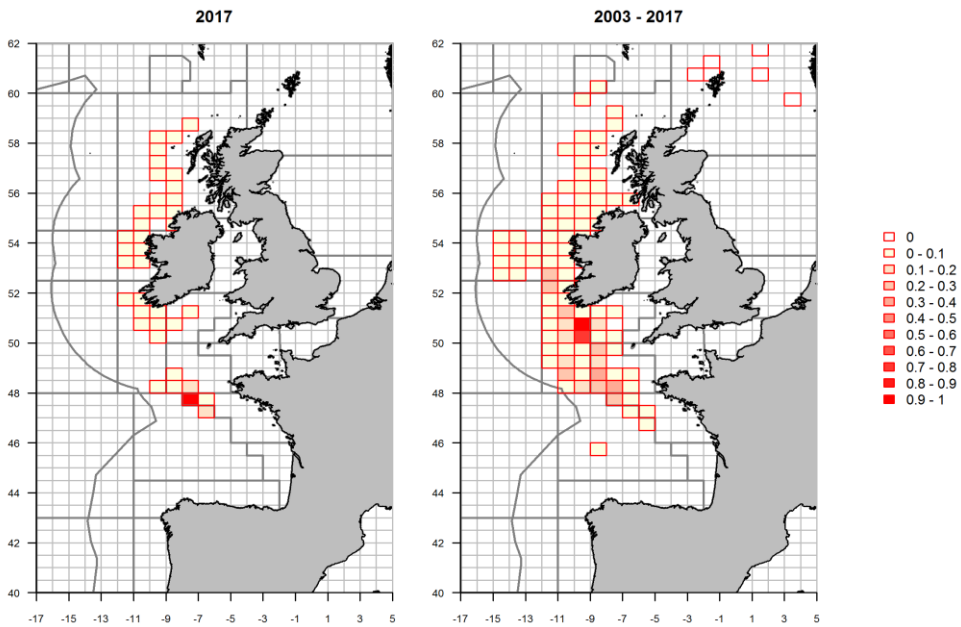

Figure 3.1.2.1. Boarfish in ICES Subareas 27.6, 7, 8. Combined Irish boarfish landings 2003-2017 by ICES rectangle (Above). Irish boarfish landings 2017 by ICES rectangle (Below).

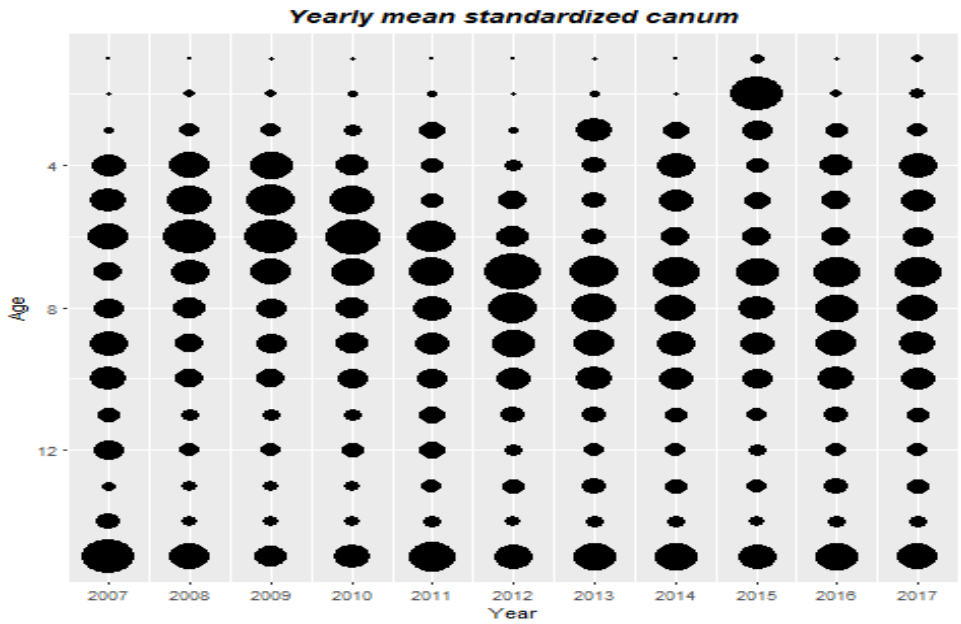

Figure 3.2.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Catch numbers-at-age standardised by yearly mean. 15+ is the plus group.

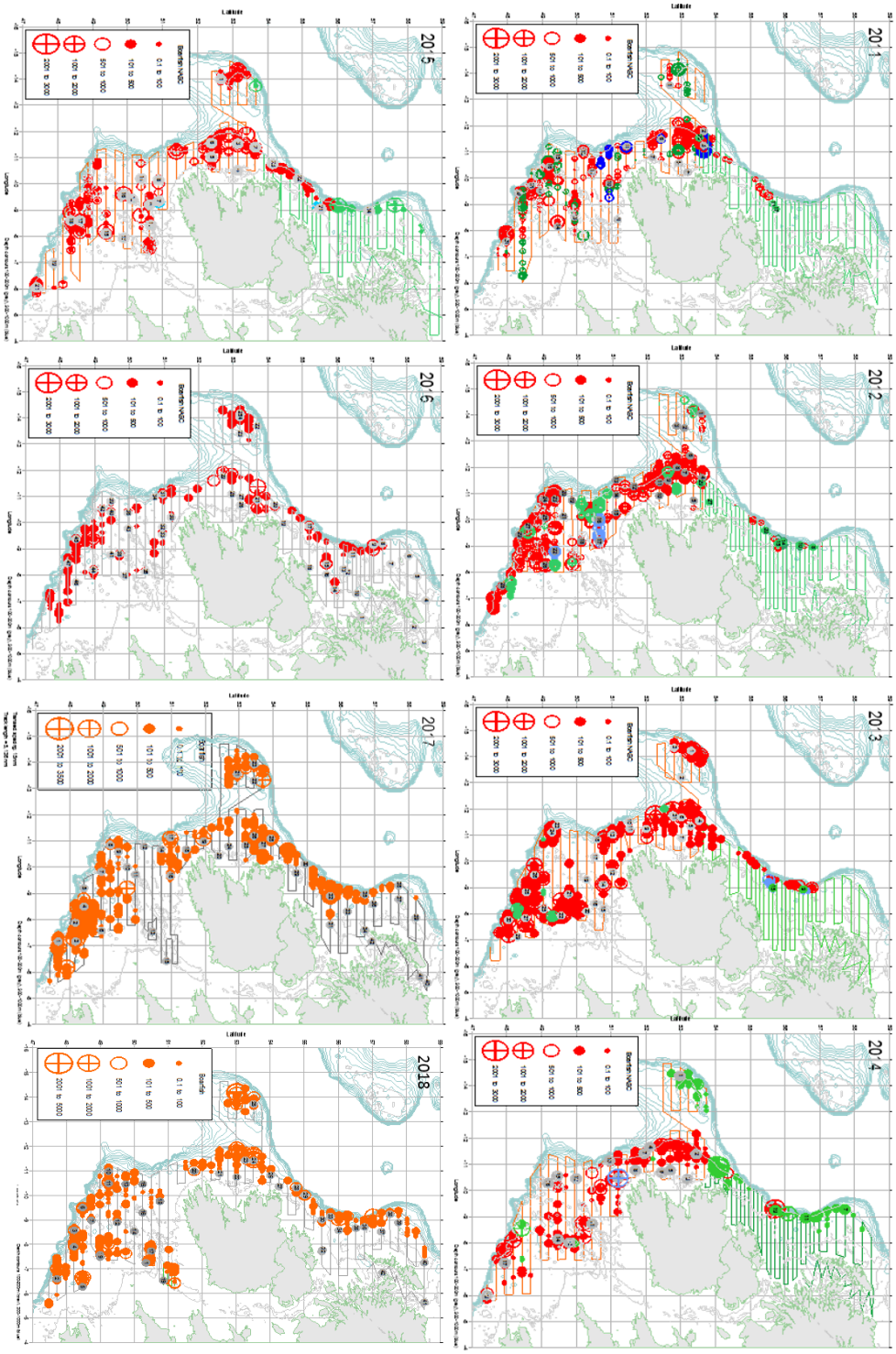

Figure 3.3.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish acoustic survey track and haul positions from acoustic survey 2011-2018. Red circles represent 'definitely' boarfish, green: 'probably boarfish', blue: 'boarfish mix' (all included in the biomass estimate).

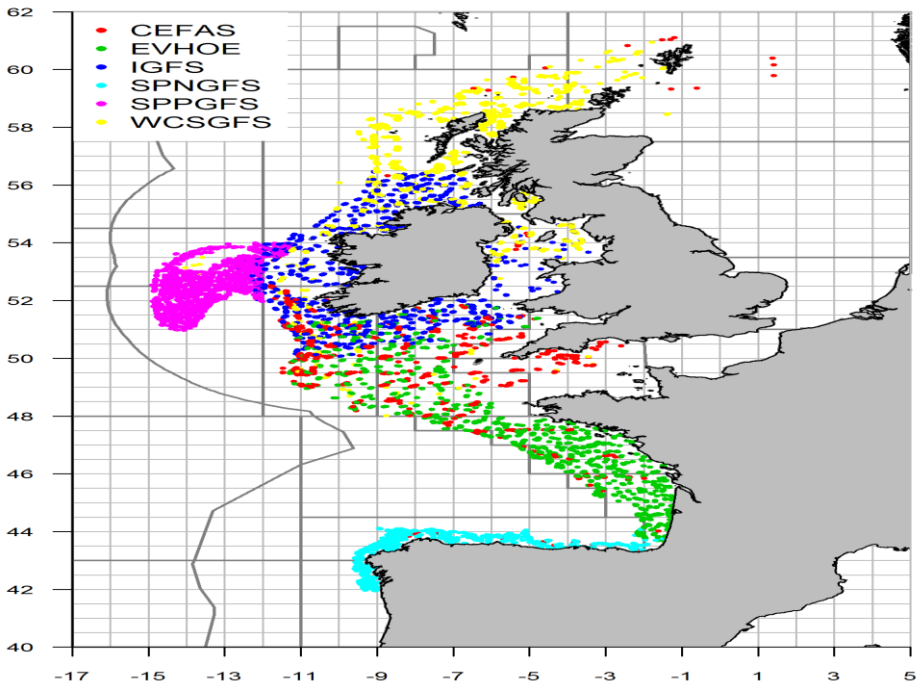

Figure 3.3.2.1. Boarfish in ICES Subareas 27.6, 7, 8. The haul positions of bottom trawl surveys analysed as an index for boarfish abundance. Note the Portuguese Groundfish survey included here was not included in the 2018 assessment.

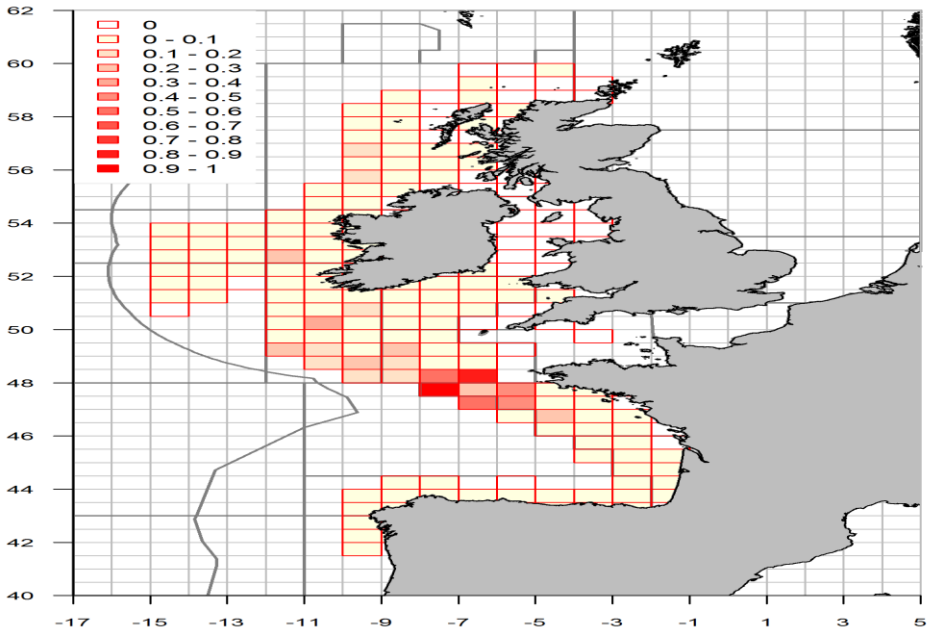

Figure 3.3.2.2. Boarfish in ICES Subareas 27.6, 7, 8. Distribution of boarfish in the NE Atlantic showing proposed management area.

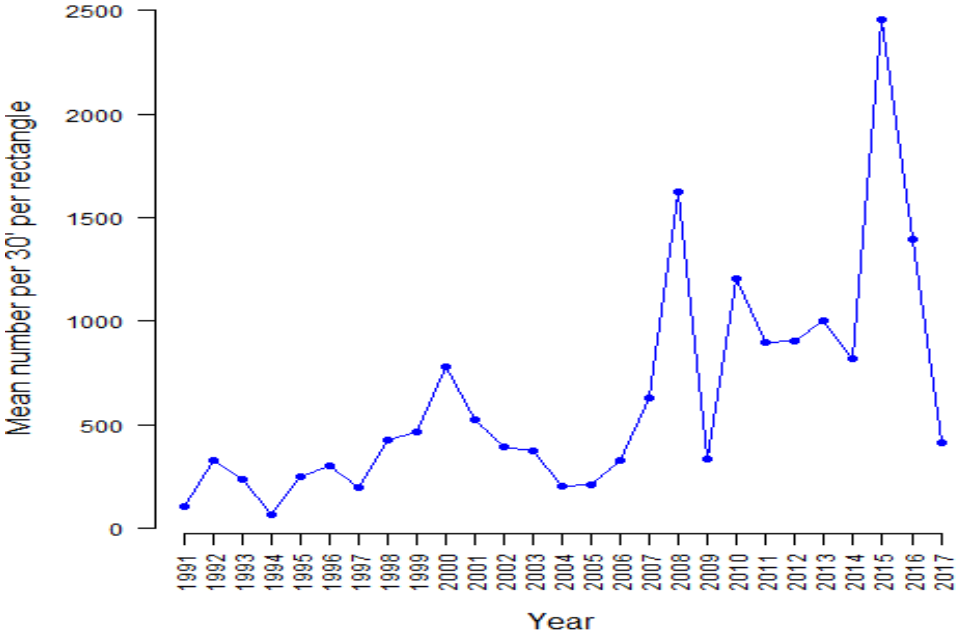

Figure 3.3.2.3. Boarfish in ICES Subareas 27.6, 7, 8. CPUE in number per 30 minute haul of boarfish per rectangle in the western IBTS survey 1982 to 2017.

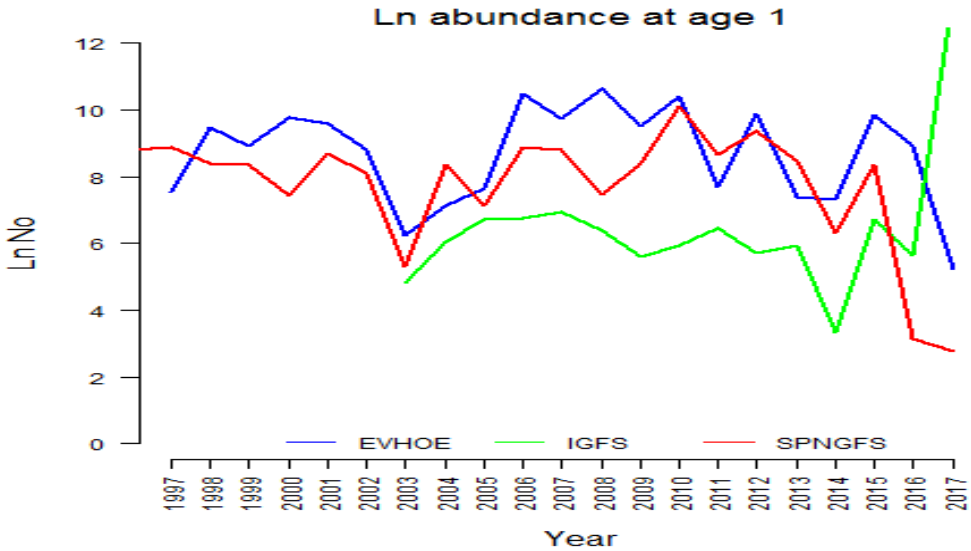

Figure 3.5.1. Boarfish in ICES Subareas 27.6, 7, 8. Recruitment-at-age 1, from various IBTS.

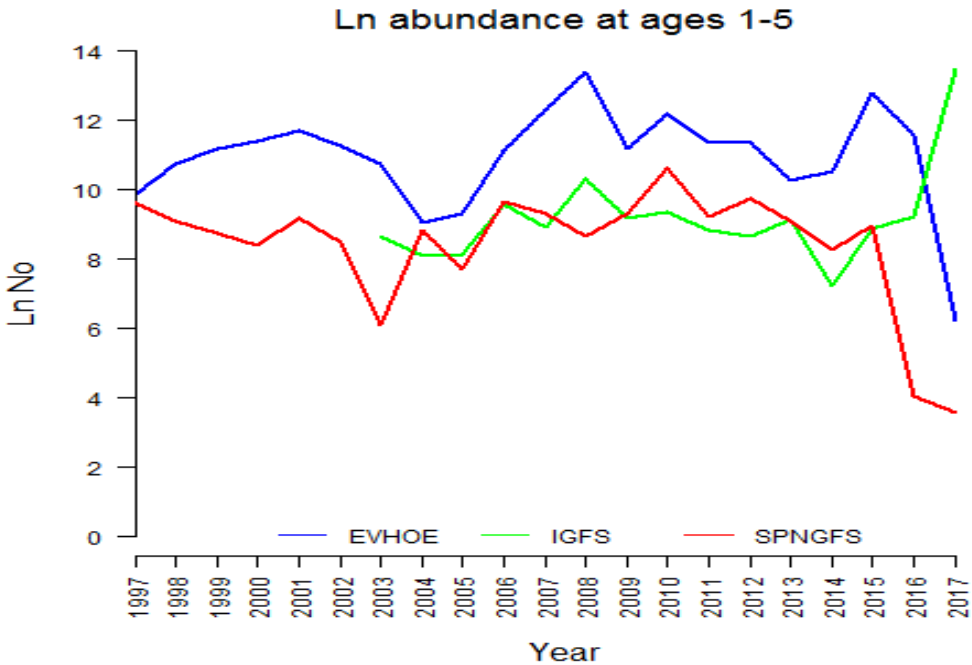

Figure 3.5.2. Boarfish in ICES Subareas 27.6, 7, 8. Recruitment-at-ages 1–5, from various IBTS.

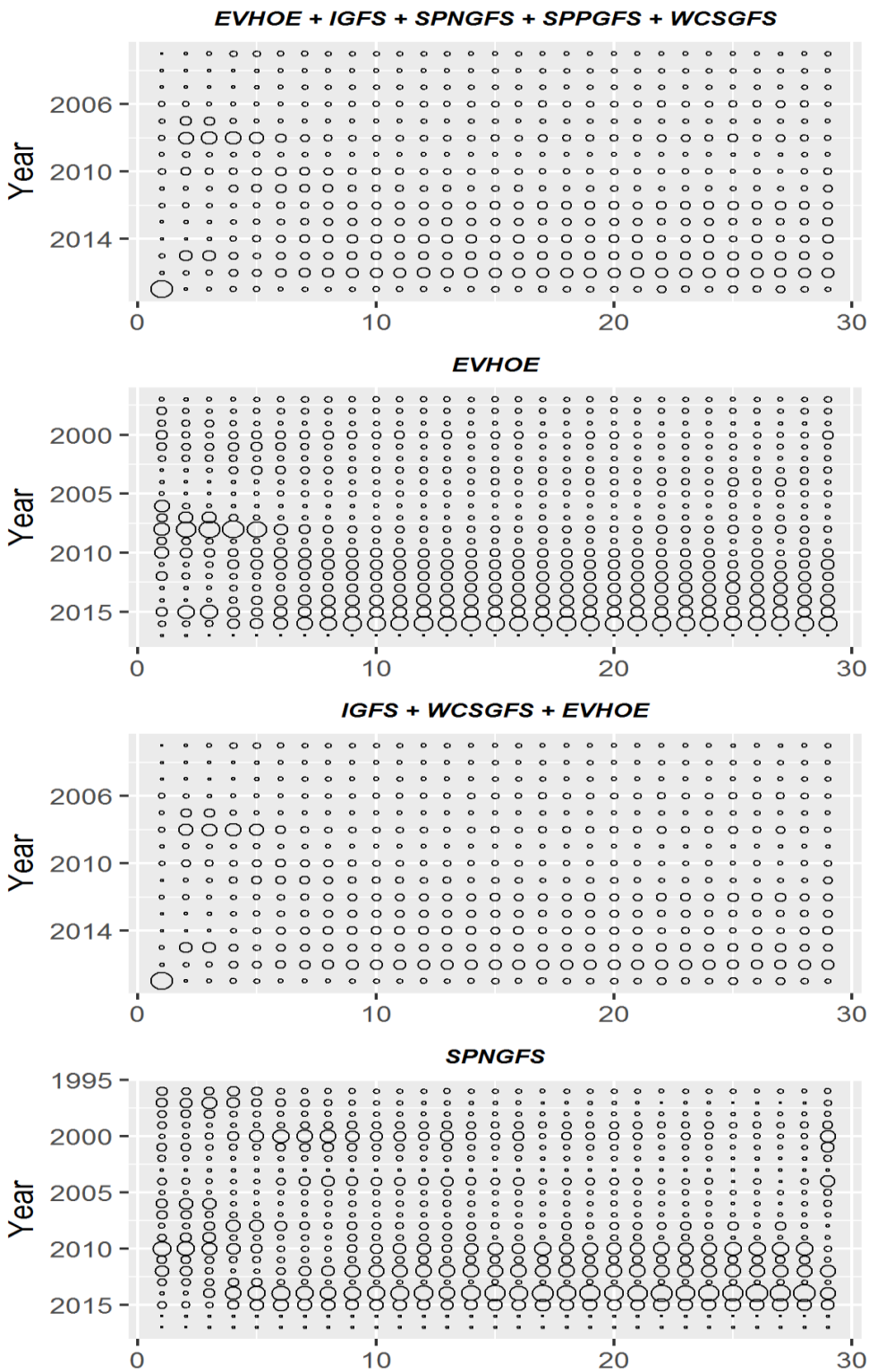

Figure 3.6.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Abundance-at-age in constituent western IBTS. Yearly mean standardised abundance-at-age.

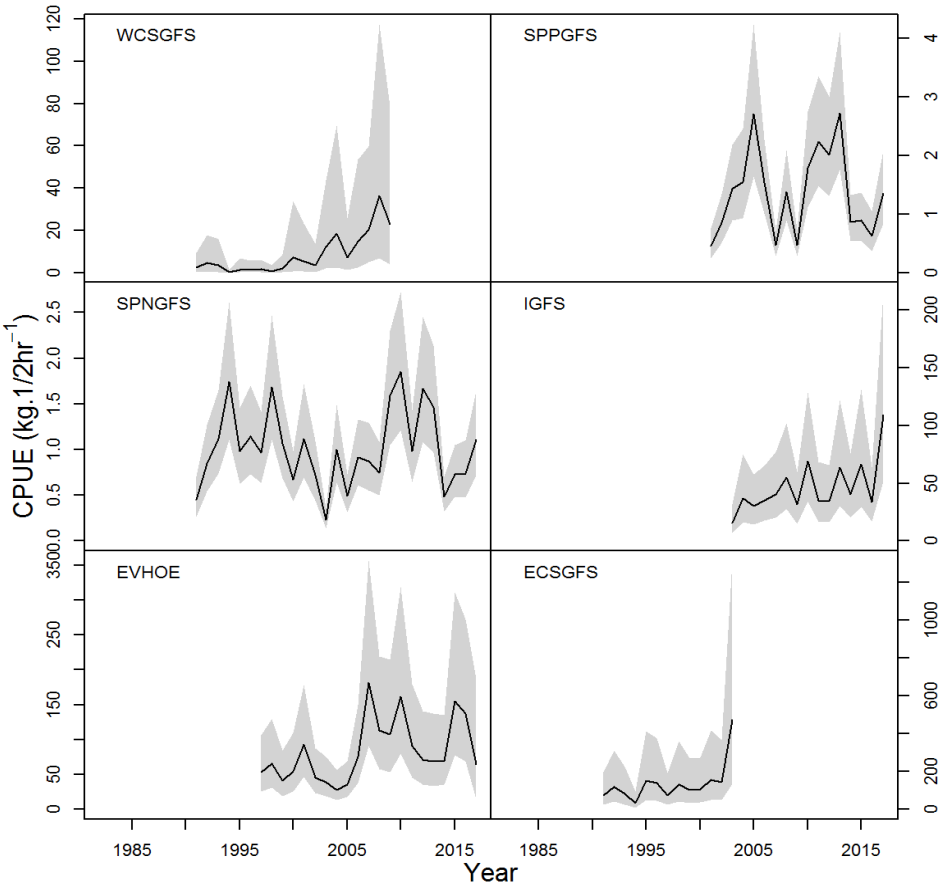

Figure 3.6.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish IBTS survey CPUE fitted delta-lognormal mean (solid line) and 95% credible intervals (grey region).

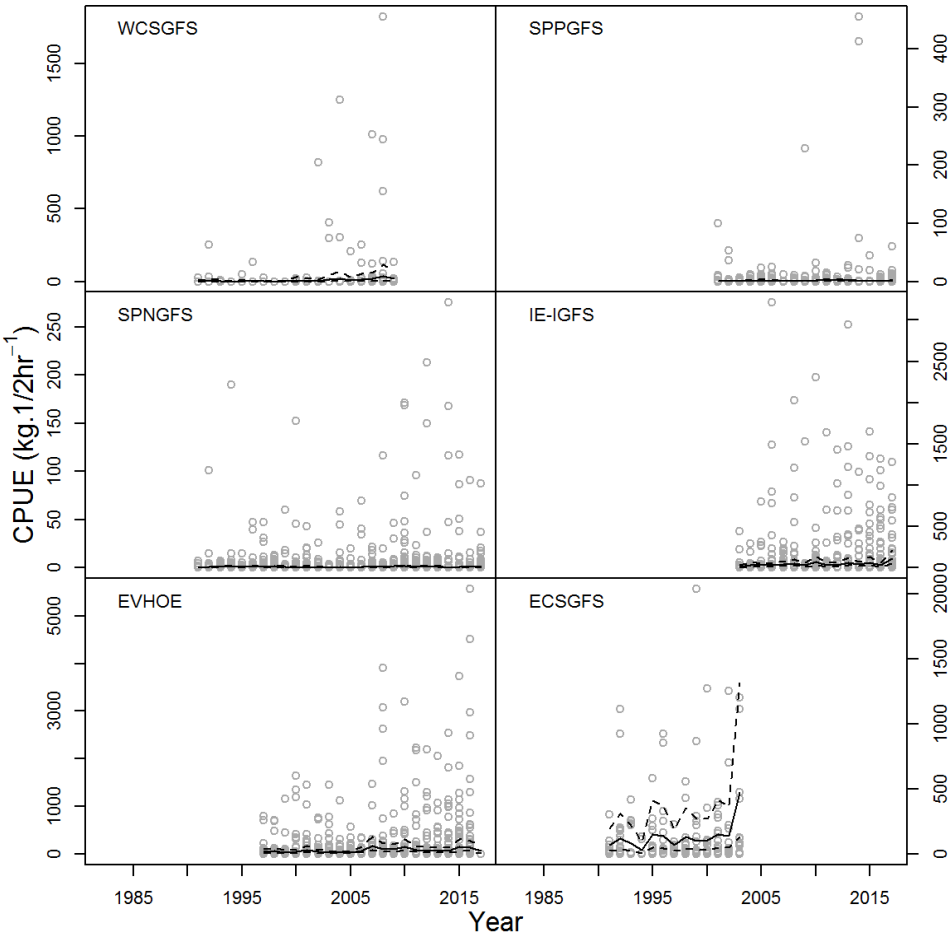

Figure 3.6.1.3. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish IBTS survey CPUE data (grey points) and fitted delta-lognormal mean (solid line) and 95% credible intervals (dashed lines).

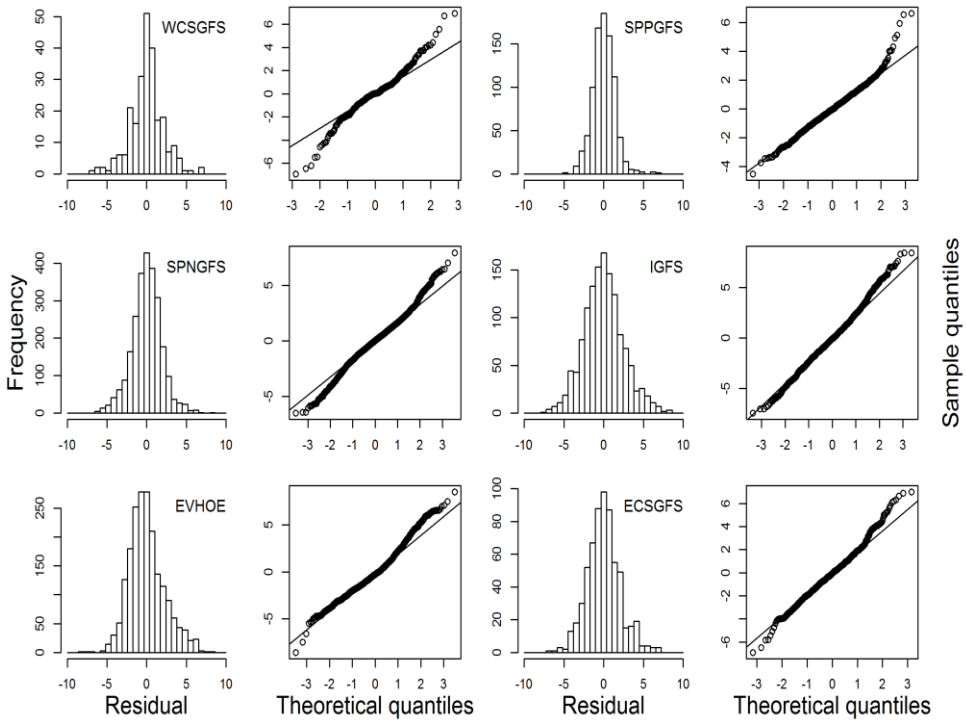

Figure 3.6.1.4. Boarfish in ICES Subareas 27.6, 7, 8. Diagnostics from the positive component of the delta-lognormal fits

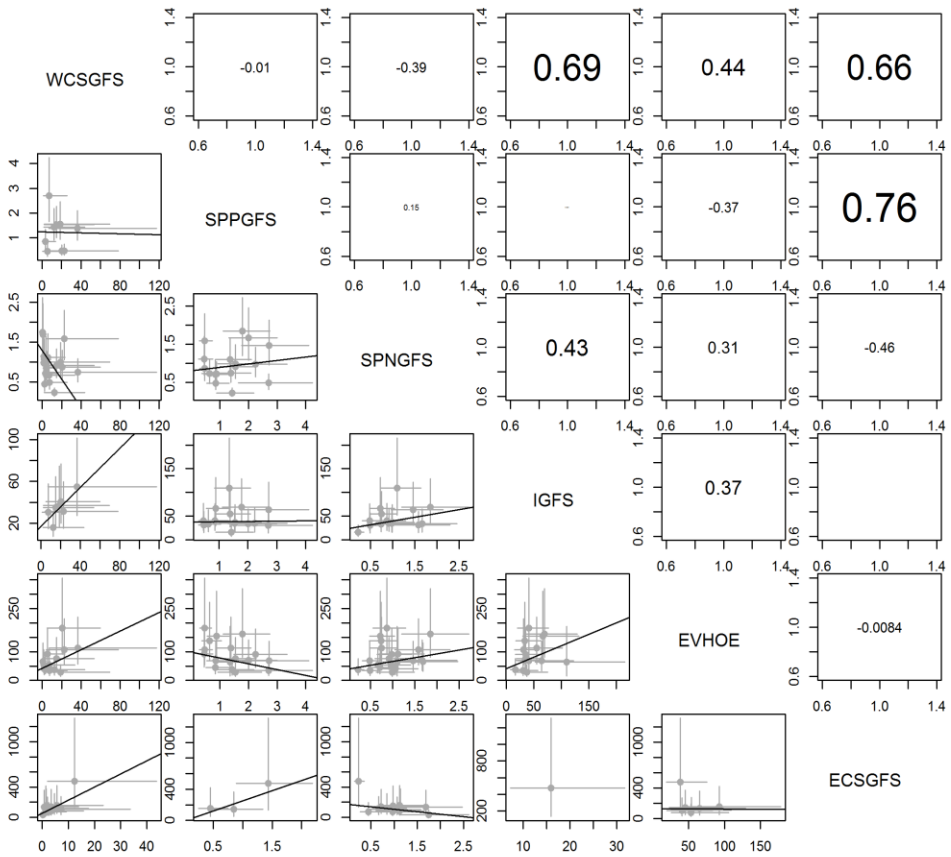

Figure 3.6.1.5. Boarfish in ICES Subareas 27.6, 7, 8. Pair-wise correlation between the annual mean survey indices.

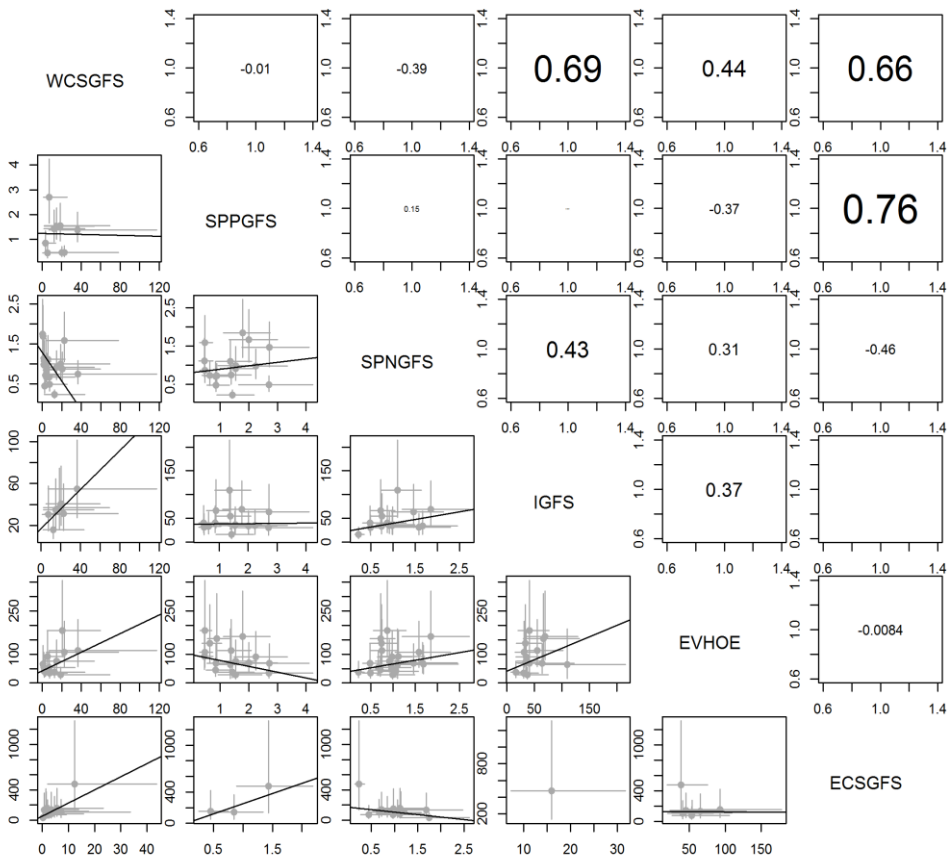

Figure 3.6.1.6. Boarfish in ICES Subareas 27.6, 7, 8. Weighted correlation between the annual mean survey indices. Correlations are weighted by the sum of the pair-wise variances.

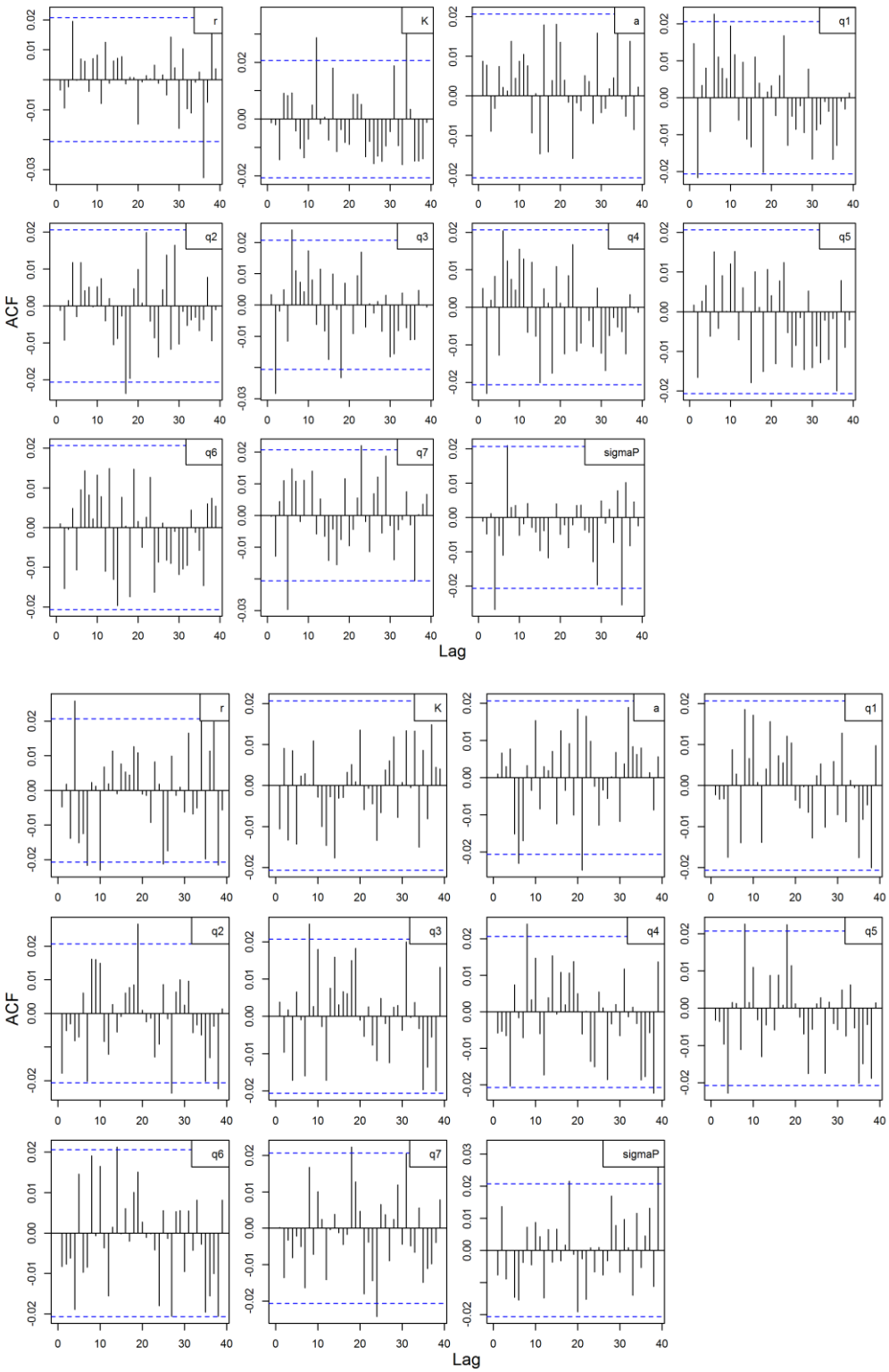

Figure 3.6.3.1. Boarfish in ICES Subareas 27.6, 7, 8. Parameters for final run converged with good mixing of the chains.

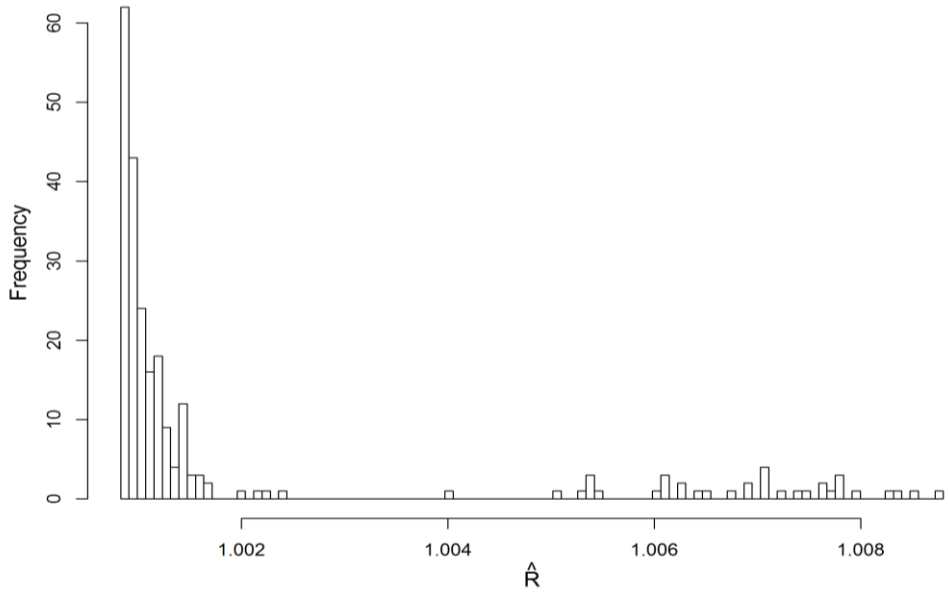

Figure 3.6.3.2. Boarfish in ICES Subareas 27.6, 7, 8. Rhat values lower than 1.1 indicating convergence.

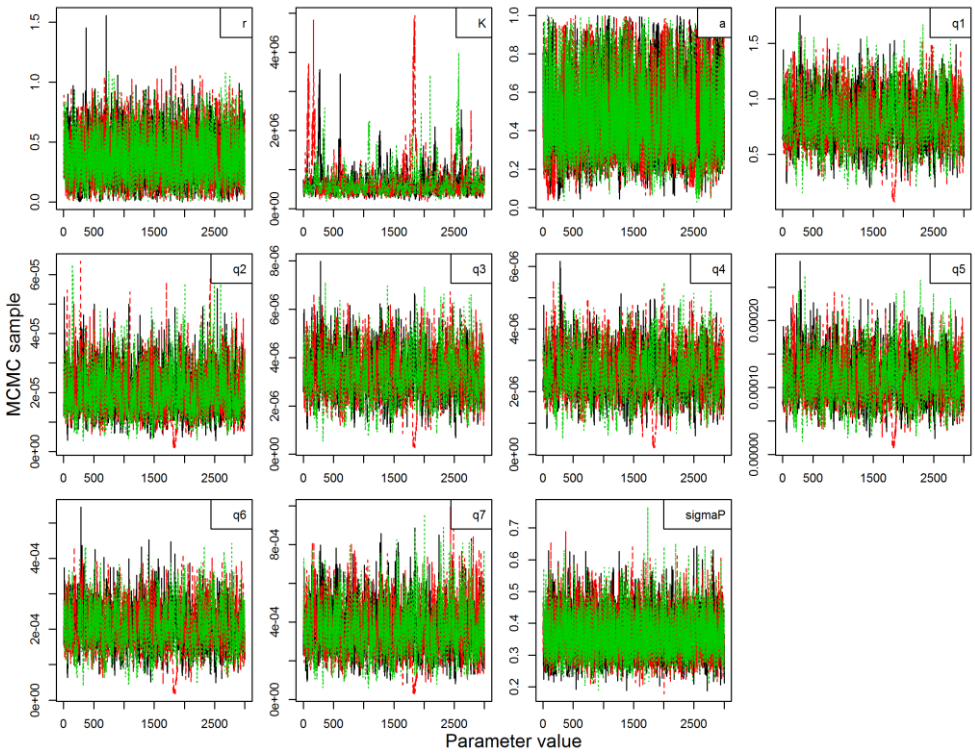

Figure 3.6.3.3. Boarfish in ICES Subareas 27.6, 7, 8. MCMC chain autocorrelation for final run.

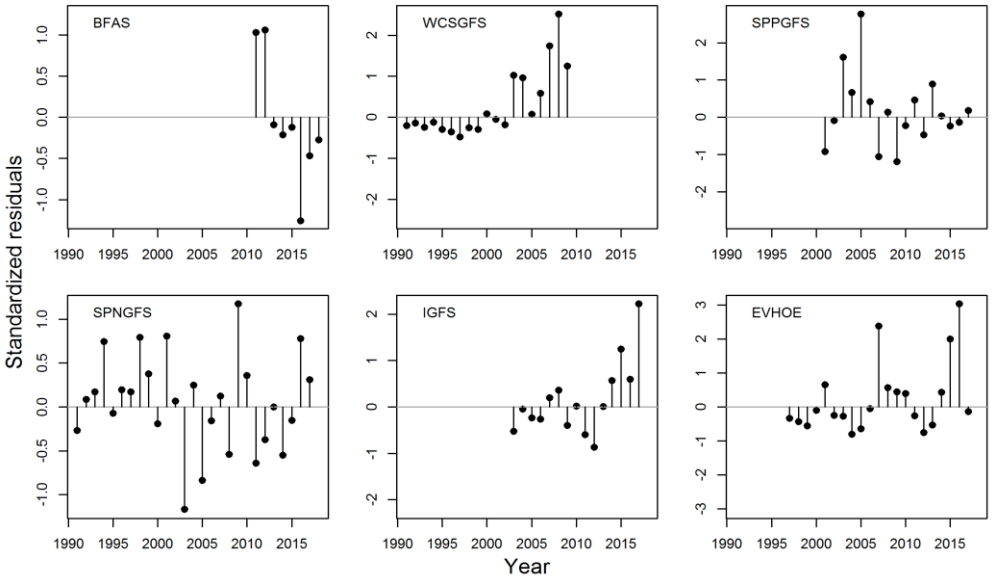

Figure 3.6.3.4. Boarfish in ICES Subareas 27.6, 7, 8. Residuals around the model fit for the final assessment run.

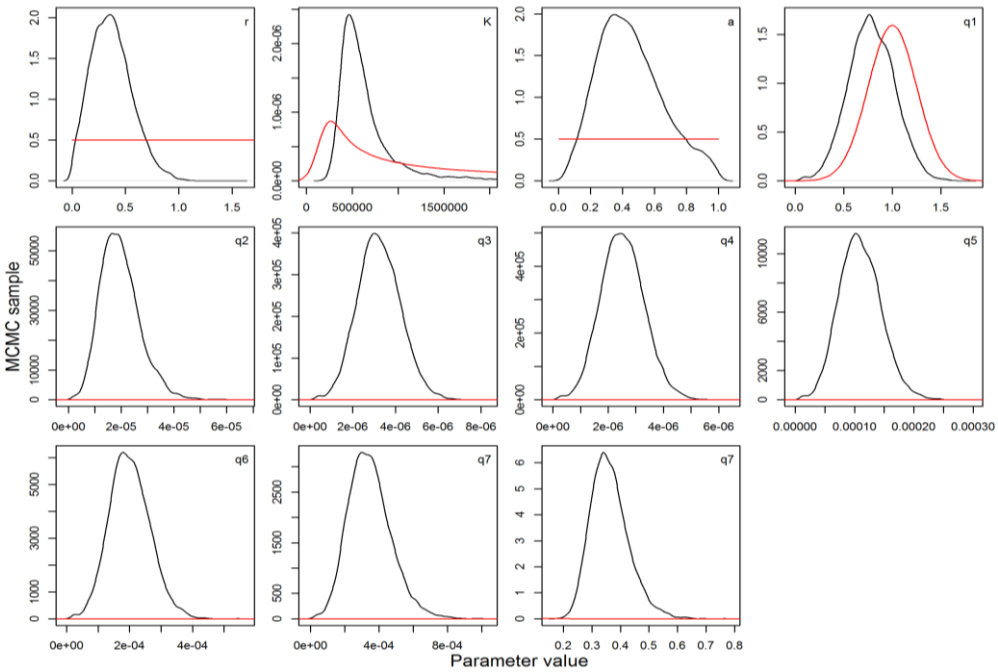

Figure 3.6.3.5. Boarfish in ICES Subareas 27.6, 7, 8. Prior (red) and posterior (black) distributions of the parameters of the biomass dynamic model.

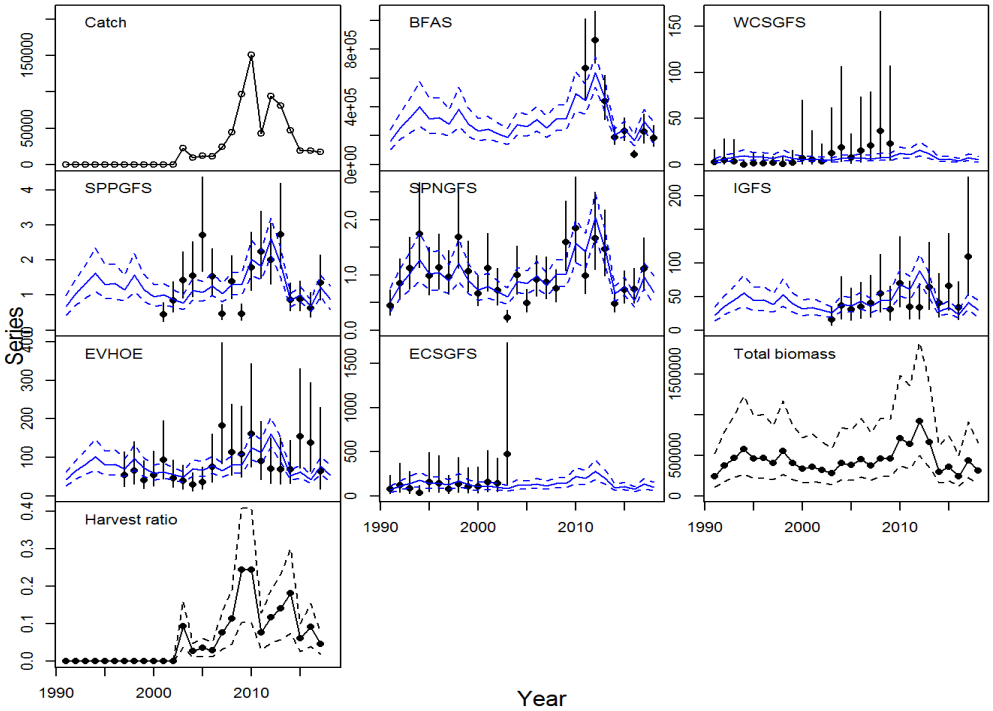

Figure 3.6.3.6. Boarfish in ICES Subareas 27.6, 7, 8. Trajectories of observed and expected indices for the final assessment run. The stock size over time and a harvest ratio (total catch divided by estimated biomass) are also shown.

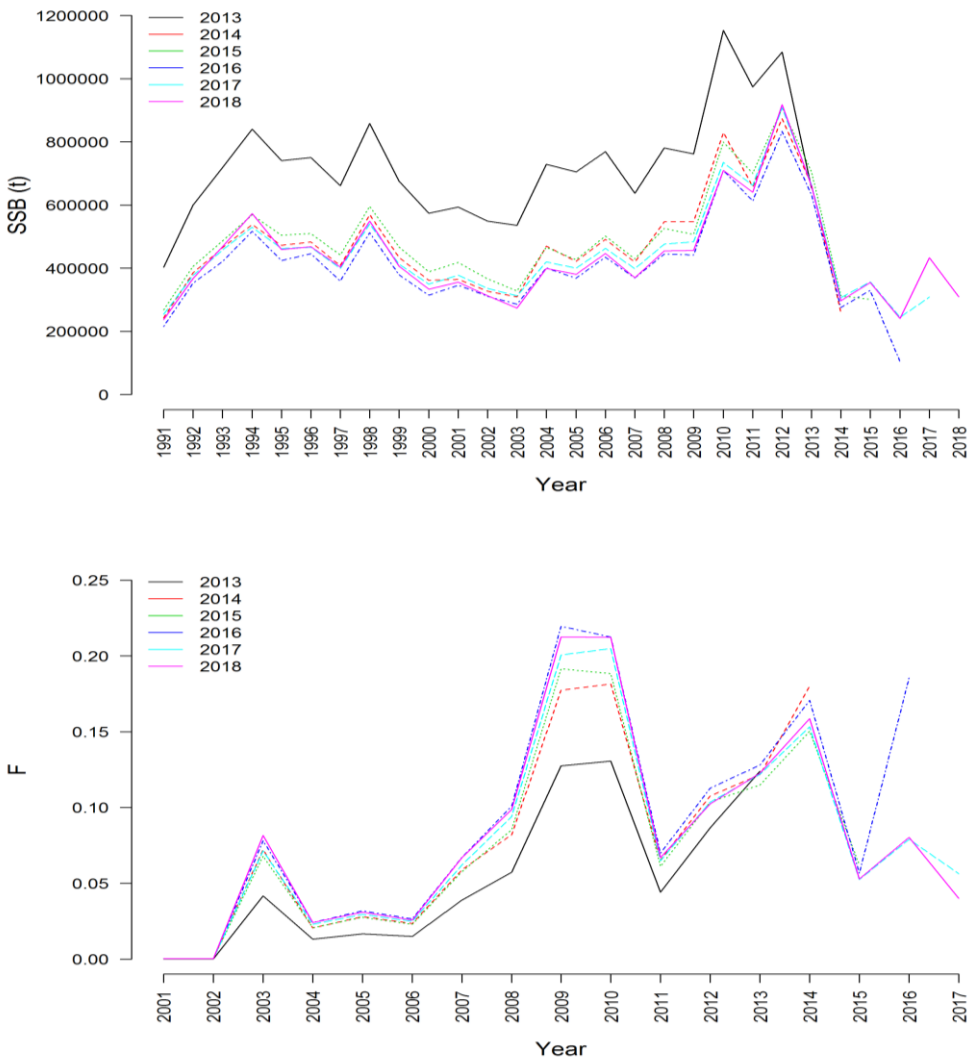

Figure 3.6.3.7. Boarfish in ICES Subareas 27.6, 7, 8. Retrospective plot of total stock biomass (above) and fishing mortality (below) from the surplus production model in 2013-2018. Heavy line is current assessment.

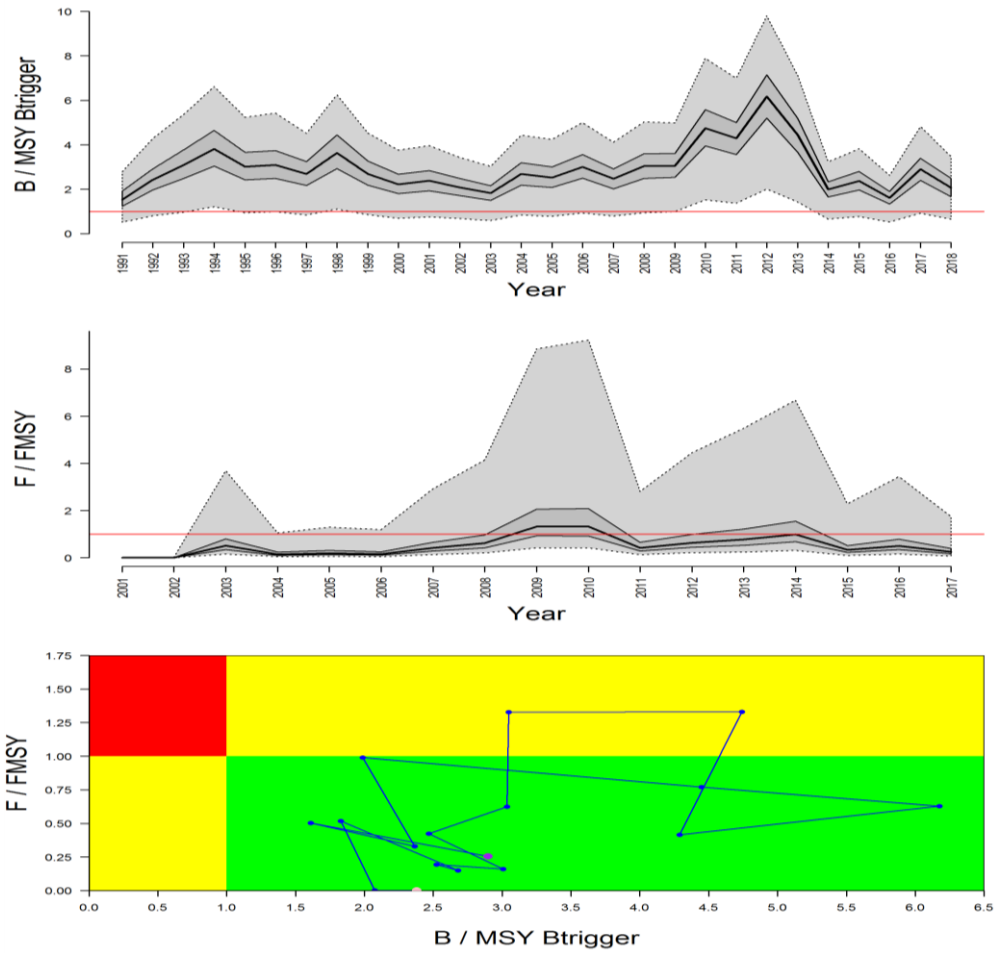

Figure 3.6.6.1. Boarfish in ICES Subareas 27.6, 7, 8. Ratios 'B / MSYBtrigger' and 'F / FMSY' through time and corresponding Kobe plot. Confidence intervals (50 and 95%) are given for the first two panels, the third displays median estimates only with the pink point representing the first point of the time series and the purple point the last.

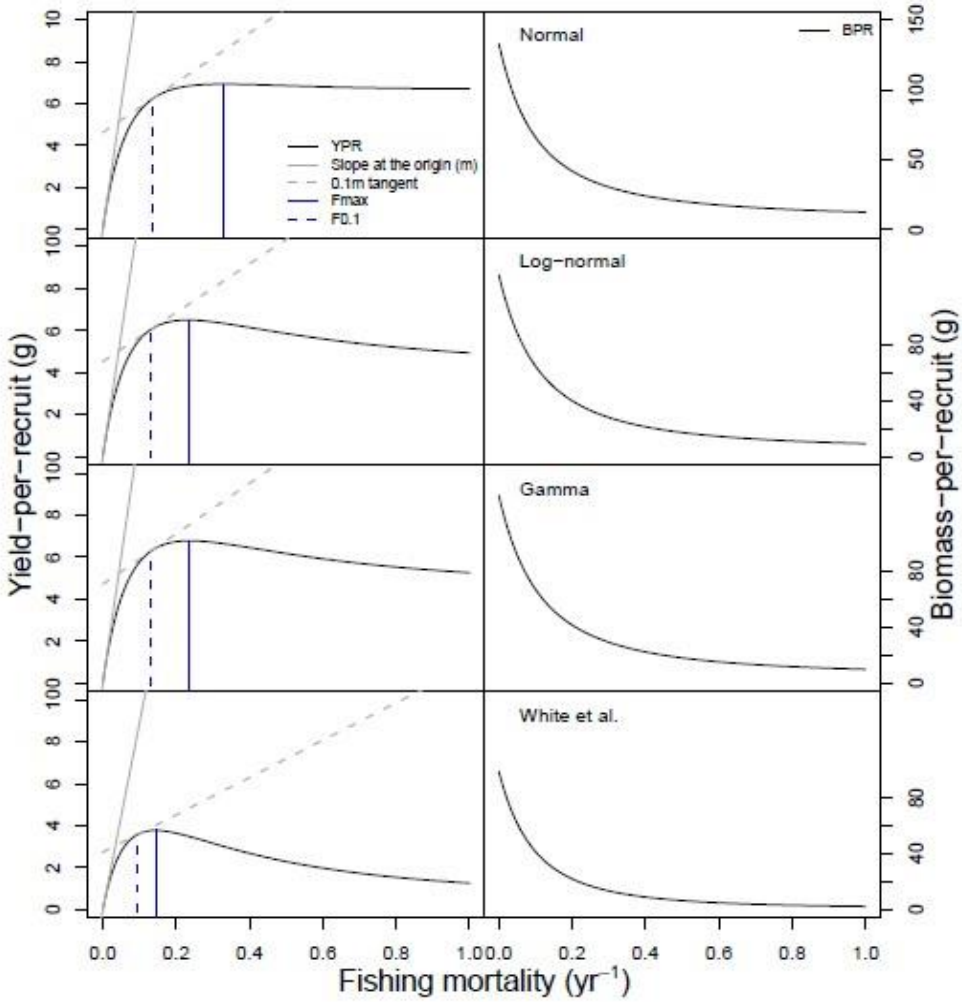

Figure 3.9.1.1. Boarfish in ICES Subareas 27.6, 7, 8. Results of exploratory yield per recruit analysis. Beverton and Holt model applied to various fits of the VBGF and for comparison with the VBGF parameters provided by White *et al.* 2011.

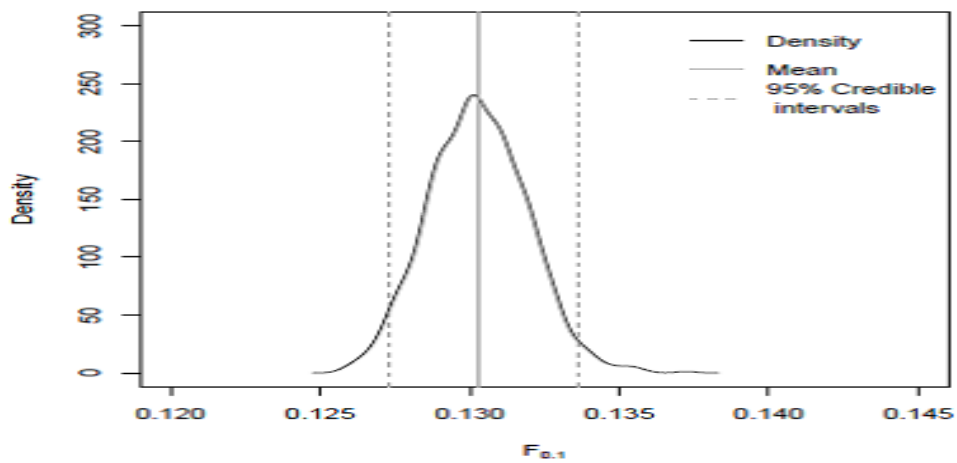

Figure 3.9.1.2. Boarfish in ICES Subareas 27.6, 7, 8. Sensitivity of estimation of F0.1.

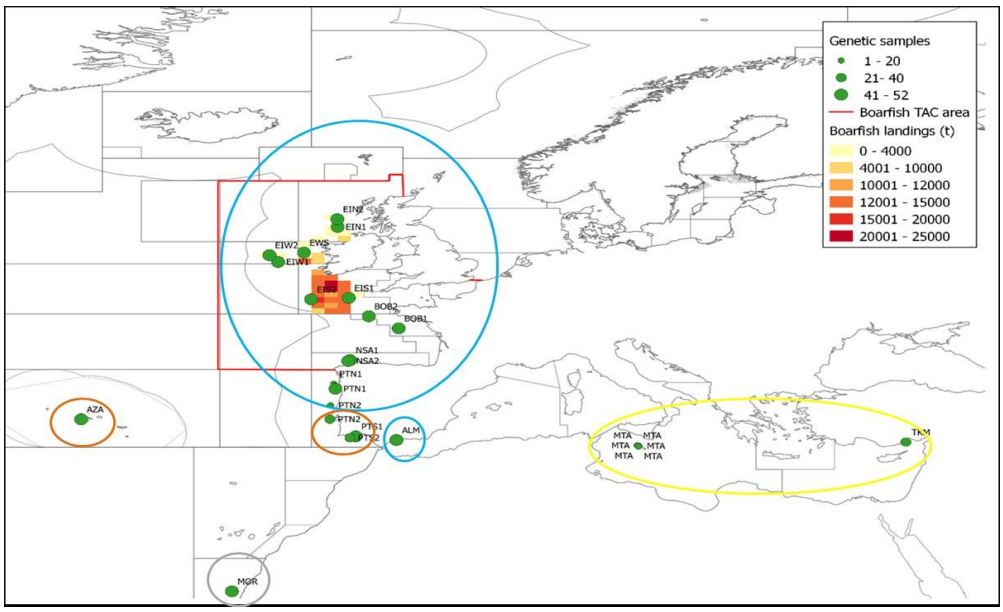

Figure 3.12.1. Boarfish in ICES Subareas 27.6, 7, 8. Boarfish samples included in the genetic stock identification study are indicated in green. Population clusters identified by the STRUCTURE analyses are indicated by colour coded circles.

4 Herring (*Clupea harengus*) in subareas 1, 2, and 5, and in divisions 4.a and 14.a, (Northeast Atlantic) (Norwegian Spring Spawning)

4.1 ICES advice in 2017

ICES noted that the stock is declining and estimated to be below MSY $B_{trigger}$(5 million tonnes) in 2017. Since 1998 four large year classes have been produced (1998, 1999, 2002, and 2004). All year classes since 2005 are estimated to be average or small. Fishing mortality has had an overall declining trend since 2010 and was well below F_{MSY} in 2016.

A long-term management plan agreed by the EU, Faroe Islands, Iceland, Norway and Russia, is operational since 1999. ICES evaluated the plan and concludes that it is in accordance with the precautionary approach. The management plan implies maximum catches of 384 197 t in 2018.

4.2 The fishery in 2017

4.2.1 Description and development of the fisheries

The distribution of the 2017 Norwegian spring-spawning herring (NSSH) fishery for all countries by ICES rectangles per year is shown in Figure 4.2.1.1 and for annual quarter in Figure 4.2.1.2. The 2017 herring fishing pattern was fairly similar to recent years. The fishery began in January on the Norwegian shelf and focused on overwintering, prespawning, spawning and post-spawning fish (Figure 4.2.1.2 quarter 1). In the second quarter, the fishery was insignificant (Figure 4.2.1.2 quarter 2, 0.5% of total catch). In summer, the fishery had moved into Faroese, Icelandic and Greenlandic waters (Figure 4.2.1.2 quarter 3). In autumn, the fishery had shifted to the overwintering area in the fjords and oceanic areas north of Tromsø and the central part of the Norwegian Sea. In particular, the catches in the international part of the Norwegian Sea were high (Figure 4.2.1.2 quarter 4). The landings in the 1st quarter constituted 22% of the total landings and the largest proportion of the landings were in the 4th quarter (69%) which is an increase from 2016, when 52% of the landings were registered in the 4th quarter.

4.3 Stock Description and management units

4.3.1 Stock description

A description of the stock is given in the Stock Annex.

4.3.2 Changes in migration

Generally, it is not clear what drives the variability in migration of the stock, but the biomass and production of zooplankton are likely factors, as well as feeding competition with other pelagic fish species (e.g. mackerel) and oceanographic conditions (e.g. limitations due to cold areas). Beside environmental factors, the age distribution in the stock will also influence the migration. Changes in migration pattern of NSSH, as well as of other herring stocks, are often linked to large year classes entering the stock initiating a different migration pattern, which subsequent year classes will follow. No large year classes have entered the stock since 2004, although the 2013 year class is estimated to be above average (since 1988) and was in 2018 observed feeding in the north-eastern part of the Norwegian Sea in May and July. In 2017/2018 there was a shift in wintering

areas. While wintering has been observed in fjords west of Tromsø (Norway) for several years, the 2013 year class wintered in fjords farther north (Kvænangen) in 2017/2018 while the older fish seemed to have had an oceanic wintering area. The oldest and largest fish move farthest south and west during feeding, and the older year classes were in May and July 2018 concentrated in the southwestern areas during the feeding season.

4.4 Input data

4.4.1 Catch data

Catches in tonnes by ICES division, ICES rectangle and quarter in 2017 were available from Denmark, Faroe Islands, Germany, Greenland, Iceland, Ireland, The Netherlands, Norway, Russia, the UK (Scotland), Poland and Sweden. The total working group catch in 2016 was 721 566 tonnes (Table 4.4.1.1) compared to the ICES-recommended catch of maximum 437 364 tonnes. The majority of the catches (91%) were taken in area 2.a as in previous years. Samples were not provided by Greenland, the UK or Poland (2.5 % of the total catch were taken by these countries). Sampled catches accounted for 95 % of the total catches, which on a similar level assign previous years. The sampling levels of catches in 2017 in total, by country and by ICES division is shown in Table 4.4.1.2, 4.4.1.3 and 4.4.1.4. Catch by nation, ICES division and quarter are shown in Table 4.4.1.5. The software SALLOC (ICES, 1998) was used to calculate total catches in numbers-at-age and mean weight at age representing the total catch. Samples allocated (termed fill-in in SALLOC) to cells (nation, ICES division and quarter) without sampling information are shown in Table 4.4.1.5.

4.4.2 Discards

In 2008, the Working Group noted that in this fishery an unaccounted mortality caused by fishing operations and underreporting probably exists (ICES, 2008). It has not been possible to assess the magnitude of these extra removals from the stock, and considering the large catches taken after the recovery of the stock, the relative importance of such additional mortality is probably low. Therefore, no extra mortality to account for these factors has been added since 1994. In previous years, when the stock and the quotas were much smaller, an estimated amount of fish was added to the catches.

The Working Group has not had access to comprehensive data to estimate discards of the herring. Although discarding may occur on this stock, it is considered to be low and a minor problem to the assessment. This is confirmed by estimates from sampling programmes carried out by some EU countries in the Data Collection Framework. Estimates on discarding in 2008 and 2009 of about 2% in weight were provided for the trawl fishery carried out by the Netherlands. In 2010 and 2012, this métier was sampled by Germany. No discarding of herring was observed (0%) in either of the two years. An investigation on fisheries induced mortality carried out by IMR with EU partners on fisheries induced and unreported mortality in mackerel and herring fisheries in the North Sea concluded with an estimated level of discarding at around 3%.

In order to provide information on unaccounted mortality caused by fishing operations in the Norwegian fishery, Ipsos Public Affairs, in cooperation with IMR and the fishing industry, conducted a survey in January/February 2016. The survey was done by phoning skippers and interviewing them. A total of 146 herring skippers participated in the survey, 31 skippers representing the bigger vessel group and 115 skippers representing the smaller vessel group. The data provided an indication that there have been periods

of increased occurrence of net bursting. This was seen especially in the period 2007–2010. There was, however, no trend in the size of catches where bursting has occurred.

When it comes to slipping, the data showed a steady increase in the percentage that has slipped herring from 2004–2012, and then a significant decline in recent years. The variations in the proportion that have slipped herring were largely driven by the skippers on smaller coastal purse-seiners. Average size of purse-seine hauls slipped seems to be relatively steady over the period. However, the average size of net hauls slipped was lowest in the recent period. An attempt to estimate the level of slipping/bursting (in tonnes) based on these data is planned.

4.4.3 Age composition of the catch

The estimated catch-at-age in numbers by years are shown in Table 4.4.3.1. The numbers are calculated using the SALLOC software. In 2017, about 14 % of the catches (in numbers) were taken from both the 2009 year class and the 2013 year class, followed by the 2006 (13%) and 2011 (12%) year classes. The 2004 year class still contributes, with 10 % of the catches in 2017.

Catch curves were made on the basis of the international catch-at-age (Figure 4.4.3.1). For comparison, lines corresponding to Z=0.3 are drawn in the background. The big year classes, in the periods of relatively constant effort, show a consistent decline in catch number by cohort, indicating a reasonably good quality of the catch-at-age data. Catch curves for year classes 2005 onwards show a more flat curve than for previous year classes indicating a lower F or a changed exploitation pattern.

4.4.4 Weight at age in catch and in the stock

The weight-at-age in the catches in 2017was computed from the sampled catches using SALLOC. Trends in weight-at-age in the catch are presented in Figure 4.4.4.1 and Table 4.4.4.1. The mean weights at age for most of the age groups have generally been increasing in 2010–2013 but levelled off in 2014 and seem to have decreased slightly during the most recent years. A similar pattern is observed in weight-at-age in the stock which is presented in Figure 4.4.4.2 and Table 4.4.4.2. These data have been taken from the survey in the wintering area until 2008. The mean weight at age in the stock for age groups 4–11 in the years 2009–2017 was derived from samples taken in the fishery in the same area and at the same time as the wintering surveys were conducted in.

4.4.5 Maturity-at-age

In 2010 the method for estimating maturity-at-age in the stock assessment of NSSH was changed based on work done by the "workshop on estimation of maturity ogive in Norwegian spring-spawning herring" (WKHERMAT; ICES, 2010a). The method which was adopted by WGWIDE in 2010 (ICES, 2010b) is based on work by Engelhard *et al*. (2003) and Engelhard and Heino (2004). They developed a method to back-calculate age at maturity for individual herring based on scale measurements, and used this to construct maturity ogives for the year classes 1930–1992.

The NSSH has irregular recruitment pattern with a few large year classes dominating in the stock when it is on a high level. Most of the year classes are, however, relatively small and referred to as "normal" year classes. The back calculation dataset indicates that maturation of the large year classes is slower than for "normal" year classes.

WKHERMAT and WGWIDE considered the dataset derived by back calculation as a suitable potential candidate for use in the assessment because it is conceived in a consistent way over the whole period and can meet standards required in a quality controlled process. However, the back calculation estimates cannot be used for recent years since all year classes have to be fully matured before included. Therefore, assumptions have to be made for recent year classes. For recent year classes, WGWIDE (2010) decided to use average back-calculated maturity for "normal" and "big" year classes, respectively and thereby reducing maturity-at-age for ages 4, 5 and 6 when strong year classes enter the spawning stock. The default maturity ogives used for "normal" and "big" year classes are given in the text table below.

AGE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
normal ycl	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
strong ycl	0	0	0	0	0.1	0.6	0.9	1	1	1	1	1	1	1	1	1

Assumed values should be replaced by back-calculated values in the annual assessments for each year where updated values are available. This was last done in the benchmark assessment in 2016. Therefore, two years (2012 and 2013) could be updated with back-calculated values in the present assessment. Assumed and updated values are shown in figure 4.4.5.1. The maturity ogives used in the present assessment are presented in Table 4.4.5.1.

4.4.6 Natural mortality

In this year's assessment, the natural mortality M=0.15 was used for ages 3 and older and M=0.9 was used for ages 0–2. These levels of M are in accordance to previous years and their justification is provided in the stock annex. Information about deviations from these levels in the time-series, e.g. due to diseases, are also provided in the stock annex.

4.4.7 Survey data

The surveys available for the assessment are described in the stock annex. Only two of the available surveys are used in the final assessment and will therefore be dealt with in this section:

1) The International Ecosystem Survey in the Nordic Seas (IESNS) in May. The survey covers the entire stock during its migration on the feeding grounds, the adults in the Norwegian Sea and adjacent waters ("Fleet 5") and the juveniles in the Barents Sea ("Fleet 4").

2) The Norwegian acoustic survey on the spawning grounds ("Fleet 1") in February.

The cruise reports from the IESNS and spawning survey in 2018 are available as working documents to this report. Both surveys were successfully conducted in 2018.

The abundance estimates from "Fleet 1" are shown in Table 4.4.7.1 and Figure 4.4.7.2; from "Fleet 4" in Table 4.4.7.2 and Figure 4.4.7.1 and "Fleet 5" in Table 4.4.7.3and Figure 4.4.7.1.

Catch curves were made on the basis of the abundance estimates from the surveys "Fleet 1" (Figure 4.4.7.3) and "Fleet 5" (Figure 4.4.7.4). The same arguments are valid for the interpretation of the catch curves from the surveys as from the catches. In 2010,

the number of all age groups decreased suddenly in "Fleet 5" and this is seen as a drop in the catch curves that year. This drop has continued for some of the year classes and the year classes 1998 and 1999 are disappearing faster from the stock than expected. This observed fast reduction in these age classes may also be influenced by the changes in "Fleet 5" catchability, with seemingly higher catchability in years 2006—2009. Like the catch curves from commercial landings, the corresponding curves from "Fleet 5" are also quite flat for year classes 2005 onwards. As "Fleet 1" was not conducted in the years 2009–2014, there is a gap in the catch curves, making it difficult to interpret them.

4.4.8 Sampling error in catches and surveys

Sampling errors for Norwegian catch-at-age for the years 2010-2017 is estimated using ECA (Salthaug and Aanes 2015, Hirst *et al.* 2012). Using the Taylor function (Aanes 2016a) to model the sampling variance of the catches yields a very good fit (R^2_{adj} = 0.94) and using this function to impute missing sampling variances for catch-at-age yields relative standard errors shown in Table 4.4.8.1. It is assumed that the relative standard errors in the total catches are equal to the Norwegian catches (which comprise ~60% of the total catches). Sampling errors for survey indices are estimated using StoX (http://www.imr.no/forskning/prosjekter/stox/nb-no). For Fleet 1 estimates are available for the years 1988–1989, 1994–1996, 1998–2000, 2005–2008, and 2015–2018, for Fleet 4 estimates of sampling errors are available for 2009–2018, and for Fleet 5 for 2008–2018. Missing values for sampling variances are imputed using the Taylor function which provides goods fits (R^2_{adj}'s are 0.94, 0.98, 0.96, respectively). The resultant relative standard errors are given in Tables 4.4.8.2-4.4.8.4. Due to the very good fits of the Taylor functions, estimates of relative standard where empirical estimates are available, are also replaced by the model predicted values to reduce potential effects of imprecise estimates of errors.

4.4.9 Information from the fishing industry

No information is made available for the working group.

4.5 Stock assessment

The first benchmark of the NSSH took place in 2008. The assessment tool TASACS was then chosen to be the standard assessment tool for the stock. The second benchmark took place in 2016 (ICES 2016c) where three assessment models were explored, TASACS, XSAM and one separable model. WKPELA accepted XSAM as the standard assessment tool for the NSSH.

4.5.1 XSAM final assessment 2018

The XSAM model is documented in Aanes 2016a and 2016b. XSAM includes the option to utilize the prediction of total catch in the assessment year (typically sum of national quotas) along with the precision of the prediction. This was changed in 2017 as it was found that the model estimated a highly variable and significantly lower compared to the working group's prediction (sum of national quotas). In addition, this caused an abrupt change in the selection pattern from 2017 and onwards. The abrupt change in the selection pattern was not fully understood by the working group, but the effect was less pronounced if not using the catch prediction from the model for 2017. Therefore, it was decided to not utilize the prediction of total catches in 2017 when fitting the model to data (i.e. the assessment) and consequently in the short-term forecast. The same approach is taken in the 2018 assessment, i.e. the catch prediction for 2018 is not included when fitting the model to data. The resulting estimated selection pattern is

gradual (Figure 4.5.1.1) and in line with the current knowledge about the fishery. It is important to notice that this has marginal effect on the assessment, but larger effects on the prediction and short-term forecast.

This year's XSAM assessment was performed with the same model options as in 2017. In summary this means that the model was fitted with time varying selectivity and effort according to AR(1) models in the model for fishing mortality; the recruitment was modelled as a process with constant mean and variance; the standard errors for all input data were predetermined using sample data (Tables 4.4.8.1–4.4.8.4), but estimating a scaling constant common for all input data to allow additional variability in the input data that is not controlled by sampling. Other details in settings are given in the Stock Annex.

The same input data over the same age ranges was used as in 2017. At the 2016 benchmark, data from 1988 and onwards was used, the considered age-span was 3–12+ with input data catch-at-age, Fleet 1 and Fleet 5 and in WGWIDE 2016 it was decided to start the model at age 2 to enable short-term predictions with reasonable levels of variability. To achieve this, age 2 from Fleet 4, and age 2 in catch-at-age is included in input data. Evaluation of diagnostics including lower ages than 2 and/or other fleets resulted in excluding lower ages than 2 and other fleets for the final assessment. Input data are listed in Table C.1.1 in the Stock Annex.

The parameter estimates are shown in Table 4.5.1.1. For a precise definition of the parameters it is referred to Aanes 2016a in ICES (2016). Note that the variance components σ_1^2 (variability in the separable model for F) and σ_R^2 (variability in recruitment) is rather imprecise. The estimate of the scaling constant h is larger than 1 showing that the model adds additional variability on the observation errors than explained by the sampling errors alone.

The catchabilities for all the fleets are on average positively correlated indicating some uncertainty due to a common scaling of all surveys to the total abundances although the correlations in general are small (Figure 4.5.1.2). There is a slight negative correlation between σ_1^2 and σ_2^2 (variability in the AR process for time varying selectivity) indicating little contrast in data for separating variability in the separable model from variability due to changes in selection pattern. The slopes in the multivariate AR model for time-varying selectivity gradually changes from negative to positive, but is expected as it is imposed due to the sum to zero constraint for the selection (see Aanes 2016a for details).

The weights each datum is given in the model fit (inverse of the sampling variance) is proportional to the empirical weights derived from sampling variances (Tables 4.4.8.1–4.4.8.4) which shows that the strong year classes in general is given larger weight to the model than weak year classes, and the ordering of the average weights (from high to low) is Catch-at-age, Fleet 5, Fleet 1 and Fleet 4 (Figure 4.5.1.3).

Two types of residuals are considered for this model. The first type is the model prediction (based on all data) vs. the data. In such time-series models, the residuals based on the prediction which uses all data points will be serially correlated although useful as they explain the unexplained part of the model (cf Harvey 1990 p 258).This means that patterns in residuals over time is to be expected and questions the use of e.g. qq-plots as an additional diagnostic tools to assess distributional assumptions. To obtain residuals which follow the assumptions about the data in the observation models (e.g. serially uncorrelated) single joint sample residuals are extracted (ICES 2017). In short these are obtained by sampling predicted values from the conditional distribution of

values given the observations. This sample corresponds to a sample from the joint distribution of latent variables and observations. The third approach could have been to extract the one step ahead observation residuals which are standard for diagnostics for regular state-space models (cf Harvey 1990). This is not done here.

The negative residuals tracing the 1983 year class for catch-at-age represents low fishing mortalities examining the type 1 residuals (Figure 4.5.1.4). This effect is less pronounced considering the type 2 residuals. The type 2 residuals are qualitatively comparable with the type 1 residuals but generally display more mixed residuals as predicted by the theory. Otherwise the residuals for catch-at-age appears fairly mixed apart for some serial correlation for age 2 and 3 (which are very low), and some negative residuals for the plus group the most recent years. The residuals for Fleet 1 in 1994 and 2015 for young and old ages are all of the same signs and may appear as year effects. Also note that the residuals for Fleet 1 for ages 10+ in 2015 and 2016 are all positive (Figure 4.5.1.4) which shows that the abundance indices from Fleet 1 displays a larger stock size over these ages and years compared to the assessment using all input data. However, these data points are given low weights (Figure 4.5.1.3) as they are found imprecise (Tables 4.4.8.1–4.4.8.4). Some serial correlation for residuals for ages 3 and 4 in Fleet 1 can also be detected, but is down weighted by the same reasons. Serial correlation in residuals for age 2 in Fleet 4 can also be detected indicating trends over time in mismatch between estimates and observations of abundance at age 2. Residuals for Fleet 5 appears adequate compared to previous years although some serial correlations can be detected also here.

The residuals for small values are bigger than residuals for the larger values since smaller values in general have higher variances than larger values (Tables 4.4.8.1–4.4.8.4) (Figure 4.5.1.5).The qq-plots for the standardized residuals show that the distributional assumptions on the observation errors are adequate, except for the smallest and largest values of catch-at-age and indices from Fleet 1. As qq-plots for residuals of type 1 may be questioned (see above) it is noted that qq-plots for residuals of type 2 is more relevant and generally shows a significantly better fit based on a visual inspection compared to using type 1.

The marginal likelihood and the components for each data source (see Aanes 2016b for details) are profiled over a range of the common scaling factor h for all input data (Figure 4.5.1.6). It is apparent that the optimum of the marginal likelihood is clearly defined. The catch component is decreasing with decreasing values of h indicating that the model puts more weight on the catch component than indicated by the comparing sampling errors for all input data. This is in line with the findings in Aanes (2016a and 2016b) who showed that these types of models tends to put too much weight on the catch data if the weighting is not constrained. However, the likelihood component for the catch is overruled by the information in Fleet 1, 4 and 5 such that the optimum for the marginal likelihood is clearly defined. The point estimates of SSB and F is insensitive to different values of h.

The retrospective runs for this model shows estimates which is within the estimated levels of precision (Figure 4.5.1.7). The indices from Fleet 1 indicate, on average, a relatively larger abundance than the indices from Fleet 5 for 2015-2017 which is supported by the positive residuals for ages 9–10+ (Figure 4.5.1.4). Consequently, the increased estimates of SSB and decreased estimates of F after 2014 is a response to the indices from Fleet 1 which not was conducted in the years 2009–2014. Note that the retrospective estimates are remarkably stable from 2015 and onwards. To illustrate the conflict in data and increased uncertainty in estimates the most recent years, the abundance

indices are scaled to the absolute abundance by the estimated catchabilities. Then the spawning-stock biomass based on each survey index is calculated using the stock weights at age and proportion mature at age (Figure 4.5.1.8). Here we see a fairly good temporal match between the model estimate of SSB and the survey SSBs except for the years 2015 and 2016 for Fleet 1, which display a significantly faster reduction in the stock compared to Fleet 5 which shows a more flat trend in the same years. It is worth noticing that although the point estimate of SSB based on Fleet 1 appear very much higher than Fleet 5 in 2015 and 2016, the uncertainty in the estimates are very high, such that the respective estimates do not appear as significantly different. However, the effect on the final assessment is to lift the point estimate of SSB and increase the uncertainty which is in accordance with the data used (Figure 4.5.1.9).

The final assessment results are shown in Figure 4.5.1.9. The estimates of fishing mortality for 2017 is rather high, as a response to the high catch in 2017 with a point estimate of 0.174 although the estimate is rather imprecise since the 95% confidence interval ranges from 0.123 – 0.224. The spawning stock shows a declining trend since 2009, and the 95% confidence interval of the stock level in 2018 ranges from ~3.1 to ~4.6 million tonnes which barely envelopes B_{mp}=3.184 million tonnes, such that the probability of the stock being above B_{lim}=2.5 million tonnes is high. Note the rather large uncertainty in the absolute levels since the peak in 2009 with the further increase in the most recent years. This high uncertainty is a result of the conflicting signals in data concerning the degree of decrease in the stock over this time period.

The final results of the assessment are also presented in Tables 4.5.1.2 (stock in numbers), 4.5.1.3 (fishing mortality) and Table 4.5.1.4 is the summary table of the assessment.

4.5.2 Exploratory assessments

4.5.2.1 TASACS

TASACS was run according to the benchmark in 2008 using the VPA population model in the TASACS toolbox with the same model options as the benchmark (see Stock Annex). The information used in the TASACS run is catch data and survey data from eight surveys. The analysis was restricted to the years 1988—2018. The model was run with catch data from 1988 to 2017, and projected forwards through 2018 assuming Fs in 2018 equal to those in 2017, to include survey data from 2018. The larval survey (SSB fleet) was discontinued in 2017 and no new information is therefore available from this survey.

The model fit to the tuning data is shown with Q-Q plots in Figure 4.5.2.1.1. Surveys 1, 2, 3 and 7 seem to fit rather well to the assumed linear relationship in the TASACS model, but surveys 4, 6 and 8 have rather poor fit. Since 2016 the TASACS run Q-Q plots for fleet 5 shows a poorer fit compared to earlier assessments. This is mainly caused by a change in estimated catchability.

Particularly Survey 8 (larval survey) seems to have a poor fit. This can also be seen as a block of positive residuals for this survey in later years (Figure 4.5.2.1.2). The residual plot for survey 5 (IESNS) also shows some pattern with consecutive series of negative and positive residuals indicating year-effects.

The results from TASACS are compared to those from XSAM and TISVPA in Figure 4.5.2.1.3.The time-series of SSB show similar trends for XSAM and TASACS while TISVPA do not show the same downward trend in the later period. For most of the years,

the estimates from TASACS and TISVPA are mostly within the confidence limits estimated by XSAM. The SSB on 1 January 2018 is estimated by TASACS to be 3.693 million tonnes, which is lower than the estimated value from TISVPA but close to the point estimate from XSAM.

4.5.2.2 TISVPA

The TISVPA model was applied using the catch-at-age data with range from 0 to 15+ and data from three surveys (Survey 1, 4 and 5). No data points were down-weighted. Two-parametric selection pattern used in the model revealed some obvious peculiarities in the interaction between the stock and the fishery.

Rather clear signals about the stock biomass in 2018 were obtained from just catch-at-age and surveys 1, 4 and 5. Catch-at-age and Survey 1 data, as well as the overall objective function of the model, indicate the SSB value in 2018 about 4.7 million tonnes (see WD 12). Surveys 4 and 5 indicate the SSB value about 6 and 4 million tonnes respectively.

The results from TISVPA are compared to those from XSAM and TASACS in Figure 4.5.2.1.3.

4.6 NSSH reference points

ICES last reviewed the reference points of Norwegian spring spawning herring in April 2018. ICES concluded that B_{lim} should remain unchanged at 2.5 million tonnes and $MSYB_{trigger} = B_{pa}$ was estimated at 3.184 million tonnes. F_{MSY} was estimated at 0.102, but during an ongoing work on Management Strategy Evaluation F_{MSY} has been revisited, because issues were found with numerical instability and settings when $F_{MSY} = 0.102$ was set. Therefore F_{MSY} is currently being re-estimated.

4.6.1 PA reference points

The PA reference points for the stock were last estimated by WKNSSHREF in 2018. The group concluded that B_{lim} should be kept at 2.5 million tonnes but B_{pa} was estimated at 3.184 million tonnes and F_{pa}=0.182. F_{pa} is presently being revisited in WKNSSHMSE.

4.6.2 MSY reference points

The MSY reference points were evaluated by WKNSSHREF in 2018. In the ICES MSY framework Bpa is proposed/adopted as the default trigger biomass $B_{trigger}$ and was estimated at 3.184 million tonnes. F_{MSY} is currently being revisited by WKNSSHMSE.

4.6.3 Management reference points

In the current management plan the Coastal States have agreed a target reference point defined at F_{target}=0.125 when the stock is above B_{pa}. If the SSB is below $B_{pa,}$ a linear reduction in the fishing mortality rate will be applied from 0.125 at B_{pa} to 0.05 at B_{lim}.

There is ongoing work (WKNSSHMSE) to answer a request from the Coastal States on updated Management Strategy.

4.7 State of the stock

The SSB on 1 January 2018 is estimated by XSAM to be 3.826 million tonnes which is above B_{pa} (3.184 million t). The stock is declining and the SSB time-series from the 2018 assessment is in line with the SSB time-series from the 2017 assessment. In the last 15 years, five large year classes have been produced (1998, 1999, 2002, 2003, and 2004). The 2005 to 2015 year classes are estimated to be average or small, however, the 2016 year class is estimated to be well above average (from 1988). Fishing mortality in 2017 is estimated to be 0.174 which is above the management plan F that was used to give advice for 2017. A new management plan is being developed for the 2019 advisory year.

4.8 NSSH Catch predictions for 2018

4.8.1 Input data for the forecast

Forecasting was conducted using XSAM according to the method described in the Stock Annex and by Aanes (2016c). WGWIDE 2016 decided to use the point estimates from this forecast as basis for the advice. In short the forecast is made by applying the point estimates of the stock status as input to set TAC, then based on the TAC a stochastic forecast were performed to determine levels of precision in the forecast. Table 4.8.1.1 list the point estimates of the starting values for the forecast. The input stock numbers-at-age 2 and older were taken from the final assessment. The catch weight-at-age, used in the forecast, is the average of the observed catch weights over the last 3 years (2015—2017).

For the weight-at-age in the stock, the values for 2018 were obtained from the commercial fisheries in the wintering areas in January. For the years 2019 and 2020 the average of the last 3 years (2016 —2018) was used.

Standard values for natural mortality were used. Maturity-at-age was based on the information presented in Section 4.4.5.

The exploitation pattern used in the forecast is taken from the predictions made by the model (see Aanes 2016c for details). The resultant mean annual exploitation pattern is shown in Figure 4.8.1.1 and displays a shift towards older fish in the recent years and further in the prediction. Prediction of recruitment at age 2 is obtained by the model with a mean that in practice represents the long term (1988-2018) estimated mean recruitment (back-transformed mean at log scale) and variance the corresponding recruitment variability over the period. Forecasted values of recruits are highly imprecise but have little influence on the short-term forecast of SSB as the herring starts to mature at age 4.

The average fishing mortality defined as the average over the ages 5 to 12 is weighted over the population numbers in the relevant year

$$\bar{F}_y = \sum_{a=5}^{12} N_{a,y} F_{a,y} \Big/ \sum_{a=5}^{12} N_{a,y}$$

where $F_{a,y}$ and $N_{a,y}$ are fishing mortalities and numbers by age and year. This procedure is in accordance with previous years for this stock but the age range is shifted from 5-11 to 5-12.

There was no agreement of a TAC for 2018. To obtain an estimate of the total catch to be used as input for the catch-constraint projections for 2019, the sum of the unilateral

quotas was used. In total, the expected outtake from the stock in 2018 amounts to 546 448 tonnes. F in 2018 is estimated by XSAM based on this catch.

4.8.2 Results of the forecast

The Management Options Table with the results of the forecast is presented in Table 4.8.2.1. Assuming a total catch of 546 448 tonnes is taken in 2018, it is expected that the SSB will increase from 3.826 million tonnes (95% confidence interval 3.065 to 4.587 million tonnes) on 1 January in 2018 to 3.859 million tonnes in 2019 (95% confidence interval 3.069 to 4.866 million tonnes). The 95% confidence interval for weighted F over ages 5-11 in 2018 ranges from 0.03 to 0.275 with a mean of 0.117, while the corresponding values for ages 5-12 are 0.035, 0.280 and 0.125, respectively.

4.9 Comparison with previous assessment

A comparison between the assessments 2008—2017 is shown in Figure 4.9.1. In the years 2008—2015 the assessments were made with TASACS, whereas since 2016 XSAM has been applied, as accepted by WKPELA 2016. With the change of the assessment tool in 2016 the age of the recruitment changed from 0 to 2 and the age span in the reference F changed from 5—14 to 5—11. In WKNSSHREF (2018) this was further changed to 5-12.

The table below shows the SSB (thousand tonnes) on 1 January in 2017 and weighted F in 2016 as estimated in 2017 and 2018.

	ICES 2017	WG 2018	%DIFFERENCE
SSB(2017)	4 131	4 235	2.5%
Weighted F (2016)*	0.084	0.092	

*F in the 2017 assessment was based on the age span 5-11 and therefore not directly comparable to the F in the 2018 assessment which was based on the age span 5-12.

4.10 Management plans and evaluations

The long-term management plan of Norwegian spring spawning herring aims for exploitation at a target fishing mortality below F_{pa} and is considered by ICES in accordance with the precautionary approach (WKBWNSSH, ICES, 2013d). The management plan in use contains the following elements:

Every effort shall be made to maintain a level of Spawning-stock biomass (SSB) greater than the critical level (B_{lim}) of 2 500 000 t.

For 2012 and subsequent years, the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of less than 0.125 for appropriate age groups as defined by ICES, unless future scientific advice requires modification of this fishing mortality rate.

Should the SSB fall below a reference point of 5 000 000 t (B_{pa}), the fishing mortality rate, referred under Paragraph 2, shall be adapted in the light of scientific estimates of the conditions then prevailing to ensure a safe and rapid recovery of the SSB to a level in excess of 5 000 000 t. The basis for such adaptation should be at least a linear reduction in the fishing mortality rate from 0.125 at B_{pa} (5 000 000 t) to 0.05 at B_{lim} (2 500 000 t).

The Parties shall, as appropriate, review and revise these management measures and strategies on the basis of any new advice provided by ICES.

A brief history of it is in the stock annex. In general, the stock has been managed in compliance with the management plan.

There is ongoing work to answer a request from the Coastal States on updated Management Strategy, which will be based on the new MSY reference points.

4.11 Management considerations

Perception of the stock has not changed since last year's assessment (estimated SSB in 2017 is 2.5% higher in this year's assessment). Results of exploratory runs by other models match with those of XSAM.

Historically, the size of the stock has shown large variations and dependency on the irregular occurrence of very strong year classes. Between 1998 and 2004 the stock produced several strong year classes which lead to an increase in SSB until 2009. Since then, SSB has declined due to absence of strong year classes after 2004, but the 2016 year class is estimated to be above average (since 1988).

Since 1999 catches have been regulated through an agreed management plan, which is considered to be precautionary. However, since 2013, a lack of agreement by the Coastal States on their share in the TAC has led to unilaterally set quotas which together are higher than the TAC indicated by the management plan resulting in steeper reduction in the SSB than otherwise.

At present work on management strategy evaluation is ongoing and a new management strategy is expected to be in place for the advisory year 2019.

4.12 Ecosystem considerations

NSS herring juveniles and adults are an important part of the ecosystems in the Barents Sea, along the Norwegian coast, in the Norwegian Sea and in adjoining waters. This refers both to predation on zooplankton by herring and herring being a food resource to higher trophic levels (e.g. cod, saithe, seabirds, and marine mammals). The predation intensity of and on herring have seasonal, spatial and temporal variation as a consequence of variation in migration pattern, prey density, stock size, size of year classes and stock sizes of competing stocks for resources and predators. Recent features of some of these ecosystem factors of relevance for the stock are summarized below.

- The stock's more westerly feeding distribution in recent years (ICES 2017a; 2017b) might be due to better feeding opportunities there or a response to feeding competition with mackerel but the consequence is a less spatial overlap of herring and mackerel in Norwegian Sea and adjoining waters since around 2014 (Nøttestad *et al*., 2014; ICES, 2015b; 2016b; 2017b).
- Where herring and mackerel overlap spatially they compete for food to some extent (Bachiller *et al*., 2015; Debes *et al*., 2012; Langøy *et al*., 2012; Óskarsson *et al*., 2015) but studies showing mackerel being more effective feeder might indicate that the herring is forced to the western and northern fringe of Norwegian Sea, although higher zooplankton biomass there could also attract the herring (Nøttestad *et al*., 2014; ICES, 2015b; 2016b).
- Results of stomach analyses of mackerel on the Norwegian coastal shelf (between about 66°N and 69°N) suggest that mackerel fed opportunistically on herring larvae, and that predation pressure therefore largely depends on the degree of overlap in time and space (Skaret *et al*., 2015).

- The 2013 year class of herring is the strongest since the 2004 year class. In the May survey it was found both in the north eastern and in the central part of the Norwegian Sea.
- Herring growth (i.e. length-at-age) varied over the period 1994-2015 and was negatively related to stock size (Homrum *et al*., 2016), which indicates interaction between fish density and prey availability.
- Following a maximum in zooplankton biomass during the early 2000s the biomass declined with a minimum in 2006. From 2010, the trend turned to an increase and reached the long-term mean in 2014. Zooplankton biomass dropped again in 2015, but has been increasing since then. Interestingly, all the areas, excluding east of Iceland and on few occasions Jan Mayen AF (Figure 6.2), show parallel changes in zooplankton biomass.
- The Subpolar gyre, which has been in a weak state since mid 1990's, has been strengthening during the last three years. If this trend continues, we should expect increased levels of silicate entering the Norwegian Sea over the coming years and consequently a reversal in the declining trend of silicate observed in the Norwegian Sea since 1990. Increasing silicate concentrations are expected to affect growth of silicate demanding phytoplankton, which again will affect zooplankton grazing (ICES, 2018a, and references therein).
- The temperatures of the inflowing Atlantic water were in 2017 above the long-term means (1981-2010) for the whole region. The salinity in the Atlantic Water was below the long-term means in the south and close to or higher than the normal in the north. The heat content increased in the North and Norwegian Seas and it was record-high in the Norwegian Sea. In the Barents Sea the ice cover during 2017 was below the long-term mean during the whole year (ICES, 2018b).

4.13 Changes in fishing patterns

The fishery for Norwegian spring spawning herring has generally been described as progressing clockwise in the Nordic Seas as the year progresses. In the recent years (after ~2013) this pattern has changed, because there has been an extended fishery in the south and southwestern areas in the Norwegian Sea in the 3rd and 4th quarters (8% and 69% respectively in 2017), and thus almost ¾'s of the herring catch was taken in the last quarter of 2017. The majority of the catches in the 4th quarter are now taken in the central parts of the Norwegian Sea, whereas in the preceding years there was a more significant fishery in northeastern areas (outside northern Norway and southwest of the Bear Island). This change in migration resulted in late arrival at the Norwegian coast for this part of the stock during the winter 2017/2018. The Norwegian coastal fleet (smaller vessel that cannot go that far offshore) could therefore not access this herring during the winter fishery and targeted younger fish (mostly of the 2013 and 2014 year classes) which overwintered in Norwegian fjords.

4.14 Recommendation

In the IESNS survey other herring stocks (e.g. Icelandic summer spawning herring and North Sea herring) are found in the boundary regions of the survey area. WGWIDE recommends that WGIPS initiates work to distinguish between herring stocks on the individual level as well as to provide abundance indices by stock.

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4.16 Tables

Table 4.4.1.1 Total landings (ICES estimate) of Norwegian spring-spawning herring (tons) since 1972. Data provided by Working Group members.

Year	Norway	USSR/ Russia	Denmark	Faroes	Iceland	Ireland	Netherlands	Greenland	UK	Germany	France	Poland	Sweden	Total
1972	13161	-	-	-	-	-	-	-	-	-	-	-	-	13161
1973	7017	-	-	-	-	-	-	-	-	-	-	-	-	7017
1974	7619	-	-	-	-	-	-	-	-	-	-	-	-	7619
1975	13713	-	-	-	-	-	-	-	-	-	-	-	-	13713
1976	10436	-	-	-	-	-	-	-	-	-	-	-	-	10436
1977	22706	-	-	-	-	-	-	-	-	-	-	-	-	22706
1978	19824	-	-	-	-	-	-	-	-	-	-	-	-	19824
1979	12864	-	-	-	-	-	-	-	-	-	-	-	-	12864
1980	18577	-	-	-	-	-	-	-	-	-	-	-	-	18577
1981	13736	-	-	-	-	-	-	-	-	-	-	-	-	13736
1982	16655	-	-	-	-	-	-	-	-	-	-	-	-	16655
1983	23054	-	-	-	-	-	-	-	-	-	-	-	-	23054
1984	53532	-	-	-	-	-	-	-	-	-	-	-	-	53532
1985	167272	2600	-	-	-	-	-	-	-	-	-	-	-	169872
1986	199256	26000	-	-	-	-	-	-	-	-	-	-	-	225256
1987	108417	18889	-	-	-	-	-	-	-	-	-	-	-	127306
1988	115076	20225	-	-	-	-	-	-	-	-	-	-	-	135301
1989	88707	15123	-	-	-	-	-	-	-	-	-	-	-	103830
1990	74604	11807	-	-	-	-	-	-	-	-	-	-	-	86411
1991	73683	11000	-	-	-	-	-	-	-	-	-	-	-	84683
1992	91111	13337	-	-	-	-	-	-	-	-	-	-	-	104448
1993	199771	32645	-	-	-	-	-	-	-	-	-	-	-	232457
1994	380771	74400	-	2911	21146	-	-	-	-	-	-	-	-	479228
1995	529838	101987	30577	57084	174109	-	7969	2500	881	556	-	-	-	905501
1996	699161	119290	60681	52788	164957	19541	19664	-	46131	11978	-	-	22424	1220283
1997	860963	168900	44292	59987	220154	11179	8694	-	25149	6190	1500	-	19499	1426507

Year	Norway	USSR/ Russia	Denmark	Faroes	Iceland	Ireland	Netherlands	Greenland	UK	Germany	France	Poland	Sweden	Total
1998	743925	124049	35519	68136	197789	2437	12827	-	15971	7003	605	-	14863	1223131
1999	740640	157328	37010	55527	203381	2412	5871	-	19207	-	-	-	14057	1235433
2000	713500	163261	34968	68625	186035	8939	-	-	14096	3298	-	-	14749	1207201
2001	495036	109054	24038	34170	77693	6070	6439	-	12230	1588	-	-	9818	766136
2002	487233	113763	18998	32302	127197	1699	9392	-	3482	3017	-	1226	9486	807795
2003*	477573	122846	14144	27943	117910	1400	8678	-	9214	3371	-	-	6431	789510
2004	477076	115876	23111	42771	102787	11	17369	-	1869	4810	400	-	7986	794066
2005	580804	132099	28368	65071	156467	-	21517	-	-	17676	0	561	680	1003243
2006*	567237	120836	18449	63137	157474	4693	11625	-	12523	9958	80	-	2946	968958
2007	779089	162434	22911	64251	173621	6411	29764	4897	13244	6038	0	4333	0	1266993
2008	961603	193119	31128	74261	217602	7903	28155	3810	19737	8338	0	0	0	1545656
2009	1016675	210105	32320	85098	265479	10014	24021	3730	25477	14452	0	0	0	1687371
2010	871113	199472	26792	80281	205864	8061	26695	3453	24151	11133	0	0	0	1457015
2011	572641	144428	26740	53271	151074	5727	8348	3426	14045	13296	0	0	0	992997
2012	491005	118595	21754	36190	120956	4813	6237	1490	12310	11945	0	0	705	826000
2013	359458	78521	17160	105038	90729	3815	5626	11788	8342	4244	0	0	23	684743
2014	263253	60292	12513	38529	58828	706	9175	13108	4233	669	0	0	0	461306
2015	176321	45853	9105	33031	42625	1400	5255	12434	55	2660	0	0	0	328740
2016	197501	50455	10384	44727	50418	2048	3519	17508	4031	2582	0	0	0	383174
2017	389383	91118	19037	98170	90400	3495	6679	12569	4358	5201	0	1	1155	721566

***In 2003 the Norwegian catches were raised of 39433 to account for changes in percentages of water content.**

Table 4.4.1.2 Norwegian spring-spawning herring. Sampling coverage by year.

Year	Total catch	% catch covered by sampling programme	No. samples	No. Measured	No. Aged
2000	1207201	86	389	55956	10901
2001	766136	86	442	70005	11234
2002	807795	88	184	39332	5405
2003	789510	71	380	34711	11352
2004	794066	79	503	48784	13169
2005	1003243	86	459	49273	14112
2006	968958	93	631	94574	9862
2007	1266993	94	476	56383	14661
2008	1545656	94	722	81609	31438
2009	1686928	94	663	65536	12265
2010	1457015	91	1258	124071	12377
2011	992.997	95	766	79360	10744
2012	825.999	93	649	59327	14768
2013	684.743	91	402	33169	11431
2014	461.306	89	229	18370	5813
2015	328.739	92	177	25156	5039
2016	383.174	91	203	39120	5892
2017	721566	95	335	31755	7241

Table 4.4.1.3 Norwegian spring-spawning herring. Sampling coverage by country in 2017.

Country	Official catch	% catch covered by sampling programme	No. samples	No. measured	No. aged
Denmark	19037.4	74	5	704	140
Faroe Islands	98170.3	94	13	806	666
Germany	5201.1	99	5	321	321
Greenland	12569	0	0	0	0
Iceland	90400	100	90	2164	2008
Ireland	3494.7	100	2	91	76
Norway	389383.5	99	94	2222	2222
Poland	0.7	0	0	0	0
The Netherlands	6678.8	94	29	1854	725
UK_Scotland	4358	0	0	0	0
Sweden	1155	0	0	0	0
Russia	91118	99	97	23595	1083
Total for Stock	721566	95	335	31755	7241

Table 4.4.1.4 Norwegian spring-spawning herring. Sampling coverage by ICES Division in 2017.

Area	Official Catch	No Samples	No Aged	No Measured	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
2.a	660042.9	278	5990	30414	9	46
4.a	426.17	0	0	0	0	0
5.a	44722	57	1251	1341	28	30
5.b	6353.9	0	0	0	0	0
14.a	10021.2	0	0	0	0	0
Total	721566	335	7241	31755	10	44

Table 4.4.1.5 Norwegian spring-spawning herring. Catch data provided by working group members and samples allocated to unsampled catches in SALLOC

Country	Div.	Q.	Catch (t)	Samples allocated ('fill in')
DE	2a	1	2.2	NO_2a_q1,DK_2a_q1
DE	2a	3	64.5	IS_2a_q3,NL_2a_q3,RU_2a_q3
DE	2a	4	5134.4	
DK	2a	1	14020.6	
DK	2a	4	5016.8	NO_2a_q4,FO_2a_q4,IS_2a_q4,NL_2a_q4,RU_2a_q4,DE_2a_q4
FO	2a	2	54.0	
FO	2a	3	7029.8	
FO	2a	4	84732.6	
FO	5b	2	125.2	FO_2a_q2
FO	5b	3	71.7	FO_2a_q3
FO	5b	4	6157.0	FO_2a_q4
GL	14a	2	1078.0	RU_2a_q2
GL	14a	3	8943.2	IS_2a_q3,NL_2a_q3,RU_2a_q3,IS_5a_q3
GL	2a	3	618.7	IS_2a_q3,NL_2a_q3,RU_2a_q3
GL	2a	4	1929.1	NO_2a_q4,FO_2a_q4,IS_2a_q4,NL_2a_q4,RU_2a_q4,DE_2a_q4
IR	2a	1	2315.8	
IR	2a	4	1178.9	
IS	2a	3	3358.0	
IS	2a	4	42320.0	
IS	5a	3	25446.0	
IS	5a	4	19276.0	
NL	2a	3	616.4	
NL	2a	4	5721.3	
NL	4a	4	341.2	NO_2a_q4,FO_2a_q4,IS_2a_q4,NL_2a_q4,RU_2a_q4,DE_2a_q4
NO	2a	1	144054.6	
NO	2a	2	2156.7	NO_2a_q1
NO	2a	3	773.2	IS_2a_q3,NL_2a_q3,RU_2a_q3
NO	2a	4	242313.9	
NO	3a	2	0.1	NO_2a_q1
NO	4a	1	56.7	NO_2a_q1
NO	4a	2	0.0	NO_2a_q1
NO	4a	3	28.3	NO_2a_q4
PL	2a	1	0.7	NO_2a_q1,DK_2a_q1
RU	2a	1	957.0	NO_2a_q1,DK_2a_q1
RU	2a	2	129.0	
RU	2a	3	9945.0	
RU	2a	4	80087.0	
SE	2a	1	405.0	NO_2a_q1,DK_2a_q1
SE	2a	4	750.0	NO_2a_q4,FO_2a_q4,IS_2a_q4,NL_2a_q4,RU_2a_q4,DE_2a_q4

Country	Div.	Q.	Catch (t)	Samples allocated ('fill in')
UKS	2a	1	4356.2	NO_2a_q1,DK_2a_q1
UKS	2a	4	1.7	NO_2a_q4,FO_2a_q4,IS_2a_q4,NL_2a_q4,RU_2a_q4,DE_2a_q4

Table 4.4.3.1. Norwegian spring spawning herring. Catch in numbers (thousands).

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	5112600	2000000	600000	276200	184800	185500	547000	628600	79500	88600	109500	86900	194500	368300	66400	344300
1951	1635500	7607700	400000	6600	383800	172400	164400	515600	602000	77100	82700	103100	107600	253500	348000	352500
1952	13721600	9149700	1232900	39300	60500	602300	136300	204500	380200	377900	79200	85700	107700	106800	186500	564400
1953	5697200	5055000	581300	740100	46600	100900	355600	81900	110900	314100	394900	61700	91200	94100	98800	730400
1954	10675990	7071090	855400	266300	1435500	142900	236000	490300	128100	199800	440400	460700	88400	100600	133000	803200
1955	5175600	2871100	510100	93000	276400	2045100	114300	189600	274700	85300	193400	295600	203200	58700	84600	580600
1956	5363900	2023700	627100	116500	251600	314200	2555100	110000	203900	264200	130700	198300	272800	163300	63000	565100
1957	5001900	3290800	219500	23300	373300	153800	228500	1985300	72000	127300	182500	88400	121200	149300	131600	281400
1958	9666990	2798100	666400	17500	17900	110900	89300	194400	973500	70700	123000	200900	98700	77400	70900	255600
1959	17896280	198530	325500	15100	26800	25900	146600	114800	240700	1103800	88600	124300	198000	88500	77400	235900
1960	12884310	13580790	392500	121700	18200	28100	24400	96200	73300	203900	1163000	85200	129700	153500	56700	168900
1961	6207500	16075600	2884800	31200	8100	4100	15000	19400	61600	49200	136100	728100	49700	45000	63000	60100
1962	3693200	4081100	1041300	1843800	8000	3100	7200	20200	11900	59100	52600	117000	813500	44200	54700	152300
1963	4807000	2119200	2045300	760400	835800	5300	1800	3600	18300	9300	107700	92500	174100	923700	79600	185300
1964	3613000	2728300	220300	114600	399000	2045800	13700	1500	3000	24900	29300	95600	82400	153000	772800	336800
1965	2303000	3780900	2853600	89900	256200	571100	2199700	19500	14900	7400	19100	40000	100500	107800	138700	883100
1966	3926500	662800	1678000	2048700	26900	466600	1306000	2884500	37900	14300	17400	26200	11000	69100	72100	556700
1967	426800	9877100	70400	1392300	3254000	26600	421300	1132000	1720800	8900	5700	3500	8500	8900	17500	104400
1968	1783600	437000	388300	99100	1880500	1387400	14220	94000	134100	345100	2000	1100	830	2500	2600	17000
1969	561200	507100	141900	188200	800	8800	4700	700	11700	33600	36000	300	200	200	200	2400
1970	119300	529400	33200	6300	18600	600	3300	3300	1000	13400	26200	28100	300	100	200	2000
1971	30500	42900	85100	1820	1020	1240	360	1110	1130	360	4410	6910	5450	0	20	120
1972	347100	41000	20400	35376	3476	3583	2481	694	1486	198	0	494	593	593	0	0
1973	29300	3500	1700	2389	25200	651	1506	278	178	0	0	0	0	0	180	0
1974	65900	7800	3900	100	241	24505	257	196	0	0	0	0	0	0	0	0

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1975	30600	3600	1800	3268	132	910	30667	5	2	0	0	0	0	0	0	0
1976	.20100	2400	1200	23248	5436	0	0	13086	0	0	0	0	0	0	0	0
1977	43000	6200	3100	22103	23595	336	0	419	10766	0	0	0	0	0	0	0
1978	20100	2400	1200	3019	12164	20315	870	0	620	5027	0	0	0	0	0	0
1979	32600	3800	1900	6352	1866	6865	11216	326	0	0	2534	0	0	0	0	0
1980	6900	800	400	6407	5814	2278	8165	15838	441	8	0	2688	0	0	0	0
1981	8300	1100	11900	4166	4591	8596	2200	4512	8280	345	103	114	964	0	0	0
1982	22600	1100	200	13817	7892	4507	6258	1960	5075	6047	121	37	37	121	0	0
1983	127000	4680	1670	3183	21191	9521	6181	6823	1293	4598	7329	143	40	143	860	0
1984	33860	1700	2490	4483	5388	61543	18202	12638	15608	7215	16338	6478	0	0	0	1650
1985	28570	13150	207220	21500	15500	16500	130000	59000	55000	63000	10000	31000	50000	0	0	2640
1986	13810	1380	3090	539785	17594	14500	15500	105000	75000	42000	77000	19469	66000	80000	0	2470
1987	13850	6330	35770	19776	501393	18672	3502	7058	28000	12000	9500	4500	7834	6500	7000	450
1988	15490	2790	9110	62923	25059	550367	9452	3679	5964	14583	8872	2818	3356	2682	1560	540
1989	7120	1930	25200	2890	3623	5650	324290	3469	800	679	3297	1375	679	321	260	0
1990	1020	400	15540	18633	2658	11875	10854	226280	1289	1519	2036	2415	646	179	590	480
1991	100	3370	3330	8438	2780	1410	14698	8867	218851	2499	461	87	690	103	260	540
1992	1630	150	1340	12586	33100	4980	1193	11981	5748	225677	2483	639	247	1236	0	0
1993	6570	130	7240	28408	106866	87269	8625	3648	29603	18631	410110	0	0	0	0	0
1994	430	20	8100	32500	110090	363920	164800	15580	8140	37330	35660	645410	2830	460	100	2070
1995	0	0	1130	57590	346460	622810	637840	231090	15510	15850	69750	83740	911880	4070	250	450
1996	0	0	30140	34360	713620	1571000	940580	406280	103410	5680	7370	66090	17570	836550	0	0
1997	0	0	21820	130450	270950	1795780	1993620	761210	326490	60870	20020	32400	90520	19120	370330	300
1998	0	0	82891	70323	242365	368310	1760319	1263750	381482	129971	42502	25343	3478	112604	5633	108514
1999	0	0	5029	137626	35820	134813	429433	1604959	1164263	291394	106005	14524	40040	7202	88598	63983
2000	0	0	14395	84016	560379	34933	110719	404460	1299253	1045001	216980	71589	16260	22701	23321	71811
2001	0	0	2076	102293	160678	426822	38749	95991	296460	839136	507106	73673	23722	3505	3356	22164
2002	0	0	62031	198360	643161	255516	326495	29843	93530	264675	663059	339326	52922	12437	7000	10087

	AGE															
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
2003	0	3461	4524	75243	323958	730468	175878	167776	22866	74494	217108	567253	219097	38555	8111	6192
2004	125	1846	43800	24299	92300	429510	714433	111022	137940	26656	52467	169196	401564	210547	28028	11883
2005	0	442	20411	447788	94206	170547	643600	930309	121856	123291	37967	65289	139331	344822	126879	15697
2006	0	1968	45438	75824	729898	82107	171370	726041	772217	88701	77115	30339	57882	133665	142240	49128
2007	0	4475	8450	224636	366983	1804495	152916	242923	728836	511664	47215	25384	15316	24488	64755	58465
2008	0	39898	123949	36630	550274	670681	2295912	199592	256132	586583	369620	29633	36025	23775	25195	63176
2009	0	3468	113424	192641	149075	1193781	914748	1929631	142931	262037	423972	238174	45519	9337	10153	70538
2010	0	75981	61673	101948	209295	189784	1064866	711951	1421939	175010	180164	340781	179039	12558	11602	49773
2011	0	126972	249809	61706	104634	234330	210165	755382	543212	642787	90515	117230	136509	45082	6628	11638
2012	0	2680	13083	211630	49999	119627	281908	263330	747839	314694	357902	53109	44982	64273	12420	3604
2013	0	1	20715	60364	276901	71287	112558	283658	242243	591912	169525	145318	24936	10614	9725	2299
2014	0	265	1441	28301	57838	257529	50424	71721	194814	147083	381317	83050	57315	12746	1809	7501
2015	0	647	3244	16139	55749	52369	152347	34046	65728	156075	103393	201141	24310	49373	3369	6397
2016	0	197	2351	45483	43416	112147	85937	164454	52267	73576	174655	96476	179051	38546	32880	8379
2017	0	618	16390	64275	305483	114976	248192	162566	289931	98836	133145	276874	107473	220368	22357	49442

Table 4.4.4.1. Norwegian spring spawning herring. Weight at age in the catch (kg).

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	0.007	0.025	0.058	0.110	0.188	0.211	0.234	0.253	0.266	0.280	0.294	0.303	0.312	0.32	0.323	0.334
1951	0.009	0.029	0.068	0.130	0.222	0.249	0.276	0.298	0.314	0.330	0.346	0.357	0.368	0.377	0.381	0.394
1952	0.008	0.026	0.061	0.115	0.197	0.221	0.245	0.265	0.279	0.293	0.308	0.317	0.327	0.335	0.339	0.349
1953	0.008	0.027	0.063	0.120	0.205	0.230	0.255	0.275	0.290	0.305	0.320	0.330	0.34	0.347	0.351	0.363
1954	0.008	0.026	0.062	0.117	0.201	0.225	0.250	0.269	0.284	0.299	0.313	0.323	0.333	0.341	0.345	0.356
1955	0.008	0.027	0.063	0.119	0.204	0.229	0.254	0.274	0.289	0.304	0.318	0.328	0.338	0.346	0.350	0.362
1956	0.008	0.028	0.066	0.126	0.215	0.241	0.268	0.289	0.304	0.320	0.336	0.346	0.357	0.365	0.369	0.382
1957	0.008	0.028	0.066	0.127	0.216	0.243	0.269	0.290	0.306	0.322	0.338	0.348	0.359	0.367	0.371	0.384
1958	0.009	0.030	0.070	0.133	0.227	0.255	0.283	0.305	0.321	0.338	0.355	0.366	0.377	0.386	0.390	0.403
1959	0.009	0.030	0.071	0.135	0.231	0.259	0.287	0.310	0.327	0.344	0.360	0.372	0.383	0.392	0.397	0.409
1960	0.006	0.011	0.074	0.119	0.188	0.277	0.337	0.318	0.363	0.379	0.360	0.420	0.411	0.439	0.450	0.447
1961	0.006	0.010	0.045	0.087	0.159	0.276	0.322	0.372	0.363	0.393	0.407	0.397	0.422	0.447	0.465	0.452
1962	0.009	0.023	0.055	0.085	0.148	0.288	0.333	0.360	0.352	0.350	0.374	0.384	0.374	0.394	0.399	0.414
1963	0.008	0.026	0.047	0.098	0.171	0.275	0.268	0.323	0.329	0.336	0.341	0.358	0.385	0.353	0.381	0.386
1964	0.009	0.024	0.059	0.139	0.219	0.239	0.298	0.295	0.339	0.350	0.358	0.351	0.367	0.375	0.372	0.433
1965	0.009	0.016	0.048	0.089	0.217	0.234	0.262	0.331	0.360	0.367	0.386	0.395	0.393	0.404	0.401	0.431
1966	0.008	0.017	0.040	0.063	0.246	0.260	0.265	0.301	0.410	0.425	0.456	0.460	0.467	0.446	0.459	0.472
1967	0.009	0.015	0.036	0.066	0.093	0.305	0.305	0.310	0.333	0.359	0.413	0.446	0.401	0.408	0.439	0.430
1968	0.010	0.027	0.049	0.075	0.108	0.158	0.375	0.383	0.364	0.382	0.441	0.410		0.517	0.491	0.485
1969	0.009	0.021	0.047	0.072		0.152	0.296		0.329	0.329	0.341					0.429
1970	0.008	0.058	0.085	0.105	0.171		0.216	0.277	0.298	0.304	0.305	0.309				0.376
1971	0.011	0.053	0.121	0.177	0.216	0.250		0.305	0.333		0.366	0.377	0.388			
1972	0.011	0.029	0.062	0.103	0.154	0.215	0.258		0.322							
1973	0.006	0.053	0.106	0.161	0.213		0.255									
1974	0.006	0.055	0.117			0.249										
1975	0.009	0.079	0.169	0.241			0.381									

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1976	0.007	0.062	0.132	0.189	0.250			0.323								
1977	0.011	0.091	0.193	0.316	0.350				0.511							
1978	0.012	0.100	0.210	0.274	0.424	0.454				0.613						
1979	0.010	0.088	0.181	0.293	0.359	0.416	0.436				0.553					
1980	0.012			0.266	0.399	0.449	0.460	0.485				0.608				
1981	0.010	0.082	0.163	0.196	0.291	0.341	0.368	0.380	0.397							
1982	0.010	0.087	0.159	0.256	0.312	0.378	0.415	0.435	0.449	0.448						
1983	0.011	0.090	0.165	0.217	0.265	0.337	0.378	0.410	0.426	0.435	0.444					
1984	0.009	0.047	0.145	0.218	0.262	0.325	0.346	0.381	0.400	0.413	0.405	0.426				0.415
1985	0.009	0.022	0.022	0.214	0.277	0.295	0.338	0.360	0.381	0.397	0.409	0.417	0.435			0.435
1986	0.007	0.077	0.097	0.055	0.249	0.294	0.312	0.352	0.374	0.398	0.402	0.401	0.410	0.410		0.410
1987	0.010	0.075	0.091	0.124	0.173	0.253	0.232	0.312	0.328	0.349	0.353	0.370	0.385	0.385	0.385	
1988	0.008	0.062	0.075	0.124	0.154	0.194	0.241	0.265	0.304	0.305	0.317	0.308	0.334	0.334	0.334	
1989	0.010	0.060	0.204	0.188	0.264	0.260	0.282	0.306			0.422	0.364				
1990	0.007		0.102	0.230	0.239	0.266	0.305	0.308	0.376	0.407	0.412	0.424				
1991		0.015	0.104	0.208	0.250	0.288	0.312	0.316	0.330	0.344						
1992	0.007		0.103	0.191	0.233	0.304	0.337	0.365	0.361	0.371	0.403			0.404		
1993	0.007		0.106	0.153	0.243	0.282	0.320	0.330	0.365	0.373	0.379					
1994			0.102	0.194	0.239	0.280	0.317	0.328	0.356	0.372	0.390	0.379	0.399	0.403		
1995			0.102	0.153	0.192	0.234	0.283	0.328	0.349	0.356	0.374	0.366	0.393	0.387		
1996			0.136	0.136	0.168	0.206	0.262	0.309	0.337	0.366	0.360	0.361	0.367	0.379		
1997			0.089	0.167	0.184	0.207	0.232	0.277	0.305	0.331	0.328	0.344	0.343	0.397	0.357	
1998			0.111	0.150	0.216	0.221	0.249	0.277	0.316	0.338	0.374	0.372	0.366	0.396	0.377	0.406
1999			0.096	0.173	0.228	0.262	0.274	0.292	0.307	0.335	0.362	0.371	0.399	0.396	0.400	0.404
2000			0.124	0.175	0.222	0.242	0.289	0.303	0.310	0.328	0.349	0.383	0.411	0.410	0.419	0.409
2001			0.105	0.166	0.214	0.252	0.268	0.305	0.308	0.322	0.337	0.363	0.353	0.378	0.400	0.427
2002			0.056	0.128	0.198	0.255	0.281	0.303	0.322	0.323	0.334	0.345	0.369	0.407	0.410	0.435
2003		0.062	0.068	0.169	0.218	0.257	0.288	0.316	0.323	0.348	0.354	0.351	0.363	0.372	0.376	0.429

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2004	0.022	0.066	0.143	0.18	0.227	0.26	0.29	0.323	0.355	0.375	0.383	0.399	0.395	0.405	0.429	0.439
2005		0.092	0.106	0.181	0.235	0.266	0.290	0.315	0.344	0.367	0.384	0.372	0.384	0.398	0.402	0.413
2006		0.055	0.102	0.171	0.238	0.268	0.292	0.311	0.330	0.365	0.374	0.376	0.388	0.396	0.398	0.407
2007	0.000	0.074	0.137	0.162	0.228	0.271	0.316	0.332	0.342	0.358	0.361	0.381	0.390	0.400	0.405	0.399
2008	0.000	0.026	0.106	0.145	0.209	0.254	0.296	0.318	0.341	0.353	0.363	0.367	0.395	0.396	0.386	0.413
2009		0.040	0.156	0.184	0.220	0.251	0.291	0.311	0.338	0.347	0.363	0.375	0.382	0.375	0.375	0.387
2010		0.059	0.107	0.177	0.218	0.261	0.279	0.311	0.325	0.343	0.362	0.370	0.388	0.391	0.376	0.441
2011		0.011	0.098	0.200	0.257	0.273	0.300	0.316	0.340	0.348	0.365	0.371	0.387	0.374	0.403	0.401
2012		0.034	0.126	0.211	0.272	0.301	0.308	0.331	0.335	0.351	0.354	0.370	0.389	0.389	0.382	0.388
2013		0.048	0.163	0.237	0.276	0.300	0.331	0.339	0.351	0.357	0.370	0.373	0.394	0.391	0.389	0.367
2014		0.057	0.179	0.233	0.271	0.293	0.322	0.342	0.353	0.367	0.365	0.374	0.375	0.378	0.418	0.371
2015		0.059	0.146	0.203	0.272	0.323	0.331	0.358	0.370	0.372	0.383	0.382	0.392	0.386	0.383	0.391
2016		0.048	0.111	0.212	0.255	0.290	0.333	0.339	0.361	0.367	0.370	0.381	0.378	0.388	0.383	0.395
2017		0.092	0.143	0.205	0.241	0.292	0.322	0.350	0.360	0.382	0.392	0.391	0.396	0.399	0.407	0.394

Table 4.4.4.2. Norwegian spring spawning herring. Weight at age in the stock (kg).

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1951	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1952	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1953	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1954	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1955	0.001	0.008	0.047	0.100	0.195	0.213	0.260	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1956	0.001	0.008	0.047	0.100	0.205	0.230	0.249	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1957	0.001	0.008	0.047	0.100	0.136	0.228	0.255	0.262	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1958	0.001	0.008	0.047	0.100	0.204	0.242	0.292	0.295	0.293	0.305	0.315	0.330	0.340	0.345	0.352	0.363
1959	0.001	0.008	0.047	0.100	0.204	0.252	0.260	0.290	0.300	0.305	0.315	0.325	0.330	0.340	0.345	0.358
1960	0.001	0.008	0.047	0.100	0.204	0.270	0.291	0.293	0.321	0.318	0.320	0.344	0.349	0.370	0.379	0.378
1961	0.001	0.008	0.047	0.100	0.232	0.250	0.292	0.302	0.304	0.323	0.322	0.321	0.344	0.357	0.363	0.368
1962	0.001	0.008	0.047	0.100	0.219	0.291	0.300	0.316	0.324	0.326	0.335	0.338	0.334	0.347	0.354	0.358
1963	0.001	0.008	0.047	0.100	0.185	0.253	0.294	0.312	0.329	0.327	0.334	0.341	0.349	0.341	0.358	0.375
1964	0.001	0.008	0.047	0.100	0.194	0.213	0.264	0.317	0.363	0.353	0.349	0.354	0.357	0.359	0.365	0.402
1965	0.001	0.008	0.047	0.100	0.186	0.199	0.236	0.260	0.363	0.350	0.370	0.360	0.378	0.387	0.390	0.394
1966	0.001	0.008	0.047	0.100	0.185	0.219	0.222	0.249	0.306	0.354	0.377	0.391	0.379	0.378	0.361	0.383
1967	0.001	0.008	0.047	0.100	0.180	0.228	0.269	0.270	0.294	0.324	0.420	0.430	0.366	0.368	0.433	0.414
1968	0.001	0.008	0.047	0.100	0.115	0.206	0.266	0.275	0.274	0.285	0.350	0.325	0.363	0.408	0.388	0.378
1969	0.001	0.008	0.047	0.100	0.115	0.145	0.270	0.300	0.306	0.308	0.318	0.340	0.368	0.360	0.393	0.397
1970	0.001	0.008	0.047	0.100	0.209	0.272	0.230	0.295	0.317	0.323	0.325	0.329	0.380	0.370	0.380	0.391
1971	0.001	0.015	0.080	0.100	0.190	0.225	0.250	0.275	0.290	0.310	0.325	0.335	0.345	0.355	0.365	0.390
1972	0.001	0.010	0.070	0.150	0.150	0.140	0.210	0.240	0.270	0.300	0.325	0.335	0.345	0.355	0.365	0.390
1973	0.001	0.010	0.085	0.170	0.259	0.342	0.384	0.409	0.404	0.461	0.520	0.534	0.500	0.500	0.500	0.500
1974	0.001	0.010	0.085	0.170	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1975	0.001	0.010	0.085	0.181	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1976	0.001	0.010	0.085	0.181	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1977	0.001	0.010	0.085	0.181	0.259	0.343	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1978	0.001	0.010	0.085	0.180	0.294	0.326	0.371	0.409	0.461	0.476	0.520	0.543	0.500	0.500	0.500	0.500
1979	0.001	0.010	0.085	0.178	0.232	0.359	0.385	0.420	0.444	0.505	0.520	0.551	0.500	0.500	0.500	0.500
1980	0.001	0.010	0.085	0.175	0.283	0.347	0.402	0.421	0.465	0.465	0.520	0.534	0.500	0.500	0.500	0.500
1981	0.001	0.010	0.085	0.170	0.224	0.336	0.378	0.387	0.408	0.397	0.520	0.543	0.512	0.512	0.512	0.512
1982	0.001	0.010	0.085	0.170	0.204	0.303	0.355	0.383	0.395	0.413	0.453	0.468	0.506	0.506	0.506	0.506
1983	0.001	0.010	0.085	0.155	0.249	0.304	0.368	0.404	0.424	0.437	0.436	0.493	0.495	0.495	0.495	0.495
1984	0.001	0.010	0.085	0.140	0.204	0.295	0.338	0.376	0.395	0.407	0.413	0.422	0.437	0.437	0.437	0.437
1985	0.001	0.010	0.085	0.148	0.234	0.265	0.312	0.346	0.370	0.395	0.397	0.428	0.428	0.428	0.428	0.428
1986	0.001	0.010	0.085	0.054	0.206	0.265	0.289	0.339	0.368	0.391	0.382	0.388	0.395	0.395	0.395	0.395
1987	0.001	0.010	0.055	0.090	0.143	0.241	0.279	0.299	0.316	0.342	0.343	0.362	0.376	0.376	0.376	0.376
1988	0.001	0.015	0.050	0.098	0.135	0.197	0.277	0.315	0.339	0.343	0.359	0.365	0.376	0.376	0.376	0.376
1989	0.001	0.015	0.100	0.154	0.175	0.209	0.252	0.305	0.367	0.377	0.359	0.395	0.396	0.396	0.396	0.396
1990	0.001	0.008	0.048	0.219	0.198	0.258	0.288	0.309	0.428	0.370	0.403	0.387	0.440	0.440	0.440	0.44
1991	0.001	0.011	0.037	0.147	0.210	0.244	0.300	0.324	0.336	0.343	0.382	0.366	0.425	0.425	0.425	0.425
1992	0.001	0.007	0.030	0.128	0.224	0.296	0.327	0.355	0.345	0.367	0.341	0.361	0.430	0.470	0.470	0.46
1993	0.001	0.008	0.025	0.081	0.201	0.265	0.323	0.354	0.358	0.381	0.369	0.396	0.393	0.374	0.403	0.4
1994	0.001	0.010	0.025	0.075	0.151	0.254	0.318	0.371	0.347	0.412	0.382	0.407	0.410	0.410	0.410	0.41
1995	0.001	0.018	0.025	0.066	0.138	0.230	0.296	0.346	0.388	0.363	0.409	0.414	0.422	0.410	0.410	0.426
1996	0.001	0.018	0.025	0.076	0.118	0.188	0.261	0.316	0.346	0.374	0.390	0.390	0.384	0.398	0.398	0.398
1997	0.001	0.018	0.025	0.096	0.118	0.174	0.229	0.286	0.323	0.370	0.378	0.386	0.360	0.393	0.391	0.391
1998	0.001	0.018	0.025	0.074	0.147	0.174	0.217	0.242	0.278	0.304	0.310	0.359	0.340	0.344	0.385	0.369
1999	0.001	0.018	0.025	0.102	0.150	0.223	0.240	0.264	0.283	0.315	0.345	0.386	0.386	0.386	0.382	0.395
2000	0.001	0.018	0.025	0.119	0.178	0.225	0.271	0.285	0.298	0.311	0.339	0.390	0.398	0.406	0.414	0.427
2001	0.001	0.018	0.025	0.075	0.178	0.238	0.247	0.296	0.307	0.314	0.328	0.351	0.376	0.406	0.414	0.425
2002	0.001	0.010	0.023	0.057	0.177	0.241	0.275	0.302	0.311	0.314	0.328	0.341	0.372	0.405	0.415	0.438
2003	0.001	0.010	0.055	0.098	0.159	0.211	0.272	0.305	0.292	0.331	0.337	0.347	0.356	0.381	0.414	0.433

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2004	0.001	0.010	0.055	0.106	0.149	0.212	0.241	0.279	0.302	0.337	0.354	0.355	0.360	0.371	0.400	0.429
2005	0.001	0.010	0.046	0.112	0.156	0.234	0.267	0.295	0.330	0.363	0.377	0.414	0.406	0.308	0.420	0.452
2006	0.001	0.010	0.042	0.107	0.179	0.232	0.272	0.297	0.318	0.371	0.365	0.393	0.395	0.399	0.415	0.428
2007	0.001	0.010	0.036	0.086	0.155	0.226	0.265	0.312	0.310	0.364	0.384	0.352	0.386	0.304	0.420	0.412
2008**	0.001	0.010	0.044	0.077	0.146	0.212	0.269	0.289	0.327	0.351	0.358	0.372	0.411	0.353	0.389	0.393
2009***	0.001	0.010	0.044	0.077	0.141	0.215	0.270	0.306	0.336	0.346	0.364	0.369	0.411	0.353	0.389	0.393
2010****	0.001	0.01	0.044	0.077	0.188	0.22	0.251	0.286	0.308	0.333	0.344	0.354	0.373	0.353	0.389	0.393
2011	0.001	0.01	0.044	0.118	0.185	0.209	0.246	0.277	0.310	0.322	0.339	0.349	0.364	0.363	0.389	0.393
2012	0.001	0.01	0.044	0.138	0.185	0.256	0.273	0.290	0.305	0.330	0.342	0.361	0.390	0.377	0.389	0.393
2013	0.001	0.01	0.044	0.138	0.204	0.267	0.305	0.309	0.320	0.328	0.346	0.350	0.390	0.377	0.389	0.393
2014	0.001	0.01	0.044	0.138	0.198	0.274	0.301	0.326	0.333	0.339	0.347	0.344	0.362	0.362	0.389	0.393
2015	0.001	0.01	0.044	0.138	0.187	0.243	0.299	0.326	0.319	0.345	0.346	0.354	0.382	0.376	0.389	0.393
2016	0.001	0.01	0.054	0.115	0.186	0.247	0.293	0.320	0.334	0.353	0.354	0.352	0.361	0.370	0.380	0.388
2017	0.001	0.01	0.054	0.115	0.190	0.247	0.282	0.322	0.338	0.351	0.359	0.361	0.361	0.368	0.380	0.386
2018	0.001	0.01	0.054	0.115	0.149	0.225	0.260	0.289	0.312	0.343	0.359	0.361	0.369	0.368	0.377	0.386

**** mean weight at ages 11 and 13 are mean of 5 previous years at the same age. These age groups were not present in the catches of the wintering survey from which the stock weight are derived.**

***** derived from catch data from the wintering area north of 69°N during December 2008 – January 2009 for age groups 4—11.**

******derived from catch data from the wintering area north of 69°N during January 2010 for age groups 4—12.**

Table 4.4.5.1. Norwegian Spring-spawning herring. Mature at age. The time-series was provided by WKHERMAT in 2010 and are used in the assessment since 2010.

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
1951	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
1952	0	0	0	0	0.1	0.6	1	1	1	1	1	1	1	1	1	1
1953	0	0	0	0	0.3	0.4	0.9	1	1	1	1	1	1	1	1	1
1954	0	0	0	0	0.1	0.7	0.9	1	1	1	1	1	1	1	1	1
1955	0	0	0	0.1	0.4	0.4	1	1	1	1	1	1	1	1	1	1
1956	0	0	0	0	0.5	0.7	0.6	1	1	1	1	1	1	1	1	1
1957	0	0	0	0	0.3	0.8	0.8	0.7	1	1	1	1	1	1	1	1
1958	0	0	0	0	0.3	0.5	0.9	0.9	1	1	1	1	1	1	1	1
1959	0	0	0	0	0.7	0.8	1	0.9	1	1	1	1	1	1	1	1
1960	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
1961	0	0	0	0	0.1	0.8	1	0.9	1	1	1	1	1	1	1	1
1962	0	0	0	0	0.1	0.7	1	1	1	1	1	1	1	1	1	1
1963	0	0	0	0	0.1	0.4	1	1	1	1	1	1	1	1	1	1
1964	0	0	0	0	0.1	0.4	0.8	1	1	1	1	1	1	1	1	1
1965	0	0	0	0	0.5	0.4	0.9	0.8	1	1	1	1	1	1	1	1
1966	0	0	0	0	0.5	0.7	0.9	1	1	1	1	1	1	1	1	1
1967	0	0	0	0	0.3	0.8	1	1	1	1	1	1	1	1	1	1
1968	0	0	0	0	0	0.7	0.9	1	1	1	1	1	1	1	1	1
1969	0	0	0	0.1	0.2	0.3	1	1	1	1	1	1	1	1	1	1
1970	0	0	0	0	0.4	0.3	0.4	1	1	1	1	1	1	1	1	1
1971	0	0	0	0	0.1	0.7	1	1	1	1	1	1	1	1	1	1
1972	0	0	0	0	0.4	0.3	1	1	1	1	1	1	1	1	1	1
1973	0	0	0	0.1	0.6	1	1	1	1	1	1	1	1	1	1	1
1974	0	0	0	0	0.6	0.9	1	1	1	1	1	1	1	1	1	1
1975	0	0	0	0.1	0.5	0.9	1	1	1	1	1	1	1	1	1	1
1976	0	0	0	0.1	0.9	0.9	1	1	1	1	1	1	1	1	1	1
1977	0	0	0	0.3	0.8	1	1	1	1	1	1	1	1	1	1	1
1978	0	0	0	0.2	0.9	1	1	1	1	1	1	1	1	1	1	1
1979	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1	1
1980	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1	1
1981	0	0	0	0.1	1	1	1	1	1	1	1	1	1	1	1	1
1982	0	0	0	0.1	0.8	1	1	1	1	1	1	1	1	1	1	1
1983	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1	1
1984	0	0	0	0.1	0.7	1	1	1	1	1	1	1	1	1	1	1
1985	0	0	0	0.1	0.8	0.9	1	1	1	1	1	1	1	1	1	1
1986	0	0	0	0	0.5	0.9	0.9	1	1	1	1	1	1	1	1	1
1987	0	0	0	0	0.1	0.8	0.9	0.9	1	1	1	1	1	1	1	1
1988	0	0	0	0	0.2	0.7	0.9	1	1	1	1	1	1	1	1	1
1989	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
1990	0	0	0	0.2	0.5	0.9	1	1	1	1	1	1	1	1	1	1
1991	0	0	0	0	0.9	0.9	1	1	1	1	1	1	1	1	1	1
1992	0	0	0	0	0.8	1	1	1	1	1	1	1	1	1	1	1
1993	0	0	0	0	0.5	1	1	1	1	1	1	1	1	1	1	1

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1994	0	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1
1995	0	0	0	0	0	0.6	1	1	1	1	1	1	1	1	1	1
1996	0	0	0	0	0	0.5	0.9	1	1	1	1	1	1	1	1	1
1997	0	0	0	0.1	0	0.4	0.9	1	1	1	1	1	1	1	1	1
1998	0	0	0	0	0.6	0.4	0.9	1	1	1	1	1	1	1	1	1
1999	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
2000	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2001	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
2002	0	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1
2003	0	0	0	0	0.2	0.7	1	1	1	1	1	1	1	1	1	1
2004	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1
2005	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2006	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2007	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2008	0	0	0	0	0.1	0.7	0.9	1	1	1	1	1	1	1	1	1
2009	0	0	0	0	0.1	0.4	0.9	1	1	1	1	1	1	1	1	1
2010	0	0	0	0	0.2	0.4	0.7	1	1	1	1	1	1	1	1	1
2011	0	0	0	0	0.4	0.7	0.8	0.9	1	1	1	1	1	1	1	1
2012	0	0	0	0	0.5	0.9	0.9	1	1	1	1	1	1	1	1	1
2013	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2014	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2015	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2016	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2017	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2018	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1

Table 4.4.7.1. Norwegian Spring-spawning herring. Estimated indices (with StoX) from the acoustic surveys on the spawning grounds in February-March. Numbers in millions. Biomass in thousand tonnes. "Fleet 1"

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
1988	0	375	299	8066	86	33	11	38	22	41	0	0	0	0	8970	1631
1989	164	17	336	89	3995	106	12	8	59	0	4	39	0	8	4835	1175
1990	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
1991	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
1992*	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
1993*	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
1994	43	99	48	851	480	73	15	152	43	1838	3	3	0	0	3651	1215
1995	4	409	4643	3186	1986	292	18	0	141	76	2299	0	0	0	13053	3669
1996	126	147	1885	7923	2384	887	314	0	0	121	0	1830	0	0	15616	3382
1997*	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
1998	41	330	984	3012	13089	8214	1909	588	194	35	0	359	0	1415	30169	7008
1999	119	1572	379	1366	2593	9356	6979	1632	495	124	0	0	360	359	25333	6235
2000	1399	672	2617	103	485	1139	4193	2864	547	48	2	0	15	217	14301	3282
2001**	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2002**	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2003**	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2004**	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2005	39	270	662	2086	5871	8223	660	457	183	113	557	1138	595	6	20859	5223
2006	27	98	6073	478	912	3291	3290	122	67	25	72	54	265	63	14836	3392
2007	32	369	1594	12175	622	646	2842	3258	137	223	34	179	262	554	22925	5238
2008	15	70	2449	2699	9060	530	476	1599	1600	153	104	49	138	152	19094	4581
2009	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2010	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2011	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2012	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2013	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
2014	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2015	230	516	2748	768	3223	377	650	2868	720	7251	336	1733	50	229	21712	6390
2016	17	218	253	539	404	2288	242	569	2792	681	4144	197	982	107	13433	4338
2017	13	95	1078	666	868	411	1376	176	231	1903	295	2600	74	697	10486	3295
2018	95	145	1779	2780	485	824	622	1083	463	378	1188	360	1524	321	12047	3260

Table 4.4.7.2. Norwegian spring-spawning herring. Acoustic estimates (billion individuals) of immature herring in the Barents Sea in May/June from IESNS. Values in the years 2009–2017 are estimated with StoX. "Fleet 4"

	AGE				
YEAR	1	2	3	4	5
1991	24.3	5.2			
1992	32.6	14	5.7		
1993	102.7	25.8	1.5		
1994	6.6	59.2	18	1.7	
1995	0.5	7.7	8	1.1	
1996*	0.1	0.25	1.8	0.6	0.03
1997**	2.6	0.04	0.4	0.35	0.05
1998	9.5	4.7	0.01	0.01	0
1999	49.5	4.9	0	0	0
2000	105.4	27.9	0	0	0
2001	0.3	7.6	8.8	0	0
2002	0.5	3.9	0	0	0
2003***					
2004***					
2005	23.3	4.5	2.5	0.4	0.3
2006	3.7	35.0	5.3	0.87	0
2007	2.1	3.7	12.5	1.9	0
2008^					
2009	0.286	0.286	0.215	0.072	0
2010	5.121	1.366	0	0	0
2011	1.079	3.802	0.039	0	0
2012	0.884	0.015	0	0	0
2013	0.132	1.982	0.264	0.088	0
2014	3.727	3.055	1.797	0.131	0.044
2015	0.33	11.471	1.218	0.198	0
2016	1.677	5.463	1.668	0.103	0.042
2017	14.658	3.266	0	0	0
2018	6.866	17.404	0.943	0.009	0

***Average of Norwegian and Russian estimates**

****Combination of Norwegian and Russian estimates as described in 1998 WG report, since then only Russian estimates**

*****No surveys**

^Not a full survey

Table 4.4.7.3. Norwegian spring-spawning herring. Estimates from the international acoustic survey on the feeding areas in the Norwegian Sea in May (IESNS). Numbers in millions. Biomass in thousands. Values in the years 2008-2017 are estimated indices by StoX. "Fleet 5"

	Age															Total	
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
1996	0	0	4114	22461	13244	4916	2045	424	14	7	155	0	3134			50514	8532
1997	0	0	1169	3599	18867	13546	2473	1771	178	77	288	190	60	2697		44915	9435
1998	24	1404	367	1099	4410	16378	10160	2059	804	183	0	0	35	0	492	37415	8004
1999	0	215	2191	322	965	3067	11763	6077	853	258	5	14	0	158	128	26016	6299
2000	0	157	1353	2783	92	384	1302	7194	5344	1689	271	0	114	0	75	20758	6001
2001	0	1540	8312	1430	1463	179	204	3215	5433	1220	94	178	0	0	6	23274	3937
2002	0	677	6343	9619	1418	779	375	847	1941	2500	1423	61	78	28	0	26089	4628
2003	32073	8115	6561	9985	9961	1499	732	146	228	1865	2359	1769		287	0	75580	6653
2004	0	13735	1543	5227	12571	10710	1075	580	76	313	362	1294	1120	10	88	48704	7687
2005	0	1293	19679	1353	1765	6205	5371	651	388	139	262	526	1003	364	115	39114	5109
2006	0	19	306	14560	1396	2011	6521	6978	679	713	173	407	921	618	243	35545	9100
2007	0	411	2889	5877	20292	1260	1992	6780	5582	647	488	372	403	1048	1010	49051	12161
2008	0	1240	631	10809	8271	14827	1513	2257	4848	2734	449	149	151	270	491	48665	10558
2009	0	144	1669	2159	12300	8994	9527	2147	1435	2466	1411	188	193	123	231	43082	9728
2010	234	125	542	2334	1781	8351	5988	5601	869	882	983	578	90	72	57	28622	6633
2011	0	1205	977	1528	3607	2564	9420	4542	4298	825	892	712	261	37	39	30917	7395
2012	0	378	2895	412	670	1646	2560	4226	2026	2097	298	607	315	155	47	18331	4435
2013	0	205	776	3955	434	1211	2036	3070	4652	2767	1873	692	805	186	83	22747	5888
2014	17	517	1231	798	2790	749	1065	2681	2285	2842	1119	778	350	76	198	17505	4555
2015	0	385	468	1299	1176	3548	1399	1160	3178	2523	4350	712	788	262	194	21443	5846
2016	0	75	3549	1508	2215	1779	2683	929	1143	1770	1851	2877	928	439	136	21889	5419
2017	11	132	1063	4363	1192	1522	874	1453	327	727	975	1785	2229	538	238	17441	4203
2018	0	500	1052	2063	5686	973	1434	561	1328	338	689	1565	1478	1529	488	19684	5042

Table 4.4.8.1 Norwegian spring-spawning herring. Relative standard error of estimated catch-at-age used by XSAM.

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
1988	0.346	0.205	0.263	0.114	0.343	0.442	0.388	0.305	0.349	0.475	0.357
1989	0.263	0.472	0.444	0.394	0.132	0.449	0.668	0.698	0.455	0.577	0.591
1990	0.3	0.285	0.483	0.322	0.33	0.145	0.587	0.562	0.519	0.495	0.529
1991	0.454	0.353	0.477	0.573	0.304	0.349	0.147	0.491	0.775	1.216	0.554
1992	0.581	0.317	0.244	0.407	0.599	0.321	0.392	0.145	0.492	0.71	0.565
1993	0.368	0.255	0.178	0.188	0.351	0.443	0.252	0.285	0.124	NA	NA
1994	0.357	0.246	0.177	0.128	0.158	0.299	0.357	0.236	0.239	0.11	0.397
1995	0.608	0.21	0.13	0.111	0.11	0.145	0.3	0.298	0.2	0.19	0.1
1996	0.251	0.242	0.107	0.086	0.099	0.124	0.18	0.393	0.367	0.203	0.102
1997	0.273	0.169	0.138	0.083	0.081	0.105	0.132	0.207	0.28	0.246	0.119
1998	0.191	0.199	0.143	0.127	0.084	0.091	0.126	0.169	0.228	0.263	0.145
1999	0.406	0.166	0.239	0.167	0.122	0.086	0.093	0.136	0.178	0.305	0.15
2000	0.306	0.19	0.114	0.241	0.176	0.124	0.091	0.096	0.147	0.198	0.167
2001	0.516	0.18	0.159	0.122	0.234	0.183	0.135	0.102	0.117	0.197	0.215
2002	0.206	0.151	0.11	0.141	0.132	0.251	0.185	0.139	0.109	0.13	0.191
2003	0.418	0.196	0.132	0.106	0.156	0.158	0.27	0.196	0.147	0.113	0.138
2004	0.227	0.266	0.185	0.122	0.107	0.176	0.166	0.259	0.216	0.157	0.109
2005	0.278	0.121	0.184	0.157	0.11	0.099	0.172	0.171	0.235	0.203	0.11
2006	0.224	0.195	0.106	0.191	0.157	0.106	0.104	0.187	0.194	0.25	0.126
2007	0.353	0.146	0.128	0.083	0.162	0.143	0.106	0.117	0.222	0.262	0.159
2008	0.171	0.238	0.114	0.108	0.078	0.15	0.141	0.112	0.127	0.252	0.163
2009	0.175	0.152	0.163	0.093	0.1	0.081	0.165	0.14	0.123	0.143	0.167
2010	0.207	0.18	0.148	0.152	0.096	0.107	0.088	0.156	0.155	0.13	0.141
2011	0.142	0.206	0.179	0.144	0.148	0.105	0.115	0.11	0.186	0.174	0.15
2012	0.314	0.148	0.219	0.173	0.137	0.14	0.105	0.133	0.128	0.215	0.171
2013	0.277	0.208	0.138	0.199	0.176	0.137	0.143	0.112	0.157	0.164	0.222
2014	0.57	0.255	0.21	0.14	0.218	0.198	0.151	0.163	0.126	0.191	0.193
2015	0.458	0.297	0.212	0.216	0.162	0.242	0.203	0.161	0.18	0.15	0.19
2016	0.499	0.224	0.227	0.176	0.189	0.158	0.216	0.197	0.156	0.183	0.14
2017	0.295	0.204	0.134	0.175	0.142	0.159	0.136	0.182	0.168	0.138	0.125
2018	0.331	0.222	0.194	0.179	0.178	0.189	0.207	0.218	0.232	0.291	0.247

Table 4.4.8.2 Norwegian spring-spawning herring. Relative standard error of Fleet 1 used by XSAM.

Year/Age	3	4	5	6	7	8	9	10	11	12
1988	0.334	0.353	0.159	0.476	0.599	0.781	0.579	0.661	0.569	NA
1989	0.703	0.343	0.472	0.189	0.453	0.765	0.843	0.521	NA	0.54
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1991	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1992	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1994	0.46	0.548	0.274	0.315	0.495	0.725	0.415	0.562	0.228	0.904
1995	0.327	0.182	0.199	0.223	0.355	0.694	NA	0.422	0.49	0.216
1996	0.418	0.226	0.16	0.214	0.271	0.348	NA	NA	0.438	0.228
1997	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1998	0.344	0.265	0.202	0.142	0.159	0.226	0.3	0.391	0.591	0.23
1999	0.236	0.333	0.244	0.21	0.154	0.165	0.234	0.312	0.436	0.285
2000	0.29	0.209	0.456	0.314	0.255	0.187	0.205	0.305	0.548	0.374
2001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2002	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2003	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2004	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2005	0.361	0.291	0.221	0.172	0.159	0.291	0.318	0.397	0.446	0.216
2006	0.461	0.171	0.315	0.269	0.198	0.198	0.437	0.505	0.641	0.319
2007	0.335	0.236	0.144	0.296	0.293	0.205	0.198	0.425	0.378	0.262
2008	0.5	0.212	0.208	0.155	0.307	0.315	0.235	0.235	0.414	0.321
2009	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2015	0.309	0.207	0.281	0.199	0.333	0.292	0.205	0.285	0.164	0.215
2016	0.38	0.367	0.306	0.328	0.216	0.371	0.302	0.206	0.289	0.175
2017	0.465	0.259	0.291	0.273	0.327	0.244	0.4	0.375	0.226	0.193
2018	0.42	0.229	0.206	0.314	0.276	0.296	0.259	0.317	0.333	0.196

Table 4.4.8.3 Norwegian spring-spawning herring. Relative standard error of Fleet 4 used by XSAM.

YEAR/AGE	2
1991	0.351
1992	0.337
1993	0.286
1994	0.423
1995	0.61
1996	0.767
1997	0.483
1998	0.402
1999	0.318
2000	0.285
2001	0.656
2002	0.61
2003	NA
2004	NA
2005	0.354
2006	0.459
2007	0.498
2008	0.865
2009	0.661
2010	0.439
2011	0.547
2012	0.563
2013	0.738
2014	0.459
2015	0.648
2016	0.514
2017	0.378
2018	0.421

Table 4.4.8.4 Norwegian spring-spawning herring. Relative standard error of Fleet 5 used by XSAM.

Year/Age	3	4	5	6	7	8	9	10	11	12+
1996	0.206	0.139	0.157	0.198	0.243	0.35	0.776	0.912	0.443	0.22
1997	0.276	0.213	0.145	0.156	0.232	0.251	0.429	0.521	0.383	0.223
1998	0.362	0.28	0.203	0.149	0.167	0.242	0.302	0.426	NA	0.333
1999	0.239	0.373	0.289	0.221	0.161	0.188	0.298	0.393	0.986	0.38
2000	0.267	0.226	0.5	0.358	0.27	0.181	0.194	0.254	0.389	0.423
2001	0.175	0.264	0.262	0.428	0.415	0.218	0.193	0.274	0.498	0.425
2002	0.186	0.169	0.264	0.304	0.36	0.298	0.246	0.232	0.264	0.435
2003	0.185	0.168	0.168	0.261	0.308	0.449	0.405	0.248	0.235	0.242
2004	0.259	0.195	0.159	0.165	0.282	0.326	0.523	0.376	0.363	0.231
2005	0.143	0.267	0.251	0.187	0.194	0.317	0.358	0.454	0.392	0.244
2006	0.378	0.154	0.265	0.244	0.185	0.182	0.314	0.31	0.432	0.239
2007	0.224	0.19	0.142	0.272	0.244	0.184	0.192	0.317	0.339	0.225
2008	0.319	0.165	0.175	0.153	0.26	0.237	0.198	0.227	0.346	0.283
2009	0.254	0.24	0.16	0.172	0.17	0.24	0.264	0.232	0.265	0.308
2010	0.331	0.235	0.251	0.175	0.189	0.192	0.296	0.295	0.288	0.302
2011	0.288	0.26	0.213	0.23	0.17	0.201	0.204	0.3	0.294	0.284
2012	0.224	0.353	0.315	0.255	0.23	0.205	0.243	0.241	0.38	0.279
2013	0.304	0.208	0.348	0.274	0.243	0.221	0.2	0.226	0.248	0.251
2014	0.273	0.302	0.226	0.307	0.283	0.228	0.236	0.225	0.279	0.265
2015	0.342	0.27	0.276	0.213	0.265	0.277	0.219	0.231	0.204	0.245
2016	0.213	0.261	0.238	0.251	0.228	0.292	0.278	0.251	0.248	0.203
2017	0.283	0.203	0.275	0.26	0.296	0.263	0.372	0.309	0.288	0.199
2018	0.283	0.242	0.191	0.289	0.264	0.328	0.268	0.369	0.313	0.196

Table 4.5.1.1. Norwegian spring-spawning herring. Parameter estimates of the final XSAM model fit. The estimates from last year's assessment (from October 2017) are also shown.

Parameter	Estimate	Std. Error	CV	Estimate 2017	Std. Error 2017
$\log(N_{3,1988})$	7.072	0.173	0.024	7.073	0.168
$\log(N_{4,1988})$	6.606	0.212	0.032	6.624	0.205
$\log(N_{5,1988})$	9.577	0.079	0.008	9.594	0.076
$\log(N_{6,1988})$	4.792	0.371	0.077	4.796	0.363
$\log(N_{7,1988})$	3.474	0.508	0.146	3.471	0.494
$\log(N_{8,1988})$	3.132	0.557	0.178	3.126	0.538
$\log(N_{9,1988})$	4.079	0.455	0.112	4.082	0.444
$\log(N_{10,1988})$	3.28	0.653	0.199	3.29	0.638
$\log(N_{11,1988})$	2.989	0.716	0.239	3.015	0.691
$\log(N_{12,1988})$	3.479	0.732	0.21	3.496	0.711
$\log(q_3^{F1})$	-9.544	0.199	0.021	-9.566	0.212
$\log(q_4^{F1})$	-8.064	0.14	0.017	-8.119	0.159
$\log(q_5^{F1})$	-7.507	0.126	0.017	-7.551	0.146
$\log(q_6^{F1})$	-7.31	0.127	0.017	-7.323	0.145
$\log(q_7^{F1})$	-7.134	0.14	0.02	-7.161	0.158
$\log(q_8^{F1})$	-6.917	0.103	0.015	-6.945	0.108
$\log(q_2^{F4})$	-14.46	0.189	0.013	-14.418	0.182
$\log(q_3^{F5})$	-7.597	0.116	0.015	-7.56	0.117
$\log(q_4^{F5})$	-7.127	0.104	0.015	-7.109	0.105
$\log(q_5^{F5})$	-6.891	0.102	0.015	-6.892	0.103
$\log(q_6^{F5})$	-6.768	0.106	0.016	-6.752	0.106
$\log(q_7^{F5})$	-6.693	0.112	0.017	-6.668	0.112
$\log(q_8^{F5})$	-6.509	0.119	0.018	-6.482	0.119
$\log(q_9^{F5})$	-6.508	0.133	0.02	-6.46	0.134
$\log(q_{10}^{F5})$	-6.439	0.15	0.023	-6.405	0.151
$\log(q_{11}^{F5})$	-6.438	0.15	0.023	-6.441	0.152
$\log(\sigma_1^2)$	-5	1.486	0.297	-5	1.422
$\log(\sigma_2^2)$	-2.651	0.275	0.104	-2.493	0.246
$\log(\sigma_4^2)$	-2.108	0.314	0.149	-2.209	0.322
$\log(\sigma_R^2)$	-0.09	0.267	2.973	-0.066	0.269
$\log(h)$	1.581	0.07	0.044	1.553	0.072
μ_R	9.361	0.18	0.019	9.312	0.186
α_Y	-0.535	0.32	0.598	-0.459	0.303
β_Y	0.803	0.115	0.144	0.838	0.11
α_{2U}	-1.245	0.176	0.141	-1.234	0.176
α_{3U}	-0.615	0.102	0.165	-0.608	0.103
α_{4U}	-0.201	0.066	0.329	-0.203	0.07
α_{5U}	0.054	0.057	1.054	0.056	0.061
α_{6U}	0.195	0.061	0.314	0.19	0.065
α_{7U}	0.261	0.066	0.251	0.247	0.069
α_{8U}	0.316	0.072	0.228	0.32	0.076

Parameter	Estimate	Std. Error	CV	Estimate 2017	Std. Error 2017
α_{9U}	0.373	0.079	0.211	0.366	0.081
α_{10U}	0.425	0.085	0.2	0.422	0.087
β_U	0.605	0.055	0.091	0.61	0.054

Table 4.5.1.2 Norwegian spring-spawning herring. Point estimates of Stock in numbers (millions).

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
1988	640	1178	739	14435	120	32	23	59	27	20	32
1989	1168	248	950	619	11941	99	26	17	40	16	37
1990	4275	470	209	804	519	9943	82	21	13	30	41
1991	11293	1732	399	177	677	433	8297	67	17	10	57
1992	18521	4586	1483	340	150	568	364	6918	55	14	56
1993	49735	7525	3933	1260	286	125	475	303	5720	45	57
1994	59395	20202	6447	3317	1029	232	102	385	243	4529	79
1995	15537	24118	17304	5428	2606	774	179	80	298	183	3414
1996	5706	6301	20605	14477	4149	1754	510	129	58	205	2227
1997	2086	2309	5350	17031	11085	2804	1129	334	90	39	1364
1998	10762	842	1915	4300	12956	7712	1750	661	206	54	759
1999	6439	4346	693	1480	3306	9448	5368	1115	406	120	457
2000	33070	2608	3621	541	1129	2451	6695	3599	697	240	302
2001	28868	13404	2183	2713	406	829	1750	4567	2226	406	268
2002	11423	11708	11367	1740	1994	303	615	1260	3165	1471	447
2003	6582	4626	9891	9175	1282	1395	220	431	853	2093	1282
2004	57638	2669	3919	8171	7204	945	1018	160	303	574	2214
2005	24130	23391	2268	3264	6599	5552	703	737	116	212	1736
2006	42853	9787	19783	1868	2605	5043	3937	479	497	76	1131
2007	11871	17381	8322	16368	1501	2035	3700	2710	330	343	711
2008	17281	4808	14743	6853	12594	1137	1488	2523	1795	221	723
2009	6603	6972	4067	12142	5303	8812	803	1022	1608	1129	631
2010	4053	2648	5832	3333	9387	3780	5726	536	633	953	1084
2011	15792	1625	2203	4781	2647	7071	2634	3568	335	387	1098
2012	4658	6341	1354	1801	3838	2062	5318	1791	2367	217	935
2013	7854	1883	5307	1113	1443	3030	1575	3909	1261	1649	804
2014	4789	3181	1585	4346	890	1136	2353	1176	2860	908	1915
2015	15817	1943	2705	1319	3525	716	907	1846	899	2156	2255
2016	8816	6422	1658	2272	1086	2870	580	722	1451	694	3525
2017	7135	3579	5475	1385	1853	866	2281	453	553	1095	3263
2018	24928	2891	3025	4454	1082	1377	624	1655	310	368	3089

Table 4.5.1.3 Norwegian spring-spawning herring. Point estimates of Fishing mortality.

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
1988	0.05	0.066	0.028	0.04	0.05	0.056	0.156	0.232	0.352	0.204	0.204
1989	0.011	0.021	0.016	0.025	0.033	0.039	0.075	0.106	0.148	0.091	0.091
1990	0.004	0.013	0.014	0.023	0.031	0.031	0.052	0.074	0.1	0.07	0.07
1991	0.001	0.005	0.011	0.018	0.024	0.025	0.032	0.043	0.056	0.043	0.043
1992	0.001	0.004	0.013	0.023	0.028	0.029	0.033	0.04	0.054	0.051	0.051
1993	0.001	0.005	0.02	0.053	0.06	0.056	0.062	0.068	0.083	0.098	0.098
1994	0.001	0.005	0.022	0.091	0.135	0.111	0.096	0.106	0.134	0.15	0.15
1995	0.002	0.007	0.028	0.119	0.246	0.268	0.173	0.171	0.221	0.329	0.329
1996	0.005	0.014	0.041	0.117	0.242	0.291	0.272	0.21	0.242	0.429	0.429
1997	0.007	0.037	0.068	0.123	0.213	0.321	0.385	0.334	0.358	0.465	0.465
1998	0.007	0.044	0.108	0.113	0.166	0.212	0.301	0.337	0.393	0.426	0.426
1999	0.004	0.033	0.097	0.121	0.149	0.194	0.25	0.32	0.376	0.497	0.497
2000	0.003	0.028	0.139	0.139	0.159	0.187	0.232	0.33	0.389	0.555	0.555
2001	0.003	0.015	0.077	0.158	0.14	0.149	0.179	0.217	0.264	0.262	0.262
2002	0.004	0.019	0.064	0.155	0.208	0.172	0.205	0.24	0.263	0.253	0.253
2003	0.003	0.016	0.041	0.092	0.155	0.165	0.168	0.203	0.246	0.272	0.272
2004	0.002	0.013	0.033	0.064	0.111	0.145	0.173	0.175	0.204	0.324	0.324
2005	0.002	0.018	0.044	0.075	0.119	0.194	0.234	0.244	0.268	0.394	0.394
2006	0.002	0.012	0.039	0.069	0.097	0.16	0.223	0.223	0.222	0.379	0.379
2007	0.004	0.015	0.044	0.112	0.128	0.163	0.233	0.262	0.249	0.227	0.227
2008	0.008	0.017	0.044	0.106	0.207	0.198	0.226	0.301	0.314	0.253	0.253
2009	0.014	0.028	0.049	0.107	0.189	0.281	0.254	0.329	0.373	0.334	0.334
2010	0.014	0.034	0.049	0.08	0.133	0.211	0.323	0.322	0.343	0.468	0.468
2011	0.012	0.032	0.051	0.07	0.1	0.135	0.236	0.26	0.285	0.313	0.313
2012	0.006	0.028	0.046	0.072	0.086	0.119	0.158	0.2	0.212	0.209	0.209
2013	0.004	0.022	0.05	0.074	0.089	0.103	0.143	0.163	0.179	0.097	0.097
2014	0.002	0.012	0.034	0.059	0.067	0.076	0.093	0.118	0.133	0.074	0.074
2015	0.001	0.009	0.024	0.044	0.056	0.062	0.077	0.091	0.109	0.074	0.074
2016	0.002	0.01	0.03	0.054	0.077	0.08	0.096	0.117	0.132	0.107	0.107
2017	0.003	0.018	0.057	0.097	0.147	0.177	0.171	0.23	0.258	0.194	0.194
2018	0.003	0.017	0.052	0.093	0.139	0.164	0.172	0.219	0.244	0.184	0.184

Table 4.5.1.4 Norwegian spring spawning herring. Final stock summary table. High and low represent approximate 95 % confidence limits.

Year	Recruitment (Age 2)	High	Low	Stock Size: SSB	High	Low	Catches	Fishing Pressure: F	High	Low
	MILLIONS			THOUSND TONNES			THOUSAND TONNES	AGES 5–12		
1988	640	338	942	2108	1794	2422	135	0.042	0.022	0.062
1989	1168	687	1649	3260	2774	3747	104	0.034	0.017	0.05
1990	4275	3179	5371	3528	3013	4043	86	0.031	0.016	0.046
1991	11293	9162	13423	3303	2822	3783	85	0.031	0.016	0.046
1992	18521	15447	21596	3331	2872	3789	104	0.038	0.021	0.056
1993	49735	43368	56103	3302	2890	3714	232	0.076	0.048	0.104
1994	59395	52269	66520	3431	3022	3841	479	0.125	0.089	0.161
1995	15537	12910	18163	3508	3114	3902	906	0.215	0.167	0.263
1996	5706	4485	6927	4096	3696	4496	1220	0.188	0.152	0.225
1997	2086	1518	2655	5355	4873	5836	1427	0.195	0.16	0.229
1998	10762	8793	12731	5908	5378	6438	1223	0.192	0.156	0.228
1999	6439	5110	7768	5770	5219	6322	1235	0.214	0.173	0.256
2000	33070	28460	37680	4799	4296	5303	1207	0.257	0.205	0.309
2001	28868	24671	33066	3986	3535	4437	766	0.203	0.159	0.248
2002	11423	9310	13536	3528	3109	3946	808	0.226	0.176	0.276
2003	6582	5193	7972	4172	3707	4637	790	0.151	0.118	0.184
2004	57638	50230	65046	5270	4706	5834	794	0.127	0.099	0.155
2005	24130	20221	28038	5401	4810	5993	1003	0.172	0.135	0.208
2006	42853	36496	49210	5365	4783	5947	969	0.175	0.136	0.215
2007	11871	9462	14280	6901	6176	7627	1267	0.153	0.12	0.186
2008	17281	13971	20591	6987	6215	7759	1546	0.2	0.158	0.242
2009	6603	5061	8146	6956	6128	7784	1687	0.207	0.165	0.249
2010	4053	2955	5151	6149	5338	6960	1457	0.217	0.169	0.264
2011	15792	12222	19361	5774	4938	6610	993	0.163	0.125	0.2
2012	4658	3283	6033	5544	4684	6404	826	0.144	0.109	0.179
2013	7854	5529	10178	5158	4320	5997	685	0.125	0.092	0.158
2014	4789	3038	6539	4924	4091	5757	461	0.087	0.063	0.11
2015	15817	10382	21253	4615	3811	5419	329	0.071	0.05	0.092
2016	8816	4504	13129	4336	3577	5095	383	0.092	0.065	0.12
2017	7135	2158	12112	4235	3485	4985	722	0.174	0.123	0.224
2018	24928	0	57788	3826	3065	4587				
Average	16765	13046	20741	4672	4072	5271	798	0.144	0.110	0.178

Table 4.8.1.1 Norwegian Spring-spawning herring. Input to short-term prediction. Stock size is in millions and weight in kg.

INPUT FOR	2018							
	STOCKNO.	NATURAL	MATURITY	PROPORTION OF M	PROPORTION OF F	WEIGHT	EXPLOITATION	WEIGHT
AGE	1-JAN.	MORTALITY	OGIVE	BEFORE SPAWNING	BEFORE SPAWNING	IN STOCK	PATTERN	IN CATCH
2	24928	0.9	0	0	0	0.054	0.003	0.133
3	2891	0.15	0	0	0	0.115	0.014	0.207
4	3025	0.15	0.4	0	0	0.149	0.043	0.256
5	4454	0.15	0.8	0	0	0.225	0.076	0.301
6	1082	0.15	1	0	0	0.226	0.114	0.328
7	1377	0.15	1	0	0	0.289	0.135	0.349
8	624	0.15	1	0	0	0.312	0.142	0.364
9	1655	0.15	1	0	0	0.343	0.18	0.374
10	310	0.15	1	0	0	0.359	0.201	0.382
11	368	0.15	1	0	0	0.361	0.152	0.384
12	3089	0.15	1	0	0	0.375	0.152	0.389
INPUT FOR	2019 AND 2020							
	STOCKNO.	NATURAL	MATURITY	PROPORTION OF M	PROPORTION OF F	WEIGHT	EXPLOITATION	WEIGHT
AGE	1-JAN.	MORTALITY	OGIVE	BEFORE SPAWNING	BEFORE SPAWNING	IN STOCK	PATTERN	IN CATCH
2	11621	0.9	0	0	0	0.054	0.014	0.133
3		0.15	0	0	0	0.115	0.071	0.207
4		0.15	0.4	0	0	0.175	0.21	0.256
5		0.15	0.8	0	0	0.24	0.385	0.301
6		0.15	1	0	0	0.278	0.565	0.328
7		0.15	1	0	0	0.31	0.669	0.349
8		0.15	1	0	0	0.328	0.726	0.364
9		0.15	1	0	0	0.349	0.888	0.374
10		0.15	1	0	0	0.357	1	0.382
11		0.15	1	0	0	0.358	0.855	0.384
12		0.15	1	0	0	0.374	0.855	0.389

Table 4.8.2.1 Norwegian spring spawning herring. Short-term prediction.

BASIS:	
SSB (2018):	3.826 (3.065, 4.587) * million t
Landings(2018):	546 448 t (sum of national quotas)
SSB(2019):	3.859 (3.069,4.866)* million t
Fw5-11 (2018):	0.117 (0.030, 0.275)*
Fw5-12(2018)	0.125 (0.035,0.280)*
Recruitment(2018-2020):	24.928 (0,57.788)*, 11.621 (1.009,48.205)*, 11.621 (1.009,48.205)*

The catch options:

RATIONALE	CATCHES (2019)	BASIS	FW(2019)	SSB2020	P(SSB2020 <BLIM)	% SSB CHANGE	%TAC CHANGE**
ZERO CATCH	0	F=0	0	4.510 (3.468,6.056)*	0	17 (3,52)*	-100
STATUS QUO	530319	F=0.125	0.125 (0.099,0.165)*	4.065 (3.050,5.552)*	0.001	5 (-9,36)*	-3
MANAGENENT PLAN 1999–2017	420197	F=0.091**	0.091** (0.053,0.12)*	4.157 (3.126,5.883)*	0	8 (-6,44)*	-23
F=0.085	367038	F=0.085	0.085 (0.067,0.109)*	4.202 (3.170,5.711)*	0	9 (-5,42)*	-33
F=0.125***	529333	F=0.125	0.125 (0.099,0.161)*	4.066 (3.099,5.581)*	0	5 (-9,39)*	-3
F=0.157	654642	F=0.157	0.157 (0.126,0.205)*	3.962 (2.950,5.387)*	0	2 (-12,35)*	20
$SSB_{2020}=B_{PA}$	1598052	F=0.436	0.436 (0.341,0.652)*	3.184 (2.114,4.726)*	0.124	-18 (-35,13)	192
$SSB_{2020}=B_{LIM}$	2449509	F=0.771	0.771 (0.593,1.360)*	2.500 (1.450,4.106)*	0.539	-35 (-55,-2)*	348

***95% confidence interval**

****compared to sum of national quotas in 2017, not advice for 2017**

*****difference in fourth decimal compared to F status quo**

4.17 Figures

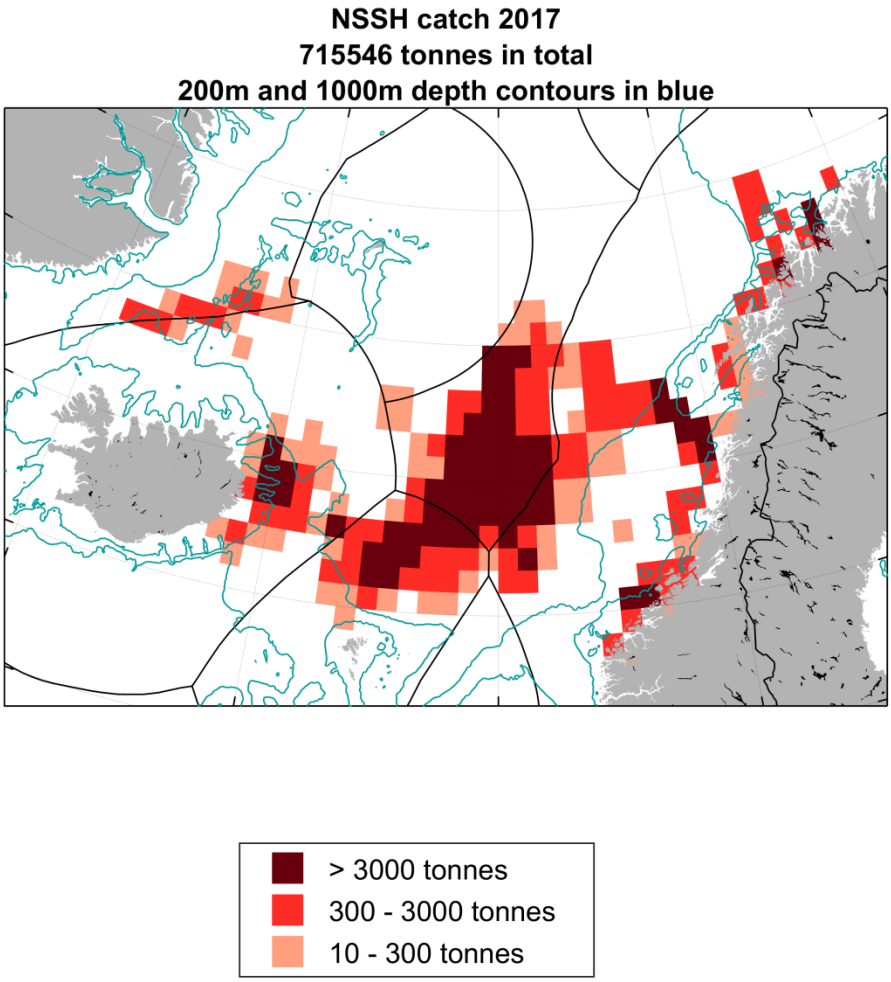

Figure 4.2.1.1. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2017 by ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. The landings with information on statistical rectangle constitute 99% of the reported landings.

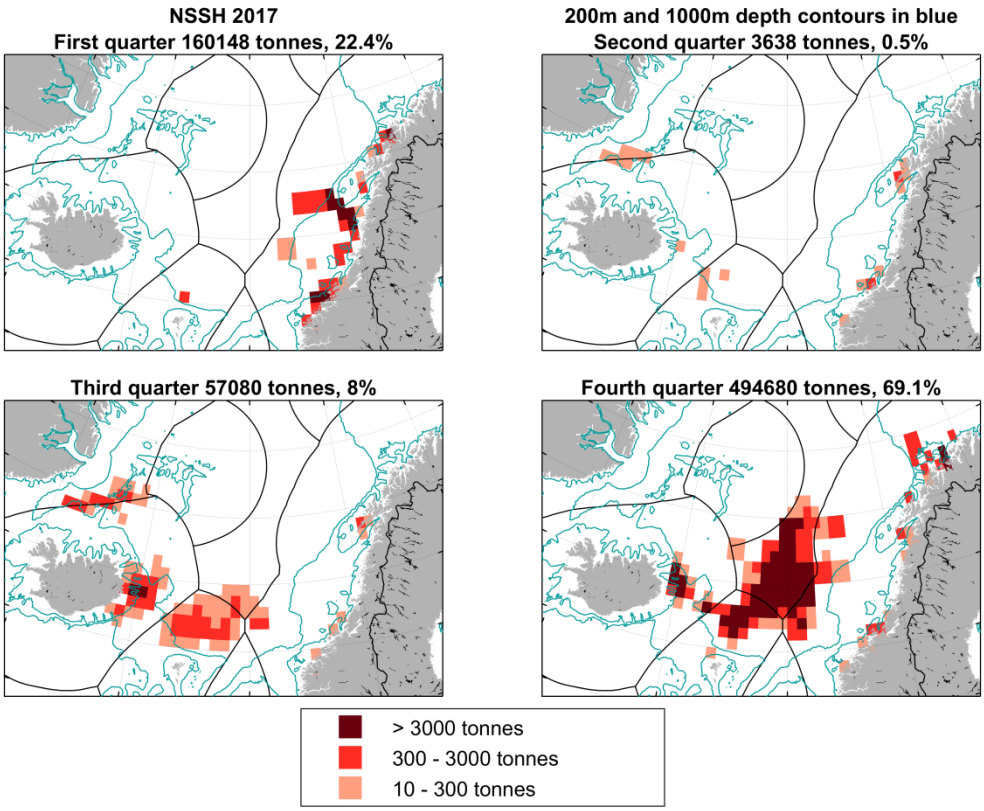

Figure 4.2.1.2. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2017 by quarter and ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. The landings with information on statistical rectangle constitute 99% of the reported landings.

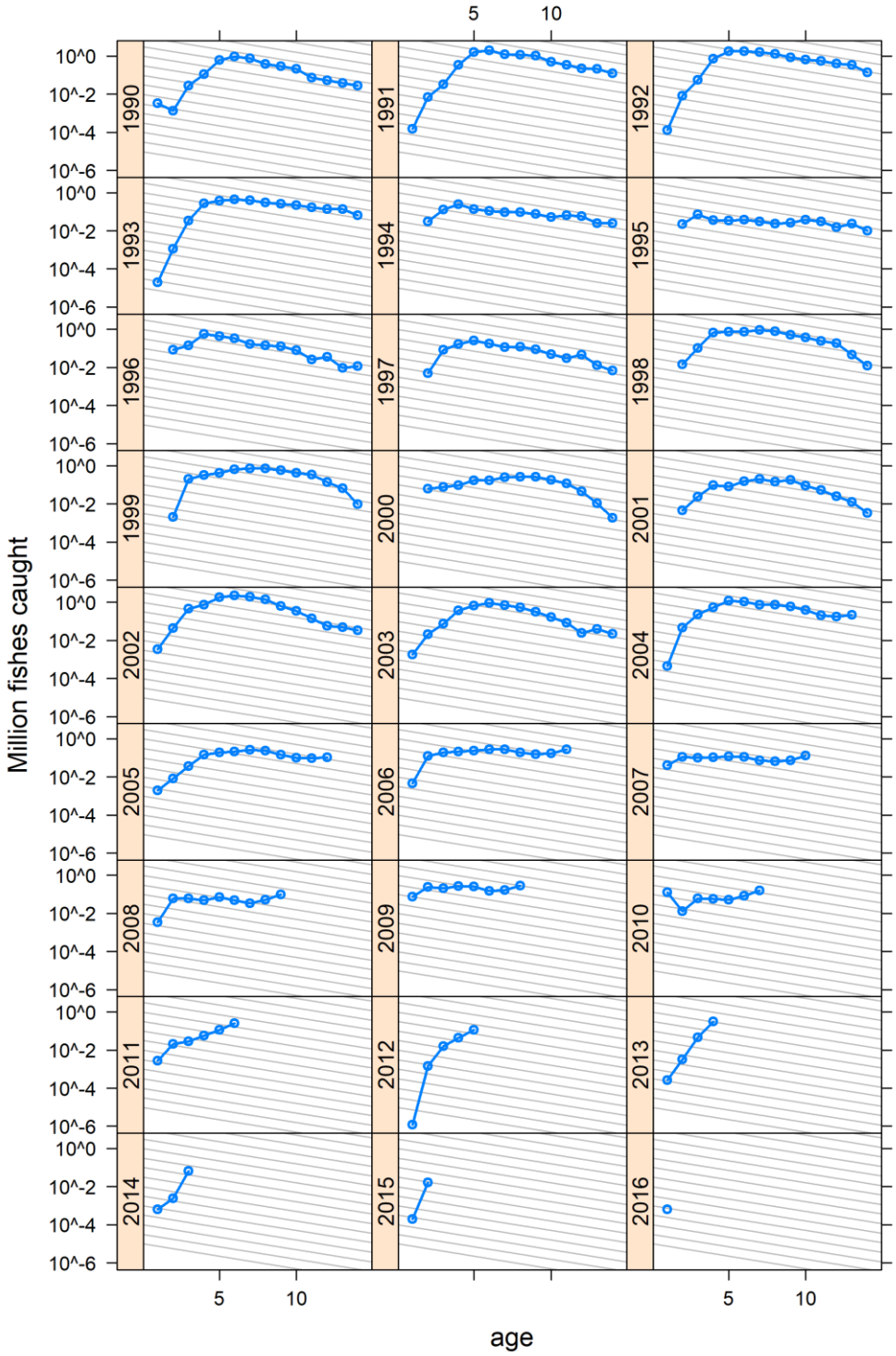

Figure 4.4.3.1. Norwegian spring spawning herring. Age disaggregated catch in numbers plotted on a log scale. Age is on x-axis. The labels indicate year classes and grey lines correspond to Z = 0.3.

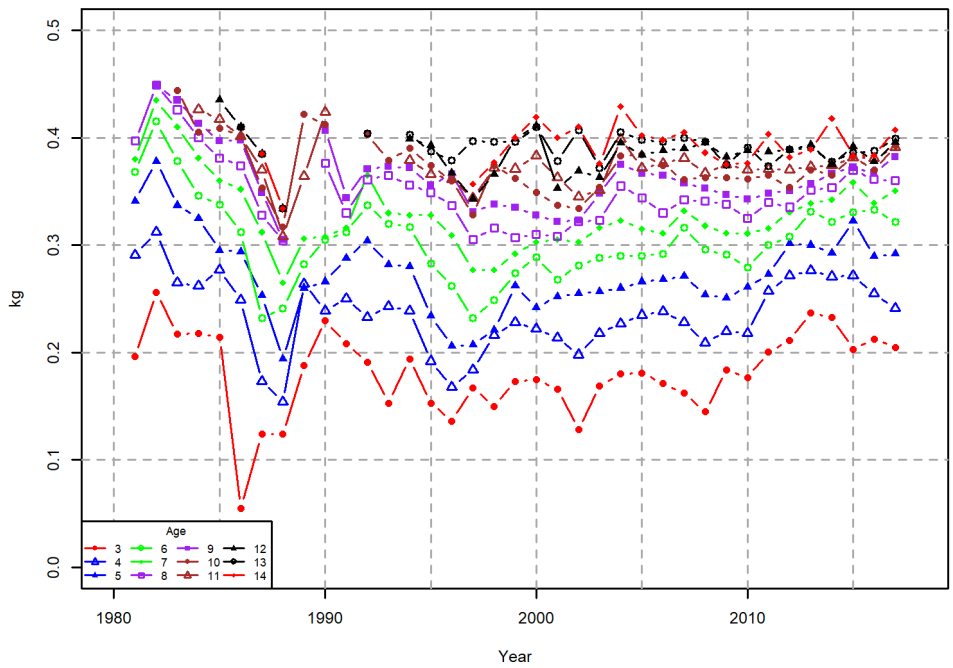

Figure 4.4.4.1.Norwegian spring spawning herring. Mean weight at age by age groups 3–14 in the years 1981—2017 in the catch (weight at age for zero catch numbers were omitted).

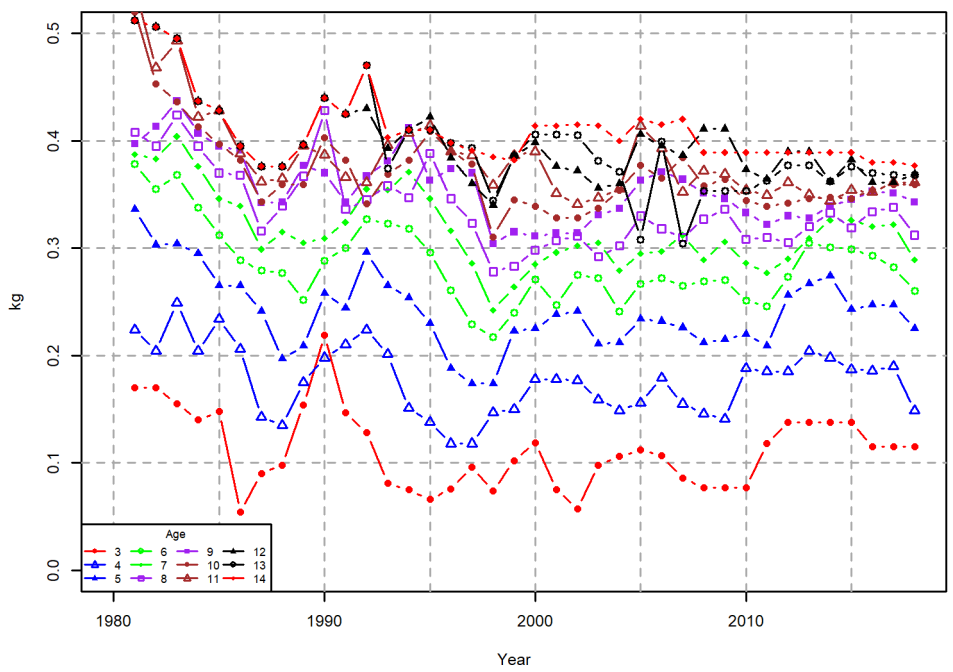

Figure 4.4.4.2.Norwegian spring-spawning herring. Mean weight at age in the stock 1981—2018.

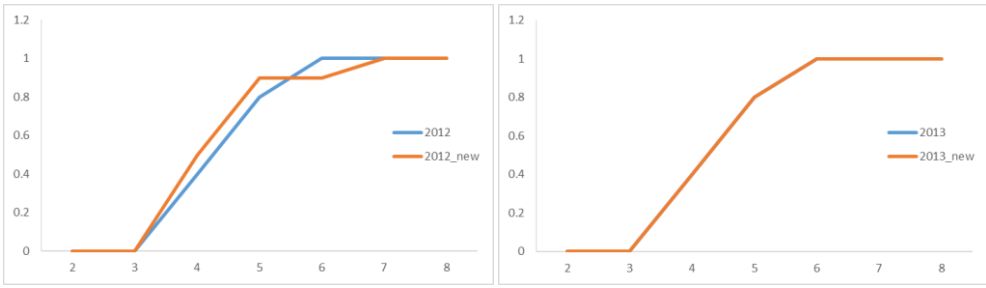

Figure 4.4.5.1. Assumed (blue line) and updated (orange line) maturity-at-age for the years 2012 and 2013.

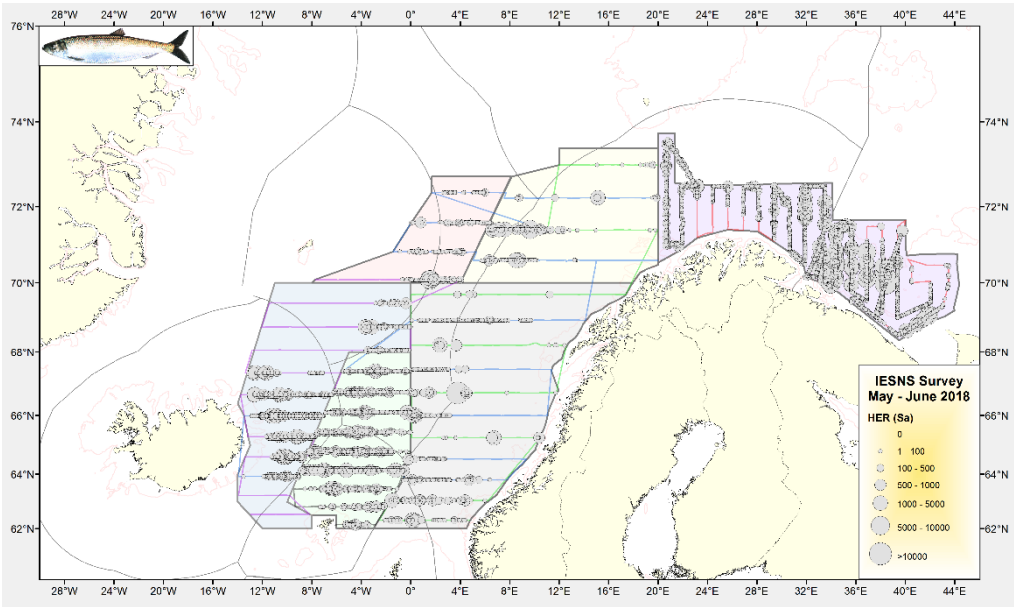

Figure 4.4.7.1.Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in April-June 2018 in terms of NASC values (m^2/nm^2) for every 1 nautical mile. The stratification of the survey area is shown on the map.

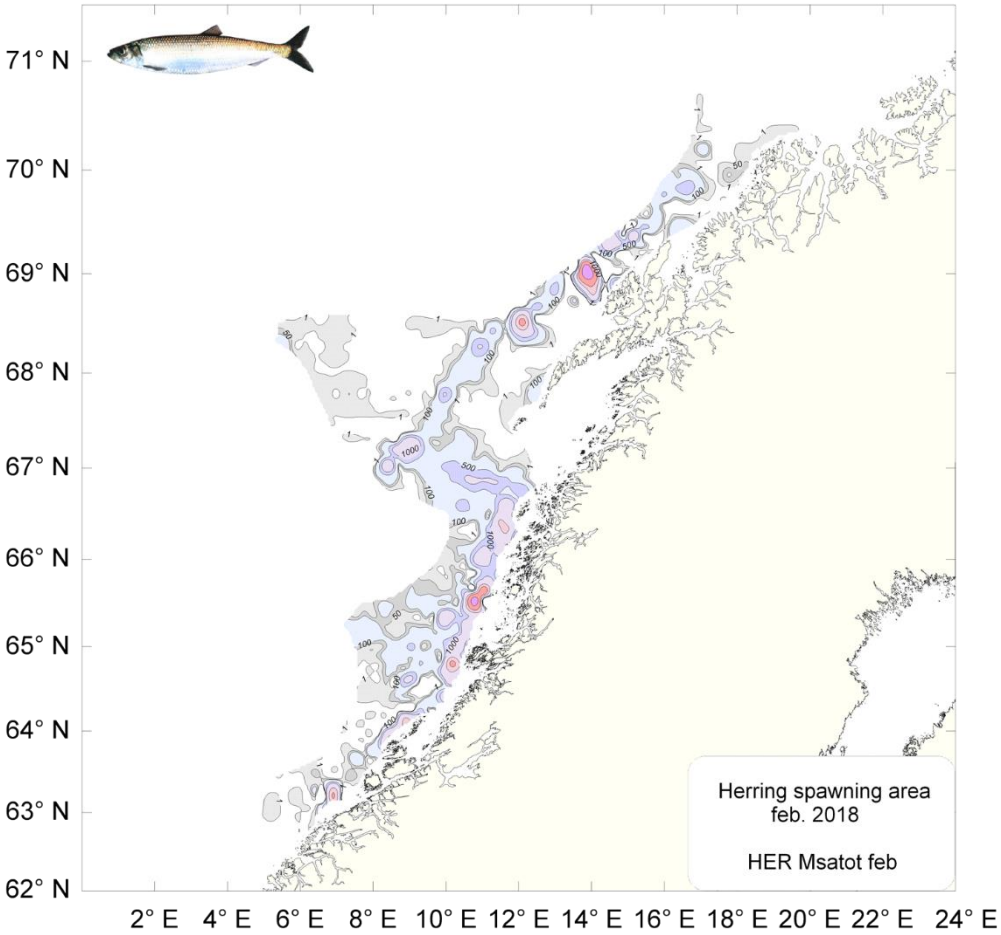

Figure 4.4.7.2. Norwegian acoustic survey on the NSSH spawning grounds. Distribution and acoustic density of herring recorded in 2018.

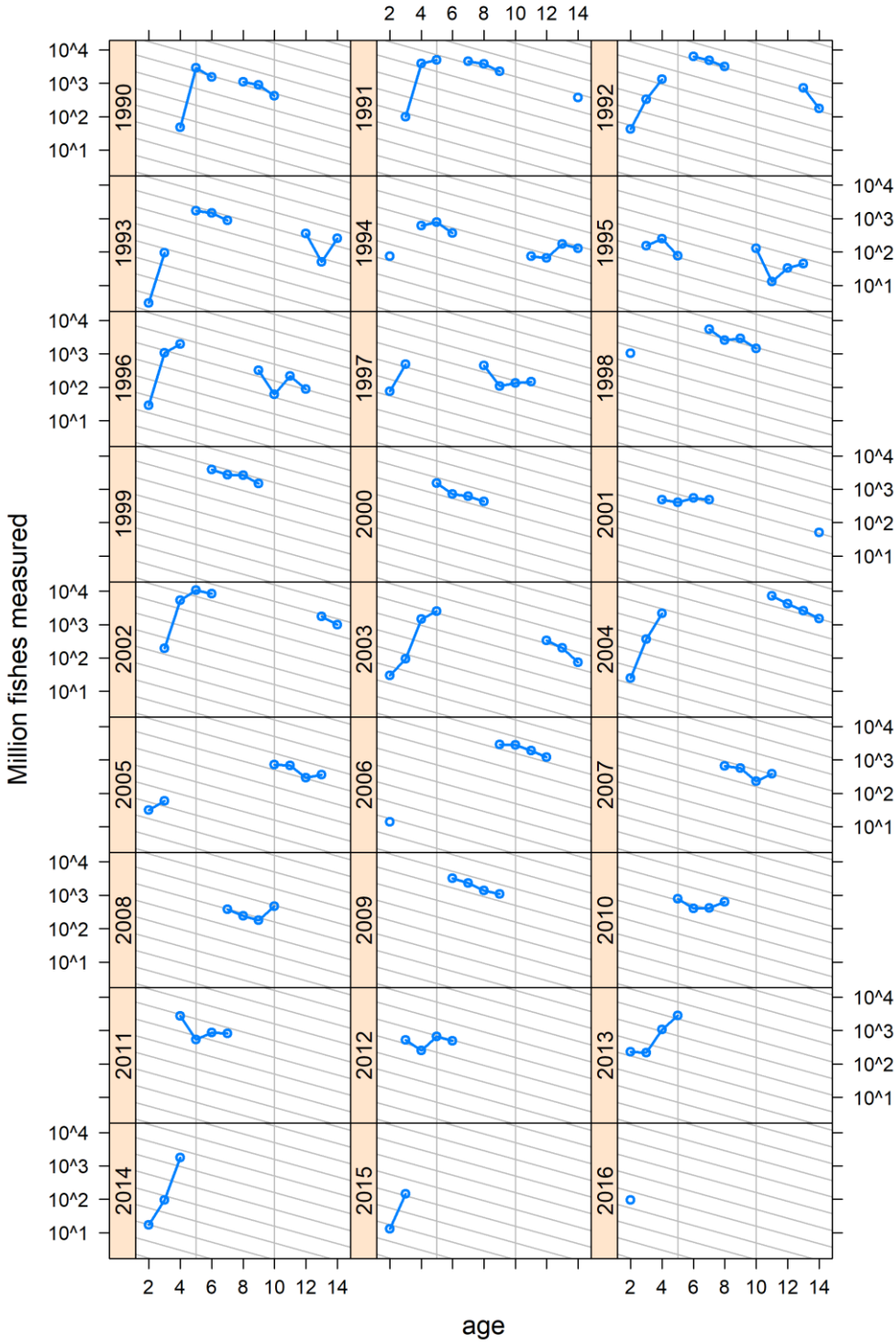

Figure 4.4.7.3. Norwegian spring spawning herring. Age disaggregated abundance indices (billions) from the acoustic survey on the spawning area in February-March (survey 1) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3. Age is on x-axis. The labels indicate year classes and grey lines correspond to Z = 0.3.

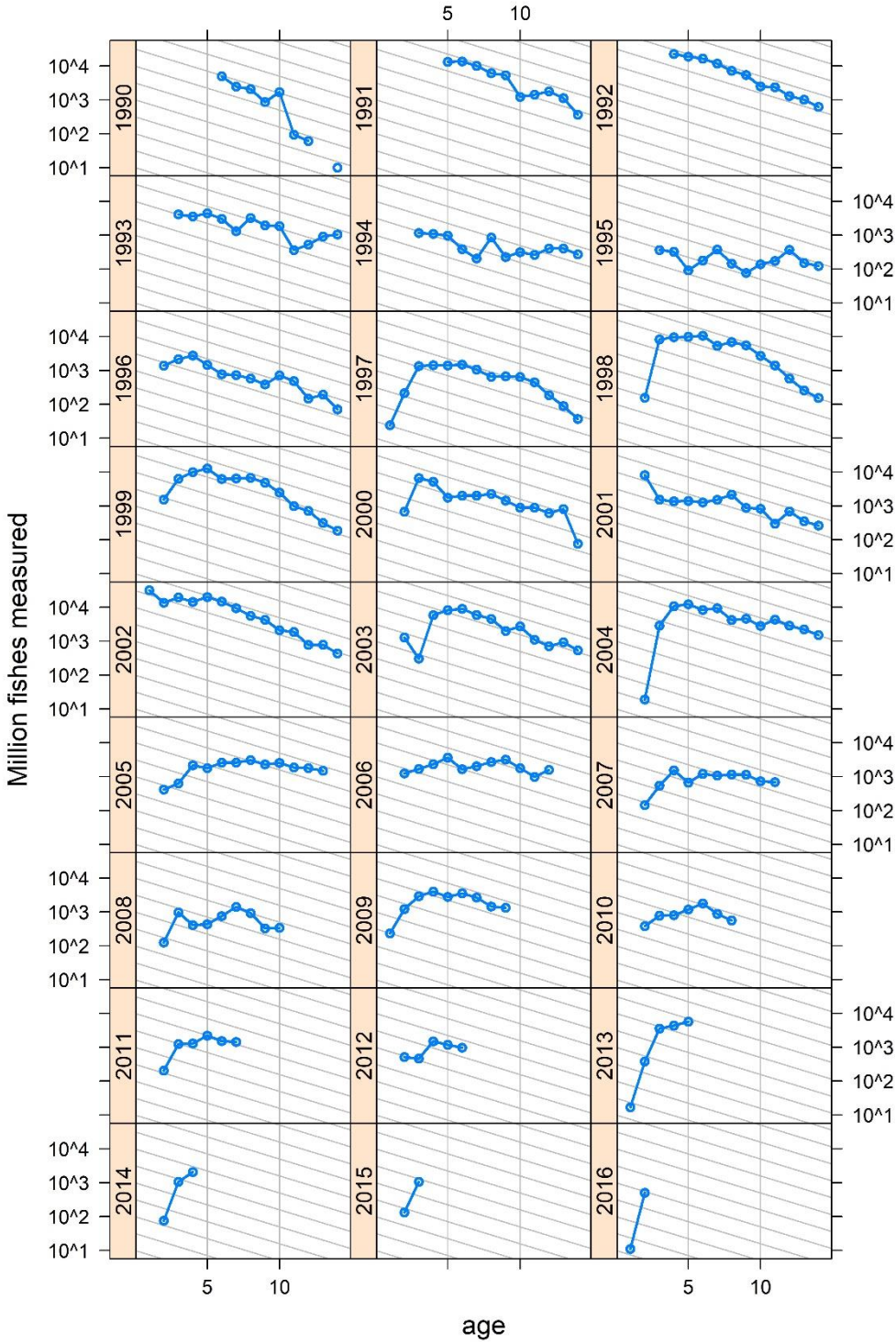

Figure 4.4.7.4. Norwegian spring spawning herring. Age disaggregated abundance indices (billions) from the acoustic survey on the feeding area in the Norwegian Sea in May (survey 5) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3.

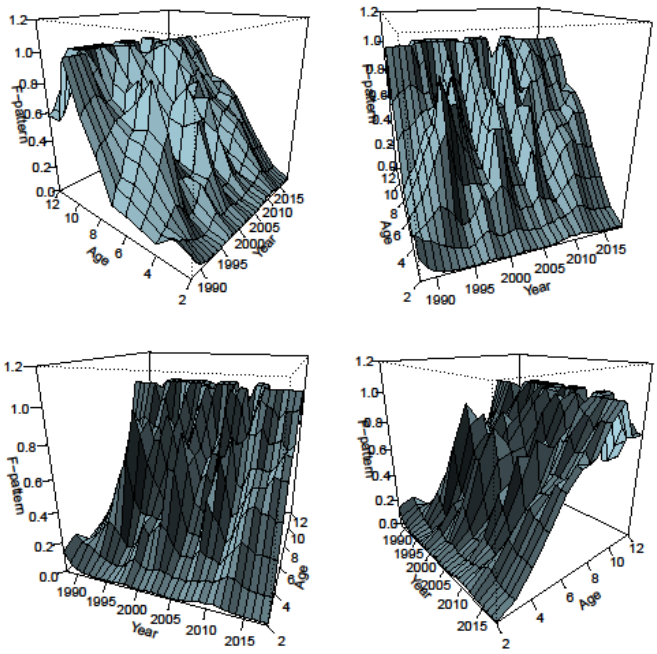

Figure 4.5.1.1.Estimated exploitation pattern for the years 1988–2018 by the XSAM model fit. All panels shows includes the same data, but shown at different angles to improve visibility at different time periods

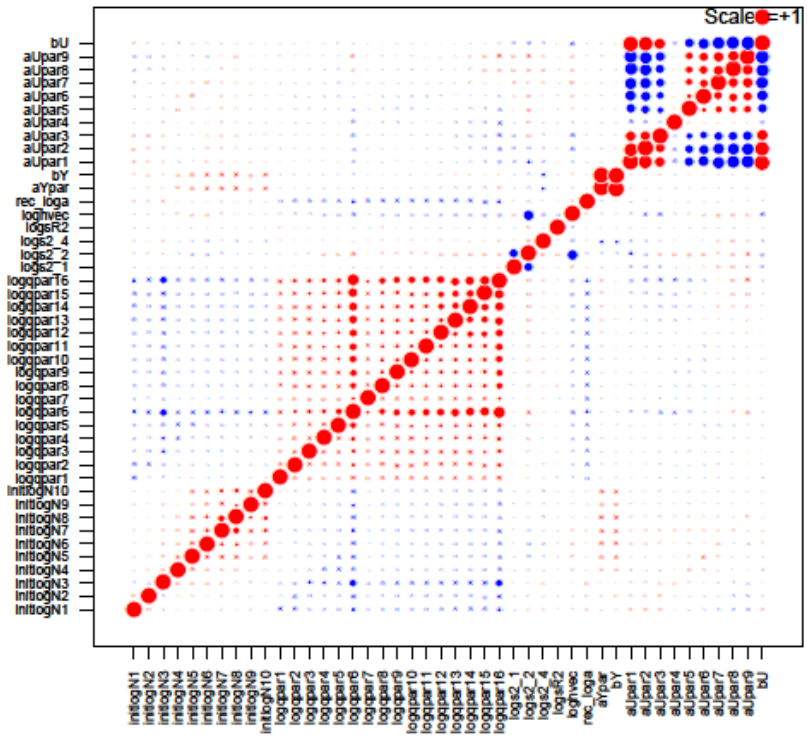

Figure 4.5.1.2. Norwegian spring spawning herring. Correlation between estimated parameters in the final XSAM model fit.

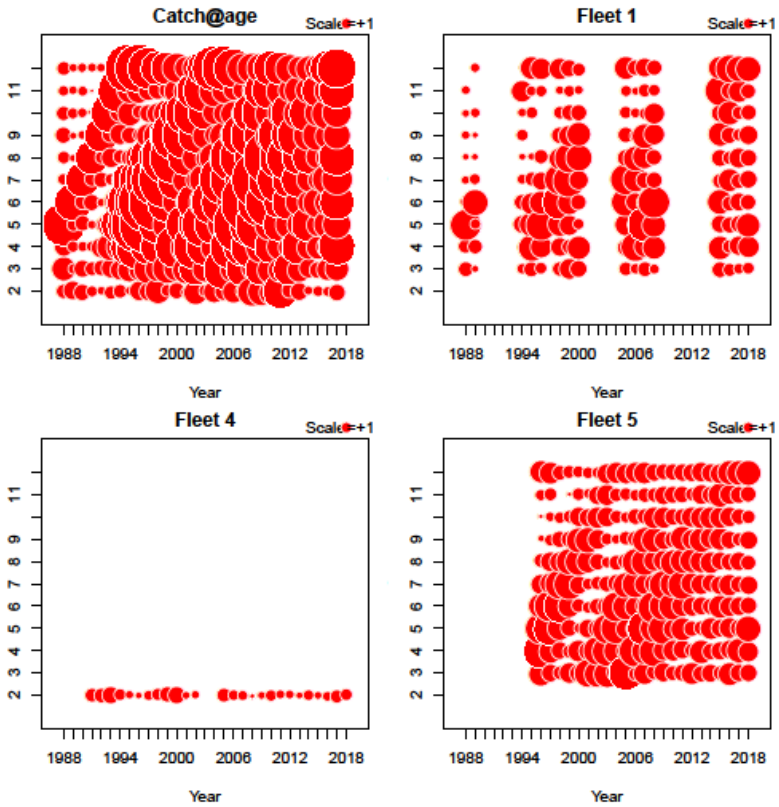

Figure 4.5.1.3. Norwegian spring spawning herring. Weights (inverse of variance) of data-input of the final XSAM model fit.

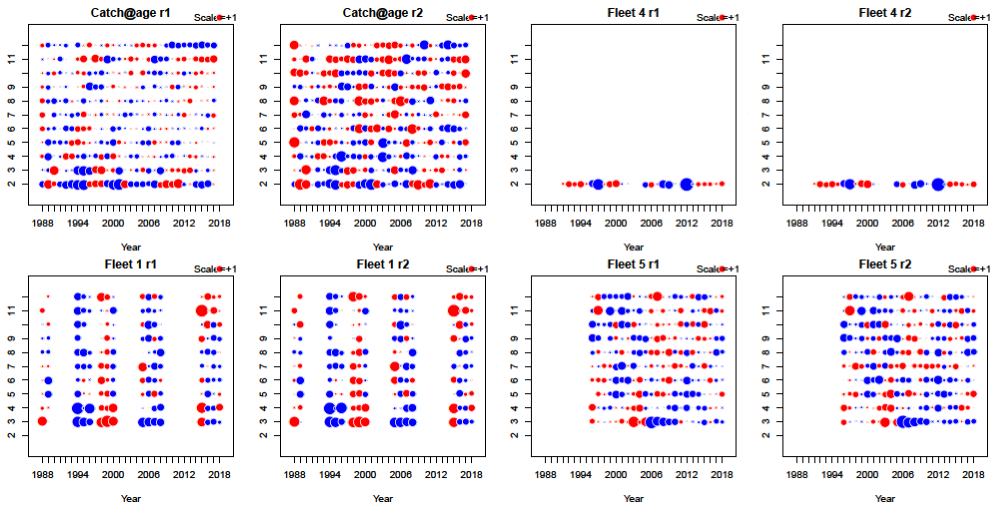

Figure 4.5.1.4. Norwegian spring spawning herring. Standardized residuals type 1 (left) and type 2 (right) (see text) of data-input of the final XSAM model fit.

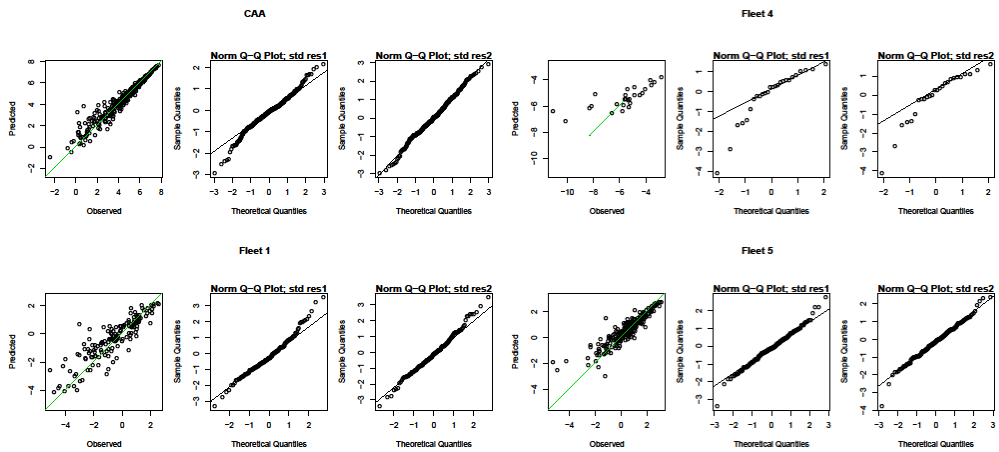

Figure 4.5.1.5. Norwegian spring spawning herring. Observed vs. predicted values (left column) and qq-plot based on type 1 (middle) and type 2 (right) residuals (see text) based on the final XSAM model fit.

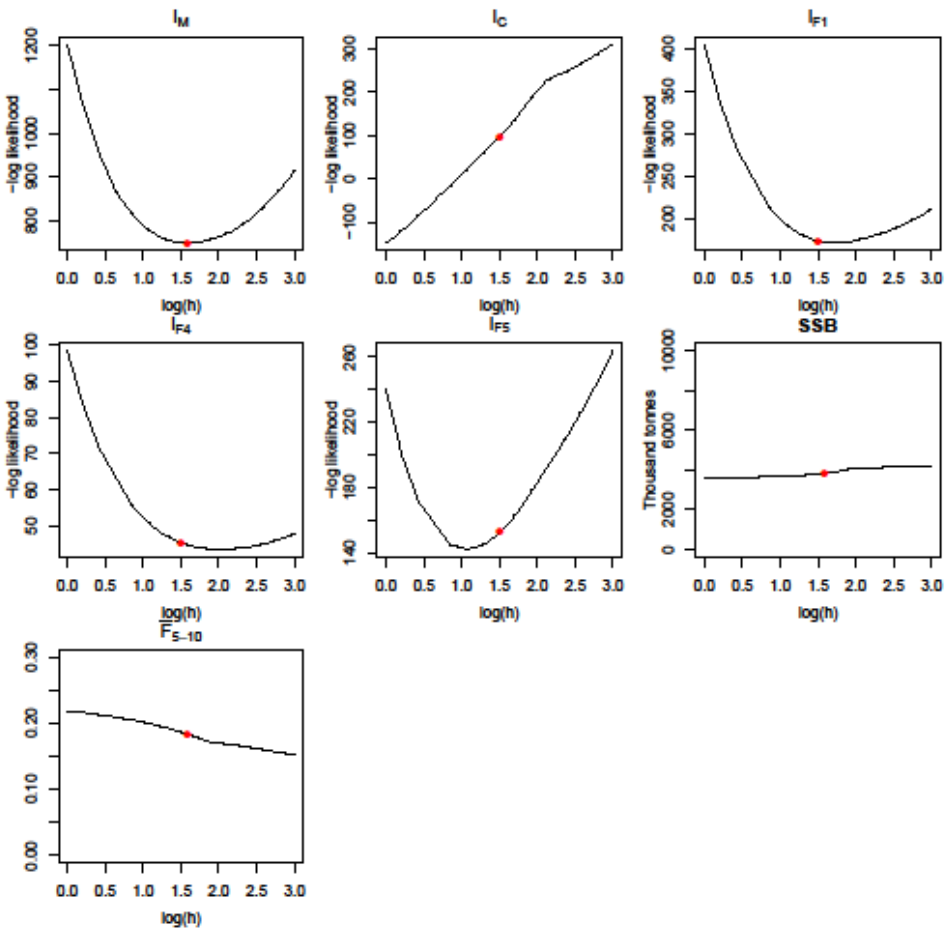

Figure 4.5.1.6. Norwegian spring spawning herring. Profiles of marginal log-likelihood l_M, the catch component l_C, Fleet 1 component l_{F1}, Fleet 4 component l_{F4}, Fleet 5 component l_{F5}, point estimate of SSB and average F (ages 5-12+) in 2017 over the common scaling factor for variance in data h for the final XSAM fit. The red dots indicate the value of the respective scaling factors for which the log-likelihood is maximized.

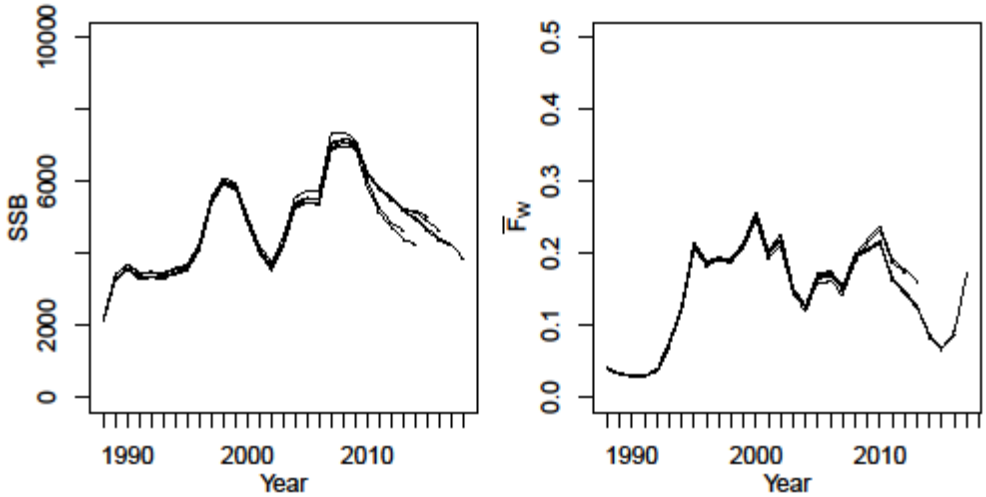

Figure 4.5.1.7. Norwegian spring spawning herring. Retrospective XSAM model fits of SSB and weighted average of fishing mortality ages 5-11 for the years 2012-2017.

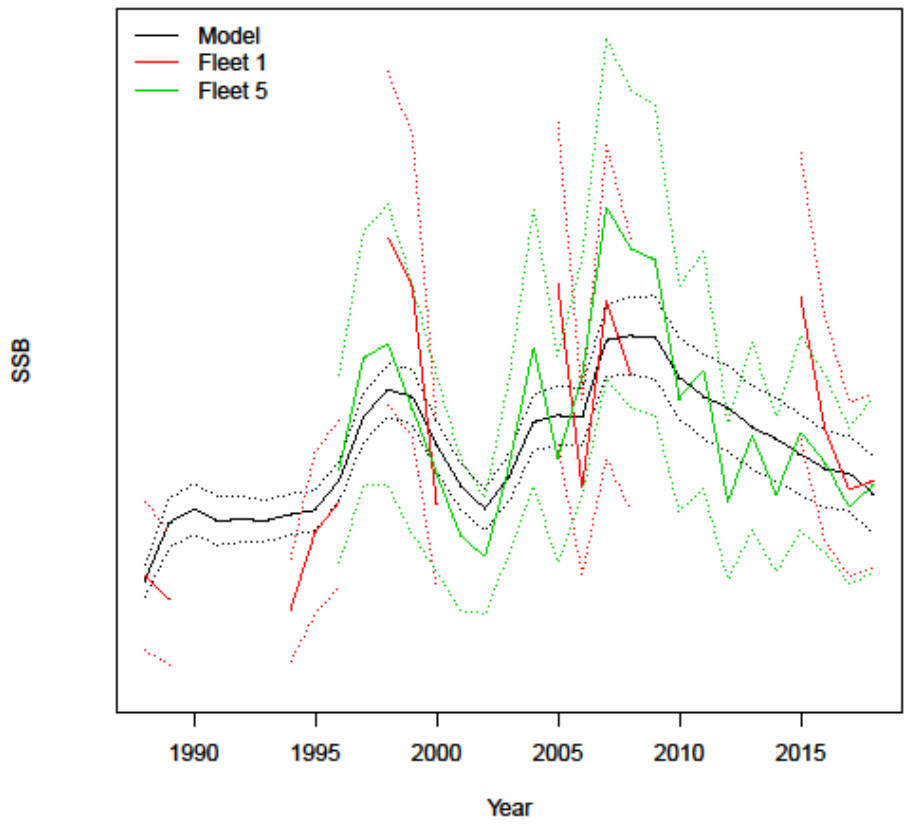

Figure 4.5.1.8. Norwegian spring spawning herring. Point estimates of Spawning-stock biomass by years 1988-2018 from model (black lines) and by survey indices from Fleet 1 (red) and Fleet 5 (green). Dotted lines are approximate 95% confidence interval.

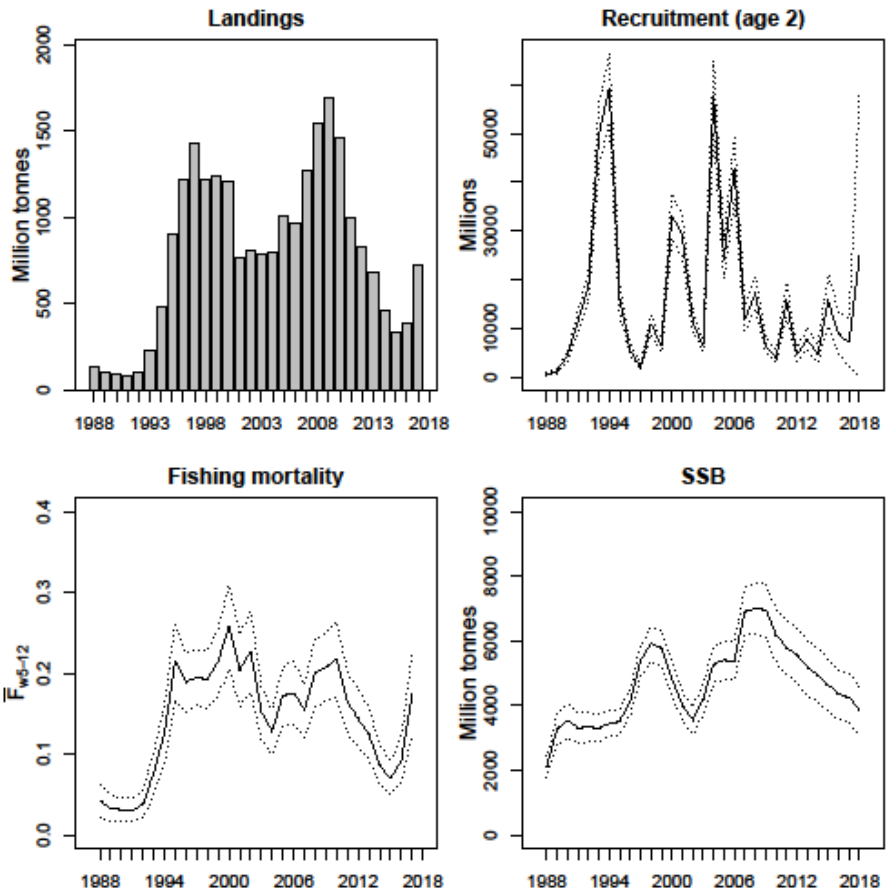

Figure 4.5.1.9. Total reported landings 1988-2017, estimated recruitment, weighted average of fishing mortality (ages 5-12) and spawning-stock biomass for the years 1988–2018 based on the final XSAM model fit. The broken lines are approximate 95% confidence limits.

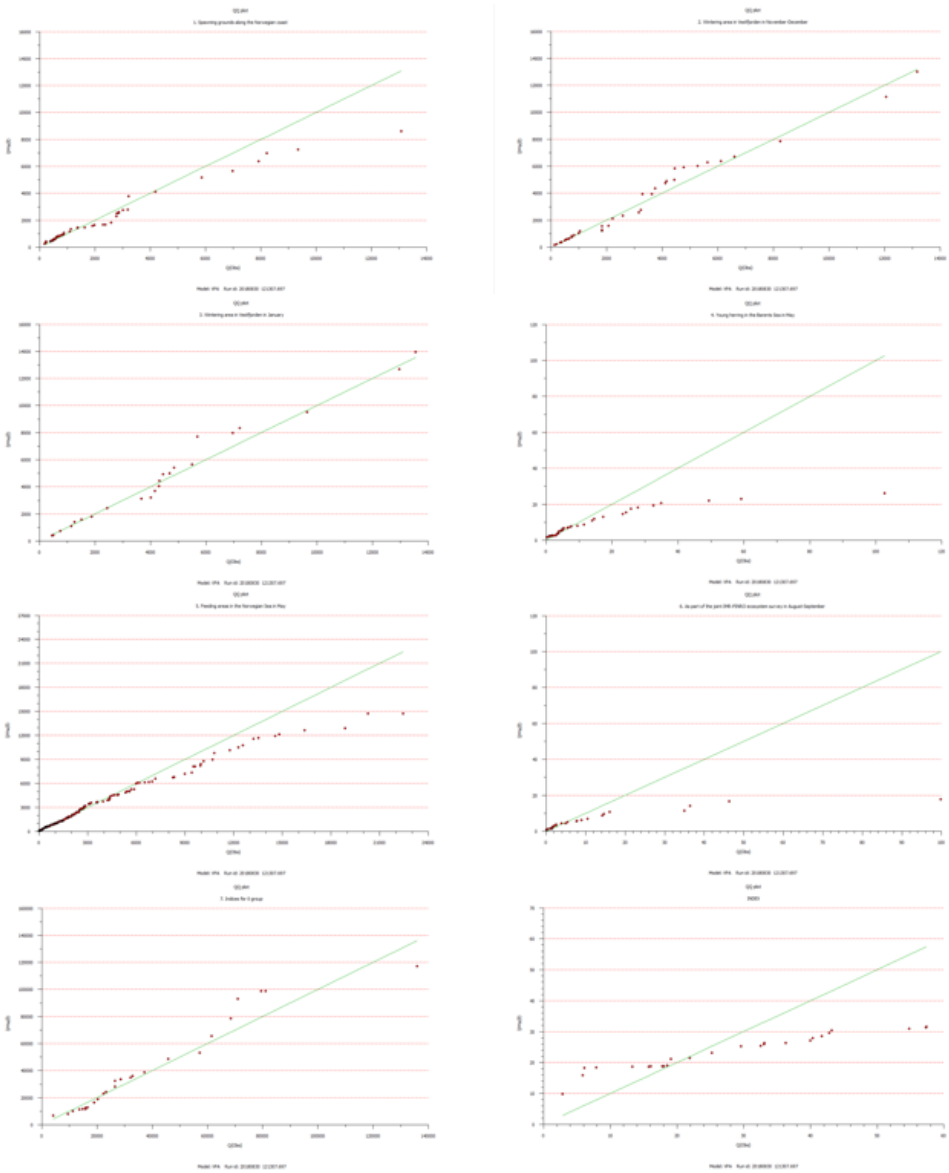

Figure 4.5.2.1.1. Norwegian spring spawning herring. Q-Q plot from the eight different surveys used in tuning in TASACS. First row starts with survey 1 and the last one in row four is larval survey.

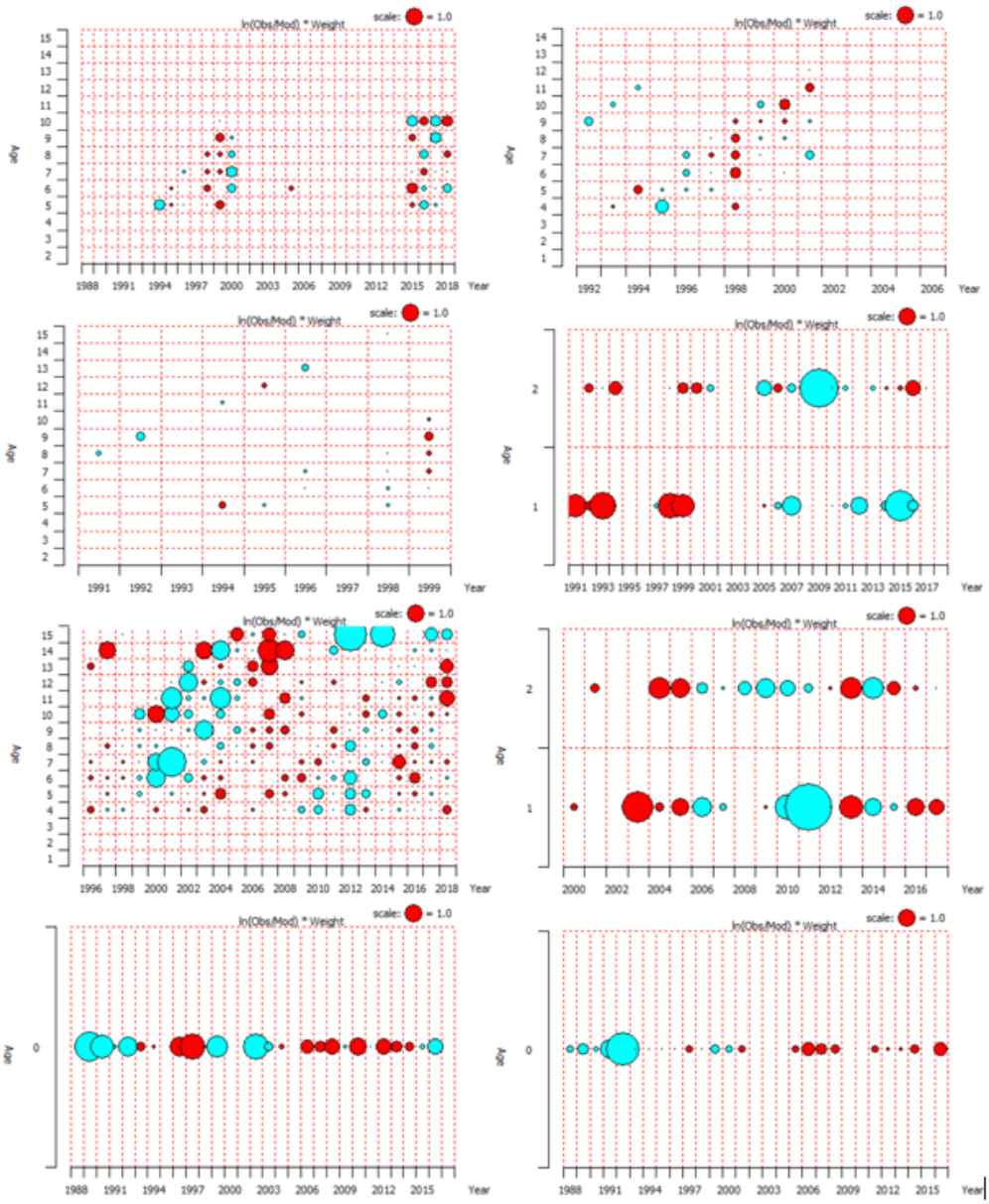

Figure 4.5.2.1.2. Norwegian spring-spawning herring. Residual sum of squares in the surveys separately from TASACS. First row starts with survey 1 and the last one in row four is larval survey.

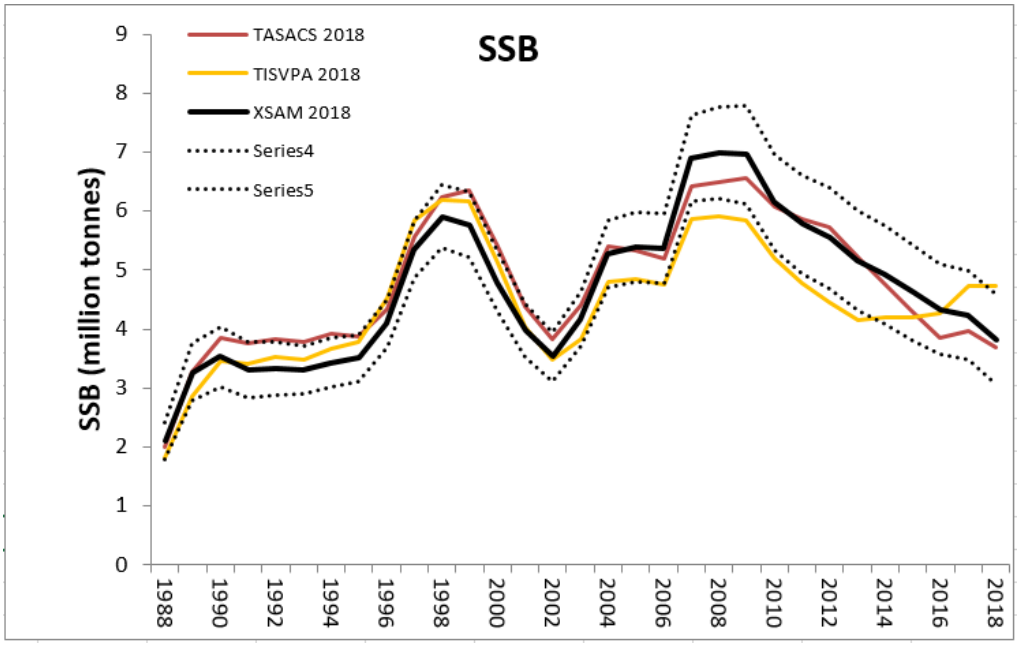

Figure 4.5.2.1.3. Comparison of SSB time-series from the final assessment from XSAM and exploratory runs from TASACS (following the 2008 benchmark procedure) and TISVPA. 95% confidence intervals from the XSAM final assessment are shown.

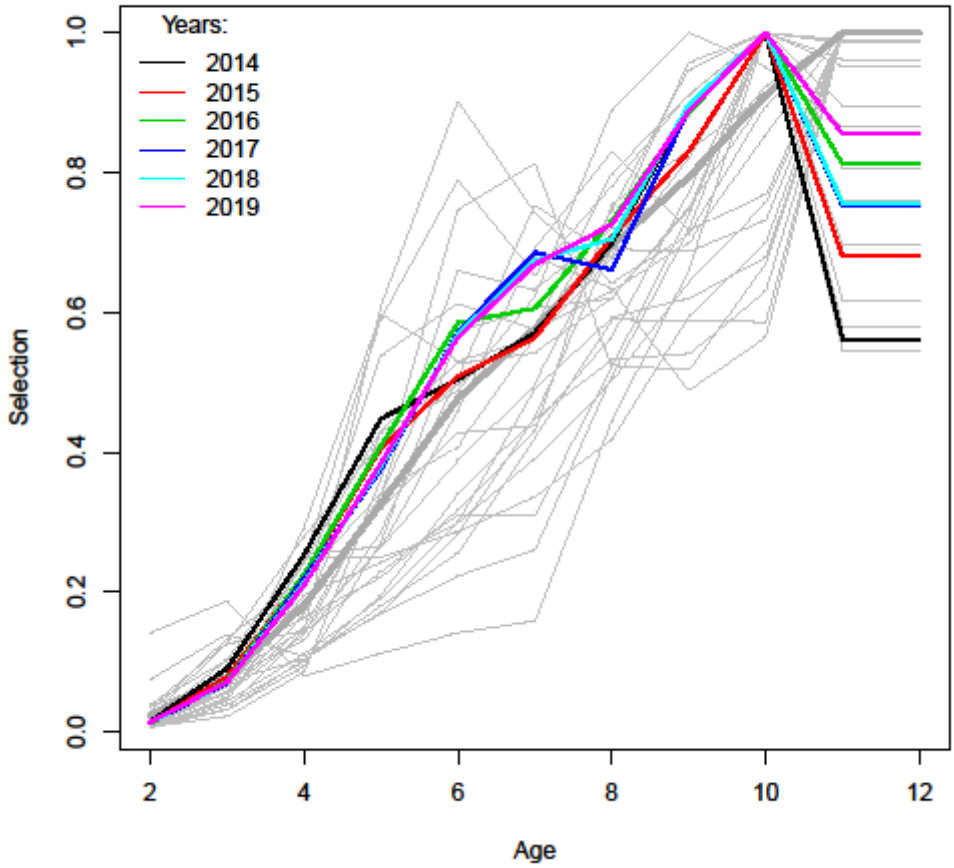

Figure 4.8.1.1. Estimated selection pattern by XSAM; thin grey lines shows annual estimates 1988–2017, the median value is indicated by the thick grey line, while selected years (estimates for 2014–2017 and predictions for 2018-2019) are shown in colours as indicated in the legend.

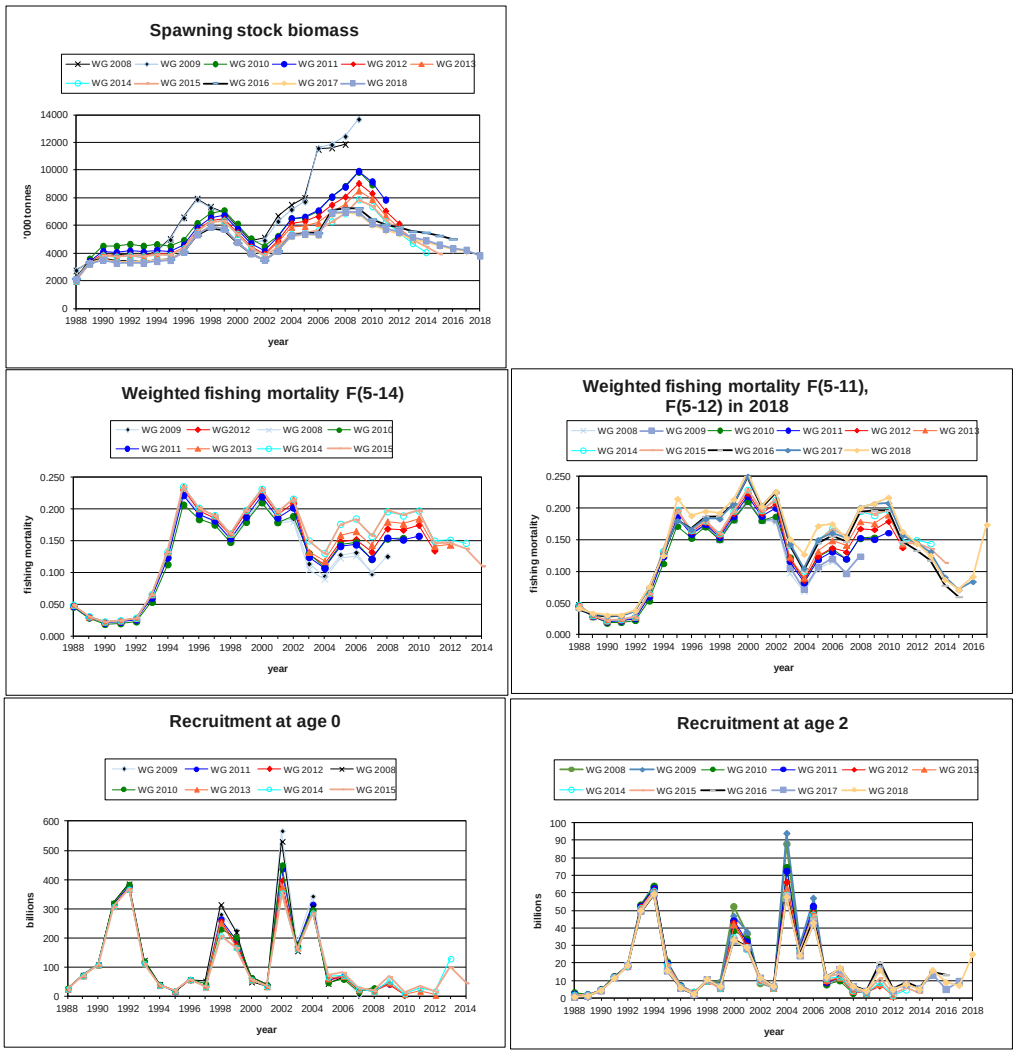

Figure 4.9.1. Norwegian spring spawning herring. Comparisons of spawning stock; weighted fishing mortality F(5-14) and F(5-11); and recruitment at age 0 and age 2 with previous assessments. In 2016 the proportion mature in the years 2006-2011 was changed; recruitment age changed from 0 to 2 and fishing mortality is calculated over ages 5 to 11. In 2018 (WKNSSHREF) the age range for the fishing mortality changed to ages 5-12.

5 Horse Mackerel in the Northeast Atlantic

5.1 Fisheries in 2017

The total international catches of horse mackerel in the North East Atlantic are shown in Table 5.1.1 and Figure 5.4.1. The southern horse mackerel stock is currently assessed by ICES WGHANSA. The total catch from all areas in 2017 for the Western and North Sea stock was 97,540 tons which is 16611 tons less than in 2016 (and 12% lower than in 2015). France and the Netherlands have a directed trawl fishery and Norway and France a directed purse-seine fishery for horse mackerel. Spain has directed and mixed trawl and purse-seine fisheries. In earlier years most of the catches were used for meal and oil while in later years most of the catches have been used for human consumption.

The quarterly catches of North Sea and western horse mackerel by Division and Sub-division in 2017 are given in Table 5.1.2 and the distributions of the fisheries are given in Figure 5.1.1.a–d. The maps are based on data provided by Belgium, Faroe Islands, France, Germany, Ireland, Netherlands, Norway, Sweden, Spain and UK (Engl. And Wales) representing 99% of the total catches. The distribution of the fishery is similar to the later years.

The Dutch, Danish, Irish and German fleets operated mainly in the North and West of Ireland and the Western waters off Scotland. The French fleet were in the Bay of Biscay and West Scotland whereas the Norwegian fleet fished in the North-eastern part of the North Sea. The Spanish fleet operated mainly in waters of Cantabrian Sea and Bay of Biscay.

First quarter: The fishing season with most of the catches 39,251 tons (47% of the total catches). The fishery was mainly carried out west of Scotland and West and North of Ireland and along the Spanish coast (Figure 5.1.1.a).

Second quarter: 7,377 tons. As usual, catches were significantly lower than in the first quarter as the second quarter is the main spawning period. Most of the catches were taken West of Ireland and along the Spanish coast. (Figure 5.1.1.b)

Third quarter: 12,921 tons. Most of the catches were taken in Spanish waters and at the Norwegian coast. Also some smaller catches were reported in the Southern part of the North Sea (Figure 5.1.1.c).

Fourth quarter: Catches were 23,381 tons. The catches were distributed in four main areas (Figure 5.1.1.d):

- Spanish waters,
- Northern Irish waters and West of Scotland
- Norwegian coast
- East part of Channel

5.2 Stock Units

For many years the Working Group has considered the horse mackerel in the Northeast Atlantic as separated into three stocks: the North Sea, the Southern and the Western stocks (ICES 1990, ICES 1991). For further information see Stock Annex Western Horse Mackerel and to the WD document on horse mackerel stock structure (WD Brunel et al., 2016). The boundaries for the different stocks are given in Figure 5.2.1.

To improve on the understanding of the stock structure, horse mackerel samples for genetic analysis have been collected in the central and Northern North Sea, Channel, West of Ireland, the Bay of Biscay, Cantabrian Sea and in the waters around Morocco and Mauritania (as out-group). Samples have been collected mostly during spawning time in the years 2015 to 2017. It is foreseen that the genetic analysis will be carried out in 2018 leading to potential results before the next WGWIDE in 2019.

5.3 WG Catch Estimates

In 2017, a review of catch statistics for North Sea and Western horse mackerel stocks was carried out. The results of this report have been reported in previous Working Groups reports. (Costas, 2017)

As a result of this review catches and catch-at-ages of reported historical data of both North Sea and Western stocks of horse mackerel were updated. Catch statistics were reviewed since 1990 onward for Western stock and since 2000 onward for North Sea stock. Main mismatches between the catch statistics in working group reports and these reviewed data were originated by several reasons such as late availability of some data for the report or the availability of only official catch figures.

5.4 Allocation of Catches to Stocks

The distribution areas for the three stocks are given in the Stock Annex for the Western Horse Mackerel. The catches in 2017 were allocated to the three stocks as follows:

Western stock: 3 and 4 quarter: Divisions 3.a and 4.a. 1-4 quarter: 2.a, 5.b, 6.a, 7.a–c, e–k and 8.a-e.

North Sea stock: 1 and 2 quarter: Divisions 3.a and 4.a 1-4 quarter: Divisions 4.b, 4.c and 7.d.

Southern stock: Division 9.a. All catches from these areas were allocated to the southern stock. This stock is now dealt with by another working group (ICES WGHANSA).

The catches by stock are given in Table 5.4.1 and Figure 5.4.1. The catches by ICES sub-Area and division for the Western and North Sea stocks for period 1992-2017 are shown in Figures 5.4.2-3. The catches by stock and countries for the period 1997-2017 are given in Table 5.4.2-5.4.3.

5.5 Estimates of discards

Over the years only Netherlands had provided data on discards and in some few years also Germany and Spain. For 2017 almost all of countries provided such data. The provided discard rate is less than 5.3 % in weight for the combined Horse mackerel stocks. The discard rate for the North Sea stock is estimated to be 8.3% and for the Western stock 4.7% in 2017.

5.6 *Trachurus* Species Mixing

Three species of genus *Trachurus*: *T. trachurus*, *T. mediterraneus* and *T. picturatus* are found together and are commercially exploited in NE Atlantic waters. Following the Working Group recommendation (ICES 2002/ACFM: 06) special care was taken to ensure that catch and length distributions and numbers-at-age of *T. trachurus* supplied to the Working Group did not include *T. mediterraneus* and/or *T. picturatus*.

T. mediterraneus fishery takes mainly place in the eastern part of ICES Division 8.c. There is not a clear trend in *T. mediterraneus* catches in this area but in the last year's

show a low level (Table 5.6.1). Information of *T. picturatus* fishery is available in the WGHANSA Report (Working Group on Horse Mackerel, Anchovy and Sardine).

Taking into account that the assessment is only made for *T. trachurus*, the Working Group recommends that the TACs and any other management regulations which might be established in the future should be related only to *T. trachurus* and not to Trachurus spp. More information is needed about the *Trachurus spp*. before the fishery and the stock can be evaluated.

5.7 Length Distribution by Fleet and by Country:

Ireland, Germany, Netherlands, Norway, France, Scotland and Spain provided length distributions for their catches in 2017. The length distributions are covering app. 97% of the total landings of the Western and North Sea horse mackerel catches and are shown in Table 5.7.1.

5.8 Comparing trends between areas and stocks

Horse mackerel (*Trachurus trachurus*) in the northeast Atlantic is assumed to be separate into three stocks:

- North Sea (4a part of the year, 4b, 4c and 7d)
- Western (4a part of the year, 5b, 6a, 7a-c,e-k, 8a-d)
- Southern (9a)

Catches in biomass between 2000 and 2017 are shown in figure 5.8.1 indicated an overall decline in the catches of horse mackerel, but with a relative increase in southern horse mackerel in the recent years.

The catch in numbers by age groups 0-3 (juveniles), 4-10 (adults), 11-15 (seniors) are shown in figure 5.8.2. The values are indicating an increase in the catches of juveniles in the Western and North Sea stocks in recent years. This could be an indication of a stronger recruitment of horse mackerel which has been reported by surveys and fishermen. However, it is also an alarming signal if a larger proportion of the catch consists of juveniles.

The relative catch in numbers by stock, age, year and cohort are shown in figure 5.8.3. This type of display allows the cohorts to be followed through the ages and years. The strong 2001 year class clearly stands out alone in the Western stock whereas in the North Sea stock the same year class and the surrounding year classes seem to be relatively strong. Year classes in the Southern area are less clearly identified which could be due to the fishery concentrating on the younger year classes.

The relative catch in numbers by stock/area, age, year and cohort are shown in figure 5.8.4. The strong 2001 year class is most noticeable in area 6 and 7 and for the younger ages in area 8. The 2001 year class is not very apparent in the western stock in 4a. For the North Sea stock, the cohort signal is only apparent in area 7 and not in area 4.

The catch in number by area and age from sampled catches is shown in figure 5.8.5. There appears to be a very limited sampling for horse mackerel in area 8a in the recent year even though there are sizeable catches in that area, predominantly believed to be of younger ages. Also in area 7.h there has been no sampling in 2016. An important signal to be derived from these plots is that there appears to be an increase in the catches of juveniles in the most recent years, mostly in area 7.d and to a lesser extend

also in area 7e. Measures to protect the incoming year classes of these species should be considered.

5.9 Quality and Adequacy of fishery and sampling data

Table 5.9.1 shows a summary of the overall sampling intensity on horse mackerel catches in recent years in all areas 1992—2017 and in the Western and North Sea stock areas for the following years. Since 2009 the Southern horse mackerel is dealt with by ICES WGHANSA.

Countries that usually carried out sampling were Ireland, the Netherlands, Germany, Norway and Spain and they covered 42—100% of their respective catches. In 2017 Denmark, France, Germany, Ireland, the Netherlands, England, Scotland and Spain provided samples and length distributions and Germany, Ireland, the Netherlands, and Spain provided also age distributions. However, the lack of age distribution data for relatively large portions of the horse mackerel catches continues to have a serious effect on the accuracy and reliability of the assessment and the Working Group remain especially concerned about the low number of fish which are aged.

Table 5.9.2 shows the sampling intensity for the Western stock in 2017, table 5.9.3 shows the sampling intensity for the North Sea stock in 2017

An analysis on the sampling intensity was carried out for the was made analyzing sampling intensity in period 2000-2017 for both the North Sea and the Western stock in last WIDE meeting (Costas, 2017b). Sampling intensity in fisheries can be defined as the ratio of sampled catch to the total catch. The precision and accuracy of sampled catch are considerable importance to obtain a reliable estimate of the commercial catch. Sampled catch is used to extrapolate to total catch in order to obtain a catch-at-age (length) and weight at age which are often used as inputs for the stock assessment models. In addition, in case of horse mackerel the impact of temporal (quarter) and spatial (area by ICES division) factors have to be taken in account in order to obtain a reliable estimate of the commercial catches.

Figure 5.9.1 shows the proportion of sampled catches by division for the North Sea stock. In general all ICES divisions show low levels of sampling especially in the last years. The sampling intensity in relation to the length composition of catch was 62% but in relation to age composition around 39 % in 2017 (Figure 5.9.2). In addition, divisions that are usually not sampled can be affect the precision and accuracy of total catch-at-age and weight at age. Figures 5.9.3 show ratio of numbers of individuals and otoliths taken to characterize the length and age composition by 1000 t of the commercial horse mackerel catches from the North Sea. These estimates can be biased, however, since samples are usually less than the recommended 100 fish/sample. (Table 5.9.1)

The proportion of the sampled catches by region for the Western stock are showed in figure 5.9.5. Most of the regions present an adequate level of sampling although the Biscay and Channel regions show low levels of sampling in the last years. The general index of sampling intensity is around 63 %, although divisions (regions) that are not sampled can affect the precision and accuracy of total catch-at-age and weight at age (Figure 9.5.6). Figures 5.9.7-8 show the ratio of numbers of individuals and otoliths taken to characterize the length and age composition by 1000 t of the commercial catches. These estimates can be biased, however, since samples are usually less than the recommended 100 fish/sample. (Table 5.9.1). It has been a significant increase in

number of measured individuals per 1000 t in 2016 and 2017 produced by large increase of number of sampled individuals in division 8.b.

Length distributions were supplied by a number of countries. However, as some countries only deliver catch-at-age distributions and others only length distributions of the catch, the obtained catch-at-age and length distributions are not reflecting the total catch especially in case of North Sea horse mackerel. Furthermore, some of the length distributions are only taken from discards of non-horse mackerel targeting fleets omitting the horse mackerel targeting fleet. This lack of coverage might also have a serious effect on the accuracy and reliability of the assessment and is a matter of concern for the Working Group.

5.10 References

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5.11 Tables

Table 5.1.1 HORSE MACKEREL general. Catches (t) by Sub-area. Data as submitted by Working Group members. Data of limited discard information are only available for some years.

SUBAREA	1979	1980	1981	1982	1983	1984	1985	1986
2	2	-	+	-	412	23	79	214
4 + 3.a	1,412	2,151	7,245	2,788	4,420	25,987	24,238	20,746
6	7,791	8,724	11,134	6,283	24,881	31,716	33,025	20,455
7	43,525	45,697	34,749	33,478	40,526	42,952	39,034	77,628
8	47,155	37,495	40,073	22,683	28,223	25,629	27,740	43,405
9	37,619	36,903	35,873	39,726	48,733	23,178	20,237	31,159
Total	137,504	130,970	129,074	104,958	147,195	149,485	144,353	193,607

SUBAREA	1987	1988	1989	1990	1991	1992	1993	1994
2	3,311	6,818	4,809	11,414	3200	13457	0	759
4 + 3.a	20,895	62,892	112,047	145,062	71,195	120,054	145,965	111,899
6	35,157	45,842	34,870	20,904	29,726	39,061	65,397	69,616
7	100,734	90,253	138,890	192,196	150,575	183,458	202,083	196,192
8	37,703	34,177	38,686	46,302	42,840	54,172	44,726	35,501
9	24,540	29,763	29,231	24,023	34,992	27,858	31,521	28,442
Disc					5,440	2,220	9,530	4,565
Total	222,340	269,745	358,533	439,901	337,968	440,280	499,222	446,974

SUBAREA	1995	1996	1997	1998	1999	2000	2001	2002
2	13151	3366	2601	2544	2557	919	310	1324
4 + 3.a	100,916	25,998	79,761	34,917	58,745	31,435	18,513	52,337
6	83,568	81,311	40,145	35,073	40,381	20,735	24,839	14,843
7	328,995	263,465	326,469	300,723	186,622	140,190	138,428	98,677
8	28,707	48,360	40,806	38,571	48,350	54,197	75,067	55,897
9	25,147	20,400	29,491	41,574	27,733	26,160	24,912	23,665
Disc	2,076	17,082	168	996	0	385	254	307
Total	582,560	459,982	519,441	454,398	364,388	274,022	282,323	247,049

SUBAREA	2003	2004	2005	2006	2007	2008	2009	2010
2	36	42	176	27	366.34	572	1847	1667
4 + 3.a	34,095	30,736	40,594	37,583	16,226	15,628	78,064	13,600
6	23,772	22,177	22,053	15,722	25,949	25,867	17,775	23,199
7	123,428	115,739	106,671	101,183	93,013	102,755	96,915	148,701
8	41,711	24,126	41,491	34,121	28,396	33,756	33,580	39,659
9	19,570	23,581	23,111	24,557	23,423	23,596	26,496	27,217
Disc	842	2,356	1,864	1,431	509	474	1,483	434
Total	243,455	218,758	235,961	214,624	187,882	202,649	256,161	254,478

SUBAREA	2011	2012	2013	2014	2015	2016	2017[1]
2	647.588	66.02912	30	424.291	10	45.276	5
4 + 3.a	25,158	5,234	8,183	17,270	10,560	11,565	12,609
6	39,496	44,971	43,266	32,444	24,153	32,186	28,170
7	120,340	120,476	100,859	66,853	49,644	46,901	33,297

8	35,245	17,209	26,983	30,844	19,822	17,511	18,307
9[3]	22,575	25,316	29,382	29,205	33,179	41,081	37,080
Disc	430	3,279	4,582	1,904	6,232	5,944	5,488[2]
Total	243,892	216,552	213,285	178,945	143,600	155,232	134,956

[1] Preliminary. [2] includes BMS of 11 tonnes

[3] Southern Horse Mackerel (ICES Division 9) is assessed by ICES WGHANSA since 2011

Table 5.1.2 HORSE MACKEREL Western and North Sea Stock combined. Quarterly catches (1000 t) by Division and Subdivision in 2017.

DIVISION	1Q	2Q	3Q	4Q	TOTAL
2.a+5.b	3	0	0	2	5
3	+	0	703	9	712
4.a	29	28	7275	2129	9461
4.bc	68	274	116	2119	2577
7.d	2851	528	848	7719	11946
6.a,b	17914	222	20	10061	28355*
7.a–c,e–k	17909	2162	632	2638	23340
8.a-e	3425	4954	4292	8543	21213
Sum	42199	8167	13886	33219	97540

+ less than 50 t, * for the total 69t were added which were only declared as yearly catch

Table 5.4.1 HORSE MACKEREL general. Landings and discards (t) by year and Division, for the North Sea, Western, and Southern horse mackerel stocks. (Data submitted by Working Group members.)

Year	3.a	4.a	4.b,c	7.d	Disc	NS Stock	2.a 5.b	3.a	4.a	6.a,b	7.a–c, e–k	8.a–e	Disc	Western Stock	W + NS Stock	Southern Stock(9.a)[x]	All stocks
1982	2,788*		-	1,247		4,035	-		-	6,283	32,231	3,073	-	61,197	65,232	39,726	104,958
1983	4,420*		-	3,600		8,020	412		-	24,881	36,926	28,223	-	90,442	98,462	48,733	147,195
1984	25,893*		-	3,585		29,478	23		94	31,716	38,782	25,629	500	96,744	126,222	23,178	149,400
1985	-		22,897	2,715		26,750	79		203	33,025	35,296	27,740	7,500	103,843	129,455	20,237	150,830
1986	-		19,496	4,756		24,648	214		776	20,343	72,761	43,405	8,500	145,999	170,251	31,159	201,806
1987	1,138		9,477	1,721		11,634	3,311		11,185	35,197	99,942	37,703	-	187,338	199,674	24,540	223,512
1988	396		18,290	3,120		23,671	6,818		42,174	45,842	81,978	34,177	3,740	214,729	236,535	29,763	268,163
1989	436		25,830	6,522		33,265	4,809		85304**	34,870	131,218	38,686	1,150	296,037	328,825	29,231	358,533
1990	2,261		17,437	1,325		18,762	11,414	14,878	112753**	20,794	182,580	46,302	9,930	398,645	419,668	24,023	441,430
1991	913	0	11,400	600	0	12,913	3,200	2,725	56,157	29,726	149,975	42,840	5,440	290,063	302,976	34,992	337,968
1992	0	0	13,955	688	400	15,043	13,457	2,374	103,725	39,061	182,770	54,172	1,820	397,379	412,422	27,858	440,280
1993	0	0	3,895	8,792	930	13,617	0	850	141,220	65,397	193,291	44,726	8,600	454,084	467,701	31,521	499,222
1994	0	0	2,496	2,503	630	5,629	759	2,492	106,911	69,616	193,689	35,501	3,935	412,903	418,532	28,442	446,974
1995	112	0	7,948	8,666	30	16,756	13,151	128	92,728	83,568	320,329	28,707	2,046	540,657	557,413	25,147	582,560
1996	1,657	0	7,558	9,416	212	18,843	3,366	0	16,783	81,311	254,049	48,360	16,870	420,739	439,582	20,400	459,982
1997	0	0	14,078	5,452	10	19,540	2,601	2,037	63,646	40,145	321,017	40,806	158	470,410	489,950	29,491	519,441
1998	3,693	0	10,530	16,194	83	30,500	2,544	3,693	17,001	35,073	284,529	38,571	913	382,324	412,824	41,574	454,398
1999	0	0	9,335	27,889	0	37,224	2,557	2,095	47,315	40,381	158,733	48,350	0	299,431	336,655	27,733	364,388
2000	0	176	25,931	19,019	4	45,130	919	1,014	4,314	20,735	121,171	54,197	382	202,732	247,862	26,160	274,022
2001	43	212	6,686	21,390	0	28,331	310	134	11,438	24,839	117,038	75,067	254	229,081	257,411	24,912	282,323
2002	0	639	15,303	11,323	0	27,264	1,324	174	36,221	14,843	87,354	55,897	307	196,120	223,384	23,665	247,049
2003	49	622	10,309	21,049	0	32,028	36	1,843	21,272	23,772	102,379	41,711	842	191,856	223,885	19,570	243,455
2004	303	133	18,544	16,455	0	35,435	42	48	11,708	22,177	99,284	24,126	2,356	159,742	195,177	23,581	218,758
2005	0	1,331	13,995	15,460	62	30,848	176	284	24,983	22,053	91,211	41,491	1,802	182,001	212,850	23,111	235,961
2006	185	2,192	7,996	23,789	78	34,240	27	58	27,152	15,722	77,394	34,121	1,353	155,827	190,067	24,557	214,624
2007	11	2,051	9,114	29,789	139	41,103	366	110	4,940	25,949	63,224	28,396	370	123,356	164,459	23,423	187,882
2008	27	910	2,582	32,185	0	35,704	572	3	12,107	25,867	70,570	33,756	474	143,349	179,053	23,596	202,649
2009	21	314	18,975	25,537	1,036	45,883	1,847	17	58,738	17,775	71,378	33,580	447	183,782	229,665	26,496	256,161
2010	0	100	1,969	22,077	2	24,149	1,667	88	11,442	23,199	126,624	39,659	432	203,112	227,261	27,217	254,478
2011	0	0	10,435	17,184	0	27,619	648	0	14,723	39,496	103,156	35,245	430	193,698	221,317	22,575	243,892
2012	0	355	1,559	19,464	0	21,378	66	9	3,311	44,971	101,012	17,209	3,279	169,858	191,236	25,316	216,552
2013	0	17	1,453	17,175	0	18,645	30	10	6,702	43,266	83,684	26,983	4,582	165,258	183,903	29,382	213,285
2014	1	2	2,597	10,772	7	13,380	424	4,096	10,573	32,444	56,081	30,844	1,896	136,360	149,740	29,205	178,945

Year	3.a	4.a	4.b,c	7.d	Disc	NS Stock	2.a 5.b	3.a	4.a	6.a,b	7.a–c, e–k	8.a–e	Disc	Western Stock	W + NS Stock	Southern Stock(9.a)[x]	All stocks
2015	3	644	770	8,581	2,004	12,002	10	65	9,078	24,153	41,063	19,822	4,228	98,419	110,421	33,179	143,600
2016	2	1,628	975	11,209	1,527	15,341	45	0	8,960	32,186	35,692	17,511	4,417	98,811	114,151	41,081	155,232
2017	0	22	2,557	10,787	1,213	145,79	5	697	9,332	28,170	22,510	18,307	3,939	82,961	97,540	37,088	134,956

***Divisions 3.a and 4.b,c combined· **Norwegian catches in 4.b included in Western horse mackerel· [x] Southern Horse Mackerel is assessed by ICES WGHANSA since 2011**

Table 5.4.2 National catches of the Western Horse mackerel stock.

COUNTRY	1997	1998	1999	2000	2001	2002	2003	2004	2005
Belgium	18	19	21	0	-	-	-	-	-
Denmark	62,897	31,023	26,040	16,385	21,254	10,147	11340	11,667	10,155
Estonia	78	22	-	0	-	-	-	3,826	3,695
Faroe Islands	1,095	216	1,040	24	800	671	4	8,056	10,690
France	39,188	26,667	25,141	20,457	15,145	18,951	10,381	17,744	16,364
Germany, Fed.Rep.	28,533	33,716	23,549	13,014	11,491	12,658	15,696	26,432	34,607
Ireland	74,250	73,672	57,983	55,229	51,874	36,422	35,857	-	-
Lithuania	-	-	-	-	-	-	-	40986	41,057
Netherlands	82,885	103,246	83,450	57,261	73,440	44,997	48,924	10729	24,909
Norway	45,058	13,363	46,648	1,982	7,956	36,164	20,371	16,272	16,636
Russia	554	345	121	80	16	3	2	567	216
Spain	31,087	43,829	39,831	24,204	23,537	24,763	24,599	4,617	3,560
Sweden	1,761	3411	1,957	1009	68	561	1,002	458	210
UK (Engl. + Wales)	19,778	13,068	9,268	4,554	7,096	5,970	4,438	1,522	143
UK (N. Ireland)	-	1,158	-	625	1140	1129	914	14,506	17,962
UK (Scotland)	32,865	18,283	11,197	10,283	8,026	2,905	721	2356	1802
Unallocated	17,158	15,262	23,763	-2757	6,978	472	16,765	159,737	182,006
Discard	158	913	-	382	254	307	842	-	-
Total	437,363	378,213	350,009	202,732	229,075	196,120	191,856	11,667	10,155

COUNTRY	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	-	-	-	-	19	2	0.2	14
Denmark	8,411	7,617	5,261	6,027	5,940	6,108	4,002	6,820
Faroe Islands	-	478	841	-	377	349	-	
France	11,031	12,748	12,626	-	260	8,271	1,797	3,595
Germany, Fed.Rep.	10,862	5,784	11,801	15,122	17,688	21,114	17,063	24,835
Ireland	26,779	29,759	35,332	40,754	44,488	38,466	45,239	35,791
Lithuania	6,828	5,467	5,548	-	-	-	-	
Netherlands	37,130	29,462	43,648	39,453	61,504	55,690	66,396	53,697
Norway	27,114	4,182	12,223	59,764	11,978	13,755	3,251	6,596
Spain	13,877	14,277	19,851	21,077	38,745	34,581	13560	22,541
Sweden	-	76	8	258	2	90	-	1
UK (Engl. + Wales)	3,574	5,482	3,365	6,482	12,714	11,716	12,122	3,959
UK (N. Ireland)	103	-	-	-	59	198	-	2,325
UK (Scotland)	468	776	1,077	1,412	2,349	2,928	1,335	504
Unallocated	8,292	6,878	-8,703	-7,014	6,556	-	1815	-
Discard	1353	370	474	447	432	430	3,280	4,582
Total	155,822	123,356	143,352	183,782	203,111	193,698	169,860	165,260

COUNTRY	2014	2015	2016	2017[1]
Belgium				
Denmark	5,945	4,556	321	4,541
Faroe Islands	68	-	-	180
France	3,428	3,247	2,797	3,923
Germany, Fed.Rep.	17,161	9,417	11,414	7,172
Ireland	32,667	21,654	27,605	23,560
Lithuania	-	-	2,596	-
Netherlands	25,053	24,958	23,792	14,269
Norway	14,353	8,897	9,438	9,885
Spain	19,442	13,071	14,235	14,901
Sweden	0	10	-	41
UK (Engl. + Wales)	4,832	2,063	842	549
UK (N. Ireland)	1,579	1,204	-	
UK (Scotland)	1,389	738	970	-
Unallocated	8,545	4,377	1,010	3,994
Discard	1,896	4,228	4,417	3,928
Total	136,360	98,419	98,810	82,950

[1]**Preliminary**

Table 5.4.3. National catches of the North Sea Horse mackerel stock.

COUNTRY	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Belgium	-	19	21			30	5	4	4	-
Denmark	180	1,481	3,377	4,403	885	2,315	3,301	8,690	3,987	8,353
Faroe Islands	-	-	135	-	-	28	804	21	-	-
France	3,246	2,399	-	-		1,246	2,326	231	5,236	1,205
Germany, Fed.Rep.	7,847	5,844	5,920	3,728	974	6,532	2,936	5,194	2,725	11,034
Ireland	-	2,861	27	201	338	61	-	1	753	10,863
Lithuania	-	10,711	-	-	-	-	-	-	-	26,779
Netherlands	36,855	-	8,117	8,697	13,867	12,209	24,119	26,303	27,730	6,829
Norway	-	-	238	105	36	525	144	22	204	37,130
Sweden	-	3,401	5	40	46	16	72	98	4	27,114
UK (Engl. + Wales)	269	907	11	1,585	3,425	2,322	1,966	5,633	3,859	-
UK (Scotland)	29	-	-	421	-	2	1	2	-	13,878
Unallocated	-28,896	2,794	19,373	25,944	8,805	1,981	-3,645	-13,064	-13,719	-
Discard	10	83	-	4	-		-	-	62	3,583
Total	19,540	30,500	37,224	45,128	28,376	27,267	32,029	33,135	30,845	155,094

COUNTRY	2006	2007	2008	2009	2010	2011	2012	2013	2014
Belgium				4	16		46	51.077	74
Denmark	1,283	252	57	72	15	142	1514	1,020	552
Faroe Islands	-	-	-	-	-	-	0		
France	4,380	5,349	2,247	-	813	273	1,047	1,010	1,742
Germany, Fed.Rep.	1,125	65	1,081	1,539	3,794	3,461	5,356	2,941	1,619
Ireland	2,077		887	25	-	-	0		0
Lithuania	1,999	297	-	-	-	-	0		0
Netherlands	27,285	31,153	19,439	22,546	17,093	16,289	12,157	8,725	4,925
Norway	113	1,243	21	12,855	526	7,359	129	377	0
Sweden	9	21	36	401	-	-	0		1
UK (Engl. +	595	6921	1,061	1,435	1,890		935	4,401	4,198
UK (Scotland)	300	625	7	4	111	93	240	172	262
Unallocated	-5,004	-4,960	10,869	5,964	-116	0	0	0	
Discard	78	139	-	1,036	2	0	0	0	7
Total	34,240	41,105	35,705	45,881	24,144	27,617	21,424	18,696	13,380

COUNTRY	2015	2016	2017[1]
Belgium	63	51	67
Denmark	800	268	294
Faroe Islands	0	0	4
France	934	1,322	1,863
Germany, Fed.Rep.	644	1,879	949
Ireland	0	0	0
0Netherlands	3,305	3,892	5,638
Norway	662	1,701	5
Sweden	9	0	0
UK (Engl. + Wales)	3,581	4,697	4,546
UK (Scotland)	0	0	0
Unallocated	0	0	0
Discard	2,004	1,527	1,213
Total	12,002	15,337	14,579

[1]**Preliminary**

Table 5.6.1. Catches (t) of *Trachurus mediterraneus* in Divisions 8.ab, 8.c and Sub-Area 7

	7	8.ab	8.c East	8.c West	TOTAL
1989	0	23	3903		3926
1990	0	298	2943		3241
1991	0	2122	5020		7142
1992	0	1123	4804		5927
1993	0	649	5576		6225
1994	0	1573	3344		4917
1995	0	2271	4585		6856
1996	0	1175	3443		4618
1997	0	557	3264		3821
1998	0	740	3755		4495
1999	0	1100	1592		2692
2000	59	988	808		1854
2001	1	525	1293		1820
2002	1	525	1198		1724
2003	0	340	1699		2039
2004	0	53	841		894
2005	1	155	1005		1162
2006	1	168	794		963
2007	0	126	326		452
2008	0	82	405		487
2009	0	42	1082		1124
2010	0	97	370		467
2011	0	119	1096		1225
2012	0	186	667	116	969
2013	0	52	238	0	290
2014	0	130	1160	0	1290
2015	0	8	890	0	899
2016	0	5	471	0	476
2017	0	18	684	0	702

Table 5.7.1 Horse mackerel general. Length distributions (%) Catches by fleet and country in 2017. (0%= <0.5%)

	Netherlands	Netherlands	Netherlands	Netherlands	Netherlands	Netherlands	Netherlands	Netherlands	Netherlands	Germany	Germany	Germany	France	Ireland	UK (Scotland)	UK (Scotland)	Spain	Spain	Spain	Spain
	4a	4c	6a	7b	7c	7d	7e	7h	7j	6a	7b	7e	7d	all	4a	6a	8bc	8bc	8bc	8bc
cm	OTM_SPF_32-69_0_0_all	OTM_SPF_32-69_0_0_all	OTM_SPF_32-69_0_0_all	OTM_SPF_32-69_0_0_all	OTM_SPF_32-69_0_0_all	OTM_SPF_32-69_0_0_all	OTM_SPF_32-69_0_0_all	OTM_SPF_32-69_0_0_all	OTM_SPF_32-69_0_0_all	OTM_SPF_32-69_0_0_all	OTM_SPF_32-69_0_0_all	OTM_SPF_32-69_0_0_all	all - discards	HM-All	Demersal discards	Demersal discards	Trawl landings	Trawl discards	Artisanal	Purse
5																				
6																				
7																		0		
8													0					2		
9												0	0					30		
10												2	0		0	0		31		
11												7	1		0	0		10		
12												8	1		1	0		4		0
13												7	0		1	1	4	3		1
14												2	1		1	1	12	5		5
15												7	2		1	3	10	5		4
16							1					16	3		1	4	9	3		3
17		1				1	6	2				9	8	0	1	4	7	2		3
18		3				9	10	4		1		7	10	0	1	4	3	1		3
19		3	0	0		10	6	9		3	0	9	8	0	1	3	2	1		5
20		4	1	1		3	10	14		10	1	3	10	2	1	4	2	0		4
21		16	4	1		9	18	16		14	1	4	17	3	2	2	1	0		2
22		28	7	1		18	25	11		11	1	6	16	5	5	4	2	0		2
23		21	12	1		19	15	12		6	1	6	10	5	10	5	7	0		1
24		16	22	0		9	6	6		3	0	4	4	5	12	12	8	0		1
25		4	19	0		7	1	4		4	0	1	3	4	17	20	5	0	5	2
26		3	5	0		5	1	4		4	1	1	3	3	14	11	4	0	5	3
27	1		1	4		5		3		4	1	0	2	3	12	9	4	0	13	4
28	2	1	1	9		2		3		4	4		1	4	9	6	2	0	13	4
29	5		1	15	2	2		2		5	7		1	7	5	3	2	0	13	5
30	5		4	19	14	1		2		5	13		0	11	2	2	1	0	14	4
31	7		5	26	10	0		1	8	5	16		0	12	1	2	2	0	13	5
32	19		4	12	24	0		2	8	6	19		0	12	1	2	2	0	9	6
33	21		5	5	16			2	20	6	14		0	10	0	0	2	0	4	7
34	21		5	4	14			0	40	4	10		0	8	0		2	0	4	8
35	7		3	0	6			1	16	2	5		0	5		1	2	0	3	7
36	4		1	0	6			0	4	1	2		0	2			1	0		5
37	4		0	0	6			0	4	1	2		0	1			1	0		4
38	3		0	0				0		0	1		0	0			1			2
39	2									0	0			0			0	0		1
40	0		0		2					0	0			0						0
41			0							0	0		0				0		1	0
42+				0						0	0			0			0			0

Table5.9.1. Summary of the overall sampling intensity on horse mackerel catches in recent years in all areas 1992—2017

Year	TOTAL CATCH (ICES estimate)	% catch covered by sampling programme*	No. samples	No. Measured	No. Aged
1992	436 500	45	1 803	158447	5797
1993	504190	75	1178	158954	7476
1994	447153	61	1453	134269	6571
1995	580000	48	2041	177803	5885
1996	460200	63	2498	208416	4719
1997	518900	75	2572	247207	6391
1998	399700	62	2539	245220	6416
1999	363033	51	2158	208387	7954
2000	247862	50	378	33317	4126
2001	257411	61	467	46885	7141
2002	223384	68	540	79103	6831
2003	223885	77	434	59241	8044
2004	195177	62	518	62720	9273
2005	212850	76	573	67898	8840
2006	190067	75	602	57701	9905
2007	164459	58	397	41046	8061
2008	179053	72	488	46768	8870
2009	229665	84	902	57505	10575
2010	227261	82	710	49307	14159
2011	221317	71	502	40492	7484
2012	191236	69	501	41148	8220
2013	183903	75	686	87300	9776
2014	149740	83	650	53945	8085
2015	110421	68	825	39415	7034
2016	114151	76	1033	93853	6675
2017	97539	63	1113	116722	8221

***Percentage related to catch (catch-at-age) acc. to ICES estimation**

Table 5.9.2. Horse mackerel sampling intensity for the Western stock in 2017.

COUNTRY	CATCH	% CATCH SAMPLED*	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	4580	0	0	0	0
Faroe Islands	180	0	0	0	0
France**, ***	5645	0	440	4383	0
Germany	7183	68	41	13730	875
Ireland	23560	95	32	5782	1797
Netherlands	14269	89	50	7158	1236
Norway	9885	0	0	0	0
Spain	16929	95	960	83820	3545
Sweden	43				
UK (England)***	612	0	90	624	0
UK(Scotland)***	70	0	53	668	0
Total	82961	69	1226****	116165	7453

***Percentage based on ICES estimate - ** based on length samples from discards in non-targeting horse mackerel fisheries**

*****provided only length distributions **** based on age sampling**

Table 5.9.3. Horse mackerel sampling intensity for the North Sea stock in 2017

COUNTRY	CATCH	% CATCH SAMPLED*	NO. SAMPLES	NO. MEASURED	NO. AGED
Belgium	67	0	0	0	0
Denmark	340	88	1	111	44
Faroe Islands	4	0	0	0	0
France**	3023	0	250	3118	0
Germany	949	0	0	0	0
Netherlands	5637	93	29	6121	724
Norway	5	0	0	0	0
UK (England)	4578	0	0	0	0
Total	14579	46	30***	9350	768

***Percentage based on ICES estimate. **provided only length distributions**

***** based on age sampling**

5.12 Figures

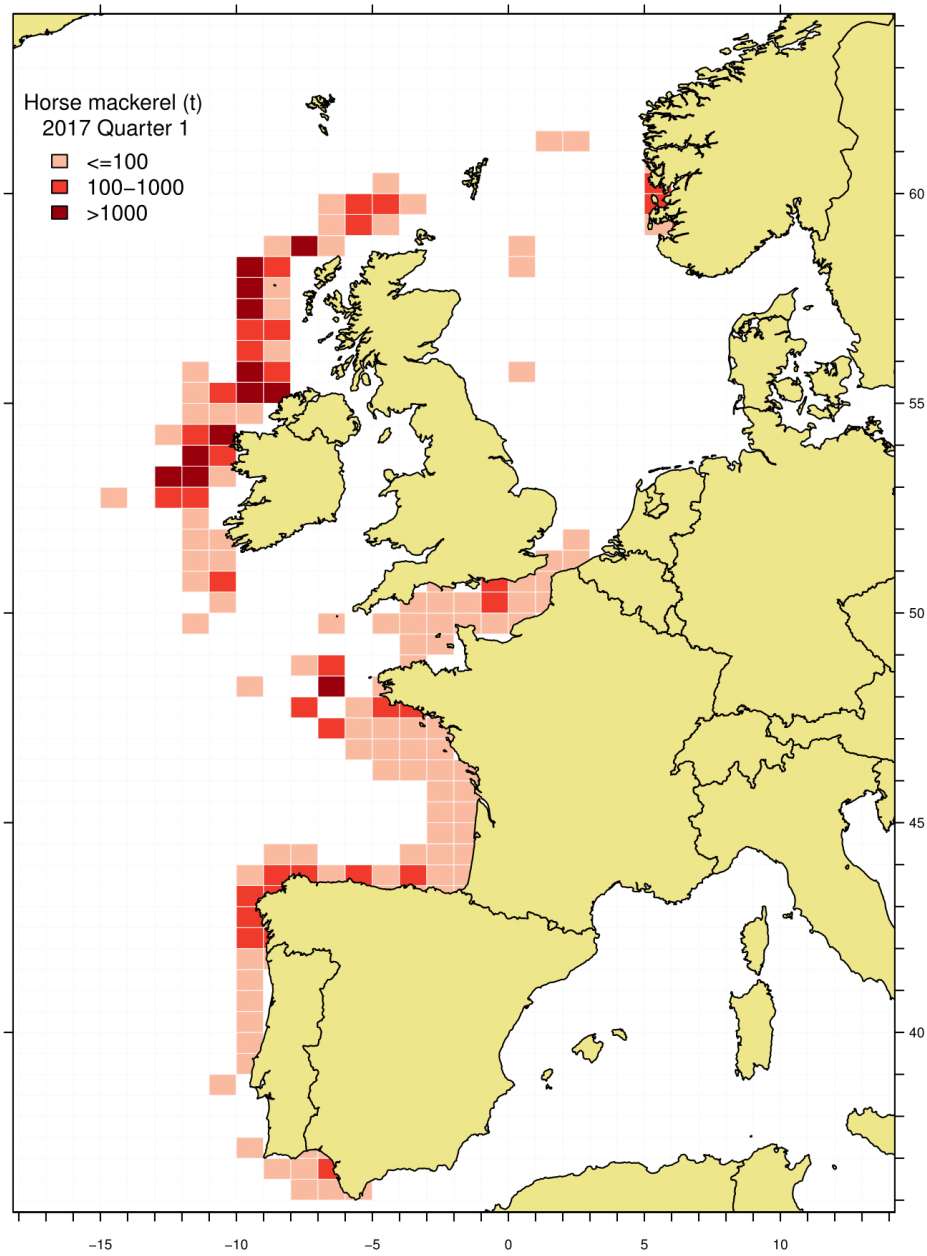

Figure 5.1.1a. Horse mackerel catches 1st quarter 2017.

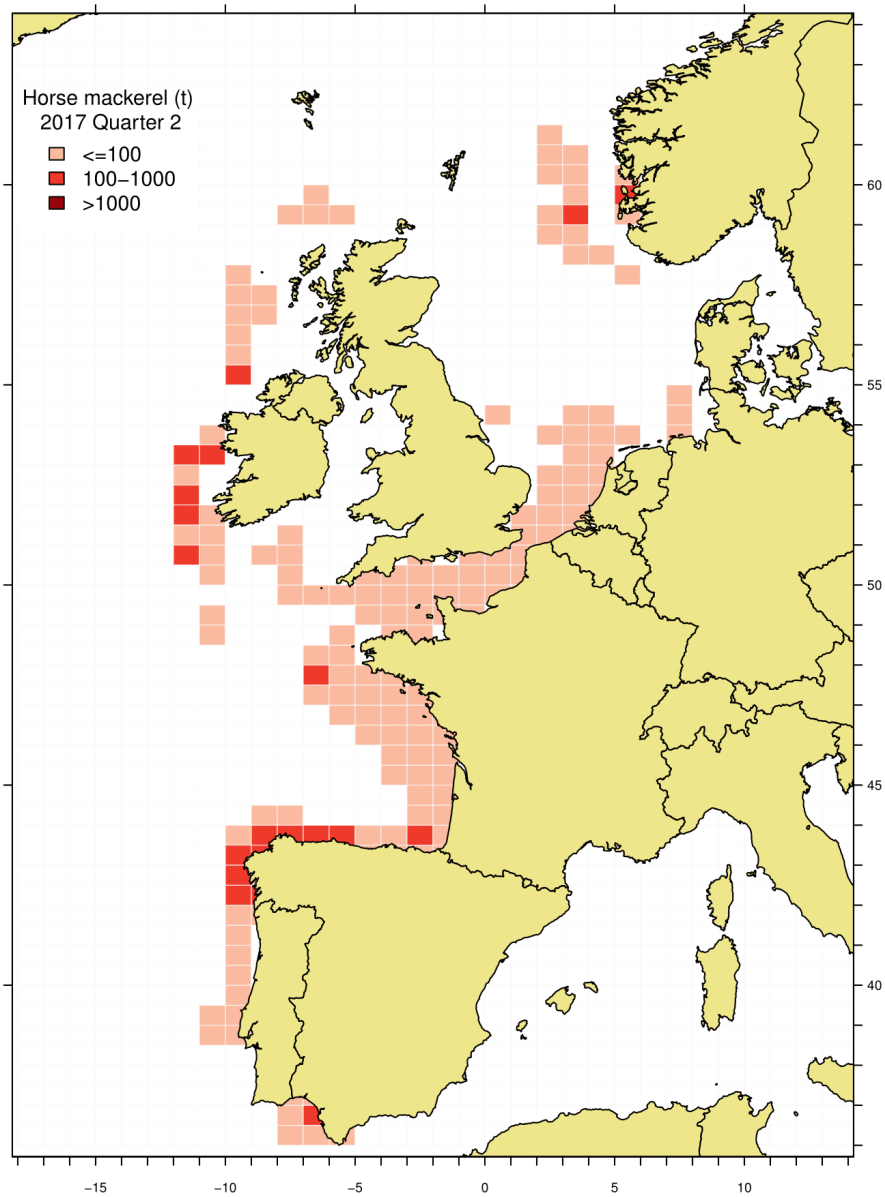

Figure 5.1.1b. Horse mackerel catches 2nd quarter 2017.

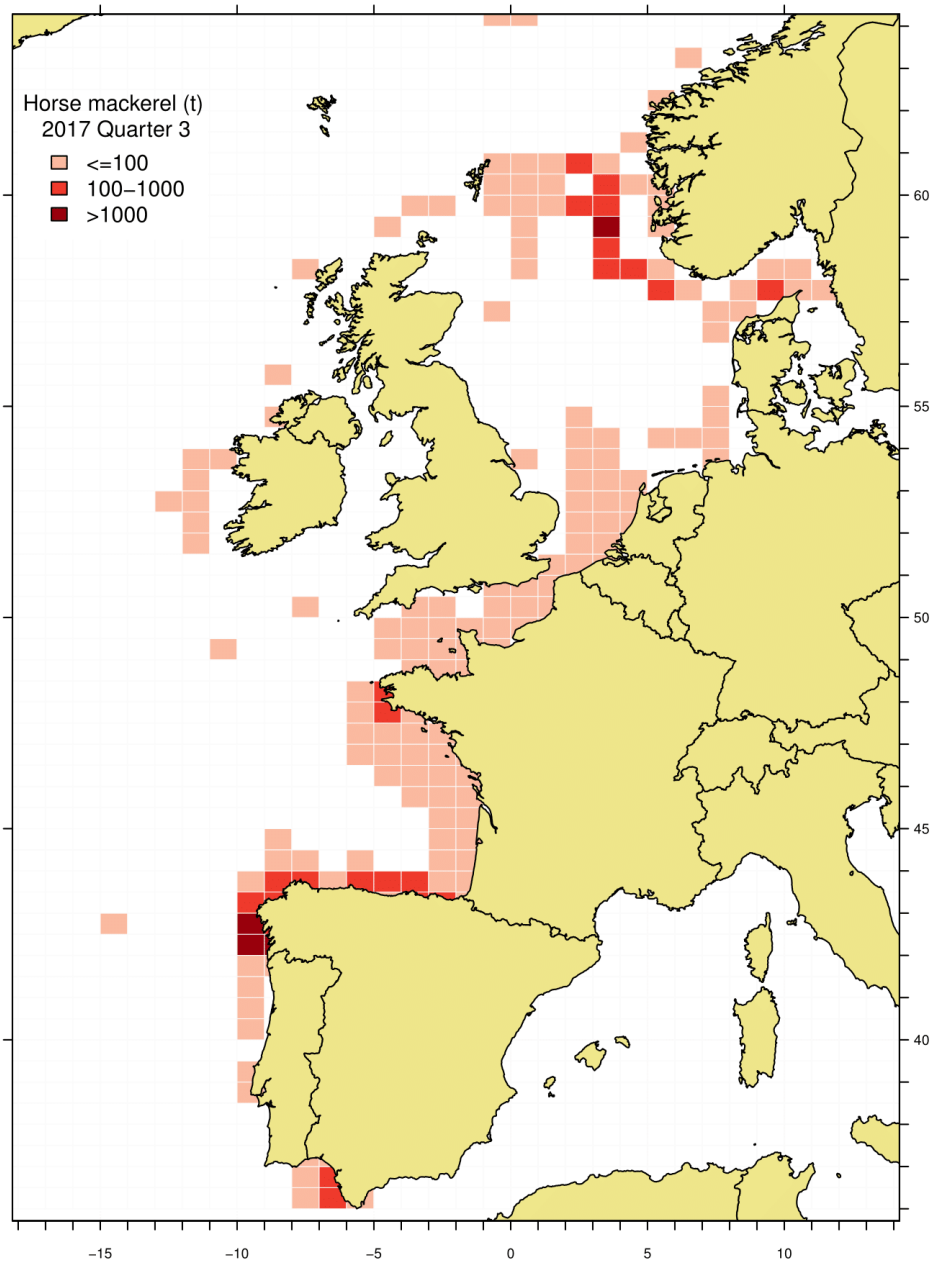

Figure 5.1.1c. Horse mackerel catches 3rd quarter 2017.

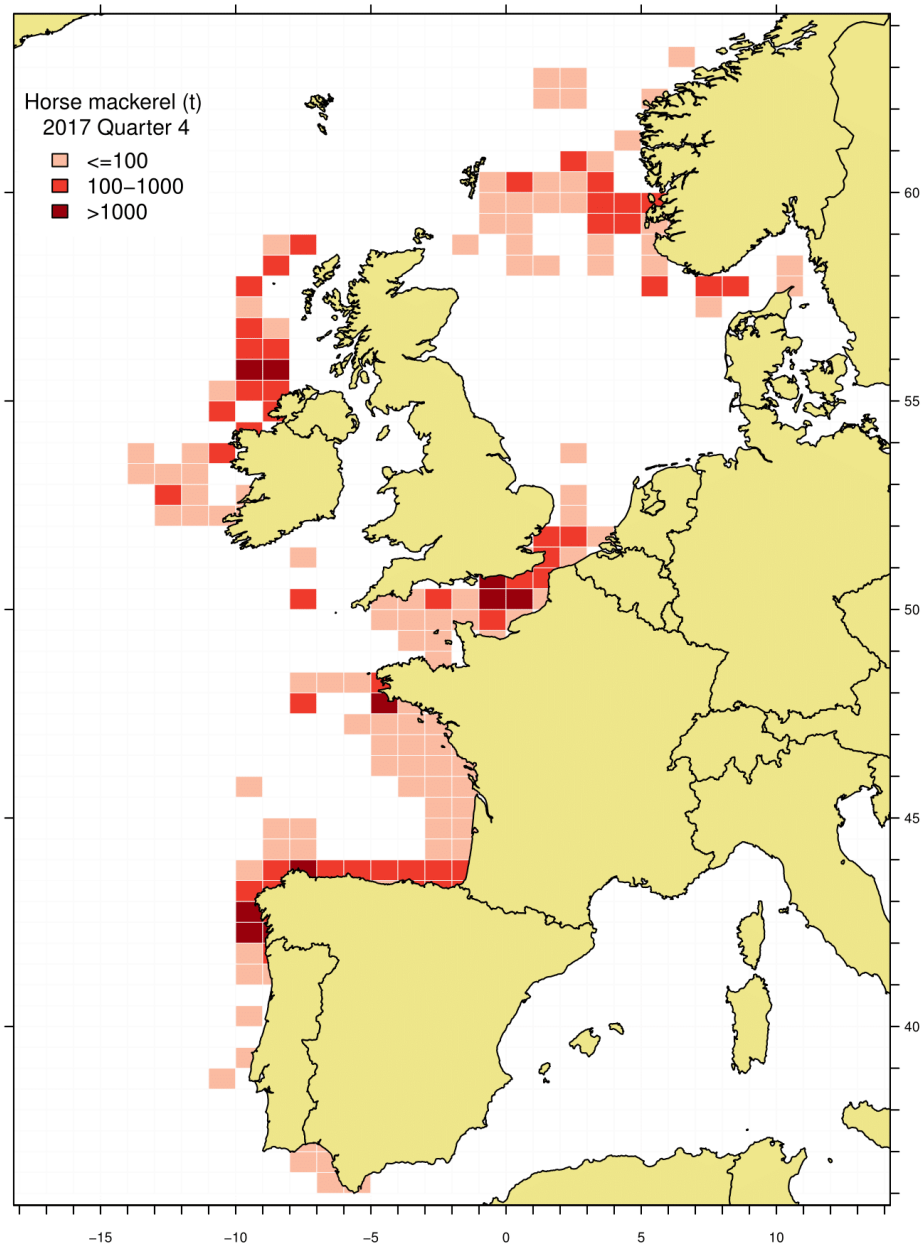

Figure 5.1.1d. Horse mackerel catches 4th quarter 2017.

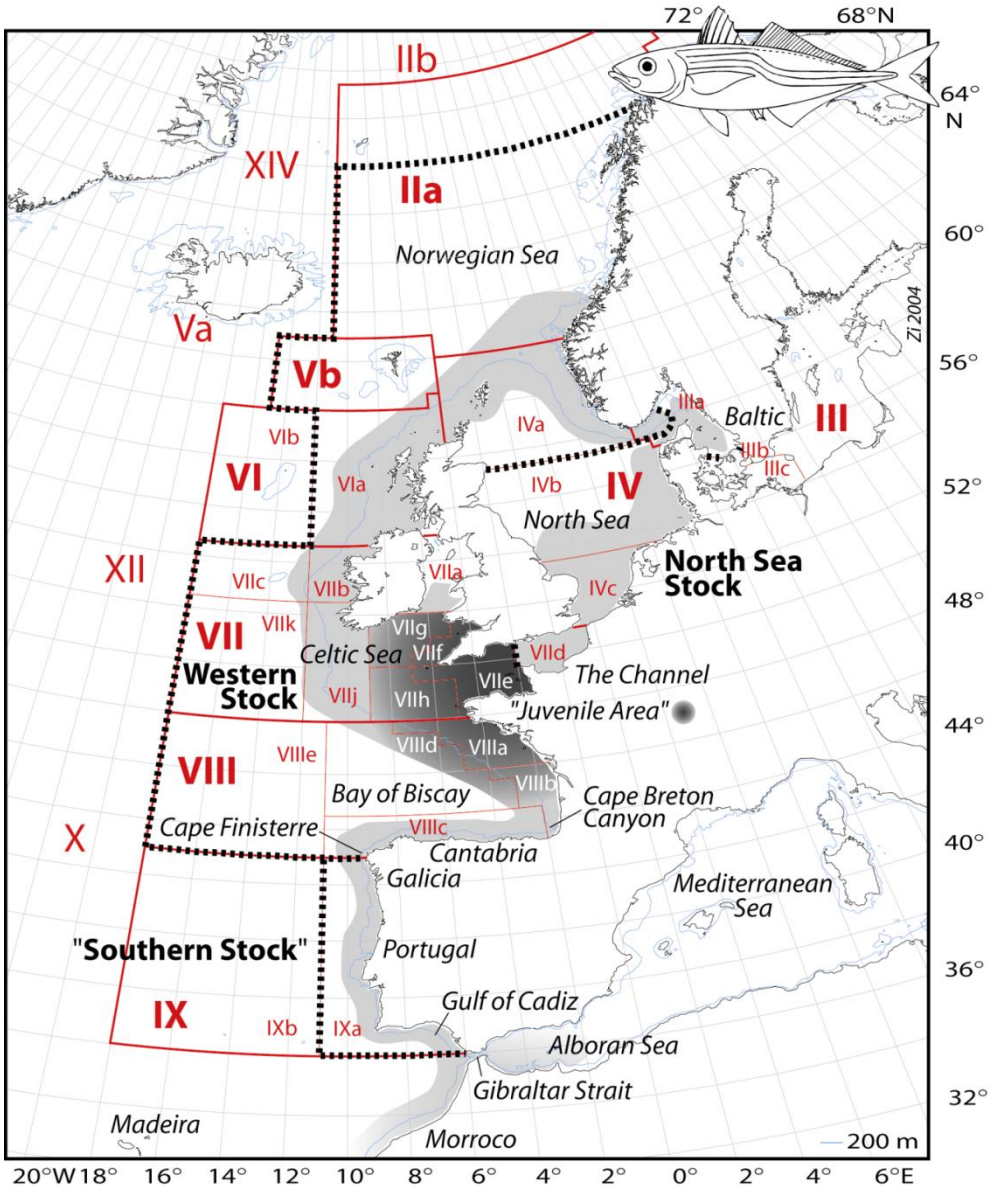

Figure 5.2.1: Distribution of Horse Mackerel in the Northeast-Atlantic: Stock definitions as used by the 2004 WG MHSA. Note that the "Juvenile Area" is currently only defined for the Western Stock distribution area – juveniles do also occur in other areas (like in Div. 7.d). Map source: GEBCO, polar projection, 200 m depth contour drawn.

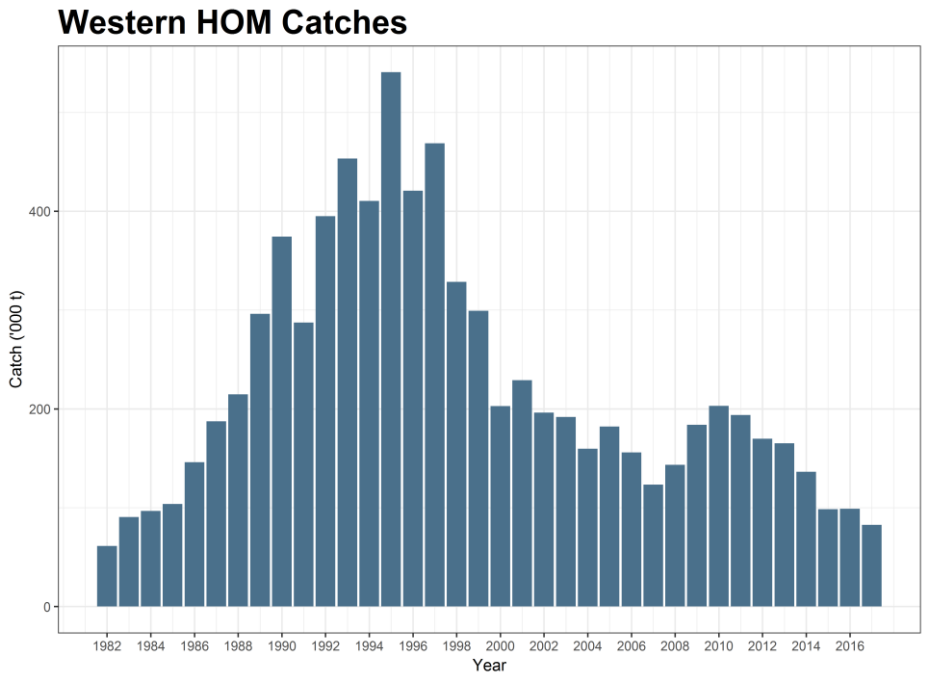

Figure 5.3.1. Total catch for Western Horse Mackerel stock, period 1982–2017.

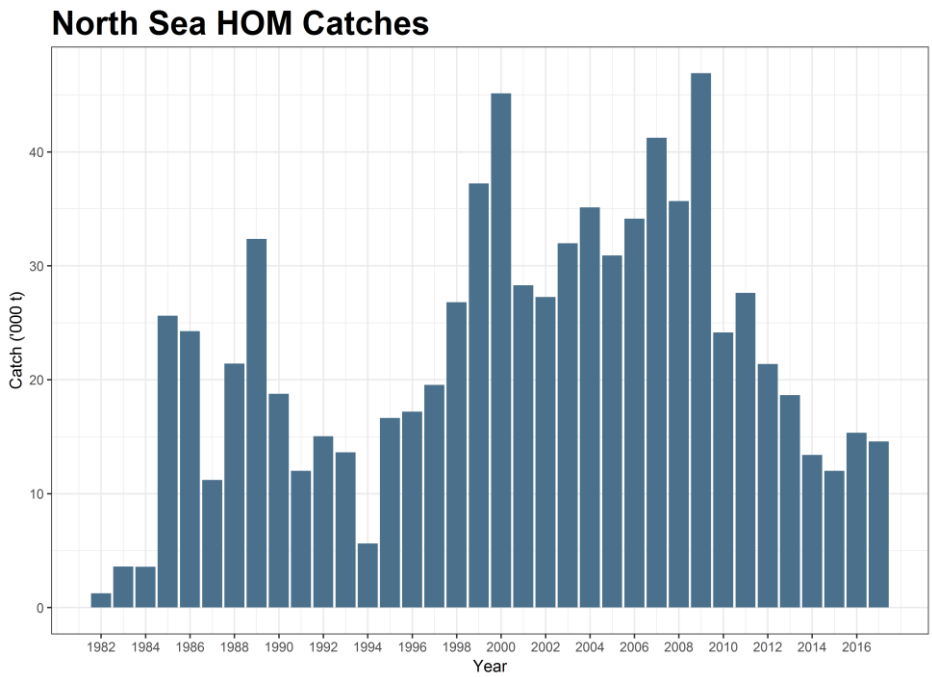

Figure 5.3.4. Total catch for North Sea Horse Mackerel stock, period 1982-2017

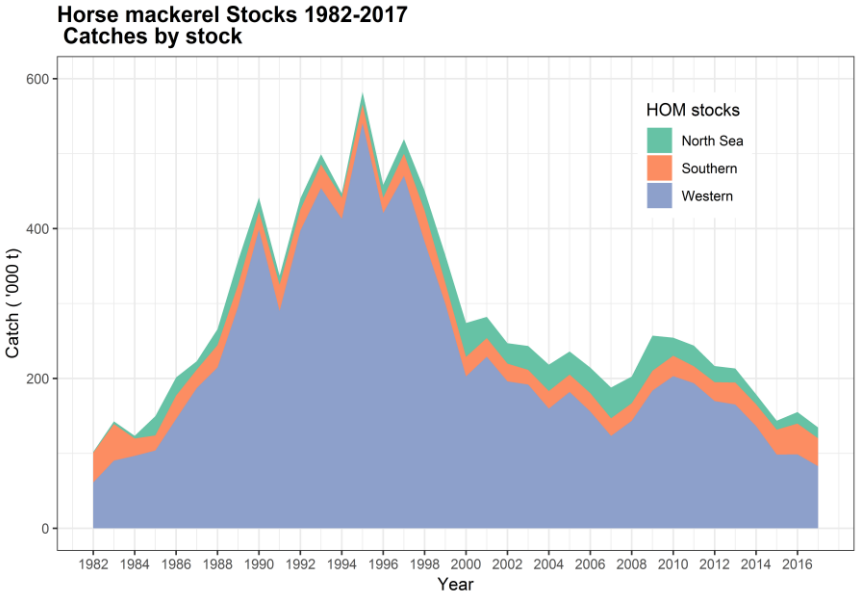

Figure 5.4.1 Horse mackerel general. Total catches in the northeast Atlantic during the period 1982—2017. The catches taken from the southern, western and North Sea horse mackerel stocks are shown in relation to the total catches in the northeast Atlantic. Catches from Div. 8.c were transferred from southern stock to western stock from 1982 onwards. Southern horse mackerel is assessed by ICES WGHANSA since 2011.

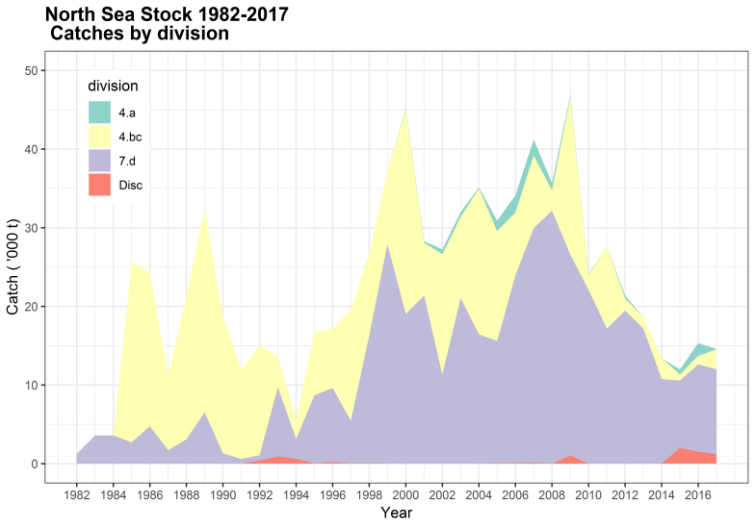

Figure 5.4.2. North Sea horse mackerel stock. Total catches by Division during the period 1982-2017.

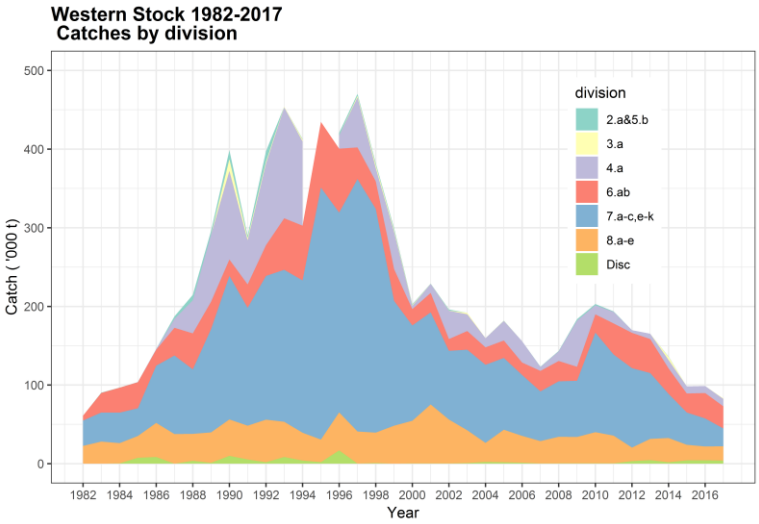

Figure 5.4.3. Western horse mackerel stock. Total catches by Sub-Area during the period 1982–2017.

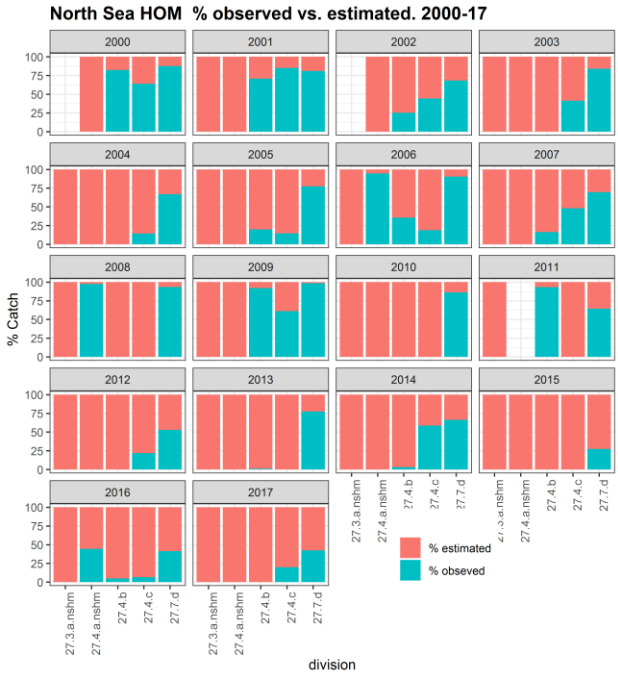

Figure 5.9.1 North Sea horse mackerel stock. Percentage sampled catch (blue) vs. unsampled catch (red) by division and year. Period 2000–2017.

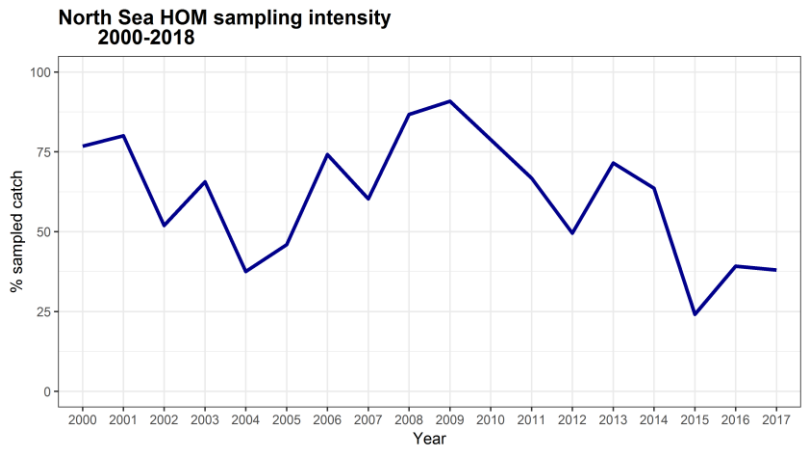

Figure 5.9.2. North Sea horse mackerel stock. Sampling intensity index as percentage sampled catch in total catch by year. Period 2000–2017.

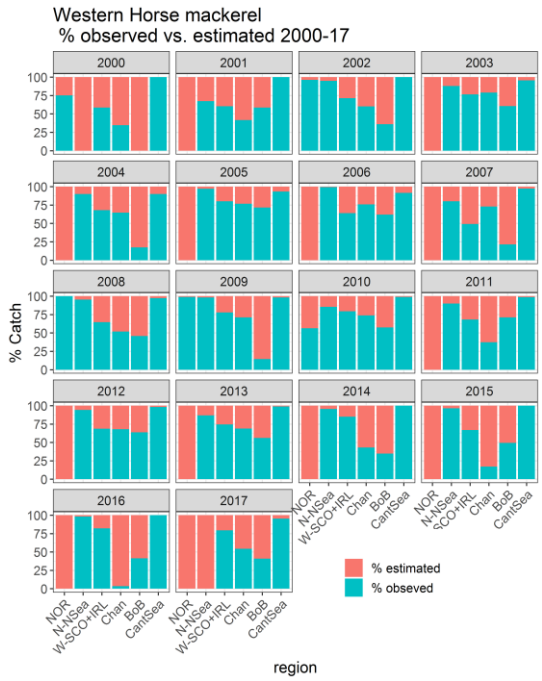

Figure 5.9.5. Western horse mackerel stock. Percentage sampled catch (blue) vs. unsampled catch (red) by division and year. Period 2000-2017. Area of distribution of Western stock was divided into different regions. Chan: (7.e,f,h); W- SCO+IRL (7.a-c, 7.j-k and 6.a); BoB (8.a,b,d); CanSea(8.c); N-Nsea (3.a and 4.a); NOR (2.a and 5.a).

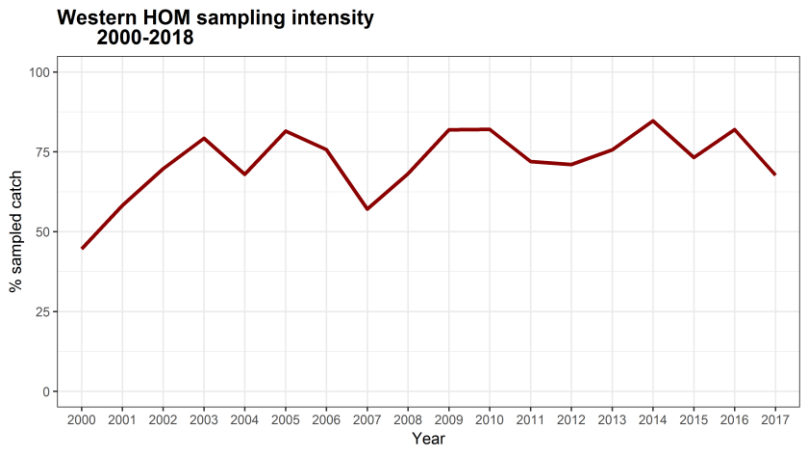

Figure 9.5.6. Western horse mackerel stock. Sampling intensity index as percentage sampled catch in total catch by year. Period 2000–2017.

6 Horse Mackerel: Divisions 27.4.a (Q1 and Q2), 27.3.a (excluding Western Skagerrak Q3 and Q4), 27.4.b, 27.4.c and 27.7.d

6.1 ICES Advice Applicable to 2018

In 2012 the North Sea horse mackerel (NSHM) was classified as a category 5 stock, based on the ICES approach to data-limited stocks (DLS). Since then, a progressive reduction of TAC was advised by ICES, from 25500 tonnes in 2013-2014 to 15200 tonnes in 2015-2016. This reduction in the advised catch was supported by the analysis of information from the North Sea International Bottom Trawl Survey (NS-IBTS) traditionally used in the assessment, but also new information from the Channel Ground Fish Survey (CGFS) since 2014. Despite the considerable increase showed by the CGFS in 2015 survey, due to the high uncertainty in the two survey indices, catch in 2017 was advised to continue at 15200 tonnes. However, new information indicated a 16.7% discards of NSHM in 2015 in non-directed fisheries. This new information is taken into account in the catch advice for 2017. The advice landings were 15200 tonnes and the advice total catch was 18247 tonnes.

In 2017 this stock was benchmarked and the NS-IBTS and CGFS survey indices where modelled together. The resulting joint index was considered a proper indication of trend in abundance over time and the NSHM stock was upgraded to category 3. The joint survey index showed in 2016 a continuation of the increasing trend started in 2013. The application of the HCR 3.1 (ICES, 2012, comparison of the two latest index values with the three preceding values multiplied by the recent advised catch) resulted in an increase higher than 20% in the catch advice for 2018 in comparison to advice for 2017. Accordingly the uncertainty cap was applied. In addition, Length Based DLS methods indicated that the F was in 2016 slightly above the F_{MSY} proxy, and stock size relative to reference points was unknown. Therefore, the precautionary buffer was also applied to the advice, since it hadn´t been applied since 2014. This resulted in a catch advice for 2018 and 2019 no more than 17517 tonnes. Considering the 13.35% average discards, were advice not being higher than 15179 tonnes.

6.2 Fishery of North Sea horse mackerel stock

Based on historical catches taken by the Danish industrial fleet for reduction into fishmeal and fish oil in the 1970s and 1980s, approximately 48% of the EU North Sea horse mackerel TAC was taken by Denmark. Catches were taken in the fourth quarter mainly in Divisions 27.4.b and 27.7.d. The 1990s saw a drop in the value of industrial fish, limited fishing opportunities and steep increases in fuel costs that affected the Danish quota uptake. In 2001, individual quota scheme for a number of species was introduced in Denmark, but not for North Sea horse mackerel. This lead to a rapid restructuring and lower capacity of the Danish fleet, which in combination with the above mentioned factors led to a decrease of the Danish North Sea horse mackerel catches.

Since the 1990's, a larger portion of catches has been taken in a directed horse mackerel fishery for human consumption by the Dutch freezer-trawler fleet. This is possible because Denmark has traded parts of its quota with the Netherlands for other species. However due to the structure of the Danish quota management setup only a limited amount of quota can be made available for swaps with other countries. These practical implications of the management scheme largely explain the consistent underutilisation of the TAC over the period 2010-2013 (approximately 50%). However, following the sharp reduction in TAC in 2014 uptake increased significantly to above 80% in 2015

and 100% in 2016 (see Figure 6.2.1), although an important part of these catches were discards (16.7% and 10% respectively). In 2017 the 80% of the TAC was used, with an 8.3% discards.

Catches taken in Divisions 27.3.a and 27.4.a during the two first quarters and all year in Divisions 27.4.b, 4.c and 27.7.d are regarded North Sea horse mackerel (Section 5, Table 5.4.1). The catches were relatively low during the period 1982—1997 with an average of 18000 tonnes, but increased between 1998 (30500 tonnes) and 2000 (45130 tonnes). From 2000 to 2010, the catches varied between 24149 and 45883 tonnes. Since 2014 a steep decline in catches is observed, both due to the reduction in the TAC since 2014 but also the underutilization of the quota. In 2017 the catch was 14579 tonnes, with an 82% of total catch being caught in area 27.7.d.

Over the period 1985-2001 most catches were taken in the area 27.4.b (Figure 6.2.3). However, since 2002 the proportion of catches from area 27.7.d increased steadily until 2013, when the 92% of total catches were fished in this area (Figure 6.2.2). Germany, UK and Netherlands accounted for most of the landings, that were taken in quarter 1, but especially in quarter 4 (Figure 6.2.3). Most of the discards were reported in area 7d, more importantly during quarters 3rd and 4th, by the French bottom-trawl fleet. Discarding in the target pelagic fisheries is considered negligible. New information in 2015 from bottom-trawl fisheries not directed at horse mackerel indicated an overall discard rate of 16.7% for the stock as a whole, while in 2016 this rate is 10%. Complete discard information for earlier years has not been submitted to ICES. However, information from national discard reports for the non-directed bottom-trawl fisheries indicates a similar level of discarding in earlier years.

6.3 Biological Data

6.3.1 Catch in Numbers at Age

In 2017, as already occurred in 2016, there has been a marked reduction in the coverage of biological sampling. Only the 38% of landings was sampled, in comparison to 2013 and 2014 when 71% and 63% were sampled respectively (section 5 figure 5.9.1). In addition, this low coverage was carried out mostly by the Dutch fleet in quarter Q4 and divisions 27.7.d and 27.4.c. Despite most landing catch was taken from this area and quarter (81.9% of landings in division 27.7.d and 75% in quarter Q4, Figure 6.3.1) still part of landings were fished in other areas and quarters. In order to avoid a biased perception of the age distribution of catches over the year and areas, this partial and uneven sampling effort should be avoided in future years.

Annual catch numbers at age by area for year 2017 are shown in table 6.3.1. Due to the low level of sampling effort out of area 27.7.d., there is not enough information to represent age distribution in those areas, and hence, the one observed in 27.7.d is taken as the basis to separate catch by age. Catch-at-age for the whole period 1995-2017 are given in, table 6.3.2 and in Figure 6.3.2. These data show that since 2005 the age distribution of catches has experienced a reduction, with a decrease in the range of ages of importance in total catches. In parallel to the rejuvenation of catches, the comparison of catch-at-age data after 1998 by area (Figure 6.3.3) shows that since 2010 commercial catches have increased in area 27.7.d in comparison to the areas 27.3.a and 4a,b and c where the opposite pattern was found. Since 2015, commercial catches are focused mostly on cohort 2014 that was the main component of catches both in and out of the area 27.7.d at age 1 in year 2015, age 2 in 2016 and age 3 in 2017. Ages 1 and 2 appear with moderate importance in the total catch.

Although 2015 cohort seems to be clear in the catch-at-age distribution, in general cohort structure is not clearly detectible in the data. This may partly be due to the shifts in distribution of the fishery. In addition, it may partly be due to age reading difficulties, which are a known to be encountered (e.g. Bolle *et al*., 2011). Most clearly detectable is the relatively large 2001 year class, although it is not clearly present in the catch in all years. There are indications that environmental circumstance may be an important factor (possibly stronger than stock size) contributing to spawning success in horse mackerel. This is for example illustrated by the largest year classes (1982 and 2001) observed in the Western stock which incidentally were produced at the lowest observed stock sizes. Since 2001 is considered to have been a relatively strong year class in the Western stock as well, it is plausible that circumstances in the North Sea were similar to those in Western areas and also allowed for relatively high spawning success in the North Sea.

Lastly, potential mixing of fish from the Western and North Sea stock in area 27.7.d and 27.7.e in winter may also confuse the cohort signals. For example, the large recruitment in the Western stock may have led to more of these fish being located in the North Sea stock area as age 1 fish in 2002. With the intention of clarifying the mixing among the North Sea and the Western horse mackerel stocks, and how this may affect to the age distribution of catches. In 2015 was conducted by IMARES and the Pelagic Freezer-trawler Association (PFA). The results of this project were not conclusive because of the low sample size and some technical glitches in the sequencing. The chemical analysis generated some new insights but also some more questions on the variability that could be expected between years and seasons. Currently more genetic samples are being taking by PFA in different areas of the North East Atlantic. In addition, catch sampling carried out by several pelagic fishery companies is being explored to give information on the separation between North Sea and Western horse mackerel. Until the mixing of both stocks is clarified and catch-at-age data can be clearly segregated the development of analytical assessment will be limited.

6.3.2 Mean weight at age and mean length at age

The mean weight and mean length-at-age in the commercial catches of 2017 are presented in tables 6.3.3 and 6.3.4 respectively by quarter and area. As explained for the distribution of catch-at-age by area, due to the biased sampling coverage in 2017 for several ages mean weight and length in quarters Q2-Q3 in areas 27.3.a, 24.7.a-b-c are assumed the same than in quarter Q1-Q4 in area 27.7.d.

The mean annual weight and length over the period 2000-2016 are presented in table 6.3.2 and figures 6.3.4 and 6.3.5 respectively. Despite there are no strong differences over this period, since 2006 there seems to be a slight but steady increase in both weight and length until 2015, when a declining pattern is observed. It may be hypothesized that this is due to density-dependent effects, due to the relatively successful recruitment of 2015.

6.3.3 Maturity-at-age

Peak spawning in the North Sea falls in May and June (Macer, 1974), and spawning occurs in the coastal regions of the southern North Sea along the coasts of Belgium, the Netherlands, Germany, and Denmark.

There is no information available about the maturity-at-age of the North Sea Horse mackerel stock.

6.3.4 Natural mortality

There is no specific information available about natural mortality of this stock.

6.4 Data Exploration

6.4.1 Catch curves

The log-catch numbers were plotted by cohort to estimate the negative gradient of the slope and get an estimate of total mortality (Z). Fully selected ages 3 to 14 from the 1992 – 2016 period provide complete data for the 1992 to 2006 cohorts (Figure 6.4.1). The estimated negative gradients by cohort (Figure 6.4.2) indicate an increasing trend in total mortality for the period examined, with a marked increment in the cohorts 2005 and 2006. However, due to the low quality of the signals for some cohorts these Z estimates has to be considered with caution.

An analysis of the catch number at age data carried out in 2011 showed that only the 1vs.2, 2vs.3, 7vs.8 and 8vs.9 age groups were positively and significantly correlated in the catch. This analysis was not updated this year but these results suggest limitations in the catch-at-age data.

6.4.2 Assessment models and alternative methods to estimate the biomass

In 2002 Ruckert *et al.* estimated the North Sea horse mackerel biomass based on a ratio estimate that related cpue data from the IBTS to cpue data of whiting (*Merlangius merlangus*). The applied method assumes that length specific catchability of whiting and horse mackerel are the same for the IBTS gear. Subsequently, they use the total biomass of whiting derived from an analytical stock assessment (MSVPA) to estimate the relationship between cpue and biomass.

At the 2014 WGWIDE some exploratory model fits were attempted with the JAXass model, using the data available. The JAXass (JAX assessment) model is a simple statistical catch-at-age model fitted to an age-aggregated index of (2+) biomass, total catch data and proportions at age from the catch. It is based on Per Sparre's "separable VPA" model, an ad hoc method tested for the first time at WGWIDE in 2003, and later 2004. A new analysis using this model was also done in 2007 using an IBTS index. In 2014 the model has been coded in ADMB (Fournier *et al*., 2012) and updated with an improved objective function (dnorm), extra years of data and new methods for calculating the index (see above).

Difficulties in fitting an assessment model for this stock include:

- Unclear stock boundaries

- Difficulty aging horse mackerel

- Lack of strong cohort signals in CAA data.

- Scientific index derived from a survey not specifically designed for horse mackerel and not covering one of the main fishing grounds for the stock (VIId)

Catches taken in area 27.7. d are close to the management boundary between the (larger) western horse mackerel stock and the NS horse mackerel stock. It is quite possible that given changes in oceanographic condition, or changes in abundance of either of the two stocks, that some proportion of the catches taken in area 27.7.d actually originated from the western horse mackerel stock. Nevertheless, all assessment models

used in the MSE assume that 100% of fish caught in area 27.7.d belong to the North Sea horse mackerel stock. This is in agreement with stock and management definitions.

6.4.3 Survey data

6.4.3.1 Egg Surveys

No egg surveys for horse mackerel have been carried out in the North Sea since 1991. Such surveys were carried out during the period 1988—1991. SSB estimates are available historically. However, they were calculated assuming horse mackerel to be a determinate spawner. Horse mackerel is now considered an indeterminate spawner. Therefore egg abundance could only be considered a relative index of SSB. The mackerel egg surveys in the North Sea do not cover the spawning area of horse mackerel.

6.4.3.2 IBTS Survey Data

Many pelagic species are frequently found close to the bottom during daytime (which is when the IBTS survey operates) and migrate upwards predominantly during the night they are susceptible to semi-pelagic fishing gear and to bottom trawls (Barange *et al.* 1998). Eaton *et al.* (1983) argued that horse mackerel of 2 years and older are predominantly demersal in habit. Therefore, in the absence of a targeted survey for this stock, the IBTS is considered a reasonable alternative. IBTS data are also used in the assessment of the southern horse mackerel stock.

IBTS data from quarter Q3 were obtained from DATRAS and analysed. Based on a comparison of IBTS data from all 4 quarters in the period 1991—1996, Ruckert *et al.* (2002) showed that horse mackerel catches in the IBTS were most abundant in the third quarter of the year. In 2013 WGWIDE considered that using an 'exploitable biomass index' estimated with the abundance by haul of individuals larger than 20 cm is the most appropriate for the purpose of interpreting trend in the stock.

To create indices, a subset of ICES rectangles was selected. Rectangles that were not covered by the survey more than once during the period 1991—2012 were excluded from the index area. In 2012, WGWIDE expressed concern that the previously selected index area did not sufficiently cover the distribution area of the stock, especially in years that the stock would be relatively more abundant and spread out more. Ruckert *et al.* (2002) also identified a larger distribution area of the North Sea stock. Based on the above, 61 rectangles were identified to be included in the index area as shown in Figure 6.4.3.

6.4.3.3 The French Channel Groundfish Survey (CGFS) in Q4

In order to improve data basis for the North Sea horse mackerel assessment, alternative survey indices have been explored. Previous indices used had only cover the North Sea distribution of the stock, while the majority of catches in recent years have come from the eastern English Channel (27.7.d). We evaluated the potential contribution of the French Channel Ground Fish Survey in 27.7.d (CGFS) in Quarter 4. The CGFS is carried out since 1990 and has frequent captures of horse mackerel. Though this survey is conducted in a different quarter to the North Sea IBTS, the observed seasonal migration patterns of horse mackerel indicate that fish move into the channel following quarter Q3, so the timing is considered appropriate.

In 2015, the RV "Gwen Drez" was replaced by the RV "Thalassa" to carry out the CGFS survey. In 2014 an inter-calibration process was conducted to quantify the differences

in catchability for a large number of species. ICES reviewed this inter-calibration exercise and found a number of drawbacks that may undermine the reliability of the estimated conversion factors. The main concerns were:

- The analyses were limited in the number of tows. Considering that a number of these tows could be zeros for one of the two vessels and possibly resulting in highly uncertain estimates.
- Lack of length-specific correction factor.
- At a standardized depth of 50 m and above, wing spread estimates for the R/V Thalassa as measured by the MARPORT sensor were deemed erroneous, which may question the validity of estimated area swept by the net on the R/V Thalassa and the effect it may have on correction factors for species caught at depth at 50m and greater.
- A number of tow locations including areas outside 27.7.d were excluded. Changing the depth range of a survey can add serious bias in the calibration and the current approach seems to be ignoring this issue.
- Correction coefficients were not measured without error.

However, these limitations were considered by WGWIDE to be of minor importance for the North Sea horse mackerel since:

- Despite being still a low sample size the North Sea horse mackerel was present in all the 32 paired hauls.
- There are no important differences in size distribution (Figure 6.4.4).
- The analysis with and without the areas excluded in the new sampling design did not show important differences (ICES, 2017).
- cpue or North Sea horse mackerel for hauls deeper than 50 m was relatively low (Figure 6.4.5), and it is expected than the potential problems in determining the conversion factor bellow that depth range would have a relatively minor impact in the estimated abundance.

For these reasons it was finally decided to continue using the CGFS survey, standardizing the time-series of abundance for the period 1990-2015 with the estimated conversion factor 10.363.

6.4.3.4 Norht Sea horse mackerel benchmark exercise

In January 2017, a benchmark process was conducted for NSHM (ICES, 2017). Based on capacity to model the overdispersion and the high proportion of zero values in the survey catch data the hurdle models was concluded the best option of all the model alternatives tested. The log-likelihood ratio test, the AIC and the evidence ratio statistic supported that the model that best represented the data was a hurdle model with Year and Survey as explanatory factors (including the interaction term) in the count model (GLM-negative binomial), and Year and Survey (without the interaction) in the zero model (GLM-binomial).

The probability of having a cpue zero was modelled by a logistic regression with a GLM-binomial distribution model:

$$logit(\pi_i) = Intercept_{zero} + Year_{i,zero} + Survey_{i,zero}$$

Where π_i is the mean probability of having a cpue zero as a function Year and Survey.

The expected cpue of North Sea horse mackerel, conditional to not having a zero in hurdle models (not having a false zero in zero inflated models) was modelled with a GLM-negative binomial distribution model:

$$\log(CPUE_i) = Intercept_{count} + Year_{i,count}\ x\ Survey_{i,count}$$

This model was used to synthesise the information from both the GCFS and IBTS and predict the average annual cpue index per haul as an indicator of trends in stock abundance both for the juvenile (<20cm) and exploitable (>20cm) substocks. The contribution of the two surveys to the combined index is weighted taken into consideration their respective surface coverage as well as the mean wing spread. This index model allowed upgrading the NSHM to a category 3 stock within the ICES classification.

6.4.4 Summary of index trends

The survey index for both the small and exploitable substocks experienced a marked decline in the early-mid 2000s (Figure 6.4.6; table 6.4.1). This reduction was due in part to the decline of the average abundance by haul over time, but also to the increase of hauls with zero catch of horse mackerel, from 26% in 1998 to the highest observed value of 72% in 2013 (Figure 6.4.7). Since 2014 a slight decrease in zero hauls was observed in juveniles group (smaller than 20 cm). Since 2013, in addition to the decline of zero hauls, the mean cpue in the non-zero hauls has increased. After an increase in 2016, the abundance survey index for the exploitable substock has shown a marked decline in 2017. This pattern has been mostly due to the decline of the survey index estimated for the CGFS in comparison to the value in 2016 (Figure 6.4.8). The survey index of the juvenile substock, that also showed an increasing pattern since 2013, seems to be stabilized since 2014 in the CGFS, but in the IBTS is in 2017 at the lowest level since 1992. Due to this compensation by the CGFS, the abundance index for juveniles, show a less steep decline than the exploitable substock index. The size distribution in both the CGFS and the IBTS suggest the entrance of a moderate new cohort in 2017 (between 4-7cm in the IBTS and 7-11cm in the CGFS) age 0 (Figures 6.4.9 and 6.4.10).

However, despite the index of abundance of individuals smaller than 20 cm could be considered a recruitment index, it has to be considered with caution. Preliminary examinations of how the juvenile (0–19cm) indices relate to subsequent exploitable abundance (20+ cm) do not indicate strong linkages. The very high juvenile indices in the early 2000s in the IBTS were not subsequently picked up in the exploitable component. Hence while increases in the juvenile indices are encouraging, whether these lead to increases in the exploitable component of the stock need to be confirmed in the future with observations in the 20+ cm indices.

6.4.5 Data Limited Stock methods and MSY proxy reference points

As part of the ICES approach to provide advice within the MSY framework for stocks of category 3 and 4, different Data Limited methods to estimate MSY proxy reference points for the North Sea horse mackerel were explored. This analysis and results were presented in a separate working document (Pérez-Rodríguez, 2017). After exploring the compliance with each method assumptions and assessing the data availability the group decided that the Length Based Indicators would be the only DLS method to be applied to the NSHM.

Despite this length based method will have to be applied in the future to a longer time-series of catch length frequencies, only length data have been collected for 2016 and 2017. The estimates of F/F_{MSY} proxy indicate that fishing mortality seems to be, both in

2016 and 2017, slightly above F_{MSY} for the North Sea horse mackerel, with F/F_{MSY}=1.082 and 1.073 respectively (Figure 6.4.11).

6.4.6 Ongoing work

To improve the knowledge base for North Sea horse mackerel about the degree of connection and migrations in between the North Sea and the Western Stock, catch sampling carried out by several pelagic fishery companies is being explored to give information on the separation between North Sea and Western horse mackerel. To improve the abundance indicators the potential application of a commercial fishery search time index will be explored. Horse mackerel is fished while it is very close to the bottom in relatively dispersed, small schools. The fishery is mostly executed using long hauls and there may be extensive search time involved. Handled in an appropriate statistical framework, taking into account the nature of the fishery and other factors such as seasonality and alternative fishing opportunities, the search time and catch rates could provide for an indication of changes in stock size over time. Catch rates in areas 27.7.e, 27.7.d and southern North Sea will be analysed from skippers' private logbooks.

6.5 Basis for 2019 Advice. ICES DLS approach.

Stock advice for NSHM is biannual. In 2017 the advice for years 2018 and 2019 was provided. The joint abundance survey index indicated a continuation in the increasing trend observed since 2013. This increase was due mostly to the increment observed in the CGFS survey index. Despite that, as mentioned in the previous section, the joint survey index for 2017 has shown a sudden change and steep decline due to the drop of the CGFS survey index, WGWIDE decided to continue with the current advice of 17517 tonnes for 2019.

The fisheries in the area have largely been focused on the smaller fish in 2015, 2016, 2017 and it is expected that this will continue in 2018 and 2019. With this pattern of exploitation, mostly immature individuals are caught which might hinder the recovery of the stock by removing an important portion of the recent year classes before they enter the spawning stock.

6.6 Management considerations

In the past, Division 27.7.d was included in the management area for Western horse mackerel together with Divisions 27.2.a, 27.7.a–c, 27.7.e–k, 27.8.a, 27.8.b, 27.8.d, 27.8.e, Subarea 6, EU and international waters of Division 5.b, and international waters of Subareas 12 and 14. ICES considers Division 27.7.d to be part of the North Sea horse mackerel distribution area. Since 2010, the TAC for the North Sea area has included Divisions 27.4.bc and 27.7.d. Considering that a majority of the catches are taken in Division 27.7.d, the total of North Sea horse mackerel catches are effectively constrained by the TAC since the realignment of the management areas in 2010.

Catches in Divisions 27.3.a (Western Skagerrak) and 27.4.a in quarters 3 and 4 are considered to be from the Western horse mackerel stock, while catches in quarters 1 and 2 are considered to be from the North Sea horse mackerel stock. Catches in area 27.4.a and 27.3.a are variable. In recent years only Norway has had significant catches in this area, but these are only taken in some years.

6.7 References

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6.8 Tables

Table 6.3.1. North Sea Horse Mackerel stock. Catch in numbers (1000) by quarter and area in 2017.

	Number/1000					
1Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.99	44.35	96.06	10.51	0	151.91
2	0.9	40.45	87.61	9.59	1579.74	1718.29
3	2.73	122.35	265.02	29	6243.76	6662.86
4	0.4	17.94	38.85	4.25	4502.28	4563.72
5	0.25	11.08	24	2.63	3308.95	3346.91
6	0.15	6.87	14.89	1.63	1229.79	1253.33
7	0.11	4.99	10.8	1.18	2074.86	2091.93
8	0.1	4.45	9.63	1.05	1604.79	1620.02
9	0.04	1.75	3.78	0.41	558.59	564.58
10	0.01	0.49	1.06	0.12	261.55	263.23
11	0.02	1.02	2.2	0.24	297.05	300.53
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.01	0.49	1.06	0.12	261.55	263.23
15	0.01	0.49	1.06	0.12	261.55	263.23
Sum	5.72	256.7	556.04	60.84	22184.47	23063.76
2Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	16.65	24.39	17.35	411.9	828.12	1298.41
2	15.18	22.24	15.83	375.67	755.27	1184.19
3	45.93	67.28	47.87	1136.4	2284.7	3582.19
4	6.73	9.86	7.02	166.61	334.96	525.18
5	4.16	6.09	4.34	102.93	206.94	324.46
6	2.58	3.78	2.69	63.83	128.32	201.19
7	1.87	2.74	1.95	46.31	93.1	145.97
8	1.67	2.44	1.74	41.29	83.02	130.17
9	0.66	0.96	0.68	16.22	32.61	51.13
10	0.18	0.27	0.19	4.55	9.15	14.35
11	0.38	0.56	0.4	9.45	18.99	29.77
12	0	0	0	0	0	0

13	0	0	0	0	0	0
14	0.18	0.27	0.19	4.55	9.15	14.35
15	0.18	0.27	0.19	4.55	9.15	14.35
Sum	96.37	141.15	100.44	2384.26	4793.5	7515.73

3Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	59.57	59.57
1	0	0	70.95	111.67	1329.97	1512.59
2	0	0	64.71	101.85	1212.97	1379.53
3	0	0	195.75	308.08	3669.25	4173.08
4	0	0	28.7	45.17	537.94	611.81
5	0	0	17.73	27.9	332.34	377.98
6	0	0	10.99	17.3	206.08	234.38
7	0	0	7.98	12.55	149.52	170.05
8	0	0	7.11	11.19	133.33	151.64
9	0	0	2.79	4.4	52.38	59.57
10	0	0	0.78	1.23	14.7	16.72
11	0	0	1.63	2.56	30.5	34.68
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.78	1.23	14.7	16.72
15	0	0	0.78	1.23	14.7	16.72
Sum	0	0	410.69	646.39	7757.96	8815.04
4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	391.05	391.05
1	0	0	6.18	1874.01	15901.14	17781.33
2	0	0	5.64	4425.6	12187.97	16619.21
3	0	0	17.06	11524.87	36654.11	48196.04
4	0	0	2.5	1611.53	2872.44	4486.47
5	0	0	1.55	250.28	1730.29	1982.11
6	0	0	0.96	0	1722.52	1723.48
7	0	0	0.7	0	413.71	414.4
8	0	0	0.62	0	542.37	542.99
9	0	0	0.24	0	263.86	264.1
10	0	0	0.07	0	0	0.07
11	0	0	0.14	0	173.56	173.7

12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.07	0	0	0.07
15	0	0	0.07	0	0	0.07
	0	0	786.34	999.45	80108.12	81893.91

1-4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	450.61	450.61
1	17.64	68.73	190.55	2408.1	18059.23	20744.25
2	16.09	62.69	173.79	4912.7	15735.95	20901.21
3	48.66	189.63	525.7	12998.35	48851.82	62614.16
4	7.13	27.8	77.07	1827.55	8247.61	10187.17
5	4.41	17.18	47.62	383.74	5578.52	6031.46
6	2.73	10.65	29.53	82.76	3286.72	3412.39
7	1.98	7.73	21.42	60.04	2731.19	2822.36
8	1.77	6.89	19.1	53.54	2363.51	2444.81
9	0.69	2.71	7.5	21.03	907.44	939.38
10	0.19	0.76	2.11	5.9	285.41	294.37
11	0.4	1.58	4.37	12.25	520.09	538.69
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.19	0.76	2.11	5.9	285.41	294.37
15	0.19	0.76	2.11	5.9	285.41	294.37
Sum	102.09	397.85	1102.97	22777.77	107588.92	131969.6

Table 6.3.2. Numbers at age (millions), weight at age (kg) and length at age (cm) for the North Sea horse mackerel 1995-2017 in the commercial fleet catches.

MILLIO

AGE	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	1.8	4.6	12.6	2.3	12.4	70.2	12.8	60.4	13.8	15.7	52.4	5	3.4	1.7	34.1	3.3	8.1	9.5	7.6	15.4	49.7	3.6	20.7
2	3.1	13.8	27.2	22.1	31.5	78	36.4	16.8	56.2	17.5	29.8	23.7	15.5	8.8	13.9	22.5	23.3	24.3	10	15.3	23.8	65.2	20.9
3	7.2	11	14.1	36.7	23.1	28.4	174.3	19.3	23.4	34.4	27.8	61.5	22.8	36.1	28.4	10.7	76.5	20.4	21.3	8.7	10.1	15.9	62.6
4	10.3	11.9	14.9	38.8	17.6	21.4	87.8	11.9	33.2	14.5	12.6	40.9	82.6	16.7	22.1	15.7	37.3	40.2	22.2	30.2	5.8	9.8	10.2
5	12.1	9.6	14.6	20.8	23.1	31.3	18.5	5.6	26.9	27.8	16.7	73	71.2	36.4	17.3	23.7	14.6	25.8	27.1	13.8	7.2	7.7	6
6	13.2	12.5	12.4	12.1	26.2	19.6	11.5	5.8	10.6	20.2	5.2	23.4	30.5	36.1	16.3	15.9	9.9	20.8	6	7.1	3.8	5.7	3.4
7	11.4	8	10.1	14	20.6	19.5	18.3	5.5	6.3	10.6	2.9	13.7	23.9	27.3	21.5	27.6	5.8	3.1	7.2	2.7	3.3	2.5	2.8
8	12.6	6.6	8.6	10.8	21.8	9	14.7	10.5	9.6	3.8	2.4	5.9	17.3	21.9	47.1	5.6	6	5	4.3	3.4	1.4	5.1	2.4
9	7.3	1.5	2.5	8.3	12.9	11.5	10.2	6.3	10.9	5.4	3.8	1.6	7.9	10.2	11.2	6.3	3.4	4.6	4	0.9	1.6	1.2	0.9
10	5.9	5.3	0.8	4	8.2	9	10	6.8	1.5	11	5.8	1.4	1.7	7.5	9.3	8.3	10.1	1.5	5.4	1	0.9	0.1	0.3
11	0	0.3	0.3	2.7	2.1	7	9.6	5.1	3.4	6.2	2.3	0.2	0.6	1.9	7.2	2.9	6.9	0.5	3.7	1.3	0.2	0.1	0.5
12	8.8	1.3	0.3	0.7	0.4	3.1	5.4	3	3.3	4.5	4.1	1.7	0.2	2.1	3.7	0.3	3.6	0.1	1	0.4	0.9	0.4	0
13	0.2	8.9		1.8	1.4	1.6	3.7	2.2	2.3	6.2	2.5	0.6	0.7	0.4	0.3	0.3	0.8		0.6	0	0.2	1.4	0
14	4.4	8	1.4	0.3	3.8		2	1.3	3.4	2.3	9.9	1	0.7	2.4	0.9	0.2	0.3	0.2	0	0.2	0.2	0.5	0.3
15+				5.1	4	12.2	5.8	2.7	4.7	8.5	9.6	0.8		1	6.1	1.1	0.5		0.1	0.1			0.3

KG WEIGHT

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	0.076	0.107	0.063	0.063	0.063	0.075	0.067	0.066	0.075	0.076	0.07	0.074	0.615	0.063	0.074	0.077	0.061	0.069	0.077	0.078	0.062	0.07	0.06
2	0.126	0.123	0.102	0.102	0.102	0.1	0.09	0.096	0.105	0.105	0.087	0.098	0.081	0.096	0.087	0.101	0.092	0.09	0.099	0.11	0.099	0.093	0.086
3	0.125	0.143	0.126	0.126	0.126	0.137	0.094	0.129	0.122	0.122	0.104	0.116	0.104	0.109	0.113	0.118	0.096	0.118	0.112	0.113	0.13	0.115	0.113
4	0.133	0.156	0.142	0.142	0.142	0.152	0.117	0.155	0.136	0.146	0.133	0.124	0.115	0.125	0.134	0.137	0.115	0.142	0.138	0.135	0.15	0.126	0.131
5	0.146	0.177	0.16	0.16	0.16	0.165	0.159	0.171	0.164	0.174	0.159	0.141	0.13	0.145	0.152	0.155	0.145	0.152	0.166	0.144	0.169	0.158	0.173
6	0.164	0.187	0.175	0.175	0.175	0.192	0.183	0.195	0.18	0.198	0.197	0.178	0.163	0.161	0.182	0.183	0.166	0.172	0.18	0.177	0.196	0.155	0.189
7	0.161	0.203	0.199	0.199	0.199	0.194	0.198	0.216	0.193	0.224	0.238	0.212	0.192	0.193	0.195	0.206	0.193	0.183	0.2	0.184	0.26	0.162	0.177
8	0.178	0.195	0.231	0.231	0.231	0.216	0.201	0.227	0.212	0.229	0.248	0.247	0.197	0.221	0.258	0.199	0.193	0.188	0.216	0.201	0.29	0.235	0.188
9	0.165	0.218	0.25	0.25	0.25	0.244	0.237	0.228	0.24	0.256	0.259	0.236	0.257	0.286	0.253	0.241	0.305	0.212	0.223	0.222	0.265	0.246	0.222
10	0.173	0.241	0.259	0.259	0.259	0.283	0.246	0.253	0.27	0.29	0.287	0.286	0.255	0.295	0.322	0.227	0.334	0.204	0.226	0.22	0.312	0.359	0.233
11	0.317	0.307	0.3	0.3	0.3	0.286	0.26	0.303	0.24	0.3	0.335	0.237	0.517	0.273	0.422	0.284	0.345	0.275	0.242	0.264	0.262	0.369	0.257
12	0.233	0.211	0.329	0.329	0.329	0.354	0.286	0.293	0.298	0.297	0.349	0.261	0.279	0.309	0.447	0.234	0.408	0.195	0.263	0.287	0.318	0.379	
13	0.241	0.258	0.367	0.367	0.367	0.316	0.287	0.317	0.356	0.301	0.338	0.267	0.339	0.375	0.383	0.288	0.474		0.262	0.252	0.351	0.242	
14	0.348	0.277	0.299	0.299	0.299		0.295	0.32	0.316	0.338	0.373	0.302	0.414	0.277	0.362	0.315	0.415	0.187	0.559	0.408	0.235	0.39	0.214
15+	0.348	0.277	0.36	0.36	0.36	0.35	0.336	0.389	0.353	0.402	0.375	0.404		0.389	0.46	0.351	0.475		0.339	0.273		0.378	0.26

CM LENGTH

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	19.2	19.2	19.2	19.2	19.2	19.1	19.5	19.4	20.3	19.8	18.1	20.1	19.9	20	20.3	20.8	19.2	19.9	20.9	20.4	19.8	20	19.1
2	22	22	22	22	22	21.5	21.5	21.7	22.3	22.2	21.5	22	20.8	21.6	21.6	22.6	21.7	21.7	22.4	22.9	22.9	22	21.3
3	23.5	23.5	23.5	23.5	23.5	23.9	21.9	23.8	23.7	23.6	22.9	23.4	22.5	23.2	23.2	23.9	23	23.5	23.5	23.6	24.6	23.6	23.3
4	24.8	24.8	24.8	24.8	24.8	24.9	23.4	25.4	24.6	25.2	24.7	24.1	23.6	24.1	24.6	25	24.5	25	25.3	24.8	25.8	24.8	24.1
5	25.5	25.5	25.5	25.5	25.5	26	26.7	26.3	26.2	26.6	25.9	25.4	24.4	25.6	25.8	25.7	25.9	25.7	27	25.4	26.6	26.4	26.7
6	26.4	26.4	26.4	26.4	26.4	27.6	27.5	27.4	27.3	27.5	27.7	27	26.6	26.3	27.2	27.1	27.6	27	27.1	27.3	28.2	26.1	27.5
7	27.2	27.2	27.2	27.2	27.2	28.1	28.1	28.6	28.2	28.8	29.8	28.6	27.8	28.1	28.1	28.3	27.7	27.1	28.3	27.5	30.4	27.5	27.5
8	29.2	29.2	29.2	29.2	29.2	28.6	28.5	29.3	29	29.2	30.4	29.8	28.1	28.8	30.6	28.4	27.8	27	28.9	28	31.7	30.2	28
9	29.5	29.5	29.5	29.5	29.5	29.9	29.8	29.4	29.9	30.4	30.8	30.8	30.1	31.2	31.1	30.2	31.9	28.6	29.2	28.8	30.5	30.5	29.1
10	29.5	29.5	29.5	29.5	29.5	31.2	30.2	30.3	30.9	31.4	31.8	31.5	31	31.8	32.5	30	32.5	28	29.5	29.2	32.5	34.7	29.5
11	30.6	30.6	30.6	30.6	30.6	31.5	30.7	31.4	30.7	31.9	33.8	31.2	39.5	31.6	35	32.2	33.2	30.1	30	30.7	31.5	35.2	31.1
12	32.1	32.1	32.1	32.1	32.1	33.6	32	31.6	31.9	31.7	35.6	30.8	31.5	32.2	35.3	30.8	34.6	27.5	30.4	30.6	32.3	35.5	
13	33.3	33.3	33.3	33.3	33.3	33.3	31.7	32.4	32.8	31.9	34	32.1	33.4	33.9	34	31.8	36.4		32.1	30	32.5	31.5	
14	31.1	31.1	31.1	31.1	31.1		32.1	32.4	32.5	33	34.4	32.5	34.5	32.3	34.2	33	36	27.5	38.5	36	30.5	36.1	30.5
15+	32.5	32.5	32.5	32.5	32.5	33.8	33.4	34.3	33.6	34.8	35.2	35.3		35.1	36.1	34.5	36.9		34.2	32.5		36.1	31.5

Table 6.3.3. North Sea Horse Mackerel stock. Mean weight at age (kg) in the catch by quarter and area in 2017.

	Number/1000					
1Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.06	0.06	0.06	0.06	0	0.06
2	0.086	0.086	0.086	0.086	0.058	0.081
3	0.114	0.114	0.114	0.114	0.087	0.108
4	0.13	0.13	0.13	0.13	0.112	0.127
5	0.172	0.172	0.172	0.172	0.151	0.168
6	0.19	0.19	0.19	0.19	0.159	0.184
7	0.175	0.175	0.175	0.175	0.163	0.173
8	0.188	0.188	0.188	0.188	0.178	0.186
9	0.222	0.222	0.222	0.222	0.225	0.223
10	0.233	0.233	0.233	0.233	0.233	0.233
11	0.257	0.257	0.257	0.257	0.277	0.261
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.214	0.214	0.214	0.214	0.214	0.214
15	0.26	0.26	0.26	0.26	0.26	0.26
2Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.06	0.06	0.06	0.06	0.06	0.06
2	0.086	0.086	0.086	0.086	0.086	0.086
3	0.114	0.114	0.114	0.114	0.114	0.114
4	0.13	0.13	0.13	0.13	0.13	0.13
5	0.172	0.172	0.172	0.172	0.172	0.172
6	0.19	0.19	0.19	0.19	0.19	0.19
7	0.175	0.175	0.175	0.175	0.175	0.175
8	0.188	0.188	0.188	0.188	0.188	0.188
9	0.222	0.222	0.222	0.222	0.222	0.222
10	0.233	0.233	0.233	0.233	0.233	0.233
11	0.257	0.257	0.257	0.257	0.257	0.257
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.214	0.214	0.214	0.214	0.214	0.214

15	0.26	0.26	0.26	0.26	0.26	0.26

3Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	0.06	0.06	0.06	0.06
2	0	0	0.086	0.086	0.086	0.086
3	0	0	0.114	0.114	0.114	0.114
4	0	0	0.13	0.13	0.13	0.13
5	0	0	0.172	0.172	0.172	0.172
6	0	0	0.19	0.19	0.19	0.19
7	0	0	0.175	0.175	0.175	0.175
8	0	0	0.188	0.188	0.188	0.188
9	0	0	0.222	0.222	0.222	0.222
10	0	0	0.233	0.233	0.233	0.233
11	0	0	0.257	0.257	0.257	0.257
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.214	0.214	0.214	0.214
15	0	0	0.26	0.26	0.26	0.26
4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	0.06	0.06	0.059	0.074
2	0	0	0.086	0.092	0.088	0.089
3	0	0	0.114	0.115	0.117	0.115
4	0	0	0.13	0.141	0.148	0.14
5	0	0	0.172	0.18	0.198	0.183
6	0	0	0.19	0	0.206	0.132
7	0	0	0.175	0	0.215	0.13
8	0	0	0.188	0	0.208	0.132
9	0	0	0.222	0	0.219	0.147
10	0	0	0.233	0	0	0.078
11	0	0	0.257	0	0.234	0.164
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.214	0	0	0.071
15	0	0	0.26	0	0	0.087

1-4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.06	0.06	0.06	0.06	0.059	0.075
2	0.086	0.086	0.086	0.088	0.081	0.087
3	0.114	0.114	0.114	0.114	0.109	0.117
4	0.13	0.13	0.13	0.133	0.131	0.135
5	0.172	0.172	0.172	0.174	0.174	0.167
6	0.19	0.19	0.19	0.19	0.187	0.178
7	0.175	0.175	0.175	0.175	0.182	0.179
8	0.188	0.188	0.188	0.188	0.191	0.257
9	0.222	0.222	0.222	0.222	0.222	0.291
10	0.233	0.233	0.233	0.233	0.233	0.359
11	0.257	0.257	0.257	0.257	0.255	0.369
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.214	0.214	0.214	0.214	0.214	0.379
15	0.26	0.26	0.26	0.26	0.26	0.37

Table 6.3.4. North Sea Horse Mackerel stock. Mean length (cm) at age in the catch by quarter and area in 2017.

	Number/1000					
1Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	19.1	19.1	19.1	19.1	0	19.1
2	21.3	21.3	21.3	21.3	18	20.7
3	23.4	23.4	23.4	23.4	21.5	23
4	24.1	24.1	24.1	24.1	22.9	23.8
5	26.6	26.6	26.6	26.6	25.7	26.4
6	27.5	27.5	27.5	27.5	26.3	27.3
7	27.4	27.4	27.4	27.4	26.8	27.3
8	28	28	28	28	27.8	28
9	29.1	29.1	29.1	29.1	29.6	29.2
10	29.5	29.5	29.5	29.5	29.5	29.5
11	31.1	31.1	31.1	31.1	32.5	31.4
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	30.5	30.5	30.5	30.5	30.5	30.5
15	31.5	31.5	31.5	31.5	31.5	31.5
2Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	19.1	19.1	19.1	19.1	19.1	19.1
2	21.3	21.3	21.3	21.3	21.3	21.3
3	23.4	23.4	23.4	23.4	23.4	23.4
4	24.1	24.1	24.1	24.1	24.1	24.1
5	26.6	26.6	26.6	26.6	26.6	26.6
6	27.5	27.5	27.5	27.5	27.5	27.5
7	27.4	27.4	27.4	27.4	27.4	27.4
8	28	28	28	28	28	28
9	29.1	29.1	29.1	29.1	29.1	29.1
10	29.5	29.5	29.5	29.5	29.5	29.5
11	31.1	31.1	31.1	31.1	31.1	31.1
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	30.5	30.5	30.5	30.5	30.5	30.5

15	31.5	31.5	31.5	31.5	31.5	31.5

3Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	19.1	19.1	19.1	19.1
2	0	0	21.3	21.3	21.3	21.3
3	0	0	23.4	23.4	23.4	23.4
4	0	0	24.1	24.1	24.1	24.1
5	0	0	26.6	26.6	26.6	26.6
6	0	0	27.5	27.5	27.5	27.5
7	0	0	27.4	27.4	27.4	27.4
8	0	0	28	28	28	28
9	0	0	29.1	29.1	29.1	29.1
10	0	0	29.5	29.5	29.5	29.5
11	0	0	31.1	31.1	31.1	31.1
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	30.5	30.5	30.5	30.5
15	0	0	31.5	31.5	31.5	31.5
4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	19.1	19.2	19.1	19.1
2	0	0	21.3	21.9	21.6	21.6
3	0	0	23.4	23.4	23.6	23.5
4	0	0	24.1	24.8	25.3	24.7
5	0	0	26.6	28.5	27.5	27.5
6	0	0	27.5	0	28.1	18.5
7	0	0	27.4	0	28.7	18.7
8	0	0	28	0	28.5	18.8
9	0	0	29.1	0	28.4	19.2
10	0	0	29.5	0	0	9.8
11	0	0	31.1	0	29.5	20.2
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	30.5	0	0	10.2
15	0	0	31.5	0	0	10.5

1-4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	19.1	19.1	19.1	19.1	19.1	19.1
2	21.3	21.3	21.3	21.5	20.7	21.3
3	23.4	23.4	23.4	23.4	23	23.3
4	24.1	24.1	24.1	24.3	24.1	24.1
5	26.6	26.6	26.6	27.1	26.6	26.7
6	27.5	27.5	27.5	27.5	27.4	27.5
7	27.4	27.4	27.4	27.4	27.6	27.5
8	28	28	28	28	28.1	28
9	29.1	29.1	29.1	29.1	29	29.1
10	29.5	29.5	29.5	29.5	29.5	29.5
11	31.1	31.1	31.1	31.1	31	31.1
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	30.5	30.5	30.5	30.5	30.5	30.5
15	31.5	31.5	31.5	31.5	31.5	31.5

Table 6.4.1. North Sea Horse Mackerel. cpue Indices of abundance (individuals/hour) for juvenile (<20cm) and exploitable (>20cm) substocks, estimated as a combined index for the NS-IBTS Q3 (North Sea only, no 27.7.d included) and the Channel Ground Fish Survey in Q4 (CGFS, 27.7.d). The survey indices are derived from the prediction of a hurdle model fit to data over the period 1992-2017.

	Juvenile substock (<20cm)			Exploitable substock (>20cm)		
Year	**Index**	**CI_low**	**CI_high**	**Index**	**CI_low**	**CI_high**
1992	4865	2293	9237	1498	663	2915
1993	1917	959	3415	565	291	974
1994	3288	1593	6067	1322	635	2368
1995	2232	1107	4115	1621	669	3401
1996	1178	447	2480	1080	482	1987
1997	3350	1516	6253	714	336	1286
1998	858	414	1573	436	201	806
1999	1475	794	2433	517	257	905
2000	1139	516	2333	289	137	570
2001	3431	1580	7437	508	245	916
2002	2999	1515	5386	501	240	937
2003	2116	1190	3499	381	179	726
2004	1064	559	1844	428	199	754
2005	987	530	1727	759	366	1370
2006	502	271	880	834	422	1523
2007	665	375	1107	411	197	787
2008	394	224	695	209	101	458
2009	758	416	1265	104	47	212
2010	1611	863	2981	234	106	459
2011	569	317	1091	282	136	583
2012	354	189	705	185	93	437
2013	1062	572	1882	146	64	335
2014	1609	909	2747	430	193	876
2015	2257	1220	4527	580	261	1146
2016	1752	959	2976	803	376	1557
2017	973	505	1714	131	54	282

6.9 Figures

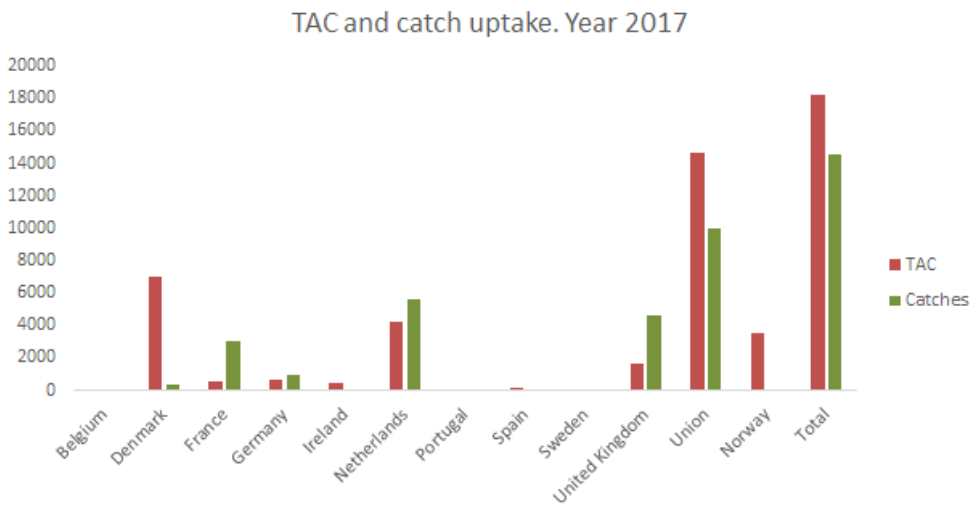


Figure 6.2.1. North Sea horse mackerel. Utilisation of quota by country.

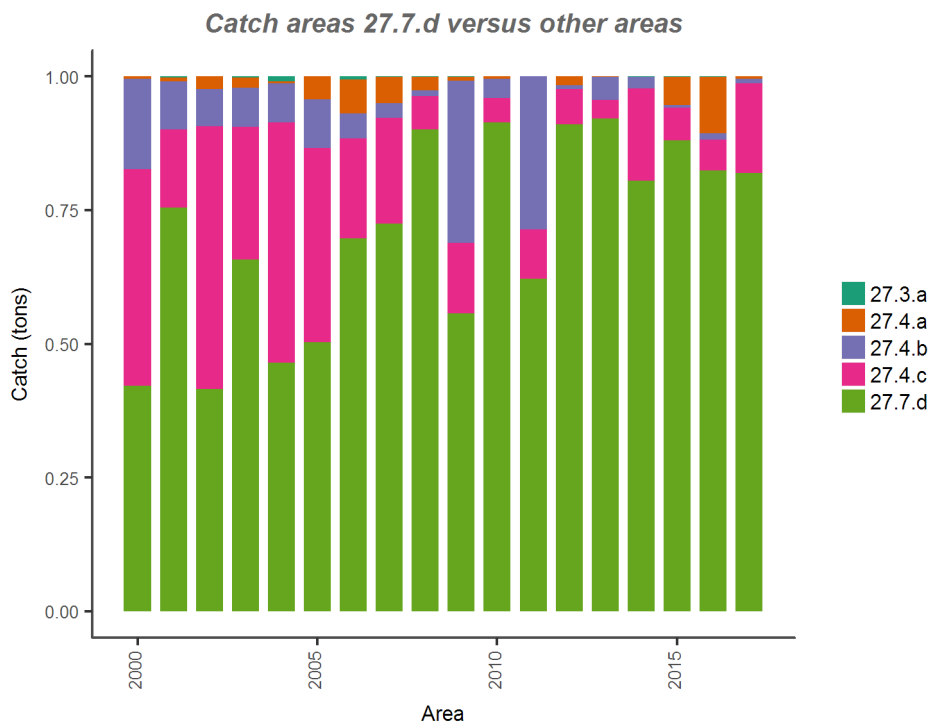
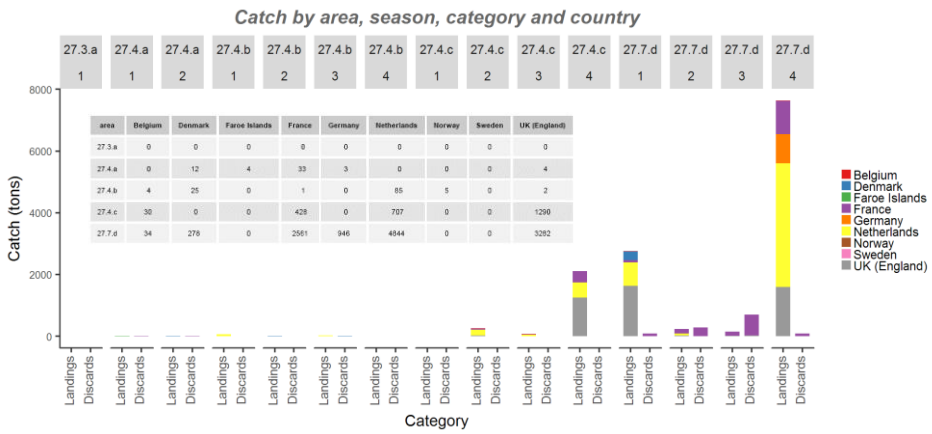


Figure 6.2.2 North Sea Horse Mackerel. North Sea horse mackerel. Catch by ICES Division for 2000–2017.



area	Belgium	Denmark	Faroe Islands	France	Germany	Netherlands	Norway	Sweden	UK (England)
27.3.a	0	0	0	0	0	0	0	0	0
27.4.a	0	12	4	33	3	0	0	0	4
27.4.b	4	25	0	1	0	85	5	0	2
27.4.c	30	0	0	428	0	707	0	0	1290
27.7.d	34	278	0	2561	946	4844	0	0	3282

Figure 6.2.3.- North Sea Horse Mackerel. Total catch (in tonnes) by area, quarter, catch category and country. BMS landing refers to landings below minimum legal size.

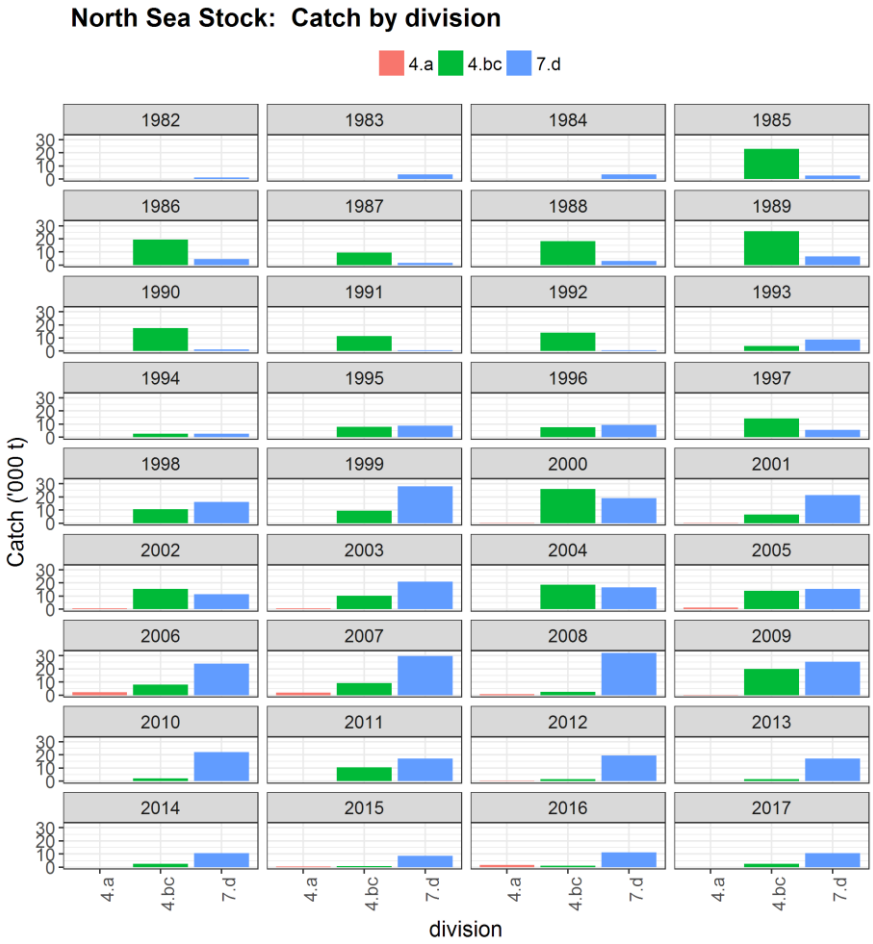


Figure 6.3.1.- North Sea Horse Mackerel. Proportion of NSHM total catch per year and station that have been sampled.

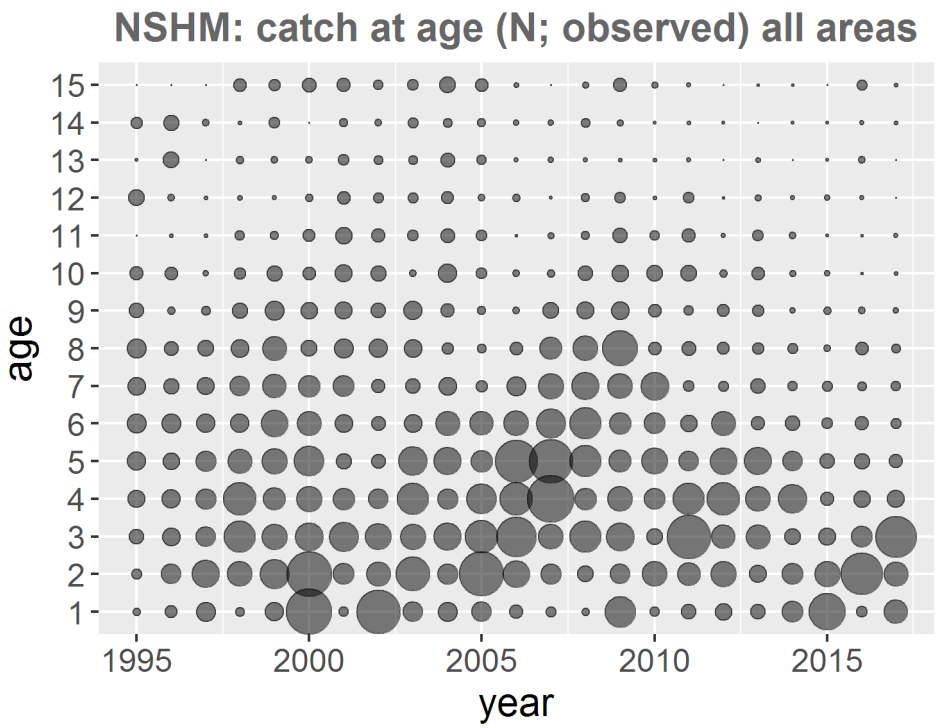


Figure 6.3.2.- North Sea horse mackerel age distribution in the catch for 1995–2017. The area of bubbles is proportional to the catch number. Note that age 15 is a plus group.

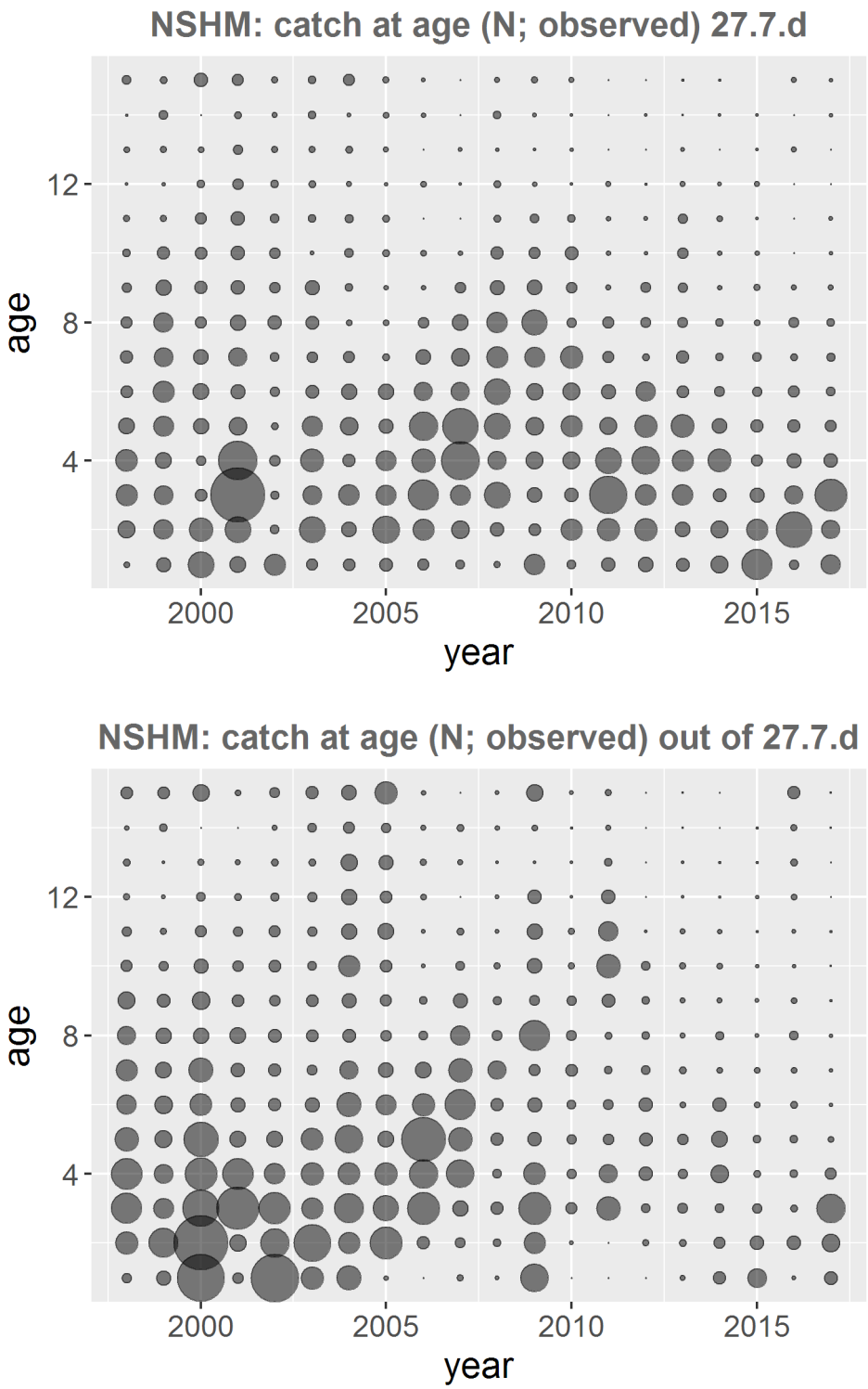


Figure 6.3.3. North Sea horse mackerel. Bubbleplots of age distribution in the catch by area for 1998-2017 for area 7.d (upper panel) and out of 7.d (bottom panel). The area of bubbles is proportional to the total catch number for the stock. Note that age 15 is a plus group.

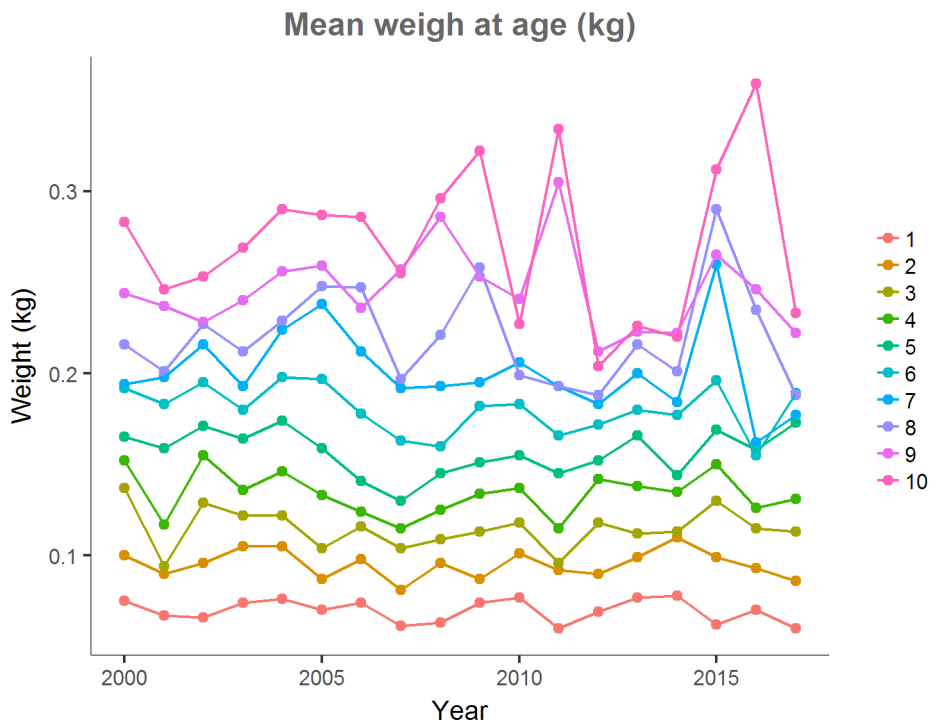


Figure 6.3.4. North Sea horse mackerel. Mean weight at age in commercial catches over the period 2000–2017

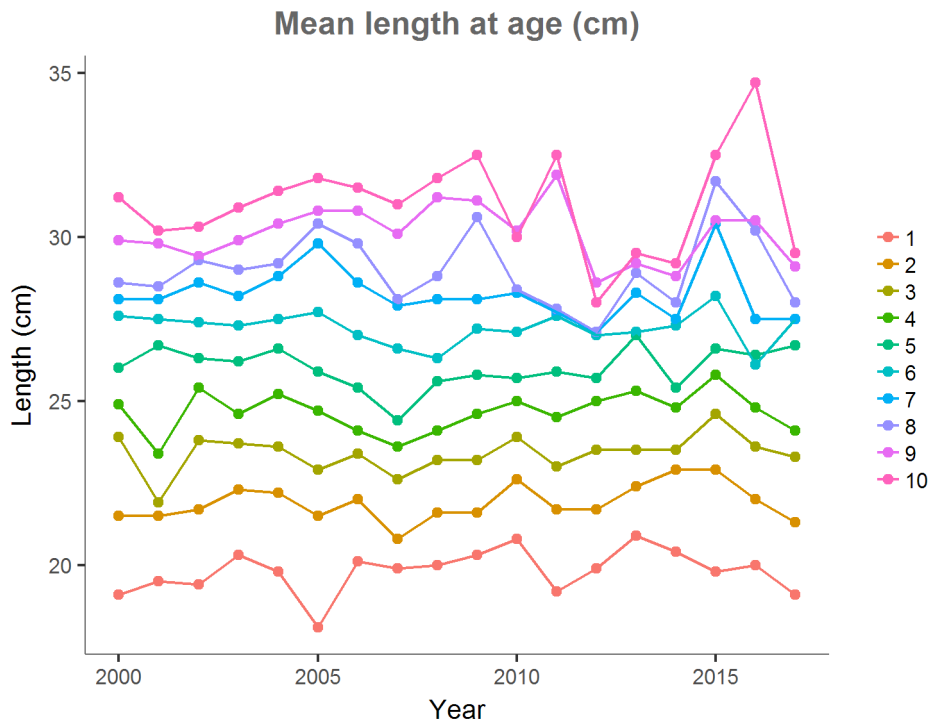


Figure 6.3.5. North Sea horse mackerel. Mean length at age in commercial catches over the period 2000–2017.

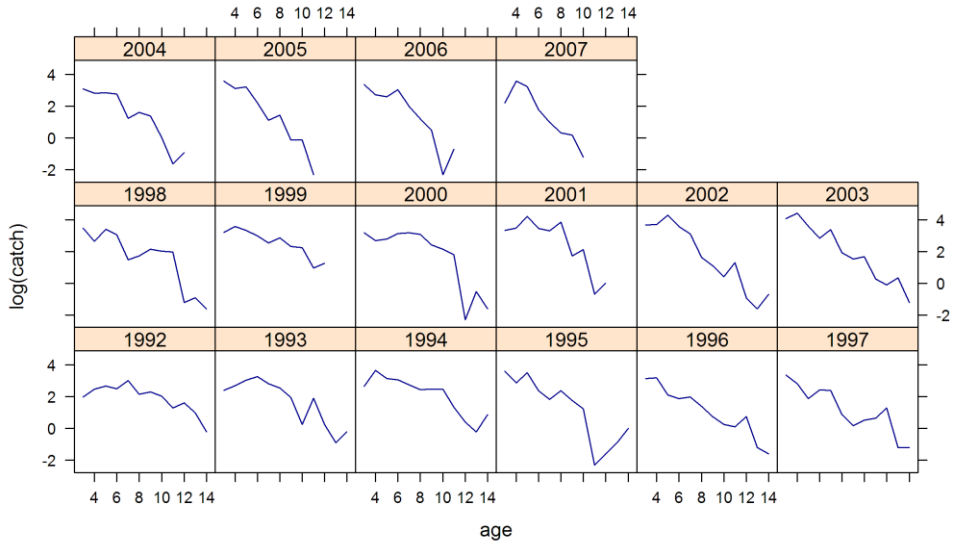


Figure 6.4.1. North Sea Horse Mackerel. Catch curves for the 1994 to 2007 cohorts, ages from 3 to 14. Values plotted are the log(catch) values for each cohort in each year. The negative slope of these curves estimates total mortality (Z) in the cohort.

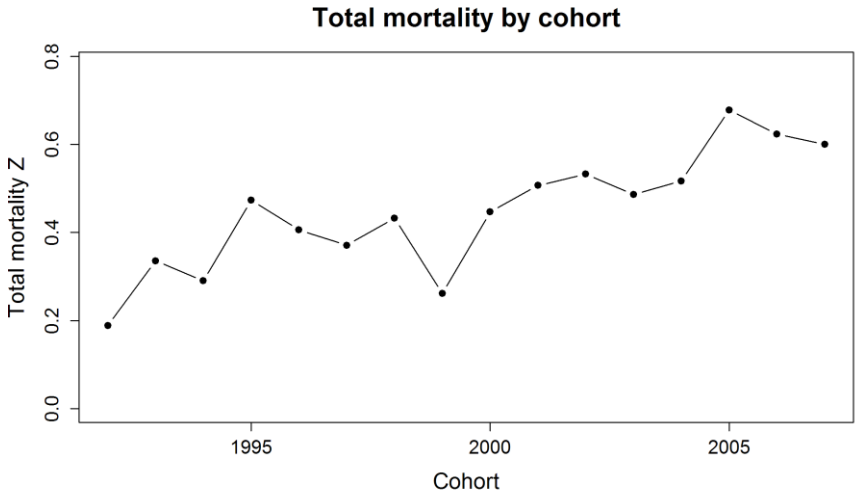


Figure 6.4.2. North Sea Horse Mackerel. Total mortality by cohort (Z) estimated from the negative gradients of the 1992–2006 cohort catch curves (Figure 6.4.1).

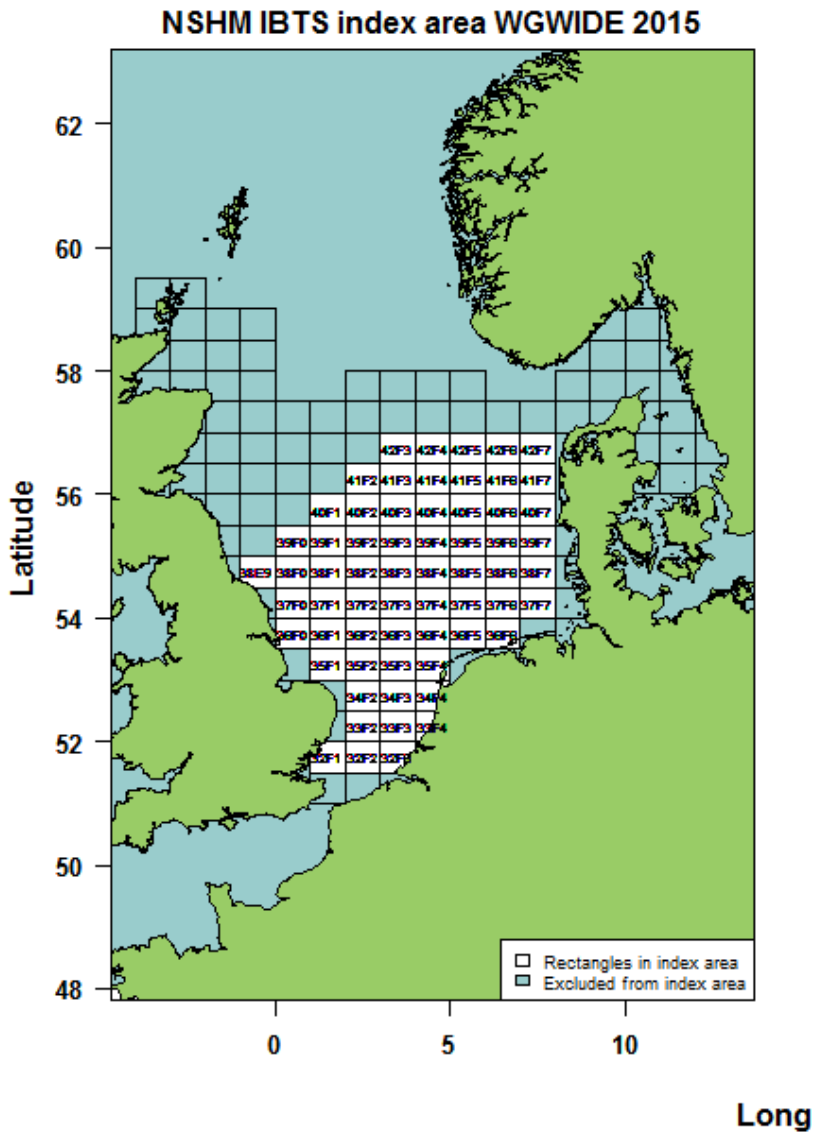


Figure 6.4.3.- North Sea horse mackerel. ICES rectangles selected in 2013 and currently used by the working group.

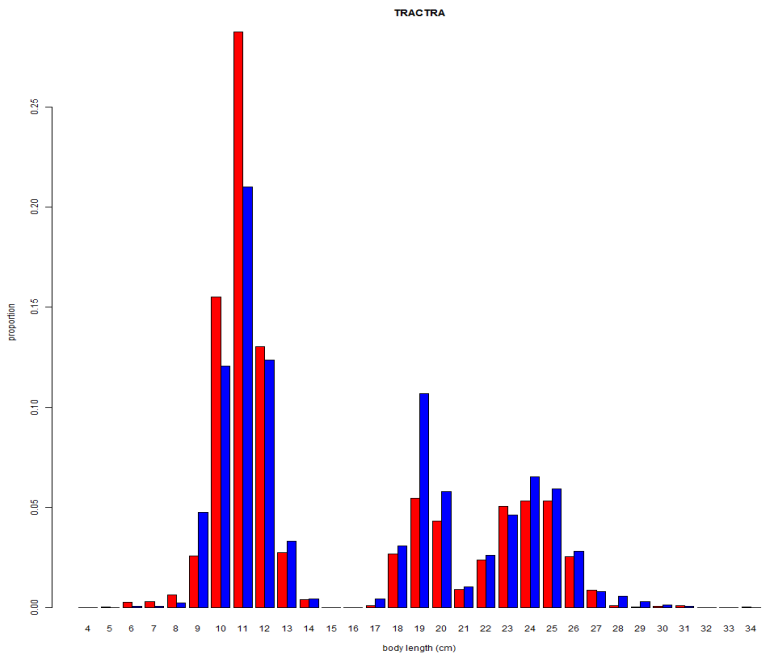


Figure 6.4.4.- North Sea horse mackerel. Size distribution of North Sea horse mackerel catches during the inter-calibration exercise conducted in 2014 between the RV Gwen Drez (red bars) and Thalassa (blue bars).

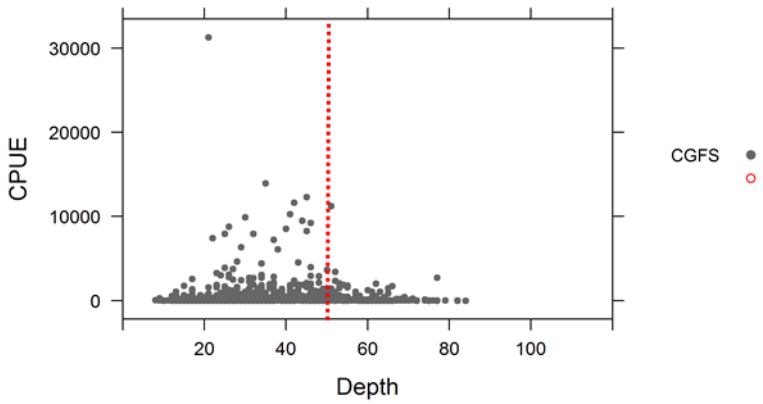


Figure 6.4.5. North Sea horse mackerel. cpue by depth for the CGFS survey from 1992 to 2017.

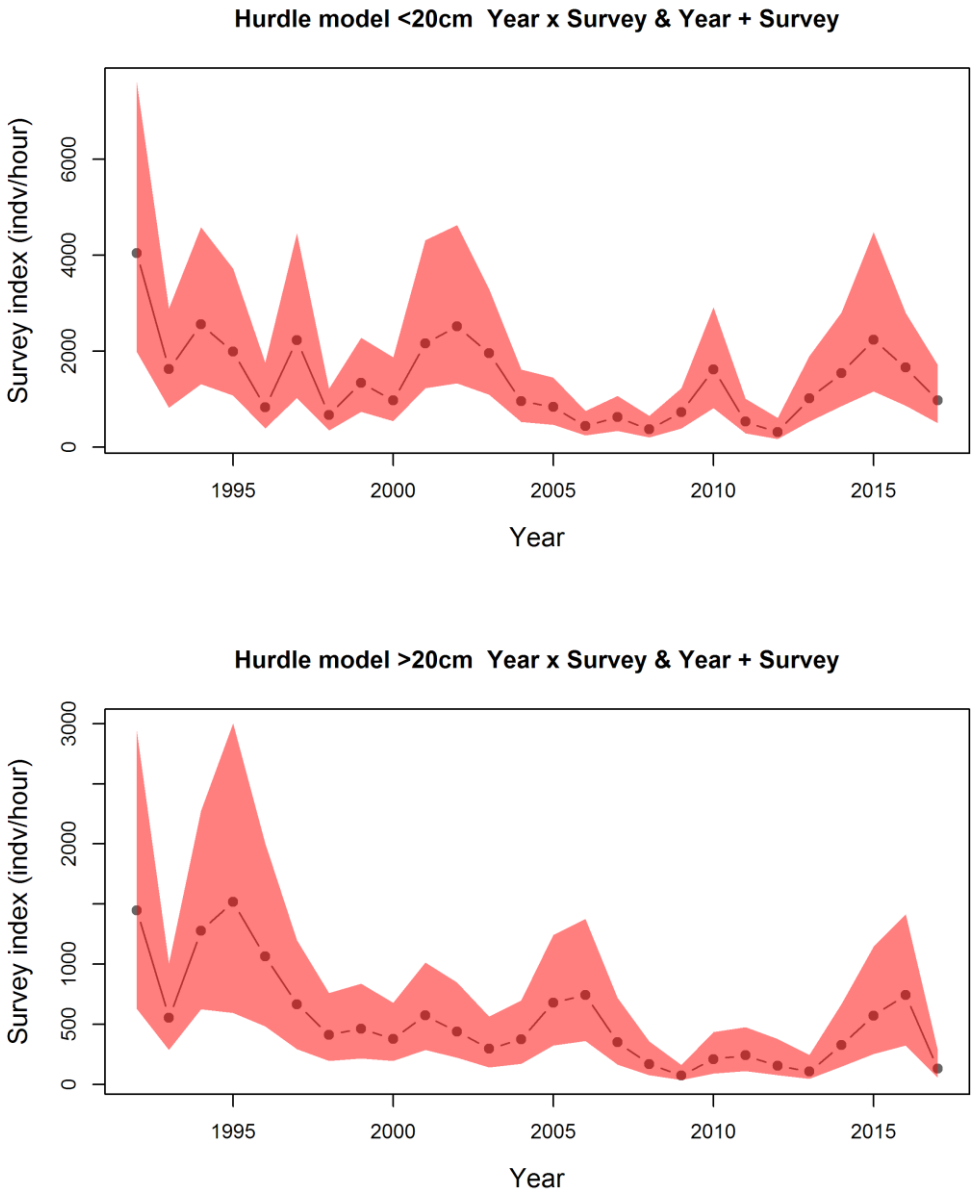


Figure 6.4.6. North Sea Horse Mackerel. Combined cpue survey index (indiv/hour) derived from the hurdle model fit to the IBTS survey in the North Sea (4.bc) and the CGFS survey in the English channel. Top: Juvenile substock (<20 cm); Bottom: exploitable substock (>20cm). The abundance index values are presented as number of individuals per hours. The confidence interval is determined by bootstrap resampling of Pearson residuals with 1000 iterations.

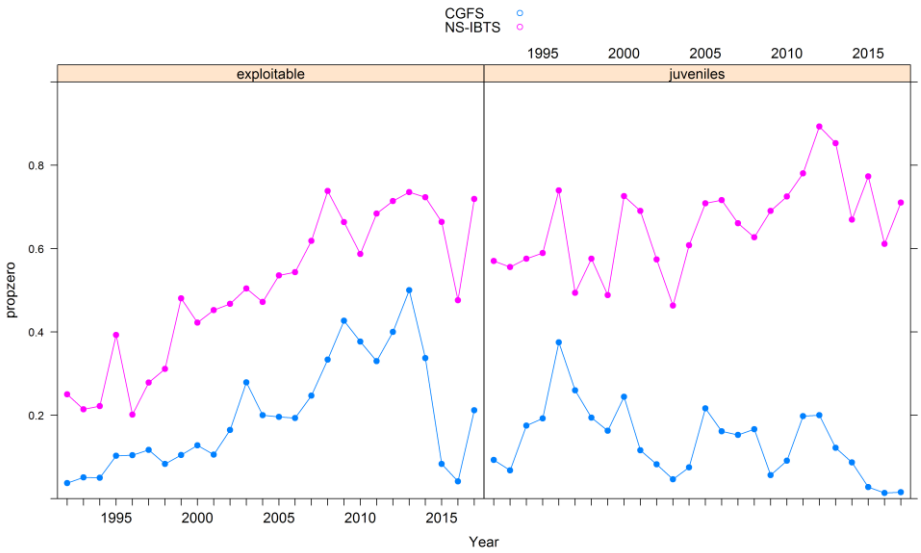


Figure 6.4.7.- North Sea horse mackerel. Proportion of hauls with zero catch for the exploitable (>20cm) and juvenile (<20 cm) substocks in the NS-IBTS (pink dotted lines) and the CGFS (blue dotted lines).

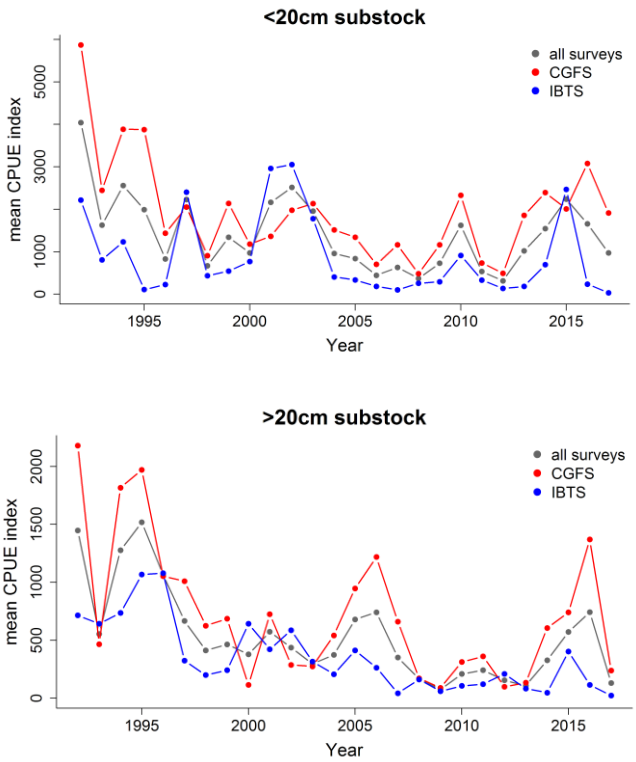


Figure 6.4.8. North Sea Horse Mackerel. Mean CPUE survey index (indiv/hour) obtained from the hurdle model fit to the IBTS survey in the North Sea (4.bc) and the CGFS survey in the English channel. Top: Juvenile substock (<20 cm); Bottom: exploitable substock (>20cm). The abundance index values are presented as number of individuals per hours.

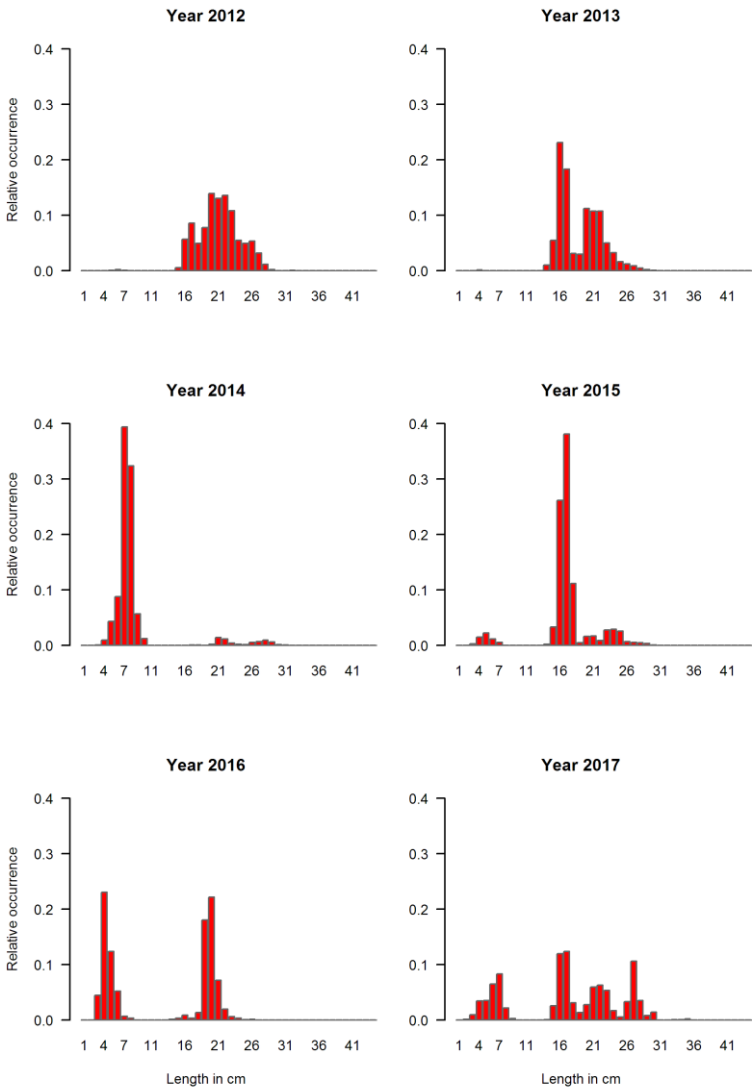


Figure 6.4.9. North Sea horse mackerel. Relative occurrence by length for the period 2012–2017 in the CGFS.

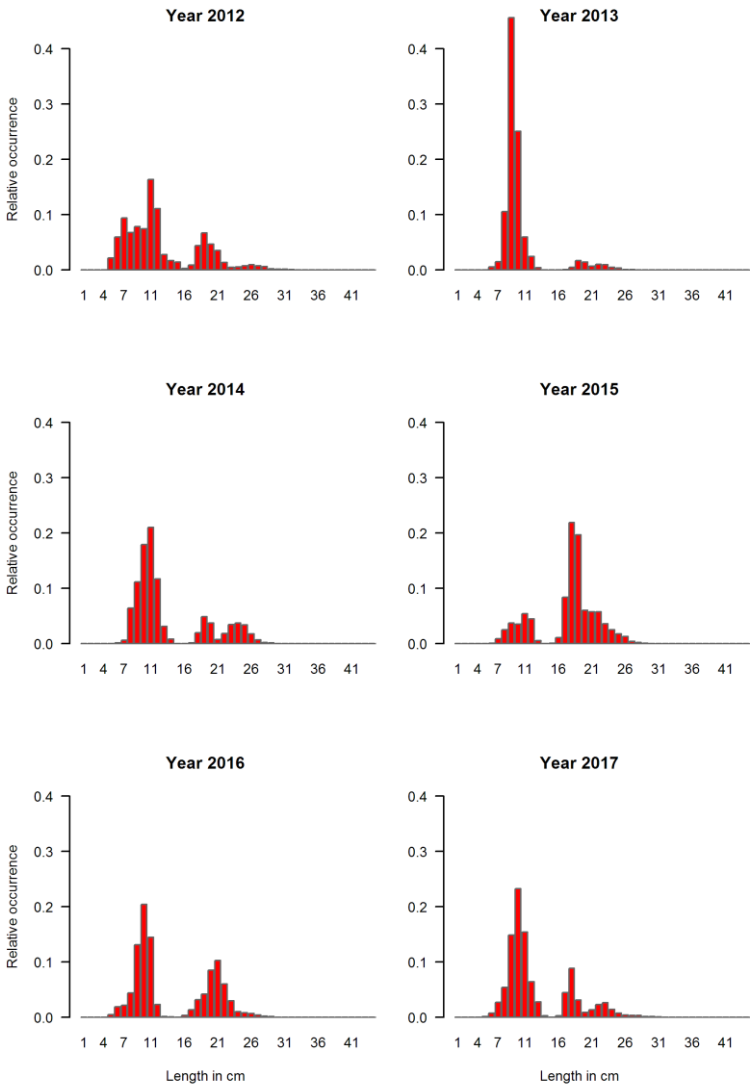


Figure 6.4.10. North Sea horse mackerel. Relative occurrence by length for the period 2012-2017 in the IBTS.

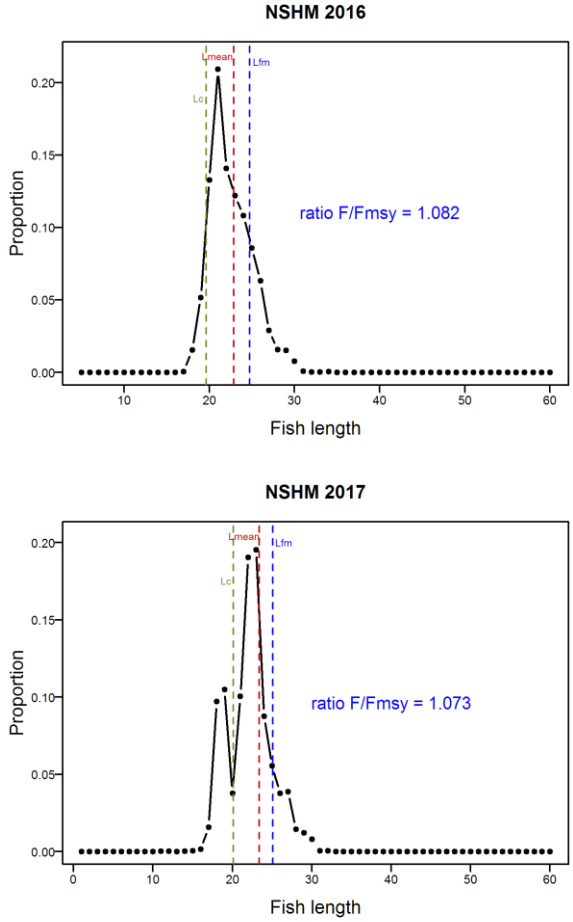


Figure 6.4.11.- Length distribution, as well as the estimated parameters Lc, Lmean, Lf=m for the Dutch fleet in 2016 and 2017.

6 North Sea Horse Mackerel: Divisions 27.4.a (Q1 and Q2), 27.3.a (excluding Western Skagerrak Q3 and Q4), 27.4.b, 27.4.c and 27.7.d

6.1 ICES Advice Applicable to 2018

In 2012 the North Sea horse mackerel (NSHM) was classified as a category 5 stock, based on the ICES approach to data-limited stocks (DLS). Since then, a progressive reduction of TAC was advised by ICES, from 25500 tonnes in 2013-2014 to 15200 tonnes in 2015-2016. This reduction in the advised catch was supported by the analysis of information from the North Sea International Bottom Trawl Survey (NS-IBTS) traditionally used in the assessment, but also new information from the Channel Ground Fish Survey (CGFS) since 2014. Despite the considerable increase showed by the CGFS in 2015 survey, due to the high uncertainty in the two survey indices, catch in 2017 was advised to continue at 15200 tonnes. However, new information indicated a 16.7% discards of NSHM in 2015 in non-directed fisheries. This new information is taken into account in the catch advice for 2017. The advice landings were 15200 tonnes and the advice total catch was 18247 tonnes.

In 2017 this stock was benchmarked and the NS-IBTS and CGFS survey indices where modelled together. The resulting joint index was considered a proper indication of trend in abundance over time and the NSHM stock was upgraded to category 3. The joint survey index showed in 2016 a continuation of the increasing trend started in 2013. The application of the HCR 3.1 (ICES, 2012, comparison of the two latest index values with the three preceding values multiplied by the recent advised catch) resulted in an increase higher than 20% in the catch advice for 2018 in comparison to advice for 2017. Accordingly the uncertainty cap was applied. In addition, Length Based DLS methods indicated that the F was in 2016 slightly above the F_{MSY} proxy, and stock size relative to reference points was unknown. Therefore, the precautionary buffer was also applied to the advice, since it hadn´t been applied since 2014. This resulted in a catch advice for 2018 and 2019 no more than 17517 tonnes. Considering the 13.35% average discards, were advice not being higher than 15179 tonnes.

6.2 Fishery of North Sea horse mackerel stock

Based on historical catches taken by the Danish industrial fleet for reduction into fishmeal and fish oil in the 1970s and 1980s, approximately 48% of the EU North Sea horse mackerel TAC was taken by Denmark. Catches were taken in the fourth quarter mainly in Divisions 27.4.b and 27.7.d. The 1990s saw a drop in the value of industrial fish, limited fishing opportunities and steep increases in fuel costs that affected the Danish quota uptake. In 2001, individual quota scheme for a number of species was introduced in Denmark, but not for North Sea horse mackerel. This lead to a rapid restructuring and lower capacity of the Danish fleet, which in combination with the above mentioned factors led to a decrease of the Danish North Sea horse mackerel catches.

Since the 1990's, a larger portion of catches has been taken in a directed horse mackerel fishery for human consumption by the Dutch freezer-trawler fleet. This is possible because Denmark has traded parts of its quota with the Netherlands for other species. However due to the structure of the Danish quota management setup only a limited amount of quota can be made available for swaps with other countries. These practical implications of the management scheme largely explain the consistent underutilisation of the TAC over the period 2010-2013 (approximately 50%). However, following the sharp reduction in TAC in 2014 uptake increased significantly to above 80% in 2015

and 100% in 2016 (see Figure 6.2.1), although an important part of these catches were discards (16.7% and 10% respectively). In 2017 the 80% of the TAC was used, with an 8.3% discards.

Catches taken in Divisions 27.3.a and 27.4.a during the two first quarters and all year in Divisions 27.4.b, 4.c and 27.7.d are regarded North Sea horse mackerel (Section 5, Table 5.4.1). The catches were relatively low during the period 1982—1997 with an average of 18000 tonnes, but increased between 1998 (30500 tonnes) and 2000 (45130 tonnes). From 2000 to 2010, the catches varied between 24149 and 45883 tonnes. Since 2014 a steep decline in catches is observed, both due to the reduction in the TAC since 2014 but also the underutilization of the quota. In 2017 the catch was 14579 tonnes, with an 82% of total catch being caught in area 27.7.d.

Over the period 1985-2001 most catches were taken in the area 27.4.b (Figure 6.2.3). However, since 2002 the proportion of catches from area 27.7.d increased steadily until 2013, when the 92% of total catches were fished in this area (Figure 6.2.2). Germany, UK and Netherlands accounted for most of the landings, that were taken in quarter 1, but especially in quarter 4 (Figure 6.2.3). Most of the discards were reported in area 7d, more importantly during quarters 3rd and 4th, by the French bottom-trawl fleet. Discarding in the target pelagic fisheries is considered negligible. New information in 2015 from bottom-trawl fisheries not directed at horse mackerel indicated an overall discard rate of 16.7% for the stock as a whole, while in 2016 this rate is 10%. Complete discard information for earlier years has not been submitted to ICES. However, information from national discard reports for the non-directed bottom-trawl fisheries indicates a similar level of discarding in earlier years.

6.3 Biological Data

6.3.1 Catch in Numbers at Age

In 2017, as already occurred in 2016, there has been a marked reduction in the coverage of biological sampling. Only the 38% of landings was sampled, in comparison to 2013 and 2014 when 71% and 63% were sampled respectively (section 5 figure 5.9.1). In addition, this low coverage was carried out mostly by the Dutch fleet in quarter Q4 and divisions 27.7.d and 27.4.c. Despite most landing catch was taken from this area and quarter (81.9% of landings in division 27.7.d and 75% in quarter Q4, Figure 6.3.1) still part of landings were fished in other areas and quarters. In order to avoid a biased perception of the age distribution of catches over the year and areas, this partial and uneven sampling effort should be avoided in future years.

Annual catch numbers at age by area for year 2017 are shown in table 6.3.1. Due to the low level of sampling effort out of area 27.7.d., there is not enough information to represent age distribution in those areas, and hence, the one observed in 27.7.d is taken as the basis to separate catch by age. Catch-at-age for the whole period 1995-2017 are given in, table 6.3.2 and in Figure 6.3.2. These data show that since 2005 the age distribution of catches has experienced a reduction, with a decrease in the range of ages of importance in total catches. In parallel to the rejuvenation of catches, the comparison of catch-at-age data after 1998 by area (Figure 6.3.3) shows that since 2010 commercial catches have increased in area 27.7.d in comparison to the areas 27.3.a and 4a,b and c where the opposite pattern was found. Since 2015, commercial catches are focused mostly on cohort 2014 that was the main component of catches both in and out of the area 27.7.d at age 1 in year 2015, age 2 in 2016 and age 3 in 2017. Ages 1 and 2 appear with moderate importance in the total catch.

Although 2015 cohort seems to be clear in the catch-at-age distribution, in general cohort structure is not clearly detectible in the data. This may partly be due to the shifts in distribution of the fishery. In addition, it may partly be due to age reading difficulties, which are a known to be encountered (e.g. Bolle *et al*., 2011). Most clearly detectable is the relatively large 2001 year class, although it is not clearly present in the catch in all years. There are indications that environmental circumstance may be an important factor (possibly stronger than stock size) contributing to spawning success in horse mackerel. This is for example illustrated by the largest year classes (1982 and 2001) observed in the Western stock which incidentally were produced at the lowest observed stock sizes. Since 2001 is considered to have been a relatively strong year class in the Western stock as well, it is plausible that circumstances in the North Sea were similar to those in Western areas and also allowed for relatively high spawning success in the North Sea.

Lastly, potential mixing of fish from the Western and North Sea stock in area 27.7.d and 27.7.e in winter may also confuse the cohort signals. For example, the large recruitment in the Western stock may have led to more of these fish being located in the North Sea stock area as age 1 fish in 2002. With the intention of clarifying the mixing among the North Sea and the Western horse mackerel stocks, and how this may affect to the age distribution of catches. In 2015 was conducted by IMARES and the Pelagic Freezer-trawler Association (PFA). The results of this project were not conclusive because of the low sample size and some technical glitches in the sequencing. The chemical analysis generated some new insights but also some more questions on the variability that could be expected between years and seasons. Currently more genetic samples are being taking by PFA in different areas of the North East Atlantic. In addition, catch sampling carried out by several pelagic fishery companies is being explored to give information on the separation between North Sea and Western horse mackerel. Until the mixing of both stocks is clarified and catch-at-age data can be clearly segregated the development of analytical assessment will be limited.

6.3.2 Mean weight at age and mean length at age

The mean weight and mean length-at-age in the commercial catches of 2017 are presented in tables 6.3.3 and 6.3.4 respectively by quarter and area. As explained for the distribution of catch-at-age by area, due to the biased sampling coverage in 2017 for several ages mean weight and length in quarters Q2-Q3 in areas 27.3.a, 24.7.a-b-c are assumed the same than in quarter Q1-Q4 in area 27.7.d.

The mean annual weight and length over the period 2000-2016 are presented in table 6.3.2 and figures 6.3.4 and 6.3.5 respectively. Despite there are no strong differences over this period, since 2006 there seems to be a slight but steady increase in both weight and length until 2015, when a declining pattern is observed. It may be hypothesized that this is due to density-dependent effects, due to the relatively successful recruitment of 2015.

6.3.3 Maturity-at-age

Peak spawning in the North Sea falls in May and June (Macer, 1974), and spawning occurs in the coastal regions of the southern North Sea along the coasts of Belgium, the Netherlands, Germany, and Denmark.

There is no information available about the maturity-at-age of the North Sea Horse mackerel stock.

6.3.4 Natural mortality

There is no specific information available about natural mortality of this stock.

6.4 Data Exploration

6.4.1 Catch curves

The log-catch numbers were plotted by cohort to estimate the negative gradient of the slope and get an estimate of total mortality (Z). Fully selected ages 3 to 14 from the 1992 – 2016 period provide complete data for the 1992 to 2006 cohorts (Figure 6.4.1). The estimated negative gradients by cohort (Figure 6.4.2) indicate an increasing trend in total mortality for the period examined, with a marked increment in the cohorts 2005 and 2006. However, due to the low quality of the signals for some cohorts these Z estimates has to be considered with caution.

An analysis of the catch number at age data carried out in 2011 showed that only the 1vs.2, 2vs.3, 7vs.8 and 8vs.9 age groups were positively and significantly correlated in the catch. This analysis was not updated this year but these results suggest limitations in the catch-at-age data.

6.4.2 Assessment models and alternative methods to estimate the biomass

In 2002 Ruckert *et al.* estimated the North Sea horse mackerel biomass based on a ratio estimate that related cpue data from the IBTS to cpue data of whiting (*Merlangius merlangus*). The applied method assumes that length specific catchability of whiting and horse mackerel are the same for the IBTS gear. Subsequently, they use the total biomass of whiting derived from an analytical stock assessment (MSVPA) to estimate the relationship between cpue and biomass.

At the 2014 WGWIDE some exploratory model fits were attempted with the JAXass model, using the data available. The JAXass (JAX assessment) model is a simple statistical catch-at-age model fitted to an age-aggregated index of (2+) biomass, total catch data and proportions at age from the catch. It is based on Per Sparre's "separable VPA" model, an ad hoc method tested for the first time at WGWIDE in 2003, and later 2004. A new analysis using this model was also done in 2007 using an IBTS index. In 2014 the model has been coded in ADMB (Fournier *et al*., 2012) and updated with an improved objective function (dnorm), extra years of data and new methods for calculating the index (see above).

Difficulties in fitting an assessment model for this stock include:

- Unclear stock boundaries

- Difficulty aging horse mackerel

- Lack of strong cohort signals in CAA data.

- Scientific index derived from a survey not specifically designed for horse mackerel and not covering one of the main fishing grounds for the stock (VIId)

Catches taken in area 27.7. d are close to the management boundary between the (larger) western horse mackerel stock and the NS horse mackerel stock. It is quite possible that given changes in oceanographic condition, or changes in abundance of either of the two stocks, that some proportion of the catches taken in area 27.7.d actually originated from the western horse mackerel stock. Nevertheless, all assessment models

used in the MSE assume that 100% of fish caught in area 27.7.d belong to the North Sea horse mackerel stock. This is in agreement with stock and management definitions.

6.4.3 Survey data

6.4.3.1 Egg Surveys

No egg surveys for horse mackerel have been carried out in the North Sea since 1991. Such surveys were carried out during the period 1988—1991. SSB estimates are available historically. However, they were calculated assuming horse mackerel to be a determinate spawner. Horse mackerel is now considered an indeterminate spawner. Therefore egg abundance could only be considered a relative index of SSB. The mackerel egg surveys in the North Sea do not cover the spawning area of horse mackerel.

6.4.3.2 IBTS Survey Data

Many pelagic species are frequently found close to the bottom during daytime (which is when the IBTS survey operates) and migrate upwards predominantly during the night they are susceptible to semi-pelagic fishing gear and to bottom trawls (Barange *et al.* 1998). Eaton *et al.* (1983) argued that horse mackerel of 2 years and older are predominantly demersal in habit. Therefore, in the absence of a targeted survey for this stock, the IBTS is considered a reasonable alternative. IBTS data are also used in the assessment of the southern horse mackerel stock.

IBTS data from quarter Q3 were obtained from DATRAS and analysed. Based on a comparison of IBTS data from all 4 quarters in the period 1991—1996, Ruckert *et al.* (2002) showed that horse mackerel catches in the IBTS were most abundant in the third quarter of the year. In 2013 WGWIDE considered that using an 'exploitable biomass index' estimated with the abundance by haul of individuals larger than 20 cm is the most appropriate for the purpose of interpreting trend in the stock.

To create indices, a subset of ICES rectangles was selected. Rectangles that were not covered by the survey more than once during the period 1991—2012 were excluded from the index area. In 2012, WGWIDE expressed concern that the previously selected index area did not sufficiently cover the distribution area of the stock, especially in years that the stock would be relatively more abundant and spread out more. Ruckert *et al.* (2002) also identified a larger distribution area of the North Sea stock. Based on the above, 61 rectangles were identified to be included in the index area as shown in Figure 6.4.3.

6.4.3.3 The French Channel Groundfish Survey (CGFS) in Q4

In order to improve data basis for the North Sea horse mackerel assessment, alternative survey indices have been explored. Previous indices used had only cover the North Sea distribution of the stock, while the majority of catches in recent years have come from the eastern English Channel (27.7.d). We evaluated the potential contribution of the French Channel Ground Fish Survey in 27.7.d (CGFS) in Quarter 4. The CGFS is carried out since 1990 and has frequent captures of horse mackerel. Though this survey is conducted in a different quarter to the North Sea IBTS, the observed seasonal migration patterns of horse mackerel indicate that fish move into the channel following quarter Q3, so the timing is considered appropriate.

In 2015, the RV "Gwen Drez" was replaced by the RV "Thalassa" to carry out the CGFS survey. In 2014 an inter-calibration process was conducted to quantify the differences

in catchability for a large number of species. ICES reviewed this inter-calibration exercise and found a number of drawbacks that may undermine the reliability of the estimated conversion factors. The main concerns were:

- The analyses were limited in the number of tows. Considering that a number of these tows could be zeros for one of the two vessels and possibly resulting in highly uncertain estimates.
- Lack of length-specific correction factor.
- At a standardized depth of 50 m and above, wing spread estimates for the R/V Thalassa as measured by the MARPORT sensor were deemed erroneous, which may question the validity of estimated area swept by the net on the R/V Thalassa and the effect it may have on correction factors for species caught at depth at 50m and greater.
- A number of tow locations including areas outside 27.7.d were excluded. Changing the depth range of a survey can add serious bias in the calibration and the current approach seems to be ignoring this issue.
- Correction coefficients were not measured without error.

However, these limitations were considered by WGWIDE to be of minor importance for the North Sea horse mackerel since:

- Despite being still a low sample size the North Sea horse mackerel was present in all the 32 paired hauls.
- There are no important differences in size distribution (Figure 6.4.4).
- The analysis with and without the areas excluded in the new sampling design did not show important differences (ICES, 2017).
- cpue or North Sea horse mackerel for hauls deeper than 50 m was relatively low (Figure 6.4.5), and it is expected than the potential problems in determining the conversion factor bellow that depth range would have a relatively minor impact in the estimated abundance.

For these reasons it was finally decided to continue using the CGFS survey, standardizing the time-series of abundance for the period 1990-2015 with the estimated conversion factor 10.363.

6.4.3.4 Norht Sea horse mackerel benchmark exercise

In January 2017, a benchmark process was conducted for NSHM (ICES, 2017). Based on capacity to model the overdispersion and the high proportion of zero values in the survey catch data the hurdle models was concluded the best option of all the model alternatives tested. The log-likelihood ratio test, the AIC and the evidence ratio statistic supported that the model that best represented the data was a hurdle model with Year and Survey as explanatory factors (including the interaction term) in the count model (GLM-negative binomial), and Year and Survey (without the interaction) in the zero model (GLM-binomial).

The probability of having a cpue zero was modelled by a logistic regression with a GLM-binomial distribution model:

$$logit(\pi_i) = Intercept_{zero} + Year_{i,zero} + Survey_{i,zero}$$

Where π_i is the mean probability of having a cpue zero as a function Year and Survey.

The expected cpue of North Sea horse mackerel, conditional to not having a zero in hurdle models (not having a false zero in zero inflated models) was modelled with a GLM-negative binomial distribution model:

$$\log(CPUE_i) = Intercept_{count} + Year_{i,count}\ x\ Survey_{i,count}$$

This model was used to synthesise the information from both the GCFS and IBTS and predict the average annual cpue index per haul as an indicator of trends in stock abundance both for the juvenile (<20cm) and exploitable (>20cm) substocks. The contribution of the two surveys to the combined index is weighted taken into consideration their respective surface coverage as well as the mean wing spread. This index model allowed upgrading the NSHM to a category 3 stock within the ICES classification.

6.4.4 Summary of index trends

The survey index for both the small and exploitable substocks experienced a marked decline in the early-mid 2000s (Figure 6.4.6; table 6.4.1). This reduction was due in part to the decline of the average abundance by haul over time, but also to the increase of hauls with zero catch of horse mackerel, from 26% in 1998 to the highest observed value of 72% in 2013 (Figure 6.4.7). Since 2014 a slight decrease in zero hauls was observed in juveniles group (smaller than 20 cm). Since 2013, in addition to the decline of zero hauls, the mean cpue in the non-zero hauls has increased. After an increase in 2016, the abundance survey index for the exploitable substock has shown a marked decline in 2017. This pattern has been mostly due to the decline of the survey index estimated for the CGFS in comparison to the value in 2016 (Figure 6.4.8). The survey index of the juvenile substock, that also showed an increasing pattern since 2013, seems to be stabilized since 2014 in the CGFS, but in the IBTS is in 2017 at the lowest level since 1992. Due to this compensation by the CGFS, the abundance index for juveniles, show a less steep decline than the exploitable substock index. The size distribution in both the CGFS and the IBTS suggest the entrance of a moderate new cohort in 2017 (between 4-7cm in the IBTS and 7-11cm in the CGFS) age 0 (Figures 6.4.9 and 6.4.10).

However, despite the index of abundance of individuals smaller than 20 cm could be considered a recruitment index, it has to be considered with caution. Preliminary examinations of how the juvenile (0–19cm) indices relate to subsequent exploitable abundance (20+ cm) do not indicate strong linkages. The very high juvenile indices in the early 2000s in the IBTS were not subsequently picked up in the exploitable component. Hence while increases in the juvenile indices are encouraging, whether these lead to increases in the exploitable component of the stock need to be confirmed in the future with observations in the 20+ cm indices.

6.4.5 Data Limited Stock methods and MSY proxy reference points

As part of the ICES approach to provide advice within the MSY framework for stocks of category 3 and 4, different Data Limited methods to estimate MSY proxy reference points for the North Sea horse mackerel were explored. This analysis and results were presented in a separate working document (Pérez-Rodríguez, 2017). After exploring the compliance with each method assumptions and assessing the data availability the group decided that the Length Based Indicators would be the only DLS method to be applied to the NSHM.

Despite this length based method will have to be applied in the future to a longer time-series of catch length frequencies, only length data have been collected for 2016 and 2017. The estimates of F/F_{MSY} proxy indicate that fishing mortality seems to be, both in

2016 and 2017, slightly above F_{MSY} for the North Sea horse mackerel, with F/F_{MSY}=1.082 and 1.073 respectively (Figure 6.4.11).

6.4.6 Ongoing work

To improve the knowledge base for North Sea horse mackerel about the degree of connection and migrations in between the North Sea and the Western Stock, catch sampling carried out by several pelagic fishery companies is being explored to give information on the separation between North Sea and Western horse mackerel. To improve the abundance indicators the potential application of a commercial fishery search time index will be explored. Horse mackerel is fished while it is very close to the bottom in relatively dispersed, small schools. The fishery is mostly executed using long hauls and there may be extensive search time involved. Handled in an appropriate statistical framework, taking into account the nature of the fishery and other factors such as seasonality and alternative fishing opportunities, the search time and catch rates could provide for an indication of changes in stock size over time. Catch rates in areas 27.7.e, 27.7.d and southern North Sea will be analysed from skippers' private logbooks.

6.5 Basis for 2019 Advice. ICES DLS approach.

Stock advice for NSHM is biannual. In 2017 the advice for years 2018 and 2019 was provided. The joint abundance survey index indicated a continuation in the increasing trend observed since 2013. This increase was due mostly to the increment observed in the CGFS survey index. Despite that, as mentioned in the previous section, the joint survey index for 2017 has shown a sudden change and steep decline due to the drop of the CGFS survey index, WGWIDE decided to continue with the current advice of 17517 tonnes for 2019.

The fisheries in the area have largely been focused on the smaller fish in 2015, 2016, 2017 and it is expected that this will continue in 2018 and 2019. With this pattern of exploitation, mostly immature individuals are caught which might hinder the recovery of the stock by removing an important portion of the recent year classes before they enter the spawning stock.

6.6 Management considerations

In the past, Division 27.7.d was included in the management area for Western horse mackerel together with Divisions 27.2.a, 27.7.a–c, 27.7.e–k, 27.8.a, 27.8.b, 27.8.d, 27.8.e, Subarea 6, EU and international waters of Division 5.b, and international waters of Subareas 12 and 14. ICES considers Division 27.7.d to be part of the North Sea horse mackerel distribution area. Since 2010, the TAC for the North Sea area has included Divisions 27.4.bc and 27.7.d. Considering that a majority of the catches are taken in Division 27.7.d, the total of North Sea horse mackerel catches are effectively constrained by the TAC since the realignment of the management areas in 2010.

Catches in Divisions 27.3.a (Western Skagerrak) and 27.4.a in quarters 3 and 4 are considered to be from the Western horse mackerel stock, while catches in quarters 1 and 2 are considered to be from the North Sea horse mackerel stock. Catches in area 27.4.a and 27.3.a are variable. In recent years only Norway has had significant catches in this area, but these are only taken in some years.

6.7 References

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6.8 Tables

Table 6.3.1. North Sea Horse Mackerel stock. Catch in numbers (1000) by quarter and area in 2017.

	Number/1000					
1Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.99	44.35	96.06	10.51	0	151.91
2	0.9	40.45	87.61	9.59	1579.74	1718.29
3	2.73	122.35	265.02	29	6243.76	6662.86
4	0.4	17.94	38.85	4.25	4502.28	4563.72
5	0.25	11.08	24	2.63	3308.95	3346.91
6	0.15	6.87	14.89	1.63	1229.79	1253.33
7	0.11	4.99	10.8	1.18	2074.86	2091.93
8	0.1	4.45	9.63	1.05	1604.79	1620.02
9	0.04	1.75	3.78	0.41	558.59	564.58
10	0.01	0.49	1.06	0.12	261.55	263.23
11	0.02	1.02	2.2	0.24	297.05	300.53
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.01	0.49	1.06	0.12	261.55	263.23
15	0.01	0.49	1.06	0.12	261.55	263.23
Sum	5.72	256.7	556.04	60.84	22184.47	23063.76
2Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	16.65	24.39	17.35	411.9	828.12	1298.41
2	15.18	22.24	15.83	375.67	755.27	1184.19
3	45.93	67.28	47.87	1136.4	2284.7	3582.19
4	6.73	9.86	7.02	166.61	334.96	525.18
5	4.16	6.09	4.34	102.93	206.94	324.46
6	2.58	3.78	2.69	63.83	128.32	201.19
7	1.87	2.74	1.95	46.31	93.1	145.97
8	1.67	2.44	1.74	41.29	83.02	130.17
9	0.66	0.96	0.68	16.22	32.61	51.13
10	0.18	0.27	0.19	4.55	9.15	14.35
11	0.38	0.56	0.4	9.45	18.99	29.77
12	0	0	0	0	0	0

13	0	0	0	0	0	0
14	0.18	0.27	0.19	4.55	9.15	14.35
15	0.18	0.27	0.19	4.55	9.15	14.35
Sum	96.37	141.15	100.44	2384.26	4793.5	7515.73

3Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	59.57	59.57
1	0	0	70.95	111.67	1329.97	1512.59
2	0	0	64.71	101.85	1212.97	1379.53
3	0	0	195.75	308.08	3669.25	4173.08
4	0	0	28.7	45.17	537.94	611.81
5	0	0	17.73	27.9	332.34	377.98
6	0	0	10.99	17.3	206.08	234.38
7	0	0	7.98	12.55	149.52	170.05
8	0	0	7.11	11.19	133.33	151.64
9	0	0	2.79	4.4	52.38	59.57
10	0	0	0.78	1.23	14.7	16.72
11	0	0	1.63	2.56	30.5	34.68
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.78	1.23	14.7	16.72
15	0	0	0.78	1.23	14.7	16.72
Sum	0	0	410.69	646.39	7757.96	8815.04
4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	391.05	391.05
1	0	0	6.18	1874.01	15901.14	17781.33
2	0	0	5.64	4425.6	12187.97	16619.21
3	0	0	17.06	11524.87	36654.11	48196.04
4	0	0	2.5	1611.53	2872.44	4486.47
5	0	0	1.55	250.28	1730.29	1982.11
6	0	0	0.96	0	1722.52	1723.48
7	0	0	0.7	0	413.71	414.4
8	0	0	0.62	0	542.37	542.99
9	0	0	0.24	0	263.86	264.1
10	0	0	0.07	0	0	0.07
11	0	0	0.14	0	173.56	173.7

12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.07	0	0	0.07
15	0	0	0.07	0	0	0.07
	0	0	786.34	999.45	80108.12	81893.91

1-4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	450.61	450.61
1	17.64	68.73	190.55	2408.1	18059.23	20744.25
2	16.09	62.69	173.79	4912.7	15735.95	20901.21
3	48.66	189.63	525.7	12998.35	48851.82	62614.16
4	7.13	27.8	77.07	1827.55	8247.61	10187.17
5	4.41	17.18	47.62	383.74	5578.52	6031.46
6	2.73	10.65	29.53	82.76	3286.72	3412.39
7	1.98	7.73	21.42	60.04	2731.19	2822.36
8	1.77	6.89	19.1	53.54	2363.51	2444.81
9	0.69	2.71	7.5	21.03	907.44	939.38
10	0.19	0.76	2.11	5.9	285.41	294.37
11	0.4	1.58	4.37	12.25	520.09	538.69
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.19	0.76	2.11	5.9	285.41	294.37
15	0.19	0.76	2.11	5.9	285.41	294.37
Sum	102.09	397.85	1102.97	22777.77	107588.92	131969.6

Table 6.3.2. Numbers at age (millions), weight at age (kg) and length at age (cm) for the North Sea horse mackerel 1995-2017 in the commercial fleet catches.

MILLIO

AGE	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	1.8	4.6	12.6	2.3	12.4	70.2	12.8	60.4	13.8	15.7	52.4	5	3.4	1.7	34.1	3.3	8.1	9.5	7.6	15.4	49.7	3.6	20.7
2	3.1	13.8	27.2	22.1	31.5	78	36.4	16.8	56.2	17.5	29.8	23.7	15.5	8.8	13.9	22.5	23.3	24.3	10	15.3	23.8	65.2	20.9
3	7.2	11	14.1	36.7	23.1	28.4	174.3	19.3	23.4	34.4	27.8	61.5	22.8	36.1	28.4	10.7	76.5	20.4	21.3	8.7	10.1	15.9	62.6
4	10.3	11.9	14.9	38.8	17.6	21.4	87.8	11.9	33.2	14.5	12.6	40.9	82.6	16.7	22.1	15.7	37.3	40.2	22.2	30.2	5.8	9.8	10.2
5	12.1	9.6	14.6	20.8	23.1	31.3	18.5	5.6	26.9	27.8	16.7	73	71.2	36.4	17.3	23.7	14.6	25.8	27.1	13.8	7.2	7.7	6
6	13.2	12.5	12.4	12.1	26.2	19.6	11.5	5.8	10.6	20.2	5.2	23.4	30.5	36.1	16.3	15.9	9.9	20.8	6	7.1	3.8	5.7	3.4
7	11.4	8	10.1	14	20.6	19.5	18.3	5.5	6.3	10.6	2.9	13.7	23.9	27.3	21.5	27.6	5.8	3.1	7.2	2.7	3.3	2.5	2.8
8	12.6	6.6	8.6	10.8	21.8	9	14.7	10.5	9.6	3.8	2.4	5.9	17.3	21.9	47.1	5.6	6	5	4.3	3.4	1.4	5.1	2.4
9	7.3	1.5	2.5	8.3	12.9	11.5	10.2	6.3	10.9	5.4	3.8	1.6	7.9	10.2	11.2	6.3	3.4	4.6	4	0.9	1.6	1.2	0.9
10	5.9	5.3	0.8	4	8.2	9	10	6.8	1.5	11	5.8	1.4	1.7	7.5	9.3	8.3	10.1	1.5	5.4	1	0.9	0.1	0.3
11	0	0.3	0.3	2.7	2.1	7	9.6	5.1	3.4	6.2	2.3	0.2	0.6	1.9	7.2	2.9	6.9	0.5	3.7	1.3	0.2	0.1	0.5
12	8.8	1.3	0.3	0.7	0.4	3.1	5.4	3	3.3	4.5	4.1	1.7	0.2	2.1	3.7	0.3	3.6	0.1	1	0.4	0.9	0.4	0
13	0.2	8.9		1.8	1.4	1.6	3.7	2.2	2.3	6.2	2.5	0.6	0.7	0.4	0.3	0.3	0.8		0.6	0	0.2	1.4	0
14	4.4	8	1.4	0.3	3.8		2	1.3	3.4	2.3	9.9	1	0.7	2.4	0.9	0.2	0.3	0.2	0	0.2	0.2	0.5	0.3
15+				5.1	4	12.2	5.8	2.7	4.7	8.5	9.6	0.8		1	6.1	1.1	0.5		0.1	0.1			0.3

KG WEIGHT

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	0.076	0.107	0.063	0.063	0.063	0.075	0.067	0.066	0.075	0.076	0.07	0.074	0.615	0.063	0.074	0.077	0.061	0.069	0.077	0.078	0.062	0.07	0.06
2	0.126	0.123	0.102	0.102	0.102	0.1	0.09	0.096	0.105	0.105	0.087	0.098	0.081	0.096	0.087	0.101	0.092	0.09	0.099	0.11	0.099	0.093	0.086
3	0.125	0.143	0.126	0.126	0.126	0.137	0.094	0.129	0.122	0.122	0.104	0.116	0.104	0.109	0.113	0.118	0.096	0.118	0.112	0.113	0.13	0.115	0.113
4	0.133	0.156	0.142	0.142	0.142	0.152	0.117	0.155	0.136	0.146	0.133	0.124	0.115	0.125	0.134	0.137	0.115	0.142	0.138	0.135	0.15	0.126	0.131
5	0.146	0.177	0.16	0.16	0.16	0.165	0.159	0.171	0.164	0.174	0.159	0.141	0.13	0.145	0.152	0.155	0.145	0.152	0.166	0.144	0.169	0.158	0.173
6	0.164	0.187	0.175	0.175	0.175	0.192	0.183	0.195	0.18	0.198	0.197	0.178	0.163	0.161	0.182	0.183	0.166	0.172	0.18	0.177	0.196	0.155	0.189
7	0.161	0.203	0.199	0.199	0.199	0.194	0.198	0.216	0.193	0.224	0.238	0.212	0.192	0.193	0.195	0.206	0.193	0.183	0.2	0.184	0.26	0.162	0.177
8	0.178	0.195	0.231	0.231	0.231	0.216	0.201	0.227	0.212	0.229	0.248	0.247	0.197	0.221	0.258	0.199	0.193	0.188	0.216	0.201	0.29	0.235	0.188
9	0.165	0.218	0.25	0.25	0.25	0.244	0.237	0.228	0.24	0.256	0.259	0.236	0.257	0.286	0.253	0.241	0.305	0.212	0.223	0.222	0.265	0.246	0.222
10	0.173	0.241	0.259	0.259	0.259	0.283	0.246	0.253	0.27	0.29	0.287	0.286	0.255	0.295	0.322	0.227	0.334	0.204	0.226	0.22	0.312	0.359	0.233
11	0.317	0.307	0.3	0.3	0.3	0.286	0.26	0.303	0.24	0.3	0.335	0.237	0.517	0.273	0.422	0.284	0.345	0.275	0.242	0.264	0.262	0.369	0.257
12	0.233	0.211	0.329	0.329	0.329	0.354	0.286	0.293	0.298	0.297	0.349	0.261	0.279	0.309	0.447	0.234	0.408	0.195	0.263	0.287	0.318	0.379	
13	0.241	0.258	0.367	0.367	0.367	0.316	0.287	0.317	0.356	0.301	0.338	0.267	0.339	0.375	0.383	0.288	0.474		0.262	0.252	0.351	0.242	
14	0.348	0.277	0.299	0.299	0.299		0.295	0.32	0.316	0.338	0.373	0.302	0.414	0.277	0.362	0.315	0.415	0.187	0.559	0.408	0.235	0.39	0.214
15+	0.348	0.277	0.36	0.36	0.36	0.35	0.336	0.389	0.353	0.402	0.375	0.404		0.389	0.46	0.351	0.475		0.339	0.273		0.378	0.26

CM LENGTH

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	19.2	19.2	19.2	19.2	19.2	19.1	19.5	19.4	20.3	19.8	18.1	20.1	19.9	20	20.3	20.8	19.2	19.9	20.9	20.4	19.8	20	19.1
2	22	22	22	22	22	21.5	21.5	21.7	22.3	22.2	21.5	22	20.8	21.6	21.6	22.6	21.7	21.7	22.4	22.9	22.9	22	21.3
3	23.5	23.5	23.5	23.5	23.5	23.9	21.9	23.8	23.7	23.6	22.9	23.4	22.5	23.2	23.2	23.9	23	23.5	23.5	23.6	24.6	23.6	23.3
4	24.8	24.8	24.8	24.8	24.8	24.9	23.4	25.4	24.6	25.2	24.7	24.1	23.6	24.1	24.6	25	24.5	25	25.3	24.8	25.8	24.8	24.1
5	25.5	25.5	25.5	25.5	25.5	26	26.7	26.3	26.2	26.6	25.9	25.4	24.4	25.6	25.8	25.7	25.9	25.7	27	25.4	26.6	26.4	26.7
6	26.4	26.4	26.4	26.4	26.4	27.6	27.5	27.4	27.3	27.5	27.7	27	26.6	26.3	27.2	27.1	27.6	27	27.1	27.3	28.2	26.1	27.5
7	27.2	27.2	27.2	27.2	27.2	28.1	28.1	28.6	28.2	28.8	29.8	28.6	27.8	28.1	28.1	28.3	27.7	27.1	28.3	27.5	30.4	27.5	27.5
8	29.2	29.2	29.2	29.2	29.2	28.6	28.5	29.3	29	29.2	30.4	29.8	28.1	28.8	30.6	28.4	27.8	27	28.9	28	31.7	30.2	28
9	29.5	29.5	29.5	29.5	29.5	29.9	29.8	29.4	29.9	30.4	30.8	30.8	30.1	31.2	31.1	30.2	31.9	28.6	29.2	28.8	30.5	30.5	29.1
10	29.5	29.5	29.5	29.5	29.5	31.2	30.2	30.3	30.9	31.4	31.8	31.5	31	31.8	32.5	30	32.5	28	29.5	29.2	32.5	34.7	29.5
11	30.6	30.6	30.6	30.6	30.6	31.5	30.7	31.4	30.7	31.9	33.8	31.2	39.5	31.6	35	32.2	33.2	30.1	30	30.7	31.5	35.2	31.1
12	32.1	32.1	32.1	32.1	32.1	33.6	32	31.6	31.9	31.7	35.6	30.8	31.5	32.2	35.3	30.8	34.6	27.5	30.4	30.6	32.3	35.5	
13	33.3	33.3	33.3	33.3	33.3	33.3	31.7	32.4	32.8	31.9	34	32.1	33.4	33.9	34	31.8	36.4		32.1	30	32.5	31.5	
14	31.1	31.1	31.1	31.1	31.1		32.1	32.4	32.5	33	34.4	32.5	34.5	32.3	34.2	33	36	27.5	38.5	36	30.5	36.1	30.5
15+	32.5	32.5	32.5	32.5	32.5	33.8	33.4	34.3	33.6	34.8	35.2	35.3		35.1	36.1	34.5	36.9		34.2	32.5		36.1	31.5

Table 6.3.3. North Sea Horse Mackerel stock. Mean weight at age (kg) in the catch by quarter and area in 2017.

	Number/1000					
1Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.06	0.06	0.06	0.06	0	0.06
2	0.086	0.086	0.086	0.086	0.058	0.081
3	0.114	0.114	0.114	0.114	0.087	0.108
4	0.13	0.13	0.13	0.13	0.112	0.127
5	0.172	0.172	0.172	0.172	0.151	0.168
6	0.19	0.19	0.19	0.19	0.159	0.184
7	0.175	0.175	0.175	0.175	0.163	0.173
8	0.188	0.188	0.188	0.188	0.178	0.186
9	0.222	0.222	0.222	0.222	0.225	0.223
10	0.233	0.233	0.233	0.233	0.233	0.233
11	0.257	0.257	0.257	0.257	0.277	0.261
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.214	0.214	0.214	0.214	0.214	0.214
15	0.26	0.26	0.26	0.26	0.26	0.26
2Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.06	0.06	0.06	0.06	0.06	0.06
2	0.086	0.086	0.086	0.086	0.086	0.086
3	0.114	0.114	0.114	0.114	0.114	0.114
4	0.13	0.13	0.13	0.13	0.13	0.13
5	0.172	0.172	0.172	0.172	0.172	0.172
6	0.19	0.19	0.19	0.19	0.19	0.19
7	0.175	0.175	0.175	0.175	0.175	0.175
8	0.188	0.188	0.188	0.188	0.188	0.188
9	0.222	0.222	0.222	0.222	0.222	0.222
10	0.233	0.233	0.233	0.233	0.233	0.233
11	0.257	0.257	0.257	0.257	0.257	0.257
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.214	0.214	0.214	0.214	0.214	0.214

15	0.26	0.26	0.26	0.26	0.26	0.26

3Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	0.06	0.06	0.06	0.06
2	0	0	0.086	0.086	0.086	0.086
3	0	0	0.114	0.114	0.114	0.114
4	0	0	0.13	0.13	0.13	0.13
5	0	0	0.172	0.172	0.172	0.172
6	0	0	0.19	0.19	0.19	0.19
7	0	0	0.175	0.175	0.175	0.175
8	0	0	0.188	0.188	0.188	0.188
9	0	0	0.222	0.222	0.222	0.222
10	0	0	0.233	0.233	0.233	0.233
11	0	0	0.257	0.257	0.257	0.257
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.214	0.214	0.214	0.214
15	0	0	0.26	0.26	0.26	0.26
4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	0.06	0.06	0.059	0.074
2	0	0	0.086	0.092	0.088	0.089
3	0	0	0.114	0.115	0.117	0.115
4	0	0	0.13	0.141	0.148	0.14
5	0	0	0.172	0.18	0.198	0.183
6	0	0	0.19	0	0.206	0.132
7	0	0	0.175	0	0.215	0.13
8	0	0	0.188	0	0.208	0.132
9	0	0	0.222	0	0.219	0.147
10	0	0	0.233	0	0	0.078
11	0	0	0.257	0	0.234	0.164
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.214	0	0	0.071
15	0	0	0.26	0	0	0.087

1-4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.06	0.06	0.06	0.06	0.059	0.075
2	0.086	0.086	0.086	0.088	0.081	0.087
3	0.114	0.114	0.114	0.114	0.109	0.117
4	0.13	0.13	0.13	0.133	0.131	0.135
5	0.172	0.172	0.172	0.174	0.174	0.167
6	0.19	0.19	0.19	0.19	0.187	0.178
7	0.175	0.175	0.175	0.175	0.182	0.179
8	0.188	0.188	0.188	0.188	0.191	0.257
9	0.222	0.222	0.222	0.222	0.222	0.291
10	0.233	0.233	0.233	0.233	0.233	0.359
11	0.257	0.257	0.257	0.257	0.255	0.369
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.214	0.214	0.214	0.214	0.214	0.379
15	0.26	0.26	0.26	0.26	0.26	0.37

Table 6.3.4. North Sea Horse Mackerel stock. Mean length (cm) at age in the catch by quarter and area in 2017.

	Number/1000					
1Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	19.1	19.1	19.1	19.1	0	19.1
2	21.3	21.3	21.3	21.3	18	20.7
3	23.4	23.4	23.4	23.4	21.5	23
4	24.1	24.1	24.1	24.1	22.9	23.8
5	26.6	26.6	26.6	26.6	25.7	26.4
6	27.5	27.5	27.5	27.5	26.3	27.3
7	27.4	27.4	27.4	27.4	26.8	27.3
8	28	28	28	28	27.8	28
9	29.1	29.1	29.1	29.1	29.6	29.2
10	29.5	29.5	29.5	29.5	29.5	29.5
11	31.1	31.1	31.1	31.1	32.5	31.4
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	30.5	30.5	30.5	30.5	30.5	30.5
15	31.5	31.5	31.5	31.5	31.5	31.5
2Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	19.1	19.1	19.1	19.1	19.1	19.1
2	21.3	21.3	21.3	21.3	21.3	21.3
3	23.4	23.4	23.4	23.4	23.4	23.4
4	24.1	24.1	24.1	24.1	24.1	24.1
5	26.6	26.6	26.6	26.6	26.6	26.6
6	27.5	27.5	27.5	27.5	27.5	27.5
7	27.4	27.4	27.4	27.4	27.4	27.4
8	28	28	28	28	28	28
9	29.1	29.1	29.1	29.1	29.1	29.1
10	29.5	29.5	29.5	29.5	29.5	29.5
11	31.1	31.1	31.1	31.1	31.1	31.1
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	30.5	30.5	30.5	30.5	30.5	30.5

15	31.5	31.5	31.5	31.5	31.5	31.5

3Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	19.1	19.1	19.1	19.1
2	0	0	21.3	21.3	21.3	21.3
3	0	0	23.4	23.4	23.4	23.4
4	0	0	24.1	24.1	24.1	24.1
5	0	0	26.6	26.6	26.6	26.6
6	0	0	27.5	27.5	27.5	27.5
7	0	0	27.4	27.4	27.4	27.4
8	0	0	28	28	28	28
9	0	0	29.1	29.1	29.1	29.1
10	0	0	29.5	29.5	29.5	29.5
11	0	0	31.1	31.1	31.1	31.1
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	30.5	30.5	30.5	30.5
15	0	0	31.5	31.5	31.5	31.5
4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	19.1	19.2	19.1	19.1
2	0	0	21.3	21.9	21.6	21.6
3	0	0	23.4	23.4	23.6	23.5
4	0	0	24.1	24.8	25.3	24.7
5	0	0	26.6	28.5	27.5	27.5
6	0	0	27.5	0	28.1	18.5
7	0	0	27.4	0	28.7	18.7
8	0	0	28	0	28.5	18.8
9	0	0	29.1	0	28.4	19.2
10	0	0	29.5	0	0	9.8
11	0	0	31.1	0	29.5	20.2
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	30.5	0	0	10.2
15	0	0	31.5	0	0	10.5

1-4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	19.1	19.1	19.1	19.1	19.1	19.1
2	21.3	21.3	21.3	21.5	20.7	21.3
3	23.4	23.4	23.4	23.4	23	23.3
4	24.1	24.1	24.1	24.3	24.1	24.1
5	26.6	26.6	26.6	27.1	26.6	26.7
6	27.5	27.5	27.5	27.5	27.4	27.5
7	27.4	27.4	27.4	27.4	27.6	27.5
8	28	28	28	28	28.1	28
9	29.1	29.1	29.1	29.1	29	29.1
10	29.5	29.5	29.5	29.5	29.5	29.5
11	31.1	31.1	31.1	31.1	31	31.1
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	30.5	30.5	30.5	30.5	30.5	30.5
15	31.5	31.5	31.5	31.5	31.5	31.5

Table 6.4.1. North Sea Horse Mackerel. cpue Indices of abundance (individuals/hour) for juvenile (<20cm) and exploitable (>20cm) substocks, estimated as a combined index for the NS-IBTS Q3 (North Sea only, no 27.7.d included) and the Channel Ground Fish Survey in Q4 (CGFS, 27.7.d). The survey indices are derived from the prediction of a hurdle model fit to data over the period 1992-2017.

	Juvenile substock (<20cm)			Exploitable substock (>20cm)		
Year	**Index**	**CI_low**	**CI_high**	**Index**	**CI_low**	**CI_high**
1992	4865	2293	9237	1498	663	2915
1993	1917	959	3415	565	291	974
1994	3288	1593	6067	1322	635	2368
1995	2232	1107	4115	1621	669	3401
1996	1178	447	2480	1080	482	1987
1997	3350	1516	6253	714	336	1286
1998	858	414	1573	436	201	806
1999	1475	794	2433	517	257	905
2000	1139	516	2333	289	137	570
2001	3431	1580	7437	508	245	916
2002	2999	1515	5386	501	240	937
2003	2116	1190	3499	381	179	726
2004	1064	559	1844	428	199	754
2005	987	530	1727	759	366	1370
2006	502	271	880	834	422	1523
2007	665	375	1107	411	197	787
2008	394	224	695	209	101	458
2009	758	416	1265	104	47	212
2010	1611	863	2981	234	106	459
2011	569	317	1091	282	136	583
2012	354	189	705	185	93	437
2013	1062	572	1882	146	64	335
2014	1609	909	2747	430	193	876
2015	2257	1220	4527	580	261	1146
2016	1752	959	2976	803	376	1557
2017	973	505	1714	131	54	282

6.9 Figures

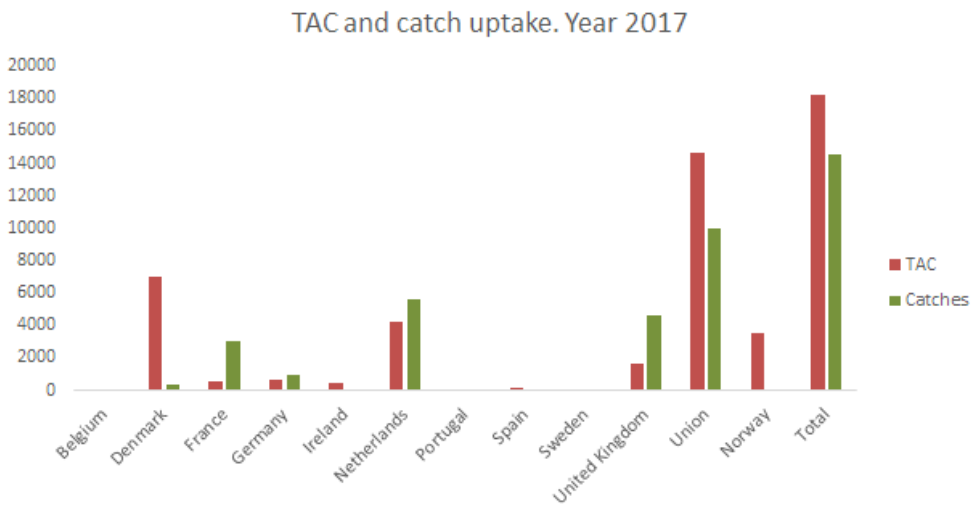


Figure 6.2.1. North Sea horse mackerel. Utilisation of quota by country.

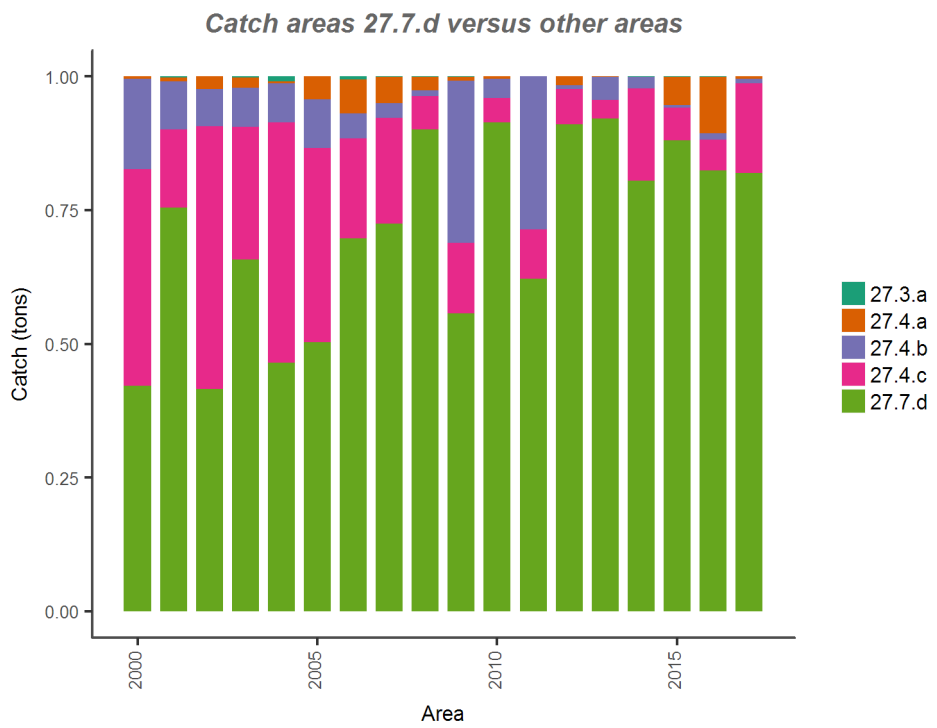
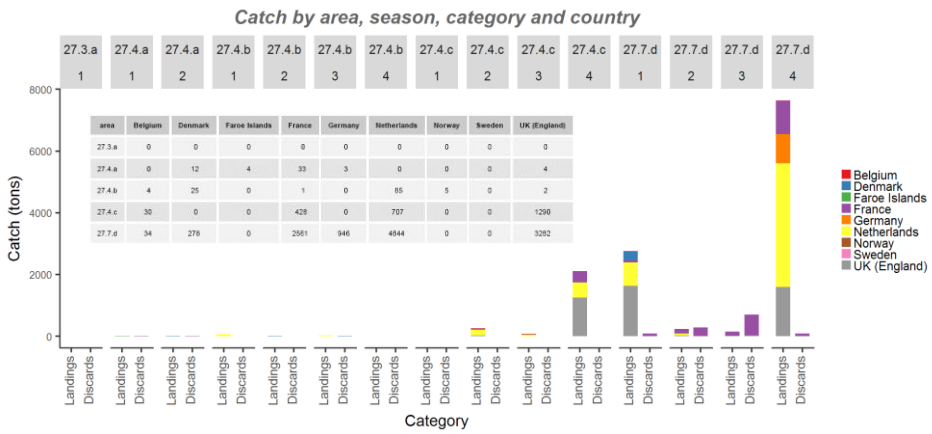


Figure 6.2.2 North Sea Horse Mackerel. North Sea horse mackerel. Catch by ICES Division for 2000–2017.



area	Belgium	Denmark	Faroe Islands	France	Germany	Netherlands	Norway	Sweden	UK (England)
27.3.a	0	0	0	0	0	0	0	0	0
27.4.a	0	12	4	33	3	0	0	0	4
27.4.b	4	25	0	1	0	85	5	0	2
27.4.c	30	0	0	428	0	707	0	0	1290
27.7.d	34	278	0	2561	946	4844	0	0	3282

Figure 6.2.3.- North Sea Horse Mackerel. Total catch (in tonnes) by area, quarter, catch category and country. BMS landing refers to landings below minimum legal size.

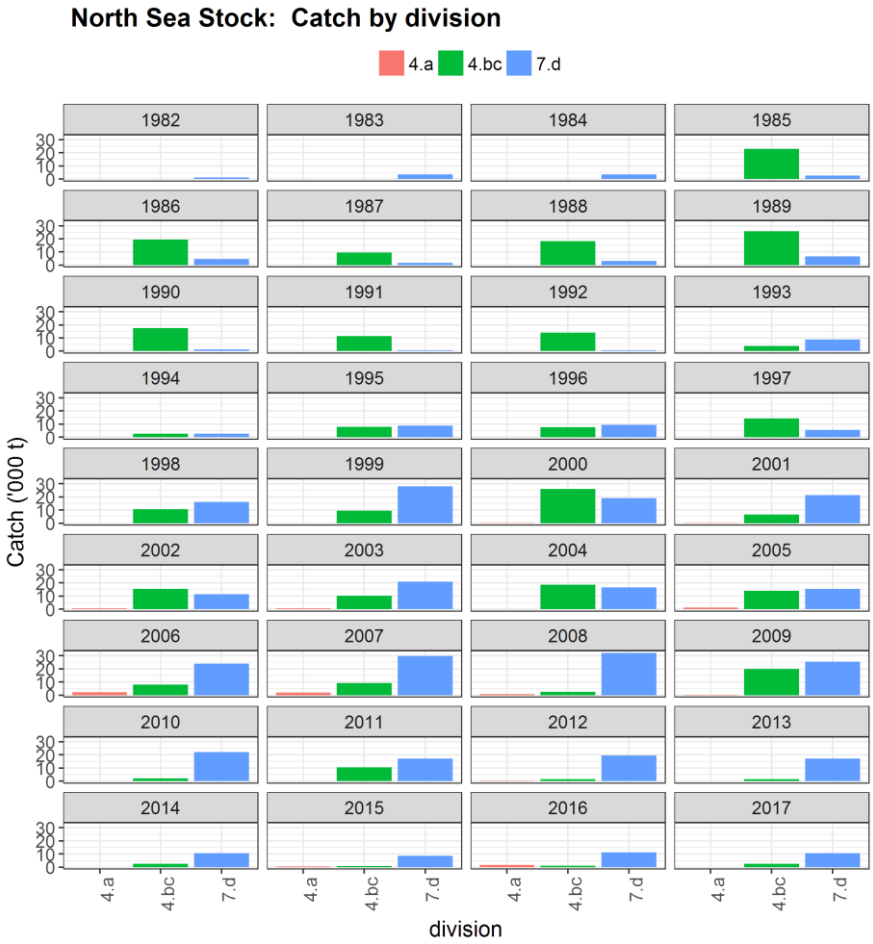


Figure 6.3.1.- North Sea Horse Mackerel. Proportion of NSHM total catch per year and station that have been sampled.

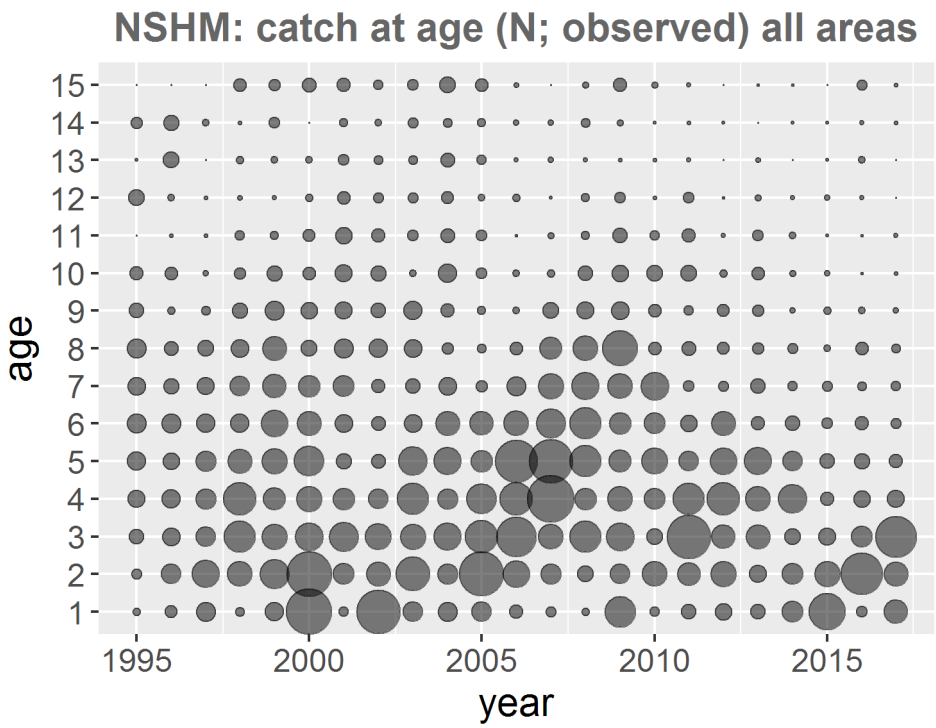


Figure 6.3.2.- North Sea horse mackerel age distribution in the catch for 1995–2017. The area of bubbles is proportional to the catch number. Note that age 15 is a plus group.

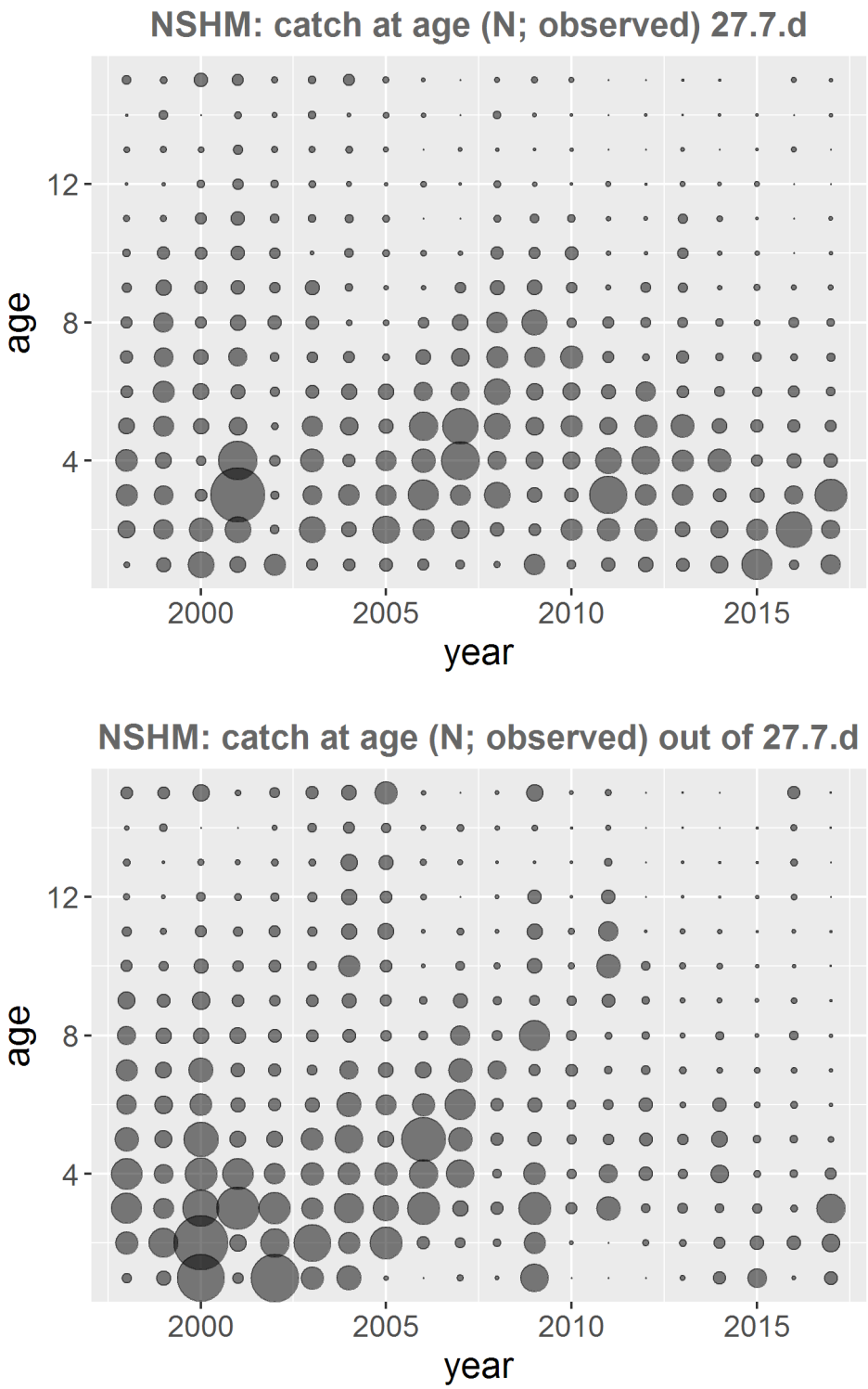


Figure 6.3.3. North Sea horse mackerel. Bubbleplots of age distribution in the catch by area for 1998-2017 for area 7.d (upper panel) and out of 7.d (bottom panel). The area of bubbles is proportional to the total catch number for the stock. Note that age 15 is a plus group.

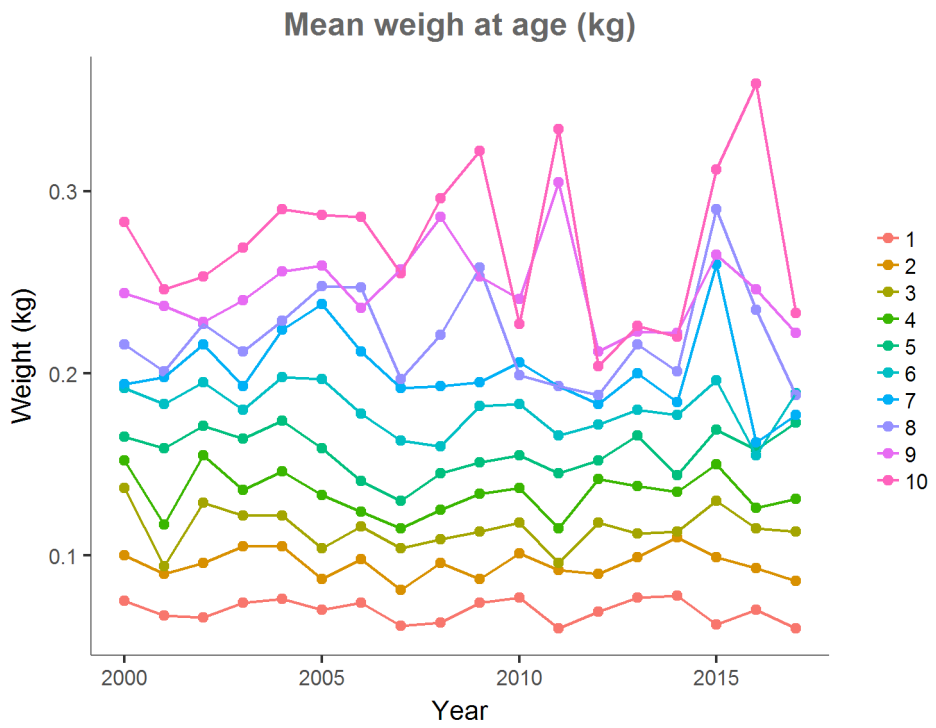


Figure 6.3.4. North Sea horse mackerel. Mean weight at age in commercial catches over the period 2000–2017

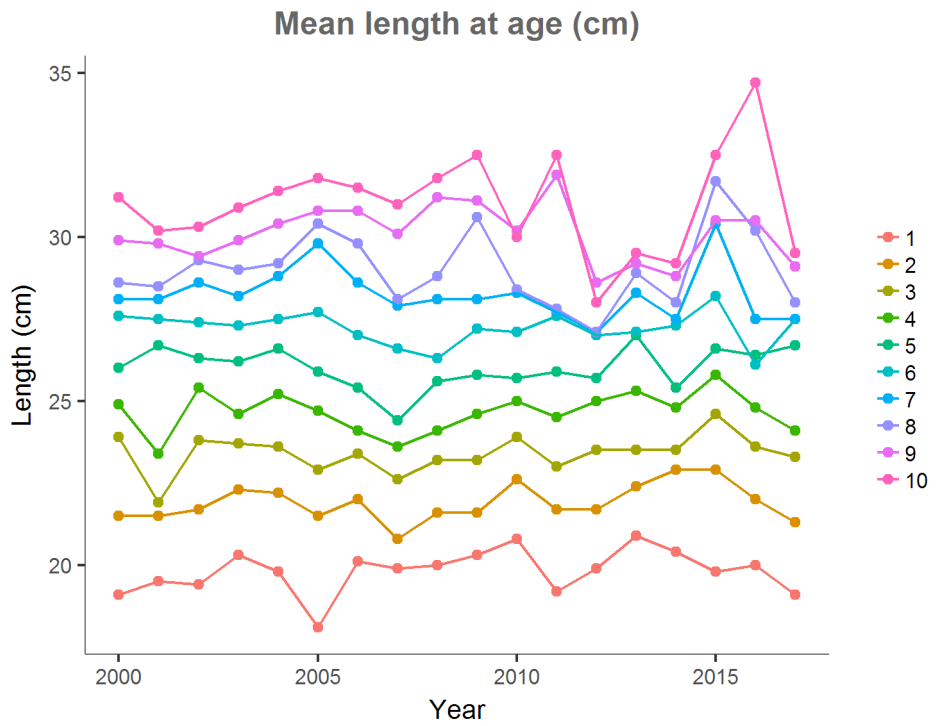


Figure 6.3.5. North Sea horse mackerel. Mean length at age in commercial catches over the period 2000–2017.

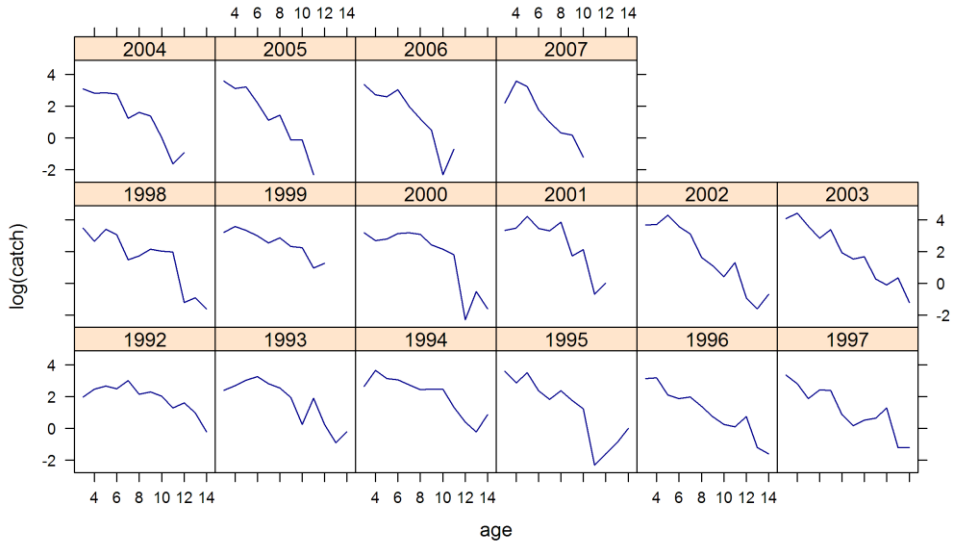


Figure 6.4.1. North Sea Horse Mackerel. Catch curves for the 1994 to 2007 cohorts, ages from 3 to 14. Values plotted are the log(catch) values for each cohort in each year. The negative slope of these curves estimates total mortality (Z) in the cohort.

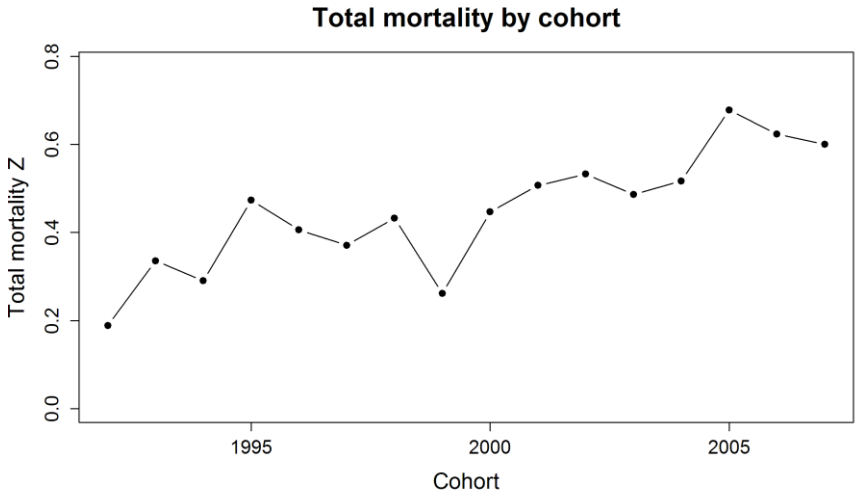


Figure 6.4.2. North Sea Horse Mackerel. Total mortality by cohort (Z) estimated from the negative gradients of the 1992–2006 cohort catch curves (Figure 6.4.1).

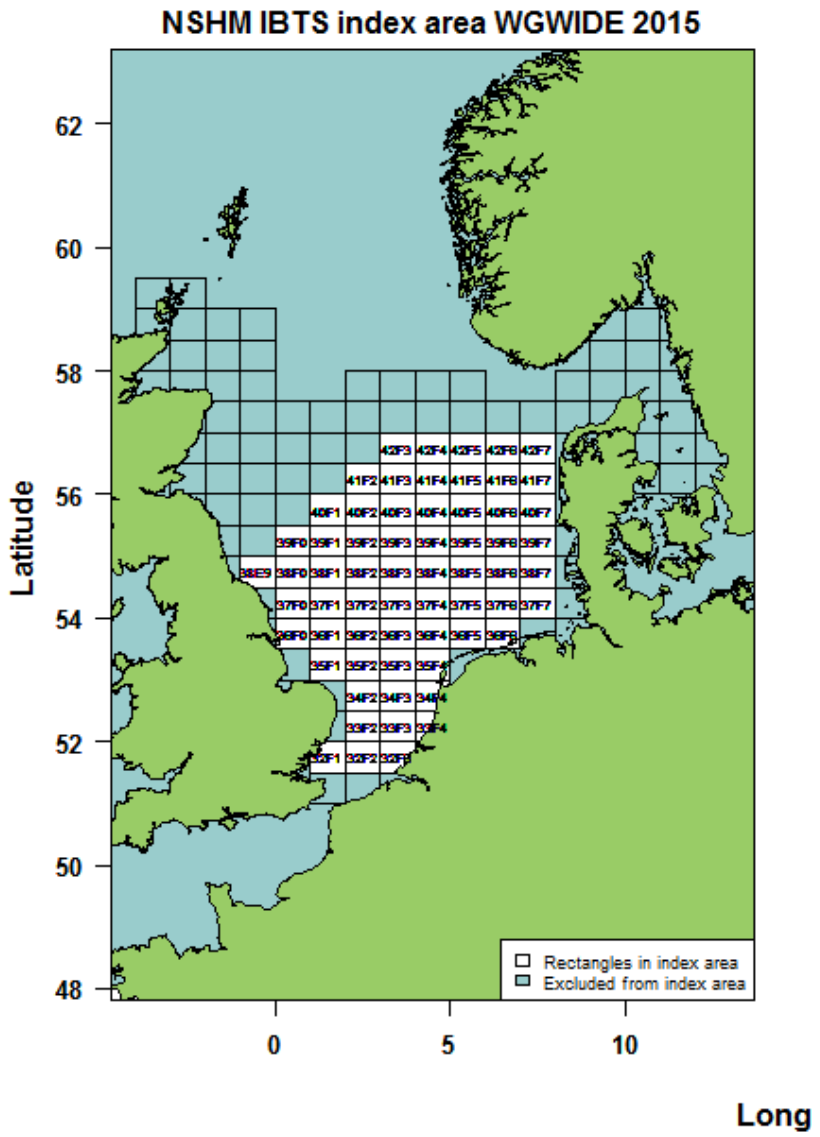


Figure 6.4.3.- North Sea horse mackerel. ICES rectangles selected in 2013 and currently used by the working group.

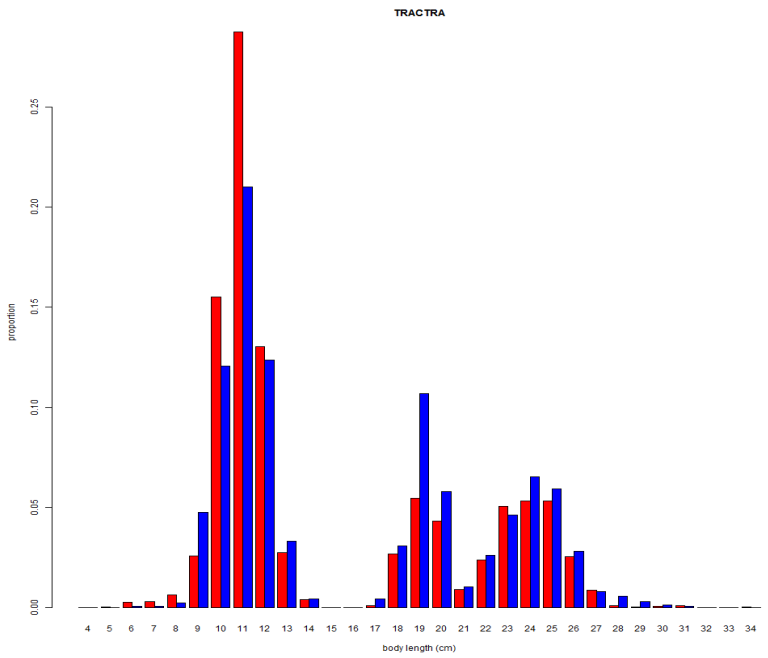


Figure 6.4.4.- North Sea horse mackerel. Size distribution of North Sea horse mackerel catches during the inter-calibration exercise conducted in 2014 between the RV Gwen Drez (red bars) and Thalassa (blue bars).

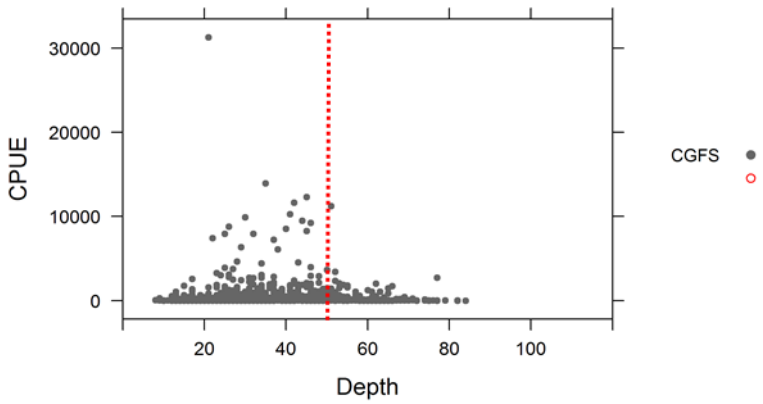


Figure 6.4.5. North Sea horse mackerel. cpue by depth for the CGFS survey from 1992 to 2017.

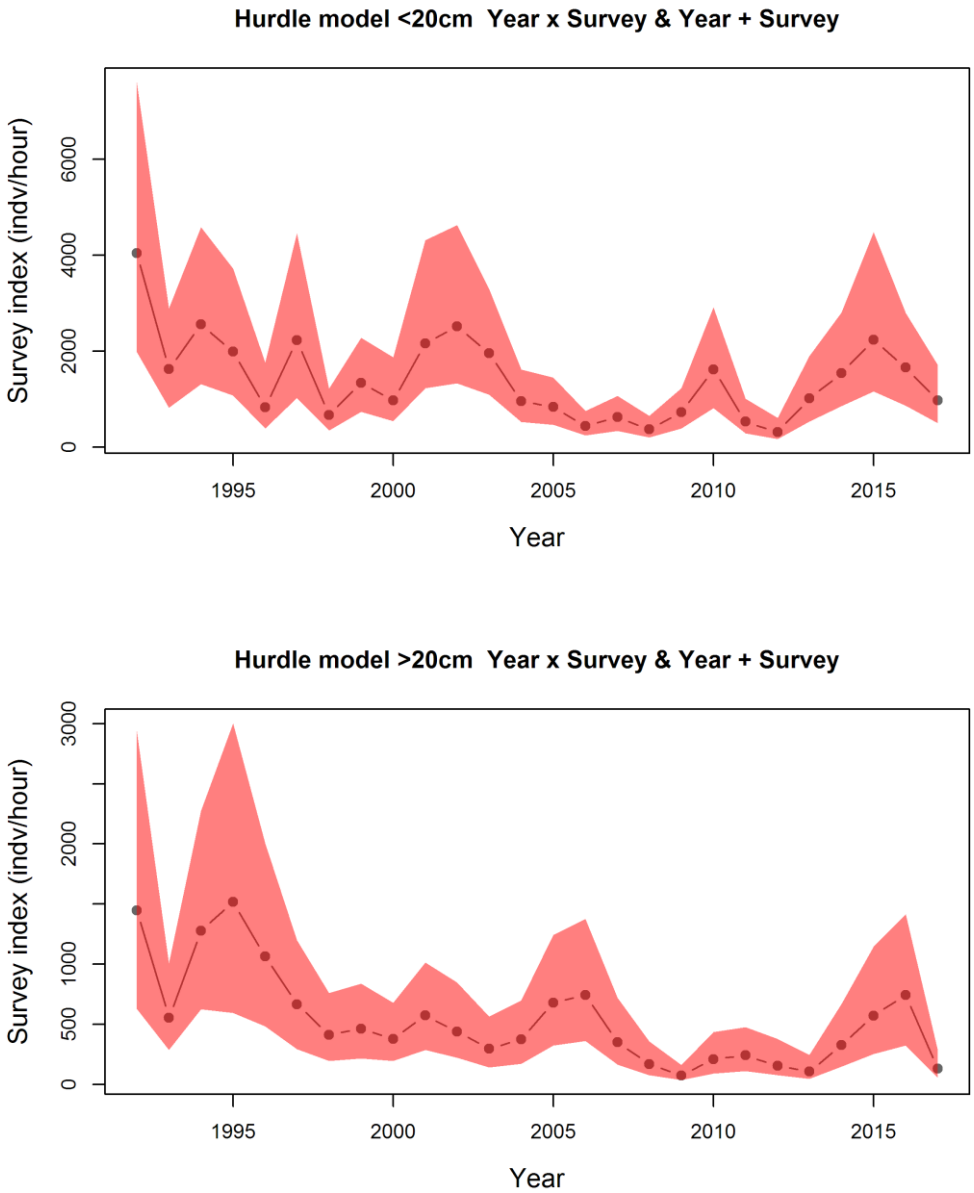


Figure 6.4.6. North Sea Horse Mackerel. Combined cpue survey index (indiv/hour) derived from the hurdle model fit to the IBTS survey in the North Sea (4.bc) and the CGFS survey in the English channel. Top: Juvenile substock (<20 cm); Bottom: exploitable substock (>20cm). The abundance index values are presented as number of individuals per hours. The confidence interval is determined by bootstrap resampling of Pearson residuals with 1000 iterations.

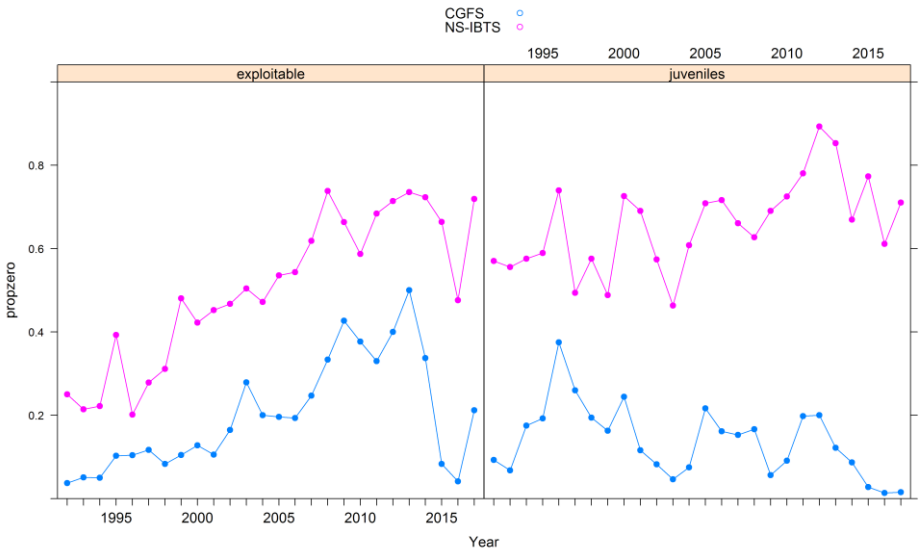


Figure 6.4.7.- North Sea horse mackerel. Proportion of hauls with zero catch for the exploitable (>20cm) and juvenile (<20 cm) substocks in the NS-IBTS (pink dotted lines) and the CGFS (blue dotted lines).

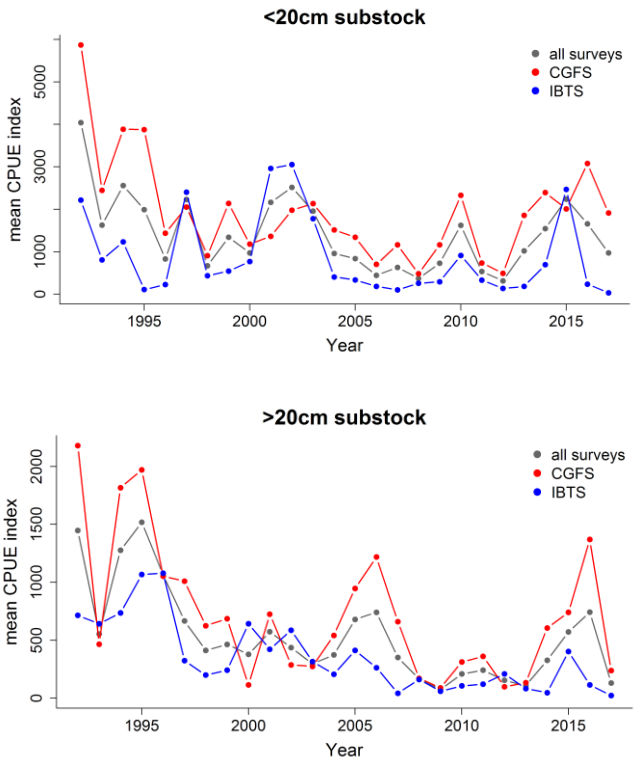


Figure 6.4.8. North Sea Horse Mackerel. Mean CPUE survey index (indiv/hour) obtained from the hurdle model fit to the IBTS survey in the North Sea (4.bc) and the CGFS survey in the English channel. Top: Juvenile substock (<20 cm); Bottom: exploitable substock (>20cm). The abundance index values are presented as number of individuals per hours.

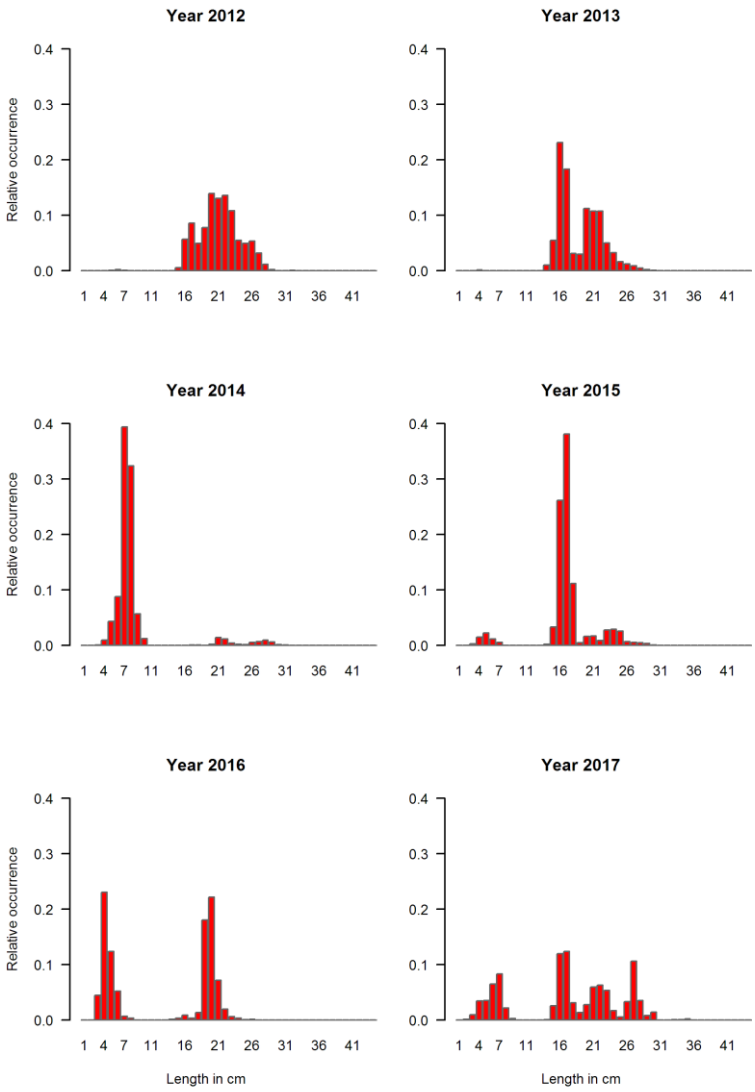


Figure 6.4.9. North Sea horse mackerel. Relative occurrence by length for the period 2012–2017 in the CGFS.

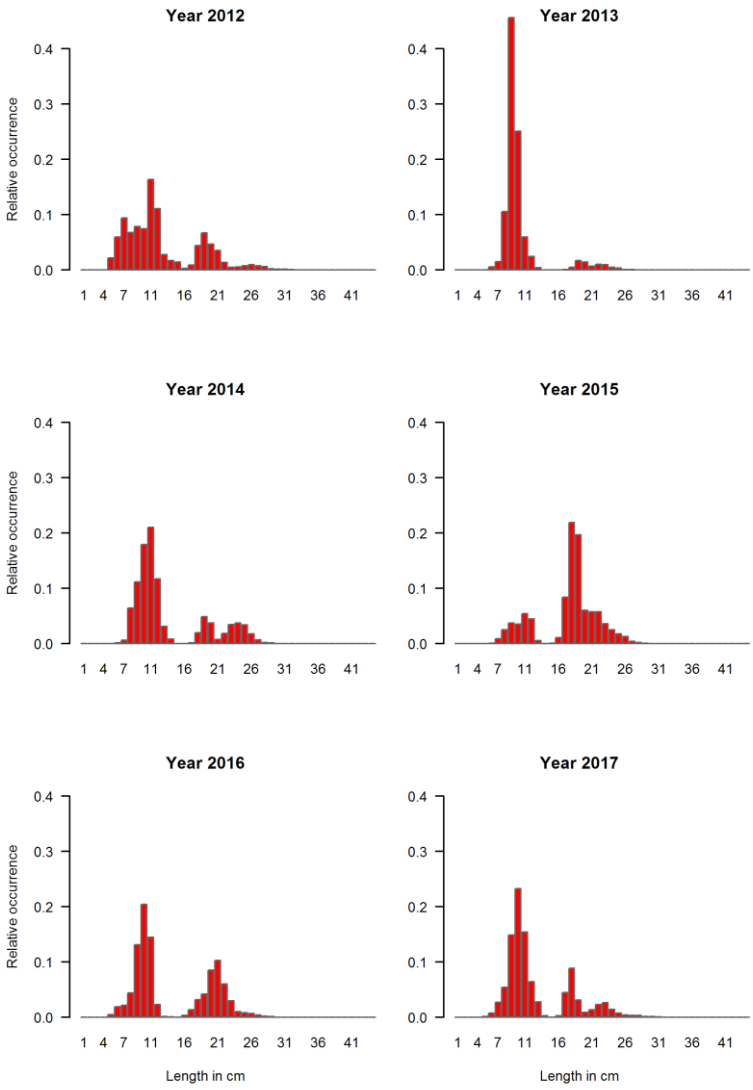


Figure 6.4.10. North Sea horse mackerel. Relative occurrence by length for the period 2012-2017 in the IBTS.

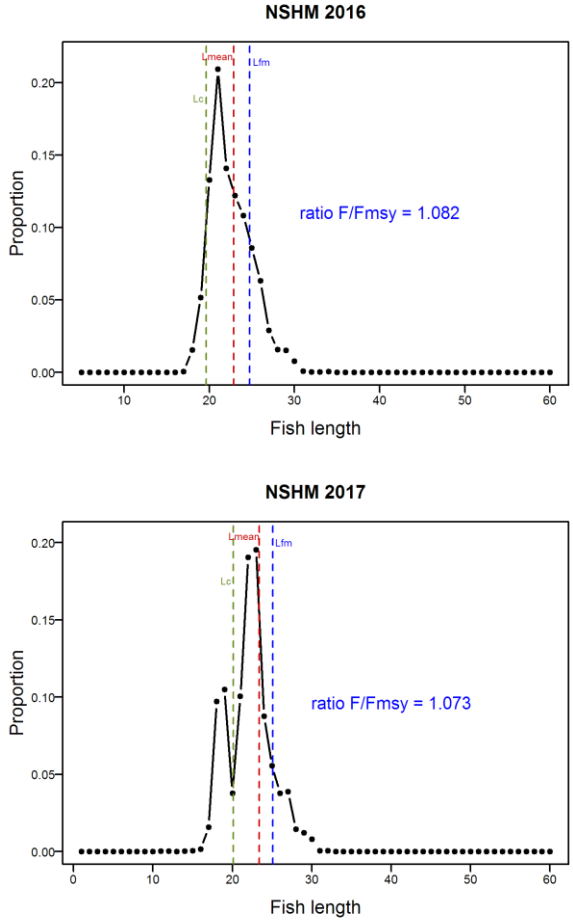


Figure 6.4.11.- Length distribution, as well as the estimated parameters Lc, Lmean, Lf=m for the Dutch fleet in 2016 and 2017.

7 Western Horse Mackerel –in Subarea 8 and divisions 2.a, 3.a (Western Part), 4.a, 5.b, 6.a, 7.a–c and7.e–k

7.1 ICES advice applicable to 2017and 2018

Since 2011, the TACs cover areas in line with the distribution areas of the stock.

For 2017 the TAC set in EU waters (EU 2017/127) was the following:

AREAS IN EU WATERS	TAC 2017	STOCKS FISHED IN THIS AREA
• 2.a, 4.a, 5.b, Subareas 6, 7.a-c, 7.e-k, 8.abde, 12, 14	82 229 t	Western stock & North Sea stock in 4.a 1-2 quarters
4.b,c, 7.d	14 697t	North Sea stocks
Division 8.c	13 271 t	Western stock

For 2018 the TAC set in EU waters (EU 2018/120) was the following:

AREAS IN EU WATERS	TAC 2018	STOCKS FISHED IN THIS AREA
• 2.a, 4.a, 5.b, Subareas 6, 7.a-c, 7.e-k, 8.abde, 12, 14	99 470 t	Western stock & North Sea stock in 4.a 1-2 quarters
4.b,c, 7.d	12 629 t	North Sea stocks
Division 8.c	16 000 t	Western stock

The TAC for the western stock should apply to the distribution area of western horse mackerel as follows:

All Quarters: 2.a, 5.b, 6.a, 7.a-c, 7.e-k, 8.a-e

Quarters 3&4: 3.a (west), 4.a

The TAC for the North Sea stock should apply to the distribution area of North Sea horse mackerel as follows:

All Quarters: 3.a (east), 4.b-c, 7.d

Quarters 1&2: 3.a (west), 4.a

In 2017 ICES advised on the basis of MSY approach that Western horse mackerel catches in 2018 should be no more than 117 070 tonnes. The Western horse mackerel TAC for 2018 is 117 070 tonnes, the TAC for EU waters only is 115 470 tonnes. The TAC should apply to the total distribution area of this stock. The EU horse mackerel catches in Division 3.a are taken outside the horse mackerel TACs.

7.1.1 The fishery in 2017

Information on the development of the fisheries by quarter and division is shown in Tables 5.1.1 and 5.1.2 and in Figures 5.1.1.a–d. The total catch allocated to western horse mackerel in 2017 was 82 961 t which is 15 850 t less than in 2016 and in line with ICES advice. The catches of horse mackerel by country and area are shown in Tables 7.1.1.1-5 while the catches by quarter since 2000 are shown in Figure 7.1.1.1

7.1.2 Estimates of discards

Discard data are available since 2000 for few countries. Until 2013 however the estimates available are considered an underestimation of the overall amount. (Figure 7.1.2.1)

In 2017 most countries have presented discard information. Countries that reported discard for horse mackerel were Spain, Denmark, France, Sweden, UK (England + Wales) and Scotland. 2017 discard for Germany, Ireland, Netherland, Norway and Faroe Island is considered equal to zero. Discard rate for western horse mackerel was equal to 3 926 tonnes, equal to 4.3 % in weight of the total catches.

Discard data are included in the assessment as part of the total catches.

Length frequency distributions of discard were provided by Spain and France.

7.1.3 Stock description and management units

The western horse mackerel stock spawns in the Bay of Biscay, and in UK and Irish waters. After spawning, parts of the stock migrate northwards into the Norwegian Sea and the North Sea, where they are fished in the third and fourth quarter. The stock is distributed in Divisions 2.a, 5.b, 3.a, 4.a, 6.a, 7.a-c, 7.e-k and 8.a-e. The stock is caught in these areas following the yearly distribution described in Section 5.3 (Figures 7.1.3.1-2). The western stock is considered a management unit and advised accordingly. At present there are no international agreed management measures. EU regulates the fishery by TAC. This TAC is now set in accordance with the distribution of the stock although catches in 3.a are taken outside the TAC.

7.2 Scientific data

7.2.1 Egg survey estimates

Last egg survey was carried out in the western and southern spawning areas in 2016 and a presentation with the final results were given during the WGWIDE meeting by the survey coordinator in 2017 (ICES, 2017a).

The time-series of egg production estimates for western horse mackerel is presented in Table 7.2.1.1 and shown in figure 7.2.1.1

The ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS) (ICES 2018) met in Dublin on April 2018, to plan the 2019 Mackerel and Horse Mackerel Egg Survey for the Western horse mackerel stock.

7.2.2 Other surveys for western horse mackerel

Bottom-trawl surveys

An update bottom-trawl survey index for recruitment was available for the 2017 assessment: the index is based on IBTS surveys conducted by Ireland, France and Scotland covering the main distribution of the stock (Bay of Biscay, Celtic Sea, West of Ireland and West of Scotland) from 2003 to 2017, and uses a Bayesian Delta-GLMM for the calculation of an index of juvenile abundance based on catch rates (ICES 2017b). The update index is shown in figure 7.2.2.1 (plot in the middle). The 2017 data point is highly uncertain due to the very little coverage of the French survey: the French research vessel had technical issue and could therefore only cover less than 1/3 of the stations usually sampled. Despite this huge uncertainty, the 2017 data point suggests a very strong recruitment to be expected next year. This perception is confirmed by the

presence of numerous small fish in the 2017 catch data. The overall trend suggests an increase in recruitment from 2013, being the 2017 estimates one of the highest of the time-series; anecdotal information from Spanish fisheries independent surveys confirms the good incoming recruitment.

Further information on how the recruitment index is estimated can be found in the stock annex, in ICES (2008/ACOM:13), ICES (2009/RMC:04) and in ICES (2017b).

Acoustic surveys

In the Bay of Biscay two coordinated acoustic surveys are taking place at the spring time, PELGAS (Ifremer-France) and PELACUS (IEO-Spain)

PELACUS 0318 was carried out on board RV Miguel Oliver from 25th March till 18th April. The methodology was similar to that of the previous surveys (. This year the surveyed area was steamed clockwise from the inner part of the Bay of Biscay to the Spanish-Portuguese border, thus contrary to the normal procedure (see Carrera *et al.* WD03; Carrera et al. WD04) for further details). Weather conditions were adverse, with a continuous low pressure fronts with dominant SW/W winds and swell of about 4 m height, resulted in an important haline front all around the surveyed area due to the river run-offs, and a poleward current with clear influence up to 6ª30′ W (Galician waters). Fish spatial distribution was rather coastal for all species but blue whiting and pearlside.

Horse mackerel mainly occurred at the inner part of the Bay of Biscay and also in 9a (southern component), but in general the density was low (figure 7.2.2.2). This resulted in an estimation of 9 thousand tonnes, a clear decreasing trend since 2015 when biomass peaked at 67 thousand tonnes. Nevertheless it should be noted that age 1 and 2 accounted up to 88% of the abundance estimates. Both year classes were shown higher figures than those estimated in 2017 (figure 7.2.2.3).

In French waters, PELGAS took place in May (e.g. one month later), steamed northwards (Duhamel *et al.,* WD11). Main concentrations were located between Garonne and Arcachon areas (figure 7.2.2.4), and well distributed throughout the surveyed area. This resulted in 92 thousand tonnes, higher than that estimated last year (figure 7.2.2.5), but still below the average time-series estimate (2000–18). On the other hand, as in the case of PELACUS, the bulk of the estimation was composed by young fish.

7.2.3 Effort and catch per unit effort

No new information was presented on effort and catch per unit effort. Further information can be found in the stock annex.

7.2.4 Catch in numbers

In 2017, the Netherlands (4.a, 6.a, 7.b,c,e,h,j), Norway (4.a, 3.a), Ireland (6.a and 7.b,g), Germany (6.a, 7.b.e) and Spain (8.abc) provided catch in numbers at age. The catch sampled for age readings in 2017 covered 63%, in 2016 covered 82% and in 2015 covered 69%. (Figure 7.2.4.1). In addition France (4.a, 6a, 7.e,g,h, 8.a,b), England (7.e,f,g) and Scotland (6.a) provided catch in number at length.

The total annual and quarterly catches in number for western horse mackerel in 2017 are shown in Table 7.2.4.1. The sampling intensity is discussed in Section 5.9.

The catch-at-age matrix is given in Table 7.2.4.2, and illustrated in Figure 7.2.4.2. It shows the dominance of the 1982 year class in the catches since 1984 until it entered the plus group in 1997. Since 2002, the 2001 year class, which has now entered the plus

group in 2016, has been caught in considerable numbers. The 2008 year class can be followed in the catch data suggesting it was stronger than other year classes subsequent to the 2001.

In addition, Germany and Spain provided the Age Length Keys (ALK) which were used in 2017 to convert catch at length into catch-at-age.

7.2.5 Mean length at age and mean weight at age

Mean length at age and mean weight at age in the catches

The mean weight and mean length at age in the catches by area, and by quarter in 2017 are shown in Tables 7.2.5.1 and 7.2.5.2. Weight at age time-series is shown in Figure 7.2.5.1.

Mean weight at age in the stock

Mean weight-at-age in the stock is presented in Table 7.2.5.3. Further information can be found in the stock annex.

7.2.6 Maturity ogive

Maturity-at-age is presented in Table 7.2.6.1. In the assessment model a constant logistic function was used (figure 7.2.6.1). Further information can be found in the stock annex.

7.2.7 Natural mortality

A fixed natural mortality of $0.15.year^{-1}$ is assumed for all ages and years in the assessment. Further information can be found in the stock annex.

7.2.8 Fecundity data

Potential fecundity data (10^6 eggs) per kg spawning females are available for the years 1987, 1992, 1995, 1998, 2000, 2001: the data are presented in table 7.2.8.1 but were not used in the assessment model. In the assessment the fecundity is modelled as linear eggs/kg on body weight. Further information can be found in the stock annex.

7.2.9 Information from the fishing industry

The fishing industry in conjunction with the Pelagic AC (PELAC) has been working actively on a number issues namely a large-scale genetics project on stock identification, development of a management strategy with the scientists and number of voluntary industry measure to protect juveniles.

The genetic work is now close to being finalized. Samples have been collected during the years 2015-2017 from area between Mauritania and the Northern North Sea. DNA has been extracted from the samples and are currently being worked up. It is expected that the genetic analysis will be finished in the first half of 2019.

The Irish and Dutch fishing industry reported good catches of horse mackerel catches southwest of Ireland (division 7.j) and west of Scotland (Division 6.a) during the first months of 2018, also including bigger sizes of horse mackerel (e.g. WGWIDE WD17).

7.2.10 Data exploration

The length frequency distributions of the catches for the whole fleet included in the model are shown in Figure 7.2.10.1. The length distributions available for 2015-2017

show a considerable amount of very small fish, mostly driven by the Spanish catches. Length frequency distribution from discards was analysed alongside the length frequency distribution from the landings. The huge numbers of small individuals from the discards have a strong impact on the overall LFD of the catches. These data were not available at the benchmark and to include those in the assessment model would require major changes in the modelling structure: for this reason were only used in the explorative analysis.

Within-cohort consistency of the catch-at-age matrix is investigated in Figure 7.2.10.2: this shows that the catch-at-age data contains information on year-class strength that could form the basis for an age-structured model.

The numbers at age in the catch by decade show a trend towards younger individuals when moving from the beginning of the time-series towards the end (Figure 7.2.10.3).

The indices of abundance used in the assessment cover different areas and represents different part of the stock. Negative correlations between indices that should represent the same portion of the population might cause problem in the fitting. The correlation between time-series was therefore estimated and presented in figure 7.2.10.4. Given the fact that the IBTS index is a recruitment index and that most of the juveniles are located in the area partially covered by the PELACUS survey, a higher correlation is expected. On the other hand, the egg survey should represent the adult portion of the stock: since no stock-recruitment relationship has been observed for the western horse mackerel stock, it is not surprising that the trajectory of this SSB index differs from the other two.

7.2.11 Assessment model, diagnostics

A one fleet, one sex, one area stock synthesis model (SS; Stock Synthesis v3.30; Methot, 2011) is used for the assessment of western horse mackerel stock in the Northeast Atlantic. A description of the model can be found in the stock annex. The assessment is presented as an update to the benchmark, and sees the inclusion of the 2017 estimates for the three surveys used, the 2017 length frequency distribution from the catches and the PELACUS survey and the 2017 total catch and conditional ALKs.

Fits to the available data are given in Figure 7.2.11.1, and model estimates with associated precision in Figure 7.2.11.2. Model estimates and residual patterns are similar to those presented in the benchmark (ICES, 2017b) and remain unchanged from last year assessment for almost all variables. Recruitment estimates for the years 2015-2017 were revised downwards with consequent degradation of the fitting to the IBTS recruitment index: this revision was caused by the model expecting a larger number of bigger/older fish in the catches that didn't occur. The model fitting to the most recent length frequency distributions and the conditional ALKs remain not optimal, due to changes in the overall pattern of the catches with a significant increase of smaller fish compared to the past.

Retrospective plots are shown for 10 years. Major rescaling of the estimates are observed in correspondence of the availability of a new egg survey data point. The inclusion of the 2016 length frequency distribution also caused a major deviation from the previous year assessment. The 2017 assessment shows only a minor revision upwards of the SSB, and a minor revision downwards of recruitment and F.

7.3 State of the Stock

7.3.1 Stock assessment

The SS model with new length and age data from the commercial fleet, and the 2017 information from the 3 surveys available, is presented as the final assessment model. Stock numbers-at-age and fishing mortality-at-age are given in Tables 7.3.1.1 and 7.3.1.2, and a stock-summary is provided in Table 7.3.1.3, and illustrated in Figure 7.3.1.1. and 7.3.1.2. SSB peaked in 1988 following the very strong 1982 year class. Subsequently SSB slowly declined till the second lowest value of the time-series in 2003 and then recovered again following the moderate-to-strong year class of 2001 (a third of the size of the 1982 year class). Year classes following 2001 have been weak: 2011, 2010 and 2013 recruitment in particular has been estimated as the lowest values in the time-series together with the 1983. The 2008 year class has been estimated to be fairly strong. Recruitment estimates for 2015-2017 are the highest observed since 2008 and are higher than the geometric mean estimated over the years 1983-2017. SSB in 2017 is estimated as the lowest in the time-series. Fishing mortality has been increasing since 2007 as a result of increasing catches and decreasing biomass as the 2001 year class was reduced. Since 2012 the F has been decreasing, dropping to low values in 2015-2017 due to lower catches and a reduced proportion of the adult population in the exploited stock.

7.4 Short–term forecast

A deterministic short-term forecast was conducted using the 'fwd()' method in FLR (Flash R add-on package).

Input

Table 7.4.1. lists the input data for the short–term predictions. Weight at age in the stock and weight at age in the catch are equal to the year invariant weight at age function used in the stock synthesis model. Exploitation pattern is based on F in 2017 and is the average of ages 1 to 10. Natural mortality is assumed to be 0.15 across all ages. The proportion mature for this stock has a logistic form with fully mature individuals at age 4 as used in the assessment model. As with last year, the expected landings for the intermediate year were set to the level that corresponds to the 2017 TAC in EU waters, equal to 115 470 t. Note that -despite the plus group in the catch being equal to 15+- the true population in SS model is set to arrive up to age 20 (as from literature) and is therefore estimated accordingly.

Output

A range of predicted catch and SSB options from the short-term forecast are presented in Table 7.4.2.

7.5 Uncertainties in the assessment and forecast

Despite the increased amount of data used and information available to the stock assessment, the model still suffers of retrospective pattern whenever a new year of data is included. This year rescaling is however small compared to past assessment and it influenced by the 2017 length frequency distribution, which is skewed towards a higher amount of small specimen.

The fitting to the fishery independent indices remains good for two of the three surveys used: a degradation of the fitting to the IBTS recruitment index is observed, but the

estimates remain within the confidence intervals provided. The fit the acoustic index remains poor.

The change in selectivity, which is detected from both the length and the age composition of the catch data, is not entirely picked up from the model. In general, SS tend to overestimate the mean age of the last decade, as well as underestimate the presence of small individuals. The selectivity issue should be further investigated and somehow addressed: for example, it is not clear whether the high presence of small specimen in the landings data is due to the inclusion of BMS individuals in the overall catch instead of having it as discard (the discard ban applies since 2015) or if this is due to an effective change in selectivity (i.e. catchability of the gear and availability of the stock).

The model fix the realised fecundity with a constant number of eggs/kg independently of the individual weight. However, western horse mackerel is known to be an indeterminate spawner, which implies this relationship being not appropriate when it comes to the use of an egg survey as index of spawning biomass. During the benchmark it was attempted to estimate the parameters relative to fecundity, but the information provided were not enough. The inclusion of this feature, whenever appropriate data will become available, would help to improve the reliability of the assessment.

The assumed value for M should be investigated. However, there is no data available (such as tagging) that could assist in estimating M more accurately. Nevertheless, total mortality appears to be low, given the persistence of the 1982 year class in the catch data.

In general Stock Synthesis tends to underestimate the uncertainty of the main variables: in the present case, the estimated uncertainty, despite being low, remains higher than the yearly fluctuations; it is therefore considered reasonable.

The assessment, as was built at the benchmark, has now a fairly good amount of information for the estimates of recruitment, which is also informed by the strong, occasional year classes observed in the catch. On the contrary, the SSB is informed only by the triennial egg survey and by the acoustic survey (that however covers only a small part of the stock distribution and targets the smallest fraction of the population, has a really low weight in the model and is really noisy): a new index for the spawning biomass would therefore be beneficial for the future stability of this assessment. The development of a SSB index from the IBTS survey as well as merging the information available from the Pelacus and the Pelgas acoustic survey in the Bay of Biscay should be pursued.

7.6 Comparison with previous assessment and forecast

A comparison of the update assessment (with and without the inclusion of the 2016 data) with the benchmark assessment is shown in Figure 7.2.11.3: SSB and fishing mortality are strongly influenced by the length composition in the catches: this information create an upward rescaling of the assessment. Recruitment, on the other hand, remains fairly stable.

7.7 Management Options

7.7.1 MSY approach

In 2017 stochastic equilibrium analyses were carried out using the eqSim software (WKWIDE 2017) to provide an estimate for F_{MSY}. Since there is no clear evidence of

stock recruitment relationship for western horse mackerel, the stock has been considered as a type 5 (ICES guidelines), so B_{lim} was set equal to B_{loss}. A segmented regression S-R was used excluding the 1982 year class and setting the breakpoint at B_{lim}. Biological parameters (mean weights at age, maturity and natural mortality) and exploitation pattern were as in the last 10 years (2006–2015) of the stock assessment. Assessment and advice error for the estimation of the MSY reference points were fixed as the default value used during the WKMSYREF4 (F_{cv}=0.212; F_{phi} =0.433, estimated as the median of 5 stocks). The FMSY was estimated equal to 0.1079.

During WGWIDE 2017 further investigations on these reference points and the methodology used were carried out: these are summarised in the Working Document attached to WGWIDE report (ICES, 2017a).

7.7.2 Management plans and evaluations

An overview of earlier management plans and management plans evaluations was presented at WGWIDE 2017. To date, no agreed management plan is available for this stock despite several attempts to develop such management plans.

New work on the development of a potential Harvest Control Rule (HCR) for Western horse mackerel has been initiated by the Pelagic Advisory in 2018. The PELAC requested Landmark Fisheries Research (Canada) to develop a proof-of-concept of a Management Strategy Evaluation (MSE) testing different types of HCRs. Previously, Landmark Fisheries Research has done similar exercises for e.g. Sablefish in British Columbia.

The approach presented by Landmark Fisheries Research was based on a full-feedback MSE with an embedded stock assessment model included. The approach explicitly recognizes both biomass and fishery objectives. Simulated outcomes under alternative rebuilding plans defined by alternative harvest control rules can be used to examine potential trade-offs among stock rebuilding and fishery performance objectives in both the short and long-term. As expected, risks of the stock being below Blim are highest in the short term; however, long term performance clearly demonstrates the precautionary aspects of the simulated rebuilding plans. In particular, all harvest control rules lead to stock growth in the long term, but with different outcomes in terms of yield, yield variability, and probably of fishery closure. Although some rules led to more rapid stock growth, they did so at considerably higher cost to the fishery than other rules. So far no uncertainty in the initial conditions have been included. Nevertheless, these results suggest that a full MSE could be used to identify management procedures that provide acceptable trade-offs between fishing and spawning biomass conservation of Western horse mackerel.

7.8 Management considerations

The 2001 year class has now entered the plus group and there are no detectable strong year classes entering the fishery, even though a higher amount of age 1 and 2 fish has recently been observed in the catches.

With the inclusion of the 2017 length frequency distribution –which, together with the LFD from 2015-2016, shows a change in selectivity toward smaller fish - the SSB is rescaled to higher levels. This rescaling affects the perception of the stock relative to the reference points estimated at the benchmark: even though the 2017 SSB estimate is the lowest point of the time-series, it is now higher than the B_{lim} reference point and close to $B_{trigger}$. This, together with the decrease in fishing mortality in the last 3 years, implies an advice which disregard the overall decreasing trend of the population.

The way the current reference points have been estimated is strongly driven by the assumptions on the stock recruitment relationships: the stock was considered as a type 5, therefore B_{lim} was set equal to B_{loss}, i.e. the SSB in 2015. In general, the last year in a stock assessment model is estimated with a higher uncertainty and it is more unstable due to the lower amount of information compared to earlier years in the time-series: in a stock that has always suffered of retrospective problems, such as the case of Western Horse mackerel, this issue is even more relevant. The use of the last year for the reference point estimation is therefore not advisable and can cause biases in the advice.

The TAC has only been given for parts of the distribution and fishing areas (EU waters). The Working Group advises that the TAC should apply to all areas where western horse mackerel are caught. Note that subarea 8.c is now included in the Western stock distribution area. If (as planned) the management area limits are revised, measures should be taken to ensure that misreporting of juvenile catch taken in subareas 7.e,h and 7.d (the latter then belonging to the North Sea stock management area) is effectively hindered. The mismatch between TAC and fishing areas and the fact that the TAC is only applied to EU waters has resulted in the catch prior to 2007 exceeding those advised by ICES.

The management plan proposed by the Pelagic RAC in 2007 was evaluated by ICES and considered to be precautionary in the short term. This plan makes use of the information available in the egg production surveys, and bases triennial TACs on the slope of the three previous egg production estimates. The rule proposed by the plan was used to set the TAC for 2008—2010 at 180kt. Using the finalised egg survey time-series the catch advice for 2014-2016 is 137 534 t. It should be noted that the management plan assumes that all catches are taken against the TAC and, should the management and assessment areas be combined in the future, the TAC as set by the EU will not cover all fisheries. Following an evaluation in 2013, ICES considered this management plan is not precautionary.

7.9 Ecosystem considerations

Knowledge about the distribution of the western horse mackerel stock is mostly gained from the egg surveys and the seasonal changes in the fishery. Based on these observations it is not possible to infer a similar changing trend in the distribution of western horse mackerel as for NEA mackerel. However, from catch data it appears that the stock is concentrating in the southern areas and it is mostly characterized by small individuals.

7.10 Regulations and their effects

There are no horse mackerel management agreements between EU and non EU countries. The TAC set by EU therefore only apply to EU waters and the EU fleet in international waters. The minimum landing size of horse mackerel by the EU fleet is 15 cm (10% undersized allowed in the catches).

The stock allocations were changed in 2005 following the results of the HOMSIR project (Abaunza *et al.* 2003) and 8.c now belongs to the western stock. Landings from 7.d are now allocated to the North Sea horse mackerel. A research project is currently underway in the Netherlands and Ireland, to review the stock separation between the Western stock and the North Sea stock in the Channel area (see North Sea horse mackerel section in the report). Results are expected to be available in the first half of 2019.

In Norwegian waters there is no quota for horse mackerel but existing regulations on bycatch proportions as well as a general discard prohibition (for all species) apply to horse mackerel.

7.11 Changes in fishing technology and fishing patterns

The description of the fishery is given in Sections 5.1 and 7.2.1 and no large changes in fishing areas or patterns have taken place. However, there has been a gradual shift from an industrial fishery for meal and oil towards a human consumption fishery.

7.12 Changes in the environment

Migrations are closely associated with the slope current, and horse mackerel migrations are known to be modulated by temperature. Continued warming of the slope current is likely to affect the timing and spatial extent of this migration.

Since the strong 1982 year class of the western stock started to appear in the North Sea in 1987 a good correspondence between the modelled influx of Atlantic water to the North Sea in the first quarter and the horse mackerel catches taken by Norwegian purse-seiners in the Norwegian EEZ (NEZ) later (October-November) the same year (Iversen *et al.* 2002, Iversen WD presented in ICES 2007/ACFM:31) has been noted in most years.

7.13 References

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7.14 Tables

Table 7.1.1.1. Western horse mackerel. Catches (t) in Subarea 2. (Data as submitted by Working Group members).

Country	1980	1981	1982	1983	1984	1985	1986	1987
Denmark	-	-	-	-	-	-	-	39
France	-	-	-	-	1	1	-[2]	-[2]
Germany, Fed.Rep	-	+	-	-	-	-	-	-
Norway	-	-	-	412	22	78	214	3,272
USSR	-	-	-	-	-	-	-	-
Total	-	+	-	412	23	79	214	3,311

	1988	1989	1990	1991	1992	1993	1994	1995
Faroe Islands	-	-	9643	1,115	9,157[3]	1,068	-	950
Denmark	-	-	-	-	-	-	-	200
France	-2	-	-	-	-	-	55	-
Germany, Fed. Rep.	64	12	+	-	-	-	-	-
Norway	6,285	4,770	9,135	3,200	4,300	2,100	4	11,300
USSR / Russia (1992 -)	469	27	1,298	172	-	-	700	1,633
UK (England + Wales)	-	-	17		-	-	-	-
Total	6,818	4,809	11,414	4,487	13,457	3,168	759	14,083

	1996	1997	1998	1999	2000	2001	2002	2003
Faroe Islands	1,598	799[3]	188[3]	132[3]		-	-	-
Denmark	-	-	1,755[3]	-		-	-	-
France	-	-	-	-		-	-	-
Germany	-	-	-	-		-	-	-
Norway	887	1,170	234	2,304	841	44	1,321	22
Russia	881	554	345	121	78	16	3	2
UK (England + Wales)	-	-	-	-	-	-	-	-
Estonia	-	78	22	-	-	-	-	-
Total	3,366	2,601	2,544	2557	919	60	1,324	24

	2004	2005	2006	2007	2008	2009	2010
Faroe Islands	-	-	3	-	-	-	222
Denmark	-	-	-	-	-	-	-
France	-	-	-	-	-	-	-
Germany	-	-	-		-	-	-
Ireland	-	-	-		-	-	-
Norway	42	176	27	-	572	1,847	1,364
Russia	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-
Total	42	176	27	0	572	1,847	1,586

[2]Included in Subarea 4.
[3]Includes catches in Div. 5.b.
[4]Taken in Div. 5.b

Table 7.1.1.1 cont. Western horse mackerel. Catches (t) in Subarea 2. (Data as submitted by Working Group members).

	2011	2012	2013	2014	2015	2016	2017[1]
Faroe Islands	224	-	-	-	-		
Denmark	-	-	-	-	-		
France	-	+	-	-	-		
Germany	-	-	-	-	-		
Ireland	-	-	-	-	-		
Netherlands	1	-		107	-		
Norway	298	66	30	302	10	45	5
Russia	-	-		-	-		
UK (England + Wales)	-	-		-	-		
Estonia	-	-		-	-		
Total	523	66	30	409	10	45	5

[1]**Preliminary**
[2]**Included in 4.**
[3]**Includes catches in Div. 5.b.**
[4]**Taken in Div. 5.b.**

Table 7.1.1.2. Western horse mackerel. Catches (t) in North Sea Subarea 4 and Skagerrak Division 3.a by country. (Data submitted by Working Group members). Catches partly concern the North Sea horse mackerel.

COUNTRY	1980	1981	1982	1983	1984	1985	1986	1987	1988
Belgium	8	34	7	55	20	13	13	9	10
Denmark	199	3,576	1,612	1,590	23,730	22,495	18,652	7,290	20,323
Faroe Islands	260	-	-	-	-	-	-	-	-
France	292	421	567	366	827	298	231[2]	189[1]	784[1]
Germany, Fed.Rep.	+	139	30	52	+	+	-	3	153
Ireland	1,161	412	-	-	-	-	-	-	-
Netherlands	101	355	559	2,029[2]	824	160[2]	600[2]	850[3]	1,060[3]
Norway[2]	119	2,292	7	322	[2]	203	776	11,728[3]	34,425[3]
Poland	-	-	-	2	94	-	-	-	-
Sweden	-	-	-	-	-	-	2	-	-
UK (Engl. + Wales)	11	15	6	4	-	71	3	339	373
UK (Scotland)	-	-	-	-	3	998	531	487	5,749
USSR	-	-	-	-	489	-	-	-	-
TOTAL	**2,151**	**7,253**	**2,788**	**4,420**	**25,987**	**24,238**	**20,808**	**20,895**	**62,877**

COUNTRY	1989	1990	1991	1992	1993	1994	1995	1996	1997
Belgium	10	13	-	+	74	57	51	28	-
Denmark	23,329	20,605	6,982	7,755	6,120	3,921	2,432	1,433	976
Estonia	-	-	-	293	-		17	-	-
Faroe Islands	-	942	340	-	360	275	-	-	296
France	248	220	174	162	302		-	-	-
Germany, Fed.Rep.	506	2,4694	5,995	2,801	1,570	1,014	1,600	7	37
Ireland	-	687	2,657	2,600	4,086	415	220	1,100	8,152
Netherlands	14,172	1,970	3,852	3,000	2,470	1,329	5,285	6,205	52
Norway	84,161	117,903	50,000	96,000	126,800	94,000	84,747	14,639	43,888
Poland	-	-	-	-	-	-	-	-	-
Sweden	-	102	953	800	697	2,087	-	95	1761
UK (Engl. + Wales)	10	10	132	4	115	389	478	40	10
UK (N. Ireland)	-	-	350	-	-		-	-	-
UK (Scotland)	2,093	458	7,309	996	1,059	7,582	3,650	2,442	10,511
USSR / Russia (1992 -)	-	-	-						
Unallocated+discards	12,4823	-3173	-7503	-2785	-3,270	1,511	-28	136	-31,615
TOTAL	**112,047**	**145,062**	**77,904**	**114,133**	**140,383**	**112,580**	**98,452**	**26,125**	**34,068**

COUNTRY	1998	1999	2000	2001	2002	2003	2004	2005	2006
Belgium	19	21							
Denmark	2048	2026	7	98	53	841	48	216	60
Estonia		-							
Faroe Islands	28	908	24	0	671	5	76	35	0
France	379	60	49			255		1	
Germany	4620	4072	0	0	4	534	0	44	1
Ireland	-	404	32	332	11	93	378		
Lithuania									
Netherlands	4548	3285	10	1	0	36	0	0	0

Norway	13129	44344	1141	7912	34843	20349	10687	24733	27087
Russia	-	-	2						
Sweden	1761	1957	1009	68	561	1002	567	216	0
UK (Engl. + Wales)	1	12					0		
UK (Scotland)	3041	1658	3054	3161	252	0	0	22	61
Unallocated+discards	737	-325	10	0	0	-36	0	0	0
Total	30311	58422	5338	11572	36395	23079	11756	25267	27210

[1] Includes Division 2.a. [2] Estimated from biological sampling. [3] Assumed to be misreported. [4] Includes 13 t from the German Democratic Republic. [5] Includes a negative unallocated catch of -4,000 t.

Table 7.1.1.2 cont. Western horse mackerel. Catches (t) in North Sea Subarea 4 and Skagerrak Division 3.a by country. (Data submitted by Working Group members). Catches partly concern the North Sea horse mackerel.

Country	2007	2008	2009	2010	2011	2012	2013	2014
Denmark	74	2	207	61	19	9	0	23
Faroe Islands	3	55	0	8	0	0	0	53
France		1			268			17
Germany, Fed.Rep.	6	93	0	4	0	0	20	0
Ireland	651	298	342	14	755	25	7	
Netherlands								
Lithuania	22	0	7	339	81	92	0	310
Norway	4180	11631	57890	10556	13409	3183	6566	14051
Sweden	76	9	258	2	90	0	1	0
UK (Engl. + Wales)	31						16	203
UK (Scotland)	7	20	51	546	101	12	102	11
Unallocated +discards	0	0	0	0	0	0	0	30
Total	5050	12110	58755	11531	14723	3320	6712	14699

1-Preliminary.

Table 7.1.1.2 cont. Western horse mackerel. Catches (t) in North Sea Subarea 4 and Skagerrak Division 3.a by country. (Data submitted by Working Group members). Catches partly concern the North Sea horse mackerel.

Country	2015	2016	2017[1]
Denmark	37	7	21
Faroe Islands	0	0	67
France	12	4	1
Germany, Fed.Rep.	6	28	1
Ireland	8		
Netherlands		0	14
Lithuania	12	130	
Norway	8887	8765	9880
Sweden	10	0	41
UK (Engl. + Wales)	134	13	4
UK (Scotland)	36	14	
Unallocated +dis-cards	32	97	87
Total	9175	9057	10117

1-Preliminary.

Table 7.1.1.3 Western horse mackerel. Catches (t) in Subarea 6 by country. (Data submitted by Working Group members).

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Denmark	734	341	2,785	7	-	-	-	769	1,655
Faroe Islands	-	-	1,248	-	-	4,014	1,992	4,450[2]	4,000[2]
France	45	454	4	10	14	13	12	20	10
Germany, Fed. Rep.	5,550	10,212	2,113	4,146	130	191	354	174	615
Ireland	-	-	-	15,086	13,858	27,102	28,125	29,743	27,872
Netherlands	2,385	100	50	94	17,500	18,450	3,450	5,750	3,340
Norway	-	5	-	-	-		83	75	41
Spain	-	-	-	-	-		-[1]	-[1]	-[1]
UK (Engl. + Wales)	9	5	+	38	+	996	198	404	475
UK (N. Ireland)						-	-	-	-
UK (Scotland)	1	17	83	-	214	1,427	138	1,027	7,834
USSR.	-	-	-		-	-	-	-	-
Unallocated + disc						-19,168	-13,897	-7,255	-
Total	**8,724**	**11,134**	**6,283**	**19,381**	**31,716**	**33,025**	**20,455**	**35,157**	**45,842**

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Denmark	973	615	-	42	-	294	106	114	780
Faroe Islands	3,059	628	255	-	820	80	-	-	-
France	2	17	4	3	+	-	-	-	53
Germany, Fed. Rep.	1,162	2,474	2,500	6,281	10,023	1,430	1,368	943	229
Ireland	19,493	15,911	24,766	32,994	44,802	65,564	120,124	87,872	22,474
Netherlands	1,907	660	3,369	2,150	590	341	2,326	572	1335
Norway	-	-	-	-	-	-	-	-	-
Spain	-[1]	-[1]	1	3	-	-	-	-	-
UK (Engl. + Wales)	44	145	1,229	577	144	109	208	612	56
UK (N.Ireland)	-	-	1,970	273	-	-	-	-	767
UK (Scotland)	1,737	267	1,640	86	4,523	1,760	789	2,669	14,452
USSR/Russia (1992-)	-	44	-	-	-	-	-	-	-
Unallocated + disc.	6,493	143	-1,278	-1,940	-6,960[3]	-51	-41,326	-11,523	837
Total	**34,870**	**20,904**	**34,456**	**40,469**	**53,942**	**69,527**	**83,595**	**81,259**	**40,983**

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006
Denmark		79							
Faroe Islands	-	-							
France	221			428	55	209	172	41	411
Germany	414	1031	209	265	149	1337	1413	1958	1025
Ireland	21951	31736	15843	20162	12341	20903	15702	12395	9780
Lithuania									2822
Netherlands	983	2646	686	600	450	847	3702	6039	1892
Spain	-	-						0	0
UK (Engl.+Wales)	227	344	41	91		46	5	52	
UK (N.Ireland)	1132	-	79	272	654	530	249	210	82
UK (Scotland)	10147	4544	1839	3111	1192	453	377	62	43
Unallocated+disc.	98	1507	0	0	0	0	0	0	0
Total	**34815**	**41887**	**18697**	**24929**	**14840**	**24325**	**21619**	**20757**	**16055**

[1]Included in Subarea 7. [2]Includes Divisions 3.a, 4.a, b and 6.b. [3]Includes a negative unallocated catch of -7000 t.

Table 7.1.1.3. cont. Western horse mackerel. Catches (t) in Subarea 6 by country. (Data submitted by Working Group members).

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015
Denmark					58	1,131	433	856	3,045
Faroe Islands		573		66					
France		73			246			195	65
Germany	1,835	5,097	635	773	6,508	671	8,616	4,194	1,980
Ireland	20,010	18,751	16,596	19,985	23,556	29,282	19,979	15,745	10,894
Lithuania	80	641							
Netherlands	2,177	3,904	2,332	1,684	6,353	12,653	11,078	8,580	6,211
Norway	2	20	27	18	48	2			
Spain	0								
UK (Engl. + Wales)	332			463			451	18	58
UK (N.Ireland)				59	198		2,325	1,579	1,204
UK (Scotland)	38	588	243	89	2,528	1,231	385	1,277	696
Unallocated+disc.	0	0	0	0	230	2	-	123	
Total	24,474	29,648	19,833	23,136	39,726	44,973	43,266	32,567	24,153

[1]**Preliminary.**

Table 7.1.1.3. cont. Western horse mackerel. Catches (t) in Subarea 6 by country. (Data submitted by Working Group members).

Country	2016	2017[1]
Denmark		3,462
Faroe Islands		113
France	23	1,025
Germany	4,069	2,884
Ireland	15,381	15,123
Lithuania	2,510	
Netherlands	9,246	5,497
Norway		
Spain		
UK (Engl. + Wales)		66
UK (N.Ireland)	0	
UK (Scotland)	956	
Unallocated+disc.		116
Total	32,186	28,286

[1]**Preliminary.**

Table 7.1.1.4. Western horse mackerel. Catches (t) in Subarea 7 by country. (Data submitted by the Working Group members).

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Belgium	-	1	1	-	-	+	+	2	-
Denmark	5,045	3,099	877	993	732	1477**	30408**	27,368	33,202
France	1,983	2,800	2,314	1,834	2,387	1,881	3,801	2,197	1,523
Germany, Fed.Rep.	2,289	1,079	12	1,977	228	-	5	374	4,705
Ireland	-	16	-	-	65	100	703	15	481
Netherlands	23,002	25,000	27500**	34,350	38,700	33,550	40,750	69,400	43,560
Norway	394	-	-	-	-	-	-	-	-
Spain	50	234	104	142	560	275	137	148	150
UK (Engl. + Wales)	12,933	2,520	2,670	1,230	279	1,630	1,824	1,228	3,759
UK (Scotland)	1	-	-	-	1	1	+	2	2,873
USSR	-	-	-	-	-	120	-	-	-
Total	**45,697**	**34,749**	**33,478**	**40,526**	**42,952**	**39,034**	**77,628**	**100,734**	**90,253**

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Faroe Islands	-	28	-	-	-	-	-	-	-
Belgium	-	+	-	-	-	1	-	-	18
Denmark	34,474	30,594	28,888	18,984	16,978	41,605	28,300	43,330	60,412
France	4,576	2,538	1,230	1,198	1,001	-	-	-	30,571
Germany, Fed.Rep.	7,743	8,109	12,919	12,951	15,684	14,828	17,436	15,949	28,267
Ireland	12,645	17,887	19,074	15,568	16,363	15,281	58,011	38,455	43,624
Netherlands	43,582	111,900	104,107	109,197	157,110	92,903	116,126	114,692	131,701
Norway	-	-	-	-	-	-	-	-	-
Spain	14	16	113	106	54	29	25	33	6
UK (Engl. + Wales)	4,488	13,371	6,436	7,870	6,090	12,418	31,641	28,605	17,464
UK (N.Ireland)	-	-	2,026	1,690	587	119	-	-	1,093
UK (Scotland)	+	139	1,992	5,008	3,123	9,015	10,522	11,241	7,902
Unallocated + discards	28,368	7,614	24,541	15,563	4010***	14,057	68,644	26,795	58,718
Total	135,890	192,196	201,326	188,135	221,000	200,256	330,705	279,100	379,776

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006
Faroe Islands	-	-		550	-	-	3,750	3,660	
Belgium	-	-	-	-		-			
Denmark	25,492	19,166	13,794	20,574	10,094	10,499	11,619	9,939	6,838
France	22,095	25,007	20,401	9,401	5,220	5,010	5,726	7,108	6,680
Germany	24,012	13,392	9,045	7,583	10,212	13,319	16,259	9,582	6,511
Ireland	48,860	25,816	32,869	29,897	23,366	13,533	8,469	20,405	16,841
Lithuania	-	-							3,606
Netherlands	95,753	63,091	44,806	37,733	32,123	38,808	32,130	26,424	29,165
Spain	-	58	50	7	11	1	27	12	3
UK (Engl. + Wales)	11,925	7,249	4,391	5,913	4,393	3,411	4,097	2,670	2,754
UK (N.Ireland)	27	-	546	868	475	384	209		21
UK (Scotland)	5,095	4,994	5,142	1,757	1,461	268	1,146	59	365
Unallocated+discards	12,706	31,239	-9,515	2,888	434	17,146	16,553	11,875	4,679
Total	**245,965**	**190,012**	**121,530**	**117,170**	**87,788**	**102,379**	**99,985**	**91,733**	**77,463**

Table 7.1.1.4. cont. Western horse mackerel. Catches (t) in Subarea 7 by country. (Data submitted by the Working Group members).

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015
Faroe Islands	475	212		-	-	-	0		
Belgium				19	2		14		
Denmark	4856	1970	2710	5247	5831	2281	6373	5066	1474
France	2007	9703		260	7431	579	744	940	1552
Germany	3943	5693	14205	16847	14545	16391	15781	12948	7382
Ireland	8039	16282	23816	24491	14154	15893	15805	16922	10751
Lithuania	5387	4907				-	0		
Netherlands	32654	28077	23263	65865	49207	53644	41562	15529	18100
Norway	-	-	-	40		-	0		
Spain	11	11	6	3		10	0		
UK (Engl. + Wales)	5119	3245	6257	12139	11688	12122	3388	4576	1798
UK (Scotland)		469	1119	1713	299	91	17	101	6
Unallocated+discards	6012	-4624	-10891	6511	1	3038	4399	974	1929
Total	**68504**	**65946**	**60487**	**133136**	**103157**	**104049**	**88083**	**57055**	**42992**

Country	2016	2017[1]
Faroe Islands		
Belgium		
Denmark	314	1057
France	551	595
Germany	7313	4077
Ireland	12193	7857
Lithuania	86	
Netherlands	14415	8445
Norway		
Spain	0	
UK (Engl. + Wales)	820	478
UK (Scotland)		
Unallocated+discards	1692	830
Total	**37384**	**23340**

[1]Preliminary. [2]French catches landed in the Netherlands

Table 7.1.1.5. Western horse mackerel. Catches (t) in Subarea 8 by country. (Data submitted by Working Group members).

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
Denmark	-	-	-	-	-	-	446	3,283	2,793
France	3,361	3,711	3.073	2,643	2,489	4,305	3,534	3,983	4,502
Netherlands	-	-	-	-	-2	-2	-2	-2	-
Spain	34,134	36,362	19,610	25,580	23,119	23,292	40,334	30,098	26,629
UK (Engl.+Wales)	-	+	1	-	1	143	392	339	253
USSR	-	-	-	-	20	-	656	-	-
Total	**37,495**	**40,073**	**22,684**	**28,223**	**25,629**	**27,740**	**45,362**	**37,703**	**34,177**

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997
Denmark	6,729	5,726	1,349	5,778	1,955	-	340	140	729
France	4,719	5,082	6,164	6,220	4,010	28	-	7	8,564
Germany, Fed. Rep.	-	-	80	62	-		-	-	-
Netherlands	-	6,000	12,437	9,339	19,000	7,272	-	14,187	-
Spain	27,170	25,182	23,733	27,688	27,921	25,409	28,349	29,428	31,082
UK (Engl.+Wales)	68	6	70	88	123	753	20	924	430
Unallocated+dis-cards	-	1,500	2,563	5,011	700	2,038	-	3,583	-2,944
Total	**38,686**	**43,496**	**46,396**	**54,186**	**53,709**	**35,500**	**28,709**	**48,269**	**37,861**

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006
Denmark	1,728	4,769	2,584	582					1,513
France	1,844	74	7	5,316	13,676	4,908	2,161	3,540	3,944
Germany	3,268	3,197	3,760	3,645	2,293	504	72	4,776	3,326
Ireland	-	-	6,485	1,483	704	1,314	1,882	1,808	158
Lithuania	-	-							401
Netherlands	8,123	13,821	11,769	35,106	12,538	6,620	1,047	6,372	6,073
Spain	23,599	24,461	24,154	23,531	24,752	24,598	16,245	16,624	13,874
UK (Engl. + Wales)	9	28	121	1,092	1,578	982	516	838	821
UK (Scotland)	-	-	249						
Unallocated+dis-cards	1,884	-8658	5,093	4,365	1,705	2,785	2,202	7,302	4,013
Total	**40,455**	**37,692**	**54,222**	**75,120**	**57,246**	**41,711**	**24,125**	**41,260**	**34,122**

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017[1]
Denmark	2,687	3,289	3,109	632	200	581	14				1
France	10,741	2,848			326	1,218	2,849	2,277	1,618	2,219	2,303
Germany		918	281	64	61		417	19	49	4	210
Ireland	694					39			0	32	580
Netherlands	211	6,269	1,848	98	49	7	1,057	526	635	1	313
Spain	14,265	19,840	21,071	38,742	34,581	13,502	22,542	19,443	13,072	14,235	14,901
UK (Engl. + Wales)		120	224	112	28		104	35	72	9	
Unalloca-ted+discards		67	913	7,412	417	431	2,055	182	9,314	6,643	2,907
Total	**28,598**	**33,352**	**27,447**	**47,060**	**35,662**	**15,777**	**29,039**	**22,483**	**24,760**	**23,143**	**21,213**

[1]Preliminary. [2]Included in Subarea 7. [3]French catches landed in the Netherlands

Table 7.2.1.1. Western horse mackerel. The time-series of Total Annual Egg Production (TAEP) estimates (10^{12} eggs).

Year	TAEP
1992	2094
1995	1344
1998	1242
2001	864
2004	884
2007	1486
2010	1033
2013	366
2016	331

Table 7.2.4.1. Western Horse Mackerel stock. Catch in numbers (thousands) at age by quarter and area in 2017

Q1														
Age	27.2.a	27.5.b.1.b	27.6.a	27.7.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.j.2	total
0									0					0
1									0					0
2	0		130	0			79	333	0	1	1403	15	12	1973
3	7		32049	80	708		872	3662	0	14	13463	165	131	51151
4	1		6835	17	1495		369	166	0	4	4130	70	55	13143
5	2		10081	25	13541	166	1174		0	2	2196	223	177	27588
6	0		2523	6	3269	76	292		0	1	709	55	44	6975
7	0		1635	4	3081		258			0	370	49	39	5436
8	1		6059	15	3920	277	348		0	1	578	68	54	11320
9	2		16445	41	16373	689	1310		0	0	496	251	199	35806
10	0		2246	6	1930	118	154		0			29	23	4506
11	0		916	2	872	38	81		0	0	84	14	11	2019
12	0		1018	3	398	83	44		0	0	74	8	7	1635
13	0		1391	3	1067	194	99		0	0	213	20	16	3004
14	0		2028	5	389	76	38		0			7	6	2550
15	1		10360	26	4813	273	414		0	0	70	77	61	16096
sum	16		93717	234	51857	1991	5532	4161	0	24	23785	1051	833	183203

Table 7.2.4.1 cont. Western Horse Mackerel stock. Catch in numbers (thousands) at age by quarter and area in 2017

Q2												
Age	27.5.b.1.b	27.6.a	27.7.b	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.j.2	27.7.k.2	total
0					267							267
1					335							335
2		1		1	229		21	29	371	321	1	974
3		160		11	1211		204	284	3610	3123	5	8609
4		24		5	26		57	79	1007	872	1	2071
5		36		15	38		30	41	527	456	1	1144
6		8		4			10	13	170	147	0	353
7		17	42	3			5	7	90	77	0	242
8		32	42	5			8	11	140	121	0	358
9		90	124	17			7	9	120	104	0	471
10		32	82	2				0	2	1	0	119
11		26	80	1			1	2	21	18	0	150
12		27	82	1			1	1	18	16	0	146
13		16	40	1			3	4	51	44	0	160
14		54	164	0				0	0	0	0	219
15		422	1354	5			1	1	17	15	0	1816
sum		945	2011	72	2107		347	484	6145	5316	9	17435

Table 7.2.4.1 cont. Western Horse Mackerel stock. Catch in numbers (thousands) at age by quarter and area in 2017

Q3														
Age	27.3.a	27.4.a	27.5.b.1.b	27.6.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.k.2	total
0								692	39	49				779
1	533							867	48	61				1509
2	486			1		0	0	593	28	35				1143
3	1485	335		228	362	3	4	3133	116	147	67	11	1	5893
4	291	1617		28	89	1	2	67	1	1	17	3	0	2116
5	214	1733		45	20	4	6	99	6	7	4	1	0	2138
6	90	168		9	14	1	1		2		3	0	0	288
7	90	655		7		1	1							755
8	163	2340		24	25	1	2		2	1	5	1	0	2563
9	247	4845		63	69	4	7		15	1	13	2	0	5266
10	116	2359		11	10	1	1		5	0	2	0	0	2504
11	40	590		4		0	0		7	0				641
12	26	550		4	10	0	0		3	0	2	0	0	596
13	53	1143		5	5	0	0		4	0	1	0	0	1212
14	71	1401		9		0	0		3					1484
15	324	6814		41	40	1	2		15	0	7	1	0	7247
sum	4230	24550		479	645	19	27	5451	291	302	120	20	2	36136

Table 7.2.4.1 cont. Western Horse Mackerel stock. Catch in numbers (thousands) at age by quarter and area in 2017

Q4																
Age	27.2.a	27.3.a	27.4.a	27.5.b.1.b	27.6.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.k	27.7.k.2	total
0									1400	6						1406
1		3							1755	8						1765
2	0	3	20		94		6	8	978	4		15		0	0	1129
3	5	8	7379		35030	802	71	89	3894	18		173		0	4	47472
4	1	2	528		2521	531	30	38	24	0				0	2	3676
5	1	1	917		4370	990	95	120	200	1	14		23	0	5	6739
6	0	1	126		603	122	24	30		0	32			0	1	938
7	0	1	111		532	199	21	26						0	1	891
8	1	1	403		1923	473	28	36		0	32		39	0	2	2936
9	2	1	1016		4855	898	106	134		2	266		62	0	6	7347
10	0	1	263		1253	83	12	16		1	82		8	0	1	1719
11	0	0	82		392	50	7	8		1	122		8	0	0	670
12	0	0	81		385	138	4	4		0	53		8	0	0	673
13	0	0	64		306	50	8	10		1	72		15	0	0	527
14	0	0	174		830	128	3	4		0	53			0	0	1193
15	1	2	691		3300	720	34	42		2	261		31	0	2	5085
sum	11	24	11855		56392	5184	449	566	8251	45	986	188	193	0	23	84167

Table 7.2.4.1 cont. Western Horse Mackerel stock. Catch in numbers (thousands) at age by quarter and area in 2017

Q1-4																		
Age	27.2.a	27.3.a	27.4.a	27.5.b.1.b	27.6.a	27.7.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.j.2	27.7.k	27.7.k.2	total
0										2360	45	49						2453
1		536								2957	56	61						3610
2	0	489	20		224	0		7	89	2133	32	57	1447	386	333	0	1	5217
3	12	1494	7715		66987	80	1871	74	977	11899	134	365	13988	3787	3254	0	10	112644
4	2	293	2145		9337	17	2116	31	413	283	1	62	4226	1080	927	0	3	20936
5	3	215	2650		14424	25	14551	266	1315	337	7	54	2241	774	632	0	6	37499
6	1	91	294		3119	6	3404	101	327		2	43	725	226	191	0	2	8531
7	0	91	767		2174	4	3322	22	289			5	377	138	116	0	1	7307
8	1	164	2743		7978	15	4461	306	390		2	41	593	247	175	0	2	17117
9	4	249	5861		21290	41	17465	800	1467		17	274	518	434	302	0	6	48728
10	1	117	2622		3516	6	2105	131	173		5	82	2	39	24	0	1	8823
11	0	40	672		1329	2	1003	45	91		8	123	86	43	29	0	0	3471
12	0	26	631		1423	3	629	87	49		3	54	77	35	22	0	0	3040
13	0	54	1207		1705	3	1162	202	111		5	75	218	86	60	0	1	4890
14	1	72	1575		2900	5	681	79	43		3	53	0	7	6	0	0	5425
15	2	326	7505		14020	26	6927	308	463		17	262	79	126	76	0	2	30140
sum	27	4254	36405		150425	234	59697	2458	6197	19969	337	1659	24577	7409	6149	0	34	319831

Table 7.2.4.2. Western horse mackerel. Catch-at-age (thousands).

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0	3713	21072	134743	11515	13197	11741	8848	1651	414	1651	6582	18483	28679	19432	8210
1983	0	7903	2269	32900	53508	15345	44539	52673	17923	3291	5505	3386	17017	23902	38352	46482
1984	0	0	241360	4439	36294	149798	22350	38244	34020	14756	4101	0	639	1757	5080	50895
1985	0	1633	4901	602992	4463	41822	100376	12644	16172	6200	9224	339	850	3723	1250	34814
1986	0	0	0	1548	676208	8727	65147	109747	25712	21179	15271	3116	1031	855	292	51531
1987	0	99	493	0	2950	891660	2061	41564	90814	11740	9549	19363	8917	1398	200	32899
1988	876	27369	6112	2099	4402	18968	941725	12115	39913	67869	9739	16326	17304	5179	4892	32396
1989	0	0	0	20766	18282	5308	14500	1276731	12046	59357	83125	13905	24196	13731	8987	18132
1990	0	20406	45036	138929	61442	33298	10549	20607	1384850	37011	70512	101945	14987	34687	18077	56598
1991	24021	20176	56066	17977	159643	97147	49515	21713	17148	1028419	20309	12161	43665	8141	7053	25553
1992	229694	14888	36332	80550	56280	255874	126816	48711	18992	23447	1099780	13409	23002	65250	11967	33246
1993	131108	46	109807	16738	62342	105760	325674	141148	68418	55289	30689	1075607	11373	24018	68137	32140
1994	60759	3686	911713	115729	53056	44520	38769	221863	106390	40988	43083	22380	918512	10143	14599	36635
1995	233030	2702	646753	526053	269658	74592	114649	36076	228687	113304	96624	59874	63187	951901	39278	148243
1996	19774	10729	659641	864188	189273	87562	52050	55914	53835	57361	56962	91690	67114	56012	349086	165611
1997	110451	4860	471611	732959	408648	256563	141168	143166	143770	123043	133165	96059	176730	98196	51674	283111
1998	91505	744	184443	488661	359590	217571	153136	119309	77494	67073	50108	58791	30536	65838	57584	141361
1999	97561	14822	83714	176919	265820	254516	212217	187195	147271	77622	35582	22909	34440	29743	41831	122176
2000	565	66210	130897	64801	119297	232346	202175	165745	109218	54365	14594	17509	18642	18585	10031	73174
2001	60561	93125	204360	166641	113659	120410	141419	259974	218002	110319	38576	22749	17102	14092	18857	64868
2002	14044	505717	122603	158114	123258	66640	68890	95052	132743	87285	46167	29692	25333	11305	12753	72682
2003	1913	323194	509889	141442	148989	89122	59047	48582	52305	102089	57089	31748	27158	8832	7683	40641
2004	22237	159011	116055	486195	81099	98855	69441	48969	32589	51953	54542	33298	12581	13407	4305	21278
2005	1305	74538	171420	310767	540649	69957	74746	61889	44443	22726	27019	42746	23677	6849	7491	18626
2006	1905	53322	58091	75505	91274	482229	57377	37222	41970	16865	11828	17073	32025	12877	7464	24645
2007	5121	32399	38598	40530	61938	112724	347284	48160	29112	21504	8728	7015	8462	14021	7618	18335
2008	30155	78121	24456	53525	57125	84358	54701	297879	49889	36692	25172	14466	12787	9269	13194	24124
2009	47421	86053	31431	56816	40104	36174	62700	57683	273217	68318	42063	30583	21230	8266	6811	39752
2010	4331	68198	122386	69381	29371	30496	51312	110033	73973	285281	70041	34486	24421	14887	14942	44201
2011	1136	17035	61864	106032	51259	35380	38626	59428	59031	61017	239472	88764	29187	17731	9783	35379
2012	5383	48396	42933	64404	171353	56060	37949	28163	25641	45516	41305	162155	50561	24067	11649	30636
2013	94165	138663	34651	34171	76847	248958	67370	25070	18447	20746	31217	20836	106242	21316	16279	24536
2014	19215	26080	83034	34591	28200	62102	152650	56679	21786	16441	23876	23654	24509	57284	25197	23878
2015	85629	108174	25416	51631	31604	24613	46201	118679	27331	12698	10883	12584	11794	7272	48586	15935
2016	133936	168323	97368	18662	31033	18762	14519	22754	80818	19004	10531	10298	14703	16212	18451	62769
2017	2453	3610	5217	112644	20936	37499	8531	7307	17117	48728	8823	3471	3040	4890	5425	30140

Table 7.2.5.1. Western horse mackerel stock. Mean weight (kg) in catch-at-age by quarter and area in 2017

Q1														
Age	27.2.a	27.5.b.1.b	27.6.a	27.7.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.j.2	mean
0									0.015					0.015
1									0.041					0.041
2	0.238	0.238	0.280	0.289			0.052	0.046	0.092	0.051	0.052	0.052	0.052	0.131
3	0.101	0.101	0.087	0.084	0.078		0.075	0.064	0.111	0.070	0.071	0.075	0.075	0.083
4	0.144	0.144	0.133	0.131	0.160		0.126	0.042	0.115	0.102	0.103	0.126	0.126	0.121
5	0.200	0.200	0.196	0.194	0.214	0.230	0.210		0.181	0.156	0.156	0.210	0.210	0.197
6	0.220	0.220	0.215	0.214	0.238	0.259	0.232		0.338	0.181	0.181	0.232	0.232	0.230
7	0.236	0.236	0.228	0.228	0.249		0.252			0.228	0.228	0.252	0.252	0.239
8	0.268	0.268	0.264	0.264	0.246	0.253	0.249		0.407	0.237	0.237	0.248	0.248	0.266
9	0.268	0.268	0.264	0.264	0.262	0.298	0.266		0.387	0.248	0.248	0.265	0.265	0.275
10	0.297	0.297	0.287	0.285	0.277	0.280	0.281		0.417			0.276	0.276	0.297
11	0.324	0.324	0.319	0.323	0.324	0.296	0.338		0.439	0.291	0.291	0.324	0.324	0.326
12	0.325	0.325	0.314	0.313	0.368	0.289	0.364		0.433	0.331	0.331	0.351	0.351	0.341
13	0.316	0.316	0.314	0.312	0.332	0.353	0.336		0.408	0.306	0.306	0.334	0.334	0.331
14	0.332	0.332	0.326	0.324	0.345	0.321	0.343		0.441			0.331	0.331	0.342
15+	0.333	0.334	0.327	0.326	0.324	0.361	0.324		0.427	0.374	0.374	0.320	0.320	0.346

Q2												
Age	27.5.b.1.b	27.6.a	27.7.b	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.j.2	27.7.k.2	mean
0					0.015	0.015						0.015
1					0.041	0.041						0.041
2	0.238	0.238		0.052	0.084	0.092	0.051	0.051	0.051	0.051	0.051	0.096
3	0.101	0.101		0.075	0.094	0.111	0.070	0.070	0.070	0.070	0.070	0.083
4	0.144	0.144		0.126	0.055	0.115	0.102	0.102	0.102	0.102	0.102	0.109
5	0.200	0.200		0.210	0.163	0.181	0.156	0.156	0.156	0.156	0.156	0.174
6	0.220	0.220		0.232		0.338	0.181	0.181	0.181	0.181	0.181	0.213
7	0.236	0.260	0.269	0.252			0.228	0.228	0.228	0.228	0.228	0.239
8	0.268	0.314	0.332	0.249		0.407	0.237	0.237	0.237	0.237	0.237	0.276
9	0.268	0.307	0.323	0.266		0.387	0.248	0.248	0.248	0.248	0.248	0.279
10	0.297	0.351	0.372	0.281		0.417		0.270	0.270	0.270	0.270	0.311
11	0.324	0.363	0.379	0.338		0.439	0.291	0.291	0.291	0.291	0.291	0.330
12	0.325	0.367	0.384	0.364		0.433	0.331	0.331	0.331	0.331	0.331	0.353
13	0.316	0.356	0.372	0.336		0.408	0.306	0.306	0.306	0.306	0.306	0.332
14	0.332	0.346	0.352	0.343		0.441		0.350	0.350	0.350	0.350	0.357
15+	0.334	0.383	0.402	0.324		0.427	0.374	0.373	0.373	0.373	0.373	0.374

Table 7.2.5.1 cont. Western horse mackerel stock. Mean weight (kg) in catch-at-age by quarter and area in 2017

Q3														
Age	27.3.a	27.4.a	27.5.b.1.b	27.6.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.k.2	mean
0								0.015	0.015	0.015				0.015
1	0.060							0.041	0.041	0.041				0.041
2	0.086		0.238	0.176		0.052	0.052	0.084	0.092	0.092				0.112
3	0.153	0.193	0.101	0.114	0.111	0.075	0.075	0.094	0.111	0.111	0.111	0.111	0.111	0.102
4	0.182	0.234	0.144	0.176	0.185	0.126	0.126	0.055	0.115	0.115	0.185	0.185	0.185	0.145
5	0.203	0.234	0.200	0.213	0.245	0.210	0.210	0.163	0.181	0.169	0.245	0.245	0.245	0.211
6	0.218	0.246	0.220	0.240	0.235	0.232	0.232		0.338		0.235	0.235	0.235	0.245
7	0.227	0.279	0.236	0.256		0.252	0.252							0.249
8	0.244	0.300	0.268	0.282	0.317	0.249	0.249		0.407	0.347	0.317	0.317	0.317	0.307
9	0.249	0.277	0.268	0.282	0.301	0.266	0.266		0.387	0.342	0.301	0.301	0.301	0.301
10	0.266	0.300	0.297	0.317	0.343	0.281	0.281		0.417	0.351	0.343	0.343	0.343	0.331
11	0.295	0.333	0.324	0.326		0.338	0.338		0.439	0.348				0.352
12	0.310	0.310	0.325	0.352	0.400	0.364	0.364		0.433	0.306	0.400	0.400	0.400	0.374
13	0.309	0.309	0.316	0.334	0.427	0.336	0.336		0.408	0.359	0.427	0.427	0.427	0.380
14	0.273	0.332	0.332	0.347		0.343	0.343		0.441					0.361
15+	0.296	0.333	0.334	0.355	0.396	0.324	0.324		0.427	0.376	0.396	0.396	0.396	0.372

Q4																
Age	27.2.a	27.3.a	27.4.a	27.5.b.1.b	27.6.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.k	27.7.k.2	mean
0									0.015	0.015						0.015
1		0.060							0.042	0.041						0.048
2	0.238	0.086	0.151	0.238	0.176		0.052	0.052	0.092	0.092		0.083		0.052	0.052	0.114
3	0.101	0.153	0.120	0.101	0.119	0.147	0.075	0.075	0.112	0.111		0.099		0.075	0.075	0.105
4	0.144	0.182	0.188	0.144	0.177	0.193	0.126	0.126	0.115	0.115				0.126	0.126	0.147
5	0.200	0.203	0.218	0.200	0.209	0.221	0.210	0.210	0.163	0.181	0.305		0.293	0.210	0.210	0.217
6	0.220	0.218	0.248	0.220	0.235	0.234	0.232	0.232		0.338	0.338			0.232	0.232	0.248
7	0.236	0.227	0.265	0.236	0.256	0.254	0.252	0.252						0.252	0.252	0.248
8	0.268	0.244	0.287	0.268	0.278	0.271	0.249	0.249		0.407	0.407		0.347	0.248	0.248	0.290
9	0.268	0.249	0.288	0.268	0.275	0.287	0.266	0.266		0.387	0.387		0.342	0.265	0.265	0.293
10	0.297	0.266	0.325	0.297	0.310	0.311	0.281	0.281		0.417	0.417		0.351	0.276	0.276	0.316
11	0.324	0.295	0.327	0.324	0.322	0.354	0.338	0.338		0.439	0.439		0.348	0.324	0.324	0.346
12	0.325	0.310	0.362	0.325	0.351	0.312	0.364	0.364		0.433	0.433		0.306	0.351	0.351	0.353
13	0.316	0.309	0.341	0.316	0.334	0.354	0.336	0.336		0.408	0.408		0.359	0.334	0.334	0.345
14	0.332	0.273	0.354	0.332	0.335	0.297	0.343	0.343		0.441	0.441			0.331	0.331	0.346
15+	0.333	0.296	0.362	0.334	0.346	0.298	0.324	0.324		0.427	0.427		0.376	0.320	0.320	0.345

Q1-4																		
Age	27.2.a	27.3.a	27.4.a	27.5.b.1.b	27.6.a	27.7.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.j.2	27.7.k	27.7.k.2	mean
0										0.015	0.015	0.015						0.015
1		0.060								0.042	0.041	0.041						0.046
2	0.238	0.086	0.151	0.238	0.218	0.289		0.052	0.052	0.079	0.092	0.069	0.061	0.051	0.052	0.052	0.052	0.114
3	0.101	0.153	0.162	0.101	0.104	0.084	0.109	0.075	0.075	0.093	0.111	0.088	0.086	0.081	0.073	0.075	0.086	0.097
4	0.144	0.182	0.214	0.144	0.158	0.131	0.175	0.126	0.126	0.069	0.115	0.108	0.125	0.128	0.114	0.126	0.138	0.137
5	0.200	0.203	0.227	0.200	0.205	0.194	0.223	0.218	0.210	0.163	0.181	0.199	0.180	0.219	0.183	0.210	0.204	0.201
6	0.220	0.218	0.247	0.220	0.228	0.214	0.236	0.243	0.232		0.338	0.241	0.196	0.210	0.206	0.232	0.216	0.231
7	0.236	0.227	0.273	0.236	0.249	0.228	0.256	0.252	0.252			0.228	0.228	0.238	0.240	0.252	0.240	0.242
8	0.268	0.244	0.295	0.268	0.283	0.264	0.284	0.251	0.249		0.407	0.316	0.259	0.281	0.243	0.248	0.267	0.277
9	0.268	0.249	0.281	0.268	0.281	0.264	0.289	0.279	0.266		0.387	0.314	0.262	0.285	0.257	0.265	0.271	0.280
10	0.297	0.266	0.310	0.297	0.314	0.285	0.318	0.281	0.281		0.417	0.381	0.302	0.304	0.273	0.276	0.296	0.306
11	0.324	0.295	0.330	0.324	0.331	0.323	0.349	0.321	0.338		0.439	0.348	0.291	0.318	0.308	0.324	0.308	0.330
12	0.325	0.310	0.332	0.325	0.344	0.313	0.363	0.334	0.364		0.433	0.350	0.350	0.341	0.341	0.351	0.360	0.346
13	0.316	0.309	0.323	0.316	0.334	0.312	0.362	0.343	0.336		0.408	0.350	0.339	0.346	0.320	0.334	0.356	0.338
14	0.332	0.273	0.341	0.332	0.337	0.324	0.333	0.334	0.343		0.441	0.441	0.350	0.342	0.340	0.331	0.340	0.346
15+	0.333	0.296	0.345	0.334	0.351	0.326	0.348	0.339	0.324		0.427	0.388	0.380	0.365	0.347	0.320	0.363	0.349

Table 7.2.5.2. Western horse mackerel stock. Mean length (cm) in catch-at-age by quarter and area in 2017

Q1													
Age	27.2.a	27.5.b.1.b	27.6.a	27.7.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	mean
0								12.8					12.8
1								17.7					17.7
2	31.4	34.5	34.5			19.5	18.5	22.6	19.4	19.5	19.5	19.5	22.7
3	23.8	22.6	22.6	22.1		21.7	20.8	23.9	21.3	21.3	21.7	21.7	21.7
4	26.7	26.0	26.1	27.9		25.7	18.5	24.2	24.2	24.3	25.7	25.7	24.2
5	29.7	29.5	29.5	30.0	30.3	29.8		26.9	27.8	27.8	29.8	29.8	29.2
6	30.6	30.5	30.5	31.3	31.5	31.1		34.1	29.1	29.1	31.0	31.0	30.5
7	31.3	31.0	31.1	31.8		32.0			31.4	31.4	32.0	32.0	31.5
8	32.6	32.5	32.5	31.8	32.1	31.9		36.2	31.9	31.9	31.9	31.9	32.1
9	32.7	32.5	32.5	32.3	33.6	32.4		35.7	32.7	32.7	32.4	32.4	32.7
10	33.7	33.4	33.4	32.5	32.4	32.6		36.5			32.5	32.5	33.0
11	34.7	34.5	34.7	34.6	33.5	34.9		37.2	33.5	33.5	34.5	34.5	34.2
12	34.6	34.3	34.3	36.1	33.0	36.1		37.0	38.5	38.5	35.7	35.7	36.1
13	34.5	34.4	34.4	35.0	34.9	35.0		36.3	34.5	34.5	34.9	34.9	34.7
14	34.9	34.7	34.7	35.4	34.5	35.2		37.2			34.9	34.9	35.0
15+	35.0	34.9	34.9	34.5	35.7	34.5		36.8	37.5	37.5	34.4	34.4	35.6

Q2											
Age	27.2.a	27.5.b.1.b	27.6.a	27.7.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	mean
0				12.8	12.8						12.8
1				17.7	17.7						17.7
2			19.5	21.9	22.6	19.4	19.4	19.4	19.4	19.4	20.1
3			21.7	22.7	23.9	21.3	21.3	21.3	21.3	21.3	21.8
4			25.7	19.5	24.2	24.2	24.2	24.2	24.2	24.2	23.8
5			29.8	26.0	26.9	27.8	27.8	27.8	27.8	27.8	27.7
6			31.1		34.1	29.1	29.1	29.1	29.1	29.1	30.1
7	32.5	32.5	32.0			31.4	31.4	31.4	31.4	31.4	31.7
8	34.5	34.5	31.9		36.2	31.9	31.9	31.9	31.9	31.9	33.0
9	34.2	34.2	32.4		35.7	32.7	32.7	32.7	32.7	32.7	33.3
10	35.5	35.5	32.6		36.5		32.6	32.6	32.6	32.6	33.8
11	35.5	35.5	34.9		37.2	33.5	33.5	33.5	33.5	33.5	34.5
12	35.5	35.5	36.1		37.0	38.5	38.4	38.4	38.4	38.4	37.3
13	34.5	34.5	35.0		36.3	34.5	34.5	34.5	34.5	34.5	34.8
14	35.2	35.2	35.2		37.2		35.7	35.7	35.7	35.7	35.7
15+	36.8	36.8	34.5		36.8	37.5	37.5	37.5	37.5	37.5	36.9

Table 7.2.5.2 cont. Western horse mackerel stock. Mean length (cm) in catch-at-age by quarter and area in 2017

Q3													
Age	27.3.a	27.4.a	27.6.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.k.2	mean
0							12.8	12.8	12.8				12.8
1	19.1						17.7	17.7	17.7				18.1
2	21.3		26.1		19.5	19.5	21.9	22.6	22.6				21.9
3	25.9	28.5	25.1	23.0	21.7	21.7	22.7	23.9	23.9	23.0	23.0	23.0	23.8
4	27.2	30.4	28.7	27.3	25.7	25.7	19.5	24.2	24.2	27.3	27.3	27.3	26.2
5	28.6	30.7	30.3	29.8	29.8	29.8	26.0	26.9	26.3	29.8	29.8	29.8	29.0
6	29.5	31.5	31.5	29.5	31.1	31.1		34.1		29.5	29.5	29.5	30.7
7	30.2	33.0	32.3		32.0	32.0							31.9
8	30.8	33.6	33.1	33.7	31.9	31.9		36.2	34.1	33.7	33.7	33.7	33.3
9	31.0	32.9	33.2	33.3	32.4	32.4		35.7	34.4	33.3	33.3	33.3	33.2
10	31.8	34.0	34.5	34.0	32.6	32.6		36.5	34.5	34.0	34.0	34.0	33.9
11	33.3	35.5	34.6		34.9	34.9		37.2	34.5				35.0
12	33.4	33.4	35.7	35.5	36.1	36.1		37.0	33.5	35.5	35.5	35.5	35.2
13	34.0	34.0	35.0	37.5	35.0	35.0		36.3	35.0	37.5	37.5	37.5	35.8
14	32.8	35.1	35.4		35.2	35.2		37.2					35.1
15+	33.5	35.4	35.7	36.3	34.5	34.5		36.8	35.5	36.3	36.3	36.3	35.5

Q4															
Age	27.2.a	27.3.a	27.4.a	27.6.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.k	27.7.k.2	mean
0								12.8	12.8						12.8
1		19.1						17.9	17.7						18.2
2	31.4	21.3	26.1	26.1		19.5	19.5	22.6	22.6		22.0		19.5	19.5	22.7
3	23.8	25.9	25.1	25.2	26.7	21.7	21.7	23.9	23.9		23.7		21.7	21.7	23.7
4	26.7	27.2	28.7	28.6	29.2	25.7	25.7	24.2	24.2				25.7	25.7	26.5
5	29.7	28.6	30.3	30.0	30.4	29.8	29.8	26.0	26.9	33.0		32.2	29.8	29.8	29.7
6	30.6	29.5	31.5	31.1	31.0	31.1	31.1		34.1	34.1			31.0	31.0	31.5
7	31.3	30.2	32.3	32.2	31.8	32.0	32.0						32.0	32.0	31.7
8	32.6	30.8	33.1	32.8	32.4	31.9	31.9		36.2	36.2		34.1	31.9	31.9	33.0
9	32.7	31.0	33.2	32.7	33.0	32.4	32.4		35.7	35.7		34.4	32.4	32.4	33.2
10	33.7	31.8	34.4	34.0	33.9	32.6	32.6		36.5	36.5		34.5	32.5	32.5	33.8
11	34.7	33.3	34.5	34.4	35.4	34.9	34.9		37.2	37.2		34.5	34.5	34.5	35.0
12	34.6	33.4	35.7	35.7	33.9	36.1	36.1		37.0	37.0		33.5	35.7	35.7	35.4
13	34.5	34.0	35.0	35.0	35.4	35.0	35.0		36.3	36.3		35.0	34.9	34.9	35.1
14	34.9	32.8	35.4	34.7	33.5	35.2	35.2		37.2	37.2			34.9	34.9	35.1
15+	35.0	33.5	35.7	35.3	33.5	34.5	34.5		36.8	36.8		35.5	34.4	34.4	35.0

Table 7.2.5.2 cont. Western horse mackerel stock. Mean length (cm) in catch-at-age by quarter and area in 2017

Q1-4																		
Age	27.2.a	27.3.a	27.4.a	27.5.b.1.b	27.6.a	27.7.a	27.7.b	27.7.c	27.7.c.2	27.7.e	27.7.f	27.7.g	27.7.h	27.7.j	27.7.j.2	27.7.k	27.7.k.2	mean
0										12.8	12.8	12.8						12.8
1		19.1								17.8	17.7	17.7						18.1
2	31.4	21.3	26.1	31.4	30.2	34.5		19.5	19.5	21.4	22.6	20.8	20.2	19.4	19.5	19.5	19.5	23.5
3	23.8	25.9	27.0	23.8	23.9	22.6	23.8	21.7	21.7	22.7	23.9	22.4	22.2	21.8	21.5	21.7	22.0	23.1
4	26.7	27.2	29.7	26.7	27.3	26.1	28.2	25.7	25.7	20.6	24.2	24.2	25.1	25.4	24.9	25.7	25.7	25.8
5	29.7	28.6	30.5	29.7	29.8	29.5	30.1	30.0	29.8	26.0	26.9	28.7	28.4	29.7	28.8	29.8	29.2	29.1
6	30.6	29.5	31.5	30.6	30.9	30.5	30.8	31.2	31.1		34.1	31.1	29.2	29.9	30.1	31.0	29.9	30.7
7	31.3	30.2	32.7	31.3	31.8	31.1	32.0	32.0	32.0			31.4	31.4	31.6	31.7	32.0	31.7	31.6
8	32.6	30.8	33.4	32.6	33.0	32.5	32.9	32.0	31.9		36.2	33.7	32.4	32.8	31.9	31.9	32.5	32.7
9	32.7	31.0	33.0	32.7	33.0	32.5	33.1	32.9	32.4		35.7	34.0	32.9	33.2	32.6	32.4	32.8	32.9
10	33.7	31.8	34.2	33.7	34.1	33.4	33.8	32.6	32.6		36.5	35.4	33.2	33.3	32.5	32.5	33.0	33.5
11	34.7	33.3	35.1	34.7	34.7	34.7	35.1	34.3	34.9		37.2	34.8	33.5	34.1	34.0	34.5	34.0	34.6
12	34.6	33.4	34.4	34.6	35.0	34.3	35.3	34.8	36.1		37.0	36.5	37.6	36.0	37.0	35.7	36.5	35.6
13	34.5	34.0	34.4	34.5	34.6	34.4	35.4	35.0	35.0		36.3	35.1	35.3	35.2	34.7	34.9	35.7	34.9
14	34.9	32.8	35.2	34.9	34.9	34.7	34.8	34.9	35.2		37.2	37.2	35.7	35.3	35.3	34.9	35.3	35.2
15+	35.0	33.5	35.5	35.1	35.4	34.9	35.1	34.9	34.5		36.8	36.7	37.1	36.0	35.9	34.4	36.0	35.4

Table 7.2.5.3. Western horse mackerel. Catch weights-at-age (kg).

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.015	0.054	0.09	0.142	0.178	0.227	0.273	0.276	0.292	0.305	0.369	0.348	0.348	0.348	0.356	0.366
1983	0.015	0.039	0.113	0.124	0.168	0.229	0.247	0.282	0.281	0.254	0.26	0.3	0.31	0.315	0.311	0.332
1984	0.015	0.034	0.073	0.089	0.13	0.176	0.216	0.245	0.278	0.262	0.259	0.255	0.344	0.232	0.306	0.308
1985	0.015	0.029	0.045	0.087	0.15	0.156	0.199	0.243	0.256	0.294	0.257	0.241	0.251	0.314	0.346	0.321
1986	0.015	0.029	0.045	0.11	0.107	0.171	0.196	0.223	0.251	0.296	0.28	0.319	0.287	0.345	0.26	0.36
1987	0.015	0.068	0.067	0.11	0.155	0.143	0.174	0.198	0.249	0.264	0.321	0.336	0.244	0.328	0.245	0.373
1988	0.015	0.031	0.075	0.114	0.132	0.147	0.157	0.24	0.304	0.335	0.386	0.434	0.404	0.331	0.392	0.424
1989	0.012	0.05	0.075	0.149	0.142	0.142	0.22	0.166	0.258	0.327	0.33	0.381	0.4	0.421	0.448	0.516
1990	0.015	0.032	0.031	0.09	0.124	0.126	0.129	0.202	0.183	0.227	0.32	0.328	0.355	0.399	0.388	0.379
1991	0.012	0.031	0.046	0.113	0.125	0.148	0.141	0.144	0.187	0.185	0.215	0.303	0.323	0.354	0.365	0.33
1992	0.008	0.014	0.092	0.117	0.139	0.143	0.157	0.163	0.172	0.235	0.222	0.288	0.306	0.359	0.393	0.401
1993	0.01	0.033	0.083	0.12	0.126	0.142	0.154	0.163	0.183	0.199	0.177	0.238	0.308	0.327	0.376	0.421
1994	0.021	0.037	0.052	0.106	0.124	0.158	0.153	0.167	0.194	0.199	0.28	0.275	0.24	0.326	0.342	0.383
1995	0.015	0.038	0.052	0.073	0.089	0.126	0.13	0.17	0.176	0.2	0.204	0.222	0.215	0.246	0.237	0.298
1996	0.015	0.059	0.078	0.09	0.125	0.141	0.155	0.166	0.177	0.191	0.206	0.224	0.233	0.229	0.28	0.332
1997	0.017	0.039	0.075	0.093	0.109	0.142	0.179	0.189	0.199	0.209	0.234	0.24	0.246	0.272	0.309	0.288
1998	0.014	0.041	0.087	0.102	0.113	0.14	0.162	0.172	0.183	0.192	0.213	0.227	0.242	0.231	0.239	0.272
1999	0	0.05	0.089	0.108	0.121	0.14	0.162	0.186	0.203	0.21	0.217	0.231	0.29	0.276	0.263	0.362
2000	0.026	0.058	0.084	0.101	0.118	0.149	0.164	0.155	0.193	0.209	0.234	0.215	0.252	0.195	0.274	0.362
2001	0.018	0.045	0.071	0.104	0.113	0.129	0.139	0.151	0.169	0.195	0.223	0.227	0.296	0.277	0.271	0.304
2002	0.018	0.037	0.062	0.095	0.124	0.143	0.152	0.167	0.182	0.210	0.256	0.296	0.357	0.32	0.309	0.369
2003	0.041	0.062	0.061	0.082	0.127	0.149	0.172	0.167	0.178	0.189	0.220	0.275	0.363	0.315	0.331	0.379
2004	0.033	0.037	0.091	0.097	0.136	0.152	0.164	0.173	0.190	0.179	0.192	0.208	0.355	0.257	0.366	0.33
2005	0.022	0.030	0.059	0.085	0.106	0.157	0.184	0.214	0.209	0.203	0.237	0.229	0.300	0.309	0.342	0.410
2006	0.036	0.039	0.062	0.095	0.131	0.135	0.191	0.225	0.258	0.291	0.271	0.256	0.269	0.269	0.319	0.380
2007	0.013	0.050	0.076	0.101	0.119	0.125	0.159	0.178	0.220	0.231	0.239	0.248	0.247	0.256	0.286	0.371
2008	0.033	0.045	0.088	0.105	0.120	0.141	0.161	0.181	0.219	0.249	0.278	0.272	0.302	0.292	0.306	0.352
2009	0.031	0.041	0.072	0.095	0.121	0.160	0.177	0.219	0.226	0.279	0.311	0.396	0.404	0.308	0.355	0.446
2010	0.044	0.040	0.087	0.110	0.143	0.164	0.180	0.193	0.217	0.237	0.248	0.279	0.297	0.322	0.308	0.347
2011	0.034	0.048	0.087	0.111	0.134	0.164	0.182	0.192	0.211	0.228	0.255	0.304	0.303	0.299	0.346	0.363
2012	0.058	0.061	0.083	0.108	0.148	0.166	0.182	0.207	0.228	0.242	0.266	0.269	0.296	0.298	0.336	0.375
2013	0.039	0.056	0.089	0.112	0.141	0.163	0.191	0.226	0.235	0.254	0.250	0.287	0.294	0.316	0.368	0.388
2014	0.035	0.055	0.086	0.119	0.140	0.172	0.197	0.223	0.250	0.258	0.271	0.289	0.301	0.304	0.342	0.374
2015	0.020	0.015	0.075	0.113	0.139	0.162	0.196	0.220	0.246	0.263	0.279	0.312	0.298	0.317	0.322	0.339
2016	0.016	0.024	0.076	0.110	0.153	0.177	0.193	0.228	0.241	0.262	0.286	0.294	0.311	0.323	0.327	0.34
2017	0.013	0.013	0.055	0.097	0.136	0.193	0.196	0.223	0.257	0.268	0.289	0.312	0.328	0.324	0.339	0.344

Table 7.2.6.1. Western horse mackerel. Maturity-at-age.

	0	1	2	3	4	5	6	7	8	9	10	11+
1982	0	0	0.4	0.8	1	1	1	1	1	1	1	1
1983	0	0	0.3	0.7	1	1	1	1	1	1	1	1
1984	0	0	0.1	0.6	0.85	1	1	1	1	1	1	1
1985	0	0	0.1	0.4	0.8	0.95	1	1	1	1	1	1
1986	0	0	0.1	0.4	0.6	0.9	1	1	1	1	1	1
1987	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1988	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1989	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1990	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1991	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1992	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1993	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1994	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1995	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1996	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1997	0	0	0.1	0.4	0.6	0.8	1	1	1	1	1	1
1998	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
1999	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2000	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2001	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2002	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2003	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2004	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2005	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2006	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2007	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2008	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2009	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2010	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2011	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2012	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2013	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2014	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2015	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2016	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1
2017	0	0	0.05	0.25	0.7	0.95	1	1	1	1	1	1

Table 7.2.8.1. Western horse mackerel. Potential fecundity (10^6 eggs) per kg spawning female vs. weight in kg.

	1987		1992		1995		1998		2000		2001		2001 (CONT)	
	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.	w	pfec.
1	0.168	1.524	0.105	1.317	0.13	1.307	0.172	1.318	0.258	0.841	0.086	0.688	0.165	1.382
2	0.179	0.916	0.109	2.056	0.157	1.246	0.104	0.867	0.268	0.747	0.08	0.812	0.166	1.579
3	0.192	2.083	0.11	1.869	0.168	1.699	0.112	1.312	0.304	1.188	0.081	0.535	0.167	1.479
4	0.233	1.644	0.112	1.772	0.179	1.135	0.206	0.382	0.311	1.411	0.095	0.88	0.113	0.527
5	0.213	1.066	0.115	1.188	0.189	1.529	0.207	0.78	0.337	0.613	0.11	1.164	0.14	0.876
6	0.217	2.392	0.119	1.317	0.168	1.1	0.109	1.133	0.339	1.571	0.113	1.106	0.122	0.589
7	0.277	1.617	0.12	1.413	0.209	1.497	0.132	1.02	0.341	1.522	0.095	0.823	0.12	0.68
8	0.279	1.018	0.123	1.293	0.215	1.524	0.2	1.088	0.355	1.056	0.11	0.883	0.121	0.578
9	0.274	1.62	0.123	1.991	0.218	1.616	0.152	1.417	0.357	0.604	0.108	0.823	0.139	0.723
10	0.3	1.513	0.131	1.617	0.226	1.883	0.149	1.004	0.367	1.15	0.097	0.741	0.144	1.213
11	0.32	1.647	0.135	0.793	0.22	1.324			0.393	1.279	0.101	0.853	0.144	1.265
12	0.273	1.956	0.131	1.039	0.236	1.221			0.393	0.668	0.106	1.133	0.171	0.956
13	0.212	2.83	0.136	1.06	0.261	1.21			0.413	0.694	0.107	0.935	0.121	0.607
14	0.268	1.687	0.138	1.489	0.245	1.445			0.421	1.339	0.107	0.494	0.122	0.689
15	0.32	1.088	0.147	1.214	0.306	1.693			0.423	0.798	0.11	0.85	0.139	0.915
16	0.318	1.208	0.151	1.158	0.314	1.312			0.445	1.03	0.111	0.67	0.153	0.943
17	0.343	1.933	0.16	1.349	0.46	1.575			0.446	1.208	0.103	0.632	0.154	0.709
18	0.378	1.429	0.165	1.359	0.449	1.43			0.152	0.643	0.111	0.547	0.156	0.773
19	0.404	1.849	0.165	0.945					0.165	0.579	0.118	0.88	0.162	1.158
20	0.428	2.236	0.167	1					0.175	0.596	0.107	0.944	0.174	1.389
21	0.398	1.538	0.168	1.545					0.179	0.997	0.104	0.724	0.175	1.426
22	0.431	1.223	0.18	1.299					0.19	0.744	0.111	0.86	0.179	1.248
23	0.432	1.465	0.174	1.487					0.197	0.613	0.11	0.728	0.179	1.236
24	0.421	1.843	0.178	1.594					0.203	0.702	0.111	0.544	0.18	2.353
25	0.481	1.757	0.185	1.475					0.219	0.472	0.129	0.935	0.184	2.255
26	0.494	1.611	0.195	1.41					0.223	0.806	0.114	0.901	0.139	0.931
27	0.54	1.754	0.203	1.937					0.227	0.606	0.114	0.557	0.161	1.037
28	0.564	2.255	0.205	1.534					0.289	1.273	0.151	1.377	0.162	0.893
29	0.585	1.221	0.213	1.577					0.294	1.395	0.153	1.596	0.169	0.691
30			0.222	0.958					0.3	1.305	0.154	1.699	0.18	1.609
31			0.275	2.444							0.103	0.679	0.185	1.776
32											0.12	1.14	0.211	2.102
33											0.12	0.631	0.224	1.466
34											0.121	0.834	0.162	0.849
35											0.144	0.626	0.17	0.668
36											0.116	0.668	0.187	1.453
37											0.118	1.194	0.198	1.371
38											0.112	0.779	0.219	1.847
39											0.126	0.782	0.22	1.578
40											0.139	1.244	0.201	0.878
41											0.119	1.212	0.206	1.196
42											0.109	0.755	0.223	1.115
43											0.122	0.841	0.225	1.43
44											0.131	0.929	0.233	1.724
45											0.135	0.862	0.241	1.131
46											0.142	1.834	0.219	0.96
47											0.146	1.689	0.237	1.33
48											0.148	1.357	0.241	0.918
49											0.151	1.817	0.34	0.605

	1987	1992	1995	1998	2000	2001		2001 (CONT)	
50						0.164	1.631	0.407	1.189
51						0.164	1.052		

Table 7.3.1.1. Western horse mackerel. Final assessment. Numbers-at-age (thousands).

YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1982	51838500	807247	268750	657640	917916	138992	128338	612639	249333	216110	213261	377943	624319	990087	464875	153639	141511	12998	11871	10676	124220
1983	108587000	445961	692451	229181	558001	775506	117061	107881	514438	209296	181310	178892	317008	523639	830401	389891	128856	11866	10903	99863	113340
1984	126635050	934013900	381500	588770	193580	468660	648713	976772	898872	428290	174179	150858	148831	263726	435604	690781	324333	10718	98726	90686	102590
1985	202682020	108933	799530	324790	498280	163000	393190	543008	816559	750918	357668	145431	125947	124248	220156	363639	576651	27078	89478	82411	932110
1986	272181750	174367	933354	681953	275674	421140	137350	330704	456226	685664	630358	300191	122054	105698	104269	184753	305154	48392	22721	75080	851355
1987	548522020	234130	149240	794393	576914	232000	353110	114904	276270	380861	572190	525940	250450	101820	881740	869813	154110	25457	40361	18956	772810
1988	218704010	471760	200090	126640	668971	482640	193180	293160	952320	228770	315240	473500	435170	207210	842400	729470	719590	12750	21050	33390	796115
1989	235806080	188080	402870	169540	106390	557938	400440	159750	241980	785307	188560	259750	390100	358504	170697	693930	600905	59270	10500	17340	930896
1990	177976090	202780	160590	341260	142370	886913	462620	330920	131770	199405	646780	155250	213850	321140	295117	140510	571212	49461	48791	86442	908992
1991	352130600	153000	172610	135190	283840	117210	724760	376290	268470	106750	161430	523420	125620	173010	259790	238730	113660	46200	40010	39460	805202
1992	685270500	302680	130050	104890	500700	900400	951340	520400	400400	210000	904000	500500	400200	300100	400300	700400	400500	200600	500700	300800	400900
1993	711375800	589480	255560	107710	117530	892020	182760	742460	454630	234780	167030	663250	100210	324810	779380	107320	161140	14800	70490	28650	548680
1994	724010500	610630	491580	209000	853800	773000	690800	511510	103040	414670	252660	130150	497490	367980	242390	580560	800810	12020	11040	52590	430742
1995	482540800	621400	511680	403450	165610	662270	693220	511510	103040	414670	252660	130150	924760	366930	554220	179580	430850	59320	89070	81840	358053
1996	244170300	413560	513700	406240	306600	121230	471960	485770	355040	711590	285620	173800	894650	635420	252070	380690	123340	29590	40740	61170	302090
1997	168649090	209360	343470	411660	313180	228670	882960	338650	345630	251490	502890	201610	122600	630900	448010	177700	268360	86940	208500	28710	256040
1998	288220400	144370	171270	267010	302840	219770	155120	586400	222220	225360	163440	326270	130690	794370	408650	290140	115070	17370	56290	13500	184362
1999	320650900	247160	120010	137490	206420	226680	160730	111820	419230	158180	160050	115940	231310	926230	562890	289530	205550	81520	12310	39880	226262
2000	238609000	274970	205410	963030	106210	154350	165590	115720	798380	298010	112190	113380	163710	164710	658420	398270	208360	14540	57670	87080	188270
2001	167000700	200600	300000	600000	600000	800000	600000	600000	200000	700000	600000	836590	845140	611690	700000	488290	296690	21410	11010	06000	415897
2002	700100000	700500	700800	500500	800800	580050	610800	900100	300300	620020	430000	160700	600700	410130	440520	880350	352391	11000	20000	78170	100001
2003	305000900	300500	500000	900400	900900	400400	000300	900900	400400	400300	300900	100900	110000	445970	450320	325850	649670	50000	00900	81260	900009
2004	244970400	400400	100700	700600	600800	800100	100900	900800	700700	600700	700700	700600	885110	332610	335830	242990	500010	10100	10100	10200	200002

20	15009	21041	12590	11758	79247	88078	89914	60128	25742	26607	37102	38862	26805	18368				1875	3739	1496	19368
05	30	60	10	00	50	2	3	0	1	0	7	1	9	5	68323	25673	25920	4	0	6	7
20	13013	12890	17741	10398	94969	62797	68844	69678	46369	19800	20438	28481	29821	20565	14091			1988	1438	2867	16003
06	30	50	60	80	3	20	4	1	3	5	6	6	4	9	0	52409	19692	1	5	8	4
20	23863	11180	10906	14756	84900	76316	49891	54306	54742	36352	15505	15996	22284	23329	16087	11021		1540	1555	1125	14759
07	20	40	80	30	1	2	60	8	8	1	9	5	7	2	1	7	40992	2	0	0	3
20	63901	20509	94937	91366	12181	69210	61655	40079	43487	43762	29035	12379	12767	17784	18617	12837		3270	1229	1240	12674
08	90	90	0	6	30	7	1	90	6	3	1	3	9	7	0	2	87948	9	0	8	3
20	13691	54906	17369	79108	74808	98251	55225	48865	31644	34265	34445	22841		10040	13983	14637	10092	6914	2571		10939
09	00	70	70	5	6	4	5	5	60	4	9	7	97359	0	7	4	7	4	5	9662	6
20	97218	11756	46235	14309	63642	58973	76333	42515	37425	24169	26134	26253	17402			10649	11146	7685	5265	1958	
10	8	60	80	50	2	6	8	8	5	80	6	2	3	74159	76466	5	8	7	3	2	90659
20	44158	83447	98602	37783	11369	49365	44962	57571	31870	27963	18028	19477	19557	12960				8299	5722	3920	
11	5	8	3	90	60	8	0	7	1	3	80	7	2	5	55223	56937	79292	1	1	0	82072
20	27999	37901	69947	80485	29968	87988	37536	33811	43024	23738	20792	13393	14463	14518				5884	6159	4246	
12	10	2	1	5	10	7	3	9	4	1	6	90	6	9	96203	40987	42257	6	1	5	89997
20	98087	24035	31816	57264	64127	23329	67367	28440	25467	32305	17795	15574	10028	10826	10866			3162	4403	4608	
13	3	30	2	0	8	90	0	6	7	2	2	2	00	3	2	71994	30672	1	3	6	99115
20	36009	84187	20145	25967	45411	49617	17735	50647	21248	18964	24014	13216	11561	74424				2275	2346	3266	10772
14	50	7	70	7	4	9	00	3	3	0	2	5	6	3	80337	80627	53417	6	0	9	3
20	28710	30914	70734	16522	20747	35479	38149	13499	38331	16032	14287	18077			55980			4017	1711	1764	10557
15	80	60	9	50	4	8	0	10	4	8	0	2	99448	86975	5	60424	60639	3	4	3	8
20	36749	24663	26118	58657	13427	16572	27992	29865	10521	29807	12452	11089	14027			43423		4703	3115	1327	
16	10	00	30	3	70	9	4	5	60	1	4	6	0	77153	67470	5	46868	4	9	4	95571
20	50847	31565	20822	21630	47573	10697	13035	21840	23196	81524	23066			10842			33558	3621	3634	2407	
17	00	80	90	20	7	70	3	8	6	6	7	96303	85735	4	59631	52144	1	9	7	9	84110

Table 7.3.1.2. Western horse mackerel. Final assessment. Fishing mortality-at-age.

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1982	0.0005	0.0046	0.0093	0.0143	0.0186	0.0217	0.0236	0.0247	0.0253	0.0256	0.0257	0.0258	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259	0.0259
1983	0.0006	0.0061	0.0122	0.0188	0.0245	0.0285	0.0311	0.0325	0.0333	0.0337	0.0339	0.0340	0.0340	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341
1984	0.0006	0.0055	0.0109	0.0169	0.0219	0.0256	0.0279	0.0292	0.0298	0.0302	0.0304	0.0305	0.0305	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306
1985	0.0005	0.0045	0.0091	0.0140	0.0182	0.0212	0.0231	0.0241	0.0247	0.0250	0.0252	0.0252	0.0253	0.0253	0.0253	0.0253	0.0253	0.0253	0.0253	0.0253	0.0253
1986	0.0006	0.0056	0.0112	0.0173	0.0225	0.0262	0.0285	0.0298	0.0305	0.0309	0.0311	0.0312	0.0312	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313
1987	0.0007	0.0071	0.0142	0.0218	0.0284	0.0331	0.0361	0.0377	0.0386	0.0391	0.0393	0.0395	0.0395	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396	0.0396
1988	0.0008	0.0078	0.0157	0.0242	0.0315	0.0367	0.0400	0.0418	0.0428	0.0433	0.0436	0.0437	0.0438	0.0439	0.0439	0.0439	0.0439	0.0439	0.0439	0.0439	0.0439
1989	0.0008	0.0080	0.0160	0.0246	0.0320	0.0373	0.0407	0.0425	0.0435	0.0441	0.0443	0.0445	0.0445	0.0446	0.0446	0.0446	0.0446	0.0446	0.0446	0.0447	0.0447
1990	0.0012	0.0111	0.0222	0.0342	0.0445	0.0519	0.0565	0.0592	0.0605	0.0613	0.0616	0.0618	0.0619	0.0620	0.0620	0.0620	0.0621	0.0621	0.0621	0.0621	0.0621
1991	0.0013	0.0125	0.0251	0.0387	0.0503	0.0587	0.0639	0.0669	0.0684	0.0692	0.0697	0.0699	0.0700	0.0701	0.0701	0.0701	0.0702	0.0702	0.0702	0.0702	0.0702
1992	0.0020	0.0192	0.0384	0.0593	0.0771	0.0899	0.0979	0.1024	0.1049	0.1061	0.1067	0.1071	0.1072	0.1074	0.1074	0.1075	0.1075	0.1075	0.1075	0.1075	0.1075
1993	0.0027	0.0255	0.0511	0.0788	0.1025	0.1195	0.1301	0.1362	0.1394	0.1410	0.1419	0.1423	0.1426	0.1427	0.1428	0.1428	0.1429	0.1429	0.1429	0.1429	0.1429
1994	0.0028	0.0268	0.0537	0.0827	0.1076	0.1254	0.1366	0.1430	0.1463	0.1480	0.1489	0.1494	0.1497	0.1498	0.1499	0.1499	0.1500	0.1500	0.1500	0.1500	0.1500
1995	0.0043	0.0403	0.0807	0.1245	0.1619	0.1888	0.2056	0.2151	0.2202	0.2228	0.2242	0.2249	0.2252	0.2255	0.2256	0.2257	0.2257	0.2258	0.2258	0.2258	0.2258
1996	0.0038	0.0357	0.0714	0.1102	0.1433	0.1670	0.1819	0.1904	0.1948	0.1971	0.1983	0.1989	0.1993	0.1995	0.1996	0.1997	0.1997	0.1997	0.1998	0.1998	0.1998
1997	0.0054	0.0509	0.1018	0.1570	0.2042	0.2380	0.2593	0.2713	0.2777	0.2810	0.2826	0.2835	0.2840	0.2843	0.2845	0.2846	0.2846	0.2847	0.2847	0.2847	0.2847
1998	0.0037	0.0348	0.0697	0.1074	0.1397	0.1628	0.1774	0.1856	0.1899	0.1922	0.1933	0.1940	0.1943	0.1945	0.1946	0.1947	0.1947	0.1947	0.1948	0.1948	0.1948
1999	0.0037	0.0350	0.0701	0.1082	0.1407	0.1640	0.1786	0.1869	0.1913	0.1935	0.1947	0.1953	0.1957	0.1958	0.1960	0.1960	0.1961	0.1961	0.1961	0.1962	0.1962
2000	0.0027	0.0258	0.0517	0.0797	0.1036	0.1208	0.1316	0.1377	0.1409	0.1426	0.1435	0.1439	0.1441	0.1443	0.1444	0.1444	0.1445	0.1445	0.1445	0.1445	0.1445
2001	0.0033	0.0315	0.0630	0.0972	0.1264	0.1474	0.1605	0.1679	0.1719	0.1739	0.1750	0.1755	0.1758	0.1760	0.1761	0.1762	0.1762	0.1762	0.1762	0.1763	0.1763
2002	0.0029	0.0275	0.0551	0.0849	0.1104	0.1287	0.1402	0.1467	0.1501	0.1519	0.1528	0.1533	0.1536	0.1537	0.1538	0.1539	0.1539	0.1539	0.1539	0.1540	0.1540
2003	0.0027	0.0256	0.0513	0.0791	0.1029	0.1200	0.1307	0.1367	0.1399	0.1416	0.1425	0.1429	0.1431	0.1433	0.1434	0.1434	0.1435	0.1435	0.1435	0.1435	0.1435
2004	0.0021	0.0195	0.0390	0.0601	0.0782	0.0912	0.0993	0.1039	0.1064	0.1076	0.1083	0.1086	0.1088	0.1089	0.1090	0.1090	0.1090	0.1090	0.1090	0.1091	0.1091
2005	0.0022	0.0206	0.0412	0.0636	0.0827	0.0964	0.1050	0.1098	0.1124	0.1137	0.1144	0.1148	0.1150	0.1151	0.1152	0.1152	0.1152	0.1153	0.1153	0.1153	0.1153
2006	0.0018	0.0171	0.0342	0.0528	0.0687	0.0801	0.0872	0.0912	0.0934	0.0945	0.0951	0.0954	0.0955	0.0956	0.0957	0.0957	0.0957	0.0957	0.0957	0.0958	0.0958
2007	0.0014	0.0135	0.0271	0.0418	0.0543	0.0633	0.0690	0.0722	0.0739	0.0747	0.0752	0.0754	0.0756	0.0756	0.0757	0.0757	0.0757	0.0757	0.0757	0.0758	0.0758
2008	0.0017	0.0162	0.0324	0.0499	0.0650	0.0757	0.0825	0.0863	0.0883	0.0894	0.0899	0.0902	0.0904	0.0904	0.0905	0.0905	0.0906	0.0906	0.0906	0.0906	0.0906
2009	0.0023	0.0219	0.0438	0.0675	0.0878	0.1024	0.1115	0.1167	0.1195	0.1209	0.1216	0.1220	0.1222	0.1223	0.1224	0.1224	0.1225	0.1225	0.1225	0.1225	0.1225

2010	0.0027	0.0259	0.0519	0.0800	0.1040	0.1213	0.1321	0.1382	0.1415	0.1431	0.1440	0.1444	0.1447	0.1448	0.1449	0.1450	0.1450	0.1450	0.1450	0.1451	0.1451
2011	0.0028	0.0265	0.0530	0.0817	0.1063	0.1240	0.1350	0.1413	0.1446	0.1463	0.1472	0.1476	0.1479	0.1480	0.1481	0.1482	0.1482	0.1482	0.1482	0.1483	0.1483
2012	0.0026	0.0250	0.0501	0.0772	0.1004	0.1171	0.1275	0.1334	0.1365	0.1382	0.1390	0.1394	0.1397	0.1398	0.1399	0.1399	0.1400	0.1400	0.1400	0.1400	0.1400
2013	0.0028	0.0265	0.0531	0.0819	0.1065	0.1242	0.1353	0.1415	0.1449	0.1466	0.1475	0.1479	0.1482	0.1483	0.1484	0.1485	0.1485	0.1485	0.1485	0.1486	0.1486
2014	0.0026	0.0241	0.0483	0.0744	0.0968	0.1129	0.1229	0.1286	0.1316	0.1332	0.1340	0.1344	0.1346	0.1348	0.1349	0.1349	0.1349	0.1350	0.1350	0.1350	0.1350
2015	0.0020	0.0186	0.0372	0.0574	0.0747	0.0870	0.0948	0.0992	0.1015	0.1027	0.1033	0.1037	0.1038	0.1039	0.1040	0.1040	0.1041	0.1041	0.1041	0.1041	0.1041
2016	0.0020	0.0193	0.0385	0.0594	0.0773	0.0901	0.0982	0.1027	0.1051	0.1064	0.1070	0.1073	0.1075	0.1076	0.1077	0.1077	0.1077	0.1078	0.1078	0.1078	0.1078
2017	0.0017	0.0160	0.0321	0.0495	0.0643	0.0750	0.0817	0.0855	0.0875	0.0885	0.0890	0.0893	0.0895	0.0896	0.0896	0.0896	0.0897	0.0897	0.0897	0.0897	0.0897

Table 7.3.1.3. Western horse mackerel. Final assessment. Stock summary table.

Year	Recruit (thousands)	Total Biomass	Spawning biomass	Catch	Yield/SSB	Fbar(1–3)	Fbar(4–8)	Fbar(1–10)
1982	5183850	2736280	2237440	61197	0.02735135	0.009398	0.02277	0.0193358
1983	1085870	3325300	2386510	90442	0.03789718	0.01236933	0.029969	0.025449
1984	1266350	4130340	2534530	96244	0.03797312	0.01109467	0.02688	0.022826
1985	2026820	4687270	2990120	96343	0.03222045	0.009188	0.0222606	0.0189033
1986	2721850	5088210	4251360	137499	0.03234236	0.01135367	0.027508	0.0233591
1987	5485220	5273690	4980480	187338	0.03761445	0.01436267	0.034798	0.0295498
1988	2187010	5281810	5030810	210989	0.04193937	0.015922	0.038576	0.0327579
1989	2358060	5149600	4846530	209583	0.04324393	0.016189	0.039222	0.0333066
1990	1779760	4913440	4606770	275968	0.05990488	0.022506	0.0545286	0.0463044
1991	3521350	4545340	4303910	287438	0.06678532	0.02544267	0.0616424	0.0523455
1992	6862720	4146630	3932390	393631	0.10009968	0.038979	0.0944382	0.0801951
1993	7113760	3701450	3422420	453245.754	0.13243429	0.051813	0.125533	0.1066
1994	7240170	3294240	2878890	412291	0.14321179	0.05439233	0.1317824	0.1119069
1995	4825480	3020070	2480760	538949.517	0.21725178	0.081862	0.198335	0.1684222
1996	2441730	2676910	2125500	422395.72	0.1987277	0.07242733	0.175477	0.1490115
1997	1686490	2440850	1973210	534673.078	0.27096613	0.10322333	0.2500896	0.2123711
1998	2882240	2059310	1741720	325340.313	0.18679255	0.070613	0.1710812	0.1452787
1999	3206590	1856200	1633280	298991.58	0.18306205	0.071109	0.1722828	0.1462991
2000	2386090	1673430	1465660	202732.18	0.13832143	0.05239033	0.1269306	0.107787
2001	16647700	1582560	1346660	229080.72	0.17011029	0.063902	0.1548228	0.1314723
2002	1972870	1625080	1220330	196119.96	0.16071059	0.05581367	0.1352252	0.1148305
2003	1737630	1770040	1168270	191856.15	0.16422244	0.05202533	0.1260478	0.1070371
2004	2449740	1847090	1244030	159741.56	0.12840652	0.039536	0.0957882	0.0813414
2005	1500930	1910830	1554580	182001.22	0.11707421	0.041792	0.101254	0.0859828
2006	1301330	1895890	1691260	155826.51	0.09213634	0.03471633	0.0841106	0.0714251
2007	2386320	1846670	1680980	123355.68	0.07338319	0.02746167	0.0665344	0.0564997
2008	6390190	1798180	1645700	143349.28	0.08710535	0.03283967	0.079564	0.0675642
2009	1369100	1763820	1550930	183782.41	0.1184982	0.04441	0.1075974	0.0913695
2010	972188	1696120	1407530	203112.27	0.14430404	0.052587	0.127408	0.1081924
2011	441585	1574140	1301230	193698.04	0.14885765	0.05374933	0.1302244	0.110584
2012	2799910	1431620	1271950	169858.73	0.13354199	0.05075767	0.1229762	0.1044289

Year	Recruit (thousands)	Total Biomass	Spawning biomass	Catch	Yield/SSB	Fbar(1–3)	Fbar(4–8)	Fbar(1–10)
2013	980873	1308910	1200660	165258.35	0.13763959	0.053855	0.1304804	0.1108012
2014	3600950	1188860	1067470	136359.64	0.12774096	0.04893767	0.1185654	0.1006835
2015	2871080	1113760	949935	98419.2	0.10360625	0.03774033	0.0914376	0.0776469
2016	3674910	1106830	902625	98810	0.1094696	0.03907633	0.0946744	0.0803955
2017	5084700	1127290	872011	82961	0.09513756	0.03251467	0.078777	0.0668958

Table 7.4.1. Western Horse Mackerel. Short-term prediction: INPUT DATA. *geometric mean of the recruitment time-series from 1983 to 2017.

Age	N	Mat	M	PF	PM	Swt
0	2584327*	0.000	0.15	0	0	0.000396
1	3156580	0.000	0.15	0	0	0.014395
2	2082290	0.047	0.15	0	0	0.040471
3	2163020	0.269	0.15	0	0	0.068313
4	475737	0.731	0.15	0	0	0.099264
5	1069770	0.953	0.15	0	0	0.130931
6	130353	0.993	0.15	0	0	0.161589
7	218408	0.999	0.15	0	0	0.190145
8	231966	1.000	0.15	0	0	0.216006
9	815246	1.000	0.15	0	0	0.23894
10	230667	1.000	0.15	0	0	0.258956
11	96303	1.000	0.15	0	0	0.27621
12	85735	1.000	0.15	0	0	0.290939
13	108424	1.000	0.15	0	0	0.303419
14	59631	1.000	0.15	0	0	0.313927
15	52144	1.000	0.15	0	0	0.322733
16	335581	1.000	0.15	0	0	0.330083
17	36219	1.000	0.15	0	0	0.336199
18	36347	1.000	0.15	0	0	0.341275
19	24079	1.000	0.15	0	0	0.345479
20	84110	1.000	0.15	0	0	0.352296

Table 7.4.2. Western Horse Mackerel. Short-term prediction; single area management option table. OPTION: Catch constraint 115,470 t in 2018 (EU TAC).

SCENARIOS	FFACTOR	FBAR	CATCH_2017	CATCH_2018	CATCH_2019	CATCH_2020	SSB_2019	SSB_2020	CHANGE_SSB_2019-2020(%)	CHANGE_CATCH_2018-2019(%)
F_0	0.00	0.000	82961	115470	0	0	941821	1113644	18.24	-100.000
	0.10	0.007	82961	115470	9506	10904	941821	1105377	17.37	-91.767
	0.20	0.013	82961	115470	18944	21581	941821	1097174	16.49	-83.594
	0.30	0.020	82961	115470	28313	32034	941821	1089035	15.63	-75.480
	0.40	0.027	82961	115470	37614	42268	941821	1080960	14.77	-67.425
	0.50	0.033	82961	115470	46848	52287	941821	1072947	13.92	-59.428
	0.60	0.040	82961	115470	56016	62095	941821	1064998	13.08	-51.489
	0.70	0.047	82961	115470	65117	71694	941821	1057110	12.24	-43.607
	0.80	0.054	82961	115470	74152	81090	941821	1049284	11.41	-35.782
	0.90	0.060	82961	115470	83123	90285	941821	1041518	10.59	-28.014
F_{stq}	1.00	0.067	82961	115470	92028	99283	941821	1033814	9.77	-20.301
	1.10	0.074	82961	115470	100870	108088	941821	1026169	8.96	-12.644
	1.20	0.080	82961	115470	109648	116702	941821	1018584	8.15	-5.042
	1.30	0.087	82961	115470	118363	125131	941821	1011058	7.35	2.505
	1.40	0.094	82961	115470	127015	133376	941821	1003591	6.56	9.998

	1.50	0.100	82961	115470	135604	141441	941821	996181	5.77	17.437
	1.60	0.107	82961	115470	144133	149329	941821	988830	4.99	24.823
F_{MSY}	1.61	0.108	82961	115470	145237	150342	941821	987878	4.89	25.779
	1.70	0.114	82961	115470	152600	157044	941821	981535	4.22	32.155
	1.80	0.120	82961	115470	161006	164588	941821	974297	3.45	39.435
	1.90	0.127	82961	115470	169352	171965	941821	967116	2.69	46.663
	2.00	0.134	82961	115470	177638	179177	941821	959990	1.93	53.839
F_{lim}	2.26	0.151	82961	115470	198662	196980	941821	941931	0.01	72.046
$B_{2020}=B_{pa}$	2.70	0.181	82961	115470	234063	225348	941821	911587	-3.21	102.704
$B2_{020}=B_{lim}$	7.08	0.474	82961	115470	529777	385231	941821	661917	-29.72	358.800

7.15 Figures

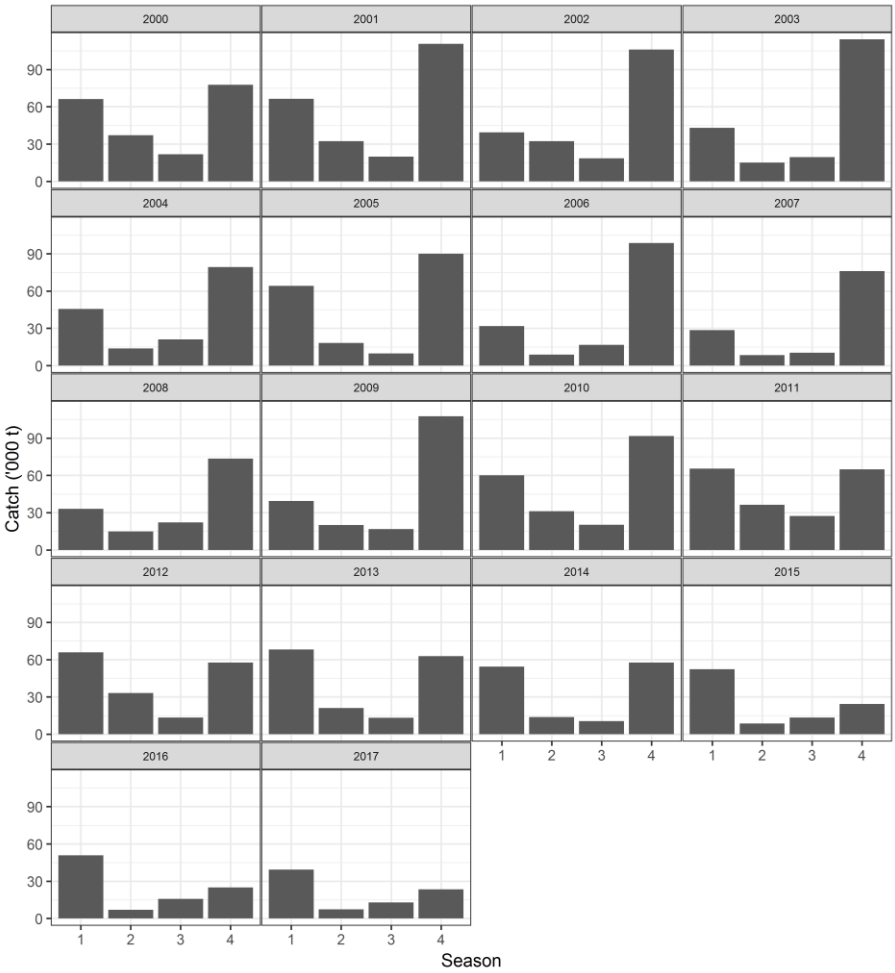

Figure 7.1.1.1: Western horse mackerel. Catch by quarter and year for 2000–2017

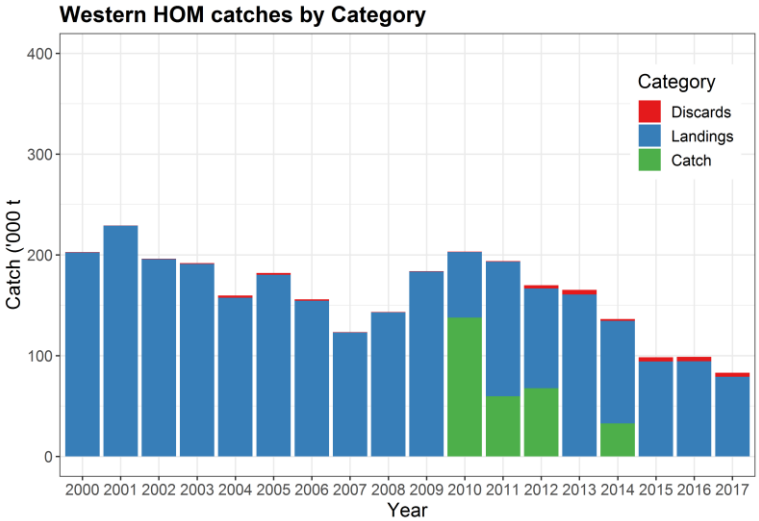

Figure 7.1.2.1. Western horse mackerel. Catch categories since 2000.

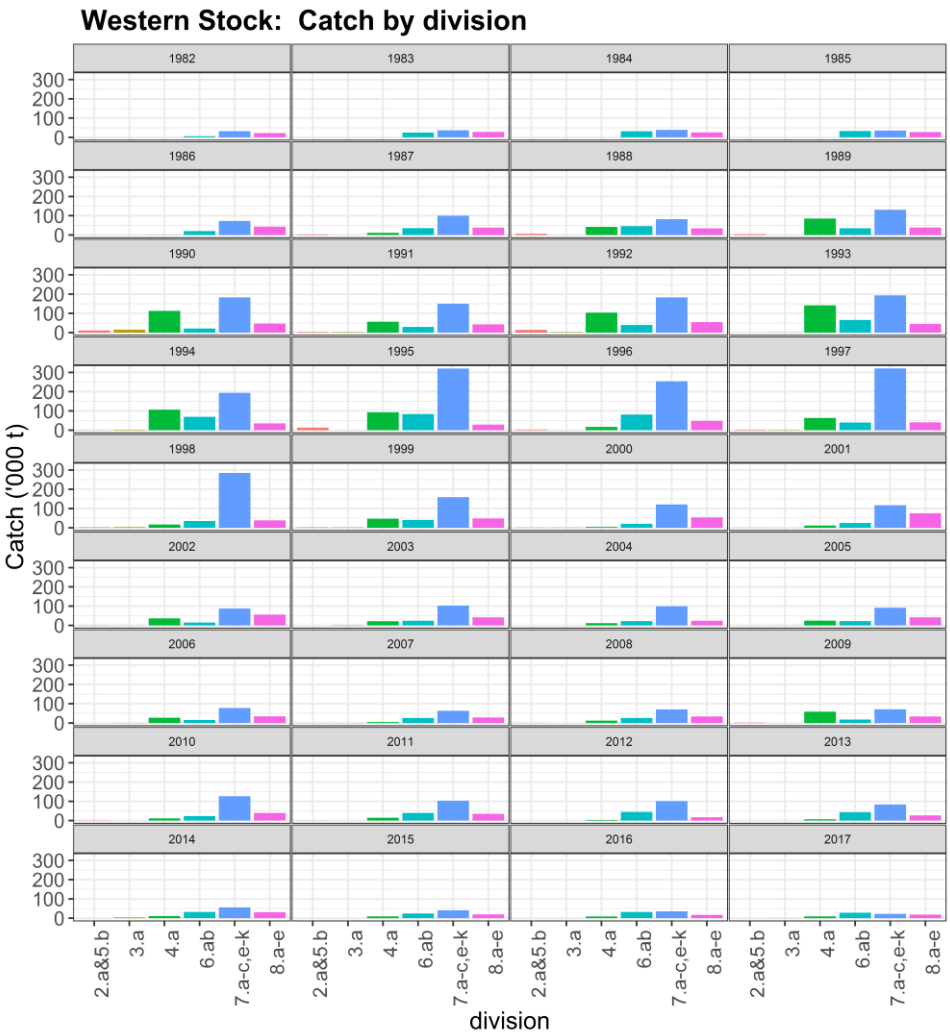

Figure 7.1.3.1: Western horse mackerel. Catch by ICES Division and year for 1982–2017

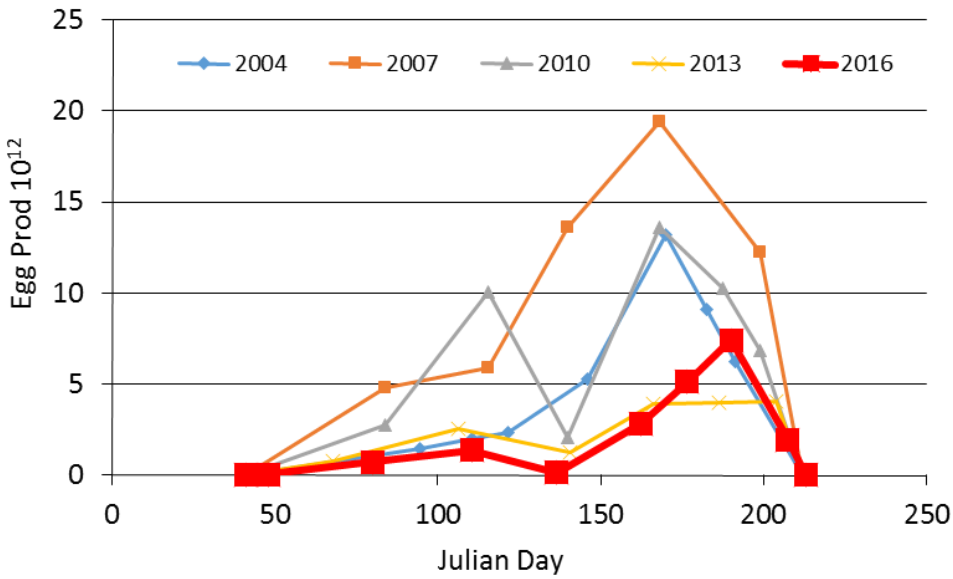

Figure 7.2.1.1: Western horse mackerel. annual egg production curve for western horse mackerel. The curves for 2004, 2007 2010 and 2013 are included for comparison.

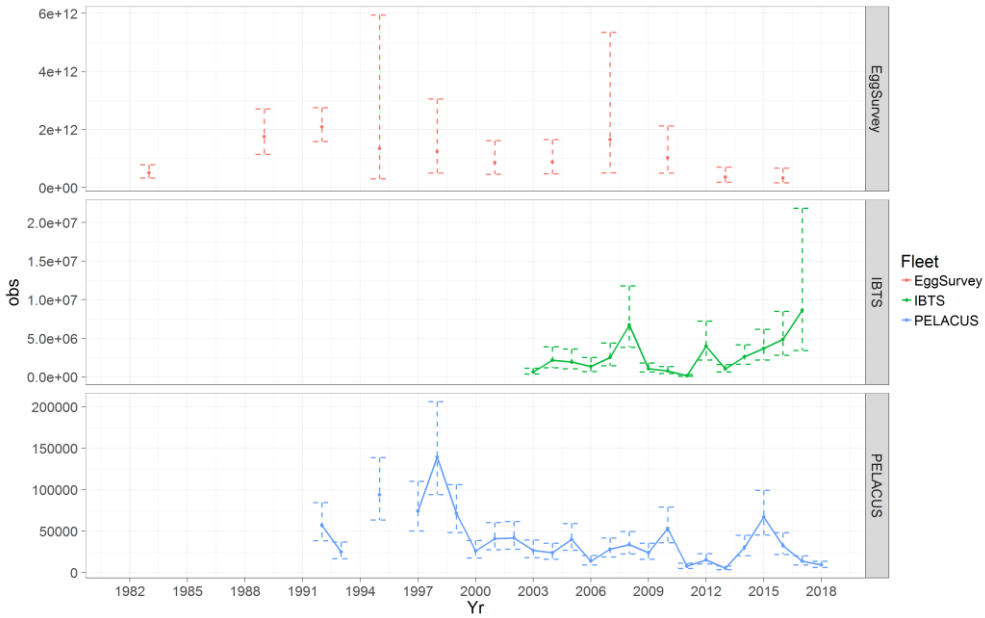

Figure 7.2.2.1: Western horse mackerel. Trend of the fisheries independent indices of abundance used in the assessment of Western Horse mackerel -- Plot on top: Spawning index from egg survey; plot in the middle: recruitment index from IBTS survey; plot at the bottom: biomass estimates from Pelacus acoustic survey. Confidence intervals are shown as well.

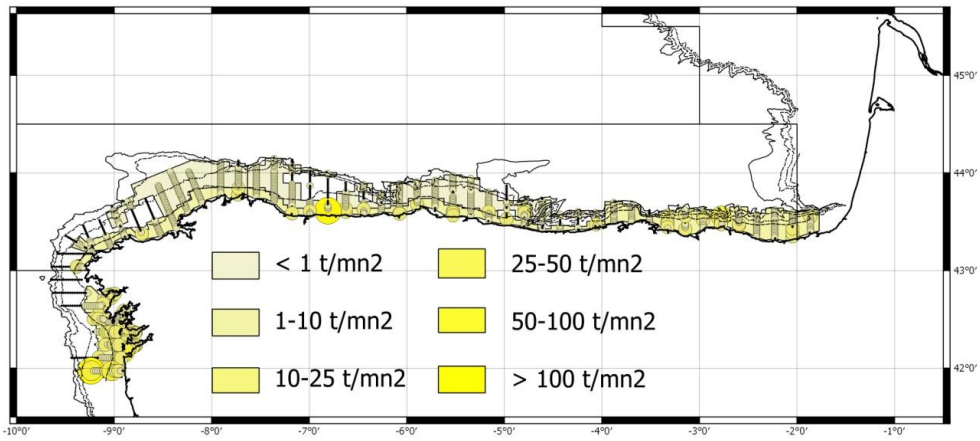

Figure 7.2.2.2: Western horse mackerel. spatial distribution estimated during PELACUS 0318 in the Cantabrian Sea (NASC values and density -biomass expressed as tonnes per square nautical mile)

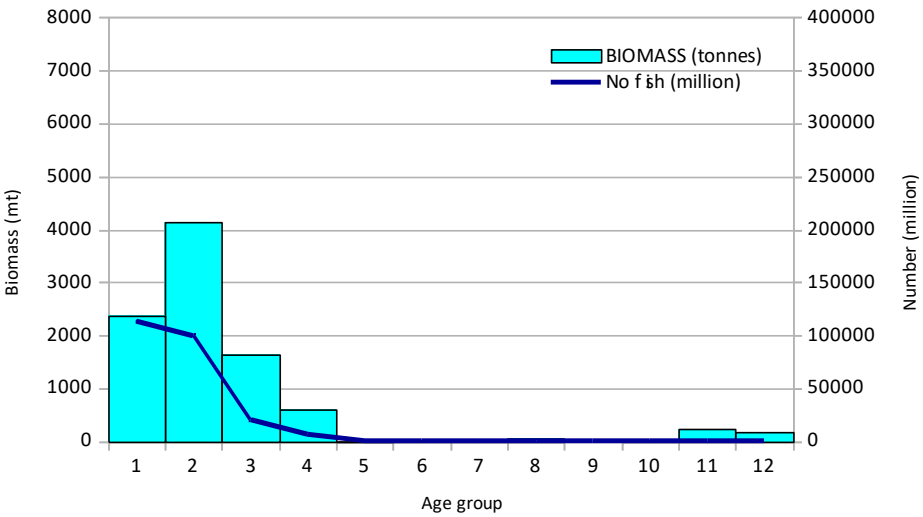

Figure 7.2.2.3: Western horse mackerel abundance and biomass estimates by age group during PELACUS 0318.

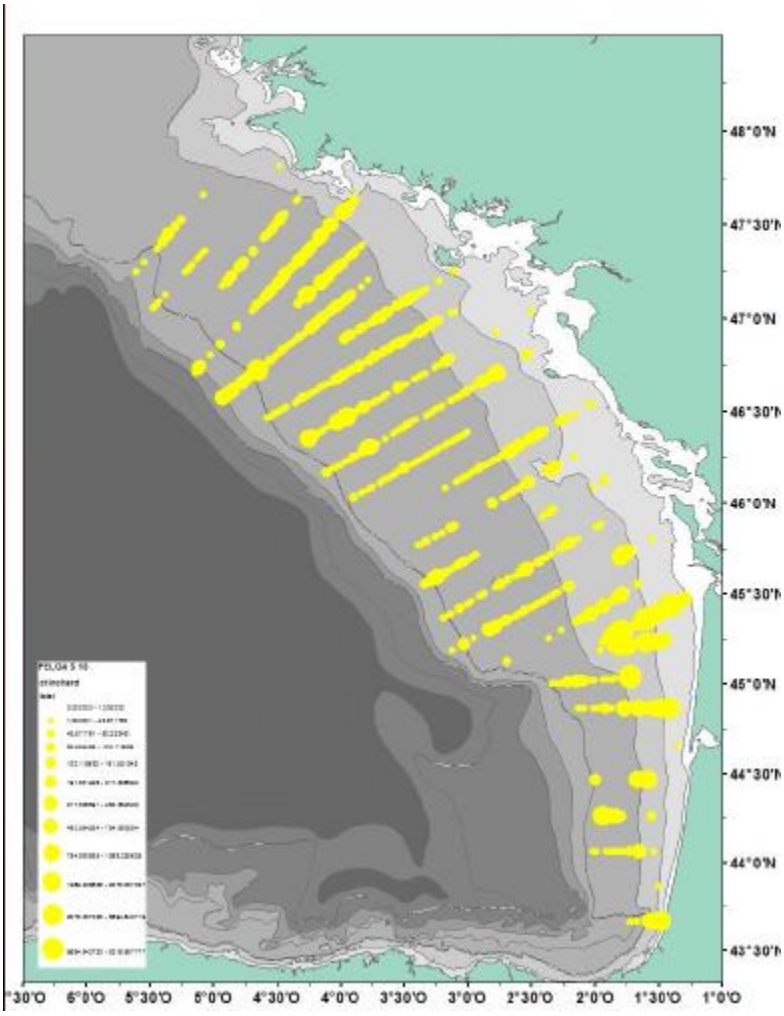

Figure 7.2.2.4: Western horse mackerel. Spatial distribution estimated during PELGAS 2018 (NASC values)

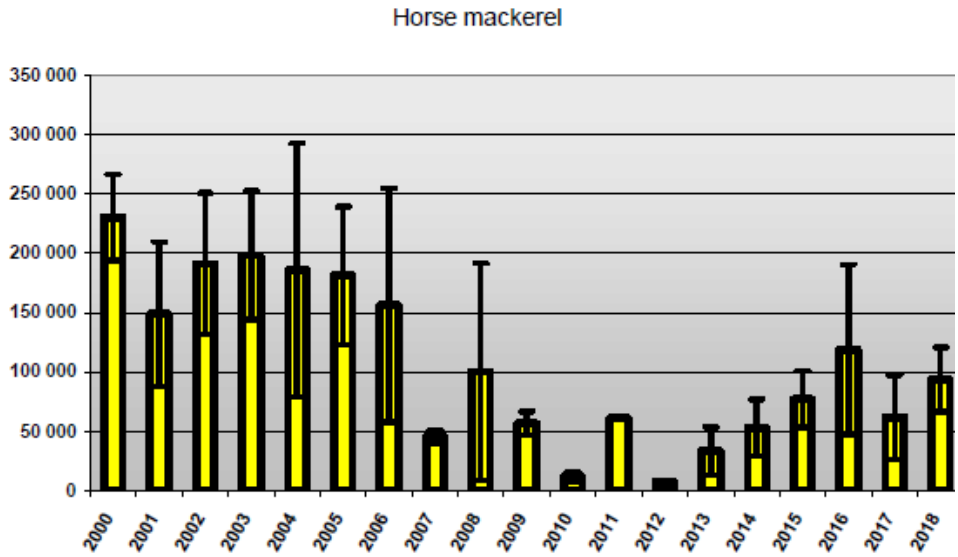

Figure 7.2.2.5: Western horse mackerel biomass estimates (2000-18) during PELGAS

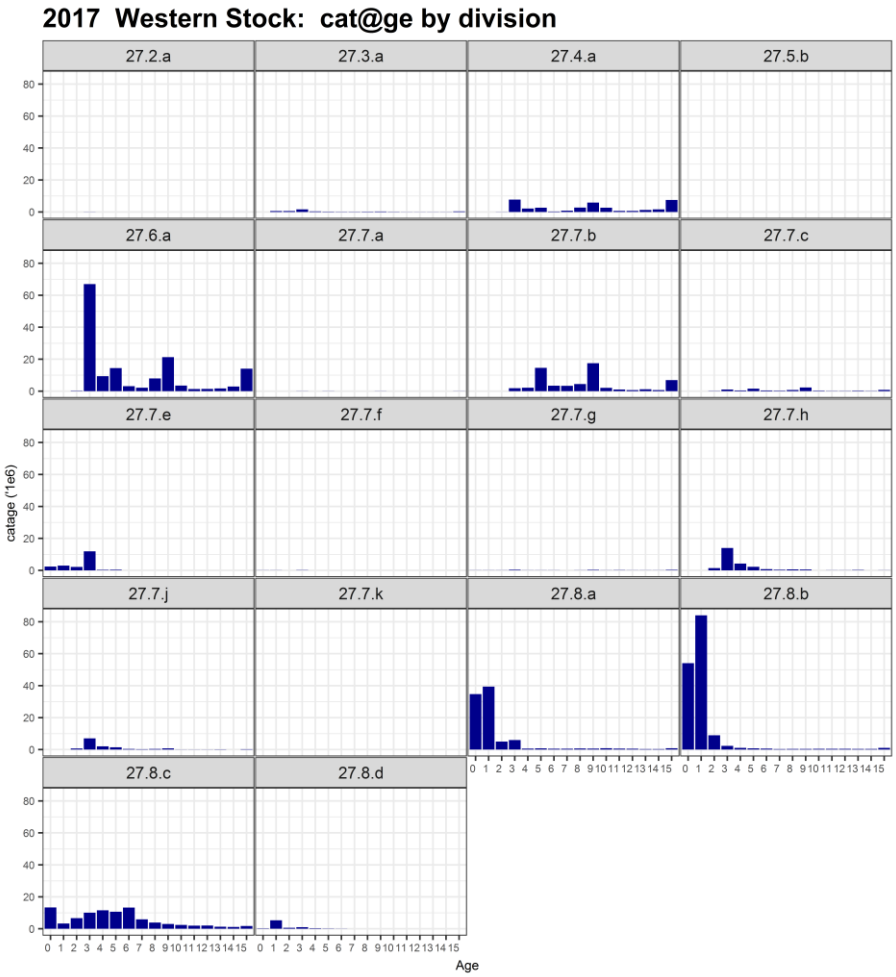

Figure 7.2.4.1: Western horse mackerel.. Catch-at-age matrix by division in 2017, expressed as numbers (millions)

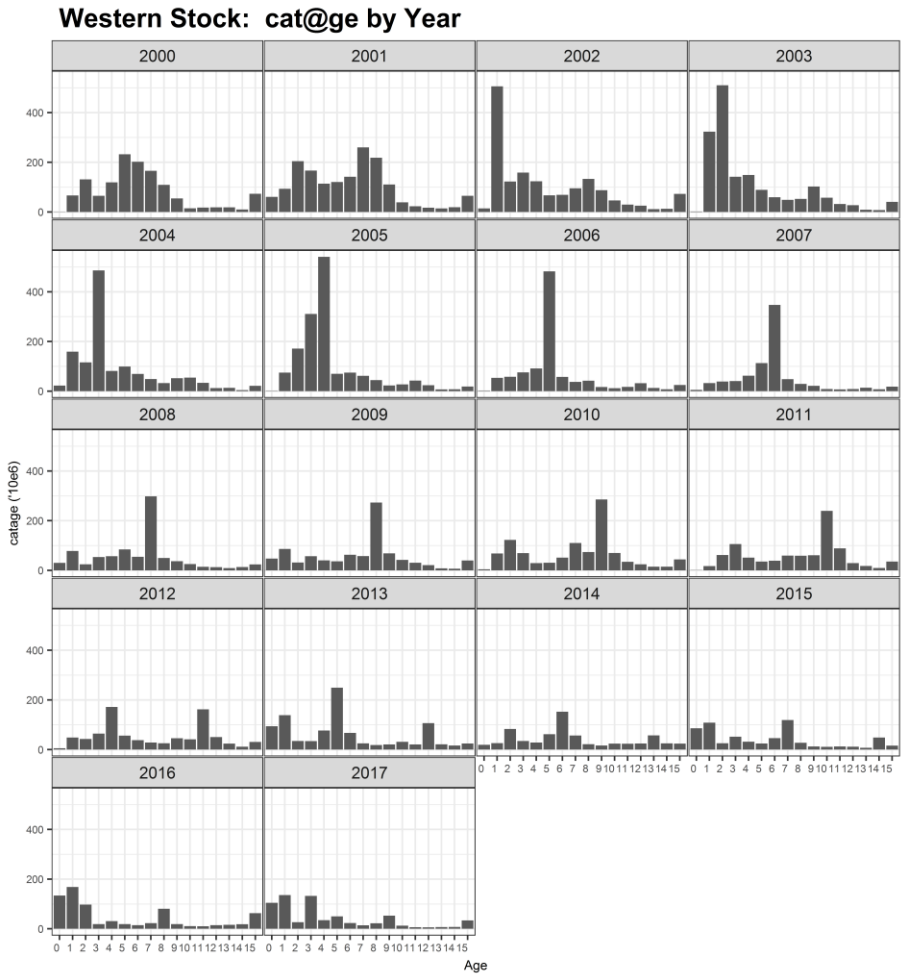

Figure 7.2.4.2: Western horse mackerel.. Catch-at-age matrix by year, expressed as numbers (millions).

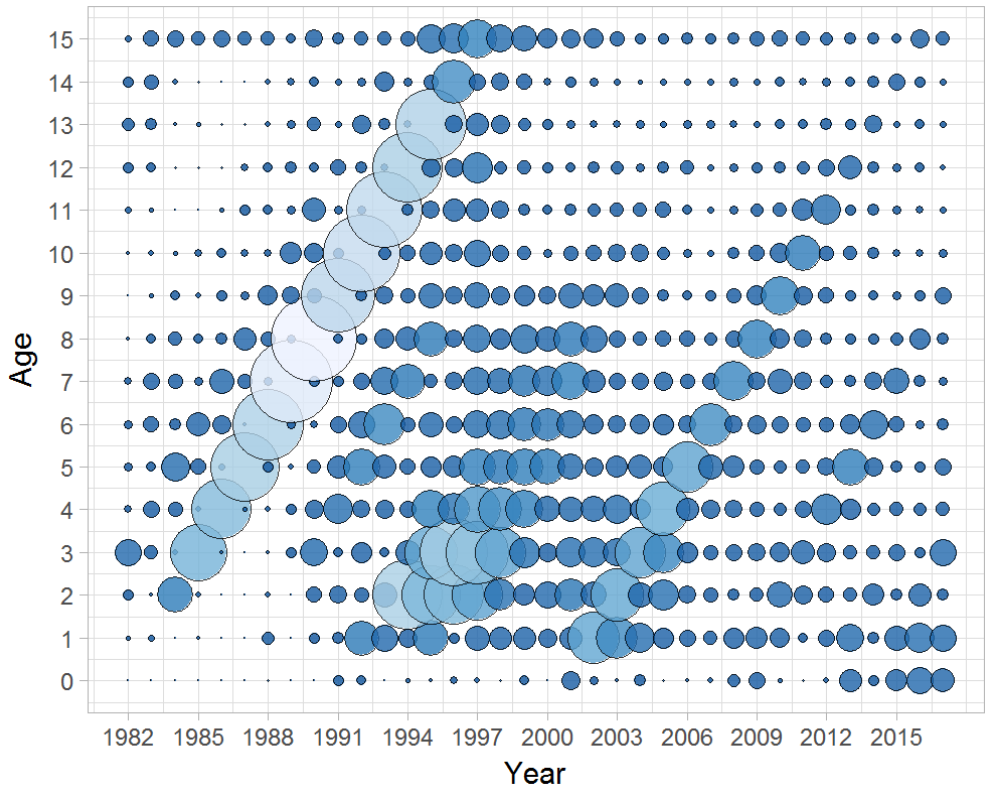

Figure 7.2.4.1: Western horse mackerel. Catch-at-age matrix, expressed as numbers (thousands). The area of bubbles is proportional to the catch number. Note that age 15 is a plus group.

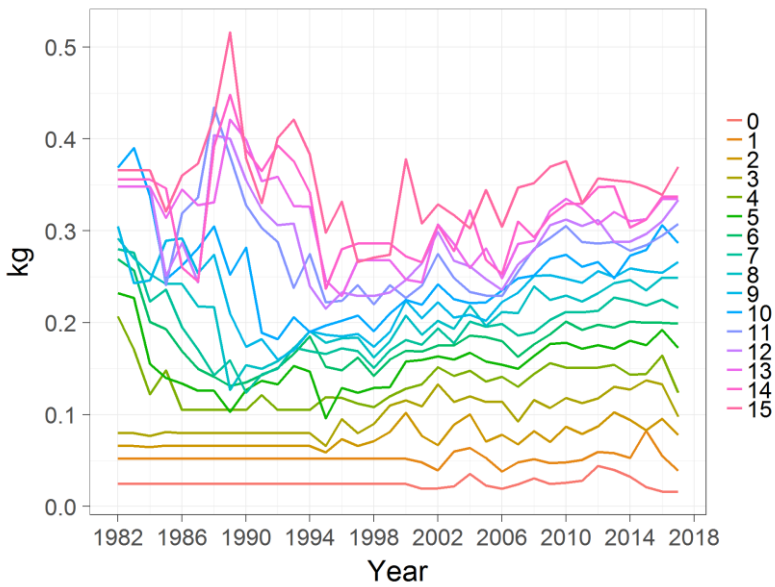

Figure 7.2.5.1: Western horse mackerel. Weight at age in the catch (kg) by year.

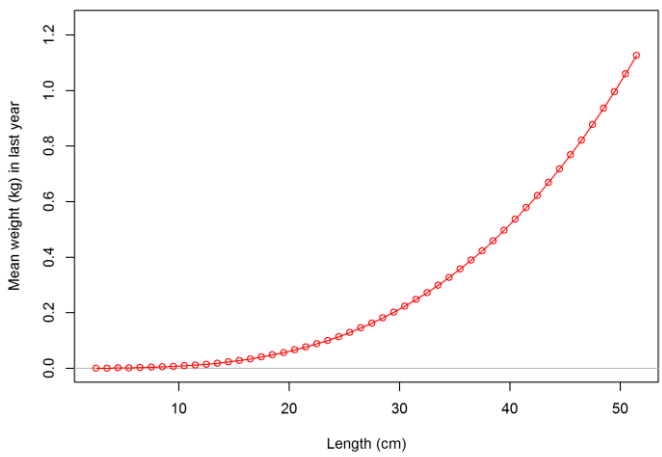

Figure 7.2.5.2: Western horse mackerel. Weight at length in the stock (kg) as estimated by SS.

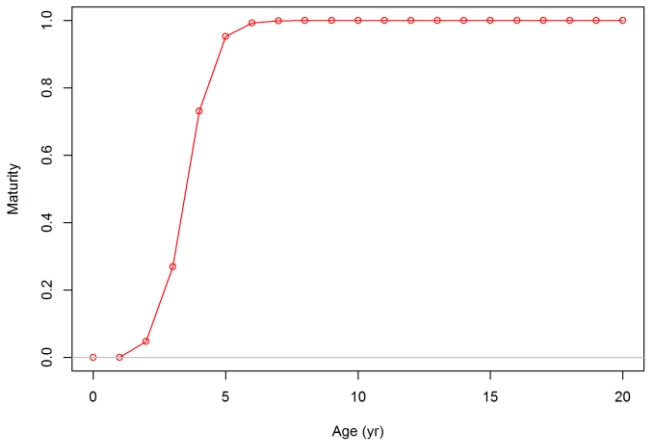

Figure 7.2.6.1: Western horse mackerel. Maturity-at-age as used in the assessment model.

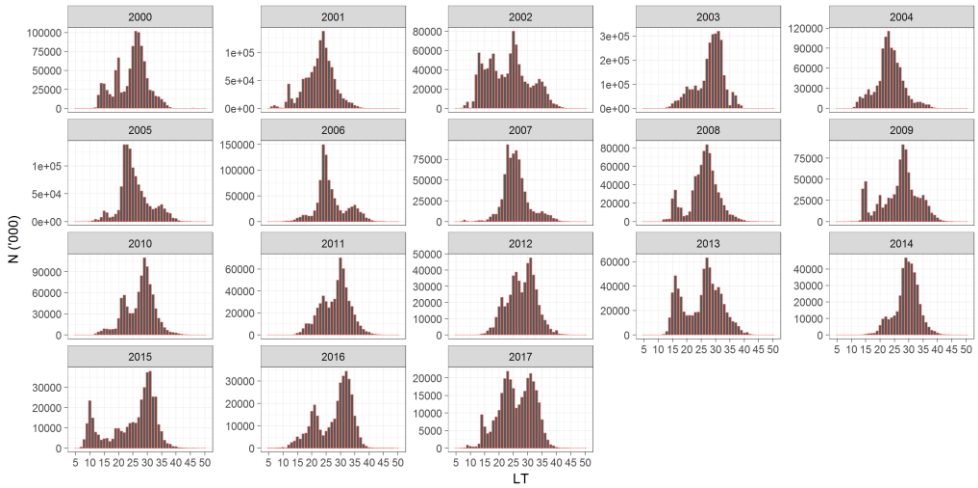

Figure 7.2.10.1: Western horse mackerel. Length frequency distribution of the catch data as used in the assessment model.

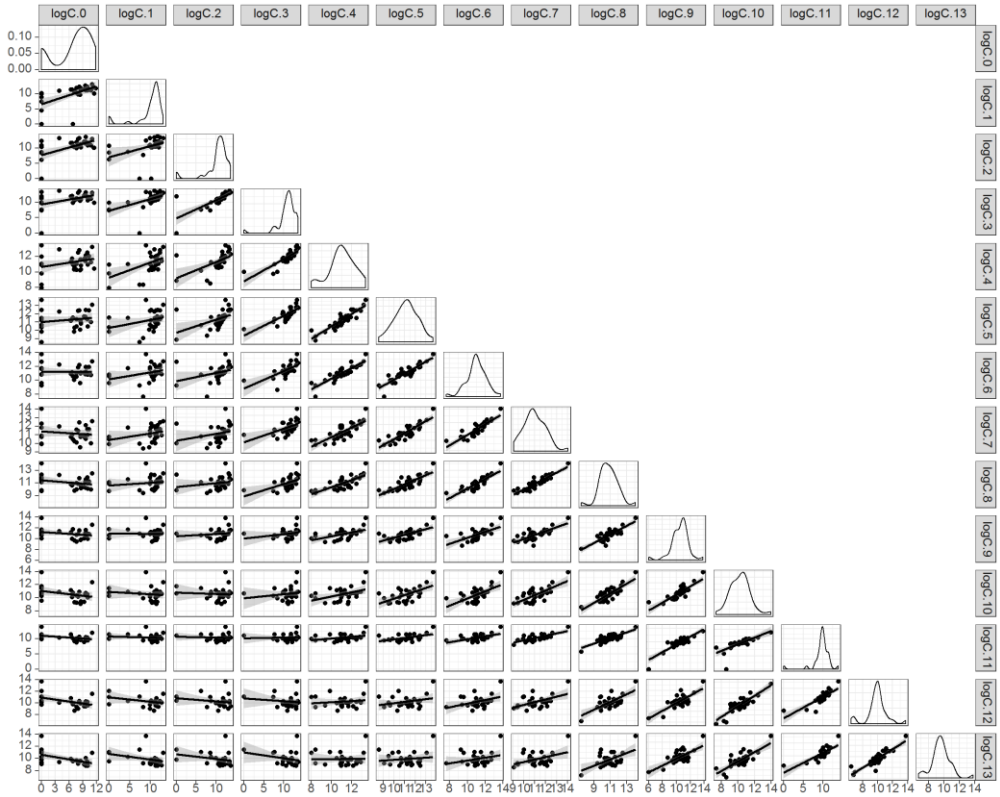

Figure 7.2.10.2: Western horse mackerel. Within-cohort consistency in the catch-at-age matrix, shown by plotting the log-catch of a cohort at a particular age against the log-catch of the same cohort at subsequent ages. Thick lines represent a significant (p<0.05) regression and the curved lines are approximate 95% confidence intervals.

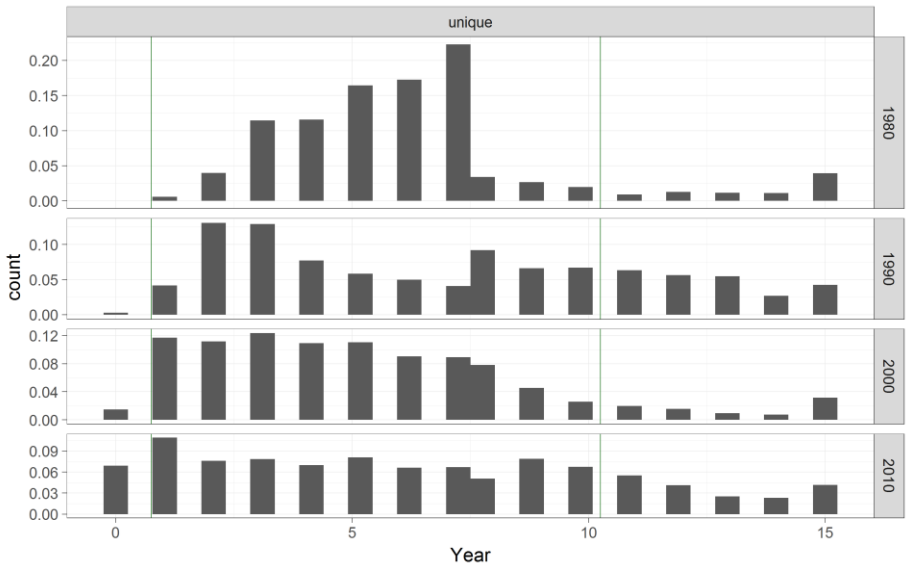

Figure 7.2.10.3: Western horse mackerel. Catch numbers at age composition by decade.

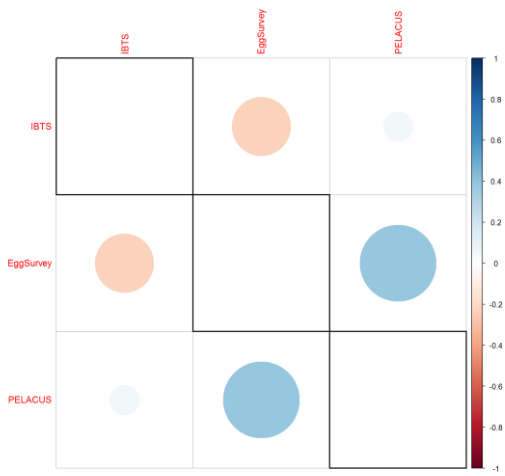

Figure 7.2.10.4: Western horse mackerel. Data exploration. Correlation plot between indices of abundance.

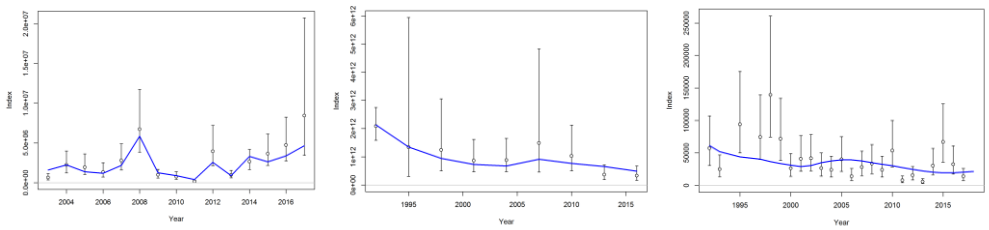

Figure 7.2.11.1: Western horse mackerel. Model fitting. Fitting of the model to the fisheries independent indices.

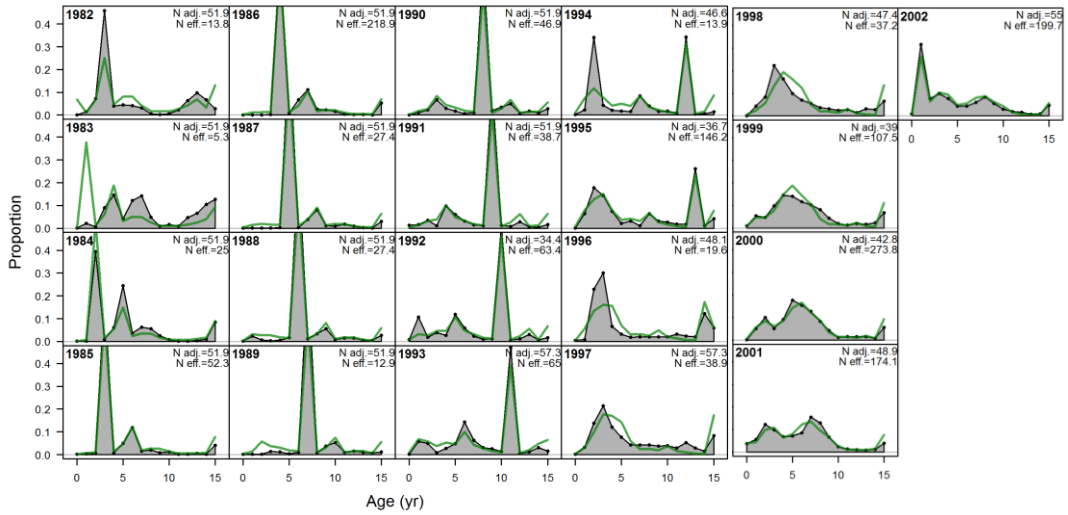

Figure 7.2.11.1: Western horse mackerel. Model fitting. Fitting of the model to the catch-at-age matrix from 1982 to 2002.

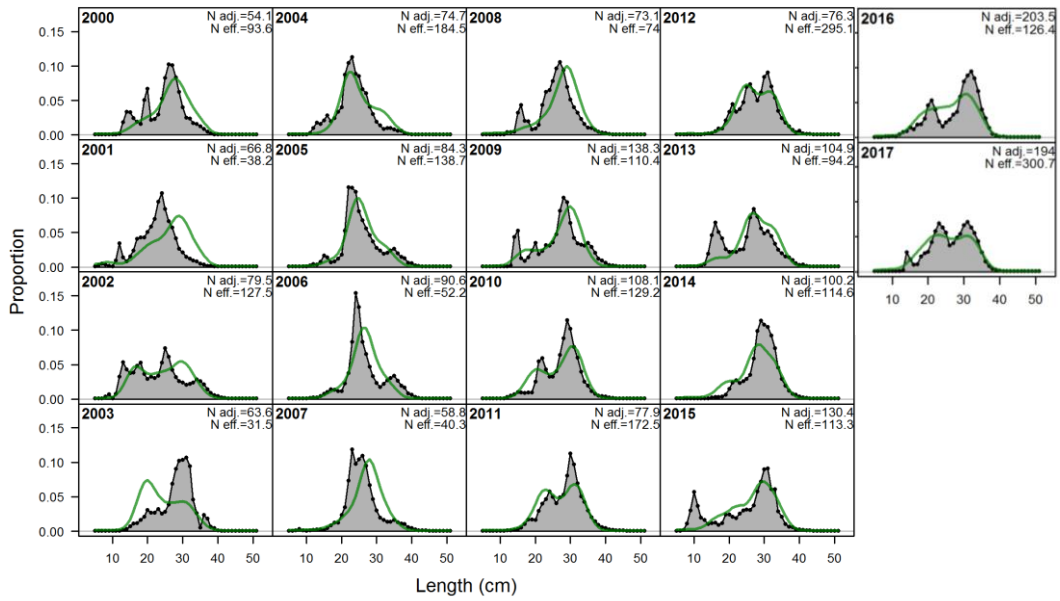

Figure 7.2.11.1 (cont'd): Western horse mackerel. Model fitting. Fitting of the model to the length compostion of the catch data from 2002 to 2017.

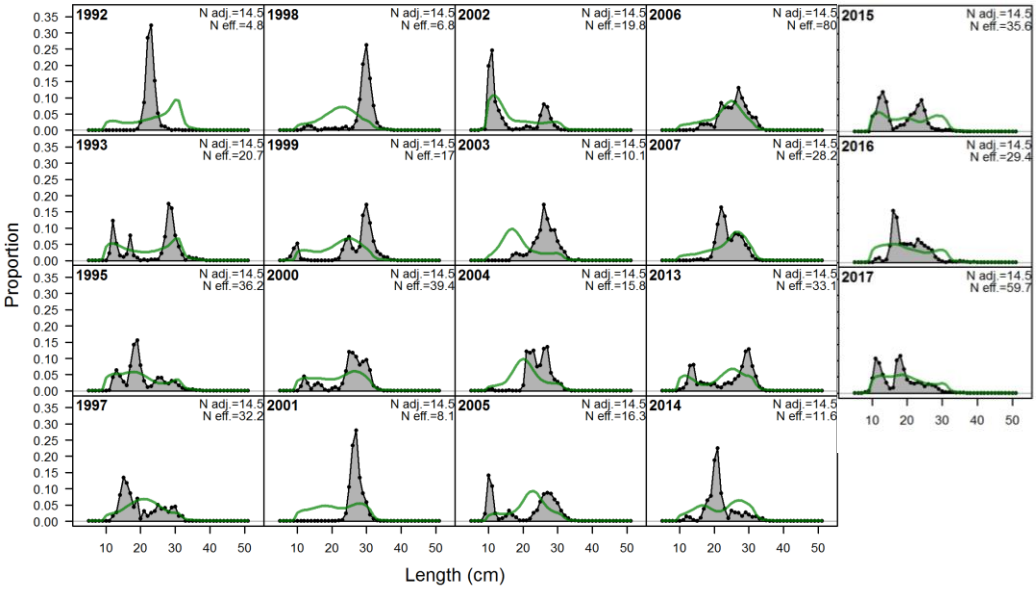

Figure 7.2.11.1 (cont'd): Western horse mackerel. Model fitting. Fitting of the model to the length composition of the acoustic survey.

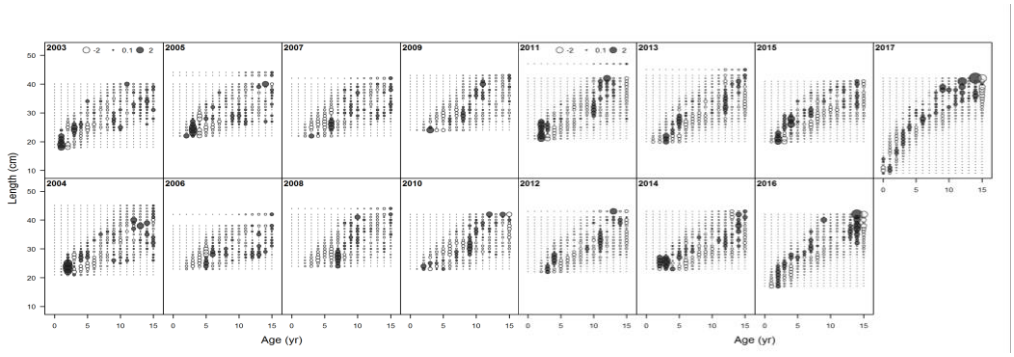

Figure 7.2.11.1 (cont'd): Western horse mackerel. Model fitting. Fitting of the model to the Age length comp of the catch.

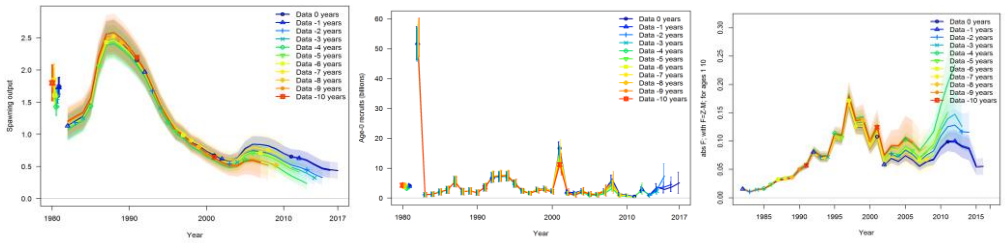

Figure 7.2.11.2: Western horse mackerel. Retrospective analysis. 10 years of retrospective analysis for SSB (left), Recruitment (middle), and F (right).

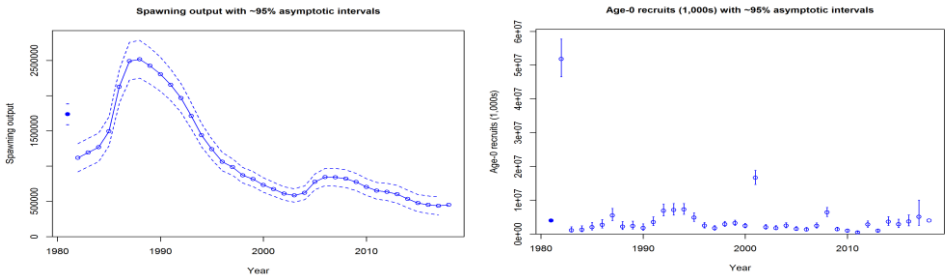

Figure 7.3.1.1: Western horse mackerel. Model results. Spawning-stock biomass (0.5 of the overall SSB only is shown; plot on the left) and recruitment estimates (plot on the right) from the assessment model from 1982 to 2017. 95% CI are shown as well.

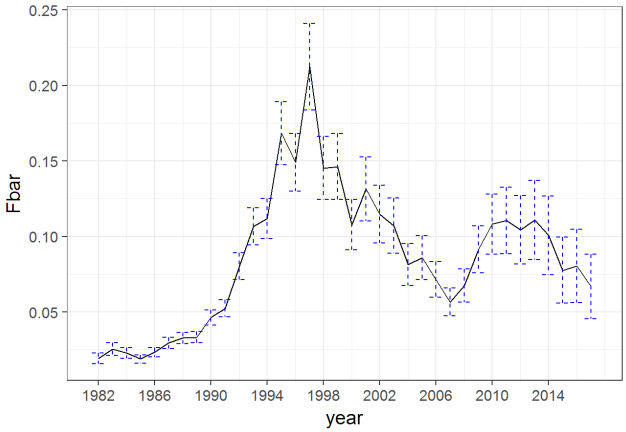

Figure 7.2.11.2: Western horse mackerel. Model results. Fishing mortality estimates (F_{bar} ages 1-10) from the assessment model from 1982 to 2017. 95% CI intervals are shown as well.

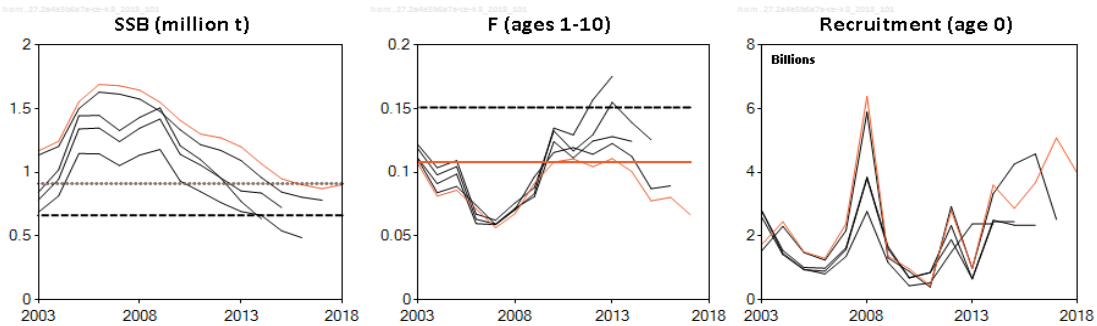

Figure 7.2.11.3: Western horse mackerel. Model results. Historical assessment results. Note: since the 2017 assessment, SSB is estimated on 1st of January. Prior to 2017 SSB has been estimated in May (spawning time).

8 Northeast Atlantic Mackerel

8.1 ICES Advice and International Management Applicable to 2017

From 2001 to 2007 the internationally agreed TACs covered most of the distribution area of the Northeast Atlantic mackerel. From 2008 to 2014, no agreement has been reached among the Coastal States on the sharing of the mackerel quotas. In 2014, three of the Coastal States agreed on a Management Strategy for 2015 and the subsequent five years. However, the total declared quotas for 2015 to 2018 all exceed the TAC advised by ICES. An overview of the declared quotas and transfers for 2018, as available to WGWIDE, is given in the text table below. Total removals of mackerel are expected to be approximately 1 000 559 t in 2018, exceeding the ICES advice for 2018 by about 450 000 t, and the agreed TAC by the three Coastal States (EU, NO and FO) and when employing the -20% interannual TAC stabiliser in the management rule by about 184 000 t.

Estimation of 2018 catch	Tonnes	Reference
EU quota	404 815	European Council Regulation 2018/120
Norwegian quota	183 857	Directorate of Fisheries in Norway
Inter-annual quota transfer 2017->2018 (NO)	-8 621	Directorate of Fisheries in Norway
Russian quota	109 415	NEAFC HOD 18/18
Discards	2 832	Previous years estimate
Icelandic quota	134 772	Icelandic regulation No. 351/2018
Faroese quota	102 924	Faroese regulation No. 1/2018
Inter-annual quota transfer 2017->2018 (FO)	4 200	Faroese regulation No. 1/2018
Greenland quota	66 365	Ministry of Fisheries, Hunting and Agriculture in Greenland
Total expected catch (incl. discard) [1,2]	1 000 559	

[1] No guesstimates of banking from 2018 to 2019

[2] Quotas refer to claims by each party for 2018

The quota figures and transfers in the text table above were based on various national regulations, official press releases, and discard estimates.

Various international and national measures to protect mackerel are in operation throughout the mackerel catching countries. Refer to Table 8.2.4.1 for an overview.

Since the mid-1970s, ICES has continuously recommended conservation measures for the North Sea component of the Northeast Atlantic mackerel stock (e.g. ICES, 1974; ICES, 1981). The recommended closure of Division 4.a for fishing during the first half of the year is based on the perception that the western mackerel enter the North Sea in July/August, and remain there until December before migrating to their spawning areas. Updated observations from the late 1990s suggested that this return migration actually started in mid- to late February (Jansen *et al.*, 2012). The EU TAC regulations stated that within the limits of the quota for the western component (ICES Subareas and Divisions 6, 7, 8.a,b,d,e, 5.b (EU), 2.a (non-EU), 12, 14), a certain quantity of this stock may be caught in Division 4.a during the periods 1 January to 15 February and 1 September to 31 December. Up to 2010, 30% of the Western EU TAC of mackerel (MAC/2CX14-) could be taken in Division 4.a. From 2011 onwards, this percentage has been set at 40% and from 2015 at 60%.

8.2 The Fishery

8.2.1 Fleet Composition in 2017

A description of the fleets operated by the major mackerel catching nations is given in Table 8.2.1.

The total fleet can be considered to consist of the following components:

Freezer trawlers. These are commonly large vessels (up to 150 m) that usually operate a single mid-water pelagic trawl, although smaller vessels may also work as pair trawlers. These vessels are at sea for several weeks and sort and process the catch on board, storing the mackerel in frozen 20 kg blocks. The Dutch, German and the majority of the French and English fleets consist of these vessels which are owned and operated by a small number of Dutch companies. They fish in the North Sea, west of the UK and Ireland and also in the English Channel and further south along the western coast of France. The Russian summer fishery in Division 2.a is also prosecuted by freezer trawlers and partly the Icelandic fishery in Division 5.a and in some years in 14.b.

Purse seiners. The majority of the Norwegian catch is taken by these vessels, targeting mackerel overwintering close to the Norwegian coastline. The largest vessels (> 20 m) used refrigerated seawater (RSW), storing the catch in tanks containing refrigerated seawater (RSW). Smaller purse seiners use ice to chill their catch which they take on prior to departure. A purse seine fleet is also the most important component of the Spanish fleet. They are numerous and target mackerel early in the year close to the northern Spanish coast. These are dry hold vessels, chilling the catch with ice. Denmark also has a purse seine fleet operating in the northern North Sea.

Pelagic trawlers. These vessels vary in size from 20—100 m and operate both individually and as pairs. The largest of the pelagic trawlers use RSW tanks for storage. Iceland, Greenland, Faroes, Scotland and Ireland fish mackerel using pelagic trawlers. Scottish and Icelandic vessels mostly operate singly whereas Ireland and Faroes vessels tend to use pair trawls. Spain also has a significant trawler fleet which target mackerel with a demersal trawl in Subarea 8 and Division 9.a.N.

Lines and jigging. Norway and England have handline fleets operating inshore in the Skagerrak (Norway) and in Divisions 7.e/f (England) around the coast of Cornwall, where other fishing methods are not permitted. Spain also has a large artisanal handline fleet as do France and Portugal. A small proportion of the total catch reported by Scotland (Divisions 4.a and 4.b) and Iceland (Division 5.a) is taken by a handline fleet.

Gillnets. Gillnet fleets are operated by Norway and Spain.

8.2.2 Fleet Behaviour in 2017

The most important changes in recent years are related to the geographical expansion of the northern summer fishery (Subareas 2, 5 and 14) and changes in southern waters due to stricter TAC compliance by Spanish authorities. Fishing in the North Sea and west of the British Isles followed a traditional pattern, targeting mackerel on their spawning migration from the Norwegian deep in the northern North Sea, westwards around the north coast of Scotland and down the west coast of Scotland and Ireland.

The Russian freezer trawler fleet operates over a wide area in northern waters. This fleet targets herring and blue whiting in addition to mackerel. In the third quarter of 2017 the Russian vessels took all their catch in Division 2.a.

Total catches from Icelandic vessels were similar to those in recent years with the majority of the catch taken in Division 5.a in waters south and south-east of Iceland. Catches were also taken to the east and west of Iceland. In 2017, Iceland and Greenland targeted mackerel in Division 14.b, with 3% of the total catch coming from this area. Catches from Greenland have increased in 2017 to 46 kt from 30 kt in 2016 but are still lower than the 87 kt caught in 2014 which was the biggest catch by this fleet to date.

Concerning the Spanish fisheries, no new regulations have been implemented since 2010 when a new control regime was enforced. Fishery has started as in previous years at the beginning of March, although the southern spawning component was already concentrated at their spawning grounds as earlier as February.

8.2.3 Recent Changes in Fishing Technology and Fishing Patterns

Northeast Atlantic mackerel, as a widely distributed species, is targeted by a number of different fishing métiers. Most of the fishing patterns of these métiers have remained unchanged during the most recent years, although the timing of the spawning migration and geographical distribution can change from year to year and this affects the fishery in various areas.

Recent changes are notable for two areas and métiers in particular:

In 2010, the Faroese fleet switched from purse-seining in Norwegian and EU waters to pair trawling in the Faroese area. The Faroese fleet used to catch their mackerel quota in Divisions 4.a and 6.a during September-October with purse-seiners. However, as no agreement has been reached between the Coastal States since 2009, the mackerel quota has been taken in Faroese waters during June-October by the same fleet using pair trawls. The mackerel distribution is more scattered during summer and pair trawls seem to be effective in such circumstances. However, since the agreement between the three of the Coastal States for the fisheries in 2015, parts of the Faroese quota will now again be taken with purse-seines in Divisions 5.a and 6.a. In recent years, up to 25% of the Faroese quota have been granted to smaller, traditionally demersal trawlers using pair trawls.

Also targeting summer feeding mackerel, Icelandic vessels have increased effort and catch dramatically in recent years from 4 kt in 2006 to an average 160 kt annually since 2011. This fishery operates over a wide area E, NE, SE, S and SW off Iceland. Since 2011, there has been less fishing activity to the north and north-east and an increase in catches taken south and west of Iceland. Greenland has reported catches from Division 14.b since 2011.

In Spain part of the purse seiner fleet is using hand lines instead of nets. Although, neither the number of vessels and its evolution nor the reason for such change were deeply analysed, it seems market reasons are driving this shift.

8.2.4 Regulations and their Effects

An overview of the major existing technical measures, effort controls and management plans are given in Table 8.2.4.1. Note that there may be additional existing international and national regulations that are not listed here.

Between 2010 and 2016 no overarching Coastal States Agreement/NEAFC Agreement was in place and no overall international regulation on catch limitation was in force. Currently there is no agreement on a management strategy covering all parties fishing mackerel. In 2014, three of the Coastal States (The EU, Faroes and Norway) agreed on

a Management Strategy for 2015 and the subsequent five years. However, the total declared quotas taken by all parties since 2015 have greatly exceeded the TAC advised by ICES (see Section 8.1).

Management aimed at a fishing mortality in the range of 0.15—0.20 in the period 1998—2008. The current management plan aims at a fishing mortality in the range 0.20—0.22. The fishing mortality realised during 1998—2008 was in the range of 0.27 to 0.46. Implementation of the management plan resulted in a reduced fishing mortality and increased biomass. Since 2008 catches have greatly exceeded those given by the plan.

The measures advised by ICES to protect the North Sea spawning component aim at setting the conditions for making a recovery of this component possible. Before the late 1960s, the North Sea spawning biomass of mackerel was estimated at above 3 million tonnes. The collapse of mackerel in the North Sea in the late 1960s was most likely driven by very high catches and associated fishing mortality. However, the lack of recovery of mackerel in the North Sea was probably associated with unfavourable environmental conditions, particularly reduced temperatures (unfavourable for spawning), lower zoo-plankton availability in the North Sea and increased wind-stress induced turbulence. These unfavourable environmental conditions probably led the mackerel to spawn in western waters instead of in the North Sea.

A review of the mackerel in the North Sea, carried out during WKWIDE 2017 (ICES, 2017a) concluded that Northeast Atlantic mackerel should be considered as a single population (stock) with individuals that show stronger or weaker affinity for spawning in certain parts of the spawning area. Management should ensure that fisheries do not decrease genetic and behavioural diversity, since this could reduce future production. Protection of mackerel that tend to spawn in the north-eastern parts of the spawning area is therefore still advisable to some extent.

In the southern area, a Spanish national regulation affecting mackerel catches of Spanish fisheries has been implemented since 2010. In 2015, fishing opportunity was distributed by region and gear and for the bottom trawl fleet, by individual vessel. This year, Spanish mackerel fishing opportunity in Divisions 8.c and 9.a was established at 39 674 t resulting from the quota established (Commission Regulation (EU) No 104/2015. This was reduced by 9 797 t due to the scheduling payback quota due to overfishing of the mackerel quota allocated to Spain in 2010 (Commission Regulation No 976/2012).

Within the area of the southwest Mackerel Box off Cornwall in southern England only handliners are permitted to target mackerel. This area was set up at a time of high fishing effort in the area in 1981 by Council Regulation to protect juvenile mackerel, as the area is a well-known nursery. The area of the box was extended to its present size in 1989.

Additionally, there are various other national measures in operation in some of the mackerel catching countries.

The first phase of a landing obligation came into force in 2015 for all EU vessels in pelagic and industrial fisheries. All species that are managed through TACs and quotas must be landed under the obligation unless there is a specific exemption such as *de minimis*. There are no *de minimis* exemptions for mackerel.

8.3 Quality and Adequacy of sampling Data from Commercial Fishery

The sampling of the commercial catch of North East Atlantic (NEA) mackerel is summarised below:

Year	WG Total Catch (t)	% catch covered by sampling programme*	No. Samples	No. Measured	No. Aged
1992	760000	85	920	77000	11800
1993	825000	83	890	80411	12922
1994	822000	80	807	72541	13360
1995	755000	85	1008	102383	14481
1996	563600	79	1492	171830	14130
1997	569600	83	1067	138845	16355
1998	666700	80	1252	130011	19371
1999	608928	86	1109	116978	17432
2000	667158	76	1182	122769	15923
2001	677708	83	1419	142517	19824
2002	717882	87	1450	184101	26146
2003	617330	80	1212	148501	19779
2004	611461	79	1380	177812	24173
2005	543486	83	1229	164593	20217
2006	472652	85	1604	183767	23467
2007	579379	87	1267	139789	21791
2008	611063	88	1234	141425	24350
2009	734889	87	1231	139867	28722
2010	869451	91	1241	124695	29462
2011	938819	88	923	97818	22817
2012	894684	89	1216	135610	38365
2013	933165	89	1092	115870	25178
2014	1394454	90	1506	117250	43475
2015	1208990	88	2132	137871	24283
2016	1094066	89	2200	149216	21456
2017	1155944	87	2183	151548	24104

Overall sampling effort in 2017 was similar to previous years with 87% of the catch sampled. It should be noted that this proportion is based on the total sampled catch. Nations with large, directed fisheries are capable of sampling 100% of their catch which may conceal deficiencies in sampling elsewhere.

The 2017 sampling levels for countries with a WG catch of greater than 100 t are shown below.

Country	Official Catch (t)	% WG catch covered by sampling programme	No. Samples	No. Measured	No. Aged
Belgium	128	0%	0	0	0
Denmark	40080	93%	3	214	214
Faroe Islands	99667	85%	14	750	712
France	23800	0%	0	0	0
Germany	24832	33%	63	13562	819
Greenland	46388	79%	15	2395	125
Iceland	167366	99%	107	4209	2431
Ireland	84915	98%	44	7751	1587
Netherlands	43766	60%	33	2174	825
Norway	222356	96%	73	2126	2126
Portugal	634	100%	136	6735	766
Russia	138061	98%	175	54185	1503
Spain	22172	100%	920	15367	7295
UK (England & Wales)	26463	3%	74	6054	3578
UK (Northern Ireland)	16888	0%	0	0	0
UK (Scotland)	182528	97%	38	4505	1081

The majority of countries achieved a high level of sampling coverage. Belgian catches are by-catch in the demersal fisheries in the North Sea. France supplied a quantity of length-frequency data to the working group which can be utilised to characterise the selection of the fleet but requires an allocation of catch at age proportions from another sampled fleet in order to raise the data for use in the assessment. England only samples landings from the handline fleet operating off the Cornish coast, representing only a small proportion of the national catch, the remainder reported from freezer trawlers. Cooperation between the Dutch and German sampling programmes (which sampled 60% and 33% respectively) is designed to provide complete coverage for the freezer trawlers operating under these national flags and also those of England and France. There is however, an absence of sampling from ICES Division 4.a in quarter 4 for this fleet with landings of 37 kt. Northern Ireland, with a WG catch of 17 kt did not provide any sampling information. Catch sampling levels per ICES Division (for those with a WG catch of >100 t) are shown below.

Division	Official Catch (t)	WG Catch (t)	No. Samples	No. Measured/ per kt	No. Aged/per kt
2.a	465355	465355	287	57988/126	4714/10
3.a	686	686	0	0/0	0/0
4.a	263825	263825	87	9200/35	2338/9
4.b	4723	4723	1	87/18	25/5
4.c	532	532	0	0/0	0/0
5.a	87734	87734	66	2794/32	1510/17
5.b	11344	11344	1	165/15	122/11
6.a	226056	226056	90	16804/74	2091/9
7.b	6421	6421	22	2306/359	435/68
7.d	6082	6082	0	0	0
7.e	956	956	38	2213/2314	2074/2169
7.f	679	679	36	3841/5657	1504/2215
7.j	1817	1817	160	366/201	3/2
8.a	2150	2150	0	0	0
8.b	4854	4854	45	1866/388	4164/116
8.c	31059	31059	362	26719/860	
9.a	777	777	345	7106/9145	1582/2036
9.a.N	1206	1206	67	3613/2995	753/624
14.a	174	174	0	0	0
14.b	39263	39263	18	2489/63	194/5

In general, areas with insufficient sampling have relatively low levels of catch. The exception is Division 7.d from which 6 kt (mainly French) was caught which was not sampled. The number of age samples in southern fleets is disaggregated by area (included in Division 8.c total)

8.4 Catch Data

8.4.1 ICES Catch Estimates

The total ICES estimated catch for 2017 was 1 155 944 t, an increase of 61 878 t on the estimated catch in 2016. Catches increased substantially from 2006—2010 and have averaged 1 089 kt since from 2011.

The combined 2017 TAC, arising from agreements and autonomous quotas, amounts to 1 194 000 t). The ICES catch estimate (1 155 944 t) represents a slight undershoot of this. The combined fishable TAC for 2018, as best ascertained by the Working Group (see Section 8.1), amounts to 1 000 559 t.

Catches reported for 2017 and in previous Working Group reports are considered to be best estimates. In most cases, catch information comes from official logbook records. Other sources of information include catch processors. Some countries provide information on discards and slipped catch from observer programs, logbooks and compliance reports. In several countries discarding is illegal. Spanish data is based on the official data supplied by the Fisheries General Secretary (SGP) but supplemented by scientific estimates which are recorded as unallocated catch in the ICES estimates.

The text table below gives a brief overview of the basis for the ICES catch estimates.

Country	Official Log Book	Other Sources	Discard Information
Denmark	Y (landings)	Y (sale slips)	Y
Faroe[1]	Y (catches)	Y (coast guard)	NA
France	Y (landings)		Y
Germany	Y (landings)		Y
Greenland	Y (catches)	Y (sale slips)	Y
Iceland[1]	Y (landings)		NA
Ireland	Y (landings)		Y
Netherlands	Y (landings)	Y	Y
Norway[1]	Y (catches)		NA
Portugal		Y (sale slips)	Y
Russia[1]	Y (catches)		NA
Spain	Y	Y	Y
Sweden	Y (landings)		N
UK	Y (landings)	Y	Y

[1]For these nations a discarding ban is in place such that official landings are considered to be equal to catches.

The Working Group considers that the estimates of catch are likely to be an underestimate for the following reasons:

- Estimates of discarding or slipping are either not available or incomplete for most countries. Anecdotal evidence suggests that discarding and slipping can occur for a number of reasons including high-grading (larger fish attract a premium price), lack of quota, storage or processing capacity and when mackerel is taken as by-catch.
- Confidential information suggests substantial under-reported landings for which numerical information is not available for most countries. Recent work has indicated considerable uncertainty in true catch figures (Simmonds *et al.,* 2010) for the period studied.
- Estimates of the magnitude and precision of unaccounted mortality suggests that, on average for the period prior up to 2007, total catch related removals were equivalent to 1.7 to 3.6 times the reported catch (Simmonds *et al.,* 2010).
- Reliance on logbook data from EU countries implies (even with 100% compliance) a precision of recorded landings of 89% from 2004 and 82% previous to this (Council Regulation (EC) Nos. 2807/83 & 2287/2003). Given that over reporting of mackerel landings is unlikely for economic reasons; the WG considers that the reported landings may be an underestimate of up to 18% (11% from 2004), based on logbook figures. Where inspections were not carried out there is a possibility of a 56% under reporting, without there being an obvious illegal record in the logsheets. Without information on the percentage of the landings inspected it is not possible for the Working Group to evaluate the underestimate in its figures due to this technicality. EU landings represent about 65% of the total estimated NEA mackerel catch.
- The accuracy of logbooks from countries outside the EU has not been evaluated by WGWIDE. Monitoring of logbook records is the responsibility of the national control and enforcement agencies.

The total catch as estimated by ICES is shown in Table 8.4.1.1. It is broken down by ICES area group and illustrates the development of the fishery since 1969.

Discard Estimates

With a few exceptions, estimates of discards have been provided to the Working Group for the ICES Subareas and Divisions 6, 7/8.a,b,d,e and 3/4 (see Table 8.4.1.1) since 1978. Historical discard estimates were revised during the data compilation exercise undertaken for the 2014 benchmark assessment (ICES, 2014). The Working Group considers the estimates for these areas are incomplete. In 2017, discard data for mackerel were provided by The Netherlands, France, Germany, Ireland, Spain, Portugal, Greenland, Denmark, England, Scotland and Sweden. Total discards amounted to 2 832 t from these nations (mainly Spain and France). The German, Dutch, Irish and Portuguese pelagic discard monitoring programmes did not record any instances of discarding of mackerel. Estimates from the other countries supplying data include results from the sampling of demersal fleets.

Age-disaggregated data was limited but data available indicates that, in Divisions 8.a, 8.b and 8.c the majority of discarded fish were aged 0 to 3. In Division 9.a the majority of the discarded fish were 0 group.

Discarding of small mackerel has historically been a major problem in the mackerel fishery and was largely responsible for the introduction of the south-west mackerel box. In the years prior to 1994, there was evidence of large-scale discarding and slipping of small mackerel in the fisheries in Division 2.a and Sub-area 4, mainly because of the very high prices paid for larger mackerel (> 600 g) for the Japanese market. This factor was put forward as a possible reason for the very low abundance of the 1991 year class in the 1993 catches. Anecdotal evidence from the fleet suggests that since 1994, discarding/slipping has been reduced in these areas.

In some of the horse mackerel directed fisheries, e.g. those in Subareas 6 and 7, mackerel is taken as by-catch. Reports from these fisheries have suggested that discarding may be significant because of the low mackerel quota relative to the high horse mackerel quota, particularly in those fisheries carried out by freezer trawlers in the fourth quarter. The level of discards is greatly influenced by the market price and by quotas.

8.4.2 Distribution of Catches

A significant change in the fishery took place between 2007 and 2009 with a greatly expanded northern fishery becoming established, and maintained to the present. Of the total catch in 2017, Norway accounted for the greatest proportion (19%) followed by Scotland (16%), Iceland (14%), Russia (12%) and Faroe (9%). In the absence of an international agreement, Faroe, Greenland, Iceland and Russia declared unilateral quotas in 2017. Russia and Iceland both had catches over 100 kt with Faroes catching 99 kt. Greenlandic catches accounted for 46 kt of the total. Scotland had catch in excess of 100 kt and Ireland caught almost 86 kt. Germany, Netherlands, Spain, Denmark, France and England had catches of the order of 20—50 kt.

In 2017, catches in the northern areas (Subareas 2, 5, 14) amounted to 603 869 t (see Table 8.4.2.1), an increase of 40 366 t on the 2016 catch. Icelandic, Norwegian and Russian catches were all over 100 kt. Catches from Division 2.a accounted for 40% of the total catch in 2017. All the Russian catch in 2017 was taken in Division 2.a with Greenlandic catches taken further east into Division 2.a than in 2016. The wide geographical distribution of the fishery noted in previous years has continued.

The time series of catches by country from the North Sea, Skagerrak and Kattegat (Subarea 4, Division 3.a) is given in Table 8.4.2.2. Catches in 2017 amounted to 269 804 t, an increase on 2016 (21 193 t). The majority of the catch is from Subarea 4 with small catches were also reported in Divisions 3.a-d.

Catches in the western area (Subareas 6, 7 and Divisions 8.a,b,d and e) increased slightly to 249 229 t with most of the traditional fishing nations catching an increased proportion of their total catch in this area, likely due to the timing of the spawning migration. These catches are detailed in Table 8.4.2.3.

Table 8.4.2.4 details the catches in the southern areas (Divisions 8.c and 9.a) which are taken almost exclusively by Spain and Portugal. The reported catch of 33 042 t represents a decrease from 2016. The catch is close to the long-term average.

The distribution of catches by quarter (%) is described in the text table below:

Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4
1990	28	6	26	40	2004	37	6	28	29
1991	38	5	25	32	2005	46	6	25	23
1992	34	5	24	37	2006	41	5	18	36
1993	29	7	25	39	2007	34	5	21	40
1994	32	6	28	34	2008	34	4	35	27
1995	37	8	27	28	2009	38	11	31	20
1996	37	8	32	23	2010	26	5	54	15
1997	34	11	33	22	2011	22	7	54	17
1998	38	12	24	27	2012	22	6	48	24
1999	36	9	28	27	2013	19	5	52	24
2000	41	4	21	33	2014	20	4	46	30
2001	40	6	23	30	2015	20	5	44	31
2002	37	5	29	28	2016	23	4	44	29
2003	36	5	22	37	2017	24	3	45	28

The quarterly distribution of catch in 2017 is similar to recent years (since 2010) with the northern summer fishery in Q3 accounting for the greatest proportion of the total catch.

Catches per ICES statistical rectangle are shown in Figures 8.4.2.1 to 8.4.2.4. It should be noted that these figures are a combination of official catches and ICES estimates and may not indicate the true location of the catches or represent the location of the entire stock. These data are based on catches reported by all the major catching nations and represents almost the entire ICES estimated catch.

- First quarter 2017 (272 514 t – 24%)

The distribution of catches in the first quarter is shown in Figure 8.4.2.1. The quarter 1 fishery is similar to that in previous years with the Scottish and Irish pelagic fleets targeting mackerel in Divisions 6.a, 7.b and 7.j. Substantial catches are also taken by the Dutch owned freezer trawler fleet. The largest catches were taken in Division 6.a, as in recent years. The Spanish fisheries also take significant catches along the north coast of Spain during the first quarter.

- Second quarter 2017 (39 972 t – 3%)

The distribution of catches in the second quarter is shown in Figure 8.4.2.2. The quarter 2 fishery is traditionally the smallest and this was also the case in 2017. The most significant catches where those in Division 8.c and at the start of the summer fishery in northern waters by Icelandic, Norwegian and Russian fleets.

- Third quarter 2017 (515 346 t – 45%)

Figure 8.4.2.3 shows the distribution of the quarter 3 catches. Large catches were taken throughout Divisions 2.a (Russian, Norwegian vessels), 4.a (Norwegian, Scottish vessels), 5.a (Icelandic vessels). Catch was also taken in Division 14.b in quarter 3.

- Fourth quarter 2017 (328 112 t – 28%)

The fourth quarter distribution of catches is shown in Figure 8.4.2.4. The summer fishery in northern waters has largely finished although there are substantial catches reported in the southern part of Division 2.a. The largest catches are taken by Norway, Scotland and Ireland around the Shetland Isles and along the north coast of Scotland. The pattern of catches is very similar to that reported in recent years.

ICES cannot split the reported mackerel catches into different stock components because there is no clear distinction between components upon which a split could be determined. Mackerel with a preference for spawning in the northeast area, including the North Sea, cannot presently be identified morphometrically or genetically (Jansen and Gislason, 2013). Separation based on time and area of the catch is not a precise way of splitting mackerel with different spawning preferences, because of the mixing and migration dynamics including inter-annual (and possibly seasonal) variation of the spawning location, combined with the post-spawning immigration of mackerel from the south-west where spawning ends earlier than in the North Sea.

8.4.3 Catch-at-Age

The 2017 catches in number-at-age by quarter and ICES area are given in Table 8.4.3.1. This catch in numbers relates to a total ICES estimated catch of 1 155 944 t. These figures have been appended to the catch-at-age assessment table (see Table 8.7.1.2).

Age distributions of commercial catch were provided by Denmark, England, Germany, Greenland, Faroes, Iceland, Ireland, the Netherlands, Norway, Portugal, Russia, Scotland and Spain. There remain gaps in the age sampling of catches, notably for French (length samples were provided), Swedish and Northern Irish fleets.

Catches for which there were no sampling data were converted into numbers-at-age using data from the most appropriate fleets. Accurate national fleet descriptions are required for the allocation of sample data to unsampled catches.

The percentage catch numbers-at-age by quarter and area are given in Table 8.4.3.2.

Over 80% of the catch in numbers consists of 3 to 8-year olds with all year classes between 2010 and 2014 contributing over 10% to the total catch by number.

There is a small presence of juvenile (age 0) fish within the 2017 catch. As in previous years catches from Divisions 8.c and 9.a have contained a proportion of juveniles.

8.5 Biological Data

8.5.1 Length Composition of Catch

The mean lengths-at-age in the catch per quarter and area for 2017 are given in Table 8.5.1.1.

For the most common ages which are well sampled there is little difference to recent years. The length of juveniles is traditionally rather variable. Lengths recorded in 2017 for 0 and 1 group mackerel are lower than those in 2016.The rapid growth of 0-group fish combined with variations in sampling (in recent years more juvenile fish have been sampled in northern waters whereas previously these fish were only caught in southern waters) will contribute to the observed variability in the observed size of 0-group fish. Growth is also affected by fish density as indicated by a recent study which demonstrated a link between growth of juveniles and adults (0—4 years) and the abundance of juveniles and adults (Jansen and Burns, 2015). A similar result was obtained for mature 3- to 8-year-old mackerel where a study over 1988—2014 showed declining growth rate since the mid-2000s to 2014, which was negatively related to both mackerel stock size and the stock size of Norwegian spring spawning herring (Ólafsdóttir *et al*., 2015).

Length distributions of the 2017 catches were provided by England, Faroes, France, Iceland, Ireland, Germany, Greenland, the Netherlands, Portugal, Russia, Scotland and Spain. The length distributions were available from most of the fishing fleets and account for over 90% of the catches. These distributions are only intended to give an indication of the size of mackerel caught by the various fleets and are used as an aid in allocating sample information to unsampled catches. Length distributions by country and fleet for 2017 catches are given in Table 8.5.1.2.

8.5.2 Weights at Age in the Catch and Stock

The mean weights-at-age in the catch per quarter and area for 2017 are given in Table 8. 5.2.1. There is a trend towards lighter weights-at-age for the most age classes (except 0 to 2 years old) starting around 2005 is continuing until 2013 (Figure 8. 5.2.1). This decrease in the catch mean weights-at-age seems to have stopped since 2013 and values for the last five years do not show any particular trend for the older ages (age 6 and older) and are slightly increasing for younger ages (ages 1 to 5). These variations in weight-at-age are consistent with the changes noted in length in Section 8. 5.1.

The Working Group used weights-at-age in the stock calculated as the average of the weights-at-age in the three spawning components, weighted by the relative size of each component (as estimated by the 2016 egg survey for the southern and western components and the 2017 egg survey for the North Sea component). Mean weights-at-age for the western component are estimated from Dutch, Irish and German commercial catch data, the biological sampling data taken during the egg surveys and during the Norwegian tagging survey. Only samples corresponding to mature fish, coming from areas and periods corresponding to spawning, as defined at the 2014 benchmark assessment (ICES, 2014) and laid out in the Stock Annex, were used to compute the mean weights-at-age in the western spawning component. For the North Sea spawning component, mean weights-at-age were calculated from samples of the commercial catches collected from Divisions 4.a and 4.b in the second quarter of 2017 and the biological samples collected during the 2017 North Sea mackerel egg survey. Stock weights for the southern component, are based on samples from the Portuguese and Spanish catch taken in Divisions 8.c and 9.a in the 2nd quarter of the year. The mean weights in the three component and in the stock in 2017 are shown in the text table below.

As for the catch weights, the decreasing trend observed since 2005 for fish of age 3 and older seems to have stopped in 2013 and values in the last four years do not show any specific trend (except for weights of ages 2 to 7 which have been increasing, Figure 8.5.2.2).

	North Sea Component	Western Component	Southern Component	NEA Mackerel 2017
Age				Weighted mean
0				0.000
1			0.084	0.058
2	0.275	0.196	0.218	0.204
3	0.266	0.232	0.252	0.237
4	0.343	0.270	0.299	0.278
5	0.370	0.303	0.308	0.308
6	0.390	0.299	0.327	0.308
7	0.402	0.331	0.361	0.338
8	0.401	0.374	0.387	0.377
9	0.443	0.390	0.395	0.394
10	0.435	0.426	0.414	0.426
11	0.459	0.427	0.440	0.430
12+	0.489	0.490	0.536	0.494
Component Weighting	6.7%	83.0%	10.3%	
Number of fish sampled	399	458	1691	

8.5.3 Natural Mortality and Maturity Ogive

Natural mortality is assumed to be 0.15 for all age groups and constant over time.

The maturity ogive for 2017 was calculated as the average of the ogives of the three spawning components weighted by the relative size of each component calculated as described above for the stock weights. The ogives for the North Sea and Southern components are fixed over time. For the Western component the ogive is updated every year, using maturity data from commercial catch samples collected during the first and second quarters (ICES, 2014 and Stock Annex). The 2017 maturity ogives for the three components and for the mackerel stock are shown in the text table below.

A trend towards later maturation (decreasing proportion mature at age 2) has been observed from the mid-2000s to 2011. A change in the opposite direction has been observed since then and the maturity ogive in 2017 is comparable with the one observed in the mid-2000s (Figure 8.5.3.1).

Age	North Sea	Western Component	Southern Component	NEA Mackerel
0	0	0	0	0
1	0	0.12	0.02	0.10
2	0.37	0.81	0.54	0.75
3	1	0.96	0.70	0.94
4	1	1	1	1
5	1	1	1	1
6	1	1	1	1
7	1	1	1	1
8	1	1	1	1
9	1	1	1	1
10	1	1	1	1
11	1	1	1	1
12+	1	1	1	1
Component Weighting	6.7%	83.0%	10.3%	

8.6 Fishery Independent Data

8.6.1 International Mackerel Egg Survey

8.6.1.1 Survey Planning for the 2019 Northeast Atlantic survey

The last mackerel egg survey was carried out in the NEA mackerel spawning areas in 2016 and a presentation with the final results were given during the WGWIDE meeting by the survey coordinator in 2017 (ICES, 2017b).

The ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS) met in Dublin in April 2018 to plan the international mackerel and horse mackerel egg survey in 2019. The nations participating in the 2019 survey will be Portugal, Spain, UK Scotland, Ireland, The Netherlands, Germany, Norway, Iceland and the Faroe Islands.

The 2019 survey will be based on seven regular sampling periods. Additional information collated from summer surveys undertaken in 2017/2018 (Section 8.6.1.2) shows that mackerel spawning does only take place northwards the Faroe Islands if the temperature is higher than 8.5ºC at 20 m depth. In addition, in 2018 summer survey was successful in delineating a zero-spawning boundary in the region encompassing Hatton Bank, the South Iceland Basin and all the way up to the Iceland Shelf.

The provisional survey plan of the 2019 mackerel and horse mackerel egg survey, as agreed during last the WGMEGS meeting (ICES, 2018c), is presented in Table 8.6.1.1.1.

In preparation for the 2019 survey a workshop dealing with egg identification and staging will take place during October 2018 in Bremerhaven. Procedures for fecundity and atresia estimation will be standardized and training conducted at the fecundity workshop to be held in IJmuiden in November 2018.

8.6.1.2 Results of the 2018 additional Mackerel Egg Survey in the northern survey area

The WGMEGS has been observing the offshore westwards and northwards expansion of the mackerel spawning area since 2007. In addition, results from the most recent

triennial MEGS survey in 2016 provided evidence that peak spawning of NEA mackerel had moved away from the traditional hotspots between the Bay of Biscay and the Porcupine Bank and instead was dispersed over a large swathe of open ocean, well away from the continental shelf to the West and Northwest of Scotland and importantly very close to the Northern and North-western survey boundary (Figure 8.6.1.2.1).

During the last mackerel benchmark in 2017, WGMEGS proposed several areas of additional work that required to be undertaken during the interim period (2017, 2018) and prior to the next triennial survey in 2019 (ICES, 2017a). The aim was to map the mackerel spawning activity within the North and North-western boundary areas and also hopefully delineate fully the mackerel spawning boundary, something that the triennial survey has hitherto been unable to deliver. The timing for these exploratory surveys/additional sampling was set at May/June.

The first exploratory egg survey was completed by Ireland during May/June of 2017. Results were presented at the last WGWIDE meeting (ICES, 2017b). The areas selected for survey were west of Hatton Bank, Southeast Iceland and the Faroes/Shetland channel. The results show that no stage 1 mackerel eggs were recorded in any of the sampled stations where the temperature at 20 m was less than 8 degrees Celsius (Figure 8.6.1.2.2). Therefore, the expected drop in temperature as the surveys proceeded northwards provides a physical barrier to mackerel spawning and the Northern boundary used by MEGS in 2016 should be relatively secure. However, potential mackerel spawning to the West of Hatton Bank and onto the South Icelandic Basin was less clear. This last area would be the target focus of the Scottish survey which was now scheduled for the same temporal period in 2018 (Burns *et al*, 2018).

During May/June of 2018 it was carried out the second exploratory survey on board a chartered Scottish fishing vessel (Altaire) with the objective of exploring the Northwestern boundary region and survey as far west as required until a zero spawning boundary was established. The survey deployed the Gulf 7 plankton sampler on a series of transects commencing on Rockall Bank and tracking East to West and vice versa heading steadily North up towards the Icelandic Shelf and also surveyed the West side of Iceland. In addition, there was support of the Nordic countries collecting extra plankton samples within this period during the International Ecosystem survey in the Norwegian Sea (IESNS) and Icelandic Spring Capelin surveys.

In this exploratory survey mackerel eggs were present in 49 of the 79 stations sampled with stage 1 mackerel eggs being identified in 60% of sampled stations. Virtually no mackerel eggs were recorded on stations where the temperature at 20 m was less than 8.5 degrees Celsius which is consistent with what is already known surrounding the temperatures tolerated by spawning mackerel. The survey successfully delineated the zero-spawning boundary in the Northwest (Figure 8.6.1.2.3). The relatively warmer temperatures observed on the flanks of Hatton Bank yielding moderate numbers of mackerel eggs whereas the colder water over the South Iceland Basin and also Northwards towards the Reykjanes Ridge being sufficiently cool as to provide the physical boundary and delivering few or zero mackerel eggs.

During 2018, additional plankton samples were collected by the Faeroe Islands, Iceland and also Norway during the IESNS survey. They covered a large swathe of ocean ranging from the East side of Iceland and North of Shetland to the Norwegian Coast. In addition, Iceland also collected 27 samples during their Capelin spring survey at the end of May and additional samples were also collected on the Icelandic Ecosystem surveys in the Nordic Seas in July-August (IESSNS) survey in mid-July. Analysis of the

IESNS samples concluded that none contained mackerel eggs (Figure 8.6.1.2.3). The same was found in both the Icelandic spring capelin survey samples and also those from the Icelandic IESSNS samples from July (Figure 8.6.1.2.4).

The survey results show that during May/June the spawning mackerel are avoiding crossing the cooler waters of the South Iceland Basin and instead are favouring the conditions on the Eastern side of the basin as they head North and certainly this is a widely held view. The total absence of mackerel eggs within the analysed IESNS samples is consistent with the results that were presented in 2017 and reaffirm the assessment that for the region stretching from the East coast of Iceland across to the Faroe/Shetland channel the existing Northern boundary surveyed by MEGS should be relatively secure with very little if any mackerel spawning taking place at that time of year at latitudes North of the Faroe Islands. No mackerel eggs were found in samples from any of the surveys where the recorded temperature at 20 m was less than 8 degrees Celsius. The significantly cooler sub-surface temperatures experienced in 2018 in the sampled areas around the Southern coast of Iceland had a significant impact on the abundance of mackerel eggs reported from the Icelandic Spring Capelin Survey samples with zero mackerel being reported in 2018. This was in a marked contrast to 2017 which recorded several stations with low to moderate densities of stage 1 mackerel eggs but with correspondingly warmer temperatures. It is entirely conceivable that this temperature anomaly may have had some impact regarding the distribution of spawning mackerel over the Hatton and South Iceland Basin region in 2018. However, the limited results reported from that area in 2017 provide some evidence that the pattern may not have been very different to that seen in 2018.

8.6.2 Demersal trawl surveys (Recruitment Index)

The index of survivors in the first autumn-winter (recruitment index) could not be updated due to input data quality issues in the ICES DATRAS system that had not been updated as recommended by WKWIDE 2017 (ICES, 2017a) and WGWIDE 2017 (ICES, 2017b). The outdated time series from WGWIDE 2016 (ICES, 2016a) was therefore used in the assessment. The assessment was therefore conducted without an index value for the 2016 and 2017 year classes and with the knowledge of an upcoming revision of the time series when the data quality issues has been sorted out.

The following text describes the methods used in 2016 and the data quality issues.

The data and the model

An index of survivors in the first autumn-winter (recruitment index) was derived from a geostatistical model fitted to catch data from bottom trawl surveys conducted during autumn and winter. A complete description of the data and model can be found in Jansen *et al*. (2015) and the Stock Annex.

The data were compiled from several bottom trawl surveys conducted between October and March from 1998—2016 by research institutes in Denmark, England, France, Germany, Ireland, Netherlands, Norway, Scotland and Sweden. Surveys conducted on the European shelf in the first and fourth quarters are collectively known as the International Bottom Trawl Survey (IBTS). All surveys sample the fish community on the continental shelf and upper shelf slope. IBTS Q4 covers the shelf from the Bay of Biscay to North of Scotland, excluding the North Sea, while IBTS Q1 covers the shelf waters from north of Ireland, around Scotland, the North Sea, Skagerrak and Kattegat.

Trawl operations during the IBTS have largely been standardized through the relevant ICES working group (ICES, 2013a). Furthermore, the effects of variation in wing-

spread and trawl speed were included in the model (Jansen *et al*., 2015). Trawling speed was generally 3.5—4.0 knots, and trawl gear is also standardized and collectively known as the Grande Ouverture Verticale (GOV) trawl. Some countries use modified trawl gear to suit the particular conditions in the respective survey areas, although this was not expected to change catchability significantly. However, in other cases, the trawl design deviated more significantly from the standard GOV type, namely the Spanish BAKA trawl, the French GOV trawl, and the Irish mini-GOV trawl. The BAKA trawl had a vertical opening of only 2.1—2.2 m and was towed at only 3 knots. This was considered substantially less suitable for catching juvenile mackerel and, therefore, was excluded from the analysis. The French GOV trawl was rigged without a kite and typically had a reduced vertical opening, which may have reduced the catchability of pelagic species like mackerel. Catchability was assumed to equal the catchability of the standard GOV trawl because testing has shown that the recruitment index was not very sensitive to this assumption (Jansen *et al*., 2015). Finally, the Irish mini-GOV trawl, used during 1998—2002, was a GOV trawl in reduced dimensions which was accounted for by inclusion of the wing-spread parameter in the model.

A geostatistical log-Gaussian Cox process model (LGC) with spatiotemporal correlations was used to estimate the catch rates of mackerel recruits through space and time. The modelled average recruitment index (squared CPUE) surface was mapped in Figure 8.6.2.1. The time–series of spatially integrated recruitment index values was used in the assessment as a relative abundance index of mackerel at age 0 (recruits) – see Figure 8.6.2.2.

Survey Coverage

The combined demersal surveys have insufficient spatial coverage in some areas that can be important for the estimation of age-0 mackerel abundance, namely: (i) Since 2011, the English survey (covering the Irish sea and the central-eastern part of the Celtic sea including the area around Cornwall) has been discontinued; (ii) the Scottish survey has not consistently covered the area around Donegal Bay; and (iii) the IBTS has observed high catch rates in some years at the north-eastern edge of the survey area (towards the Norwegian trench) in winter. It is therefore possible that some recruits are also overwintering on the other side of the trench along the south western shelf edge of Norway. Consequently, the Norwegian Sea IBTS (NS-IBTS) in first quarter (Q1) should be extended to include the south-western Norwegian shelf and shelf edge in proximity to the Norwegian trench.

Data Quality

Errors in the input dataset have been detected since WGWIDE 2016. Data revisions by Scotland and Ireland were done before WGWIDE 2017, but for WGWIDE 2018 the ICES DATRAS system was not updated to deliver data and quality assurance reports as recommended by WGWIDE 2017 and WKWIDE 2017. It was therefore not possible to update the time series during the meeting. It is expected that the ICES datacentre will complete this work during autumn 2018, well before the next assessment (or intermediate benchmark), because significant progress was seen in the weeks before the meeting and during the meeting. The recommendations to ICES datacentre will therefore not be repeated this year.

This should facilitate a revision of the recruitment index in time for the 2019 assessment. For the update assessment WGWIDE 2018 used the time series from WGWIDE 2016 (Figure 8.6.2.2).

Mackerel samples collected on the EVHOE fourth quarter (Q4) survey are not aged. The current practice of applying age-length keys from Ireland and Scotland to catches in the more southern EVHOE survey is not ideal, because the mackerel growth during the first year is related to latitude (Jansen *et al.*, 2013). WGWIDE therefore recommends that Ifremer (France) initiate aging of mackerel starting from Q4 2018.

Finally, WGWIDE encourage studies of vertical distribution and catchability of age-0 mackerel in the Q4 and Q1 surveys.

8.6.3 Ecosystem surveys in the Nordic Seas in July–August (IESSNS)

The IESSNS was successfully conducted in the summer of 2018 (Figure 8.6.3.1). Five vessels sampled 290 predetermined surface trawl stations in the period from June 30 to August 6 which covered an area of 2.8 mill. km^2 which is the same as in 2017 (ICES, 2018a). At each surface trawl station, a standardized trawl (Multpelt832) is employed for 30-min according to a standardize operation protocol which is designed to catch mackerel. Additionally, abundance of herring and blue whiting is measured using acoustic methods and backscatter is verified by trawling on registrations as needed. The aim is to establish an index for blue whiting and herring abundance to be used in stock assessment in a few years. The cruise report is available as a working document to the current report (ICES, 2018a) and a detailed survey description is in the Stock Annex.

IESSNS provides annual age-segregated index for mackerel abundance of which age classes 3-11 are used to tune the mackerel stock assessment (Table 8.6.3.1; Ólafsdóttir *et al.*, 2017; ICES, 2017a).

Excluding the North Sea, the total swept area abundance index of mackerel in 2018 was estimated 16.9 billion individuals which is a decrease of 30% compared to 2017. Mackerel biomass index declined 40% between years (Figure 8.6.3.2). The discrepancy in decline of abundance index and biomass index is due to record high numbers of age-1 and age-2 mackerel and lower weight-at-age for these age classes in 2018 compared to 2017. The most abundant year classes were 2010, 2011, 2014, 2016 and 2017 respectively presenting 11%, 14%, 14%, 15%, and 13% of the stock in numbers (Figure 8.6.3.3). The incoming 2017-year class has the largest age-1 index value recorded in IESSNS and is 150% larger than the incoming age-1 cohort in 2017. Mackerel cohort internal consistency has improved by adding the 2018 survey data to the time series. Mackerel cohort internal consistency remained relatively high. Internal consistency is strong for ages 1 to 5 years ($r > 0.8$) and a fair/good internal consistency for ages 5 to 11 years ($r > 0.5$), except for 7-8 year old mackerel (Figure 8.6.3.4)

The North Sea (southward of latitude 60 °N) was included in the IESSNS for the first time in July 2018 and 39 predetermined surface trawl stations were sampled. The survey area was 0.25 mill. km^2, and the estimate index for mackerel abundance was 2.2 billion individuals and the biomass index was 0.4 million tonnes. The North Sea survey areas is excluded for the calculations of the mackerel abundance index used in the assessment according to the 2017 benchmark (Ólafsdóttir *et al.*, 2017; ICES, 2017a), hence the results are presented separately from the traditional survey north of latitude 60 °N.

8.6.4 Tag Recapture data

The Institute of Marine Research in Bergen has annually conducted tagging experiments on mackerel since 1968, both in the North Sea and to the west of Ireland during the spawning season May–June. However, only the information from mackerel tagged west of Ireland is used in the mackerel assessment, and only information on recaptures

of mackerel tagged with steel-tags until 2006. A new RFID tagging method from 2011 onwards was accepted and used in the assessment based on the conclusions from the 2017 WKWIDE benchmark workshop (ICES, 2017a).

Steel-tags

These tags have been recovered at metal detector/deflector gate systems installed at plants processing mackerel for human consumption. This system demanded a lot of manual work, paying for external personnel to stay at the plants during processing. Among the typical 50 fish deflected, the hired personal must find the tagged fish with a hand-hold detector and send the fish to IMR for analysis. This has been time consuming and expensive. Besides being used in present mackerel assessment model, the tagging data have also been used in estimates of mortality, and recently in estimation of spawning stock biomass, and further has the tagging data been valuable for understanding the migration of the mackerel (Tenningen *et al*., 2011).

RFID tags

General description of data

The radio-frequency identification (RFID) tagging project on NEA mackerel was initiated in 2011 at the Institute of Marine Research, Bergen (IMR) in Norway. RFID is a technology that uses radio waves to transfer data from an electronic tag, called an RFID tag, through a reader for the purpose of identifying and tracking the object. The new RFID tagging project has moved away from manual and expensive to an automatic and cost-effective scanning system.

During the period 2011—2016 as many as 353 541 mackerel has been tagged with the new tags and 3 337 of these tags have been recaptured (Table 8.6.4.1). This includes an experiment off the Norwegian Coast on young mackerel in September 2011 as well as three experiments carried out in August in Iceland 2015-2017, none of which is included as input data in the assessment. Data from the releases at the spawning grounds in May-June of Ireland and the Hebrides are the only data included in the assessment.

The RFID-tagged mackerel recaptured up to 1st September 2018, came from 22 European factories processing mackerel for human consumption (Table 8.6.4.2). The project started with RFID antenna reader systems connected to conveyor belt systems at 8 Norwegian factories in 2012. Now there are 6 operational systems at 5 factories in UK (Denholm has 2 RFID systems) and 2 in Iceland. Norway has installed RFID systems at 8 more factories in 2017-2018, most of which with the purpose of scanning Norwegian spring spawning herring catches (IMR started tagging herring in 2016), but some also processing mackerel. More systems are also bought by Ireland (3), which up to now has been non-operational. Note also that in the current assessment data from the factories Sæby (Denmark), Lunar Freezing Frazerburgh (Scotland), Höfn (Iceland), Austevoll and Egersund (after 2013) in Norway are all excluded due to problems with efficiencies and low recapture rates. The factories having operational systems are all online on internet and RFID tagged mackerel recaptured by the systems are automatically updated in the central database in Bergen with date, time, and factory of location.

There is a web-based software solution and database that is used to track the different systems, import data on catch information, and biological sampling data of released fish and screened catches. Based on this information the system can estimate numbers released every year, and the concurrent numbers screened and recaptured over the next years (by year class), which is what is used in the assessment. The development of the tagging data time series is dependent on the work from each country's research

institutes, fisheries authorities or the industry its selves to provide additional data about catches screened through the RFID systems, such as total catch weight, position of catch (ICES rectangle), mean weight in catch, etc. Regular biological sampling of the catches landed at these factories is also needed. Altogether, these data are essential for the estimation of numbers screened per year class. Responsible scientists in Norway, Iceland, Faroes and Scotland has been following up the factories, and delivering the catch data and biological data. In the future, it is planned that annual workshops should occur prior to the assessment, where more scientists go through the new data being updated from new tagging experiments, as well as recaptures from all previous experiments, and undertake analyses of the trends in the data outside of the assessment model, see suggestions to terms of reference for such an annual workshop at the end of this section.

Trends and bias concerns in the RFID tag-recapture data

The way the tagging data is used in the SAM assessment model is more of a raw data format, rather than an abundance index adding one new number per age per year (one line in a table). What is used is number released every year of a year class, and the numbers scanned and recaptured every year of the same year classes in all the years after release. The model is estimating the size of a year class in the release year, based on data from all recapture years. This means for example that the recaptures from the 2011 experiment in year 2017, in fact influences the prediction of the abundance in 2011, meaning that the prediction of 2011 abundance may change over time with more recapture years. This is very different from other typical indexes of abundance normally used in assessments.

The way the tagging data are handled also means that there is no index presented really showing the trends in the data, such as with the egg survey and the IESSNS trawl survey. However, this is possible by estimating the abundance/biomass in the release year using the Petersons model (N=numbers released/numbers recaptured*numbers scanned). During WGWIDE 2018 several results were shown to demonstrate the trends in the RFID tag data based on Peterson's estimation, some of which indicated biases in the data that could influence the assessment. In the following the main results will be described. All estimates are scaled to the 10% survival also used as scaling in SAM, not taking into account the mortality happening over the year (which also currently is not being taken into account in SAM).

When only estimating the biomass in release year based on recaptures the first year after release, one is able to follow the trend from 2011-2017 (Figure 8.6.4.1), where the estimate in 2017 is based only on quarter 1 recaptures in 2018. The trends in biomass of age2+, 3+ and 4+ mackerel show some similarities, all decreasing in the end towards 2017. However, the age2+ index seems to have a jump in 2013, suggesting some noise in the data when the large 2010-2011 year classes are entering in the tagging experiments at the ages 2-3 years.

However, given that SAM takes into account all recapture years, it is important to look at potential changes in the estimates related to recaptures at longer times after release than 1 year. The results when estimating the trends in biomass of age2$^+$, but based on different numbers of years out (1-6 years), clearly show a trend for release years 2011-2012 that is indicating a bias in the data (Figure 8.6.4.2), the estimates increasing heavily with the numbers of years out. This is not according to the assumption in using tag data for abundance estimation, where it is expected that it should be stable when the fish has mixed in the stock. The bias is not so clear for the years after 2012.

When looking closer into the bias in estimating biomass by age groups from tagging data with numbers of years out, from all release years (Figure 8.6.4.3), it indicates that the problem is highest in the young fish, where the change over time is highest. Especially, this can be seen for the strong 2010-2011 year classes entering the tagging data.

There seems to be some change in the estimates from tagging data happening after 2012, and it is important to notice that this also corresponds to a large change in the distribution and abundance of catches scanned for tags (Figure 8.6.4.4). From 2014 onwards Icelandic, Faroes and Scottish factories really contributed to a tripling of the scanned biomass, and a change with a broader distribution of scanned catches in the Norwegian Sea and eastwards to Iceland during quarter 3-4, as well as a significant increase in quarter 1 along the British Isles and Ireland. This change alone could have caused changes in the ways the tagging data effect the assessment, especially if the recapture rates in different areas/seasons vary, according to lack of mixing of tagged fish, or according to mortality happening between seasons (for instance between quarter 1 and quarter 4 catches), which is not taken account for in SAM assessment today.

To check for potential area/season effects on the tag recapture data, the data were reanalysed, based on a splitting in 4 different areas/seasons (Figure 8.6.4.5). The results when looking at trends in the biomass of age 2+ mackerel, when estimated based on recaptures from the 4 areas in the year 1 after release, shows more noise and variation, but still the same trend towards lower biomass in 2016-2017 (Figure 8.6.4.6). The area that seems to stick out is the central Norwegian Sea, which tend to have higher estimates than the others, indicating lower recapture rates, which could suggest a problem with mixing. When looking more detailed into this potential problem, estimating the biomass by age for each release year, based on each of the 4 recapture areas, and different numbers of years after release (Figure 8.6.4.7), even more of the variability in the data are shown. One thing to notice is the noise in the data in 2013, especially coming from the estimate of the 2010 year class based on recaptures from area in the central Norwegian Sea.

Exploratory runs in SAM related to concerns of bias issues in the RFID tagging data

Based on the results above it was decided to do some exploratory runs in SAM to look for sensitivity to the inclusion of different ranges of age groups, different numbers of years of recaptures included after releases, and different areas/seasons.

- Using ages 2+, 3+, 4+
- Using years out=all years or years out < 3
- Using the new tag data set split into 4 areas/seasons

The results of these exploratory runs are shown under SAM assessment results (see Section 8.7.4).

Alternative use of tag data in the assessment – use an index?

In WGWIDE 2018 there was a lot of discussion with regard to the handling of the tag data in SAM. One point raised was that the "raw data" format used for tag data, results in a lot more data, increasing for every year, and how this is handled for instance with regard degrees of freedom. It was discussed in the group that a simpler use of the tag data, in terms of a regular abundance index, perhaps would be more appropriate. At least this would open up for an easier way for other assessment models to use the data for comparisons, especially given the circumstances of the current assessment, where the tag data seems to get a very high weight. There are several ways to make such and index, one attempt is shown in Table 8.6.4.3 and Figure 8.6.4.8. Here it is assumed that

by only including recapture data from the two first years after release (YearsOut=1-2), the estimation in all release years are treated in the same way, and a potential bias with reduced recapture rates with increasing numbers of years after a release is reduced. It is also assumed that data from fish at ages 2-3 are more uncertain, noisier, for instance the 2010-2011 year classes tagged at ages 2-3 years seems noisy. Hence, only data from ages 4-12 were included. For the sake of comparison, the data were also scaled down to the 10% survival used in SAM assessment. This index is something that can be tried out in SAM and other models as an alternative way to use the data, at least for exploration.

Regarding the issue with low survival rate in the RFID tag data

Work is being done to try understanding the different estimated scaling parameters on the 'old' steel tag (survival= 40%) vs the new RFID tag times series (survival=10%), that cannot be explained by suggested bias issues in the new RFID-time series, but actual change in tagging mortality, tag loss or detection-efficiencies at factories. This needs focus and attention as it is not understood by the responsible taggers who evaluate every single fish prior to tagging, nor the responsible scientists.

Some work is already done, such as testing off detection efficiencies at the factories. However, there is clearly need for more testing, several times over the season at all factories. This is something that needs priority, and the plan is to carry out extensive testing until next WGWIDE meeting, or potentially prior to an intermediate benchmark at an earlier date. We need to make sure if the efficiency is stable at high levels, or to adjust for potential variability if this should be the result of extensive testing.

With regard to testing of tagging mortality, some tests are also carried out already. One test is that Iceland in fact has started their own experiments, where the handling of the fish is a little different than in the experiments of Ireland, and where the fish itself perhaps is less sensitive as it is not in a spawning condition as it is off Ireland. However, a comparison in biomass estimates by age and totally between the two experiments in 2016 based on recaptures in 2017 (Figure 8.6.4.9), showed overlapping estimates. This suggests equal survival rates from the two experiments despite the different handling, and condition of the fish. There has also been experiments of Iceland in 2017 and 2018, and it will be of value to follow and compare with the experiments off Ireland in the years to come, to follow up on the discussion of low survival rate on RFID tagged fish estimated by SAM.

Another test for evaluating if the change of handling of the mackerel from the old steel tagging to the new RFID tagging, is that in 2017 a proportion of the tagged fish was handled in the exact same way as used for the steel tags; meaning that: (i) using manual jigging instead of automatic jigging machines; and (ii) using old rectangular tanks for keeping the fish compared with circular tanks, and releasing the fish directly to the sea on starboard side instead of through pipes on the port side. The difference is only in the tag type used, and to some extent the placement of tags; meaning that the old steel tags were inserted into abdomen of the fish, if not in a spawning stage, and into the muscle of the fish when in a spawning stage, as compared with RFID tags, which always are inserted into the abdomen. The decision to always insert the RFID tags into abdomen is to avoid that tags are going all the way to the consumer. The result from the 2017 experiments may help understanding if the handling of the fish is a reason to the differences in survival rates estimated by SAM, but some time with recaptures is necessary prior to conclusion from this experiment.

Another alternative is to carry out large scale tagging experiments at sea, releasing tagged fish into large sea pens, floating around for a period, after which the mortality

could be assessed. Such experiments are possible to conduct, but they will not necessarily show realistic mortalities, as swimming in a pen is not comparable to swimming in the open ocean. Still, such experiments may increase the understanding of the low estimated survival rate, and it is clearly something that should be considered in the future. It must, however, be emphasized that all previous experiments on tagging mortality on mackerel are not realistic with regard to the actual mortalities that are happening out at sea. To underline this, IMR has carried out experiments on both herring and mackerel, with close to zero mortality due to tagging process, when the fish were in really good condition under low stress prior to tagging. The conclusion is that most of the mortality happening is caused by all the handling and stress caused from being hooked with jigging, until the release at sea, not the tag insertion itself. This means that realistic experiments must be carried out under the same conditions normally experienced when tagging in the open ocean with the vessels currently used.

Suggested terms of references for an annual ICES workshop on tagging data

As mentioned above, there is need for an annual workshop dealing with the tagging data for mackerel, but also for Norwegian Spring Spawning herring where tagging started in 2016. Below are the suggested terms of reference for such a working group that should preferably meet in spring prior to the WGWIDE assessment.

- Update the tagging database with all new data needed (catch data and biological data) and carry out estimations needed for updating the tag data table used in the SAM assessment.
- Quality assurance of the tag data table, hereunder to consider if adjustments are needed in tag data table, such as removal of data previously used from factories with low efficiency or alternative use of biological data (such as ALKs) to estimate numbers released and scanned by age.
- Carry out analyses of the trends (indexes of abundance by age and biomass) in the tag data outside the SAM model that can be presented to WGWIDE.
- Plan experiments and carry out analyses that may be used to shed light on the low survival rate estimated for the RFID tags, such as proper testing and control of detection efficiency at factories, survival experiments, special tagging experiments.
- Prepare a full report of the results from the workshop to be presented at WGWIDE.

8.6.5 Other surveys

8.6.5.1 International Ecosystem survey in the Norwegian Sea (IESNS)

After the mid-2000s an increasing amount of mackerel has been observed in catches in the Norwegian Sea during the combined survey in May (IESNS) targeting herring and blue whiting (Rybakov *et al*., 2016; 2017). The spatial distribution pattern was slightly reduced in 2018, where mackerel was caught within a more limited area and in fewer trawl stations of the Norwegian Sea compared to 2017 (Rybakov *et al*., 2017; ICES, 2018b). Mackerel at age 2 (mean length 26.4 cm) was most numerous in the combined samples and amounted to 26%, followed by age 1 (17%) and age 5 (13%) (ICES 2018b).

The mackerel distribution was further east in 2018 compared to in 2017. In 2018, the northernmost mackerel catch was at 70°N and the westernmost catch was at 2°W. In 2017, the northernmost mackerel catch was at 71°N and the westernmost catch was at 10°W. There was a less pronounced distribution of 1-year old mackerel found in 2018

compared to in 2017. There was still a northerly distribution of 1-year old mackerel in the northeast, whereas it was indicated that the 2017-year class also was the most dominant one year later, now as 2-year old mackerel in 2018. The IESNS survey provide valuable although limited quantitative information can be drawn. This acoustic based survey is not designed to monitor mackerel, and do not provide proper mackerel sampling in the vertical dimension, and also involve too low trawl speed for representative sampling of all size groups of mackerel. The trawl hauls are mainly targeting acoustical registrations of herring and blue whiting during the survey in May (IESNS).

8.6.5.2 Acoustic estimates of mackerel in the Iberian Peninsula and Bay of Biscay (PELACUS)

Due to the participation in the International Blue Whiting Spawning Stock Survey (IBWSS), PELACUS 0318, was started a little bit later than previous years (25/03 instead 16/03), and the area was clockwise steamed, from the inner part of the Bay of Biscay to the Spanish –Portuguese border, thus contrary to the normal procedure (Carrera *et al*., 2018a,b). Weather conditions were adverse, with a continuous low-pressure fronts with dominant SW/W winds and swell of about 4 m height, resulted in an important haline front all around the surveyed area due to the river run-offs, and a poleward current with clear influence up to 6ª30′ W (Galician waters). These conditions might have been an important influence in both aggregation pattern and spatial distribution in most of the fish species. In the case of mackerel, the distribution area was mainly restricted to coastal waters (<150 m depth) and mainly occurring in thick bottom layers. Together with mackerel, other swim bladder species were also found in these layers, as revealed by the frequency response done in those echotraces. The increase towards higher frequencies was lower than expected. Ground truth fishing stations confirmed this presence, although mackerel accounted up to 95% of the total catch in number. For this reason, instead of direct allocation, the Nakken and Dommasnes (1975) method for multiple species was used to split backscattering energy into those fish species caught at the ground truthing trawl hauls.

The bulk of the distribution, as in previous years, was located just in the middle of the Cantabrian Sea (Cape Peñas), extending throughout the surveyed area (Figure 8.6.5.2.1). A total of 557 thousand tonnes, corresponding to 1 640 million fish were estimated, most of them, as expected, in central Cantabrian Sea (Figure 8.6.5.2.2, Tables 8.6.5.2.1-2). This is similar to that assessed in 2017 (548 thousand tonnes corresponding to 1 777 million fish). As observed in previous years, only few individuals younger than 5 years were estimated (less than 10% in weight, 14% in number) Age group 6 was dominant (25 %). Mean length was 36.1 cm with a mean weight of 318.3 g, without any significant change in mean length nor in length distribution along the surveyed area.

On the other hand, this year mackerel egg collected by CUFES were counted and staged. 98% (364 of 373 station- each of them corresponding to 3 nmi on average-) resulted positive for mackerel eggs, with a mean of 248 egg per station (24 eggs/m^3). These figures are much higher than those collected at the Porcupine Sea Bight, where only few eggs were counted, with only 0.62 eggs/station (0.05 eggs/m^3) (Figure 8.6.5.2.3).

8.7 Stock Assessment

8.7.1 Update assessment in 2017

NEA mackerel was classed as an update assessment this year. The update assessment was carried out by fitting the state-space assessment model SAM (Nielsen and Berg,

2014) using the R library stock assessment (downloadable at install_github("fishfollower/SAM/stockassessment", ref="mack")) and adopting the configuration described in the Stock Annex.

The assessment model is fitted to catch-at-age data for ages 0 to 12 (plus group) for the period 1980 to 2017 (with a strong down-weighting of the catches for the period 1980-1999) and three surveys: (i) the SSB estimates from the triennial Mackerel Egg survey (every three years in the period 1992-2016); (ii) the recruitment index from the western Europe bottom trawl IBTS Q1 and Q4 surveys (1998-2015, not updated for the last 2 years); and (iii) the abundance estimates for ages 3 to 11 from the IESSNS survey (2010, 2012-2018). The model also incorporates tagging-recapture data from the Norwegian tagging program (for fish recaptured between 1980 and 2005 for the steel tags time series, and fish recaptured between 2012 and 2017 for the radio frequency tags time series).

Fishing mortality-at-age and recruitment are modelled as random walks, and there is a process error term on ages 1-11.

The differences in the new data used in this assessment compared to the last year's assessment were:

- No update of the IBTS recruitment index was available and the time series did not include any 2016 and 2017 estimates (see Section 8.6.2).
- Addition of the 2018 survey data in the IESSNS indices.
- Addition of the 2017 catch-at-age, weights-at-age in the catch and in the stock and maturity ogive, proportions of natural and fishing mortality occurring before spawning.
- The inclusion of the tag recaptures from 2017, and minor revision in the tagging recapture data set for the RFID tagging program for the earlier recapture years (differences less than 1% in the recapture rates).

Input parameters and configurations are summarized in Table 8.7.1.1. The input data are given in Tables 8.7.1.2 to 8.7.1.9. Given the size of the data base the tagging data are not presented in this report, but are available on www.stockassessment.org in the data section (files named tag.dat and tag3.dat).

8.7.2 Model diagnostics

Parameter estimates

The estimated parameters and their uncertainty estimates are shown in Table 8.7.2.1 and Figure 8.7.2.1. The model gives a good fit to the catch data (lowest observation standard deviation). The observation standard deviations for the egg survey is also low, indicating a good fit to this survey. The observations standard deviations for the recruitment index and the IESSNS surveys ages 4 to 11 are higher indicating that the assessment gives a lower weight to the information coming from these surveys. The IESSNS age 3 has a very low weight in the assessment (high observation standard deviation). Overdispersion of the tag recaptures is not directly comparable with observation standard deviation, but has the same meaning. The model assigns a similar overdispersion to the steel tag data and the RFID tag data.

The catchability of the egg survey is 1.37, significantly larger than 1, which implies that the assessment considers the egg survey index to be an overestimate. The catchabilities at age for the IESSNS increase from close to 1 for age 3 to 2.69 for age 7 and decreases slightly for older ages. Since the IESSNS index is expressed as fish abundance, this also

means that the assessment considers the IESSNS to provide over-estimated abundance values for the oldest ages. The post tagging survival estimate is higher for the steel tags (around 40%) than for the RFID tags (around 10%).

The process error standard deviation (ages 1-11) is moderate (lower than in previous assessments) as well as the standard deviation of the F random walk.

The catchability parameters appear to be estimated more precisely than the observation standard deviations, except for the catchability of the IESSNS at age 3 which has a higher standard deviation. Uncertainty on the tags post release survival is low. Uncertainty on the observation standard deviations is larger for the egg survey and the IESSNS age 3 than for the other survey indices. Uncertainty on the overdispersion of the RFID tag data is high.

The estimated AR1 error correlation structure for the observations from the IESSNS survey age 3 to 11 a high correlation between the errors of adjacent ages (r=0.82), then decreasing exponentially with age difference (Figure 8.7.2.2.). This high error correlation implies that the weight of this survey in the assessment in lower than for a model without correlation structure, which is also reflects in the high observation standard deviation for this survey.

There are some strong correlations between parameter estimates (Figure 8.7.2.3):

- Catchabilities are positively correlated (especially for the IESSNS age 4 to 11), and negatively correlated to the survival rate for the RFID tags. This implies that the model cannot distinguish well between low catchabilities / high tag survival (larger stock) and high catchability / low survival (smaller stock).
- The observation variance for the IESSNS age 4-11 is positively correlated to the autocorrelation in the errors for these observations. This implies that when the model estimates highly correlated errors between age-groups, the survey is considered more noisy.
- The observation variance of the catches is negatively correlated to the variance of the fishing mortality random walk. This implies that when the model tends to consider the catches as more precise, this implies a more variable fishing mortality.

These correlations mean that the model is not able to estimate these parameters independently and may indicate that it is overparameterised.

Residuals

The "one step ahead" (uncorrelated) residuals for the catches did not show any temporal pattern (Figure 8.7.2.4) except for 2014 for which they were mainly positive for 2014 (modelled catches lower than the observed ones). This may result from the random walk that constraints the variations of the fishing mortality, which prevents the model from increasing the fishing mortality suddenly (which probably happened given the sharp increase in the catches in 2014). Residuals for ages 0 and 1 are larger than for subsequent ages 2 to 10. Residuals for ages 11 to 12 are also larger than for ages 2 to 10. This suggest that decoupling the observation variance of the catches (for example by grouping age 0 and 1, ages 2 to 10 and ages 11 and older) could be more appropriate. This has been investigated during the last benchmark assessment, but the model with decoupled observation variances gave a very tight fit to the recruitment index (observation standard deviation close to 0.05) and a very large observation standard deviation for the catches of ages 0 and 1. WKWIDE 2017 regarded the tight fit to

the recruitment index as unrealistic and chose to retain the current model structure because there was insufficient time to continue with this analysis (ICES, 2017a). WGWIDE recommends that this work is prioritized during the next benchmark, because the problem with juvenile catches remained unsolved.

The residuals for the egg survey show a slight temporal pattern with negative residuals in the period 2001-2004 and followed by positive residuals for the period 2007-2013. The residual for the 2016 point is large and negative, indicating that the model has difficulties fitting to this low estimate, despite the overall decrease in the estimated SSB over the recent years.

Residuals for the IESSNS indices do not show any marked pattern, except the predominance of positive residuals for the two recent years (2016 and 2017) which indicate that the model does not agree with the high value of the survey observed for these 2 years. Residuals for the latest year are more balanced.

Residuals to the recruitment index show no particular pattern.

Finally, inspection of the residuals for the tag recaptures (Figure 8.7.2.5) did not show any sign of model misspecification. The only minor concern was for fish released at age 2 for which the predominance of positive residuals suggested that the post-release mortality for those fish may have been lower than for other ages (more tags return than expected). This issue is studied in more details in Section 8.7.4.

Leave one out runs

In order to visualise the respective impact of the different surveys on the estimated stock trajectories, the assessment was run leaving out successively each of the data sources (Figure 8.7.2.6). All leave out one runs showed parallel trajectories in SSB and F_{bar}, except the run removing the tagging data which shows a different dynamics in the early period of the assessment (before 2000) and in the recent years (since the start of the RFID time series). Further inspection of the output of the run without the tagging data showed that the model is not able to estimate accurately the parameters (it resulted this year in a variance for the F random walk close to 0, corresponding to constant F for the whole time series). This is explained by the fact that, without tagging data, the model has no information on the period prior to 2000, expect 3 egg survey points. The leave one out run excluding the tagging data should therefore be disregarded.

Removing the recruitment index had only on minor effect on the estimated stock trajectory. Removing the IESSNS resulted in lower SSB estimates and higher Fbar estimates for the period covered by the survey. On the opposite, removing the egg survey results in a larger estimated stock, exploited with a lower fishing mortality. These 2 surveys have a notable contribution to the assessment (even if the leave one out runs fall within the confidence intervals of the assessment using all data), and in a way, the final assessment seems to make a trade-off between the information coming from the IESSNS which lead to a more optimistic perception of the stock, and the information from the egg survey which suggest a more pessimistic perception of the stock. This conflict between the 2 surveys seem to have decreased compared to previous years, as the difference between the 2 leave one out runs is less pronounced this year than in the past.

The sensitivity of the assessment was tested for the RFID data alone in a separate analysis (Figure 8.7.2.7). Removing this source of data result in a very different perception of the development of the stock after 2012: the SSB in the assessment without RFID tag

data continues to increase to reach close to 5.5 million tonnes in 2015 before declining to 4 million tonnes in 2017, while the SSB in the assessment using the RFID tags decreases continuously since 2011 to reach levels close to 3 million tonnes in 2017. The influence of a single year of data for the RFID tags was also tested by removing the recaptures from 2017 (Figure 8.7.2.8). This also resulted in a higher estimated SSB for the period since 2012, although the magnitude of the difference was less than when the entire RFID data set was removed. For comparison, the same exercise was done removing the last year of data for the IESSNS (Figure 8.7.2.9). This resulted only in a minor (downward) revision of the recent estimates of SSB.

This shows that the RFID tagging data has a very strong weight on the assessment, and pulls recent estimates of abundance downward. This feature of the assessment has not been investigated in the previous years, although it was noted during the previous benchmark that the decision to include the RFID data resulted in a lower SSB in the recent years. WGWIDE recommends that this aspect of the assessment should be further studied, and that the better understanding of the relative weight of the different data sources should be gained. Since the tag recaptures are modelled with an error distribution (negative binomial) different from the error distribution used for the other observations (log normal), model parameters cannot be used to compare their relative weight.

8.7.3 State of the Stock

The stock summary is presented in Figure 8.7.3.1 and Table 8.7.3.1. The stock numbers-at-age and fishing mortality-at-age are presented in Tables 8.7.3.2-3, respectively. The spawning stock biomass is estimated to have increased almost continuously from just below 2 million tonnes in the late 1990s and early 2000s to 4.79 million tonnes in 2011 and subsequently declined continuously to reach a level just above 3 million tonnes in 2017. The fishing mortality has declined from levels close to F_{lim} (0.46) in the mid-2000s to 0.26 in 2012 and has increased again since then to levels above F_{pa}. The recruitment time series from the assessment shows a clear increasing trend since the late 1990s with a succession of large year classes (2002, 2006, 2011 and 2014). The estimates for the year classes 2015 and 2016 indicate low recruitment, likely the lowest in the time series for the 2016 year class. There is insufficient information to estimate accurately the size of the 2017 year class. The estimate is very high but highly uncertain as it relies only on the age 0 catch data (in absence of a 2017 IBTS index).

There is some indication of changes in the selectivity of the fishery over the last 20 years (Figure 8.7.3.2.). In the year 1994, the fishery seems to have exerted a high fishing mortality on the fish 7 years and older. This changed gradually until 2000, when the fishing mortality on younger ages (3- to 6-years) increased compared to the older fish. In the following years, the selectivity pattern changed towards a lower fishing mortality on the age-classes younger than 6 years until 2008 when it changed again towards a higher selection on the fish age 3 to 6.

8.7.4 Additional exploratory runs with different selection criteria for the tagging data

8.7.4.1 Accounting for the geographic area of recapture

Exploratory analyses presented in Section 8.6.4 suggest that the tag recapture rates may change according to the area of recapture. Potential biological explanations are given in the Section 8.6.4. If such is that case, it may be appropriate to take account of these differences in the assessment model. This can be done by estimating a different post

release survival rate for the different areas considered in Section 8.6.4 (see Figure 8.6.4.5).

The RFID tag dataset structured by area is different from the one used in the update assessment: for each recapture year, there can be up to 4 data points (for the 4 areas) instead of one for each cohort in each release year. In order to assess the effect of using an area effect in the model, the model without area effect therefore had to be run first on the data set structured by area.

Model parameters were slightly changed when replacing the RFID tagging data by the data set structured by area (Figure 8.7.4.1.1). A small reduction of the observation variance for the egg survey and an increase for the IESSNS are observed. The overdispersion for the RFID tags decreases slightly, but the parameter is extremely badly defined (such that the parameter standard deviation could not be estimated). Including the area effect has only a minor effect on the parameters, and the problem with the high uncertainty on the overdispersion for the RFID tag remains. The problem with the estimation of the parameters was even more acute when the model was configured with separate overdispersion parameters for each geographical area (result not shown). The estimated survival rates show some differences between areas, with lower values for the area 3, average values for the areas 1 and 4 (similar to the parameter estimate without area effect) and high value for the area 2 (Figure 8.7.4.1.2). These values are consistent with the observations made in Section 8.6.4. Introducing an area specific survival rate resulted in smaller changes in the recent SSB and F (+7% and – 7% for 2018 SSB and Fbar respectively). Changing the RFID tagging dataset without any change in model configuration resulted in a downward revision by -18% of the recent SSB estimates and an upward revision of the same magnitude in the fishing mortality (Figure 8.7.4.1.3).

Although the differences in model AIC and the differences in estimated survival rates between areas suggest that it might be appropriate to take account of recapture area in the model, the issues found with parameter estimation deserve further attention. It is likely that data series may still be too short for some areas where the scanning of the RFID tags started only in the recent years.

8.7.4.2 Influence of the number of years before recapture

Investigations presented in Section 8.6.4 suggest that the recapture rates of a cohort tagged in a given year tend to decrease with the number of years separating tagging and recapture. In the context of the assessment model, this could be translated in differences in survival rate with the number of years between release and recapture. Since the model assumes a unique rate, this would result in a pattern in the residuals, with larger values (for a given cohort tagged in a given years) for the first recapture years, and lower residuals for fish that remained longer in the sea.

In order to investigate the existence of such patterns, the residuals were grouped by year-class and release year (or equivalently age at release). For each group, the residuals for the different recapture years were then centred (subtracting the mean) and inspected for pattern. Figure 8.7.4.2.1 shows that for a number of instances the residuals tend to decrease with the number of years spent at sea, which supports the hypothesis that mortality increase with the number of years after tagging. However, this is not the case of each cohort/age at release combination.

The existence of such patterns may indicate that the model is not formulated appropriately, and that the cumulative mortality with the successive years spent before recapture should be explicitly accounted for in the model. As an attempt to remove this potential bias in the assessment, the model was run using only the recapture of the first

2 years after tagging. This assessment estimated a lower overdispersion of the RFID tags, and a 20% higher estimated survival rate (which was to be expected if indeed mortality due to tagging continues in the years after release). There was however a slight increase in the uncertainty around these parameters. The corresponding stock trajectories are substantially revised (by +20% for 2017 SSB and by -21% for Fbar) (Figure 8.7.4.2.2).

This issue deserves further investigations, and potential model modifications to better model mortality after release should be investigated in a future benchmark.

8.7.5 Quality of the assessment

Parametric uncertainty

Large confidence intervals are associated with the SSB in the years before 1992 (Figure 8.7.3.1 and Figure 8.7.5.1). This results from the absence of information from the egg survey index, the downweighing of the information from the catches and the assessment being only driven by the tagging data and natural mortality in the early period. The confidence intervals become narrower from the early 1990s to the mid-2000s, corresponding to the period where information is available from the egg survey index, the tagging data and (partially) catches. The uncertainty increases slightly in the most recent years and the SSB estimate for 2017 is estimated with a precision of +/- 28% (Figure 8.7.3.1 and Table 8.7.3.1). There is generally also a corresponding large uncertainty on the fishing mortality, especially before 1995. The estimate of Fbar4-8 in 2017 has a precision of +/- 31%. The uncertainty on the recruitment is high for the years before 1998 (precision of on average +/- 63%). The precision improves for the years for which the recruitment index is available (+/- 39%) except for the last estimated recruitment (+/- 99%).

Model instability

The retrospective analysis was carried out for 5 retro years, by fitting the assessment using the 2018 data, removing successively 1 year of data (Figure 8.7.5.2). Since some of the time series are still short (8 years for the IESSNS index, 6 years for the RFID tags), the parameters corresponding to these sources of data are expected to change from year to year, until the time series are long enough to have stable estimates.

There is no strong retrospective pattern observed in the SSB, as indicated by the reasonably low Mohn's rho value (i.e. average relative bias of retrospective estimates; Mohn, 1999; Brooks and Legault, 2016). All runs, except the one removing 5 years of data, provide estimates which are within the confidence intervals of the current assessment. Differences in the estimated F_{bar} values are larger than for SSB and tend to show a pattern to towards systematic overestimation, as indicated by the Mohn's rho value of 0.23. Recruitment appears to be quite consistently estimated.

Model behaviour

The realisation of the process error in the model was also inspected. The process error expressed as annual deviations in abundances-at-age (Figure 8.7.5.3) shows indications of some pattern across time and ages. There is a predominance of positive deviations in the recent years for age-classes 4 to 8. While process error is assumed to be independent and identically distributed, there is clear evidence of correlations in the realisation of the process error in the mackerel assessment, which appears to be correlated both across age-classes and temporarily.

The temporal autocorrelation can also be visualised if the process error is expressed in term of biomass (process error expressed as deviations in abundances-at-age multiplied by weight at age and summed over all age classes, Figure 8.7.5.4). Periods with positive values (when the model globally estimates larger abundances-at-age than corresponding to the survival equation) have been alternating with periods with negative values (between 2004 and 2007). For the years since 2010 the cumulated process error remains positive, with the magnitude reaching a third of the volume of the catches for 2009. The reason for this misbehaviour of the model could not be identified. It should be noted, however, that the magnitude and autocorrelation of the biomass cumulated process error in the 2018 assessment is lower than in the previous year's assessment.

8.8 Short term forecast

The short-term forecast provides estimates of SSB and catch in 2019 and 2020, given assumption of the current year's (also called intermediate year) catch and a range of management options for the catch in 2019.

All procedures used this year follow those used in the benchmark of 2014 as described in the Stock Annex.

8.8.1 Intermediate year catch estimation

Estimation of catch in the intermediate year (2018) is based on declared quotas and interannual transfers as shown in the text table in Section 8.1.

8.8.2 Initial abundances at age

The recruitment estimate at age 0 from the assessment in the terminal assessment year (2017) was considered too uncertain to be used, because this year class has not yet fully recruited into the fishery. The last recruitment estimate is normally replaced by predictions from the RCT3 software (Shepherd, 1997). The RCT3 software evaluates the historical performance of the IBTS recruitment index, by performing a linear regression between the index and the SAM estimates over the period 1998 to the year before the terminal year. The recruitment is then calculated as a weighted mean of the prediction from this linear regression based on the IBTS index value, and a time tapered geometric mean of the SAM estimates from 1990 to the year before the terminal year. The time tapered geometric mean gives the latest years more weight than a geometric mean. This is done because the recent productivity of the stock appears different than in the 1990's.

The recruitment index for 2016 and 2017 could not be calculated (see Section 8.6.2). The time tapered geometric mean (5 267 776) from 1990—2015 was therefore used as the recruitment in 2016 and 2017 in the forecast. This is equivalent to the standard method using RCT3, except that (missing) recruit index value has no influence.

8.8.3 Short term forecast

A deterministic short-term forecast was calculated using FLR. Table 8.8.3.1 lists the input data and Tables 8.8.3.2 and 8.8.3.3 provide projections for various fishing mortality multipliers and catch constraints in 2019.

Assuming catches for 2018 of 1 001 kt, F was estimated at 0.46 (close to F_{lim}) and SSB at 2.35 Mt (below B_{pa}) in spring 2018. If catches in 2019 equal the catch in 2018, F is expected to increase to 0.66 (above F_{lim}) in 2019 with a corresponding reduction in SSB to

1.98 Mt in spring 2019, which is close to B_{lim} (1.94 Mt). Assuming an F of 0.66 again in 2020, the SSB will decrease further to 1.71 Mt in spring 2020.

Following the MSY approach, exploitation in 2019 shall be at F_{MSY} * SSB(2019) /MSY $B_{trigger}$, because SSB is predicted to be below MSY $B_{trigger}$ (2.57 Mt) in spring 2019. This is equivalent to an F at 0.173, catches of 318 kt and a reduction in SSB to 2.12 Mt in spring 2019 (-10 % change). This is still below $B_{trigger}$. During the subsequent year, SSB is predicted increase with 10% to 2.33 Mt in spring 2020.

8.9 Biological Reference Points

A long-term management plan evaluation was conducted in 2017 (ICES, 2017b) which resulted in the adoption of new reference points for NEA mackerel stock by ICES.

8.9.1 Precautionary reference points

B_{lim} - There is no evidence of significant reduction in recruitment at low SSB within the time series hence the previous basis for B_{lim} was retained. B_{lim} is taken as B_{loss}, the lowest estimate of spawning stock biomass from the revised assessment. This was estimated to have occurred in 2002; B_{loss} = 1 940 000 t.

F_{lim} - F_{lim} is derived from B_{lim} and is determined from the long-term equilibrium simulations as the F that on average would bring the stock to B_{lim}; F_{lim} = 0.48.

B_{pa} - The ICES basis for advice requires that a precautionary safety margin incorporating the uncertainty in actual stock estimates leads to a precautionary reference point B_{pa}, which is a biomass reference point with a high probability of being above B_{lim}. B_{pa} was calculated as $B_{lim} \cdot exp(1.645 \cdot \sigma)$ where $\sigma = 0.17$ (the estimate of uncertainty associated with spawning biomass in the terminal year in the assessment, 2016, as estimated in the 2017 management plan evaluation); B_{pa} = 2 570 000 t.

F_{pa} -The ICES basis for advice requires that a precautionary safety margin incorporating the uncertainty in actual stock estimates leads to a precautionary reference point F_{pa}, which is a fishing mortality reference point designed to avoid reaching F_{lim}. Consequently, F_{pa} was calculated as F_{lim} * exp(1.645 σ) where σ = 0.20 default value was taken following the guidelines, as the estimated standard deviation of ln(F) in the final assessment year (2016) provided by the SAM assessment (i.e. σ = 0.14 corresponding to the uncertainty of ln(F_{2015})) was smaller than 0.20 but considered unrealistically low.; F_{pa} = 0.35.

8.9.2 MSY reference points

The ICES MSY framework specifies a target fishing mortality, F_{MSY}, which, over the long term, maximises yield, and also a spawning biomass, MSY $B_{trigger}$, below which target fishing mortality is reduced linearly relative to the SSB $B_{trigger}$ ratio.

Following the ICES guidelines (ICES, 2013b), long term equilibrium simulations indicated that F=0.21 would be an appropriate F_{MSY} target as on average it resulted in the highest mean yields in the long term, with a low probability (less than 5%) of reducing the spawning biomass below B_{lim}.

The ICES basis for advice notes that, in general, F_{MSY} should be lower than F_{pa}, and MSY $B_{trigger}$ should be equal to or higher than B_{pa}. Simulations indicated that potential values for MSY Btrigger were below B_{pa}. Following the ICES procedure MSY $B_{trigger}$ was set equal to B_{pa}, 2 570 000 t.

Updated ICES reference points for NEA mackerel

Type		Value	Technical basis
MSY approach	MSY $B_{trigger}$	2.57 million tonnes	B_{pa} [1]
	F_{MSY}	0.21	Stochastic simulations [1]
Precautionary approach	B_{lim}	1.94 million tonnes	B_{loss} in 2002 [2]
	B_{pa}	2.57 million tonnes	$B_{lim} \times \exp(1.654 \times \sigma)$, $\sigma = 0.17$ [1]
	F_{lim}	0.48	F that on average leads to B_{lim} [1]
	F_{pa}	0.35	$F_{lim} \times \exp(1.654 \times \sigma)$, $\sigma = 0.20$[1]

[1] **2017 management plan evaluation (ICES, 2017b)**

[2] **2017 benchmark assessment (ICES, 2017a)**

8.10 Comparison with previous assessment and forecast

Assessment

The last available assessment used for providing advice was carried out in 2017 at WGWIDE. The new 2018 WGWIDE assessment gives a slightly different perception of the recent development of the stock (Figure 8.10.1). While the previous assessment gave the perception of a stock stable at high levels after 2011, the new assessment now indicates that the stock has been declining since 2011. Conversely the new assessment suggests that F has been increasing constantly since 2011, while the previous assessment indicated a less pronounced increase.

The differences in the 2016 TSB and SSB estimates between the previous and the present assessments are moderate, of -11% in both cases. The upward revision of the 2016 fishing mortality estimate is small, of 4%.

	TSB 2016	**SSB 2016**	**F_{4-8} 2016**
Values			
2017 WGWIDE	4752576	3970992	0.322
2018 WGWIDE	4216702	3527235	0.335
% difference	-11%	-11%	+4 %

The exploratory runs presented in Section 8.7. 2 showed that removing the last year of tagging data (recaptures from 2017) modified strongly the perception of the stock. The estimated SSB is in this case more similar to last year's assessment (see Figure 8.7.2.8). The same section shows that the 2018 IESSNS data point has little influence on the recent SSB and F_{bar} estimates (Figure 8.7.2.9). The recaptures from 2017 added in this update assessment inform the model on the abundance-at-age for ages 2 to 12 for the period 2011 to 2017 (so basically 1 additional year of RFID data may potentially provide as much information as the entire IESSNS index).

Inspecting the changes in the estimated model parameters can help understand the reason for these revisions (Figure 8.10.2). The addition of an additional year of data has slightly modified the relative weight of the different data sources: the estimated observation standard deviation has decreased for the catches and the egg survey, and increased for the IESSNS age 4-11 and the recruitment index. The overdispersion for the

RFID tags also increased. The model also estimates this year more variable recruitment and fishing mortality, and a smaller process error.

The uncertainty on the parameter estimates has decreased for a number of parameters (Figure 8.10.2). It is for instance the case for the observation standard deviations for the IESSNS, the overdispersion of the RFID tags, and some of the catchabilities estimates. However, the observation standard deviation for the catches has become slightly more uncertain. The joint uncertainty on recent SSB and F_{bar4-8} in this year's assessment is lower than for last year's assessment (Figure 8.10.3).

Forecast

The prediction of the mackerel catch for 2017 used for the short-term forecast in the advice given last year was very close to the actual 2017 catch reported in 2018 and used in the present assessment (text table below). The new assessment produced an estimate of the SSB in 2017 10.5% lower than the 2017 forecast prediction. The fishing mortality F_{bar4-8} for 2017 estimated this year is 6.2% lower than the value estimated by the short term forecast in the previous assessment. Most of these discrepancies can be explained by the revision of the perception of the stock described above.

	Catch (2017)	**SSB (2017)**	**F4-8(2017)**
2017 WGWIDE forecast	1 178 850 t	3 443 926 t	0.405
2018 WGWIDE assessment	1 155 944 t	3 081 442t	0.38
% difference	-1.9%	-10.5%	-6.2%

8.11 Management Considerations

Details and discussion on quality issues in this year's assessment is given in Section 8.7 above.

The Atlantic mackerel in the Northeast Atlantic is traditionally characterised as three distinct 'spawning components': the southern component, the western component and the North Sea component. The basis for the components is derived from tagging experiments (ICES, 1974), however, the methods normally used to identify stocks or components (e.g. ectoparasite infections, blood phenotypes, otolith shapes and genetics) have not been able to demonstrate significant differences between animals from different components. The mackerel in the Northeast Atlantic appears on one hand to mix extensively whilst, on the other hand, exhibit some tendency for homing (Jansen *et al.*, 2013; Jansen and Gislason, 2013). Consequently, it cannot be considered either a panmictic population, nor a population that is composed of isolated components (Jansen and Gislason, 2013).

Nevertheless, stock components are still being used to identify the different spawning areas where mackerel are known to spawn. The trends in the different components is derived from the triennial egg survey in the western and southern area and a dedicated egg survey in the North Sea the year following the western survey.

Since the mid-1970s, ICES has continuously recommended conservation measures for the North Sea component of the Northeast Atlantic mackerel stock (e.g. ICES, 1974; ICES, 1981). The measures advised by ICES to protect the North Sea spawning component (i.e. closed areas and minimum landing size) aimed to promote the conditions that make a recovery of this component possible.

The recommended closure of Division 4.a for fishing during the first half of the year is based on the perception that the western mackerel enter the North Sea in July/August, and remain there until December before migrating to their spawning areas. Updated observations from the late 1990s suggested that this return migration actually started in mid- to late February (Jansen *et al*., 2012). The EU TAC regulations stated that within the limits of the quota for the western component (ICES Subareas and Divisions 6, 7, 8.a,b,d,e, 5b (EU), 2a (non-EU), 12, 14), a certain quantity of this stock may be caught in 4.a during the periods 1 January to 15 February and 1 September to 31 December. Up to 2010, 30% of the Western EU TAC of mackerel (MAC/2CX14-) could be taken in 4.a. From 2011 onwards, this percentage has been set at 40% and from 2015 at 60%.

The minimum landing size (MLS) for mackerel is currently set at 30 cm for the North Sea and 20 cm in the western area. The historical basis for the setting of minimum landing sizes is described in a working document to WGWIDE in 2015 (Pastoors, 2015). The MLS of 30 cm in the North Sea was originally introduced by Norway in 1971 and was intended to protect the very strong 1969 year class from exploitation in the industrial fishery. The 30 cm later became the norm for the North Sea MLS while the MLS for mackerel in western waters was set at 20 cm. In the early 1990s, ICES recommended that, because of mixing of juvenile and adult mackerel on western waters fishing grounds, the adoption of a 30 cm minimum landing size for mackerel was not desirable as it could lead to increased discarding (ICES, 1990; 1991). A substantial part of the catch of (western) NEA mackerel is taken in ICES division 4.a during the period October until mid-February to which the 30 cm MLS applies even though there is limited understanding on the effectiveness of minimum landing sizes in achieving certain conservation benefits (STECF, 2015).

8.12 Ecosystem considerations

An overview of the main ecosystem drivers possibly affecting the different life-stages of Northeast Atlantic mackerel and relevant observations are given in the Stock Annex. The discussion here is limited to recent features of relevance.

Production (recruitment and growth)

Mackerel recruitment (age 1) has been higher since 2001 compared to previous decades with several very large cohorts (Jansen, 2016). Increasing stock size was suggested to have an effect through density driven expansion of the spawning area into new areas with Calanus in oceanic areas west of the North European continental shelf (Jansen, 2016). There are several indications of a shift in spawning and mackerel recruitment/larvae and juvenile areas towards northern and north-eastern areas preceding the 2016 mackerel spawning (ICES, 2016b; Nøttestad *et al*. 2018). This northerly shift in spawning and recruitment pattern of NEA mackerel seem to have continued also in 2017 and 2018 (Nøttestad *et al*., 2018). The incoming 2017-year class has the largest age-1 index value recorded in IESSNS and is 150% larger than the incoming age-1 cohort in 2017 (ICES, 2018a).

During the recent decade, mackerel length- and weight-at-age declined substantially for all ages (Jansen and Burns, 2015; Ólafsdóttir *et al*., 2015). Growth of 0–3 years old mackerel decreased from 1998 to 2012. Mean length at age 0 decreased by 3.6 cm, however the growth differed substantially among cohorts (Jansen and Burns, 2015). For the 3-8 years old mackerel, the average size was reduced by 3.7 cm and 175 g from 2002 to 2013 (Ólafsdóttir *et al*., 2015). The variations in growth of mackerel in all ages are correlated with mackerel density. Furthermore, the density dependent regulation of growth from younger juveniles to older adult mackerel, appears to reflect the spatial

dynamics observed in the migration patterns during the feeding season. (Jansen and Burns, 2015; Ólafsdóttir *et al*., 2015). Growth rates of the juveniles were tightly correlated with the density of juveniles in the nursery areas (Jansen and Burns, 2015). For adult mackerel (age 3-8) growth rates were correlated with the combined effects of mackerel and herring stock sizes (Ólafsdóttir et al., 2015). Conspecific density-dependence was most likely mediated via intensified competition associated with greater mackerel density.

Furthermore, the last few years after 2014, the recruitment appear weaker for NEA mackerel (ICES, 2017b; 2018c) and the density dependent growth has stabilized and mean weights per age group have even slightly increased during the last 2-3 years for several age groups (ICES, 2018c).

Spatial mackerel distribution and timing

In the mid-2000s, summer feeding distribution of Northeast Atlantic mackerel (*Scomber scombrus*) in Nordic Seas began expanding into new areas (Nøttestad *et al*., 2016). During 2007 - 2016 period mackerel distribution range increased three-fold and the centre-of-gravity shifted westward by 1650 km and northward by 400 km. Distribution range peaked in 2014 and was positively correlated to Spawning Stock Biomass (SSB).

After a mackerel stock expansion during the feeding season in summer from 1.3 million km^2 in 2007 to at least 2.9 million km^2 in 2014, mainly towards western and northern regions of the Nordic seas (Nøttestad *et al*., 2016c), we have now a slightly decreased distribution area of mackerel in the Nordic Seas (Nøttestad *et al*. 2017; ICES, 2018a). The survey coverage area was 2.8 million square kilometres in 2018, which is the same as in 2017 (Nøttestad *et al*. 2017; ICES, 2018a). The mackerel appeared more evenly distributed within the survey area and more easterly distributed in 2018 than in 2017 (ICES, 2018a). This difference in distribution primarily consists of a marked biomass decline of 76% in the west. In the eastern areas, the decline was less with 21%. Furthermore, there was also an eastward shift of distribution and centre of gravity within the Norwegian Sea (ICES, 2018a).

Geographical distribution of the 2016 cohort at age 0 and 1 was different from the traditional juvenile distribution patterns. The 2016 cohort was observed from latitude 60-71°N along the coast and offshore areas of Norway based on various survey data and fishing data (Nøttestad *et a*l., 2018). Traditional, 0- and 1-group of mackerel reside further south in waters of the southernmost part of Norway.

An historical and very pronounced shift in distribution of juvenile mackerel took place along the Norwegian coast starting off during the autumn of 2016 onwards (ICES, 2017b; Nøttestad *et al*., 2017; Nøttestad *et al*., 2018). This also coincided with increased number of adult and mature mackerel in northern waters from May to July 2016 (ICES, 2016) as well as from May to July 2017-2018 (ICES, 2017; Nøttestad *et al*. 2018). The prevalence of adult mackerel in the northern North Sea and southern Norwegian Sea increased markedly in first quarter and second quarter 2016, compared to the two previous years in 2014 and 2015, suggesting a shift in spawning of mackerel towards the north and northeast (Nøttestad *et al*., 2018).

The results showed also a marked increase in the presence of zero-year and one-year old mackerel in the northern North Sea and Skagerrak first quarter 2017, compared to first quarter 2014-2016. In the second quarter there were strong indications of spawning mackerel outside and north of the spatial and temporal coverage during the 2016 mackerel egg survey (Nøttestad *et al*., 2018).

Spatial mackerel distribution related to environmental conditions

Mackerel was present in temperatures ranging from 5 °C to 15 °C, but preferred areas with temperatures between 9 °C and 13 °C according to univariate quotient analysis according to Ólafsdóttir *et al*. (2018). Generalized additive models showed that both mackerel occurrence and density were positively related to location, ambient temperature, meso-zooplankton density and SSB, explaining 47% and 32% of deviance, respectively (Ólafsdóttir *et al*. 2018). Mackerel relative mean weight-at-length was positively related to location, day-of-year, temperature and SSB, but not with meso-zooplankton density, explaining 40% of the deviance. Geographical expansion of mackerel during the summer feeding season in Nordic Seas was driven by increasing mackerel stock size and constrained by availability of preferred temperature and abundance of meso-zooplankton (Ólafsdóttir *et al*., 2018). Marine climate with multidecadal variability probably impacted the observed distributional changes but were not evaluated. Our results were limited to the direct effects of temperature, meso-zooplankton abundance, and SSB on distribution range during the last two decades (1997-2016) and should be viewed as such. In the 2018 IESSNS a marked change in the spatial distribution of mackerel was observed with lower densities of mackerel in the western distributions areas (East Greenland and Iceland) as compared to the recent years (see Figure 8.6.3.1). It is not clear what causes this distributional shift, but the SST were 1-1.5°C lower in the western and south-western areas as compared to a 20 years mean (1999-2009) might partly explain such changes (ICES, 2018a).

Trophic interactions

There are strong indications for interspecific competition for food between NSS-herring, blue whiting and mackerel (Huse *et al*., 2012). According to Langøy *et al*. (2012), Debes *et al*. (2012), Óskarsson *et al*. (2015) and Bachiller *et al*. (2016), the herring may suffer from this competition, as mackerel had higher stomach fullness index than herring and the herring stomach composition is different from previous periods when mackerel stock size was smaller. Langøy *et al* (2012) and Debes *et al*. (2012) also found that mackerel consumed wider range of prey species than herring. Mackerel may thus be thriving better in periods with low zooplankton abundances. Feeding incidence increased with decreasing temperature as well as stomach filling degree, indicating that feeding activity is highest in areas associated with colder water masses (Bachiller *et al*., 2016). A bioenergetics model being developed by Bachiller *et al*. (2016) estimates that the NEA mackerel, NSS herring and blue whiting can consume between 122 and 135 million tonnes of zooplankton per year (2005-2010) This is higher than that estimated in previous studies (e.g. Utne *et al*., 2012; Skjoldal *et al*., 2004). NEA mackerel feeding rate can consequently be as high as that of the NSS herring in some years. Geographical distribution overlap between mackerel and NSS herring during the summer feeding season is highest in the south-western part of the Norwegian Sea (Faroe and east Icelandic area) (Nøttestad *et al*. 2016; 2017; Ólafsdóttir *et al*., 2018). The spatio-temporal overlap between mackerel and herring was highest in the southern and south-western part of the Norwegian Sea in 2018 (ICES, 2018a). This is similar as seen in previous years (Nøttestad *et al*. 2016; 2017). There was practically no overlap between NEA mackerel and NSSH in the central and northern part of the Norwegian Sea in 2018, mainly because of very limited amounts of herring in this area (ICES, 2018a).

The increase of 0- and 1-groups of NEA mackerel found along major coastlines of Norway both in 2016 and 2017 (Nøttestad *et al*., 2018), has created some interesting new trophic interactions. Increasingly numbers of adult Atlantic bluefin tuna (*Thynnus thunnus*), with an average size of approximately 200 kg, have been documented to feed

on 0-group mackerel from the 2016, 2017-year classes during the commercial bluefin tuna fishery in Norway (Nøttestad *et al*., 2017b). Additionally, the new situation of numerous 0- and 1-group mackerel in Norwegian coastal waters have created favourable feeding possibilities for larger cod, saithe, marine mammals and seabirds in these waters. Repeated stomach samples from several species document that smaller sized mackerel is now eaten by different predators in northern waters (60-70°N).

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8.14 Tables

Table 8.2.1. 2017 Mackerel fleet composition of major mackerel catching nations.

Country	Len (m)	Engine power (hp)	Gear	Storage	No vessels
Denmark	57-88	4077-8158	Trawl	Tank	8
Faroe Islands	50-69	3460-8000 kw	Purse Seine/Trawl	RSW	3
	70-76	3920-7500 kw	Purse Seine/Trawl	RSW	4
	73-104	6000-6600 kw	Trawl	Freezer	2
	15-49	300-1940 kw	Trawl		20
	50-79	3000-7680 kw	Trawl		7
France	<24		Trawl		1230
	>24		Trawl		36
Germany	90-140	3800-12000	Single Midwater Trawl	Freezer	4
Greenland	66-80	4011-10034	Trawl	RSW	9
	55-88	3712-8164	Trawl	Freezer/RSW	5
	65-120	3002-9517	Trawl	Freezer	12
Iceland	51-60	2502-4079	Single Midwater Trawl	RSW, Freezer	6
	61-70	2000-7507	Single Midwater Trawl	RSW, Freezer	17
	71-80	3200-11257	Single Midwater Trawl	RSW, Freezer	12
	>80	8051	Single Midwater Trawl	Freezer	1
Ireland	27m-65m	522-2720	Pair Midwater Trawl	RSW	14
	14m-45m	160-1119	Pair Midwater Trawl	Dryhold	23
	51m-71m	1007-3840	Midwater Trawl	RSW	8
	12m-17m	90-171	Midwater Trawl	Dryhold	2
Netherlands	55	2125	Pair Midwater Trawl	Freezer	1
	88-145	4400-10455	Single Midwater Trawl	Freezer	9
Norway	60-85 m		Purse seiner	RSW	78
	30-40 m		Purse seiner	Dryhold, RSW	16
	10-17 m		Purse seiner	Dryhold	178
	10-17 m		Hook and line/nets	Dryhold	169
	10-17 m		PS/hooks/nets	Dryhold	200
	30-40 m		Trawl	Dryhold.Tankhold	17
Portugal	0-10		Other		94
	10-20		OTB		3
	10-20		Other		86
	20-30		OTB		27
	20-30		Other		16
	30-40		Trawl		7
Spain	12-18	80-294	Trawl	Dryhold	12
	18-24	96-344	Trawl	Dryhold	30
	24-40	191-876	Trawl	Dryhold	72
	40-	353	Trawl	Dryhold	2
	0-10	34-44	Purse Seine	Dryhold	2
	10-12	20-106	Purse Seine	Dryhold	13
	12-18	21-245	Purse Seine	Dryhold	112
	18-24	70-397	Purse Seine	Dryhold	100
	24-40	140-809	Purse Seine	Dryhold	99
	0-10	3-74	Artisanal	Dryhold	329
	10-12	12-118	Artisanal	Dryhold	203
	12-18	18-239	Artisanal	Dryhold	208
	18-24	59-368	Artisanal	Dryhold	40
	24-40	129-368	Artisanal	Dryhold	11

1 RSW = refrigerated seawater.

Table 8.2.4.1. Overview of major existing regulations on mackerel catches.

TECHNICAL MEASURE	NATIONAL/INTERNATIONAL LEVEL	SPECIFICATION	NOTE
Catch limitation	Coastal States/NEAFC	2010-2018	Not agreed
Management strategy (EU, NO, FO agreement London 12. Oct. 2014)	European (EU, NO, FO)	If SSB >= 3.000.000t, F = 0.24 If SSB is less than 3.000.000t, F = 0.24 * SSB/3.000.000 TAC should not be changed more than 20% A party may transfer up to 10% of unutilised quota to the next year	Not agreed by all parties
Management strategy with updated reference points 2017 (EU, NO, FO agreement London 11. Oct. 2017)	European (EU, NO, FO)	If SSB >= 2.570.000t, F = 0.21 If SSB is less than 2.570.000t, F = 0.21 * SSB/2.570.000 TAC should not be changed more than +25% or -20% A party may transfer up to 10% of unutilised quota to the next year A party may fish up to 10% beyond the allocated quota, that have to be deduced from next years quota.	Not agreed by all parties
Minimum size (North Sea)	European (EU, NO, FO)	30 cm in the North Sea	
Minimum size (all areas except North Sea)	European (EU, NO)	20 cm in all areas except North Sea	10% undersized allowed
Minimum size	National (NO)	30 cm in all areas	
Catch limitation	European (EU, NO, FO)	Within the limits of the quota for the western component (VI,VII, VIIIabde, Vb(EC), IIa(nonEC), XII, XIV), a certain quantity may be taken from IVa but only during the periods 1 January to 15 February and 1 October to 31 December.	
Area closure	National (UK)	South-West Mackerel Box off Cornwall	Except where the weight of the mackerel does not exceed 15 % by liveweight of the total quantities of mackerel and other marine organisms onboard which have been caught in this area
Area limitations	National (IS)	Pelagic trawl fishery only allowed outside of 200m depth contours around Iceland and/or 12 nm from the coast.	
National catch limitations by gear, semester and area	National (ES)	28.74% of the Spanish national quota is assigned for the trawl fishery, 34.29% for purse seiners and 36.97% for the artisanal fishery	Since 2015, the trawl fishery has the individual quotas assigned by vessel.
Discard prohibition	National (NO, IS, FO)	All discarding is prohibited for Norwegian, Icelandic and Faroese vessels	
Landing Obligation	European	From 2015 onwards a landing obligation for European Union fisheries is in place for small pelagics including mackerel, horse mackerel, blue whiting and herring. Since 2016 is also partly in place for demersal fisheries.	

Table 8.4.1.1. NE Atlantic Mackerel. ICES estimated catches by area (t). Discards not estimated prior to 1978 (data submitted by Working Group members).

Year	Subarea 6			Subarea 7 and Divisions 8.abde			Subareas 3 and 4			Subareas 1 2 5 and 14			Divisions 8.c and 9.a			Total		
	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch
1969	4800		4800	47404		47404	739175		739175	7		7	42526		42526	833912		833912
1970	3900		3900	72822		72822	322451		322451	163		163	70172		70172	469508		469508
1971	10200		10200	89745		89745	243673		243673	358		358	32942		32942	376918		376918
1972	13000		13000	130280		130280	188599		188599	88		88	29262		29262	361229		361229
1973	52200		52200	144807		144807	326519		326519	21600		21600	25967		25967	571093		571093
1974	64100		64100	207665		207665	298391		298391	6800		6800	30630		30630	607586		607586
1975	64800		64800	395995		395995	263062		263062	34700		34700	25457		25457	784014		784014
1976	67800		67800	420920		420920	305709		305709	10500		10500	23306		23306	828235		828235
1977	74800		74800	259100		259100	259531		259531	1400		1400	25416		25416	620247		620247
1978	151700	15100	166800	355500	35500	391000	148817		148817	4200		4200	25909		25909	686126	50600	736726
1979	203300	20300	223600	398000	39800	437800	152323	500	152823	7000		7000	21932		21932	782555	60600	843155
1980	218700	6000	224700	386100	15600	401700	87931		87931	8300		8300	12280		12280	713311	21600	734911
1981	335100	2500	337600	274300	39800	314100	64172	3216	67388	18700		18700	16688		16688	708960	45516	754476

Year	Subarea 6	Subarea 7 and Divisions 8.abde				Subareas 3 and 4			Subareas 1 2 5 and 14		Divisions 8.c and 9.a		Total			
1982	340400	4100	344500	257800	20800	278600	35033	450	35483	37600	37600	21076	21076	691909	25350	717259
1983	320500	2300	322800	235000	9000	244000	40889	96	40985	49000	49000	14853	14853	660242	11396	671638
1984	306100	1600	307700	161400	10500	171900	43696	202	43898	98222	98222	20208	20208	629626	12302	641928
1985	388140	2735	390875	75043	1800	76843	46790	3656	50446	78000	78000	18111	18111	606084	8191	614275
1986	104100		104100	128499		128499	236309	7431	243740	101000	101000	24789	24789	594697	7431	602128

Table 8.4.1.1. NE Atlantic Mackerel. ICES estimated catches by area (t). Discards not estimated prior to 1978 (data submitted by Working Group members). Continued.

Year	Subarea 6			Subarea 7 and Divisions 8.abde			Subareas 3 and 4			Subareas 1 2 5 and 14			Divisions 8.c and 9.a			Total		
	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch
1987	183700		183700	100300		100300	290829	10789	301618	47000		47000	22187		22187	644016	10789	654805
1988	115600	3100	118700	75600	2700	78300	308550	29766	338316	120404		120404	24772		24772	644926	35566	680492
1989	121300	2600	123900	72900	2300	75200	279410	2190	281600	90488		90488	18321		18321	582419	7090	589509
1990	114800	5800	120600	56300	5500	61800	300800	4300	305100	118700		118700	21311		21311	611911	15600	627511
1991	109500	10700	120200	50500	12800	63300	358700	7200	365900	97800		97800	20683		20683	637183	30700	667883
1992	141906	9620	151526	72153	12400	84553	364184	2980	367164	139062		139062	18046		18046	735351	25000	760351
1993	133497	2670	136167	99828	12790	112618	387838	2720	390558	165973		165973	19720		19720	806856	18180	825036
1994	134338	1390	135728	113088	2830	115918	471247	1150	472397	72309		72309	25043		25043	816025	5370	821395
1995	145626	74	145700	117883	6917	124800	321474	730	322204	135496		135496	27600		27600	748079	7721	755800
1996	129895	255	130150	73351	9773	83124	211451	1387	212838	103376		103376	34123		34123	552196	11415	563611
1997	65044	2240	67284	114719	13817	128536	226680	2807	229487	103598		103598	40708		40708	550749	18864	569613
1998	110141	71	110212	105181	3206	108387	264947	4735	269682	134219		134219	44164		44164	658652	8012	666664
1999	116362		116362	94290		94290	313014		313014	72848		72848	43796		43796	640311		640311

Year	Subarea 6			Subarea 7 and Divisions 8.abde			Subareas 3 and 4			Subareas 1 2 5 and 14			Divisions 8.c and 9.a			Total		
2000	187595	1	187595	115566	1918	117484	285567	165	304898	92557		92557	36074		36074	736524	2084	738608
2001	143142	83	143142	142890	1081	143971	327200	24	339971	67097		67097	43198		43198	736274	1188	737462
2002	136847	12931	149778	102484	2260	104744	375708	8583	394878	73929		73929	49576		49576	749131	23774	772905
2003	135690	1399	137089	90356	5712	96068	354109	11785	365894	53883		53883	25823	531	26354	659831	19427	679288
2004	134033	1705	134738	103703	5991	109694	306040	11329	317369	62913	9	62922	34840	928	35769	640529	19962	660491
2005	79960	8201	88162	90278	12158	102436	249741	4633	254374	54129		54129	49618	796	50414	523726	25788	549514

Table 8.4.1.1. NE Atlantic Mackerel. ICES estimated catches by area (t). Discards not estimated prior to 1978 (data submitted by Working Group members). Continued.

Year	Subarea 6			Subarea 7 and Divisions 8.abde			Subareas 3 and 4			Subareas 1 2 5 and 14			Divisions 8.c and 9.a			Total		
	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch	Ldg	Disc	Catch
2006	88077	6081	94158	66209	8642	74851	200929	8263	209192	46716		46716	52751	3607	56358	454587	26594	481181
2007	110788	2450	113238	71235	7727	78962	253013	4195	257208	72891		72891	62834	1072	63906	570762	15444	586206
2008	76358	21889	98247	73954	5462	79416	227252	8862	236113	148669	112	148781	59859	750	60609	586090	37075	623165
2009	135468	3927	139395	88287	2921	91208	226928	8120	235049	163604		163604	107747	966	108713	722035	15934	737969
2010	106732	2904	109636	104128	4614	108741	246818	883	247700	355725	5	355729	49068	4640	53708	862470	13045	875515
2011	160756	1836	162592	51098	5317	56415	301746	1906	303652	398132	28	398160	24036	1807	25843	935767	10894	946661
2012	121115	952	122067	65728	9701	75429	218400	1089	219489	449325	1	449326	24941	3431	28372	879510	15174	894684
2013	132062	273	132335	49871	1652	51523	260921	337	261258	465714	15	465729	19733	2455	22188	928433	4732	933165
2014	180068	340	180408	93709	1402	95111	383887	334	384221	684082	91	684173	46257	4284	50541	1388003	6451	1394454
2015	134728	30	134757	98563	3155	101718	295877	34	295911	632493	78	632571	36899	7133	44033	1198560	10431	1208990
2016	206326	200	206526	37300	1927	39227	248041	570	248611	563440	54	563494	32987	3220	36207	1088094	5971	1094066
2017	225959	151	226110	21128	1992	23119	269404	400	269804	603806	62	603869	32815	227	33042	1153112	2832	1155944

Table 8.4.2.1. NE Atlantic Mackerel. ICES estimated catch (t) in Subareas 1, 2, 5 and 14, 1984–2017 (Data submitted by Working Group members).

Country	1984	1985	1986	1987	1988	1989	1990	1991	1992
Denmark	11787	7610	1653	3133	4265	6433	6800	1098	251
Estonia									216
Faroe Islands	137				22	1247	3100	5793	3347
France		16				11		23	6
Germany Fed. Rep.			99		380				
Germany Dem. Rep.			16	292		2409			
Iceland									
Ireland									
Latvia									100
Lithuania									
Netherlands									
Norway	82005	61065	85400	25000	86400	68300	77200	76760	91900
Poland									
Sweden									
United Kingdom			2131	157	1413		400	514	802
USSR/Russia	4293	9405	11813	18604	27924	12088	28900	13361	42440
Misreported (Area 4.a)									
Misreported (Area 6.a)									
Misreported (Unknown)									
Unallocated									
Discards									
Total	98222	78096	101112	47186	120404	90488	118700	97819	139062

Table 8.4.2.1. NE Atlantic Mackerel. ICES estimated catch (t) in Areas 1, 2, 5 and 14, 1984–2017. Continued.

COUNTRY	1993	1994	1995	1996	1997	1998	1999	2000
Denmark			4746	3198	37	2090	106	1375
Estonia		3302	1925	3741	4422	7356	3595	2673
Faroe Islands	1167	6258	9032	2965	5777	2716	3011	5546
France	6	5	5		270			
Germany								
Greenland				1				
Iceland				92	925	357		
Ireland							100	
Latvia	4700	1508	389	233				
Lithuania								2085
Netherlands				561			661	
Norway	100500	141114	93315	47992	41000	54477	53821	31778
Poland					22			
Sweden								
United Kingdom		1706	194	48	938	199	662	
Russia	49600	28041	44537	44545	50207	67201	51003	491001
Misreported (Area 4.a)		-109625	-18647			-177	-40011	
Misreported (Area 6.a)							-100	
Misreported (Unknown)								
Unallocated								
Discards								
Total	165973	72309	135496	103376	103598	134219	72848	92557

Table 8.4.2.1. NE Atlantic Mackerel. ICES estimated catch (t) in Areas 1, 2, 5, and 14, 1984–2017. Continued.

Country	2001	2002	2003	2004	2005	2006	2007	2008
Denmark	7	1						
Estonia	219							
Faroe Islands	3272	4730		650	30		278	123
France				2	1			
Germany							7	
Greenland								
Iceland		53	122		363	4222	36706	112286
Ireland			495	471				
Latvia								
Lithuania								
Netherlands		569	44	34	2393		10	72
Norway	21971	22670	125481	10295	13244	8914	493	3474
Poland								
Sweden	8							
United Kingdom	54	665	692	2493				4
Russia	41566	45811	40026	49489	40491	33580	35408	32728
Misreported (Area 4.a)								
Misreported (Area 6.a)								
Misreported (Unknown)		-570		-553				
Unallocated			-44	32	-2393		-10	-18
Discards				9				112
Total	67097	73929	53883	62922	54129	46716	72891	148781

Table 8.4.2.1. NE Atlantic Mackerel. ICES estimated catch (t) in Areas 1, 2, 5, and 14, 1984–2017. Continued.

COUNTRY	2009	2010	2011	2012	2013	2014	2015	2016	2017
Denmark		4845	269		391	2345	4321	1	2
Estonia					13671		0		
Faroe Islands	2992	66312	121499	107198	142976	103896	76889	61901	66194
France			2		197	8	36		
Germany				107	74		2963	3499	4064
Greenland			621	74021	541481	875811	30351	36142	46388
Iceland	116160	121008	159263	149282	151103	172960	169333	170374	167366
Ireland			90			1725	6	2	
Latvia									
Lithuania						1082		1931	
Netherlands		90	178	5	1	5887	6996	8599	7671
Norway	3038	104858	43168	110741	33817	192322	204574	153228	167739
Poland									
Sweden				4	825	3310	740	730	1720
United Kingdom					2	5534	7851	5240	4601
Russia	414141	58613	73601	74587	80812	116433	128433	121614	138061
Misreported (Area 4.a)									
Misreported (Area 6.a)									
Misreported (Unknown)									
Unallocated									
Discards		5	28	1	151	911	78	54	62
Total	163604	355729	398160	449326	465729	684173	632571	563315	603869

Table 8.4.2.2. NE Atlantic Mackerel. ICES estimated catch (t) in the North Sea, Skagerrak and Kattegat (Subarea 4 and Division 3.a), 1988-2017 (Data submitted by Working Group members).

Country	1988	1989	1990	1991	1992	1993	1994	1995
Belgium	20	37		125	102	191	351	106
Denmark	32588	26831	29000	38834	41719	42502	47852	30891
Estonia					400			
Faroe Islands		2685	5900	5338		11408	11027	17883
France	1806	2200	1600	2362	956	1480	1570	1599
Germany Fed. Rep.	177	6312	3500	4173	4610	4940	1497	712
Iceland								
Ireland		8880	12800	13000	13136	13206	9032	5607
Latvia					211			
Lithuania								
Netherlands	2564	7343	13700	4591	6547	7770	3637	1275
Norway	59750	81400	74500	102350	115700	112700	114428	108890
Poland								
Romania							2903	
Sweden	1003	6601	6400	4227	5100	5934	7099	6285
United Kingdom	1002	38660	30800	36917	35137	41010	27479	21609
USSR (Russia from 1990)								
Misreported (Area 2.a)							109625	18647
Misreported (Area 6.a)	180000	92000	126000	130000	127000	146697	134765	106987
Misreported (Unknown)								
Unallocated	29630	6461	-3400	16758	13566			983
Discards	29776	2190	4300	7200	2980	2720	1150	730
Total	338316	281600	305100	365875	367164	390558	472397	322204

Table 8.4.2.2. NE Atlantic Mackerel. ICES estimated catch (t) in the North Sea, Skagerrak and Kattegat (Sub-area 4 and Division 3.a), 1988-2017. Continued.

Country	1996	1997	1998	1999	2000	2001	2002
Belgium	62	114	125	177	146	97	22
Denmark	24057	21934	25326	29353	27720	21680	343751
Estonia							
Faroe Islands	13886	32882	4832	4370	10614	18751	12548
France	1316	1532	1908	2056	1588	1981	2152
Germany	542	213	423	473	78	4514	3902
Iceland				357			
Ireland	5280	280	145	11293	9956	10284	20715
Latvia							
Lithuania							
Netherlands	1996	951	1373	2819	2262	2441	11044
Norway	88444	96300	103700	106917	142320	158401	161621
Poland							
Romania							
Sweden	5307	4714	5146	5233	49941	5090	52321
United Kingdom	18545	19204	19755	32396	58282	52988	61781
Russia		3525	635	345	1672	1	
Misreported (Area 2.a)				40000			
Misreported (Area 6.a)	51781	73523	98432	59882	8591	39024	49918
Misreported (Unknown)							
Unallocated	236	1102	3147	17344	34761	24873	22985
Discards	1387	2807	4753		1912	24	8583
Total	212839	229487	269700	313015	304896	339970	394878

Table 8.4.2.2. NE Atlantic Mackerel. ICES estimated catch (t) in the North Sea, Skagerrak and Kattegat (Subarea 4 and Division 3.a), 1988-2017. Continued.

Country	2003	2004	2005	2006	2007	2008	2009
Belgium	2	4	1	3	1	2	3
Denmark	275081	25665	232121	242191	252171	26716	23491
Estonia							
Faroe Islands	11754	11705	9739	12008	11818	7627	6648
France	1467	1538	1004	285	7549	490	1493
Germany	4859	4515	4442	2389	5383	4668	5158
Iceland							
Ireland	17145	18901	15605	4125	13337	11628	12901
Latvia							
Lithuania							
Netherlands	6784	6366	3915	4093	5973	1980	2039
Norway	150858	147068	106434	113079	131191	114102	118070
Poland			109				
Romania							
Sweden	4450	4437	3204	3209	38581	36641	73031
United Kingdom	67083	62932	37118	28628	46264	37055	47863
Russia			4				
Misreported (Area 2.a)							
Misreported (Area 6.a)	62928	23692	37911	8719		17280	1959
Misreported (Unknown)							
Unallocated	-730	-783	7043	171	2421	2039	-629
Discards	11785	11329	4633	8263	4195	8862	8120
Total	365894	317369	254374	209192	257208	236111	235049

Table 8.4.2.2. NE Atlantic Mackerel. ICES estimated catch (t) in the North Sea, Skagerrak and Kattegat (Subarea 4 and Division 3.a), 1988-2017. Continued.

COUNTRY	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	27	21	39	62	56	38	99	107
Denmark	36552	32800	36492	31924	21340	35809	21696	27457
Estonia								
Faroe Islands	4639	543	432	25	42919	25672	18193	12915
France	686	1416	5736	1788	4912	7827	3448	5942
Germany	25621	52911	4560	5755	4979	6056	10172	11185
Iceland								
Ireland	14639	15810	20422	13523	45167	34167	24437	35957
Latvia								
Lithuania					8340		596	
Netherlands	1300	9881	6018	4863	24536	17547	11434	17401
Norway	129064	162878	64181	130056	85409	36344	55089	51960
Poland						24		0.721
Romania								
Sweden	34291	32481	4560	2081	1112	3190	2933	1981
United Kingdom	52563	69858	75959	70840	145119	129203	99945	104499
Russia	696			4				
Misreported (Area 2.a)								
Misreported (Area 6.a)								
Misreported (Unknown)								
Unallocated	660							
Discards	883	1906	1089	337	334	34	559	400
Total	247700	303652	219489	261258	384221	295911	248611	269804

Table 8.4.2.3. NE Atlantic Mackerel. ICES estimated catch (t) in the Western area (Sub-areas 6 and 7 and Divisions 8.a,b,d,e), 1985–2017 (Data submitted by Working Group members).

Country	1985	1986	1987	1988	1989	1990	1991	1992
Belgium								
Denmark	400	300	100		1000		1573	194
Estonia								
Faroe Islands	9900	1400	7100	2600	1100	1000		
France	7400	11200	11100	8900	12700	17400	4095	
Germany	11800	7700	13300	15900	16200	18100	10364	9109
Guernsey								
Ireland	91400	74500	89500	85800	61100	61500	17138	21952
Isle of Man								
Jersey								
Lithuania								
Netherlands	37000	58900	31700	26100	24000	24500	64827	76313
Norway	24300	21000	21600	17300	700		29156	32365
Poland								
Spain				1500	1400	400	4020	2764
United Kingdom	205900	156300	200700	208400	149100	162700	162588	196890
Misreported (Area 4.a)		-148000	-117000	-180000	-92000	-126000	-130000	-127000
Misreported (Unknown)								
Unallocated	75100	49299	26000	4700	18900	11500	-3802	1472
Discards	4500			5800	4900	11300	23550	22020
Total	467700	232599	284100	197000	199100	182400	183509	236079

Table 8.4.2.3. NE Atlantic Mackerel. ICES estimated catch (t) in the Western area (Sub-areas 6 and 7 and Divisions 8.a,b,d,e), 1985–2017 (Data submitted by Working Group members).

COUNTRY	1993	1994	1995	1996	1997	1998	1999	2000
Belgium								
Denmark		2239	1143	1271			552	82
Estonia			361					
Faroe Islands		4283	4284		24481	3681	4239	4863
France	2350	9998	10178	14347	19114	15927	14311	17857
Germany	8296	25011	23703	15685	15161	20989	19476	22901
Guernsey								
Ireland	23776	79996	72927	49033	52849	66505	48282	61277
Isle of Man								
Jersey								
Lithuania								
Netherlands	81773	40698	34514	34203	22749	28790	25141	30123
Norway	44600	2552			223			
Poland	600							
Spain	3162	4126	4509	2271	7842	3340	4120	4500
United Kingdom	215265	208656	190344	127612	128836	165994	127094	126620
Misreported (Area 4.a)	-146697	-134765	-106987	-51781	-73523	-98255	-59982	-3775
Misreported (Unknown)								
Unallocated		4632	28245	10603	4577	8351	21652	31564
Discards	15660	4220	6991	10028	16057	3277		1920
Total	248785	251646	270212	213272	196110	218599	204885	297932

Table 8.4.2.3. NE Atlantic Mackerel. ICES estimated catch (t) in the Western area (Sub-areas 6 and 7 and Divisions 8.a,b,d,e), 1985–2017. Continued.

Country	2001	2002	2003	2004	2005	2006	2007	2008
Belgium				1				
Denmark	835		113				6	10
Estonia								
Faroe Islands	2161	2490	2260	674		59	1333	3539
France	18975	19726	21213	18549	15182	14625	12434	14944
Germany	20793	22630	19200	18730	14598	14219	12831	10834
Guernsey						10		
Ireland	60168	51457	49715	41730	30082	36539	35923	33132
Isle of Man								
Jersey					9	8	6	7
Lithuania						95	7	
Netherlands	33654	21831	23640	21132	18819	20064	18261	17920
Norway							7	3948
Poland					461	1368	978	
Russia								
Spain	4063	3483			4795	4048	2772	7327
United Kingdom	139589	131599	167246	149346	115586	67187	87424	768821
Misreported (Area 4.a)	-39024	-43339	-62928	-23139	-37911	-8719		-17280
Misreported (Unknown)								
Unallocated	37952	27558	5587	9714	13412	4783	10042	-952
Discards	1164	15191	7111	7696	20359	14723	10177	27351
Total	280553	252620	233157	244432	190597	169009	192201	177662

Table 8.4.2.3. NE Atlantic Mackerel. ICES estimated catch (t) in the Western area (Sub-areas 6 and 7 and Divisions 8.a,b,d,e), 1985–2017. Continued.

COUNTRY	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgium	1	2					14	44	21
Denmark		48	2889	8	903	18538	6741	19443	12569
Estonia									
Faroe Islands	4421	36	8			3421	5851	13173	20559
France	16464	10301	11304	14448	12438	16627	17820	16634	16925
Germany	17545	16493	18792	14277	15102	23478	19238	9740	9608
Guernsey			10	5	9	9	4		
Ireland	48155	43355	45696	42627	42988	56286	54571	52087	48957
Isle of Man		14	11	11	8	3		8	2
Jersey	8	6	7	8	8	7	3	3	0.003
Lithuania			23			176	554	13	
Netherlands	20900	21699	18336	19794	16295	16242	15264	17896	18694
Norway	121	30	2019	1101	734		1313	1035	2657
Poland									
Russia		1						30	
Spain	8462	6532	1257	773	635	1796	951	1253	786
United Kingdom	109147	107840	111103	93775	92957	137195	110932	112268	116308
Misreported (Area 4.a)	-1959								
Misreported (Unknown)									
Unallocated	490	4503	399	16	-144		34		
Discards	6848	7518	7153	10654	2105	1742	3185	2126	2142
Total	230603	218377	219007	197496	183857	275519	236475	245754	249229

Table 8.4.2.4. NE Atlantic Mackerel. ICES estimated catch (t) in Divisions 8.c and 9.a, 1977–2017 (Data submitted by Working Group members).

COUNTRY	DIV	1977	1978	1979	1980	1981	1982	1983	1984	1985
France	8.c									
Poland	9.a	8								
Portugal	9.a	1743	1555	1071	1929	3108	3018	2239	2250	4178
Spain	8.c	19852	18543	15013	11316	12834	15621	10390	13852	11810
Spain	9.a	2935	6221	6280	2719	2111	2437	2224	4206	2123
USSR	9.a	2879	189	111						
Total	9.a	7565	7965	7462	4648	5219	5455	4463	6456	6301
Total		27417	26508	22475	15964	18053	21076	14853	20308	18111

Country	**Div**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
France	8.c									
Poland	9.a									
Portugal	9.a	6419	5714	4388	3112	3819	2789	3576	2015	2158
Spain	8.c	16533	15982	16844	13446	16086	16940	12043	16675	21246
Spain	9.a	1837	491	3540	1763	1406	1051	2427	1027	1741
USSR	9.a									
Total	9.a	8256	6205	7928	4875	5225	3840	6003	3042	3899
Total		24789	22187	24772	18321	21311	20780	18046	19719	25045

Country	**Div**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
France	8.c									226
Poland	9.a									
Portugal	9.a	2893	3023	2080	2897	2002	2253	3119	2934	2749
Spain	8.c	23631	28386	35015	36174	37631	30061	38205	38703	17384
Spain	9.a	1025	2714	3613	5093	4164	3760	1874	7938	5464
Discards	8.c									531
Discards	9.a	3918	5737	5693	7990	6165	6013			
Total	9.a	27549	34123	40708	44164	43796	36074	4993	10873	8213
Total								43198	49575	26354

Table 8.4.2.4. NE Atlantic Mackerel. ICES estimated catch (t) in Divisions 8.c and 9.a, 1977–2017 (Data submitted by Working Group members). Continued.

COUNTRY	DIV	2004	2005	2006	2007	2008	2009	2010	2011	2012
France	8.c	177	151	43	55	168	383	392	44	283
Poland	9.a									
Portugal	9.a	2289	1509	2620	2605	2381	1753	2363	962	824
Spain	8.c			43063	53401	50455	91043	38858	14709	17768
Spain	9.a			7025	6773	6855	14569	7347	2759	845
Discards	8.c	928	391	3606	156	73	725	4408	563	2187
Discards	9.a		405	1	916	677	241	232	1245	1244
Unallocated	8.c	28429	42851						4691	4144
Unallocated	9.a	3946	5107					108	871	1076
Total	9.a	6234	7021	9646	10293	9913	16562	10049	5836	3989
Total		35768	50414	56358	63906	60609	108713	53708	25843	28372

Country	**Div**	**2013**	**2014**	**2015**	**2016**	**2017**
France	8.c	220	171	21	106	83
Portugal	9.a	254	618	1456	619	634
Spain	8.c	14617	33783	29726	26553	30893
Spain	9.a	1162	2227	3853	2229	1206
Discards	8.c	1428	2821	4724	2469	84
Discards	9.a	1027	1463	2409	751	143
Unallocated	8.c	-573	8795	11	1357	
Unallocated	9.a	4053	662	1831	2123	
Total	9.a	6497	4308	9550	5722	1983
Total		22188	45570	44033	36207	33042

Table 8.4.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2017.

Quarters 1-4

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	6469.5	1.2	166.3	22.5	1.2	1.1	0.1	16153.1	59.3
2	4144.3	2.4	332.5	51.0	1.9	1.0	0.3	47117.9	1966.2
3	184206.6	40.7	1342.7	278.4	8.3	10.9	1.6	144879.1	5758.8
4	137156.9	56.4	1360.5	196.7	0.6	4.7	1.7	93088.2	1235.3
5	130056.2	104.1	1511.4	224.5	2.4	8.8	1.4	96425.7	1163.5
6	207130.8	274.1	1374.7	284.7	6.2	12.3	1.5	100433.4	1241.8
7	192363.7	193.2	930.2	269.3	6.2	8.1	1.1	81246.2	1142.2
8	98036.7	95.1	250.1	186.5	3.5	5.8	0.6	51452.8	935.5
9	69092.1	50.1	483.4	104.0	2.0	2.9	0.3	31025.3	428.7
10	52518.2	19.8	591.1	98.1	2.0	2.0	0.4	25330.3	550.1
11	21175.0	1.0	143.3	28.2	0.6	0.6	0.1	9160.7	44.2
12	13075.8	1.0	143.3	23.0	0.1	0.1	0.1	5059.8	138.8
13	5163.8			16.3	0.1		0.1	1819.4	129.2
14	1652.8			10.7	0.1	0.1		844.7	105.8
15+	1328.8			0.8				220.1	5.4
Catch	461313.5	404.3	3636.5	686.0	12.4	22.8	3.5	263824.6	4723.4
SOP	461303.9	404.3	3636.5	686.3	12.4	22.8	3.6	263661.4	4725.4
SOP%	100%	100%	100%	100%	100%	100%	98%	100%	100%
AGE	**4.c**	**5.a**	**5.b**	**6.a**	**6.b**	**7.a**	**7.b**	**7.c**	**7.d**
0				36.1					
1	22.3		29.6	1896.2		0.1	30.3	20.3	395.9
2	516.6	908.6	128.2	4510.6	47.2	0.9	182.6	6.6	5676.2
3	436.5	8545.6	3134.2	46897.1	106.3	2.8	1378.1	3.3	5653.7
4	107.2	20461.0	2819.6	58059.9	39.7	2.3	770.4	1.4	1499.6
5	207.1	39384.5	3956.7	85304.6	0.9	4.5	2813.3	2.7	2376.4
6	135.8	49629.6	5602.4	105243.8	1.0	4.0	3360.9	5.2	1637.2
7	98.1	32370.6	4854.3	94518.4	0.7	5.5	2314.0	6.4	883.3
8	61.0	19226.1	3360.7	72337.6	0.4	2.5	2933.7	3.2	719.1
9	58.1	15585.2	1941.0	59501.7	0.3	3.5	2509.9	4.7	470.2
10	48.3	7674.4	1771.6	44873.8	0.2	3.1	1219.3	2.3	316.5
11	22.7	2953.6	222.5	23383.1	0.1	1.6	722.1	1.4	105.8
12	4.5	1420.9	424.4	11126.9		0.4	113.2		44.2
13	2.6	4.9	325.3	4280.6		0.1	65.0		17.0
14	2.1		269.6	1803.1		0.0	17.3		6.9
15+	1.2			600.7		0.0	0.0		12.6
Catch	531.6	87734.0	11343.6	226056.0	53.6	10.5	6420.5	17.8	6082.3
SOP	528.0	87738.8	11343.3	226102.9	54.9	10.5	6421.6	17.8	6033.4
SOP%	101%	100%	100%	100%	97%	100%	100%	100%	101%

Table 8.4.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2017 (cont.).

Quarters 1-4

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0	0.0	0.0	0.0	0.0	0.0	0.0	10111.7	17053.3
1	237.5	36.2	71.0	58.8	352.4	0.0	2086.3	6006.8
2	332.5	246.3	17.4	17.4	100.1	0.1	1808.5	3365.2
3	835.7	1273.6	3.7	9.1	214.9	0.1	1375.5	2963.7
4	360.5	868.3	1.1	2.9	193.8	0.04	632.4	1239.8
5	236.9	319.0	1.3	8.1	488.7	0.05	669.0	2277.2
6	194.6	147.3	1.8	7.6	897.5	0.04	673.1	2187.7
7	150.0	79.8	1.6	4.4	902.2	0.04	485.5	1411.7
8	161.4	51.4	1.2	6.7	687.0	0.01	278.8	726.4
9	130.9	39.1	1.1	5.3	622.2	0.02	154.5	401.7
10	108.8	20.4	0.5	2.8	281.0	0.01	95.9	150.9
11	147.5	18.1	0.3	3.0	194.8	0.01	16.6	38.4
12	49.0	6.6	0.1	0.6	93.0	0.00	29.8	7.3
13	63.9	8.8	0.1	0.7	69.8	0.0	0.9	2.1
14	32.0	4.4	0.0	0.3	26.5	0.0	0.0	0.0
15+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Catch	956.0	678.7	22.5	34.8	1817.3	0.2	2149.6	4853.5
SOP	956.7	678.6	22.5	34.8	1817.3	0.2	2154.2	4863.2
SOP%	100%	100%	100%	100%	100%	98%	100%	100%
Age	**8.c**	**8.c.E**	**8.d**	**9.a**	**9.a.N**	**14.a**	**14.b**	**All**
0	329.63	0.0	59.5	435.9	279.8	0.0	0.0	28306.0
1	2702.36	1032.4	47.8	1319.9	1370.4	13.5	2853.7	43457.9
2	4991.5	1605.4	18.5	346.3	1019.5	38.7	8236.9	87739.1
3	8591.24	1919.1	18.8	811.0	1055.6	170.5	36373.9	458301.2
4	5192.66	2098.1	10.9	338.9	462.5	107.8	23407.2	351779.0
5	11664.52	5844.9	43.8	93.4	403.8	47.9	11215.3	396862.3
6	13062.37	6765.4	38.2	66.0	356.3	7.0	2816.8	503601.1
7	10188.69	5306.6	42.5	65.8	243.5	0.2	920.3	431014.2
8	6487.7	3208.7	15.1	47.2	146.5	0.0	530.5	261959.5
9	3844.51	1899.4	21.9	32.8	91.5	0.0	441.8	188949.9
10	1444.85	694.8	14.3	51.8	38.7	0.0	217.0	138143.1
11	446.91	265.3	8.5	4.7	14.5	0.0	85.9	59210.9
12	154.2	40.6	0.2	19.2	4.8	0.0	40.4	32022.0
13	94.33	53.5	0.1	0.0	3.0	0.0	0.0	12121.5
14	0	0.0	0.0	0.0	0.0	0.0	0.0	4776.4
15+	0	0.0	0.0	0.0	0.0	0.0	0.0	2169.6
Catch	20769.4	10289.9	75.9	776.6	1206.1	173.6	39263.1	1155943.8
SOP	20767.8	10289.5	75.9	776.6	1206.2	173.5	39263.9	1155785.1
SOP%	100%	100%	100%	100%	100%	100%	100%	100%

Table 8.4.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2017 (cont.).

Quarter 1

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1								3.8	
2								36.1	
3	0.6			1.3			0.1	4832.1	0.1
4	0.6			0.8				2996.4	
5	1.3			0.7				2655.8	0.1
6	1.9			1.1			0.1	4409.7	0.1
7	1.5			1.5			0.1	5380.1	0.1
8	1.0			1.2			0.1	4235.3	0.1
9	0.7			0.5				1846.4	
10	0.5			0.7				2557.5	
11	0.2							81.2	
12	0.1			0.2				680.3	
13	0.1			0.2				661.7	
14				0.2				547.6	
15+								0.0	
Catch	3.74			2.85			0.13	10717.97	0.13
SOP	3.74			2.87			0.13	10720.48	0.13
SOP%	100%			99%			102%	100%	99%
AGE	**4.c**	**5.a**	**5.b**	**6.a**	**6.b**	**7.a**	**7.b**	**7.c**	**7.d**
0				35.9					
1				1871.0			30.2	20.3	92.2
2	0.7		0.1	4255.7			170.2	4.9	73.7
3	7.1	0.1	2156.5	46521.3		0.6	1292.3	1.0	571.0
4	4.3	0.3	1347.8	57870.8		0.8	726.9	0.8	337.4
5	7.1	0.5	1078.3	83936.6		1.5	2645.6	1.9	560.4
6	6.3	0.6	1886.9	104111.4		2.1	3178.4	4.7	516.8
7	5.5	0.4	2426.0	92769.9		2.6	2184.3	6.2	447.9
8	3.6	0.2	1940.8	71779.2		1.7	2750.0	3.2	296.4
9	2.7	0.1	808.7	58446.8		1.5	2365.1	4.6	213.5
10	1.2	0.1	1186.0	44031.6		1.6	1144.4	2.3	102.3
11	0.1		0.0	22776.0		0.7	630.3	1.3	10.9
12	0.2		323.5	11049.4		0.4	90.7		20.1
13	0.1		323.5	4214.6		0.1	38.0		11.2
14	0.0		269.6	1769.9		0.0	4.3		1.2
15+	0.0		0.0	598.3		0.0	0.0		0.0
Catch	13.1	1.0	4765.1	223122.1		5.1	5974.1	15.6	1082.3
SOP	13.1	1.0	4765.3	223167.9		5.1	5973.9	15.6	1082.6
SOP%	100%	99%	100%	100%		100%	100%	100%	100%

Table 8.4.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2017 (cont.).

Quarter 1

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							1811.5	4297.5
1	208.7	10.1	71.0	58.8	352.4		776.3	4083.8
2	66.0	52.8	16.2	13.8	91.1		363.7	2585.9
3	146.3	649.2	1.3	3.9	190.6		331.8	2363.1
4	93.0	464.2	0.1	1.4	181.7		132.9	904.0
5	85.4	137.5	0.1	5.7	461.6		267.9	1833.3
6	75.2	53.0	0.1	5.6	859.5	0.020	248.0	1716.4
7	44.0	21.7	0.1	3.0	836.3	0.030	147.4	1037.8
8	57.5	9.7	0.1	5.3	623.3	0.010	70.1	503.5
9	45.6	10.7	0.1	4.4	584.7	0.020	36.9	266.4
10	25.3	2.8	0.0	2.2	257.5	0.010	12.8	92.5
11	14.5	0.6	0.0	1.4	96.5	0.010	3.2	23.2
12	1.2				56.4		0.3	2.4
13	0.4				22.7		0.2	1.3
14	0.3				3.2		0.0	0.0
15+	0.0						0.0	0.0
Catch	228.5	281.5	18.4	26.1	1570.7	0.04	509.2	3464.5
SOP	228.6	281.5	18.4	26.1	1570.8	0.04	510.1	3470.5
SOP%	100%	100%	100%	100%	100%	93%	100%	100%
Age	**8.c**	**8.c.E**	**8.d**	**9.a**	**9.a.N**	**14.a**	**14.b**	**All**
0	0	0	5.53	0	0			6150.4
1	1560.4	1026.0	25.0	66.9	0.4			10257.2
2	3533.4	1501.7	12.9	87.1	25.1			12891.2
3	4900.4	1685.8	17.3	154.6	164.1			65992.4
4	2974.0	1828.4	10.1	132.1	118.9			70127.6
5	6847.1	5110.5	22.8	12.6	194.5			105868.6
6	7487.7	5906.1	25.3	15.1	161.4			130673.6
7	5445.8	4603.0	18.5	35.2	69.3			115488.0
8	3203.8	2785.9	11.0	23.6	26.0			88332.2
9	1820.3	1620.0	6.2	18.9	12.2			68117.0
10	670.5	580.8	2.5	40.6	4.7			50720.1
11	172.5	188.1	0.7	2.7	1.6			24005.7
12	50.4	36.7	0.2	19.2	1.0			12332.8
13	12.3	15.0	0.1		0.4			5301.8
14			0.0					2596.3
15+								598.4
Catch	11357.5	8906.9	39.9	191.0	216.7			272514.0
SOP	11357.2	8906.9	39.9	191.0	216.7			272586.7
SOP%	100%	100%	100%	100%	100%			100%

Table 8.4.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2017 (cont.).

Quarter 2

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	56.3			1.2				6.4	18.5
2	77.2			0.0				55.1	1759.6
3	12817.9			86.5	0.4	0.01	0.3	323.1	3977.8
4	9812.6			52.4	0.2	0.01	0.2	104.7	794.1
5	5319.6			54.2	0.2	0.02	0.2	270.6	863.9
6	6074.7			95.3	0.3	0.03	0.3	524.9	1024.3
7	7487.9			116.4	0.4	0.03	0.4	569.9	1046.3
8	1727.3			86.4	0.4	0.01	0.3	387.0	893.5
9	1034.2			47.4	0.1	0.02	0.1	314.1	406.0
10	636.8			55.0	0.2	0.01	0.2	239.9	534.9
11	275.1			12.2		0.02		110.7	39.7
12	398.8			15.3	0.1	0.00	0.1	70.0	136.6
13	11.4			14.1	0.1	0.00	0.1	43.0	128.0
14	4.1			9.9	0.1	0.00		13.1	104.8
15+	1.0			0.6		0.00		12.9	5.2
Catch	15594.0			238.8	0.9	0.1	0.7	1334.4	3714.6
SOP	15594.6			238.9	0.9	0.1	0.7	1333.8	3714.9
SOP%	100%			100%	100%	108%	99%	100%	100%
AGE	**4.c**	**5.a**	**5.b**	**6.a**	**6.b**	**7.a**	**7.b**	**7.c**	**7.d**
0				0.2					0.0
1	10.6			2.2					43.1
2	229.8	23.9	25.8	217.9	0.1	0.2	12.0	1.6	913.6
3	200.0	157.5	241.3	224.7	0.1	0.7	84.6	2.2	770.3
4	50.1	330.8	159.8	169.3	0.0	0.5	42.6	0.6	174.5
5	111.2	647.5	307.1	1308.3	0.04	0.3	166.5	0.8	297.0
6	74.8	764.5	390.3	1014.9	0.03	0.2	181.3	0.5	182.1
7	72.1	455.6	209.8	1593.2	0.01	0.2	116.3	0.2	77.6
8	35.1	251.8	107.8	461.5	0.00	0.2	170.7	0.1	70.5
9	42.6	153.6	82.2	999.3	0.00	0.2	140.3		48.1
10	36.2	75.3	46.0	785.8	0.00	0.2	70.6		39.8
11	17.8	19.6	16.5	482.6	0.00		58.4		19.1
12	2.9	12.8	9.2	34.3	0.00		10.0		4.1
13	2.1		1.5	11.2	0.00		10.4		1.1
14	1.8			5.7	0.00		4.6		1.1
15+	0.5			2.4	0.00		0.0		2.1
Catch	276.7	1222.0	670.3	2485.8	0.1	0.7	382.0	2.1	800.8
SOP	274.7	1222.0	670.4	2487.5	0.1	0.7	382.8	2.1	792.6
SOP%	101%	100%	100%	100%	100%	100%	100%	100%	101%

Table 8.4.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2017 (cont.).

Quarter 2

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0	0.0	0.0	0.0	0.0	0.0	0.0	1082.6	3639.6
1	0.0	0.2	0.0	0.0	0.0	0.0	457.3	1545.1
2	43.2	5.4	0.6	3.5	6.4	0.1	63.5	141.5
3	104.6	27.4	1.1	5.1	18.2	0.1	106.2	178.9
4	42.3	17.1	0.5	1.5	9.9	0.0	104.6	148.7
5	49.1	9.3	1.1	2.5	27.1	0.0	299.8	395.2
6	40.8	8.0	1.5	2.0	38.0	0.0	349.3	440.6
7	19.8	3.2	1.3	1.0	65.6	0.0	299.2	358.7
8	25.7	5.4	1.0	0.9	63.4	0.0	183.8	214.1
9	20.4	4.6	0.9	0.8	37.4	0.0	117.6	135.3
10	11.0	5.7	0.4	0.4	23.4	0.0	44.6	51.1
11	6.3	0.1	0.2	0.2	97.5	0.0	13.4	15.2
12	0.3	0.0	0.1	0.0	36.3	0.0	1.4	1.6
13	0.1	0.0	0.0	0.0	46.7	0.0	0.8	0.9
14	0.1	0.0	0.0	0.0	23.1	0.0	0.0	0.0
15+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Catch	112.0	22.1	3.1	6.2	242.2	0.1	596.7	815.5
SOP	112.0	22.1	3.1	6.2	242.2	0.1	600.2	818.6
SOP%	100%	100%	100%	100%	100%	102%	99%	100%
Age	**8.c**	**8.c.E**	**8.d**	**9.a**	**9.a.N**	**14.a**	**14.b**	**All**
0	0.0	0.0	54.0	0.0	0.0		0.0	4776.4
1	1025.8	2.2	22.7	863.2	59.7		6.0	4120.5
2	1335.2	52.6	5.5	43.4	377.3		17.2	5412.3
3	3522.2	165.4	1.5	333.1	353.1		75.7	23780.1
4	2165.3	243.2	0.8	107.3	94.0		47.8	14675.3
5	4806.9	729.2	21.0	56.4	147.7		21.3	15913.8
6	5570.1	856.7	13.0	46.4	178.8		3.1	17876.8
7	4740.2	702.5	24.1	28.3	167.6		0.1	18157.8
8	3282.6	421.8	4.2	23.5	119.5		0.0	8538.2
9	2024.2	279.4	15.7	13.9	79.3		0.0	5997.5
10	773.8	111.3	11.7	11.3	34.0		0.0	3599.8
11	274.4	77.2	7.8	2.0	12.8		0.0	1558.6
12	103.7	3.8	0.0	0.0	3.8		0.0	845.0
13	82.1	38.5	0.0	0.0	2.6		0.0	394.6
14	0.0	0.0	0.0	0.0	0.0		0.0	168.4
15+	0.0	0.0	0.0	0.0	0.0		0.0	24.6
Catch	9289.1	1338.4	36.0	272.9	437.2		77.0	39972.4
SOP	9289.3	1338.5	36.0	272.9	437.1		77.0	39971.2
SOP%	100%	100%	100%	100%	100%		100%	100%

Table 8.4.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2017 (cont.).

Quarter 3

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	940.1			17.4	1.2	1.0	0.1	730.6	30.4
2	3076.3			40.3	1.9	0.9	0.2	1249.7	171.7
3	139839.6	31.3	35.6	150.7	7.8	9.7	1.1	4961.8	1657.7
4	115443.9	47.0	53.4	110.1	0.4	4.2	1.3	1571.0	395.3
5	107814.9	94.0	106.8	131.0	2.2	7.8	1.0	1899.1	262.8
6	170535.3	266.4	302.6	147.5	5.9	11.0	1.0	2730.8	192.5
7	155562.2	188.0	213.6	120.4	5.7	7.2	0.6	2482.0	83.0
8	75970.7	94.0	106.8	79.1	3.1	5.2	0.3	1754.1	37.2
9	51287.8	47.0	53.4	45.9	1.8	2.6	0.2	1405.0	19.7
10	37407.1	15.7	17.8	35.0	1.8	1.8	0.1	1176.3	13.5
11	14848.1			13.4	0.6	0.5	0.1	507.1	3.8
12	9157.3			6.4		0.1		280.9	2.0
13	4390.8			1.7		0.0		65.4	1.1
14	1470.4			0.5		0.1		15.7	1.0
15+	1127.5			0.2				19.2	0.2
Catch	369931.2	381.3	433.2	350.7	11.5	20.3	2.3	7734.3	911.4
SOP	369913.5	381.3	433.2	350.8	11.5	20.3	2.4	7735.0	912.8
SOP%	100%	100%	100%	100%	100%	100%	96%	100%	100%
AGE	**4.c**	**5.a**	**5.b**	**6.a**	**6.b**	**7.a**	**7.b**	**7.c**	**7.d**
0									
1	10.4						0.1		124.2
2	230.8	883.7	57.7	1.4	47.1	0.7	0.3	0.06	2530.6
3	192.9	8372.0	546.0	0.4	106.0	1.1	1.1	0.14	2174.9
4	45.2	20121.7	1311.8	0.3	39.6	0.9	0.9	0.05	492.7
5	73.4	38720.3	2524.1	6.6	0.8	2.6	1.0	0.00	799.8
6	45.3	48843.8	3184.0	4.1	1.0	1.5	1.1	0.00	489.2
7	17.5	31904.1	2079.8	7.7	0.6	2.7	9.9	0.01	179.0
8	18.2	18969.4	1236.6	1.4	0.4	0.5	9.6		186.8
9	10.5	15428.0	1005.7	5.1	0.3	1.8	3.3		108.4
10	8.8	7596.8	495.2	3.8	0.2	1.3	3.2		90.4
11	4.0	2933.3	191.2	2.5	0.1	0.9	24.2		40.9
12	1.1	1407.6	91.8				9.1		10.8
13	0.3	4.8	0.3				12.1		2.5
14	0.2						6.0		2.5
15+	0.5								5.7
Catch	200.1	86476.0	5637.2	11.1	53.4	4.4	47.2	0.1	2187.0
SOP	198.7	86476.7	5637.3	11.1	54.7	4.4	47.2	0.1	2164.3
SOP%	101%	100%	100%	100%	98%	100%	100%	104%	101%

Table 8.4.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2017 (cont.).

Quarter 3

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							4520.1	2833.5
1	4.9	0.5				0.00	69.5	39.2
2	69.9	31.6	0.5		2.6	0.00	457.7	128.8
3	183.3	159.8	1.2		5.9	0.00	656.6	141.3
4	92.3	132.2	0.5		2.2	0.01	304.5	67.0
5	38.4	56.1	0.0		0.0	0.00	83.2	18.3
6	23.5	26.6	0.0		0.0	0.00	65.4	12.4
7	39.0	15.8	0.1	0.1	0.3	0.00	35.2	6.5
8	35.0	10.9	0.04	0.1	0.3	0.00	22.8	3.9
9	14.7	7.6	0.01	0.0	0.1	0.00	0.0	0.0
10	14.0	3.1	0.0	0.0	0.1	0.00	37.3	4.4
11	68.4	3.4	0.1	0.3	0.7	0.00	0.0	0.0
12	25.7	1.3		0.1	0.3	0.00	27.8	2.7
13	34.2	1.7		0.1	0.3	0.00	0.0	0.0
14	17.1	0.9		0.1	0.2	0.00	0.0	0.0
15+	0.0	0.0		0.0	0.0	0.00	0.0	0.0
Catch	241.4	117.4	0.8	0.6	4.2	0.004	602.6	168.6
SOP	241.5	117.4	0.8	0.6	4.2	0.004	602.4	168.5
SOP%	100%	100%	100%	99%	100%	100%	100%	100%
Age	**8.c**	**8.c.E**	**8.d**	**9.a**	**9.a.N**	**14.a**	**14.b**	**All**
0	10.8			280.3	245.0			7889.6
1	32.8			264.0	163.8	13.5	2847.7	5291.3
2	44.6	1.88	0.01	143.1	152.5	38.7	8219.7	17584.8
3	94.3	3.87	0.06	208.3	252.2	170.5	36298.3	196265.5
4	35.5	2.03	0.02	48.6	126.7	107.8	23359.4	163918.4
5	8.8	0.52	0.01	17.4	40.5	47.9	11194.0	163953.4
6	3.9	0.25	0.01		9.3	7.0	2813.7	229724.9
7	2.3	0.09	0.01		4.7	0.2	920.2	193888.3
8	1.2	0.05			0.8		530.5	99078.8
9	0.0	0.00					441.8	69890.5
10	0.5	0.04					217.0	47145.2
11	0.0						85.9	18729.3
12	0.1						40.4	11065.4
13								4515.4
14								1514.7
15+								1153.3
Catch	57.7	2.6	0.04	197.4	199.9	173.6	39186.1	515345.6
SOP	57.7	2.6	0.04	197.4	200.1	173.5	39187.1	515307.4
SOP%	100%	100%	97%	100%	100%	100%	100%	100%

Table 8.4.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2017 (cont.).

Quarter 4

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	5473.0	1.2	166.3	4.0		0.1	0.0	15412.2	10.5
2	990.8	2.4	332.5	10.6	0.01	0.1	0.1	45777.0	34.9
3	31548.4	9.4	1307.1	39.9	0.05	1.2	0.1	134762.0	123.2
4	11899.9	9.4	1307.1	33.4	0.01	0.5	0.2	88416.1	45.8
5	16920.4	10.1	1404.6	38.7	0.02	0.9	0.2	91600.2	36.9
6	30519.0	7.7	1072.1	40.8	0.04	1.3	0.1	92768.0	24.9
7	29312.1	5.2	716.6	31.1	0.03	0.9	0.1	72814.2	12.9
8	20337.7	1.0	143.3	19.9	0.02	0.6	0.1	45076.5	4.8
9	16769.4	3.1	430.0	10.2	0.01	0.3	0.03	27459.9	3.0
10	14473.8	4.1	573.3	7.4	0.01	0.2	0.02	21356.7	1.7
11	6051.6	1.0	143.3	2.6		0.1	0.01	8461.7	0.7
12	3519.6	1.0	143.3	1.1				4028.6	0.3
13	761.6			0.3				1049.2	0.1
14	178.3			0.1				268.3	0.0
15+	200.4							187.9	0.1
Catch	75784.6	23.0	3203.3	93.7	0.1	2.4	0.4	244037.9	97.3
SOP	75784.7	23.0	3203.2	93.8	0.1	2.5	0.4	243858.9	97.6
SOP%	100%	100%	100%	100%	97%	100%	99%	100%	100%
AGE	**4.c**	**5.a**	**5.b**	**6.a**	**6.b**	**7.a**	**7.b**	**7.c**	**7.d**
0									
1	1.27		29.62	22.92		0.02	0.01		136.39
2	55.37	0.92	44.64	35.58		0.08	0.02		2158.27
3	36.38	16	190.44	150.76		0.3	0.09		2137.51
4	7.62	8.19	0.19	19.46		0.17	0.07		494.93
5	15.41	16.18	47.29	53.19		0.14	0.08		719.08
6	9.33	20.67	141.2	113.42		0.14	0.09		449.15
7	2.98	10.49	138.72	147.6		0.09	3.51		178.78
8	4.12	4.73	75.45	95.5		0.06	3.49		165.42
9	2.36	3.48	44.44	50.62		0.03	1.17		100.2
10	2.07	2.16	44.43	52.63		0.02	1.16		83.99
11	0.94	0.65	14.82	122.02		0	9.2		34.94
12	0.25	0.45		43.17		0	3.45		9.08
13	0.06	0.11		54.86		0	4.6		2.12
14	0.06			27.43		0	2.3		2.12
15+	0.13					0	0		4.79
Catch	41.7	35.0	270.9	437.0		0.3	17.2		2012.2
SOP	41.6	35.0	270.9	437.0		0.3	17.2		1993.9
SOP%	100%	100%	100%	100%		100%	100%		101%

Table 8.4.3.1. NE Atlantic Mackerel. Catch numbers ('000s) -at-age by area for 2017 (cont.).

Quarter 4

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							2697.5	6282.8
1	23.9	25.4	0.01				783.2	338.7
2	153.5	156.5	0.01		0.06		923.6	509.0
3	401.6	437.2	0.1	0.1	0.14		280.9	280.5
4	133.0	254.8	0.1	0.0	0.05		90.6	120.1
5	64.0	116.1	0.1	0.0	0.00		18.1	30.4
6	55.0	59.7	0.1	0.0	0.00		10.4	18.3
7	47.2	39.1	0.1	0.4	0.03		3.8	8.8
8	43.2	25.4	0.1	0.4	0.03		2.1	4.9
9	50.3	16.2	0.03	0.1	0.01		0.0	0.0
10	58.5	8.9	0.02	0.1	0.01		1.2	2.9
11	58.4	14.1	0.02	1.1	0.07		0.0	0.0
12	21.9	5.3	0.01	0.4	0.03		0.3	0.6
13	29.2	7.0	0.01	0.5	0.04		0.0	0.0
14	14.6	3.5	0.00	0.3	0.02		0.0	0.0
15+							0.0	0.0
Catch	374.1	257.7	0.2	2.0	0.2		441.2	404.9
SOP	374.6	257.7	0.2	2.0	0.2		441.0	405.2
SOP%	100%	100%	98%	100%	95%		100%	100%
Age	**8.c**	**8.c.E**	**8.d**	**9.a**	**9.a.N**	**14.a**	**14.b**	**All**
0	318.9	0.0		155.7	34.8			9489.6
1	83.5	4.2		125.9	1146.5			23788.8
2	78.3	49.2		72.8	464.6			51850.8
3	74.4	64.0		115.1	286.2			172263.1
4	17.9	24.5		50.9	122.9			103057.7
5	1.7	4.7		7.0	21.1			111126.5
6	0.7	2.4		4.5	6.8			125325.8
7	0.4	1.0		2.3	1.9			103480.1
8	0.1	1.0		0.1	0.3			66010.3
9	0.0	0.0						44944.8
10	0.1	2.7						36678.0
11								14917.2
12								7778.8
13								1909.7
14								497.1
15+								393.3
Catch	65.0	42.0		115.3	352.4			328111.6
SOP	65.1	42.0		115.3	352.4			327929.8
SOP%	100%	100%		100%	100%			100%

Table 8.4.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2017. Zeros represent values <1%.

Quarters 1-4

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	1%	0%	2%	1%	3%	2%	2%	2%	0%
2	0%	0%	4%	3%	5%	2%	3%	7%	13%
3	16%	5%	16%	16%	24%	19%	17%	21%	39%
4	12%	7%	16%	11%	2%	8%	19%	13%	8%
5	12%	12%	18%	13%	7%	15%	15%	14%	8%
6	18%	33%	16%	16%	18%	21%	16%	14%	8%
7	17%	23%	11%	15%	18%	14%	12%	12%	8%
8	9%	11%	3%	10%	10%	10%	7%	7%	6%
9	6%	6%	6%	6%	6%	5%	4%	4%	3%
10	5%	2%	7%	5%	6%	3%	4%	4%	4%
11	2%	0%	2%	2%	2%	1%	1%	1%	0%
12	1%	0%	2%	1%	0%	0%	1%	1%	1%
13	0%			1%	0%	0%	1%	0%	1%
14	0%			1%	0%	0%	0%	0%	1%
15+	0%								

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0									
1	1%		0%	0%	0%	0%	0%	35%	2%
2	30%	0%	0%	1%	24%	3%	1%	11%	29%
3	25%	4%	11%	8%	54%	9%	7%	6%	29%
4	6%	10%	10%	9%	20%	7%	4%	2%	8%
5	12%	20%	14%	14%	0%	14%	15%	5%	12%
6	8%	25%	19%	17%	1%	13%	18%	9%	8%
7	6%	16%	17%	15%	0%	18%	13%	11%	4%
8	4%	10%	12%	12%	0%	8%	16%	6%	4%
9	3%	8%	7%	10%	0%	11%	14%	8%	2%
10	3%	4%	6%	7%	0%	10%	7%	4%	2%
11	1%	1%	1%	4%	0%	5%	4%	2%	1%
12	0%	1%	1%	2%	0%	1%	1%	0%	0%
13	0%	0%	1%	1%	0%	0%	0%	0%	0%
14	0%		1%	0%	0%	0%	0%	0%	0%
15+	0%			0%		0%			0%

Table 8.4.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2017. Zeros represent values <1% (cont.).

Quarters 1-4

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							55%	45%
1	8%	1%	70%	46%	7%	0%	11%	16%
2	11%	8%	17%	14%	2%	20%	10%	9%
3	27%	41%	4%	7%	4%	30%	7%	8%
4	12%	28%	1%	2%	4%	9%	3%	3%
5	8%	10%	1%	6%	10%	11%	4%	6%
6	6%	5%	2%	6%	18%	9%	4%	6%
7	5%	3%	2%	3%	18%	9%	3%	4%
8	5%	2%	1%	5%	13%	2%	2%	2%
9	4%	1%	1%	4%	12%	5%	1%	1%
10	4%	1%	0%	2%	5%	2%	1%	0%
11	5%	1%	0%	2%	4%	2%	0%	0%
12	2%	0%	0%	0%	2%	0%	0%	0%
13	2%	0%	0%	1%	1%			
14	1%	0%		0%	1%			
15+								

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0	0%		17%	12%	5%			1%
1	4%	3%	14%	36%	25%	3%	3%	1%
2	7%	5%	5%	10%	19%	10%	9%	3%
3	12%	6%	6%	22%	19%	44%	42%	15%
4	8%	7%	3%	9%	8%	28%	27%	12%
5	17%	19%	13%	3%	7%	12%	13%	13%
6	19%	22%	11%	2%	6%	2%	3%	17%
7	15%	17%	12%	2%	4%	0%	1%	14%
8	9%	10%	4%	1%	3%		1%	9%
9	6%	6%	6%	1%	2%		1%	6%
10	2%	2%	4%	1%	1%		0%	5%
11	1%	1%	3%	0%	0%		0%	2%
12	0%	0%	0%	1%	0%			1%
13	0%	0%			0%			0%
14	0%	0%						0%
15+		0%						0%

Table 8.4.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2017. Zeros represent values <1% (cont.).

Quarter 1

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	0%								
2	0%						0%	0%	0%
3	7%			16%			16%	16%	16%
4	7%			10%			11%	10%	11%
5	15%			8%			8%	9%	13%
6	22%			14%			13%	14%	16%
7	18%			18%			18%	17%	16%
8	11%			14%			13%	14%	13%
9	8%			6%			5%	6%	5%
10	6%			9%			8%	8%	5%
11	2%			0%			0%	0%	0%
12	2%			2%			3%	2%	3%
13	1%			2%			3%	2%	3%
14	0%			2%			3%	2%	
15+	0%			0%					

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0									
1				0%		0%	0%	40%	3%
2	2%	1%		1%		0%	1%	10%	2%
3	18%	5%	16%	8%		4%	7%	2%	18%
4	11%	11%	10%	10%		6%	4%	2%	10%
5	18%	22%	8%	14%		11%	15%	4%	17%
6	16%	26%	14%	17%		15%	18%	9%	16%
7	14%	16%	18%	15%		19%	13%	12%	14%
8	9%	9%	14%	12%		13%	16%	6%	9%
9	7%	5%	6%	10%		11%	14%	9%	7%
10	3%	3%	9%	7%		12%	7%	4%	3%
11	0%	1%	0%	4%		5%	4%	3%	0%
12	1%	0%	2%	2%		3%	1%		1%
13	0%		2%	1%		1%	0%		0%
14			2%	0%		0%			
15+				0%		0%			

Table 8.4.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2017. Zeros represent values <1% (cont.).

Quarter 1

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							43%	22%
1	24%	1%	80%	56%	8%		18%	21%
2	8%	4%	18%	13%	2%		9%	13%
3	17%	46%	1%	4%	4%		8%	12%
4	11%	33%	0%	1%	4%		3%	5%
5	10%	10%	0%	5%	10%		6%	9%
6	9%	4%	0%	5%	19%	20%	6%	9%
7	5%	2%	0%	3%	18%	30%	4%	5%
8	7%	1%	0%	5%	13%	10%	2%	3%
9	5%	1%	0%	4%	13%	20%	1%	1%
10	3%	0%	0%	2%	6%	10%	0%	0%
11	2%			1%	2%	10%	0%	0%
12	0%				1%			
13					0%			
14					0%			
15+								

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0			3%					1%
1	4%	4%	16%	11%	0%			1%
2	9%	6%	8%	14%	3%			2%
3	13%	6%	11%	25%	21%			9%
4	8%	7%	6%	22%	15%			9%
5	18%	19%	14%	2%	25%			14%
6	19%	22%	16%	2%	21%			17%
7	14%	17%	12%	6%	9%			15%
8	8%	10%	7%	4%	3%			11%
9	5%	6%	4%	3%	2%			9%
10	2%	2%	2%	7%	1%			7%
11	0%	1%	0%	0%	0%			3%
12	0%	0%	0%	3%	0%			2%
13		0%						1%
14								0%
15+								0%

Table 8.4.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2017. Zeros represent values <1% (cont.).

Quarter 2

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	0%			0%				0%	0%
2	0%			0%				2%	15%
3	28%			13%	16%	6%	15%	11%	34%
4	21%			8%	10%	6%	9%	3%	7%
5	12%			8%	8%	13%	8%	9%	7%
6	13%			15%	14%	19%	14%	17%	9%
7	16%			18%	17%	19%	18%	19%	9%
8	4%			13%	14%	6%	13%	13%	8%
9	2%			7%	6%	13%	6%	10%	3%
10	1%			9%	9%	6%	8%	8%	5%
11	1%			2%	0%	13%	1%	4%	0%
12	1%			2%	2%		2%	2%	1%
13				2%	2%		2%	1%	1%
14				2%	2%		2%	0%	1%
15+				0%	0%			0%	

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0									
1	1%					0%			2%
2	26%	1%	2%	3%	27%	6%	1%	27%	35%
3	23%	5%	15%	3%	37%	29%	8%	36%	29%
4	6%	11%	10%	2%	10%	18%	4%	10%	7%
5	13%	22%	19%	18%	13%	12%	16%	13%	11%
6	8%	26%	24%	14%	9%	9%	17%	9%	7%
7	8%	16%	13%	22%	3%	6%	11%	3%	3%
8	4%	9%	7%	6%	1%	6%	16%	1%	3%
9	5%	5%	5%	14%	0%	6%	13%	1%	2%
10	4%	3%	3%	11%	0%	7%	7%	0%	2%
11	2%	1%	1%	7%		1%	5%	0%	1%
12	0%	0%	1%	0%			1%		0%
13	0%		0%	0%			1%		
14	0%			0%			0%		
15+	0%						0%		0%

Table 8.4.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2017. Zeros represent values <1% (cont.).

Quarter 2

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							35%	50%
1		0%					15%	21%
2	12%	6%	7%	20%	1%	28%	2%	2%
3	29%	32%	13%	29%	4%	38%	3%	2%
4	12%	20%	6%	8%	2%	9%	3%	2%
5	13%	11%	12%	14%	5%	13%	10%	5%
6	11%	9%	17%	11%	8%	9%	11%	6%
7	5%	4%	15%	5%	13%	3%	10%	5%
8	7%	6%	12%	5%	13%		6%	3%
9	6%	5%	11%	4%	8%		4%	2%
10	3%	7%	5%	2%	5%		1%	1%
11	2%	0%	2%	1%	20%		0%	0%
12	0%		1%	0%	7%			
13			0%		9%			
14			0%		5%			
15+								

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0			30%					4%
1	3%	0%	12%	56%	4%		3%	3%
2	4%	1%	3%	3%	23%		10%	4%
3	12%	4%	1%	22%	22%		44%	19%
4	7%	7%	0%	7%	6%		28%	12%
5	16%	20%	12%	4%	9%		12%	13%
6	19%	23%	7%	3%	11%		2%	14%
7	16%	19%	13%	2%	10%		0%	14%
8	11%	11%	2%	2%	7%		0%	7%
9	7%	8%	9%	1%	5%			5%
10	3%	3%	6%	1%	2%			3%
11	1%	2%	4%	0%	1%			1%
12	0%	0%			0%			1%
13	0%	1%			0%			0%
14								0%
15+								0%

Table 8.4.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2017. Zeros represent values <1% (cont.).

Quarter 3

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	0%			2%	4%	2%	2%	4%	1%
2	0%			4%	6%	2%	4%	6%	6%
3	16%	4%	4%	17%	24%	19%	18%	24%	58%
4	13%	6%	6%	12%	1%	8%	22%	8%	14%
5	12%	12%	12%	15%	7%	15%	17%	9%	9%
6	19%	34%	34%	16%	18%	21%	17%	13%	7%
7	18%	24%	24%	13%	18%	14%	10%	12%	3%
8	9%	12%	12%	9%	10%	10%	4%	8%	1%
9	6%	6%	6%	5%	6%	5%	3%	7%	1%
10	4%	2%	2%	4%	6%	3%	2%	6%	0%
11	2%			1%	2%	1%	1%	2%	0%
12	1%			1%		0%		1%	0%
13	0%			0%		0%		0%	
14	0%			0%		0%		0%	
15+	0%							0%	

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0									
1	2%			0%			0%		2%
2	35%	0%	0%	4%	24%	5%	0%	19%	35%
3	29%	4%	4%	1%	54%	8%	1%	45%	30%
4	7%	10%	10%	1%	20%	7%	1%	16%	7%
5	11%	20%	20%	20%	0%	18%	1%		11%
6	7%	25%	25%	12%	0%	11%	1%		7%
7	3%	16%	16%	23%	0%	19%	12%	3%	2%
8	3%	10%	10%	4%	0%	4%	12%	3%	3%
9	2%	8%	8%	15%	0%	13%	4%	0%	1%
10	1%	4%	4%	11%	0%	9%	4%	0%	1%
11	1%	2%	2%	8%		6%	30%	6%	1%
12	0%	1%	1%				11%	3%	0%
13							15%	3%	0%
14							7%		0%
15+	0%								0%

Table 8.4.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2017. Zeros represent values <1% (cont.).

Quarter 3

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							72%	87%
1	1%	0%					1%	1%
2	11%	7%	21%	2%	20%		7%	4%
3	28%	35%	49%	3%	46%	24%	10%	4%
4	14%	29%	19%	1%	17%	55%	5%	2%
5	6%	12%	1%	1%	0%	20%	1%	1%
6	4%	6%	1%	1%	0%		1%	0%
7	6%	3%	2%	11%	2%		1%	0%
8	5%	2%	2%	11%	2%		0%	0%
9	2%	2%	0%	4%	1%			
10	2%	1%	0%	4%	1%		1%	0%
11	10%	1%	2%	29%	5%			
12	4%	0%	1%	11%	2%		0%	0%
13	5%	0%	1%	14%	3%			
14	3%	0%	0%	7%	1%			
15+								

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0	5%			29%	25%			1%
1	14%	0%	8%	27%	16%	3%	3%	0%
2	19%	22%	8%	15%	15%	10%	9%	1%
3	40%	44%	46%	22%	25%	44%	42%	16%
4	15%	23%	15%	5%	13%	28%	27%	13%
5	4%	6%	8%	2%	4%	12%	13%	13%
6	2%	3%	8%		1%	2%	3%	19%
7	1%	1%	8%		0%		1%	16%
8	1%	1%			0%		1%	8%
9	0%	0%					1%	6%
10	0%	0%					0%	4%
11							0%	2%
12	0%							1%
13								0%
14								0%
15+								0%

Table 8.4.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2017. Zeros represent values <1% (cont.).

Quarter 4

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	3%	2%	2%	2%	5%	2%	1%	2%	3%
2	1%	4%	4%	4%	5%	2%	7%	7%	12%
3	17%	17%	17%	17%	24%	19%	15%	21%	41%
4	6%	17%	17%	14%	5%	8%	21%	14%	15%
5	9%	18%	18%	16%	10%	15%	17%	14%	12%
6	16%	14%	14%	17%	19%	21%	14%	14%	8%
7	16%	9%	9%	13%	14%	14%	12%	11%	4%
8	11%	2%	2%	8%	10%	10%	7%	7%	2%
9	9%	6%	6%	4%	5%	5%	3%	4%	1%
10	8%	7%	7%	3%	5%	4%	2%	3%	1%
11	3%	2%	2%	1%		1%	1%	1%	0%
12	2%	2%	2%	0%		0%		1%	0%
13	0%			0%				0%	0%
14	0%			0%		0%		0%	
15+	0%								

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0						0%			
1			4%	2%		2%			2%
2	40%	1%	6%	4%		8%	0%		32%
3	26%	19%	25%	15%		29%	0%		32%
4	6%	10%		2%		16%	0%		7%
5	11%	19%	6%	5%		13%	0%		11%
6	7%	25%	18%	11%		13%	0%		7%
7	2%	12%	18%	15%		9%	12%		3%
8	3%	6%	10%	10%		6%	12%		2%
9	2%	4%	6%	5%		3%	4%		2%
10	1%	3%	6%	5%		2%	4%		1%
11	1%	1%	2%	12%			31%		1%
12	0%	1%	0%	4%			12%		0%
13		0%		6%			16%		
14				3%			8%		
15+	0%								0%

Table 8.4.3.2. NE Atlantic Mackerel. Percentage catch numbers-at-age by area for 2017. Zeros represent values <1% (cont.).

Quarter 4

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							56%	83%
1	2%	2%	2%				16%	4%
2	13%	13%	2%	1%	12%		19%	7%
3	35%	37%	17%	3%	29%		6%	4%
4	12%	22%	8%	1%	10%		2%	2%
5	6%	10%	14%				0%	0%
6	5%	5%	19%				0%	0%
7	4%	3%	14%	12%	6%		0%	0%
8	4%	2%	10%	12%	6%			0%
9	4%	1%	5%	4%	2%			
10	5%	1%	3%	4%	2%			
11	5%	1%	3%	31%	14%			
12	2%	0%	2%	12%	6%			
13	3%	1%	2%	15%	8%			
14	1%	0%	0%	7%	4%			
15+								

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0	55%			29%	2%			1%
1	14%	3%		24%	55%			3%
2	14%	32%		14%	22%			6%
3	13%	42%		22%	14%			20%
4	3%	16%		10%	6%			12%
5	0%	3%		1%	1%			13%
6	0%	2%		1%	0%			14%
7	0%	1%		0%	0%			12%
8		1%						8%
9								5%
10		2%						4%
11								2%
12								1%
13								0%
14								0%
15+								0%

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2017.

Quarters 1-4

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	291	335	335	284	280	282	292	288	282
2	328	335	335	323	311	321	320	317	313
3	324	345	331	326	327	334	328	328	316
4	328	355	355	346	344	352	350	348	341
5	345	362	366	351	347	357	356	353	344
6	353	370	372	357	346	360	364	360	351
7	357	386	376	361	353	368	367	365	354
8	367	396	379	373	365	378	383	374	368
9	374	391	386	375	370	381	375	377	368
10	379	403	395	383	381	385	384	380	385
11	384	395	395	383	390	389	385	386	393
12	389	395	395	386	383	393	382	390	382
13	393			385	382	410	381	392	381
14	398			366	360	386	362	371	361
15+	408			409				411	412

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0				165		165			
1	271		280	274		242	298	298	278
2	311	338	327	291	335	291	304	341	311
3	317	338	313	313	335	297	316	356	317
4	334	348	342	340	335	317	321	371	335
5	342	354	350	348	357	345	344	362	343
6	348	358	355	353	360	350	346	375	351
7	359	364	357	360	366	359	362	383	365
8	365	373	370	369	374	368	368	381	369
9	377	376	372	379	376	382	373	392	376
10	384	382	385	382	382	388	379	394	378
11	396	387	387	385	387	389	371	405	397
12	393	393	383	391	393	391	392	404	399
13	388	420	380	393	420	390	407	410	395
14	373		360	406		385	416	419	406
15+	413			399		381			413

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2017 (cont.).

Quarters 1-4

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							137	136
1	295	231	298	298	298	0	215	190
2	299	268	342	343	338	348	304	303
3	310	291	349	349	320	367	334	328
4	318	305	347	346	336	377	349	346
5	339	317	357	353	347	384	357	354
6	347	325	356	351	352	388	364	359
7	368	334	364	370	362	390	373	369
8	371	352	375	369	375	390	382	379
9	380	351	377	372	377	396	389	386
10	388	386	382	380	383	397	398	390
11	401	405	384	385	391	409	402	400
12	408	408	391	408	394	445	427	417
13	410	410	408	410	409		438	437
14	420	420	416	420	418			
15+	413							

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0	181		131	189	212			138
1	257	263	185	219	256	352	352	269
2	296	299	299	313	292	336	336	315
3	321	327	319	333	324	357	357	327
4	345	347	345	364	343	372	371	340
5	355	354	352	371	351	383	381	350
6	361	361	357	371	357	400	380	355
7	371	372	363	390	372	422	367	360
8	380	379	377	389	382		374	370
9	385	386	385	394	388		376	376
10	389	390	394	400	393		382	381
11	403	407	395	408	403		387	385
12	414	416	405	393	412		394	390
13	433	436	418		440			393
14			372					394
15+								406

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2017 (cont.).

Quarter 1

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	237					215		224	249
2	334							308	307
3	333			304		310	304	304	306
4	344			336		334	336	336	338
5	351			340		340	340	342	348
6	357			349		351	349	349	354
7	362			351		355	351	352	358
8	372			369		366	369	369	373
9	375			367		367	367	368	375
10	382			388		375	388	387	388
11	386					373		386	392
12	389			380		383	380	380	382
13	395			380		380	380	380	381
14	399			360		420	360	360	360
15+	408							408	

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0				165		165			
1	249			274		239	298	298	298
2	306	334	349	290		295	304	339	317
3	308	341	304	313		310	316	333	308
4	340	345	336	340		337	322	366	340
5	354	352	340	348		346	344	352	354
6	361	356	349	353		351	346	373	360
7	369	360	351	360		360	361	383	369
8	384	373	369	369		368	368	380	383
9	383	372	367	378		380	373	392	383
10	391	381	388	382		382	379	393	390
11	398	385	445	384		382	369	405	395
12	393	378	380	391		391	389	400	392
13	385		380	392		390	407	411	386
14	372		360	406		385	405	405	369
15+				399		381			

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2017 (cont.).

Quarter 1

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							129	129
1	297	257	298	298	298		174	188
2	326	279	342	341	338		302	302
3	304	296	359	328	317		325	326
4	310	303	365	317	336	395	344	345
5	335	312	360	343	347	355	352	353
6	342	316	355	343	352	380	357	358
7	357	326	361	362	361	385	367	367
8	366	347	375	366	374	383	378	378
9	370	350	378	371	377	394	384	384
10	378	417	382	377	381	395	388	387
11	370	367	380	367	377	408	399	399
12	394	405	386	405	386		411	410
13	401	405	407	405	407		435	435
14	372		405		405			
15+								

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0			151					130
1	268	263	197	192	269			232
2	294	298	295	296	308			296
3	320	327	319	323	327			313
4	346	347	345	362	339			340
5	354	354	354	373	345			348
6	360	361	359	372	348			353
7	369	371	369	394	361			361
8	379	379	378	391	377			370
9	384	385	384	393	386			378
10	388	390	387	400	390			382
11	398	402	396	410	408			384
12	411	416	405	393	417			390
13	427	440	418		429			391
14			372					391
15+								399

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2017 (cont.).

Quarter 2

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	230			218		215	215	250	264
2	282			311				311	313
3	315			307	304	310	304	325	315
4	313			336	336	334	336	339	336
5	329			342	340	340	340	348	338
6	338			351	349	351	349	356	347
7	348			354	351	355	351	363	352
8	355			369	369	366	368	371	367
9	364			369	367	367	367	376	368
10	374			385	388	375	386	382	385
11	383			379		373	373	386	394
12	380			383	380	383	380	390	382
13	423			382	380	380	380	394	381
14	436			365	360	420	362	389	361
15+	408			408				408	412

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0									
1	269			268		235			269
2	311	334	334	315	349	271	305	349	311
3	316	341	332	309	369	290	317	369	318
4	333	345	348	339	380	304	318	380	333
5	343	352	353	350	387	330	344	387	340
6	348	356	359	352	393	345	344	392	346
7	357	360	363	359	405	349	364	403	360
8	366	373	371	373	423	349	369	417	360
9	379	372	376	384	433	380	374	417	372
10	388	381	380	392	437	382	381	417	375
11	395	385	384	394	445	395	371	419	396
12	388	378	396	391	445		401	445	404
13	384		420	395			406		409
14	367			377			420		407
15+	413			397					413

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2017 (cont.).

Quarter 2

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0								
1	254	235					173	172
2	338	270	347	348	341	349	323	308
3	332	291	354	365	337	369	340	333
4	329	304	354	374	339	380	352	348
5	355	327	357	374	349	387	358	356
6	356	344	356	374	351	393	365	363
7	368	343	363	382	379	405	376	374
8	368	348	374	374	384	423	384	383
9	372	378	377	378	381	433	391	390
10	379	379	381	383	397	437	395	394
11	368	367	375	375	404	445	403	402
12	399	406	386	411	407	445	407	407
13	402	405	407	405	410		439	439
14	372		405		420			
15+	413							

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0								
1	238	262	172	210	239		352	201
2	299	307	310	318	295		336	308
3	322	332	322	325	315		357	317
4	345	348	338	358	336		372	323
5	355	355	351	362	353		383	344
6	362	362	352	371	363		400	352
7	374	374	358	387	377		422	360
8	382	380	375	386	384			373
9	386	390	385	395	388			379
10	390	394	395	400	393			386
11	405	419	395	405	402			394
12	416	412	419	405	410			388
13	434	435			441			405
14								376
15+								408

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2017 (cont.).

Quarter 3

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	248			288	280	282	294	293	291
2	329			322	311	321	319	311	317
3	323	350	350	334	328	334	334	325	320
4	328	355	355	350	350	352	353	341	350
5	345	362	362	354	348	357	359	348	361
6	353	370	370	360	346	360	369	356	372
7	356	387	387	367	353	368	378	362	376
8	367	397	397	376	365	378	402	368	381
9	374	392	392	379	370	381	382	373	378
10	379	405	405	380	380	385	380	378	382
11	384			386	390	390	390	383	391
12	389			392	398	394		387	389
13	393			402	408	415		391	387
14	399			389		385		396	370
15+	408			410				410	413

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0									
1	272			284		235	284		270
2	311	338	338	316	335	298	325	335	311
3	317	338	338	335	335	295	335	335	318
4	334	348	348	351	335	308	350	335	333
5	339	354	354	351	354	346	354		340
6	346	358	358	352	358	349	361		346
7	362	364	364	359	364	357	393	395	361
8	360	373	373	375	373	371	394	395	360
9	370	376	376	385	376	384	394	395	370
10	371	382	382	395	382	395	413	415	371
11	396	387	387	395	387	395	406	406	397
12	404	393	393	396	393		408	408	405
13	414	420	420	411	420		410	410	415
14	415			385			420	420	415
15+	413								413

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2017 (cont.).

Quarter 3

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							141	141
1	280	235	284				276	273
2	285	266	335	349	335	335	324	317
3	306	295	335	369	335	335	340	339
4	317	308	336	380	335	335	350	351
5	327	320	354	387			371	370
6	339	327	361	393			382	379
7	376	334	380	395	395		378	379
8	382	350	388	395	395		385	385
9	383	345	388	395	395			
10	402	385	400	415	415		405	405
11	406	406	406	406	406			
12	408	408	408	408	408		429	428
13	410	410	410	410	410			
14	420	420	420	420	420			
15+	413							

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0	196			192	211			145
1	260	271	289	244	252	352	352	312
2	313	335	305	324	309	336	336	328
3	331	340	323	347	333	357	357	330
4	343	352	341	367	349	372	371	337
5	368	366	352	397	362	383	381	350
6	381	381	359		371	400	380	355
7	381	395	359		376	422	367	358
8	387	394	376		385		374	369
9			375				376	375
10	400	395					382	380
11							387	385
12	415	415					394	390
13								393
14								399
15+								408

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2017 (cont.).

Quarter 4

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	299	335	335	285	283	282	288	288	289
2	328	335	335	324	312	321	325	317	312
3	328	330	330	335	329	334	336	329	323
4	339	355	355	351	353	352	351	348	346
5	350	367	367	355	354	357	355	354	354
6	356	372	372	361	353	360	364	360	364
7	362	373	373	368	358	368	370	366	367
8	368	365	365	379	371	378	383	374	372
9	373	385	385	382	372	381	382	377	375
10	379	395	395	382	380	385	379	379	375
11	383	395	395	388	390	390	387	386	391
12	388	395	395	395		394	398	392	396
13	392			410		415	408	400	405
14	395			385		385		392	408
15+	410			410				411	413

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0									
1	269		280	286		247	284		274
2	312	341	310	313		269	324		310
3	316	332	328	328		300	335		318
4	332	347	340	355		320	351		333
5	337	354	347	354		343	354		340
6	344	359	346	349		355	361		347
7	361	362	352	366		362	394		360
8	357	370	364	377		373	395		360
9	369	375	370	379		373	395		371
10	371	379	380	391		383	415		372
11	397	383	390	405		390	406		397
12	405	395		408		394	408		405
13	415	420		410		415	410		415
14	415			420		385	420		415
15+	413								413

Table 8.5.1.1. NE Atlantic Mackerel. Mean length (mm) -at-age by area for 2017 (cont.).

Quarter 4

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							141	141
1	274	220	283				274	274
2	282	264	325	335	335		294	301
3	308	284	334	335	335		329	335
4	321	307	351	335	335		350	352
5	339	320	357				368	369
6	351	330	361				373	376
7	371	338	371	395	395		379	379
8	371	355	380	395	395		386	386
9	390	347	383	395	395			
10	390	381	388	415	415		404	404
11	406	406	401	406	406			
12	408	408	406	408	408		419	419
13	410	410	410	410	410			
14	420	420	414	420	420			
15+	413.00							

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0	181			184	225			143
1	264	286		248	258			288
2	295	324		309	283			316
3	317	335		348	325			329
4	327	348		376	345			347
5	368	367		368	363			353
6	375	376		371	368			359
7	377	381		362	376			365
8	385	385		385	385			372
9								376
10	404	405						380
11								385
12		415						390
13								397
14								396
15+								410

Table 8.5.1.2. NE Atlantic Mackerel. Percentage length composition in catches by country and fleet in 2017. Zeros represent values <1%. Handline Fleet. UKE=UK England and Wales.

	UKE LINES							
	7.E				7.F			
LENGTH CM	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
15								
16								
17								
18								0%
19								0%
20								0%
21	0%		0%					0%
22	0%			0%	0%			1%
23	0%		0%	1%	0%	0%	0%	1%
24	0%		0%	2%	0%	1%	2%	1%
25	0%		3%	6%	1%	2%	4%	8%
26	3%	1%	13%	11%	2%	5%	3%	14%
27	5%	5%	13%	17%	4%	8%	7%	13%
28	8%	20%	7%	14%	11%	8%	6%	6%
29	20%	33%	9%	4%	30%	15%	14%	7%
30	35%	22%	12%	2%	29%	13%	20%	10%
31	16%	10%	14%	4%	13%	8%	21%	15%
32	8%	4%	13%	6%	5%	6%	10%	11%
33	3%	1%	6%	6%	2%	6%	8%	6%
34	1%	1%	3%	5%	1%	9%	3%	2%
35	0%	1%	3%	3%	0%	6%	1%	1%
36	0%	1%	1%	5%	0%	4%	0%	1%
37	0%	0%	1%	5%	0%	4%	0%	0%
38	0%	0%	1%	2%	0%	2%	0%	0%
39	0%	0%	0%	3%		1%		0%
40	0%	0%	0%	2%	0%	1%	0%	
41	0%		0%	0%				
42	0%	0%		1%		0%		
43	0%	0%	0%	1%				
44								
45								
46								
47								

Table 8.5.1.2. NE Atlantic Mackerel. Percentage length composition in catches by country and fleet in 2017. Zeros represent values <1% (cont.). Southern Fleets. ES=Spain.

	ES Purse Seine				ES Trawl				ES Artisanal			
LENGTH CM	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
12												
13												
14												
15												
16												
17												
18					0%							
19					0%	0%	4%					
20					0%	0%	13%					
21					0%	0%	20%					
22				3%	0%	0%	8%	2%				
23				2%		0%	2%	3%				
24			0%	10%		0%	1%	11%				
25		0%	4%	23%		1%	1%	18%				
26		1%	9%	20%	2%	0%	2%	10%			1%	
27		2%	7%	9%	6%	1%	1%	14%			2%	
28	0%	6%	3%	2%	9%	2%	1%	6%			2%	
29	0%	11%	1%	3%	6%	3%	2%	8%	0%		5%	2%
30	0%	9%	3%	6%	11%	7%	7%	7%	0%		5%	5%
31	1%	3%	7%	5%	11%	10%	10%	5%	0%	0%	19%	16%
32	2%	3%	6%	8%	5%	11%	7%	6%	1%	0%	32%	35%
33	7%	5%	8%	4%	3%	11%	4%	2%	5%	3%	14%	20%
34	18%	9%	14%	2%	10%	10%	4%	2%	17%	12%	10%	9%
35	23%	12%	24%	2%	12%	10%	5%	2%	21%	16%	6%	7%
36	18%	12%	9%	3%	10%	9%	5%	3%	18%	18%	3%	7%
37	14%	11%	4%		7%	10%	3%	2%	17%	20%		
38	10%	7%	0%		3%	9%	1%	0%	12%	16%		
39	4%	4%	0%		2%	2%	0%		6%	9%		
40	2%	3%			0%	1%			2%	4%		
41	0%	1%			0%	1%			1%	1%		
42	0%	0%			0%	1%			0%	1%		
43	0%	0%			0%	0%			0%	0%		
44		0%								0%		
45						0%						
46												
47												
49												

Table 8.5.1.2. NE Atlantic Mackerel. Percentage length composition in catches by country and fleet in 2017. Zeros represent values <1% (cont.). Southern Fleets (cont.). BQ=Basque, PT=Portugal.

	BQ Purse Seine				BQ Artisanal				BQ Trawl			PT All			
LENGTH CM	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q4	Q1	Q2	Q3	Q4
11															
12															
13															
14															
15															
16															
17															
18															
19															
20									0%						
21															
22															
23									0%						3%
24					1%				1%						13%
25		0%			2%				3%	0%				0%	11%
26				3%	1%				3%	0%			0%	0%	9%
27				1%	1%				7%	0%			0%	0%	1%
28				2%	0%				10%	1%		5%	1%	0%	2%
29	0%			1%	0%				22%	4%	13%	4%	1%	1%	2%
30	0%	1%		5%	0%				22%	5%	7%	6%	5%	1%	2%
31	0%	1%		8%	0%	0%			21%	5%	20%	11%	8%	6%	2%
32	2%	4%		15%	2%	2%	19%		7%	2%	13%	7%	15%	17%	5%
33	7%	9%		27%	5%	4%	18%	50%	2%	1%	27%	6%	12%	17%	8%
34	15%	17%		17%	13%	13%	26%	50%	1%	1%	7%	5%	7%	17%	8%
35	19%	21%		11%	17%	22%	24%			2%		4%	15%	17%	9%
36	21%	15%		5%	18%	21%	13%			2%	7%	7%	10%	10%	6%
37	15%	13%		2%	17%	17%				3%		9%	5%	4%	8%
38	11%	11%		3%	12%	12%				13%		13%	7%	4%	8%
39	5%	5%			6%	5%				8%		12%	6%	1%	3%
40	2%	2%			2%	3%				18%	7%	6%	4%	1%	1%

	BQ Purse Seine				BQ Artisanal				BQ Trawl			PT All			
LENGTH CM	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q4	Q1	Q2	Q3	Q4
41	1%	1%			1%	1%				18%		3%	2%	0%	0%
42	0%	0%			0%	0%				0%		1%	0%	2%	0%
43	0%				0%	0%				18%		1%	0%		
44	0%				0%							0%			
45															0%
46															
47															
49															

Table 8.5.1.2. NE Atlantic Mackerel. Percentage length composition in catches by country and fleet in 2017. Zeros represent values <1% (cont.). Pelagic Trawl Fleets. IE=Ireland, UKS=UK Scotland, IS=Iceland, DK=Denmark.

	IE			UKS		IS			DK
	4.a	6.a	7.b	4.a	6.a	2.a, 5.a, 14.b			4.a
Length cm	Q4	Q1	Q1	Q4	Q1	Q2	Q3	Q4	Q4
15									
16		0%							
17									
18									
19									
20		0%							
21									
22					0%				
23		0%							
24	0%	0%			0%				
25	0%								
26				0%			0%		
27	1%	0%		0%	0%		0		
28	1%	0%		1%	0%		0%		
29	1%	0%	0%	1%	1%		0%	0%	0%
30	0%	1%	1%	1%	2%	0%	0%	1%	3%
31	2%	2%	1%	3%	2%	1%	3%	6%	3%
32	6%	1%	2%	8%	3%	5%	5%	8%	3%
33	10%	6%	6%	10%	12%	17%	13%	15%	5%
34	12%	18%	16%	18%	20%	27%	24%	24%	15%
35	21%	19%	20%	21%	18%	22%	21%	20%	20%
36	19%	15%	16%	17%	14%	13%	16%	14%	15%
37	13%	15%	18%	11%	15%	9%	11%	7%	11%
38	9%	12%	12%	7%	8%	4%	5%	3%	12%
39	4%	7%	5%	3%	3%	1%	2%	2%	7%
40	1%	3%	2%	1%	1%	0%	1%	0%	3%
41	1%	1%	1%	0%	0%		0%	0%	1%
42	0%	0%	0%	0%	0%				0%
43	0%	0%	0%		0%		0%		0%
44				0%	0%				0%
45									

Table 8.5.1.2. NE Atlantic Mackerel. Percentage length composition in catches by country and fleet in 2017. Zeros represent values <1% (cont.). Freezer Trawlers. NL=The Netherlands, DE=Germany, RU= Russia.

	NL				DE				RU	
	2.a,4.a,4.b,6.a,7.b,7.c				6.a	4.a	2.a	7.b	2.a	2.a
LENGTH CM	Q1	Q2	Q3	Q4	Q1	Q3	Q4	Q1	Q3	Q4
15										
16					0%					
17					1%					
18					1%					
19					0%					
20					0%					
21					0%	0%	0%		0%	
22					0%	0%	0%			0%
23					0%	0%	0%		0%	0%
24					0%	0%	0%			0%
25					0%	0%	0%		0%	0%
26	1%		0%		0%	0%	0%			0%
27			0%		1%	0%	0%	0%	0%	0%
28	1%		0%		2%	1%	1%	1%	0%	0%
29	3%		2%		3%	5%	5%	3%	0%	0%
30	8%		2%		3%	24%	24%	3%	5%	1%
31	6%	0.04	6%	2%	2%	28%	28%	4%	22%	10%
32	2%	0%	6%	9%	5%	12%	12%	4%	19%	21%
33	6%	4%	4%	9%	14%	10%	10%	13%	10%	15%
34	14%	12%	7%	8%	17%	8%	8%	22%	16%	17%
35	18%	28%	15%	16%	15%	5%	5%	16%	15%	18%
36	13%	8%	14%	18%	14%	3%	3%	16%	7%	10%
37	10%	8%	9%	19%	12%	1%	1%	12%	3%	4%
38	10%	24%	15%	8%	6%	0%	0%	4%	1%	2%
39	5%	4%	10%	7%	2%	0%	0%	2%	1%	1%
40	1%	8%	7%	4%	1%	0%	0%	1%	0%	0%
41	2%		2%		0%	0%	0%	0%	0%	0%
42	1%		0%		0%	0%	0%	0%	0%	0%
43	0%		0%		0%				0%	0%
44									0%	
45									0%	0%
46										
47										
48										

Table 8.5.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2017.

Quarters 1-4

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	220	318	318	188	171	176	199	199	191
2	333	316	316	282	246	272	278	270	269
3	327	380	306	289	290	309	300	302	259
4	348	407	386	351	343	368	375	365	330
5	392	430	424	368	355	384	391	380	345
6	418	464	442	389	352	397	415	402	363
7	434	527	465	404	376	429	424	421	366
8	466	542	462	446	422	467	486	454	412
9	489	533	494	457	442	481	445	468	416
10	510	593	581	484	487	497	481	483	475
11	528	612	612	494	532	514	503	506	534
12	549	542	542	493	467	531	459	520	463
13	572			482	459	606	455	526	457
14	604			406	376	497	384	431	383
15+	639			634				614	611

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0				27		27			
1	175		170	192		111	187	187	179
2	262	369	318	193	276	177	212	272	260
3	276	370	256	232	276	214	237	314	272
4	320	400	352	310	277	261	250	361	314
5	331	419	388	332	416	304	314	342	338
6	345	433	399	350	432	318	317	383	357
7	353	454	399	371	454	332	363	417	392
8	396	485	439	407	486	376	391	403	414
9	401	494	454	440	495	401	406	429	434
10	451	516	490	455	516	444	424	464	449
11	432	539	537	464	539	400	402	504	522
12	514	563	478	491	564	476	476	527	526
13	485	671	452	504	670	470	550	588	513
14	434		376	546		449	664	708	574
15+	602			530		434			602

Table 8.5.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2017 (cont.).

Quarters 1-4

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							17	17
1	185	97	187	187	187		79	49
2	208	150	274	275	267	289	201	196
3	238	190	300	301	237	338	267	250
4	256	218	306	302	280	369	306	298
5	308	247	338	331	312	389	329	318
6	330	270	338	330	323	408	349	334
7	414	299	363	399	356	432	378	365
8	431	356	405	402	405	426	407	398
9	453	356	412	411	410	439	431	421
10	472	460	429	434	429	473	462	435
11	553	572	456	476	491	516	478	471
12	608	611	476	605	501	594	583	539
13	616	617	566	615	584		630	623
14	716	719	665	719	692			
15+	602							

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0	47		15	54	74			18
1	120	124	46	81	127	431	431	178
2	178	189	181	260	182	369	369	266
3	228	251	226	307	243	422	422	312
4	283	300	283	397	289	481	479	356
5	305	322	302	421	298	532	523	377
6	320	341	310	405	311	577	516	397
7	350	375	322	473	354	644	477	415
8	374	397	363	464	381		501	444
9	387	422	377	483	397		510	466
10	400	437	442	510	412		532	484
11	444	501	374	539	443		554	497
12	482	535	474	483	473		581	523
13	549	621	528		574			537
14			424					535
15+								606

Table 8.5.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2017 (cont.).

Quarter 1

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	188					67		77	106
2	358							206	199
3	345			215		232	215	215	211
4	382			300		298	300	299	296
5	403			312		316	312	315	326
6	422			339		353	339	341	347
7	443			348		365	348	351	361
8	475			409		403	409	410	419
9	491			400		406	400	405	419
10	517			479		437	479	477	475
11	538					430		452	456
12	552			450		471	450	452	456
13	581			450		457	450	451	453
14	599			376		643	376	378	378
15+	641							641	

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0				27		27			
1	106			193		96	187	187	187
2	196	358	289	192		190	212	267	219
3	205	376	215	232		220	236	259	206
4	290	386	300	310		291	251	357	290
5	336	406	312	332		316	314	321	335
6	358	420	339	350		332	317	380	357
7	381	431	348	372		363	361	416	380
8	438	475	409	407		389	389	402	437
9	437	469	400	441		432	404	429	437
10	471	502	479	455		440	423	463	469
11	458	515	594	465		439	392	503	457
12	474	492	450	491		476	452	475	474
13	460		450	502		470	522	528	464
14	423		376	544		448	507	507	412
15+				530		434			

Table 8.5.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2017 (cont.).

Quarter 1

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							14	14
1	186	128	187	187	187		36	46
2	245	158	274	272	266		193	194
3	209	187	315	259	233		244	245
4	224	202	336	242	280	442	291	293
5	291	221	333	314	312	337	312	315
6	310	231	327	313	323	401	328	330
7	358	252	348	373	349	425	358	359
8	390	311	399	386	397	408	393	394
9	404	337	408	403	407	433	415	415
10	429	569	422	423	422	469	426	426
11	397	387	418	388	411	515	467	466
12	500	541	434	541	435		515	511
13	534	541	517	541	518		615	615
14	424		507		507			
15+								

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0			21					14
1	134	124	58	52	134			105
2	175	186	176	200	201			189
3	225	249	224	262	239			230
4	283	300	284	375	266			306
5	304	321	304	409	280			328
6	318	341	319	406	289			346
7	344	374	346	487	321			369
8	369	397	373	473	365			405
9	384	420	388	480	391			436
10	397	435	405	510	404			454
11	428	481	434	549	462			462
12	471	536	474	483	490			487
13	528	637	528		532			493
14			424					491
15+								530

Table 8.5.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2017 (cont.).

Quarter 2

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	125			86		67	67	182	166
2	226			261				262	269
3	301			231	215	232	216	312	255
4	292			304	300	298	300	351	308
5	335			329	312	316	312	389	324
6	371			361	339	353	341	420	346
7	397			372	348	365	350	446	357
8	426			421	409	403	408	471	409
9	428			431	400	406	401	496	413
10	486			483	479	437	475	518	475
11	505			478		430	430	542	536
12	537			475	450	471	452	555	462
13	684			468	450	457	451	569	456
14	737			400	376	643	386	542	382
15+	641			641				641	611

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0				27					
1	173			163		100			173
2	259	358	334	198	289	153	214	289	261
3	275	376	341	217	342	191	239	342	280
4	317	386	390	301	374	219	244	374	321
5	325	406	411	306	393	276	314	393	337
6	335	420	430	311	412	314	315	412	354
7	334	431	445	318	452	308	378	450	390
8	389	475	473	378	515	326	403	498	396
9	389	469	492	385	549	410	420	502	421
10	453	502	510	450	565	428	436	519	441
11	403	515	524	382	594	369	407	538	499
12	491	492	574	483	594		524	594	566
13	467		690	510			546		585
14	405			440			713		578
15+	602			519					602

Table 8.5.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2017 (cont.).

Quarter 2

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							14	14
1	123	100					34	34
2	267	154	286	288	275	289	243	209
3	257	192	310	334	276	342	281	264
4	250	220	317	361	287	374	313	304
5	328	273	334	370	321	393	331	324
6	336	318	333	376	324	412	351	345
7	380	315	356	410	446	452	385	381
8	390	327	397	403	486	515	411	408
9	406	423	408	417	463	549	436	433
10	424	423	423	437	497	565	449	446
11	392	388	407	412	568	594	480	479
12	516	543	437	549	603	594	499	501
13	537	541	518	541	616		634	634
14	424		507		718			
15+	602							

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0			14					14
1	97	122	34	68	97		431	62
2	183	207	193	248	176		369	234
3	230	262	237	264	214		422	279
4	281	304	277	360	261		481	296
5	306	323	300	372	302		532	327
6	324	345	292	400	327		577	352
7	357	384	303	459	366		644	378
8	379	403	338	456	385			405
9	390	435	373	488	397			412
10	402	451	450	509	413			456
11	453	549	369	527	440			460
12	487	522	549	450	468			519
13	552	615			580			537
14								463
15+								619

Table 8.5.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2017 (cont.).

Quarter 3

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	161			196	171	177	202	216	202
2	344			281	246	272	275	262	269
3	333	403	403	316	293	309	324	296	268
4	353	411	411	368	372	368	389	344	371
5	397	431	431	380	359	384	406	367	409
6	423	465	465	402	353	397	440	393	447
7	439	529	529	428	378	429	474	418	463
8	474	544	544	465	423	467	584	438	482
9	499	536	536	478	446	482	482	459	464
10	519	596	596	486	488	497	488	479	478
11	538			505	532	517	533	500	520
12	561			531	554	533		517	504
13	578			580	605	634		536	486
14	610			513		494		553	422
15+	643			615				614	604

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0									
1	177			181		113	181		174
2	263	369	369	204	276	185	283	276	261
3	280	369	369	318	276	225	316	276	280
4	325	401	401	369	277	256	367	276	322
5	339	419	419	305	419	298	381		339
6	359	433	433	300	433	292	402		357
7	412	454	454	307	454	302	518	527	409
8	403	485	485	353	485	338	557	562	398
9	435	495	495	375	495	373	581	590	432
10	441	516	516	451	516	450	568	573	438
11	535	539	539	370	539	369	578	578	537
12	569	564	564	545	564		611	611	571
13	612	670	670	618	670		617	617	613
14	613			494			719	719	613
15+	602								602

Table 8.5.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2017 (cont.).

Quarter 3

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							19	19
1	186	113	181				148	143
2	194	164	276	289	276	276	244	228
3	239	226	277	342	276	276	283	279
4	266	256	281	374	276	276	310	313
5	297	286	381	394			373	368
6	329	308	402	412			411	399
7	462	327	473	525	527		395	396
8	505	379	522	562	562		417	418
9	522	370	534	590	590			
10	533	492	535	573	573		490	489
11	578	578	576	578	578			
12	611	611	609	611	611		588	584
13	617	617	617	617	617			
14	719	719	717	719	719			
15+	602							

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0	60			57	72			22
1	134	137	200	111	123	431	431	311
2	230	269	232	300	223	369	369	331
3	268	282	287	372	273	422	422	348
4	298	316	337	448	314	481	479	377
5	364	357	360	582	346	532	523	410
6	401	407	375		373	577	516	426
7	402	451	412		386	644	477	442
8	420	450	418		413		501	476
9			429				510	497
10	464	453					532	517
11							554	537
12	514	530					581	560
13								578
14								611
15+								642

Table 8.5.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2017 (cont.).

Quarter 4

Age	2.a	2.a.1	2.a.2	3.a	3.b	3.c	3.d	4.a	4.b
0									
1	231	318	318	184	177	177	191	198	200
2	307	316	316	284	250	272	290	271	261
3	311	303	303	318	300	309	326	305	286
4	351	385	385	370	389	368	376	367	357
5	381	423	423	383	384	384	389	382	381
6	401	436	436	406	377	397	420	405	412
7	420	446	446	432	396	429	441	426	436
8	440	401	401	475	448	467	497	458	443
9	462	489	489	486	450	482	488	472	451
10	487	580	580	490	488	497	484	483	461
11	504	612	612	509	533	517	508	506	521
12	519	542	542	542		533	554	532	545
13	538			611		634	605	571	586
14	554			496		494		528	589
15+	616			616				612	603

AGE	4.c	5.a	5.b	6.a	6.b	7.a	7.b	7.c	7.d
0									
1	173		170	186		125	181		179
2	267	370	243	253		156	283		260
3	278	341	292	293		222	318		279
4	320	391	314	385		269	369		321
5	335	414	355	382		336	381		340
6	354	433	351	362		378	402		357
7	409	442	375	422		405	525		407
8	396	473	420	481		447	561		398
9	433	492	444	489		448	588		434
10	439	508	488	524		483	572		442
11	537	525	533	575		516	578		537
12	571	575		608		533	611		571
13	613	686		617		634	617		613
14	613			719		494	719		613
15+	602								602

Table 8.5.2.1. NE Atlantic Mackerel. Mean weight (g) -at-age by area for 2017 (cont.).

Quarter 4

Age	7.e	7.f	7.g	7.h	7.j	7.k	8.a	8.b
0							19	19
1	174	85	177				142	142
2	183	144	274	276	276		180	195
3	242	181	308	276	276		254	269
4	272	227	364	276	276		310	314
5	322	256	386				360	364
6	351	282	400				378	387
7	441	312	438	527	527		397	397
8	450	369	478	562	562		419	419
9	497	343	490	590	590			
10	484	438	504	573	573		486	486
11	578	578	560	578	578			
12	611	611	597	611	611		548	548
13	617	617	618	617	617			
14	719	719	683	719	719			
15+	602							

Age	8.c	8.c.E	8.d	9.a	9.a.N	14.a	14.b	All
0	46			49	87			21
1	141	163		119	129			199
2	194	244		260	173			267
3	237	269		376	254			305
4	260	302		481	305			365
5	363	360		439	349			382
6	383	388		450	364			404
7	389	403		413	385			424
8	415	418		413	413			453
9								469
10	477	490						486
11								507
12		530						527
13								560
14								556
15+								614

Table 8.6.1.1.1 International mackerel and horse mackerel egg survey: Periods and area assignments for vessels by week for the 2019 survey. Area assignments and dates are provisional.

		Area							
week	Starts	Portugal, Cadiz & Galicia	Cantabrian Sea	Bay of Biscay	Celtic Sea	North west Ireland	West of Scotland	Northern Area	Period
3	13-Jan-19	PO1 (DEPM)							1
4	20-Jan-19	PO1 (DEPM)							1
5	27-Jan-19	PO1 (DEPM)		IRL1	IRL1				2
6	03-feb-19	PO1 (DEPM)		IRL1	IRL1				2
7	10-feb-19	PO1 (DEPM)		IRL1	IRL1				2
8	17-feb-19	PO1 (DEPM)				SCO (IBTS)	SCO (IBTS)		2
9	24-feb-19					SCO (IBTS)	SCO (IBTS)		2
10	03-mar-19								3
11	10-mar-19		IEO1			SCO2	SCO2		3
12	17-mar-19		IEO1	AZTI1	GER1	SCO2	SCO2		3
13	24-mar-19		IEO1	AZTI1	GER1	GER1			3
14	31-mar-19		IEO1	AZTI1	GER1	GER1			3
15	07-Apr-19		IEO2	IEO2 AZTI1	GER2	GER2			4
16	14-Apr-19		IEO2	IEO2	GER2	GER2	DEN	DEN	4
17	21-Apr-19		IEO2	IEO2	GER2	DEN	DEN	DEN	4
18	28-Apr -19		IEO2	IEO2					4
19	05-may-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO3	SCO3	ICE	5
20	12-may-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO3	SCO3	ICE	5
21	19-may-19		AZTI2 (DEPM)	AZTI2 (DEPM)	NED1	SCO3	SCO3	FAR	5
22	26-may-19		AZTI2 (DEPM)	AZTI2 (DEPM)				FAR	5
23	02-jun-19			NED2	NED2			FAR	5
24	09-jun-19			NED2	NED2	IRL2	IRL2	NOR	6
25	16-jun-19			NED2	NED2	IRL2	IRL2	NOR	6
26	23-jun-19					IRL2	IRL2	NOR	6
27	30-jun-19								6
28	07-jul-19				SCO3	SCO4	SCO4		7
29	14 –Jul-19				SCO3	SCO4	SCO4		7
30	21-jul-19				SCO3	SCO4	SCO4		7
31	28-jul-19								7

Table 8.6.3.1. Abundance index, mean weight-at-age, and biomass index for mackerel from the IESSNS in 2007 and from 2010 to 2018.

	2007			**2010**			**2011**			**2012**		
AGE	Number (billions)	W (g)	Biomt (million)	Number (billions)	W (g)	Biomt (million)	Number (billions)	W (g)	Biomt (million)	Number (billions)	W (g)	Biomt (million)
1	1.33	133	0.18	0.03	133	0	0.21	133	0.03	0.5	112	0.06
2	1.86	233	0.43	2.8	212	0.59	0.26	278	0.07	4.99	188	0.94
3	0.9	323	0.29	1.52	290	0.44	0.87	318	0.28	1.22	286	0.35
4	0.24	390	0.09	4.02	353	1.42	1.11	371	0.41	2.11	347	0.73
5	1	472	0.47	3.06	388	1.19	1.64	412	0.67	1.82	397	0.72
6	0.16	532	0.09	1.35	438	0.59	1.22	440	0.54	2.42	414	1
7	0.06	536	0.03	0.53	512	0.27	0.57	502	0.29	1.64	437	0.72
8	0.04	585	0.02	0.39	527	0.2	0.28	537	0.15	0.65	458	0.3
9	0.03	591	0.02	0.2	548	0.11	0.12	564	0.07	0.34	488	0.17
10	0.01	640	0.01	0.05	580	0.03	0.07	541	0.04	0.12	523	0.06
11	0.01	727	0.01	0.03	645	0.02	0.06	570	0.03	0.07	514	0.03
12	0	656	0	0.02	683	0.01	0.02	632	0.01	0.02	615	0.01
13	0.01	685	0.01	0.01	665	0.01	0.01	622	0.01	0.01	509	0
14+	0	671	0	0.01	596	0	0	612	0	0.01	677	0
TOTAL	5.65	512	1.64	13.99	469	4.89	6.42	467	2.69	15.91	426	5.09

	2013			**2014**			**2015**			**2016**		
AGE	Number (billions)	W (g)	Biomt (million)	Number (billions)	W (g)	Biomt (million)	Number (billions)	W (g)	Biomt (million)	Number (billions)	W (g)	Biomt (million)
1	0.06	96	0.01	0.01	228	0	1.2	128	0.15	<0.01	95	<0.01
2	7.78	184	1.43	0.58	275	0.16	0.83	290	0.24	4.98	231	1.15
3	8.99	259	2.32	7.8	288	2.24	2.41	333	0.8	1.37	324	0.45
4	2.14	326	0.7	5.14	335	1.72	5.77	342	1.97	2.64	360	0.95
5	2.91	374	1.09	2.61	402	1.05	4.56	386	1.76	5.24	371	1.95
6	2.87	399	1.15	2.62	433	1.14	1.94	449	0.87	4.37	394	1.72
7	2.68	428	1.15	2.67	459	1.23	1.83	463	0.85	1.89	440	0.83
8	1.27	445	0.56	1.69	477	0.8	1.04	479	0.5	1.66	458	0.76
9	0.45	486	0.22	0.74	488	0.36	0.62	488	0.3	1.11	479	0.53
10	0.19	523	0.1	0.36	533	0.19	0.32	505	0.16	0.75	488	0.37
11	0.16	499	0.08	0.09	603	0.05	0.08	559	0.04	0.45	494	0.22
12	0.04	547	0.02	0.05	544	0.03	0.07	568	0.04	0.2	523	0.1
13	0.01	677	0.01	0.02	537	0.01	0.04	583	0.02	0.07	511	0.04
14+	0.02	607	0.01	0	569	0	0.02	466	0.01	0.07	664	0.04
TOTAL	29.57	418	8.85	24.37	441	8.98	20.72	431	7.72	24.81	367	9.11

Table 8.6.3.1. Abundance index , mean weight-at-age, and biomass index for mackerel from the IESSNS in 2007 and from 2010 to 2018. Cont.

	2017			2018		
AGE	Number (billions)	W (g)	Biom. t (million)	Number (billions)	W (g)	Biom. t (million)
1	0.86	86	0.07	2.18	67	0.15
2	0.12	292	0.03	2.5	229	0.57
3	3.56	330	1.18	0.5	330	0.16
4	1.95	373	0.73	2.38	390	0.93
5	3.32	431	1.43	1.2	420	0.5
6	4.68	437	2.04	1.41	449	0.63
7	4.65	462	2.15	2.33	458	1.07
8	1.75	487	0.86	1.79	477	0.85
9	1.94	536	1.04	1.05	486	0.51
10	0.63	534	0.33	0.5	515	0.26
11	0.51	542	0.28	0.56	534	0.3
12	0.12	574	0.07	0.29	543	0.16
13	0.08	589	0.05	0.14	575	0.08
14+	0.04	626	0.03	0.09	643	0.05
TOTAL	24.22	425	10.29	16.92	368	6.22

Table 8.6.4.1. Numbers of RFID tagged and recaptured (by 31.08.2018) mackerel by tagging experiment. In the 2018 tagging survey off Ireland-Hebrides a proportion of the tagged mackerel were handled in the old way (marked * in the table), with manual jigging, and released directly to the sea at starboard side. This was to test whether differences in survival rates between the steel tag time series and the RFID tag time series is due to handling.

Year	Period	Area	N-Released	N-Recaptured
2011	May-June	Ireland-Hebrides	18645	133
2011	Sep	Norwegian west coast	31253	144
2012	May-June	Ireland-Hebrides	32137	276
2013	May-June	Ireland-Hebrides	22792	328
2014	May-June	Ireland-Hebrides	55185	885
2015	May-June	Ireland-Hebrides	43910	561
2015	August	Iceland	806	11
2016	May-June	Ireland-Hebrides	43959	537
2016	August	Iceland	4884	119
2017	May-June	Ireland-Hebrides	56082	286
2017	August	Iceland	3891	43
2018	May-June	Ireland-Hebrides	35336	13
2018*	May-June	Ireland-Hebrides	4661	1
Total			353541	3337

Table 8.6.4.2. Numbers of recaptured mackerel with RFID tags by factory and recapture year.

Factory	2012	2013	2014	2015	2016	2017	2018	Total
DK01 Sæby	0	0	8	11	0	0	0	19
FO01 Vardin Pelagic	0	0	15	37	23	13	0	88
GB01 Denholm Coldstore	0	0	0	10	10	28	25	73
GB01 Denholm Factory	0	0	25	64	79	119	31	318
GB02 Lunar Freezing Peterhead	0	0	33	51	60	42	20	206
GB03 Lunar Freezing Fraserburgh	0	0	0	9	16	7	5	37
GB04 Pelagia Shetland	0	0	25	130	162	157	53	527
GB05 Northbay Pelagic	0	0	0	0	0	0	23	23
IC01 Vopnafjord	0	0	24	61	81	73	37	276
IC02 Neskaupstad	0	0	0	19	93	58	23	193
IC03 Höfn	0	0	0	1	0	1	0	2
NO01 Pelagia Egersund Seafood	12	25	19	7	1	0	53	117
NO02 Skude Fryseri	6	9	21	19	27	55	16	153
NO03 Pelagia Austevoll	1	1	7	5	1	0	3	18
NO04 Pelagia Florø	6	19	33	22	18	0	0	98
NO05 Pelagia Måløy	6	19	21	46	42	89	7	230
NO06 Pelagia Selje	19	35	38	77	59	102	24	354
NO07 Pelagia Liavågen	10	13	34	34	30	102	0	223
NO08 Brødrene Sperre	7	18	21	66	117	85	30	344
NO09 Lofoten Viking	0	0	0	0	0	0	7	7
NO14 Nils Sperre	0	0	0	0	0	0	30	30
NO16 Vikomar	0	0	0	0	0	0	1	1
All factories summed	67	139	324	669	819	931	388	**3337**

Table 8.6.4.3. Abundance index in billions individuals ages 4-12 per release years 2011-2016. The index is based on RFID tagging experiments and data from scanned catches and recaptures the two first years after a relase year (yearsout=1-2). The index is already scaled down to the 10% survival estimated by SAM.

					Age				
Year	4	5	6	7	8	9	10	11	12
2011	3,236171	2,813887	2,017941	0,635952	0,322985	0,137462	0,036253	0,041593	0,064976
2012	3,484761	3,284821	2,956715	1,741262	0,572768	0,361678	0,128663	0,056303	0,036048
2013	1,974994	2,161885	1,956662	1,423692	0,709068	0,246734	0,141168	0,040904	0,009638
2014	3,206810	1,412106	1,636556	1,360554	0,890053	0,437290	0,191334	0,077791	0,037645
2015	2,696358	2,484074	1,350807	1,331608	1,065801	0,835234	0,400878	0,219851	0,061100
2016	0,890211	1,764716	1,618460	0,741481	0,727085	0,506326	0,355878	0,176446	0,048090

Table 8.6.5.2.1. Biomass, abundance, mean length and mean weight at age of mackerel from the Spanish spring acoustics surveys (PELACUS) from 2001 to 2018.

	2001				**2002**				**2003**			
AGE	Number (millions)	L (cm)	W (g)	Biomass t ('000)	Number (millions)	L (cm)	W (g)	Biomass t ('000)	Number (millions)	L (cm)	W (g)	Biomass t ('000)
1	29.0	25.9	126.2	3.7	621.4	23.3	80.5	50.0	5678.6	23.1	81.6	463.2
2	47.6	31.0	213.7	10.2	94.8	32.0	221.9	21.0	324.5	28.9	165.1	53.6
3	184.3	33.7	277.3	51.1	378.1	34.3	277.1	104.8	109.0	33.5	261.3	28.5
4	386.6	36.1	340.3	131.6	706.8	35.8	317.9	224.7	229.0	35.0	299.7	68.6
5	382.1	37.5	383.0	146.4	1065.9	36.8	348.0	370.9	265.2	37.1	359.1	95.2
6	393.6	38.0	397.7	156.5	604.6	38.2	390.9	236.3	230.1	38.0	385.7	88.8
7	202.7	39.5	446.7	90.5	674.5	39.1	419.2	282.8	94.3	39.8	443.4	41.8
8	143.5	40.0	464.5	66.7	191.4	39.9	447.2	85.6	88.5	40.1	454.6	40.2
9	83.7	40.5	481.7	40.3	158.4	40.3	461.4	73.1	19.6	41.5	505.1	9.9
10	17.0	40.2	469.3	8.0	100.2	41.0	490.2	49.1	10.0	41.9	519.9	5.2
11	26.3	42.1	541.4	14.2	54.0	41.4	504.0	27.2	14.0	42.6	549.6	7.7
12	12.3	41.9	533.8	6.5	12.4	43.5	586.7	7.3	3.8	41.5	503.1	1.9
13	1.9	41.5	517.1	1.0	0.0	0.0	0.0	0.0	3.7	43.1	566.9	2.1
14	6.1	43.5	596.5	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15+	9.4	42.8	568.1	5.3	2.9	45.5	676.9	2.0	2.0	43.3	578.1	1.2
TOTAL	1926.2	37.3	381.9	735.6	4665.3	35.5	329.0	1534.8	7072.1	25.5	128.4	907.8
	2004				**2005**				**2006**			
1	195.2	25.0	114.6	22.4	43.4	24.8	112.1	4.6	83.7	20.8	58.5	4.9
2	952.4	28.3	164.5	156.6	106.5	29.2	181.8	19.0	9.3	29.7	177.2	1.7
3	599.3	32.8	258.1	154.7	229.1	32.3	245.4	56.1	57.3	31.9	223.1	12.8
4	227.5	37.5	377.8	86.0	259.6	36.5	349.4	92.4	230.7	33.5	262.7	60.6
5	425.6	38.1	395.5	168.3	82.6	38.3	403.4	34.2	104.7	36.7	345.0	36.1
6	336.7	39.1	428.4	144.2	163.8	38.8	417.6	70.4	34.2	38.5	398.1	13.6
7	181.5	40.1	461.7	83.8	114.9	39.5	438.4	52.0	22.2	39.2	420.5	9.3
8	106.1	40.8	483.2	51.3	63.8	39.8	451.7	29.8	7.6	40.9	483.3	3.6
9	76.5	41.0	492.5	37.7	33.6	41.0	493.9	17.2	2.0	41.9	513.6	1.0
10	31.1	42.3	538.0	16.7	15.3	42.3	535.4	8.5	3.4	41.3	495.1	1.7
11	18.9	42.2	533.9	10.1	13.7	41.8	518.8	7.4	1.4	42.7	545.7	0.8
12	13.5	43.3	573.8	7.7	6.6	42.0	526.6	3.6	0.5	42.8	551.1	0.3
13	3.2	43.9	599.8	1.9	11.3	42.5	544.1	6.4	0.1	43.8	590.7	0.1
14	0.0	0.0	0.0	0.0	5.1	43.8	592.6	3.2	0.0	0.0	0.0	0.0
15+	5.9	46.4	710.5	4.2	7.3	43.7	594.9	4.6	0.0	44.5	621.0	0.0
TOTAL	3173.2	33.8	298.0	945.6	1156.6	35.9	346.7	409.5	557.3	32.7	263.0	146.6

Table 8.6.5.2.1. Biomass, abundance, mean length and mean weight at age of mackerel from the Spanish spring acoustics surveys (PELACUS) from 2001 to 2018 (cont.).

	2007				**2008**				**2009**			
AGE	Number (millions)	L (cm)	W (g)	Biomass t ('000)	Number (millions)	L (cm)	W (g)	Biomass t ('000)	Number (millions)	L (cm)	W (g)	Biomass t ('000)
1	182.2	21.5	64.1	11.7	407.1	24.4	100.4	40.9	7.5	24.3	98.5	0.7
2	34.6	25.6	110.5	3.8	100.5	27.1	135.2	13.6	65.1	29.3	176.1	11.5
3	22.1	33.4	254.5	5.6	327.4	29.8	180.7	59.1	148.4	30.0	189.4	28.1
4	129.6	34.9	291.7	37.8	125.8	33.5	261.9	32.9	201.7	32.5	248.1	50.0
5	189.4	36.1	324.0	61.4	233.6	36.2	328.2	76.5	86.8	35.0	314.3	27.3
6	117.5	38.1	379.7	44.6	277.5	36.3	328.5	91.0	148.8	36.9	370.0	55.0
7	31.9	39.8	435.9	13.9	131.0	37.9	374.1	48.9	180.8	37.7	394.7	71.3
8	20.5	39.7	431.5	8.8	25.2	39.5	423.4	10.6	93.0	39.5	454.8	42.2
9	4.8	41.2	484.0	2.3	20.1	39.5	422.7	8.5	32.6	40.2	484.7	15.7
10	6.1	40.7	464.7	2.8	20.5	40.2	443.6	9.0	14.9	40.7	500.8	7.5
11	1.5	41.4	490.3	0.8	9.2	41.1	474.8	4.4	4.6	41.6	537.0	2.4
12	4.7	44.5	608.6	2.8	7.3	41.8	500.0	3.6	3.5	42.2	561.9	2.0
13	0.7	43.5	567.6	0.4	2.4	43.4	561.4	1.3	4.1	42.4	569.2	2.3
14	2.6	44.0	591.5	1.5	1.1	44.6	607.1	0.7	0.0	0.0	0.0	0.0
15+	0.7	46.5	697.9	0.5	0.4	46.5	690.3	0.3	0.0	0.0	0.0	0.0
TOTAL	748.9	32.5	265.4	198.8	1689.2	31.7	238.0	401.4	991.8	34.8	319.0	316.2
	2010				**2011**				**2012**			
1	431.8	23.6	89.2	38.6	1936.9	22.5	77.4	149.3	698.05	22.07	74.36	51.83
2	72.7	30.6	194.8	14.2	29.7	30.5	201.3	6.0	16.7	27.71	150.62	2.5
3	189.6	31.5	214.9	40.9	63.1	32.3	239.2	15.1	11.18	33.27	265.58	2.98
4	662.7	33.6	262.3	174.1	90.6	33.7	273.6	24.7	32.34	34.63	299.04	9.69
5	873.3	35.0	296.3	258.8	154.8	35.0	308.5	47.6	60.04	35.62	325.28	19.53
6	306.6	36.8	346.3	106.1	144.1	36.1	340.6	49.0	147.09	36.58	353.17	51.84
7	388.9	38.1	385.6	149.8	57.7	38.2	406.2	23.4	121.31	37.66	386.73	46.77
8	239.2	38.2	388.3	92.8	54.2	39.5	446.9	24.1	61.9	39.43	445.95	27.53
9	113.9	39.5	427.5	48.6	31.2	39.6	451.5	14.0	32.39	40.12	470.22	15.19
10	26.4	40.8	470.2	12.4	10.3	41.0	503.5	5.2	19.11	40.54	485.42	9.26
11	16.5	40.9	475.8	7.8	4.7	41.0	503.1	2.4	8.07	40.66	489.56	3.94
12	10.3	41.4	492.4	5.0	3.1	41.8	533.3	1.6	2.78	41.94	538.24	1.49
13	7.5	41.9	509.7	3.8	2.4	41.6	527.1	1.2	1.36	42.38	555.37	0.75
14	5.3	42.4	530.5	2.8	0.0	0.0	0.0	0.0	1.36	42.38	555.37	0.75
15+	3.0	43.1	557.7	1.7	0.0	0.0	0.0	0.0	1.19	44.53	649.03	0.78
TOTAL	3347.8	34.0	286.0	957.5	2582.9	25.8	141.2	363.7	1214.88	28.46	201.91	244.81

Table 8.6.5.2.1. Biomass, abundance, mean length and mean weight at age of mackerel from the Spanish spring acoustics surveys (PELACUS) from 2001 to 2018 (cont.).

	2013				**2014**				**2015**			
AGE	Number (millions)	L (cm)	W (g)	Biomass t ('000)	Number (millions)	L (cm)	W (g)	Biomass t ('000)	Number (millions)	L (cm)	W (g)	Biomass t ('000)
1	99	24.5	93.0	9	68.1	22.5	71.5	5.1	101.38	22.34	69.55	7.50
2	653	26.5	119.1	81	42.8	32.0	217.4	9.1	11.91	31.88	214.66	2.60
3	123	28.6	152.4	20	157.4	32.3	223.7	34.6	43.16	32.69	232.42	10.20
4	114	34.2	267.6	31	340.4	33.3	245.5	81.9	112.36	34.05	264.52	29.81
5	228	35.3	296.0	68	675.8	34.5	275.3	181.7	299.50	35.09	290.94	86.92
6	235	36.2	322.3	76	581.1	36.1	318.0	179.5	348.66	36.40	326.84	112.95
7	178	36.7	335.3	60	502.4	36.6	333.9	163.0	344.06	37.03	345.17	117.63
8	64	37.6	361.4	23	246.9	36.7	335.2	80.4	164.59	37.02	344.84	56.24
9	11	38.1	378.2	4	84.5	38.2	381.8	31.3	71.17	38.37	386.31	27.15
10	8	40.0	439.4	4	33.1	39.2	414.3	13.3	29.50	39.17	412.51	12.00
11	3	40.8	470.1	1	34.7	39.4	420.9	14.2	29.95	39.24	414.69	12.25
12	2	41.2	490.3	1	34.7	39.4	420.9	14.2	29.95	39.24	414.69	12.25
13												0
14												0
15+												0
TOTAL	1718	31.2	200.2	379	2802.0	35.1	291.0	808.4	1586.20	35.40	299.24	487.49
	2016				**2017**				**2018**			
1	12.61	22.4	74.0	1.0	170.5	21.9	67.2	12.4		22.72	81.99	5.3
2	73.54	28.0	144.1	11.2	12.4	27.8	141.3	1.9		27.46	142.93	5.1
3	26.62	30.9	193.1	5.3	91.4	62.8	234.2	22.6		33.56	256.69	10.1
4	54.98	34.5	268.2	14.8	115.6	64.8	283.1	34.5		35.73	309.38	30.9
5	230.22	35.7	297.7	68.9	438.3	65.4	298.2	137.2		35.99	315.99	124.3
6	406.48	36.4	315.3	128.9	421.2	36.1	316.4	139.9		36.52	329.78	143.6
7	318.08	37.3	337.3	107.8	278.3	37.1	344.8	100.7		37.33	351.83	116.2
8	271.41	37.8	353.4	96.2	128.7	38.1	374.3	50.4		38.04	371.91	58.1
9	102.70	38.3	365.1	37.6	84.4	38.2	377.0	33.2		38.12	374.13	41.8
10	50.36	38.4	367.8	18.6	21.8	38.4	384.1	8.7		38.30	379.46	10.8
11	13.83	38.9	383.8	5.3	11.8	40.1	439.1	5.4		40.10	434.16	7.0
12	5.31	39.4	398.6	2.1	2.7	39.5	418.0	1.2		41.64	484.65	3.4
13		-	-	-								
14	-	-		-								
15+	´-	-	-	-								
TOTAL	1566.14	36.3	311.7	497.7	1777.0	34.7	280.4	548.2		36.10	318.83	556.53

Table 8.6.5.2.2. Mackerel abundance and biomass by ICES sub-divisions from Spanish spring acoustic surveys (PELACUS) from 2001 to 2018.

	ICES 9.a–N		ICES 8.c–W		8.c–EW		8.c–EE		TOTAL	
	Abund. (10^9)	Biomass (kt)	Abund. (10^9)	Biomass (kt)	Abund. (10^9)	Biomass (kt)	Abund. (10^9)	Biomass (kt)	Abund. (10^9)	Biomass (kt)
2001	0.02	7.4	0.31	120.1	1.23	489.1	0.36	119.1	1.93	735.7
2002	0.00	0.0	0.82	333.7	3.80	1191.1	0.04	10.0	4.67	1534.8
2003	4.58	376.6	1.07	184.4	0.88	202.5	0.54	144.3	7.14	907.8
2004	0.61	118.6	1.03	304.3	1.50	515.7	0.03	7.0	3.17	945.6
2005	0.16	45.6	0.23	13.0	0.60	228.6	0.16	32.3	1.06	409.5
2006	0.01	0.7	0.39	100.5	0.15	41.5	0.02	4.0	0.56	146.6
2007	0.16	11.2	0.22	77.4	0.36	108.4	0.01	1.8	0.75	198.8
2008	0.16	21.4	0.38	109.0	0.84	235.0	0.05	4.2	1.42	369.7
2009	0.06	11.8	0.04	10.1	0.57	220.2	0.33	74.1	0.99	316.2
2010	0.38	34.2	0.88	293.7	2.09	628.6	0.00	1.0	3.35	957.5
2011	1.42	109.2	0.51	39.4	0.65	212.4	0.01	2.7	2.58	363.7
2012	0.61	45.03	0.02	1.3	0.57	190.7	0.02	7.8	1.21	244.8
2013	0.00	00.00	0.46	58.0	1.06	270.9	0.19	49.7	1.72	378.6
2014*	0.02	2.4	0.03	3.0			2.75	803	2.80	808.4
2015*	0.21	73.6	0.3	7.4			1.36	410	1.57	483.3
2016*	0.00	0.2	0.09	13.7			1.48	484	1.57	498
2017*	.17	14.7	.36	119.0			1.25	415	1.78	548.7
2018*	0.10	27.8	0.01	031			1.55	528*	1.64	556.5

*** Without split between 8.c-EW and 8.c-EE.**

Table 8.7.1.1. NE Atlantic mackerel. Input data and parameters and the model configurations for the assessment.

Input data types and characteristics:

Name	Year range	Age range	Variable from year to year
Catch in tonnes	1980 -2017		Yes
Catch-at-age in numbers	1980 -2017	0-12+	Yes
Weight-at-age in the commercial catch	1980 – 2017	0-12+	Yes
Weight-at-age of the spawning stock at spawning time.	1980 – 2018	0-12+	Yes
Proportion of natural mortality before spawning	1980 -2018	0-12+	Yes
Proportion of fishing mortality before spawning	1980 -2018	0-12+	Yes
Proportion mature-at-age	1980 -2018	0-12+	Yes
Natural mortality	1980 -2018	0-12+	No, fixed at 0.15

Tuning data:

Type	Name	Year range	Age range
Survey (SSB)	ICES Triennial Mackerel and Horse Mackerel Egg Survey	1992, 1995, 1998, 2001, 2004, 2007, 2010, 2013,2016.	Not applicable (gives SSB)
Survey (abundance index)	IBTS Recruitment index (log transformed)	1998-2015	Age 0
Survey (abundance index)	International Ecosystem Summer Survey in the Nordic Seas (IESSNS)	2010, 2012-2018	Ages 3-11
Tagging/recapture	Norwegian tagging program	Steal tags : 1980 (release year)-2006 (recapture years) RFID tags : 2011 (release year) 2017 (recapture year)	Ages 2 and older (age at release)

SAM parameter configuration :

Setting	Value	Description
Coupling of fishing mortality states	1/2/3/4/5/6/7/8/8/8/8/8/8	Different F states for ages 0 to 6, one same F state for ages 7 and older
Correlated random walks for the fishing mortalities	0	F random walk of different ages are independent
Coupling of catchability parameters	0/0/0/0/0/0/0/0/0/0/0/0 1/0/0/0/0/0/0/0/0/0/0/0 2/0/0/0/0/0/0/0/0/0/0/0 0/0/0/3/4/5/6/7/8/9/10/10/0	No catchability parameter for the catches One catchability parameter estimated for the egg One catchability parameter estimated for the recruitment index One catchability parameter for each age group estimated for the IESSNS (age 3 to11)
Power law model	0	No power law model used for any

		of the surveys
Coupling of fishing mortality random walk variances	1/1/1/1/1/1/1/1/1/1/1/1	Same variance used for the F random walk of all ages
Coupling of log abundance random walk variances	1/2/2/2/2/2/2/2/2/2/2/2	Same variance used for the log abundance random walk of all ages except for the recruits (age 0)
Coupling of the observation variances	1/1/1/1/1/1/1/1/1/1/1/1 0/0/0/0/0/0/0/0/0/0/0/0 2/0/0/0/0/0/0/0/0/0/0/0 0/0/0/3/4/4/4/4/4/4/4/0	Same observation variance for all ages in the catches One observation variance for the egg survey One observation variance for the recruitment index 2 observation variances for the IESSNS (age 3 and ages 4 and older)
Stock recruitment model	0	No stock-recruiment model
Correlation structure	"ID", "ID", "ID", "AR"	Auto-regressive correlation structure for the IESSNS index, independent observations assumed for the other data sources

Table 8.7.1.2. NE Atlantic Mackerel. CATCH IN NUMBER

Units : thousands

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	33101	56682	11180	7333	287287	81799	49983	7403	57644	65400	24246	10007
1	411327	276229	213936	47914	31901	268960	58126	40126	152656	64263	140534	58459
2	393025	502365	432867	668909	86064	20893	424563	156670	137635	312739	209848	212521
3	64549	231814	472457	433744	682491	58346	38387	663378	190403	207689	410751	206421
4	328206	32814	184581	373262	387582	445357	76545	56680	538394	167588	208146	375451
5	254172	184867	26544	126533	251503	252217	364119	89003	72914	362469	156742	188623
6	142978	173349	138970	20175	98063	165219	208021	244570	87323	48696	254015	129145
7	145385	116328	112476	90151	22086	62363	126174	150588	201021	58116	42549	197888
8	54778	125548	89672	72031	61813	19562	42569	85863	122496	111251	49698	51077
9	130771	41186	88726	48668	47925	47560	13533	34795	55913	68240	85447	43415
10	39920	146186	27552	49252	37482	37607	32786	19658	20710	32228	33041	70839
11	56210	31639	91743	19745	30105	26965	22971	25747	13178	13904	16587	29743
12	104927	199615	156121	132040	69183	97652	81153	63146	57494	35814	27905	52986

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	43447	19354	25368	14759	37956	36012	61127	67003	36345	26034	70409	14744
1	83583	128144	147315	81529	119852	144390	99352	73597	102407	40315	222577	187997
2	156292	210319	221489	340898	168882	186481	229767	132994	142898	158943	70041	275661
3	356209	266677	306979	340215	333365	238426	264566	223639	275376	234186	367902	91075
4	266591	398240	267420	275031	279182	378881	323186	261778	390858	297206	350163	295777
5	306143	244285	301346	186855	177667	246781	361945	281041	295516	309937	262716	235052
6	156070	255472	184925	197856	96303	135059	207619	244212	241550	231804	237066	183036
7	113899	149932	189847	142342	119831	84378	118388	159019	175608	195250	151320	133595
8	138458	97746	106108	113413	55812	66504	72745	86739	106291	120241	118870	94168
9	51208	121400	80054	69191	59801	39450	47353	50613	52394	72205	79945	75701
10	36612	38794	57622	42441	25803	26735	24386	30363	31280	42529	43789	45951
11	40956	29067	20407	37960	18353	13950	16551	17048	18918	20546	21611	25797
12	68205	68217	57551	39753	30648	24974	22932	32446	34202	40706	40280	30890

age \ year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	11553	12426	75651	19302	25886	17615	23453	30429	23872	11325	62100	6732
1	31421	46840	149425	88439	59899	36514	78605	62708	66196	47020	43173	104019
2	453133	135648	173646	190857	167748	113574	137101	115346	200167	235411	137788	124411
3	529753	668588	159455	220575	399086	455113	303928	322725	214043	399751	669949	248852
4	147973	293579	470063	215655	284660	616963	739221	469953	415884	370551	829399	579835
5	258177	120538	195594	455131	260314	319465	611729	654395	456404	442597	564508	646894
6	145899	121477	97061	203492	255675	224848	284788	488713	511270	429324	549985	450344
7	89856	63612	73510	77859	124382	194326	143039	244210	323835	336701	503300	415107
8	65669	38763	33399	59652	57297	73171	102072	113012	142948	188910	339538	355997
9	40443	23947	18961	30494	32343	29738	45841	53363	69551	112765	141344	205691
10	35654	18612	13987	16039	19482	14989	21222	25046	30619	45938	63614	107685
11	16430	7955	8334	11416	6798	7470	6255	12311	11603	18928	21294	26939
12	19509	10669	10186	12801	9581	5003	8523	10775	11678	17857	13136	22700

age \ year	2016	2017
0	716	28306
1	45199	43458
2	203753	87739
3	257293	458301
4	424843	351779
5	589549	396862
6	532890	503601
7	340155	431014
8	269962	261959
9	170373	188950
10	94778	138143
11	33896	59211
12	24420	51090

Table 8.7.1.3. NE Atlantic Mackerel. WEIGHTS AT AGE IN THE CATCH

Units : Kg

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.057	0.060	0.053	0.050	0.031	0.055	0.039	0.076	0.055	0.049	0.085	0.068	0.051	0.061
1	0.131	0.132	0.131	0.168	0.102	0.144	0.146	0.179	0.133	0.136	0.156	0.156	0.167	0.134
2	0.249	0.248	0.249	0.219	0.184	0.262	0.245	0.223	0.259	0.237	0.233	0.253	0.239	0.240
3	0.285	0.287	0.285	0.276	0.295	0.357	0.335	0.318	0.323	0.320	0.336	0.327	0.333	0.317
4	0.345	0.344	0.345	0.310	0.326	0.418	0.423	0.399	0.388	0.377	0.379	0.394	0.397	0.376
5	0.378	0.377	0.378	0.386	0.344	0.417	0.471	0.474	0.456	0.433	0.423	0.423	0.460	0.436
6	0.454	0.454	0.454	0.425	0.431	0.436	0.444	0.512	0.524	0.456	0.467	0.469	0.495	0.483
7	0.498	0.499	0.496	0.435	0.542	0.521	0.457	0.493	0.555	0.543	0.528	0.506	0.532	0.527
8	0.520	0.513	0.513	0.498	0.480	0.555	0.543	0.498	0.555	0.592	0.552	0.554	0.555	0.548
9	0.542	0.543	0.541	0.545	0.569	0.564	0.591	0.580	0.562	0.578	0.606	0.609	0.597	0.583
10	0.574	0.573	0.574	0.606	0.628	0.629	0.552	0.634	0.613	0.581	0.606	0.630	0.651	0.595
11	0.590	0.576	0.574	0.608	0.636	0.679	0.694	0.635	0.624	0.648	0.591	0.649	0.663	0.647
12	0.580	0.584	0.582	0.614	0.663	0.710	0.688	0.718	0.697	0.739	0.713	0.708	0.669	0.679

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0.046	0.072	0.058	0.076	0.065	0.062	0.063	0.069	0.052	0.081	0.067	0.048	0.038	0.089
1	0.136	0.143	0.143	0.143	0.157	0.176	0.135	0.172	0.160	0.170	0.156	0.151	0.071	0.120
2	0.255	0.234	0.226	0.230	0.227	0.235	0.227	0.224	0.256	0.267	0.263	0.268	0.197	0.215
3	0.339	0.333	0.313	0.295	0.310	0.306	0.306	0.305	0.307	0.336	0.323	0.306	0.307	0.292
4	0.390	0.390	0.377	0.359	0.354	0.361	0.363	0.376	0.368	0.385	0.400	0.366	0.357	0.372
5	0.448	0.452	0.425	0.415	0.408	0.404	0.427	0.424	0.424	0.438	0.419	0.434	0.428	0.408
6	0.512	0.501	0.484	0.453	0.452	0.452	0.463	0.474	0.461	0.477	0.485	0.440	0.479	0.456
7	0.543	0.539	0.518	0.481	0.462	0.500	0.501	0.496	0.512	0.522	0.519	0.496	0.494	0.512
8	0.590	0.577	0.551	0.524	0.518	0.536	0.534	0.540	0.536	0.572	0.554	0.539	0.543	0.534
9	0.583	0.594	0.576	0.553	0.550	0.569	0.567	0.577	0.580	0.612	0.573	0.556	0.584	0.573
10	0.627	0.606	0.596	0.577	0.573	0.586	0.586	0.603	0.600	0.631	0.595	0.583	0.625	0.571
11	0.678	0.631	0.603	0.591	0.591	0.607	0.594	0.611	0.629	0.648	0.630	0.632	0.636	0.585
12	0.713	0.672	0.670	0.636	0.631	0.687	0.644	0.666	0.665	0.715	0.684	0.655	0.689	0.666

age \ year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0.051	0.104	0.048	0.029	0.089	0.091	0.043	0.051	0.035	0.018
1	0.105	0.153	0.118	0.113	0.123	0.173	0.127	0.154	0.158	0.178
2	0.222	0.213	0.221	0.231	0.187	0.234	0.232	0.242	0.240	0.266
3	0.292	0.283	0.291	0.282	0.285	0.277	0.282	0.294	0.297	0.312
4	0.370	0.331	0.331	0.334	0.340	0.336	0.324	0.320	0.329	0.356
5	0.418	0.389	0.365	0.368	0.375	0.360	0.362	0.351	0.356	0.377
6	0.444	0.424	0.418	0.411	0.401	0.386	0.395	0.392	0.383	0.397
7	0.497	0.450	0.471	0.451	0.431	0.406	0.422	0.420	0.411	0.415
8	0.551	0.497	0.487	0.494	0.469	0.431	0.444	0.443	0.438	0.444
9	0.571	0.538	0.515	0.540	0.503	0.454	0.468	0.465	0.453	0.466
10	0.620	0.586	0.573	0.580	0.537	0.472	0.482	0.489	0.479	0.484
11	0.595	0.599	0.604	0.611	0.538	0.493	0.523	0.522	0.499	0.497
12	0.662	0.630	0.630	0.664	0.585	0.554	0.583	0.560	0.520	0.531

Table 8.7.1.4. NE Atlantic Mackerel. WEIGHTS AT AGE IN THE STOCK

Units : Kg

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.063	0.063	0.063	0.063	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.125	0.123	0.122	0.122	0.119	0.123	0.115	0.076	0.111	0.114	0.096	0.174	0.130	0.145
2	0.205	0.179	0.159	0.179	0.204	0.244	0.184	0.157	0.181	0.162	0.166	0.184	0.201	0.190
3	0.287	0.258	0.217	0.233	0.251	0.281	0.269	0.234	0.238	0.230	0.247	0.243	0.260	0.266
4	0.322	0.312	0.300	0.282	0.293	0.308	0.301	0.318	0.298	0.272	0.290	0.303	0.308	0.323
5	0.356	0.335	0.368	0.341	0.326	0.336	0.350	0.368	0.348	0.338	0.332	0.347	0.360	0.359
6	0.377	0.376	0.362	0.416	0.395	0.356	0.350	0.414	0.392	0.392	0.383	0.392	0.397	0.410
7	0.402	0.415	0.411	0.404	0.430	0.407	0.374	0.415	0.445	0.388	0.435	0.423	0.419	0.432
8	0.434	0.431	0.456	0.438	0.455	0.455	0.434	0.431	0.442	0.449	0.447	0.492	0.458	0.459
9	0.438	0.454	0.455	0.475	0.489	0.447	0.428	0.483	0.466	0.432	0.494	0.500	0.487	0.480
10	0.484	0.450	0.473	0.467	0.507	0.519	0.467	0.487	0.506	0.429	0.473	0.546	0.513	0.515
11	0.520	0.524	0.536	0.544	0.513	0.538	0.506	0.492	0.567	0.482	0.495	0.526	0.543	0.547
12	0.534	0.531	0.544	0.528	0.567	0.591	0.542	0.581	0.594	0.556	0.536	0.615	0.568	0.577

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.114	0.116	0.097	0.084	0.083	0.087	0.093	0.113	0.109	0.112	0.112	0.106	0.108	0.083
2	0.163	0.201	0.185	0.196	0.172	0.210	0.194	0.190	0.206	0.181	0.158	0.140	0.164	0.149
3	0.240	0.278	0.250	0.257	0.248	0.260	0.253	0.246	0.245	0.251	0.258	0.221	0.236	0.206
4	0.306	0.327	0.322	0.310	0.299	0.317	0.301	0.303	0.288	0.277	0.318	0.328	0.291	0.288
5	0.368	0.385	0.372	0.356	0.348	0.356	0.357	0.342	0.333	0.341	0.355	0.378	0.333	0.330
6	0.418	0.432	0.425	0.401	0.383	0.392	0.394	0.398	0.360	0.401	0.406	0.403	0.400	0.362
7	0.459	0.458	0.446	0.460	0.409	0.424	0.416	0.417	0.418	0.407	0.449	0.464	0.413	0.451
8	0.480	0.491	0.471	0.473	0.455	0.456	0.438	0.451	0.429	0.489	0.482	0.481	0.437	0.452
9	0.496	0.511	0.513	0.505	0.475	0.489	0.464	0.484	0.458	0.490	0.506	0.547	0.455	0.508
10	0.550	0.517	0.508	0.511	0.530	0.508	0.489	0.521	0.511	0.488	0.519	0.538	0.469	0.527
11	0.592	0.560	0.538	0.546	0.500	0.545	0.514	0.535	0.523	0.521	0.579	0.509	0.531	0.533
12	0.604	0.602	0.573	0.585	0.547	0.576	0.551	0.574	0.557	0.540	0.588	0.603	0.566	0.586

age \ year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.133	0.107	0.096	0.080	0.089	0.076	0.107	0.078	0.059	0.058
2	0.160	0.162	0.161	0.175	0.155	0.144	0.165	0.207	0.184	0.204
3	0.207	0.214	0.201	0.223	0.216	0.179	0.199	0.247	0.239	0.237
4	0.260	0.268	0.249	0.274	0.255	0.249	0.238	0.254	0.283	0.278
5	0.346	0.295	0.297	0.332	0.288	0.281	0.291	0.288	0.299	0.308
6	0.354	0.351	0.342	0.369	0.312	0.318	0.321	0.336	0.336	0.308
7	0.393	0.386	0.389	0.389	0.360	0.341	0.341	0.350	0.364	0.338
8	0.448	0.437	0.411	0.430	0.390	0.374	0.387	0.381	0.382	0.377
9	0.452	0.461	0.442	0.452	0.453	0.414	0.416	0.412	0.403	0.394
10	0.478	0.517	0.491	0.495	0.498	0.441	0.466	0.447	0.427	0.426
11	0.487	0.548	0.535	0.518	0.503	0.500	0.472	0.485	0.442	0.430
12	0.511	0.559	0.573	0.525	0.557	0.520	0.517	0.549	0.470	0.494

Table 8.7.1.5. NE Atlantic Mackerel. NATURAL MORTALITY

Units : NA

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
3	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
4	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
5	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
6	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
7	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
8	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
9	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
11	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
12	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

age \ year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
3	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
4	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
5	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
6	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
7	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
8	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
9	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
11	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
12	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

age \ year	2014	2015	2016	2017
0	0.15	0.15	0.15	0.15
1	0.15	0.15	0.15	0.15
2	0.15	0.15	0.15	0.15
3	0.15	0.15	0.15	0.15
4	0.15	0.15	0.15	0.15
5	0.15	0.15	0.15	0.15
6	0.15	0.15	0.15	0.15
7	0.15	0.15	0.15	0.15
8	0.15	0.15	0.15	0.15
9	0.15	0.15	0.15	0.15
10	0.15	0.15	0.15	0.15
11	0.15	0.15	0.15	0.15
12	0.15	0.15	0.15	0.15

Table 8.7.1.6. NE Atlantic Mackerel. PROPORTION MATURE

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.093	0.097	0.097	0.098	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103
2	0.521	0.497	0.498	0.485	0.467	0.516	0.522	0.352	0.360	0.372	0.392	0.435	0.520	0.534
3	0.872	0.837	0.857	0.863	0.853	0.885	0.926	0.922	0.901	0.915	0.909	0.912	0.928	0.934
4	0.949	0.934	0.930	0.940	0.938	0.940	0.983	0.994	0.989	0.994	0.996	0.991	0.996	0.996
5	0.972	0.976	0.969	0.972	0.966	0.966	0.965	0.997	0.994	0.996	0.998	0.996	0.997	0.997
6	0.984	0.984	0.987	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.996	0.994	0.994
7	0.990	0.987	0.985	0.984	0.975	0.976	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	0.999	0.999	0.999	0.999	0.999	0.991	0.992	0.991	0.993	0.995	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.103	0.103	0.103	0.097	0.097	0.097	0.104	0.104	0.104	0.107	0.107	0.107	0.095	0.095
2	0.621	0.599	0.586	0.621	0.688	0.669	0.692	0.675	0.710	0.690	0.761	0.616	0.589	0.546
3	0.938	0.931	0.936	0.880	0.886	0.876	0.909	0.909	0.937	0.940	0.962	0.959	0.928	0.921
4	0.994	0.993	1.000	0.993	0.994	0.989	0.989	0.987	0.992	0.988	0.993	0.993	0.994	0.994
5	0.997	0.994	1.000	0.998	0.999	0.999	0.998	0.998	1.000	1.000	0.999	0.999	1.000	1.000
6	0.993	0.987	0.994	0.999	0.999	0.999	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000
7	0.999	0.999	0.999	1.000	1.000	1.000	1.000	0.999	1.000	0.999	0.999	0.999	1.000	1.000
8	1.000	1.000	1.000	0.994	0.995	0.996	0.997	0.997	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

age \ year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.095	0.096	0.096	0.096	0.094	0.092	0.092	0.104	0.103	0.101
2	0.524	0.541	0.667	0.655	0.604	0.683	0.675	0.763	0.755	0.749
3	0.917	0.919	0.930	0.927	0.926	0.921	0.916	0.944	0.941	0.936
4	0.999	0.999	0.999	0.999	0.999	0.998	0.999	0.998	0.998	0.998
5	0.999	1.000	1.000	1.000	0.999	1.000	1.000	0.999	0.999	1.000
6	1.000	1.000	0.999	0.999	0.999	0.999	0.999	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000	1.000	0.999	0.999	0.999	0.999
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 8.7.1.7. NE Atlantic Mackerel. FRACTION OF HARVEST BEFORE SPAWNING

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.177	0.179	0.181	0.216
2	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.177	0.179	0.181	0.216
3	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.253	0.285	0.316	0.318
4	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.253	0.285	0.316	0.318
5	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.392	0.403	0.414	0.439
6	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.392	0.403	0.414	0.439
7	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.392	0.403	0.414	0.439
8	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.392	0.403	0.414	0.439
9	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.392	0.403	0.414	0.439
10	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.392	0.403	0.414	0.439
11	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.392	0.403	0.414	0.439
12	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.381	0.392	0.403	0.414	0.439

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.252	0.287	0.250	0.212	0.175	0.179	0.183	0.187	0.201	0.216	0.231	0.230	0.229	0.229
2	0.252	0.287	0.250	0.212	0.175	0.179	0.183	0.187	0.201	0.216	0.231	0.230	0.229	0.229
3	0.321	0.323	0.328	0.334	0.339	0.364	0.390	0.415	0.408	0.400	0.393	0.375	0.357	0.338
4	0.321	0.323	0.328	0.334	0.339	0.364	0.390	0.415	0.408	0.400	0.393	0.375	0.357	0.338
5	0.464	0.489	0.492	0.494	0.497	0.462	0.425	0.390	0.405	0.420	0.434	0.402	0.368	0.336
6	0.464	0.489	0.492	0.494	0.497	0.462	0.425	0.390	0.405	0.420	0.434	0.402	0.368	0.336
7	0.464	0.489	0.492	0.494	0.497	0.462	0.425	0.390	0.405	0.420	0.434	0.402	0.368	0.336
8	0.464	0.489	0.492	0.494	0.497	0.462	0.425	0.390	0.405	0.420	0.434	0.402	0.368	0.336
9	0.464	0.489	0.492	0.494	0.497	0.462	0.425	0.390	0.405	0.420	0.434	0.402	0.368	0.336
10	0.464	0.489	0.492	0.494	0.497	0.462	0.425	0.390	0.405	0.420	0.434	0.402	0.368	0.336
11	0.464	0.489	0.492	0.494	0.497	0.462	0.425	0.390	0.405	0.420	0.434	0.402	0.368	0.336
12	0.464	0.489	0.492	0.494	0.497	0.462	0.425	0.390	0.405	0.420	0.434	0.402	0.368	0.336

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.197	0.165	0.133	0.126	0.119	0.111	0.137	0.164	0.191	0.191
2	0.197	0.165	0.133	0.126	0.119	0.111	0.137	0.164	0.191	0.191
3	0.305	0.270	0.237	0.183	0.129	0.075	0.121	0.168	0.214	0.214
4	0.305	0.270	0.237	0.183	0.129	0.075	0.121	0.168	0.214	0.214
5	0.305	0.272	0.241	0.232	0.223	0.214	0.199	0.183	0.169	0.169
6	0.305	0.272	0.241	0.232	0.223	0.214	0.199	0.183	0.169	0.169
7	0.305	0.272	0.241	0.232	0.223	0.214	0.199	0.183	0.169	0.169
8	0.305	0.272	0.241	0.232	0.223	0.214	0.199	0.183	0.169	0.169
9	0.305	0.272	0.241	0.232	0.223	0.214	0.199	0.183	0.169	0.169
10	0.305	0.272	0.241	0.232	0.223	0.214	0.199	0.183	0.169	0.169
11	0.305	0.272	0.241	0.232	0.223	0.214	0.199	0.183	0.169	0.169
12	0.305	0.272	0.241	0.232	0.223	0.214	0.199	0.183	0.169	0.169

Table 8.7.1.8. NE Atlantic Mackerel. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
1	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
2	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
3	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
4	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
5	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
6	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
7	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
8	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
9	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
10	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
11	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341
12	0.397	0.396	0.394	0.392	0.394	0.396	0.397	0.388	0.378	0.369	0.357	0.345	0.333	0.341

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
1	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
2	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
3	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
4	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
5	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
6	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
7	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
8	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
9	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
10	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
11	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339
12	0.349	0.357	0.339	0.322	0.304	0.325	0.346	0.366	0.361	0.355	0.350	0.346	0.342	0.339

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
1	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
2	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
3	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
4	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
5	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
6	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
7	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
8	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
9	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
10	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
11	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343
12	0.311	0.283	0.255	0.252	0.249	0.246	0.278	0.311	0.343	0.343

Table 8.7.1.9. NE Atlantic Mackerel. SURVEY INDICES

```
Some random text
103
SSB-egg-based-survey

1992    2018
1       1       0       0
-1      -1
1       3874476.93
1       -1
1       -1
1       3766378.516
1       -1
1       -1
1       4198626.531
1       -1
1       -1
1       3233833.244
1       -1
1       -1
1       3106808.703
1       -1
1       -1
1       3782966.707
1       -1
1       -1
1       4810751.571
1       -1
1       -1
1       4831948.353
1       -1
1       -1
1       3524054.85
1       -1
1       -1
R-idx(sqrt transf)

1998    2017
1       1       0       0
0       0
1       0.015720899
1       0.017996206
1       0.012743674
1       0.022164525
1       0.023618634
1       0.013230785
1       0.024607411
1       0.038156211
1       0.037598707
1       0.020352249
1       0.018292615
1       0.015170405
1       0.027764032
1       0.036979005
1       0.02420564
1       0.023257095
1       0.025778066
1       0.023169671
1       -1
1       -1
Swept-idx
2010    2018
1       1       0.58    0.75
3       11
1       1617005 4035646 3059146 1591100 691936  413253  198106  65803   24747
1       -1      -1      -1      -1      -1      -1      -1      -1      -1
1       1283247 2383260 2164365 2850847 1783942 740361  299490  149282  84344
1       9201746 2456618 3073772 3218990 2540444 1087937 377406  144695  146826
1       7034162 4896456 2659443 2630617 2768227 1910160 849010  379745  95304
1       2539963 6409324 4802298 1795564 1628872 1254859 727691  270562  72410
1       1374705 2635033 5243607 4368491 1893026 1658839 1107866 754993  450100
1       3562908 1953609 3318099 4680603 4653944 1754954 1944991 626406  507546
1       496595  2384310 1200541 1408582 2330520 1787503 1049868 499295  557573
```

Table 8.7.2.1. NE Atlantic Mackerel. SAM parameter estimates for the 2018 update.

	estimate	std. dev	confidence interval lower bound	confidence interval upper bound
observation standard deviations				
Catches	0.18	0.15	0.14	0.25
Egg survey	0.20	0.29	0.11	0.37
Recruitment index	0.36	0.23	0.23	0.56
IESSNS age 3	0.68	0.27	0.40	1.15
IESSNS ages 4-11	0.40	0.20	0.27	0.59
Recapture overdispersion steal tags	1.21	0.27	1.36	1.12
Recapture overdispersion RFID tags	1.16	0.63	1.55	1.04
random walk standard deviation				
F	0.25	0.15	0.18	0.33
N@age0	0.78	0.15	0.58	1.06
process error standard deviation				
N@age1-12+	0.17	0.13	0.13	0.21
catchabilities				
egg survey	1.37	0.08	1.16	1.61
recruitment index	0.00	0.12	0.00	0.00
IESSNS age 3	1.00	0.27	0.58	1.71
IESSNS age 4	1.49	0.18	1.04	2.14
IESSNS age 5	1.99	0.18	1.39	2.85
IESSNS age 6	2.35	0.18	1.63	3.38
IESSNS age 7	2.69	0.18	1.87	3.87
IESSNS age 8	2.57	0.18	1.77	3.71
IESSNS age 9	2.56	0.18	1.77	3.70
IESSNS ages 10-11	2.18	0.18	1.52	3.12
post tagging survival steal tags	0.39	0.10	0.34	0.43
post tagging survival RFID tags	0.10	0.08	0.09	0.12

Table 8.7.3.1. NE Atlantic Mackerel. STOCK SUMMARY. Low = lower limit and High = higher limit of 95% confidence interval.

Year	Recruitment (Age 0)	High	Low	SSB	High	Low	Total Catch	F (Ages 4–8)	High	Low
	thousands			tonnes			tonnes	per year		
1980	7750521	16984113	3536869	4017907	8457837	1908712	734950	0.171	0.34	0.087
1981	6406269	12337825	3326379	3639690	6906887	1917990	754045	0.171	0.32	0.091
1982	1976069	4143932	942305	3651751	6260529	2130057	716987	0.172	0.31	0.095
1983	1571022	3517044	701756	3969695	6114088	2577404	672283	0.173	0.30	0.099
1984	5911986	11635802	3003796	4194238	6089443	2888873	641928	0.174	0.29	0.104
1985	3856995	7251430	2051514	4034958	5635108	2889188	614371	0.179	0.29	0.110
1986	3835380	6929670	2122776	3661554	4952706	2707000	602201	0.186	0.29	0.118
1987	5394520	9378868	3102810	3689032	4948576	2750075	654992	0.195	0.30	0.127
1988	3362579	5796405	1950681	3609380	4717758	2761401	680491	0.20	0.30	0.138
1989	3601083	6225603	2082979	3334286	4254397	2613169	585920	0.22	0.32	0.153
1990	2584288	4615319	1447038	3390278	4220794	2723181	626107	0.25	0.35	0.174
1991	3243249	5537959	1899375	3226020	3954919	2631459	675665	0.28	0.39	0.20
1992	3886031	6639093	2274594	2890322	3483688	2398022	760690	0.31	0.43	0.23
1993	3045153	5191337	1786237	2526363	3023607	2110892	824568	0.35	0.47	0.26
1994	2888409	4882393	1708774	2202704	2619309	1852360	819087	0.36	0.49	0.27
1995	2425238	4122421	1426778	2198832	2596179	1862300	756277	0.34	0.44	0.26
1996	3468432	6357582	1892232	2092064	2458667	1780123	563472	0.29	0.38	0.23
1997	2676317	4716590	1518612	2078029	2412438	1789976	573029	0.27	0.35	0.21
1998	3246924	5010572	2104054	2109062	2458101	1809586	666316	0.27	0.35	0.21
1999	3753406	5630541	2502079	2253952	2610229	1946305	640309	0.30	0.37	0.24
2000	2588498	3794164	1765955	2181219	2482469	1916526	738606	0.33	0.39	0.29
2001	5132275	7328207	3594365	2059605	2327376	1822643	737463	0.39	0.45	0.33
2002	8708579	12577632	6029700	1885840	2146182	1657079	771422	0.43	0.50	0.37
2003	2992952	4284375	2090798	1910203	2198387	1659796	679287	0.46	0.54	0.39
2004	3936957	5726238	2706774	2410549	2831564	2052132	660491	0.42	0.49	0.36

Year	Recruitment (Age 0)	High	Low	SSB	High	Low	Total Catch	F (Ages 4–8)	High	Low
	thousands			tonnes			tonnes	per year		
2005	6300180	9244002	4293840	2269837	2705129	1904590	549514	0.32	0.38	0.27
2006	11464574	16692197	7874126	2215900	2618927	1874894	481181	0.29	0.34	0.25
2007	5374061	7823457	3691531	2417312	2820632	2071663	586206	0.33	0.39	0.28
2008	5604311	8168336	3845128	2986019	3534299	2522795	623165	0.32	0.38	0.27
2009	5200071	7550819	3581167	3634054	4324811	3053624	737969	0.29	0.34	0.25
2010	6683926	9631467	4638427	4025533	4732936	3423862	875515	0.28	0.34	0.24
2011	7483547	10773616	5198207	4794839	5605302	4101560	946661	0.28	0.33	0.24
2012	4793523	6980496	3291723	4388467	5125670	3757293	892353	0.26	0.32	0.22
2013	3220460	4867764	2130621	4097288	4816614	3485388	931732	0.29	0.35	0.24
2014	8120609	12377522	5327746	4130139	4869649	3502932	1393000	0.33	0.40	0.27
2015	2588980	4292931	1561361	3962603	4726385	3322248	1208990	0.34	0.42	0.28
2016	784490	1514562	406338	3527235	4358303	2854640	1094066	0.34	0.43	0.26
2017	5267776*			3081442	4048464	2345404	1155944	0.38	0.52	0.28
2018	3977184**			2353927***						

*** Time-tapered weighted mean of recruitment estimates for 1990-2016.**

**** Geometric mean 1990–2016.**

***** Estimated value from the forecast.**

Table 8.7.3.2. NE Atlantic Mackerel. ESTIMATED POPULATION ABUNDANCE

Units : Thousands

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988
0	7750521	6406269	1976069	1571022	5911986	3856995	3835380	5394520	3362579
1	4653503	6674218	5704000	1616192	1251155	5420373	3217029	3214005	4790054
2	1994678	3851943	5596469	4948040	1288926	972292	4842709	2622680	2635582
3	859737	1618606	3202496	4822696	4516385	1006458	755269	4369121	2102982
4	1436702	677785	1255507	2669203	4073668	3961881	807785	568199	3770464
5	3133512	1086645	502708	900550	2047940	3175475	3039200	652426	394514
6	2510612	2319913	814036	382695	652194	1561824	2343384	2157767	523863
7	863764	1795418	1654449	581517	279837	470366	1093914	1620849	1453406
8	331686	616978	1282244	1179309	411693	205305	328654	786281	1123879
9	893401	236932	440339	915906	839983	294981	148484	228410	559979
10	254857	638392	169181	314231	654130	597984	212258	105041	157144
11	370675	182078	455649	120858	224335	466509	423241	149601	73519
12	720141	779558	686085	813009	664842	633036	776749	837345	681914

age \ year	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	3601083	2584288	3243249	3886031	3045153	2888409	2425238	3468432	2676317
1	2791294	3116740	2146980	2776509	3371213	2574073	2473456	2018977	3033938
2	4151447	2263634	2630428	1741654	2320685	2853235	2120474	2063911	1638484
3	2267428	3809144	1986829	2416739	1482507	1901314	2351623	2087839	1886939
4	1648739	1800686	2923925	1458623	1936356	1048497	1395745	1761690	1728231
5	2885724	1094092	1239644	1838572	946709	1315821	667912	947183	1183072
6	280542	1993896	803823	946094	1156693	598254	934839	486344	700631
7	411136	188509	1271565	511140	595837	667257	364148	563023	323875
8	1060679	309038	123601	745711	311527	325256	282228	208508	331667
9	779546	719709	216105	77710	403224	169709	159252	135522	141769
10	388105	513918	474639	135206	43802	198426	90147	81118	84077
11	105748	262315	324277	284713	77335	22471	103818	48353	44956
12	516017	416934	438303	459432	412102	261141	145339	134326	108136

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	3246924	3753406	2588498	5132275	8708579	2992952	3936957	6300180	11464574
1	2230568	2717670	3214851	1656113	5540645	7640107	2374435	3434107	6745432
2	2589748	1811668	2225301	2598715	1156202	4778023	6322183	2163769	3206972
3	1235950	2399436	1606592	1718343	2288967	863689	3630261	4805540	1796105
4	1603085	1148736	1825073	1181814	1376087	1507762	725866	2007947	3141256
5	1442468	1246929	887036	1248500	872918	828969	939853	533921	1174809
6	843866	899401	858755	571109	792513	513453	441021	494521	374910
7	466220	596413	617614	568121	353005	384012	253679	230731	283550
8	253753	305369	371428	407934	323896	207701	173905	124998	134023
9	207980	177515	189592	233962	215643	170164	103054	84052	70411
10	97984	132390	114796	116459	121321	104783	77607	54332	49742
11	54502	64192	75161	69488	59571	58960	43288	31887	30210
12	101486	106159	114888	117007	101807	74253	52784	40653	38505

age \ year	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	5374061	5604311	5200071	6683926	7483547	4793523	3220460	8120609	2588980
1	8364901	5023296	4767259	5132389	6100878	6435719	3666510	2653561	5729227
2	5761560	6799560	4475215	4861233	4241194	5854904	5875273	2836051	2139734
3	2674246	4974795	5957253	4072078	4872581	3228525	5167586	5056793	2190824
4	1524897	2160727	4082726	4939563	3665559	3604041	2320908	3809943	3546703
5	2021532	1211576	1694921	2990105	3640896	2898278	2438039	1820046	2697023
6	756155	1134335	857849	1261783	2099677	2599148	2061105	1749681	1337925
7	252284	432420	656180	546902	858589	1388862	1516822	1486047	1268619
8	171286	161852	249913	348960	366556	552617	755650	1005593	1017669
9	87865	91768	100362	153527	193504	232924	321638	472405	684094
10	42040	51283	47692	65513	85207	115615	126056	204054	330069
11	30128	20710	27323	24875	40456	48998	70568	69010	105121
12	37494	30676	22847	30202	34270	41879	50179	53444	68892

age \ year	2016	2017	2018
0	784490	12549868	12549868
1	1945108	832500	10779246
2	4183158	1544466	685512
3	1581349	3327781	1156774
4	1786534	1275182	2501606
5	2338797	1337856	831220
6	1814684	1584788	788762
7	909373	1282719	965217
8	819252	622176	716721
9	557457	560140	389037
10	358043	339104	258445
11	174934	214525	221993
12	86911	155190	205492

Table 8.7.3.3. NE Atlantic Mackerel. ESTIMATED FISHING MORTALITY

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.010	0.010	0.010	0.010	0.010	0.011	0.010	0.010	0.011	0.011	0.011	0.011	0.011	0.011
1	0.036	0.036	0.036	0.036	0.036	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
2	0.054	0.053	0.053	0.052	0.052	0.052	0.051	0.051	0.050	0.050	0.051	0.051	0.052	0.053
3	0.086	0.086	0.085	0.085	0.086	0.088	0.091	0.094	0.098	0.102	0.107	0.112	0.116	0.121
4	0.148	0.148	0.149	0.149	0.150	0.154	0.160	0.173	0.184	0.201	0.215	0.229	0.234	0.234
5	0.149	0.150	0.150	0.153	0.155	0.158	0.163	0.166	0.175	0.184	0.190	0.199	0.216	0.224
6	0.185	0.186	0.188	0.190	0.195	0.202	0.209	0.217	0.222	0.243	0.265	0.284	0.302	0.319
7	0.186	0.186	0.186	0.185	0.186	0.190	0.198	0.209	0.221	0.240	0.278	0.339	0.409	0.479
8	0.186	0.186	0.186	0.185	0.186	0.190	0.198	0.209	0.221	0.240	0.278	0.339	0.409	0.479
9	0.186	0.186	0.186	0.185	0.186	0.190	0.198	0.209	0.221	0.240	0.278	0.339	0.409	0.479
10	0.186	0.186	0.186	0.185	0.186	0.190	0.198	0.209	0.221	0.240	0.278	0.339	0.409	0.479
11	0.186	0.186	0.186	0.185	0.186	0.190	0.198	0.209	0.221	0.240	0.278	0.339	0.409	0.479
12	0.186	0.186	0.186	0.185	0.186	0.190	0.198	0.209	0.221	0.240	0.278	0.339	0.409	0.479

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0.011	0.011	0.011	0.011	0.011	0.012	0.012	0.007	0.007	0.005	0.004	0.003	0.005	0.004
1	0.035	0.035	0.035	0.035	0.034	0.034	0.033	0.030	0.034	0.026	0.017	0.016	0.019	0.013
2	0.054	0.055	0.057	0.060	0.062	0.065	0.069	0.068	0.068	0.068	0.073	0.066	0.055	0.039
3	0.124	0.124	0.125	0.128	0.136	0.154	0.177	0.165	0.169	0.142	0.159	0.146	0.109	0.096
4	0.233	0.224	0.215	0.203	0.207	0.223	0.254	0.281	0.289	0.251	0.229	0.193	0.180	0.166
5	0.222	0.223	0.231	0.249	0.278	0.306	0.357	0.338	0.367	0.368	0.343	0.279	0.240	0.265
6	0.318	0.311	0.296	0.290	0.291	0.313	0.357	0.438	0.443	0.464	0.425	0.350	0.329	0.332
7	0.520	0.463	0.362	0.294	0.290	0.320	0.353	0.437	0.523	0.611	0.549	0.387	0.353	0.456
8	0.520	0.463	0.362	0.294	0.290	0.320	0.353	0.437	0.523	0.611	0.549	0.387	0.353	0.456
9	0.520	0.463	0.362	0.294	0.290	0.320	0.353	0.437	0.523	0.611	0.549	0.387	0.353	0.456
10	0.520	0.463	0.362	0.294	0.290	0.320	0.353	0.437	0.523	0.611	0.549	0.387	0.353	0.456
11	0.520	0.463	0.362	0.294	0.290	0.320	0.353	0.437	0.523	0.611	0.549	0.387	0.353	0.456
12	0.520	0.463	0.362	0.294	0.290	0.320	0.353	0.437	0.523	0.611	0.549	0.387	0.353	0.456

age \ year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0.005	0.004	0.004	0.004	0.005	0.004	0.005	0.003	0.002	0.002
1	0.012	0.010	0.013	0.012	0.012	0.014	0.017	0.021	0.028	0.044
2	0.030	0.029	0.031	0.032	0.037	0.044	0.052	0.059	0.057	0.061
3	0.090	0.086	0.082	0.078	0.081	0.095	0.131	0.139	0.166	0.164
4	0.160	0.169	0.167	0.154	0.154	0.189	0.227	0.219	0.267	0.308
5	0.252	0.233	0.235	0.218	0.211	0.237	0.304	0.297	0.309	0.343
6	0.307	0.307	0.282	0.278	0.263	0.275	0.345	0.379	0.361	0.389
7	0.443	0.370	0.366	0.374	0.347	0.382	0.384	0.415	0.369	0.437
8	0.443	0.370	0.366	0.374	0.347	0.382	0.384	0.415	0.369	0.437
9	0.443	0.370	0.366	0.374	0.347	0.382	0.384	0.415	0.369	0.437
10	0.443	0.370	0.366	0.374	0.347	0.382	0.384	0.415	0.369	0.437
11	0.443	0.370	0.366	0.374	0.347	0.382	0.384	0.415	0.369	0.437
12	0.443	0.370	0.366	0.374	0.347	0.382	0.384	0.415	0.369	0.437

Table 8.8.3.1. NE Atlantic Mackerel. Short-term prediction: INPUT DATA

	Stock Numbers	M	Maturity ogive	Prop of F before spw.	Prop of M before spw.	Weights in the stock	Exploitation pattern	Weights in the catch
2018								
0	3977184	0.15	0	0	0.332	0	0.002	0.035
1	4524562	0.15	0.10	0.182	0.332	0.065	0.031	0.163
2	685511.6	0.15	0.76	0.182	0.332	0.198	0.059	0.249
3	1156774	0.15	0.94	0.199	0.332	0.241	0.157	0.301
4	2501606	0.15	1	0.199	0.332	0.272	0.264	0.335
5	831220	0.15	1	0.174	0.332	0.298	0.316	0.361
6	788762	0.15	1	0.174	0.332	0.327	0.377	0.391
7	965217	0.15	1	0.174	0.332	0.351	0.407	0.415
8	716721	0.15	1	0.174	0.332	0.380	0.407	0.442
9	389037	0.15	1	0.174	0.332	0.403	0.407	0.461
10	258445	0.15	1	0.174	0.332	0.433	0.407	0.484
11	221993	0.15	1	0.174	0.332	0.452	0.407	0.506
12+	205492	0.15	1	0.174	0.332	0.504	0.407	0.537
2019								
0	3977184	0.15	0	0	0.332	0	0.002	0.035
1	-	0.15	0.10	0.182	0.332	0.065	0.031	0.163
2	-	0.15	0.76	0.182	0.332	0.198	0.059	0.249
3	-	0.15	0.94	0.199	0.332	0.241	0.157	0.301
4	-	0.15	1	0.199	0.332	0.272	0.264	0.335
5	-	0.15	1	0.174	0.332	0.298	0.316	0.361
6	-	0.15	1	0.174	0.332	0.327	0.377	0.391
7	-	0.15	1	0.174	0.332	0.351	0.407	0.415
8	-	0.15	1	0.174	0.332	0.380	0.407	0.442
9	-	0.15	1	0.174	0.332	0.403	0.407	0.461
10	-	0.15	1	0.174	0.332	0.433	0.407	0.484
11	-	0.15	1	0.174	0.332	0.452	0.407	0.506
12+	-	0.15	1	0.174	0.332	0.504	0.407	0.537
2020								
0	3977184	0.15	0	0	0.332	0	0.002	0.035
1	-	0.15	0.10	0.182	0.332	0.065	0.031	0.163
2	-	0.15	0.76	0.182	0.332	0.198	0.059	0.249
3	-	0.15	0.94	0.199	0.332	0.241	0.157	0.301
4	-	0.15	1	0.199	0.332	0.272	0.264	0.335
5	-	0.15	1	0.174	0.332	0.298	0.316	0.361
6	-	0.15	1	0.174	0.332	0.327	0.377	0.391
7	-	0.15	1	0.174	0.332	0.351	0.407	0.415
8	-	0.15	1	0.174	0.332	0.380	0.407	0.442
9	-	0.15	1	0.174	0.332	0.403	0.407	0.461

	Stock Numbers	M	Maturity ogive	Prop of F before spw.	Prop of M before spw.	Weights in the stock	Exploitation pattern	Weights in the catch
10	-	0.15	1	0.174	0.332	0.433	0.407	0.484
11	-	0.15	1	0.174	0.332	0.452	0.407	0.506
12+	-	0.15	1	0.174	0.332	0.504	0.407	0.537

Table 8.8.3.2. NE Atlantic Mackerel. Short-term prediction: Multi-option table for 1 001 kt catch in 2018 and a range of F-values in 2019.

2018			
TSB	**SSB**	**Fbar**	**Catch**
2977734	2353927	0,455	1000559

2019				2020		
TSB	**SSB**	**Fbar**	**Catch**	**TSB**	**SSB**	**Implied change in the catch**
2667210	2167164	0,00	0	3166783	2642785	-100%
-	2164240	0,01	19776	3149804	2623332	-98%
-	2161320	0,02	39374	3132980	2604087	-96%
-	2158405	0,03	58798	3116309	2585049	-94%
-	2155496	0,04	78048	3099789	2566214	-92%
-	2152591	0,05	97126	3083420	2547581	-90%
-	2149691	0,06	116034	3067199	2529148	-88%
-	2146796	0,07	134774	3051124	2510910	-87%
-	2143905	0,08	153347	3035196	2492867	-85%
-	2141020	0,09	171755	3019411	2475016	-83%
-	2138140	0,10	190001	3003769	2457355	-81%
-	2135264	0,11	208084	2988267	2439882	-79%
-	2132393	0,12	226007	2972906	2422593	-77%
-	2129527	0,13	243772	2957682	2405488	-76%
-	2126666	0,14	261380	2942596	2388563	-74%
-	2123810	0,15	278833	2927644	2371817	-72%
-	2120958	0,16	296132	2912827	2355248	-70%
-	2118112	0,17	313279	2898142	2338853	-69%
-	2115270	0,18	330275	2883589	2322630	-67%
-	2112433	0,19	347122	2869166	2306578	-65%
-	2109600	0,20	363822	2854871	2290695	-64%
-	2106773	0,21	380375	2840704	2274977	-62%
-	2103950	0,22	396784	2826663	2259424	-60%
-	2101132	0,23	413049	2812746	2244034	-59%
-	2098319	0,24	429172	2798953	2228804	-57%
-	2095510	0,25	445155	2785283	2213732	-56%
-	2092706	0,26	460999	2771733	2198818	-54%
-	2089907	0,27	476705	2758303	2184058	-52%
-	2087113	0,28	492275	2744992	2169451	-51%
-	2084323	0,29	507710	2731799	2154996	-49%
-	2081538	0,30	523012	2718721	2140690	-48%
-	2078758	0,31	538181	2705759	2126532	-46%
-	2075982	0,32	553219	2692910	2112520	-45%
-	2073211	0,33	568128	2680174	2098652	-43%
-	2070445	0,34	582908	2667550	2084926	-42%
-	2067683	0,35	597561	2655037	2071342	-40%
-	2064926	0,36	612089	2642632	2057896	-39%
-	2062174	0,37	626491	2630336	2044589	-37%
-	2059426	0,38	640771	2618147	2031417	-36%
-	2056683	0,39	654928	2606065	2018380	-35%
-	2053944	0,40	668965	2594087	2005475	-33%
-	2051210	0,41	682881	2582213	1992702	-32%
-	2048481	0,42	696680	2570442	1980058	-30%
-	2045756	0,43	710360	2558774	1967543	-29%
-	2043036	0,44	723925	2547206	1955154	-28%
-	2040320	0,45	737375	2535738	1942890	-26%
-	2037609	0,46	750710	2524368	1930751	-25%
-	2034903	0,47	763933	2513097	1918733	-24%

-	2032201	0,48	777044	2501922	1906836	-22%
-	2029503	0,49	790045	2490844	1895059	-21%
-	2026810	0,50	802936	2479860	1883400	-20%
-	2024122	0,51	815719	2468971	1871858	-18%
-	2021438	0,52	828394	2458174	1860431	-17%
-	2018758	0,53	840964	2447470	1849117	-16%
-	2016084	0,54	853427	2436857	1837917	-15%
-	2013413	0,55	865787	2426334	1826828	-13%
-	2010747	0,56	878044	2415901	1815849	-12%
-	2008086	0,57	890198	2405556	1804978	-11%
-	2005429	0,58	902251	2395299	1794216	-10%
-	2002776	0,59	914204	2385128	1783559	-9%
-	2000128	0,60	926058	2375044	1773008	-7%
-	1997484	0,61	937814	2365044	1762560	-6%
-	1994845	0,62	949472	2355129	1752215	-5%
-	1992210	0,63	961034	2345297	1741971	-4%
-	1989580	0,64	972501	2335548	1731828	-3%
-	1986954	0,65	983873	2325880	1721783	-2%
-	1984332	0,66	995152	2316293	1711837	-1%
-	1981715	0,67	1006338	2306786	1701987	1%
-	1979102	0,68	1017433	2297359	1692234	2%
-	1976494	0,69	1028436	2288010	1682574	3%
-	1973890	0,70	1039350	2278739	1673009	4%
-	1971290	0,71	1050175	2269545	1663535	5%
-	1968695	0,72	1060911	2260427	1654153	6%
-	1966104	0,73	1071561	2251384	1644861	7%
-	1963517	0,74	1082124	2242417	1635659	8%
-	1960934	0,75	1092601	2233523	1626545	9%
-	1958356	0,76	1102993	2224702	1617518	10%
-	1955783	0,77	1113302	2215954	1608577	11%
-	1953213	0,78	1123527	2207278	1599722	12%
-	1950648	0,79	1133670	2198673	1590951	13%
-	1948087	0,80	1143732	2190138	1582263	14%
-	1945531	0,81	1153712	2181673	1573657	15%
-	1942978	0,82	1163613	2173276	1565133	16%
-	1940430	0,83	1173435	2164949	1556689	17%
-	1937886	0,84	1183178	2156688	1548325	18%
-	1935347	0,85	1192843	2148495	1540040	19%
-	1932812	0,86	1202432	2140368	1531832	20%
-	1930281	0,87	1211944	2132307	1523701	21%
-	1927754	0,88	1221381	2124311	1515646	22%
-	1925231	0,89	1230744	2116379	1507667	23%
-	1922713	0,90	1240032	2108511	1499761	24%
-	1920199	0,91	1249247	2100706	1491929	25%
-	1917689	0,92	1258389	2092964	1484170	26%
-	1915183	0,93	1267460	2085283	1476482	27%
-	1912681	0,94	1276459	2077664	1468866	28%
-	1910184	0,95	1285388	2070106	1461319	28%
-	1907691	0,96	1294247	2062607	1453842	29%
-	1905201	0,97	1303037	2055168	1446433	30%
-	1902716	0,98	1311759	2047788	1439093	31%
-	1900236	0,99	1320412	2040467	1431819	32%
-	1897759	1,00	1328999	2033203	1424612	33%
-	1895286	1,01	1337519	2025996	1417470	34%
-	1892818	1,02	1345973	2018847	1410393	35%
-	1890354	1,03	1354362	2011753	1403379	35%
-	1887893	1,04	1362686	2004715	1396430	36%
-	1885437	1,05	1370946	1997731	1389543	37%

-	1882985	1,06	1379143	1990803	1382718	38%
-	1880537	1,07	1387277	1983928	1375954	39%
-	1878094	1,08	1395348	1977107	1369250	39%
-	1875654	1,09	1403358	1970338	1362607	40%

Table 8.8.3.3. NE Atlantic Mackerel. Short-term prediction: Management option table for 1 001 kt catch in 2018 and a range of catch options in 2019.

Rationale	Catch (2019)	Fbar (2019)	SSB (2019)	SSB (2020)	% SSb change	% catch change	% advice change
MSY AR	318403	0,173	2117257	2333959	10%	-68%	-42%
Catch(2019) = Zero	0	0,000	2167164	2642785	22%	-100%	-100%
Catch(2019) = 2018 catch -20%	800447	0,498	2027332	1885650	-7%	-20%	45%
Catch(2019) = 2018 catch	1000559	0,665	1983069	1707074	-14%	0%	82%
Catch(2019) = 2018 +20%	1200671	0,858	1933279	1533339	-21%	20%	118%
Fbar(2019) = 0.23	413049	0,230	2101132	2244034	7%	-59%	-25%
Fbar(2019) = 0.31 (Fpa)	538181	0,310	2078758	2126532	2%	-46%	-2%
Fbar(2019) = 0.43 (Flim)	710360	0,430	2045756	1967543	-4%	-29%	29%
Fbar(2019) = 0.21 (Fmsy)	380375	0,210	2106773	2274977	8%	-62%	-31%
Fbar(2019) = 0.26	460999	0,260	2092706	2198818	5%	-54%	-16%
Fbar(2019) = 0.27	476705	0,270	2089907	2184058	5%	-52%	-13%
Fbar(2019) = 0.28	492275	0,280	2087113	2169451	4%	-51%	-11%
SSB(2020) = MSY Btrigger = Bpa	78048	0,040	2155496	2566214	19%	-92%	-86%
SSB(2020) = Blim	737375	0,450	2040320	1942890	-5%	-26%	34%
Fbar(2019) = F2018	744410	0,455	2038892	1936484	-5%	-26%	35%
F = 0.20	363822	0,200	2109600	2290695	9%	-64%	-34%
F = 0.21	380375	0,210	2106773	2274977	8%	-62%	-31%
F = 0.22	396784	0,220	2103950	2259424	7%	-60%	-28%
F = 0.23	413049	0,230	2101132	2244034	7%	-59%	-25%
F = 0.24	429172	0,240	2098319	2228804	6%	-57%	-22%
F = 0.25	445155	0,250	2095510	2213732	6%	-56%	-19%
F = 0.26	460999	0,260	2092706	2198818	5%	-54%	-16%
F = 0.27	476705	0,270	2089907	2184058	5%	-52%	-13%
F = 0.28	492275	0,280	2087113	2169451	4%	-51%	-11%
F = 0.29	507710	0,290	2084323	2154996	3%	-49%	-8%

8.15 Figures

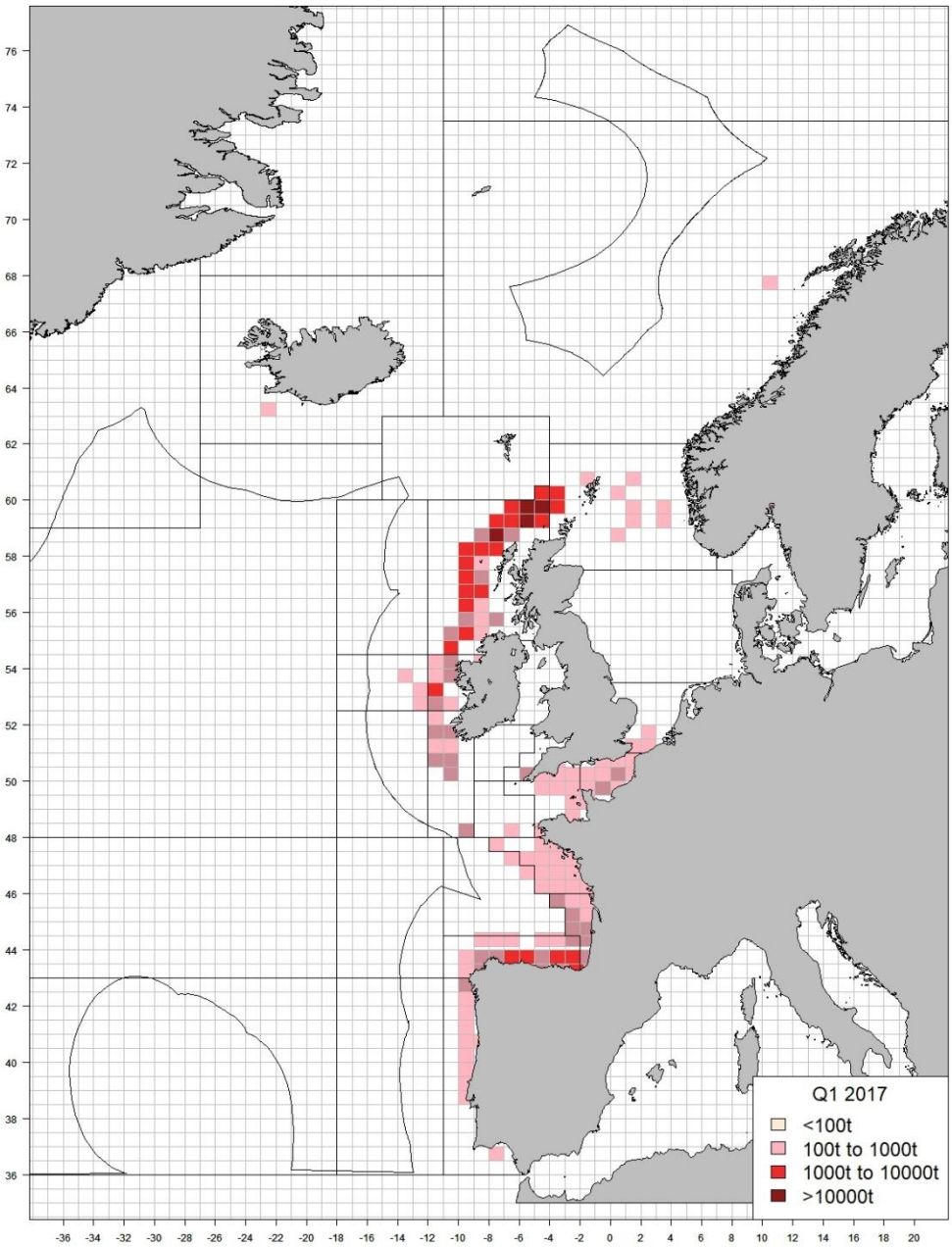

Figure 8.4.2.1. NE Atlantic Mackerel. Commercial catches in 2017, quarter 1.

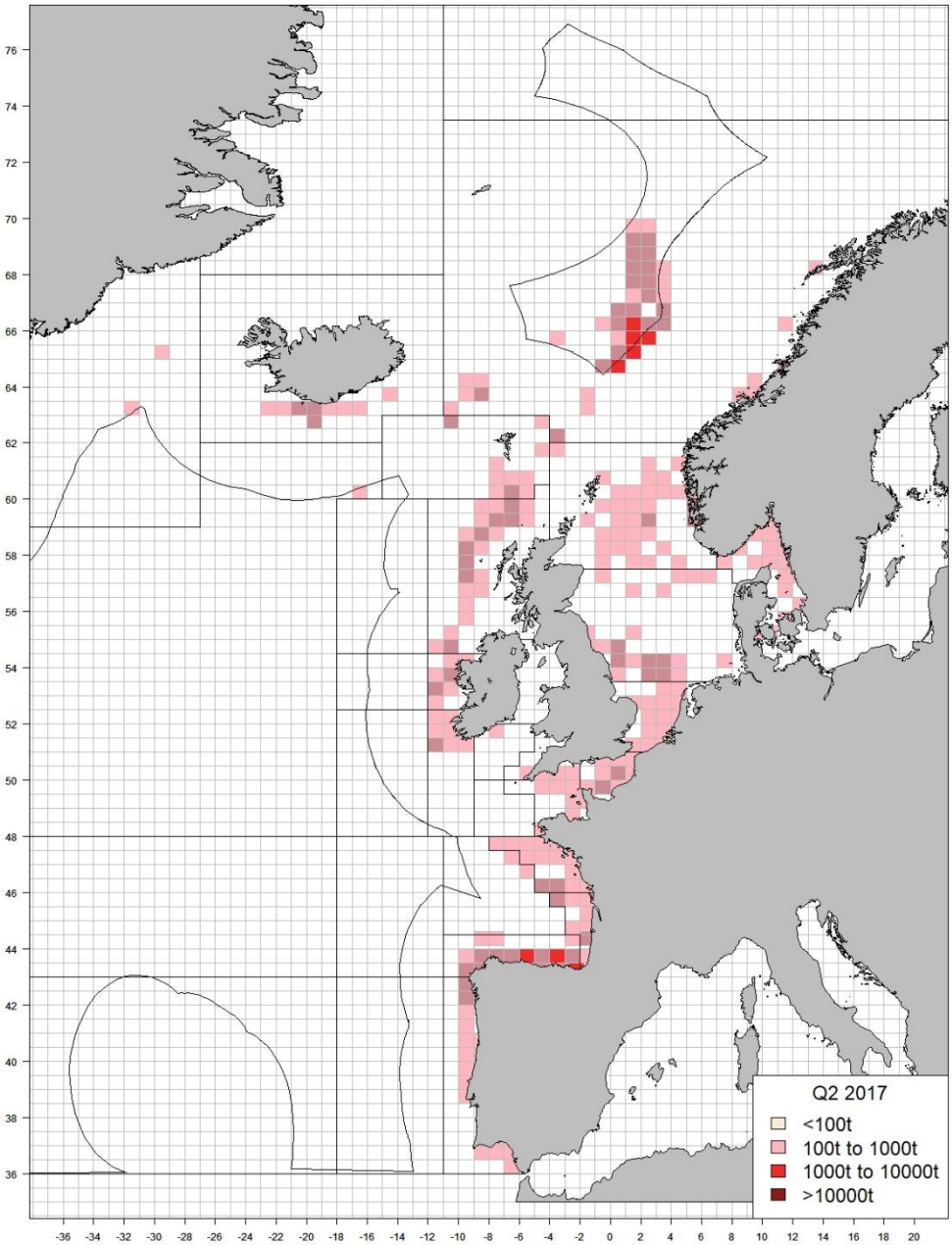

Figure 8.4.2.2. NE Atlantic Mackerel. Commercial catches in 2017, quarter 2.

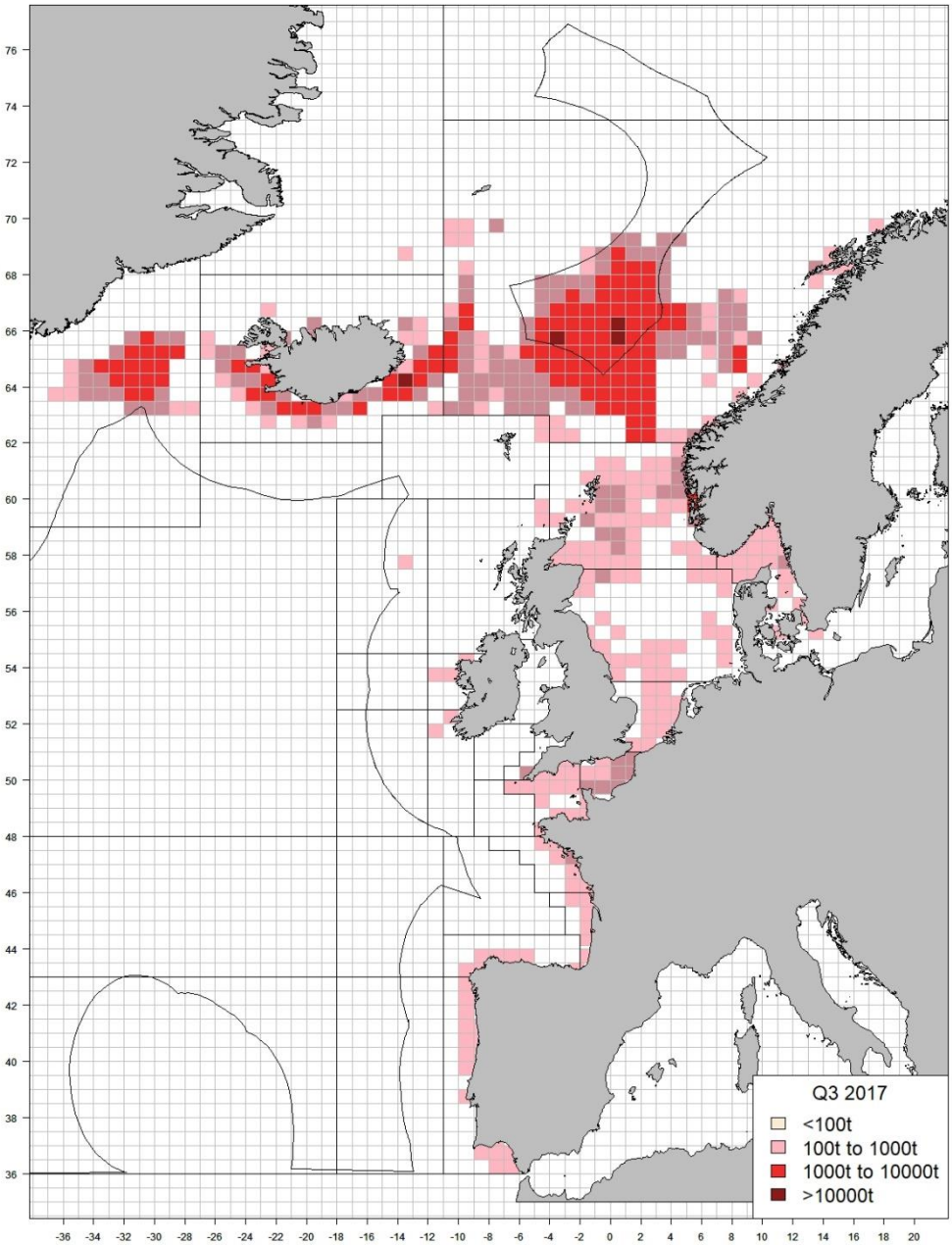

Figure 8.4.2.3. NE Atlantic Mackerel. Commercial catches in 2017, quarter 3.

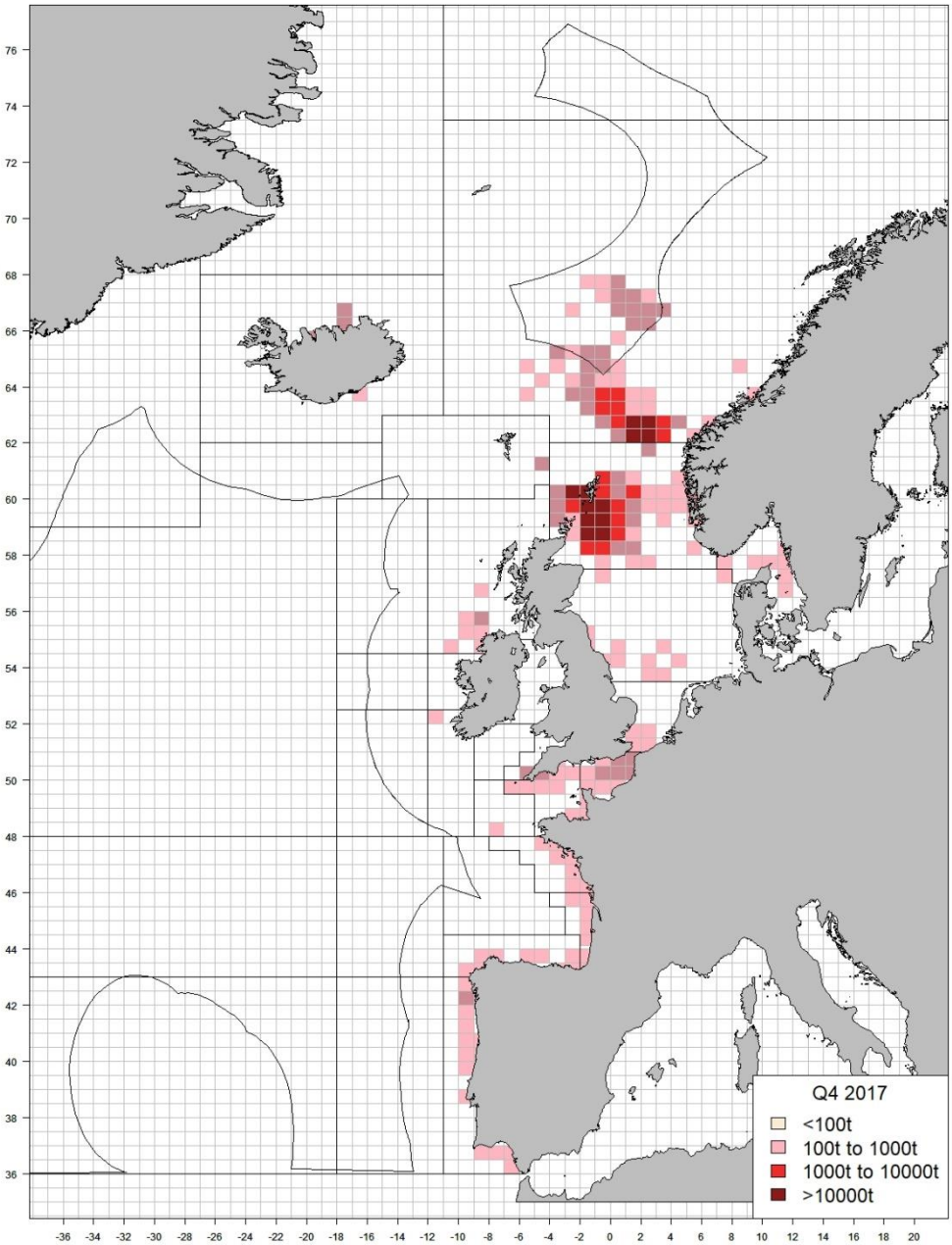

Figure 8.4.2.4. NE Atlantic Mackerel. Commercial catches in 2017, quarter 4.

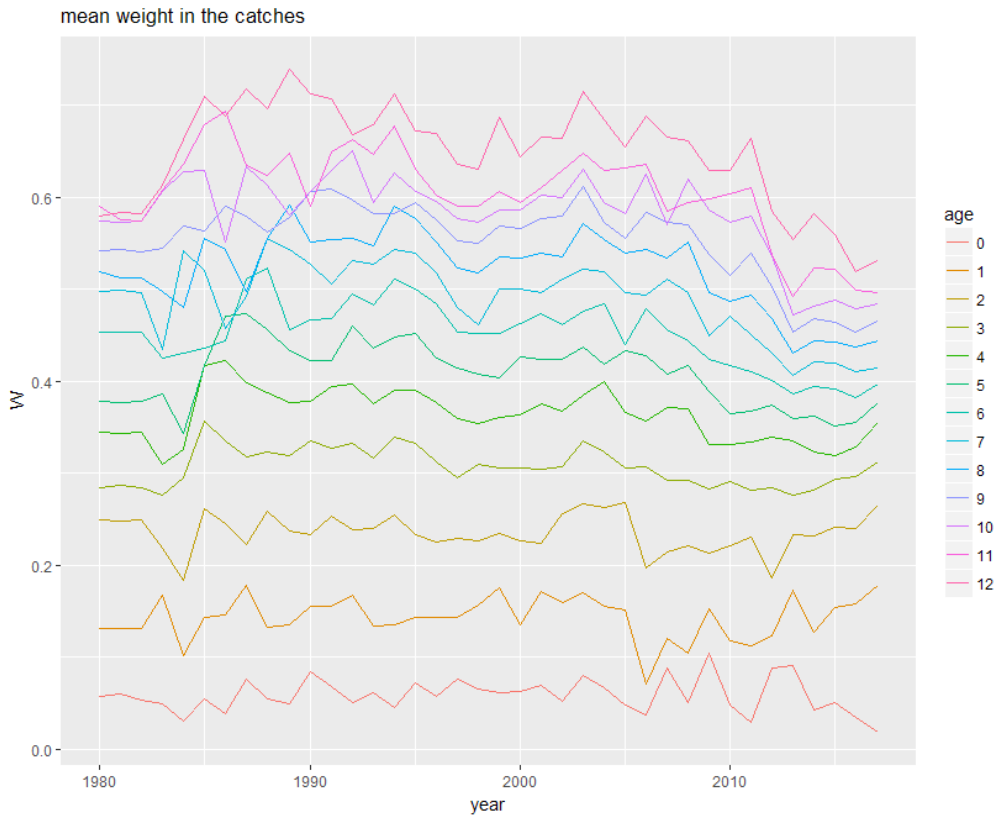

Figure 8.5.2.1. NE Atlantic mackerel. Weights-at-age in the catch.

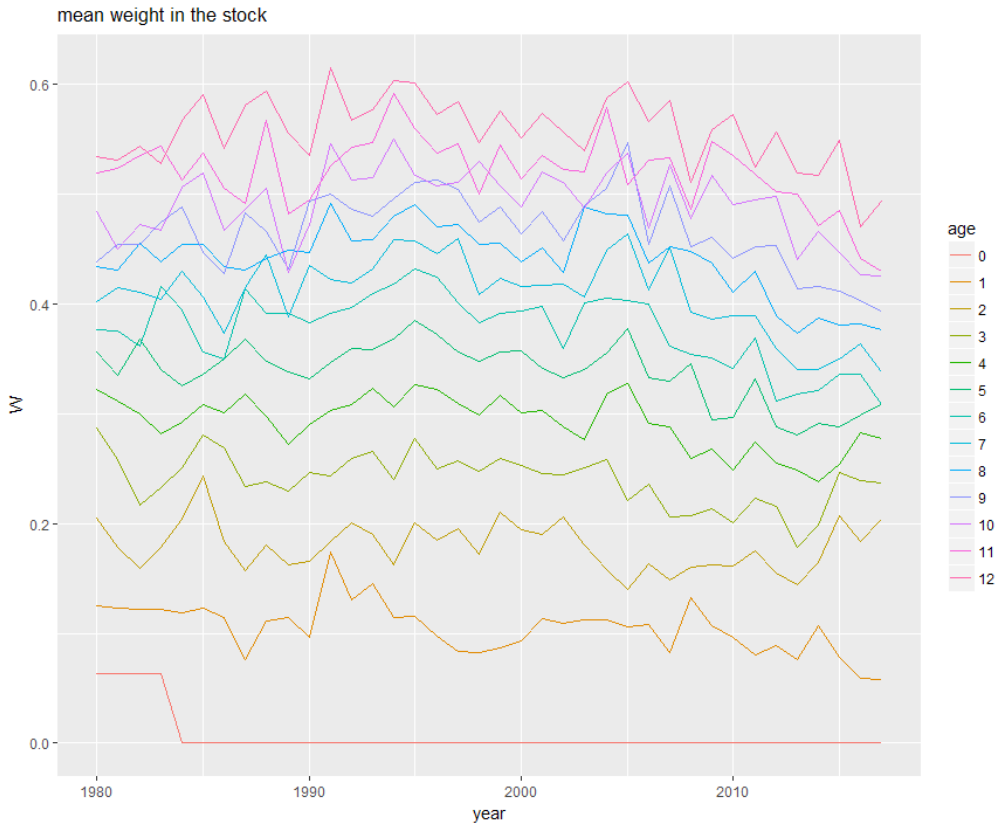

Figure 8.5.2.2. NE Atlantic mackerel. Weights-at-age in the stock.

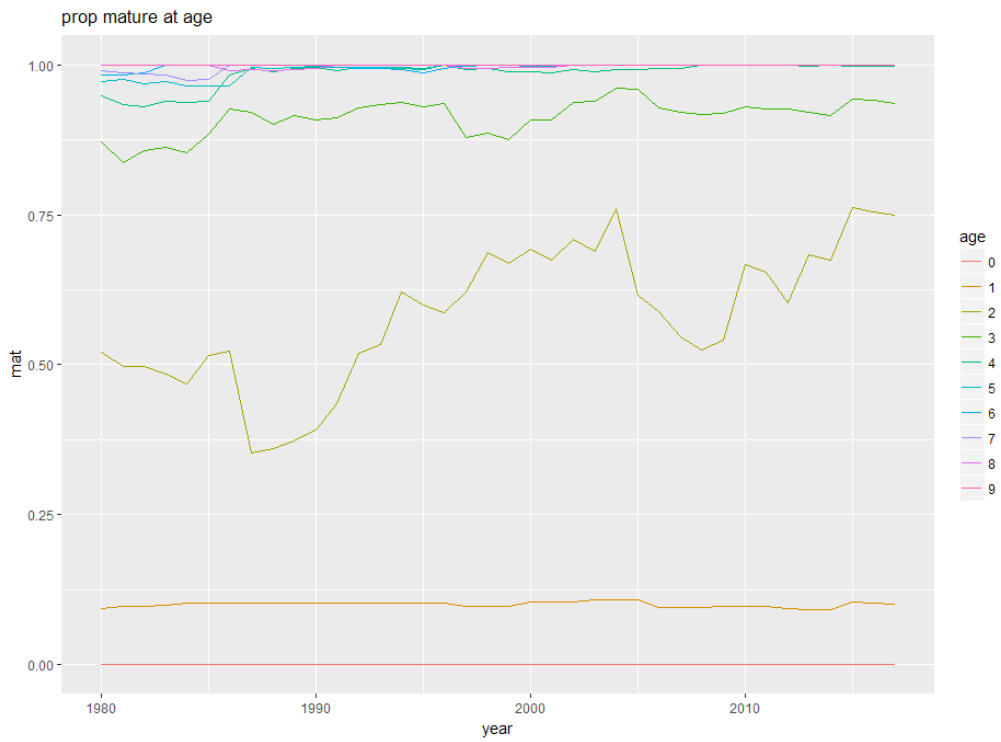

Figure 8.5.3.1. NE Atlantic mackerel. Proportion of mature fish at age.

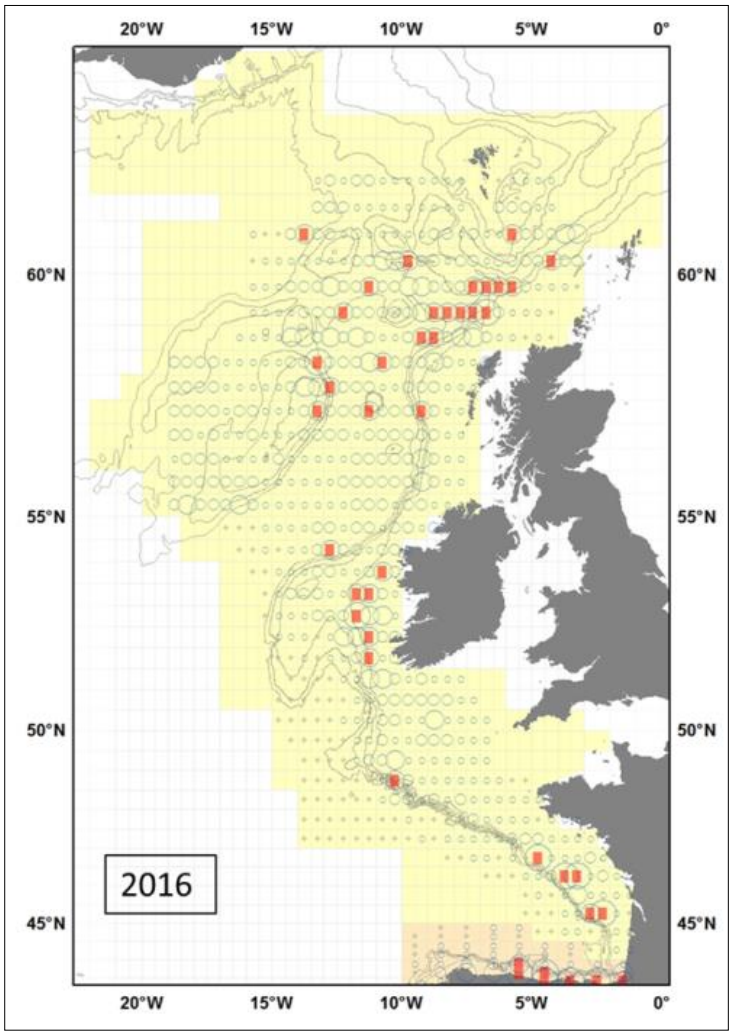

Figure 8.6.1.2.1.: Mean egg production (stage 1 eggs/m²/day) by half ICES rectangle for all Mackerel and Horse Mackerel Egg Surveys (MEGS) stations sampled in 2016. Egg production values are square root transformed. Crosses denote locations where sampling was undertaken but where no spawning was recorded. Area in yellow denotes the maximum geographical survey extent for the western survey area. Area/stations capturing 50% of spawning activity within that year are overlaid in red

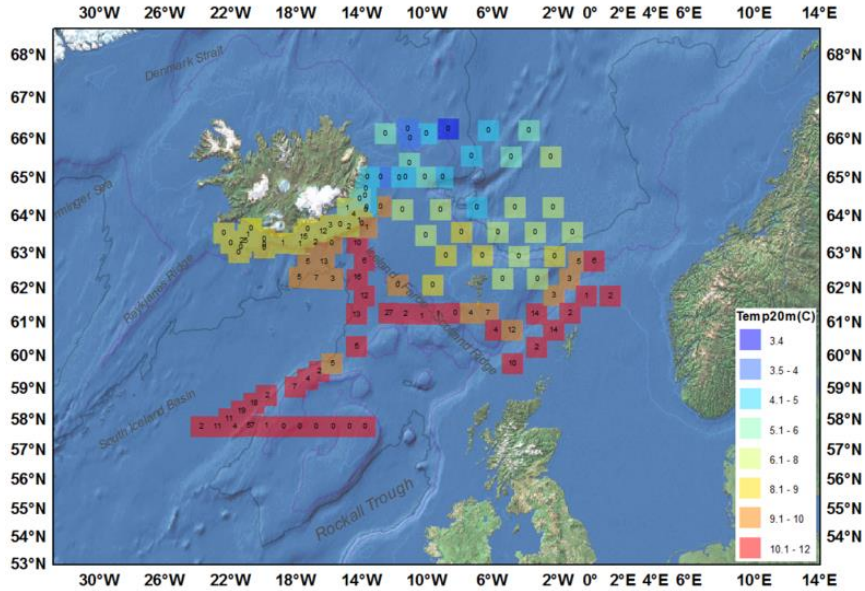

Figure 8.6.1.2.2: Mackerel stage 1 egg counts /m²/day, May/June 2017, for all relevant surveys and all stations. The coloured squares correspond to the observed temperature recorded at 20 m depth during the plankton deployments. The 200, 1000 and 2000m contours are included for reference.

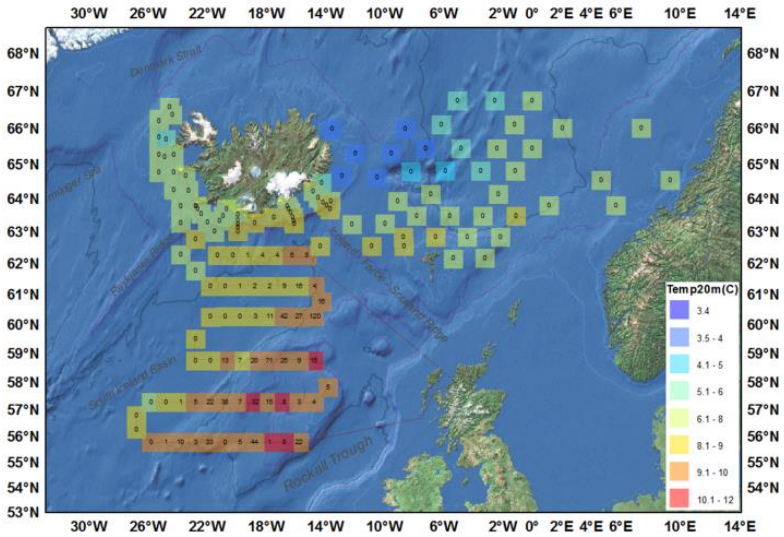

Figure 8.6.1.2.3: Mackerel stage 1 egg counts/m²/day 2018, for all surveys/stations sampled. The coloured squares represent the temperature in degrees Celsius at 20 m depth recorded during the plankton deployments.

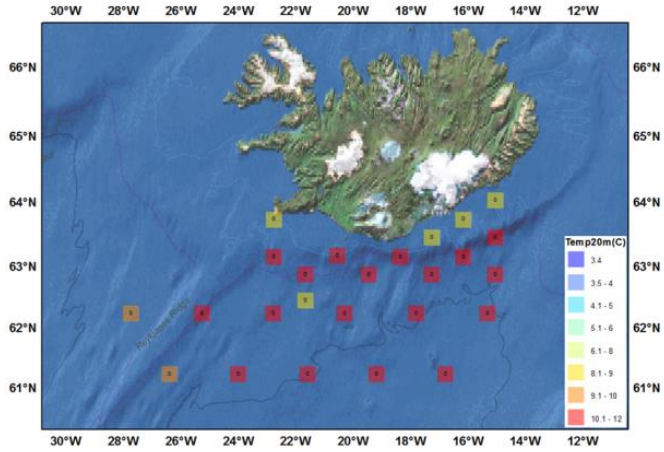

Figure 8.6.1.2.4: Results of analysed Icelandic Ecosystem surveys in the Nordic Seas in July-August (IESSNS) station results, July 2018. The coloured squares represent the temperature in degrees Celsius at 20 m depth recorded during the plankton deployments.

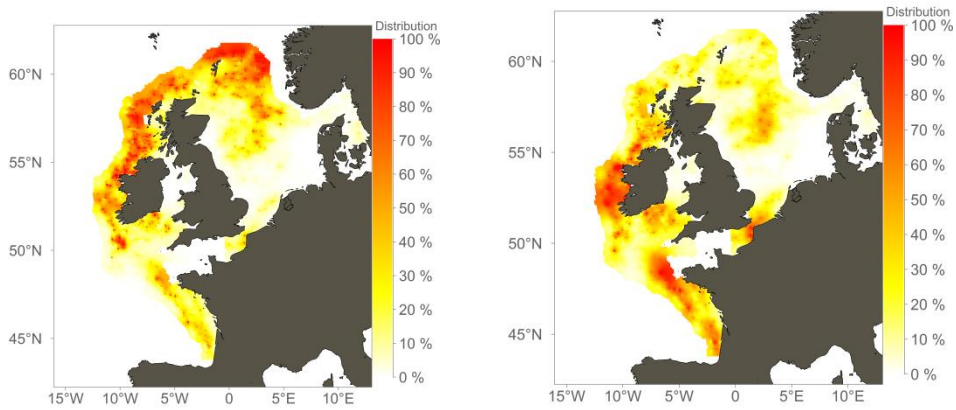

Figure 8.6.2.1. Distributions of modelled squared catch rates of mackerel at approximately 3-9 months of age in first and fourth quarter demersal trawl surveys. Left) average rates for cohorts from 1998-2015; and Right) 2015 cohort. See Jansen *et al.* (2015) for details.

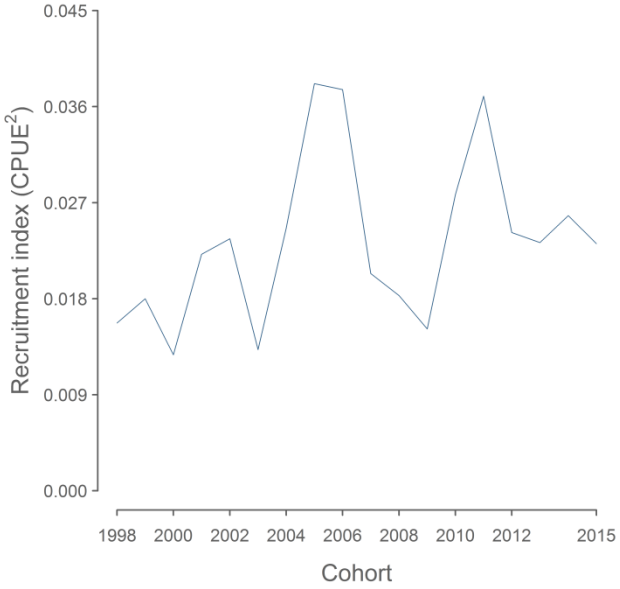

Figure 8.6.2.2. IBTS recruitment index derived from square root transformed CPUE. See Jansen *et al.* (2015) for details.

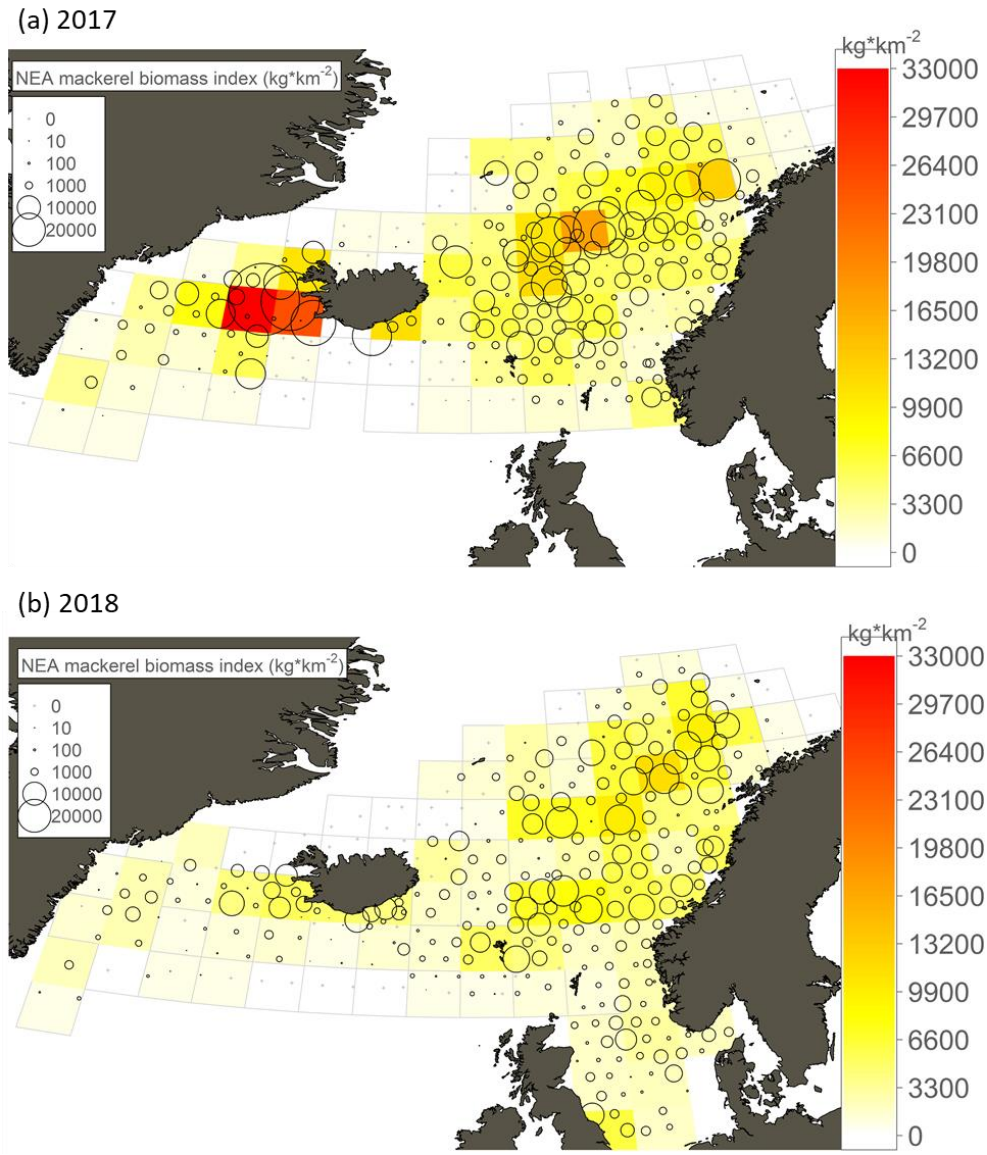

Figure 8.6.3.1. Mackerel catch rates from surface trawl hauls (circle size represents catch rate in kg/km²) overlaid on mean catch rate per standardized rectangle (1° lat. x 2° lon.) from the IESSNS survey in 2017 (a) and in 2018 (b).

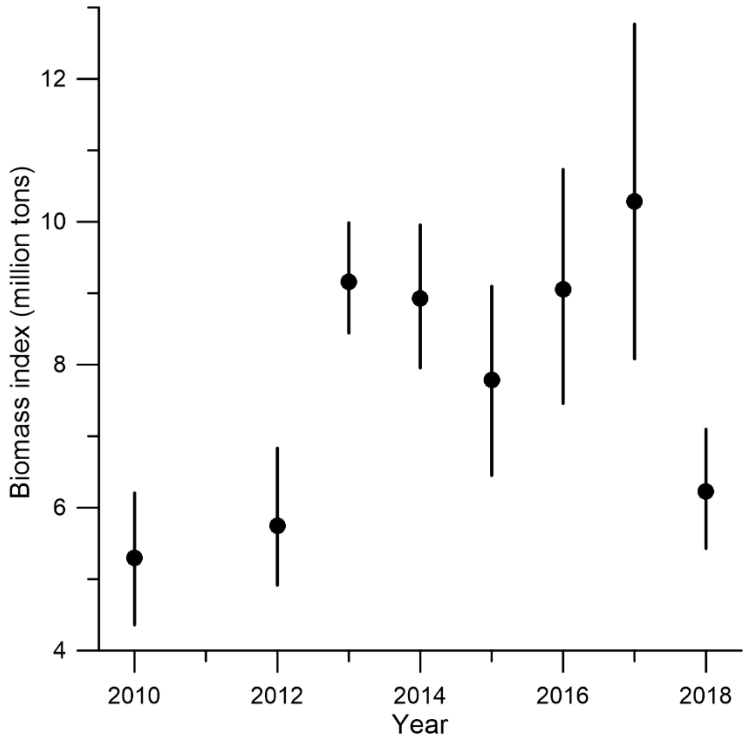

Figure 8.6.3.2. Estimated mackerel total stock biomass, with 90% CI, from the IESSNS for the years included in the assessment. North Sea is excluded from biomass index calculations in 2018.

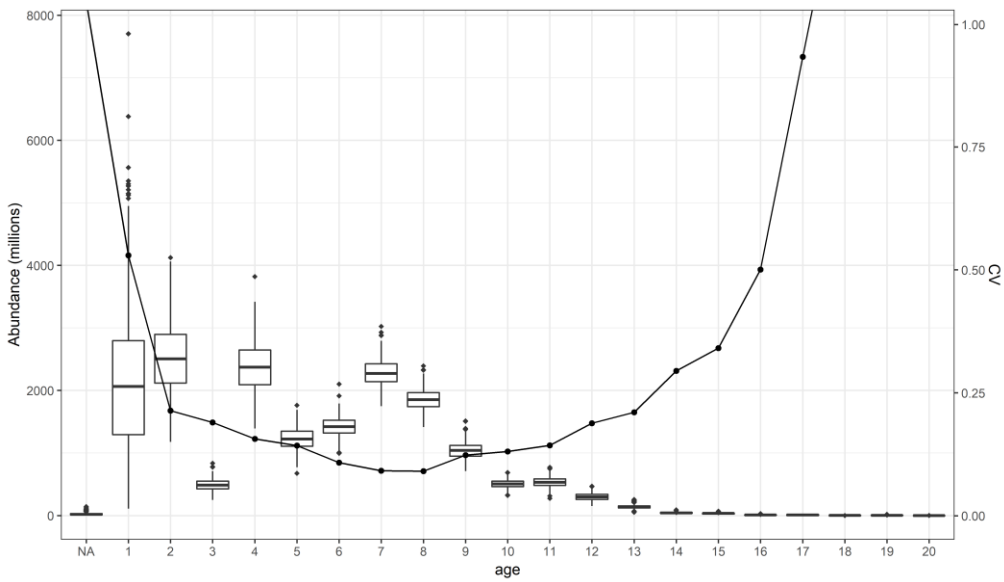

Figure 8.6.3.3. Mackerel numbers by age from the IESSNS survey in 2018, excluding North Sea. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 500 replicates using the StoX software (http://www.imr.no/forskning/prosjekter/stox/nb-no).

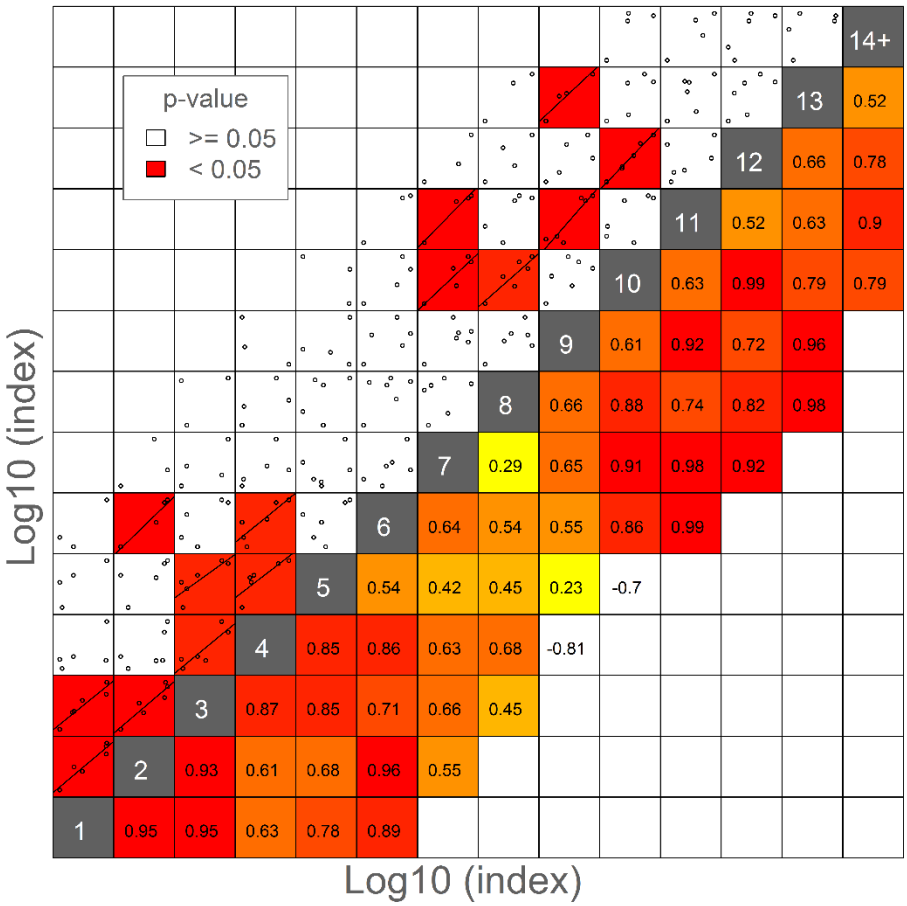

Figure 8.6.3.4. Internal consistency of the mackerel abundance index from the IESSNS surveys including data from 2012 to 2018, excluding North Sea in 2018. Ages indicated by white numbers in grey diagonal cells. Statistically significant positive correlations (*p<0.05*) are indicated by regression lines and red cells in upper left half. Corelation coefficients (r) are given in the lower right half.

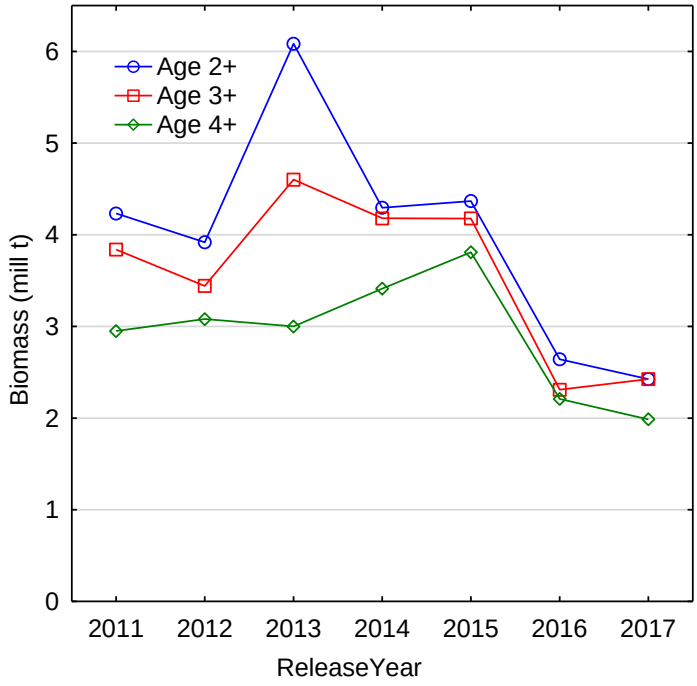

Figure 8.6.4.1. Biomass (mill t) estimates of mackerel at ages 2+, 3+ and 4+ based on RFID tagging data and recaptures at year 1 after release (YearsOut=1). Estimates are scaled to the 10% survival used in SAM. Estimates for release year 2017 is only based on landings in quarter 1 2018. Note that the mortality happening over the year is not taken into account in the estimation.

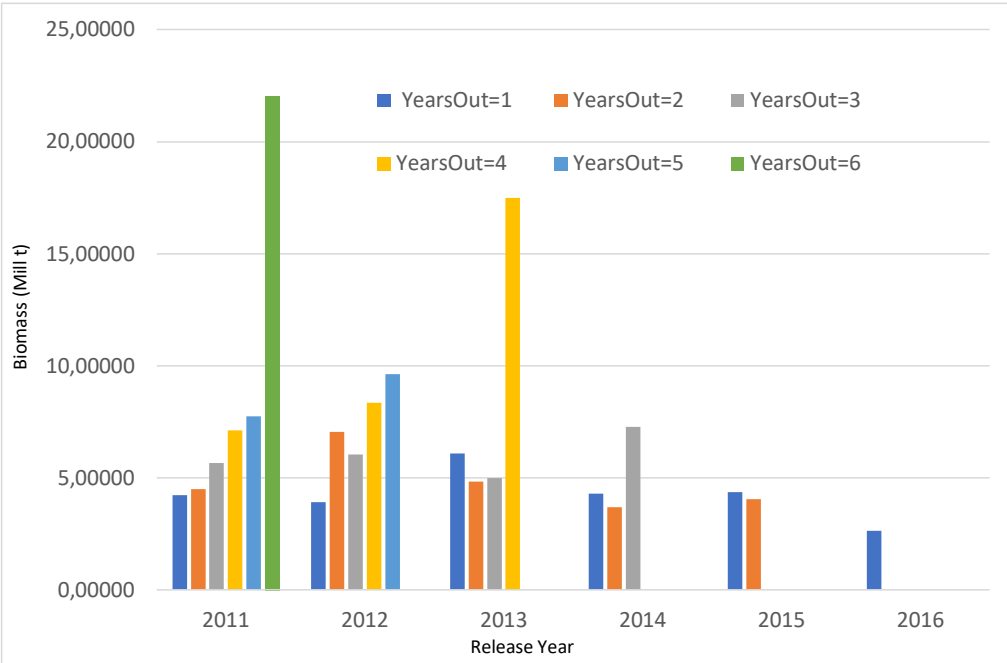

Figure 8.6.4.2. Biomass (mill t) estimates of Age 2+ mackerel based on RFID tagging data and recaptures at different numbers of years after release (YearsOut=1-6). Estimates are scaled to the 10% survival used in SAM. Note that the mortality happening over the year is not taken into account in the estimation.

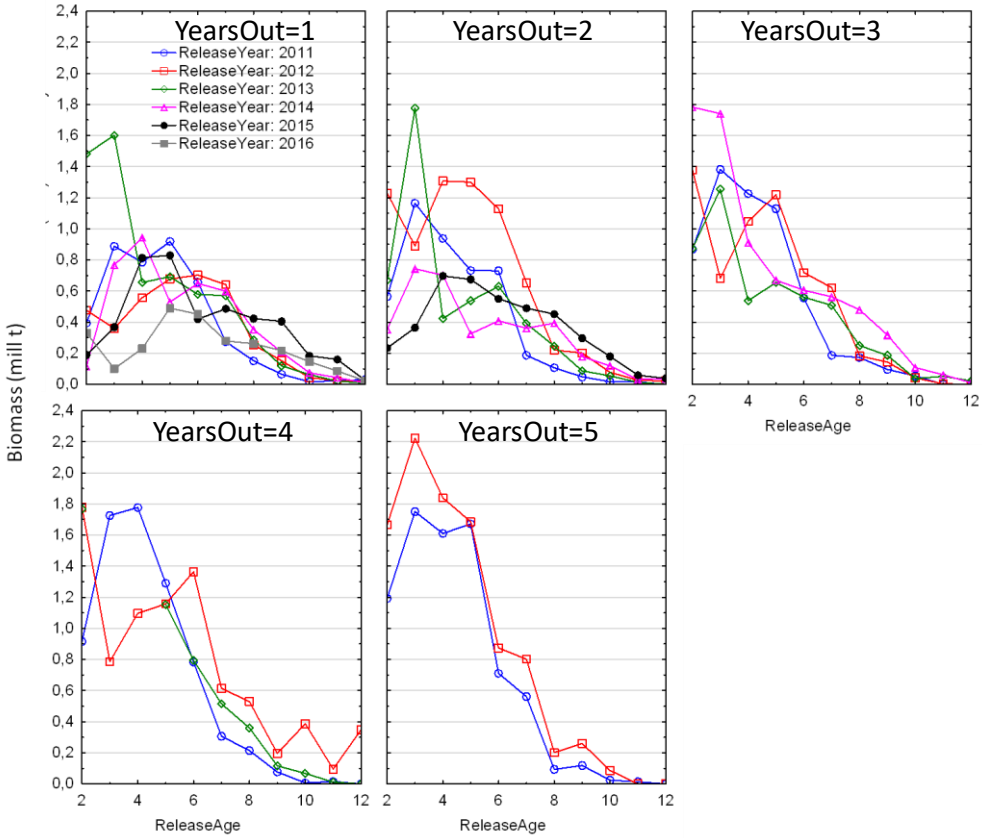

Figure 8.6.4.3. Biomass (mill t) estimates by age for the years 2011-2016 based on RFID tagging data and recaptures at different numbers of years after release (YearsOut=1-5). Estimates are scaled to 10% survival used in SAM. Note that the mortality happening over the year is not taken into account in the estimation.

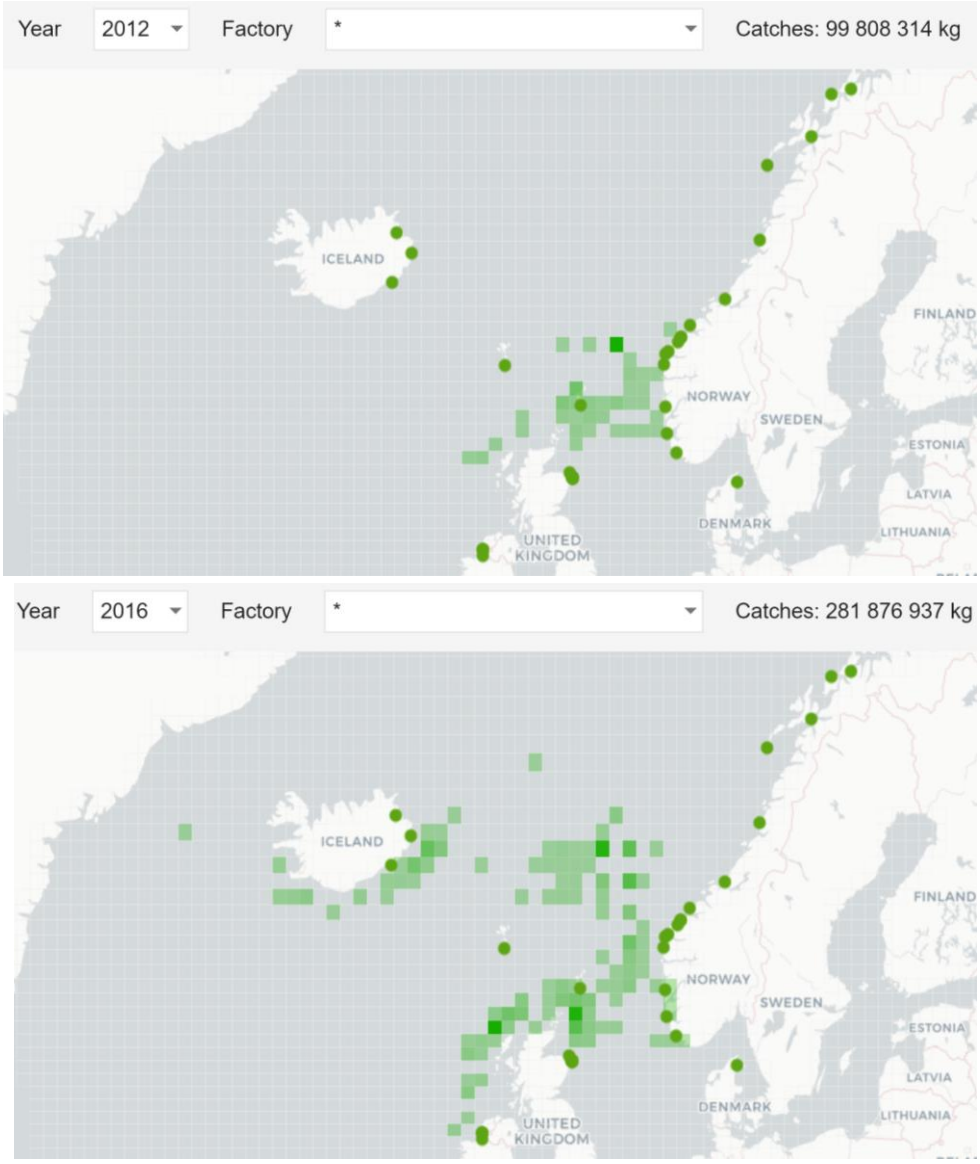

Figure 8.6.4.4. Illustration of the change in distribution of catches and biomass scanned for tags over the time series of RFID-tagging data. A marked change happened from 2014 onwards, when Icelandic, Faroese and Scottish factories installed RFID antenna systems. The pictures are from a map websolution (www.smartfishmap.hi.no) where it is given an overview of tagging experiments, scanned catches and recaptures, where it is possible to filter by year and factory, and where there also is a list of recaptures. All ICES rectangles with info are clickable for more info.

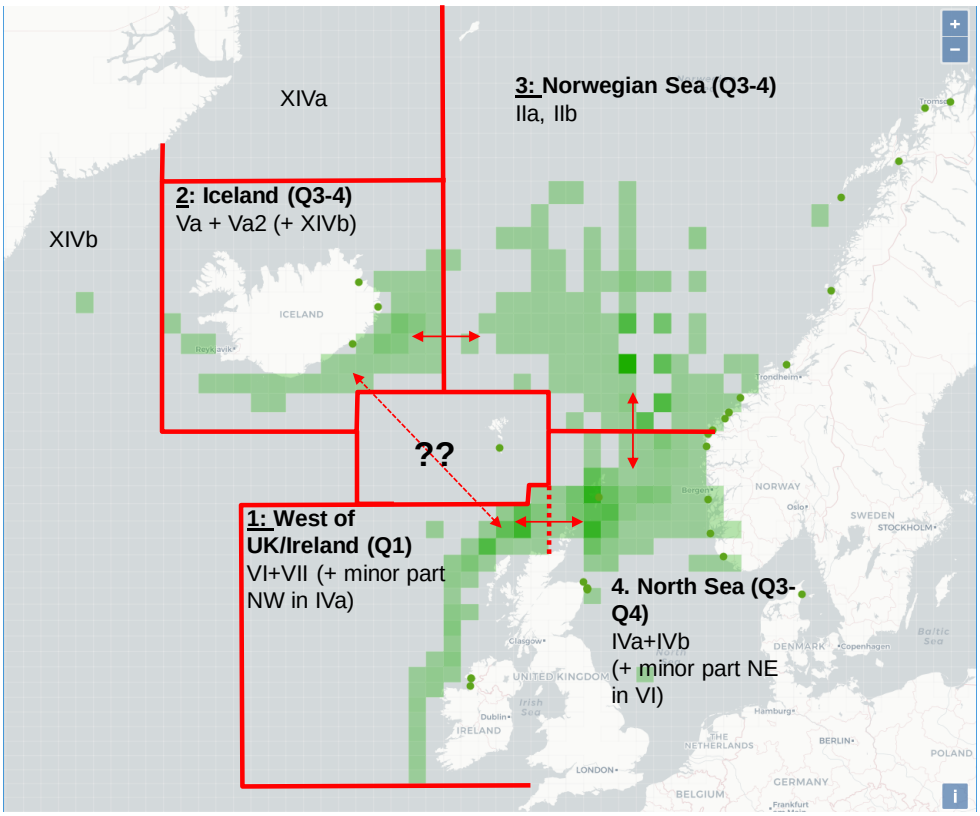

Figure 8.6.4.5. Suggestion of a possible split into 4 areas/seasons with scanned catches and recaptures handled, by area. Note that this also would imply that SAM would have to include mortality happening over the year for the tagging data. At present it is not taken into account whether recaptures are coming in quarter Q1, Q3 or Q4.

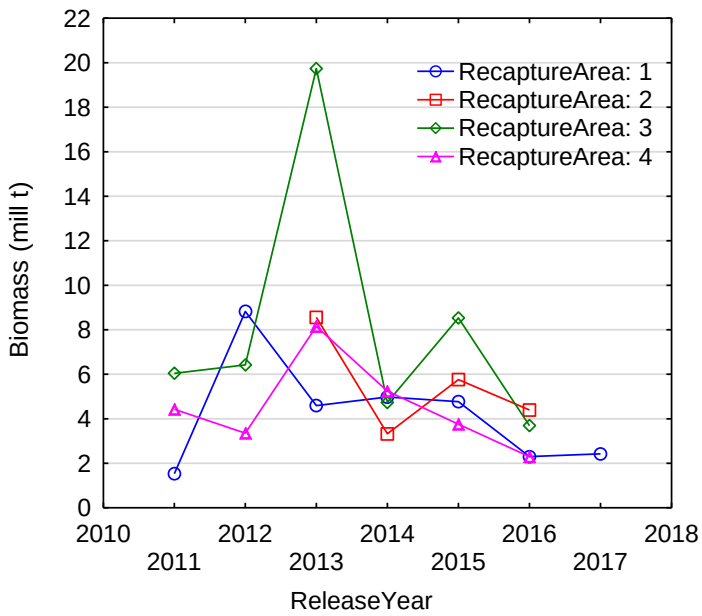

Figure 8.6.4.6. Biomass (mill t) estimates of mackerel at ages 2+ based on RFID tagging data and recaptures at year 1 after release (YearsOut=1), and based on recaptures in 4 different areas/seasons. Estimates are scaled to the 10% survival used in SAM. Estimates for release year 2017 is only based on landings in quarter 1 2018. Note that the mortality happening over the year is not taken into account in the estimation.

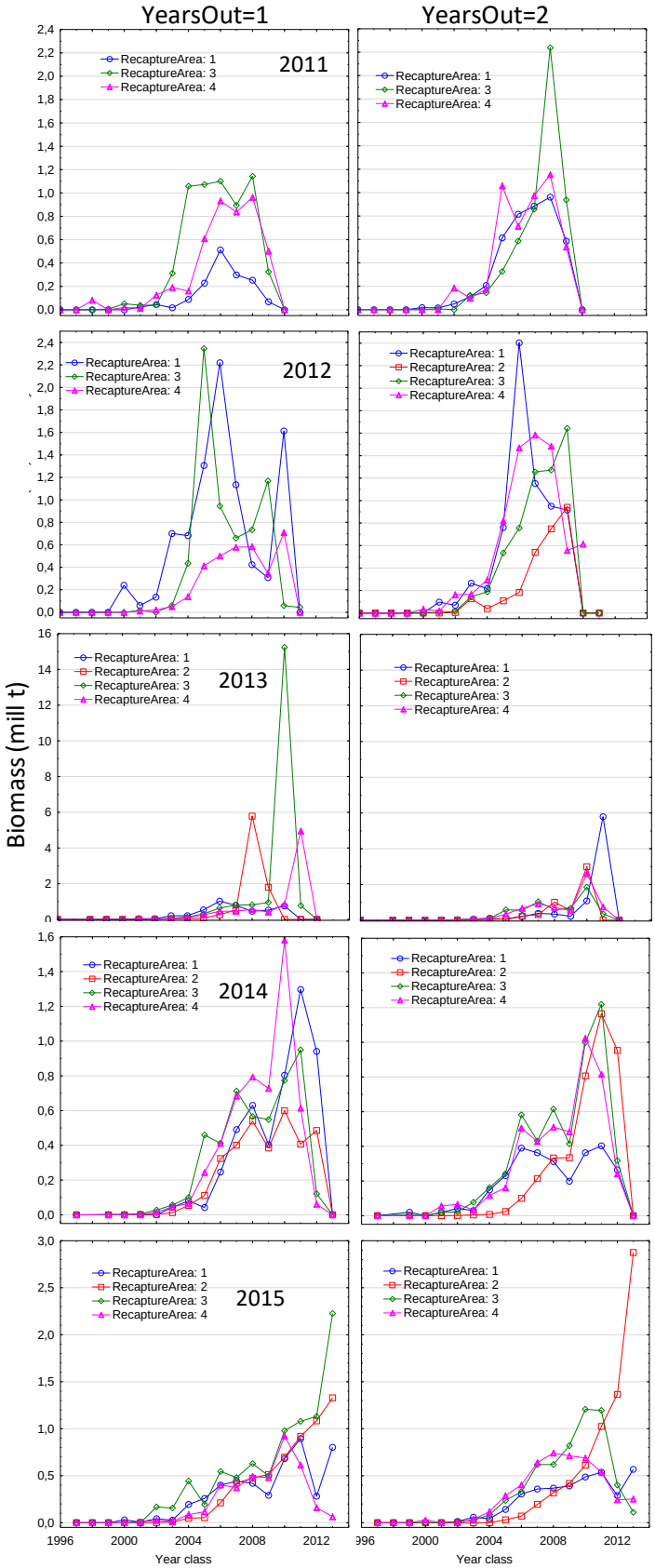

Figure 8.6.4.7. Biomass (mill t) estimates of mackerel by age in 2011-2015 based on RFID tagging data and recaptures at 1-2 years out after release (YearsOut=1-2), and based on recaptures in 4 different areas/seasons. Estimates are scaled to the 10% survival used in SAM. Note that the mortality happening over the year is not taken into account in the estimation.

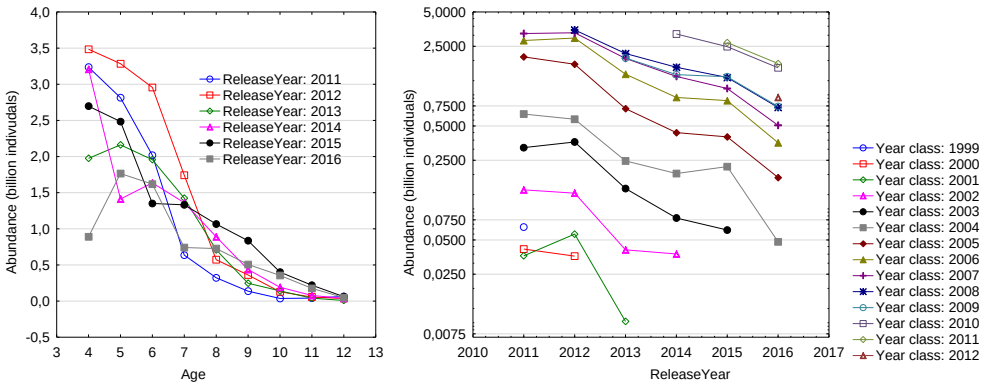

Figure 8.6.4.8. Left: Abundance index in billions individuals ages 4-12 per release years 2011-2016. Right: Year class trends in abundance (log scale) 2011-2016 from the index. The index is based on RFID tagging experiments 2011-2016, and data from scanned catches and recaptures in the two first years after a release year (yearsout=1-2).The index is already scaled down to the 10% survival estimated by SAM (see Table 8.6.4.3 for data).

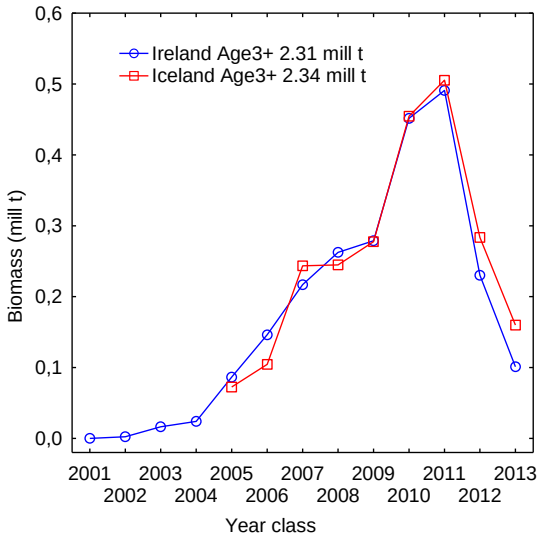

Figure 8.6.4.9. Biomass (mill t) estimates of mackerel by age (and total estimate) in 2016 based on RFID tagging off Ireland and Iceland and recaptures in 2017. Estimates are scaled to the 10% survival used in SAM. Note that the mortality happening over the year is not taken into account in the estimation.

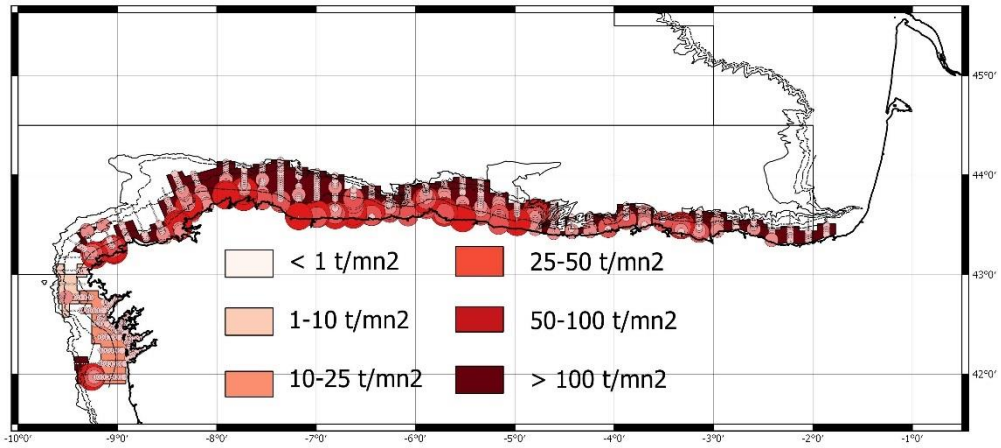

Figure 8.6.5.2.1. PELACUS 0318 mackerel density distribution. Polygons are drawn to encompass the backscattering energy, and polygon colour indicates the mean density expressed as tonnes per squared nautical mile (<1; 1-10; 10-25; 25-50; 50-100; and >100).

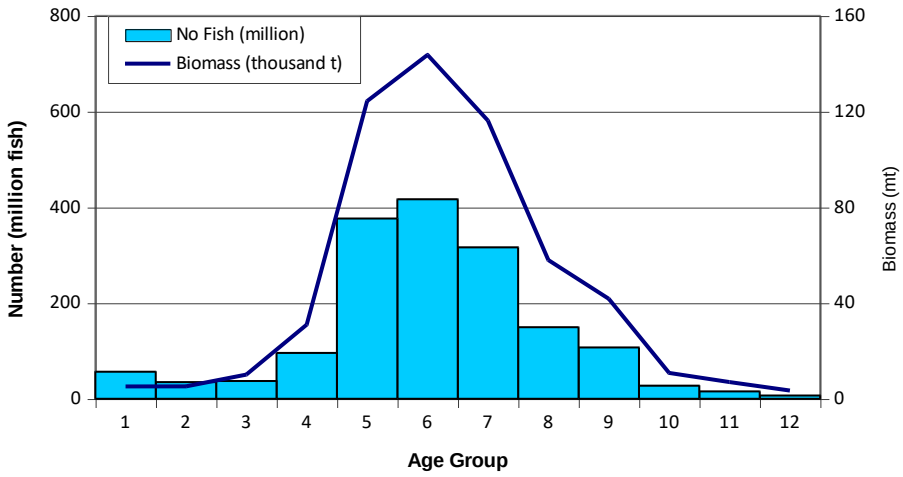

Figure 8.6.5.2.2: Mackerel abundance and biomass estimates by age group in ICES Divisions 8c. and 9.a during PELACUS 0318.

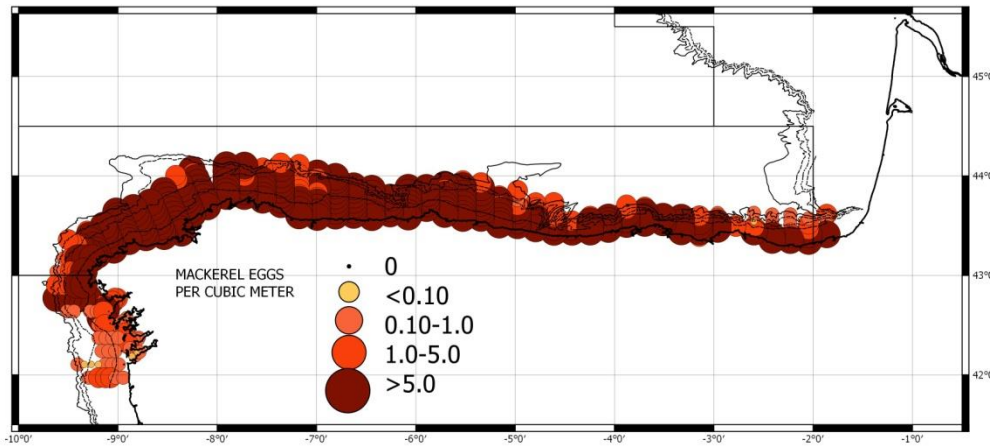

Figure 8.6.5.2.3: Mackerel subsurface egg distribution (no eggs/m³) as recorded by CUFES during PELACUS 0318.

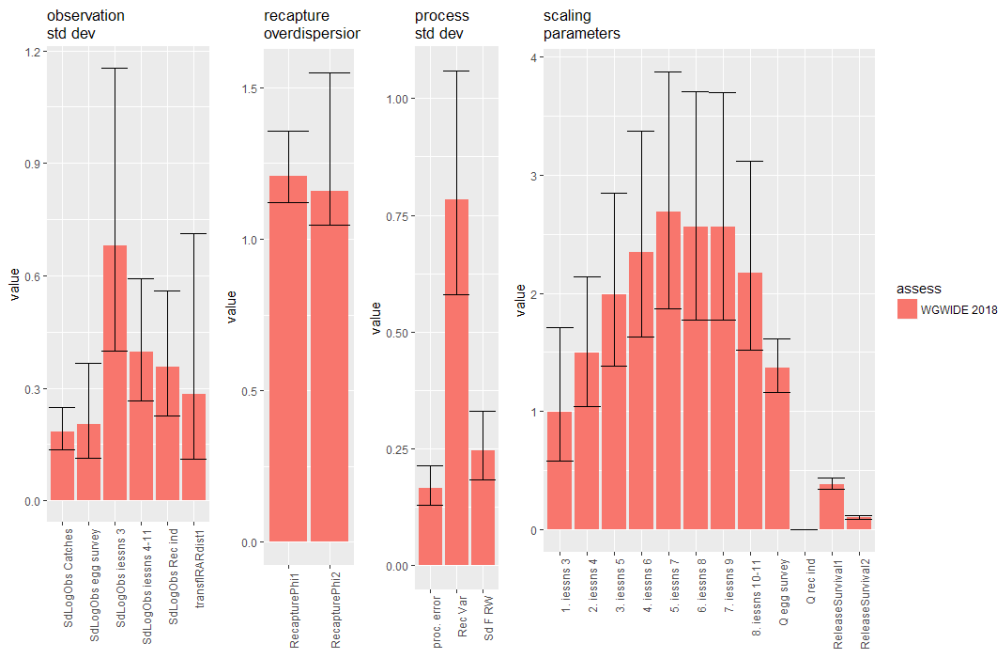

Figure 8.7.2.1. NE Atlantic mackerel. Parameter estimates from the SAM model (and associated confidence intervals) for the WGWIDE 2018 update assessment.

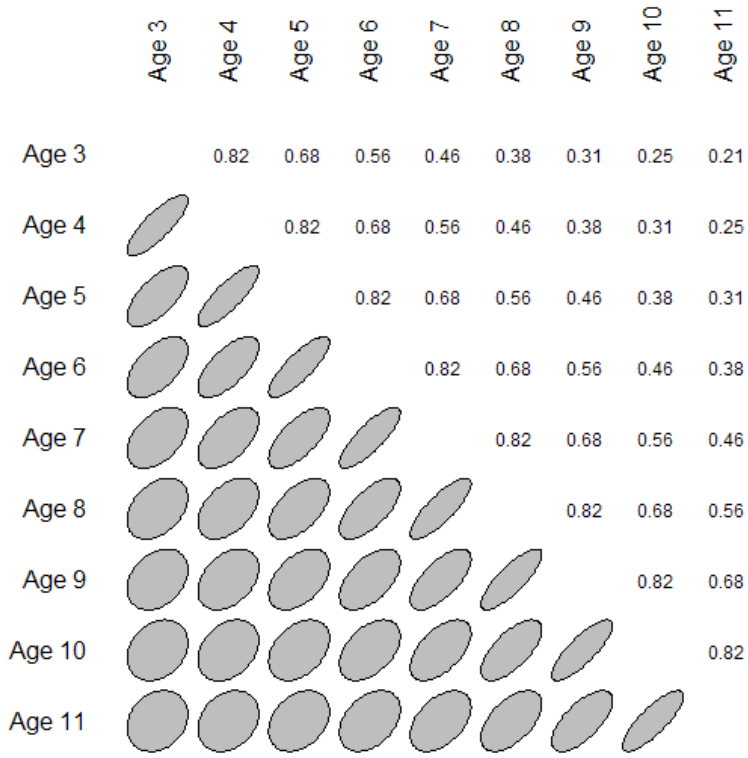

Figure 8.7.2.2. NE Atlantic mackerel. Estimated AR1 error correlation structure for the observations from the IESSNS survey age 3 to 11.

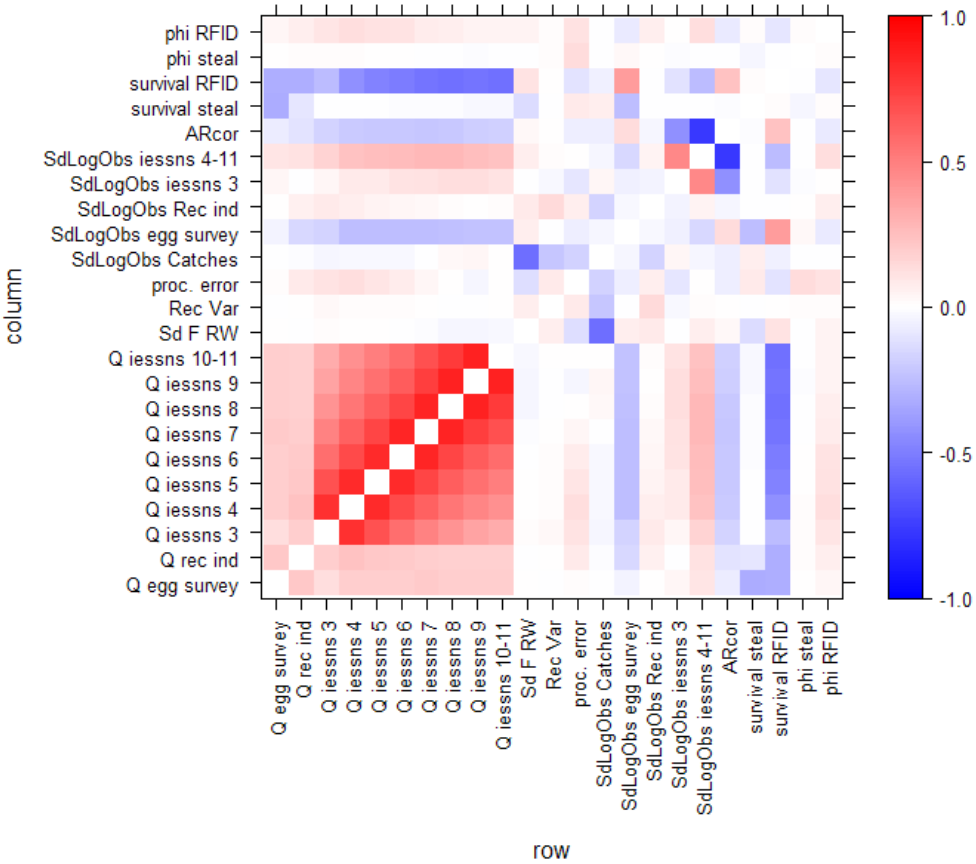

Figure 8.7.2.3. NE Atlantic mackerel. Correlation between parameter estimates from the SAM model for the WGWIDE 2018 update assessment.

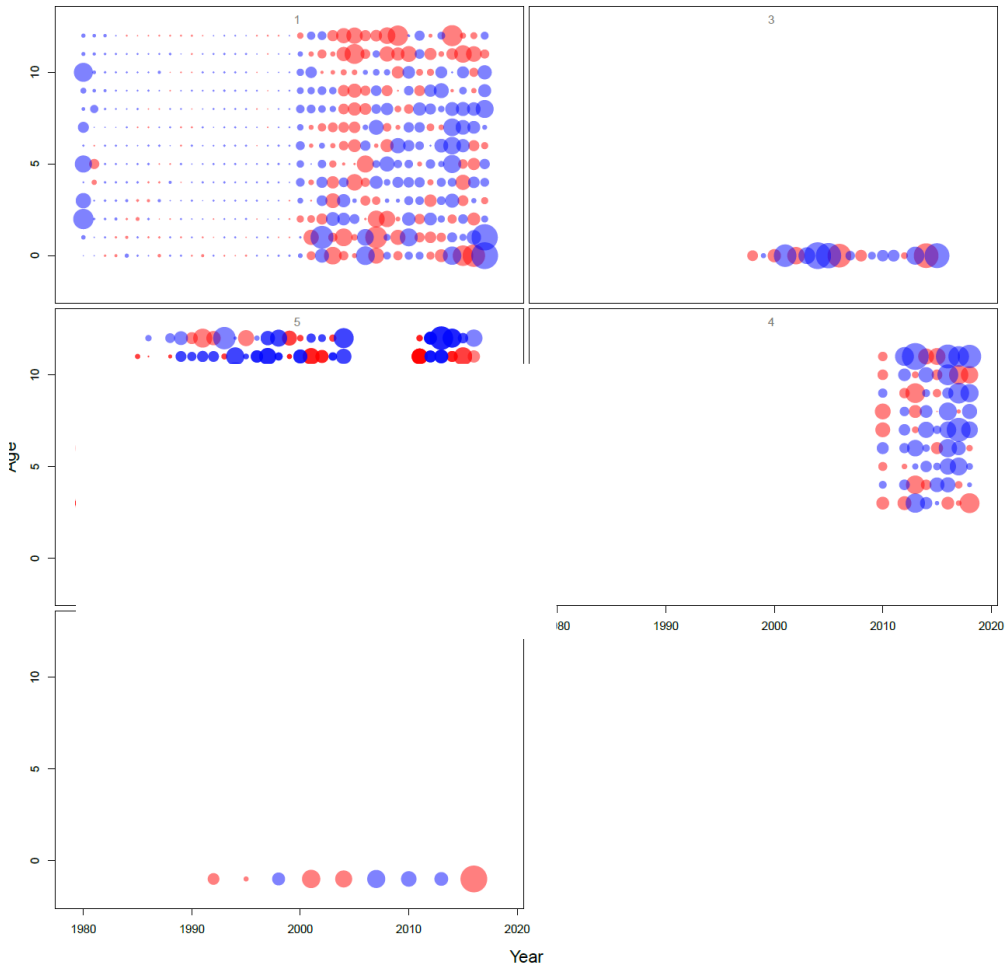

Figure 8.7.2.4. NE Atlantic mackerel. One Step Ahead Normalized residuals for the fit to the: (1) catch data (catch data prior to 2000 were not used to fit the model); (2) SSB estimates from egg survey; (3) recruitment index from the western Europe bottom trawl IBTS Q1 and Q4 surveys; and (4) abundance estimates at age from IESSNS survey. Blue circles indicate positive residuals (observation larger than predicted) and filled red circles indicate negative residuals.

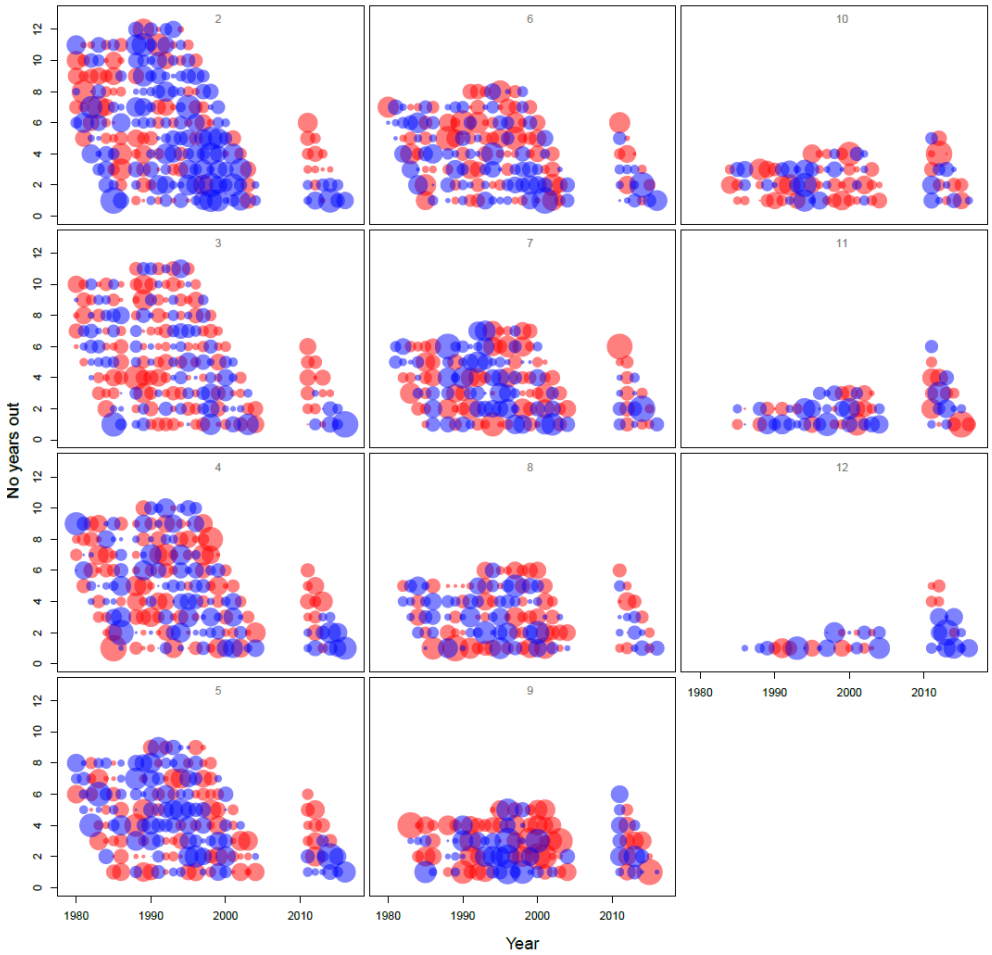

Figure 8.7.2.5. NE Atlantic mackerel. One step ahead residuals for the fit to the recaptures of tags in the final assessment. The x-axis represents the release year, and the y-axis is the number of years between tagging and recapture. Each panel correspond to a given age at release. Blue circles indicate positive residuals (observation larger than predicted) and filled red circles indicate negative residuals.

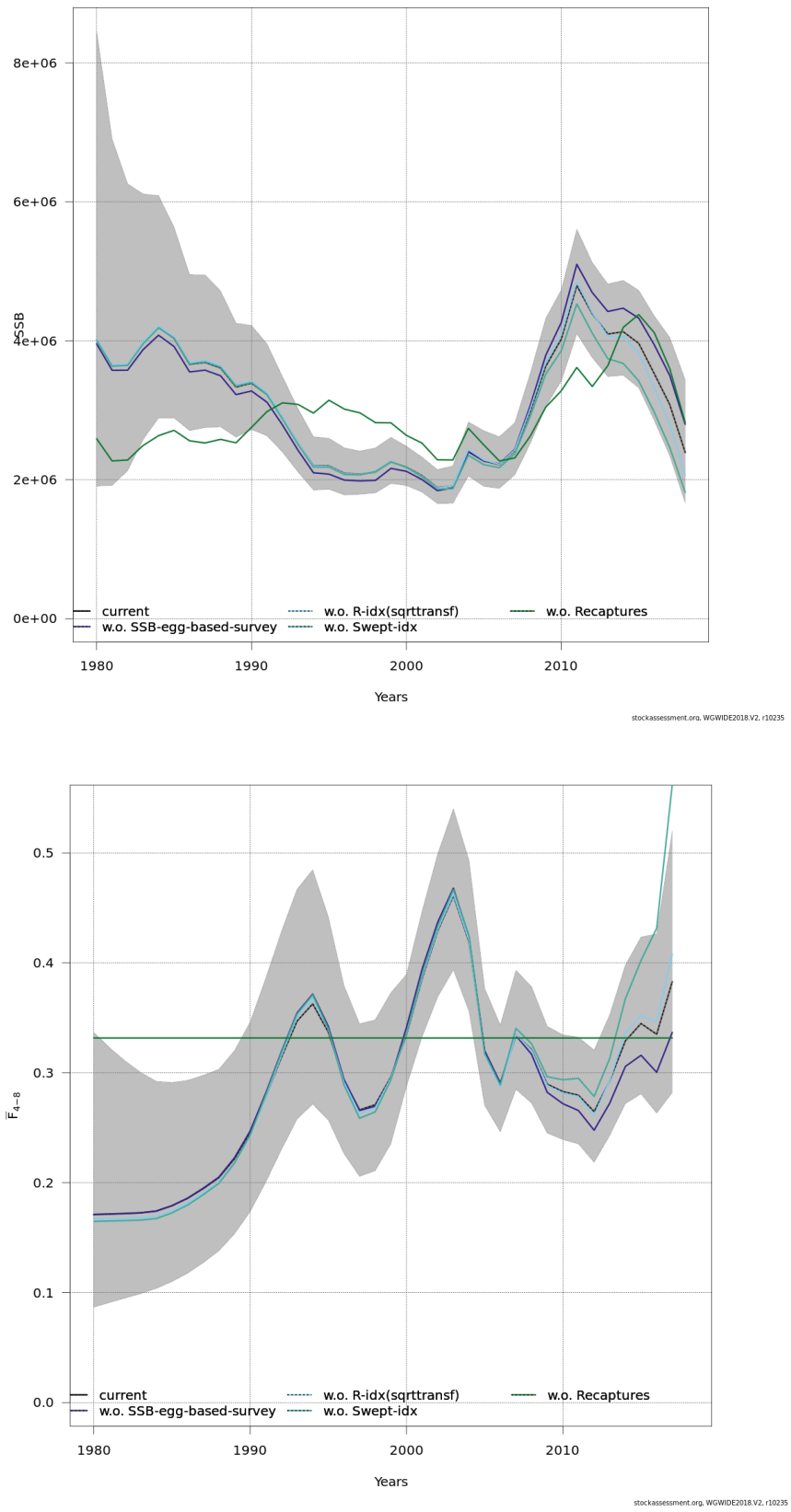

Figure 8.7.2.6. NE Atlantic mackerel. Leave one out assessment runs. SAM estimates of SSB and Fbar, for assessments runs leaving out one of the observation data sets. 2018 WGWIDE assessment (black) and current assessment leaving out: egg survey (purple), the recruitment index (light blue), IESSNS index (seagreen) and without tagging data (dark green).

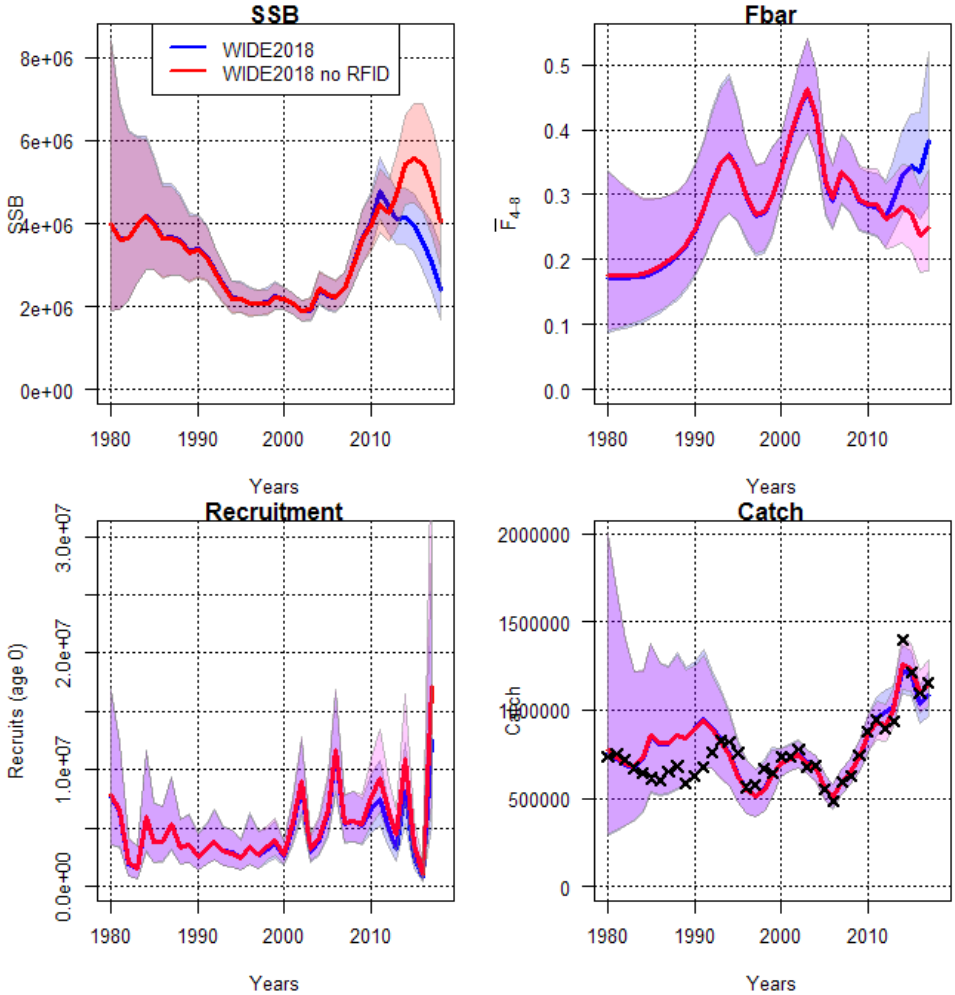

Figure 8.7.2.7. NE Atlantic mackerel. Leave one out assessment run excluding the RFID tagging data.Comparison of stock estimates from the 2018 WGWIDE assessment (blue) and the 2018 WGWIDE assessment without the 2017 RFID tagging data (red).

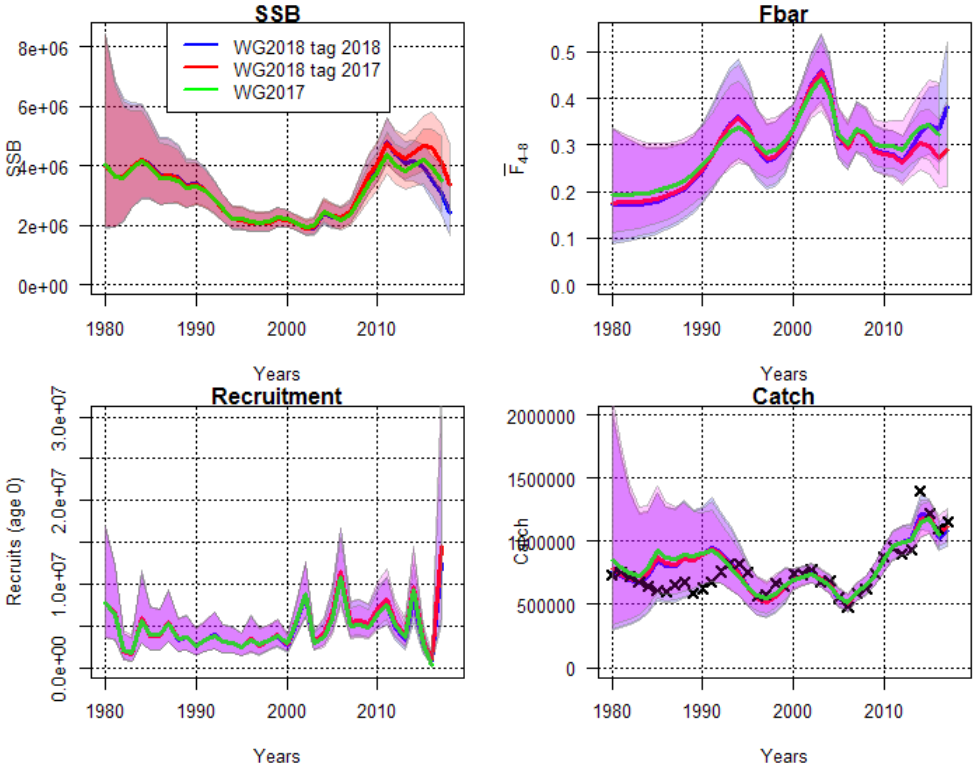

Figure 8.7.2.8. NE Atlantic mackerel. Influence of the latest year of data (recaptures from 2017) for the RFID tags on the output of the assessment. Comparison of stock estimates from the 2018 WGWIDE assessment (blue), the 2018 WGWIDE assessment without the 2017 recaptures (red) and the 2017 WGWIDE assessment (green).

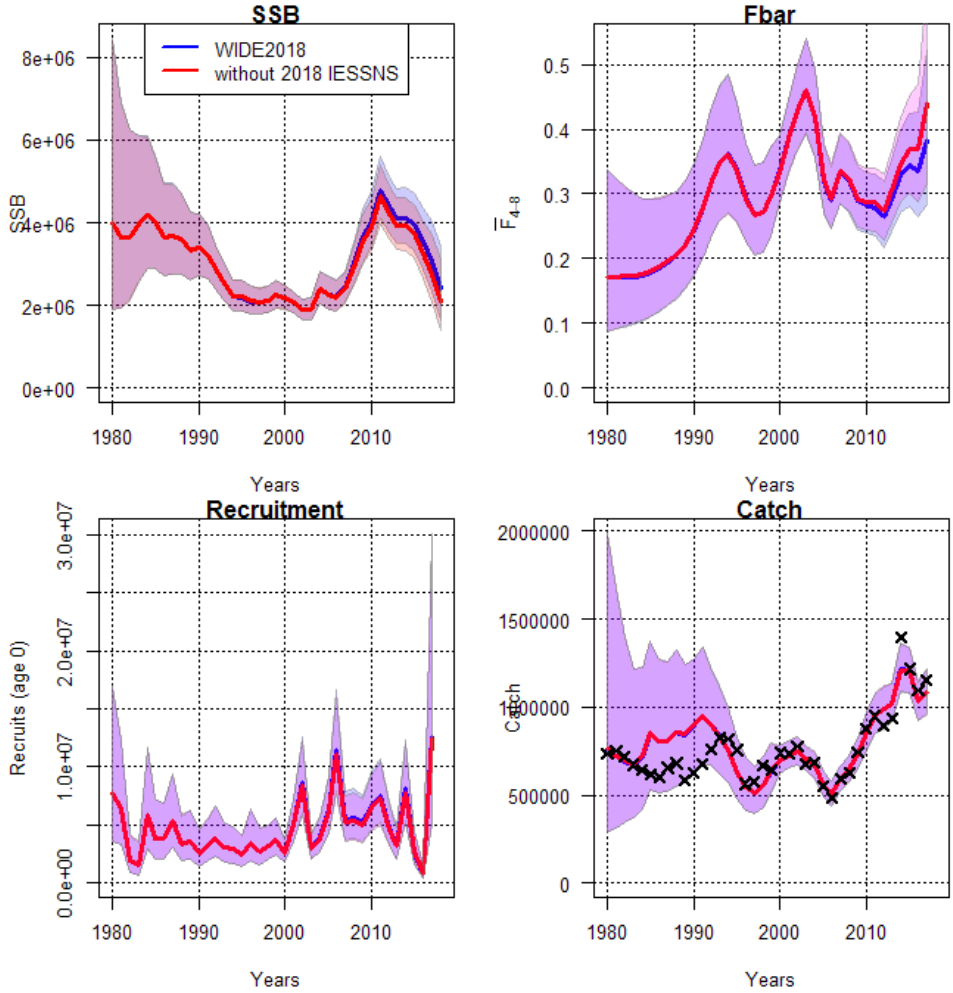

Figure 8.7.2.9. NE Atlantic mackerel. Influence of the latest year of data for the IESSNS survey on the output of the assessment. Comparison of stock estimates from the 2018 WGWIDE assessment (blue) and the 2018 WGWIDE assessment without the 2018 IESSNS index (red).

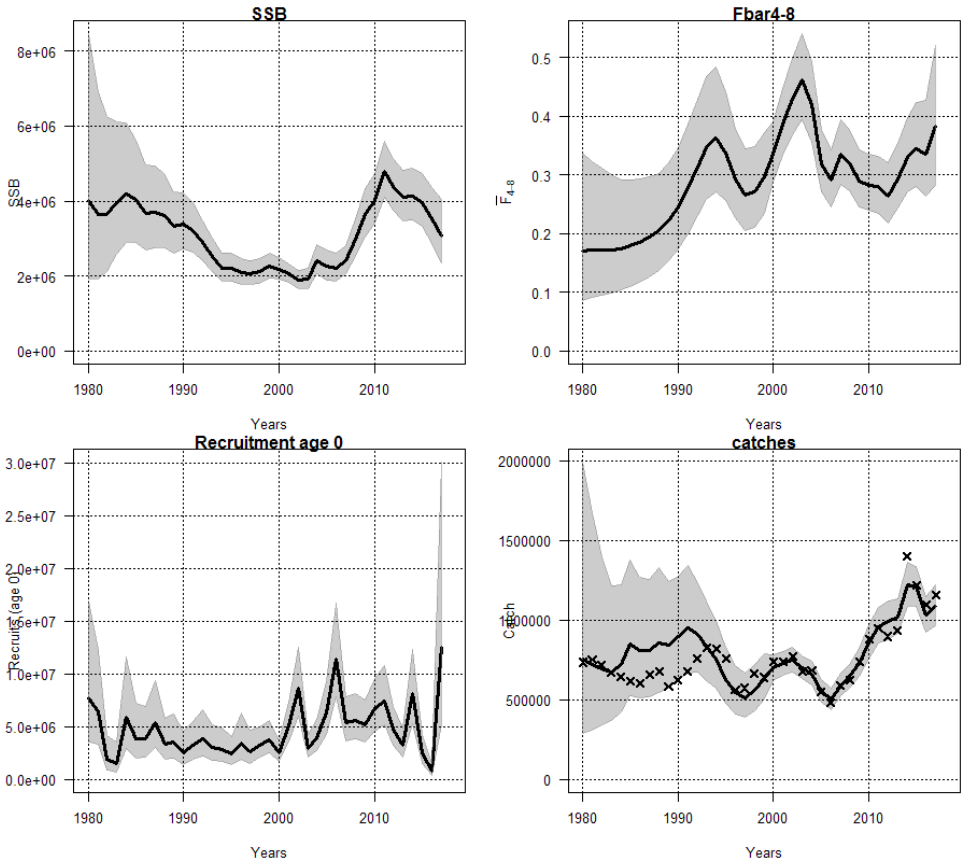

Figure 8.7.3.1. NE Atlantic mackerel. Perception of the NEA mackerel stock, showing the SSB, Fbar4-8 and recruitment (with 95% confidence intervals) from the SAM assessment.

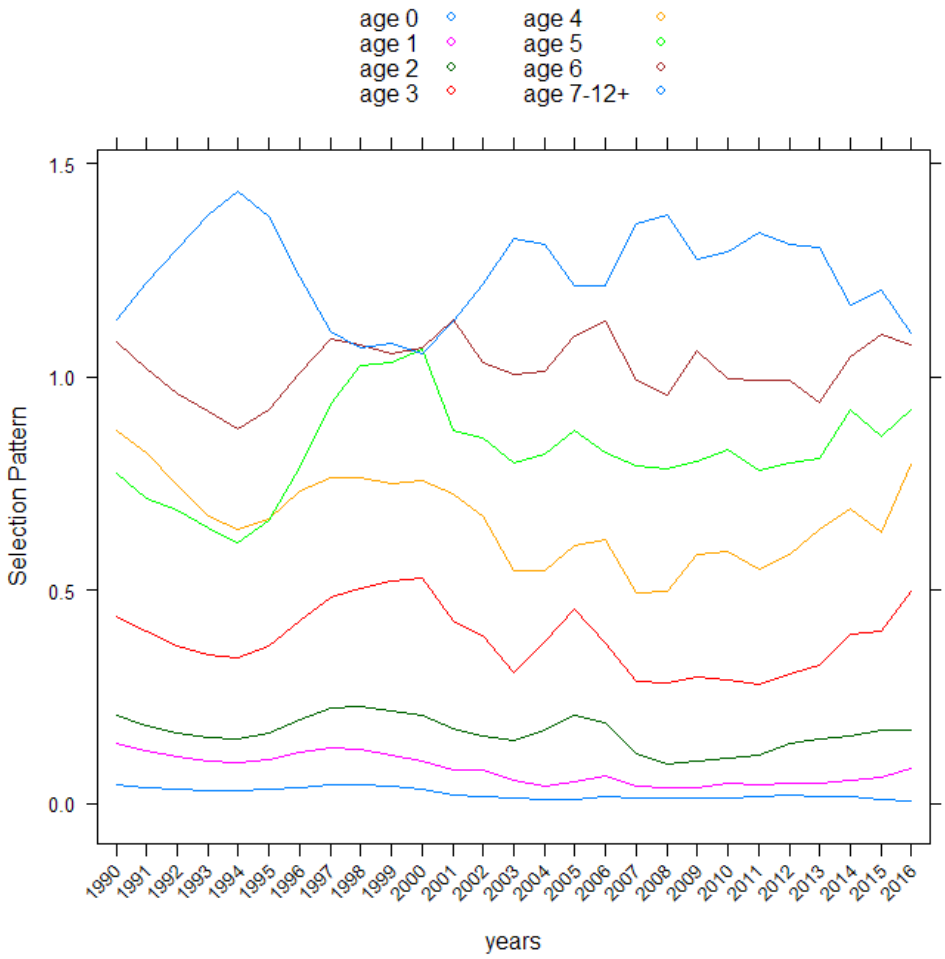

Figure 8.7.3.2. NE Atlantic mackerel. Estimated selectivity for the period 1990 to 2017, calculated as the ratio of the estimated fishing mortality-at-age and the Fbar4-8 value in the corresponding year.

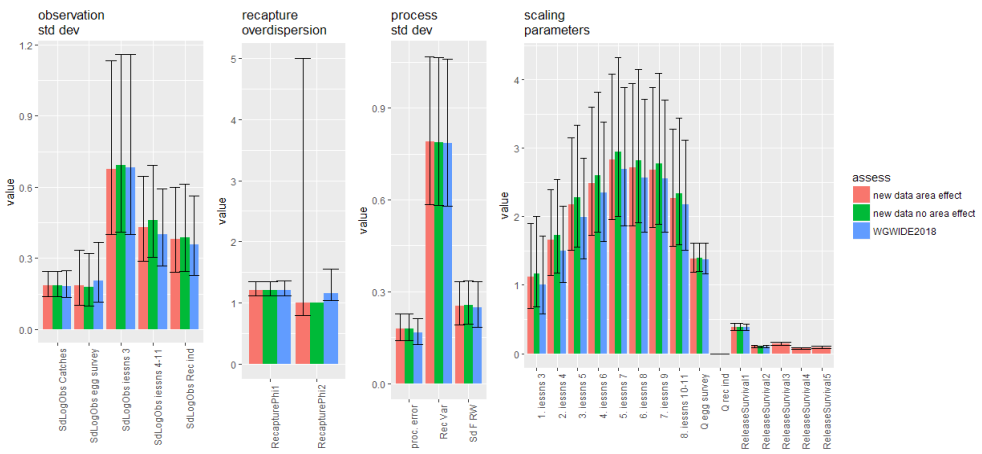

Figure 8.7.4.1.1. NE Atlantic mackerel. Comparison of estimated model parameters for the WGWIDE 2018 update assessment (blue), the assessment run with the same configuration on the RFID tag dataset structured by recapture area (green), and the assessment with survival rate for the RFID tag estimated for each area (red).

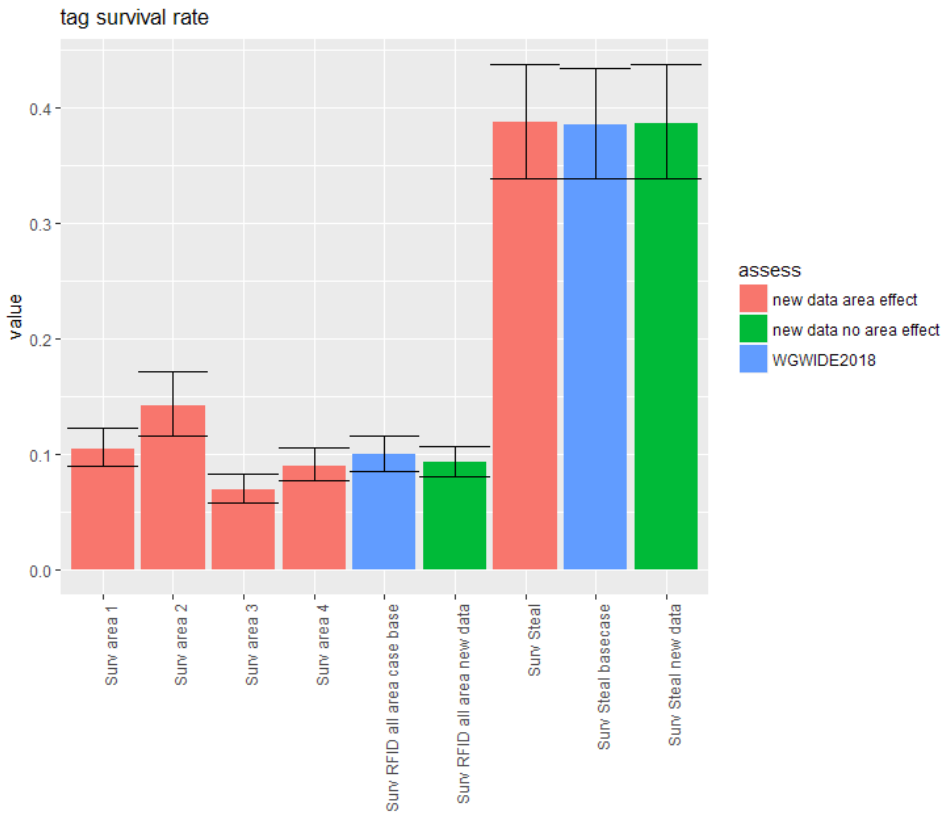

Figure 8.7.4.1.2. NE Atlantic mackerel. Comparison of estimated post release survival rates for the WGWIDE 2018 update assessment (blue), the assessment run with the same configuration on the RFID tag dataset structured by recapture area (green), and the assessment with survival rate for the RFID tag estimated for each area (red).

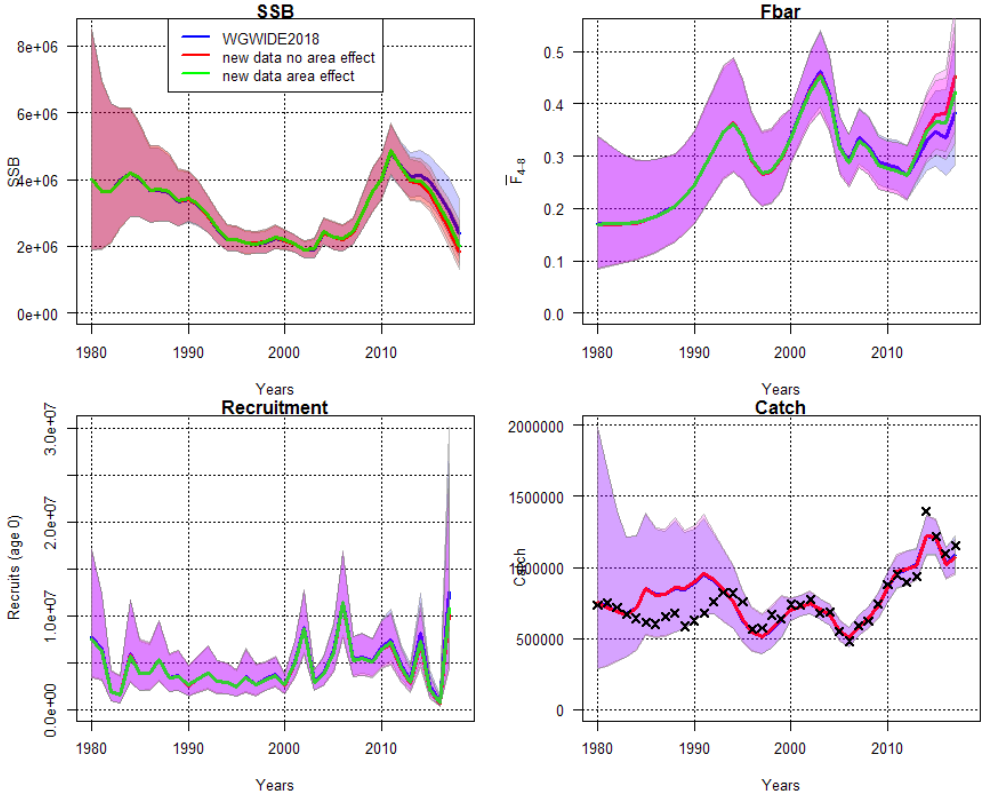

Figure 8.7.4.1.3. NE Atlantic mackerel. Comparison of the stock trajectories between the WGWIDE 2018 update assessment (blue), the assessment run with the same configuration on the RFID tag dataset structured by recapture area (red), and the assessment with survival rate for the RFID tag estimated for each area (green).

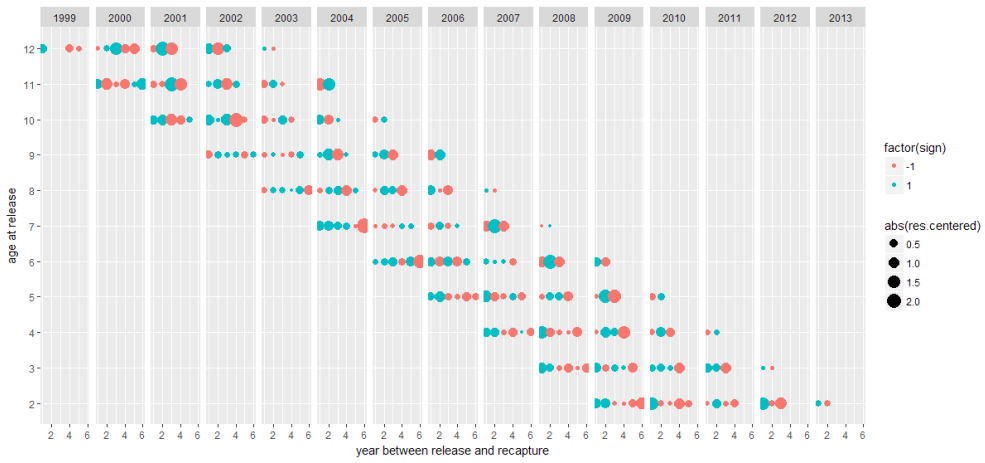

Figure 8.7.4.2.1. NE Atlantic mackerel. Residuals (OAS) for the RFID tags grouped by year-class and age at release and centred. The different panels correspond to different year-classes. Green circles indicate positive residuals (observation larger than predicted) and filled red circles indicate negative residuals.

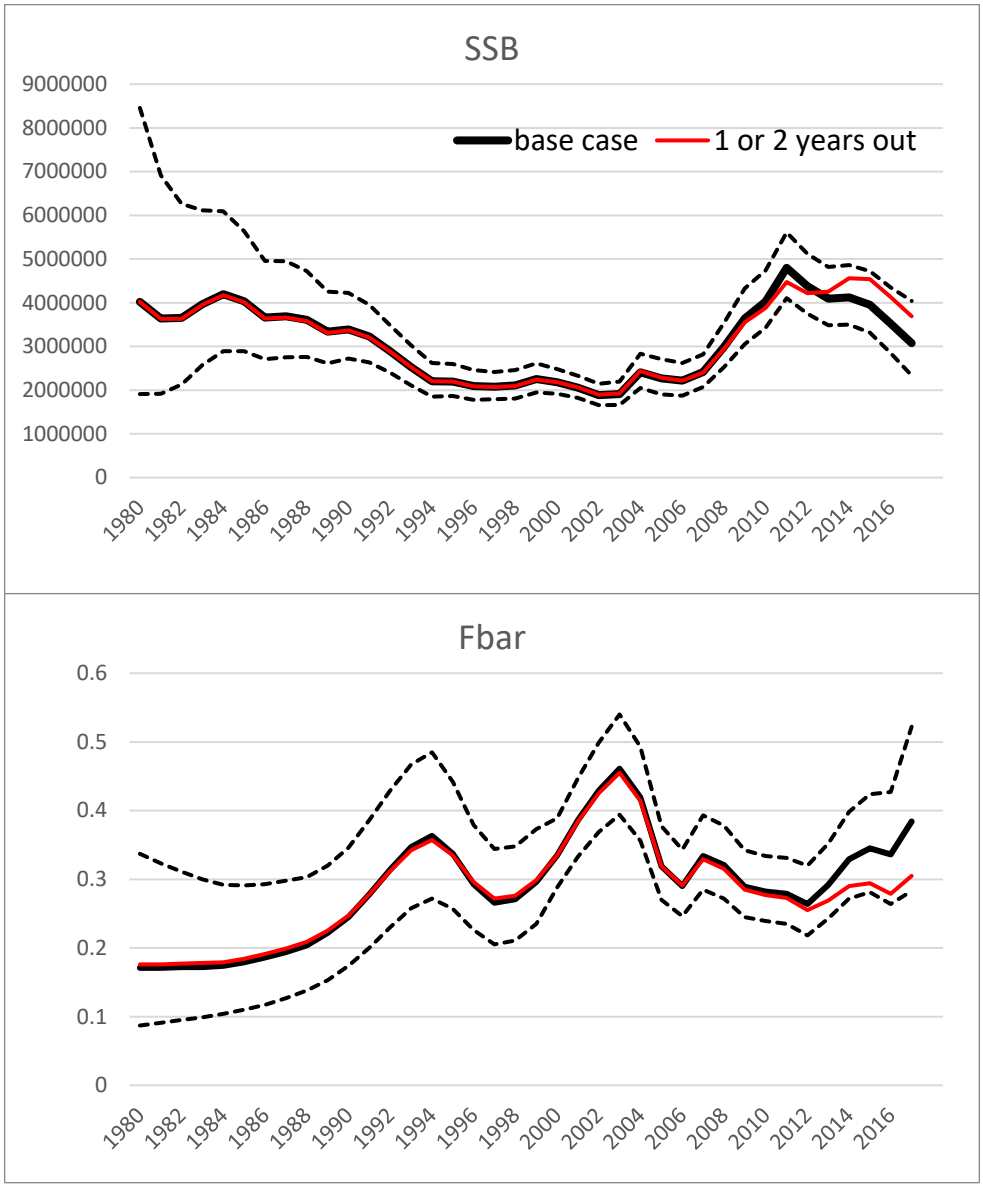

Figure 8.7.4.2.2. NE Atlantic mackerel. Comparison of the stock trajectories between the WGWIDE 2018 update assessment (black) and the same assessment using only the RFID tag data corresponding to the first 2 years of recapture after tagging (red).

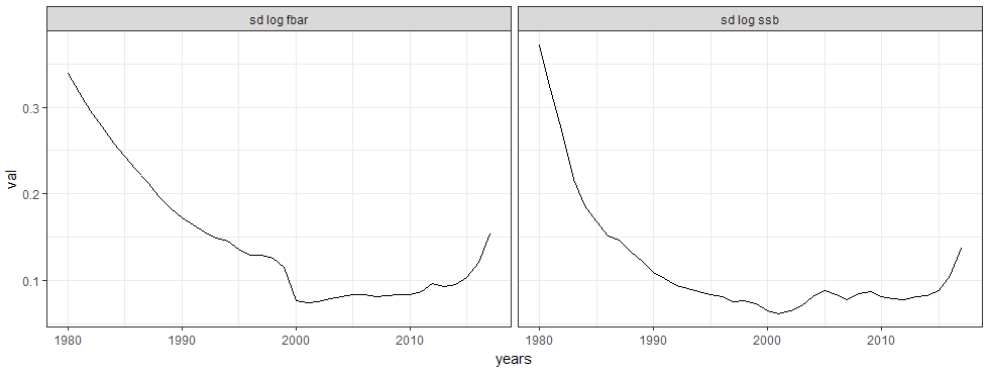

Figure 8.7.5.1. NE Atlantic mackerel. Uncertainty (standard deviation of the log values) of the estimates of SSB and Fbar from the SAM for the 2018 WGWIDE assessment.

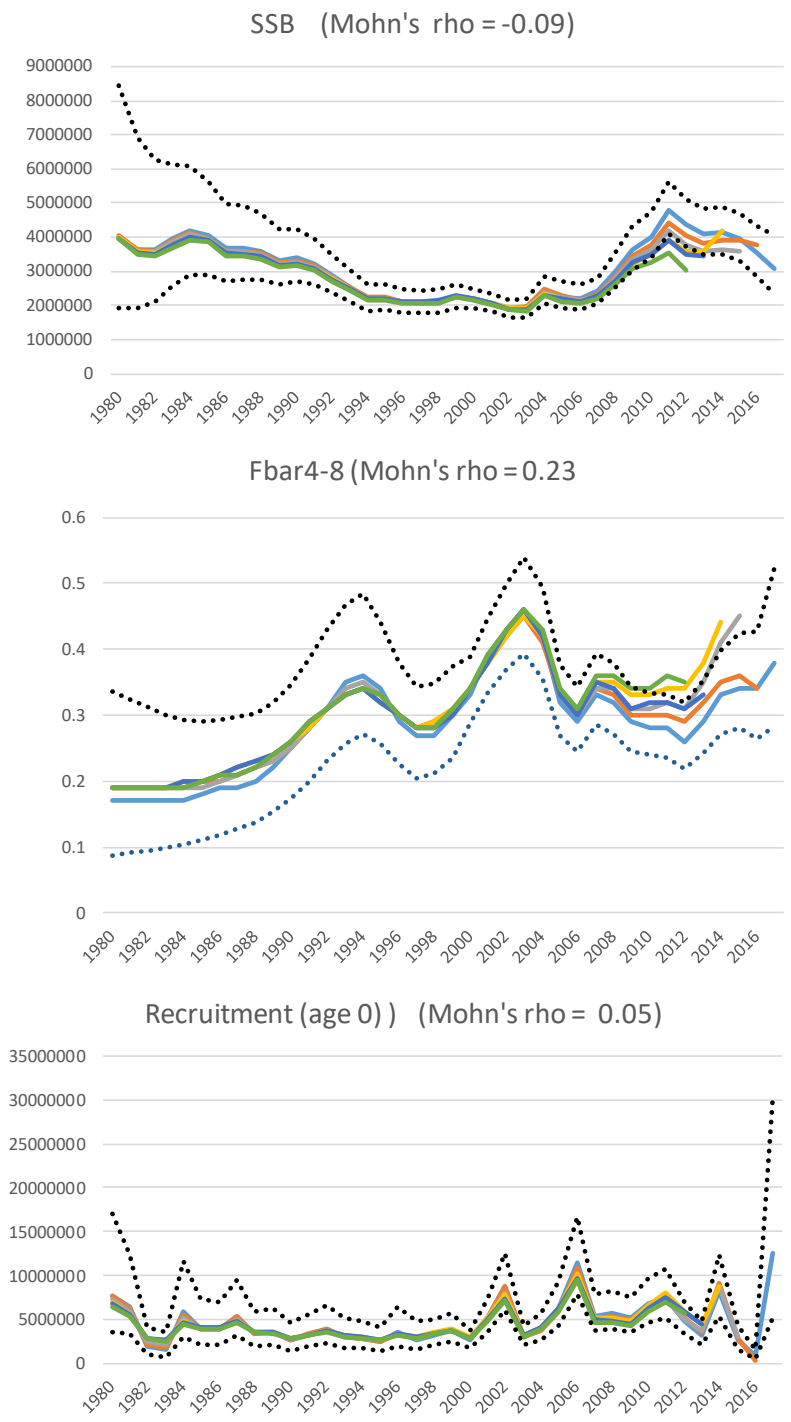

Figure 8.7.5.2. NE Atlantic mackerel. Analytical retrospective patterns (5 years back) of SSB, Fbar4-8 and recruitment from the WGWIDE 2018 update assessment.

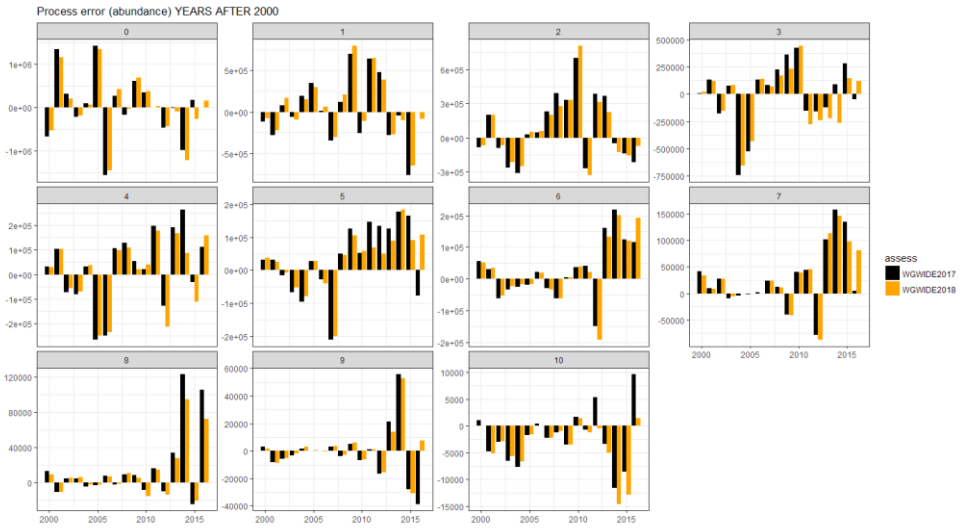

Figure 8.7.5.3. NE Atlantic mackerel. Process error expressed as annual deviations of abundances at age, for the 2018 WGWIDE assessment (orange) and from the 2017 WGWIDE assessment (black).

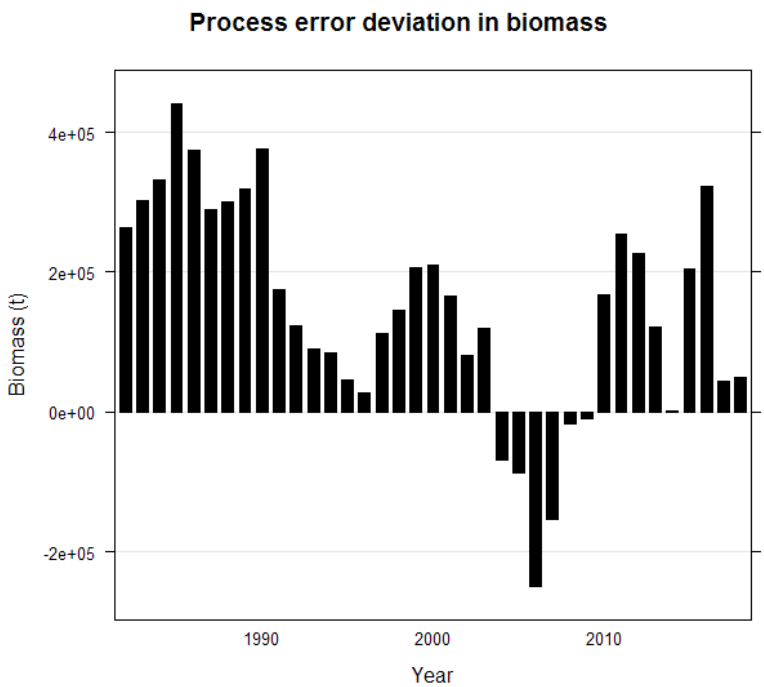

Figure 8.7.5.4. NE Atlantic mackerel. Model process error expressed in biomass cumulated across age-group for the 2018 WGWIDE assessment.

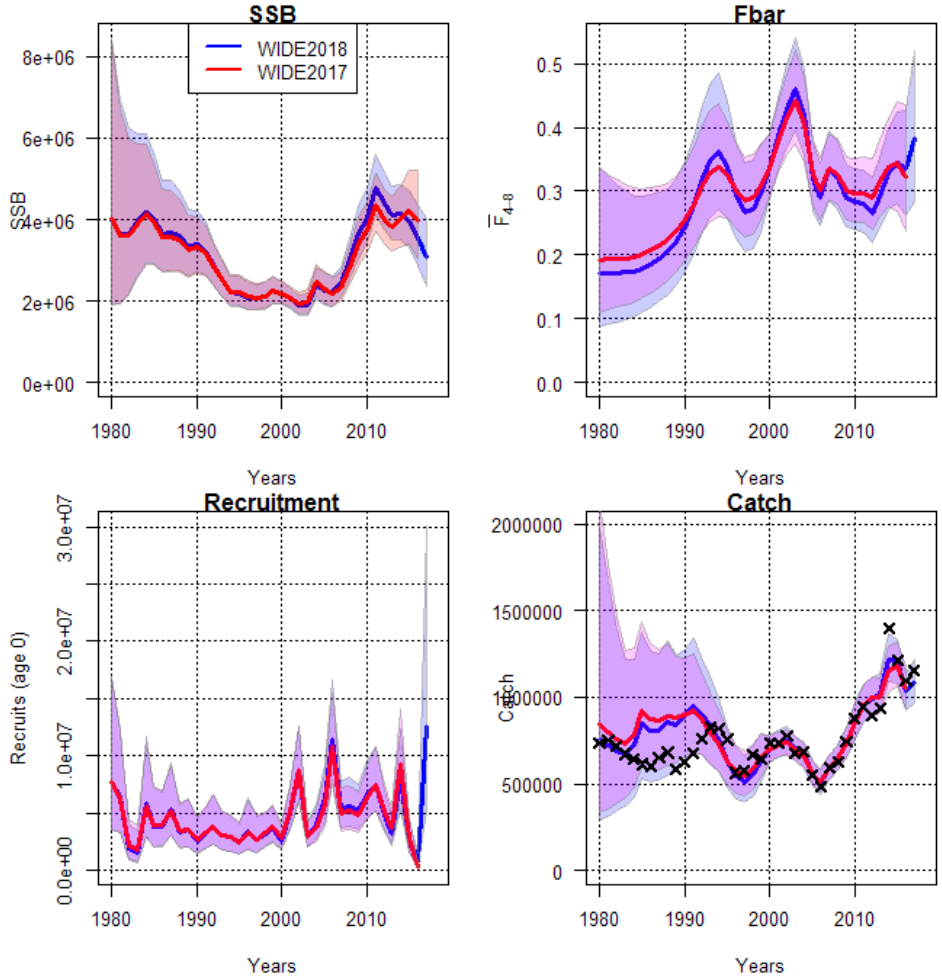

Figure 8.10.1. NE Atlantic mackerel. Comparison of the stock trajectories between the 2018 WGWIDE assessment (blue)and the 2017 assessment (red).

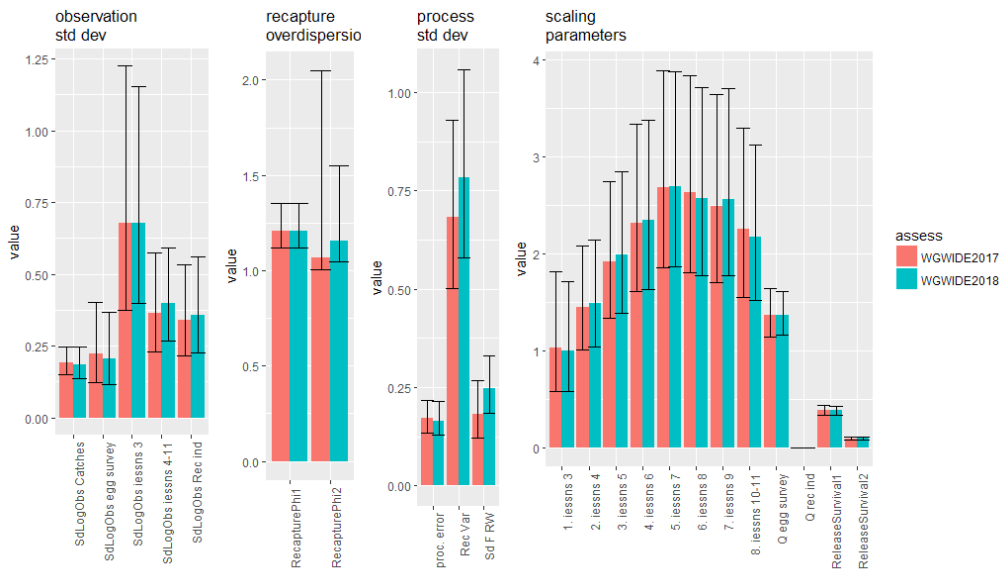

Figure 8.10.2. NE Atlantic mackerel. Comparison of model parameters and their uncertainty for the 2018 WGWIDE (green) and the 2017 WGWIDE assessment (red).

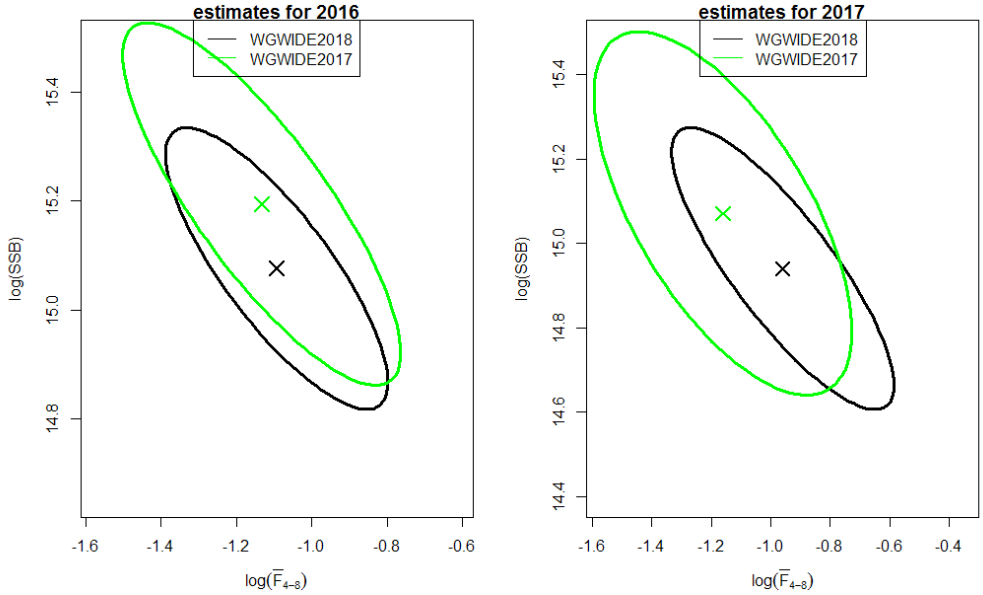

Figure 8.10.3. NE Atlantic mackerel. Comparison of the joint uncertainty on recent estimates of SSB and Fbar for the WGWIDE 2018 update assessment and last year's assessment.

9 Red gurnard in the Northeast Atlantic

9.1 General biology

The main biological features known for red gurnard (*Aspitrigla (Chelidonichthys) cuculus*) are described in the stock annex. This species is widely distributed in the Northeast Atlantic from South Norway and North of the British Isles to Mauritania on grounds between 20 and 250 m. This benthic species is abundant in the Channel (7de) and on the shelf West of Brittany (7h, 8a), living on gravel or coarse sand. In the Channel, the size at first maturity is ~25cm at 3 years old (Dorel, 1986).

9.2 Stock identity and possible assessments areas

A compilation of datasets from bottom-trawl surveys undertaken within the project 'Atlas of the marine fishes of the northern European shelf' has produced a distribution map of red gurnard. Higher occurrences of red gurnard with patchy distribution have been observed along the Western approaches from the Shetlands Islands to the Celtic Seas and the Channel.

A continuous distribution of fish crossing the Channel and the area West of Brittany does not suggest a separation of the Divisions 7d from 7e and 7h. Therefore a split of the population between the Ecoregions does not seem appropriate. Similar temporal signals observed in NS-IBTS and SCO-WCIBTS surveys, which are not seen in other survey series, may suggest a linkage between subareas 4 and 6. Further investigations are needed to progress on stocks boundaries such as morphometric studies, tagging and genetic population studies.

9.3 Management regulations

There is currently no technical measure specifically applied to red gurnard or other gurnard species. The exploitation of red gurnard is submitted to the general regulation in the areas where they are caught. There is no minimum landing size set.

9.4 Fisheries data

Red gurnard is mainly landed as bycatch by demersal trawlers in mixed fisheries, predominantly in Divisions 7d, 7e and 7h (Figure 9.1). High discard rates and lack of resolution at a species level make interpretation of spatial trends in catches in other areas problematic.

9.4.1 Historical landings

Official landings reported at ICES are available in Table 9.1 and Table 9.2. Before 1977, red gurnard was not specifically reported. Landings of gurnards are still not always reported at a species level, but rather as mixed gurnards. This makes interpretations of the records of official landings difficult.

International landings have fluctuated between 3452 - 5171 tonnes since 2006. France is the main contributor of 'red gurnard' landings, with around 80% of landings coming from ICES Subarea 7d-h (Celtic Sea/English Channel). In the North Sea red gurnard landings are variable, but roughly evenly distributed between Divisions 4a,b and c. Landings from the west of Scotland and Ireland, and the Irish Sea (ICES Subarea 6a-b, 7a-c, 7j) and Bay of Biscay (ICES Division 8) have been consistently low.

9.4.2 Discards

Discard data for red gurnard has been provided for 2015, 2016 and 2017 through Intercatch (Table 9.3). For those countries which provided data, discard rates ranged between from 48% and 91% of catch in 2017 (Table 9.4).

9.5 Survey data

Information on gurnard abundance are available in DATRAS for the IBTS-Q1 survey in the North Sea, Scottish West Coast Groundfish Survey (WCGFS), Irish Groundfish Survey (IGFS) and the French EVHOE-WIBTS-Q4 survey in the Celtic Sea and Bay of Biscay and CGFS-Q4 in Division 7d. Each of these surveys covers a specific area of red gurnard distribution. Lengths at age are available from CGFS-Q4 in and IGFS-Q4

- • NS- IBTS-Q1 series. Before 1990, red gurnard was scarce in North Sea and the abundance index was close to 0. The abundance index of red gurnard has trended generally upwards between 1994–2013, before declining somewhat, although it remains well above long-term average values. This change reflects an increase of the abundance in the northern and central North Sea (4a-b). It is interesting to contrast these trends with the apparent very low abundances in the NS-IBTS-Q3 series.
- • SCO-WCGFS series. Before 1996, red gurnard was also scarce on the west of Scotland. The abundance index trended strongly upwards after 1997, reaching a peak in 2013, before declining to around the series average in recent years.
- • IGFS series. The abundance index of red gurnard in the IGFS series has varied around the series mean without trend between 2002 and 2017.
- • CGFS-Q4 series. Over the time-series 1988—2011, the abundance index has fluctuated, peaked in 1994, reached a low in 2011, but is above long term mean in 2016.
- • EVHOE-WIBTS-Q4 series. Over the period 1997—2011, the abundance index in Nb or kg/hr has increased over time. Age reading of red gurnards caught during EVHOE survey has been carried out in 2006 and routinely since 2008. They indicate that the individuals caught are mainly of age 1 and 2.

Survey abundance information was provided separately for the Spanish Porcupine and Northern Spanish groundfish surveys (SP-PORC and SP-NSGFS). Both survey indices are variable, but show an overall upwards trend over time in numbers and weight per tow.

9.6 Biological sampling

Number at length information was provided by French and Portuguese landings and discards. There remains a lack of regular sampling for red gurnard in commercial landings and discarding to provide series of length or age compositions usable for a preliminary analytical assessment.

9.7 Biological parameters and other research

There is no update of growth parameters and available parameters from several authors are summarized in the Stock Annex. They vary widely. Available length–weight relationships are also shown in Stock Annex. Natural mortality has not been estimated in the areas studied at this Working Group.

9.8 Analyses of stock trends

In the North Sea, the appearance of red gurnard in the index of the IBTS Survey since 1990 is in line with an increase of the abundance in 4a. In Eastern Channel, the abundance index of the CGFS-Q4 survey has widely fluctuated, with a weak decline. The EVHOE-WIBTS-Q4 survey has slightly increased since its beginning in the 1990s.

9.9 Data requirements

Gurnards are still not always reported by species, but rather as mixed gurnards (see WDocument08 and WDocument09). This makes interpretations of the records of official landings difficult. Extending the studied area by a survey in 7e and collecting length and age data of red gurnard in the main area of production should help in better understanding the biology and dynamics of this species.

9.10 References

Dorel, D. 1986. Poissons de l'Atlantique nord-est relations taille-poids. Institut Francais de Recherche pour l'Exploitation de la Mer. Nantes, France. 165 p.

9.11 Tables

Table 9.1 Red gurnard in the Northeast Atlantic official landings by country in tonnes.

Year	Belgium	Spain	France	Jersey	Guernsey	Ireland	IM	Netherlands	Portugal	UK	Total
2006	313	0	4552	10	0	0	0	57	125	115	5172
2007	328	0	4494	4	0	0	1	66	127	156	5176
2008	352	0	4045	8	0	0	0	92	112	166	4776
2009	227	0	3310	6	0	1	0	160	150	263	4118
2010	237	0	3437	2	0	0	0	251	115	362	4403
2011	306	0	3176	2	0	1	1	295	134	257	4172
2012	306	0	2706	4	26	0	3	329	148	257	3778
2013	288	576	3154	9	16	2	3	267	113	329	4756
2014	263	399	3782	6	0	5	3	241	108	283	5089
2015	187	91	2919	3	0	0	2	210	122	341	3874
2016	238	87	2598	0	9	1	3	224	106	381	3646
2017*	265	103	2396	0	0	9	1	226	126	327	3452
2017**	258	61	2410			9		228		94	3061

***Preliminary Data,**

****Intercatch Data**

Table 9.2 Red gurnard in the Northeast Atlantic official landings by area in tonnes.

***Preliminary Data,**

Year	4a	4b	4c	5b	6a	6b	7a	7b	7c	7d	7e	7f	7g	7h	7j	7nk	8a	8b	8c	8d	9a	9nk	10a	10nk	14a	Total
2006	13	83	64	0	32	1	11	9	12	1101	2803	229	16	446	5	1	153	60	1	5	9	115	0	1	0	5171
2007	12	120	55	2	21	0	7	7	15	1229	2674	246	15	437	4	0	139	59	3	2	125	0	0	2	0	5175
2008	34	64	54	0	28	3	5	7	16	1236	2451	249	9	408	5	0	66	24	3	1	109	0	3	0	0	4775
2009	58	59	92	0	94	2	4	8	6	1293	1557	112	22	510	7	0	98	40	1	3	148	0	1	0	0	4115
2010	79	63	86	0	101	46	13	8	10	1531	1608	132	23	433	9	0	100	33	0	2	114	0	0	1	0	4393
2011	66	29	51	0	69	54	13	5	6	1295	1753	124	20	372	9	0	112	46	1	3	133	0	1	0	1	4164
2012	83	71	78	0	51	7	8	2	5	1244	1441	145	53	294	2	0	83	50	8	1	136	4	1	0	1	3770
2013	88	109	60	0	47	0	10	2	6	1193	1692	170	58	477	2	0	79	72	532	1	155	0	2	0	0	4755
2014	102	52	68	0	47	3	7	1	2	1294	1642	115	19	1069	1	0	82	75	363	3	139	0	3	0	0	5088
2015	133	102	53	0	58	1	4	3	1	790	1553	87	6	703	1	0	95	70	81	2	128	0	2	0	0	3874
2016	112	83	117	0	76	1	11	3	1	906	1268	114	16	608	1	0	87	63	56	1	120	0	1	0	0	3645
2017*	52	43	87	0	29	1	11	0	0	868	1424	83	38	473	3		77	48	58	1	154		1			3453

Table 9.3 Red gurnard in the Northeast Atlantic, discards (t) by country, 2015–2017.

Country	2015	2016	2017
France	1323	2249	2232
Ireland	10	147	93
Spain		286	272
UK (ENG)	74	30	
UK (SCO)	649	411	198
Total	2057	3125	2796

Table 9.4. Discarding of Red gurnard in the Northeast Atlantic, as a percentage of catch, by country, in 2017.

Country	Discard rate (%)
France	48
Ireland	91
Spain	82
UK (SCO)	68

9.12 Figures

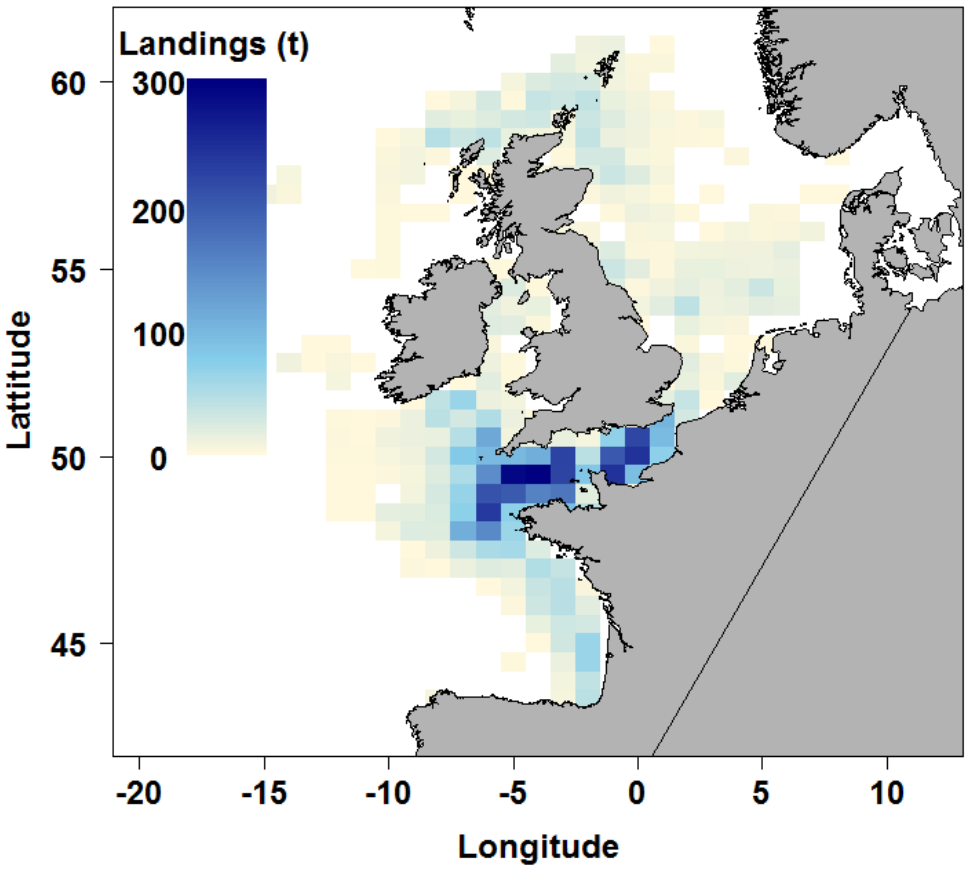

Figure 9.1.Red gurnard in the Northeast Atlantic. Landings in 2017, by statistical rectangle, from BEL, FRA, UK(E&W), UK(IoM) & UK(SCO).

10 Striped red mullet in Subareas and Divisions 6, 7a–c, e–k, 8, and 9a

10.1 General biology

Striped red mullet (*Mullus surmuletus*) is a predominantly benthic species found along the coasts of Europe, southern Norway and northern Scotland (northern Atlantic, Baltic Sea, North Sea and the English Channel), up to the Northern part of West Africa, in the Mediterranean Basin, and in the Black Sea (Hureau, 1986; Mahé *et al.*, 2005). Young fish are distributed in lower salinity coastal areas, while adults have a more offshore distribution.

Adult red mullet feed on small crustaceans, annelid worms and molluscs, using their chin barbels to detect prey and search the mud. As a consequence, striped red mullet are typically found on sandy, gravelly and shelly sediments where they can excavate sediment with their barbels and dislodge the small invertebrates. The main natural predators of striped red mullet are sea basses, pollacks, barracudas, monkfish, congers and sharks (Caill-Milly *et al.*, 2017).

Sexual maturity is reached at the beginning of the second year for males, followed by a marked decrease in growth rates, and at the end of the second or beginning of the third year for females which therefore continue their rapid growth a little longer (Déniel, 1991). In the English Channel, this species matures at approximately 16 cm (Mahé *et al.*, 2005), while in the Bay of Biscay, the sizes of first sexual maturity are given by Dorel (1986) as: males 16 cm, females 18 cm and a length at which 50% of the individuals are mature (the distinction between the two sexes is not mentioned) of 22cm.

Spawning occurs in the spring and early summer (May to June according to Desbrosses, 1935) with a spawning peak in June in the northern Bay of Biscay (N'Da & Déniel, 1993). Eggs and larvae average 2.8mm and are pelagic (Jones, 1972; Russell, 1976). The hatching takes place after three days at 18°C and after eight days at a temperature of 9°C (Quéro & Vayne, 1997). After metamorphosis juveniles become first demersal then benthic. At the age of one month, they measure about 5cm and weigh 0.9 to 1.6g. They show rapid growth during their first four months of life between July and October. Increases in length and mass are about 7cm and 25g on average during this period (N'Da & Déniel, 2005). The rate of growth declines sharply in October due to the cooling of water and the scarcity of trophic resources in the environment. These conditions contribute to the initiation of migration of red mullets to greater depths offshore. Until the age of two, there is no significant difference in size between males and females; they then measure 20-23cm. Sexual dimorphism is observed from the age of first maturity due to growth rates that will then differ between the two sexes. From age three, females exceed males in length by 4 cm on average and 7cm beyond 5 years (N'Da & Déniel, 2006).

The maximum reported age of the striped red mullet is 11 years (Quéro & Vayne, 1997; ICES, 2012), while the maximum length given is 44.5cm in the Bay of Biscay (Dorel, 1986) and 40cm elsewhere (Hureau, 1986; Bauchot, 1987). The maximum reported mass is 1kg (Muus and Nielsen, 1999).

10.2 Management regulations

Prior to 2002, France enforced a minimum landing size of 16cm. Since this minimal size requirement has been removed, immature individuals (< 14cm) have been recorded in landings. There is no TAC for this stock.

10.3 Stock ID and possible management areas

In 2004 and 2005, a study using fish geometrical morphometry was carried out in the Eastern English Channel and the Bay of Biscay. It pointed out a morphological difference on striped red mullets between those from the Eastern English Channel and those from the Bay of Biscay.

Benzinou *et al.* (2013) conducted stock identification studies based on otolith and fish shape in European waters and showed that striped red mullet can be geographically divided into three zones:

- • The Bay of Biscay (Northern Bay of Biscay – NBB, and Southern Bay of Biscay - SBB)
- • A mixing zone composed of the Celtic Sea and the Western English Channel (CS + WEC)
- • A northern zone composed of the Eastern English Channel and the North Sea (EEC + NS)

The distinction between the putative Biscay and Western Channel/Celtic Sea populations is supported by the distribution of landings at a statistical rectangle level (Fig. 10.1). This assessment treats these putative components as one population. At present there are no management measures in place, however this structuring should be taken into account if measures are considered.

10.4 Fisheries data

Official landings have been recorded since 1975 and after early increases they have declined in recent years (Table 10.1). Landings are mainly taken from Subarea 7 and 8 (Table 10.2) and France accounts for the majority of removals. The striped red mullet is one species among set of benthic (demersal) species targeted by the French fleet, and is mainly caught by bottom trawlers with a mesh size of 70–99mm. In the Western English Channel striped red mullet is also caught by gillnets. Danish seine appeared in 2008 as a result of some trawlers converting to use seine gears.

The average characteristics of vessels in French fleets that caught red mullet from 2000 to 2015 are: 41.1 GRT, 191.1kW engine power, 12.9m length and 22 years of service. Net vessels are made up of the smallest units (85% are less than 12m long), while 52% of bottom trawlers are less than 15 m; the seiners are by far the largest and the oldest vessels (Caill-Milly *et al.*, 2017).

The French activity on this species differs between the area composed by West Scotland/Celtic sea (including West Channel) and the area comprising the Bay of Biscay. In the first one, landings are mainly taken by bottom trawlers, followed by gillnet. In the second one, they are mainly done by bottom trawls, seine and nets. French activity in the Atlantic Iberian waters remains limited. The Spanish activity is located in the north (8.a,b) and the south (8.c) of the Bay of Biscay.

Prior to 2015 this species was not recorded as being discarded by French or Portuguese vessels and was infrequent in Spanish sampling. Discarding represented between 9% and 68% of UK catches in 2014 - 17 (Table 10.3), however there are concerns about how

these discards have been estimated – the 2016 figure is based on a sample of 2 fishes. French discard estimates for 2017 represented 7% of catch. For French demersal trawls (70-99mm mesh size), discards are essentially composed of individuals measuring between 8 and 17cm (Fig. 10.2).

10.5 Survey data, recruit series

Exchange data is available in Datras since 1997 for the French EVHOE survey, covering the Bay of Biscay and Celtic Sea, and from 2002 onwards for the Portuguese groundfish survey (PT-IBTS), covering the Portuguese coast. Standardised catch rates in the EVHOE survey are variable around the series mean between 1997–2011, before falling to a lower level thereafter. Similarly, catch rates in the PT-IBTS are at a low level in 2005, peak in 2010, before falling back to near the series mean in recent years (Fig. 10.3).

Abundance indices per size class during EVHOE-WIBTS-Q4 show mainly fish between 8 and 17 cm (TL).

Data was provided separately for the northern Spanish groundfish survey (SP-NSGFS), showing a similar variable trend to the EVHOE survey in the early part of the series, followed by a decline to lower levels in recent years (Fig. 10.4).

10.6 Biological sampling

In the Bay of Biscay sexual maturity and length measures were taken in 2009 by AZTI. French samplings started in 2004 in the Eastern Channel and in the south North Sea, and since 2008 in the Bay of Biscay.

10.7 Biological parameters and other research

Since 2004, data (age, length, sexual maturity) are usually collected by France for the Eastern English Channel and the southern North Sea. France started to collect data for 8a,b at the end of 2007. In 2007–2008, the striped red mullet otolith exchange had for goal to optimize age estimation between countries.

In 2011, an Otolith Exchange Scheme was carried out, which was the second exercise for the Striped red mullet (*Mullus surmuletus*). Four readers of this exchange interpreted an images collection coming from the Bay of Biscay, the Spanish coasts and the Mediterranean coasts (Spain and Italy). A set of *Mullus surmuletus* otoliths (N=75) from the Bay of Biscay presented highest percentage of agreement (82%). On 75 otoliths, 34 were read with 100% agreement (45%) and thus a CV of 0%. Modal age of these fishes was comprised between 0 and 3 years (Mahé *et al.*, 2012).

10.8 Analysis of stock trends/ assessment

Currently, age structured analytical stock assessment is not possible due to a too short time-series of available data.

10.9 Data requirements

Regular sampling of biological parameters of striped red mullet catches must be continued under DCF. Sampling in the Celtic Sea and in the Bay of Biscay started in 2008. In 2010 and 2011, sampling for age and maturity data was reduced compared to 2009, due to the end of the Nespman project. Since 2009, a concurrent sampling design carried out, should provide more data (length compositions) than in recent years.

10.10 References

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10.11 Tables

Table 10.1 Striped red mullet in Subareas and Divisions 6, 7a–c, e–k, 8, and 9a official landings by country in tonnes

Year	Belgium	Spain	France	Guernsey	Ireland	Jersey	Netherlands	Portugal	UK	Total
2006	33	379	1944	8	15	1	115	11	170	2675
2007	43	390	1926	9	17	1	148	222	193	2949
2008	26	379	1384	9	17	0	165	169	164	2314
2009	20	490	1539	5	10	0	110	199	131	2504
2010	20	465	1725	5	5	0	128	276	132	2756
2011	21	504	1722	0	5	0	130	245	154	2782
2012	37	328	1318	0	4	1	125	217	122	2152
2013	28	245	925	5	3	0	50	187	70	1514
2014	12	265	914	5	2	0	1	221	53	1474
2015	23	248	1207	5	3	0	110	282	102	1980
2016	28	194	1166	0	4	0	69	204	83	1748
2017*	35	118	988	5	10		16	157	64	1393
2017**	36	328	997	0	10		13	154	64	1602

*** Preliminary Data**

**** Intercatch Data**

Table 10.2 Striped red mullet in Subareas and Divisions 6, 7a–c, e–k, 8, and 9a official landings by area in tonnes

Year	6a	6b	7a	7b	7c	7e	7f	7g	7h	7j	7k	8a	8b	8c	8d	8e	9a	Total
2006	0	0	1	1	0	869	50	24	103	5	0	1023	468	71	14	0	39	2668
2007	1	0	1	1	1	1047	54	22	104	12	0	861	473	90	16	0	267	2949
2008	0	0	1	1	0	880	46	16	73	13	0	639	246	87	18	0	296	2314
2009	2	0	1	2	1	592	25	9	74	17	0	879	460	156	44	0	243	2504
2010	2	0	1	3	1	642	26	10	59	16	1	1033	467	146	19	0	331	2756
2011	1	1	1	0	0	665	20	10	55	6	0	970	513	214	17	0	310	2782
2012	0	0	0	0	0	493	23	7	34	4	0	696	387	200	27	0	280	2152
2013	0	0	0	1	0	232	23	7	36	2	0	473	328	166	6	0	241	1514
2014	1	0	0	0	0	192	15	3	40	1	0	523	240	151	12	0	297	1474
2015	0	0	0	1	0	595	10	2	35	1	0	506	327	127	7	0	369	1980
2016	0	0	0	2	0	417	21	7	35	3	0	549	311	117	10	0	277	1748
2017*	0	0	0	1	0	283	26	21	36	0	0	505	244	82	5	0	185	1393
2017**	0	0	0	1	0	277	27	21	37	3	0	514	324	160	5	0	231	1601

*** Preliminary Data**

**** Intercatch Data**

Table 10.3 Striped red mullet in Subareas and Divisions 6, 7a–c, e–k, 8, and 9a discards (t) by country in 2012-2016

Country	2012	2013	2014	2015	2016	2017
BE						2
ES			4	5	8	0
FR				115	213	74
IE						0
PT	0.0	0.0	0.0		0	0
UK	2	1	5	77	171	11
Total	2	1	9	197	392	87

10.12 Figures

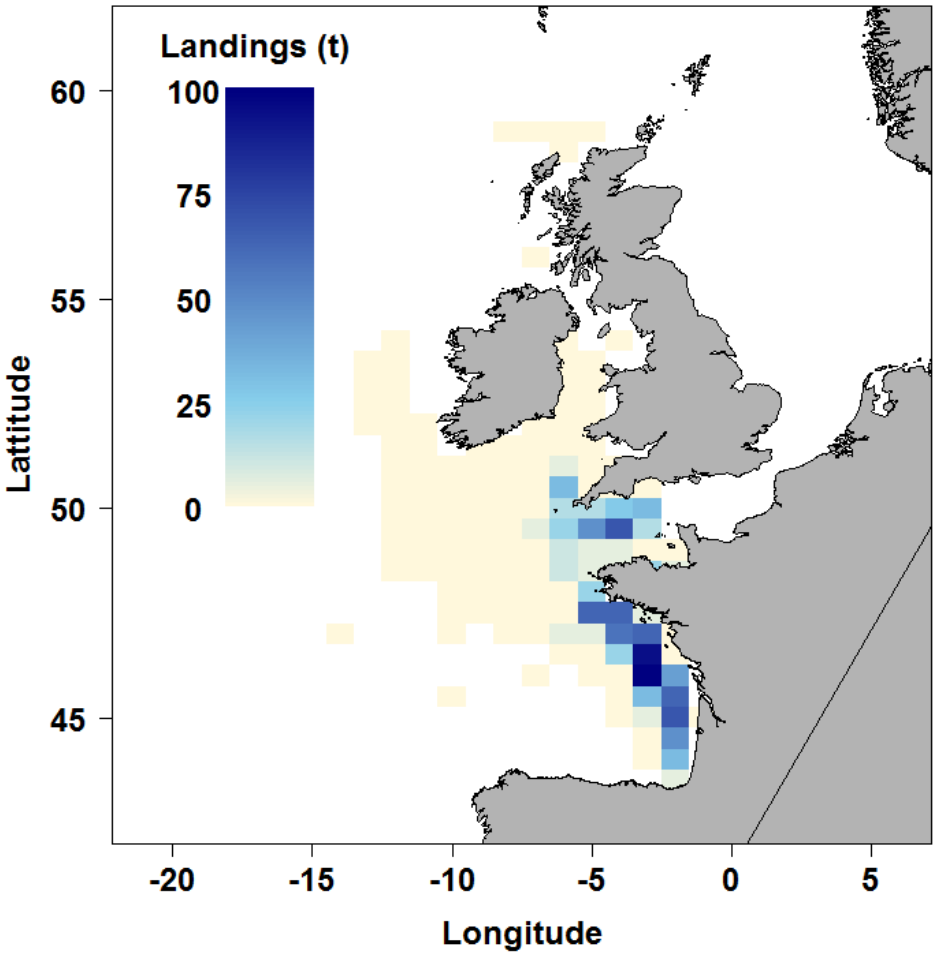

Figure 10.1. Striped red mullet in Subareas and Divisions 6, 7a-c, e-k, 8 and 9a. Landings by statistical rectangle in 2017 for BEL, FRA, IRE, UK (E&W) & UK (SCO).

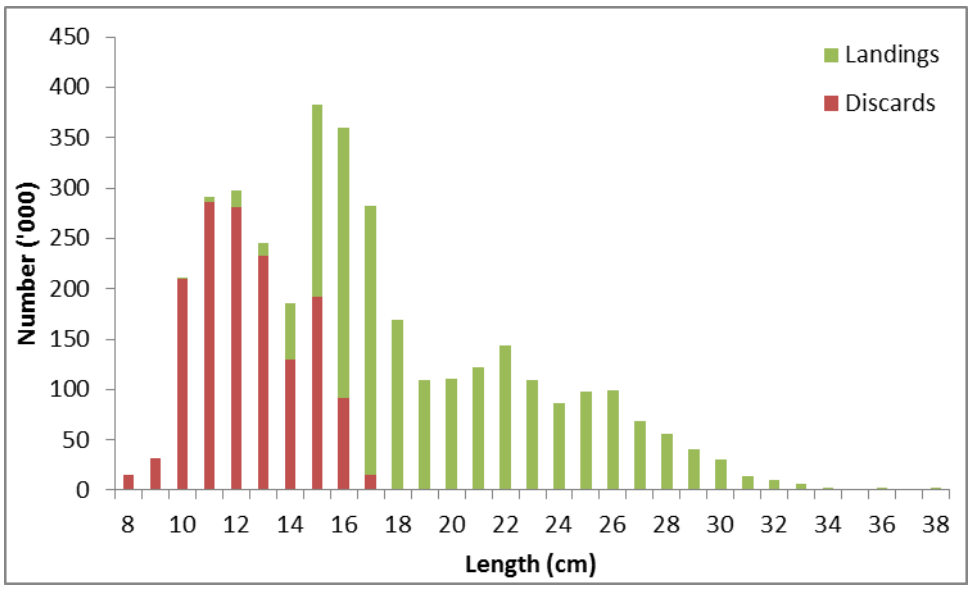

Fig 10.2. Striped red mullet in Subareas and Divisions 6, 7a-c, e-k, 8 and 9a. Length distribution of French catches from OTB_DEF_70–99.

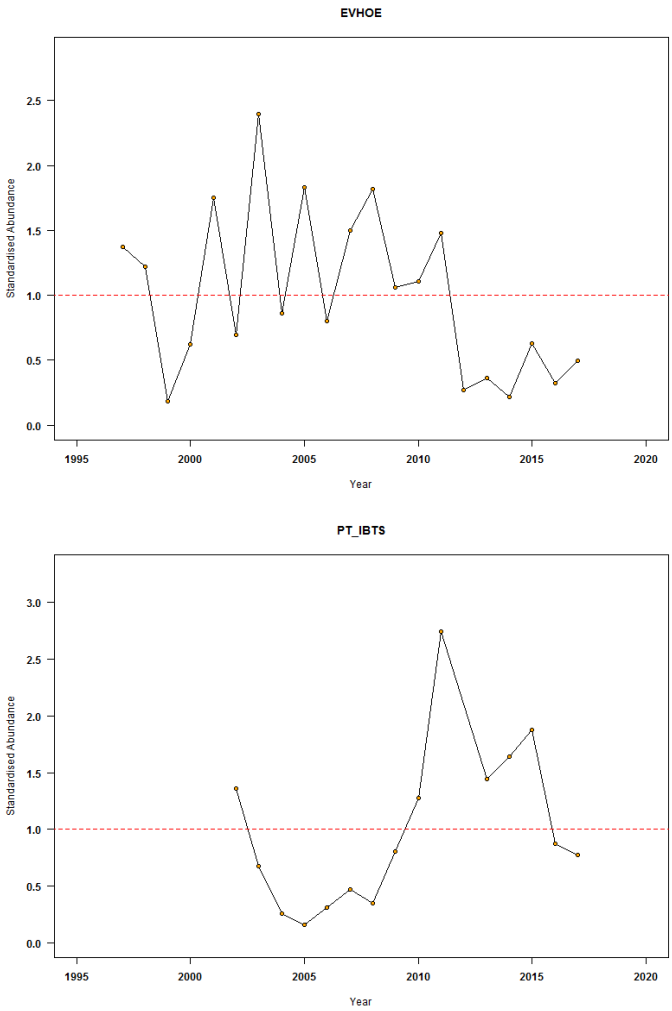

Figure 10.3. Striped red mullet in Subareas and Divisions 6, 7a-c, e-k, 8 and 9a. Standardised survey abundances for EVHOE (1997–2017) and Portuguese IBTS (2002–2017) surveys.

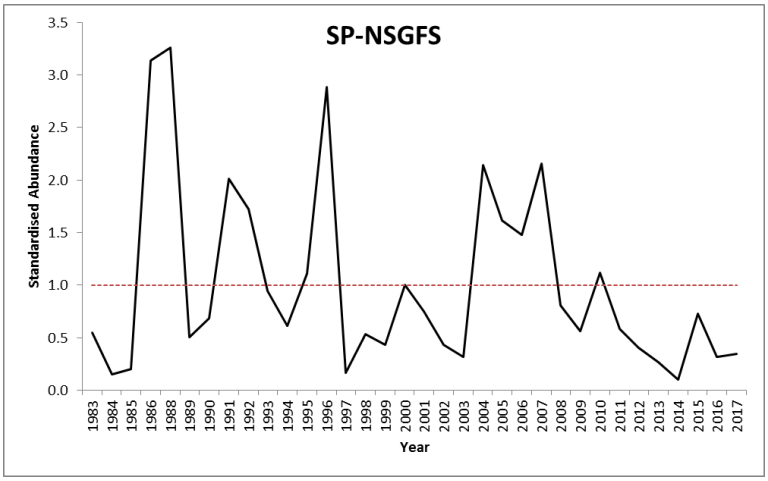

Figure 10.4. Striped red mullet in Subareas and Divisions 6, 7a-c, e-k, 8 and 9a. Standardised survey abundances for SP-NSGFS (1983–2017).

Annex 1: List of Participants

Working Group on Widely Distributed Stocks (WGWIDE)

28 August- 3 September 2018

Name	Institute	e-mail	Country
Afra Egan (by correspondance)	Marine Institute	afra.egan@marine.ie	Ireland
Åge Højnes	Institute of Marine Research	Aageh@hi.no	Norway
Alexander Krysov	Knipovich Polar Research Institute of Marine Fisheries and Oceanography(PINRO)	a_krysov@pinro.ru	Russia
Alfonso Pérez	IMARES Wageningen UR	alfonso.perezrodriguez@wur.nl	The Netherlands
Anatoly Chetyrkin	Knipovich Polar Research Institute of Marine Fisheries and Oceanography(PINRO)	chaa@pinro.ru	Russia
Andrew Campbell	Marine Institute	andrew.campbell@marine.ie	Ireland
Anna Olafsdottir	Marine and Freshwater Research Institute	anna.olafsdottir@hafogvatn.is	Iceland
Are Salthaug	Institute of Marine Research	are.salthaug@hi.no	Norway
Aril Slotte	Institute of Marine Research	aril.slotte@hi.no	Norway
Claus Sparrevohn	Danish Pelagic Producers' Organisation	crs@pelagisk.dk	Denmark
Diana Feijó (by correspondance)			Portugal
Dmitry Vasilyev (by correspondance)	Russian Federal Research Institute of Fisheries and Oceanography	dvasilyev@vniro.ru	Russia
Erling Kåre Stenevik	Institute of Marine Research	erling.kaare.stenevik@hi.no	Norway
Eydna í Homrum	Faroe Marine Research Institute	eydnap@hav.fo	Faroe Islands
Gersom Costas	Instituto Español de Oceanografía Centro Oceanográfico de Vigo	gersom.costas@ieo.es	Spain
Gudmundur J. Óskarsson (chair)	Marine and Freshwater Research Institute	gudmundur.j.oskarsson@hafogvatn.is	Iceland
Guillaume Bal	Marine Institute	guillaume.bal@marine.ie	Ireland
Höskuldur Björnsson	Marine and Freshwater Research Institute	hafogvatn@hafogvatn.is	Iceland

Jan Arge Jacobsen	Faroe Marine Research Institute	janarge@hav.fo	Faroe Islands
Jens Ulleweit (by correspondance)	Thünen Institute of Sea Fisheries	jens.ulleweit@thuenen.de	Germany
Konstantina Dimitrakopoulou	Institute of Marine Research	Konstantina.Dimitrakopoulou@hi.no	Norway
Leif Nøttestad	Institute of Marine Research	leif.noettestad@hi.no	Norway
Martin Pastoors	Pelagic Freezer-Trawler Association	mpastoors@pelagicfish.eu	The Netherlands
Morten Vinther	DTU Aqua -National Institute of Aquatic Resources	mv@aqua.dtu.dk	Denmark
Nathalie Caill-Milly (by correspondance)	Ifremer		France
Neil Campbell	Marine Science Scotland	neil.campbell@gov.scot	Scotland
Nikolay Timoshenko	AtlantNIRO	timoshenko@atlantniro.ru	Russia
Pablo Carrera	Instituto Español de Oceanografía Centro Oceanográfico de Vigo	pablo.carrera@ieo.es	Spain
Patricia Goncalves	Portuguese Institute for the Sea and the Atmosphere (IPMA)	patricia@ipma.pt	Portugal
Piera Carpi	Centre for Environment, Fisheries and Aquaculture Science (Cefas)	piera.carpi@cefas.co.uk	UK
Sindre Vatnehol	Institute of Marine Research	sindre.vatnehol@hi.no	Norway
Sólva Eliasen	Faroe Marine Research Institute	Solvae@hav.fo	Faroe Islands
Sondre Aanes	Norwegian computing Cente	sondre.aanes@nr.no	Norway
Sonia Sanchez	AZTI Pasaia	ssanchez@azti.es	Spain
Teunis Jansen	Greenland Institute for Natural Resources	tej@aqua.dtu.dk	Greenland
Thomas Brunel	Wageningen University & Research	thomas.brunel@wur.nl	The Netherlands

Annex 2: Recommendations

RECOMMENDATION	TO
It is recommended that a new Working Group will be established to address methodology and dataanalyses in relation tothe RFID taggings of mackerel (and NSS-herring) There is a need for international body (e.g. WG comparable to survey groups) to analyse and explore the recapture data etc. A proposal of ToRs for this WG can be found in the Report section 8.6.4..	ACOM
It is recommended that differing national approaches to the assignment of mixed gurnard catches to species level be reviewed in order to develop a standardised procedure which can be used going forwards, and investigate the assignment of historical mixed catches. Large catches of mixed gurnards (GUX) are still reported from several countries. This has a strong, negative impact on the development of future assessments and advice of the stock. Section in the report this relates to: 9.9.	WGCATCH
It is recommended that any available data on stock structuring of red gurnards in Divs. 3-8 (and elsewhere) are presented to the ICES Stock Identification Methods Working Group for future consideration on the stock identity and structure of this species before a new benchmark workshop is considered Based on differing trends in survey abundances there appears to be spatial structuring of red gurnard populations within the area considered in the present assessment unit (Div. 3-8). In order to further develop the assessment of this species it is important that stock structuring is taken into account	SIMWG
WGWIDE recommends that IBWSS explores methods/approaches to survey division 8abd in order to understand the dynamics and connectivity between blue whiting spawning components IBWSS covers the core spawning area of blue whiting, but little is known about the connectivity between this area and the possible southern spawning areas as revealed in recent research papers. Section in the report this relates to: 2.3.7.2	WGIPS
It is recommended that work is initiated on how to separate among different stock components of herring in internationally coordinated surveys In the IESNS survey other herring stocks (e.g. Icelandic summer spawning herring and North Sea herring) are found in the boundary regions of the survey area that may mix with the NSS herring in the survey area. Section in the report this relates to: 4.14	WGIPS, WGBIOP
It is recommended to age read mackerel in the EVHOE survey starting from Q42018 Catch rates of age 0 mackerel from the EVHOE survey are used for the recruitment index. The age 0 mackerel are currently separated from age 1 mackerel by length frequency distributions, because the mackerel are not aged. Section in the report this relates to: 8.6.2	IBTSWG
Increase the spatial coverage of the IBTS in Q4 to include the areas that was covered by the English Q4SWIBTS survey up to 2011 Since 2011, the English Q4SWIBTS survey (covering the Irish sea and the central-eastern part of the Celtic sea including the area around Cornwall) has been discontinued. In some years, this has been an important nursery area for mackerel and it is not completely covered by other surveys (Irish and French). Section in the report this relates to: 8.6.2	IBTSWG

Increase the spatial coverage of NS-IBTS Q1 to include the south-western Norwegian shelf and shelf edge in proximity to the Norwegian trench The IBTS has observed high catch rates in some years at the north-eastern edge of the survey area (towards the Norwegian trench) in winter. It is therefore possible that some recruits are also overwintering on the other side of the trench along the south western shelf edge of Norway. Section in the report this relates to: 8.6.2	IBTSWG

Annex 3: WGWIDE 2019 Terms of Reference

WGWIDE– Working Group on Widely Distributed Stocks

2018/2/ACOM23 The **Working Group on Widely Distributed Stocks** (WGWIDE), chaired by Gudmundur J. Óskarsson, Iceland, will meet in Spain (location tbd), 28 August–3 September 2019 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 2019:

i) Update the MSY proxy reference points for those category 3 and 4 stocks with existing proxy reference points using most recent data. For those stocks without reference points listed below, collate necessary data and information in order to estimate MSY proxy reference points prior to the Expert Group meeting. The official ICES data call included a call for length and 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 (ICES, 2017) along with available data and expert judgement.

Stock Code	Stock name description	EG	Data Category
gur.27.3-8	Red gurnard (*Chelidonichthys cuculus*) in subareas 3-8 (Northeast Atlantic)	WGWIDE	6.2
hom.27.3a4bc7d	Horse mackerel (*Trachurus trachurus*) in divisions 3.a, 4.b–c, and 7.d (Skagerrak and Kattegat, southern and central North Sea, eastern English Channel)	WGWIDE	3

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

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

WGWIDE will report by 10 September 2019 for the attention of ACOM.

Annex 4: List of Stock Annexes

STOCK ID	STOCK NAME	LAST UPDATED	LINK
boc.27.6-8	Boarfish (*Capros aper*) in Sub areas 6– 8 (Celtic Seas, English Channel, and Bay of Biscay)	11 September 2017	boc.27.4-8_SA
her.27.1-24a514a	Herring (*Clupea harengus*) in subareas 1, 2, and 5, and in divisions 4.a and 14.a, Norwegian spring-spawning herring (the Northeast Atlantic and Arctic Ocean)	4 March 2016	her.27.1-24a514a_SA
hom.27.3a4bc7d	Horse mackerel (*Trachurus trachurus*) in divisions 3.a, 4.b-c, and 7.d (Skagerrak and Kattegat, southern and central North Sea, eastern English Channel)	31 March 2017	hom.27.3a4bc7d_SA
hom.27.2a4a5b6a 7a-ce-k8	Horse mackerel (*Trachurus trachurus*) in Subarea 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a-c,e-k (the Northeast Atlantic)	September 2017	hom.27.2a4a5b6a7a-ce-k8_SA
mac.27.nea	Mackerel (*Scomber scombrus*) in subareas 1-7 and 14 and divisions 8.a-e, 9.a (the Northeast Atlantic and adjacent waters)	September 2017	mac.27.nea_SA
whb.27.1-91214	Blue whiting (*Micromesistius poutassou*) in subareas 1-9, 12, and 14 (Northeast Atlantic and adjacent waters)	14 June 2016	whb.27.1-91214_SA

Annex 5: Audit Reports

Audit of North Sea horse mackerel (WGWIDE 2018)

Date: 11.09.2018

Auditor: Leif Nøttestad

General

In 2012 the North Sea horse mackerel (NSHM) was classified as a category 5 stock, based on the ICES approach to data-limited stocks (DLS). Since then, a progressive reduction of TAC was advised by ICES, from 25500 tonnes in 2013-2014 to 15200 tonnes in 2015-2016.

In 2017 this stock was benchmarked and the North Sea International Bottom Trawl Survey (NS-IBTS) and Channel Ground Fish Survey (CGFS) abundance indices where modeled together. The resulting joint index was considered a proper indication of trend in abundance over time and the NSHM stock was upgraded to category 3. Stock advice for NSHM is biannual. In 2017 the advice for years 2018 and 2019 was provided. The joint abundance survey index indicated a continuation in the increasing trend observed since 2013. Nevertheless, the joint survey index for 2017 has shown a sudden change and steep decline, due to the drop of the CGFS survey index, WGWIDE decided to continue with the current advice of 17517 tonnes for 2019.

The data used as input to the NSHM assessment is as provided to the stock assessor by the stock and survey coordinators. The assessment and forecast appear to have been run in accordance with the stock annex.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

- **Assessment type: update** (benchmarked early 2017)
- **Assessment**: analytical category 3 (survey based method)
- **Forecast**: not presented
- **Assessment model**: JAXass model. Separable VPA type model
- **Data issues:** Data available as described in stock annex. Considerable uncertainties may be present in both survey indices, as well as in catch and bycatch statistics within and between years. Marked decline in the exploitable biomass index, mostly due to the decrease in the CGFS index. Signals of lower recruitment in the English Channel in 2017 compared to 2016. Steps may need to be taken next year for NSHM, if this steep decline continue, to ensure that the stock is kept in a healthy state and fished sustainably.
- **Consistency**: This years's assessment has been conducted in a manner consistent with last year (benchmark) and stock annex.
- **Stock status**: F/Fmsy slightly above 1
- Management Plan: No

General comments

The assessment is well documented and structured. It is quite easy to follow**.** Applying CPUE from the fishery is not optimal as input data for stock abundance and may involve uncertainties not possible to properly identify and quantify.

Technical comments

The assessment is done according to decisions taken during benchmark in 2017 and according to the stock annex.

Conclusions

The updated assessment has been performed correctly. Stock advice for NSHM is bi-annual. Given the steep decline in the index documented in 2017 compared to 2016 during the second year of an advice, care should be taken when establishing biannual advice for NSHM in the future.

Audit of Boarfish

Date: 2018.09.13

Auditor: Sólvá Káradóttir Eliasen (input data and assessment)

For single stock summary sheet advice:

- Assessment type: update
- **Assessment**: trends – Category 3 stock
- **Forecast**: not presented
- **Assessment model**: Bayesian Schaefer state space surplus production model fitted using catch data, 6 delta-lognormal estimated IBTS survey indices, and 1 acoustic survey estimate. Key parameters (r, K, Fmsy, Bmsy and TSB) have been estimated using the exploratory Schaeffer state space surplus production model. The assessment has been run by the WinBUGS14 program.
- **Data issues:** Input data (i.e. yearly total biomass derived from acoustics, annual total catches and survey data) are available on Sharepoint as described in the Stock Annex. Catch and acoustic biomasses are also available in the WGWIDE report and in stock annex. There are inconsistencies between assessment input in landings/discards/catch data (catch.data.xlsx) and landings/discards/catch data in table 3.1.2.1. However, this does not affect the assessment, since the total catches are correct. This issue will be clarified in next year's report. The survey data are only available in the data folder, and thus it is not possible to double check whether these are consistent.
- **Stock status**: <Bmsy> = 1.63e5 < TSB.50 = 2.5e5 and <Fmsy> = 0.18. F for 2018 has not yet been estimated, but it was 0.056 in 2017.
- Management Plan:

General comments

In general, the assessment model is well described.

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
  - Yes
- Is the assessment according to the stock annex description?
  - Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
- Have the data been used as specified in the stock annex?

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Audit of Red gurnard

Date: 07.09.2018

Auditor: Konstantina Dimitrakopoulou

General

Survey data available in DATRAS was reported for this stock for the IBTS-Q1 survey in the North Sea, the WCGFS Scottish West Coast Groundfish Survey, the IGFS Irish Groundfish Survey, the French EVHOE-WIBTS-Q4 in the Celtic Sea and Bay of Biscay and CGFS-Q4 in Division 7d. Survey abundance information was provided separately for SP-PORC and SP-NSGFS, the Spanish Porcupine and Northern Spanish groundfish surveys.

The landings data are not species-specific in the fisheries and there are currently no technical measures specifically for managing the fishery. There is need for regular sampling of red gurnard in commercial landings and discarding to provide series of length or age compositions to conduct analytical assessment.

For single stock summary sheet advice:

- Assessment type: update
- **Assessment**: not presented
- Assessment model: NA
- **Data issues:** landings data are not species-specific, lack of biological sampling in commercial landings and discarding
- Consistency: NA
- Stock status: Uncertain
- Management Plan: NA

General comments

This is a well-documented section.

Technical comments

None

Conclusions

The assessment has been performed correctly.

Audit of Blue whiting (*Micromesistius poutassou*) in subareas 27.1–9, 12, and 14 (Northeast Atlantic)

Date: September 6, 2018

Auditor: Anna H. Olafsdottir

General

Assessment model, recruitment estimates, and forecast model were executed according to stock annex description. The updated assessment gives a valid basis for advice.

For single stock summary sheet advice:

- **Assessment type:** update. Benchmark in 2012 (WKPELA 2012) and adaptation of model at an inter benchmark in 2016 (IBPBLW 2016).
- **Assessment**: age-based analytical assessment that uses catches both in the model and the forecast.
- **Forecast**: presented.
- **Assessment model**: SAM with length and age composition of commercial catch and as tuning series an age segregated tuning index from scientific acoustic survey of the spawning stock in March on main spawning grounds on the shelf west of Ireland.
- **Data issues:** input data for the assessment, as described in the stock annex, are available online at https://www.stockassessment.org/index.php in folder "BW_2018". The mean weight at age from the Faroese catch-at-age data from 2016 were brought up for discussion at this years assessment. Exploratory runs indicated some discrepancy when included in the assessment. It was decided to await for updated age-readings at next year's assessment, before any changes will be made to the input data.
- **Consistency**: assessment results for SSB and F show a decline in SSB and increase in F compared to last year assessment.
- **Stock status**: SSB > $B_{trigger}$ and F_{MSY} < F < F_{pa}. Trend in recruitment low for the last two years.
- **Management Plan:** Long-term management strategy agreed in 2016. The main elements of the plan is catch set at F_{MSY} when SSB forecast ≥ $B_{trigger}$, reduced F when $B_{trigger}$ > SSB > B_{lim}, and set F = 0.05 when SSB < B_{lim}. There are 20% reductions and 25% increase contain on annual deviation in TAC. Plan is evaluated by ICES and regarded consistent with the precautionary approach.

General comments

This was a well documented, well ordered, short and to the point section. It was easy to follow and interpret. There were minor discrepancies between subchapters number and numbering of figures and tables.

Technical comments

- Consider supplying the results of the forecast and annual catch scenarios online with the assessment.
- There are minor errors in text on the advice sheet: 1) in section "Basis of the assessment" length frequency of catch data is listed as input data. Also,

weight-at-age in the catch is missing from the input data list; 2) in section "Indicators" list of surveys used to evaluate recruitment for age-1 and age-2 is wrong. According to presentation at WGWIDE and the stock annex, the IESSNS and EVHOV are not used to evaluate recruitment.

- There are minor issues with numbering of figures and tables in the report text. Numbering of figures and tables is not coordinated with subchapter numbering in report text. This applies to all figures and tables from report subchapter 2.4.1 and onward. Labelling of some figures and tables is not in chronological order in the report text. For example, in report text reference to Table 2.3.1.2.5 before Table 2.3.1. This occurs at several occasions of figures and tables in the report. Tables 2.3.1.4, 2.3.2.1.3, 2.4.2.4, and 2.4.2.6 are not referred to in report. Figure 2.3.1.5. is not referred to report.
- Minor discrepancies between report text and data reported in tables: 1) in sub-chapter 2.4.1.1: sampling intensity in report text missing a few areas; 2) in sub-chapter 2.4.2 report text has preliminary catches for Q1 and Q2 in 2018 as 1351802 ton compared to 1330754 in Table 2.3.2.1.
- Minor mistakes in Tables and Figures: 1) in Table 2.8.2.2.1: when F=0, catch in 2019 is listed as 4 ton; 2) Figure 2.9.1 is labelled as displaying the period from 2010 to 2018, however it appears to display assessments from 2013 to 2018.

Conclusions

The assessment has been performed correctly

Blue whiting.

Date: 2 September 2018

Auditor: Nikolay Timoshenko

General

WG suggests that the catches in 2018 should be no more than 1712870 tonnes. The assessment is based on knowledge of the level and structure of the catch in the first half of year. Proportion of the annual catch-at-age taken in the first semester of 2015-2017 was used for raising the preliminary first half year of 2018 catch data. Such predicts have not so far been accompanied by notable deviations and seem acceptable to be applied in the cohort programs. BWSSS provides the basis of fitting which from two youngest age groups are excluding. Comparison with the results of other surveys convinces that as data accumulates, it will be possible to return to this question. In general, the assessment is satisfactorily provided by the input data.

For single stock summary sheet advice:

The evaluation methodology was described in the previous reports of WGWIDE.

- Assessment type: update/SALY
- **Assessment**: analytical
- **Forecast**: presented
- **Assessment model**: SAM, TISVPA, XSA +1 survey
- **Data issues:** The data for 2017 presented completely in the annex. Data for 2018 in part were as the results of the assumptions.
- **Consistency**: The view of the WG was that last years assess should have been accepted.
- **Stock status**: B is clearly more than Bpa. F<Fpa. R seems to be low last years.

General comments

Report is well documented, contains relevant explanations and references. Assessment provides a valid basis for advice. The contents of the report correspond to the agenda. The data been used as specified in the stock annex. There is no reason to deviate from the standard procedure for this stock. Reliable recruitment forecast remains to be as the main task.

Technical comments

The three models applied show similar dynamics in biomass and recruitment. The SSB values are estimated to be increasing in 2011-2018. That growth potential is corresponding by the presence of strength generations of 2013-2015. Later, the growth of biomass has ceased to prevail over its decline in accordance with the conclusion of WG last year. Dynamics of F is also the same in all models until 2017. In 2018, SAM and TISWPA show a decrease in F in the age range 3-7 while XSA records a slight increase. However, if the range is extended to the ages of 1-8, XSA also shows a decrease. Such differences are due to the difference in the selection pattern.

Conclusions

The assessment has been performed correctly. The dynamics of the blue whiting stock has been described by the fishing mortality exceeding F_{msy} for a long time. The biomass

remains noticeably higher than the corresponding reference points. That means that the chosen strategy facilitated the retention of the SSB in precautionary boundaries. The detected decline in biomass will require a more careful attitude to the recommendations of the group in respect of following the F_{MSY} rule.

Audit of (Stock name)

Date: 02-09-2018

Auditor: Claus Reedtz Sparrevohn

General

This audit is written for the use during the ADG. There has been no deviation from the stock annex and the assessment are much in line with the previous 2018 assessment.

This assessment only prompted few discussions during the meeting. That the 2019 advice was smaller than the 2018 advice was a bit surprising giving that the IBWSS index was historical high. However, the EG agreed that this could fully be explained by 1) the higher TAC (+325 002 tons) and 2) the small incoming year classes (2015 and 2016). It should be noted by the ADG, that in the advice it is stated that the recruitment in both 2016 and 2017 was low, although in the report it is only stated that the 2017 is low (section 2.1). The size of the 2016 recruitment (2015 yearclass) can be discussed.

As part of the audit the numbers presented in the advice has been check with the numbers that appear in the report. Some small discrepancy:

- Total 2017 catches is 1558061 kt in the rapport and 1555069 in table 12 in the advice sheet.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM.

- Assessment type: update
- **Assessment**: analytical
- **Forecast**: presented
- Assessment model: *SAM*
- **Data issues:** One survey (IBWSS) used. Catch data for 2018 estimated by raising the quarter 1 and 2 catches.
- **Consistency**: This year assessment is basically in line with last year assessement
- **Stock status**: Above MSY $B_{trigger}$
- **Management Plan**: Agreed in 2017. In the management plan a stability clause (-20% / +25 TAC constraint) is set out. The plan is evaluated by ICES assuming that catches will equal the advised management plan TAC. This is not the case for 2018, where the total catch is assumed to equal the sum of national quotas, which is 23.4% higher, that the advice when applying the Management Plan. Therefore, the EG was in agreement that the -20% should be calculated from the latest ICES advice and not the TAC. This lead to a decrease on -17.6% and hence the TAC constraint was not considered relevant.

General comments

The assessment was performed correctly and did not prompt much discussion at the meeting.

Technical comments

None

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
    - Yes
- Is the assessment according to the stock annex description?
    - Yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
    - Yes
- Have the data been used as specified in the stock annex?
    - Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
    - Yes
- Is there any **major** reason to deviate from the standard procedure for this stock?
    - No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?
    - Yes

Striped red mullet.

Date: 6 September 2018

Auditor: Anatoly Chetyrkin

General

For single stock summary sheet advice:

- **Assessment type:** no assessment due to lack of age structured analytical input data
- **Assessment**: Not presented
- **Forecast**: Not presented
- Assessment model: None
- **Data issues:** General lack of data, both sampling and time-series.
- Consistency: NA
- Stock status: undefined.
- Management Plan: undefined.

General comments

This is a well documented section, but the lack of information and data omit any usable conclusion and advice on this species.

Technical comments

The total number in the table 10.1 for 2006,2008,2011,2013,2014 and 2017 ** years does not coincide with the sum of the columns by 1. This is certainly a rounding problem in the calculation. For 2017* there is an error in total value calculation.

The total number in the table 10.2 for 2007,2010-2014,2016 and 2017 ** years does not coincide with the sum of the columns by 1. This is certainly a rounding problem in the calculation. For 2008 the total value is calculated incorrectly.

There is no reference to Table 10.2 in the text.

Conclusions

The assessment has been performed correctly when a few corrections have been made in the tables.

Audit of Striped red mullet

Date: 07/09/2018

Auditor: Patrícia Gonçalves

General

Age structured analytical model is not possible due to short time-series of available data.

For single stock summary sheet advice:

- **Assessment type: update/SALY** There is no assessment, due to a short time-series of age data available.
- **Assessment**: limited data available to evaluate stock trends.
- **Assessment model**: no assessment.
- **Data issues:**
- **Consistency**:
- **Stock status**: undefined.
- **Management Plan**: there is no management plan.

General comments

The section is well structured.

Technical comments

The 2006 total landings are different in Table 10.1 and Table 10.2.

Table 10.2 is not mentioned on the text.

The cited references: Jones, 1972; Russel, 1976; are not included on the references list.

Assessment type: update Western horse mackerel (hom.27.2a4a5b6a7a-ce-k8) - data audit

Date: 8 September 2018

Auditor: Martin Pastoors

General

The Western horse mackerel assessment has been carried out using Stock Synthesis 3.30. This audit only focusses on the data that is being used for the assessment.

When auditing the input and output data to this assessment, it was noticed that the tracking of the data throughout the assessment process is quite challenging. Input datafiles are prepared specifically in the format required by Stock Synthesis, however the link between the basic input data and the input file for the assessment needs to be better documented and explained. Ideally, the input data should be available in standard readable formats so that other assessment models than Stock Synthesis could also be deployed.

The assessment itself is consistent with the assessment carried out in 2017, although the retrospective upward revision of biomass and downward revision of fishing mortality has again occurred this year.

Summary

- Assessment type: update/SALY
- **Assessment**: analytical
- **Forecast**: presented
- **Assessment model**: Stock Synthesis 3.30
- **Data issues:** The main issue with the data for this assessment is the difficult in tracking the different sources of input data and how they lead to the Stock Synthesis input file. It is recommended to provide a detailed step-by-step documentation how the data is being worked up. In the current situation it is not feasible to completely check derivation of the input data to the stock assessment from the raw data files.
- **Consistency**: The view of the WG was that the assessment should be accepted. However, there was a major discussion on the applicability of the biomass reference points which were estimated at the benchmark in 2017. Due to the retrospective revisions after the benchmark, the stock size over a period of around 15 years has been estimated to be higher than in the previous assessments. Because the B_{lim} was set as the B_{loss} of the benchmark assessment in 2017 which also happened to be the last data point in the time series, the applicability of the biomass reference points was seriously questioned. An interbenchmark has been proposed to address this issue.
- **Stock status**: B is between B_{lim} and $B_{trigger}$. F is well below F_{MSY}.

General comments

The report is well documented and contains relevant explanations and references in line with the reports of previous years. The assessment has been used as the basis for the advice although concerns have been raised in the WG about the applicability of the biomass reference points or on the question whether the assessment should be used as an absolute or relative indication of development of the stock. Given that this was an

update assessment, in the end the stock annex was followed which resulted in the advice that is in the draft advice document. The data been used as specified in the stock annex although, as mentioned above, the documentation of the input data is difficult to track. Reliable stock indicators remain an important challenge for the assessment, since there is only the egg survey (every three years), a recruitment index and a biomass and length-frequency index from the southern part of the distribution area.

Technical comments

Only one model (Stock Synthesis) has been applied to this stock as specified in the stock annex. Previously the stock was assessed with the SAD model, but the development of that model has been terminated. Stock Synthesis requires two input files: a control file and a data file. The control file contains the settings to be used in the model and also the values of the assumed variables like natural mortality (M=0.15 for all ages and years).

The data file contains a specification of the datasources that are being used and the actual data series. Data series that are not used in the model but instead are calculated (e.g. maturity, weight, fecundity) are not included in the data file even though that data may be available in the underlying data sources.

SSB is around the lowest of the time series but recruitment appears to have been a bit higher over the past few years. Fishing mortality is estimate around 0.06 in the most recent year which is substantially lower than the F_{MSY}. The retrospective revisions of the stock estimates have been a feature of the western horse mackerel assessment for many years already. Unfortunately, the Stock Synthesis model does not seem to have remedied that situation.

Conclusions

The assessment has been performed according to the specifications in the stock annex. Concerns have been raised about whether the assessment is capable of measuring the absolute level of biomass and fishing mortality of this stock. The biomass is now estimated to be close to MSY $B_{trigger}$ by the virtue of the retrospective revisions of the assessment relative to the fixed reference points. An interbenchmark has been proposed to address this issue. The interbenchmark could also explore the potential application of a second assessment model as a confirmation of the trends observed in Stock Synthesis.

The documentation and transparency of the input data for the assessment needs to be improved.

Audit of mac.27.nea

Date: 3rd September 2018

Auditor: Andrew Campbell

General

The WG accepted the update assessment as a basis for advice for 2019 but is concerned with some aspects of the data and assessment model. The assessment is particularly sensitive to the inclusion of an additional year of RFID tagging data. However, the group could find no compelling argument to exclude this data from this update assessment. A need for improved understanding of model behavior the development of additional model metrics to investigate the weighting given to individual datasets prompted the group to propose ToRs for an interbenchmark exercise.

The fishery independent datasets currently indicate a declining stock, which, combined with high catches assumed for 2018 lead to a predicted SSB below MSY Btrigger (2.57Mt) in 2018.

There are possible issues with over parameterization of the assessment model with some strong correlations between parameters are noted.

The data used as input to the assessment is as provided to the stock assessor by the stock and survey coordinators. The mechanism for the delivery of this data requires formalization for auditing and quality checking purposes. The assessment and forecast appear to have been run in accordance with the stock annex.

For single stock summary sheet advice:

- **Assessment type: update** (benchmarked early 2017)
- **Assessment**: analytical, category 1
- **Forecast**: presented
- **Assessment model**: SAM, modified to utilise tag/recapture dataset. FLR forecast.
- Data issues:

No recruitment index is available for 2016 and 2017. This necessitates a departure from the procedure outlined in the stock annex for estimating the recruitment estimates required for the short term forecast, whereby the terminal assessment year recruitment estimate is replaced.

There were minor updates to the historical RFID tagging dataset although changes to recapture rates were generally < 1%.

Some other issues were clarified by the stock assessor during the audit and did not necessitate any changes to the assessment.

- **Consistency:** This year's assessment has been conducted in a manner consistent with last year and the stock annex. Outputs indicate revisions to absolute SSB and F over the last 10 years of the order of 10%.
- **Stock status**: SSB is forecast to fall below MSY $B_{trigger}$ (2.57Mt) in 2018 if the intermediate year catch (approx. twice the advice) is realised. Intermediate year catch assumptions in previous years have proved accurate. Maintain-

ing the current catches (approx. 1Mt) into 2020 would result in the SSB falling below B_{lim} in 2020. Fishing mortality has been increasing since 2011 and exceeds F_{pa} (0.35) in 2017.

- **Management Plan:** ICES advised on a proposed management plan from EU, Norway and Faroe Islands in September 2017 (and also revised the fishing mortality reference points). A suite of target fishing mortality and biomass trigger points were evaluated for a hockey-stick type HCR. The requesting parties agreed on a LTMP with a target F of 0.21 and a trigger point of 2.57Mt (coinciding with the MSY reference points). However, since not all fishing parties are in agreement, ICES advice is based on the MSY approach.

General comments

The draft report text that was available at the time of this audit is well structured and clear. The assessment code is relatively clear and concise. However, a number of assessment model parameter settings are not explicitly detailed in the code (likely because they assume default values). An explicit line of code/comment would aid auditing.

Inclusion of code for tabulating the assessment output would be beneficial for auditing purposes.

The STF code was slightly more complex. IBTS index time series is hard-coded in script and ideally should be input from the same file as used for the assessment script.

Technical comments

The IESSNS catchability parameter couplings (-1/-1/-1/3/4/4/4/4/4/4/4/4/-1) do not match those in the stock annex (-1/-1/-1/2/3/4/5/6/7/8/9/9/-1) or the draft report but they are consistent with the 2017 assessment.

The stock annex includes a clear explanation with regard to the calculation of the recruitment estimate in the terminal assessment year. However, for both this and last year it has not been possible to follow the procedure and an alternative has been used. This should be described in the stock annex along with an exact specification of the years to be used when calculating the geometric mean for the recruitments in the period of the short term forecast.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice?
- Is the assessment according to the stock annex description?
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary?
- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

1) **/SALY** There is no assessment, due to a short time-series of age data available.

2) **Assessment**: limited data available to evaluate stock trends.

3) **Assessment model**: no assessment.

4) Data issues:

5) Consistency:

6) **Stock status**: undefined.

7) **Management Plan**: there is no management plan.

General comments

The section is well structured.

Technical comments

The 2006 total landings are different in Table 10.1 and Table 10.2.

Table 10.2 is not mentioned on the text.

The cited references: Jones, 1972; Russel, 1976; are not included on the references list.

Audit of Mackerel (WGWIDE 2018)

Date: 7. September 2018

Auditor: Jan Arge Jacobsen

General

The stock assessment for NEA mackerel in 2016 has been done according to the stock annex. The stock is estimated to be below MSY $B_{trigger}$ in 2018, for the first time since 2007, and the advice is thus based on the MSY approach: F_{MSY} * SSB(2019) /MSY $B_{trigger}$

For single stock summary sheet advice:

Short description of the assessment:

- Assessment type: update
- **Assessment**: analytical
- **Forecast**: presented
- **Assessment model**: State-space model (SAM) fitted to catch-at-age data for ages 0 to 12 (+ group) (1980-2017, strongly down-weighted for 1980-1999) and three surveys: 1) Mackerel Egg survey (triennial, 1992-2016); 2) Recruitment index from IBTS Q1 and Q4 surveys (1998-2015); and 3) abundance estimates, ages 6 to 11, from IESSNS survey (2007 and 2010-2018). The model also incorporates tagging-recapture data from the Norwegian tagging program (1980-2005) and the new RFID tagging series (2011 and onwards).
- **Data issues:** New survey input data for the assessment, as described in the stock annex, were available for the IESSNS, tagging-recapture data from the Norwegian tagging program and egg survey series. However, no data was available for the IBTS recruitment index from the North Sea for the second year in a row. With the addition of 2017 catch-at-age, weights-at-age in the catch and in the stock, maturity ogive and proportions of natural and fishing mortality occurring before spawning.
- **Consistency**: Last year's assessment was accepted
- **Stock status**: $B<B_{MSY\ Btrigger}$ and $B_{lim}<B<B_{pa}$, $F>F_{MSY}$ and $F_{pa}<F<F_{lim}$, R has bee high since early 2000s but the 2015 and 2016 year-classes are estimated to be below average.
- **Management Plan**: There is no agreement on an overarching management plan for mackerel. ICES have based their advice on the MSY approach. However EU, NO and FO agreed in 2014 on an *ad hoc* management plan for the years 2015-2018. The *ad hoc* Management Plan was evaluated by ICES in 2017 after the benchmark, and was adjusted accordingly for the updated reference points by the three parties for the 2018 advice (refer to Table 8.2.4.1 in the WG report).

General comments

The sections were well ordered, however not all were finished by the time of the audit. This did not affect the main conclusions. Analyses were well described and the results presented clearly. The conclusions regarding advice are appropriate, given the divergent survey trends, increased reliance on catch data and associated change in perception of stock status. The short time series of some of the survey caused instability in the model, as the "leave out" runs clearly demonstrated. The perception of the stock

changed proportionally much by on removal of single input series. The model might be over parameterized.

Technical comments

Due to missing IBTS recruitment index the setting for the SAM run were not entirely in accordance with stock annex (benchmark 2017). The outdated time series from WGWIDE 2016 was used in the assessment and it was therefore conducted without an index value for the 2016 and 2017 year classes (see Sec. 8.6.2 for details).

There might be some issues with the use of the tagging data (RFID) in the SAM model. In Section 8.6.4 a discussion of possible effects/biases were discussed that might have large influences on the model runs, e.g. if the recapture rates in different areas/seasons vary due according to incomplete mixing of tagged fish, or due to mortality happening between seasons (for instance between quarter 1 and quarter 4 catches). These potential biases are not taken into account in SAM assessment model today. Also the high tagging mortality for the RFID tags that the model estimates were considered problematic in the assessment. Alternative use of tag data in the assessment was discussed in this section. An ICES workshop on tagging data was suggested.

The realisation of the process error in the model was also inspected (Section 8.7.5). While process error is assumed to be independent and identically distributed, there is clear evidence of correlations in the realisation of the process error in the mackerel assessment, which appears to be correlated both across age-classes and temporarily. The temporal autocorrelation can also be visualised if the process error is expressed in term of biomass (deviations in abundances-at-age multiplied by weight at age and summed over all age classes, Figure 8.7.5.4 in the WG report). For the years since 2010 the cumulated process error remains positive, with the magnitude reaching a third of the volume of the catches for 2009. The reason for this misbehaviour of the model could not be identified.

Conclusions

The update assessment has been performed correctly and gives a valid basis for advice.

The WG recommends an interbenchmarch as soon as possible (2019) to deal with data/model issues.

Annex 6: List of Working Documents

i) Cruise report on the International ecosystem survey in Nordic Seas (IESNS) in May – June 2018. Authors: ICES 2018 with contribution from Maxim Rybakov, Tatyana Sergeeva, Anna Gordeeva, Valantine Anthonypillai, Are Salthaug, Erling Kåre Stenevik, Kjell Arne Mork, Cecilie Thorsen Broms, Øystein Skagseth, Karl-Johan Stæhr, Benoît Bergès, Mathias Kloppmann, Sven Kupschus, Guðmundur J. Óskarsson, Anna Heiða Ólafsdóttir, Hildur Pétursdóttir, Eydna í Homrum, Ebba Mortensen, Sólva Eliassen, Poul Vestergaard, Leon Smith.

ii) Herring distribution in the Norwegian Sea in May. Authors: S. K. Eliasen, E. í Homrum, and J. A. Jacobsen.

iii) Pelagic ecosystem acoustic-trawl survey PELACUS 0318: mackerel, horse mackerel, blue whiting and boar fish abundance estimates. Authors: Pablo Carrera, Paz Díaz, Rosario Domínguez, Gonzalo González-Bueno, Isabel Riveiro

iv) Pelagic ecosystem acoustic-trawl survey PELACUS-IBWSS 0318: blue whiting and müeller's pearlside fish abundance estimates in Porcupine Seabight. Authors: Pablo Carrera, Paz Díaz, Rosario Domínguez, Gonzalo González-Bueno, Isabel Riveiro

v) Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 30th of June – 6th of August 2018. Authors: Anna Heiða Ólafsdóttir, Sigurður Þór Jónsson, James Kennedy, Jan Arge Jacobsen, Ebba Mortensen, Leon Smith, Teunis Jansen, Søren Post, Lars Heilmann, Kjell Rong Utne, Leif Nøttestad, Valantine Anthonypillai, Are Salthaug, Åge Høines, Geir Odd Johansen, and Kai Weiland.

vi) Comments on incongruous formulations in the SAM (state-space assessment model) model and consequences for fish stock assessment. Authors: M. Aldrin, S. Aanes, S. Subbey (Reference: M, A., Fisheries Research (2018), https://doi.org/10.1016/j.fishres.2018.08.001).

vii) Reference fleets identification by LPUE data filtering applied to the striped red mullet (Mullus surmulletus) in the Bay of Biscay. Authors: Nathalie Caill-Milly, Muriel Lissardy, Noëlle Bru, Marie-Adèle Dutertre, Cassandre Saguet.

viii) Red gurnard in DCF/NP samplings for ICES Division 27.9a. Authors: Diana Feijó and Alberto Rocha

ix) Gurnards: species landings' composition in ICES Division 27.9a. Authors: Alberto Rocha, Diana Feijó and Patrícia Gonçalves.

x) NEA mackerel, alternative assessment. Authors: Höskuldur Björnsson

xi) Direct assessment of small pelagic fish by the PELGAS18 acoustic survey. Authors:Duhamel, E., Doray, M., Huret, M., Sanchez, F., Marie-Lepoittevin, T., Peltier, H., and Autthier, M.

xii) Norwegian Spring Spawning Herring stock assessment by means of TISVPA. Authors: Dimitry Vasilyev

xiii) Survey report for MS Eros, MS Kings Bay MS Vendla 13.-25.02.2018 in relation to Distribution and abundance of Norwegian spring-spawning herring during the spawning season in 2018. Authors: Aril Slotte, Are

Salthaug, Åge Høines, Erling Kåre Stenevik, Sindre Vatnehol and Egil Ona.

xiv) Blue Whiting stock assessment by means of TISVPA. Authors: Dimitry Vasilyev.

xv) Evaluation of potential rebuilding strategies for the Western Horse Mackerel (Trachurus trachurus) fishery. Authors: S.P. Cox, A.J. Benson, B. Doherty, and S. Johnson.

xvi) Developing a standardized Horse mackerel CPUE index. Authors: Esther Beukhof and Martin Pastoors.

xvii) PFA self-sampling report for WGWIDE (2015-2018). Authors: Martin Pastoors.

xviii)2018 mackerel egg exploratory survey. Authors: Finlay Burns, Brendan O'Hea, Bjorn Gunnarsson

xix) Nøttestad, L. Utne, K.R., Sandvik, A., Skålevik, A., Slotte, A. and Huse, G. 2018. Historical distribution of juvenile mackerel northwards along the Norwegian coast and offshore following the 2016 mackerel spawning. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE), Havstovan, Tórshavn, Faroe Islands, 28. August – 3. September 2018, 25 pp.

xx) Authors: Leif Nøttestad, Kjell Rong Utne, Anne Sandvik, Åsmund Skålevik, Aril Slotte, Geir Huse